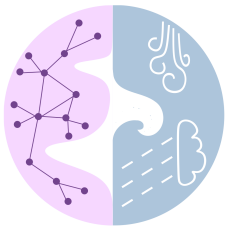
Journal Club

Circumglobal Teleconnection in the Northern Hemisphere Summer



Machine Learning in Climate Science (MLCS), University of Tuebingen

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Circumglobal Teleconnection in the Northern Hemisphere Summer*

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Outline

Key Questions, Results and Impact

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Discussion: How to explain these observation?

Summary

Key Questions, Results and Impact

Questions:

- What are the recurrent circumglobal teleconnection (CGT) pattern in the summertime midlatitude circulation of the Northern Hemisphere (NH)?
- Are there connections between the CGT, the Indian summer monsoon (ISM) and El Niño–Southern Oscillation (ENSO) (and other major modes of climate variability)?

Key results:

- A circumglobal teleconnection (CGT) exists during the NH summer which can be identified with the second leading empirical orthogonal function of interannual variability of the uppertropospheric circulation.
- The ISM acts as a "conductor" connecting the CGT and ENSO.

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Key results:

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Impact:

- Better predictability when the ISM and ENSO is active, ENSO may influence northern China via the ISM and the CGT.
- The interaction between the global jet streams and the ISM can help understanding the boreal summer on the NH.

Data and Methods

- **Geopotential height:** monthly averaged, period 1948-2003, provided by National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis data
- **Sea Surface Temperature (SST)**: monthly averaged, period 1948-2003, provided by National Oceanic and Atmospheric Administration (NOAA) extended reconstructed SST (ERSST)
- **Precipitation**: weather station observations, monthly averaged rainfall from a) 29 stations in India from 1948–98 b) 160 weather stations in China 1951-99 c) land-only coverage from 1950-99, provided by the University of Delaware from the Global Historical Climate Network(GHCN)
- **Preprocessing**: The long-term trend and decadal variations with a period $\geq$ 8yr are removed using Fourier harmonic analysis of the monthly mean anomalies.

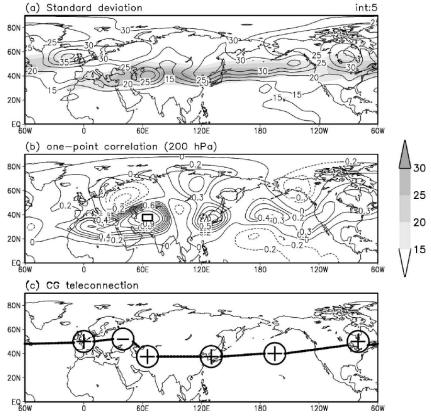
What do the authors mean by the term "teleconnection"?

- Relationships in the low-frequency variability of the tropical and extratropical atmospheric circulations, precipitation, and temperatures.
- Often related to using principal component analysis (PCA) to reveal (mainly on a regional scale) a wavelike structure in climate observables.

Circumglobal Teleconnections analysis

CGT pattern

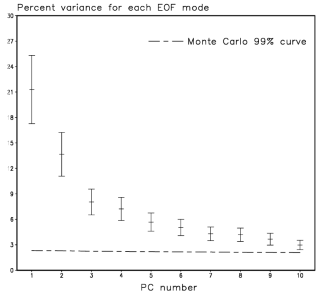
- Centers of variability: Northeast Atlantic, Western Europe, West-central Asia, East Asia to the Gulf of Alaska, and northern North America. These variability centers are closely associated with the major summertime jet streams.
- Pressure variations between the different centers are nearly in phase (resp. anti-phase). Box defines CGT-Index (CGTI).
- CGT can be defined as the global zonal wavenumber-5 teleconnection pattern with six prominent "centers of action"



(a) Standard deviation of summer 200-hPa NH heights (contour) and jet stream speed $\geq$ 15m/s (shading). (b) Correlation map between the box and summer 200-hPa geopotential height. (c) Schematic illustrating 6 main action centers.

What defines the CGT?

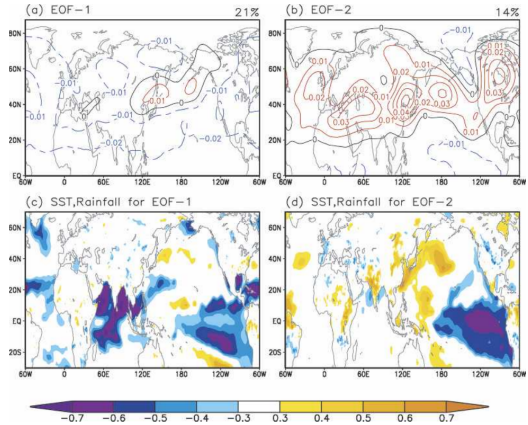
- PCA analysis of the temporal covariance matrix using the seasonal summer mean 200-hPa geo-potential height field. EOFs were computed over the entire NH, with the data weighted by the square root of the cosine of latitude to ensure that an equal area has the same contribution to the total variance.
- The first two dominant modes account for 21% and 14% of the total variance.
- The correlation to precipitation and SST distribution are obtained by correlating the time series of each principal component (PC) with the seasonal precipitation anomalies over land and SST over ocean.



Eigenvalues of first principle components of PCA analysis of geopotential height.

Interpretation of CGT

- The second EOF mode (14% of the variance), shows strong similarity to the CGT in its spatial structure and the locations of the five positive centers, the PC time series of the second EOF has a correlation coefficient of 0.6 with the CGT-Index.
- The negative correlation between the anomalous SST and time series of EOF-2 in the eastern equatorial Pacific accompanied with a positive correlation on the north, west, and south, corresponds to a La Niña event.



(a), (b) First two modes of an EOF analysis applied to NCEP–NCAR reanalysis seasonal geopotential height anomalies at 200 hPa. (c),(d) Correlation coefficient between the time series EOF 1,2 and precipitation data over land and SST data over ocean.

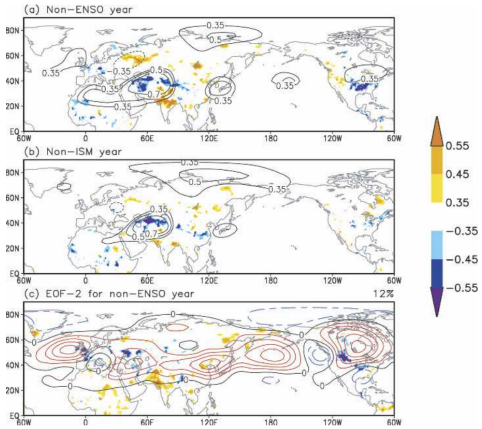
Connection of CGT to ENSO and ISM

How is CGT correlated to ENSO and ISM?

- Correlation coefficient between
  - CGT-Index - All-Indian Rainfall Index (AIRI): 0.69
  - AIRI - Niño-3.4 SST: 0.52
  - CGT-Index - Niño-3.4 SST: 0.43
- Partial correlation between the CGTI and Niño-3.4 suggests that the simultaneous relationship results mainly from the correlation between the ISM and CGTI.
- What is the concrete influence of ENSO on CGT?

Connection CGT, ENSO, ISM

- The structure of the CGT remains intact as ENSO is excluded ⇒ the CGT exists independent of ENSO.
- In the absence of the ISM the CGT pattern nearly completely vanishes.
- Possibly ENSO exerts an influence on the midlatitude rainfall variability through the ISM.

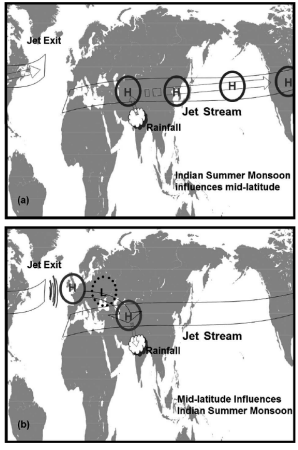


(a), (b) One-point correlation map between CGT-Index and global precipitation at Non-ISM, resp. Non-ENSO year. (c) Correlation map between EOF 2 and precipitation.

Discussion: How to explain these observation?

Explanation of CGT influence on Jet Streams

- The zonal wavenumber-5 structure of CGT, is in accordance with the theoretically deduced zonal wavenumber of the stationary Rossby waves around 5 along the circumglobal waveguide, associated with the westerly jet stream.
- Scenario I: An enhanced ISM initially generates an upper-level anomalous high over west-central Asia, and then excites successive downstream cells along the waveguide through Rossby wave dispersion.
- Scenario II: an anomalous high triggered over western Europe is transported by a Rossby wave train to west-central Asia, which also implies a strong stationary wave energy transport from a high latitude to west-central Asia.



Schematic diagram illustrating the entire mechanism of the CGT consisting of two scenarios.

Summary

Summary

- The CGT is primarily confined within the waveguide that is associated with the NH summer jet stream. This teleconnection is similar to the EOF-2 mode of the interannual variability of the NH summer circulation.
- The precipitation anomalies associated with the CGT are consistent with the rainfall anomaly patterns associated with regional teleconnections eg. ISM-East Asian SM and the east Asia-North America. Thus, already known regional teleconnection patterns can be understood as the regional component of the CGT.
- CGT is closely related with the ISM, however not significantly correlated with ENSO.

Ding and Wang 2005

Ding, Qinghua and Bin Wang (2005). "Circumglobal teleconnection in the Northern Hemisphere summer". In: *Journal of Climate* 18.17, pp. 3483–3505. ISSN: 08948755. DOI: 10.1175/JCLI3473.1.