Geophysical Research Abstracts
Vol. 13, EGU2011-7774-2, 2011
EGU General Assembly 2011

Surface transport in coastal and open-sea areas of the Adriatic Sea from Finite-Scale Lyapunov Exponents

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In two-dimensional flows, a simple time dependence in the velocity field is enough to induce turbulent structures and consequently chaotic advection in particles trajectories.

Analysing these fields in the context of dynamical systems, an Eulerian approach would provide the configuration of the eddies at a given scale and time, while the application of a Lagrangian technique will show the spatio-temporal variability of these eddies.

The fundamental assumption of chaotic advection is the sensibility of trajectories to initial conditions, meaning that fluid elements initially very close would follow diverging trajectories.

The exponential rate of separation between two particles is defined by the Lyapunov exponent λ.

The classical definition of Lyapunov exponent refers to the exponential rate of divergence, over infinite time, of infinitesimally closed initial points. The FSLE technique keeps the original idea of capturing the rate of divergence between trajectories, but overcomes the limit operations dealing with real data.

$$\lambda_r\left(x_i, \delta_i, t, r\right) = \frac{1}{\tau} \ln r$$

Since the choice of δi and$r$ depends mainly on currents characteristics and length scale of the structures of interest, there is not a parameters choice suitable for any velocity field.

FSLE technique shows how portions of fluid initially compact can be stretched and/or folded as time goes by, producing a “cascade” of inhomogeneities from large to smaller scales. This allows to identify dynamical structures within scales far below the finest resolution achievable by the classical Eulerian analyses, without any assumption on the sub-grid velocity field.

In the previous years, the FSLE technique was applied in the Adriatic Sea dealing with dispersion studies based on drifters experiments or on velocity data produced by NCOM model. These analyses, involving different areas and times, led to the identification of the whole basin mixing scales (Lacorata et al., 2001; Haza et al., 2008) and to the characterization of an hyperbolic point located in the South Adriatic (Haza et al., 2007).

The new analysis proposed involves the northernmost part of the Adriatic Sea and it is based on high resolution measurements of the velocity field coming from a radars system placed along Italian and Croatian coasts. Data, belonging to NASCUM project - North Adriatic Surface CUrrent Mapping, are available for the period 2007-2008 and cover a regular grid with the following dimensions and resolution: 50km x 50km with 2km spatial resolution and 1h temporal resolution.

Since Adriatic Sea is strongly affected by Bora and Scirocco winds the aim is to find a correlation between wind forcing over the basin and surface dispersion.

Typical wind events have been already identified in the time series, coming from a meteo-oceanographic buoy in the Gulf of Trieste, measuring wind intensity and direction.

During these specific episodes, a preliminary analysis has been done identifying a clear correspondence between Bora blowing direction and the main direction along which filamental structures develop.

Further results, including the comparison between FSLE maps and wind maps (from ALADIN Numerical Weather Prediction Project), will be shown in this work.

REFERENCES

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