Eulerian and Lagrangian statistics of mesoscale motions in the Tyrrhenian Sea

V. RUPOLO* , V. ARTALE+, G.P. GASPARINI++ and A. PROVENZALE**

* Dip.to di Fisica, Università "La Sapienza", ROMA (**Italy**)
+ ENEA CRE Casaccia, ROMA (**Italy**)
++ CNR Stazione Oceanografica, POZZUOLO di LERICI (**Italy**)
** CNR Istituto di Cosmogeofisica, TORINO (**Italy**)

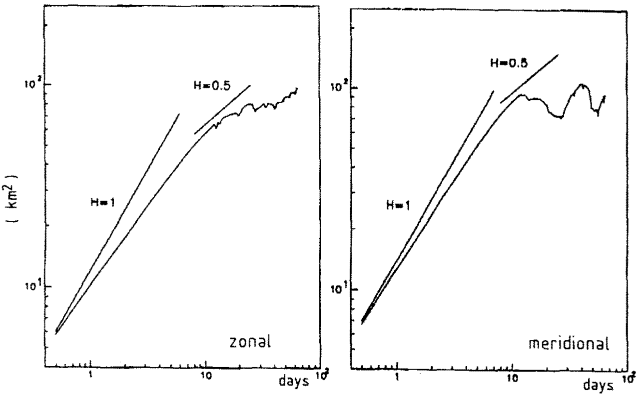
A data set from the three free satellite-tracked drifter buoys (drogued at a depth of ten meters) and the three current-meter moorings deployed in the central Tyrrhenian sea in autumn 1989 during the TEMPO experiment (TEMPO Group, 1990), was analyzed. The circulation in this area is dominated by large and coherent systems of vortex of an estimated scale of about 100-200 Km. Other than the surface dynamical and statistical properties of these vortices, the study focused on relating the Eulerian and Lagrangian description of the flow field on the basis of the drifter data and the data from a current-meter placed at depth of 8 meters.

Both the drifter and current-meter spectra indicate that the characteristic frequencies of the basin (around 20 and 10 days) exhibit a high anticlockwise polarization, which drastically decreases with depth. The autocorrelation functions reach the zero value after about 10 days for both the drifters and the surface current-meter with the relative integral time scales, $(T_{Lx}, T_{Ly}) = (2.0, 1.8)$ days and $(T_{Ex}, T_{Ey}) = (2.3, 0.9)$ days. The substantial equivalence between the Eulerian and the Lagrangian time scale infers weak non-linear (advective) effects for periods extending from 1 to 10 days.

The study of the structure function $S_i(t) = \langle[X_i(t+\tau) - X_i(\tau)]^2\rangle^{1/2}$ (COLIN de VERDIERE, 1983) showed an anomalous behaviour ($S_i(t) \propto t^H$ with $1/2 < H < 1$) for $1 \leq t \leq 7\sim8$ days with a scaling exponent of $H \sim 0.8$. For $8 < t < \sim15$ days, a transition, especially on the zonal direction, towards a brownian like motion can be observed (Figure). For greater t the drifters are diffused less than required by a random walk and the motion is dominated by the strong wave like vortex circulation. The analysis of the behaviour of the coefficient of eddy diffusivity with time provided a numerical estimate of $(K_x, K_y) = (2.9, 3.5) \cdot 10^7$ cm^2/sec which was however valid only for $8 < t < 15$ days. For greater t our drifter records are too short to resolve the properties of diffusion of the vortex although a value of $O(10^6)$ cm^2/sec or less for K seems appropriate.

Moreover, the drifter trajectories display a homogeneous fractal behaviour with a dimension $D \sim 1.3$, for $1 < t < 7$ days and $10 < L < 80$ Km in the time-space scale of both the eddy dynamics and the anomalous diffusion. A fictitious trajectory obtained by integrating the velocity data of the surface current-meter displayed similar fractal and diffusion characteristics in the same space and time scale. A multifractal analysis of the velocity time series of the same current-meter using the generalized Reny's dimension showed homogeneous behaviour in the eddy time scale and evidence of multifractality or intermittency for $t \leq 4\sim5$ hours. The spectra of the surface current meter and the freely moving drifters demonstrated a similar shape with the same slope in the range of 1-10 days. The results of our analysis, thus seem to indicate that, in these time scales, the fractal and diffusion characteristics of the drifter trajectories are "driven" by the Eulerian field and are apparently less influenced by nonlinear phenomena like chaotic advection.

On the other hand, a significant difference between the root mean square velocities of the drifters and the surface current-meter (the drifter values were definitively larger) was observed suggesting the relevance of nonlinear effects in high frequency time scales.



A log-log plot of the dispersion versus time

REFERENCES

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