LAGRANGIAN MEASUREMENTS OF SURFACE CIRCULATION AND KINETIC ENERGY DISTRIBUTION IN THE NORTHERN ADRIATIC

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Abstract
The near-surface circulation of the Northern Adriatic is explored using Lagrangian drifting buoy measurements obtained between September 2002 and October 2003. The data set presents a very good coverage over the studied area and within the measurement period. The main pathways of the surface waters are defined and the major persistent surface features are described, together with their variability. Mean kinetic energy (MKE) and eddy kinetic energy (EKE) have been calculated and their spatial and seasonal variability is presented. Autumn and winter have been found to be the most energetic seasons.

Key-words: Surface Circulation, Energy, Adriatic Sea

Introduction
As part of the ONR-sponsored DOLCEVITA program, more than 120 surface drifters were deployed in the Northern Adriatic starting in September 2002 to monitor the surface circulation in most areas of the Northern Adriatic until the end of 2003.

Data and methods
Two versions of the CODE drifter were mainly used: the first one uses the standard ARGOS telemetry [1] and the second one is equipped with an additional GPS system, which permits to obtain a finer resolution both in time and space. Position sampling for GPS-CODE drifters was programmed at 0.5 or 1 hour intervals. The data set analyzed in this paper starts on 21 of September 2002 and ends on 1 October 2003. Both ARGOS and GPS position data have been quality controlled, while only ARGOS data have been objectively interpolated every 2 hours, low-pass filtered (36 hour cut-off) and re-sampled every 6 hours. Surface velocities have been then calculated as finite differences of the position data. All available low-passed ARGOS tracks in the Northern Adriatic are shown in Figure 1a, while the data density is presented in Figure 1b. The Northern Adriatic is well covered by drifters, with maximum density in the northernmost part of the basin, due both to a major number of deployments and to a larger time of residence of drifters in that zone.

Mean Circulation and Energy
The mean surface flow has been calculated for the whole period from the low-passed data binned in circles of 10 km of radius, separated by 10 km. The resulting field is depicted in Figure 1c. It reveals the well-known persistent features of the Adriatic surface circulation, such as the Western Adriatic Current (WAC) along the Italian coast, the Eastern Adriatic Current (EAC) along the Croatian coast that re-circulates partially around the Middle Adriatic Pit (MAP) and partially to the south of Istria, and finally the northernmost cyclonic gyre [1, 2]. A zone of almost no flow and no variance is evident in front of the tip of Istria, showing an almost steady pool all over the period. From the mean flow field and variance, the MKE and EKE have been calculated. They are depicted in Figure1e and 1f, respectively. The highest values for MKE are found in three zones: i) in front of the Po river delta, ii) along the Italian coast south of the delta, and iii) over the MAP. The maximum value, equal to 362 cm^2/s^2, is located north of Ancona, where the EKE is the same order of magnitude (107 cm^2/s^2), indicating an equal partition of energy between the two. On the contrary, the zone south of Ancona is characterized by the maximum in EKE (about 256 cm^2/s^2), indicating a highly variable zone with current reversals. The already mentioned zone in front of the tip of Istria shows very low values for MKE (<5 cm^2/s^2) with higher values for EKE (about 30 cm^2/s^2). Calculating the ratio EKE/MKE (not shown), the lower values are found principally in the zones of re-circulation of the EAC and along the Italian coast near Ancona. The temporal distribution of the kinetic energy for the whole basin (Figure 2), shows that autumn and winter are the more energetic seasons, both in MKE and in EKE. In autumn (not shown) the MKE is strong along the Italian coast, probably due to strong Po River outflow, and around the MAP, with high values for EKE in

front of the Po River and south of Ancona. In winter, the MKE is particularly strong in the zone between the tip of Istria and the Italian coast, due to strong Bora wind activity. In spring large values for the MKE and the EKE are found only to the south of Ancona. Finally, in summer the MKE is weak all over the basin, with EKE strong only along the Italian coast south of Ancona.

Conclusions

Direct surface measurements obtained from drifting buoys over one year, provided the first detailed description of the circulation in the northern Adriatic. The mean flow pattern confirmed the major well-known features but also evidenced new structures with their spatial and temporal evolution. The calculated kinetic energy shows an almost permanent and very energetic zone along the Italian coast. Energy results maximum in autumn and winter, while it is very weak in summer.

Acknowledgments

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References

1. P.-M. Poulain, 2001. Adriatic Sea surface circulation as derived from drifter data between 1990 and 1999. *J. Mar. Syst.*, 29: 3-32.
2. B. Cushman-Roisin, M. Gacic, P.-M. Poulain and A. Artegiani, 2001. Physical Oceanography of the Adriatic Sea. Kluwer Academic Publishers, 304 pp.

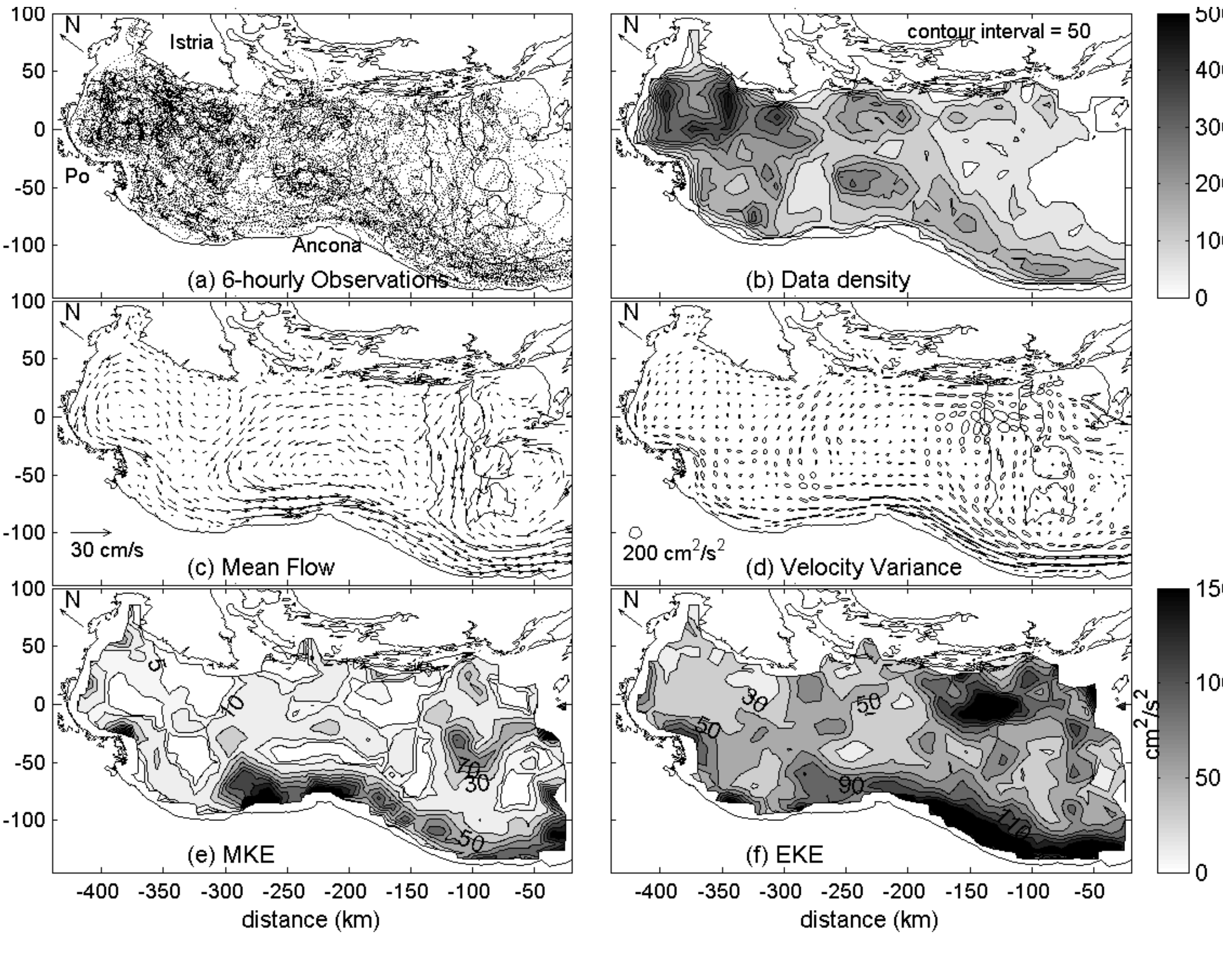

Figure 1: (a) 6-hourly observation, (b) number of 6h observations in 10 km bins, (c) mean flow, (d) velocity variance, (e) mean kinetic energy and (f) eddy kinetic energy, in the rotated Northern Adriatic for the period 21 September 2002 to 1 October 2003. Only bins with more than 10 observations have been taken into account.

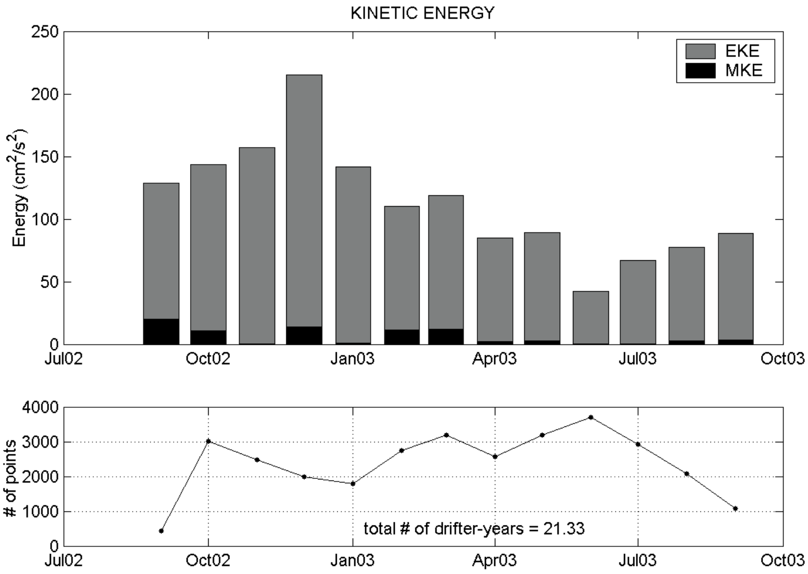

Figure 2: Temporal distribution of total kinetic energy (top) and of the number of points (bottom) for the whole period considered all over the basin. The energy is divided into MKE (black) and EKE (gray).