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Deducing an upper bound to the horizontal eddy diffusivity using a stochastic Lagrangian model

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We present a method for estimating the upper bound of the horizontal eddy diffusivity using a non-stationary Lagrangian stochastic model. First, we identify a mixing barrier using a priori evidence (e.g., aerial photographs or satellite imagery) and using a Lagrangian diagnostic calculated from observed or modeled velocities (for instance, the relative dispersion or finite time Lyapunov exponent). Second, we add a stochastic component to the observed (or modeled) spatially non-trivial, time-dependent velocity field. The stochastic component represents sub-grid stochastic diffusion and its maximum possible magnitude is set by the eddy diffusivity. The relative dispersion of Lagrangian trajectories is computed for increasing values of the eddy diffusivity until the mixing barrier is no longer present. The value at which the mixing barrier disappears provides a dynamical estimate of the upper bound of the eddy diffusivity. The erosion of the mixing barrier is visually observed, and quantified by computing higher moments (for instance, the kurtosis) of the relative dispersion for each value of the eddy diffusivity. We demonstrate our method using a double gyre circulation model and apply it to high frequency radar observations of surface currents in the Gulf of Eilat.