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Non-local eddy-mean kinetic energy transfers in submesoscale-permitting ensemble simulations

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Understanding processes associated with eddy-mean flow interactions helps our interpretation of the ocean energetic balance, and guides the development of parameterizations. Here, we focus on the non-local nature of Kinetic Energy (KE) transfers between mean (MKE) and turbulent (EKE) reservoirs. Following previous studies, we interpret these transfers as non-local when the energy extraction from the mean flow does not locally sustain energy production of the turbulent flow, or vice versa. The novelty of our approach is to use ensemble statistics, rather than time averaging or coarse-graining methods, to define the mean and the turbulent flow. Based on KE budget considerations, we first rationalize the eddy-mean separation in the ensemble framework, and discuss the interpretation of a mean flow (<**u**>) driven by the prescribed (surface and boundary) forcing and a turbulent flow (**u**') driven by non-linear dynamics sensitive to initial conditions. Our results, based on the analysis of 120-day long, 20-member ensemble simulations of the Western Mediterranean basin run at 1/60^{o}, suggest that eddy-mean kinetic energy exchanges are largely non-local at small scales. Our main contribution is to recognize the prominent contribution of the cross energy term (<**u**>.**u**') to explain this non-locality, providing a strong constraint on the horizontal organization of eddy-mean flow KE exchanges since this term vanishes identically for perturbations (**u**') orthogonal to the mean flow **(** Our results also highlight the prominent contribution of vertical turbulent fluxes for energy exchanges within the surface mixed layer. Analyzing the scale dependence of these non-local energy exchanges supports the local approximation usually made in the development of meso-scale, energy-aware parameterizations for non-eddying models, but points out to the necessity of accounting for these non-local effects in the meso-to-submeso scale range.