POLinSAR 2003 *Workshop on Application of SAR Polarimetry and Polarimetric Interferometry*

With ten radar satellites expected to be in orbit by the end of the decade, radar imagery and POLinSAR techniques could find practical uses in a wide range of applications. These include detecting buried landmines, providing early warning of threats to agricultural areas, certifying forests for logging, monitoring compliance with international treaties on global warming and helping national governments to protect the biodiversity and ecological balance of their forests, wetlands and other natural assets.

An advanced technique for analysing radar images – SAR polarimetry and polarimetric interferometry – shows tremendous promise for scientists studying forests, agriculture, ice and other terrain types. More than 120 scientists and researchers from 20 countries gathered at ESA's ESRIN facility in Frascati, Italy, during January 2003 for a three-day workshop to share the latest results on scientific experiments and potential applications of SAR polarimetry and polarimetric interferometry. The workshop was also an opportunity to present the final findings of ESA-funded studies into the applications of SAR Polarimetry and Polarimetric Interferometry for two consortia involving Qinetiq, AELc, University of Rennes, SarVision and Vexcel UK and the Technical University of Denmark, CESBIO, DLR and the University of Sheffield.

Seeing the forest, measuring the trees

The capability of radar to penetrate ground cover and 'see' the underlying terrain, coupled with POLinSAR techniques to detect forest canopies, makes characterising tree structure and height using SAR imagery a possibility. Knowledge of the types and heights of trees in a forest enables an estimation of the biomass, which in turn provides information about an area's capacity to act as a carbon sink. Measuring these factors accurately is critical for environmental scientists to whom national governments are turning for help in meeting their international obligations under the Kyoto Protocol.

In response to this challenge, a number of tests are underway to assess how polarimetric interferometry could be used to produce accurate biomass estimates. Tree height measurements undertaken by Shane Cloude, with the UK-based AEL Consultants, produced promising validation results, within about a ten percent margin of error. "It's tough to do, and we are further along with single-species forests," Cloude said. "Forest biomass estimates are very important for measuring compliance with Kyoto targets, but we are far away from the political dimensions of using POLinSAR techniques for monitoring compliance."

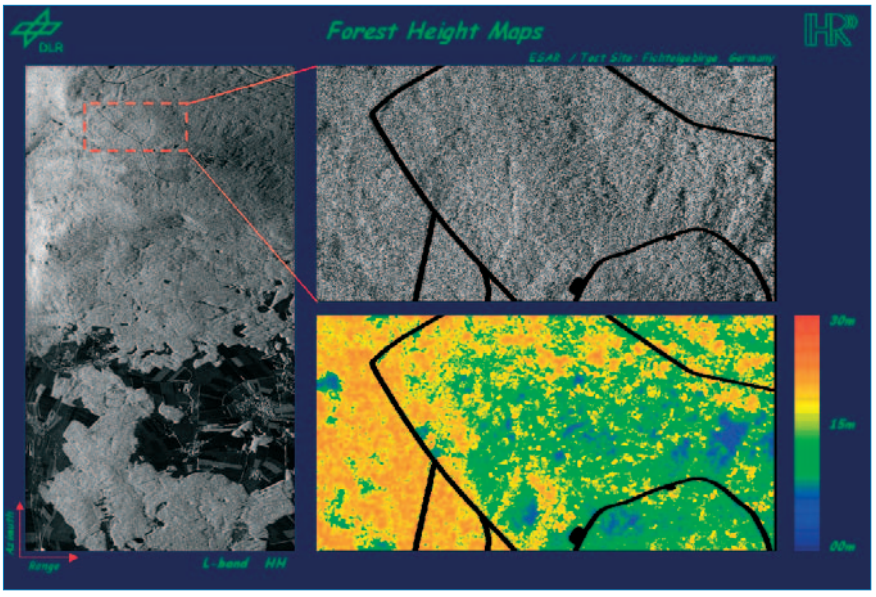
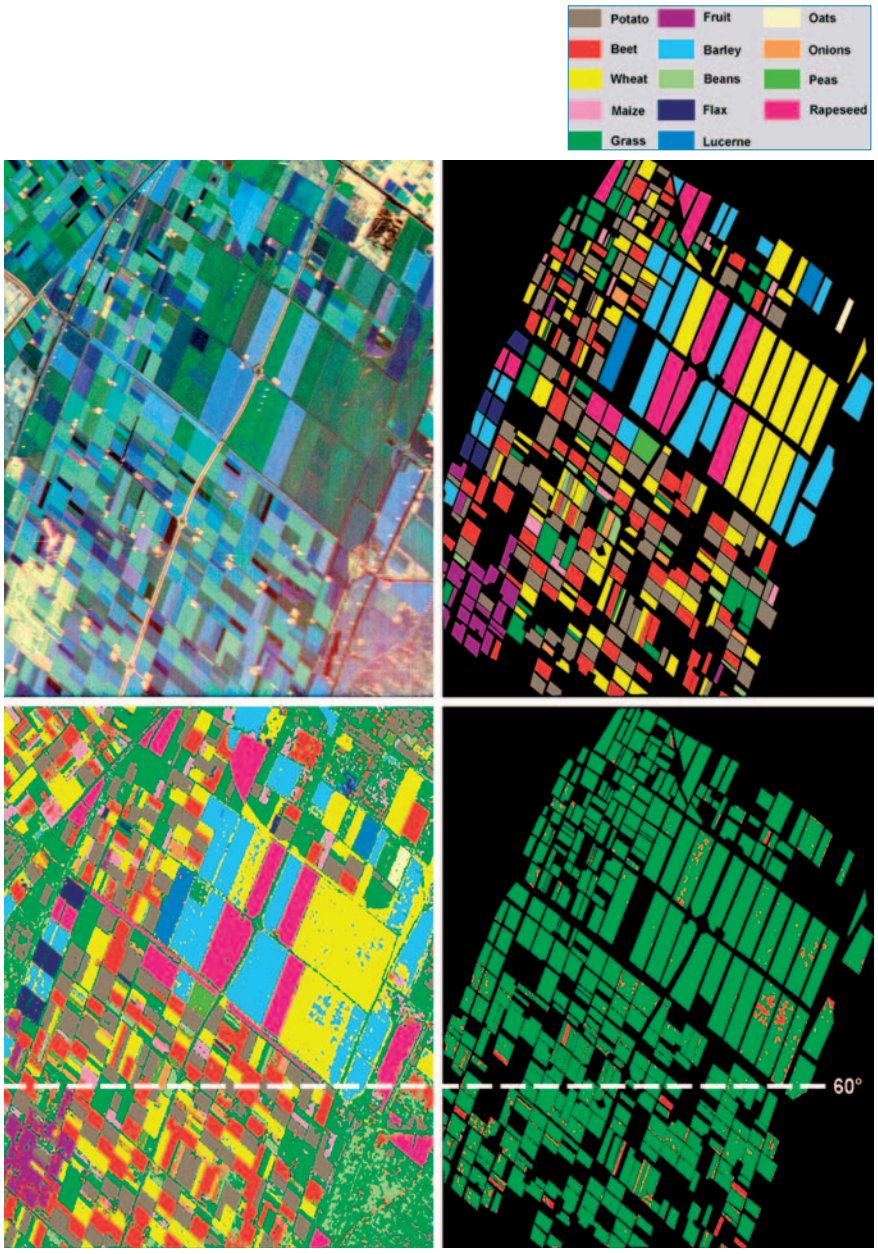


Figure 1 - Forest height derived from L-band POLinSAR data and presented in three dimensions. Courtesy of DLR.



From polarimetry to polarimetric interferometry

The workshop addressed the latest developments, as the research emphasis shifts from classical Synthetic Aperture Radar (SAR) studies to polarimetric SAR analysis of the Earth's surface by the combination of variously polarised views.

The POLinSAR approach combines techniques for analysing the orientation, or polarisation, of radar signals (polarimetry) with those for the analysis of phase differences between signals and to measure differential range (interferometry) using two or more images captured by synthetic aperture radar instruments (SARs). Taken together, polarimetry and interferometry offer the potential to summarise Earth surface characteristics in three dimensions with colour.

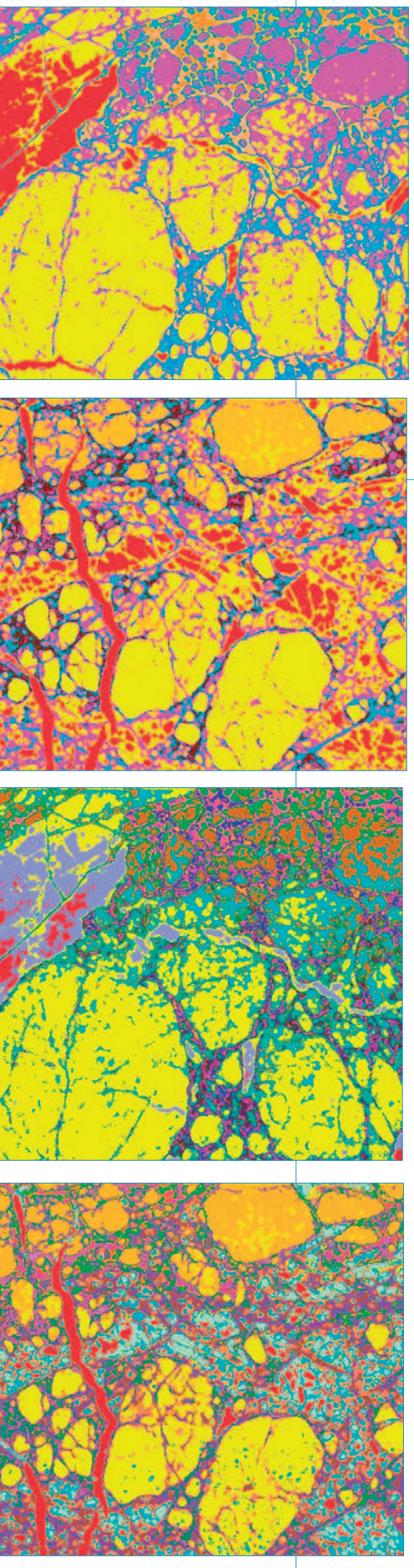
POLinSAR analysis techniques emerged in the mid-1990s and are developing quickly. "POLinSAR has matured from a 'first-results' to a 'science' status," said Konstantinos Papathanassiou, a researcher with the Institute for Radio Frequency Technology and Radar Systems at the German Aerospace Centre (DLR). "You can do things that were not possible before and are needed now."

New model for classifying agriculture

At a roundtable discussion following the presentation of results from forest studies at the workshop, several participants urged that research be expanded to include more types of forests. Dirk Hoekman, with the Department of Environmental Sciences at Wageningen University in the Netherlands, pointed out that the recent Indonesian forest fires released a gigaton of carbon into the atmosphere, or one-third of the total annual increase of global carbon gases. More POLinSAR research should be directed at tropical and peat moss forests, he said.

Hoekman's own paper on a new model for accurately classifying agricultural types in SAR imagery addresses a problem that has plagued researchers and hampered the development of reliable applications. Tests of crop classifications from imagery taken over the Dutch Flevoland agricultural test site indicate that new ways to classify the radar data can achieve levels of accuracy up to 90.4% for C-band and 88.7 % for L-band, according to Hoekman.

Figure 2 - (Top left) AirSAR Total Power image (C-band blue; L-band green; P-band red) of Flevoland, 3 July 1991. (Top right) Crop type map (ground truth). (Bottom left) Classification using C- and L-band full polarimetry model. (Bottom right) Error map: errors in red. The classification accuracy is 96.3% for the area above the 60º incidence angle line (and 95.1% for the whole image). Courtesy of D. Hoekman.



Sessions reveal potential applications

Workshop presentations, including a lively poster session gave a glimpse at the diversity of research now underway in the SAR science community.

Alex Rodrigues of Qinetiq presented details of a sea-ice classification technique employing Entropy, Alpha and Anisotropy decomposition parameters do discriminate characteristic scattering mechanisms. Initial results using L- and C-band JPL AIRSAR fully polarimetric data show that there is good discrimination between the major ice classes.

Figure 3 - L-Band unsupervised classifications of sea ice. Courtesy of A. Rodrigues.

Plans for new space SARs

With their all-weather and nighttime capabilities, coupled with these promising new analytical methods for interpreting data, space-based radars are providing new insights into the Earth's land, waters and atmosphere. Participants at the POLinSAR workshop heard details of upcoming satellite missions that will incorporate new advances in SAR technology, faster revisit times and offer a better service to scientists and users.

Canada's RADARSAT-2 satellite, planned for 2004, will feature a 3-metre resolution mode and left- or right-looking capability and will offer improvements particularly for the purposes of crop classification and monitoring and sea ice applications. The TerraSAR-X satellite will be the first German SAR for scientific and commercial applications. Planned for a 2005 launch, the X-band SAR features a 1-metre "spotlight" mode. The applications for X-band data mostly concern sea ice, snow cover and urban planning, with other uses in agriculture, map-making and risk assessment studies for floods, fires and storms. Also scheduled in 2005, beginning a program developed by the Italian Space Agency with the cooperation of France's space agency, CNES, the first of four further X-band SARs will be launched to initiate the Cosmo-SkyMed constellation. Eventually, coordinated radar and optical satellites will provide high-resolution imagery with revisit times of just a few hours.

The ESA POLinSAR workshop clearly demonstrated the strides taken by the radar research community in the past few years in radar polarimetry techniques and applications, and that more work is needed to move to applications and later services to users. The results presented confirmed that the combination of polarimetry with interferometry represents a significant breakthrough in quantitative parameter estimation for combined surface and volume scatterering mechanisms.

Following the recommendations of the workshop, ESA will support R&D efforts in the field of POLinSAR by initiating a new mission application study for future SAR missions, supporting the development of POLSAR tools and coordinating dedicated airborne campaigns.

For more information, visit the workshop web site at: ***http://earth.esa.int/polinsar/***