Two-way nesting high-resolution model of the Gibraltar Strait

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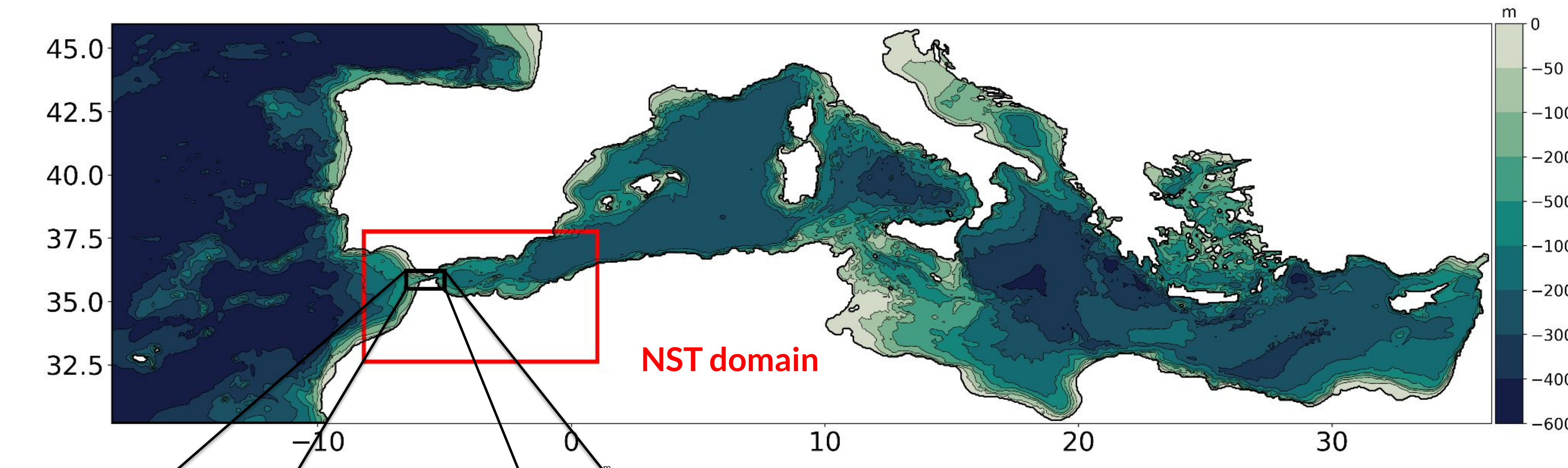

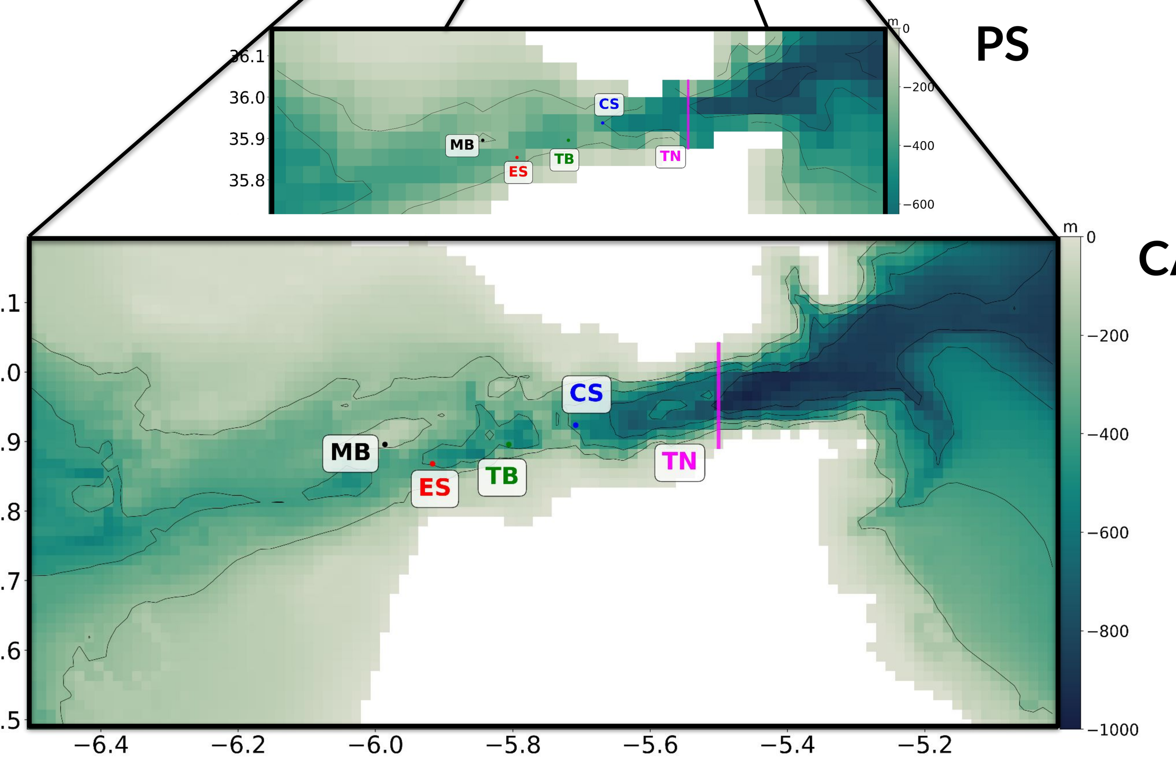

Motivation

PS and NST (PA+**CA**) experiments have been run in order to:

- Improve model representation of small scale processes in Gibraltar
- Understand the effect of the embedded zoom
  - in the Gibraltar exchanges
  - in the overall Mediterranean circulation

Locations
MB Majuan Bank
ES Espartel Sill
TB Tangier Basin
CS Camarinal Sill
TN Tarifa Narrows (5.5°W)

Experiments	**Parent Standalone (PS)**	**Nested Experiment (NST)**	
Models	*PS*	*Parent AGRIF (PA)*	*Child AGRIF (CA)*
Horizontal resolution	1/24° (150 arcsec, ~3.77 km)		1/72° (50 arcsec, ~1.25 km)
Domain area	30.19°N – 45.98°N, 18.13°W – 36.29°E		32.62°N – 37.76°N, 8.18°W – 1.03°W
Vertical levels	141, z* coordinates + bottom partial steps		
Timestep	240 s		80 s
Period	May 1, 2000 - April 30, 2001		
Initial Conditions (T, S)	from previous MedFS reanalysis		
Tracer Advection Scheme	MUSCL		FCT
Momentum Advection Scheme	vector form, second order, centered		flux form, UBS
Vertical Mixing Closure Scheme	GLS		
Bottom Friction Regional Boost	32.62°N – 37.72°N, 7.24°W – 4.93°W (boost factor = 25)	no	32.62°N – 37.72°N, 7.24°W – 4.93°W (boost factor = 25)
Atmospheric Forcing Bulk Formulae	ECMWF		

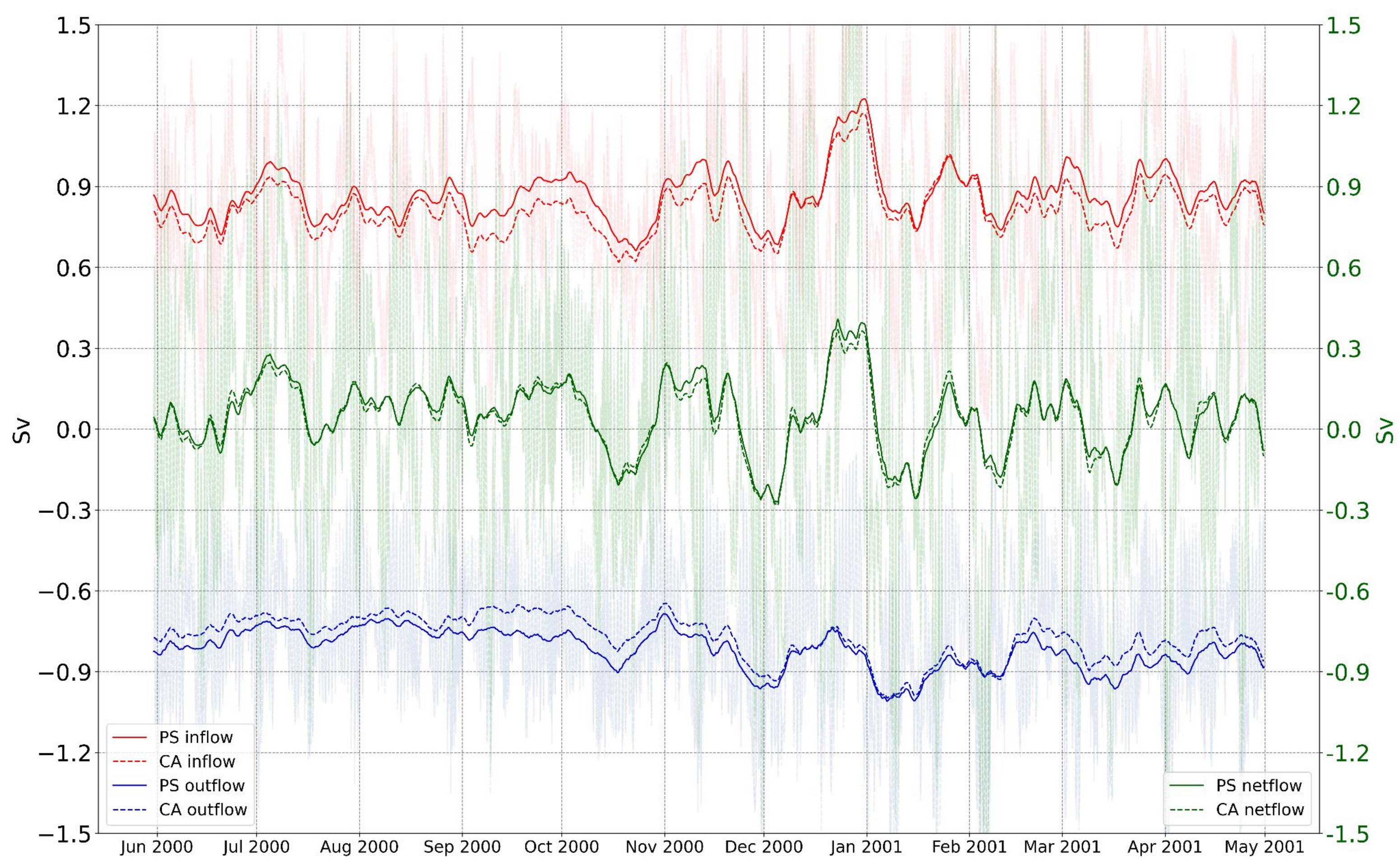

Figure 1. Transport estimates at TN

Key improvements

- NST model greatly improves the transport estimates, which are more aligned with recent observations in the same decade
- The higher-resolution bathymetry allows a better representation of the Mediterranean outflow. In general the characteristics of the water exchanges are different with the refined grid centered in Gibraltar, as expected in a region where changes in the topography can strongly affects the flow.

Results and comparison with observation study	Transports and standard deviation [Sv]		
	Inflow	Netflow	Outflow
PS: TN	0.87 ± 0.10	0.051 ± 0.131	-0.82 ± 0.09
CA: TN	0.82 ± 0.10	0.044 ± 0.128	-0.77 ± 0.08
Soto-Navarro et al. (2010) ES, 2004-2009	0.81± 0.06	0.038 ± 0.007	-0.78 ± 0.05

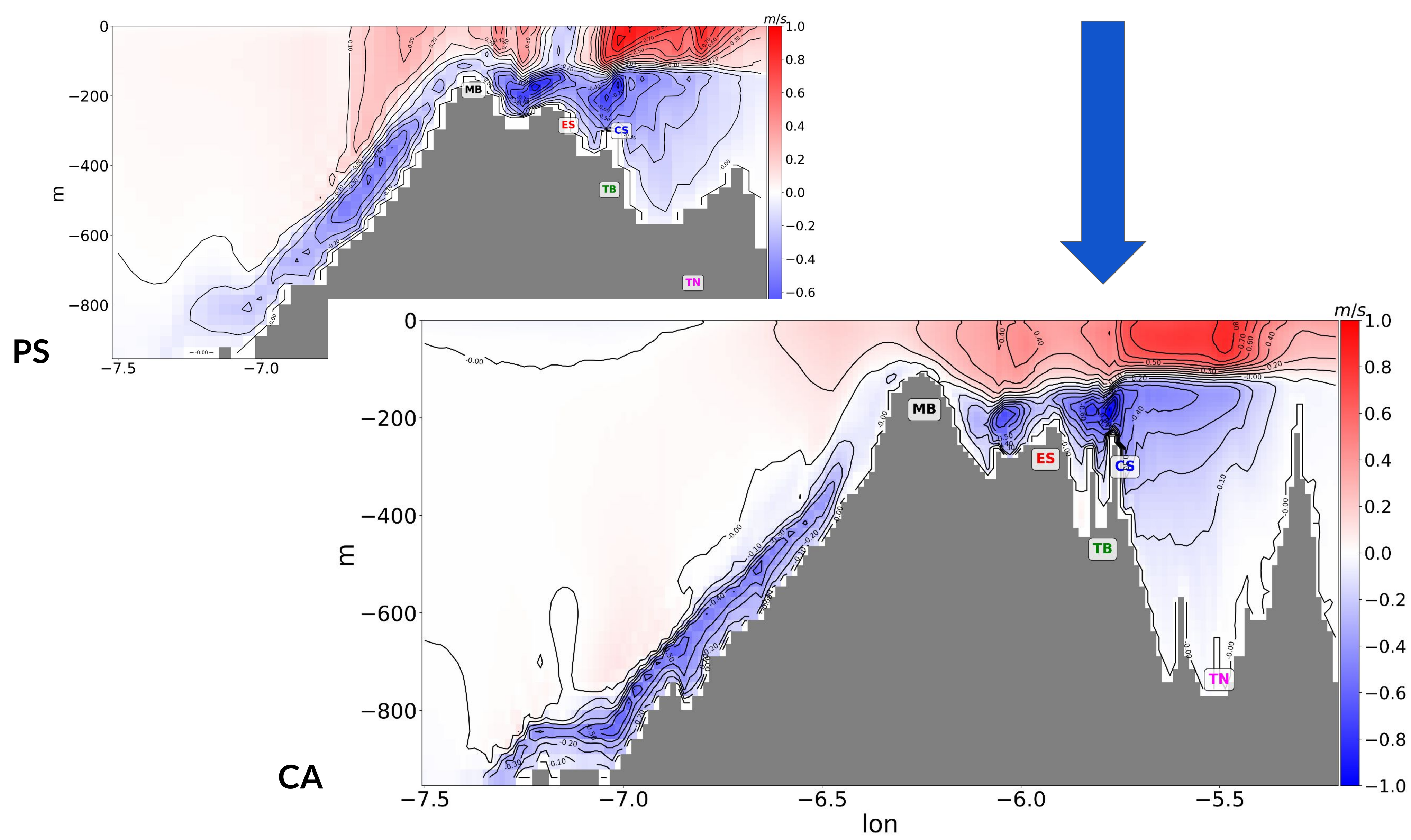

FIgure 2. Annual average zonal velocity at 35.94°N

Materials

NEMO 4.2.2

Nucleus for European Modelling of the Ocean is an ocean modeling framework written in Fortran.

The dynamical core uses finite-difference spatial discretization with centred second-order scheme in an Arakawa C grid, leapfrog-scheme time discretization and a forward scheme for diffusion processes.

MedFS EAS9

Mediterranean analysis and Forecasting System is a code base for a nested model in the Atlantic domain running on top of NEMO

AGRIF

Adaptive Grid Refinement in Fortran provides mesh refinement features to structured grid models such as NEMO, including a source code converter and a library. The resulting models (parent + child) run independently. At each parent's timestep the child's lateral open boundary conditions are updated and the child provides weighted averages to the parent. Computational overhead (+64% runtime for our experiments) and artifacts at the boundary are possible drawbacks.

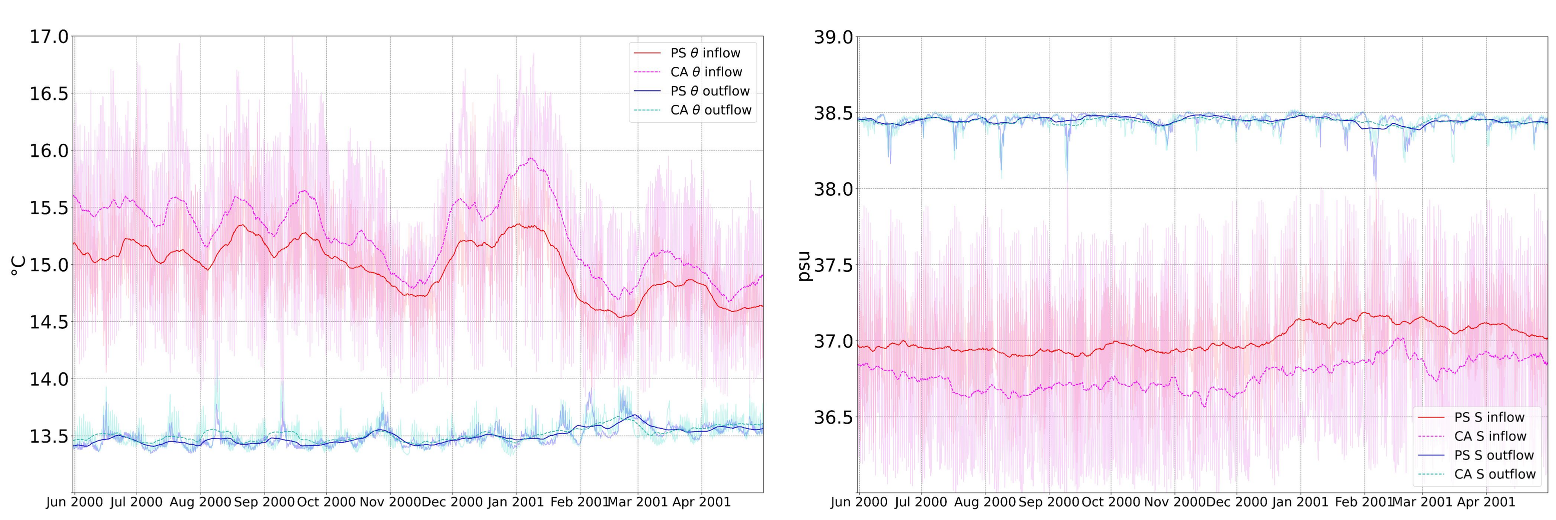

Figure 3. Inflow and outflow temperature (left) and salinity (right) at TN

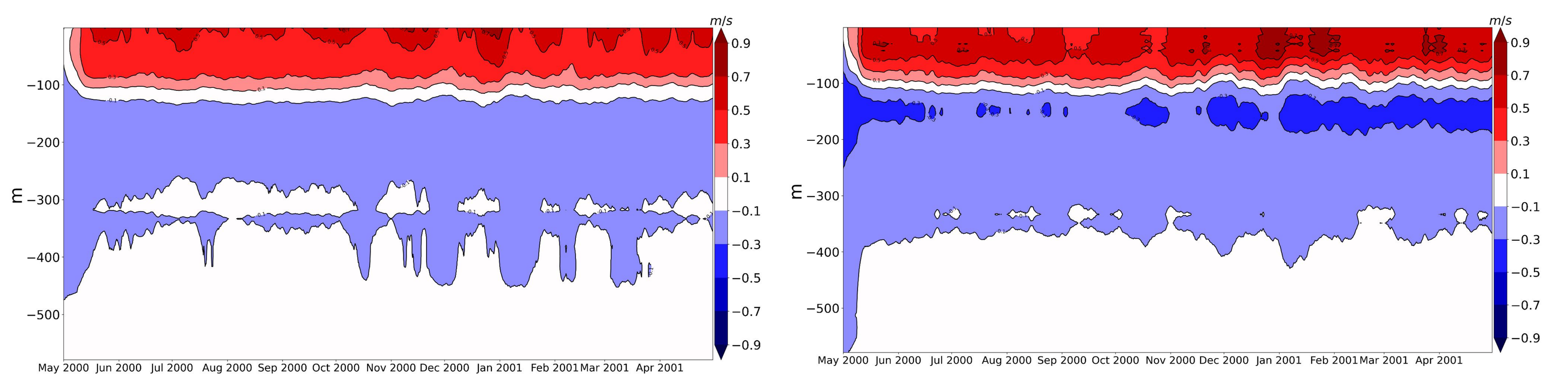

Figure 4. Hovmöller diagrams of the mean zonal velocity vertical profile at TN

Final remarks

- Outflows are significantly less affected than the inflows by the introduction of the nested domain (Figure 3). A longer run is needed to better estimate the effects of the grid refinement on the overall Mediterranean circulation
- Child model exhibits more intense zonal velocity (Figure 4) and better defined average two-layer flow (Figure 2)
- The nested experiment's increased variability in inflow water properties and observed intensification of some structures such as the Alboran Gyres should be further investigated
- Comparing our findings with more detailed observations is essential to validate the improvements