# Synchronous climate transitions during the Holocene in Asia derived from speleothems

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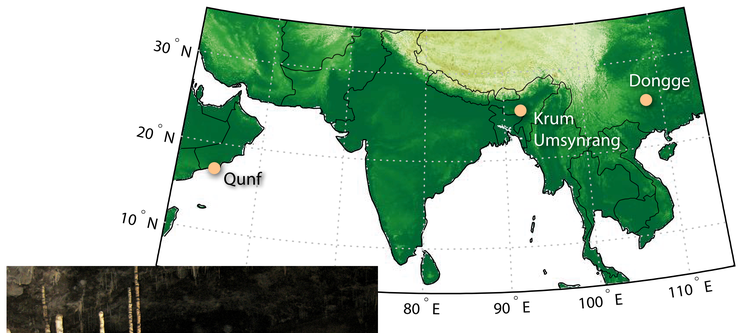
## Motivation

Asian speleothem records of $\delta^{18}O$ provide past continental monsoonal variability. Available stalagmite records cover a region in western, central and eastern Asia, where the Indian Summer Monsoon (ISM) and the East Asian Monsoon (EAM) are active. We try to detect past interrelations between these two Monsoon branches, which may help in further investigation of past movements of the *ITCZ* and of the impact of teleconnections.

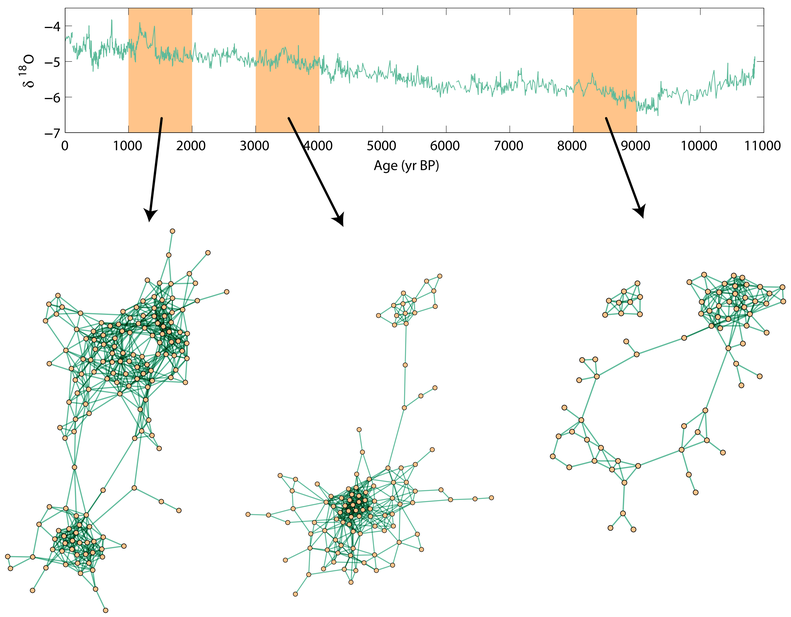
## Speleothem data

We analyse $\delta^{18}O$ records measured on stalagmites from Qunf cave (Oman), Krum Umsynrang (India), and Dongge cave (China). They cover roughly the Holocene.




*Location of the stalagmite KRUM-3 in cave Krem Umsynrang (India, Meghalaya). At this place, several measurements (like drip water rate, cave climate) are still going on.*

## Network-based recurrence analysis




*KRUM-3 record and complex networks of the recurrence structure of exemplary epochs.*

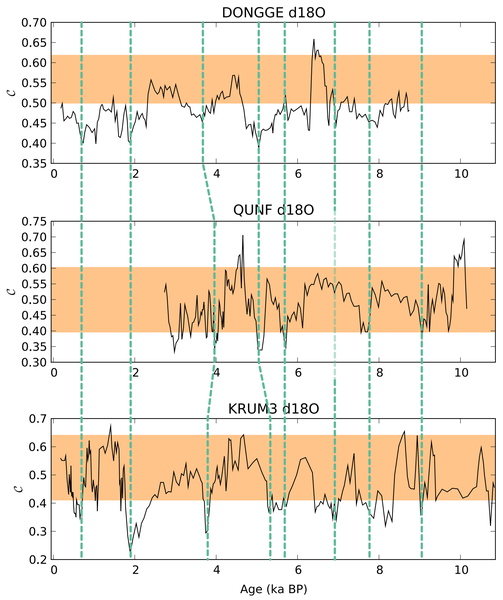
Recurrence is a fundamental property of dynamical systems. Recurrence plots are appropriate tools to study complex and dynamial properties by means of recurrences [1],

$$\mathbf{R}_{i,j} = \Theta\left(\varepsilon - \left\|\vec{x}_i - \vec{x}_j\right\|\right), \quad i, j = 1, \ldots, N.$$

The binary and square recurrence matrix **R** can be identified as the link matrix of a complex network, resulting in a network representation of the recurrence structure of the time series [2, 3]. Clustering coefficient measures the probability that two neighbours of a node are also mutual neighbours.

## Results

The clustering coefficient reveals synchronous drop of regular dynamics at the three locations (around 0.8, 2, 3.7, 5.2, 5.7, 7, 7.8, 9.2 ka BP).




*Network analysis using time windows of 500 a (50 a overlap), embedding m=2, τ=2, and recurrence rate 5%.*

## References

[1] N. Marwan, M. C. Romano, M. Thiel, J. Kurths: Recurrence Plots for the Analysis of Complex Systems, Physics Reports, 438 (2007).

[2] N. Marwan, J. F. Donges, Y. Zou, R. V. Donner, J. Kurths: Complex network approach for recurrence analysis of time series, Physics Letters A, 373 (2009).

[3] R. V. Donner, Y. Zou, J. F. Donges, N. Marwan, J. Kurths: Recurrence networks – A novel paradigm for nonlinear time series analysis, New Journal of Physics, 12 (2010).

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