

TreeNet – The biological drought and growth indicator network

New results from the Pfynwald experiment

What happens to trees that get cut off from irrigation?

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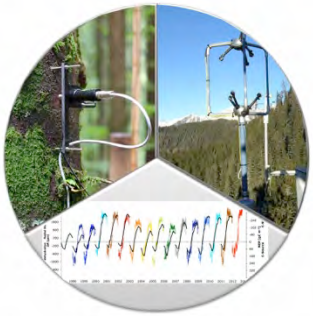
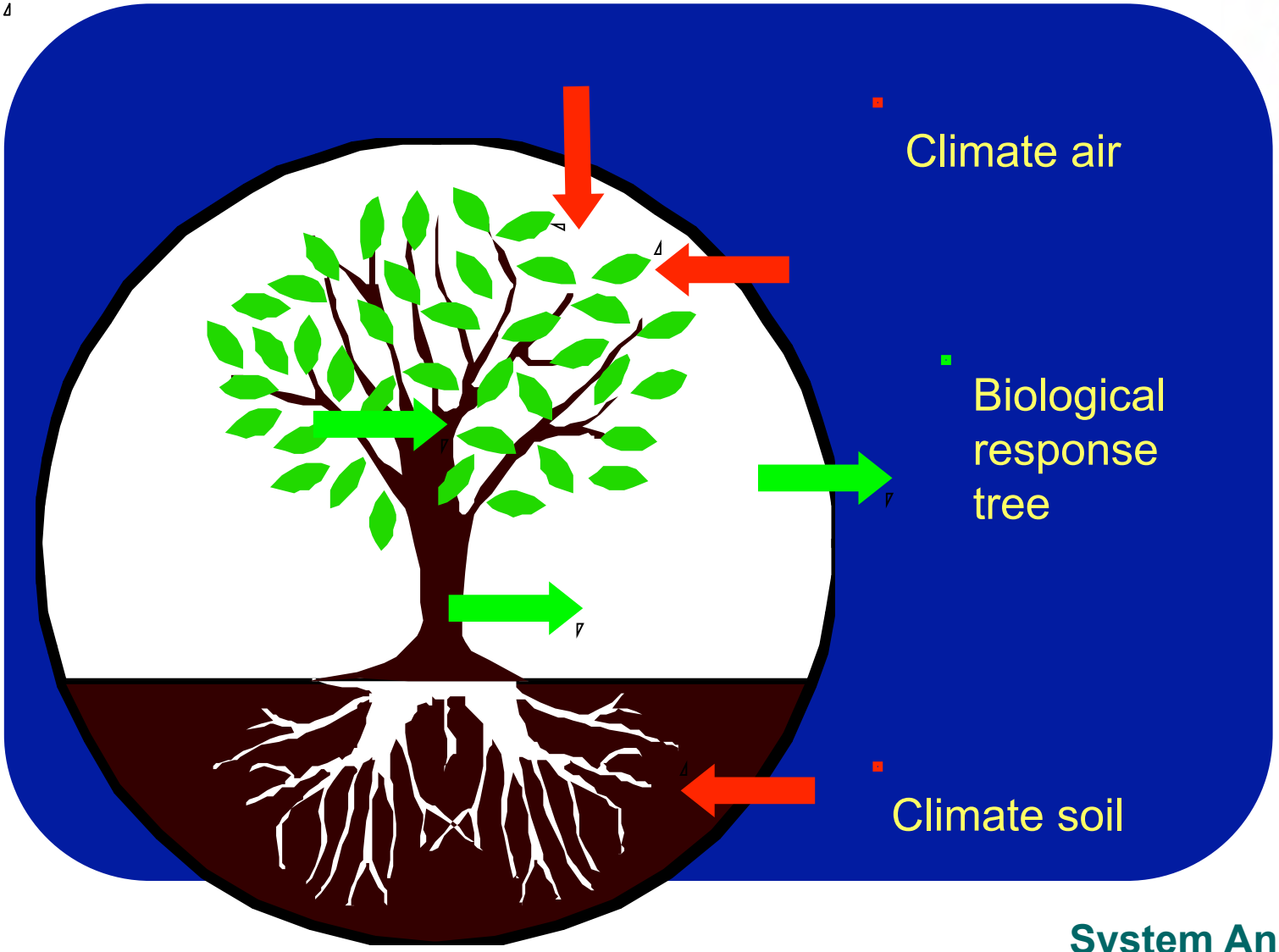
16 November 2015



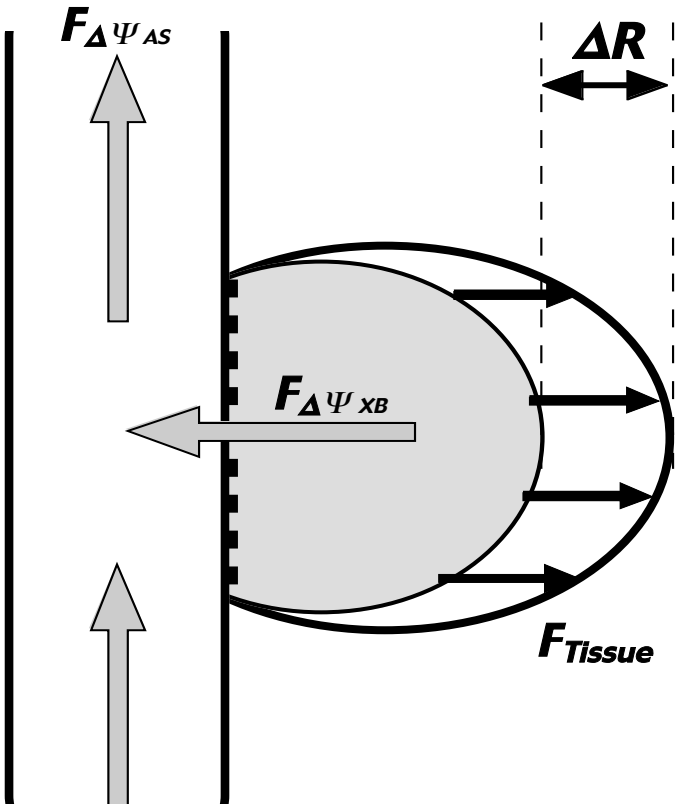


- Many climate variables measurable
- Few physiological methods available

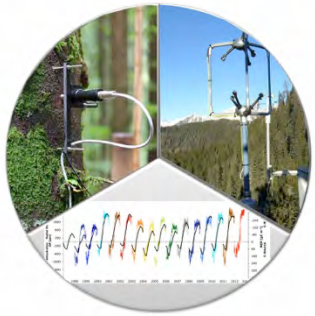
System Analysis

Flow path

Water storage

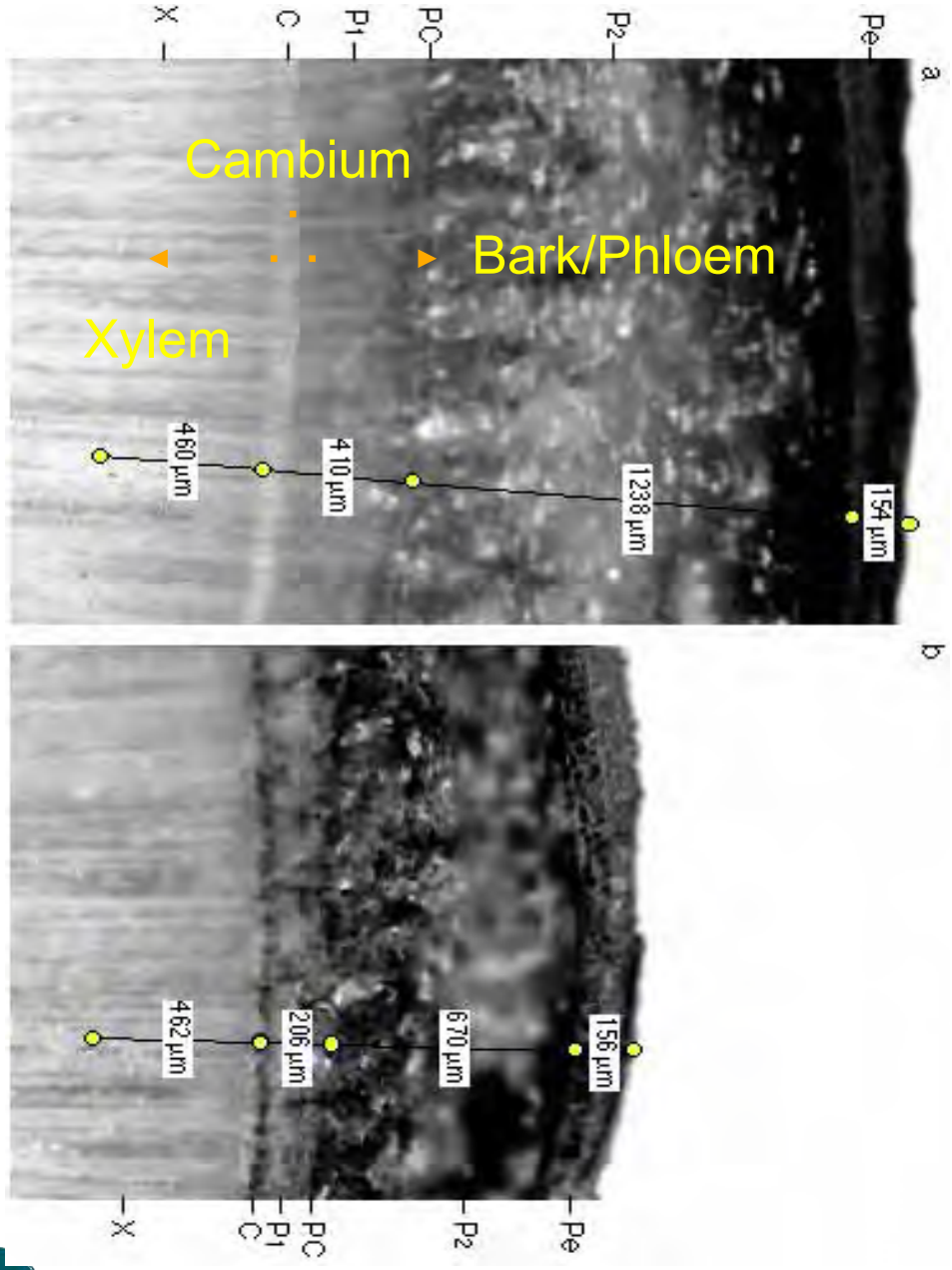


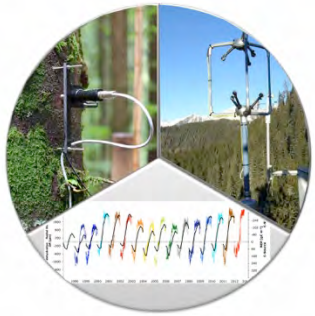
Wood (Xylem) Bark (Cambium, Phloem, Parenchyma)



Saturated tree stem

Dry tree stem



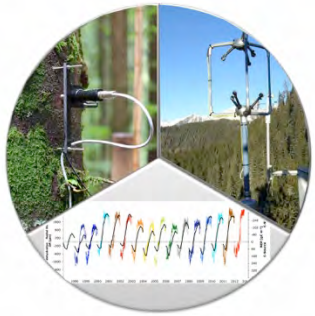


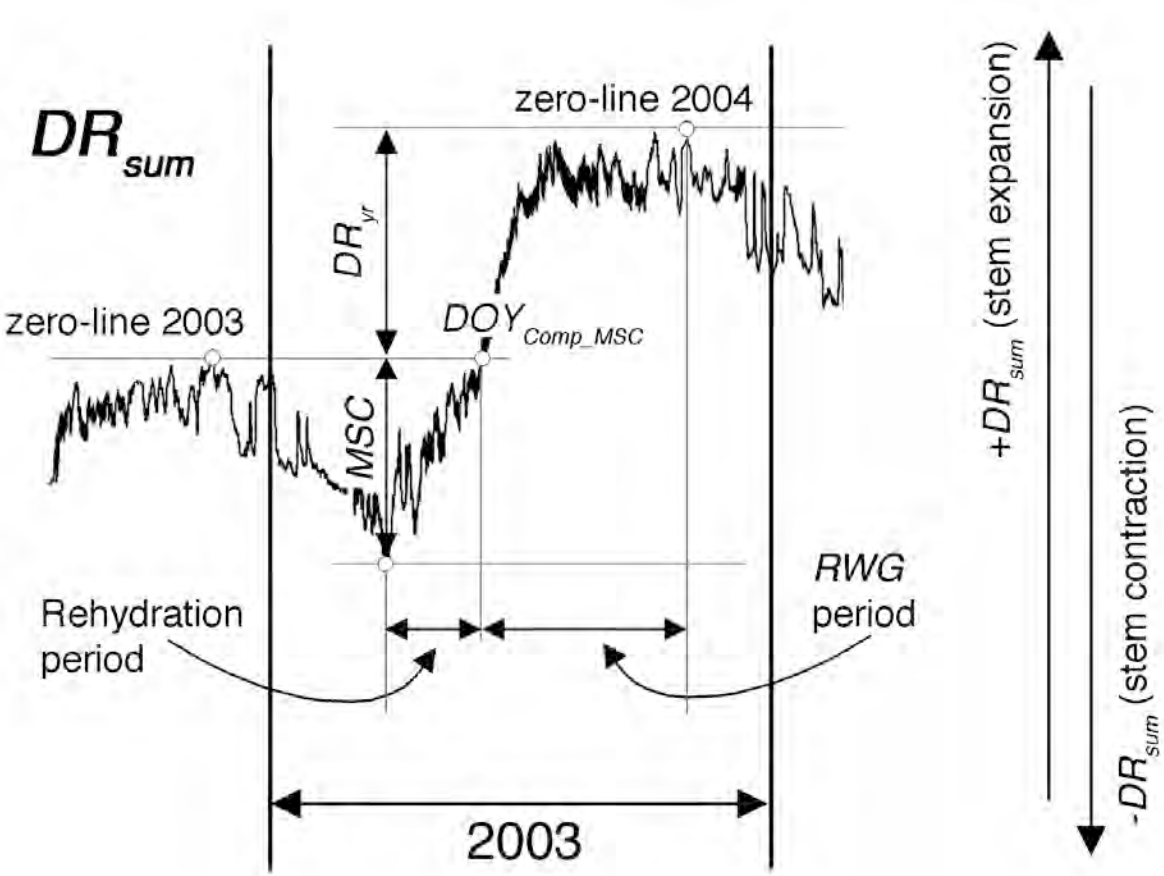
Point dendrometers measure:

- **water related shrinkage and expansion of stem (reversible)**
- **stem growth: cell division and elongation (irreversible)**

⇒ Link between tree water relations and carbon balance
⇒ Growth is possible under (near) water saturated conditions only
⇒ Shrunken stems do not grow

The Rhythm of Trees
DR = Tree water deficit (TWD) + growth (GRO)

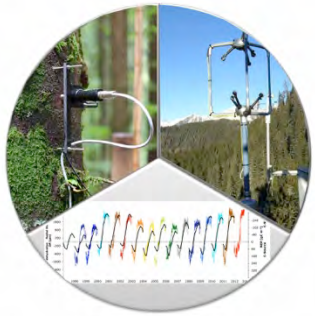


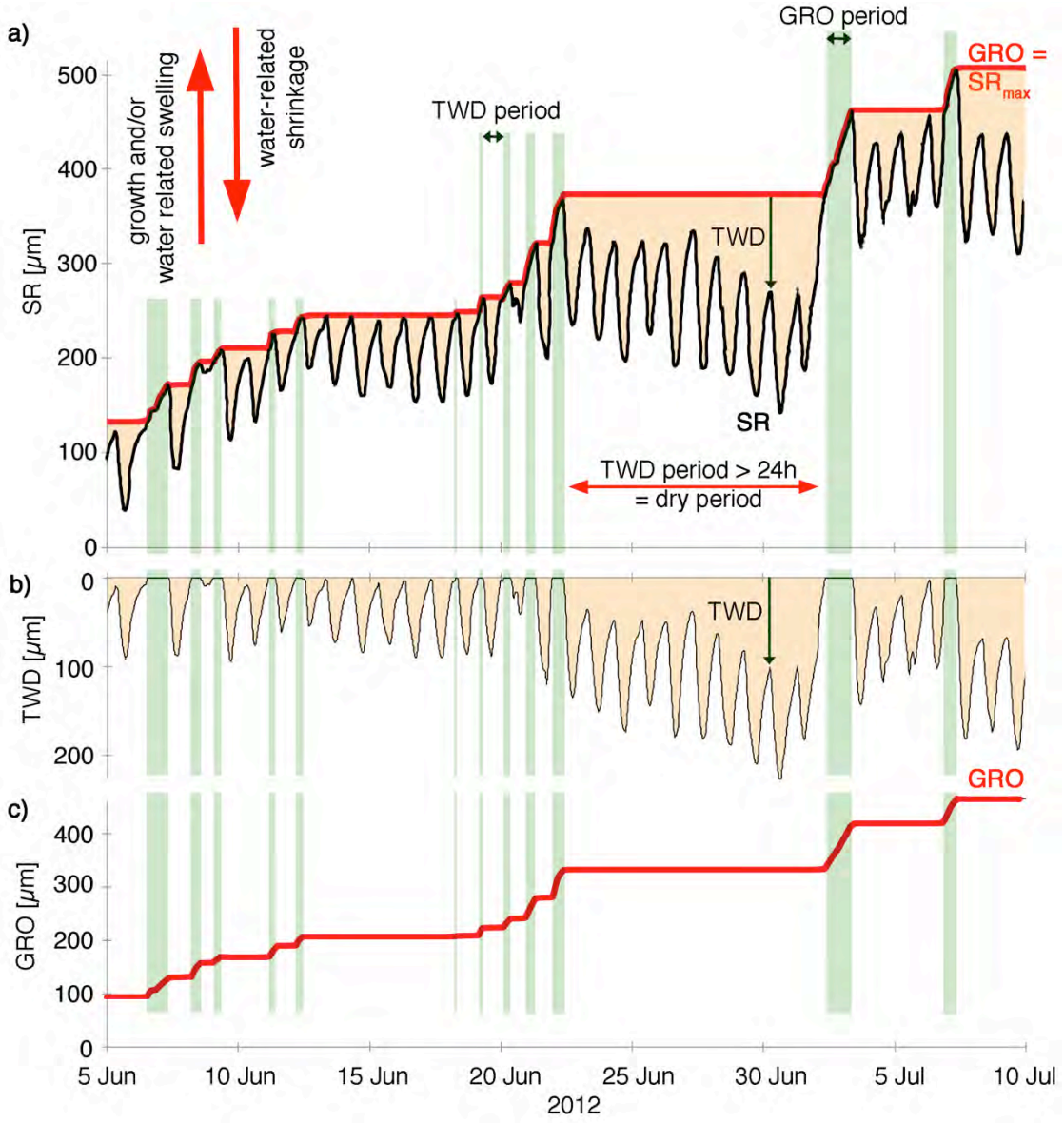


- **Many indicators**
- **Growth**
- **Water related shrinkage and expansion**

⇒ **Disentangling DR (measured stem radius fluctuation over time) into tree water deficit (TWD) and growth (GRO)**

The Rhythm of Trees
DR = Tree water deficit (TWD) + growth (GRO)





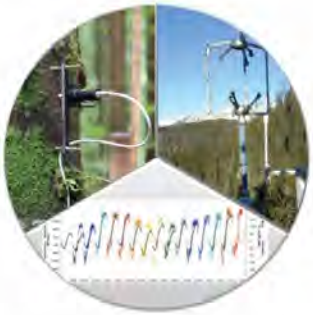
TWD is the missing water of a tree to fully saturate its tissues (Daudet et al. 2005, Steppe et al. 2006, 2008, Zweifel et al. 2001, 2007, 2015)

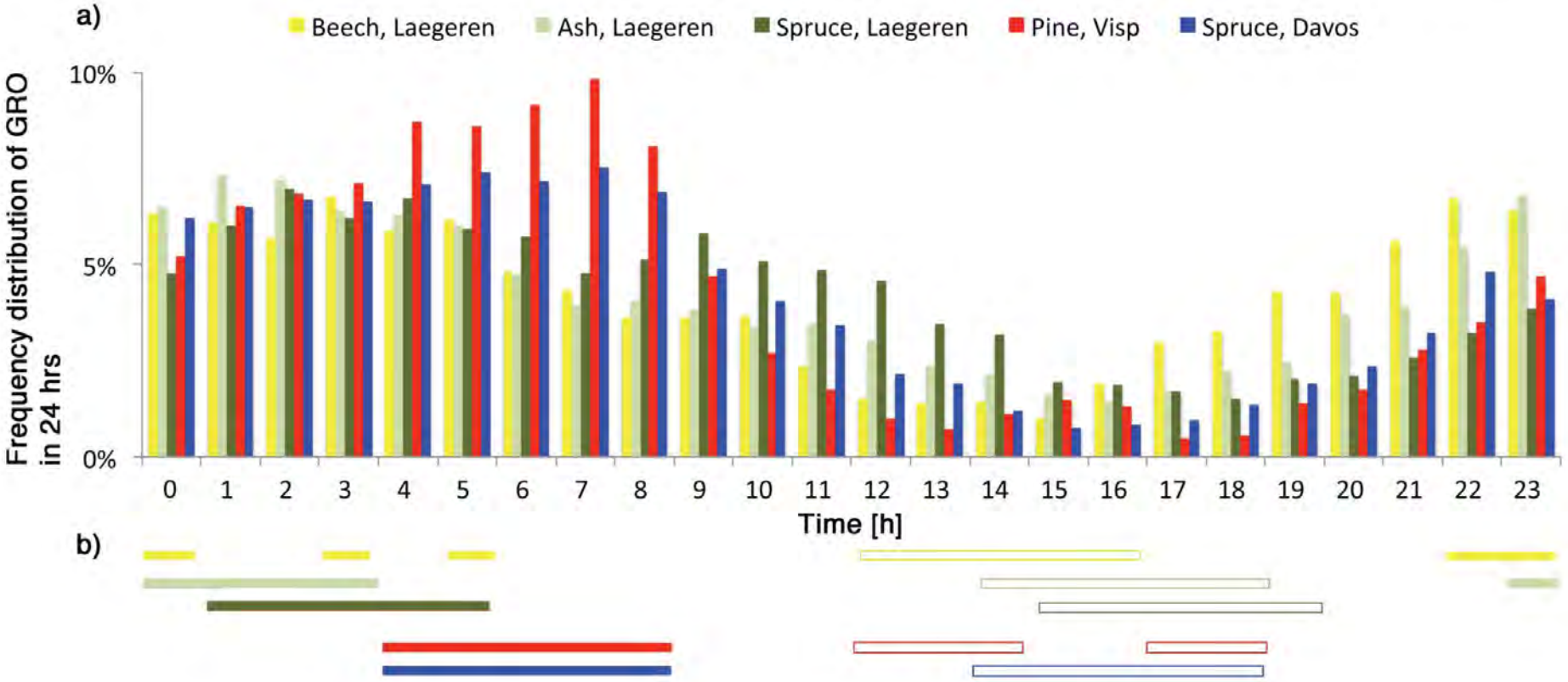
⇒ **GRO occurs only for TWD = 0** (Lockhart 1965)

⇒ **Dry period when replenishment is incomplete at night**

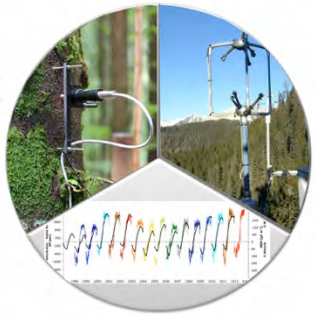
⇒ **Growth = cell division and cell expansion**

When do trees grow?





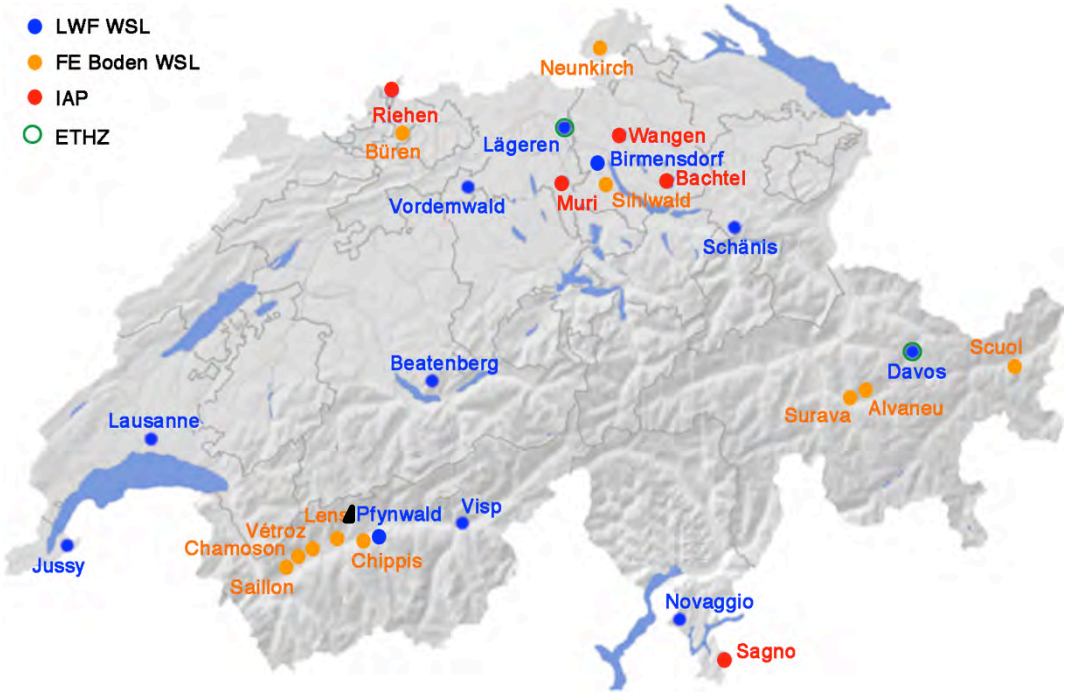
TREENET - The biological drought and growth indicator network



Monitoring- and research network based on stem radius change data (point dendrometer).

-> TreeNet Switzerland

- o about 250 trees
- o at 30 sites in CH
- o main tree species



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From dendrometer readings to biological drought and growth indicators

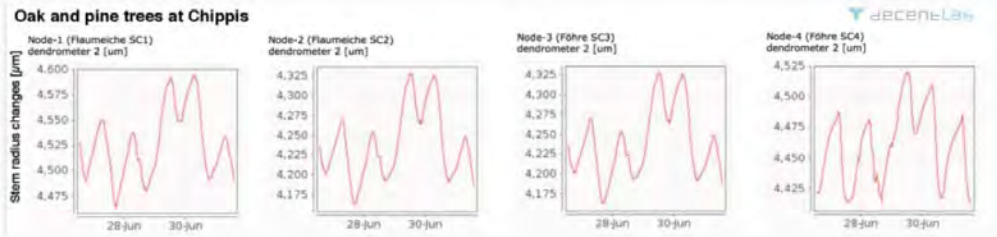
Point dendrometers

Point dendrometers are high precision devices that allow stem radius changes to be detected at a resolution of micrometers. The measurement devices consist of a mounting frame incl. an anchoring system and an electronic sensor with a sensor head slightly pressed against the surface of the measurement object by a spring. All parts of such measurement devices are more or less temperature sensitive. The quality of a dendrometer depends on the interaction of artificial responses of different parts of a device to temperature. A high quality sensor, as used in TreeNet_Switzerland, has an overall temperature sensitivity between 0.2 and 0.5 μm per °C.

Figure M1 Collection of point dendrometers (natkon.ch). The carbon frames are either T-shaped (for large stems) or O-shaped (for small stems or branches) and are anchored in the stem with stainless steel rods. Up to three sensors are attached to the different type of frames in order to measure different expositions at the stem or to measure stem radius fluctuations over bark and on the xylem separately.

Stem radius changes – raw data

Tree stems usually shrink during the day and expand during the night. These fluctuations are mostly driven by **tree water relations** and their dependencies on conditions in air and soil. Trees are coupled to the air by many square meters of leaf area and to the soil by many square meters of root surface. Any change in conditions in air and soil affect tree water relations. The determining forces in tree water relations over a day start with the transpiration in the leaves (driven by a combination of vapor pressure deficit of the air, light and wind), being followed by the flow resistance- and storage capacitance-induced delay of sap flow in twigs, branches and stem, to finally a delayed depletion of elastic stem storage tissues at the location where the point dendrometer is mounted.



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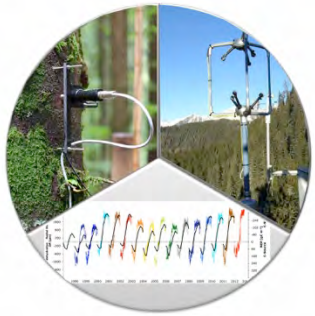
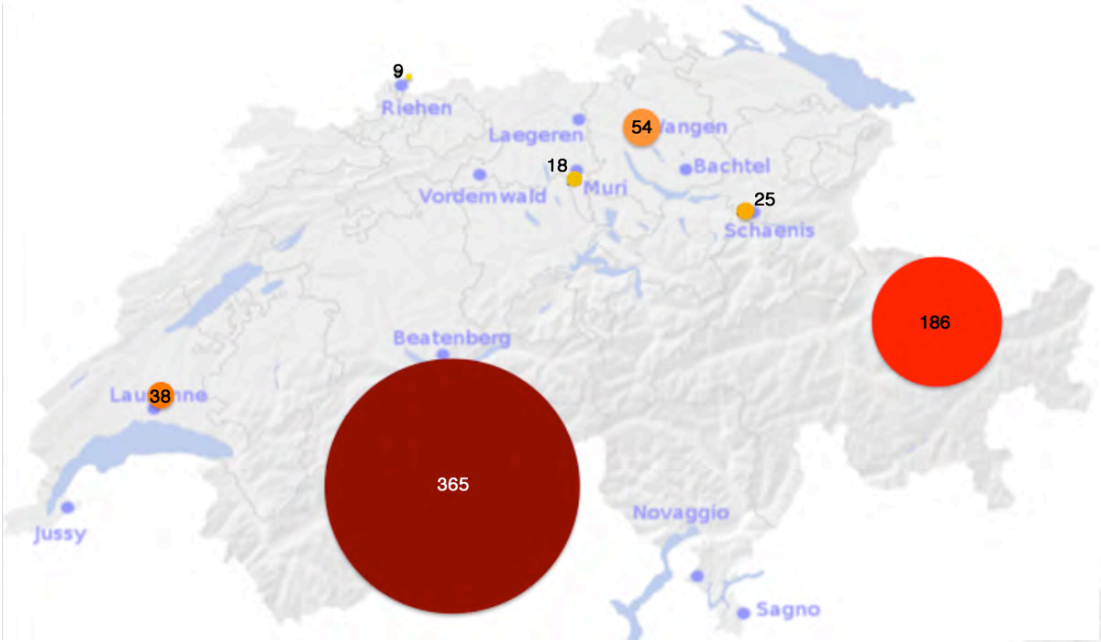
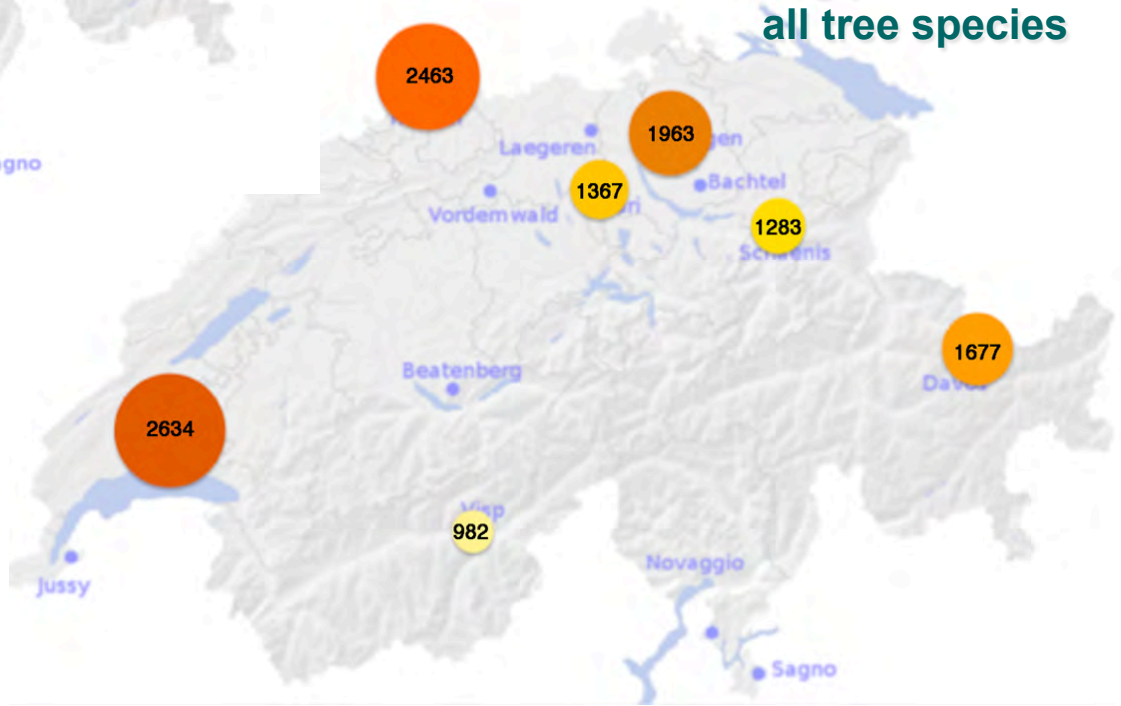
Tree water deficit (TWD) + Growth (GRO) pattern



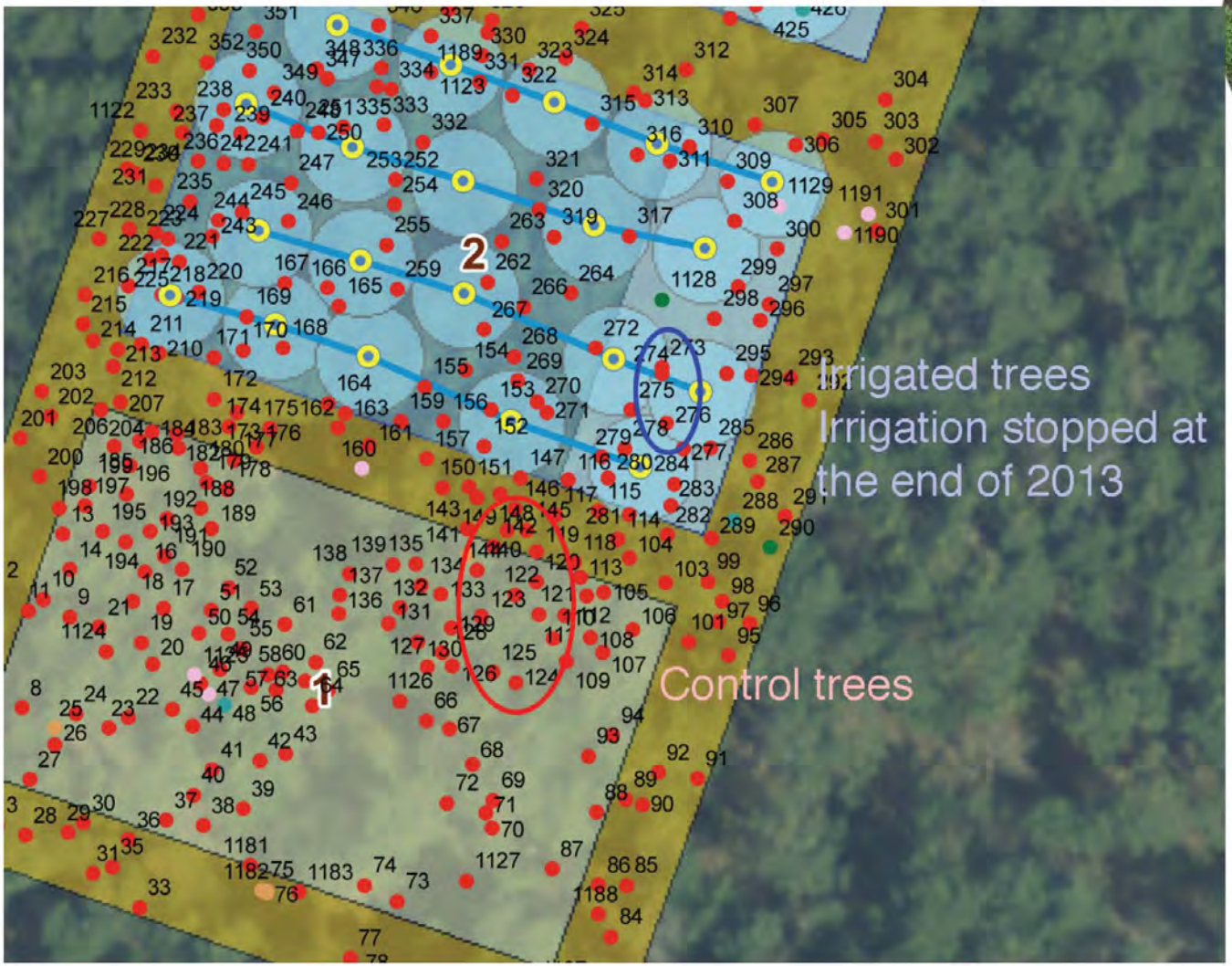


TWD
avg per site
all tree species

GRO
avg per site
all tree species

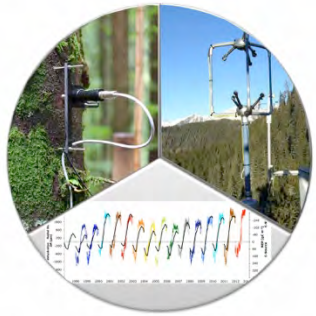


What happens to irrigated trees ...

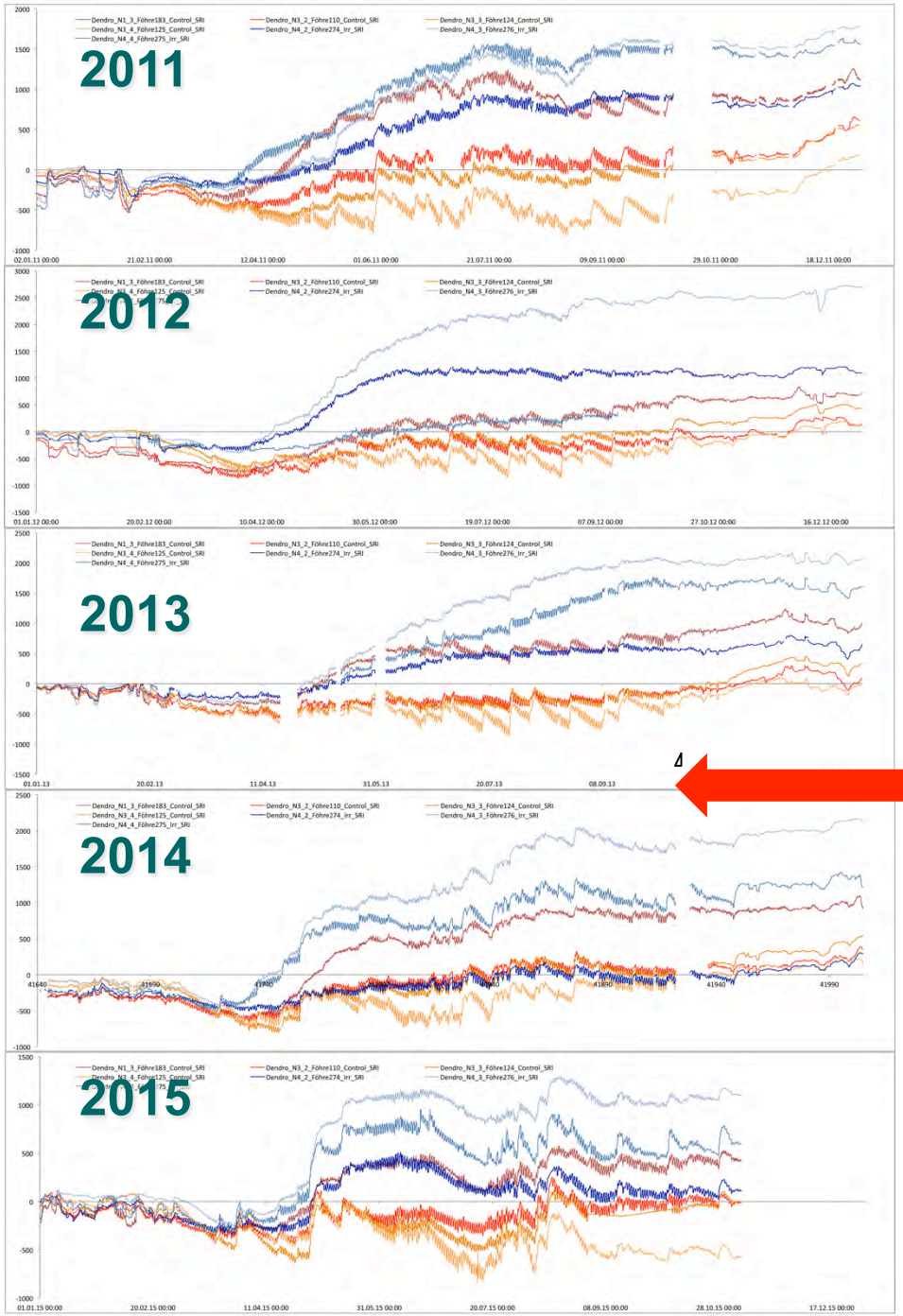


... that were set dry again?

Pfynwald experiment

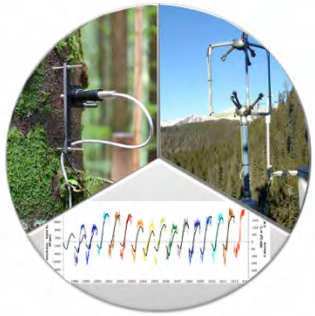


Dendrometer data
blue = irrigated
red = control



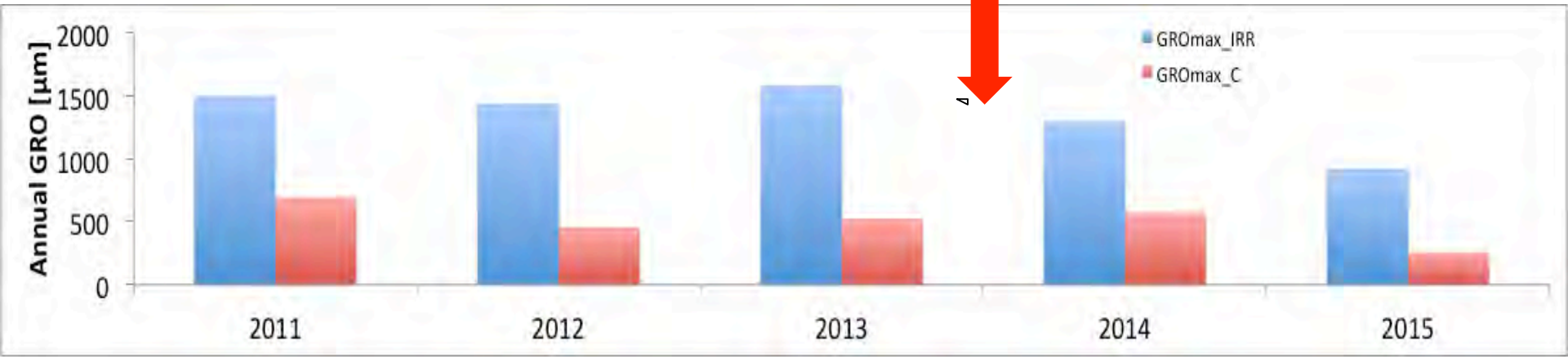
Irrigation stop

Pfynwald experiment



Irrigation stop

Growth



⇒ **Irrigated trees remain growing better even after stopping the irrigation**

Pfynwald experiment

Tree water deficit TWD

Dendrometer data
blue = irrigated
red = control

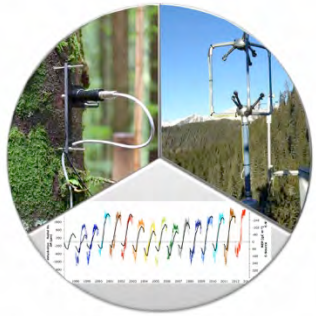
2011

2012

2013

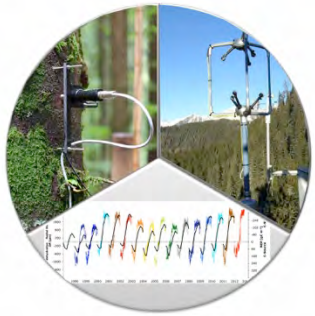
2014

2015



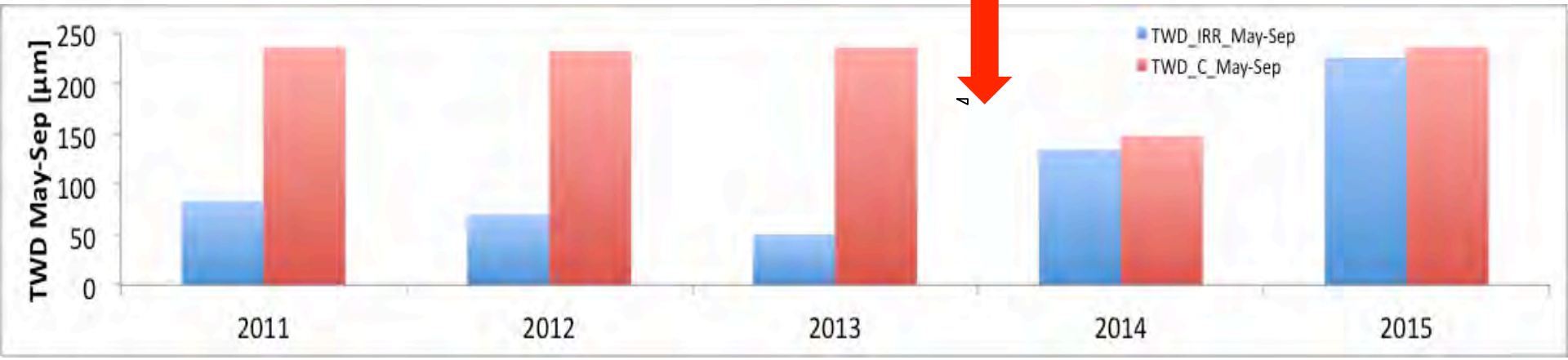
Irrigation stop

Pfynwald experiment



Irrigation stop

TWD

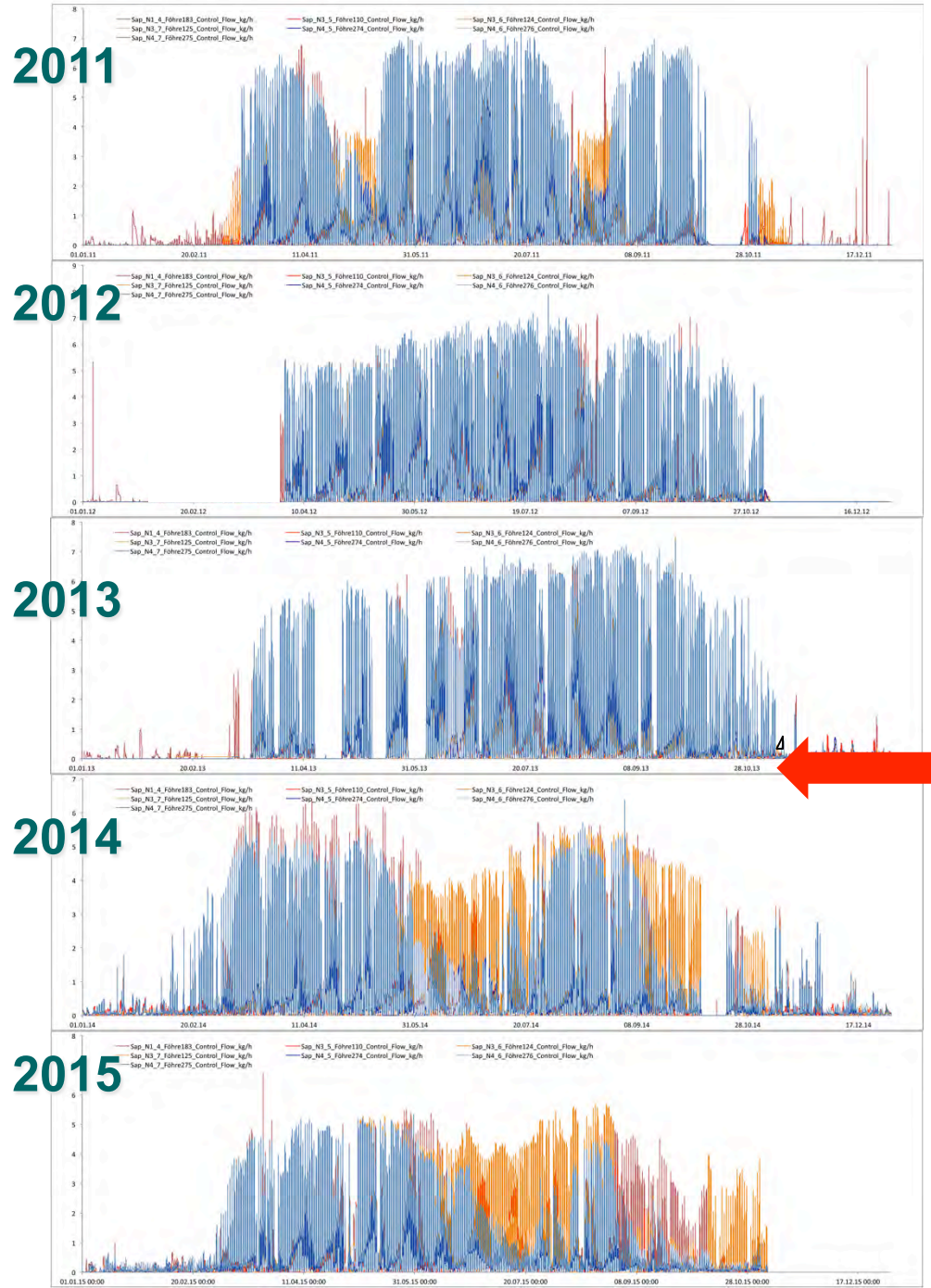


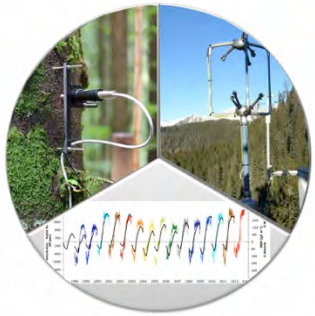
⇒ **Tree water deficit levels off after irrigation stop**

Pfynwald experiment

Sap flow

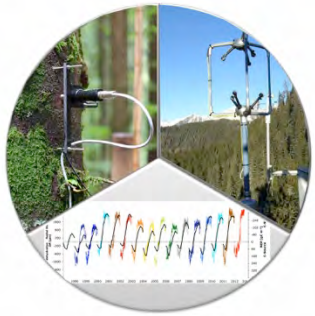
Dendrometer data
blue = irrigated
red = control





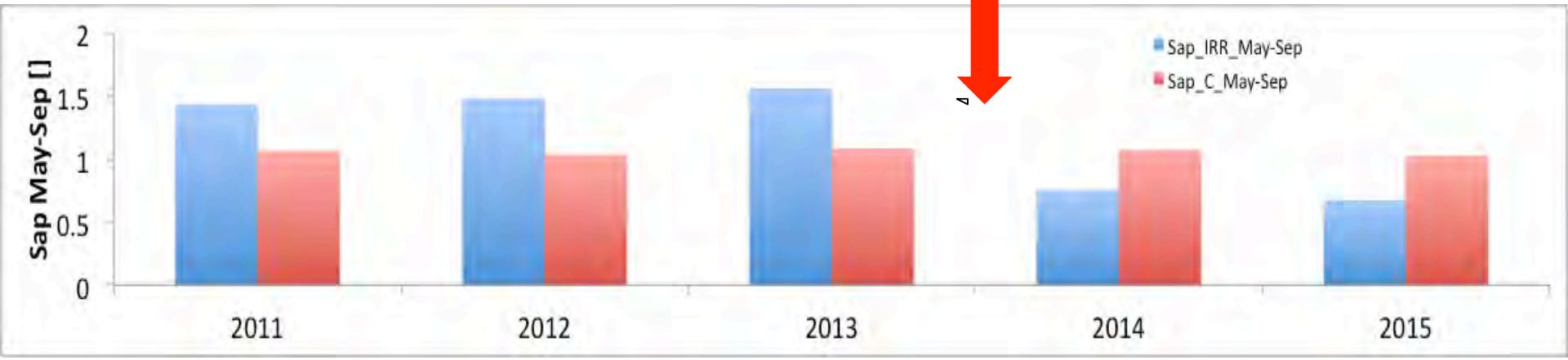
Irrigation stop

Pfynwald experiment



Irrigation stop

Sap flow



⇒ **Sap flow of irrigated trees is strongly reduced after the irrigation stop**



The Pfynwald experiment, preliminary conclusions ...

... **Tree water relations** quickly respond to irrigation stop

-> TWD differences level off

-> Supporting the theory that TWD is largely driven by water conditions in air and soil independent of biological regulations

-> Water consumption of former irrigated trees breaks in

-> Strong stomatal down-regulation (more needles but lower transpiration at the same stem cross-section area)

... **Growth** benefits from previous irrigation (at least the first two years)

-> Either due to benefitting from (carbon) reserves

-> Or due to the need to support the increased crown area



Take home message ...

... Stay tuned to www.treenet.info

The biological drought and growth indicator network



Thank you very much to ...

... **Collaborators:** Matthias Häni, Susanne Buri, Elena Haeler, Sophia Etzold, Andreas Rigling, Marcus Schaub, Lorenz Walthert, Georg von Arx, Patrick Fonti, Christian Hug, Fredi Potzinger, Peter Bleuler, Peter Jakob, Flurin Sutter, Sabine Braun (IAP), Nina Buchmann (ETHZ), Werner Eugster (ETHZ), Elena Perez-Ojeda (ETHZ), Marcus Mäder (ZHdK), Yann Salmon (Fi), Maurizio Mencuccini (UK, E) and many more

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