The Abdus Salam
International Centre
for Theoretical Physics

2356-13

Targeted Training Activity: ENSO-Monsoon in the Current and Future Climate

30 July - 10 August, 2012

The Potential for Skill across the range of the Seamless-Weather Climate Prediction Problem

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UNITED KINGDOM

Imperial College London

The University of Reading

The Potential for Skill across the range of the Seamless-Weather Climate Prediction Problem

Brian Hoskins

Grantham Institute for Climate Change, Imperial College London
Department of Meteorology, University of Reading, UK

Grantham Institute for Climate Change

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Outline of talk

1. Introduction
2. The seamless weather - climate prediction problem
   & the basis for prediction
3. Increasing time-scales
   a) 1-day
   b) 1-day – 1 week
   c) 1 week – 1month
   d) 1 month – seasons
   e) 1 year- 1 decade
   f) 1 decade – 1 century
4. Concluding comments

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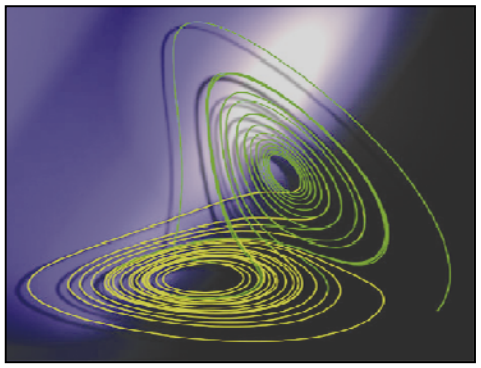
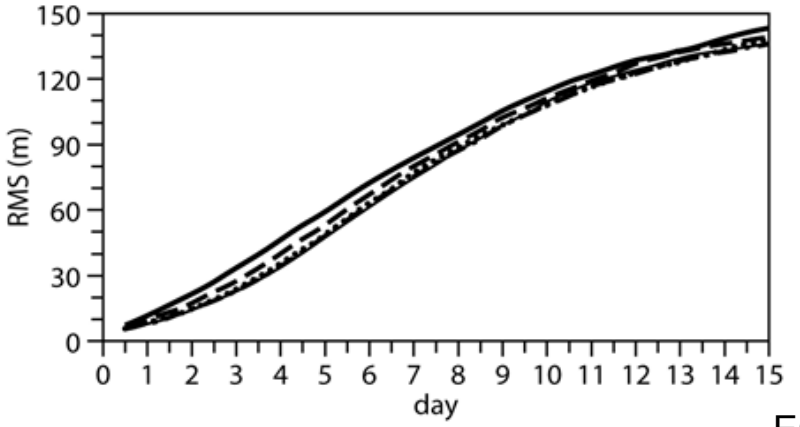
Introduction



Lorenz model: chaos
sensitivity to initial conditions

Up-scale cascade and error doubling time ~ 1-2 days

Forecast error



ECMWF

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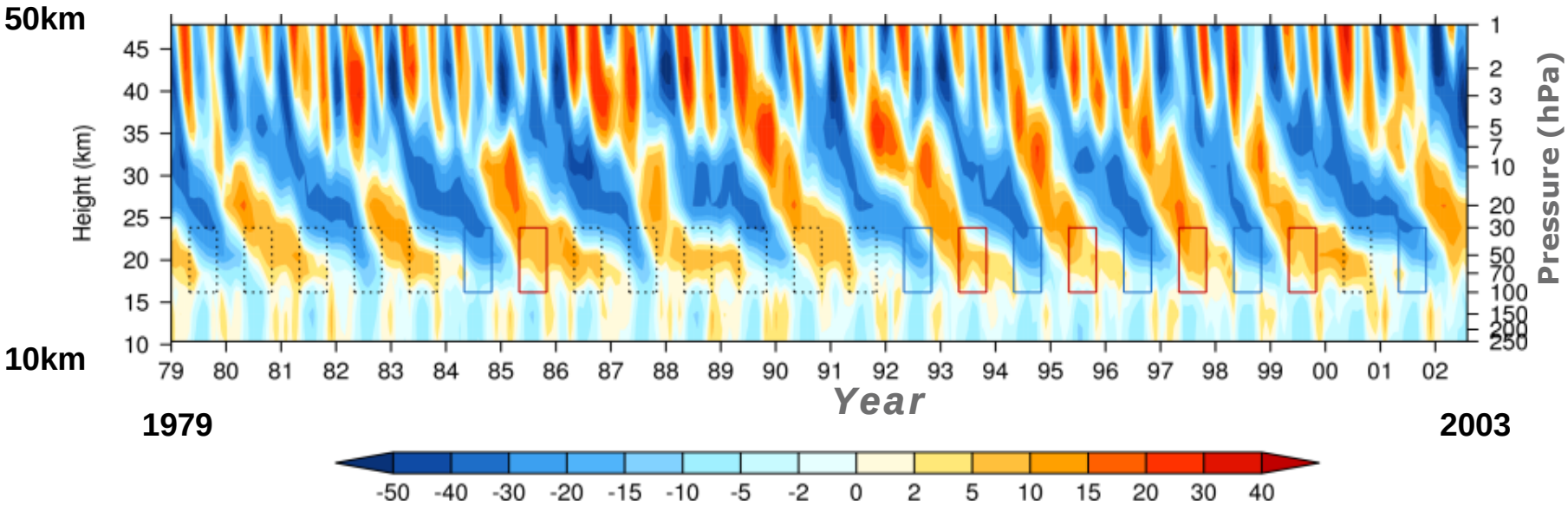
Dynamics can lead to predictable behaviour

The Quasi-Biennial Oscillation in the equatorial stratosphere



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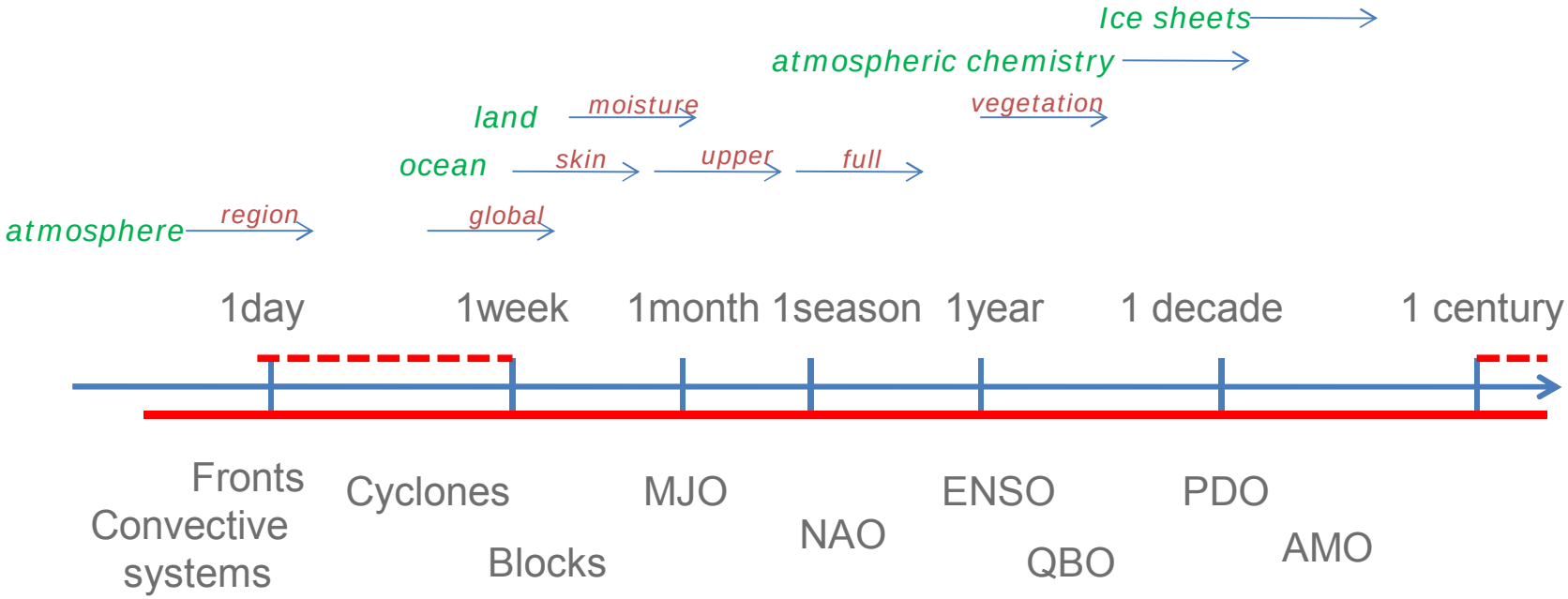
The Seamless Weather-Climate Prediction Problem



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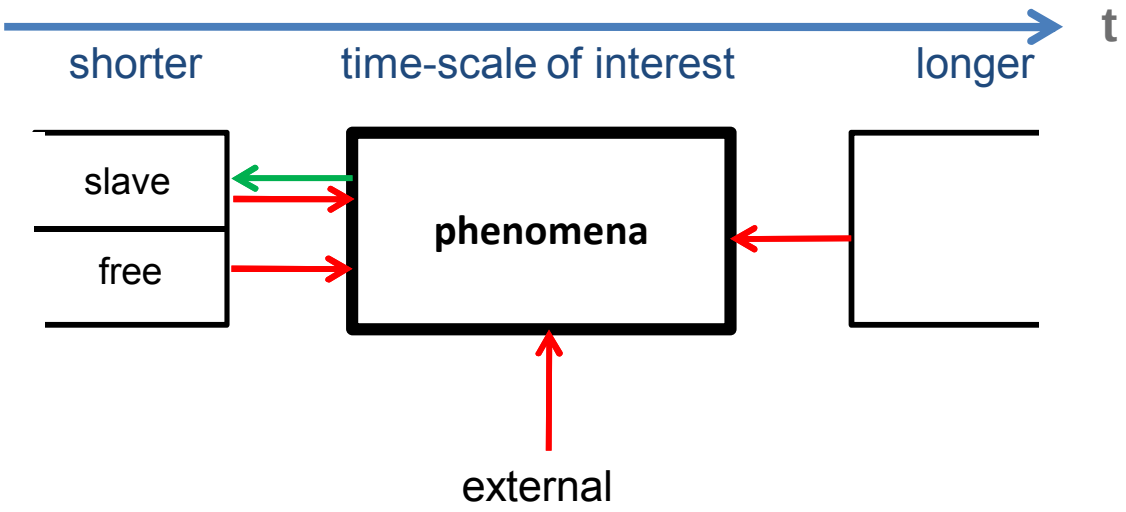
The Prediction Problem



•Observations → initial conditions
•Ensembles (many runs of the forecast model) → probability information
•Phenomena → potential predictability

•Noise or music?

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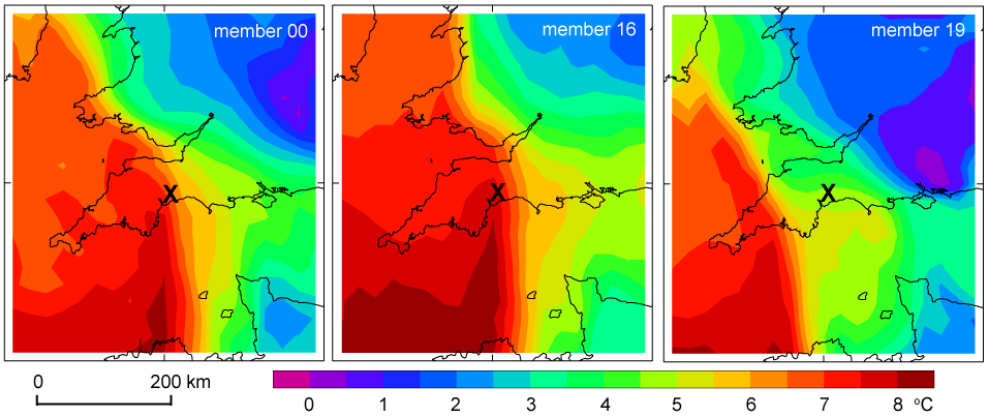
Day 1: Hindcasts for an extreme precipitation event

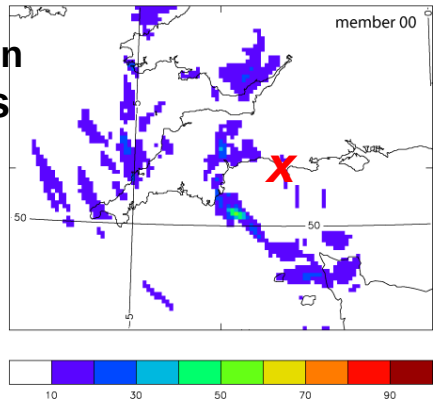
UK MetO 12km ensemble members & embedded 1.5km model

N Roberts 2011

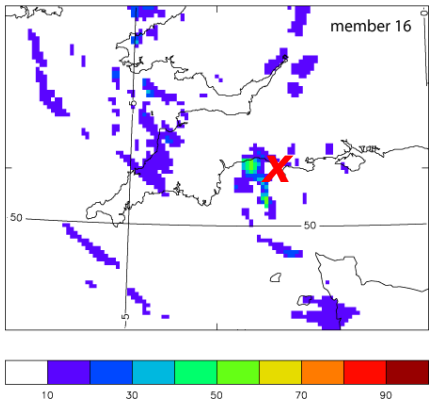
12km model T



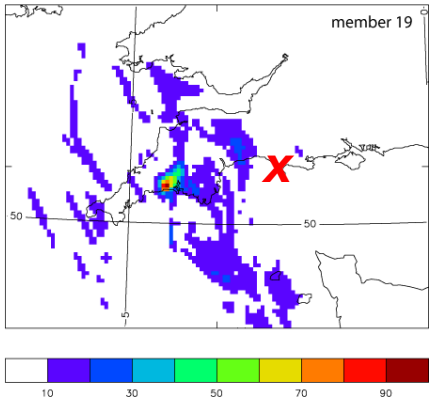
1.5km model 6h precipitation accumulations



55 mm



55 mm



96 mm

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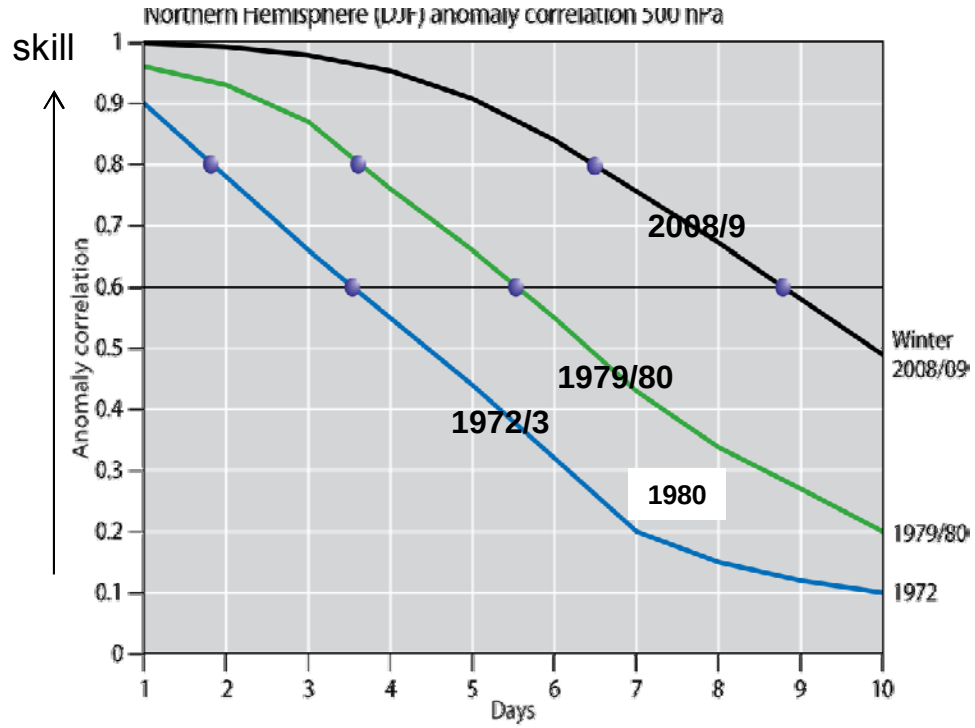
Week 1: Increasing forecast skill

ECMWF

NH winter 500Z anomaly correlation



Day of forecast

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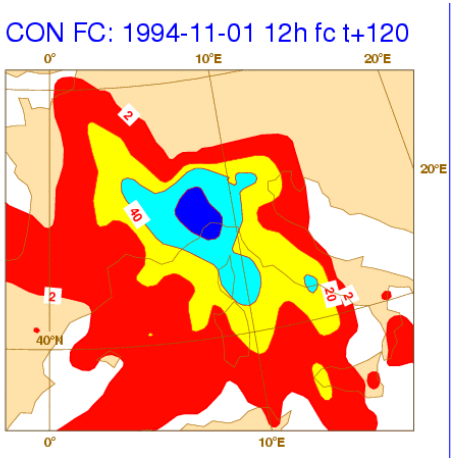
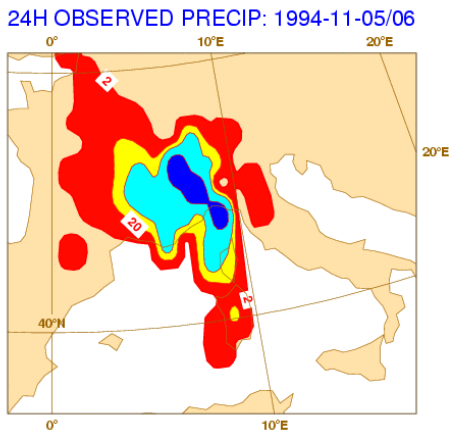
Forecasts for an extreme flood event 5-days ahead

ECMWF

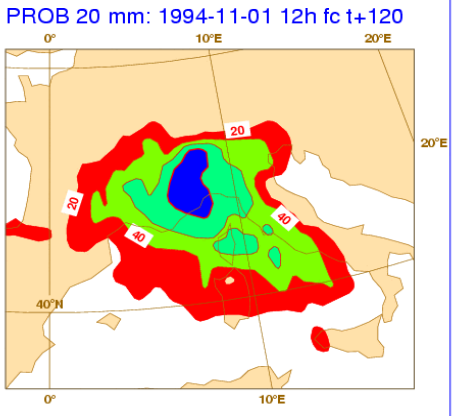
Forecast 24 h precip from 5 days before

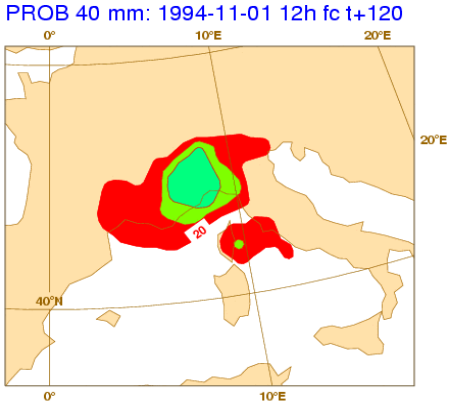




Observed 24h precip 5/6 June 1994

Probability of more than 20mm





Probability of more than 40mm

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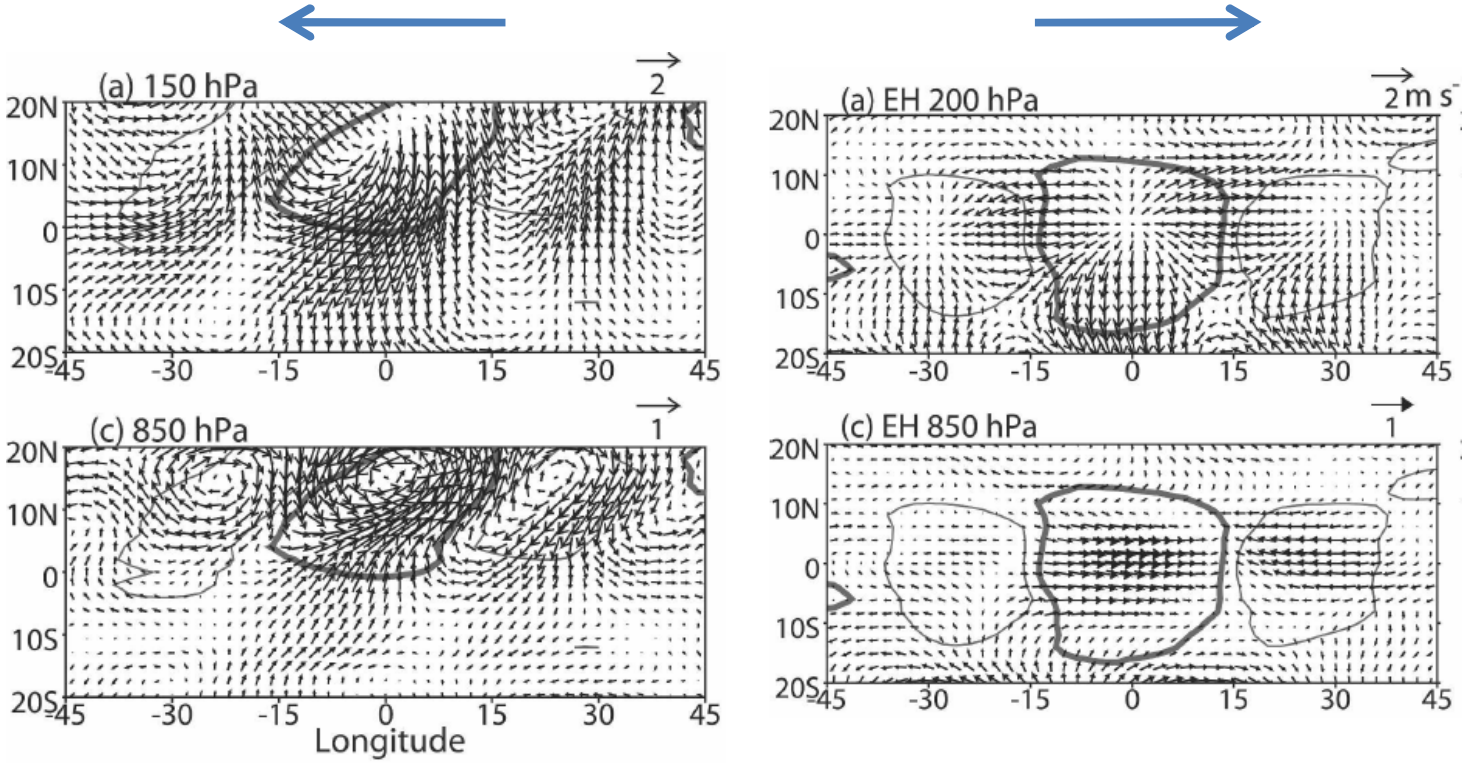
Possibility of enhanced synoptic predictive power in the tropics

Convectively couple equatorial waves in analyses



Potential predictability in the tropics on 1-7 days

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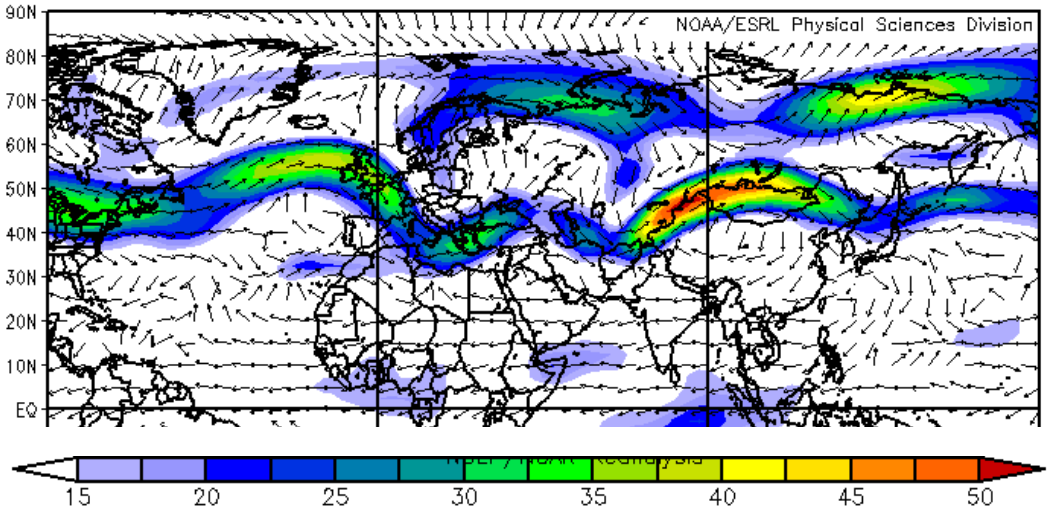
Russian heat wave & Pakistan floods summer 2010

250hPa winds 24-30 July



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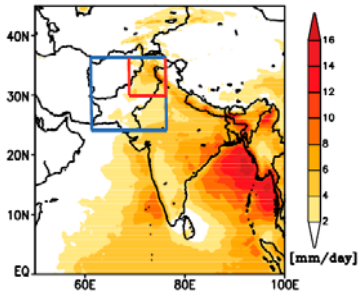
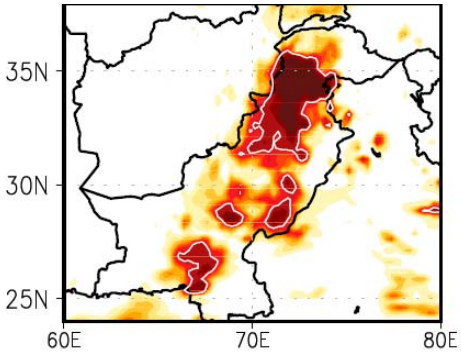
Forecasts for Pakistan floods of 2010

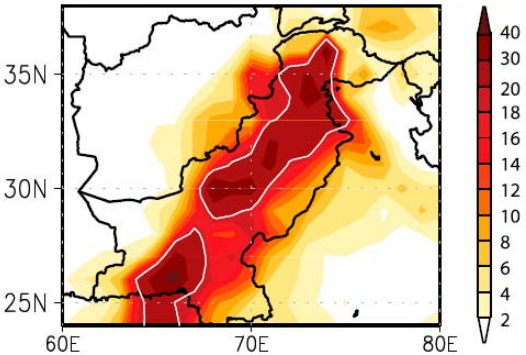
ECMWF

Rainfall 28 & 29 July : Observed

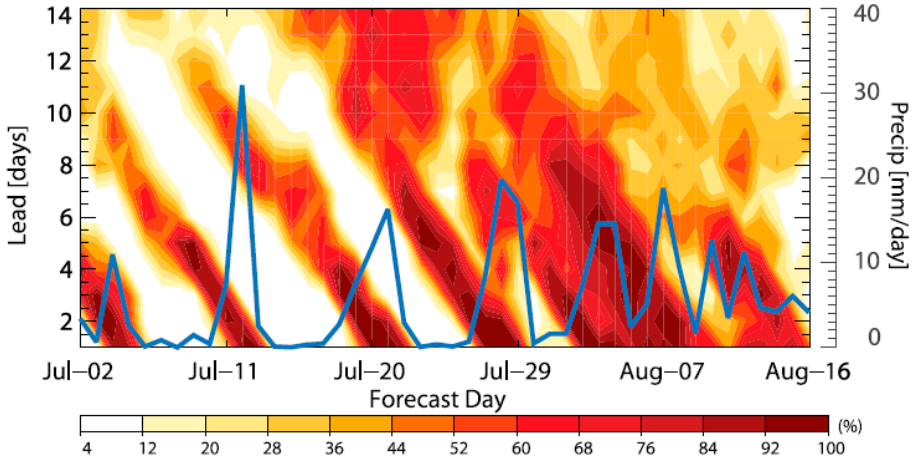




4-day forecast



Forecast lead time



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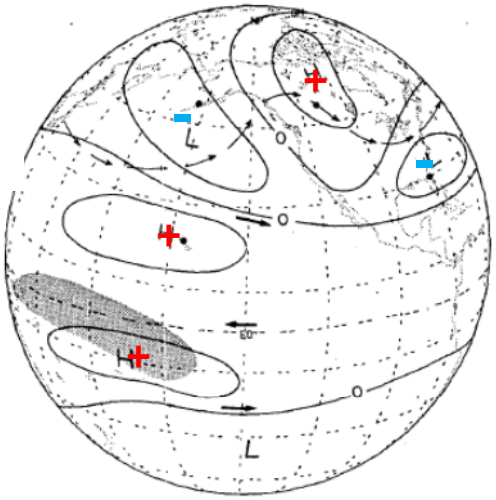
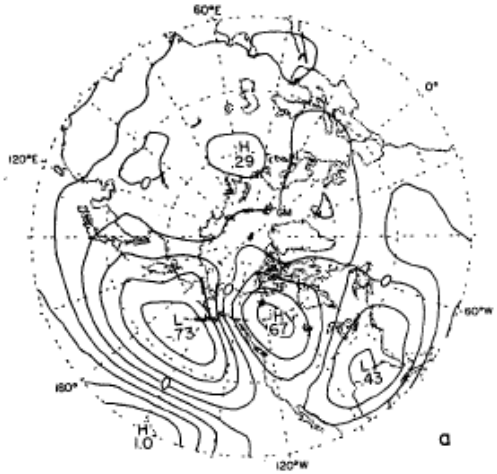
One mechanism leading to predictable behaviour: Forcing and propagation of Rossby waves

Observations

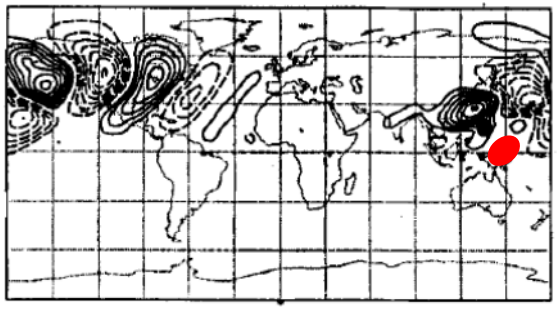
Horel & Wallace 1981



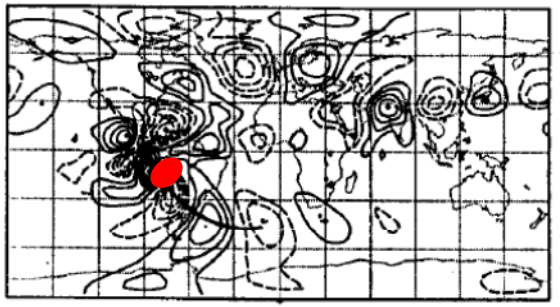
Wallace & Gutzler 1981



Theoretical model
3-D basic state
Heating on at t=0



After 9 days



After 9 days

Ambrizzi & Hoskins 1997

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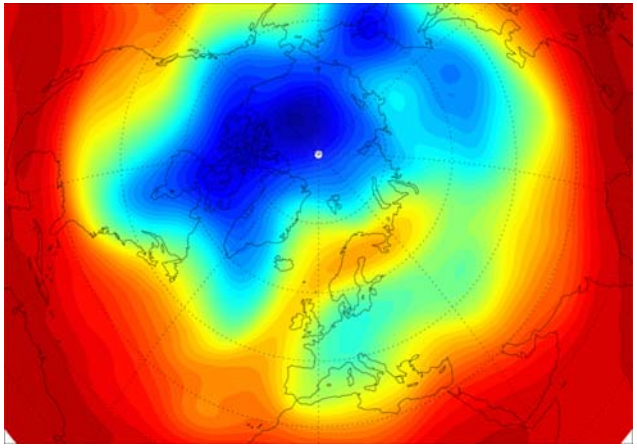
Blocking

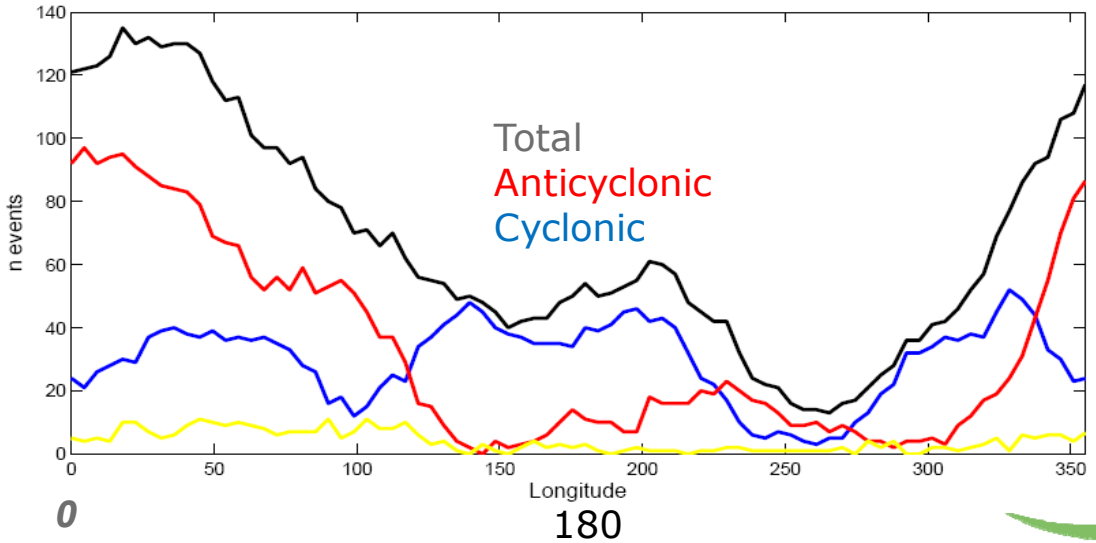
A Typical European Block: 20 November 1993



Z on 250 hPa

Tyrlis & Hoskins 2008

NH Winter blocking climatology



Masato et al 2011

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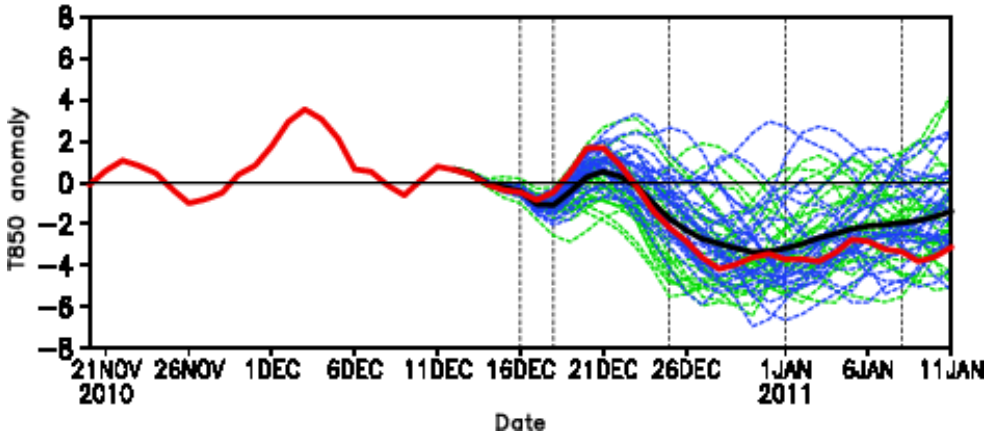
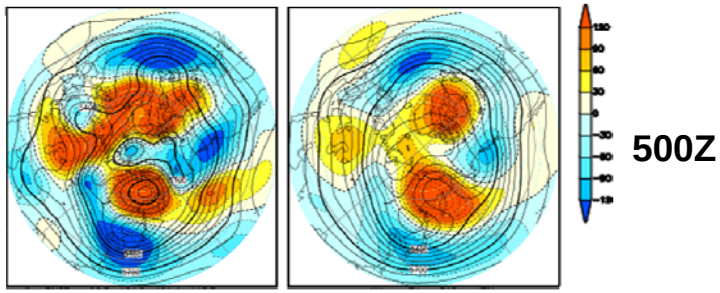
1week- 1month: Cold Event in Western Japan 2010/11

JMA

850 T (Western Japan)
Forecasts from 16 Dec



Analysis
Ensemble mean
Esbl members (1 day)
Esbl members (2 day)



500Z

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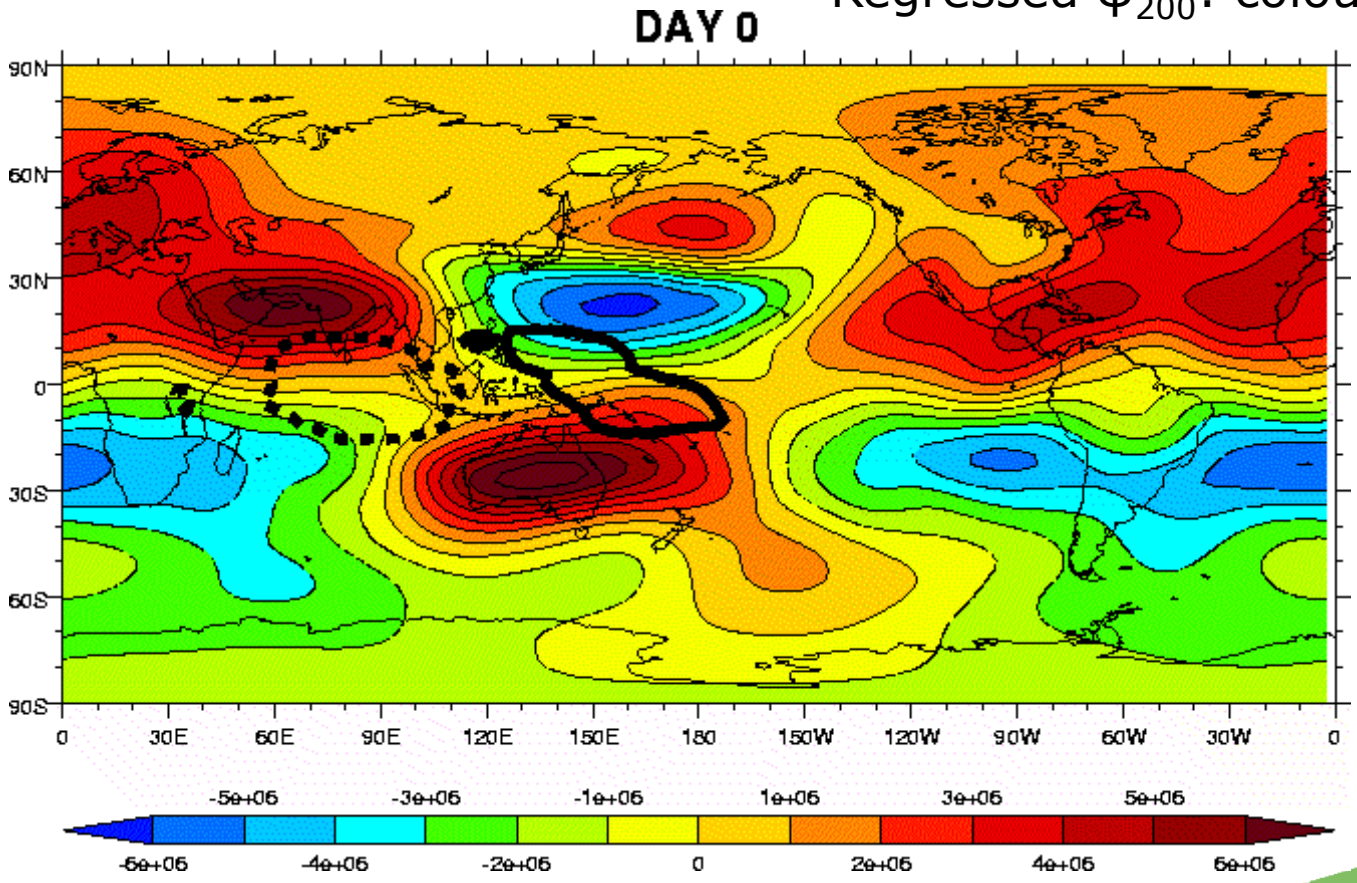
DJF global circulation anomalies associated with an MJO cycle

Matthews et al 2004

45-day cycle from 2 EOFs of 20-200 day filtered OLR: heavy contours

Regressed ψ_{200}: colours



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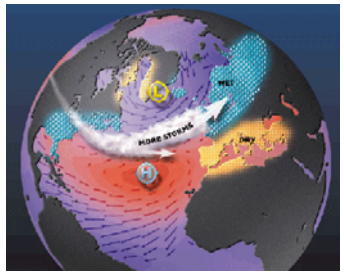
1 month – seasons: North Atlantic Oscillation Northern Annular Mode

+



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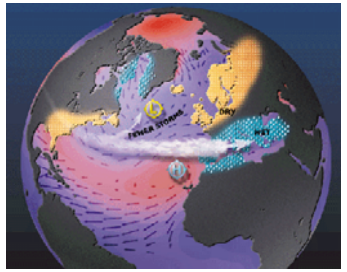
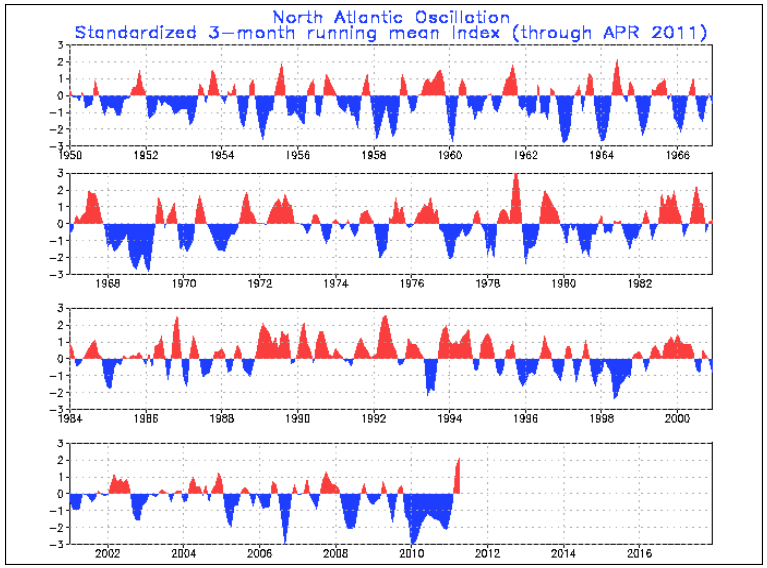
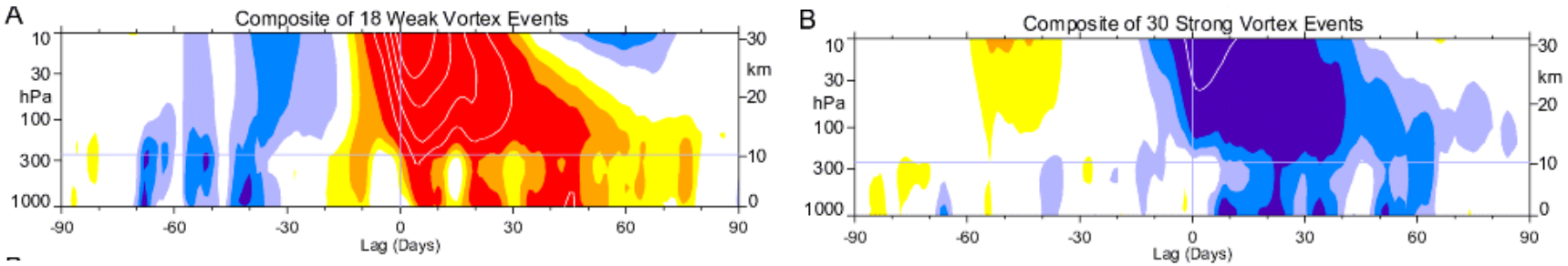


3-month running mean of NAO index 1950-date



The stratospheric connection



Baldwin & Dunkerton 2001

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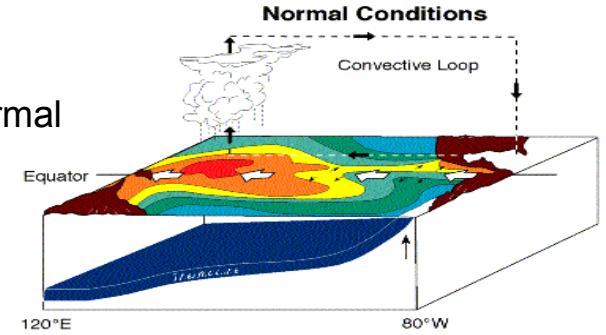
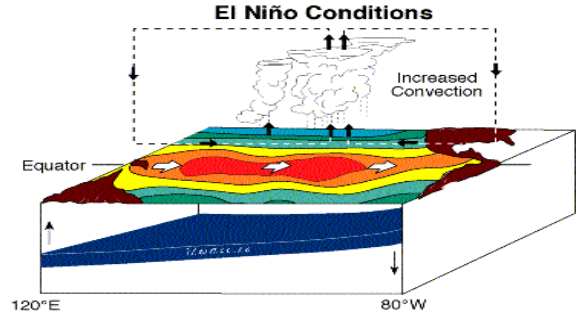
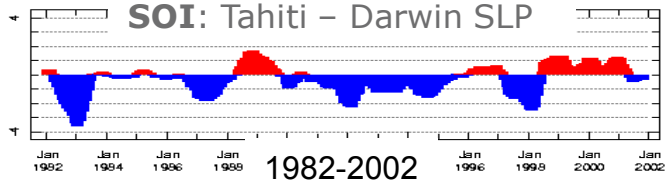
El Niño- Southern Oscillation (ENSO)

Normal

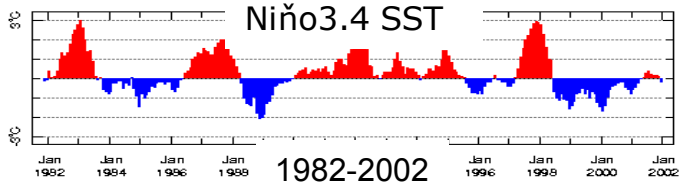




El Niño

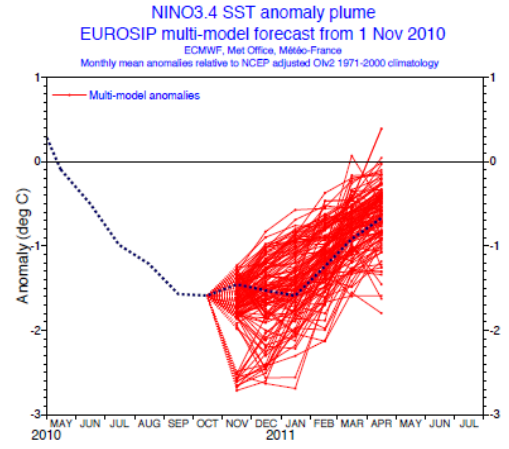


1982-2002

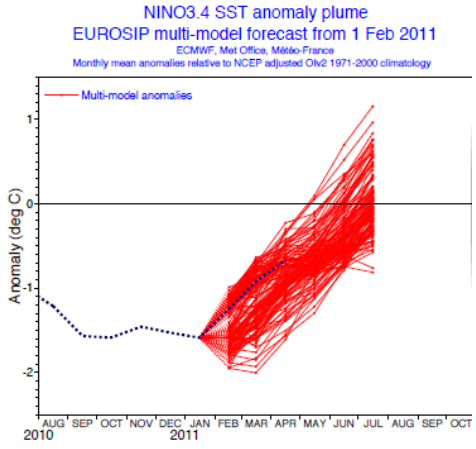


1982-2002

EUROSIP Niño3.4 plumes



1 November



1 February

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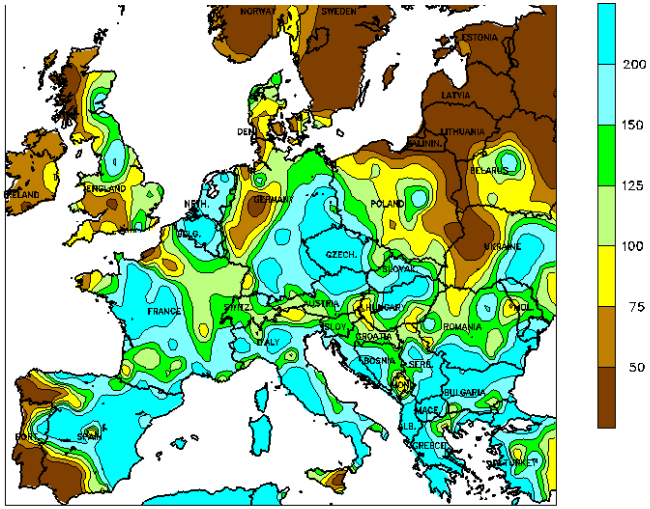
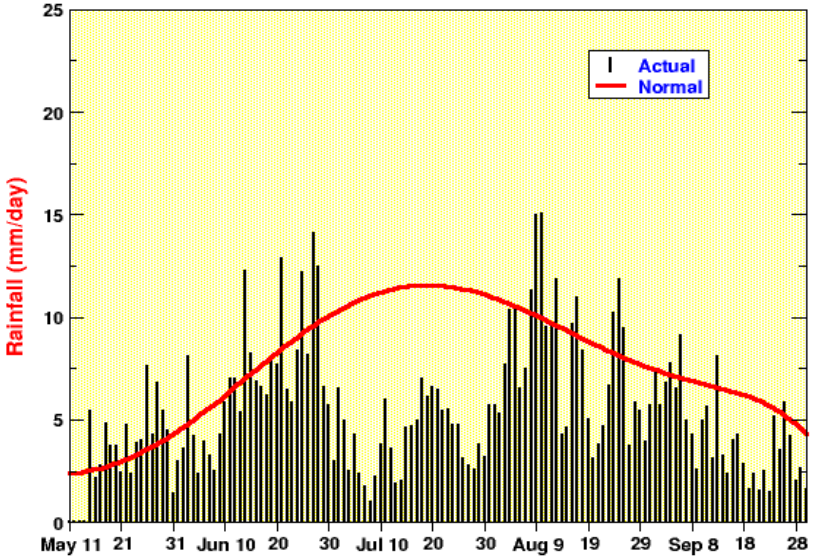
Summer 2002

Flooding in Central Europe



Blackburn & Hoskins 2006

Drought in India



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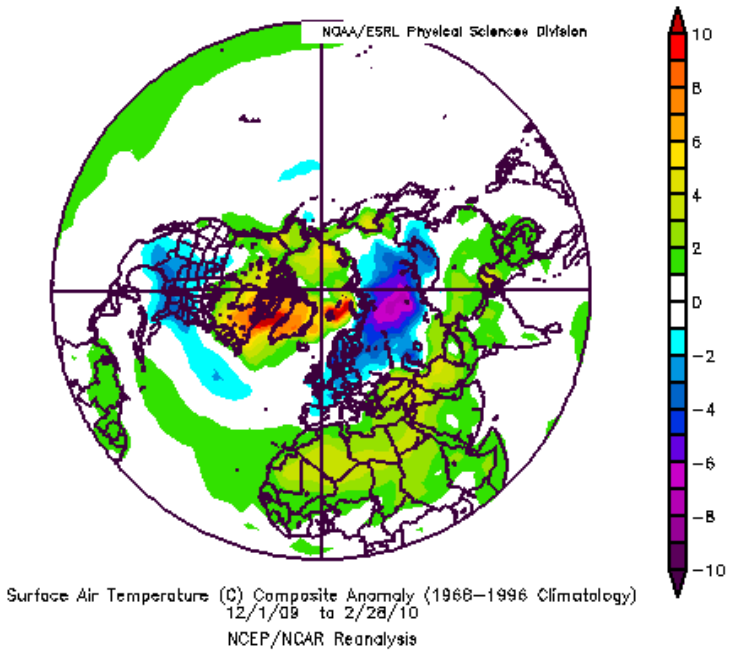
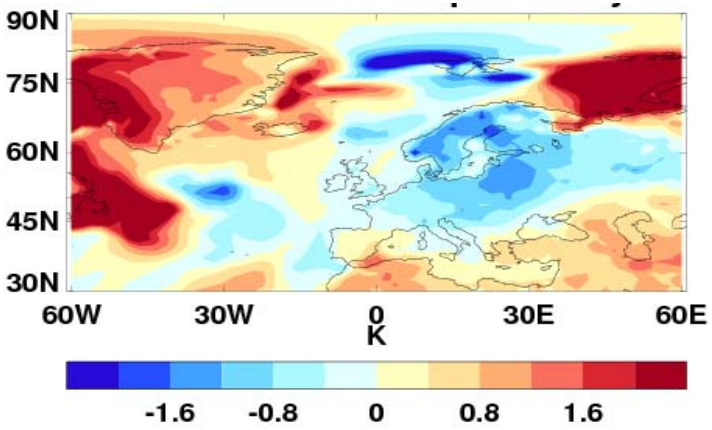
Northern Hemisphere Winter 2009/10

Observed T anomalies



MetO hindcast



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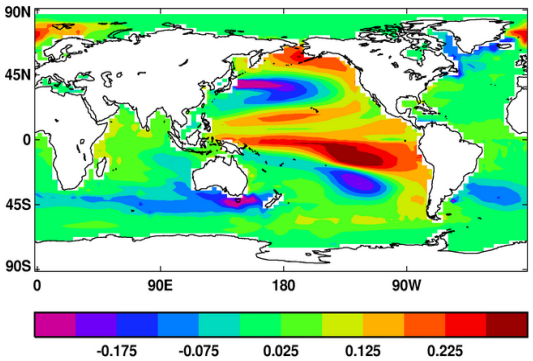
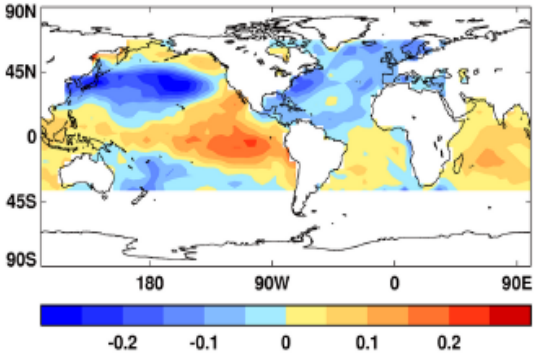
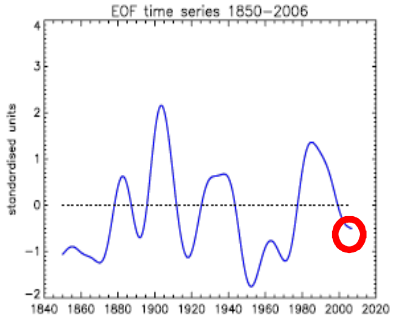
Natural decadal variability in models & observations

Model | **Observation**

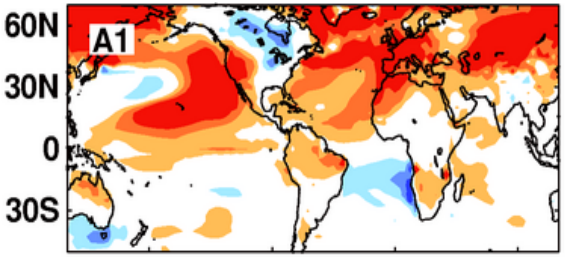
Pacific Decadal Oscillation

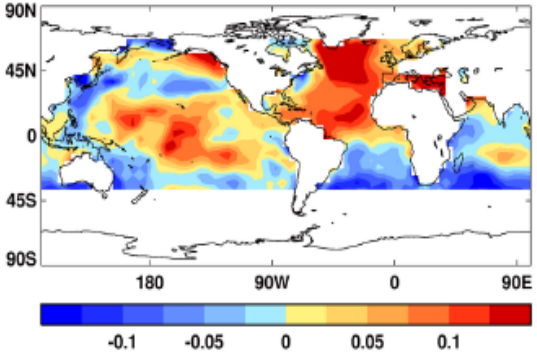


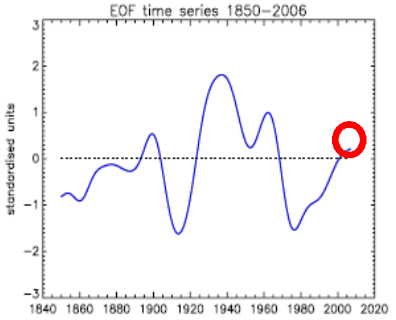




Atlantic Multidecadal Oscillation







Knight et al 2005, Parker et al 2007

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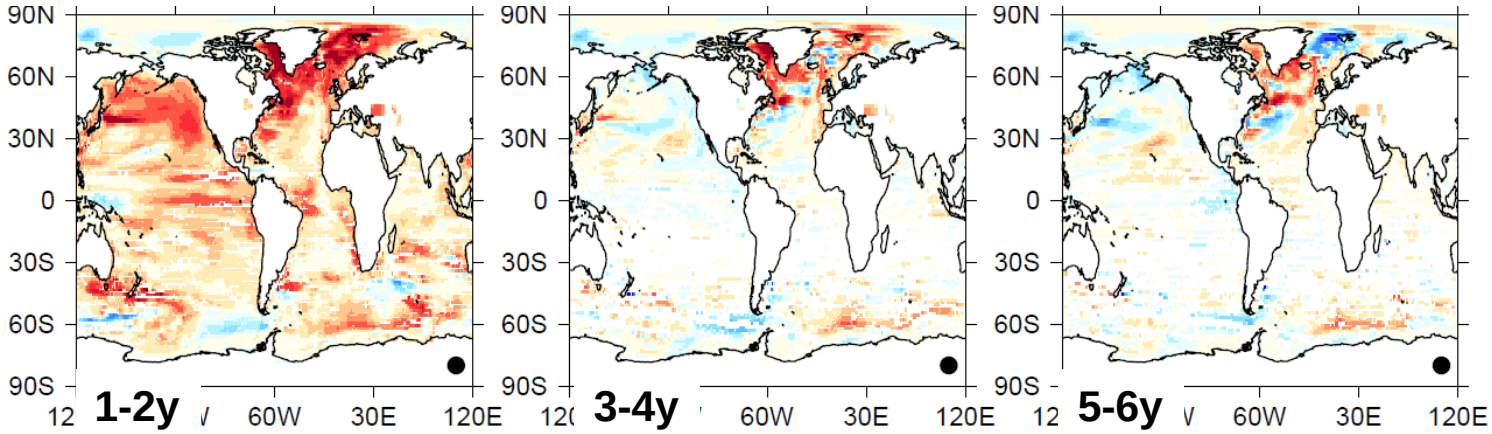
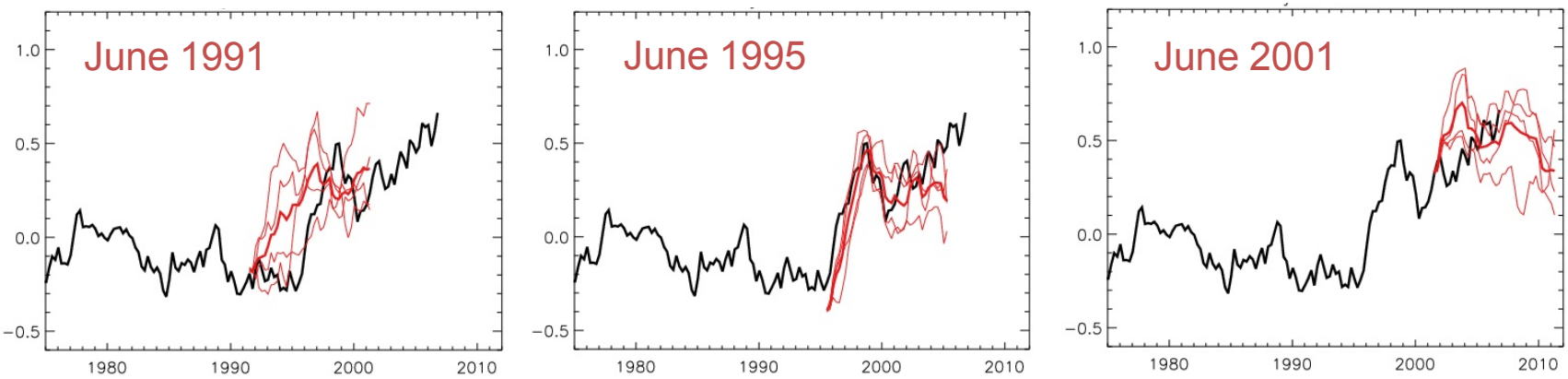
Skill on 1-10 year time-scale

UK JWCRP

Heat in top 100m ocean: Improvement in Skill from initialisation



Hindcast predictions of 500m heat content in Atlantic subpolar gyre



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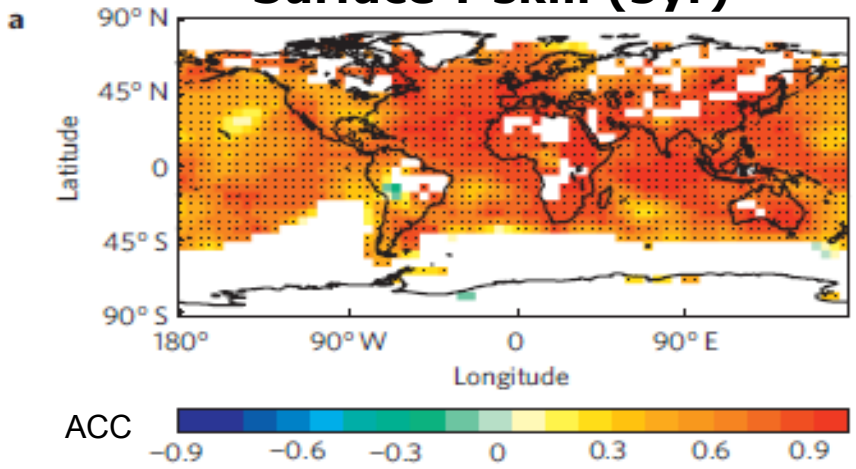
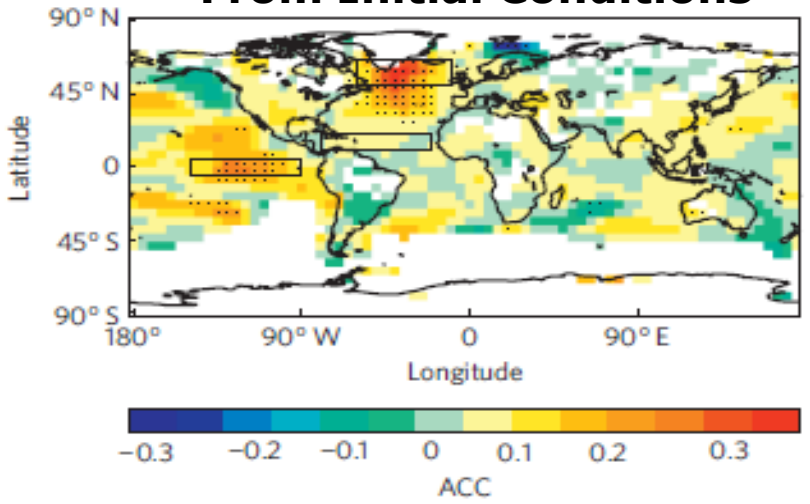
Skill in Surface temperature and Atlantic tropical cyclone numbers

Smith et al. 2010

Surface T skill (5yr)

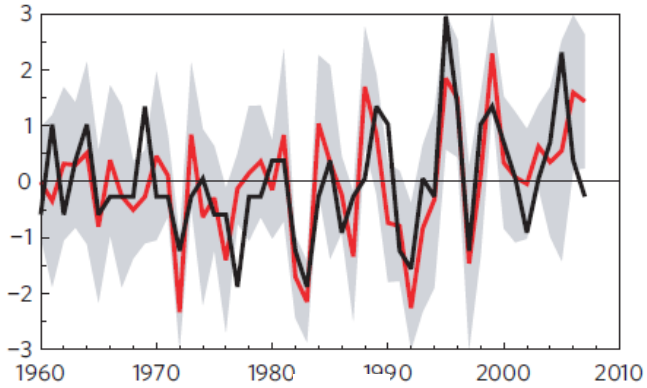


From Initial Conditions



From GHGs, volcanoes, ozone…

Numbers of storms (normalised)



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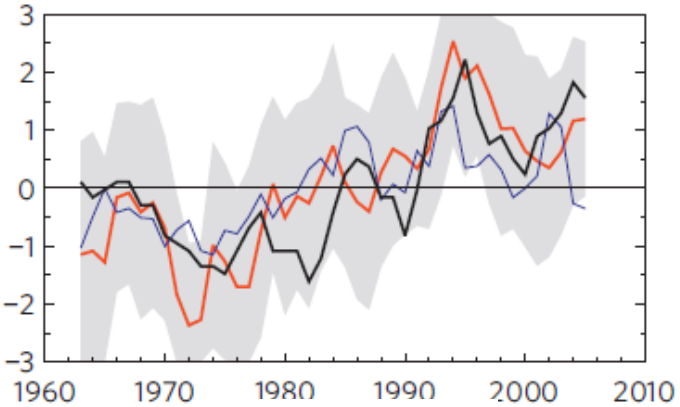

5y average

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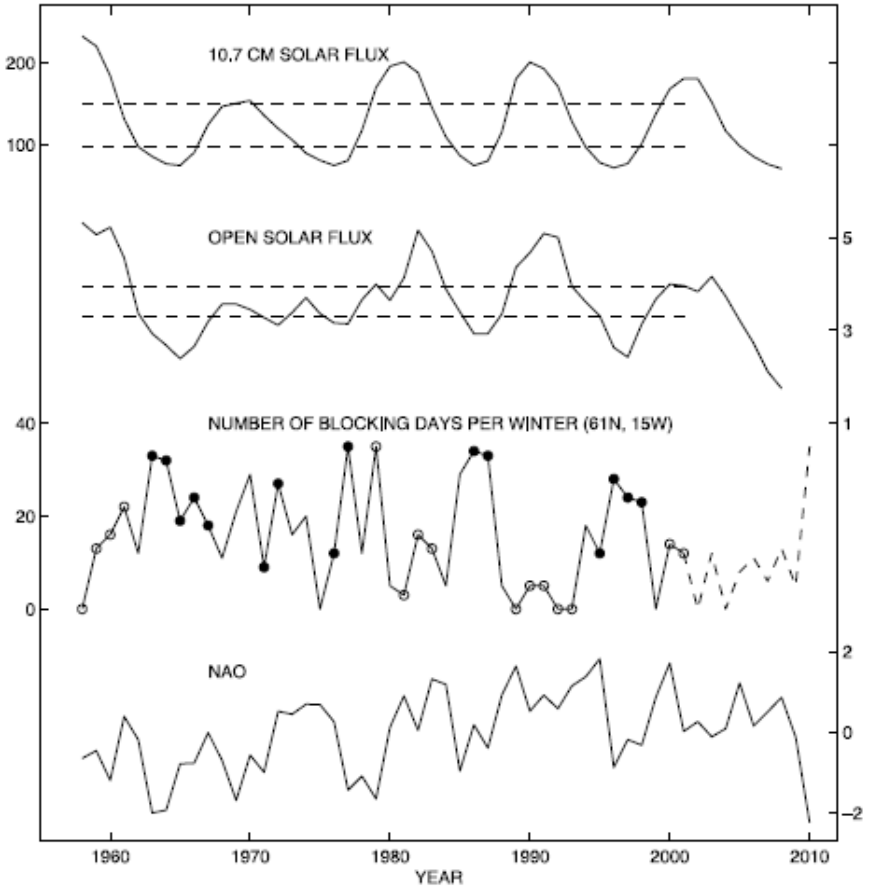
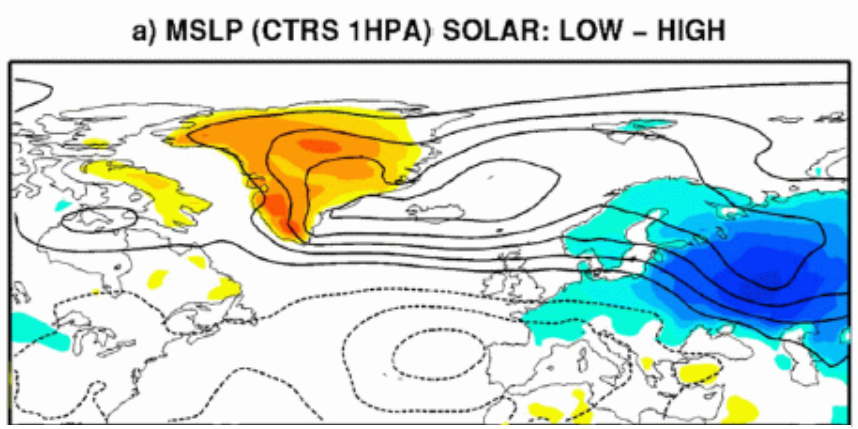
Solar variability & European winter climate

Observation

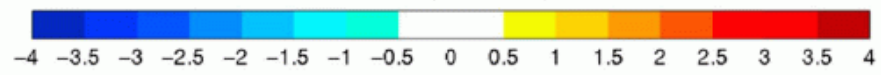
Woollings et al. 2010

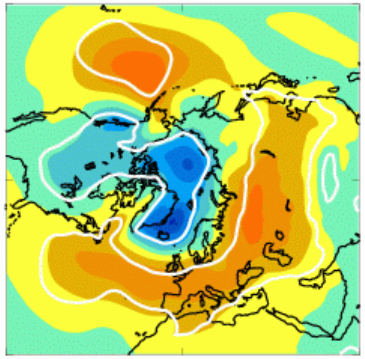


Lockwood et al. 2010



Composite low minus high solar activity





MetO model
2m T

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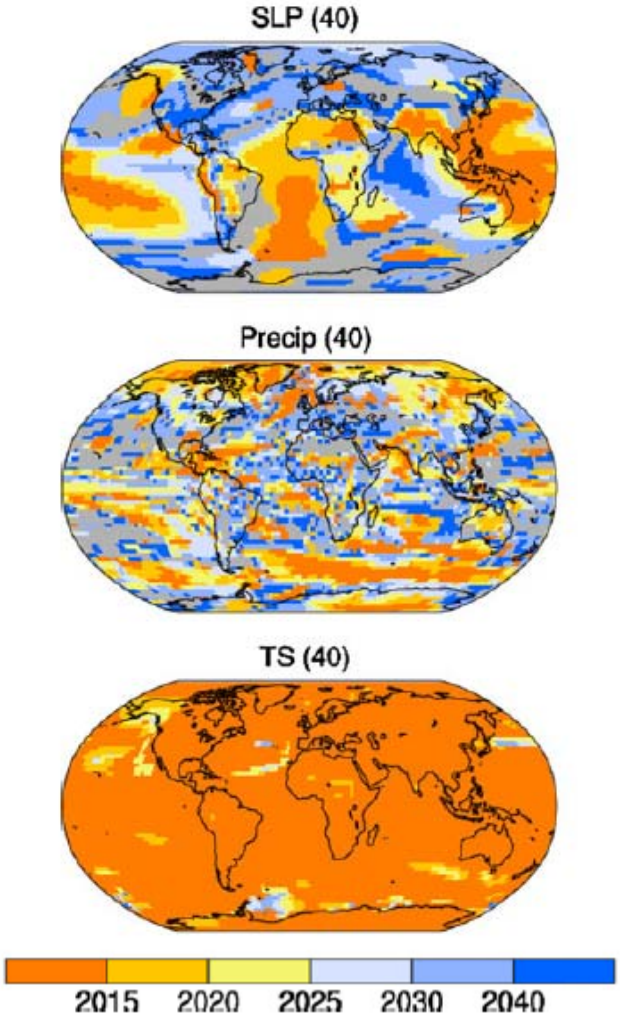
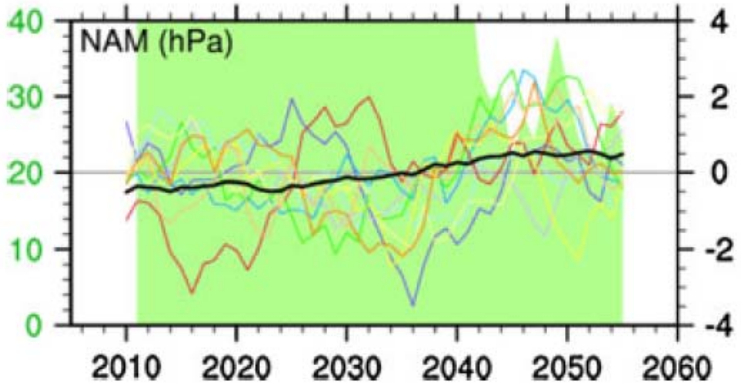
Climate "noise" will tend to obscure the climate change signal



40 runs of climate model: year at which climate change signal emerges

NAM in runs



Deser et al 2010

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Concluding Comments

The Potential for Skill across the range of the Seamless-Weather Climate Prediction Problem – a Stimulus for our Science

- On all time-scales natural phenomena and external conditions give promise of some possible predictability
- The extent to which the possible skill on various time-scales may be useful is not yet clear
- We need to observe, model and understand to realise the potential skill
- We need to learn to recognise how much music there is in what may seem like noise!

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