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Parameterising subgrid-scale turbulence in Lagrangian trajectory models

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Lagrangian trajectory models are widely used in studies of e.g. the transport of water masses, spreading of oil spills, or connectivity between regions, but their realism is limited by the realism of the velocity fields used to advect the trajectories. It is well known that velocity fields in non-eddying or eddy-permitting ocean models often underestimate the speed and intrinsic variability of ocean flows due to high horizontal viscosity and no or too weak inverse cascade of kinetic energy. While the Lagrangian trajectories become more realistic when advected with eddy-resolving velocity fields, such calculations are computationally expensive. We simulate trajectories using the TRACMASS Lagrangian trajectory model and velocity fields from both an eddy-permitting (horizontal resolution $\Delta x \sim 25\,\mathrm{km}$) and an eddy-resolving ocean model ($\Delta x \sim 8\,\mathrm{km}$). We find, similarly to previous studies, that trajectories advected on eddy-permitting velocity fields have less absolute diffusivity, less relative dispersion and longer Lagrangian time scales than trajectories advected on eddy-resolving velocity fields.

We present a new scheme for parameterising subgrid-scale turbulence in Lagrangian trajectory models. The parametrisation represents unresolved turbulent stresses by a stress tensor for non-Newtonian fluids, and is similar to an eddy parametrisation recently applied to an idealised Eulerian model. We apply the new scheme to the Lagrangian trajectories advected with velocity fields from the eddy-permitting ocean model and show that the parametrisation improves Lagrangian statistics e.g. increasing absolute diffusivity, increasing relative dispersion and shortening Lagrangian time scales. We also find that the parametrisation increases kinetic energy of the trajectories on short time scales and increases the finite-scale Lyapunov exponents.