Investigating the impact of tides in the North Aegean on the Deep Water Formation Events (DWFe) during Eastern Mediterranean Transient.

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Introduction

The North Aegean Sea is one of the most interesting seas of the Mediterranean, being under the dominant impact of the Black Sea waters' inflow though the so-called Turkish Strait System. Moreover, it constitutes a potential deep water formation site of the Eastern Mediterranean Sea along with the Adriatic Sea. Previous studies for the region focused - rightly - on the crucial role of low salinity Black Sea waters in controlling the overall thermohaline function and dynamics of the North Aegean, but none of them studied the impact of tides in the mixing processes and the production of extremely dense water, especially during 1987, 1992 and 1993 when major deep water formation events took place in the region. In this work we examine the tidal impact via several long term simulations using a high resolution ocean model covering the period from 1985 to 2013.

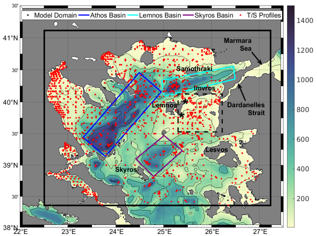

Figure 1: Map of the North Aegean Sea. The model's computational grid is defined by the black rectangle. The blue rectangle identifies the Athos deep basin, the green the Skyros basin and cyan the Lemnos basin. The red dots are T/S profiles from R/Vs for the period from 1986 to 2013. Dash black line denotes the area of Dardanelles Strait exit. The star symbols (*) identify the locations of the HF radar antenna sites

Model description and validation

The Regional Ocean Model System (ROMS) was used for two 28-year-long hindcasts: one with tidal forcing and one without. A grid of approximately 1.0 *km* horizontal resolution in both directions and 31 vertical sigma (σ) levels was develop to cover the region of interest. Input data consisted from:

a) ECMWF ERA5 reanalysis data for atmospheric forcing.
b) Maderich (2015) data for eastern open boundary.
c) 8 tidal constituents – 4 diurnal and 4 semi-diurnal – from OSU inverse tidal model (*Egbert*, 2002).
d) CMEMS MED-MFC daily average output for the southern open boundary.

The model's validation was extensive, using all available *in situ* data from different platforms.

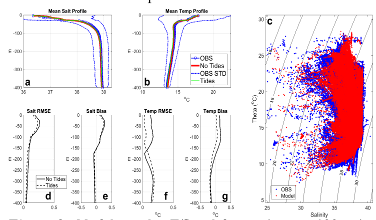

Figure 2: Model results T/S validation (upper 400 m). Panel (*a*) shows the modeled mean salinity profile from observations (blue line) and model's output (red line no tidal, green line tidal run). The dashed blue line is the observations standard deviation. Panel (*b*) is the same for potential temperature. Panels (*d–g*) is the error estimation for salinity and temperature in terms of Bias and RMSE solid line for no tidal tun and dashed for tidal respectively. Panel (*c*) is the θ/S diagram from all observations and model data for the period from 1986 to 2013.

Results

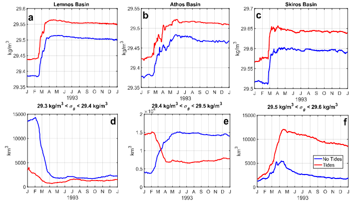

Figure 3: Upper panels (***a***, ***b*** and ***c***) show the evolution of integrated potential density from 600 m to maximum depth for North Aegean's deep basins during 1993. Lower panels (***d***, ***e*** and ***f***) shows the total volume - in km^3 - of the produced dense waters for the whole basin during 1993. For all panel red line denotes tidal results and blue line non tidal.

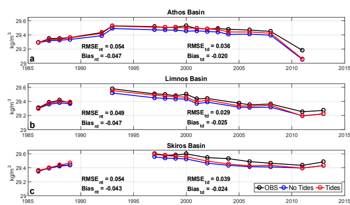

Figure 4: Interannual evolution of North Aegean deep basins' potential density, vertically integrated from 600 m to maximum depth, for the period from 1986 to 2013. The blue line refers to non-tidal results, red line to tidal results and the black line to observations.

Conclusions

The employment of tidal forcing leads to a closer proximity to observations than non-tidal results, thus validating the necessity to incorporate tidal forcing. The use of tidal forcing enhanced meridional exchanges of heat, salt and buoyancy between the North and South Aegean, thus increasing the stratification and buoyancy content of the upper water column prior to winter mixing. The most significant and surprising result however is that the dense-water volumes produced using tidal forcing were much higher than the ones without tides, a fact signifying the complexity of processes involved prior to and during dense-water formation.

References

1) Shchepetkin, A. F. and McWilliams, J. C.: The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography following coordinate oceanic model. Ocean Modelling, 9(4):347–404, 2005.
2) Maderich, V., Ilyin, Y., and Lemeshko. E.: Seasonal and interannual variability of the water exchange in the Turkish Straits system estimated by modelling. Mediterranean Marine Science, 16(2):444–459, 2015.
3) Egbert, G. D. and Erofeeva, S. Y.: Efficient inverse modeling of barotropic ocean tides. Journal of Atmospheric and Oceanic Technology, 2002, 19(2):183–204.
4) I. G. Mamoutos, E. Potiris, E. Tragou, V. Zervakis, and S. Petalas. A high-resolution numerical model of the North Aegean sea aimed at climatological studies. Journal of Marine Science and Engineering, 9(12):1463, 2021.

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