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Climatic and anthropogenic stress on water levels: basin-scale observations with seismic noise

Thomas Lecocq (1), Helle Pedersen (2,3), Florent Brenguier (2,3), and Klaus Stammler (4)

(1) Royal Observatory of Belgium (thomas.lecocq@seismology.be), (2) Univ. Grenoble Alpes, ISTerre, F-38041 Grenoble, France, (3) CNRS, ISTerre, F-38041 Grenoble, France, (4) BGR Federal Institute for Geosciences and Natural Resources, Germany

Monitoring changes in shear wave velocities within the crust have become possible through recently developed techniques based on seismic noise analysis. In the present work we address the challenge of using these techniques for environmental monitoring at upper crustal level. Our work is based on data from the broadband Gräfenberg array (Germany) which was installed in 1976 and for which the continuous data acquired has been preserved until today.

Using state of the art pre-processing and cross-correlation techniques (MSNoise), we computed daily cross-correlation functions (CCF) between 4 stations (6 pairs) of the Gräfenberg array over the period 1977-2007. The daily CCFs are then stacked to form an average CCF per month. Instead of doing classic "one versus reference" comparisons, the monthly CCFs are compared pairwise using Moving Window Cross-Spectral analysis (MWCS). In total, 387 720 MWCS have been computed between 20 s and 80 s lapse time to obtain relative velocity changes (dv/v). All dv/v are then inverted using a Bayesian weighted least square procedure. Depending on the smoothing weight used during the inversion, seasonal to long term trends can be evidenced.

The results show clear and stable trends in the data. We present possible causes explaining these trends and abrupt changes of dv/v by showing modelled (GLDAS) and observed climatic data together with anthropogenic observables.

A combination of climatic (warmer surface temperatures, less rainfall) and anthropogenic (more population, more irrigated land) factors are the most probable causes of the progressive relative increase of seismic velocities under the Gräfenberg array. We interpret these results as a progressive depletion of the water resources in the large karstified Malm reservoir (Late Jurassic) below the array.