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Ice age True Polar Wander: raising debates and new analyses

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Issues related to long time scale instability in the Earth's rotation, named True Polar Wander (TPW), have continuously been debated, after the pioneering works of the sixties. Since Maxwell Earth models with elastic or high viscosity viscoelastic lithospheres predict different ice-age TPW in the lower mantle viscosity range $10^{21} - 10^{22}$ Pa s, it has been recently suggested that the observed fluid Love number should be used to describe the initial equatorial bulge rather than the tidal fluid limit resulting from the viscoelastic modelling itself. We show that different ice-age TPW predictions have to be expected due to the dependence of TPW on the Earth's initial state, characterized by a larger and stress-free equatorial bulge for the viscoelastic lithosphere, compared to the elastic one, and that there is no shortcomings or errors in the traditional approach based on the use of tidal Love number from the model. The use of the observed fluid Love number represents in fact a simplified attempt to couple the effects on TPW from mantle convection and glacial forcing, by including the non-hydrostatic flattening due to mantle convection but not its driving part. This partial coupling freezes in space the non-hydrostatic contribution due to mantle convection, thus damping the present-day ice-age TPW and forcing the axis of instantaneous rotation to come back to its initial position when ice ages started. In this perspective, we discuss the implication of self-consistent convection calculations of the non-hydrostatic contribution and its impact on the long-term Earth's rotation stability during ice-age. We develop a full compressible model, based on the numerical integration in the radial variable of the momentum and Poisson equations and on the contour integration in the Laplace domain, which allows us to deal with the non-modal contribution from continuous radial rheological variations. We quantify the effects of the compressible rheology, compared to the widely used incompressible ones