Lagrangian Data Analysis in Mesoscale Prediction Studies

Pierre-Marie Poulain
Naval Postgraduate School, Code OC/Pn
Monterey, CA 93943
phone: (831) 656-3318 fax: (831) 656-2712 email: poulain@oc.nps.navy.mil
Award #: N0001499WR30014
http://www.oc.nps.navy.mil/~drifter

LONG-TERM GOALS

To develop new methods of investigation for use of Lagrangian data in mesoscale problems, with main applications to coastal regions and semi-enclosed basins.

OBJECTIVES

1) To assess the instrumental and sampling errors on Eulerian velocity statistics derived from Lagrangian drifter data.

2) To use Lagrangian data sets and stochastic models to describe and predict the mesocale dynamics in coastal areas, with focus on transports and particle dispersion.

3) To investigate the generation mechanisms (wind forcing and mean flow instability) of coastal mesoscale motions and to assess the importance of topographical effects.

APPROACH

The use of a multi-year (1986-1999) surface drifter data set in the Mediterranean Sea (NPS, 1999) to:

1) Assess the slippage errors on drifter-derived surface velocities, utilizing satellite wind observations (ERS, TOPEX-POSEIDON) and wind products (ECMWF, NOGAPS, NORAPS and COAMPS).

2) Estimate the random and bias errors affecting Eulerian velocity statistics (mean flow and velocity variance) computed from Lagrangian drifters. To develop new techniques to estimate these statistics and the corresponding errors.

3) Study mesoscale prediction skills in areas where the drifter population is abundant, i.e., in the Adriatic Sea and in the Strait of Sicily region. To investigate the transport properties and to assess the predictability of particle trajectories in these two sea areas, using statistical models tuned with real drifter statistics and using data assimilation techniques. Collaborators for this work item are: Drs. A. Griffa, S. Castellari, A. Mariano (RSMAS, University of Miami) and Drs. P. Falco and E. Zambianchi (Istituto Universario Navale, Naples, Italy).

WORK COMPLETED

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE **Lagrangian Data Analysis in Mesoscale Prediction Studies**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Department of Oceanography,Code OC/Pn,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

The following work items were completed in FY99:

1) Standard and "array" bias (Davis, 1991) errors were estimated for the mean surface circulation in the Adriatic Sea (Poulain, 1999).

2) The surface transport properties of the Adriatic were computed using drifter data for the period Dec. 1994 – Mar. 1996 (Falco et al., 1999).

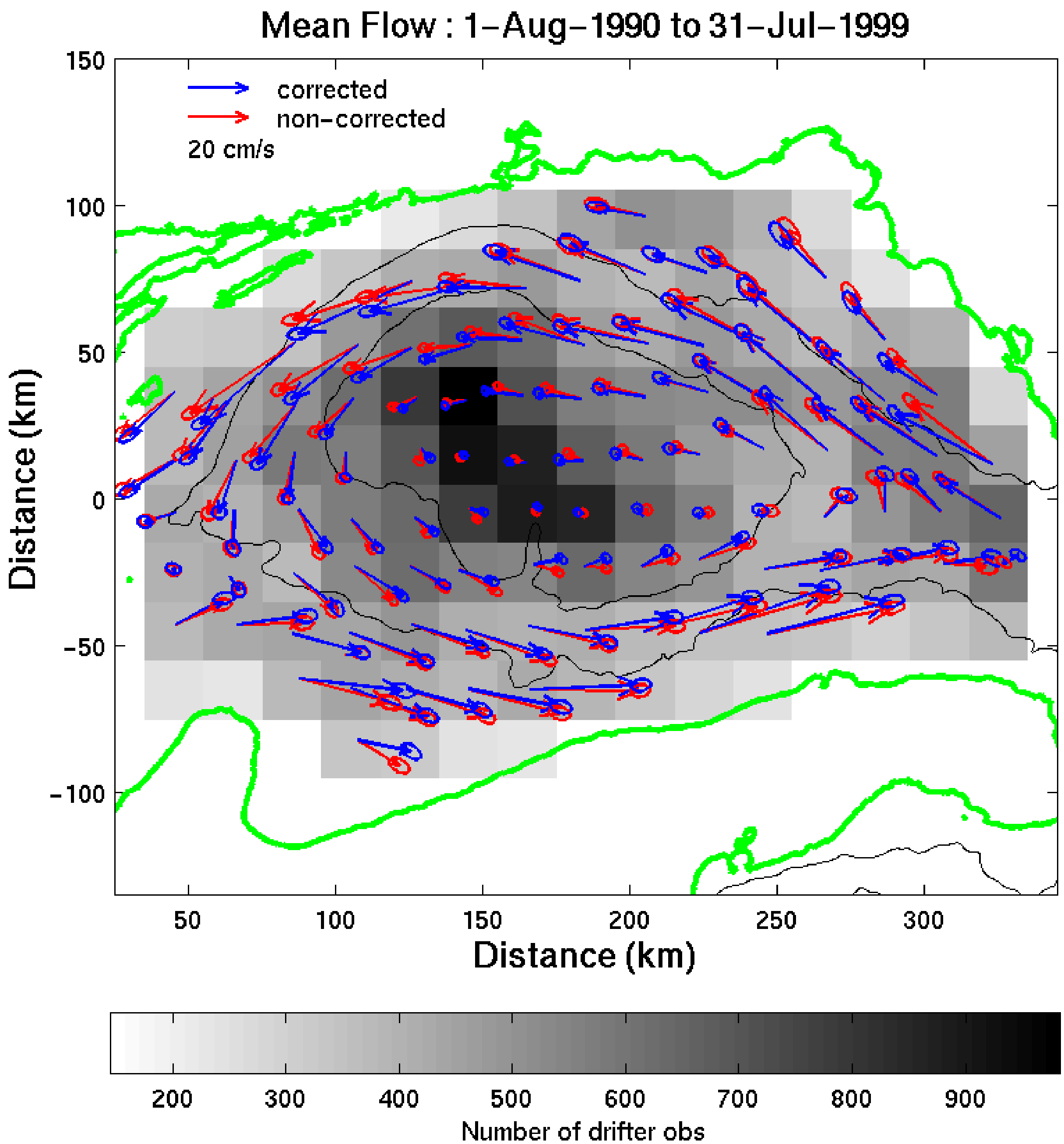
3) Analyses of prediction of particle trajectories were performed in the eastern Adriatic using the drifter data for the period Dec. 1994 – Mar. 1996 (Castellari et al., 1999).

RESULTS

1) "Array" bias corrections (Poulain, 1999) of the drifter-derived mean velocities provide significantly better estimates of the mean water flow in the surface layer of the Adriatic Sea. As illustrated in Fig.1, regions such as the southern Adriatic are characterized by a important central maximum in drifter observation concentration. Note that few drifters were released in this area and that the maximum concentration is due to their "natural" accumulation. The "array" bias is directed outward from this maximum and is generally larger than the standard error (shown as ellipses). Corrected currents appear to follow better the isobaths, as is expected since the topographic steering of the mean flow is important in this area.

2) Surface transport properties in the Adriatic Sea (Falco et al., 1999): First, the role of topography in dispersion transport properties has been studied. A significant cross-topography exchange has been found, probably due to stratification and direct wind forcing. Second, a stochastic Lagrangian model of transport has been implemented, and tested with positive results against data results. Finally, the residence time, i.e., the average time spent by a surface particle in the basin, has been estimated using data and model results, suggesting a residence time of approximately 200 days. This study was performed in collaboration with Drs. Falco, Griffa and Zambianchi.

3) Prediction of particle trajectories in the Adriatic Sea (Castellari et al., 1999): To test the new prediction scheme of Ozgokmen et al. (1999) with real drifter data, the predictability of Lagrangian particle trajectories in the Adriatic Sea has been investigated using three clusters consisting of 5-7 drifters each over a period of 1-2 weeks. The results of this study confirm those with synthetic data, i.e., that the assimilation of the drifter data is efficient for $N_R > 1$, while it does not improve the prediction for $N_R > 1$, where N_R is the number of drifters within the Rossby radius of deformation R. Also, when the mean flow is assumed unknown or an error in the initial position (smaller than R) is introduced, predictions are still in good agreement with observations. This work was done in close collaboration with Drs. Castellari, Griffa and Ozgokmen.



1. Mean circulation in the southern Adriatic derived from surface drifter data between August 1999 and July 1999. The number of 6-hourly observations in circular bins of 20 km radius is represented with gray shades. The mean current vectors are displayed without (red) and with the correction (blue) for the "array" bias. Standard error ellipses are plotted at the tip of both corrected and uncorrected arrows.

IMPACT/APPLICATION

The scientific impact of this project will be to increase our understanding of the Adriatic Sea dynamics and transports. We have proved that statistical prediction of transports and particle trajectories can be performed using appropriate stochastic models parameterizing particle motions. The study of the predictability of particle motion has a number of potential practical applications at very different scales, including search and rescue, floating mines and ecological problems such as the spreading of pollutants or fish larvae.

TRANSITIONS

The velocity statistics, along with the errors associated with them, estimated from drifter data are used to study the surface circulation dynamics in coastal areas and semi-enclosed seas such as the Adriatic Sea (Poulain, 1999) and the Strait of Sicily region. The drifter statistics will be compared to results of numerical models (e.g., Cushman-Roisin and Naimie, 1999; MFSPP, 1999) in order to improve their prediction skills.

RELATED PROJECTS

Other ONR Projects: Drs. B. Cushman-Roisin and C. Naimie (Dartmouth College) are funded to develop a comprehensive, finite-element model of the Adriatic Sea. Comparison studies between model results and the drifter data are in progress. Drs. A. Griffa , T. Ozgokmen and A. Mariano (RSMAS, University of Miami) are funded to develop new methodologies to use Lagrangian data to study ocean dynamics and, in particular, to enhance mesoscale prediction skills. Their work is closely related to this project. I am funded to study the surface circulation and the surface temperature/chlorophyll fields in the Adriatic using drifter and satellite data. The enhanced velocity statistics estimated from the drifter data are used in that work.

Mediterranean Forecasting System: Future application of this project will be the assimilation of the drifter data into numerical models in the framework of the Mediterranean Forecasting System (MFSPP, 1999).

REFERENCES

Castellari, S., A. Griffa, T. Ozgokmen and P.-M. Poulain, 1999: Prediction of particle trajectories in the Adriatic Sea using Lagrangian data assimilation*, Journal of Marine Systems*, submitted.

Cushman-Roisin, B. and C. E. Naimie, 1999: A 3D finite-element model of the Adriatic Sea. Part 1: Tides. *Journal of Physical Oceanography*, submitted.

Davis, R. E., 1991: Observing the general circulation with floats. *Deep Sea Research*, **38**, Suppl.1, S531-S571.

Falco, P., A. Griffa, P.-M. Poulain and E. Zambianchi, 1999: Transport properties in the Adriatic Sea as deduced from drifter data, *Journal of Physical Oceanography*, accepted.

MFSPP, 1999: Mediterranean Forecasting System Pilot Project (http://www.cineca.it/~mfspp000).

NPS, 1999: NPS Mediterranean drifter web site (http://www.oc.nps.navy.mil/~drifter).

Ozgokmen, T. M., A. Griffa, L. I. Piterbarg, and A. J. Mariano, 1999: On the predictability of Lagrangian trajectories in the ocean. *Journal of Atmospheric and Oceanic Technology*, accepted.

Poulain, P.-M., 1999: Adriatic Sea surface circulation as derived from drifter data between 1990 and 1999, *Journal of Marine Systems*, submitted.

PUBLICATIONS

Castellari, S., A. Griffa, T. Ozgokmen and P.-M. Poulain, 1999: Prediction of particle trajectories in the Adriatic Sea using Lagrangian data assimilation, *Journal of Marine Systems*, submitted.

Falco, P., A. Griffa, P.-M. Poulain and E. Zambianchi, 1999: Transport properties in the Adriatic Sea as deduced from drifter data, *Journal of Physical Oceanography*, accepted.

Poulain, P.-M., 1999: Adriatic Sea surface circulation as derived from drifter data between 1990 and 1999, *Journal of Marine Systems*, submitted.