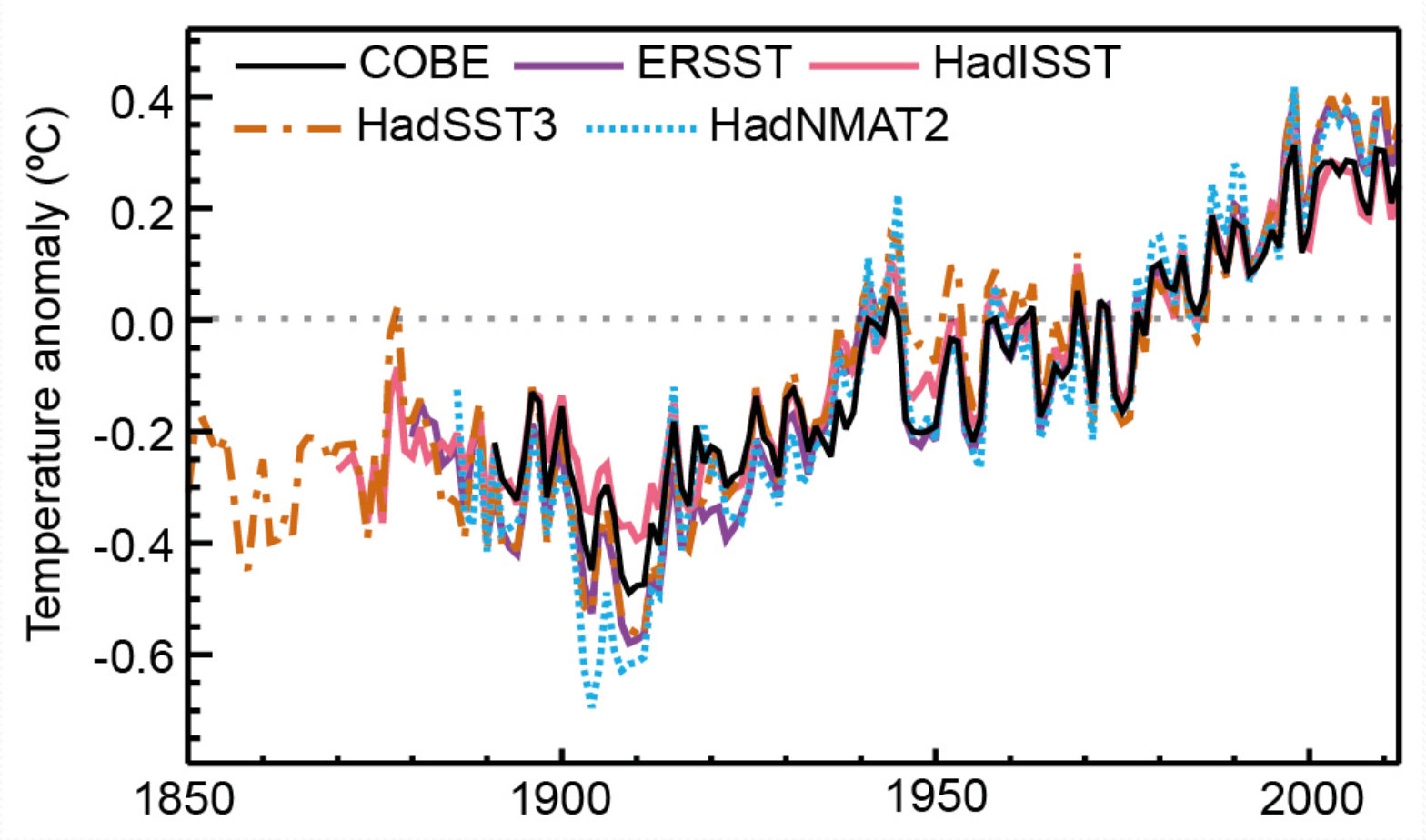
The influence of atmospheric circulation on marine air temperature

By Jonathan Harrison, Elizabeth C. Kent and David Berry

Marine surface temperature variability



Main aims:

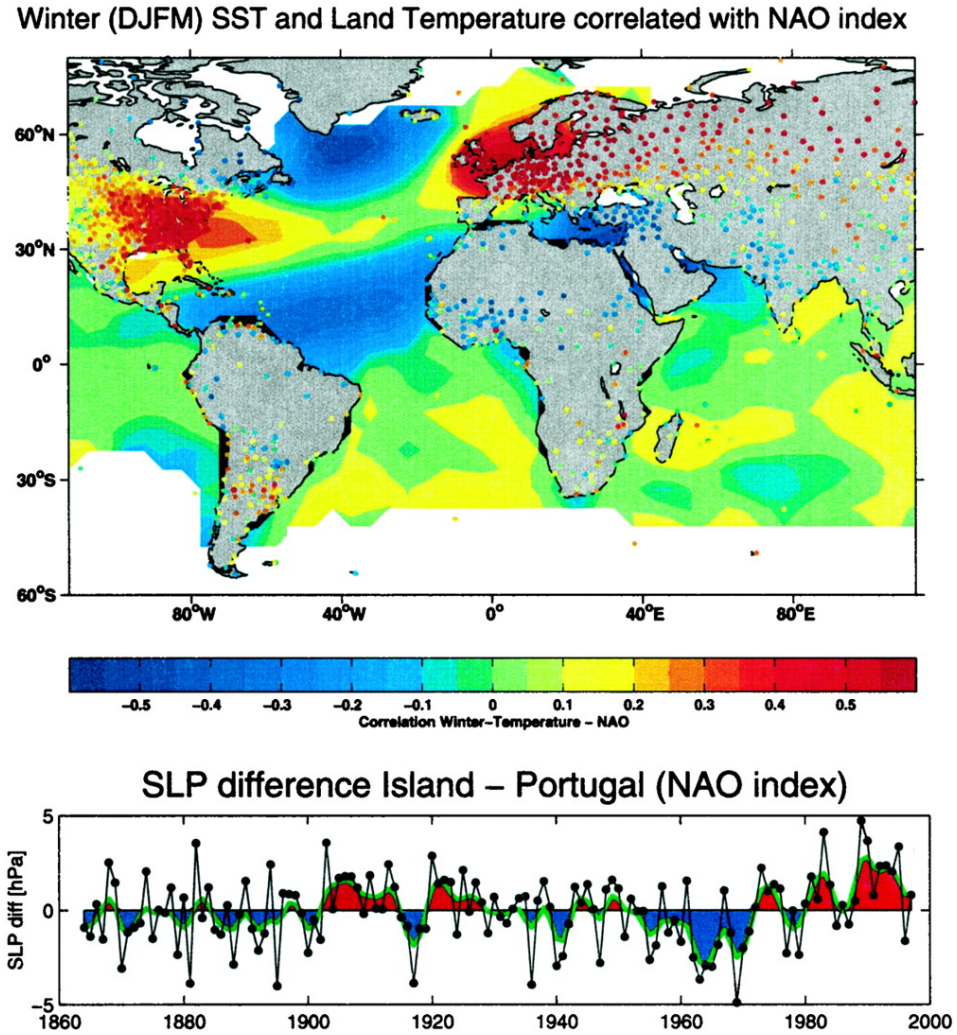
- What causes the variability seen in the marine temperature record?
- What can we learn by identifying the causes?

- **The importance of atmospheric circulation**
  - **Why look at atmospheric circulation patterns?**
  - **Can we use techniques developed over land in marine areas?**

- **Developing a new comparison to marine air temperature**
  - **Defining atmospheric circulation patterns.**
  - **Relating atmospheric circulation to temperature variability.**
  - **Developing a flexible approach to look at temperature/ atmospheric circulation relationships.**

- **Results for the Eastern North Atlantic**
  - **Marine air temperature comparisons.**
  - **Past temperature variability from 1880-2010.**

Spatial correlation map of mean winter (DJFM) station temperature and sea surface temperature (SST) correlated against the NAO index (Lower).



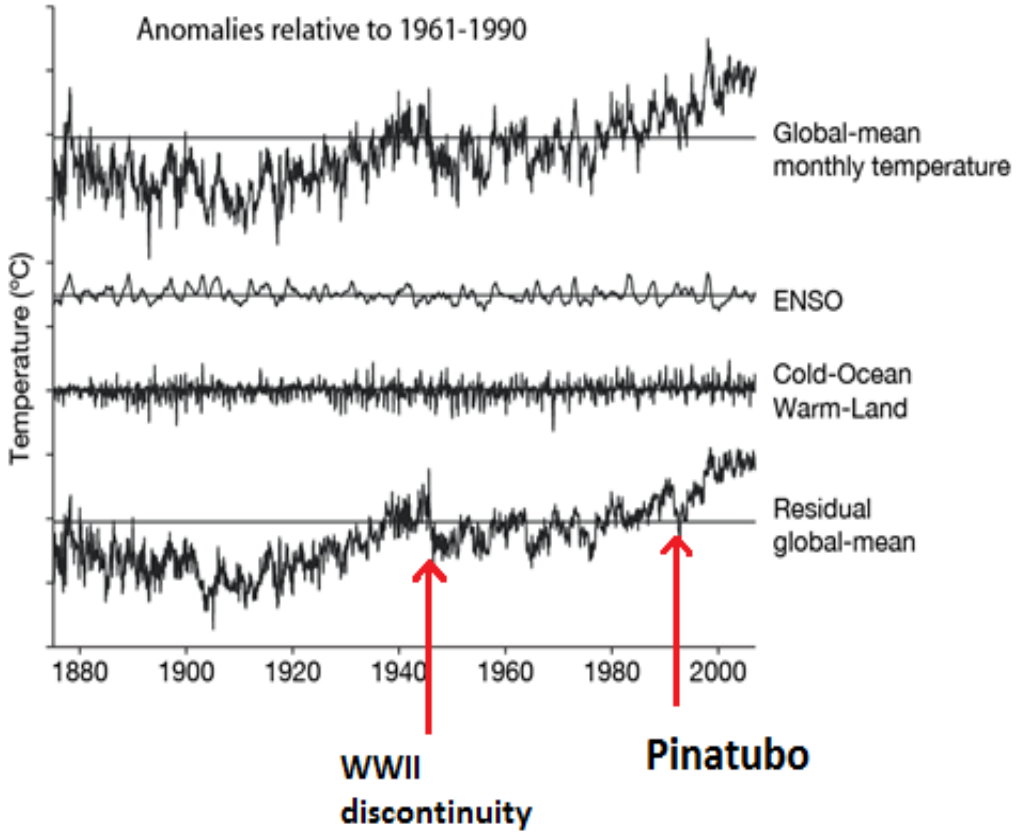
Martin H. Visbeck et al. PNAS 2001;98:12876-12877

Global mean surface temperature (Land + ocean)

nature Vol 453|29 May 2008 |doi:10.1038/nature06982

A large discontinuity in the mid-twentieth century in observed global-mean surface temperature

David W. J. Thompson[1], John J. Kennedy[2], John M. Wallace[3] & Phil D. Jones[4]



Global mean temp.

-

ENSO

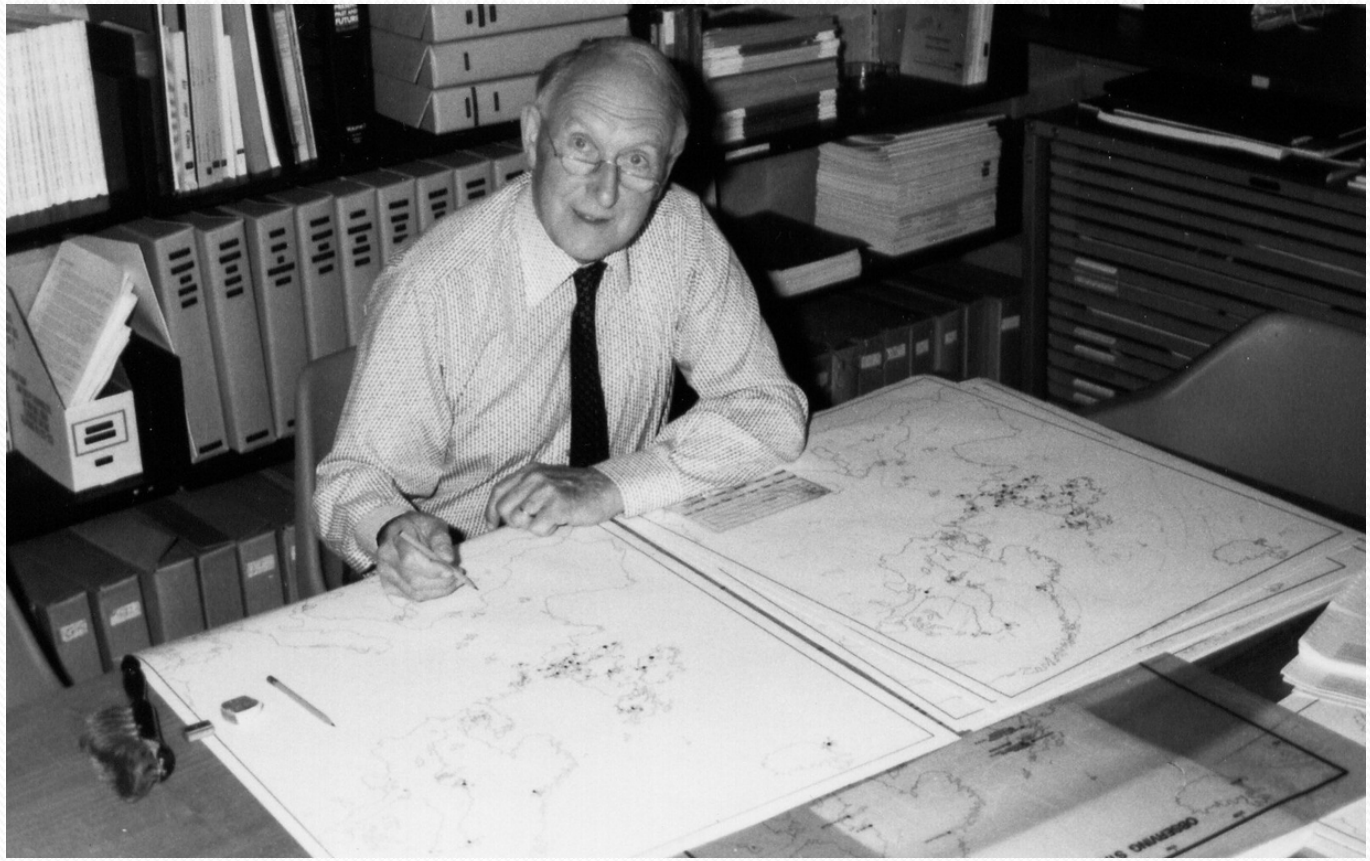
-

N. Hemisphere atmospheric circ^{n}

=

residual effects

Atmospheric circulation research



- Hubert Lamb looked at how small-scale atmospheric circulation influences UK climate in detail.
- His method has not been applied over the oceans.

- The importance of atmospheric circulation
  - Why look at atmospheric circulation patterns?
  - Can we use techniques developed over land in marine areas?

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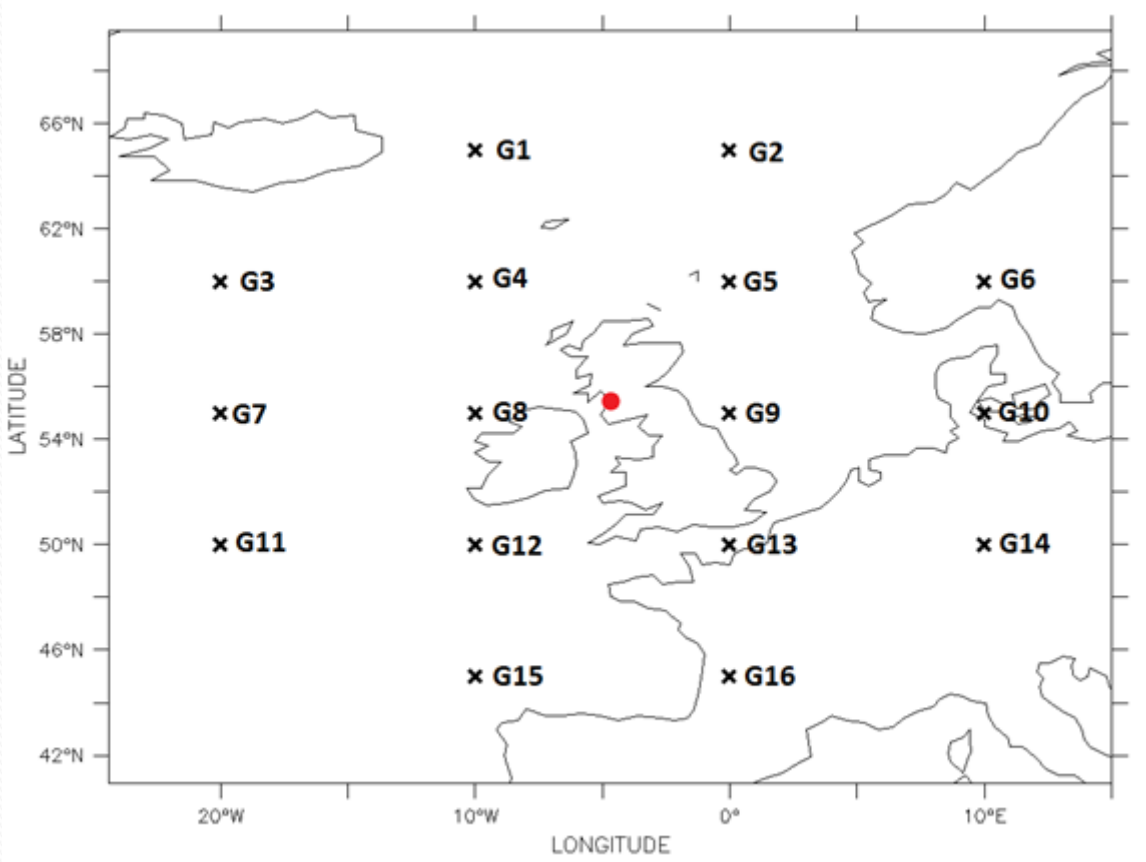
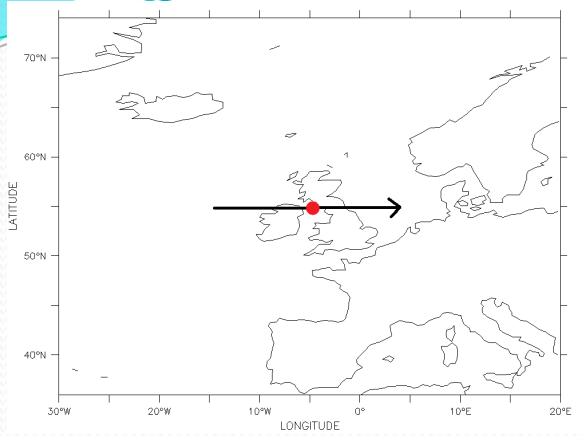
Defining atmospheric circulation



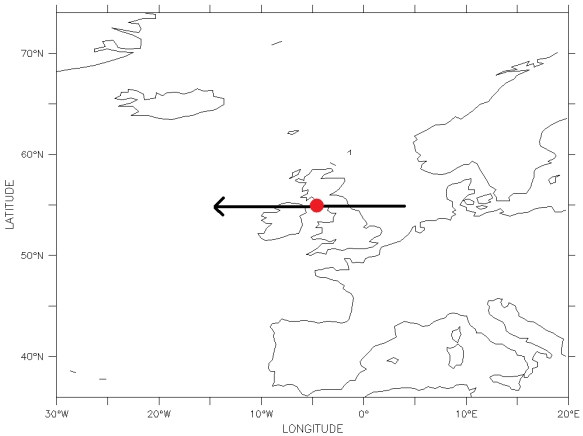
Jones et al (2013)

- These 16 grid points are used to define atmospheric circulation.
- SLP gradients can be used to calculate flow direction and rotation (curl of the flow).

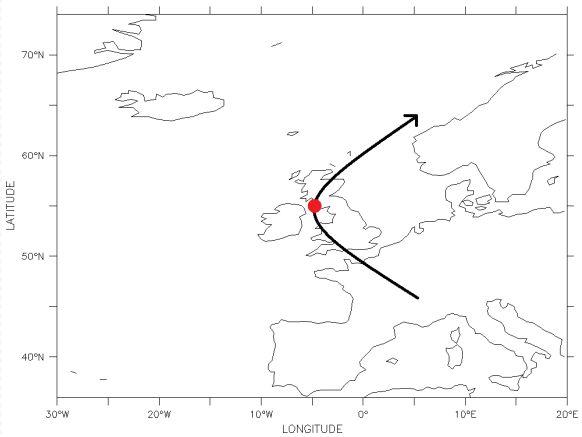
Combining the flow parameters



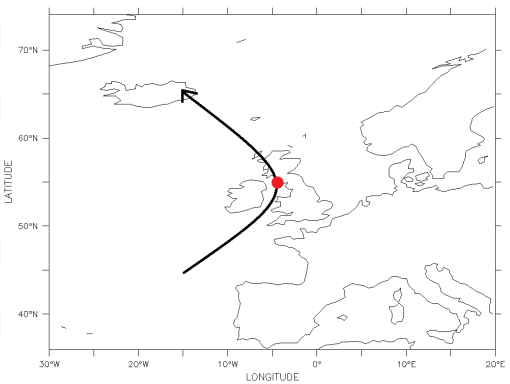
Flow direction = 270°
Flow rotation = 0.0



Flow direction = 90°
Flow rotation = 0.0



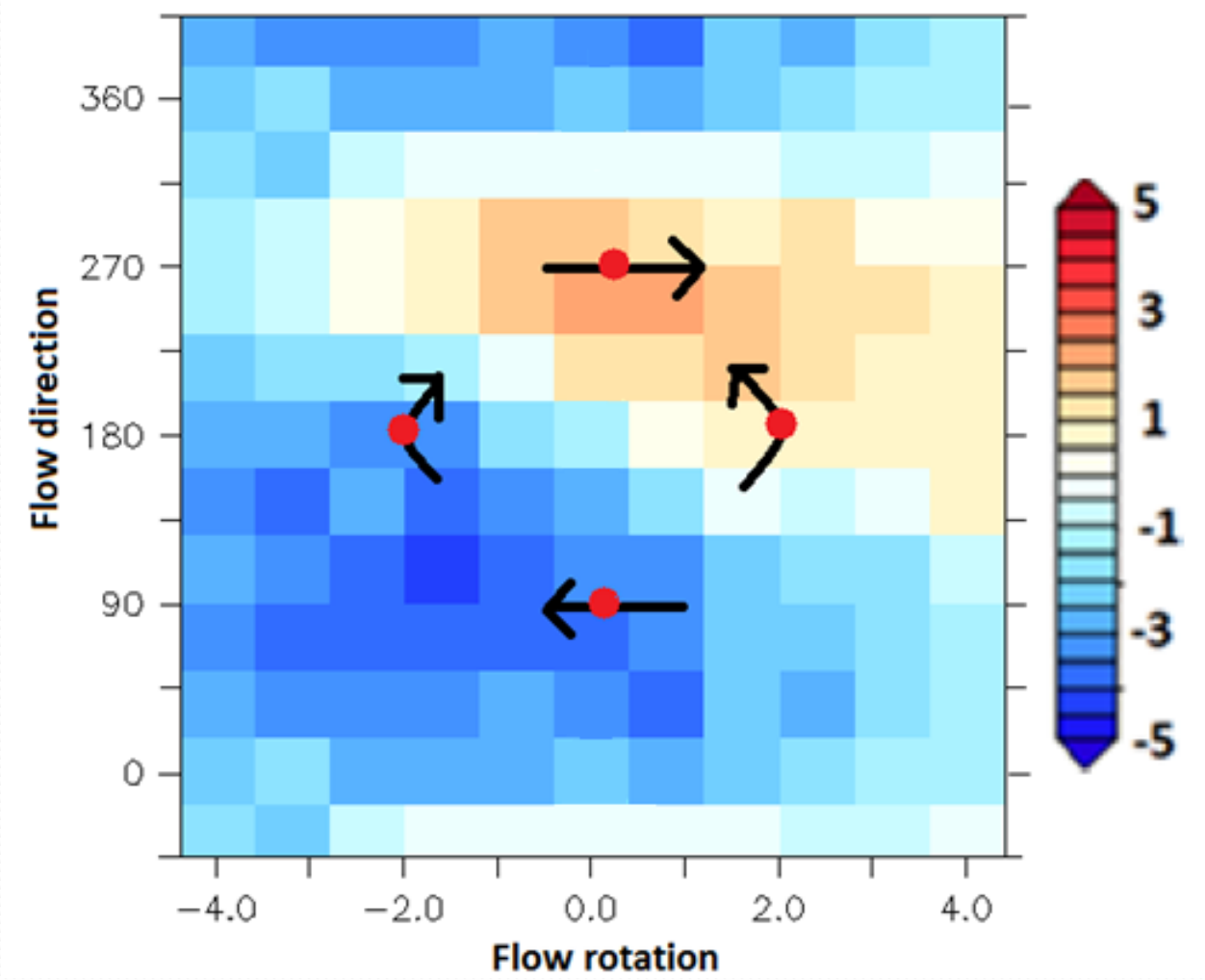
Flow direction = 180°
Flow rotation = -2.0



Flow direction = 180°
Flow rotation = +2.0

- Combining flow direction and rotation observations can help us determine the source of an air mass.

Relating atmospheric circulation to temperature anomalies



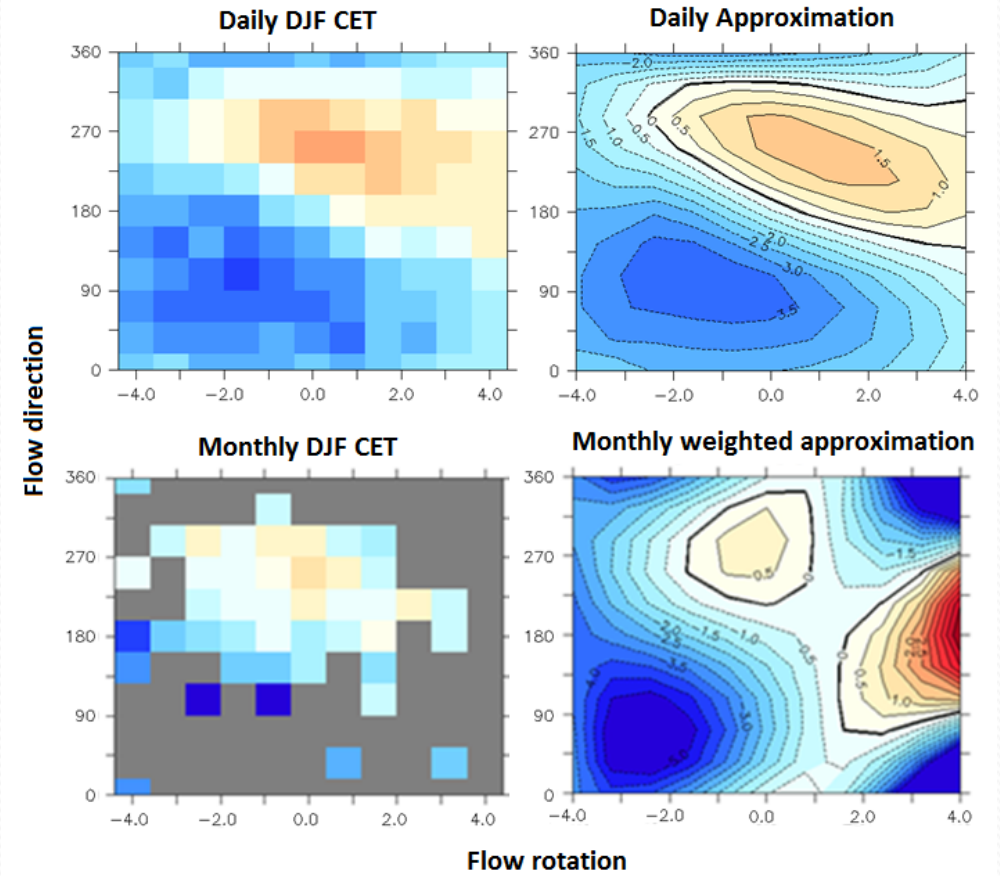
Daily winter (Dec –Feb) Central England Temperature anomalies from 1981-2010 climatological average

Jones et al (2014)

Developing a flexible approach

- CET series is the longest daily temperature record in the world and climate is highly variable.
- We want a more flexible approach if we are to use relationships over the oceans to predict temperature.

Relationships at monthly timescales

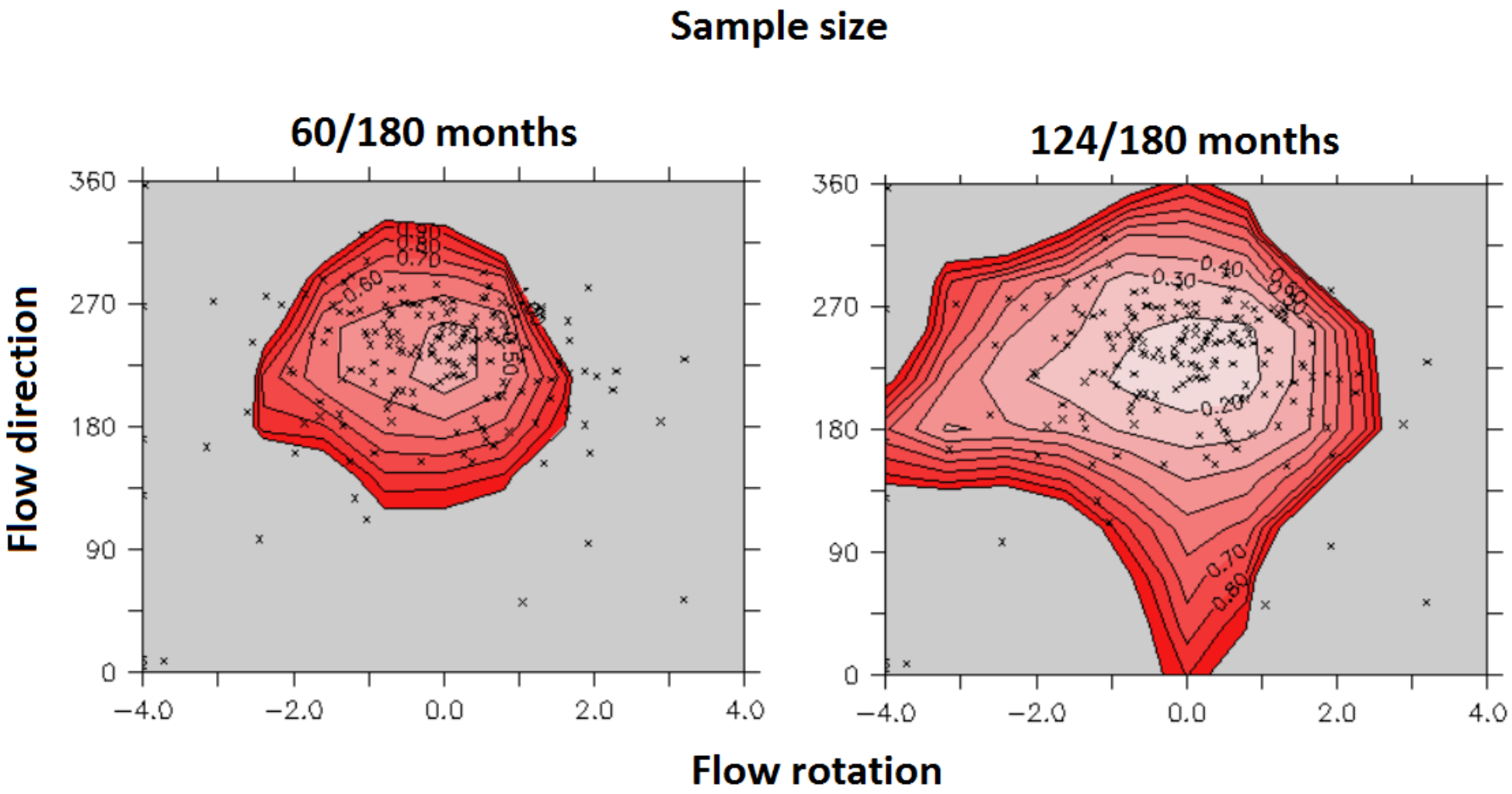


Training period 1871-2012
12000+ days used

Training period 1951-2010
180 months used

- Approximations from using a bicubic spline.
- We can still predict temperature from the mid 19th century onwards using SLP but we need to move outside the training period.

Estimating uncertainties



- Ensembles generated by subsampling the data.
- Uncertainties calculated by taking the standard deviation of 50 realisations.
- Uncertainties greater then 1^{o}C are highlighted in grey.

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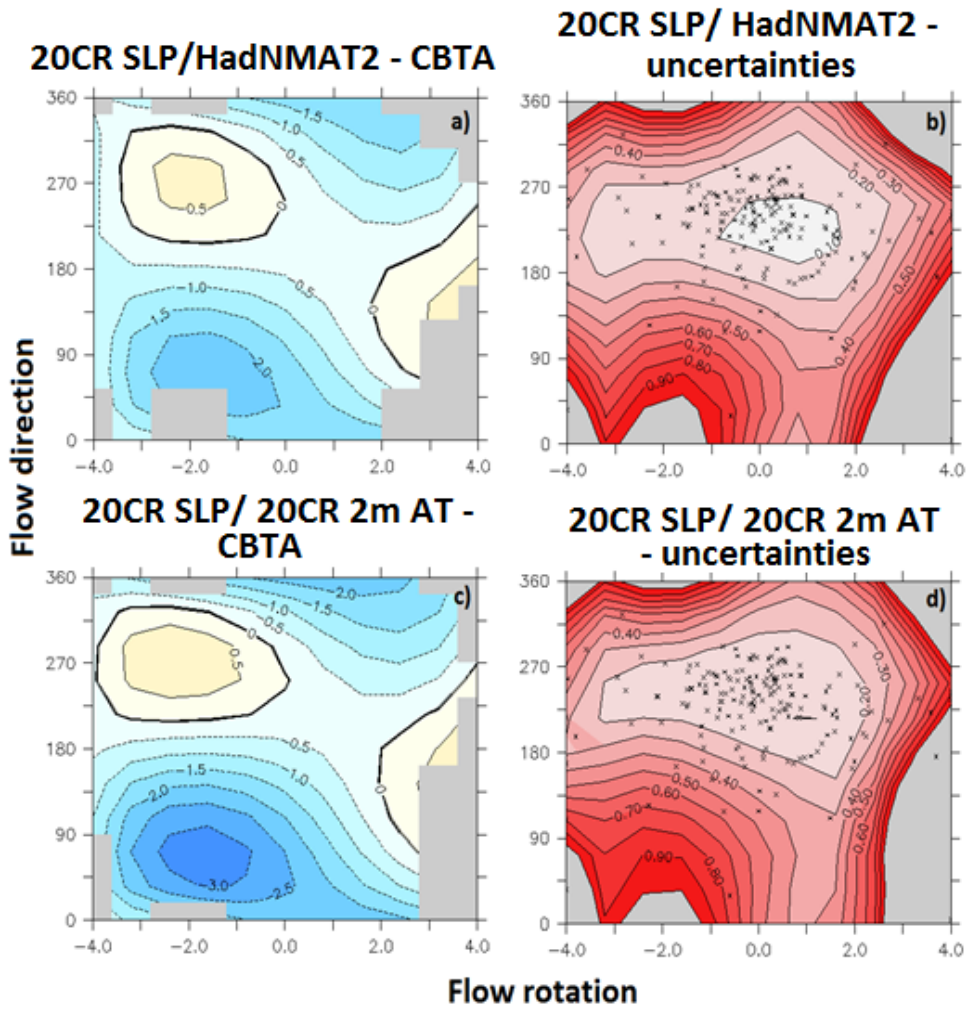
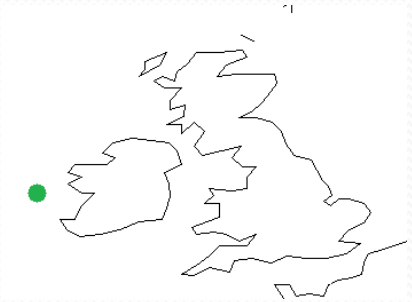
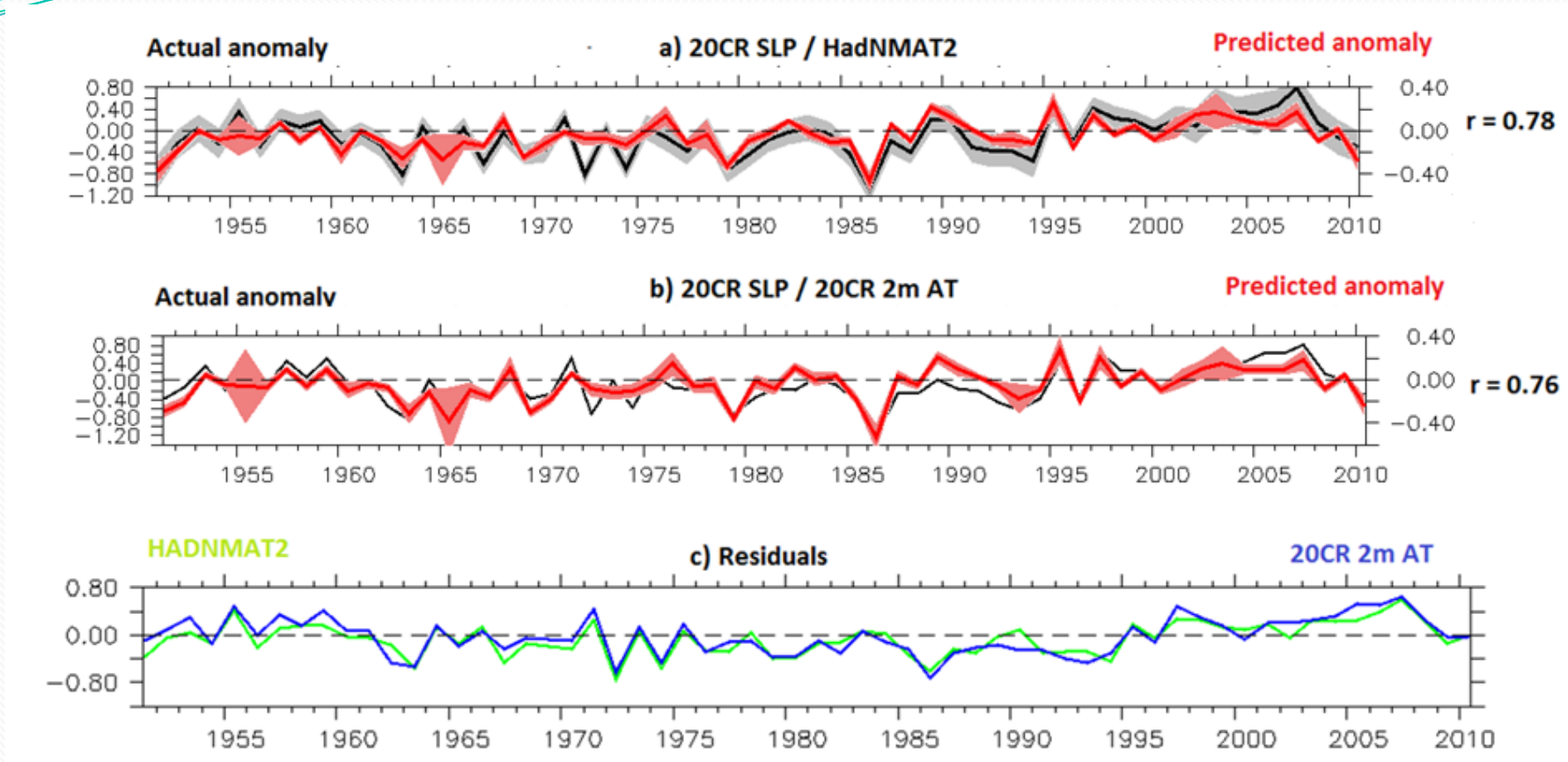
Results: Does the reanalysis show the same temperature relationship as observations?



- Plot for January training period 1951-2010.
- Grey areas represent uncertainties greater then 1°C.

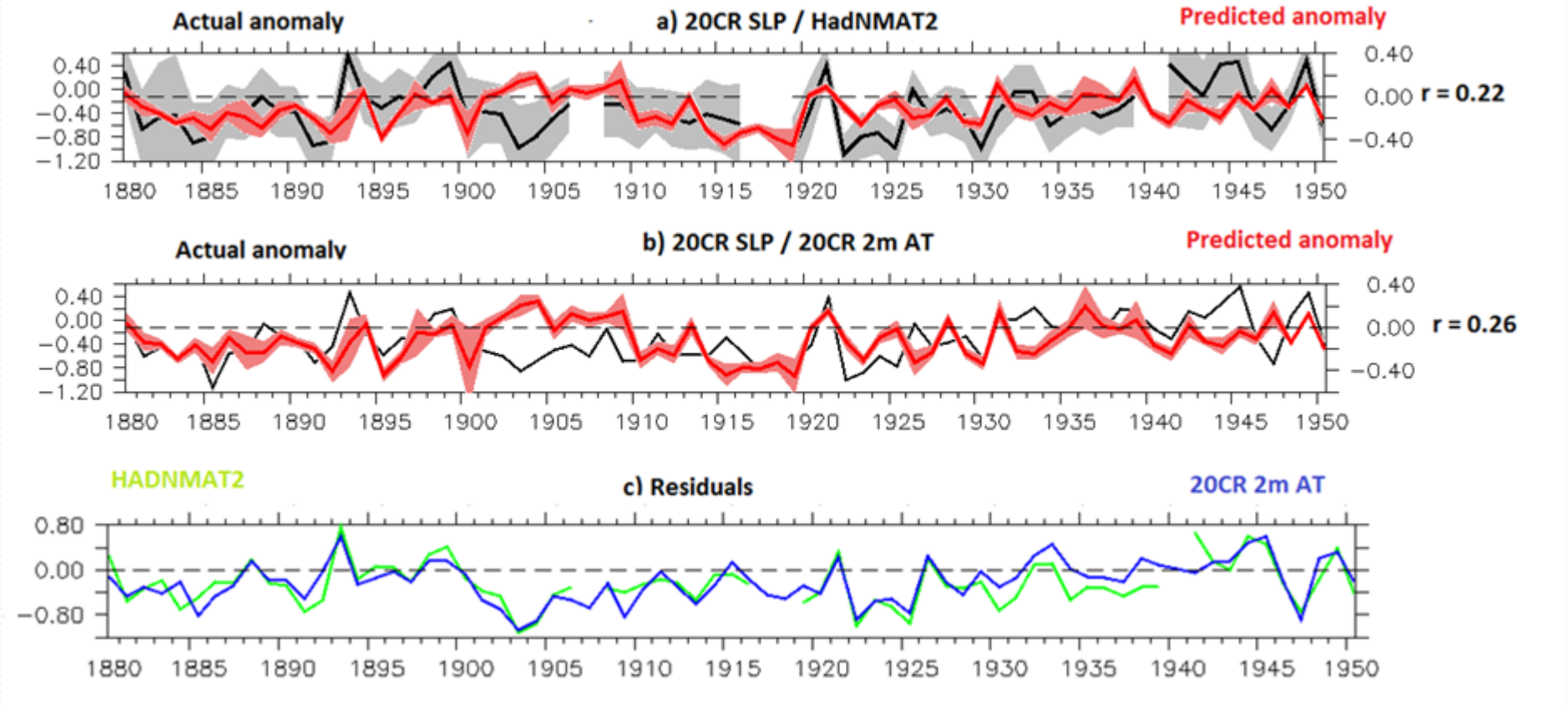


Air temperature anomalies driven by reanalysis pressure



- HadNMAT2 and 20CR 2 metre air temperature in good agreement.
- Predicted and annual observed temperatures strongly correlated but predicted series has half the amplitude.

Relationships outside the training period

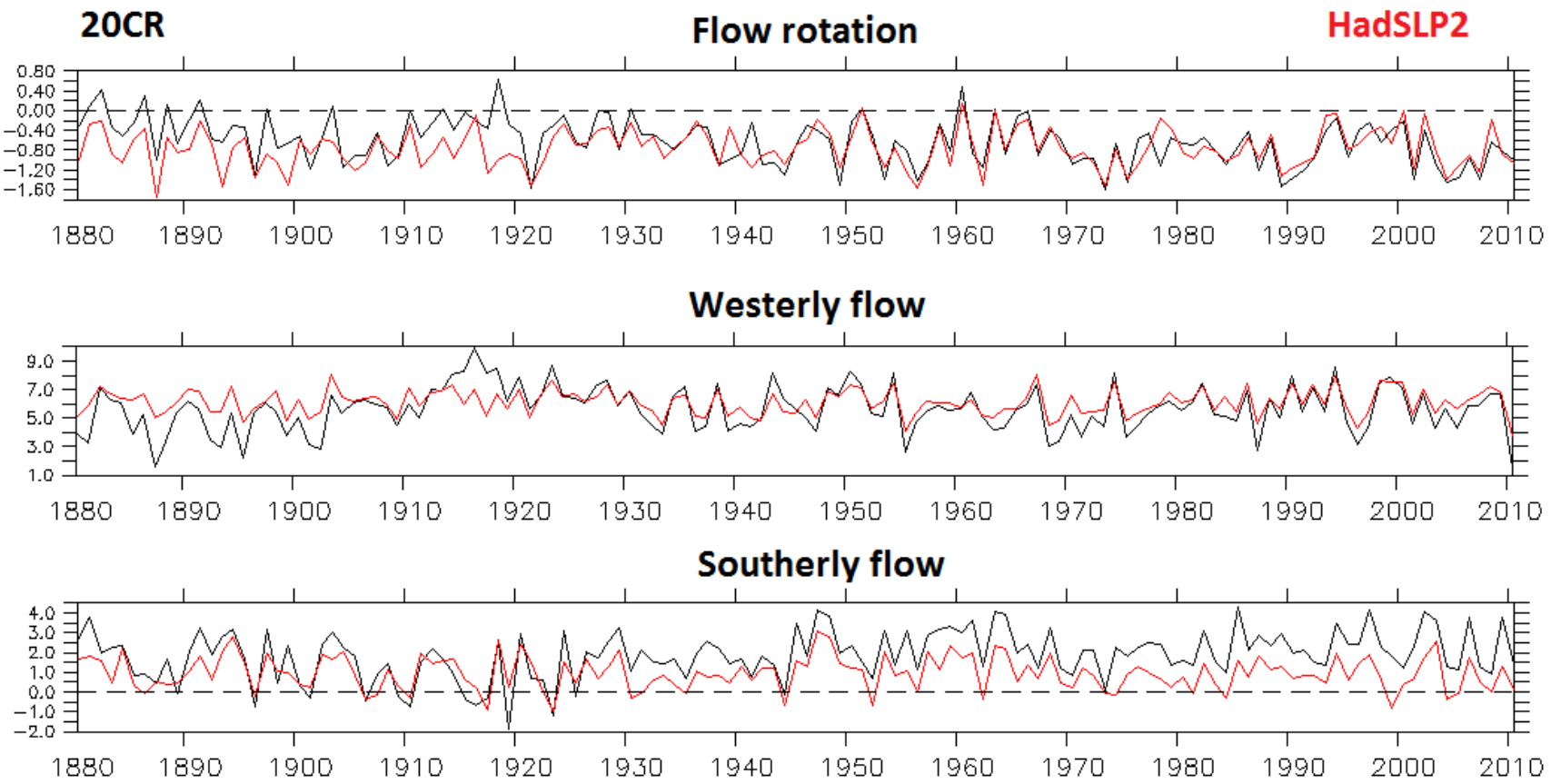


- Relationship outside training period is weaker.
- Potential reasons include erroneous temperature estimates, changing relationship between temperature and atmospheric circulation.
- Also uncertainties in marine air temperature estimates.

SLP uncertainties

- How good are the SLP observations?

SLP comparisons – flow parameters

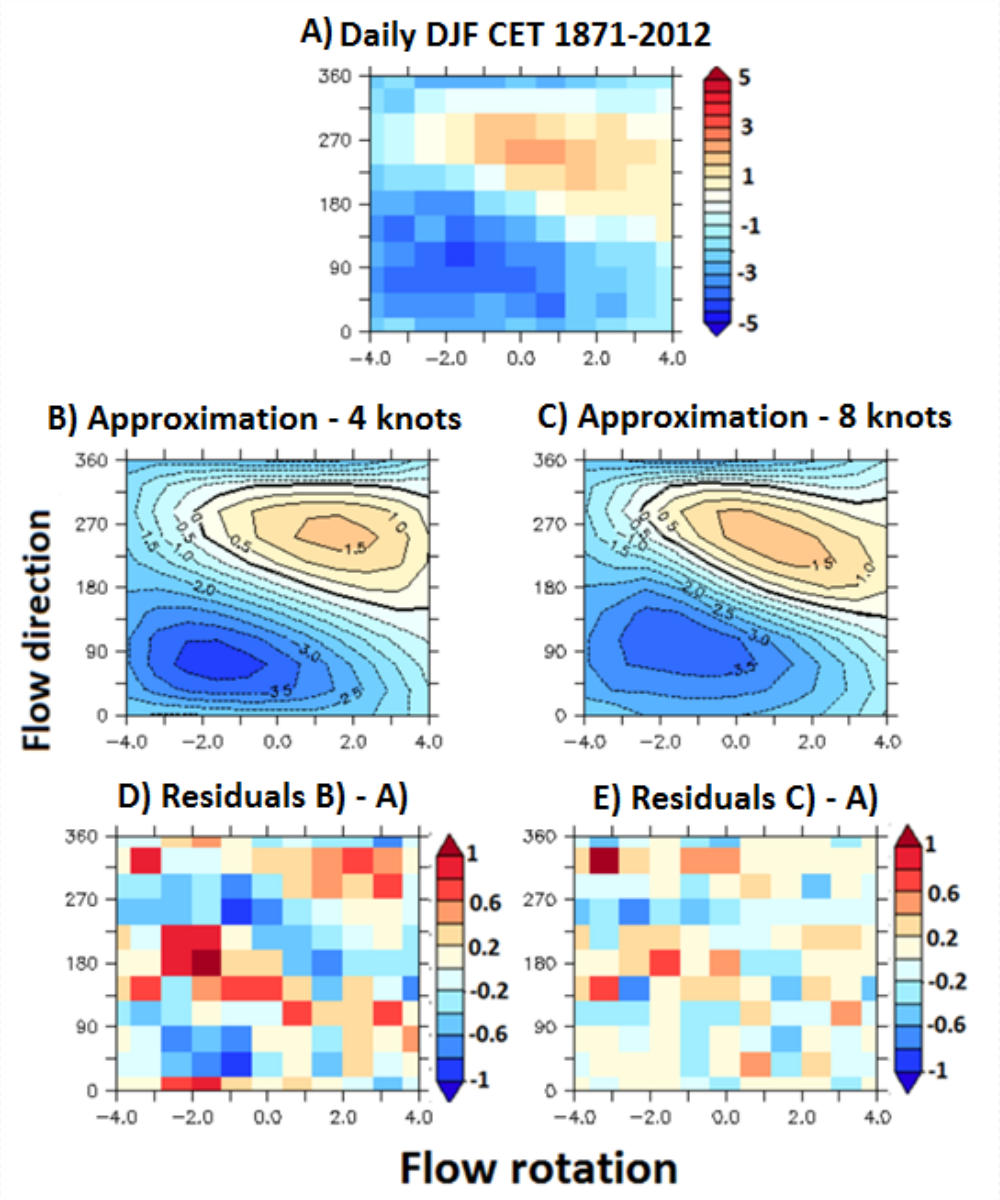


- Annual averages at 50˚N 10˚W

Summary

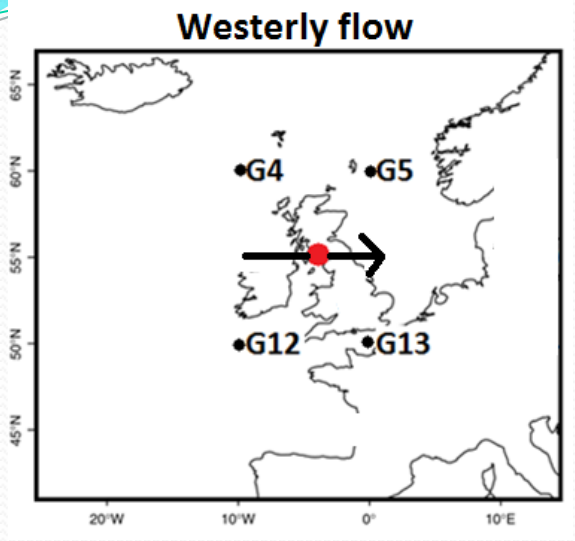
- We have predicted marine air temperature from atmospheric circulation patterns.
  - Started to look at uncertainty in this method
- Shown that circulation-based temperature estimates can be made over the ocean
  - HadNMAT2 and 20CR 2 metre air temperature show very similar relationships with atmospheric circulation.
  - Sample point 52.5˚N, 12.5˚W shows correlations of ~ 0.75 for 1951-2010
  - Much lower correlations for period 1880-1950 ~0.2
    - Reasons: uncertainty in pressure fields, uncertainty in temperature anomalies, possible extrapolation of relationships

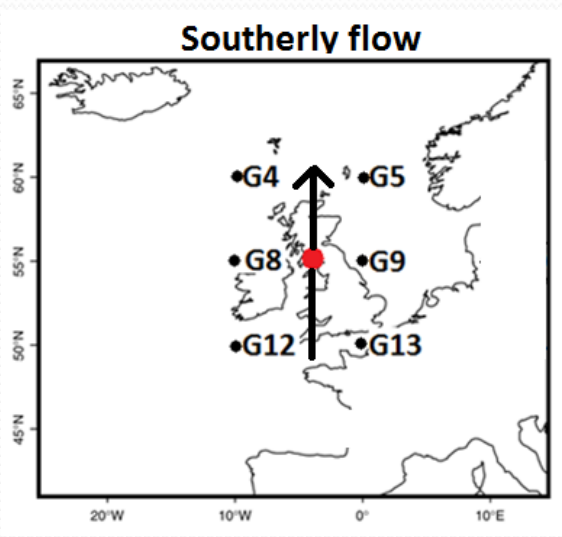
Fitting the temperature anomalies



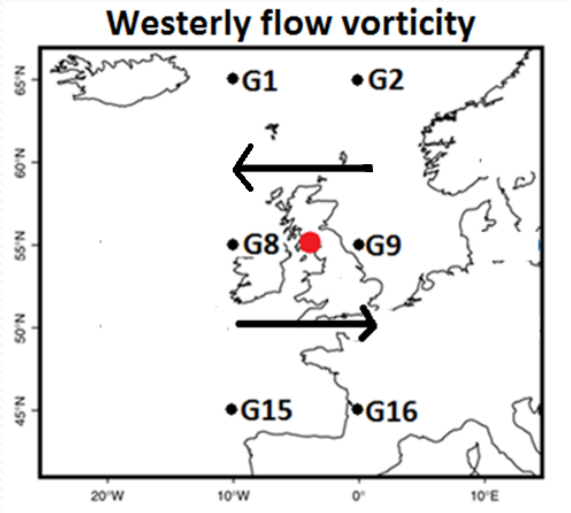
- A bicubic spline is used to produce a complete field in flow direction/rotation space
- Cubic spline is made up from cubic polynomials with different coefficients joined at “knot” points
- 6-8 knots (2 or 3 sets of polynomial coefficients in x and y directions) used

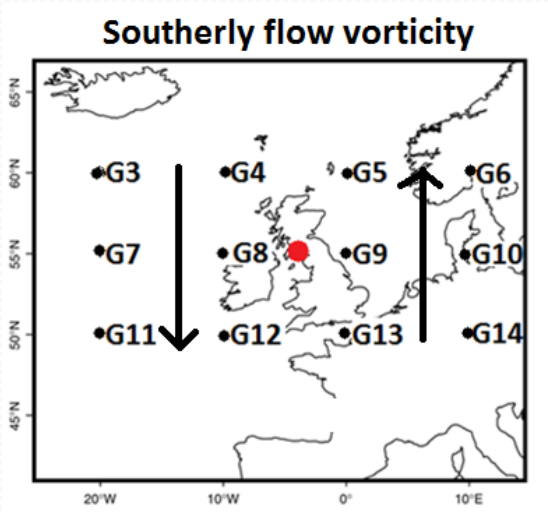
Calculating flow parameters





Westerly and southerly flow used to calculate flow direction and strength.





Flow rotation – Ratio of flow vorticity to strength (curvature of the flow)