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Towards a paremeterisation of horizontal stirring

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Horizontal stirring has an important effect on biogeochemical cycles in both the atmosphere and the ocean. The common presence of horizontal stirring is well reflected in the spatial distribution of heterogeneous tracers like ozone, phytoplankton, surface temperature that all share characteristic lobular and filamental patterns. The length of filaments may reach the meso- or synoptic scales, but the width of these structures and their lifetimes may often fall below the resolution of circulation models. This characteristic renders the horizontal stirring a major unknown for our understanding of biogeochemical cycles.

Here we present a method able to identify the filamental process and to quantify the associated mixing. The method combines information of forward and backward Lyapunov exponents and Lyapunov vectors calculation ans is able to recover part of the small-scale dynamics from the spatiotemporal variability of mesoscale structures. By using ECMWF reanalysis and altimetric data, examples of both seasonal and interannual synoptic-scale climatotologies are given, focusing on the upper troposphere-lower stratosphere and to the ocean surface at the middle-latitude and discussing ENSO and NAO modulation.

Although computationally too expensive for being implemented on circulation models, this approach suggests the basic ingredients and the degree of variability that a parameterisation scheme should be able to reproduce for a correct representation of horizontal stirring.