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EFFECTS OF THE OCEANS
ON POLAR MOTION:
EXTENDED INVESTIGATIONS

Semi-annual Status Report

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SEMI-ANNUAL REPORT

This progress report for grant NAG 5-145/Supplement 4 covers the period July through December 1985. A progress report which includes this time period can also be found in my grant proposal for Supplement 5, submitted in March 1986 with a start date of September 1, 1986. Most of the research discussed here concerns the pole tide, the oceanic response to the Chandler wobble. For background material and some of the mathematical detail, the reader should consult earlier progress reports and that grant proposal.

As in some of the previous Supplements, the primary goal of Supplement 4 was the derivation, in non-differential matrix form, and solution, by straightforward matrix inversion, of tide equations governing the dynamical behavior of the pole tide. The project began in Supplement 1 with global oceans subject to bottom friction; in Supplement 3 the ocean model was extended to include continents; and in Supplement 4, turbulent dissipation within the oceans was to be included as well. In all cases the tide equations had to be solved simultaneously with the equation (conservation of angular momentum) governing the effects of the tide on wobble.

In previous Supplements, the procedure was to combine the tide equations into a single equation whose only "unknown" was the tide height T; by expanding the spatial portion of T into spherical harmonics, and applying orthogonality, a set of non-differential equations involving the collection of unknown harmonic coefficients T_ℓ^n could eventually be obtained. However, because of the mathematical nature of the turbulent forces, a single equation for T cannot be isolated in the case of turbulent oceans. The approach chosen instead was to expand the tide current velocities in spherical harmonics as well. Then, after determining an analytical solution to the general integral,

$$\int_{-1}^{1} \sqrt{1-\mu^2}\, P_\ell^{|n|} P_L^{|n|} d\mu$$

where $P_\ell^n(\mu)$ is a Legendre function, it became possible to use orthogonality and obtain matrix equations for the unknowns. The results were

$$\underline{\underline{m}} \cdot \vec{u} + \underline{\underline{b}} \cdot \vec{V} = \vec{\Delta}$$

$$\underline{\underline{m}} \cdot \vec{V} - \underline{\underline{b}} \cdot \vec{u} = \vec{\Gamma}$$

where $\vec{U}$ and $\vec{V}$ represent the collections of unknown tide velocity coefficients and $\vec{\Delta}$, $\vec{\Gamma}$ involve the $\{T_\ell^n\}$; see the supplement 5 grant proposal for further details. These equations could be used to express $\vec{U}$ and $\vec{V}$ in terms of $\{T_\ell^n\} \equiv \vec{T}$; substitution into the remaining tide equation would then yield a single matrix equation for $\vec{T}$.

At the beginning of this reporting period, the status of my Supplement 3 research was as follows: matrix formulation of the tide equations (pole tide in non-global oceans) was complete; matrix formulation of the associated boundary conditions (constraints on the tide velocity at coastlines) was complete; FORTRAN encoding of the tide equations excluding boundary conditions was complete; and the need for supercomputer facilities was evident.

During the present reporting period, I looked into the possibility of running my programs on a supercomputer such as the NASA/GSFC CYBER 205; talked with several people at GSFC concerning the use of the CYBER; visited Goddard to obtain an active account for the CYBER and get "on-line"; and successfully ran large versions of my programs on the CYBER, submitting the jobs from SUNY through the BITNET network (the final links of that network to SUNY were set up in November 1985). I also restructured my code to include boundary constraints.

The results of my theory appeared to be quite provocative: the dynamic pole tide in non-global oceans was capable of lengthening the Chandler wobble period by about 50% more than a static ("equilibrium") tide in non-global oceans would, and also dissipated a significant fraction of Chandler wobble energy. See the Supplement 5 grant proposal for all details. Other exceptional features of my solutions included the existence of rotational resonances (wobble enhancement rather than damping) caused by certain combinations of bottom drag and coastline configuration; and the failure of the tide to conserve mass globally (a problem commonly encountered by other tide theorists).

During this reporting period, I completed (with co-author D. J. Steinberg) a manuscript describing our grant-related research on "New Aspects of the Equilibrium Pole Tide"; it was submitted to Geophys. J. Roy. Astr. Soc. in late July, 1985. I also extensively revised a manuscript, "Another Look at North Sea Pole Tide Dynamics", which had been submitted at a prior date to GJRAS by me and J. R. Preisig.