140,000 years of precipitation dynamics on the Western Chinese Loess Plateau

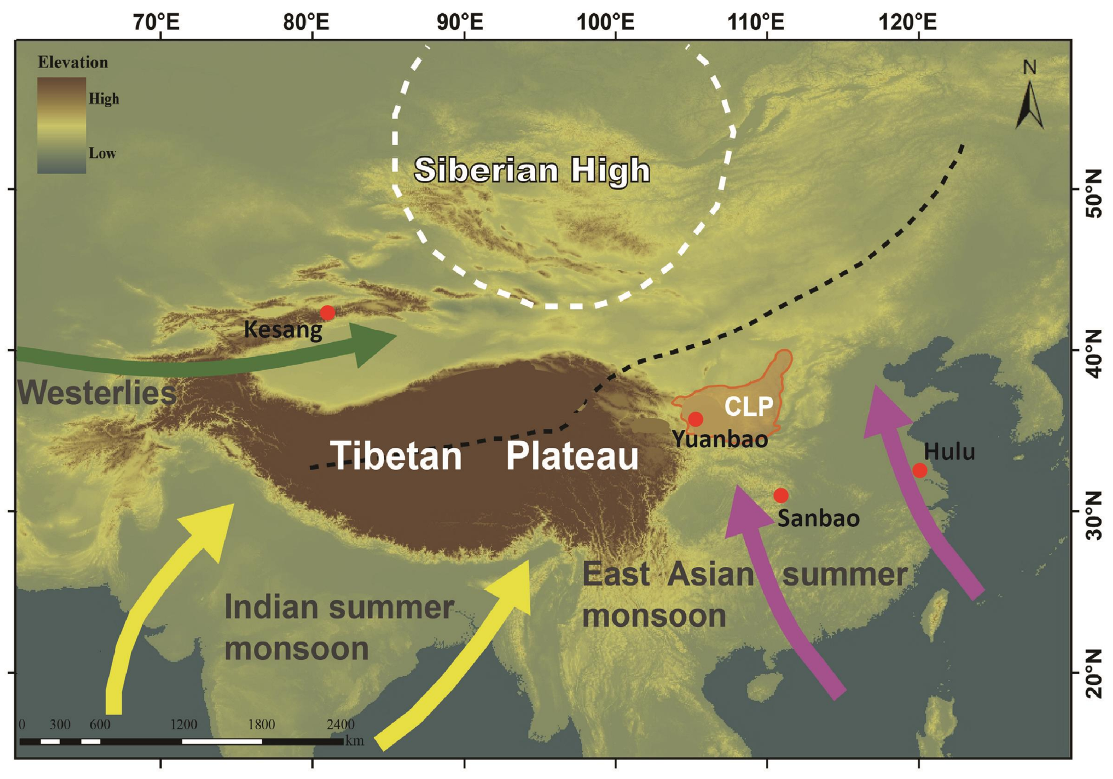
Louise Fuchs[1]*, Jingjing Guo[1], Enno Schefuß[2], Youbin Sun[3], Jibao Dong[3], Martin Ziegler[1], Francien Peterse[1]

Our loess team

Introduction

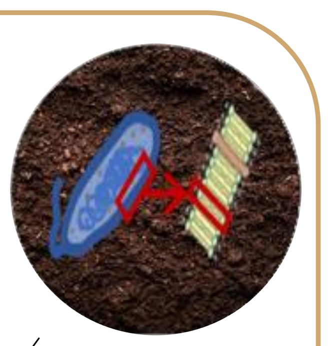
Paleorecords of East Asian Monsoon (EAM) climate variability indicate large changes on (sub)orbital timescales, but often represent a mixed signal of temperature and precipitation, thereby limiting our understanding of the response of EAM climate dynamics to global warming. The Chinese Loess Plateau (CLP) is one of the best continuous paleoclimate archives on land, and its sediments host a long record of EAM climate variability in the alternating layers of loess and paleosols reflecting glacial and interglacial period, respectively[1].

Here we reconstruct a continuous, high-resolution record of the precipitation dynamics for continental China over the past 140,000 years.



Study site. Yuanbao loess paleosol sequence (LPS) is located at 2177m on the western CLP (with a mean annual temperature of 4 °C[2], and mean annual precipitation of 500 mm), under the influence of the East Asian Summer Monsoon (EASM) and the East Asian Winter Monsoon (EAWM)[3]. The red circles also show the location of Kesang, Hulu and Sanbao caves, used for Speleothem $\delta^{18}O$ (Fig. 1a, f).

Methods



BrGDGTs (branched Glycerol Dialkyl Glycerol Tetraether lipids) are pH-sensitive soil microbial membrane lipids. BrGDGT-based soil pH represents the net moisture (precipitation-evaporation) balance.

Plant wax *n*-alkanes are resistant to degradation. Hydrogen isotopic values of plant waxes (δ^2H_{wax}) reflect the isotopic composition of moisture used for lipid synthesis.

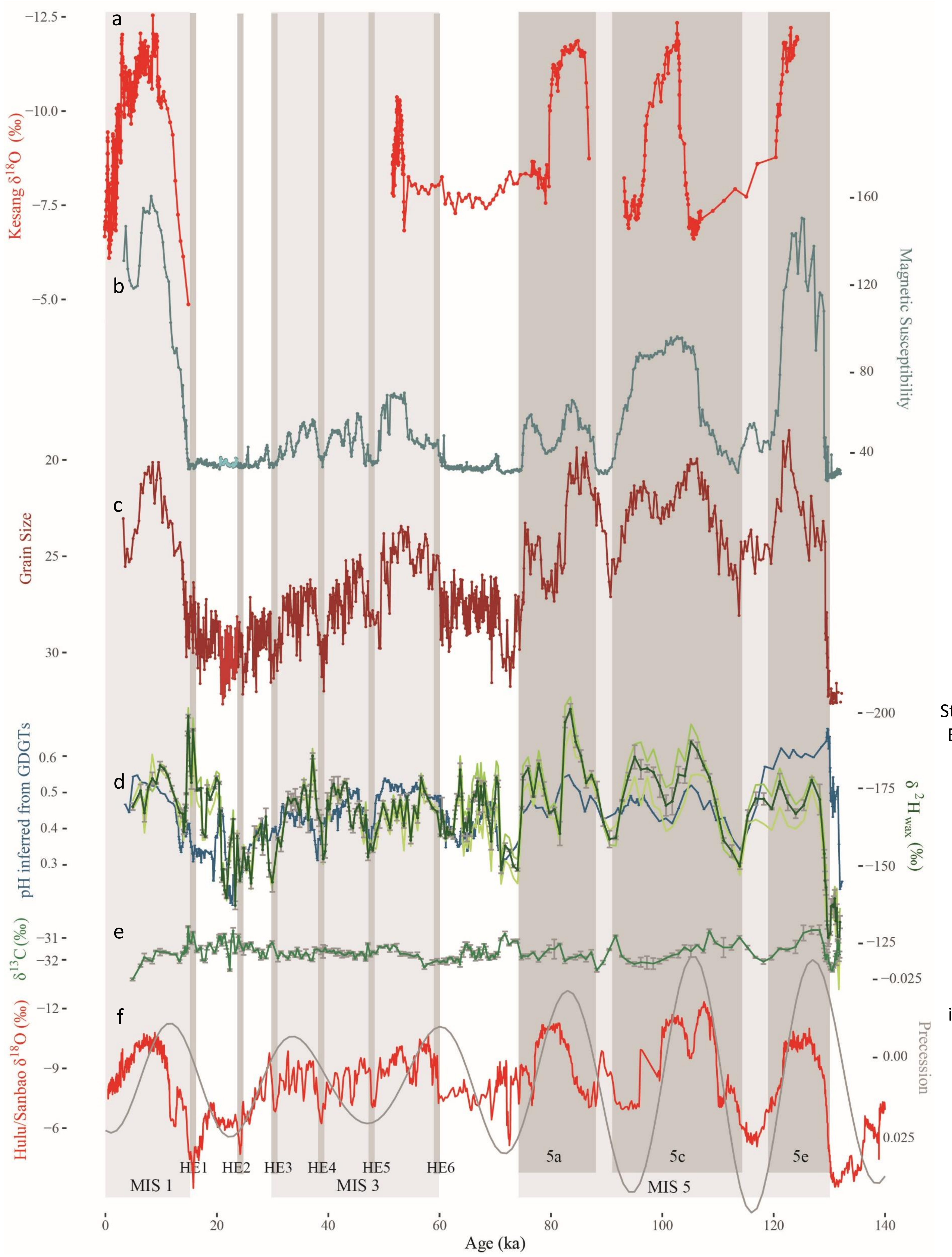


Figure 1. Comparison among proxy records for the Yuanbao LPS.
a) Composite speleothem $\delta^{18}O$ record from the Kesang cave[4] (central Asia), b) Magnetic susceptibility (MagSus) at Yuanbao, c) Mean grain size (GS; µm) at Yuanbao, d) pH (inferred from brGDGTs) and δ^2H_{wax} at Yuanbao. Error bars indicates mean standard deviation based on at least duplicate analysis. VSMOW – Vienna standard mean ocean water, e) $\delta^{13}C_{wax}$ at Yuanbao. Error bars indicates mean standard deviation based on at least duplicate analysis. VPDB – Vienna Peedee belemnite, f) Composite speleothem $\delta^{18}O$ record from the Hulu[5] and Sanbao[6] caves (red), and precession[7] (grey).

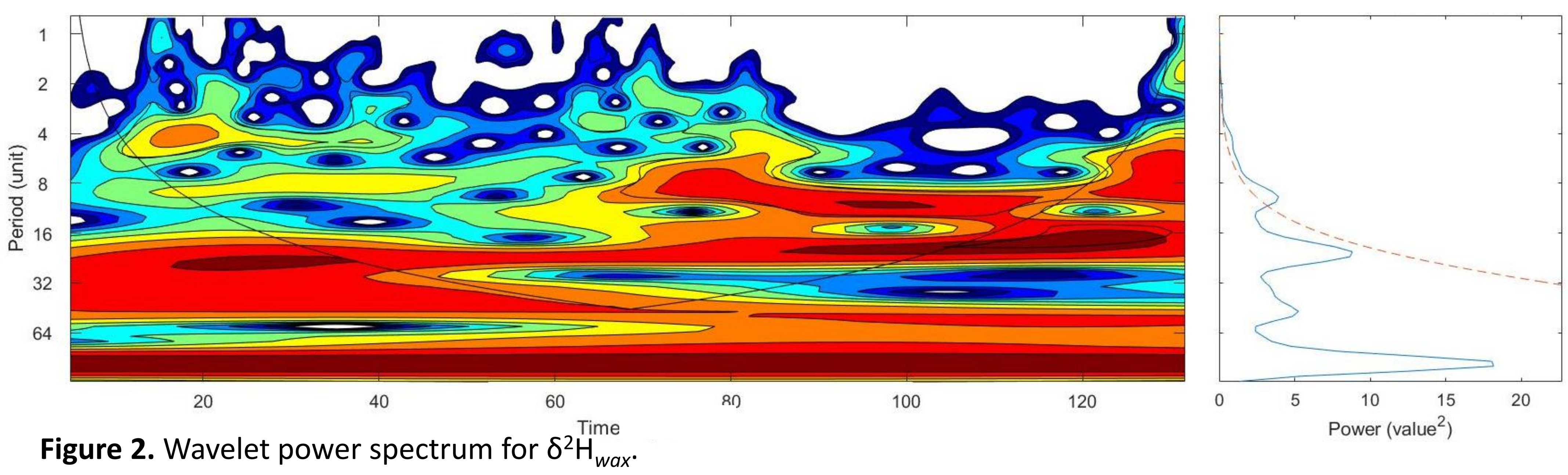


Figure 2. Wavelet power spectrum for δ^2H_{wax}.

Results and discussion

- Yuanbao, Kesang and Hulu/Sanbao records show same trend and timing despite their large geographic distance and different modern hydroclimate.
- Precession is the main driver of the Yuanbao δ^2H_{wax} record.
- Yuanbao δ^2H_{wax} and GS show half-precession cycles during MIS 5 (Fig. 2).
- Yuanbao δ^2H_{wax} suggests stronger summer monsoon during MIS 5a than 5c and 5e, different from MagSus and speleothem $\delta^{18}O$ records → Seasonality / growing season / precipitation source?
- δ^2H_{wax} is not influenced by vegetation change (flat $\delta^{13}C_{wax}$).
- δ^2H_{wax} and pH are similar during the LGM.
- Large pH increase during MIS 4.
- δ^2H_{wax} is less depleted during the Holocene than in MIS 5.
- δ^2H_{wax} is relatively stable during MIS 3, different from GS and MagSus.

Conclusions

- **The half-precession cycles during MIS 5 suggest that Yuanbao responds to Southern Hemisphere forcing, possibly due to its close position to the Tibetan Plateau (TP).**
- **Yuanbao also responds to North Atlantic cooling events (Heinrich events).**
- **North Atlantic processes could explain the lag between δ^2H_{wax} and GS/MagSus, as they could lead the Westerlies North or South of the TP, influencing the precipitation.**

1. Utrecht University, Department of Earth Sciences, 3584 CS Utrecht, the Netherlands
2. MARUM-Center for Marine Environmental Sciences, University of Bremen, D-28334 Bremen, Germany
3. State key laboratory of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an, 710061, China

Contact me! l.fuchs@uu.nl

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