Previsioni decadali.
Stato dell'arte, Prospettive e Opportunita'

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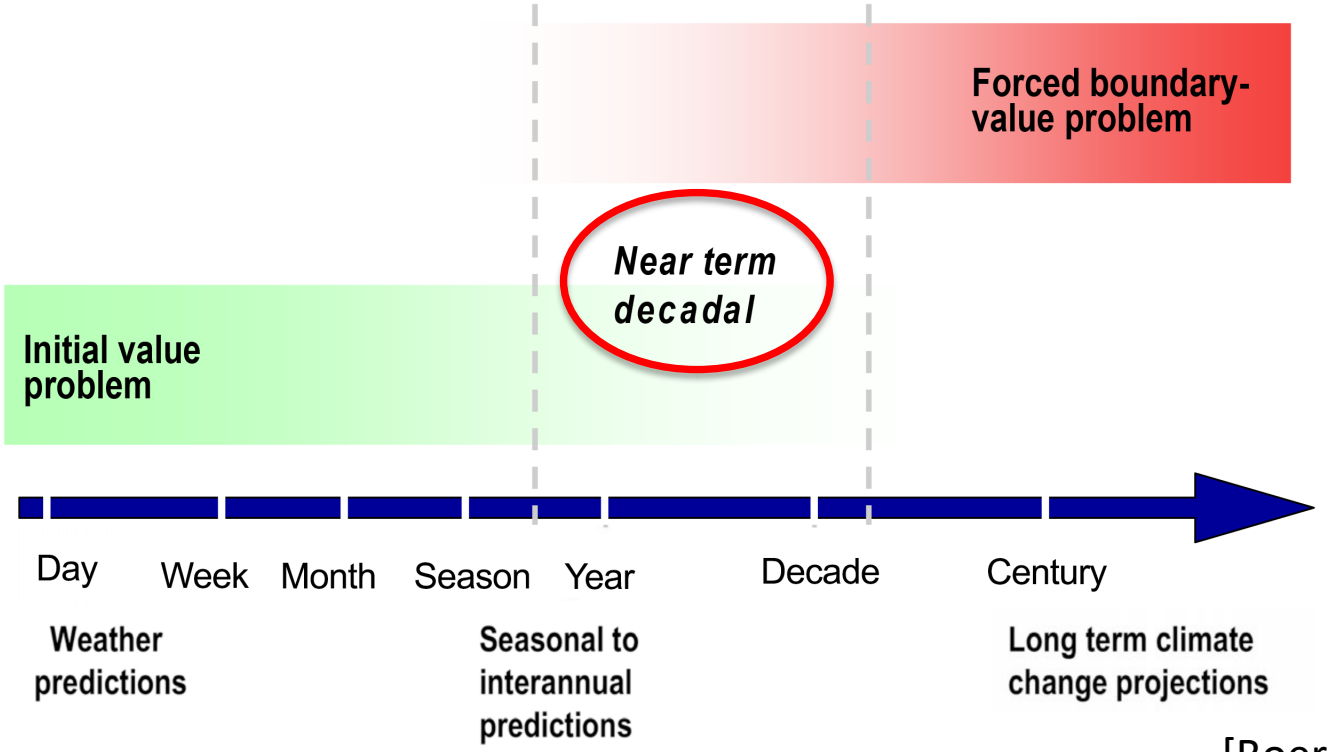
[*] On behalf of the CMCC Climate Prediction Group

BLUE ACTION
Arctic Impact on Weather and Climate

EUCP
European Climate Prediction system
Grant Agreement 776613

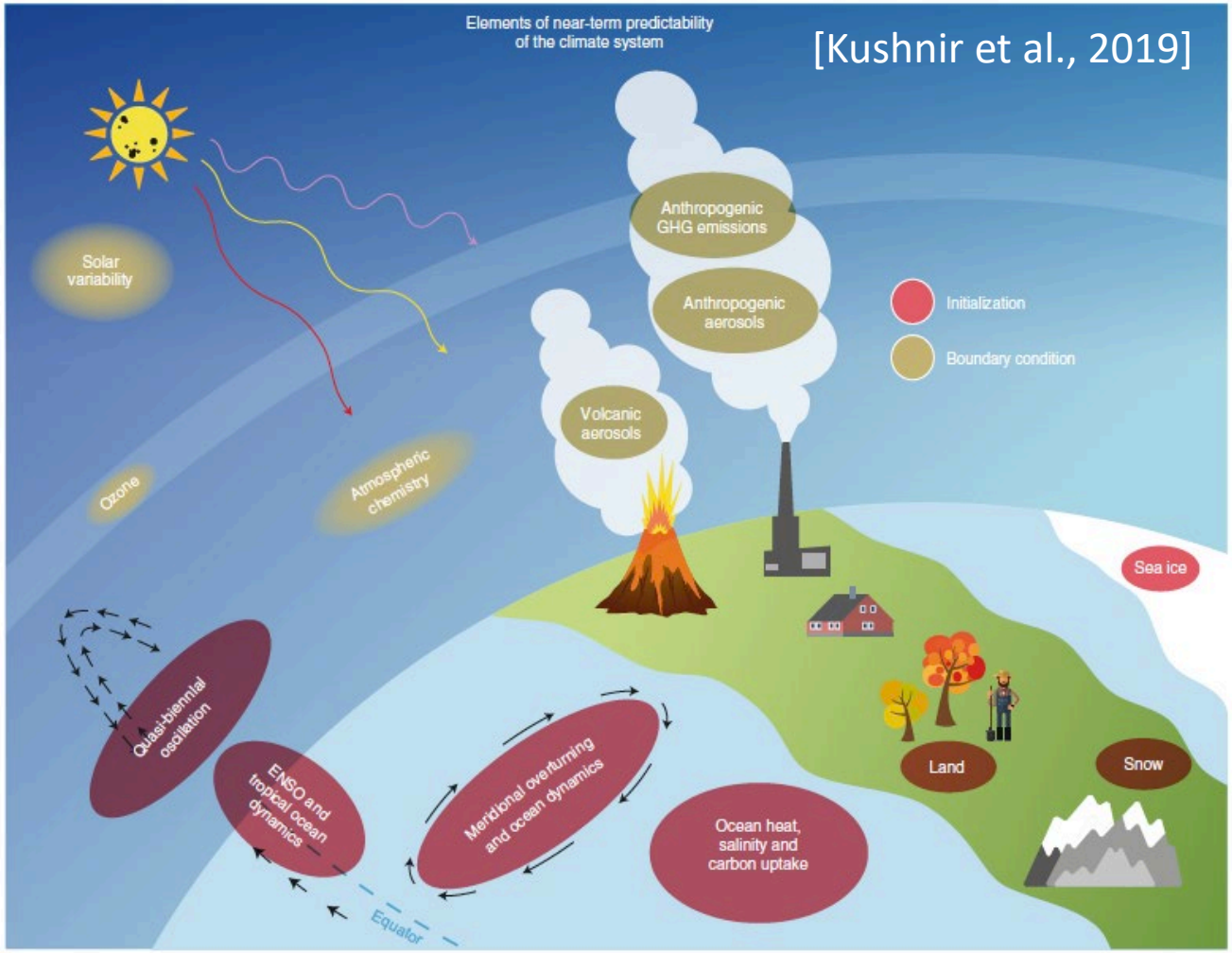
cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

Decadal Climate Prediction



[Boer et al., 2016]

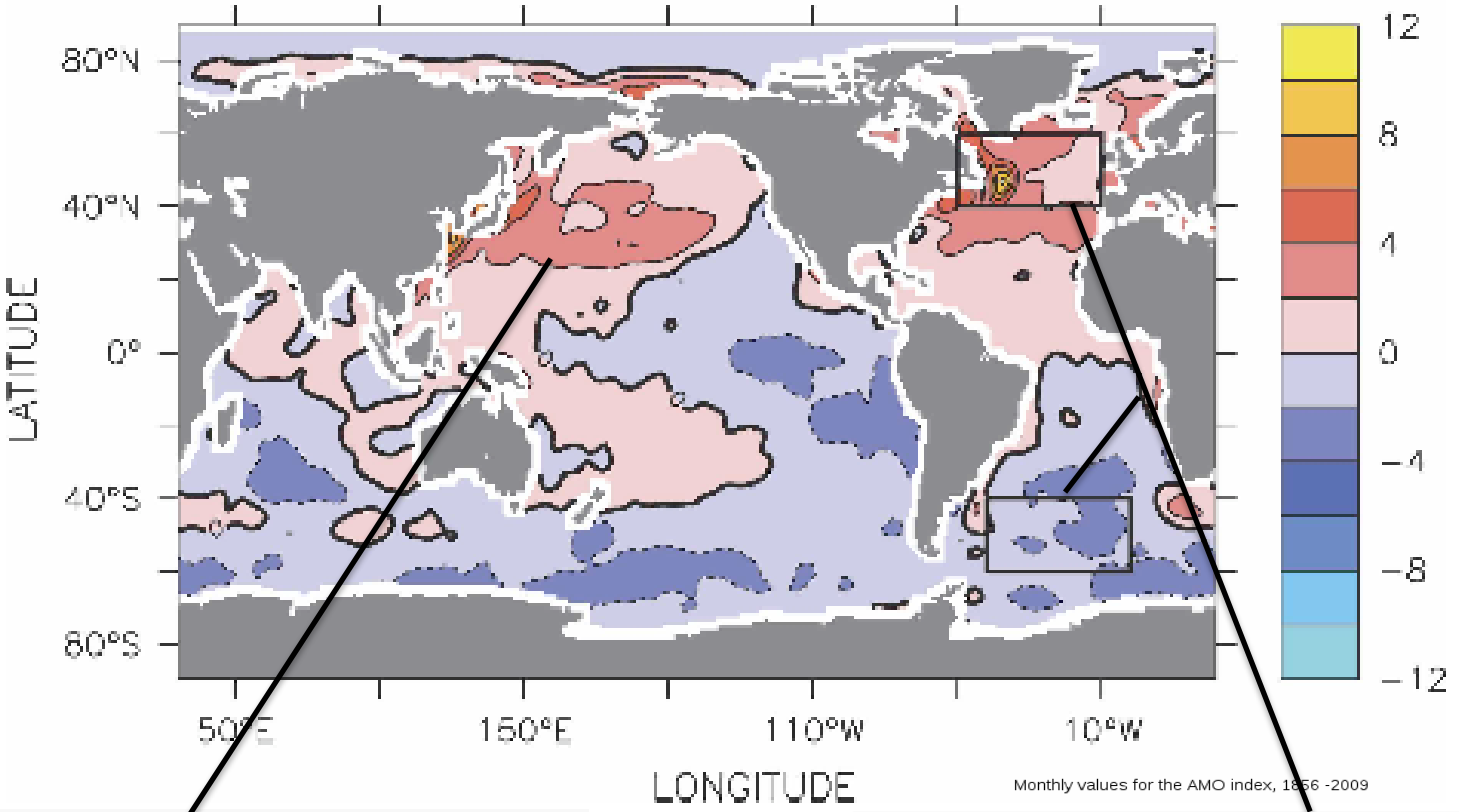
Decadal predictions lie at the confluence between initial-value seasonal/interannual forecasts and boundary-value century scale projections. As such, DP represent a **hybrid initial/boundary-value problem**, potentially benefitting from both a realistic initial state assignment, and imposed boundary forcing (including GHG, Aerosols, solar variability, land use changes).

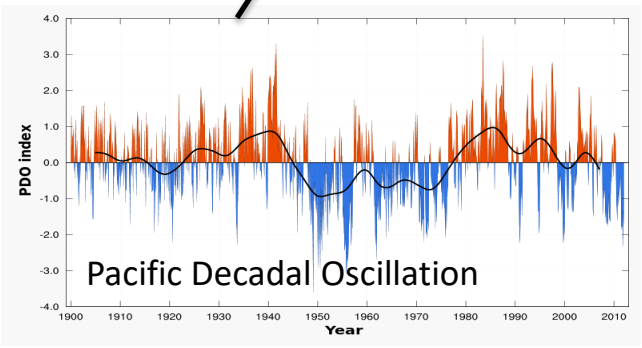


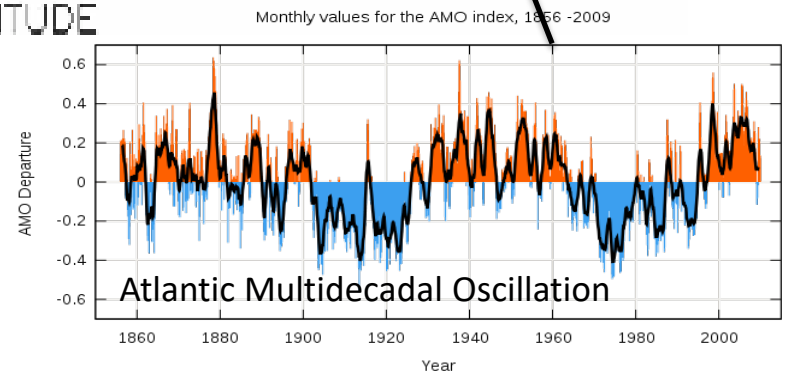
The premise of decadal prediction is that the coupled climate system — the atmosphere, ocean, land and cryosphere — contains elements, interactions and responses that are predictable on interannual to decadal timescales

Internal Climate Variability

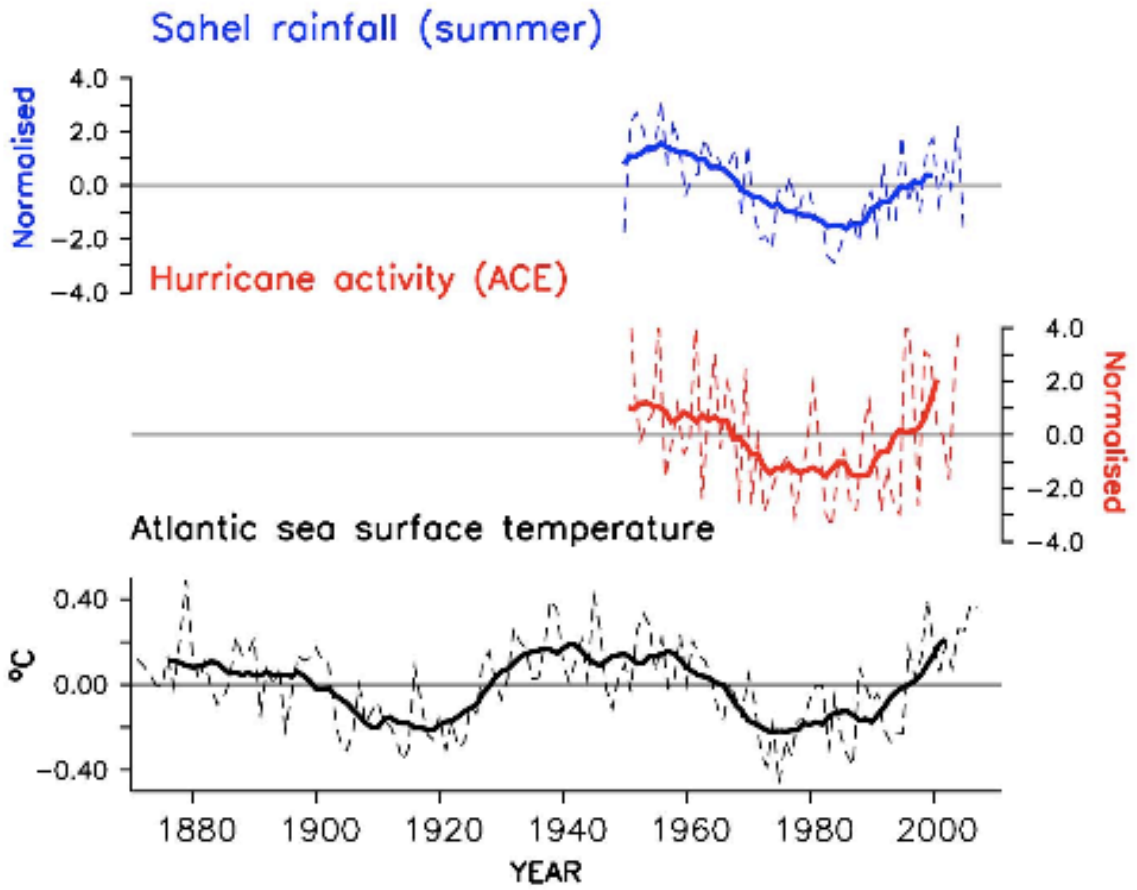
Linear SST trend (1980-2004) after removing the global mean trend (Latif et al. 2006)







Atlantic multi-decadal variability: impacts on Sahel precipitation and hurricane activity



Low-frequency fluctuations in the Atlantic SSTs can have profound socio-economic impacts.

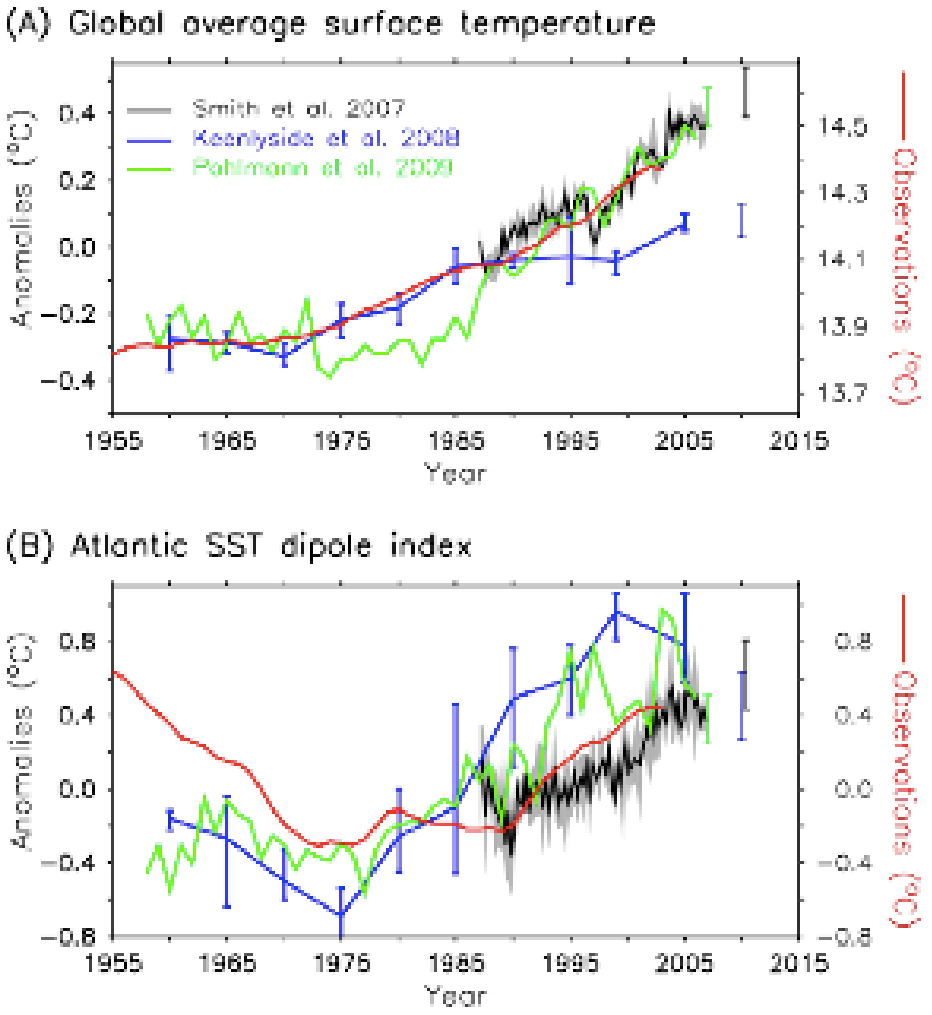
Early attempts towards reliable decadal predictions

◆ **Smith et al. (2007)**: global mean surface temperature predictive skill enhancement mainly from upper-**ocean heat content initialization.**

◆ **Keenlyside et al. (2008)**: skill in predicting North Atlantic SST changes induced by MOC, but overstimated due to overly strong MOC.

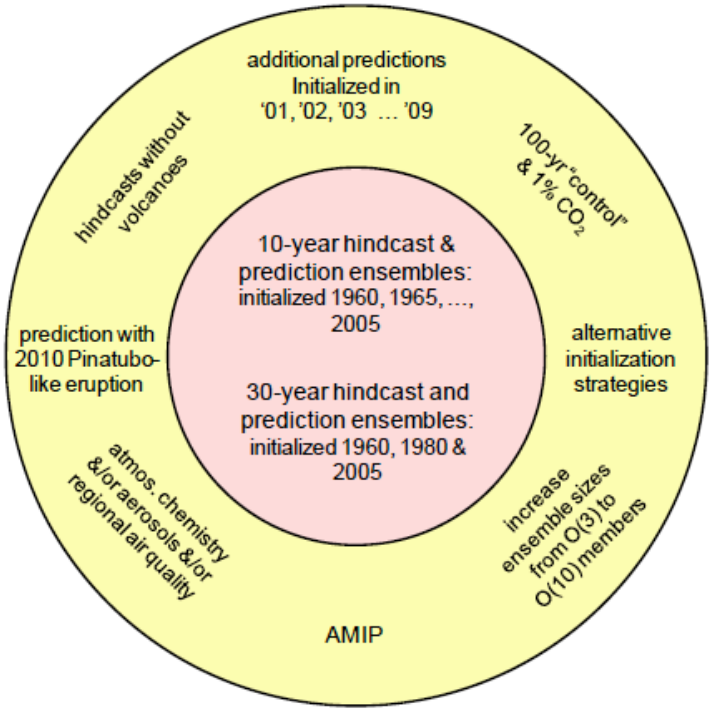
◆ **Pohlmann et al. (2009)**: predictive skill through initialization, particularly over the North Atlantic.

Differences in the results mirroring differences in the initialization, data and models?

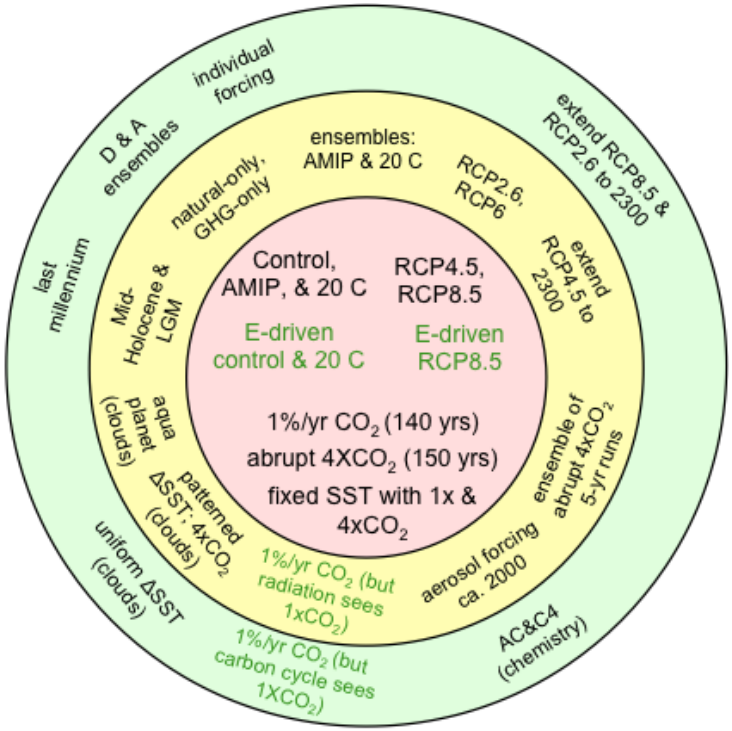


[Meehl et al. 2009]

CMIP5



Decadal Predictions

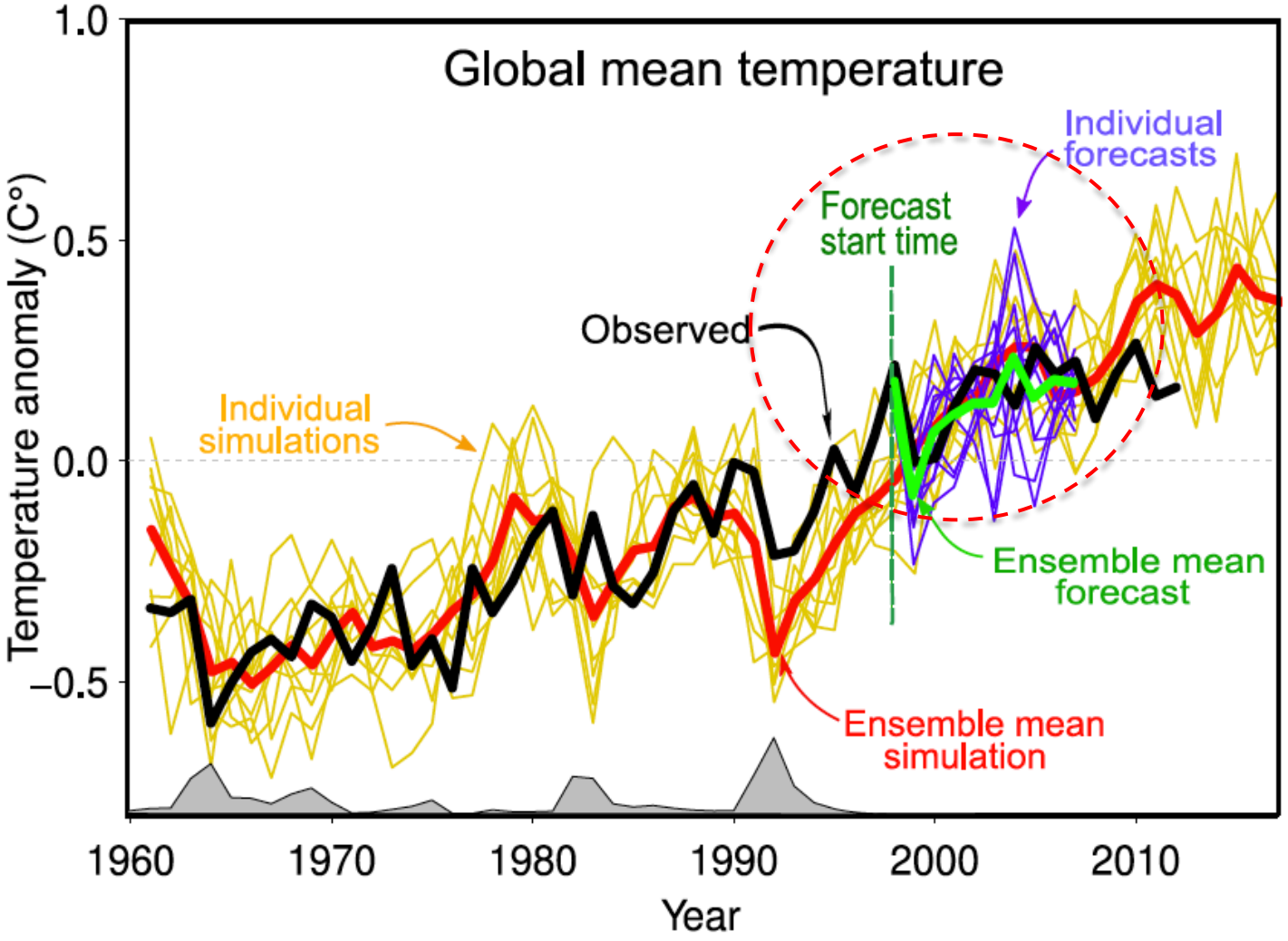


Long-term Experiments

(green font: experiments with models including carbon-cycle)

A multi-model set of coordinated near-term prediction experiments was carried out under the framework of CMIP5 (contributing to the IPCC WG1 AR5 assessment report), involving several climate centers around the world.

[WG1 AR5, Chap. 11]



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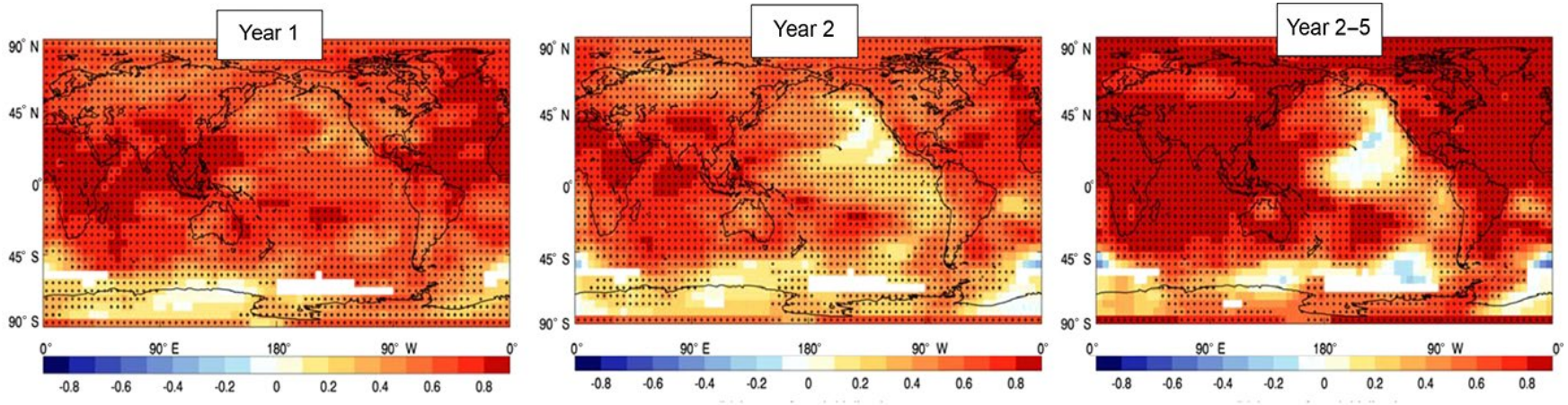
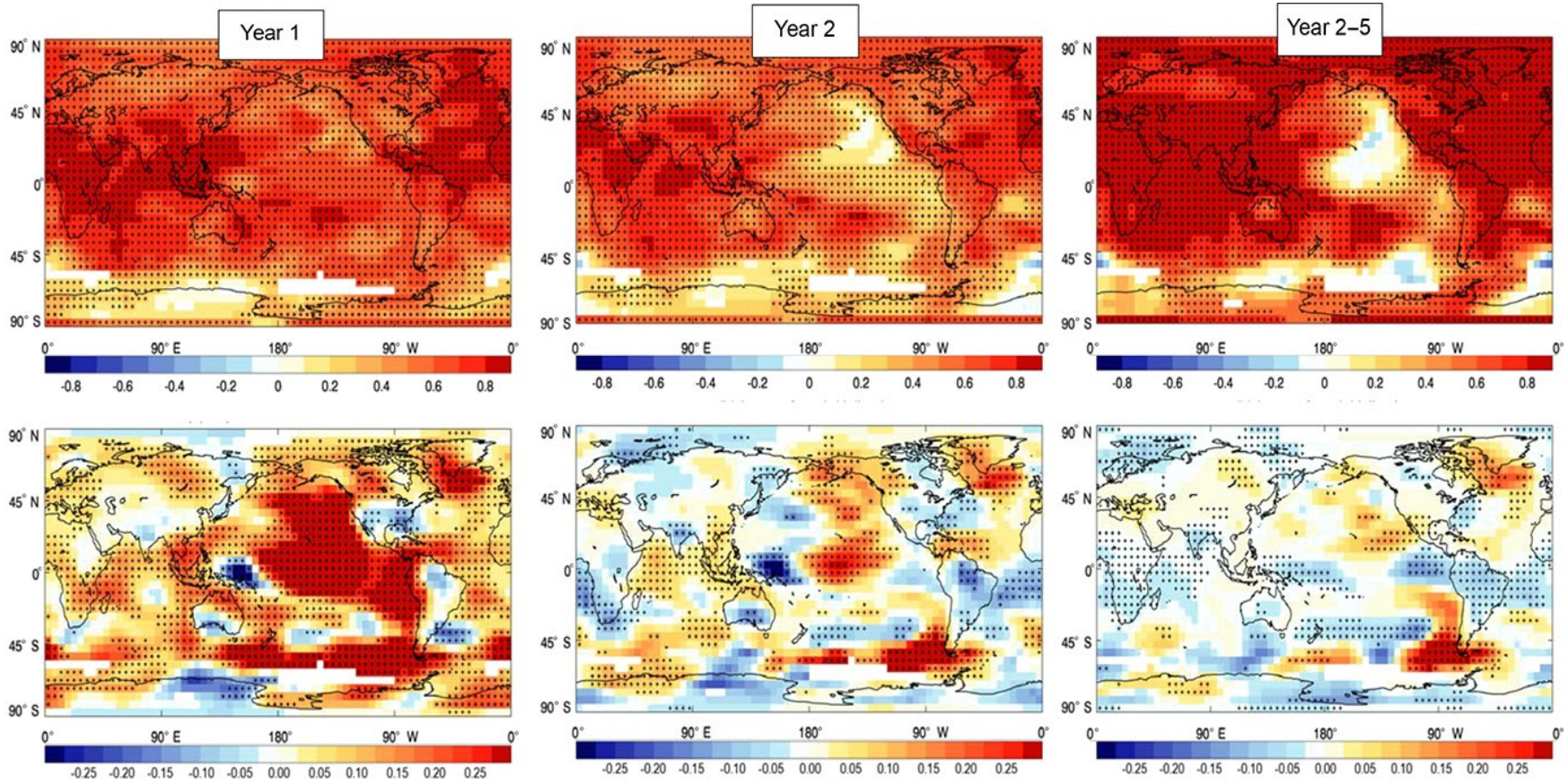
Lessons learned from CMIP5: the impact of initialization



[Boer et al. 2016]

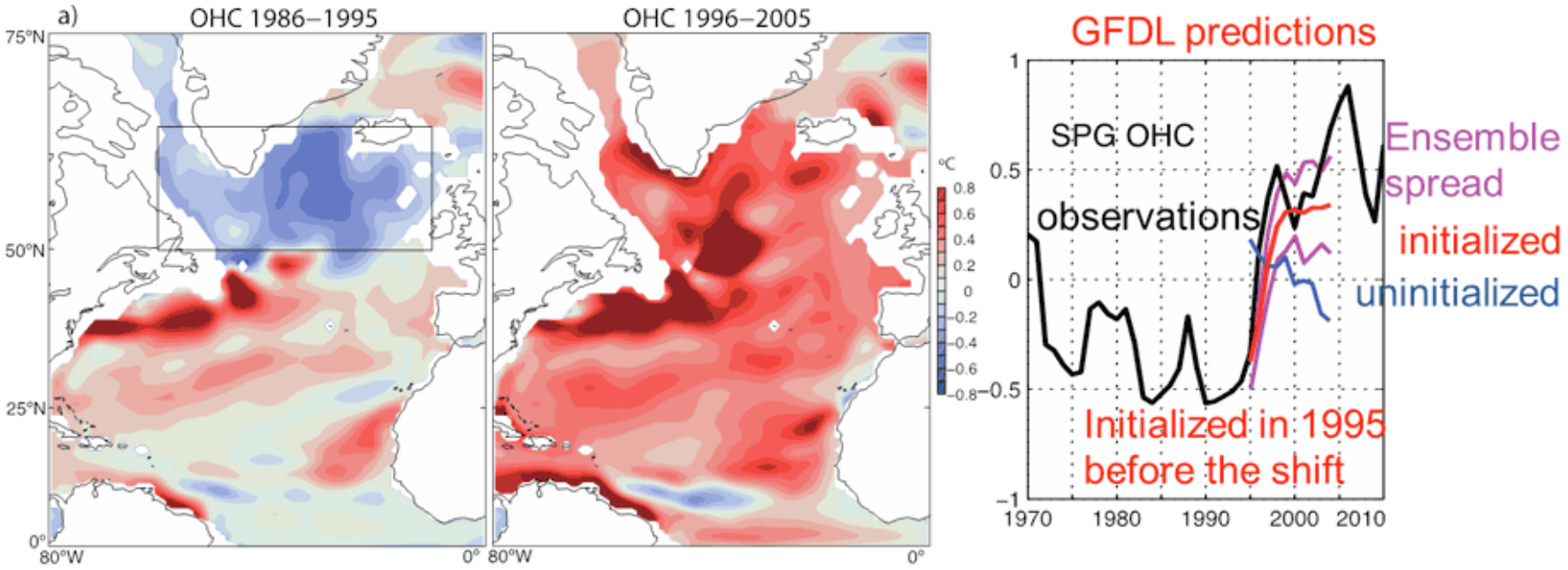
Total skill

Lessons learned from CMIP5: the impact of initialization



Residual skill (Init-NonInit)

The North Atlantic mid-90s warming



[Msadek et al., 2014]

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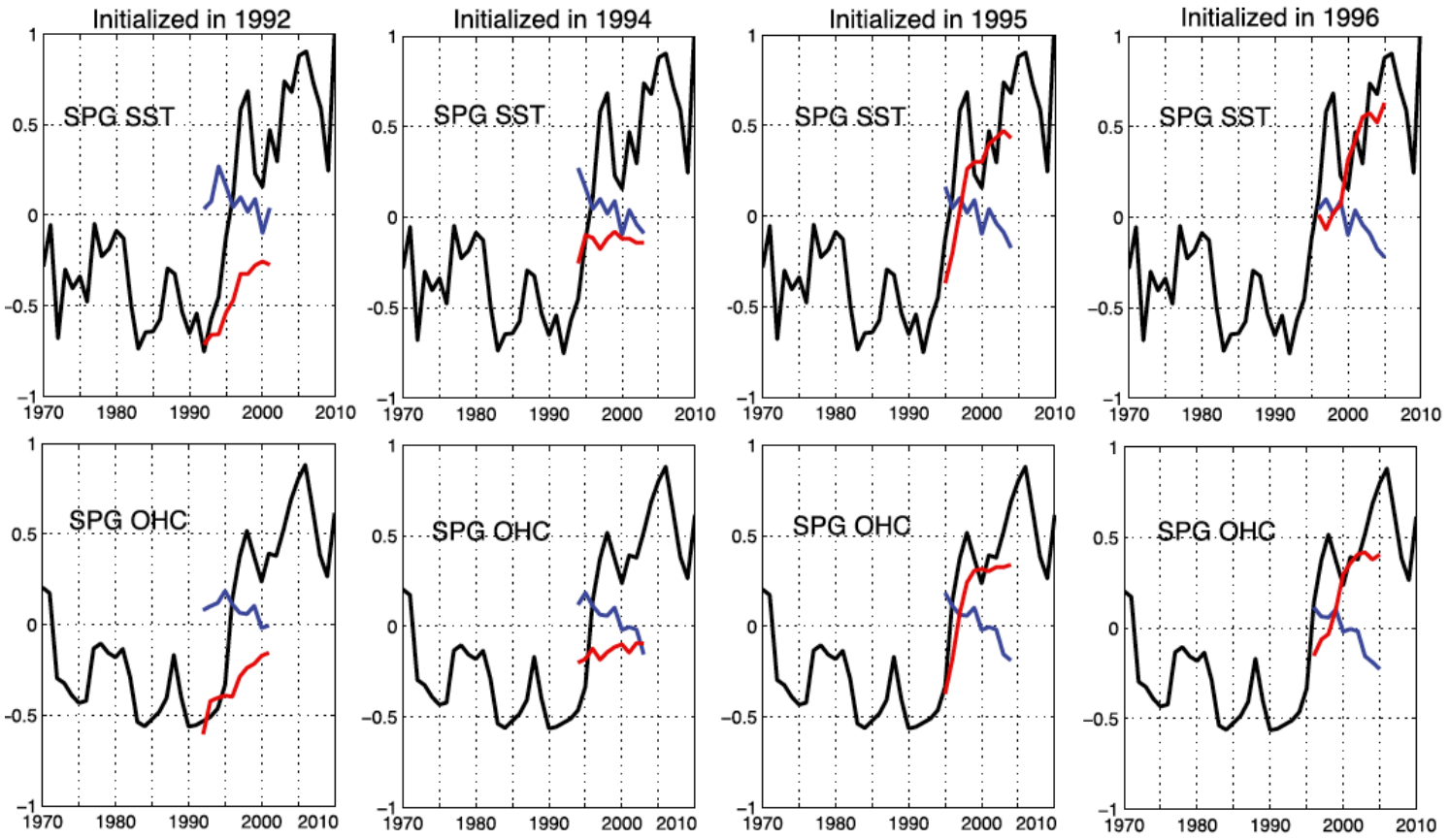
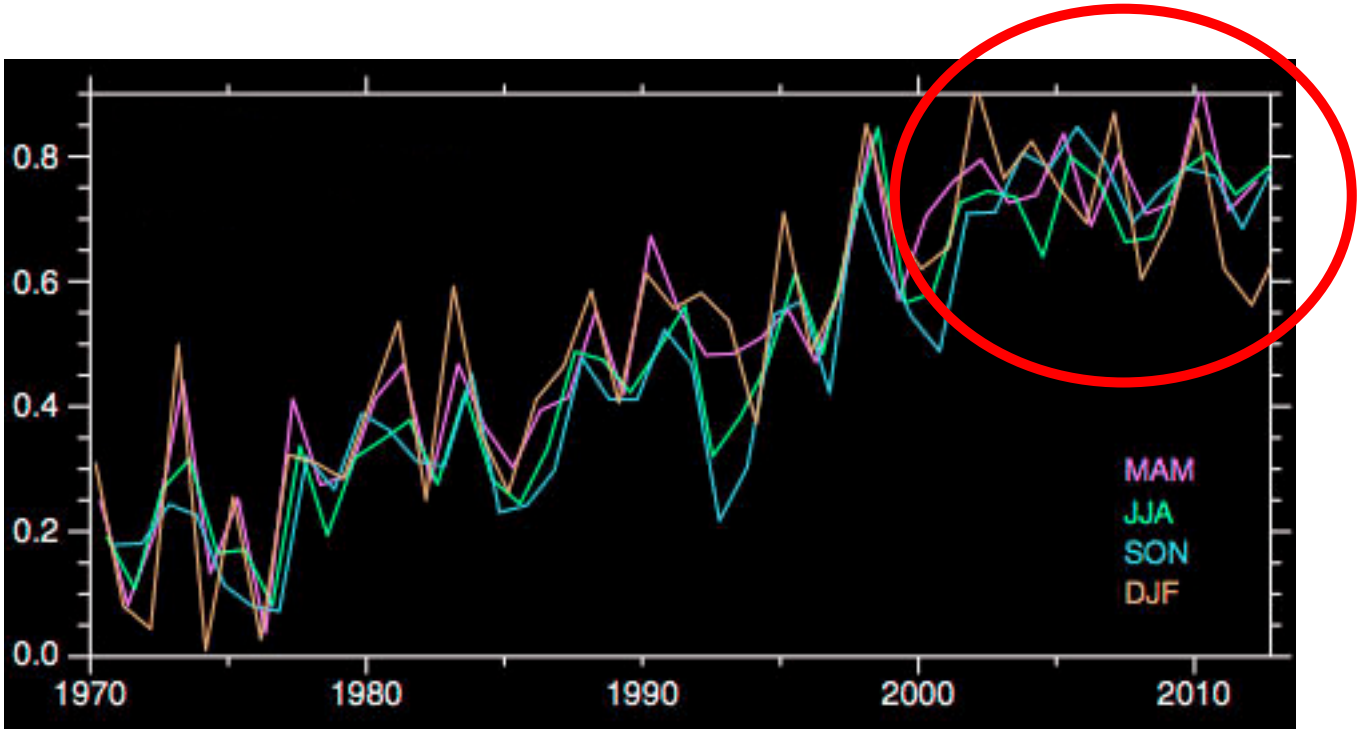


[Msadek et al., 2014]

The global warming hiatus



[Trenberth and Fasullo, 2013]

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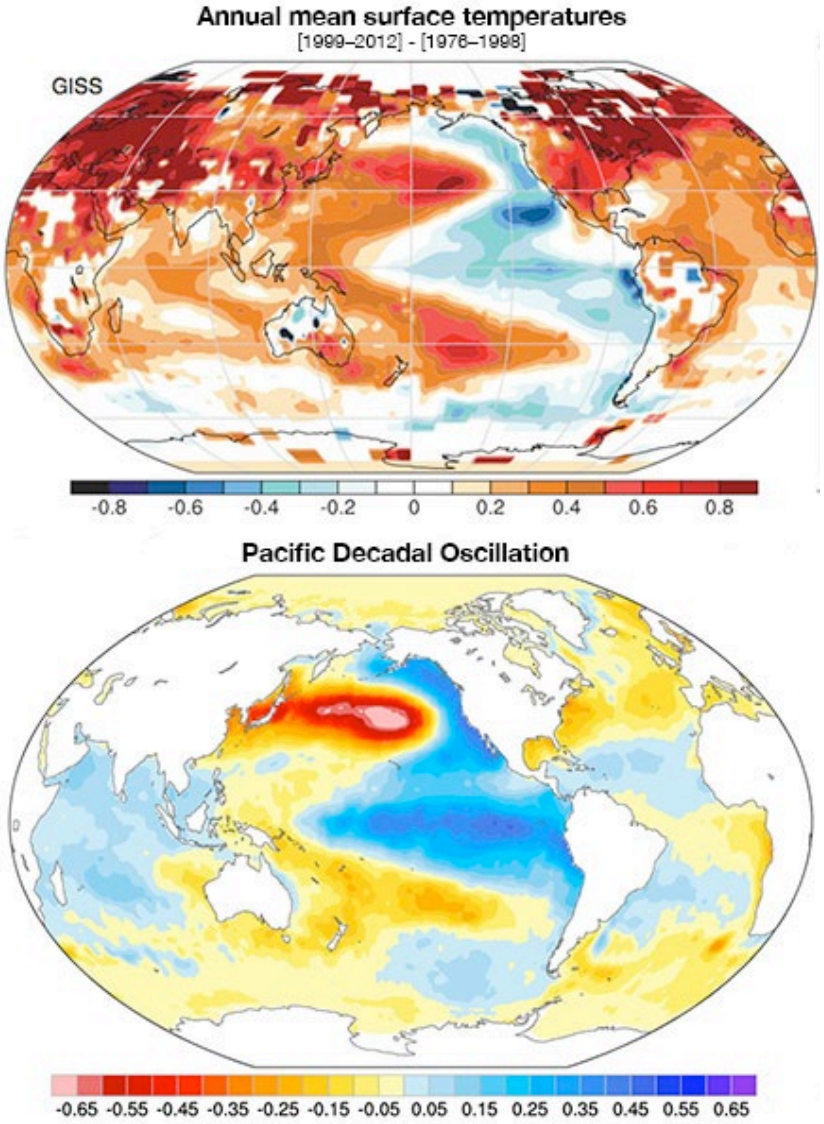

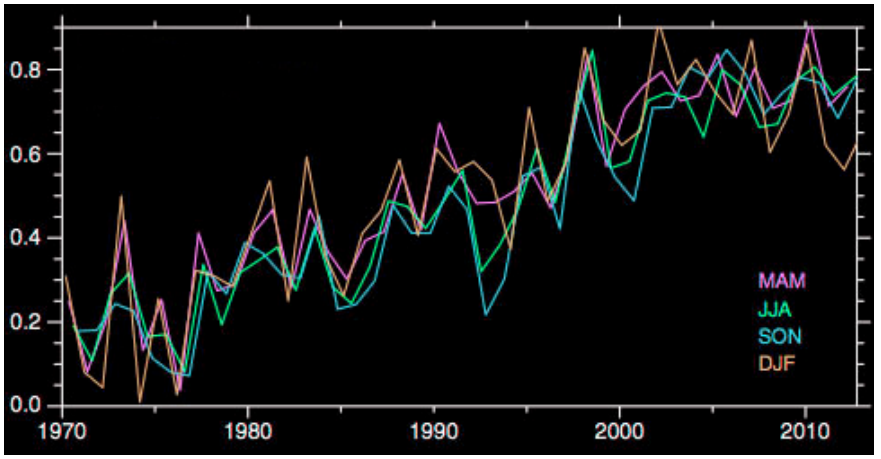

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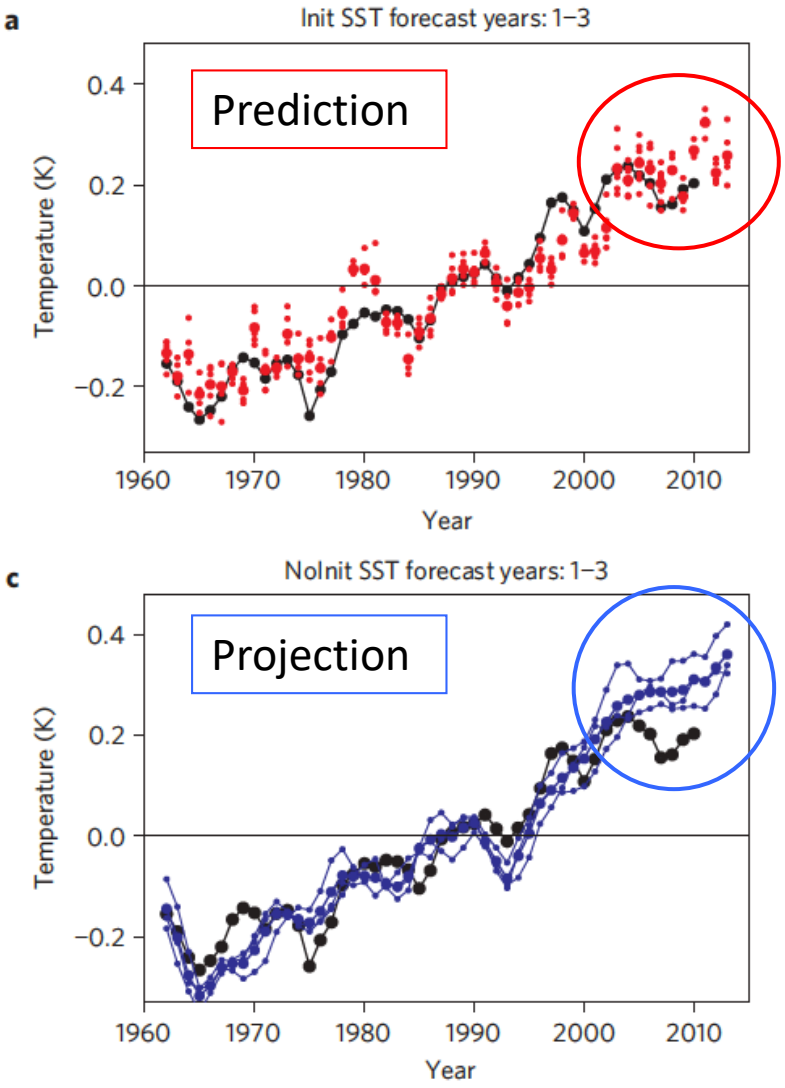

[Guemas et al., 2013]

WCRP Grand Challenge on Near-Term Climate Prediction

WCRP World Climate Research Programme

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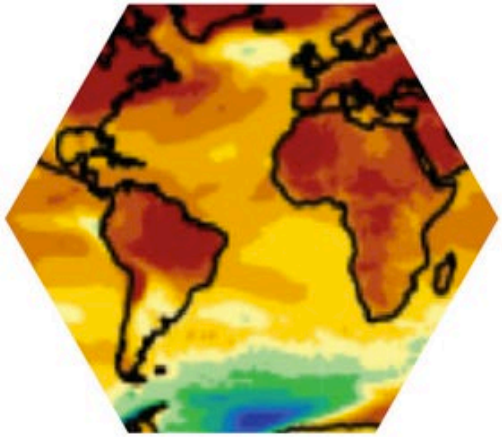
Near-Term Climate Prediction



The Grand Challenge on Near-Term Climate Prediction will support research and development to improve multi-year to decadal climate predictions and their utility to decision makers. It will furthermore support the development of organizational and technical processes for future routine provision of decadal prediction services that can assist stakeholders and decision-makers.

Background

The evolution of climate in the near term, out to a decade or two ahead, is the combination of natural climate variability and human-forced climate change (see Figure 1 below). Changes in natural variability are large enough from one decade to the next to temporarily exacerbate or counter underlying anthropogenic trends.

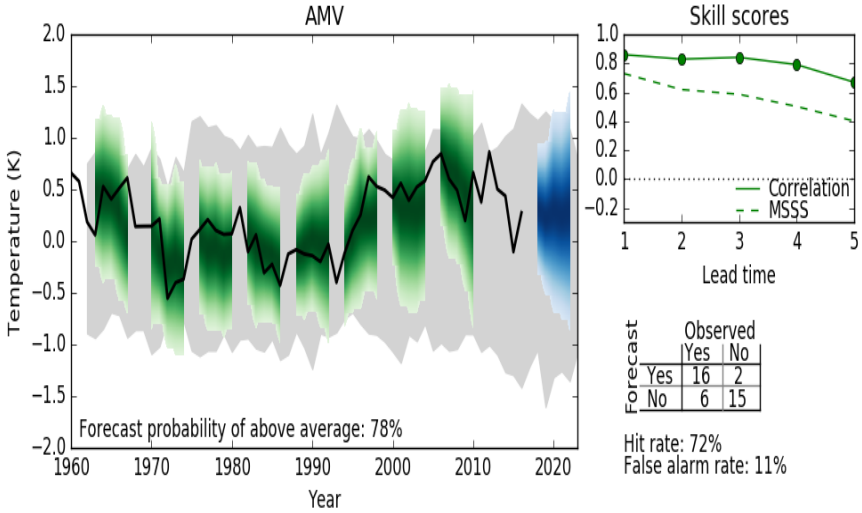
Collecting and disseminating decadal predictions. Promoting operational activity

Updated forecast as part of WMO activity

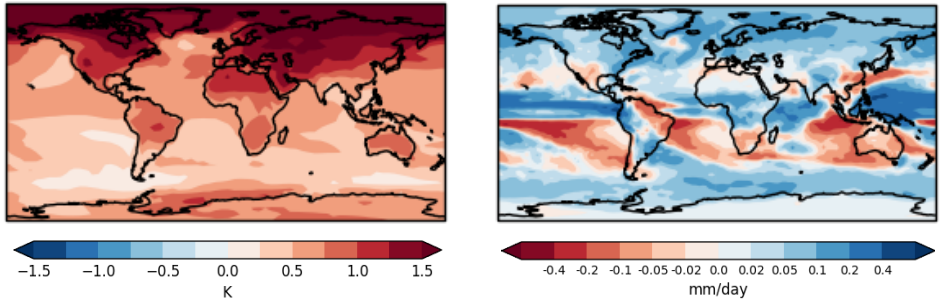
WMO Lead Centre for Annual-to-Decadal Climate Prediction

The Met Office is a designated Lead Centre for Annual-to-Decadal Climate Prediction (LC-ADCP). The LC-ADCP collects and provides hindcasts, forecasts and verification data from a number contributing centres worldwide.

Draft Annual to Decadal Climate Update



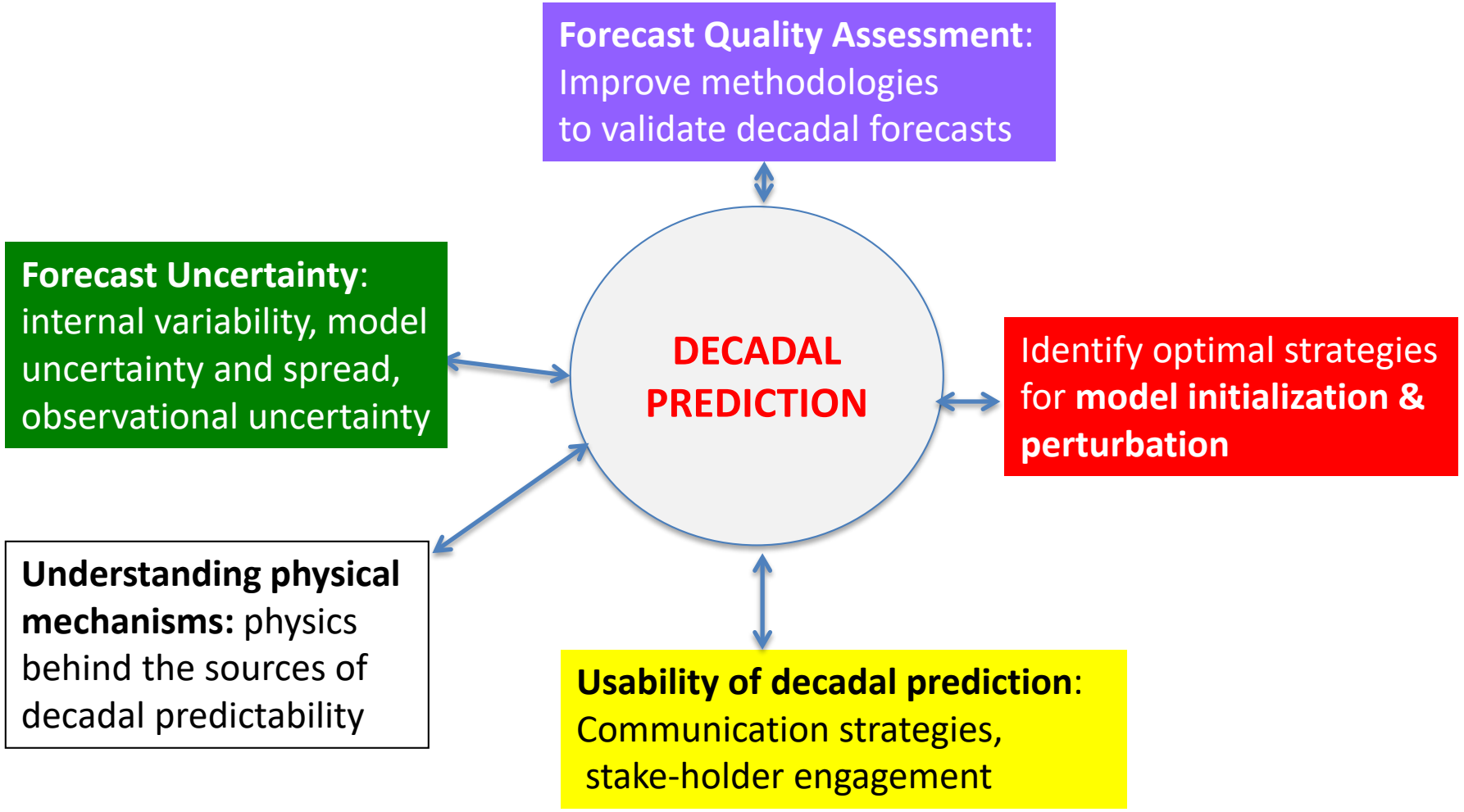
Multi-model forecast for 2018-2022



- Part of WCRP Grand Challenge on Near Term Climate Prediction
- Based on WMO decadal predictions
- Will be updated each year

[Courtesy of A. Scaife]

What is next?: Key issues and challenges for decadal predictions:



[Outcomes of EUCP-organised workshop on "Scientific knowledge gaps related to decadal climate prediction", Barcelona, March, 2019.]

CMCC Decadal Prediction for CMIP6

- DPS based on **CMCC-CM2-SR5** model (Cherchi et al., 2018) – CAM5 1°x1° L30 TOA 2 hPa, NEMO3.6 1°x1° L50, CICE4, CLM4.5
- **Full value initialisation** based on:
- Ocean/Sea-Ice: **Ensemble of CMCC (**ORCA0.5) **ocean reanalyses** combining different assimilation schemes (SST nudging with/without 3DVAR assimilation of in-situ T/S) and atmospheric forcings (Yang et al., 2017)
- Atmosphere: ERA40/ERA-Interim atmospheric reanalyses
- Land: 2 **forced land analyses** (off-line land model forced with different atmospheric fluxes)
- Start dates: 1 Nov. 1960-2014 **every second year**
- **10-member** ensembles of **5-year** hindcasts
- Starting soon!

Questions?

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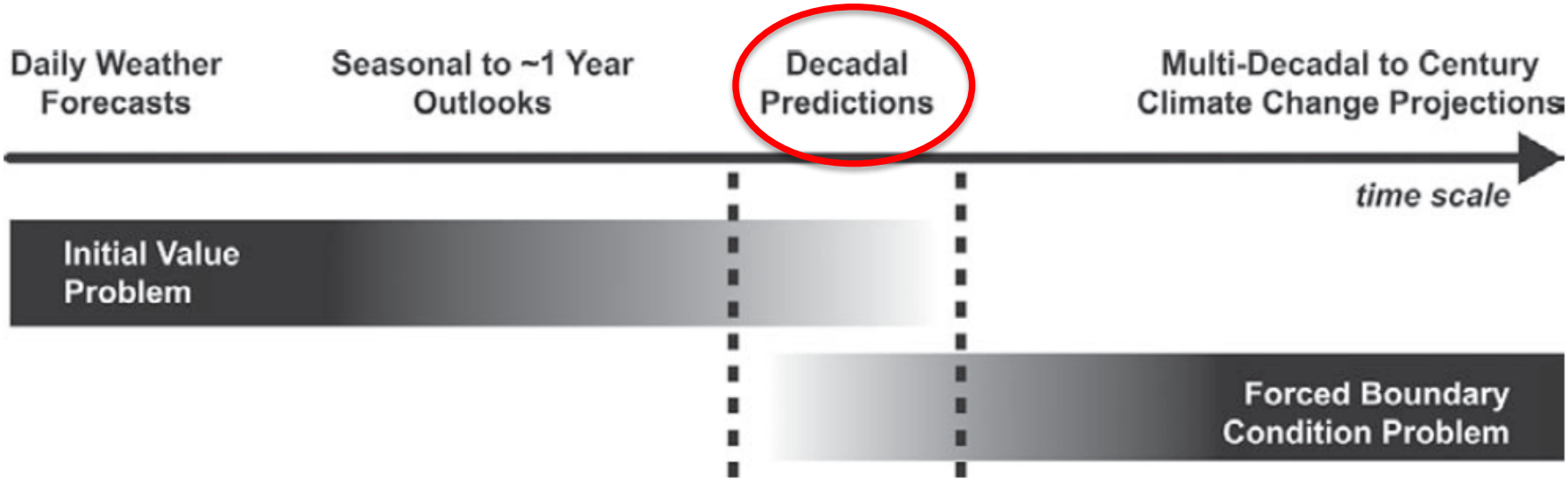
[*] NON-Senior Scientist @ CMCC

Decadal Climate Prediction



[Meehl et al., 2009]

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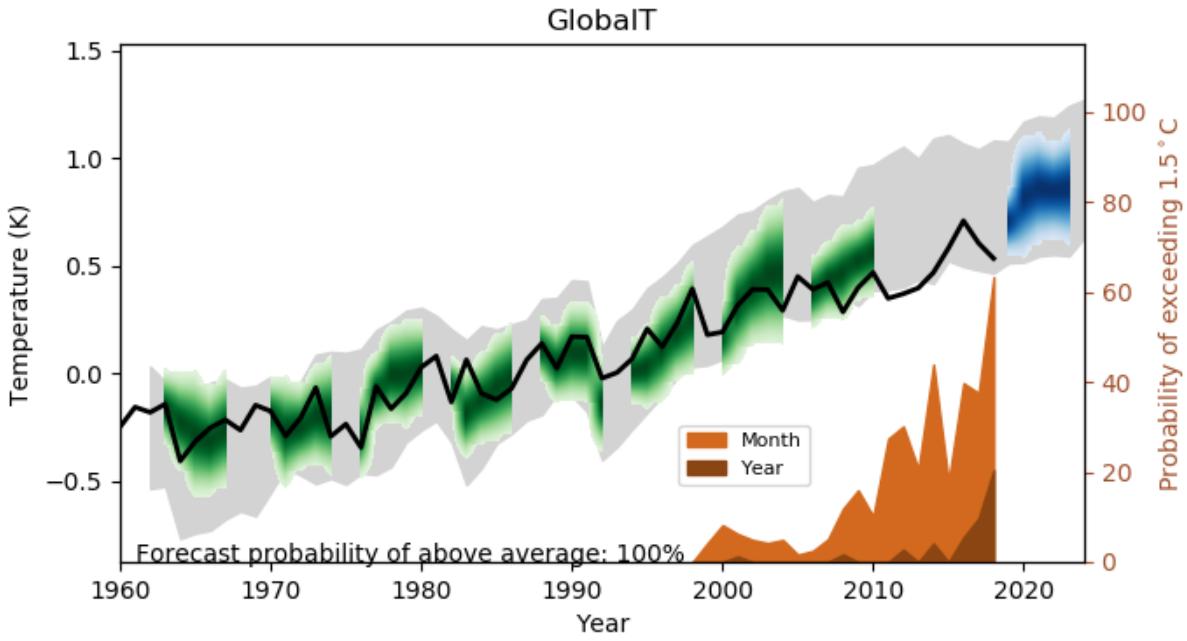
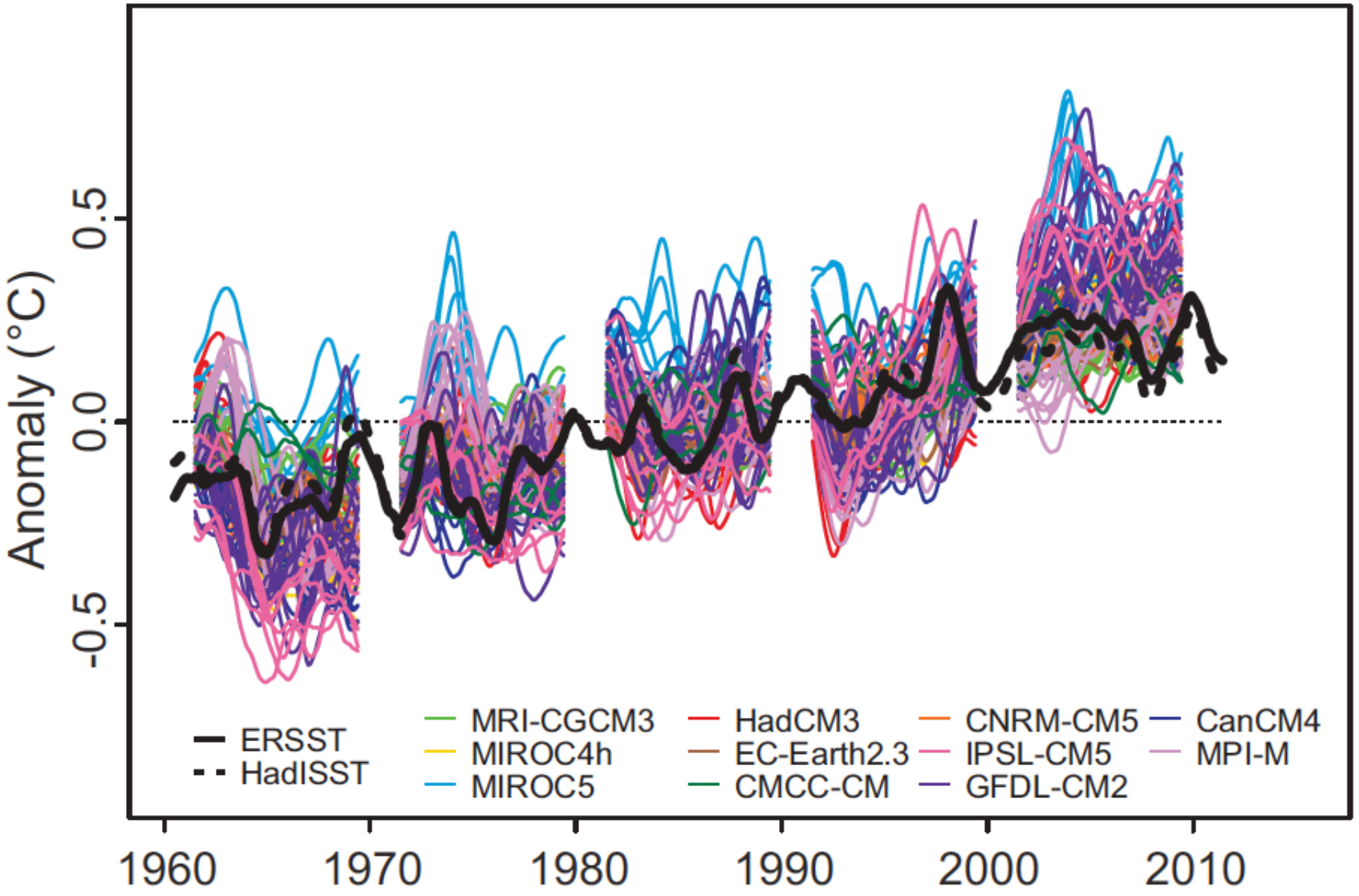
Collecting and disseminating decadal predictions. Promoting operational activity

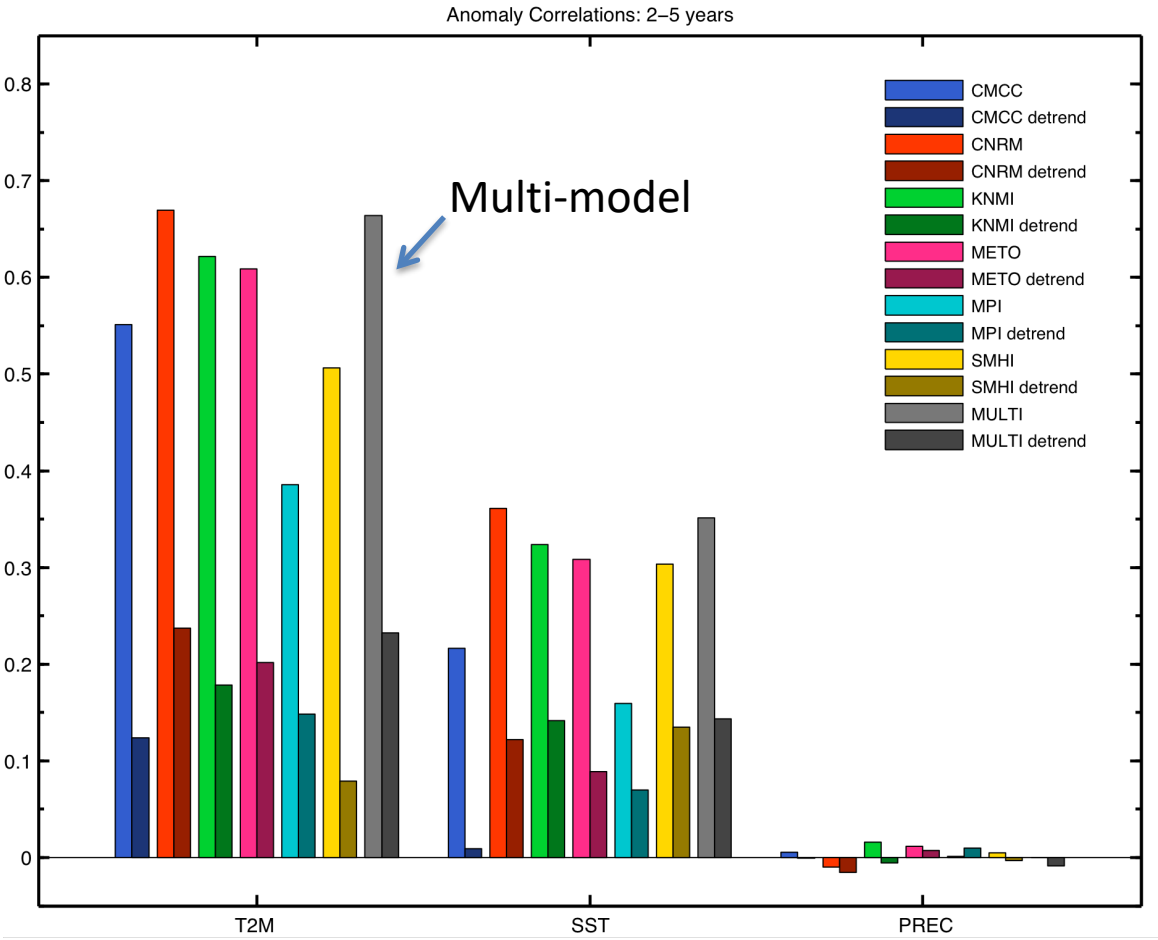


Forecast \ Observed	Yes	No
Yes	16	1
No	0	22

Hit rate: 100%
False alarm rate: 5%


Anomaly (°C)
0.5
0.0
-0.5
1960
1970
1980
1990
2000
2010
ERSST
HadISST
MRI-CGCM3
MIROC4h
MIROC5
HadCM3
EC-Earth2.3
CMCC-CM
CNRM-CM5
IPSL-CM5
GFDL-CM2
CanCM4
MPI-M

Lessons learned from CMIP5



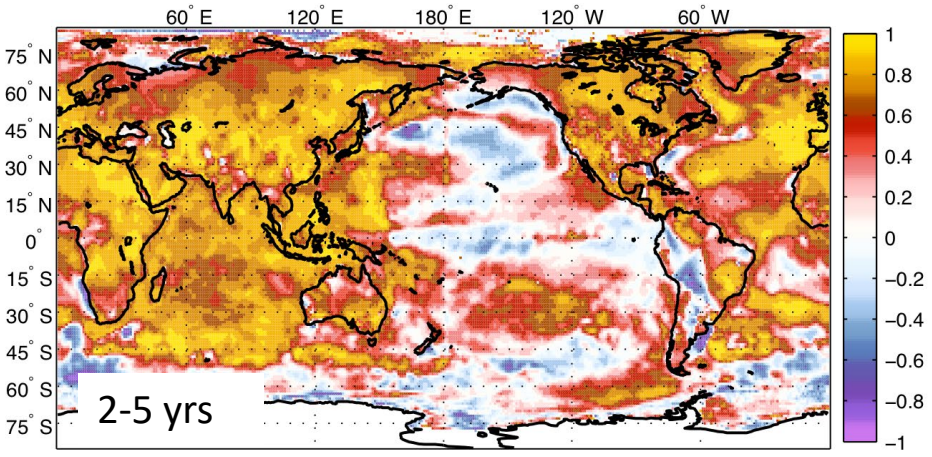
[Bellucci et al., 2014]

Multimodel Ensemble Mean outperforms (most of) individual model members

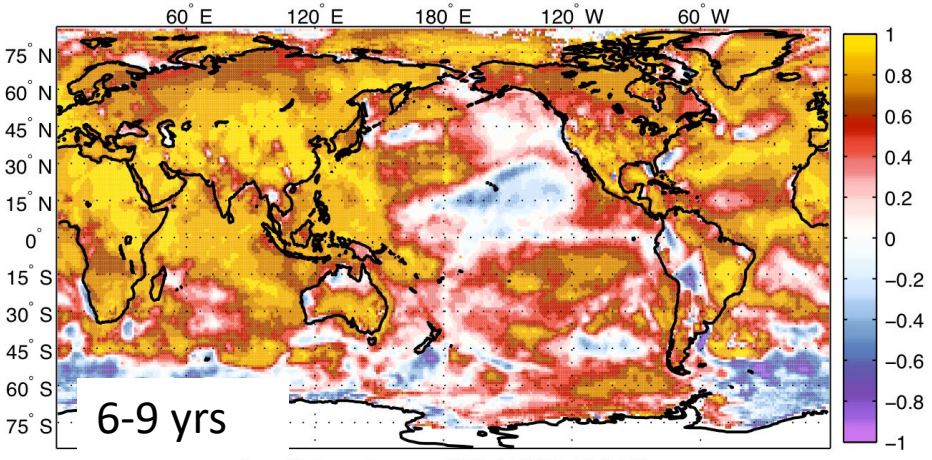
SST/T2M skill (ACC*) including trend

Statistically significant (90%, ACC>0.47) correlations over extensive portions of ocean and land.

ACC features a highly **inhomogeneous** distribution (negative ACC over Pacific and Southern Oceans, and over land, near the Andes)



Lead Time: 2–5 yrs (SST–T2M, MULTI)



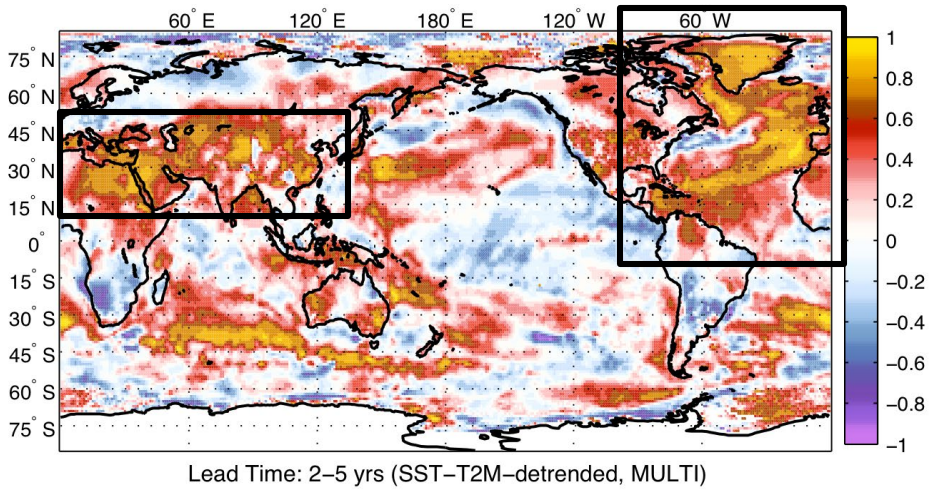
Lead Time: 6–9 yrs (SST–T2M, MULTI)

[*] ACC: Anomaly corr. between annual mean observations and MM ensemble mean anomalies [Bellucci et al., 2014]

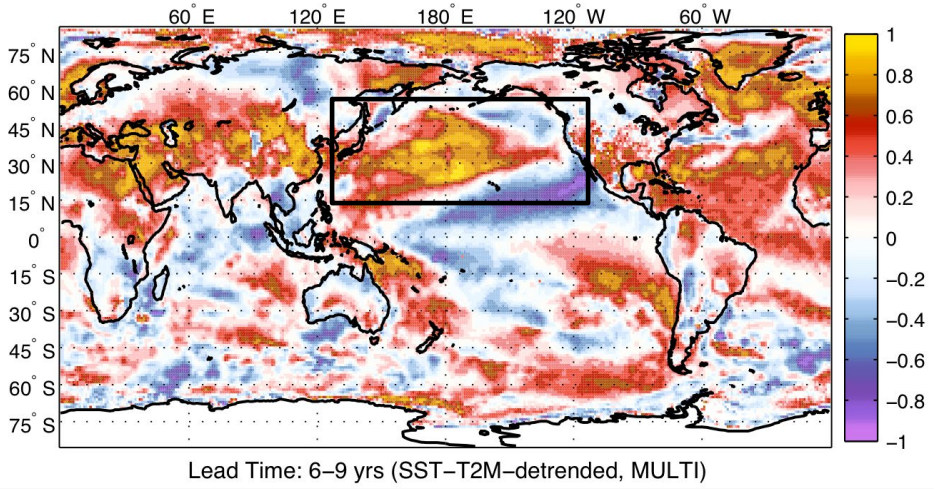
SST/T2M skill (ACC*) after removing a long-term linear trend

After detrending, **local forecast skill undergoes a dramatic reduction**, over most of the global domain.

Residual predictability beyond a pure trend is found over the extra-tropical North Atlantic, North Pacific and a zonal belt stretching from the Mediterranean basin, to Northern Africa and Eurasia.



Lead Time: 2–5 yrs (SST–T2M–detrended, MULTI)



Lead Time: 6–9 yrs (SST–T2M–detrended, MULTI)

[Bellucci et al., 2014]