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Refined “Effective Angular Momentum Functions” for Earth’s rotation

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Predictions of the rotational fluctuations excited by a geophysical source can be carried out theoretically with varying levels of complexity. This complexity centers on the responses of the different components of the Earth system to the rotational fluctuation. As a consequence of axial non-symmetry of the oceans and solid earth, for example, exciting a change in the length of day (l.o.d.) will also produce a wobble, and vice versa; dubbed “spin-wobble coupling” by Dahlen (1976), this leads theoretically to coupled governing equations requiring simultaneous solution (see, e.g., Dickman 1993, also Seitz et al. 2004). Most researchers, instead, employ separated equations along the lines of the “effective angular momentum functions” (EAMF) first developed by Barnes et al. (1983) and subsequently corrected and updated by Eubanks (1993), Aoyama & Naito (2000), and Dickman (2003).

Complicating factors such as core-mantle decoupling and mantle anelasticity can be incorporated into the EAMF approach. With a low core viscosity, limited lower mantle electrical conductivity, and a nearly spherical (and generally smooth) core-mantle boundary, it is reasonable to expect at most weak coupling between core and mantle at short periods. Under such conditions, the core would not participate in a rotational acceleration or wobble of the overlying mantle, resulting in an elimination of core inertia from the l.o.d. *and* polar motion equations. Even on a 14-month time scale this decoupling is nearly complete – in fact, the lack of core participation is key to explaining the observed Chandler wobble period. At still longer periods, of course, core-mantle coupling should become increasingly effective.

The Love numbers characterizing the solid-earth deformation during wobble or changes in l.o.d. also depend on the extent of core participation. The Love numbers thus modified can be easily modeled theoretically using the decoupling parameters introduced by Merriam (1980). For near-complete decoupling at the Chandler period, the inferred value of k2, the degree 2 Love number, implies significant dispersion of k2 relative to its value at short periods (Dickman 2006); this in turn suggests that simple anelastic models (e.g. power-law rules) of k2 extending over wide ranges of frequency are inadequate.

The oceanic response to rotational fluctuations will be increasingly dynamic at shorter periods, less so at longer periods (though even at a 14-month period the dynamic effects, a few percent, are not negligible); such a contrasting frequency dependence versus that of k2 suggests that a combined or ‘effective’ solid earth plus oceanic Love number should be implemented cautiously, if at all. And, although core, mantle, and oceanic factors come together at a 14-month period to produce the rotational normal mode we know as the Chandler wobble, parameterizing the EAMF in terms of the Chandler frequency mistakenly ignores the underlying frequency dependence of those factors. This review will thus conclude with a call for the use of EAMF with an explicit frequency dependence; that, in turn, will require an improved model of mantle anelasticity.