Antarctic ice mass change since the LGM: constraints from geodetic measurements of bedrock crustal motions

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Abstract

Crustal motions measured by GPS provide crucial constraints on ice mass change in Antarctica by recording the elastic and viscoelastic response of the earth to removal of ice loads. To isolate the longer-term GIA component of measured crustal motions, we compute and remove elastic displacements due to recent ice mass change. Uplift due to elastic rebound is substantial in West Antarctica, very minimal in East Antarctica, and variable across the Weddell Embayment. The residual 'GIA' bedrock velocities are spatially complex and vary strongly both within and between different regions. Comparison of these GIA uplift rates with predicted values from GIA models show discrepancies as high as ~25 mm/yr. Measured uplift rates are substantially lower than most current GIA model predictions in the Weddell and Marie Byrd Land regions and much higher in the Amundsen Sea Embayment and southern Transantarctic Mountains regions. GIA velocities in the Amundsen sector show high uplift flanked by subsiding flanks. 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. The inconsistency of measured GIA rates with leading GIA models demonstrates that either the radial viscosity profiles and/or the deglaciation histories used by the models are incorrect, and (given their coupling) most likely both. The bedrock motion data can be used to improve current GIA models, which estimate loss of Antarctic ice since the Last Glacial Maximum (LGM) in terms of globally averaged sea-level change between ~7 and 14 m. Improved geodetically-derived constraints for the 'GIA correction' required for estimating rates of ice mass change from satellite gravity measurements also will improve our understanding of ongoing ice sheet evolution and sea level projections.

Keywords: geodesy, glacial isostatic adjustment, ice mass change