Impact of an IPCC-B2 scenario on Mediterranean sea temperature

Michel Déqué, Florence Sevault and Samuel Somot
Météo-France/CNRM Toulouse France

A coupled climate simulation of the B2 IPCC scenario has been conducted with ARPEGE-Climate atmosphere model coupled with OPA ocean model (Douville et al.,2002). These two global models have a resolution of 2.8° and 2° respectively. This integration starts in 1950 with climatological conditions and undergoes during 150 years a radiative forcing with prescribed concentrations of carbon dioxide, methane, nitrous oxide, CFCs, and sulphate aerosols. These concentrations follow observations till 2000, then IPCC-B2 projections.

Decadal mean SST anomalies are extracted from this first simulation. A second simulation in uncoupled mode is performed with a high resolution version of ARPEGE-Climate (Gibelin and Déqué, 2003). This global model has a resolution of 0.5° in the Mediterranean sea, increasing to 4.5° at the antipodes. This 140-year simulation starts in 1960 and uses observed monthly SSTs till 2000, then artificial SSTs obtained by blending observed data with the decadal SST anomalies calculated from the coupled simulation (each calendar month having a different anomaly). The radiative forcing is exactly the same as in the coupled simulation. The radiative and SST constraints are consistent over the Mediterranean sea since the difference in the surface heat flux between 2070-2099 and 1960-1989 is almost zero, given the interannual variability. In other words, the raise in SST balances the increased downward radiation. This property, obvious in coupled mode, is obtained in forced mode since we use the same physical parameterizations and since the impact of horizontal resolution on the large-scale flux impact is negligible.

A third simulation has been produced with a regional version of the OPA ocean model. This version has 0.125° resolution and covers the whole Mediterranean sea (not the Black sea). A buffer zone in the near Atlantic with a strong relaxation towards climatology allows to simulate the Gibraltar straights flow. The river run-off (including the Black sea flow) is simulated by a surface salinity relaxation. The simulation lasts 130 years and is driven by the daily heat, water, and momentum fluxes from the high resolution atmosphere model from 1970 through 2099. The heat flux is recalculated as a function of SST by a linear correction. For the sake of simplicity rather than realism, we neglect the impact of the hydrological cycle in this simulation. In fact the hydrologic cycle decreases by 0.3 mm/day over the Mediterranean sea between the first 30 and the last 30 years of the atmosphere simulation. But we maintain the surface salinity relaxation constant, as well as the Atlantic buffer-zone. This experiment is more a sensitivity study to heat fluxes than an actual scenario. We will restrict our analysis to sea temperature at different level, and discard the salinity field.

Figure 1 shows the trend in annual mean temperature in three layers for three different sub-basins (western basin, Adriatic sea, eastern basin). The observed climatological conditions in the western basin are 15.1, 13.5 and 12.9°C in the 3 layers from top to bottom. In the Adriatic sea, the values are 14.9, 13.6 and 13.2°C respectively. In the eastern basin, the values are 17.2, 14.5 and 13.4°C respectively. The model starts in a slightly colder state than the clima-

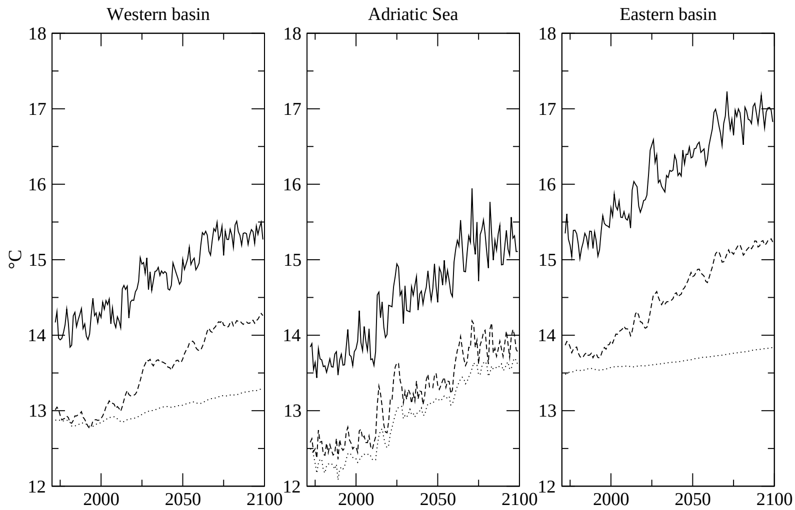

Figure 1: Annual mean sea temperature (°C) for the upper (0-150m; solid), middle (150-600m; dash), and lower (600m-bottom; dot) layers in the three basins of the Mediterranean sea, as simulated in the 130-year ocean model integration.

tological conditions. In the western basin, the upper layer warms up linearly by 1.5°C with some interannual variation. The middle layer warms up by the same amount, but the warming is delayed by a few decades. The lower layer warms up by only 0.5°C with some delay. A similar behavior is obtained in the eastern basin, except that the upper layer warming is more intense (2°C). The Adriatic sea is smaller and shallower than the other two basins. The warming in the 3 layers (the lower layer covers less than half of the basin) is similar and delayed in the middle and lower layer.

This experiment shows that the surface warming penetrates into the deep ocean in less than one century, despite the stabilization of the vertical profile. A next question to address is whether the expected increase in surface salinity will increase further the warming by modifying the thermohaline circulation. Further simulations in a more realistic way, including fully coupled simulations, will help our understanding of the impact of anthropogenic climate change on the Mediterranean sea.

References

- Douville, H., Chauvin, F., Planton, S., Royer, J.F., Salas y Mélia, D., and Tyteca S., 2002: Sensitivity of the hydrological cycle to increasing amounts of greenhouse gases and aerosols. *Clim. Dyn.*, **20**, 45-68.

- Gibelin, A.L., and Déqué, M., 2003: Anthropogenic climate change over the Mediterranean region simulated by a global variable resolution model. *Clim. Dyn.*, **20**,327-339.