AGRICULTURAL LAND COVER FROM SHORT REVISIT SAR DATA – SENTINEL-1 OPERATION SIMULATED BY AIRCRAFT AND SATELLITE SAR DATA

Henning Skriver

DTU Space
Technical University of Denmark
Ørsteds Plads, Building 348, DK-2800 Lyngby
Ph.: +45 4525 3792; Fax: +45 4593 1634; e-mail: hs@space.dtu.dk

Background

Remote sensing has the potential to provide estimates of important inputs for the land process models, for instance the land cover type, the soil moisture and the LAI. Such models can provide information that is crucial for a number of applications such as flood and drought prediction, crop irrigation scheduling, and meteorology. Also, land cover maps provide fundamental information to many aspects of land use planning and policy development, as a prerequisite for monitoring and modelling land use and environmental change, and as a basis for land use statistics at all levels.

It is well known that remote sensing may provide important and valuable information about crops and other land cover classes. This is true for both optical/infrared and radar data, where radar data is especially important for regions where cloud cover is a problem. The investigation focus in this paper on the determination of the land covers type using SAR data from high revisit acquisitions, including single polarisation, dual polarisation and fully polarimetric data, at C-band. The analysed data sets were acquired during two campaigns, AgriSAR06 with the airborne ESAR system, and AgriSAR09 with the Radarsat-2 system. Ground surveys to obtain detailed land cover maps were performed during the campaigns.

Problem description

In this paper, the focus is on the statistically-based methods using single-polarisation data, dual-polarisation data, and fully polarimetric data - in all cases using multitemporal data with short revisit time. Results for airborne campaigns have previously been reported in Skriver et al.

(2007a and 2007b) and Skriver (2008, 2009). In this paper, a new short revisit satellite SAR data set will be used to assess the trade-off between using advanced polarimetric SAR data and using less advanced data as single or dual polarisation SAR data with short revisit time. This is particularly important in relation to the operation of the future GMES Sentinel-1 SAR satellites, where two satellites with a relatively wide swath will ensure a short revisit time all over the world. Especially questions such as, which accuracy can we expect from a high-revisit SAR mission like the Sentinel-1 mission, what is the improvement, if any, of using polarimetric SAR compared to single polarisation or dual polarisation SAR, and what is the optimum/minimum number of acquisitions needed and their timing relative to the growing season, are dealt with.

Data Sets

Two different SAR data sets were used in the analysis in the paper, one from an airborne system: the AgriSAR06 data set acquired by the German ESAR over the Demmin site, in the Mecklenburg-Western Pomerania (Northern Germany) with 11 acquisitions from April to August 2006. The other data set is acquired by the Canadian Radarsat-2 satellite over the Flevoland site, in the Netherlands with more than 50 acquisitions from April to August 2009 during the AgriSAR09 campaign. This is a unique data set due to a very large number of polarimetric SAR acquisitions during the growing season. Both campaigns were funding by the European Space Agency, ESA. In both cases, extensive ground truth collection has taken place, and as part of this activity a crop map has been produced. For the AgriSAR06 only a few crop types were present, whereas a fairly large number was covered during the AgriSAR09 campaign.

Methodology

The statistical, data-driven methods have been studied for single, dual, and full-polarisation data. The data used are about 10 look data, and hence a Gaussian assumption for the probability density function for the backscatter coefficients for the individual polarisations is valid. The classification method used for the single and dual polarisation cases is therefore the standard Baysian classification method for multivariate Gaussian statistics.

Different approaches have been suggested in the literature to extract land cover and crop

information from polarimetric SAR data, i.e. statistical methods based on the Wishart distribution (Lee et al., 1994) or covariance matrix elements transformed into backscatter coefficients (Hoekman and Vissers, 2003), methods based on scattering mechanisms (Cloude and Pottier, 1997; Freeman and Durden, 1998), and knowledge-based methods (Ferrazzoli et at., 1999; Pierce et al., 1994; Skriver, 2001). For the full-polarimetric cases, the standard ML Wishart classifier originally proposed by Lee et al. (1994) is used in this study. In addition, the method introduced by Hoekman and Vissers (2003) using a reversible transform of the covariance matrix into backscatter intensities has also been applied.

The following pre-processing steps were performed on both data sets: The scattering matrix data in the form of SLC products were coregistered, converted to covariance matrix format and multilooked with an equivalent number of looks of approximately 10.

General Conclusions

The data sets provides results for the general trends of classification performance, i.e. the multitemporal data improve significantly the classification results, and single acquisition data cannot provide the necessary classification performance for single, dual and fully polarimetric data. The multitemporal acquisitions are especially important for the single and dual polarization data, whereas the improvement is less for the fully polarimetric data.

The airborne data set produces extremely low classification errors of a few percent. These results are considered too optimistic, because of the very few number of crops. The satellite data set, on the other hand, produces more realistic classification results, but with the same trend as the airborne data set.

The results in this study clearly show, that relatively simple systems with short revisit time can provide results that correspond with more advanced systems with longer revisit time. This is a very important result, because it shows that systems like the Sentinel-1 mission will be able to produce fairly good results for land cover due to the short revisit time.

References

Cloude, S.R., and E. Pottier, 1997, An entropy based classification scheme for land applications of polarimetric SAR, *IEEE Trans. Geosci. Rem. Sens*., vol. 35, 68-78.

Ferrazzoli, P., L. Guerriero, and G. Schiavon, 1999, Experimental and model investigation on radar classification capability, *IEEE Trans. Geosci. Rem. Sens*., vol. 37, pp. 960-968.

Freeman, A., and S.L. Durden, 1998, A three-component scattering model for polarimetric SAR data, *IEEE Trans. Geosci. Rem. Sens*., vol. 36, pp. 963-973.

Hoekman, D.H., and M.A.M. Vissers, 2003, A new polarimetric classification approach evaluated for agricultural crops, *IEEE Trans. Geosci. Rem. Sens*., vol. 41, pp. 2881-2889.

Lee, J.S., M.R. Grunes, and R. Kwok, 1994, Classification of multi-look polarimetric SAR imagery based on complex Wishart distribution, *International Journal of Remote Sensing*, vol. 15, pp. 2299-2311.

Pierce, L.E., F.T. Ulaby, K. Sarabandi, and M.C. Dobson, 1994, Knowledge-based classification of polarimetric SAR images, *IEEE Trans. Geosci. Rem. Sens*., vol. 32, pp. 1081-1086.

Skriver, H., 2001, Land-cover map information from polarimetric SAR using knowledge-based techniques, 3rd Int. Symp. on Retrieval of Bio- and Geophysical Parameters from SAR data for Land Applications.

Skriver, H., F. Mattia, G. Satalino, A. Balenzano, V. Pauwels, N. Verhoest, and M. Davidson, 2007a, Land-Cover Classification from AgriSAR SAR Data, AgriSAR Final Workshop, ESA.

Skriver, H., F. Mattia, G. Satalino, A. Balenzano, V. Pauwels, N. Verhoest, and M. Davidson, 2007b, Land-Cover Classification from SAR Data for Hydrological Modelling, 5th Int. Symp. on Retrieval of Bio- and Geophysical Parameters from SAR data for Land Applications, Bari, Italy.

Skriver, H., 2008, Comparison between Multitemporal and Polarimetric SAR Data for Land Cover Classification, IGARSS.

Skriver, H., 2009, Land cover classification from multitemporal C- and L-band SAR data, MultiTemp 2009 - The Fifth International Workshop on the Analysis of Multi-temporal Remote Sensing Images, July 28-30, 2009, Groton, Connecticut.