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Modelling the Mediterranean Sea interannual variability over the last 40 years : focus on the EMT

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The circulation of the Mediterranean Sea is characterized by a strong interannual variability and some long term trends have been observed for the water masses that could be related to climate change. This work is dedicated to the study of the past-climate variability of the Mediterranean Sea, in particular the study of the Eastern Mediterranean Transient (EMT) which occurred in the early 1990's.

The NEMO Ocean General Circulation Model is run with MED8 configuration of the Mediterranean Sea (horizontal resolution of about 10 km), with a climatological Atlantic bufferzone. It does not include the Black Sea. Initial conditions of temperature and salinity are extracted from the Medatlas-II climatology. Climatological runoff and Black Sea inputs are used.
In our study, NEMOMED8 is forced by the ARPERA model. It is built from the ARPEGE-Climate Atmosphere General Circulation Model in a regional configuration centered above the Tyrrhennian Sea (resolution of about 50 km above the Mediterranean Sea), spectrally embedded in the ERA-40 reanalysis. It provides a 40-year chronological dataset for the atmospheric forcing.

We carried out three companion simulations. The first simulation was run in the standard configuration. The two others differed by the choice of interannual variability in the hydrological forcing. The second simulation included interannual river runoff and Black Sea freshwater flow. The third simulation included interannual river runoff and Black Sea freshwater flow and also interannual conditions for temperature and salinity in the bufferzone, in order to simulate variations in the exchanges with the Atlantic Ocean.

The validation of the three simulations is investigated through several diagnostics for the 40-year period. In particular, the volume transport through the Strait of Gibraltar correspond to an inflow of 0,88 Sv of Atlantic waters and an outflow of 0,83 Sv of Mediterranean waters, which is in good agreement with literature. Then, the heat and salt contents are compared with interannual climatological data of temperature and salinity (Rixen et al. 2005). Considering the whole Mediterranean Sea, the variations of the heat and salt contents are qualitatively in good agreement with the climatology, even if the simulations are too cold by 0,16°C in average.

We focus on the thermohaline circulation by investigating the winter convection. The depth reached by the convection shows interannual variations of high amplitude, in particular in the Aegean Sea. Thus, the Cretan Deep Waters (CDW) are formed during many cold winters in the 1970's and the 1980's.
Notably, a nice feature is the enhancement of the winter convection during the EMT period in the early 1990's. For example in 1993, dense waters fill about 75% of the Aegean Sea. This leads to an overflow of the CDW (warmer, saltier and denser than before the EMT) through the straits of the Cretan Arc toward the Ionian and Levantine basins. Unlike several studies, we precise that the EMT is here simulated using a realistic forcing without any physical adjustment.
Finally, considering that the main characteristics of the EMT do not differ between the three simulations, we conclude that the atmospheric forcing is the main motor of this EMT event in our simulations.