Analysis of a 44-Year Hindcast for the Mediterranean : Comparison with Altimetry and In Situ Observations

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We study the interannual and seasonal variability in the Mediterranean Sea over the period 1958-2004 by comparing a numerical simulation with altimetry and a temperature and salinity database (MEDAR). The numerical simulation is the ORCA-R025 G70 (1/4º resolution) of the DRAKKAR global ocean general circulation model, which is forced by ERA40 and has a salinity restoring term applied at surface.

The temperature comparison between ORCA and MEDAR shows good interannual variability agreement (correlations of ~0.8 in the WMED, ~0.5 in the EMED at the 99% confidence level) at surface layers (0 - 150 m), whereas the salinity analysis shows that the surface salinity restoring term applied to the model (a correction of the model data towards the MEDAR climatology in the form of either rainfall or evaporation) has obliterated most of the interannual variability. Regarding mean values, average temperatures over the Mediterranean basin at all vertical levels are slightly higher in the model (0.08 - 0.16 ºC) caused by an underestimation of winter heat loss in the ERA40 atmospheric forcing. Mean surface salinities are slightly lower in the model (~0.3 psu), being replicated in deeper layers to a lesser degree and could mean that the restoring might be too weak, without sufficient evaporation to compensate for a weak atmospheric forcing (ERA40) water loss flux.

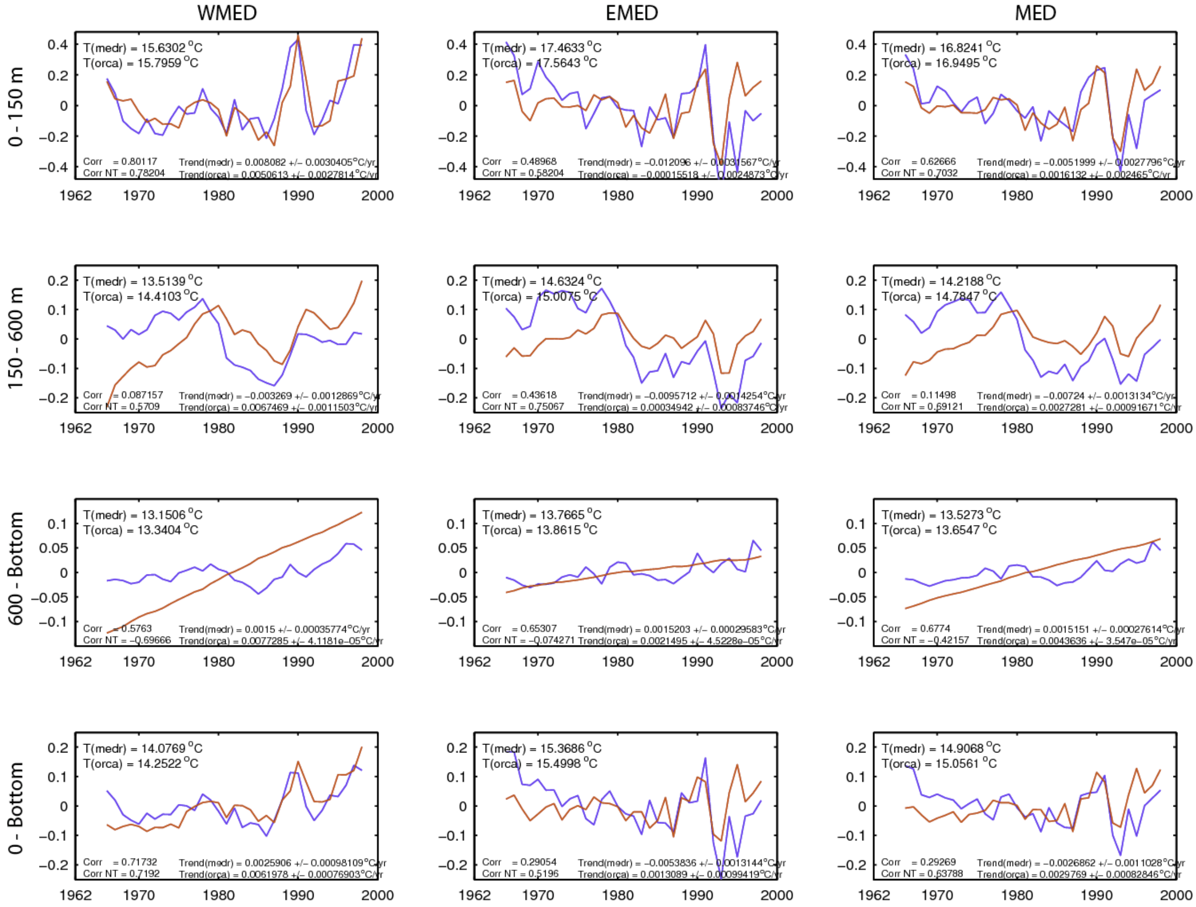

Figure 1: ORCA (red) and MEDAR (blue) temperature timeseries divided into basins and layers

Comparison of Sea Surface Height (SSH) and Steric Height (SH) from the model and the sea level anomalies (SLA) obtained from altimetry over the 1993-2004 period shows that the interannual variability and the annual cycle are well reproduced, with good correlations, especially at the basin scale (Figure 2).

The sea level analysis comparing Sea Surface Height (SSH) and Steric Height (SH) from ORCA and sea level anomalies from altimetry (1993-2004) shows good correlations (~0.8) in the interannual variability and the annual cycle, especially at the basin scale. However, the model's SSH, which is a prognostic variable including the effect of wind, water and heat fluxes, as well as temperature/salinity fronts, overestimates (~15 mm/yr) the observed altimetric positive trend (~3 - 4 mm/yr). It is interesting to note that the steric height computed from the model's temperature and salinity data does not display the same exaggerated trend, moreover, the trend is much more in line with Altimetry. In an attempt to identify the source of the SSH trend overestimation, a water budget calculation was performed between the horizontal fluxes into the Mediterranean Sea and the net vertical water fluxes (E-P-R). If was found that the horizontal transport through the main straits shows adequate values when compared to observations. Thus, the model's exaggerated SSH trend is probably caused by an E-P-R imbalance due to an inaccurate atmospheric forcing (ERA40), with too coarse a resolution (0.2º x 0.2º) to resolve the typical scales in the Mediterranean Sea.

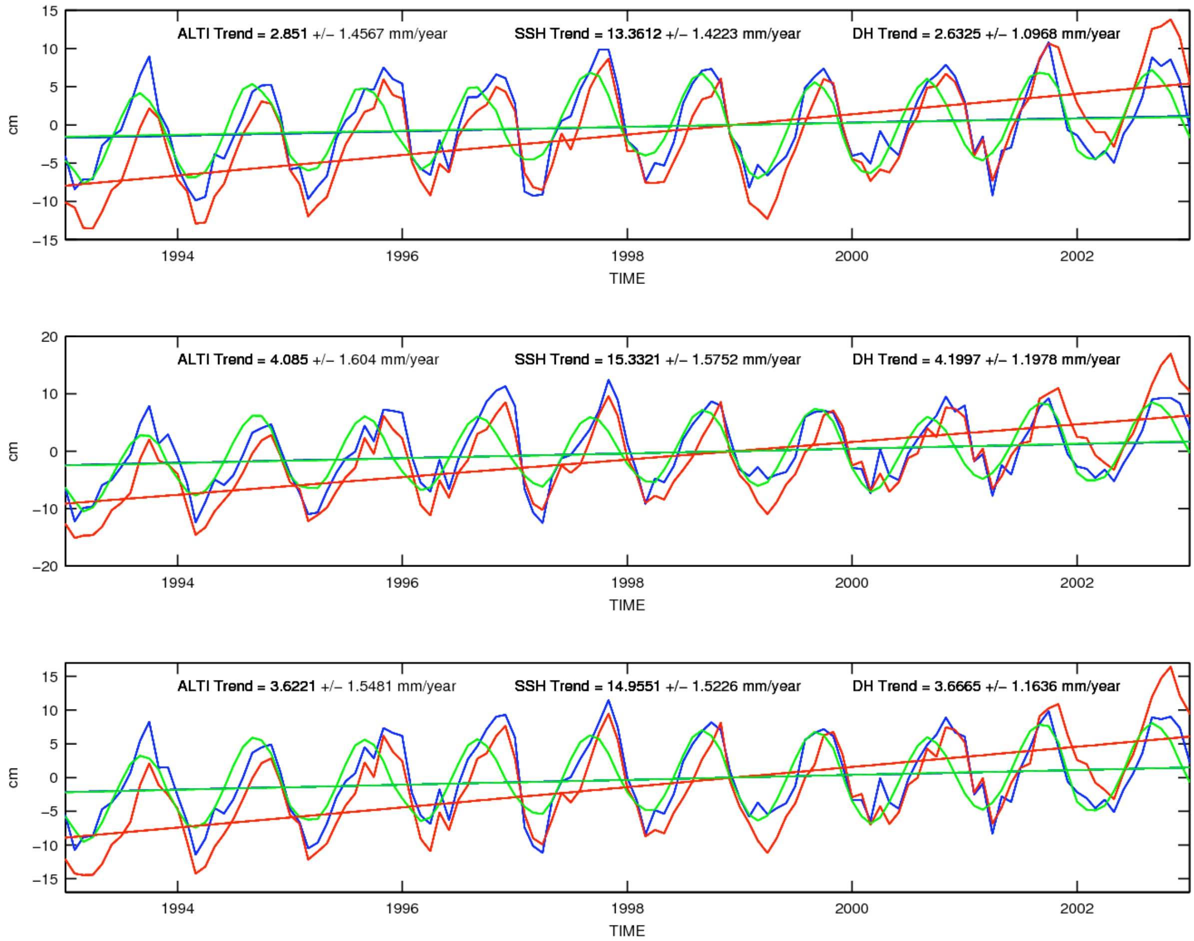

Figure 2: Timeseries of ORCA sea surface height (red), steric height (green) and altimetry (blue) for the WMED (top), EMED (middle) and whole Mediterranean (bottom)

Transport through the Gibraltar Strait shows adequate values when compared to observations with an inflow of about 1.07Sv and an outflow of about 1.01 Sv (0.067 Sv net inflow). Transport through the Turkish Straits (0.0190 ± 0.021 Sv net outflow) is of the order of magnitude as the limited studies available (~0.01 ± 0.0057 Sv).

As expected with this model‘s low resolution, it is incapable of correctly reproducing most mesoscale features. This is especially notable in the Alboran Sea and Algerian Current where the model is unable to reproduce the gyres and eddies that are formed in these regions.

Besides the mesoscale and sea level trends, it is surprising how well this global ocean model behaves in the Mediterranean Sea, taking into account its relatively low resolution for the dynamic features of this semi-enclosed sea. With a few key issues (such as surface salinity restoring and atmospheric forcing) that, once identified, can be improved, the ORCA-R025 ocean model can provide a very promising tool for the study of the Mediterranean seasonal cycle and interannual variability characteristics.