ISODROUGTH Project at Pfynwald 2019

Triple isotope signatures to understand tree physiological responses - intra and inter annual trends

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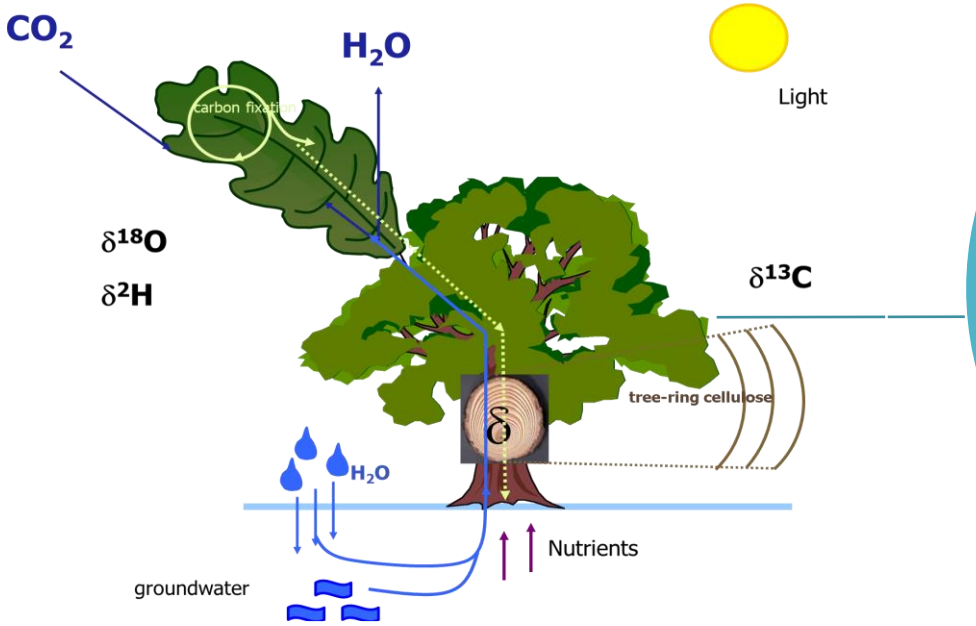
Isotopes, what do they tell us?

Isotopes are tracers of climatic and physiological processes. Tracing the **“natural” variability** of isotopes we can have an in depth characterisation of trees **physiological responses to drought**, an **assessment of tree vitality,** an attempt at **disentangling processes of mortality** (Carbon starvation and Hydraulic failure).



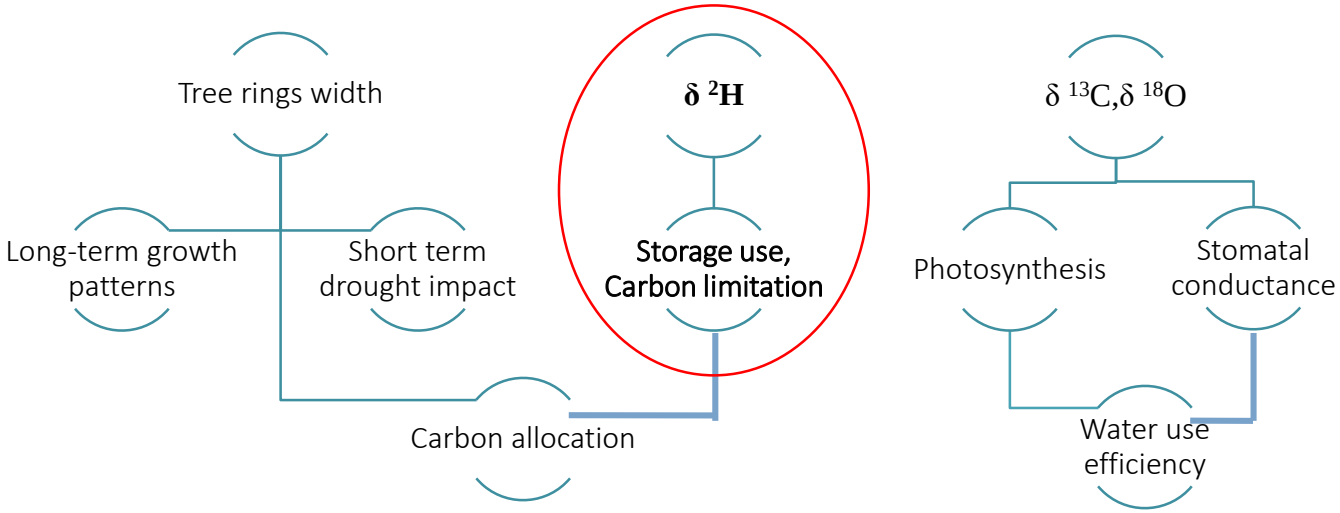
We can create the full isotopic fractionation pathway with the sampling of: needles, twigs, stem, tree rings, soil and air moisture

Different tissues have different time resolutions:

- Water, sugars, cellulose: Short-term **seasonal resolution**
- Tree rings cellulose: Long-term **annual resolution**

Triple isotope approach

$\delta^{13}C$, and $\delta^{18}O$ are powerful indicators linking plant physiological responses to climate. **$\delta^{2}H$**, lacking a clear climatic signal, has been often overlooked, but new knowledge on H^2-isotope fractionations shows its **potential for the reconstruction of trees carbon use strategies** (e.g. storage and remobilization vs utilization of fresh assimilates).



The triple isotope approach will be a **novel diagnostic tool** for retrospective analysis and interpretation of the physiological effects of drought.

The Pfynwald experiment provides a unique set-up for investigating isotope patterns both in the long term, and at the seasonal level and direct comparisons between soil moisture conditions.

Seasonal evaluation of source-to-sink, compounds-specific triple-isotope variation in the Pfynwald experiment.

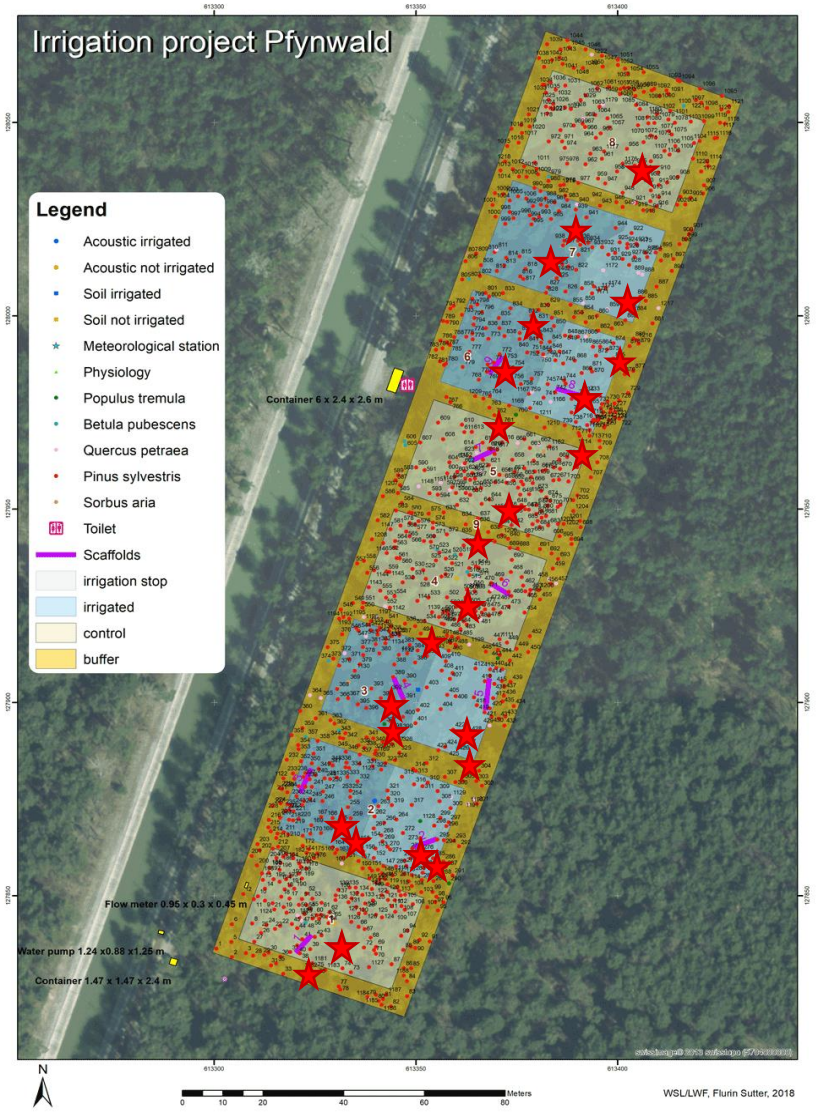
To trace the isotopic fractionation in the whole system and how this is affected by irrigation treatment, and vitality, based on crown transparency assessment, we sampled **24 trees**, and 4 times over the vegetative season 2019.

$\delta^{18}O$, $\delta^{2}H$ and $\delta^{13}C$ were measured from:

✓Water samples from:
- Soil (10-20 cm depth)
- Stem (pholoem and xylem)
- Twigs (phloem and xylem)
- Needles
- Air vapour
- Channel water

✓ Cellulose :
- Twigs
- Needles
- 2019 tree ring E/LW

✓ Sugars:
- Twigs
- Needles



Tree-ring chronologies and xylogenesis were also measured, to create a bridge between physiology and resulting growth and tree-ring structure.

Seasonal trends modified by irrigation: Xylogenesis – clear effect of irrigation on timing of cell production

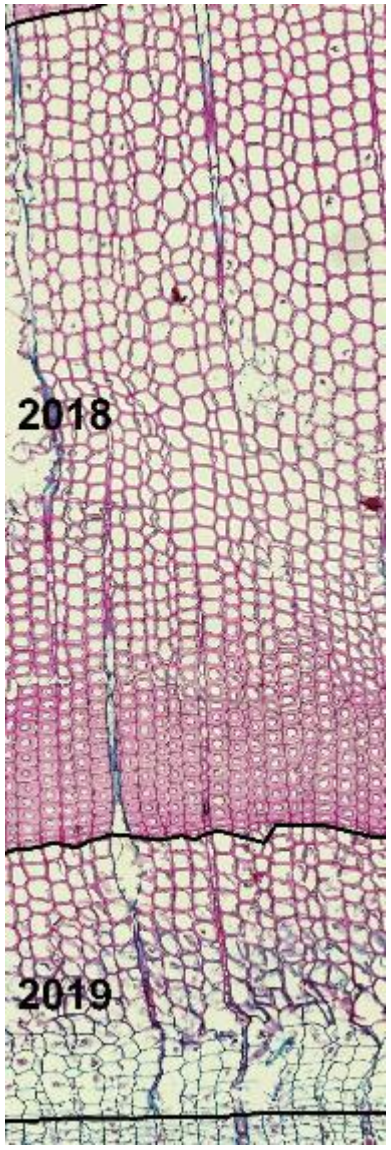
June 4th

Irrigated

Mature cells:8

Thickening: 5

Expanding: 3

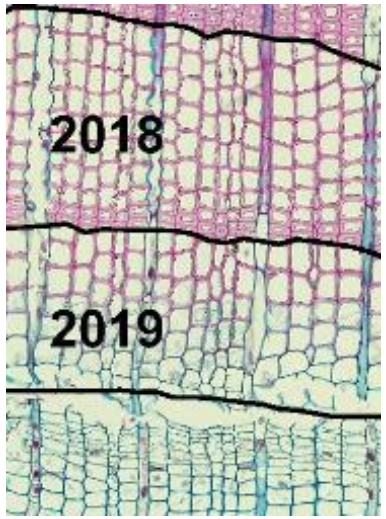


“Stop”

Mature cells:3

Thickening: 2

Expanding: 2

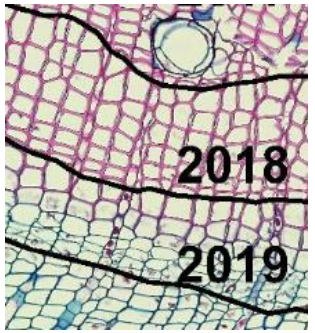


Control

Mature cells:2

Thickening: 2

Expanding:1



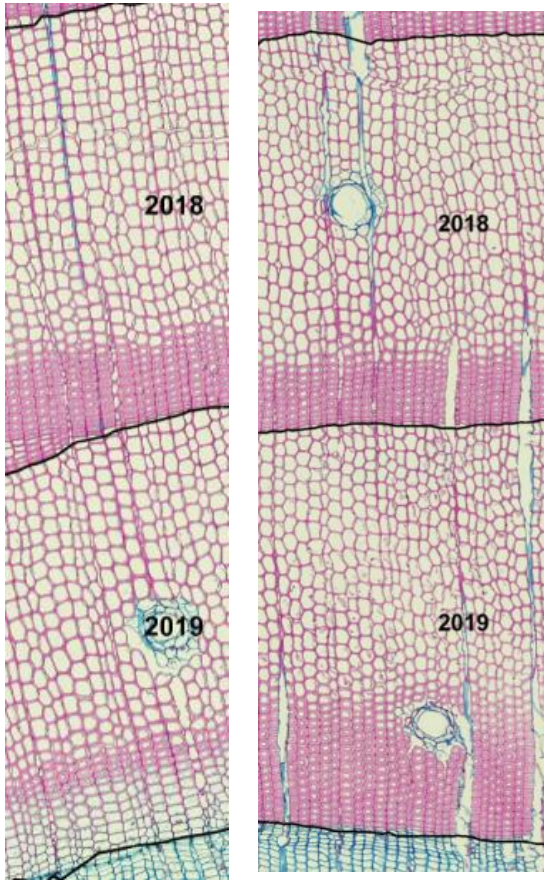
Strong differences in productivity are visible already in the early growing period.

Seasonal trends modified by irrigation:
Xylogenesis – clear effect of irrigation on total cell production

Irrigated

Aug. 20th

Oct.20th

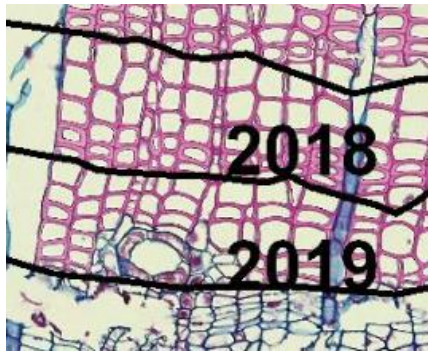


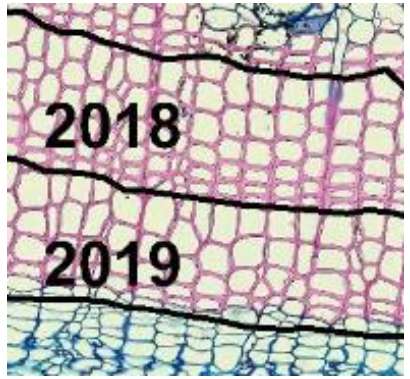
Thickening and Expanding cells

Control

Aug. 20th

Oct.20th



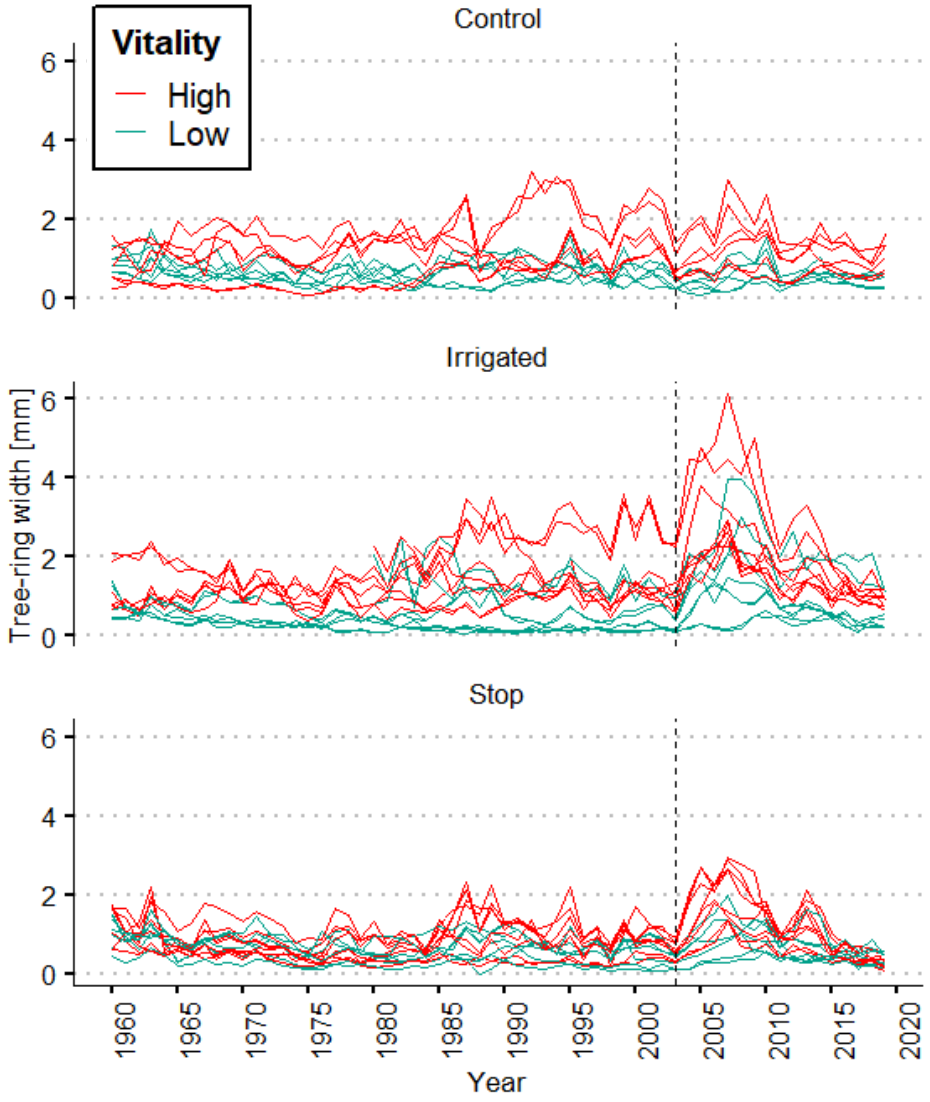


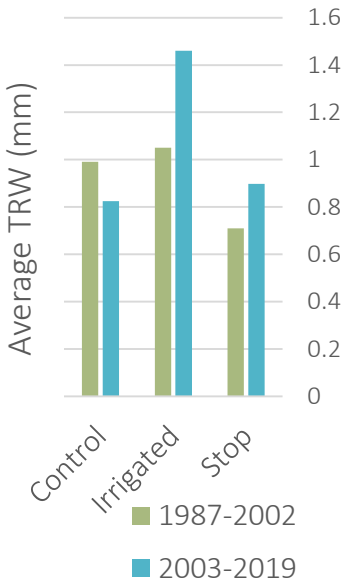
Cambial activity protracts longer in irrigated plots, when control plots have already stopped cell production in August.
The climate signal stored in the tree-ring cellulose is different.

Inter-annual evaluation isotopic signal ($\delta^{13}C$, $\delta^{18}O$, $\delta^{2}H$) in tree-rings

Tree-rings chronologies have been created, and cellulose has been extracted for the last 20 years, to compare annual signature of $\delta^{13}C$, $\delta^{18}O$, $\delta^{2}H$ for:

- Irrigation treatment.
- High/low vitality trees
- Early/late wood 2019 and 2018





Thanks to this extensive database, we want to create a more comprehensive assessment of climate impact on tree's physiology, creating a direct link between triple isotope signature stored in tree rings and seasonal physiological mechanisms.

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