Conference on Teleconnections in the Atmosphere and Oceans

17 - 20 November 2008

Vertical propagation of teleconnections and the North Atlantic oscillation.

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Vertical teleconnections and North Atlantic Climate

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David Fereday and Sarah Ineson
November 2008
1) European response to ENSO

- Tropics to extratropics – PNA
- Extratropics: troposphere -> stratosphere
- Wave mean flow interaction
- Descent of zonal winds
- Euro-Atlantic effects
Enhanced stationary waves

Climatology (black)

El Nino anomaly (colours)
Filling of the stratospheric cyclone

Model El Nino anomaly
(50hPa geopotential height)

Observations (Hamilton, 1993)

ENSO events produce a –ve NAO response (e.g. Moron and Gourand 2003, Bronnimann et al. 2004)
Clearly visible in 2/3 of observed El Nino events (Toniazzo and Scaife 2006)
Stratospheric component appears in models (Hamilton, 1993, Manzini et al. 2006)
Downward progression

Descending zonal mean wind signals, slower at lower altitudes

Consistent with wave-mean flow interaction from a steady wave source

Intraseasonal transition in NAO

Agrees with observations
Surface climate Response

Arctic Oscillation
Cold in Northern Europe
Warm in southern Europe
Useful for seasonal forecasting

Ineson and Scaife, in press, Nat. Geosci.
2) European climate change

<table>
<thead>
<tr>
<th>Standard Model</th>
<th>Extended Model</th>
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<tbody>
<tr>
<td><strong>Resolution:</strong> L38 N96</td>
<td><strong>Resolution:</strong> L60 N96</td>
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<tr>
<td><strong>Lid:</strong> ~40km</td>
<td><strong>Lid:</strong> ~85km</td>
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Pre-industrial SST, Sea-Ice and CO$_2$

or

4xCO$_2$ SST, Sea-Ice and CO$_2$
Preindustrial Winter Climate

Sea Level Pressure

Tropospheric U wind

Standard Model

Extended Model
Winter Climate Change: 1.5m Temperature (K)

Standard Model

Extended Model
Winter Climate Change:
Sea Level Pressure (hPa)

Standard Model

IPCC AR4 Models

Extended Model
Causes of increased tropospheric shear

- Stratospheric dipole interannual and climate timescales
- Extends into troposphere in both cases
Baroclinic Eddy Response

- Very large increase in the Eady growth rate in the extended model
- Not present in the standard model
- Just S of the low pressure response in the extended model

$$\sigma = \frac{0.3U_z f}{\text{NH}}$$

=> Enhanced cyclones and low P in mid lats
Storm Track Changes

Eddy activity (2-6 days)

Storm track changes
(Huebener et al. 2007)
Rainfall Changes

Mean Rainfall

Frequency of Heavy Rainfall

Standard Model

Extended - Standard
SUMMARY

Vertical teleconnections play a key role in global variability

European response to ENSO is a clear example

Regional climate change may also be affected:

- Increased meridional circulation (Butchart and Scaife 2001)
- Upper level dipole response in U
- Changes in $U_z$ => increased growth of baroclinic eddies
- Circulation changes exacerbate climate change in W Europe
- more storms => larger increase in heavy rainfall events than in IPCC