A NUMERICAL STUDY ON THE CAUSES OF THE EASTERN MEDITERRANEAN TRANSIENT : THE ROLE OF THE NORTHERN AEGEAN AND THE BLACK SEA WATERS

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Abstract

We investigate the role that the Northern Aegean Sea and the Black Sea waters might have played in triggering the Eastern Mediterranean Transient. Our results indicate that neither a decrease (even a total absence) of the low salinity Black Sea waters and/or a simple cooling of the Northern and Southern Aegean can be considered responsible for the production of the EMT in the Southern Aegean Sea.

Keywords : Aegean Sea, Circulation models, Deep waters, Eastern Mediterranean

Introduction

In the late 80's and early 90's an abrupt climatic change (the EMT) occurred in the Eastern Mediterranean Sea, by which the deep water formation site moved momentarily from the Adriatic Sea to the Southern Aegean Sea (Cretan Sea). [1], [2], [3], [4], [5]. The origins and causes of the EMT have been the object of some controversy. Some [2], [3], stress the combined role of the salinity increase in the Cretan Sea during the late 80's and the very cold winters of 92-93 which triggered the very large amount of high density waters produced in the Cretan Sea, others [4], claim that the EMT was solely caused by extra cooling, and the observed salinity increase is a consequence and not a forerunner of the event, while finally [5] based on data analysis of water masses at various years, claim that the EMT was triggered in the Northern Aegean where dense waters were formed due to low temperatures and possibly reduced inflow of the low salinity Black Sea waters in to the Aegean which then influenced the Southern Aegean Sea. We further investigate the question of the EMT with a series of numerical experiments focusing mostly on the eventual role of the Black Sea waters and the Northern Aegean Sea.

The numerical model

We use an implementation of the POM model with a horizontal resolution of 1/20 of a degree (~ 5.5 km) in both horizontal directions with 30 sigma levels in the vertical. The model is initialized with the MED4-MODB data set and is forced with monthly values of a 'perpetual year' forcing atmospheric data set derived from the 1979-1993 6-hour ECMWF reanalysis data. The model includes a parameterization of the Dardanelles outflow with a salinity of 28.3 psu and a mean volume of 10000 m^3/sec. The results of the 3rd year of the climatological run are kept as out reference experiment to which all other subsequent runs are compared.

Numerical experiments

We conducted a series of 5 numerical experiments (including the reference run). With these experiments out intention is a) to investigate the possible effects of the Black Sea waters and b) to examine the role of extra cold winters in the area. See table 1.

Table 1: Description of numerical experiments conducted and corresponding forcing applied

Experiments	Dardanelles	Extra cooling in degrees Celsius	
		N. Aegean	S. Aegean
1	Yes	0	0
2	No	0	0
3	No	-2	0
4	No	0	-2
5	No	-2	-2

The switching-off of the Dardanelles outflow is of course an extreme condition which we nevertheless impose to validate their impact in winter dense water formation in the Northern and Southern Aegean Sea. The extra cooling is applied by decreasing the air temperature by 2° Celsius from January up to March in each consecutive year which results in an SST decrease of 0.5° C approximately. We believe this to be more realistic than the 2° C drop in SST used in [4] which in fact implies a much more important decrease of atmospheric temperatures (of the order of 8° C). All above experiments were run for three years following the climatological run and the results of the last year are compared to climatology.

Results and discussion

In experiment 2 we observe an increase in deep waters densities in the Northern Aegean (by 0.05 sigma-t units), which is further enhanced in experiment 3 (0.1 sigma-t units). A very small increase (0.01) of density is observed in the Western Cretan sea. No EMT produced. In experiment 4, we obtain slightly lighter waters in the Northern Aegean compared to experiment 3 and a relatively important increase of densities in the Western Cretan Sea by .05 (29.28). Still no EMP produced although a small volume of dense waters starts to appear in the Western Cretan Sea. Finally the experiment 5 results are an almost perfect combination of experiment 3 and 4 with no synergies observed.

From all the above we conclude that without the salt preconditioning observed in the Cretan Sea (not simulated in any of our experiments) the EMT is not realistically produced. In our various experiments we have tried various forcings that might be responsible for the EMT with the exception of one which is the very important salinity increase observed in the data of the Cretan Sea prior to the occurrence of the EMT. We ended up not producing the EMT. In contrast to [3] where this effect was simulated and the EMT successfully produced. We conclude that the salt preconditioning (either due to increase of evaporation and/or increase of salty water inflow from the Levantine basin due to circulation pattern changes as mentioned in [3], play a major crucial role in producing the EMT.

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