Challenges and Progress in Sub-Seasonal to Decadal Prediction on Regional Scales

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WCRP Open Science Conference 2011
Why monthly to decadal prediction?

Climate varies a lot and this can greatly amplify or oppose any trend:

- Tropical Floods during 2010/11
- Russian heatwave 2010
- African Drought 2011
- Recent Cold European and US winters
If weather forecasts are poor after a few days how can we hope to do this?

**OPTIONS:**

- **Initial values only:** weather forecasts: an accurate measure of the weather today is enough to predict the weather tomorrow

- **Boundary values only:** climate projections: the future level of greenhouse gases constrains the statistics of weather

- **Initial AND Boundary values:** climate predictions for months or years ahead

But we need ALL the processes to be well represented if we are to maximise skill or accurately estimate predictability…
Forecast Capability

Monthly
Seasonal
Decadal

Future Developments

Improved Models
Boundary Conditions
Monthly Predictability

Monthly timescale predictability highest in tropics

For extratropics MJO and SSWs => Conditional Forecast Skill

(Kumar et al, Clim. Dyn., 2011)


(Kuroda, GRL, 2008)
El Niño-Southern Oscillation: a cornerstone of seasonal prediction

Seasonal Forecast Skill

Interannual Forecast Skill

Arribas et al., MWR, 2011

Luo et al., J. Clim., 2008

ENSO peaks in winter

Remarkable predictability months ahead, some skill further ahead

Remote effects?
ENSO effects on rainfall

Skilful forecast signals in the tropics – even for rainfall
e.g. Australia…
ENSÖ and Australian Floods (c.f. 1973/4)

Very wet signals for NE Australia due to La Niña

Increased risk predicted several months in advance

Potential for adaptation

Flooding at Toowoomba, Australia, 2011
BUT...long range predictability of the extratropics is often low:

Seasonal Predictions of the NAO in UKMO system (Arribas et al., 2011, MWR)

Seasonal Predictions of the AO in JMA system (Maeda, 2011, JMA)
Multimodel Forecast from the WMO Lead Centre for Winter 2010

Blocked Atlantic flow predicted in early winter (12 GPCs)
Good match with observations
Window of opportunity?
Winter 2010

Sea level pressure forecast for NDJ: issued early Oct 2010

UK Government advised from October:

Coldest UK December for more than 100 years

<table>
<thead>
<tr>
<th>Probability</th>
<th>Temperature</th>
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<tbody>
<tr>
<td>45%</td>
<td>Cold</td>
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<tr>
<td>30%</td>
<td>Near average</td>
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<tr>
<td>25%</td>
<td>Mild</td>
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Extreme Events: Atlantic Hurricanes

Tropical cyclone numbers can be predicted months ahead
Last year’s *real time* forecast: Well above average vs 19 Observed

Predictability several years ahead
Originates in the North Atlantic
(Doug Smith's talk on Monday)

Smith et al., *Nat. Geosci.*, 2010
Decadal Forecast Skill

Decadal predictability from boundary conditions (GHGs, aerosols, ozone etc)

Additional decadal predictability from initial conditions (North Atlantic and Equatorial Pacific)

Global Temperature from Year to Year

Forecast for 2010: “it is more likely than not that 2010 will be the warmest year in the instrumental record”
Issued Dec 2009

Forecast for 2011: “unlikely to be a record year…”
Issued Dec 2010

1 yr lead time: correlation ~0.7

Forecast for 2010: “it is more likely than not that 2010 will be the warmest year in the instrumental record”
Issued Dec 2009

<table>
<thead>
<tr>
<th>Rank</th>
<th>HadCRUT3</th>
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<th>NASA GISS</th>
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<td>2009</td>
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<td>2006</td>
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Extreme Events: Hot Summer Days

If we can predict the mean climate shift maybe we can predict extremes?

Predicting number of hot summer days for the coming 5 summers

Skilful over continental scales using 1960-2003 data

Same skill as shifting distribution

Hamilton et al, JGR, submitted
Sources of Forecast Error

- **Initial Conditions**
  - Obs
  - Analysis

- **Forecast System**
  - Model
  - Ensembles
  - Hcast

- **Boundary Conditions**
  - GHGs
  - Aerosol
  - Solar

Could perturb models but need model improvements
Ocean Biases and Blocking Errors

Current Model

New Model

Gulf Stream Bias
Wly wind bias
=> Blocking Deficit

No Gulf Stream Bias
No Wly wind bias
=> Good Blocking

Scaife et al., Geophys. Res. Lett., submitted. – see also poster at 10.30 today
Vertical Resolution

El Nino => negative Arctic Oscillation/NAO
Cold European Winter signal
Only works in high vertical resolution model

Observations

Old Model

Current Model

Ineson and Scaife 2009,
Cagnazzo and Manzini 2009
and others...

Winter 2009/10

Record low NAO

UKMO GloSea4
Solar Variability Effects?

Large differences in spectral solar irradiance variability

Descending easterlies in Winter => negative AO

Potentially useful surface signal

Harder et al., GRL, 2009 and Ineson et al., Nat. Geosci., 2011. – see also poster at 10.30 today
Summary

• Initialisation improves prediction months to years ahead
  • Monthly to seasonal forecasts: tropics higher skill.
  • Interannual to Decadal: more uniform skill
• Conditional skill => intelligent use of forecasts
• Some key extremes such as hurricanes or frequency of hot days show skill
• Improvements come from models, initialisation, ensemble generation and boundary forcing – some way to go but understanding mechanisms gives confidence
• Rapidly growing international activities: CMIP5 decadal hindcasts, CLIVAR WGSIP/WGCM, WMO Lead Centre for Long Range Forecast input to the Global Framework for Climate Services etc