High-Resolution Estimates of Soil Moisture from ASCAT

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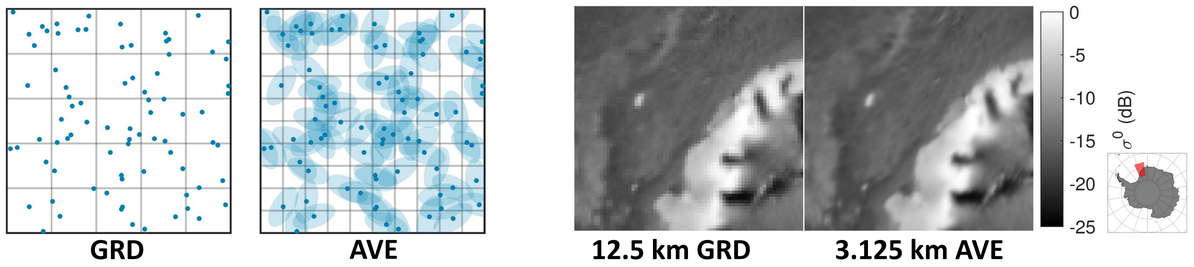
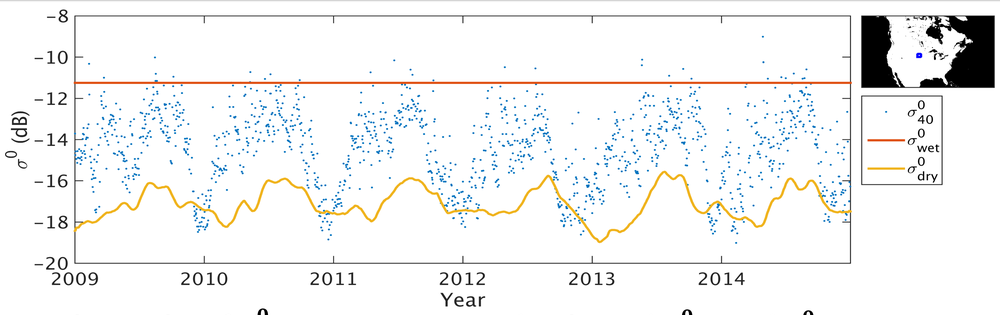
Overview

Satellite-borne C-band scatterometer measurements of the radar backscatter coefficient (σ^0) of the earth can be used to estimate soil moisture levels over land. Such estimates are currently produced with 25 km resolution using the Advanced Scatterometer (ASCAT) sensor and a change-detection algorithm originally developed at the Vienna University of Technology (TU-Wien). Using the AVE image reconstruction algorithm, high resolution (15-20 km) images of σ^0 can be produced, enabling the creation of a high-resolution soil moisture product using a modified version of the TU-Wien algorithm [1].

Conventional resolution images can be reconstructed onto a coarse grid using gridding (GRD) by averaging measurements whose centers fall into the same grid cell. The AVE algorithm uses the ASCAT spatial response function to identify the contribution of each area of the ground footprint to the measured σ^0 value, enabling reconstruction on a fine grid [2].



Methodology



Time series of σ^0 measurements and estimated σ^0_{dry} and σ^0_{wet} for a single pixel area in North America.

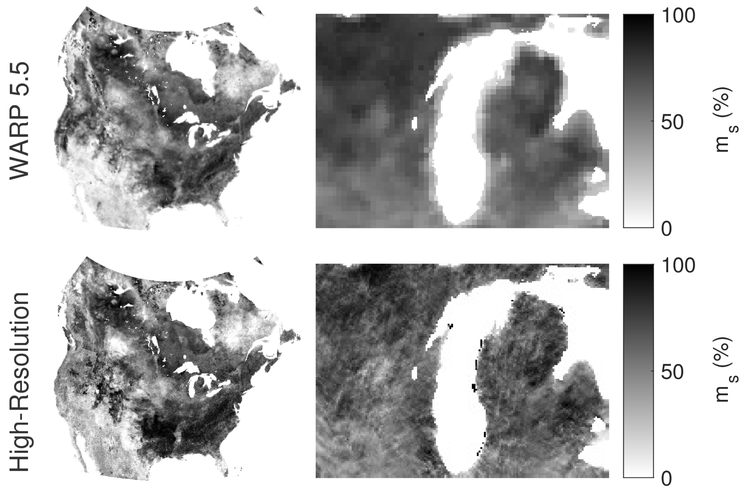
To determine the relative surface soil moisture levels for a given area, the local reported backscatter under entirely dry and water-saturated conditions is found. Minimum and maximum backscatter values ($\sigma^0_{dry}$and σ^0_{wet}) in a multiyear time series of local backscatter observations are assumed to correspond to entirely dry and water-saturated soil conditions. The relative topsoil moisture (m_s), given by the below equation, is an estimate of the water saturation in the top few centimeters of the soil and takes on values between 0% and 100% for different σ^0 values .

$$m_s(t) = \frac{\sigma^0(t) - \sigma^0_{dry}(t)}{\sigma^0_{wet}(t) - \sigma^0_{dry}(t)}$$

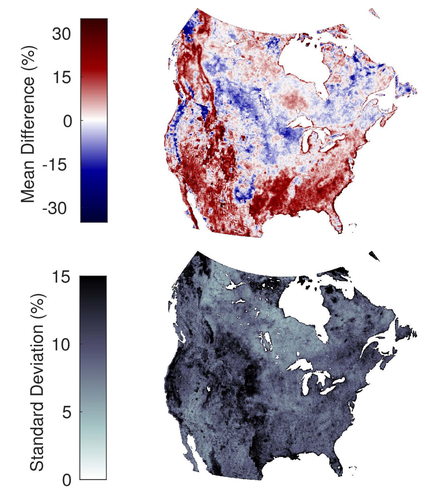
Application

Soil moisture estimates are used for a variety of applications including drought detection, flood and landslide forecasts, crop yield monitoring, and rain precipitation models. Exploiting ASCAT's high-resolution image capability enables higher resolution images of soil moisture than are currently available to be developed. By resolving finer soil moisture features, the higher resolution soil moisture images could complement current soil moisture-related studies.

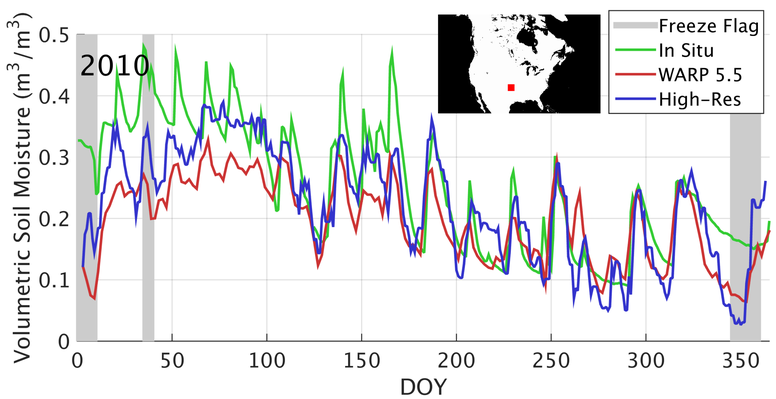
Results



Images comparing the high-resolution and TU-Wien low-resolution m_s values over North America and near Lake Superior using data from day of year 121-125, 2009. Note the greater detail in the high-resolution images.



Mean (top) and standard deviation (bottom) of the pixel value differences between the high-resolution and TU-Wien low-resolution m_s estimates over a time series of images for 2009 for North America.



Time series of volumetric soil moisture versus day of year for 2010. Plots are shown for *in situ* data from Stillwater, OK, and corresponding grid cell values from the TU-Wien and high-resolution data.

[1] D. Lindell and D.G. Long, "High-resolution soil moisture retrieval with ASCAT," *IEEE Geosci. Remote Sens. Lett.*, to appear, 2016.

[2] R. Lindsley and D.G. Long, "Enhanced-resolution reconstruction of ASCAT backscatter measurements," *IEEE Trans. Geosci. Remote Sens.*, Vol. 54, No. 5, pp. 2589-2601, 2016.