Seasonal Variations in Geodetic Strain Induced by Hydrological Surface Loading in the Himalaya and Implications for Shallow Elastic Structure of the Earth

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Geodetic time series from continuous Global Positioning System (GPS) stations across the Himalaya of Nepal show strong seasonal variations observed on both horizontal and vertical components (Bettinelli and others, 2008). We show here that seasonal variations of surface loading, due to continental water storage (monsoon cycle mostly), is most probably the primary cause for these geodetic seasonal variations and that this effect can be used to constrain the shallow elastic structure of the Earth.

The integrated land-water mass determined from the global time variations of the Earth's gravity field measured by the Gravity Recovery and Climate Experiment (GRACE) is used to estimate surface load variations. To test the proposed model we take advantage of a larger dataset of GPS time series in the India - Nepal area and a longer time period of GRACE water-storage data than previous studies.

We model seasonal variations of geodetic surface displacements using first an elastic half-space approximation (Farrell, 1972) and find that the observed signal at a number of stations in Nepal and India can indeed be predicted reasonably well. The best fit, in the least-squares sense, is obtained for an elastic modulus of 145 GPa. This model is however difficult to assess given that it ignores the spherical and internal structure of the Earth. We therefore show simulations based on a more realistic spherical layered Earth structure (Farrell, 1972; Guo and others, 2004) . We consider an initial model based on the Preliminary Reference Earth Model (PREM), which is found to underestimate seasonal strain amplitude. We next determine a best fitting model, in the Bayesian sense (Fukuda, 2008), by adjusting the distribution of velocities and density with depth to best match the geodetic time series. Variations by up to 10% relative to PREM in the upper 200 km are inferred.

References

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