The effects of large-scale circulation on temperature and precipitation in the Himalayas and Tibetan Plateau

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Introduction

At least 1.3 billion people in South Asia depend on Himalayan water resources to survive. Despite the importance of these resources, the area's high topography coupled with the complexity of the seasonal monsoon limit our ability to model and understand Himalayan climate. Recent work strives to correct this trend, focusing on local controllers of temperature and precipitation in Central Asia (Böhner 2006) and deriving models to explain the effect of large-scale circulation on drought in the Tibetan Plateau (Bothe et al., 2006). The aim of this study is to determine statistically how seasonal temperature and precipitation anomalies in our study area (Figure 1) may or may not be affected by large-scale circulation patterns. Using gridded datasets provided by the IRI/LDEO Climate Data Library and NOAA, we looked for seasonally significant correlations between principal components describing temperature and precipitation and large-scale climatic indices. As a preliminary study, this research suggests relationships for further exploration that may ultimately help to better predict and model climate variability in the Himalayas and Tibetan Plateau.

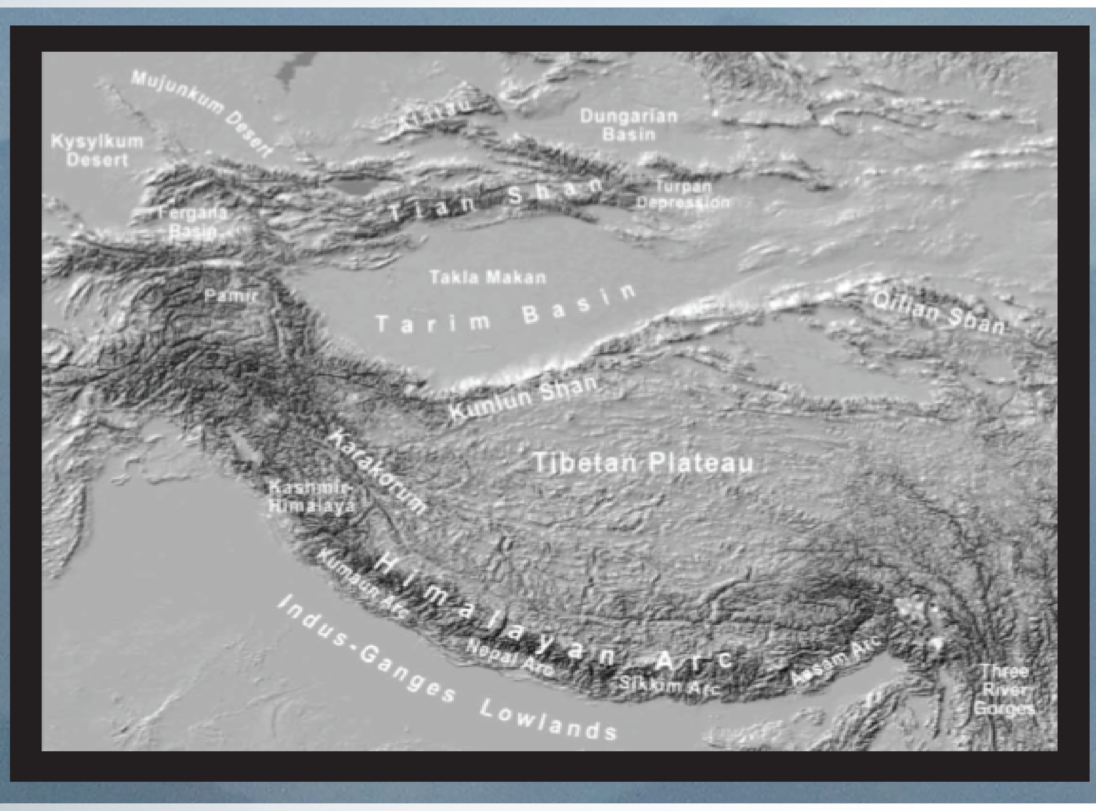


Figure 1: Map of study area highlighting major topographical features (Bohner, 2006).

Methods

We used gridded temperature and precipitation datasets from the IRI/LDEO Climate Library to then calculate de-trended, monthly anomalies from the yearly monsoon climatology over the period 1950-1999. Each set was then further broken up into principal components.

The montly data from cach of the first twelve components for both precipitation and tempreature were seasonally averaged and correlated with seasonal climate indices for the Southern Annular Mode (SAM), North Atlantic Oscillation (NAO), NINO34, Atlantic Multi-decadal Oscillation (AMO) and the Indian Ocean Dipole (IOD). Significant correlations were chosen for further mapping and analysis.

References

Bothe, O., Fraedrich, K., and X. Zhu, 2010: Large-scale circulations and Tibetan Plateau summer drought and wetness in a high-resolution climate model. *Int. J. Climatol.*, Vol. 30, pp. 844-855.

Böhner, J., 2006: General climatic controls and topoclimatic variations in Central and High Asia. *Boreas*, Vol. 35, pp. 279-295.

Large-scale circulation is most highly correlated to temperature during the monsoon and post-monsoon seasons...

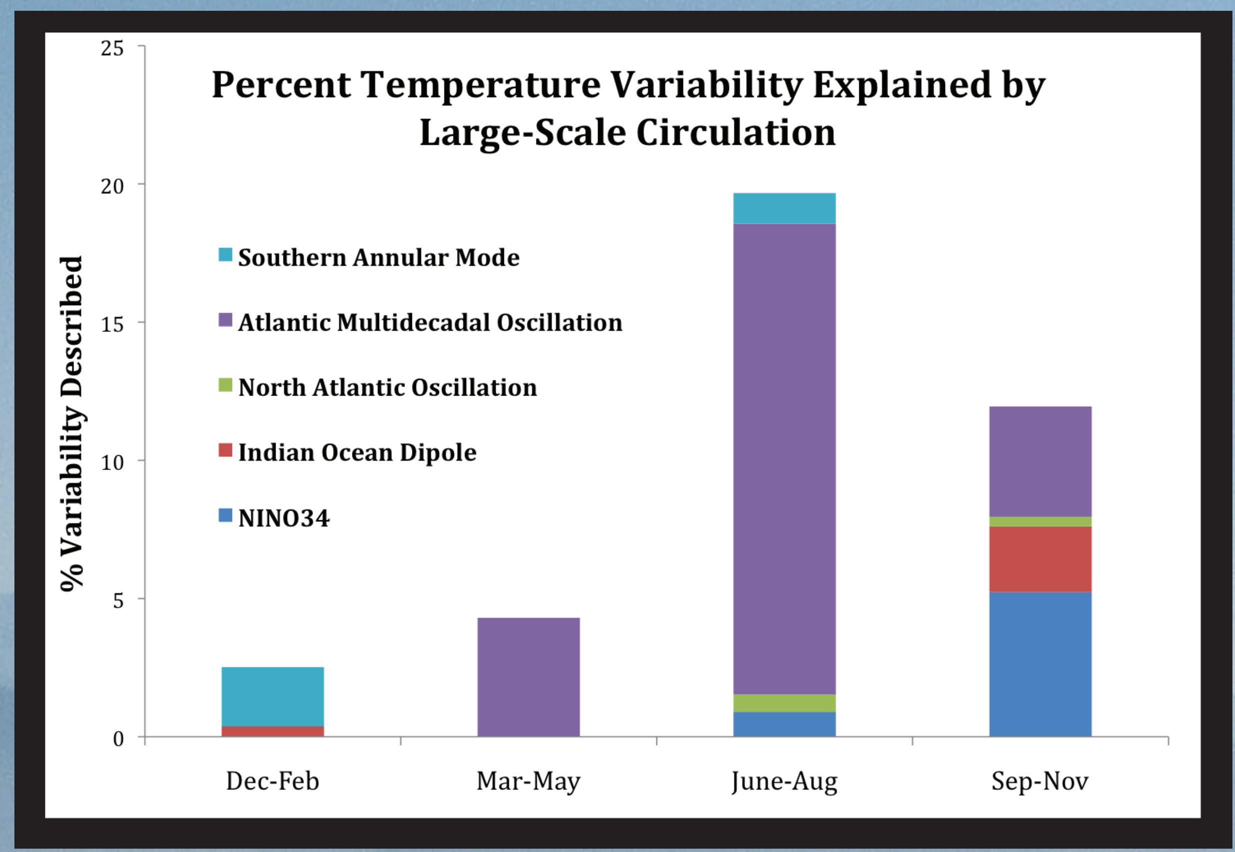
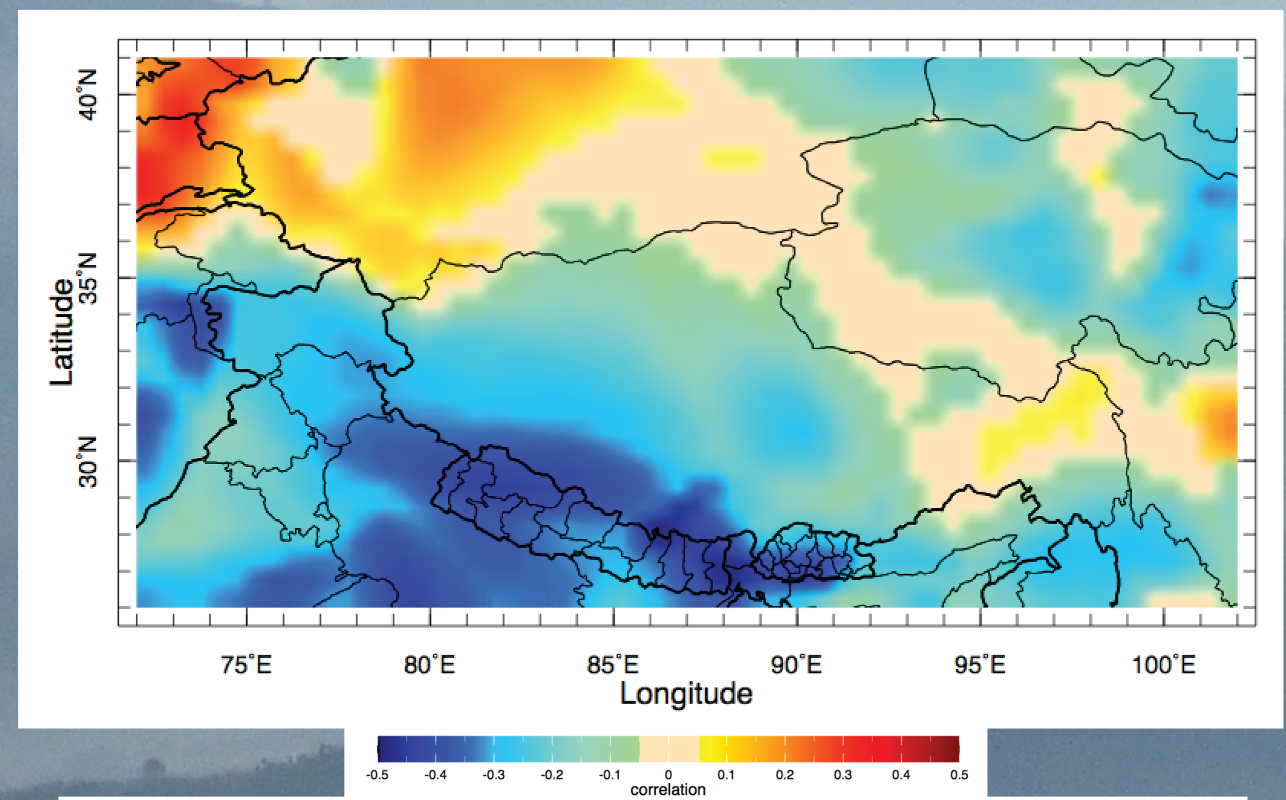


Figure 2: The total seasonal variance in temperature explained by various large-scale circulation anomalies over the period 1950-1999

Figure 6: Correlation between percipitation and NINO34 anomalies mapped during Jun-Aug over 1950-1999.



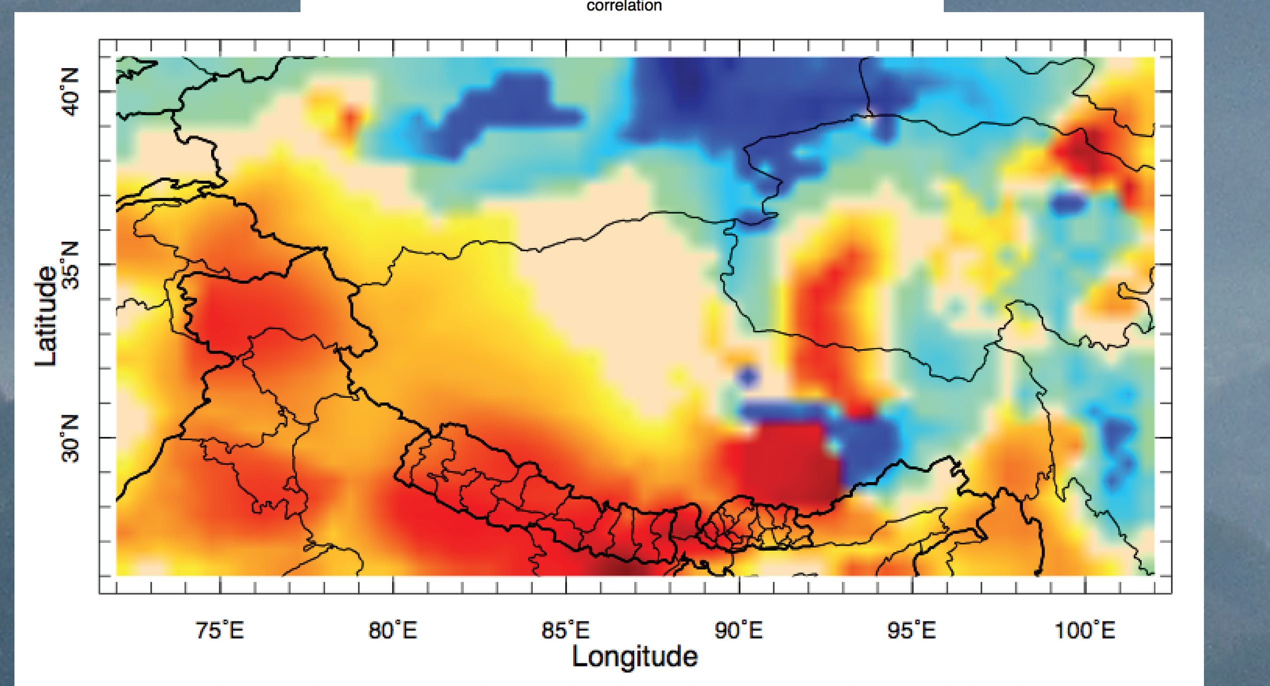
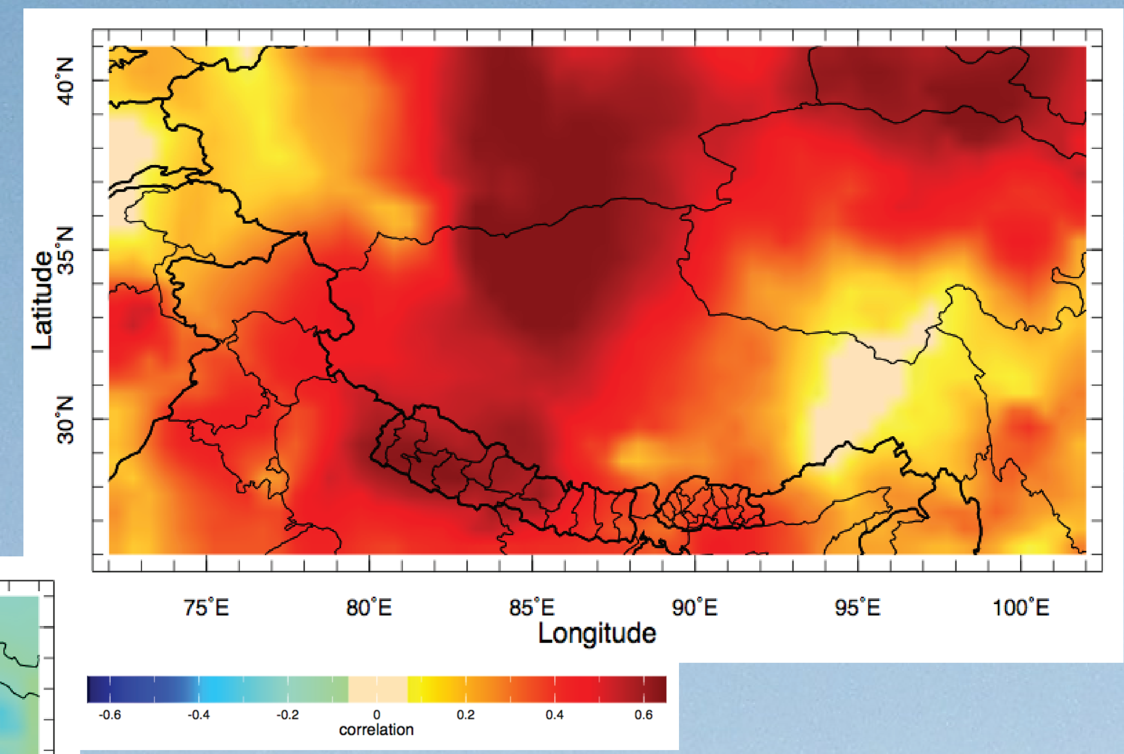
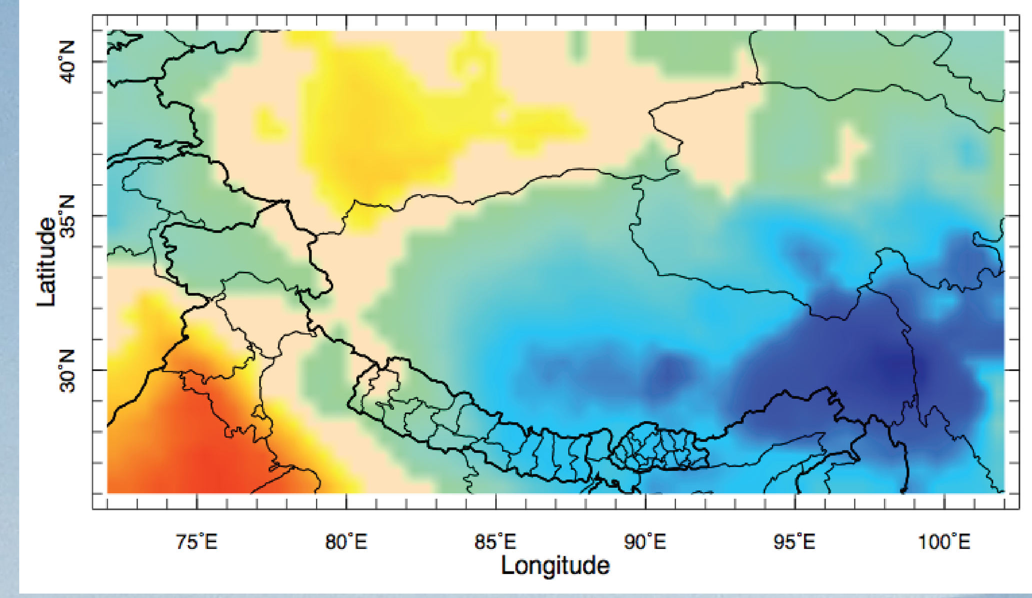


Figure 7: Correlation between percipitation and NAO anomalies mapped during Dec-Feb over 1950-1999.

...and the dark areas in Figures 3 and 4 show where these high correlations occur for the different circulation patterns.





Figures 3 and 4: Correlations between temp. and AMO anomlies during Jun-Aug (above) and NINO34 anomalies during Sep-Nov (left) mapped for each grid point from 1950-1999.

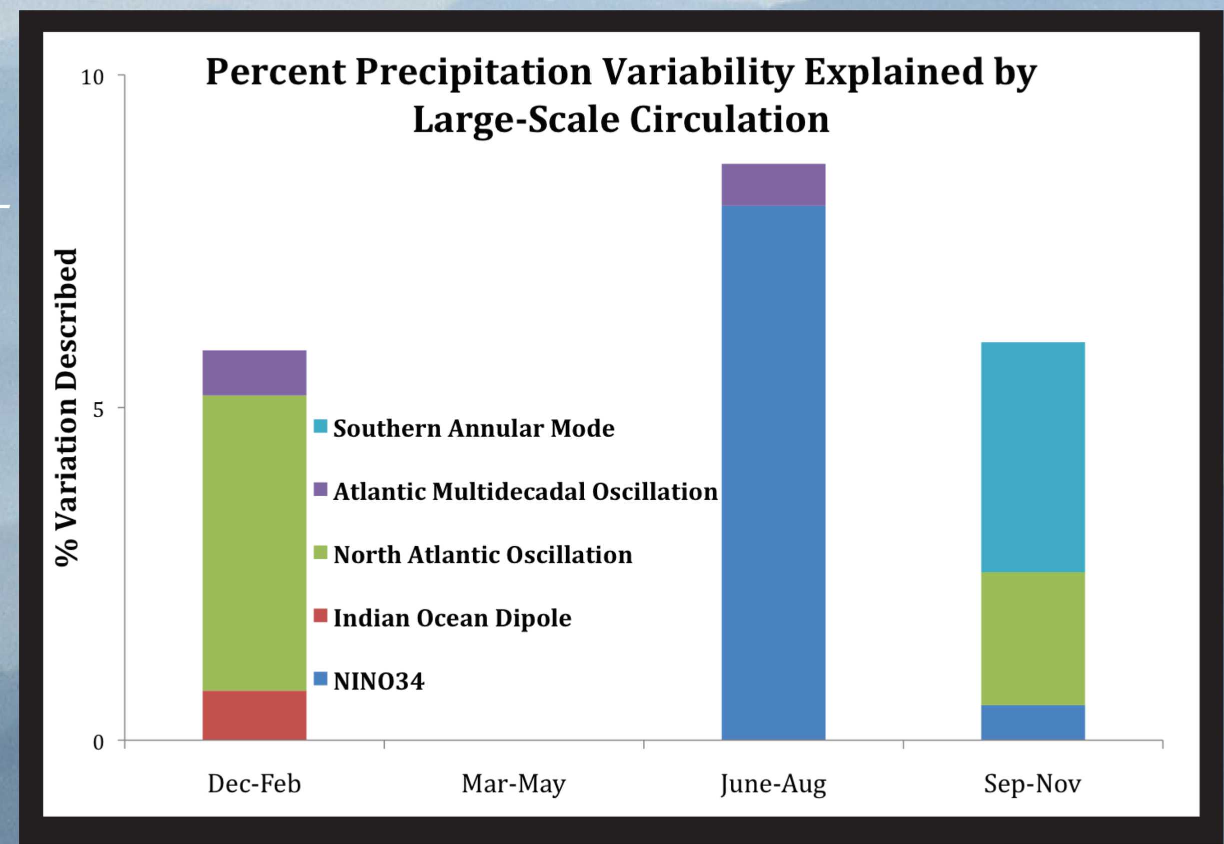


Figure 5: The total seasonal variance in precipitation explained by various large-scale circulation anomalies over the period 1950-1999

Precipitation is more variable than temperature, shown by looking at the different scales in Figures 2 and 5. These graphs show that large-scale circulation is less able to describe precipitation variability, especially in Mar-May. The maps left (Figs 6 and 7) show where the correlations are strongest between precipitation and NINO34 (Jun-Aug) and NAO (Dec-Feb) respectively.

Conclusions

Seasonal large-scale circulation anomalies were shown to be significantly correlated with temperature and precipitation. Temperature was most notably correlated with AMO during the monsoon and NINO34 post-monsoon. Precipitation was correlated with NAO during the winter and post-monsoon months and SAM also post-monsoon. The high correlation between precipitation and NINO34 during Jun-Aug is likely due to the connection between ENSO and All Indian Rainfall, seen in Figure 6 where high correlations are centered in northern India and the southern Himalaya.

The calculations in Figures 2 and 5 are conservative since they only included significant correlations within the first five principal components of temprature and precipitation. Further study should include alternate correlation methods (e.g. weighting the correlation factor with variance) as well as lag correlations between seasons.

Acknowledgements

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