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Earth Rotation: A Reappraisal of the Ongoing Impact of the Last Ice Age

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Any theoretical formulation for assessing the rotational stability of an ice age Earth requires a methodology for calculating the adjustment of the planet in response to changes in the surface mass and centrifugal loads, as well as an expression for the background oblateness of the planet. For 1-D viscoelastic Earth models, which are generally prescribed by a purely elastic lithosphere of given thickness and a multi-layer model for sub-lithospheric mantle viscosity, the response to loading is generally based on viscoelastic Love number theory. Moreover, for mathematical convenience, traditional treatments of ice age rotation approximate the background oblateness using the fluid limit of Love numbers adopted in the loading calculations. Mitrovica, Wahr, Matsuyama and Paulson [GJI, 2005] (henceforth MWMP) have shown that the traditional rotation theory, developed in the early 1980s, underestimates the Earth's background flattening and therefore underestimates the rotational stability; on this basis they have advocated a new formulation of ice age rotation in which the oblateness is tied to the observed flattening of the planet. The impact of the previous, approximate treatment for the oblateness is significant. As one example, consider predictions of the present-day secular motion of the rotation pole relative to the surface geography, or true polar wander (TPW). Using the so-called VM2 [Peltier, Ann. Rev. Earth and Planet. Sci., 2004] viscosity model, the traditional rotation theory predicts an ongoing polar motion of $\sim$1 degree/Myr, which is a factor of 3-4 higher than a prediction based on the more accurate treatment of the Earth's oblateness. In this talk, we extend the discussion to review the implications of the new theory for a large suite of geophysical observables, with particular emphasis on results that impact our understanding of modern climate (e.g., resolving the so-called enigma of global sea-level rise) and ice age paleo-climate.