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Deriving surface roughness dynamics from multi-temporal and multi-parametric airborne SAR-data

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The roughness of natural surfaces plays an important role in numerous physical processes, such as the shortwave radiation balance, wind and water induced soil erodibility or near-surface soil moisture and their description in respective models. The scattering behaviour of rough surfaces can be described statistically by means of a vertical parameter, the RMS height, and a horizontal parameter, the surface correlation length. Surface roughness is highly variable due to wind, agricultural practice or elutriation from precipitation or irrigation, yet little knowledge is available on these effects. Thus, roughness is often assumed constant in respective modeling efforts, introducing strong simplification and considerable data uncertainty. To bridge this scientific gap, the capacity to retrieve this information from multitemporal airborne SAR imagery is investigated.

The presented study is performed in the frame of AgriSAR 2006, a ESA-funded project in preparation of ESA's multi-satellite SENTINEL mission. A major component of this study was to generate an image and ground data base for the examination and validation of bio-/geo-physical parameter retrievals, obtained at different radar frequencies and polarisations (X-, C- and L-Band) from the airborne sensor E-SAR, operated by the German Aerospace Center (DLR). A total of 16 respective E-SAR flights were performed during the agri-phenological cycle in the consolidated test-site of Demmin, North-Germany. Each image acquisition was accompanied by intense ground truthing, including the photogrammetric determination of soil surface roughness under various crop types (maize, sugar beet, wheat and barley) using a Rollei d7 metric digital camera. Micro-DEMs (70 x 70cm horizontal coverage, approx. 1.2

mm vertical accuracy) were computed from stereo-photogrammtric image pairs and the geometric properties RMS height and a turtuosity index, defined as the ratio of the 3D-surface area to the 2D-projected area, were derived. Due to the short profile lengths of ground measurements and the consequent bias towards underestimated values, autocorrelation lengths were furtherly neglected. RMS height and turtuosity index proved to be poorly correlated, thus providing a sufficient data base for statistical analyes with multi-parametric image data, for which priority was given to polarimetric C- and L-band-data.

In order to obtain an improved understanding of the involved scattering mechanisms, a Cloude decomposition of the backscatter signal is performed on the SLC images. It distinguishes the dominant scattering process (surface, volume or double-bounce) by means of the alpha angle and allows to determine the proportional fraction of the other scattering components by means of backscatter entropy and anisotropy. After radiometric processing and geocoding of the decomposed image features, regression analyses were performed with field measurements. First results demonstrate a significant correlation between the measured geometric soil surface properties and the decomposed backscatter signals, indicating the feasibility to determine surface roughness dynamics from multitemporal SAR-imagery.

The poster presents the full processing chain, shows first results and discusses constraints, possibilities and application potential of the proposed approach.