Sentinel-1 Land Surface Parameter Applications

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Abstract

The availability of reliable land surface information is crucial for a wide range of applications such as environmental monitoring including essential climate change variables, or agro-economical aspects for a sustainable land management. Compared to optical remote sensing data, radar sensors can provide datasets with regular coverage of a specific area without suffering from missing images because of cloud cover. The regular coverage is crucial for the mapping of land surface characteristics. The availability of a multi-temporal dataset allows high accuracy in mapping basic land-cover classes and change, phenological stage of crops, vegetation structure and biomass of crops and forests.

This paper gives an overview of state-of-the-art methodologies for large area mapping of land cover characteristics with the radar sensors on board ERS-1/-2, ENVISAT and ALOS. Focus is on natural, vegetated surfaces. The examples given demonstrate the added value to existing land cover products based on optical data when radar Earth observation is being introduced.

In ESA's RADARCOVER project, an algorithm for the classification of five basic land cover classes, namely Water, Grassland, Agriculture, Forest and Settlement, was developed based on multi-temporal datasets of C-band backscatter. The analysis revealed a high accuracy of Maximum Likelihood and Decision Tree classifiers above the widely accepted success criteria of 85% when having at least four C-band acquisitions in two polarizations (VV&VH or HH&HV). The results indicated a high potential of the upcoming SENTINEL-1 mission for land cover mapping applications as SENTINEL-1 will consistently provide the required dual polarization C-band measurements with short revisit times. The algorithm developed was shown to be independent of specific acquisition dates, i.e. arbitrary combinations of acquisition dates, preferable during period of growth (except winter acquisitions) could be used to classify land cover with high accuracy. The methodology has only been tested for a single test site in Thuringia, Germany, for which an adequate reference land cover map as well as an extended ENVISAT ASAR AP dataset was available. The next step is to transfer the method to larger areas using archived ENVISAT ASAR AP data. The basic layout of the algorithm resp. the properties of the utilized multi-temporal metrics of C-band backscatter are expected to allow a transfer to other areas with only minor adjustments.

The region for the analysis in the ESA project RADARCOVER-2 consists of two transects, one covering most of the Netherlands, eastern Belgium and western North-Rhine-Westphalia and the second covering Mecklenburg-Vorpommern, Berlin and Brandenburg in Germany. This paper will present first results. For both a multi-temporal coverage of ASAR AP data is available in the archives, i.e. at least four acquisitions. Land cover products like CORINE will be used as reference data. In case of North-Rhine-Westphalia GIS reference data for the test area "Klein Altendorf", collected in the framework of the DLR/BMBF ENVILAND project, is available as well. In case of Mecklenburg-Vorpommern ground diverse truth data information are available for the test area "Demmin", which were collected in the ESA-campaign AGRISAR 2006. Different vegetation parameter e.g. biomass, soil moisture,

vegetation type and height were collected. Further, hyperspectral CASA and AHS data are available as well and could be used as additional reference data if necessary.

The continuous acquisition of C-band data since 1991 with ESA's ERS-1/-2 and ASAR (to be continued with SENTINEL-1) represents a great resource of information about very specific vegetation parameters only radar sensors are able to detect: height of cereal crops and grassland, structure of crops (grain vs. large leaf types), moisture conditions, height and density of forest. Pixel and object based segmentation results will be presented with respect to their suitability for SENTINEL-1 level-2 products.

ASAR's additional multi-angle, multi-polarisation, multi-resolution capabilities add new dimensions to the product generation and a series of recently advanced land surface parameter retrieval results are being presented. Large area forest parameter mapping was already performed in the EC-projects SIBERIA, SIBERIA-II, and the ESA-projects GSE Forest Monitoring and Forest DRAGON where first validated biomass maps were generated over several million square kilometres. Results and publications can be accessed via http://www.eo.uni-jena.de/351.0.html.

SAR backscattered intensity is related to forest density properties thus allowing in theory the retrieval of the growing stock volume (GSV), i.e. the density of volume per unit area, which can be converted to above-ground and below-ground biomass by means of allometric equations. In this context the configuration of the SAR system in terms of frequency, polarization, look angle and repeat-pass period is fundamental. The only sensor that currently operates with regular acquisitions over large areas is ENVISAT ASAR. ASAR operates at C-band so that the backscatter is primarily sensitive to the properties of the upper part of the canopy. Another limitation of using C-band for the retrieval of GSV is the strong sensitivity of the backscatter to moisture conditions. This explains why ASAR is typically discarded when it comes to delineate a retrieval scheme based on remote sensing data. However, in ScanSAR mode (Wide Swath Mode, WSM, and Global Monitoring Mode, GMM) each point on the ground can be imaged with daily frequency thanks to the large swath (400 km) that implies a strong overlap of adjacent swaths. In this way large stacks of backscatter measurements become available in a short period of time. If the different response of the backscatter to different environmental conditions is exploited in such a way that more weight is given to data showing highest sensitivity to GSV, it becomes possible to maximize the GSV information in the backscatter and significantly improve the estimates with compared to a single-date case. To validate this methodology is the task of the recent ESA-project BIOMASAR of which first results will be presented.

This paper encourages the remote sensing land community to explore the existing ESA C-band archives for the generation of enhanced value-added products. The paper demonstrates the multiple benefits of future SENTINEL-1 data and data products.