MODELLING THE MEDITERRANEAN SEA OVER THE LAST 40 YEARS USING HIGH RESOLUTION DYNAMICAL DOWNSCALING OF THE ERA40 REANALYSIS

Samuel Somot *, Jeanne Colin , Florence Sevault and Michel Déqué
Centre National de Recherches Météorologiques, Météo-France, Toulouse, France - samuel.somot@meteo.fr

Abstract

Modelling the evolution of the Mediterranean Sea over the last decades is needed to understand better its functionning and thus to foresee its possible future evolution. To achieve this goal, a 40-year high-resolution simulation of the Mediterranean Sea was carried out using high resolution air-sea fluxes coming from a dynamical downscaling of the ERA40 reanalysis. This simulation enables us to study the interannual variability and the trend of various physical processes in the Mediterranean basin. It shows a good representation of the heat content temporal evolution as well as of the Eastern Mediterranean Transient.

Keywords : Circulation Models, Deep Waters, Heat Budget, Global Change, Aegean Sea.

The Mediterranean Sea is known to show a high interannual variability in terms of deep water formation [1]. It also experiences decadal variability as proved by the Eastern Mediterranean Transient event [2] and the existence of long-term trends [3]. Moreover, the first scenarios of climate change applied to the Mediterranean Sea result in a strong impact on its hydrology and thermohaline circulation [4]. Therefore simulating and understanding the evolution of the Mediterranean Sea over the last decades can be considered as quite a challenging task for the ocean and climate modelling community.

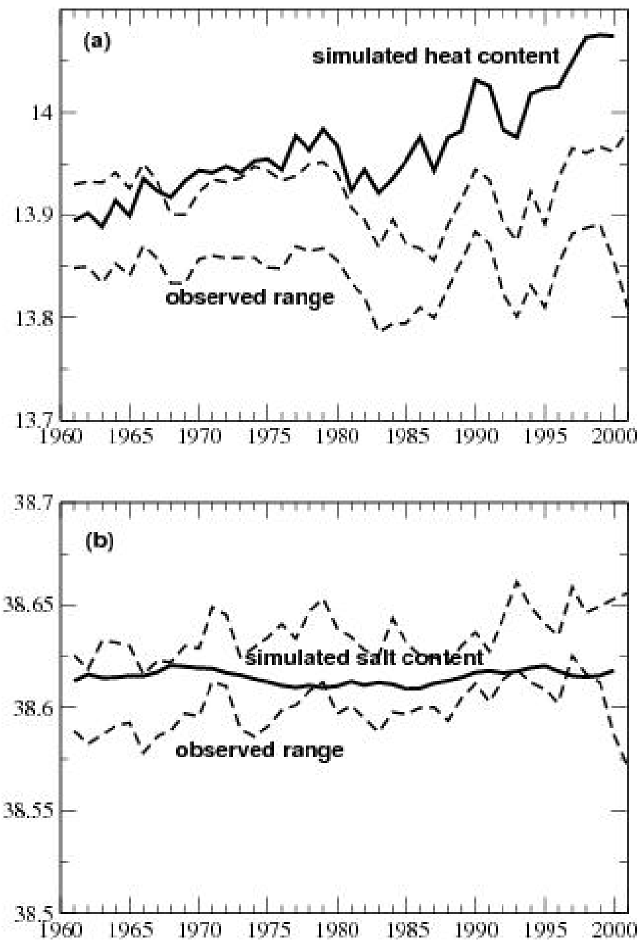

Fig. 1. Time series (1 point per year) of (a) the Mediterranean Sea heat content (expressed as a 3D mean temperature in °C) and (b) the salt content (expressed as salinity). In dashed line the observed range (Michel Rixen, personal communication) and in black, the simulated values.

Achieving such a goal requires working with high resolution models forced by a high resolution atmospheric forcing that follows the observed chronology. In agreement with this statement, we performed a dynamical downscaling of the ERA40 reanalysis with the ARPEGE-Climate model [5] (Atmosphere General Circulation Model with a stretched grid) in order to obtain a better horizontal resolution (50 km) over the Mediterranean area (spectral nudging method). A 40-year long simulation (1960-2000) was carried out with this method. The air-sea fluxes (radiative and turbulent) were extracted and then used to force a Mediterranean version [4] of the OPA model whose horizontal resolution reaches about 10 km. The SST relaxation was computed using the ERA40 SST dataset. Climatological river runoff fluxes along with an additive constant correction were applied to make the water budget realistic. However, no surface salinity relaxation was applied letting free the spatial and temporal variability of this field. This simulation can be considered as a first step towards a 40-year reanalysis of the Mediterranean Sea in which only realistic air-sea fluxes and SST would be imposed.

Firstly, the temporal evolution of the heat and salt content of the whole Mediterranean Sea is analyzed using recent observed datasets [3]. The average value, the interannual variability and the observed trend of the heat content are well simulated by the Mediterranean model apart from a weak bias of about 0.1°C at the end of the 20^{th} century (see figure 1a). The spatial pattern of the warming trend is also studied compared to observations. Concerning the salinity, only the average value is well reproduced (see figure 1b) proving a deficiency in the way the sources of the salinity interannual variability are modelled. In the Western Basin, the open-sea deep convection and the formation of the WMDW show a realistic interannual variability. However, no clear time correlation is found with the observed values [1] because the long-term temporal evolution of the vertical stratification seems to be too difficult to simulate without in-situ ocean data assimilation. Contrary to the WMDW formation, the Eastern Mediterranean Transient is mainly due to atmospheric flux anomalies and is then partly reproduced by our simulation without tuning the precipitation or the Black Sea freshwater input. Very cold winter and dense water formation are observed in 1993 filling the Aegean Sea (yearly deep water formation rate of 0.7 Sv). This newly formed water goes outside the Aegean Sea but does not sink to the bottom layer of the Levantine Basin.
In the future, improvements could be achieved by introducing interannual variability for the river runoff fluxes and for the Atlantic T-S characteristics as well as by using in situ ocean data assimilation. In forthcoming studies, this simulation will also be used as a reference to study the interannual variability of Mediterranean physical processes and to perform sensitivity tests in order to understand the recent past of this sea and consequently better foresee its future.

References

1 - Mertens C. and Schott F., 1998. Interannual variability of deep-water formation in the Northwestern Mediterranean. *J. Phys. Oceanogr.*, 28: 1410-1424.
2 - Roether W., Manca B., Klein B., Bregant D., Georgopoulos D., Beitzel W., Kovacevic V. and Luchetta A., 1996. Recent changes in Eastern Mediterranean Deep Waters. *Science*, 271: 333-334.
3 - Rixen M. et al., 2005. The Western Mediterranean Deep Water: A proxy for climate change. *Geophys. Res. Lett.,* 32: L12608.
4 - Somot S., Sevault F. and Déqué M., 2006. Transient climate change scenario simulation of the Mediterranean Sea for the 21st century using a high-resolution ocean circulation model. *Clim. Dyn.,* 27: 851-879.
5 - Déqué M. and Piedelievre J.-P., 1995. High-resolution climate simulation over Europe. *Clim. Dyn.,* 11: 321-339.