



**Met Office**  
Hadley Centre

# **Strategy for Seasonal Prediction Development: UKMO and WGSIP activities**

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**December 2010**

# CLIVAR WGSIP – Working Group on Seasonal to Interannual Prediction

A panel of 13 international members. Co-chairs: Ben Kirtman and Adam Scaife

“develop a programme of numerical experimentation for seasonal-to-interannual variability and predictability, paying special attention to assessing and improving predictions”

## WCRP Workshop on Seasonal Prediction, 2007:

- Launched the Climate Historical Forecast Project
- Identified 3 major areas for improvement of seasonal forecast skill: **sea-ice, stratosphere, land surface**

## Another major activity involves CMIP5:

- CMIP5 protocol for decadal predictions jointly developed between WGSIP and the WGCM

# Climate-system Historical Forecast Project

## Forecasts for past seasons being made available by WGSIP:

Seasonal hindcasts (re-forecasts) with actual O-A initial conditions and forcings such as GHGs but no “cheating” i.e. no future information

4 seasons (1<sup>st</sup> November, 1<sup>st</sup> February, 1<sup>st</sup> May and 1<sup>st</sup> August start dates)

At least 6 members per start date, for years since 1979 depending on forecast centre

Data is being made available from a dedicated server and most major seasonal forecast groups worldwide are participating: <http://www.clivar.org/organization/wgsip/chfp/chfp.php>

## AIMS

Provide a *baseline assessment* of our seasonal prediction capabilities using the best available models of the climate system and data for initialisation.

Provide a framework for assessing of current and planned *observing systems*, and a test bed for integrating process studies and field campaigns into model improvements

Provide an experimental framework for focused research on how various *components of the climate system* interact and affect one another

Provide a test bed for *evaluating IPCC class models* in seasonal prediction mode.

# **Three major topics and (now) three experiments:**

**Land Surface: the GLACE experiment:**

**Soil moisture experiments in seasonal mode**

**Led by R Koster**

**Stratosphere: Stratospheric Historical Forecast Project**

**High Top – Low Top hindcasts**

**Led by A Scaife**

**Sea Ice: Ice Historical Forecast Project**

**Case studies with/without initial sea-ice data (2007/1996)**

**Led by D Peterson**

# Developments at UKMO

**UKMO GloSea4 now operational**

**Model Development**

**Potential for Extratropics?**

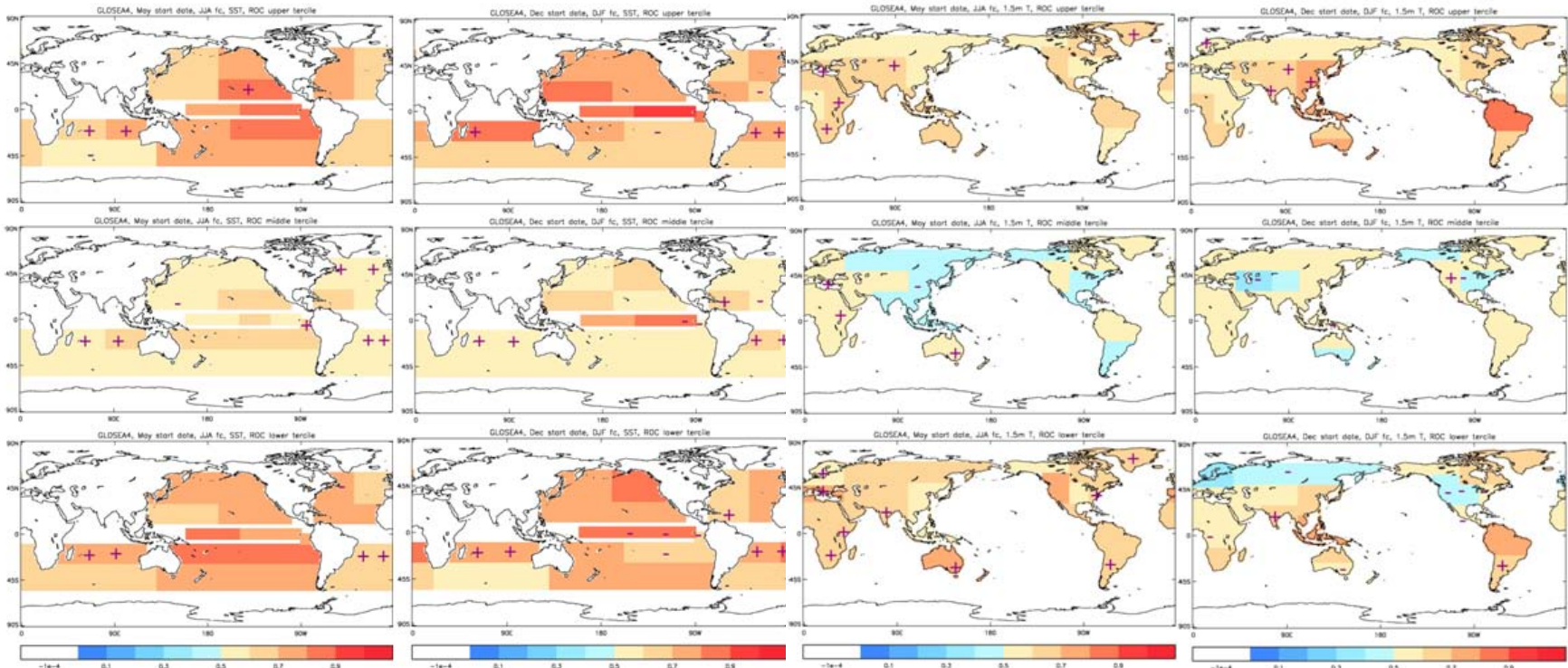
# UKMO GloSea4 now operational

JJA Ocean

DJF Ocean

JJA Land

DJF Land



Warm

Av'ge

Cold

14 members per week

A - N96L38 O-1,L42 => A - N96L85 O-1,L75

Hindcast run in real time

Arribas et al, Mon Wea Rev, in press

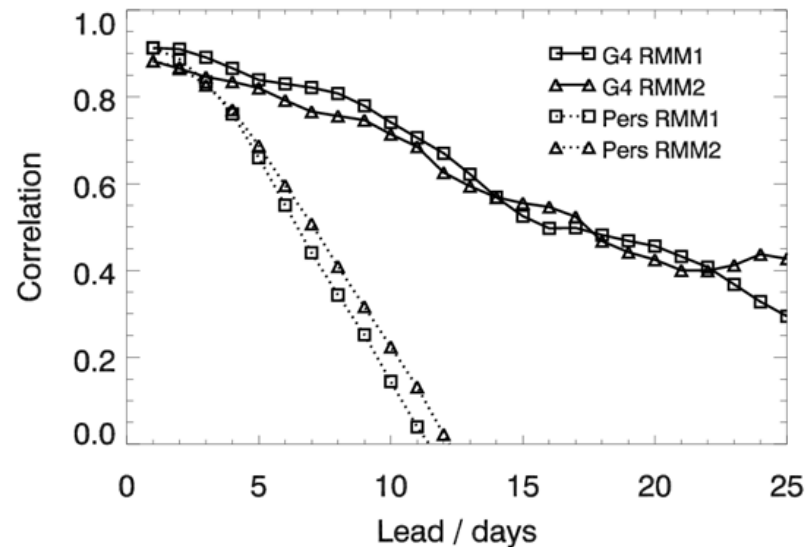
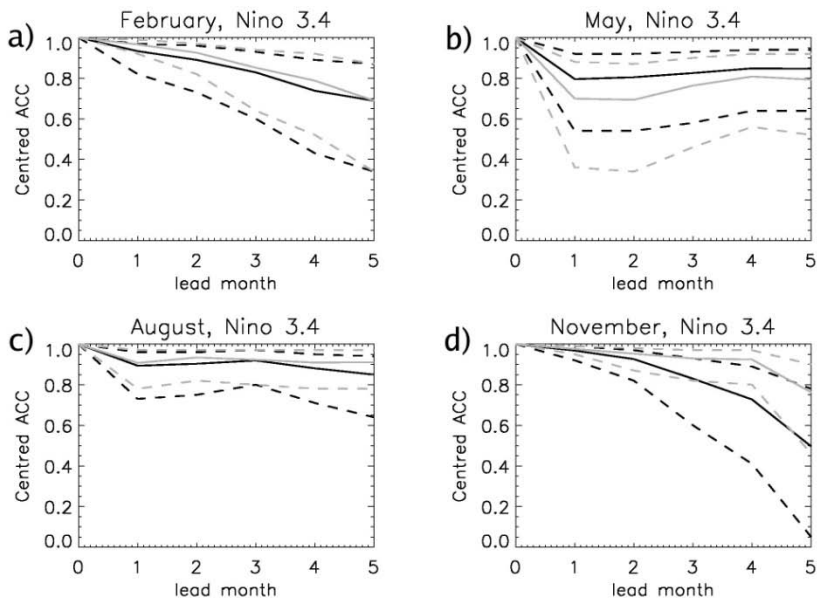
ROC scores improved over GloSea3

Lower skill in middle tercile

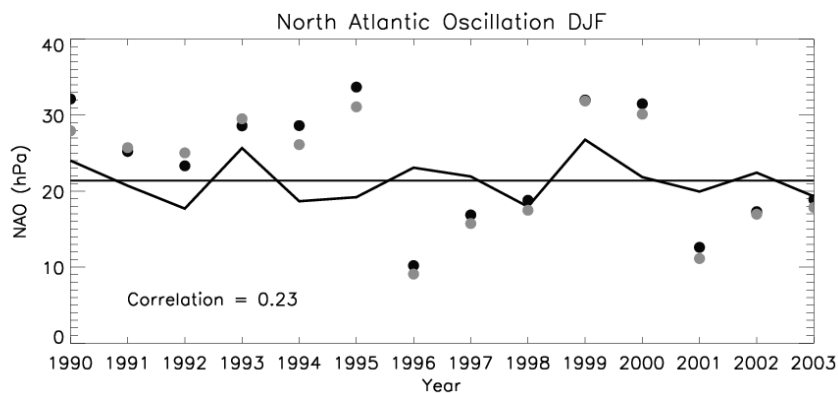
Smaller improvements over land

# UKMO GloSea4 now operational

**ENSO similar to GloSea3**



**MJO correlation ~0.6 at 15 days lead time**



**NAO skill still low of course...**

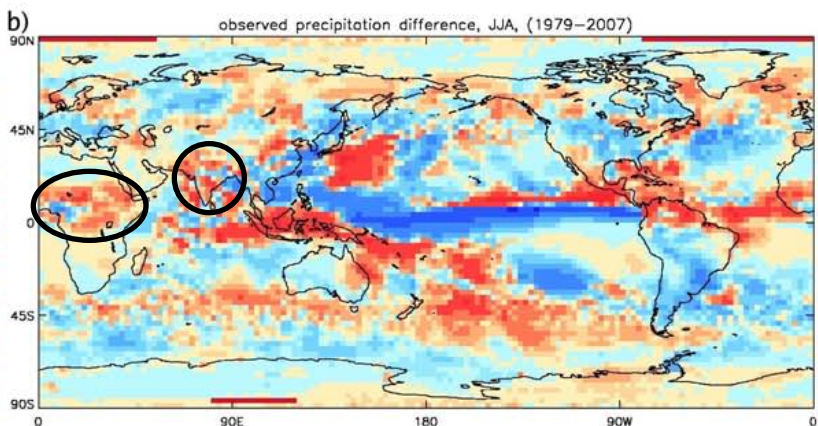
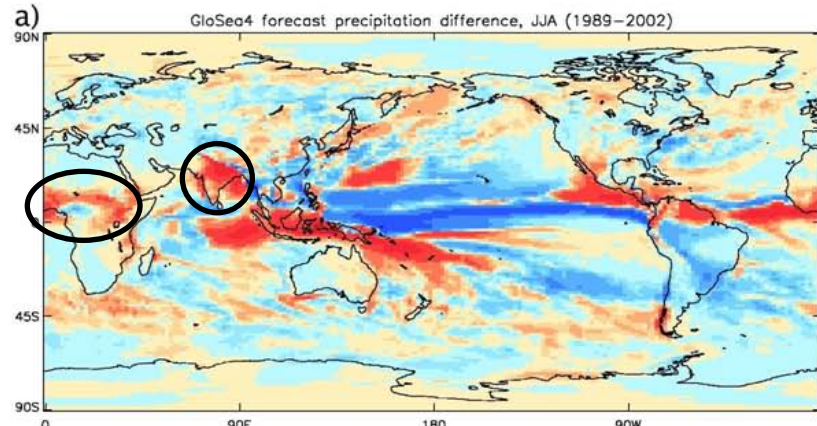


# El Niño/La Niña difference in rainfall

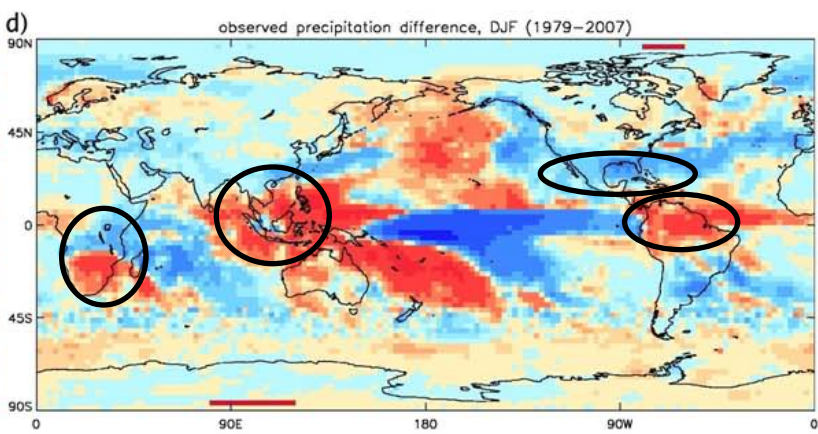
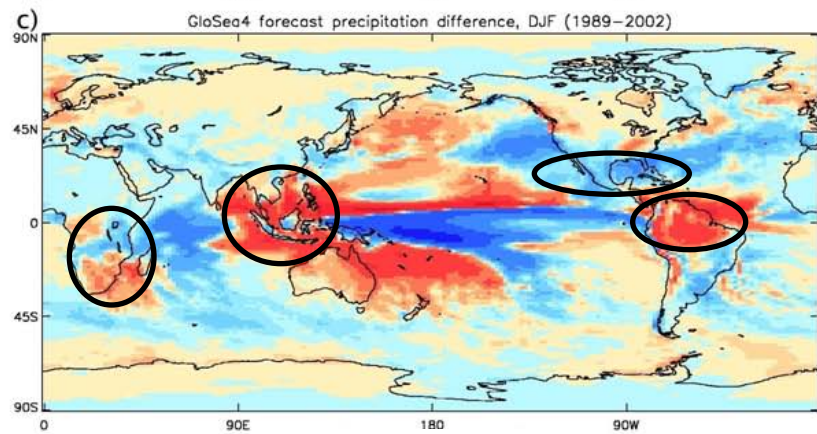
Forecast

Observed

JJA



DJF



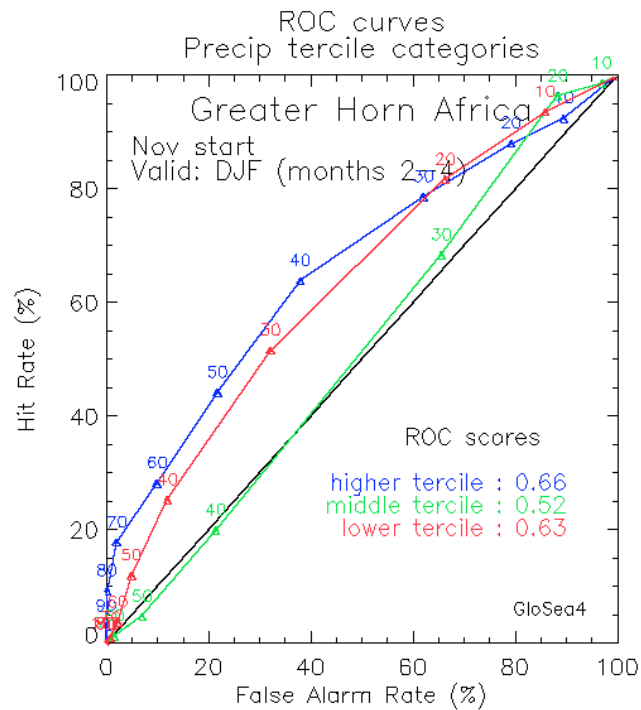
**Skilful signals in the tropics – even for rainfall**  
**Main teleconnections reproduced**



# Conditional Skill?

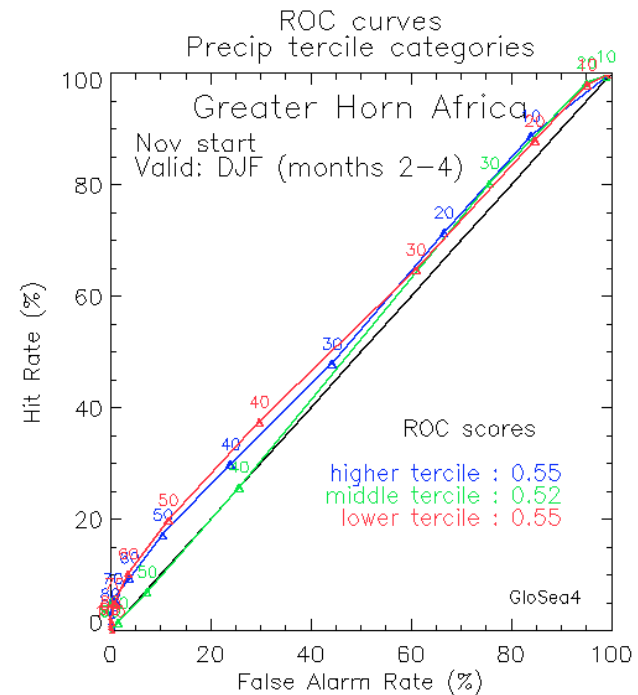
## Land Precipitation: Horn of Africa

### Nino years



Threshold values (%)  
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 (>100)

### All years



Threshold values (%)  
0.0 10.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 (>100)

# Upcoming System Changes

*We run the forecast in real time to allow all rapid changes:*

- **Increased vertical resolution L85 (Autumn 2010)**
  - To better capture stratospheric processes
- **Sea-ice initialisation (Autumn 2010)**
  - Some evidence of a possible remote response
  - Sea Ice predictions
  - See WGSIP experiment
- **Monthly system (Spring 2011)**
  - Seasonal forecast will run 4 members every day (2 members out to 2 mths)
- **Higher horizontal resolution (late 2011?)**

# Developments at UKMO

**UKMO GloSea4 now operational**

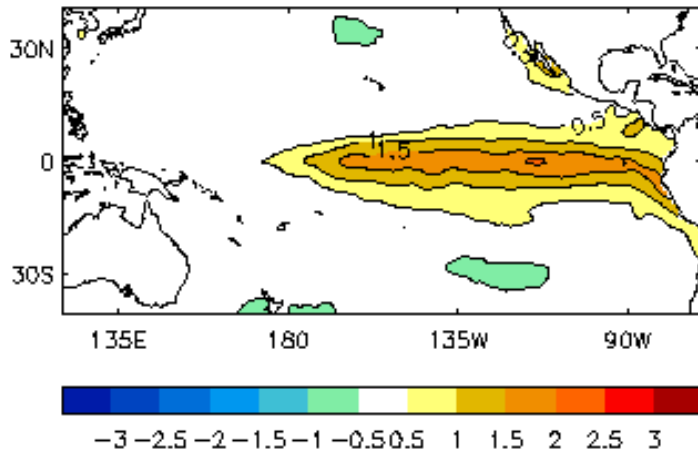
**Model Development**

**Potential for Extratropics?**

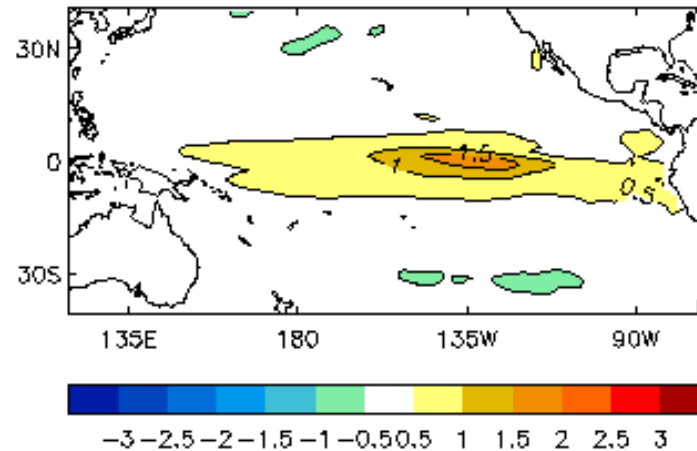
# Improved ENSO Pattern

(teleconnections, climate change? seasonal forecasting)

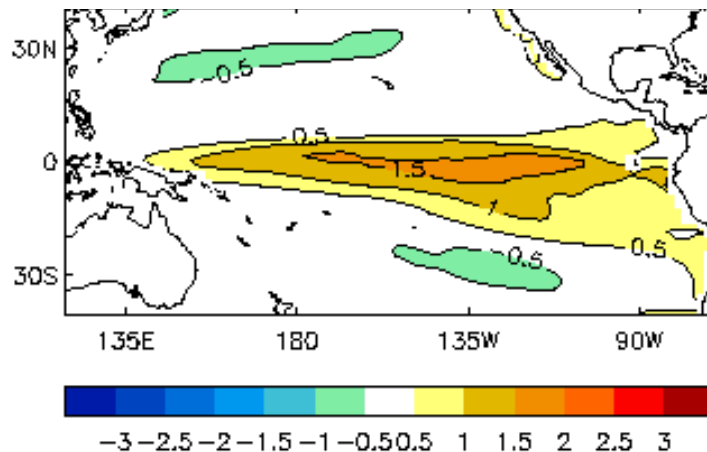
## Observations



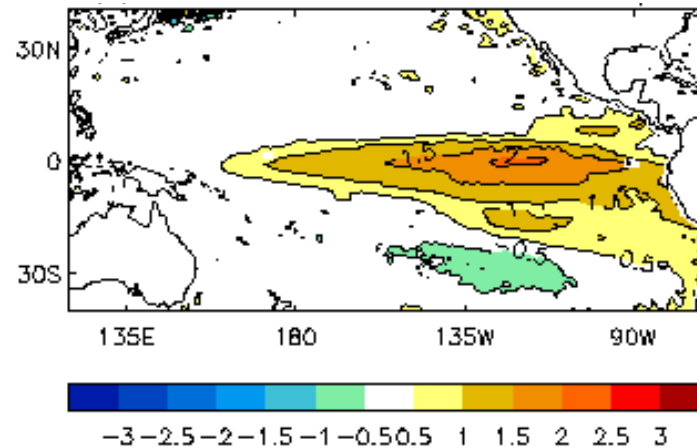
## HadGEM1



## HadGEM3 – N96



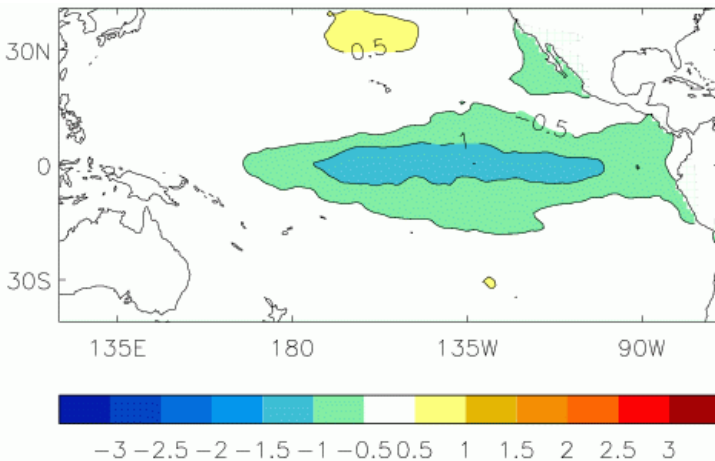
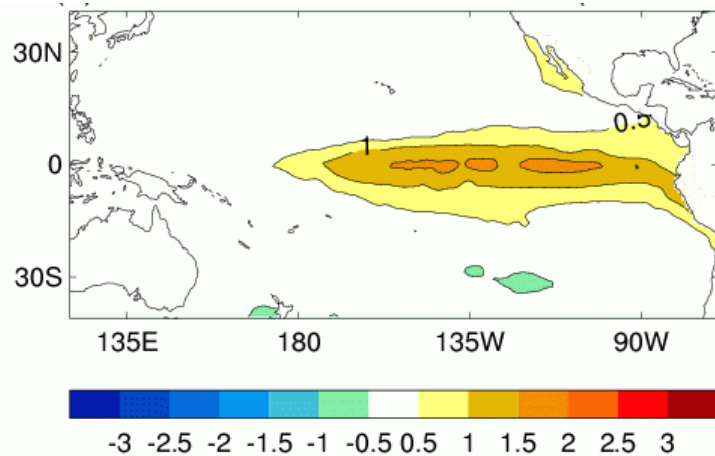
## HadGEM3 – N216



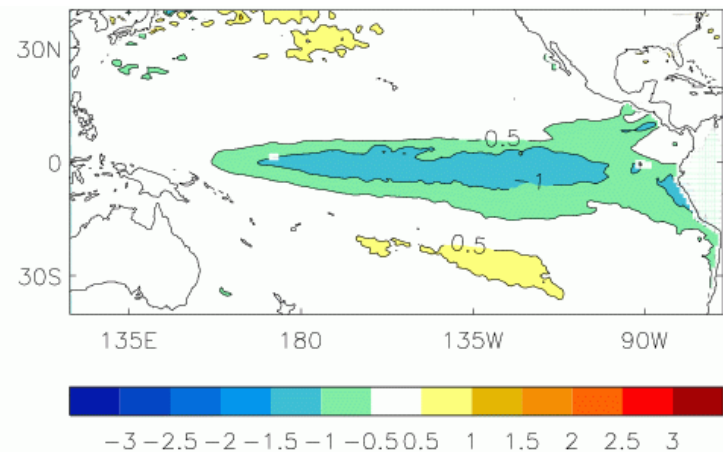
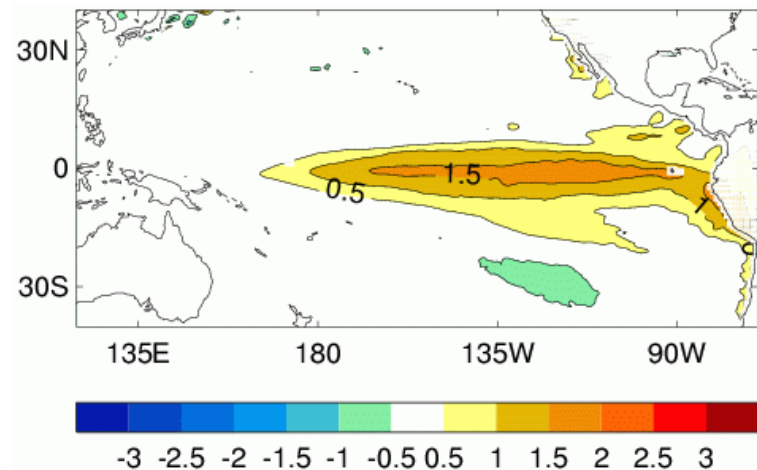
# ENSO Asymmetry

(teleconnections, climate change? seasonal forecasting)

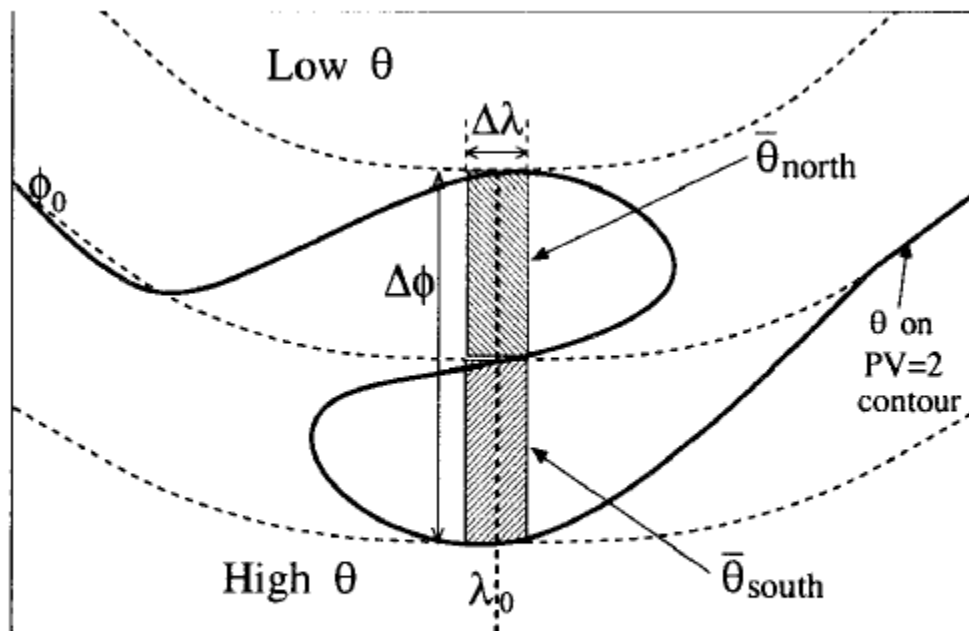
## Observations



## HadGEM3 – N216



# Atmospheric Blocking



**Pelly and Hoskins (2003): Blocking index  $B$  is the difference between the average potential temperature in the N box and the average potential temperature in the S box.**

**$B > 0$  implies blocking**

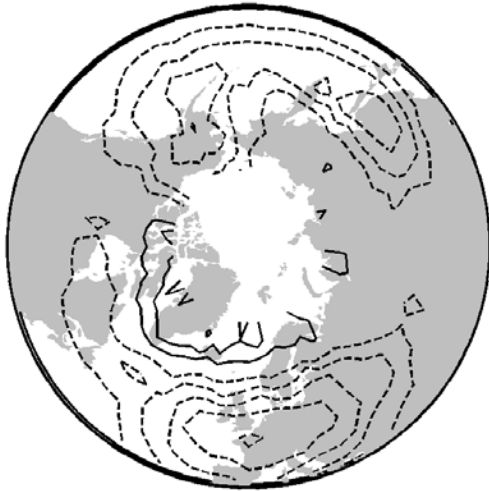
**Tibaldi and Molteni (1990): similar index based on GPH at 500hPa**

**A signature of atmospheric *wave breaking***



# Atmospheric Blocking

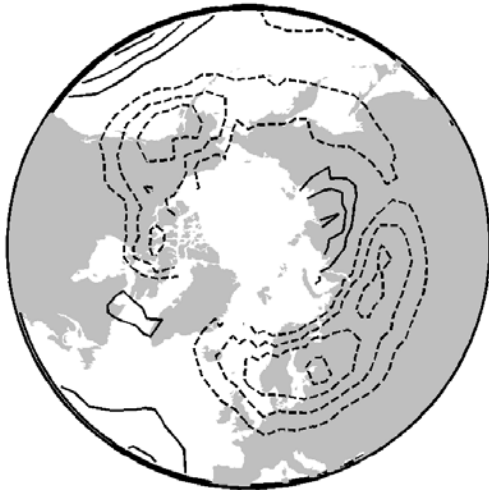
Winter



**Lack of blocking in both Atlantic and Pacific**

**Same error in Summer and Winter**

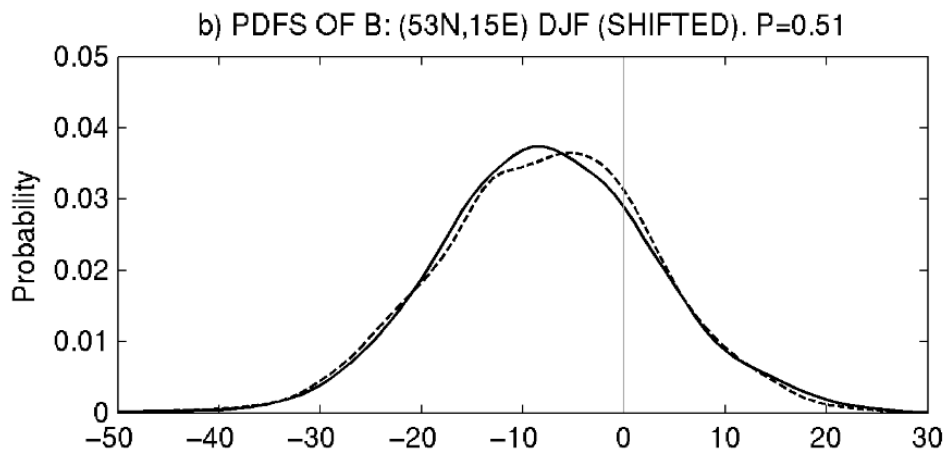
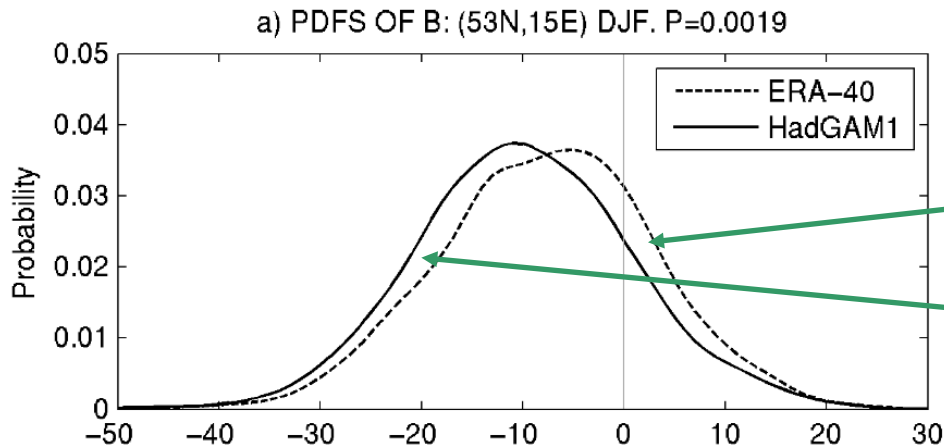
Summer



**Peak deficit > 0.15 day<sup>-1</sup>**

**Mean values ~0.25 day<sup>-1</sup>**

# Mean versus variability



Underestimated blocking

Balanced by overestimated  
'anti-blocking' or 'mobile' days!

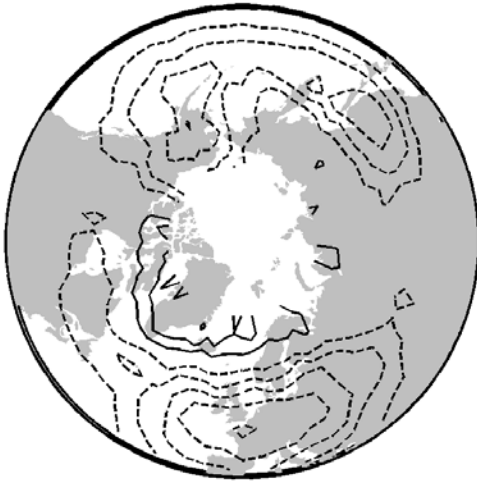
=> width (variability) is  
relatively well modelled

=> error is in mean climate and  
not in variability

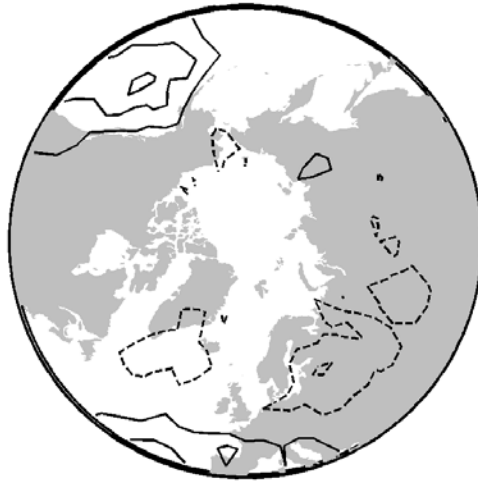
**So can our model simulate the  
blocking process after all?**

# Bias corrected errors in our model

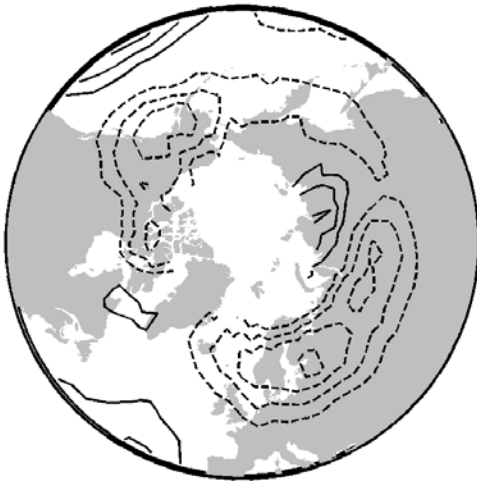
Winter



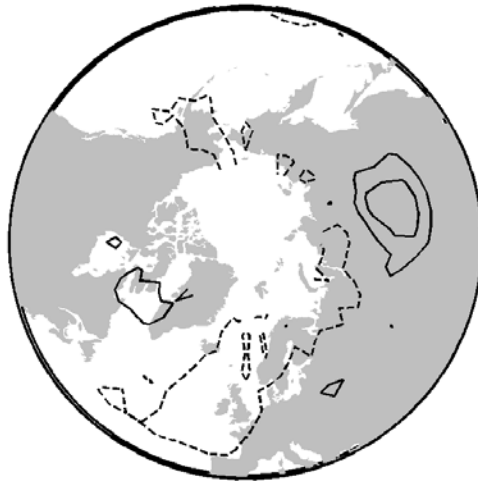
Winter bias corrected



Summer



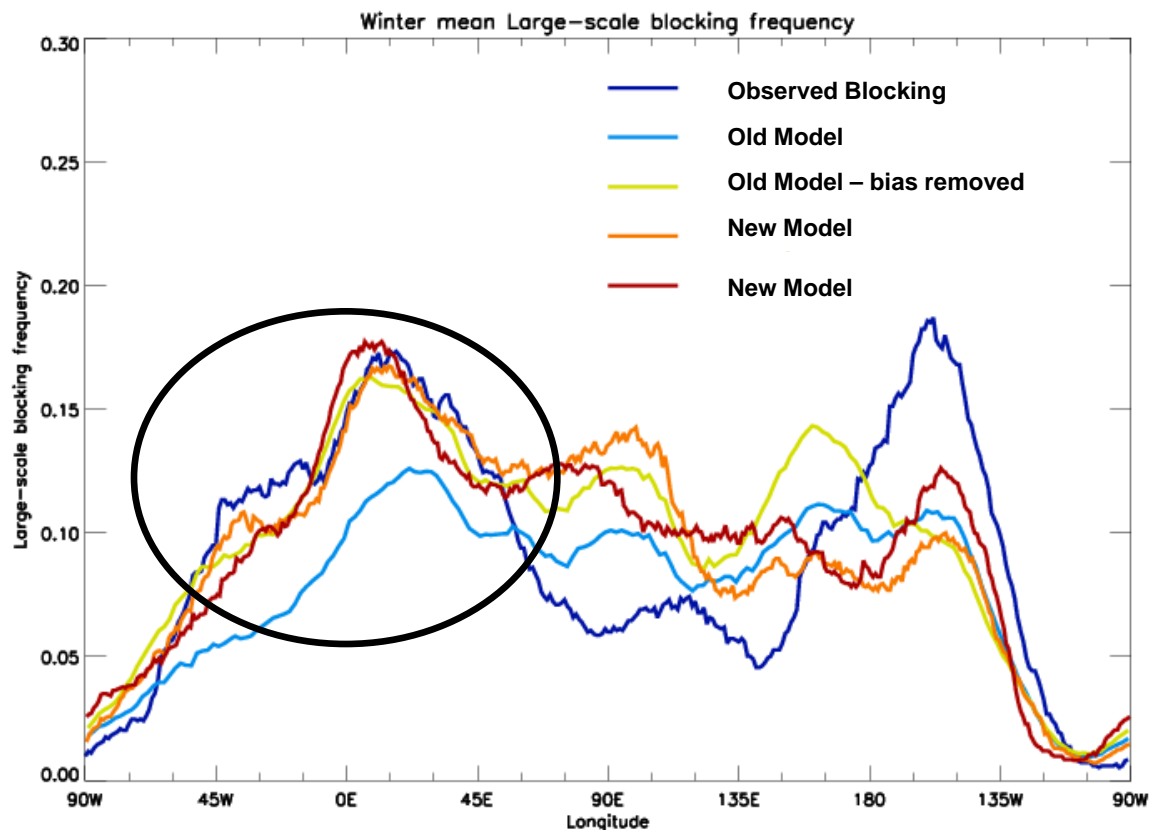
Summer bias corrected



Error removed in both  
Atlantic and Pacific

Error removed in Summer  
and Winter

# New Model:



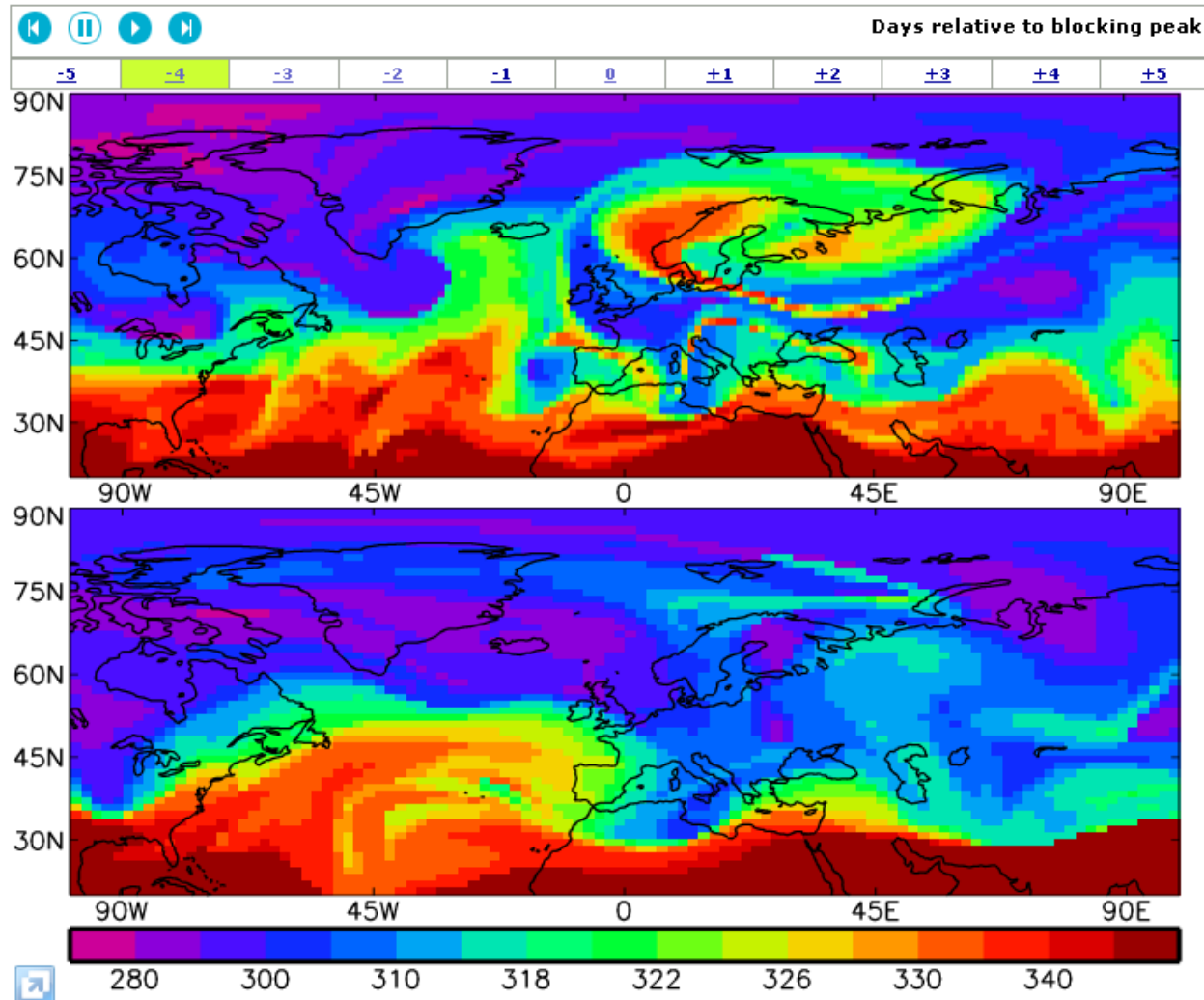
**New model has small atmospheric mean biases.**

**This leads to a good representation of Atlantic blocking.**

# An example blocking event:

## North Atlantic Blocking

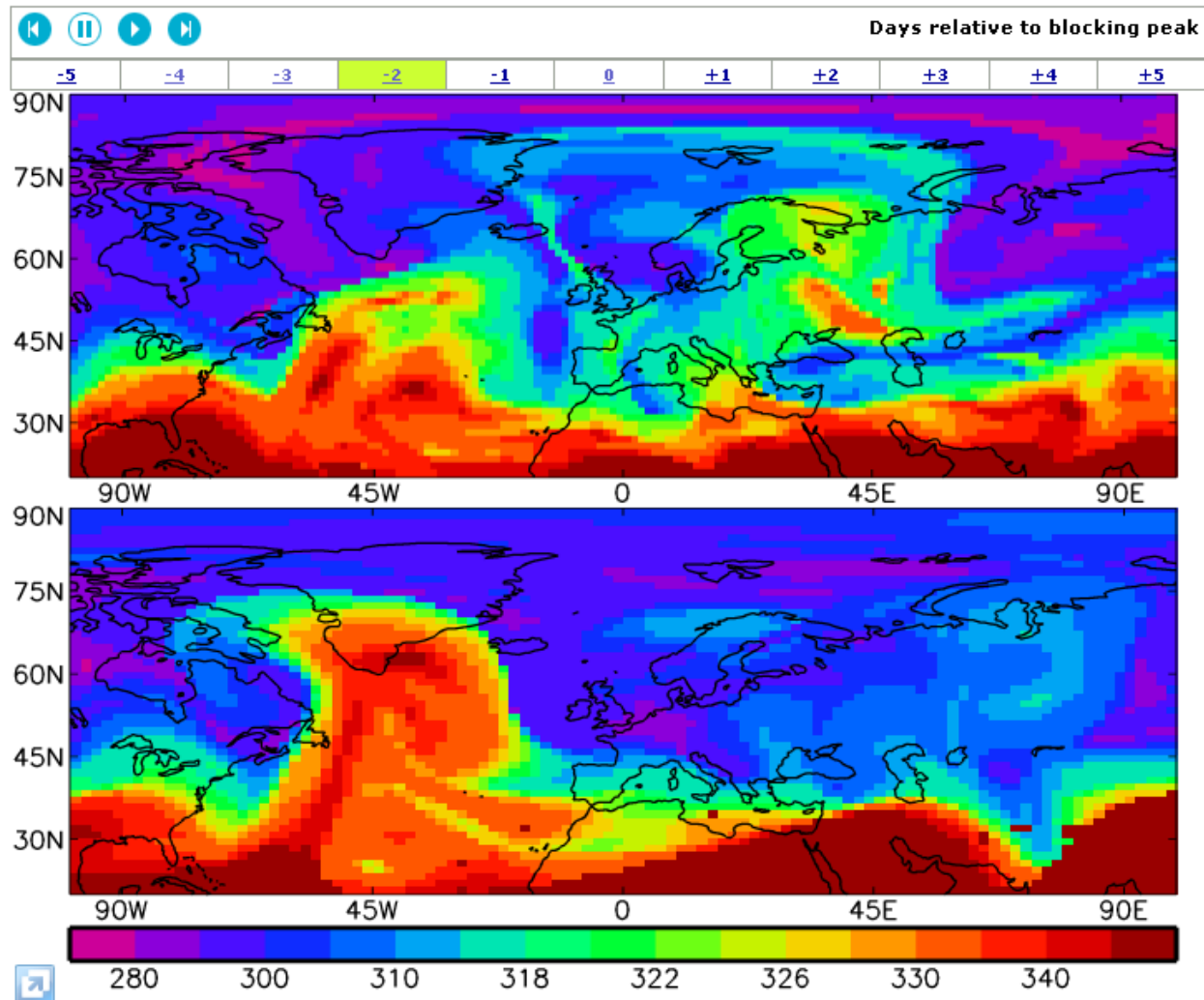
The two panels show the potential temperature on the PV= $\pm 2$  surface, with colours labelled in Kelvin on the colour bar. The top panel shows data from the MERRA reanalysis, with results from the medium resolution model below.



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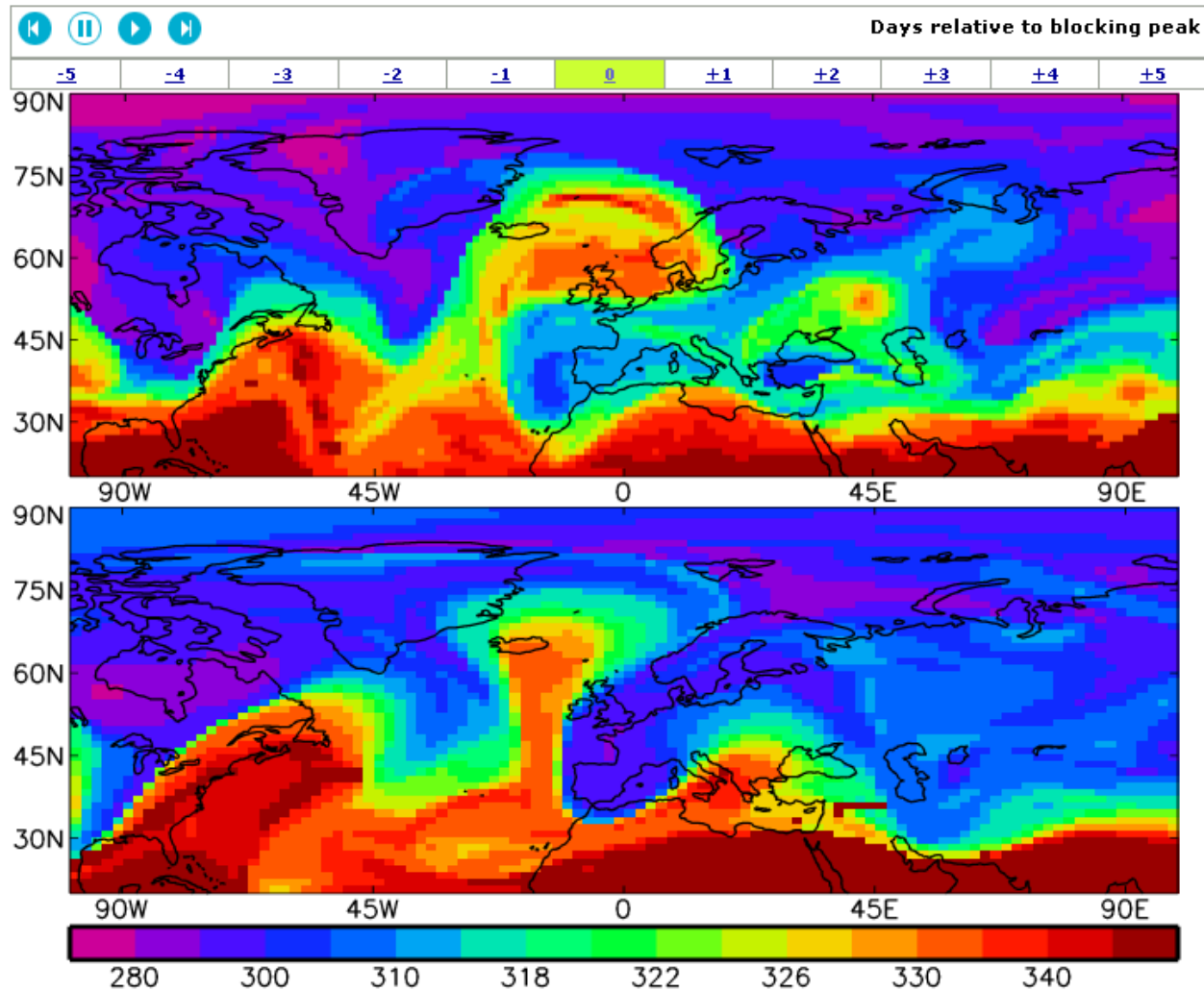




# An example blocking event:

## North Atlantic Blocking

The two panels show the potential temperature on the  $PV=\pm 2$  surface, with colours labelled in Kelvin on the colour bar. The top panel shows data from the MERRA reanalysis, with results from the medium resolution model below.



# Developments at UKMO

**What's in the pipeline?**

**Model Development**

**Potential for Extratropics?**

# Can we improve extratropical forecasts?

Seasonal prediction is a fluid dynamical “jigsaw puzzle”

Key drivers of seasonal climate are being identified by researchers

These suggest useful levels of skill may be possible....

**Sea surface conditions**

Volcanoes

**El Nino**

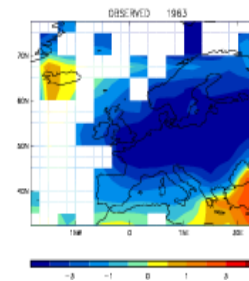
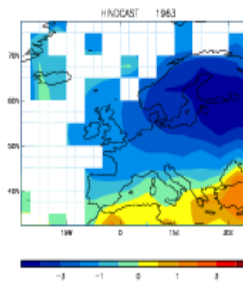
Stratospheric winds

Climate change

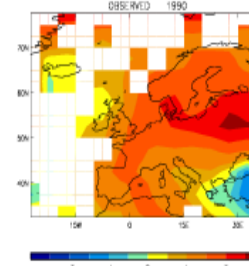
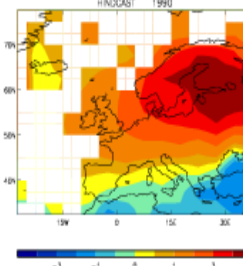
1962/63

Reconstruction

Observations

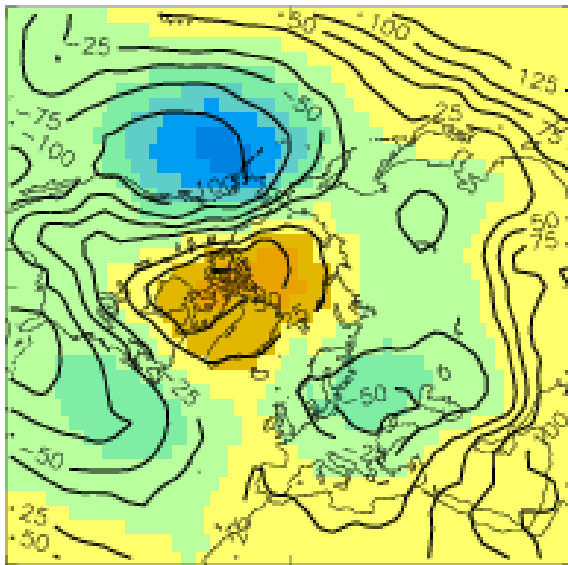


1989/90

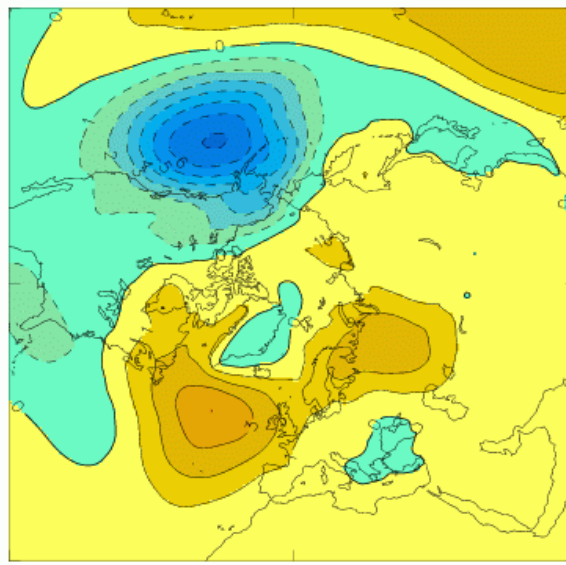


# We are building models that represent these processes:

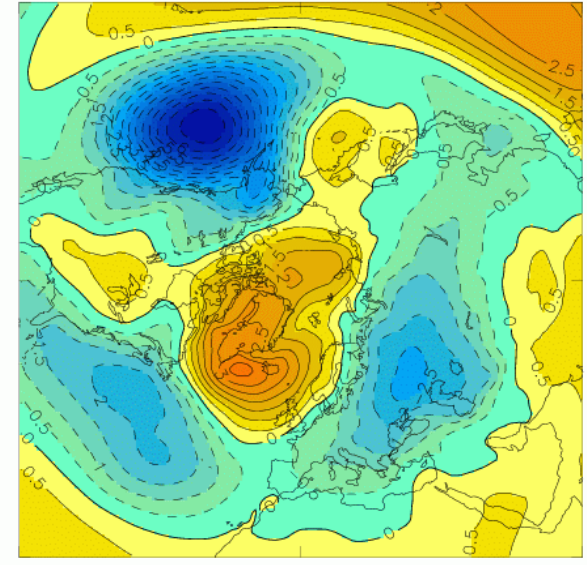
## Observations



## Old Model

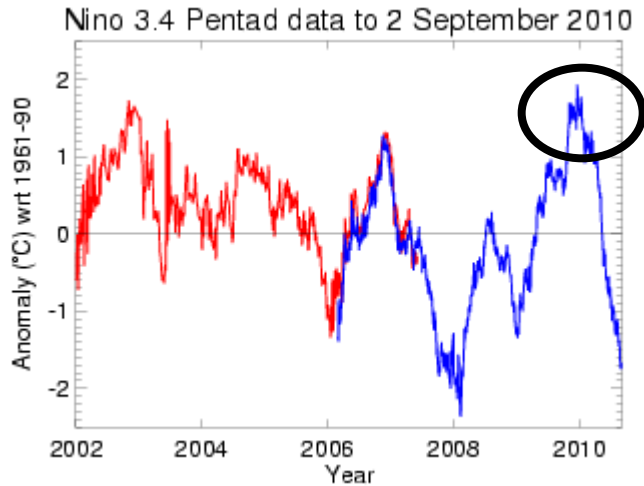


## New Model

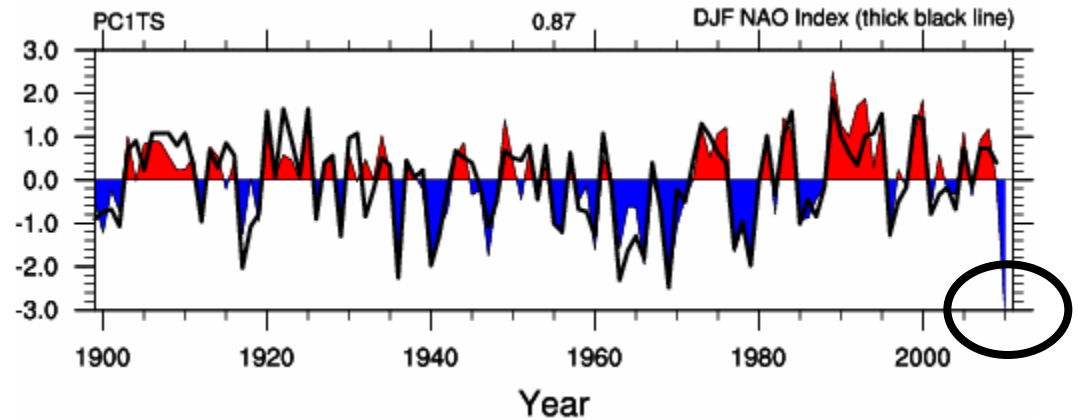


# Winter 2009/10

## El Nino



## N Atlantic Oscillation



**Moderate El Nino and negative Arctic Oscillation**

**Not a coincidence!**

# Winter 2009/10

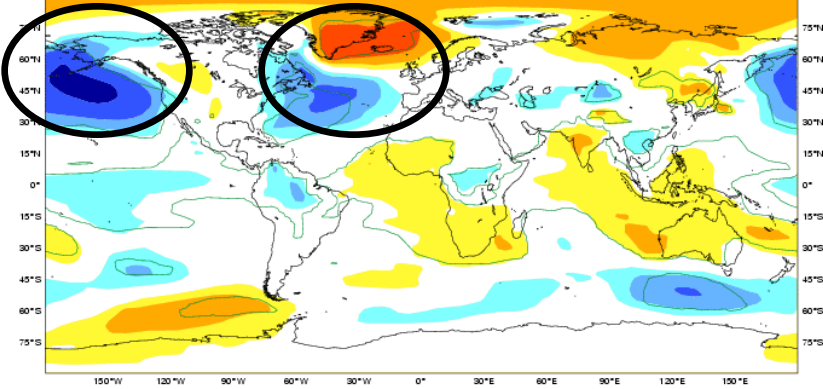
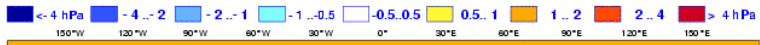
## Seasonal Prediction

System 4

DJF 2009/10

Solid contour at 1% significance level

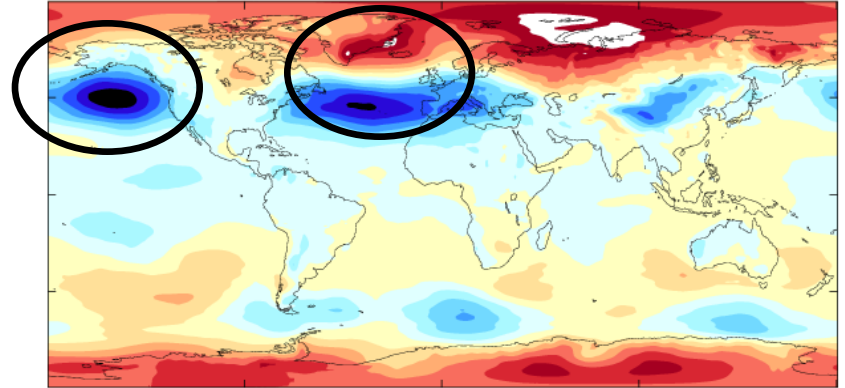
Forecast start reference is 01/11/09  
Ensemble size = 42, climate size = 168



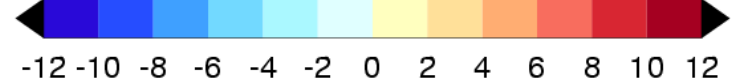
Forecast issue date: 15/11/2009

CECMWF

## Observations



Daily average pressure anomaly (operational analysis wrt 1961-90) December 1st 2009 to February 28



**Negative NAO/AO signal for Winter 2009/10**

**Captured in forecast from early November  
(Sep and Oct forecasts too)**

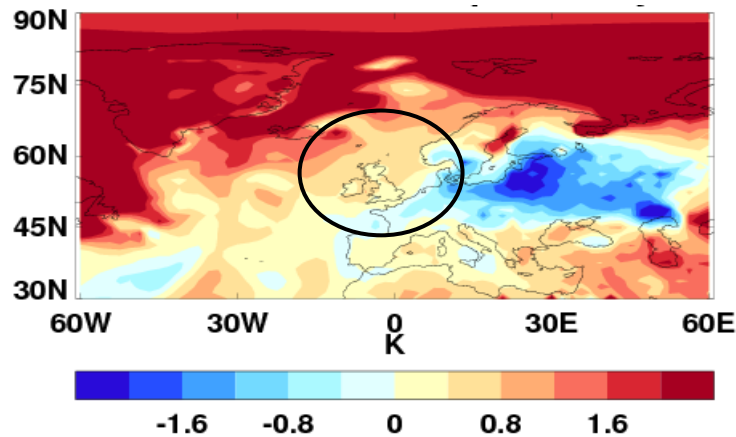


# We are using these new models to improve forecasts:

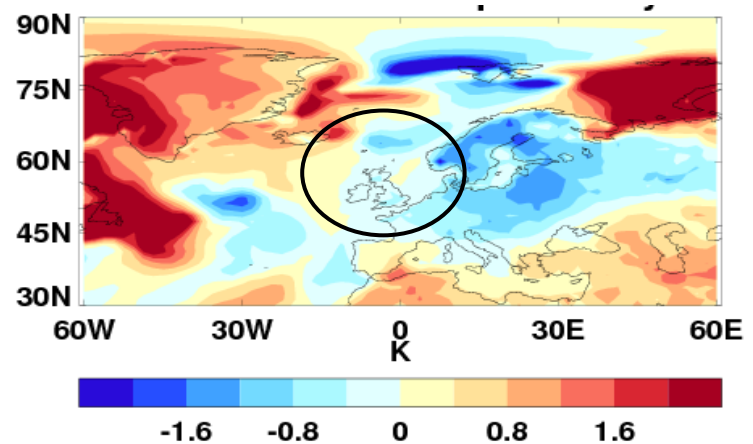
E.g. Winter 2009/10



Old System

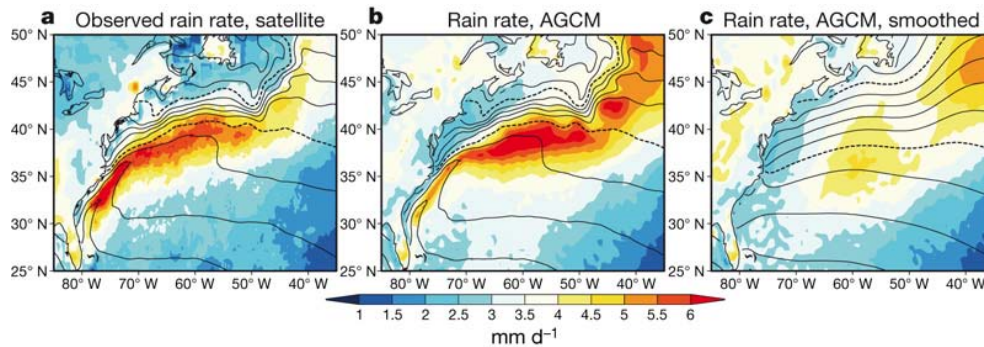


New System



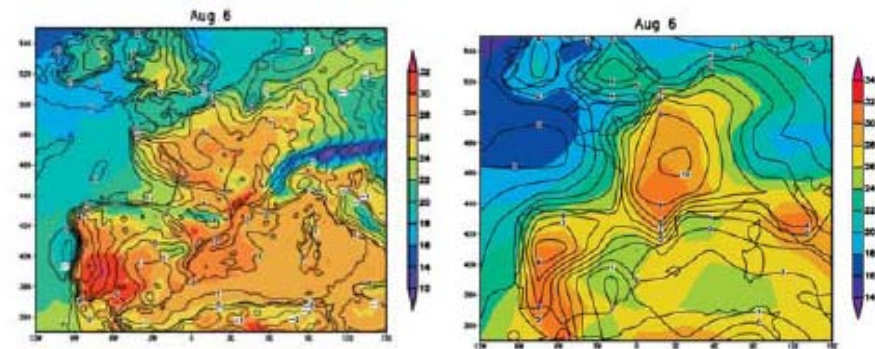
# Ocean-Atmosphere interaction

For seasonal to decadal climate predictions the response to SST is key and this is sensitive to resolution so we are aiming for higher resolution



Response to SST, Minobe et al. 2008

Summer 2003, Nakamura et al., 2005



# Summary

- **WGSIP involved in coordinated experiments on land surface, sea ice and stratosphere and provides hindcast data for research (CHFP)**
- **GloSea4 introduced and now operational at UKMO**
  - Hindcast run in real time
  - Similar or better skill than GloSea3 in most regions
- **Model development is showing some key improvements:**
  - Better ENSO patterns including a lack of westward extension
  - Better Atlantic blocking frequency through reduced mean bias
- **There is more extratropical predictability than we currently have:**
  - Used the Atlantic basin as an example
  - Key drivers with influence on the AO/NAO identified
  - Suggests reasonable levels of skill may be possible