Forecast Skill Assessment of Atlantic Tropical Activity over a 5-year Horizon

Louis-Philippe Caron

Climate Forecasting Unit, IC3, Barcelona

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Climate factors influencing Atlantic hurricane activity

Climate factor	Description	Timescale
North Atlantic Sea Surface Temperature		Annual, Decadal, +
El Niño Southern Oscillation	Oscillation in Tropical Pacific Ocean Temp.	Annual (~3-5 yr cycle)
West African Monsoon	Rainfall over Sahel region	Annual
North Atlantic Oscillation (NAO)	Seesaw pattern in sea level pressures b/w Iceland and the Azores	Annual
Solar activity		11-year cycle
Ozone concentration in upper atmosphere		Annual
Dust/aerosols over the Atlantic	Dust originating from Sahara desert	Annual
Madden-Julian Oscillation	Eastward propagating disturbances in the tropics	Intra-seasonal

• If slow variability in Atlantic TC activity is driven by North Atlantic SST

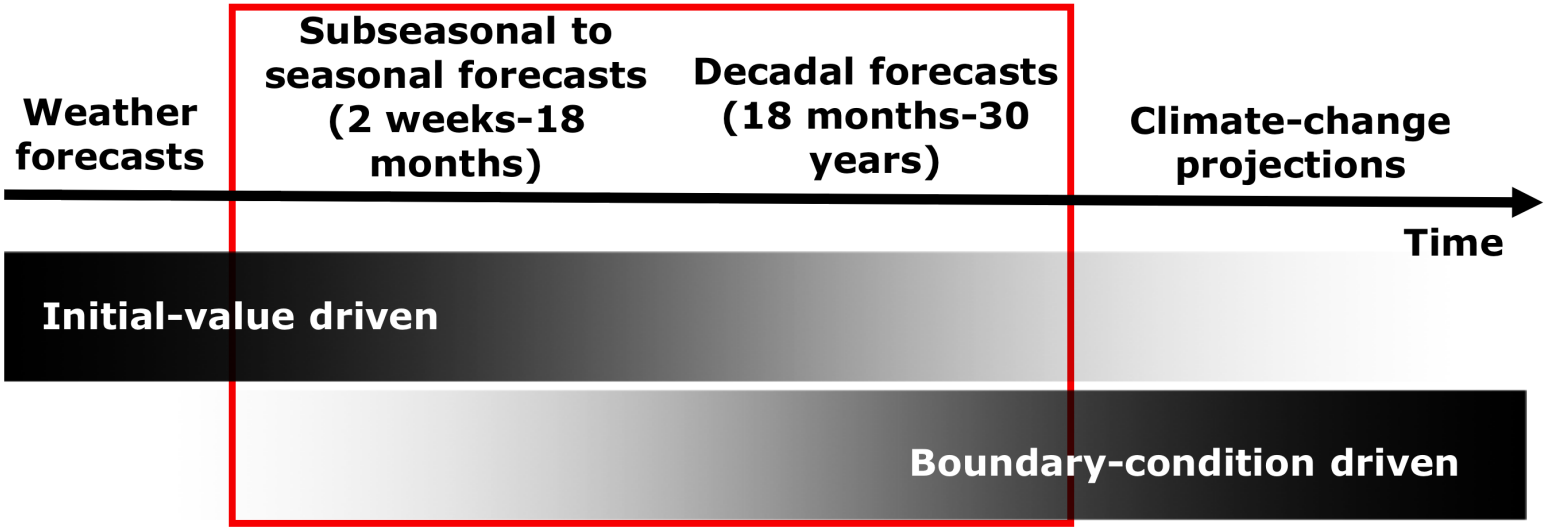
And

• If North Atlantic SST can be predicted at multi-annual timescale (5 yrs)

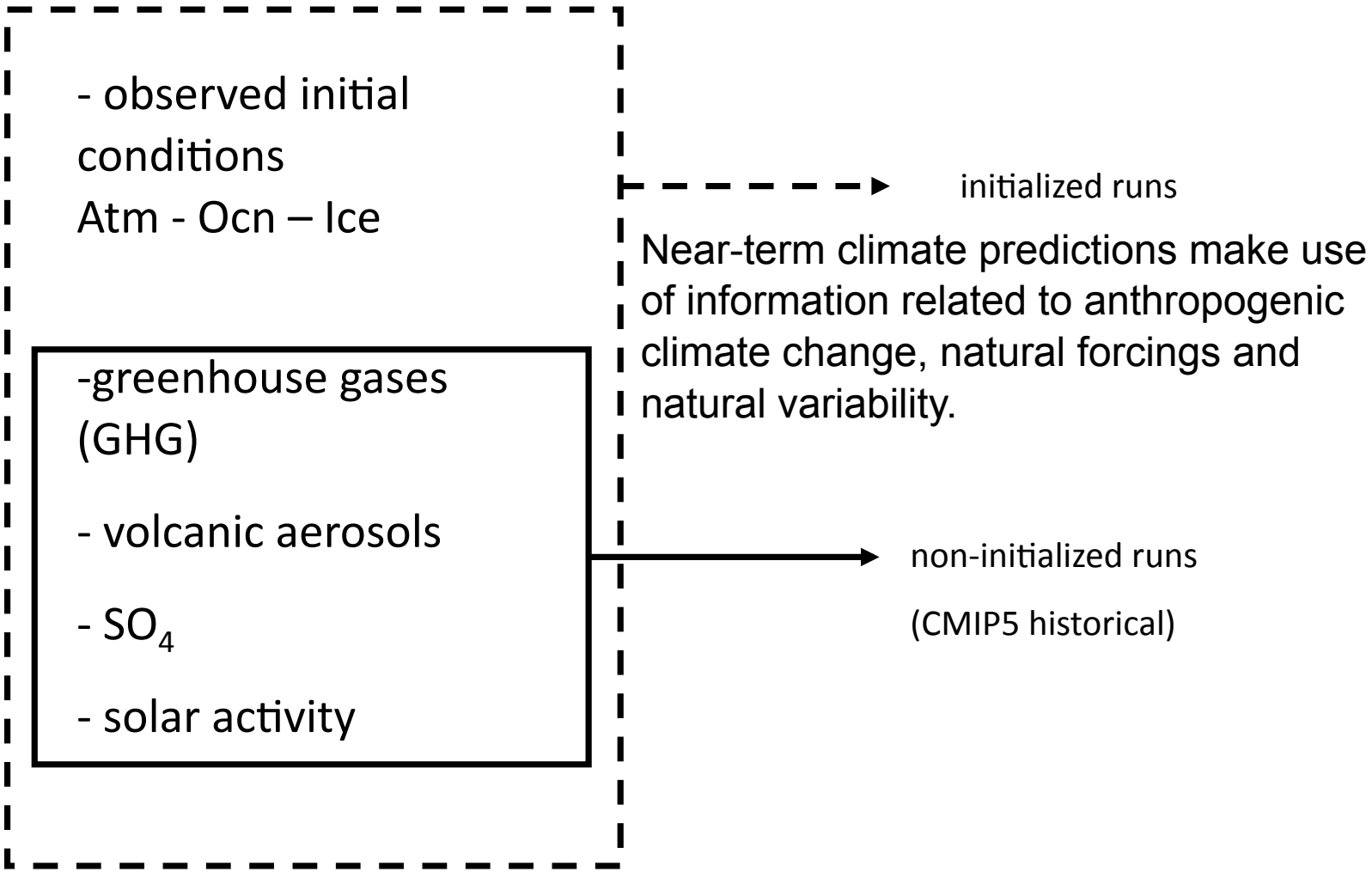
→ (Reliable) Multi-annual forecasts of Atlantic TC activity should be possible

Climate prediction

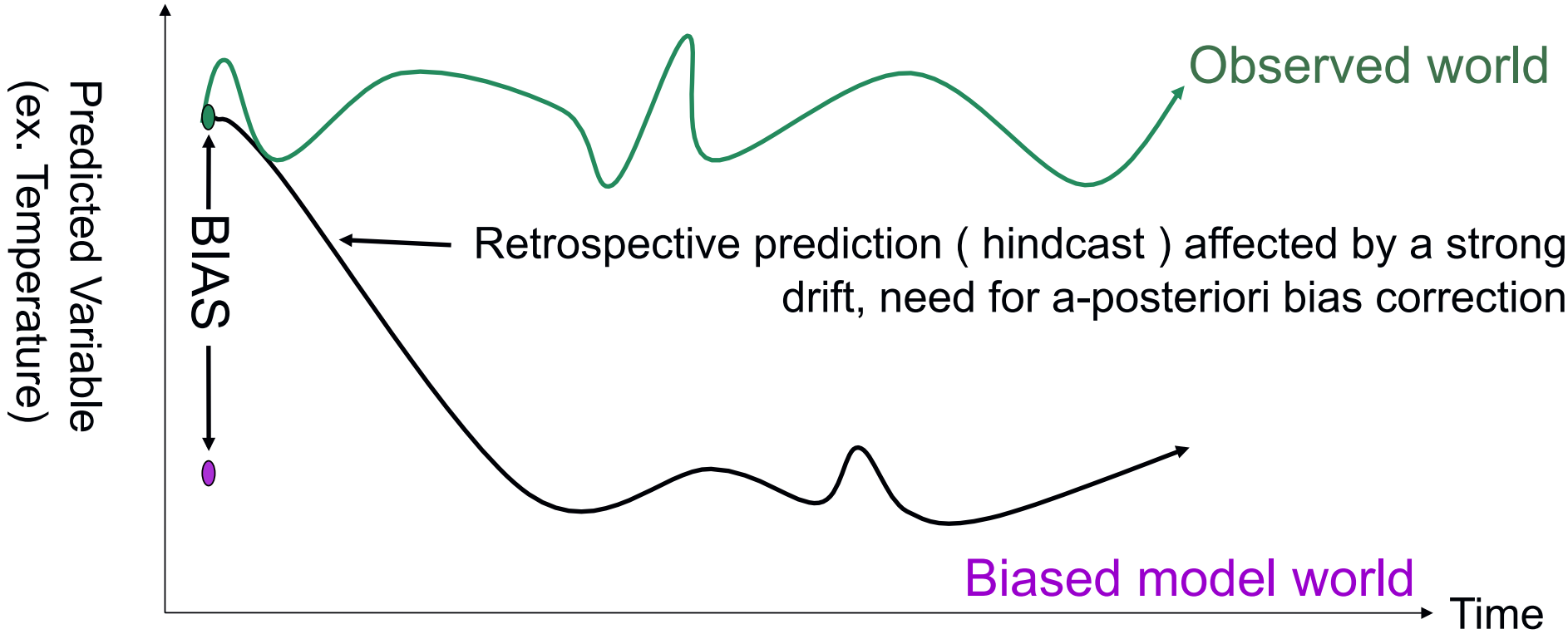
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



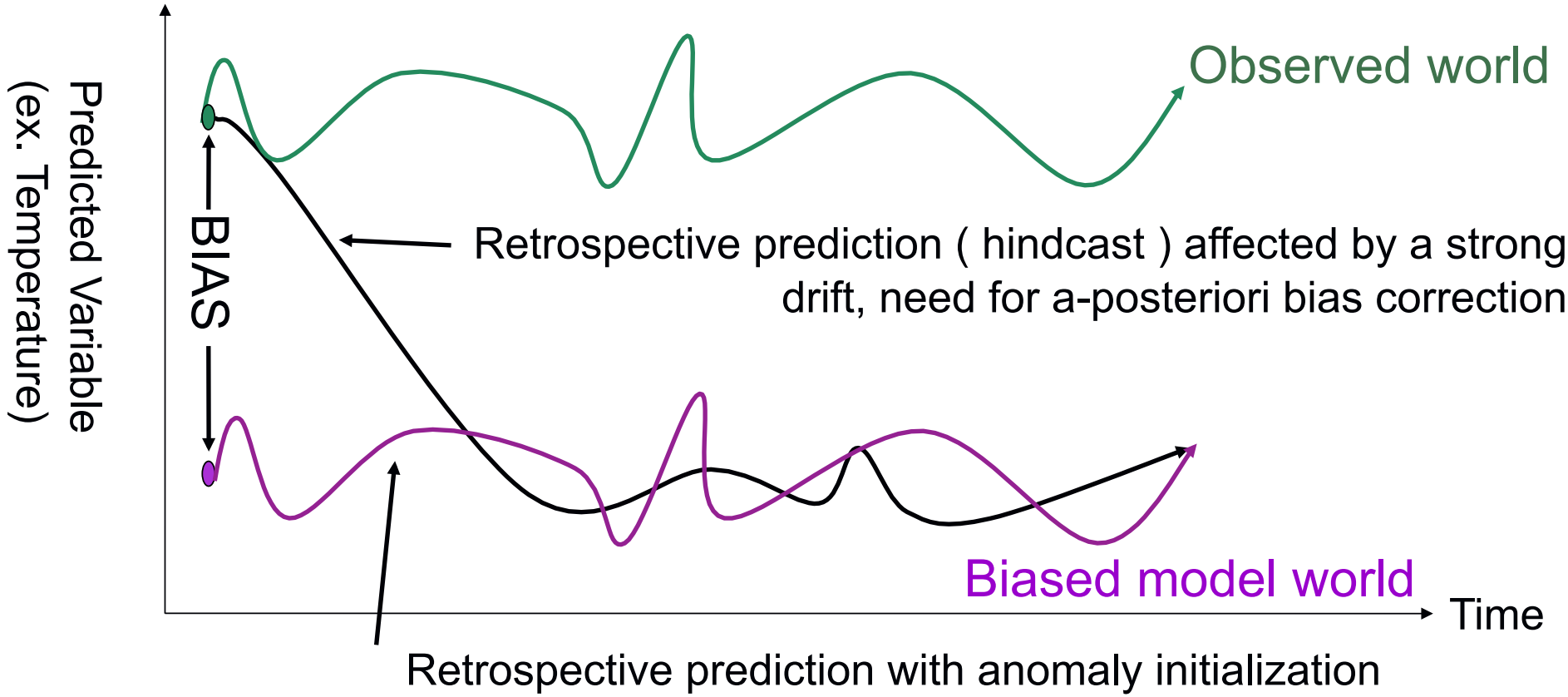
Adapted from Meehl et al. (2009)


- observed initial conditions
Atm - Ocn – Ice
-greenhouse gases (GHG)
- volcanic aerosols
- SO_4
- solar activity
initialized runs
Near-term climate predictions make use of information related to anthropogenic climate change, natural forcings and natural variability.
non-initialized runs
(CMIP5 historical)

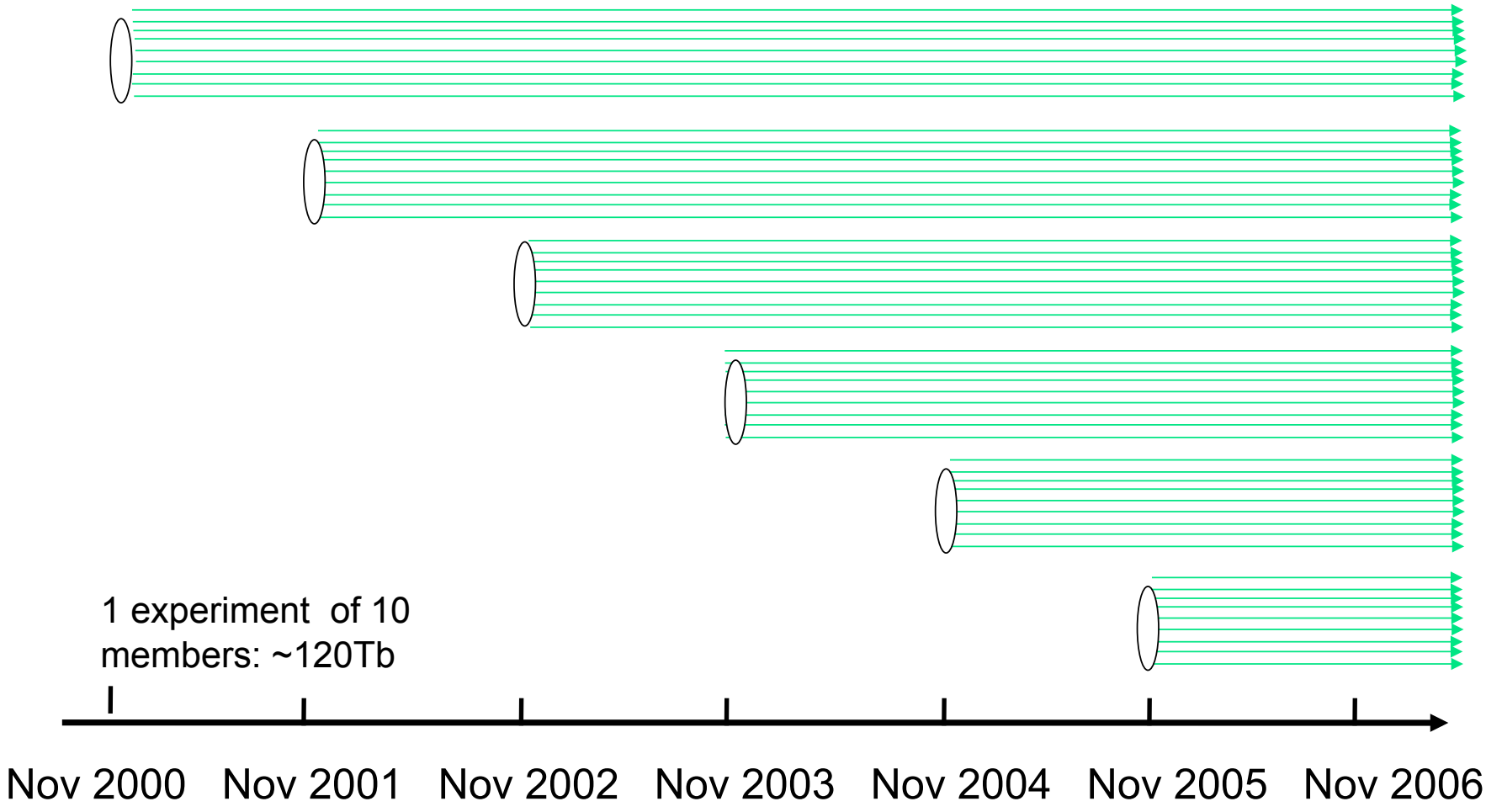
The climate prediction drift issue



The climate prediction drift issue

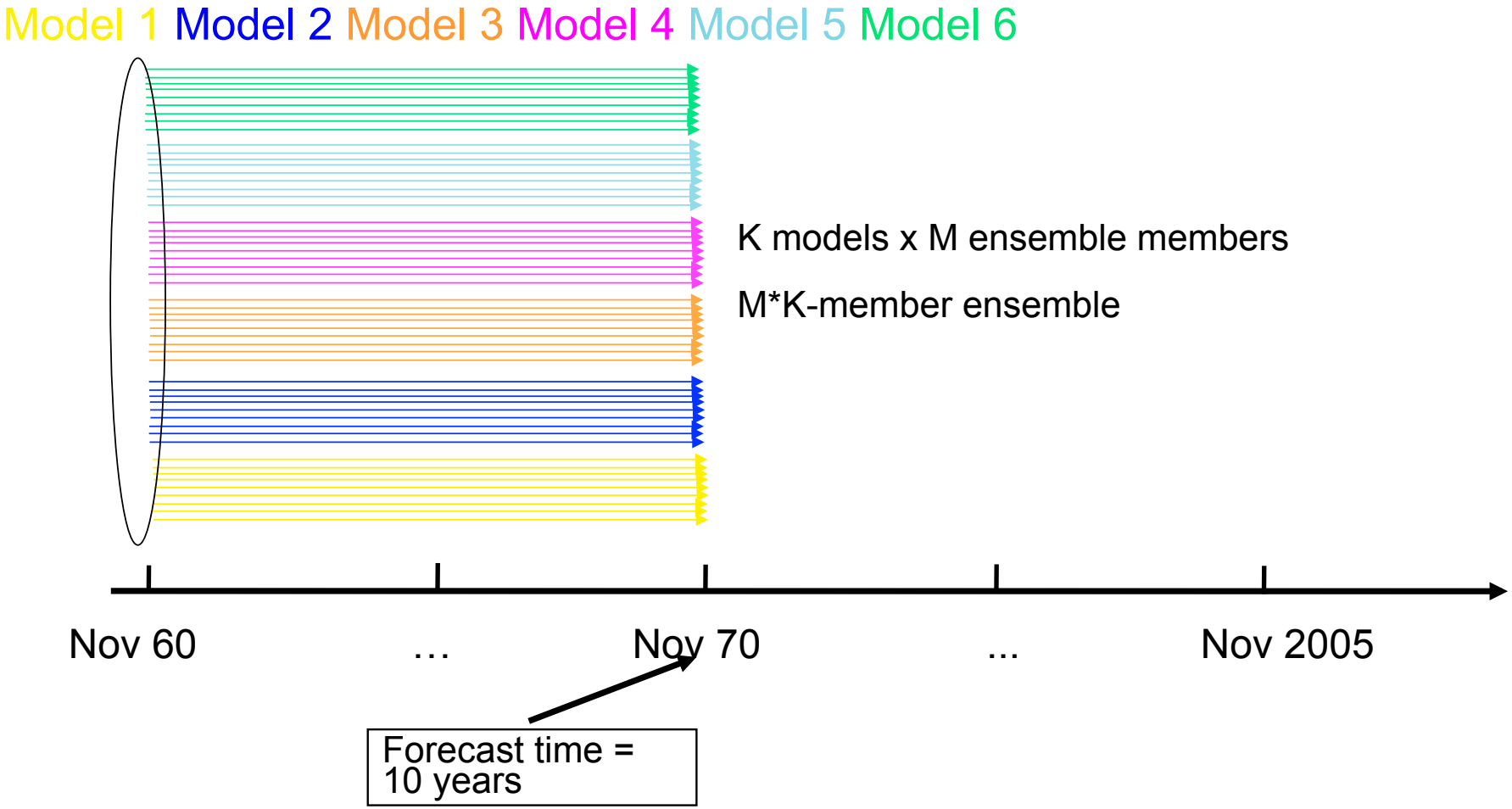


Ensemble initialized near-term predictions

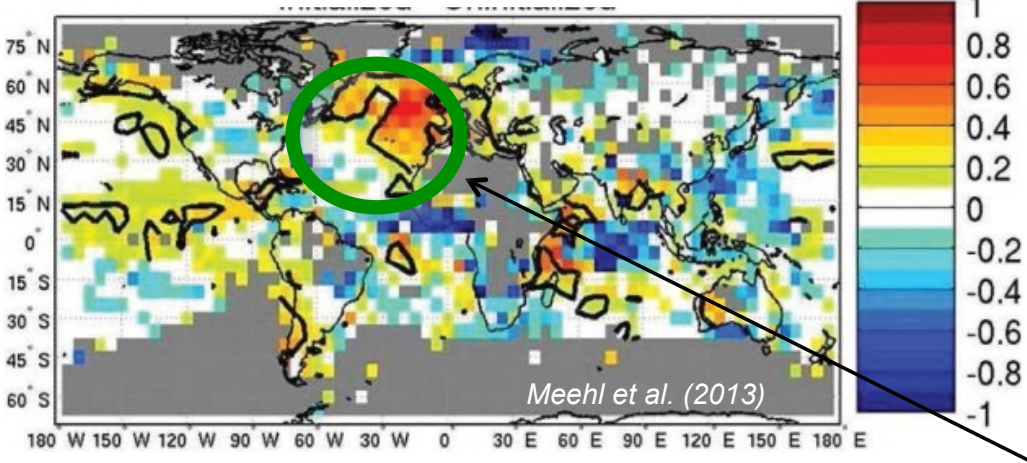


Ensemble climate forecast systems

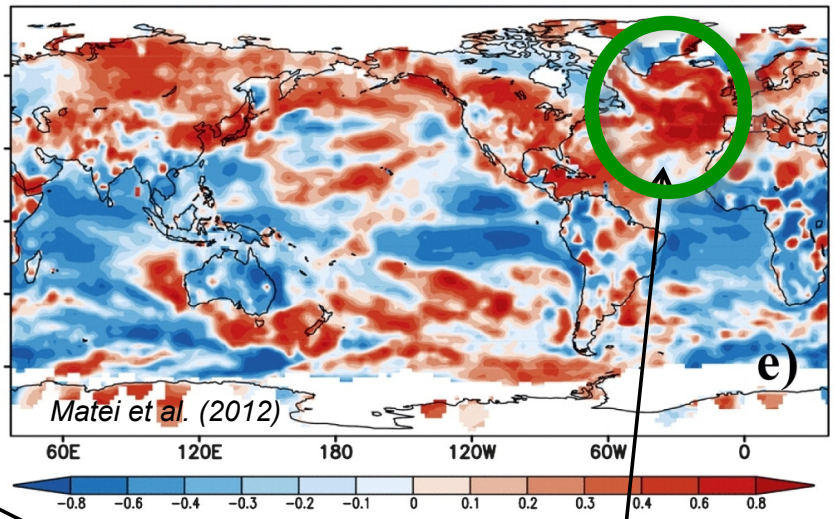
Assume a multi-model ensemble system with coupled initialized GCMs



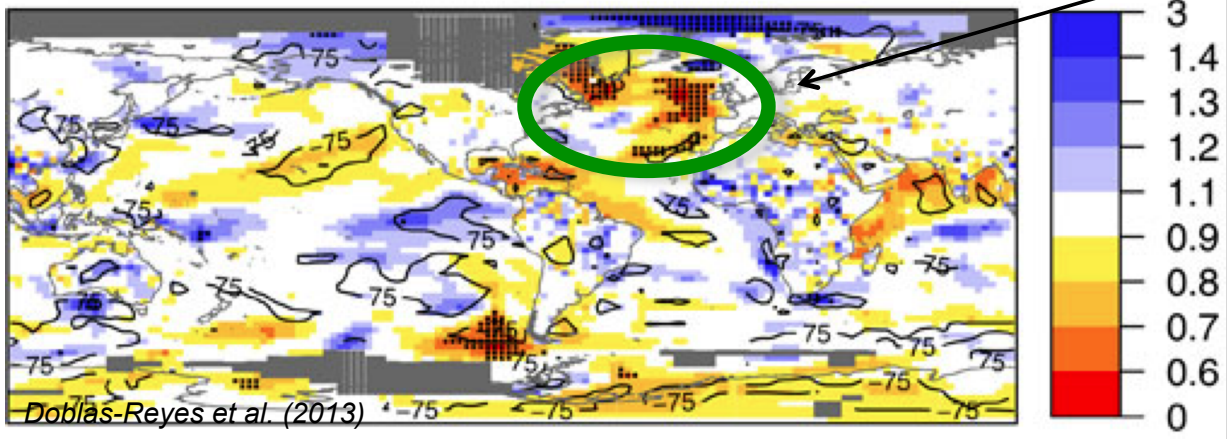
MME temperature MSSS: year 2-9
Initialized – Non-Initialized



Difference ACC (Initialized – Non Initialized, yr 2-5)

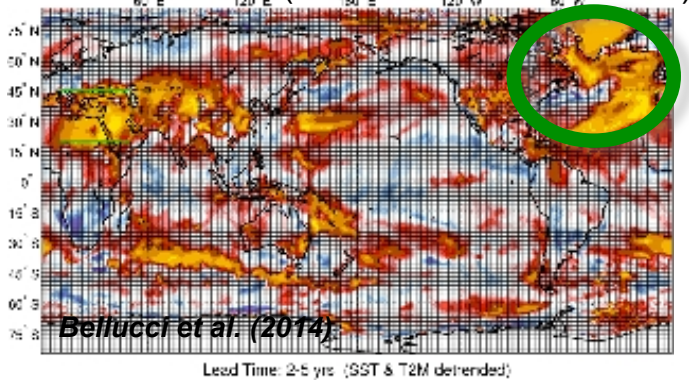


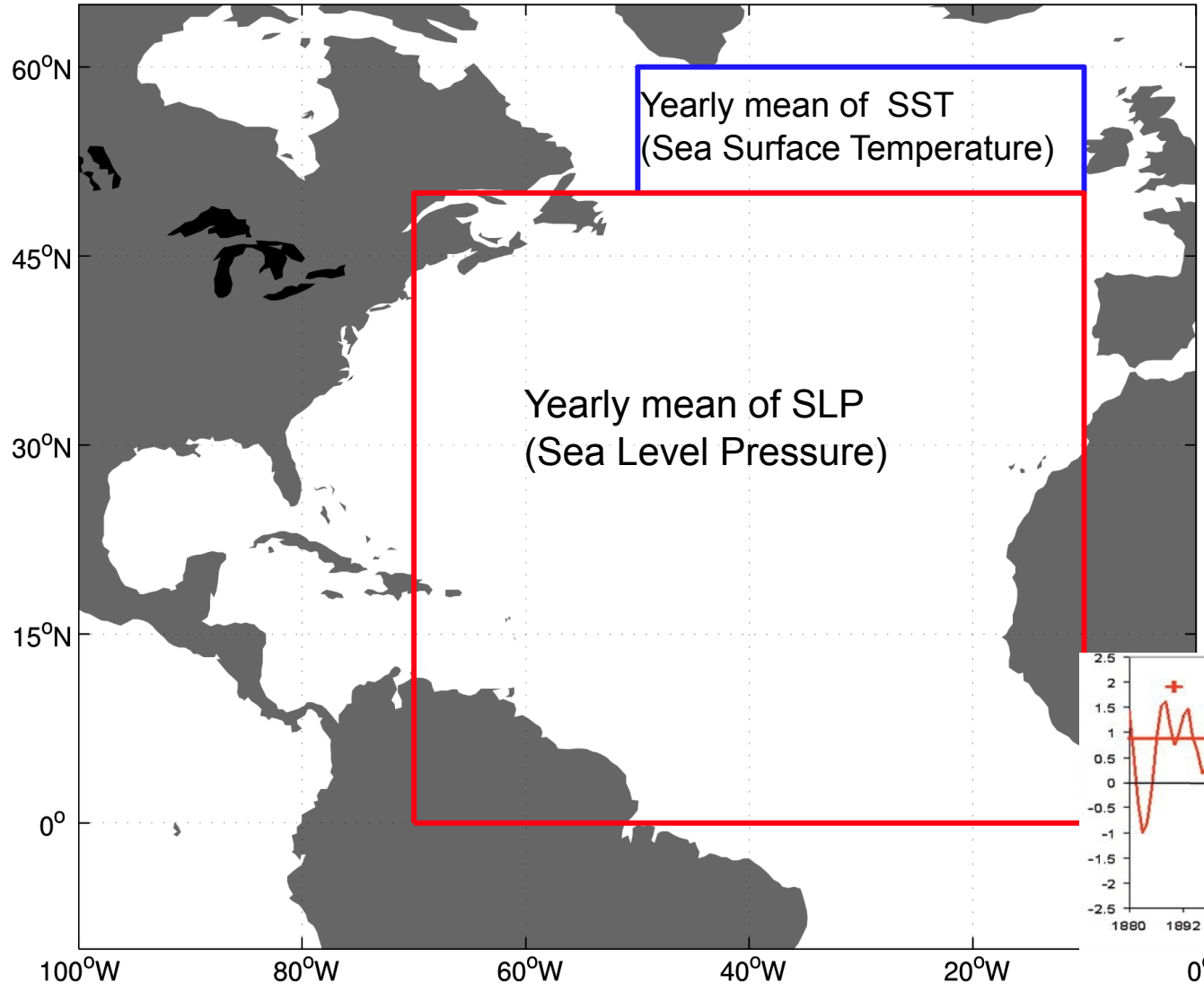
Ratio of the root mean square error (RMSE) of the initialised and uninitialised predictions for the near-surface temperature from the multi-model CMIP5 experiment (1960-2005) for forecast years 2-5.



Added-value from initialisation

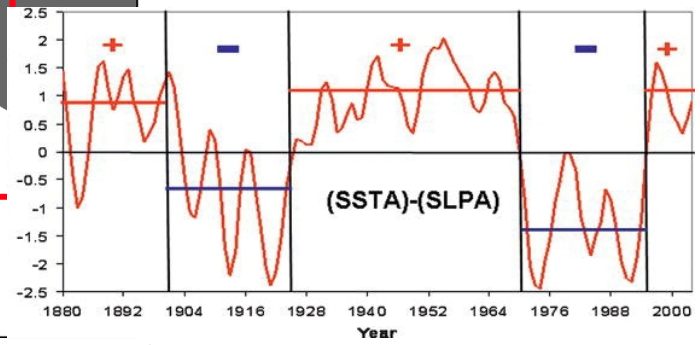
Difference ACC (Initialized – Non Initialized)



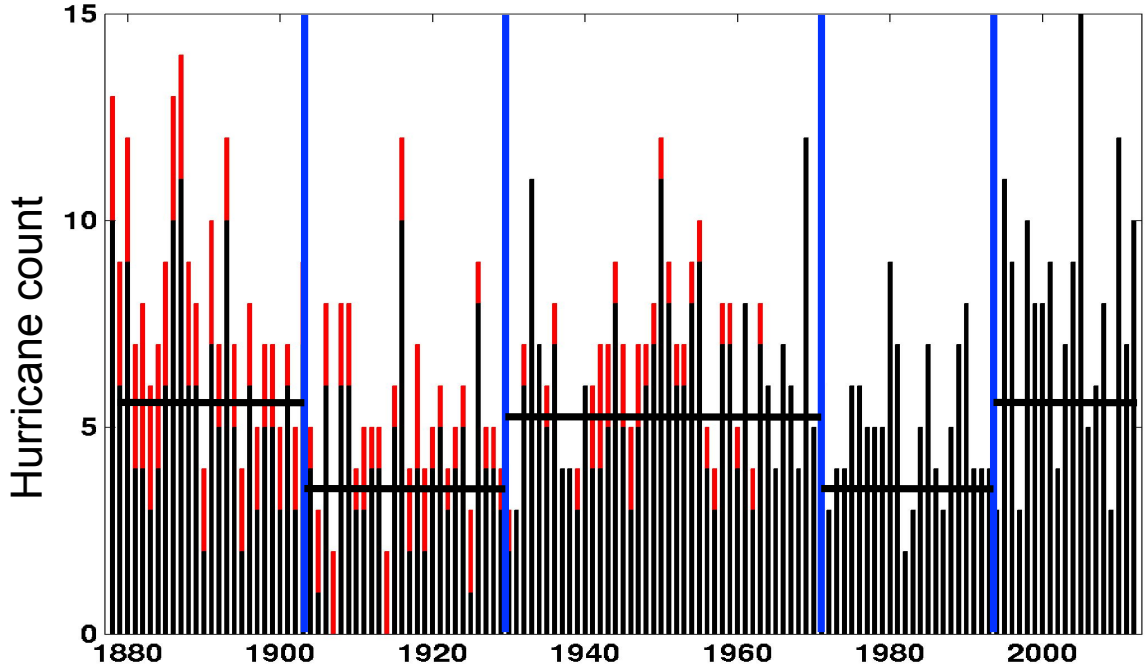


From CSU
Seasonal forecasts:

Index =
Standardized SSTA
–
Standardized SLPA

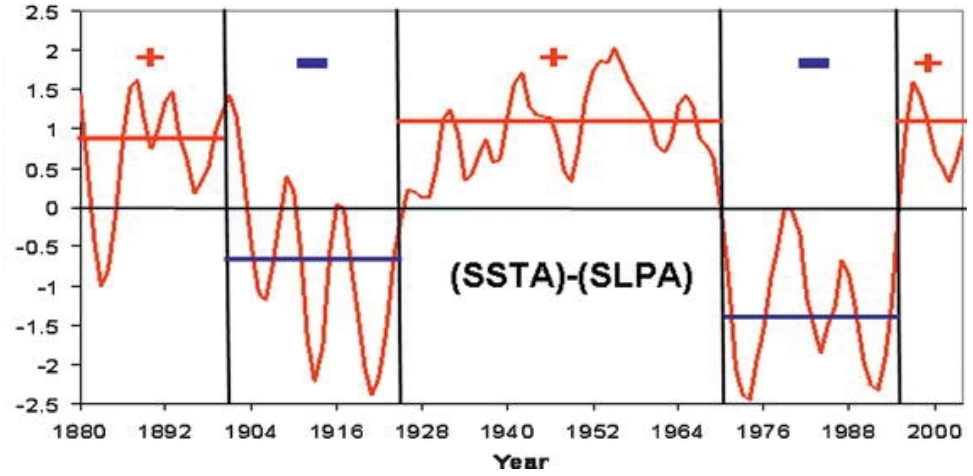


from Klotzbach and Gray (2008)

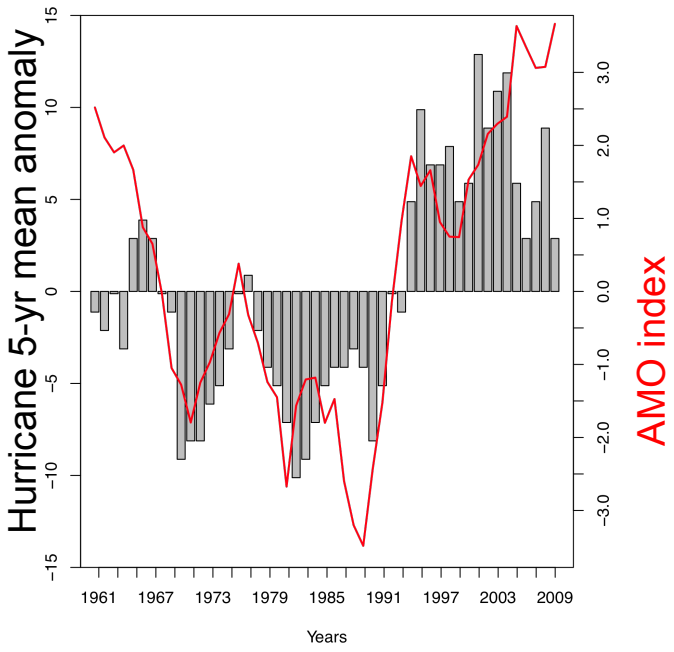


HURDAT2

Correction by Vecchi and Knutson (2011)

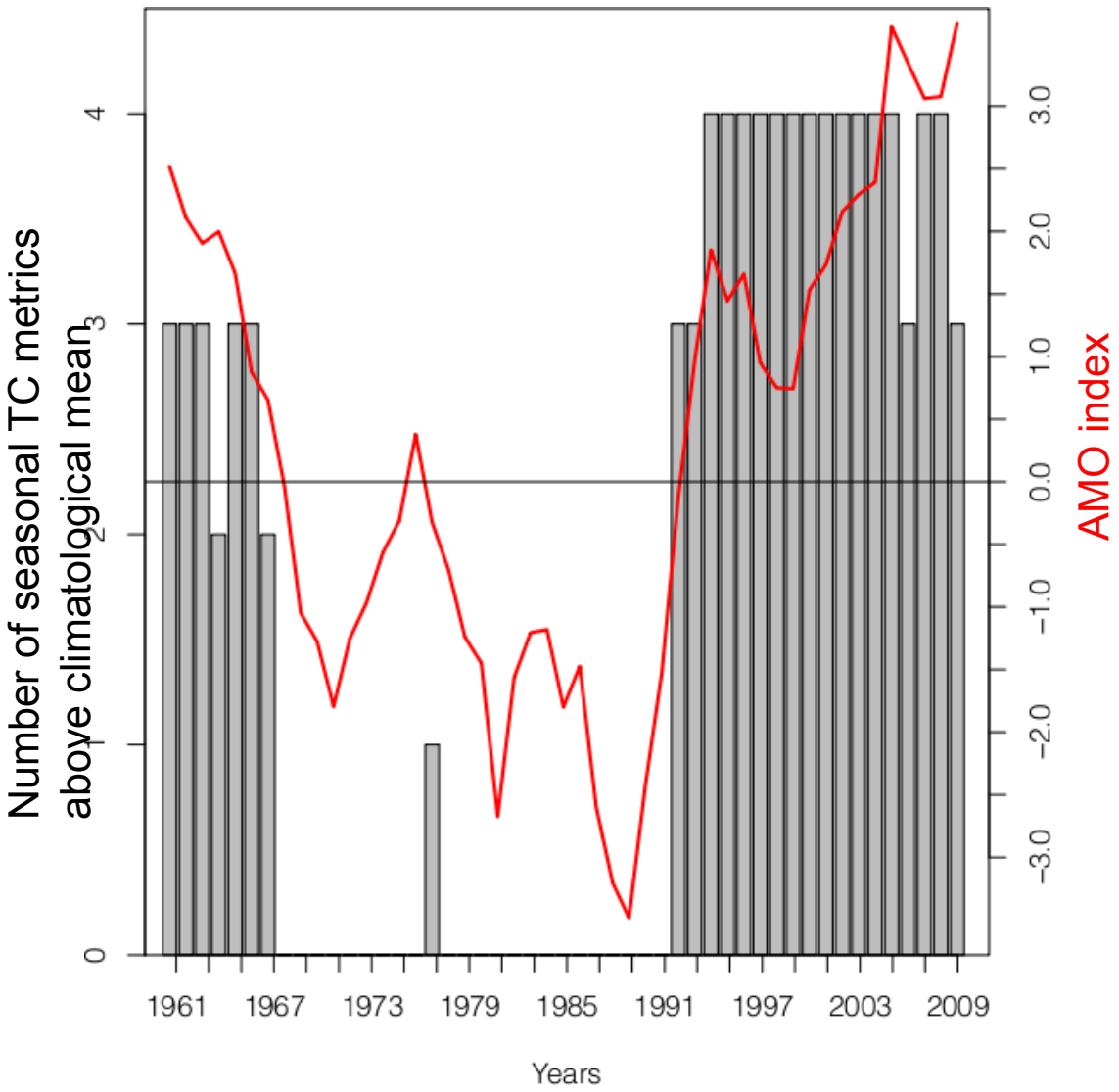


from Klotzbach and Gray (2008)



TC metrics are:

- **Number of hurricanes**
- **Number of major hurricanes**
- **Number of hurricane days**
- **Number of major hurricane days**



GCMs	Initialized	Non-Initialized
GFDL CM2.1	10	10
HadCM3	10	10
MIROC5	6	3
MPI-ESM-LR	5	3

CMIP5

SPECS (Seasonal-to-decadal climate Prediction for the improvement of European Climate Services)

Start dates: yearly, 1961 to 2010

5-year mean predictions (1961-1966 to 2010-2014)

Model selected based on

1) skill over designated area,
2) start dates available every year

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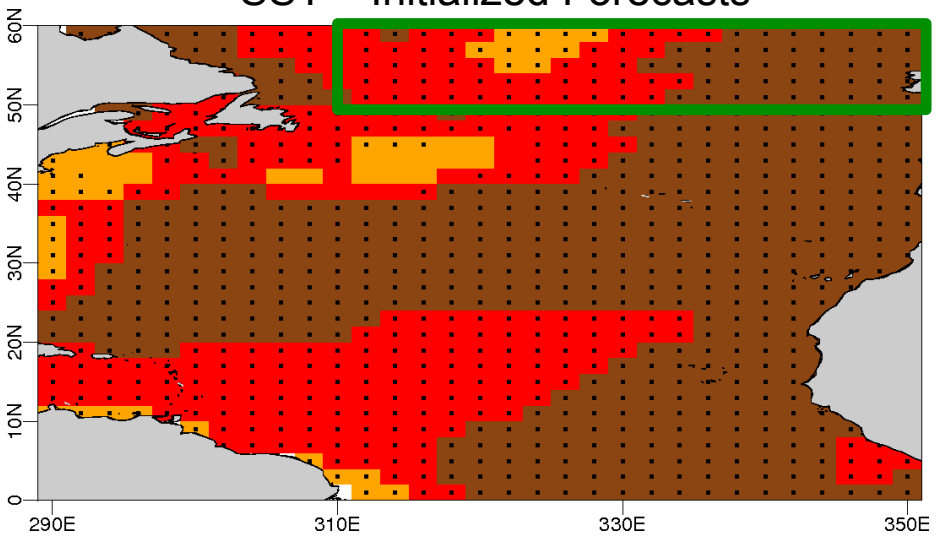
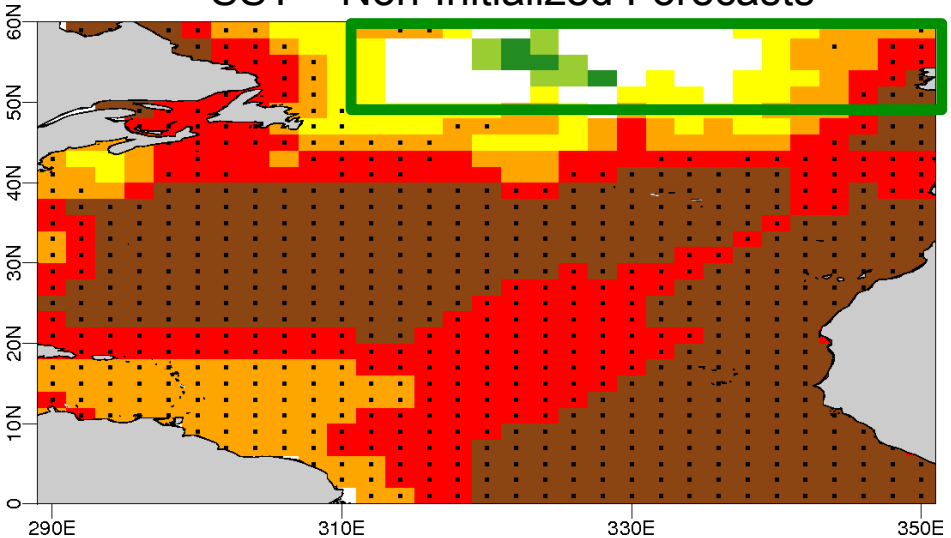
SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

RPI2.0
Connecting Science and (Re)Insurance

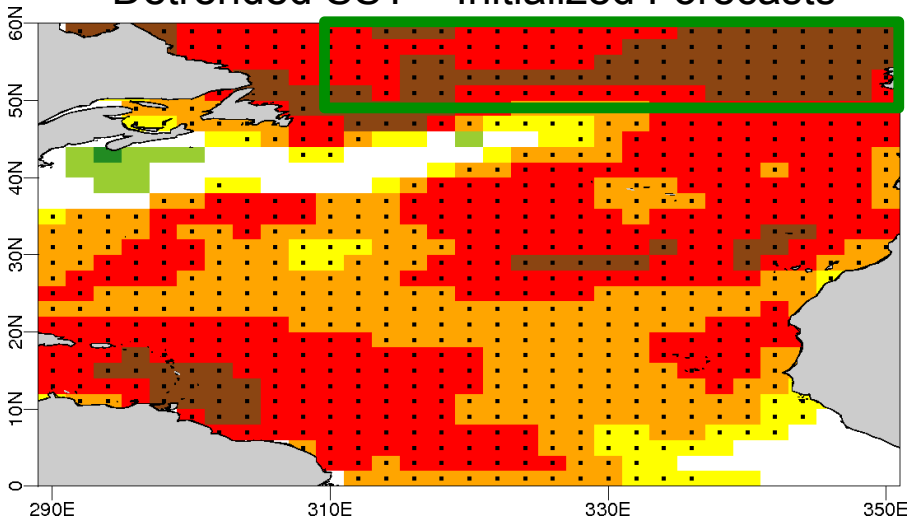
SST – Initialized Forecasts



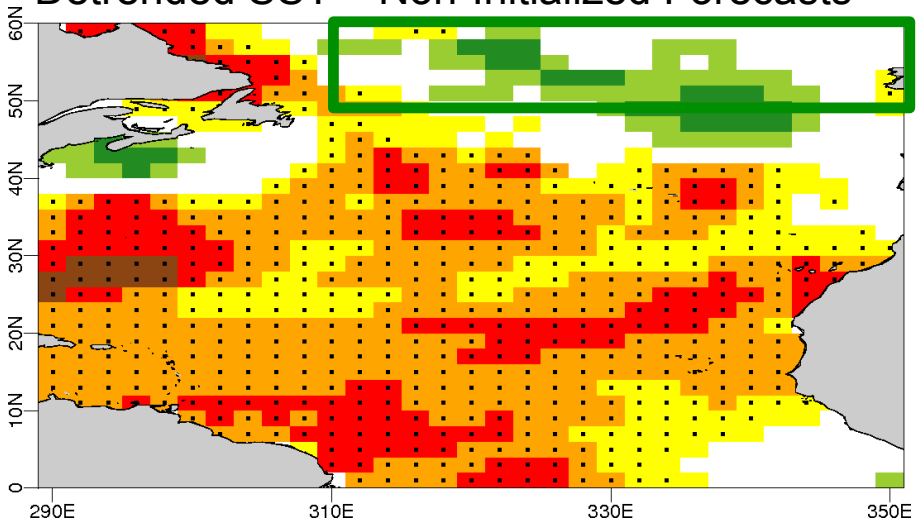
SST – Non-Initialized Forecasts

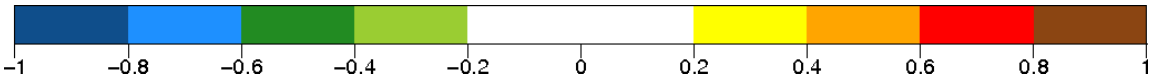


Detrended SST – Initialized Forecasts



Detrended SST – Non-Initialized Forecasts





Anomaly Correlation Coefficient (ACC)-Year 1-5

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Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

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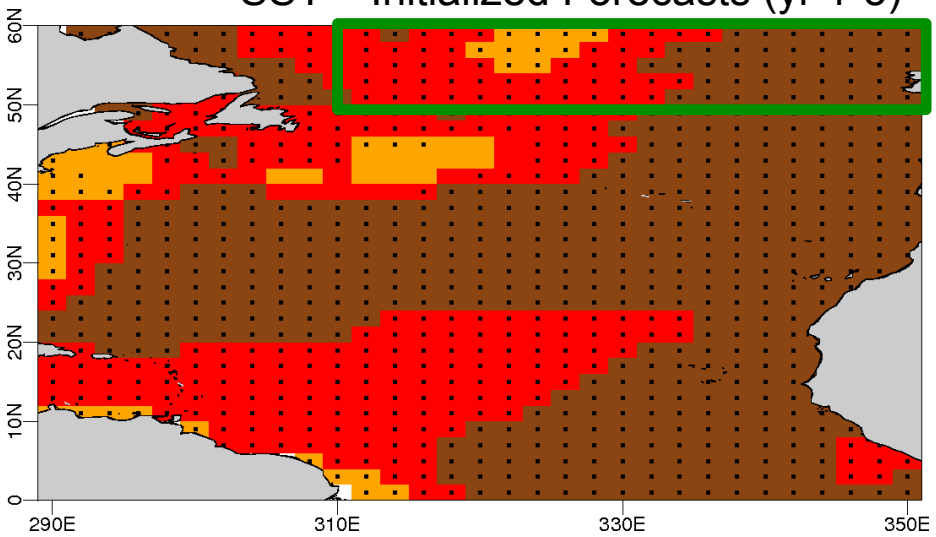
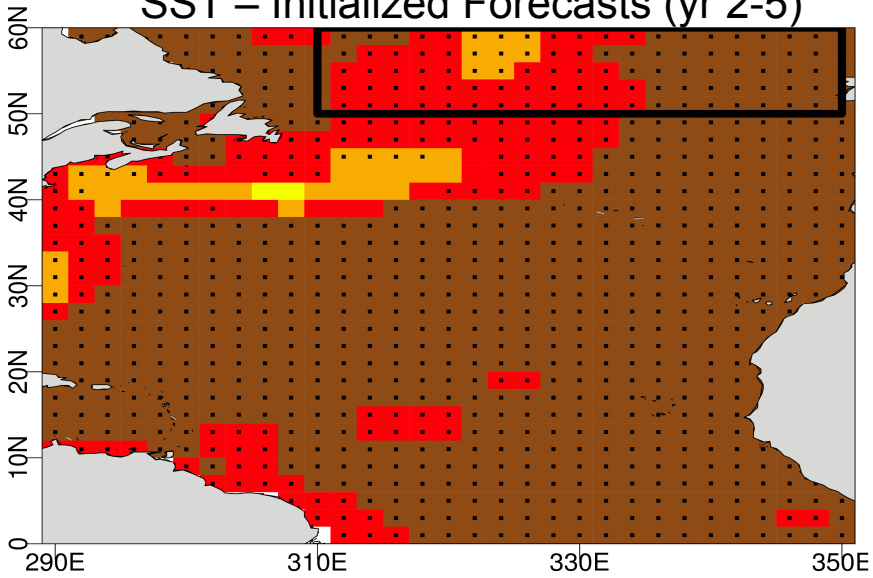
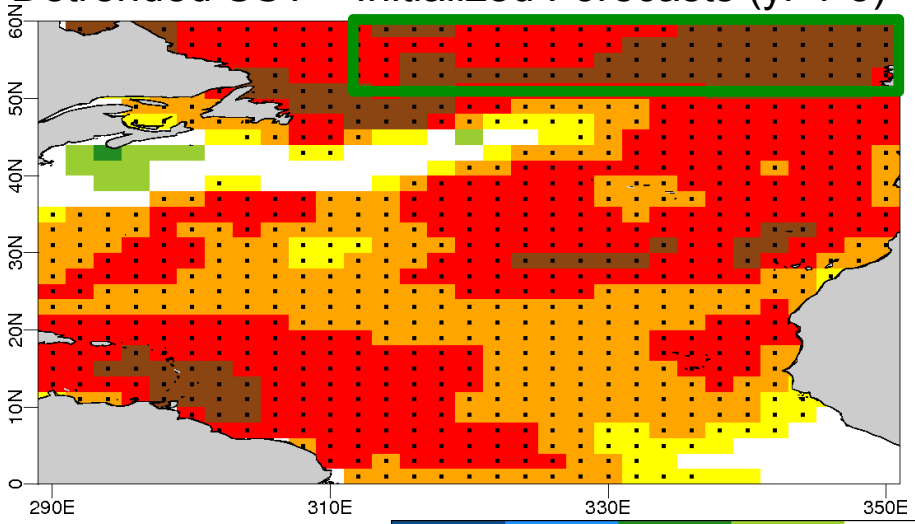
SST – Initialized Forecasts (yr 1-5)



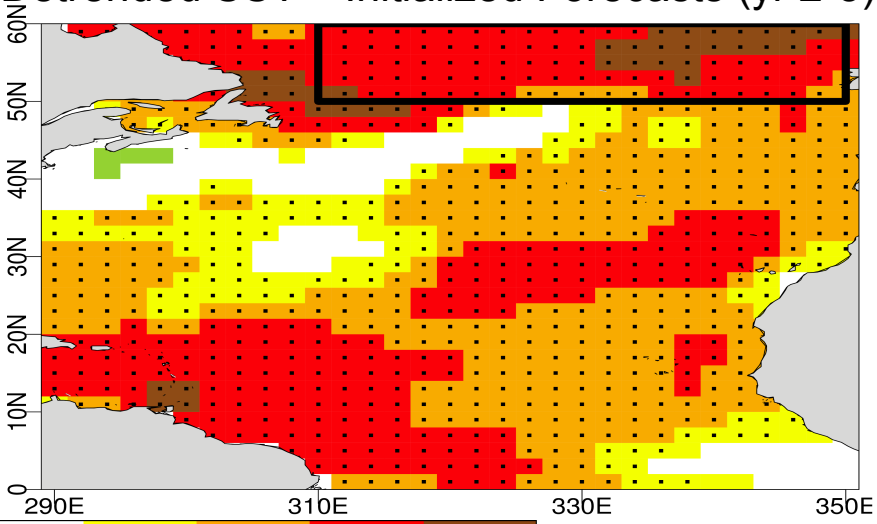
SST – Initialized Forecasts (yr 2-5)

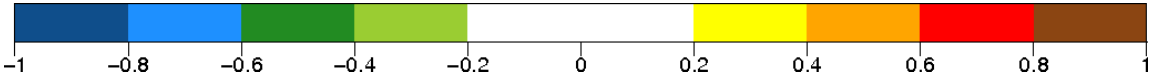


Detrended SST – Initialized Forecasts (yr 1-5)

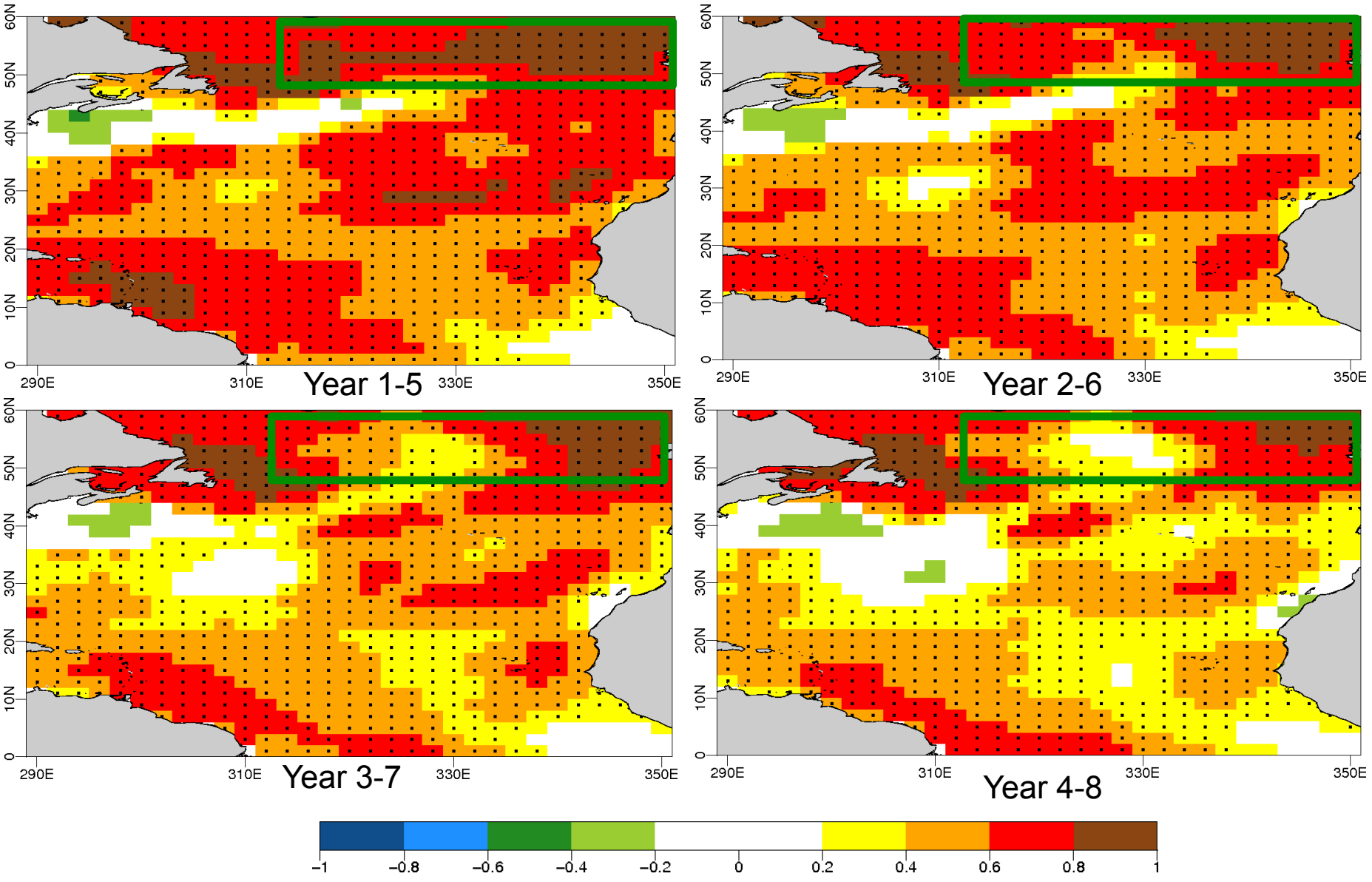


Detrended SST – Initialized Forecasts (yr 2-5)



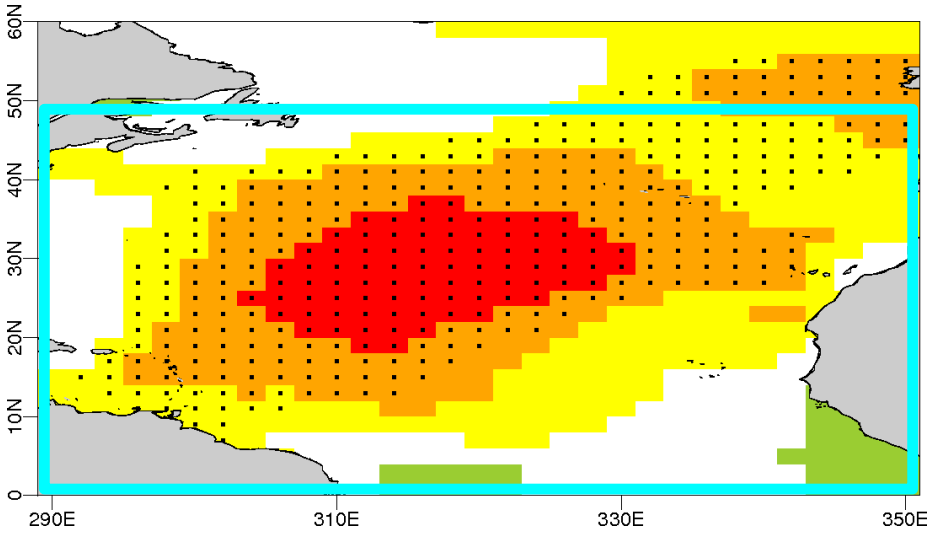


ACC, 5-year mean MME detrended SST – Initialized Forecasts

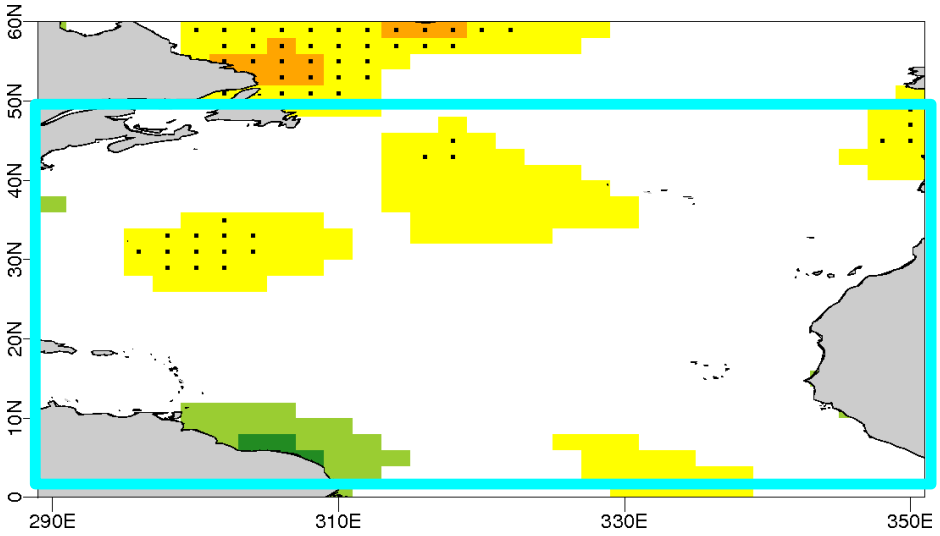


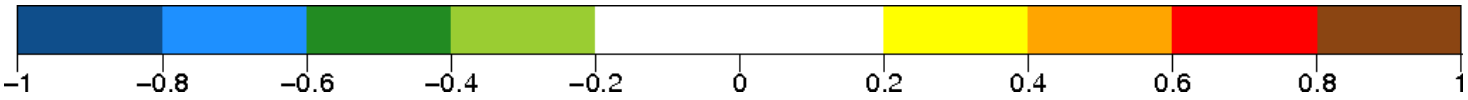
ACC MME – MSLP (year 1-5)

Initialized Forecasts



Non-Initialized Forecasts

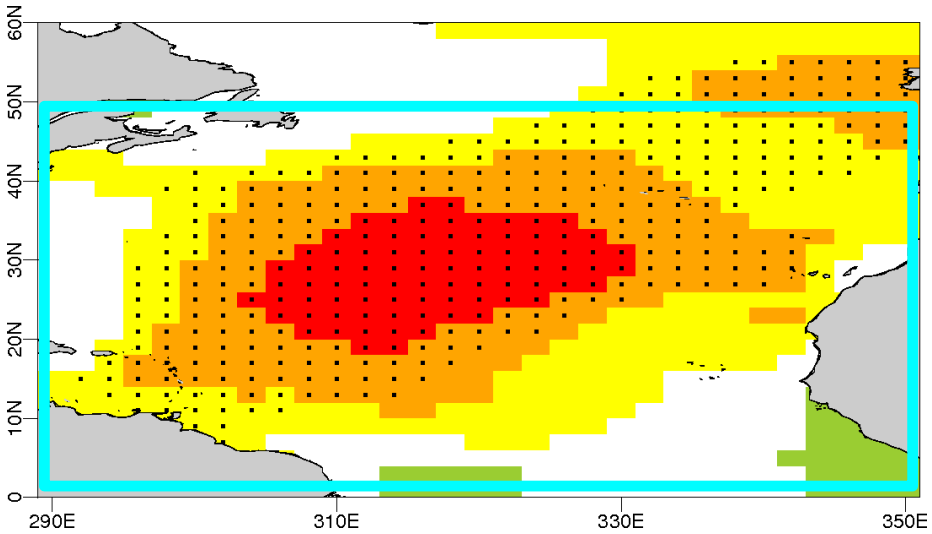




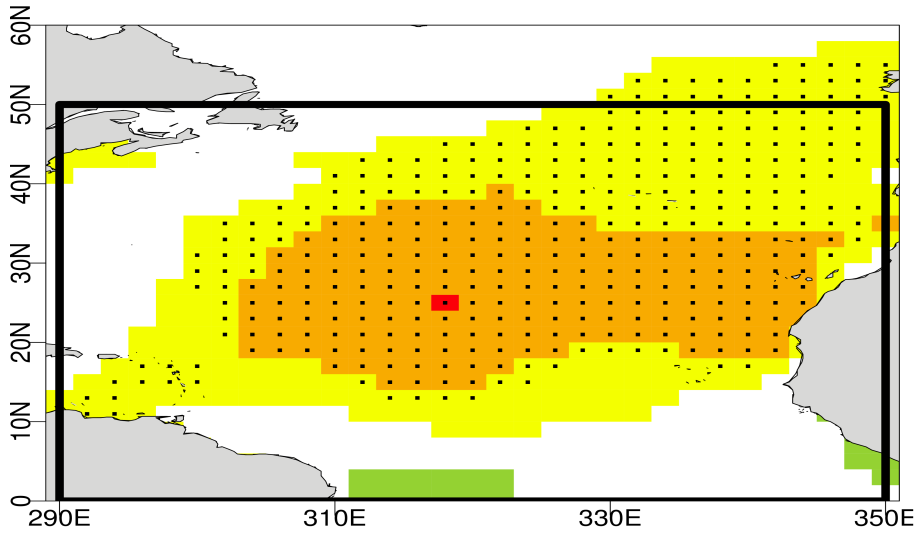
ACC - MME

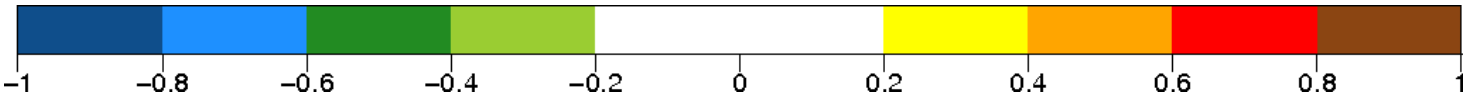
MSLP –Initialized Forecasts

Year 1-5

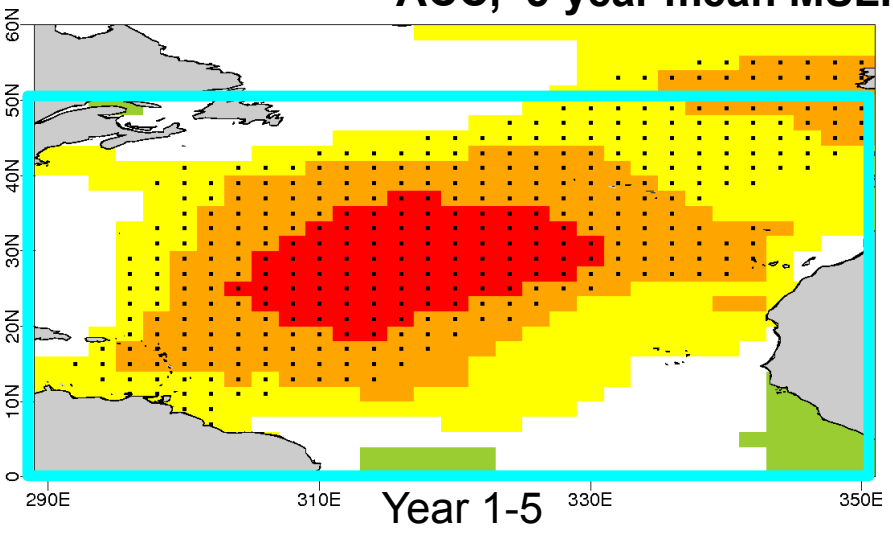


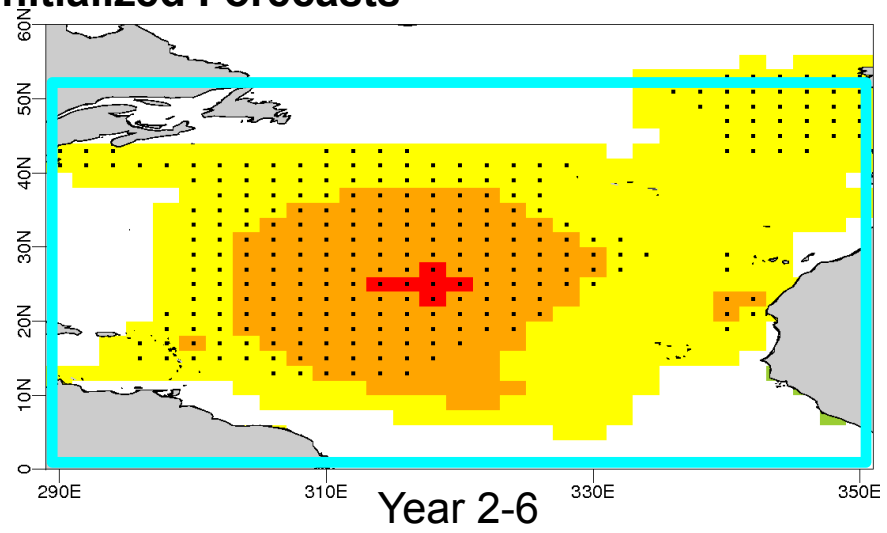
Year 2-5

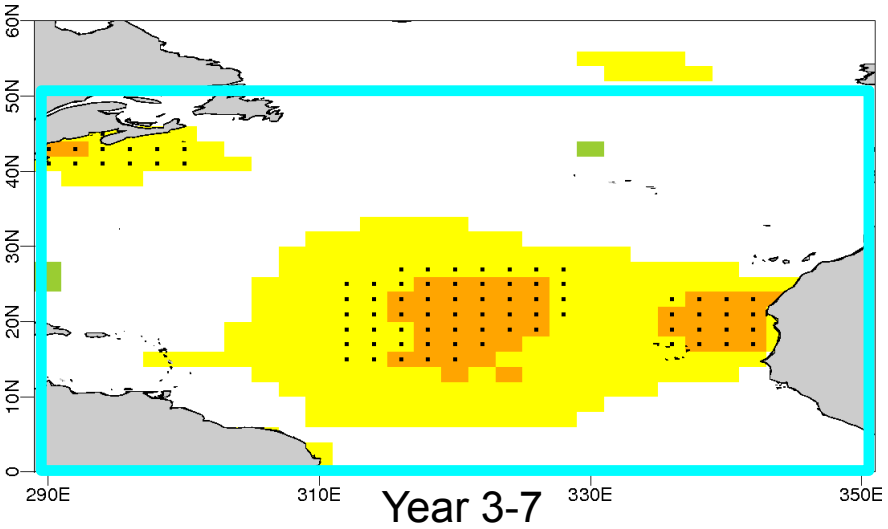


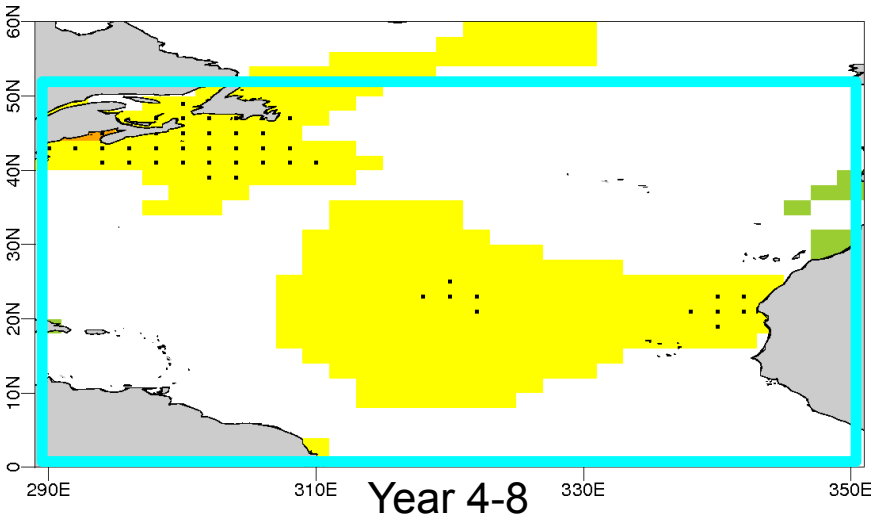


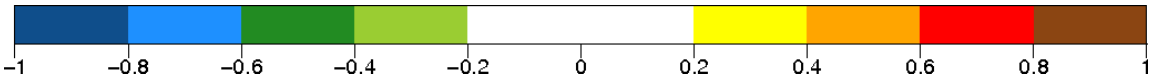
ACC, 5-year mean MSLP – Initialized Forecasts



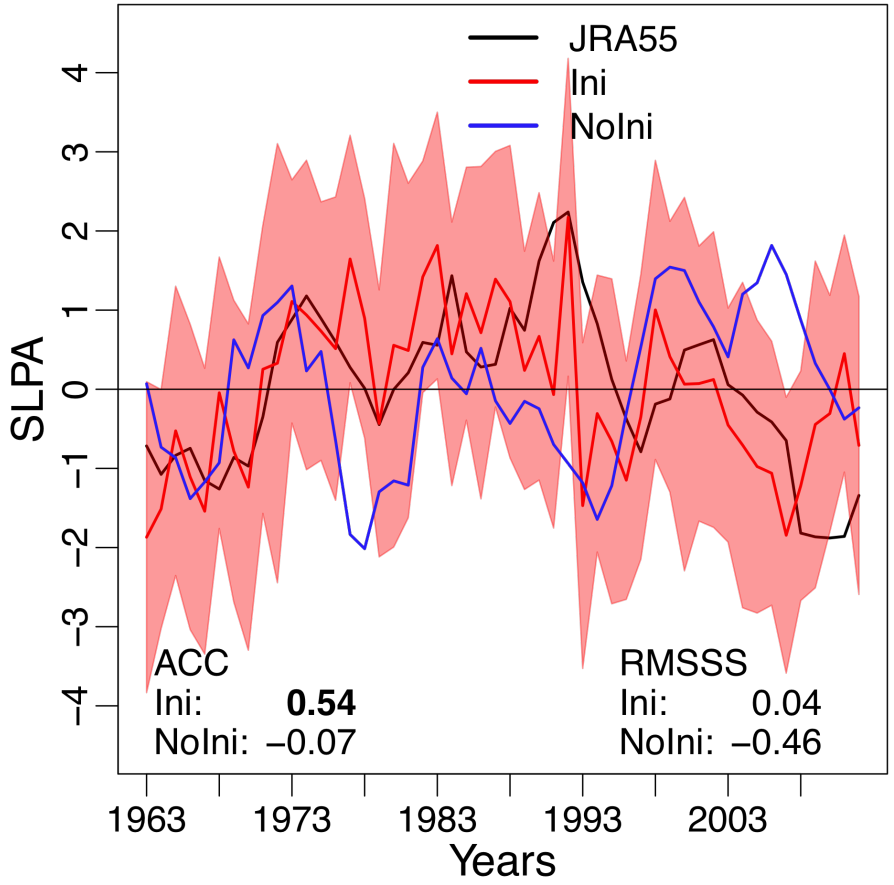




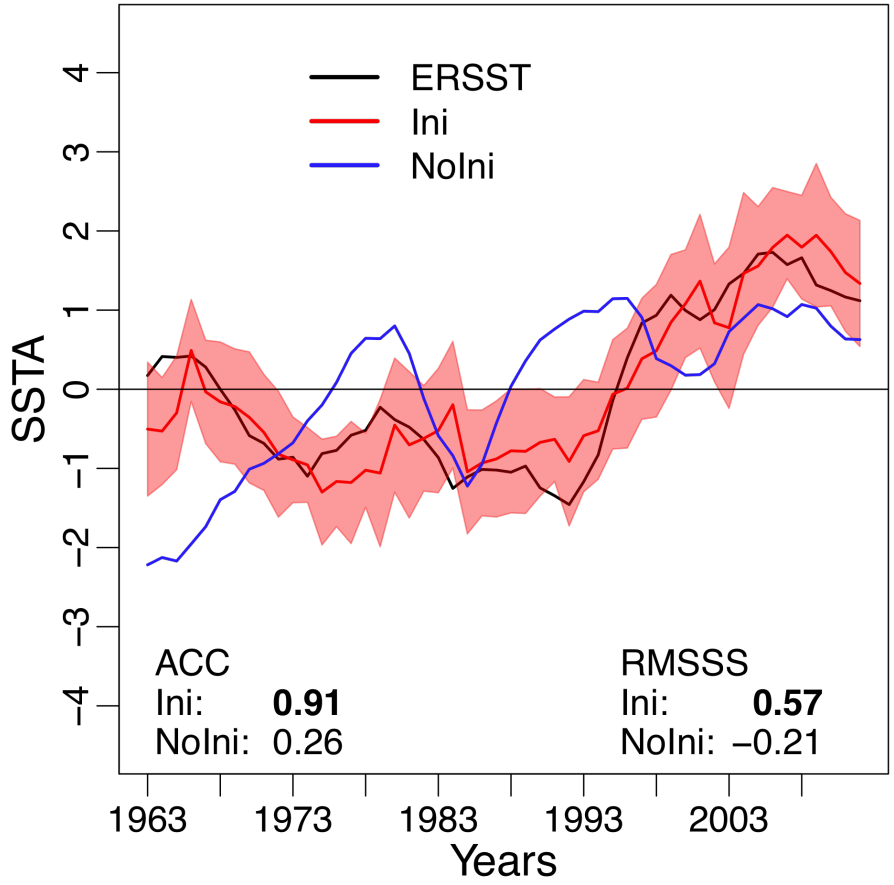




5-year mean standardized SLPA



5-year mean standardized SSTA

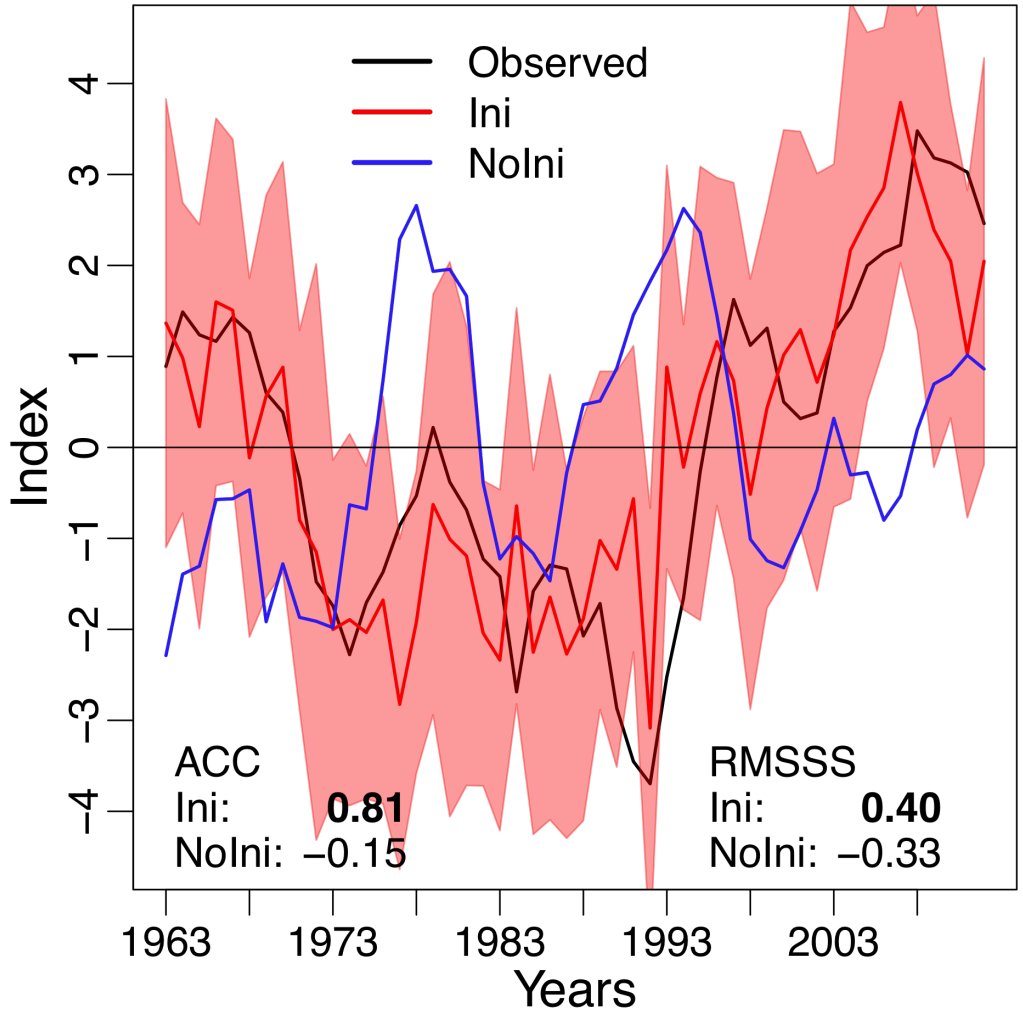


RMSSS = 1 – RMSE / $RMSE_{clim}$

1: perfect prediction

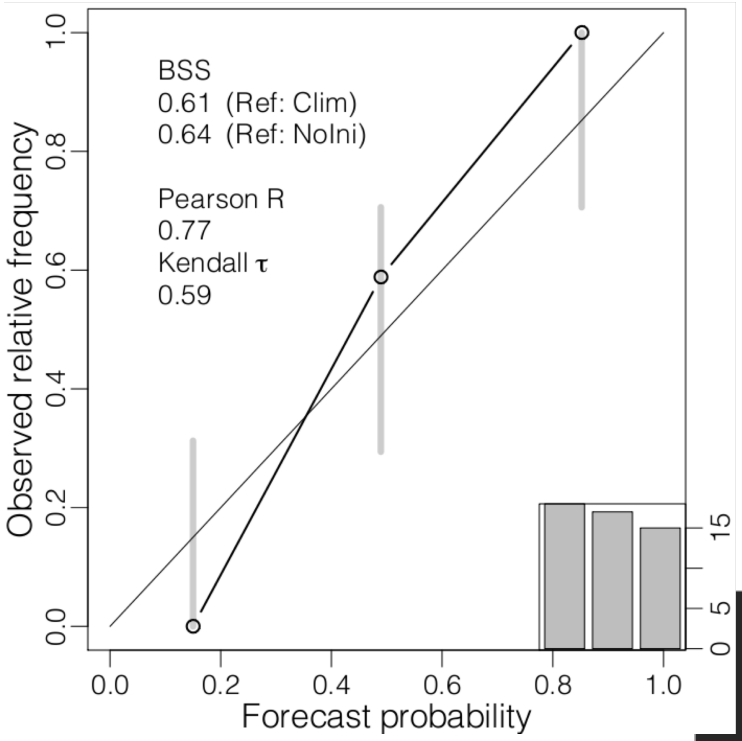
0: no improvement over climatological forecast

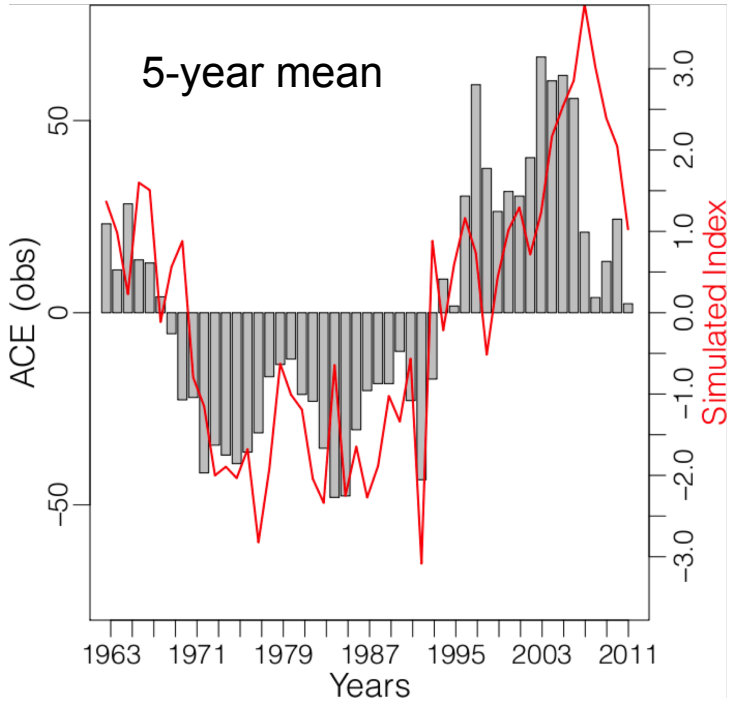
5-year mean index



How does this skill translate into forecasting cyclone activity?

Probability to have + ACE anomaly

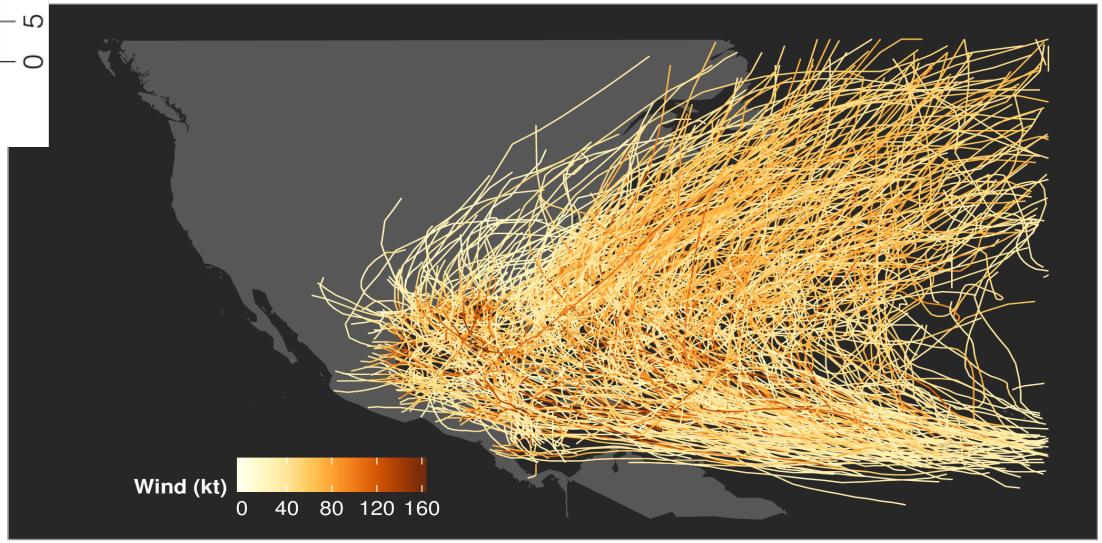




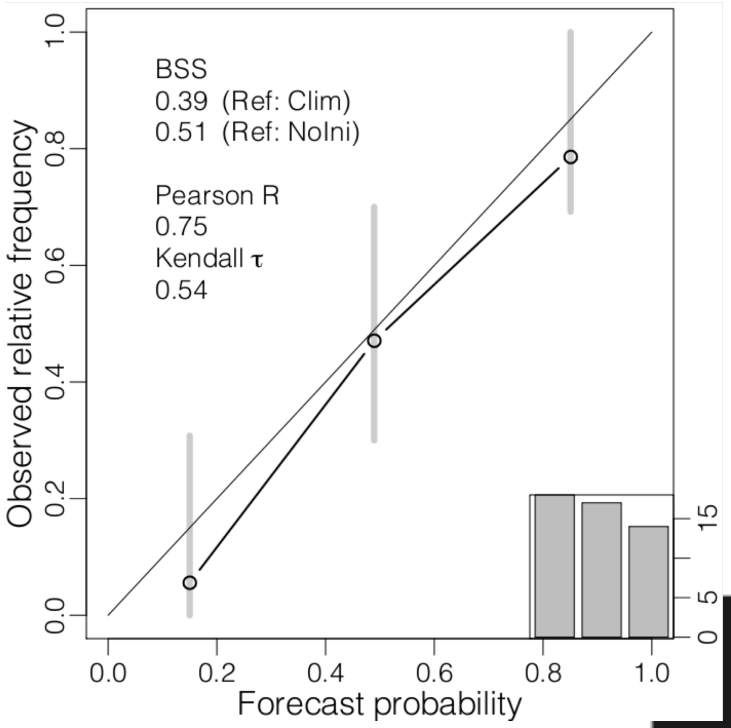
$BSS = 1 - BS / Bs_{ref}$

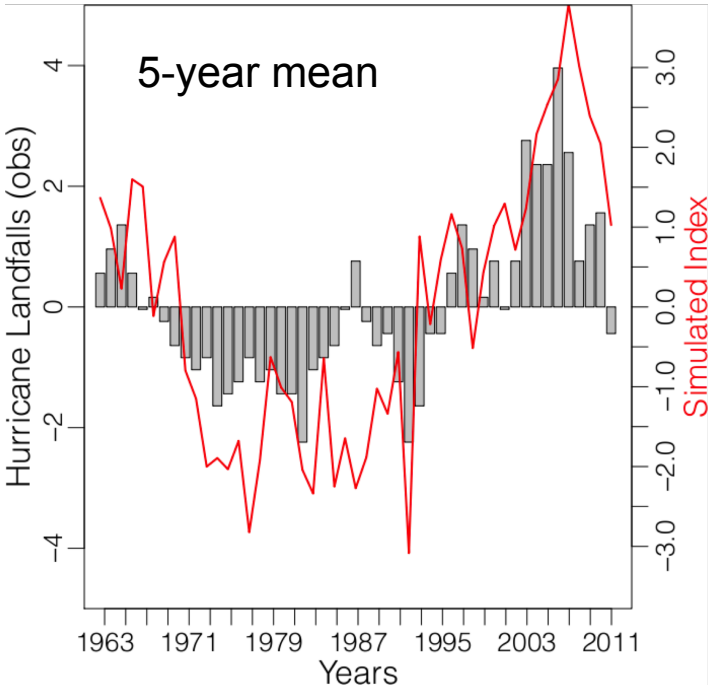
1: perfect prediction

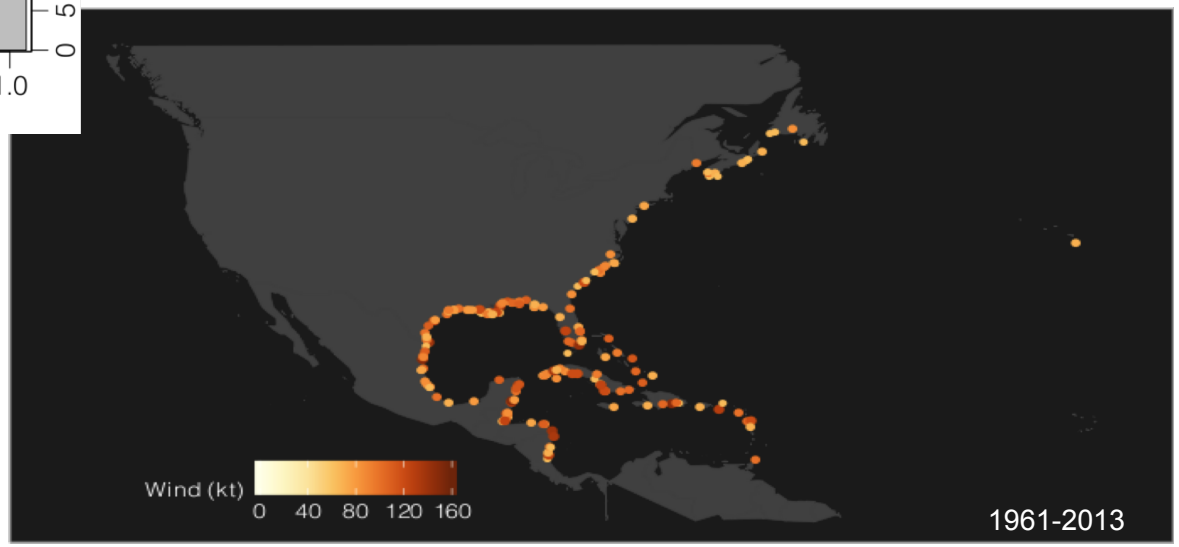
0: no improvement over climatological forecast



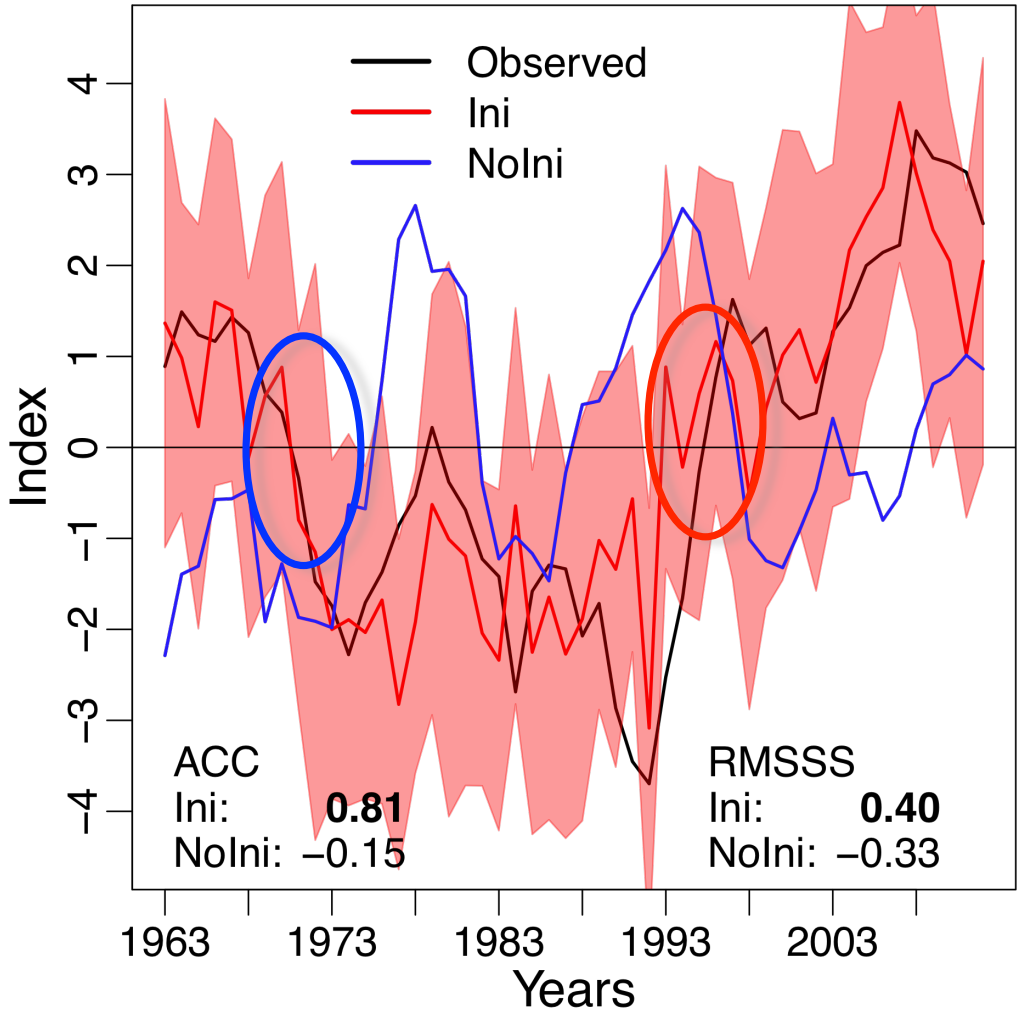
Probability to have + hurricane landfall anomaly

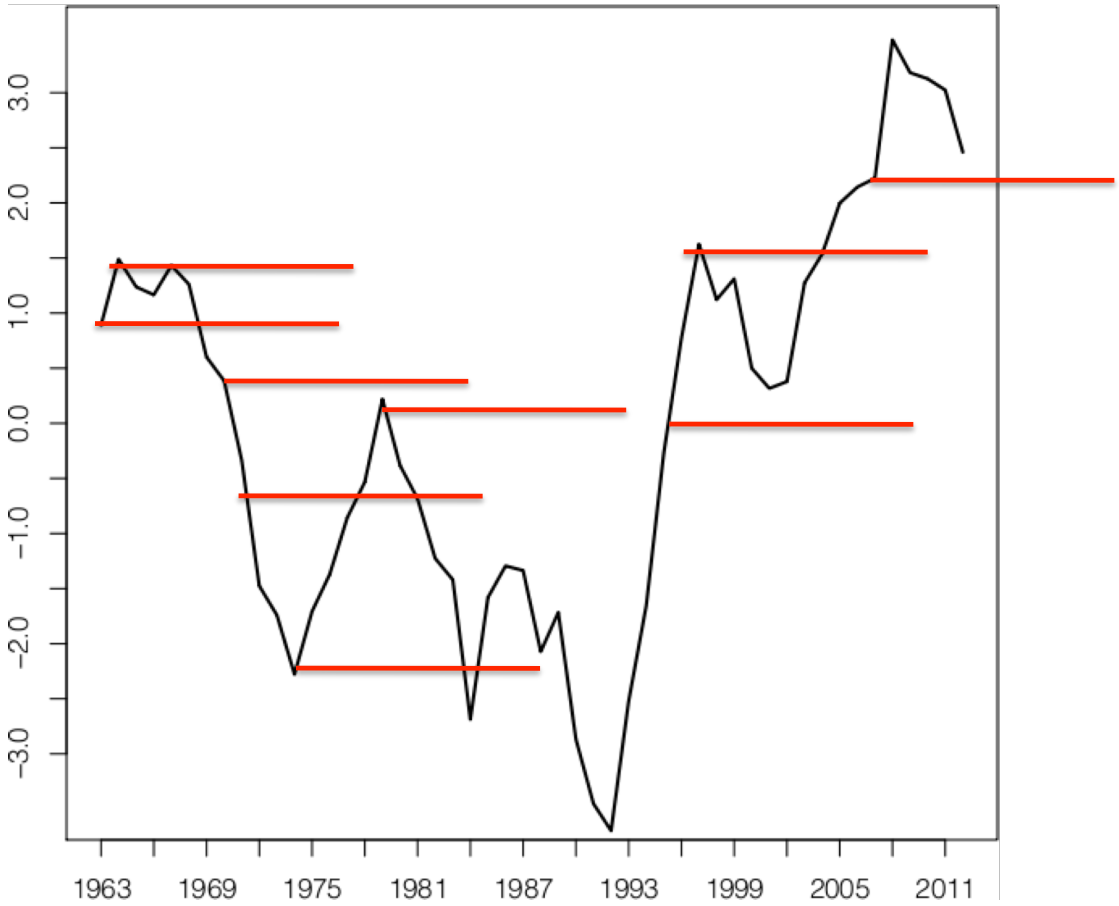


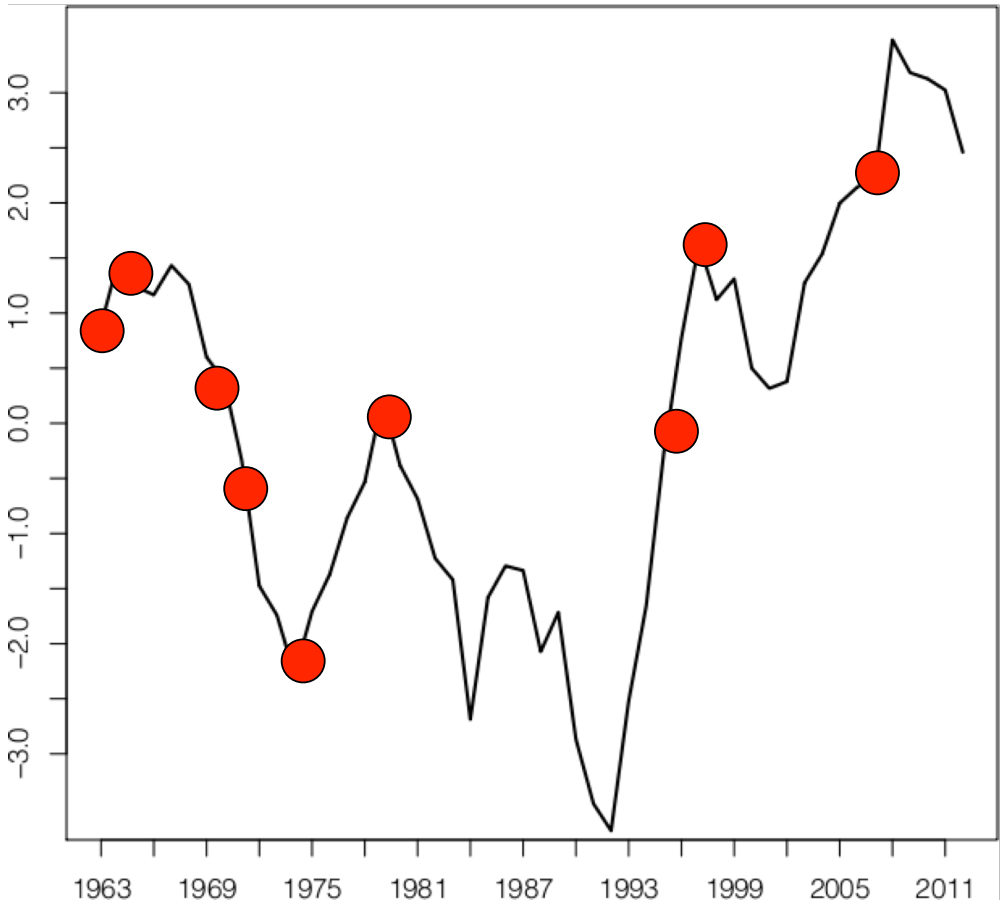




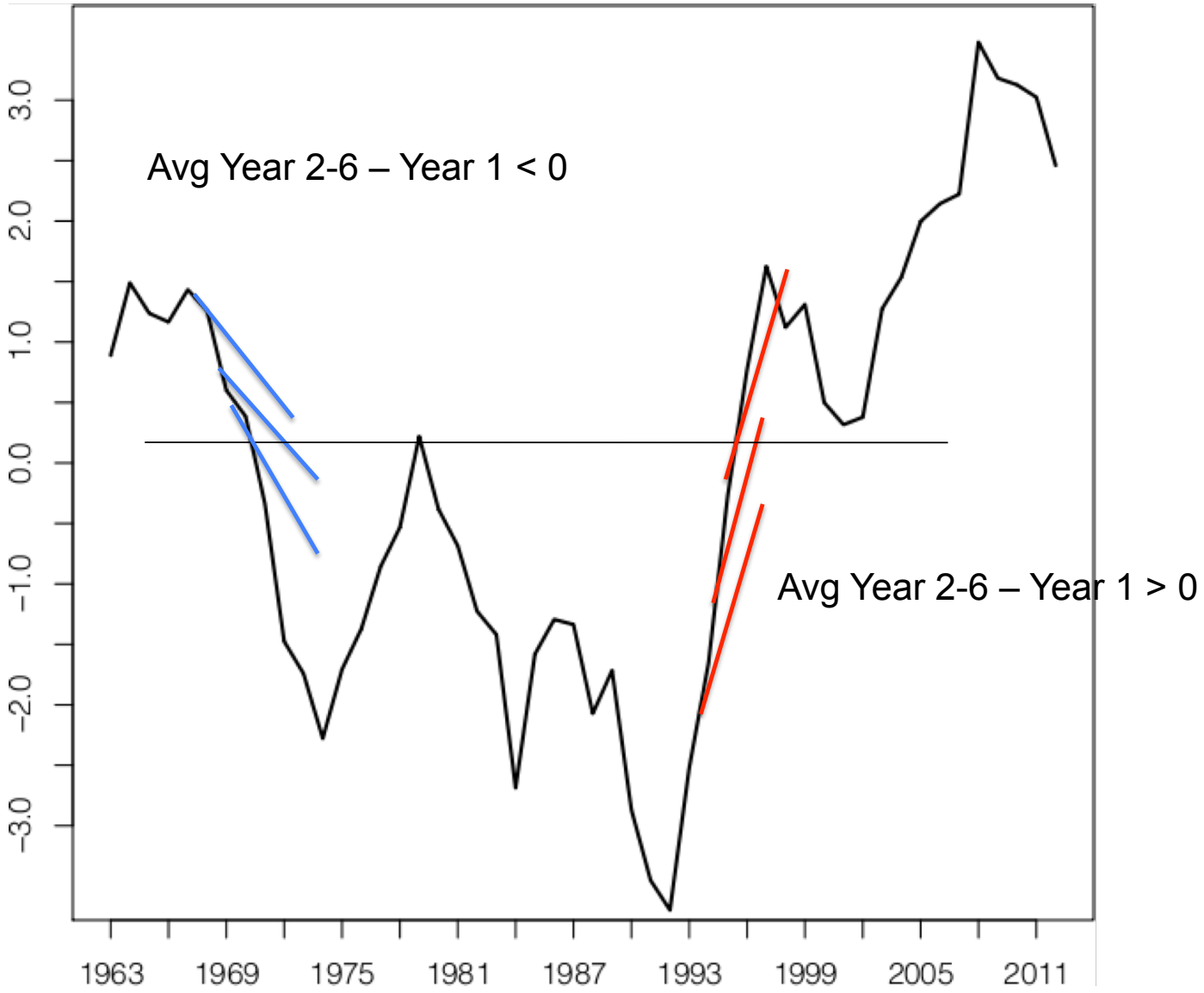
Can we predict the shift between active and inactive phases?

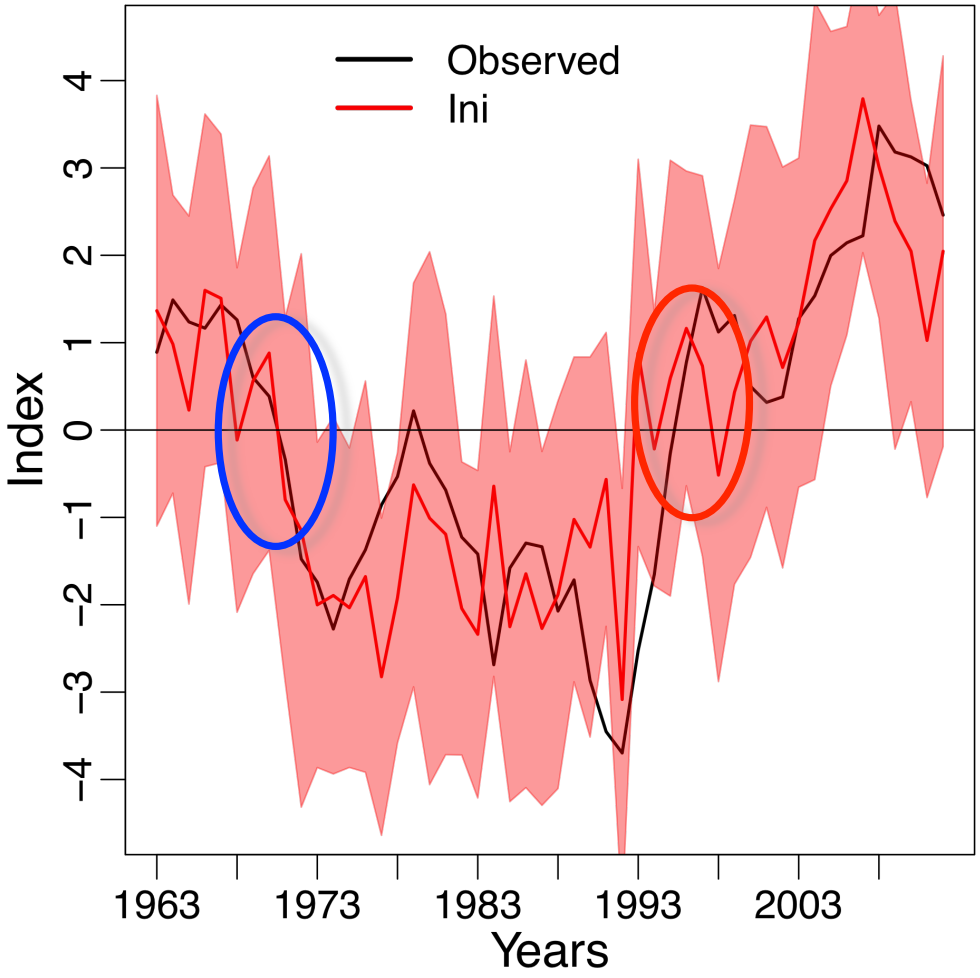



3.0
2.0
1.0
0.0
−1.0
−2.0
−3.0
1963
1969
1975
1981
1987
1993
1999
2005
2011



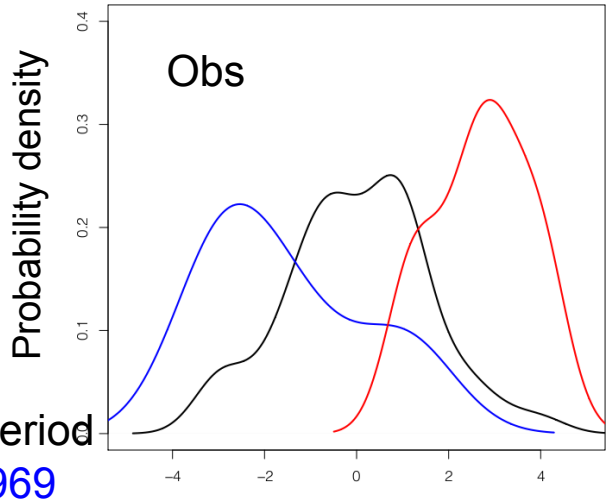
Still good correlation, but no predictive power

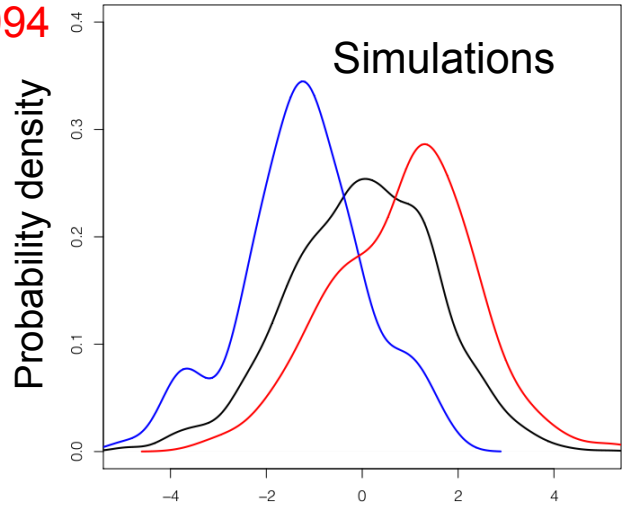

Avg Year 2-6 – Year 1 < 0
Avg Year 2-6 – Year 1 > 0
3.0
2.0
1.0
0.0
−1.0
−2.0
−3.0
1963
1969
1975
1981
1987
1993
1999
2005
2011



PDF Distribution
Avg Year 2-6 – Year 1

Entire period
1966-1969
1991-1994

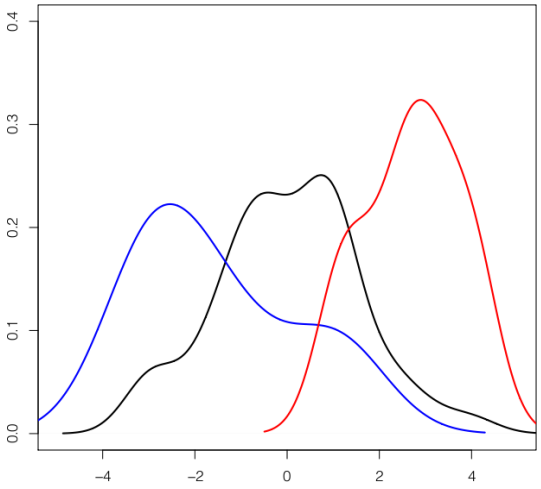




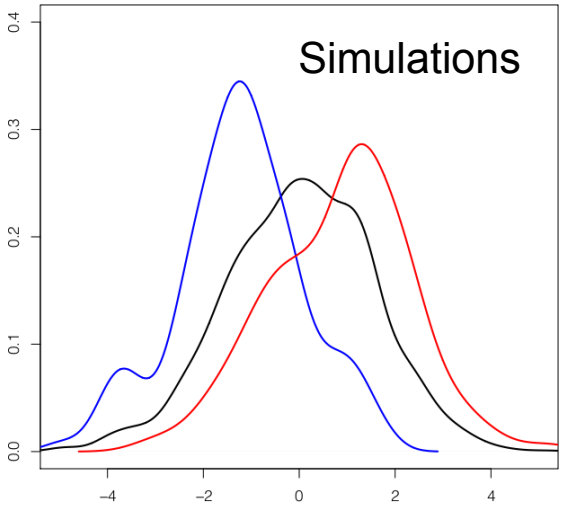
(Average Year 2-6) – (Year 1)

Probability density

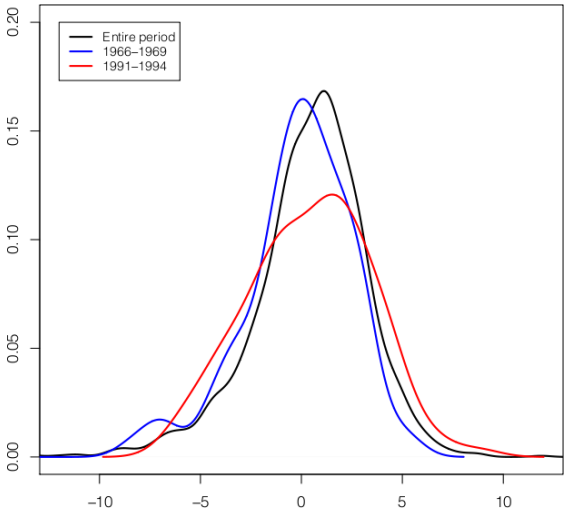
Observed Index



Simulated Index



Downscaled ACE (based on MDR SST)



Entire period
1966-1969
1991-1994

$$ACE = e^{1.707 + \beta_1 SST_{MDR} - \beta_2 1.521 SST_{TROP}}$$

Based on Villarini and Vecchi (2012)

Summary

- Initialized GCMs do seem capable of predicting CSU index, which is linked to Atlantic TC activity, at multi-annual timescale (5yrs)
- Skill doesn't come only from persistence, i.e. we have some skill at predicting shift between active and quiet phases
- Perspective: plan to extend period of study using decadal forecasts spanning the entire 20th century

More info:
Caron, L.-P., L. Hermanson, and F. J. Doblas-Reyes (2015) Multiannual forecasts of Atlantic U.S. tropical cyclone wind damage potential, Geophys. Res. Lett.,42, 2417–2425.

Special thank you to

RPI2.0
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Image credit: NASA