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Assessing seasonal backscatter variations with respect to uncertainties in soil moisture retrieval in Siberian tundra regions

Elin Högström (1,2), Anna Maria Trofaier (1,2,3), Isabella Gouttevin (4), Annett Bartsch (1,2,5)

(1) Vienna University of Technology (TUW), Research Group Remote Sensing, Department of Geodesy and Geoinformation (GEO), Vienna, Austria (elin.hoegstroem@geo.tuwien.ac.at), (2) Research Group Remote Sensing, Austrian Polar Research Institute, Vienna University, Althanstraße 14, A-1090 Vienna, Austria, (3) ESA Climate Office, ECSAT, Atlas Building, Harwell-Oxford Campus, Didcot, Oxfordshire OX11 0QX, UK, (4) Institut National de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture, Unité de Recherche Hydrologie-Hydraulique, 5 rue de la Doua, CS 70077, F-69626 Villeurbanne Cedex, France, (5) Zentralanstalt für Meteorologie und Geodynamik (ZAMG), 1190 Vienna, Hohe Warte 38, Vienna, Austria.

Data from the Advanced Scatterometer (ASCAT) instrument provide the basis of a near real-time, coarse scale, global soil moisture product. Numerous studies have shown the applicability of this product, including recent operational use for numerical weather forecasts. Soil moisture is a key element in the global cycles of water, energy and carbon. Among many application areas, it is essential for the understanding of permafrost development in a future climate change scenario. Dramatic climate changes are expected in the Arctic, where ca 25% of the land is underlain by permafrost, and it is to a large extent remote and inaccessible. The availability and applicability of satellite derived land-surface data relevant for permafrost studies, such as surface soil moisture, is thus crucial to landscape-scale analyses of climate-induced change. However, there are challenges in the soil moisture retrieval that are specific to the Arctic. This study investigates backscatter variability unrelated to soil moisture variations in order to understand the possible impact on the soil moisture retrieval. The focus is on tundra lakes, which are a common feature in the Arctic and are expected to affect the retrieval. ENVISAT Advanced Synthetic Aperture Radar (ASAR) Wide Swath (120 m) data are used to resolve lakes and later understand and quantify their impacts on Metop ASCAT (25 km) soil moisture retrieval during the snow free period. Sites of interest are chosen according to high or low agreement between output from the land surface model ORCHIDEE and ASCAT derived SSM. The results show that in most cases low model agreement is related to high water fraction. The water fraction correlates with backscatter deviations (relative to a smooth water surface reference image) within the ASCAT footprint areas ($R = 0.91$-0.97). Backscatter deviations of up to 5 dB can occur in areas with less than 50% water fraction and an assumed soil moisture related range (sensitivity) of 7 dB in the ASCAT data. The study demonstrates that the usage of higher spatial resolution data than currently available for SSM is required in lowland permafrost environments. Furthermore, the results show that in the flat and open Arctic tundra areas, wind likely affects the soil moisture retrieval procedure rather than rain or remaining ice cover on the water surface. Therefore, the potential of a wind correction method is explored for sites where meteorological field data are available.