



**The Abdus Salam  
International Centre for Theoretical Physics**



**1968-28**

**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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Exeter EX1 3PB  
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# Vertical teleconnections and North Atlantic Climate

*Adam Scaife*

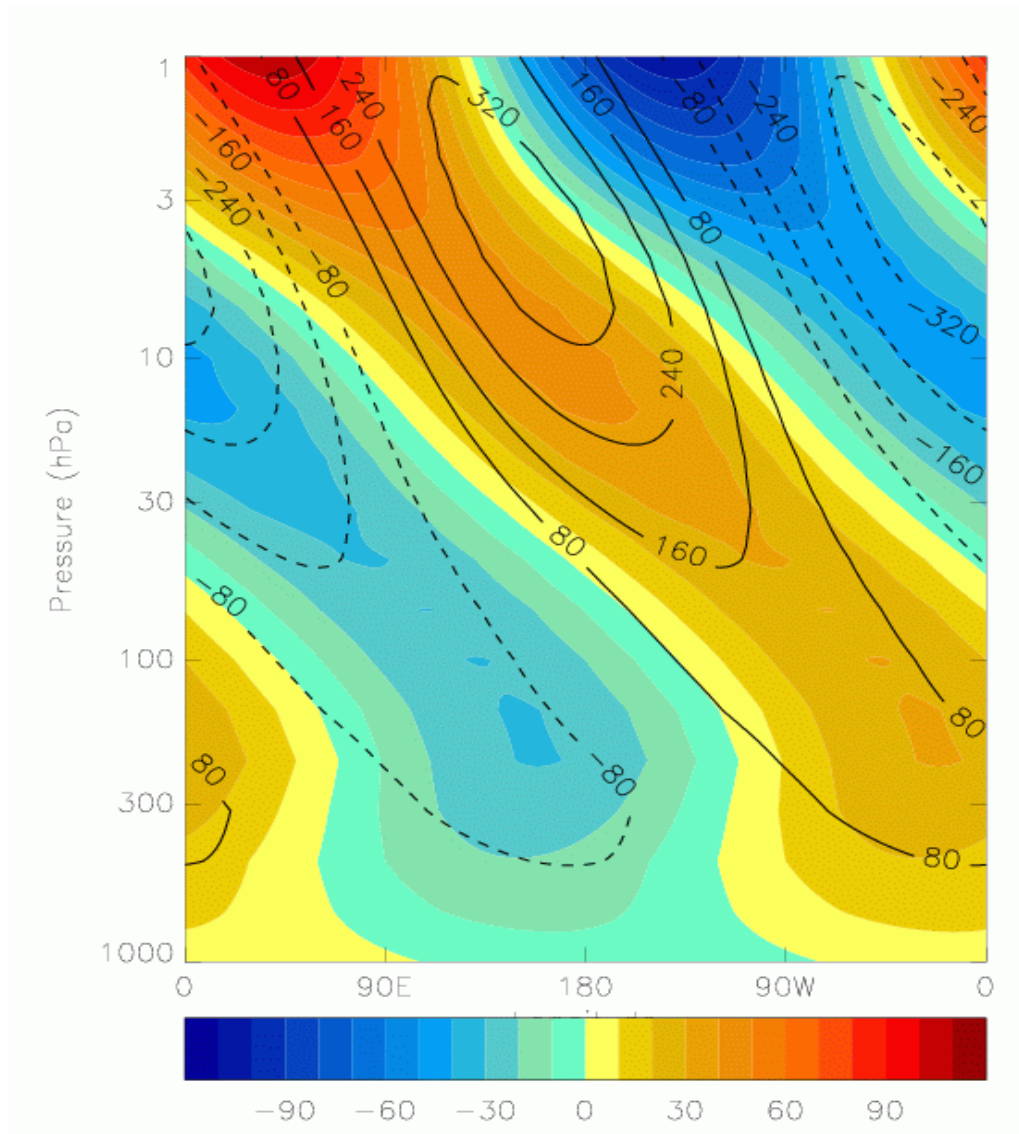
David Fereday and Sarah Ineson

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

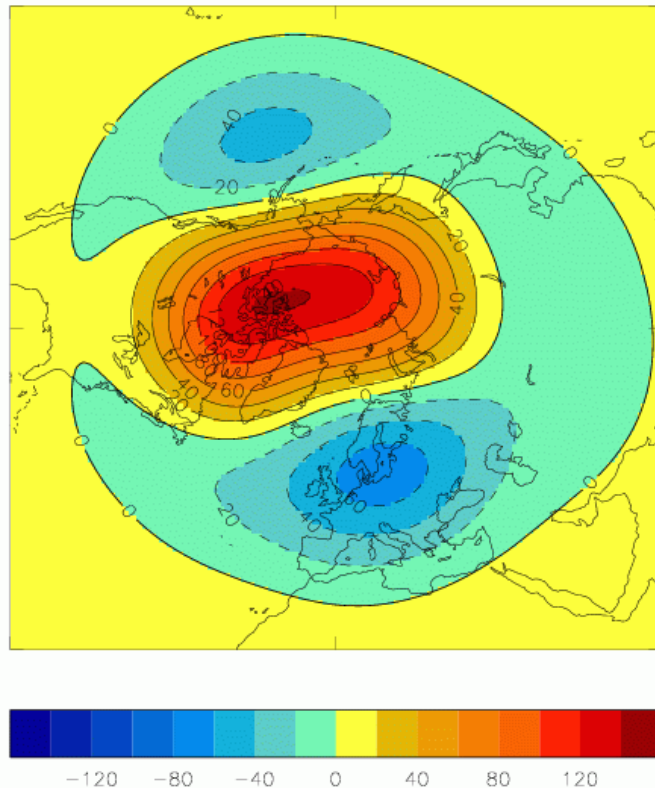


**Climatology  
(black)**

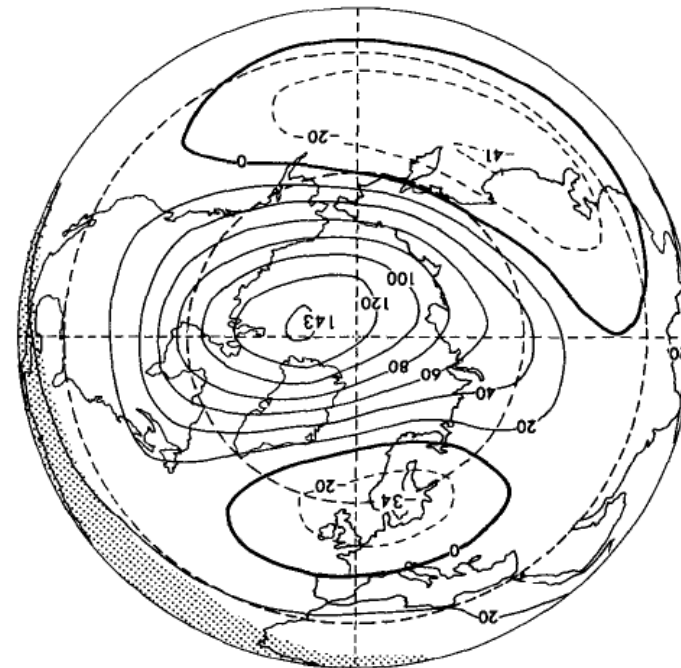
**El Niño anomaly  
(colours)**

# Filling of the stratospheric cyclone

**Model El Nino anomaly  
(50hPa geopotential height)**



**Observations (Hamilton, 1993)**



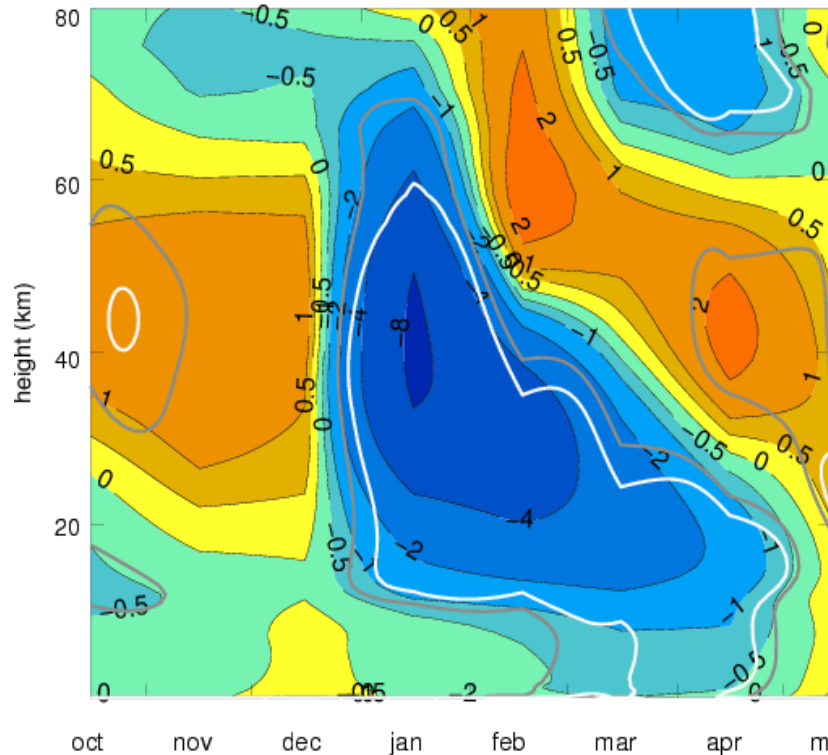
**ENSO events produce a –ve NAO response (e.g. Moron and Gouirand 2003, Bronniman et al. 2004)**

**Clearly visible in 2/3 of observed El Niño events (Tonizzo and Scaife 2006)**

**Stratospheric component appears in models (Hamilton, 1993, Manzini et al. 2006)**

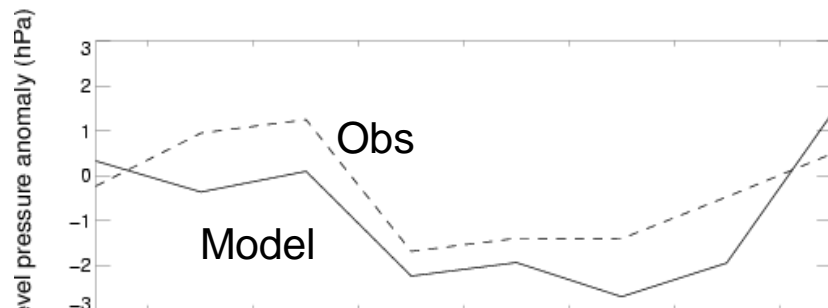
# Downward progression

U at 60N



**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**

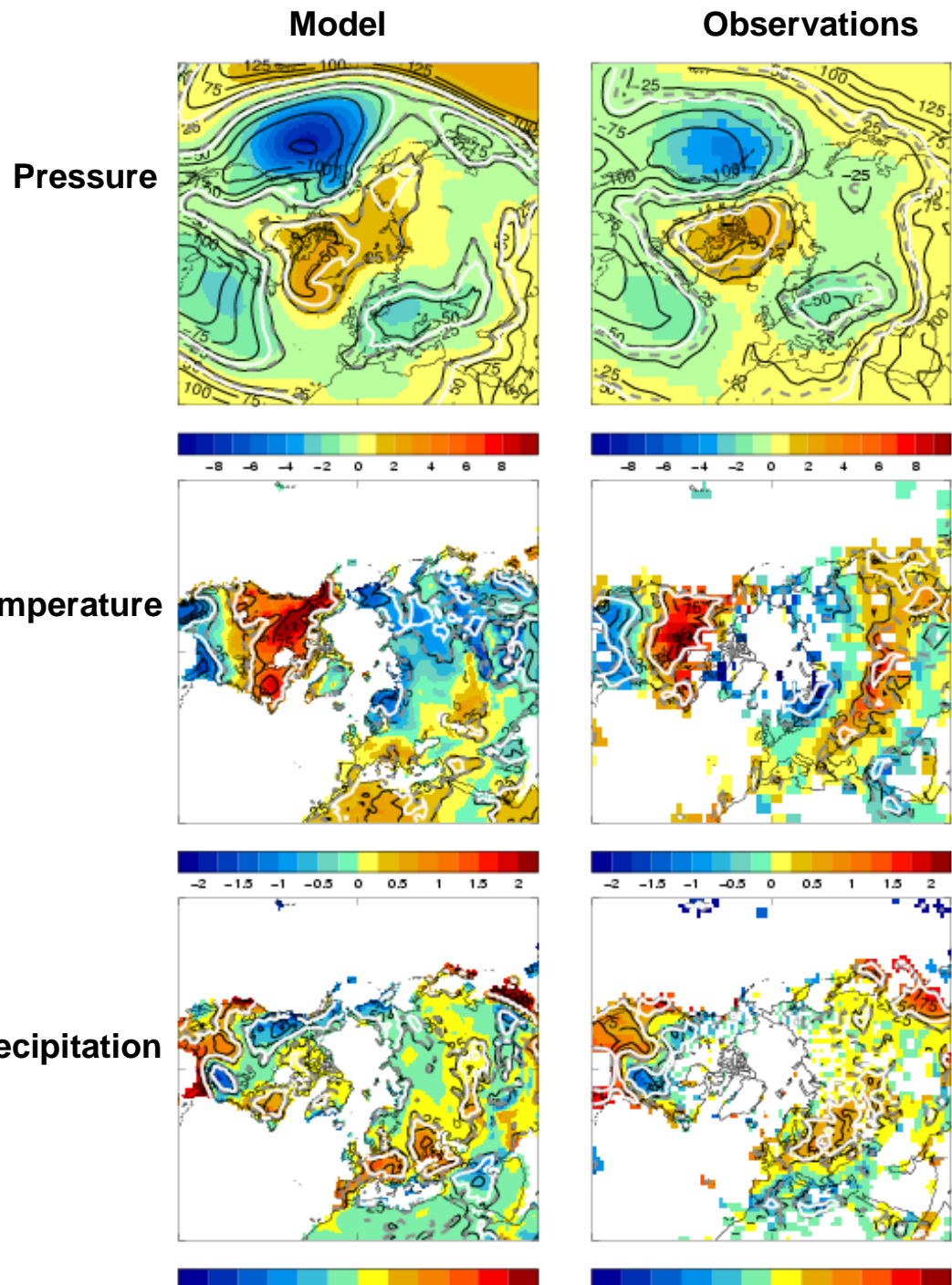
# Surface climate Response

Arctic Oscillation

Cold in Northern Europe

Warm in southern Europe

Useful for seasonal forecasting



## 2) European climate change

Pre-industrial SST, Sea-Ice and CO<sub>2</sub>  
or  
4xCO<sub>2</sub> SST, Sea-Ice and CO<sub>2</sub>

CTL L38  
4xCO<sub>2</sub> L38

**Standard Model**

**Resolution:** L38 N96  
**Lid:** ~40km

CTL L60  
4xCO<sub>2</sub> L60

**Extended Model**

**Resolution:** L60 N96  
**Lid:** ~85km

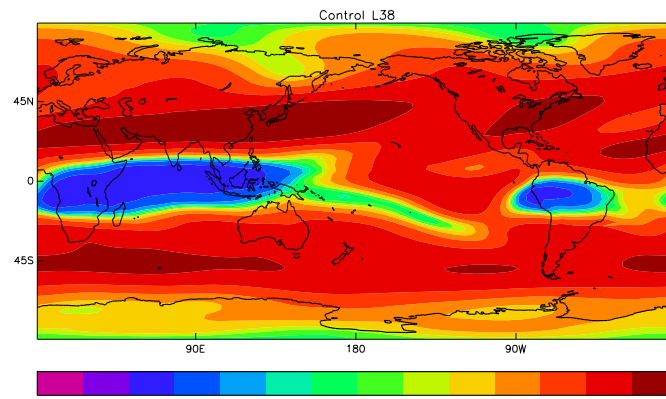
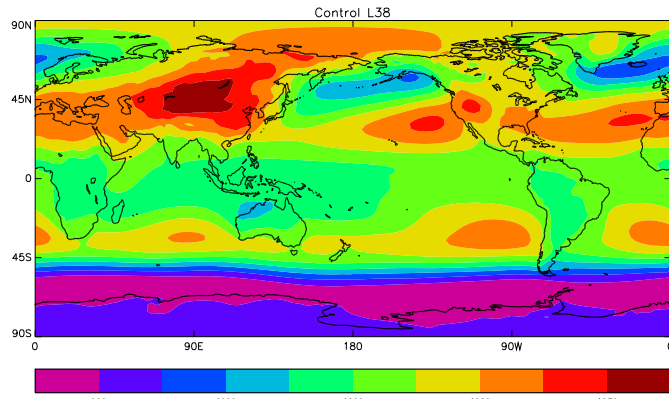




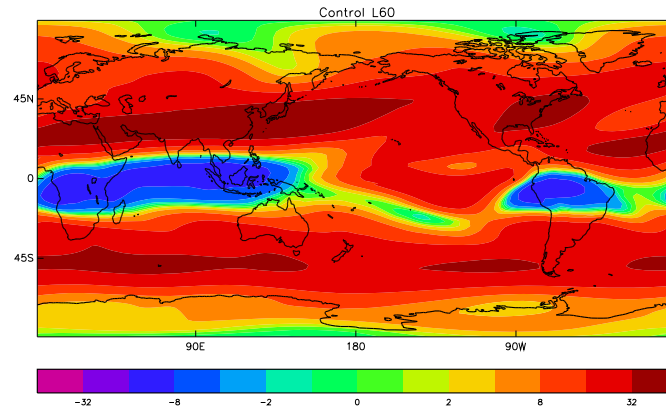
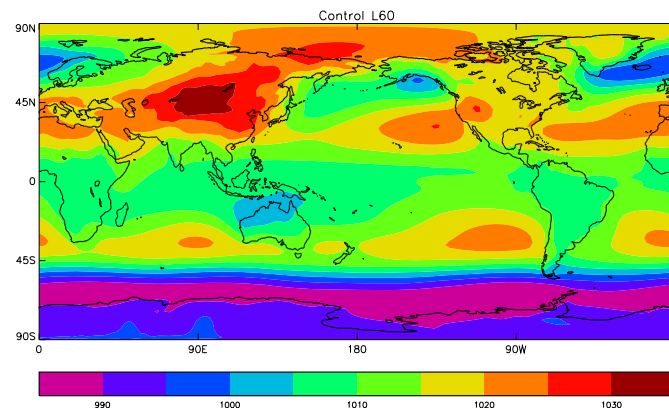
# Preindustrial Winter Climate

## Sea Level Pressure

## Tropospheric U wind



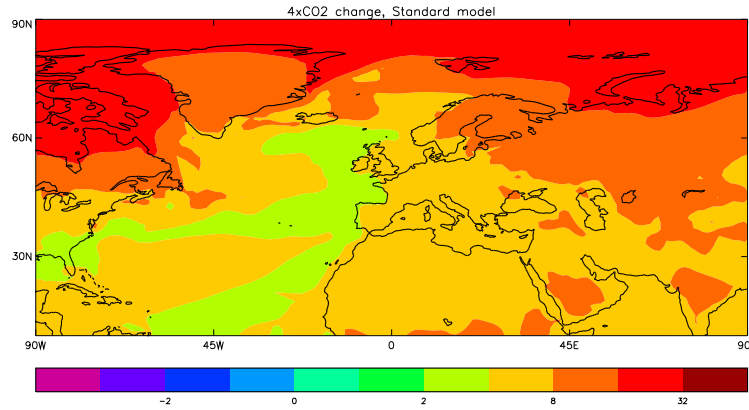
**Standard Model**



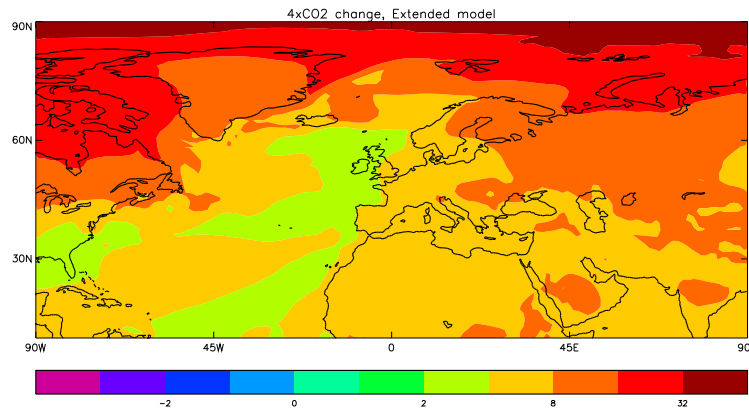
**Extended Model**



# Winter Climate Change: 1.5m Temperature (K)



**Standard Model**



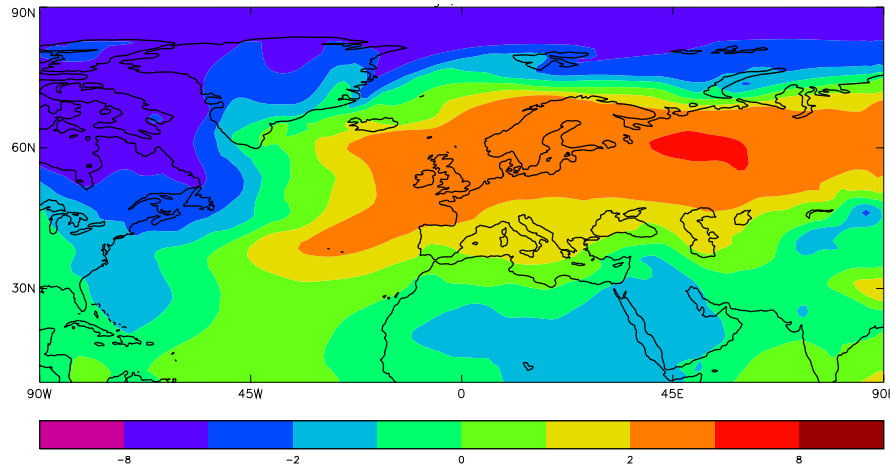
**Extended Model**



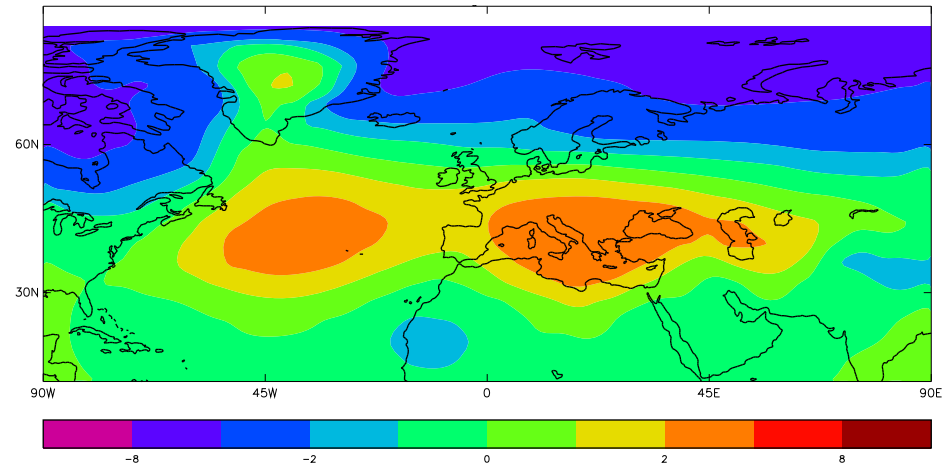
Met Office

# Winter Climate Change: Sea Level Pressure (hPa)

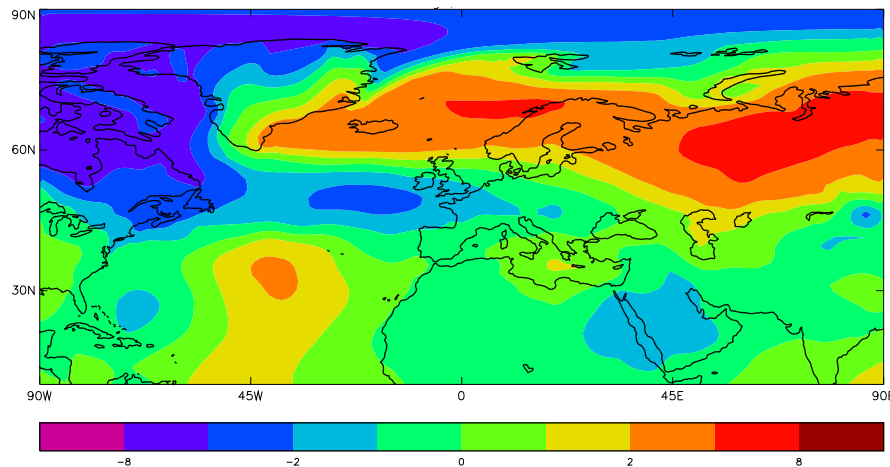
## Standard Model



## IPCC AR4 Models



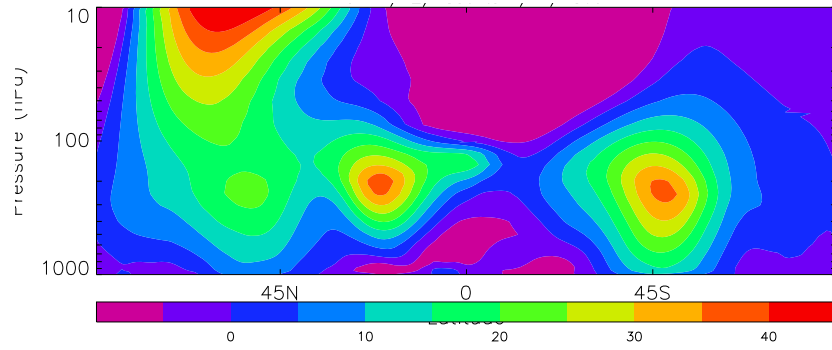
## Extended Model



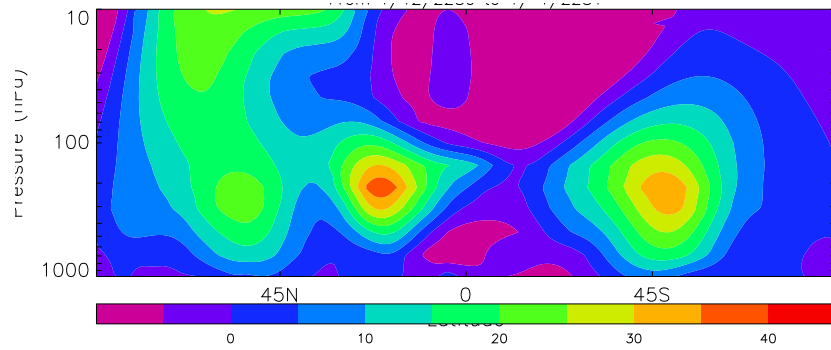


# Zonal Wind Response (10W)

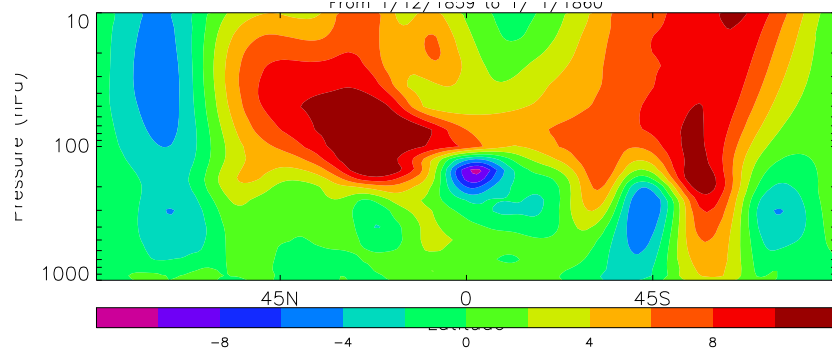
### Standard Model



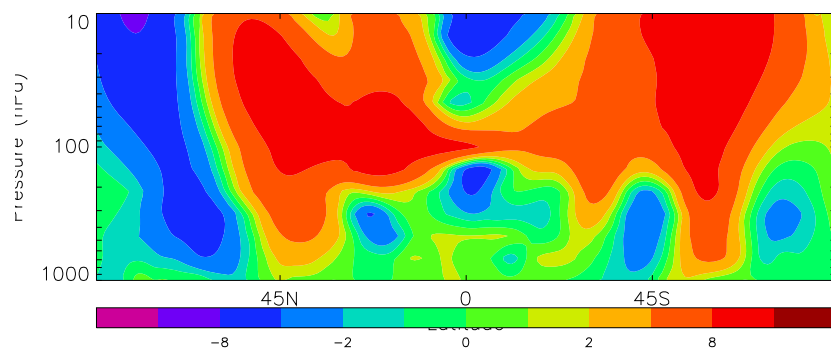
### Extended Model



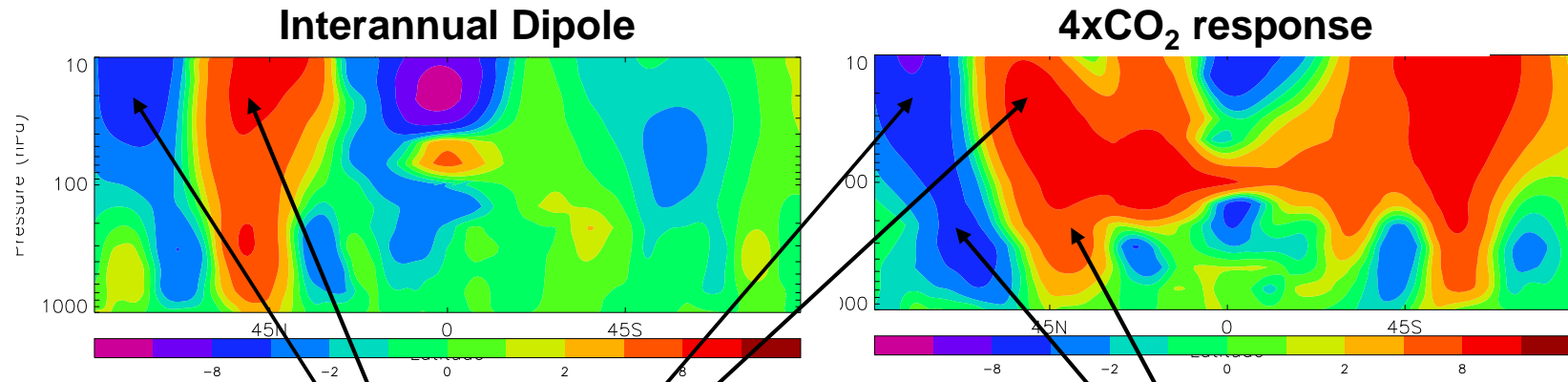
### 4xCO<sub>2</sub> response



### 4xCO<sub>2</sub> response



# Causes of increased tropospheric shear

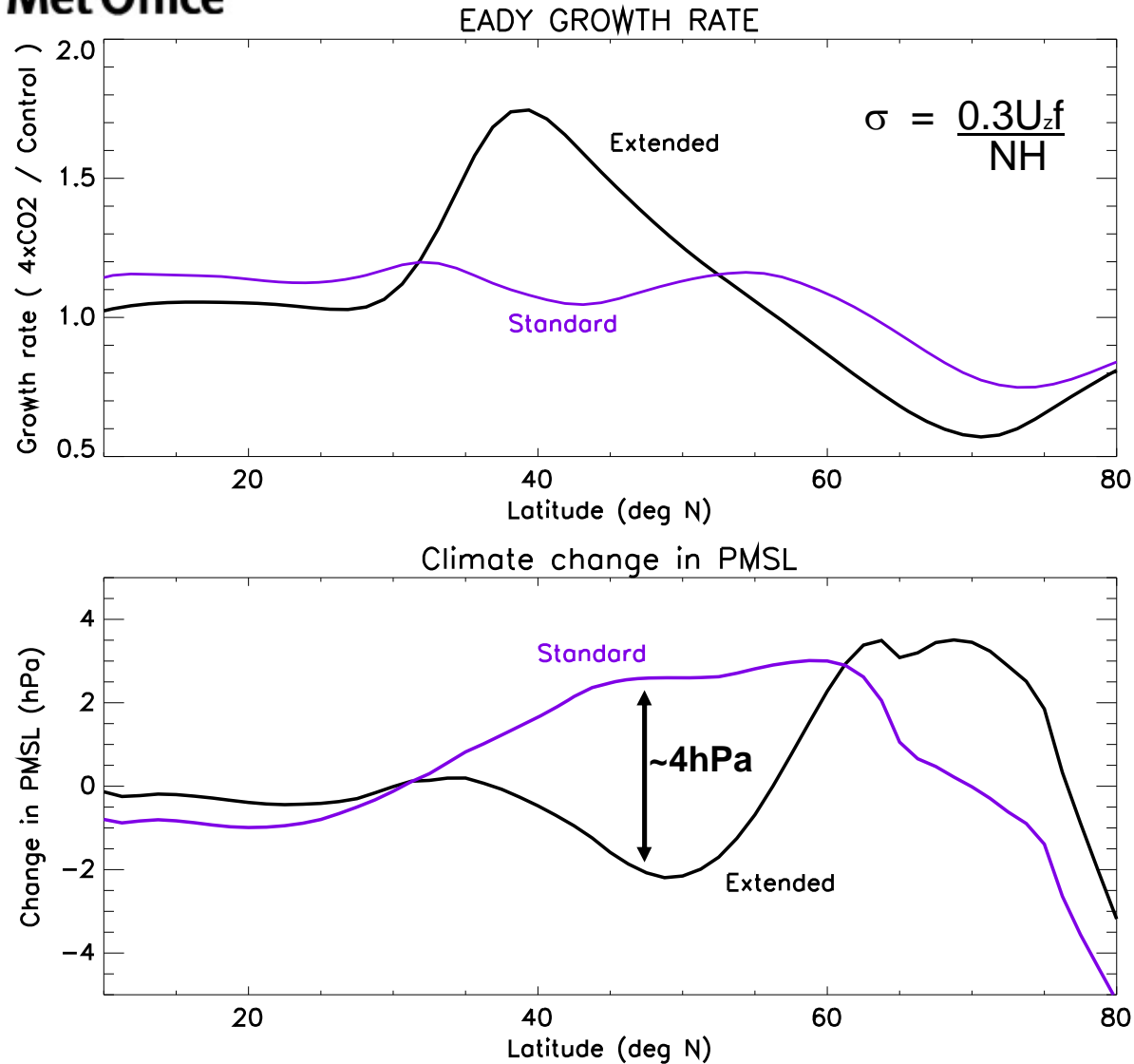


- **Stratospheric dipole interannual *and* climate timescales**

- **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

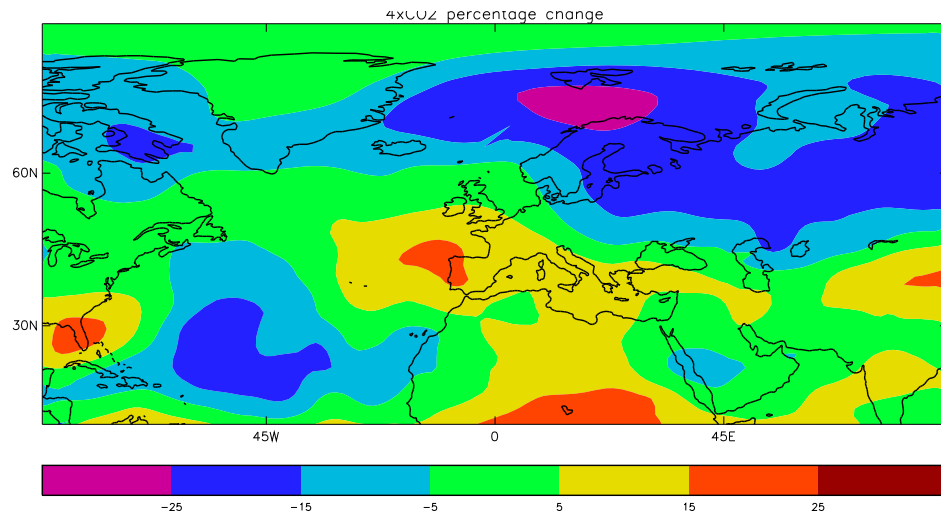
- Just S of the low pressure response in the extended model

=> *Enhanced cyclones and low P in mid lats*

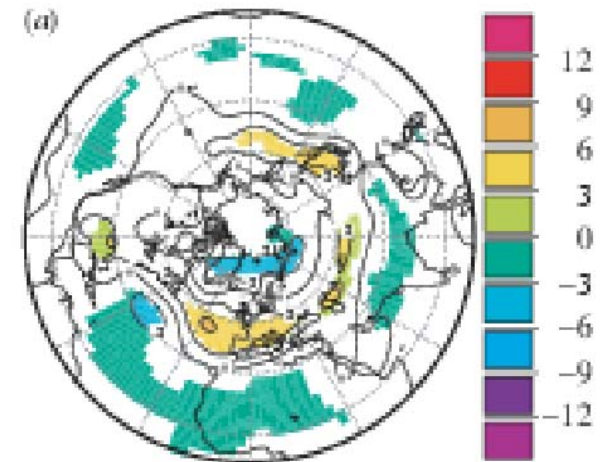


# Storm Track Changes

## Eddy activity (2-6days)



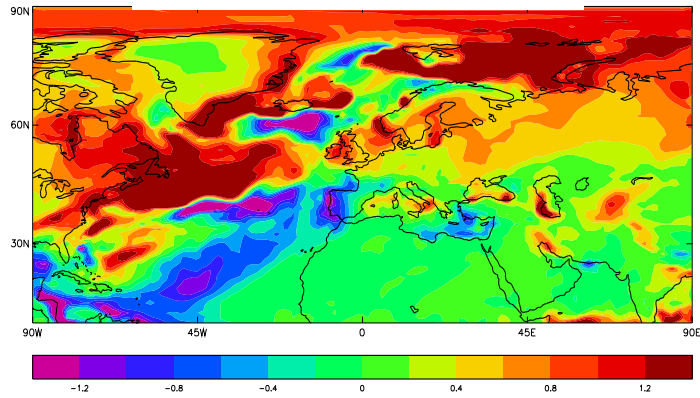
## Storm track changes (Huebener et al. 2007)



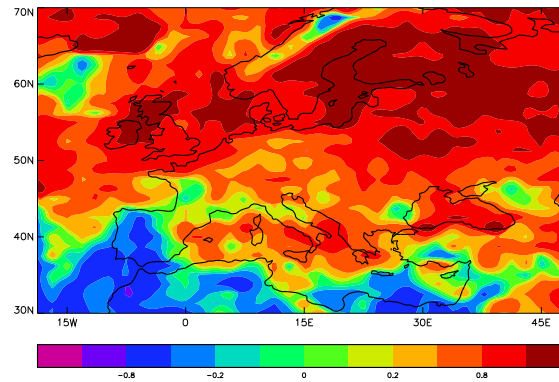


# Rainfall Changes

## Mean Rainfall

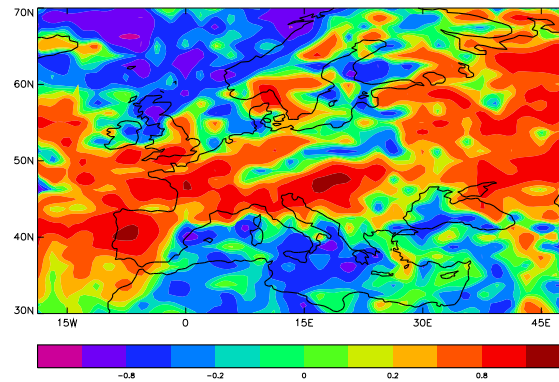
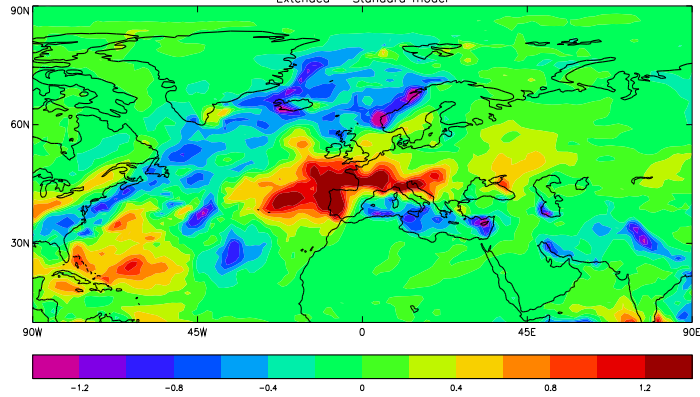


## Frequency of Heavy Rainfall



**Standard Model**

Extended - 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  $U_z \Rightarrow$  increased growth of baroclinic eddies***
- ***Circulation changes exacerbate climate change in W Europe***
- ***more storms  $\Rightarrow$  larger increase in heavy rainfall events than in IPCC***