Effects of the 11-year solar cycle on correlation and teleconnection structures in tropospheric circulation

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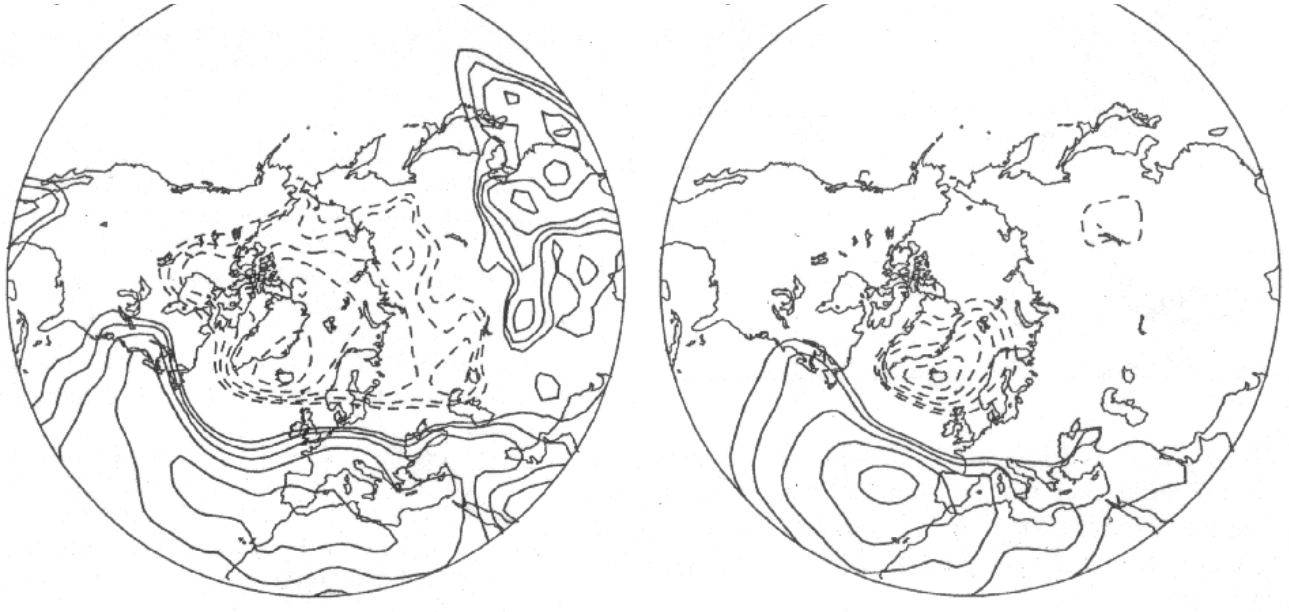
Motivation #1: NAO

Kodera (*Geophys. Res. Lett.* 2002, 2003):

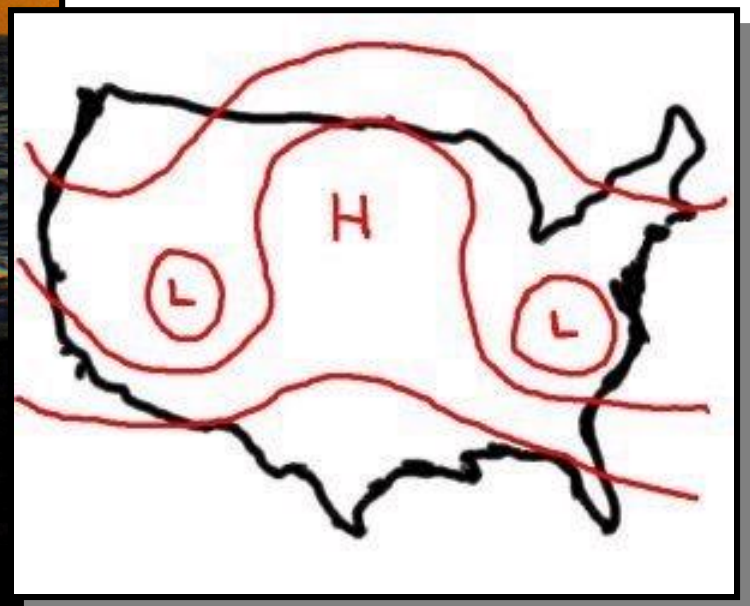
NAO in sea level pressure (i.e., correlations of NAO index with it) – much larger geographical extension under maxima of 11-year solar cycle

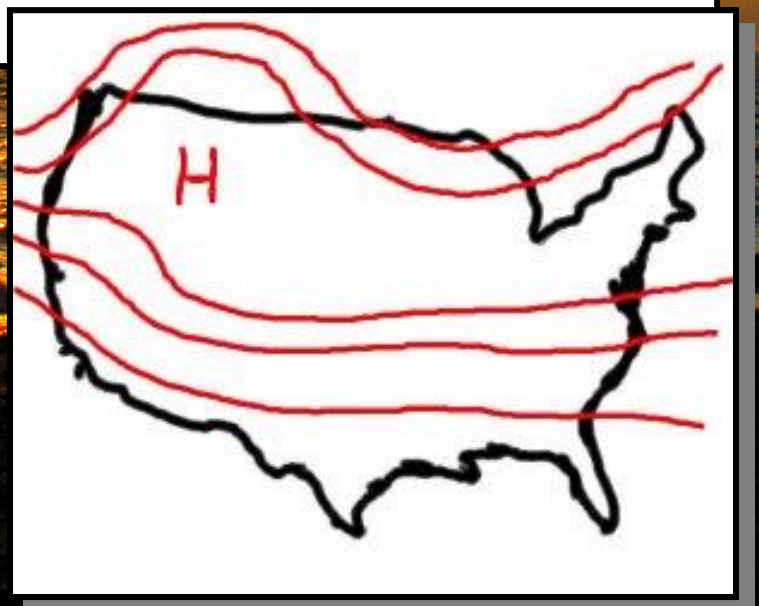
SOLAR MAX **SOLAR MIN**



Motivation #2: Blocking

- quasi-stationary and persistent formations
- anticyclones / ridges of high pressure
- in mid latitudes
- interrupt / deflect / split zonal flow
- ➔ considerably affect weather conditions
- typically occur e.g. under the negative phase of NAO

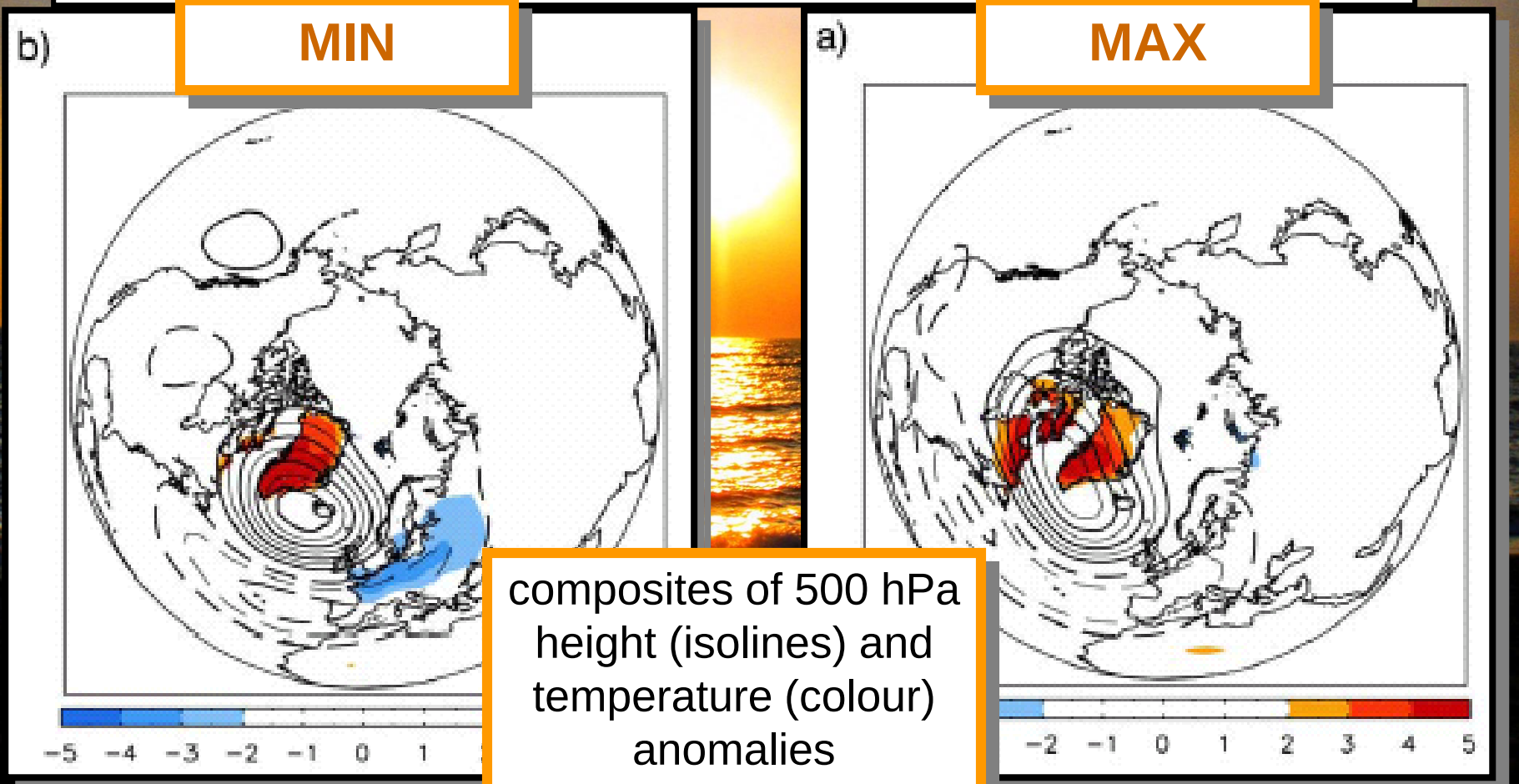




Motivation #2: Blocking

(Barriopedro et al., J. Geophys. Res. 2008)

areal extent & effect on temperature of blockings in Atlantic domain



composites of 500 hPa height (isolines) and temperature (colour) anomalies

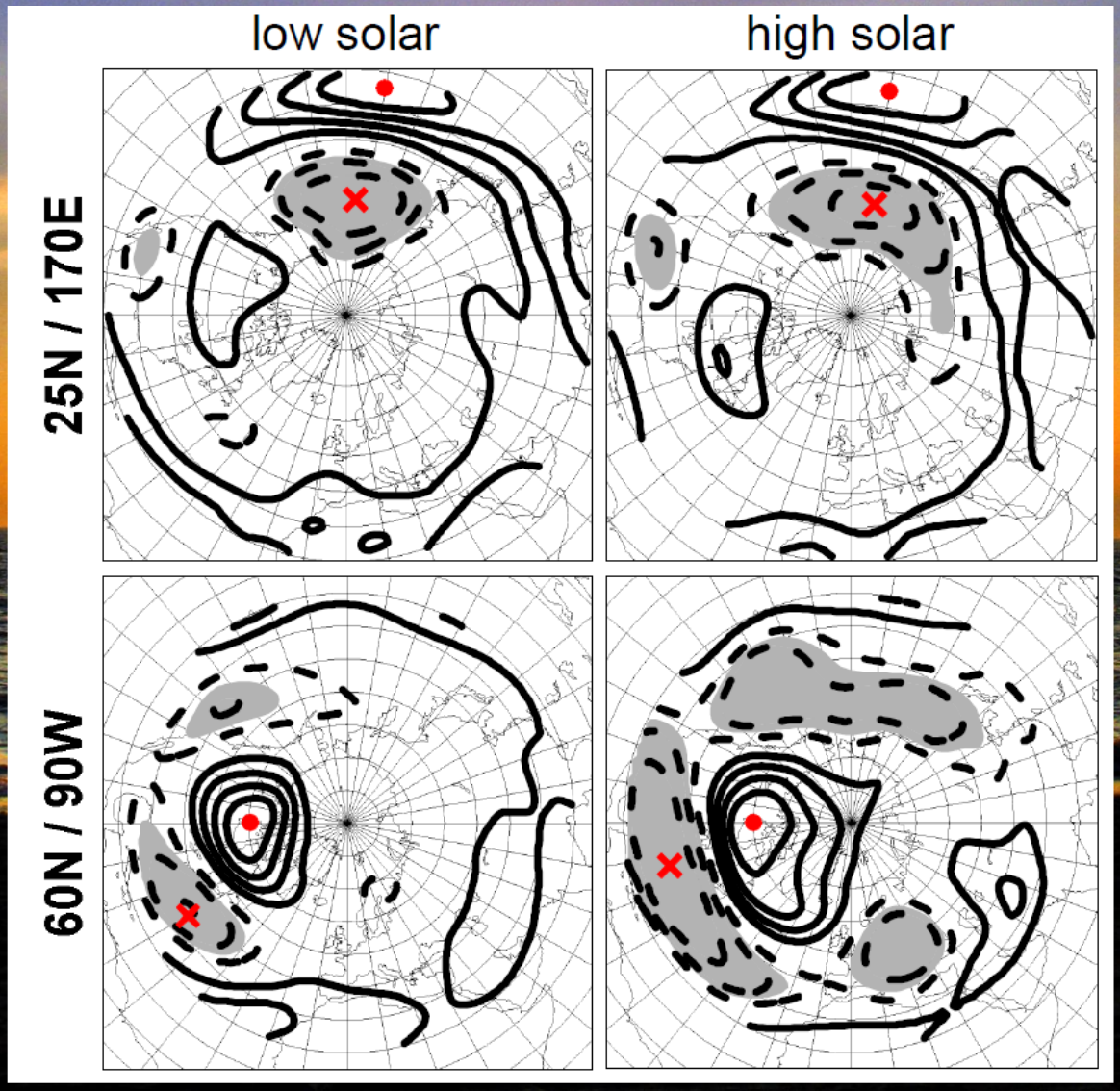
DATABASE

- monthly values
- extended winter (Dec – Mar)
- 1950 – 2003
- circulation
  - NCEP / NCAR reanalysis
  - 500 hPa heights
  - Northern Hemisphere, north of 20°N
- solar activity
  - Wolf numbers (R)
  - choice of variable has a negligible effect on the results

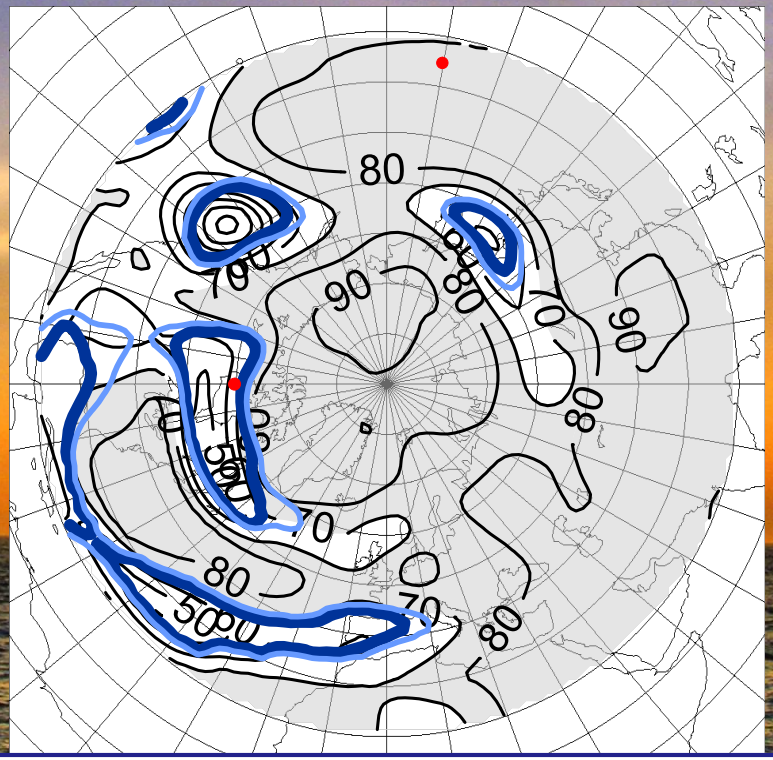
METHODS

- separate analyses for low, moderate, high solar activity
- solar minima / maxima defined subjectively (numbers of min / neutral / max months: 64 / 84 / 68)
- results are analogous for other definitions of phases of the solar cycle
- basic (simple) tool: one point correlation maps
- teleconnectivity: the property of being (anti)correlated over large distances

Spatial autocorrelations
(one-point correlation maps)



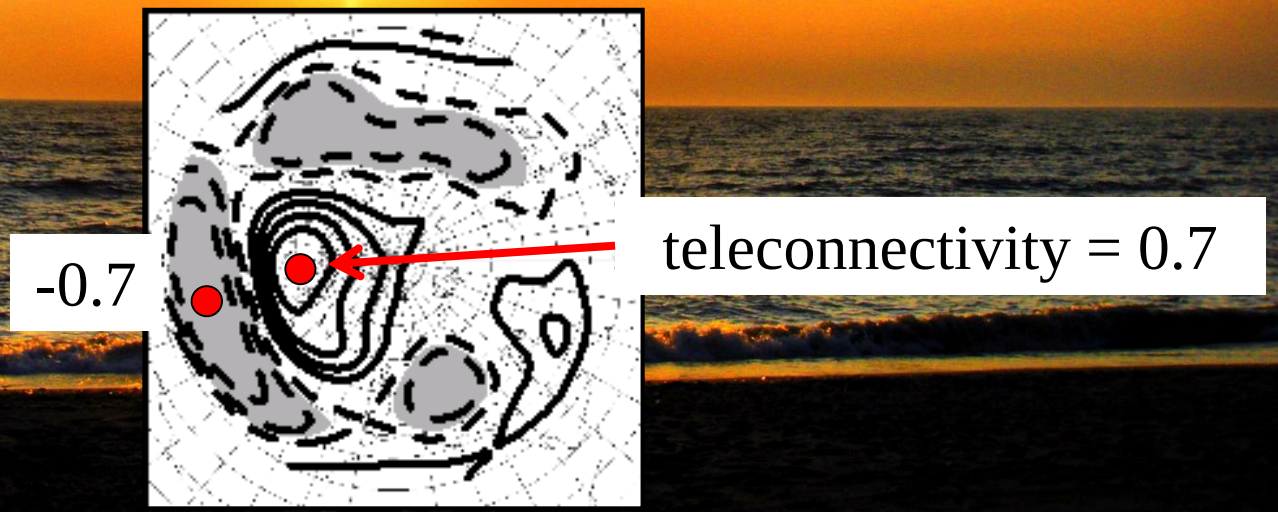
Similarity of one-point correlation maps, max vs min



black contours: Congruence coefficient between one-point correlation maps for solar minimum and solar maximum (multiplied by 100; values exceeding 70 shaded).
blue contours: Statistically significant differences between the two correlation maps at the 5% and 1% level.

Teleconnectivity

- for each gridpoint, largest negative correlation with that point is mapped



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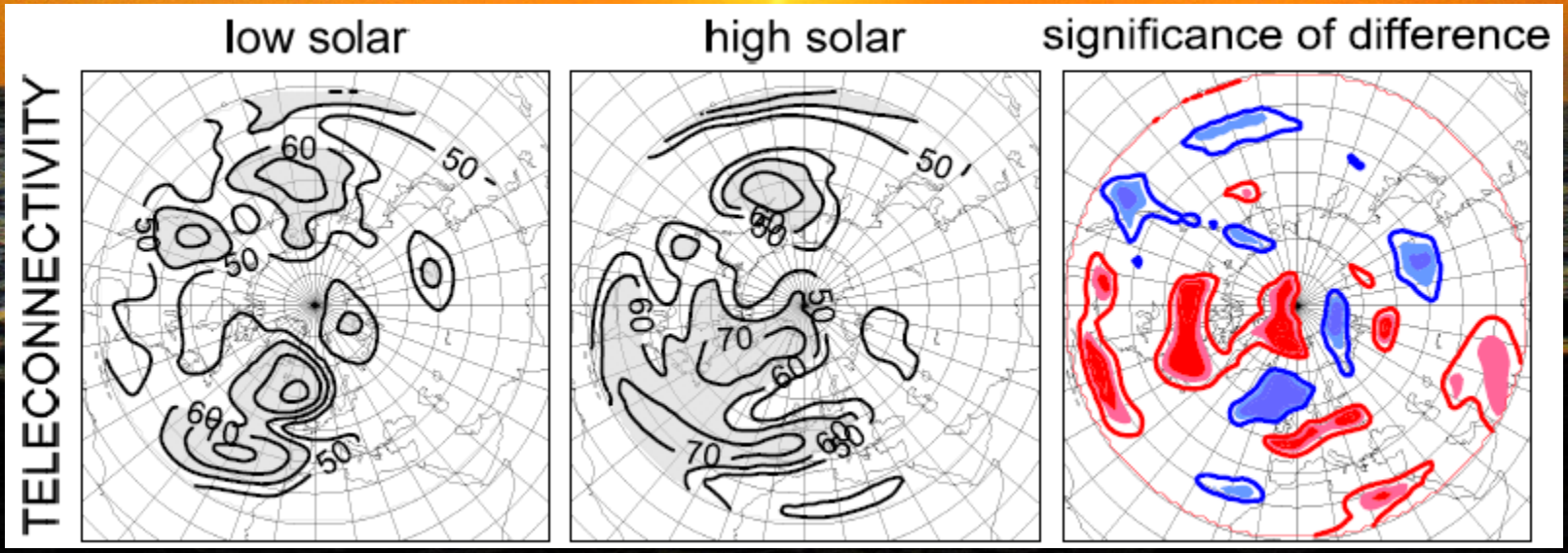
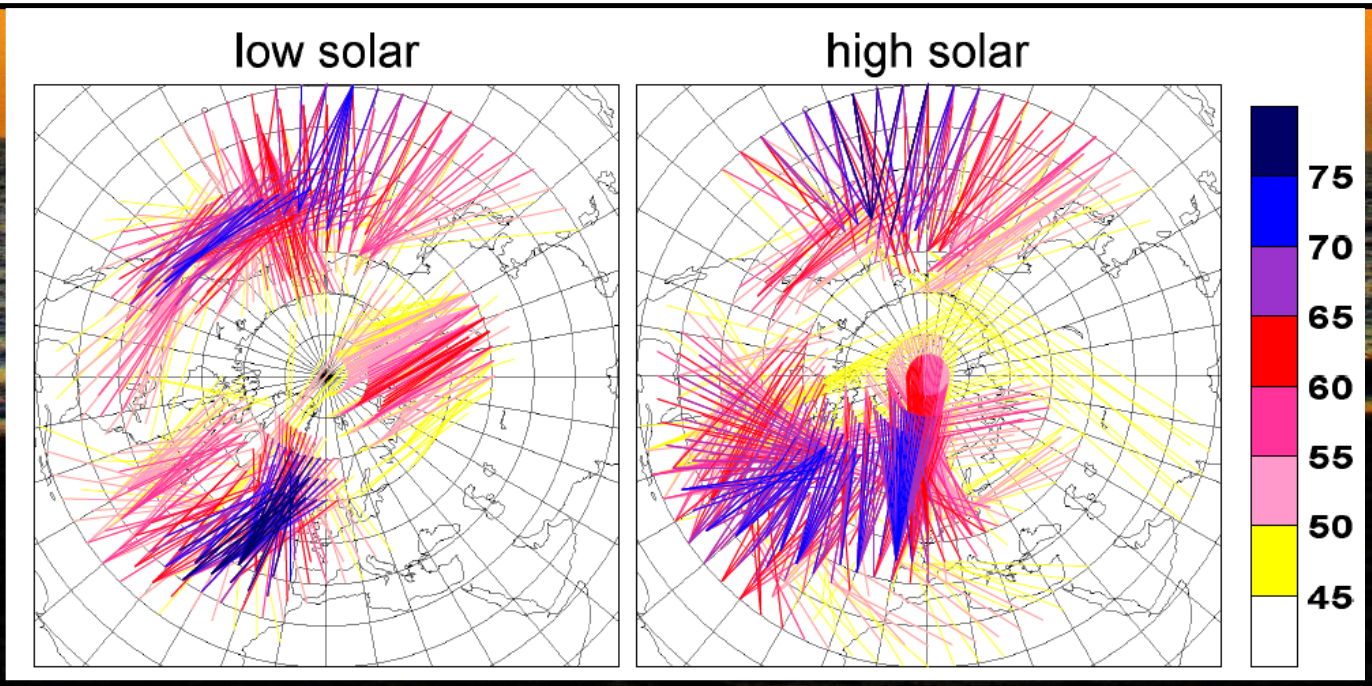


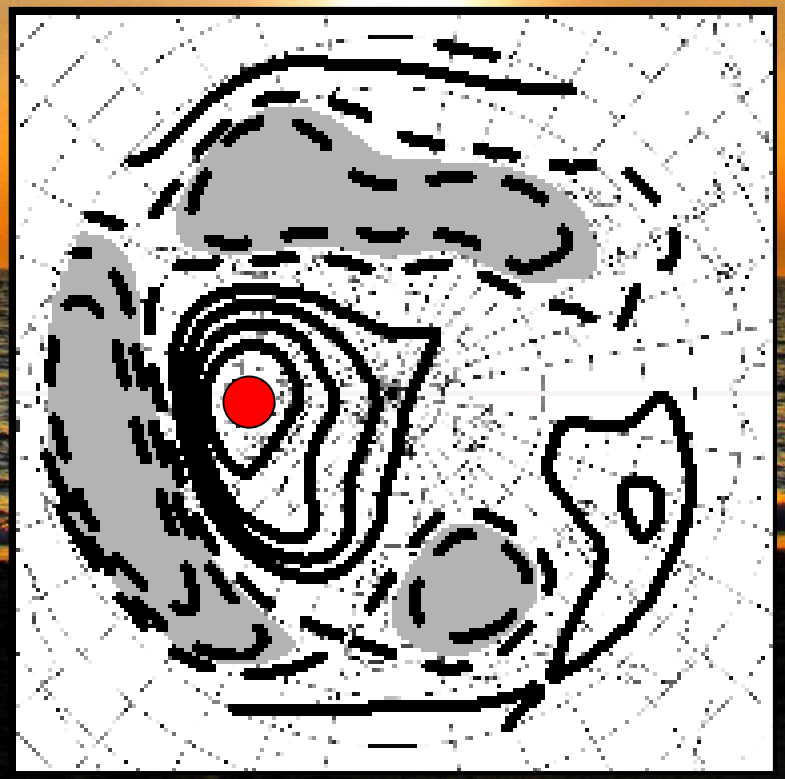
Teleconnectivity

Teleconnection diagram. Each point is connected to the point with which it is most strongly negatively correlated. Only correlations (in absolute value) over 0.45 are displayed.



Teleconnected area

for each grid point, area with correlations below –0.3 is mapped



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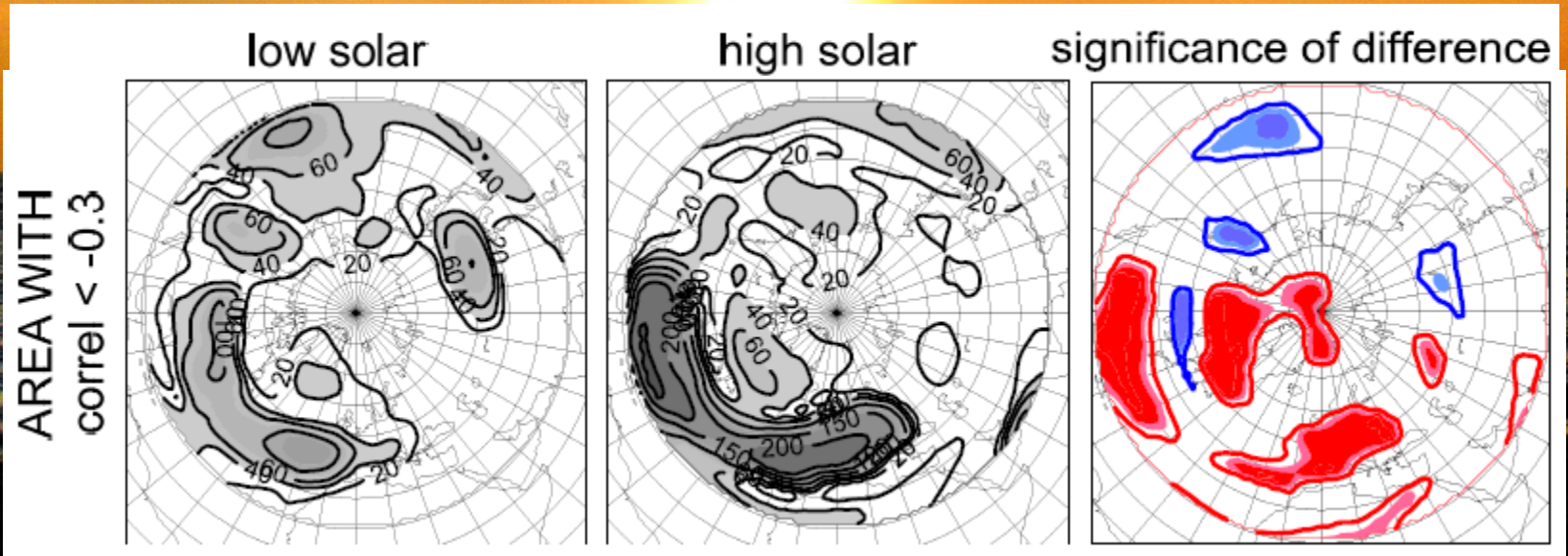

Summary

- teleconnectivity is significantly affected by solar activity
- in solar maxima:
  - autocorrelation structures more spatially extensive in the Euro-Atlantic domain
  - reduction of spatial extent of teleconnections in subtropical east Pacific

Outlook

- update to today
- other reanalyses
- can surface-input (century-long) reanalyses capture these effects?
- if so, then extension back in time (latest version of 20CR reanalysis starts before 1850)
- lagged analyses: for which lag is the response largest?