



# Decadal climate predictions with the ECMWF coupled system

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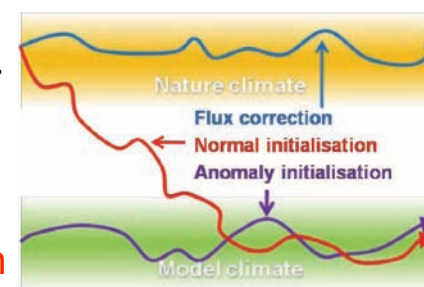
With contributions from Magdalena Balmaseda, Linus Magnusson, Franco Molteni, Frederic Vitart, Antje Weisheimer and Tim Palmer



# 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 5<sup>th</sup> 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

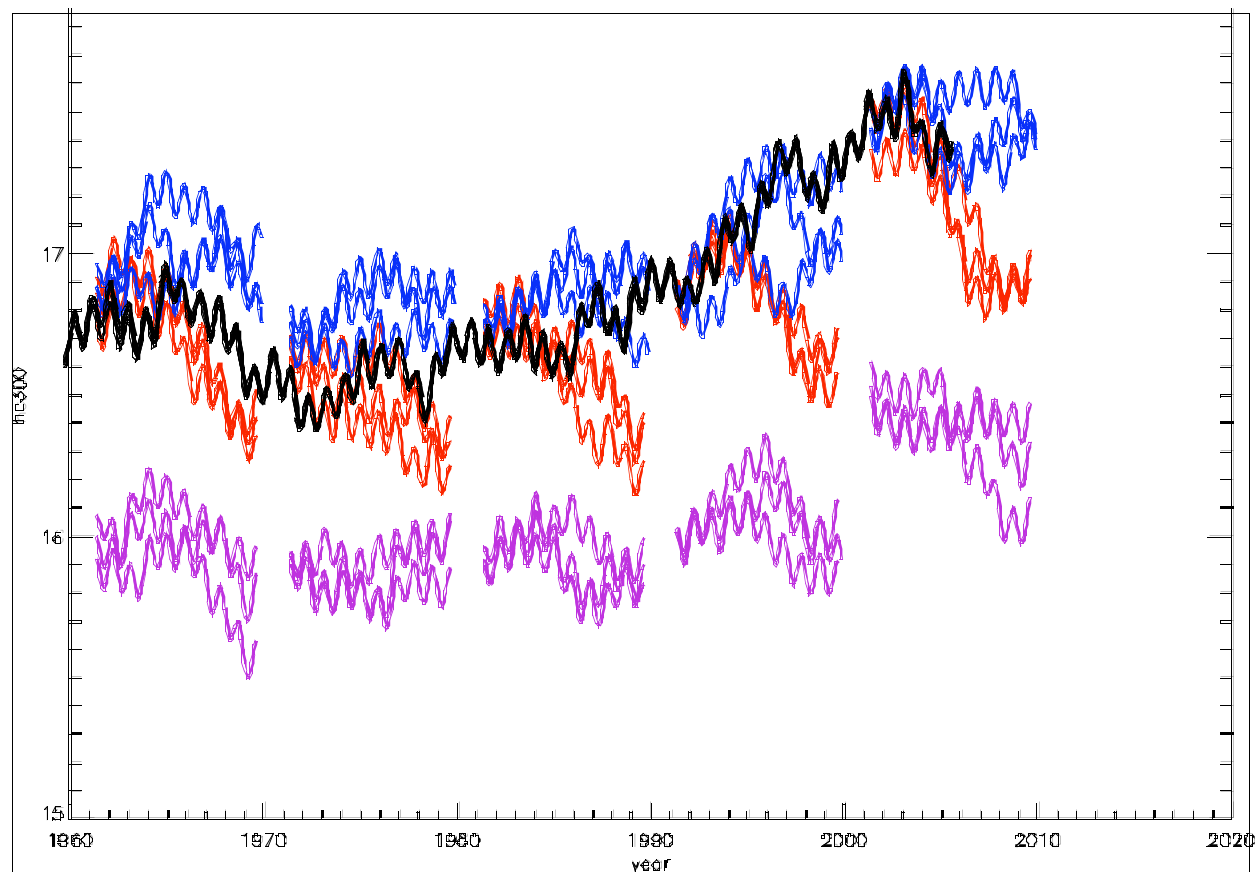
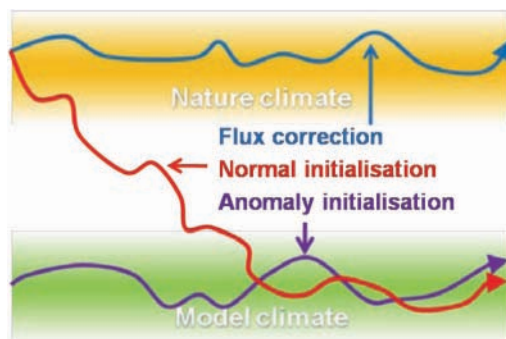


## Diagnostics:

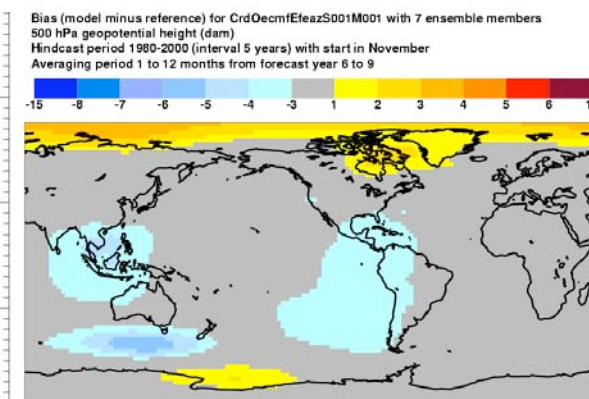
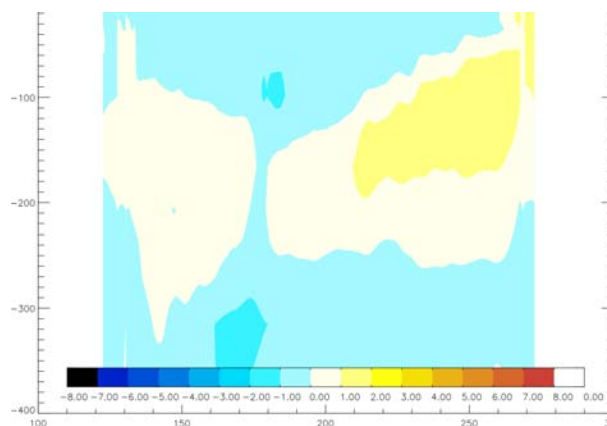
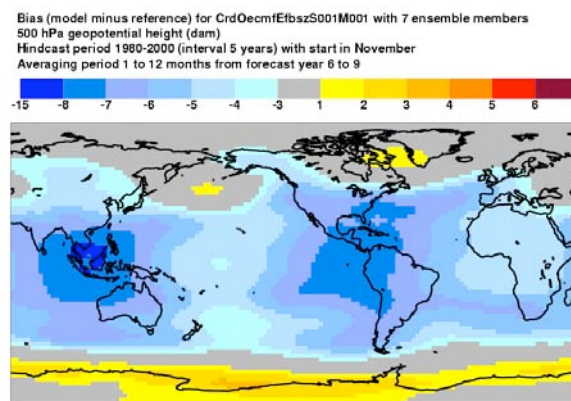
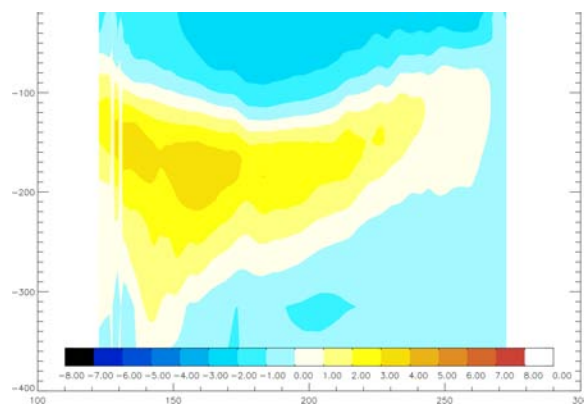
- Heat content and heat transport (very preliminary diagnostics)
- Nino3.4 plumes for 2 major El Nino events
- Teleconnection patterns (i.e. Regressions between SSTs and Atmospheric fields)
- Deterministic & Probabilistic scores



# North Atlantic 300 m Heat Content



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

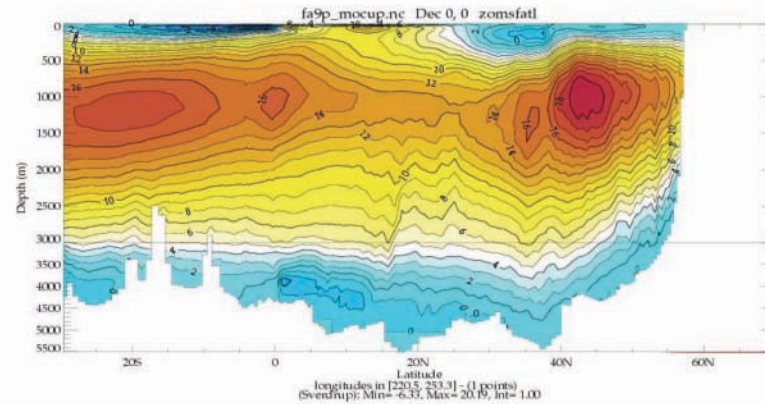




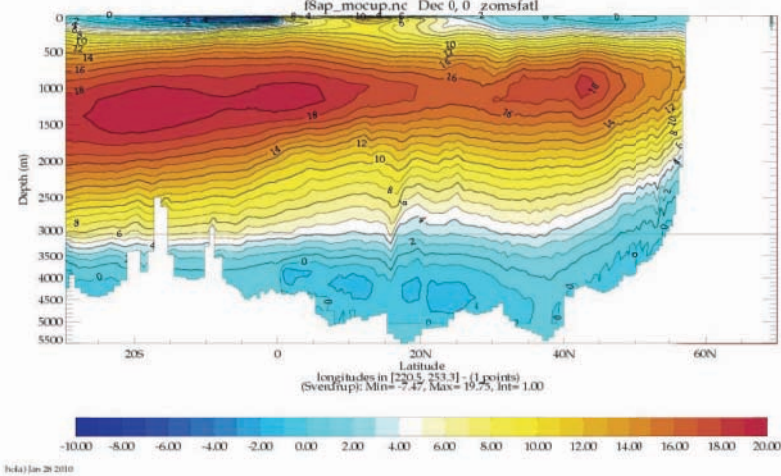


# MOC

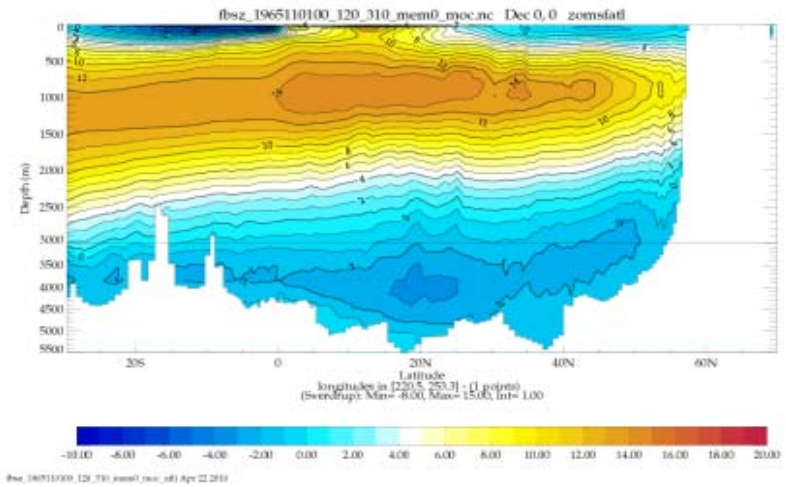
?????pppp?



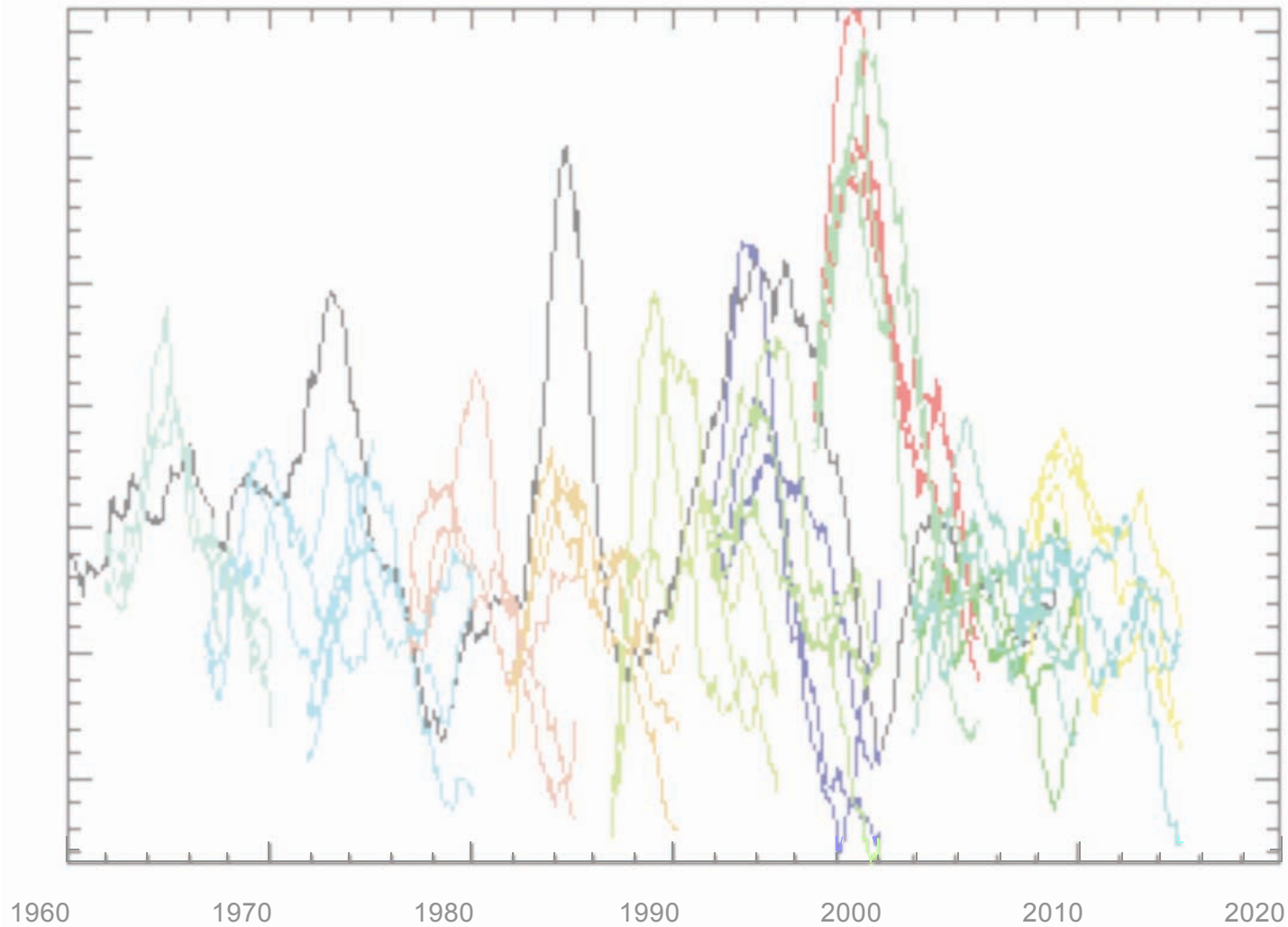
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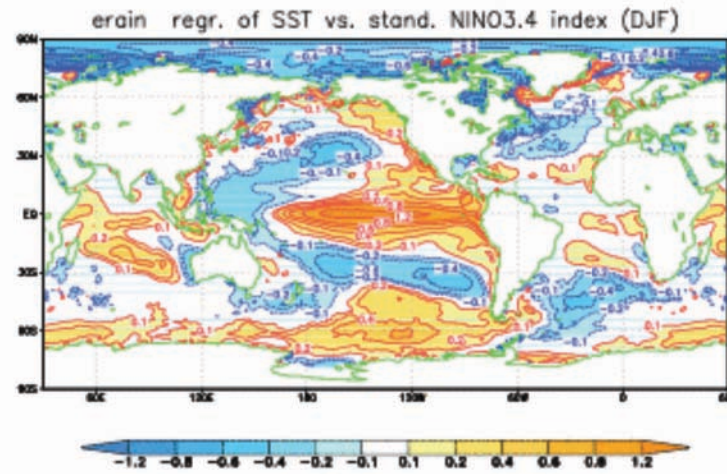


## North Atlantic Heat Transport –50N



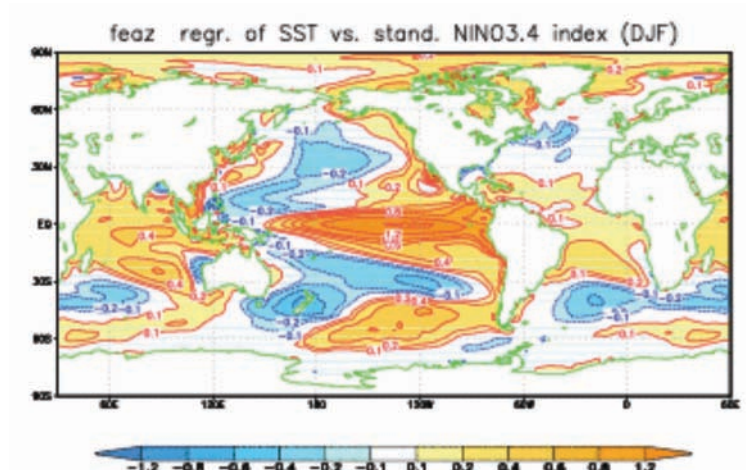
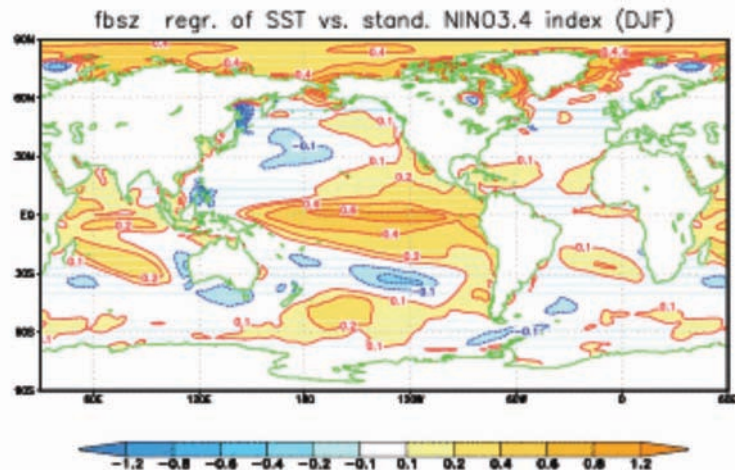
# Diagnostics – Regression SST in Nino3.4 vs. SST

?? ???? ? ?



?? ???? ? ?

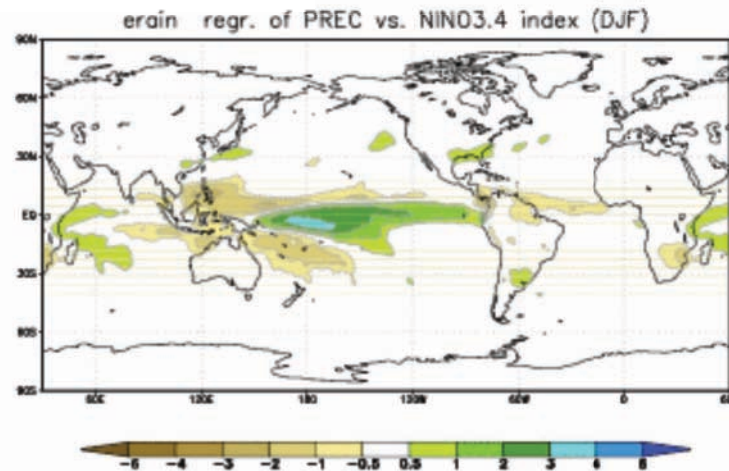
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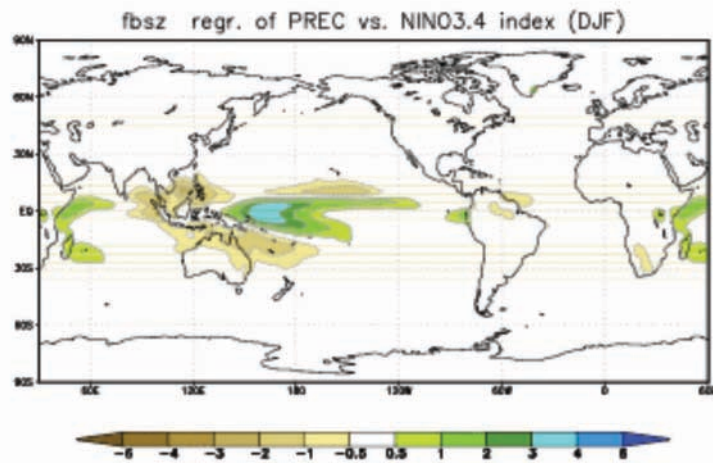


# Diagnostics – Regression SST in Nino3.4 vs. Precipitation

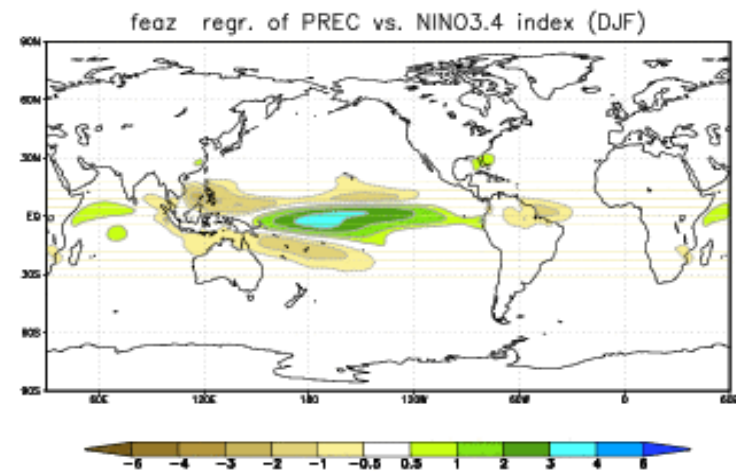
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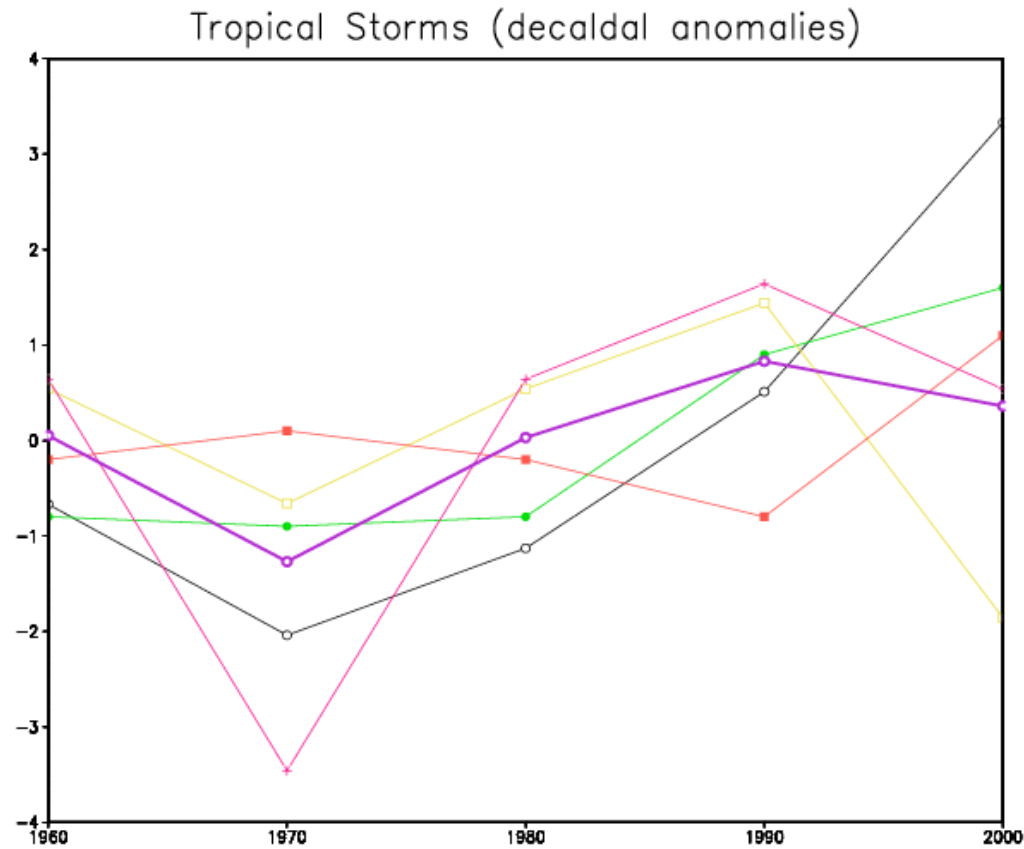


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## Tropical storms - Flux corrected exp.



# ↻ Diagnostics – NHE Winter -500hPa regional EOFs – Full Ini.

## Reanalysis

## Model

**EOF1 DJF  
American-Pacific**

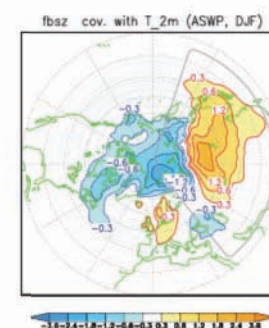
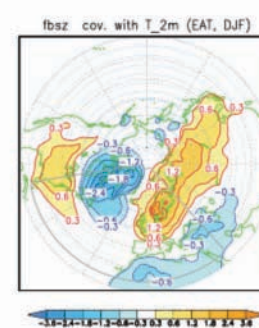
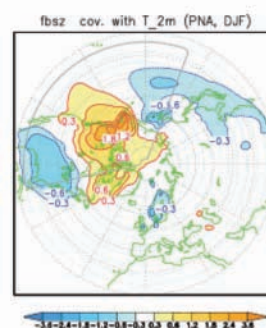
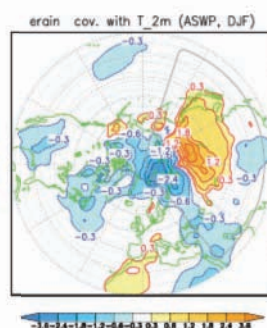
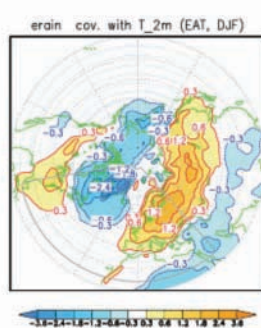
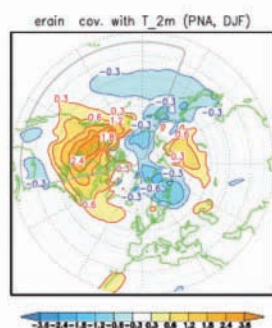
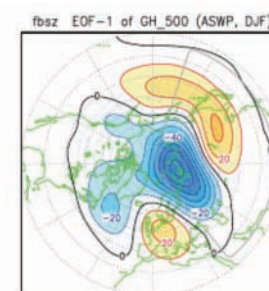
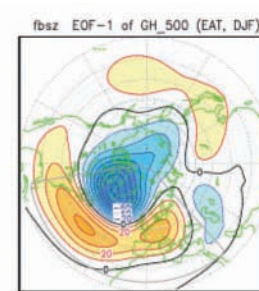
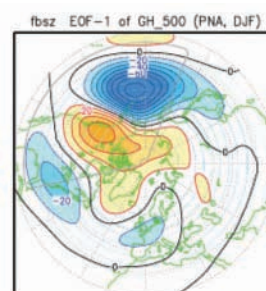
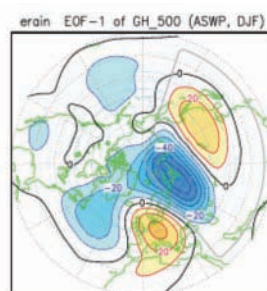
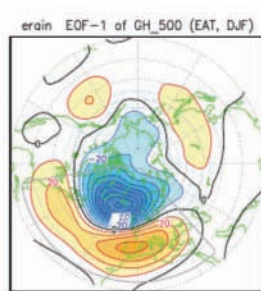
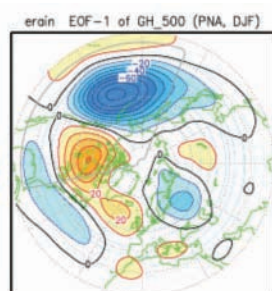
**EOF1 DJF  
Euro-Atlantic**

**EOF1 DJF  
Asian-West Pacific**

**EOF1 DJF  
American-Pacific**

**EOF1 DJF  
Euro-Atlantic**

**EOF1 DJF  
Asian-West Pacific**



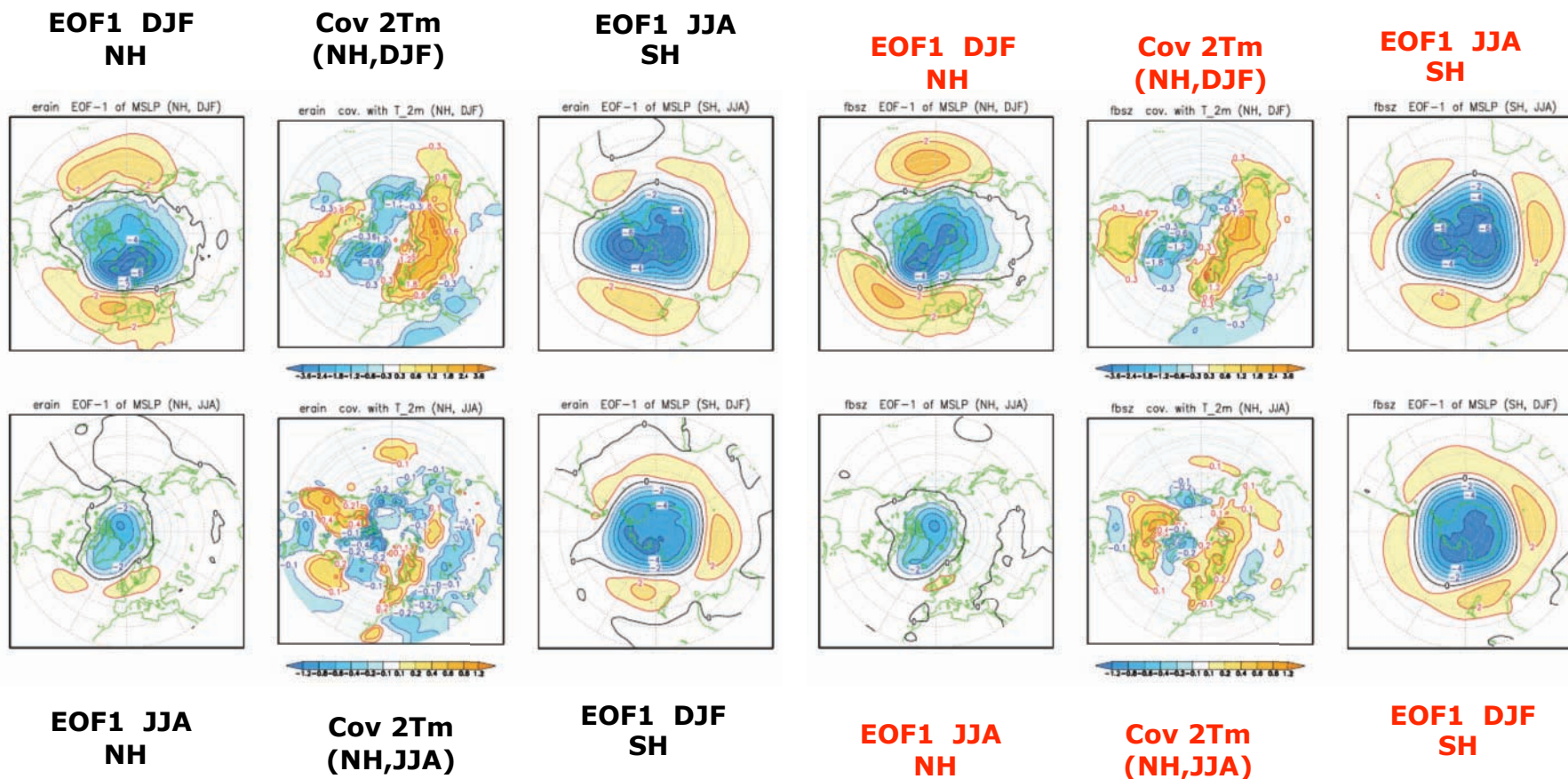
**Covariance with 2m temperature**

**Covariance with 2m temperature**

# Diagnostics – NHE Winter - MSLP 1<sup>st</sup> EOF – Full Ini.

## Reanalysis

## Model

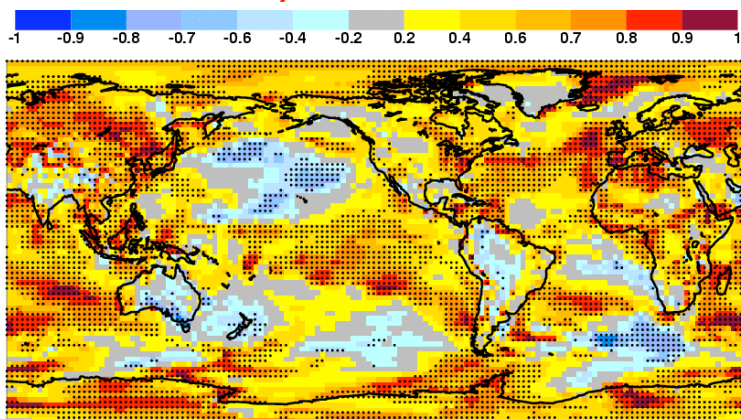




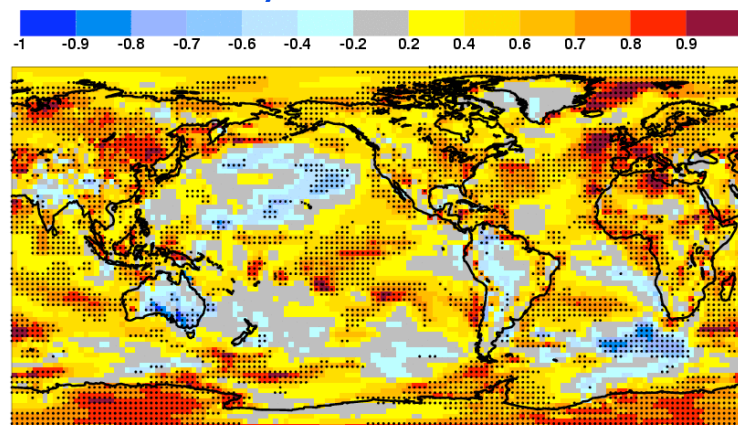


## ACC – YR 2-6 - YRs 6-9 - 12-month average – T2m

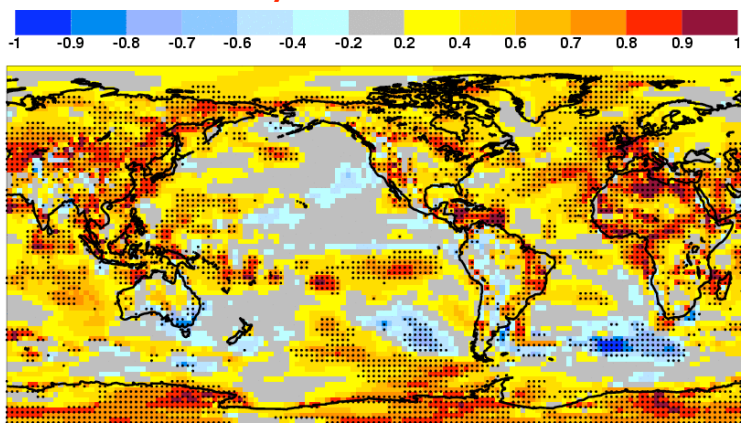
Near surface Air temperature  
ACC yr 2-5 - full ini.



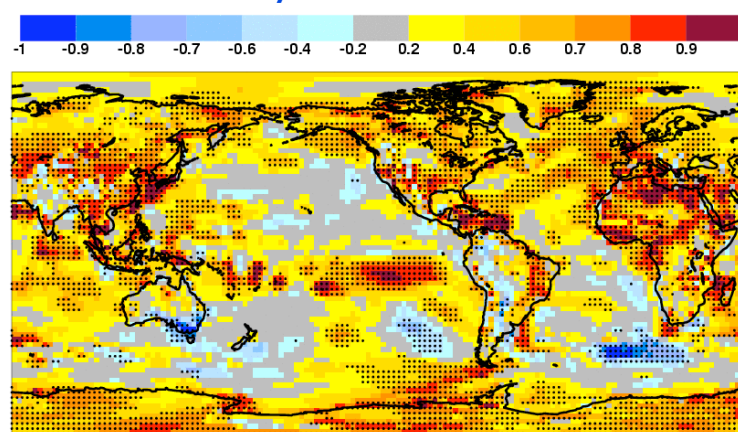
Near surface Air temperature  
ACC yr 2-5 – flux cor.



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



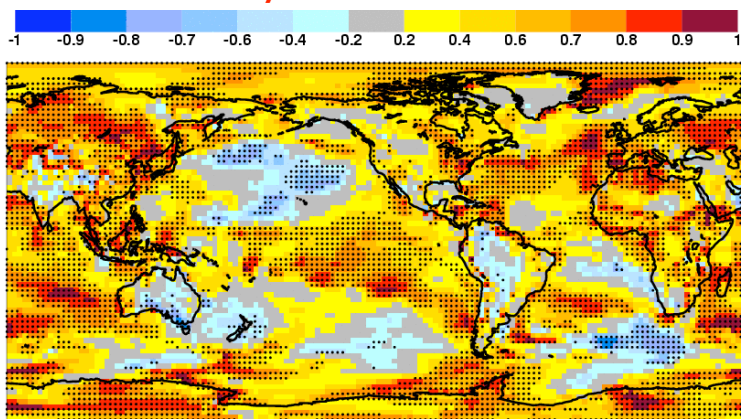
Near surface Air temperature  
ACC yr 6-9 – flux cor.



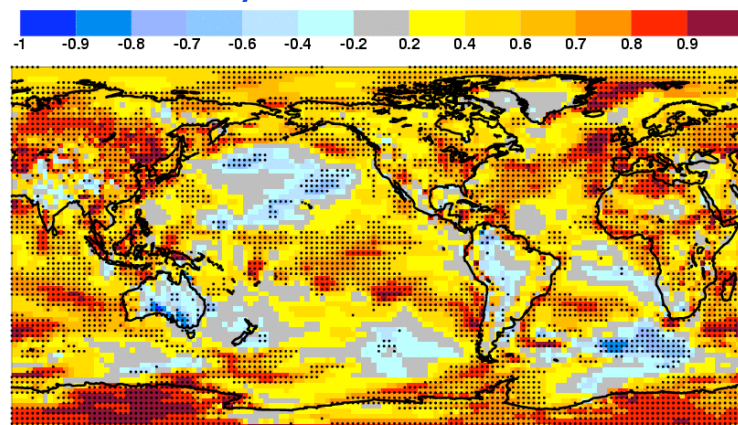


# ACC – YR 2-6 - YRs 6-9 - 12-month average – T2m

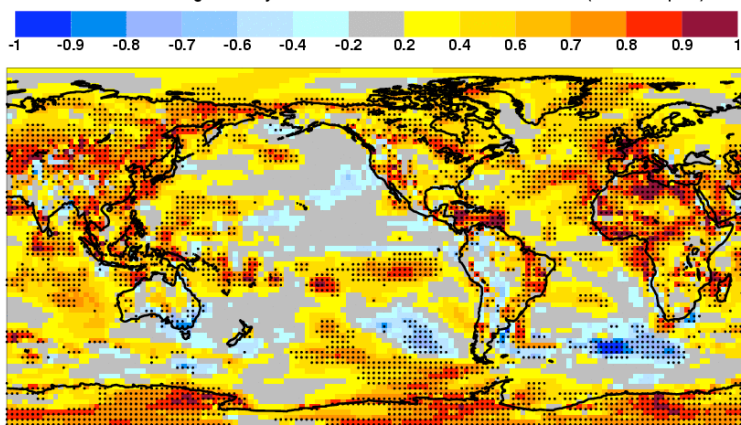
Near surface Air temperature  
ACC yr 2-5 - full ini.



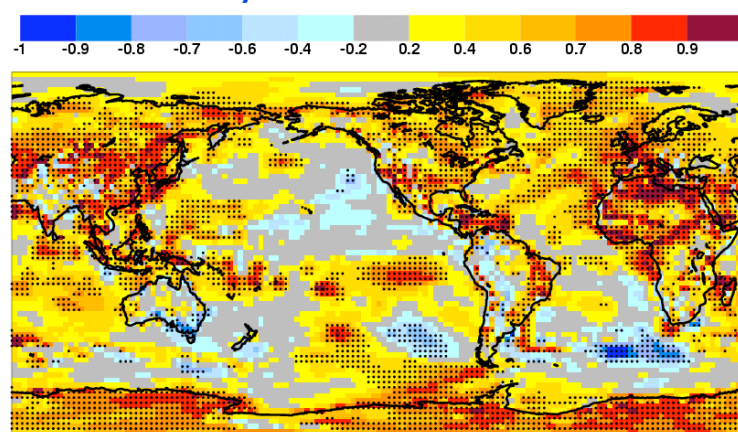
Near surface Air temperature  
ACC yr 2-5 – Grand Ens.



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

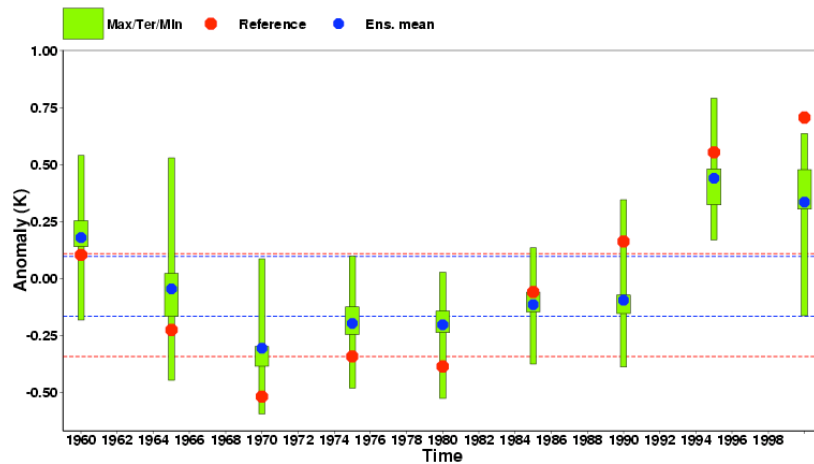


Near surface Air temperature  
ACC yr 6-9 – Grand Ens.

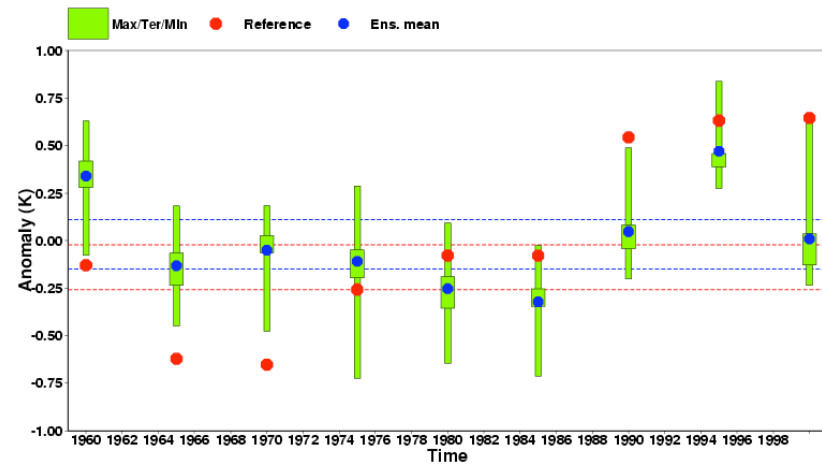


## Time series - AMO index

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

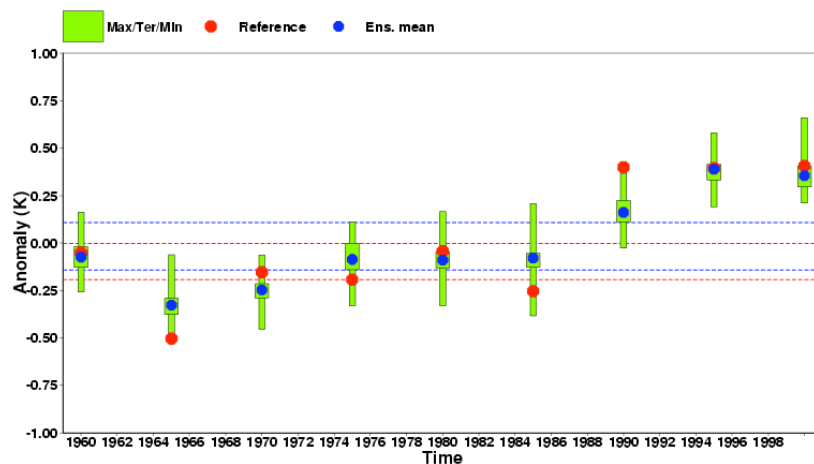


6-9 yr - Cor=0.45  
Spread/RMSE=0.45  
RPSS=-0.15

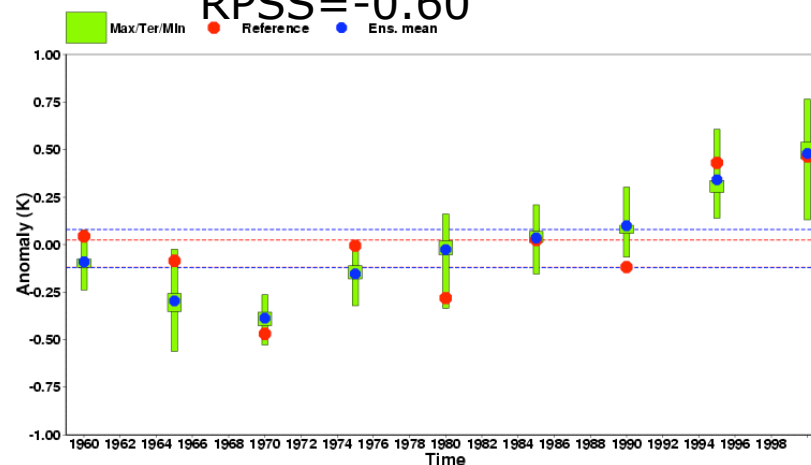


## Time series - North Atlantic SSTs

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



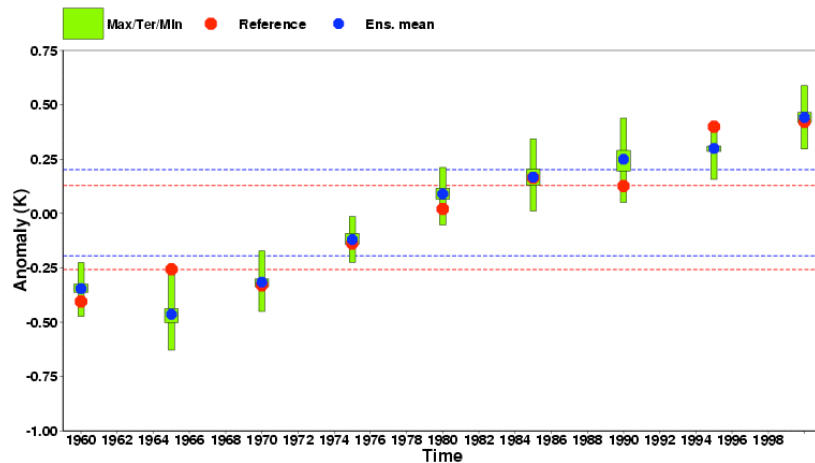
6-9 yr - Cor=0.93  
Spread/RMSE=0.67  
RPSS=-0.60



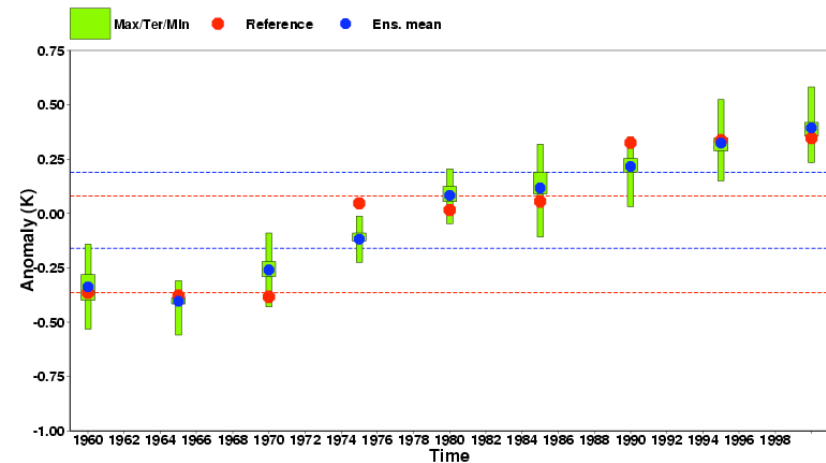


## Time series - Global average 2-metre temperature

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

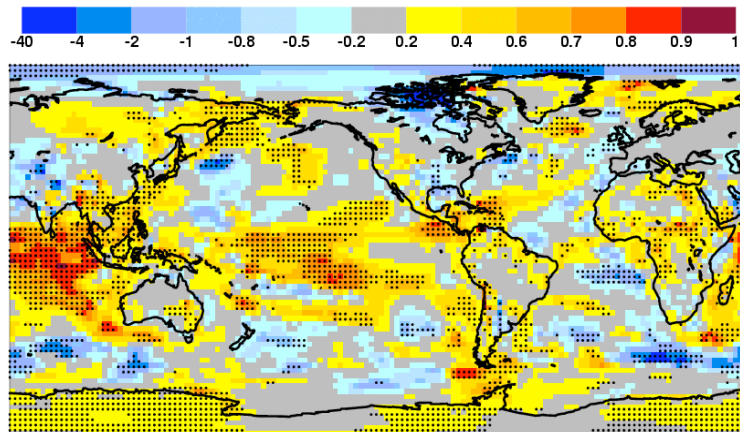


6-9 yr - Cor=0.96  
Spread/RMSE=0.73  
RPSS=-0.67

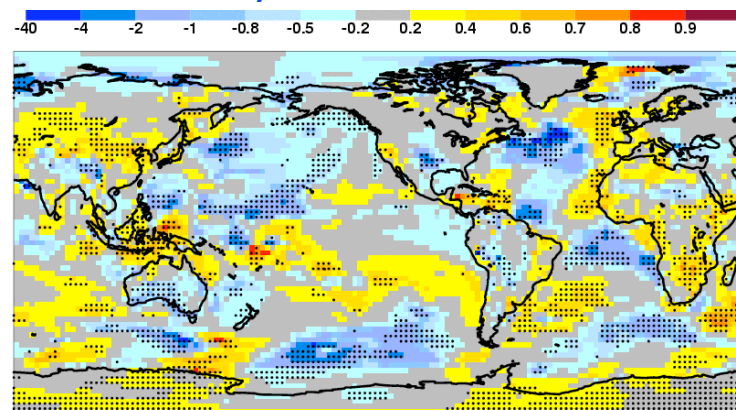


## Probabilistic scores - Mean Square Skill Score MSSS

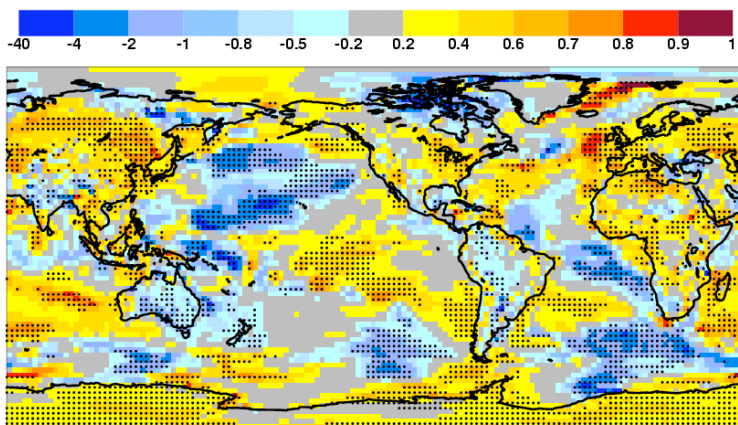
Near surface Air temperature  
MSSS yr 1 – Grand Ens.



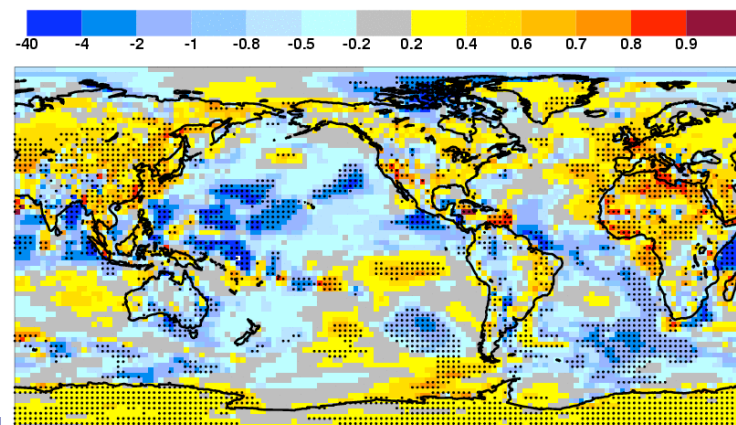
Near surface Air temperature  
MSSS yr 2 – Grand Ens.



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



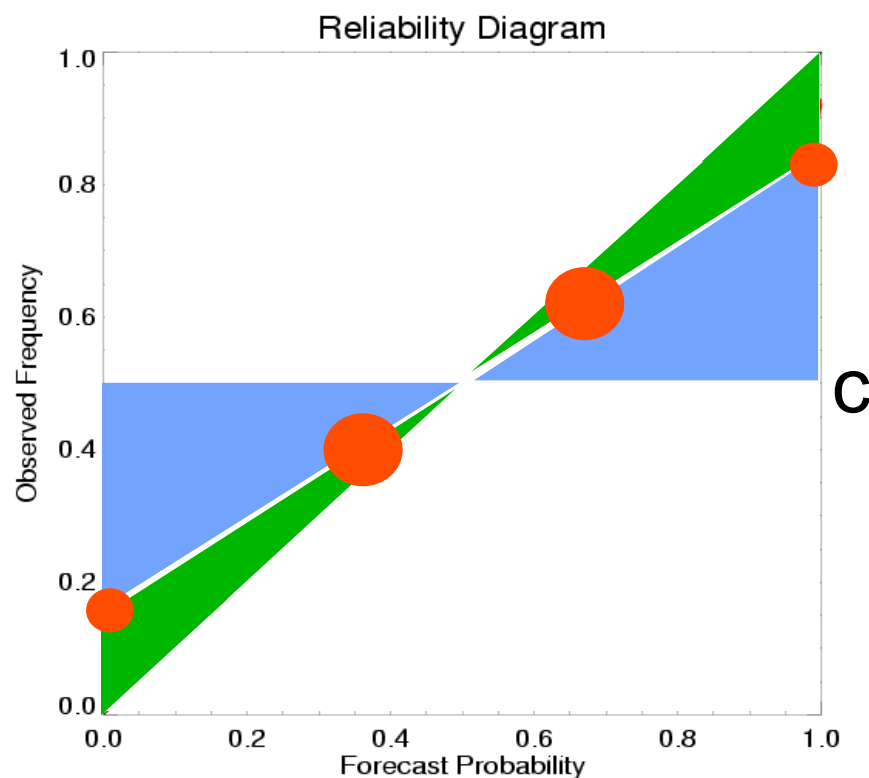
Near surface Air temperature  
MSSS yr 6-9 – Grand Ens.



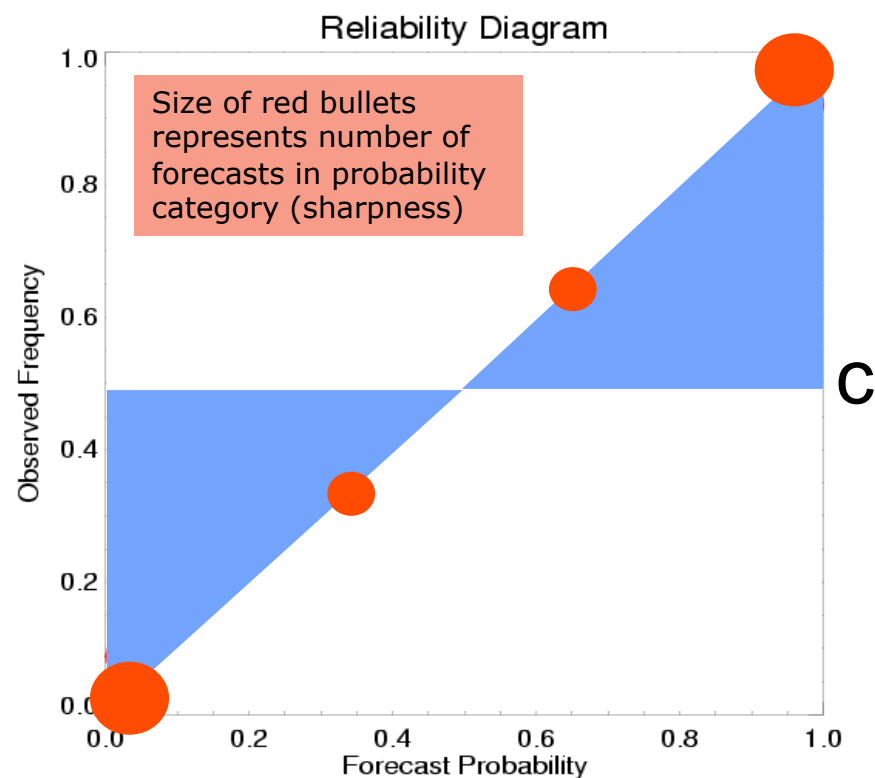


# Reliability diagram

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



Poor resolution

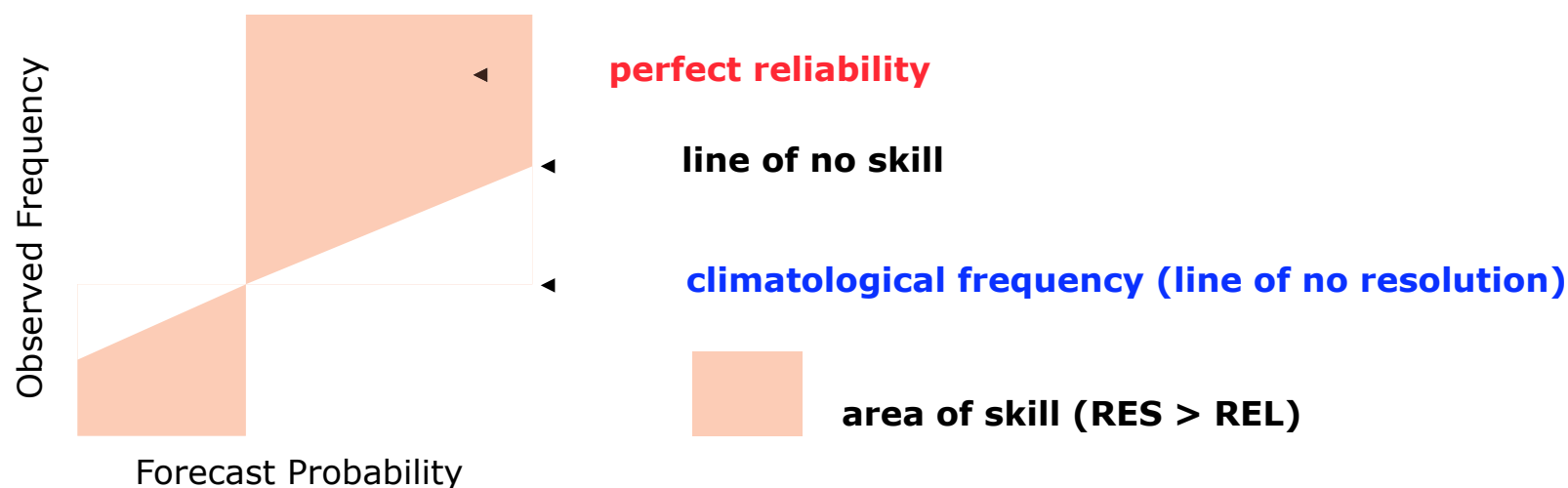


Good resolution

# ■ Brier Skill Score & Reliability Diagram

- How to construct the area of positive skill?

$$\begin{aligned}
 BSS &= 1 - \frac{BS}{BS_c} \\
 &= 1 - \frac{REL - RES + UNC}{UNC} = \frac{RES - REL}{UNC}
 \end{aligned}$$

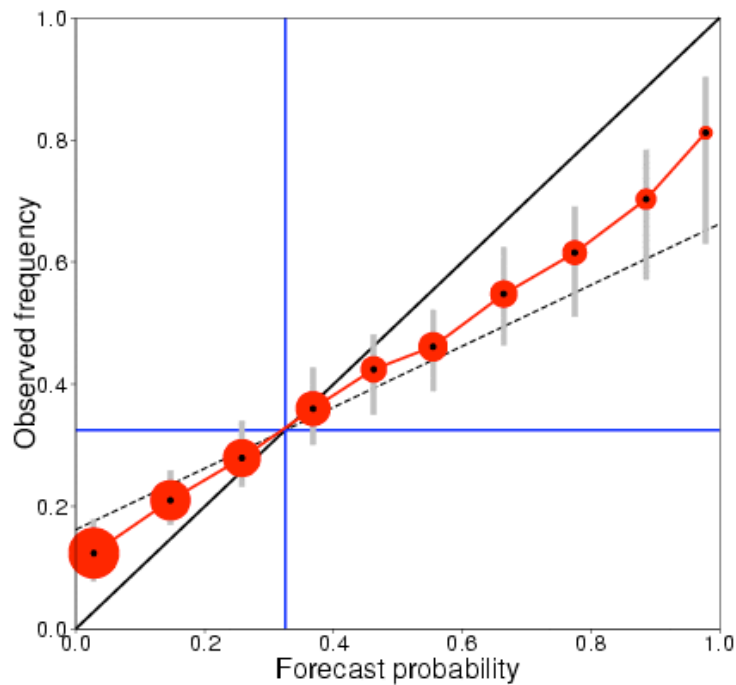




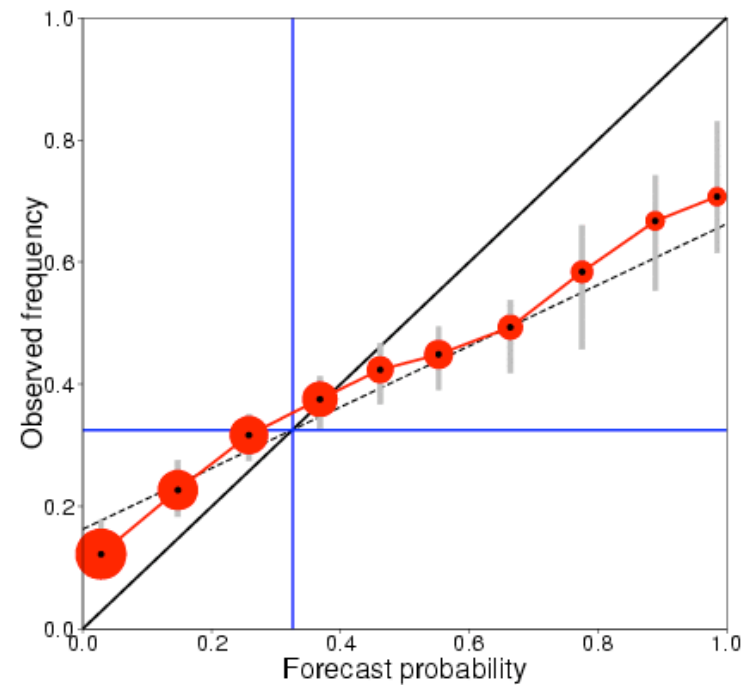


## Reliability diagrams - T2m - 2-5 yr

T2m anomaly below the lower tercile - Global average



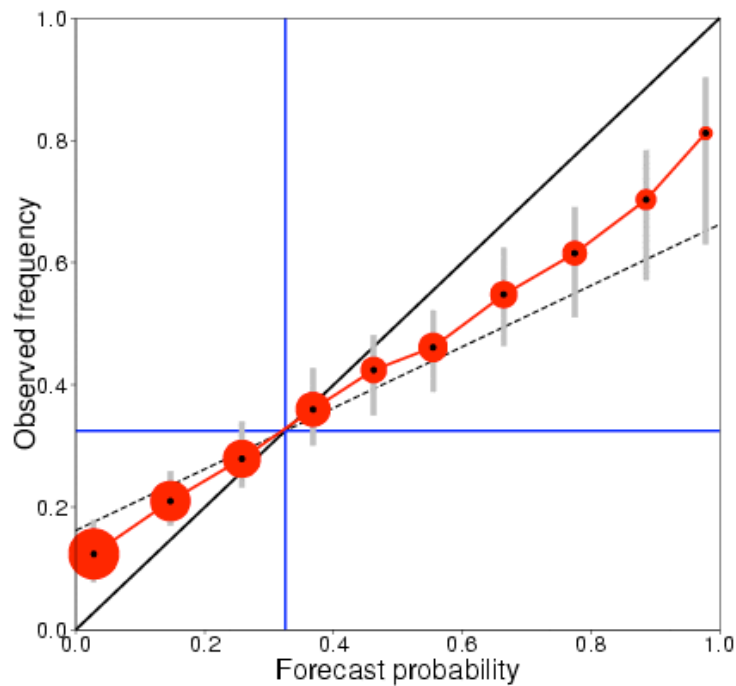
T2m anomaly above the upper tercile - Global average



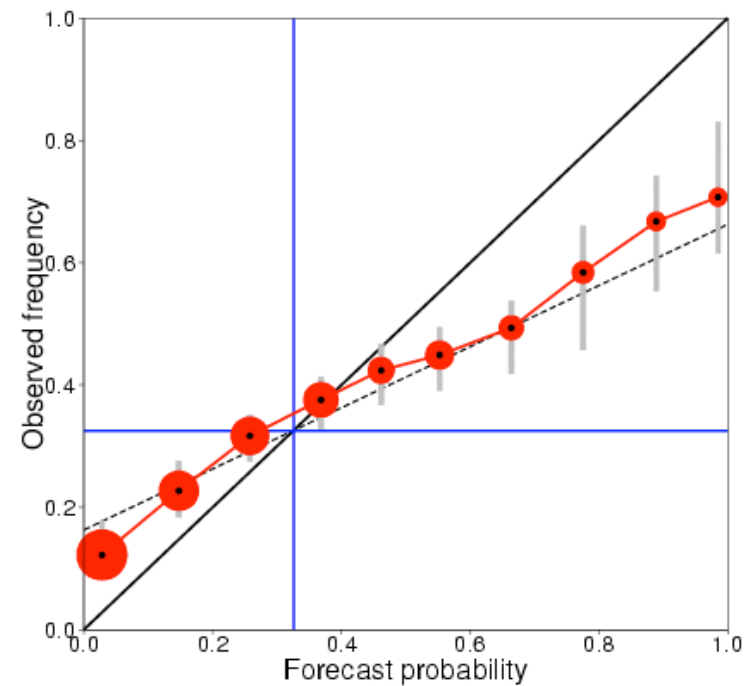


## Reliability diagrams - T2m - 6-9 yr

T2m anomaly below the lower tercile - Global average



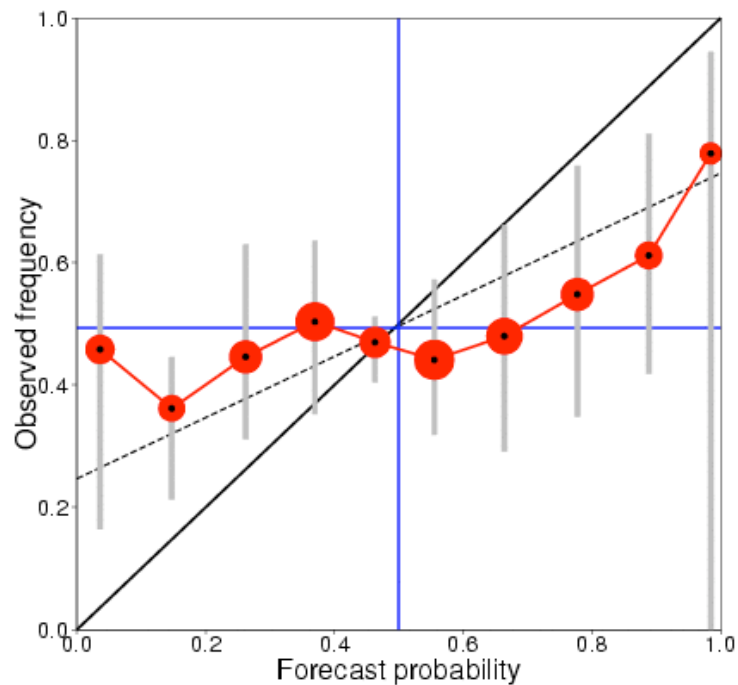
T2m anomaly above the upper tercile - Global average



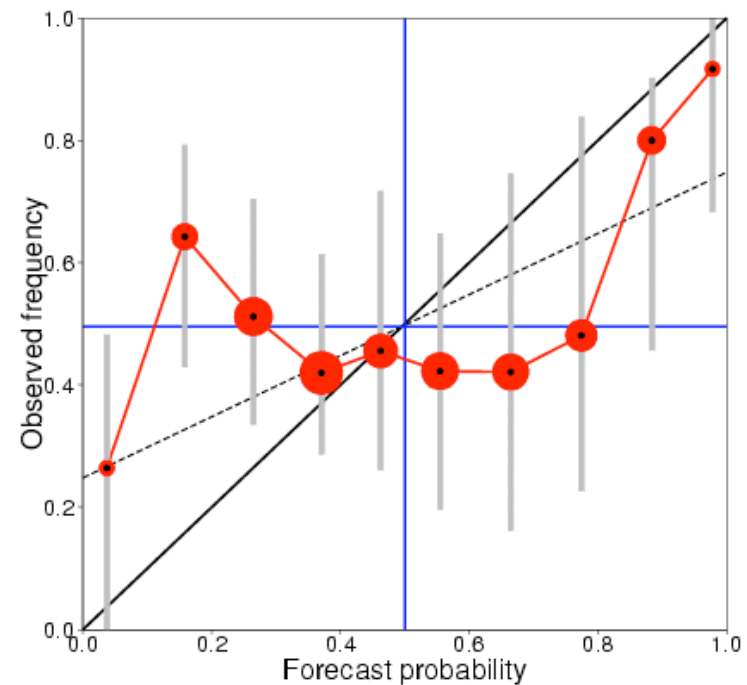


## Reliability diagrams - T2m - 2-5 yr

T2m anomaly above the median over Europe



T2m anomaly above the median over North America



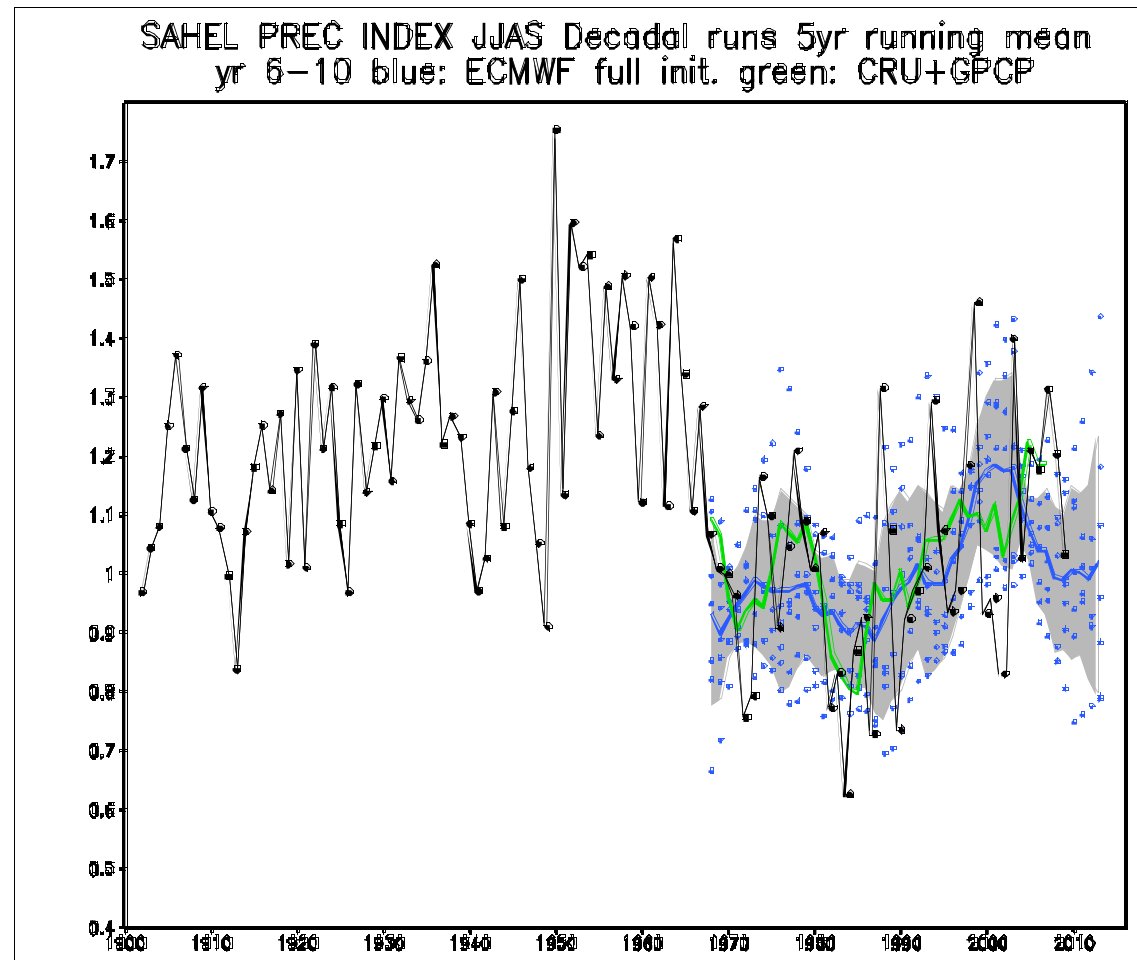
## Summary

- 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.



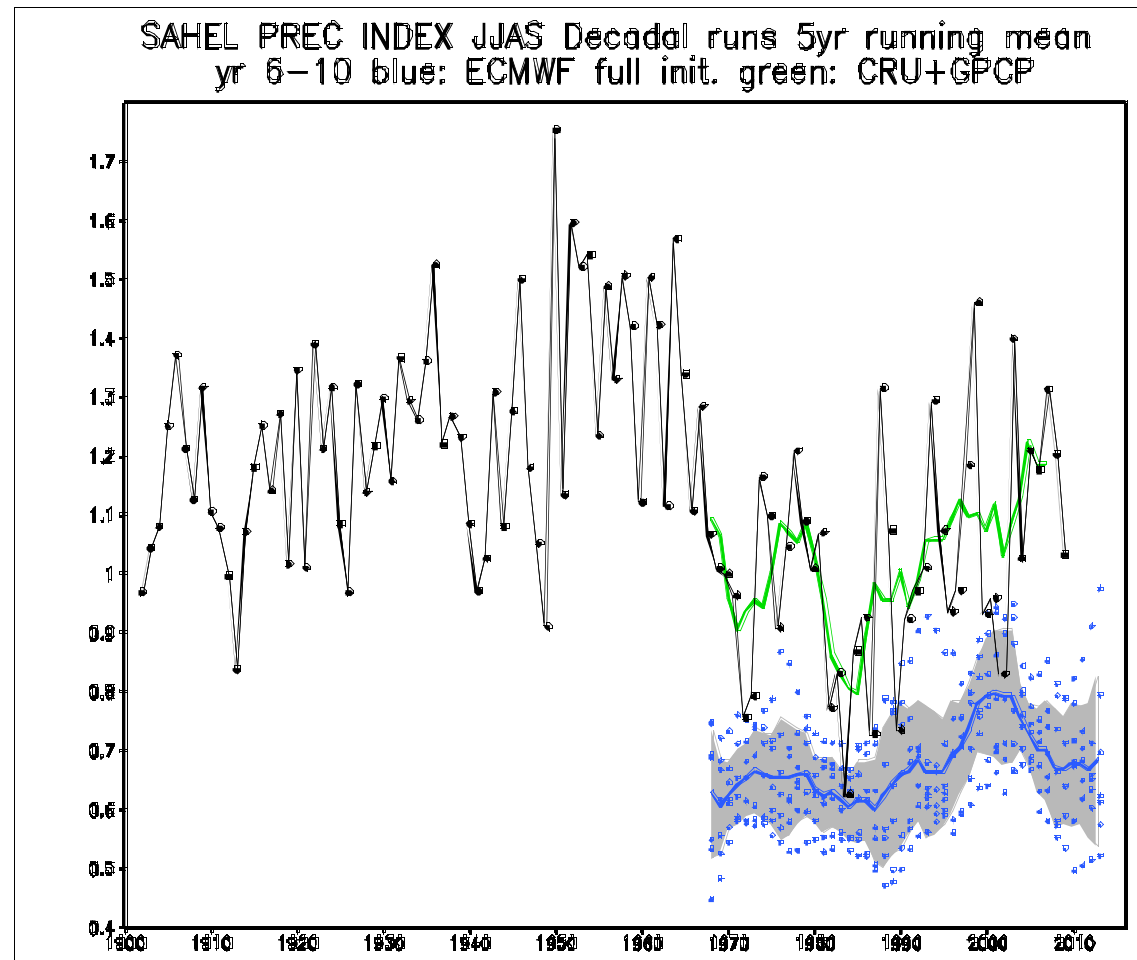


## Yr 6-10 Full Initialisation (bias correction)





## Yr 6-10 Full Initialisation





# Yr 6-10 Full Initialisation

