Decadal climate predictions with the ECMWF coupled system

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Outline

Experiments:
- Decadal (10-year), 1960-2005 (varying GHG, no volcanoes)
- IFS cycle 36r1 (T159 91 vertical levels), Nemo 3 (42 vertical levels 1° average resolution), sampled sea-ice. Initialisation: ECMWF reanalysis ERA and NemoVar
- Starting dates November every 5th year
  - Full initialisation
  - Anomaly initialisation
  - Heat and momentum flux correction
- 7 ensemble members (+3 with volcanoes for control and flux correction)
- Overall Grand Ensemble of 27 members

Diagnostics:
- Heat content and heat transport (very preliminary diagnostics)
- Nino3.4 plumes for 2 major El Nino events
- Teleconnection patterns (i.e. Regressions between SSTs and Atmospheric fields)
- Deterministic & Probabilistic scores
Momentum flux correction - rationale

Cross-section ocean bias

U-current

Temperature

(Walker circulation feedback)
North Atlantic 300 m Heat Content

- Black: Analysis
- Red: Full Ini.
- Purple: Anom. Ini
- Blue: Flux Correction

AGCI Workshop on Decadal Predictions - Aspen 26 June -1 July 2011
Control

U- and H-flux correction
MOC
North Atlantic Heat Transport –50N
Diagnostics – Regression SST in Nino3.4 vs. SST
Diagnostics – Regression SST in Nino3.4 vs. Precipitation
Tropical storms - Flux corrected exp.
Diagnostics – NHE Winter -500hPa regional EOFs – Full Ini.

**Reanalysis**

<table>
<thead>
<tr>
<th>EOF1 DJF</th>
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**Model**

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Covariance with 2m temperature

Covariance with 2m temperature
Diagnostics – NHE Winter - MSLP 1st EOF – Full Ini.

Reanalysis

Model

EOF1 DJF NH

Cov 2Tm (NH,DJF)

EOF1 JJA SH

EOF1 DJF NH

Cov 2Tm (NH,DJF)

EOF1 JJA SH
ACC – YR 2-6 - YRs 6-9 - 12-month average – T2m

Near surface Air temperature
ACC yr 2-5 - full ini.

Near surface Air temperature
ACC yr 6-9 - full ini.

Near surface Air temperature
ACC yr 2-5 – flux cor.

Near surface Air temperature
ACC yr 6-9 – flux cor.
ACC – YR 2-6 - YRs 6-9 - 12-month average – T2m

Near surface Air temperature
ACC yr 2-5 - full ini.

Near surface Air temperature
ACC yr 2-5 – Grand Ens.

Near surface Air temperature
ACC yr 6-9 - full ini.

Near surface Air temperature
ACC yr 6-9 – Grand Ens.
Time series - AMO index

2-5 yr - Cor=0.92
Spread/RMSE=0.67
RPSS=0.39

6-9 yr - Cor=0.45
Spread/RMSE=0.45
RPSS=-0.15
Time series - North Atlantic SSTs

2-5 yr - Cor=0.85
Spread/RMSE=0.58
RPSS=0.13

6-9 yr - Cor=0.93
Spread/RMSE=0.67
RPSS=-0.60
Time series - Global average 2-metre temperature

2-5 yr - Cor=0.95
Spread/RMSE=0.63
RPSS=0.52

6-9 yr - Cor=0.96
Spread/RMSE=0.73
RPSS=-0.67
Probabilistic scores - Mean Square Skill Score MSSS

Near surface Air temperature MSSS yr 1 – Grand Ens.

Near surface Air temperature MSSS yr 2 – Grand Ens.

Near surface Air temperature MSSS yr 2-5 – Grand Ens.

Near surface Air temperature MSSS yr 6-9 – Grand Ens.
Reliability diagram

- Reliability score (the smaller, the better)
- Resolution score (the bigger, the better)

Size of red bullets represents number of forecasts in probability category (sharpness)

Poor resolution

Good resolution
Brier Skill Score & Reliability Diagram

- How to construct the area of positive skill?

\[
BSS = 1 - \frac{BS}{BS_c}
\]

\[
= 1 - \frac{REL - RES + UNC}{UNC} = \frac{RES - REL}{UNC}
\]

- Observed Frequency
- Forecast Probability
- perfect reliability
- line of no skill
- climatological frequency (line of no resolution)
- area of skill (RES > REL)
Reliability diagrams - T2m - 2-5 yr

T2m anomaly below the lower tercile - Global average

T2m anomaly above the upper tercile - Global average
Reliability diagrams - T2m - 6-9 yr

T2m anomaly below the lower tercile - Global average

T2m anomaly above the upper tercile - Global average
Reliability diagrams - T2m - 2-5 yr

T2m anomaly above the median over Europe

T2m anomaly above the median over North America
Summary

- The IFS/NEMO coupled model is affected by an overall cold SST bias, with a too strong Pacific equatorial cold tongue (especially in summer).
- Flux correction improves the mean state and ENSO variability.
- In spite of model drift and the fact that several climate processes, such as those related to sea-ice formation, export and melting, are not represented in the model, the decadal prediction experiments show a positive forecast quality that can be statistically significant over several areas.
Yr 6-10 Full Initialisation (bias correction)
Yr 6-10 Full Initialisation
Yr 6-10 Full Initialisation