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

DePreSys

NoAssim

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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

- North Atlantic SST
- Sahel rainfall
- India rainfall
- Hurricanes

(Observations vs. Model)

(Zhang and Delworth, 2006)
Statistical hurricane projections
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

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(Zhao et al. 2009)
Atlantic tropical storms
Seasonal forecasts from May for June-Nov

HadCM3 (DePreSys) forecasts

Observations

Forecast

No. of storms
(normalised anomaly)

Corr = 0.61


(Smith et al. 2010)
Tropical storm predictions beyond the seasonal range

(Smith et al. 2010)

Skill from external forcing and initialisation
Ensemble size: 5 year means

(b) 9 members (r=0.60)

(b) 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

DePreSys
NoAssim
Persistence
Observations

Time series of 5-year means
Influence of high latitudes on ITCZ

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

ITCZ shifts towards the warmer hemisphere
Influence of high latitudes on ITCZ

- Atmosphere GCM, slab ocean
- Imposed flux anomalies only at high latitudes (> 40°)

Forcing flux

Precipitation response

(Kang et al. 2008, J. Climate)
Observed relationships: 5 year means

- 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

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

Forecast period (years)

Surface Air Temperature
Precipitation
ITCZ Position
Wind Shear
Mean Sea Level Pressure
Tropical Storms

Correlation

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Dunstone et al, 2011, in press
Skill originates from sub-polar gyre

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
External forcing

(a) ACC

Forecast period (years)

Atlantic tropical storms in 25 years

1850 1900 1950 2000 2050

All No GHG No aerosol No volcano
No ozone No solar Control Obs

(standard deviations of control)
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

(b)

No. of storms (normalised)


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

Initialised hindcasts

Externally-forced hindcasts

(Pohlmann et al. 2011, in revision)