

Remote Sensing at High Latitudes – The value of Active Microwave Satellite Data

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Introduction

Active microwave sensors onboard satellites provide coarse (scatterometer) to medium (ScanSAR and SAR) resolution backscatter images at regular time intervals. In general, satellites with microwave sensors are polar orbiting platforms. This means that data coverage increases with latitude due to overlapping footprints and swaths respectively. At high latitudes, scatterometers can provide several measurements per day and medium resolution ScanSAR up to daily acquisitions. Microwaves have a high application potential in hydrology since backscatter is amongst others related to dielectric properties and thus water content. Time series can be used to monitor soil moisture, snowmelt, and inundation. This extended abstract gives an overview of some available datasets. Additional information can be found on <http://www.ipf.tuwien.ac.at/radar/>.

Near Surface Soil Moisture

The ERS-1 and ERS-2 C-band scatterometer have been proven useful for derivation of relative soil moisture (Wagner et al. 1999). Such data are available globally with 50 km resolution since 1992. The long dataset allows the determination of deviations and thus anomalies. Continuation is ensured due to the launch of Metop in October 2006. The new ASCAT instrument on Metop provides even shorter revisit intervals and increased spatial resolution (25 km; Bartalis et al. 2007). The near surface soil moisture can be determined by time series analysis (Wagner et al. 2003). Figure 1 shows an example of soil moisture anomalies for July 2007 over the northern high latitude regions. The quality of the soil moisture retrievals have been assessed in many studies, e.g. by comparing the satellite retrievals with in-situ measurements, modeled soil moisture data and other remotely sensed soil moisture data sets (Scipal et al., 2008). Figure 2 shows the correlation of scatterometer derived soil moisture values with ERA Interim model results (ECMWF) over the northern hemisphere. For most of the regions in the world, the correlation coefficients are positive, with maximum values around 0.9 especially in areas that are characterized by a seasonal cycle of soil moisture.

However, in the boreal and tundra zones, correlations are generally lower than in temperate regions (Figure 2). Due to the very limited availability of in-situ observations in these regions, the reasons for the lower correlation are not yet understood but might be related to the short summer season, retrieval errors and/or high uncertainties in the modeled soil moisture data.

Another source of soil moisture data is the European satellite ENVISAT which carries a C-band SAR instrument onboard. This Advanced SAR (ASAR) provides higher resolution data (image mode) as well as medium resolution ScanSAR (Wide Swath and Global Mode). A similar time series analyses as developed for scatterometer data can be applied to Global Mode data for extraction of near surface relative soil moisture. These data can also be used to derive spatial scaling properties which allow an interpretation of coarse resolution soil moisture from scatterometer (25km) at local scale (1km) (Wagner et al. 2008).

Snowmelt

C-Band (~5.6 cm) as well as Ku-band (~2.1 cm) radars are suitable for snowmelt detection. Changes in the snowpack, however, have stronger impact on backscatter at shorter wavelengths. The SeaWinds Quikscat is a Ku-band scatterometer which provides measurements with 25 km resolution since 1999. Large changes in backscatter between morning and evening acquisitions are characteristic for the snowmelt period, when freezing takes place over night and thawing of the surface during the day. When significant changes due to freeze/thaw cycling cease, closed snow cover also disappears (Bartsch et al. 2007a). The exact day of year of beginning and end of freeze/thaw cycling can be clearly determined with consideration of long-term noise.

Lakes and Wetlands

Due to the backscatter properties of open water (even surface), lakes can in general be easily identified with active microwave data. Although wind may increase surface roughness, lakes can be identified based on time series (Bartsch et al. 2007b). Due to the wider swath and thus increased spatial and temporal coverage of ScanSARs, large regions can be processed. For example, ENVISAT ASAR Wide Swath data with 150 m resolution provide considerably more detailed information in Tundra regions than land cover products from e.g. MODIS (500m; Bartsch et al. 2008). The spatial distribution of lakes can be used for determination of Tundra wetland extent and also estimation of methane emissions. Peatlands are characterized by high soil moisture conditions. They can be identified due to the sensitivity of microwaves to moisture/ dielectric properties

(Bartsch et al. 2007b). ENVISAT ASAR Wide Swath (150 m) as well as Global Mode (1km) time series are suitable for mapping of large regions such as the West Siberian Lowlands (Bartsch et al. 2008).

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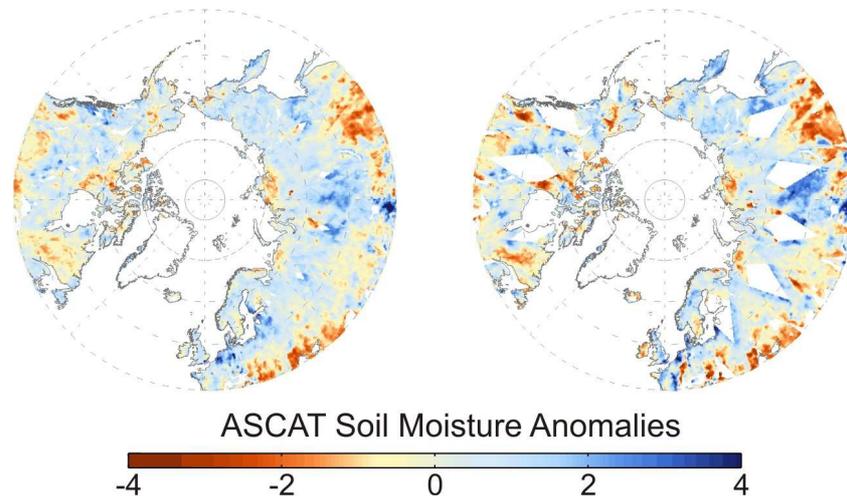


Figure 1. Polar view of soil moisture anomalies from ASCAT data from July 2007. Left: 3 day composite (July 29-31). Right: 1-day composite (July 30th).

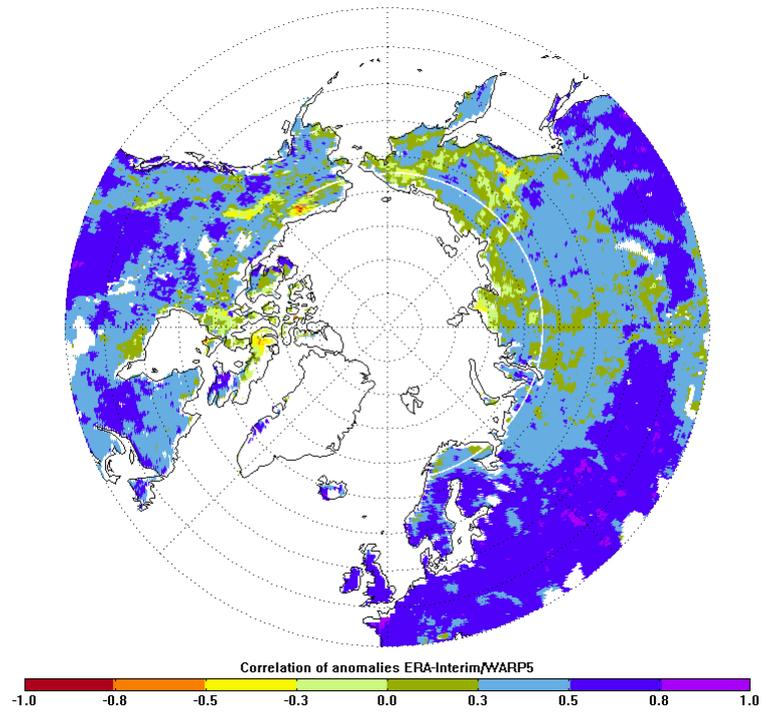
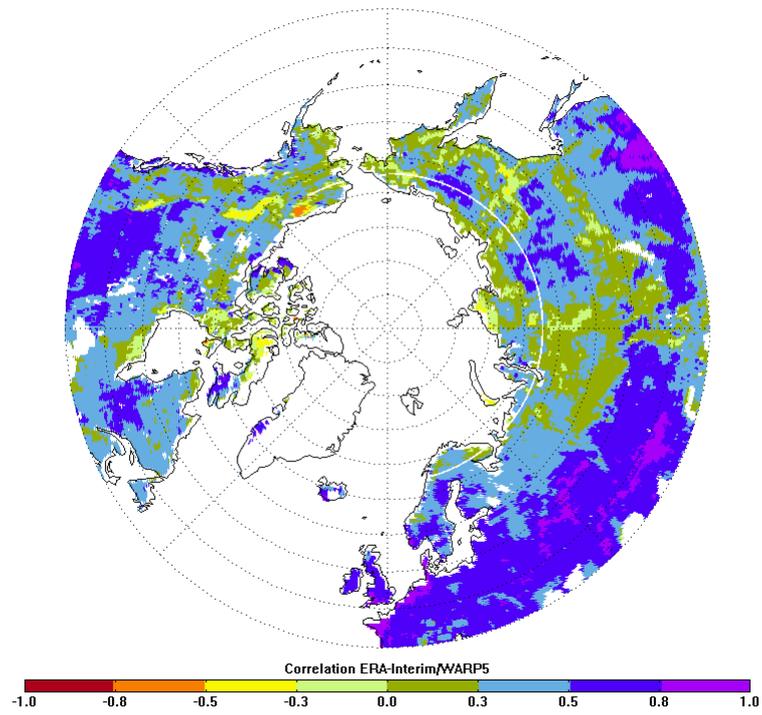


Figure 2. Polar view of a) correlation and b) correlation of anomalies between scatterometer derived soil moisture and ERA Interim modeling results.