Surface transport in the Northeastern Adriatic Sea during Bora and Sirocco events from Finite-Size Lyapunov Exponents (FSLE)

Maristella Berta

Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS), Trieste, Italy

Observations of water mass properties and current have revealed that the circulation in the Northern Adriatic is quite complex and highly variable, in response to wind and river forcing that have both small-scale structures and high temporal variability [Cushman-Roisin et al., 2001]. The understanding of the intrinsic sea processes concerning physical, chemical and biological dynamics but also the demand to progress in search and rescue operations at sea are driving the development of Lagrangian research programs for the study of transport and mixing.

Artale et al. [1997] and Lacorata et al. [2001] observed that in quasi-enclosed basins, such as the Adriatic Sea, a characterization of the mechanism of mixing is non-trivial. The use of the standard diffusion coefficient can have limited applicability for the study of dispersion in a finite size basin, since it characterizes long-time dispersion processes. The intrinsic weakness contained in this asymptotic quantity may be solved by the use of more appropriate Lagrangian descriptors, like the Finite-Size Lyapunov Exponents (FSLE).

The FSLE technique keeps the idea of the original definition of the Lyapunov Exponent by capturing the rate of divergence between trajectories, but its new formulation overcomes the mathematical limits dealing with real data. FSLE technique can be regarded as a complementary approach to the widely spread Eulerian techniques, since it shows the spatio-temporal variability of dynamical structures and not only the configuration of the eddies at a given scale and time. Moreover it identifies structures within scales far below the finest resolution achievable by the classical Eulerian analyses avoiding any assumption of small-scales processes in the Eulerian flow field under investigation.

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].

This new analysis involves the northernmost part of the Adriatic Sea. It is based on high resolution measurements of sea surface currents coming from the High-Frequency (HF) radar network placed along Italian and Croatian coasts. Data, collected within the Interreg 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: about 50km x 50km with 2km spatial resolution and 1h temporal resolution

The purpose of this study is the evaluation of FSLE in the Northeastern corner of the Adriatic Sea, well-known for being particularly affected by Bora and Sirocco winds, in order to map at high resolution the surface transport during these events. Typical wind events have been identified through the wind forecast maps available from ALADIN Numerical Weather Prediction Model. The goal will be achieved thanks to the combination between the fine coverage measurements of the sea current field, available from the radar network, and the FSLE technique, known for its capability to catch sub-grid features of the currents dynamics.

References

Artale, V., Boffetta, G., Celani, A., Cencini, M., and Vulpiani, A. (1997). Dispersion of passive tracers in closed basins: Beyond the diffusion coefficient. *Physical Fluids*, 9(11):3162–3171.

Cushman-Roisin, B., Gačić, M., Poulain, P.-M., and Artegiani, A. (2001). *Physical Oceanography of the Adriatic Sea: Past, Present and Future*. Kluwer Academic Publishers.

Haza, A. C., Griffa, A., Martin, P., Molcard, A., Ozgokmen, T. M., Poje, A. C., Barbanti, R., Book, J. W., Poulain, P.-M., Rixen, M., and Zanasca, P. (2007). Model-based directed drifter launches in the Adriatic Sea: Results from the DART experiment. *Geophysical Research Letters*, 34(L10605).

Haza, A. C., Poje, A. C., Ozgokmen, T. M., and Martin, P. (2008). Relative dispersion from a high-resolution coastal model of the Adriatic Sea. *Ocean Modelling*, 22(1-2):48–65.

Lacorata, G., Aurell, E., and Vulpiani, A. (2001). Drifter dispersion in the Adriatic Sea: Lagrangian data and chaotic model. *Annales Geophysicae*, 19:121–129.