The impact of freshwater flux on Mediterranean thermohaline circulation: a model inter-comparison study

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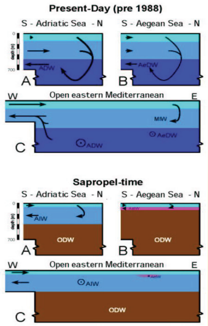
1.Background

The formation of the organic-rich layers (sapropels) of the Mediterranean Neogene is known to occur at precession minima and has been attributed to (1) increased production of organic matter and (2) increased preservation due to a decrease in THC and hence oxygenation of the deep waters.

We use three general circulation models (POM, MOMA and MED16), in setups of increasing degree of sophistication, to simulate the Mediterranean thermohaline circulation (MTHC) for the present day and a precession minimum situation.



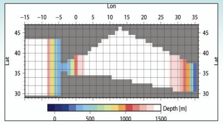
Schematic presentation of hypothesis of the changes in subsurface circulation patterns between the present day (upper panel) and times of sapropel formation (lower panel) [Rohling, 2001].

2.Aims

- How does the MTHC respond to climate changes (Precipitation, Evaporation and Runoff)?
- Can we explain the relation between changes in the MTHC and sapropel formation?

3.Model setup

3.1.POM: idealized basin

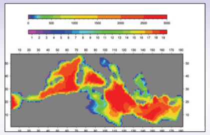


POM bottom topography

★ The Princeton Ocean Model (POM) is a primitive equation, sigma-coordinate and free-surface model (Blumberg and Mellor,1987). The grid horizontal resolution is ~100 km with 21 vertical sigma levels.

★ A buffer zone in the Atlantic Ocean is used to ensure the exchange at Gibraltar strait.

3.2.MOMA: low resolution

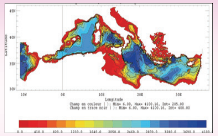


MOMA bottom topography

★ The model is an array processor version of MOM with z-coordinate and free-surface assumptions (Meijer et al, 2004). The horizontal resolution is ~25 km with 19 vertical levels.

★ A small box of the Atlantic Ocean is used to ensure the exchange at Gibraltar strait.

3.3.MED16: high resolution



MED16 bottom topography

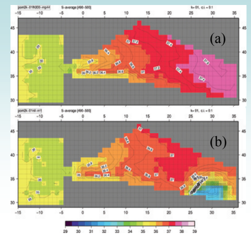
★ MED16 is based on the OPA code with z-coordinate and rigid-lid assumptions (Beranger et al, 2005). The horizontal resolution is ~5 km with 43 vertical levels.

★ A buffer zone is used to simulate the Atlantic Ocean and to ensure the exchange at Gibraltar strait.

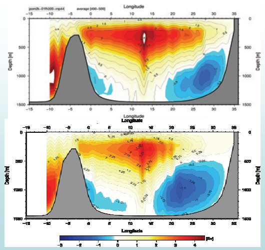
Two experiments were performed with each model: (1) Reference: with present-day conditions and (2) Precession minimum: with increased Nile discharge.

4.Results

4.1. POM

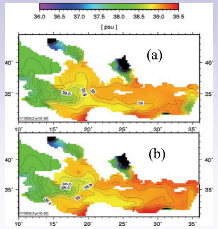


Annual mean of POM Sea surface salinity (average over 10 years). (a) Reference experiment, (b) experiment with Nile discharge adjusted to 5 times the precipitation in the southern part of the basin.

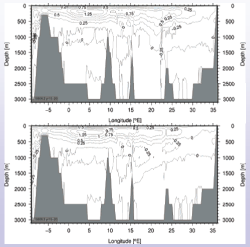


Annual mean zonal overturning stream function. Upper panel: Reference experiment. Contour interval is 0.25 Sv. Lower panel: as previous for experiment with enhanced Nile discharge.

4.2. MOMA

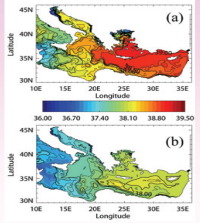


MOMA Sea surface salinity in February (average of years 15-20). (a) Reference experiment, (b) experiment with Nile discharge adjusted to 5 times the precession minimum value.

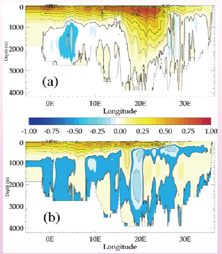


Annual mean zonal overturning stream function. Upper panel: Reference experiment. Contour interval is 0.25 Sv. Lower panel: as previous for experiment with Nile discharge adjusted to 5 times the precession minimum value.

4.3. MED16



MED16 Monthly mean sea surface salinity in February (a) Present-day experiment, (b) experiment with Nile discharge adjusted to the precession minimum value.



Annual mean zonal overturning stream function. (a) present-day experiment. Contour interval is 0.1 Sv. (b) as previous, for experiment with Nile discharge adjusted to the precession minimum value.

5. Conclusions

- **The three models provide reasonable agreement between the simulated present-day MTHC and the literature.**
- **A reduction of the upper zonal overturning cell and an intensification of the deep cell is found in response to extra freshwater input, as inferred to characterise precession minima.**
- **The higher the horizontal resolution, the higher the sensitivity to the fresh water flux.**

On-going work:

To study the impact of the Nile discharge on the convection and deep-water formation.

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References:

Béranger, K., Mortier, L., and Crépon, M. (2005). "Seasonal variability of water transport through the straits of Gibraltar, Sicily and Corsica, derived from a high-resolution model of the Mediterranean circulation." Prog. in Oceano., 66(2-4).

Blumberg, A.F., and G.L. Mellor (1987), A description of a three-dimensional coastal ocean circulation model, in Three-Dimensional Coastal Ocean Models, Coastal Estuarine Sci., Vol 4, ed: N.S. Heaps, 1-16, AGU, Washington, DC.

Meijer, P.Th., and Tuenter, E. (2007). " The effect of precession-induced changes in the Mediterranean freshwater budget on circulation at shallow and intermediate depth"*J. of Marine Sys.*, *68*(3), 349-365.

Rohling, E.J. (2001). " The dark secret of the Mediterranean - a case history in past environmental reconstruction ", www.soc.soton.ac.uk/soes/staff/ejr/DarkMed/dark-title.html.

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