Mediterranean sea-surface and deep responses to large-scale atmospheric forcing in *evaluation* Med-Cordex simulations

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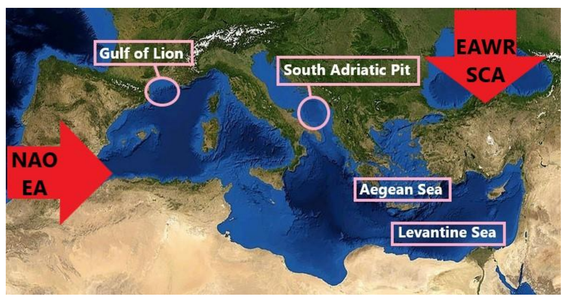
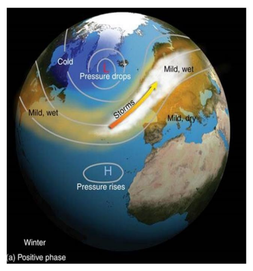
Research area



Why the Mediterranean Sea?

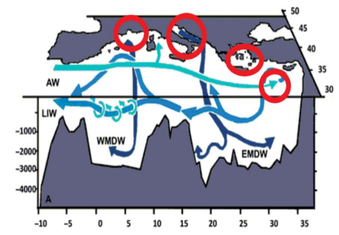
- Laboratory basin for general atmospheric and ocean studies
- Ocean in miniature due to the presence of deep-water formation processes that trigger the thermohaline circulation
- Climate and hydroclimate variability is affected by Euro-Atlantic climate modes

Objective



Euro-Atlantic climate modes (NAO, EA, EAWR, SCA)

Atmospheric forcing:
- **Freshwater fluxes**
- **Heat fluxes**

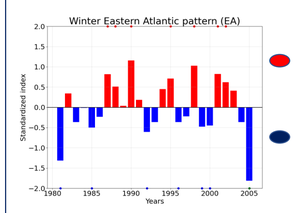


Thermohaline properties (temperature, salinity and density) at sea surface and at deeper layers

Extension of the work of *Cusinato et al., 2018* with a multi-model ensemble of ***evaluation*** simulations of the Med-Cordex initiative.
Evaluation simulations are forced at their boundary by ERA-Interim reanalysis, here are needed to validate the models and to give a representation of the Mediterranean oceanic processes as near as possible as the reality

1. How does the deep-water formation changes in response to the Euro-Atlantic climate modes?
2. From where the uncertainties among simulations come?

Method: Composite Analysis

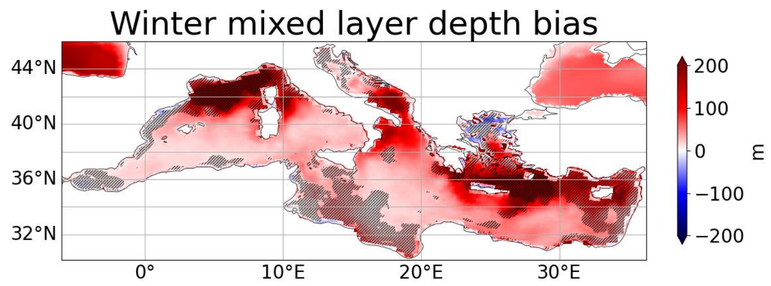


- Positive anomalous years (above 75th percentile)
- Negative anomalous years (below 25th percentile)

(Average positive data values) – (Average negative data values)

Model	Characteristics	Forcing at the boundary
COSMO-NEMO-MFS (CMCC, Italy)	COSMO-CLM=atmosphere, 11km; NEMO-MFS=ocean,5-7km,71 vertical levels	ERA-Interim
CNRM-RCSM4 (CNRM, France)	ALADIN52=atmosphere, 50km; NEMOMED8=ocean,9-12km,43 vertical levels	ERA-Interim
ROM (AWI, Germany)	REMO=atmosphere; MPIOM=ocean,10-18km, 40 levels	ERA-Interim
ENEAMITgcm12 (ENEA, Italy)	MIT=ocean, 6km; 75 vertical levels	Alderav1
INSTMED (INSTM, France)	INSTMED06=25km; 40 vertical levels	Arpera2 & Lmdera

Model validation: Multi-model ensemble mean – Copernicus (1988-2005)

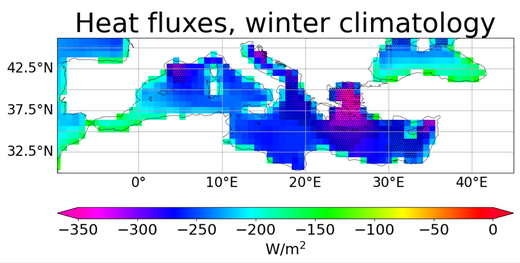


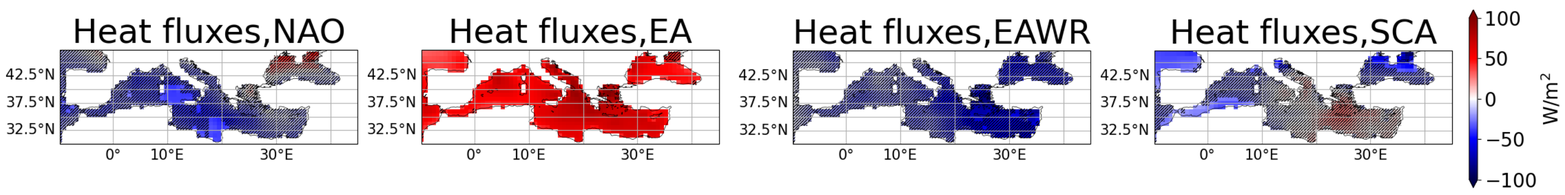
Model simulations overestimate deep-water formation processes

Bias of mixed layer depth	Ocean stand-alone model simulations	Coupled model simulations
South Adriatic Pit	+189m	+71m
Aegean Sea	+242m	+33m
Levantine Sea	+93m	+37m
Gulf of Lion	+386m	+58m

Coupled model simulations better represent the ocean processes in the Mediterranean Sea

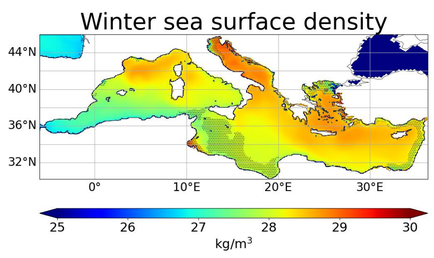
Results 1: Regional atmospheric forcing (1981-2005)

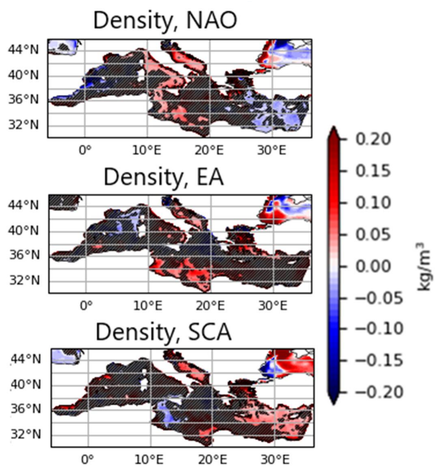




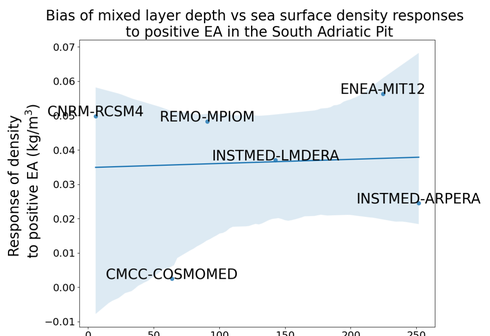
EA is the dominant mode in controlling **winter heat fluxes** in the Mediterranean Sea

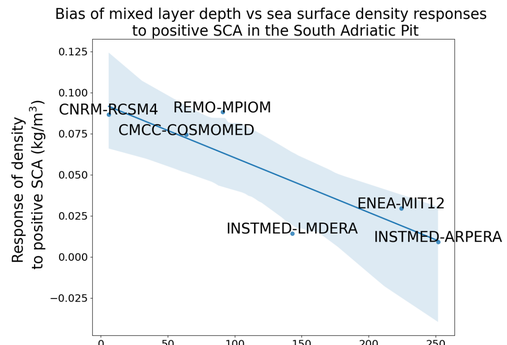
Results 2: Ocean surface response, multi-model ensemble mean, 1981-2005





NAO, EA and SCA contribute to **increase deep-water formation** processes in the Adriatic Sea

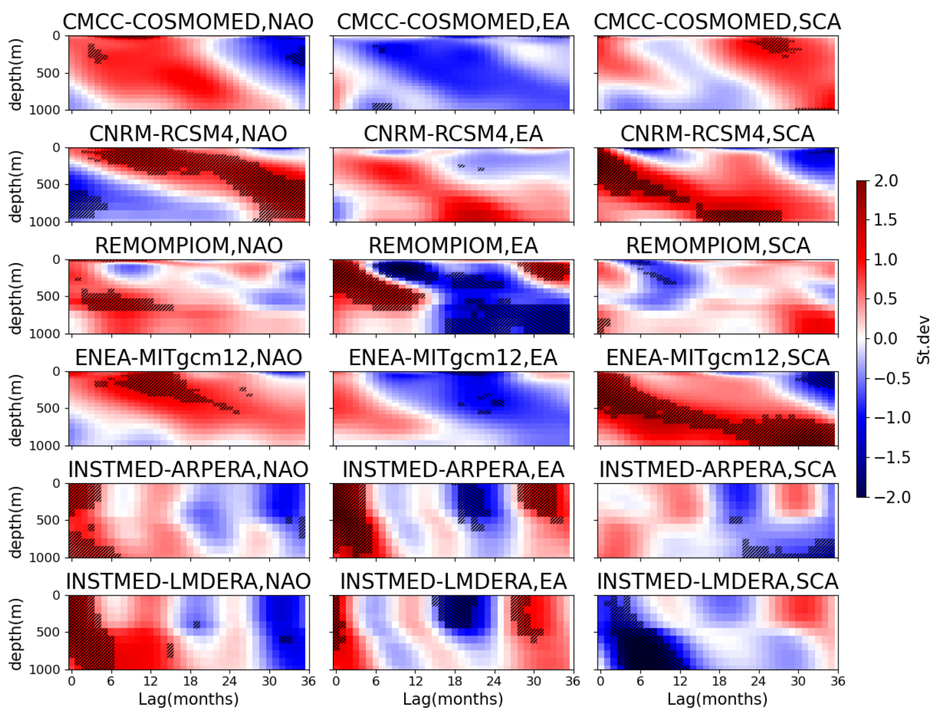




- **Bias** does **not affect** the response to **EA**
- Simulations are sparse

- **Bias affects** the response **to SCA**
- Simulations are clustered

Results 3: Deep ocean response, individual simulations, 1981-2005



Note: Standardized data over depth

Conclusions

- **Bias** of mixed layer depth **could affect the response** of the density to the climate modes whose different forcing mechanism have to be also considered
- **Deep ocean responses** could represent more **local process** rather than impacts of the climate modes
- Are ***evaluation*** simulations **reliable**?

References

Cusinato et al., 2019: Mediterranean thermohaline response to large-scale winter atmospheric forcing in a high-resolution ocean model simulation. In *Meteorology and Climatology of the Mediterranean and Black Seas*

Josey et al., 2011: Impacts of atmospheric modes of variability on Mediterranean Sea surface heat exchange. In *Journal of Geophysical Research: Oceans*

Scan to abstract of the project