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Glacial isostatic adjustment (GIA) following the last glacial maximum is a major driver of mass redistribution in the upper mantle, and hence one of the largest corrections applied to GRACE/GRACE-FO data to isolate ice and water mass changes. However, there are remaining inconsistencies between Earth parameters and GIA predictions based on different approaches, particularly in simplified 1D-Earth models. We show that accounting for 3D-viscosity in GIA models reconciles two outstanding issues: (i) In North America, 1D-models of GIA require a strong lower mantle to fit relative sea level (RSL) records but a weak lower mantle for GNSS-uplift rates; (ii) 1D-models of GIA require a relatively weak lower mantle (~10 times upper mantle viscosity) to fit observational data including global RSL records, GNSS uplift, and the pre-1990's time variable J2, while mantle circulation calculations based on density estimated from seismic tomography require a strong lower mantle (~30 times upper mantle viscosity) to reproduce the static geoid.
Considering global RSL records and global GNSS data (Schumacher et al., 2018; Hammond et al., 2016; Argus et al., 2021), we show the misfit to RSL records is reduced significantly (~40%) while incurring only a small (~5%) penalty of increased GNSS-uplift misfit when 3D viscosity with (i) strong lateral viscosity variations and (ii) a strong lower mantle (~30 times the upper mantle viscosity) is implemented in models of GIA compared to VM5a using the ICE-6G ice loading history. The reason for this is that the misfit to GNSS-uplift becomes insensitive to lower mantle viscosity for strong LVVs, and the source of a decades-long disagreement about lower mantle viscosity may have, in fact, been variations in lithospheric thickness. Regional results exhibit additional tradeoffs but indicate consistent solutions might be found with additional model refinement. Implications for mass trends estimated from GRACE/GRACE-FO will be discussed.
Presentation file
bellasmanley-ashley.pdf
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