21^{ST} CENTURY CLIMATE CHANGE SCENARIO OF THE MEDITERRANEAN SEA : A HIGH-RESOLUTION MODELLING APPROACH

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Abstract

This study analyses the results of an IPCC-A2 transient climate change simulation over the Mediterranean Sea. We also carried out a control simulation. For both runs, a Mediterranean Sea high-resolution model was forced by high-resolution air-sea fluxes (1960-2099). At the end of the 21^{st} century, the surface warming and the salting amount to +3.1°C and +0.48 psu respectively. The Mediterranean thermohaline circulation (MTHC) is strongly weakened because of a decrease in surface density. The ocean-only simulation is also compared with a regional atmosphere-ocean coupled scenario performed with the same models. We obtain a comparable behavior for the SST and a stronger increase in SSS changing the response of the MTHC.

Keywords : Circulation Models, Deep Waters, Global Change.

A climate change IPCC-A2 scenario run with an atmosphere regional climate model (ARPEGE-Climate, 50 km horizontal resolution, [1]) was used to force a Mediterranean Sea high resolution ocean model (OPA-MED, 10 km, [2]) over the 1960-2099 period. Thus we obtained the first high-resolution transient climate change scenario for the Mediterranean Sea over the 21^{st} century [2]. A control simulation over the same period of time was also carried out under present climate fluxes in order to evaluate the potential drift of the model. This control run shows air-sea fluxes in agreement with observations, stable temperature and salinity characteristics, and a realistic thermohaline circulation simulating the formation of the different intermediate and deep water masses as described in the literature.

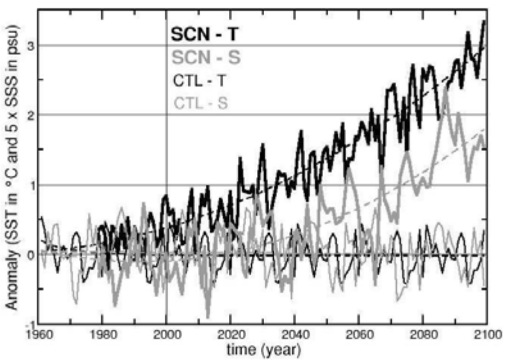

Fig. 1. Yeary time series of the SST (°C, in black) and SSS (psu, in grey) anomalies for the Gulf of Lions area (0°E-9.5°E; 40°N-44°N) for the control simulation (CTL, thin lines) and the scenario (SCN, thick lines). Exponential fits have been added for each curve (dashed lines). The anomalies have been computed with respect to the 1961-1980 period and the SSS anomalies have been multiplied by 5 for rescaling.

In the scenario, we can notice that the simulated warming and salting are in agreement with the trends observed for the Mediterranean Sea over the last decades [3]. At the end of the 21^{st} century, the warming and the salting amount to +3.1°C and +0.48 psu respectively, over the Mediterranean sea surface (see also figure 1 for the Gulf of Lions area) and to +1.5°C and +0.23 psu respectively, when averaged over the whole water column. In addition, the Mediterranean thermohaline circulation (MTHC) is strongly weakened at the end of the 21^{st} century (see figure 2). This simulated evolution is mainly due to a decrease in the surface water density leading to a shrinking in deep water formation in winter. Thus the warming effect is more important than the salting one as shown in figure 1. In this figure, the SSS anomalies have been rescaled in order to be compared to the SST anomalies in terms of density changes. However, locally (in the Adriatic and Aegean seas) the weakening of the deep water formation is lessened by the Po and the Black Sea changes. The characteristics of the Mediterranean Outflow Waters flowing into the Atlantic Ocean are also strongly impacted. This water mass experiences a negligible decrease of the water transport (-4%, 2070-2099 period) along with an increase in temperature (+2.5°C) and in salinity (+0.45 psu) in agreement with a low-resolution Mediterranean Sea scenario [4]. Such a phenomenon could influence the Atlantic Ocean circulation at the century time-scale. However there are numerous uncertainties related to this scenario: at least, the choice of the IPCC scenario, the choice of the modelling strategy, the choice of the ocean model, and the climate change impact on the river runoff fluxes. Among them, a key issue in the modelling strategy is the use of an ocean model, forced by air-sea fluxes instead of coupled to the atmosphere. Indeed, the way of dealing with the SST evolution is completely different and more physical with an interactive Mediterranean Sea. A scenario with a regional air-sea coupled model (ARPEGE-Climate/OPA-MED, see [5]) has also been run. The comparison with the forced ocean model shows that the SST evolution is comparable at the basin scale with some local differences. However, concerning the salinity, the regional coupled model simulates a larger increase in SSS and consequently a smaller decrease for the MTHC. Therefore we think that ensemble simulations are required to assess in details the different sources of uncertainty and thus determine more precisely the possible evolution of the Mediterranean Sea over the 21^{st} century.

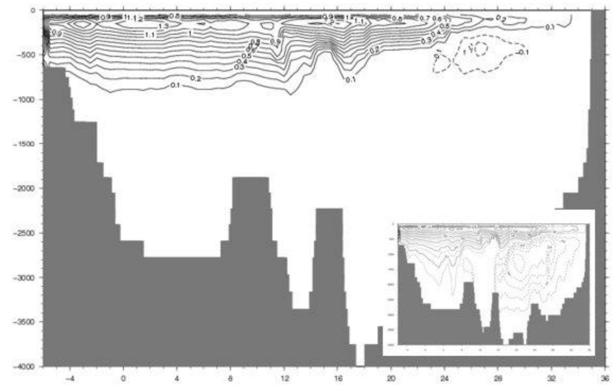

Fig. 2. Vertical section averaged over the 2070-2099 period for global Mediterranean Zonal Overturning stream Function (ZOF) for the scenario (the control run ZOF is represented in small).

References

1 - Déqué M. and Piedelievre J.P., 1995. High-Resolution climate simulation over Europe. *Clim. Dyn.,* 11: 321-339.
2 - 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, doi: 10.1007/s00382-006-0167-z.
3 - Rixen M. et al. 2005. The Western Mediterranean Deep Water: A proxy for climate change. *Geophys. Res. Lett.,* 32: L12608.
4 - Thorpe R.B. and Bigg G.R., 2000. Modelling the sensitivity of Mediterranean Outflow to anthropogenically forced climate change. *Clim. Dyn.,* 16: 355-368.
5 - Somot S., Sevault F., Déqué M. and Crépon M., 2007. 21st century climate change scenario for the Mediterranean using a coupled Atmosphere-Ocean regional Climate Model. *Global and Planetary Change* (submitted).