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Anisotropic dissipation of the global internal tide from a higher-order multiscale barotropic tidal simulation

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Increasing recognition of the importance of the diapycnal mixing induced by the dissipation of internal tides excited by the interaction of the barotropic tide with bottom topography has begun to attract increasing attention. The partition of the dissipation of the barotropic tide between that related to the internal tide and that related to bottom friction is also of considerable interest as this partition has been shown to shift significantly between the modern and Last Glacial Maximum tidal regimes [Griffiths and Peltier, 2008, 2009] . Ocean general circulation models, though clearly unable to explicitly resolve small scale mixing processes, currently rely on the introduction of an appropriate parameterization of the contribution to such mixing due to dissipation of the internal tidal. One widely-used parameterization of this kind (which is currently employed in POP2) is that proposed by Jayne and St. Laurent [GRL 2001] and is based on topographic roughness. This contrasts with the parameterization of Carrere and Lyard [GRL 2003] and Lyard [Ocean Dynamics, 2006] which also considers the flow direction with respect to the topographic features. Both of these parameterizations require the tuning of parameters to arrive at sensible tidal amplitudes.

We have developed an original higher order barotropic tidal model based on the discontinuous Galerkin finite element method applied on global triangular grids [Salehipour et al., submitted to Ocean Modelling] in which we parameterize the energy conversion to baroclinic tides by introducing an anisotropic internal tide drag [Griffiths and Peltier GRL 2008, Griffiths and Peltier J Climate 2009] which also considers the time dependent angle of attack of the barotropic tidal flow on abyssal topographic features but requires no tuning parameters. The model is massively parallelized which enables very high resolution modeling of global barotropic tides as well as the implementation of local grid refinement.

In this paper we will present maps of energy dissipation for different tidal constituents using grids with resolutions up to 1/18° in coastal regions as well as in areas with high gradients in the bottom topography. The discontinuous Galerkin formulation provides important energy conservation properties as well as enabling the accurate representation of sharp topographic gradients without smoothing, a feature well matched to the multi-scale problem of the dissipation of the internal tide. We will describe the detailed energy budgets delivered by this model under both modern and Last Glacial Maximum oceanographic conditions, including relative sea level and internal density stratification effects. The results of the simulations will be illustrated with global maps with enhanced resolution for the internal tidal dissipation which may be exploited in the parameterization of vertical mixing. We will use the reconstructed paleotopography of the ICE-5G model of Peltier [Annu. Rev. Earth Planet Sci. 2004] as well as the more recent refinement (ICE-6G) to compute the characteristics of the LGM tidal regime and will compare these characteristics to those of the modern ocean.