OBSERVATION OF UPPER LAYER INERTIAL AND INTERNAL WAVES IN THE CENTRAL LIGURIAN SEA

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Abstract

Inertial and internal waves in the Central Ligurian Sea are investigated by using long time series of high frequency observations of both ADCP currents and temperature profiles in the upper thermocline. Horizontal variability is dominated by the inertial currents which have a kinetic energy comparable with that of the mean currents. Time frequency analysis evidences the presence of internal waves having periods in the sub-daily band, between 6 and 17 h (the local inertial period). During summer, these vertical oscillations may affect the temperature time series at a fix depth up to several degrees.

Keywords: Air-Sea Interactions, Currents, Ligurian Sea, Time Series, Temperature

Data and methods

In order to investigate the variability of the upper layer, a mooring equipped with an upward-looking ADCP (Acoustic Doppler Current Profiler) RD&I 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 from 13 September, 2003 to 25 May 2004 and from September 2004 to June 2006 thus providing a long-term time series of 3-D currents data. 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. Spectral analysis and the methodology proposed by Jacobs et al. [1] were used to evidence the time-spectral characteristics of the observed oscillations.

Results

The upper layer currents variability in the investigated area is mainly due to the inertial currents. They occur very often, can persist several days and have a kinetic energy comparable with that of the mean currents. The more energetic ones are found at the end of the summer, when the thermocline is still well developed, while during winter their amplitude is reduced. Inertial oscillations are very common in the ocean. They can be locally generated at the sea surface by changes in wind stress or by the rapid transit of a low and can persist for several days. These oscillations propagate energy far from the area of generation as well as downward in the water column, generating higher-frequency internal waves through non linear interactions [2]. For their contribution to the mixing, they are of particular importance in regions such as the Ligurian Sea, since they compensate the lack of the tidal mixing. No clear relation between local wind stress and the onset of horizontal inertial currents was found in this analysis. The existence of mixed layer inertial currents unrelated to wind forcing is reported by different authors. Van Haren and Millot [3] found similar results in the Ligurian Sea and gave evidence to the important role of the thermal stratification of waters in the vertical propagation. The time series of the vertical currents clearly show the occurrence of intermittent burst of oscillations reaching the amplitude of few centimeters per second. The signal was present in the entire sampled water column, but the amplitude attenuated with increasing depth. The time-frequency analysis confirms that these oscillations develop both in summer and in winter, even the episodes last only a few days. Their frequency varies in the sub-daily band, spanning from few cycles per day to the local inertial frequency (local inertial period is 17.3 h). Differently from the horizontal inertial currents, the comparison with available local wind time series evidenced a nearly one-to-one correspondence between the wind stress relative maximum and the occurrence of vertical currents oscillations, identified by a maximum of daily standard deviation, but at a first analysis their amplitude doesn't seem relate to the intensity of wind stress. Bursts of oscillation in the sub-daily band are detected also in the temperature time series in the upper thermocline. During summer months, when the thermal stratification reaches its maximum, the temperature variation at 35 m due to the internal waves reached more than 4 °C.

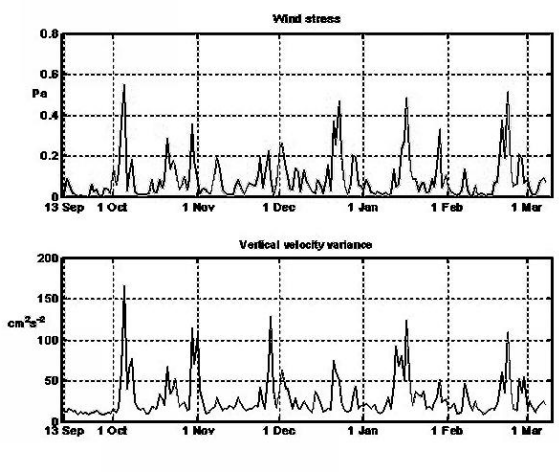

Fig. 1. Time series of daily mean wind stress magnitude and vertical velocities standard deviation.

References

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