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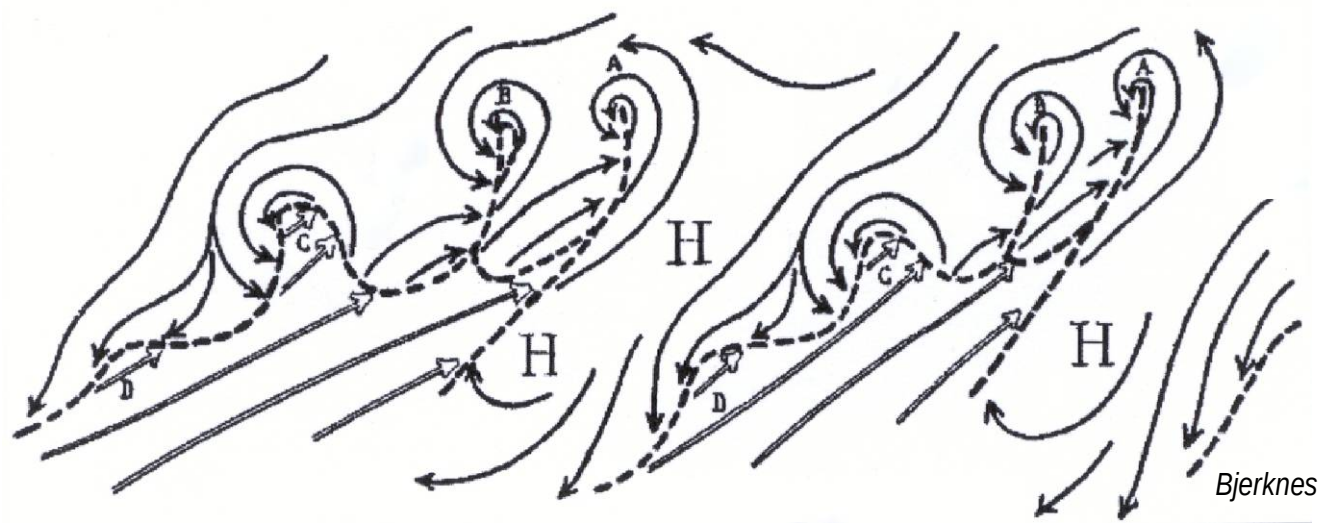
Clustering of cyclones and linkage to large scale flow patterns

KVAMSTO Nils Gunnar
University of Bergen
Geophysical Institute
Allegaten 70
N-5007 Bergen
NORWAY

Clustering of Extratropical Cyclones

and linkage to large scale flow patterns



Bjerknes and Solberg (1922)

Nils Gunnar Kvamstø[1], Yongjia Song[1], Ivar A Seierstad[1], David B. Stephenson[1,2],
[1]University of Bergen, Norway, [2]University of Exeter, UK

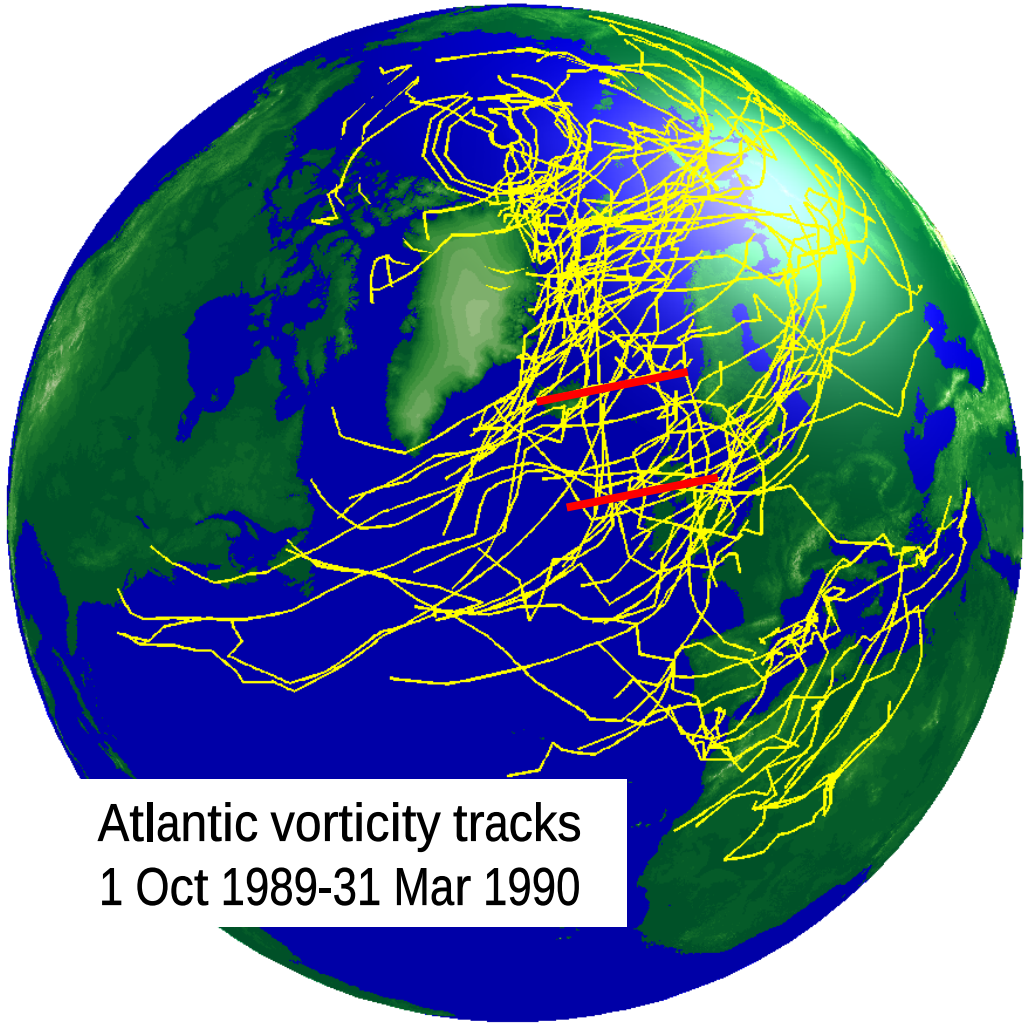
(Publ. in Tellus A 2008)

Effects of clustering

Mailier et al (2006) MWR:

- Clustering of European winter storms leads to cumulative insurance losses comparable to those from a catastrophic hurricane.
  - Dec 1999: 3 consecutive storms (insured loss $7.5 bn)
  - Dec 1989/Jan 1990: 8 consecutive storms (insured loss $10.5 bn.)
- The scientific reasons for storm clustering have not previously been investigated
- Clustering may change and needs to be accounted for in hazard models. ← Depends on realistic representation in GCMs/RCMs

Identification of clustering



Atlantic vorticity tracks
1 Oct 1989-31 Mar 1990

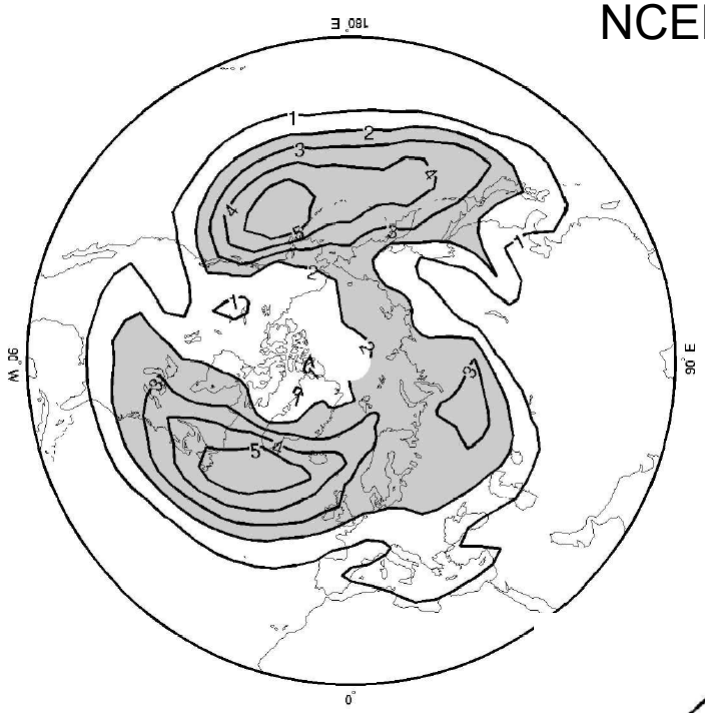
First, we count cyclone transits:

n = number of storms
crossing a 20˚ E-W barrier
in each grid point

Feature tracking 1948-2005

- Extended winters (1 Oct-31 Mar)
- 6 hourly NCAR/NCEP reanalyses from 1948 – 2005)
- 6 hourly output from an AMIP run (obs sst 1948 – 2005) with the ARPEGE GCM T63L31
- Maximas in ζ_{850} is used to identify cyclones
- Northward cyclone tracks identified objectively using TRACK software (Hodges, 1995, 1996)

NCEP

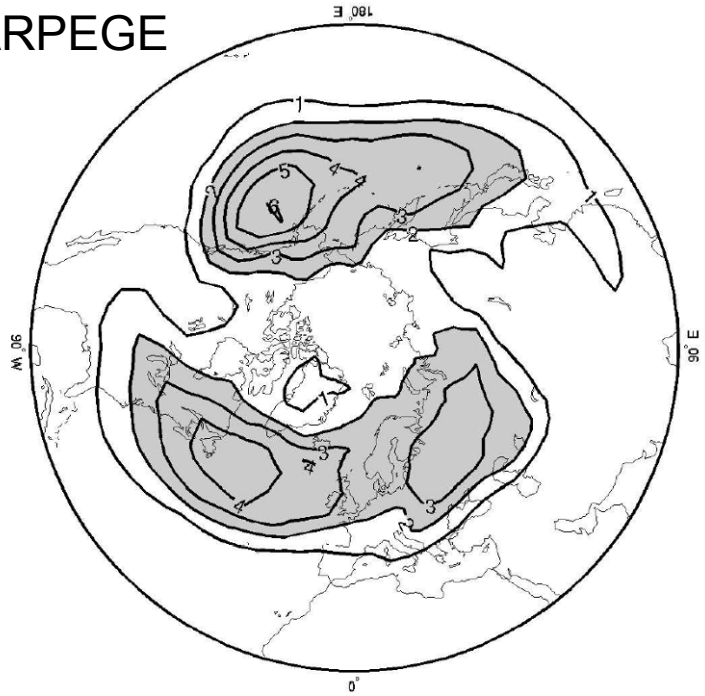


N

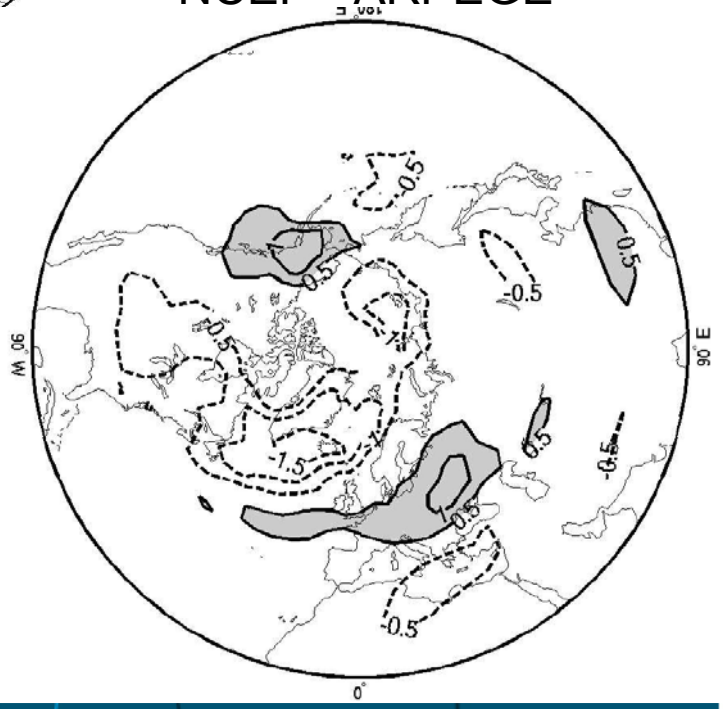
S

$\overline{n}$

ARPEGE



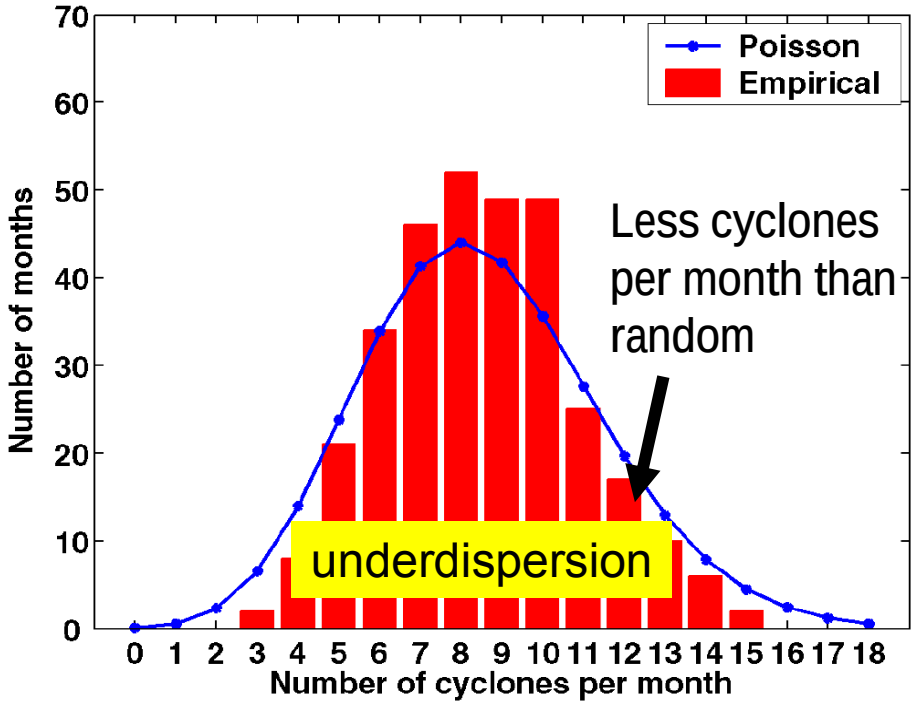
NCEP - ARPEGE

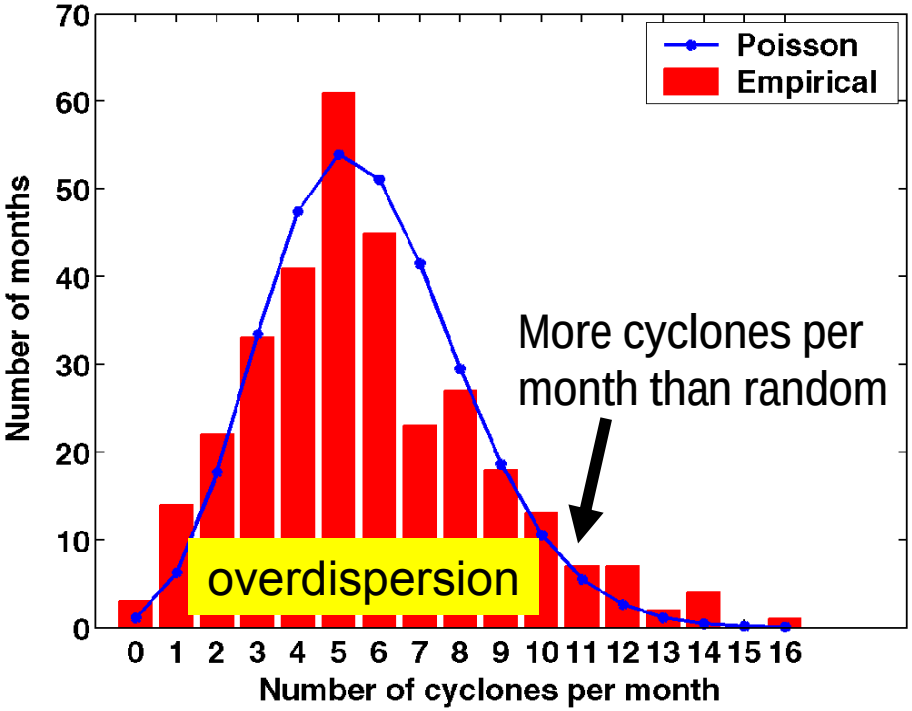


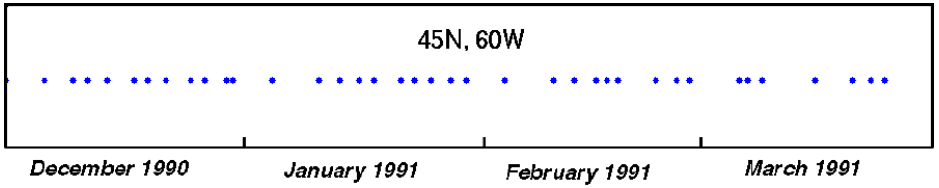
- Atlantic bias
- ~10% less in GCM

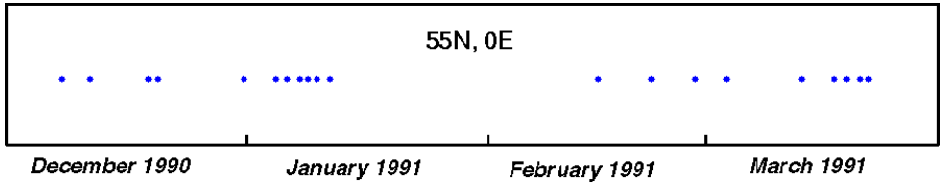
ONDJFM

Time dependence: Comparison of West and East Atlantic



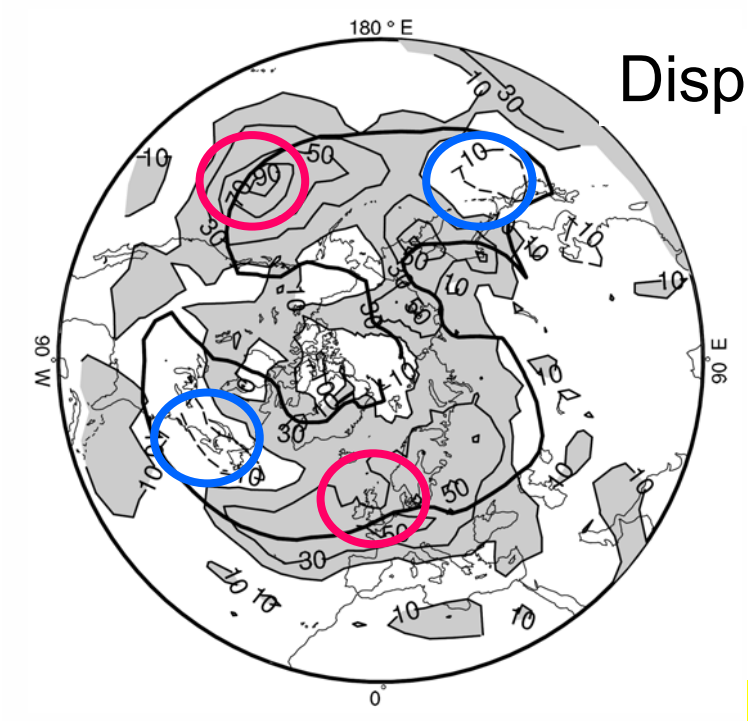




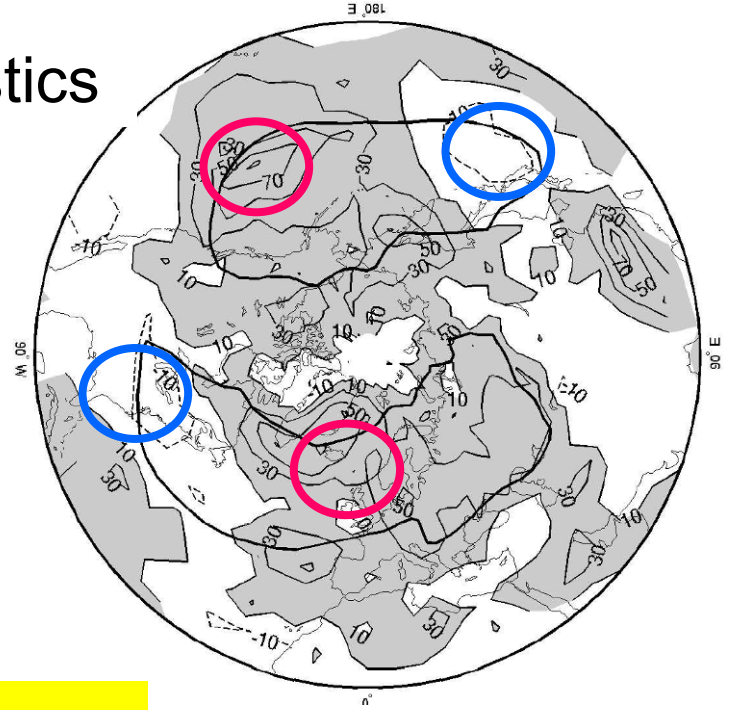


→ regular (in west) and clustered (in east) random processes

Dispersion statistics



NCEP



ARPEGE

$$\psi = \frac{s_n^2}{\overline{n}} - 1$$

$$\psi > 0, \rightarrow \textit{over}$$

$$\psi < 0, \rightarrow \textit{under}$$

- over

- under

Can flow variations explain overdispersion?

Quasi-Poisson regression:

$$n \mid x \sim Poisson(\mu)$$

$$\log(\mu) = \beta_0 + \sum_{i=1}^{k} \beta_i x_i$$

n = number of storms crossing a 20^0 W-E barrier

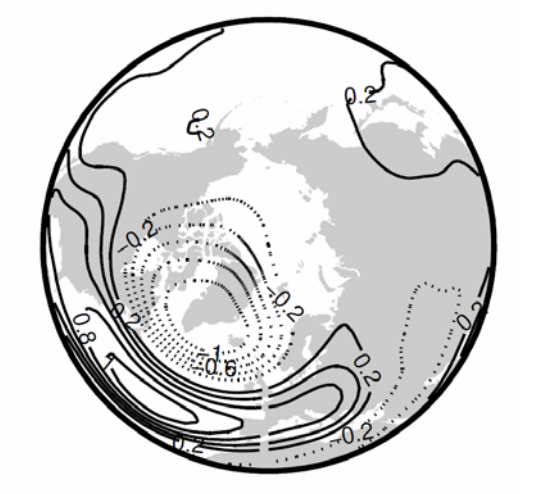
μ = flow-dependent rate

x_1, x_2, … , x_k = teleconnection indices

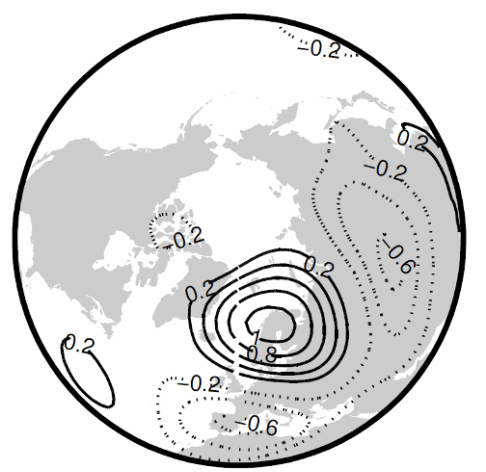
Maximum likelihood estimation of $ß_0$, $ß_i$

Teleconnection patterns

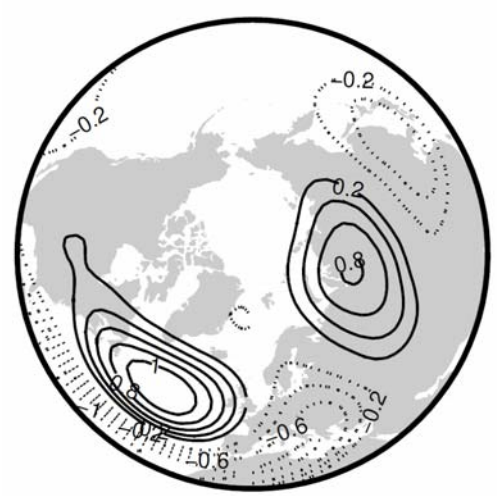
NAO



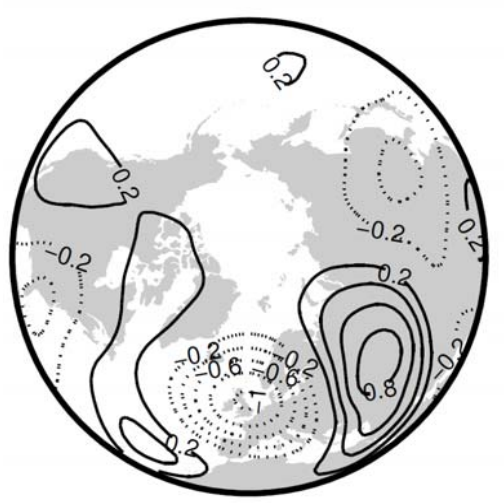
Scandinavian



East Atlantic



E. Atl/W. Russian

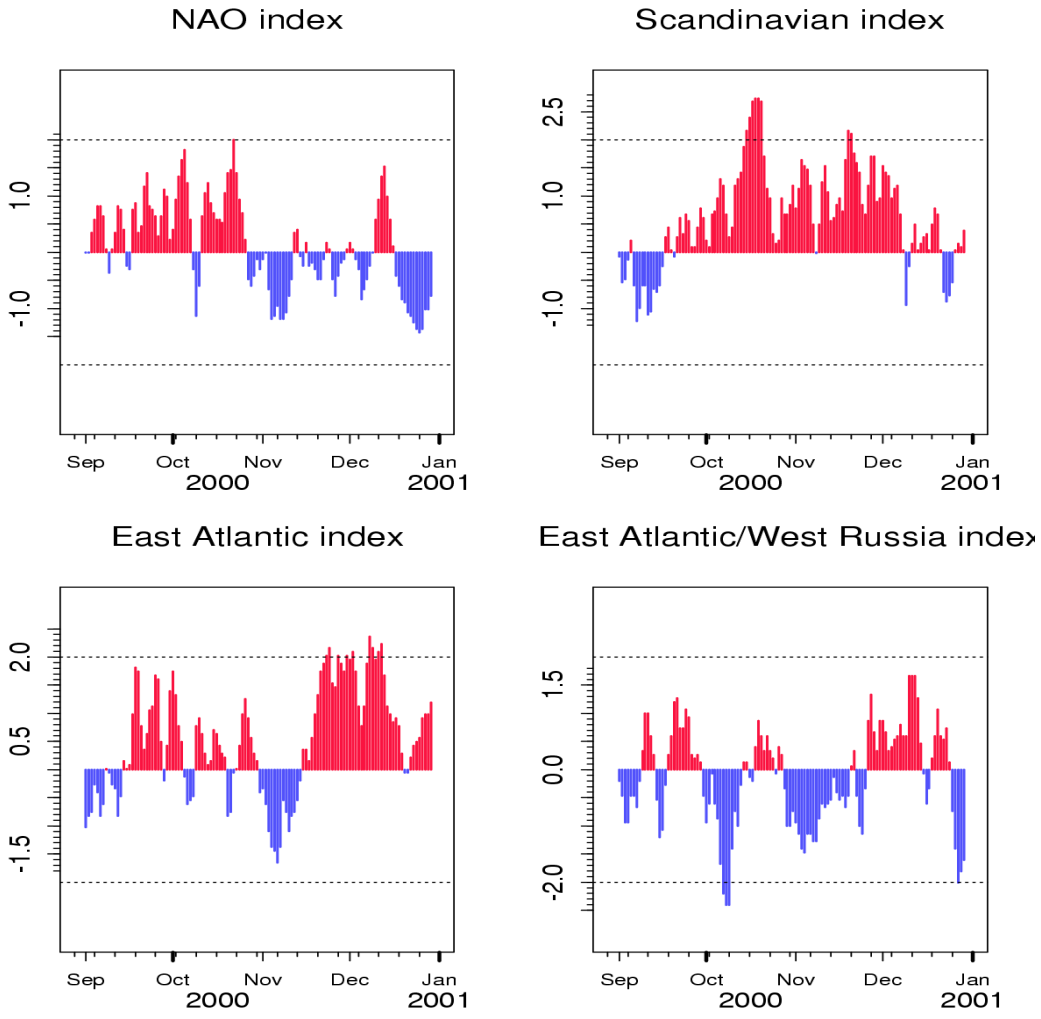


10 leading rotated EOFs of 500hPa geopotential height.

Can be downloaded from CPC-website:
http://www.cpc.noaa.gov/data/teledoc/telecontents.shtml

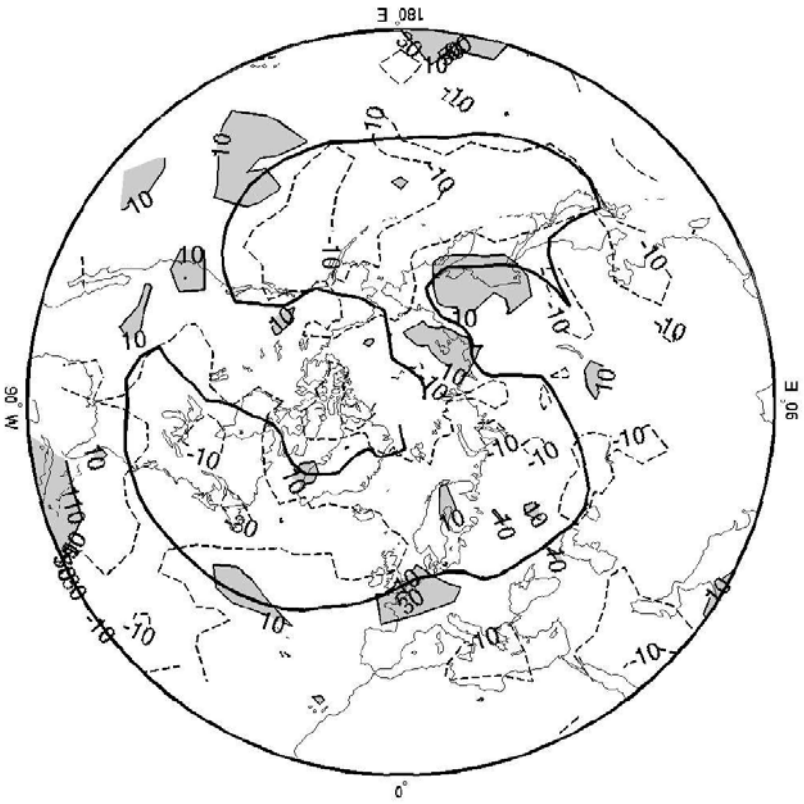
Barston and Livezey (1987)

Daily teleconnection indices x
1 Sep-31 Dec 2000



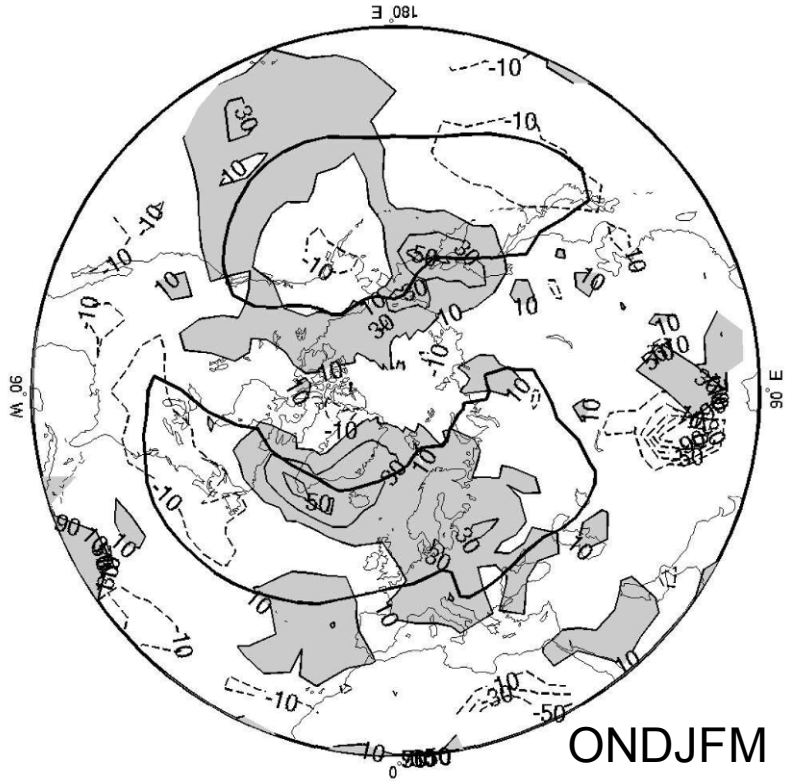
RESIDUAL DISPERSION

NCEP



%

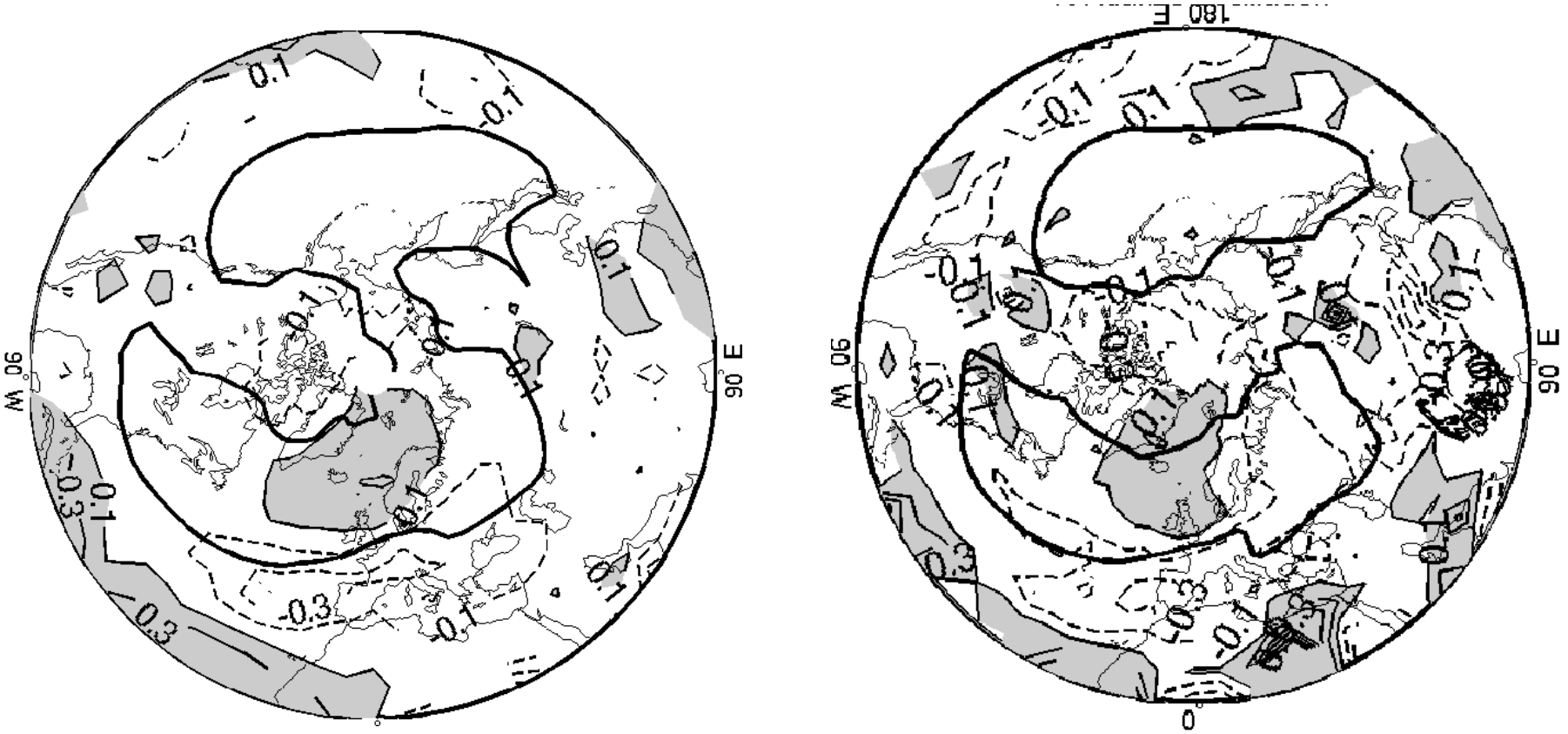
ARPEGE



ONDJFM

→ Large scale flow accounts for clustering – but not in the GCM

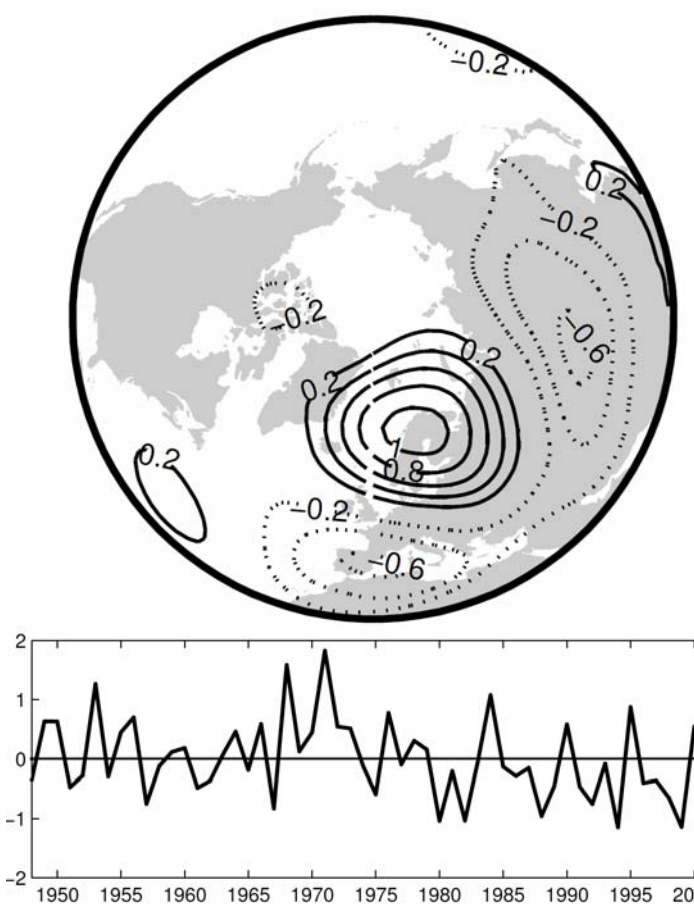
The NAO as explanatory factor



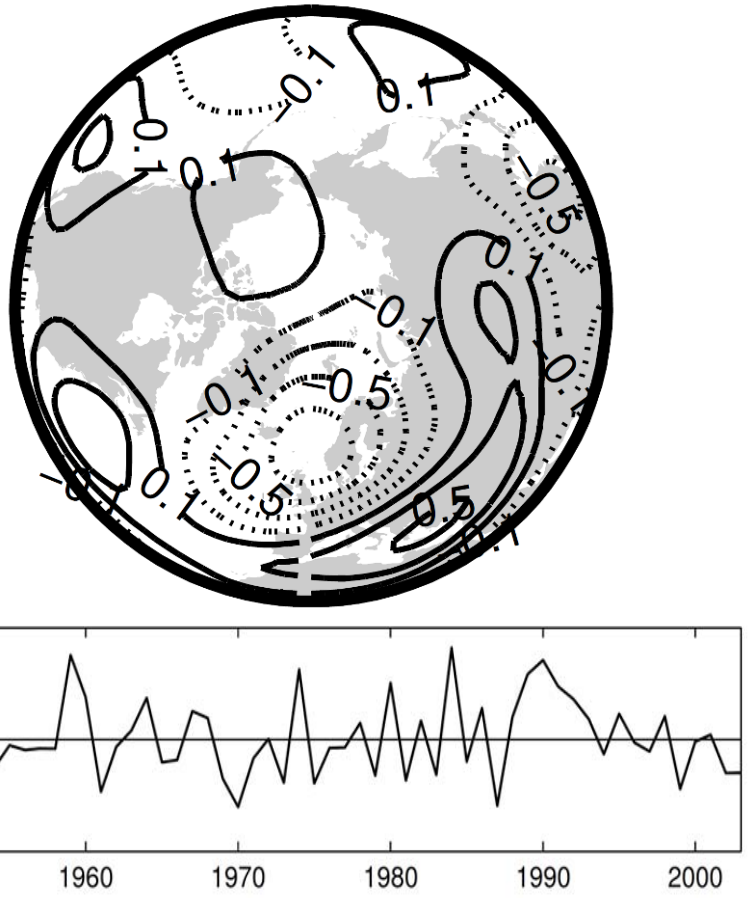
→ The NAO has similar impact on clustering in NCEP and the GCM

Scandinavian pattern

NCEP



ARPEGE



→ But not the other patterns

Conclusions

- Overall good resemblance of the ONDJFM mean # of cyclones
- Model biases are mostly present in the Atlantic sector
- South-North moving cyclones appear more regular than random in the western basins and become more clustered as they move Eastward
- The teleconnection patterns (not only NAO!) account for much of the cyclone clustering in NCEP, not in ARPEGE
- Reduced confidence in regional prediction of clustering (& synoptic variability)
- Can not use projected L-S flow indices as proxies for future estimates of clustering
- NCEP based results are consistent with Mailier et al (2006) MWR