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When can we assume that a planetary body is in hydrostatic equilibrium during true polar wander?

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During true polar wander (TPW), the rotational axis and the axis of the maximum moment of inertia (AoM) of the body do not coincide any more. Thus, equatorial bulge readjustment happens which causes the AoM to follow the rotational axis. Strictly speaking, during TPW the body is not in hydrostatic equilibrium. However, if the speed of TPW is very slow or the viscosity of the planetary body is low enough which makes the equatorial bulge readjustment fast enough, then the body can be assumed to be in hydrostatic equilibrium. If the body is in hydrostatic equilibrium than the following approximate methods for TPW are valid:

- method which assumes that the AoM and the rotational axis coincide during TPW (e.g. Nakada, 2007).
- method which is based on the quasi-fluid approximation (e.g. Ricard et al, 1993).
- method which is based on the fluid-limit assumption (e.g. Matsuyama & Nimmo, 2007).

However, it is not clear how slow the TPW needs to be and how low the viscosity of the body needs to be to safely assume hydrostatic equilibrium.

Here we present a quantitative criterion to test for a give interior model and TPW speed, if these approximations can be adopted. We define a dimensionless *fluid limit process number* $\mathcal{F}$, which depends on the visco-elastic Love numbers, the maximum polar wander speed and a tidal deformation factor (which is 0 for negligible tidal bulges such as for Earth and Mars).

We state that a planetary body during TPW can be assumed to be in hydrostatic equilibrium only when the fluid process number is smaller than 0.001. This criterion can help to properly interpret the validity of previous studies which are based on an approximated solution or to test if an approximated method can be adopted in future studies of TPW.