Probing the uppermost mantle rheology using surface deformation associated with the Lake Mead load fluctuations

Marie-Pierre Doin, Olivier Cavalie, Cecile Lasserre, Pierre Briole
Laboratoire de Géologie, Ecole Normale Supérieure, Paris

Water level fluctuations in the Lake Mead (Basin and Range, USA) act as a time varying load on the lithosphere. The monitoring of the surface deformation induced by the water load is performed by InSAR using ERS-1, ERS-2 and Envisat radar acquisitions between 1992 and 2007. The comparison between load and deformation could bring constraints on the uppermost mantle viscosity structure, provided a sufficient accuracy of InSAR measurements.

Interferograms from ERS-1 and ERS-2 SAR acquisitions were previously calculated and inverted to retrieve the temporal and spatial subsidence around lake Mead between 1992 and 2001. A peak to peak subsidence of 1.5 cm is recorded between 1995 and 1999 and corresponds to 10m of lake level increase. It was shown in a previous study that the ground motion evolution can be closely associated with the load/unload of lake Mead water level fluctuations (Cavalié et al., J. Geophys. Res, 2007). The ground motion amplitude, evolution, and pattern could be best explained by a visco-elastic rebound of the lithosphere-asthenosphere, with a 30 km thick elastic plate overlying a 10^{18} Pa.s asthenosphere.

In order to provide further constraints on the lithosphere and asthenosphere rheology it was found necessary to extend the monitoring of surface deformation up to 2007. We need, in particular, to record the uplift that is associated with the drastic lake level fall (30 m) from 2000 to 2004. This should theoretically allow to measure not-in-phase ground motions with respect to loading, that were not yet clearly visible in the 1992-2001 time series. To achieve that goal, we use Envisat data from 2003 to 2007, and a few additional ERS-2 data from 2004 to 2007, acquired with a "reasonable" Doppler centroid frequency. The link between the ERS 1992-2001 and the Envisat 2003-2006 time series is obtained through a few cross-platform ERS/Envisat interferograms and a few ERS-2 interferograms covering the data gap in 2002-2003. We shortly describe (1) the mitigation of atmospheric artefacts, (2) the formation of cross-platform ERS/Envisat interferograms. More than 350 -ERS/ERS, ERS/Envisat and Envisat/Envisat- interferograms, performed with the JPL ROI-PAC software, are then included in an inversion to obtain maps of the ground subsidence from 1992 to 2007. We give the elastic thickness and asthenosphere viscosity that allow the best adjustment between the model and the spatial and temporal behavior of the inverted displacement. Although extended to 2007, the ERS-Envisat displacement time series accuracy is still marginally acceptable to place strong constraints on a complete asthenosphere/lithosphere layered mechanical behavior.