UPPER LAYER CURRENTS VARIABILITY IN THE CENTRAL LIGURIAN SEA

P. Picco [1] *, P. Paterlini [2], S. Pensieri [3], M. Borghini [4], R. Bozzano [3], M.E. Schiano [5], S. Sparnocchia [6]
[1] ENEA-CRAM, Forte S. Teresa, 19036 Pozzuolo di Lerici (SP), Italy - paola.picco@santateresa.enea.it
[2] Università Cattolica del Sacro Cuore, Via dei Musei 41, 25121 Brescia, Italy
[3] CNR-ISSIA-GE, Via dei Marini 6, 16149 Genova, Italy
[4] CNR-ISMAR-SP, Forte S. Teresa, 19036 Pozzuolo di Lerici (SP), Italy
[5] CNR-ISMAR-GE, Via dei Marini 6, 16149 Genova, Italy
[6] CNR-ISMAR-TS, Viale R. Gessi 2, 34123 Trieste, Italy

Abstract
The effects of wind stress on the variability of the surface circulation in the Ligurian Sea are investigated by the analysis of a long time series of marine currents and meteorological observations and by numerical model simulations. Observed currents in the upper 50 m are mainly directed NW, according to the general circulation of the area and display the same pattern slightly attenuating the intensity with the depth. Most of the sub-daily variability is due to the inertial currents, which occur at all the examined depths very often. The direction and the intensity of the current in the near surface layer (0-8 m) is sometimes different from those recorded in the layers below. Observations and model results indicate that the wind is able to modify significantly the currents in the upper 14-15 m, thus explaining a huge part of the observed variability.
Keywords : Air-sea Interactions, Circulation, Ligurian Sea, Time Series.

Data and methods
In order to investigate the variability of the upper layer currents and the relationships with surface atmospheric forcing, a mooring equipped with an upward-looking ADCP (Acoustic Doppler Current Profiler) [1] RDI Sentinel 300 kHz and CTD sensors was deployed in the open Ligurian Sea (43° 47.77' N; 9°02.85' E) near the meteo-oceanographic buoy ODAS ITALIA1. The ADCP sampled the upper 50 m of water column with 8 m vertical resolution and 1h time interval from 13 September 2003 to 25 May 2004. Meteorological parameters, in particular wind speed and direction and atmospheric pressure, were measured each hour from the buoy ODAS at 13.5 m above the sea surface until 11 March 2004; sea temperature and conductivity at six different depths, between surface and 36 m, were also collected each hour from the buoy.
The effects of the local wind were estimated by means of a 1-D numerical model integrating the Ekman equations in the vertical plane up to a depth of 100 m, where free-slip conditions were imposed. The vertical turbulent coefficient was chosen constant (0.01), wind stress was computed from the available time series according to [2]. Constant or linearly increasing wind stress at surface was imposed considering some test-cases based on the different observed wind regimes.

Results
Wind regime during the observed period was characterized by calm and breeze for about 60% of the recorded data, strong winds, mainly blowing from SW, occurred in 7%, moderate winds are concentrated in the northern sector. Prevailing direction is SW/W while intensity -excluding the calms- is 6.2 m/s.
Although the mean currents are mainly directed NW, according to the general cyclonic circulation of the Ligurian Sea, currents alternate periods with an almost constant NW direction and periods lasting few days characterized by strong variability, particularly meandering. Only few short events with southward component currents occurred during the studied period.
Mean velocity was about 11 cm/s with hourly mean peaks up to 80 cm/s. The vertical structure was characterized by highly correlated currents having the same pattern, with intensity weakly attenuating with the depth. Currents in the first layer differ from that of the layers below, in some case being less intense and displaying more variability and meandering.
Low frequency variability was characterised by mesoscale and atmospheric components because the 28 and 6 days components were among the more energetic peaks. Rotary spectral analysis [3] evidenced the inertial motions as the prevailing feature at sub-daily scale [4], whereas tides on both diurnal and semidiurnal band were negligible. The resulting average spectrum computed on 22 samples, 256 hours long, displayed at all depths a net energy peak in the clockwise part centred around the theoretical inertial period value for this latitude (17.3 h). Well developed inertial currents, in some cases lasting for more than a week, were in fact observed at all the examined depths for about 25% of the total period of registration.
Even correlation between wind stress and kinetic energy of the surface currents was poor, thus indicating a minor role of surface atmosphere forcing. The results from the simulated test cases gave some insight on the local wind effect, explaining a huge part of the observed variability [5].
A constant wind stress of 0.2 N/m^2, representing the mean observed value, can drift a mean current in the upper 10 m of about 15 cm/sec; for a wind stress of 0.35 N/m^2, corresponding to a wind speed of 14 m/s, the velocity increases up to 28 cm/s, comparable with the intensity of the geostrophic components.

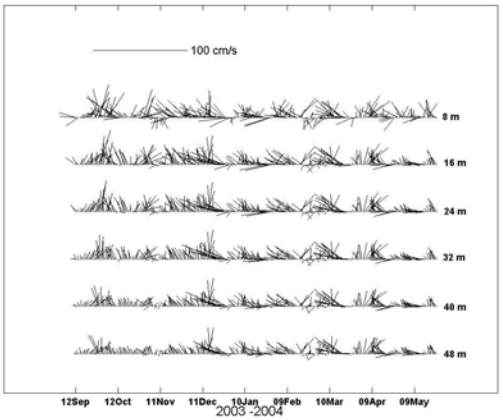

Fig. 1. Stick diagram of daily mean currents at each depth.

References

1 - Visbeck M. and Fischer J., 1995. Sea surface conditions remotely sensed by upward-looking ADCPs. *J. Atmos. Ocean. Tech*., 12: 141-149.
2 - Fairall C.W., Bradley E.F., Rogers D.P., Edson J.B., and Young G.S., 1996. Bulk parameterization of air-sea fluxes for Tropical Ocean-Global Atmosphere Coupled-Ocean Atmosphere Response Experiment. *J. Geophys. Res.*, 101 (C2): 3747-3764.
3 - Gonella J., 1972. A rotary-component method for analysing meteorological and oceanographic vector time series. *Deep-Sea Res*., 19: 833-846.
4 - Van Haren H. and Millot C., 2003. Seasonality of internal gravity waves kinetic energy spectra in the Ligurian Basin. *Oceanol. Acta,* 26: 635-644.
5 - Wang W., Huang R.X., 2004. Wind energy input to the Ekman Layer. *J. Phys. Oceanogr.,* 34: 1267-1275.