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Prospect for Robust Constraints on Glacial Isostatic Adjustment Models using GPS Imaging of Ultra-Low Strain Rates

Geoffrey Blewitt, Corné Kreemer, and William Hammond
Nevada Geodetic Laboratory (NGL), University of Nevada, Reno, United States (gblewitt@unr.edu)

Glacial isostatic adjustment (GIA) models have been used to predict contemporary Earth surface displacements, which in turn can be compared with GPS station velocities either to assess or refine those models. One problem with using station velocities for comparison purposes is that they are reference frame dependent, and so are affected both by rotation and translation rates. Ensuring that the GIA model and GPS station velocities are in the same reference frame is not trivial, particularly with regard to rotation of the horizontal velocity field, considering that plate tectonics and more localized processes than GIA also affect the velocity field. Here we mitigate the reference frame problem by using GPS velocities to create a robust image of the horizontal strain rate tensor. This can then be decomposed into scalar fields such as dilitation rate and shear magnitude rate. Here we use a new robust strain rate estimation method (MELD—Median Estimation of Local Deformation) applied to 3,271 GPS velocities in North America that were estimated using a robust algorithm MIDAS (Median Interannual Difference Adjusted for Skewness). The resulting images of strain rate are robust to anomalies localized in time or space, while respecting the inherent spatial resolution of the network. Despite the inherent high resolution of this method when applied to dense networks, our results show ultra-low strain rates with plate-scale coherence in intraplate North America, thus providing a coherent image of GIA, superimposed by more localized processes such as delta subsidence and ground fluid extraction. Our key finding is that the area underneath the Laurentide ice sheet is undergoing extension, surrounded by a semi-annular belt of contraction of up to ∼4 nanostrains per year. We conclude with the prospect that the observed long wavelength characteristics of the ultra-low strain rate field in intraplate regions can therefore be used to provide robust constraints on viable GIA models.