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An inter-comparison of soil moisture variations detected by satellite remote sensing, satellite gravimetry, and hydrological modeling

Sarah Abelen (1), Florian Seitz (1), Michael Schmidt (2), and Andreas Guentner (3)

(1) Technische Universitaet Muenchen (TUM), Munich, Germany (sarah.abelen@bv.tum.de), (2) Deutsches Geodaetisches Forschungsinstitut (DGFI), Munich, Germany, (3) German Research Centre for Geosciences (GFZ), Potsdam, Germany

Common methods for the determination of soil moisture over large areas include satellite remote sensing and hydrological modeling. On local scales, also the gravimetric determination of soil moisture has a long history. However, on regional and global scales satellite gravimetry is hardly used to assess variations in soil moisture due to the superposition of the relatively weak signal of moisture-related mass variations by a multitude of other effects. In our study we aim at the inter-comparison of soil moisture variations derived from satellite remote sensing and hydrological modeling with observations from satellite gravimetry. Therefore test areas are selected, where mass variations from other origin than soil moisture (surface waters, snow water, non-hydrological signals etc.) can be corrected for or can be neglected.

Being in orbit since 2002, GRACE provides a unique data source for the quantification of spatio-temporal variations of the terrestrial water storage (TWS). In our study we apply different algorithms based on global and regional mathematical base functions in order to analyse the observations of GRACE with respect to water mass changes in the region of interest. Since GRACE provides a temporal resolution of one month, seasonal variations of TWS are detectable. The spatial resolution of the mission amounts to approximately 300 to 400 km.

For the part of satellite remote sensing the soil moisture products of the passive sensor AMSR-E of the NASA mission Aqua and the active sensor ASCAT of the EUMETSAT mission MetOp are compared. The WaterGAP Global Hydrological Model (WGHM) as well as data from the Global Land Data Assimilation System (GLDAS) make up the third component of the analysis.

In order to compare the various data sets with respect to signatures of soil moisture variations, their spatio-temporal patterns as well as their inter-annual changes and long term trends are analyzed. For this purpose we apply different mathematical functions such as the Principle Component Analysis (PCA), B-Splines, and/or spherical wavelets. Thereby the various temporal and spatial resolutions have to be considered. From the confrontation of data we will draw conclusions on the usability of gravimetric data from satellite missions for the determination of soil moisture changes over large areas. Also deviations and agreements of different data sets will be highlighted and analyzed. On the basis of the results two questions will be discussed (1) if gravimetry can contribute to a better understanding of regional and global soil moisture variations and (2) if it can therefore be integrated in the validation of other independent data sets on soil moisture.