Complex network analysis of Indian Summer Monsoon variability for the past 1000 years

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1. BACKGROUND

The Indian Monsoon *is the result of complex interactions between atmospheric and oceanic processes.*

To understand *monsoon variability* during the past periods of Earth Climate: *the Medieval Warm Period (MWP; 900–1100 AD) and the Little Ice Age (LIA; 1515–1715 AD*) we construct ***climate networks*** using regional climate model HIRHAM, *compare them to* ***paleoclimate networks*** *built on paleorecords e.g.stalagmites, trees or ice cores (1)* using network theory measures.

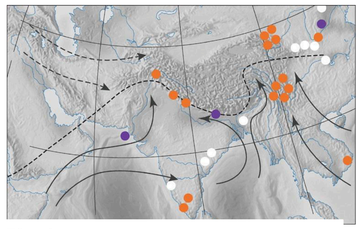


Fig.1
Monsoon Domain: paleorecords

2. MOTIVATION

Paleorecords irregularly spread over the Globe while model data are regular. How do network properties change when we come from one type of the grid to another? Can we validate model using climate network approach?

3. MEASURES and METHODS for analyzing paleoclimate networks

$$P_{1-2} = \frac{\sum_{i\in H_1, j\in H_2} LW_{i,j}}{N_{no}^{H_1} \cdot N_{no}^{H_2}}$$

$$LD'(G) = \frac{\sum_{i,j} A_{i,j}}{(N_{no}-1)\, N_{no}}$$

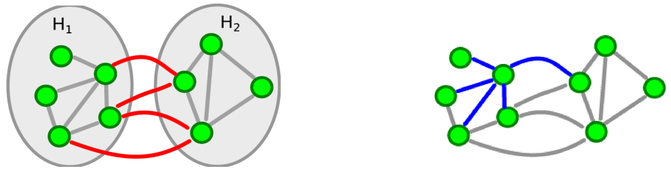


Fig.2
We measure how parts of the network are connected using network measures such as *cross link ratio (CLR or P_{1-2})* and *average link density* (LD' or ALD).

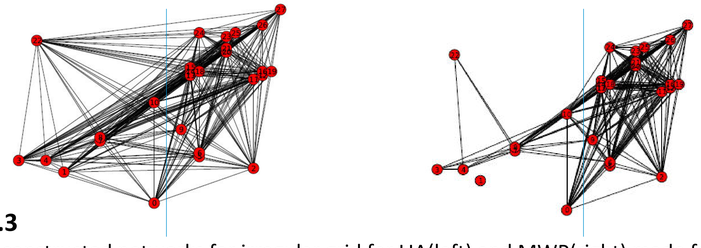
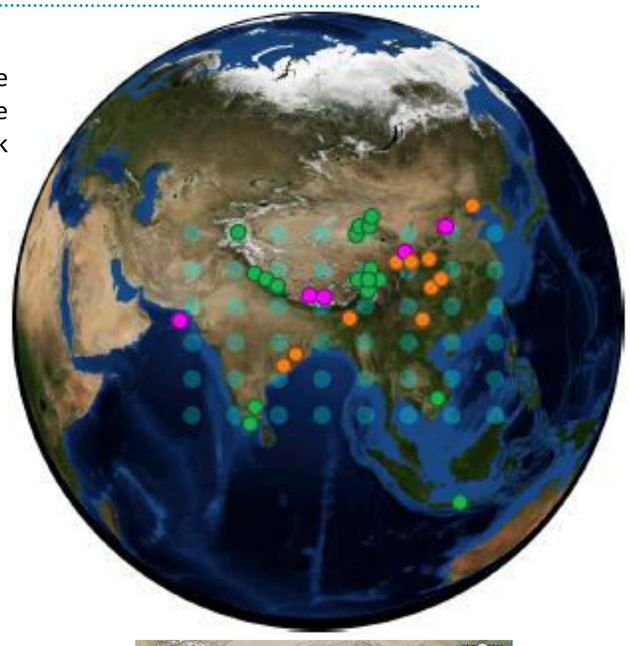


Fig.3
We constructed networks for irregular grid for LIA(left) and MWP(right) made for threshold 0.6. To count CLR for these networks we divided nodes into two parts: West and East from 98° (blue line).



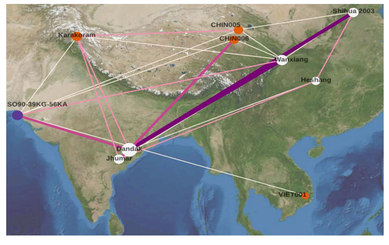


Fig.5
Network for the proxy data in MWP: a higher node degree west of the artificial boundary.

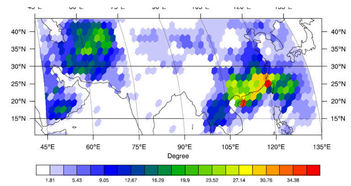
4. PRELIMINARY RESULTS and CONCLUSIONS

-For each period we compared CLR-measures for paleoclimate networks (Fig.5) and climatic model networks built on irregular grid. In both cases we obtained *higher CLR value for the Medieval Warm Period*. It confirms the results derived from paleorecords.

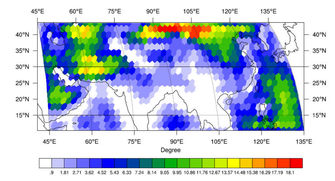
-We suggest that higher CLR corresponds to stronger West-East connection during MWP.

-Regular and irregular grid data give us similar results. It allows us to compare model with paleorecords using network approach even for the irregular grid.

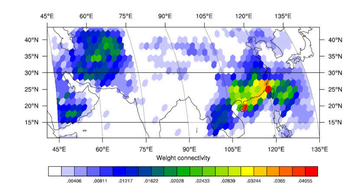
Node degree (LIA)



Node degree (MWP)



Node-Weighted connectivity (LIA)



Node-Weighted connectivity (MWP)

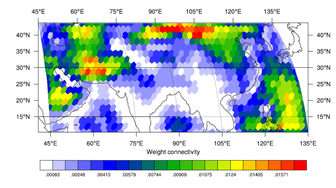


Fig.4 Degree and weighted connectivity measures. Link density 0.005, thresholds: 0.95(LIA) and 0.98 (MWP) Data: Regional climatic model HIRHAM 1.5° resolution.

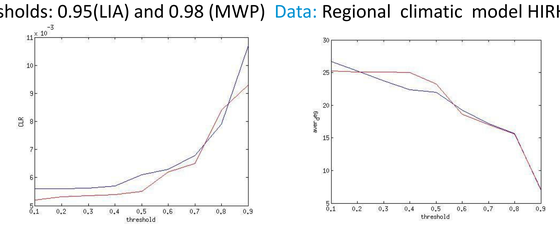


Fig.5
Cross link ratio and average degree for different threshold values.
LIA (blue line), MWP (red line).

5. OUTLOOK

-What is the effect of homogeneity of the grid for a spatio-embedded climate networks?

-How are networks for model data for different periods of time changing and what can we learn about paleoclimate from these changes?

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References:
[1] *Rehfeld et al.2012*
[2] Pyunicorn package: http://www.pik-potsdam.de/~donges/pyunicorn

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