"Drivers and Impacts of CGCM biases in representing the decadal variability of Labrador Sea convection."

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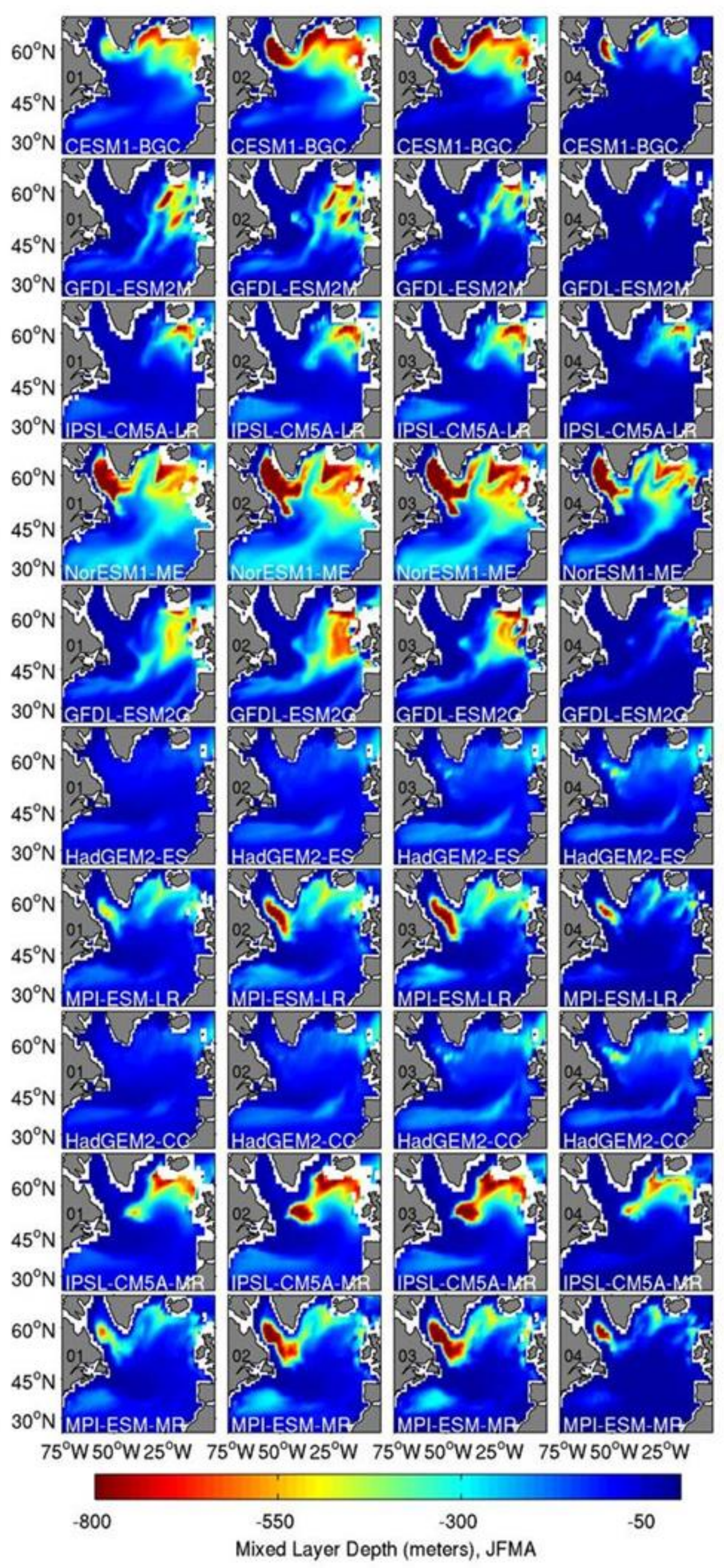
BACKGROUND AND OBJECTIVES

- Climate model historical simulations and future projections indicate weakening of the convective events in the Labrador Sea. These models are not capable yet of reproducing well the statistical properties and spatial and temporal characteristics of convection and hydrography.
- Here we use nested simulations with a regional ocean model to explore possible improvements on the representation of convective events as function of horizontal resolution (from 50 to 1 km), vertical mixing parametrizations and atmospheric and oceanic boundary conditions as extracted from a subset of CMIP5.

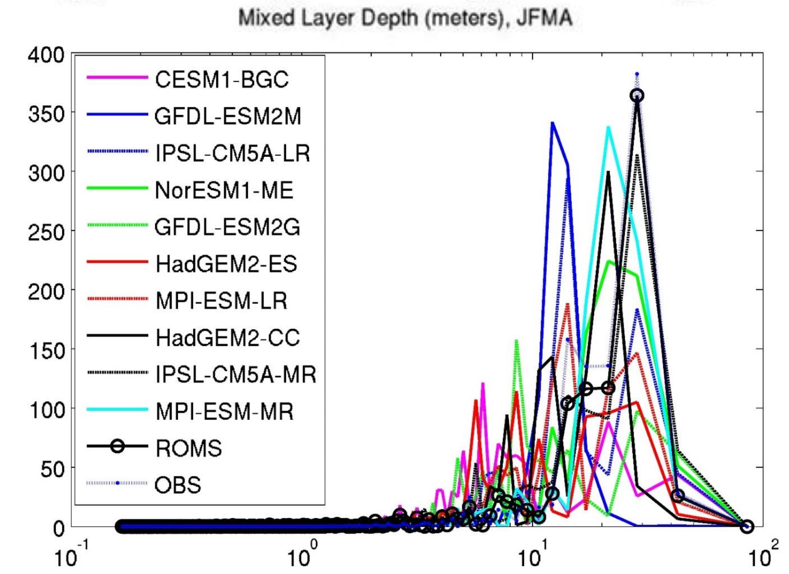
LABRADOR SEA CONVECTION AND VARIABILITY IN THE CMIP5



- Within the CMIP5 archive, LS convection is often misplaced **(Fig 1)**, its strength underestimated and the initiation delayed pointing to biases in the representation of the atmospheric heat fluxes, but also in the ocean mean state which is generally too warm.

[**Figure 1**]: Labrador Sea mixed-layer depth in a suite of CMIP5 models during the convective season (January-February-March-April) and the historical period 1950-2005.

- Another important problem, common to all models is the underestimation of the observed variability at decadal scales as displayed in **(Fig. 2).** This bias intrinsically limits the model skills in multi-decadal runs and future scenarios.

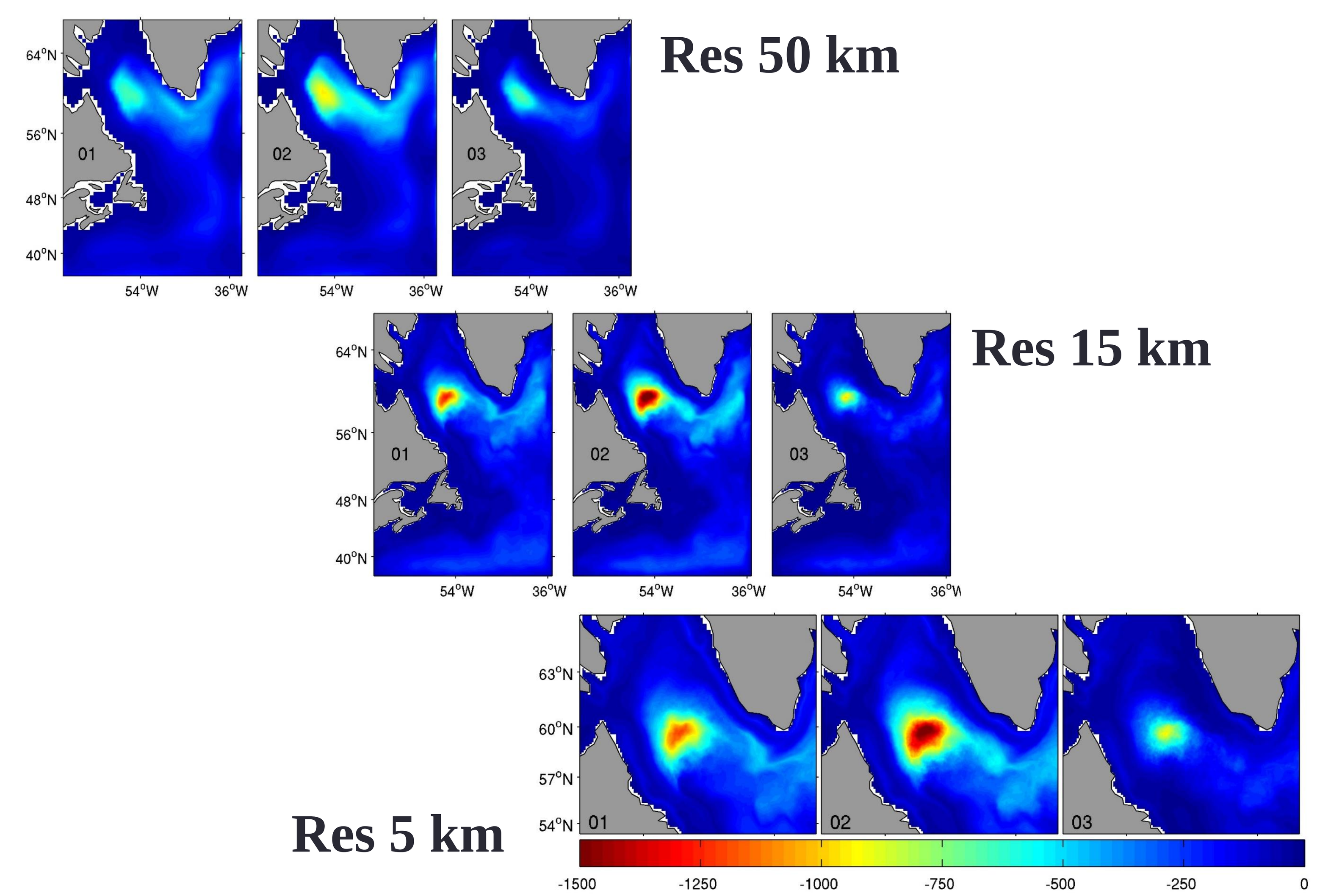


[**Figure 2**]: Power spectra derived from the detrended monthly time-series of potential temperature anomalies over LS convective region averaged between 200 and 2000 m using data over the period 1950-2005.

CONTROL RUN AND THE ROLE OF RESOLUTION

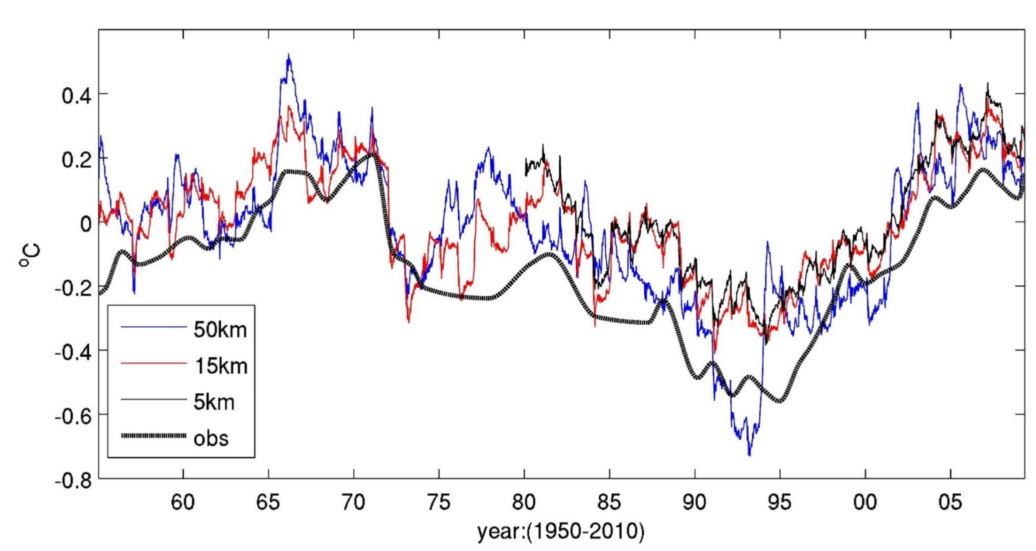
For the resolution investigation, we completed the CONTROL RUN on 50 km, 15 km and a two way nested simulation of 5km resolution (LS) on the 15 km as a parent domain. The model was forced using NCEP reanalysis and SODA2.2.4 as atmospheric and ocean boundary conditions, over the period 1954-2010.

- Convective depth **(Fig. 4)** is underestimated for the 50 km but interannual variability of potential temperature **(Fig. 5)** is realistically represented.



[**Figure 4]:** Labrador Sea mixed-layer depth (meters) for 50 km, 15 km, and 5 km during the convective season (February-March-April) and the period 1980-2010.

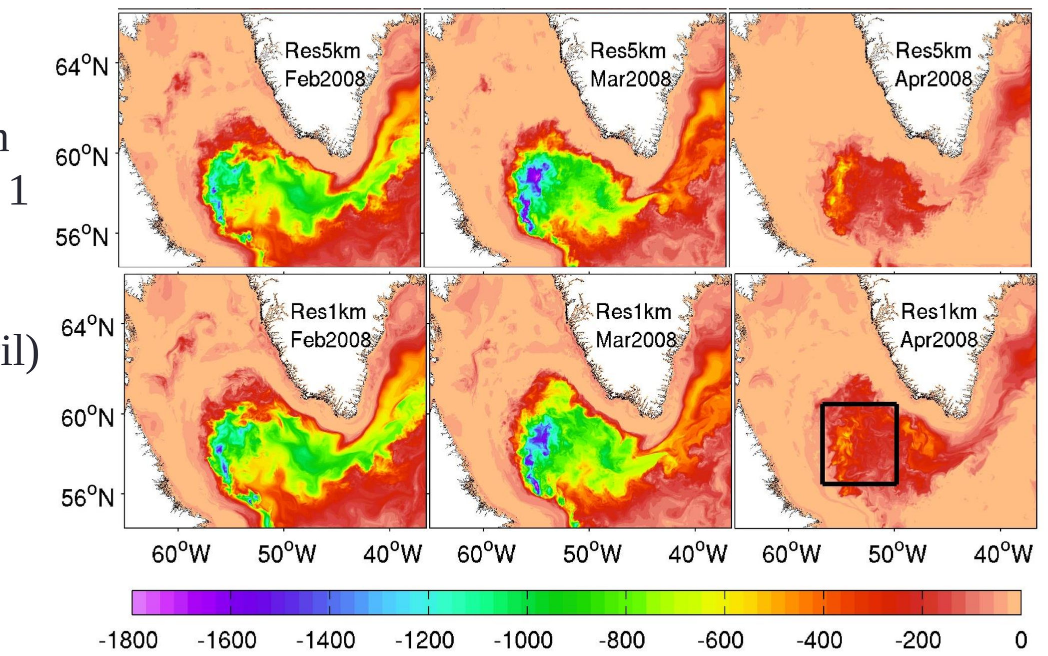
[**Figure 5**] **:** Time-series of potential temperature anomaly in the LS convective region averaged between 200 and 2000m for ROMS and observations (annual dataset compiled by Yashayaev and Greenan, NAFO Report # N5893, 2011).

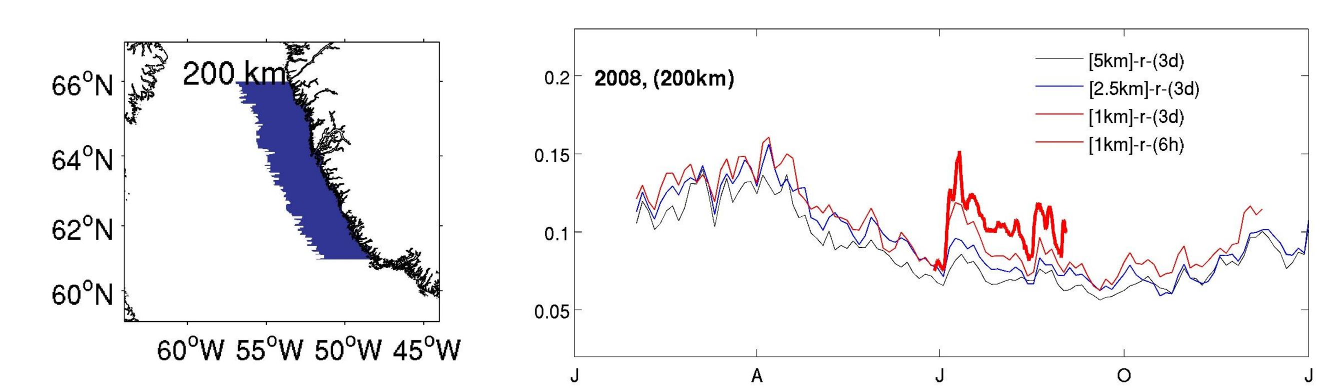


Independent sensitivity runs over the LS domain were implemented for the set of 10, 5, 2.5 and 1 km to investigate their behavior transporting meltwater from the Greenland fjords towards the central LS and possible effects.

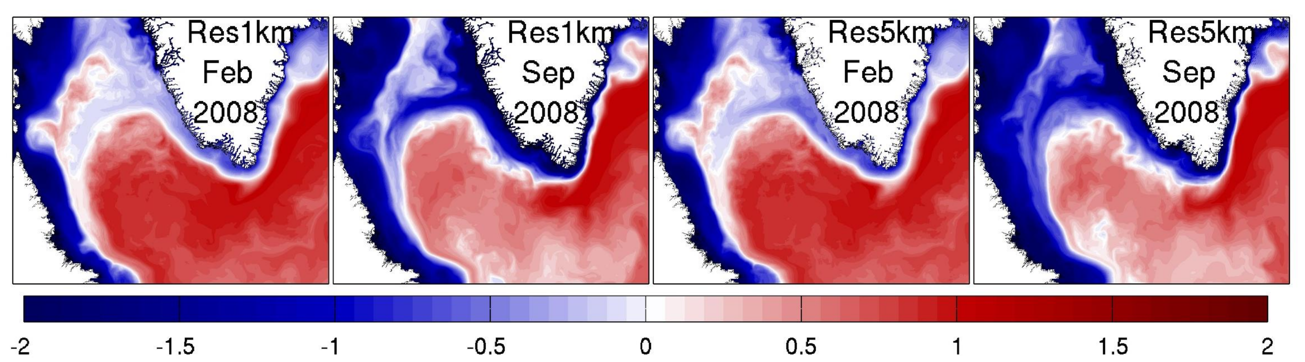
- Not significant changes are observed regarding convective region and depth for resolution higher than 5 km to 1 km **(Fig.6)**.
- Strong seasonal **(Fig.7)** and interannual variability in the submesocale contribution to the surface vorticity budget
  - a clear maximum between mid-June and the end of August
  - low winter sub-mesoscale activity and comparable distribution of near-surface vorticity across resolutions

[**Figure 6]:** Labrador Sea mixed-layer depth (meters) for 5km, and 1 km during the convective season (February-March-April) for the year 2008.





[**Figure 7]** Surface relative vorticity normalized by the Coriolis frequency in the area extending 200 km off-shore from the Greenland coast in 2008 in the 1 km 2.5 km and 5 km horizontal resolution simulation.



[**Figure 8]:** Surface salinity anomaly (SSS-34) in the 1km and 5km horizontal resolution simulation for the months February (left) and September (right).

AIM AND NEXT STEPS

1. **To diagnose the sources of CGCM biases and controls in simulating the Labrador Sea convective variability on a subset of CMIP5 runs**

   Sensitivity runs with CMIP5 atmospheric and oceanic boundary conditions to quantify:
   - the impact of the atmospheric forcing on the ROMS representation of convective activity and its variability.
   - the role played by biases in the oceanic mean state.
2. **To develop theory and metrics to quantify the effect of LS convection on regional ocean carbon uptake and inventory.**

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