Mediterranean water-mass variability in T-S coordinates
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Mediterranean water-mass variability in $\Theta$-$S$ coordinates
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Motivations

The Mediterranean Sea is a miniature ocean with an overturning circulation but with reduced time and spatial scales.

Two major transient events have driven drastic changes in the thermohaline properties of Mediterranean Bottom Waters:

- In the eastern basin, the Eastern Mediterranean Transient (EMT) resulted in a switch from the Adriatic Sea to the Aegean Sea as the main bottom water formation site in 1991-1992 [1].
- In the western basin, the Western Mediterranean Transition (WMT) resulted in the formation of a new, warmer, saltier bottom water between 200 and 2006 [2].

These water-mass anomalies spread across the basin in a few years allowing to investigate the impact of such changes on the Mediterranean Overturning Circulation.

Data and Methods

We use 33 years of output from the regional circulation model NEMO-MED12 model. The model has a horizontal resolution of $\frac{1}{6}$ (~7km) and 75 vertical levels.

Boundary conditions:
- Exchanges with the Atlantic: Buffon zone from the 2005 World Ocean Atlas for $\Theta$ and $S$.
- Surface: daily evaporation, precipitation, radiative and turbulent heat fluxes, and momentum fluxes from the ARPEGE data set.
- River runoff and exchanges with the Black Sea included as surface freshwater forcing.

We investigate the contribution from air-sea fluxes and mixing (all mixing processes altogether) to water-mass transformation and variability in the Mediterranean Sea by projecting the model’s output in a water-mass framework.

$\Theta$-$S$ framework: Cross-haline and cross-thermal fluxes (see [4] for example):

\[ \begin{align*} 
G_\Theta &= \frac{\partial \Theta}{\partial t} + \nabla \cdot \mathbf{u} + \nabla \cdot \mathbf{Q} - \frac{1}{c} \frac{\partial \Theta}{\partial S} + \frac{F_{\text{air}}}{\rho} \\
G_S &= \frac{\partial S}{\partial t} + \nabla \cdot \mathbf{u} + \nabla \cdot \mathbf{Q} - \frac{1}{c} \frac{\partial S}{\partial \Theta} \end{align*} \]

Cross-haline and cross-thermal fluxes from the water-mass transformation vector $J$:

\[ J = \frac{\partial \Theta}{\partial t} + \nabla \cdot \mathbf{u} + \nabla \cdot \mathbf{Q} - \frac{1}{c} \frac{\partial \Theta}{\partial \Theta} + \frac{F_{\text{air}}}{\rho} \]

\[ J = \frac{\partial \Theta}{\partial t} + \nabla \cdot \mathbf{u} + \nabla \cdot \mathbf{Q} - \frac{1}{c} \frac{\partial \Theta}{\partial S} + \frac{F_{\text{air}}}{\rho} \]

Take Home message

- $\Theta$-$S$ framework allows to track the water-mass transformation between inflow and outflow at Gibraltar.
- Mixing (isopycnal and diazonal) plays a dominant role.
- Sicily and Messina Straits seem to play a pivotal role where diazonal mixing occurs.
- Bottom waters span a small $\Theta$ – $S$ range.

Perspectives

- Investigate changes in water-mass transformation vectors for different time periods (pre/post EMT and WMT).
- Focus on deep water cells.
- What are the dominant mixing processes involved?

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References


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