Observations and Models of Oceanic Macroturbulence: Meet the New Bias, Same as the Old Bias (Invited)

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On scales larger than the ocean is deep, there are mesoscale eddies which interact in a strongly nonlinear manner constituting a macroscopic turbulence. Similar dynamics occur in the troposphere where cyclones and anticyclones greatly exceed the tropospheric depth in horizontal dimension. However, the largest ocean eddies are much smaller than the basin width, so modeling oceanic mesoscales has been slow to realize and the constraints of the horizontal basin dimension are minimal. These turbulent interactions lead to an approximately power-law spectrum, exhibiting few peaks, indicative of a strong nonlinear interactions across scales. And yet, the scale of these features demands that they must be anisotropic with strong influences of rotation and stratification.

A number of theoretical approaches have sought to explain these dynamics--2D, quasigeostrophic, and multifractal--and a few new results will be presented here under realistic modeled primitive-equation and observational global applications. 1) A scale-aware quasigeostrophic cascade subgrid scheme, following the approach of Smagorinsky in 3D and Leith in 2D, is shown to provide viscosity, diffusivity, and eddy-induced velocity coefficients in idealized and realistic ocean models. This scheme does a good job of preserving spectral slope down to the gridscale, is significantly less dissipative on average than traditional approaches, and thus it has significantly different pathways to dissipation of kinetic energy. Using the scheme, bottom drag is the second-most important energy sink instead of horizontal viscosity or hyperviscosity. 2) The statistical distributions of kinetic energy dissipation in oceanic mesoscale models is shown to be approximately lognormal, which is a curious result as such intermittent distributions were thought to be common only in small-scale turbulence. A derivation of this result and its implications for observations and parameterizations will be presented. 3) Structure function approaches to studying the dynamics of oceanic mesoscales will be presented, with an emphasis on identifying regions, seasons, and scales where high-resolution models and observations diverge so that improvements to model closures and numerics can be assessed. Finally, 4) a caution on using Lagrangian observations to estimate Eulerian structure functions will be noted, based on analysis of experiments in models and observations where both Eulerian and

Lagrangian statistics were simultaneously available. It will be shown that in the oceanic submesoscales where surface convergences can be large, Lagrangian observations tend to cluster and thus offer biased statistical estimates.