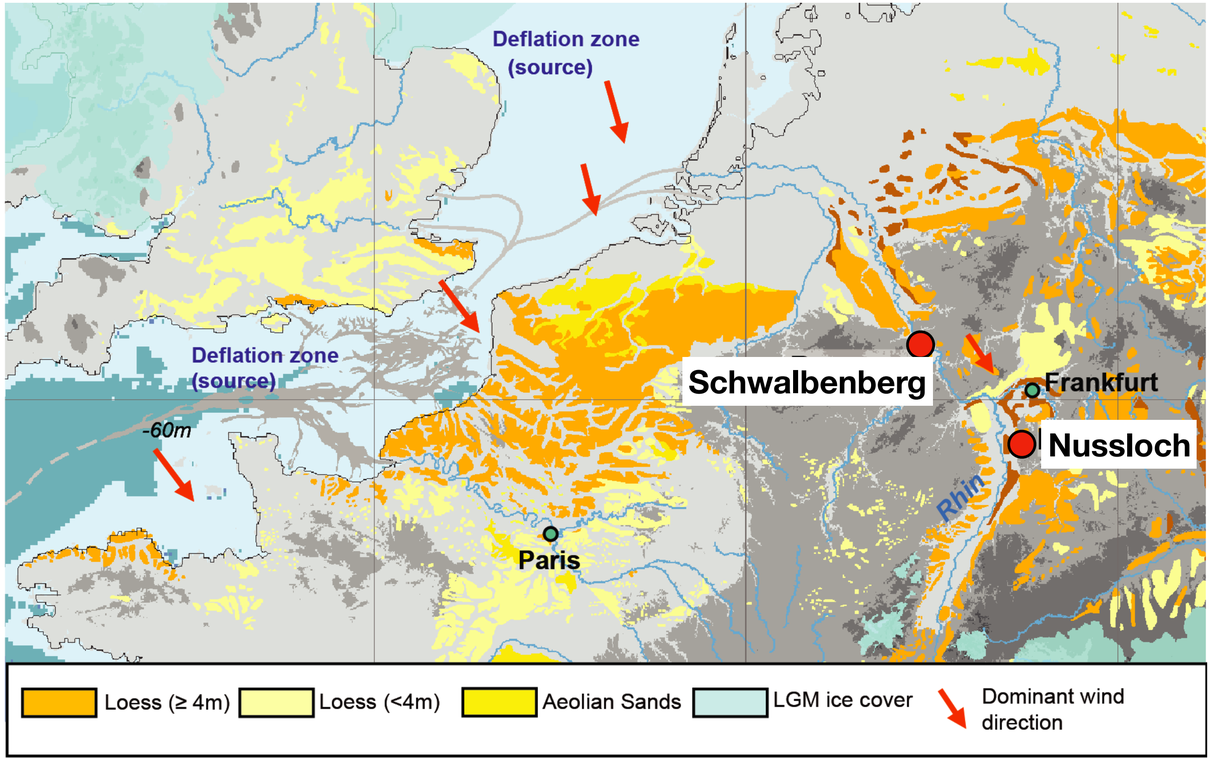
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Millennial-timescale reconstruction of Upper Pleistocene temperature and precipitation derived from earthworm calcite granules in western European loess profiles

Charlotte Prud'homme[1], Peter Fischer[2], Olaf Jöris[3] , Christine Hatté[4], Mathias Vinnepand[2], Hubert Vonhof[5], Olivier Moine[6], Andreas Vött[2], Kathryn E. Fitzsimmons[1]

EGU General Assembly 2021

Loess sequences in the Rhin Valley



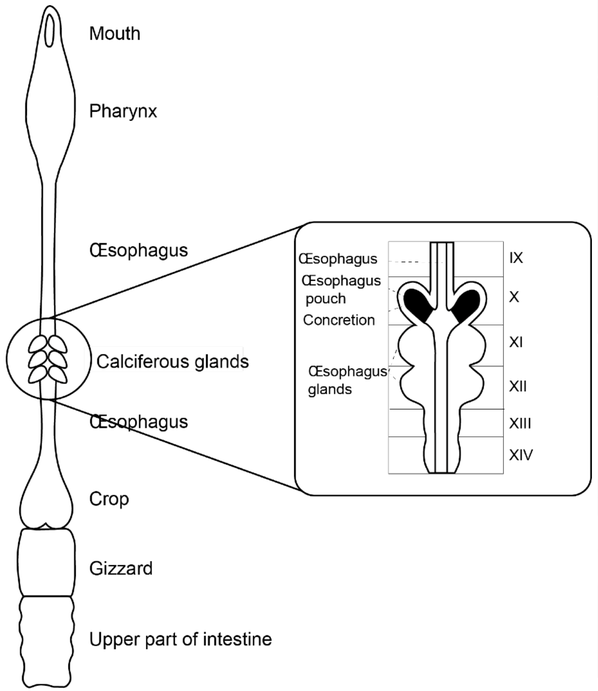
Haase et al. (2007) modified by Antoine et al. (2013)

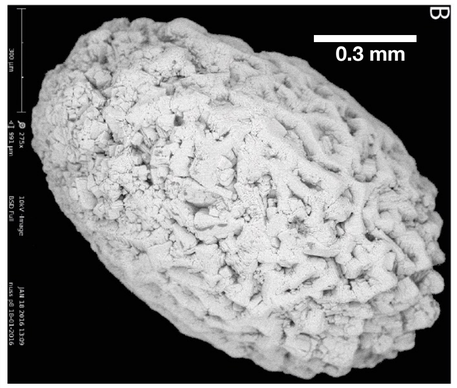
- Two major loess sequences in the Middle and Upper Rhine Valley provide high-resolution records of climatic changes over the last glacial period: **Schwalbenberg and Nussloch**
- High concentrations of **fossil calcite granules** produced by earthworms (ECG) occur throughout most of the horizons
- **The characteristics and concentrations of ECGs reflect variations in climate through time**.

Earthworm calcite granules

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Darwin 1881, modified





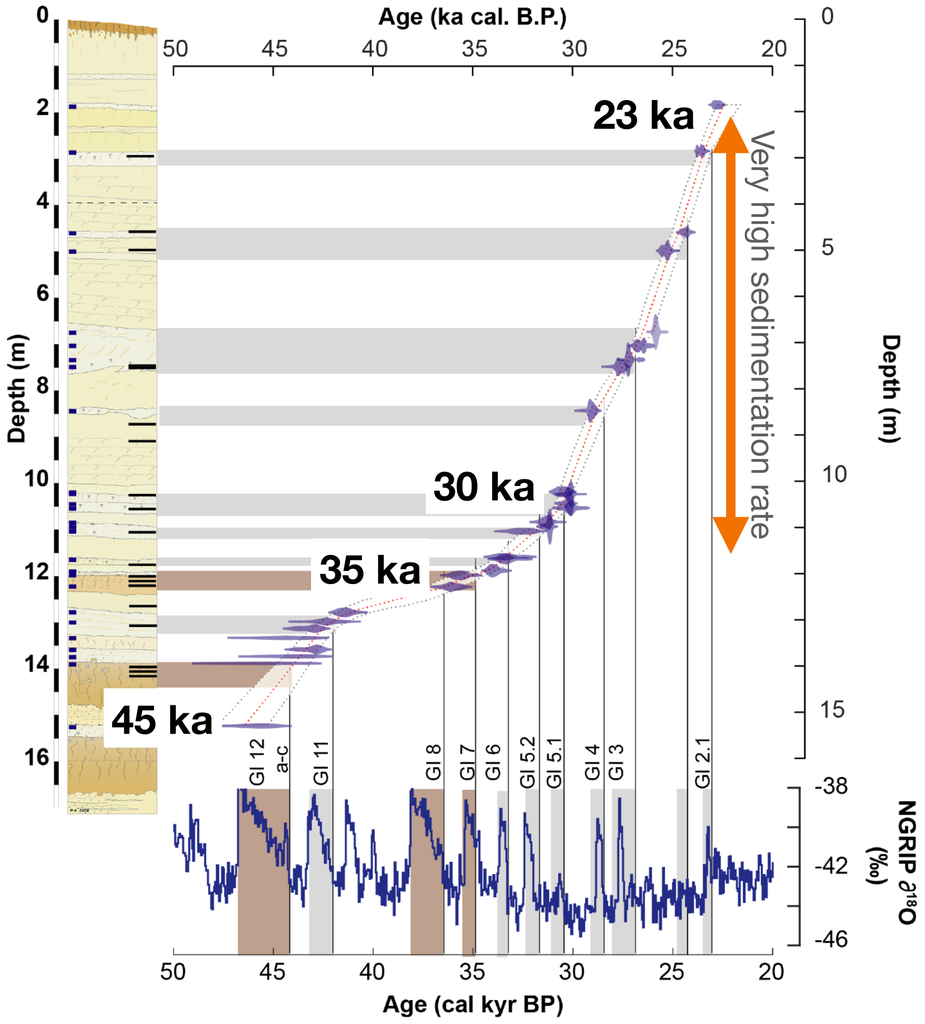


- Ovoid calcitic granules (0.1–2 mm) are mostly produced in the calciferous glands of ***Lumbricus* sp.**
- Experimental observations show that ECGs are released in the upper part of the topsoil
- Concentrations of ECGs reflect abundance and activity of earthworms
- Radiocarbon dating provide **high resolution chronological framework**
- Stable isotope compositions are reflecting **climate parameters** (temperature and precipitation)

Chronological framework - ^{14}C

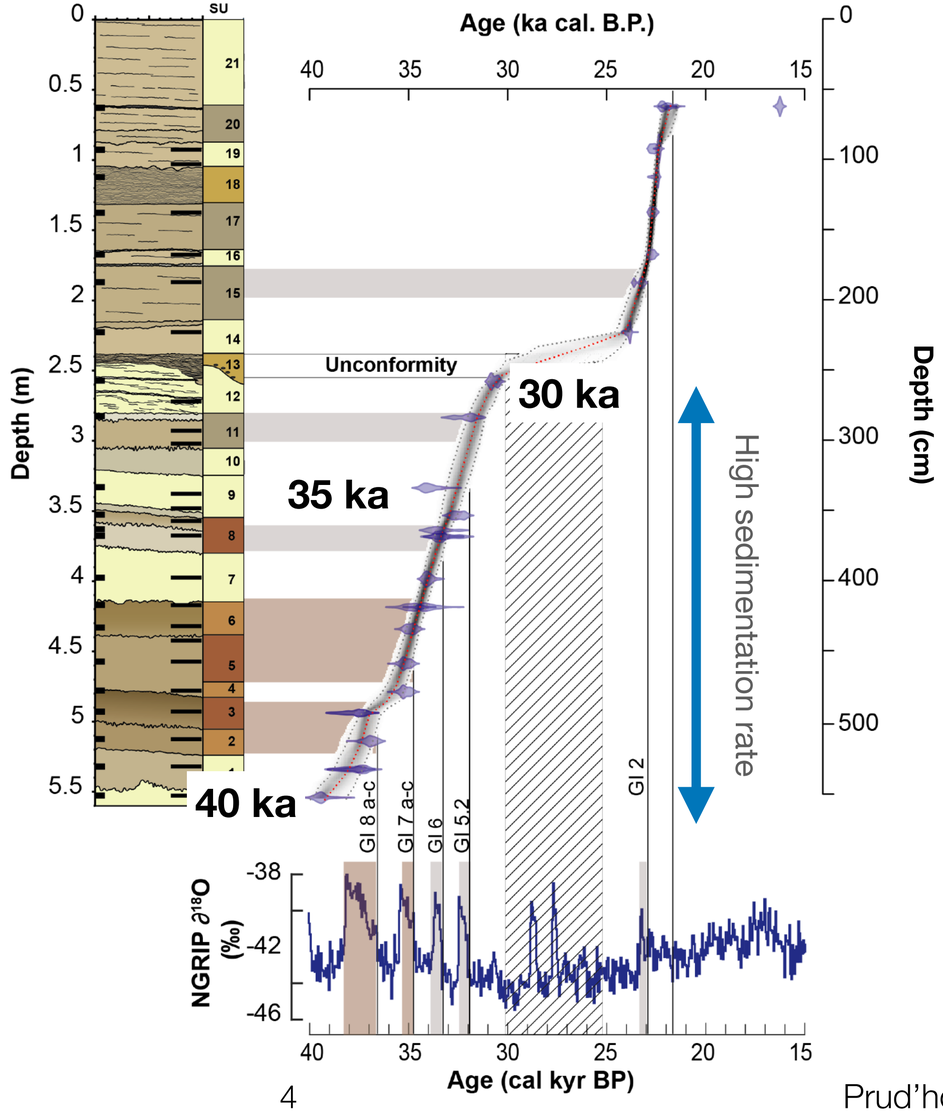
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Nussloch



Modified after Moine et al., 2017

Schwalbenberg



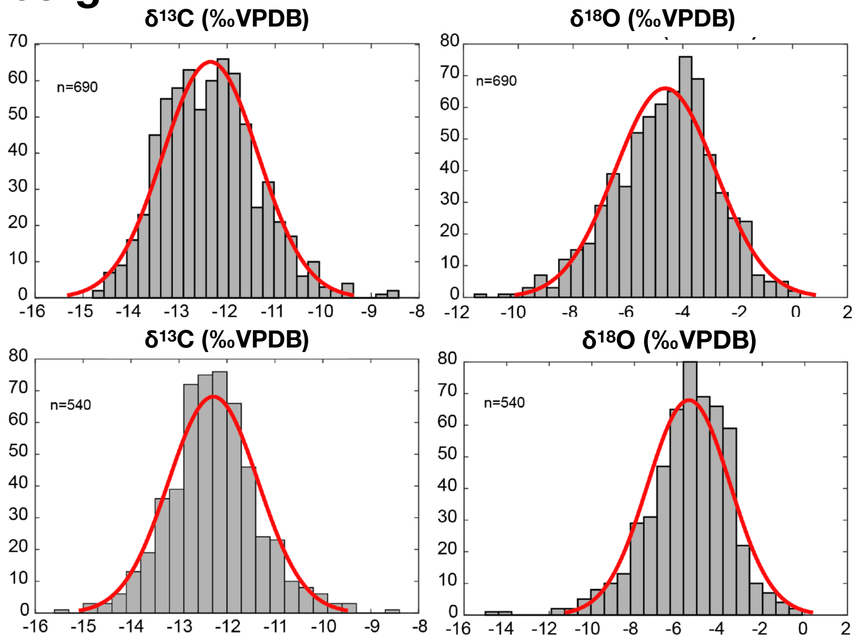
Prud'homme et al., in prep

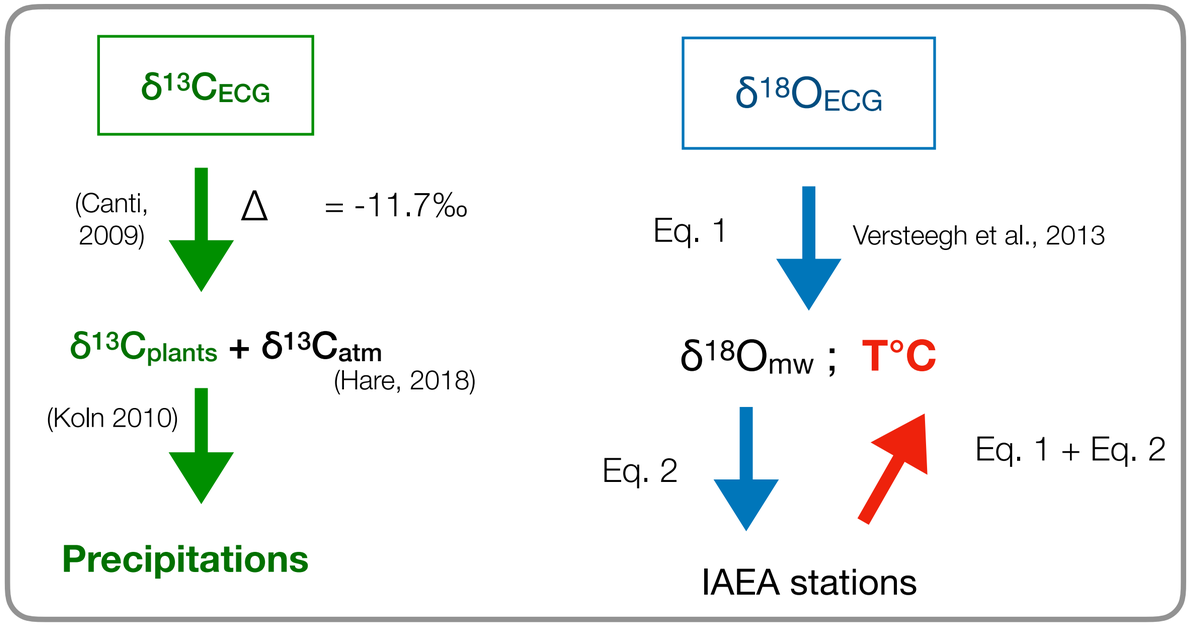
- **Nussloch** : high resolution between 30 and 23 ka
- **Schwalbenberg**: high resolution between 40 and 30 ka
- Complementary sequences
- Age model based on Bayesian statistique (Bacon, Blaauw & Christeny, 2011)

Stable isotopique composition of ECG

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Schwalbenberg





Nussloch

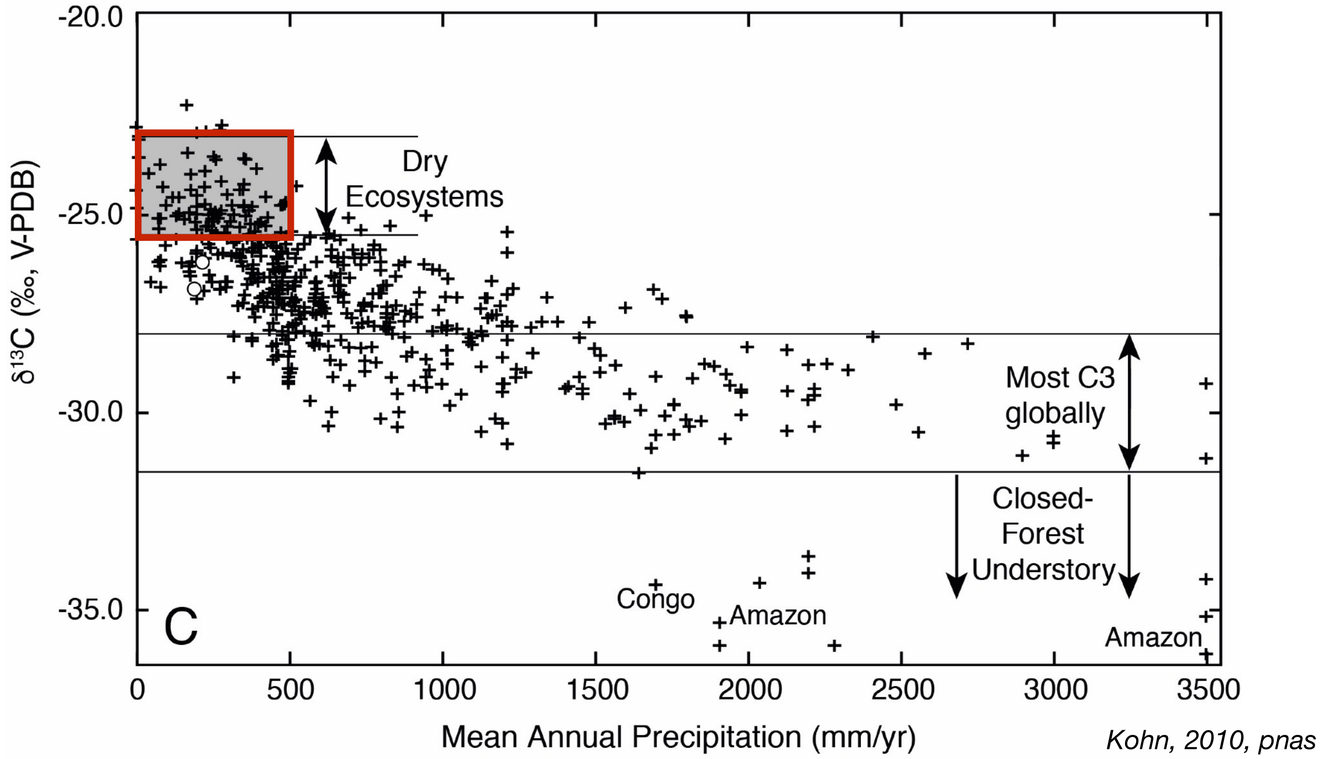
Prud'homme et al., 2016; 2018

- 30 granules per layer of 5 cm were selected (18 layers for Nussloch and 23 layers for Schwalbenberg)
- **$\delta^{18}O$** and **$\delta^{13}C$** values were measured on each ECG

Relation between $\delta^{13}C_{ECG}$, $\delta^{13}C_{atm}$ and precipitations

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- Source of carbon: mainly diet (Briones et al., 2008, Canti 2009)
- Carbon isotopic fractionation of **-11.7±1.5 ‰** between carbon ingested by worms and carbon output in granules (Canti 2009)
- $\delta^{13}C_{atm}$ data from air bubbles in Vostok ice core (Leuenberger et al., 1992; Schmitt et al., 2012, Hare et al., 2018)



Kohn, 2010, pnas

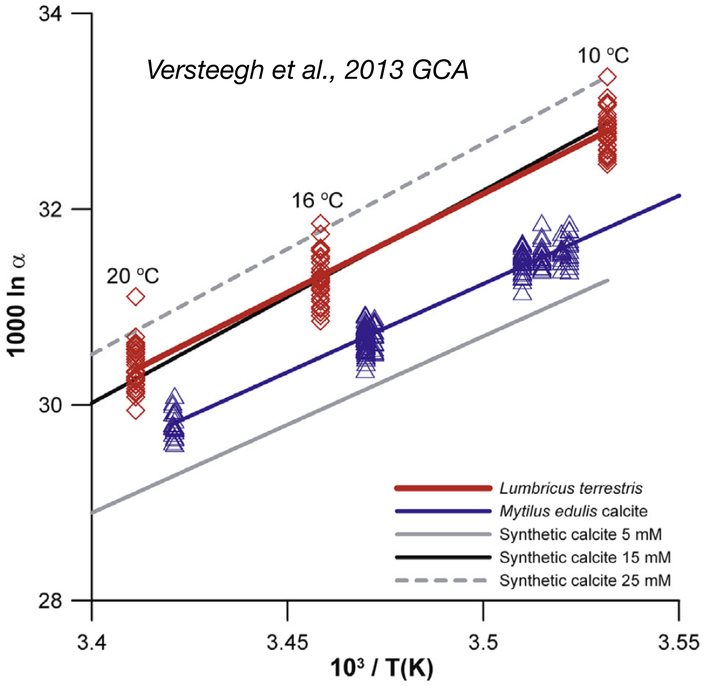
$$Log_{10}(MAP + 300(mm.yr^{-1})) = 0.092(\pm 0.004)\Delta^{13}C_{pl} + 1.148(\pm 0.074)$$

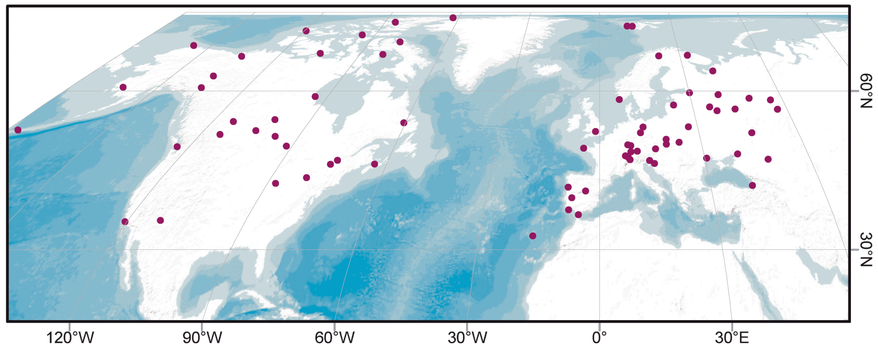
$$\Delta^{13}C_{pl} = \frac{\delta^{13}C_{atm} - \delta^{13}C_{pl}}{1 + \frac{\delta^{13}C_{pl}}{1000}}$$

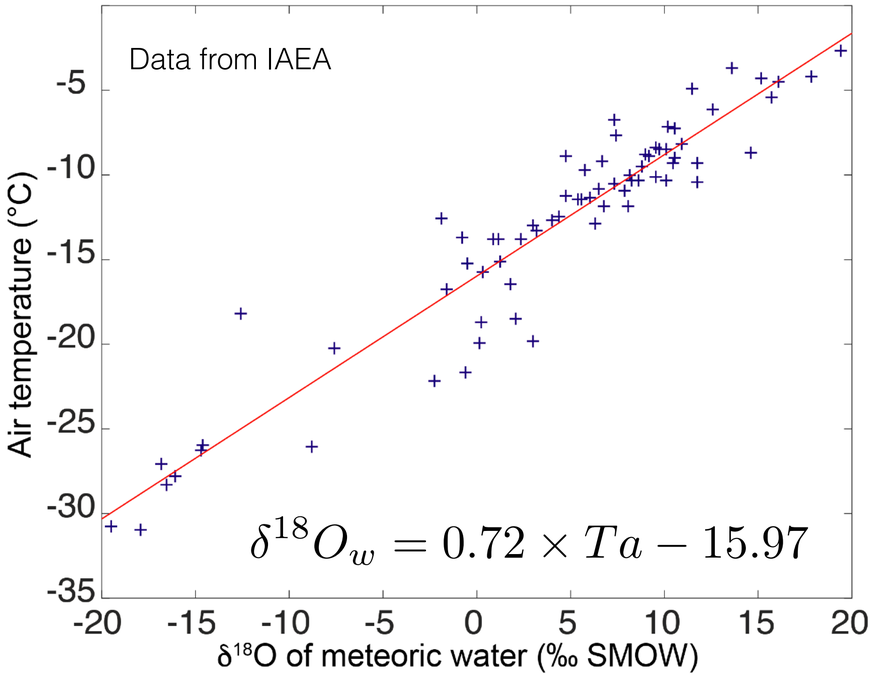
Relation entre $\delta^{18}O_{GV}$, température et $\delta^{18}O_{mw}$

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$$10^3 \ln \alpha = \frac{20.21 \times 10^3}{T} - 38.58$$

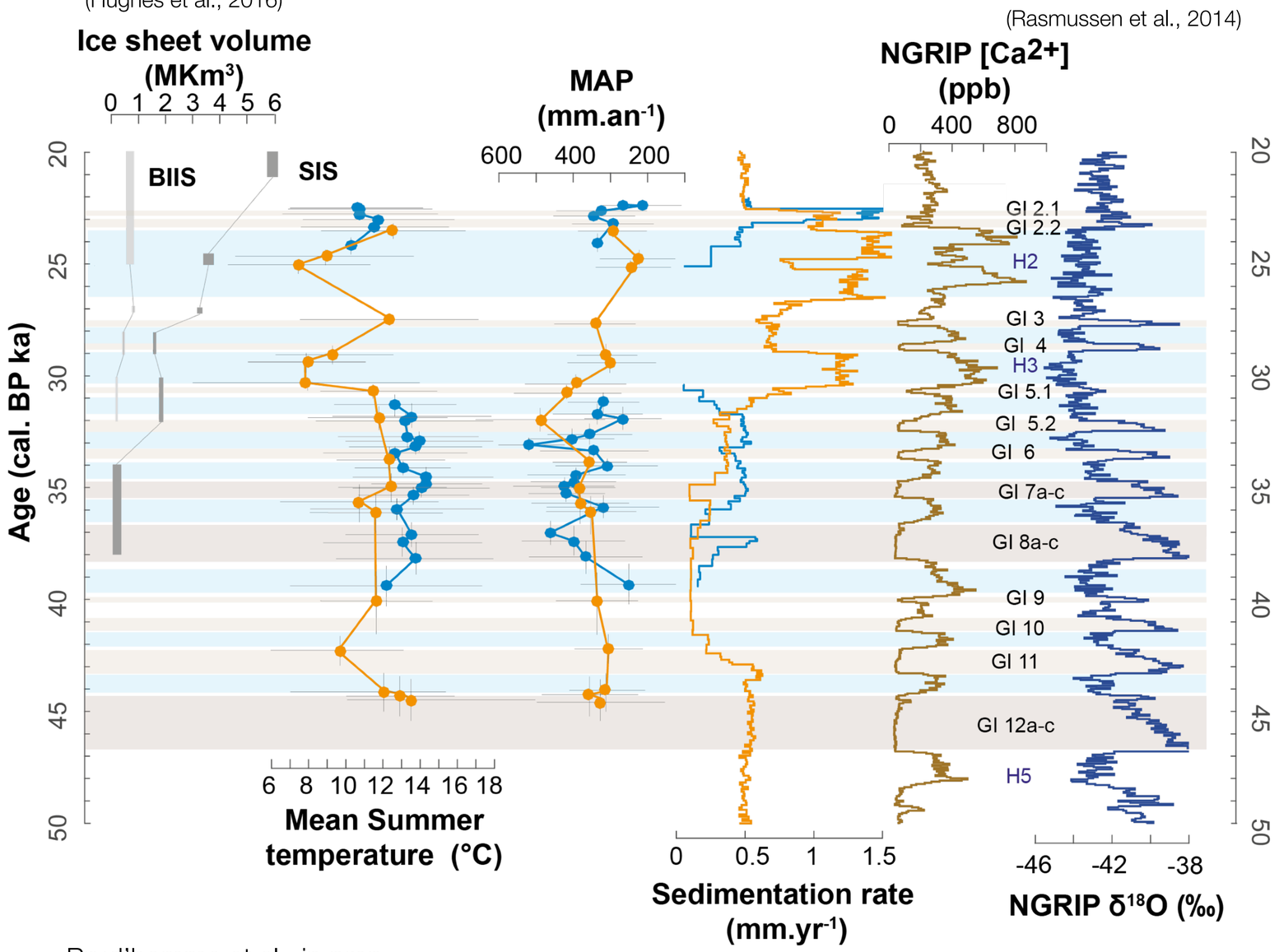






- $\delta^{18}O_{ECG}$ depends on **temperature** and $\delta^{18}O$ **of meteoric water**
- By combining the equations the **paleotemperatures** can be calculated

Quantification of temperature and precipitation



Mean Summer T : 8 and 13±4°C

MAP: 250 and 370±100 mm.yr^{-1}

Loess - Cold periods — Stadial

Tundra Gley - Short Interstadials (warm)

Brown sol - Long Interstadial (warm)

Nussloch **Schwalbenberg**

BIIS: British ice sheet
SIS: Scandinavian ice sheet

Prud'homme et al., in prep

Summary

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- Radiocarbon dating on ECG and age-depth modelling — High temporal resolution for the Last Glacial period
- **δ^{18}O and δ^{13}C of ECG** — First quantification of past summer temperature and mean annual precipitation
- Reinforcement of the characterisation of the interstadials palaeoenvironment and climate variations by studying a new proxy available in loess environment