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Derivation of soil moisture in an arctic tundra landscape with SAR - suitability of different wavelengths and spatial resolutions

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Soil moisture is an important variable in the hydrological cycle, as evapotranspiration is highly dependent on the availability of water stored in the soil just beneath the surface. Radar remote sensing has been identified as a suitable tool for the detection of spatial and temporal soil moisture variability. Especially in Arctic regions, where a cloud cover is present during 80% of the year, SAR (Synthetic Aperture Radar) is a valuable tool for monitoring of the environment on a regular basis as it penetrates the cloud cover and works independently from sunlight. Ground measurements are sparse in arctic regions. Remote sensing allows high spatial and temporal observations of a variety of environmental variables. These data help us to a better understanding of arctic environments.

The study area, Samoylov Island (4.37 km^2), is located in the central part of the Lena River Delta in Northern Siberia at 72°N, 126°E in a zone of continuous permafrost. Almost half of the Island is characterized by moss dominated wet polygonal tundra; the other half of the island is a floodplain area, partly vegetated by small bushes, grasses and sedges.

Field measurements were carried out in the study area during summer 2010. The soil moisture of the floodplain area was mapped in a 100 m wide raster under wet and dry conditions. In this study, we compare the capability of X-, C-, and L-Band SAR to represent the soil moisture distribution. We use the data of TerraSAR-X (Spotlight mode), Envisat ASAR (WideSwath mode), and ALOS PALSAR (Finebeam dual-polarization mode). It turns out that the backscatter of the high frequency X-band SAR does not show the soil moisture distribution in the floodplain area, but the distribution of the different vegetation types. In contrast, the lower frequency L-Band SAR is not influenced by the vegetation cover and the signal matches the spatial soil moisture distribution very well. The backscatter of the C-Band SAR is influenced by both the vegetation cover and the soil moisture distribution.

In addition, we analysed if C-Band SAR is able to represent the soil moisture changes under wetter and dryer conditions. To exclude that backscatter changes are related to a different imaging geometry, we took only image pairs received on the same orbit track for these analyses. The vegetation structure does not change significantly during the study period, thus we assume that backscatter change is not related to differences in the vegetation cover. As reference for the real soil moisture conditions, we used soil moisture data recorded hourly at Samoylov climate station. A change detection analysis shows that the backscatter value for the moss dominated polygonal tundra area is significantly higher under wetter conditions than under dryer conditions. In contrast, no significant changes explainable by soil moisture changes only occur for the floodplain area. To conclude, C-Band SAR is able to detect soil moisture changes in moss dominated polygonal environments, but backscatter changes on floodplains vegetated by small bushes, grasses and sedges are more complex.