GIA in West Antarctica: Improved Constraints from Crustal Motion Measurements from the POLENET Antarctic GPS Network

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Crustal motions measured by GPS provide a unique proxy record of ice mass change, due to the elastic and viscoelastic response of the earth to removal of ice loads. The ANET/POLENET array of bedrock GPS sites spans much of the Antarctic interior, encompassing regions where glacial isostatic adjustment (GIA) models predict large crustal displacements due to ice loss since the Last Glacial Maximum (LGM), and including the sector of coastal West Antarctica where major modern ice mass loss is documented. To isolate the long-term GIA component of measured crustal motions, we computed and removed elastic displacements due to recent ice mass change. We used the annually resolved ice mass balance data from Martín-Español et al. [2016] with the Regional Elastic Rebound Calculator (REAR) [Melini et al., 2015] to compute elastic vertical and horizontal surface displacements. Uplift due to elastic rebound is substantial in West Antarctica, very minimal in East Antarctica, and variable across the Weddell Embayment.

The ANET GPS-derived and elastic-corrected crustal motion patterns ascribed to GIA are spatially complex, and differ significantly in magnitude from model predictions for many sectors of Antarctica. We present a systematic comparison of measured and predicted velocities within different sectors of Antarctica, in order to examine spatial patterns relative to modern ice mass changes, ice history model uncertainties, and lateral variations in earth properties. In the Weddell Embayment region most vertical velocities are lower than uplift predicted by GIA models. Several sites in the southernmost Transantarctic Mountains and the Whitmore Mountains have vertical uplift significantly exceeding GIA model predictions. Highest velocities occur in the Amundsen Sea Embayment sector of West Antarctica, flanked by subsiding regions. This pattern can be modeled as a viscoelastic response to ice loss on decadal-centennial time scales in a region with weak upper mantle, consistent with seismic results in the region.