Coordinated Weakening of the Asian and West African Monsoons and Links to North Atlantic Cooling in the 1960's

Yuwei Liu (yuwei@atmos.berkeley.edu) and John C.H. Chiang, University of California, Berkeley

Introduction

Summertime precipitation experienced coincident abrupt reduction over the Sahel, South Asia and East Asia during the 1960's, as shown in Fig.1.

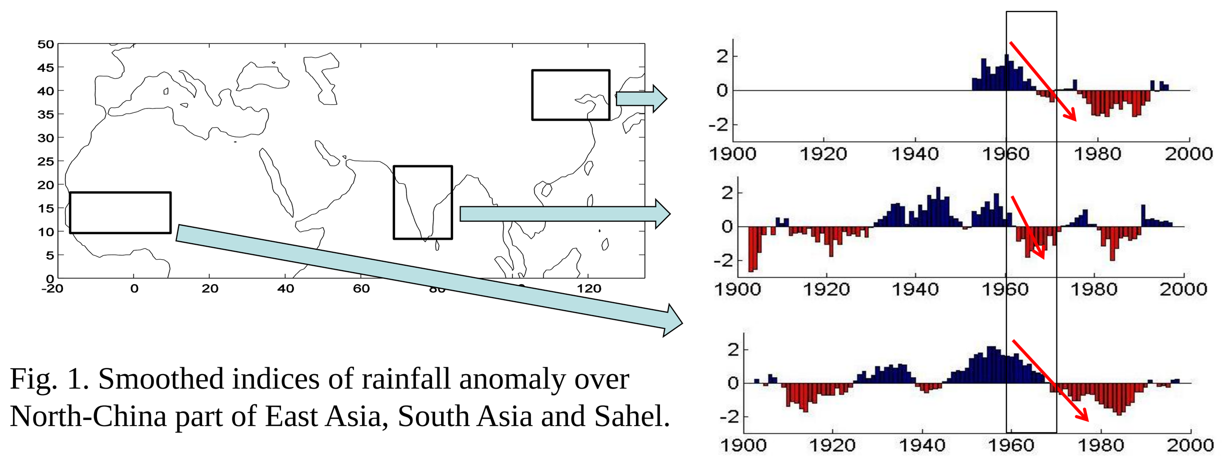

Fig. 1. Smoothed indices of rainfall anomaly over North-China part of East Asia, South Asia and Sahel.

The Sahelian rainfall reduction in the 1960's and persistent drying in the following two decades, i.e. the Sahel Drought, has been extensively studied, and tied to an interhemispheric SST contrast, especially over the Atlantic. The SST contrast consists of warming over tropical South Atlantic and Indian Ocean, cooling in tropical North Atlantic, and striking cooling over high-latitude North Atlantic.

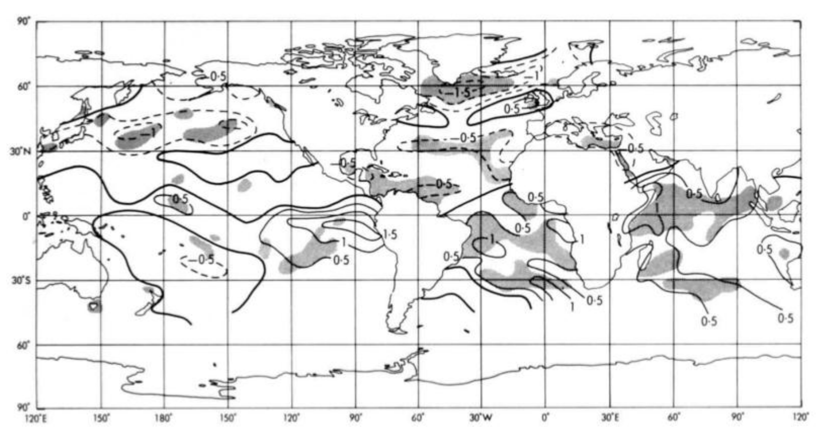

Fig. 2. From Folland et al (1986), global boreal summer SST anomalies associated with the drought period over the Sahel. Plotted are SST, July to September, average of (1972-73, 1982- 84) (Sahel dry) minus average of (1950,1952-54, 1958) (Sahel wet).

Paleoclimate studies show that weakenings to the Asian and African monsoons are tied to cooling over the high-latitude North Atlantic. And models simulating effect of the cooling show rainfall reduction over the three aforementioned regions, as well as a climate shift over Eurasia and North Africa, including cooling and sea level pressure (SLP) increase.

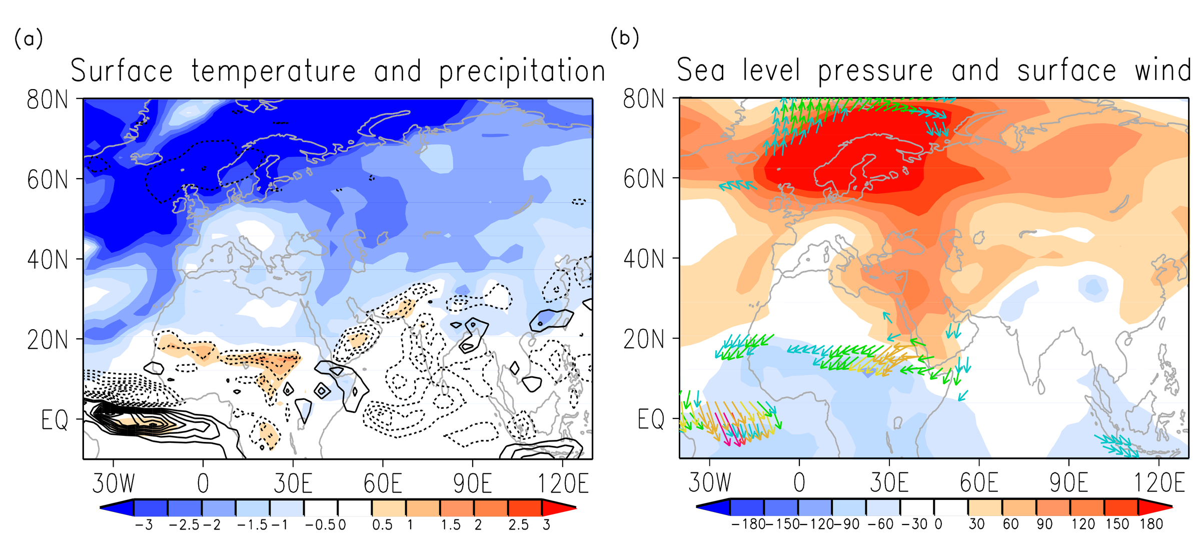

Fig. 3. July-September climate anomalies in years 10-14 of a 'hosing' simulation with the Community Climate System Model version 3 (CCSM3), where the upper 970 m of the North Atlantic and Arctic Oceans from 55-90°N and 90°W-20°E are freshened by an average of 2 psu.

- Is it possible that the rainfall reduction in the 1960's is a reproduction of the paleo scenario of high-latitude North Atlantic cooling?
- Is there also a climate shift over Eurasia and North Africa?

The climate shift

The leading principal component (PC) of the combination of precipitation, surface temperature and SLP does show a jump in the 1960's.

The spatial pattern associated with the jump are:
1. Rainfall reduction over the Sahel, India and North China;
2. Cooling over Eurasia and North Africa.
3. Uniform SLP increase.

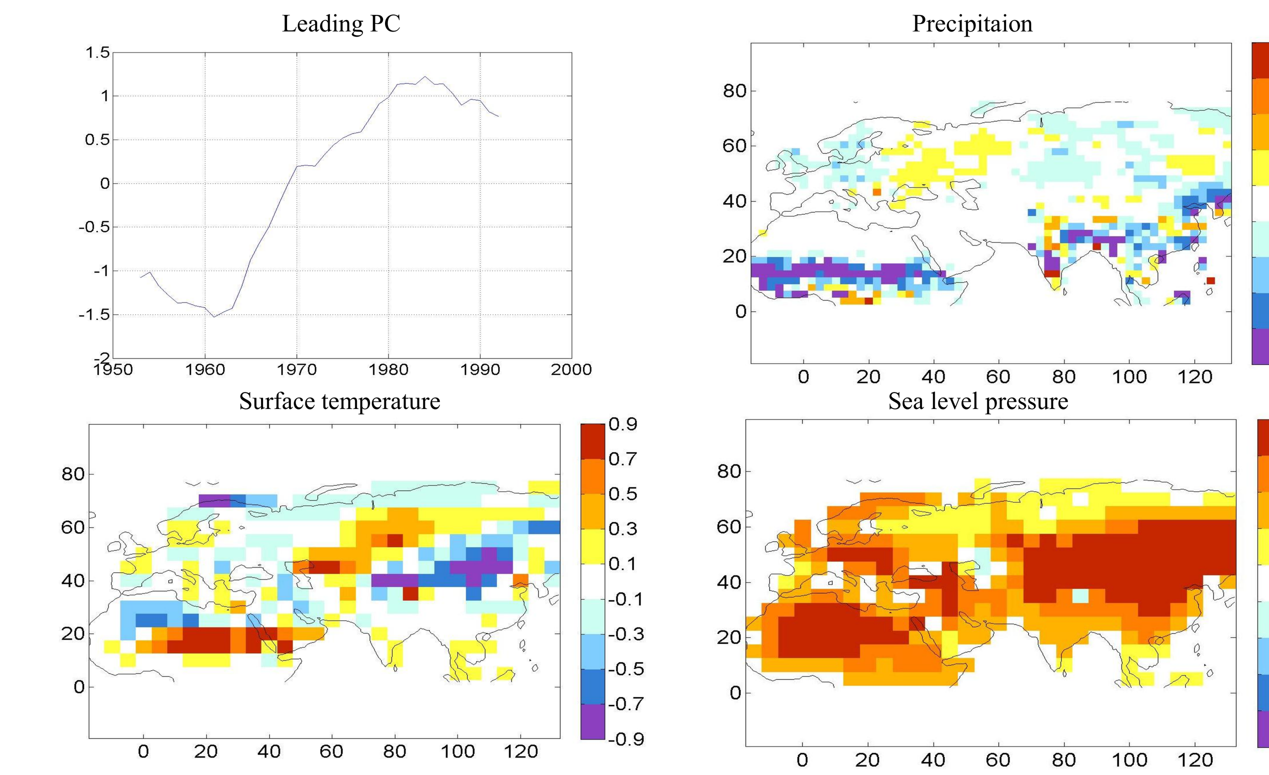

Fig. 4. Temporal pattern of the climate shift shown as leading PC and spatial pattern shown as regression of the PC onto the three fields. The leading PC explains 37% of the variance. Data source: surface temperature and SLP from NCEP/NCAR Reanalysis, and GISS land Precipitation. All data are smoothed by applying 7-year-running mean and global mean subtracted in temperature field. The data are then combined and principle component analysis (PCA) applied.

The PCA is repeated to a dataset of pure observations (as opposed to reanalysis). The results hold despite of smaller magnitude, suggesting the shift is not an artifact in NCEP/NCAR Reanalysis.

Causes of the climate shift I

Ensemble mean of AMIP-type runs forced with observed 20th century SST and atmospheric forcings are able to simulate the climate shift, suggesting the origin of the shift resides in the applied **forcings** as opposed to atmospheric internal variability.

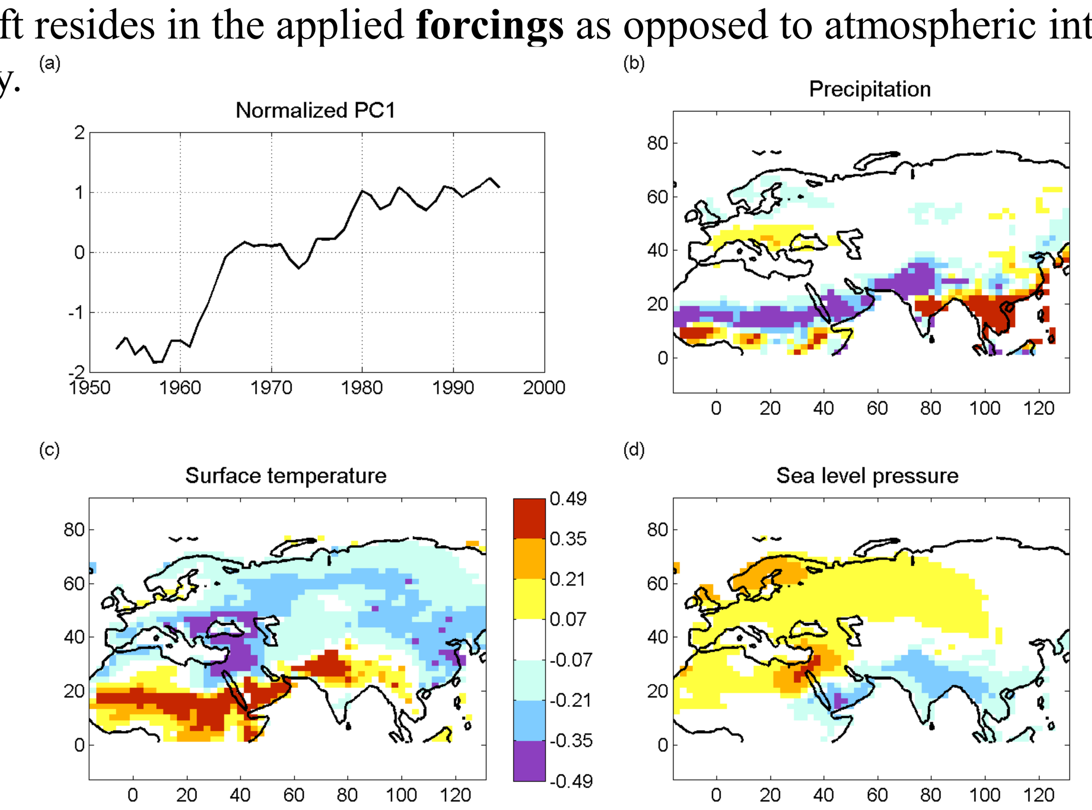

Fig. 5. Same as Fig. 4, but for GFDL AM2.1 all-forcing run

Causes of the climate shift II

Ensemble means of AMIP-type runs forced with observed 20th century SST and atmospheric forcings, and those with observed SST only, are both able to simulate the climate shift with identical pattern, suggesting the origin of the shift resides in the **SSTs** as opposed to other forcings.

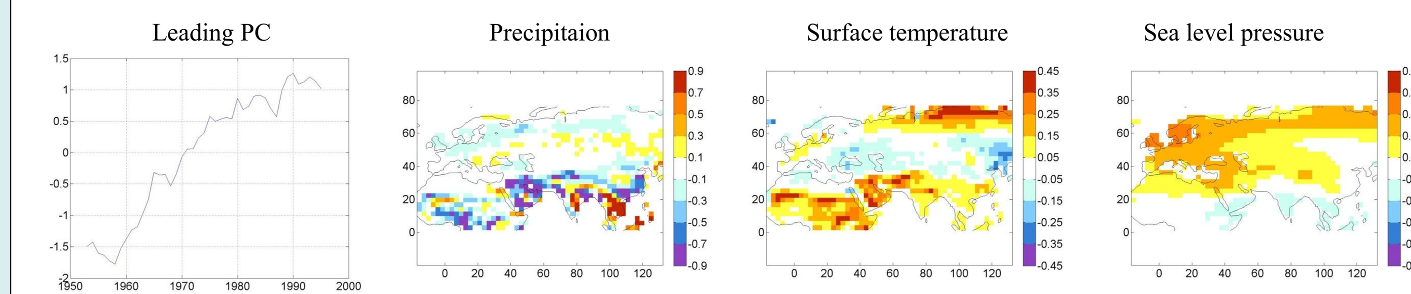

Fig. 6. Same as Fig. 4, but for CAM3 all-forcing run

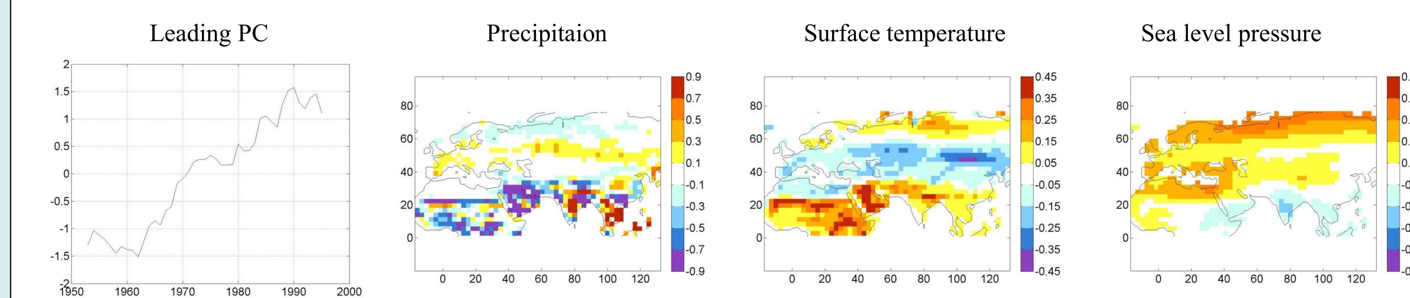

Fig. 7. Same as Fig. 4, but for CAM3 SST-only run

Causes of the climate shift III

Regression of global SST onto PC1 from both observation and SST-only simulation, not surprisingly, shows similar pattern as in Fig. 2. If we focus on the 1960's, however, influence of **high-latitude North Atlantic cooling** stands out.

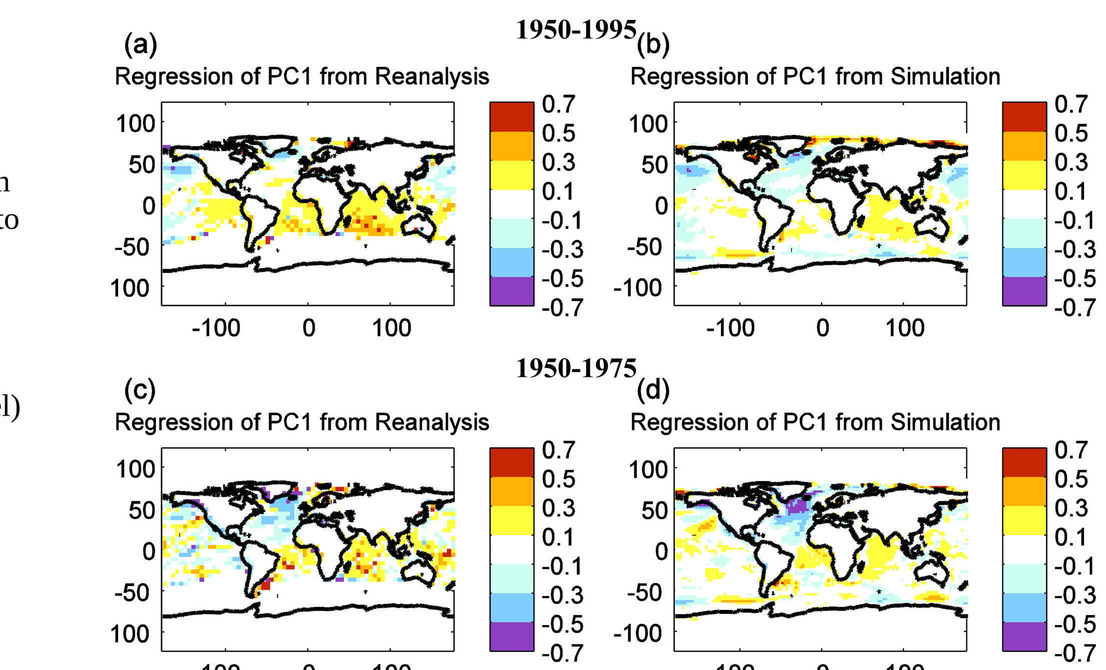

Fig. 8. Regression of global SST onto PC1 from the combined PC analysis over the period of 1950-1995 (upper panel) and 1950-1975 (lower panel).

And high-latitude North Atlantic indeed experienced abrupt cooling in the 1960's

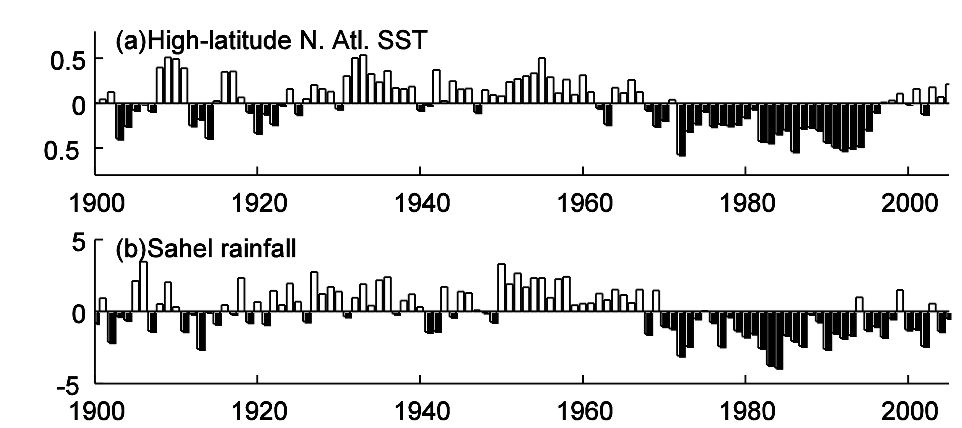

Fig. 9. The timeseries of high-latitude North Atlantic SST, and the unsmoothed June-July-August-September-October Sahel rainfall. The high-latitude North Atlantic SST timeseries is computed as SST averaged over 50°N-70°N and 70°W-0° with global mean SST subtracted.

References

1. Liu, Y., J. C. H. Chiang, 2012: Coordinated Abrupt Weakening of the Eurasian and North African Monsoons in the 1960s and Links to Extratropical North Atlantic Cooling. *J. Climate*, **25**, 3532–3548
2. Chiang, J.C.H. and Bitz, C.M. Influence of high latitude ice cover on the marine Intertropical Convergence Zone. *Climate Dynamics,* **25**, 477-496 (2005).
3. Folland, C.K., T.N. Palmer and D.E. Parker, 1986: Sahel Rainfall and Worldwide Sea Temperatures, 1901-85: *Nature*, 320(6063), 602-607. 619

Summary

- An abrupt shift in Eurasian and North African climate occurred in the 1960's, including widespread cooling and SLP increase, and rainfall reduction over the Sahel, India and North China.
- Signature of the shift is consistent with a high-latitude North Atlantic source, specifically the abrupt cooling that occurred in the late 1960's.