Geophysical Research Abstracts
Vol. 18, EGU2016-5951, 2016
EGU General Assembly 2016

Monitoring and modeling of sinkholes affecting the Jordanian coast of the Dead Sea through satellite interferometric techniques

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Differential Interferometric Synthetic Aperture Radar (DInSAR) techniques have been applied to investigate sinkholes affecting the Jordanian coast of the Dead Sea. The Dead Sea is a hyper saline terminal lake located in a pull-apart basin. Most of the area is characterized by highly karstic and fractured rock formations that are connected with faults. Karstic conduits extend from the land into the sea.
Since the 1960s, the Dead Sea level is dropping at an increasing rate: from about 60 cm/yr in the 1970s up to 1 m/yr in the 2000s. From about the mid-1980s, sinkholes appeared more and more frequently over and around the emerged mudflats and salt flats. Strong subsidence and landslides also affect some segments of the coast. Nowadays, several thousands of sinkholes attest that the degradation of the Dead Sea coast is worsening.
Deformation analysis has been focused on the Ghor Al Haditha area, located in the South-Eastern part of the lake coast. SAR data acquired by three different sensors, ERS, ENVISAT and COSMO- SkyMed have been analysed. 70 ERS images from 1992 to 2009 and 30 ENVISAT images from 2003 to 2010 have been processed. SBAS technique has been applied to define surface velocity and displacement maps. Results obtained from the SBAS technique, applied to ERS and Envisat data, highlight a diffuse subsiding of the entire Eastern coast of the Dead Sea. It was not possible to detect single sinkholes because of the resolution of these sensors (25m2) and the small size of each punctual event that is generally varying from a few meters to a hundred meters diameter.
Furthermore, SBAS has been applied to 23 COSMO-SkyMed SAR satellite images from December 2011 to May 2013. The high resolution of these data (3m x 3m) and the short revisiting time allowed precise information of the displacement of punctual sinkholes beyond the overall subsidence of the coast. A specific sinkhole has been identified in order to understand its temporal evolution. The considered phenomenon reached a total displacement of around 120 mm in 18 months in its central part.
On the basis of the results from DInSAR processing, a simplified analytical model has been implemented. Vertical and horizontal components of the surface displacement field obtained from analysis of SAR images have been used as input data to derive geometric parameters of the source and in particular to estimate the volumetric strain of the phenomenon. Position, dimension and mechanism have been obtained.