A novel initialisation technique for decadal climate predictions

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Motivation

To address the model drift caused by initialising the model away from its attractor

SST Global mean climatology
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SST Global mean climatology

- To tackle the potential inconsistencies between the observed/model distribution of variability

Standard deviation of the barotropic stream function

- Calculated as the ocean horizontal transport integrated vertically
Quantile matching experiment -QM-

Implementation

- Quantile matching calculated for each ocean model variable, at each grid point.
- 2 2D vars, and 14 3D vars
- Calculated for 5 members and 55 start dates
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**Experiment comparison**

The model in use is EC-Earth 3.3.1

| QM                          | FFI                          |
|-----------------------------|------------------------------|
| 10 ensemble members         | 10 ensemble members          |
| 5-year long hindcast        | 5-year long hindcast         |
| 55 start dates (November 1960-2014) | 55 start dates (November 1960-2014) |

Identical ensemble generation

**Initial conditions**

- Atm./surf.: ERA40/ERA-Interim
- Ocean: Quantile matching to NEMOVAR-ORAS4
- Sea ice: nudged simulation to NEMOVAR-ORAS4

- Compared with 15 historical simulations
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Compared with 15 historical simulations
Near surface temperature correlation with GISTEMP dataset
Convection
February-March-April mixed layer depth in the Labrador Sea

Histo Conv Labrador Sea MLD

Time (years)
m
1960 1970 1980 1990 2000 2010 2020
0 500 1000 1500
ORAS4

Histo NoConv Labrador Sea MLD

Time (years)
m
1960 1970 1980 1990 2000 2010 2020
0 500 1000 1500
ORAS4

QM Labrador Sea MLD

Time (years)
m
1960 1970 1980 1990 2000 2010 2020
0 500 1000 1500
ORAS4

FFI Labrador Sea MLD

Time (years)
m
1960 1970 1980 1990 2000 2010 2020
0 500 1000 1500
ORAS4

Full Field Ini (FFI)
Mixed layer depth and Barotropic stream function skill

MLD AC

BSF AC

MLD RMSE

BSF RMSE

Forecast time

Yr 1 Yr 2 Yr 3 Yr 4 Yr 5

Forecast time

Yr 1 Yr 2 Yr 3 Yr 4 Yr 5
AMOC correlation

- QM
- FFI
- Histo
- QM-FFI
Summary

Issues to address

- The drift coming from initialising the predictions away from the model attractor;
- The inconsistencies between the observed/model variability amplitudes.

Quantile matching experiment

The initial condition is the model state which is identically located in the model distribution as the observed initial state in the observed distribution.

Results: improvements of the QM

- Skill improvements in the subpolar gyre region for SST and ocean heat content throughout the whole forecast period.
- It avoids a collapse of deep convection in the Labrador Sea that occurred in FFI, although this does not translate into an improved skill compared to the historical simulations. → Mixed layer depth signal is probably dominated by the trend.
- Skill improvements in the western Subpolare Gyre region of the barotropic stream function.
- Skill improvements of the AMOC during the whole forecast period at high latitudes.
Future work

Towards more consistency between the model components

- Use the QM technique to create the reference files for a nudging simulation of ocean (temperature and salinity) and sea ice (sea ice concentration);
- Use the nudging simulation to initialise all the model components and run the hindcasts.

Thank you!

Volpi et al. (2021): Front. Clim. 3, doi: 10.3389/fclim.2021.681127.
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Heat content 0-300m correlation with EN4 data
Convection
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Histo Conv

Histo NoConv

MLD Climatology in the Labrador Sea
AMV

Calculated as the difference between the regional SST anomalies in the North Atlantic (0° to 60° N and 80° to 0° W) and the global mean SST anomalies (between 60° S and 60° N)
Correlation for the surface temperature residuals
Comparison with Anomaly initialization hindcast
SST correlation difference using only 5 members

QM–FFI correlation year 1
QM–AI correlation years 1–4
AI–FFI correlation year 1
AI–FFI correlation years 1–4
QM–AI correlation years 1–4
Comparison with Anomaly initialization hindcast
SST correlation difference using only 5 members