Met Office
Hadley Centre

Multi-year predictability of the tropical Atlantic atmosphere driven by the high latitude north Atlantic ocean

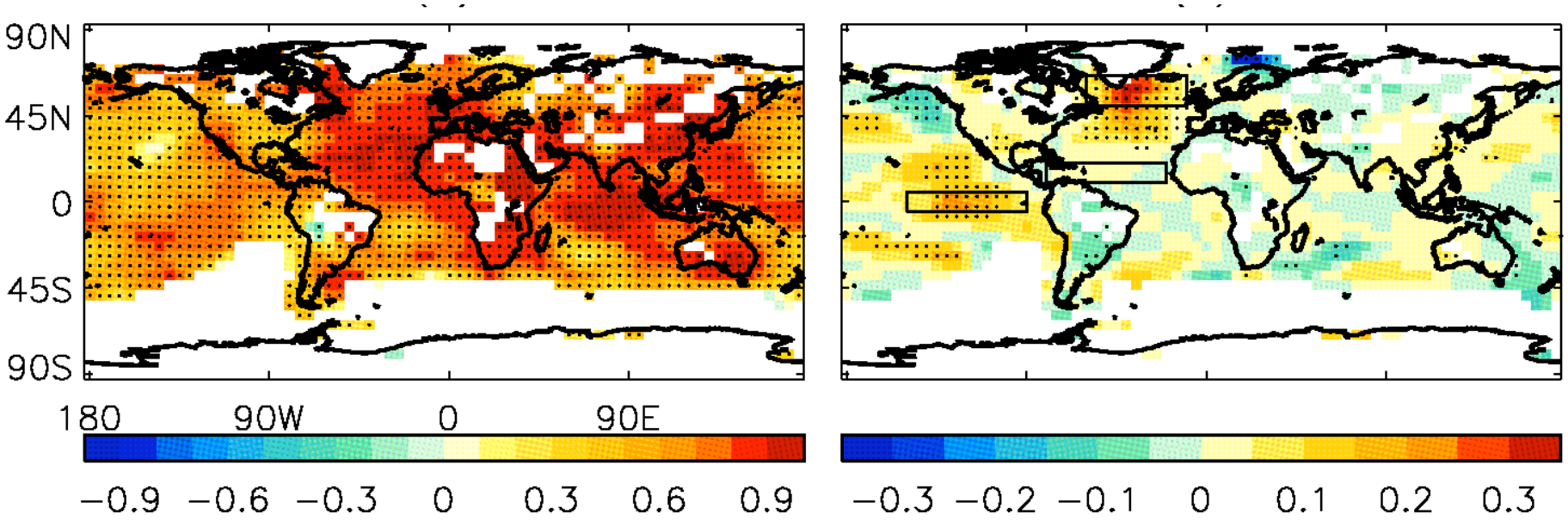
Doug Smith, Nick Dunstone, Rosie Eade, Holger Pohlmann, Adam Scaife

Impact of initialisation on hindcast skill

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

DePreSys anomaly correlation

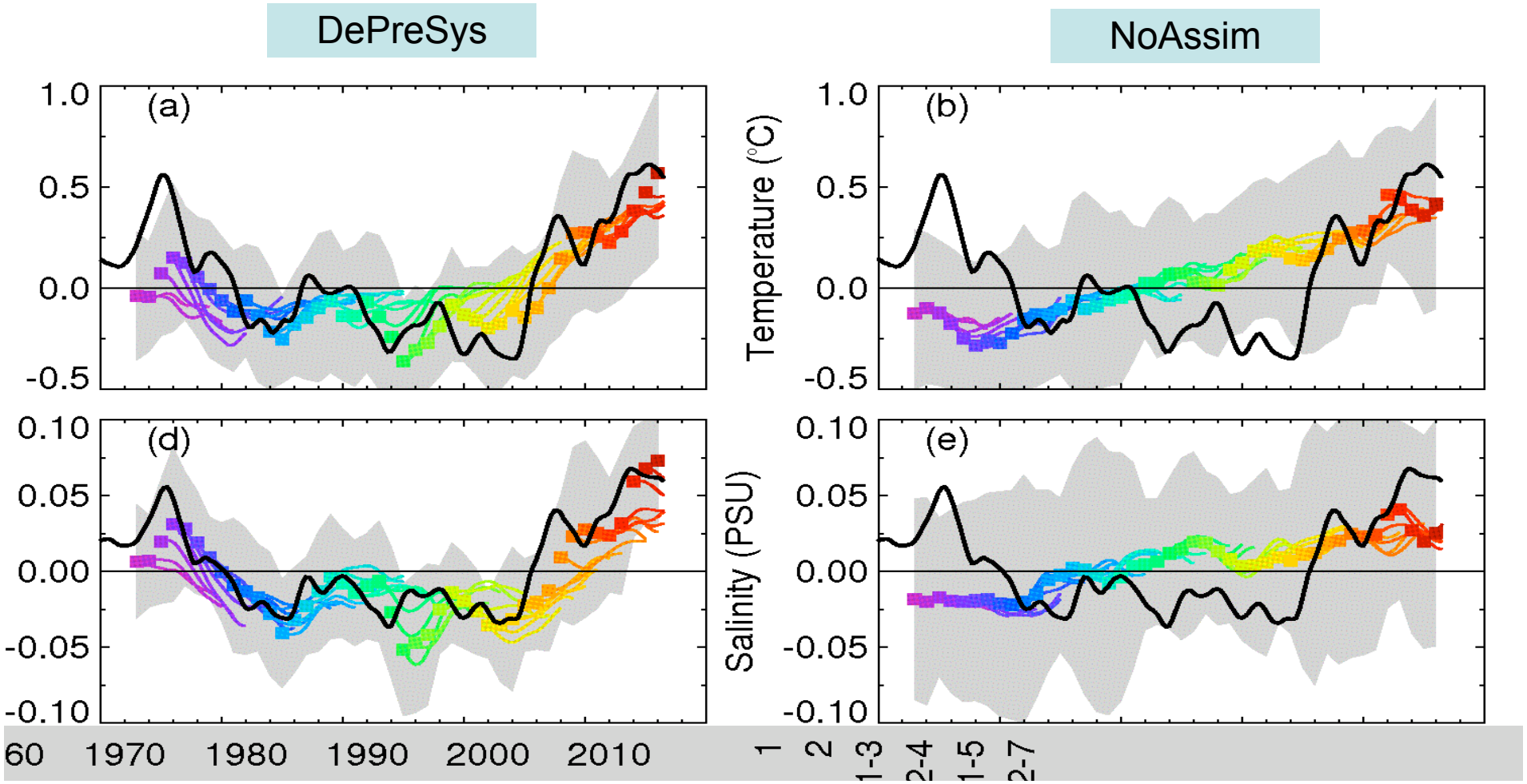
DePreSys-NoAssim correlation



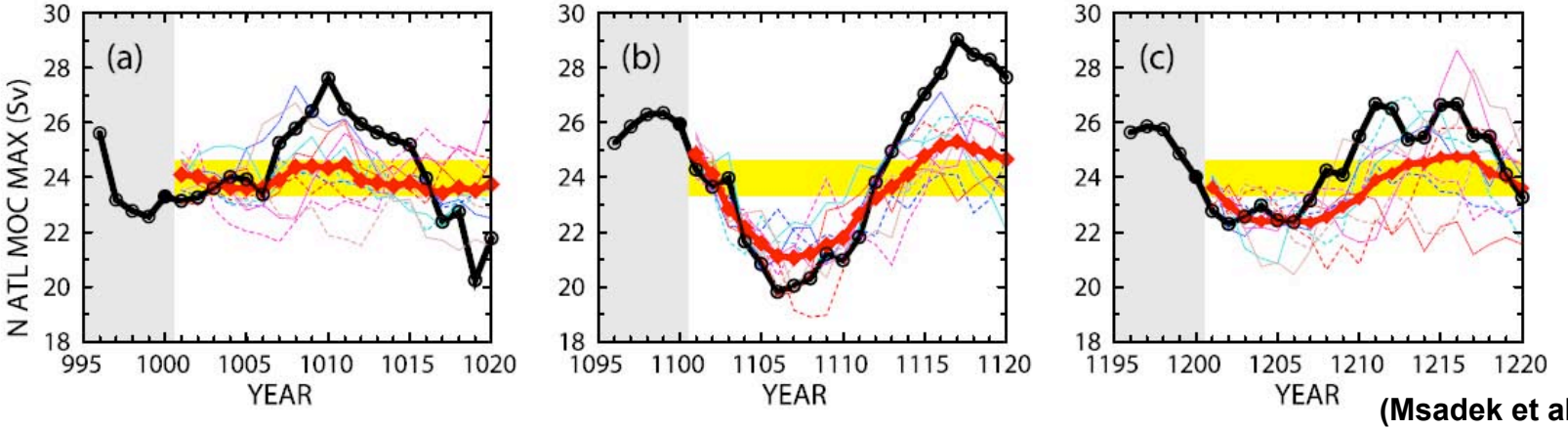
- HadCM3
- 9 member perturbed physics ensemble
- Starting every Nov from 1960 to 2005

(Smith et al. 2010)

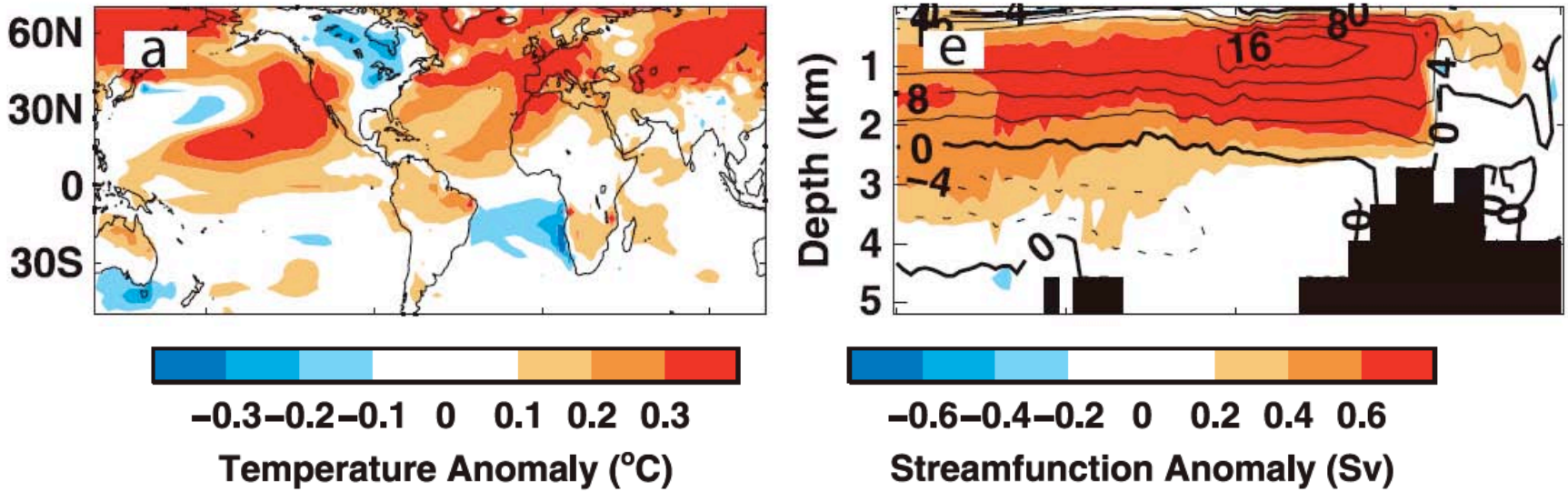
Annual upper 500m Atlantic sub-polar gyre T & S



Atlantic meridional overturning circulation (AMOC)

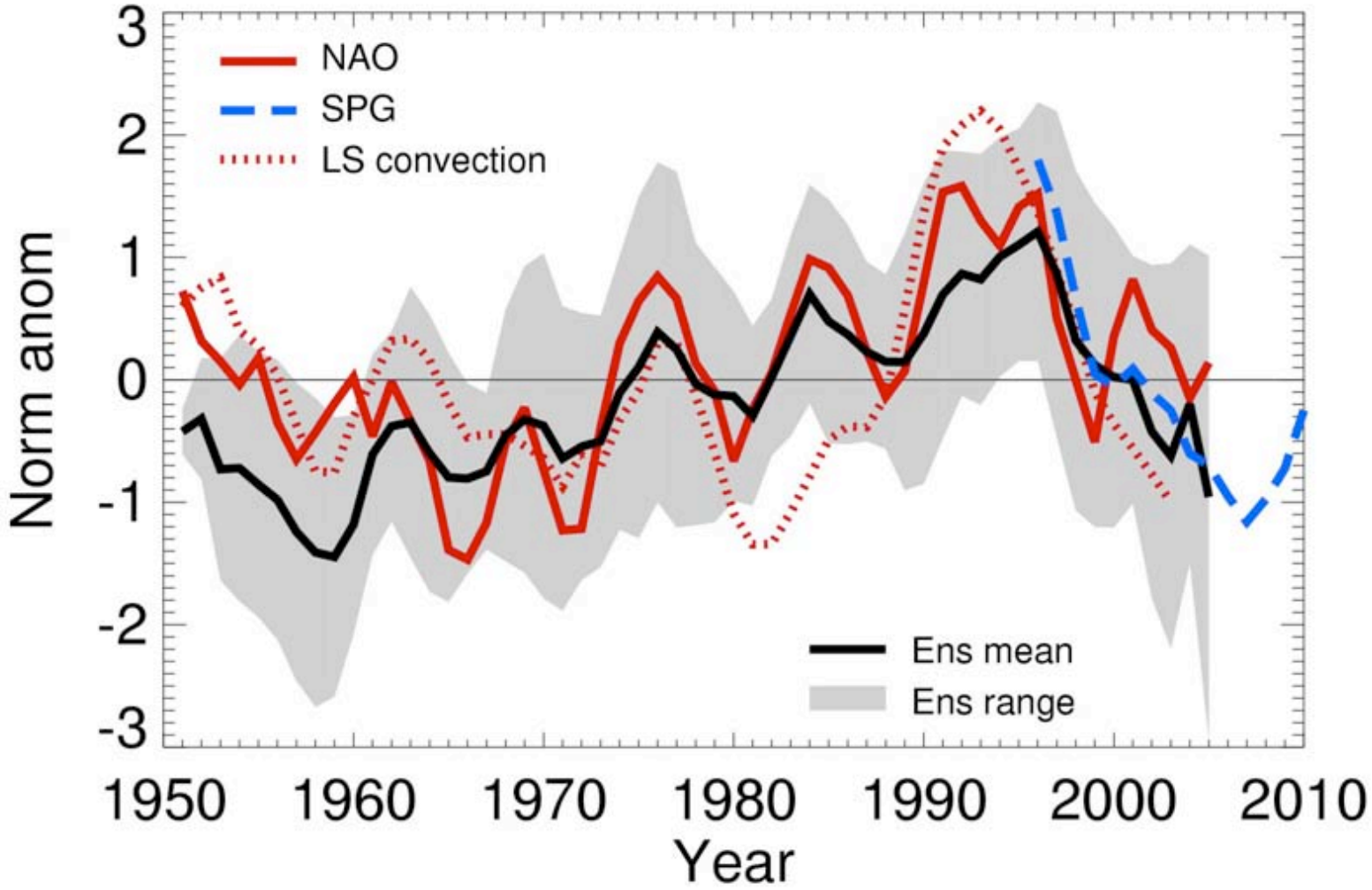


(Msadek et al. 2010)



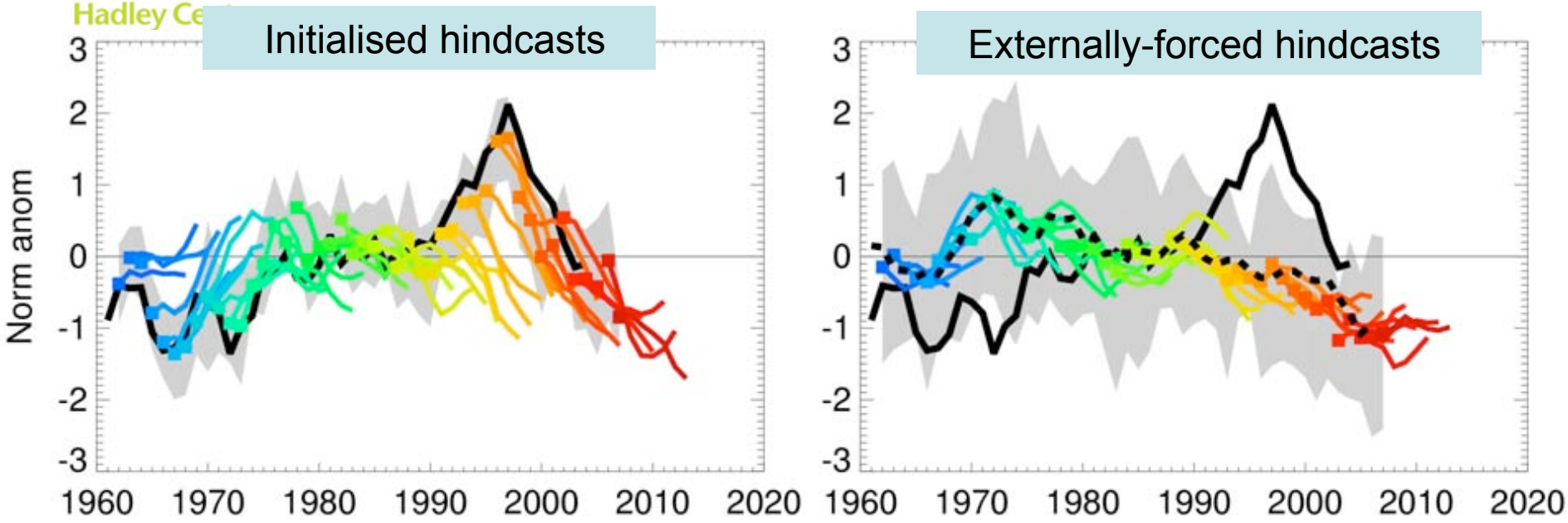
(Knight et al. 2005)

AMOC at 45°N in assimilation experiments



(Pohlmann et al. 2011, in revision)

AMOC at 45°N in hindcast experiments



(Pohlmann et al. 2011, in revision)

Potential climate impacts of north Atlantic SST

Met Office Hadley Centre

Observations

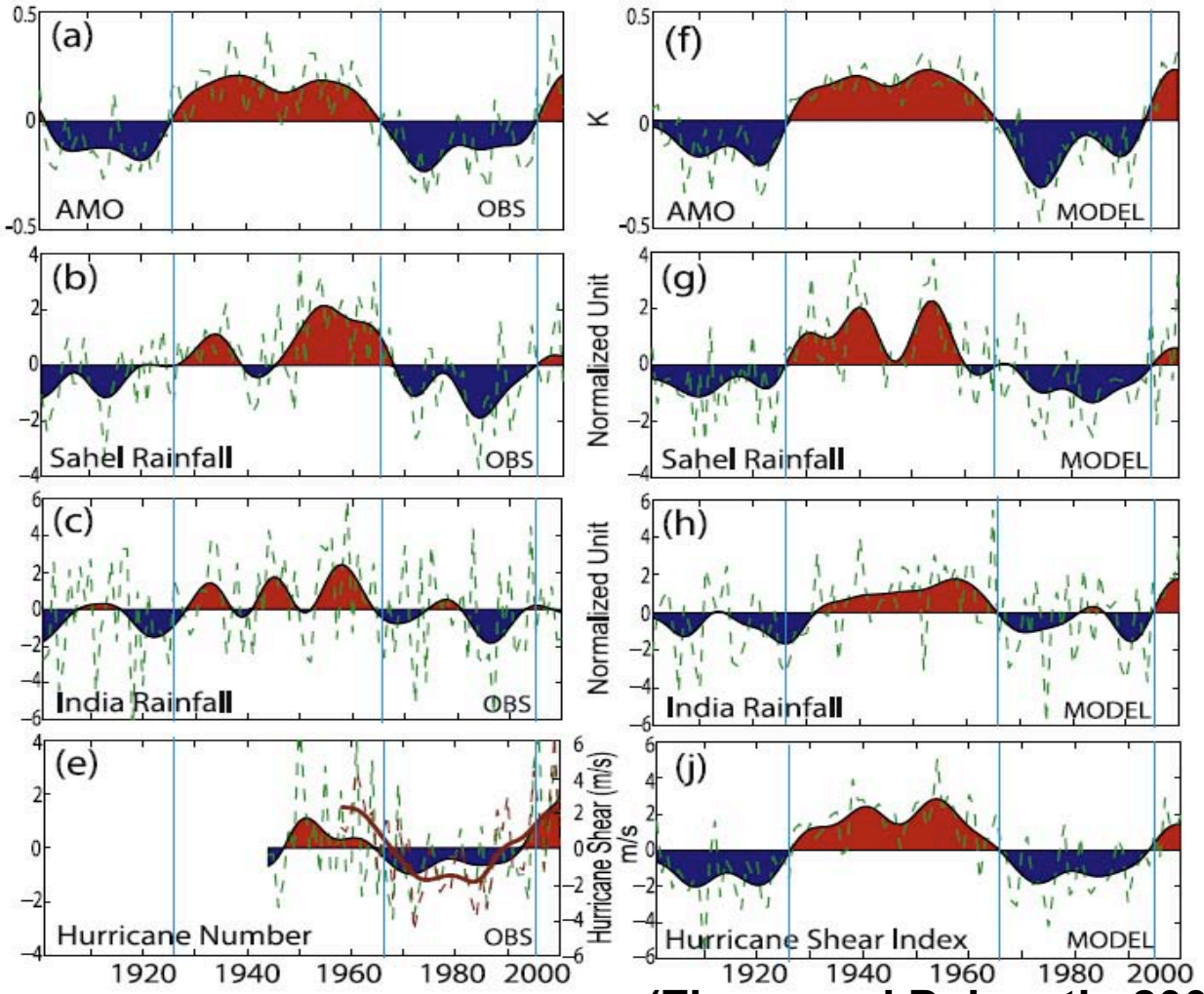
Model

North Atlantic SST

Sahel rainfall

India rainfall

Hurricanes



(Zhang and Delworth, 2006)

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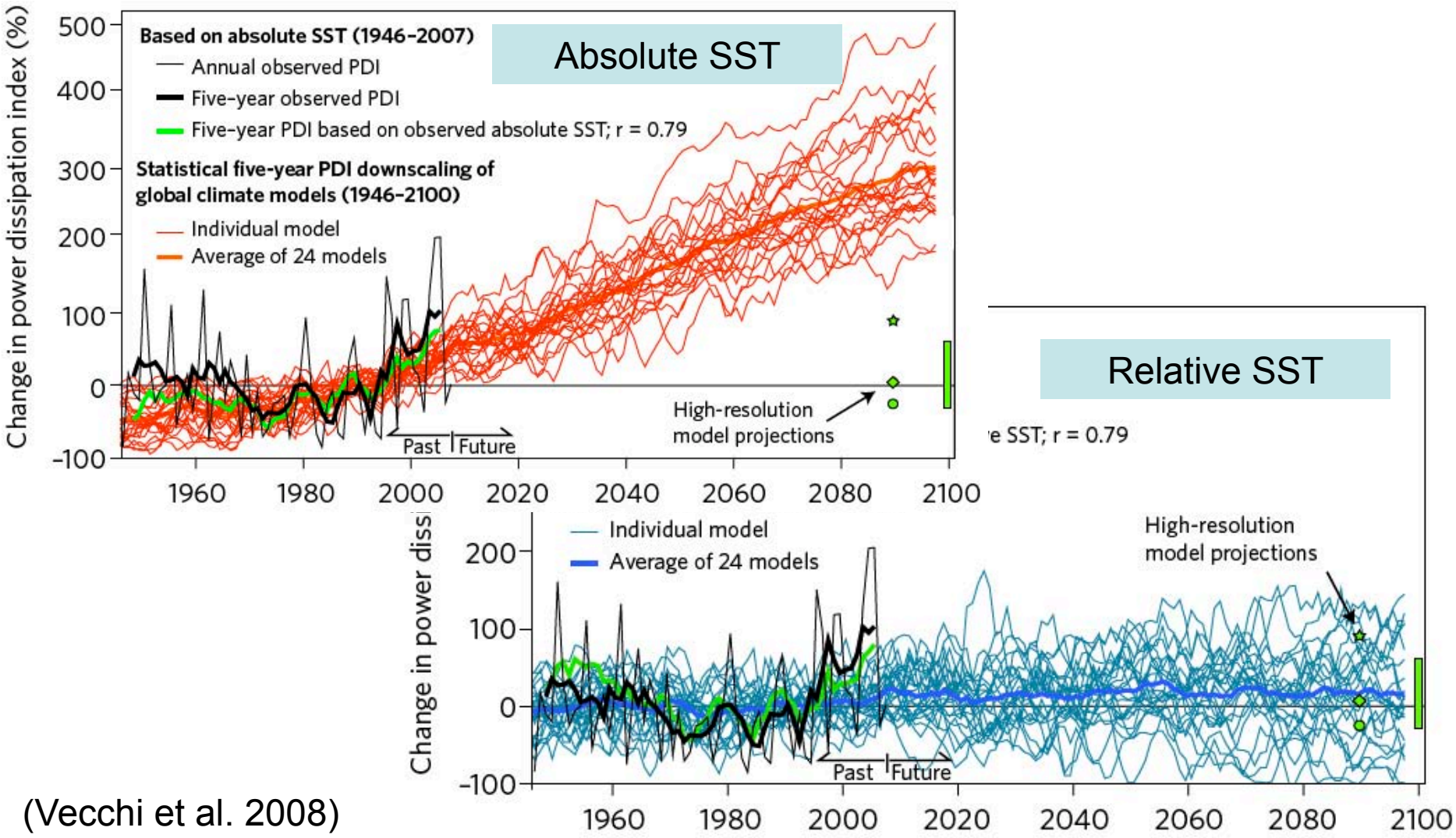
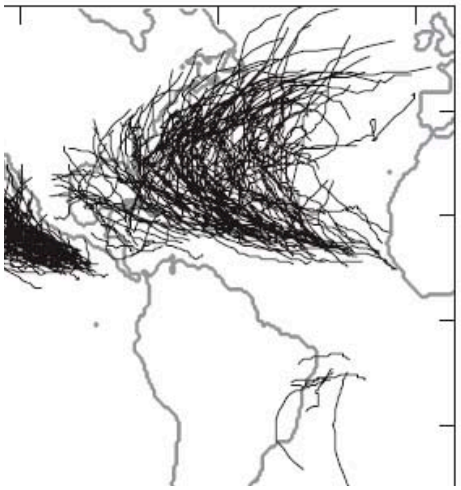
Hadley Centre

Statistical relationships

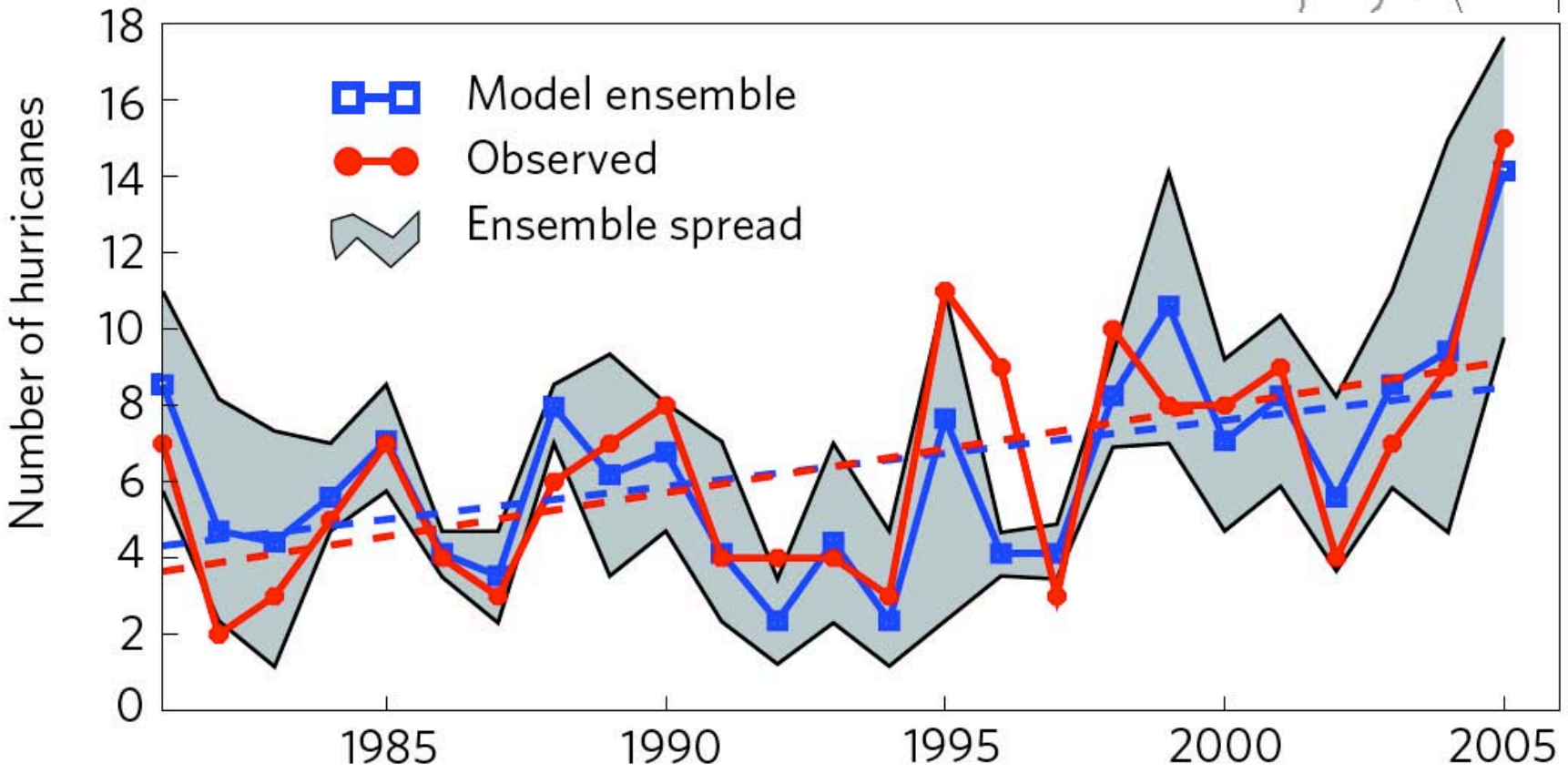


(Vecchi et al. 2008)

Model simulations of hurricane frequency



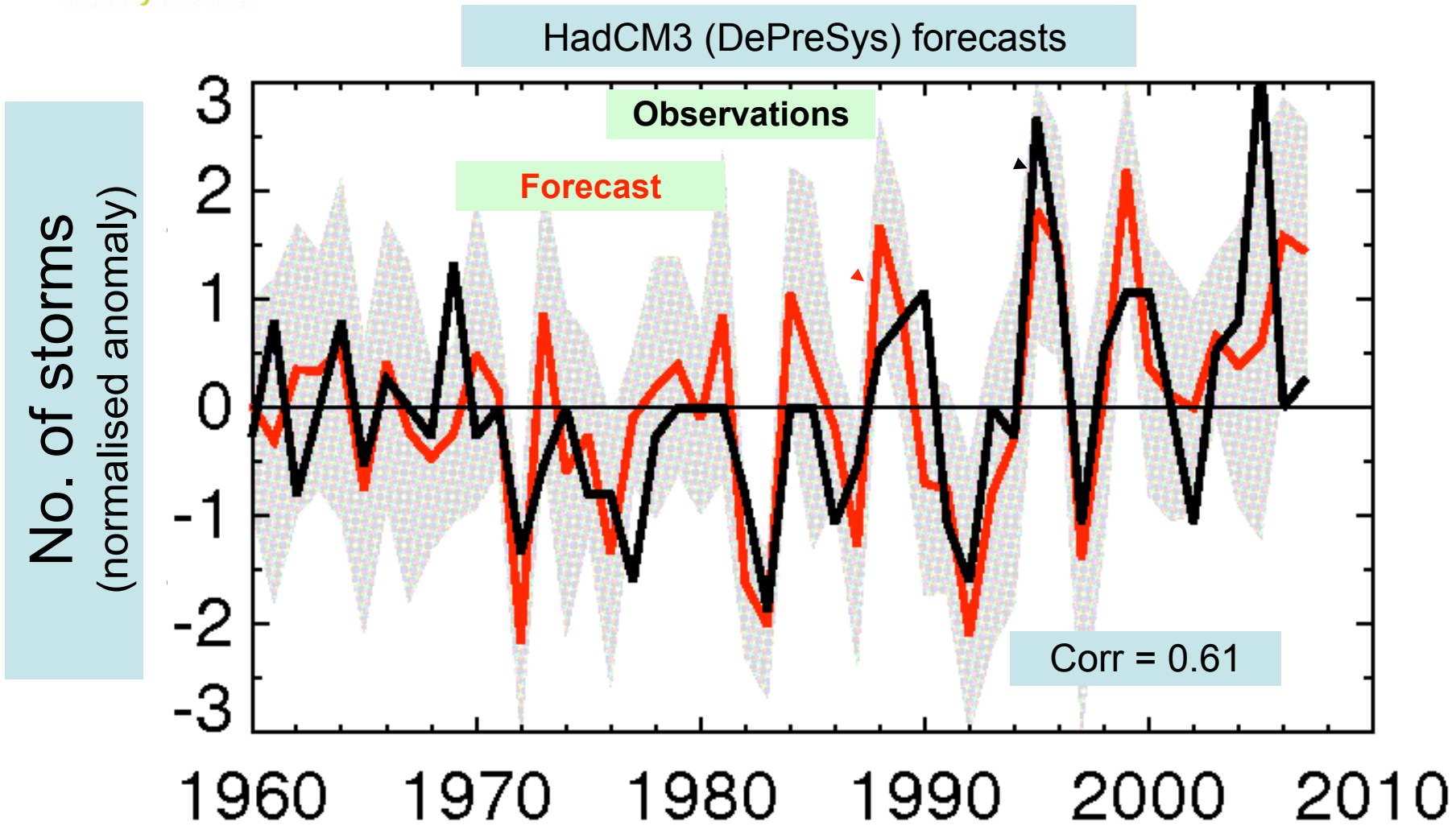
Dynamical models driven by sea surface temperatures simulate nearly all of the observed hurricane variations



(Zhao et al. 2009)

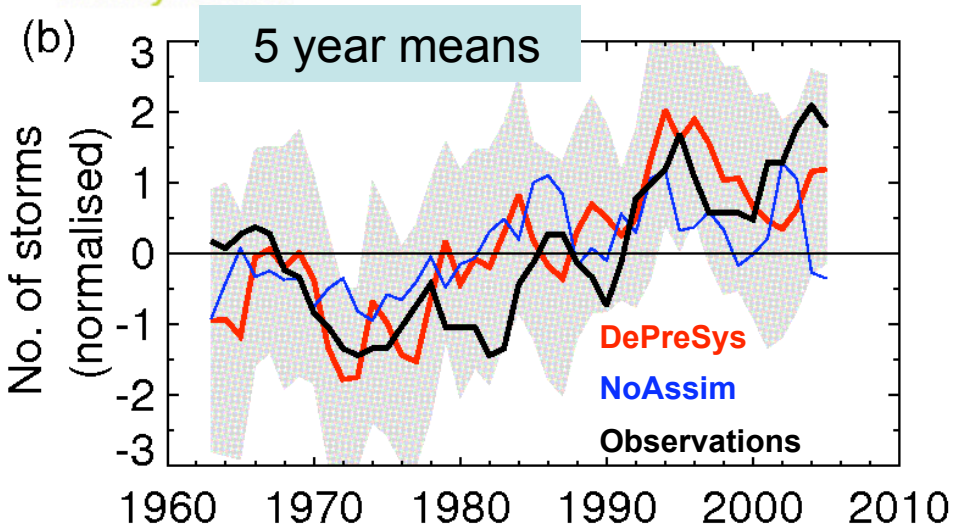
Atlantic tropical storms

Seasonal forecasts from May for June-Nov

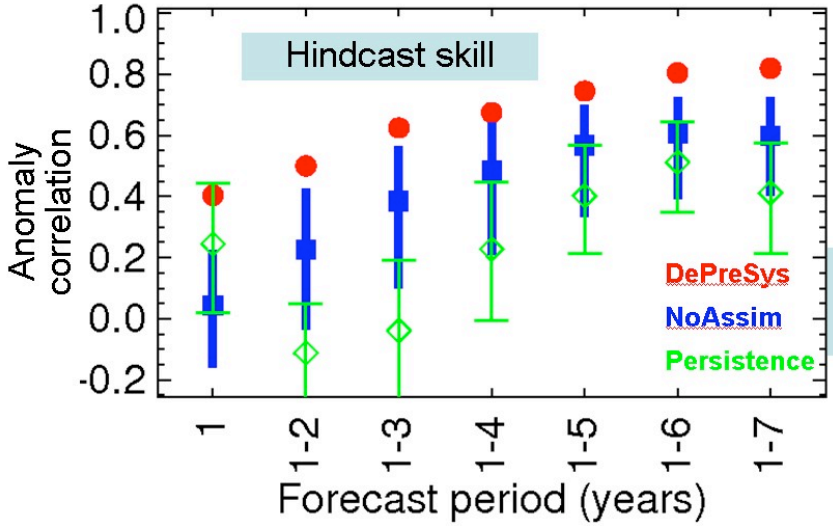


(Smith et al. 2010)

Tropical storm predictions beyond the seasonal range

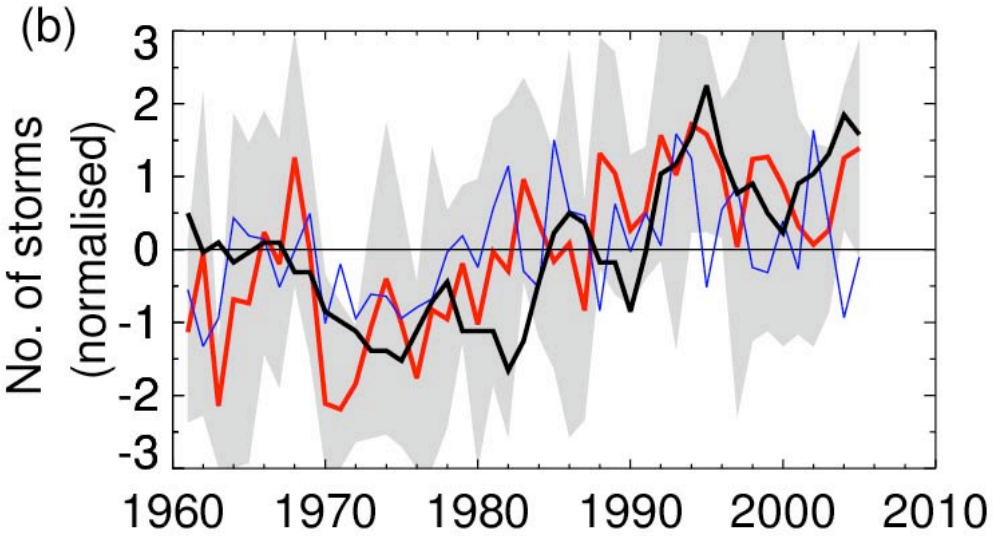


Skill from external forcing and initialisation



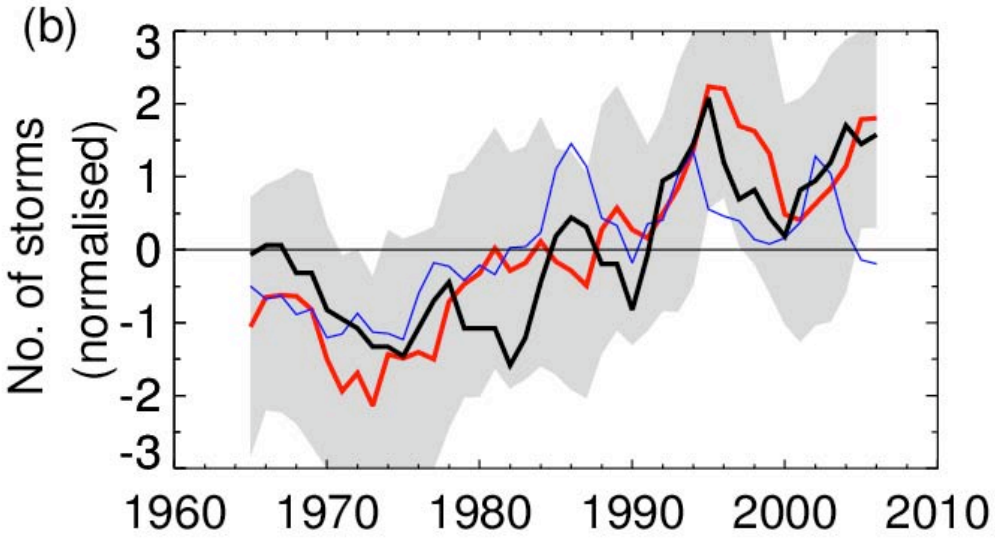
(Smith et al. 2010)

Ensemble size: 5 year means



9 members

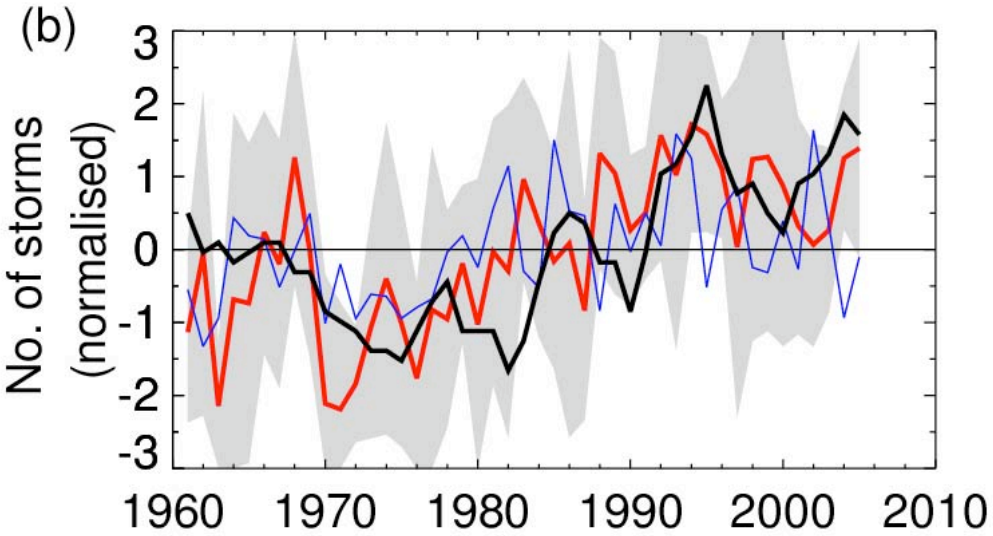
(r=0.60)



45 members

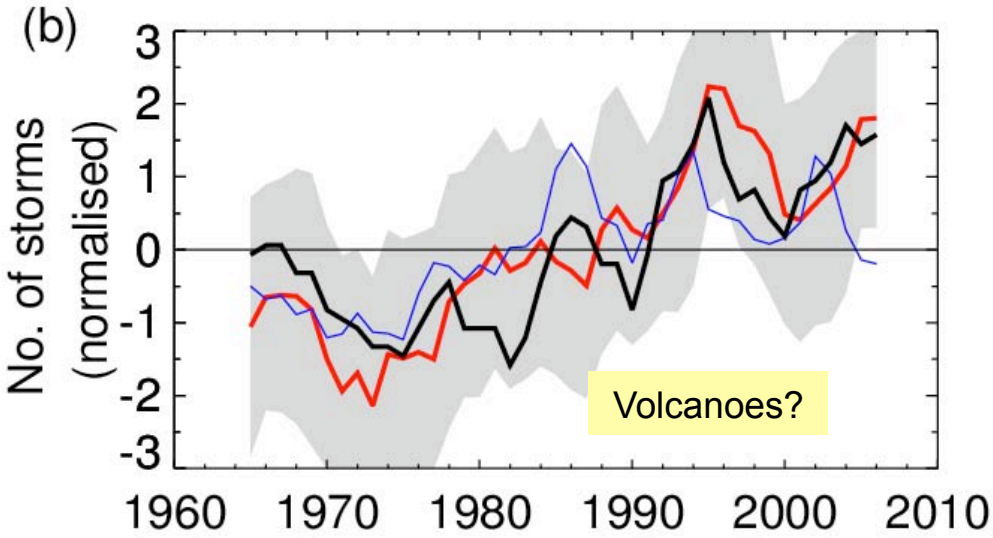
(r=0.82)

Ensemble size: 5 year means



9 members

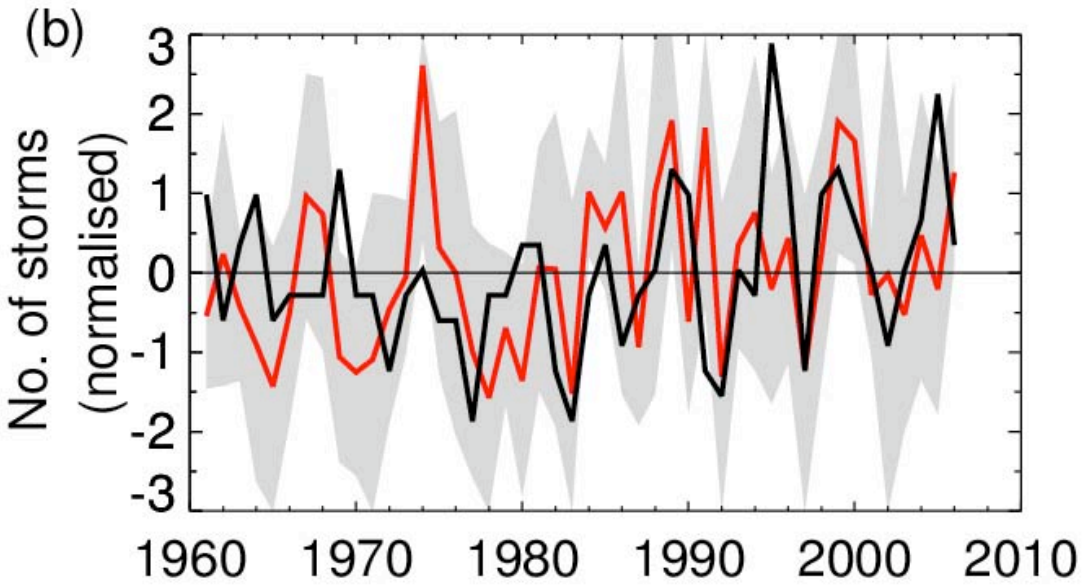
(r=0.60)



45 members

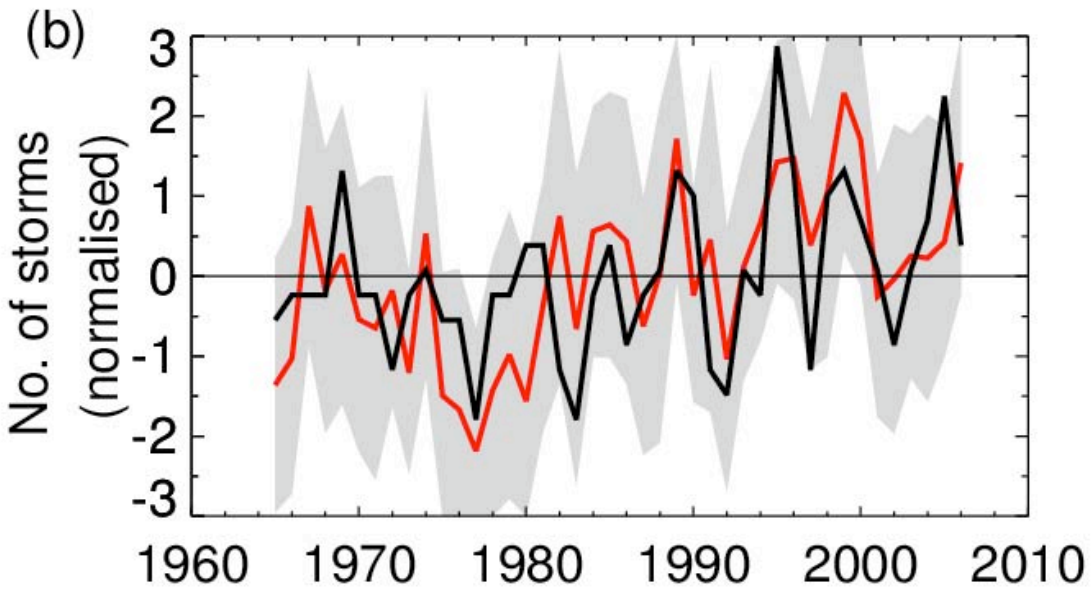
(r=0.82)

First season (from Nov, months 8-13)



9 members

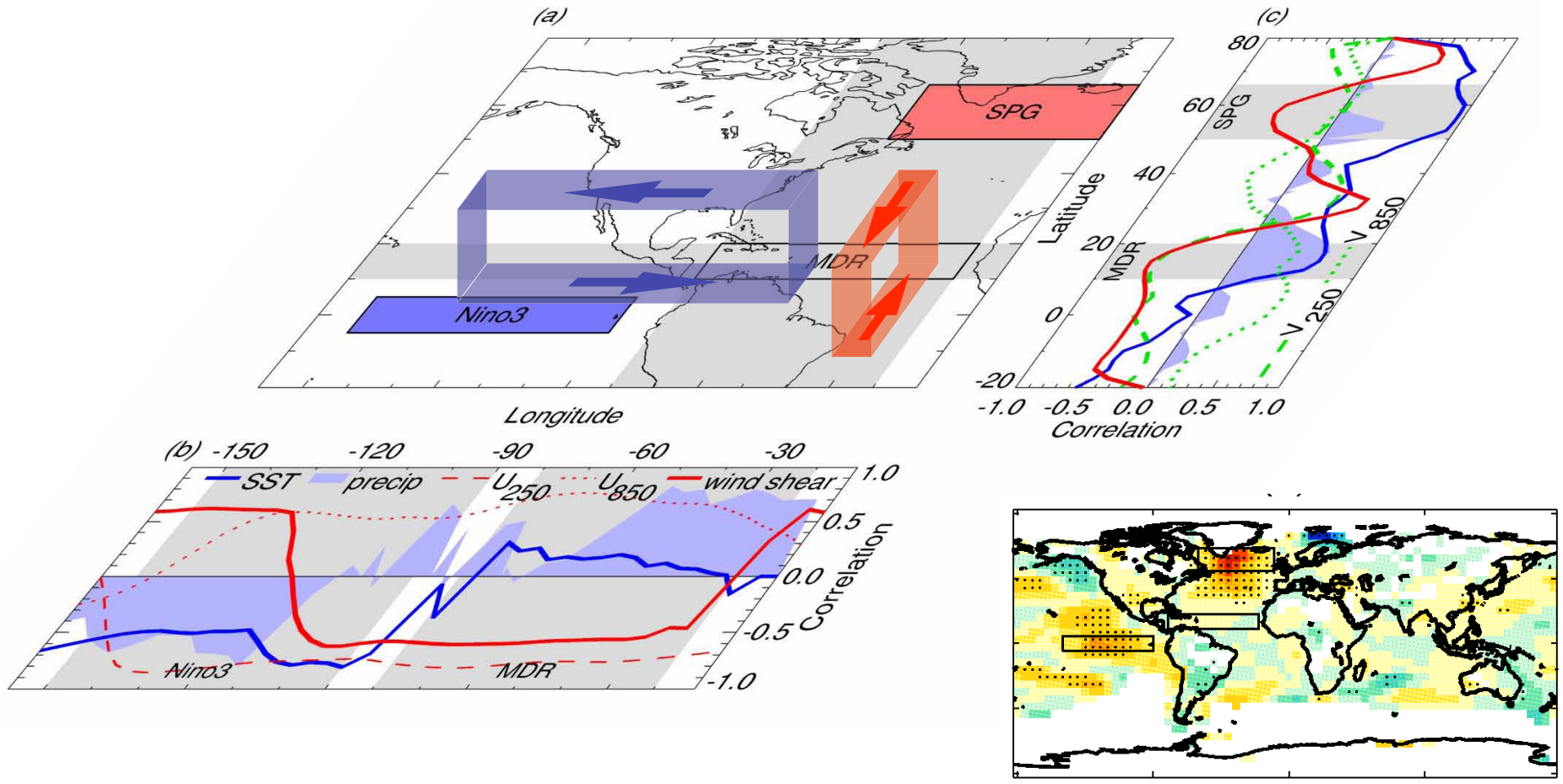
(r=0.21)



45 members

(r=0.54)

Remote influences on Atlantic hurricanes

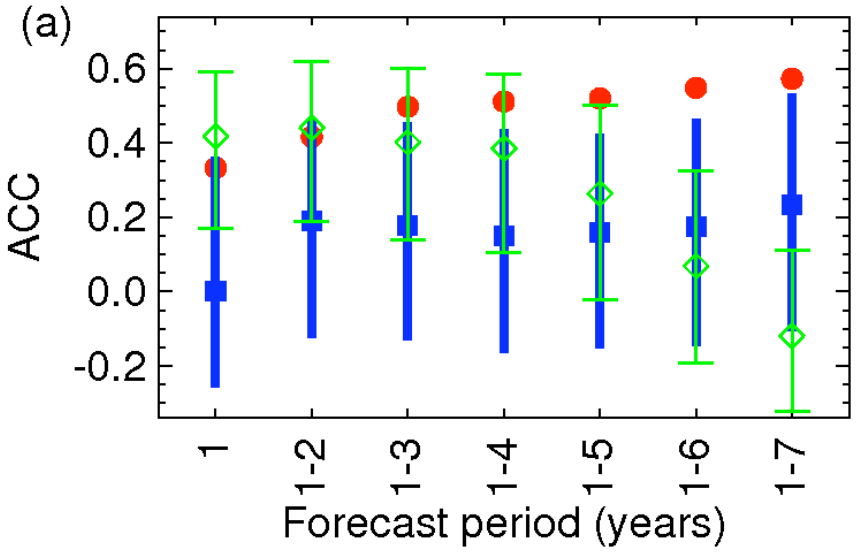


(Smith et al. 2010)

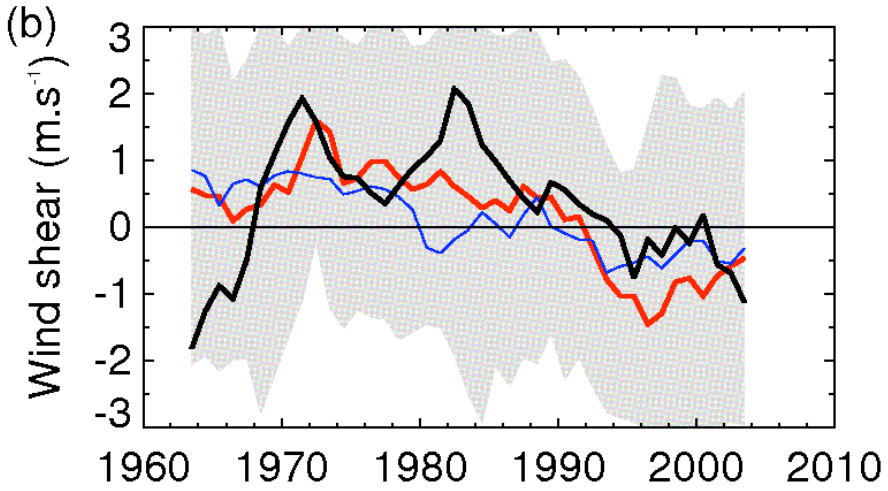
MDR wind shear

Forecasts from Nov for June-Nov

Hindcast skill



Time series of 5-year means



DePreSys

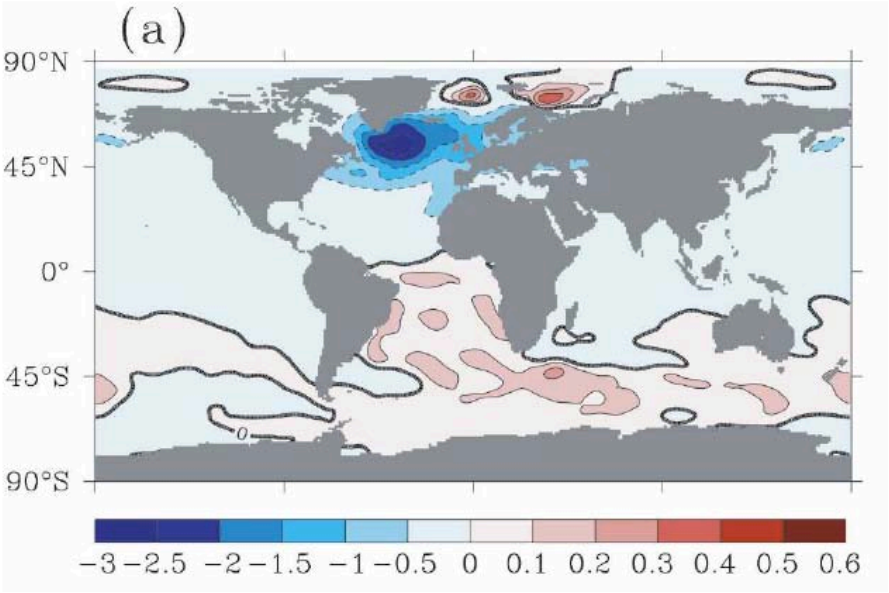
NoAssim

Persistence

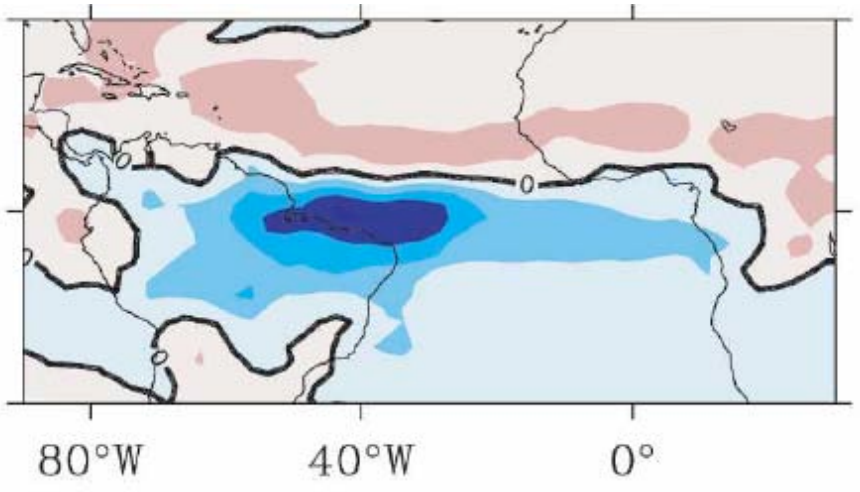
Observations

Influence of high latitudes on ITCZ

SST



Precipitation

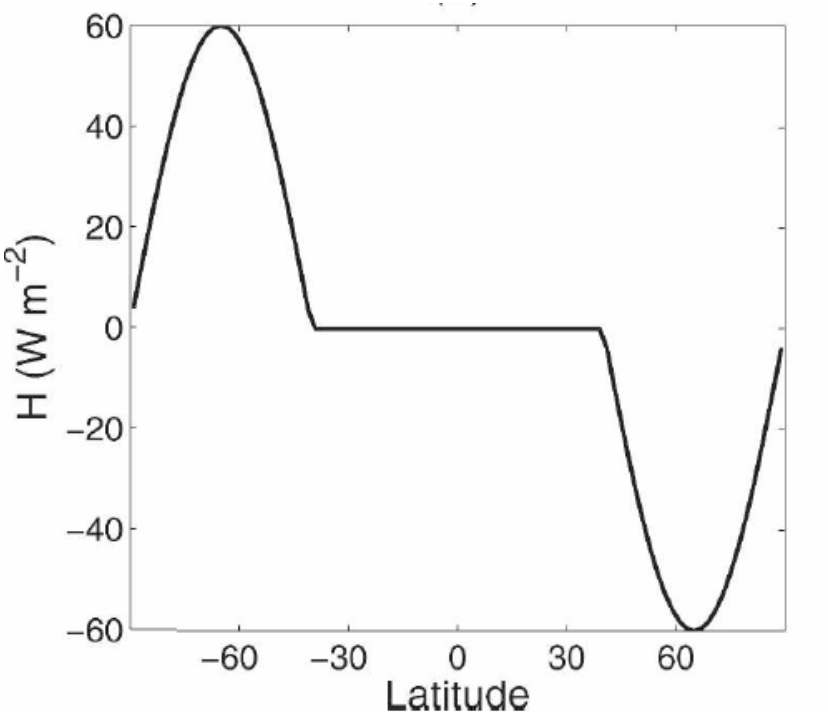


ITCZ shifts towards the warmer hemisphere

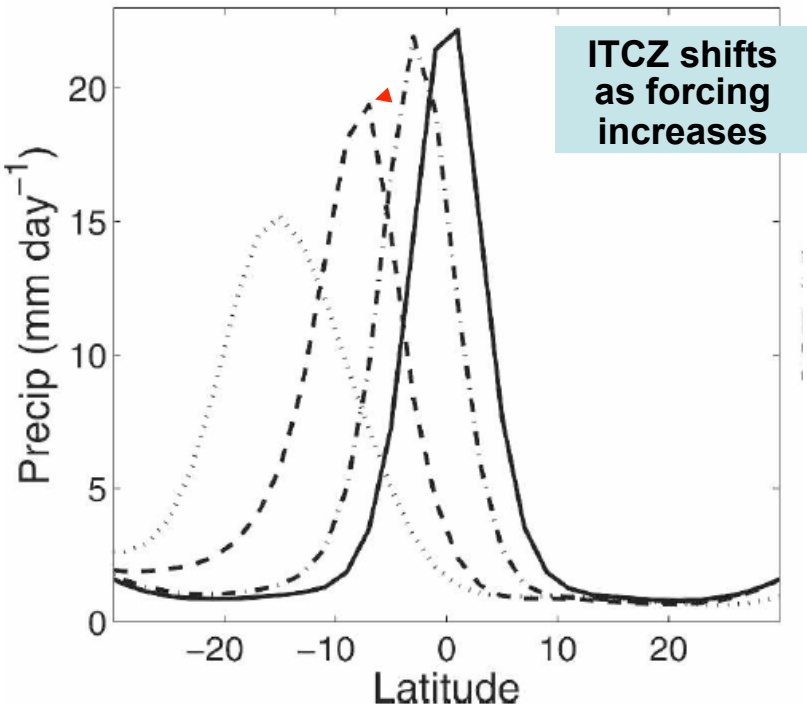
Stouffer *et al*, 2006, Zhang and Delworth, 2005, Chiang and Bitz, 2005, Chiang *et al*. 2008

Influence of high latitudes on ITCZ

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



Forcing flux



Precipitation response

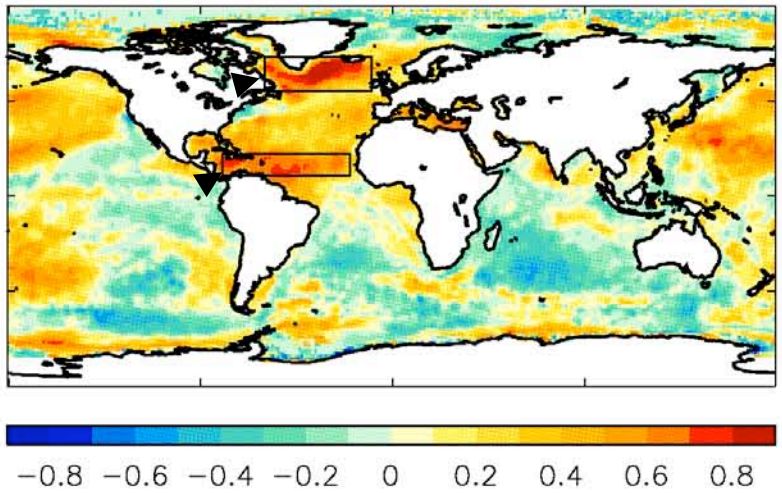
(Kang et al. 2008, J. Climate)

Observed relationships: 5 year means

Met Office Hadley Centre

Sub-polar gyre (SPG)

Hurricane main development region (MDR)

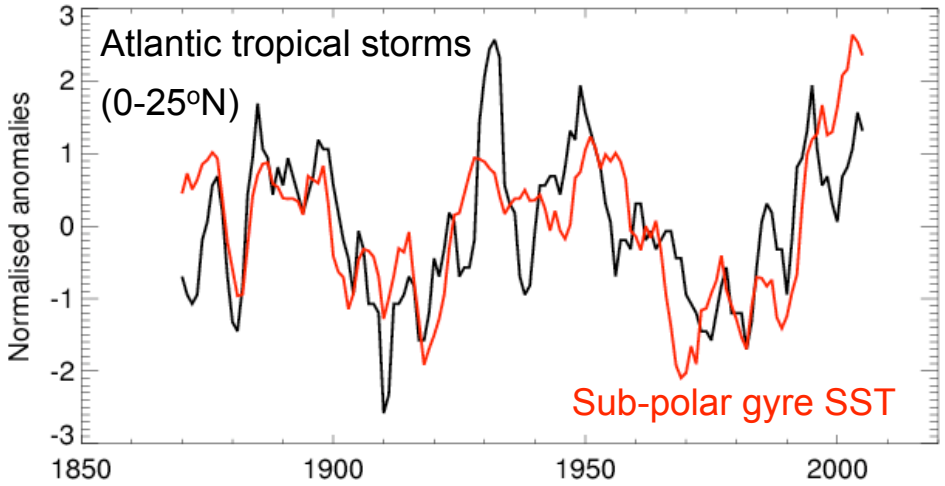


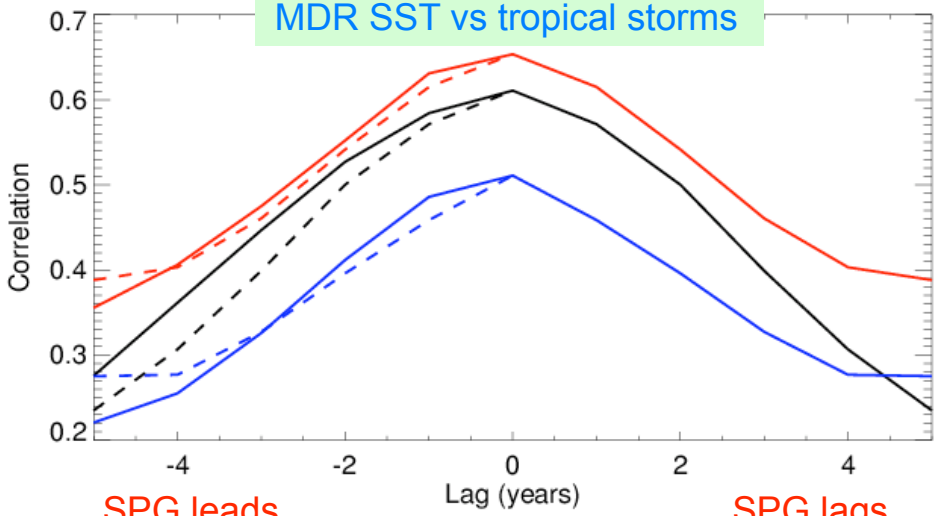
Correlation: sub-polar gyre upper 500m temperature and SST

SPG SST vs tropical storms

SPG SST vs MDR SST

MDR SST vs tropical storms





SPG leads

MDR SST leads

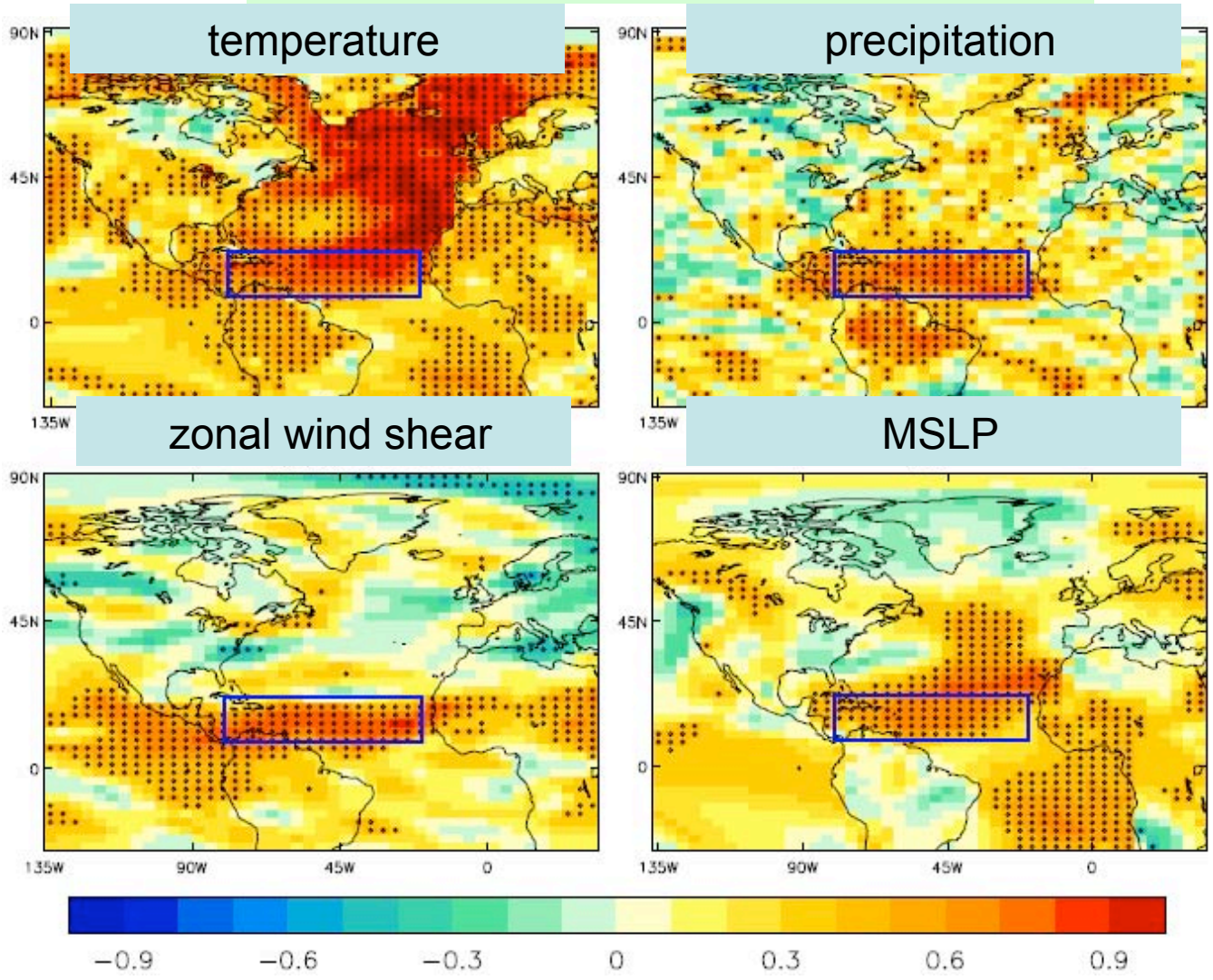
SPG lags

MDR SST lags

Skill in tropical Atlantic atmosphere in idealised experiments

Met Office Hadley Centre

JJASON seasons, Forecast years 2-6:

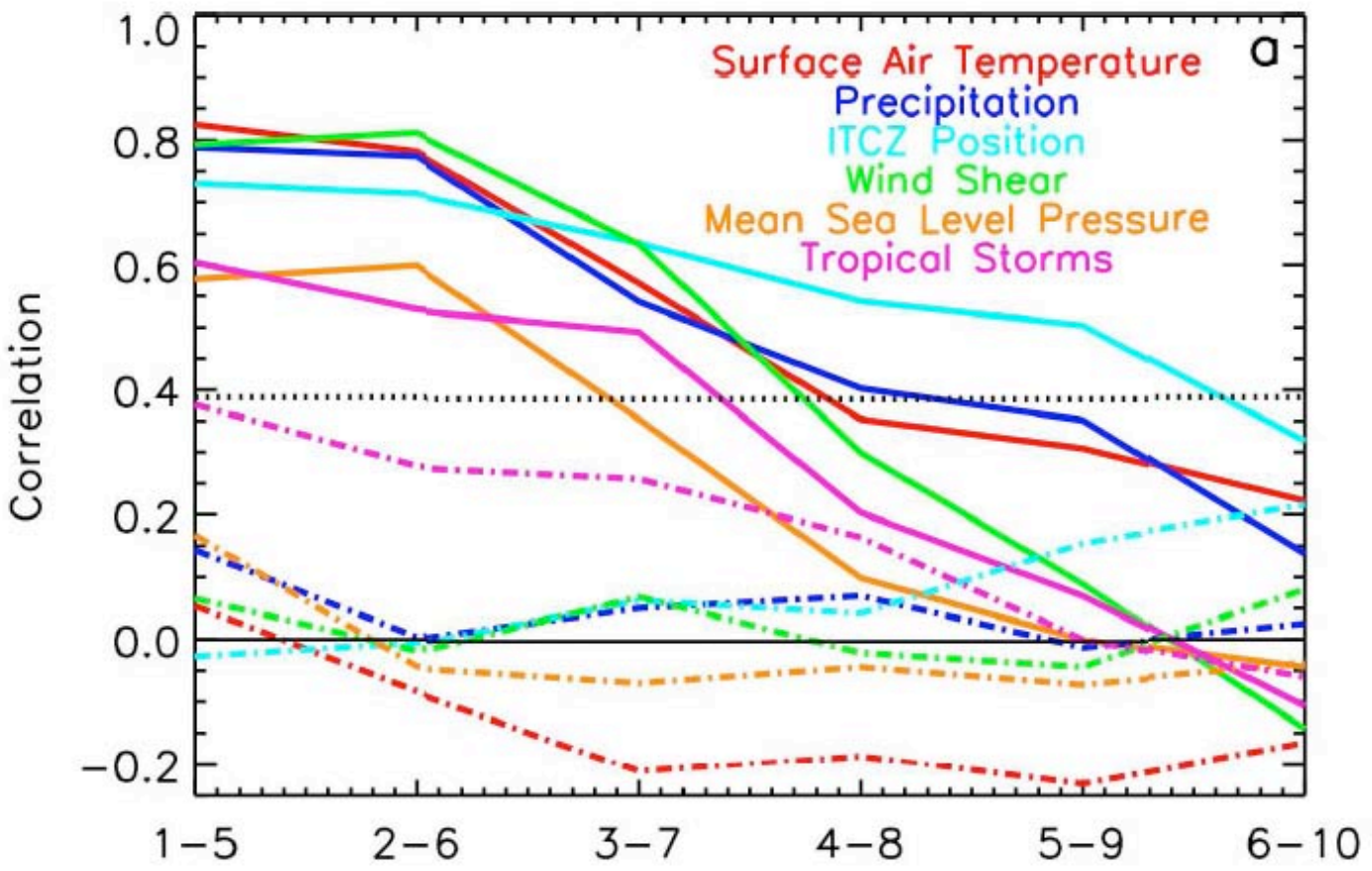


- 26 start dates
- Assimilate monthly mean ocean T and S
- Dunstone et al, 2011, in press

Hurricane main development region

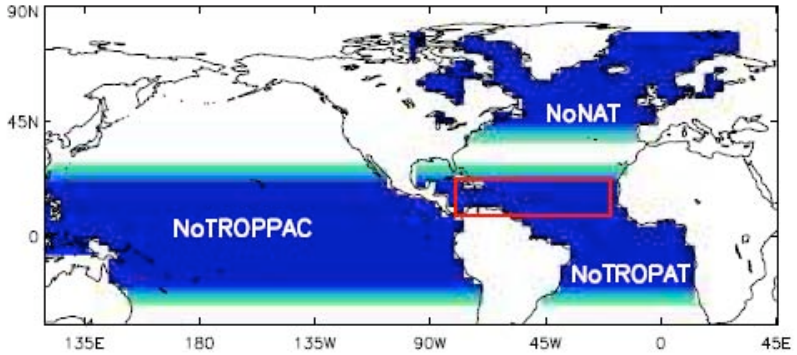
Solid = forecasts

Dotted = persistence

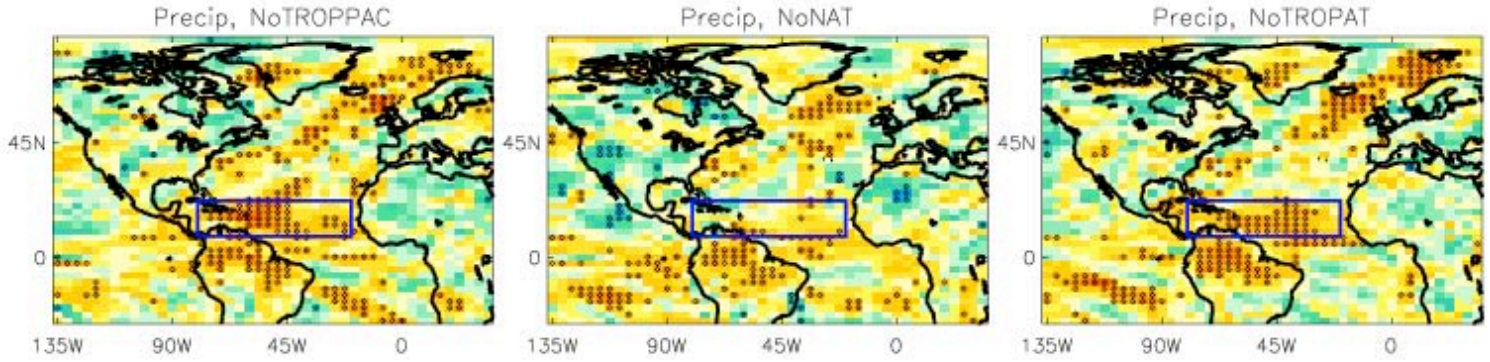


Dunstone et al, 2011, in press

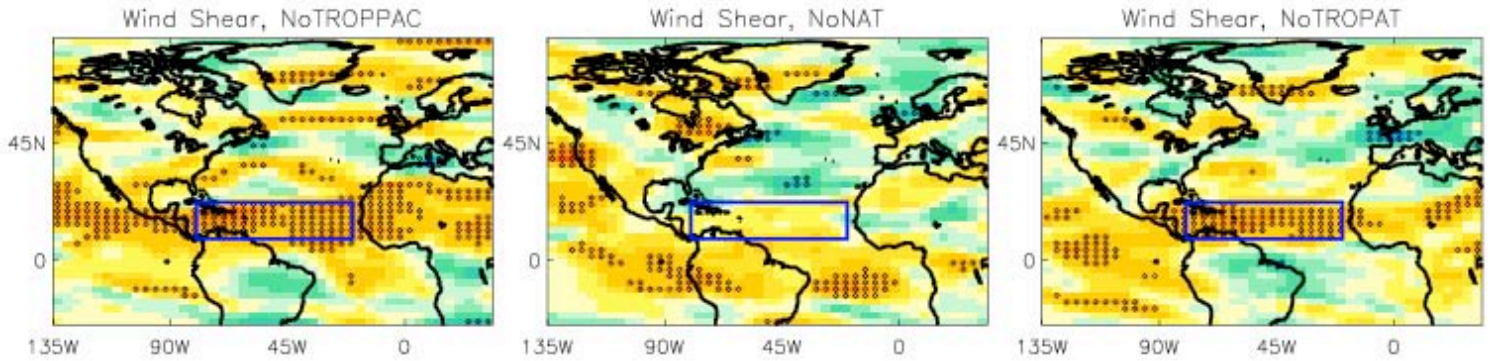
Skill originates from sub-polar gyre



precipitation

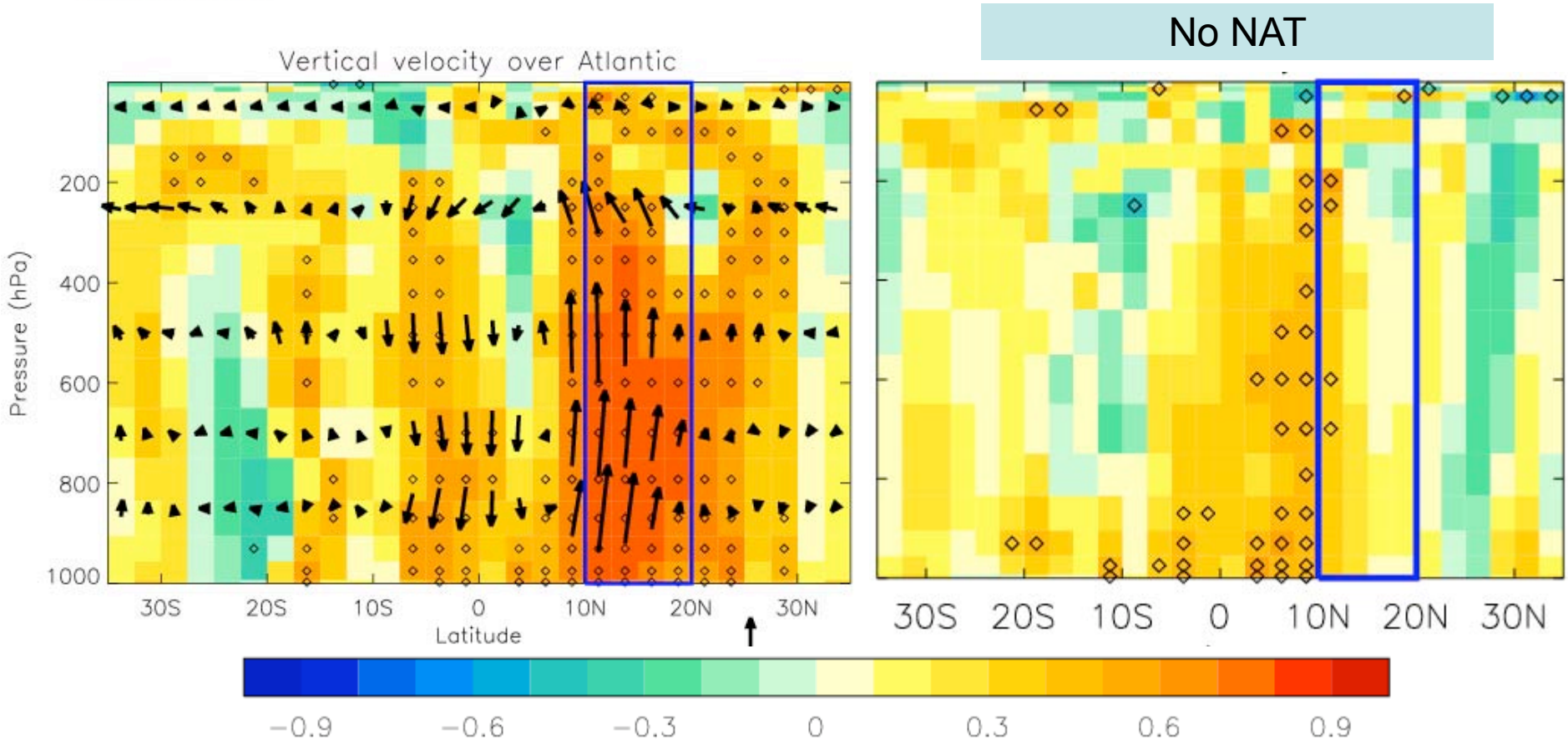


wind shear



Dunstone et al, 2011, in press

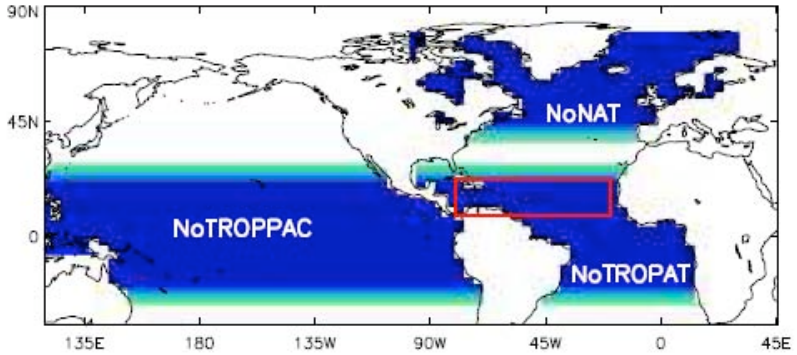
Sub-polar gyre influence on tropical Atlantic

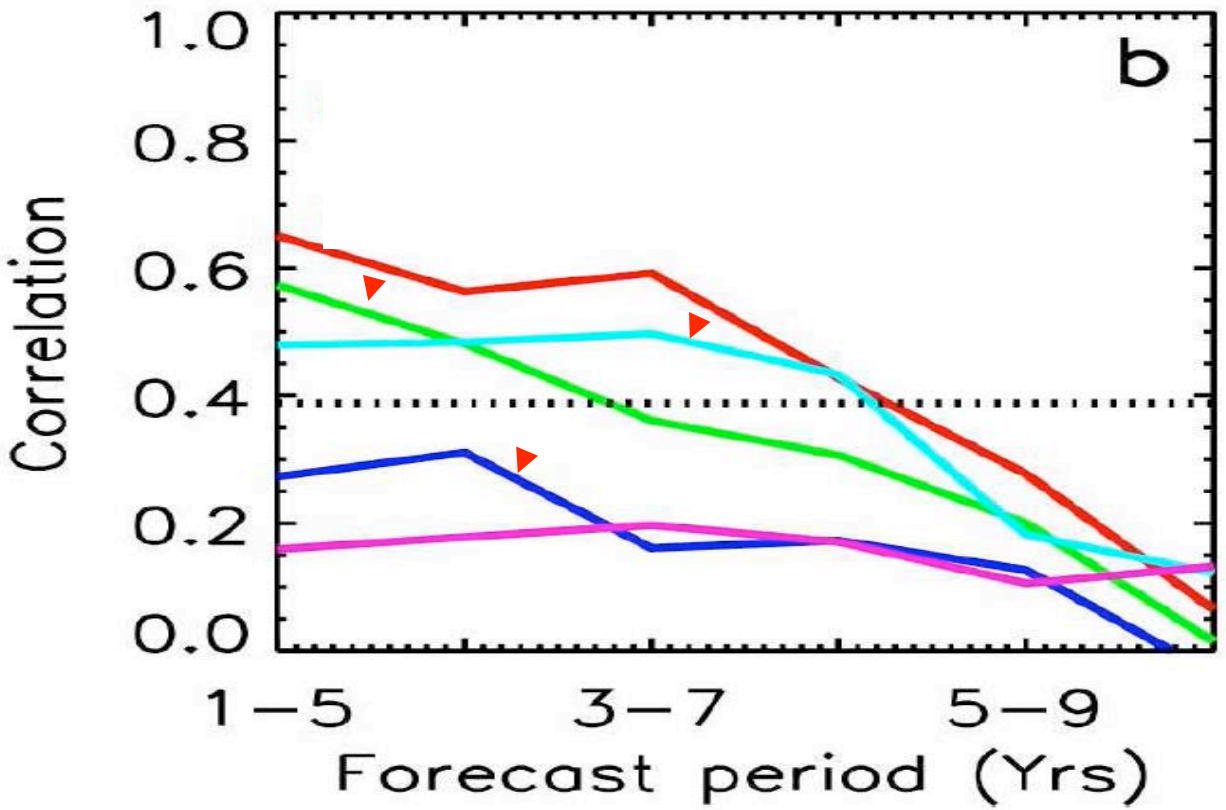


Arrows = warm minus cold sub-polar gyre composite

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

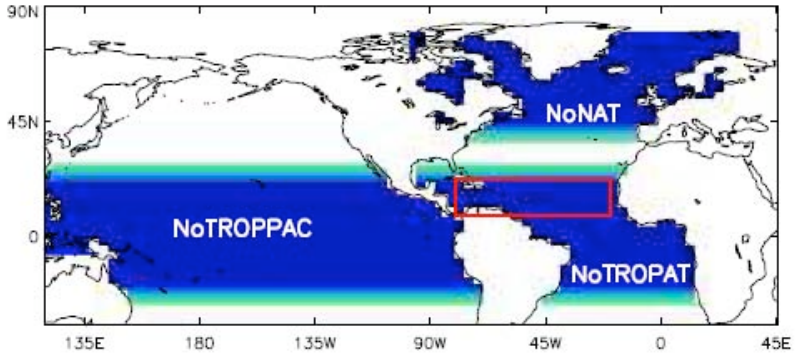
Number of tropical storms

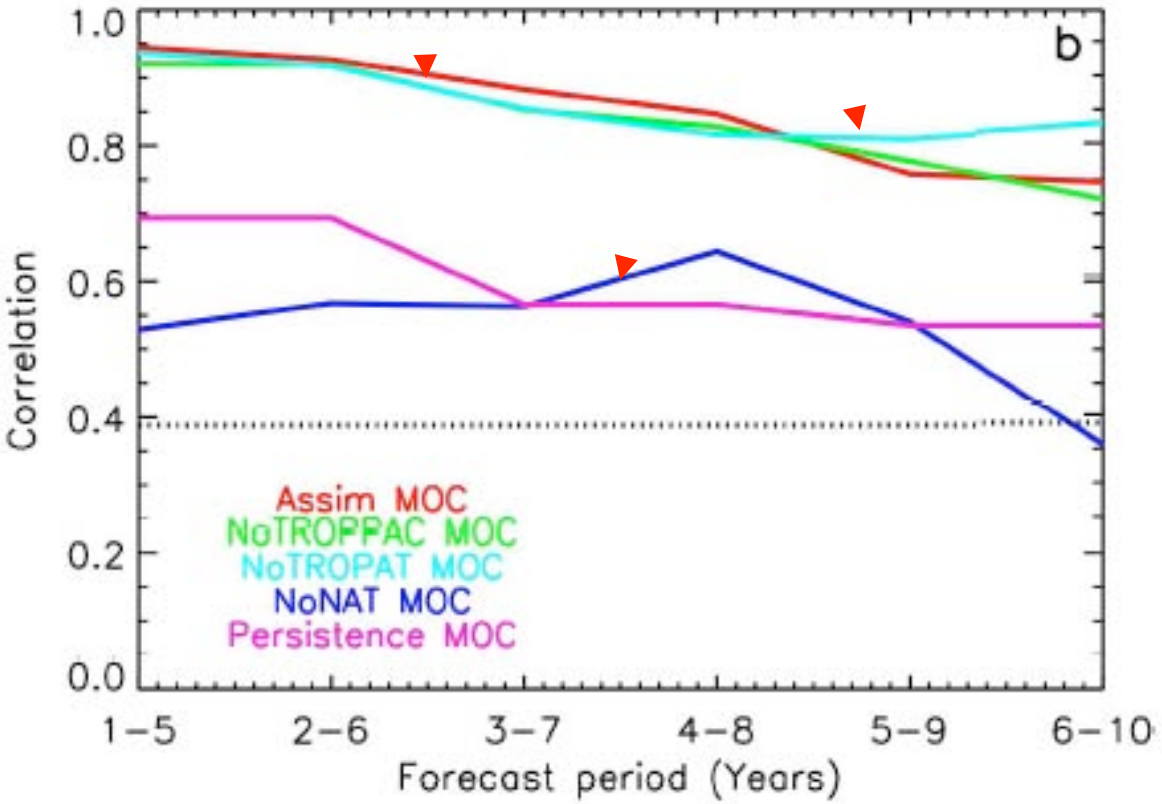




Dunstone et al, 2011, in press

AMOC at 26° N





Dunstone et al, 2011, in press

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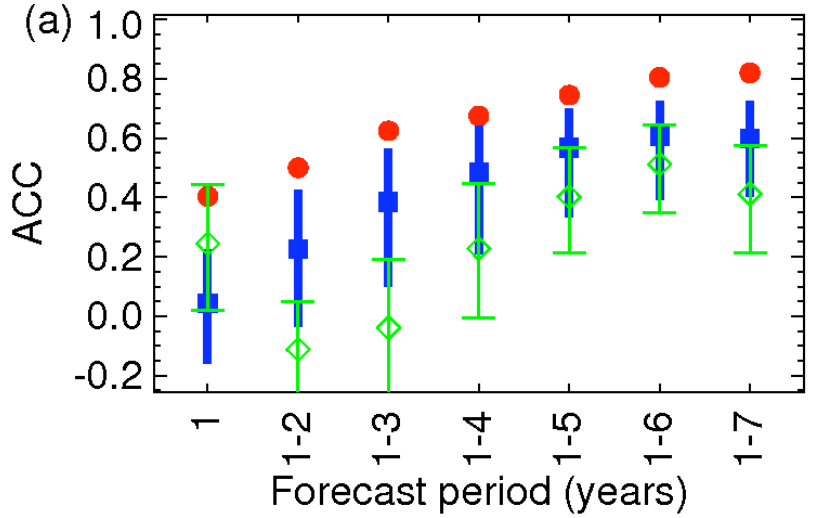
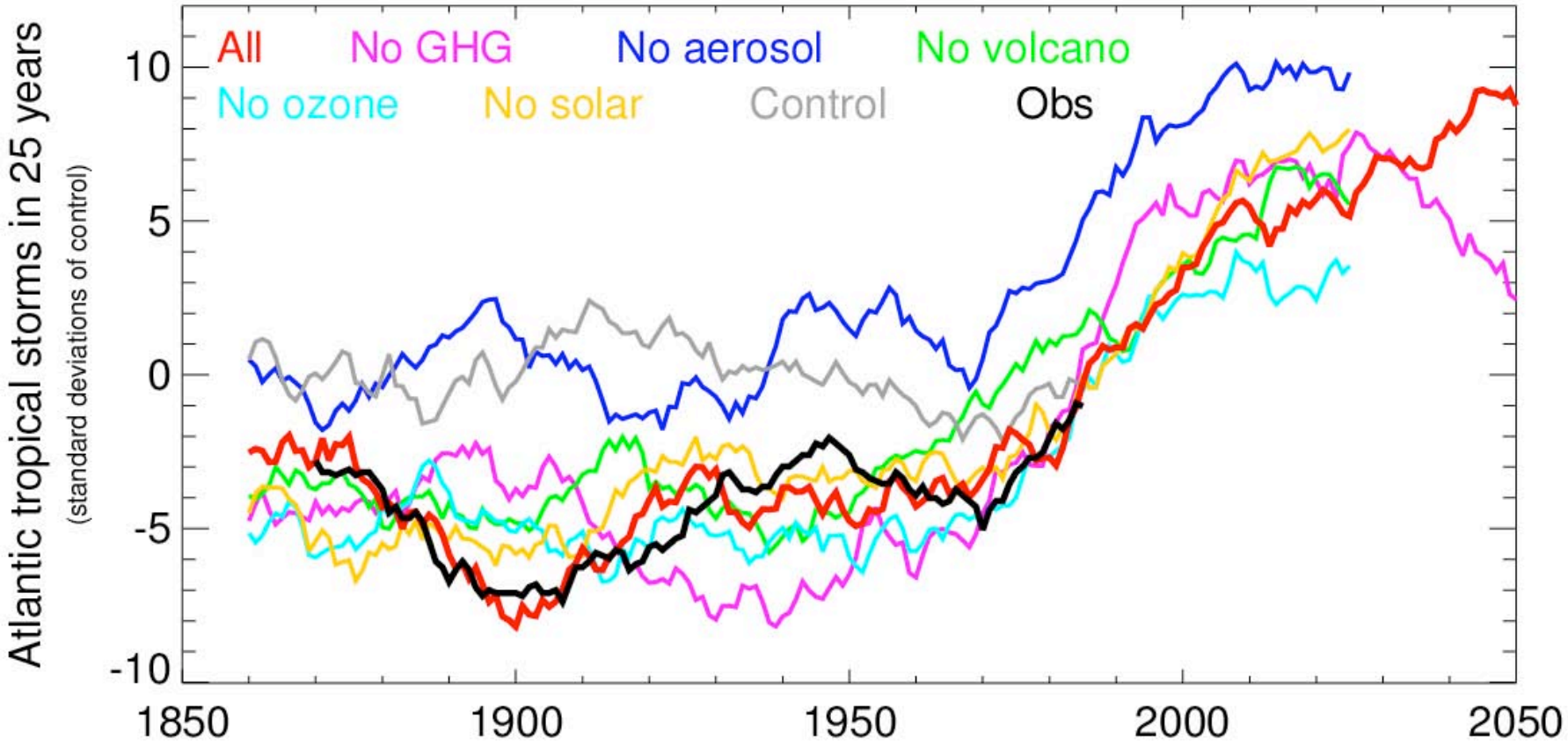
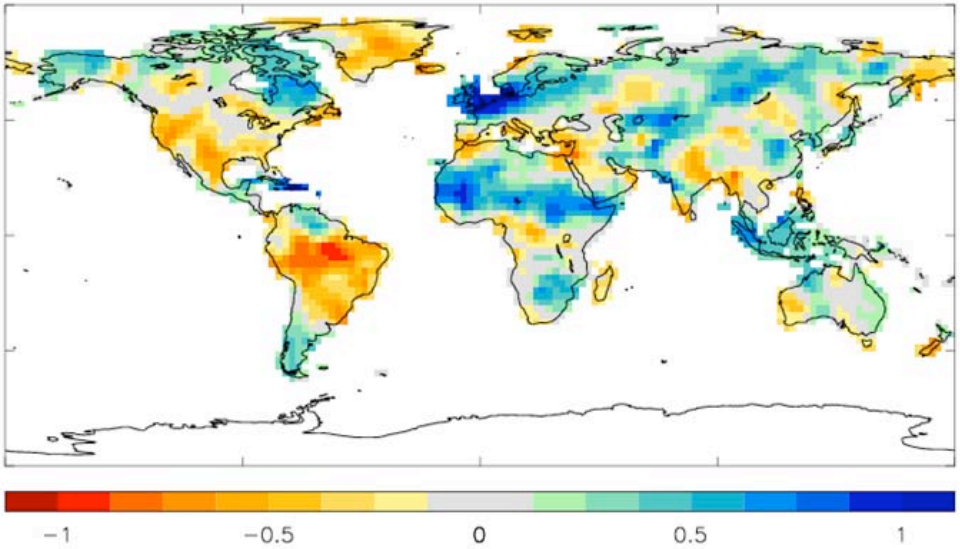
External forcing

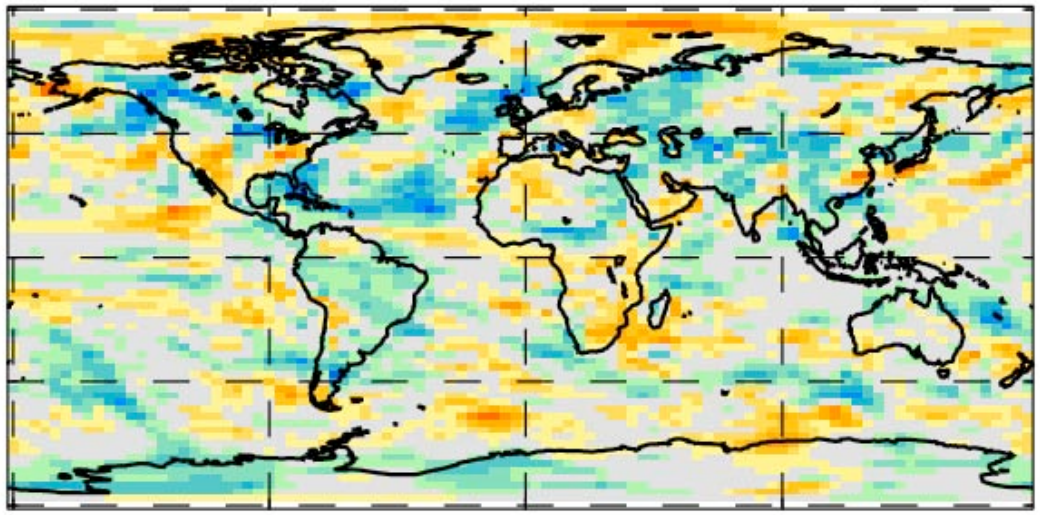




Precipitation teleconnections with sub-polar gyre SST



Observations

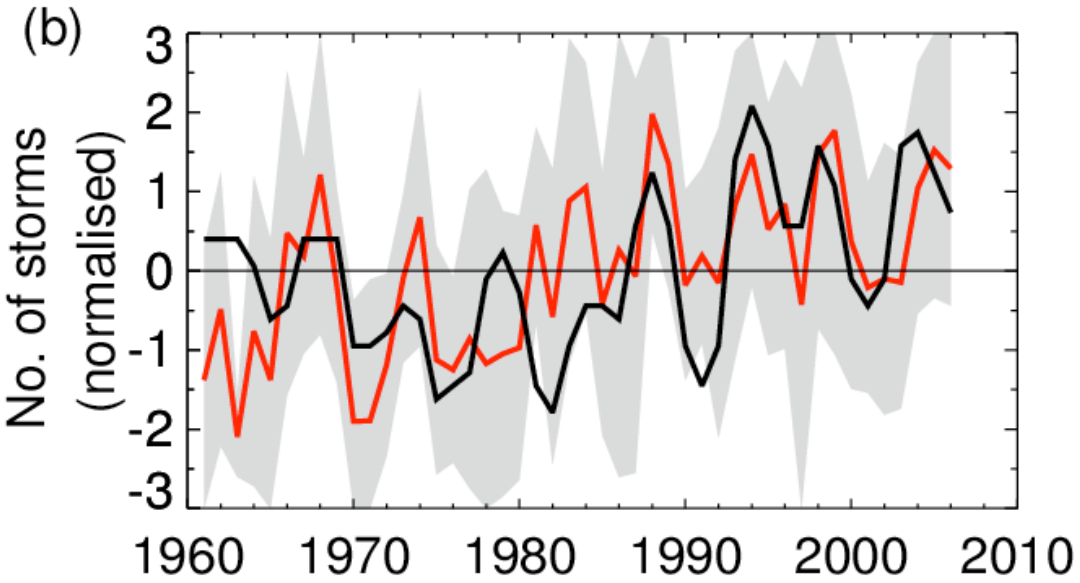


HadCM3

Summary

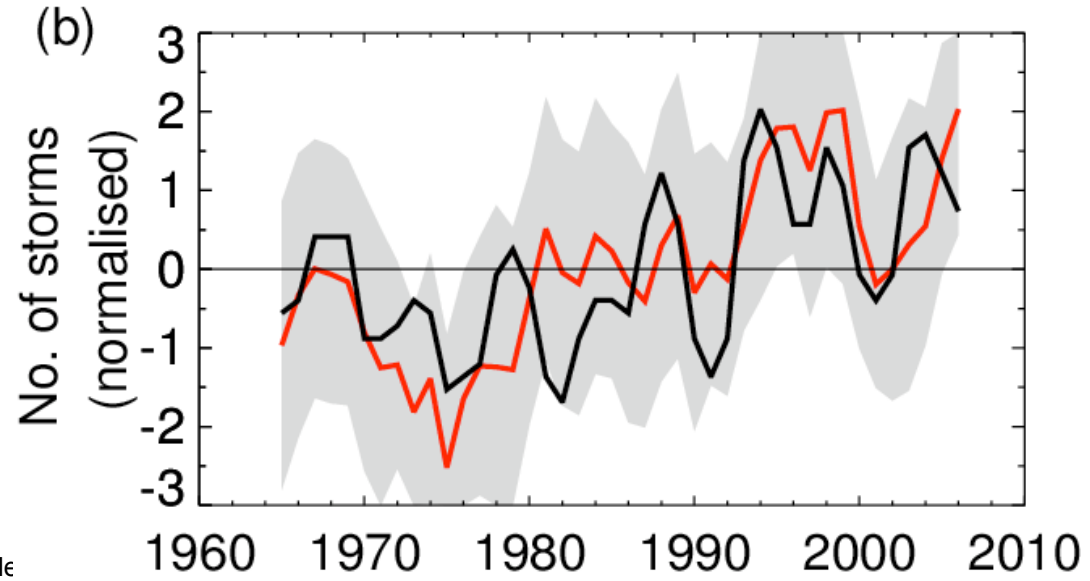
- Initialisation improves temperature predictions in north Atlantic sub-polar gyre and tropical Pacific
- Present generation climate models can predict hurricane frequency for the coming few years
  - ➢Not perfect! Intensity? Land fall?
- The recent increase is at least partly externally forced
  - ➢How much? Relative importance of different factors?
- The high latitude north Atlantic plays an active role
- Need improved models to predict impacts over land

Ensemble size: 3 year means



9 members

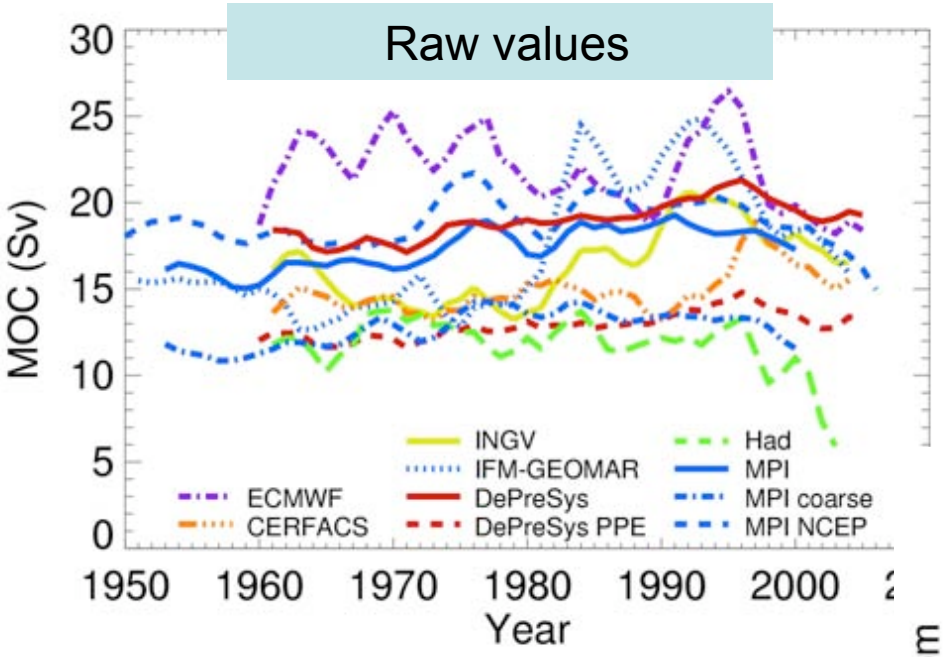
(r=0.52)

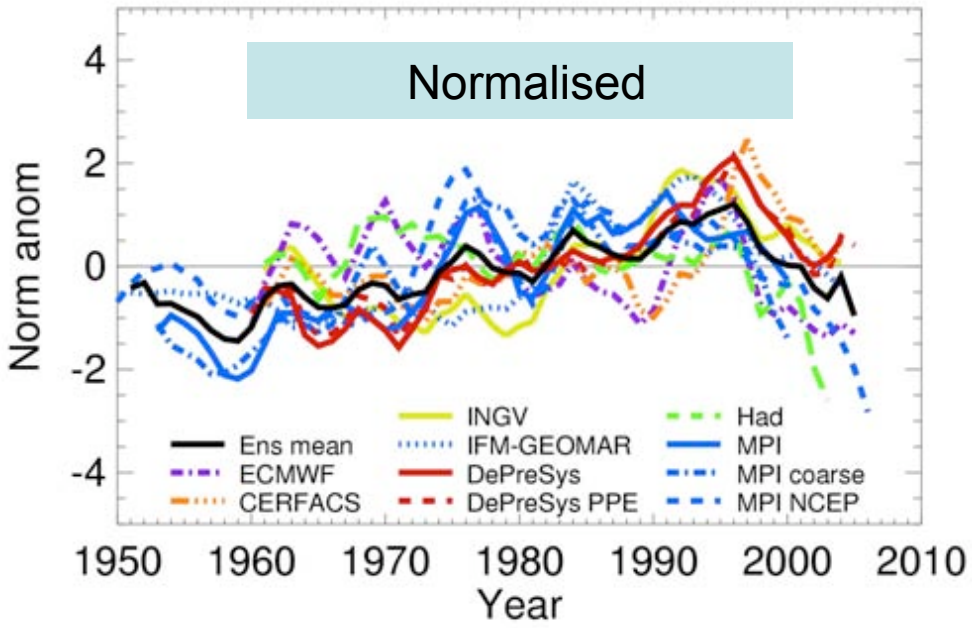


45 members

(r=0.67)

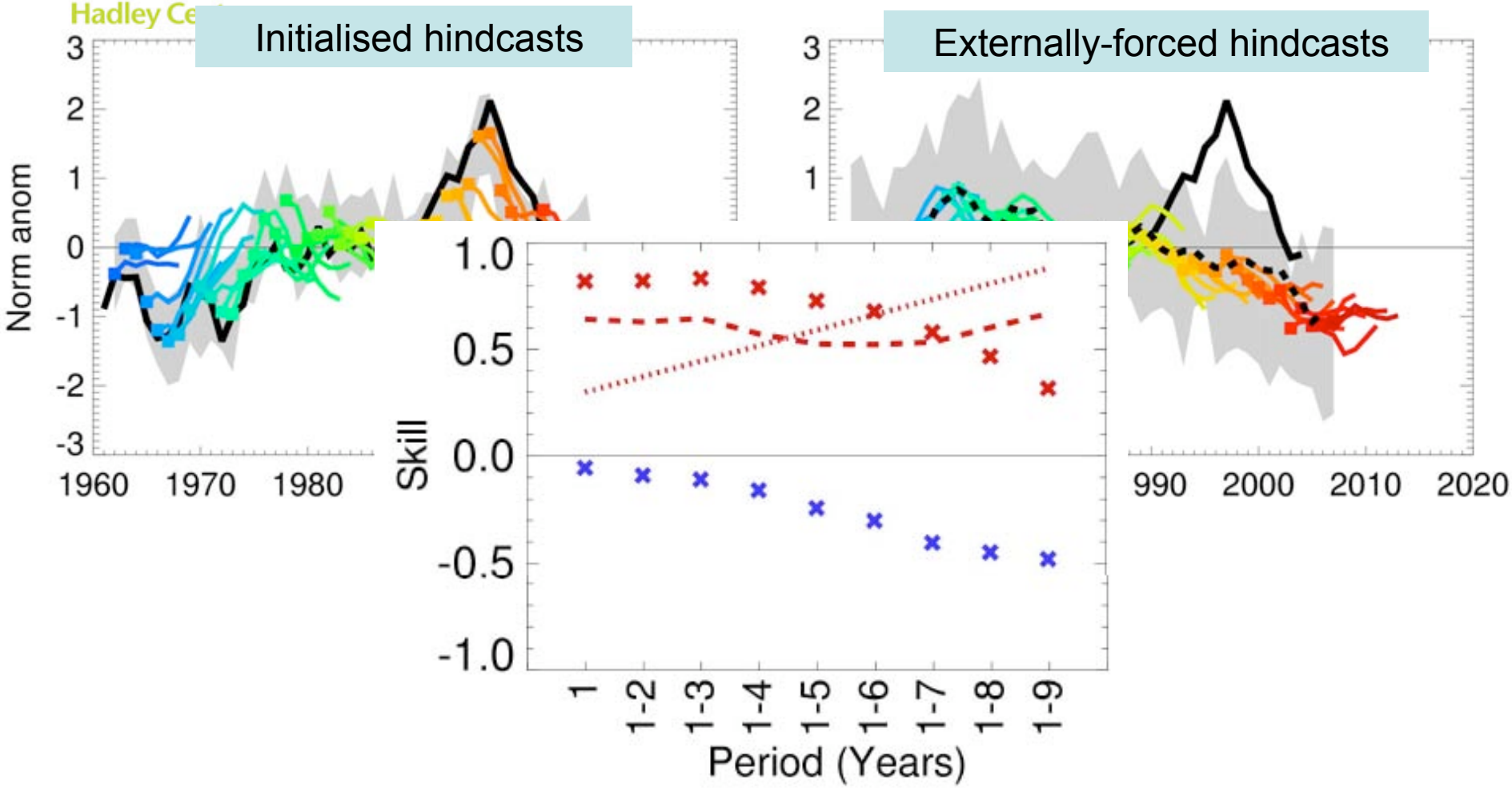
AMOC at 45°N in assimilation experiments





(Pohlmann et al. 2011, in revision)

AMOC at 45°N in hindcast experiments



(Pohlmann et al. 2011, in revision)