Protocol to reconstruct the Atlantic climate of the 20th century

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Can we use surface data for historical climate reconstructions?

GOAL

i) To obtain a reconstruction of the Atlantic Meridional Overturning Circulation (AMOC) from 1900

ii) Use this reconstruction as initial condition for Decadal predictions experiments (DCPPA)

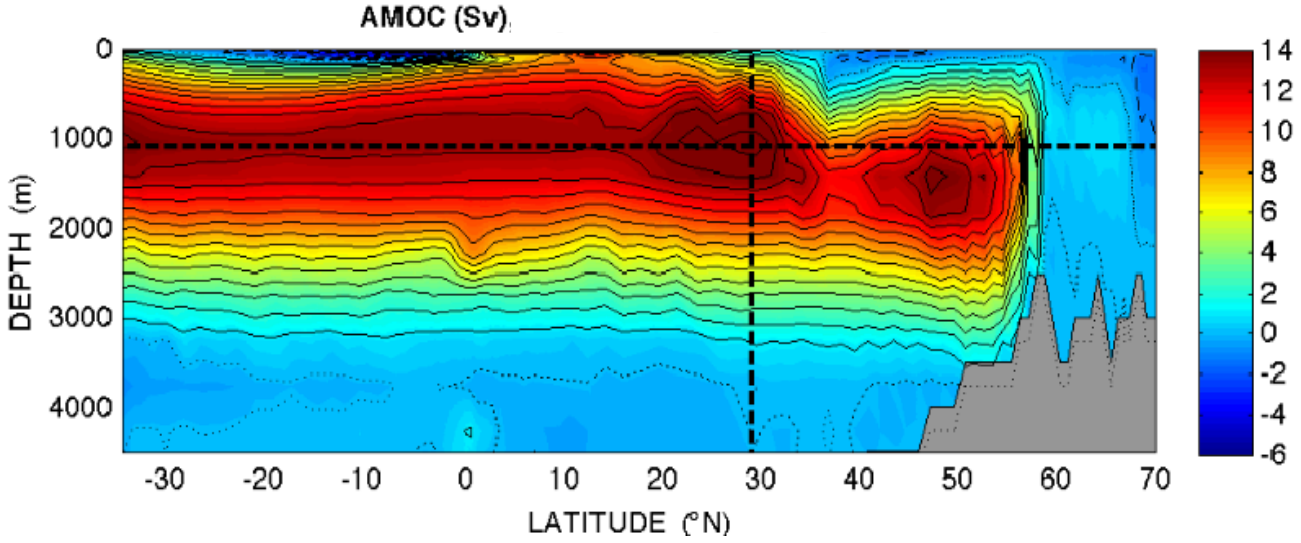
Atlantic Meridional Overturning Circulation (AMOC)

- Key driver of the Atlantic and Global climate in long time scales.
- Primary means of heat & carbon transport from surface to deep ocean.
- Provides a milder weather for western Europe when compared to similar latitudes
- Strong connections with various elements of the climate system: NAO, Arctic, etc.

Increase the skill of the AMOC reconstruction with surface data

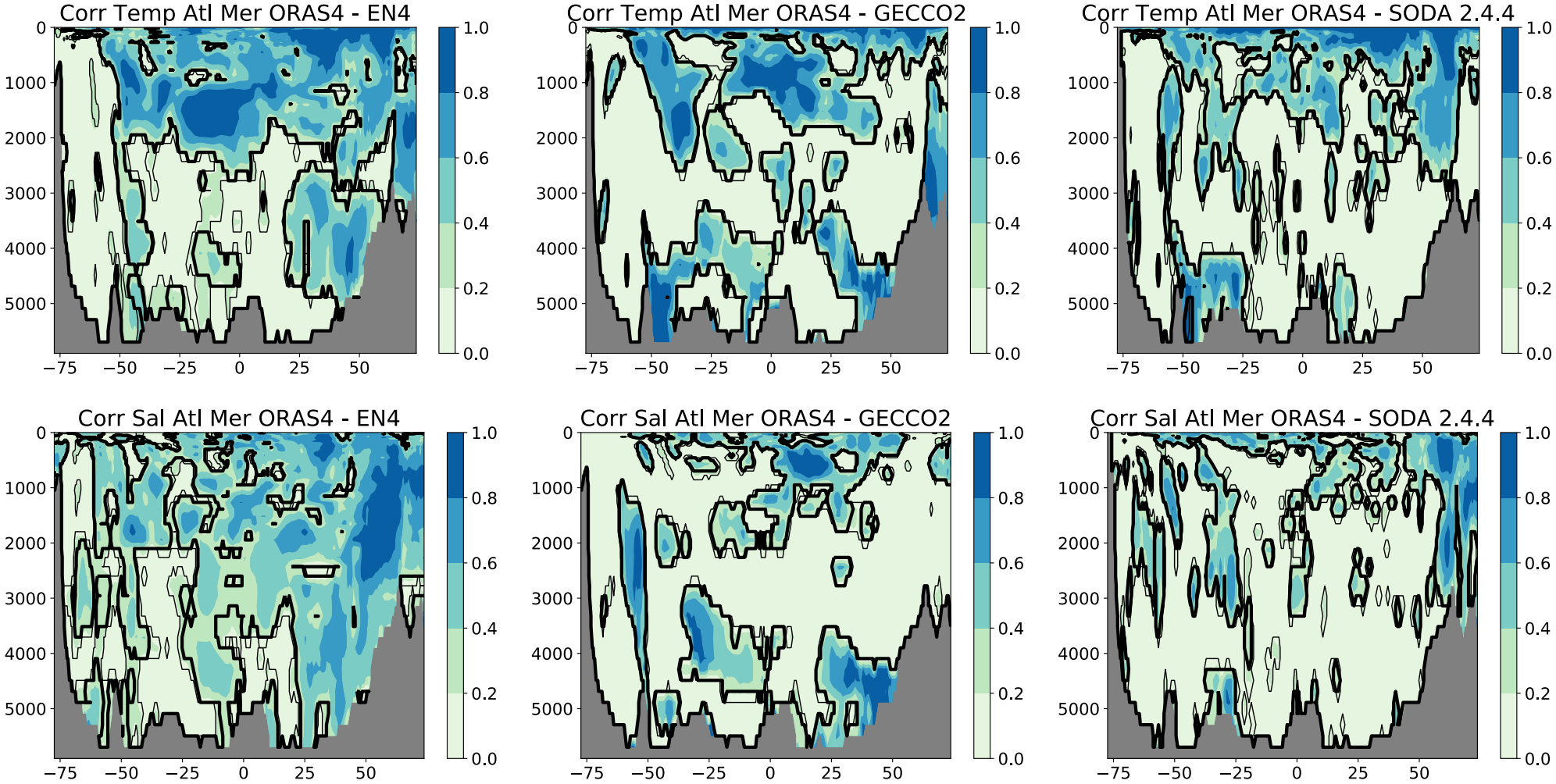
$\Rightarrow$

Improve the Initial Conditions for decadal predictions?



Why Surface data?

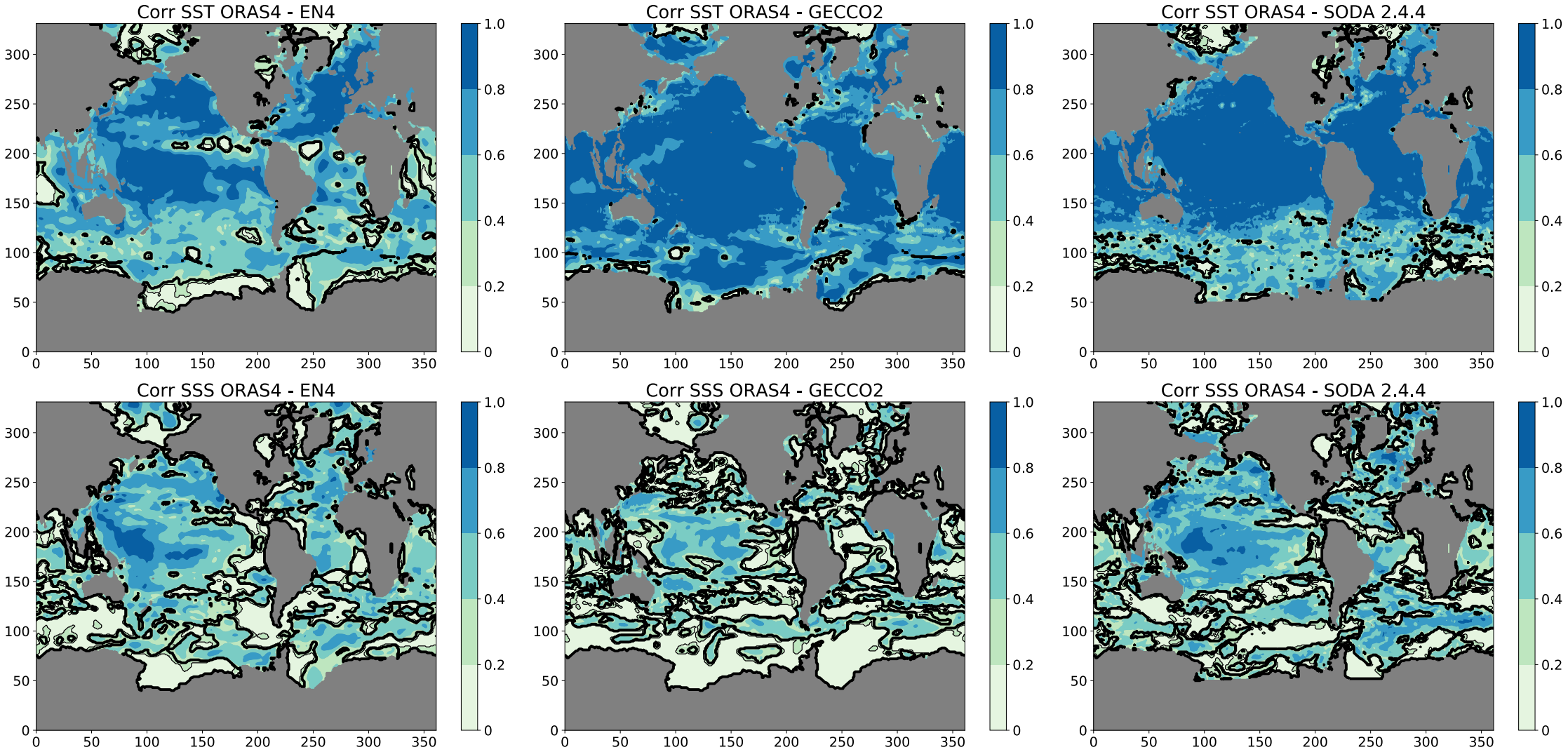
Meridional correlations of Salinity (top) and Temperature (bottom) 1960-2010
ORAS4 vs EN4, GECCO2 and SODA 2.4



- 3D data assimilation don’t agree over the historical period
- There is no long term 3D data
- Introduce a drift in the ocean dynamics

Why Surface data?

Surface correlations of SSS (top) and SST (bottom)
ORAS4 vs EN4, GECCO2 and SODA 2.4
Between 1960 and 2010

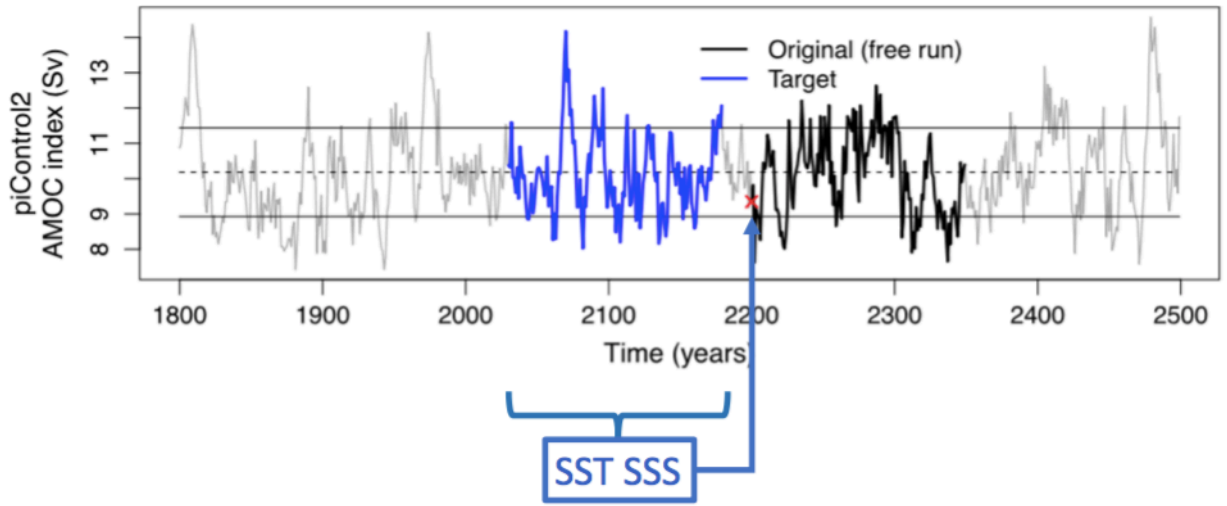


- Don't interfere too much with ocean dynamics
- Longer records with better quality (biases and uncertainties better studied)

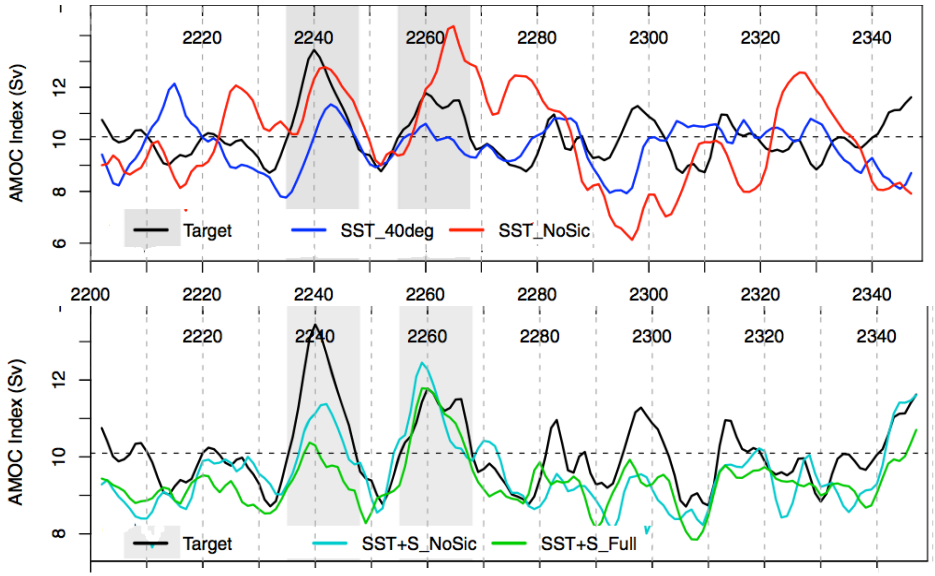
Previous experience on using surface data to reconstruct the AMOC

$$\frac{\partial SST_{model}}{\partial t} = \ldots + \gamma_T (SST_{model} - SST_{target})$$

$$\frac{\partial SSS_{model}}{\partial t} = \ldots + \gamma_S (SSS_{model} - SSS_{target})$$

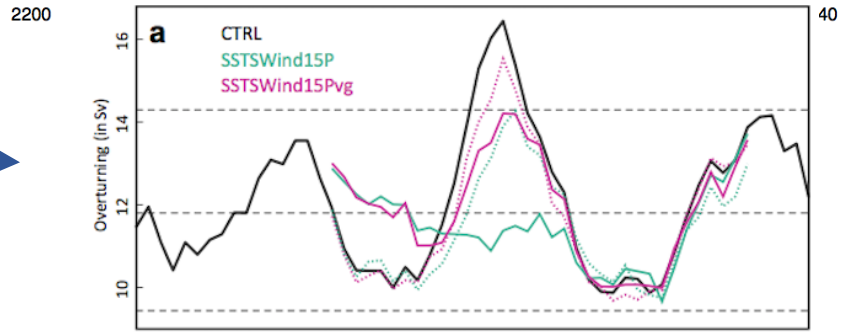


Servonnat et al. 2014



1) We both need SSS and SST to be able to reconstruct the AMOC
2) We need to nudge outside the ice

Ortega et al. 2017



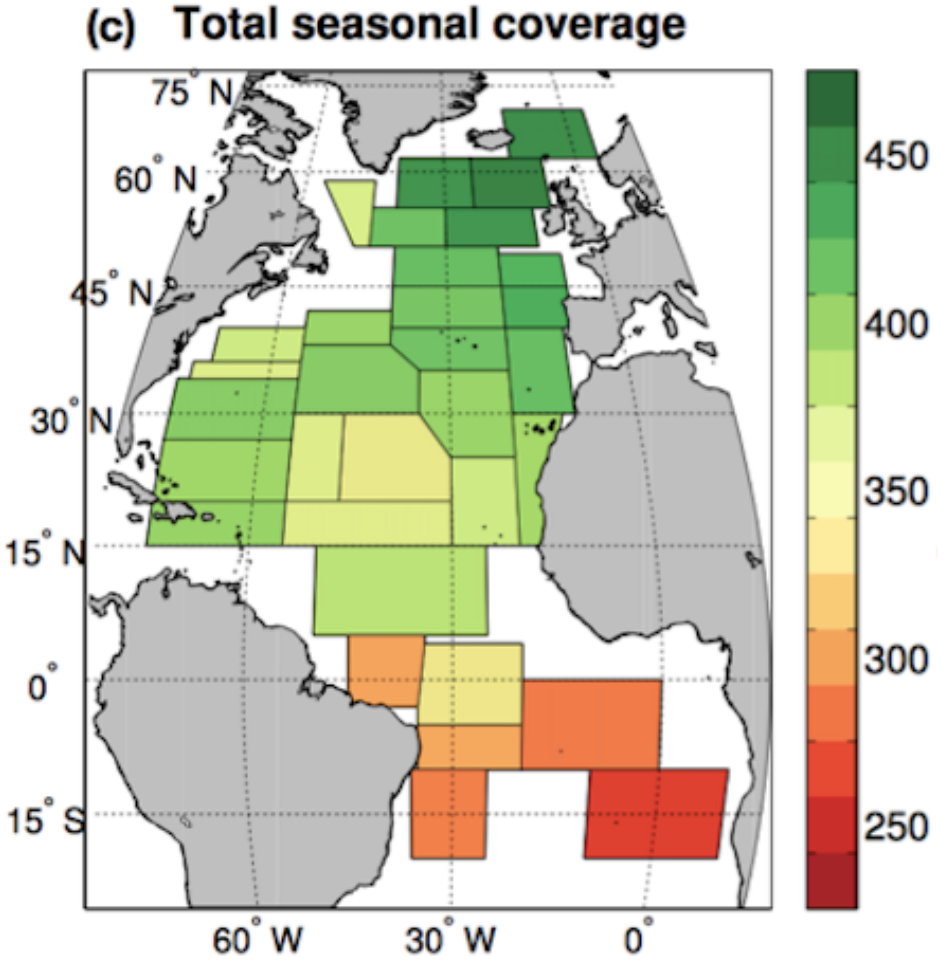
3) Variable with respect to the mixed layer depth
4) Variable gamma, and wind, improve the AMOC reconstruction.

Historical Surface Data

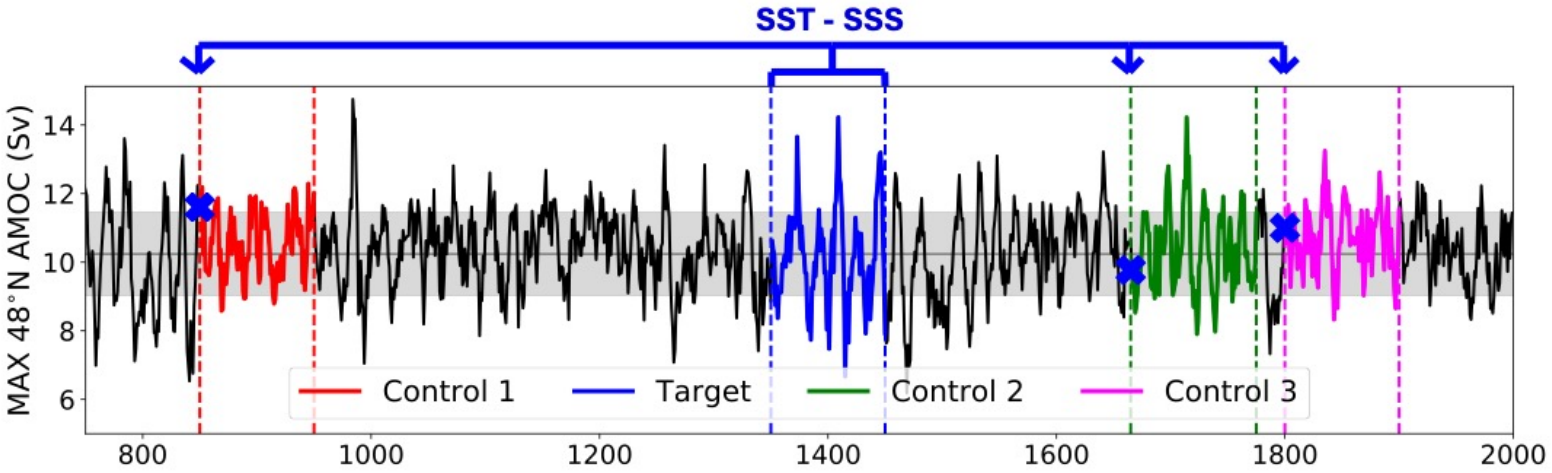
SST - assuming good coverage 👍

SSS - Friedman Data Set (FDS, Friedman et al. 2017)

- Based on data only 👍
- Long 1896–2013 👍
- 32 Boxes on scales between 100-1000 Km 👎
- Anomalous annual means 👎
- Not well sampled: Amazon, North of gulf Stream, or gulf of Guinea. 👎



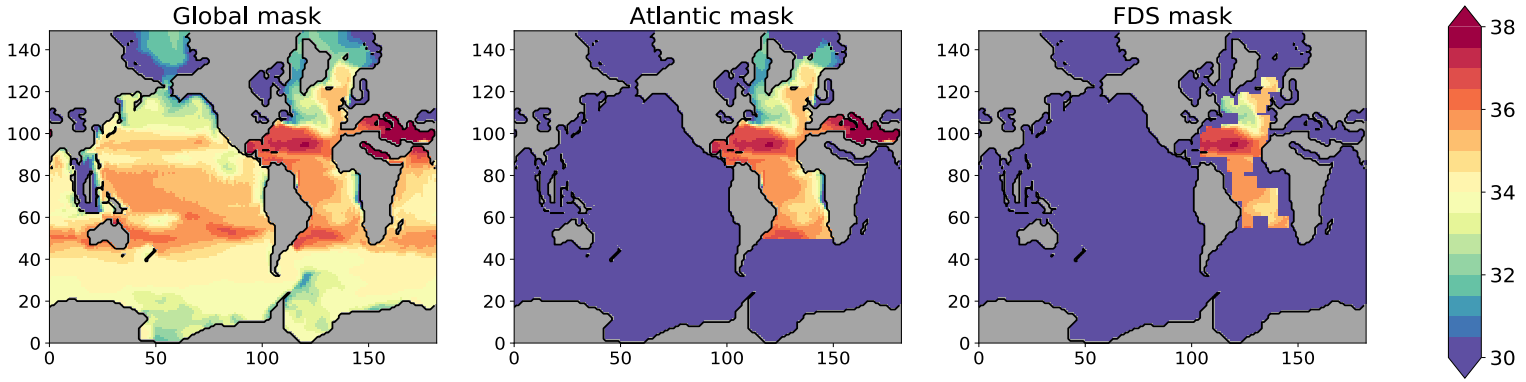
Can we use these data for historical reconstructions? ⇒ Test first in a perfect model framework



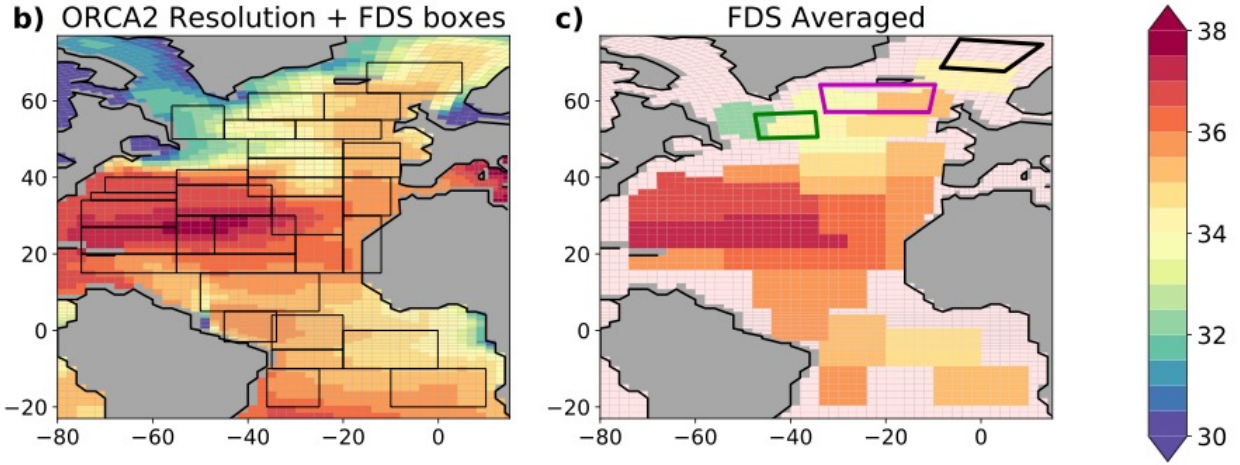
Perfect model framework

2 Main problems to solve

Reduce the SSS nudging region to the FDS mask



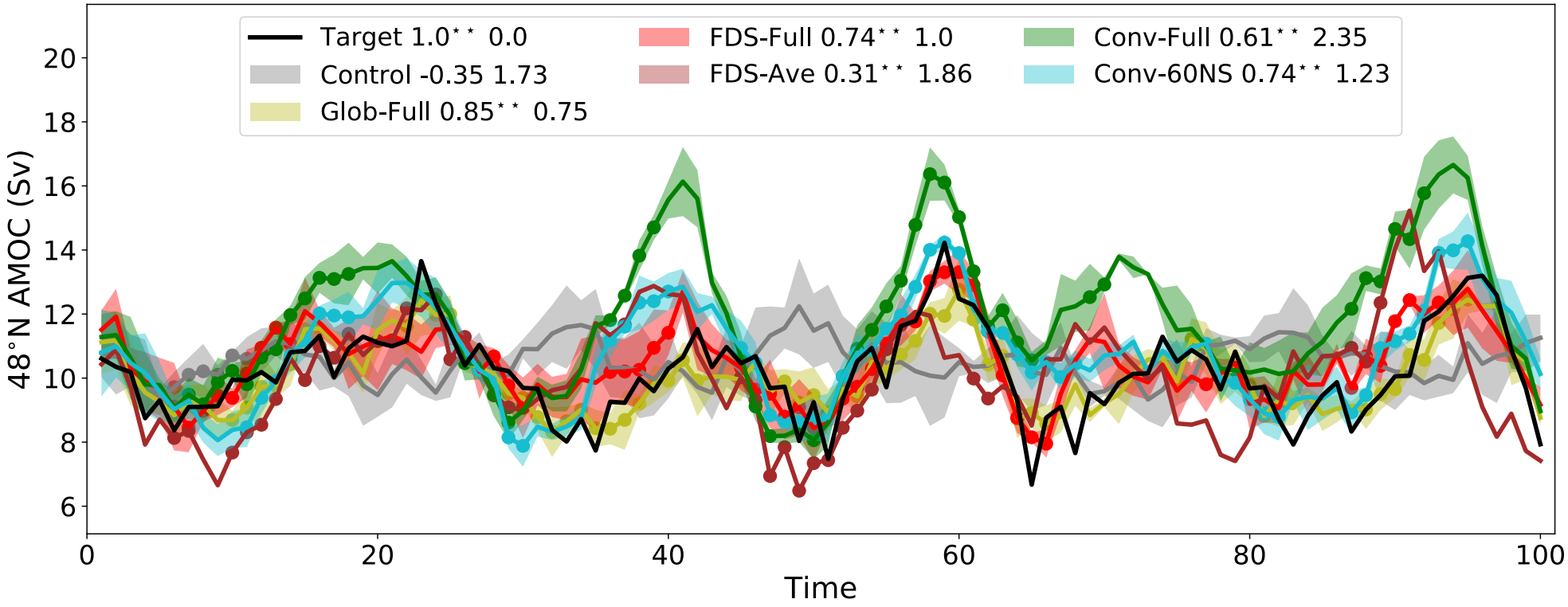
Reduce the SSS resolution to the given by FDS



2 metrics

- Pearson correlation on annual means (R)

- Root Square Mean Error (RSME)



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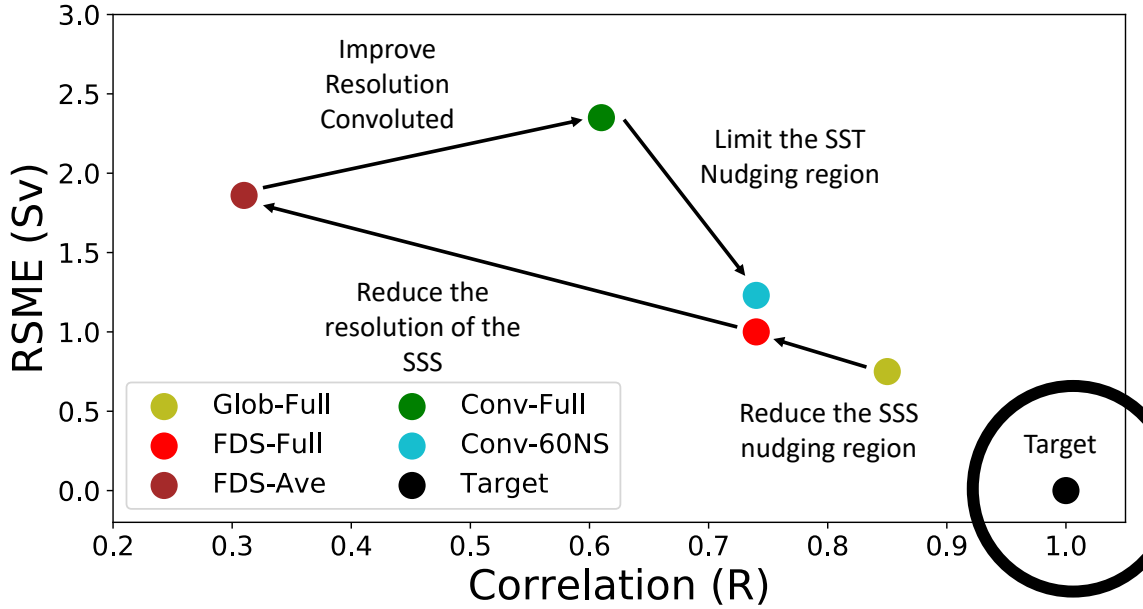
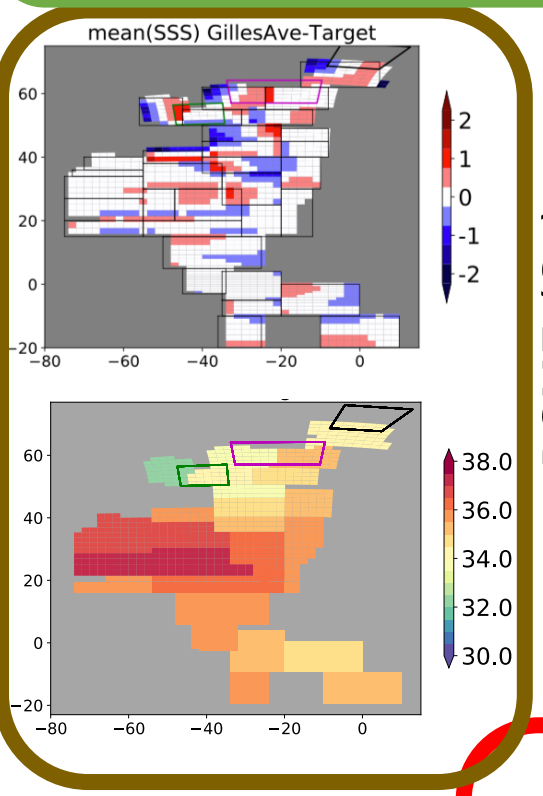
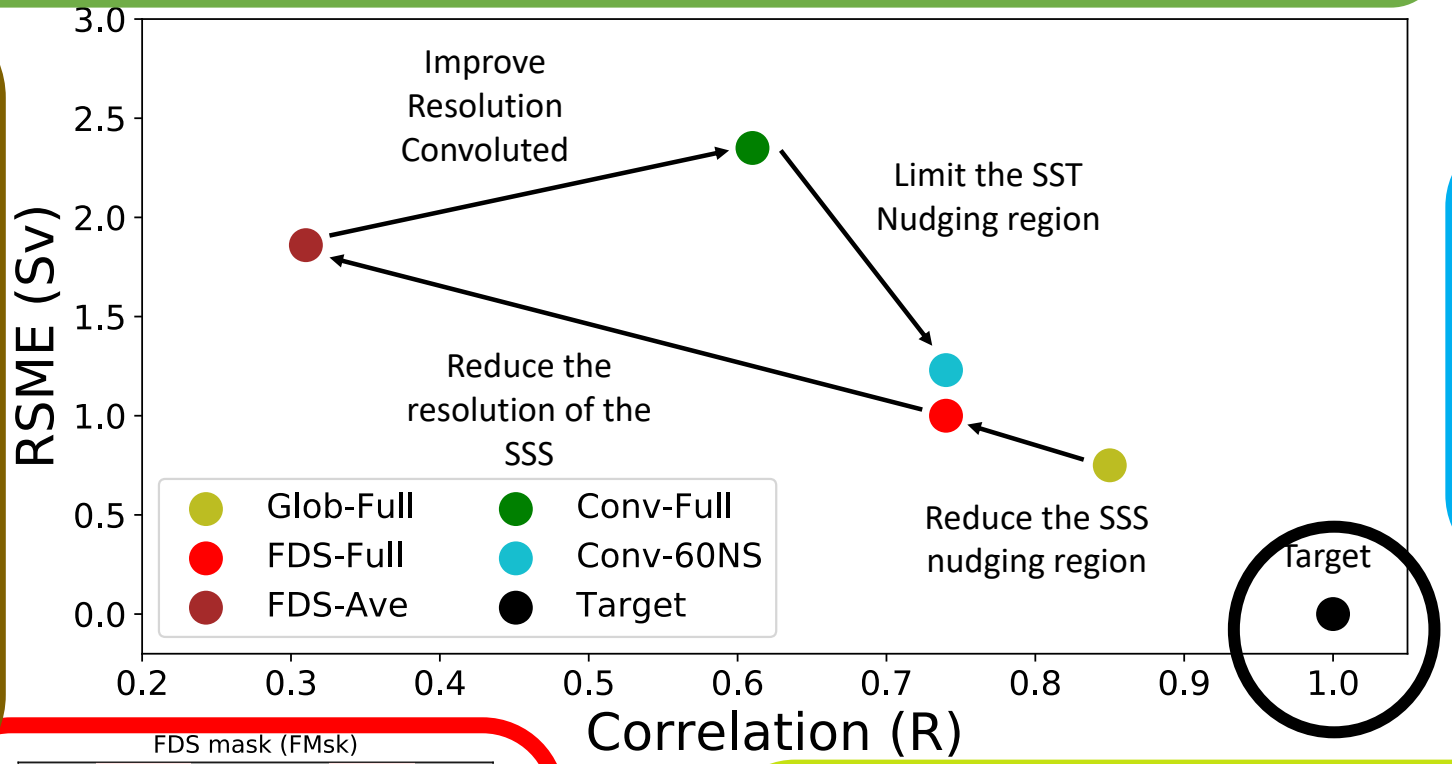
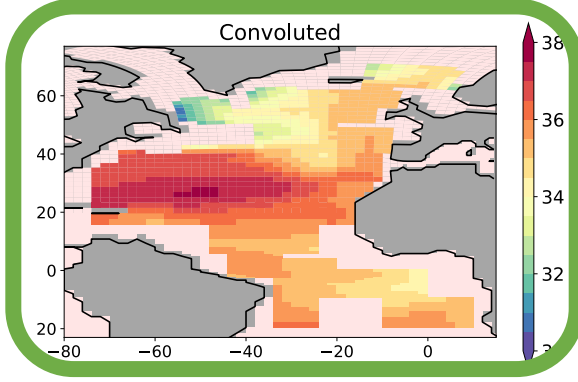


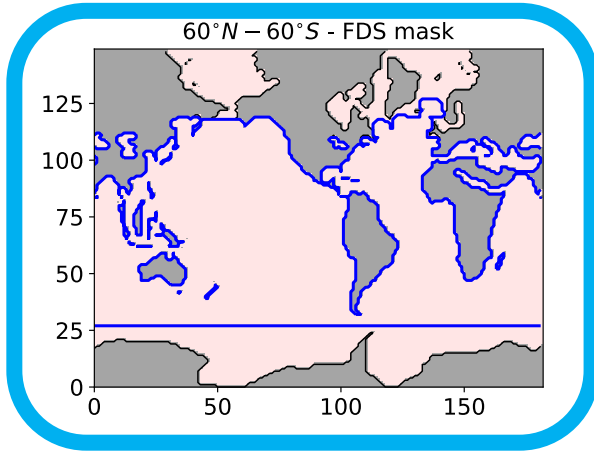
$$SSS_{Conv}[x, y, t] = SSS_{FAve}[Box_n(x, y), t] * SSS'_{climat}[x, y] \quad (1$$

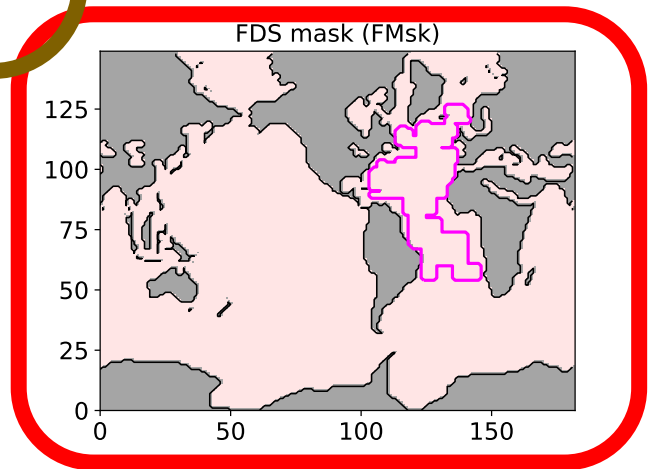
for t in monthly values, (x, y) gridpoints of the ORCA2 grid and $n(x, y)$ the FDS-box.

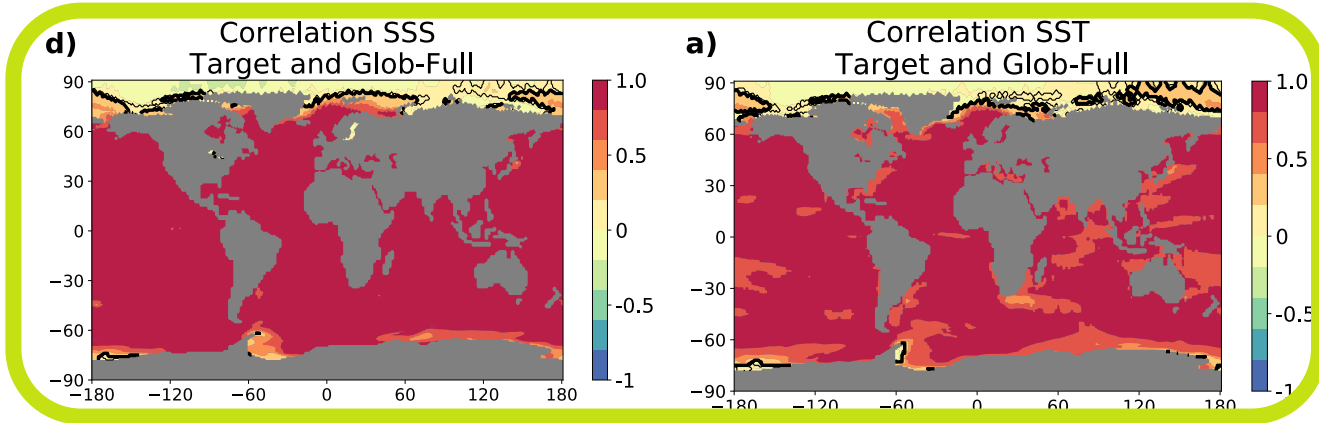






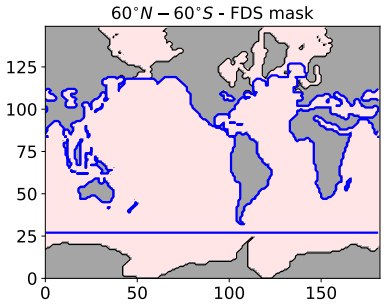






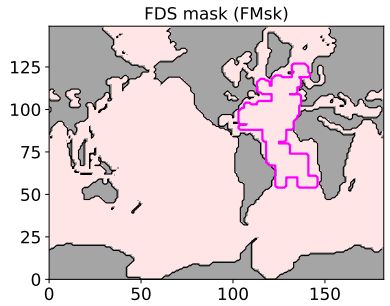
ORCA1

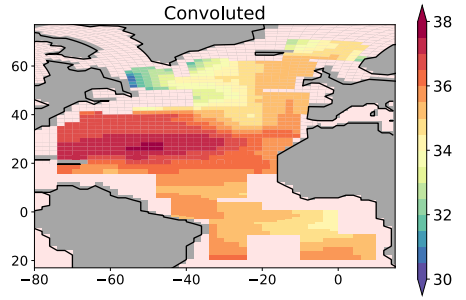
Our final configuration – IPSLCM6

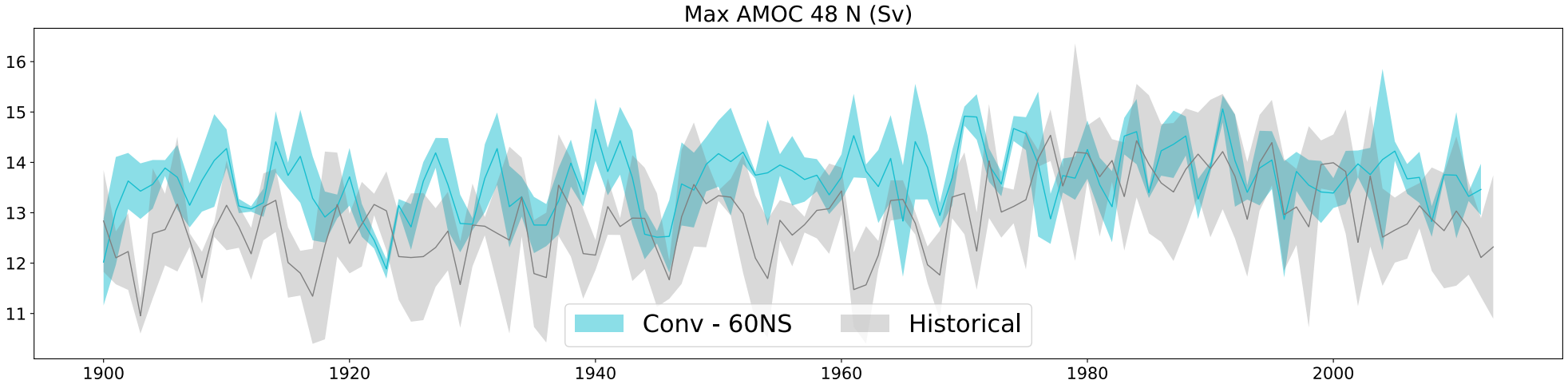


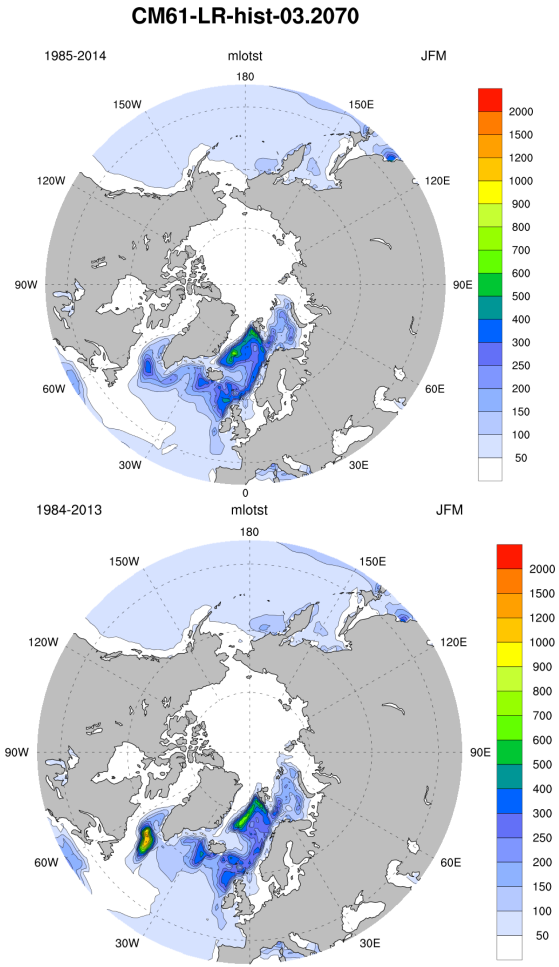
SST

SSS









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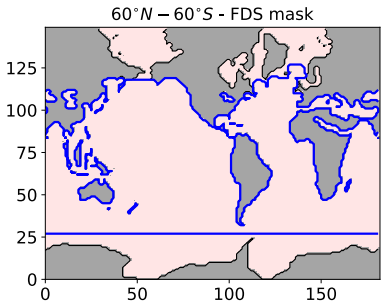
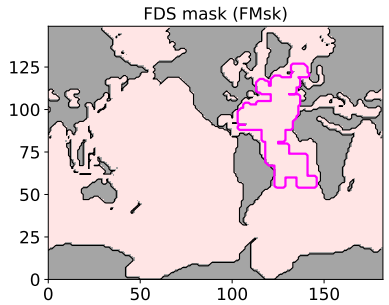
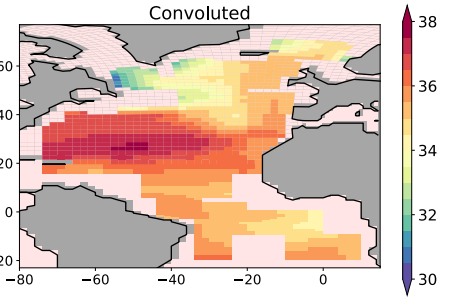
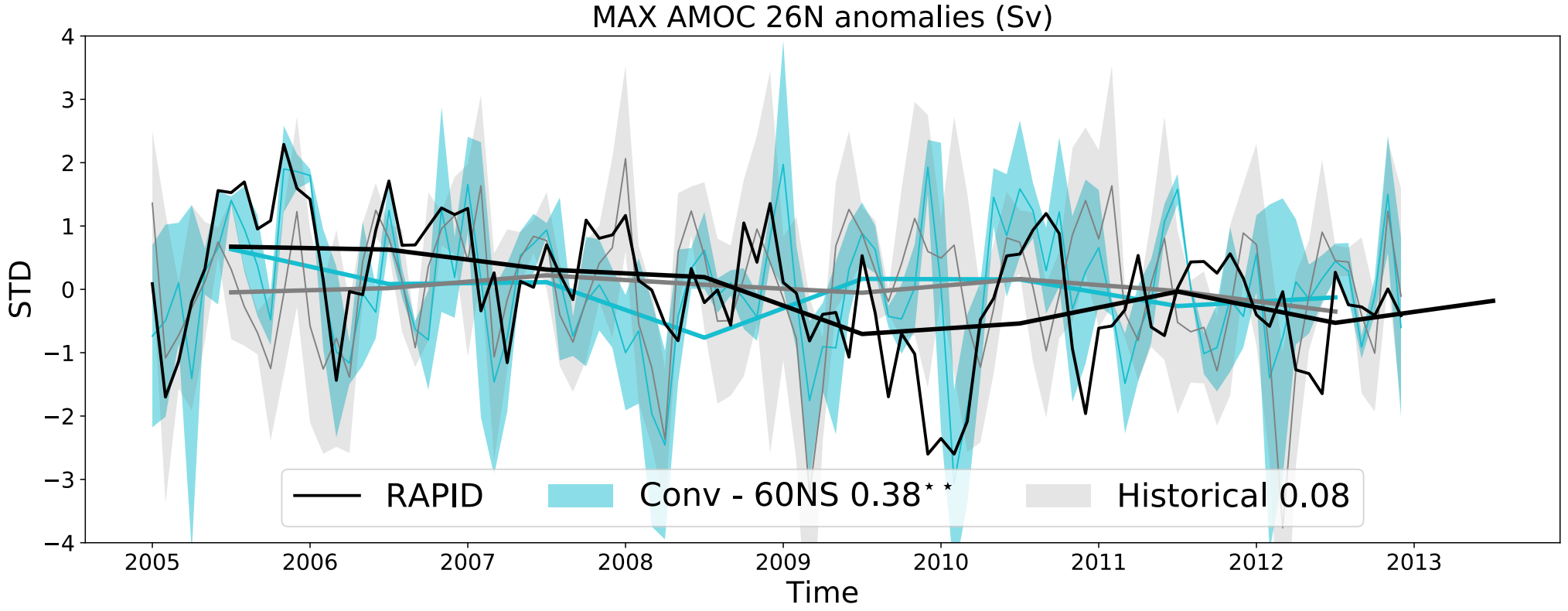


SST

SSS



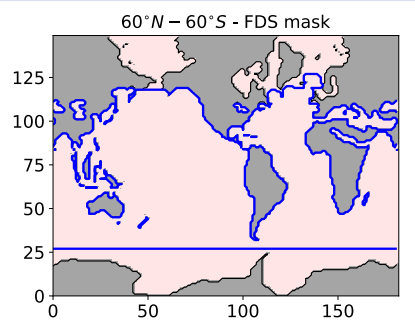




Conclusions

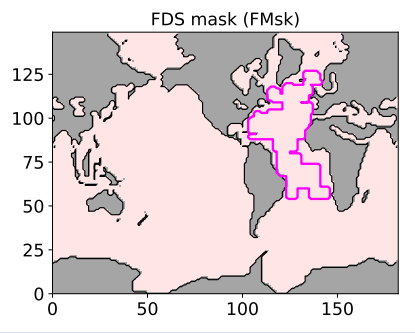
1900 — Historical Reconstruction — 31/12/2013 — Present

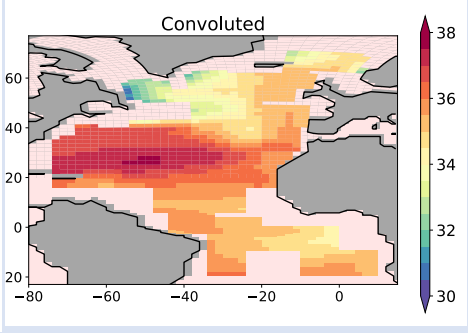
SST



ORCA1

SSS





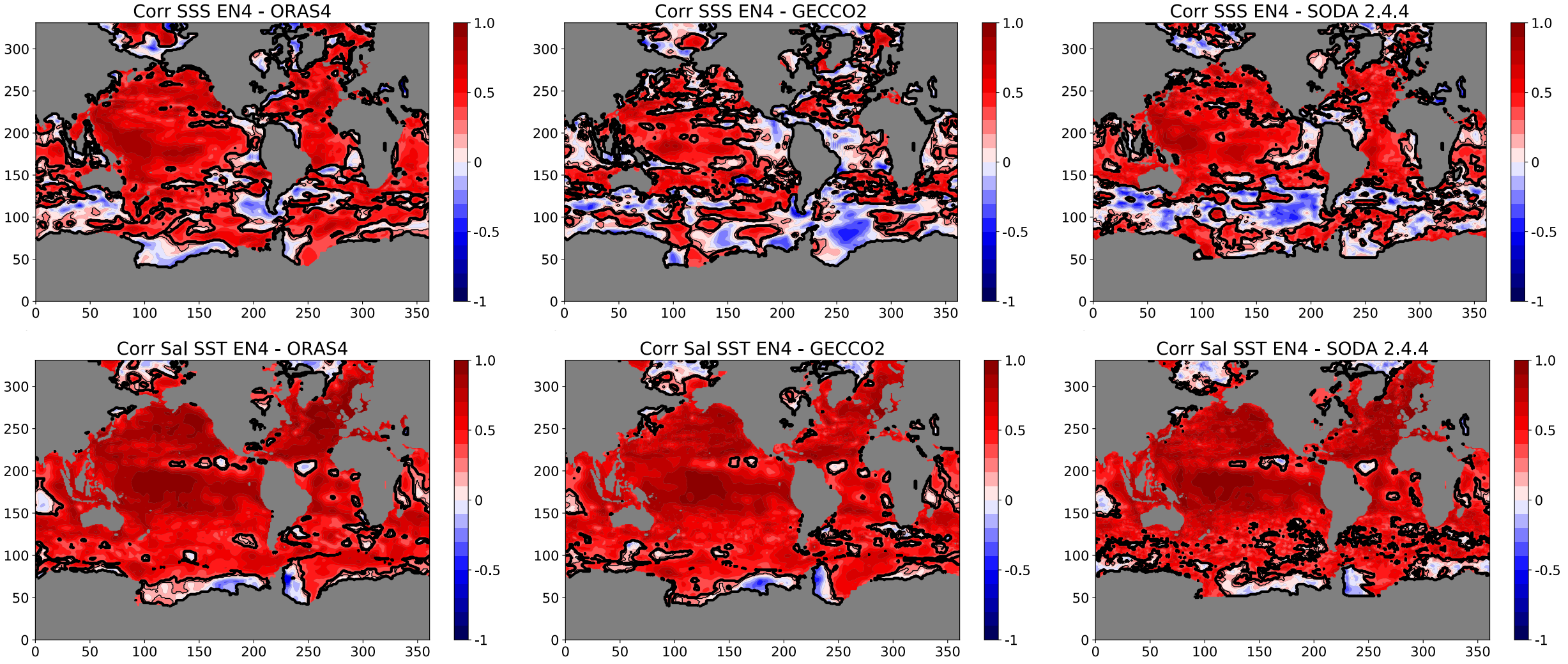
- Analyse the results of the reconstruction
- Compare to other reconstructions (Caesar 2018, Thornalley 2018, Jackson 2016, E. Frajka-Williams 2015, etc.)

Future work

- *Did we improve predictability?*
- *Include winds?* *(Ortega et al. 2017)*

Include Satellite Data

ESA CCI+SSS


Corr SSS EN4 - ORAS4
Corr SSS EN4 - GECCO2
Corr SSS EN4 - SODA 2.4.4
Corr Sal SST EN4 - ORAS4
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Corr Sal SST EN4 - SODA 2.4.4
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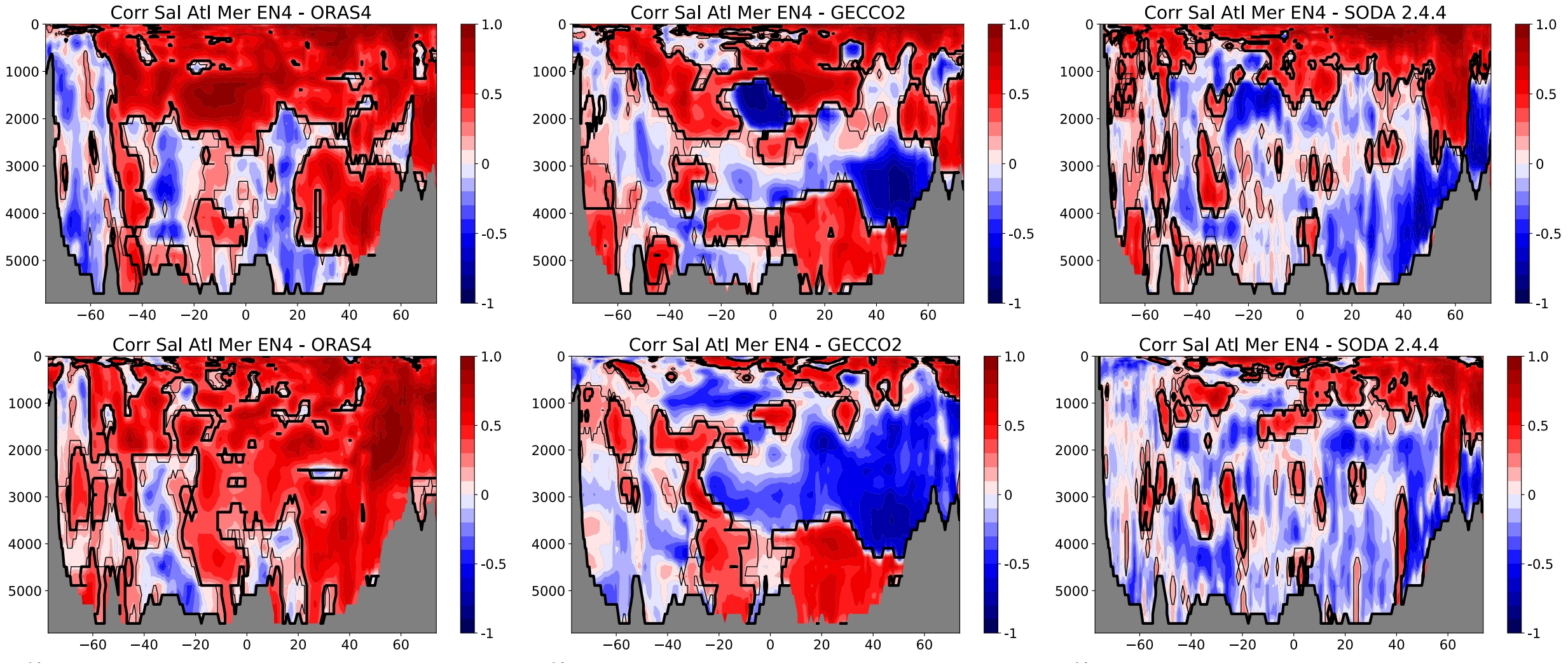
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