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An inversion method for retrieving soil moisture information from satellite altimetry observations

Bernd Uebbing, Ehsan Forootan, Jürgen Kusche, and Anne Braakmann-Folgmann
University of Bonn, Institue of Geodesy and Geoinformation, Bonn, Germany (uebbing@geod.uni-bonn.de)

Soil moisture represents an important component of the terrestrial water cycle that controls., evapotranspiration and vegetation growth. Consequently, knowledge on soil moisture variability is essential to understand the interactions between land and atmosphere. Yet, terrestrial measurements are sparse and their information content is limited due to the large spatial variability of soil moisture. Therefore, over the last two decades, several active and passive radar and satellite missions such as ERS/SCAT, AMSR, SMOS or SMAP have been providing backscatter information that can be used to estimate surface conditions including soil moisture which is proportional to the dielectric constant of the upper (few cm) soil layers .

Another source of soil moisture information are satellite radar altimeters, originally designed to measure sea surface height over the oceans. Measurements of Jason-1/2 (Ku- and C-Band) or Envisat (Ku- and S-Band) nadir radar backscatter provide high-resolution along-track information ($\sim$ 300m along-track resolution) on backscatter every $\sim$10 days (Jason-1/2) or $\sim$35 days (Envisat). Recent studies found good correlation between backscatter and soil moisture in upper layers, especially in arid and semi-arid regions, indicating the potential of satellite altimetry both to reconstruct and to monitor soil moisture variability.

However, measuring soil moisture using altimetry has some drawbacks that include: (1) the noisy behavior of the altimetry-derived backscatter (due to e.g., existence of surface water in the radar foot-print), (2) the strong assumptions for converting altimetry backscatters to the soil moisture storage changes, and (3) the need for interpolating between the tracks.

In this study, we suggest a new inversion framework that allows to retrieve soil moisture information from along-track Jason-2 and Envisat satellite altimetry data, and we test this scheme over the Australian arid and semi-arid regions. Our method consists of: (i) deriving time-invariant spatial patterns (base-functions) by applying principal component analysis (PCA) to simulated soil moisture from a large-scale land surface model. (ii) Estimating time-variable soil moisture evolution by fitting these base functions of (i) to the along-track retracked backscatter coefficients in a least squares sense. (iii) Combining the estimated time-variable amplitudes and the pre-computed base-functions, which results in reconstructed (spatio-temporal) soil moisture information.
We will show preliminary results that are compared to available high-resolution soil moisture model data over the region (the Australian Water Resource Assessment, AWRA model). We discuss the possibility of using altimetry-derived soil moisture estimations to improve the simulation skill of soil moisture in the Global Land Data Assimilation System (GLDAS) over Australia.