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Lateral eddy diffusivity estimates from simulated and observed drifter trajectories: a case study for the Agulhas Current system

Siren Rühs (1), Victor Zhurbas (2), Jonathan V. Durgadoo (1), and Arne Biastoch (1)

(1) GEOMAR Helmholtz Centre for Ocean Research Kiel, Düsternbrooker Weg 20, Kiel, Germany (sruehs@geomar.de), (2) Shirshov Institute of Oceanology, Nakhimovsky Prospect, 36, 117998 Moscow, Russia

The Lagrangian description of fluid motion by sets of individual particle trajectories is extensively used to characterize connectivity between distinct oceanic locations. One important factor influencing the connectivity is the average rate of particle dispersal, generally quantified as Lagrangian diffusivity. In addition to Lagrangian observing programs, Lagrangian analyses are performed by advecting particles with the simulated flow field of ocean general circulation models (OGCMs). However, depending on the spatio-temporal model resolution, not all scale-dependent processes are explicitly resolved in the simulated velocity fields. Consequently, the dispersal of advective Lagrangian trajectories has been assumed not to be sufficiently diffusive compared to observed particle spreading.

In this study we present a detailed analysis of the spatially variable lateral eddy diffusivity characteristics of advective drifter trajectories simulated with realistically forced OGCMs and compare them with estimates based on observed drifter trajectories. The extended Agulhas Current system around South Africa, known for its intricate mesoscale dynamics, serves as a test case. We show that a state-of-the-art eddy-resolving OGCM indeed features theoretically derived dispersion characteristics for diffusive regimes and realistically represents Lagrangian eddy diffusivity characteristics obtained from observed surface drifter trajectories. The estimates for the maximum and asymptotic lateral single-particle eddy diffusivities obtained from the observed and simulated drifter trajectories show a good agreement in their spatial pattern and magnitude. We further assess the sensitivity of the simulated lateral eddy diffusivity estimates to the temporal and lateral OGCM output resolution and examine the impact of the different eddy diffusivity characteristics on the Lagrangian connectivity between the Indian Ocean and the South Atlantic.