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The potential of using meteorological data to correct for water surface roughness impacts on soil moisture retrieval in the Arctic

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Permafrost temperatures have risen significantly over the past two to three decades, and the Arctic, which to a large extent is underlain by permafrost, is expected to warm rapidly compared to the global mean temperature until the end of the 21st century. In remote areas that are difficult to access for ground measurements, such as the Arctic, satellite-derived data are essential. For permafrost studies in particular, satellite derived soil moisture data is one important parameter which is needed for modelling purposes. To assess the applicability of such data at high latitudes has been given little attention but recent studies have pointed out that seasonal land cover variations and the presence of small water bodies. The presence of small water bodies is characteristic for the Arctic and we expect it to cause complications for soil moisture retrieval from satellite data in these regions.

In the present study, we hypothesize that a bias related to water fraction is caused by variations in the water surface roughness (wind, precipitation). The impact is quantified for the active microwave remote sensing instrument Metop Advanced Scatterometer (ASCAT) by investigating the higher spatial resolution synthetic aperture radar (SAR) data acquired by ENVISAT Advanced SAR. The bias is calculated as an average over time for 11 sites across the Siberian Arctic. It is concluded that a water fraction higher than 20% causes a bias of more than 10% relative surface soil moisture.

Comparisons with in situ collected meteorological data showed that the bias to a great extent could be attributed to the wind and therefore a bias correction was developed based on this. The wind correction was applied and evaluated with in-situ soil moisture data, which were available from one of the sites: the Lena Delta.

The results from the correction were weak, which is likely explained by the fact that the water surfaces at this specific site mainly correspond to rivers: variations in discharge, water height, and streams may affect the water surface roughness, which makes it hard to isolate the actual wind effect. There can be substantial changes in river discharge, which means that the water depth can fluctuate seasonally. This is observed over large parts of the Lena River around the in situ site. We assume that shallow water depth can contribute to unexpectedly low bias, since waves cannot develop the same amplitude as in deep water, even with high wind speed. The results from the Lena delta are finally discussed with respect to comparisons between ASCAT derived soil moisture and in situ data at other sites across the Arctic.