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Hadley Centre

Decadal predictions of the north Atlantic sub-polar gyre and associated climate

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Summary

- Present generation climate models can predict hurricane frequency for the coming few years
- The high latitude north Atlantic plays an active role
- Recent increase is at least partly externally-forced

Decadal Prediction System (DePreSys)

- HadCM3 (2.5 x 3.75 atmos, 1.25^{o} ocean)
- External forcing as in IPCC (GHGs, aerosols, ozone, solar, volcanoes)
- Initialised with ocean T & S, atmos U, V, T and p*

Hindcast experiments

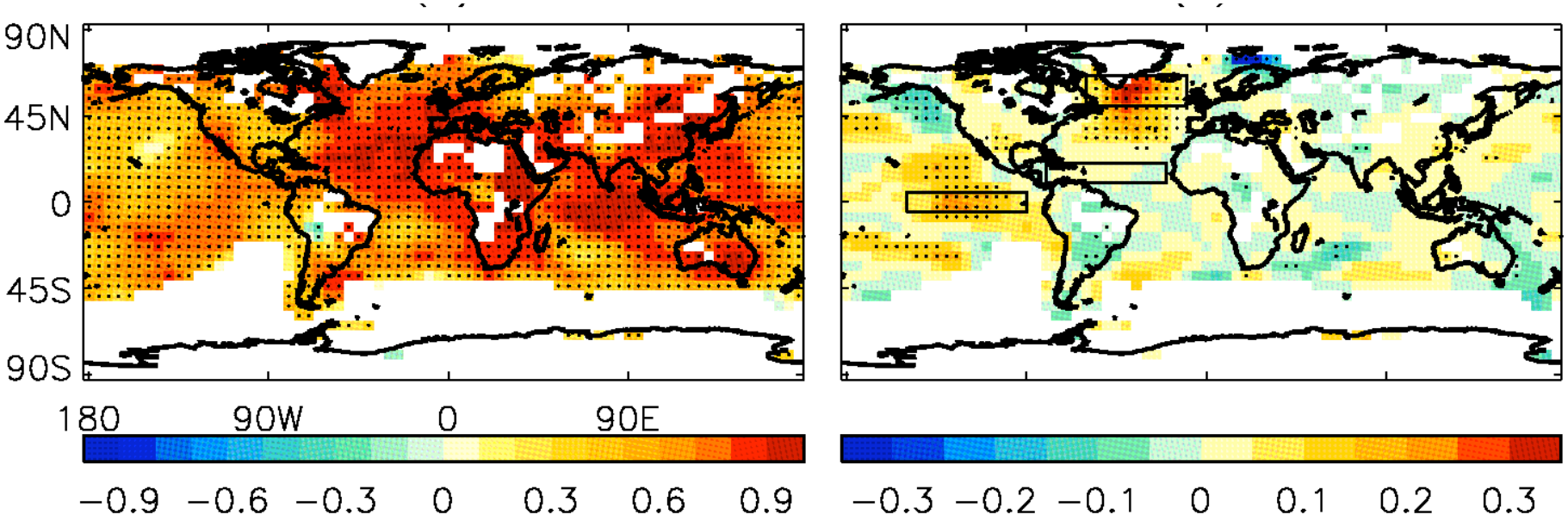
- DePreSys_PPE
  - EU ENSEMBLES project
  - Start dates each November 1960 to 2005
  - 9 ensemble members, each with different parameter settings
  - 10 years long
  - Initialised with ocean T,S and atmosphere p*, U, V, theta
- Parallel NoAssim experiments
  - Identical external forcing
  - Not initialised (initial conditions from control simulation in 1860)

Impact of initialisation on hindcast skill

5 year mean (Jun-Nov) surface temp :
15x15 degrees : start dates each Nov 1960 to 2005

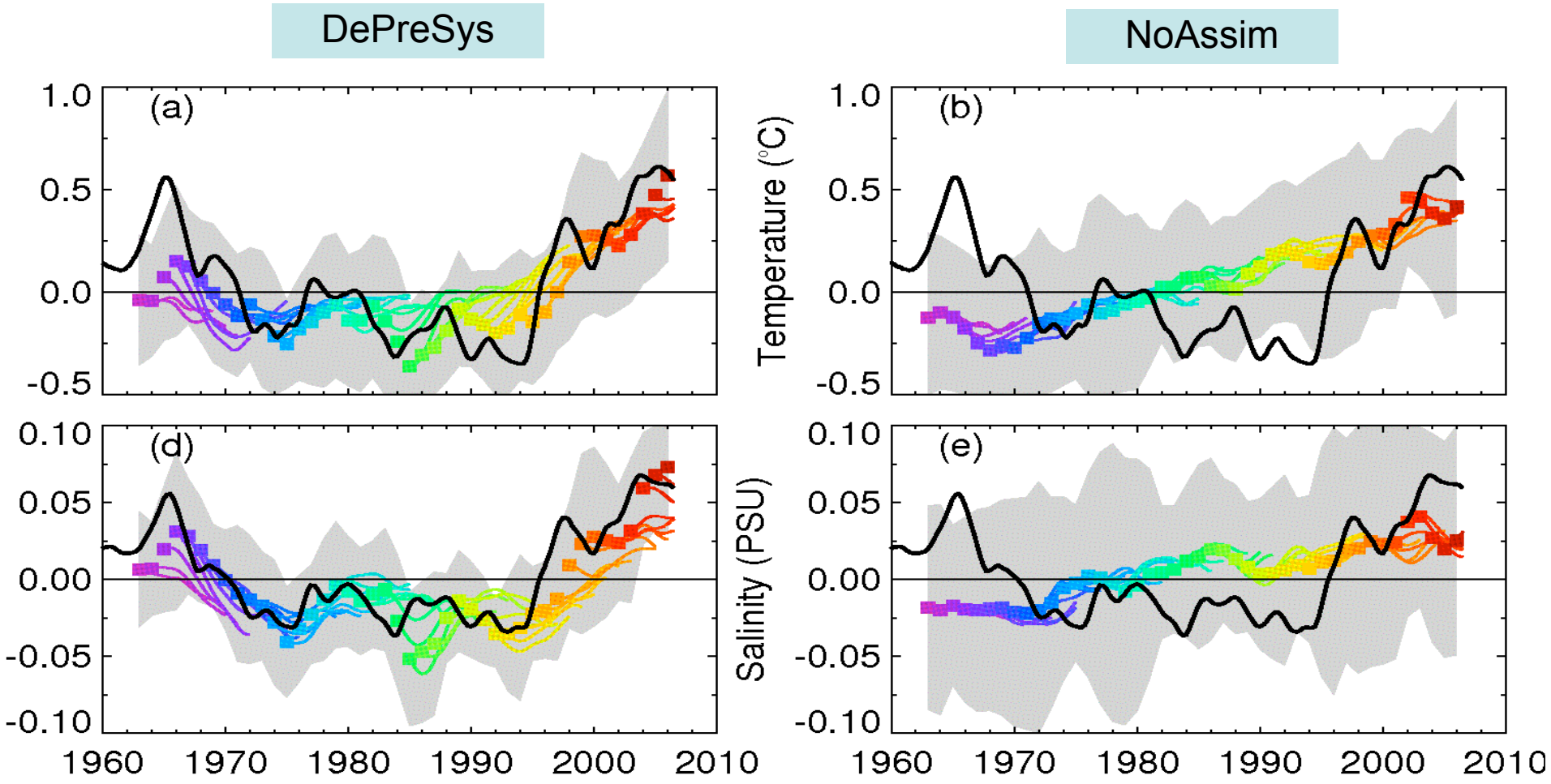
DePreSys anomaly correlation

DePreSys-NoAssim correlation

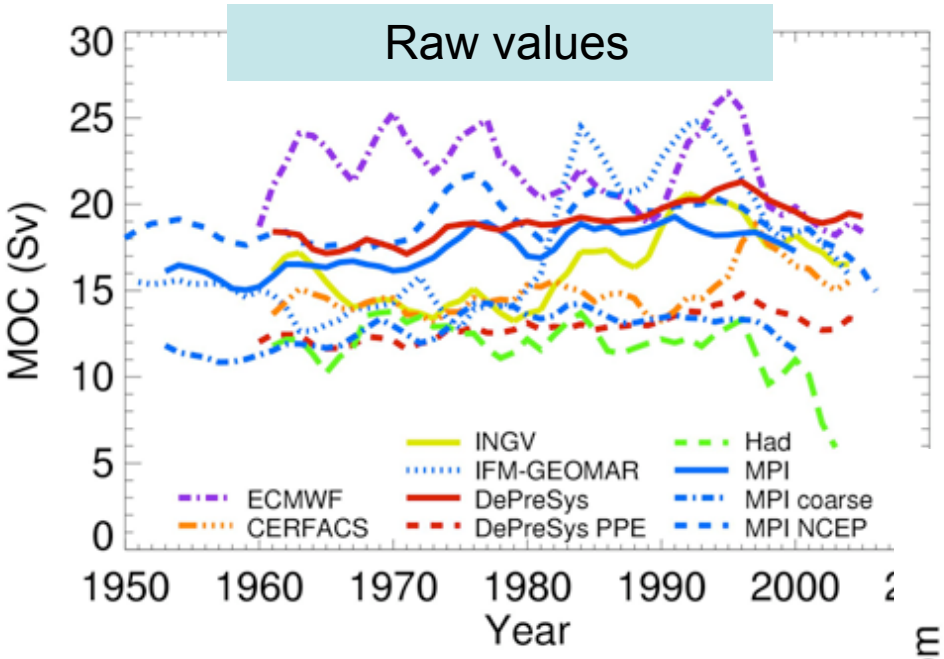


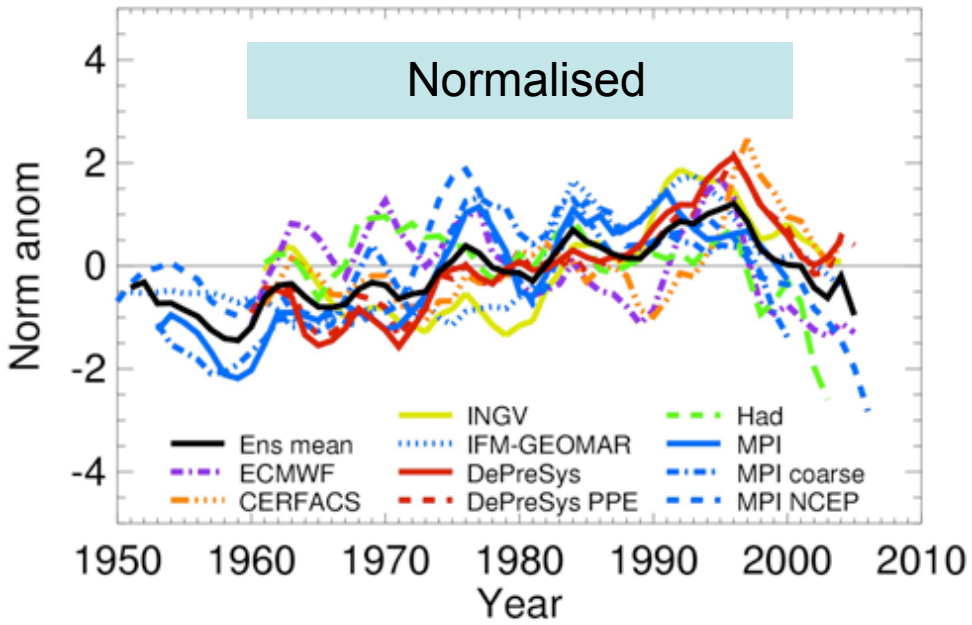
- HadCM3
- 9 member perturbed physics ensemble
- Starting every Nov from 1960 to 2005

Annual upper 500m Atlantic sub-polar gyre T & S



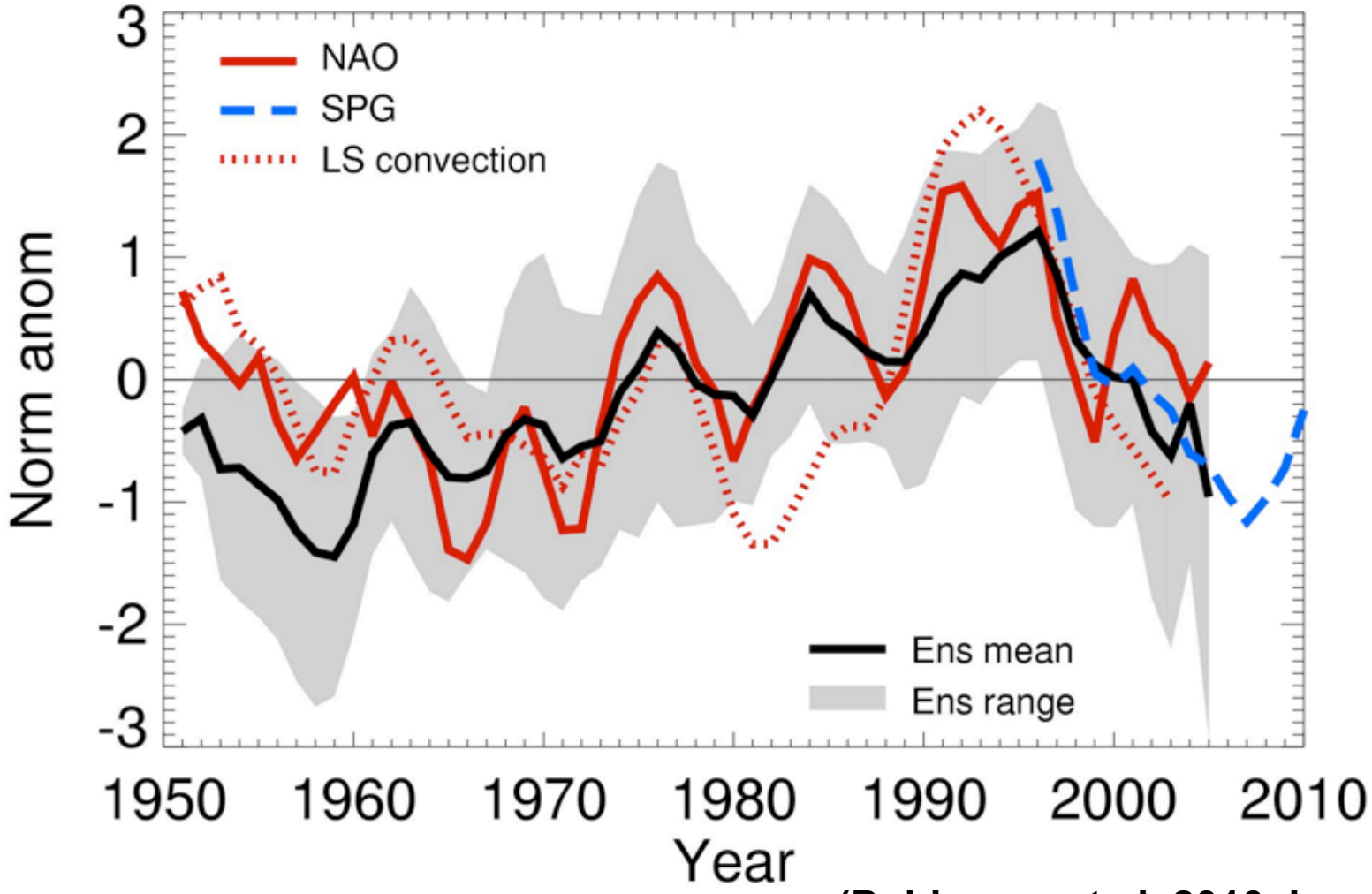
AMOC at 45°N in assimilation experiments





(Pohlmann et al. 2010, in prep)

AMOC at 45°N in assimilation experiments



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AMOC at 45°N in hindcast experiments

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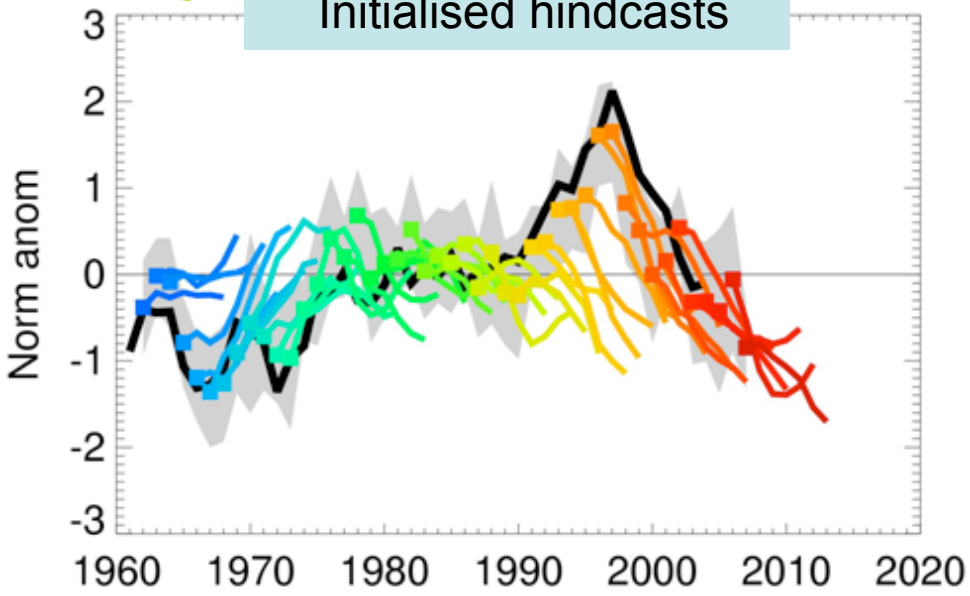
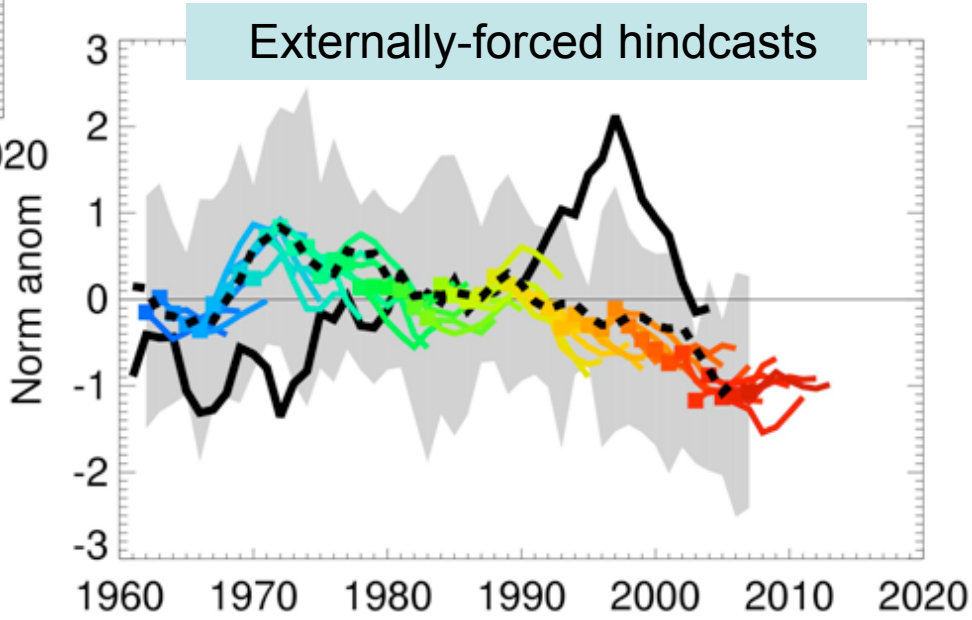
Initialised hindcasts



Externally-forced hindcasts



(Pohlmann et al. 2010, in prep)

Relationship between north Atlantic SST and hurricanes

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Observations

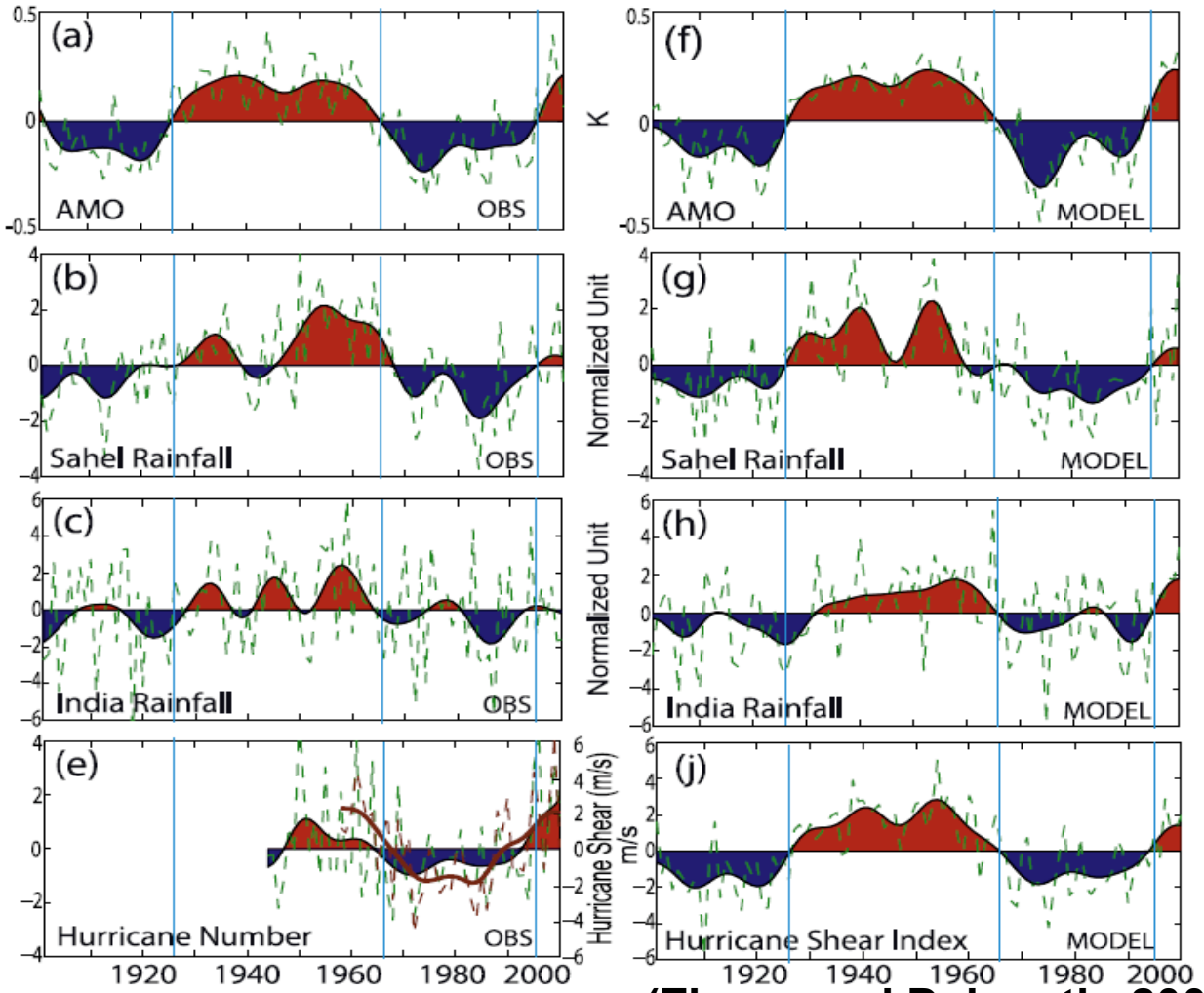
Model

North Atlantic SST

Sahel rainfall

India rainfall

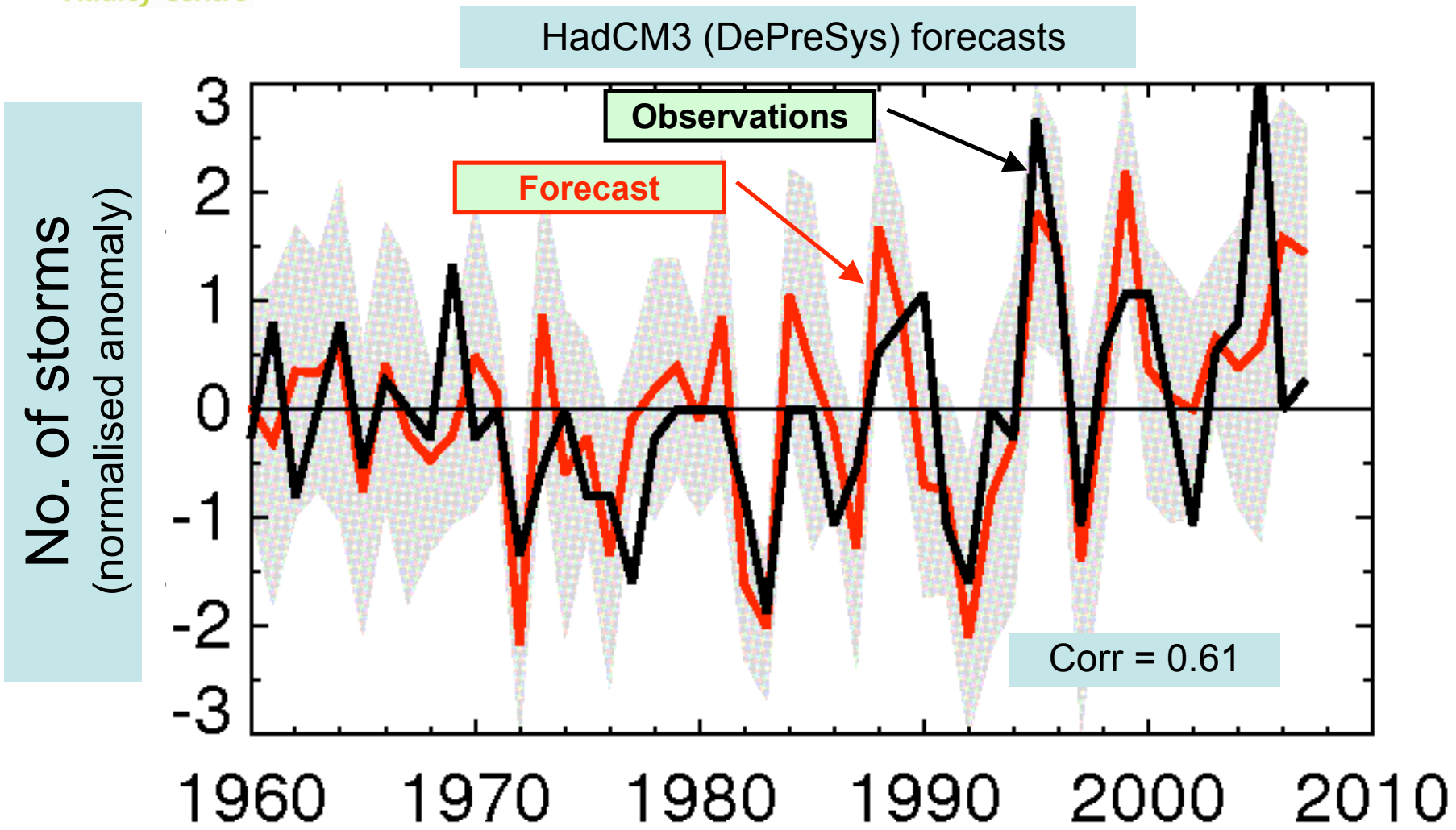
Hurricanes



(Zhang and Delworth, 2006)

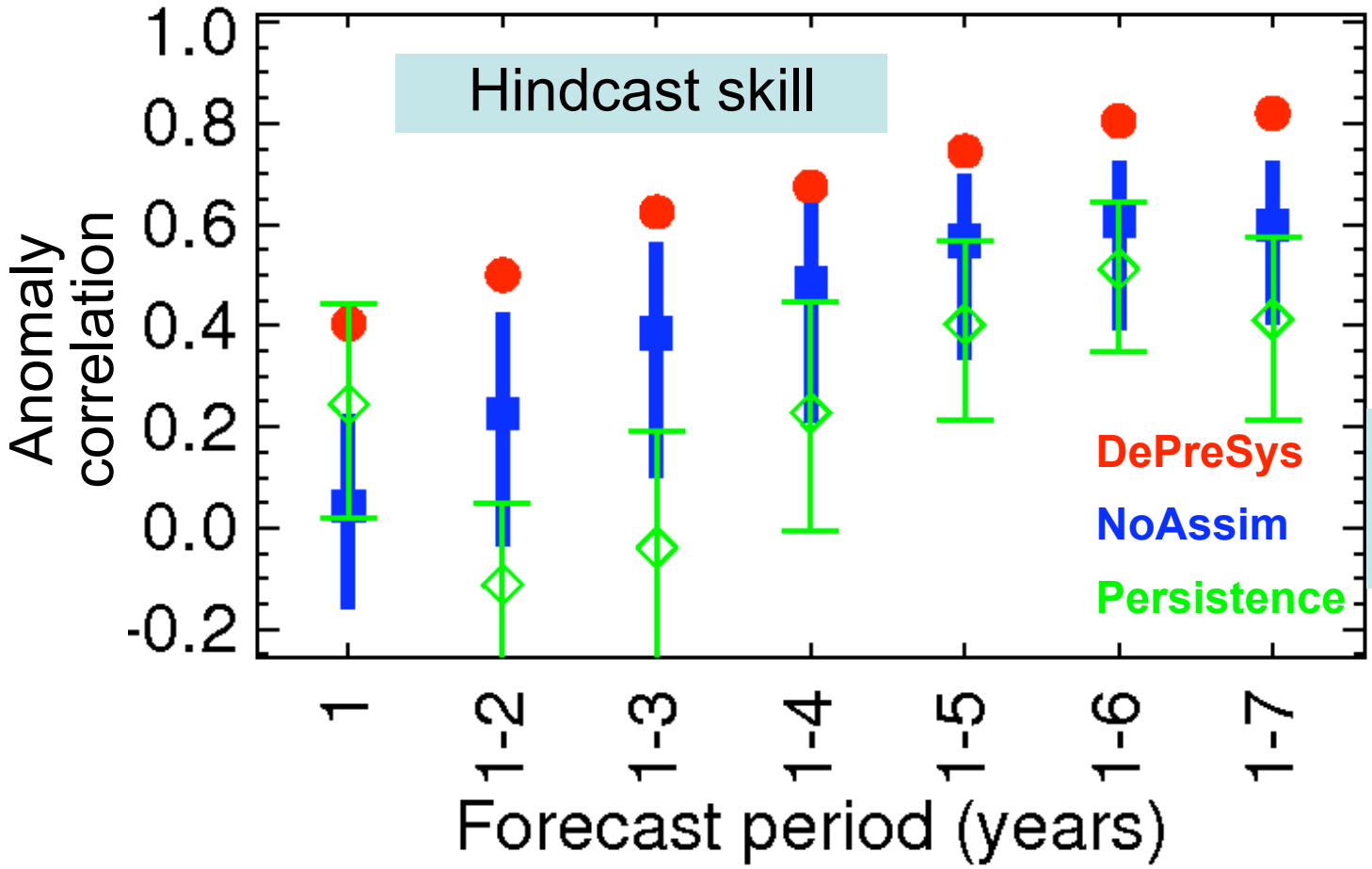
Atlantic tropical storms

Seasonal forecasts from May for June-Nov



Atlantic tropical storms

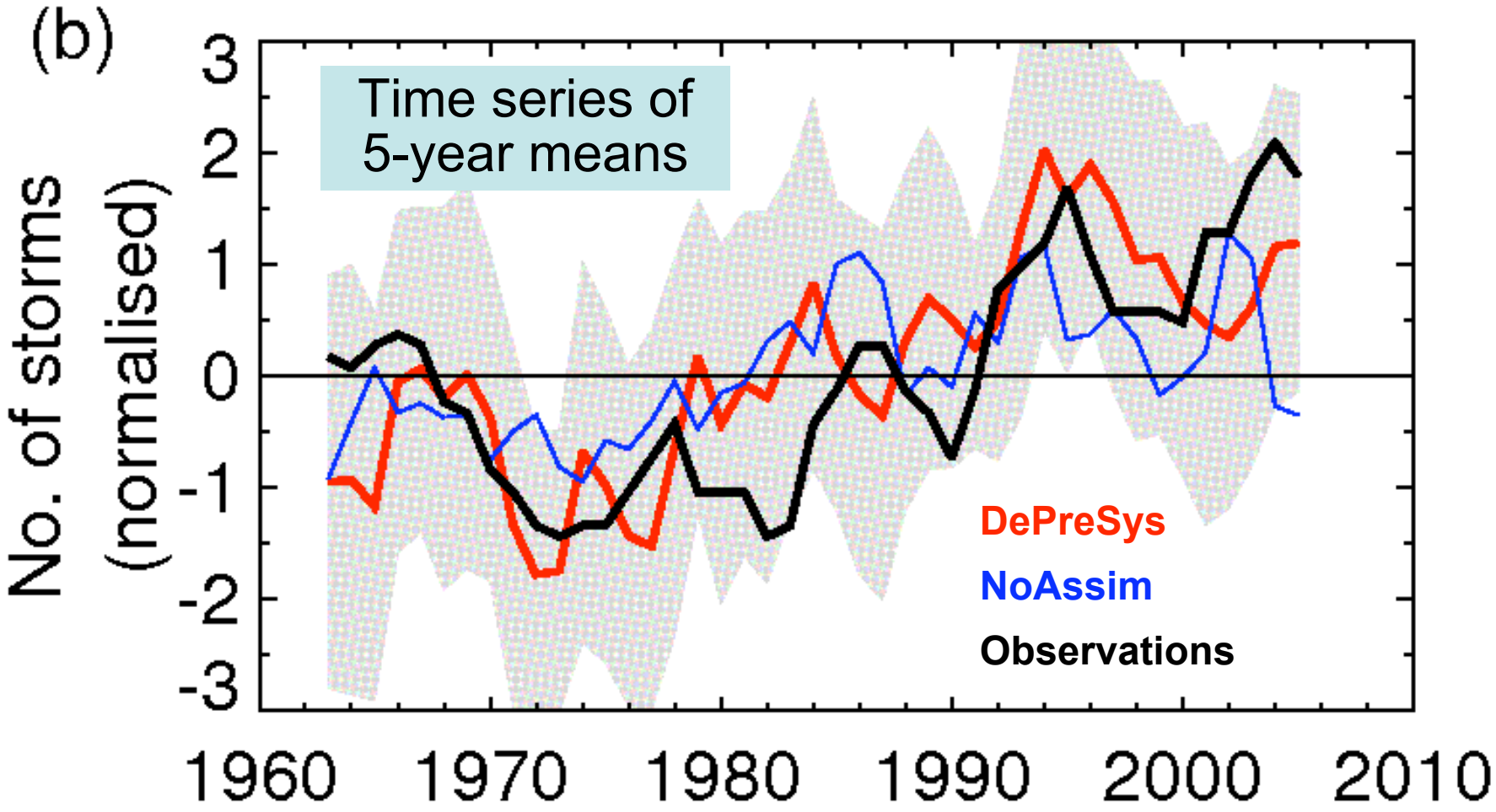
Forecasts from Nov for June-Nov



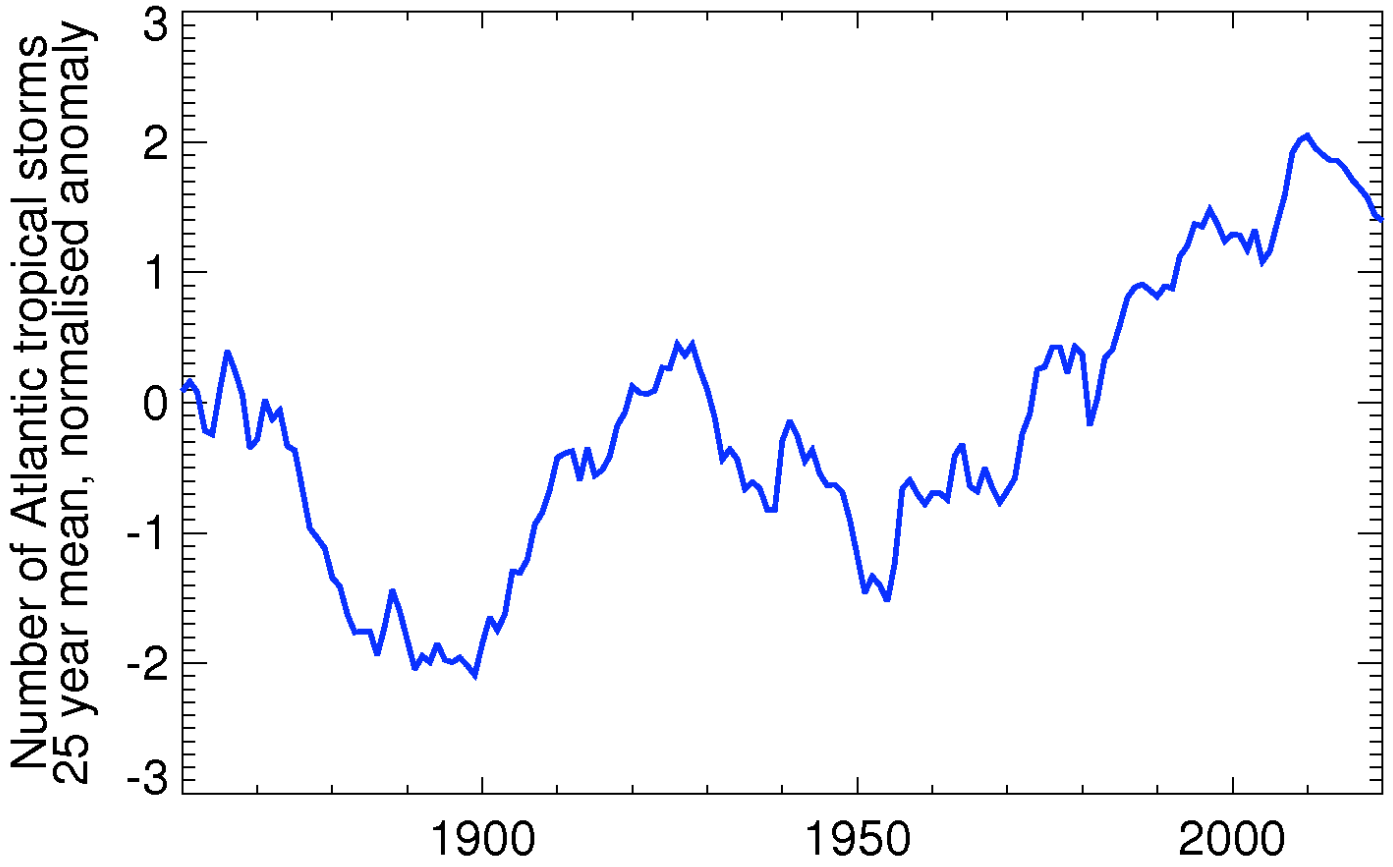
NoAssim = external forcing only

Atlantic tropical storms

Forecasts from Nov for June-Nov



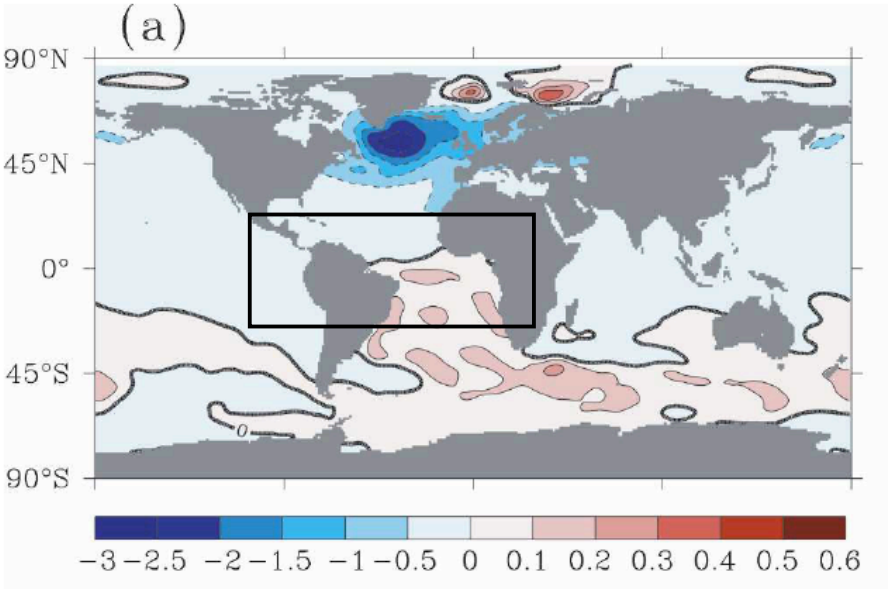
External forcing of Atlantic tropical storms in HadCM3 transient runs



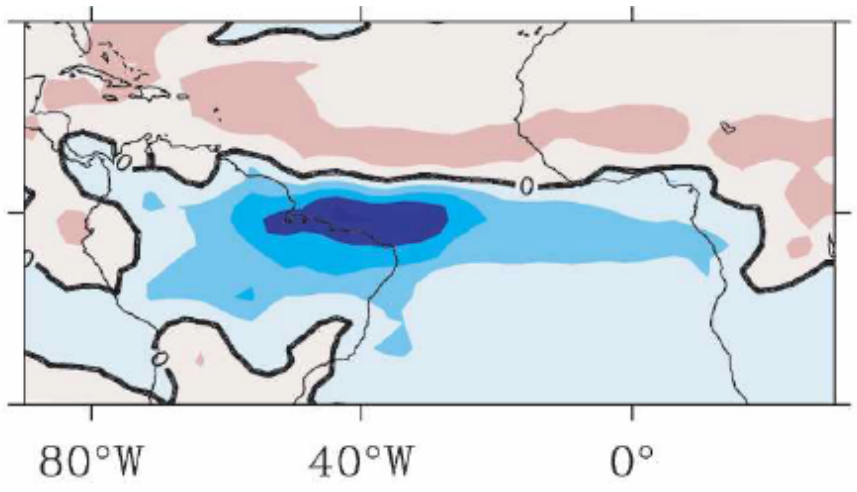
17 member, HadCM3, perturbed parameters, 20th century simulations

Influence of high latitudes on ITCZ

SST



Precipitation

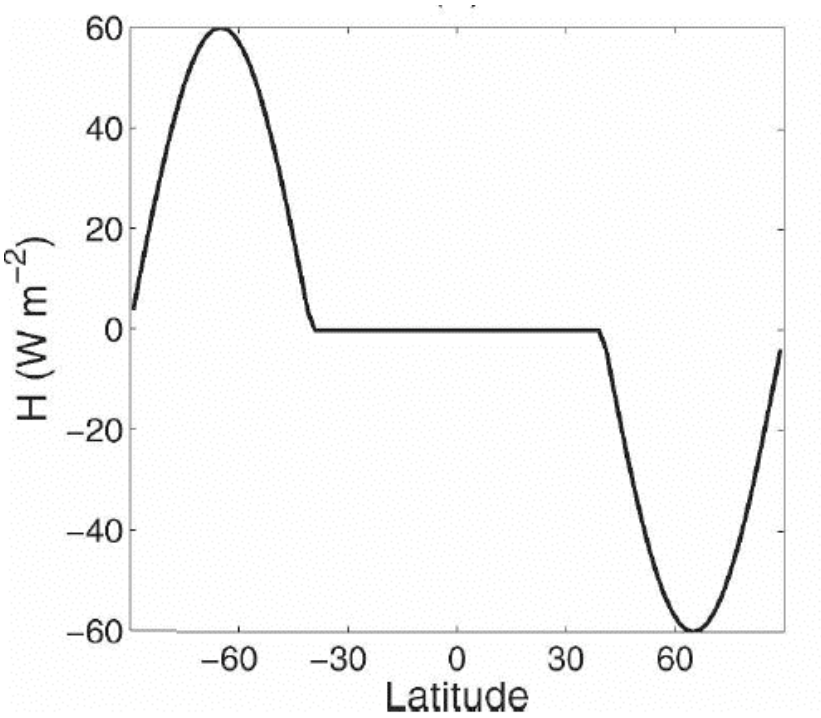


ITCZ shifts towards the warmer hemisphere

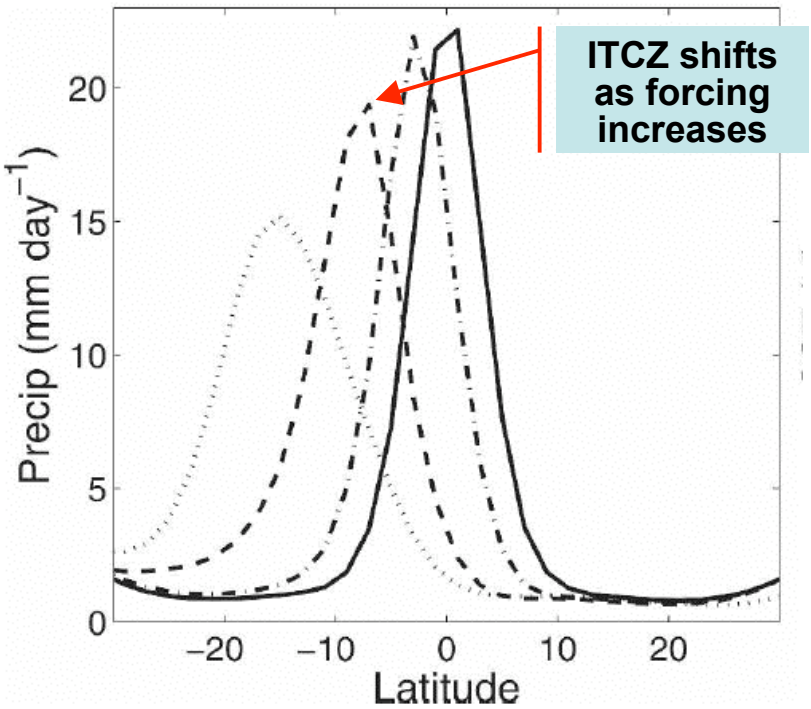
Stouffer *et al*, 2006, Zhang and Delworth, 2005, Chiang and Bitz, 2005, Chiang *et al*. 2008

Influence of high latitudes on ITCZ

- Atmosphere GCM, slab ocean
- Imposed flux anomalies only at high latitudes (> 40^{o})



Forcing flux



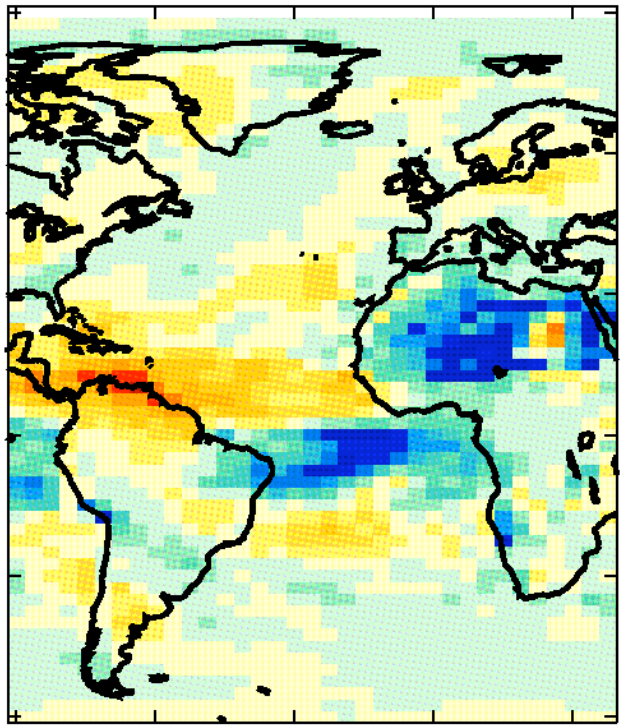
Precipitation response

(Kang et al. 2008, J. Climate)

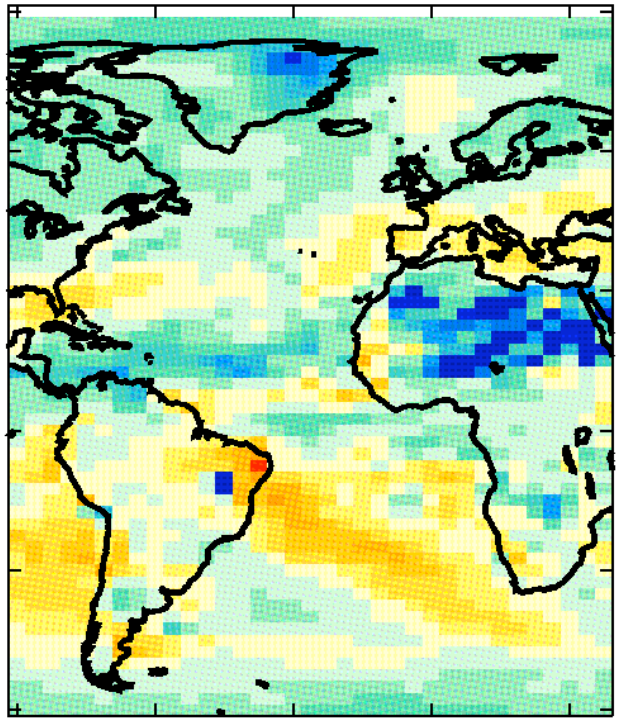
Forecast shift in ITCZ

- DePreSys precipitation
- 10 year means

1975 to 1985

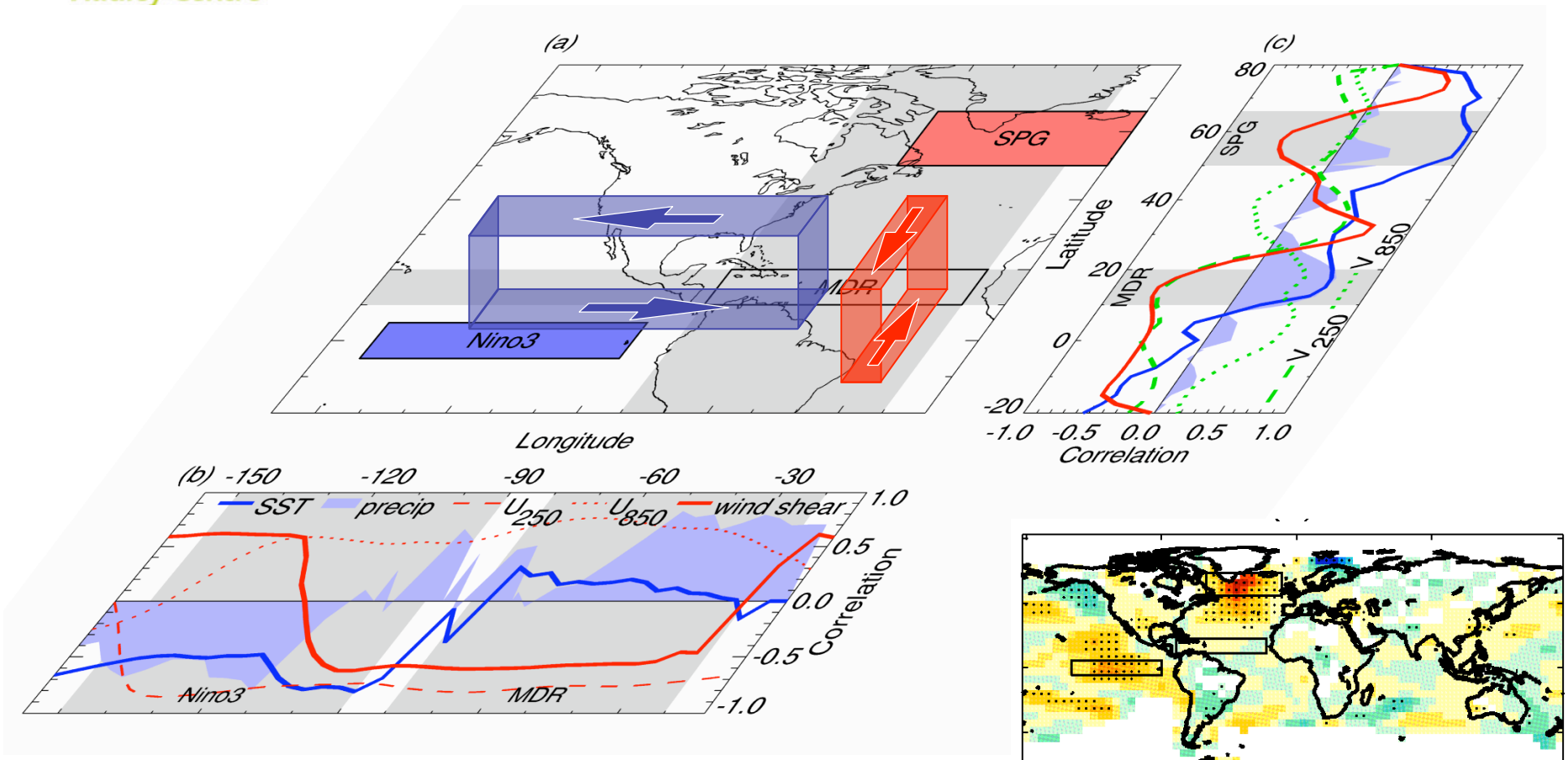


1995 to 2005



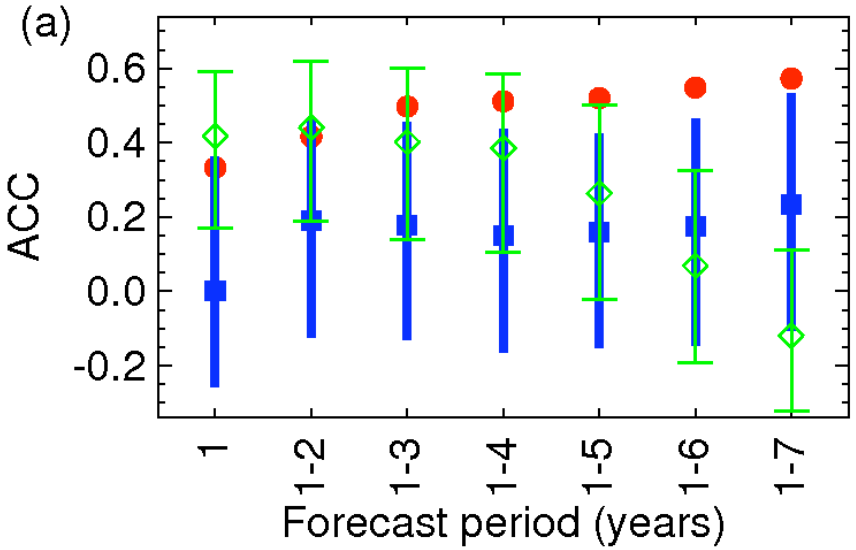
−20 −15 −10 −5 0 5 10 15 20

Remote influences on Atlantic hurricanes



MDR wind shear
Forecasts from Nov for June-Nov

Hindcast skill



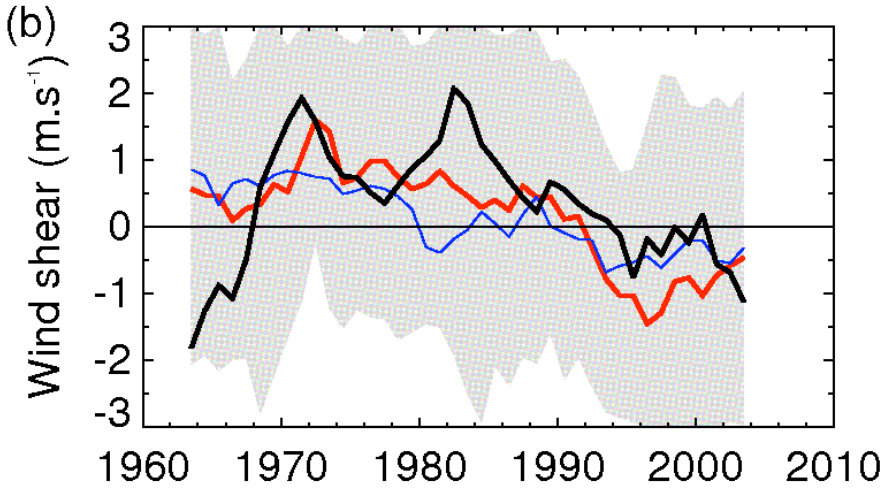
DePreSys

NoAssim

Persistence

Observations

Time series of 5-year means



Skill in tropical Atlantic variables seen in idealised experiments

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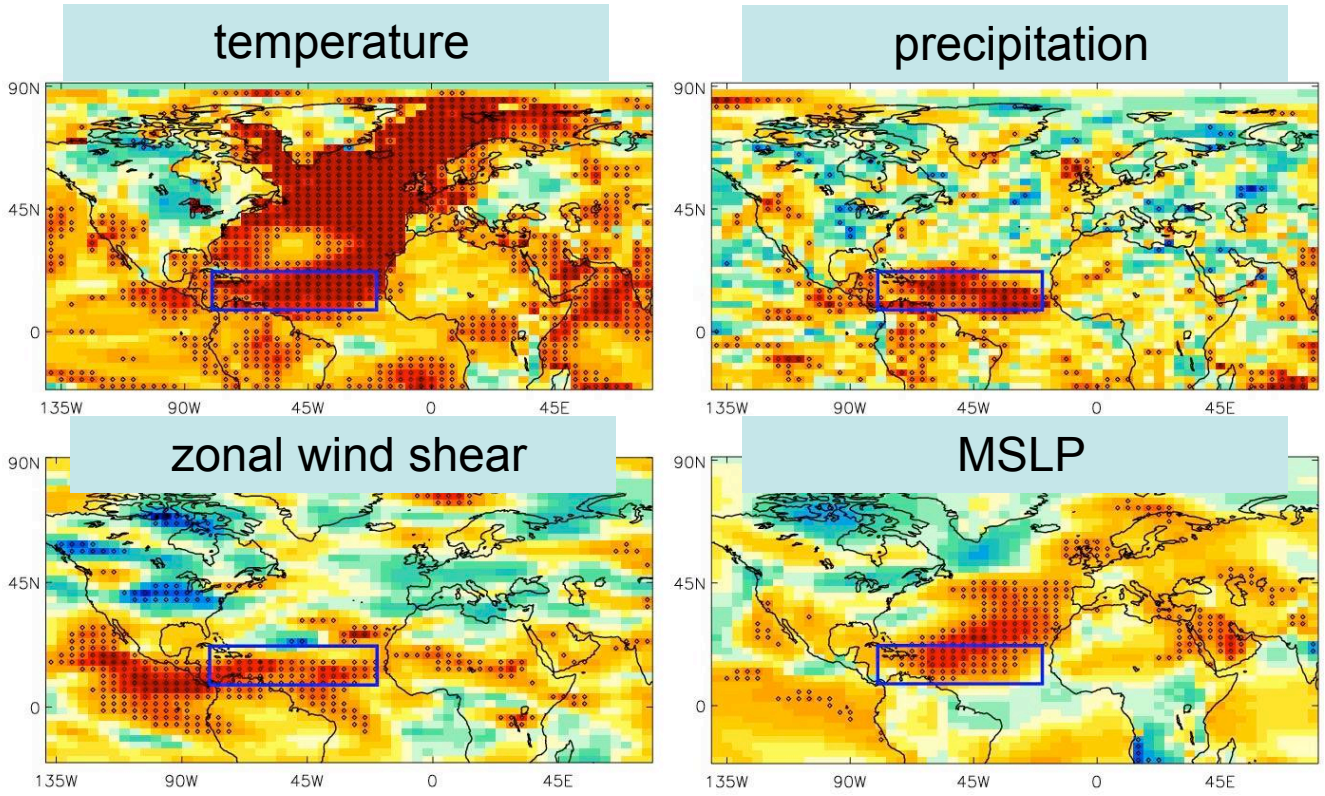
JJA season, Forecast years 2-6:

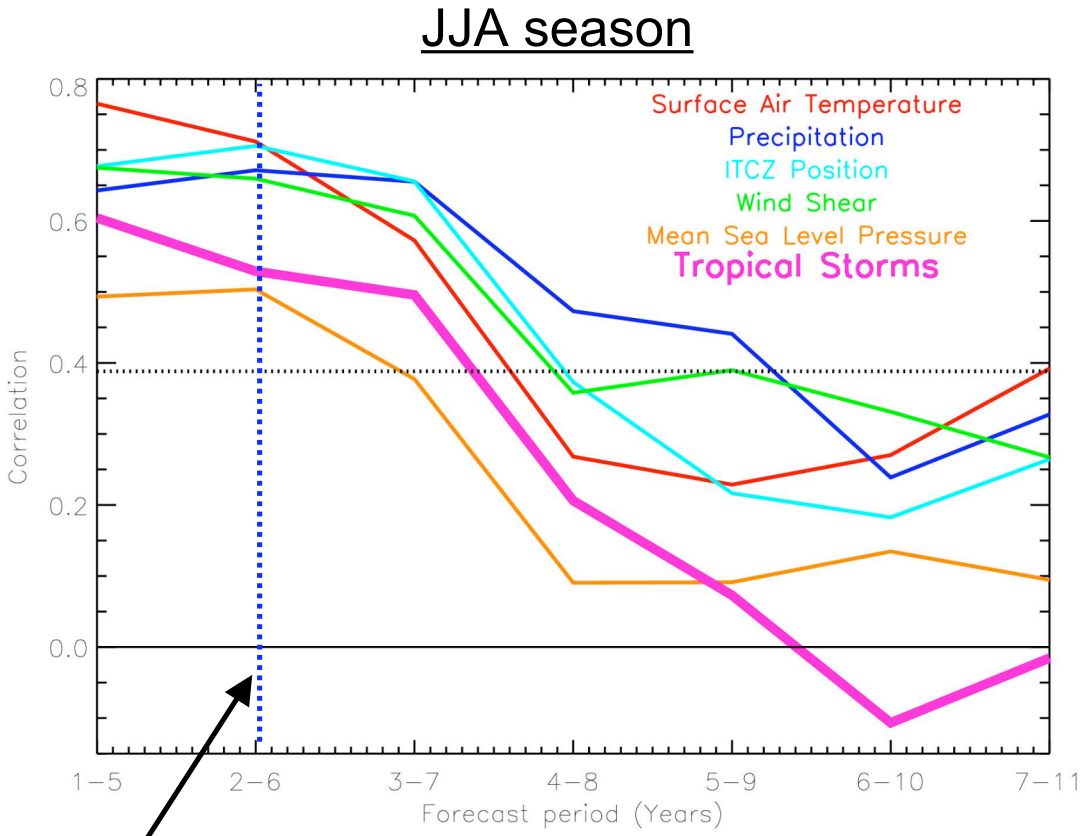
Dunstone & Smith, 2010, in prep



- Large set of idealised model experiments (>25 start dates)
- Monthly mean T & S ocean data is assimilated at all model locations (no atmosphere assimilation)
- Stippled regions are significant at the 5% level
- Blue box shows the main hurricane development region (MDR)

Skill in tropical Atlantic storms in idealised experiments

Dunstone & Smith, 2010, in prep

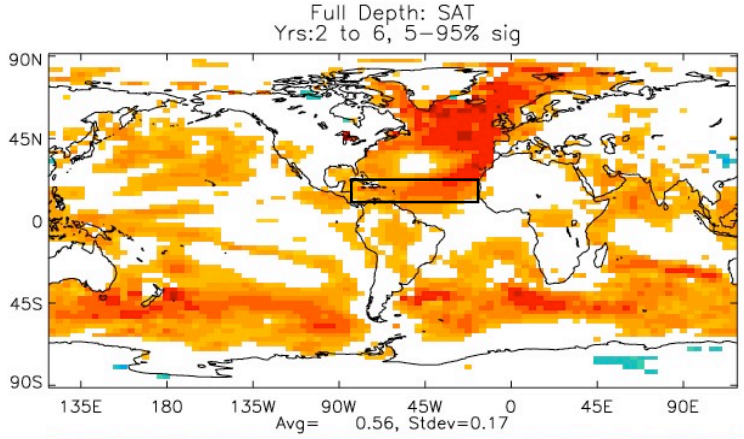


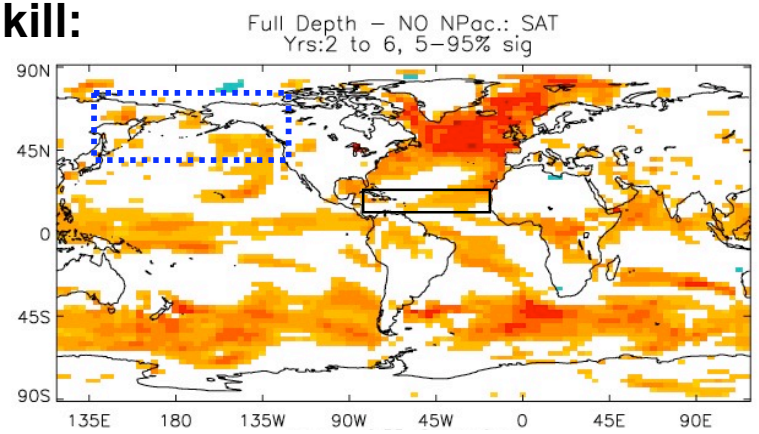
Maps on previous slide.

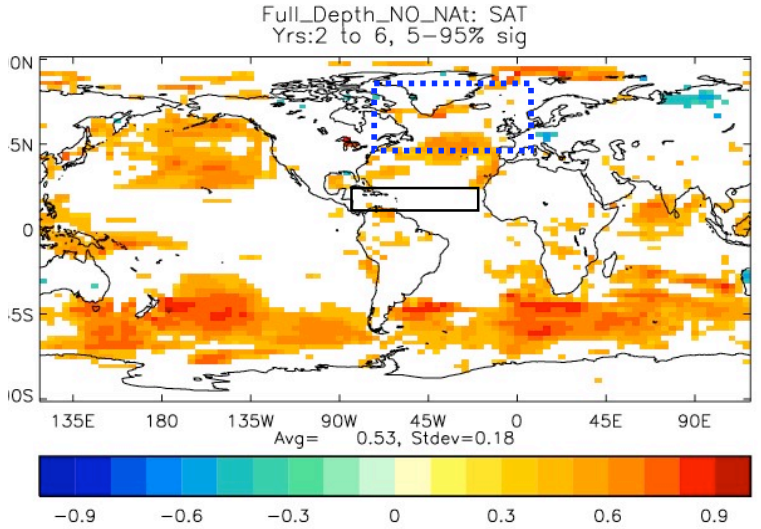
- Skill as a function of lead time for the area-average of the MDR box for different variables
- Skill in surface temperature and wind shear leads to skill in predicting the numbers of tropical storms
- Black horizontal dotted line shows correlations significant at the 5% level

Investigating origin of tropical Atlantic skill

Two further experiments run to assess impact of different ocean regions on forecast skill:







- Both set-up as *Full_Depth* except one experiment assimilates climatology in the North Atlantic and other climatology in the North Pacific.
- It is clear that removing any data can only degrade forecast skill.
- However, skill in MDR appears more sensitive to North Atlantic ocean assimilation than North Pacific.

Summary

- Present generation climate models can predict hurricane frequency for the coming few years
  - ➢Skill in real and idealised experiments
  - ➢Skill in associated environmental factors (SST, wind shear)
  - ➢But far from perfect!
- The high latitude north Atlantic plays an active role
  - ➢Improved skill in DePreSys relative to NoAssim in SPG and AMOC

  Link between SPG and ITCZ
  - ➢Large impact removing SPG data in idealised studies
- Recent increase is at least partly externally-forced

Any questions?