Programme & Abstract Book

POLinSAR 2011

5th International Workshop on Science and Applications of SAR Polarimetry and Polarimetric Interferometry

24-28 January 2011

ESA-ESRIN

Frascati (Rome), Italy
Index

Committees ..........................................................................................................................4

Programme

- Monday 24 January ........................................................................................................5
- Tuesday 25 January .........................................................................................................7
- Wednesday 26 January .................................................................................................9
- Thursday 27 January ....................................................................................................11
- Friday 28 January .........................................................................................................13
- Posters ..........................................................................................................................14

Abstracts

- Missions .....................................................................................................................17
- Calibration & Data Quality .......................................................................................25
- Applications on Urban ...............................................................................................33
- Polarimetric Interferometry (Pol-InSAR) .................................................................41
- Applications on Soil Moisture/Wetlands .................................................................55
- Polarimetry & PSI – Tomography ............................................................................63
- Methods & Theoretical Modelling .........................................................................69
- Applications on Ocean/Cryosphere & Hazards .......................................................81
- Applications on Forest .............................................................................................91
- Applications on Agriculture ....................................................................................103
- Airborne and Spaceborn Pol-InSAR campaigns ......................................................113
- Posters ........................................................................................................................121
Committees

ESA Organising Committee

Y.-L. Desnos, A. Minchella, M. Engdahl, M. Davidson, N. Miranda, B. Rosich

Scientific Committee

Prof. Wolfgang-Martin Boerner - University of Illinois, USA
Dr. Shane R Clode - AEL Consultants, UK
Dr. Wolfgang Dierking - Alfred Wegener Institute for Polar and Marine Research, Germany
Prof. Chen Erxue - Chinese Academy of Forestry, China
Dr. Anthony Freeman - Jet Propulsion Laboratory (JPL), USA
Dr. Irena Hajnsek - German Aerospace Center (DLR), Germany
Dr. Thuy Le Toan - Centre d’Etudes Spatiales de la Biosphere (CESBIO), France
Prof. Pierfrancesco Lombardo - University of Rome - La Sapienza, Italy
Prof. Alberto Moreira - German Aerospace Center (DLR), Germany
Stephane Chalifoux - Canadian Space Agency (CSA), Canada
Dr. Konstantinos P. Papathanassiou - German Aerospace Center (DLR), Germany
Prof. Eric Pottier - University of Rennes 1 - UFR S.P.M, France
Prof. Motoyuki Sato - Tohoku University, Japan
Dr. Carlos Lopez-Martinez - Universitat Politecnica de Catalunya - BarcelonaTech (UPC), Spain
Prof. Christiana Schmullius - Friedrich-Schiller - University Jena, Germany
Dr. Masanobu Shimada - EORC/JAXA, Japan
Prof. Henning Skrøyer - Technical University of Denmark, Denmark
Dr. Jean-Claude Soulris - Centre National d’Etudes Spatiales (CNES), France
Dr. Ridha Touzi - Canada Centre for Remote Sensing (CCRS), Canada
Dr. Dan Weydahl - Norwegian Defence Research Establishment, Norway
Prof. Wooll M. Moon - University of Manitoba, Canada
Prof. Dr. Yoshio Yamaguchi - Niigata University, Japan
Prof. Andrea Monti Guarneri - POLIMI, Italy
Prof. Shaun Quegan - University of Sheffield, UK
Dr. Tom Ainsworth - U.S. Naval Research Laboratory, USA
Dr. Iain Woodhouse - University of Edinburgh, UK
Dr. Laurent Ferro-Famil - Université de Rennes 1, France
Dr. Scott Hensley - NASA Jet Propulsion Laboratory, USA
Dr. Pascale Dubois - French Aerospace Lab ONERA, France
Dr. Wen Hong - Institute of Electronics, Chinese Academy of Sciences (IECAS), China
Dr. Alessandro Coletta - Italian Space Agency (ASI), Italy
Programme

Monday 24 January 2011

08:00 Workshop Registration
09:25 Opening Session

Missions

10:05 TanDEM-X: Mission Overview & Scientific Contributions
Hajnsek, Irena 1; Krieger, Gerhard 2; Papathanassiou, Kostas 2; Kugler, Florian 2; Baumgartner, Stefan 2; Rodriguez-Cassola, Marc 2; Prats, Pau 2
1ETH Zürich / DLR, (GERMANY); 2German Aerospace Center, (GERMANY)

10:25 RADARSAT Missions for EO Science and Operational Applications
Stephane Chalifoux
Canadian Space Agency (CANADA)

10:45 Cosmo-Skymed , Results and Applications
Paolillo, F.; Coletta, A.
Italian Space Agency, (ITALY)

11:05 Coffee Break

11:30 GMES Sentinel-1 Mission and System Performance
Snoeij, P.; Torres, R.; Davidson, M.; Rommen, B.; Floury, N.
European Space Agency, (NETHERLANDS)

11:50 THE BIOMASS EARTH EXPLORER MISSION CANDIDATE– STATUS AND RESULTS FROM PHASE-A ACTIVITIES
Scipal, K 1; Arcioni, M 1; Chave, J 1; Dall, J 1; LeToan, T 2; Lin, C.-C. 1; Piso, F 1; Papathanassiou, K 1; Quegan, S 1; Rocca, F 1; Saatchi, S 1; Shugart, H 1; Ulzander, L 1; Williams, M 1
1European Space Agency, (NETHERLANDS); 2Centre National de la Recherche Scientifique, (FRANCE); 3Technical University of Denmark, (DENMARK); 4Centre d’Etudes Spatiales de la Biosphère, (FRANCE); 5German Aerospace Center, (GERMANY); 6University of Sheffield, (UNITED KINGDOM); 7Politecnico di Milano, (ITALY); 8Jet Propulsion Laboratory, (UNITED STATES); 9The University of Virginia, (UNITED STATES); 10Swedish Defence Research Agency, (SWEDEN); 11University of Edinburgh, Edinburgh, (UNITED STATES)

12:10 Smos Polarimetric Mode
Martín-Neira, M. 1
1ESA, (NETHERLANDS)

12:30 Round Table Missions

Calibration & Data Quality

12:50 On the Application of Polarimetric Calibration by Means of Permanent Scatterers on C-band SAR Data
Iannini, Lorenzo; Monti Guarnieri, Andrea
Politecnico di Milano, (ITALY)

13:10 An Ionospheric Calibration Scheme for the BIOMASS Pol-InSAR Data Space
Kim, Jun Su; Danklmayer, Andreas; Papathanassiou, Konstantinos
German Aerospace Center, (GERMANY)

13:30 Severe Radio Frequency Interference in PALSAR images
Doulgeris, A. P. 1; Meyer, F. 2
1University of Tromso, (NORWAY); 2Geophysical Institute, University of Alaska, Fairbanks, (UNITED STATES)

13:50 Lunch Break

15:00 On the use of Transponder Measurements for high Precision Assessment and Calibration of Polarimetric Radarsat-2
Touzi Ridha, RT 1; R.K. Hawkins, BH 1; S. Coté, SC 1
1Canada Centre for Remote Sensing, (CANADA)

---

30
15:20  Data Quality and Scientific Analysis of fully Polarimetric TerraSAR-X Data
Hajnsek, I \(^1\); Papathanassiou, K \(^2\)
\(^1\)ETH Zürich / DLR, (GERMANY); \(^2\)German Aerospace Center, Microwaves and Radar Institute, (GERMANY) ....... 31

15:40  Round Table Calibration & Data Quality

Applications on Urban

16:00  An Advanced Method for the Three-Component Decomposition Applied to Azimuthally Inclined Objects
Kusano, Shunichi; Watanabe, Manabu; Sato, Motoyuki
Tohoku University, (JAPAN)........................................................................................................................ 35

16:20  Coherence Optimization for Estimation of building Heights on a Segmented high Resolution POLINSAR Urban Area
Colin-Koeniguer, E.; Trouvé, N.
ONERA, (FRANCE)............................................................................................................................................. 36

16:40  Coffee Break

17:05  Shape Constraint Region Growing Process and Application to 3D Rendering of High Resolution Urban Images.
Trouvé, N.; Colin-Koeniguer, E
ONERA, (FRANCE)............................................................................................................................................. 37

17:25  Improved Tomographic SAR Focusing using Automatic Baseline Error Compensation
Ferro-Famil, L \(^1\); Huang, Y \(^1\); Lombardini, F \(^2\)
\(^1\)University of Rennes 1, (FRANCE); \(^2\)University of Pisa, (ITALY)........................................................................................................... 38

17:45  Natural Environment Characterization using Hybrid Tomographic Approaches
Huang, Yue \(^1\); Ferro-Famil, L \(^1\); Reigber, A \(^2\)
\(^1\)University of rennes 1, (FRANCE); \(^2\)DLR, (GERMANY) ............................................................................................ 39

18:05  Round Table Applications on Urban

18:25  Welcome Drink
Tuesday 25 January 2011

Polarimetric Interferometry (Pol-InSAR)

09:05  An Assessment of the Polinsar Performance of Tandem-X for Forestry Applications  
Claude, S. R.  
AEL Consultants, (UNITED KINGDOM) ........................................................................................................ 43

09:25  Forest Characterisation by Means of TerraSAR-X and TanDEM-X Polarimetric Interferometric Data  
Kugler, Florian ¹; Hajnsek, Irena ²; Papathanassiou, Konstantinos ³  
¹German Aerospace Centre (DLR), (GERMANY); ²ETH Zürich, Institute of Environmental Engineering, (SWITZERLAND) ...................................................... 44

09:45  A new Test for Target Stationarity for POLinSAR Applications  
Marino, A ¹; Claude, S. R. ²  
¹The University of Edinburgh, (UNITED KINGDOM); ²AEL Consultants, (UNITED KINGDOM) .................... 45

10:05  Separation of scattering contributions in Polarimetric SAR Interferometry  
López-Martínez, C. ¹; Papathanassiou, K.P. ²; Alonso, A. ¹; Fàbregas, X. ²  
¹Universitat Politècnica de Catalunya UPC, (SPAIN); ²German Aerospace Center DLR, (GERMANY) ........... 46

10:25  Overview and Applications of UAVSAR’s Multi-squint Polarimetric Imaging Mode  
Hensley, Scott ; Jones, C ; Michel, T ; Chen, C ; Chapman, B ; Muellerschoen, R.  
Jet Propulsion Laboratory, (UNITED STATES) ......................................................................................... 47

10:45  Biomass Estimation from Forest Vertical Structure: Potentials and Challenges for Multi-Baseline Pol-InSAR Techniques  
Pardini, Matteo ; Kugler, Florian ; Lee, Seung-Kuk ; Sauer, Stefan ; Torano Caicoya, Astor ; Papathanassiou, Konstantinos  
German Aerospace Center (DLR), (GERMANY) ...................................................................................... 48

11:05  Coffee Break

11:30  Forest above Ground Biomass Estimation based on Forest Vertical Structure Information Extracted from POLInSAR Data  
Luo, H.M. ¹; Chen, E.X. ²; Li, Z.Y. ²; Li, X.W. ²  
¹Institute of Geo-Spatial Information Science and Technology, Univ. Electron. Sci. Tech. China, (CHINA); ²Institute of Forest Resources Information Technique of Chinese Academy of Forestry, (CHINA) .......................... 49

11:50  Two-Layered Forest Models in Multibaseline Polinsar  
Stefano, Tebaldini ; Fabio, Rocca  
Politecnico di Milano, (ITALY) .................................................................................................................. 50

12:10  Dependence of Multi-Frequency and and Multi-Polarization SAR Coherence on Land Cover  
Atwood, D.K. ; Meyer, F.  
University of Alaska Fairbanks, (UNITED STATES) .................................................................................... 51

12:30  Exploring the Potential Pol-InSAR Techniques at X-Band: First Results and Experiments from TanDEM-X  
Papathanassiou, Konstantinos ; Kugler, Florian ; Hajnsek, Irena  
German Aerospace Center, (GERMANY) ................................................................................................. 52

12:50  Temporal and Volume Effects in Polarimetric Sar Interferometry  
Lavalle, M ; Simard, M.  
JPL/Caltech, (UNITED STATES) ............................................................................................................. 53

13:10  Round Table Pol-InSAR

13:50  Lunch Break
Applications on Soil Moisture/Wetlands

15:00  A Hybrid Decomposition for Soil Moisture Estimation under Vegetation Cover Using Polarimetric SAR
Jagdhuber, Thomas 1; Hajnsek, Irena 2; Papathanassiou, Konstantinos P. 2; Bronstert, Axel 3
1German Aerospace Center, (GERMANY); 2ETH Zurich, Institute of Environmental Engineering, (SWITZERLAND);
3University of Potsdam, Institute of Earth and Environmental Sciences, (GERMANY) ........................................ 57

15:20  Investigation of Polarimetric radarsat 2 for Peatland Characterization
Touzi Ridha, RT
Canada Centre for Remote Sensing, (CANADA) .......................................................... 58

15:40  Extraction of Benthic Fauna Habitat in Tidal Flats using Multi-Frequency polarimetric SAR Data
Choe, B. 1; Kim, D.J. 1; Hwang, J.H. 2; Moon, W.M. 3
1Seoul National University, (KOREA, REPUBLIC OF); 2Hong University, (KOREA, REPUBLIC OF);
3University of Manitoba, (CANADA) .................................................................................. 59

16:00  Soil Moisture Retrieval in Alpine Areas by using Support Vector Regression Techniques and polarimetric
RADARSAT2 Images
Luca, Pasolli 1; Claudia, Notarnicola 2; Lorenzo, Bruzzone 3; Giacomo, Bertoldi 4; Stefano, Della Chiesa 4; Ulrike, Tappeiner 4; Marc, Zebisch 2; Fabio, Del Frate 3; Gaia, Vaglio Laurin 5
1UniTrento-EURAC, (ITALY); 2EURAC-Institute for Applied Remote Sensing, (ITALY); 3Dep. of Information
Engineering and Computer Science, University of Trento, (ITALY); 4EURAC-Institute for Alpine Environment, (ITALY);
5Dep. of Computer, System and Production Engineering, Tor Vergata University, (ITALY) ........................................ 60

16:20  Radarsat-2 fully Polarimetric Time-Series Datasets for Wetlands Delineation and Characterization
Marechal, C 1; Pottier, E 1; Hubert-Moy, L 2; Corgne, S 2; Meric, S 2; Allain, S 1
1IETR, University of Rennes 1, (FRANCE); 2COSTEL, University of Rennes 2, (FRANCE) ........................................ 61

16:40  Round Table Applications on Soil Moisture/Wetlands

17:00  Coffee Break

Polarimetry & PSI - Tomography

17:25  The UniPI Diff-Tomo Framework: Evolutions of SAR Interferometry for Complex Non-Stationary Scenes
Lombardini, F.; Cai, F.
University of Pisa, (ITALY) ........................................................................................................... 65

17:45  Polarimetric Stationarity Criteria Applied to the Selection of Persistent Scatterer Candidates
Navarro Sanchez, Victor Diego; Lopez Sanchez, Juan Manuel
Universidad de Alicante, (SPAIN) .................................................................................................. 66

18:05  Target Characterization and Interpretation of Deformation Using Persistent Scatterer Interferometry and
Polarimetry
Dheenathayalan, P.; Hanssen, R.F.
Delft University of Technology, (NETHERLANDS) ........................................................................... 67

18:25  Application of Polarimetric Techniques in DinSAR Processing for Space Borne Subsidence Monitoring
Monells, Dani; Mallorqui, Jordi; Centolanza, Giuseppe; Lopez-Martinez, Carlos
Universitat Politècnica de Catalunya, (SPAIN) ................................................................................. 68

18:45  Round Table Polarimetry & PSI – Tomography
Wednesday 26 January 2011

Methods

08:45 Compact Polarimetry at the Moon: The Mini-RF Radars
Raney, R. K. 1; Spudis, P. 2; Bussey, B. 1; Jensen, J. R. 1; Marinelli, W. 3; McKerracher, P. 4; Schulze, R. 5; Sequeira, H. 1; Winters, H. 1
1 Johns Hopkins University APL, (UNITED STATES); 2 Lunar and Planetary Institute, (UNITED STATES); 3 NASA Headquarters, (UNITED STATES) .................................................................................................................... 71

09:05 StereoPol of Radarsat-2 Data for DEM Generation without GCP
Toutin, Th; Zakharov, I
Canada Centre for Remote Sensing, (CANADA) ........................................................................................................................ 72

Theoretical Modelling

09:25 Bistatic Polarimetric SAR Decomposition in Terms of Roll-Invariant Parameters
Bombrun, L
GIPSA-lab, (FRANCE) .......................................................................................................................... 73

09:45 PolSAR Speckle Filtering and Segmentation based on Binary Partition Tree Representation
Alonso-González, A.; López-Martínez, C.; Salembier, P.
Universitat Politècnica de Catalunya UPC, (SPAIN) ........................................................................................................... 74

10:05 Heterogeneous Clutter Model for high Resolution Polarimetric SAR Data Parameter Estimation
Gabriel, Vasile 1; Pascal, Frédéric 2; Ovarlez, Jean-Philippe 3
1 GIPSA-lab / CNRS, (FRANCE); 2 SONDRA / SUPELEC, (FRANCE); 3 ONERA, (FRANCE) .......................................................................................................................... 75

10:25 Coffee Break

10:50 Hypothesis Test in Complex Wishart Distributions
Frery, Alejandro 1; Cintia, Renato 2; Nascimento, Abraão 2
1 UFAL, (BRAZIL); 2 UFPE, (BRAZIL) .......................................................................................................................... 76

11:10 H/α Unsupervised Classification for highly textured Polinsar Images using Information Geometry of Covariance Matrices
Formont, Pierre 1; Ovarlez, Jean-Philippe 2; Pascal, Frederic 3; Vasile, Gabriel 4; Ferro-Famil, Laurent 5
1 ONERA & SONDRA, (FRANCE); 2 SONDRA & ONERA, (FRANCE); 3 SONDRA, (FRANCE); 4 GIPSA Lab, (FRANCE); 5 IETR, (FRANCE) .......................................................................................................................... 77

11:30 Lossless W-Invariant Decomposition of Deterministic Target
Paladini, Eng. 1; Ferro Famil, Prof. 2; Pottier, Prof. 3; Berizzi, Prof. 4
1 University of Pisa - University of Rennes 1, (ITALY); 2 University of Rennes 1, (FRANCE); 3 University of Rennes, (ITALY); 4 University of Pisa, (ITALY) .......................................................................................................................... 78

11:50 On the Supremacy of Logging
Anfinsen, S.N.
University of Tromsø, (NORWAY) .......................................................................................................................... 79

12:10 Round Table Methods & Theoretical Modelling

Applications on Ocean/Cryosphere & Hazards

12:50 Potential of Polarimetric SAR data for Snow Water Equivalent Estimation in Subarctic Regions
Duguay, Y.; Bernier, M.
Institut National de la recherche scientifique, (CANADA) .......................................................................................................................... 83

13:10 Ship Detection in Variable Sea States and Depolarised Sea Clutter: a Polarimetric Notch Filter
Marino, A.; Walker, N
1 The University of Edinburgh, (UNITED KINGDOM); 2 eOsphere, (UNITED KINGDOM) .......................................................................................................................... 84

13:30 Maximum Likelihood Shift Estimation using High Resolution Polarimetric SAR Clutter Model
Harant, O. 1; Bombrun, L. 2; Vasile, G. 1; Ferro-Famil, L. 2; Gay, M. 1
1 Gipsa-lab, (FRANCE); 2 IETR, (FRANCE) .......................................................................................................................... 85

13:50 Lunch Break
15:00 Physical Significance of Radar Texture in Sea Ice Studies
Moen, Mari-Ann Norum ¹; Anfinsen, Stian Normann ²; Doulgeris, Anthony ¹; Gerland, Sebastian ²; Eltaft, Torbjørn ¹
¹University of Tromsø, (NORWAY); ²Norwegian Polar Institute, (NORWAY) .......................................................... 86

15:20 Polarimetric RADARSAT-2 for River Freeze-up Monitoring
van der Sanden, J.J.; Drouin, H.
Natural Resources Canada, (CANADA) ................................................................................................................... 87

15:40 Cosmo SkyMed Multi-Polarization SAR Data for Vessels Observation
Nunziata, Ferdinando; Migliaccio, Maurizio; Montuori, Antonio
Università di Napoli Parthenope, (ITALY)............................................................................................................. 88

16:00 UAVSAR L-band Polarimetric Data to analyze BP Oil Spill
Migliaccio, Maurizio ¹; Nunziata, Ferdinando ¹; Holt, Benjamin ²
¹Università di Napoli Parthenope, (ITALY); ²Jet Propulsion Laboratory, California Institute of Technology, (UNITED STATES) ........................................................................................................................................... 89

16:20 A Multi-Frequency Polarimetric SAR Processing Chain to observe Oil Fields in Gulf of Mexico
Montuori, Antonio ¹; Nunziata, Ferdinando ¹; Migliaccio, Maurizio ²; Li, Xiaofeng ²; Pichel, William ³
¹Università di Napoli Parthenope, (ITALY); ²IMSG at NOAA/NESDIS, (UNITED STATES); ³NOAA/NESDIS/STAR, (UNITED STATES) ........................................................................................................................................... 90

16:40 Round Table Applications and Ocean/Cryosphere & Hazards

17:20 Free Poster Session (with refreshment)
Applications on Forest

08:45  Relating Biophysical Properties of Secondary Succession in Eastern Amazon using ALOS/PALSAR Data  
Liesenberg, Veraldo; Gloaguen, Richard; Heilmeyer, Hermann  
TU Bergakademie Freiberg, (GERMANY) ................................................................. 93

09:05  A Comparison Study of Biomass Estimation Using ALOS PALSAR and LiDAR Data  
Tan, Chue Poh; Marino, Armanda; Woodhouse, Iain; Cloude, Shane; Suarez, Juan; Edwards, Colin  
2 University of Edinburgh, (UNITED KINGDOM); 3 AEL Consultants, (UNITED KINGDOM);  
3 Forestry Commission UK, (UNITED KINGDOM) ..................................................... 94

09:25  Influence of Reflection Symmetry Properties for Tropical Forest Classification with Radar Polarimetry  
Lardeux, C.L; Niamen, D; Routier, J.B; Giraud, A; Frison, P.L; Pottier, E; Rudant, J.P  
2 University Rennes 1, (FRANCE); 1 University Paris-Est, (FRANCE); 2 ONF-International, (FRANCE) ............... 95

09:45  A Hybrid Model for Extended Covariance Matrix Prediction for Forest Imaging in P-band  
Synthetic Aperture Radar  
Soja, Maciej J; Ulander, Lars M. H  
1 Chalmers University of Technology, (SWEDEN); 2 Swedish Defence Research Agency (FOI), (SWEDEN) .......... 96

10:05  A new Backscattering Coefficient Normalization for Dense Forest: Application to Biomass Retrieval from Band SAR Data  
Villard, L; Lasne, Y; Le Toan, T  
CESBIO, (FRANCE) ........................................................................................................ 97

10:25  Coffee Break

10:50  Forest Biomass Estimates from an Airborne Single-Pass L-Band Pol-Insar System  
Mercer, B; Zhang, Q; Schwaebisch, M; Denbina, M  
1 Intmap Technologies Corporation, (CANADA); 2 Intmap Technologies Corporation, (GERMANY) ................. 98

11:10  Boreal Forest Biomass Estimation using PolInSAR Vertical and Morphological Structure Indicators  
Neumann, Maxim; Saatchi, S.S  
JPL, (UNITED STATES) .................................................................................................... 99

11:30  Biomass Retrieval on Tropical Forests: The BIOMASS Mission  
Le Toan, T; Villard, L; Lasne, Y; Kolecak, T; Dubois-Fernandez, P; Chave, J; Blanc, L  
1 CESBIO, (FRANCE); 2 ONERA, (FRANCE); 3 EDB, (FRANCE); 4 CIRAD, (FRANCE) ......................................... 100

11:50  Fourier Scales of Tropical-Forest Structure and their Relation to Biomass Estimation from C- and L-band InSAR and Lidar  
Treuhaft, Robert; Goncalves, F.G; Hensley, S  
1 Jet Propulsion Laboratory, (UNITED STATES); 2 California Institute of Technology, (UNITED STATES) ............. 101

12:10  Round Table Applications on Forest

Applications on Agriculture

12:50  Polarimetric Studies of Native Grasslands in Western Canada using RADARSAT-2 Imagery  
Buckley, J; Smith, A  
1 Royal Military College of Canada, (CANADA); 2 Agriculture and Agri-Food Canada, (CANADA) ...................... 105

13:10  Crop Change Assessment using Polarimetric RADARSAT-2 Data  
Liu, C; Shang, J; Vachon, P.W; McNairn, H  
1 Defence R&D Canada - Ottawa, (CANADA); 2 Agriculture and Agri-Food Canada, (CANADA) ..................... 106

13:30  Retrieval of Rice Phenology by Means of SAR Polarimetry at C and X Band  
Lopez-Sanchez, J.M; Cloude, S.R; Ballester-Berman, J.D  
1 University of Alicante, (SPAIN); 2 AEL Consultants, (UNITED KINGDOM) ..................................................... 107

13:50  Lunch Break
15:00 Fully Polarimetric SAR Mosaicing and Land Cover Classification in the Northern Taiga Region
Antropov, O.; Yrjö, Rauste; Lönnqvist, A.; Hämne, T.
VTT Technical Research Centre of Finland, (FINLAND) ......................................................................................... 108
15:20 Temporal and Incidence Angle Dependency of PolSAR Data for Agricultural Land Cover Analysis and Characterization
López-Martínez, C.; Montero, I.; Fàbregas, X.
Universitat Politècnica de Catalunya UPC, (SPAIN) .................................................................................................. 109
15:40 Analysis on the Potential of L-Band PolSAR Data for Crop Monitoring
Ballester-Berman, J. David; Lopez-Sanchez, Juan M.
University of Alicante, (SPAIN) ............................................................................................................................... 110
16:00 Multitemporal Analysis of Agricultural Fields using Polarimetric Radarsat-2 Images
Weydahl, D J
Norwegian Defence Research Establishment, (NORWAY) ......................................................................................... 111
16:20 Multi-Temporal Polarimetric Signatures of Crops: Overview and Results from the AgriSAR 2009 Campaign
Caves, R 1; Davidson, M 2; Hui, G 1; Davidson, G 1; Ma, A 1; Padda, J 1; Staples, G 1
1MDA, (CANADA); 2ESA, (NETHERLANDS) ............................................................................................................. 112
16:40 Round Table Applications on Agriculture

Airborne and Spaceborn Pol-InSAR campaigns

17:35 The TropiSAR campaign in French Guiana: SAR dataset and first PolInSAR analysis
Dubois-Fernandez, P 1; Daniel, S 2; Le Toan, T 3; Chove, J 4; Blanc, L 5; Davidson, M 6
1ONERA, (FRANCE); 2CESBIO-ONERA, (FRANCE); 3CESBIO, (FRANCE); 4EDB, (FRANCE); 5CIRAD, (FRANCE);
6ESTEC, (FRANCE) .......................................................................................................................................................... 115
17:55 First Demonstration of Agriculture Height Retrieval with POLINSAR Airborne Data
Lopez-Sanchez, J. M. 1; Hajnsek, I 1; Ballester-Berman, J. D. 1
1University of Alicante, (SPAIN); 2DLR, (GERMANY) ................................................................................................ 116
18:15 Mapping Vegetation 3D Structure and Biomass with UAVSAR and LVIS
Simard, M. 1; Pinto, N. 2; Lavalle, M. 1; Dubayah, R. 1; Hensley, S. 1
1Jet Propulsion Laboratory, (UNITED STATES); 2University of Maryland, (UNITED STATES) ........................................ 117
18:35 Airborne SAR Campaign Activities in Support of the ESA Earth Observation Programme
Davidson, M 1; Hajnsek, I 1; Dubois-Fernandez, P 1
1ESA, (NETHERLANDS); 2DLR, (GERMANY); 3ONERA, (FRANCE) ........................................................................... 118
18:55 ALOS-Indonesia POL-InSAR Experiment (AIPEX): A Capacity Development for REDD Application
Raimadaya, Mahmud 1; Trisassongko, Bambang 1; Sarbini, Nurwadjedi 1; Zakharova, Ludmilla 1
1Bogor Agricultural University, (INDONESIA); 2National Survey and Mapping Coordination Agency, (INDONESIA);
3Russian Academy of Sciences, (RUSSIAN FEDERATION) ......................................................................................... 119
19:15 Round Table Airborne and Spaceborn Pol-InSAR campaigns

12
<table>
<thead>
<tr>
<th>Time</th>
<th>Session Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:45</td>
<td>Session Summary: Missions</td>
</tr>
<tr>
<td>09:05</td>
<td>Session Summary: Calibration &amp; Data Quality</td>
</tr>
<tr>
<td>09:25</td>
<td>Session Summary: Applications on Urban</td>
</tr>
<tr>
<td>09:45</td>
<td>Session Summary: Polarimetric Interferometry (Pol-InSAR)</td>
</tr>
<tr>
<td>10:05</td>
<td>Session Summary: Applications on Soil Moisture/Wetlands</td>
</tr>
<tr>
<td>10:25</td>
<td>Session Summary: Polarimetry &amp; PSI – Tomography</td>
</tr>
<tr>
<td>10:45</td>
<td>Coffee Break</td>
</tr>
<tr>
<td>11:10</td>
<td>Session Summary: Methods &amp; Theoretical Modelling</td>
</tr>
<tr>
<td>11:30</td>
<td>Session Summary: Applications on Ocean/Cryosphere &amp; Hazards</td>
</tr>
<tr>
<td>11:50</td>
<td>Session Summary: Applications on Forest</td>
</tr>
<tr>
<td>12:10</td>
<td>Session Summary: Applications on Agriculture</td>
</tr>
<tr>
<td>12:30</td>
<td>Session Summary: Airborne and Spaceborn Pol-InSAR campaigns</td>
</tr>
<tr>
<td>12:50</td>
<td>Closing Session</td>
</tr>
</tbody>
</table>
Posters

A Neural Network Approach for the Retrieval of Soil Parameters using a Two Layers Multi-Scale Bi-Dimensional SPM Model .......................................................... 123
One Channel SAR Image Texture Based Interpretation .......................................................................................................................... 123
Standard Hough Transform and Line Segment Coordinates ...................................................................................................................... 123
One Channel SAR Image Texture Based Interpretation .......................................................................................................................... 123
New Simple Decomposition Technique for Polarimetric SAR Images ........................................................................................................ 124
PolInSAR Complex Coherence Estimation Based on Similarity Test of Covariance Matrix ................................................................. 124
Recent Polarimetric SAR Models for Danube Delta Monitoring using PALSAR Images ........................................................................ 125
An Unsupervised Classification of Fully Polarimetric SAR Data using the PSO Algorithm and H-1A Decomposition .............................. 125
Regrowth Monitoring in Mining Areas Using Polarimetric and Dual-pol PALSAR Data ............................................................................. 126
Decomposition of Rotated Dihedral and Volume Scattering Components in Cross-Polarimetric SAR Observations .............................. 127
Comparison of Alos/Palsar Polarization Modes to Discriminate Land Use/Cover Classes in Eastern Amazon ............................................. 127
First Analysis on Snow Cover Change Using Fully Polarimetric TerraSAR-X Data ................................................................................ 128
Opium Field Detection in South Oxfordshire Using SAR Polarimetry ........................................................................................................ 128
The potential of TerraSAR-X in Assessing Forest Above-Ground Biomass in Scotland ........................................................................... 129
Monitoring of Fine Scale Sea Ice Features in the Baltic Sea Using Polarimetric and Dual-Pol SAR Data .................................................... 129
Forest Biomass Retrieval using Polarimetric Decompositions and 3D Sar Backscattering Maps .............................................................. 130
Differential Shift Estimation in the Absence of Coherence: Performance Analysis and Benefits of Polarimetry ........................................ 130
Collective Network of Evolutionary Binary Classifiers for Polarimetric SAR Images ........................................................................... 131
Multitemporal PolSAR for Snow Cover Monitoring in the Boreal Forest Zone .......................................................................................... 131
A Statistical Approach for Studying the Influence of In-Homogeneity in Pol-InSAR Data on Biomass Parameter Retrieval ......................................................... 131
Identifying Persistent Scatterers in Open and Natural Areas .................................................................................................................... 132
Energy-Spectrum-Based Adaptive Windowing for Speckle Filtering of PolSAR Data .............................................................. 132
Forest Structural Parameters and Growing Stock Volume Retrieval in Thuringian Forest using L-band Polarimetric Radar ...................... 133
Multibaseline Polarimetric SAR Interferometry Forest Height Inversion Approaches ............................................................................ 133
Automated K-Wishart Clustering of PolSAR Images ................................................................................................................................. 134
Topographic Mapping with P-band SAR System with Wide Beam Width ................................................................................................. 134
Robust Estimation of the Vertical Structure of Forests with Coherence Tomography ........................................................................... 135
Polarimetric Investigation of a Two Surface Layer Structure using L-band PALSAR data ........................................................................... 135
Heterogeneous Clutter Models for Change Detection in PolSAR Imagery ................................................................. 136
A Complete Coverage of Log-Cumulant Space in Terms of Distributions for Polarimetric SAR Data ................................. 136
Characterization of Alpine Glaciers using Fully-Polarimetric TerraSAR-X Data ................................................................ 137
Regrowth after Forest Fires in Greece as seen with ALOS PALSAR Data ........................................................................ 138
Monitoring of Dams and Bridges using Interferomeric Synthetic Aperture Radar (InSAR) ................................................ 138
Coastal Deformation and Global Mean Sea Level Monitoring using GPS and InSAR Techniques ........................................ 138
Topographic Mapping with P-band SAR System with Wide Beam Width ........................................................................... 138
Biomass Estimation as Function of Vertical Forest Structure. Potential and limitations for Radar (and LiDAR) .................. 139
Leaf Area Index and Biomass Assessment over Tropical Peatland Forest Ecosystem using ALOS Palsar and ENVISAT SAR data ............................................................................................................ 140
Multiscale Analysis of SAR and ASAR River Plumes and Coastal Features ..................................................................... 140
Detect Urban Poverty Pockets with Radarsat-2 Ultra Fine Beam Images. The Rosario City Case - Argentina ..................... 141
Boundary Detection with Stochastic Distances in Polarimetric Imagery ............................................................................. 142
Improved Ship Detection in Polarimetric SAR Images by Log-Space Estimation ................................................................. 142
Preliminary Studies on a Target inside a Urban Canyon using POLINSAR Data. ................................................................. 143
Identification of Structural Changes Caused by Weed Infection in Agriculture by Optical and Radar Data ......................... 143
Using Quad-Pol and Single-Pol RADARSAT-2 Data for Monitoring Cold Alpine and Outlet Antarctic Glaciers .................... 144
Characterizing the Back-Scattering Properties of a Forest by Polarimetric SAR Tomography at L- and P-Band ................. 145
Use of PALSAR and TerraSAR-X for Tropical Forest Stratification .................................................................................. 145
Cosmo SkyMed Dual-Polarization Mode to observe Gulf of Mexico Oil Spill ..................................................................... 146
Case Studies of Ship Classification from SAR Data based on Polarimetric Scattering Characteristics ........................... 147
TropiSCAT : a Ground based Polarimetric Scatterometer Experiment in French Guiana Forests ........................................ 147
PolSAR Classification based on the SIRV Model with a Region growing Initialization ....................................................... 148
Urban Structure Orientation using Radarsat2 Polarimetric Data .................................................................................... 148
Marine Pollution in Algerian Coastal Waters using Polarimetric Radarsat2 Data ............................................................... 149
Supervised Land-Cover Classification by ALOS/PALSAR Polarimetric Interferometry .................................................... 149
Spectral Graph Segmentation using Probabilistic Boundaries for Polarimetric SAR Imagery in Urban Areas .............. 149
Best Feature Selection for the Classification of Polarimetric SAR Images ........................................................................... 150
Mixture Models and Hidden Markov Models for Modeling High Resolution SAR Imagery of Urban Areas .................. 151
A new Approach for Estimating Sea Ice Thickness using X- and C-Band Space-Borne polarimetric SAR Data ................. 151
End-to-end Simulation of SAR Mission Performance for the ESA BIOMASS and CoreH2O Missions ............................. 152
Unsupervised Forest Mapping using full Polarimetric SAR Data based on Target Decomposition Parameters .......................... 153
A Multi-Polarization Study on Ship Detection over X-Band full-resolution Cosmo SkyMed SAR Data .............................. 153
Polarimetric signature Analysis of Deformed Arctic Land-Fast ice using TerraSAR-X Quad-Pol Data ................................. 153
Annual Variability in Prairie vegetation as seen by SAR Polarimetry ................................................................................. 154
Lossless $\Psi$ - Invariant Decomposition of Random Target .................................................................................................. 154
Forest Monitoring in Norway by Means of fully Polarimetric Radarsat-2 Images ............................................................... 155
Multi-scale Deformable Part Model for Building Extraction From High Resolution Polarimetric SAR Imagery ................ 155
Ship Detection using Polarimetric Features from Radarsat-2 images .................................................................................. 156
A new Functional Expansion for Polarization Coherence Tomography .................................................................................. 156
Performance Study of Forest Height Estimation using Chinese airborne Dual-Antenna X-band PolInSAR data ................. 157
Day 1 - Monday 24 January

Session: Missions
TanDEM-X: Mission Overview & Scientific Contributions
Hajnsek, Irena¹; Krieger, Gerhard²; Papathanassiou, Kostas³; Kugler, Florian⁴; Baumgartner, Stefan⁵; Rodriguez-Cassola, Marc⁶; Prats, Pau⁷
¹ETH Zürich / DLR, GERMANY; ²German Aerospace Center, GERMANY

In this paper new and innovative techniques during the commissioning phase of TanDEM-X will be presented that are firstly demonstrated on a satellite platform. The focus is on the secondary goals of TanDEM-X that are assigned for the third year of the mission time life due to the tight schedule for the acquisition of the highly accurate global digital elevation model. Therefore, a variety of scientific experiments are planned to be performed already during the commissioning phase. The first experiments are related to bistatic processing, Polarmetric SAR Interferometry, double differential SAR Interferometry, decorrelation measurements, superresolution and velocity measurements. The data quality and the results obtained will be validated and are discussed.

TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurements) is an innovative spaceborne radar interferometer that is based on two TerraSAR-X radar satellites flying in close formation. The primary objective of the TanDEM-X mission is the generation of a consistent global digital elevation model (DEM) with an unprecedented accuracy, which is surpassing the new HREGP specification defined by NIMA, US. Beyond that, TanDEM-X provides a highly reconfigurable platform for the demonstration of new radar imaging techniques and applications [1]. Both satellites will then act as a large single-pass radar interferometer with the opportunity for flexible baseline selection. This enables the acquisition of highly accurate cross- and along-track interferograms without the inherent accuracy limitations imposed by repeat-pass interferometry due to temporal decorrelation and atmospheric disturbances.

This paper is focusing on the innovative secondary goals of TanDEM-X and their demonstration during the commissioning phase in space. The key elements are the bistatic data acquisition employing an innovative phase synchronization link, a novel satellite formation flying concept allowing for the collection of bistatic data with short along-track baselines, as well as the use of new interferometric modes for system verification and DEM calibration. Beside this new modes as along-track SAR interferometry, polarimetric SAR interferometry (Pol-InSAR), digital beamforming, superresolution etc, performed for the demonstration of innovative technology, also the development of new applications products is a major topic. References [1] Krieger, Gerhard und Hajnsek, Irena und


Notes: ...

RADARSAT Missions for EO Science and Operational Applications
Stephane Chalifoux
Canadian Space Agency (CANADA)

Notes: ...
In 2007 and 2008 ASI (Italian Space Agency) launched three out of four X-band SAR satellites of the COSMO-SkyMed (CONstellation of small Satellites for Mediterranean basin Observation) Mission, making available to the users a unique SAR constellation dedicated to the Earth Observation. Since 23rd of August 2009 the three satellite constellation entered its fully operational phase. In particular COSMO-SkyMed-3 has been put in an orbital position at 67.5° from COSMO-SkyMed-2, in the so-called “one-day interferometry configuration”, providing interferometric pairs for a wide range of applications.

COSMO-SkyMed is the largest Italian investment in Space Systems for Earth Observation, commissioned and funded by ASI and Italian Ministry of Defense (MoD). COSMO-SkyMed is a Dual-Use end-to-end Earth Observation System aimed to establish a global service supplying provision of data, products and services relevant to a wide range of applications, especially in the field of Risk Management for both Scientific/Commercial and Defence/Intelligence use. The system consists of a constellation of four Low Earth Orbit mid-sized satellites, each equipped with a multi-mode high-resolution Synthetic Aperture Radar (SAR) operating at X-band. The system is completed by dedicated full featured Ground infrastructures for managing the constellation and granting ad-hoc services for ordering, planning, collection, archiving and distribution of acquired remote sensing data. The high resolution imaging and time performances, make of COSMO-SkyMed a unique system that already showed all its potentiality in several application domain such as risk and emergency management (i.e.: China and L’aquila’s earthquake, Myanmar and Haiti flood,), ice monitoring (reduction of the glaciers, Wilkins Ice Shelf disintegration), multi-temporal acquisition for agriculture monitoring, ship detection, interferometry, landslides monitoring, maritime surveillance (i.e. Lusiana Oil Spill) and security, rapid mapping. After a brief introduction to the current COSMO-SkyMed mission configuration, this paper deal with the status of the mission and its results with focus on those obtained during the operational phase.

* * * * * * * * *

Notes: ...
The Sentinel-1 mission is designed to be a source of continuous and reliable C-band SAR imagery. Requirements for the Sentinel-1 end-to-end system, as part of the complete family of GMES Sentinels, guarantee continuity of C-band SAR data and product availability to operational entities that exploit satellite radar imagery since ERS 1 operations started in 1991. Typical drivers for current- and future-generation Remote Sensing LEO satellite missions are fast target access capability and small on-board data latency in order to speed up data download and product delivery to the end-users. However repetitive complete global coverage is also required. The satellite orbit and sensor swath determine the access capability and SAR power demand limits the satellite operational duty cycle in each orbit. Therefore a careful trade-off between frequent acquisition of a small number of selected targets and maximum geographical coverage is required. To comply with mission timeliness requirements the performance had to be improved by increasing the number of satellites in a constellation. Sentinel-1 applies a new operational mission concept; SAR acquisitions by Sentinel-1A (and Sentinel-1B launched 18 months later) in a main operational mode designed according to conflict-free pre-defined operational sequences to ensure:

- continuous and systematic acquisition of data during the complete mission life time to satisfy the prime mission requirements
- specially allocated mission capability for fast response to emergency requests
- complete global coverage during every orbit repeat cycle (175 orbits in 12 days)
- more frequent additional coverage of high priority regions (North Atlantic Maritime Transport zones, Europe and Canada) for near real time applications
- a growing global data archive

A key element in the design of the Sentinel-1 mission is the relation between the technical implementation of the mission and the accuracy of the geophysical information products the mission is required to generate and support in the applications community. Data products involving information about geophysical variables (Level-2 products) such as ocean surface wind speed, ocean waves and currents, surface pollution, ice type, soil moisture and land cover can be derived from image data products (Level-1 products) using suitable retrieval models.

Consequently the accuracy of Level-2 products is affected by measurement uncertainties associated with Level-1 products as well as by uncertainties associated with the retrieval models. In terms of the Level-1 data quality, Sentinel-1 radiometric and phase performance are defined by the magnitude of a number of error sources influencing the amplitude and the phase of its complex image products as well as the intensity of its detected image products. They include instrument gain and phase characteristics, thermal noise, effective number of looks, non-linearity's including quantisation, and errors introduced in the processing and data distribution chain. To assess the accuracy of the geophysical products of Sentinel-1, the Level-1 uncertainties above need to be translated into uncertainties in the final geophysical product through simulations based on actual or simplified retrieval algorithms.

The presentation will provide an overview of the mission status and of the Sentinel-1 products studied.

***************

Notes: ...
The BIOMASS mission concept was proposed to the European Space Agency for the third cycle of Earth Explorer Core missions and was selected for Feasibility Study (Phase A) in March 2009 alongside tow other competing candidate missions. The mission is a direct response to the urgent need for greatly improved mapping of global forest biomass and the lack of any current space systems capable of addressing this need.

To measure forest biomass on a global scale the mission is designed as a fully polarimetric P-band SAR with interferometric observation capabilities. The system will operate at a centre frequency of 435 MHz with a bandwidth of 6 MHz. To enable measurements at a scale comparable to that of deforestation and forest disturbance (i.e. around 1 ha), it is envisaged that BIOMASS will provide level-1 products with around 50 m x 50 m resolution at 4 looks. The satellite shall fly in a sun-synchronous dawn-dusk orbit to minimise ionospheric disturbances. The revisit time will be between 25-45 days to maintain high temporal coherence. In this setup the mission will achieve coverage of the earth’s forests regions at least twice per year.

The mission duration is planned for 5 years in order to obtain repeated measurements of the world’s forests. This will lead to reduced uncertainties in measurements of the biomass of undisturbed forests and will allow measurement of forest dynamics by detecting changes in biomass and forest cover. At the beginning of the mission a short tomographic phase (1 month) is foreseen during which measurements with 10-12 spatial baselines and a revisit time of 1-4 days will be collected over selected forest regions.

This presentation will give an overview and status of the scientific activities of the BIOMASS mission and will report on the status and conclusions of ongoing and recently finished studies. These studies have been initiated in order to advance methods for the retrieval of biomass from P-band PolInSAR data. Specifically they address (1) the impact of the ionosphere on the signal; (2) the formulation of a biomass retrieval algorithm that combines in an optimum way the radar intensity and interferometric information; and (3) the collection and analysis of campaign data over tropical forest. Further we will report on the status of the system and antenna design.

Notes: ...
SMOS Polarimetric Mode

Martín-Neira, M.;
ESA, NETHERLANDS;

SMOS is ESA’s second Earth Explorer mission with the objective of producing global maps of Soil Moisture and Ocean Salinity over the Earth. It carries a single payload on-board, MIRAS, the first-ever spaceborne L-band Microwave Imaging Radiometer with Aperture Synthesis in two dimensions. The performance requirements of MIRAS are demanding in terms of spatial resolution, accuracy, stability and precision, all critical to fulfil its scientific objectives. SMOS was launched 2 November 2009.

SMOS can work in two modes of operation: the dual polarisation mode and the fully polarimetric mode. In the first mode only horizontal and vertical polarisation measurements are acquired. In the fully polarimetric mode also the third and the fourth Stokes parameters of the target are measured. At the end of the commissioning phase of SMOS it was decided to operate MIRAS in the fully polarimetric mode to allow the possibility of exploiting this capability to enhance the research and scientific return of the mission. The polarimetric mode of MIRAS is somewhat complex because the receivers only observe one polarisation at any given time. Therefore, in order to form the polarimetric baselines a polarisation switching scheme is applied throughout the array. After one full polarisation switching cycle all polarimetric baselines are available. The present contribution aims at describing the operation and performance of the full polarimetric mode of MIRAS as well as to show some of the third and fourth Stokes parameter images which have been acquired from the Earth. Potential applications of these images are also discussed.

***************

Notes: ...
Day 1 - Monday 24 January
Session: Calibration & Data Quality
Day 1 - Monday 24 January

Session: Calibration & Data Quality
Different approaches have been developed through the years in order to estimate the parameters in the distortion model of a full polarimetric SAR system. So far, the most effective calibration techniques resort to calibrated targets (corner), or to the incoherent information provided by homogeneous areas of distributed targets. These techniques indeed require specific assumptions on the statistical properties of the backscatter that only a few locations (typically forested areas) on the globe can robustly grant; besides, at least one calibrated target is most often constantly (for all the acquisitions) required.

In this paper an alternative approach based on the Permanent Scatterers is discussed: the technique is meant to provide continuous monitoring of the radiometric and polarimetric quality of C-band systems through the exploitation of the available stable targets. Basically, the idea is that the robustness of the target stability assumption ideally offers the possibility of relying on a large amount of natural calibrated targets; furthermore a wide number of locations suited to the purpose could be exploited as a consequence. It must be however remarked that, whereas the estimation of the differential system parameters (changes with respect to a master image) does not any require external information, an absolute calibration can be achieved only through the use, though just once, of ad-hoc calibrated targets.

The procedure makes use of all the coherent full-pol information provided by the PS observations in order to estimate all the systems unknowns, that are the differential image gains, the PS polarimetric signature themselves, the PS noise variances and geometric phases, the system distortion parameters (i.e. the channel imbalances). Though the number of unknowns is large, the problem is nonetheless well-conditioned and can be solved through an iterative approach aiming to maximize the Maximum Likelihood estimation of the observations. A proper PS detection step in such approach is fundamental, since it allows a faster convergence to the correct solution: this step is performed by means of a Generalized Likelihood Ratio Test (LRT) on the full-pol estimates. The approach results on a RADARSAT2 dataset are then presented and a discussion on the limits and capabilities of the approach (in terms of number of PS and full-pol images required) will follow.

****************

Notes: ...
An Ionospheric Calibration Scheme for the BIOMASS Pol-InSAR Data Space
Kim, Jun Su; Danklmaier, Andreas; Papathanassiou, Konstantinos
German Aerospace Center, GERMANY

BIOMASS is one of the three Candidate Earth Explorer Core missions selected for a (actually ongoing) Phase A study in the frame of ESA’s Earth Explorer program. The scientific objective of BIOMASS is to determine, in a consistent manner, the global distribution of forest biomass in order to reduce uncertainties in carbon stocks and fluxes associated with the terrestrial biosphere. BIOMASS will be implemented in terms of a (quad-) polarimetric P-Band Synthetic Aperture Radar (SAR) mission operated in a repeat-pass interferometric mode.

Polarimetric distortions, known as Faraday rotation (FR), occur due to the slightly different propagation speeds of two eigenpolarizations in the ionosphere. Its result in linear-polarization SAR systems is the rotation of the polarization plane. The angle of the rotation is proportional to the total electron contents (TEC).

The ionosphere also delays the propagation of the electromagnetic field. The amount of the delay is proportional to TEC, and inversely proportional to the square of the frequency. Because the Earth’s ionosphere varies with time, in the repeat-pass interferometry, we have to consider the effects of differential TEC. Therefore, the accurate estimation of TEC and differential TEC (DTEC) are the key elements of the correction of those effects.

Several techniques allow the estimation of TEC. 1) Faraday rotation is one of the well established methods to estimate TEC. However, the applicability of this method is restricted to high latitude region. 2) Azimuth direction sub-band shift estimation is sensitively proportional to the second derivative of TEC. 3) Range sub-band shift estimation requires strong spatial multi-looking but can be a way of TEC estimation.

The estimation of DTEC is also possible through various methods. The subtraction of individually estimated TEC is a simple but a reliable way of DTEC estimation. Otherwise, 1) the combination of multi-squint sub-band interferograms give the spatial change rate of differential TEC. 2) Interferometric phase is directly proportional to DTEC, provided that there are no topographic and deformation contributions. 3) In the case that those contributions are needed to be separated, range sub-band analysis can be used.

We investigate the optimum combination of the individual techniques in terms of BIOMASS instrument and mission specifications.

The individual approaches are applied on several (ionospheric distorted) ALOS PALSAR data sets and the achieved performances are inferred to the P-band BIOMASS case.

***************

Notes: ...
Severe Radio Frequency Interference in PALSAR images

Doulgeris, A. P.¹; Meyer, F.²

¹University of Tromso, NORWAY; ²Geophysical Institute, University of Alaska, Fairbanks, UNITED STATES

Monitoring of sea ice cover is currently of high global importance and satellite-borne synthetic aperture radar (SAR) systems are particularly well suited to this task because of their cloud penetrating ability and broad coverage. L-band SAR systems have greater surface penetration and are sensitive to textural variation on a larger scale than C-band systems, due to their longer wavelength, and polarimetric imagery has been shown to be beneficial for distinguishing some ice types. Therefore, ALOS PALSAR L-band quad-pol imagery would be ideal to investigate sea ice classification where the thickness and large scale structures are of importance for ice mapping and climate research.

However, we found that most PALSAR images acquired near the important sea ice research station at Barrow, Alaska, were so severely affected by radio frequency interference as to become useless for image classification. The Pauli decomposition RGB images show clear and extreme colour variation that slowly changes with azimuth across the images. The extent of variation is far greater than the polarimetric differences between ice types, making them un-useable for classification and any polarimetric decomposition interpretation.

Our investigations show that the interference is caused by a military radar station of the North Warning System (NWS), located in Barrow. The NWS consists of 15 long-range L-band radars and 39 short-range radars and stretches over 4,800 kilometre from Alaska, via Canada, to Greenland. Its long-range stations are equipped with AN/FPS-117 phase array, three-dimensional search radars that have a maximum one-way range of 400km and are operating across 18 channels in the 1215-1400 MHz band. For comparison, the centre frequency of PALSAR is 1270 MHz. These broadband interference pulses, in the same range as PALSAR, were not identified and filtered by the standard processing system, and their influence had been integrated into the focussed level 1.1 image. We had to go back to the level 1.0 data, and develop additional identification and filtering algorithms to correct these images.

In this paper we will introduce the motivation of this research by showing examples of typical RF distortions along with a statistical analysis of the frequency of their occurrence. We will introduce the specifics of the interfering signal and will present a map with locations where similar distortions are likely to occur. Methods for filtering RF interferences will be introduced and their performance will be evaluated. A new approach for filtering interferences will be presented and performance enhancements will be analysed by a cross comparison with reference methods. The capabilities of

the new correction method will also be emphasised by presenting several before-and-after Pauli RGB images and clustering results to clearly show the interference problem and the subsequent filtering improvement.

***************

Notes: ...
RADARSAT-2 is equipped with polarimetric capability at multiple incidence angles and resolutions of 9 m and 24 m. Even though the original requirement on the H-V antenna isolation was too low (-20 dB), the actual RADARSAT-2 antenna isolation is better than -32 dB [1]. As such, single- or dual-polarization are not significantly contaminated with polarization cross-talk [2], and this makes RADARSAT-2 calibration much easier. In this study, an independent assessment of polarimetric RADARSAT-2 data quality is conducted using data collected over the CCRS calibration site in Ottawa. A transponder conceived by CSA in collaboration with CCRS [3] is used for the measurement of the impulse response characteristics, and for the assessment of the accuracy of polarimetric data collected at 25 degree and 40 degree incidence angle. Data collected over the Amazonian forest at various incidence angles between 20 and 40 degree are also considered in this investigation. A new method based on the transponder measurements is developed for the assessment of Radarsat2 system using uncalibrated and calibrated data. It is shown that Radarsat2 antenna is highly isolated (better than -32 dB), and the calibrated data meet comfortably the CEOS requirement in terms of cross-channel relative magnitude and phase, and channel imbalance removal. The uncalibrated data show also that the H-V cross-talk is very stable with incidence angle. In order to fully exploit the excellent low noise performance (better than -38 dB) for applications that rely on HV of low S/N, a new calibration method is developed based on transponder measurement at HV and VH configurations. The system can be accurately calibrated using only one transponder measurements at one given incidence angle. Only one distortion matrix is needed to calibrated the 30 modes of Radarsat2 (Right looking) from 20 to 50 degree. Another one is required for the 30 modes of the Left looking Mode.

References:
Data Quality and Scientific Analysis of fully Polarimetric TerraSAR-X Data
Hajnsek, I.; Papathanassiou, K.
1ETH Zürich / DLR, GERMANY; 2German Aerospace Center, Microwaves and Radar Institute, GERMANY

Abstract
In this paper the acquired data of the experimental fully polarimetric mode of TerraSAR-X are investigated in terms of data quality and the potential to use polarimetry at short wavelength. In spring 2010 the dual receive antenna was switched on for three data acquisition cycles collecting fully polarimetric data over varying natural scenes. The focus of this paper is to investigate the quality of these scenes and provide some insight into using fully polarimetric data for bio/geophysical parameter estimation.

1 The TerraSAR-X Mission
The TerraSAR-X is the first German Radar satellite for scientific and commercial applications. The project is a public-private partnership between DLR and EADS Astrium GmbH. TerraSAR-X consists of a high resolution Synthetic Aperture Radar at X-Band. The radar array is based on active phased array technology that allows the control of many different instrument parameters and operational modes (Stripmap, ScanSAR and Spotlight) with various polarizations. The TerraSAR-X launch was on the 15 June 2007. Only 4 days later the first image was delivered. The variety of TerraSAR-X polarization modes is reviewed and validation results of each mode are presented. The polarization modes include operational modes like dual-pol in Stripmap and Spotlight. Additionally there are experimental modes like twin polarization mode which is similar to the ASAR alternating polarization mode, or the full polarimetric mode which is realized in the TerraSAR-X Dual Receive Antenna configuration. The Dual Receiving Antenna Mode (DRA) of TerraSAR-X offers a high variety of interesting applications and experiments, e.g. along track interferometry, geometric resolution enhancement and especially the full polarimetric mode. In the DRA mode of TerraSAR-X, the complete antenna is used for transmission but in receive, the antenna is divided into two separate partitions in along track. The signals of both receiving antennas are recorded separately by exploiting the redundant receiver chain of the instrument. Both signals are not recorded separately but as sum and difference signal. This demands for special calibration in the reconstruction of fore and aft channel before SAR processing and has influence on the polarimetric performance.

2. The Fully Polarimetric TerraSAR-X Campaign
The TerraSAR-X fully polarimetric campaign was conducted in April to May 2010 acquiring coherent X-band fully polarimetric data over selected natural scenes being already investi-gated using longer wavelength multi-parametric airborne SAR data. The selected scenes containing natural scenes from boreal forest, tropical forest, agricultural site, open ocean and snow/ice area.

3. Data Analysis
A theoretical background is provided to the expected polarimetric signatures in X-band and is compared to the obtained parameters derived from TerraSAR-X. Important polarimetric parameters that will be used for comparison are polarimetric ratios, polarimetric coherences, statistical parameters as the polarimetric entropy and alpha angle. An outlook to the potential of bio-/geophysical parameter estimation from fully polarimetric TerraSAR-X data is given.

References
[1] www.dlr.de/tsx/

***************

Notes: ...
Day 1 - Monday 24 January

Session: Applications on Urban
An Advanced Method for the Three-Component Decomposition Applied to Azimuthally Inclined Objects
Kusano, Shunichi; Watanabe, Manabu; Sato, Motoyuki
Tohoku University, JAPAN

A new method applied to the three-component decomposition for a polarimetric synthetic aperture radar (Pol-SAR) is proposed in this study. The proposed method can deal with azimuthally inclined objects such as azimuthally tilted terrain slopes and skew-oriented buildings which are decomposed into volume scattering class due to their high HV reflection in the three-component decomposition proposed by Freeman and Durden. These targets are regarded as a source of misunderstandings when we observed resultant color-composite images. One of the common characteristics in these objects is that they have polarization orientation angles (PO angle), because the normal to their reflection planes deviates from the incident plane. In order to compensate for the effect on azimuthally tilted terrain slopes, the rotation of the sensor coordinate along the line of sight, i.e., deorientation, have been utilized. In the same manner, PO angle shifts on the wall of buildings have been investigated and a good correspondence has been shown between the PO angle and the orientation angle of buildings. Considering these facts, it is possible to compensate for the orientation effect, more or less, by considering the rotation of the scattering matrix. In order to accomplish correct decompositions, the proposed method embeds PO angles into the scattering models for surface scattering and double-bounce used for the three-component decomposition. In addition, the new decomposition is performed in the circular polarization basis due to its simplicity in handling the PO angle. For the validations, we applied the proposed method to the X-band data acquired by Pi-SAR and the L-band data acquired by PALSAR to observe the impact on double-bounce and surface scattering, respectively. By comparing the results to that in the three-component decomposition, we confirmed that the power ratio of double-bounce increases from 0.2 to 0.4 for buildings with 30 degree of orientation angle, and that the power ratio of surface scattering increases from 0.55 to 0.77 at ground slopes with 20-30 degree of azimuth tilt angle. It is found that the proposed method works well on the objects with relatively small azimuth angles. However, it was still difficult to decompose the objects with relatively large azimuth angles into their corresponding scattering mechanisms, even with application of the proposed method.

***************

Notes: ...
Coherence Optimization for Estimation of building Heights on a Segmented high Resolution POLINSAR Urban Area
Colin-Koeniguer, E.; Trouvé, N.
ONERA, FRANCE

Previous studies have shown that the combination of polarimetry and interferometry improves the estimation of the heights. However 3D renders of urban area remains rare, or restricted to small areas, because the interferometric reconstruction techniques are too noisy for being directly employed in three dimensional rendering.

This paper is intended to be a companion paper of a more general presentation about region growing on PoISAR images. In the companion paper, a whole processing chain for the estimation of PoISAR and PolInSAR parameters in the context of high resolution urban area is presented. Here we show that it is possible to greatly improve height estimation and 3D render of urban region through the shape-constraint region growing preprocessing. The interferometry tools developed to exploit the segmentation results are detailed and validated on real data. POLINSAR coherence techniques are applied in order to improve the estimation of segmented buildings.

Different areas of our X-band image of Toulouse are then analyzed and presented. We compare the resulting heights with ground truth data and evaluate the potential of this technique. Finally a 3D rendering obtained by interferometry is then shown in an urban environment on a large SAR image. This allows us to envisage optimistically realistic potential use of the POLINSAR techniques in an application framework.

********************

Notes: ...
This paper presents processing chain for the estimation of PolSAR and PolInSAR parameters in the context of high resolution urban area. PolInSAR techniques have demonstrated high efficiency in retrieving scene features in natural areas and convincing applications on forestry or biomass estimation. In most of those applications the estimation of the PolSAR or the PolInSAR coherency matrices is performed by using gaussian models and large spatial averaging windows. Most of the time this choice is convenient as the data are usually low-resolution enough to make the Gaussian assumption valid. Therefore the small spatial features are not very relevant and bright man made targets are usually very scarce in the area under study.

For high resolution urban images, large spatial averaging windows usually lead to a very significant loss of spatial information. InSAR parameters are notably sharp in a urban scenario and the convolution effect on the height estimation must be avoided. The coherency estimation process is also corrupted by the presence of multiple bright points, side lobes, and impulsive noise. This is why we propose in this paper to use a shape constraints region growing scheme as a mean to improve the estimation of PolInSAR parameters in the context of urban high resolution image.

The goal is to achieve a precise estimation of the coherency matrices over polarimetric-statistically homogeneous regions while preserving spatial features and acceptable region's shapes. The SIRV model is used to design the region growing criterion. Fuzzy logic and fuzzy inference systems are used to handle shape rules, their parameters and their relative weight. Adapted PolInSAR algorithm can be then applied to extract polarimetric information or height information over each homogeneous region. As an example, 3D rendering results are presented on a SETHI (ONERA) image from Toulouse at X-Band.

A companion paper will be devoted to the presentation and analysis of several areas of the image and their 3D rendering.

***************

Notes: ...
Improved Tomographic SAR Focusing using Automatic Baseline Error Compensation

Ferro-Famil, L.1; Huang, Y.1; Lombardini, F.2

1University of Rennes 1, FRANCE; 2University of Pisa, ITALY

SAR tomography is the extension of conventional two-dimensional SAR imaging to three dimensions [1]. A full 3D imaging of a scene is achieved by the formation of an additional synthetic aperture in elevation from several parallel flight tracks and the coherent combination of the images acquired using multibaseline interferometry techniques (MB-InSAR). This imaging technique allows a direct localization of multiple scattering contributions in a same resolution cell, leading to a refined analysis of volume structures, like forests or dense urban areas or complex infrastructures. For MB-InSAR, the undetermined phase offsets contained in real interferometric data after processing and some calibration procedure can be considered as a synthetic result of several factors, such as a suboptimal synchronization in the SAR acquisition system, SAR processing errors, and especially residual uncompensated baseline fluctuations or atmospheric propagation changes. This fact influences the estimation of interferometric phases and hence spatial frequency components along the elevation synthetic aperture corresponding to the scatterers elevations, leading to mislocalize the scatterers in the vertical direction, increase the sidelobes and degrade the tomographic resolution. Some statistical approaches such as maximum a posteriori (MAP) or maximum likelihood (ML) estimation have been applied to estimate the unknown phase offsets in the literature for DEM production; as in [2], the phase offset of each interferogram was considered as an slowly varying phase and thus modeled by a unknown constant. However, for an airborne SAR system, the fluctuations of the flight paths causes varying residual baseline errors in the azimuth and range directions, and an analogous condition stands for large scale spaceborne SAR images because of varying atmospheric residuals. In order to estimate the (variable) phase offsets, in this paper we propose to apply autofocusing concepts to the SAR tomographic calibration and focusing problem. Encompassing the image restoration techniques, autofocus has been widely used in range-azimuth SAR imaging for correcting the unknown phase aberrations using the defocused data and underlying assumptions, such as sharpness optimization in [3]. In our tomographic application, the unknown phase offsets are contained in the various interferometric phases and vary over the underlying interferograms. We propose to exploit for their autofocus-based estimation tomographic image contrast indexes applied to tomographic processors particularly sensitive to miscalibration residuals. In order to estimate the offsets over the observed image, we have two ways. One way is to estimate them block by block. The other way, particularly suited for the airborne case, is to enforce some spatial range regularity constraint in the offset estimates. In the paper we show the concept of tomographic autofocusing with first cut tests. Real airborne data are used acquired by DLR’s E-SAR system at L-band over Dresden, Germany, in 2000, for a simple condition of three flight paths (two baselines) only, employing the block estimation way. Future work will regard dealing with more complex multibaseline acquisitions, numerical optimization, and incorporation of spatial constraints.

References

***************

Notes: …
Natural Environment Characterization using Hybrid Tomographic Approaches

Huang, Yue¹; Ferro-Famil, L¹; Reigber, A.²
¹University of rennes 1, FRANCE; ²DLR, GERMANY

SAR tomography is the extension of conventional 2D SAR imaging to three dimensions [1]. Spectral analysis techniques are widely used in SAR tomography. They allow a direct localization of multiple scattering contributions contained within a resolution cell and lead to a refined analysis of volume structures, like forests or dense urban areas. It has been shown [2], [3] that the performance of spectral estimators is conditioned by the nature of the scattering response of the observed objects. Moreover, in the case of objects with a deterministic response embedded in a speckle affected environment, the parameter estimation for this type of scatterers becomes a problem of mixed-spectrum estimation. Localized scatterers generally have a deterministic response with a discrete spectrum, whereas natural environments, composed of a large number of elementary scatterers and whose response is affected by speckle, are characterized by a continuous spectrum. Nonparametric spectral estimators are adapted to estimate continuous spectra, whereas parametric ones are adapted to extract discrete spectra. Therefore, the usual spectral estimators may reach some limitations due to their lack of adaptation to both the statistical features of the backscattered information and the type of spectrum of the considered media. In order to overcome this problem, a tomographic focusing approach based on hybrid spectral estimators is introduced and extended to the polarimetric case. This tomographic focusing approach can be decomposed into two steps: detection and removal of point-like scatterers responses and analysis of the remaining continuous spectrum for the characterization of the associated natural environment. In this paper, we concentrate firstly on the detection and localization of point-like scatterers (e.g. calibrators, ground-trunk reflection . . .) embedded in a continuous environment (e.g. forests). The monochromatic discrete components of the spectrum within the 3D resolution cell under consideration are simultaneously detected and estimated by jointly using a proposed line spectra estimator F-Estimator and a decision criterion F-Criterion. The extension of this approach to the polarimetric case significantly improves the characterization of complex structures both in terms of resolution and accuracy.

The detected and estimated discrete components are then removed from the global spectrum in order to obtain a residual continuous one, corresponding to the response of the host natural environment. We propose here to characterize the continuous spectrum of the natural environment like forests using robust non-parametric spectral estimators, e.g. to estimate the canopy depth. The tomographic analysis of a volumetric forested area and sub-canopy objects is led with the proposed tomographic approach, using fully polarimetric L-band airborne data acquired by DLR’s E-SAR system over the test site of Dornstetten, Germany. The investigated scene contains some trucks over bare soil areas as well as beneath forested zones considered as localized targets. Using the proposed tomographic approach for hybrid spectral estimation, the point target feature and forest profile are extracted from the mixed spectrum. These decoupled extractions permit to better characterize natural environments and potential embedded objects.

References

***************

Notes: ...
Day 2 - Tuesday 25 January

Session: Polarimetric Interferometry (Pol-InSAR)
With the successful launch of Tandem-X, it is clear that single pass X-band interferometry in space opens up many new potential applications, aside from the main mission objective of generating a global DEM. As Tandem, like its partner Terrasar-X, has a coherent dualpol and experimental quadpol capability, interest focuses on the potential for using Tandem-X in a future polarimetric interferometric mode for deriving forest height and vertical structure products. In this paper we perform a quantitative assessment of the likely performance of a quadpol POLInSAR mission with Tandem-X using dual and quadpol data sets from the Terrasar-X archive.

There are two components to any assessment of POLInSAR performance, the first a geometrical baseline analysis to estimate basic sensitivity to volume decorrelation as a fraction of system performance budget, as manifest in the phase tube concept [1]. However, a second part deals with the so called mu-spectrum, the max-to-min variation of surface-to-volume scattering ratio at X-band [2]. The narrower this spectrum, the worse the performance of POLInSAR inversion algorithms.

This spectrum unfortunately depends on forest type and environment and hence the only way to derive it is from global data sets. In this paper we develop a new method for predicting the mu-spectrum from single pass PALSAR data, as made available by Terrasar-X during its DRA, split-antenna campaign held in Spring 2010.

We analyse data from three important forest environments, all of which have been widely studied using other sensors, such as the L-band ALOS-PALSAR satellite. These are an open savannah woodland in Injune, Queensland, Australia, a tropical peat swamp forest in Borneo and finally a mixed plantation and semi-natural pine forest in Glen Affric, Scotland.

We conclude with an assessment of the mu-spectrum for each of these sites and their implications for planning a future quadpol POLInSAR mission for forest height retrieval using Tandem-X.


**************

Notes: ...
Tandem-X - successfully launched in June 2010 - forms with TerraSAR-X the first single-pass (single- dual- and quad-) polarimetric interferometer in space. This allows for the first time the acquisition and analysis of Pol-InSAR data without the disturbing effect of temporal decorrelation.

X-band is in general - due to its limited penetration capability into dense vegetation media - a sub-optimal frequency band for global forest structure mapping. However, recent airborne experiments demonstrated a rather unexpected high sensitivity of X-band interferometric measurements on forest vertical structure attributes [3] including the potential of Pol-InSAR data inversion at X-band for forest height estimation using the RVoG model [1] over boreal and temperate forest conditions. Of course the ability of estimating height in terms of X-band interferometry depends on the capability of X-band to penetrate into and through the forest layer that directly depends on the density and hence the extinction of the volume layer. There are three thinkable scenarios that can be considered:

1. For sparse forest conditions - as found in boreal forests - X-band penetrates until the ground and the Pol-InSAR signature contains a certain ground contribution. Assuming a Random Volume as described by [1] the amount of ground contribution is polarisation dependent, allowing inversion by means of dual- or quad-polarisation Pol-InSAR acquisitions [4],[2].

2. For denser forest systems X-band may be able to penetrate through the whole volume but the ground contribution in the signal can be (and has been) assumed to be negligible low [2][3]. In this case the polarimetric diversity gets lost as the Pol-InSAR signature is dominated by the (polarisation independent) volume contribution. Assuming this and using a priori knowledge about the phase related to the underlying ground (by using for example an external ground DEM), forest height can be estimated even from a single interferometric acquisition at a single polarisation.

3. Finally, for very dense forest conditions where X-band is able to penetrate only through a fraction of the canopy layer a priori knowledge of the ground topography allows to get forest height estimates from one single interferometric channel.

In this paper first TerraSAR-X - TanDEM-X datasets are analysed with respect to the three scenarios in order to conclude about the potential of the TanDEM-X mission for forest parameter inversion and forest characterisation. For this purpose dual polarimetric (HH/VV and/or HH/HV) datasets from the pursuit monostatic commissioning phase (until September 2010 both TanDEM-X and TerraSAR-X operate in a monostatic mode separated by approximately 20km in along-track that translates in a temporal baseline of approx 3sec.) and the bistatic phase (from October 2010 TanDEM and TerraSAR are flying in a close formation and are operated in a bistatic mode with zero temporal baseline) are used. Data takes are done over several test sites in different forest ecosystems (from boreal to tropical forests). Estimated Pol-InSAR parameter/heights are compared/validated against ground measurements or reference data from LIDAR measurements.


***************

Notes: ...
A new Test for Target Stationarity for POLInSAR Applications

Marino, A.; Cloude, S. R.

1The University of Edinburgh, UNITED KINGDOM; 2AEL Consultants, UNITED KINGDOM

Many methodologies in POLInSAR are based on the concept of polarimetric and interferometric coherence (e.g. tree height inversion) [1]. The latter is the coherence between two interferometric pair of images selecting a specific scattering mechanism which can be different in the two passes. Many procedures are based on the assumption that the scattering mechanisms between the two interferometric passes are stable (in the relatively small baseline considered). On the contrary, when the scatterers change (polarimetrically) from one acquisition to another, different algorithms must be employed. In order to decide which set of algorithm is appropriate to locally use, a test of target stability must be performed as pre-processing. One commonly used methodology considers the maximum likelihood ratio of the coherency matrix determinants. However, this is often more sensitive to variations in the total power backscattered than to polarimetry. Consequently, in some instances this ratio leads to misidentification of changes. In this paper we develop a new test that is more closely linked to changes in polarimetry than radiometry and therefore provides a more robust assessment of stationarity for POLInSAR applications.

The authors have already developed a polarimetric detector able to identify targets with arbitrary degree of polarisation [2]. The algorithm is based on a geometrical perturbation [3] of the vector describing the depolarised target in a 6 dimensional complex space. This process is accomplished evaluating a (modified) polarimetric coherence, therefore it is independent of the total power backscattered by the target. This was demonstrated to be a key advantage against non-normalised classifiers [4], in all the cases where the total power is not related to physical properties (i.e. layover areas).

In this paper the already published detector is modified in order to assess polarimetric changes between two polarimetric acquisitions. The reference vector (i.e. target to detect) is selected (pixel by pixel) using the first acquisition and the detection is performed on the second acquisition. The detector threshold is set considering the differences between first and second scattering mechanisms which are considered unacceptable for the proper execution of the specific POLInSAR algorithm. Specifically, an appropriate methodology is developed in order to interpret the scattering mechanism differences in the new 6 dimensional space. The methodology was tested using ALOS PALSAR and E-SAR data. The algorithm shows significant agreement with the available information about land changes. Moreover, a detailed comparison with the maximum likelihood ratio (ML) methodology is presented.


***************

Notes: ...
Separation of scattering contributions in Polarimetric SAR Interferometry
López-Martínez, C.; Papathanassiou, K.P.; Alonso, A.; Fabregas, X.
1Universitat Politècnica de Catalunya UPC, SPAIN; 2German Aerospace Center DLR, GERMANY

Polarimetry SAR interferometric data, together with the use of coherent scattering models, have shown their potentiality for the quantitative study of forests and agricultural areas. As demonstrated, the polarimetric dependency of the interferometric complex correlation coefficient may be exploited to relate this coefficient with the different parameters employed to describe a vertical distribution of scatterers. In the case of forests, for instance, these parameters may refer to the forest height, the extinction coefficient or to the underneath topography.

In [1], the authors demonstrated that the optimization of the interferometric complex correlation coefficients as a function of polarimetry, based on a maximization of the coefficients amplitude, made possible the separation in height of these coefficients. This separation process leads to identify the different complex correlations coefficients with scattering centres close to the ground scattering centre or to the volume scattering centre taking place in the tree canopy. Nevertheless, since there is no a conventional frequency, from P- to X-band, able to be sensitive only to the ground under the vegetation or to the canopy contribution, none of the previous interferometric complex correlation coefficients may be exclusively related to one of the scattering contributions. This problem has been solved by the introduction of complex scattering models, where the Random Volume over Ground (RVoG) model represents the most successful alternative due to its simplicity. Based on this model it has been demonstrated [2] that it is possible to have access to the scattering contributions due to the underlying topography or to the tree canopy.

Regarding the retrieval of the underlying topography, the approach derived in [2] presents the drawbacks that ground topography is estimated based on a least squares approach and a necessary regularization process, since it estimates two solutions for the ground topography, one correct and the second one false. Indeed, these drawbacks are again due to the fact that it is not possible to separate ground from volume contributions, that is, it is not possible to eliminate the vegetation bias introduced by the volume scattering contribution when the underlying topography is estimated. This important limitation has been solved, as demonstrated in [3] and [4], by considering a different interpretation of the RVoG coherent scattering model. A theoretical analysis of this model has shown that it is possible to obtain algebraic expressions for the ground topography, making possible to eliminate the volume bias when the ground topography is estimated. In part, this new approach may be interpreted as a separation of scattering contributions in PolInSAR.

The objective of this work is to continue the exploration of the interpretation of the RVoG model initiated in [3] and [4]. As it will be detailed, these results can be generalized to establish those conditions under which one may assume that the complex correlation coefficient contains only contributions from the underlying topography or contributions only from the volume scattering contribution. The possibility to separate these contributions in the complex correlation coefficient allows to retrieve the information of the ground topography without the bias introduced by the volume or to retrieve information about volume without being affected by the ground scattering contribution. The first part of this work will address the presentation of the theoretical analysis demonstrating the concept of scattering contributions separation in Polarimetric SAR interferometry. In a second stage, this concept will be assessed based on a quantitative analysis on simulated PolInSAR data. Finally, these results shall be extended to real PolInSAR data. In this case, the dependency with frequency and incidence angle shall be also considered.

References:

***************

Notes: ...
Overview and Applications of UAVSAR’s Multi-squint Polarimetric Imaging Mode

Hensley, Scott; Jones, C.; Michel, T.; Chen, C.; Chapman, B.; Muellerschoen, R.
Jet Propulsion Laboratory, UNITED STATES

NASA’s Jet Propulsion Laboratory has developed reconfigurable polarimetric L-band synthetic aperture radar (SAR), specifically designed to acquire airborne repeat track interferometric (RTI) SAR data for application to monitoring surface deformation and vegetation structure measurements. The system employs a precision autopilot developed by NASA Dryden that allows the plane to fly precise trajectories usually within a 5 m tube. Also required for robust repeat pass applications is the ability to point the antenna in the same direction on repeat passes to a fraction of an azimuth beamwidth (8 degrees for UAVSAR). This precise pointing is achieved using an electronically scanned antenna whose pointing is based on INU attitude angle data. The radar design is fully polarimetric with an 80 MHz bandwidth (2 m range resolution) and has a greater than 20 km range swath when flying at its nominal altitude of 12500 m. The ability to electronically steer the beam on a pulse-to-pulse basis has allowed a new mode of SAR data acquisition whereby the radar beam is steered to different squint angles on successive pulses thereby simultaneously generating images a multiple squint angles. This mode offers the possibility of generating vector deformation measurements with a single pair of repeat passes and to obtain greater kz diversity for vegetation studies with a reduced number of passes. This talk will present an overview of the mode, discuss its potential for deformation and vegetation and show some examples using UAVSAR data.

This research was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

***************

Notes: ...
Biomass Estimation from Forest Vertical Structure: Potentials and Challenges for Multi-Baseline Pol-InSAR Techniques

Pardini, Matteo; Kugler, Florian; Lee, Seung-Kuk; Sauer, Stefan; Torano Caicoya, Astor; Papathanassiou, Konstantinos
German Aerospace Center (DLR), GERMANY

A central parameter of the terrestrial carbon budget is forest biomass which represents a proxy for the stored carbon. Despite its crucial role in the terrestrial carbon budget, forest biomass is poorly quantified across most parts of the planet due to the great difficulties in measuring biomass on the ground consistently. Accurate and reliable estimation of forest biomass is today one of the "hot topics" within the radar (and lidar) remote sensing community. In this work, we discuss the potential and limitations for estimating forest biomass through vertical forest structure parameters obtained from interferometric synthetic aperture radar (SAR) remote sensing techniques.

A first approach for biomass estimation was proposed in 2004, basing on the allometric relationship between forest biomass and forest (top canopy) height. This method provides reliable results for forest systems without strong density variations. However, changes in forest density and structure (e.g. due to tree species diversity, management system or disturbances) introduce deviations from the "standard" forest height to biomass relationship and limit the performance of biomass estimation from height data. An important extension has been recently proposed, according to which the height to biomass allometry has been extended by means of the vertical biomass distribution function. This compensates widely the structural heterogeneity within and across forest systems and opens the door for accurate and reliable biomass estimation by means of remote sensing techniques.

The estimation of forest vertical structure by means of SAR is a challenge, especially when addressed in terms of a space-borne mission implementation. Conventional SAR tomography has demonstrated the potential to "image" vertical structure by means of multiple acquisitions. However, the lack of multiple space-borne SAR configurations able to perform these acquisitions, combined with (temporal) scene decorrelation that limits the temporal baseline of the acquisitions, reduce the number of suitable (i.e. coherent) acquisitions in a realistic space-borne scenario drastically. Given the availability of only a limited number of acquisitions, alternative approaches have to be used in order to assess vertical structure information by means of SAR. Interferometric approaches are based on the fact that the (volume) interferometric coherence is directly related to the vertical distribution of scatterers seen by the radar and thus to the vertical structure of forests. This information can be either extracted by model-based inversion or by approximating the structure function through a weighted sum of a series of (orthogonal) basis functions. The individual parameterization has then to be inverted using a (limited) number of interferometric measurements at the same or different polarizations.

In this work, the biomass estimation performance from forest height and vertical structure measurements from interferometric SAR at L-band is addressed. In particular, the pros and cons of the different vertical structure estimation approaches are discussed with respect to biomass estimation. Moreover, the performance of individual techniques is demonstrated using multi-baseline SAR data acquired by DLR's E-SAR airborne sensor in the frame of different relevant and actual experiments.

***************

Notes: ...
Forest above Ground Biomass Estimation based on Forest Vertical Structure Information Extracted from POLInSAR Data
Luo, H.M.; Chen, E.X.; Li, Z.Y.; Li, X.W.
1Institute of Geo-Spatial Information Science and Technology, Univ. Electron. Sci. Tech. China, CHINA; 2Institute of Forest Resources Information Technique of Chinese Academy of Forestry, CHINA

Traditionally, forest above ground biomass (AGB) was estimated through one empirical model fitted between radar backscatter power and field-measured biomass. However, these methods are usually limited to low level biomass because of the SAR signal “saturation” phenomenon. In addition, forest height extracted from PolInSAR data can be used to estimate AGB with the known forest height to biomass allometric equations, but the changing conditions of the forest in terms of density, tree species composition etc. limit the accuracy and performance of the method. One possible way to overcome the above disadvantages and improve the estimation accuracy further is to utilize forest vertical structural parameters information, which can be extracted from PolInSAR data using polarization coherence tomography (PCT) technique. In this paper, the advantage of using L-band single baseline repeat pass polarimetric interferometric SAR (PolInSAR) data for AGB estimation was investigated with forest inventory data of 20 forest stands and corresponding repeat pass E-SAR L-band PolInSAR data in the Traunstein test site, a highly structured temperate mixed forest situated in the south east of Germany. The vertical structure function of each pixel is reconstructed using PCT and from which the average vertical structure profiles for the 20 validation stands are computed. Then the 9 forest structure parameters closely related to biomass are extracted from each of these profiles and are taken as independent variables for multivariate linear regression analysis with the field-measured biomass. The five high significant variables are selected by backward stepwise regression. Compared to the AGB estimation method only using the forest height, the squared correlation coefficient ($R^2$) is improved from 0.82 to 0.86 and the root mean squared error (RMSE) is reduced from 57.59 Mg/ha to 47.86 Mg/ha. It shows that the relationship between AGB and some key forest vertical structure parameters extracted from PolInSAR data by PCT technique is strong, and the performance of AGB estimation can be improved significantly.

***************

Notes: ...
Two-Layered Forest Models in Multibaseline PolInSAR
Stefano, Tebaldini; Fabio, Rocca
Politecnico di Milano, ITALY

The idea that Radar scattering from forested areas can be well modeled as being constituted by two Scattering Mechanisms (SMs) has largely been retained in literature. In first place, the assumptions of two SMs match the intuitive argument that a forested area is characterized by the presence of two objects, i.e.: the ground and the vegetation layer. This idea has been formalized in literature through different physical models, considering the features of ground and volume scattering in polarimetric data [1], or in polarimetric and interferometric (PolInSAR) data [2], [3]. Beside physical soundness, however, the popularity of two-layered models is also due to the fact that they provide a sufficiently simple mathematical framework to allow model inversion. This is particularly important in PolInSAR analysis, where the assumption of two layers results in the coherence loci, namely the distribution of the interferometric coherence as a function of polarization, to be given by a straight line in the complex plane [2]. This simple geometrical interpretation provides the key to decompose the interferometric coherence in ground-only and volume-only contributions, after which ground and volume are retrieved. The analysis of the shape of the coherence loci also provides a direct idea about the soundness of approximating the scene as being constituted by two SMs, allowing assessing the impact of model mismatches [4]. The Sum of Kronecker Product (SKP) structure has been proposed in [5] as a general framework to discuss problem inversion in both single and multi-baseline configurations, and independently on the particular physical model adopted to represent each SM.

Concerning two-layered models, the SKP formalism leads to the conclusion that the correct identification of the structural and polarimetric properties of ground and volume scattering is subject to an ambiguity, in that different solutions exist that fit the data up to the same error. Such an ambiguity is shown to be completely described by two degrees of freedom, which can be solved by employing physical models. In other words, the two dimensional ambiguity following after the SKP structure represents exactly the model space, meaning that a certain physical model corresponds to a certain solution of problem ambiguity, and vice-versa. Accordingly, the SKP provides a way to discuss every possible physical model, by exploring the space of ambiguous solutions. In this paper, this methodology is applied to data from the ESA campaigns BioSAR 2007 and BioSAR 2008. Different models are being investigated by exploring different solutions in the ambiguous space, whose features are discussed basing on polarimetric and tomographic features. The main conclusion of this analysis is that the retrieved forest top height appears to be substantially invariant to the choice of the solution for volume scattering, the correct retrieval being mostly a matter of finding the algorithmic procedure that best matches the features of the adopted physical model. Accordingly, forest top height appears as the most robust indicator of the forest structure as observed through microwaves measurements, providing a further and independent argument supporting the validity of PolInSAR for the remote sensing of forested scenarios. On the other hand, though, the substantial invariance of forest top height does not allow to use such parameter as a validation tool for forest structure retrieval.

In this framework, we conclude that multi-baseline PolInSAR techniques are to be considered as an essential tool for forest analysis, as they allow seeing what kind of vertical structure has been retrieved, and drive the choice of the soundest physical model accordingly.

doi: 10.1109/TGRS.2007.897929
doi: 10.1109/TGRS.2009.2031101

**************

Notes: ...
The increasing availability of SAR data is creating new opportunities for the operational use of interferometry to monitor subsidence, seismic events, glaciers, and natural hazards on a global scale. Such monitoring activities are made possible by an acquisition program that provides multiple revisits of all terrestrial surfaces on an annual schedule. This was partially accomplished with JAXA’s Basic Observation Scenario for the L-band PALSAR instrument, and will be furthered with the launch of the C-band constellations: Sentinel-1 and RADARSAT Constellation Mission (RCM). The utility of this data for interferometry is largely determined by the interferometric SAR (InSAR) coherence of the land forms in question. Thus the goal of this project is to better understand the temporal, frequency, and polarization dependences of coherence for different land cover classes.

Within the United States, land cover classification is available in datasets such as the U.S. Geological Survey’s National Land Cover Data (NLCD). NLCD, based on Landsat imagery, classifies land cover into eighteen different classes with high overall accuracy. Thus it serves as a reliable reference for characterizing trends in SAR coherence. However, direct comparison between interferometric parameters and ground truth has been stymied by the inability to compare geometrically-corrected data sets in a common projection within a GIS work environment. Consequently, studies of decorrelation over different land covers have been limited to studies of smaller parcels. While yielding valuable insights, this approach limits spatial sampling and does not permit comparisons of probability distribution functions.

In this project, SAR coherence maps of multiple frequencies and polarizations are compared to land cover directly in a GIS. The Alaska Satellite Facility’s (ASF) MapReady Remote Sensing Tool Kit is used to terrain-correct and project the SAR data products into the NLCD geometry. Using L-band ALOS PALSAR (both dual-pol and quad-pol) and C-band RADARSAT-1 data, we address coherence for several regions of interest, from urban to shrub to heavily wooded. Drawing upon the extensive data archive for these sensors, the opportunity exists to compare frequency and polarization dependences, as well as to investigate coherence variability over time spans from months to years. From these results, broad conclusions will be made about the potential for performing interferometry, as well as using coherence for the extraction of geophysical properties. Specific recommendations will be made regarding the selection of band, polarization, and temporal baseline given land cover information on the area of interest.
Exploring the Potential Pol-InSAR Techniques at X-Band: First Results and Experiments from TanDEM-X

Papathanassiou, Konstantinos; Kugler, Florian; Hainsek, Irena

German Aerospace Center, GERMANY

Polarimetric Synthetic Aperture Radar Interferometry (Pol-InSAR) has been proven to be a powerful radar remote sensing technique for the investigation of natural volume scatterers. The coherent combination of single- or multi-baseline interferograms acquired at different polarisations provides sensitivity to the vertical distribution of scattering processes and allows their characterisation by using the associated (complex) interferometric coherences.

However, in repeat-pass spaceborne implementations, the inherent presence of temporal decorrelation is biasing the interferometric coherence estimates degrading the sensitivity to vertical scattering structure and limiting the performance of Pol-InSAR inversion techniques. This is the main reason why polarimetric space-borne missions could not contribute essential neither with respect to large scale demonstration of Pol-InSAR techniques nor for the development of new Pol-InSAR applications areas.

TanDEM-X – successfully launched in June 2010 – forms together with TerraSAR-X the first single-pass polarimetric interferometer in space. This allows for the first time the acquisition and analysis of Single-, Dual-, and Quad-Pol-InSAR data without the disturbing effect of temporal decorrelation. Even if X-band has - when compared to lower frequencies - a reduced penetration capability recent airborne experiments demonstrated several cases where a rather surprising penetration into natural volume scatterers - as vegetation and ice - could be proven. In this sense, the investigation of the Tandem-X Pol-InSAR data sets will strongly contribute to our understanding of scattering processes at X-band and potential new Pol-InSAR applications.

In this presentation, first Pol-InSAR TanDEM-X datasets over a number of sites distributed across worldwide are investigated with respect to interferometric volumetric effects in order to provide first insights on the potential of the TanDEM-X mission for characterisation of natural volume scatterers. For this purpose dual polarimetric (HH/VV and/or HH/HV) datasets from the pursuit monostatic commissioning phase (lasting until September 2010 where both TanDEM-X and TerraSAR-X operated in a monostatic mode separated approximately 20km in along-track that translates in a temporal baseline of approx 3sec.) and the bistatic phase (starting in October 2010 TanDEM and TerraSAR are flying in a close formation and are operated in a bistatic mode with zero temporal baseline) are used.
This presentation addresses the role of temporal decorrelation in polarimetric SAR interferometry (PolInSAR). First, we expose a general formulation that binds structural changes with volume effects and leads to the time-varying random volume over ground (TV-RVoG) model. Then we discuss the combined inversion of temporal and volume coherence estimates using the TV-RVoG model and illustrate the results of an inversion procedure on airborne PolInSAR data.

Structural temporal decorrelation in repeat pass interferometry occurs when the vertical profile (or structure function) changes in the time between the acquisitions. This scenario can be modeled by incorporating a temporal decorrelation function in the general definition of the volume coherence. The temporal function represents the local temporal decorrelation in the canopy layer. We have proposed an explicit expression of this function based on the Brownian motion of the canopy elements and on the first-order expansion of the motion variance along the vertical dimension [1]. In the presence of structural changes, we have shown that the temporal decorrelation affects the scattering phase center of the volume coherence, depends on the structural parameters such as forest height and also changes with the wave polarization. Moreover, the TV-RVoG model has a small number of unknowns and its coherence loci in the complex plane is still a line segment as the RVoG model [2].

Given the first-order expansion of the Brownian temporal decorrelation function, the TV-RVoG model has six unknown parameters: the canopy height, the underlying ground topography phase, the ground-to-volume scattering ratio, the mean wave extinction in the canopy, the motion variance of the canopy elements at the ground-level and a reference height in the canopy. Since the ground-to-volume ratio is the only polarization-dependent parameter, it can be shown that 5 different coherence estimates suffice for balancing model unknowns and observations [3]. The detailed procedure for the estimation of model parameters (topography phase and canopy height) starts with the extraction of the model line and its intersection with the unitary circle. This intersection does not represent the true ground surface as in the RVoG case. A correction term based on the coherence amplitude and weighted by a parameter that adapts to the structure [4] can be used to compensate for the phase bias due to volume and temporal effects. Our preliminary experiments for the model inversion are supported by LiDAR data that provide ground phase and canopy height. A part for the model validation this procedure can be conveniently exploited by the future JPL/DESIGNI mission that will carry on-board two complementary instruments, a L-band SAR and a LiDAR. Airborne data from recent PolInSAR campaigns are used to illustrate the results.


Notes: ...
Day 2 - Tuesday 25 January

Session: Applications on Soil Moisture/Wetlands
A Hybrid Decomposition for Soil Moisture Estimation under Vegetation Cover Using Polarimetric SAR

Jagdhuber, Thomas¹; Hajnsek, Irena²; Papathanassiou, Konstantinos P.¹; Bronstert, Axel³
¹German Aerospace Center, GERMANY; ²ETH Zurich, Institute of Environmental Engineering, SWITZERLAND; ³University of Potsdam, Institute of Earth and Environmental Sciences, GERMANY

Concerning the identification of critical catchment states before flooding events, the possibility to retrieve soil moisture on a catchment scale with frequent coverage is highly desirable for flood forecasting and precise hydrological modelling. As the soil in temperate latitudes is covered by vegetation most of the year, a novel hybrid decomposition is investigated for soil moisture estimation under vegetation cover using fully-polarimetric SAR data.

The developed polarimetric decomposition combines a model-based decomposition separating the volume component from the ground components with an eigen-based decomposition of the two ground components into a surface and a dihedral scattering contribution, resulting in a so called hybrid decomposition based on [1]. The innovative volume component will account for different orientations and particle shapes within the vegetation layer, which allows the representation of different vegetation types. In addition the volume power, which causes problems in standard polarimetric decomposition approaches, will be constraint for the first time in a physically meaningful way. Concerning the ground components, the hybrid decomposition enables a physical separation of the surface from the dihedral component using an orthogonality condition of the two scattering mechanism. In this way the proposed decomposition utilizes physically meaningful constraints to optimize the separation of the different scattering components.

The developed algorithm is applied on fully-polarimetric L-band data of the AGRISAR and the OPAQUE campaigns conducted in the years 2006 to 2008 and acquired by DLR’s E-SAR sensor. The AGRISAR data were chosen, because they cover an entire vegetation growth cycle in order to investigate the influence of the growing vegetation. The OPAQUE data extends this study on scattering influences coming from the pronounced topography of the test site. Furthermore an extensive set of ground measurements including soil moisture, soil roughness and vegetation parameters are available for the campaigns.

Hence, the inverted soil moisture values from the airborne data are validated with corresponding ground measurements of the conducted campaigns for a quality assessment and a discussion on potentials and limitations regarding future airborne and spaceborne SAR missions like Tandem-L.


 ****************

Notes: ...
Investigation of Polarimetric radarsat 2 for Peatland Characterization

Touzi Ridha, RT
Canada Centre for Remote Sensing, CANADA

Canada has 25% of the world’s wetlands and wetland management has become a critical issue in order to avoid or mitigate further loss of wetland area or function. Mapping wetlands and monitoring their change, in a systematic and repeatable manner, are important in order to manage and protect significant wetland areas in Canada and to avoid or mitigate further loss of wetland areas. The unique polarimetric [1] and all-weather capabilities of RADARSAT-2 should play a key role to support continuous, long-term quantification of wetlands extent and type and associated dynamics, and will make a unique contribution to the sustainable development approach being developed by the federal government and the provinces for protecting wetlands and maintaining their functions in the long term.

This paper reports on the use of polarimetric target scattering decomposition for wetland characterization. Cloude-Pottier’s incoherent target scattering decomposition [2] has been for the last decade the most used method for target scattering classification. Recently, the Touzi decomposition is introduced [3, 4] for the incoherent decomposition of target scattering in terms of unique and roll invariant parameters. In contrast to the Cloude-Pottier decomposition, which uses a real entity, the so called Cloude fNN, to describe target scattering type, the Touzi decomposition characterizes uniquely the scattering type with three parameters; the symmetric scattering type magnitude fNs and phase f0fNs introduced in [3] and the target helicity [5, 6]. The Touzi decomposition has been shown to be very promising for wetland characterization using polarimetric Convair-580 C-band SAR data with a 4-look 5mx5m resolution [7, 8]. In particular, the scattering type phase f0fNs permits enhanced discrimination of shrub-bog from poor-fens. Theses classes cannot be separated using optic sensors. They cannot also discriminated using the polarization radiometric scattering information provided by the Cloude fNN, the entropy H, or the multi-polarization HH, HV, and VV intensities. f0fNs permits also the discrimination between conifer-dominated-treed bogs from upland deciduous forest, under leafy conditions.

The objective of this study is to validate the results above using the C-band polarimetric RADARDAT2 of coarser 9mx9m resolution. The investigation has been conducted using polarimetric Satellite and ground field data collected over various peatlands in Canada; Mer Bleue (East of Ottawa), Ivvavik (near Inuvik) and Wapusk (near Churchill). The effect of Look-Up-Table (LUT) on polarimetric Radarsat2 data quality is discussed. Several LUTs are used to reconstruct the original 32-bit floating point single look complex (SLC) data. The reconstructed data are used to assess the Touzi decomposition for enhanced peatland characterization. The requirement for the use of 32-bit floating point SLC in polarimetric Radarsat2 wetland applications is raised.

References:


***************

Notes: ...

58
Extraction of Benthic Fauna Habitat in Tidal Flats using Multi-Frequency polarimetric SAR Data

Choe, B.1; Kim, D.J.1; Hwang, J.H.2; Moon, W.M.3
1Seoul National University, KOREA, REPUBLIC OF;
2Hongik University, KOREA, REPUBLIC OF; 3University of Manitoba, CANADA

Recently, several researches have been conducted to monitor the environments of tidal flats using SAR techniques. However, most of the studies have focused on extracting the surface roughness parameters from various SAR systems and relating the surface roughness with sediments facies. And they just suggested those parameters are related closely with the distribution of benthic fauna and morphology of tidal flats, and can be provided as helpful basic information. However, surface roughness parameters derived from surface scattering models (ex. IEM, extended-Bragg, or semi empirical) are available to the range of smooth bare soils. And polarimetric target decomposition theorems have been developed to classify the target areas by the scattering mechanism analysis from fully polarimetric SAR data, but have not yet been applied to tidal flats which is expected only surface scattering will be dominant.

Tidal flats, as transitional zones between the ocean and the land, function as a habitat for various species of benthos. Benthic fauna form a relatively rough surface structure in tidal flats by their unique surface structure or their survival activities. The areas where benthic faunas are distributed intensively can represent the surface roughness beyond the mostly measured range in bare soil. These rough surface structure can also make the transmitted microwave signal depolarized, resulting in the increased radar backscattering in HV and VH polarization. In this study, we tried to extract directly the distribution of benthos by analyzing their unique scattering signature from polarimetric SAR data. The scattering mechanisms in tidal flats were analyzed by Freeman-Durden three component target decomposition. The target depolarization effects were quantitatively measured using the cross-polarized ratio (HV/HH), co-polarized correlation, and phase difference between HH and VV. Tidal flats of Jeju Island and Hampyung Bay in the western coastal region of the Korean peninsula were selected for the investigation.

In particular, oyster reefs are exposed and distributed intensively on those tidal flats at ebb tide. Oyster reefs form considerably rough structure (sharp and jagged surfaces), which is quite distinct from mud or sand flats. The average RMS height of oyster reefs, which is collected from in-situ measurement using a laser surface profiler system, was about 3 times greater than that of mud flats and the average correlation length of oyster reefs was 2.5 times smaller than that of mud flats. We observed the differences of scattering signature between oyster reefs areas and mud flat areas from the fully polarimetric RADARSAT-2 (C-band) data. Strong multiple/volume scattering and depolarization effects were observed in oyster reefs areas, while only surface scattering was dominant with little depolarization effects in mud flat areas. In order to verify these signatures, we also measured C-band fully polarimetric radar backscattering using a ground-based microwave scatterometer system. In oyster reef areas, whole backscattering occurred strongly than mud flats. In particular, HV and VH cross-polarized backscattering increased remarkably, causing a strong depolarization and volume/multiple scattering, which were not observed in mud flat areas.

Secondly, we also applied the same methods to ALOS PALSAR (L-band) data, and investigated the scattering behavior for oyster reefs in multiple frequency regimes. The differences of scattering signature between oyster reefs areas and mud flat areas did not observed from ALOS PALSAR (L-band) data. Any volume scattering and depolarization effect were not detected in oyster reefs areas. Only surface scattering is dominant and depolarization effects occurred poorly in both oyster reefs areas and mud flat areas. The relatively long wavelength of L-band did not discriminate the roughness difference between oyster reefs and mudflats. These results demonstrate the scattering sensitivity reacting to the surface roughness of target areas is different depending on the wavelength; as the wavelength is longer, the surface roughness represents relatively smoother effect with decreasing depolarization.

In conclusion, we verified oyster reefs areas can be discriminated from mud flats in C-band, but not in L-band. RADARSAT-2 (C-band) has more suitable frequency range for distinguishing the surface signatures of oyster reefs areas and mud flats. This study suggests that multi-frequency polarimetric SAR measurements can be used for detecting the naturally distributed oysters in tidal flats, as well as other shellfishes. In further study, X-band fully polarimetric SAR data with high resolution, such as TerraSAR-X, will be applied to acquire more robust results and find out the scattering signatures of other shellfishes which can be discriminated in frequency range between C-band and X-band.

***************

Notes: ...
Soil Moisture Retrieval in Alpine Areas by using 
Support Vector Regression Techniques and 
poIarimetric RADARSAT2 Images

Luca, Pasolli1; Claudia, Notarnicola2; Lorenzo, Bruzzone3; 
Giacomo, Bertoldi4; Stefano, Della Chiesa5; Ulrike, 
Tappeiner, Marc, Zebisch6; Fabio, Del Frate6; Gaia, 
Vaglio Laurin7

1UniTrento-EURAC, ITALY; 2EURAC-Institute for Applied 
Remote Sensing, ITALY; 3Dep. of Information 
Engineering and Computer Science, University of Trento, 
ITALY; 4EURAC-Institute for Alpine Environment, ITALY; 
5Dep. of Computer, System and Production Engineering, 
Trento University, ITALY

The project SOFIA (SOIl and Forest Information Retrieval 
by using RAdarsat images -ESA AO 6820) is devoted 
to the exploitation of polarimetric RADARSAT2 images 
in combination with advanced estimation methods for 
patroning the retrieval of soil moisture in bare and 
ground covered soils at basin scale. The use of 
polarimetry seems to be a promising solution, because 
the information associated to different polarization 
configurations (e.g., HH and HV) can help to disentangle 
the effect of roughness and vegetation from the signal 
due to soil moisture [1].

In particular, the activity will be focused in an Alpine 
catchment, where the effects determined by the 
topography of mountainous regions are enhanced thus 
making the estimation process particularly challenging. 
Here the effectiveness of the α-insensitive Support 
Vector Regression (SVR) technique [2] (an advanced 
state of the art estimation method) for the estimation of 
soil moisture is addressed. Although the 
alforementioned technique has been already tested on 
dual polarization data both from satellite and ground 
based instruments [3], in this work it will be adapted 
and applied to fully polarimetric SAR images in order to: 
1) further investigate the promising features and 
capabilities of SVR in the soil moisture estimation 
problem on spatial distributed data; and 2) assess the 
effectiveness and suitability of fully-polarimetric SAR 
data in the retrieval of soil parameters. 
The test area is the Mazia valley, located in South Tyrol 
(Northern Italy). It is mainly covered by grassland 
and has also some forest stands. Ground data, exploited for 
both the training and the validation of the estimation 
approach, are recorded in 16 measuring stations 
located in the valley, ranging from 1000 up to 3000 m 
a.s.l. and representing the test area’s spatial variability 
with respect to relief, land cover and use. In addition 
two extensive campaigns were carried out in June and 
July 2010 contemporary with two RADARSAT2 
acquisitions. 
The first results indicate a good capability to 
discriminate the soil moisture patterns in both 
meadows and pasture areas. Main difficulties were 
found for the pasture area due to the effect of 
topography causing strong variation in the local 
incidence angle and consequently in the backscattering 
coefficients.

In the presentation, several experiments will be 
presented and discussed by considering different 
features configurations (i.e. different combinations of 
polarizations) and different sizes of the set of samples 
adopted for the training of the estimation methods.

References
[1] S. Paloscia, P. Palmobini, S. Pettinato, and E. Santi, 
"A comparison of algorithms for retrieving soil moisture 
from ENVISAT/ASI images," IEEE Transaction on 
Estimation from Microwave Remote Sensing Data with 
Non-Linear Machine Learning Techniques," in Image and 
Signal Processing for Remote Sensing XV, edited by 
Lorenzo Bruzzone, Claudia Notarnicola, Francesco Posa, 
Proceedings of SPIE Vol. 7477 (SPIE, Bellingham, WA, 
2009), 7477 1C.

****************

Notes: ...
Radarsat-2 fully Polarimetric Time-Series Datasets for Wetlands Delineation and Characterization

Marechal, C; Pottier, E; Hubert-Moy, E; Corgne, S; Meric, S; Allain, S
1IETR, University of Rennes 1, FRANCE; 2COSTEL, University of Rennes 2, FRANCE

Background: Remotely sensed data are used to identify, delineate and characterize wetlands. Optical data provide interesting information on land-use and land cover but are limited to cloud-free periods. For these reasons it is not possible to precisely inventory wetland vegetation as well as water cycles and water levels in these areas with optical data. Although, the spatial resolution of radar imagery that has been used until now was too low to investigate wetlands with a sufficient level of precision. For this purpose, Radarsat-2 quad-pol fine mode data show great potential for mapping wetlands.

The two main objectives of this project are:
1. Evaluating Radarsat-2 data to delineate precisely wetlands, map detailed vegetation distribution and determine water levels;
2. Using both very high resolution optical data and radar data to evaluate the contribution of the latter for wetlands delineation and characterization.

Data description and study area: Radarsat-2 imaging mode is the Fine Quad Polarisation, a ground resolution of 7.8m. The ascending orbits were chosen to be phased with simultaneous important ground true measurements on. A high incidence angles are applied (beam FQ23, 42.6°). This project is set from February 2010 to November 2010 (12 images) over a wetland area located in France (Brittany): This investigated area is the site of Pleine-Fougères referenced in the ITER-Europe. The lower valley of the Coesnon river has five marshes, our study focus on 2 of them: The Sougàdel Marsh and The Mesnil Marsh. The research project, presented in this paper, contributes to the Application Development And Demonstration for the exploitation of fully polarimetric time-series datasets for an environmental application: the functional assessment of wetlands, and covers the following fields and thematic areas: Land Environment (Cartography / Mapping) and Hydrology (Wetlands). This project is funded by European Space Agency (ESA) jointly with the Canadian Space Agency (CSA) in the frame of the Science and Operational Applications Research (SOAR-EU) - Initiative.

Methodology:
Information on the land cover is of paramount importance for the monitoring and the management of the environment at different scale. In natural areas, land cover presents complicated structures and highly complex scattering responses, due to various scattering contributions, dielectric and shape properties and volumetric structures. The complementarities of polarimetric, high-resolution observations and time-series datasets will be necessary to provide enough information for general land classification, characterization and mapping. The proposed research activities that are presented in this paper will aim to develop and validate a general supervised and unsupervised PolSAR segmentation methodology, including multi-temporal analysis of land cover evolution, and to investigate on some polarimetric decomposition methods for physical parameter inversion algorithms. Every 24 days, corresponding to the RADARSAT-2 revisit period, ground-truth campaigns are organized in order to measure volumetric soil moisture using Time Domain Reflectometry (TDR) instruments along the transects. Concerning the surface roughness characteristic estimation (periodicity, stationarity, homogeneity), laser profiler is used to acquire roughness profile up to 100m with a very high location / precision. All these data are loaded into a database enabling spatial representation, statistic (correlation) and query. The potential impact of multi-frequency (RADARSAT-2 C-Band) PolSAR data for land cover segmentation techniques will be assessed, in addition to the investigation of the applicability of the time series PolSAR data processing technique for land cover monitoring, for the determination of the water cycle maps and water extent statistics and the determination of high (i.e. flooded), low (i.e. drought) and mean water levels.

Thematic issues
The combination of radar and optical data is needed to provide a better assessment of wetlands functionalities, almost for hydrologic processes, but also for ecological and biogeochemical processes. The use of Radarsat-2 fully polarimetric time-series datasets and the development of novel remote sensing techniques fusioning radar and optical data (ALOS-PRISM and ALOS-AVNIR) is an important aspect for future research activities. This permits to improve our knowledge on wetlands functional processes. Furthermore, the common work between remote sensing and practices analysis in wetlands opens the possibility to detect evidences for changes in agricultural practices in these areas.

During this workshop, we shall present a first qualitative analysis of the RADARSAT-2 time-series fully polarimetric datasets, which has already shown that some polarimetric descriptors are sensitive to the wetland waterlevel. We shall also present the first result of the quantitative analysis that have been conducted from the ground truth measurements.

***************

Notes: ...
Day 2 - Tuesday 25 January

Session: Polarimetry & PSI – Tomography
Interest grows in techniques of coherent combination of complex (amplitude and phase) SAR data for extraction of rich information on the observed scene. Among these, 3D SAR Tomography [1-4] (Tomo-SAR) is an experimental multibaseline (MB) mode for full 3D imaging through elevation beamforming, i.e. spatial (baseline) spectral estimation. Tomo-SAR resolves multiple scatterers in height in the same cell, allowing analysis of complex scenes. However, especially for spaceborne sensors, observed scenes are non-stationary, as deformation motions and temporal decorrelation can occur during the repeat-pass MB acquisition. This can cause height blurring in Tomo-SAR imaging [5]. Also, although Tomo-SAR can separate multiple scatterers, it has no measuring sensitivity to their deformation motions. On the other hand, D-InSAR techniques sense deformations but degrade with multiple scattering.

Therefore, a novel coherent data combination mode termed Differential SAR Tomography (Diff-Tomo) has been originated by University of Pisa (UniPi) [6], integrating D-InSAR and Tomo-SAR concepts to allow "opening" the SAR pixel in complex non-stationary scenes. Exploiting space-time spectral analysis, it allows joint resolution of multiple elevation and deformation velocity components of the scatterers mapped in a SAR cell, with application e.g. to monitoring of complex urban areas and infrastructures. Diff-Tomo enables also "volumetric differential interferometry" capabilities, in which continuous profiling may be possible of velocity vs. height. Even more generally, Diff-Tomo can identify scattering components distributions in the domain of spatial (height) and temporal frequency of harmonics in which a signal from a scatterer with temporal decorrelation can be decomposed, avoiding their misinterpretation in tomographic processing [5]. In this work, an overview of UniPi research and recent advances are presented of Diff-Tomo techniques for the analysis of complex multiple or volumetric scatterers and non-stationary deforming or decorrelating scenarios. A first theme concerns Diff-Tomo experiments over urban areas to estimate heights and deformation velocities of multiple scatterers. ERS-1/2 data results are shown, obtained with high height resolution adaptive Diff-Tomo [7]. To enhance horizontal resolution, results of adaptive Diff-Tomo with a low number of looks are shown, including first results of single look processing, and possibly COSMO-SkyMed data tests. High horizontal resolution urban applications of the Diff-Tomo framework are being developed also at IREA-CNR and DLR.

A second theme regards application of Diff-Tomo techniques to forest scenes, characterized by temporal decorrelating canopy in layover with ground. The intriguing possibility is shown of extracting decorrelation-robust tomo profiles through model-based Diff-Tomo processing accounting for the nuisance temporal frequencies [5]. First experiments are reported with MB P-band E-SAR BIOSAR-1 data. This Diff-Tomo application might overcome a possible development barrier of forest tomography recognized by JPL and ESA.

Also, the interesting possibility is shown through model-based Diff-Tomo of discriminating temporal decorrelation mechanisms of canopy and ground. Finally, another possible Diff-Tomo application in forest scenes is shown to estimate velocity of ground subsidence under the canopy, decoupling interfering volume effects [5]. First cut experiments of this challenging application are reported with the P-band data.

Besides these advances, the Diff-Tomo framework can be extended in a polarimetric sense to a Pol-Diff-Tomo method [8], to extract joint information on heights, deformation velocities and scattering mechanisms of the multiple scatterers. First P-band sample results are shown.

These investigations may be applied e.g. in the framework of the missions BIOMASS, TanDEM-X/-L, and COSMO-SkyMed.

Part of the work has been supported by ASI project I/065/09/0.


***************

Notes: ...
Polarimetric Stationarity Criteria Applied to the Selection of Persistent Scatterer Candidates
Navarro Sanchez, Victor Diego; Lopez Sanchez, Juan Manuel
Universidad de Alicante, SPAIN

Persistent Scatterers Interferometry (PSI) has been traditionally applied with the available single-pol imagery provided by ERS-1 & 2, Envisat-ASAR, Radarsat-1, etc. Since the launch in 2006-07 of SAR sensors with added polarimetric capabilities, like ALOS-PALSAR, Radarsat-2 and TerraSAR-X, there are also available series of images acquired with dual-pol and quad-pol modes. Hence, it is worth exploring the possibilities of the added polarimetric information for improving PSI.

The first step in all PSI techniques consists in the selection of a subset of the image pixels for further processing. These selected pixels, named candidates or PSC, exhibit a good a priori behaviour (i.e. phase stability) for being used in PSI. When only single-pol images are available, the selection can be based on two criteria:
- Amplitude dispersion, computed on pixel basis with full resolution or SLC images
- Average interferometric coherence for the set of selected interferograms, after multilooking for coherence estimation

In a previous work we demonstrated that both criteria can be applied also by combining coherently the available polarimetric information in order to optimise the corresponding parameter and to increase the number of PSCs [Navarro’10]. Therefore, polarimetry was used for optimising the same interferometric criteria used previously in single-pol PSI.

A more interesting approach would consist in select those pixels with stable or persistent polarimetric behaviour along the time series, since they should correspond to elements in the scene that do not change their physical properties along the time series and, thus, are well suited for the PSI processing. Consequently, we have to apply a condition to explore the polarimetric stationarity of the pixels. In this work, we make use of the stationarity criteria shown in [Ferro-Famil’08], for a pair of images, and in [Ferro-Famil’03], in the context of subaperture processing. These criteria are useful to provide a numerical estimate of the polarimetric stationarity of the pixels. In fact, these criteria correspond to the logical extension of the mentioned single-pol ones. For instance, the amplitude dispersion is substituted by a measurement of the dispersion of the determinant of the covariance matrix of each pixel, since the polarimetric information can be arranged in matrix form, instead of the scalar form of the single-pol data.

Experimental results have been obtained by applying these criteria to a set of dual-pol HHV TerraSAR-X images acquired during one and a half years over the city of Murcia (Spain). The analysis of the results includes a comparison against the previously mentioned criteria (e.g. amplitude dispersion), since we can distinguish four set of pixels:
- a) Pixels with good polarimetric stationarity and low amplitude dispersion (ideal case)
- b) Pixels with good polarimetric stationarity and high amplitude dispersion
- c) Pixels with bad polarimetric stationarity and low amplitude dispersion
- d) Pixels with bad polarimetric stationarity and bad amplitude dispersion (useless pixels)

The physical features in the scene leading to pixels of each type are also discussed. In particular, the peculiarities of types (b) and (c) are especially important, since they correspond to elements for which the hypothesis of polarimetric stationarity provides different information with respect to the common interferometric criterion.

***************

Notes: ...
Target Characterization and Interpretation of Deformation Using Persistent Scatterer Interferometry and Polarimetry
Dheenathayalan, P; Hanssen, R.F.
Delft University of Technology, NETHERLANDS

Persistent Scatterer Interferometry (PSI) can yield a positioning accuracy in the order of metres and millimetric deformation trends by exploiting coherent pixels. However, associating the Persistent Scatterer (PS) to a specific target such as a pole, building, ground or a building-to-ground interface is not straightforward. If one could precisely associate each PS point to an actual target, the deformation observed at these points can be better interpreted, thereby creating a new range of applications. One such application is to find the relative motion between a building and the ground to detect stress on pipes used for gas or sewer systems, potentially leading to damage or even gas explosions when left unnoticed.

Here we develop a systematic approach to use various types of information, such as height estimated from PSI, scattering pattern (amplitude) variation over various incidence and squint angles, and polarimetric information to best characterize the target. We investigate what information is best suitable to characterize radar targets from an application perspective, and whether a (linear) combination of different observation types could provide optimal results.

This methodology is studied for target characterization and interpretation of deformation phenomena over urban areas in the Netherlands using time-series and polarimetric data from TerraSAR-X. In future this new technique will be applied on other urban areas using low resolution ENVISAT and ERS data to test its robustness. The drifting orbits of ERS-2 and Envisat will be fully exploited for this purpose.

***************

Notes: ...
Lately SAR satellites with full polarimetric capabilities have been launched, such as Radarsat-2 and ALOS. The availability of data of the same scene in various polarimetric channels can be exploited in many ways. The objective of this work is to evaluate the benefits of using polarimetric data in Differential Interferometry (DInSAR), applied to space borne subsidence monitoring of urban areas. Some works have addressed the combination of polarimetry and DInSAR [1][2], which usually follow a theoretical polarimetric approach and are mainly focused on the manipulation of the data to optimize the results of the DInSAR processing, like the interferometric coherence optimization. In this study we will particularize the use of PoSAR data to the case of deterministic targets that can be found in an urban area. In a first stage each polarization channel will be processed separately from a DInSAR point of view. The added value will be provided from the combination of the results obtained for each channel. On a second stage, polarimetry will be used to perform a optimized selection of persistent scatters (PS) considering the different polarimetric channels simultaneously [3]. One of the benefits expected is the redundancy provided by the different channels that will help to increase the number of PS of the deformation map and reduce the noise of the deformation time-series. Another advantage is the possibility to extract additional information from the polarimetric data. For instance, each selected pixel can have information in one or more polarimetric channels. As each one could be located at a different height and present a different deformation pattern, it would be possible to distinguish different behaviors within the same resolution cell. For instance a building can be subsiding at a different rate than the surrounding terrain. The dataset used to perform this study consists of Radarsat-2 full-polarimetric SLCs over the city of Barcelona, where an important activity with the construction of new underground infrastructures is taking place. For instance, the tunnel that will connect the High Speed Train (AVE) line with the France will pass very close to the Sagrada Familia cathedral. Also the new underground line (L9) that will connect the city with the airport could generate subsidence in different urbanized areas. After the collapse of one block in El Carmel neighborhood in 2005 due to a new underground line and the building damages caused by the AVE tunnel in the South of the city, there is a clear need of a large scale monitoring of these activities. Two different datasets of images have been acquired, one in 2008 (10 images) and the other in 2010 (11 images until September), both composed by Quad-Pol Fine SAR images, with a regular interval of 24 days. The second set will expand to a total of 30 images until December 2011. These images have been acquired in the scope of the project SOAR-EU 6779. There is also a dataset of the same periods of ERS-2 and Envisat single polarization data which will be used as a reference to compare the results. Also the fact that the University is settled in the urban area of Barcelona makes feasible the on-ground inspection of susceptible subsidence areas.

***************

Notes: ...
Day 3 - Wednesday 26 January

Session: Methods & Theoretical Modelling
Compact Polarimetry at the Moon: The Mini-RF Radars


1 Johns Hopkins University APL, UNITED STATES; 2 Lunar and Planetary Institute, UNITED STATES; 3 NASA Headquarters, UNITED STATES

The Mini-RF radar aboard India’s lunar Chandrayaan-1 satellite (2008-9) was the first polarimetric synthetic aperture radar (SAR) outside of Earth orbit. The architecture of that radar—and of its more advanced two-frequency sibling on NASA’s Lunar Reconnaissance Orbiter (2009 —) is hybrid dual-polarimetric. This architecture is a form of compact polarimetry in which the dual-received data are orthogonal linear polarizations, in contrast to the transmitted polarization which is circular. Imagery from these pioneering compact polarimetric radars illustrate the value of hybrid-polarity for lunar and planetary applications.

The radars had to have relatively low mass, 15 Kg or less. The first-order science requirement was measurement of the circular-polarization ratio, defined as the ratio of the same-sense (SC) to the opposite-sense (OC) of circularly polarized backscatter, relative to the sense of the transmitted circular polarization. This measurement requires transmission of circular polarization. It also suggests that the receiver should be (dual-) circularly polarized, but that turns out to be a false conclusion.

Circularly polarized transmission may be realized by transmitting H and V polarizations simultaneously, 90-degrees out of phase. These signals are generated by running the output of the transmitter through a 90-degree hybrid. The conventional circularly-polarized approach was simplified by keeping the H- and V-polarized data received at the antenna in their linear polarizations all the way through the receiver and the processor, thus removing the need for two additional 90-degree hybrids in the receive paths. This simplification not only reduced the mass of the radar, but also improved the receiver’s noise figure. The simpler linearly polarized receiver concept was justified through a paradigm shift in radar design. Rather than imagery, the primary data product of the Mini-RF radars was stipulated to be the 2x2 covariance matrix of the backscattered field. The measurements from such a linearly dual-polarized receiver are equivalent to those from a circularly dual-polarized receiver, since the 4-element Stokes vector calculated from the covariance matrix does not depend on the polarization basis in which the data are observed. The resulting hybrid-polarity architecture is an ideal response to the requirements for the lunar Mini-RF SARs; maximal science provided through minimal hardware.

Hybrid-polarimetric architecture has the unique and appealing property that it is self-calibrating. The relative phase and magnitude balance of the receive channels may be observed and corrected, as needed, without recourse to an in situ reference such as a corner reflector. The trick is to average the returns collected at vertical incidence (over a random nominally horizontal surface). If the radar is known to be transmitting high-quality (near-unity aspect ratio) circular polarization, then nadir illumination is necessary and sufficient for polarimetric relative calibration. This is true, because in this case (1) the received data should be circularly polarized in the opposite sense, and (2) data observed through the H and V channels should be identical statistically to first and second order. Discrepancies can be measured, and turned into calibration coefficients, thus balancing the receiver’s phase and amplitude properties, antenna-to-end. The technique is especially appealing for polarimetric radars designed for lunar or planetary observations, for which in situ corner reflector calibration references would be impractical.

The radar’s transmitted polarization for the Mini-RF radars was imperfect, having an axial ratio on the order of 2.4 dB. Relative calibration under this constraint requires external resources. The receive channels were characterized by illumination from the Arecibo Radio Telescope, a circularly polarized source of known high quality. The resulting data, combined with nadir backscattering data, were sufficient to characterize the polarization of the radar’s transmitted field. In addition, the transmitted polarization was observed directly by illuminating the Green Bank Telescope. The results were in agreement between the nadir-viewing and direct observation methods of characterizing the transmitted polarization.

The hybrid-polarimetric Mini-RF radars offer the same suite of polarimetric information from lunar orbit as state-of-the-art Earth-based radar astronomy, most elegantly illustrated by the Arecibo-Green Bank combination. In particular, the Mini-RF data support determination of the circular polarization ratio (CPR) which is known to be anomalously large for backscatter from volumetric ice, or from surface structures dominated by double-bounce reflections, such as fresh impact crater ejecta. CPR mappings from the Mini-RF lunar observations of the permanently shadowed interior of many polar craters are consistent with the signals that correspond to ice deposits.

***************

Notes: ...
StereoPol of Radarsat-2 Data for DEM Generation without GCP
Toutin, Th; Zakharov, I
Canada Centre for Remote Sensing, CANADA

With the new Radarsat-2 capabilities, the full polarimetric and high-resolution data can be included for digital elevation model (DEM) generation, as part of the Canadian Space Agency’s Science and Operational Applications Research program. Two issues have to be considered: geometric and radiometric. For the geometric issue, a physical model of the SAR-Earth geometry has to be considered: a new hybrid version of the Toutin’s 3-D physical model, previously developed for Radarsat-2, was developed to be used without ground control point (GCP). The new hybrid model takes full advantages of the accurate metadata input into the 3D radargrammetric Toutin’s model. While the final accuracy of the modeling is slightly degraded (less than 10% but still around 1 m) when compared to the original version using eight dGPS GCPs, it is counterbalanced by the fact that the user does not have to survey any GCP on the study site. The precision of new hybrid model and the accuracy of the modeling are validated with different ultra-fine and polarimetric mode images acquired over a well-calibrated study site close from Quebec City as well as in the Canadian North (72° latitude) using different methods. The results are: (i) precision of the hybrid model better than 25 cm, (ii) modeling accuracy (1σ) of 1 m and (iii) 3D restitution accuracy (1σ) for 3D feature extraction of 1 m in planimetry and 2 m in elevation. For the radiometric issue in the DEM generation, it is more convenient to first fuse the full polarimetric data into a single intensity image (a requisite in any image matching) and to generate a single fused DEM, instead of first generating four DEMs from the different polarimetric stereo data with different accuracy and then fusing them into a single DEM. Different fusion approaches of the polarimetric data is investigated and their impact on the stereo-radargrammetric process is evaluated. The term of stereopol data fusion will be then used for this method. Three approaches for this stereopol fusion is developed based on: (1) multipolarisation intensity images, (2) full polarimetric complex data and (3) polarimetric decompositions. For the first approach, different techniques of fusion, which also included speckle reduction, were studied and compared to single polarization results. The results show the best DEM accuracy is obtained with the total power of multipol images, known as span. For the second approach, the existing polarimetric algorithms, such as the Polarimetric Whitening Filter (PWF), the Power Maximization Synthesis (PMS) and others enable to generate composite intensity image taking into account the complex nature of the data, including the phase information. PMS achieved better results than the previous approach, but not as much as expected when introducing the co-pol phase difference, which gives information on the scattering mechanism.

One potential reason is the look-up table applied to the data, which could generate some phase variation. For the third approach, two polarimetric decompositions (Pauli and Cloude/Pottier) could help to add additional information about dominant scattering mechanisms. The approach uses then the physical interpretation of polarimetric decompositions results to integrate then into a composite intensity images. The results on DEM accuracy show degradation of more than 15% when compared to the two other approaches and even with the DEM from single pol stereo-images. The potential reason, but not the only one, is that the polarimetric decompositions do not fully eliminate the roll effect in Earth observation (EO) images acquired over a terrain relief, and the introduction of the terrain relief in the polarimetric decompositions of EO images is not presently a resolved issue...

******************

Notes: ...
The polarimetric information has been widely used to interpret the Synthetic Aperture Radar (SAR) scene. Hence, many coherent and incoherent target decompositions have been proposed in the literature to extract polarimetric parameters with a physical meaning [1] [2]. Nevertheless, for most of them, the reciprocity assumption is assumed. For a bistatic Polarimetric SAR (PolSAR) sensor, the cross-polarization terms of the scattering matrix, $S_{\text{hv}}$ and $S_{\text{vh}}$, are generally not equal.

This paper presents a generalization of the Target Scattering Vector Model (TSVM) to the bistatic case: the bistatic TSVM [3]. Five roll-invariant parameters (independent of the orientation angles) are necessary for an unambiguous description of the target scattering mechanism: $\mu$, $\alpha$, $\Phi_{\text{los}}$, $\tau_1$, and $\tau_2$. $\mu$ is the maximum amplitude return. The scattering type magnitude $\alpha$, and phase $\Phi_{\text{los}}$ contain information on the scattering type mechanism. The target helicity $\tau_1$ is a measure of the target symmetry, i.e. $\tau_1 = 0$ for a symmetrical target. The target helicity $\tau_2$ contains information on the asymmetrical part of the scattering matrix, i.e. $\tau_2 = 0$ corresponds to $S_{\text{hv}} = S_{\text{vh}}$.

After having presented the implementation of the bistatic TSVM decomposition, some comparisons with the bistatic $\alpha/\beta$ model will be carried out. Next, a roll-invariant incoherent target decomposition (ICTD) inspired from Cloude-Pottier ICTD will be introduced for the bistatic case. As PolSAR images are corrupted by the speckle noise, incoherent target decomposition parameters can be biased. A study of the influence of the processing window size on the estimation of the bistatic TSVM parameters will be done to find the minimum window size required for a nearly unbiased parameter estimation. Finally, decomposition results will be shown on both synthetic and real PolSAR images.

PolSAR Speckle Filtering and Segmentation based on Binary Partition Tree Representation
Alonso-González, A.; López-Martínez, C.; Salembier, P.
Universitat Politècnica de Catalunya UPC, SPAIN

A new multi-scale PolSAR data filtering technique is presented, based on a Binary Partition Tree (BPT) representation of the image.

The BPT was introduced in [1] as a region-based and multi-scale image representation. It contains information about the image structure at different detail levels within a tree. Each node represents a region of the image. The tree leaves correspond to individual pixels of the image whereas the remaining nodes represent the merging of the two child regions. Consequently, the root node represents the whole image. From the leaves to the root, many regions with different sizes may be found. This tree structure contains a lot of information about the image structure that may be employed for PolSAR filtering, segmentation and for many other applications.

The tree structure can be constructed in an efficient manner by an iterative algorithm following a bottom-up approach [1]. As an initial state, every pixel conforms a single region and, iteratively, the two most similar regions are merged until a single region is achieved. To be able to employ this approach, two elements have to be defined: a region model and a similarity measure. As a region model the mean covariance matrix of the region pixels will be considered, assuming the complex Gaussian PolSAR scattering model. This option assures an unbiased estimation of the polarimetric information. For the similarity measures, several possibilities will be presented, analyzed and assessed.

As stated in [1], a tree pruning process may be performed to obtain a filtering or a segmentation over the image. For filtering applications, it may be useful to obtain large areas over homogeneous regions of the image and small regions for preserving point scatterers and small details. The multi-scale nature of the BPT may be exploited for this purpose. A homogeneity-based tree pruning process is proposed to obtain the largest homogeneous areas over the image. Applying the multi-look estimator within these regions, a better estimation of the polarimetric information may be achieved while preserving spatial resolution and small details. This technique conforms a non-linear speckle filter capable of high speckle noise reduction while preserving spatial resolution.

The proposed approach differs from [2][3] in the way the homogeneity is defined. The BPT pruning tries to identify homogeneous regions over the image, instead of homogeneous neighborhoods for each pixel, so it is a full region-based processing technique. Since this approach is a segmentation-based filtering also known as a connected operator [4], one pixel belongs only to one region. Additionally, it uses non-biased estimators over homogeneous regions, so the BPT pruning does not introduce any bias or distortion on the image and it also maintains the full polarimetric information.

In the final paper, the proposed BPT filtering approach will be evaluated with simulated PolSAR data, for a detailed quantitative evaluation, and with real data, for a qualitative evaluation. As it will be demonstrated, the BPT filtering technique is able to achieve very high speckle filtering without losing spatial resolution and preserving the small details of the image. It is important to highlight that the algorithm is sensitive to all the polarimetric information in the covariance matrix to obtain a filtered or segmented image. This is a crucial difference with respect to other state-of-the-art filtering approaches, as [2][3], where only radiometric or power elements are employed to adapt the filtering process.

As it shall be concluded and demonstrated, the BPT can be employed for PolSAR data processing as a region-based and multi-scale image representation, making possible the retrieval of useful information related to the image structure that may be successfully employed for speckle filtering, image segmentation, and many other applications.


***************

Notes: ...
Heterogeneous Clutter Model for high Resolution 
Polarimetric SAR Data Parameter Estimation 
Gabriel, Vasile\textsuperscript{1}; Pascal, Frédéric\textsuperscript{2}; Ovarlez, Jean-
Philippe\textsuperscript{3} 
\textsuperscript{1}GIPSA-lab / CNRS, FRANCE; \textsuperscript{2}SONDRA / SUPELEC, FRANCE; \textsuperscript{3}ONERA, FRANCE 

The recently launched polarimetric SAR (POL S\textsuperscript{4}) systems are now capable of producing high quality images of the Earth's surface with meter resolution. The goal of the estimation process is to derive the scene signature from the observed data set. In the case of spatially changing surfaces ("heterogeneous" or "textured" scenes) the first step is to define an appropriate model describing the dependency between the polarimetric signature and the observable as a function of the speckle. In general, the multiplicative model has been employed for POL S\textsuperscript{4} data processing as a product between the square root of a scalar positive quantity (texture) and the description of an equivalent homogeneous surface (speckle) \cite{1}. The objective of this paper is to present a new parameter estimation technique based on the Spherically Invariant Random Vectors (SIRV) model. It is important to notice that, in the SIRV definition \cite{2}, the PDF of the texture random variable is not explicitly specified. As a consequence, SIRVs describe a whole class of stochastic processes. This class includes the conventional clutter models having Gaussian, K-distributed, Chi, Rayleigh, Weibull, or Rician PDFs \cite{3}. For POL S\textsuperscript{4} data, the SIRV product model is the product of two separate random processes operating across two different statistical axes.  

1) The polarimetric diversity is modeled by a multidimensional Gaussian kernel characterized by its 
covariance matrix. 
2) The randomness of spatial variations in the radar backscattering from cell to cell is characterized by the 
texture. The corresponding random process operates along the spatial axis given by the image support. 
Relatively to the polarimetric axis, the texture random variable can be viewed as an unknown deterministic 
parameter from cell to cell. 

This paper presents a new estimation scheme for optimally deriving clutter parameters with high resolution POL S\textsuperscript{4} data. The heterogeneous clutter in POL S\textsuperscript{4} data was described by the Spherically Invariant Random Vectors model. Three parameters are introduced for the high resolution POL S\textsuperscript{4} data clutter: the span, the normalized texture and the speckle 
normalized covariance matrix. The asymptotic distribution of the novel span estimator is also investigated and a statistical test to detect SIRV homogeneous areas with respect to the Gaussian clutter is 
proposed. 
The method is tested with airborne high resolution POL S\textsuperscript{4} images provided by the ONERA RAMSES system. 

\cite{2}. Vasile G., Ovarlez J.-P., Pascal F., Tison C., Coherency matrix estimation of heterogeneous clutter in high-
\cite{3}. B. Picinbono, Spherically invariant and compound Gaussian stochastic processes, IEEE Transactions on 

************** 

Notes: ...
Contrast is a perceptual property that allows discrimination among different areas, being one of the most important features to be incorporated into segmentation and classification procedures. Such property is usually assumed as a single scalar measure, and it turns into a useful quantity when its statistical properties are known. When dealing with black-and-white images, contrast can be simply represented by the mean gray value. When available data are multispectral, different measures of intensity can be used, which may include additional descriptors of texture, for instance. Polarimetric data analysis poses the challenge of defining adequate measures of contrast among matrices of complex values, which can be conveniently modelled by the complex Wishart distribution (Conradsen et al. 2003). Previous studies (Goudail & RÃ©frÃ©gerier 2004) derived numerically the Bhattacharyya and Kullback-Leibler distances between regions described by the complex Gaussian distribution. This distribution is related to a particular case of the complex Wishart distribution. The two aforementioned distances are shown to perform appropriately as contrast measures; however no statistical analysis of property was derived. In this paper we derive analytical expressions for five distances between multilook complex Wishart distributions, namely the Bhattacharyya, the Kullback-Leibler, the RÃ©nyi (of order $\hat{R}$), the chi-squared, and the Hellinger distances. These distances are related to the class of $(h, i^f)$-divergences proposed by SalicrÃ³ et al. (1994) and, therefore, their asymptotic distributions are known (Nascimento et al. 2010). With such information, hypothesis tests are proposed for establishing whether two given samples are drawn from the same distribution. Finite samples properties of the proposed tests are assessed using Monte Carlo procedures. We show evidence that the test based on the Kullback-Leibler distance outperforms the other ones. Such results were obtained by measuring the test sizes and powers under several situations, which include "pure" and contaminated data (Allende et al. 2006, Bustos et al. 2002). The employed contamination model is a stochastic description of corner reflectors. The proposed methodology was also applied to actual data.

***************

Notes: ...
H/α Unsupervised Classification for highly textured Polinsar Images using Information Geometry of Covariance Matrices

Fortman, Pierre; Ovarlez, Jean-Philippe; Pascal, Frederic; Vasile, Gabriell; Ferro-Famil, Laurent

ONERA & SONDRA, FRANCE; SONDRA & ONERA, FRANCE; GIPSA Lab, FRANCE; IETR, FRANCE

The recently launched POLSAR systems are now capable of producing high quality polarimetric SAR images of the Earth surface under meter resolution. The additional polarimetric information allows the discrimination of different scattering mechanisms. In [1] was introduced the the entropy-alpha-anisotropy (H/α/A) classification based on the eigenvalues of the polarimetric (or coherency) covariance matrix (CM). This CM is usually estimated, under homogeneous and Gaussian assumptions, with the well known Sample Covariance Matrix (SCM) which is Wishart distributed. Based on this decomposition, the unsupervised classification of the SAR images can be performed by an iterative algorithm based on complex Wishart density function. It uses the H/α decomposition results to get an initial segmentation into eight clusters (or more), then the K-mean clustering is implemented by considering the polarimetric CM as the feature vectors. This technique needs however to derive by a classical Euclidian mean operation the averaged CM of each center of class and to compute by Wishart distance the minimal distance between each pixel CM and with all the centers of class.

The decrease of the resolution cell offers the opportunity to observe much thinner spatial features than the decametric resolution of the up-to-now available SAR images but also lead to more complicated effects like spatial heterogeneity, non Gaussianity. Hence, some areas (grass, trees, ...) usually considered as random backscattering mechanisms can become punctual deterministic backscattering mechanisms. The usual techniques of classification, detection, speckle filtering, used for decametric resolution have to be adapted to these new challenging problems.

For high resolution SAR images, recent studies have shown that the spatial heterogeneity of the observed scene leads to non-Gaussian clutter modelling. Some techniques have been recently proposed to handle such problem. One commonly used fully polarimetric non-Gaussian clutter model is the compound Gaussian model: the spatial heterogeneity of the SAR image intensity is taken into account by modelling the clutter information vector as a SIRV (Spherically Invariant Random Vector), i.e. the product between the square root of a scalar random variable (texture) and an independent, zero mean, complex circular Gaussian random vector (polarimetric speckle).

The aim of this paper is twofold. Firstly, we propose in this paper to briefly recall original results obtained recently in [2] for the joint Maximum Likelihood estimation of the texture and the polarimetric CM. These results, based on the Fixed Point CM estimate, allowed to derive a new distance for SIRV CM and to propose a new technique of speckle filtering (PWF) in heterogeneous environment. Secondly, we introduce a metric-based mean for the space of positive-definite Hermitian CM. An emerging theory [3, 4, 5] allows to take into account the fact that Euclidian space can not describe the space of positive-definite Hermitian CM. Rigorously, the averaged CM (SCM or Fixed Point) of a H/α/A cluster can not be computed with the Euclidean metric, i.e. usual arithmetic mean. It is well known that after few iterations of the unsupervised classification, all the centers of class move significantly within the H/α plane leading a more difficult physical interpretation to the final classification. The mean associated with the Riemannian metric corresponds to the geometric mean. We discuss the use of the Riemannian mean and we use differential geometric tools to give a characterization of this mean. We will show that the centers of class will remain more stable during the iteration process, leading to a different but more physical interpretation of the H/α/A classification. This technique can be applied both on classical SCM and on Fixed Point CM. Used jointly with the Fixed Point CM estimate, this technique can give nice results when dealing with high resolution and highly textured polarimetric SAR images classification.


****************

Notes: ...
Lossless $\Psi$-Invariant Decomposition of Deterministic Target

Paladini, Eng.; Ferrero Famili, Prof.; Pottier, Prof.

1University of Pisa - University of Rennes 1, ITALY;
2University of Rennes 1, FRANCE; 3University of Rennes, ITALY; 4University of Pisa, ITALY

Introduction - The radar target scattering matrix and the averaged coherency matrix, are the main mathematical tools useful for characterizing the scattering process. The classical theory developed for the analysis of radar signature is based on linear polarization measurements, whereas E. Kenough, J. R. Huynen, S. R. Cloude, E. Pottier, W. L. Cameron, R. Touzi, E. Krogager and others have shown that for obtaining a physical interpretation of the scattering mechanism the development of target decomposition theorems is necessary [1]. Target decomposition theorems are divided into two main families: the Coherent Target Decompositions (CTD) are applied to single observation scattering matrix and the Incoherent Target Decompositions (ITD) are applied to averaged measurements [2]. CTD is discussed in this paper, whereas generalization to ITD is discussed on the second part.

Methodology - In this paper, a new CTD based on right-right orthogonal circular polarization Special Unitary SU(2), basis is proposed. The proposed CTD is represented in target vector form to be applied for the recognition of deterministic target. The modulus of the proposed scattering vector is invariant to target shift exp(1j0) and orientation $\Psi$ about radar Line of Sight (LOS) being necessary and sufficient for representing all the degrees of freedom of the scattering matrix in a convenient way. The main advantage of the circular polarization analysis, proposed by S. H. Bickel and Corr-Rodriguez, is the easiest extraction of orientation $\Psi$ invariant parameters [4]-[5]. It is a well known fact on Modern Physics, that the elemental packets of energy exists only in the form of right and left polarization state, as reported also by S. R. Cloude in his PHD Thesis [6]. The analysis of the scattering matrix on circular polarization basis, characterize the scattering process as the coherent sum of the inter-action of elementary particles with matter. A six parameter model is proposed for describing the target: n, the vector norm, is the square root of the Span, $\sigma$ is the relative phase extracted from odd bounce component, $\Psi$ measures target orientation and has physical meaning for symmetric targets as the angle of maximum return on linear polarization basis [1, 3]. $\sigma$ is identical to Cloude-Pottier alpha $\alpha_1$ scattering type. Two new target characteristic parameters EI, Ch are also introduced in order to better exploit the target shape parameters that are contained in the circular polarization scattering matrix. The Elicity EI is the normalized difference between the two like circular polarization responses (the sign represents the wound). Ch for symmetric-zero oriented targets is the phase difference between the like and the cross circular polarizations and is well suited in order to discriminate for a $\sigma = \pi/4$, between anisotropic scatterers like thin wires and quarter wave devices. In other words Ch has the same role of the imaginary part of Cameron z parameter [1]. Through the paper a comparison between existing CTD theorem is also detailed pointing out the advantages of the proposed method.

Conclusion - A different approach for the decomposition of the radar scattering matrix has been formulated, by the use of SU(2) circular polarization basis. The proposed scattering vector parameters have been divided into two groups, $\sigma$ - Ch - EI are three characteristic (shape) parameters both with n are invariant. For symmetric targets, EI=0, our characteristic parameters $\sigma$, Ch and Cameron z has shown a relationship of equivalence. For not-symmetric targets the Cameron decomposition provides a proliferation of parameters, whereas in our case the decomposition is lossless. Finally, we have proposed the EI, or equivalently its square, the main parameter for assessing target elicity, following the same point of view of Huynen [3].

REFERENCES

Notes: ...
A review of new results on estimation of statistical parameters describing polarimetric synthetic aperture radar (PolSAR) data is presented. Estimators with superior bias and variance have emerged in the recent literature, with the common feature that they are based on a logarithmic transformation of the data. The equivalent number of looks and the shape parameter(s) of compound distributions that incorporate texture (such as the K distribution) are estimated from matrix log-cumulants based on Mellin transform theory (Anfinsen, 2010). Estimates of the polarimetric covariance matrix and its eigenvalues can be produced in log-Euclidean matrix space (Arsigny et al., 2005) by virtue of the matrix logarithm. This latter result has not been utilised before in the context of PolSAR data analysis.

The use of the logarithm has long traditions in analysis of radar data. Amplitude and radar data are conventionally visualised on logarithmic scale to improve the dynamic range, and homomorphic speckle filter use the logarithm to transform the product model into an additive one. The use of logarithmic transformation in estimation of distribution parameters was initiated by Nicolas (Nicolas, 2002) and extended to PolSAR data in (Anfinsen, 2010), both stressing that logarithmic space is the natural domain for radar data analysis. An intuitive explanation is given, highlighting that the logarithmic transformation makes the random variates of radar data easier to estimate, by making their distribution less asymmetric and more Gaussian-like. The improved estimability can be proven with formal estimation theory in terms of Fisher information and variance bounds.

Day 3 - Wednesday 26 January

Session: Applications on Ocean/Cryosphere & Hazards
It has been shown that snow cover acts as an insulator that keeps permafrost temperatures relatively warm during the winter [1]. This can have a noticeable impact on permafrost thawing process by increasing summer thaw depths. Knowledge of the spatial distribution of snow characteristics can therefore help the understanding of permafrost melting patterns in a context of changing arctic and subarctic climate.

This study evaluates the potential of C-band polarimetric Synthetic Aperture Radar (SAR) data to estimate Snow Water Equivalent (SWE) spatial distribution of a dry snowpack in subarctic environment. RADARSAT-2 fully polarimetric scenes were acquired during the 2010 winter over the Umbujuq community (56.55° N, 76.55° W) in northern Quebec, Canada. The area can be divided into two distinct environments: the coastal region to the east and the Lacs Guillaume-Delisle graben to the west. The vegetation in the coastal region is very sporadic and dominated by shrubs, while the graben vegetation is mainly scrublands with patches of conifers. Two field campaigns were carried out in coordination with RADARSAT-2 data acquisitions in March and May 2010, which correspond to the end of the accumulation period and the melting period respectively. Due to exceptionally warm weather conditions during the 2010 winter, most of the snowcover was melted in May. Snow depth, density and SWE as well as ground temperatures were measured over various terrain types. Snowpits were dug at selected sites to gather information on particle size and shape in addition to snow densities from the different layers of the snowpack. Land cover and soil characteristics maps are used to provide information on surface characteristics.

Two well-known polarimetric decomposition methods, Cloude-Pottier [2] and Freeman-Durden [3], are applied to the data to retrieve information on the scattering mechanisms involved. Polarimetric signatures of the snowpit sites are analyzed for the winter and snowless conditions to make a first assessment of the effect of dry snowcover on the polarimetric signal. The information derived from the decomposition parameters, such as Entropy (H), Alpha angle (α) or the Power of volume scattering (P_v) are then compared to snow cover properties in relation with land cover and soil characteristics. It has been observed that a number of decomposition parameters bear some correlation with snow characteristics. However, to fully explain the variability exhibited by these parameters, land cover and soil characteristics need to be taken into account during the analysis, pointing towards a land cover based approach to evaluate SWE from polarimetric data. The polarimetric approach is compared with a monopolarized (HH) approach implemented in the EQeau model developed at INRS-ETE [4]. The EQeau model uses backscattering ratios between a winter and a snow free image combined with snow density ground measurements to infer SWE indirectly.

References:

***************

Notes: ...
Ship Detection in Variable Sea States and Depolarised Sea Clutter: a Polarimetric Notch Filter

Marino, A¹; Walker, N²

¹The University of Edinburgh, UNITED KINGDOM;
²eOsphere, UNITED KINGDOM

The subject of vessel detection is a key component of maritime security systems, which is an application of growing importance. Synthetic Aperture Radar (SAR) can offer a number of key benefits for vessel detection because of its all weather and night capabilities and by exploiting the polarimetric modes of the new generation of satellite sensors. A key aim is to extend the range of vessel types and sizes that are detectable for a wide range of sea states.

The authors have previously developed a ship detection methodology making novel use of the polarimetric representation of targets (i.e. a vector in a 6-dimensional complex space) [1]. This algorithm is based on a perturbation analysis in the target space, which was originally developed for land based target detection [2]. The vessel detection algorithm can be considered to be a negative filter focused on sea. Consequently, all the features which have a polarimetric behaviour different from the sea are detected and considered as targets. An interesting advantage of the new 6 dimensional space is that any depolarised target has a unique characterisation. This allows the algorithm to set the notch over targets with any degree of polarisation. In the context of ship detection, it is important to be able to characterise depolarised targets since for high sea states the ocean surface can manifest low degree of polarisation (high entropy).

The aim of this paper is to show through analytical demonstrations, simulations and real data that the proposed methodology is able to detect targets in any sea state. Results are provided using RadarSat-2 Fine Quad-Pol mode scenes which were acquired off the south coast of the UK at Portsmouth harbour. An extensive ground truth campaign was also conducted that was coincident with these acquisitions which captured a large number of vessels having a range of different sizes.


***************
The new generation of high resolution (HR) Polarimetric SAR (PolSAR) sensors are able to produce high quality fully polarimetric images of the Earth's surface. As the number of scatterers per resolution cell decreases, heterogeneous clutter models should be used to extract information. In this context, Spherically Invariant Random Vector (SIRV) have been introduced. The PolSAR target vector \( \mathbf{k} \) can be rewritten as the product between the square root of a positive random variable \( \tau \) (representing the texture) and an independent circular complex Gaussian vector \( \mathbf{z} \) with zero mean and covariance matrix \( \mathbf{M} = \mathbb{E} \{ \mathbf{z} \mathbf{z}^* \} \) (representing the speckle):

\[
\mathbf{k} = \sqrt{\tau} \mathbf{z}.
\]

In this context of heterogeneous clutter, a new multivariate shift estimator based on both the texture \( \tau \) and the covariance matrix \( \mathbf{M} \) has been developed. The proposed approach generalizes and extends the Gamma PDF shift estimator introduced by Erten et al. in [1]. The Fisher PDF is introduced to model the texture parameter \( \tau \) and has been validated [2].

Each step of the general method of Maximum Likelihood (ML) shift estimation tracking is firstly described. As the definition of a similarity criterion is the core of the algorithm, it is of great importance to derive a criterion which is sensitive to changes in the images. In the context of HR, statistical based criteria are well suited to detect such variation. The ratio of two Fisher distributed texture parameters \( \tau \) and the ratio of two Gaussian vectors \( \mathbf{z} \) have been derived and included in the usual tracking method scheme. Authors highlight the improvement due to the use of both texture and speckle terms issued from the SIRV decomposition. Hence, the shift estimator is more relevant and fully exploits the information of the heterogeneous clutter.

The second part of this paper is focused on polarimetric data fusion. As both quad-pol Radarsat-2 and dual-pol TerraSAR-X HR data are available, authors propose to highlight the complementarity of these two kind of signal by merging them. A Digital Elevation Model is used to combine both shift estimators in one by summing each ML. The ML based criteria are hence more robust as it sums more samples based on various probability density functions. It enhances the robustness of the method while preserving the sensitivity. Displacement results on synthetic and real images are presented. Real experiments have been proceeded on geophysical objects. Specifically, the method is used in glaciers surface displacement estimation. The Argentière glacier test site in the Mont Blanc massif has been used to validate the method with ground truth using continuous GPS measurements.

REFERENCES:

This work was supported by the French ANR program ERIDIR.

Notes: ...
Physical Significance of Radar Texture in Sea Ice Studies

Moen, Mari-Ann Norum¹; Afninessen, Stian Normann¹; Doulgeris, Anthony¹; Gerland, Sebastian²; Eltoft, Torbjørn²

¹University of Tromsø, NORWAY; ²Norwegian Polar Institute, NORWAY

The objective of this paper is to investigate the physical significance of non-Gaussian scattering vector statistics in polarimetric radar scenes of sea ice. The study is based on clustering of image data using a recently developed algorithm, statistical properties of the backscattered signals and physical information about the scattering mechanisms inferred from polarimetric decompositions and ground truth data from field measurements.

We have available an ALOS/PALSAR quad-pol scene over the north-west coast of Svalbard from April 2009, and several Radarsat2 quad-pol scenes over the high arctic ocean from August/September 2010. Classifications are performed with a non-Gaussian K-Wishart clustering algorithm, which is an extension of the Gaussian based Wishart clustering algorithm that accounts for potential textural differences in the classes [1]. This non-Gaussian K-Wishart algorithm automatically identifies the number of classes that are statistically distinct from each other by goodness of fit tests [2]. Each class has been plotted in a log-cumulant diagram to view its goodness of fit to the K-Wishart model and justify the use of the mentioned K-Wishart model. The log-cumulant diagrams verify that the sea ice classes have non-Gaussian statistics, and for many classes (not all) the K-Wishart model seems to be an appropriate model.

For the ALOS scene we do not have ground truth from field measurements, and the classes are visually interpreted by sea ice experts to obtain their physical interpretation. For the Radarsat2 scenes we have ground measurements of sea ice thickness, optical images, and roughness measurements. These ground truth measurements are extended by polarimetric decompositions, obtained from PolSARpro.

Our preliminary analysis indicates that the entropy-alpha decomposition has limited discrimination ability on sea ice. All our sea ice classes appear to be dominated by surface scattering mechanisms. The statistical texture information significantly increase the overall classification power. Understanding how statistical properties of the polarimetric measurements relate to physical properties of the sea ice surface can enable development of robust sea ice clustering algorithms and model analysis which in turn can generate consistent high-resolution sea ice maps.

****************
River ice affects natural processes and human activities and therefore represents a significant component of the environment in northern countries like Canada. Information on river ice cover supports science, engineering and management activities including: hydraulic modelling, break-up forecasting, ice road routing, industrial water intake / discharge, hazard management, and wildlife management. SAR satellites such as RADARSAT-2 make potentially outstanding tools for collecting up to date information on river ice thanks to their capability to routinely and systematically image extended remote areas independent of weather and daylight conditions. Compared to non-polarimetric SAR systems, polarimetric SAR systems typically offer more potential for the characterization of features observed thanks to an increased sensitivity to physical structure. In the context of river ice, this strength of radar polarimetry is most advantageous when the images are acquired under mid-winter conditions, that is, when the ice is frozen solid and therefore allows radar waves to penetrate and interact with features that define its internal structure.

In this presentation we will discuss the potential of RADARSAT-2 polarimetric image products for: (a) the detection of the onset of freeze-up, (b) the mapping of river ice characteristics, and (c) the monitoring of change in river ice characteristics over the winter season. The area of interest is the Mackenzie River at Inuvik, Northwest territories, Canada. During the 2008 and 2009 freeze-up seasons RADARSAT-2 was tasked to acquire a time series of polarimetric images over the study area. In addition, ground reference data were collected to facilitate the analysis of the acquired radar images. Results achieved to date have demonstrated that linearly polarized RADARSAT-2 images, HV images in particular, show considerable potential for the mapping of the onset of freeze-up and ice cover types as well as for the monitoring of the thickening of ice over the winter season. While linearly polarized radar signals show sensitivity to ice growth, their potential for application to the mapping of ice thickness is hampered by the dominating effect of ice structure on radar backscatter. In other words, two ice covers of equal thickness but differing structure will create different radar return signals. This presentation will expand on earlier results by reporting on the results of an evaluation of the information content associated with RADARSAT-2 derived polarimetric variables.

************
Cosmo SkyMed Multi-Polarization SAR Data for Vessels Observation

Nunziata, Ferdinando; Migliaccio, Maurizio; Montuori, Antonio
Università di Napoli Parthenope, ITALY

Ship detection and identification have many potential applications within the commercial, fisheries, vessel traffic service and military sectors [1]. Synthetic Aperture Radar (SAR), due to its fine spatial resolution, together with its all-weather day and night capabilities, is the most important remote sensing tool for a synoptic ship observation.

For target detection, the target must be distinguished from the clutter background. Dealing with ship detection, the target is a ship, and the clutter background is the sea surface backscattering. Ship detection is a very complex target detection problem, which can hardly be optimized with conventional single-polarization SARs. Nowadays, the importance of the transmit-receive antenna polarizations on ship detectability is well-understood. For low incidence angle, better ship-sea contrast is achieved by using the HV channel. However, at near-grazing angle, the HH channel is to be preferred. On the other hand, the VV channel, which is more suitable for sea surface characterization, is responsible for the lowest ship-sea contrast.

Cosmo SkyMed, a constellation of 4 satellites (3 out of 4 are operational) equipped with X-band SARs able to operate in different modes and with polarization selectable among HH, HV, VH, VV (or dual-pol in Ping Pong mode), is very much interesting in vessels observation since it ensures both a wide area coverage and a small revisit time. However, the X-band peculiarities make vessels observation a very non-trivial task, hence special attention should be paid when dealing with full-resolution, i.e. speckled SAR data. The latter, on one hand are to be preferred for vessels observation since they ensure the best achievable spatial resolution, on the other hand they are difficult to be interpreted since they are affected by speckle, a multiplicative noise. A trade-off is commonly reached in classical vessels observation techniques, where speckle reduction is accomplished at the expense of spatial resolution. In this study, following the theoretical background developed in [1]-[2], the capabilities of Cosmo SkyMed full-resolution SAR data are analyzed for vessels observation purposes. A data set which consists of Spotlight, ScanSAR and Ping Pong Cosmo SkyMed full-resolution SAR data, gathered in Gulf of Naples and Gulf of Mexico, is considered.

The physically-based and computer-time approaches developed in [1]-[2] are specialized for the X-band Cosmo SkyMed SAR data and applied to data gathered in different polarizations. First results show the effectiveness of the proposed approaches and the important role played by Cosmo SkyMed in such an application.

References


***************

Notes: ...
UAVSAR L-band Polarimetric Data to analyze BP Oil Spill
Migliaccio, Maurizio; Nunziata, Ferdinando; Holt, Benjamin

1Università di Napoli Parthenope, ITALY; 2Jet Propulsion Laboratory, California Institute of Technology, UNITED STATES

The British Petroleum (BP) disaster in the Gulf of Mexico is by far the worst oil disaster in U.S. history (over 200 million gallons). It spewed as much oil in just days as the entire Exxon Valdez spill and eclipsed the notorious Ixtoc blowout in the Gulf of Mexico in 1979, which leaked 138 million gallons of crude.

Surface oil slicks and sheens believed to be associated with the BP spill have affected thousands of square miles, with oil and tar reaching the shores of Louisiana, Mississippi, Alabama and Florida. In a desperate attempt to keep the visible surface slick in check, BP flooded the ocean’s surface and depths with nearly 2 million gallons of chemical "dispersants". These chemicals bind with oil droplets so that they become "dispersed" by currents. Scientists believe that BP’s excessive use of dispersants may have contributed significantly to the enormous underwater oil plumes that remain in the Gulf, one of which was 22 miles long and six miles wide.

The BP disaster has been monitored from space by using different remote sensing technologies; among these, Synthetic Aperture Radar (SAR), a microwave high-resolution imaging radar, which played a fundamental role in identifying the extent of the oil, due to its capability to observe both day and night time and almost independently of weather conditions. To achieve as much as possible information on the polluted area, together with classical single-polarization SAR data, polarimetric SAR data has been gathered by different operational SAR missions, e.g. C-band RADARSAT-2, L-band ALOS PALSAR, X-band Cosmo SkyMed and X-band TerraSAR-X. Moreover, ad hoc flights have been accomplished by using the NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR), a L-band polarimetric SAR, which flew over the Gulf of Mexico to image the Deepwater Horizon oil spill on June 22-23, 2010. The airborne radar, built and managed by NASA’s Jet Propulsion Laboratory, Pasadena, Calif., currently flies aboard NASA’s Gulfstream-III aircraft that is based at NASA’s Dryden Flight Research Center, Edwards, Calif. UAVSAR is able to gather either polarimetric or interferometric SAR data. Polarimetric data are freely available, in both Single Look Complex (SLC) (Calibrated single look complex files for each polarization (HH, HV, VH, and VV)) and Multi Look Complex (MLC) (Calibrated multi-looked cross products) products, through the Alaska Satellite Facility (ASF).

In this study, UAVSAR polarimetric L-band SAR data are processed for oil spill observation purposes. In detail, dual- and quad-polarimetric analyses are undertaken: the former one is based on the use of the phase difference between the co-polarized channels (CPD) which has been demonstrated in [1] to be able to distinguish oil from the surrounding sea and from other weak-damping look-alikes. Moreover, the sensitivity of CPD with respect to the departure from Bragg scattering, a phenomenon which occurs when an oil slick is present over the sea surface [1], will be firstly exploited to analyze the damping properties of the spilled oil. In particular, the spatial variation of oil damping properties within the polluted area will be analyzed. This can be very interesting to indirectly provide information about the thickness of the oil layer and on ongoing aging and/or mixing phenomena. With respect to the quad-polarimetric approach, the co- and cross-polarimetric signature, i.e. a 3D view of the received power for co- and cross-polarized transmitting and receiving antenna polarization will be analyzed to infer information about the polluted area. In particular, the pedestal height, i.e. the pedestal on which the polarization signature is set, which has been shown in [2] to be able to carry information about the presence of surfactants characterized by different damping properties, is also exploited. Along with this rationale, the polarimetric analyses will be compared with ancillary information coming from a chemical-oceanographic analysis as well as additional and independent aircraft observations, to highlight aging-mixing effects.

References

***************

Notes: ...
A Multi-Frequency Polarimetric SAR Processing Chain to observe Oil Fields in Gulf of Mexico

Montuori, Antonio¹; Nunziata, Ferdinando¹; Migliaccio, Maurizio¹; Li, Xiaofeng²; Pichel, William²

¹Università di Napoli Parthenope, ITALY; ²IMSG at NOAA/NESDIS, UNITED STATES; ³NOAA/NESDIS/STAR, UNITED STATES

Gulf of Mexico is one of the largest gulf in the world, located at the south of USA and the north of Mexico. There are thousands of oil and gas rigs a few miles away from the coast running from Texas to Louisiana, until the State of Mississippi, and last estimation indicate more than 5500 structures producing the 30% of oil and the 15% of gas of the overall United States consumption. However, these oil rigs pose an important environmental risk in case of accidents, e.g. the recent Deepwater Horizon oil spill, a massive ongoing oil spill, now considered the largest offshore spill in U.S. History. Moreover, the Gulf of Mexico is famous because of the high risk of hurricanes, and, in fact, its warm water temperatures can cause hurricanes which may generate dramatic casualties in the area as in the Hurricane Katrina in 2005. During such events even these infrastructures such as oil rigs, in some cases, can be totally wrecked, generating oil pollution at sea. National Oceanic and Atmospheric Administration (NOAA) is interested in knowing real time oil rigs positions, in order to monitor damages and to verify related oil spills at sea. In fact, environmental damages caused by the destruction of an oil rig are invaluable, because of the oil spill - and further spreading - determined by winds, covering a very large area in just a few days. Within this context, space-borne-based Synthetic Aperture Radar (SAR) can offer wide area surveillance coverage day and night, independent of cloud cover and weather conditions. The system can detect oil rigs/ships and pollutants such as crude-oil emulsions from leaking ships or drilling fluids from offshore oil rigs. However, SAR oil and oil rigs/ship detection it is not an easy task since full-resolution SAR images, which are to be preferred to detect small features, are affected by speckle (a multiplicative noise which hampers image interpretation) and since other phenomena may generate false targets (look-aliases) in SAR images, i.e. natural floating films... in case of oil observation or breaking waves... in case of ship observation. Accordingly, tailored filtering techniques must be developed in order to minimize the number of false alarms. Within this context in this study an innovative electromagnetically-based processing chain, able to operate on both L- and C-band quad-pol SAR data, is proposed to observe both oil spills and man-made metallic targets, i.e. oil rigs and ships. With respect to oil spill observation, the proposed approach is based on the different scattering mechanisms which are in place when dealing with slick-free or weak-damping slick-covered sea surface and oil-covered sea surface, respectively. The former case is well-described by Bragg or tilted-Bragg scattering which calls for an high correlation between the co-polarized scattering amplitudes. When an oil slick is present over the sea surface, due to its strong damping properties, a non-Bragg scattering is in place which calls for a low correlation between the co-polarized channels. As a matter of fact, a physically-based approach has been developed to distinguish oil from sea and weak-damping look-aliases which is based on the standard deviation of the co-polarized phase difference (CPD), which is a non-biased estimator of the correlation between the co-polarized channels [1]-[2]. With respect to man-made metallic targets observation, the proposed approach is based on the different symmetry properties which characterize sea surface and metallic targets over the sea. The former is a reflection-symmetric natural distributed target, while the latter ones do not belong to this class. As a matter of fact, their different symmetry properties are read in terms of scattering mechanism through the Stokes formalism. Following this rationale, a compact parameter, i.e. the correlation between the co- and cross-polarized channels, has been considered to distinguish the two scenarios [3]. These physically-based electromagnetic approaches have been considered to develop a processing chain which, operating on full-polarimetric SAR data, is able to produce logical true and false outputs where both oils and man-made metallic targets are detected. Experiments undertaken on L-band ALOS-PALSAR and C-band RADARSAT-2 full-polarimetric SAR data gathered in Gulf of Mexico and related to the Deepwater horizon accident confirm the effectiveness of the proposed approach which is both computer-time effective and operationally interesting. In fact, the proposed approach, being able to process both L- and C-band polSAR data, can take benefit of both ALOS-PALSAR and RADARSAT-2 quad-pol SARs and, therefore is able to enhance the revisit-time and coverage which are very critical issues in oil field observation.

**************

Notes: ...
Day 4 - Thursday 27 January

Session: Applications on Forest
Relating Biophysical Properties of Secondary Succession in Eastern Amazon using ALOS/PALSAR Data
Liesenber, Veraldo; Gloaguen, Richard; Heilmeier, Hermann
TU Bergakademie Freiberg, GERMANY

Full Polarimetric and Interferometric ALOS/PALSAR data acquired in 2009 were analyzed for preliminary biophysical parameters assessment. Hyperspectral data from Hyperion (EO-1) and high spatial resolution data from SPOT-5 acquired close to the SAR images under a clear sky condition were used as reference. The study area is located inside the Tapajós National Forest (Pará State, Brazil). It is a typical Amazon landscape site where shifting agriculture practices are common. The classes under study were primary forest, forest with timber exploitation and under recovery after fire events and secondary successions (early, intermediate and advanced). Physiognomic-structural information were collected during forest inventories in this area in 2009 [e.g. tree height, above ground biomass (AGB), leaf area index (LAI), canopy cover fraction (CC), etc.]. SAR polarization images were extracted from Single Look Complex data and converted to backscattering values. We also apply texture analysis for each dataset and we explore both polarimetric and interferometric information for the description of the SAR data. Various windows sizes and filters were tried to minimize the speckles and evaluated for the biophysical parameters modeling. The combination with optical data (e.g. Hyperion and SPOT-5) in the biophysical parameters retrieval was also experimented. In this study, we apply both linear regression and neural network to assess the retrieval of the forest parameters by varying the input data (e.g. backscattering data only, adding texture, Pauli decomposition, etc) for each biophysical parameter (e.g. AGB, LAI). Preliminary results showed that the distribution of the classes under study in the temporal bi-dimensional space (i.e. H and alpha) was more frequent in the zones 4, 5 and 6 and this input data only did not improve significantly the modeling of the selected biophysical properties. Compared to linear regression, neural networks showed some improvement in the retrieval of the biophysical parameters indicated by the coefficient of determination. In general, the HV polarization alone showed better relationship than the remaining polarizations. The integration with hyperspectral data give us the better results and explained better the above ground biomass variation collected in the field measurements (from 20 to 400 Mg/ha). We also want to demonstrate the potential of temporal decorrelation for the biophysical parameters assessment.

**************

Notes: ...
A Comparison Study of Biomass Estimation Using ALOS PALSAR and LiDAR Data
Tan, Chue Poh\(^1\); Marino, Armando\(^2\); Woodhouse, Iain\(^1\);
Cloude, Shane\(^3\); Suarez, Juan\(^3\); Edwards, Colin\(^3\)
\(^1\)University of Edinburgh, UNITED KINGDOM; \(^2\)AEL Consultants, UNITED KINGDOM; \(^3\)Forestry Commission UK, UNITED KINGDOM

In this paper, biomass estimations are compared using quadpol ALOS PALSAR and LiDAR data over Glen Affric, Scotland. Biomass was retrieved from the PolSAR data using Freeman-Durden decomposition model to obtain useful information about the scattering mechanisms, and then applying the method of Cloude[1] to establish an estimate of above ground biomass. Since the study site is a mountainous region, the terrain slope effects need to be addressed towards the generalization of biomass estimation. This is done with the slope compensation procedure before retrieving the biomass. For LiDAR, the vertical structure of both the underlying topography and the forest structure were generated to estimate the biomass allometrically. Validation on the results of the biomass estimation was done by comparing the biomass estimated using ALOS PALSAR and LiDAR. The results suggest that in some areas the biomass retrievals are broadly comparable. In areas of sloping terrain the PoISAR data overestimates biomass. In full cover forests, the volume contribution is overestimated when the number density is high, but the total biomass is low. The high resolution LiDAR data allows detailed investigation into the relationship between height, number density and biomass at the stand level. These results give some indication of when to use stand height or PoISAR to retrieve forest biomass. [1]Cloude, S. R., Viergever, K, Woodhouse, I and Suarez, J., "Mapping Scotland with PALSAR: An Assessment of the importance of L-Band Polariometry," ESA workshops: ALOS 2008, 2008.

***************

Notes: ...
Considering the global warming and a future Post-Kyoto mitigation mechanism, critical information is needed to facilitate forest carbon stocks estimation. In this context, remote sensing is a valuable tool allowing repetitive observations over wide forested areas. Particularly, SAR data allow for the monitoring of tropical regions characterized by quasi-permanent cloud cover limiting optical observations. Past study have shown that radar polarimetry is especially well suited for the discrimination between different tropical forest types [2]. However, such sensors require the alternating transmission of two orthogonal polarizations, leading to halve the swath, and consequently to double the revisiting time by comparison to Dual Polarimetric mode (DP). By contrast, DP mode, like hh/hv available with PALSAR, loose a part, that may be significant, of the fully polarimetric information [3]. On the other hand, a interesting partial polarimetric mode, i.e. the Compact Polarimetric mode (CP) [4] consists in the transmission of one circular polarization (left or right) and the reception along two orthogonal polarizations. This polarimetric configuration appears to give a good compromise between system constraints and the preservation of polarimetric information, particularly for surfaces for which reflection symmetry properties are verified [1]. The goal of this work is to show the influence of reflection symmetry properties for tropical forest classification for different polarimetric modes (fully and dual) in case of different dataset and study case. In particular, the reflection symmetry assumption may not be verified due to spatial heterogeneity. In order to point out the reflection symmetry influence, we compare results of the commonly used Wishart classification method to the Support Vector Machine (SVM) algorithm. Indeed, the Wishart classifier is based on the assumption that study area is highly homogeneous whereas the Support Vector Machine algorithm does not take into account any statistical assumption.  

3 different tropical areas have been studied, : 2 natural sites located in French Polynesia and French Guyana, and one plantation located in Brazil. These sites are characterized by different landscape and strata in term of composition and size. Moreover, ground truth data are available for each of these sites, allowing for the validation of the results. It shown that the reflection symmetry assumption may not be verified due to spatial heterogeneity associated to the definition of the different classes. Thus, the DP modes loss more important polarimetric when the reflection symmetry is not verified [4]. Even if the choice of the DP modes is strongly dependant of the study site, the CP mode have shown, in all the study-cases, equivalent or better overall accuracy than the other DP modes, particularly when the study area are very homogeneous. Furthermore, the FP mode shows the best results, particularly better than other DP modes when the area is strongly heterogeneous and don’t show reflection symmetry.

References

Notes: ...
A Hybrid Model for Extended Covariance Matrix Prediction for Forest Imaging in P-band Synthetic Aperture Radar

Soja, Maciej J.1; Ulander, Lars M. H.2
1Chalmers University of Technology, SWEDEN; 2Swedish Defence Research Agency (FOI), SWEDEN

In view of the proposed ESA Earth Explorer BIOMASS mission, a polarimetric interferometric forward model and scene generator for P-band forest imaging is being developed. The first part of this text deals with different parts of that model. In the second part of the text, the model is tested and evaluated in some scenarios resembling of the proposed BIOMASS satellite.

The model requires input parameters such as radar system setup (center frequency, altitude, baselines, incident angles), biogeophysical forest parameters (forest height and/or biomass, ground slope, ground height, and biome), and some internal model parameters, and it returns three matrices that together build the extended covariance matrix.

The extended covariance matrix can be seen as an element-wise product of the coherency matrix L and the intensity matrix I. The coherency matrix can be further divided into four 3x3 matrices, of which only two need to be simulated: the polarimetric matrix T and the polarimetric interferometric matrix \( \Omega \). T describes the correlation between two polarization channels with the same geometry, and it is assumed to be equal for both master and slave geometry. \( \Omega \) describes the correlation between two polarization channels and two different geometries. The intensity matrix can, after the simplification of equal radar backscatter at both ends of the baseline, be divided into four 3x3 matrices called I. Each element of that matrix can then be re-written in terms of radar backscatter gamma nought.

The polarimetric matrix T is modeled as a sum of three components corresponding to volume, surface, and double-bounce scattering, in accordance with the decomposition theorems. The polarimetric matrix \( \Omega \) is connected to the polarimetric interferometric matrix \( \Omega \) by the ground-to-volume scattering ratios.

The polarimetric interferometric matrix \( \Omega \) is modeled by the Random Volume over Ground (RVoG) model (Papathanassiou & Cloude, 2001). The model predicts correlation between two images of a volume of randomly located and oriented scatterers above a coherently scattering ground. Even though RVoG does not have an explicit polarization dependence, different polarization channels can be simulated by different ratios of ground and volume scattering.

The intensity matrix I is modeled using regression of BioSAR (Hajnsek et al, 2008, 2009) and in the future also TropiSAR data. Presently, a simple, two-parameter model is used. The model assumes that the radar backscatter gamma nought in dB (which includes some topography compensation) is a linear function of the logarithm of biomass. The parameter variability is modeled according to the results from experimental data.

The implemented forward model is used together with lidar-based digital canopy and elevation models (DCM and DEM) over Remningstorp, Sweden, to simulate the elements of the extended covariance matrix (with system setup as close as possible to the proposed P-band SAR satellite BIOMASS). The created images are compared with airborne SAR data obtained by the ESAR system within the earlier mentioned BioSAR project. The influence of the biomass and tree height on the covariance matrix is examined carefully. Model sensitivity to uncertainties in some model parameters (such as extinction coefficient and ground-to-volume ratios in RVoG) is also evaluated.

References:

***************

Notes: ...
The retrieval of forest biomass from P-band SAR data has been relied originally on the relationship between biomass and the cross polarized SAR intensity (HV or VH). The relative generality of such relation observed on various datasets has been explained by the dominant volume scattering mechanism, making the HV intensity much less affected by the ground conditions. The first limitation of the inversion approach based on HV intensity is the limited sensitivity of the HV to biomass at high values of biomass (> 200 t/ha). To retrieve biomass in this case requires intensity measurements with a very high radiometric accuracy (high system accuracy, reduced speckle noise by increasing the number of Equivalent Number of Look from filtering and spatial averaging). The other improvement concerns the method of incidence angle normalization. When dealing with airborne data, the radar backscattering coefficient is usually normalized to account for the angular variation of the intensity. The normalization approach considers the projection onto the ground of the radar slant resolution cell. Besides, assuming a diffuse volume backscattering, the Lambertian hypothesis can be reasonably used to correct for the solid angle variation with incidence. It is understood that the method assumes that the scattering volume is delineated by the ground surface.

The purpose of this paper is to reconsider the normalization method in case of dense forest media. It can be demonstrated that when the scattering volume is limited by the penetration depth of the waves (when the underlying ground cannot be reached) the usual normalization does not hold. A new volume normalization approach needs to be introduced. From geometrical considerations of the scattering volume limited by the penetration length, an additional factor (cosine of the incident angle) has been introduced. We refer to as 'alpha' the resulting new backscattering coefficient.

To support these theoretical development, P-band SAR data from the TropiSAR airborne campaign have been analyzed. The images have a wide range of incident angle (25-60°) and the forest biomass can reach 500 t/ha. We assume the existence of the two cases in this dataset: limited penetration (e.g. dense forest at high incidence) and penetration until the ground.

In the first step, our approach is to segment the images to distinguish the two above mentioned cases. For that, we assess existing Pol-InSAR classifiers and from knowledge obtained with electromagnetic simulations, we develop new indicators more adapted to the delineation of the scattering volume. In the second step, the segmented images are normalized using the appropriate normalization factor. The results show significant improvement of the inversion results using the two step normalization.

***************

Notes: ...
Forest Biomass Estimates from an Airborne Single-Pass L-Band Pol-Insar System
Mercer, B. ; Zhang, Q. ; Schwaebisch, M. ; Denbina, M.
Intermap Technologies Corporation, CANADA;
Intermap Technologies Corporation, GERMANY

There is considerable interest, driven by climate-change concerns, in the CO2 emissions caused by the loss of biomass as a direct consequence of forest destruction. In this paper we describe the biomass results obtained from tree height allometry using an experimental airborne L-Band, fully polarimetric, single-pass InSAR system over a test area in Alberta, Canada. The significance of the single-pass characteristic is that temporal decorrelation is avoided, allowing more robust Pol-InSAR forest parameter recovery. Tree height results using this system have been published previously (Mercer, et. al., 2009) and it is the objective of this work to examine the corresponding biomass estimates obtained from the allometric approach.

Canopy heights in stands of lodgepole pine, with tree heights ranging from 15-30 meters, were extracted using single-pass L-Band Pol-InSAR, and relative to lidar-derived canopy heights, showed accuracies better than 10%. A forest biomass map was then created through height-biomass allometry. Lacking suitable ground truth data for regression analysis, the two-parameter biomass/height allometric equation used, was that published by Mette, et.al. (2003, 2004) for a group of European coniferous tree species but applied to the tree heights obtained in the current work. The results are shown to be consistent with generalised biomass maps of lodgepole pine stands in Alberta (Monserud, et.al. (2006)). These coarse-resolution maps indicated that biomass density in the general area of our test area ranges from 100 to 300 tonnes/ha while the mean L-Band biomass estimates from five sampled sub-sets of our test area were about 170 tonnes/ha, falling well within the Monserud range. More localised validation results may be obtained in the near future.

The goal of the work is to determine whether above-ground biomass density, and associated carbon estimates, can be provided at suitable accuracy and resolution levels using this technical approach. If successful, this would provide the potential to improve carbon baseline estimates in larger forest areas, particularly in the tropics, where currently the estimated uncertainty of biomass (and its associated CO2 sequestration), can be significant.

REFERENCES


***************

Notes: ...
Radar and lidar remote sensing techniques have demonstrated the ability to estimate the above ground biomass within a reasonable (10%-35%) accuracy level over a wide range of forest types. The conventional local approaches are based on relationships of biomass to polarimetric radar backscatter and to vertical height profiles derived from either lidar or radar interferometry. In the framework of the designated space-borne missions DESDyni and BIOMASS to measure the global biomass (carbon stocks and dynamics), this study examines the potential enhancement of biomass estimation using the model-based vertical and morphological structure information derived from polarimetric SAR interferometry (PolInSAR) together with forest species composition information from optical imagery.

The lidar samples the first-contact heights and is therefore most sensitive to the upper layer of the canopy, though still providing information about the lower vertical structure depending on the density and gap structure. The total backscatter from high and medium frequency radar is mostly dominated by the canopy with a ratio of 0.4 to 0.95[*]. To some extent, using structural functions or regression parameters for the individual tree species makes it possible to relate the canopy extension to the total tree biomass. However, for instance the biggest biomass contribution comes from the stems, where the ratio of stem biomass to total biomass is between 0.71 and 0.83[*]. Polarimetric interferometry height and the ability to estimate the polarimetric signature at arbitrary vertical position provide the necessary sensibility to structure components of the forests. Based on the derived parameters, the biomass estimation is examined in order to evaluate the importance of different indicators and models.

The experiments are conducted on the Krycklan catchment boreal forest site in Northern Sweden, where an extensive data set has been acquired and provided by ESA, DLR and FOI. This set consists of ground field measurements, lidar, and optical data, as well as polarimetric interferometric SAR data with several baselines acquired by DLR’s E-SAR sensor at L- and P-band frequencies. This research was supported by an appointment to the NASA Postdoctoral Program at the Jet Propulsion Laboratory, administered by Oak Ridge Associated Universities through a contract with NASA.

[*] Based on the data for the Krycklan catchment.
Biomass Retrieval on Tropical Forests: The BIOMASS Mission

Le Toan, T.¹; Villard, L.²; Lasne, Y.³; Koleck, T.⁴; Dubois-Fernandez, P.³; Chave, J.¹; Blanc, L.⁴
¹CESBIO, FRANCE; ²ONERA, FRANCE; ³EDB, FRANCE; ⁴CIRAD, FRANCE

To determine, for the first time and in a consistent manner, the distribution of forest biomass at a global scale is the objective of the BIOMASS mission, candidate for the 7th ESA Earth Explorer Mission. BIOMASS is based on a single satellite carrying a P-band SAR to provide continuous global interferometric and polarimetric radar observations of worldwide forested areas.

Data from the BIOMASS mission are expected to reduce current uncertainties in the calculations of carbon stocks and fluxes associated with the terrestrial biosphere. Of utmost importance is the biomass in tropical forests, which is a major source of error in estimates of carbon loss by deforestation. To measure biomass of dense tropical forests and to quantify its change with time is a particular goal of BIOMASS. During the BIOMASS phase A, the TropiSAR airborne campaign has been conducted over French Guiana forest. The campaigns provided measurements to test different SAR techniques including polarimetry and interferometry, at repeat intervals compatible with the future spaceborne mission. The experimental data are used to address the challenging issue of biomass retrieval in such tropical forests where biomass can reach 400-500 t/ha.

In most research works, a single type of SAR measurement is used to retrieve forest information. This is the case of the retrieval of forest biomass using SAR intensity, the retrieval of forest height using PolInSAR, or the delineation of land and forest cover classes using polarimetry. Each of the types of SAR measurements is expected to provide directly or indirectly information on biomass. However, the complementarity of the different SAR measurements in biomass retrieval has not been explored. In this paper, a new approach for biomass retrieval has been developed based on the joint use of intensity, polarimetry and interferometry measurements in a Bayesian inversion approach. The approach can be applied to any combination of radar measurement inputs, and can take into account different sources of error (both system and geophysical errors) in order to produce an estimate of biomass and an estimate of the uncertainty.

The first step consists of determining the candidate SAR measurements which are related to biomass, by analysis of experimental data (SAR data and in situ biomass) and interpretation using theoretical models. Using the TropiSAR datasets, different biomass indicators have been found, their sensitivity to biomass has been assessed and their generality tested at different test sites. Those indicators include the cross polarized intensity (HV or VH), the polarimetric features that minimize the ground contribution in the backscatter, the Pol InSAR height and the ratio between polarized interferometric coherences. The retained SAR measurements are used in a Bayes inversion approach. The retrieval results are found significantly improved by the use of different SAR measurements. Preliminary results have shown that biomass in the range of 250-480 t/ha can be retrieved with an accuracy less than 20% using HV SAR intensity and a polarimetric indicator developed for TropiSAR. The generality of the method will be discussed, possibly using datasets obtained over other forest types.

The biomass mapping results, together with their associated uncertainties will be discussed, in particular regarding the overall BIOMASS mission objective, which is to reduce the uncertainties in current forest carbon calculations. The way forward to improve the retrieval algorithms will also be outlined.

***************

Notes: ...
Fourier Scales of Tropical-Forest Structure and their Relation to Biomass Estimation from C- and L-band InSAR and Lidar

Treuhalt, Robert; Gonçalves, F. G.; Hensley, S.  
1Jet Propulsion Laboratory, UNITED STATES; 2California Institute of Technology, UNITED STATES

Tropical forests contain approximately 60% of the Earth's aboveground forested biomass. They represent a particularly challenging target for structural remote sensing. Proposed and existing spaceborne sensors will make polarimetric interferometric SAR (PolInSAR) measurements at L-band and X-band. Lidar is currently available in space and is also proposed as a future spaceborne option. Structural biomass estimation proceeds by regressing field-measured biomass to remotely sensed structural parameters. There is little consensus about which structural parameters are most directly sensitive to stand biomass, and even which sensors optimally measure biomass. In various types of forests, field biomass has been regressed to structural parameters from InSAR or lidar, including total height or height squared [1], combinations of average height and density standard deviations [2], and median height [3].

In this talk, we show results from La Selva Biological Research Station, Costa Rica, suggesting similarities between vegetation density characteristics from airborne lidar [4] and C-band, fixed baseline profiles from InSAR at vertical polarization [5]. Extinction coefficients much lower than expected (~0.1 db/m), applied to the InSAR profiles, maximized the agreement between InSAR and lidar or InSAR and field profiles. The similarity between lidar and InSAR profiles prompted using Fourier transforms of lidar—which can be seen as infinite-baseline InSAR—to suggest optimal InSAR baselines for biomass estimation. Baselines corresponding to Fourier vertical wavelengths of 14-20 m resulted in the lowest RMS scatters of biomass estimated from lidar about field biomass (58 Mg/ha). The average field biomass was 229 Mg/ha (35-457 Mg/ha). Complex coherences (Fourier transforms of the InSAR vertical response to vegetation density) from multiple baselines of InSAR, corresponding to wavelengths of 50 m-100 m, were also regressed against field biomass, and performed worse (76 Mg/ha). But both lidar and InSAR Fourier transforms performed significantly better than average heights from either lidar or InSAR. The lower quality InSAR results were demonstrated to be consistent with 0.1 coherence errors and 10 degree phase errors, both of which could be improved in the future.

L-band, repeat-track, fully polarimetric InSAR data were also taken at La Selva and structural features estimated will be compared to those at C-band. Temporal decorrelation effects will be modeled as in [7]. The improvement in biomass estimation due to the polarimetric separation of ground and volume contributions to Fourier transforms will be tested.

Finally, using a very broad range of "baselines" from lidar, it will be suggested that Fourier frequencies corresponding to 14 m - 100 m vertical wavelengths produce the best biomass regression results in the forest studied. The inquiry into optimal Fourier scales must be pursued in other tropical wet forests as well as tropical moist forests to determine if this approach is applicable to global monitoring. Preliminary field results from the moist forests of Tapajós in Brazil will also be shown to compare structure to the tropical wet forests of La Selva.

Because "height" is a near-zero Fourier frequency characteristic of the forest vertical density distribution, multiple baselines at effectively higher Fourier frequencies, suitably tuned to the most sensitive as determined by lidar, may improve upon height-only performance in the future. Although the results of the current study are empirical, we will suggest dynamical mechanisms to better understand the trends reported here and model the Fourier scales of density fluctuation for future estimation strategies.


***************

Notes: ...
Day 4 - Thursday 27 January

Session: Applications on Agriculture
Polarimetric Studies of Native Grasslands in Western Canada using RADARSAT-2 Imagery

Buckley, J.1; Smith, A.2

1Royal Military College of Canada, CANADA; 2Agriculture and Agri-Food Canada, CANADA

Native grasslands play an important role in ecosystem functioning. How we manage them can influence climate change, biodiversity and economics. Despite their importance quantifiable estimates of the rate and location of native grassland change in western Canada are not readily available. For the past two years, we have been acquiring RADARSAT-2 fine mode quad-pol imagery over several areas of southern Alberta, Canada to investigate the utility of radar polarimetry in the identification and delineation of native grasslands in a landscape increasingly dominated by large-scale cultivation, urbanization and industrial infrastructure. The radar imagery was supplemented with data from a significant ground truth campaign, and other remotely sensed data products, including space-borne multi-spectral imagery, and, over a subset of the region, airborne lidar and hyperspectral data. One significant area of difference between areas of cultivated land and natural grassland is in heterogeneity of the areas, where crops appear to be much more homogeneous than natural regions. Presence of invasive weeds also increases heterogeneity of the imagery. This heterogeneity is not quantified in the usual forms of polarimetric decomposition. We are exploring statistical measures of this heterogeneity and are investigating the potential for improvement in classification using these measures. Classification was performed using the SVM method on some common subsets of polarimetric parameters, trained on a subset of the ground truth data, and validated with the remainder. Results to date show that classification of the imagery into four super-classes of natural grasslands, improved pasture, crops and fallow is more accurate using model-based decompositions than those based on statistics. Little improvement was seen using the entire coherency matrix as the input for classification. Use of multiple incidence angles in the classification procedure did improve accuracy. In general, classification accuracy using a single RADARSAT-2 image was only slightly worse than using a high quality multi-spectral image.

***************

Notes: ...
Crop Change Assessment using Polarimetric RADARSAT-2 Data

Liu, C1; Shang, J1; Vachon, P.W.2; McNairn, H.2
1Defence R&D Canada - Ottawa, CANADA; 2Agriculture and Agri-Food Canada, CANADA

This paper studies the feasibility of monitoring the growth cycles of crops based on a multi-temporal analysis of variation of three elementary scattering mechanisms. Crop change is assessed using RADARSAT-2 polarimetric data. Existing polarimetric SAR (PolSAR) decomposition techniques are extended to monitoring of agricultural fields. This study also includes data on the application of supervised target classification to distinguish various crop types.

RADARSAT-2 carries a C-band synthetic aperture radar (SAR) which is capable of providing repeat-pass polarimetric SAR images. For this study, 10 RADARSAT-2 Fine Quad (FQ) Mode scenes over agricultural fields in eastern Ontario, Canada, were acquired from the early growth to maturity or harvest season, including two sets (FQS and FQ19) of repeat-pass Polarimetric-Interferometry SAR (Pol-InSAR) acquisitions at incidence angles of 23.4° to 25.3° and 38.3° to 39.8°, respectively. There are four repeat-passes for the FQS and for repeat-passes for the FQ19 data sets.

The main crops studied are corn, soybeans, spring-wheat and hay-forage. The images show that volume and double bounce scattering gradually increase during the crop growth season; after harvest, they decline significantly. By monitoring the significant change that occurs in scattering mechanisms, the crop growth/harvest cycle can be observed.

The PolSAR analysis is based on the Pauli decomposition. Multitemporal analysis is applied to RGB images of surface scattering, double bounce and volume scattering. The results show that changes in crop area can be clearly observed.

Supervised target classification using a Maximum Likelihood Classifier was applied to the PolSAR images used for the multi-temporal analysis. The training sites were selected from the colour map of the Pauli-basis RGB images based on ground truth information. The supervised classification results agree with the observations from the multi-temporal analysis; the detected crop growth cycles were generally in agreement with the ground truth.

***************
Retrieval of Rice Phenology by Means of SAR Polarimetry at C and X Band
Lopez-Sanchez, J. M.; Claude, S. R.; Ballester-Berman, J. D.
1University of Alicante, SPAIN; 2AEL Consultants, UNITED KINGDOM

This work presents an approach to estimate the phenological stage of rice fields from a single acquisition of TerraSAR-X or Radarsat-2, operated in standard dual-pol and quad-pol modes, respectively.

Three time series of coherent HHVV dual-pol X-band radar images acquired by the TerraSAR-X sensor at different incidence angles during a whole cultivation season, and one time series of quad-pol C-band Radarsat-2 images gathered during the first part of the same season have been employed for this purpose. All images have been processed and a set of polarimetric observables has been computed from them. The radar response of the rice fields has been interpreted by means of these observables in terms of the scattering mechanisms and polarization effects present in the scene at different phenological stages.

Among the analyzed parameters, besides backscattering coefficients and ratios, we have observed important signatures in the correlation (in magnitude and phase) between channels in both the linear and the Pauli bases, as well as in parameters provided by target decomposition techniques, like entropy and alpha from the eigenvector decomposition. A new model-based decomposition providing estimates of a random volume component plus a polarized contribution has been proposed and employed for interpreting the radar response of rice. By exploiting the clear signatures of many of these observables in terms of the phenological stages of rice, we have devised a simple approach to estimate the phenological stage at a single acquisition. This approach has been successfully tested with the available data.

The observations provided by target decomposition approaches have been especially useful both for interpretation and for designing the proposed retrieval algorithm. In particular, the eigenvector decomposition parameters, entropy and alpha, have been found very sensitive to the plants development stage, yielding a clear signature for most stages. However, when using TerraSR-X images, due to the dual-pol configuration, a region of ambiguity has been found for high entropies that may correspond to the presence of two dominant scattering mechanisms, like in the moment of plants emergence, or to a strongly depolarizing scene, as at the end of the growth cycle. In principle, this ambiguity may be solved with fully polarimetric measurements, since both situations can be distinguished by different anisotropy values, for instance. However, the lack of Radarsat-2 acquisitions at the end of the season does not allow us to confirm this point so far.

Despite the simplicity of the proposed approach, we have demonstrated the capability of this remote sensing technique to retrieve the phenological stage of rice fields at a particular date, based on the availability of an HHVV dual-pol image measured coherently or a quad-pol image. Results are useful, for instance, for detecting the moment with full emergence of the plants, which is commonly employed by farmers to go to the fields and count the number of plants or the so-called “effective germination”. If the value is lower than expected, they still have an opportunity to sow again in order to increase the plantation density and, consequently, the final yield. Thanks to the high spatial resolution provided by this technique, different growth rates can be also identified within the same fields, which is also of interest for farmers in order to optimize resources or, in some cases, to detect phenological delays caused by cultivation problems, such as water salinity and plagues.

In this work we have also outlined some further improvements of this approach, which are mostly based on the combination of multiple acquisitions. Multi-temporal techniques can help to both improve the results at a single date (in terms of robustness and increased precision in the BBCH scale) and provide a shorter refresh rate of the results, which may be necessary for some precision farming practices.

***************

Notes: ...
Fully Polarimetric SAR Mosaicing and Land Cover Classification in the Northern Taiga Region
Antropov, O.; Yrjö, Rauste; Lönnqvist, A.; Häme, T.
VTT Technical Research Centre of Finland, FINLAND

The objective of the study was to evaluate the possibility of using fully polarimetric SAR (PolSAR) mosaicing for wide area mapping and classification at the high latitude regions. A small mosaic of 4 polarimetric ALOS/PALSAR scenes acquired during the snow melting season in Finnish Lapland was produced in such a way that fully polarimetric processing methods could be applied. This allowed broadening the selection of possible methods for classification in comparison to traditional single polarization data.

The dates of PALSAR acquisitions were 02.04.2007 and 19.04.2007, with 2 images acquired on each date. High geometric accuracy that was achieved through the block adjustment technique proved that mosaicing of PolSAR data could produce geometrically homogeneous polarimetric datasets covering wide areas. No scene-to-scene calibrations were performed because it could have produced unpredictable results due to the actual change in scattering mechanisms during snow melt between the acquisition dates.

Several quad-polarimetric decomposition and classification techniques are benchmarked on the resulting PolSAR mosaic, as well as on its constituting fragments, in order to see which of these methods are capable of producing more robust results in land cover mapping. Influence of snow and its condition (dry or wet) on the results of multiclass land cover classification are discussed.

In particular, several classification approaches associated with the H/A/å decomposition were used. First values of H/A/å were calculated. Then three classification schemes were used: 1) unsupervised classification based on predefined boundaries in H/A/å space; 2) unsupervised classification with the k-means clustering of H/A/å features; 3) unsupervised classification based on the Wishart matrix distance. In the last approach different clusters are usually initialized using the results of the H/A/å decomposition. In this study also other initialization techniques based on clustering with selected polarimetric features were used in order to decrease the impact of snow. Labelling is performed using optical satellite data, classification accuracy is evaluated against Corine land cover data produced by the Finnish Environment Institute.

Supervised Wishart classification was also done on original PolSAR images and the produced mosaic, with less than 1% of pixels used as a training set. Number of classes used in all classification approaches ranged from 5 to 16.

Best classification results for the whole 4-image mosaic are obtained with the supervised Wishart classification using 10 training classes, further merged to 5 classes at the labelling stage, with overall pixel to pixel classification accuracy exceeding 64% when compared to the Corine land cover data. Classification accuracies for the single acquisitions are some 7-13% higher than for the whole 4-image mosaic for different classification methods (when 5 classes are used).

Total classification accuracies for mosaics produced from the single day acquisitions (2 PolSAR images each) were very close to the accuracies calculated for original PolSAR images, with less than 4% difference for 5 classes. It shows a high potential of polarimetric mosaicking and subsequent PolSAR classification if component images are acquired under approximately the same environmental conditions, for instance during summer. Then some kind of "polarimetric seam-hiding" procedure may be applied, especially for a highly forest dominated area at L-band, so that polarimetric signatures show a seam-less transition from one PolSAR scene to another.

***************

Notes: ...
Temporal and Incidence Angle Dependency of PolSAR Data for Agricultural Land Cover Analysis and Characterization

López-Martínez, C.; Montero, I.; Fàbregas, X. Universitat Politècnica de Catalunya UPC, SPAIN

It is well known that remote sensing data obtained by means of single polarization Synthetic Aperture Radars provide valuable information for the study and characterization of agricultural fields. As it has been demonstrated in the last years by different authors, SAR images are highly sensitive to the crop type or to the humidity of the terrain, but also to the temporal evolution of crops when multi-time acquisitions are considered. The use of dual-polarization or fully-polarimetric SAR systems make possible to improve this study and to increase the accuracy of the agricultural cover characterization, as polarimetry increases the sensitivity of data to volumetric scattering contributions taking place within the crops.

The objective of this work is to present an in-depth analysis of the polarimetric information in case of agricultural fields, and to characterize the dependency of this information on time and on incidence angle. This analysis is important for future missions as the GMES Sentinel-1 SAR system, where a system of two satellites will allow a short revisit time. Some works have partially addressed this analysis, but only from a point of view of data classification [1]. The goal of this work is to analyze the polarimetric information itself through the estimation of different polarimetric descriptors, as for instance, entropy, anisotropy, alpha angle or complex polarimetric coefficients, among others. This analysis will be conducted for dual-polarization data as well as for fully-polarimetric SAR data.

The first part of the work to be presented will focus on the dependency of fully-polarimetric information on time and on incidence angle. The objective is to determine the optimum time sampling in order to derive accurate information concerning the growing stage of different crops. In this case, both, winter and summer crops shall be analyzed. This time analysis shall be performed in parallel with an analysis of the behavior of the polarimetric information with respect to the incidence angle. In this case, the interest is on determining the optimum observation geometry to derive accurate information concerning the analysis of agricultural fields. As indicated, PolSAR data makes possible to have sensitivity to the different scattering contributions, that is, sensitivity to the ground scattering, to the volume scattering, etc... The previous analysis, specially the one concerning the dependency on the incidence angle, shall be employed to study also the visibility of the different scattering contributions in the final data. This particular study shall be finally employed to assess the performance of different polarimetric target decomposition theorems against the system configuration.

All the previous analysis will only focus on fully-polarimetric data. In a second stage, it shall be extended to different dual-polarization configurations. This study is important in the particular case of the GMES Sentinel-1 SAR system as it consists of a dual PolSAR instrument. In this case, it is important to determine the optimum channel combination that leads to a minimum loss of information with respect to fully polarimetric SAR systems. The previous analysis on time and on incidence angle shall be applied to dual-polarization data. The focus will be, specially, on determining which combinations of polarimetric channels permit to have the same time sensitivity of fully-polarimetric data to the crops growing process.

The analysis presented in the previous paragraphs has been conducted in the frame of the AGRISAR 2009 ESA project. During this project, fully-polarimetric RADARSAT-2 data were collected over different agricultural areas in Flevoland (The Netherlands), Indian Head (Canada) and Barra (Spain). These data were also employed to derive simulated Sentinel-1 data. The work to be presented will be based on the Flevoland dataset. Additionally, ground measurements were collected so the different analyses that have been explained shall be compared to this ground truth information.

References:


***************

Notes: ...
Multitemporal SAR measurements acquired over the same test site at different times is one of the strategies for enlarging the observation space and hence improving the accuracy of vegetation parameter estimation. Time coordinate is especially important when dealing with agricultural crops due to the relative short time scale for the development cycle of this type of vegetation in comparison with other vegetated covers such as forests. A number of works can be found in the literature which suggest the need of time series of PolSAR data for designing reliable crop monitoring procedures. In this work we have made use of quad-pol measurements at L-band acquired by DLR’s E-SAR system during the AgriSAR’06 campaign for analyzing time series of different polarimetric indicators over winter wheat, maize and winter rape fields. Also, their relationships with biophysical parameters and phenological stages are addressed. The second part of this paper deals with the assessment of compact-polarimetry modes, and in particular of hybrid-pol mode, for land cover monitoring as one of recommendations emerged from the POLInSAR Worshop 2009. The same data set has been used for computing decomposition parameters from a simulated hybrid-pol data set as proposed by Raney in 2007. A similar correlation study has been also performed.

Results reveal the potential of some of these observables in both the detection of particular crop conditions and the crop monitoring along certain periods within the whole growth season by means of empirical relationships. For example, we have seen that the HV/VV ratio could be useful for detecting the stem elongation of maize plants, whereas the average alpha angle over wheat fields clearly decreases at a phenological stage corresponding to the beginning of flowering. In case of hybrid-pol data, the relative phase, delta, shows a significative increase over wheat fields which could be associated with the stage of fruit development, and the degree of polarization for this same crop exhibits a parabolic variation with a maximum corresponding to the maximum LAI value, which turns out to be related to the final crop yield. These observations have been supported by the interpretation of the expected scattering response from the crop in terms of the plant morphology. Also some regression models such as the ones relating average alpha with maize and rape wet biomass up to 4 and 5 Kg/m2, respectively, and the ones relating average alpha and delta with maize wet biomass and height will be discussed.

***************
Multitemporal Analysis of Agricultural Fields using Polarimetric Radarsat-2 Images
Weydahl, D J
Norwegian Defence Research Establishment, NORWAY

Radarsat-2 quad polarimetric images have been acquired over a full growing season in a valley in Norway holding many different agricultural crop types. It may be almost impossible to distinguish between certain crop types at some SAR acquisition times during the season, even using fully polarimetric Radarsat-2 images. However, at other times, the polarimetric features show a more distinct separation. We have studied how the different C-band polarimetric channels respond to different crop types during the full growing season. Statistics from the original polarimetric channels are used together with different decompositions (e.g. Pauli) to maximize the classification of crop types for the different fields. Systematic trends can be incorporated in an operational system aimed at supporting regional agricultural authorities in their annual monitoring of agricultural fields.

***************

Notes: ...
Multi-Temporal Polarimetric Signatures of Crops: Overview and Results from the AgriSAR 2009 Campaign

Caves, R²; Davidson, M²; Hui, G³; Davidson, G³; Mo, A²; Padda, J¹; Staples, G²
¹MDA, CANADA; ²ESA, NETHERLANDS

This talk will provide an overview of results from the ESA funded AgriSAR 2009 campaign with specific emphasis on analysis of multi-temporal polarimetric signatures of crops.

The objectives of AgriSAR 2009 are to:

- Simulate Sentinel-1 data products especially in terms of repeat observation, resolution and polarization.
- Evaluate the performance of Sentinel-1 for agricultural and land cover products based on dense time series of radar data.
- Evaluate the added value of polarimetry for the same information products.
- Develop methodology for the generation and validation of agricultural and land cover map information products based on C-band radar data.

Over the 2009 growing season RADARSAT-2 polarimetric data were acquired twice weekly over three agriculture test sites:

- Barraux, Spain
- Flevoland, The Netherlands
- Indian Head, Saskatchewan

Monthly optical images were also acquired using RapidEye. Ground surveys were conducted at each site to provide extensive crop maps as well as growth stage and crop yield for selected representative fields.

A total of 193 RADARSAT-2 scenes were acquired over the 6-month growing season. These have been used to simulate Sentinel-1 Interferometric Wide Swath mode dual-pol single-look complex and multi-look detected geocoded products. The RADARSAT-2 polarimetric data was also formatted into a 5-look geocoded covariance matrix product. Over 1000 products have been delivered to ESA. Geocoding of multi-look products was based on rational function polynomials derived from orbit data, and SRTM DEM. The geocoding provides accurate pixel level (10 m) registration between the RADARSAT-2 images (including images acquired from different geometries) and with the optical imagery and ground truth data.

AgriSAR 2009 provides a rich and unique dataset for temporal analysis of C-band polarimetric signatures of numerous crop types over an entire growing season. The combination of images acquired at multiple incidence angles and ascending and descending passes provide approximately 60 observations per field over the 6-month growing season. Data analysis has focused on crop type classification at the pixel level and temporal analysis of polarimetric signatures at the field level.

The crop classification work is comparing the performance of supervised maximum likelihood classification as applied to time series of dual-pol products and quad-pol products to evaluate the expected performance of Sentinel-1 for crop classification, the impact of temporal sampling on crop classification and the added value of polarimetry.

The field level analysis has developed a database of spatially averaged dual- and quad-pol signatures for all fields with known crop type. For each date on which a field is imaged the pixels within that field are averaged and recorded in the field level database. Polarimetric signatures are recorded as a covariance matrix. Similar databases are available for the RapidEye data and ground observations. An analysis tool running on the database can plot how the radar signatures of individual fields vary over time and compare this with the temporal variability of optical (NDVI, LAI) and ground measurements for the same fields. The database and analysis tool support temporal analysis of linear polarised backscatter, Pauli components, circular polarised backscatter, correlation coefficients, phase differences, entropy, alpha and beta angle and Freeman-Durden components. Other polarimetric parameters can easily be added.

The tool allows comparison of signatures between fields of the same crop type and different crop types. The presentation will show numerous examples of polarimetric signatures varying in time including Canola which behaves as a ‘pure’ volume scatterer and spring wheat which exhibits more preferential orientation.

***************

Notes: ...
Day 4 - Thursday 27 January

Session: Airborne and Spaceborn Pol-InSAR campaigns
The TropiSAR campaign in French Guiana: SAR dataset and first PolInSAR analysis

Dubois-Fernandez, P; Daniel, S; Le Toan, T; Chave, J; Blanc, L; Davidson, M

1ONERA, FRANCE; 2CESBIO-ONERA, FRANCE; 3CESBIO, FRANCE; 4EDB, FRANCE; 5CIRAD, FRANCE; ESTEC, FRANCE

The BIOMASS mission was retained in January 2009 as one of the three candidates for the next Earth Explorer Core mission to go to phase A. BIOMASS main objective is to provide information on the carbon sinks and sources in the forests globally, which will be of essential value for climate modelling and policy adaptation, e.g. REDD.

Up to now, biomass retrieval algorithms have been developed and validated for the range of biomass up to 300 t/ha. The methods are based on combining SAR intensity and SAR PolInSAR interferometry which provide respectively estimates of biomass and canopy height. The remaining questions concern the overall performance of the retrieval algorithms in tropical forests characterized by high biomass density (> 300 t/ha) and complex structure.

The TropiSAR experiment in French Guyana was proposed to provide feedbacks on the performances of a P-band SAR to measure biomass and canopy height of a tropical forest with higher biomass density. Characterising tropical forests is essential as it represents a large component of the terrestrial carbon pool and the carbon sources. The SAR system used in the TROPISAR campaign is the ONERA airborne system SETHI.

More specifically, TropiSAR was designed to provide measurements of temporal coherence at P-band over tropical forests for time intervals compatible with space-borne missions (typically 20-30 days), to assess performances of methods transforming P-Band SAR intensity and interferometric measurements into forest biomass and forest height. This paper presents the TropiSAR SAR database and the first results from the PolInSAR analysis.

The temporal coherence at P-band over tropical forests is observed to remain high even after 22 days, a time interval period compatible with typical SAR orbit cycle. The height inversion from PolInSAR measurements are shown to be rather sensitive to topography and the vegetation height map estimated from PolInSAR interferometry is shown to be consistent with in-situ measurements and LIDAR derived information in the study area.

***************
First Demonstration of Agriculture Height Retrieval with POLINSAR Airborne Data

Lopez-Sanchez, J. M.¹; Hajnsek, I²; Ballester-Berman, J. D.¹

¹University of Alicante, SPAIN; ²DLR, GERMANY

To date, polarimetric SAR interferometry (POLINSAR) has been successfully employed for the estimation of vegetation height and other structural information of forests, including a wide variety of scenarios. Data provided by airborne sensors, such as DLR’s E-SAR, and acquired at L or P-band have been used for this purpose.

Despite the working principle of this technique is the same for both agriculture and forests, so far there has not been any demonstration of this approach with airborne data. Regarding agriculture, the only real data successfully exploited with POLINSAR for inverting vegetation height and ground topography correspond to indoor data acquired in an anechoic chamber.

In this work we make use of a set of quad-pol images acquired in interferometric repeat-pass mode by DLR with the E-SAR system, in parallel with the AgriSAR2006 campaign. The test site is located in Demmin, Germany, and includes up to 8 different crop types. A pair of images acquired at L-band with a 90 m baseline at the moment most of plants were grown has been specifically studied. By using a baseline of 90 m we ensure enough interferometric sensitivity, which can be measured in terms of the vertical wavenumber (kz).

Results demonstrate that, although the frequency band is low and the backscattered signal contains an important contribution from the ground, the volume information provided by interferometry is present and enables the application of POLINSAR-based retrieval approaches.

In this experiment we have obtained accurate estimates of vegetation height over winter rape fields, when compared with the available ground data. The same procedure yields a slight overestimation over maize fields and more over wheat fields. The mismatch between the model used for this inversion (random volume over ground) and these crop types (which exhibit some orientation features in the volume) is being analyzed at the moment. Further details will be presented at the conference.

***************

Notes: ...
We present the results of the 2009-2010 UAVSAR campaigns over boreal, temperate and tropical forests. UAVSAR is the new L-band fully polarimetric synthetic aperture radar (InSAR) capable of repeat pass interferometry [1]. Our objective is to estimate vegetation 3D structure and biomass using polarimetric backscatter, repeat-pass InSAR, lidar and ancillary data (e.g. land cover maps, climate and weather data). The campaign was designed to inform the upcoming NASA’s DESDynl mission [2] which involves a lidar and radar sensor. Data was collected over temperate forests of New Hampshire, Maine and California, boreal forests of Québec (Figure 2) and tropical forests of Costa Rica. The radar swath is 20km and data collection ran between 100 and 185km long. Each site was chosen to cover at least one National Park and an experimental forest, providing pristine and managed forests with a wealth of historical data. During the UAVSAR campaign, we also collected airborne lidar data using LVIS (Laser Vegetation Imaging System) [3] in addition to field (tree height, Diameter at Breast Height (DBH), crown size and species composition) and weather data (precipitation and wind).

The UAVSAR data was processed at JPL within a few weeks of the flights. In this presentation, we first describe the incidence angle radiometric calibration procedure for the polarimetric backscatter data. In the case of UAVSAR, the incidence angle varies from 20 to 70° from close to far range. Both topography and forest reflectivity patterns must be removed before estimating biomass at the landscape scale. We used incidence angle and facet models to correct for topographic effect and show a reduction of the small scale residuals with the latter [4]. The residuals are due to the low resolution digital elevation models used in the topographic corrections. In terms of the vegetation reflectivity pattern, we found it was specific to land cover type and differed greatly for each polarization. Thus we used land cover and polarization specific calibration curves to calibrate the backscatter data. Curves were compiled for all sites to provide a set of “universal” calibrations that can be applied to any UAVSAR image given the land cover type is known from ancillary data.

Variations in weather (precipitation and wind) induce changes in radar backscattering properties of the canopy and in particular the interferometric correlation [5]. This reduces InSAR coherence and therefore height measurement accuracy. The UAVSAR campaigns was designed to quantify the impact of these so-called temporal changes on the InSAR measurement in order to apply the polInSAR method [6]. To achieve this, UAVSAR collected data several times over each site within a 2 weeks period in order to obtain a set of temporal intervals. Weather data was collected during the entire flight campaign and used to identify spatial pattern of change in the radar data. Over each site, we flew 2 pairs of flights: one with zero baseline and one with 65m perpendicular baseline. The zero baseline is relatively free of volumetric decorrelation potentially isolating the impact of temporal decorrelation on the radar signal. The temporal decorrelation is then used to correct the polInSAR height inversion algorithm. Although we did not find any significant impact on the radar backscatter level, the impact of wind and precipitation on coherence is significant.

We used LVIS (Lidar Vegetation Imaging System), field data and Land Cover maps to assess the impact of weather as a function of vegetation structure and estimate spatial variations of microwave extinction (Figure 6).

REFERENCES

***************

Notes: ...

Mapping Vegetation 3D Structure and Biomass with UAVSAR and LVIS

Simard, M.; Pinto, N.; Lavalle, M.; Dubayah, R.; Hensley, S.

1Jet Propulsion Laboratory, UNITED STATES; 2University of Maryland, UNITED STATES
Airborne SAR Campaign Activities in Support of the ESA Earth Observation Programme

Davidson, M; Hajnsek, R; Dubois-Fernandez, P

1ESA, NETHERLANDS; 2DLR, GERMANY; 3ONERA, FRANCE

The European Space Agency (ESA) campaign activity programme includes ground-based, air-borne, balloon-borne, ship-borne and small satellite experiments, to provide support for the preparation of future Earth Observation space programmes and their users and the calibration and validation of spaceborne measurements once the mission is launched. In the last 30 years a large variety of campaigns (over 80 in total) with different instruments have been supported by the Agency including experiments related to atmospheric dynamics, atmospheric chemistry, coasts and oceans, ice and land surfaces.

More recently, in response to SAR missions and mission concepts initiated as part of the ESA GMES and Earth Explorer satellite program, the number and scope of airborne SAR campaigns have been initiated and funded by the Agency has increased considerably. The include campaigns in northern Europe (BioSAR-1, -2 and -3, IceSAR 2007), central Europe (AgriSAR 2006 and 2009, TreeSAR), southern Europe (TerraSARSIM) and Tropical Regions (TropiSAR 2009) and the development of new instruments (SnowSAR). The results for these campaigns have been important for a number of spaceborne missions including Sentinel-1, BIOMASS and CoreH2O and addressed a variety of subjects including development of retrieval algorithms, end-to-end simulation, product prototyping, instrument and instrument mode verification etc....

In addition to direct use in the context of spaceborne programmes, campaigns and external/internal research studies are an important means of supporting Earth Observation projects. At present, recently deployed and ongoing scientific campaigns produce high value datasets to support for the Living Planet Programme (Earth Explorers Core and Opportunity missions), the GMES and Earth Watch missions as well as other ESA Earth Observation projects in the fields of Atmosphere, Ocean and Ice, Land Surface Processes and Solid Earth. Campaigns to support Earth Observation exploitation projects (e.g. DUE) are also deployed. The resulting datasets, available on Internet or media, can be accessed by registering a request to ESA, thus providing a valuable resource to European and international scientists.

This presentation will give an overview of ESA SAR campaign activities and main results to date, and details on how to access and retrieve campaign data will be provided.

****************
In comparison to deforestation, forest degradation is the most difficult component to be monitored in REDD (Reducing Emissions from Deforestation and Forest Degradation). Especially for 99 tropical UNFCCC non-Annex I countries. The first objective of AIPEX is to explore the possibility of ALOS/PSR repeat pass POLInSAR to detect forest degradation in the tropical natural forest. The exercise was implemented under #402 of JAXA Second Research Announcement. However, due to experimental status of PLR acquisition mode and the imaging geometry of ALOS/PSR, including the systematic observation strategy imposed by JAXA, no complete series of PLR mode acquired in 2007/PLR-215, 2009/PLR-215, 2009/PLR-231, and 2010/PLR-231 were available for the target sites. As the consequences, POL-InSAR analysis was successfully accomplished on single pair only.

This paper presents the final result of the first complete process chain of POLInSAR analysis, locally self implemented in Indonesia. The analysis was applied to several PLR-215 SLC image pairs in the natural forest of Indonesia, by using POLSARPRO version 4.14 (November 2009). The complete POLInSAR analysis chain was successfully done on a single-baseline PLR-215 image pair (B-parallel: -1139.26m, B-normal: -1347.76m), of the following path (P) and frame (F) number: P-488, F-30 (dated: 20070311/Slave [ALPSRP060040030] and 20070426/Master [ALPSRP066750030]). This was then followed to another PLR-215 image pair: P-383, F-7150 (dated: 20060802/Master [ALPSRP027787150] and 20060917/Slave [ALPSRP034497150]). Although it only derived forest height instead of tree-stand height, this result has filled the height gap in the existing tropical forest application at the sample plot level. Further attempt to PLR-231 image pair: P-435, F-7130 (20090520/Master [ALPSRP176877130] and 20100523/Slave [ALPSRP230557130]) was fail, might be due to one year acquisition time difference. The forest height from single pair POL-InSAR analysis (RVOG approach) of L-Band ALOS/PSR is well performed for common tree height in the tropical natural forest condition. This result confirmed the strong possibility of L-Band spaceborne SAR for detection of forest degradation if two POL-InSAR single pairs were available. Especially for a systematic and consistent measurement and monitoring approach principle of IPC Good Practice Guideline (GPG). Improvement of POLSARPRO is required, to display the data profile analysis in ground range rather than in slant range, as given in the existing version. This could be achieved also through MapReady software by adding the ability to...

Notes: ...
Posters
A Neural Network Approach for the Retrieval of Soil Parameters using a Two Layers Multi-Scale Bi-Dimensional SPM Model

Bennaceur Farah, LBF; Farah, IRF; Bennaceur, RB; Hosni, Ht; Boussema, MRB
1ENIT, TUNISIA; 2ENSI, TUNISIA; 3FST, TUNISIA

The overall objective of this paper is to retrieve soil surfaces parameters namely, roughness and soil moisture related to the dielectric constant by inverting the radar backscattered signal from natural soil surfaces. Because the classical description of roughness using statistical parameters like the correlation length doesn’t lead to satisfactory results to predict radar backscattering, we used a multi-scale roughness description using the wavelet transform and the Mallat algorithm. In this description, the surface is considered as a superposition of a finite number of one-dimensional Gaussian processes each one having a spatial scale. A second step in this study has consisted in adapting a direct model simulating radar backscattering namely the small perturbation model to this multi-scale surface description. We characterize the soil surfaces and sub-surfaces by a two layer geo-electrical model. The upper layer is described by its dielectrical constant, thickness, a multi-scale bi-dimensional surface roughness model by using the wavelet transform and the Mallat algorithm, and volume scattering parameters. The lower layer is described by its dielectric constant and multi-scale surface roughness. To compute surface, sub-surface and volume scattering, we consider a two layers multi-scale bi-dimensional Small perturbations model. We have investigated the impact of this description on radar backscattering through a sensitivity analysis of backscattering coefficient to the multi-scale roughness parameters. To perform the inversion of the small perturbation multi-scale scattering model (MLS SPM) we used a multi-layer neural network (NN) architecture trained by a backpropagation learning rule. The inversion leads to satisfactory results with a relative uncertainty of 10%.

***************

One Channel SAR Image Texture Based Interpretation

Rodionova, N. V.; Rodionova, N.V.
Institute of Radioengineering and Electronics, RUSSIAN FEDERATION

In single band and single polarized synthetic aperture radar (SAR) images, the information is limited to intensity and texture, and it is very difficult to interpret such SAR images without any a priori information. There are many techniques to decompose PolSAR data on scattering mechanisms based on covariance matrix. It’s proposed to use the textural features (contrast, entropy and inverse moment), obtained from grey level co-occurrence matrix, to decompose one channel SAR images. Based on previously defined texture feature values for various surface objects (forest, town, water, and so on) and their main scattering mechanism properties for L- and C-bands, it’s possible to interpret RGB color texture merged images as CMYK color image decomposed on main scattering mechanisms (volume - cyan, surface - magenta and double bounce - yellow). Speckle reduction is one of the main moments in SAR image interpretation improvement because of strong speckle influence on texture.

The idea to use texture false color composition for image interpretation is fruitful also for individual bands of multispectral imagery with good resolution, and for panchromatic images. But it’s necessary to learn to interpret such images. SIR-C/X-SAR SLC L-band images of Moscow region and Lake Baikal region, Landsat TM images of the Northern Sinai Peninsula and panchromatic image are used for illustration.

***************

Standard Hough Transform and Line Segment Coorinates

Rodionova, N.V.
Institute of Radioengineering and Electronics, RUSSIAN FEDERATION

The Hough Transform (HT) has a broad application since 1962 when P. Hough presented algorithm for detection of features of a particular shape like lines or circles in digitalized images. The main advantage of the standard HT (SHT) technique is that it is tolerant of gaps in feature boundary descriptions and is relatively unaffected by image noise, unlike edge detectors. The main disadvantages of SHT are large memory requirement and slowness, and no knowledge about line starting and ending points. Many algorithms have been proposed, on basis of SHT or not, to find the endpoints of the line segment in the image. But SHT technique itself gives a simple way to obtain end-point coordinates of straight line segments by examining outline butterfly coordinates in 2D array-accumulator at ( teta=0° and teta=90° ) or ( teta=90° and teta=179°).

This paper demonstrates its SHT possibility for simulated binary and grey scale, SAR images with one or few line segments, with or without gaps, noisy or not.

***************

One Channel SAR Image Texture Based Interpretation

Rodionova, N. V.
Institute of Radioengineering and Electronics, RUSSIAN FEDERATION

In single band and single polarized synthetic aperture radar (SAR) images, the information is limited to intensity and texture, and it is very difficult to interpret such SAR images without any a priori information. There are many techniques to decompose PolSAR data on scattering mechanisms based on covariance matrix. It’s proposed to use the textural features (contrast, entropy
and inverse moment), obtained from grey level co-
ocurrence matrix, to decompose one channel SAR images. Based on previously defined texture feature values for various surface objects (forest, town, water, and so on) and their main scattering mechanism properties for L- and C-bands, it's possible to interpret RGB color texture merged images as CMYK color image decomposed on main scattering mechanisms (volume - cyan, surface - magenta and double bounce - yellow). Speckle reduction is one of the main moments in SAR image interpretation improvement because of strong speckle influence on texture. The idea to use texture false color composition for image interpretation is fruitful also for individual bands of multispectral imagery with good resolution, and for panchromatic images. But it's necessary to learn to interpret such images. SIR-C/X-SAR SLC L-band images of Moscow region and Lake Baikal region, Landsat TM images of the Northern Sinai Peninsula and panchromatic image are used for illustration.

***************

New Simple Decomposition Technique for Polarimetric SAR Images
Lee, K.Y1; Oh, Yisok2; Kim, Y.S1
1Korea Aerospace Research Institute, KOREA, REPUBLIC OF; 2Hong-Ik University, KOREA, REPUBLIC OF; 3Korea Aerospace Research Institute, KOREA, REPUBLIC OF

This paper proposes a new decomposition technique for polarimetric synthetic aperture radar (SAR) images. The polarimetric decomposition is very useful to understand scattering behaviors and classify the land cover of the Earth. This decomposition technique is based on the degree of polarization (DoP) and co-polarized phase-difference (CPD) of the measured polarimetric backscattering coefficients. We tested our method with the ALOS PALSAR (L-band) and RADARSAT-2 (C-band) quadruple polarimetric, and analyzed the performance by the comparison with the well-known three- and four-component decomposition techniques. Our method is quite simple and effective for the study areas such as sea, bare soil, forest, and urban area, etc. Generally, the backscattered signals can be decomposed into from single bounce, double bounce and multiple bounce returns of various parts of the structure. However, the orientation angle of scattering media, which is often ignored at the most of previous decomposition methods, affects the polarimetric radar signatures. The polarimetric signatures from man-made structures and vegetation have similar polarimetric scattering behavior due to the effect of the orientation angle. Thus the discrimination between man-made structures and the vegetated area from radar images has always been a difficult task. We, hence, also propose the decomposition method which can classify oriented urban areas into the double bounce man-made structures using cross-polarimetric phase difference.

***************

PolInSAR Complex Coherence Estimation Based on Similarity Test of Covariance Matrix
Chen, Si-Wei1; Sato, Motoyuki2
1Graduate School of Environmental Studies, JAPAN; 2Center for Northeast Asian Studies, Tohoku Univ., JAPAN

Most of polarimetric SAR interferometry (PolInSAR) data processing and applications are based on the polarimetric complex coherence descriptor which contains the full interferometric and polarimetric information. The reliable estimation of complex coherence is crucial for the accuracy of these processing and applications. Commonly, with the assumption of both stationarity and ergodic in mean for the statistic processes, a sample average is used to obtain the complex coherence estimation. The purpose and requirement for complex coherence estimation is to select sufficient and the most similar candidate pixels for sample average while keeps the assumptions and well preserves the details. Nowadays, several algorithms for PolInSAR complex coherence estimation are available. The present studies are always based on polarimetric information (intensity or span image) to select the edge-aligned window or candidate pixels with similar statistical character and do not obviously make use of the interferometric phase information for selection. However, polarimetric information is not sensitive to the interferometry. For PolInSAR, the interferometric phase is with paramount importance for target height inversion. The effective interferometric phase center is composed with different scattering mechanism contributions. For example, in forest terrain, with different dense and attenuations, there remains mainly three scattering mechanisms, volume scattering, ground-trunk scattering and surface scattering especially at lower frequency band. These scattering mechanisms have quite various interferometric phases. Therefore, during the procedure of coherence estimation, the selected pixels with different scattering mechanisms will lead to false average of the interferometric phase. In addition, the only polarization-based spatial average may inevitably include some pixels with different interferometric phases, which will cause phase errors and straightforwardly affect the following application. In this sense, in order to obtain an accurate and reliable estimation of PolInSAR complex coherence, both polarimetric and interferometric information need to be well considered. For PolInSAR, with the reciprocal condition, all the polarimetric and interferometric information are included in the complex Wishart distributed 6IA6 covariance matrix. Here a new estimation method is proposed based on similarity test of the Complex Wishart distributed PolInSAR covariance matrix. The advantage of this method is to take both polarimetric and interferometric information into the estimation procedure to select the most similar
candidate pixels for sample average and can obtain more accurate and reliable estimation. In order to avoid the tradeoff effect between polarimetry and interferometry, a double similarity test estimation scheme has been proposed. The derived similarity test indicator shows great sensitivity to both polarimetric and interferometric property. The full usage of information has the ability to select sufficient candidates with the most similar scattering mechanism. And a completely adaptive neighborhood with variable shape and dimension according to similarity test can be formed even without the pixel connection constrain. Also the sensitivity to the interferometric phase shows the potential to reduce the dependence on reference DEM to remove the topographic phase component before estimation. The efficiency of the proposed estimation scheme is demonstrated by PolInSAR data. The experimental results demonstrate that the speckle effect is greatly reduced while the details are well preserved. Meanwhile, the blur, dark ring and patchy look effects which usually occur in spatial average methods are well avoided. And from the quantitative evaluation and comparison, the accuracy and reliability of the proposed method for PolInSAR complex coherence estimation is also demonstrated. Moreover, since it can select the most similar sample pixels for estimation, this method is almost not affected by the size of the local estimation window which means a stable and robust estimator can be expected.

***************

Recent Polarimetric SAR Models for Danube Delta Monitoring using PALSAR Images
Totir, Felix1; Vasile, Gabriel2; Bombrun, Lionel3; Serban, Florin3; Raducanu, Dan1
1Military Technical Academy, ROMANIA; 2GIPSA-lab / CNRS, FRANCE; 3Advanced Studies and Research Center, ROMANIA

The Danube Delta is the second largest river delta in Europe and the best preserved on the continent. Largely a biosphere reservation (since 1938 in Romania), the Danube Delta represents a favorable place for the development of highly diverse flora and fauna, unique in Europe. Among these, the Letea subtropical forest was internationally recognized as a biosphere reserve under UNESCO’s Man and the Biosphere Program in 1992. The Danube Delta is a low alluvial plain, mostly covered by wetlands and water. The average altitude is 0.52 m ASL, with 20% of the territory below sea level, and more than half not exceeding one meter in altitude. A young region, in full process of consolidation and continuously expanding, with ever-changing landscapes, with an inherent complexity, the Danube Delta is a very challenging target for monitoring. Both difficult access and the special status of biosphere reserve of the region ask for non-intrusive monitoring methods. Vegetation cover, as well as almost continuous clouding over the region make optical surveillance a difficult task. Radar or, more precisely, SAR (Synthetic Aperture Radar) observation is the natural alternative. The complexity of the site provides an almost ideal environment for testing and evaluating the newest algorithms developed for analyzing and interpreting polarimetric SAR images. The analyzed data consists of PolSAR images acquired at L band by the ALOS / PALSAR system [1]. Firstly, the cross-polarization channels HV and VH are analyzed over wetlands. Secondly, an extensive panoply of information extraction, processing an interpretation algorithms are applied: parametric stochastic modeling (SIRV heterogeneous clutter models) [2], hierarchical segmentation [3], various decompositions (bistatic SVM) [4], etc. The obtained results are consistently compared against ground-truth and both model validation and conclusions are drawn therefrom.


***************

An Unsupervised Classification of Fully Polarimetric SAR Data using the PSO Algorithm and H/Î¼ Decomposition
Zhang, Z1; Zhang, J2; Yu, J1; Yan, Q2; Li, P2; Li, Y1; Yang, J1
1Wuhan University, CHINA; 2Chinese Academy of Surveying and Mapping, CHINA

With the emergence and rapid advancement of Synthetic Aperture Radar (SAR) technologies, including polarimetric SAR and interferometric SAR, accurate polarimetric classification has already attracted much attention from a wide variety of research communities. To date, several approaches for the classification of polarimetric SAR images have been proposed. Over the past two decades the algorithms based on the scattering mechanism of electromagnetic waves have gained prominence. Although some improvements have been made through these algorithms, a major concern today is still to continue to improve the accuracy in classification. In this paper, we introduce the PSO algorithm based on the H/Î¼ decomposition (H/Î¼-PSO) to classify polarimetric SAR images. The PSO algorithm, which was invented by Dr. Kennedy and Dr. Eberhart in
1995, is inspired by the social behavior of flocking birds or schooling fish, whose properties are used to accomplish a wide range of tasks in various areas of research on optimizing the complicated problems that are non-linear, and non-differentiable, including function optimization, neural networks, fuzzy system control and pattern classification. Being similar to other evolutionary algorithms, PSO is also operated by the value of individual adaptability, and searches each solution, called a ‘particle’, to choose the best one in the solvable space. Firstly, it initializes a group of particles randomly, and then reaches the optimization objectives through iterative operations. The motional direction and the displacement of each particle in the solvable space will be determined by a vector. Usually, a particle follows the current optimum particle to move and finally reach the optimal solution by an iterative search. In every generation, a particle tracks two extremes; one is the optimal value of the particle itself, called an individual extreme; the other is the optimal value of the whole group, known as the global extreme. Basing on the theory of PSO algorithm concluded above, the method adopted in this paper can be processed by the following steps:

1) Particle swarm initialization. Firstly, let m be the number of particles and generate m particles. Secondly, calculate the cluster centers of various categories as reference values of the particles’ locations. Also, the particles’ locations should be randomly increased and decreased from the reference values within a certain range in terms of the principle of PSO. This is because that the particle swarm is not able to move when all particles are in the same location;
2) Evaluate fitness of each particle. Notice that the Wishart distance measure is used to calculate the distance between a particle and the cluster center;
3) For each particle, compare its fitness value with its individual extreme (P_{ssub{id}}). If the current fitness is better than (P_{ssub{id}}), then (P_{ssub{id}}) should be replaced by the current fitness value. Also, if is greater than the global extreme (P_{gd}), update P_{gd} with P_{gd};
4) Update each particle’s velocity and location. 5) For each sample, determine its category in terms of the current particle’s location (i.e., cluster center) and nearest neighbor rules. If there are no samples classified into a certain category, this particle is discarded;
6) For each particle retained, compute the new cluster centers based on the clustering state of the samples. And then update the particle’s location and fitness value; 7) Judge whether the end condition is met; if not, return to Step 2), otherwise output the classification result.

The algorithm we have proposed effectively combines the advantages of H/Â with the PSO algorithm and performs well in polarimetric SAR image classification. The crucial point of this method is the process of initializing the particle swarm by the result of the H/Â classification, since it not only ensures that the classification result is H/Â in line with the H/Â mechanism, but also exerts the efficiency of PSO in the optimization problem. Comparison of experimental results proved that this new method is undeniably useful. However, there is still room for improvement. In future work, we will investigate the sensibility of our algorithm as a function of the fitness of particles. Furthermore, we will enhance our classifier by inducting anisotropy to this algorithm and explore a new method that can provide reasonable parameters.

***************

Regrowth Monitoring in Mining Areas Using Polarimetric and Dual-pol PALSAR Data
Uloupin, R.; Debiens, A*
1Tallinn University of Technology, ESTONIA; 2Catholic University Leuven, BELGIUM

Northeast Estonia is an industrial region which is known as surface and underground mining areas of oil shale. The mining area is surrounded by different land types - urban, agriculture, swamp. Due to the mining activities that have an effect on the surrounding environment the landscape goes through rapid changes in a short time. An important ecological aspect of the mining activities is the management of the landscape after the exploitation of the mining field. Current study is focused on monitoring the land cover change that is caused by the surface mining and re-growth of vegetation after abandoning activities. Secondary objective is to estimate vegetation types and stages of growth from quad- and dual-pol SAR data. For inter annual change detection PALSAR quad-pol and dual-pol data (HH, HV) were used. The change detection was carried out for summer (July 2007 and 2008) and for autumn (October 2007, 2008 and 2009). As a first step the change in backscatter was analyzed to estimate the general variations. Secondly the surface types were classified from quad-pol data based on H/A/Alpha classification. Maps of different land cover types (urban, agricultural, wetland etc.) as well as more precise vegetation type maps were created. Due to the insufficient amount of polarimetric data over the study area the dual-pol data were used to observe the temporal changes of land cover. The parameters retrieved from quad-pol data were compared against the classification maps retrieved from dual-pol imagery to identify the regions and parameters that were consistent with classification results from both datasets (polarimetric and dual-pol). Finally the changes in land cover type and vegetation growth over three years were detected. The results of change detection derived from quad-pol and dual-pol imagery were compared. The results of different change detection approaches over mining region are analyzed in the paper.

***************
Decomposition of Rotated Dihedral and Volume Scattering Components in Cross-Polarimetric SAR Observations
Hong, Sang-Hoon; Wdowinski, Shimon
1Korea Aerospace Research Institute, KOREA, REPUBLIC OF; 2University of Miami, UNITED STATES

Wetland InSAR works thanks to double bounce scattering, in which the radar pulse is backscattered twice from the water surface and vegetation. In this study, we analyze Radarsat-2 quadruple polarization (quad-pol) mode data acquired over the Everglades in south Florida. The wetland InSAR technique was applied to each polarization mode data independently for detecting surface water level changes. The results of phase information indicate that very similar fringe patterns related to water level changes were found in all four interferograms. The co-pol (HH and VV) results were expected, as both polarization components contribute to double bounce scattering. However, the cross-pol (HV and VH) results are very surprising, because the cross-pol signal has been considered by most vegetation scattering theories as representing volume scattering occurring in the upper section of the vegetation. Our cross-pol interferometric observations, which show water change fringes, suggest that the cross-pol signal reaches the water surface beneath the vegetation, just as the co-pol signal does. The simplest scattering mechanism that explains a cross-pol double bounce component is scattering by a rotated dihedral. Thus, we suggest that the cross-pol signal contains both rotated dihedral and volume scattering components.

We developed a new scattering formulation that accounts also for double bounce component in cross-pol. The coherency matrix approach, which is used to deal with non-reflection symmetric scattering condition, is proposed to decompose the cross-pol into volume and double bounce components induced by rotated dihedral plane with the orientation angle. Although the rotated dihedral component can be decomposed, their dominance in the cross-pol signal depends on the type and density of vegetation, as well as on the existence of flat water surface beneath the vegetation.

Keywords: Polarimetric synthetic aperture radar (POLSAR), Wetland interferometric SAR (InSAR), volume scattering, rotated dihedral scattering, polarimetric decomposition, Everglades.

***************

Comparison of Alos/Palsar Polarization Modes to Discriminate Land Use/Cover Classes in Eastern Amazon
Liesenberg, Veraldo; Wijaya, Arief; Glooguen, Richard
1TU Bergakademie Freiberg, GERMANY; 2Bogor Agriculture University, INDONESIA

Single, Dual and Quad Polarimetric ALOS/PALSAR data acquired in 2007 were analyzed for preliminary land use/cover classification. The images were acquired collected on January 02 for the single polarization (HH), on July 05 and August 20 for the dual polarization (HH and HV) and March 13 and April 28 for the quad polarization mode (HH, HV, VH, VV). A Landsat scene acquired on June 20 under a clear sky condition was used as reference. The study area is located in the surroundings of the Tapajós National Forest (Pará State, Brazil). It is a typical Amazon landscape site where shifting agriculture practices are common. The classes under study were primary forest, forest with timber exploitation and under recovery after fire events, secondary successions (early, intermediate and advanced), pasture and agriculture and new deforestation areas. SAR polarization images were extracted from Single Look Complex data and converted to backscattering values. We also apply texture analysis for each dataset. The combination with of Landsat data in the classification accuracy is also experimented. Each class was selected based on previous land use maps, visual interpretation and field work activities. In this study, we apply different classification methods (e.g. Multiple Discriminant analysis, Neural Networks, Maximum Likelihood and Interated Conditional Modes). Preliminary results showed that Maximum Likelihood-ICM classifier was more efficient than other classification methods. Compared to single polarization method, reasonable classification results were found in order with dual and quad polarization. However, better classification results were found with the combination of optical data. The best polarization to identify the classes was using at least the HH and HV input. A misclassification was still observed between different forest successional stages (e.g. intermediate and advanced) with forest with timber exploitation and primary forest in any polarization mode. Analysis of the optical data and field work activities reveals that this result may be related with the stage of the deforestation process that are difficult to measure using the SAR images only. Additionally, the scattering mechanism of each forest typology based on target decomposition was also explored using the dual and quad polarization. Small clear cut areas were better detected using the temporal decorrelation information coming from the two dates at dual and quad polarization mode. We conclude that the contribution of SAR data was important for general land use/cover mapping, and better results were obtained with the integration of optical data. In fact, change detection methods using temporal decorrelation should be considered and evaluated for other environmental conditions in the Amazon region. We also intend to demonstrate the classification performance by including the dual polarization information from ASAR/ENVISAT at C-band (VH and VV).

***************
Snow represents a basic reservoir of water within the global ecosystem. But over the last 30 years global warming is causing a substantial decline of this resource. Therefore the monitoring of snow cover dynamics plays an important role for weather forecasting and assessment of climate change. The ability to remotely sense the changes of snow cover and the physical properties of snow becomes of vital importance when focusing on large spatial scales. This investigation will provide first insights into the sensitivity of fully polarimetric X-Band SAR data with respect to snow parameters and changes in snow cover for hydrological and climatological research.

Fully polarimetric X-band data from TerraSAR-X are analyzed to obtain polarimetric parameters like polarimetric ratios and polarimetric coherences. In addition parameters such as entropy, anisotropy, mean alpha angle and mean beta angle are computed performing a polarimetric analysis on the eigen-basis. The scattering powers (Ps, Pd, Pv) corresponding to surface, double bounce and volume scattering components are obtained with a polarimetric model-based decomposition of the coherency matrix for an investigation of scattering mechanism within the snow covered area.

Hence, the idea is to analyze TerraSAR-X data from three different test sites, with snow and no-snow cover. The first test site is the Grand Mesa plateau, a large flat-topped mountain in western Colorado (USA). The second test site is a flat bay area around Churchill in Manitoba (Canada). Finally, the last test site is located close to the city of Sodankylae, situated in the heart of Lapland (Finland). All areas are most of the year covered by snow.

The data were acquired at three different dates, with a temporal distance of 11 days, between April and May 2010 with the TSX-DRA-Mode. In addition, field and meteorological data from collaboration partners are used for a first comparison to investigate the potentials and limitations of fully polarimetric X-Band data from TerraSAR-X for snow cover changes and derivation of snow parameters.

***************

Opium Field Detection in South Oxfordshire Using SAR Polarimetry
Walker, N; Marino, A
eOsphere Limited, UNITED KINGDOM

To-date the use of satellite imagery to monitor the growth of illicit crops such as marijuana, opium and coca has mostly been conducted using optical frequencies. However there are a number of problems commonly encountered with these techniques because of the varying spectral responses from different growth stages, plant density and health of the plants as well as the contamination caused by localised aerosols such as thin clouds, cirrus, haze and smoke. It is therefore useful to consider whether high resolution polarimetric SAR data can be applied to this application.

In this paper we present the results of an experiment whereby opium poppy fields were successfully detected in the south Oxfordshire region in the UK using RadarSat-2 quad-polarisation imagery. Opium poppies are cultivated for medicinal reasons in parts of the UK.

The locations of two fields of opium poppies were identified prior to the experiment and used as training data for an algorithm that exploits the polarimetric representation of targets contained in SAR data. The data was acquired on the 26th June 2010, approximately two months before the final harvesting of the crops.

The algorithm used is based on a perturbation analysis in the target space, which was originally designed for use on manmade land based targets [1] and which was later extended to consider ocean borne vessels [2] and depolarised target [3, 4] detection. The new methodology considers the calculation of a polarimetric coherence between the target of interest and its perturbed version. This operation is accomplished in a higher dimensional space (G-D complex) in order to accommodate a larger number of parameters needed to characterise a partial (i.e. depolarised) target.

The output from the algorithm identified locations that had a similar polarimetric signature in comparison to the training data set. Sites identified by the algorithm were then visited and it was found that poppies were indeed being cultivated in the fields at these locations. The authors do not have access to a full list of locations where poppies were being cultivated, but no other poppy fields were encountered whilst exploring the region covered by the image; i.e. poppy cultivation is relatively rare, and therefore it is highly unlikely that the technique was recording detections by coincidence.

The authors are aware that illegal opium cultivation in other countries might present a different set of parameters to those encountered in the UK. For example the poppies themselves may not be as well
fertilised, and the background crops will be substantially different from those being grown in the UK. The majority of crops in Oxfordshire are barley, wheat and oil seed rape.

Additionally, opium fields can have different polarimetric signatures in different maturation stages. Therefore ideally a time series of polarimetric images would be required to capture the seasonal evolution of these stages. In future work, the authors intend to acquire more data showing different plant maturation.


***************

The potential of TerraSAR-X in Assessing Forest Above-Ground Biomass in Scotland

Tan, Chue Poh1; Marino, Armando2; Woodhouse, Iain1; Cloude, Shane2; Suarez, Juan2; Edwards, Colin2

1University of Edinburgh, UNITED KINGDOM; 2AEL Consultants, UNITED KINGDOM; 3Forestry Commission UK, UNITED KINGDOM

In this paper, the estimation of above-ground biomass across the forests in Scotland using TerraSAR-X data is presented. The study area consists of both plantation and semi-natural forests and it covers extensive and diverse woodlands of native woodland with varied topography. The utilization of the full polarimetric TerraSAR-X technology to characterize the forest structure has made the estimation of the foliage cover, scattering mechanisms and biomass possible. TerraSAR-X has become a prominent tool to collect high-resolution and unique geometric accuracy data. Upon examining and retrieving the signals from the TerraSAR-X sensor, the analysis of the backscattering coefficient and scattering mechanisms of the forest cover is conducted to highlight the useful information carried by the TerraSAR-X imagery. The results show a great potential of TerraSAR-X in forest conservation applications and significant sensitivity to above-ground biomass estimation.

***************

Monitoring of Fine Scale Sea Ice Features in the Baltic Sea Using Polarimetric and Dual-Pol SAR Data

Uiboupin, R; Sipelgas, L

Tallinn University of Technology, ESTONIA

Monitoring of ice dynamics and ice type classification is an important task for understanding environmental changes as well as for safe winter navigation. SAR is a powerful instrument for detecting ridged ice regions, ice leads and cracks as the radar backscatter is strongly influenced by geometrical properties of the ice surface. Data from quad-pol and dual-pol SAR sensors like RADARSAT-2 and PALSAR enables to determine more precisely ice types compared to single polarization images. Use of dual polarization SAR imagery has proven to be beneficial for some applications as it has reduced the complexity, cost and data rate of SAR image while preserving most of the capabilities of quad-pol image. The focus of current study was on mapping the fine scale features of sea ice and on enhanced monitoring of small scale changes/processes in the NE Baltic Sea. Secondary objective was to compare the backscatter characteristics at different frequencies (C-band and L-band), polarizations (HH, HV, VV) and radar beam modes (quad-pol, dual-pol) to determine backscattering mechanism of different ice types. In order to determine the impact of weather conditions on backscatter variations meteorological data (wind measurements, air temperature, precipitation etc) from three different stations near the study area was also analyzed.

Sea ice classification from dual-pol RADARSAT-2 and polarimetric PALSAR imagery was performed. The ice type classification was based on analysis of covariance matrix elements and entropy/alpha/anisotropy parameters. The analysis of the classification maps showed that four ice types -level ice, fast ice, ridged ice, deformed ice and water - were identifiable from dual-pol SAR data. Also the locations and properties of ice leads and cracks, that are important factors from winter navigational point of view, were well identified on ice type classification maps derived from dual-pol imagery. The study provides additional information for enhanced ice monitoring in areas of higher interest (e.g. harbours, coastal zone, vicinity of ship lanes etc) using high resolution data at multiple bands and polarizations.

***************
Forest biomass estimation from Synthetic Aperture Radar (SAR) polarimetric backscattering measurements at low frequencies has been proposed in several works in the literature [1,2] based primarily on HV- and/or HH polarized backscatter. P-band backscatter has larger dynamic range and higher saturation level than L-band backscatter [1,2]. One of the key problems with this approach is the dependency of the backscattering - apart from the biomass level - on the topography of the forested scene and environmental effects such as precipitation. Furthermore, forest structure has an important influence on backscatter [3]: The stems contribute significantly to the total backscatter at long wavelengths [4]. The total intensity within an area is not only governed by the number of stems, but also by their shapes and sizes [5]. These issues are currently examined in the framework of BIOMASS, an ESA’s Earth Explorer Candidate Mission.

To overcome these shortcomings, this paper investigates the role that polarimetric decomposition of forest signatures into individual scattering components can play in order to enhance the biomass estimation. Foremost, a decomposition of polarimetric SAR data [6,7] into three canonical scattering mechanisms (volume, dihedral, and direct surface reflection) is utilized. The backscattering power of the three components is related to in-situ biomass measurements and LIDAR derived biomass estimates for two boreal forest test sites (Krycklan and Remningstorp) at L-band and P-band. The impact of temporal changes induced by changing weather conditions is analyzed by multi-temporal acquisitions. Slope effects are investigated using observations acquired from varying viewing angles. The performance is validated against 2D biomass maps derived from LIDAR measurements. In addition to this two-dimensional approach, three-dimensional images are produced from multibaseline interferometric POLSAR data leading to backscattering and scattering mechanisms maps in the vertical direction. This information is exploited to gain further insights of the biomass distribution inside forests.


**************

Differential Shift Estimation in the Absence of Coherence: Performance Analysis and Benefits of Polarimetry
Villano, M.; Papathanassiou, K. P.
German Aerospace Center (DLR), GERMANY

The estimation of the local differential shift between synthetic aperture radar (SAR) images has proven to be an effective technique for monitoring glacier surface motion. As images acquired over glaciers by short wavelength SAR systems, such as TerraSAR-X, often suffer from a lack of coherence, image features have to be exploited for the shift estimation (feature-tracking). The present paper addresses feature-tracking with special attention to the feasibility requirements and the achievable accuracy of the shift estimation. In particular, the dependence of the performance on image characteristics, such as texture parameters, signal-to-noise ratio (SNR) and resolution, as well as on processing techniques (despeckling, normalised cross-correlation versus maximum likelihood estimation) is analysed by means of Monte-Carlo simulations. TerraSAR-X data acquired over the Helheim glacier, Greenland, and the Aletsch glacier, Switzerland, have been processed to validate the simulation results. Feature-tracking can benefit of the availability of fully-polarimetric data. As some image characteristics, in fact, are polarisation-dependent, the selection of an optimum polarisation leads to improved performance. Furthermore, fully-polarimetric SAR images can be despeckled without degrading the resolution, so that additional (smaller-scale) features can be exploited.

**************
Collective Network of Evolutionary Binary Classifiers for Polarimetric SAR Images

Uhlmann, S.; Kiranyaz, S.; Ince, T.; Gabbouj, M.
1Tampere University of Technology, FINLAND; 2Izmir University of Economics, TURKEY

In this paper, we propose a collective network of (evolutionary) binary classifier (CNBC) framework to address the problems of feature/class scalability, feature selection and classifier evolution, and to achieve a high classification performance even though the training (ground truth) data may not be entirely accurate. The CNBC framework basically adapts a “Divide and Conquer” type approach by allocating several network of binary classifiers (NBCs) to discriminate each class and performs evolutionary search to find the optimal binary classifier (BC) in each NBC. Both visual and numerical performance evaluations of the proposed framework on the Flevoland, NL SAR dataset demonstrate its superiority and a significant performance gap against other classifiers in this field.

***************

Multitemporal PolSAR for Snow Cover Monitoring in the Boreal Forest Zone

Antropov, O.; Rauste, Y.; Häme, T.
VTT Technical Research Centre of Finland, FINLAND

Information about the extent and temporal dynamics of snow-covered areas (SCA) during the snow melt season is widely used in hydrological, meteorological and climatological applications and research related issues nowadays. The availability of data from space borne SAR sensors makes it possible to produce extensive snow maps to aid SCA monitoring process. Single polarization space borne SAR data have been used for regional-scale SCA monitoring for several years already. Utilization of currently available fully polarimetric SAR (PolSAR) data is expected to significantly improve monitoring capabilities regarding snow mapping accuracy and resolution of produced SCA map estimates.

The objective of this study was to develop a novel SCA mapping algorithm utilizing PolSAR data. As a basis for the algorithm the single-reference-image SCA method was adopted. At the first stage of the algorithm a ratio between processed SAR image and reference image is calculated. A predefined detection threshold is applied to this ratio afterwards, in order to discriminate between wet snow and bare ground areas and produce the wet snow cover map. Different modifications of the single-reference-image method were analyzed for multi-polarization data, with several combinations of polarimetric observables as well as total backscattered power used in the study. The optimal threshold level and its influence on the snow mapping accuracy, as well as a rational strategy for a choice of the optimal reference image were investigated.

A possibility of use of a second reference summer image was tested in order to develop an effective forest compensation procedure in snow-covered forested areas with encouraging results. In particular, cross-polarization channel of the second image was expected to provide a reasonable estimate for the volume scattering contribution from the forested areas.

Strong changes in temporal dynamics for selected polarimetric features were identified for several classes of the land cover data. They proved to provide a clear indication of the snow melting and flooding events in the area, for instance a significant increase of the volume scattering from wet snow (alpha angle up to 9 degrees compared to dry snow conditions), and a rapid increase of the double-bounce scattering mechanism contribution over flooded sparse forest on peat land.

The experimental data used in the study are represented by Radarsat-2 time series of 10 C-band PolSAR images acquired over the Sodankylä area in Finland during the snow melting season in 2009. For validation of the obtained results SCA estimates produced from Terra MODIS data were used. PolSAR derived SCA estimates also showed higher accuracy when compared to SCA maps derived from Radarsat-1 data using the Helsinki University of Technology SCA mapping method. Additional use of polarimetric features was also found to be useful for identifying the melting event more clearly.

***************

A Statistical Approach for Studying the Influence of In-Homogeneity in Pol-InSAR Data on Biomass Parameter Retrieval

Arnaubec, A.1; Roueff, A.2; Dubois-Fernandez, P.1; Refregier, Ph.2
1ONERA, FRANCE; 2Laboratoire Fresnel, FRANCE

Polarimetric synthetic aperture radar interferometry (PolInSAR) technique has shown its potential to retrieve forest biomass parameters. Several estimation methods have been developed based on backscattering models such as the Random Volume over Ground model (RVoG) [1,2]. Those methods assume that the data are statistically homogeneously distributed in the estimation window (ie. it is assumed that there is no variation of model parameters in the window). This hypothesis might be acceptable in plantation forest lying on flat topography. However, natural forests are known to present spatial variations which could be related to topography, species, natural causes such as storm related local event, water accessibility. As a result, trees in the forest might present significant height and density variations.
The study proceeds in two successive steps exposed below. We propose to investigate the influence of inhomogeneously distributed vegetation height or attenuation on the estimated vegetation height. The issue will be addressed both using theoretical and numerical approaches. The first approach allows one to understand the underlying behaviour using an approximation only valid for small variations. The second approach enables one to go further in the investigation and provides a validity domain of the approximation.

Then, we will explore how the regions can be chosen in order to increase the homogeneity of the selected pixels. Such a region selection can be obtained using a segmentation technique based on a recently introduced approach which goal is to provide statistically homogeneous partitions using both Polarimetric and Interferometric characteristics [3]. We will analyze on synthetic examples the estimation improvement and we will illustrate the results on real PolInSAR images.


**************

Identifying Persistent Scatterers in Open and Natural Areas
August, Yitzhak; G. Blumberg, Dan; R. Rotman, Stanley
Ben-Gurion University of the Negev, ISRAEL

The PSI (Persistent scatterers Interferometry) method relies on identifying a small group of scatterers that maintain high phase reliability over a relatively long period of time. This study demonstrates a new algorithm to identify natural PSC (persistent scatterer candidates) targets in non-inhabited areas. The application of our PSC selection process is conducted for a natural arid scene as opposed to the more common use of the PS technique, which is done mostly for urban areas with strong reflection structures (manmade objects).

We present a novel, robust, method to identify PSC in open fields and in places of low backscattering (natural areas). Our method is based on the amplitude time history signature of each point. The main difference between urban areas and open field areas is the low reflectance and less deterministic behavior of the scatter; hence it is a challenge to detect these low reflection and stable points. Conventional methods for PSC detection require a preprocessing of fine calibration and are mainly suitable to use in urban areas, but may fail when used in the open fields. One of the advantages of our method is the use of a simple process of calibration which is based only on the flight geometry and gain factors without any auxiliary data or assumptions.

Consider a vector consisting of the measurement of a PS point as a function of time. We can express this signal as an amplitude times a phase. The amplitude differs between PS points; however potential PS points should correlate spatially and temporally in terms of the phase, independent of their amplitude. Our method improves locates several candidate points with a narrow phase distribution and thus, enables the location of PSCs in open areas.

**************

Energy-Spectrum-Based Adaptive Windowing for Speckle Filtering of PolSAR Data
Qi, W; Li, Y; Hong, W; Yin, Q
Institute of Electronics, Chinese Academy of Sciences, CHINA

Speckle filtering of polarimetric synthetic aperture radar (PolSAR) data is of paramount importance for information extraction, image interpretation, and terrain classification. The basic principle is to select pixels of the same scattering characteristics to be included in the filtering process. Based on this principle, many PolSAR filters select pixels with similar scattering mechanisms within a fixed size moving window. However, in these schemes, there exists trade-off between the extent of speckle noise suppression and the capability of preserving fine textures and dominant scattering mechanisms. Consequently, it is necessary to consider adaptive selection of filtering window size according to the local variation of target scattering mechanisms.

Many adaptive window selection methods have been proposed, most of them depending on the local statistics in the spatial domain such as mean and standard deviation. However, the mere use of some statistical parameters could not fully describe distribution of pixel values, and might lead to inaccurate selection of window size.

In this paper, we propose a novel approach for the adaptive determination of filtering window size according to the local variation of polarimetric scattering characteristics of targets. The span image is
used in the determination procedure, because span has a lower speckle noise level than single polarization channels and is more sensitive to the polarimetric mechanism variation. Using the span image, an iterative procedure is performed to determine the local homogeneity for each pixel. First, filtering window size is set to 3*3 as an initial value. Then, we practice an enlarge-window-test by calculating the similarity between the images in a 3*3 window and a larger 5*5 window. The similarity of two images is defined as the correlation coefficient, i.e., cosine of the angle, between their energy spectrum functions. Unlike using mean and standard deviation, applying the correlation coefficient between two energy spectrum functions could precisely describe the local homogeneity. If the coefficient surpasses a threshold, the larger window will be selected. Until first fail, the enlarge-window-test will be repeated to find the largest window for each pixel.

The detailed procedure of the adaptive selection of filtering window size for each pixel is stated as follows: Step 1) Set window size to n*n (e.g., 3*3). Step 2) Calculate the total polarimetric power (span) image within the n*n and (n+2)*(n+2) window, which are denoted as I(n) and I(n+2). Step 3) Compute the energy spectrum functions of I(n) and I(n+2) using two dimensional FFT, which are denoted as S(n) and S(n+2). Step 4) Resample S(n+2) to an n*n sized image, and calculate the correlation coefficient δ of S(n) and S(n+2). Step 5) If δ surpasses a threshold (e.g. 0.82), enlarge window size (n=n+2) and go back to step 2). If not, terminate and return n as window size.

To illustrate the effects of the proposed algorithm, several experiments are performed using ESAR and AgriSAR data. Adaptive windowing implementations of the refined Lee filter and the scattering-model-based filter are achieved and compared with the original filters. The results demonstrate that our approach boosts the effectiveness of PolSAR speckle filters in reducing speckles in homogeneous areas and preserving textures and polarimetric scattering characteristics in high contrasting areas. Besides, the proposed algorithm enhances the performance of PolSAR filters as a preprocessing step for terrain classification especially in agriculture areas.

***************

Forest Structural Parameters and Growing Stock Volume Retrieval in Thuringian Forest using L-band Polarimetric Radar
Chowdhury, Tanvir Ahmed; Thiel, Christian; Schmullius, Christiane
Friedrich-Schiller-University Jena, Germany

Recent studies showed that there is a correlation between backscatter coefficient of synthetic aperture radar (SAR) and the retrieval of growing stock volume, GSV. However, it was also recognized that saturation level of the radar backscatter is quickly achieved, despite further increases of GSV. To avoid this effect, polarimetric technique may be one of the solutions to increase the saturation level of GSV. This includes the derivation and investigation of various polarimetric indices involving different decomposition parameters. L-band polarimetric synthetic aperture radar data acquired by ALOS-PALSAR sensor over the thousands of forest stands in thuringian forest, central part of Germany, have been evaluated for the derivation of forest parameters with focus on GSV. A large set of inventory ground data such as tree age, tree height, tree diameter, different types of species and dominant species of composition, tree volume, relative stocking were measured of these large forest stands. Investigation will be initiated by establishing a relationship between GSV and polarimetric phase difference, where sensitivity for forest parameters and saturation level increment are expected. Afterwards polarimetric parameters derived from decomposition techniques will be investigated. The relationship between polarimetric parameters and GSV can be initially described using simple and multiple regression models. Further forest parameters to be implemented in this study are tree height, tree diameter, tree age, relative stocking, and tree species.

***************

Multibaseline Polarimetric SAR Interferometry Forest Height Inversion Approaches
Lee, SeungKuk; Kugler, Florian; Hajnek, Irena; Papathanassiou, Kostas
German Aerospace Center, Germany

Polarimetric Synthetic Aperture Radar Interferometry (Pol-InSAR) is a recent radar remote sensing technique, based on the coherent combination of radar polarimetry (Pol-SAR) and SAR interferometry (InSAR) which is substantially more sensitive to structural parameters of volume scatterers (e.g. forest) than conventional interferometry or polarimetry alone [1]. Pol-InSAR height inversion performance is basically influenced by non-volumetric decorrelation and vertical wavenumber (Kz). Uncompensated non-volumetric decorrelation reduces the successful implementation of Pol-InSAR parameter inversion techniques. In addition to undesirable decorrelation contributions, inappropriate vertical wavenumber (e.g. too large or too small Kz) for forest height also leads to ill-conditioned height inversion problems. For reducing or mitigating these difficulties multibaseline Pol-InSAR inversion approaches have been recently proposed. There are principally two different methods to combine multibaseline measurements: The one is the combination/selection of individually inversion heights by using the ratio of coherence region [2] because the shape of ellipse can be used as an indicator for the
estimation accuracy for each individual inversion measurement. The second criterion used to combine multibaseline inversion results is the conventional interferometric height accuracy defined by the standard deviation of interferometric phase [3] and the vertical wavenumber. The height accuracy can also be a parameter to assess the precision of forest height inversion. In this paper, these different approaches for combining multibaseline Pol-InSAR inversion results are discussed and analyzed in detail. For this study, the multibaseline Pol-InSAR data acquired by DLR’s E-SAR system over the variety of forests characterized by different stand and terrain conditions are used.


Automated K-Wishart Clustering of PolSAR Images

Doulgeris, A. P.; Anfinsen, S. N.; Eltoft, T.
University of Tromso, NORWAY

Many studies have shown that synthetic aperture radar (SAR) amplitude distributions are non-Gaussian and polarimetric SAR covariance matrix distributions are non-Wishart, but very few examples have taken these non-Gaussian statistical characteristics right through to practical image analysis and Wishart clustering remains dominant. We present our current system to do fully unsupervised, K-Wishart mixture model clustering, of polarimetric, multi-looked, SAR data [1], including finding the optimum number of classes [2], estimating the equivalent number of looks, and utilising the latest methods of log-cumulants [3] for parameter estimation and goodness-of-fit testing [4].

The clustering is based upon an expectation maximisation algorithm with method of moment parameter estimation, and includes an additional goodness-of-fit testing stage to allow splitting and merging of clusters. We explain these stages, and describe some of the important characteristics of the cluster results. Particularly, the ability to use sub-sampling to achieve a coarse or fine clustering result, and the effect of choosing different model functions. The algorithm is not affected by initialisation conditions, because no initialisation is required, and the resulting number of clusters can be interpreted as those that are statistically supported by the actual data, with respect to the given confidence level of the Goodness-of-fit testing stage and the number of samples in the cluster. The framework is readily adaptable to other statistical models, and only requires that the matrix-variate probability density function and expressions for the first few matrix log-cumulants are known. We demonstrate its use with both simulated and real data-sets, for both the K-Wishart and standard-Wishart models.

References


Topographic Mapping with P-band SAR System with Wide Beam Width

Xia, D²; Li, Y; Pottier, E¹; Hong, W¹; Wang, P²; Xiang, M²
¹University of Science and Technology of China, CHINA;
²National Key Lab. of Science & Technology on Microwave Imaging, The Institution of Electronics & Chinese Academy of Science, CHINA;
³University of Rennes-1, FRANCE

For different SAR systems working at different bands, the beam width of the antenna can vary from 1 to 2 degrees, e.g. X-band, to up to even 46 degrees, specially for the IECAS (Institute of Electronics of Chinese Academy of Sciences) P-band SAR system. Along with such variation, for P band SAR system with wide beam width, within one aperture the azimuth squint observing angle of a same area wood vary a wide range, hence, the radar geometry would change and cause the polarization orientation angle induced by terrain slopes differ significantly from the ones obtained under the assumption of narrow beam, i.e. the right-side looking geometry. Whereas, the slope-induced changes in polarization orientation angle γp can be related to the radar-look angle, terrain slopes in the range direction,
and terrain slopes in the azimuth direction. Although the polarization orientation angle $\psi$ can be obtained from the fully polarimetric data, there are still two unknowns, i.e. the terrain slopes both in range and azimuth direction, but only one observation. To avoid such ambiguity of solving the terrain measurement several methods have been developed to increase additional prior information. However, all these methods are based on the narrow beam and right side looking assumption. In this literature, the relationship between the azimuth squint observing angle and polarization orientation angle would be studied theoretically. And consequently, based on the time-frequency decomposition method we take advantage of the wide beam effects of P band SAR system to introduce additional observations of the polarization orientation angle within different sub-apertures along the azimuth direction. However, since the requirement of resolution and coherent length of sub-aperture conflicts with each other, the guide line for the selection of sub-apertures will be analyzed to compromise between the above two requirements also. Whereas, since the variation of polarization orientation angle can be obtained directly from the radar geometry aspect, the compensation for the wide beam effects would also be accomplished by time-frequency decomposition in the range-doppler domain for the accuracy of geophysical parameter inversion. At last the method presented in this paper will be validated with the data sets of the IECAS P-band SAR system which will come soon.

***************

Robust Estimation of the Vertical Structure of Forests with Coherence Tomography
Pardini, Matteo; Papathanassiou, Konstantinos
German Aerospace Center (DLR), GERMANY

In the last decade, the accurate and reliable estimation of forest biomass has gained increasing attention within the SAR remote sensing community, given its crucial role in terrestrial carbon budget. First approaches for biomass estimation were based on the allometric relation between biomass and top canopy height; however, the performance of such estimation is limited in forest systems with strong density variations. Recently, experimental evidence has suggested the possibility to extend the height to biomass allometry by considering the vertical biomass distribution function.

Conventional SAR Tomography techniques have demonstrated the capability of imaging the vertical structure by exploiting the spatial (i.e. baseline) diversity of the acquisitions, possibly jointly with polarization diversity. However, especially considering the implementation of space-borne missions, temporal decorrelation problems limit the number of suitable acquisition for the tomographic processing. For this reason, the Coherence Tomography (CT) technique has been recently proposed. In brief, CT aims at decomposing the vertical profile on a set of orthogonal basis functions through a least squares (LS) fitting with the available complex coherences (possibly obtained by combining different polarizations), after compensating them for the phase histories produced by the ground topography and the volume depth along the baselines. So doing, the tomographic reconstruction reduces to the estimation of the coefficients of the series and can be carried out with a low number of acquisitions. However, if the topography and the volume depth are not known or estimated with enough accuracy, the related phase errors dramatically affect the CT inversion, with misleading results in terms of vertical profiles. The same effect shows up also in presence of phase non-idealities due to atmospheric propagation and inaccuracies in the relative radar platform position measurements between the acquisitions.

This work tackles the problem of the robust estimation of forest vertical profiles by means of CT in presence of the above mentioned phase errors. To counteract their effects, the proposed solution consists in relying as much as possible on the coherence amplitudes. It can be demonstrated that with the coherence amplitudes the reliable LS estimation is possible of the absolute values of the basis coefficients; to estimate their signs, the coherence phases can be used. This two-step CT is expected to furnish more accurate results with respect to the original CT inversion at the complex level. To increase the robustness, a constraint can be added to the LS estimation by exploiting the orthogonality of the basis functions. The performance in profile estimation of the proposed algorithm will be analyzed in controlled conditions by means of simulated coherences, with reference to realistic vertical profiles, and pros and cons discussed. In addition, first-cut real data results will be shown by using SAR data acquired with the DLR’s E-SAR airborne sensor.

***************

Polarimetric Investigation of a Two Surface Layer Structure using L-band PALSAR data
Al-Kahachi, Noora; Papathanassiou, Konstantinos
Panagio
Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, GERMANY

The use of fully polarimetric SAR (Synthetic Aperture Radar) in two layer surface probing can reveal facts about the regolith surface and subsurface geometric and dielectric characteristics. In this sense an analytical scattering model of a two layer structure, with small scale roughness, had been proposed [1]. The model intends to extract information about the subsurface permittivity, with a side looking SAR at a frequency, which is low enough for penetrating the upper layer. The model takes into account the distributed nature of surface and subsurface. Upper layer properties are
Hypothesis

For surface missions in polarimetric SAR, the required structure, advantages and influences that become apparent are short, and the ice water interface can be noticed by comparing the backscattered power from floating ice and grounded ice [2]. Therefore it is a good candidate for evaluating the model's performance. Further adjustment of the model is necessary regarding the surface and subsurface description, due to the different spatial properties of the interface for different sites. Other factors might influence the propagating electromagnetic wave like the crystal structure of the ice and the bubbles that might be present in the ice layer. We present the analysis of ALOS PolSAR data and discuss the inversion performance.

[1] Polarimetric SAR Investigation for a Two Layer Structure, Noora Al-kahachi ; Konstantinos P. Papathanassiou, EUSAR 2010


Heterogeneous Clutter Models for Change Detection in PolSAR Imagery

Phan, X. V.; Bombrun, L.; Vasile, G.; Gay, M.
GIPSA-lab, FRANCE

In the last decade, the new generation of airborne and spaceborne SAR sensors allow us to capture Earth surface images with very high resolution. The main advantages of these systems are the ability to operate at any time of day, in any weather conditions, and to improve the image resolution for a given aperture size. Therefore the possibility to characterize objects has become more and more attainable. In addition, the short revisit time provided by future SAR-based missions enables the development of techniques of change detection and their applications. In this paper we are particularly interested in computing the disparity map which contains the changes detected from Polarimetric SAR (PolSAR) images.

For low resolution images, the homogeneous hypothesis of the PolSAR clutter can be used. A change detection process is then applied using the classical Gaussian model [1]. The disparity map is obtained by computing the maximum likelihood function.

However, with the new SAR sensors, only a small number of scatterers are present in each resolution cell. Therefore the assumption of homogeneity can be reconsidered. In this paper, we introduce a new change detection algorithm based on the Spherically Invariant Random Vector (SIRV) model, which was designed specifically for the analysis of heterogeneous clutters. Under the SIRV model, the target vector \( \mathbf{k} \) is defined as the product of a square root of a positive random variable \( t \) (representing the texture) with an independent circular complex Gaussian vector \( \mathbf{z} \) with zero mean and covariance matrix \( \mathbf{M} = \mathbb{E}[\mathbf{z}\mathbf{z}^\dagger] \) (representing the speckle).

Once the \( N \) texture random variables \( \{t_1, \ldots, t_N\} \) are computed according to the SIRV estimation, a stochastic model can be introduced to describe it. In this context, we have focused on five probability density functions: Gamma, Inverse Gamma, Fisher, Beta, Inverse Beta distributions.

We then propose four algorithms of change detection based on different criteria including: Gaussian (sample covariance matrix estimator), Gaussian (fixed point estimator), Fisher texture-based and KummerU-based (Fisher distributed texture).

The proposed algorithms have been validated on both simulated and real PolSAR images on the mount area of Taconnaz (the area is located on the border of France, Switzerland and Italy). The TerraSAR-X images have been provided by the German Aerospace Agency (DLR) through the project "Monitoring Temperate Glacier Activity by X-band Polarimetric SAR Interferometry". This work has been funded by the EFIDIR project of the French Research Agency (ANR) (www.efidir.fr).


A Complete Coverage of Log-Cumulant Space in Terms of Distributions for Polarimetric SAR Data

Bombrun, L.; Anfinsen, S.N.; Harant, O.
GIPSA-lab, FRANCE; University of Tromsø, NORWAY

This paper introduces two new families of Probability Density Functions (PDFs) for the polarimetric target vector and the polarimetric covariance matrix. These families complete the diagram spanned by the second and third-order matrix log-cumulants, and contribute to
a holistic theory for statistical modeling of Polarimetric Synthetic Aperture Radar (PolSAR) data based on the doubly stochastic product model with a scalar texture variable. The new PDFs result from using a Beta and Inverse Beta distributed texture variable, and are referred to as the $W$ and $M$ distribution, since the respective PDFs contain the Whittaker $W$ and the Whittaker $M$ function. The characteristic of the new PDFs is an ability to model data with extreme skewness (low and high, respectively), but associated with less variance than the heavy-tailed distributions known from the literature (that is, the $K$, $G_\alpha$ and Kummer$U$ distributions). This property is especially relevant for speckle filtered data with textural variability. The utility of the models is demonstrated with multi-frequency real data.

For low resolution PolSAR images, it is generally sufficient to model the variability of distributed targets as fully developed speckle. This assumption leads to the complex multivariate Gaussian distribution for single-look data and the complex Wishart distribution for multilook data, that have been widely used in many application such as filtering, classification and change detection. With the new high resolution PolSAR sensors, the number of scatterers present in each resolution cell decreases considerably, which renders the former assumption invalid. To account for this, alternative clutter models have been proposed in the literature founded on the scalar product model. In this model, the spatial heterogeneity of the mean radar reflectivity is incorporated by introducing a scalar random variable $\tau$ representing the natural variability of the target, referred to as texture. For single-look data, the observed target vector $\mathbf{y}$ is decomposed as the product between the square root of $\tau$ and an independent, zero mean, complex, circular Gaussian random vector $\mathbf{k}$, representing fully developed speckle. For multilook data, the observed covariance matrix $[\mathbf{T}]$ is expressed as the product $\tau^2 [\mathbf{M}]$, where the covariance matrix $[\mathbf{M}]$ follows a complex Wishart distribution.

For the texture modeling of PolSAR data, distributions from the Pearson system are commonly used. This system consists of a set of distributions families, including the Gaussian, Gamma and Beta ones. The distributions in the Pearson system are generally characterized by two quantities, $\beta_1$ (square of the skewness) and $\beta_2$ (kurtosis). An alternative to the traditional $\beta_1/\beta_2$ parameters has been proposed by J.-M. Nicolas: the $k_i/k_3$ plan where $k_i$ is the log-cumulant of order $i$. This plane, which is completely covered by the set of five distribution families (Gamma, Inverse Gamma, Fisher, Beta and Inverse Beta PDFs), has the advantage of separating between “standard” light-tailed distributions and heavy-tailed distributions.

In this paper, the authors derive the analytical expressions of the target vector (for single-look data) and covariance matrix (for multilook data) PDFs for Gamma, Inverse Gamma, Fisher, Beta and Inverse Beta distributed texture. They are respectively the $K$, $G_\alpha$, Kummer$U$, $W$ and $M$ distributions. The benefit of these multivariate distributions will be shown by plotting the matrix log-cumulant diagram for various data-set acquired with different frequency bands ($X$, $C$, $L$ and $P$-bands). We further present a number of different scalar moments of the covariance matrix (specifically moments of the log-determinant and the trace of the covariance matrix, in addition to mixed moments) and show how they are used to obtain estimators for the distribution parameters with low bias and variance.

***************

Characterization of Alpine Glaciers using Fully-Polarimetric TerraSAR-X Data

Sanjuan-Ferrer, M.J.$^1$; Hajnsek, I.$^2$; Papathanassiou, K.$^3$

$^1$German Aerospace Center (DLR), GERMANY; $^2$ETH Zurich, SWITZERLAND

The objective of this paper is to evaluate the role and potential of polarimetry in ice and glacier terrain and analyse the information content using fully-polarimetric TerraSAR-X data within a month period from different points of view: the study of polarimetric features changing with time, the polarimetric Coherent Scatterers (CSs) detection and the monitoring of moving features.

For studying the polarimetric features, the eigen-based decomposition approach is used to interpret the scattering mechanisms existing in a distributed area such as ice and calculate the scattering entropy $H$ and the alpha angle $\alpha$. The entropy can be interpreted as a measure of the randomness of the scattering process and the alpha angle indicates the type of scattering process.

Recently, the CSs technique was introduced in order to detect scatterers with a deterministic point-like scattering behaviour (commonly associated with high scattering amplitudes, deterministic phases, high spectral correlation and high interferometric coherence values) in different natural and urban scattering scenarios, using a single polarimetric SAR image. In the special case of a natural volume scatter like ice, the CSs detection is possible due to the textured regions (crevasses) and features (moraines) on glaciers. Up to now, the detection of CSs has been investigated using only a single-polarization by means of TerraSAR-X data and now the intention is to extend such information making a polarimetric CSs detection, which can be potentially used for retrieving changes and different behaviours in ice.

Lastly, the detected CSs are used to monitor the moving features, typical of glacier environments. For all this analysis three quad-pol datasets acquired between the 13th April 2010 and the 5th May 2010, with a repeat-pass of 11 days, in strip map mode and 150 MHz of bandwidth were analysed. The test sites under investigation are the Aletsch Glacier (Switzerland)
and the Glacier d’Argentière (France), which correspond to mountain glaciers that move some centimetres per day. In the case of the Glacier d’Argentière in-situ measurements are available and even some artificial targets (corner reflectors) are located in the area under investigation, which are useful as a reference point and for validation purposes.

***********************

Regrowth after Forest Fires in Greece as seen with ALOS PALSAR Data

Debeni, A1; Polychronaki, A2; Uiboupin, R2
1Catholic University Leuven, BELGIUM; 2European Space Agency, ITALY; 3Tallinn University of Technology, ESTONIA

In the summer of 2007, massive forest fires broke out in Greece, mainly affecting the Peloponnese peninsula in the south of Greece, a catastrophic event which resulted in approximately 1500 km² of forest burnt. The primary objective of this research is to investigate the usability of SAR data in identifying vegetation types and stages of vegetation re-growth in the fire affected areas. We investigate whether and which different polarisation states or their combinations and different frequencies can give more information about vegetation status and change. Dual-pol and quad-pol ALOS PALSAR and ERS SAR image data were used for this investigation.

Furthermore, classification results obtained from ALOS northeast Estonia. Given that the two study influence of vegetation type and topography from the Greek study area are compared with vegetation PALSAR and ERS SAR data from a study area located in areas are dissimilar in both vegetation and topography, the on choosing optimal polarimetric data was investigated.

***********************

Coastal Deformation and Global Mean Sea Level Monitoring using GPS and InSAR Techniques

Usifoh, Ehimbledon Saturday; Usifoh, Ehimbledon Saturday
Centre for Geodesy and Geodynamics, Toro, NIGERIA

Interferometric Synthetic Aperture Radar (InSAR) provides all-weather imaging capability for measuring ground surface deformation and inferring changes in the land surface characteristic. InSAR enables scientist to monitor and characterise hazards posed by Volcanic, seismic, and hydrogeologic processes by landslides and wildfires, and by human activities such as mining and fluid extraction. measuring how landslides develop and activate in a prerequisite to minimizing associated hazards. mapping surface subsidence to extraction of fluid during exploitation of ground water aquifers or petroleum reservoirs, provides fundamental data on aquifer or reservoir properties and improve our ability to mitigating undesired consequences. InSAR imagery can provide near real time estimate of fire scan extents and fire severity for wildfire management scientist. InSAR and GPS are very important role for understanding and forecasting natural hazards.

***********************

Monitoring of Dams and Bridges using Interferometric Synthetic Aperture Radar (InSAR) at

Ali, Salamatu1; Ali, Salamatu Loraba1
1centre fo geodesy and geodynamic,federal ministry of science and technology, NIGERIA; 2centre for geodesy and geodynamic,federal ministry of science and technology, NIGERIA

During the recent synthetic aperture radar interferometry (InSAR) has become an important tools for precise measurements of the earth’s surface topography and deformation. Interferometric synthetic aperture radar is a radar technique used in geodesy, its a tool for measuring earth’s surface deformation. This paper presents an overview on the recent developments in InSAR Applications with emphasis on dams and bridges, using diapason software for natural hazard monitoring and subsidence monitoring along coastal region in Nigerian most especially dams. Due to the collapse of goroyo dam in sokoto Nigeria proper monitoring needs to be taken into consideration. Recent result on the use of repeat-pass interferometry for mapping seismic and volcanic deformation monitoring landslides ans subsidence are described.

***********************

Topographic Mapping with P-band SAR System with Wide Beam Width

Xia, D1; Li, Y2; Pottier, E3; Hong, W2; Wu, Y2; Wang, P2; Xiang, M2; Wang, Y2; Tan, W2
1University of Science and Technology of China, CHINA; 2National Key Lab. of Science & Technology on Microwave Imaging, The Institution of Electronics Chinese Academy of Science, CHINA; 3University of Rennes-1, FRANCE

For different SAR systems working at different bands, the beam width of the antenna can vary from 1 to 2 degrees, e.g. X-band, to up to even 46 degrees, specially for the IECAS (Institute of Electronics of Chinese Academy of Sciences) P-band SAR system. Along with such variation, for P band SAR system with wide beam width, within one aperture the azimuth squint observing angle of a same area would vary a wide range, hence, the radar geometry would change and cause the polarization orientation angle induced by terrain slopes differ significantly from the ones obtained under the assumption of narrow beam, i.e. the right-
side looking geometry. Whereas, the slope-induced changes in polarization orientation angle can be related to the radar-look angle, terrain slopes in the range direction, and terrain slopes in the azimuth direction. Although the polarization orientation angle can be obtained from the fully polarimetric data, there’re still two unknowns, i.e. the terrain slopes both in range and azimuth direction, but only one observation. To avoid such ambiguity of solving the terrain measurement several methods have been developed to increase additional a priori information. However, all these methods are based on the narrow beam and right side looking assumption. In this literature, the relationship between the azimuth squint observing angle and polarization orientation angle would be studied theoretically. And consequently, based on the time-frequency decomposition method we take advantage of the wide beam effects of P band SAR system to introduce additional observations of the polarization orientation angle within different sub-apertures along the azimuth direction. However, since the requirement of resolution and coherent length of sub-aperture conflicts with each other, the guide line for the selection of sub-apertures will be compromised between the above two requirements also. Whereas, since the variation of polarization orientation angle can be obtained directly from the radar geometry aspect, the compensation for the wide beam effects would also be accomplished by time-frequency decomposition in the range-doppler domain for the accuracy of geophysical parameter inversion. At last the method presented in this paper will be validated with the data sets of the IECAS P-band SAR system which will come soon.

***************

Biomass Estimation as Function of Vertical Forest Structure. Potential and limitations for Radar (and LiDAR)
Torano Caicoya, Astor; Kugler, Florian; Hajnsek, Irena; Papathanassiou, Kostas
German Aerospace Agency (DLR), GERMANY

Forest biomass stock, spatial distribution and dynamics are unknown parameters for many regions of the world. Today’s information is largely based on ground measurements on a plot basis without coverage in many remote regions that are fundamental for the global carbon cycle. Thus, a method capable of quantifying biomass by means of Remote Sensing (RS) could help to reduce these uncertainties and contribute to a better understanding of it. In this study the capacity to improve the estimation of above-ground biomass (AGB) with a new approach based on forest vertical structure and its potential to improve RS estimations is analyzed.

Height to biomass allometry allows biomass estimations from remote sensing systems capable to resolve forest height (LiDAR and polarimetric SAR interferometry (Pol-InSAR)). However, this approach meets its limitations for forest ecosystems under changing conditions in density and structure. To improve biomass estimation accuracy, additional parameters need to be measured. Pol-InSAR and LiDAR allow getting besides forest height vertical backscattering profiles which are connected to forest vertical structure. Thus, due to the relation between structural parameters and AGB expressed by the Structure to Biomass allometry, AGB can be potentially inverted from these systems.

The best characterization of forest vertical structure is obtained using the Legendre polynomials. Biomass profiles can be then characterized by the decomposition into a set of Legendre-Fourier basis functions. This method is able to accurately reconstruct vertical biomass profiles with low frequency features.

Vertical backscattering profiles are strongly dependent on the sensor used as the resulting profiles are very sensitive to the wavelength and system geometry. E.g. LiDAR profiles are more sensitive to leaves and crowns while Pol-InSAR tends to reconstruct more the woody compartments (stems and branches). In this study, vertical backscattering profiles from short footprint airborne LiDAR and Pol-InSAR data are evaluated for their potential to reconstruct vertical forest structure. With the Legendre decomposition it is possible to parameterize the vertical backscattering profiles and relate them to forest biomass; even though for each remote sensing system different calibration methodologies must be derived. A first step is achieved using the calibration of backscattering signal with known biomass levels showing optimum results. In order to reduce the need of known parameters a new calibration methodology that exploits height to biomass allometric relations has been derived. Inversions using this methodology are tested for LiDAR and SAR profiles showing good correlations for an optimum subset of samples. As each system (frequency) is sensitive to certain biomass components an underestimation is generally expected. Research in this area is ongoing and will be presented with special focus on each system capacity to reconstruct forest vertical biomass distribution for broader sets of samples.

***************
Leaf Area Index and Biomass Assessment over Tropical Peatland Forest Ecosystem using ALOS Palsar and ENVISAT SAR data

Wijaya, Arije; Susanti, Ari; Liesenberg, Veraldo; Wardhana, Wahyu; Yanto, Edi; Soepriyadi, Djoko; McFarlane, Craig; Qomar, Nurul

Remote Sensing Group, TU-Bergakademie Freiberg, B.v-Cottastr. 2, 09599, Freiberg 09599, GERMANY; Faculty of Forestry, Gadjah Mada University, Bulaksumur, Yogyakarta 55281, INDONESIA; Faculty of Natural and Agricultural Sciences, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Austra, AUSTRALIA; Faculty of Agriculture, Riou University, Jl. HR Subrantas km 12,5 Pekanbaru, Riou 28293, INDONESIA

 Provision of accurate forest parameter properties is important as a basis for forest resources monitoring and carbon cycle assessment. The present study aims to model leaf area index (LAI), above ground biomass and carbon stocks over tropical peatland forests using single polarization SAR, interferometry SAR (InSAR) and polarimetric interferometry SAR (PolinSAR) data. Single band ALOS Palsar data (HH band, acquired on November 17, 2008) and polarimetric data (HH, VV, HV and VH, collected on April 4 and May 5, 2007) are used for the study. A series of ENVISAT ASAR data (5 datasets) collected in 2004 - 2005 are also used to model the forest properties. Landsat ETM data collected on January 22, 2009 is also used as a reference. The relationship between forest parameters and normalized radar backscattering is estimated using empirical models, and the preliminary results show that Polarimetric SAR data has better correlations with the LAI and biomass than single polarimetry SAR data. Experiments with PolInSAR data will be observed, and we expect that the estimates are more accurate than previous results. The forest parameters modeling considers different forest classes in the study area, which are primary forest, secondary forest, agricultural/plantation forest and sparse vegetation/shrub classes. These field data were collected during field work in March - April 2009 and the reliability of identified forest classes was also assessed from available Landsat ETM data. Estimation of LAI and biomass using InSAR and PolInSAR data consider interferometric coherence and decorrelation parameters. Analysis will be conducted on the basis of statistical correlations between radar data and modeled forest properties. The possibility to assess LAI and forest biomass over large forest region is experimented using mosaic ALOS Palsar data available from Kyoto and Carbon (K&C) Project Initiatives. This study focuses on a unique tropical peatland ecosystem in Kampar Peninsula, Sumatera, Indonesia, which has great potentials as carbon sinks and/or sources. Only few studies have been conducted in the study area due to limited satellite and field observation data.

Keywords: PolinSAR, InSAR, peatland forest, biomass, LAI, ALOS Palsar, ENVISAT ASAR

Multiscale Analysis of SAR and ASAR River Plumes and Coastal Features

Redondo, J.M.; Redondo, J.M.2; Sekula, E.1; Martinez-Benjamin, J.I.

1Univ. Politecnica de Catalunya, SPAIN; 2U.P.C., SPAIN; 3U.P.C., POLAND

Due to high cost of satellite images, and the wealth of new physical local information obtained from the sea surface, it is worthwhile to implement new types of image analysis that can relate dynamical turbulence information to measurable multi-scale descriptors. SAR and ASAR (Advanced Synthetic Aperture Radar) are well designed to determine locally the roughness of the sea surface, and we use this property to investigate the structure of river plumes and of coastal flows, the polarimetric information from the SAR can also be used to investigate the lower atmosphere. The topological characteristics of the shape of the river plumes marked by the rugosity of the river brakish water floating over the salty Mediterranean water, when analysed in detail reveals a very complex nature. Several features, such as the local Reynolds number, the Richardson number and the distance from the wall, all affect the multifractal spectra as well as the maximum Fractal Dimension or Kolmogorov capacity Lane Serf(1993). The asymmetry between the coastal side and the deep ocean side of the river plumes, may be used to improve the estimates of local eddy diffusivity from satellite images. The relationships presented relating the structure functions and the multifractal indicators, agree with a 2D generalized Richardson’s dispersion law (Castilla et al. 2007).

Distinct fractal curves in both nearshore and outshore environmental cases are caused by the different conditions, the free-jet-like structure is not limited by the coast like in a wall-jet-like structure, (Sekula et al. 209,2010) but the influence of the shallower bathymetry and its influence is shown to affect the scaling. In the case of wind forcing or of convective structures affecting the ocean surface we have to take into account the scale to scale topology of the flow so that the scale to scale transfer properties may be very different according to the dimensionality of the flow (2D or 3D dominant features) that affect, not only the higher complexity isolines (maximum value of the fractal dimension) but also affect factors like the range of scales or the different influence of the average number of image pixels considered. Different visualization techniques are useful, when density differences are important the reflected SAR behaves like a surface tension (Bragg scatter) analyser and allows to distinguish the limits of jets or wakes thanks to changes in the physical roughness of the surface and of its contours, these techniques are similar to those used in

140
the laboratory, see Redondo et al.(1995) and Platonov et al.(2008, 2009) for further discussion. The relationship between the structure functions and the multifractal spectra can be used to estimate the local ocean surface diffusivity (Sekula 2011).

Castilla R., Redondo J.M., Gamez P.J. and Babiano A. (2007), Non Linear Processes in Geophysics, 14, 139-


***************

Detect Urban Poverty Pockets with Radarsat-2 Ultra Fine Beam Images. The Rosario City Case - Argentina. Corti, Carlos G.1; Ducati, Jorge2; Araki, Hideo2; López, Diego1 1Universidad Nacional de Rosario, ARGENTINA; 2Universidade Federal do Rio Grande do Sul, BRAZIL; 3Universidade Federal do Paraná, BRAZIL

Pockets of Poverty or Slum Areas are in all big cities from the Argentine Republic (and neighboring countries). Their permanent growth due migration from the rural areas to big cities and from a persistence migration from neighboring countries seeking for better conditions of life wrongly fuelled by an Argentine economic program with a strong currency but very poor chances of jobs, increase daily all kind of migration of people trying to escape from a middle rural poverty gets inside to the violence and strong poverty from the big cities, so difficult to escape. In the last year 2001-2002 poverty in Argentina was increased by a strong and exceptional economical recession, with national economic default, and an inverse process started: migration from neighboring countries returned home but millions of Argentine lower income working class got in "sudden poverty" (definition done by the World Bank in another economical crisis or strong recession for similar problems in another countries in Africa or Asia).

Information concerning big cities in countries like Argentina requires nearly continuous acquisition of data to formulate and monitor Governmental, Provinces and Municipalities programs against poverty and lack of social dwelling. These policies and programs might range from the social, economic, and cultural domain to the context of environmental and natural resource planning.

The role of planning agencies is becoming increasingly more complex and is extending to wider range of activities. Consequently, there is an increased need for these agencies to have timely, accurate, and cost effective sources data of poverty and potential violence areas. Several of these data need are well served by satellite image interpretation that can provide information concerning to urban Pockets of Poverty. Is not usual to find urban Radar Fine Resolution satellite images researches with the help from optical images to help Municipalities and States to detect and monitor this problem with fast and relatively low cost information. This project would be the continuation and deepening of the investigation done during the GlobeSar2 Program (1997 - 2004) with the support of Radarsat-1 and the CCRS (Canadian Center for Remote Sensing).

During the GlobeSar2 Program we got positive answers for the detection of Poverty Pockets) through the use of images Radarsat-1 and Spot (panchromatic). It is our intention to use images Radarsat-2 Ultra Fine Beam to get new ways to detect Urban Poverty Pockets under the SOAR Program (Science and Operational Applications Research) 2009-2013, with the support of the CCRS (Canadian Center for Remote Sensing) and MacDonald Dettwiler (MDA) - Canada, with a new and advanced technology which was not possible to get in 1997 when the GlobeSar2 Program was launched with images of Radarsat-1.

Also taking advantage of the new polarimetric characteristic of Radarsat-2, Quad Fine images will be used in this research. The processing to be done with the quadpolarized images include polarized ratios, Cloude-Pottier, Freeman-Durden and Pauli
decompositions. With detectors the del images. de

data. SAR number points Boundary multilook images.

initial data, provides which detection the original
detectors employed in this work are based on the
Kullback-Leibler, Bhattacharyya, Rényi (order β) and
Hellinger divergences. Analytic expressions are provided
for these distances under the complex Wishart model,
and their main properties are commented. Monte Carlo
results present evidence that the Kullback-Leibler
detector outperforms the others, including the original
proposal by Gambini et al., when empirical false-alarm
rate and execution time are used as performance
metrics. These detection procedures are applied to real
SAR imagery, using the result of the adapted k-means
algorithm proposed by Cao et al. (2007) as initial
boundary.

References
Cao, F., Hong, W., Wu, Y. & Pottier, E. (2007), 'An
unsupervised segmentation with an adaptive number of
clusters using the SPAN/H/a /A space and the Complex
Wishart clustering for fully polarimetric SAR data
analysis', IEEE Transactions on Geoscience and Remote
Sensing 45(11), 3454-3467.

Polarimetric synthetic aperture radar (PolSAR) images
are affected by speckle noise, making image processing
applications a difficult task. Edge detection is one of
such applications, its objective being the search for
transitions between different regions which exhibit
common properties. Edge detectors were successfully
employed in Gambini et al. (2006, 2008) for univariate
SAR data, and in Frey et al. (2010) for multilook PolSAR
data. The edge detection proposed in those articles has
three main steps: proposal of initial regions (in
automatic, semiautomatic, or manual way); detection of
a few points which belong to the edge and, finally,
definition of the region contour using B-Splines among
the detected points. In this manner, the technique is
local and it provides control over the result through the
number of points to detect and the specifics of the B-
spline. The original proposal consists of forming strips of
data around segments that span from the centroid of
the initial region to the background. Once strips are
collected, each one is scanned looking for the point
whose division satisfies a maximum likelihood criterion.
This proposal is open to a variety of implementations,
and some of them are further explored in this work.
This paper compares four alternative approaches based
on stochastic distances and, thus, five edge detectors
for multilook PolSAR data are analyzed. The four novel
detectors are obtained employing (h,Φ) divergences, a
class of stochastic measures proposed by Salicru et al.
(1994). In all cases, we assume that the polarimetric
SAR images are well described by the complex Wishart
law (Frey et al. 2010, Lee & Pottier 2009). Whereas the
original proposal seeks for the division that maximizes a
likelihood function, the new approach determines the
points which maximize stochastic distances between
the models that describe the two induced regions of the
strip.

Improved Ship Detection in Polarimetric SAR Images by
Log-Space Estimation
Anfinsen, S.N.; Tao, D.; Brekke, C.
University of Tromsø, NORWAY

In this paper we address a limiting factor of standard
ship detection algorithms for polarimetric SAR which is
overlooked in the literature: The detection problem
consists of a composite hypothesis test where all
parameters of the statistical model for background
clutter must be estimated. This prompts a modification
of the sampling distribution for the test statistic used in
the detection. If not accounted for, the uncertainty in
the model parameters will lead to an actual false alarm
rate which does not meet the specified one.

As a study case we use the polarimetric whitening filter
approach to ship detection proposed by Novak et al.
(Novak et al., 1993), which is still one of the dominant methods in the field. We adopt the K distribution as a model for the background clutter, both for single-look complex and multilook complex data. We further review state-of-the-art algorithms for estimation of the complete set of model parameters: the scale matrix, equivalent number of looks and K distribution shape parameter. They are all based on logarithmic transformations, reflecting that the log-space appears to be the natural arena for analysis of radar data (Anfinsen, 2010).

Simulations are used to assess the impact the new parameter estimators have on detector performance, as compared to standard estimators. That is, we study the effect discrepancy between actual versus specified false alarm rate. We also attempt to correct the sample distribution of the test statistics to match the actual and specified false alarm rates.


**************

Preliminary Studies on a Target inside a Urban Canyon using POLINSAR Data.

Colin-Koeniguer, E.; Sar, N.; Thirion-Lefevre, L. 

1ONERA, FRANCE; 2SONDRA, FRANCE

The urban environment is very complex to interpret on a high resolution radar image, partly because of the presence of many geometric effects due to a lateral line of sight, the double bounce, the very strong dynamic between the edges of buildings and horizontal surfaces, the presence of urban canyons, the artifacts due to the imaging process, and so on. It is then very difficult to interpret and distinguish all the effects observed, and also to predict them.

In this paper, we are particularly interested in understanding the urban canyon on PolInSAR data. An urban canyon is an artifact of a urban environment similar to a natural canyon, and can be defined as the free space located between two vertical walls. It is a simple element to describe but provides a difficult multipath environment to understand. Its interpretation on a PolInSAR image is already sufficiently complex to be the subject of this paper.

Our ultimate goal is to determine for which configurations a target located within an urban canyon can be detected thanks to multipath, and to find the best method of detection associated. In this context, polarimetry and interferometry are expected to be valuable tools to analyze and differentiate the different electromagnetic returns obtained on an urban canyon. We propose in this paper to use results of simulations. At first, we analyze the range profiles, without taking into account the Doppler integration effects. We are studying in particular the influence of diffraction, and the number of multipath observed. With an electromagnetic simulation tool, we will try to see if we are able to predict that number and to determine how sensitive it is to the radar configuration. Finally we will study to what extent polarimetric interferometry may help us to interpret the range profiles.

**************

Identification of Structural Changes Caused by Weed Infection in Agriculture by Optical and Radar Data

Nádor, Gizella1; Surek, György2; Fényes, Diána2

1Institute of Geodesy, Cartography and Remote Sensing, HUNGARY; 2Institute of Geodesy, Cartography and Remote Sensing, HUNGARY

The Remote Sensing Centre (RSC) of the Institute of Geodesy, Cartography and Remote Sensing (FOeMi) has provided many services in the past 30 years to the Ministry of Agriculture and Rural Development (MARD) and the Ministry of Environment and Water (MEW). FOeMi also accumulated operational experiences in the applications of remote sensing. The unique methodology of the operational Crop Monitoring and Production Forecast Programme (CROPMON, 1997 - 2003) provided an excellent methodology basis for further development. One of the operationally proven programme was the Western Corn Rootworm (WCR) damage identification, which demonstrated the potential in the integrated assessment of optical and radar (ALOS PALSAR) satellite images to assess and identify the disorder and structural changes caused by WCR larvae. Using polarimetric radar technique increased the accuracy significantly. The accuracy was more than 80%. Based on the achieved objectives of that project there is potential in the integrated analysis of optical and radar images to assess and identify disorders and structural changes in agriculture.

In most of the cases the healthy, weed-free cropland has a structure in order. This structure is determined by the unique sowing and plant-to-plant distances. Several plant diseases, weed infections can cause disorders and structural changes in cropland. According to our experience, this type of geometrical changes can be well identified by using polarimetric radar images (RADARSATZ, ALOS PALSAR) with different wavelengths (C-, L-band).
We analyze agricultural damages in different croplands which result in structural changes. In this project we are eager to complete the methodology to identify these agricultural damages based on the integrated use and data process of optical and radar satellite images. We focus on the identification of the weed infection in croplands (especially ragweed infection on sunflower land and weed infection on cereal-stubbles).

We have carried out our assessment on two study areas which are both 25x50 km². Under this project we have collected reference data of the weed-infected and weed-free (control) parcels on the selected study areas. Based on the integrated analyzes of different types of optical and radar images we have prepared weed-infection maps which are double-checked by ground observations. We calculate the spectral index features of the reference parcels derived from optical images (SPOT, DMC, Landsat TM). We also determine their polarimetric features (entropy, anisotropy) derived from radar images (RADARSAT2, ALOS PALSAR). We evaluate their efficiency and accuracy to identify weed infection by statistical comparative analysis of reference parcels.

The satellite image acquisition/purchase has carried out with our accepted SOAR-EU (called by ESA) proposal (EU 6741), entitled as "Identification of structural changes in agriculture by radar polarimetry".

***************

Using Quad-Pol and Single-Pol RADARSAT-2 Data for Monitoring Cold Alpine and Outlet Antarctic Glaciers.

Harant, O.; Le Meur, E.; Gay, M.; Vasile, G.; Ferro-Famil, L.; Trouvé, E.; Drouet, A.S.

1Gipsa-lab / IETR, FRANCE; 2LGGE/UJF, FRANCE; 3Gipsa-lab, FRANCE; 4IETR, FRANCE; 5LISTIC/UdS, FRANCE

Cold glaciers are glaciers frozen to the bedrock at a temperature inferior to 0 degrees C, resulting in insignificant movement and almost no erosion. The first test site is the Taconnaz cold glacier located in the French Alps. The glacier flows down to the altitude of about 1700 m ASL above the Taconnaz village in a small valley orthogonal to the Chamonix valley. Due to the bedrock topography, a high ice cliff develops over most of the glacier width separating the glacier into an upper accumulation area and a lower ice tongue [1]. The large ice falls breaking off the glacier at 3300 m ASL are responsible for large avalanches of snow and ice which can cause serious damage in the valley.

From the size point of view (especially the aspect ratio), outlet glaciers are very close to mountain glaciers. Measurements of ice flow through coastal outlet glaciers offer a good proxy for the total ice sheet ablation (especially in Antarctica where surface melting is negligible). Temporal variations of in this flow regime indicate volume variations more inland within the ice sheet and are therefore symptomatic of large-scale mass balance changes with sea level implications [2]. The second test site consists in the Astrolabe glacier test zone, near the Dumont d’Urville French base from the Terre Adelie sector, Antarctica. Since January 2010, this test site has been instrumented with a permanent GPS net over the glacier grounding line and with three C-band corner reflectors by the LGGE and the GIPSA laboratories.

This paper presents the preliminary analysis of RADARSAT-2 data over the Taconnaz and the Astrolabe glaciers. From January to June 2009, seven SLC Quad-Pol images have been processed and analyzed for the Taconnaz glacier. For the Astrolabe glacier, an interferometric couple acquired in January 2010 is presented. The proposed information extraction, processing an interpretation algorithms includes, cross-polarization channels HV and VH analysis, parametric stochastic modeling (SIRV heterogeneous clutter models) [3], hierarchical segmentation [4], differential interferometry, texture tracking [5], various polarimetric decompositions (H/alphaA and TSVM), etc. The obtained results are consistently compared against ground-truth and both model validation and conclusions are drawn therefrom.


***************
Characterizing the Back-Scattering Properties of a Forest by Polarimetric SAR Tomography at L- and P-Band

Frey, Othmar; Meier, Erich
1ETH / University of Zurich, SWITZERLAND; 2University of Zürich, SWITZERLAND

Forest canopies are semi-transparent to microwaves at both frequency bands, L-band and P-band. As a consequence, a number of scattering sources and different types of scattering mechanisms may contribute to a single range cell of a SAR image. By appropriately combining SAR data of multiple parallel flight paths, a large two-dimensional aperture is synthesized, which allows for tomographic imaging of the three-dimensional structure of such semitransparent media and the underlying ground.

In order to explore in detail the back-scattering behavior of radar signals within a forest a non-model-based time-domain back-projection (TDBP) tomographic imaging approach was pursued.

In particular, three different direction-of-arrival estimation techniques, multilook beamforming (MLBF), robust Capon beamforming (RCB), and MUSIC beamforming, were implemented in order to focus two airborne multibaseline SAR data sets at L-band and P-band.

In terms of focusing quality, an unprecedented level of detail was obtained using the proposed TDBP-based tomographic imaging approach:

- gaps in the canopy due to features like small forest roads are well visible in the tomographic image, for instance.
- Thus, the three-dimensional tomographic SAR imagery provides a good basis to investigate the back-scattering properties of the forested area at L-band and P-band.

With prospective spaceborne SAR remote sensing missions, such as BIOMASS at P-band, Tandem-L, or DESDynl, both at L-band, which are all aimed at global mapping and monitoring of carbon stock by assessing the above ground biomass of forests, establishing a good understanding of the interaction of microwaves at L-band and P-band with forests is critical in order to develop reliable biomass products.

Within this work, the SAR tomography data products at L-band and P-band were analyzed with respect to their ability to map structural features of the forested area under study, such as the detection of the ground level underneath foliage, forest height, as well as the prevalent scattering mechanisms. The analysis of the three-dimensional data cubes was aimed at identifying

- which frequency, which polarization, and which focusing technique (MLBF, RCB, or MUSIC beamforming) is best suitable to reveal certain features of the forest, and
- how accurately these features are detected.

It was found that, at L-band, the main back-scattering contributions are observed at both the ground level and around the tree top.

A comparison of the back-scattering locations with histograms of the tree heights as estimated from the difference between the DSM and the DEM from airborne laser scanning clearly showed that backscattering from the canopy is actually located at treetop level.

Thus, the structural information obtained from the SAR tomography data sets at L-band is in agreement with the cross-reference data.

By contrast, at P-band, the canopy of the forest under study is virtually transparent to the microwaves. The ground level is well detected in all polarization channels at L- and P-band, the detection being slightly superior at P-band.

It was also observed that RCB and MUSIC allow for an improved detection of the location of the main back-scattering contributions as compared to MLBF.

Analyzing the polarimetric decompositions as a function of height indicated that, within the forest, surface scattering occurs scarcely, even at L-band, and only in the case where no understory is present. Interestingly, the back-scattering classification does not change much as a function of height within the forest volume.

At P-band, where scattering at the ground level dominates, the entropy/alpha plots show hardly any surface scattering but mostly dipole scattering and volume scattering.

***************

Use of PALSAR and TerraSAR-X for Tropical Forest Stratification

Larouche, C.L.; Niamen, D.; Routier, J.B.; Giraud, A.; Frison, P.L.; Pottier, E.; Rudant, J.P.
1University Rennes 1, FRANCE; 2University Paris-Est, FRANCE; 3ONF-International, FRANCE

Considering the global warming and a future Post-Kyoto mitigation mechanism, critical formation is needed to facilitate forest carbon stocks estimation. In this context, remote sensing is a valuable tool allowing repetitive observations over wide forested areas. Particularly, SAR data allow for the monitoring of tropical regions characterized by quasi-permanent cloud cover limiting optical observations.

Several spaceborne SAR sensors have been launched since 2007, operating at L band (ALOS-PALSAR), C band (RADARSAT-2) and X band (TerraSAR-X). The diversity of the frequency bands as well as the polarization configurations allows a better discrimination of the different land use/land cover.
The goal of this work is to assess the potential of the ALOS PALSAR sensor for the forest stratification and to show the improvement by combining TerraSAR-X dual polarimetric mode. The observations of PALSAR, acquired at a large wavelength (\(\lambda = 23.6\) cm) able to penetrate the forest canopy, in the Fully Polarimetric mode (FP) are sensitive to the forest geometrical structure. However, TerraSAR-X sensor, due to its short wavelength (\(\lambda = 3.1\) cm) and very high resolution, is very sensitive to the canopy texture. Consequently, this sensors are really complementary. In addition, the potential of partial radar polarimetry (hh/hv, vv/hv, hh/vv and lh/lv) is also investigated by simulations from PALSAR fully polarimetric data. In order to find an appropriate combination between PALSAR and TerraSAR-X for land use discrimination over tropical environment especially for forest stratification, we evaluate the capabilities of the each polarimetric mode. The methodology of this work is based on previous work using AIRSAR data [3] and [4], where the SVM classification was found to be more efficient than standard algorithms requiring an a priori assumption on the polarimetric coherency matrix distribution (Wishart distribution).

Thus, in addition to the covariance matrix of each polarimetric mode, other parameters containing polarimetric information are combined. These parameters include among parameters derived from the Cloude and Pottier decomposition\(\times\)other, the H/A/ [1, 2], or the degrees of coherence between linear or circular polarizations. We also include textural information from the measured intensities, and from circular intensities for the FP mode. We focus our study over the southern Cardamoms mountain in Cambodia where the Royal Government of Cambodia have taken significant steps toward Reducing Emissions from Deforestation and Forest Degradation (REDD). In this context, the Office National de Foresterie International (ONFI) is conducting a global mapping and monitoring of this area which constitutes an important ground truth to assess the potential of using PALSAR and TerraSAR-X data for forest stratification according to carbon and biomass growth. Landscape of the area is composed of semi-alpine forest, hill evergreen forest, lowland evergreen forest, open forest, and melaleuca forest. Each of this landscape have different geometrical structure and/or different texture which is particularly relevant for our study.

First results show that PALSAR data allows good discrimination between lowland evergreen forest, open forest, and degraded forest. The contribution of TerraSAR-X data, will improves the discrimination of smaller forest areas and enhances the discrimination of textured areas.

References


***************
Cosmo SkyMed Dual-Polarization Mode to observe Gulf of Mexico Oil Spill

Nunziata, Ferdinando; Migliaccio, Maurizio; Montuori, Antonio

Università di Napoli Parthenope, ITALY

The Deepwater Horizon oil spill is probably the largest accidental marine oil spill in the history of the petroleum industry. The spill stemmed from a sea-floor oil gusher that resulted from the April 20, 2010 Deepwater Horizon drilling rig explosion in Gulf of Mexico. The explosion killed 11 platform workers and injured 17 others. Following the accident about 4.9 million barrels (780 million cubic meters) of crude oil have been released. It was estimated that 53,000 barrels per day (8,400 barrels per day) were escaping from the well just before it was capped. Some of the oil reached the surface to form a slick that has spread across a portion of the Gulf, threatening the Gulf’s wildlife, seafood industry and local economy. Dispersants sprayed on the oil slick by BP caused much of the oil to sink, and some oil may never have reached the surface.

Many satellite pictures of the spill have been made visible by ocean observing systems to help scientists in analyzing the effect of the spillage and its extension. Synthetic Aperture Radar (SAR) data, due to SAR all-weather day and night capabilities together with fine spatial resolution, played and are still playing a fundamental role. Among the SAR systems currently available, the Italian Cosmo SkyMed is very interesting from an operational viewpoint since, being a constellation of X-band SARs (3 out of 4 satellites are currently in orbit), it is characterized by a very short revisit time and it is able to operate in dual-polarization mode (Ping Pong mode).

In this study the capabilities of dual-polarization Ping Pong mode are firstly exploited to observe the Deepwater Horizon oil spill. A data set consisting of 13 HH-VV Ping Pong mode Single Look Complex (Level 1A) SAR data has been acquired over the polluted area from April, 24 up to the end of September. Each data is characterized by a spatial resolution of 15x15 meters (azimuth x ground range) and the scene size is 30x30 Km.

A multi-polarization analysis has been undertaken in
order to characterize the contrast, i.e. the ratio between the Normalized Cross Section (NRCS) relevant to the slick-free and oil-covered sea surface, both in the HH and VV channels.

Experimental results show that the contrast measured in HH polarization is typically larger than the VV one. Moreover, contrast values, as expected, become smaller as long as they are measured towards the edges of the spill.

A polarimetric study has been undertaken in order to exploit the peculiarities of the Ping Pong mode to observe oil at sea. Following this rationale, a simple physically-based filter has been developed to observe oil in dual-polarized data. Experimental results show the effectiveness of the proposed approach which is able to provide a logical true and false output which is very much suitable from an operational viewpoint.

In summary, polarimetric characteristics of CosmoSkyMed are firstly analyzed and exploited to observe oil spill in Gulf of Mexico. First results obtained by processing a large data set of HH-VV polarized SAR data are very much interesting from both a theoretical and operational viewpoint.

**************

Case Studies of Ship Classification from SAR Data based on Polarimetric Scattering Characteristics
Yang, Jingsong
Second Institute of Oceanography, CHINA

Case studies of ship classification from NASA SIR-C SAR and NASA JPL AIRSAR data based on polarimetric scattering characteristics are presented in this paper.

Four steps as follows are carried out: (1) the rough sketches of ships are obtained by using edge detection and mathematical morphology approaches. (2) The polarimetric scattering characteristics of each pixel is obtained by using target decomposition methods such as Pauli decomposition, Sphere-Dihedral-Helix (SDH) decomposition, Surface-Double Bounce-Volume (SDBV) decomposition, Moriyama decomposition, four component decomposition, and Cameron decomposition. (3) Scattering types of each pixel are merged from results of different decomposition methods. (4) Ships are classified into six types according to their scattering types.

**************

TropiSCAT : a Ground based Polarimetric Scatterometer Experiment in French Guiana Forests
Koleck, T.; Bordieres, P.; Rocco, F.; Le Toan, T.; Villard, L.; Albinet, C.; Lasne, Y.

1 CNES, FRANCE; 2 ONERA, FRANCE; 3 Politecnico di Milano, ITALY; 4 CESBIO, FRANCE; 5 CESBIO/CNES, FRANCE

Tropical forests present the major part of the world forest biomass and their changes in biomass by deforestation and/or by forest regeneration affect strongly the terrestrial carbon budget. To measure with accuracy tropical forest biomass and its temporal change is one of the objectives of the BIOMASS mission, a candidate for the ESA 7th Earth Explorer Mission.

The retrieval algorithms currently developed for BIOMASS are based on the use of backscatter measurements derived from intensity, polarimetry and interferometry. For tropical forests with very high biomass density ( > 300 t/ha), for which intensity inversion provides biomass values with low accuracy, the PolinSAR measurements become the key measurements. However, the condition to have exploitable interferometric information is to have high temporal coherence over forests for time intervals compatible with the BIOMASS mission. During the TropiSAR experiment, performed in August 2009 in French Guiana, the temporal coherence has been found high ( > 0.8) for time interval up to 22 days (Dubois-Fernandez et al., IGARSS 2010). In order to complement the airborne datasets, a ground based experiment over tropical forests is necessary to produce a well controlled dataset in various seasons and weather conditions.

In this context, the TropiSCAT ground based experiment is proposed in order to acquire a comprehensive dataset which will be used to refine the BIOMASS retrieval algorithms.

The experiment is designed to acquire the polarimetric intensity and the complex coherence in HH, VV and HV, together with a vertical imaging capability, and in time scales ranging from diurnal, weekly, monthly, up to one year of observation and possibly beyond.

The instrument must allow an automatic measurement cycle, with remote control capabilities. It is developed with a state-of-the-art instrumentation (a Vector network Analyser, P band antennas, a computer and RF switches box) to be assembled and installed on a tower overlooking a tropical forest. A calibration procedure will be developed in order to ensure the quality of the results during all the experiment duration (more than one year).

The Guyaflux tower in Paracou, French Guiana, has been selected to support this experiment. This site,
managed by INRA (National Agronomical Research Institute), has the following advantages:

- the French Guiana forest is one of the world forests with highest biomass density and highest number of tree species, thus constituting one of the most complex and challenging forest ecosystems for the BIOMASS mission,
- the test site (Paracou area) was overflown by TropiSAR campaign in August 2009; the interpretation of ground based experiment data will allow in depth understanding of the scattering mechanisms in airborne observations and by extension, in the forthcoming spaceborne BIOMASS observations,
- the Guyaflux tower (55 m) is used for continuous carbon flux measurements. Studies are foreseen to compare the tower flux measurements with outputs of carbon models constrained by the biomass retrieved from TropiSAR,
- detailed and comprehensive ground data are collected or recorded continuously for the flux experiment (meteorological data, soil moisture) and for the Paracou forest survey (tree measurements).

The first test experiment will be done in October 2010, to check the instrument capabilities and the calibration procedure. The final instrument set up will be mounted on January 2011 for continuous measurements during one year and beyond.

This paper will present the TropiSCAT experimental concept, and will describe the experimental set up, together with the first test results.

***************

**PolSAR Classification based on the SIRV Model with a Region growing Initialization.**

Formont, Pierre\(^1\); Trouve, Nicolas\(^2\); Ovarlez, Jean-Philippe\(^2\); Pascal, Frederic\(^2\); Vasile, Gabriel\(^4\); Colin-Koeniguer, Elise\(^2\)

\(^1\)SONDRA & ONERA, FRANCE; \(^2\)ONERA, FRANCE; \(^3\)SONDRA, FRANCE; \(^4\)GIPSA-lab, FRANCE

Polarimetry has been studied for many years in SAR. Due to the enormous quantity of SAR images acquired by satellites or airborne systems, there is an evident need for efficient automatic analysis tools. This paper describes an unsupervised classification technique for polarimetric radar images.

Formerly, the sensors typically had relatively low resolutions. This made possible to use a Gaussian model for the distribution of the backscattered signal. Nowadays, fully polarimetric high resolution sensors are more common and can reach up to centimeter resolutions. This yields a higher heterogeneity in the clutter, especially in urban areas, where the clutter can no longer be modeled as a Gaussian process.

In order to model the texture distribution, more complex models have been introduced such as the K-distributed clutter or F-distributed clutter. While those approaches are statistically satisfying, they are highly time-consuming because they need to estimate many parameters. Moreover, the data volume acquired by high resolution sensors is very large. Thus, practical applications of such models on large images are difficult.

Recent advances in the field of SIRV (Spherically Invariant Random Vectors) allow the modeling of non-Gaussian clutter as a compound Gaussian process. A texture invariant (CFAR-matrix) estimator of the covariance matrix has been derived and applied, in particular for polarimetric SAR classification by Vasile et al [1]. Spatial features extraction is improved by the Fixed Point estimation, but is still not sufficient to retrieve all spatial features in urban settings.

In this paper we propose to apply a region growing process as an initialization to a SIRV based classification technique. As the region growing process is shape constraint, spatial features are better delineated and the samples used for the estimation of the coherency matrices are more adapted. Then a statistical clustering technique adapted to the SIRV model is applied to retrieve similarities between regions in the whole image. Thanks to the data volume reduction, many ambitious clustering techniques could be considered. Physical interpretation of the classification results through polarimetric decomposition can be then performed to label and color the classification results.

Results on real data from the ONERA RAMSES system on a large data set will be presented.


***************

**Urban Structure Orientation using Radarsat2 Polarimetric Data**

Souissi, Boularbah\(^1\); Ouarzeddine, M\(^2\); Belhadj_Aissa, A\(^2\)

\(^1\)University, ALGERIA; \(^2\)University USTHB, ALGERIA

The backscattering of a polarimetric Synthetic Aperture Radar (PolSAR) from urban area structures is different from the backscattering responses from a natural medium. However, the backscattering from natural areas is often reflection symmetric. Consequently for urban areas, the reflection symmetry does not hold, and
the non-reflection has to be taken into account in this type of area. This paper analyses the polarimetric characteristics of an area containing different scatterers types. The non symmetrical condition was exploited in the analysis of the polarimetric data for a best discrimination of the urban areas. Our contribution in this article related to the discrimination of the urban structures and to identify their orientations versus the Radar line of sight. The polarimetric analysis and classification algorithms have been tested using the fully polarimetric RADARSAT2 data sets in C-band acquired over Algiers and its near regions in the north of Algeria.

***************

Marine Pollution in Algerian Coastal Waters using Polarimetric Radarsat2 Data
Souissi, B; Ouarzeddine, M.; Belhadji_Aissa, A.
University USTHB, ALGERIA

Pollution of the sea is one of the major environmental problems. It originates from ships, land-based sources and others. Oued-Elharrach in the east of Algiers which is the capital of Algeria is the main sources of the sea coastal pollution. For detecting the affected areas, the remote sensing data has been used. The polarimetric RADARSAT2 data flown over the environment of north of Algeria and near of Algiers have been extensively used for obtaining statistical information on the pollution minerals of oued-Elharrach to describe their drift and their dispersion and to identify the affected regions in the coastal areas. In this paper, the potential of the fully polarimetric SAR data to characterize and discriminate different land cover classes is investigated and it has been shown to improve the identification of the polluted regions. Firstly, we've presented an analysis on the backscattering parameters by studying directly the elements of the scattering matrix and comparing their correlations values for different sea areas. In this initial, it has been found the correlation between HH and VV elements can be used to identify and locate the polluted areas. Secondly, we've applied the most known the combined Cloud/Pottier decomposition with the complex Wishart distribution on the same areas. The results of this method have given more precise details on the drift and the dispersion of the pollution minerals. The polarimetric analysis and classification algorithms have been tested using the fully polarimetric RADARSAT2 data sets in C-band acquired over Algiers and its near regions in the north of Algeria.

***************

Supervised Land-Cover Classification by ALOS/PALSAR Polarimetric Interferometry
Ohki, M; Shimada, M
Japan Aerospace Exploration Agency, JAPAN

We will report land-cover classification results using ALOS/PALSAR polarimetric interferometry data and discuss the capability of L-band space borne SAR for land-cover monitoring. The test data obtained by multi-pass interferometry of PALSAR polarimetric observation was classified into the 7 land-cover types, water, paddy, crop fields, grass, urban, forest and bare surface. For comparison, multiple datasets and classifiers are used. The classification accuracy using the full-polarimetric interferometry datasets exceeded 80% and was better than the dual-polarimetric interferometry or single-pass polarimetry data. In particular, water, bare surface, forest and urban areas are precisely classified. Interferometry parameters played important roles in discriminating confusing land-cover types that have similar scattering characteristics.

***************

Spectral Graph Segmentation using Probabilistic Boundaries for PolSAR Imagery in Urban Areas
He, W; Hellwich, O
Berlin University of Technology, GERMANY

We investigate boundary extraction and segmentation of high resolution polarimetric Synthetic Aperture Radar (PolSAR) images of urban areas. Probabilistic boundary extraction (Pb) framework [1] is adopted to generate intervening curve features. Then we combine patch features and intervening curves in a spectral graph segmentation framework [2]. Spectral graph segmentation has the advantage of capturing non-local properties. Accurate boundaries extraction and efficient patch features improve the segmentation. On the other hand, a better segmentation corresponds to a refined binary boundary map. The probabilistic boundaries and segmentations are valuable in further object detection applications. Probabilistic boundaries provide efficient features for object discrimination tasks. The segmentation framework is efficient and provides a complementary segmentation to Normalized cuts.

Pb algorithm makes use of gradients of brightness, color and texture features over several orientations. It models the true posterior probability of a boundary at different orientations and every location of an image. The algorithm detects boundaries by measuring each pixel for local discontinuities in several feature images, which are provided by filtering using odd- and even-symmetric quadrature filters at a range of orientations and scales. Gradient Magnitude, brightness gradient, texture gradient and PolSAR CFAR gradient are computed over 8 orientations. The integration of these gradient features
using supervised fitting, e.g. logistic regression, provides promising boundary maps. Non-maxima suppression is adopted to reduce multiple detections at the same place.

We evaluate the probabilistic boundary methods on a testing set consisting of 50 images with ground truth segmentation. The ground truth segmentation also defines a ground truth boundary map. The boundary maps after non-maxima suppression are evaluated using the ground truth. Amplitude gradient is efficient in identifying large and evident boundaries. The integration of texture gradient and PolSAR edge detection seems to degrade the performance of amplitude gradient. However, the combination of cues suppresses false boundaries in homogeneous regions. Furthermore, the contrast of boundaries is enhanced. We find that the integration of magnitude gradient improves the Pb algorithm.

Then we integrate probabilistic boundaries and patch features in a spectral segmentation. These two types of information are combined using a logistic regression classifier trained on the ground-truth data. Affinity between two pixels are produced by the classifier. For a test image, the affinity between each pair of pixels i and j is given by the output of the classifier. The trailing eigenvectors of the affinity matrix are used to construct segmentation results. The rule of normalized cuts is adopted here.

We use 30 images with ground truth segmentations to validate the segmentation algorithm. Best spatial support (BSS) score is adopted as the measure to evaluate the segmentation accuracies. The averaged BSS score over these 30 images is 41.96%. The segmentations are compared to normalized cuts algorithm. Some correct segments in normalized cuts segmentations are not available in the proposed method. However, once an object region is discriminated from nearby segments, the proposed method is more accurate at its borders. Furthermore, the proposed method improves significantly the segmentation over building roof regions. It generates smoother segmentation at homogeneous regions than normalized cuts. Normalized cuts tends to divide homogeneous regions of high amplitudes. Normalized cuts also contaminates its segmentation boundaries by a couple of pixels. This effect is not present in the proposed method. The segmentations by the compound method and normalized cuts can be combined for further object or boundary analysis.


Best Feature Selection for the Classification of Polarimetric SAR Images
Dumitru, Corneliu Octavian; Cui, Shiying; Schwarz, Gottfried; Datcu, Mihai
German Aerospace Center, DLR, GERMANY

Surface cover classification using polarimetric synthetic aperture radar (PolSAR) airborne and spaceborne images has been a very active research field over recent years. Although lots of features have been proposed and many classifiers have been employed, there are few publications on how to combine and select a minimum set of optimal features for classification purposes.

In principle, there are many features and feature combinations that can be very useful for PolSAR image classification. However, many of these features may be completely irrelevant for classification, or redundant when being combined with others. Therefore, an important research direction is to identify meaningful selected feature subsets.

In this paper, we propose a solution to exploit the full PolSAR image content by combining the information extracted from the various polarization channels in order to obtain an optimum classification performance.

On a conceptual level, one can divide the feature extraction task in two parts: (1) deciding which features can be extracted in general and (2) combining and selecting a best subset of meaningful features. This selection can be based on information theory; the concepts of mutual information help us to understand how to extract as much information as possible.

On a practical level, we propose the following approach: (1a) we apply Gabor filtering to extract any geometrical or neighbourhood relationships, (1b) gray level co-occurrence feature extraction for texture analysis, and (1c) radiometric decomposition methods (namely Pauli decomposition, Freeman decomposition, H/A/á decomposition, and modified H/A/á decomposition); (2) we select a balanced and compact combination of feature subsets that yield a representative description of the data content. This step will be based on mutual information in order to identify the subset of features which are "minimal redundant and maximal relevant" for image content classification.

For the classification task, we use a Support Vector Machine (SVM), a popular tool for machine learning and image classification. As our images may contain diverse targets, we have to re-run this tool for various typical sceneries and application cases.
Our proposed method was tested with quad-pol TerraSAR-X images taken over central Europe where the actual ground cover was known to us. This helped us in the verification of the results.

***************

Mixture Models and Hidden Markov Models for Modeling High Resolution SAR Imagery of Urban Areas
He, W; Hellwich, O
Berlin University of Technology, GERMANY

Fisher distribution is efficient in modeling high resolution Synthetic Aperture Radar (SAR) images over urban areas [1]. We expect to strengthen its capacity by considering a mixture of Fisher distributions. We propose three mixture models, i.e. Gamma mixture model, Log-normal mixture model and Fisher mixture model, for describing local areas in SAR images. The model parameters are learned by expectation maximization algorithm based on maximum likelihood estimation. These models are effective in identifying different components in a local area. We posit trivariate Log-normal mixture model as emission function in a HMM. The HMM is used for classification and behavior analysis of scatterers in subaperture data.

Fisher distribution is capable of capturing the variations in amplitude distribution. In [1] each object class in an urban area is modeled by a Fisher distribution. However, a single distribution is not enough to describe the variations inside an object class. A more refined model, e.g. a mixture model, is required. Mixture model has great potential for SAR amplitude distribution modeling. Gaussian mixture model is able to approximate SAR amplitude density. Gamma mixture, Log-normal mixture and Fisher mixture models are investigated to model the distribution of a SAR amplitude image. The parameters of each model are estimated by maximum likelihood using expectation maximization (EM) algorithm. Log-normal mixture model is straightforward to implement. We apply logarithm operator to the amplitude image and then fit them using GMM. These mixture models fit well to the local statistics in our experiments.

Scatterers in SAR images exhibit high dependence on scatterer-sensor alignment. This phenomenon is prevalent on buildings in urban areas. We apply Hidden Markov Model (HMM) to characterize the dependence and model the variations with respect to building alignment. Buildings in high resolution SAR images of urban areas are studied. We model the variations of scatterers characteristics throughout the subapertures using HMM. We consider Log-normal mixture model as emission density. A state in HMM represents a stationary sector of amplitude characteristics.

Observations are assumed to be sampled from a sequence of states based on a Log-normal mixture.

EMISAR PolSAR data of Copenhagen are used in the experiments. The feature used in the HMM is the amplitude of 8-subaperture data (HH, HV, VV). We are interested in the classes of building layover, tree and lawn. We randomly sample 2000 pixels for each class from ground truth regions in the training dataset. We train 11 HMMs for building layover, a HMM for tree and another HMM for lawn. Buildings are divided into 11 classes, each having a different range of alignment angles. The HMMs are validated on sample pixels from a testing dataset. The error rate of classification on layover samples using all HMMs is 16.48%. The error rate on tree and lawn samples is 20.80%. The state transition rate measures the frequency the states varying inside the 8-subapertures. Pixels in building layover regions have a state transition rate of 25.04%. It is lower than that of 58.15% in tree and lawn regions.


***************

A new Approach for Estimating Sea Ice Thickness using X- and C-Band Space-Borne polarimetric SAR Data
Kim, Jin-Woo1; Kim, Duk-jin2; Hwang, Byong Jun2
1Seoul National University, KOREA, REPUBLIC OF;
2Scottish Association for Marine Science, UNITED KINGDOM

The depolarization generally indicates the degree of changes in polarization state of the scattered wave. The depolarization can occur by multiple scattering from random rough surface and/or volume scattering from sub-surface. These facts are important to understand the relation between the physical parameters of sea ice in the Arctic Ocean and polarimetric properties of space-borne SAR data. For thicker and older ice, the degree of depolarization is expected to increase due to the increased surface roughness and volume scattering from low-density layer of sea ice. The increased surface roughness can enhance the multiple scattering from the surface, and desalinated low-density layer in Multi-Year Ice can also enhance volume scattering from sub-surface layer.

The degree of depolarization was usually measured by the co-polarized correlation and cross-polarized ratios. The HH and VV polarization are closely correlated when the returned signal is dominated by surface scattering in a relatively smooth surface. However, the correlation is decreased by the effect of multiple scattering as surface roughness increases, or by the effect of volume
scattering as the desalination increases. On the other hand, the HV and HH (or VH and VV) ratio is increased for those cases. Either way, we can calculate the degree of depolarization using the co-polarized correlation or cross-polarized ratios.

In this study, we investigated the possibility of estimating the thickness of sea ice using the relation between the physical parameters of sea ice and the depolarization factors, the co-polarized correlation and cross-polarized ratios, of X- and C-band space-borne SAR data. The ground truth data was collected by an ice camp which was set up on landfast ice in the north of Greenland on 1st of May, 2009. The acquired multi-frequency space-borne SAR data are dual-polarization data of TerraSAR-X (X-band) and RADARSAT-2 (C-band), respectively.

In order to understand the characteristics of depolarization factors as the physical parameters of sea ice changes, we first derived the variation of depolarization factors using the covariance matrix calculated by the extended Bragg scattering model and Sea ice Dielectric constant Model (SDM). As a result, the surface dielectric constant of thick FYI (150 - 200 cm) and MYI (> 200 cm) was relatively insensitive as ice grows due to the desalination of ice surface, while the surface dielectric constant of thin FYI (30 - 150cm) was rapidly decreased versus ice thickness. The depolarization factors were insensitive with those changes and local incidence angle. On the other hand, the depolarization factors were strongly sensible with the changes of the target surface roughness. In general, the backscattering signatures of space-borne SAR data are affected by the surface roughness and dielectric constant of the target. Here, based on the results of numerical experiments, we could be decoupled the contribution between the surface roughness and dielectric constant of thick FYI and MYI using the depolarization factors of X- and C-band space-borne SAR data.

As above results, we calculated the relationship between the observed thickness of thick FYI and MYI and the depolarization factors of TerraSAR-X and RADARSAT-2. The co-polarized correlation calculated by TerraSAR-X and the cross-polarized ratios calculated by RADARSAT-2 was strongly correlated with the thickness of thick FYI and MYI. On the other hand, the cross-polarized ratio of TerraSAR-X was poorly correlated with those. It is reported that Noize Equivalent Sigma Zero (NESZ) of TerraSAR-X is almost -19 dБ and the most sigma zero of TerraSAR-X HV polarization was below NESZ. Therefore, the cause of poor relationship between the cross-polarized ratio of TerraSAR-X and the thickness of thick FYI and MYI is the effect of the noise. In addition, we calculated the relationship between the observed thickness of thin FYI and the depolarization factors of X-band SAR data. However, they were closely not related due to rapidly dielectric constant changes.

In summary, a new approach, the depolarization, was applied to estimate sea ice thickness in an area of thick FYI and MYI by using C- and X-band SAR data. Although the relative contribution of ice surface roughness cannot be exactly quantified, sensitivity study was conducted by using an extended Bragg scattering model for various surface roughness conditions. The results showed, for thick FYI and MYI, the depolarization was strongly affected by surface roughness not by variations in dielectric constants and incidence angle and we found strong and significant correlation between observed ice thickness and the depolarization factors X- and C-band space-borne SAR data. In addition, cautions should be taken that our results are based on one set of field data over winter landfast ice condition. More sea ice field data coordinated with space-borne SAR are necessary to draw more rigorous conclusion.

End-to-end Simulation of SAR Mission Performance for the ESA BIOMASS and CoreH2O Missions

ESA, NETHERLANDS

When a mission is at its initial phases, the scientific goals can be documented but the instrument and mission characteristics that impact data quality need to be determined in order to achieve these goals. As a consequence it is necessary to evaluate whether the performance of the instrument will be sufficiently good to meet the objectives, aiming at the best trade-off solution which could allow, by properly tuning the instrument parameters, hardware simplification and cost reduction.

In this paper/poster we present the results of an End-to-End (E2E) simulator which is able to predict the geophysical retrieval performance as a function of the radiometric uncertainties of the SAR instrument. The approach is based on a Monte Carlo approach. In particular the software has been used to assess the achievable accuracy of BIOMASS and CoreH2O retrievals based on SAR intensity, i.e. snow water equivalent and forest biomass, and guide trade-offs in the mission design. The software is implemented in terms of an easy-to-use GUI and can summarise mission performance in terms of synthetic plots and images.

The sources of error which are taken into account in the simulations are the ones which are considered to have a major impact on the retrieval errors, and they include the speckle, the instrument noise caused by the electronic components of the receiver chain which add a statistical variation to the measured values, calibration biases which account for the bias in the measured intensity due to a not perfect calibration process and lastly geophysical errors as uncertainty.
introduced in the forward model which relates the
deposition parameters to the radar observation.

At the end of the paper, applications of this software are illustrated for two test cases which are ESA SAR missions under feasibility study: Biomass and CoreH2O.

Unsupervised Forest Mapping using full Polarimetric SAR Data based on Target Decomposition Parameters
Wang, P.; Li, Y.; Xia, D.; Hong, W.
Institute of Electronics, Chinese Academy of Sciences, CHINA

An unsupervised forest mapping method using full polarimetric SAR data is introduced. Firstly an improved Wishart classifier is applied to the PolSAR data to get convergent clusters, then eigenvalue decomposition parameters are used to identify clusters that representing forests. The well known Wishart classifier that introduced by Lee in 1994 is proved to be very effective to multi-looked PolSAR data classification. The Wishart distance measurement that often used is under the assumption of equal a priori probabilities to all clusters. It works well when the number of looks is large enough, because the a priori probability is less important in this condition. However, when the number of looks is not so large, the affection of a priori probability is uneligible. Therefore, we try to improve the Wishart classifier by including the a priori probability in the distance measurement. During the Wishart iterations, we take the proportion of the number of pixels in each cluster as the according a priori probability in the next iteration. Improvement can be observed.

When the Wishart clustering procedure gets convergent result, several eigenvalue decomposition parameters are used to identify forest clusters. E.g. the combination parameter H(1-A) introduced by Cloude and Pottier, the Radar Vegetation Index rvi, and so on. Though the selection of appropriate identification parameters, this method can also be used for the mapping of other land cover types, such as water mapping, and so on.

A Multi-Polarization Study on Ship Detection over X-Band full-resolution Comsot SkyMed SAR Data
Migliaccio, Maurizio; Nunziata, Ferdinando; Sorrentino, Antonio; Ferrara, Giuseppe
Università di Napoli Parthenope, ITALY

Ship detection over marine Synthetic Aperture Radar (SAR) it is a topic of considerable interest in several applications concerning environmental monitoring and marine surveillance. Unfortunately, SAR images are tainted by a high level of multiplicative noise, i.e. speckle, that hinders their interpretation. Moreover, other factors affect SAR ship observation, such as construction material, incidence and aspect angle, radar frequency and polarization. As matter of fact, both single-polarization and polarimetric approaches have been exploited to effectively observe ship by means of SAR. An important issue which characterized these algorithms is the choice of a suitable threshold and, very often, their heavy computational load which make these approaches not generally sufficient to perform an effective SAR ship detection. Typically, to make SAR ship detection easier speckle noise is mitigated through multi-looking techniques at the expense of the available spatial resolution. Recently, it has been demonstrated that, if properly modeled, speckle carries on information about the scattering properties related to the observed scene [1]. Along with this rationale, a model to read full-resolution, i.e. speckled, SAR data in terms of sea surface scattering with and without metallic objects has been developed, based on the Generalized-K (GK) distribution. The model, successfully validated on multi-polarization C-band SAR data, has been shown a different sensitivity with respect to sea surface with and without metallic targets. Moreover, a very pronounced sensitivity to those targets has been found in HV channel. In this study, following the rationale previously described, the GK-model is firstly applied to read multi-polarization X-band full-resolution Cosmo SkyMed SAR data in terms of sea surface scattering with and without metallic targets. It must be noted that, due to the peculiarities of X-band scattering, this is a very challenging case study. Experiments accomplished over a meaningful set of X-band Single Look Complex (SLC) CosmoSkyMed StripMap SAR data confirm the physical soundness of the proposed approach.

References

Polarimetric signature Analysis of Deformed Arctic Land-Fast ice using TerraSAR-X Quad-Pol Data
Haas, Christian1; Hajnsek, Irena2; Papathanassiou, Konstantinos3
1University of Alberta, Depts. Earth & Atmospheric Sciences and Geophysics, CANADA; 2German Aerospace Center (DLR) e.V. & ETH Zurich, Switzerland, GERMANY; 3German Aerospace Center (DLR) e.V., Microwaves and Radar Institute, GERMANY

The coastal areas of the North Canadian Archipelago and Greenland are regions (of the most) intensive sea ice deformation in the Arctic. Powered by the Transpolar Drift polar water masses and sea ice is transported westward from the Eurasian coasts towards the shelf regions of Greenland and Canada, causing
shearing, deformation, and dynamic sea ice growth. At some areas of the North Canadian/Greenland continental shelf the pack ice stops drifting, and freezes along the coast, forming large areas of so called landfast ice. Depending on thickness and location the landfast ice can survive several melt seasons. In this study we focus on such a land-fast ice area, which is located near Alert (83.5N 62W) on Ellesmere Island, Nunavut, Canada. The test site is located at the Lincoln Sea coast near the entry of Nares Strait, which is an important outlet of the Arctic Ocean and which is characterized by intensive ridging, a variety of different ice types, and large range of ice thickness classes. We examine an X-band quad polarized SAR data set that was acquired during the TerraSAR-X Dual Receive Antenna Mode campaign in May 2010. The ice and snow thickness represent maximum end-of-winter values, and the physical snow and ice properties are comparable to their microwave properties throughout the (dry) winter season. For comparison with the SAR data sea ice thickness profile measurements are used. This data set was acquired by means of a helicopter-borne electromagnetic induction sensor (EM-bird) during a ground measurement campaign that was conducted in May 2010 by personnel of the University of Alberta, Edmonton, Canada. In this study the first results from a comparison of the entropy, alpha and anisotropy decomposition parameters with the different ice thickness values extracted along the sea ice thickness profiles are presented. The final goal is to identify proxies for sea ice thickness estimation from spaceborne

***************

Annual Variability in Prairie vegetation as seen by SAR Polarimetry

Buckley, J.

Royal Military College of Canada, CANADA

Ever since the commissioning of RADARSAT-2 in the early summer of 2008, the last remaining piece of never-cultivated prairie in southwestern Manitoba, Canada, has been the subject of a long-term study to examine the relationship between elements of the natural landscape and their polarimetric backscatter throughout the seasons, and from year to year. Since June 2008, the site has been imaged by RADARSAT-2 in fine mode quad-pol format every 24 days at an incidence angle of 38° on a descending path. Only a few imaging opportunities have been missed. A smaller set of imagery on ascending passes at the same incidence angle were also acquired. Specific areas of interest were selected in the region, representing healthy grassland, unhealthy grassland, burned grassland, aspen forest, spruce forest, wetlands and sand dunes. These areas were analysed using different decomposition protocols, both statistical and model-based, and time series of the results were plotted. Heterogeneity statistics were also examined. There is a strong, statistically significant annual signal evident in the volume scattering, that may be related to the annual cycle of vegetation growth and decay or to the annual cycle of precipitation. The signal is weaker but evident in double bounce scattering, and not significant in the surface scattering. There are no systematic differences evident between ascending and descending passes.

***************

Lossless Ψ - Invariant Decomposition of Random Target

Riccardo, Paladini¹; Ferro Famili, Prof.²; Pottier, Prof.²; Berizzi, Prof.²

¹University of Pisa - University of Rennes, ITALY; ²University of Rennes 1, FRANCE; ³University of Pisa, ITALY

Introduction - In 1985 S.R Cloude extended Wiener wave 2x2 Coherence matrix representation of light polarization to a 4x4 target coherency matrix that is decomposed in four orthogonal rank-1 matrices representing the eigenvalue-weighted behavior of four deterministic targets (three for backscatter) [1]. At the beginning the S. R. Cloude decomposition received deep criticism by J. R. Huyten, "The Cloude proposal for target decomposition is upon the mathematical generalization of the Huyten - case. An immediate criticism is the proliferation of parameters which is the results of this approach. Out of nine independent parameters of the mixed Muller parameters are generated eighteen parameters on the decomposition side" [2]. Methodology - In this paper we answer to the question raised by Huyten, in 1992, by characterizing the coherency matrix eigenvalues - eigenvectors in term of eight orientation invariant parameters and a significant averaged target orientation estimate. The decomposed parameters are the minimum number of features sufficient and necessary to represent the Coherency matrix. The solution is described in two steps our main contributes.

Step-1 The lossless decomposition method for 3x3 Hermitian matrix having nine degrees of freedom is introduced. Different methods applied for the representation of the decomposed parameters has provided "proliferation of parameters"or information lost, as summarized below: the original Cloude Decomposition is a 15 parameter model, the Gelman decomposition provides 11 parameter, and the H/A/α/SPAN, nevertheless is very effective it looses part of the information [3,4]. The main eigenvector of the Covariance matrix, decomposed according to Cloude Theorem, is shown to be a four parameter model, due to unitary modulus constraints in C³ and absolute phase ambiguity. The second eigenvector is represented in a subspace orthogonal to the dominant one and is shown to be a two parameter model, due to the mathematical structure of a basis of unit vectors. In other word the null inner product between first and
second eigenvector gives the two constraints. Finally last eigenvector is forced in its position on \( \mathbb{C}^3 \) space and has no degree of freedom. By the application of this principle a new six angles \( \Theta \) model of the entire eigenvector basis \( U \) is shown.

Step-2 A new set of orientation invariant parameters and a good estimate of mean orientation is presented. The second main contribute is detailed, the polarization basis space has been exploited, finding that the use of circular polarization provides a unique parameterization of the eigenvectors in term of orientation invariant parameters. The proposed CTD \([6]\), is applied to the dominant eigenvector, characterizing the main eigen - scattering mechanism in term of orientation invariant parameters. To obtain a complete description of the eigenvector basis without any information loss, two novel orientation invariant parameters have been introduced: \( Z \), is a orientation invariant quantity that removes the phase difference between \( u_2-u_3 \) and \( u_1 \) permitting to describe (after \( Z \)-phase removal) the direction of the second and third eigenvectors in term of a real rotation \( \hat{\alpha} \). The \( \hat{\alpha} \) is a real rotation giving an estimate of the predictability of \( u_2 \) given the knowledge of \( u_1 \).

Conclusion - In this paper the Lossless Incoherent Target Decomposition (L-ITD), has been introduced and applied to the Cloude-Pottier eigenvector decomposition projecting the eigenvectors on right-right orthogonal basis. By the application of the Cloude’s theorem, the covariance matrix has been diagonalized in term of their principal components. First eigenvector is decomposed by extracting the scattering phase, the elicity, the quarter wave angle and the mean orientation. Then a novel procedure has been defined that permits, by applying a complex series of rotations, to define the other two basis elements with only two (the minimum number) of angles \( \hat{\alpha}, Z \). The procedure permits to extracts eight orientation invariant parameters and a measure of the orientation angle without introducing redundancy or information loss.

REFERENCES

Forest Monitoring in Norway by Means of fully Polarimetric Radarsat-2 Images
Weydahl, D J; Solberg, S
1Norwegian Defence Research Establishment, NORWAY; 2The Norwegian Forest and Landscape Institute, NORWAY

We have regularly every 24 day been gathering fully polarimetric Radarsat-2 images over a forested area in Norway from March 2010 to December 2010. This unique data set will be used together with high-resolution lidar DEM data and field measurements to develop models that possibly can be used for extracting forest parameters. We will show some preliminary results and how the project is planned for the next year to come.

Multi-scale Deformable Part Model for Building Extraction From High Resolution Polarimetric SAR Imagery
He, W.; Hellwich, O.
Berlin University of Technology, GERMANY

In meter-resolution polarimetric SAR imagery over urban areas, a building layover is usually accompanied by a shadow region. Polarimetric SAR data provide effective features for layover and shadow detection. The connectivity between these two kinds of objects can be exploited to improve the detection. In some circumstances, e.g. when a building is not aligned with the azimuth direction, its layover exhibits volume scattering and may be missed. The knowledge of the existence of an adjacent shadow region will increase the chance that the layover is detected. Sometimes there is a building roof region between a layover and a shadow region. The brightness of the roof region typically lies between those of the layover and shadow regions. The roof region is very unlikely to be detected as a part of the building. Similarly, the confidence of the shadow region will partially solve the problem.

On the other hand, the shadow effect also applies to other ground objects, e.g. trees. It is difficult to differentiate between the shadow regions of a building and a tree. However, the presence of a layover region will help to alleviate the ambiguity. The propagation of the layover probability to its neighboring regions has proved to improve building shadow detection in our previous work.

The multi-scale deformable part model [1] is an discriminative framework for efficient object detection. The model has been successful in the PASCAL Visual Object Classes Challenge 2009. It relies on deformable parts. The model contains a coarse global template for
the whole object and fine part templates for its parts. The model is trained discriminatively. A latent SVM is adopted to perform semi-supervised learning of model parameters.

We consider a building consisting of a layover region and an adjacent shadow region as the global object. A global root filter is trained. Two part models are based on the layover and shadow regions, respectively. Two part filters are trained. The positions of the layover and the shadow are treated as latent variables in the SVM. The partially labeled data are handled in the discriminative SVM training. In the testing stage, detection score is the sum of the scores of the part models and the root filter. The placement of a part within the global object introduces an negative deformation cost to the score of the part model. A multi-scale model is necessary because buildings have various dimensions.


*************

Ship Detection using Polarimetric Features from Radarsat-2 images
Hannewik, TNA; Weydahl, DJ
Norwegian Defence Research Establishment, NORWAY

We have been collecting numerous Radarsat-2 images over ship targets in Norwegian waters. Detecting ships is often linked to the situation of maximizing the contrast between the radar cross section of the ship and the sea clutter background. We investigate how this can be maximized using different combinations of polarimetric channels and polarimetric features, and show that different algorithms mutually can work together to obtain the best possible detection criteria for ship targets at sea. We also show how the ship detection algorithms can be adapted according to the SAR image resolution (ScanSAR versus Standard/Fine mode) and polarimetric channel combinations of like-polarimetry and cross-polarimetry.

*************

A new Functional Expansion for Polarization Coherence Tomography
ZANG, Hong1; MA, Peifeng2; WANG, Chao3
1Center for Earth Observation and Digital Earth, CHINA; 2Graduate University of Chinese Academy of Sciences, CHINA; 3CAS, CHINA

In this paper we investigate the Polarization Coherence Tomography (PCT) technique and propose a different functional expansion to reconstruct a vertical profile function. Admittedly, there are some factors that affect the accuracy of a vertical profile function approximation. For instance, two higher-order polynomials will be added by adding each additional baseline, steadily increasing the resolution of the reconstruction, but multi-baseline measurements are expensive and difficult to obtain and so we only investigate single- and dual-baseline cases. In addition, the accuracy of volume depth and topographic phase estimation has vital impact on final result. However, what we concentrate on in this paper is another functional expansion’s influence on the reconstruction of the vertical structure profile. Assuming we have a priori knowledge of volume depth and ground topography by Three-Stage method, estimation of the profile coefficients is feasible. Instead of developing the profile function in a Fourier-Legendre series, firstly we construct orthogonal family of function on [-1, 1] by the weight, deducing the first few orthogonal polynomials. And then we represent the vertical profile function using these orthogonal series, constructing the linear matrix by equation relations. Finally the coefficients are estimated by matrix inversion for the specific orthogonal polynomials. In this way the polynomials for approximation will be promoted up to four order using single-baseline data and up to six order using dual-baseline data. In terms of analysis of condition number of the linear matrix, we find that the CN in this way is smaller than the CN obtained in Fourier-Legendre series, indicating that the inversion in this way is more stable and less susceptible to noise. In the end this method is validated using simulated data and real data. Keywords—PCT, functional expansion, vertical profile function

*************
Performance Study of Forest Height Estimation using Chinese airborne Dual-Antenna X-band PolInSAR data

Zhang, Hong1; Chen, Jiehong2; Wang, Chao1; Jiang, Kai1
1CAS, CHINA; 2East China Research Institute of Electronic Engineering, CHINA

With the development of polarimetric SAR interferometry (PolInSAR), it is of interest to develop quantitative inversion methods for the estimation of forest parameters. In this paper the potential of Chinese airborne single baseline high resolution X band polarimetric SAR interferometry (PolInSAR) data for forest parameters estimation is investigated. The airborne Dual-Antenna PolInSAR data were acquired in January, 2010, by East China Research Institute of Electronic Engineering, China Electronics Technology Group Corporation (CETC), over the test site near Sanya city, Hainan Province China. Here we first analysis how channel imbalance impact the performance of polarimetric interferometry of each channel and optimal channel, and then introduce a new method based on an assumptions that the absolute coherence of each channel can get maximum value to calibrate channel imbalance without putting corner reflector in the scene or choosing a patch of water area. And we validate the new method using airborne single pass single baseline data. To quantify the PolInSAR information about forest contained in X band data, the combination of ESPRIT method and Three-stage method is used to retrieve the forest height, and the performance of the hybrid method is validated by in situ measurements. The experiment results demonstrate that Chinese airborne Dual-Antenna X band polarimetric SAR data can be used for PolInSAR applications. Keywords-forest height; X-band; PolInSAR; ESPRIT; hybrid method

******************