ON THE FORMATION OF LEVANTINE INTERMEDIATE WATERS

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A theory of LIW water formation has been developed and is being tested out by appropriate numerical experiments. It ascribes an important role to baroclinic eddies which form around the periphery of the formation site and flux in water and bouyancy from the side keeping the convection shallow. The eddies also carry the LIW away.

Previous open ocean convection studies (JONES and MARSHALL, 1993) have shown that the rim current at the periphery of the cooling patch, becomes unstable and baroclinic eddies develop. These eddies advect heat laterally towards the cooling region. Under continuous atmospheric cooling, a final steady state is reached in which the heat brought in by the eddies balances the heat lost to the atmosphere. At this stage convection is 'switched off' and the mixed layer stops from deepening. The time needed for this equilibrium to be reached is (VISBECK and MARSHALL, 1994) Tfinal=9*(r**2/B)**(1/3), where r is the radius of the cooling patch and B the bouyancy loss.

In areas of cyclonic circulation such as the Rhodes Gyre the typical preconditionned stratification can be thought of as a stratified layer of depth H and constant N overlying a homogeneous deep layer. The time needed for convection to break the stratification and penetrate the deep layer (thus producing deep waters) is Tbreak_through=(NH)**2/2B.

We argue that if Tbreak_through is longer than Tfinal then the eddies will take control of the convection process before the chimney penetrates deep. In such a case intermediate, not deep, waters will be produced.

In a series of numerical experiments we show that such a mechanism could be responsible for the production of intermediate waters (LIW) in the Rhodes Gyre area under normal climatological forcing. On the other hand we show that this equilibrium is quite sensitive and that under severe winter forcing Tbreak_through can be smaller than Tfinal, in which case deep waters are expected to be produced.

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LIW FORMATION AND SPREADING : A 3–D NUMERICAL STUDY

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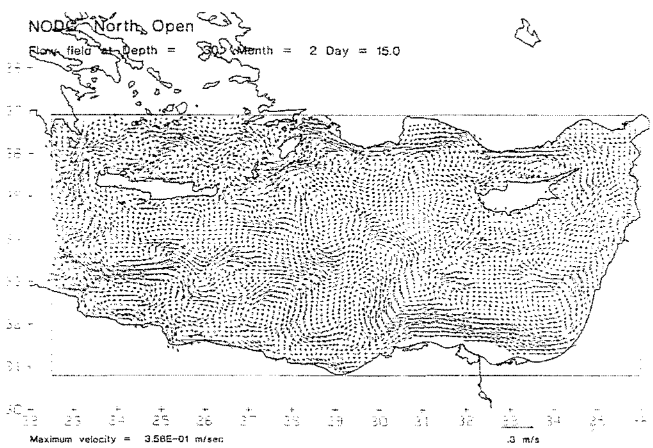
The Levantine Intermediate Water (LIW) is the characteristic saline water mass of the Eastern Mediterranean that is formed in the Levantine sea. Various hypotheses have been introduced on the mechanism and the exact location of this formation, most of them indicating the Rhodes Cyclonic Gyre, in the northwestern Levantine, as the main formation site (OVCHINNIKOV, 1984; LASCARATOS *et al.*, 1993). During the spreading phase this water mass occupies the intermediate layers (typically 300 m) of the whole Mediterranean sea and exits through the straits of Gibraltar with modified, due to mixing, characteristics. It can be also found isolated at deeper layers, trapped by the energetic eddy field of the Eastern Mediterranean (THEOCHARIS *et al.*, 1993).

We use POM, a sigma coordinates, free surface, 3–D primitive equation model (BLUMBERG & MELLOR, 1987) to study the LIW formation and spreading in the Levantine sea. The model contains an imbedded second moment turbulence closure sub–model to provide vertical mixing coefficients. The area (east of 22.5E) is covered by a 220 x 120 high resolution (5–6 km) eddy resolving grid (first baroclinic Rossby Radius ~13 km). In the vertical 30 sigma–coordinate levels with logarithmic distribution near the surface are used. Open boundary conditions are used for the communication with the Ionian (to the West) and the Aegean sea (to the North).

The model will be initialized with POEM hydrological data and forced by heat and water fluxes computed from the model's SST and atmospheric parameters taken from the NMC data set (CASTELLARI *et al.*, 1990). The POEM–V data set (August – September 1987) is currently being analyzed to fit the model grid. Objective analysis is being used for the horizontal interpolation while vertical extrapolation through EOFs is being considered since most of the casts do not exceed 2000 m. The model will be forced with the September 1987 – April 1988 twice a day NMC fluxes. Currently, a number of sensitivity tests are being carried out using climatological initial (Levitus or NODC data sets) and forcing data (NMC 1980–1988 monthly climatology). One of the main goals of these customization runs is to investigate the ability of the model to reproduce the main circulation features of the Levantine Sea under different model configurations. A typical summer surface circulation field as reproduced by the model is presented in figure 1. Most of the well known upper thermocline features of the area (ROBINSON *et al.*, 1991) can be recognized, namely : a. The Mid–Mediterranean Jet entering from the west and transporting the Atlantic Water towards the Levantine; b. The Asia Minor Current flowing westrard along the southern coast of Turkey; c. The Rhodes cyclonic gyre bounded by these two jets; d. The extended anticyclonic Mersa–Matruh gyre south of Crete; e. The Shikmona anticyclonic gyre south of Cyprus and f. The West Cyprus cyclone. This realistic circulation field is a significant prerequisite for our LIW formation and spreading studies.



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