MODELLING THE MEDITERRANEAN SEA INTERANNUAL VARIABILITY OVER 1961-2000: FOCUS ON THE EASTERN MEDITERRANEAN TRANSIENT (EMT)

J. Beuvier [1]*, F. Sevault [2], M. Herrmann [2], H. Kontoyiannis [3], W. Ludwig [4], M. Rixen [5], E. Stanev [6], K. Béranger [1] and S. Somot [2]
[1] Unité de Mécanique, Ecole Nationale Supérieure de Techniques Avancées ParisTech (ENSTA-ParisTech/UME), Palaiseau, France - jonathan.beuvier@ensta.fr
[2] Centre National de Recherches Météorologiques (CNRM), Météo-France, Toulouse, France
[3] Hellenic Center for Marine Research (HCMR), Athens, Greece
[4] Centre de Formation et de Recherche sur l'Environnement Marin (CEFREM), Perpignan, France
[5] NATO Undersea Research Center (NURC), La Spezia, Italy
[6] Institute for Coastal Reasearch (ICR), GKSS Research Center, Geesthacht, Germany

Abstract

We study the climate variability of the Mediterranean Sea and the Eastern Mediterranean Transient by carrying out a simulation over 1961-2000 with a Mediterranean OGCM driven by realistic interannual high-resolution air-sea fluxes. Interannual databases for Atlantic T-S characteristics and rivers and Black Sea runoff are used. The sequence of the EMT events is well reproduced: the high winter oceanic surface cooling and drought over the Aegean Sea in the early 1990's, the high amount of dense Cretan Deep Water formed during these winters and the overflow and the spreading of this CDW in the eastern Mediterranean.

Keywords: Eastern Mediterranean, Water Convection, Circulation Models, Aegean Sea, Air-Sea Interactions

In this work, we study the Mediterranean interannual variability and in particular the Eastern Mediterranean Transient, by using NEMOMED8, an eddy-permitting Mediterranean OGCM at 1/8° of resolution (about 10 km), regional version of the NEMO model. A realistic hindcast is performed from 1961 to 2000, forcing the model with daily atmospheric fluxes produced with ARPERA, a dynamical downscaling of the ERA40 reanalyses (resolution of about 50 km). Interannual datasets are used to represent the hydrological fluxes of the river runoff [1], the Black Sea discharge [2] and the Atlantic Water characteristics [3], in addition to the freshwater flux from the atmosphere.

Considering heat and salt contents at basin-scale, the simulation show a good agreement when comparing to an interannual gridded database based on observations [4]. This simulation is able to reproduce the sequence of the EMT events in very good agreement with the observations [5]:

- the strong heat and water losses at the surface of the Aegean Sea observed during the winters 1991-92 and 1992-93 (respectively -73 W/m^2 and -2.0 mm/day in NDJF 1991-92, -65 W/m^2 and -2.8 mm/day in NDJF 1992-93, in agreement with [6]), due to the relatively high resolution of the ARPERA atmospheric dataset,
- the strong winter convection in the Aegean Sea triggered by these strong atmospheric fluxes (1.22 Sv of waters denser than 29.2 kg/m3 formed in 1993, in which 0.48 Sv are denser than 29.3 kg/m3),
- the huge outflow of dense waters from the Aegean Sea to the Ionian and Levantine basins through the Cretan Arc straits, especially through the eastern part during the two years following the intense convection event,
- the spreading of this water mass in the eastern Mediterranean, with a scheme of the path followed by this dense water mass from 1993 to 2000 (Fig. 1): the waters exiting the Aegean Sea through the western straits of the Cretan Arc spread in a cyclonic manner in the Ionian Sea; the waters exiting the Aegean Sea through the eastern straits of the Cretan Arc spread in the Levantine basin: a part of them crosses the Cretan Passage and joins the waters outflowing from the western straits while another part sinks at deeper levels in the Levantine basin. That part first spreads southwards following the bathymetry in a cyclonic manner and also propagates eastwards mainly driven by diffusive processes or trapped by eddies.

Among the preconditioning hypotheses proposed in the literature, we find that in the simulation:

- the surface circulation was modified in the late 1980's and the early 1990's, changing the AW path in the Levantine basin; combined with a long drought period over the far eastern Mediterranean which induces a salt increase of the surface layer in this area, this led to a salt increase of the Aegean Sea through a saltier Asia Minor Current,
- the three anticyclonic eddies observed in 1991 play a role in deviating and trapping the AW in the Levantine basin, rather than the LIW as mentionned in the literature, whereas those eddies are not at the observed locations,
- there was no huge decrease of the Black Sea freshwater discharge during the early 1990's according to our interannual dataset,
- several convection events in winters 1987, 1989 and 1990 took place before the major events of winters 1992 and 1993; they induced a steady filling of the Aegean Sea by the dense waters formed during these winters.

The sensitivity of using different hydrological fluxes on the simulation of the sequence of the EMT is investigated in [7].

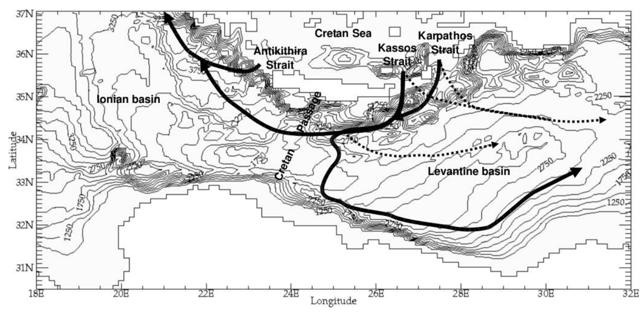

Fig. 1. Scheme of the path followed by the CDW after having exited the Aegean Sea. In full lines: direct advective path. In dashed lines: indirect diffusive path. Contours in back: bathymetry (in meters) of the NEMOMED8 model, interval of 250 m from 1000 m to 4000 m.

References

1 - Ludwig W., Dumont E., Meybeck M. and Heussner S., 2009. River discharges of water and nutrients to the Mediterranean and Black Sea: Major drivers for ecosystem changes during past and future decades ?, *Prog. Oceanogr.*, 80, 199–217.
2 - Stanev E. V. and Peneva E.L., 2002. Regional sea level response to global climatic change: Black Sea examples, *Global and Planetary Changes*, 32, 33–47.
3 - Daget N., Weaver A.T. and Balmaseda M.A., 2009. Ensemble estimation of background-error variances in a three-dimensional variational data assimilation system for the global ocean, *Quater. J. Roy. Meteor. Soc.*, 135, 1071–1094.
4 - Rixen M. et al., 2005. The Western Mediterranean Deep Water: A proxy for climate change, *Geophys. Res. Lett.*, 32 (L12608), 1–4.
5 - Roether W., Klein B., Manca B.B., Theocharis A. and Kioroglou S., 2007. Transient Eastern Mediterranean deep waters in response to the massive dense-water output of the Aegean Sea in the 1990s, *Prog. Oceanogr.*, 74, 540–571.
6 - Josey S.A., 2003. Changes in the heat and freshwater forcing of the eastern Mediterranean and their influence on deep water formation, *J. Geophys. Res.*, 108 (C7), 1–18.
7 - Beuvier J., Sevault F., Herrmann M., Kontoyiannis K., Ludwig W., Rixen M., Stanev E., Béranger K. and Somot S. (in revision). Modelling the Mediterranean Sea interannual variability over 1961-2000: focus on the Eastern Mediterranean Transient (EMT), *J. Geophys. Res.*