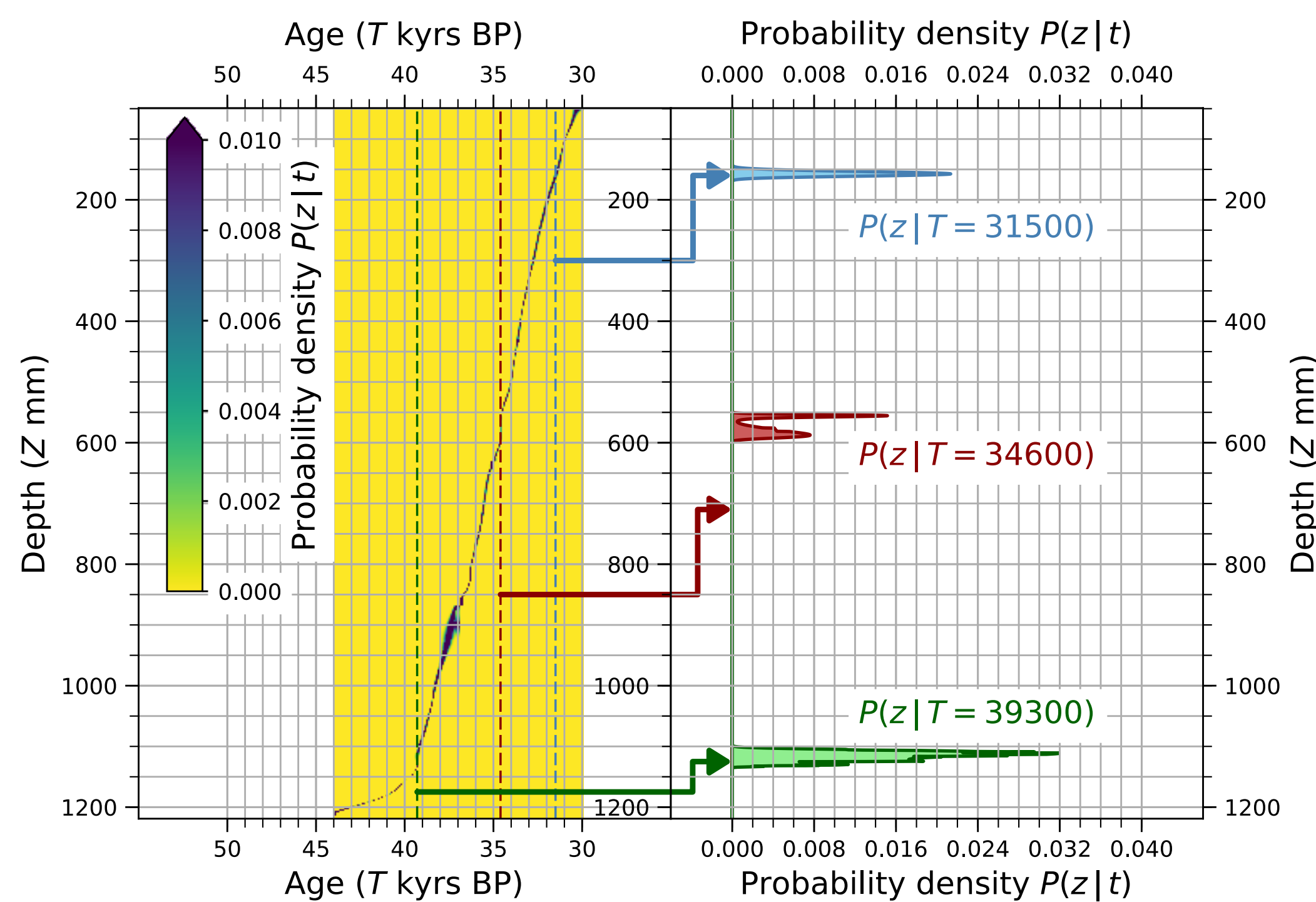
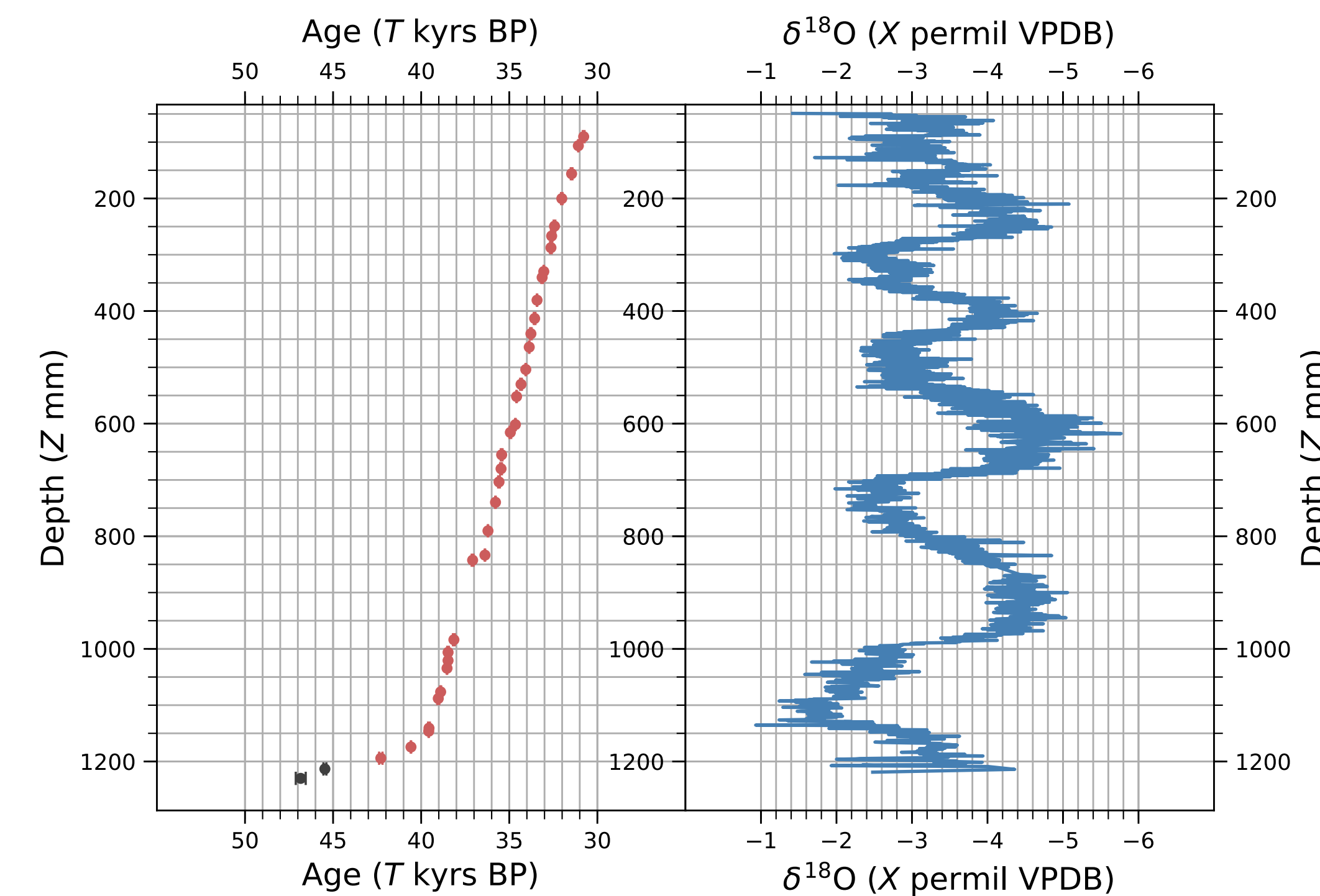


# Is this an event? Detecting abrupt changes in palaeoclimate records

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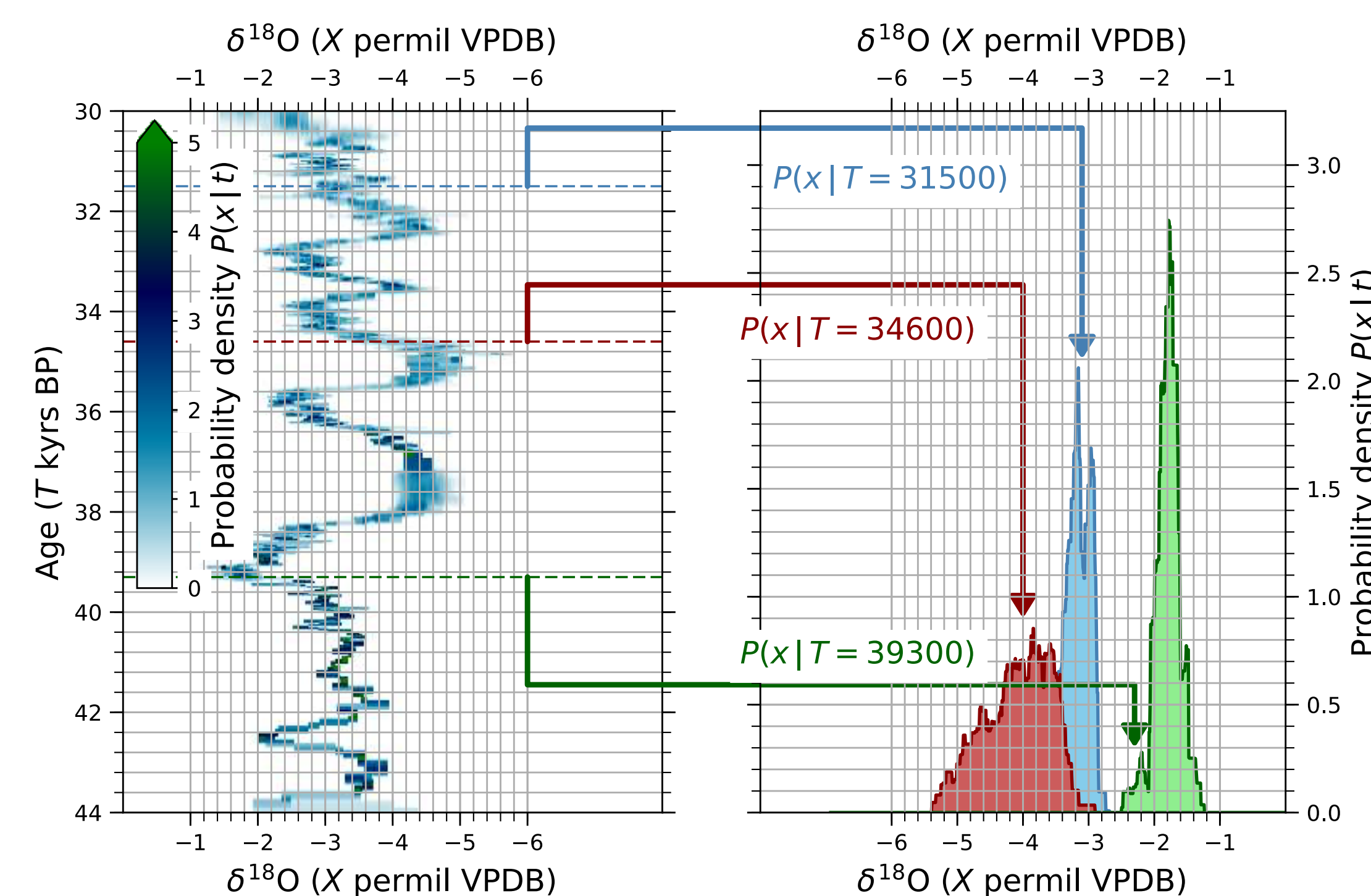
## DATA

- » We use oxygen isotope ratios from Mawmluh cave in northeastern India.
- » Proxy for Indian Summer Monsoon (ISM) and moisture source during the last glacial.
- » ISM intensity is inversely related to  $\delta^{18}\text{O}$ : more negative values indicate stronger ISM and *vice versa*.



- » We construct a probabilistic age model as per [1].
- » Sequence of probability density functions (PDFs) that encode dating uncertainties.
- » Height of PDF is the likelihood of depth  $Z = z$  for given age  $T = t$ , i.e.,  $P(z|t)$ .
- » The PDFs differ in shape and peakedness for different time points.

## AGE MODEL

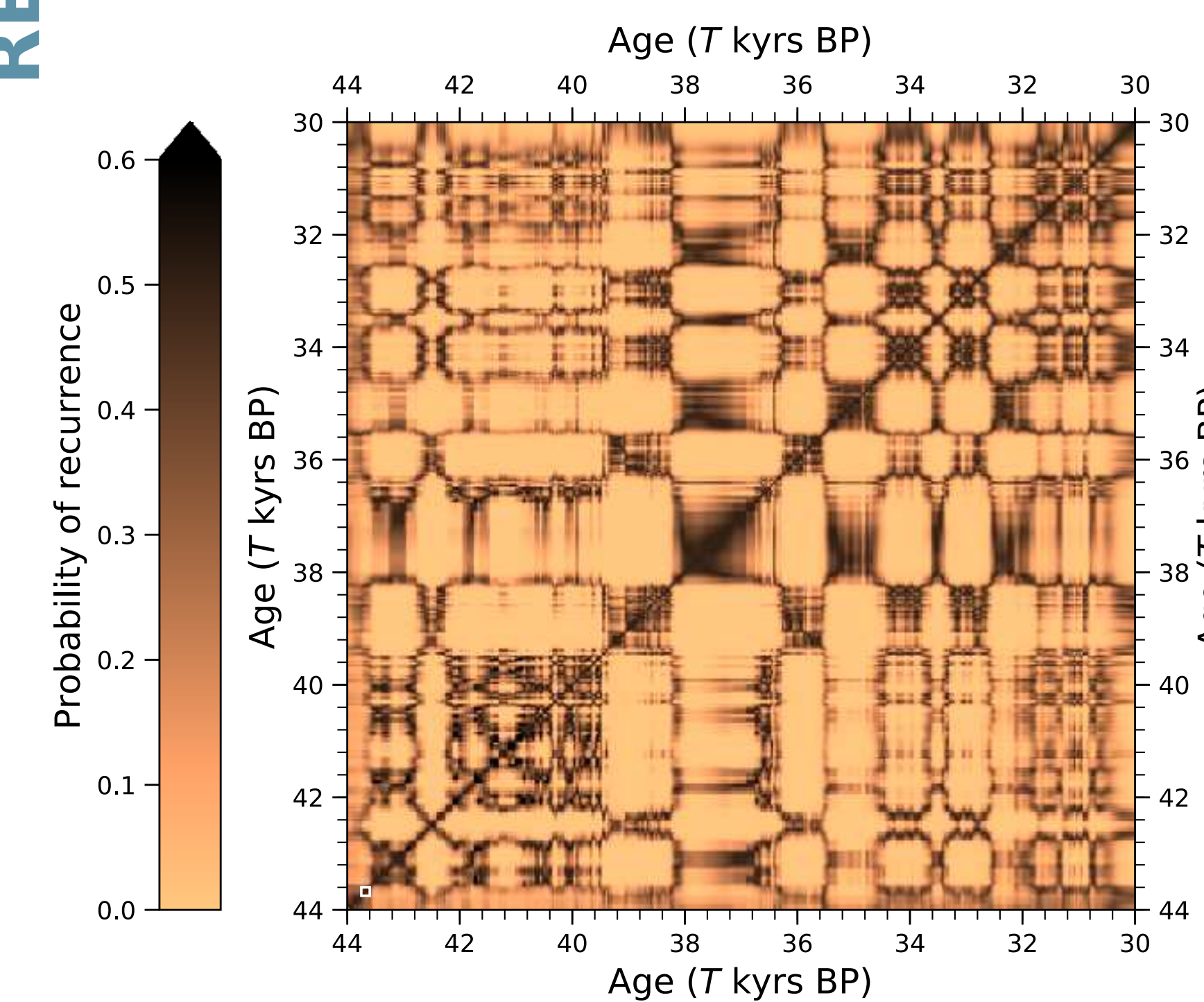


## PROXY RECORD

- » The age model PDFs are used as weights for all proxy measurements for a chosen  $T = t$ .
- » The weighted mean of  $P(x|z)$  gives  $P(x|t)$  [1].
- » We get a series of PDFs that encode all uncertainties into a final proxy probability.
- » This contrasts to standard point-like time series representations.

## RECURRENCES

- » We estimate probabilities of recurrence of  $\delta^{18}\text{O}$  values for all pairs of time points [2].
- » Dynamical properties of the recorded climate signal is captured in the matrix  $\hat{\mathbf{A}}$  of the probabilities of recurrence.

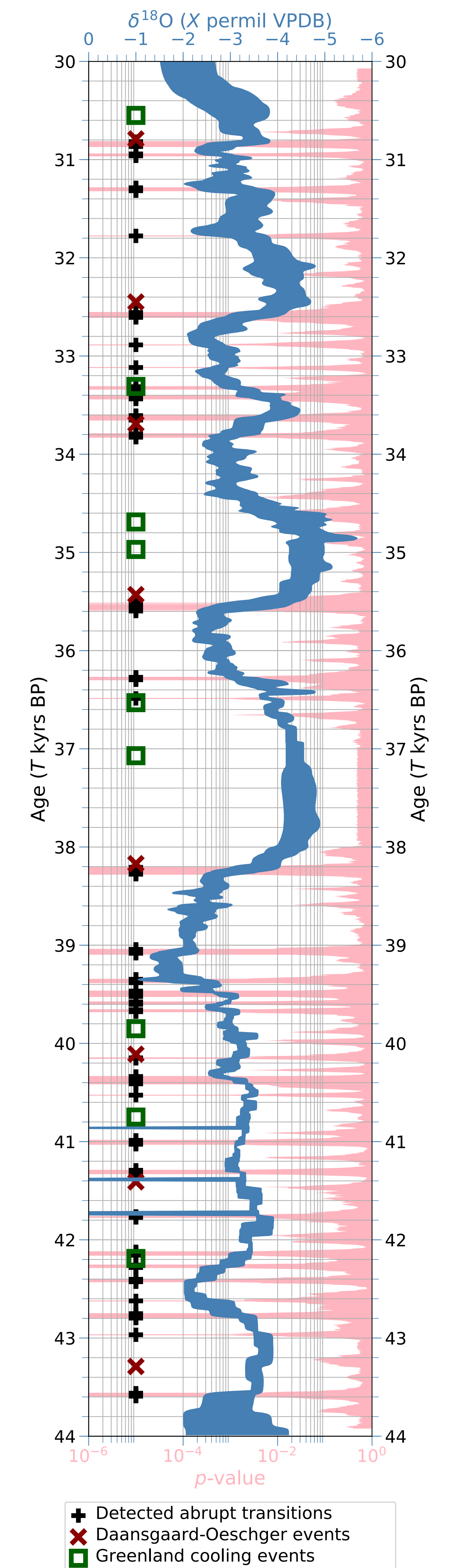


## TRANSITIONS

- » Sliding a window of 150 years, we estimate the probability  $p$  of observing a randomly occurring block structure in  $\hat{\mathbf{A}}$ .
- » Statistically significant dips in this  $p$ -value indicate the occurrence of non-random abrupt transitions [2].

## CONCLUSIONS

- » Detected transitions are synchronous to Dansgaard-Oeschger (DO) events and with several Greenland cooling events.
- » DOs (Greenland cooling) coincide with a strengthening (weakening) of ISM intensity.
- » Robust, 'uncertainty-aware' evidence of teleconnection between the North Atlantic and the ISM during the last glacial.



## Affiliations

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## References

- [1] Goswami, Bedartha, et al. "Estimation of sedimentary proxy records together with associated uncertainty." *Nonlin. Proc. Geophys.* **21.6** (2014): 1093-1111.
- [2] Goswami, Bedartha, et al. "Abrupt transitions in time series with uncertainties." *Nat. Comm.* **9.1** (2018): 48.