Loading-induced ground deformations around the Toktogul Reservoir, Kyrgyzstan, as observed by Envisat ASAR and Sentinel-1 data

Julia Neelmeijer*†[1,2], Tilo Schöne[1], Robert Dill[1], Volker Klemann[1], and Mahdi Motagh[2,1]

[1]German Research Centre for Geosciences - Helmholtz-Centre Potsdam – Telegrafenberg, 14473 Potsdam, Germany

[2]Leibniz Universität Hannover – Gottfried Wilhelm Leibniz Universität Hannover Welfengarten 1 D-30167 Hannover, Germany

Abstract

Large water reservoirs in the semi-arid regions of Central Asia are beneficial for the storage of drinking water, irrigation and hydropower generation. As the water is used for multiple purposes during different seasons of the year, the water level in such reservoirs changes considerably both during and between the years. The largest water reservoir in Kyrgyzstan is the Toktogul Reservoir with a total capacity of 19.5 km^3, which is affected by annual water level changes of up to 40 metres. The variation in water level implies a change of the load on the crust which leads to a subsidence response in case of water increase and uplift response in case of water decrease. In this study, we investigate loading-induced deformations at the Toktogul Reservoir using InSAR measurements. Two time periods are considered: (1) a time of overall water level decrease of 60 m (_˜13.5 km^3 water volume) between 2004 and 2009 for which we used Envisat ASAR data and (2) a period of overall water level increase of 51 metres (_˜11.2 km^3 water volume) between 2014 and 2016 for which Sentinel-1 TOPS data was used. By applying the Small Baseline Subset (SBAS) technique on networks of differential interferograms, we observe the corresponding deformation of the crust around the reservoir. Our analysis includes a test of various approaches to minimize strong atmospheric influences in the differential interferograms. We conclude that phase-based atmosphere removal approaches are superior to numerical weather model-based methods for the basin-shaped, high-mountain Toktogul area. The decomposition of Sentinel-1 ascending and descending ground deformations in line-of-sight shows that the crustal response occurs mainly in vertical direction with a rate of -1.07 mm per 1 m water level change. The observed ground deformation is closely correlated to the with radar altimetry measured Toktogul water level changes, which suggests an elastic response of the crust. This hypothesis is supported by a well agreement between elastic forward-modelling of the response reaction and the measured SBAS results.

*Speaker

†Corresponding author: neelmeijer@gfz-potsdam.de