Atmospheric forcing for dense shelf water cascading in the Northwestern Mediterranean

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1. Introduction:

The Gulf of Lion (**GoL**) in the **Northwestern Mediterranean** is known for its **dense shelf water cascading** (**DSWC**), influenced by winter oceanic conditions and river discharge. Our study utilizes **reanalysis** data to examine past cascading events and their correlation with **winter air-sea fluxes**. These fluxes increase shelf density, driving rapid sinking to the deep sea (Fig 1) at speeds exceeding 1m/s, facilitating substantial particle transport.

2. The cooling process

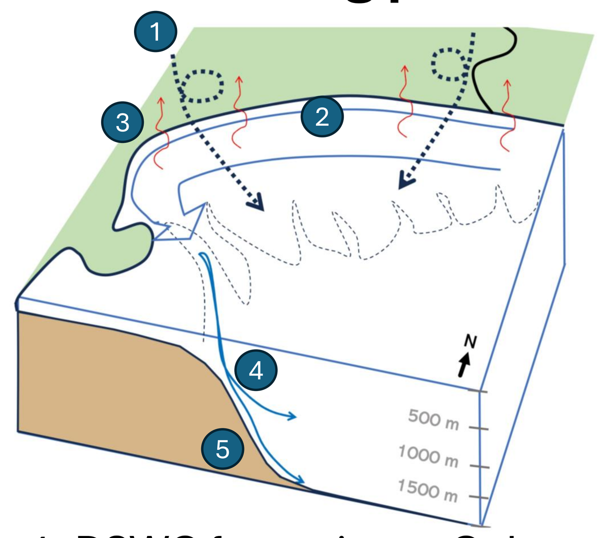


Fig 1: DSWC formation at GoL

1. Dry and cold local winds from the N and NW
2. Cyclonic circulation
3. Buoyancy loss by heat loss
4. Sinking through the canyon until neutrally buoyant
5. Cascade down if denser than intermediate water

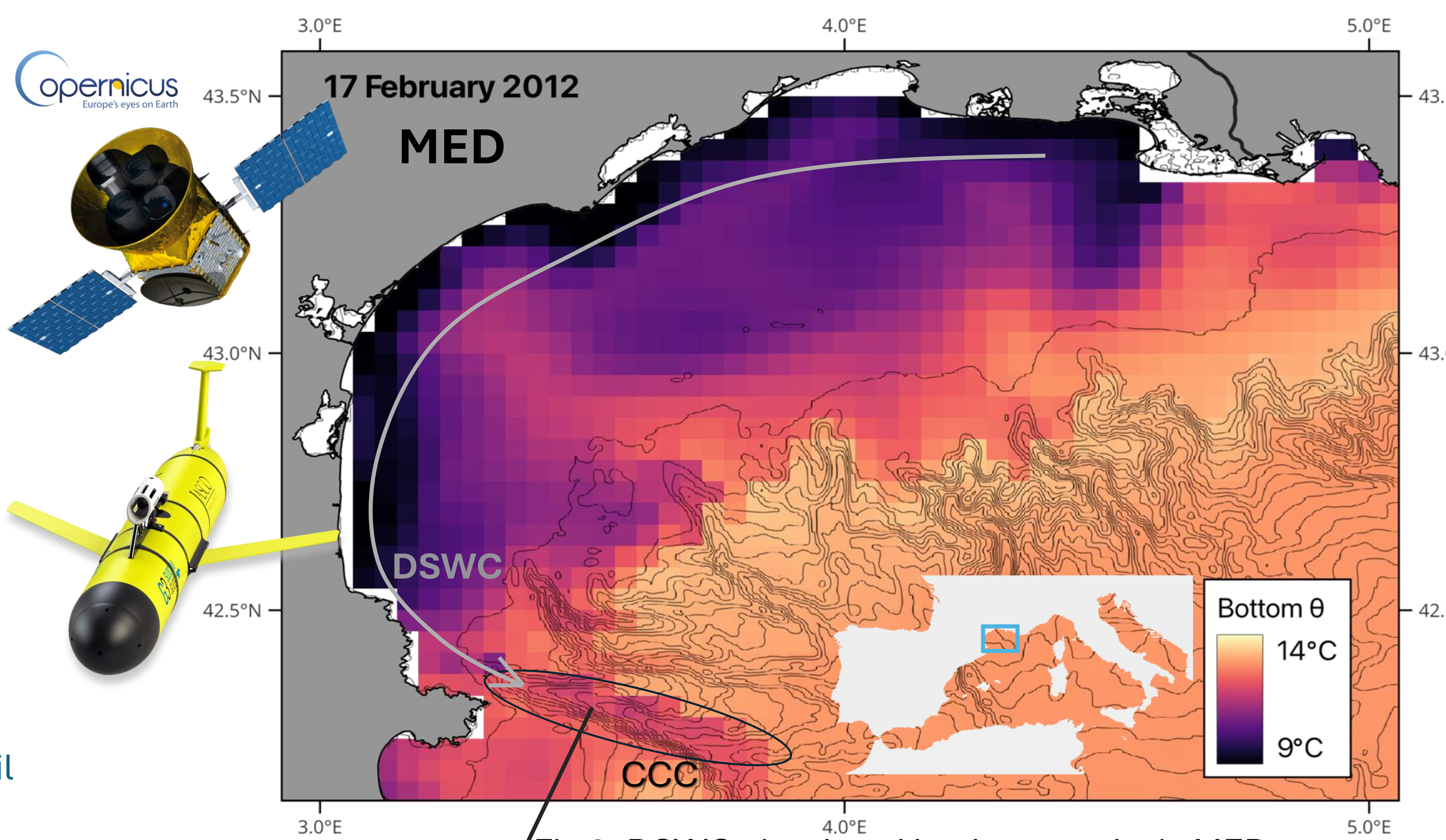


Fig 2. DSWC simulated by the reanalysis MED

3. Reanalysis vs Observations

A reanalysis is a dataset blending historical observations and computer models to reconstruct past weather and climate.

In Fig 2, we see the sea bottom potential temperature (θ) of the Mediterranean Sea Physics Reanalysis[1], hereafter **MED**.

To validate MED results on DSWC, we compare them with observations at the bottom of Cap de Creus Canyon (**CCC**) (Fig 2, 3 and 4ab).

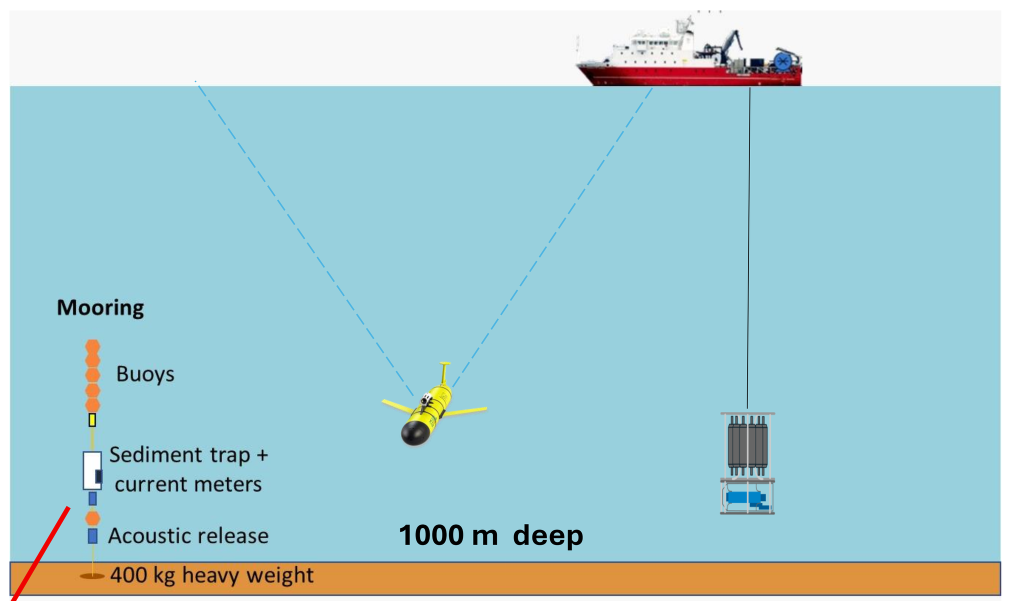


Fig 3. Observational methods of DSWC

Interannual variability of DSWC and winter atmospheric forcing

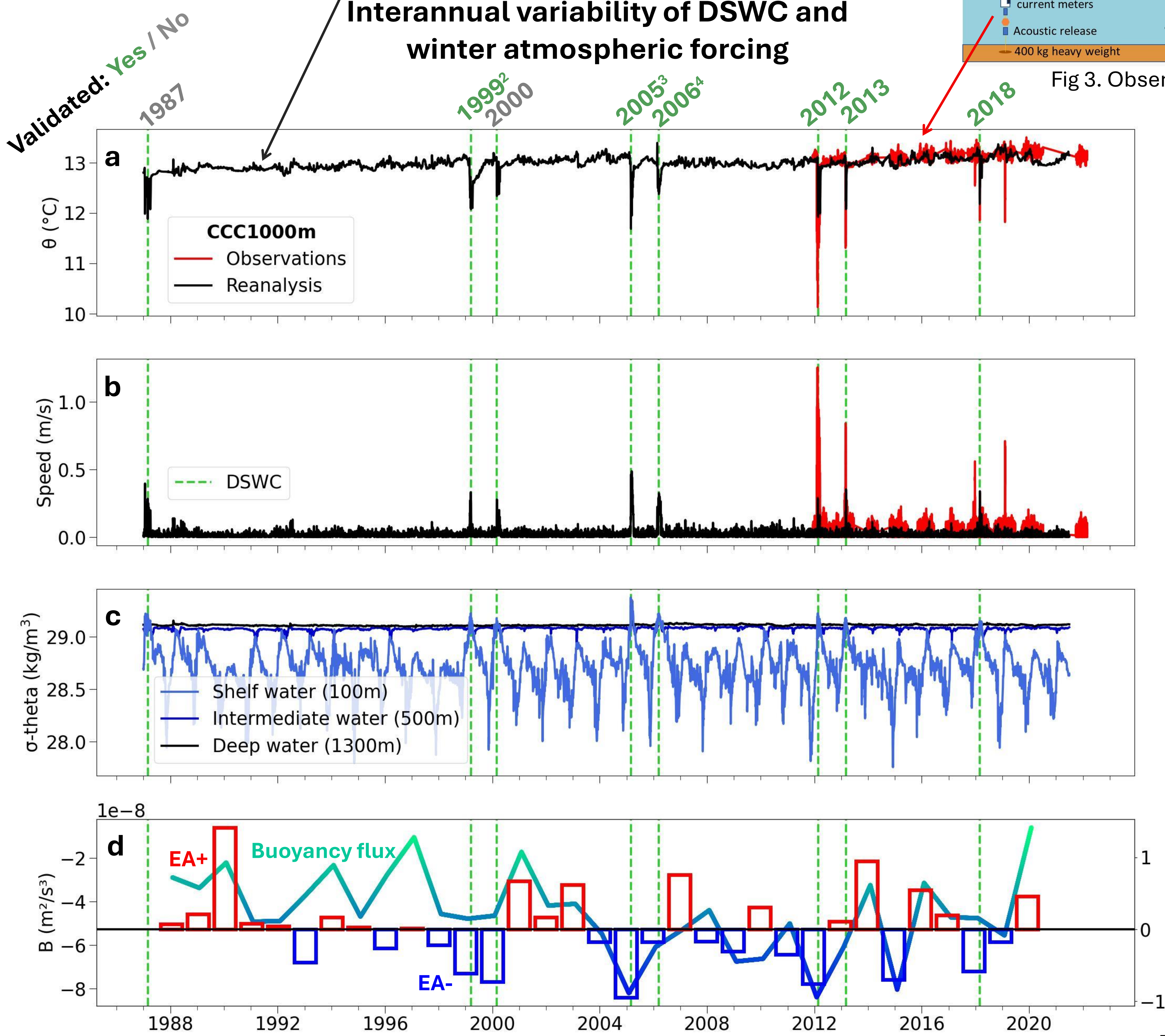


Fig 4. a,b: CCC at 1000m (daily averaged for MED, 20-minute observed by a mooring). c: MED daily density values along CCC. d: winter-averaged atmospheric forcing.

4. Physical hydrographic properties of DSWC

↓ Temperature
↑ Speed
↓ Salinity
↑ Density

5. Validation of the MED reanalysis with observed DSWC at CCC

According to MED, since 1987, DSWC occurred in 1987, 1999, 2000, 2005, 2006, 2012, 2013 and 2018 (Fig 4).

Before 2005, no DSWC observations were made at CCC and thus MED cannot strictly be validated in that canyon at that period.

In 1999, DSWC was reported at the Lacaze-Duthiers Canyon[2], next to CCC.

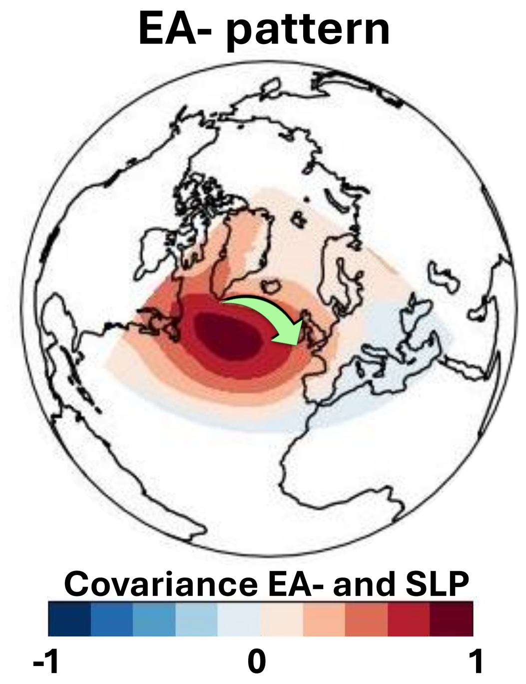
6. Validation of the atmospheric forcing

The density of MED (Fig 4c) is influenced by the ERA5[5] reanalysis. Fig 4.d. shows the buoyancy flux (B) between the surface at the GoL shelf (Fig 2) of MED and the air surface of ERA5.

B < 0 → ↑ Shelf density

Past studies[6,7] noted higher heat loss due to the East Atlantic (EA) pattern. We found a strong **correlation** (**0.57**) between **B** and the **EA** index from ERA5 sea level pressure (SLP).

EA- pattern



East Atlantic (EA-)

- Colder air from N
- Stronger winds from N
- Stronger heat loss
- Denser shelf water

7. Surface to depth: final conclusions

Atmospheric forcing impact (ERA5)
Stronger ERA5 forcing densifies MED shelf water

Denser shelf water (MED)
Dense MED shelf water triggers cascading events

Reanalysis Insights

Validated with the observations

Previous non-observed events have been found → Complete overview of the climate variability of DSWC since 1987

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Acknowledgments

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