Constraining models of postglacial rebound using space geodesy

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Using GPS, VLBI, SLR, and DORIS observations, including the Canadian Base Network and Fennoscandian BIFROST array, we constrain, in models of postglacial rebound, the thickness of the ice sheets as a function of time and the viscosity of the mantle as a function of depth. We test model ICE5G VM2 T90 Rot [Peltier 2007], which well fits many hundred Holocene relative sea level histories in North America, Europe, and worldwide. ICE5G is the deglaciation history having more ice in western Canada than ICE4G; VM2 is the mantle viscosity profile having a mean upper mantle viscosity of 0.5 X 1021 Pa s and a mean uppermost-lower mantle viscosity of 1.6 X 1021 Pa s; T90 is an elastic lithosphere thickness of 90 km, and Rot means the models include (rotational feedback) Earth's response to the wander of Earth's spin axis toward Canada.

The vertical observations in North America show that, relative to ICE5G, the Laurentide ice sheet was 26 ka (a) much thinner in southern Manitoba, (b) thinner near Yellowknife (Northwest Territories), (c) thicker in eastern and southern Quebec, and (d) thicker along the north British Columbia–Alberta border, or that ice was unloaded from these areas later (thicker) or earlier (thinner) than in ICE 5G. The data indicate that the western Laurentide ice sheet was intermediate in size between ICE 5G and ICE 4G.

VM2 poorly fits the horizontal observations in North America, predicting places along the margins of the Laurentide ice sheet to be moving laterally away from the ice center at 2 mm/a in ICE4G and 3 mm/a in ICE5G, in disagreement with the observation that the interior of the North American plate is deforming slower than 1 mm/a. Substituting VM5 T60 [Peltier and Drummond 2008] for VM2 T90, that is, introducing into the bottom of the lithosphere a layer with a high viscosity of 10 X 1021 Pa s, greatly improves the fit of the horizontal observations in North America. The ice sheet component of ICE4G VM5 T60 Rot predicts the margins of the Laurentide ice sheet to be moving away from the ice sheet center at 1 mm/a, in agreement with the data.

ICE5G VM5 T60 Rot well fits the vertical and horizontal observations in Europe.