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Hadley Centre

# Decadal predictions of the Atlantic ocean and hurricane numbers

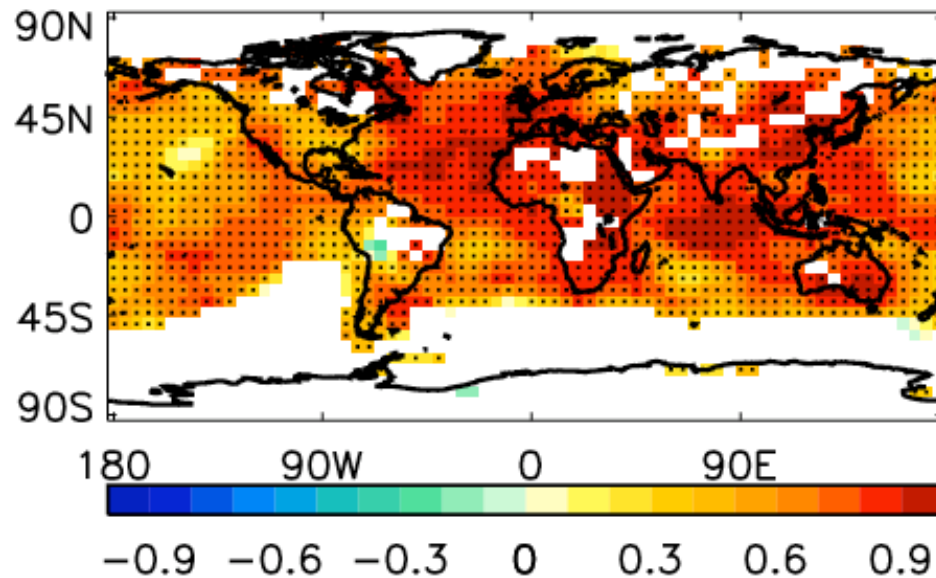
Doug Smith, Nick Dunstone, Rosie Eade, David Fereday, James Murphy, Holger Pohlmann, Adam Scaife

# Impact of initialisation on hindcast skill

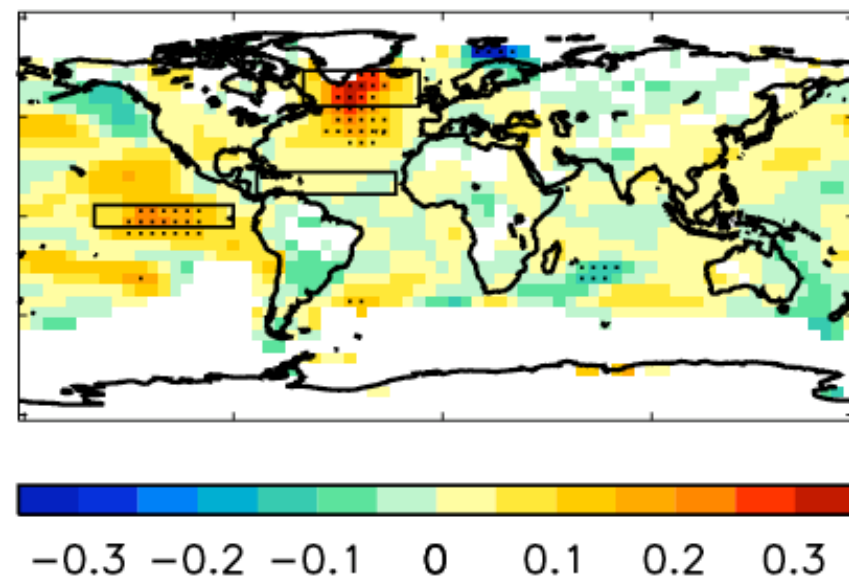
5 year mean (Jun-Nov) surface temp :

15x15 degrees : start dates each Nov 1960 to 2005

Total skill (anomaly correlation)



Impact of initialisation



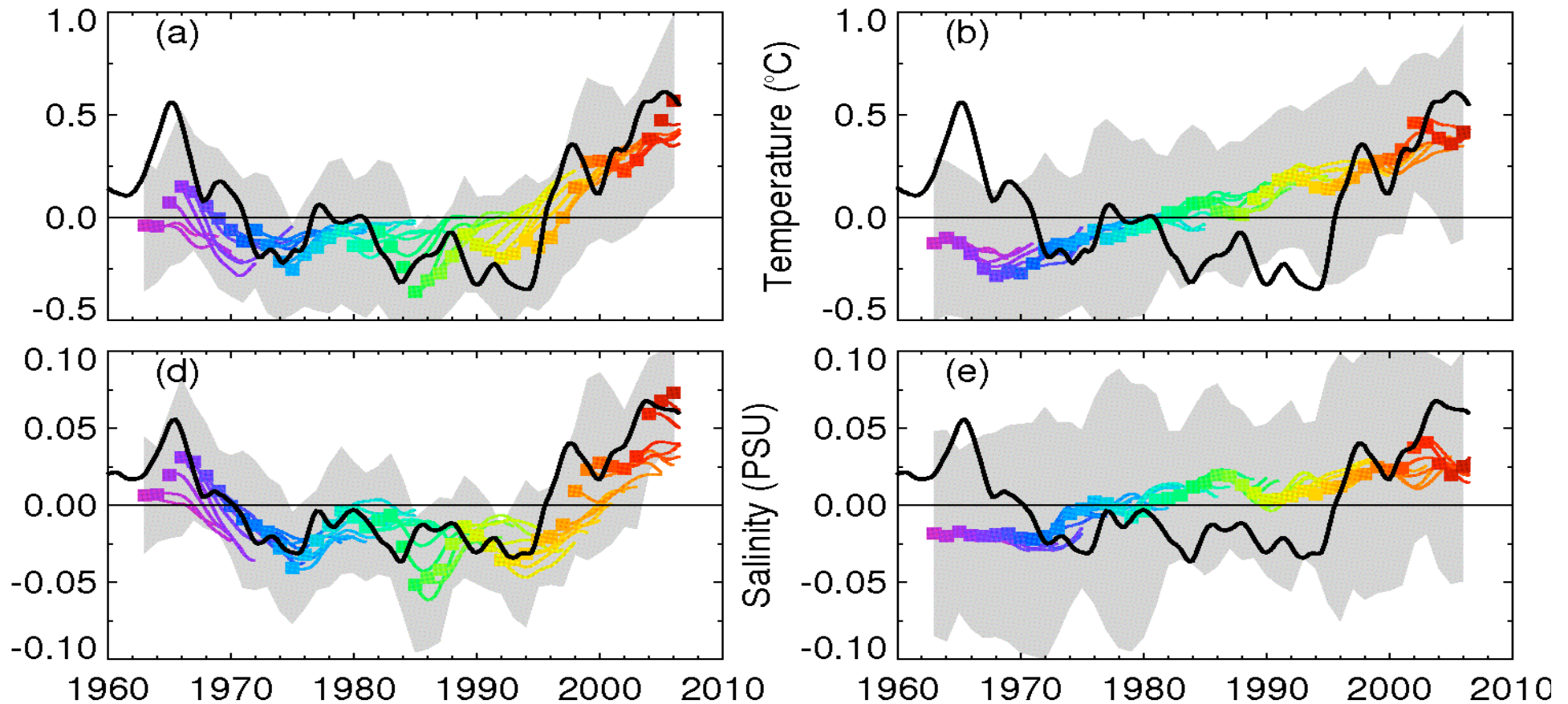
- HadCM3
- 9 member perturbed physics ensemble
- Starting every Nov from 1960 to 2005

(Smith et al. 2010)

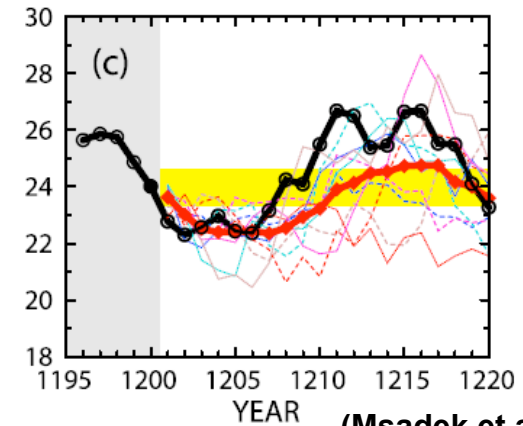
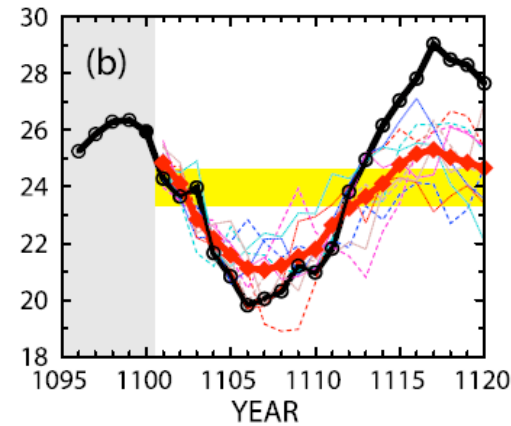
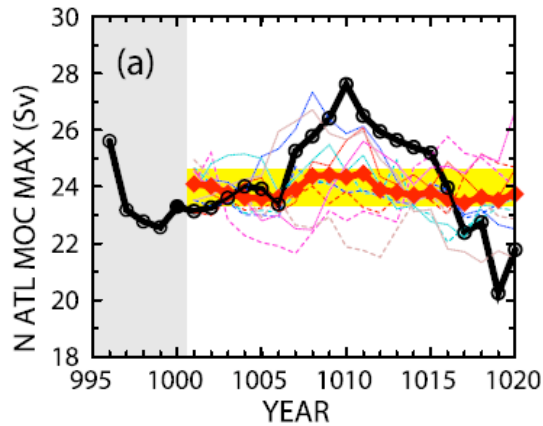
# Annual upper 500m Atlantic sub-polar gyre T & S

Initialised hindcasts

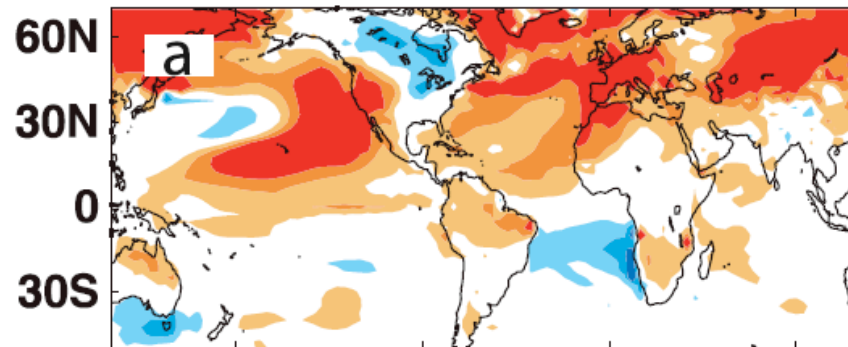
Externally-forced hindcasts



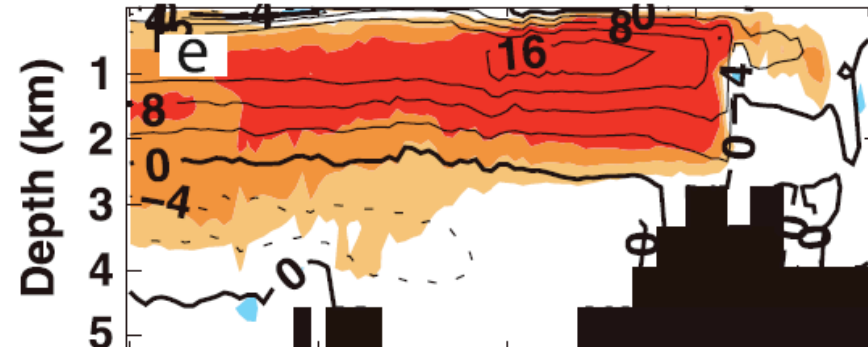
# Atlantic meridional overturning circulation (AMOC)



(Msadek et al. 2010)



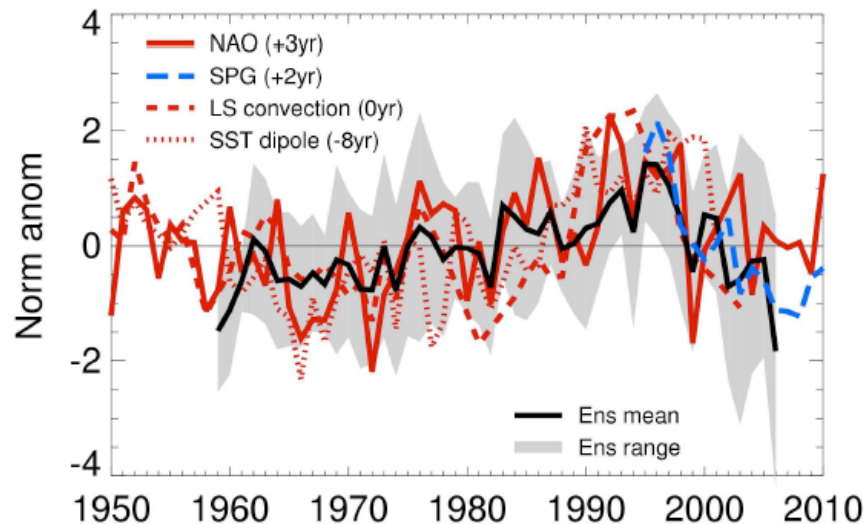
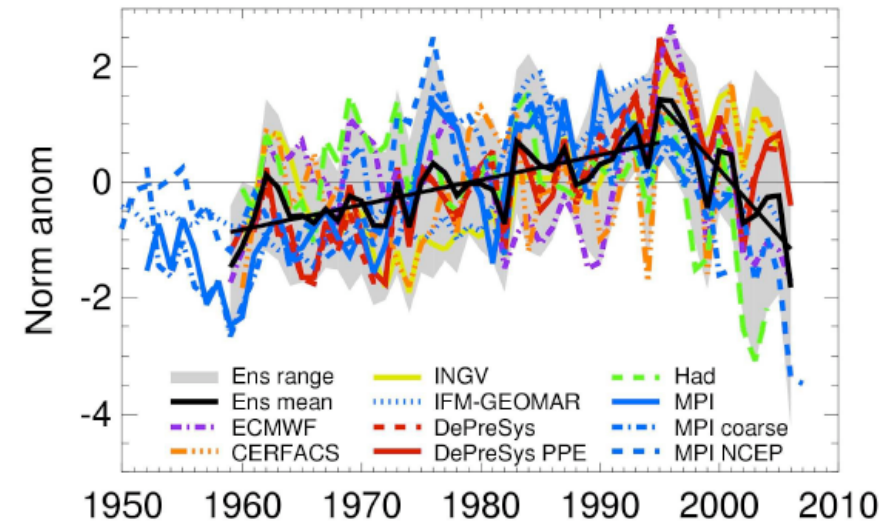
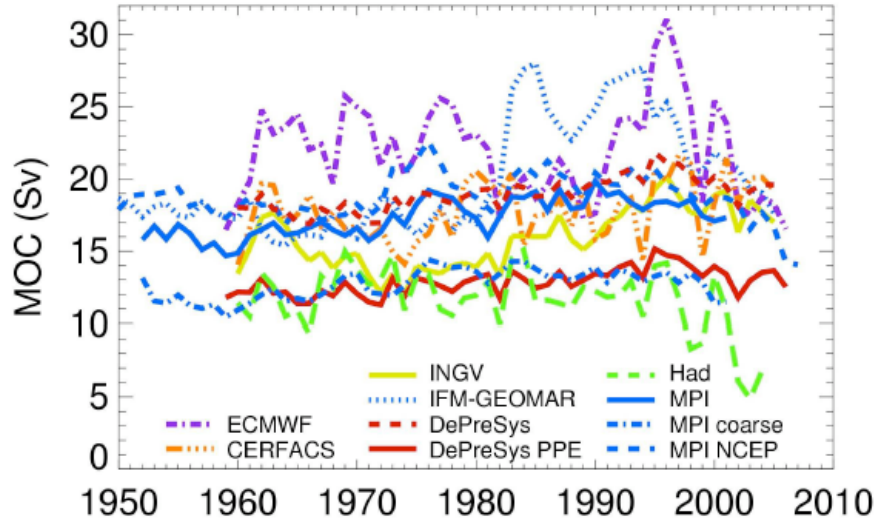
-0.3 -0.2 -0.1 0 0.1 0.2 0.3  
Temperature Anomaly (°C)



-0.6 -0.4 -0.2 0 0.2 0.4 0.6  
Streamfunction Anomaly (Sv)



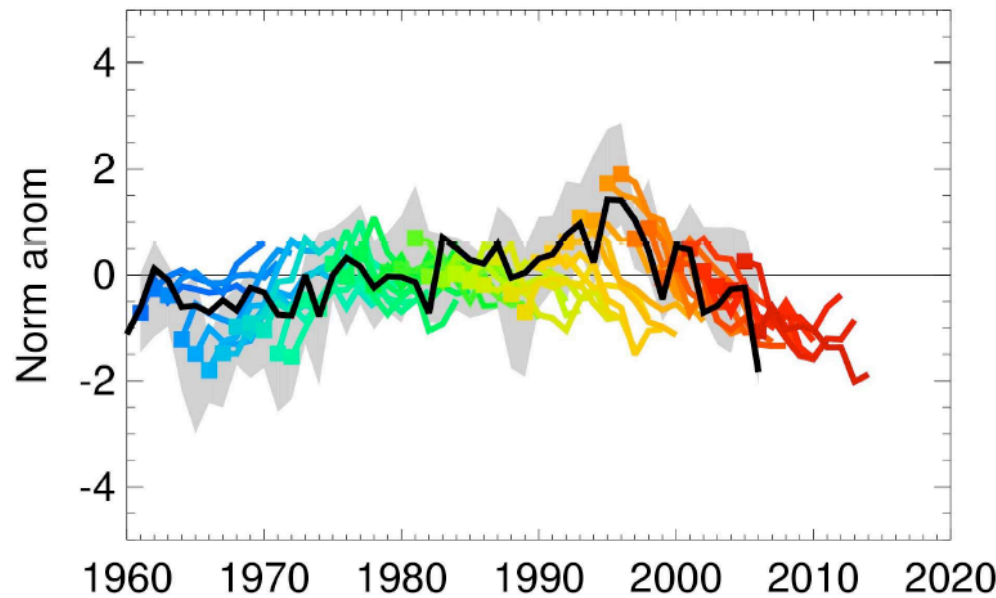
# AMOC at 45°N in assimilation experiments



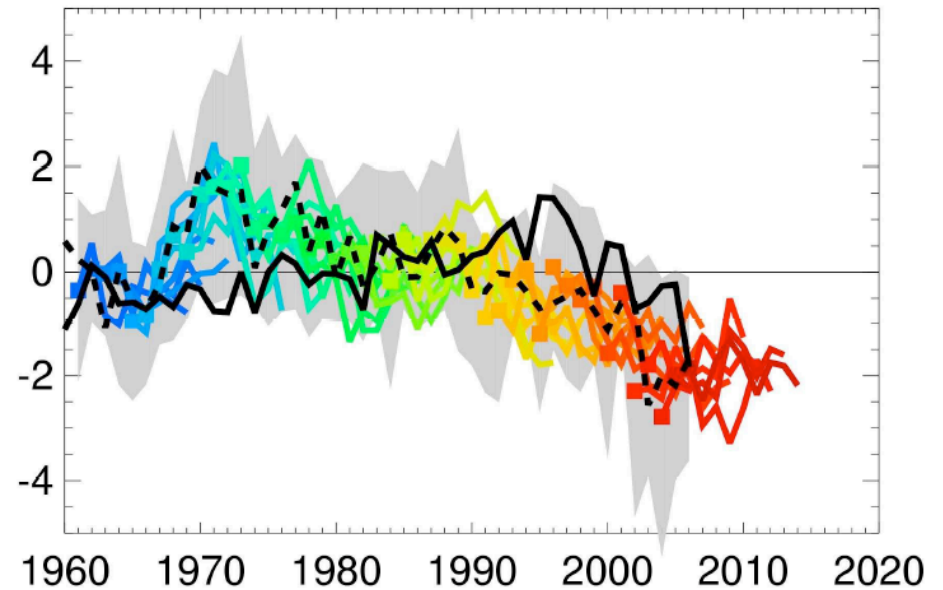
- Normalised analyses show a consistent signal
- AMOC increase from 1960-95, decrease thereafter
- Agrees with related observations

# AMOC at 45°N in hindcast experiments

Initialised hindcasts



Externally-forced hindcasts



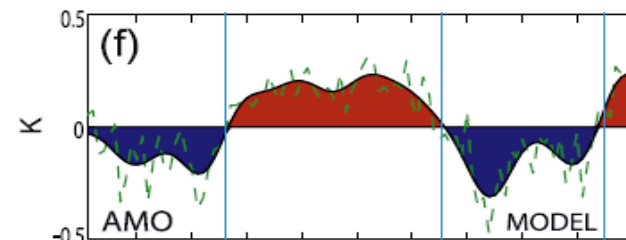
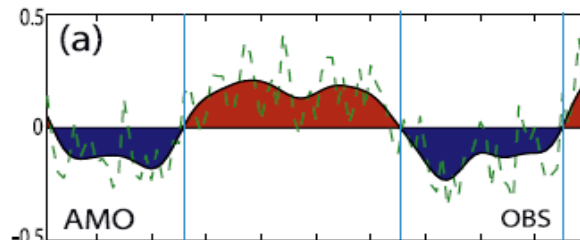
- Skill in sub-polar gyre is consistent with improved AMOC predictions

# Potential climate impacts of north Atlantic SST

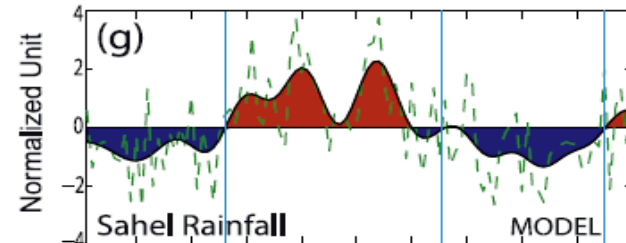
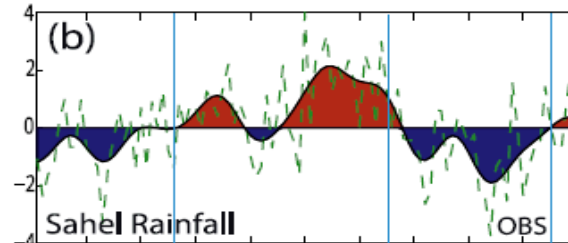
Observations

Model

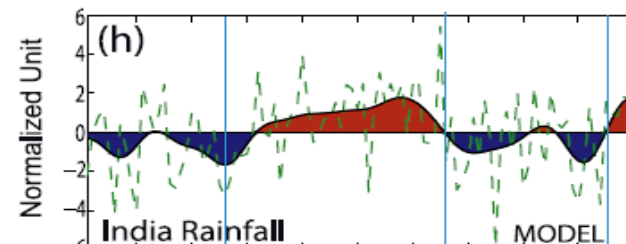
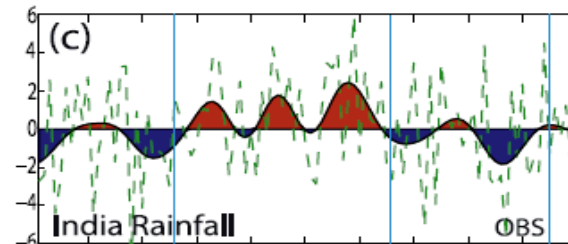
North Atlantic SST



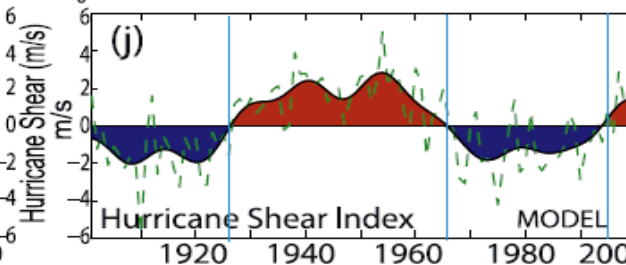
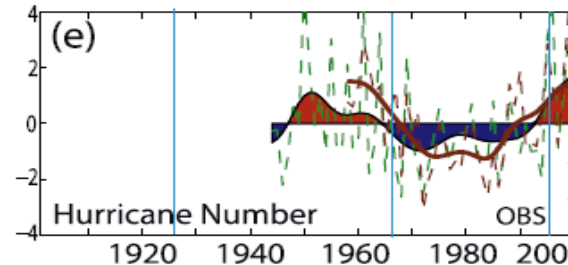
Sahel rainfall



India rainfall



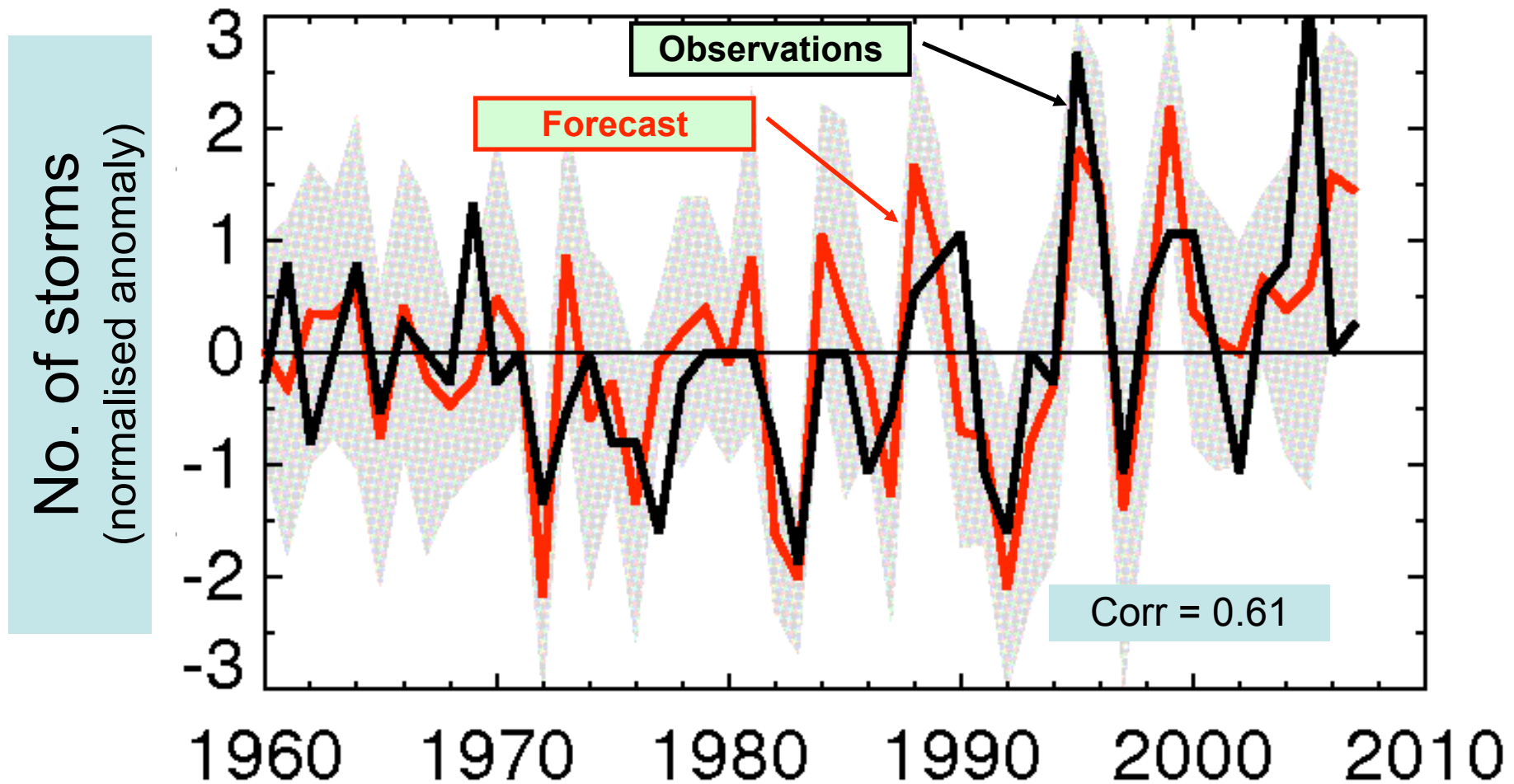
Hurricanes



# Atlantic tropical storms

## Seasonal forecasts from May for June-Nov

HadCM3 (DePreSys) forecasts

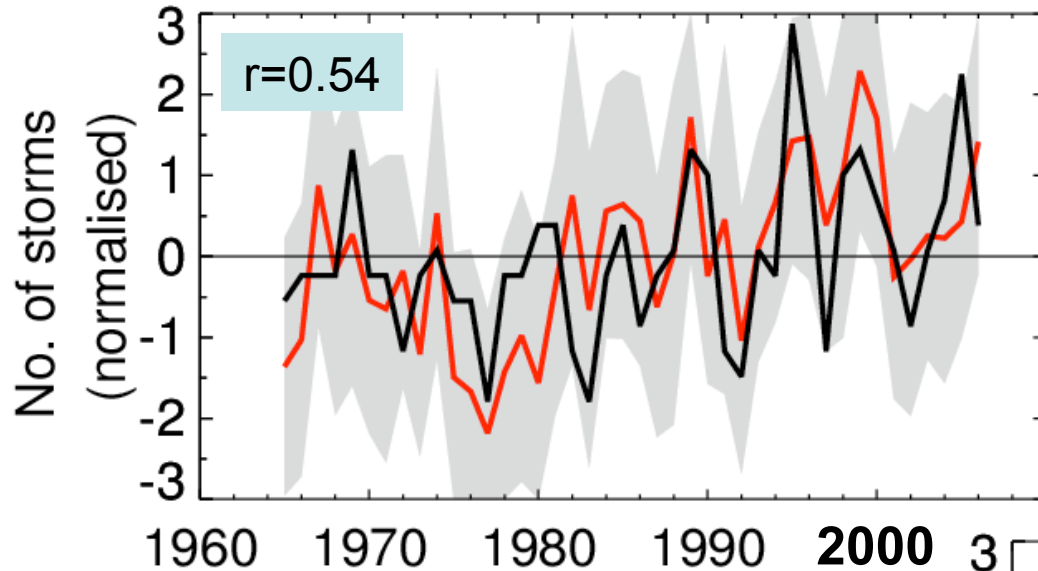


(Smith et al. 2010)





# Tropical storm predictions beyond the seasonal range

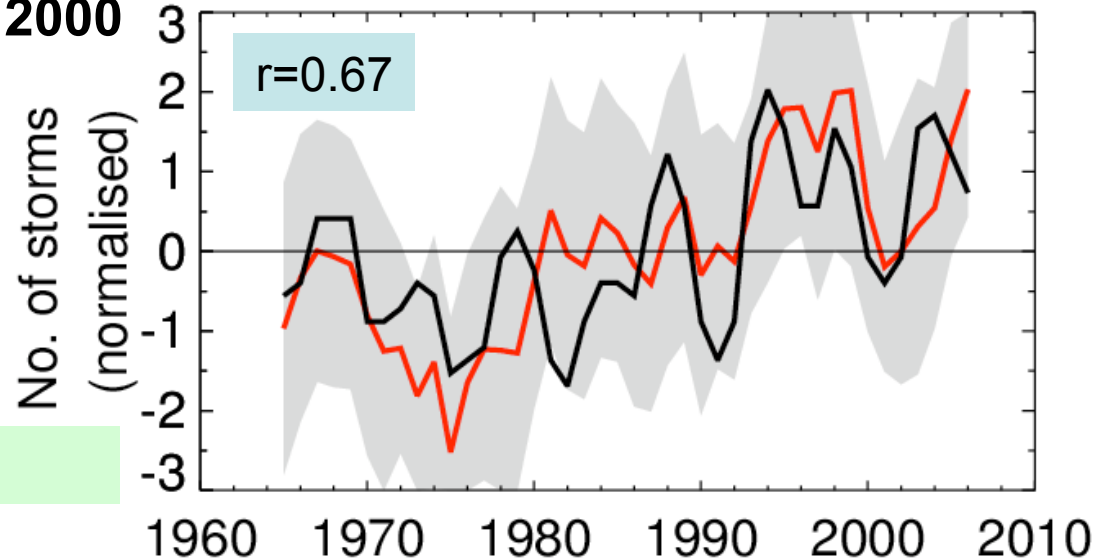


First hurricane season (June-Nov) starting from November (forecast months 8-13)

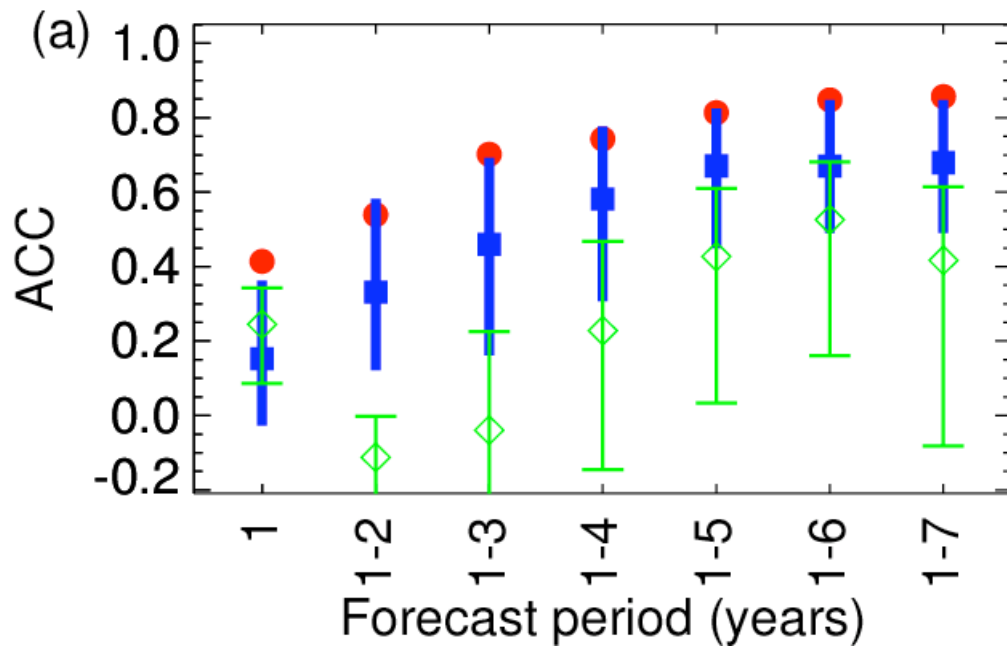
Observations

Forecasts

3-year means

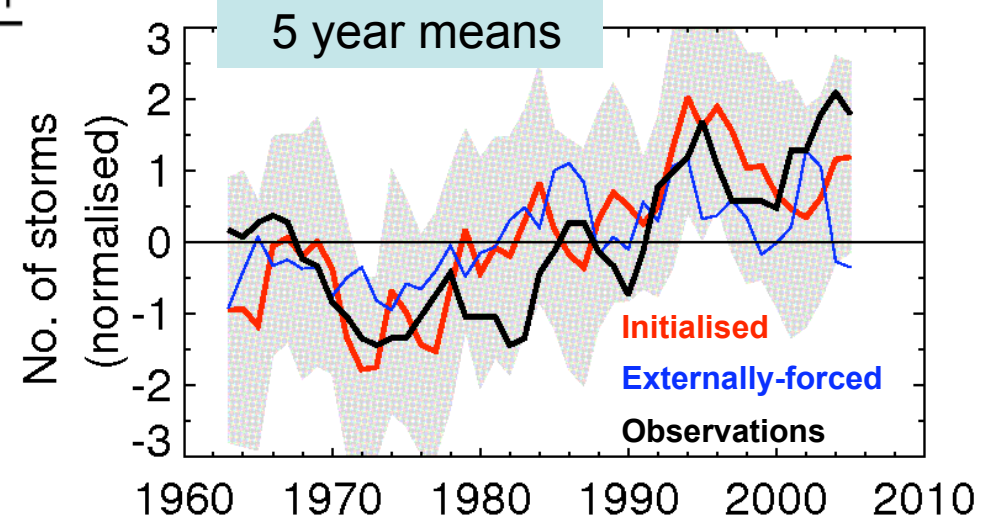


# Tropical storm predictions beyond the seasonal range

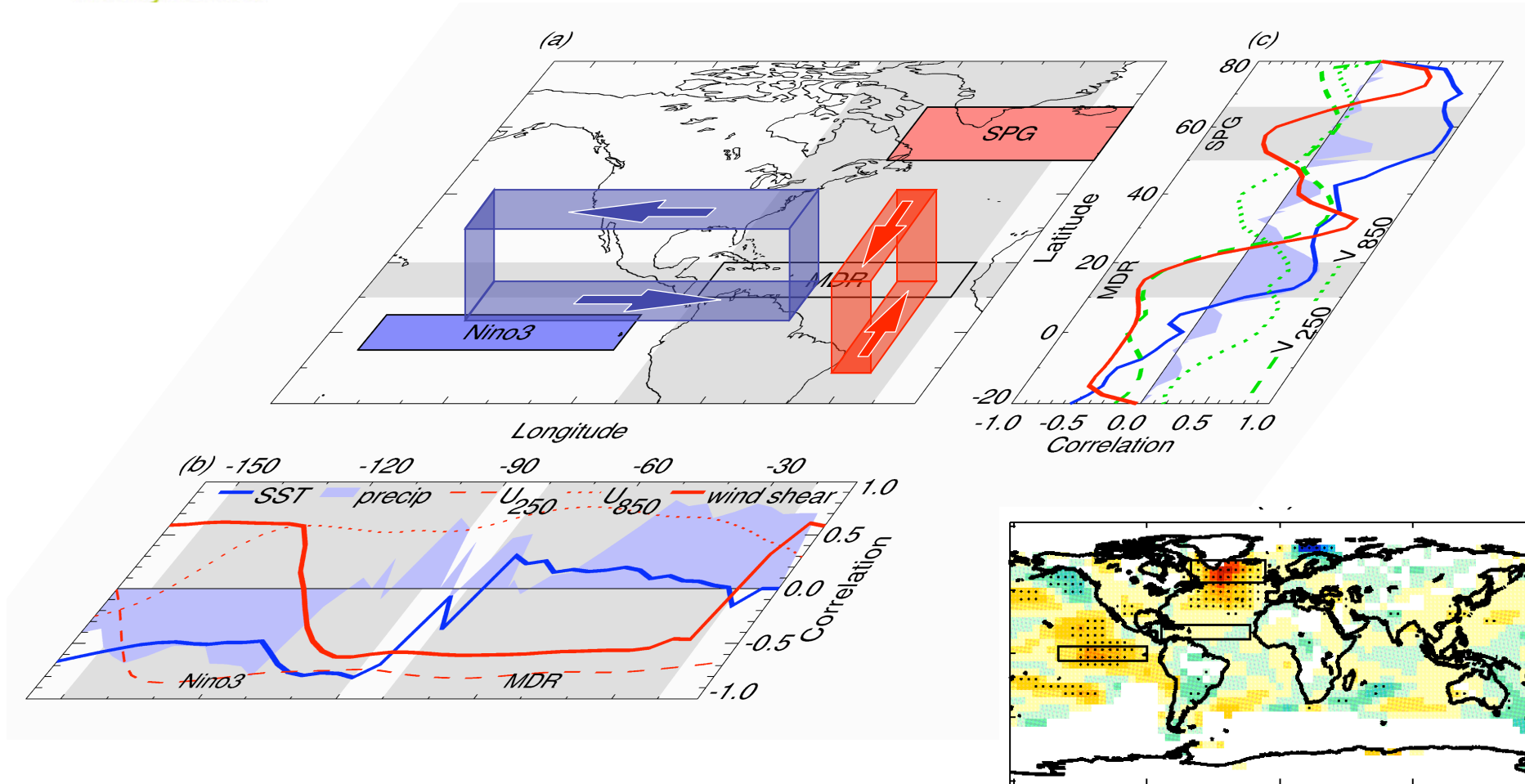


**Skill from external forcing and initialisation**

(Smith et al. 2010)



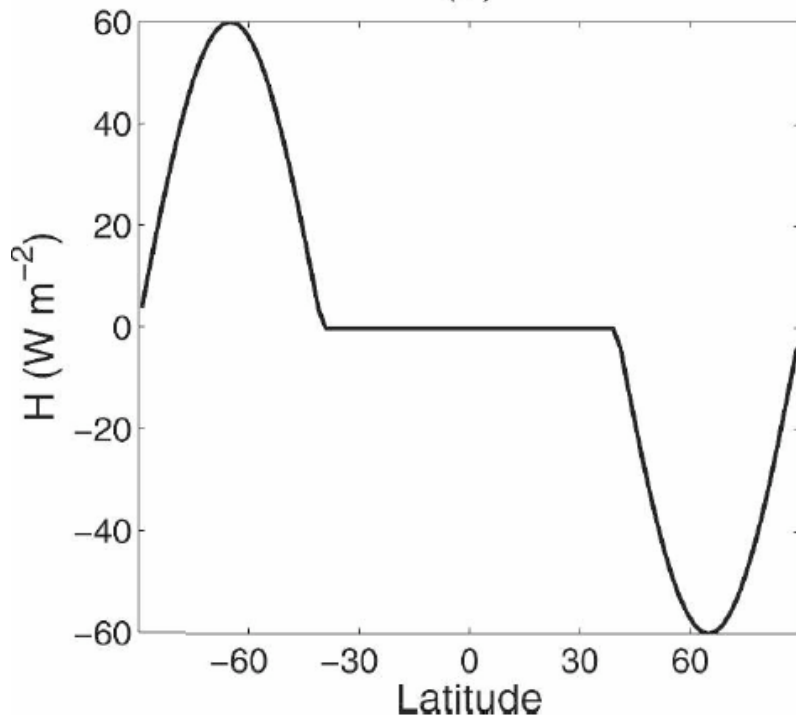
# Remote influences on Atlantic hurricanes



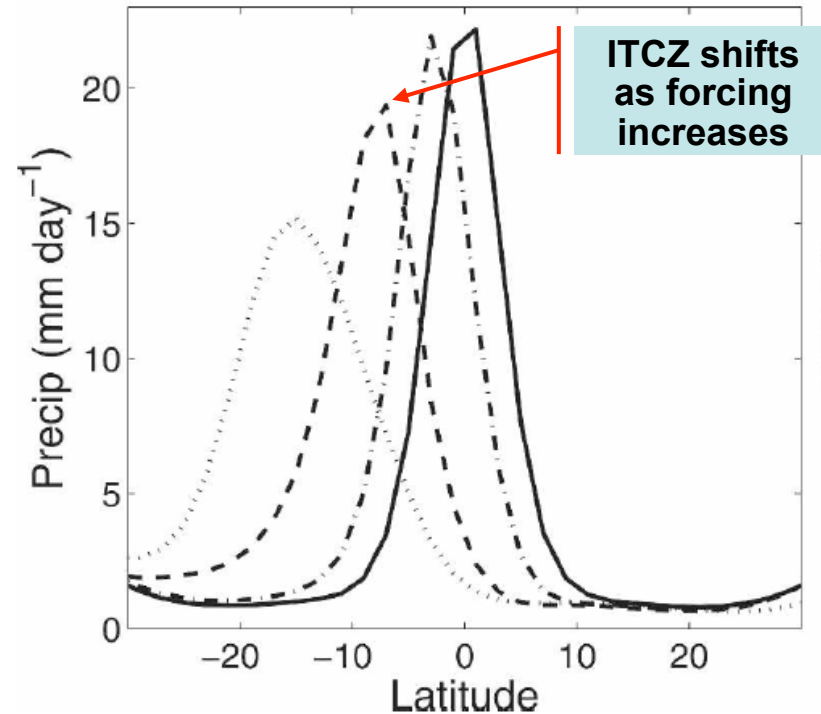
(Smith et al. 2010)

# Influence of high latitudes on ITCZ

- Atmosphere GCM, slab ocean
- Imposed flux anomalies only at high latitudes ( $> 40^\circ$ )



Forcing flux



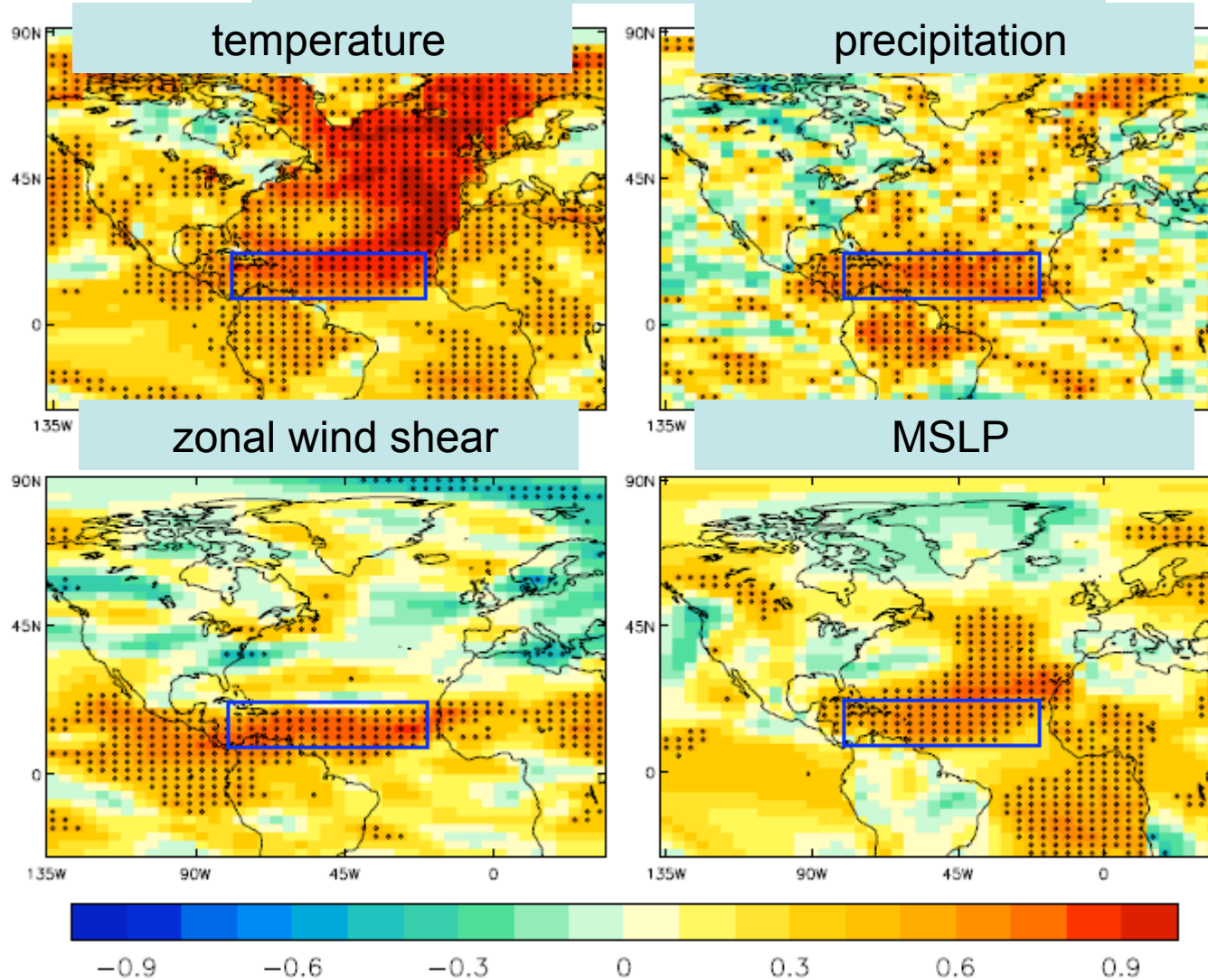
Precipitation response

(Kang et al. 2008, 2009, 2011)



# Skill in tropical Atlantic atmosphere in idealised experiments

JJASON seasons, Forecast years 2-6:

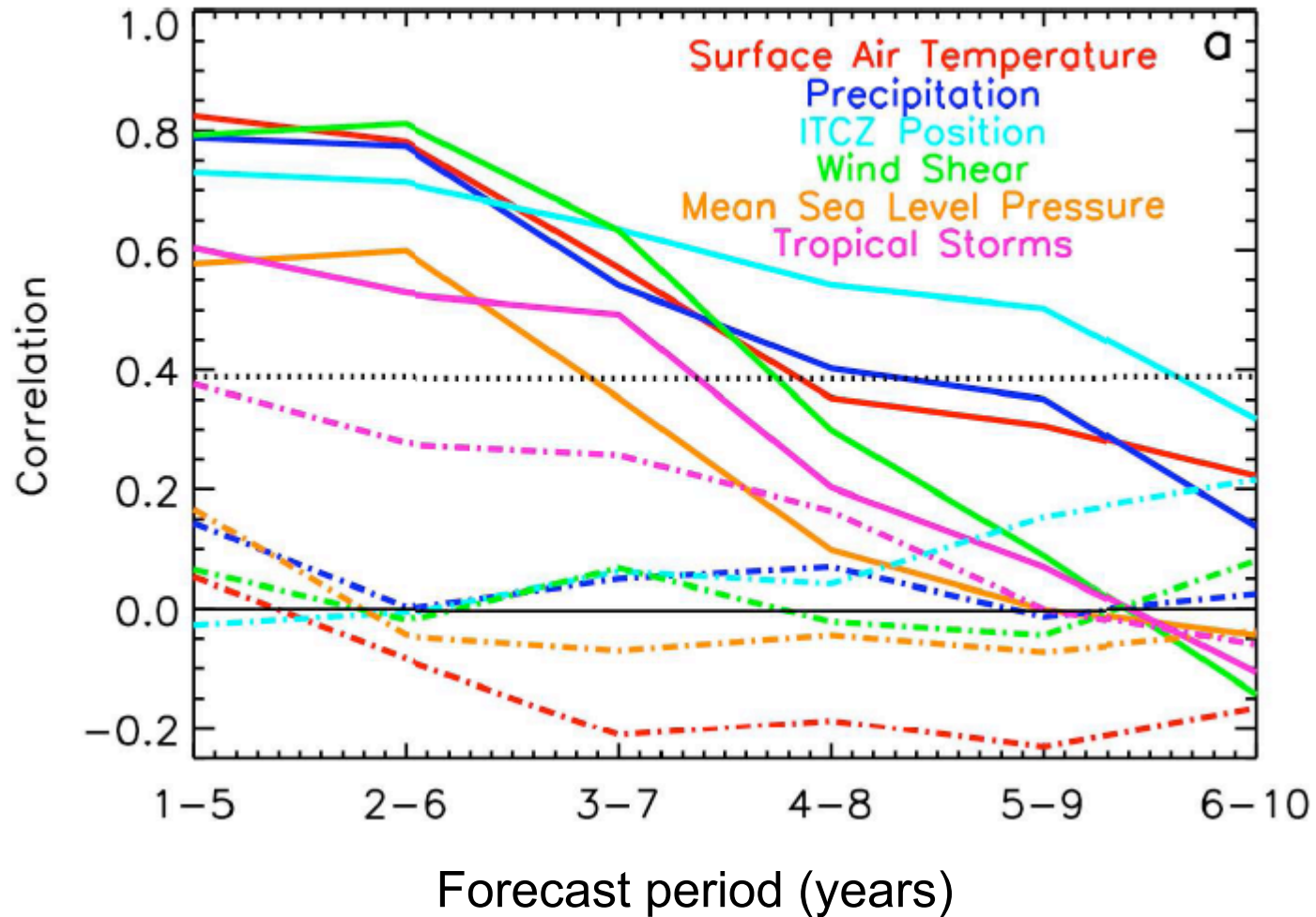


- 26 start dates
- Assimilate monthly mean ocean T and S
- Dunstone et al 2011

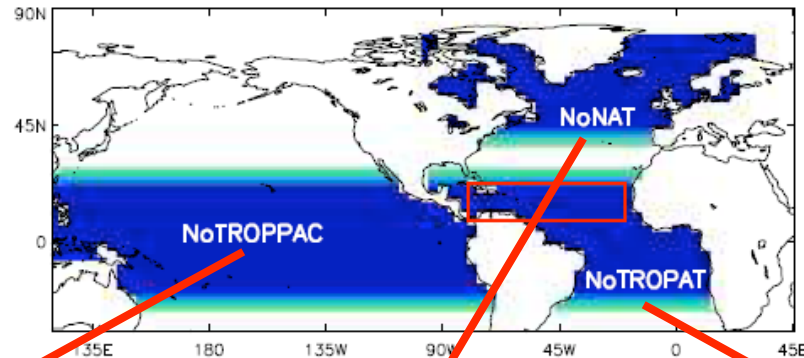
# Hurricane main development region

Solid = forecasts

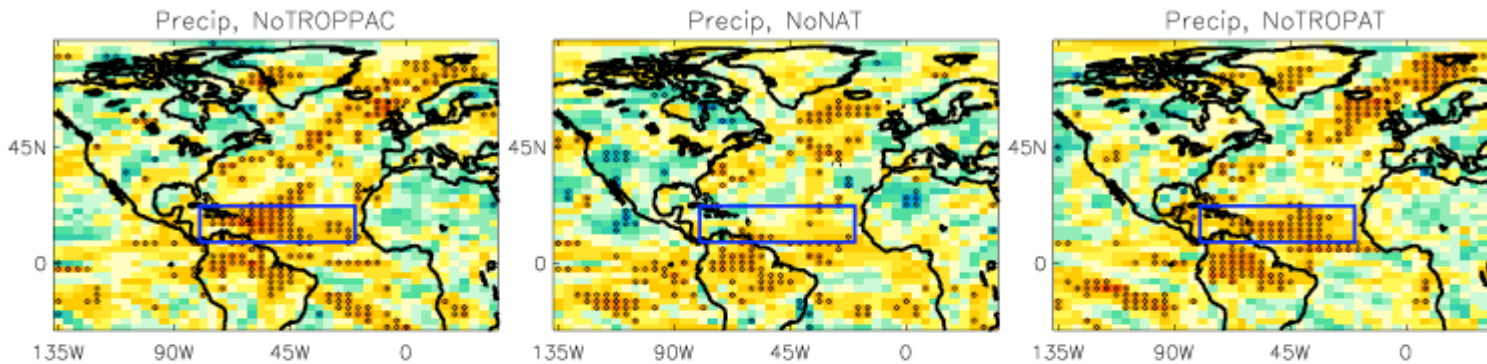
Dotted = persistence



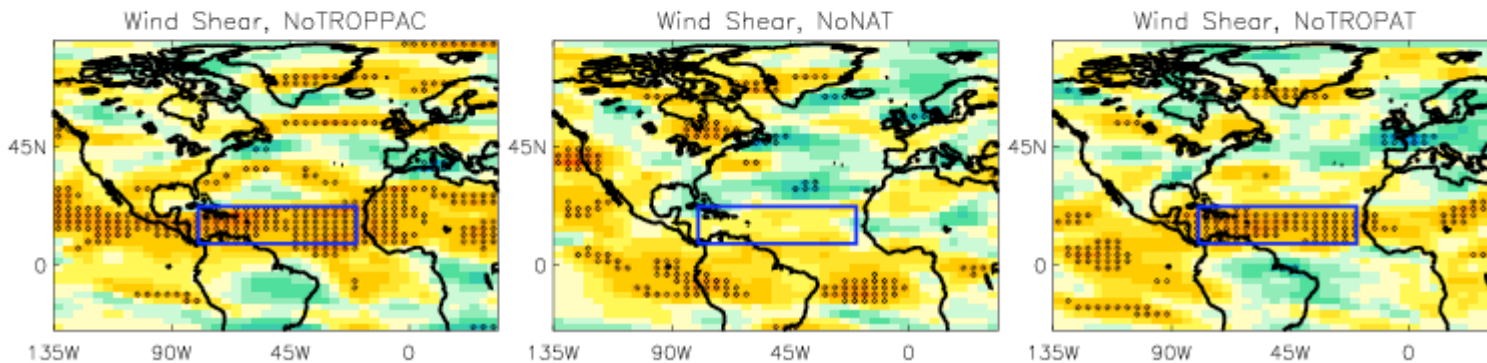
# Skill originates from sub-polar gyre



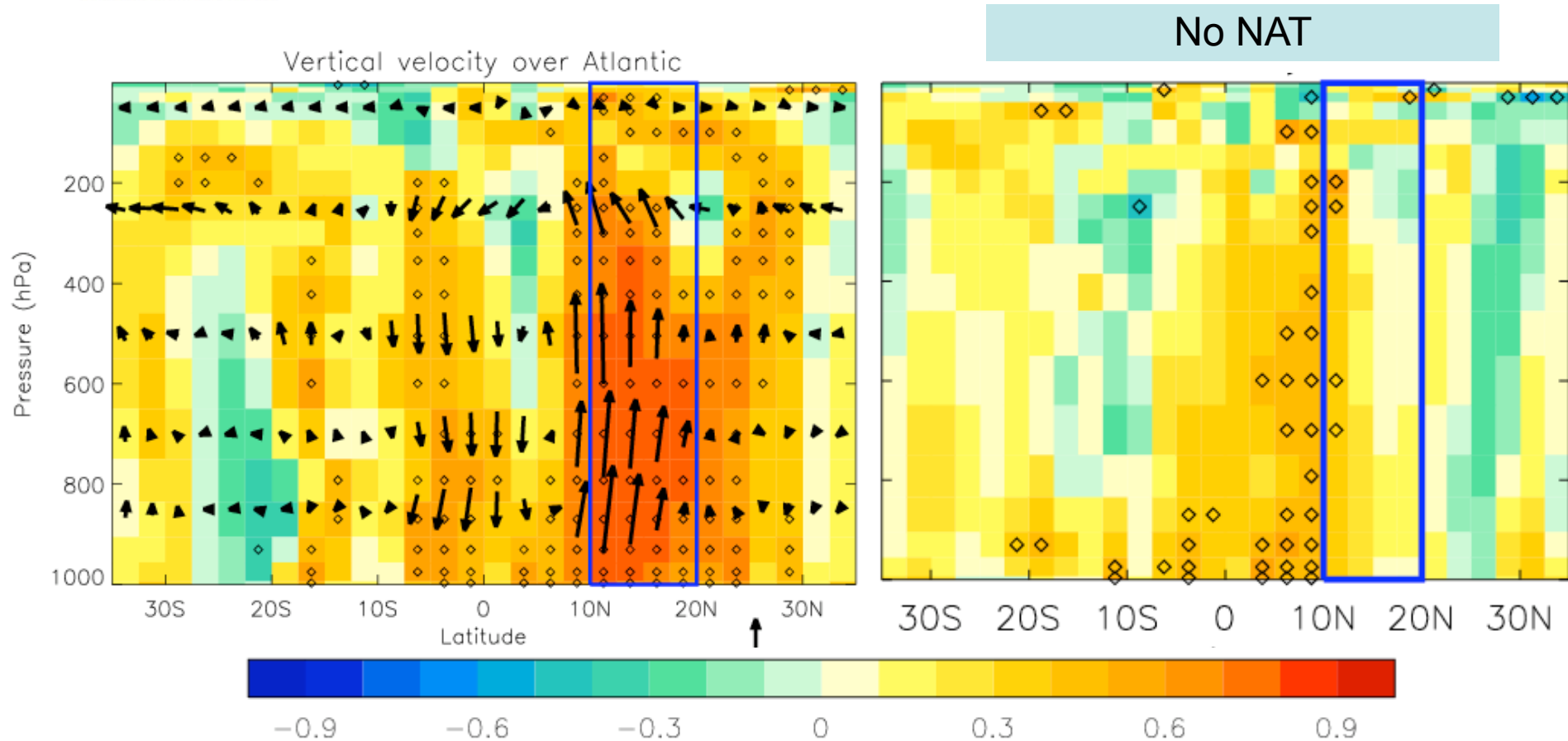
precipitation



wind shear



# Sub-polar gyre influence on tropical Atlantic



Arrows = warm minus cold sub-polar gyre composite

Colours = skill (correlation) of vertical velocity, years 2-6



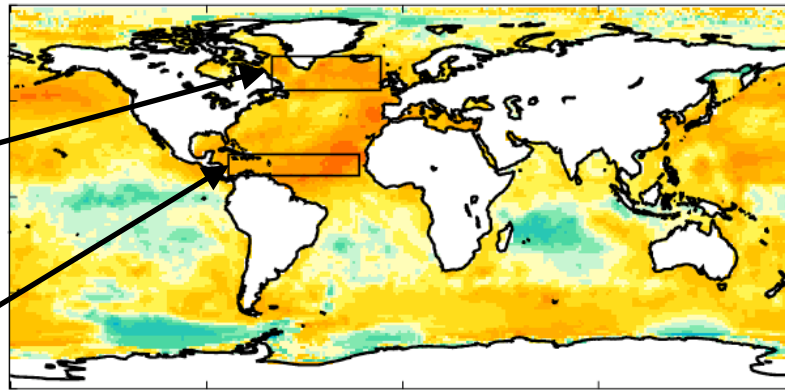


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# Observed relationships: 5 year means

Sub-polar gyre (SPG)

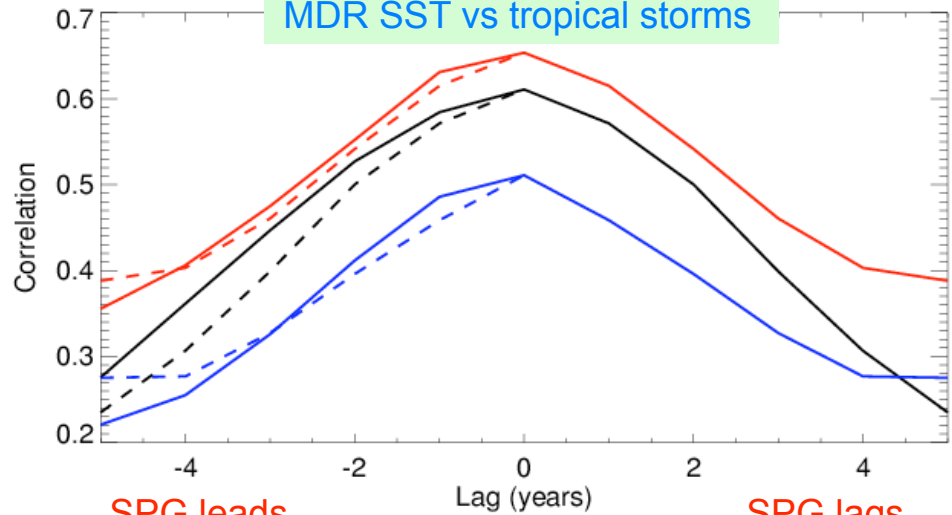
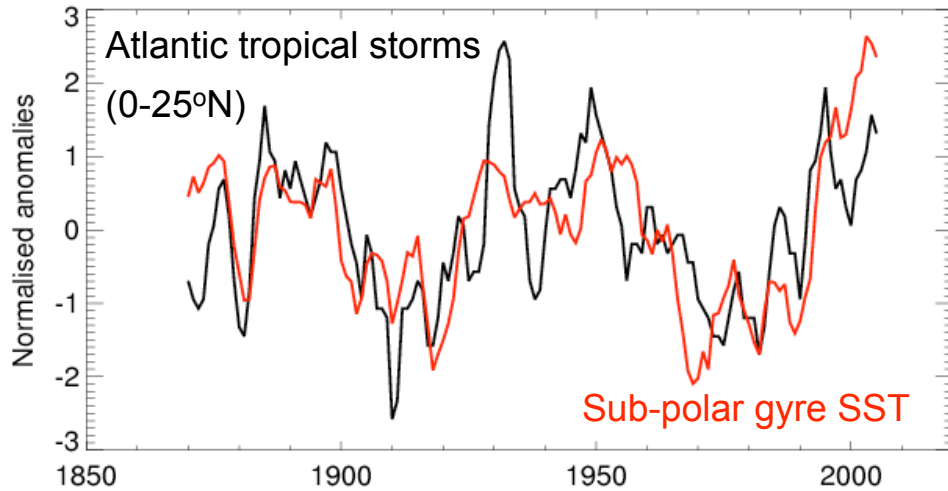
Hurricane main development region (MDR)



-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8

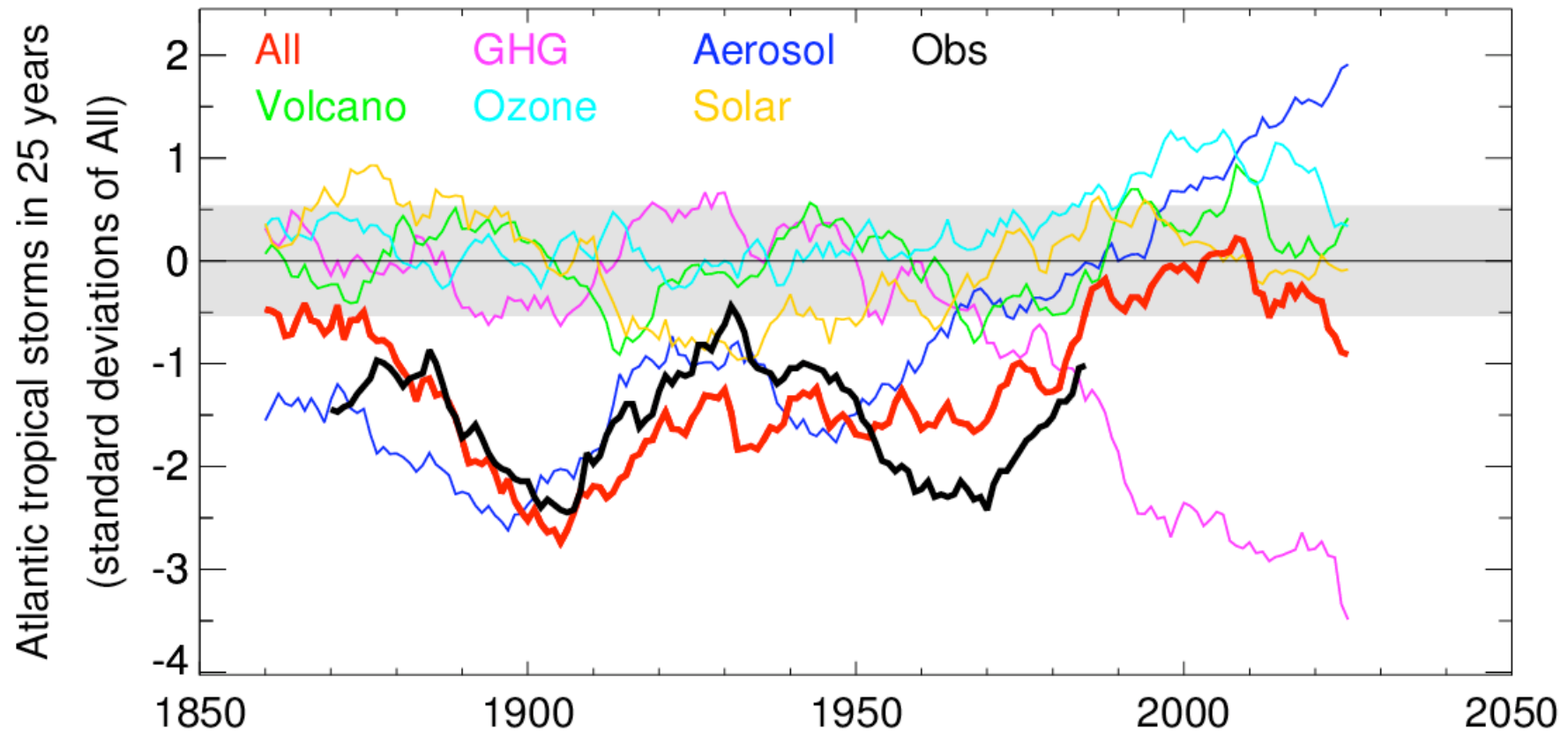
Correlation of number of hurricanes with SST

SPG SST vs tropical storms  
SPG SST vs MDR SST  
MDR SST vs tropical storms





# External forcing of tropical storms



- **Key role of aerosols in model** (and maybe in reality?)
  - suppressed the number of storms since 1860
  - produce multi-decadal variability
- **Future: opposing trends from aerosols and greenhouse gases**

# Summary

- Initialisation improves temperature predictions in north Atlantic sub-polar gyre and tropical Pacific
  - Consistent with improved AMOC predictions
- Present generation climate models can predict hurricane frequency for the coming few years
  - Not perfect! Intensity? Land fall?
- Much of the skill comes from external forcing
  - especially aerosols
- The high latitude north Atlantic plays an active role
- Need improved models to predict impacts over land

# Ensemble size: 5 year means

