Inverse cascades of kinetic energy as a source of intrinsic variability: global OGCM study

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Abstract

Two multi-decadal 1/12 global ocean/sea-ice simulations are used to characterize the spatio-temporal inverse cascade of kinetic energy (KE), its relationship with the scales of the intrinsic oceanic variability studied in a previous paper, and its sensitivity to the low-frequency (periods T > 1 year) and synoptic atmospheric forcing. Scale interactions associated with nonlinear relative vorticity advection are evaluated using cross-spectral analysis in the frequency-wavenumber domain from sea-level anomaly (SLA) timeseries. The cross-spectral analysis is applied within 4 eddy-active midlatitude regions having large intrinsic variability spread over a wide range of scales. Surface ocean geostrophic KE is shown to spontaneously cascade towards larger space and time scales over these 4 regions in a simulation driven by a repeated climatological forcing. Analysis of a fully-forced hindcast shows that low-frequency and synoptic atmospheric forcing barely affects this inverse KE cascade. The spatio-temporal inverse cascade feeds timescales that extend up to interannual-to-decadal (depending on the region considered), and space scales ranging between the deformation radius-like scales and the Rhines scale. Other nonlinear processes might have to be invoked to explain the longer timescales of intrinsic variability, which have a substantial imprint on KE at midlatitudes.

The temporal and spatial inverse cascades are part of a global process that might involve wave-eddy interactions rather than eddy-eddy interactions. This process transfer KE from high-frequency Frontal Rossby Waves (FRWs), probably generated by baroclinic instability, towards the lower-frequency westward-propagating mesoscale eddy (WME) field. The WMEs provide local gradients of potential vorticity that support short Doppler-shifted FRWs. In the midlatitude North Pacific, FRWs have timescales shorter than 2 months and might be subsampled by altimetric observations, perhaps explaining why the temporal inverse cascade deduced from models and mapped altimeter products can be quite different in certain oceanic regions. The nature of the nonlinear interactions (local or non-local) between FRWs and WMEs remains unclear but might involve wave turbulence processes.

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