Solid Earth Response to High Resolution Surface Elevation and Ice Mass Changes around GNSS Sites in West Antarctica

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Introduction
Global Navigation Satellite System (GNSS) sites, deployed in the Amundsen Sea Embayment (ASE) of West Antarctica, record unprecedented rates of bedrock uplift. This is due to a combination of near instantaneous elastic and longer-term viscoelastic rebound, occurring as a result of ice sheet mass changes. Barletta et al. (2018) suggest that this uplift is dominated by a fast viscoelastic response from a low viscosity upper mantle.

Upper mantle viscosities control rates of glacial isostatic uplift (GIA) which is vital correction for the Gravity Recovery and Climate Experiment (GRACE). Inaccurate GIA corrections can alter estimates of ice mass change, and subsequently sea level rise. Here we provide additional constraints on upper mantle viscosity by isolating instantaneous elastic uplift at GNSS sites using high resolution mass change grids fed into an elastic model. The disparity between GNSS recorded uplift and modeled elastic uplift allows us to constrain viscoelastic uplift rates.

Methodology
WorldView stereo imagery used to generate DEMs from 2009 – present. Data is distributed by the Polar Geospatial Center (PGC).

DEM grids – co-registered using ‘static’ reference points derived from REMA using MEaSUREs and ICESat.

Surface elevation change (dh/dt) at 60 km radius calculated using weighted linear regression as per Zhang et al. (2018).

dh/dt integrated to get dv/dt (volume change rate)

Ice dynamic changes delineated using MEaSUREs. Locations with velocity below 10 m/yr assigned a density of 400 kg/m³, velocities greater than 10 m/yr assigned 917 kg/m³.

Mass change rate generated using Mass = volume × density. Converted to dh/dt in meters of w.e. per year.

dh/dt in meters w.e. per year resampled onto evenly spaced discs.

Ensemble of LITHO1.0/PREM elastic profiles compiled.
LITHO1.0 ensemble used to replace PREM in order to capture the variability in elastic parameters of the crust and lithosphere (Passiasos et al. 2014; Durkin et al. 2019).

Load love numbers calculated for each elastic profile using gippy (Kachuck, 2018).

Elastic response to disc loads modeled using Regional Elastic Rebound Calculator (REAR) – (Melini et al. 2015)

Key Points
High resolution dh/dt maps around POLENET GNSS sites reveal contemporary ice surface elevation changes that may influence recorded GNSS uplift rates.

Initial modeling results at BERP suggest that bedrock uplift signals are in the ASE are dominated by viscoelastic response to ice sheet unloading, suggesting the presence of a low viscosity upper mantle.

An updated viscosity estimate of the upper mantle is required to generate accurate GIA corrections for GRACE. This will enable more accurate sea level rise predictions.

Future Work
• Expand DEM coverage at GNSS sites.
• Rigorously calculate error bounds for mass grids and elastic modeling.
• Undertake elastic modeling at other GNSS sites and compare results with previous studies.
• Use modeled elastic horizontal motion rates to identify directions of dominant load changes.
• Examine the influence of atmospheric loading on elastic uplift components.

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References