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Numerical modeling of the oceanic S_1 tide for Earth rotation studies

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Diurnal S_1 oceanic oscillations induced by atmospheric pressure loading elicit small but measurable perturbations of universal time, polar motion, and the prograde annual component of nutation. In a priori models of Earth rotation variations, these signals are as-yet unconsidered—partly due to the fact that the underlying globally-gridded S_1 harmonics can only be inferred from purely hydrodynamic ocean models which lack the reliable elevation constraints from satellite altimetry. Such free-running forward integrations of the shallow water equations usually overestimate tidal energies and therefore also OAM (oceanic angular momentum), unless the model formulation allows for significant dissipation in the deep ocean. For practical purposes, abyssal energy flux and hence the accuracy of tidal elevations can be controlled by a tunable but inordinately high viscosity value or by evoking additional quadratic wave drag when surface heights change rapidly. A third and physically plausible modeling route is to parametrize the sub-grid scale conversion of barotropic currents into small internal tides by aid of a linear drag term. In the present paper, we study the impact of these different dissipation schemes on the fidelity of surface elevations in a simple barotropic time-stepping model forced by selected gravitational equilibrium tides as well as diurnal air pressure variations. After determining the optimal drag formulation through validation runs with the well-known principal gravitational K_1 tide, the OAM values for each of the hydrodynamic S_1 solutions are documented and discussed in the specific context of their contribution to the prograde annual signal in Earth's nutation.