Determination of soil moisture in agricultural fields using X- and C- band SAR data from TerraSAR-X and RADARSAT-2

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ABSTRACT

The moisture content of soil is a term defining the quantity of water contained in the soil. In addition to supplying agricultural crops with water, soil moisture plays a significant role as a solvent and carrier of food nutrients for plant growth, especially in the early stages of the growing season. The base of this study was continuous SAR data from TerraSAR–X, RADARSAT-2, as well as data from Sentinel-1, taken in large time windows from agricultural fields and being processed with different methods, with the goal of deriving information products for agricultural applications, like for precision farming, crop risk and damage detection and yield prediction.

This project, entitled SARfields, is conducted by Spatial Business Integration GmbH and TRE ALTAMIRA Inc. under the umbrella of CSA-DLR collaboration.

The SAR amplitude data were compared with in-situ surveys of soil parameters conducted along with each satellite overpass. During the first study phase from Nov. 2015 to Aug. 2016, more than 2,000 soil samples were taken and soil moisture measured in five selected winter wheat fields in a growing area near Mannheim in Germany. Optical satellite images were used to monitor the phenological development stages of the crops’ canopies. Farming direction, soil roughness and weather data were also recorded. Several models were tested to convert the amplitude data, measured in X and C bands and HH polarization, to soil moisture information, which allow for the retrieval of the top level soil moisture with high accuracy in a spatial resolution of approximately 30 m x 30 m.

The general results achieved in winter wheat fields indicate that SAR data has a high ability to determine the soil moisture content. From October to April, the model’s accuracy reached up to 90%. However, the results achieved with X band data still show acceptable correlation until the beginning of May, with C band data even until the end of May. After May, the soil moisture signal is distorted by the vigorous growth of crop biomass in spring, also triggered by fertilization at that time. The results explain the penetration ability of X and C band SAR into the wheat canopies and defines the best period to monitor soil moisture. Additionally, SAR data were used successfully to observe the ongoing wheat development and to distinguish wheat from other crop types. These findings opened the door to further investigations to evaluate and enhance the results on soil moisture determination within other fields with different crops. Thus, measurements were started in winter rapeseed and corn in the second phase of this study.

A part of the study focused on the customers’ requirements on information products derived from SAR based soil moisture measurements. Satellite image maps for variable sowing and decisions on herbicide applications were among the most favored information products needed by farmers for precision farming purposes.