TO Seminar June 18, 2013

Marie-Pierre Doin (ISTerre, Grenoble, France)

Visco-elastic rebound of the lithosphere around the lake Siling Co in Tibet observed by InSAR

This study attempts to constrain the lithospheric strength in Central Tibet by studying the rebound of the lithosphere subjected to loading due to lake Siling Co water level increase. This lake is a large (1600 km2) endhoreic lake at 4500 m elevation located North of the strike-slip right lateral Gyaring Co fault, and South of the Bangong Nujiang suture zone, on which numerous left-lateral strike slip faults are branching. The Siling Co water level has strongly changed in the past, as testified by numerous traces of palaeo-shorelines, clearly marked until 60 m above present-day level. Altimetric measures show that during the period 1995-1999 the Siling Co water level remained stable, while it increased by about 1.0 m/yr in the period 2000-2006. The increase rate gradually stepped down to 0.2 m/yr in 2008-2011. To extent the lake level observation duration, we extract the lake contour from all cloud-free LANDSAT images available on the USGS GLOVIS server. The lake surface, used as a proxy for lake elevation, shows that the water level in the Siling Co lake in Tibet was more or less stagnant from 1973 to 1999. The ground motion associated to the water level increase is studied by InSAR using all available 56 ERS and 51 Envisat data on descending tracks 491 and 219 in the period 1992-2010, obtained through the Dragon ESA-MOST cooperation program. The interferograms covering the period 1992-1999 show no detectable deformation, whereas the ones covering the period 2000-2010 present a clear bowl shape pattern centered on the lake that extend from the shore to about ~100 km from the lake center. The amplitude is about 5 mm/yr close to the lake shores. To increase the signal to noise ratio, the interferograms are first analysed in time assuming a constant deformation shape. We then obtain the temporal evolution of the deformation amplitude: it remains constant for the period 1992-1999, and increases from 2000 until 2011. This curve thus closely follows the lake level temporal evolution, but shows a continued subsidence in 2009-2011, while lake level stagnated. The average spatial deformation pattern is then extracted for the period 2000-2010. Furthermore, we provide and discuss uncertainties on ground motion time series, focusing on the quantification of turbulent atmospheric noise and of the azimuthal phase ramp. Both the temporal evolution and the average velocity map are used to explore possible rheological models. The elastic model is based on elastic moduli extracted from Vp/Vs profile derived from INDEPTH III experiment. It could explain the observed subsidence rates if elastic moduli are about twice lower than the one derived from the lithosphere seismic velocity profiles. We discuss whether the increase in elastic moduli due to local fluid pressure disequilibrium in nearby pores, when the medium is crossed by high frequency waves, could explain this discrepancy. However, kernels of surface displacements to elastic properties at depth show little sensitivity to the shallowest (first 10~km) parameters, where one expects that the cracks may not be closed.

We then explore layered visco-elastic models, with low viscosity in the lower crust and asthenosphere. A visco-elastic model with a low viscosity lower crust (< 5x1018 Pa.s) provides a good fit to the data. Best-fit elastic thickness and viscosity depend on the assumed layering. Delays resulting from viscous relaxation do not strongly affect the correlation between ground motion and water level, but yields a slightly better fit to the observed temporal evolution than the elastic model.