Preliminary Results from TiP project: Bridging Timescales of Tibetan Plateau Environmental Change with ECHAM and REMO simulation

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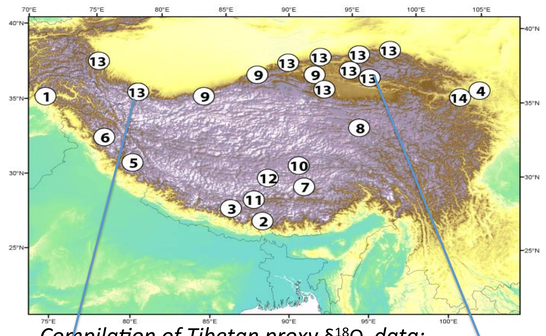
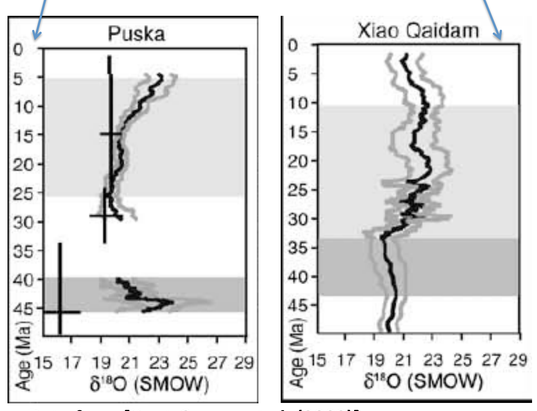
Motivation and objectives



Compilation of Tibetan proxy δ¹⁸O data: 2371 measurements over the last 22 years



Data from [Kent-Corson et al. (2009)]

Fundamentals of $\delta^{18}O$:

$\delta^{18}O$ is a measure of ratio of stable isotope **^{18}O:^{16}O** . It is commonly used as a proxy for temperature in geochemistry, paleoclimatology and paleoceanography. The definition is, in per mil

$$\delta^{18}O = \left(\frac{\left(\frac{^{18}O}{^{16}O}\right)_{sample}}{\left(\frac{^{18}O}{^{16}O}\right)_{standard}} - 1 \right) * 1000\ ^{o}/_{oo}$$

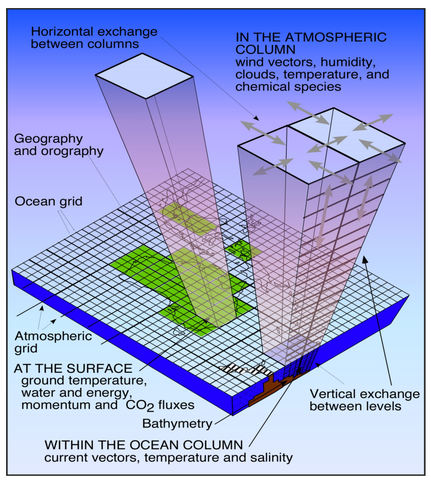
Motivation: there are difficulties in interpolating and comparing observed $\delta^{18}O$ data, because:

1. Significant patial variability in $\delta^{18}O$ is present in modern and geologic archives
2. Similar large temporal variability is documented.

Objectives of this study are to answer:

1. What is the variability in modern and paleo Tibetan Plateau climate and precipitation $\delta^{18}O$?
2. What are the geologic and atmospheric drivers for this variability?

Methods



[McGuffie and Henderson-Sellers (2005)]

Atmospheric General Circulation Model:

Global Atmospheric Circulation Model: **ECHAM5-iso**:
- T63 resolution (~250x250 km), 19 vertical levels.
- Isotope tracking capability

Regional Atmospheric Circulation Model: **REMO**
- Nested within global model
- high resolution (~55x55 km), 27 vertical levels

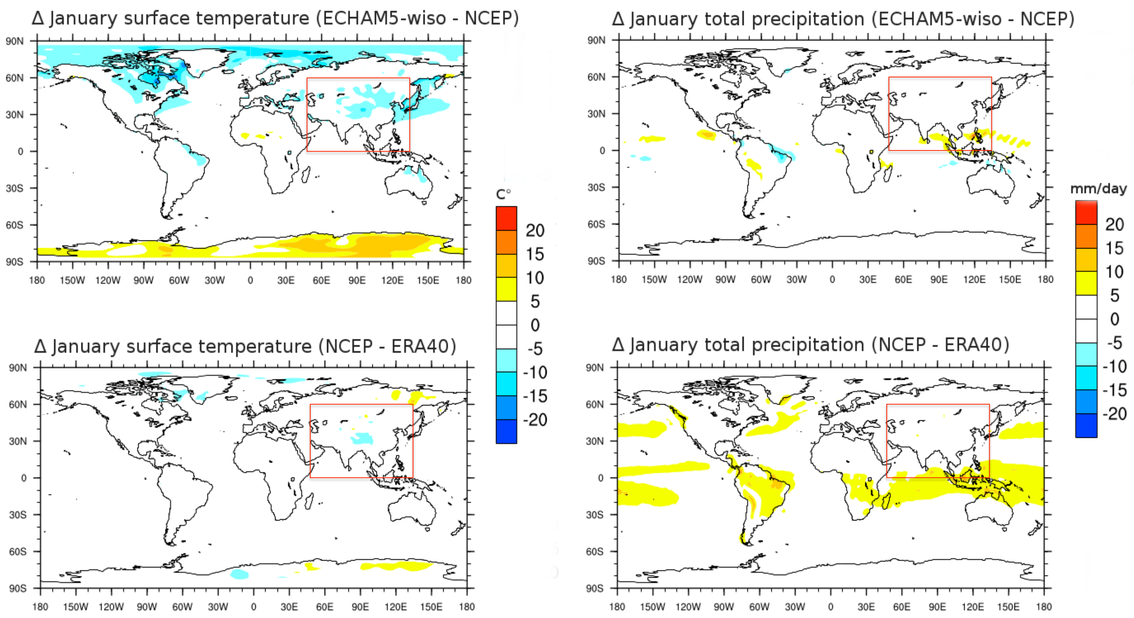
Simulations:

- Climate modeling and proxy data prediction over different timescales (Last Glacial maximum, Middle Holocene, Modern)
- Climate modeling and proxy data prediction for different geologic situation.

Model performance

Reliability of model outputs:

The reliability of the simulation results has been determined with the aid of ERA40 and NCEP re- analysis datasets. For each month, a 30 year mean of a model output variable was compared to its re-analysis equivalent. The degree of agreement is represented by January value.



Difference between observational data sets is as large or larger than model fit to data.

Summary of first year results

Model calibration to modern climate successful
- Difference between model and observations is within the variability of different observational data sets

Cluster analysis results from regional model
- Cluster (PCA) analysis approach successfully documents different regions with similar surface temperature and precipitation characteristics

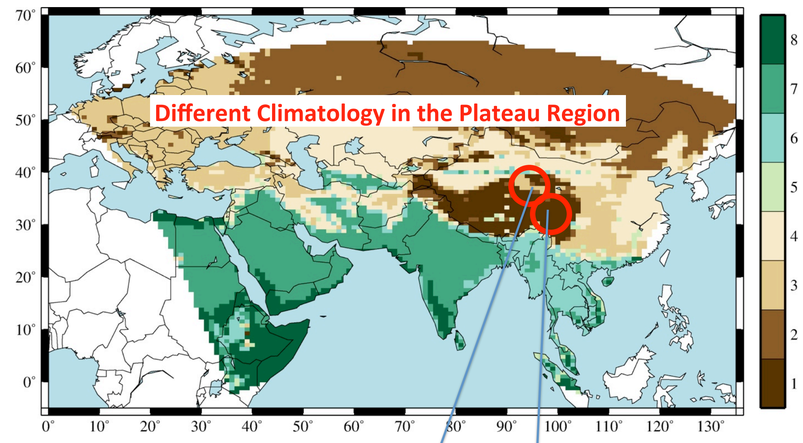
Predicted $\delta^{18}O$ demonstrates
- Winter season $\delta^{18}O$ appears to be most strongly controlled by temperature
- Summer season $\delta^{18}O$ is correlated with precipitation

Paleoclimate simulations are currently being set up and run, emphasizing:
- Last glacial maximum and Mid-Holocene climate and $\delta^{18}O$
- Influence of plateau elevation on climate over geologic timescales

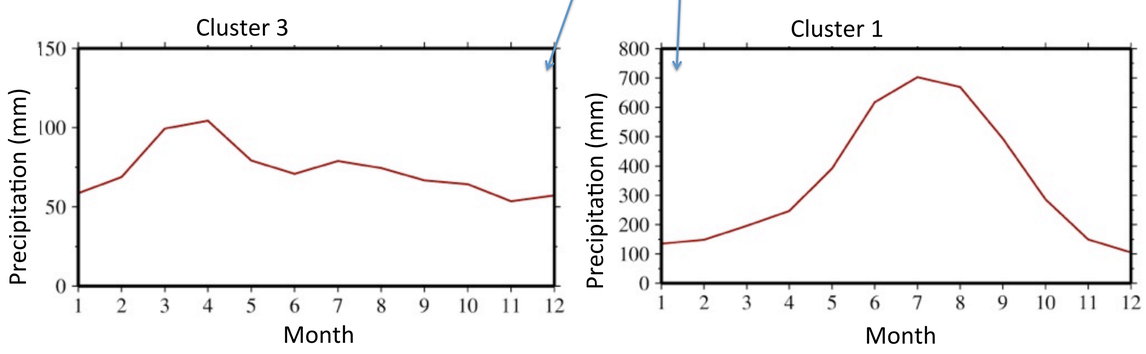
Results of modern day simulation

Cluster analysis of Plateau climate:

Cluster analysis is a statistical data analysis method which groups a set of objects in such a way that objects in the same group are more similar to each other than to those in other groups. Here the regions with similar climatology are grouped into one cluster **[fovell and Fovell (1993)]**.



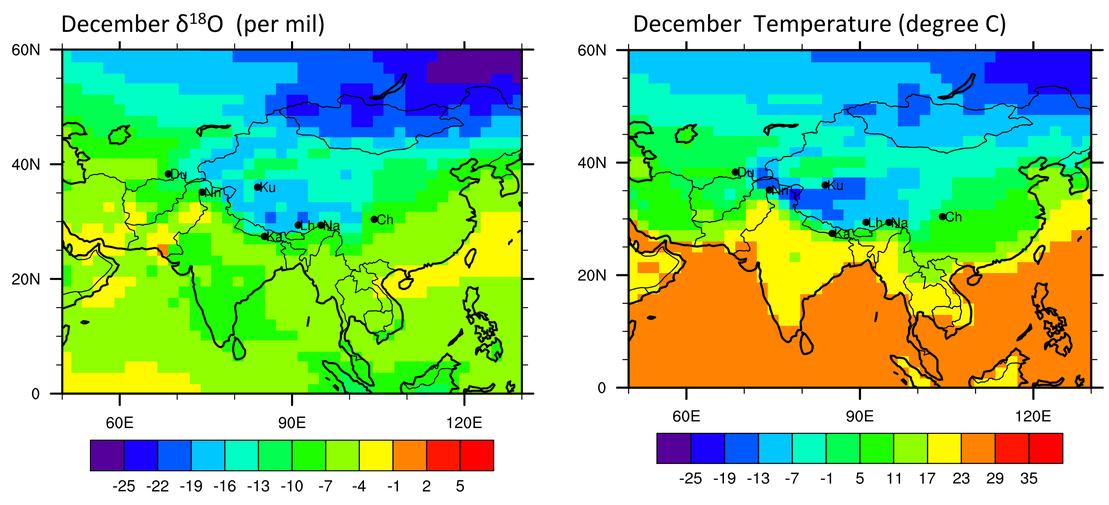
Clusters (colors) define regions with similar seasonal variations in temperature and precipitation.



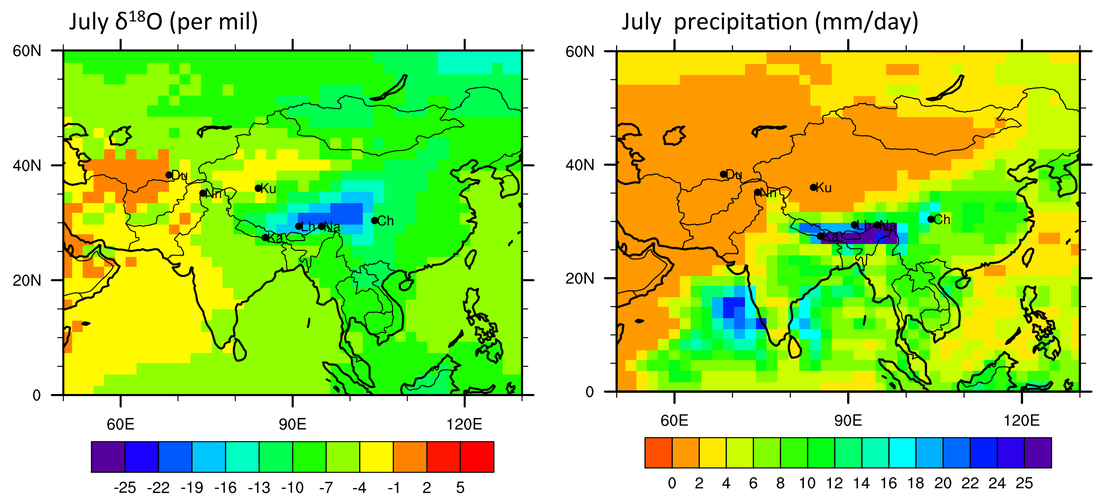
Cluster analysis documents different climatology in the Plateau Region.

Seasonal variability in modern precipitation $\delta^{18}O$:

Clear seasonal variability was found in modern precipitation $\delta^{18}O$. To understand what are the atmospheric drives for this variability, $\delta^{18}O$ distribution were compared with temperature and precipitation, similar patterns were selected and shown below.



Winter pattern in precipitation $\delta^{18}O$ is correlated with near surface temperature



Summer pattern in precipitation $\delta^{18}O$ is correlated with precipitation

Another statistical analysis method (Multiple regression analysis**) [Storch and Zwiers. (1999)]** has been applied to discover correlations between $\delta^{18}O$ and its atmospheric drives (temperature, precipitation, topography and vapor sources), the results will be published later.

References

ERA40 reanalysis data, http://data-portal.ecmwf.int/data/d/era40_moda/

Fovell, R. G., Fovell, M.-Y. C. (1993), Climate zones of the conter- minous United States defined using cluster analysis. Journal of Climate 6, 2103–2135.

Kent-Corson, et. al (2009), Stable isotopic constraints on the tectonic, topographic, and climatic evolution of the northern margin of the Tibetan Plateau. Earth and Planetary Science Letters, 282(1-4), 158-166.

Mcguffie,K. and Henderson-Sellers, A. (2005), A climate modeling primer.

NCEP reanalysis data, http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html

Storch, H. and Zwiers, F.W. (1999), Statistical Analysis in Climate Research. Cambridge university press.

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