Teleconnections in the climate system from a dendrochronological perspective

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“...tree-ring chronologies can be used not only for dendrochronology but also in historical meteorology. The procedure is somewhat different, but it appears probable that in this way a real teleconnection or correlation will be found between tree-patterns in Scandinavia, Scotland, and other parts of the world.”

Justin D. Shove 1950
Outline of presentation

- What?
- Why?
- How?
- History
- Patterns
- Teleconnections in a long-term perspective
What (is a teleconnection)?

A teleconnection is:
"1. A linkage between weather changes occurring in widely separated regions of the globe.

2. A significant positive or negative correlation in the fluctuations of a field at widely separated points.

Most commonly applied to variability on monthly and longer timescales, the name refers to the fact that such correlations suggest that information is propagating between the distant points through the atmosphere.”

(America Meteorological Society)
Why (are they of importance)?

Teleconnection patterns are of interest because of the potential for long-term predictions – but then the source of the teleconnection must be understood.
How (are they identified)?

Teleconnection are identified by using statistical tools to compare indices for regional climate (e.g. Temperature, precipitation etc.) with indices for large-scale circulation patterns (e.g. ENSO or NAO).

Changes in winter SLP, temperature, and precipitation corresponding to a unit deviation of the NAO index over 1900 to 2005. (Adapted and updated from Hurrell et al. (2003).

IPCC 2007
History
Sir Gilbert Walker (1868-1958)

Attempted to describe the relationships among climate variables (e.g. precip., temp., pressure) around the world.

Developed multiple regression equations to predict Indian monsoon rainfall (e.g. with SLP from remote stations).

*Walker identified three pressure oscillations central to world weather:*

“...there is a swaying of pressure on a big scale between the Pacific Ocean and the Indian Ocean [SO], there are swayings, on a much smaller scale, between the Azores and Iceland [NAO], and between the areas of high and low pressure in the N. Pacific [NPO].”

*Walker 1923*
Early Teleconnectors: the De Geers

Ragnar Lidén, Gerard De Geer, Ebba Hult De Geer, and Ernst V. Antevs (who would sharply criticize De Geer's attempted trans-Atlantic and inter-hemispheric varve correlations)

Modified from De Geer (1921): http://ase.tufts.edu/geology/varves/History/history2.asp

It has been doubted that very small variations in the annual deposition should be possible to recognize from one part of the world to another, but, as De Geer has emphasized, this variation has nothing to do with the relative distances on our planet, only with the enormous distance from the sun, being about 150,000,000 kilometers and practically the same to all parts of the earth. He has shown that the variations of the actual temperature of the air, directly observed, in Europe and in North America, correspond equally well as those of the varves and that both are determined by annual and not semiannual variations in the radiation from the sun, because identical variations occur also on the southern hemisphere.

Ebba Hult De Geer (1935)
The physical laws of the universe regulating the movements of the earth as a planet, directly cause seasonal variations of heat and cold on the earth and annual auto-chronologic registration by elements sensible to heat, such as melt-water sedimentation and growth of wood. This investigation, therefore, though operating now with botanic material as a basis, deals with the group of physically self-registering natural auto-chronometers, of which the clock-work is nothing less than our planetary system.

Ebba Hult De Geer (1935)
Teleconnection patterns

http://www.cpc.noaa.gov/data/teledoc/teleintro.shtml

Prominent patterns over the North Atlantic
- **East Atlantic Pattern** (EA), all months

Prominent patterns over Eurasia
- **East Atlantic/Western Russia pattern** (EATL/WRUS), all months
- **Scandinavia pattern** (SCAND), all months
- **Polar/Eurasia pattern**, all months

Prominent patterns over North Pacific/North America
- **West Pacific pattern** (WP), all months
- **East Pacific - North Pacific pattern** (EP-NP), all months
- **Pacific/North American pattern** (PNA), all months
- **Tropical/Northern Hemisphere pattern** (TNH), December-February
- **Pacific Transition pattern** (PT), August-September
More (well known) teleconnection patterns

- **El Niño-Southern Oscillation (ENSO)**
- **North Atlantic Oscillation (NAO)/Arctic Oscillation (AO)**
- **Pacific Decadal Oscillation (PDO)**
El Niño-Southern Oscillation

El Niño/La Niña: SST events in the eastern and central Pacific associated to the Southern Oscillation (SO)

SO: a tendency of the atmospheric pressure to “seesaw” between two centres of action (W Pacific and tropical/subtropical SE Pacific), related to the Walker circulation

http://image.absoluteastronomy.com
El Niño: warm water anomalies (red) develop in the Central Pacific Ocean. Winds that normally blow in a westerly direction weaken allowing the easterly winds to push the warm water up against the South American Coast. Credit: NASA
La Niña

La Nina: stronger than normal trade winds bring cold water up to the surface of the ocean. Credit: NASA
The only teleconnection pattern prominent throughout the year in the NH is the NAO (Barnston and Livezey, 1987).

Corresponds to changes in the westerlies across the North Atlantic into Europe.
Atlantic Multidecadal Oscillation (AMO)

The AMO index reflects a ~ 50-80 year pattern of North Atlantic coupled ocean-atmosphere variability. It is associated with changes in rainfall over North America and Europe, the frequency of North American droughts, and the intensity of North Atlantic hurricanes.

Fig. 2. Evidence of AMO impacts on boreal summer [June, July, and August (JJA)] climate. (A to C) Observed differences between the mean JJA conditions from 1931 to 1960 (a warm phase of the AMO) and the mean JJA conditions from 1961 to 1990 (a cold phase of the AMO). (A) Sea-level pressure Contours are in Pa with an interval of 30 Pa; shading indicates signal-to-noise ratio (12). (B) Land precipitation (mm/day). (C) Land surface air temperature (°C). The scale for precipitation is 0-15.
Teleconnections in a long-term perspective

(again)
The Summer North Atlantic Oscillation (SNAO)

28.3% of 2 month variance

Full surface pattern of the July and August mean SNAO

First area weighted covariance EOF of daily pressure at mean sea level, 1850-2003
(Folland et al. 2009)
Correlation of daily SNAO with JA surface temperature

HadCRUT3v/SNAO correlation (hi) 1900–2007

HadCRUT3v/SNAO correlation (lo) 1900–2007

Interannual > 10 years
SNAO correlation with July and Aug rainfall
SNAO and Sahel Rainfall

(Linderholm et al. 2009)
How the North Atlantic Multidecadal Oscillation may have influenced the Indian summer monsoon during the past two millennia

Song Feng and Qi Hu

Major results show that the North Atlantic SST anomalies strongly affect the Tibetan Plateau surface temperature and heat sources. The latter cause changes in the meridional temperature gradient between Tibetan Plateau and the tropical Indian Ocean. Through the thermal wind effect, the meridional temperature gradient anomalies change the lower tropospheric zonal winds and the monsoon circulation and rainfall. Citation: Feng, S., and Q. Hu (2008), How the North Atlantic Multidecadal Oscillation may have influenced the Indian summer monsoon during the past two millennia, Geophys. Res. Lett., 35, L01707, doi:10.1029/2007GL032484.

Figure 3. (a) G. bulloides percentage in box core 723A (dots) and RC2730 (open circles) from the Arabian Sea, showing variations of the Indian summer monsoon intensity. Variations in surface temperature in (b) TP and (c) the North Atlantic Ocean. Thick line in Figures 3b and 3c shows variations after 5-point running mean. Following the definition of AMO [Kerr, 2000], the linear trend in Figure 3c is removed. The vertical gray bars highlight the epochs of weak Indian summer monsoon.

Feng & Hu 2008
Correlations between the SNAO and precipitation (GPCC, upper panel) and temperature (CRUTM, lower panel) 1951-2002.

June-August mean storm track and correlation between the SNAO index and storm track during 1951-2002

Comparison of reconstructed Tibetan temperatures (Bräuning & Mantwill, 2004) and the SNAO (decadal variability) with the AMO signal removed.
Reconstructing AMO with tree-rings

Spatial Structure of Atlantic Multidecadal Oscillation (AMO) Mode in SST, 1891-2005

(Parker et al, 2007)
(Not yet the final version...)
Multicentennial megadrought in northern Europe coincided with a global El Niño Southern Oscillation drought pattern during the Medieval Climate Anomaly

Samuli Helama, Jouko Meriläinen and Heikki Tuomenvirta

*Geology* 2009;37;175-178
doi:10.1130/G25329A.1
Possible changes in the teleconnection patterns, derived from the ECHO-G model data. Here winter (Dec-Feb) temperature is taken as a base time series, and calculated the correlation to all other grid-points in the Northern Hemisphere. The left panel shows the correlation pattern calculated in the period 1900-1990 with interannual values and the right panel shows the correlation pattern calculated after 31-year running mean over the whole simulation 1000-1990.

Some features are conserved at longer time scales, for instance the anti-correlation Scandinavia -Greenland, but not all of them.
And finally...

“...Although interpretations may differ, to the geographer, whose instinct is to first get the observational data on a map and the discuss the distribution, this approach to the problems of climatic change through mapping of variations in the general circulation pattern must appeal.”

And

“Meanwhile the need for more accurate data supplemented by field work, and above all, patient integration is evident, with, as a not entirely despicable goal, the enthralling prospect of finding out what our climate is going to do.”

Gordon Manley 1951
Thank you for your attention!