Mediterranean Sea Level Analysis at Present Climate Conditions

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Introduction

In order to cope with anthropogenic climate change, we need to develop more effective and efficient sustainable adaptation and mitigation strategies in order to preserve the cultural heritage of Europe for the long-term future. More reliable assessments will lead to better prediction models, which in turn will enable preventive measures to be taken. Within the Climate for Culture project, the objective is to address the most urgent risks for cultural heritage derived from climate change. One if these risks is the potential negative impact that the sea level rise could have at specific regions in coastal areas of the Mediterranean Sea as a consequence of global warming. For this purpose, this work investigates trends at the Mediterranean sea level for present climate conditions based on simulation carried out using a fully coupled atmosphere-ocean regional model.

Model description

A 33 years simulation (1979-2010) has been carried out using an improved version of the regional coupled atmosphere-ocean model (Mikolajewicz et. al., 2005) for this region existing in house (Elizalde et. al., 2010) based on the atmospheric model REMO (Jacob, 2001) and the limited area version of ocean model MPIOM adapted to the Mediterranean Sea (Mikolajewicz, 2011). The changes in the new coupled model with respect to the older version consist in the improvement of the numerical calculation at the air-sea interface exchange and the sea level pressure as a new exchange variable. This allows to include both the effects of fast moving pressure systems on extreme sea levels as well as a proper calculation of the long-term mean effect of variations in sea level pressure on the mean sea-level including the nonlinear effects.

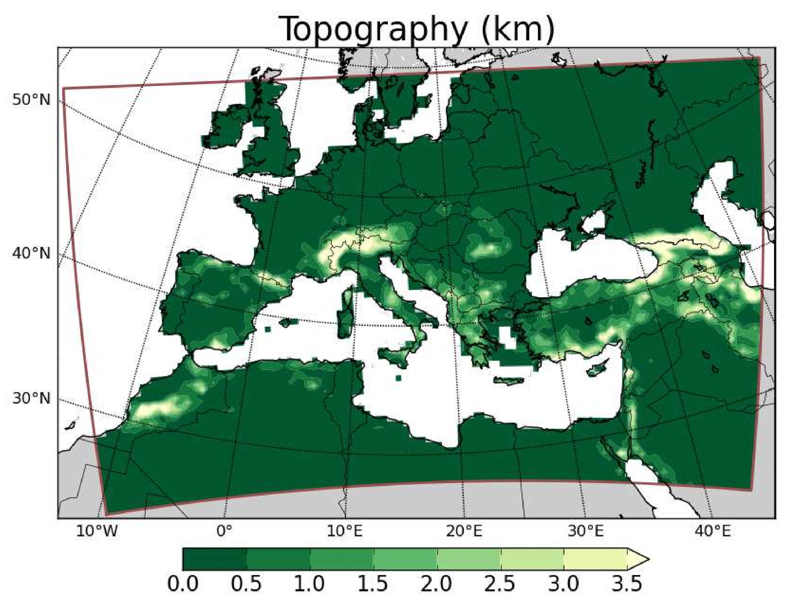

Fig. 1 Domain for the atmospheric component

The atmosphere model REMO has a resolution of 50km with a domain size of 121x73 grid boxes (Fig. 1) and 31 vertical levels. The variables air temperature, specific humidity, wind components, surface pressure and surface temperature are impose as lateral boundaries forcings using the ERA-Interim reanalysis dataset.

The ocean model MPI-OM has a resolution ~20 km with a domain size of 225x104 grid boxes (Fig. 2) and 29 vertical levels. Temperature and salinity are restored to Levitus et. al. data only at the boundaries of the Atlantic ox.

The hydrological model has a resolution of ~55 km. It accounts for the lateral waterflow on the land surface. 365 river mouths end up at the Mediterranean and Black Sea.

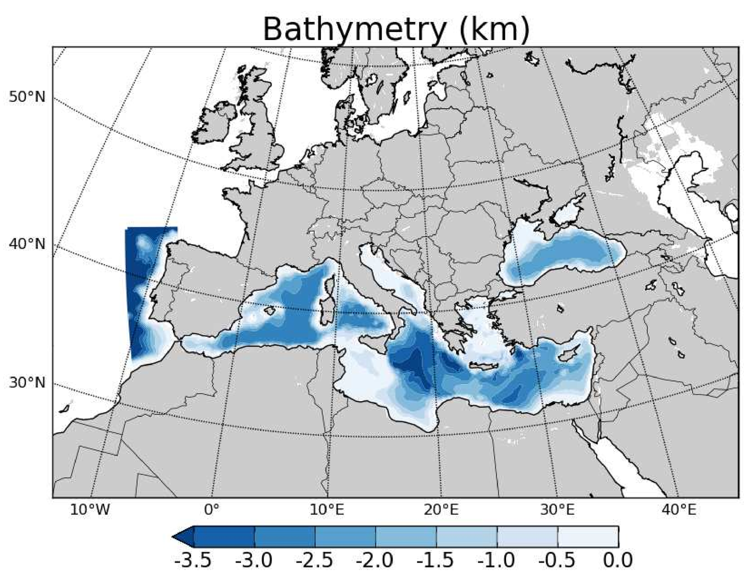

Fig. 2 Domain for the oceanic component

Nile discharge is prescribed to 1829.5 m3/s (Dümenil et. al., 2000).

Coupling strategy

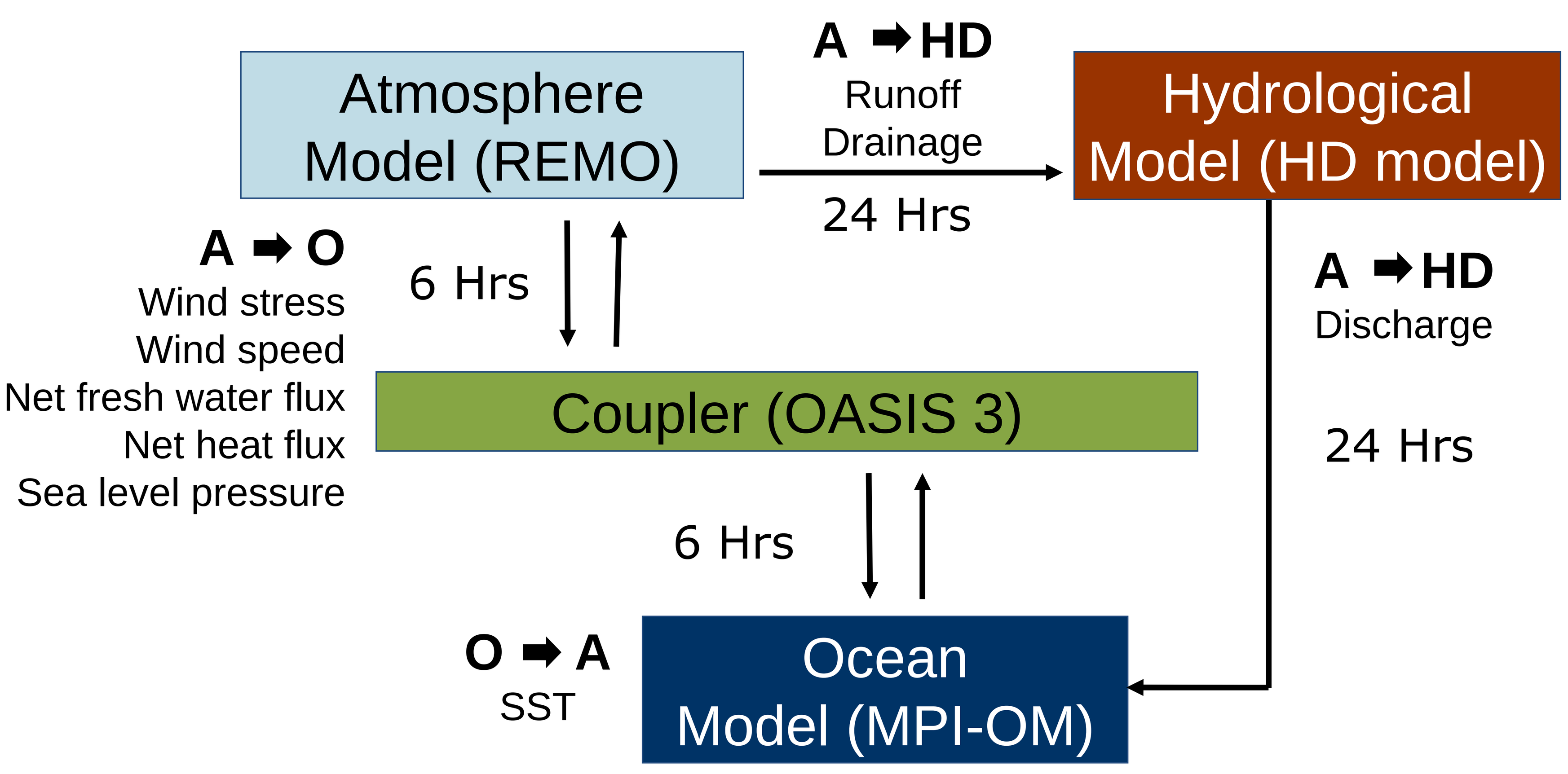

Fig. 3 Coupled system configuration

Exchange methology: Bilinear interpolation for ocean-atmosphere exchange. Reanalysis data covers the missing area for SST in the atmospheric model.

Mediterranean Sea Level

The simulated sea surface temperature agrees very well with observations. The biases are in the range ±0.6 K for both horizontal (Fig. 4) and vertical biases (Not shown). The salinity bias (not shown) is generally in the range of ±0.3 psu, up to ±0.4 psu at the north of the Ionan Sea and more than -0.5 psu in the eastern Mediterranean.

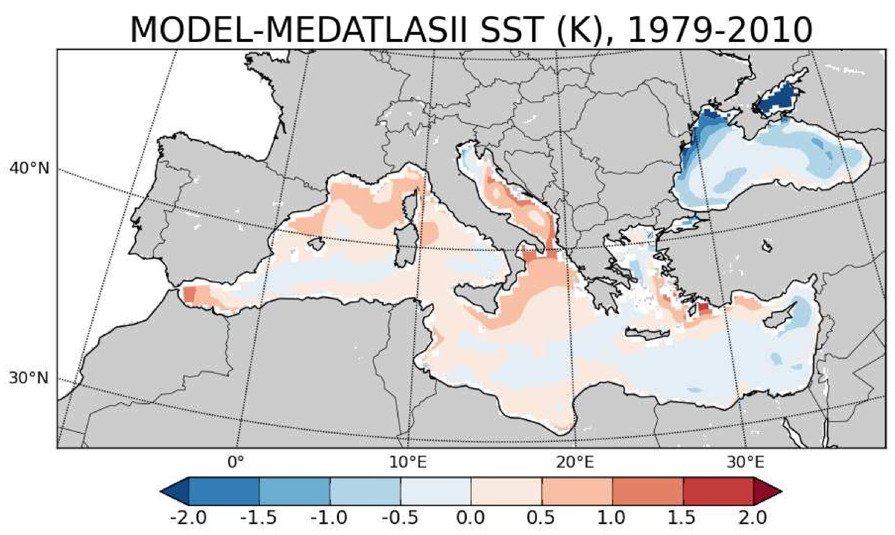

Fig. 4 Sea surface bais

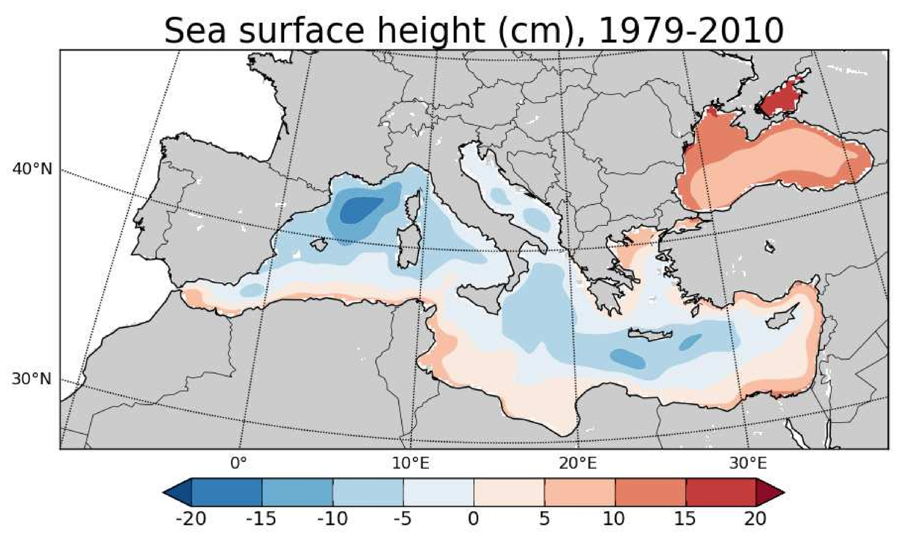

Fig. 5 Sea surface height

Inhomogeneuos pattern of Sea Surface Height (SSH) (Fig,. 5) can be produced by different mechanisms: water mass loss through evaporation, water displacement by gyres in the oceanic circulation, horizontal atmospheric pressure gradients. Positive SSH are found at freshwater input locations. Negative SSH at evaporative areas and gyres.

Time series for Mediterranean Sea Level shows a positive trend of 0.3 mm/yr in the last three decades (Fig. 6a). A positive trend is also confirmed by observations data (Tsimplis et. al., 2008). A mismatch of 1 mm/yr with the observations can be a result of the lack of yearly variability on the forcing at the Atlantic box.

Since no significant changes are seen in freshwater input, this trend is attributed mostly to the steric effects (Fig. 6b). The warmer air temperatures transfer heat energy to the water, enhancing the thermosteric effect. This compensates the halosteric effect caused by the larger evaporation which produces the salinification of the water.

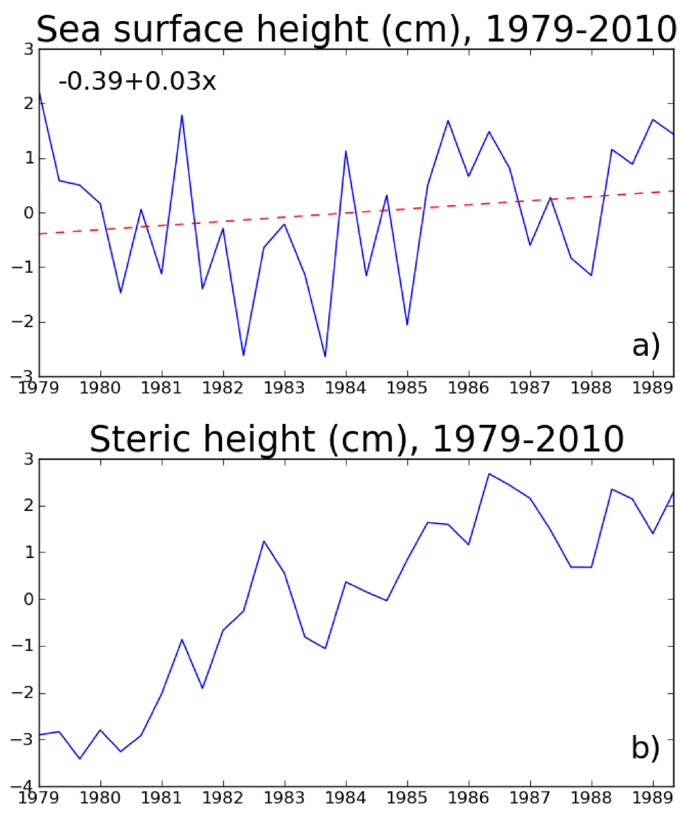

Fig. 6 Time series for horizontal averaged values over the Mediterranean Sea

Conclusions

The model produces a good climatologyof Mediterranean water temperature and salinity. The model indicates as well an increasing trend on the sea level at the Mediterranean basin in the last three decades. The positive trend is in agreement with observations. Even though this trend is not spatially homogenous distributed, the cultural heritage on the costal areas might be at risk due to this sea level rising. Since warmer air temperatures are predicted for future climate, it is necessary to estimate the ocean evolution at the Mediterranean region, especially the sea level. Not only the regional factors may have big influence on sea level, but it might be important the influence the Atlantic input, e.g. the mass addition from ice melting and due to the thermal expansion of the Atlantic ocean.

Outlook

For future Mediterranean sea level assessment, the regional coupled model will be forced with output data from the CMIP5 simulations.

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