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Hydrological storage variations in a lake water balance, observed from multi-sensor satellite data and hydrological models.

Alka Singh (1), Florian Seitz (1), Christian Schwatke (2), and Andreas Guentner (3)

(1) Technische Universität München, Institut für Astronomische und Physikalische Geodäsie, München, Germany (alka.singh@bv.tum.de, +49 89 / 289 231 78), (2) Deutsches Geodaetisches Forschungsinstitut, Alfons-Goppel-Str.11, 80539 Muenchen, Germany, (3) GFZ German Research Centre for Geosciences, Telegrafenberg 326, 14473 Potsdam, Germany

Freshwater lakes and reservoirs account for 74.5% of continental water storage in surface water bodies and only 1.8% resides in rivers. Lakes and reservoirs are a key component of the continental hydrological cycle but in-situ monitoring networks are very limited either because of sparse spatial distribution of gauges or national data policy. Monitoring and predicting extreme events is very challenging in that case. In this study we demonstrate the use of optical remote sensing, satellite altimetry and the GRACE gravity field mission to monitor the lake water storage variations in the Aral Sea. Aral Sea is one of the most unfortunate examples of a large anthropogenic catastrophe. The 4th largest lake of 1960s has been decertified for more than 75% of its area due to the diversion of its primary rivers for irrigation purposes. Our study is focused on the time frame of the GRACE mission; therefore we consider changes from 2002 onwards.
Continuous monthly time series of water masks from Landsat satellite data and water level from altimetry missions were derived. Monthly volumetric variations of the lake water storage were computed by intersecting a digital elevation model of the lake with respective water mask and altimetry water level. With this approach we obtained volume from two independent remote sensing methods to reduce the error in the estimated volume through least square adjustment. The resultant variations were then compared with mass variability observed by GRACE. In addition, GARCE estimates of water storage variations were compared with simulation results of the Water Gap Hydrology Model (WGHM).
The different observations from all missions agree that the lake reached an absolute minimum in autumn 2009. A marked reversal of the negative trend occured in 2010 but water storage in the lake decreased again afterwards. The results reveal that water storage variations in the Aral Sea are indeed the principal, but not the only contributor to the GRACE signal of mass variations in this region; this is also verified by WGHM simulations. An important implication of this finding is the possibility of GRACE to analyses storage changes in other hydrological compartments (soil moisture, snow and groundwater) once the signal has been reduced for surface water storage changes. Therefore the congruent use of multi-sensor satellite data for hydrological studies proves to be a great source of information for assessing terrestrial water storage variations.