Some recent UK extreme weather events, their possible causes and predictability

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LIAT/Holbeach, 30 May 2017

An analysis of the extreme rainfall in Yorkshire, June 2007, and its rarity

Weather – September 2008, Vol. 63, No. 9

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June 2007 was the wettest calendar month on record in much of Yorkshire. In excess of 150 mm of rain fell over much of Wales, the Midlands, Northern England, Northern Ireland, parts of Scotland and south-west England, with over 250 mm locally (Figure 1(a)). Over three times the average fell over much of the West Midlands,

estimated average r
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Table 1 shows exa
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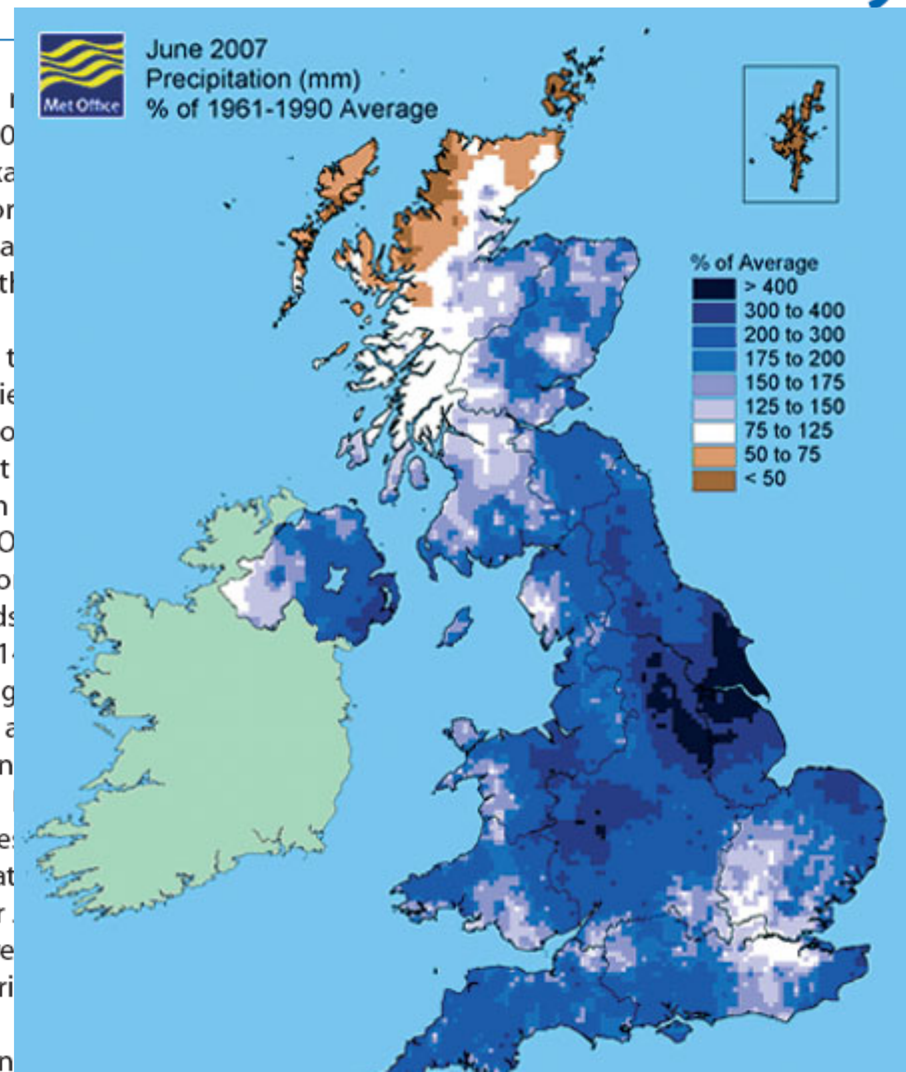
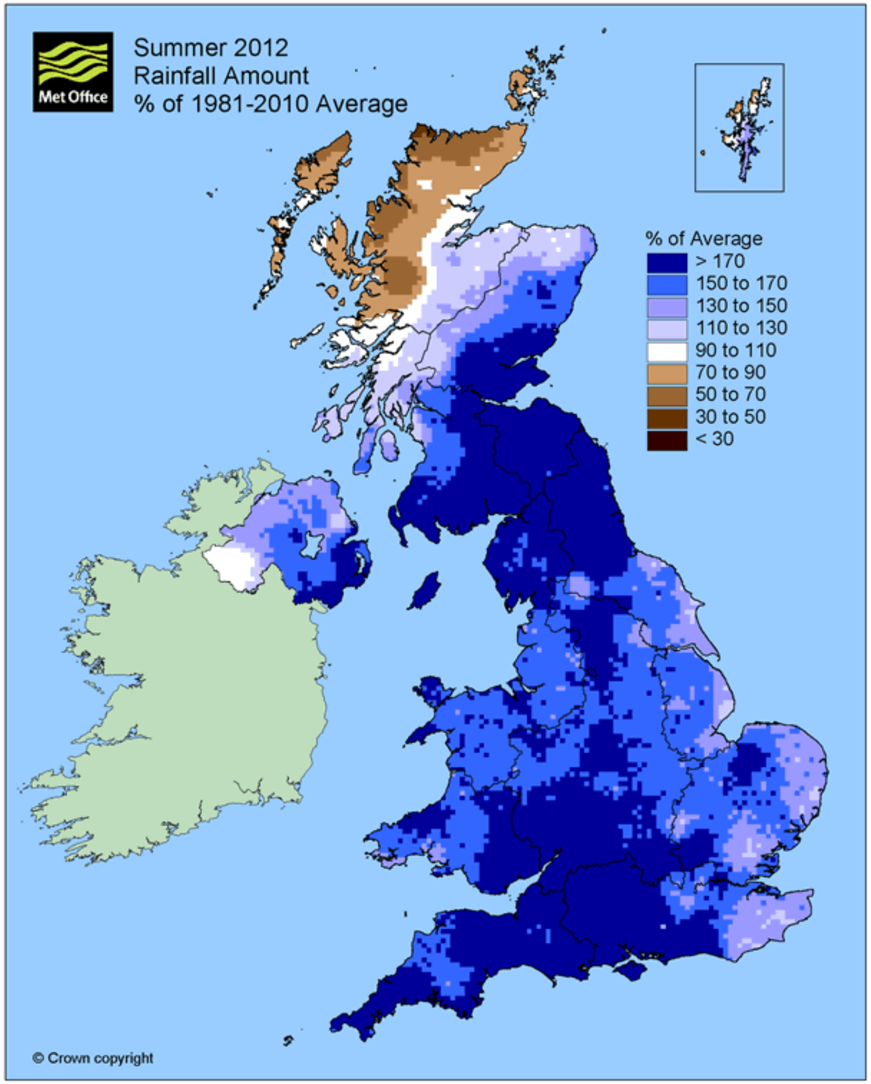
Widespread, inten

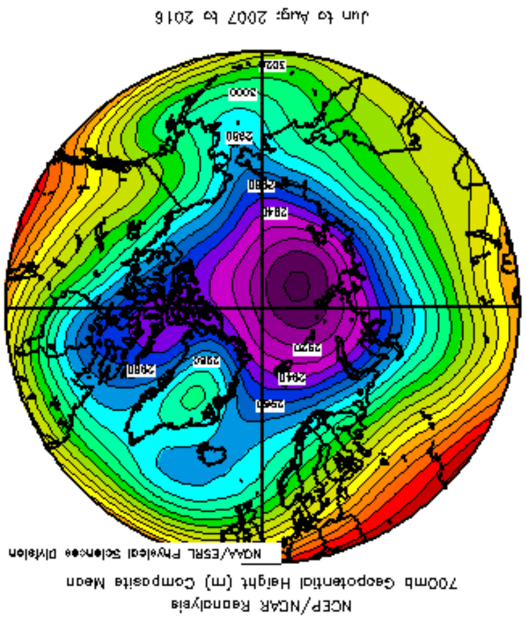


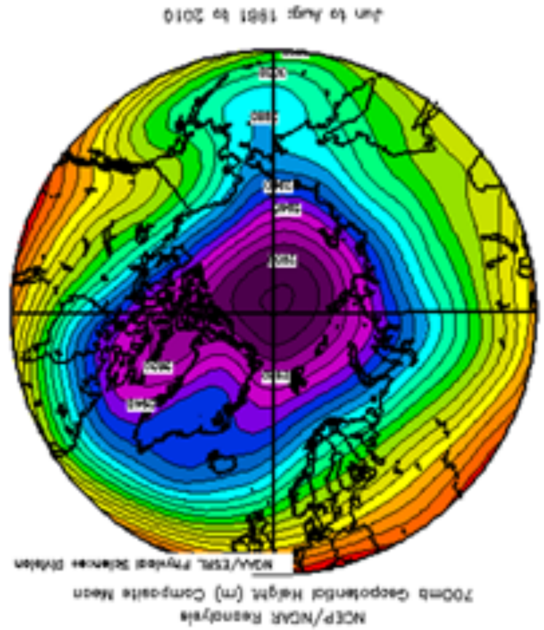
The Met Office confirmed that in 2012 England had its wettest year since records began in 1910

- 2012 was the second wettest UK year on record despite dry start
- Persistent low pressure systems particularly in summer
- Ground water now replenished throughout S. England
- A taste of things to come?

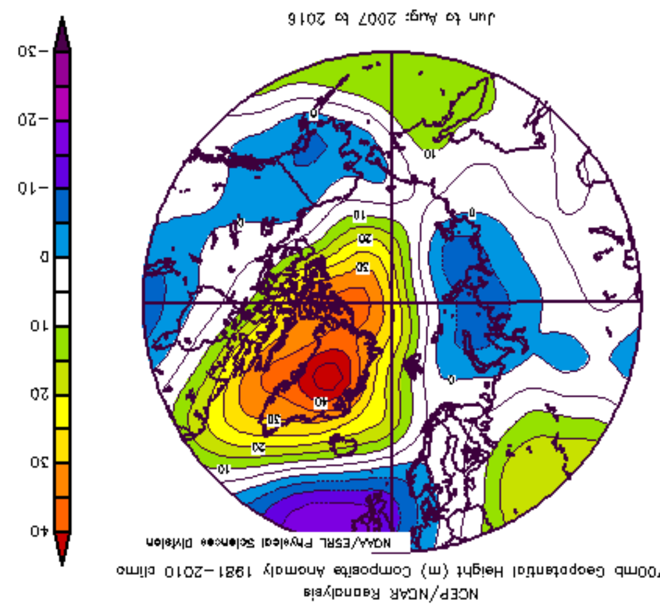
[from Geraint Vaughan RMetS talk, Manchester, February 2013]





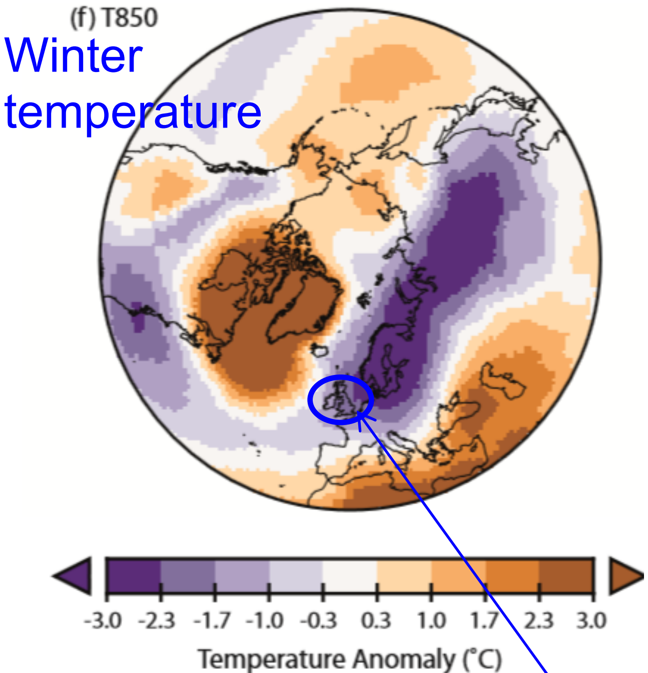


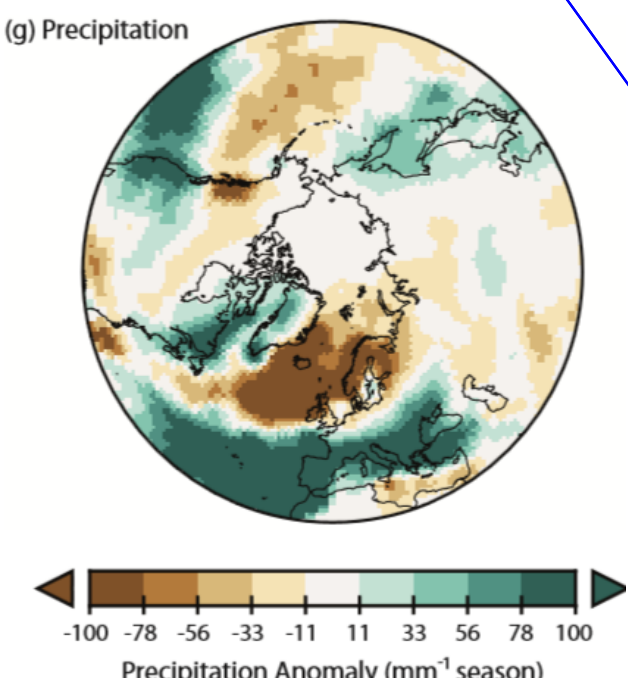
Recent anomaly



Big difference in **polar vortex** and jet-stream configuration in last 10 summers (2007-2016, left) compared with climatology (1981-2010, middle). Right shows difference between the two plots.

Units are metres of 700 mb geopotential height. Data are from the NCEP–NCAR Reanalysis through the NOAA/Earth Systems Research Laboratory.
Overland, Francis, Hanna, Wang (2012, Geophys. Res. Lett.), updated.

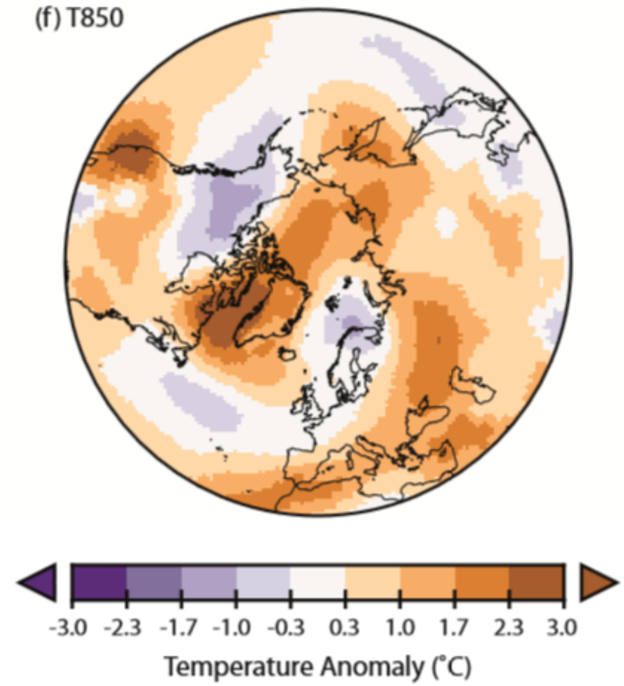


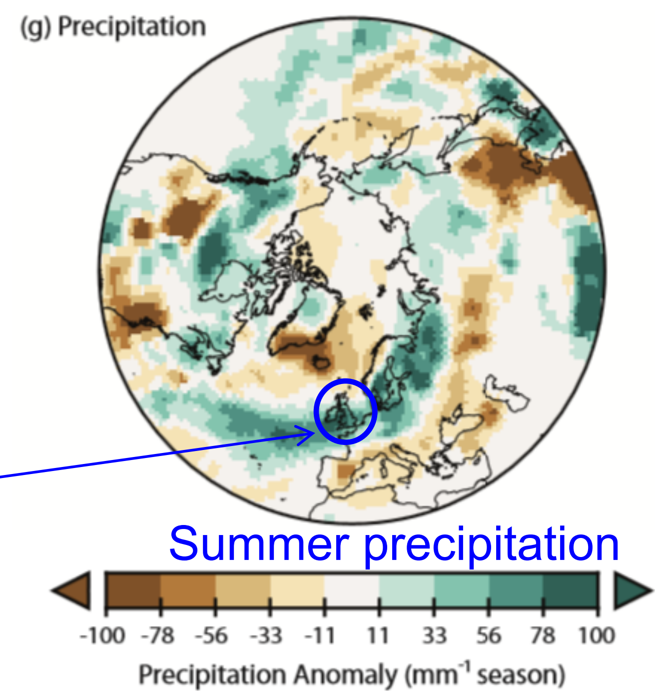


Greenland Blocking impacts on mid-latitude weather: *Near-surface temperature (top)* and *precipitation (bottom)* anomalies for **winter (left)** and **summer (right)** for 10 highest minus 10 lowest Greenland Blocking years during 1851-2015. Based on Twentieth Century Reanalysis v2c data.

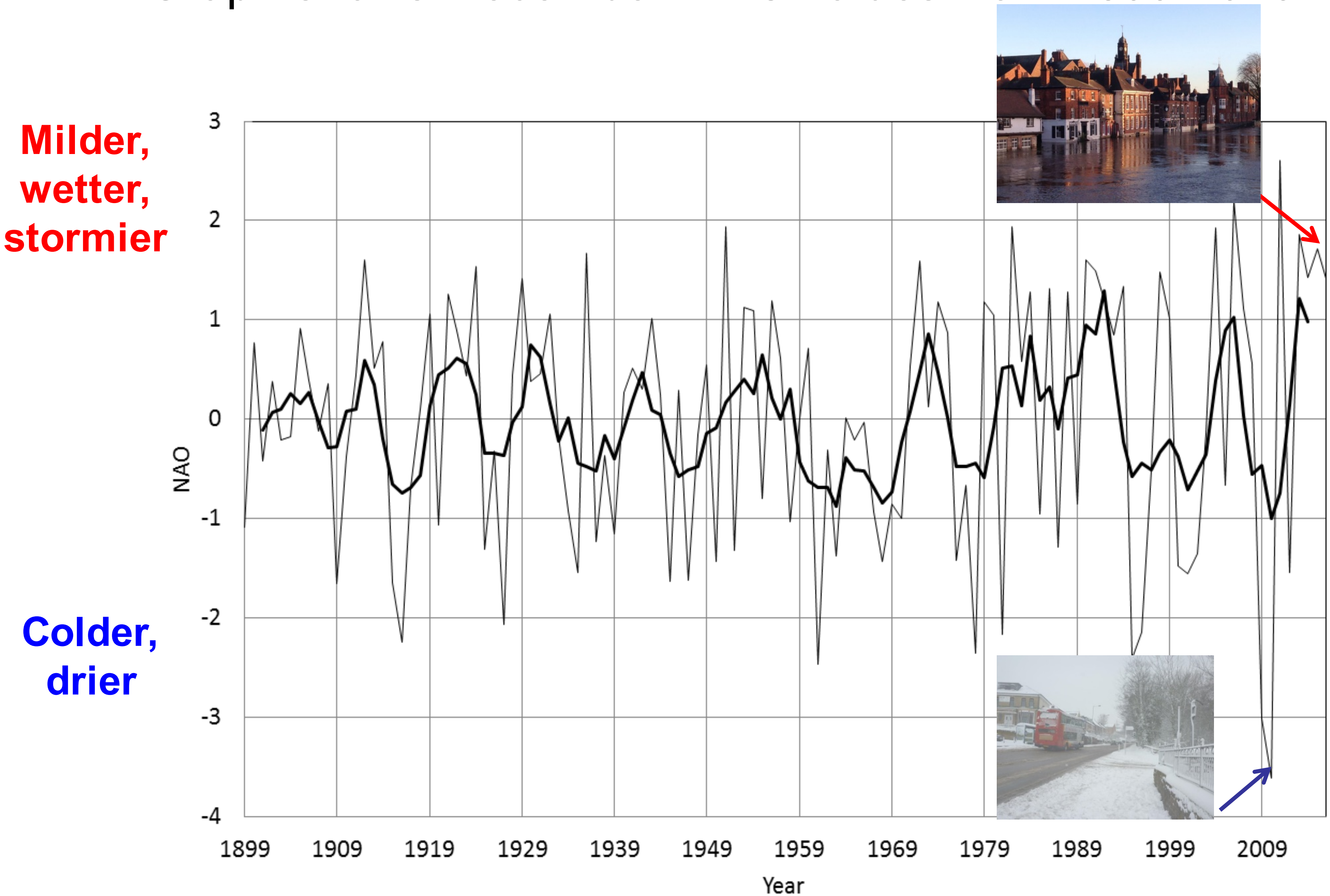
Note cold winters & wet summers over UK.

Hanna et al. (2016)





Hanna *et al*. (2015) *Int. J. Climatol.* Analysis of the North Atlantic Oscillation Index = strength of westerly winds reaching UK
Graph shows December NAO values from 1899-2016



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Winter weather is growing more extreme, say scientists

Changes in air pressure over the North Atlantic Ocean have seen five of the ten most extreme winters of the last century occuring in the past decade

The trend could be due to random fluctuations in the climate system but could equally be due to factors including changing pressure and weather systems over the Arctic Photo: ALAMY

British weather set to become more unsettled

Posted by The Watcher on September 10, 2014 in categories Climate change, Featured articles, Research

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Winters are 'more extreme' than ever

Britons should brace themselves for more extreme winters as weather conditions become more volatile, scientists have warned.

BRITONS should brace themselves for more extreme winters as weather conditions become more volatile, scientists have warned.

A study of seasonal records dating back to 1899 found while most seasons have not changed dramatically, winter has become much more unpredictable.

The results suggest the idea of a "typical" British winter is increasingly a myth, with wide swings from mild but stormy conditions like those which hit the UK this year to extremely cold temperatures and snow in another year becoming more common.

Researchers from the University of Sheffield, the University of East Anglia and the Met Office found seven out of the 10 most extreme winter conditions over the last 115 years have occurred in the last decade.

Published on the 09 September 2014 19:45

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British winters have been 'r last 10 years than in the las

Study finds fluctuations in mild and cold w

STEVE CONNOR | SCIENCE EDITOR | Tuesday 09 Septembe

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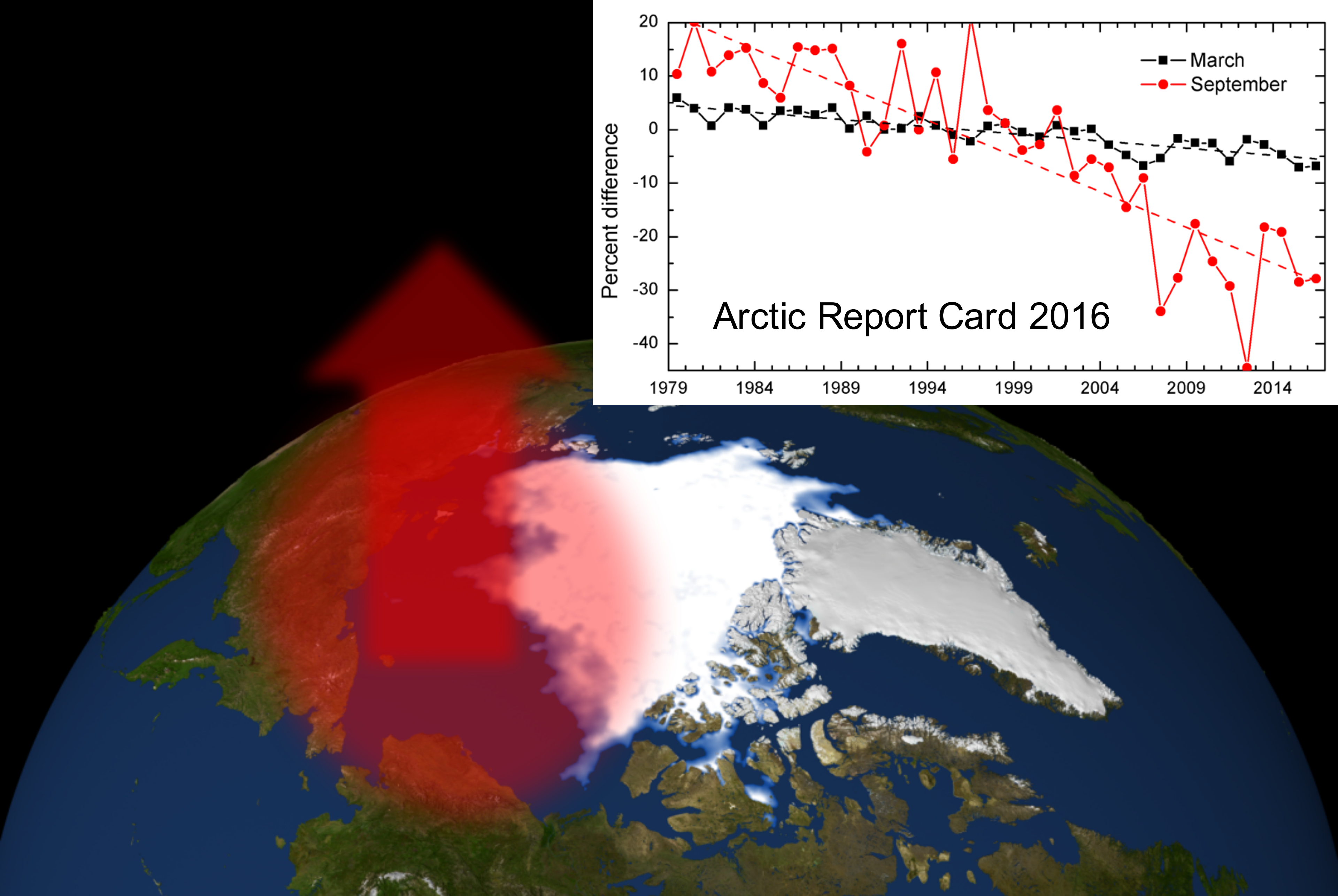
Scientists warn to expect more extreme weather

Britons should brace themselves for more extreme winters as weather conditions become more volatile, scientists from East Anglia and Sheffield have warned.



More Heat Release from Ocean from New Sea Ice Free Areas

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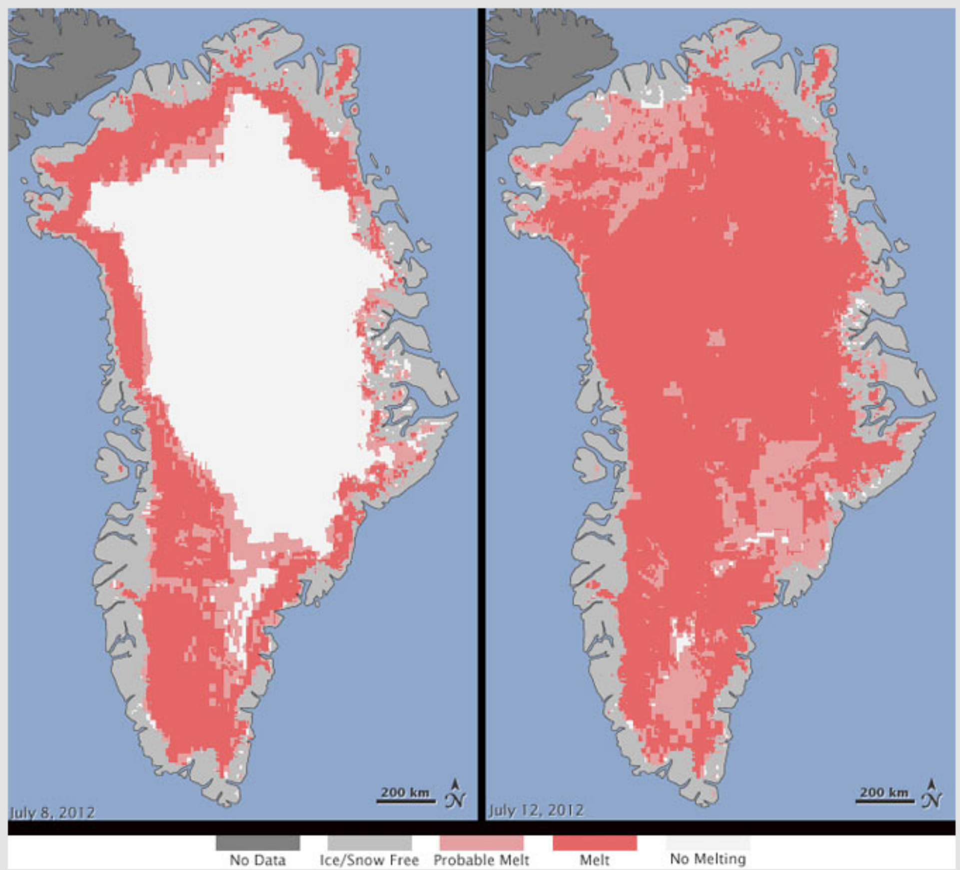
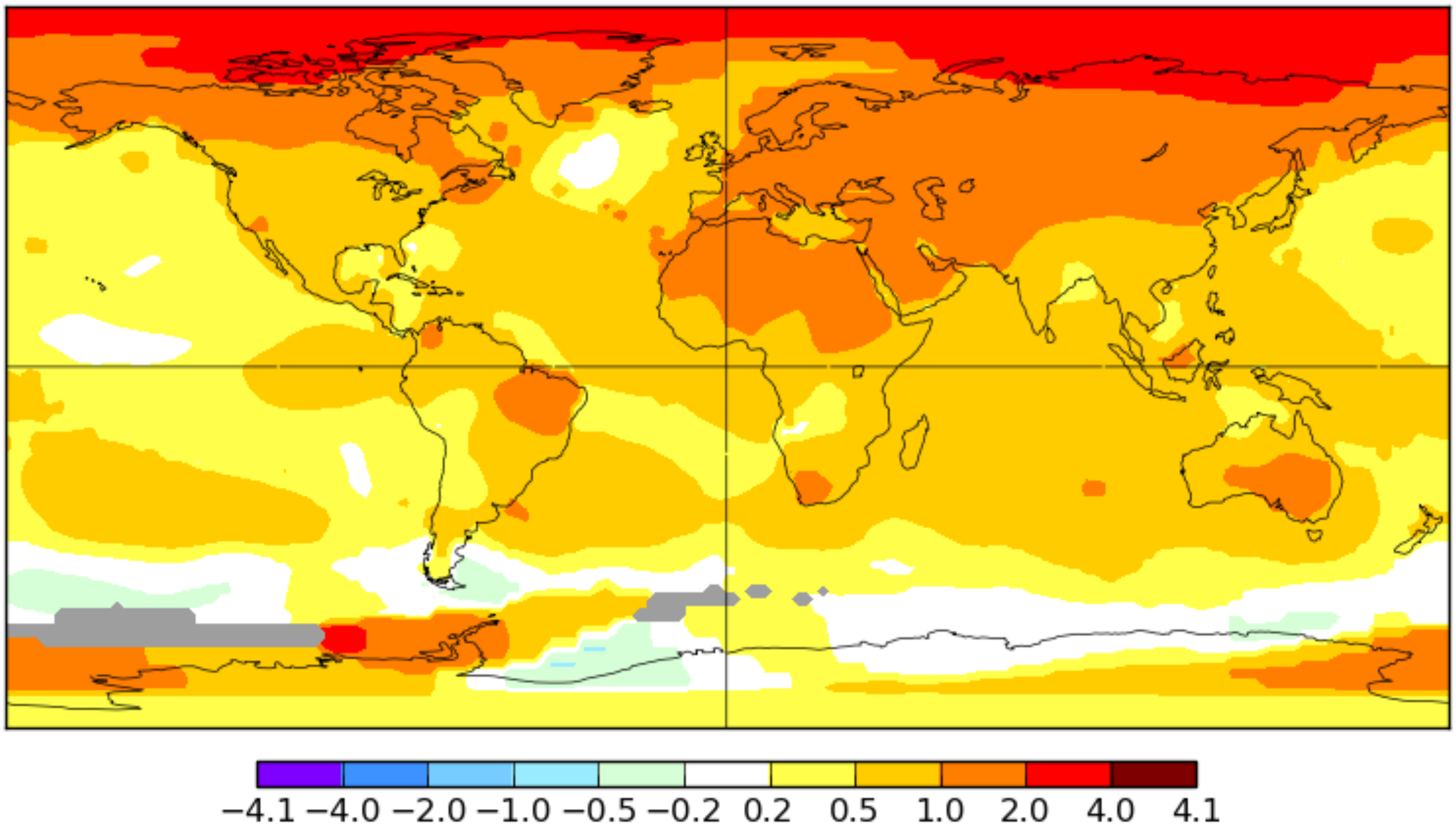
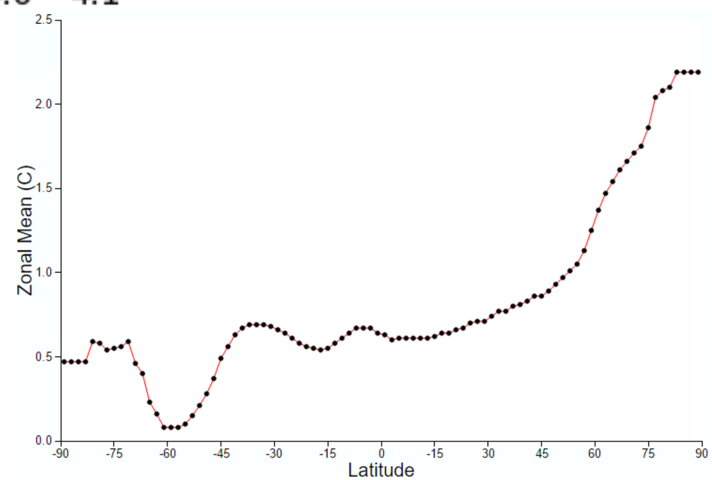


Extent of surface melt over Greenland's ice sheet on July 8 (left) and July 12 (right). Measurements from three satellites showed that on July 8, about 40 percent of the ice sheet had undergone thawing at or near the surface. In just a few days, the melting had dramatically accelerated and an estimated 97 percent of the ice sheet surface had thawed

Annual J-D 2007-2016 L-OTI(°C) Anomaly vs 1951-1980 0.70





http://data.giss.nasa.gov/gistemp/maps

Jim Hansen, NASA

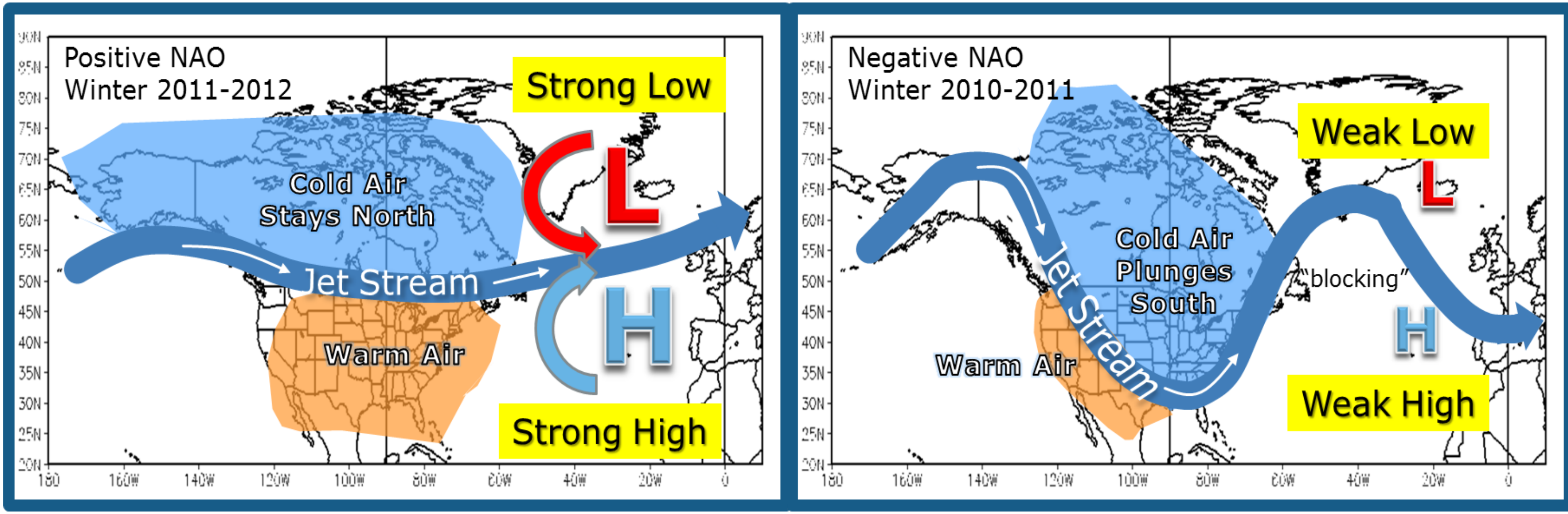
"Warm Arctic-Cold Continents" hypothesis (James E. Overland, NOAA)

We can say that loss of sea ice and snow adds additional heat to atmosphere, which pushes toward a greater chance for north<->south wind flow (Blocking patterns) and weaker, more persistent jet stream at mid-latitudes with recent "stuck" weather patterns and greater extremes: ***cold spells, heatwaves, flooding, prolonged snowfall, and drought***

BUT: it will not happen the same way in every year and location due to mid-latitude chaotic natural variability

Coarse resolution climate models do not capture Blocking Patterns very well

NAO is associated with Polar Front Jet



From National Weather Service Weather Forecast Office, http://www.srh.noaa.gov/hun/

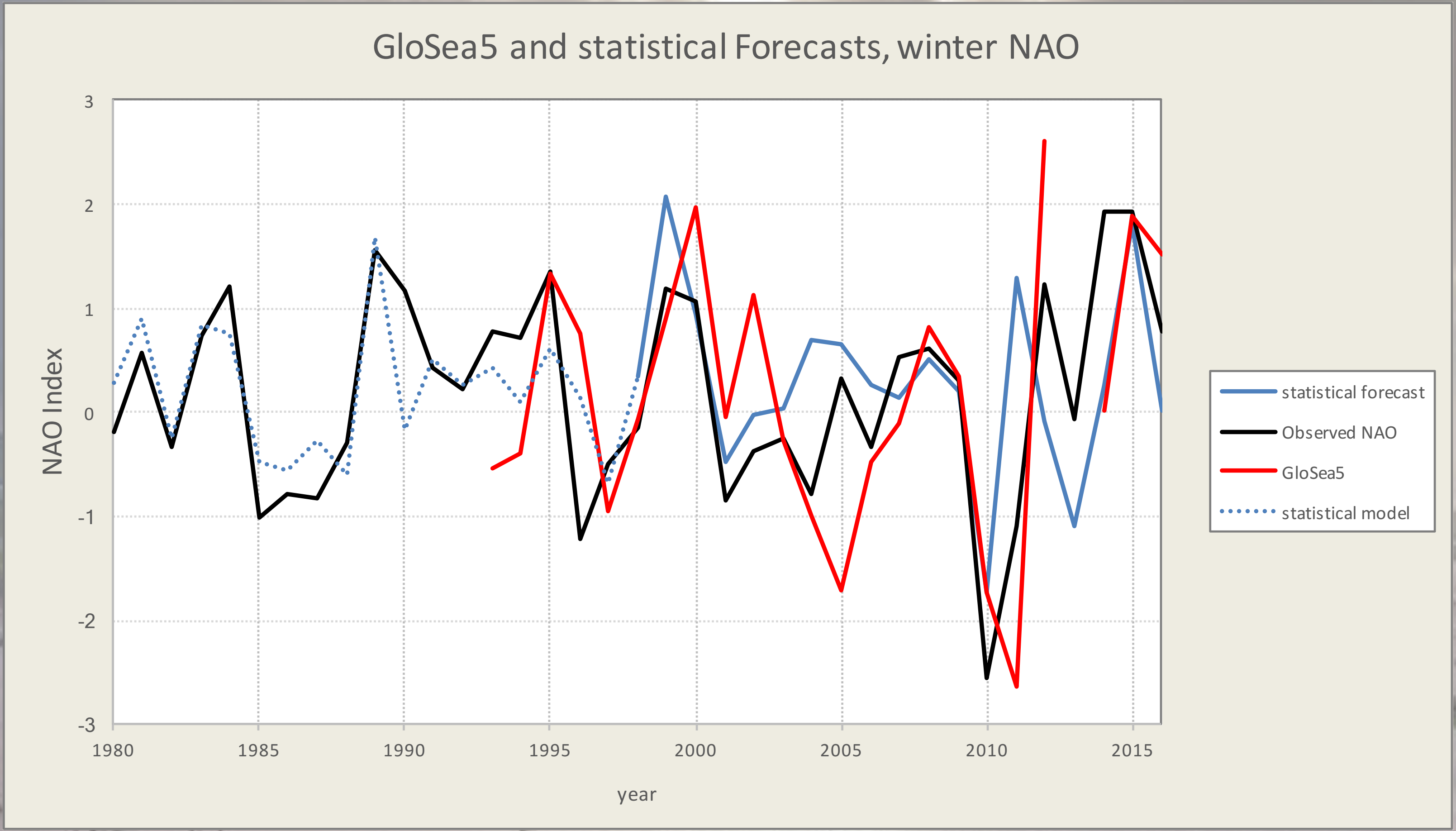
NAO response is due to latitudinal shifts in jet stream (Woollings, 2010). A positive NAO has a stronger south-north pressure gradient and stronger jet, shifted northwards. Winter sees milder, often wetter conditions over northern & central Europe + E. USA and cooler/drier over Mediterranean, E. Canada and Greenland. Summer jet stream further north so positive NAO gives sunny, warm weather in NW Europe/UK.

A negative NAO has weaker pressure gradient and more meandering jet, with opposite weather conditions to above, e.g. cold/dry in winter and wet/cool in summer in UK.

Forecasting the winter North Atlantic Oscillation

- NAO is the single most important factor in year to year seasonal weather fluctuations in NW Europe and Atlantic basin (Scaife et al., 2014)
- Positive NAO=mild, wet stormy weather, negative NAO =cold dry winters
- Met Office dynamical forecasting models have achieved a correlation skill of 0.62 for the winter NAO
- Potential benefits for winter planning: transport networks, power supply, flood preparedness.
- Skillful statistical forecasts of the NAO can help inform the next generation of dynamical models (Hall et al., 2017).
- Virtually no skill at present in dynamical forecasting of summer NAO, but statistical studies may identify sources of predictability (Hall et al., 2016)

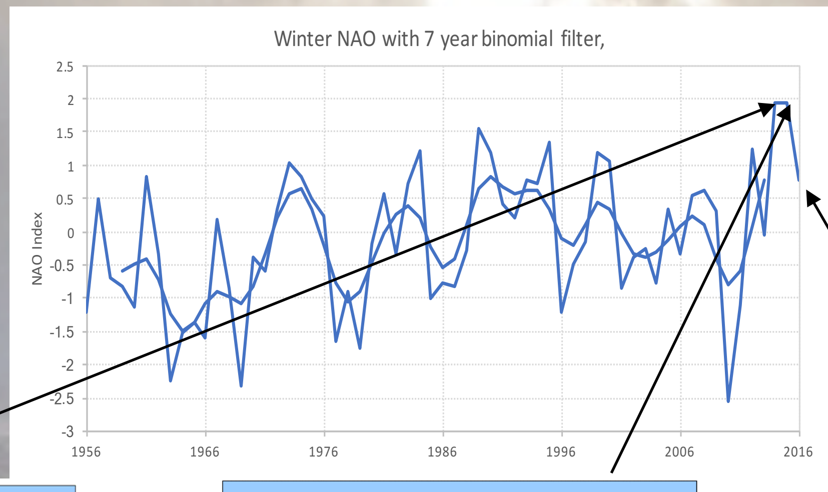
NAO Winter Forecast Skill



Correlation Skill Scores:
observations/GloSea5 (1993-2012): 0.61
observations/statistical forecast (1998-2016): 0.56
observations/statistical model (1980-1997): 0.71

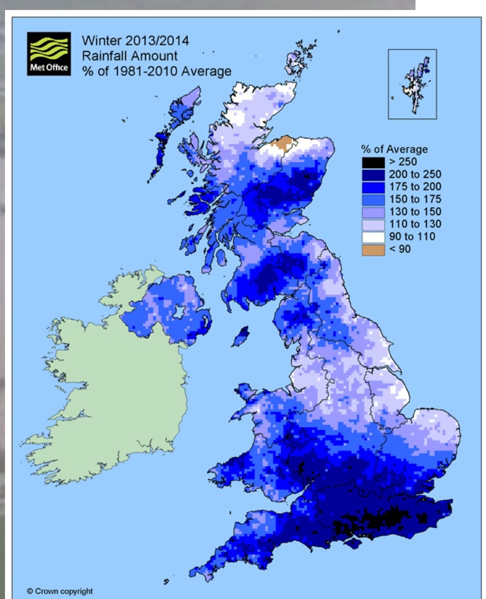
NAO variability and regional weather patterns

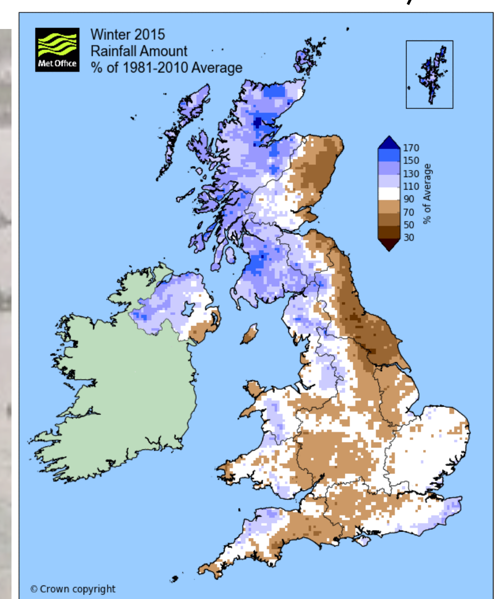
3 winters with positive NAO but different regional impacts

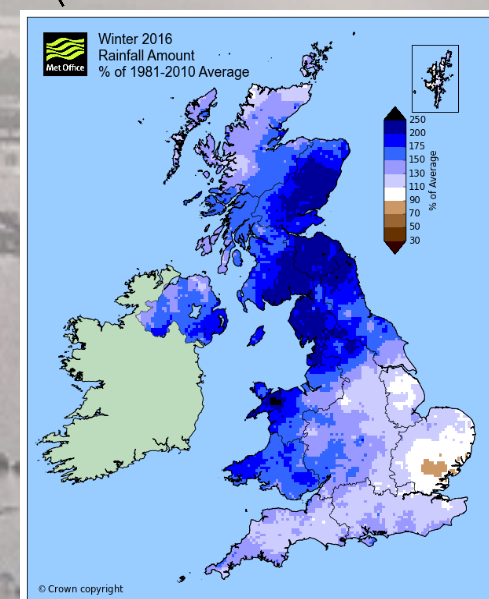


NAO Index does not give an adequate indicator of regional variations.

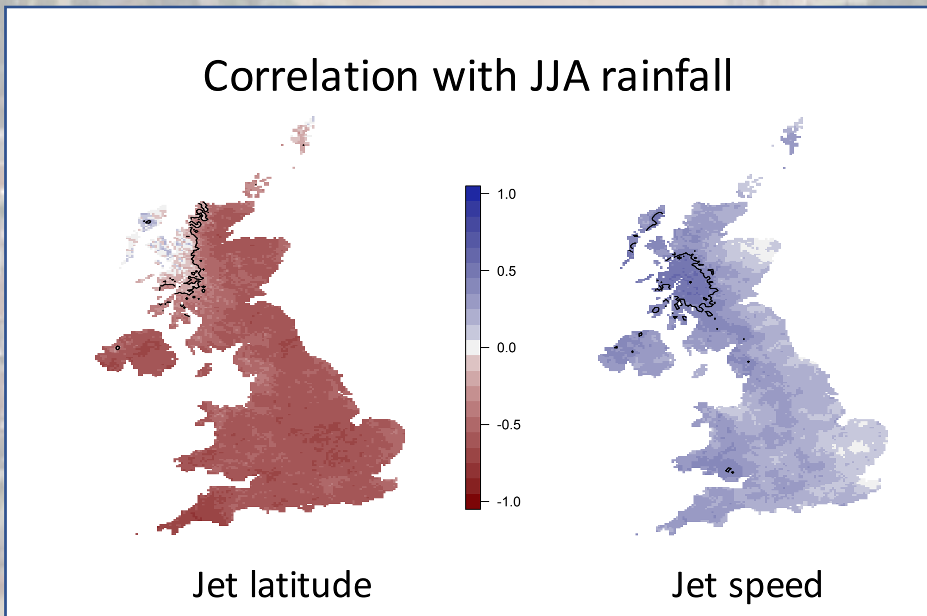
Potential for developing forecasts based on jet-stream variability that better represent regional variations

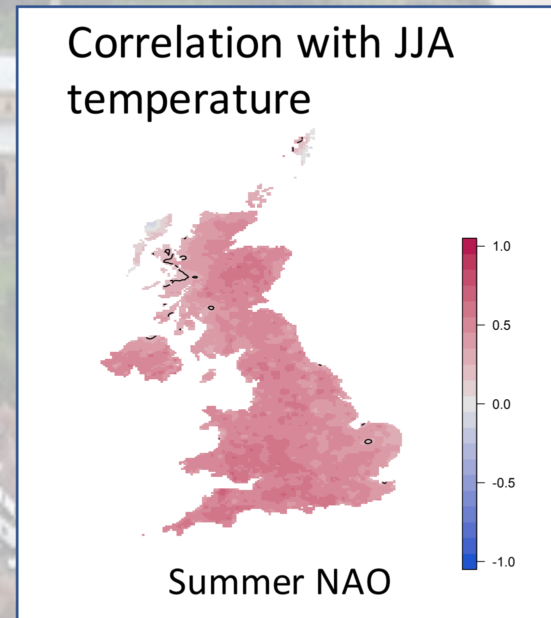






Summer variability and regional patterns





- Different indices are associated with temperature and rainfall in different regions
- Determining the predictability of these indices will enhance seasonal forecasting
- Research indicates that different drivers influence summer jet speed and latitude (Hall et al., 2016)
- Speed: Atlantic and tropical sea-surface temperature anomalies
- Latitude: Arctic sea-ice, solar variability

Summary

***Some recent observational evidence linking Arctic Amplification of global warming with North Atlantic jet stream changes since mid-2000s.**

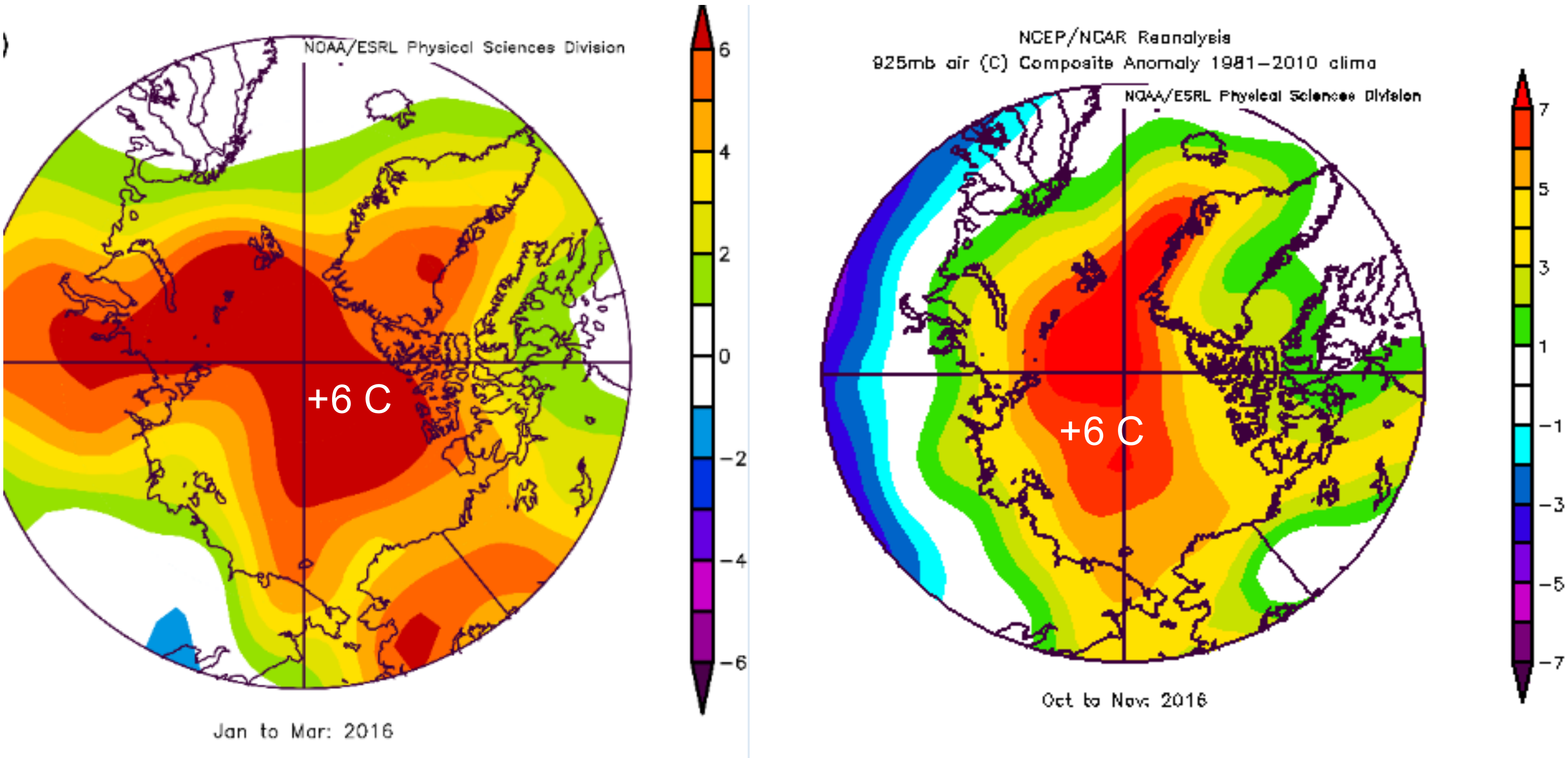
***Significant increase in blocking high pressure over Greenland in summer, associated with more frequent occurrence of low pressure (wetter!) over UK.**

***North Atlantic jet stream has become significantly more variable in December, with more variable year-to-year UK winter weather conditions in last decade. This may be due to destabilisation of early winter jet stream arising from large autumn sea-ice losses and increased ocean->atmosphere heat flux in recent years.**

***However, Linkages science is far from settled, especially given short observational period of recent Arctic Amplification. Weather Linkages have intermittent, non-linear connections - and climate-model projections give inconsistent results regarding North Atlantic jet stream changes by 2100.**

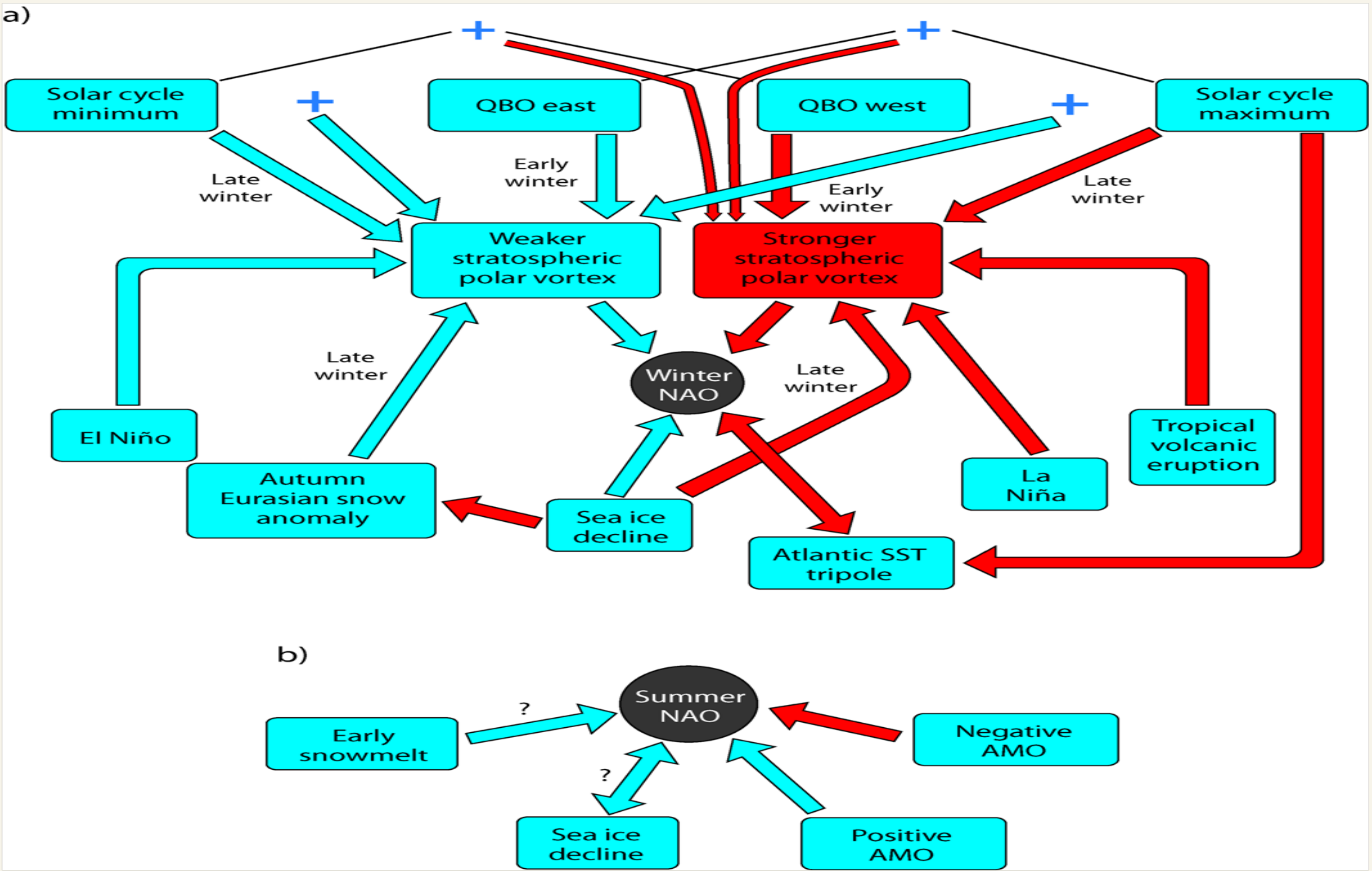
***Probabilistic statistical forecasts show clear potential for improving UK seasonal weather forecasts with continued increase in Arctic external forcing and other possible jet-stream drivers. We have recently published some promising results from work with Met Office.**


The end – thank you –
questions?



Back-to-Back Record Warm Arctic Temperatures Fall/Winter 2015-16 and 2016-17

Multiple external forcing and internal processes affecting North Atlantic polar jet stream/NAO (Richard Hall)



Nonlinear Limitations:

No one-to-one cause and effect!

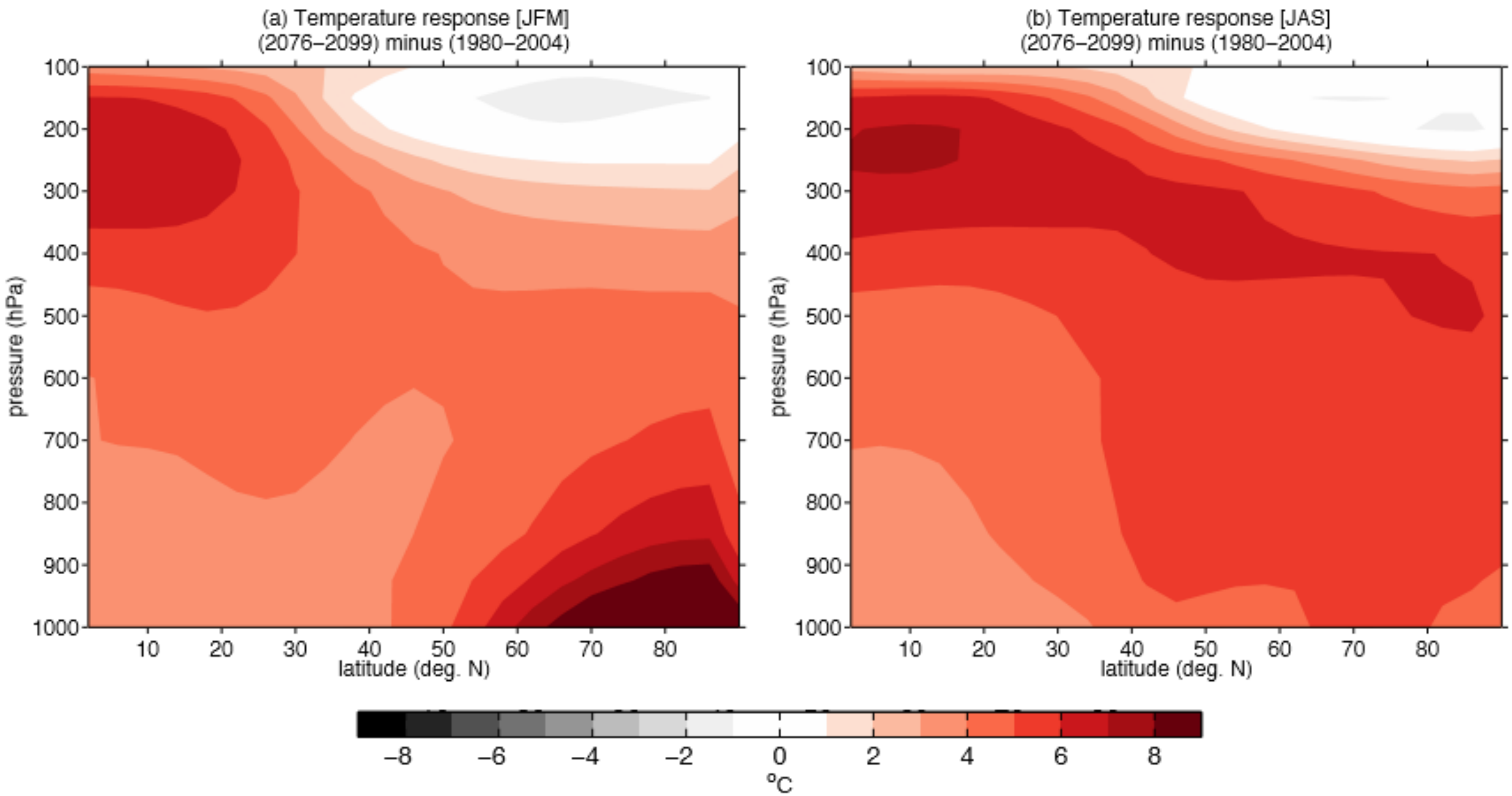
Itinerant shifts in jet stream (e.g. zonal->wavy) may be amplified by Arctic warming.

Intermittency/State Dependency

A certain jet-stream pattern may not always arise due to the same (e.g. Arctic) forcing or may arise due to different combinations of forcings. State dependence is influence of pre-existing surface heat flux anomalies on jet-stream & blocking patterns.

Multiple Regional Influences

The horizontal and vertical pattern of projected warming. Zonal-mean, multi-model mean air temperature response (shading) between 2099-2076 and 1980- 2004 under RCP8.5 for 21 CMIP5 4 models for winter (a; JFM) and summer (b; JAS). **Projected temperature changes have opposite upper and lower gradients.**



Barnes & Screen (2015)