

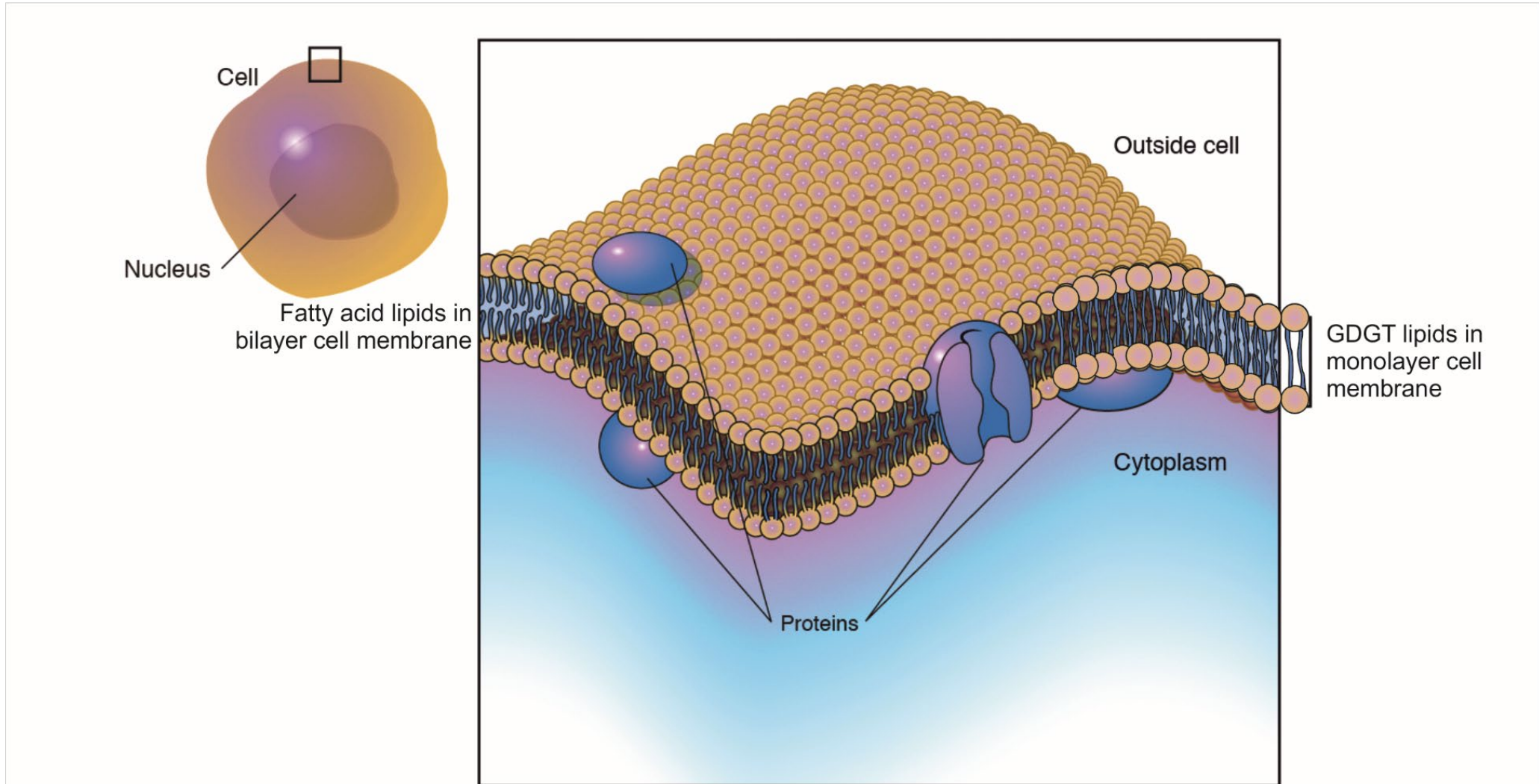
New avenues for brGDGTs: Using biomarker lipids to reconstruct soil fertility through time

Prof. Dr. Cindy De Jonge
Earth Ecosystem Dynamics –
ETH Zurich

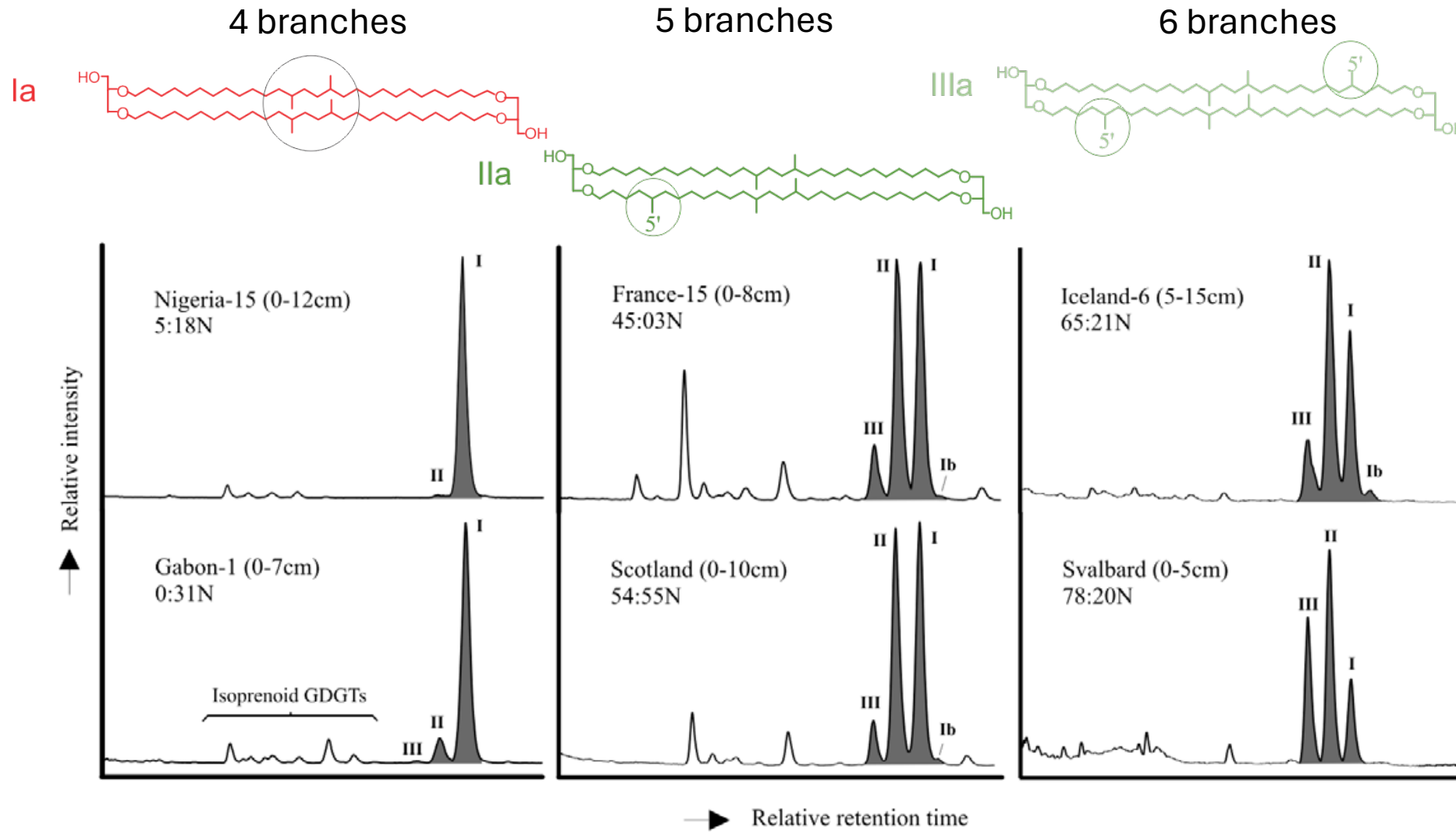
17.04.2024, EGU24, Vienna, Austria

Co-authors: Jingjing Guo, Petter Hallberg, Marco
Griepentrog, Rienk Smittenberg, Francien Peterse,
Pascal Boeckx, Gerd Dercon

BrGDGTs: membrane spanning lipids that can be conserved on long timescales (millions of years).



BrGDGTs reflect production temperature



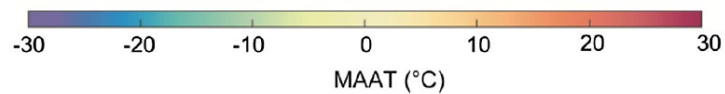
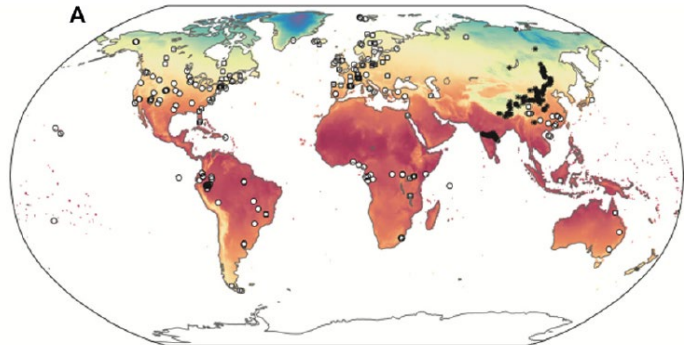
Weijers et al. (2007)

BrGDGTs reflect production temperature

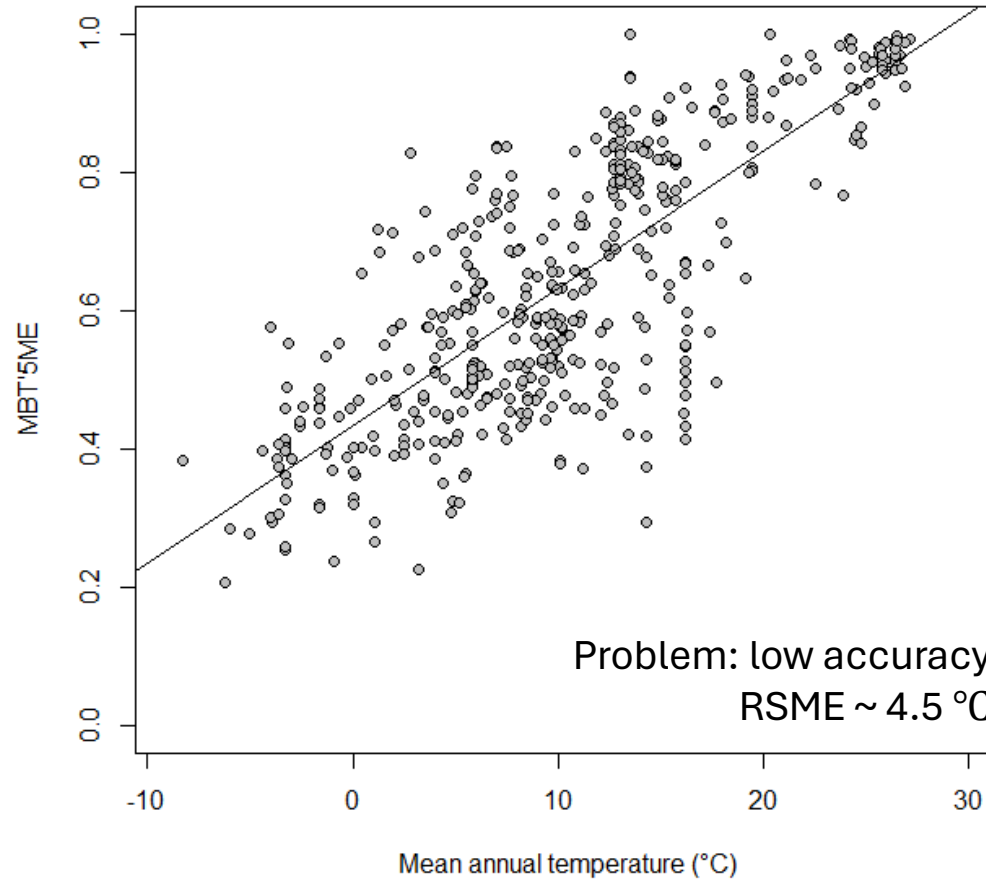
$$\text{MBT}'_{5\text{ME}} =$$

$$\frac{\text{Ia}}{\text{Ia} + \text{IIa} + \text{IIIa}}$$

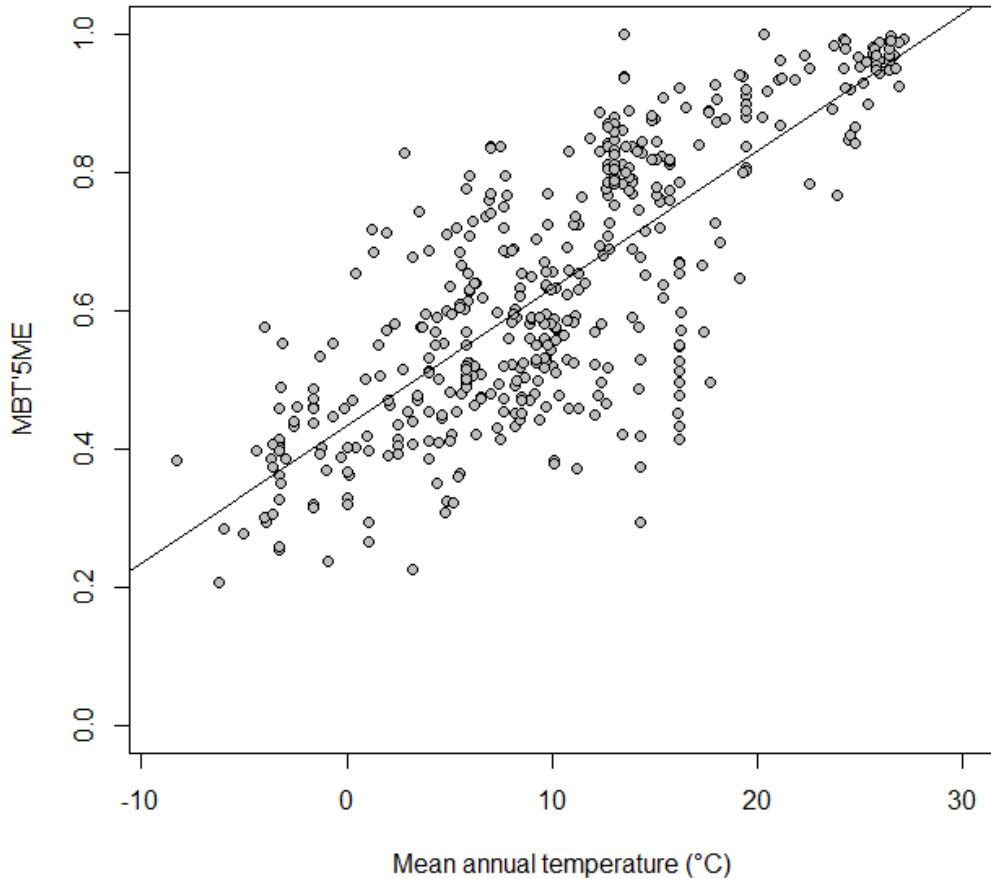
De Jonge et al. (2014)
Global scale calibration



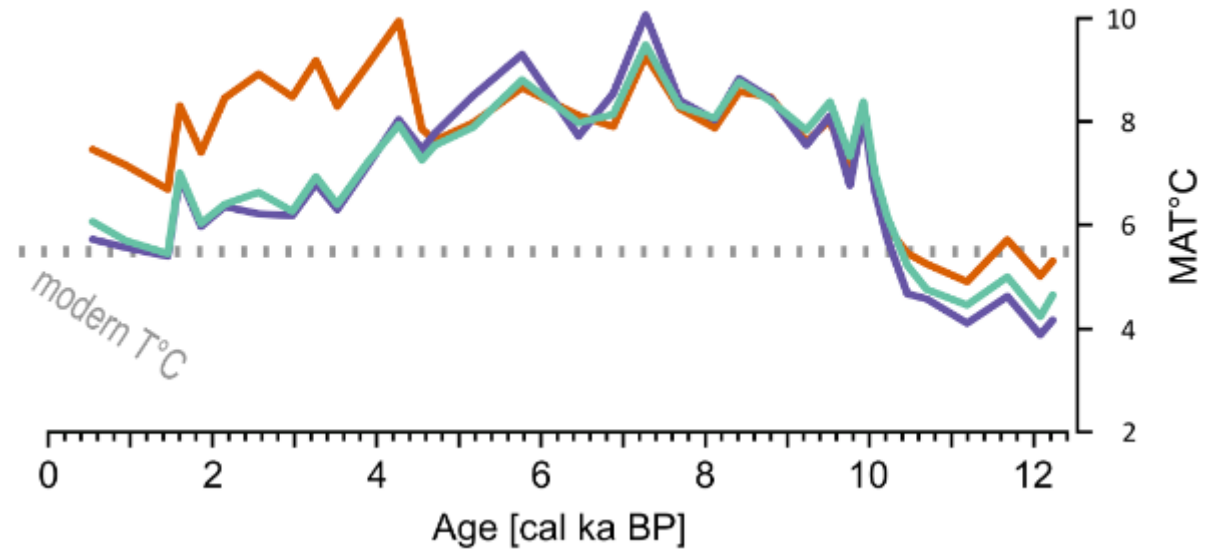
Dearing Crampton-Flood et al. (2020)



BrGDGTs reflect production temperature

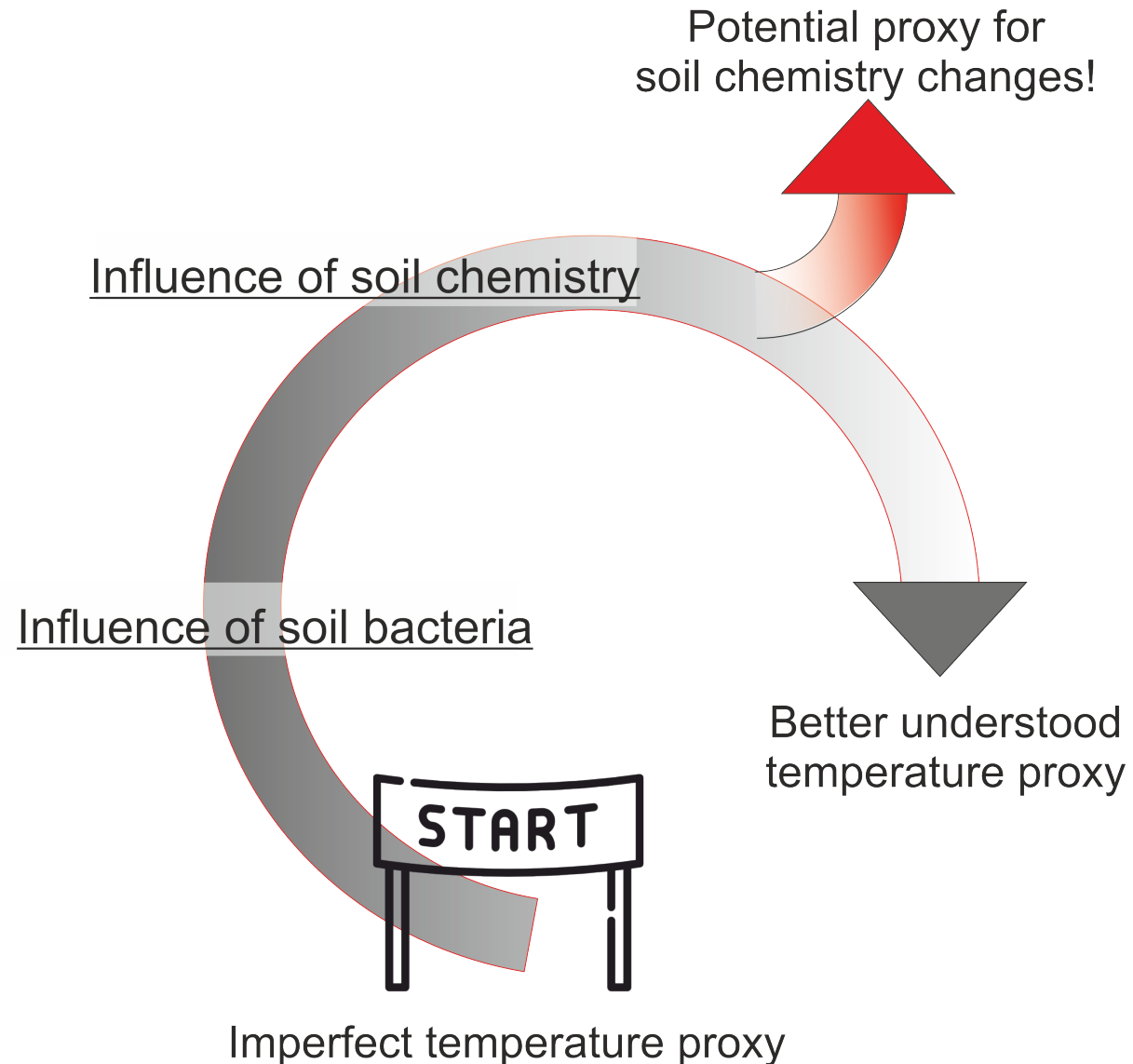


In well-dated geological archives: proxy for past temperature



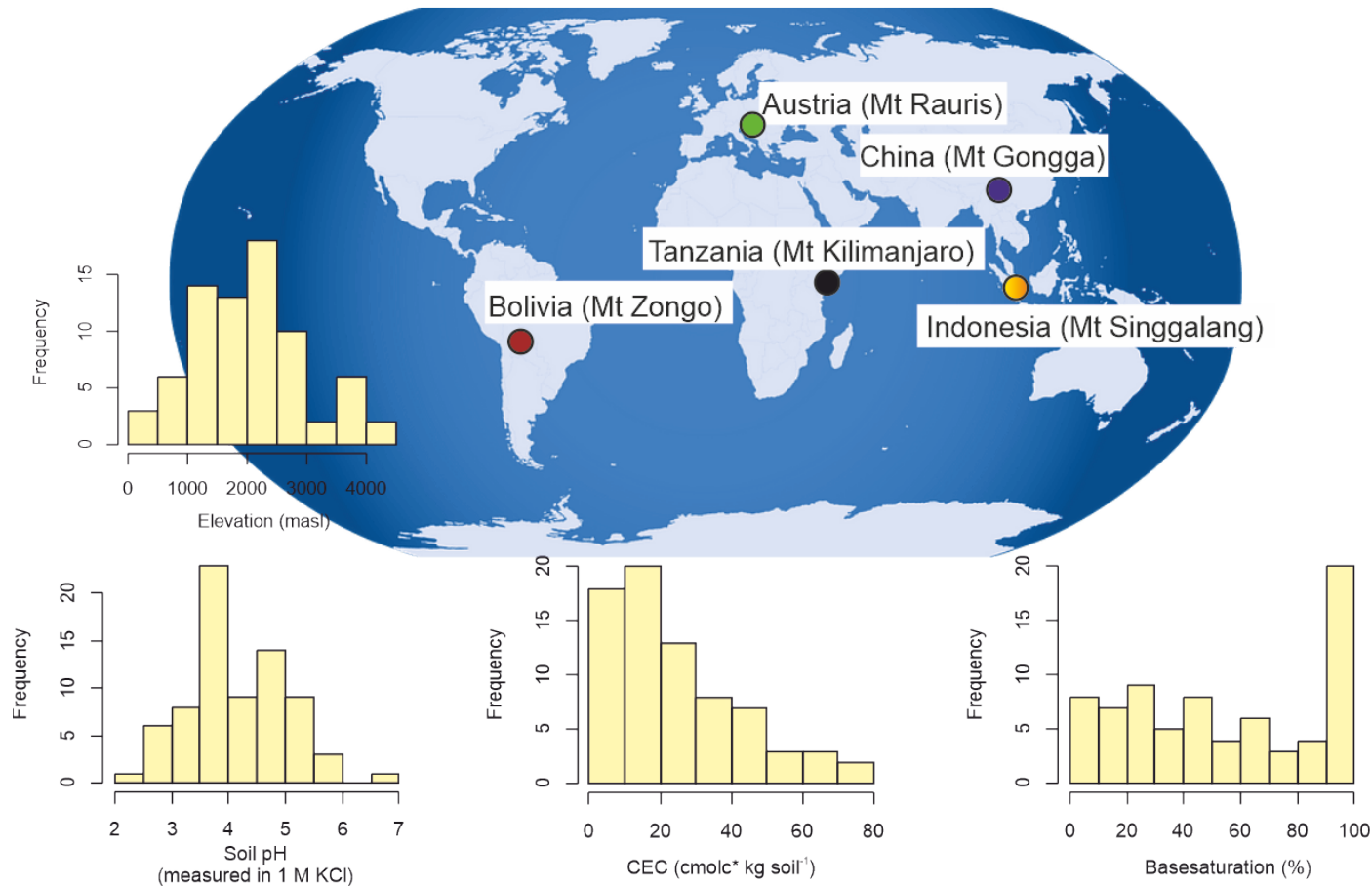
Bittner et al., (2022)

Summarizing 10 years of work in 8 minutes...



BrGDGTs as proxies for soil chemistry?

5 globally distributed elevation transects



Production of temperature-sensitive brGDGTs

$$\text{MBT}'_{5\text{ME}} = \frac{\text{Ia} + \text{Ib} + \text{Ic}}{\text{Ia} + \text{Ib} + \text{Ic} + \text{IIa} + \text{IIb} + \text{IIc} + \text{IIIa}}$$

Concentration/ g soil

- Area ~ r = 1
- Negative corr.
- Positive corr.

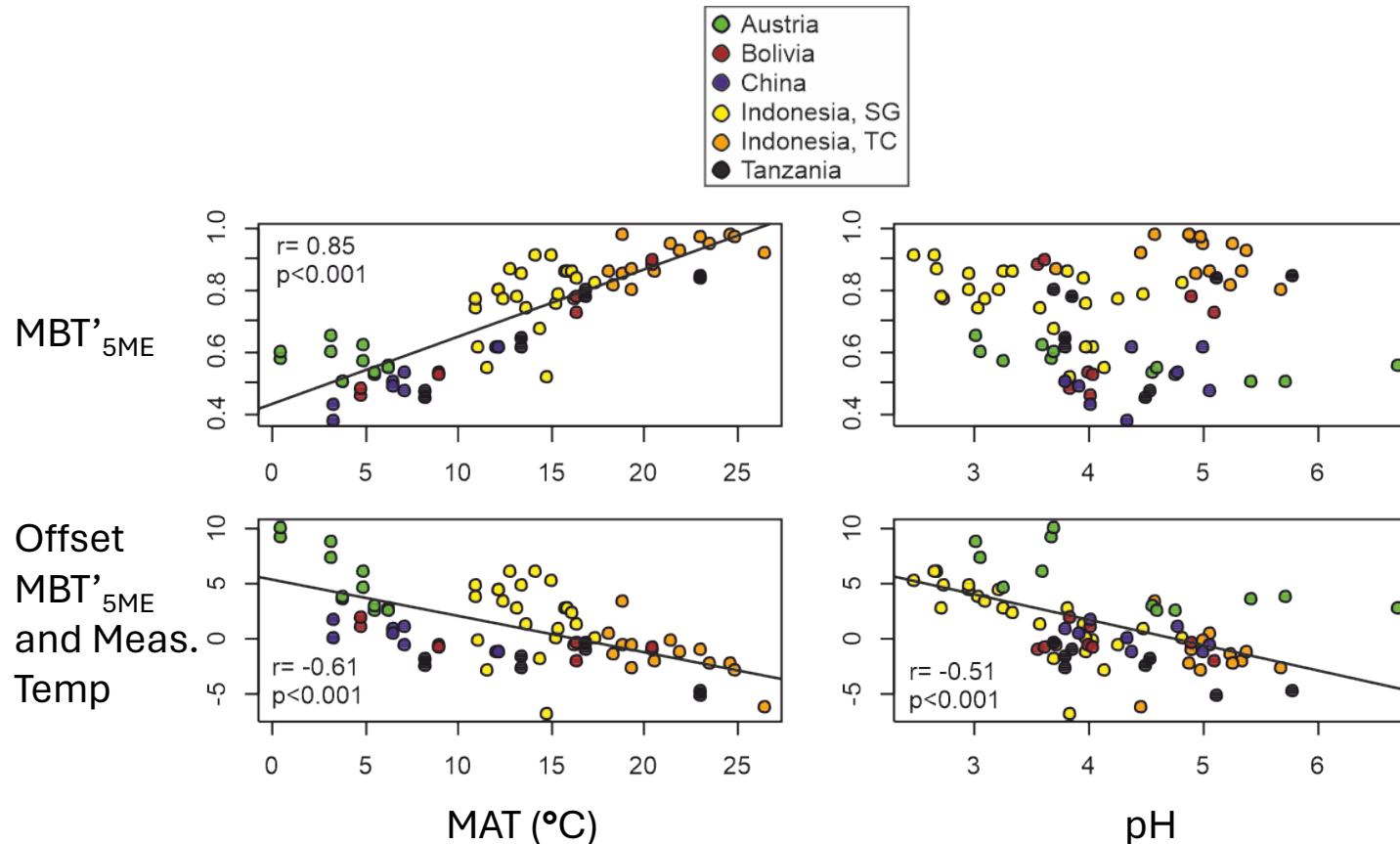
	Ia	IIa	IIIa
Temperature (°C)		●	●
Precipitation/ Evaporation			
pH	●	●	
Total Nitrogen (%)	●	●	
H ⁺ (cmol/g soil)	●	●	
Σbases			
ΣMetals	●		



Not all temperature sensitive brGDGTs respond to temperature.

‘Warm compound’ Ia is a chemistry driven compound!

MBT'_{5ME} offset in low pH soils



pH effect on the MBT'_{5ME}, with large warm offset in low pH soils.

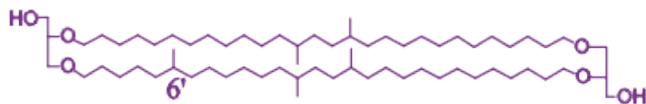
Which other brGDGTs are influenced by soil chemistry?

6-methyl brGDGTs increase with exchangeable bases concentration



Environmental driver of 6-methyl brGDGT IIa' is exchangeable calcium!

IIa'
m/z 1036



Concentration/ g soil

○ Area ~ r = 1
● Negative corr.
● Positive corr.

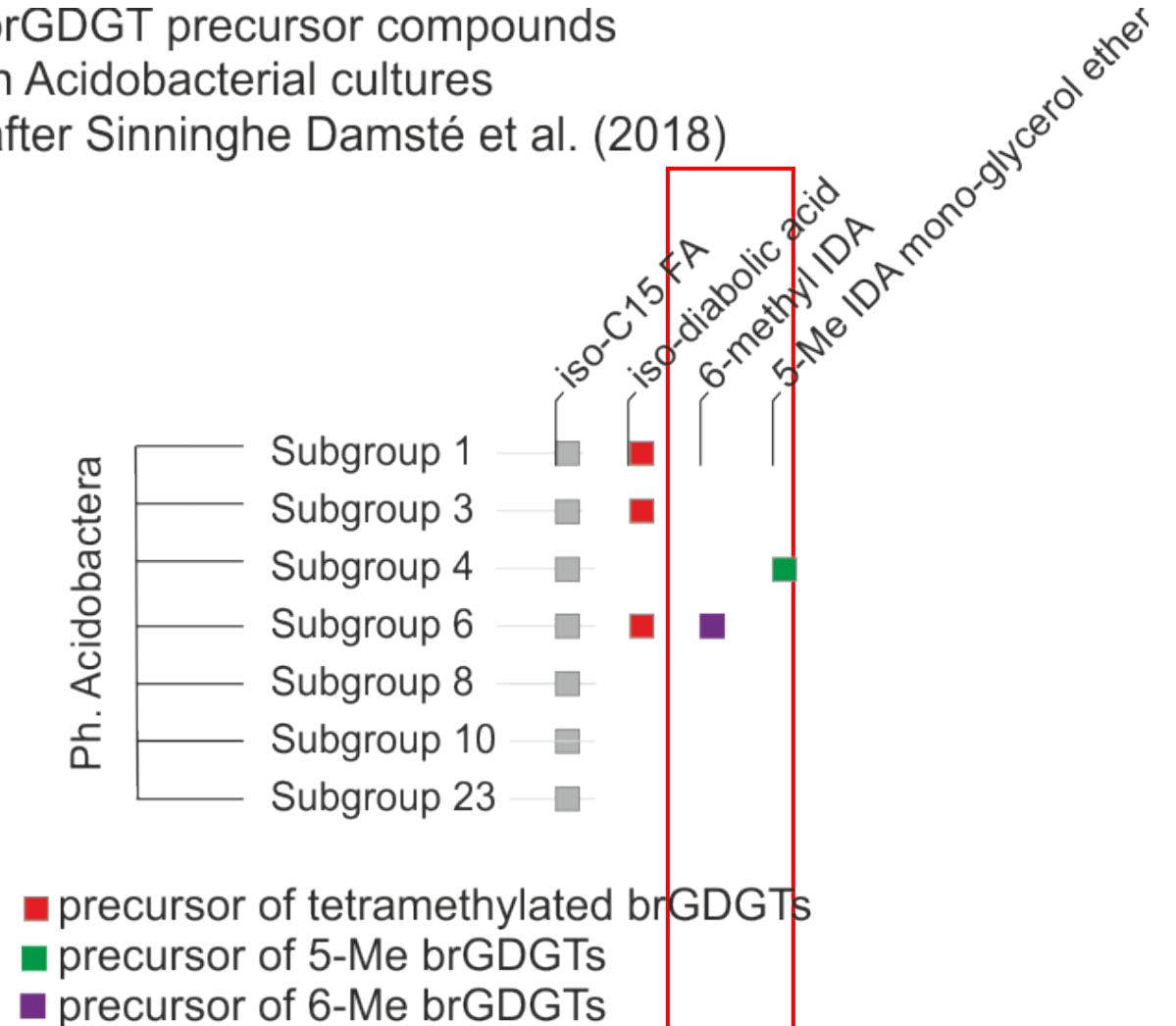
	Ia	IIa	IIIa	IIa'	IIIa'
Temperature (°C)		●	●		
Precipitation/ Evaporation					
pH	●	●		●	
Total Nitrogen (%)	●	●			
H ⁺ (cmol/g soil)	●	●			
Σbases				●	
ΣMetals	●				

Mechanism for brGDGT increase with exchangeable bases



Mechanism =
Increase of
Acidobacteria
Subgroup 6.

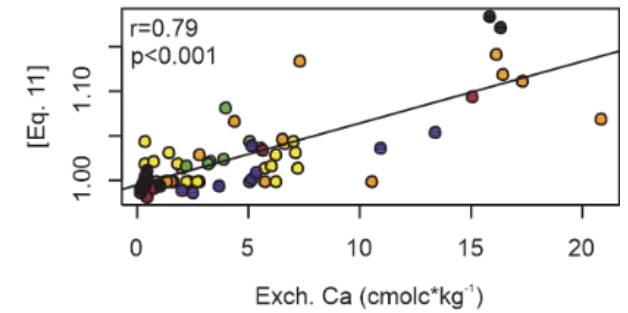
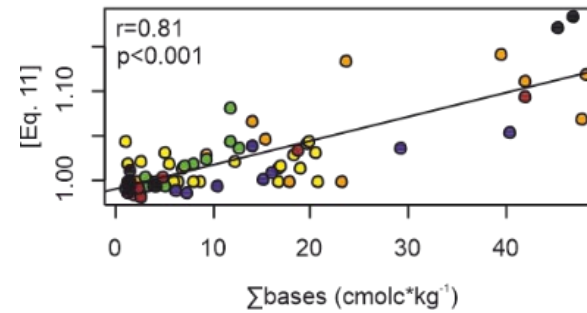
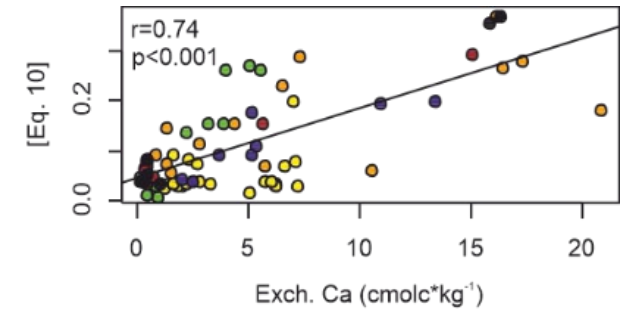
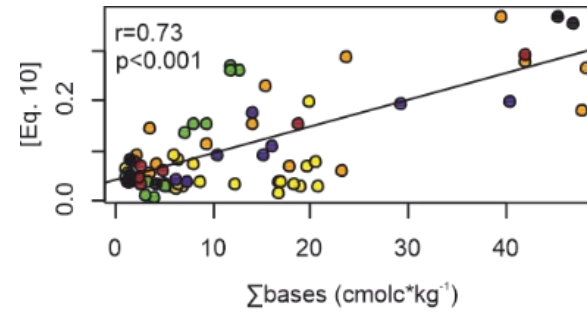
brGDGT precursor compounds
in Acidobacterial cultures
after Sinninghe Damsté et al. (2018)



GDGT calibration to reconstruct concentration of exch. bases



Developed calibration
between
brGDGT ratio and
exch. Ca^{2+} or
 Σbases



Biogeochemistry
<https://doi.org/10.1007/s10533-017-0410-1>



SYNTHESIS AND EMERGING IDEAS

Calcium-mediated stabilisation of soil organic carbon

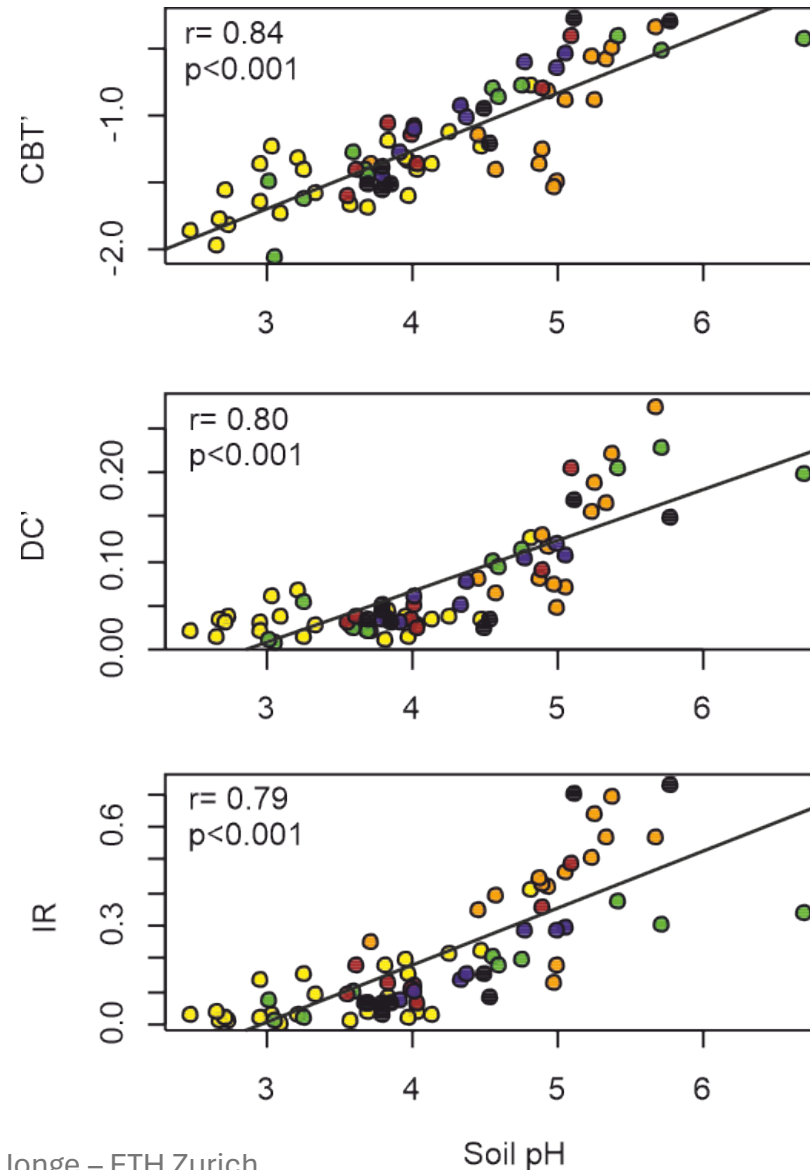
Mike C. Rowley · Stéphanie Grand · Éric P. Verrecchia

Previous ratios had been calibrated against pH



Impact of soil pH

Previously established
pH proxies based on
alkaline-promoted
brGDGTs

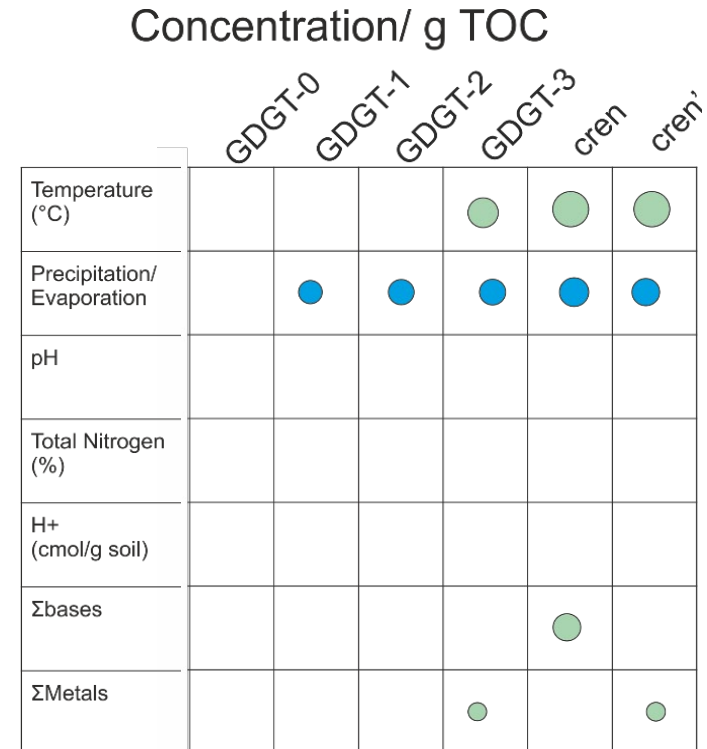


Archaeal GDGT increases with exchangeable iron concentration

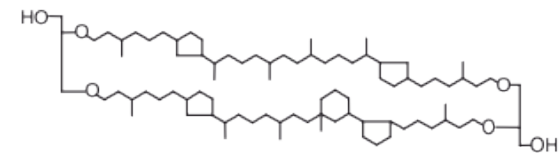


Exchangeable soil
metals

Archaeal lipid
Crenarchaeol isomer
increases



Crenarchaeol
m/z 1292

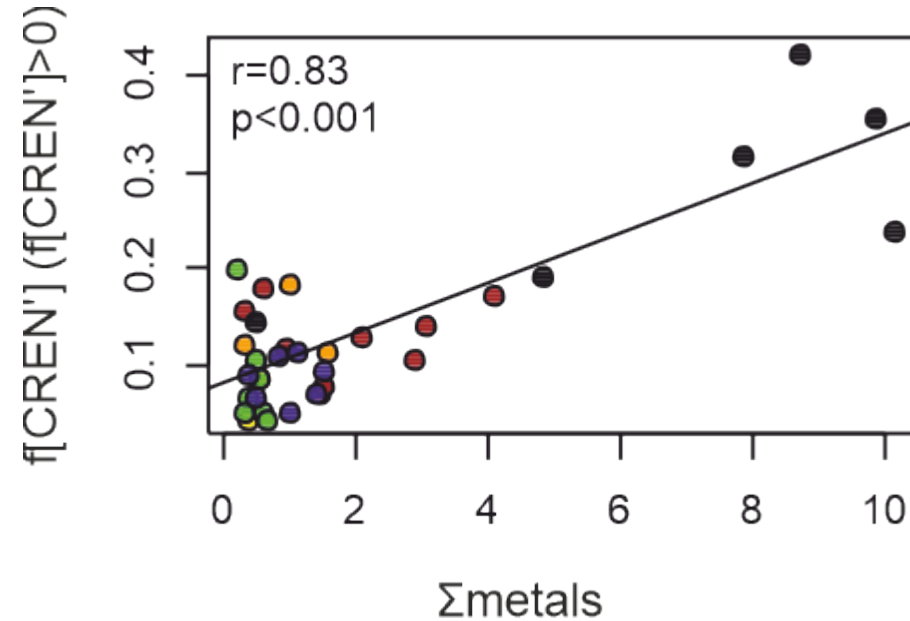


GDGT calibration to reconstruct concentration of exch. metals



Propose a tracer for exchangeable Fe.

Mechanism not known!



SPECIAL SECTION: STABILITY OF MINERAL-ORGANIC MATTER ASSOCIATIONS UNDER VARYING BIOGEOCHEMICAL CONDITIONS

What do relationships between extractable metals and soil organic carbon concentrations mean?

Steven J. Hall¹ | Aaron Thompson²

Potential! Reconstruct past changes in exchangeable Ca^{2+} , pH and exchangeable Fe^{3+} .



Soils as a
geo-archive



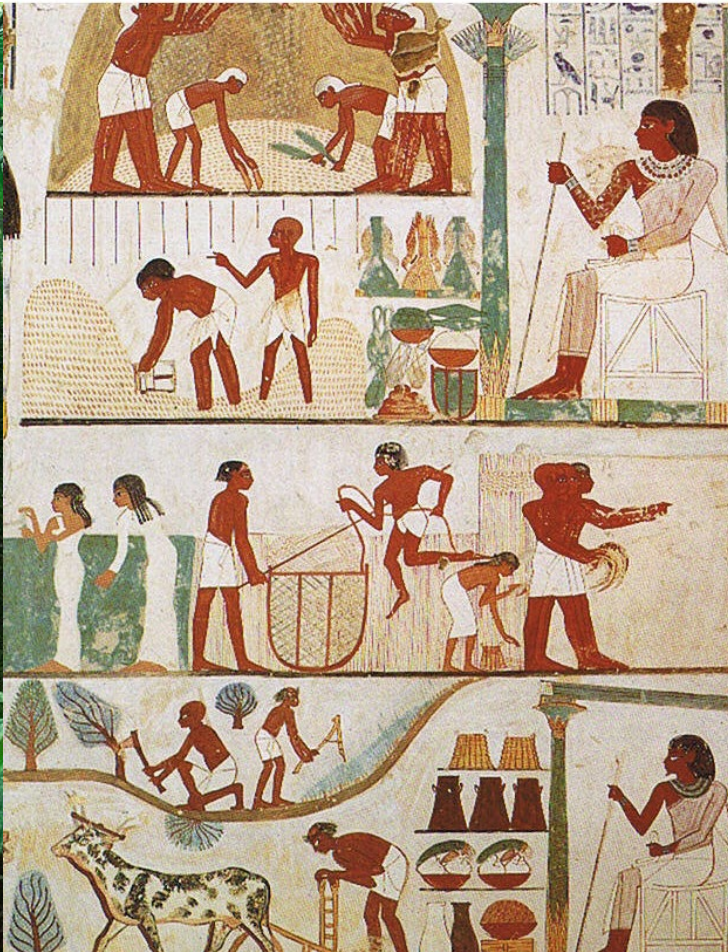
Lausanne (CH)
Van der Voort et al. (2017)
Van der Voort (*pers. comm.*)
Gies et al. (2020)

Potential! Reconstruct past changes in exchangeable Ca^{2+} , pH and exchangeable Fe^{3+} .

- Evolution of ecosystems

- Archeological

- Carbon cycle



Thank you!

Funding agencies:

NOW (NL)
BOF (Flanders)
ERC
SNSF

Universities:

Royal NIOZ (NL)
(BGC)
Antwerp University (BE)
(PLECO)
ETH Zurich
(Geological Institute)

Colleagues and co-authors (soils):

Jaap S. Damste
Ellen Hopmans
Stefan Schouten
Alina Stadnitskaia
Francien Peterse
Dajana Radujcovic
Ivan Janssens
James Weedon
Eiko Kuramae
Ivan Nijs
Jingjing Guo
Petter Hallberg
Rienk Smittenberg
Robin Halfman
Andreas Richter
Pascal Boeckx
Gerd Dercon