What goes down must come up: viscoelastic deformation in the Antarctic Peninsula

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Since 1995 several ice shelves in the Northern Antarctic Peninsula have collapsed and triggered ice-mass unloading, invoking a solid Earth response that has been recorded at GPS stations. The Palmer GPS time series, in particular, offers a rare opportunity to study the time-evolution of the low-viscosity solid Earth response to a well-captured ice unloading event. The previous attempt to model the observation of rapid uplift following the 2002 breakup of Larsen B Ice Shelf failed, being limited by incomplete knowledge of the pattern of ice unloading and possibly the assumption of an elastic-only mechanism.

We make use of a new high resolution dataset of ice elevation change that captures ice-mass loss north of 66°S to first show that non-linear uplift of the Palmer GPS station since 2002 cannot be explained by an elastic-only signal. We next apply a viscoelastic model with linear Maxwell rheology to predict uplift since 1995. We vary the thickness of the elastic lithosphere and upper mantle viscosity, and test the fit to the Palmer GPS time series showing that the observations may be closely fit with an upper mantle viscosity of less than 2×10^{18} Pa s, much lower than previously modelled. Comparison with vertical velocities from six GPS stations deployed after 2009 (the LARISSA network) verifies the results from the model. We show that variations in surface mass balance help to explain much of the residual inter-annual signal.

Despite the excellent model-data agreement, wider geophysical and laboratory studies suggest that a more complex rheological model may be required to correctly interpret the observed deformation. We report on preliminary investigations into adopting a power-law rheology, and discuss the constraints placed on such models by this dataset and the potential implication for understanding grounding line stabilization through solid earth rebound.