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Eddy-driven low-frequency variability: physics and observability through altimetry

Thierry Penduff (1), Guillaume Sérazin (1,2), Brian Arbic (3), Malte Mueller (4), James G. Richman (5), Jay F. Shriver (5), Andrew J. Morten (6), and Robert B. Scott (7)

(1) CNRS - LGGE, MEOM, Grenoble Cedex 9, France (thierry.penduff@legi.grenoble-inp.fr), (2) CERFACS - SUC, Toulouse, (3) Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, Michigan, USA, (4) University of Victoria, Victoria, British Columbia, Canada, (5) Oceanography Division, Naval Research Laboratory, Stennis Space Center, Mississippi, USA, (6) Department of Physics, University of Michigan, Ann Arbor, Michigan, USA, (7) Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin, USA

Model studies have revealed the propensity of the eddying ocean circulation to generate strong low-frequency variability (LFV) intrinsically, i.e. without low-frequency atmospheric variability. In the present study, gridded satellite altimeter products, idealized quasi-geostrophic (QG) turbulent simulations, and realistic high-resolution global ocean simulations are used to study the spontaneous tendency of mesoscale (relatively high frequency and high wavenumber) kinetic energy to non-linearly cascade towards larger time and space scales.

The QG model reveals that large-scale variability, arising from the well-known spatial inverse cascade, is associated with low frequencies. Low-frequency, low-wavenumber energy is maintained primarily by nonlinearities in the QG model, with forcing (by large-scale shear) and friction playing secondary roles. In realistic simulations, nonlinearities also generally drive kinetic energy to low frequencies and low wavenumbers.

In some, but not all, regions of the gridded altimeter product, surface kinetic energy is also found to cascade toward low frequencies. Exercises conducted with the realistic model suggest that the spatial and temporal filtering inherent in the construction of gridded satellite altimeter maps may contribute to the discrepancies seen in some regions between the direction of frequency cascade in models versus gridded altimeter maps.

Finally, the range of frequencies that are highly energized and engaged these cascades appears much greater than the range of highly energized and engaged wavenumbers. Global eddying simulations, performed in the context of the CHAOCEAN project in collaboration with the CAREER project, provide estimates of the range of timescales that these oceanic nonlinearities are likely to feed without external variability.