Geophysical Research Abstracts
Vol. 20, EGU2018-7964, 2018
EGU General Assembly 2018

Ground deformation response to varying water levels at the Toktogul Reservoir, Kyrgyzstan: Insights from SAR interferometry and geophysical modeling

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We apply synthetic aperture radar data and geophysical modeling to assess ground deformation changes at the 284 km^2 large Toktogul Reservoir in Kyrgyzstan, Central Asia, which is used for hydropower generation and irrigation. The reservoir's water level is prone to significant changes during the year, but also shows inter-annual variations due to overall water recession or accumulation. We use Envisat ASAR data to analyse the ground deformation during a time of exaggerated use of water between 2004 – 2009 (net water level drop of 60 m / 13.5 km^3) and Sentinel-1 data to derive the ground deformation during a time of overall water level increase between 2014 – 2016 (net water level plus of 51 m / 11.2 km^3). The deformation pattern was measured by generating an interferometric time-series using the Small BAseline Subset (SBAS) approach. After removing heavily impacting atmospheric effects by applying the elevation dependent powerlaw approach, results show that both sensors are able to image related uplift and subsidence signals in the order of approximately 1 mm per 1 m water level change for the investigated time periods. Moreover, time-series results from Sentinel-1 also resolve intra-annual changes induced by 40 m periodical water level changes. Reasons for this superior behaviour of Sentinel-1 data are a short temporal baseline of 12 days and a small orbital tube, which both lead to a higher temporal sampling compared to the Envisat setting and at the same time to a better correlation of points within the interferograms. The derived spatial pattern of land-deformation rate is validated against modeling of the elastic deformation, based on a Love-number approach. The load forcing due to lake-level changes is derived from satellite-based radar altimetry.