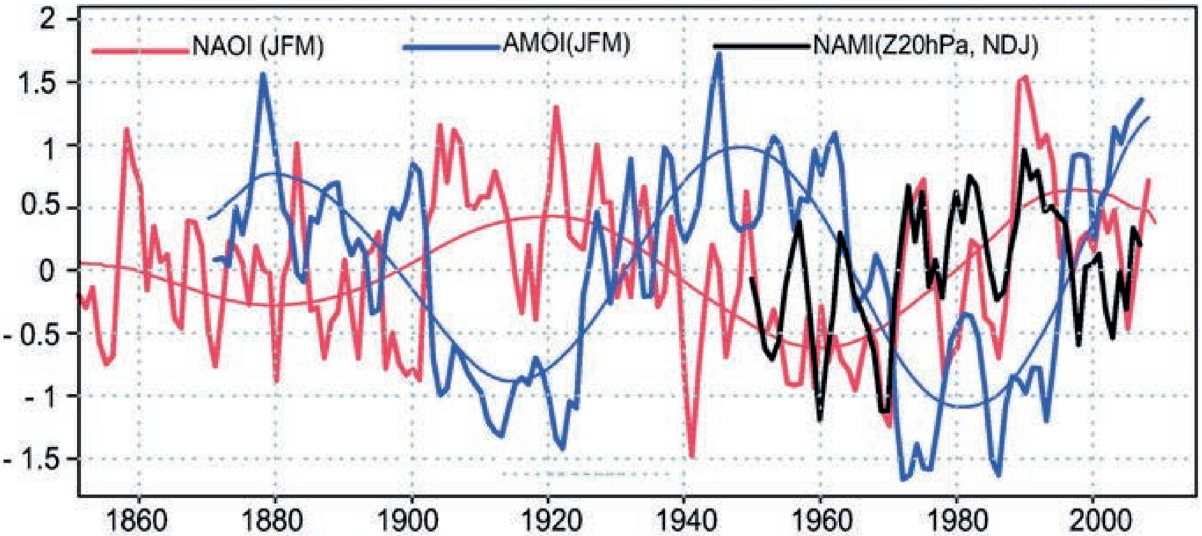
The impact of the PDO and AMO onto the Northern Hemisphere storm tracks during the Twentieth Century

Filipa Varino[1] (PhD student), Bruno Joly[1], Philippe Arbogast[1], Gwendal Rivière[2]

[1] CNRM, Météo-France & CNRS, Toulouse, France
[2] LMD, ENS, Paris, France

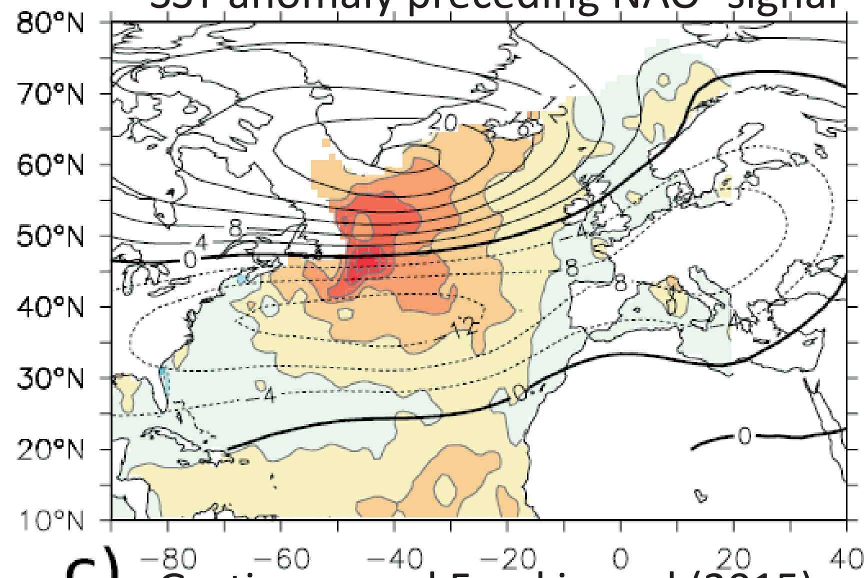
Introduction. Impact of the AMO on NAO



Omrani et al. (2014)

- Positive AMO precedes negative NAO by 4-5 years (Gastineau and Frankignoul, 2015)
- More blocking and cold extremes associated following warm AMO (Hakkinen et al., 2011)

SST anomaly preceding NAO- signal



Gastineau and Frankignoul (2015)

Introduction. Impact of the AMO / AMOC on Atlantic storm track

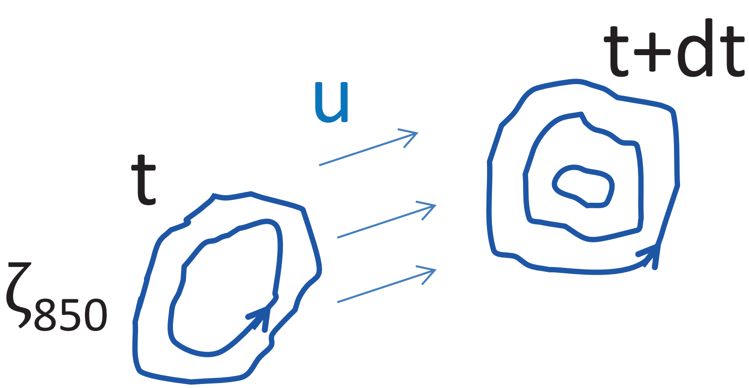
- AMOC shut down → intensification of the Atlantic storm track due to near surface baroclinicty increase associated with changes in surface temperature gradient (Brayshaw et al., 2009)
- Warm AMO → equatorward shift of the storm-track accompanied by a decrease of its intensity as seen in reanalysis and GCM simulations (Peings and Magnusdottir, 2014, 2015)

Questions of the present study:

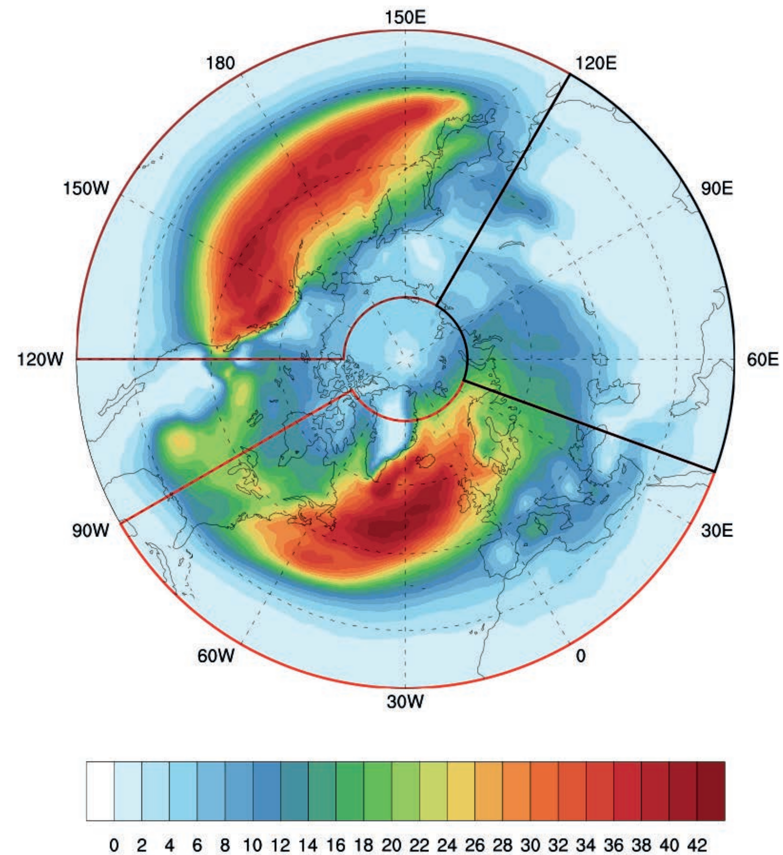
- What were the long-term variations of extratropical storms during 20th Century ?
- If yes, are they linked to multidecadal ocean variability like PDO and AMO ?

Method. Reanalysis datasets + Cyclone tracking algorithm

- ERA20-C reanalysis (ECMWF)
- Cyclone tracking algorithm developed by Ayrault & Joly (2000)
- Based on 850-hPa relative vorticity maximum
- Use of 700-Hpa U,V advection
- Final trajectories longer than 600 km and 24h

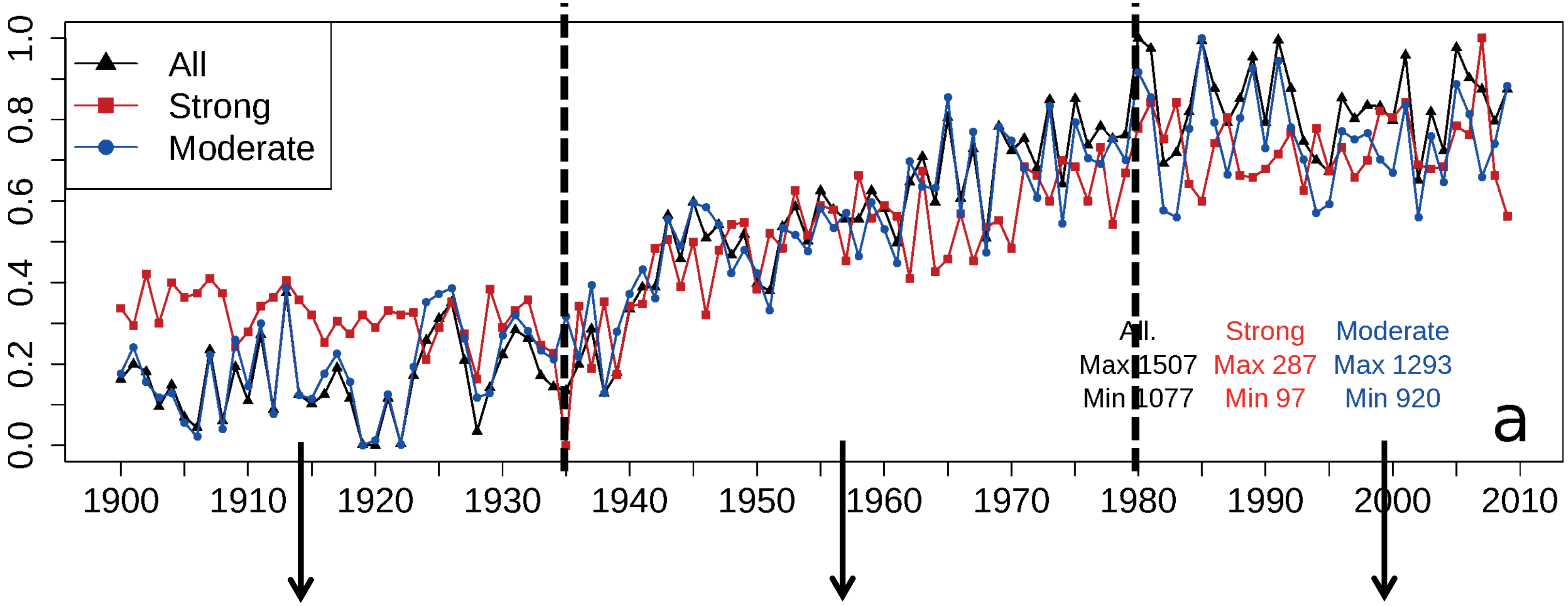


Cyclone track density



Number of extratropical cyclones per year

All: vorticity > $f_0=10^{-4}s^{-1}$; Moderate: f0< vorticity <$2f_0$; Strong: Vorticity > $2f_0$



Period I. 1900-1935

Period II. 1935-1980
Significant positive trend

Period III. 1980-2010

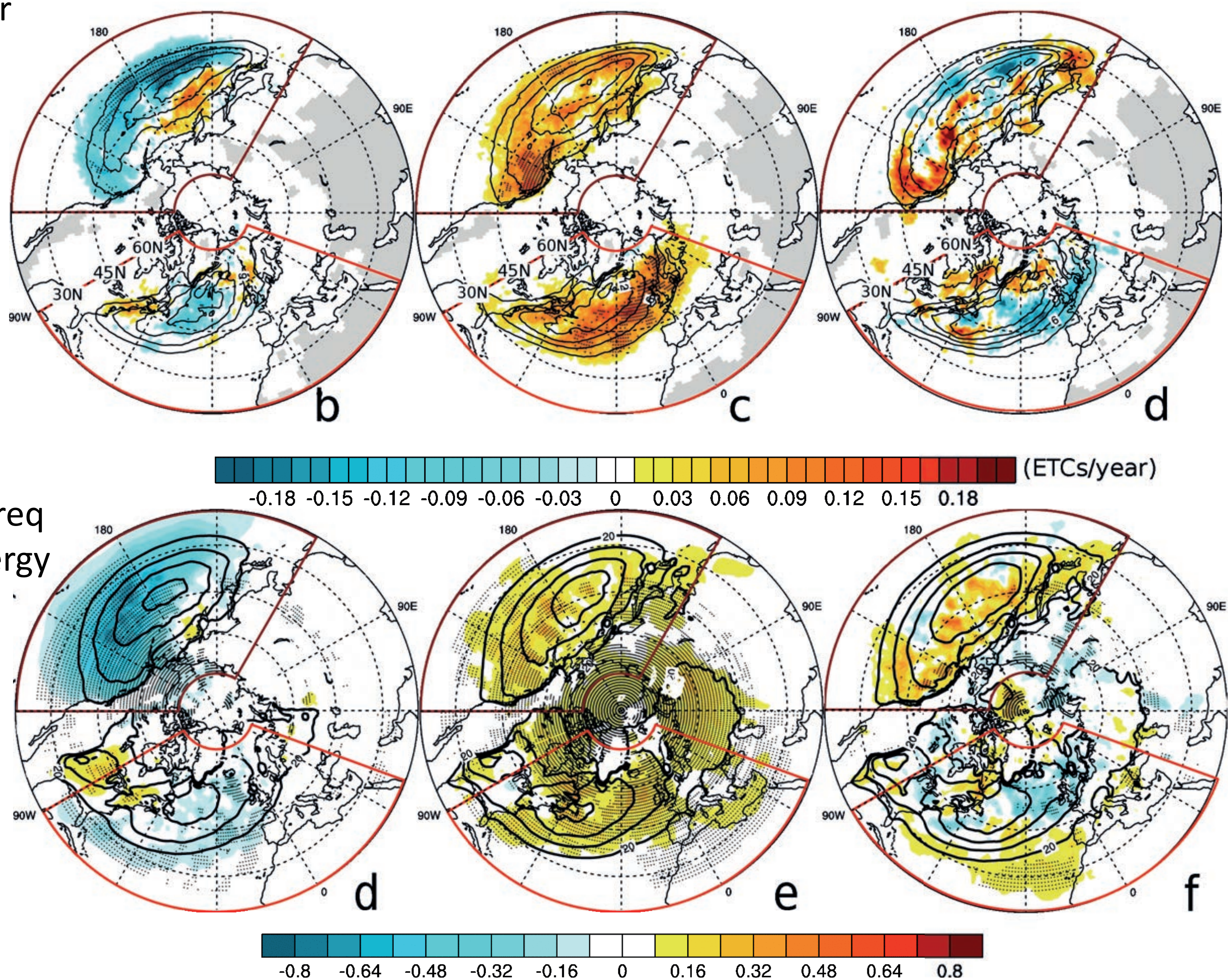
Two storm-track activity measures

I. 1900-1935 | II. 1935-1980 | III. 1980-2010

Trends in number of extratropical cyclones (vor > Coriolis)

Trends in high-freq eddy kinetic energy at 850 hPa

$$\frac{1}{2}(u'^2 + v'^2)$$



Interpretat° via baroclinic interaction

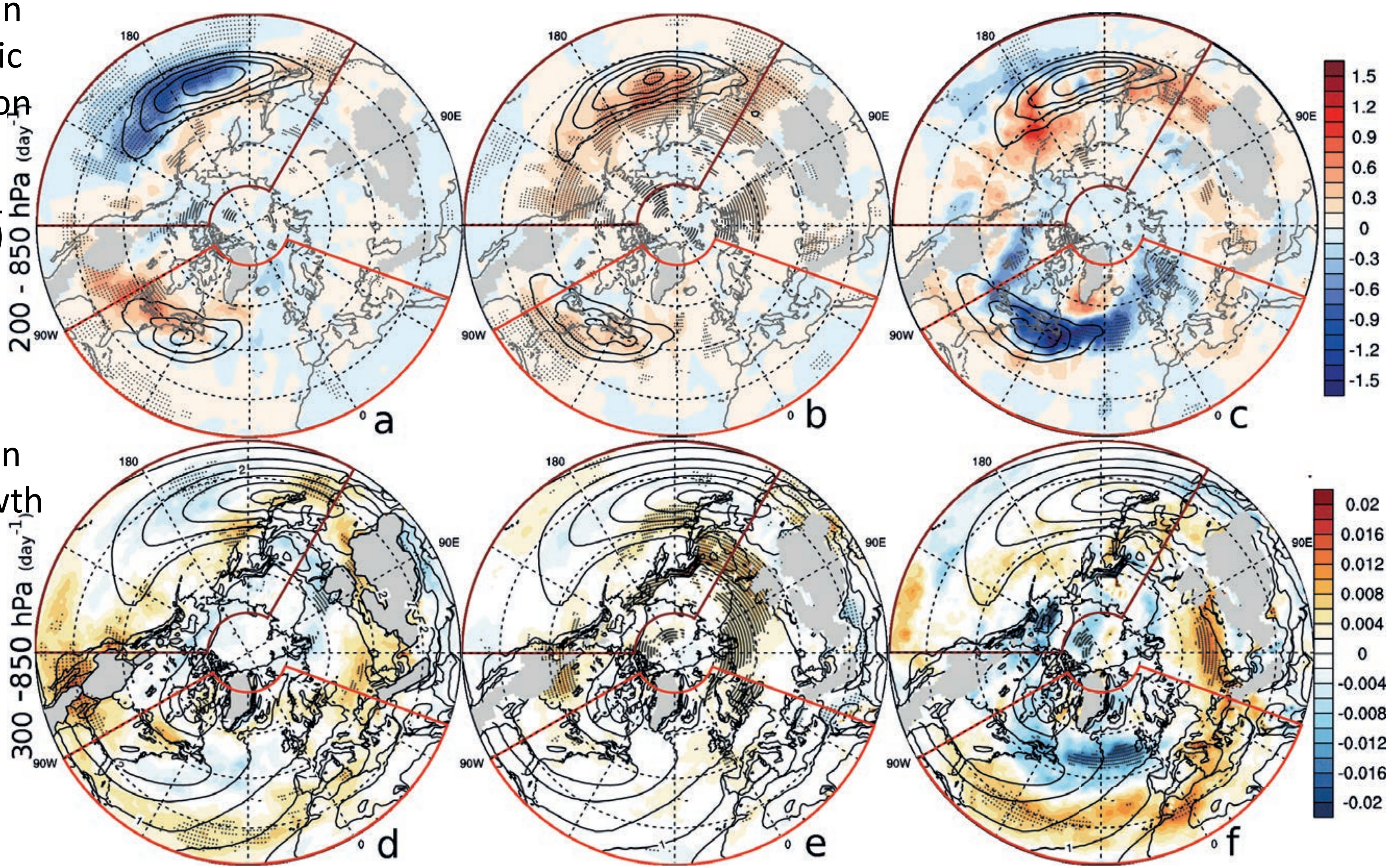
I. 1900-1935 | II. 1935-1980 | III. 1980-2010

Trends in baroclinic conversion

$$\frac{1}{S}\theta'\mathbf{u'}\nabla\bar{\theta}$$

Trends in Eady growth rate

$$\frac{1}{S}|\nabla\bar{\theta}|$$



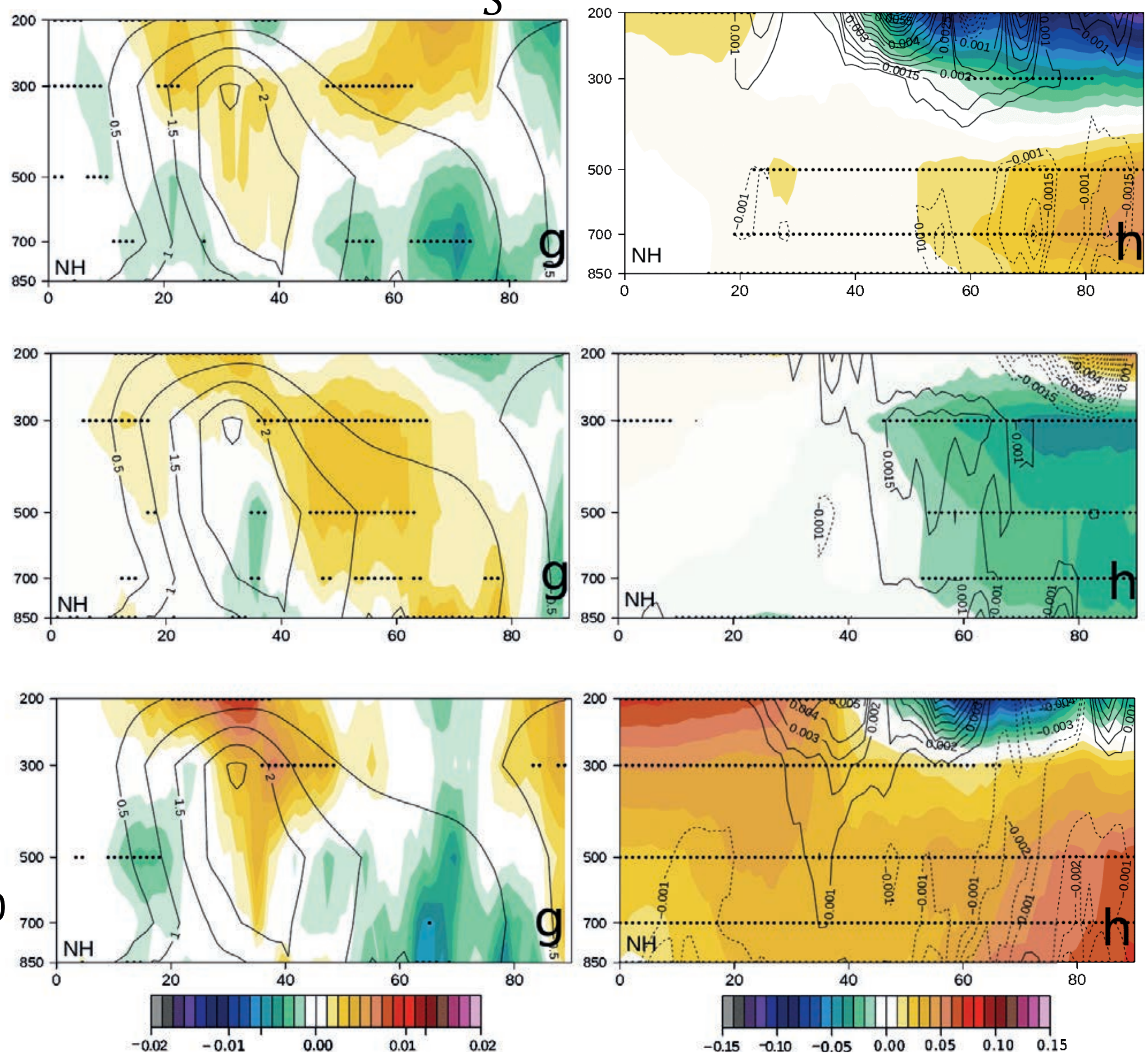
S stratification parameter

Temperature / baroclinicity vertical profiles

Eady growth rate trend $\frac{1}{S}|\nabla\bar{\theta}|$

Potential temperature trend $\bar{\theta}$ shading

$\partial_y\bar{\theta}$ contours



I. 1900-1935

Polar warming confined at low levels

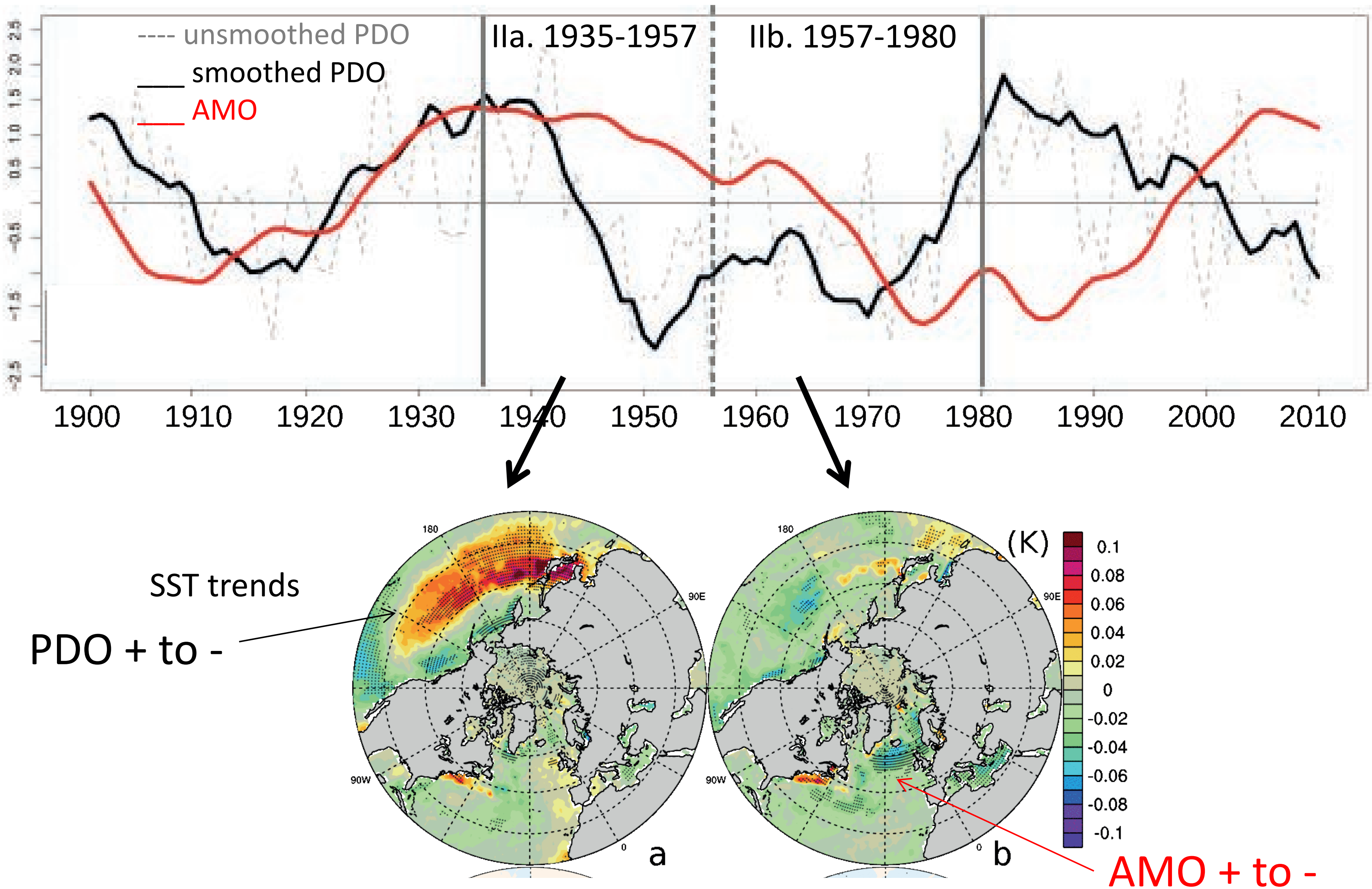
II. 1935-1980

Uniform polar cooling over troposphere

III. 1980-2010

Polar surface warming & tropical upper-level warming

AMO / PDO variations



Periods IIa and IIb

IIa. 1935-1957

IIb. 1957-1980

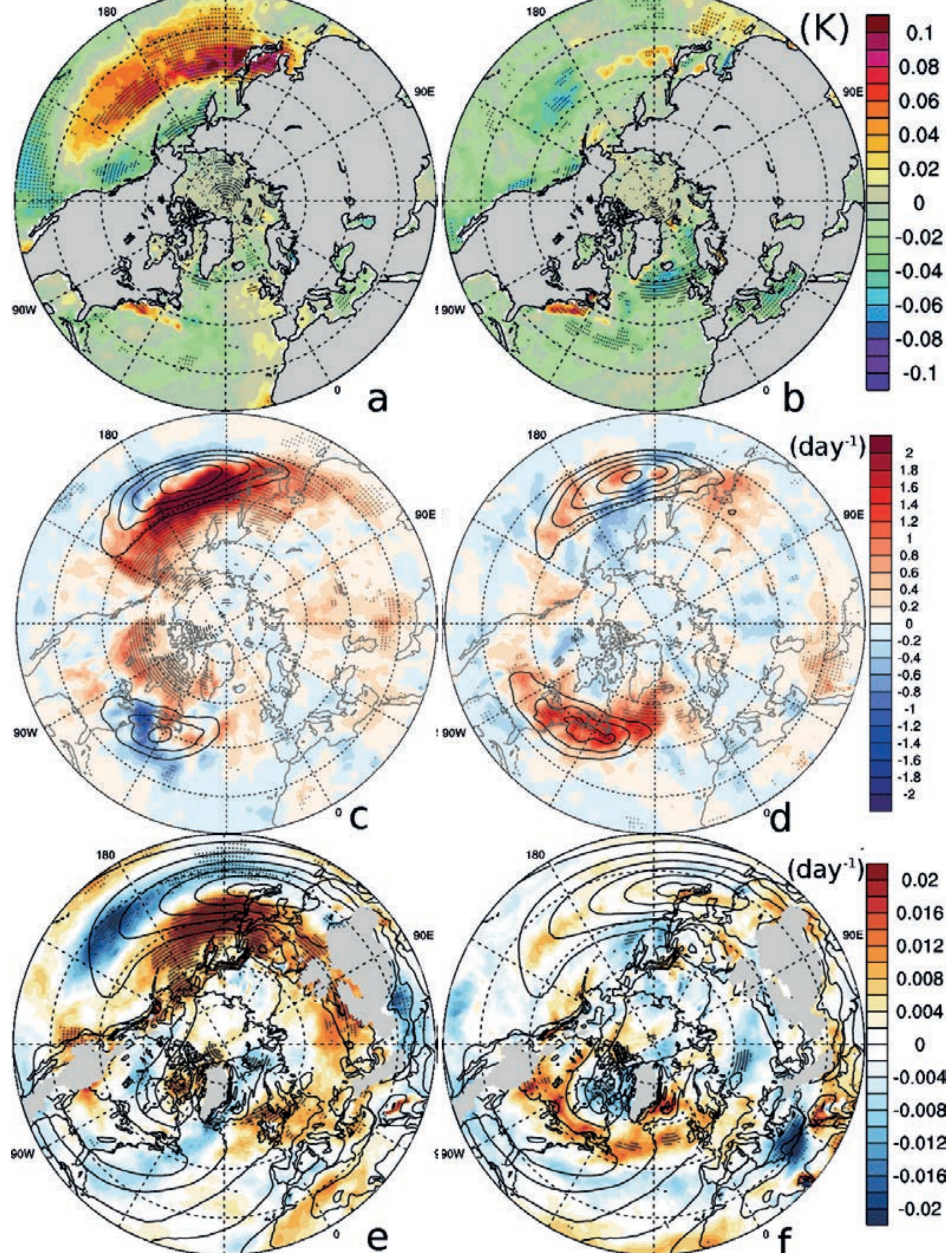
SST trends

Baroclinic conversion trends

$\frac{1}{S}\theta'\mathbf{u'}\nabla\bar{\theta}$

Baroclinicity trends

$\frac{1}{S}|\nabla\bar{\theta}|$



- IIa: negative PDO → poleward increase and strengthening of SST gradient, baroclinicity, baroclinic conversion in the North Pacific
- IIb: roughly same thing in the North Atlantic

Periods IIa and IIb

- IIa: negative PDO → poleward shift and strengthening of N Pac baroclinic conversion and storm track and in the North Atlantic due to upstream seeding
- IIb: roughly same thing by replacing N Pac and N Atl

IIa. 1935-1957 | IIb. 1957-1980

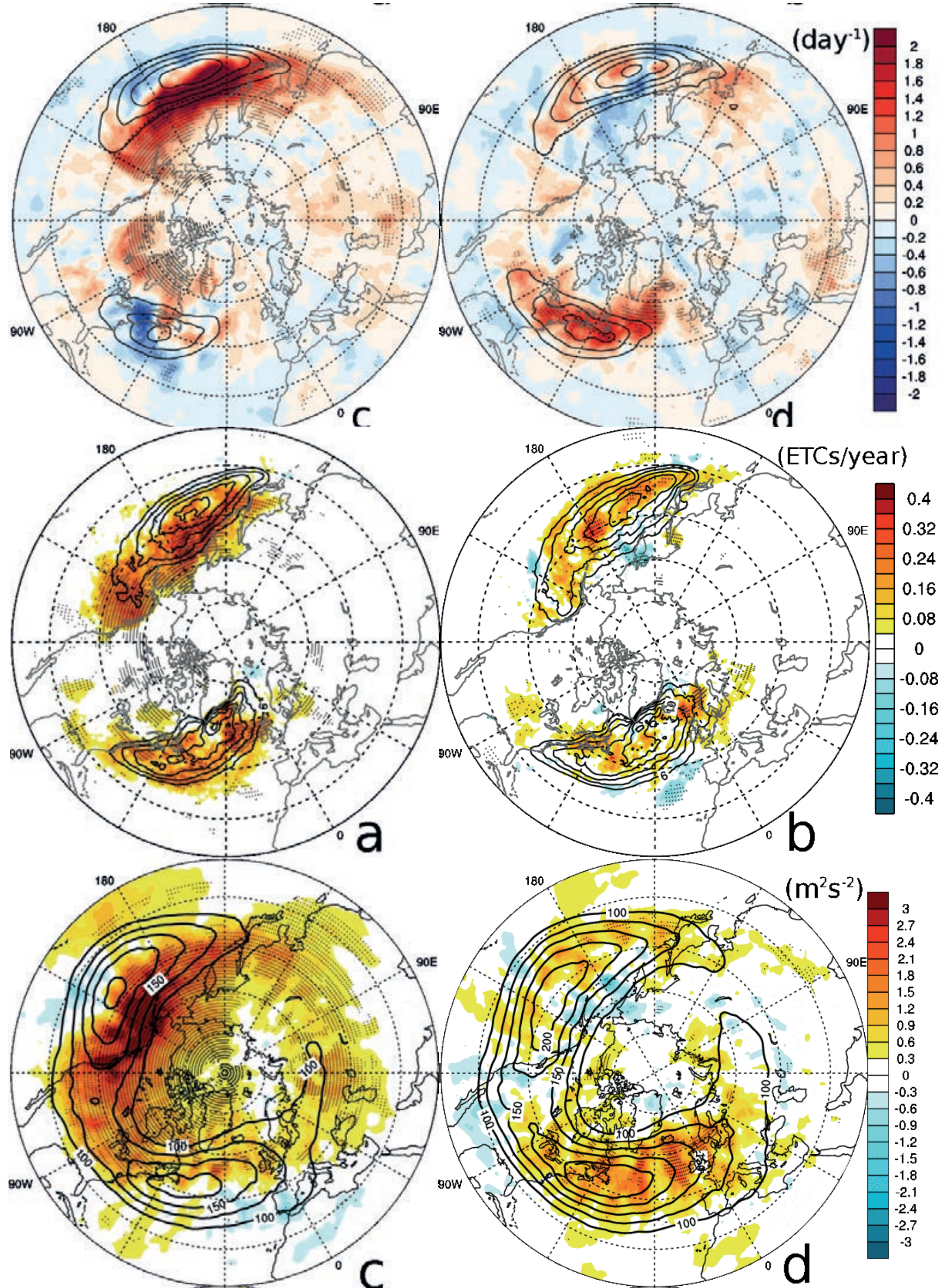
Baroclinic conversion trends

$\frac{1}{S}\theta'\mathbf{u'}\nabla\overline{\theta}$

Extratropical cyclones density trends

Eddy kinetic energy trends at 300 hPa

$\frac{1}{2}(u'^2+v'^2)$



Conclusion

Trends	I. 1900-1935	II. 1935-1980	III. 1980-2010
Storms	Not significant in NH	↗	Not significant in NH
Baroclinicity	upper-level ↗ lower-level ↘	↗	upper-level ↗ lower-level ↘
PDO/ AMO		PDO ↘ AMO ↘	PDO ↘ AMO ↗

Robust and coherent results despite some inhomogeneity in the assimilated observations of ERA-20C

Varino et al. (2017, submitted to Clim. Dyn.)