

Teleconnections

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Teleconnections contra so-called telecorrelations

By

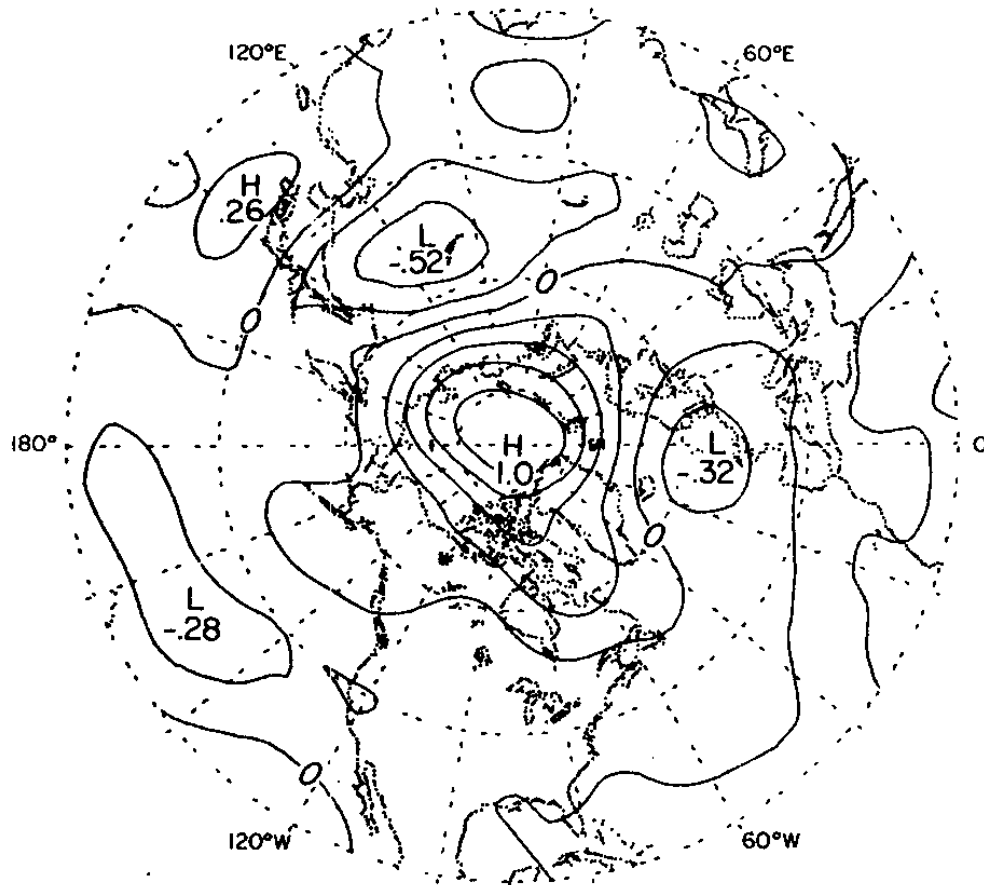
GERARD DE GEER.

(M. S. received April 8, 1935.)

Though it is somewhat trying to the patience to continue a discussion where one of the parts never concedes his own mistakes and always anew concerning the other part postulates fictive assumptions from which he gets specious conclusions which, though carefully tabulated, are quite illusory, it may still be appropriate already here to add a few remarks concerning Dr ANTEVS' last note in the preceding number of this journal.

Having found, twenty years ago (1), that the really normal or solar registration by clay varves is equally well recognisable at great distances as at small ones, I found it suitable all the same to designate identifications at greater distances by a special term as *teleconnections*. But, repeatedly, I have emphasised that there is no essential difference between close connections and teleconnections and that the latter are, in Sweden, often close-connected with each other by numerous intervening close-connections.

Teleconnectivity



Teleconnections in the Geopotential Height Field during the Northern Hemisphere Winter

John M. Wallace, David S. Gutzler - 1981

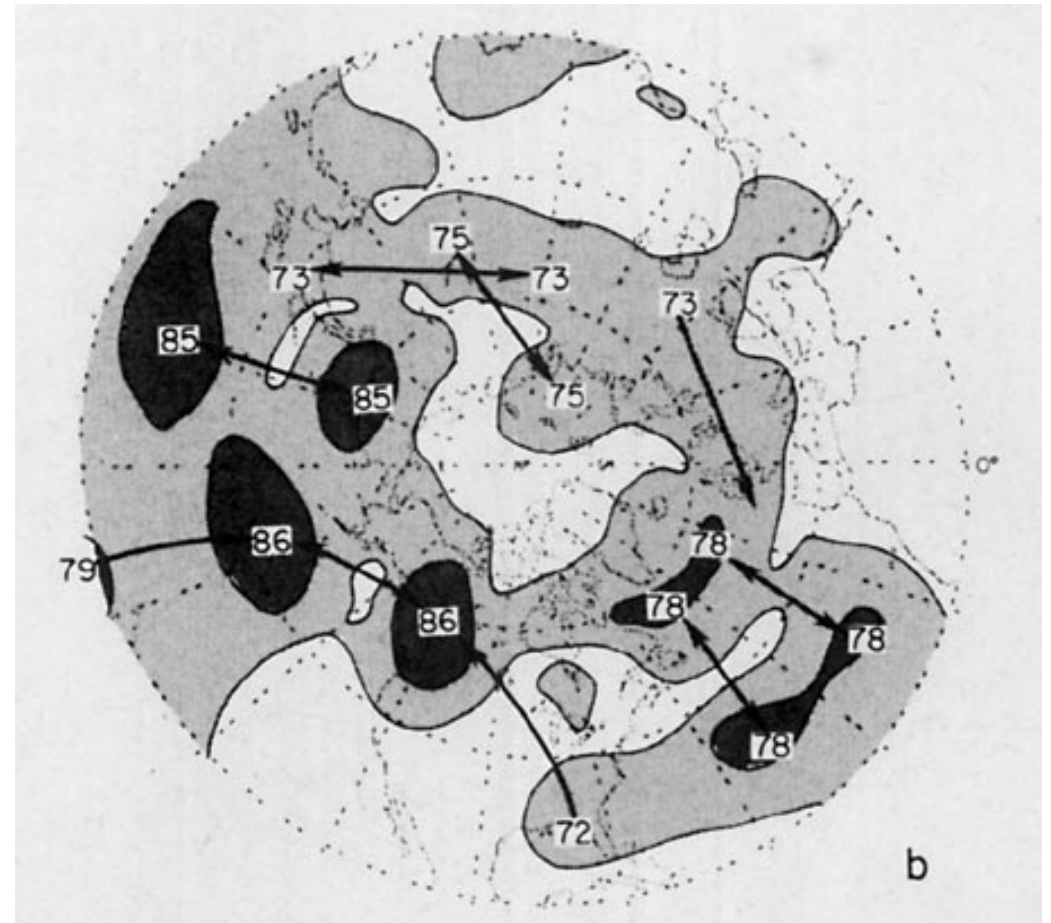
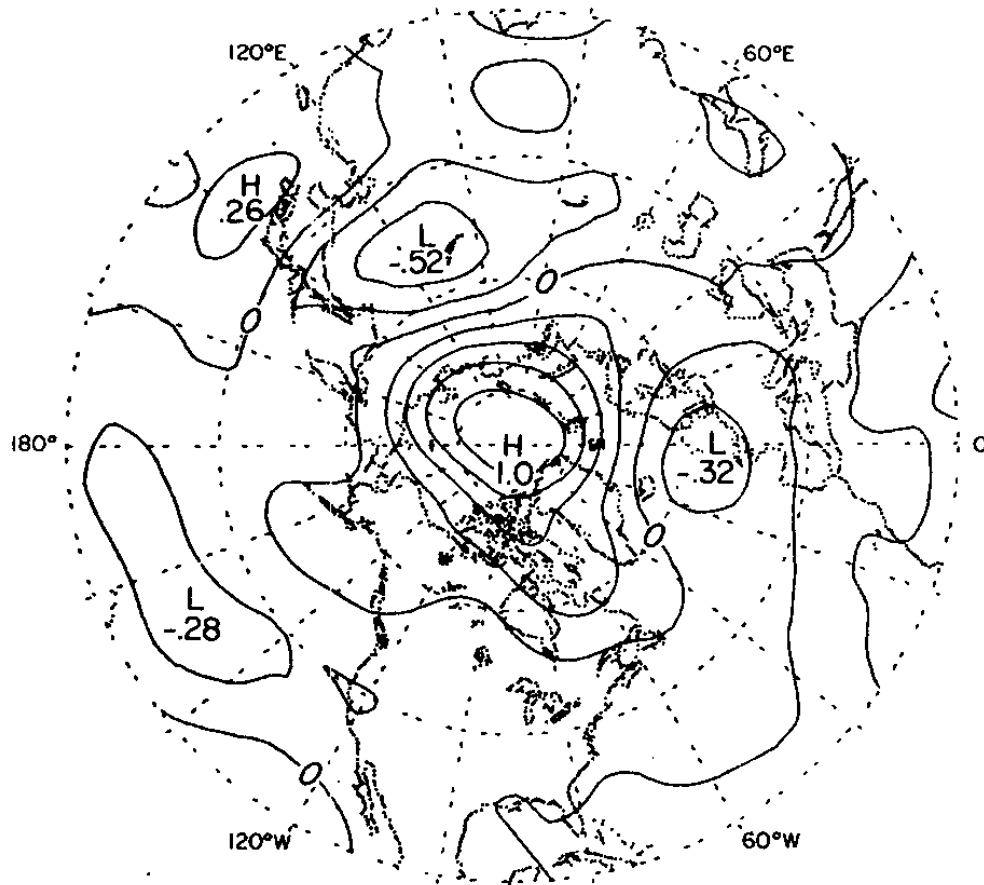


FIG. 7. Strongest negative correlation ρ_i on each one-point correlation map, plotted at the base grid point (referred to in text as “teleconnectivity”) for (a) sea-level pressure and (b) 500 mb height. Based on 45 winter months (Decembers, Januarys, and Februarys for winters 1962–63 through 1976–77).

Teleconnectivity



“Contemporaneous correlations between geopotential heights on a given pressure surface at widely separated points on Earth”

Teleconnections in the Geopotential Height Field during the Northern Hemisphere Winter

John M. Wallace David S. Gutzler - 1981

El Niño Southern Oscillation phenomena

S. G. H. Philander

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, New Jersey 08540, USA

At intervals that vary from 2 to 10 yr sea-surface temperatures and rainfall are unusually high and the tradewinds are unusually weak over the tropical Pacific Ocean. These Southern Oscillation El Niño events which devastate the ecology of the coastal zones of Ecuador and Peru, which affect the global atmospheric circulation and which can contribute to severe winters over northern America, often develop in a remarkably predictable manner. But the event which began in 1982 has not followed this pattern.

Teleconnections with extratropical latitudes

Figure 7 depicts the global teleconnection pattern, at upper tropospheric levels of the atmosphere (heights of 5–10 km) during a Northern Hemisphere winter that coincides with the mature phase of ENSO when unusually warm surface waters cover a large part of the tropical Pacific Ocean. The region of enhanced precipitation in the central Pacific is shaded. The patterns marked H and L are the regions over which the surface of constant pressure at an altitude of ~5 km is anomalously high (H) or low (L). The high pressure over western Canada is

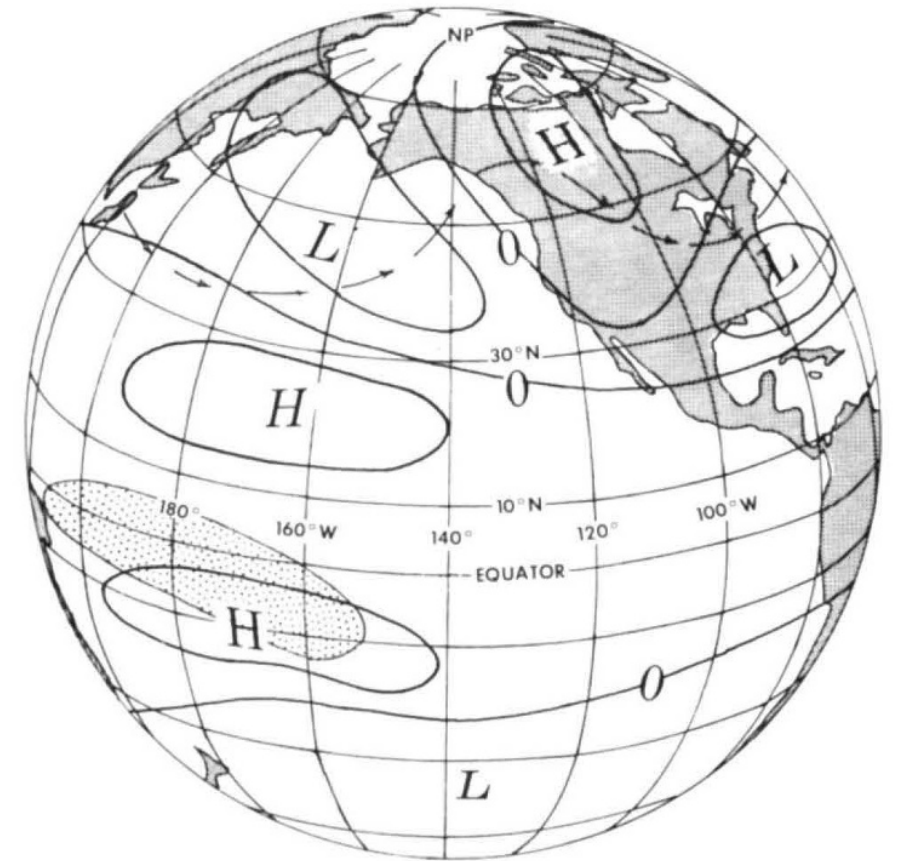
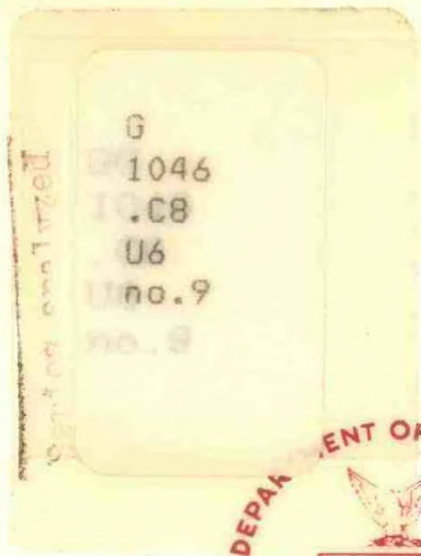


Fig. 7 Teleconnections to the extratropics during ENSO.

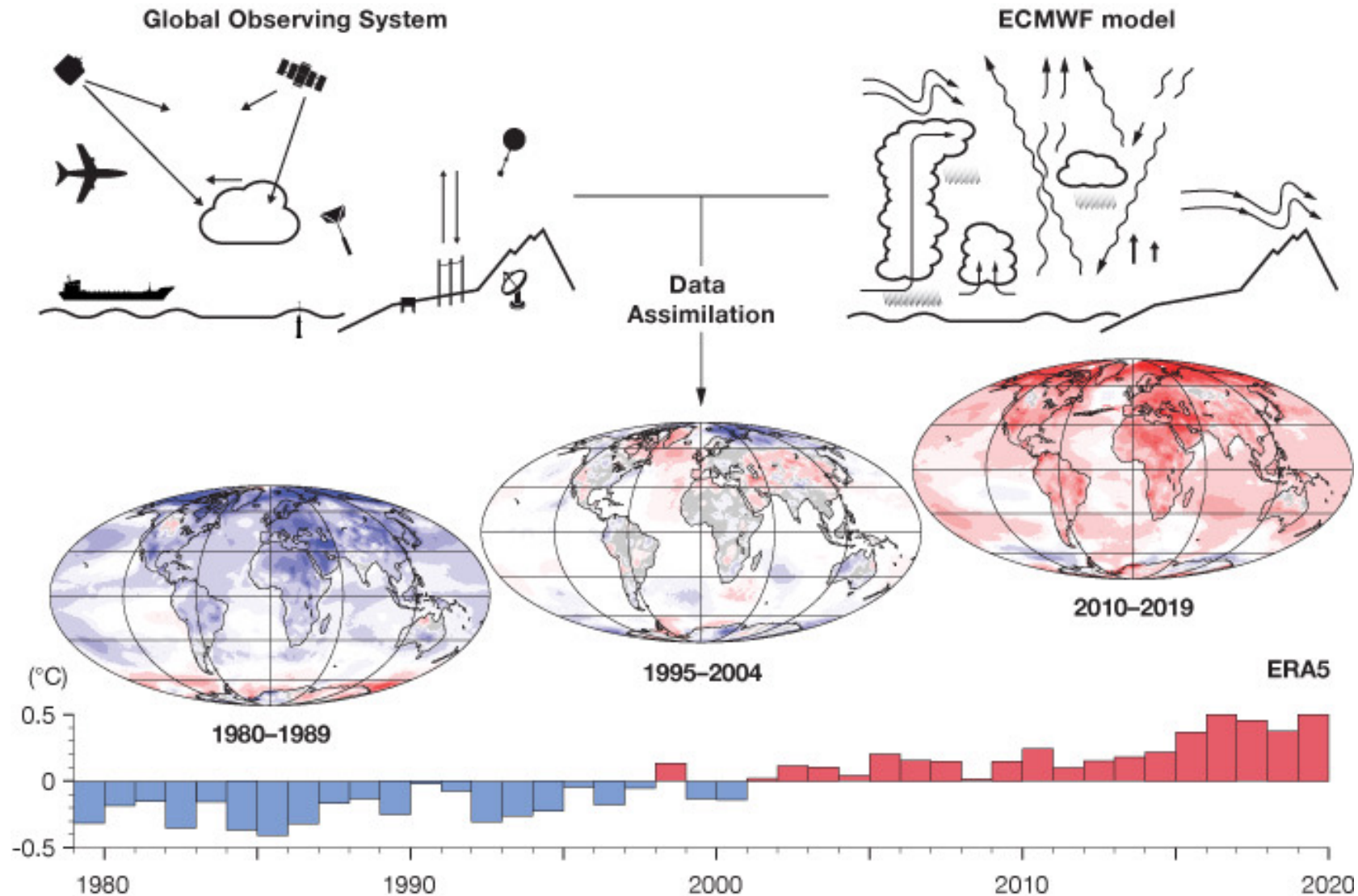


NOAA ATLAS No. 9

**Atlas of Southern Hemisphere
500 mb Teleconnection
Patterns Derived from National
Meteorological Center Analyses**

Camp Springs, Md.
March 1992

How we study teleconnections



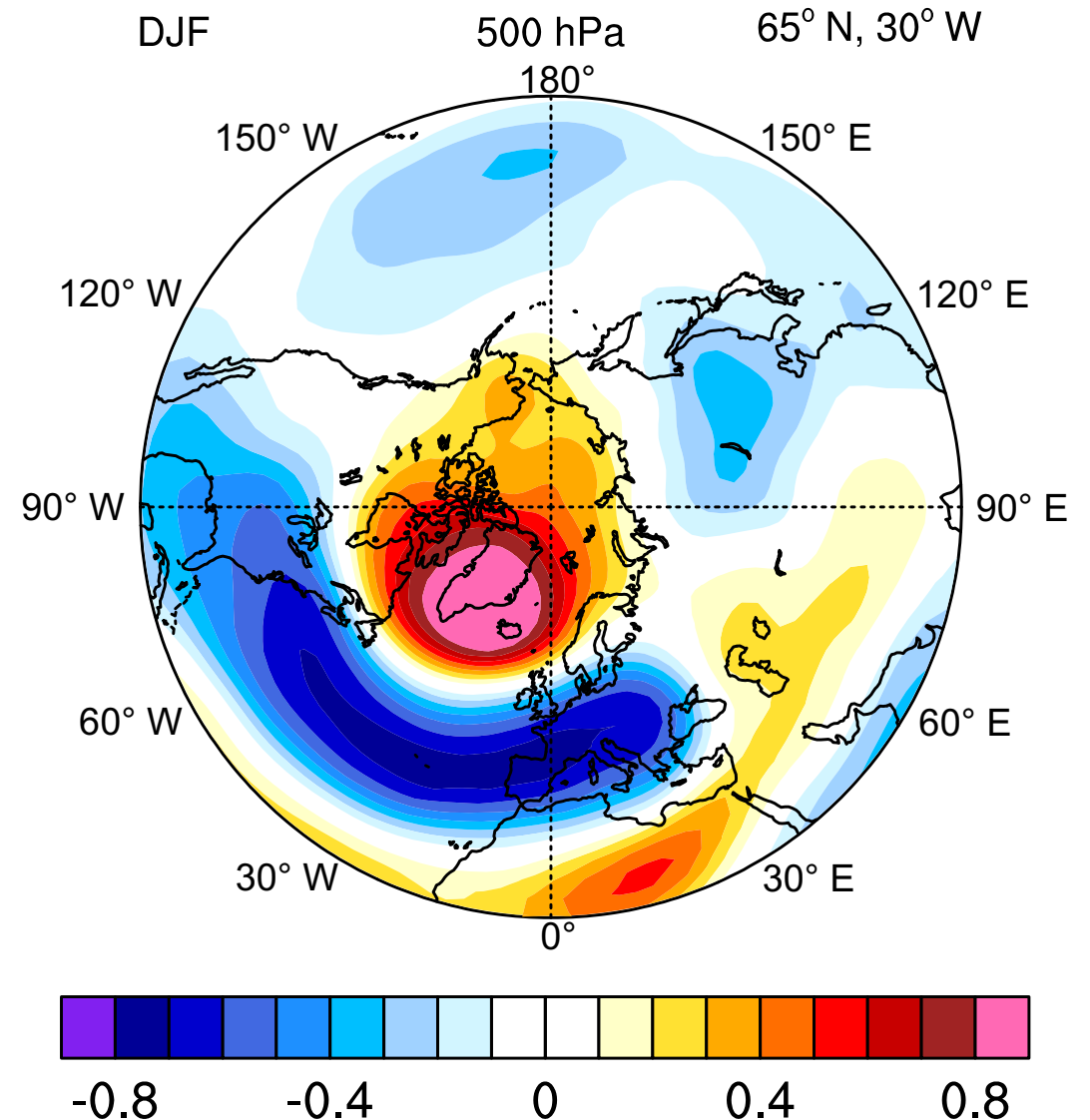
Methods

Correlation analysis

Principal components and EOFs

Clustering & Process-based
diagnostics

Model hierarchies



One-point correlation map. This is obtained by correlating the 500-hPa height time series at a selected gridpoint with the corresponding time series at all gridpoints.

Tropical-extra-tropical teleconnections

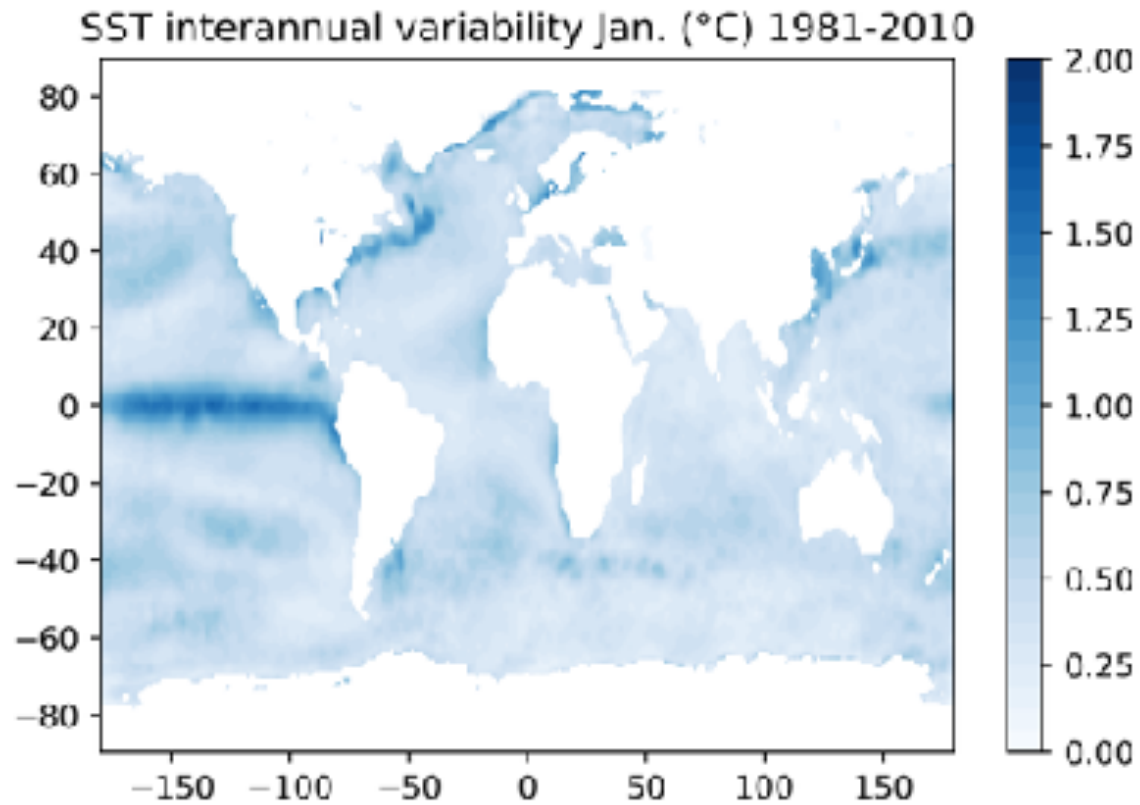
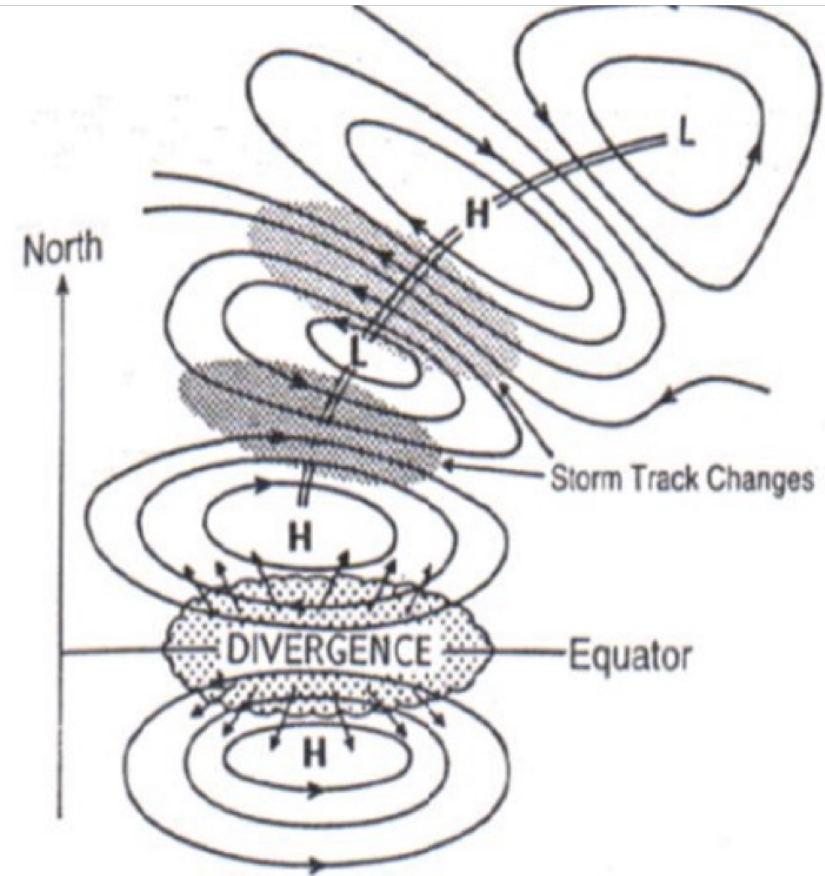


Figure 2: Interannual variability of the January monthly mean of SST.



Trenberth et al. (1998)

EFFECTS OF SST ANOMALY

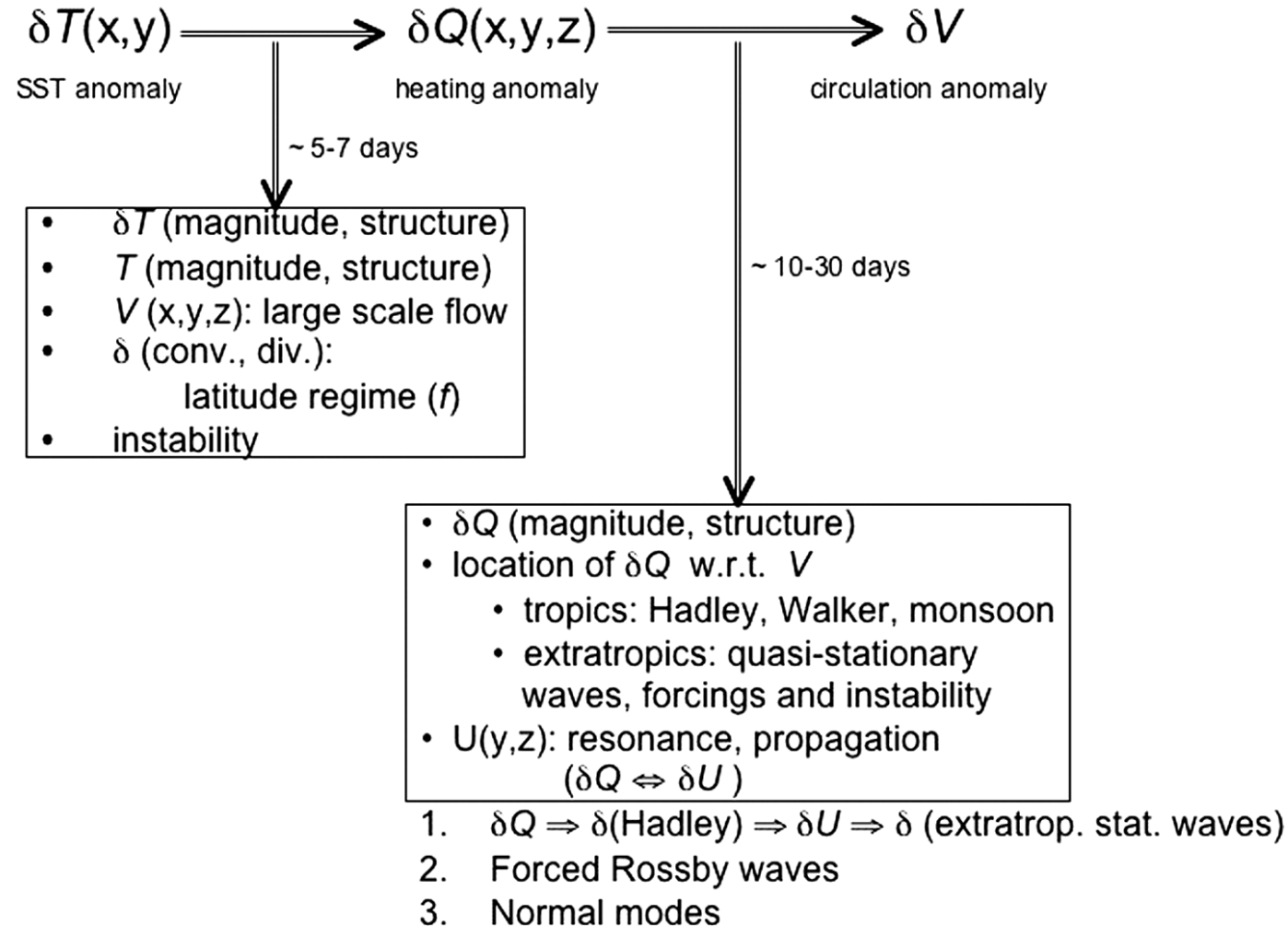
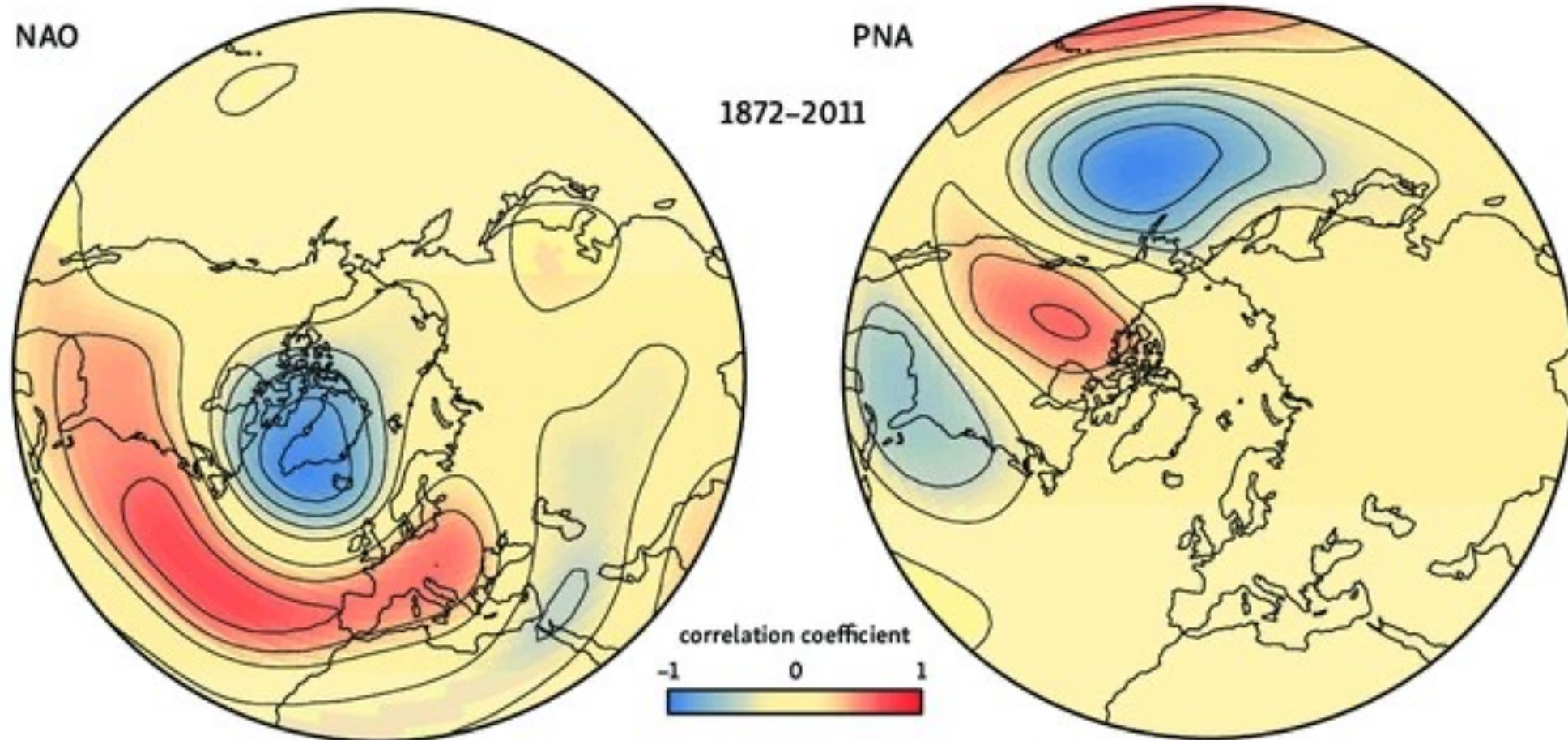


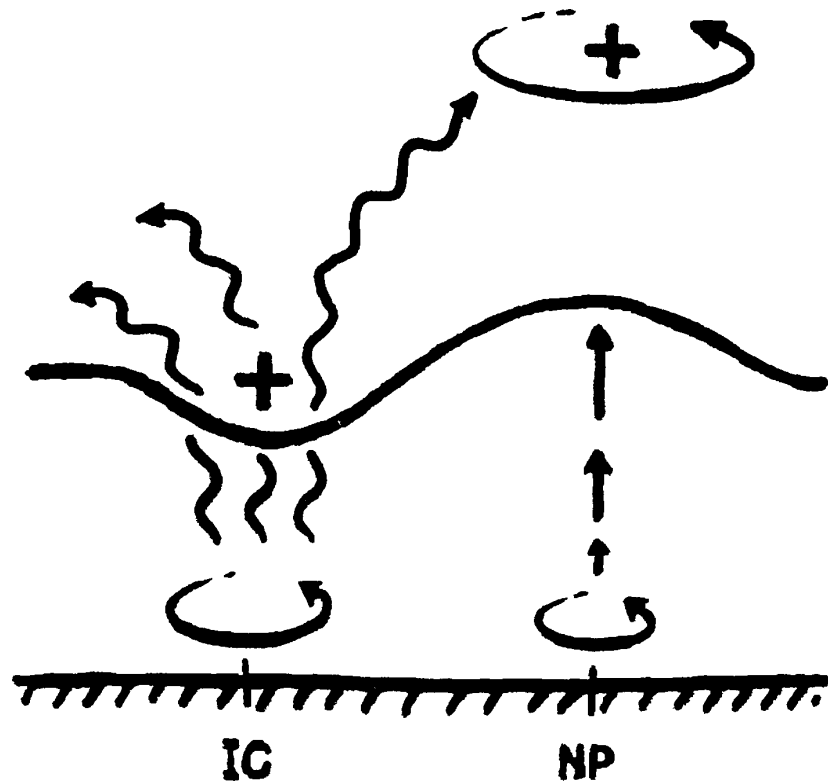
Figure 12.4 Schematic diagram of the effects of boundary condition anomalies on large-scale atmospheric heating and large-scale atmospheric circulation. See text for explanation.

Extra-tropical teleconnections



Piskala and Huth (2023)

The stratosphere



Ambaum and Hoskins (2002, JoC)

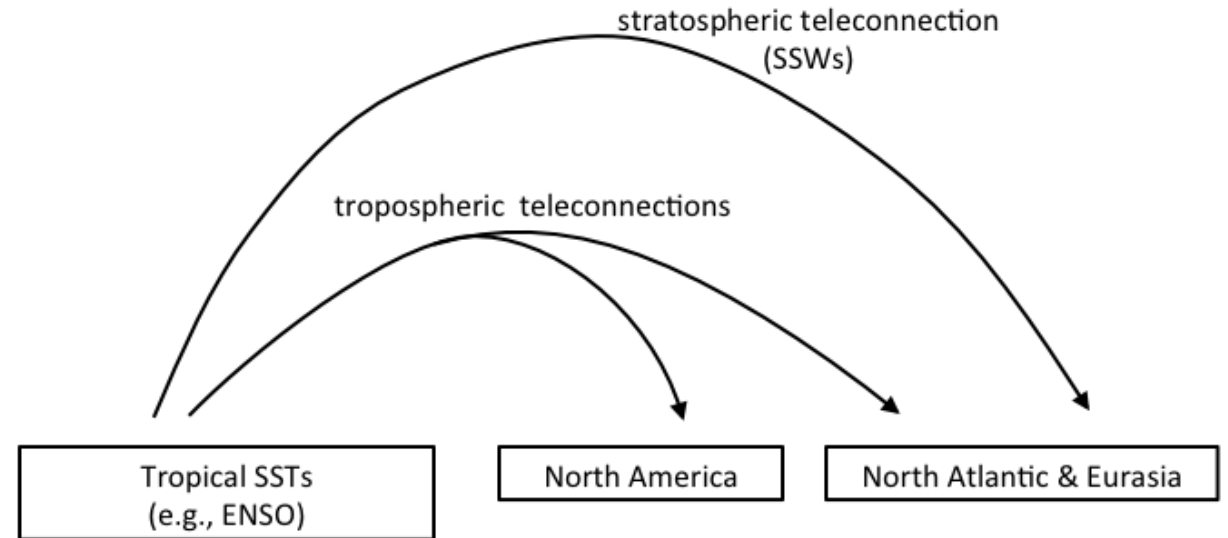
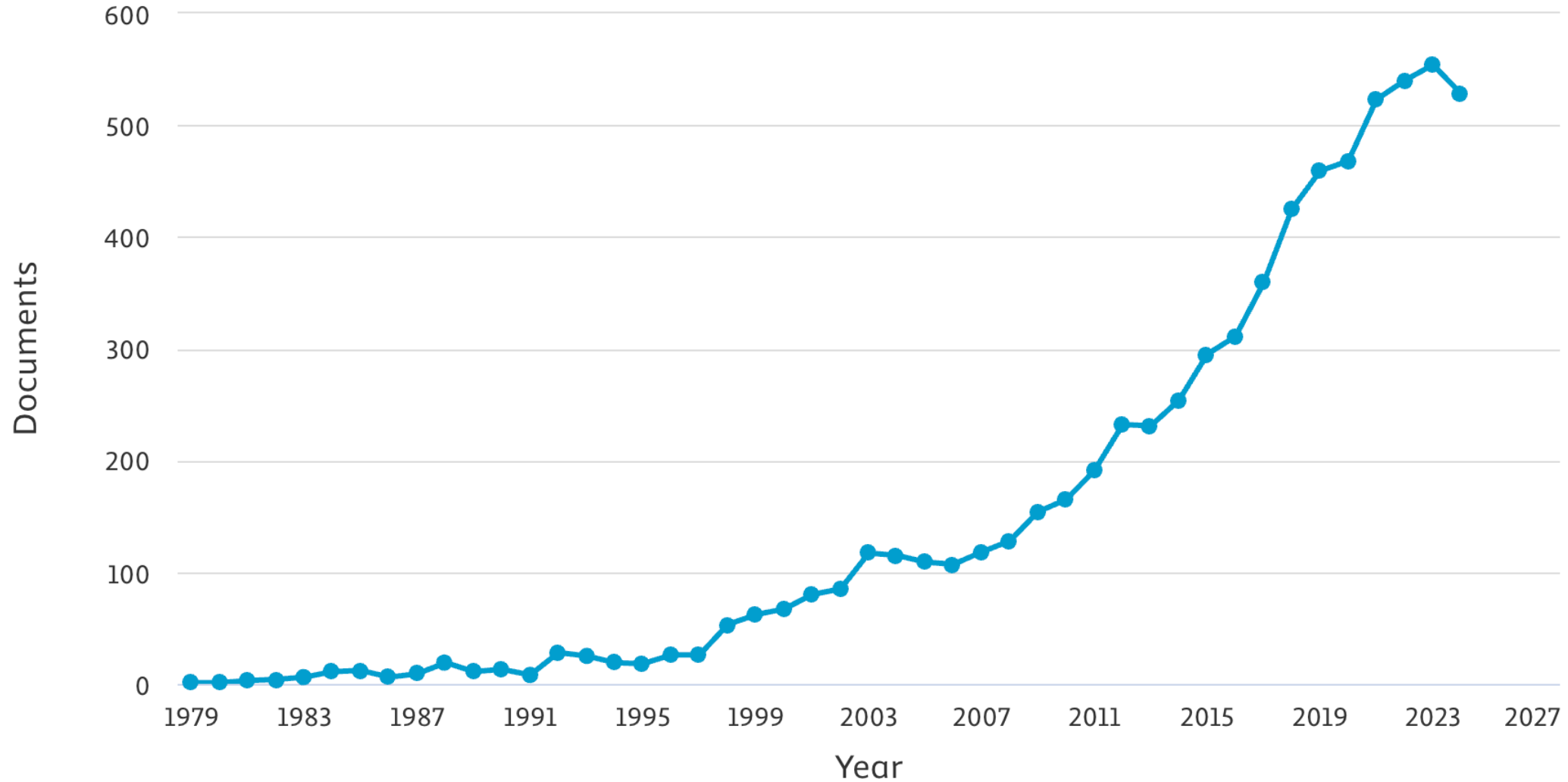


Figure 1. Schematic of possible pathways by which ENSO can influence the northern extratropics.

Butler et al. (2014, ERL)

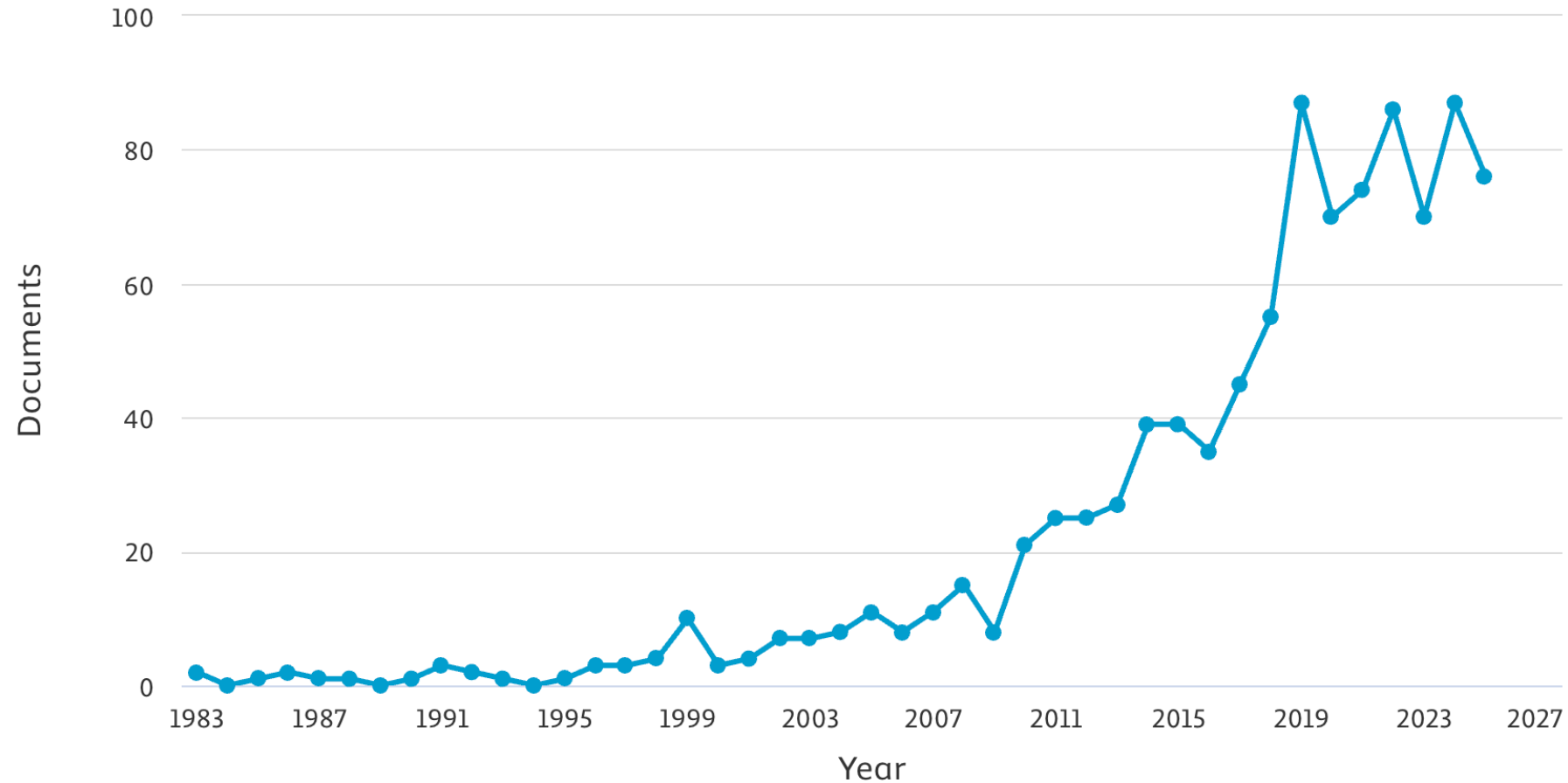
Teleconnection	Key Region	Diagnostic Variable
ENSO (El Niño–Southern Oscillation)	Tropical Pacific	Sea Surface Temperature (SST) anomalies (Niño3.4 region)
NAO (North Atlantic Oscillation)	North Atlantic	Sea-level pressure difference (Azores vs. Iceland)
AO (Arctic Oscillation)	Arctic / Northern Hemisphere	Geopotential height or sea-level pressure (zonal index)
PDO (Pacific Decadal Oscillation)	North Pacific	SST anomalies (North Pacific, after removing global trend)
AMO (Atlantic Multidecadal Oscillation)	North Atlantic	SST anomalies (basin-wide average, detrended)
IOD (Indian Ocean Dipole)	Indian Ocean	SST difference (Western vs. Eastern equatorial Indian Ocean)
MJO (Madden-Julian Oscillation)	Tropical Indian–Pacific Oceans	Outgoing Longwave Radiation (OLR) + zonal wind anomalies (850 hPa, 200 hPa)
SAM (Southern Annular Mode)	Southern Hemisphere	Sea-level pressure difference (40°S vs. 65°S)
PNA (Pacific–North American Pattern)	North Pacific / North America	500 hPa geopotential height anomalies (specific node pattern)
QBO (Quasi-Biennial Oscillation)	Equatorial Stratosphere	Zonal wind anomalies (at 30 hPa and 50 hPa over the equator)

Teleconnections in Scopus

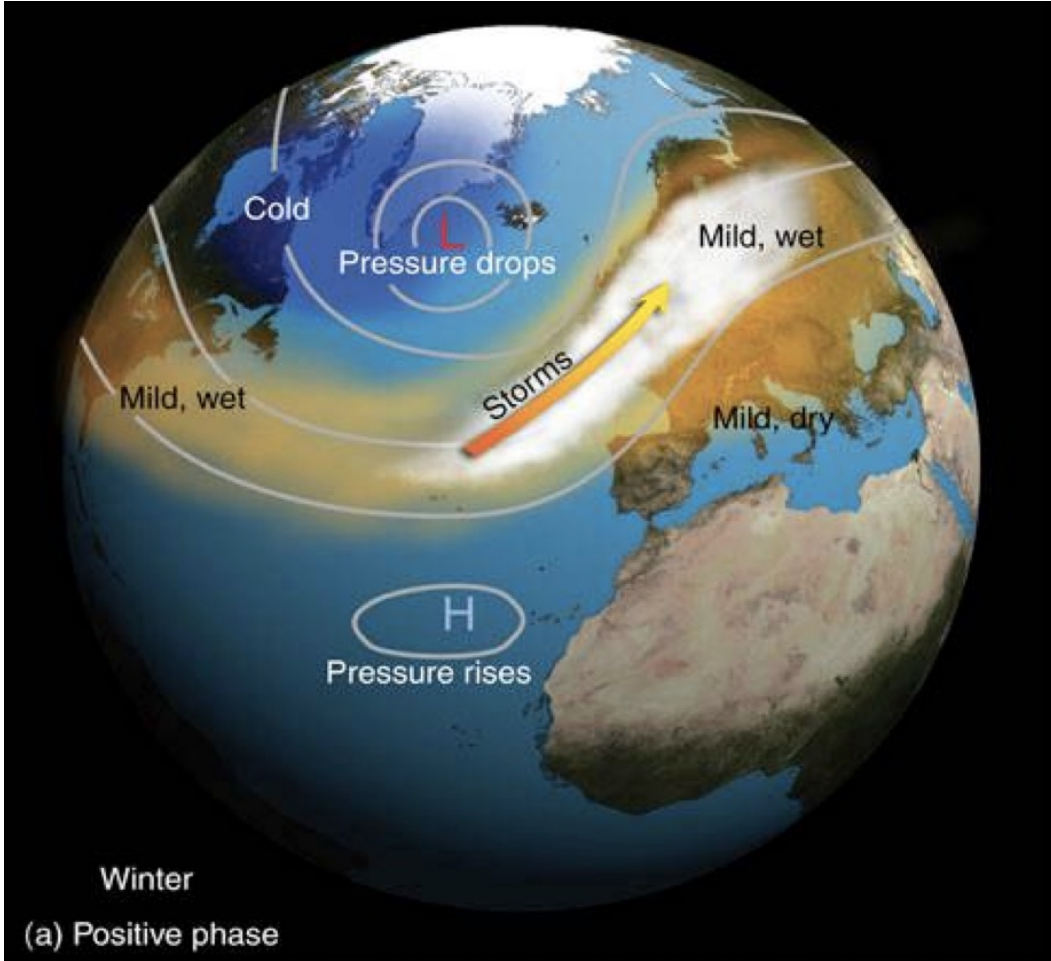


Teleconnections AND predictions

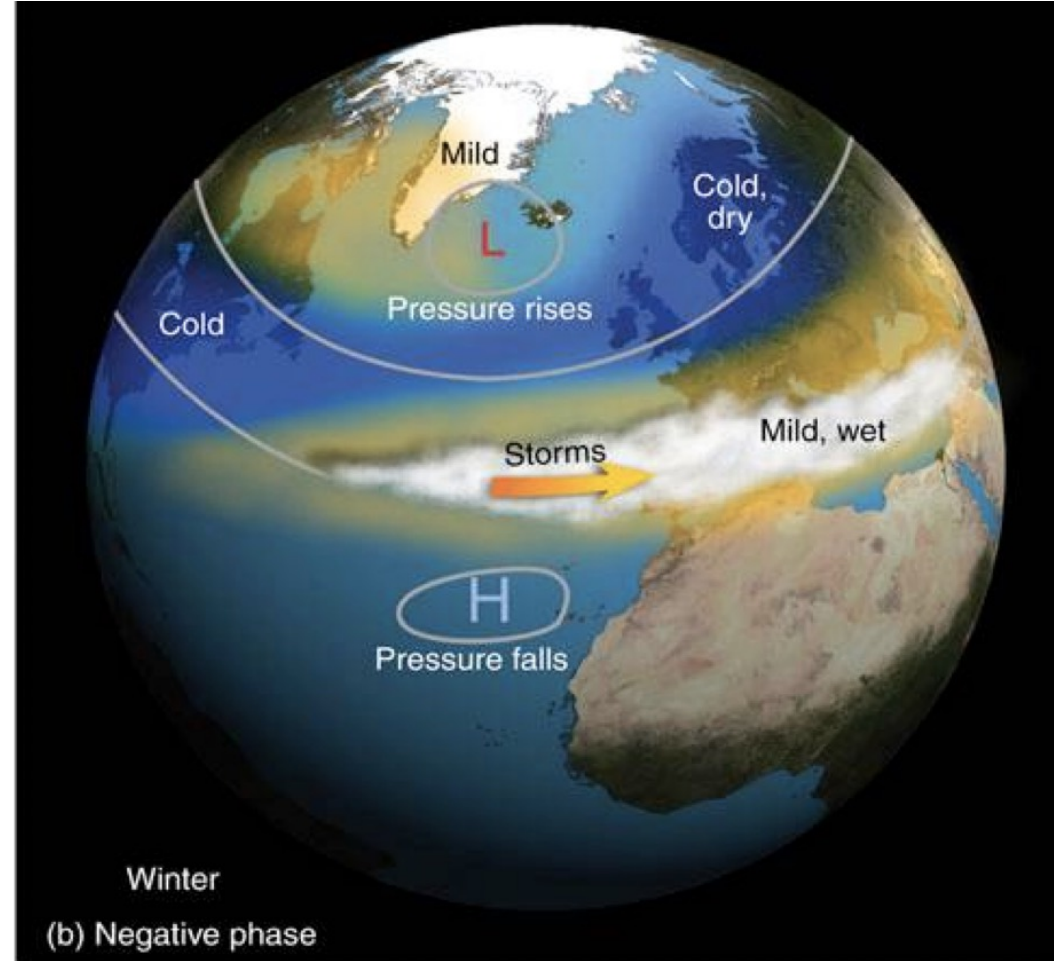
Documents by year



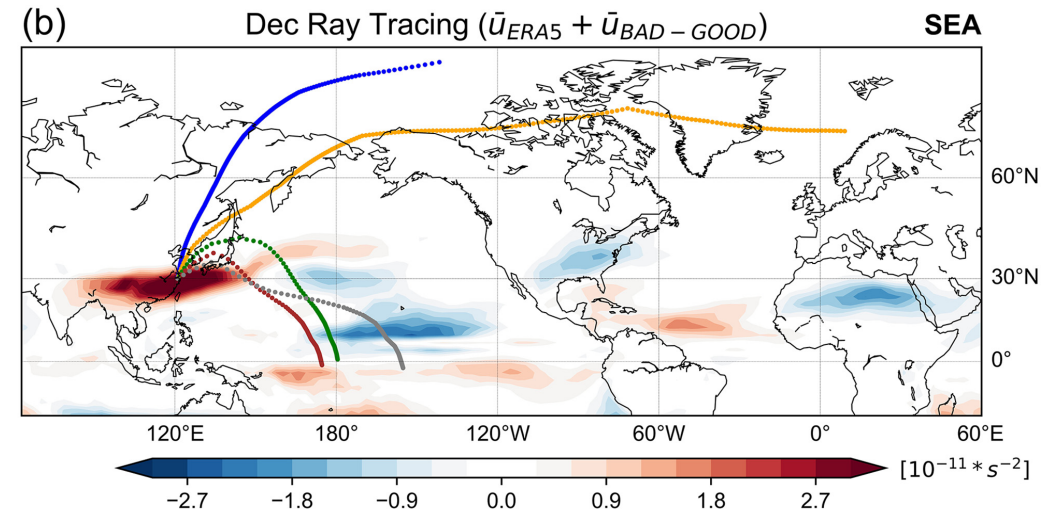
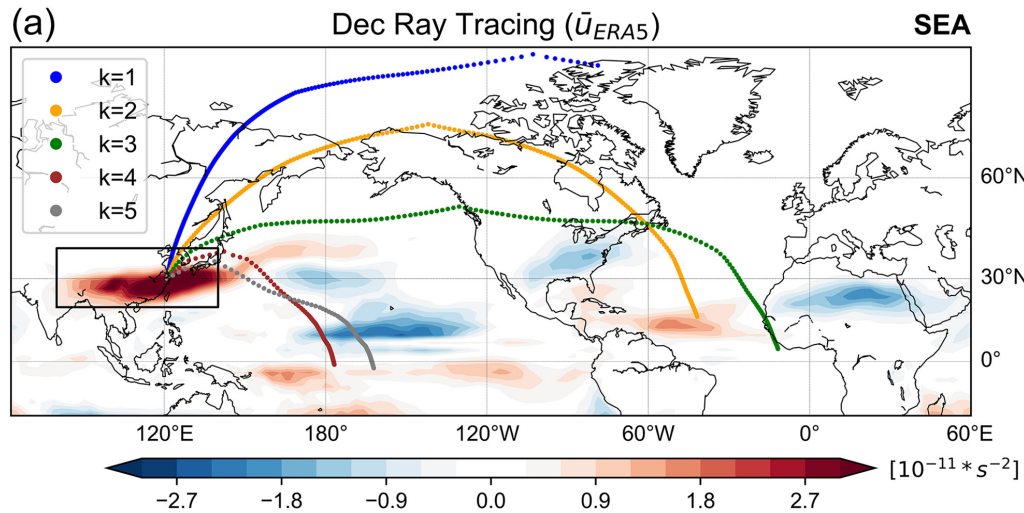
Why we study teleconnections?



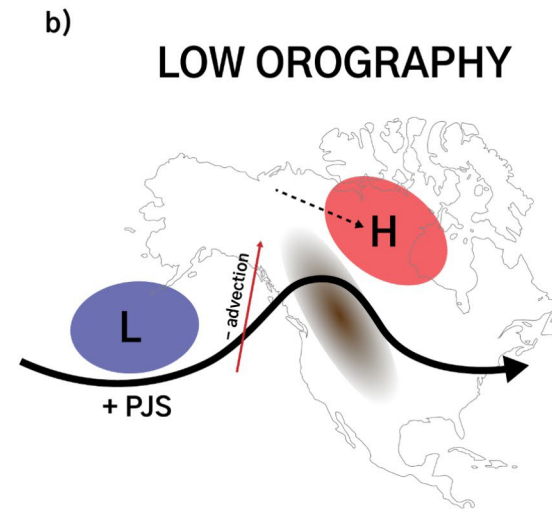
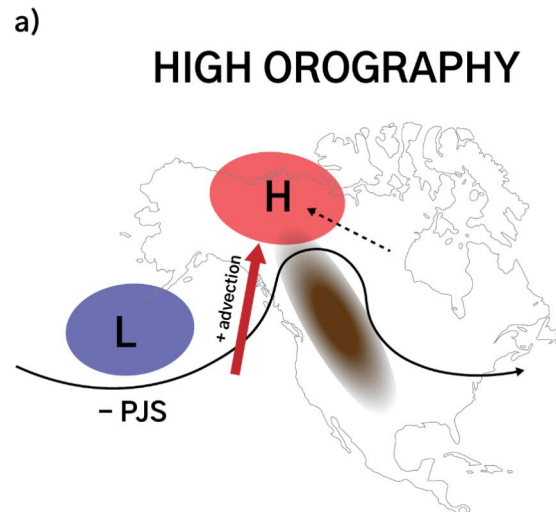
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State-dependence

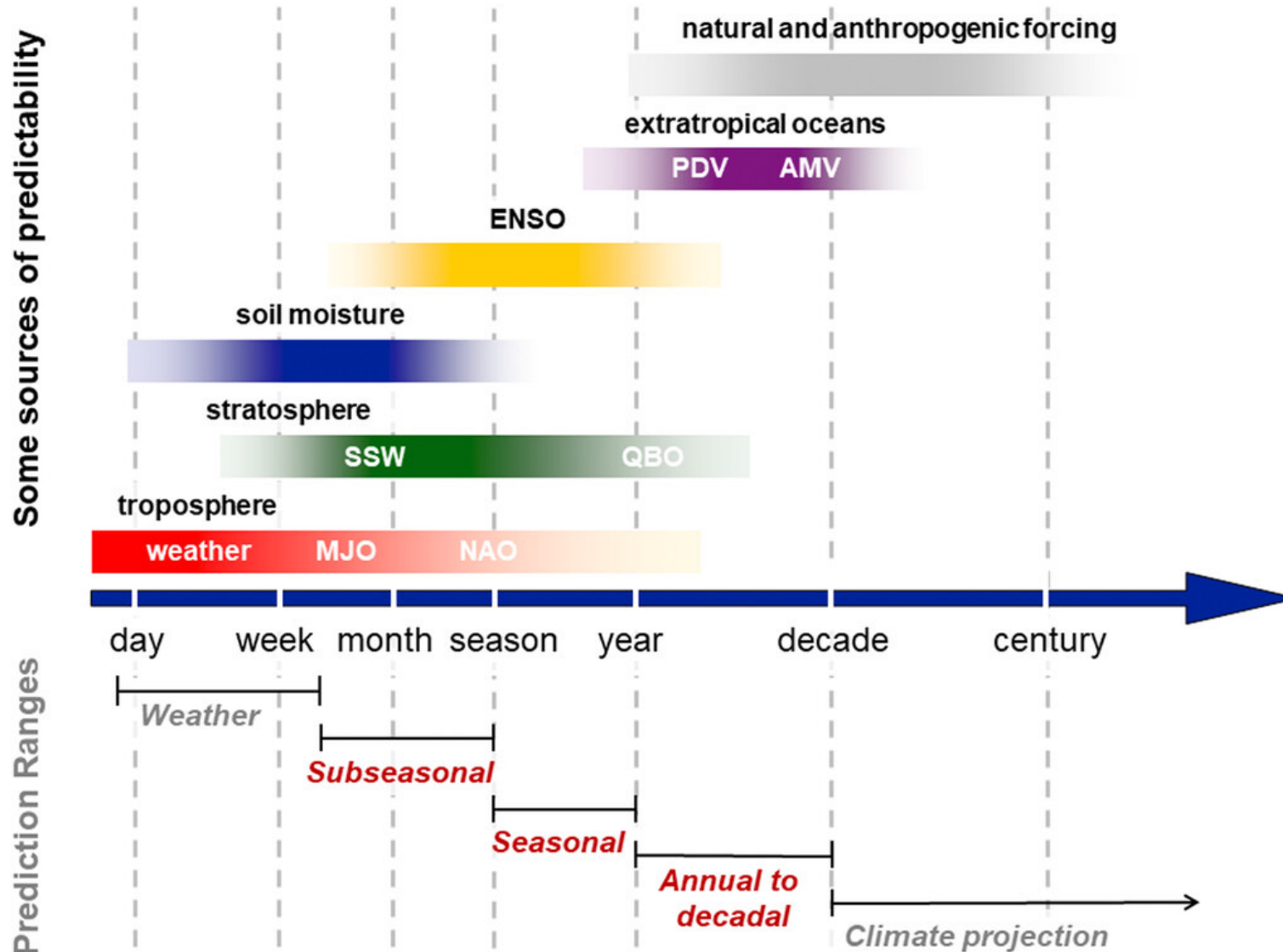


Sabatani, D., Gualdi, S. ENSO teleconnections with the NAE sector during December in CMIP5/CMIP6 models: impacts of the atmospheric mean state. *npj Clim Atmos Sci*



Di Carlo, E., Ruggieri, P., Davini, P. et al. ENSO teleconnections and atmospheric mean state in idealised simulations. *Clim Dyn* 59, 3287–3304 (2022).

Teleconnections and predictions



Merryfield et al.
(2020, BAMS)

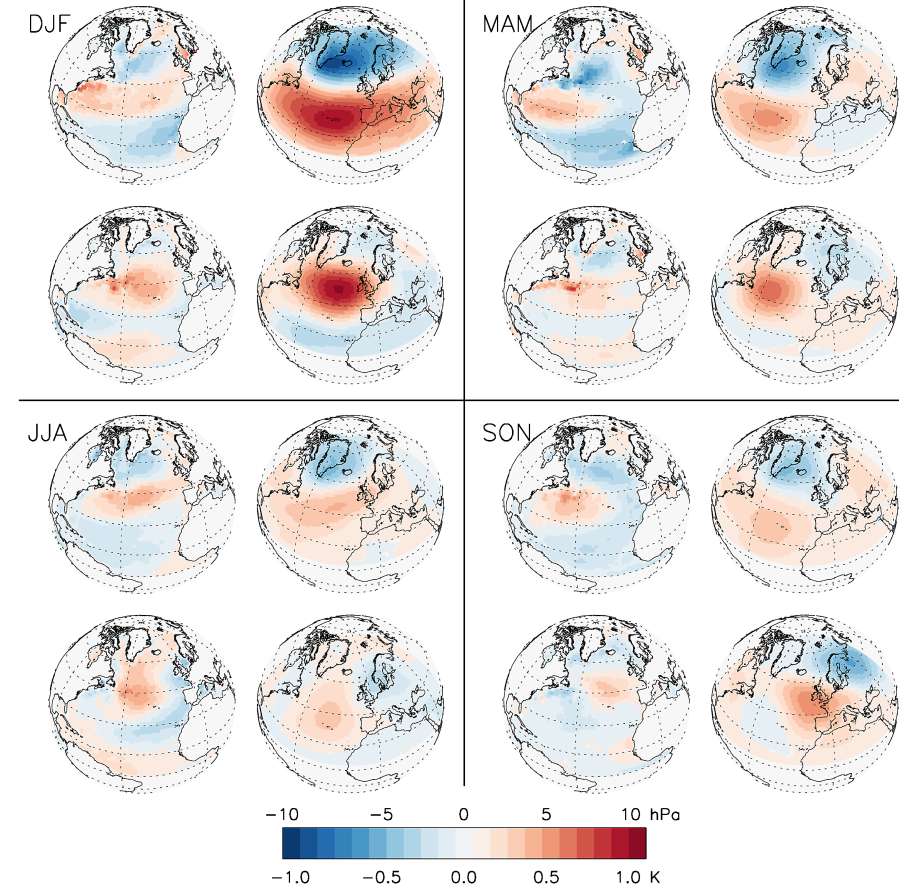
Teleconnections and predictions

$$CF \approx f(NAO, EA, EAWR, SCA)$$

$$CF(t) \approx a \cdot NAO(t) + b \cdot EA(t) + c \cdot EAWR(t) + d \cdot SCA(t)$$

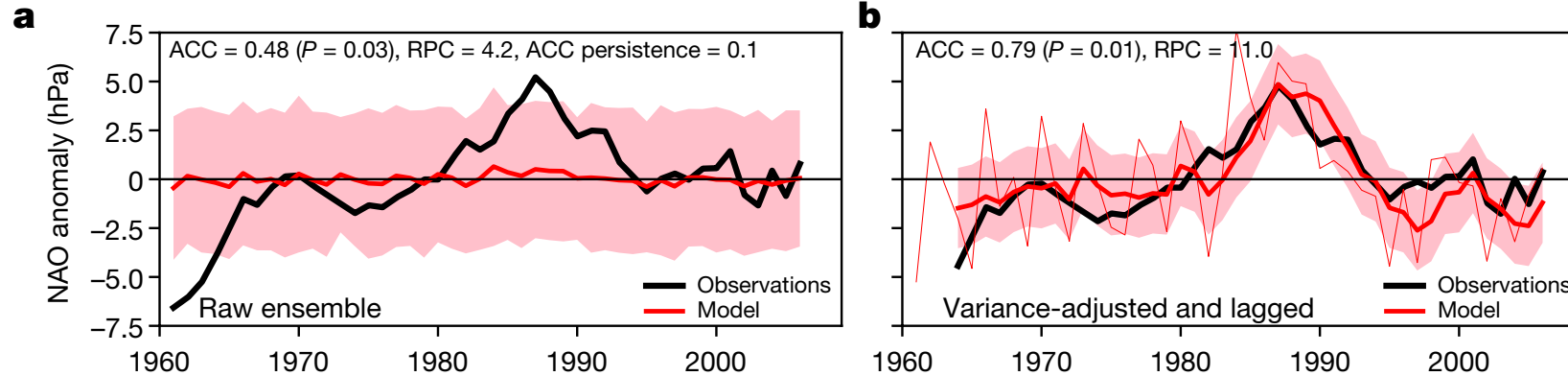


Lledó et al., 2022, Ren. Energy



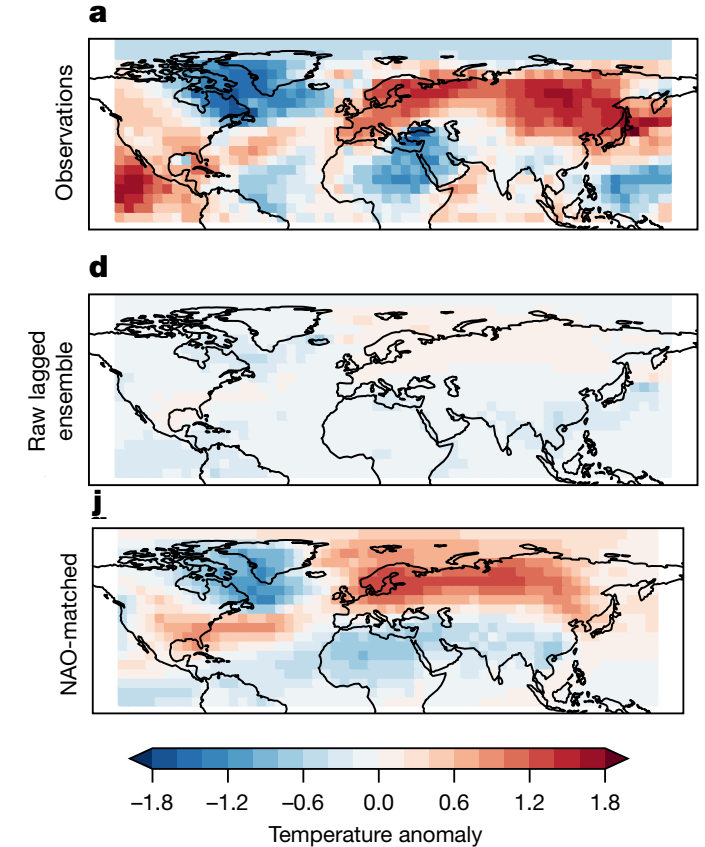
Targeted Teleconnections and their Application to the
Postprocessing of Climate Predictions
Clementine Dalelane et al, preprint

Teleconnections and predictions



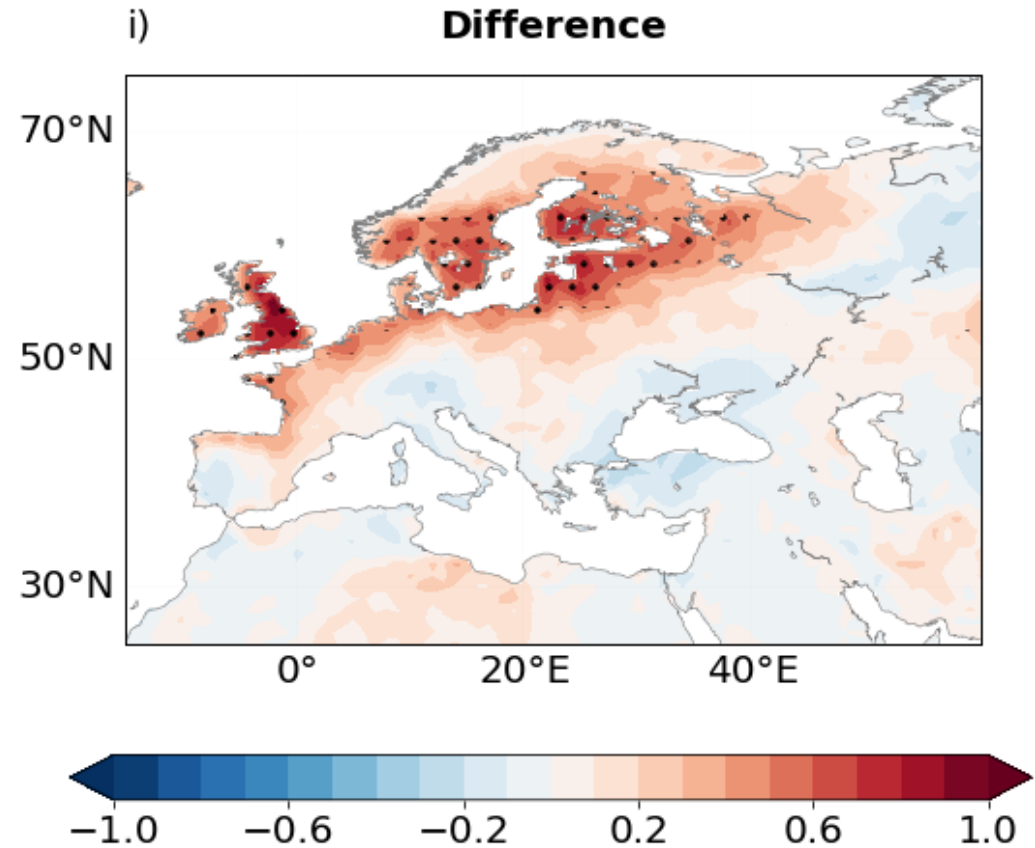
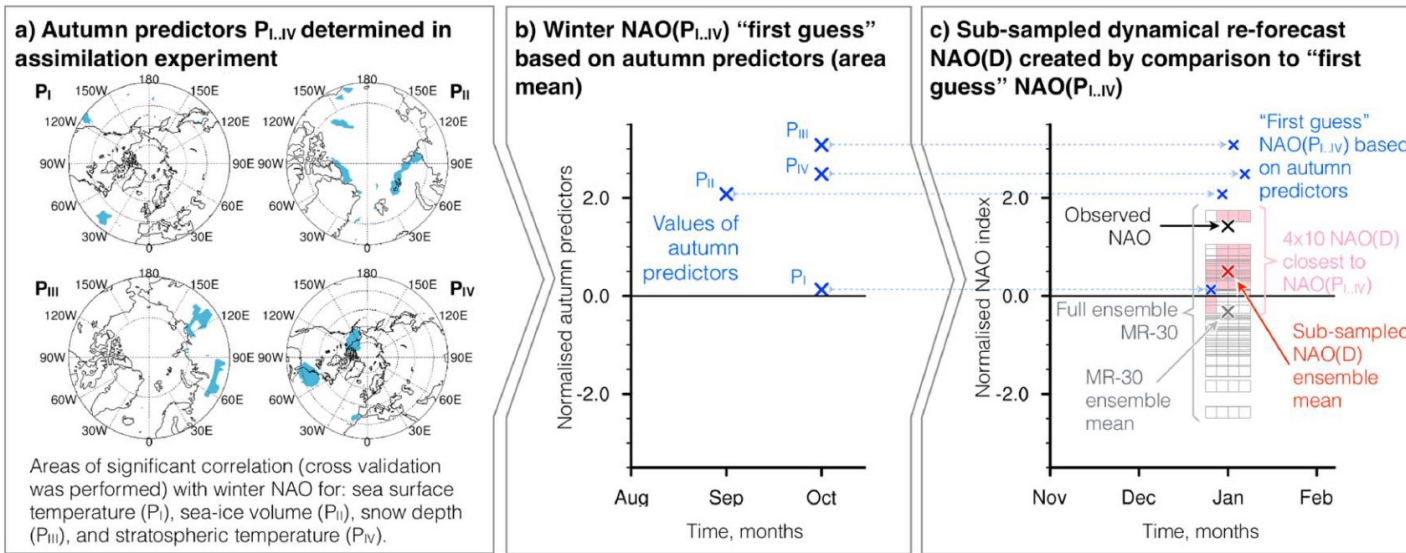
Underestimation of predictable signals for European climate in state-of-the-art GCMs (signal-to-noise paradox).

Postprocessing the output of seasonal and decadal predictions can lead to an improvement that would be achieved with a ≈ 100 times larger ensemble.



Smith, D.M., *et al.* North Atlantic climate far more predictable than models imply. *Nature* 583, 796–800 (2020)

Teleconnection-based hybrid predictions



(Dobrynin et al., 2018)

Famooss Paolini, L., et al. (2025)

Teleconnections and Artificial Intelligence

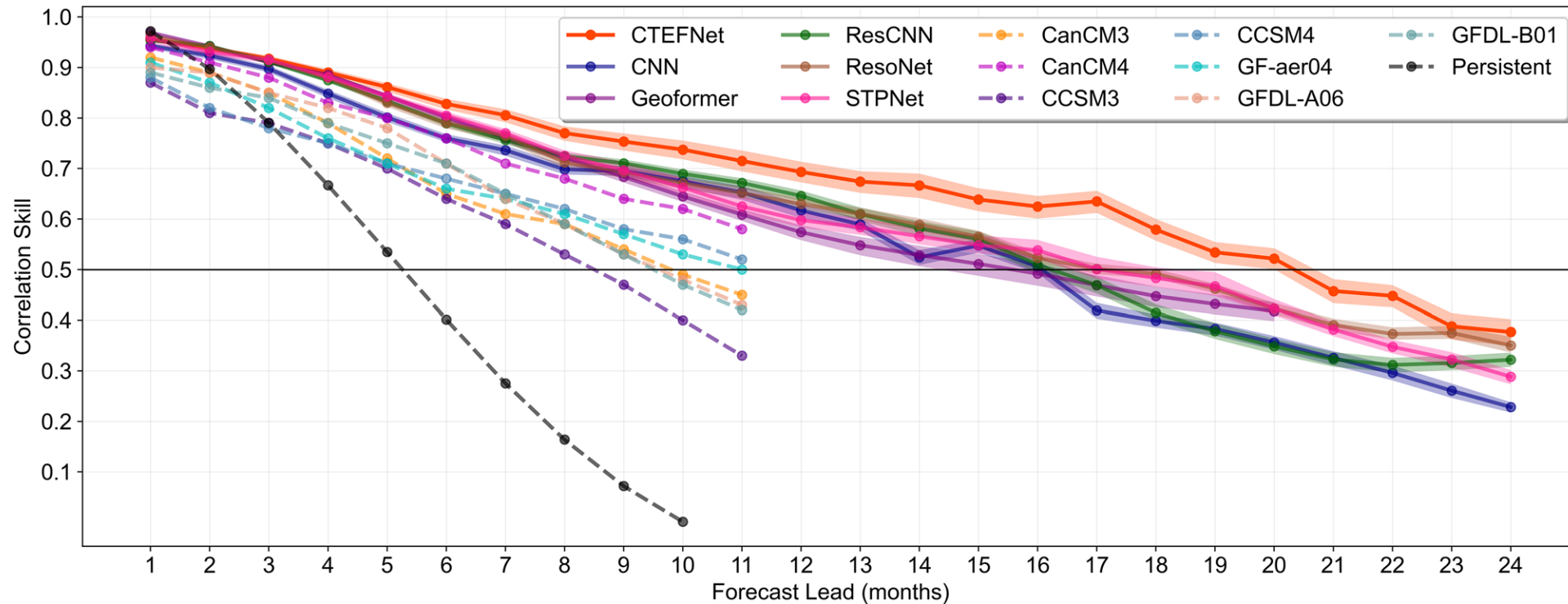


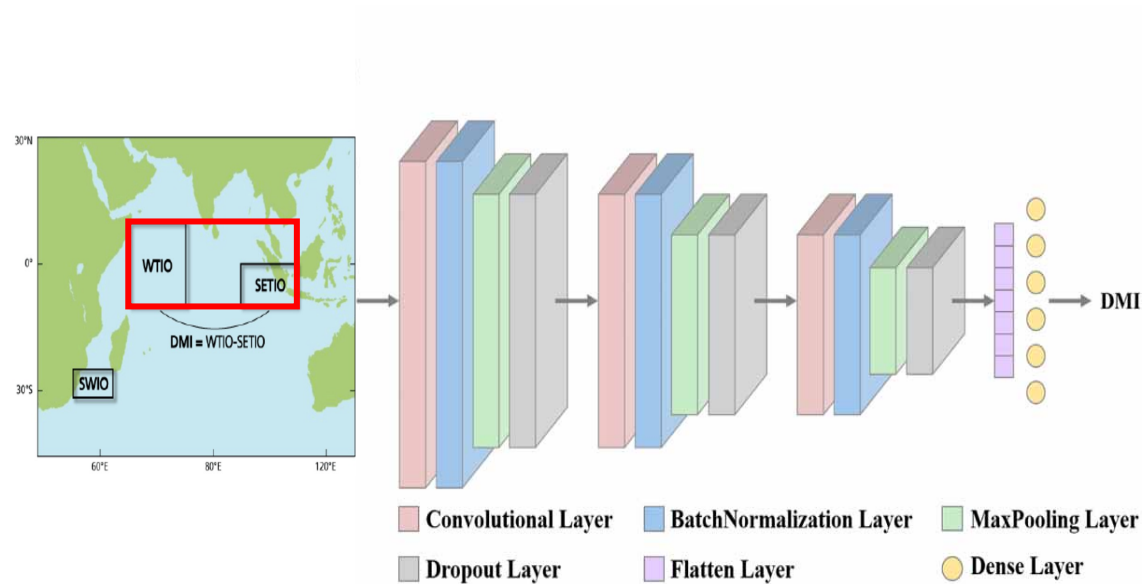
Fig. 1 | ENSO correlation skill in CTEFNet and other models. The all-season correlation skill of the three-month-moving-averaged Niño 3.4 index as a function of the forecast lead month in CTEFNet (solid orange), CNN(solid deep blue), Geoformer (solid purple), ResCNN (solid green), ResoNet (solid brown), STPNet

(solid pink), persistent forecast (dash black) and the dynamical forecast systems included in the NMME project (dash with other colors). The shading around the lines for the DL models denotes the 95% confidence interval, based on the bootstrap method. The validation period is between 1980 and 2021.

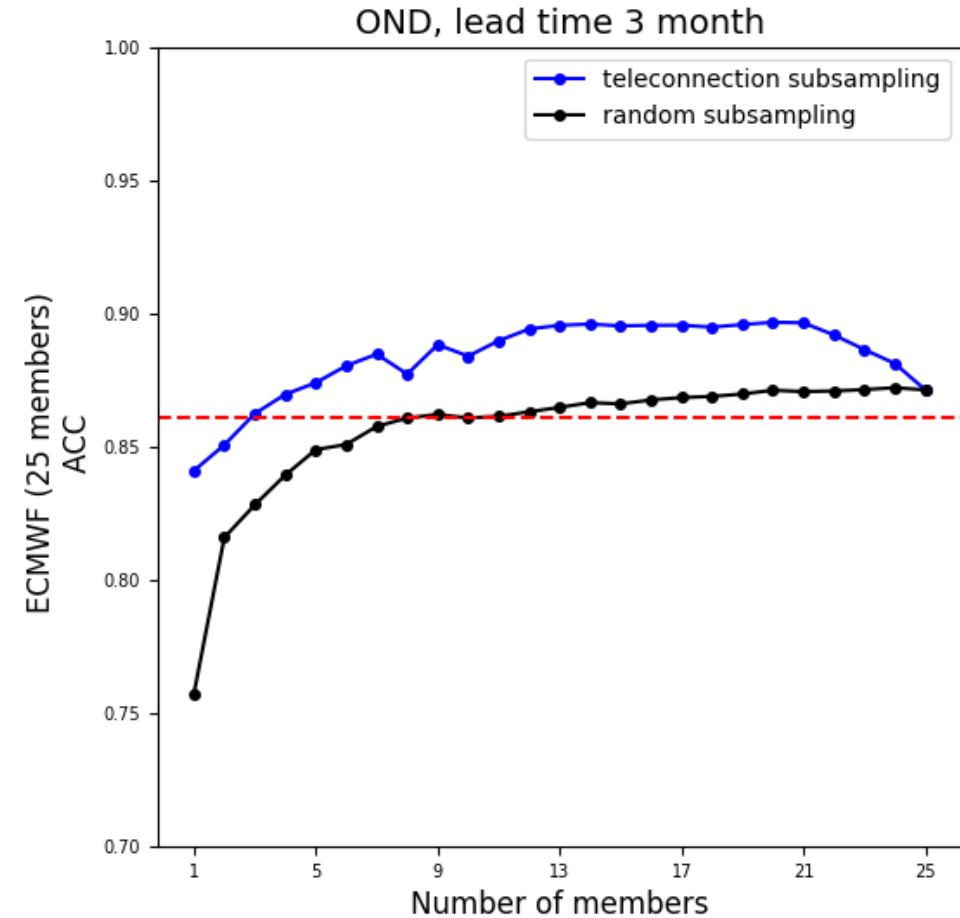
Toward long-range ENSO prediction with an explainable deep learning model

Qi Chen^{1,2,10}, Yinghao Cui^{1,10}, Guobin Hong¹, Karumuri Ashok¹, Yuchun Pu¹, Xiaogu Zheng^{1,7}, Xuanze Zhang¹, Wei Zhong^{1,8}, Peng Zhan^{1,9} & Zhonglei Wang^{1,2,10}

Teleconnections and Artificial Intelligence



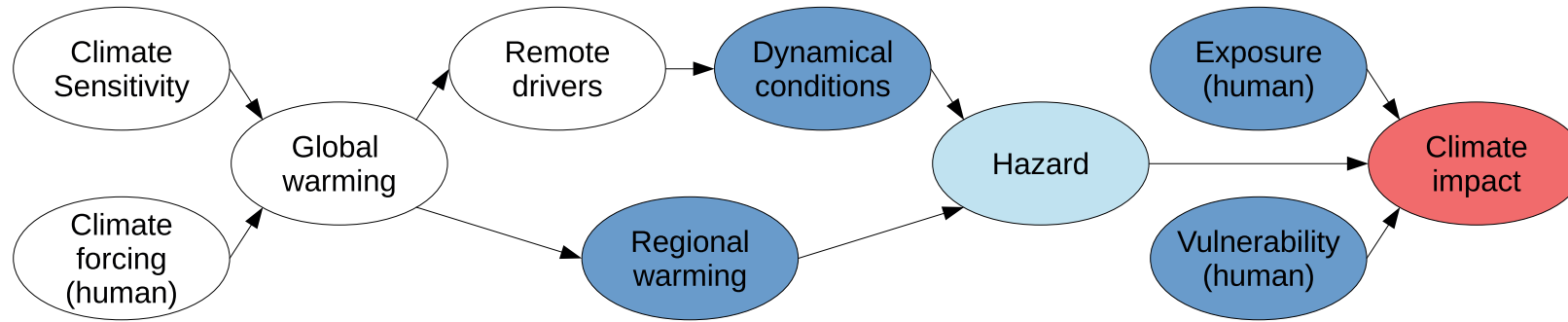
Adapted from^[19] Tao et al. (2024)



Beltrami et al. EMS 2025

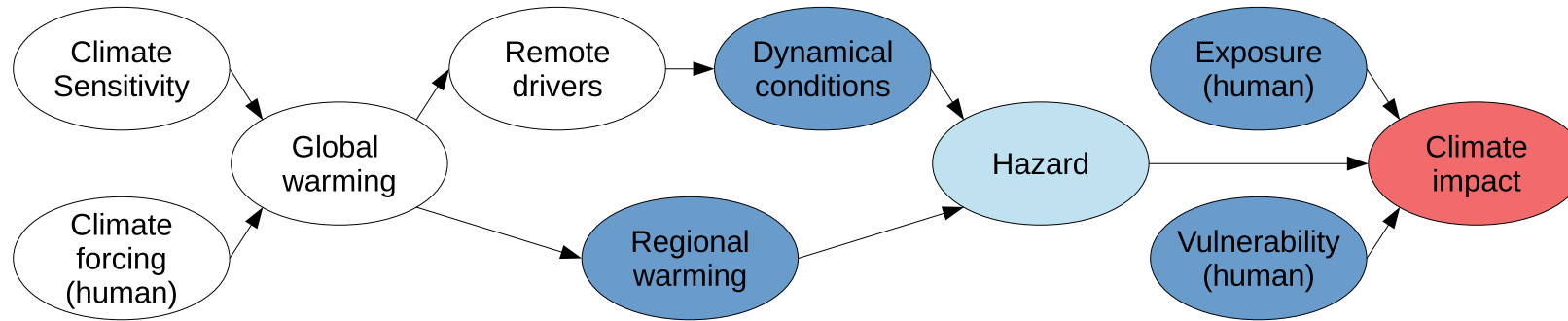
Teleconnections: a role in climate storylines

(a) Event storyline

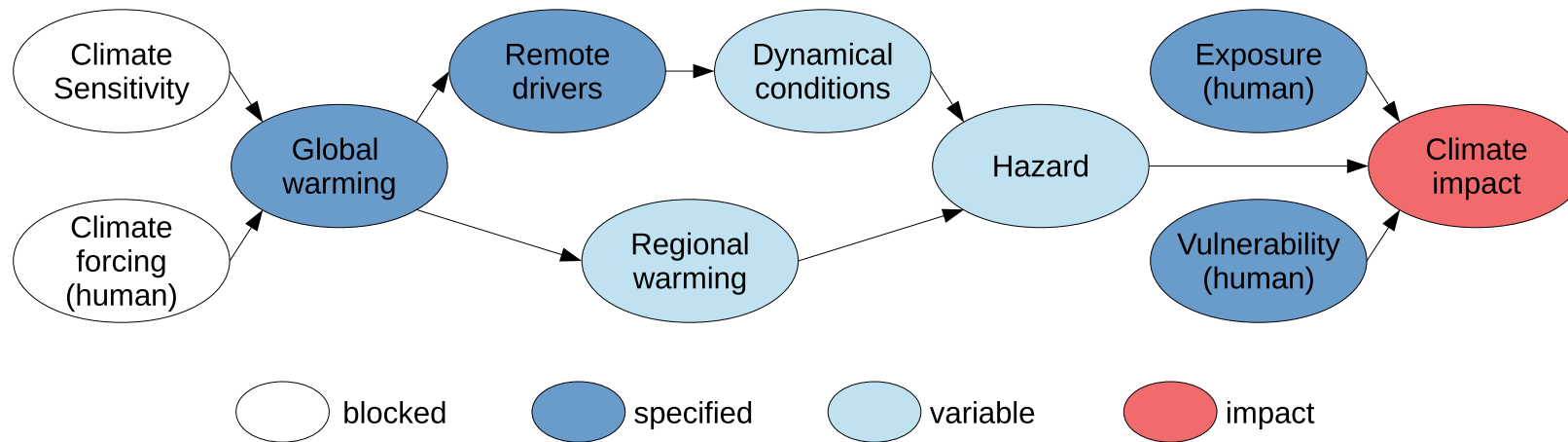


Teleconnections: a role in climate storylines

(a) Event storyline



(b) Dynamical storyline



Teleconnections among tipping elements in the Earth system

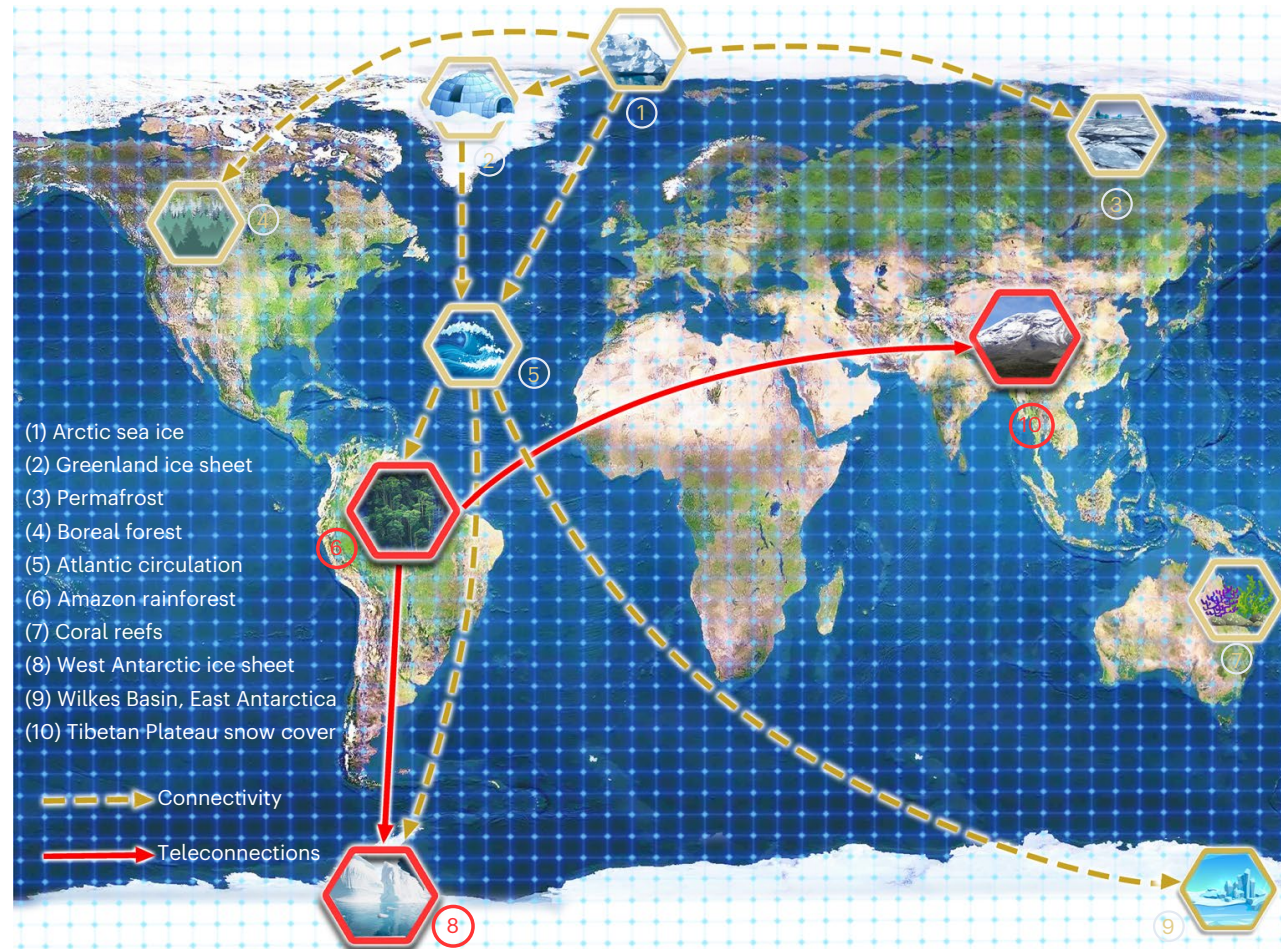


Fig. 1 | Schematic view of the tipping elements of the Earth climate system, their connectivity and teleconnections. The numbered symbols show the potential tipping elements in the Earth system. The dashed yellow lines show the

possible connections between these tipping elements² and the solid red lines show teleconnection uncovered in this article. The arrows show the direction of the influence.

Stepping out
of the niche



Thank you