Lagrangian methods like the Lyapunov exponent calculation allow to study the effects of the mesoscale turbulence on the dispersion of a tracer. In particular, by exploiting both the spatial and the temporal variability of the velocities, the Lyapunov exponent has been shown to predict part of the surface submesoscale dynamics, predicting the location of observed cross-streamline chlorophyll and sea surface temperature filaments from altimetry data at subgrid resolution. Here we show how the Lyapunov exponent can be potentially used to validate altimetry products and to extract subgrid information on horizontal mixing.

THE LYAPUNOV EXPONENT

What does the local Lyapunov exponent measure?

The local Lyapunov exponent measures the local dispersion of particles initialised nearby. By computing the exponent on a grid, one can construct a map of local dispersion rates. These maps typically show maxima of Lyapunov exponent along lines, that can interpreted as frontal regions. The intensity of the Lyapunov exponent provides the inverse timescale at which a tracer front is developed.

Tracer submesoscale filaments from altimetry data

One of the main advantage of the Lyapunov exponent is that it depends on both the spatial and the temporal variability of the velocity field. This allows to recover part of the submesoscale variability of tracers like chlorophyll or sea surface temperature from the mesoscale eddies of altimetry data. In this example, a chlorophyll pattern is reconstructed by the advection with altimetry velocities of a synthetic tracer on a high resolution grid. Maxima of Lyapunov exponents (black lines) provides the fronts that bound the filament.

Tracer scales smaller than the scale of the velocity field appear, due to the temporal dynamics.

VALIDATION OF ALTIMETRY PRODUCTS

The comparison of fronts detected from altimetry with the Lyapunov technique can be used to validate the spatial and temporal variability of altimetry data in combination with high-resolution SST images. In the example above left (Eastern Mediterranean, in collaboration with V. Taillandier, J. Taupier-Letage, and L. Mortier) the addition of a mean dynamic topography appears in fact to degrade the satellite observation along the coast.

Other applications may include the comparisons of monomissions vs. multimission products (top right).

REFERENCES

