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The influence of high viscosity slabs on post-glacial sea-level change: the case of Barbados

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The coral record at Barbados is one of the best available measures of relative sea level during the last glacial cycle and has been widely used to reconstruct ice volume (or, equivalently, eustatic sea-level, ESL) changes during the last deglaciation phase of the ice age. However, to estimate ESL variations from the local relative sea level (RSL) history at Barbados, one has to account for the contaminating effect of glacial isostatic adjustment (GIA). In previous work, the GIA signal at this site has been corrected for by assuming a spherically symmetric (i.e. 1-D) viscoelastic Earth. Since Barbados is located at the margin of the South American – Caribbean subduction zone, this assumption may introduce a significant error in inferences of ice volumes.

To address this issue, we use a finite-volume numerical code to model GIA in the Caribbean region including the effects of a lithosphere with variable elastic thickness, plate boundaries, lateral variations in lower mantle viscosity, and a high viscosity slab within the upper mantle. The geometry of the subducted slab is inferred from local seismicity. We find that predictions of relative sea-level change since the Last Glacial Maximum (LGM) in the Caribbean region are diminished by $\sim$10 m, relative to 1-D calculations, which suggests that previous studies have underestimated post-LGM ESL change by the same amount. This perturbation, which largely reflects the impact of the high viscosity slab, is nearly twice the total GIA-induced departure from eustasy predicted at Barbados using the 1-D Earth model.

Our calculations imply an excess ice-volume equivalent to $\sim$130 m ESL at the LGM, which brings the Barbados-based estimate into agreement with inferences based on other far-field RSL histories, such as at Bonaparte Gulf. This inference, together with recent studies that have substantially lowered estimates of Antarctic Ice Sheet mass at LGM, suggest that a significant amount of ice remains unaccounted for in sea-level based ice sheet reconstructions. In addition, we conclude that inference of ice age ice volumes derived from RSL histories at sites in proximity to subduction zones must incorporate slab structure into the numerical predictions of the GIA process.