C20C - Climate of the 20th Century: Interannual teleconnections between the summer North Atlantic Oscillation and the East Asian summer monsoon

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Here we present a study of the relationship between July–August (JA) mean climate over China, which is strongly linked to the East Asian summer monsoon (EASM), and the summer (JA) North Atlantic Oscillation (SNAO). The variations of temperature, precipitation [Figure 1], and cloud cover related to the SNAO were analyzed for the period 1951–2002 using gridded data sets as well as instrumental data from 160 stations in China. It was shown that the major patterns of summer climate over China are highly connected with the interannual variation of the SNAO, supporting a teleconnection between the North Atlantic region and East Asia [Figure 2]. Based on the analyses of the daily and monthly reanalysis data sets, we propose possible mechanisms of this teleconnection. Changes in the position of the North Atlantic storm tracks and transient eddy activity associated with the positive (negative) SNAO phase contribute downstream to negative (positive) sea level pressure anomalies in northeastern East Asia [Figure 3 and 4]. In negative SNAO years, a stationary wave pattern is excited from the southern SNAO center over northwestern Europe to northeastern East Asia (Figure 4). However, during positive SNAO years, a stationary wave pattern is excited extending from the SNAO center across the central Eurasian continent at around 40°N and downstream to the southeast. This may explain a connection between the positive SNAO and atmospheric circulation in middle and southeastern China [Figure 5].

Definition of SNAO

The SNAO is represented as the principal components time series corresponding to the leading EOF of daily MSLP anomalies from the EMULATE data set [Ansell et al., 2006] over extratropical European–North Atlantic sector (25°N–70°N, 70°W–50°E) for July and August 1881–2003. The leading EOF exhibits the north-south dipole pattern of MSLP over Western Europe to Greenland, which explains about 18% of the daily variance over the analyses domain and 28% of the July–August mean variance [Folland et al., 2009]. An EOF analysis over this domain for 1881–2003 in summer recreates mainly the southern part of the full summer EOF node seen in NCEP data; when the southern node has higher (lower) than average pressure the SNAO index is in a positive (negative) phase.

SNAO signatures in the East Asian summer monsoon

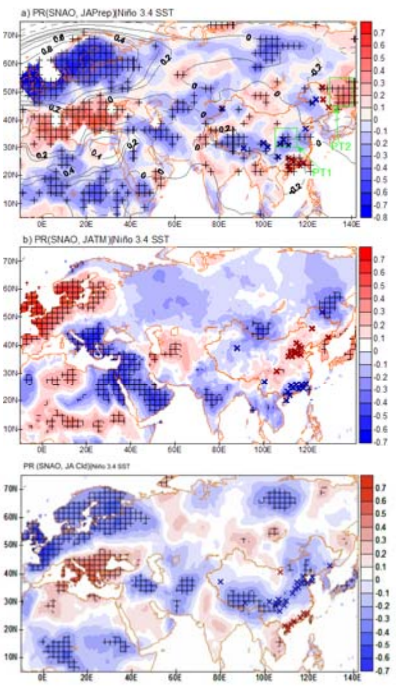

Figure 1.
[upper] the spatial distribution of partial correlation coefficients between the SNAO and July-August precipitation from the GPCC data set (http://gpcc.dwd.de) and data from 160 stations in China (data from the National Climate Centre) independent of JA Niño 3.4 SST during 1951-2002. Shaded and the correlation between SNAO and July-August MSLP (contour). Areas with significant correlations (5% level) are indicated by black crosses (GPCC data) and red/blue crosses for the station data. All data were filtered using a 9 point high-pass filter.
[middle] Same as the upper figure, but for partial correlation between the SNAO and JA mean temperatures (CRUTS2.1 and 160 Chinese stations) and NOAA ERSST V3b.
[lower] Same as Figure 3 but for partial correlations between the SNAO and JA cloud cover (CRUTS2.1 cloud cover and 160 Chinese stations total cloud cover) independent of JA Niño 3.4 SST for 1951–2002.

Here, partial correlation between X and Y, independent from Z is defined as,

$$PR_{XY \cdot Z} = \frac{R_{XY} - R_{XZ}R_{YZ}}{\sqrt{1 - R_{XZ}^2}\sqrt{1 - R_{YZ}^2}}$$

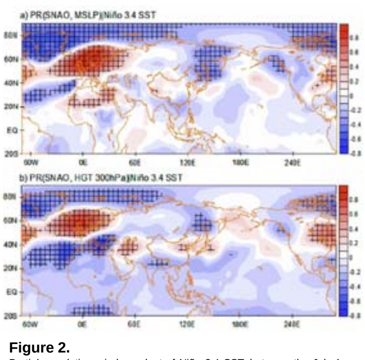

Figure 2.
Partial correlations, independent of Niño 3.4 SST, between the July-August SNAO and (a) July-August MSLP and (b) July-August 300hPa HGT 1951-2002. 9 point high-pass filters (Gaussian M-term filter) have been used for all the data sets. Positive and negative correlations locally significant at the 5% confidence level are indicated by black crosses here and in other diagrams.

Possible mechanisms

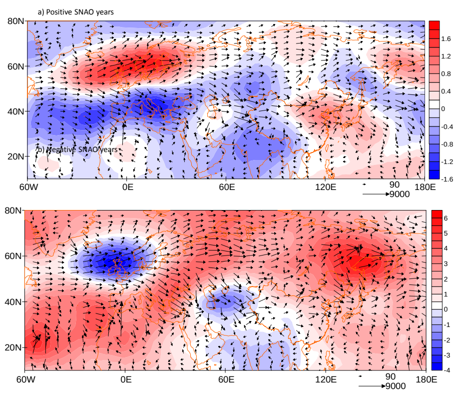

Figure 3.
300hPa July-August mean Wave-Activity Flux (arrow, units: m2 s-2) and stream function anomaly (units: 106 m2 s-1) of a) positive and b) negative SNAO years for 1951-2002, Scaling for the arrows is given near the lower right corner. The propagation of stationary Rossby waves was estimated by the wave-activity flux suggested by Takaya and Nakamura [2001], which is a generalization of Plumb [1985]'s 3-dimensional wave-activity flux (W) applying to a zonally-uniform basic flow.

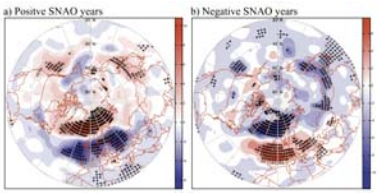

Figure 4.
Composite map of 300hPa storm tracks for positive SNAO years (SNAO index > 1 SD) (1955, 1959, 1968, 1969, 1972, 1975, 1976, 1978, 1981, 1983, 1984, 1990, 1996, 1997, 2002) (a) and for negative SNAO years (SNAO index < -1 SD) (1953, 1954, 1956, 1958, 1960, 1965, 1974, 1985, 1988, 1992, 1998) (Unites: m) (points significant at 5% level are indicated by black crosses). Red indicates increased storm activity and blue decreased storm activity relative to the average of all data.

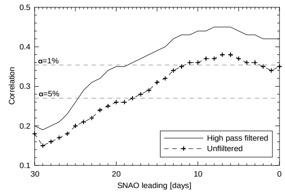

Figure 6.
Lagged correlation between the 62-day running average of the SNAO index and JA mean precipitation difference between regions PT2 and PT1 (see Figure 1 for locations of the regions) with SNAO leading the precipitation.

SNAO signal propagating to East Asia

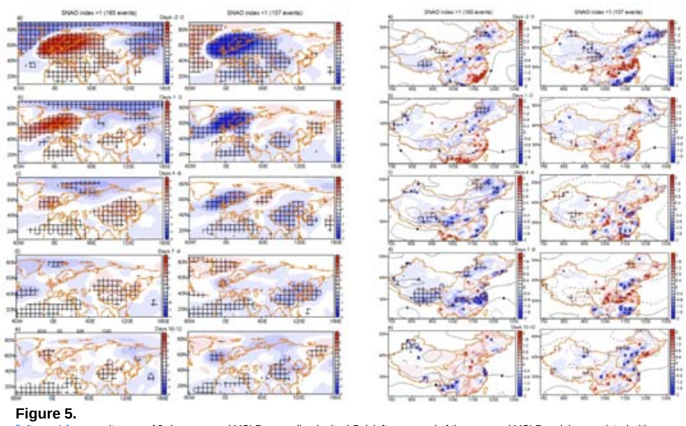

Figure 5.
[left panels] composite map of 3-day averaged MSLP anomalies (units: hPa) (after removal of the seasonal MSLP cycle), associated with positive (left) and negative (right) SNAO events. Day -2 = two days before a SNAO events, day -1 = one day before an events, day 0 = the day of the event, and so on (points with 5% significance are indicated by crosses)
[right panels] same as left panels but for daily precipitation anomalies (units: mm/day) in China [Chen et al. 2010] with MSLP anomalies (contour in 0.5, units: hPa)

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