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European storm climate: An uncertain future

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NATURAL ENVIRONMENT RESEARCH COUNCIL

National Centre for Atmospheric Science
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Walker INSTITUTE

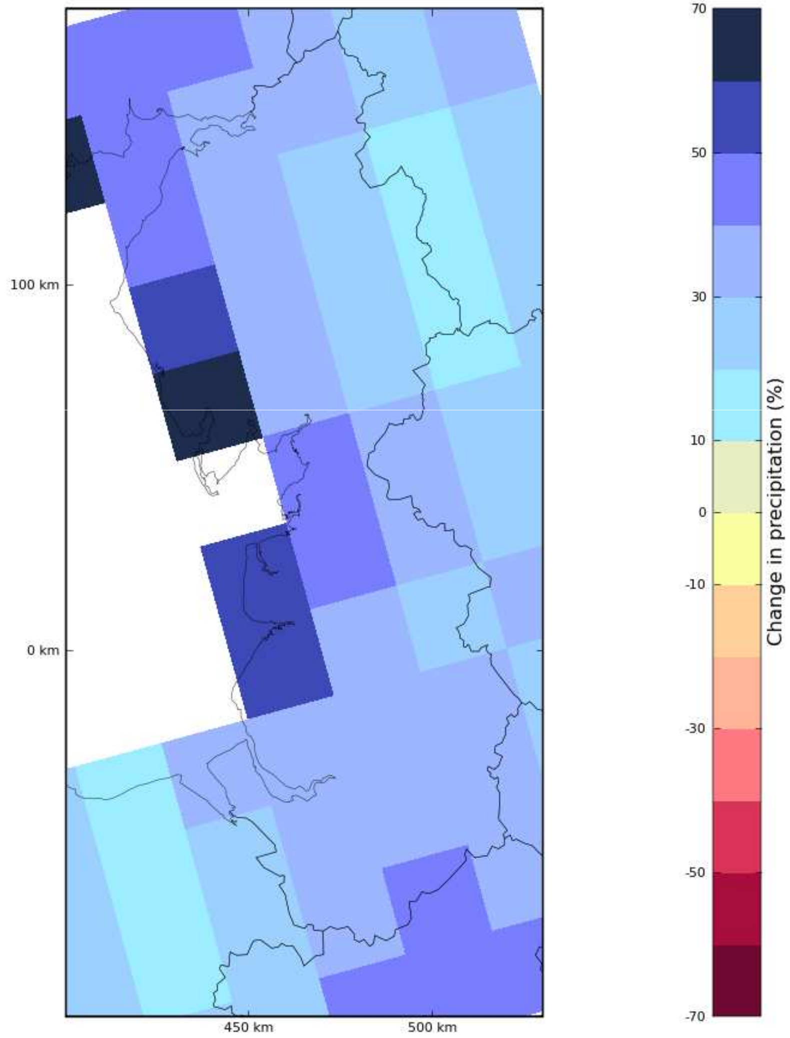
Plot Details:

Data Source: Probabilistic Land
Future Climate Change: True
Variables: precip_dmean_tmean_perc
Emissions Scenario: Medium
Time Period: 2070-2099

Temporal Average: DJF
Spatial Average: Grid Box 25Km
Location: -3.76, 52.76, -1.82, 55.25
Percentiles: 90.0
Probability Data Type: cdf

How will extreme winter rainfall in Liverpool change by 2080?

But can climate science really deliver such local predictions?



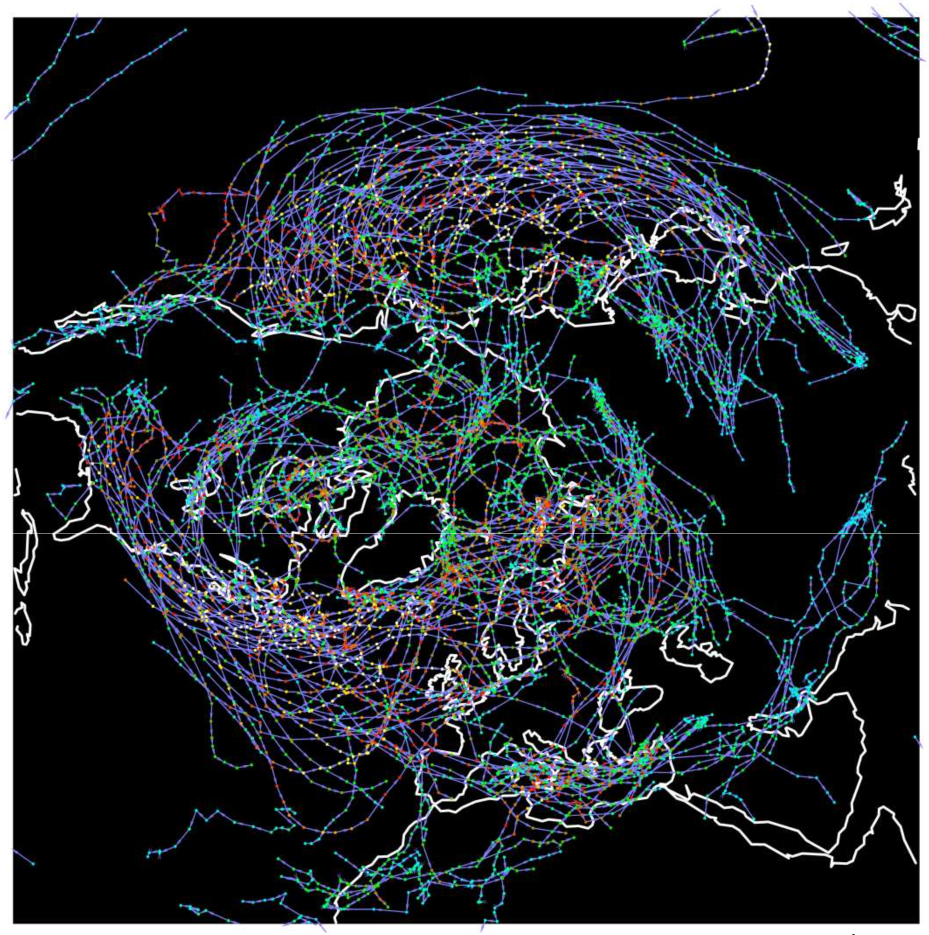
OUTLINE

1. Introduction to the storm track

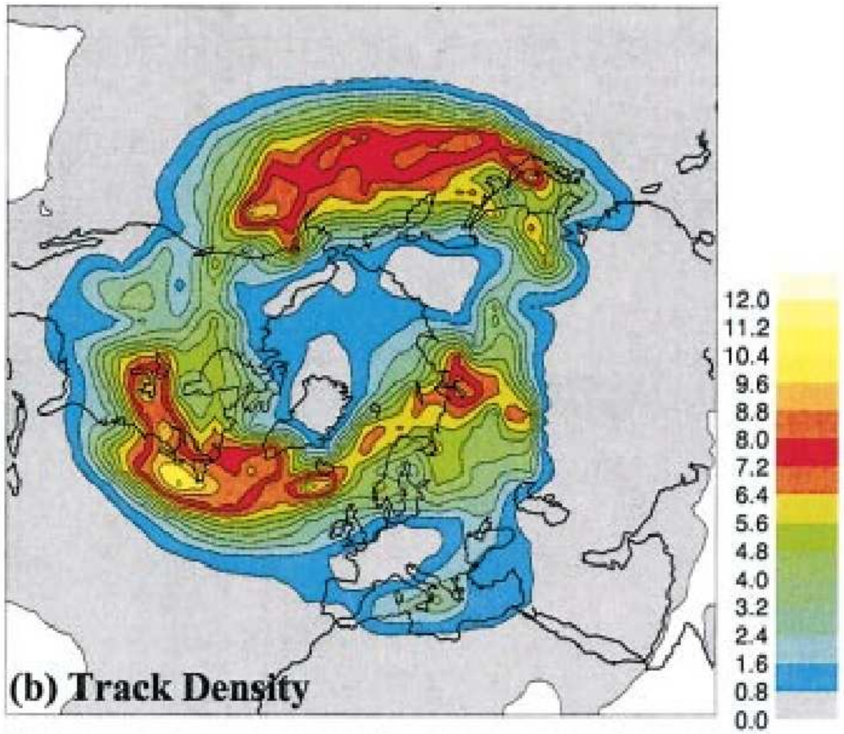
2. Model spread in current projections

3. Systematic bias in current models?

Northern Europe lies at the end of the North Atlantic storm track.



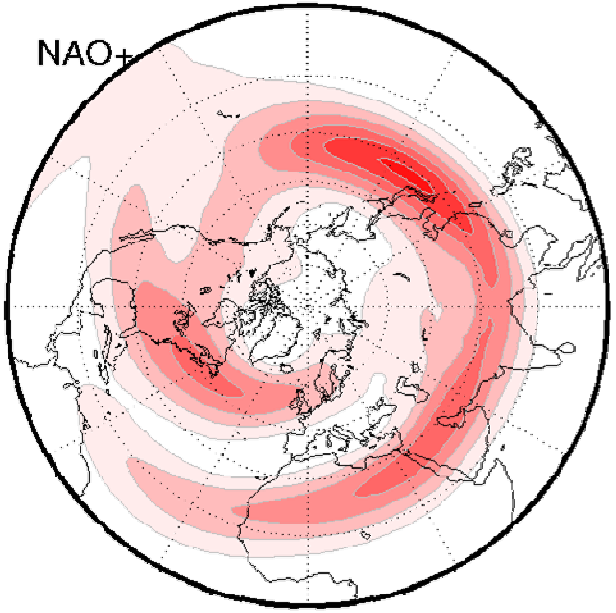
Kevin Hodges

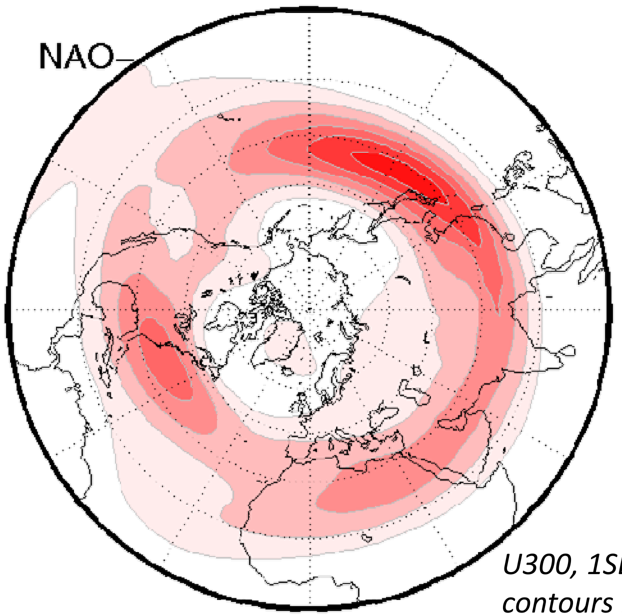


Hoskins and Hodges 2002

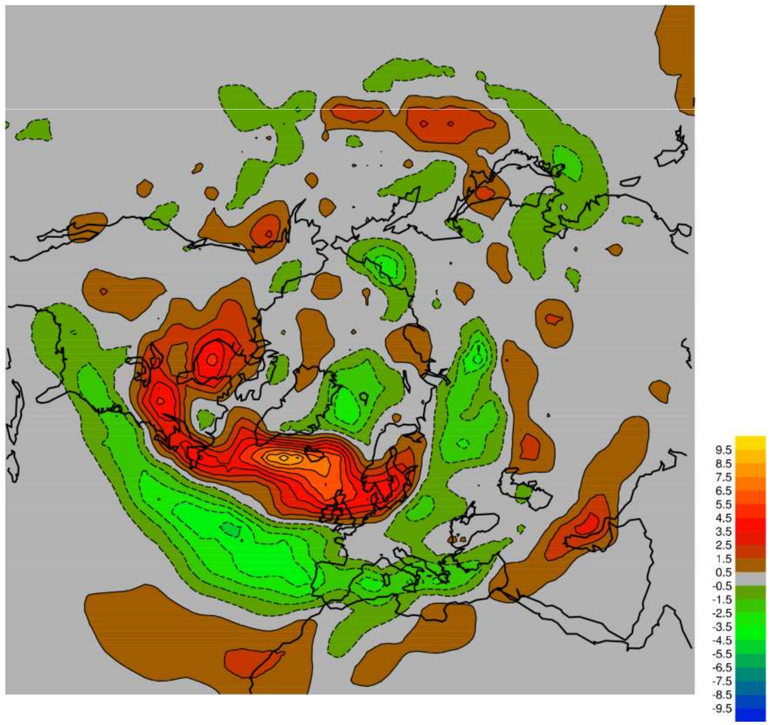
• The storm track is strongly related to the jet stream.

• The North Atlantic Oscillation (NAO) describes synchronous variations in the strength and orientation of the jet and storm track.





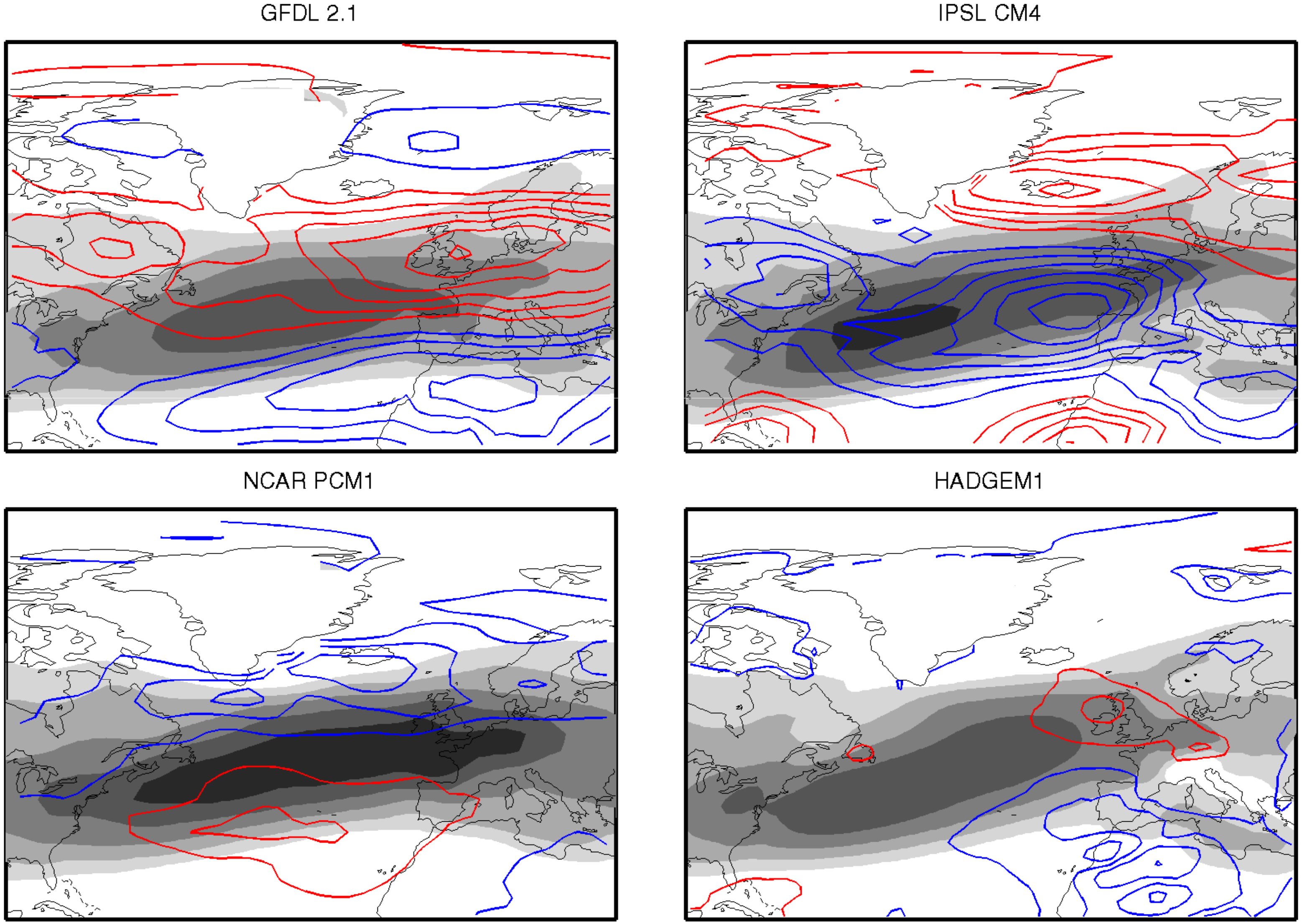
U300, 1SD daily comps, contours 10m/s



Track density regressed on NAO index; Kevin Hodges

Models generally predict that the jet streams and storm tracks will shift polewards…

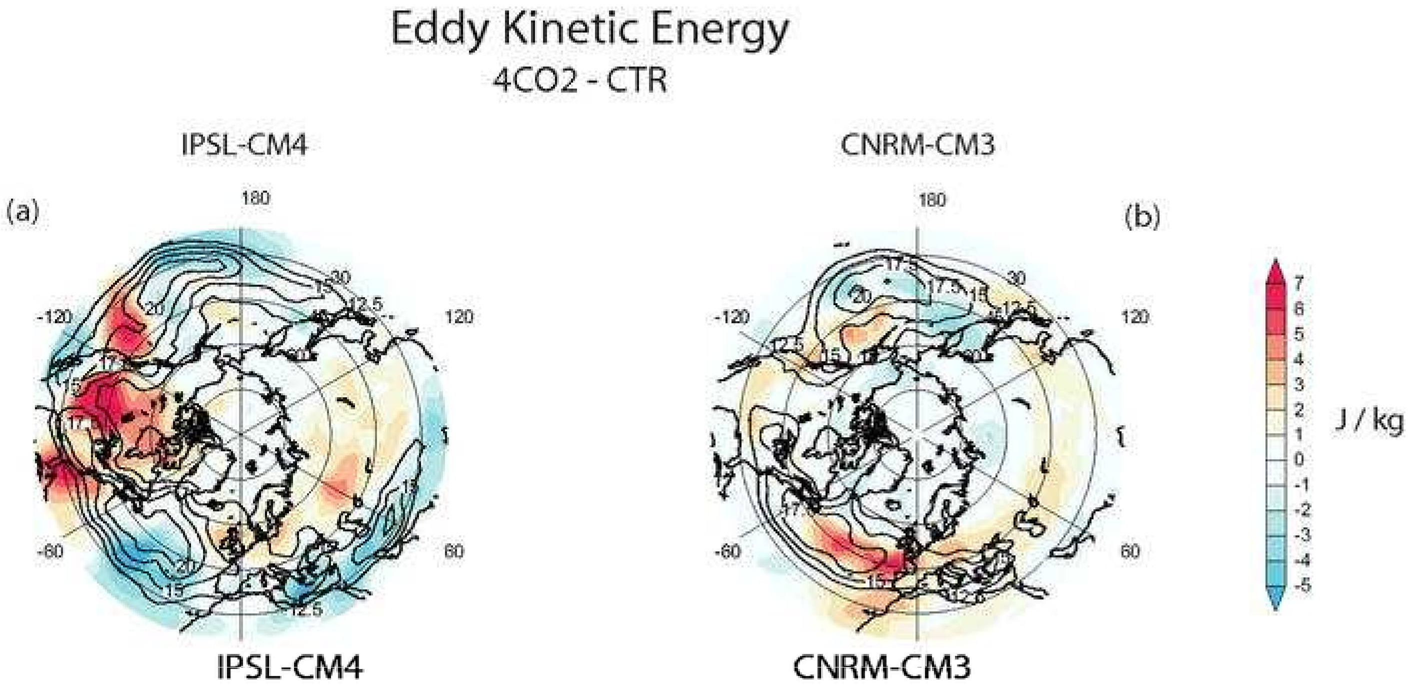
… but still some disagreement, especially in the Atlantic in winter.

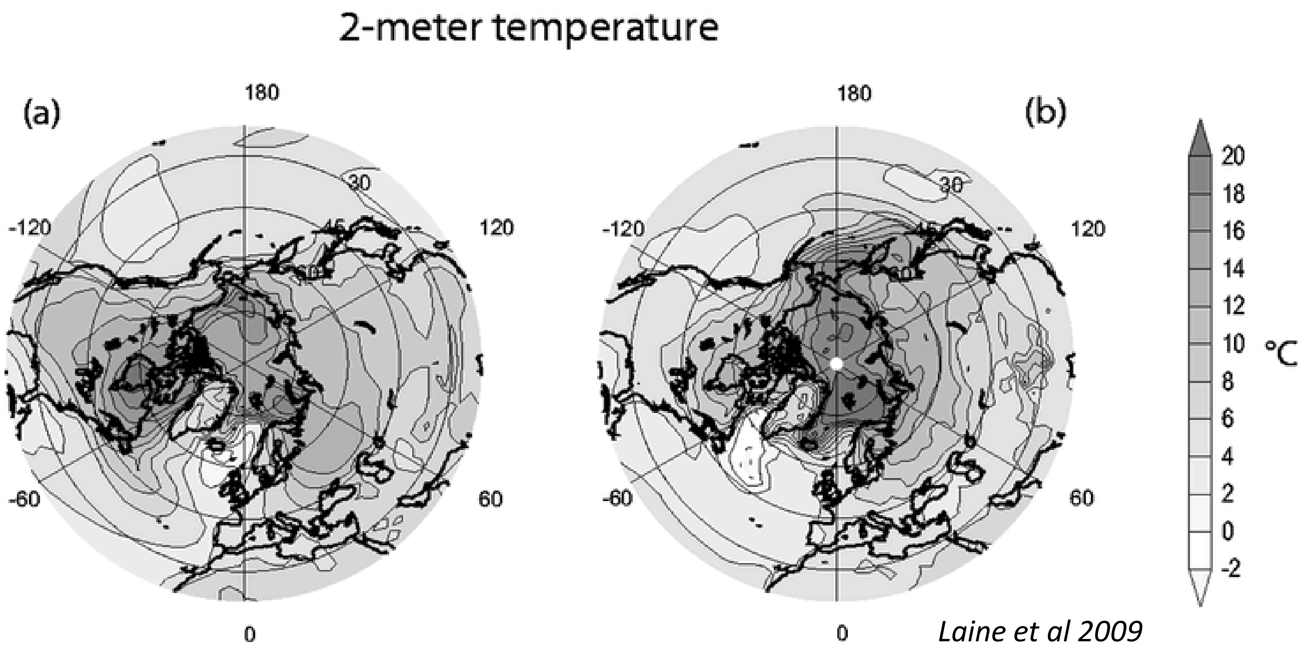


U850, DJF, 2080-99 (SRESA1B) – 1960-99 (20C3M). Contours every 2.5 / 0.5 m/s.

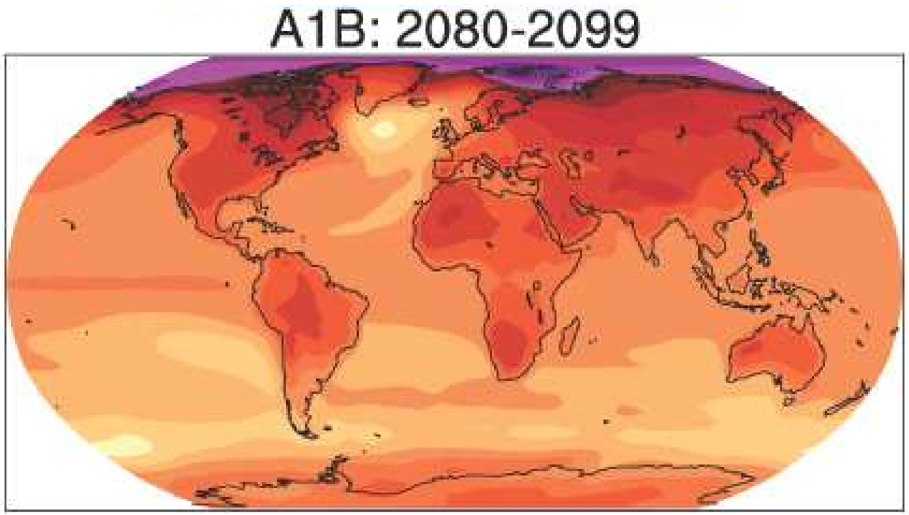
An example of very different storm track responses in the North Atlantic.

These could be due to different local SST changes.

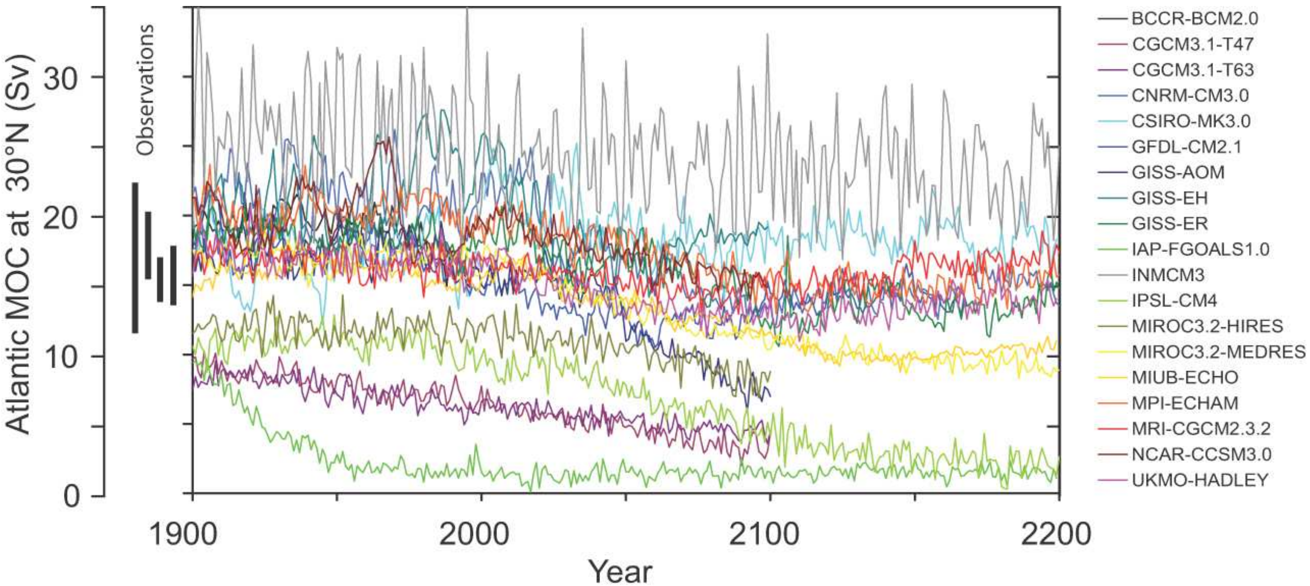




Laine et al 2009

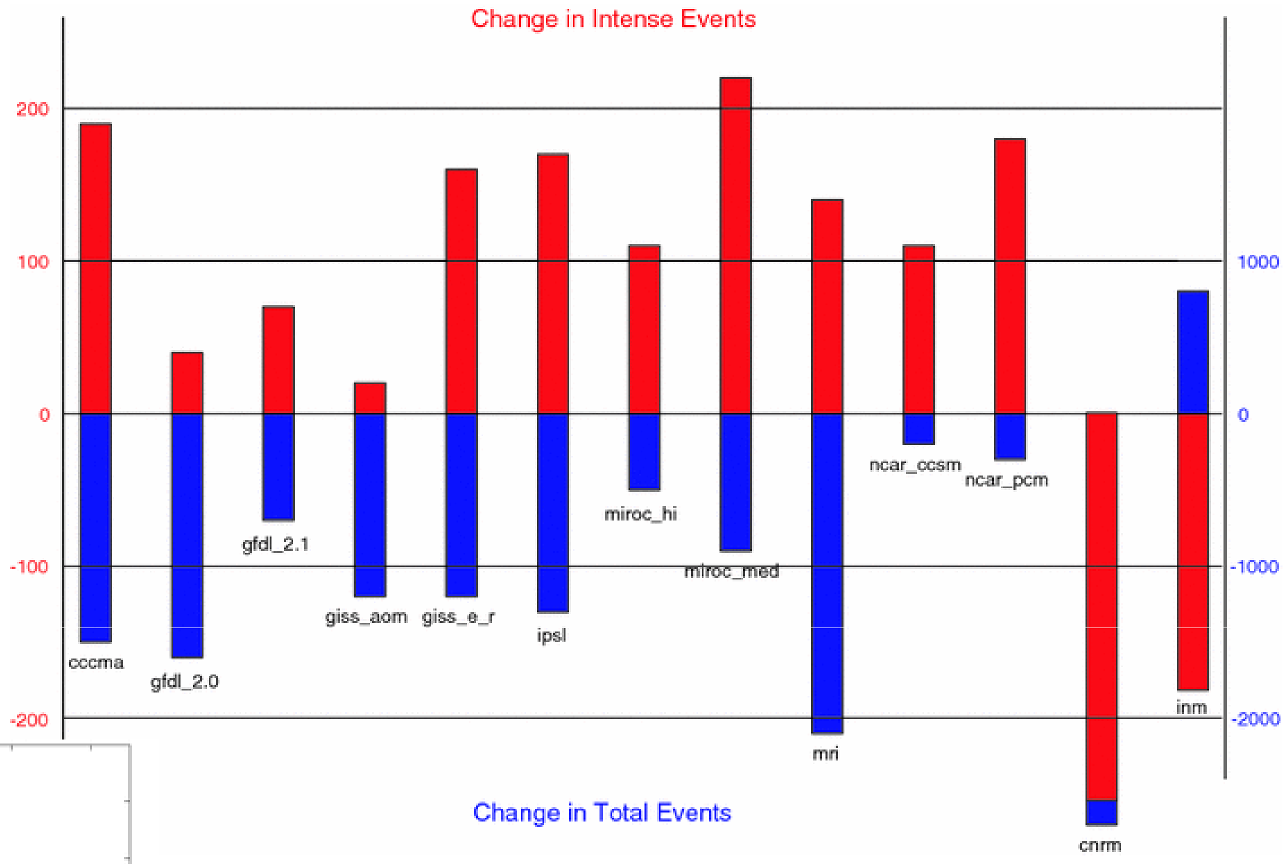


How much uncertainty arises from differing MOC responses?

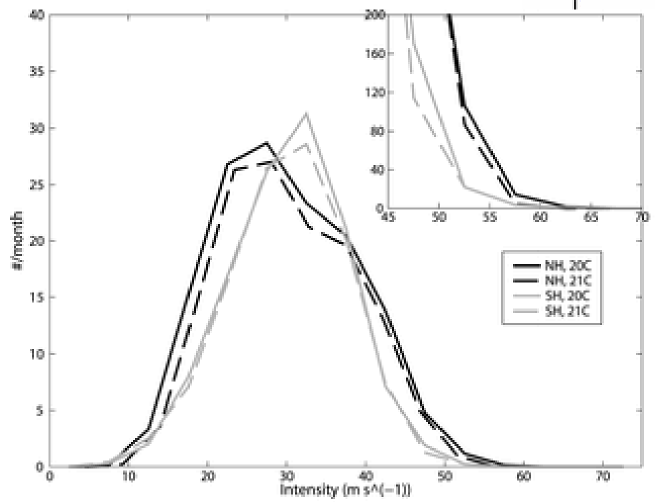


IPCC AR4

IPCC:
‘Fewer storms but more intense.’



Lambert and Fyfe 2006

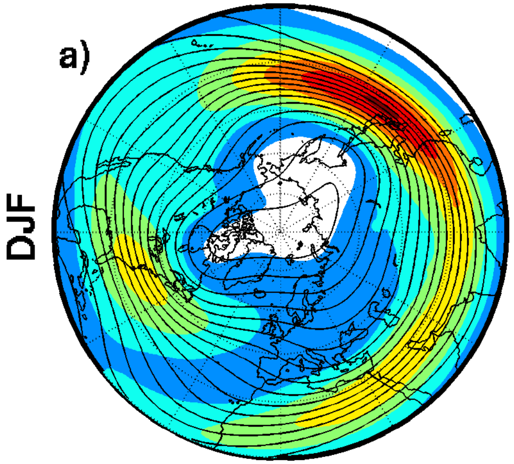


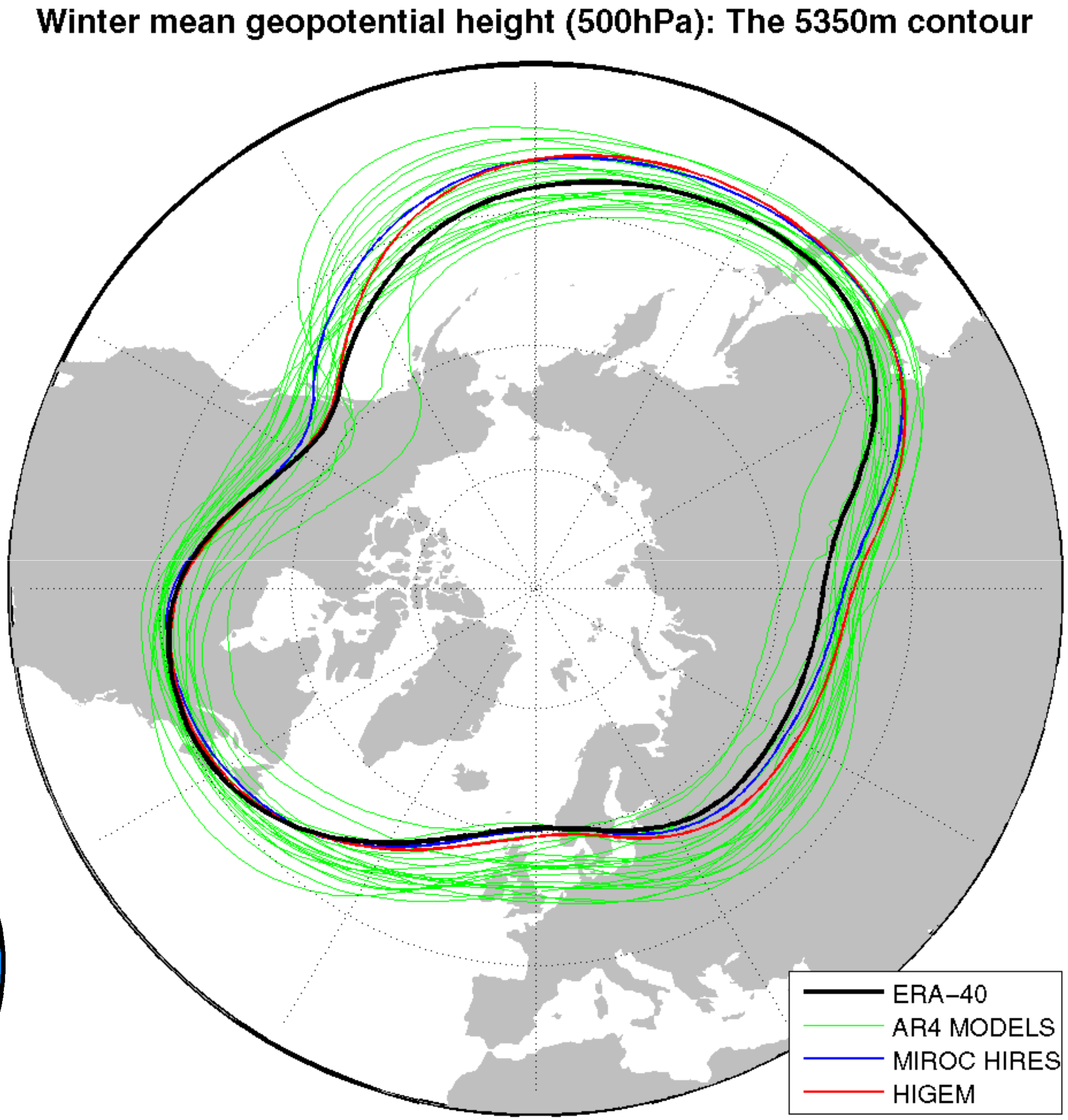
(a) DJF

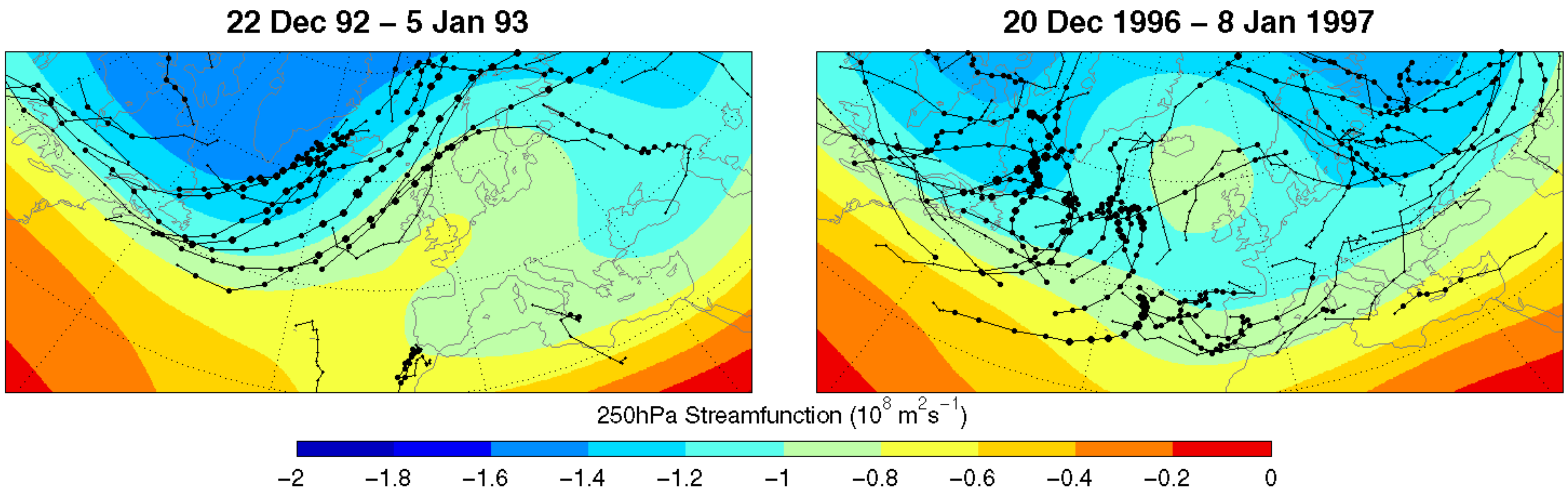
Bengtsson et al 2009

However, still strong differences between methodologies…

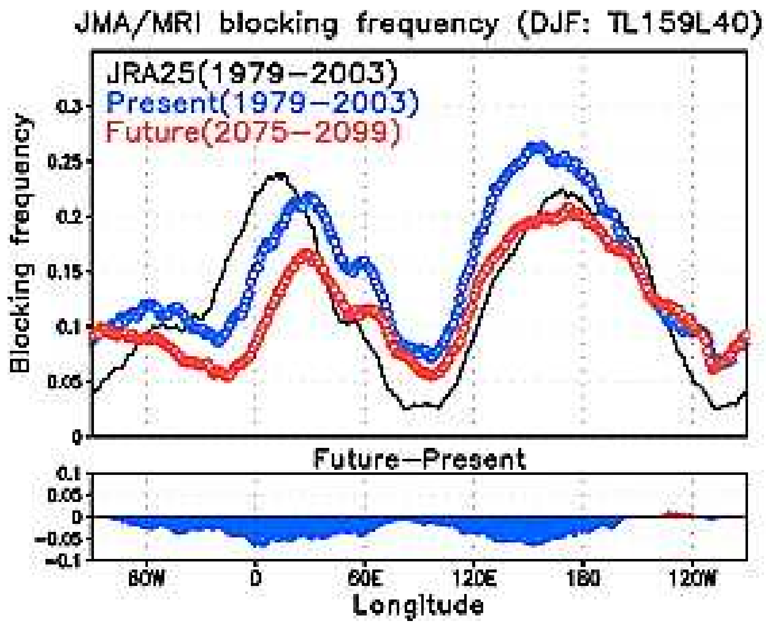
Models have a systematic bias underestimating the ridge over Europe.



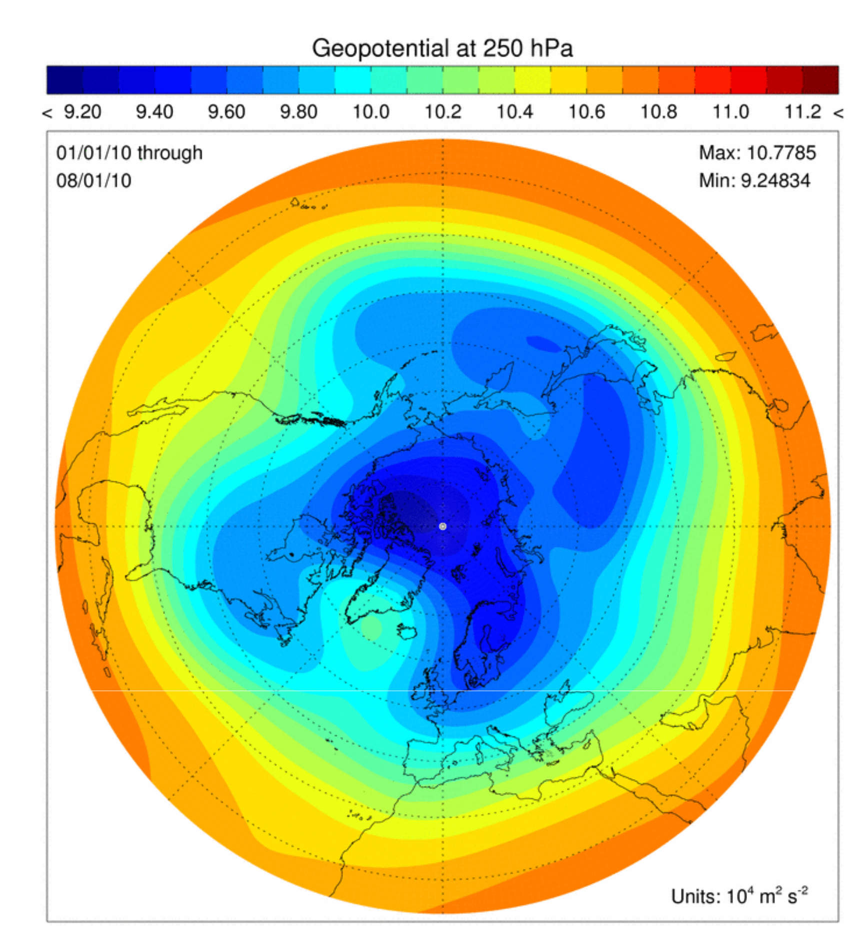




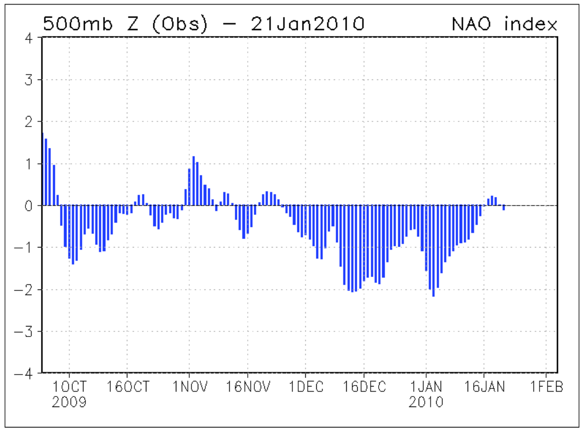
Blocking has a dramatic effect on storm activity, yet is generally believed to be underestimated in climate models.



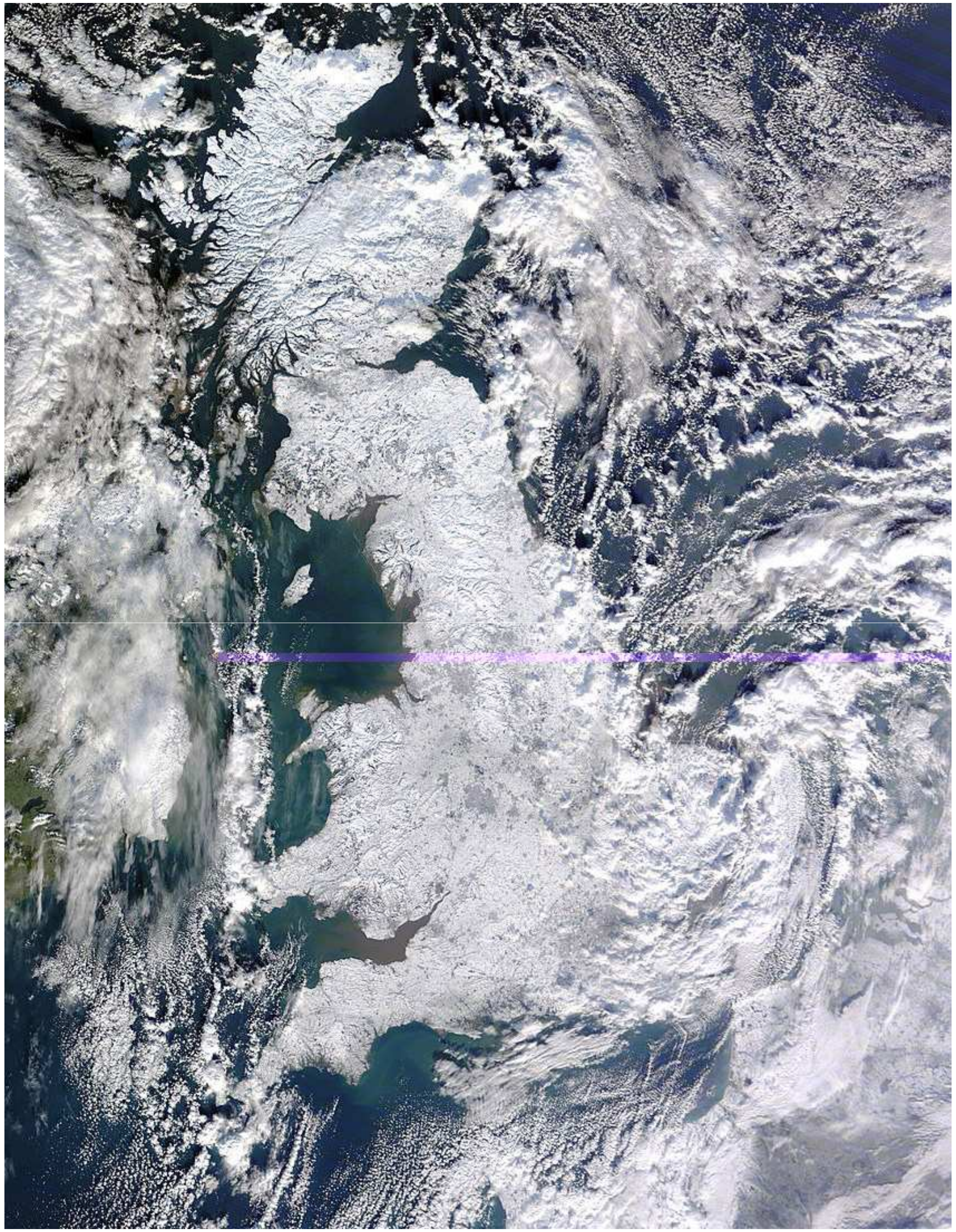
Matsueda et al (2009)



ECMWF



NOAA CPC



MODIS 7 JAN 2010

• Many climate models do not have a good representation of the stratosphere

• Including the stratosphere can alter the jet stream response to forcing

• Europe is particularly affected by the stratosphere

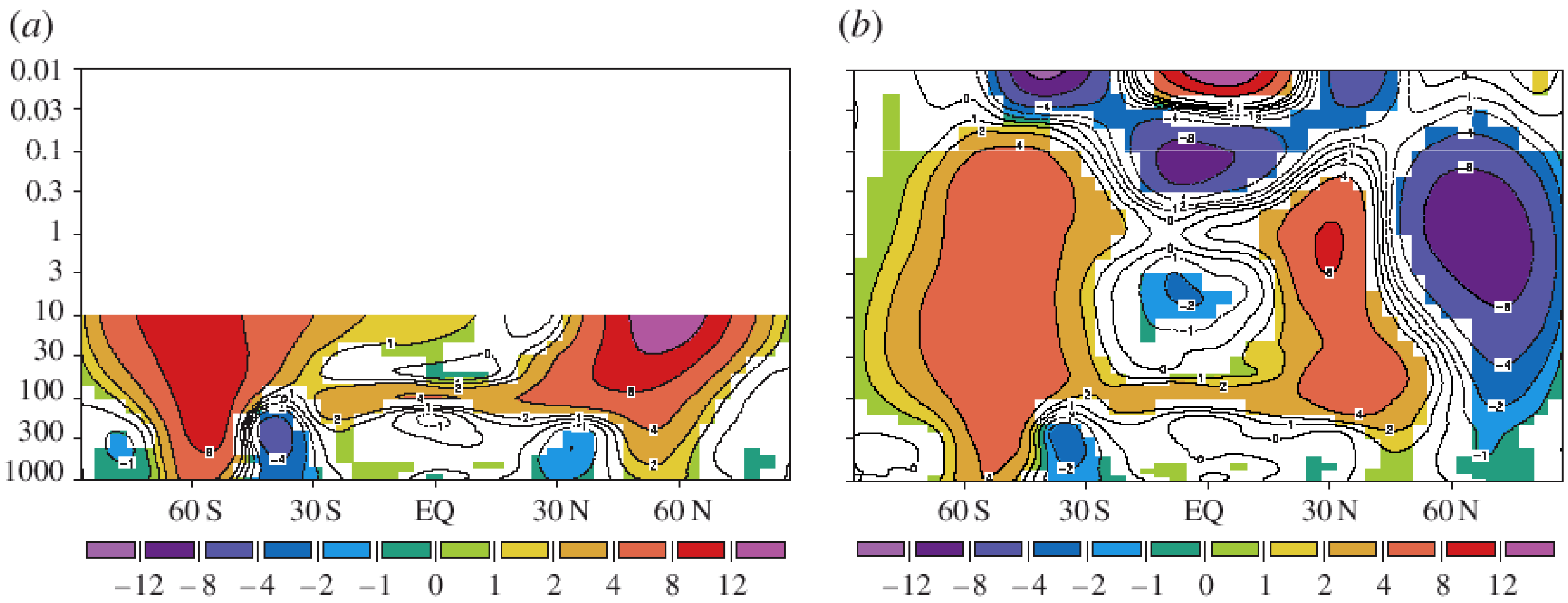
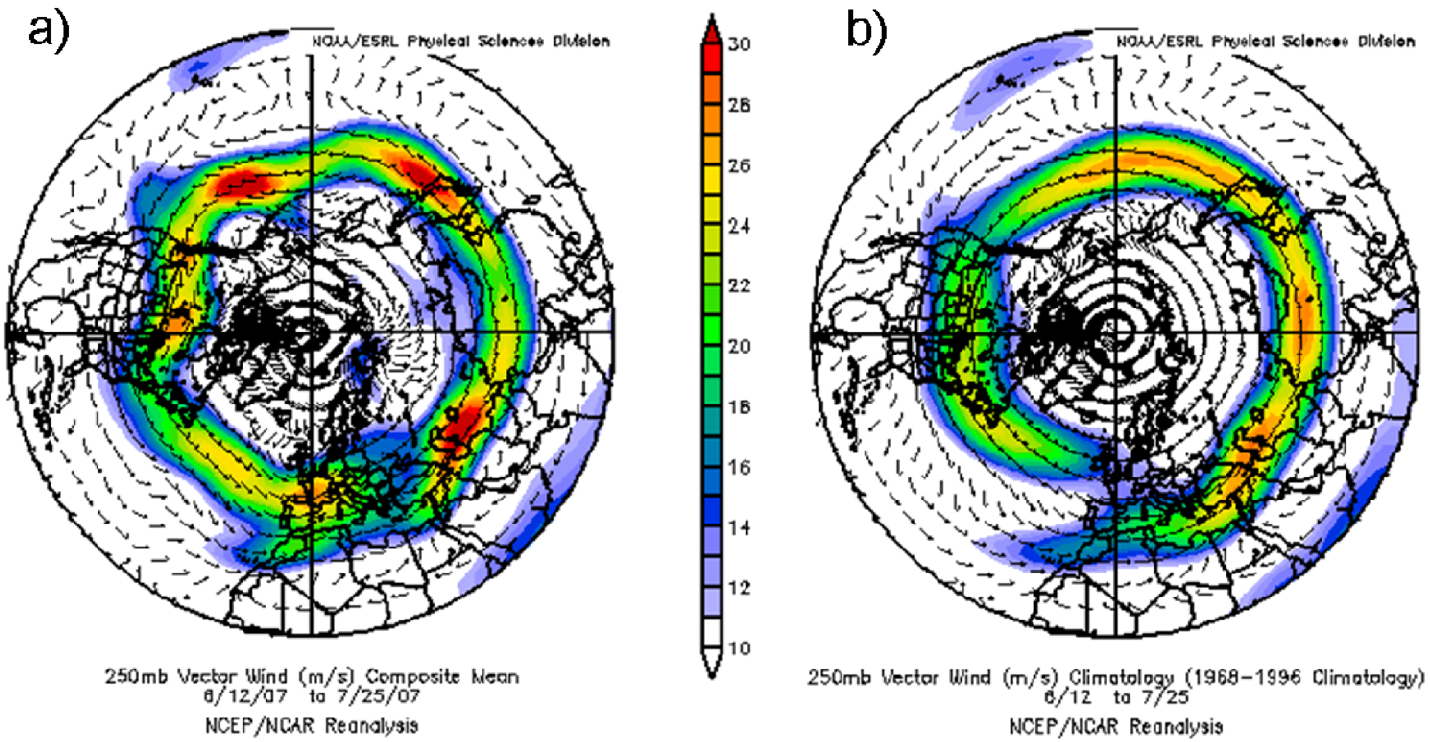


Figure 6. Latitude–height cross sections of zonal-mean zonal-wind velocity change 2061–2100 minus 1961–2000 for (*a*) ECHO-G and (*b*) EGMAM.

Huebener et al 2007

Summer 2007 Summer climatology



Blackburn, Methven and Roberts (2008)

- Recent extreme seasons have been characterised by stationary wave patterns.
- Will these become more frequent?
- But first:
    - Understand dynamics – eg what anchors the phase?
    - How well are 'regimes' like this represented in models?

Conclusions

• We can now make some useful regional climate projections.

• However, I would argue that future storm climate is more uncertain in Europe than in other mid-latitude regions because of:

1. Model spread in the response to anthropogenic forcing:
   - Jet stream
   - Storm track
   - MOC
   - Storm intensity

2. Systematic model biases:
   - Atlantic jet too zonal
   - Blocking underestimated
   - Poor representation of stratosphere
   - Poor representation of MOC