Evaporation and recent changes in Mediterranean Deep Waters

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Abstract

The Mediterranean basin, as a concentration basin contributes to a net export of water through the atmosphere out of its catchment area. Around a 5% of the input from Gibraltar (~1700 km^3/y or 0.06 Sv) comes back to the Ocean via atmosphere. The budget is controled by the evaporation and precipitation over the sea and land runoff.

From these three components only the riverine component of land runoff can be reasonably well assessed. The rest of the components can only be indirectly estimated through remote sensing, modelling and some sparse field data. Thus the global budget is estimated through the average characteristics of input and output water at the strait of Gibraltar.

Evaporation plays a role of both increasing salinity and decreasing temperature so that the resulting water is more dense and sinks towards the sea interior. Every parcel of dense water formed then remains out of the contact with the atmosphere retaining the history of its water loss to the air. In this presentation we examine the recent evolution of the newly dense water formed (2004-2009) as a tool to assess the variability of the evaporation over the Mediterranean and the water export.

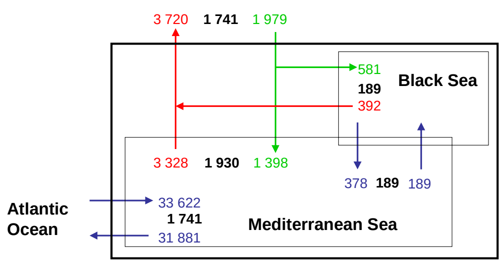
Key elements:

- Gibraltar: input/output: transport+salinity. Large uncertainty
- Sea surface: Evaporation/Precipitation. Roughly estimated
- Coast: Land runoff. Some uncertainty

Variability in water balances:

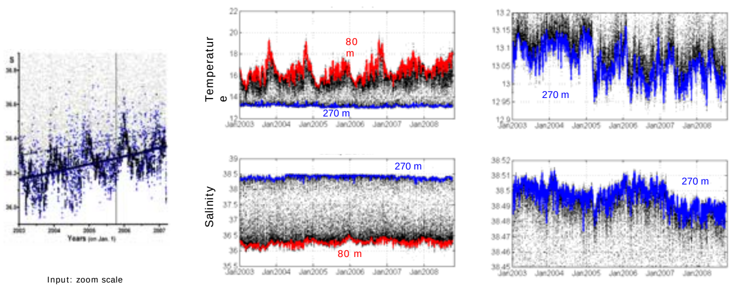
- Gibraltar: >30%
- Sea surface: >50%
- Coast: ~20%

Mediterranean water balance in km^3/year



Just an approximation!

Gibraltar input/output

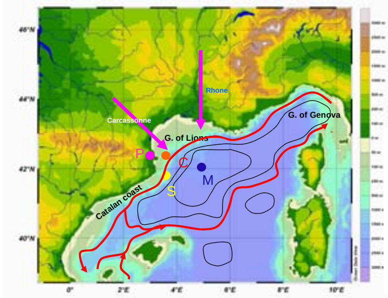


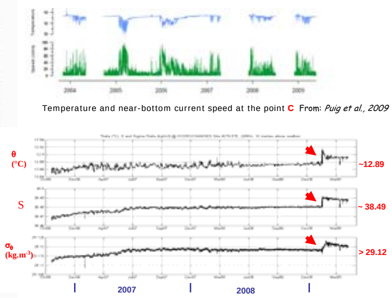
Input: zoom scale

Temperature and salinity west of Gibraltar. From: *Millot, 2009*

Output: zoom scale

Deep Water Formation (DWF) area





Temperature and near-bottom current speed at the point **C** From: *Puig et al., 2009*

Temperature, Salinity and density at the point **M** From: *Fuda et al., 2009*

DWF events (ref. to the year of mid winter):

- 2005: Shelf cascading+open sea.
  - >Extremly intense (and extense)
  - >G. of Lions to N. Balearic and Ligurian sea
- 2006: Shelf cascading+open sea.
  - >Intense
  - >Ligurian sea
- 2007: No DWF
- 2008: Very weak
- 2009: Open sea.
  - >Very intense
  - >G. of Lions

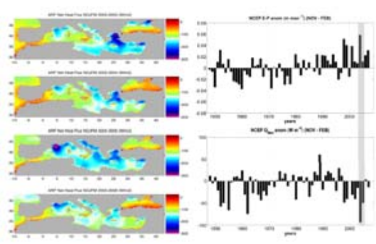
Dramatic events!

Changes in salinity structure of the deep layers:

- 2005: precedent DW as a relative minimum, and the new DW as a relative maximum.
  - >mean salinity increase (400-2600 m): +0.002
- 2009: new DW as a new relative maximum.
  - >mean salinity increase (400-2600 m): +0.001

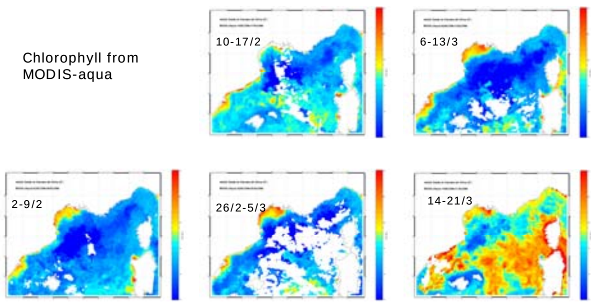
2005-2006

SST and estimations of Latent heat exchanges



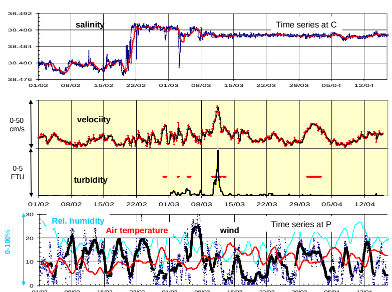
From: *Schroeder et al., 2009*

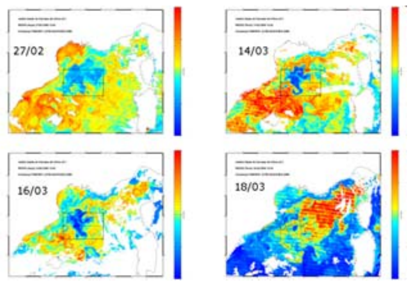
Chlorophyll from MODIS-aqua



Deep convection area in Feb-Mar 2005

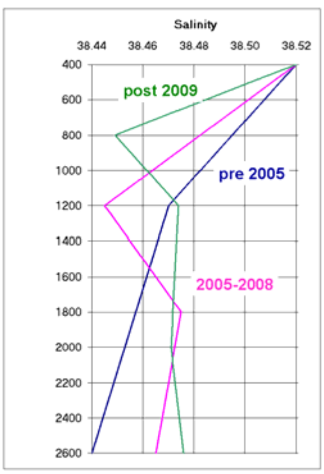
2009





Deep convection area in Feb-Mar 2009

average salinity profiles



Some concluding remarks

Much ado about nothing!

The strong evaporation during the recent important DWF events in the NW Mediterranean (2005 and 2009) involved changes in the vertical structure of salinity at the interior of the western basin. An average salinity increase of 0.003 is equivalent to an additional total water deficit of 7.5 mm. Despite the importance of these two episodes, especially that of winter 2005, the equivalent amount of water removed in terms of water cycle (<1%) is much below the current uncertainty. Moreover, the trends of the inflow at Gibraltar show a salinity increase of ~0.12 (up to 2008) while the salinity of outflow decreased ~0.03. Such a net increase of ~0.09 salinity units of the I/O at Gibraltar could have the same repercussion in the deep layers if it were invested in them.

Therefore, the uncertainties in the water balance have to be severely reduced to less that 5% to be able to catch the impact of episodes such as those presented here and to understand the impact of future changes.

How?

- Direct measurements of evaporation are almost impossible and, in any case, they can not cover the whole basin with a good resolution.
- Direct measurements of precipitation are feasible but they can not cover the whole basin with a good resolution.
- It is possible to improve the indirect estimates of precipitation (radars) but it is more difficult with evaporation.
- It is possible to improve the information of land runoff both increasing the net of water gauges in rivers and estimates of runoff after rain storms
- Information at Gibraltar may be crucial. Outflow data can be easily improved with current meters but to obtain a good coverage for inflow data remains a problem. However, it may be the key to severely reduce the uncertainties of the Mediterranean water cycle.

That's the challenge! Any proposal?