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Stable oxygen isotopes in tree rings: a climate archive

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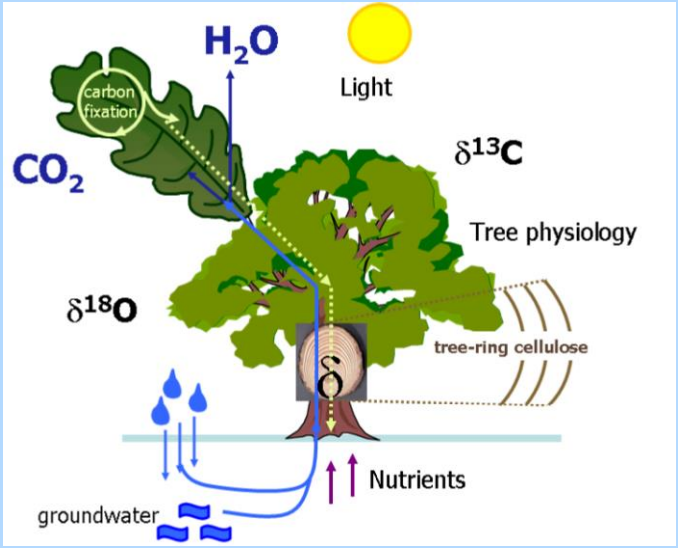
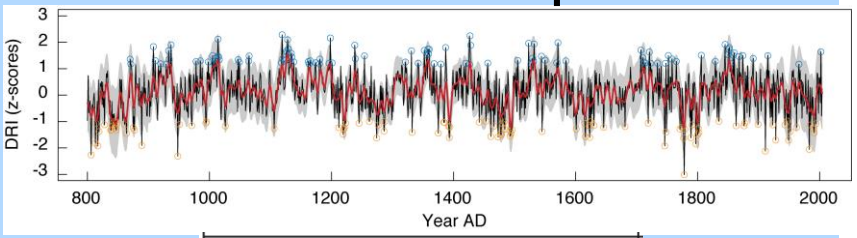
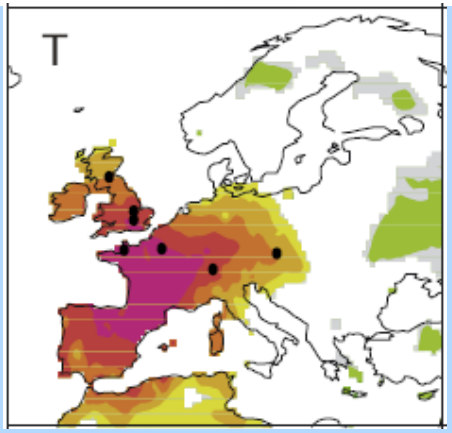
Process-oriented analysis



Climate reconstruction based on isotopes

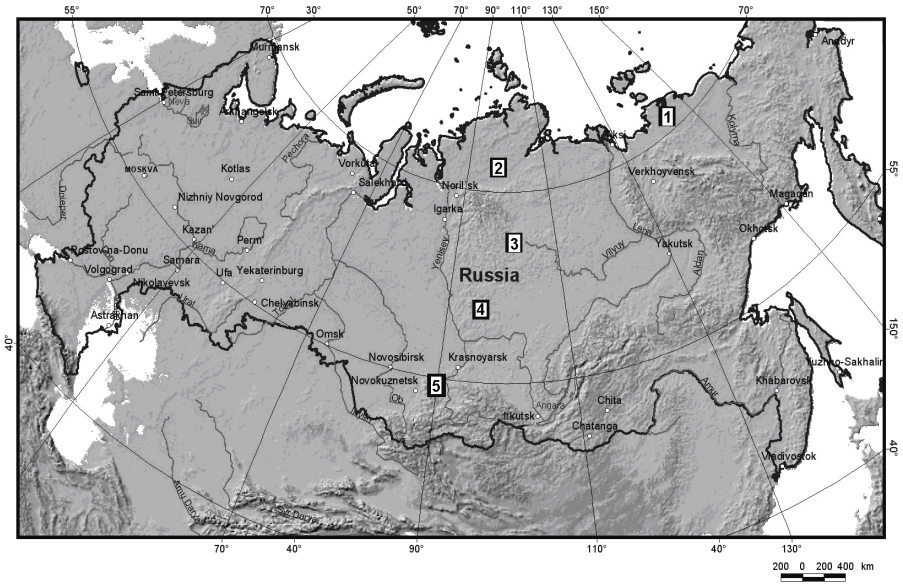




- High temporal resolution (seasonal)
- isotopes in many compartments
- Detailed microclimatic measurements
- Few sites
- isotope fractionation model

- Low temporal resolution (annual)
- isotopes in tree-rings
- monthly climate data from distant weather station
- Many sites
- statisitical analysis

Studies in Siberia



Institute of Forest, Krasnoyarsk

(1) Northeastern Yakutia (YAK) (Hughes *et al*., 1999; Sidorova *et al*. 2008)
(2) Eastern Taimyr (TAY) (Naurzbaev *et al.* 2002; Sidorova *et al*. 2009)
(3) Tura (Knorre *et al*. 2006; Sidorova *et al*. 2009)
(4) Eniseysk (Knorre *et al*. in preparation)
(5) Khakasia (Knorre *et al*. 2009, in revision).

The photos of the studied sites made by M.M. Naurzbaev (1-2) and by A.V. Kirdyanov (3-5).

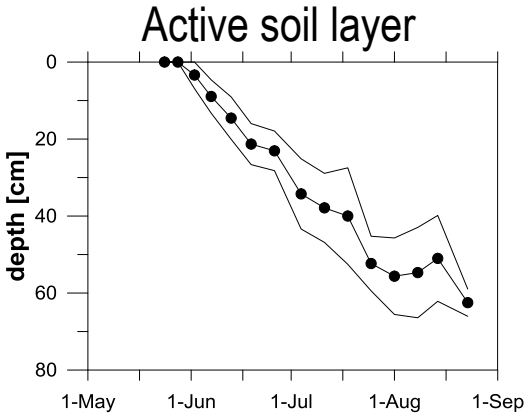
1)

2)

3)

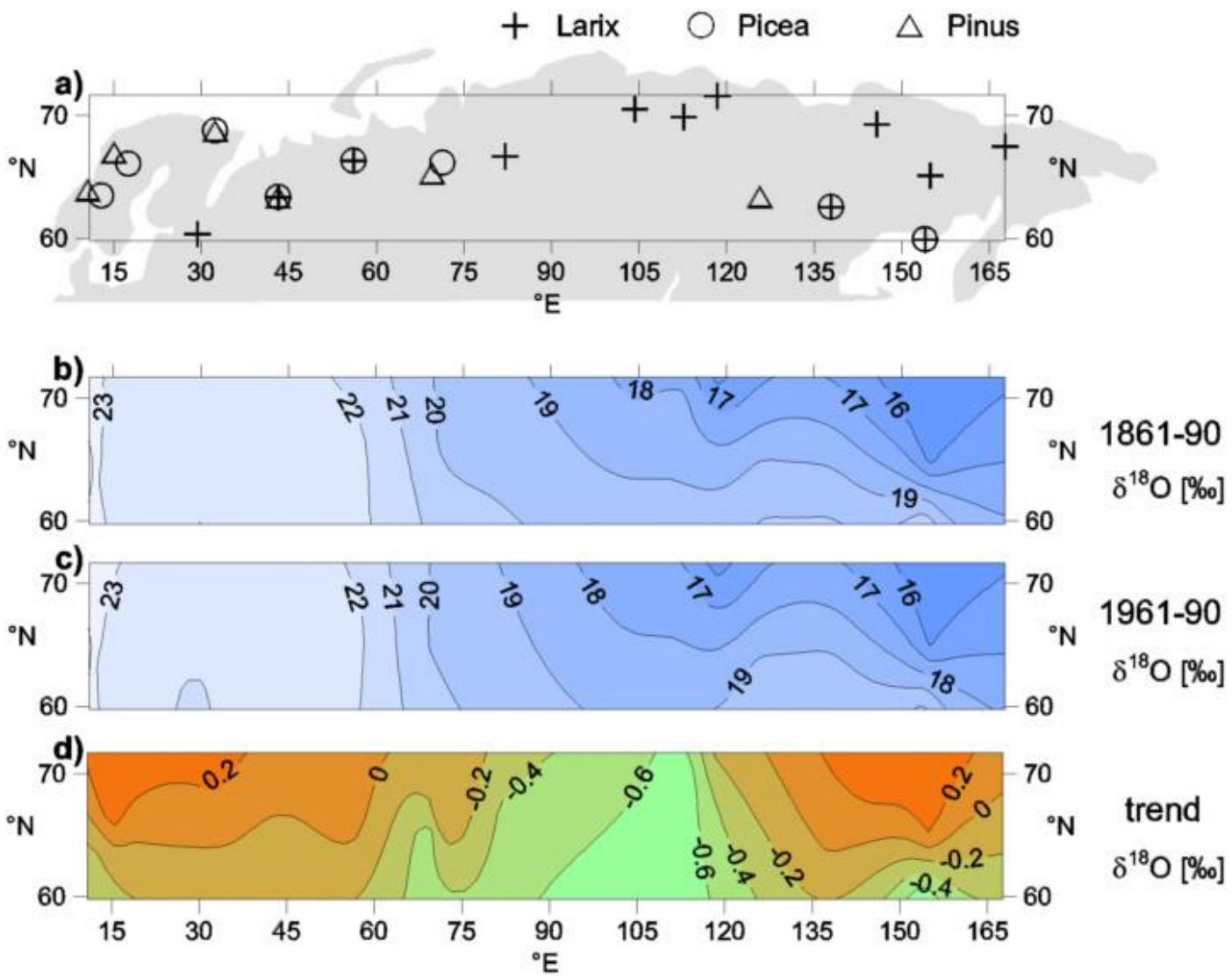
4)

5)

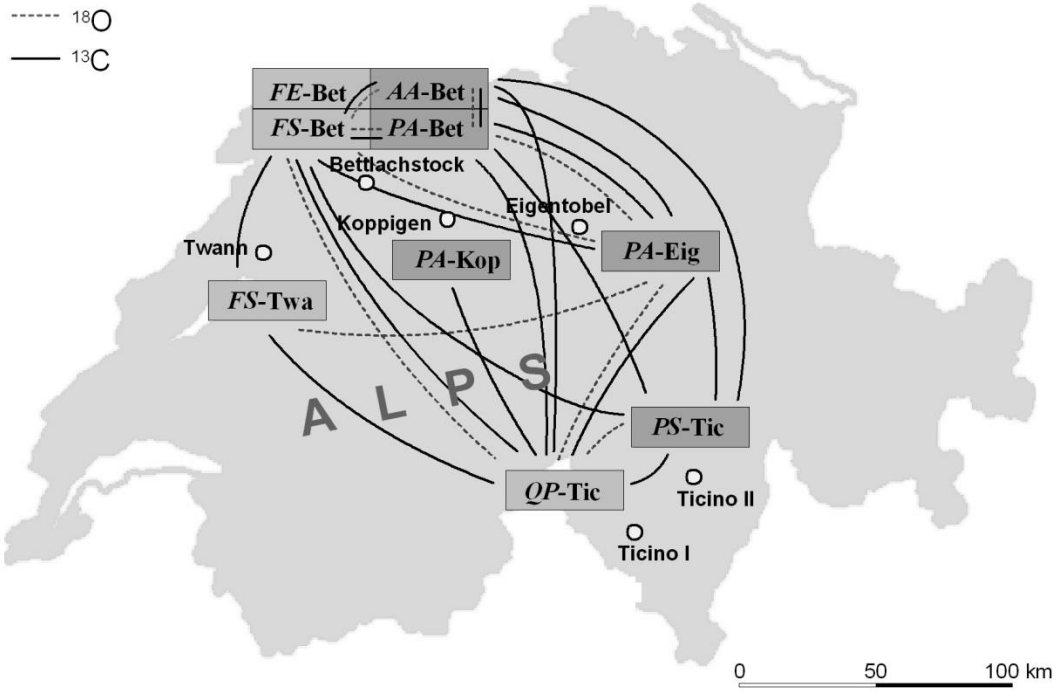
Tura: 64°N, 100°E; highly continental, mean annual air temperature of -9.2°C; annual precipitation of only 317 mm

Studies in Northern Eurasia



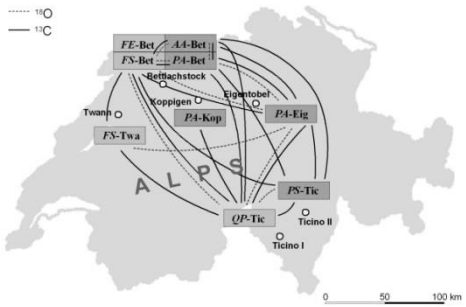
Saurer et al. GRL 2002

Comparison between species and sites

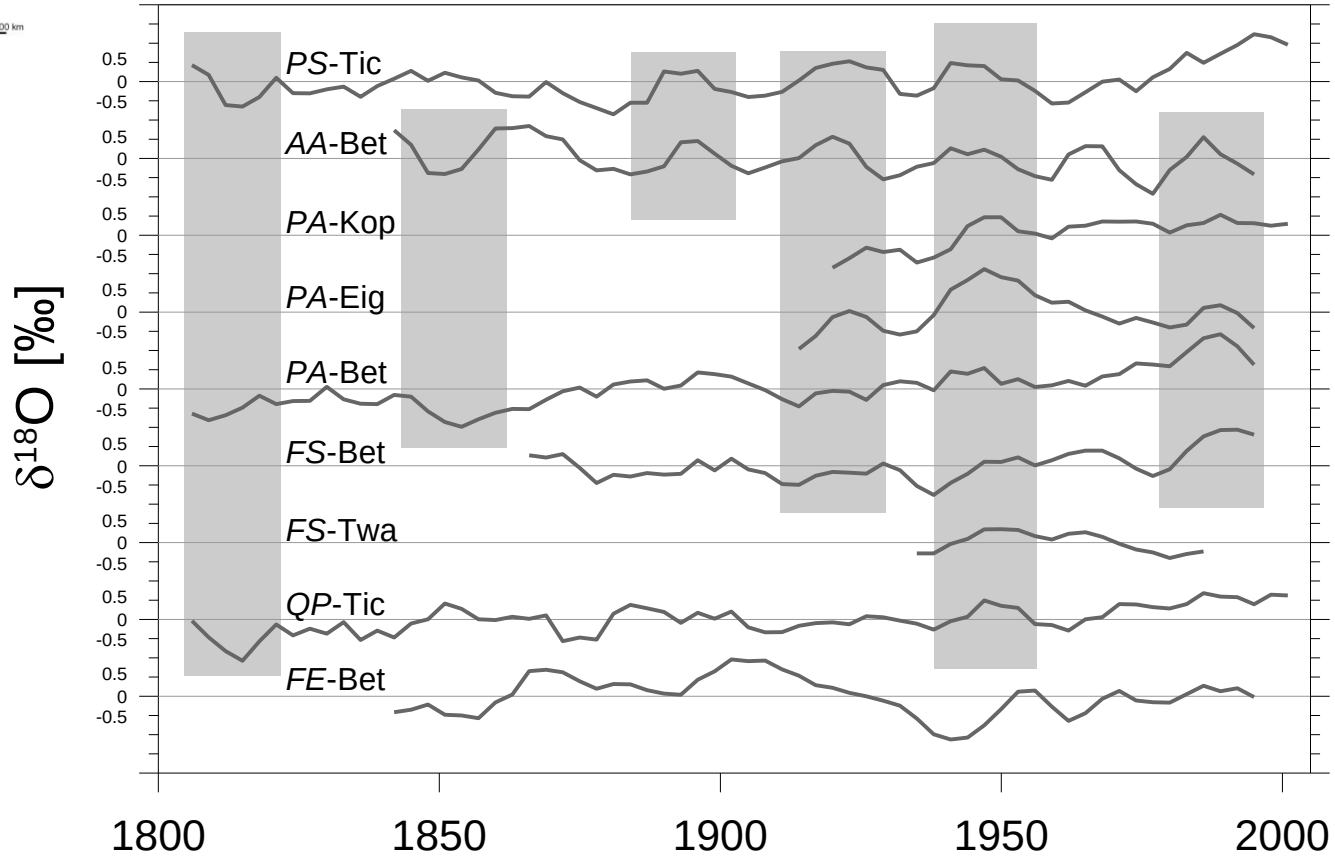


Picea abies
Pinus sylvestris
Abies alba
Fagus sylvatica
Fraxinus Excelsior
Quercus petraea

Saurer et al., JGR, 2008



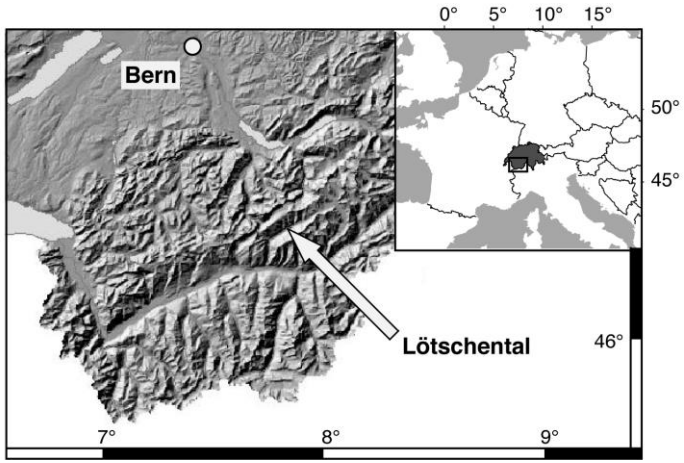
Tree-ring $\delta^{18}O$ chronologies from different species and sites in Switzerland are quite similar in decadal scale variability



Saurer et al. 2008

Alpine site

Lötschental, Switzerland
Larix decidua

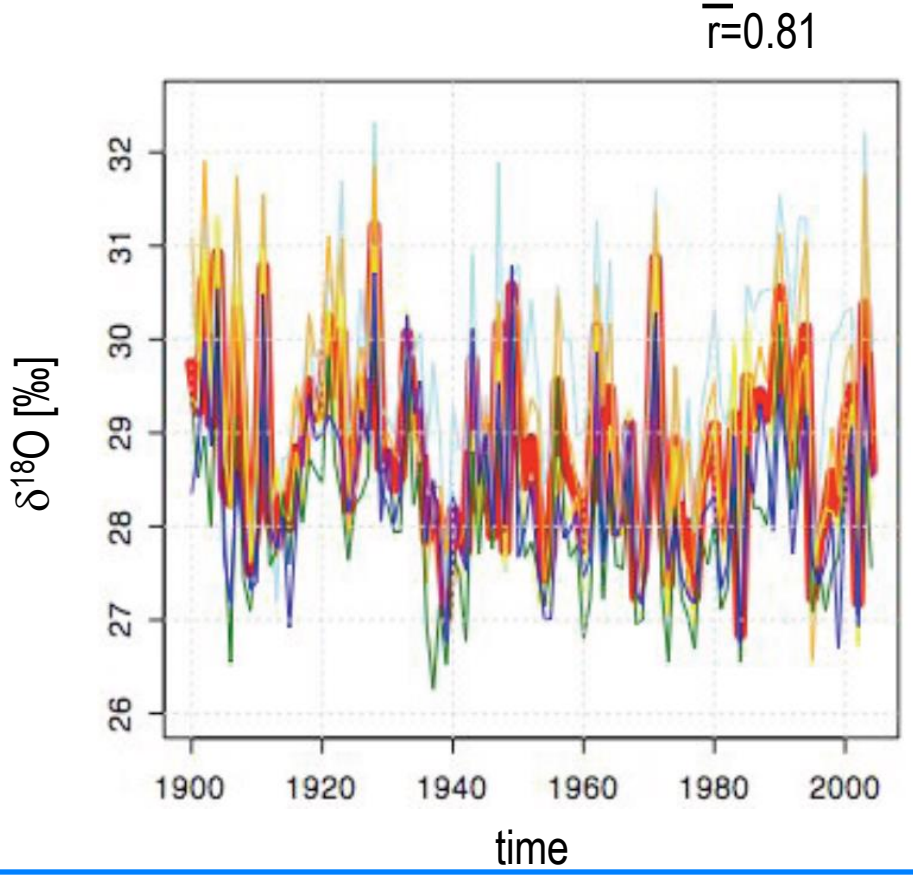


The problem/challenge:

Correlations between trees from one site often very strong

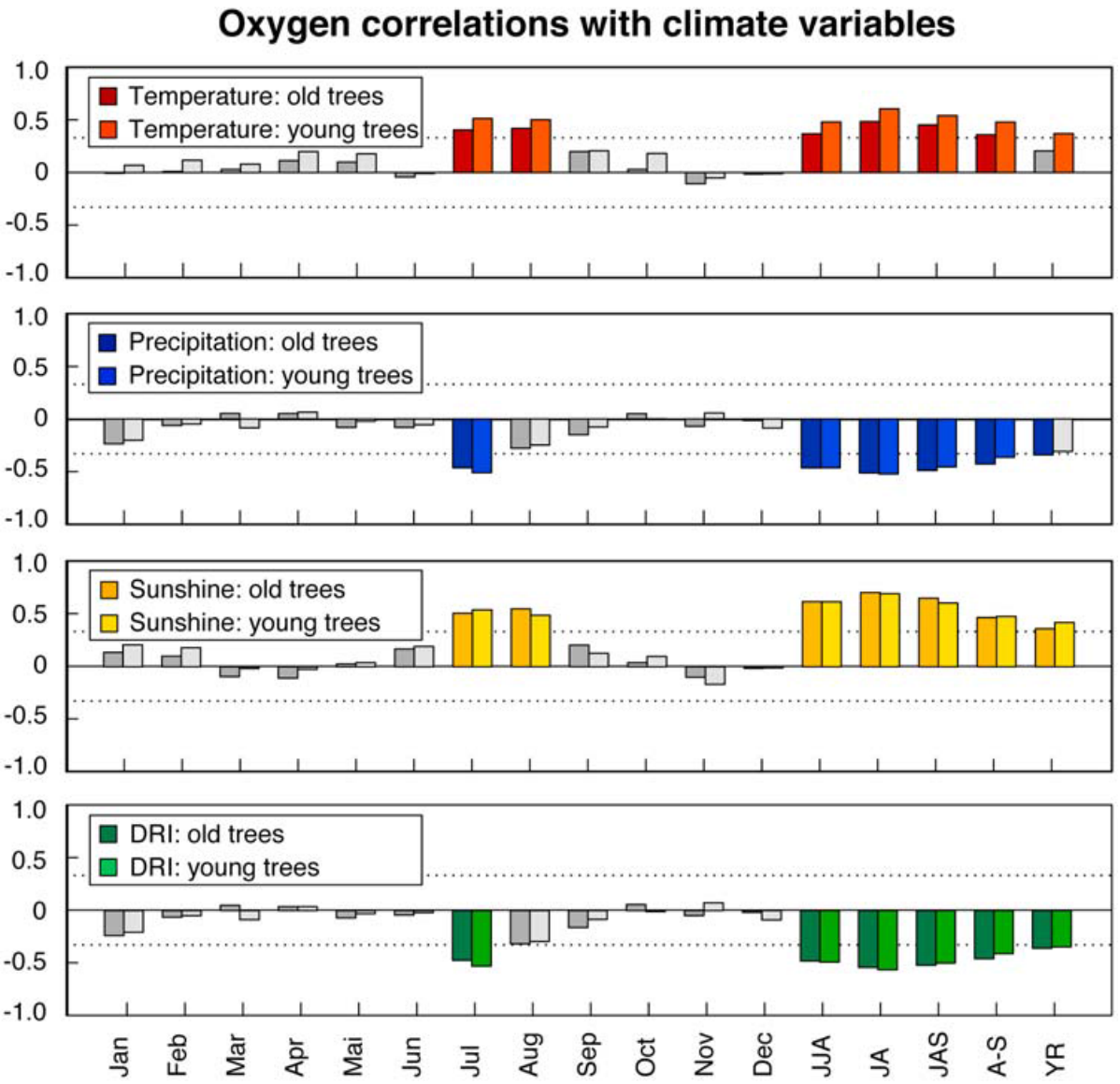
-> indicates common forcing

BUT climatic signal still not so clear



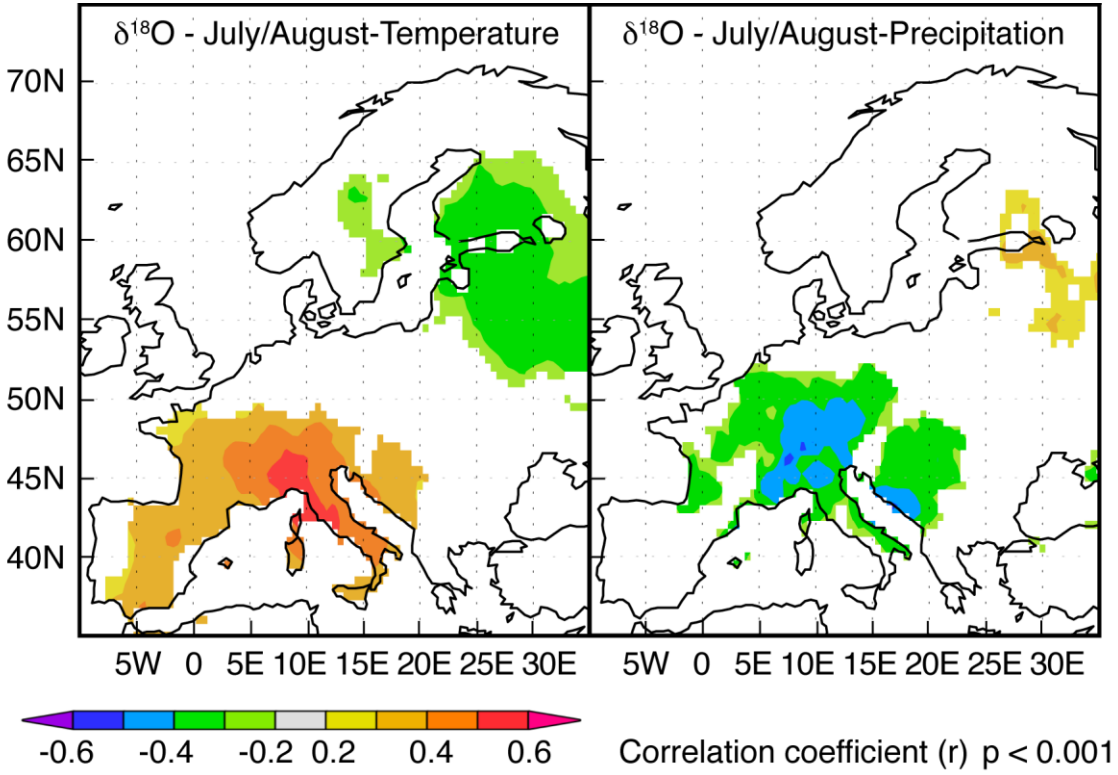
Single tree chronologies from an Alpine site (*Kress et al. 2009*)

Alpine site

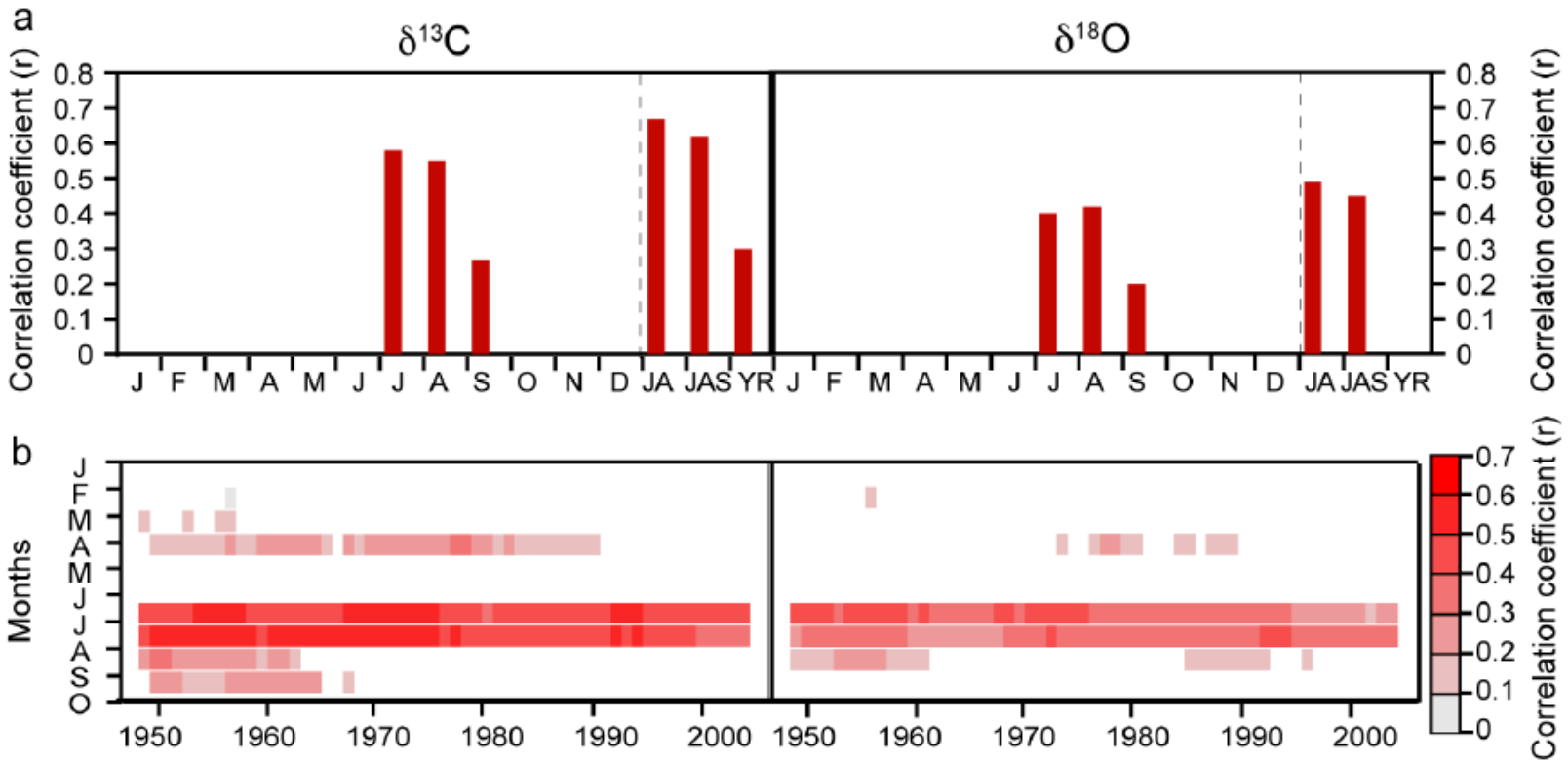


Kress et al., GBC 2010

Spatial extension of $\delta^{18}O$ signal

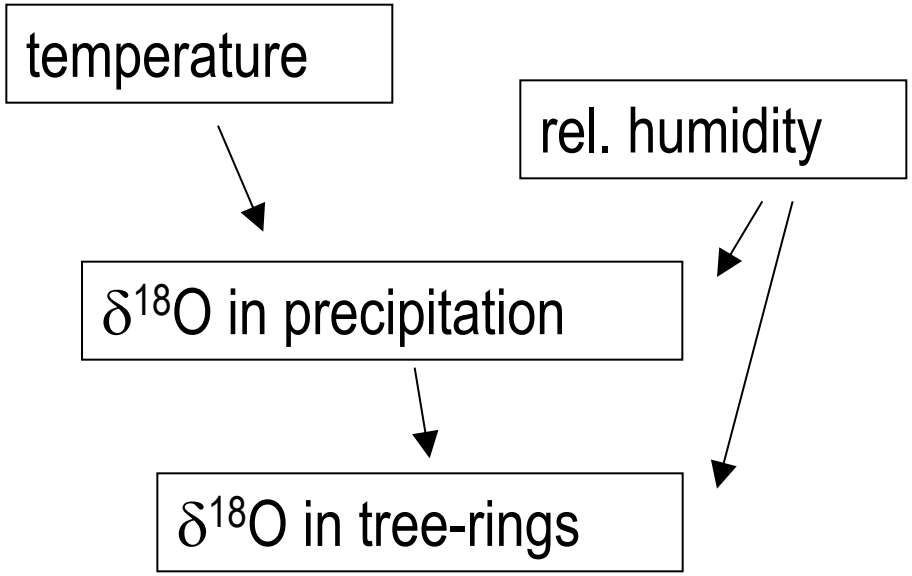


Correlations to temperature are lower for $\delta^{18}O$ compared to $\delta^{13}C$



Kress et al. 2009

What is the driving force for changes in $\delta^{18}O$?



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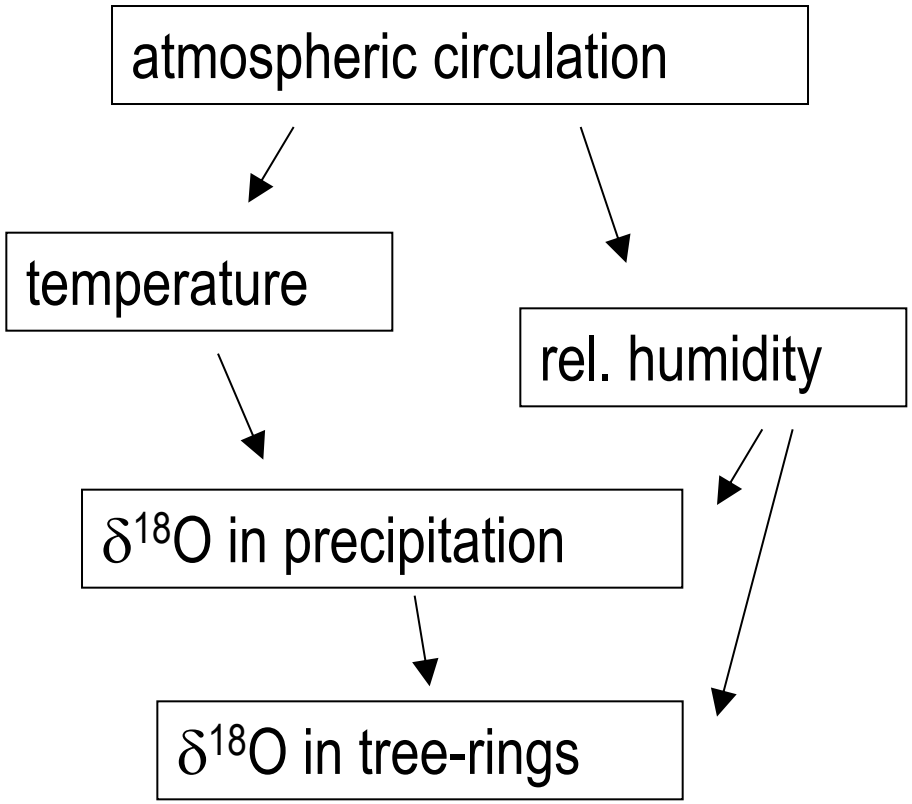
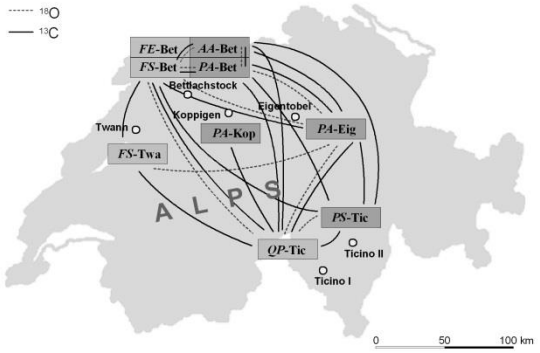


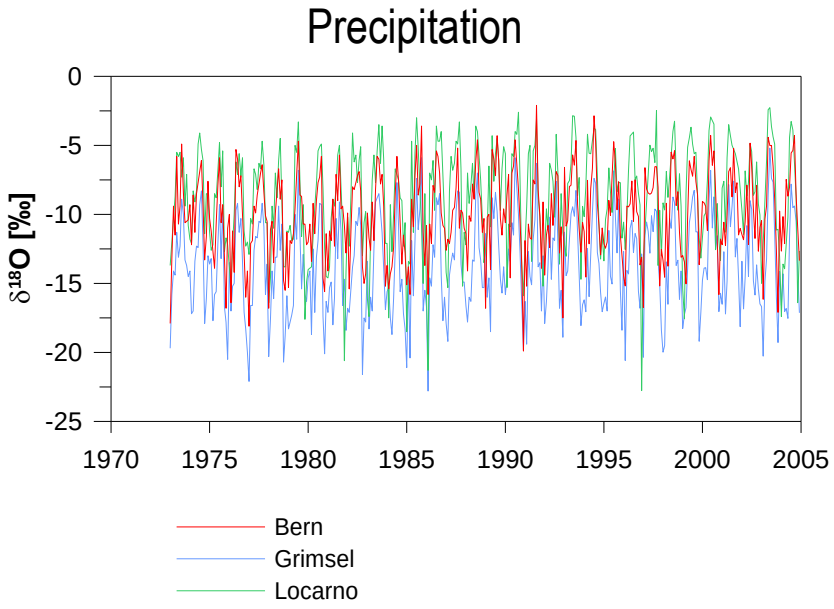


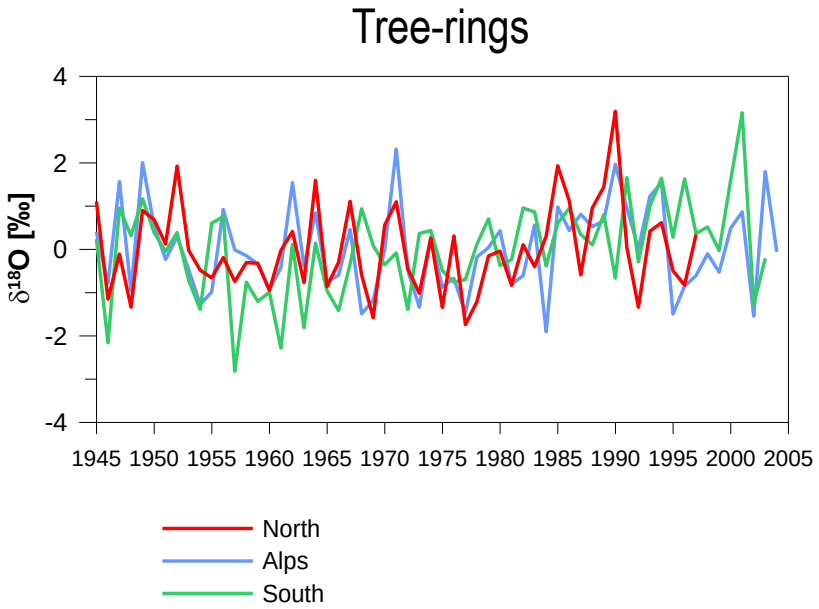
North

Alps

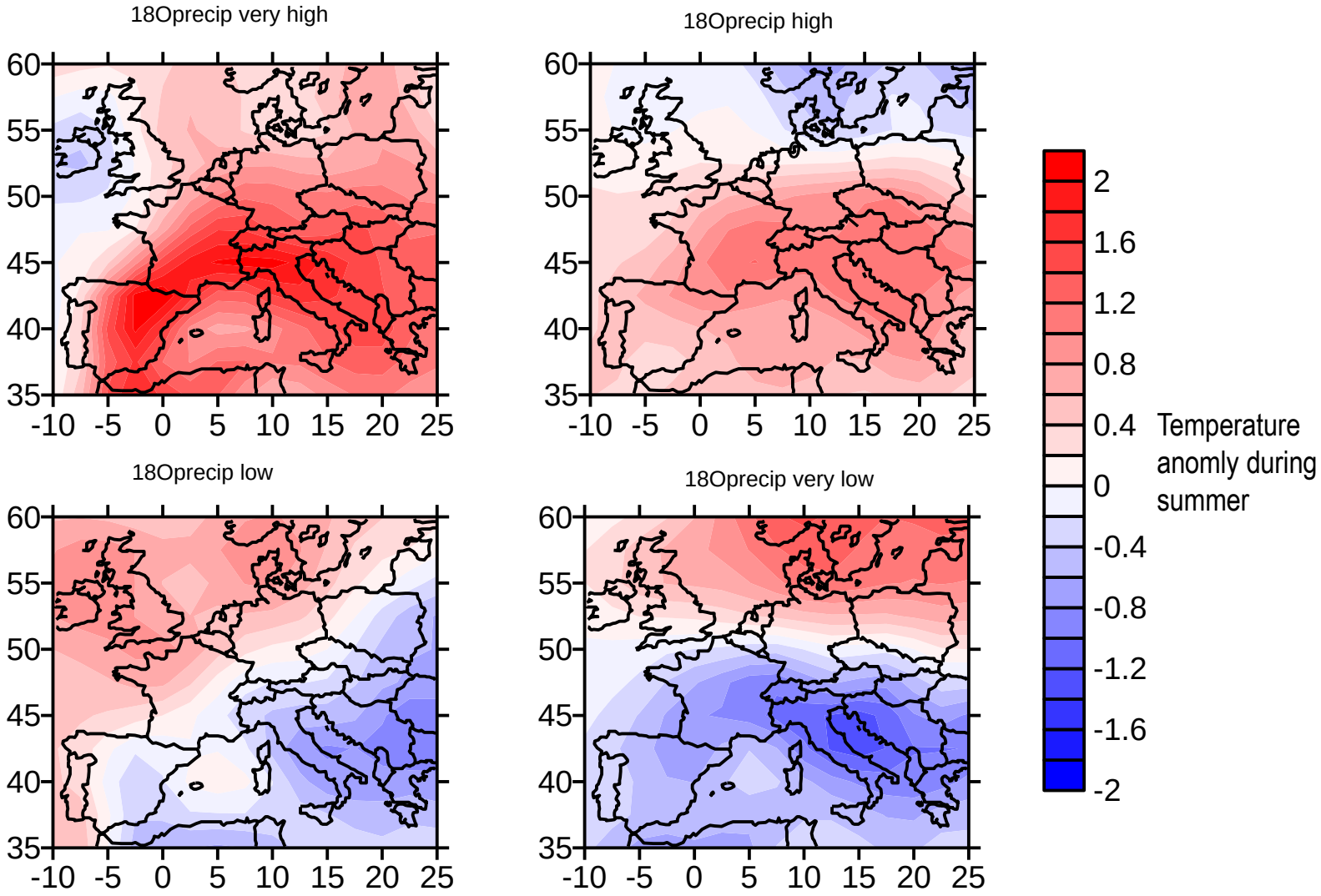
South

Tree-ring and precipitation $\delta^{18}O$ from Swiss sites

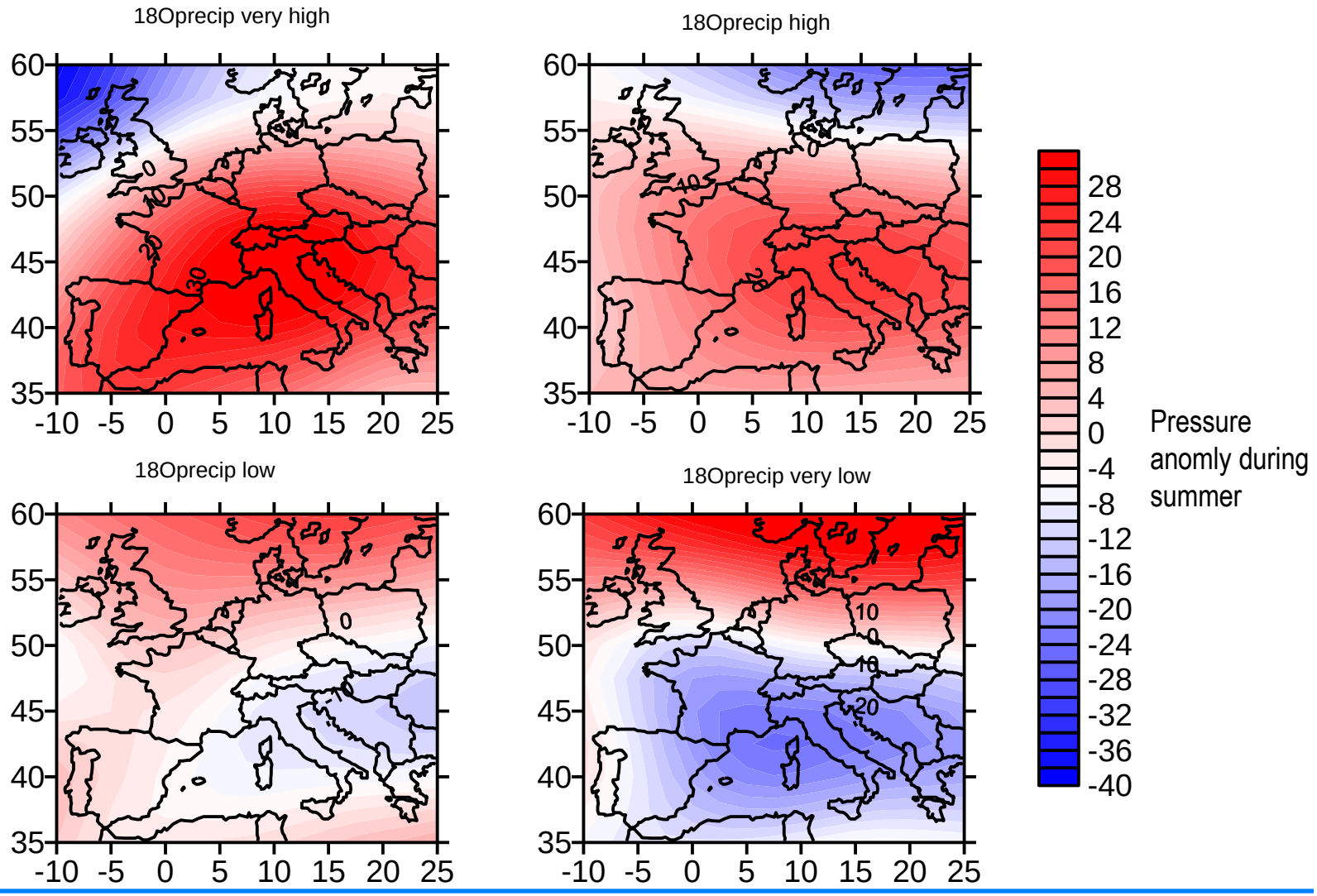


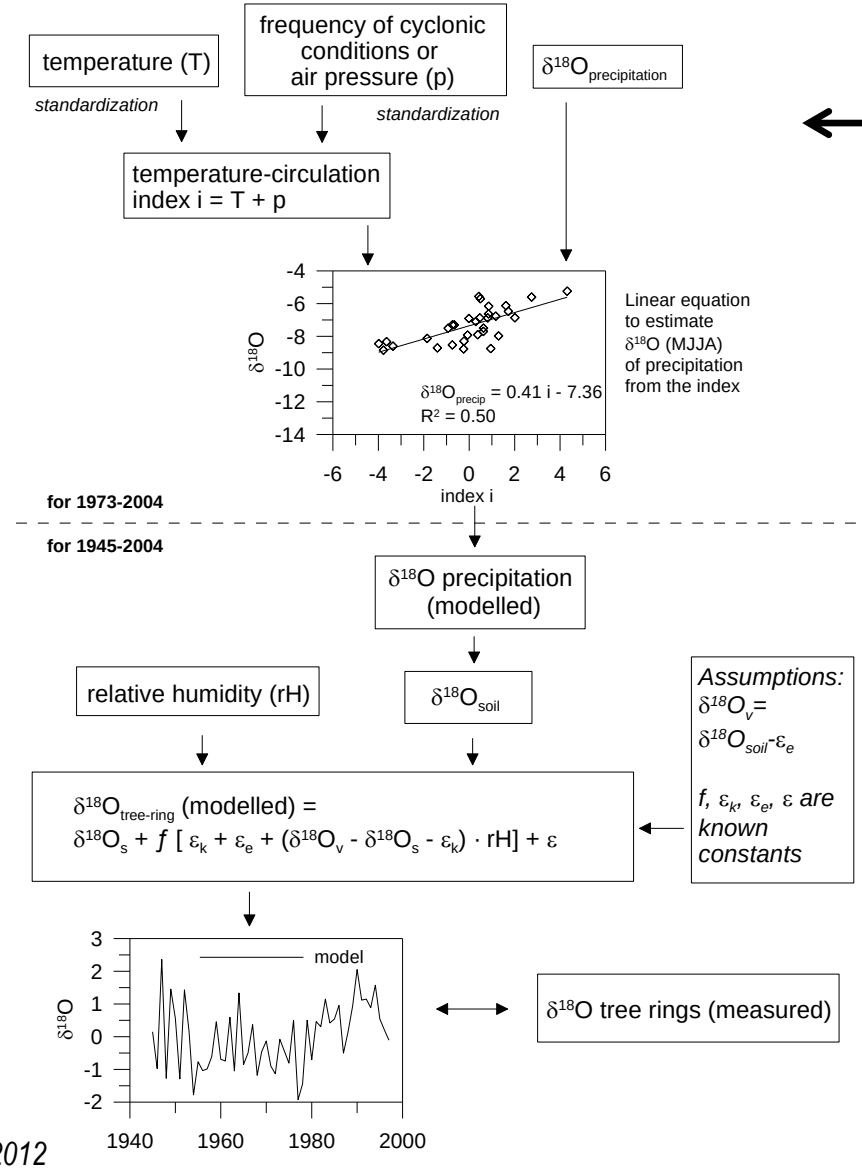


Temperature fields for classes of years with high or low $\delta^{18}O$ of precipitation



Geopotential height fields (500mbar) for years with high or low $\delta^{18}O$ of precipitation





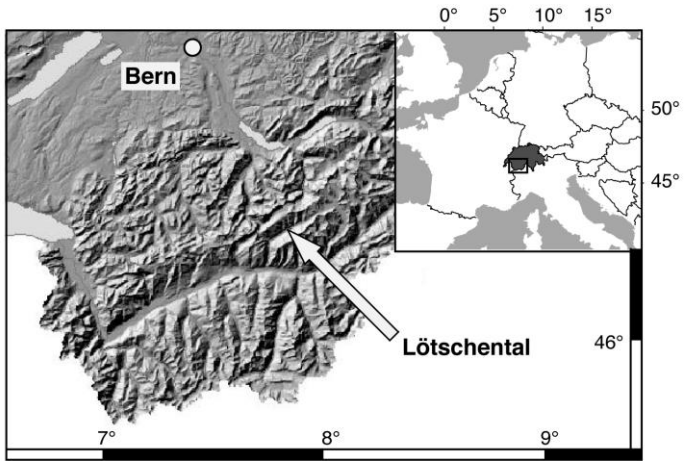
← **Frequency of cyclonic conditions**

→ **Tree-ring $\delta^{18}O$**

Saurer et al., JGR, 2012

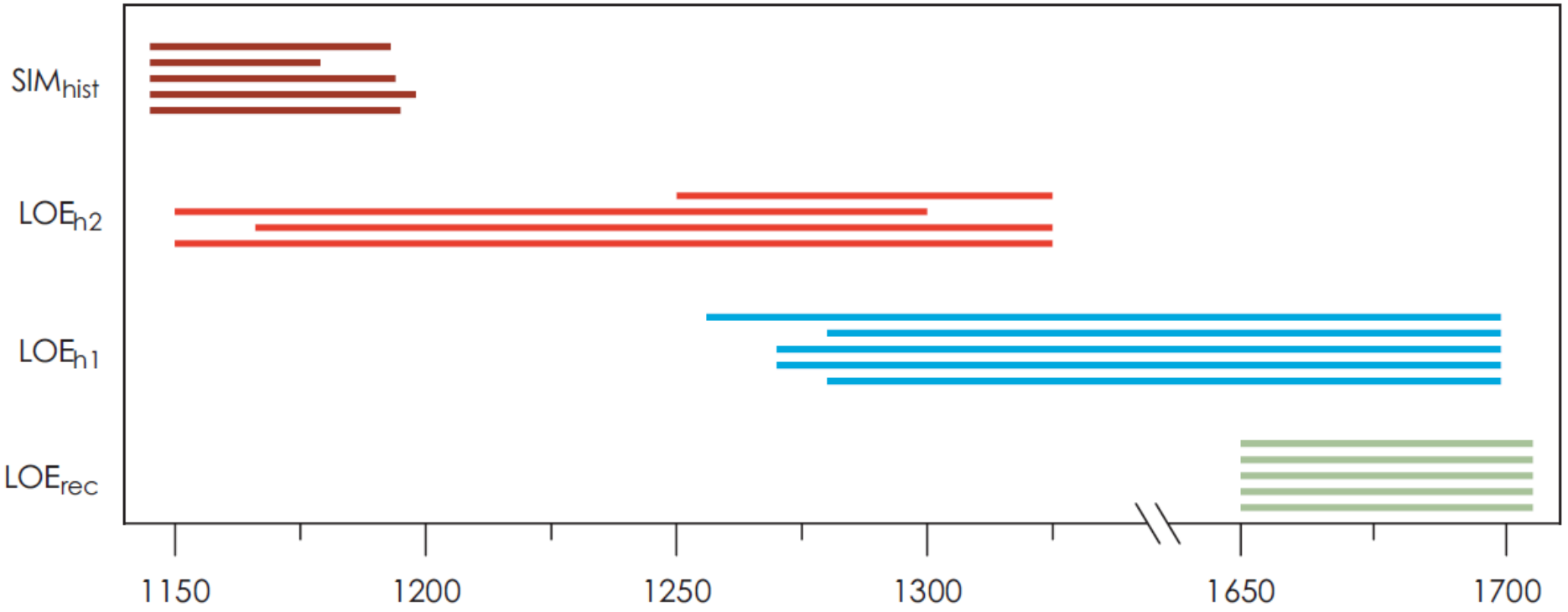
Alpine site: Working with historic material

Lötschental, Switzerland
Larix decidua



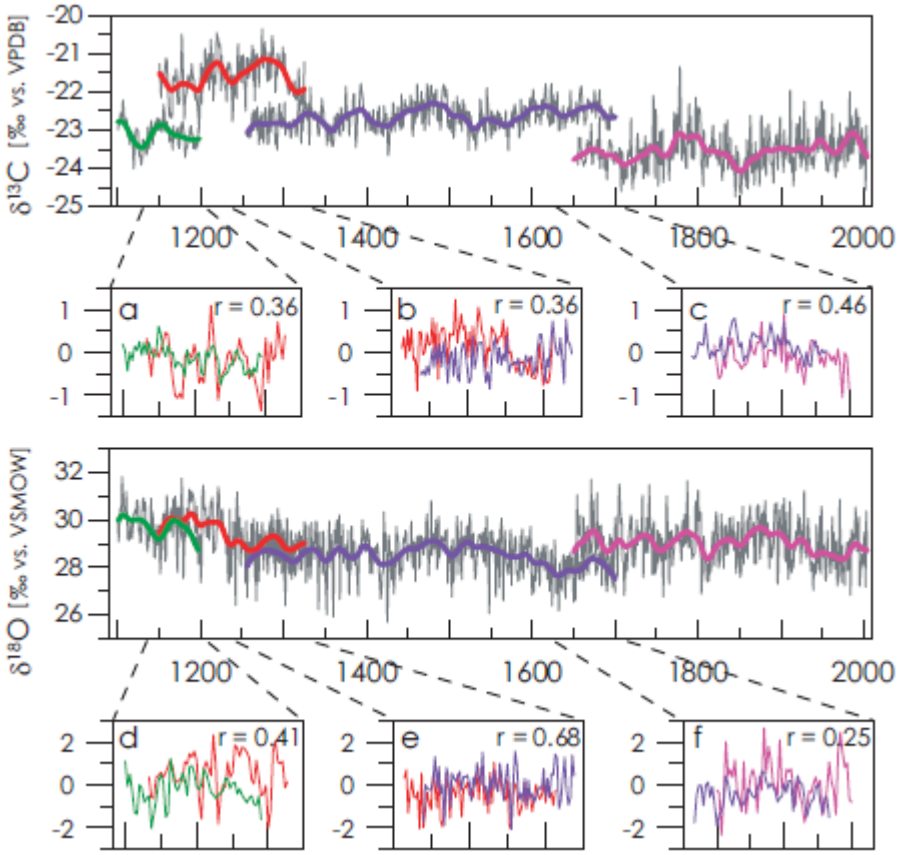
Millennium
European Climate

Merging different chronologies

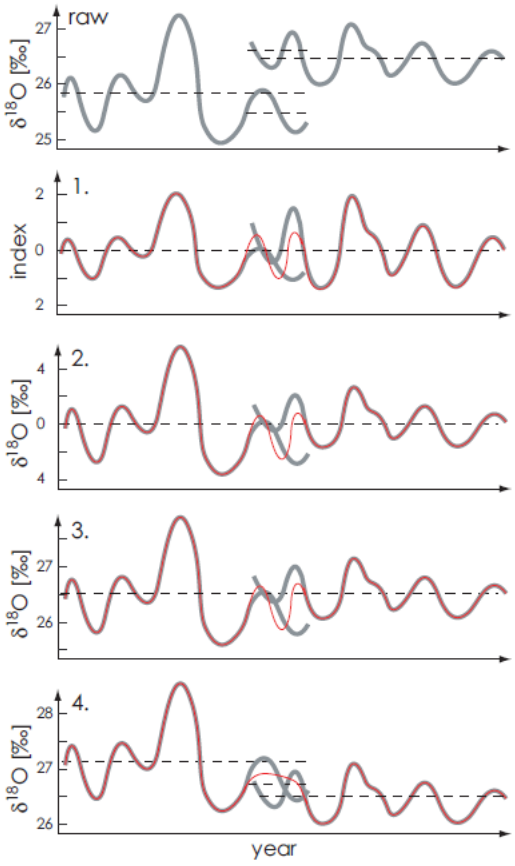


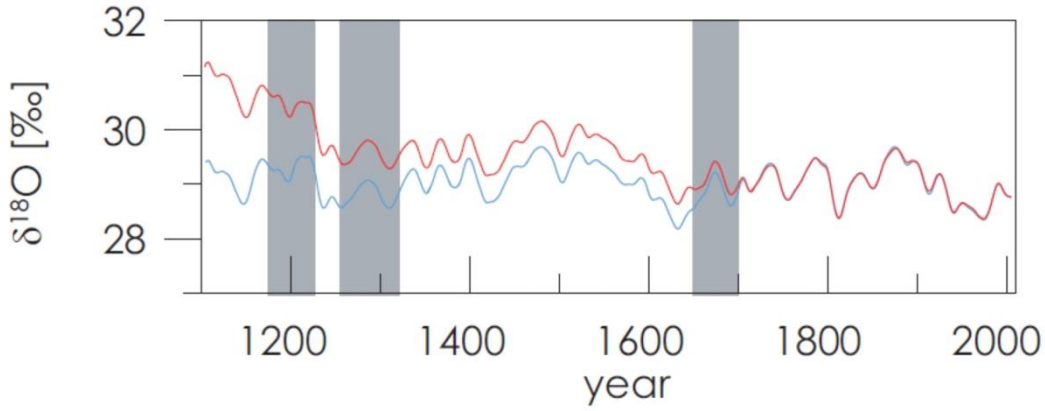
Methods to merge overlapping tree–ring isotope series to generate multi–centennial chronologies

Hangartner, Kress, Saurer, Frank and Leuenberger, Chemical Geology 2012



Methods to merge overlapping tree–ring isotope series to generate multi–centennial chronologies

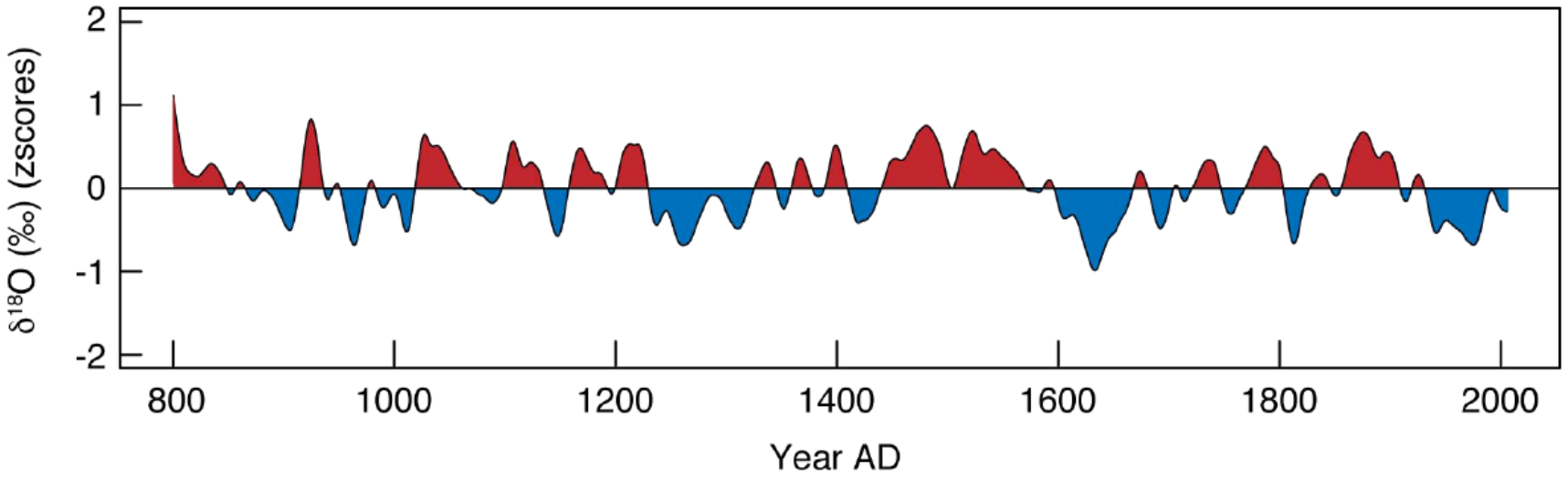




Comparison of linking methods 3 (blue) and 4 (red)

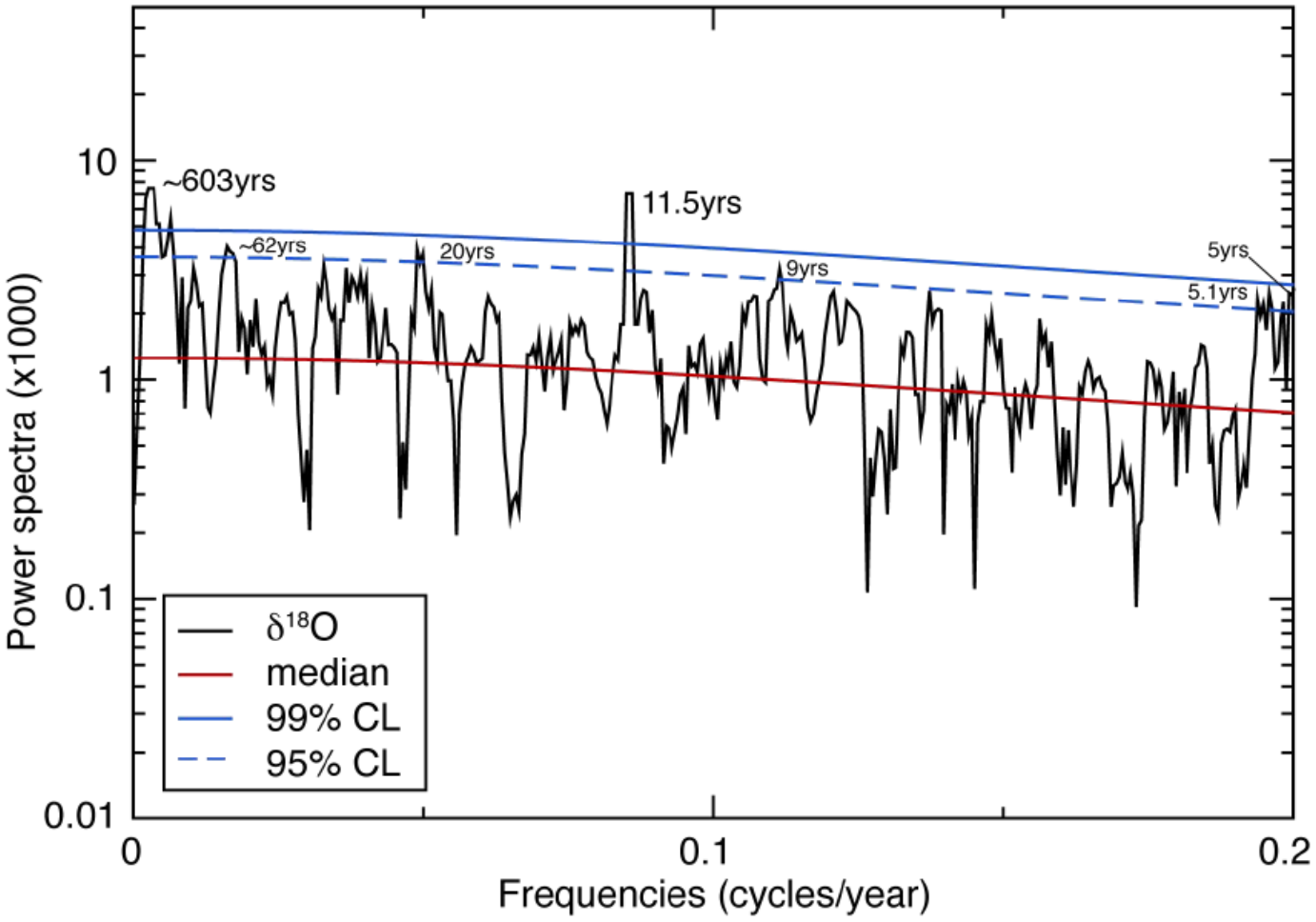
Alpine site

Standardized chronology



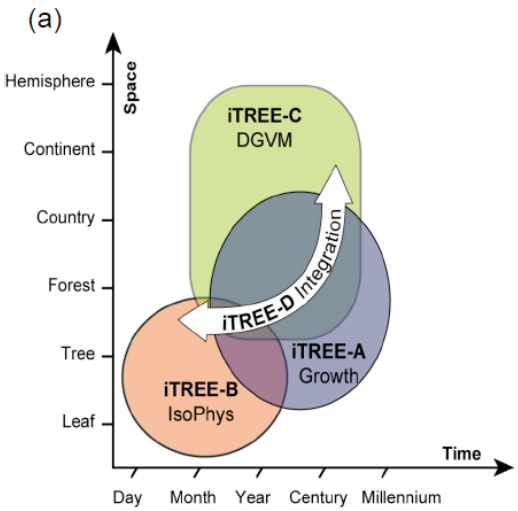
Kress 2009

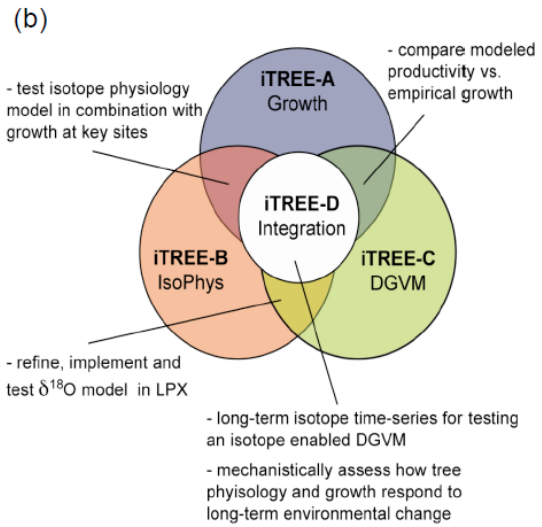
Alpine site


10
1
0.1
0.01
Power spectra (x1000)
~603yrs
11.5yrs
~62yrs
20yrs
9yrs
5yrs
5.1yrs
δ18O
median
99% CL
95% CL
0
0.1
0.2
Frequencies (cycles/year)

Long-term variability of tree growth in a changing environment – identifying physiological mechanisms using stable C and O isotopes in tree

SNF iTree





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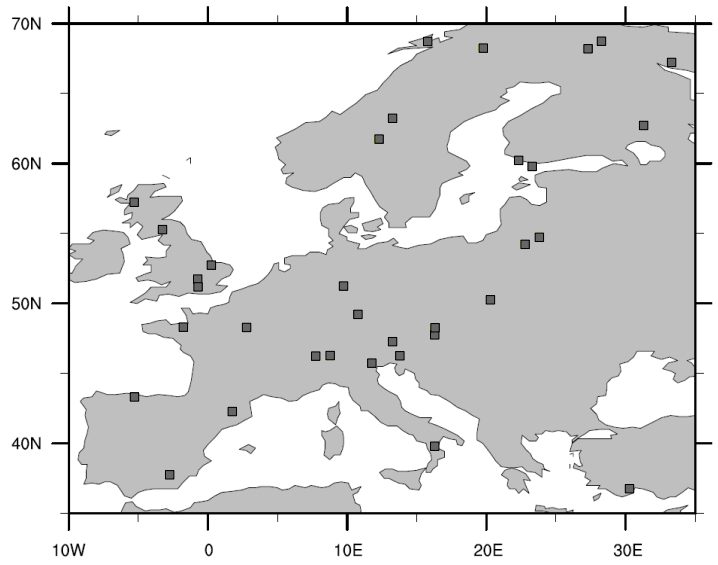
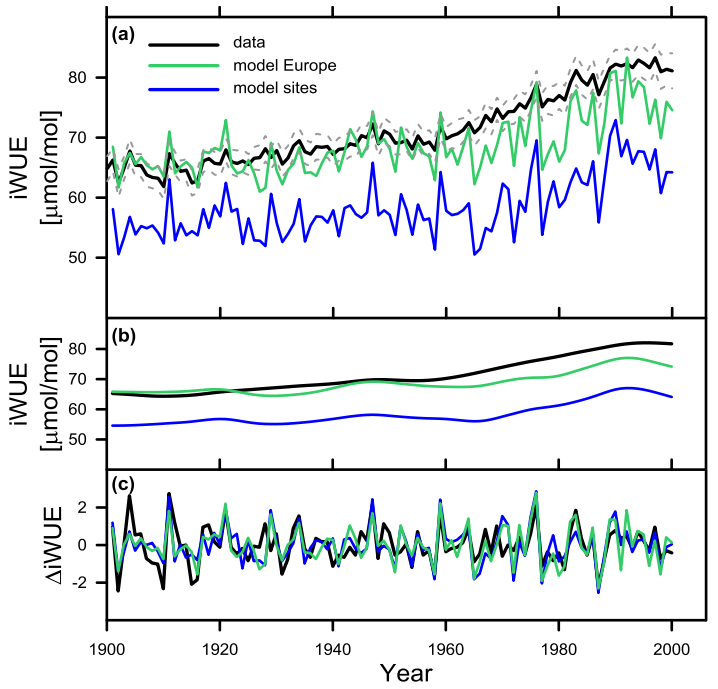
UNIVERSITÄT BERN

Tree-ring network in Europe and $\delta^{13}C$-derived water-use efficiency (WUE)

Millennium
European Climate



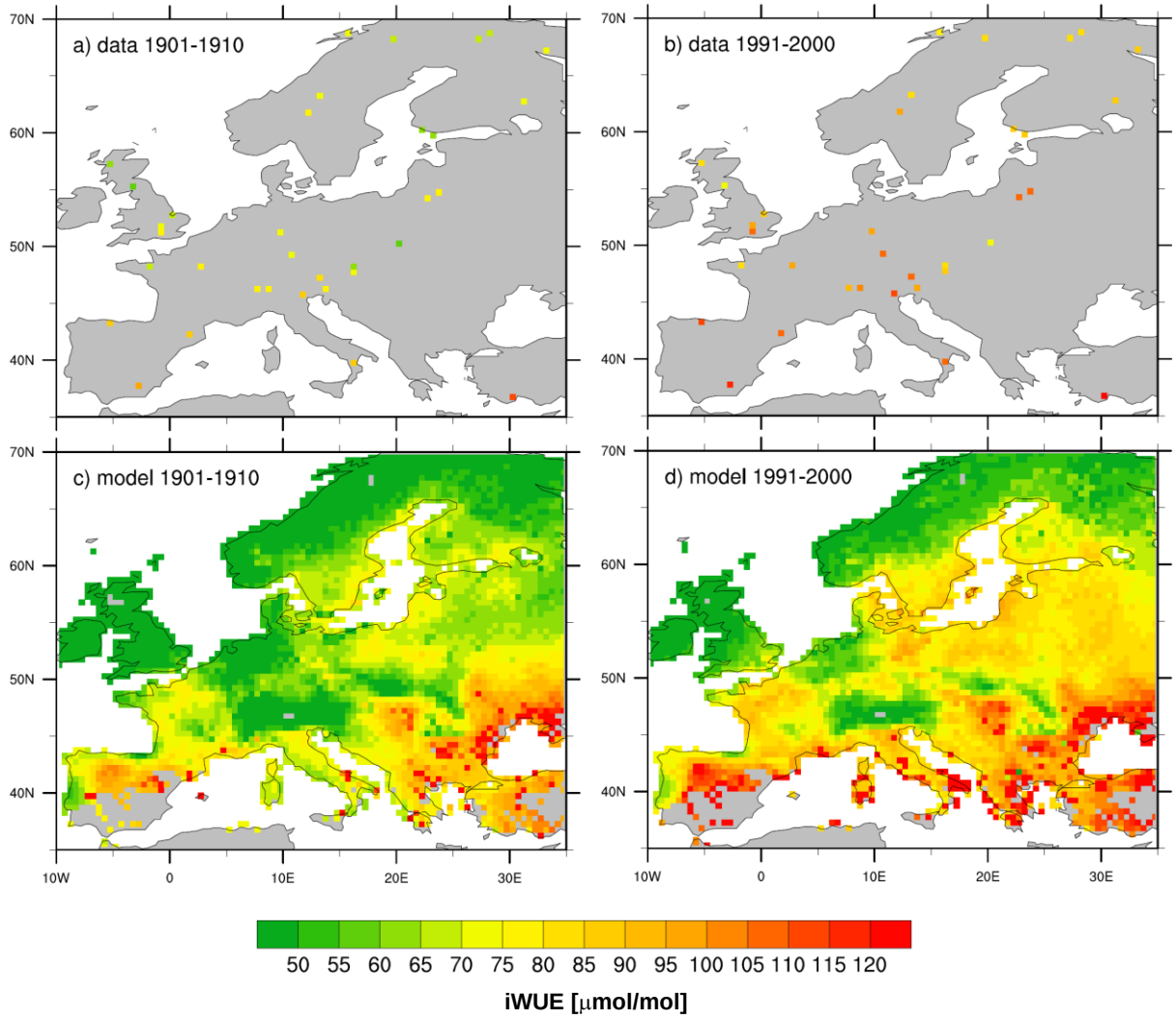


Saurer et al., Global Change Biology, 2014

1901-1910 1991-2000

Data

Model



Data: WUE calculated from tree-ring carbon isotopes

Model: WUE from Bern LPX global dynamic vegetation model

Conclusions

- $\delta^{18}O$ signal in tree-rings are regional-scale

- Generally not strongly dependent on species/site/local conditions

- $\delta^{18}O$ is not just temperature

- Models of different complexity are useful and necessary for the interpretation


Thank you for your attention!