SUMMER BREAKOUT OF TRAPPED BOTTOM DENSE WATER FROM THE NORTHERN ADRIATIC

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Abstract
An unusual drop of the bottom temperature coupled with southeasterly currents has been observed in August 2004 in the open northern Adriatic. It is hypothesised to be a result of a leakage of bottom dense water generated in the previous winter and blocked by the cyclonic Adriatic circulation. The breakout has been initiated by a storm appearing violently over the open northern Adriatic and lasting for a couple of hours. The storm has been reproduced using COAMPS^{TM} atmospheric model. The physical generator of the breakout (wind stress, wind stress curl and divergence, fluxes) is being currently investigated through process-oriented ocean modelling studies.
Keywords : Adriatic Sea, Air-sea Interactions, Models.

The northern Adriatic shelf is a complex dynamical area, characterized by large seasonal changes in surface heat and water fluxes, Po river discharge (annual average of 1500 m^3/s) and advection of middle/south Adriatic and Levantine water masses [1]. During cold and dry winters it is a place where dense water is being generated, spreading to the southeast and filling most of the Adriatic bottom layers [2]. Part of it may however be blocked in the generation area and reside there up to the following autumn, when it becomes mixed up with surface water during pycnocline destruction [1, 3]. Nevertheless, it can be also advected towards southeast in specific meteorological or oceanographic conditions. That is the topic of our study.

The breakout of the residing dense waters towards the southeast in summer 2004 has been suspected first from thermistor and current-meter data obtained at the Ivana gas field platform (lat = 44°44.8' N, lon = 13°17.7' E, depth = 41 m). A sudden temperature drop of more than 2°C has been observed near the bottom on 9/10 August 2004 (Fig. 1). At the same time, bottom currents were directed to SE with a speed of 10 cm/s. The temperature and salinity data collected in July and August 2004 on the Po-Rovinj profile (30 km north of the platform) clearly depicts the presence of a 5-10 m thick pool of cold water (13-14°C) near the bottom, being obviously a source for the observed breakout. However, the generative force remained unknown after inspection of coastal meteorological time series and estimated surface heat and water fluxes, which showed no significant changes at that time.

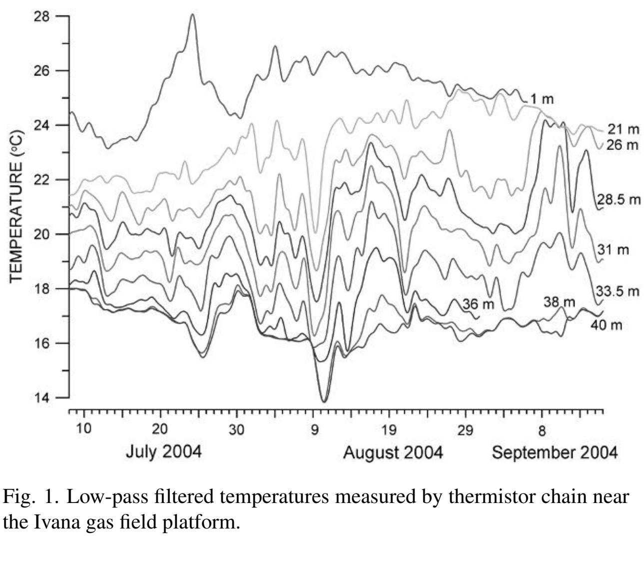

Fig. 1. Low-pass filtered temperatures measured by thermistor chain near the Ivana gas field platform.

The breakout lasted for about 3 days, being relaxed after the weakening of the bottom currents. A phase lag of about one day occurred between the appearance of southeast currents and the temperature drop. Thus, assuming southeasterly current speed of 10 cm/s and bottom thermohaline front being perpendicular to the currents (or parallel to the Po-Rovinj profile as documented in [4]), the distance between the bottom front and the platform may be estimated to about 9 km.

Fortunately, satellite images in the visible frequency band gave us a clue, as a storm was observed in the morning hours of 8 August 2004. The storm occurred almost entirely over the open northern Adriatic, therefore discarding the usefulness of the coastal surface fluxes in our analyses. Atmospheric conditions have been reproduced by COAMPS^{TM} mesoscale atmospheric model [5], being set up at 3-km resolution in horizontal, and forced by ECMWF (European Centre for Medium-range Weather Forecasts) fields at the open boundaries. The model has been initiated a day before, on 7 August 2004 at 00 UTC. Surface wind convergence occurred over the open northern Adriatic in early hours of 8 August, resulting in the generation of a storm at approx. 05 UTC with the centre very near the platform. A few hours later modelled surface winds reached 12 m/s at the storm front, diverging from the centre, which was still located over the platform. Therefore, one may suspect that the surface divergence and wind stress curl is responsible for the breakout. However, the effects of wind stress itself and also fluxes should be investigated by an oceanographic model. These studies are currently being carried out through targeted numerical experiments using the Princeton Ocean Model [6] forced by the COAMPS^{TM} surface fields.

References

1 - Poulain P.M., Kourafalou V.H. and Cushman-Roisin B., 2001. Northern Adriatic Sea. *In*: Cushman-Roisin B., Gacic M., Poulain P.M., Artegiani A. (eds.), Physical Oceanography of the Adriatic Sea - Past, Present and Future. Dordrecht, Kluwer Academic Publisher, pp 143-165.
2 - Vilibic I. and Supic N., 2005. Dense water generation on a shelf: the case of the Adriatic Sea. *Ocean Dyn.*, 55: 403-415.
3 - Supic N. and Vilibic I., 2006. Dense water characteristics in the northern Adriatic in the 1967-2000 interval with respect to surface fluxes and Po River discharges. *Estuar. Coast. Shelf S.*, 66: 580-593.
4 - Artegiani A., Bregant D., Paschini E., Pinardi N., Raicich F. and Russo A., 1997. The Adriatic Sea general circulation. Part II: Baroclinic circulation structure. *J. Phys. Oceanogr.*, 27: 1515-1532.
5 - Hodur, R.M., 1997. The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Weath. Rev.*, 125: 1414-1430.
6 - Blumberg A. F. and Mellor G. L., 1987. A description of a three-dimensional coastal ocean circulation model. *In*: Heaps N.S. (ed). Three-dimensional Coastal Ocean Models. AGU, Washington, pp 1-16.