

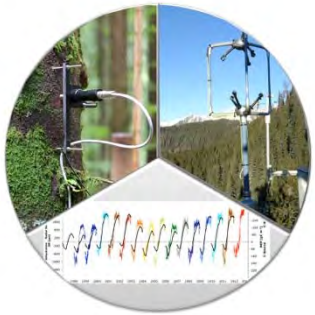
TreeNet – Linking net ecosystem productivity of forests to wood growth and tree water relations with dendrometer-based data

Roman Zweifel (WSL), Matthias Haeni (WSL), Susanne Burri (ETHZ), Reinhard Bischoff, (DecentLab), Nina Buchmann (ETHZ), Werner Eugster (ETHZ)

with the financial support of the Swiss Federal Office for the Environment FOEN

ICOS Science Conference, 27-29 September 2016, Helsinki, Finland

TreeNet - The biological drought and growth indicator network



Monitoring- and research network based on continuously measured and automatically stored stem radius change data in a central data base in the cloud.

-> TreeNet Switzerland

- o near real-time data
- o 10 min resolution
- o about 250 trees
- o at 30 sites in CH
- o main tree species

-> Financially support by FOEN

- o Federal Office of Environment
- o ICOS
- o WSL
- o ETHZ
- o SNF
- o COST
- o Mercator Stiftung

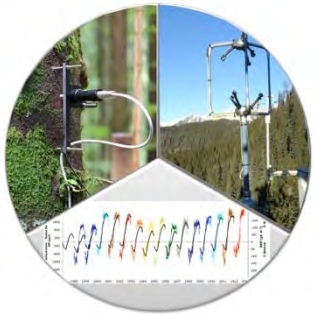
-> Project partner

- o Institute for Applied Plant Biology IAP

-> Tech partner

- o DecentLab GmbH

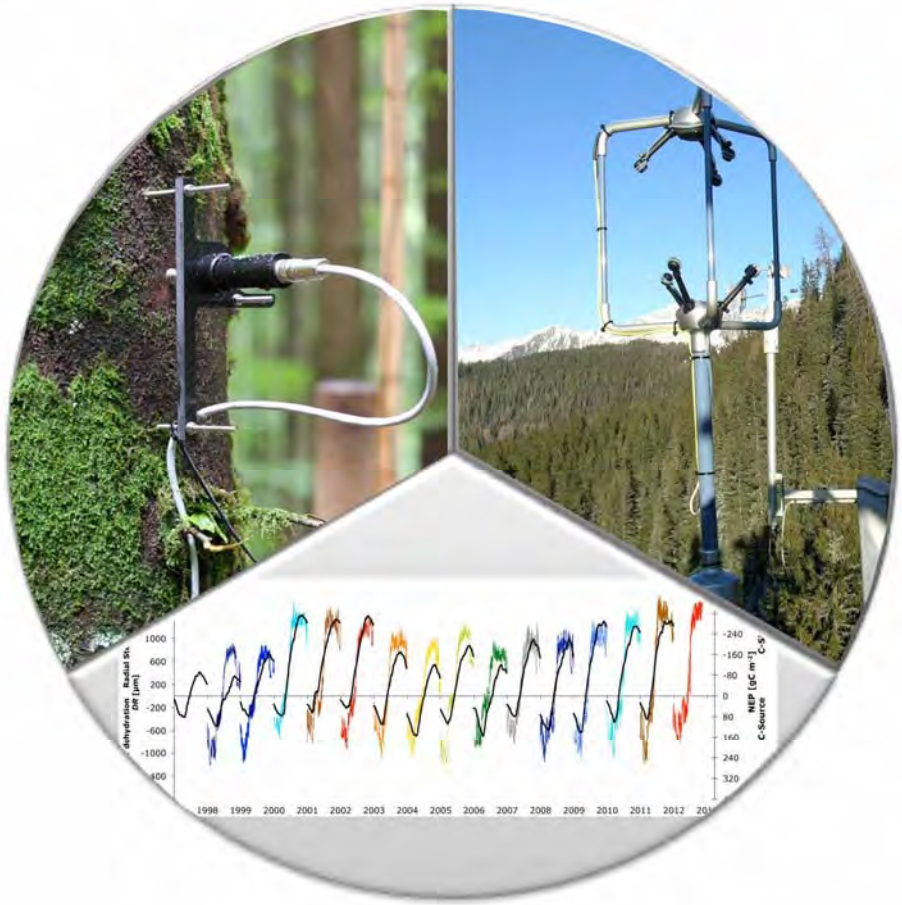
TreeNet – The smart technology behind it -> www.treenet.info



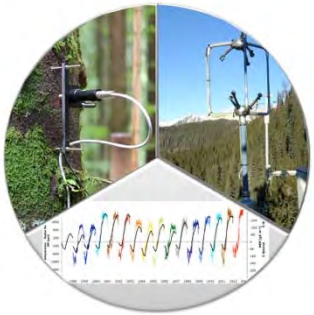
-> Measurement in the field
-> Data acquisition
-> Data transfer from the field into a data base
-> Data/infrastructure monitoring
-> Data storage, cleaning, processing and online display
-> Data download (user specific)
-> Data analysing tools

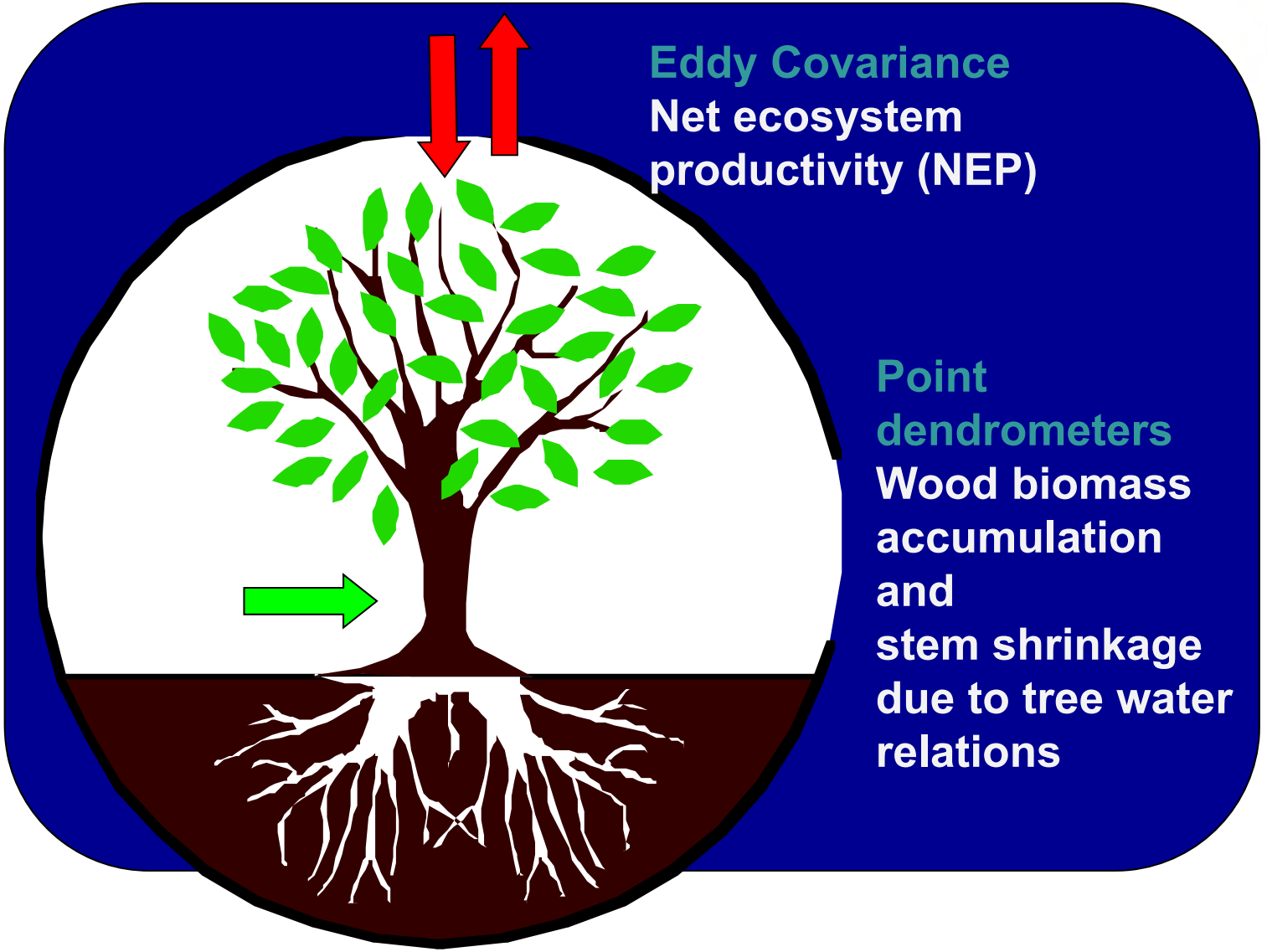
www.decentlab.com

Combining eddy covariance-based net ecosystem productivity (NEP) ...



... to dendrometer-based stem radius increments (SRI)

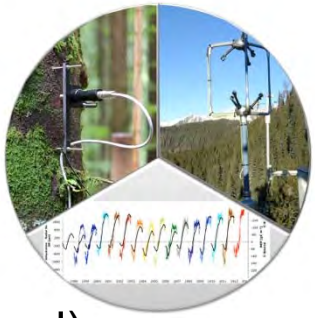




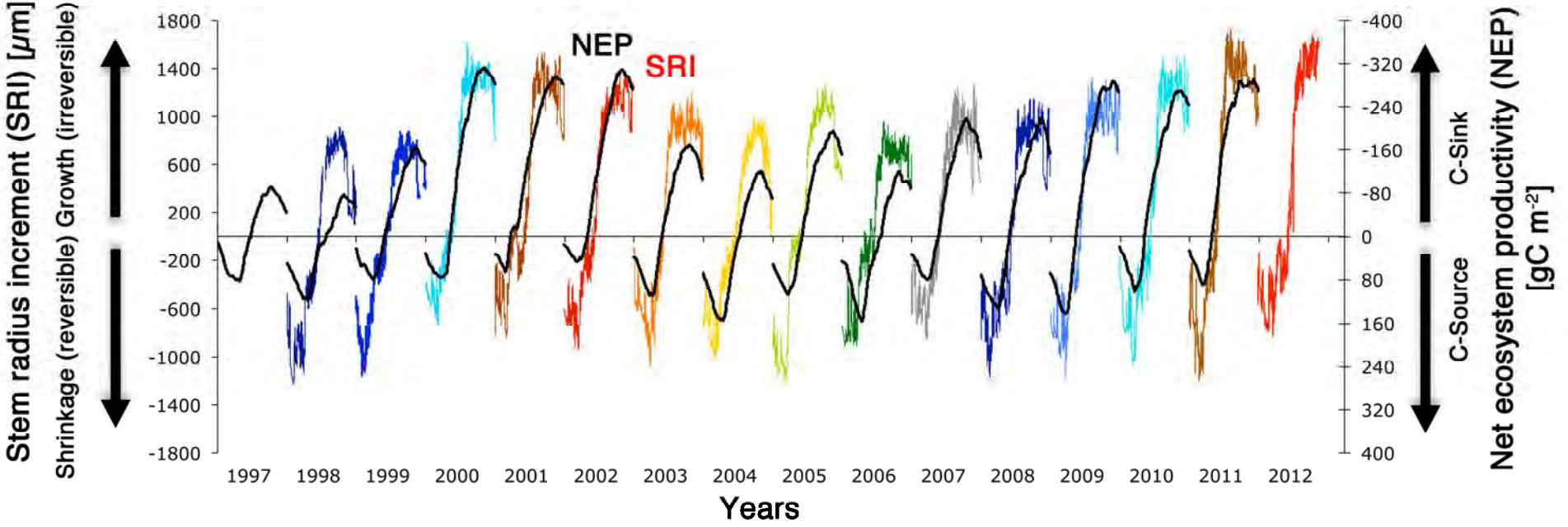
Eddy Covariance
Net ecosystem productivity (NEP)

Point dendrometers
Wood biomass accumulation and stem shrinkage due to tree water relations

Linking stem radius fluctuations (SRI) to net ecosystem productivity NEP (eddy covariance)

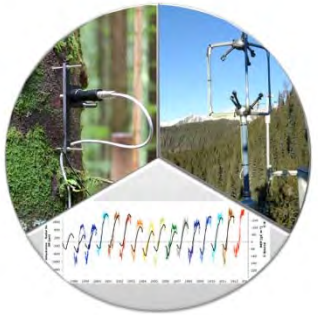


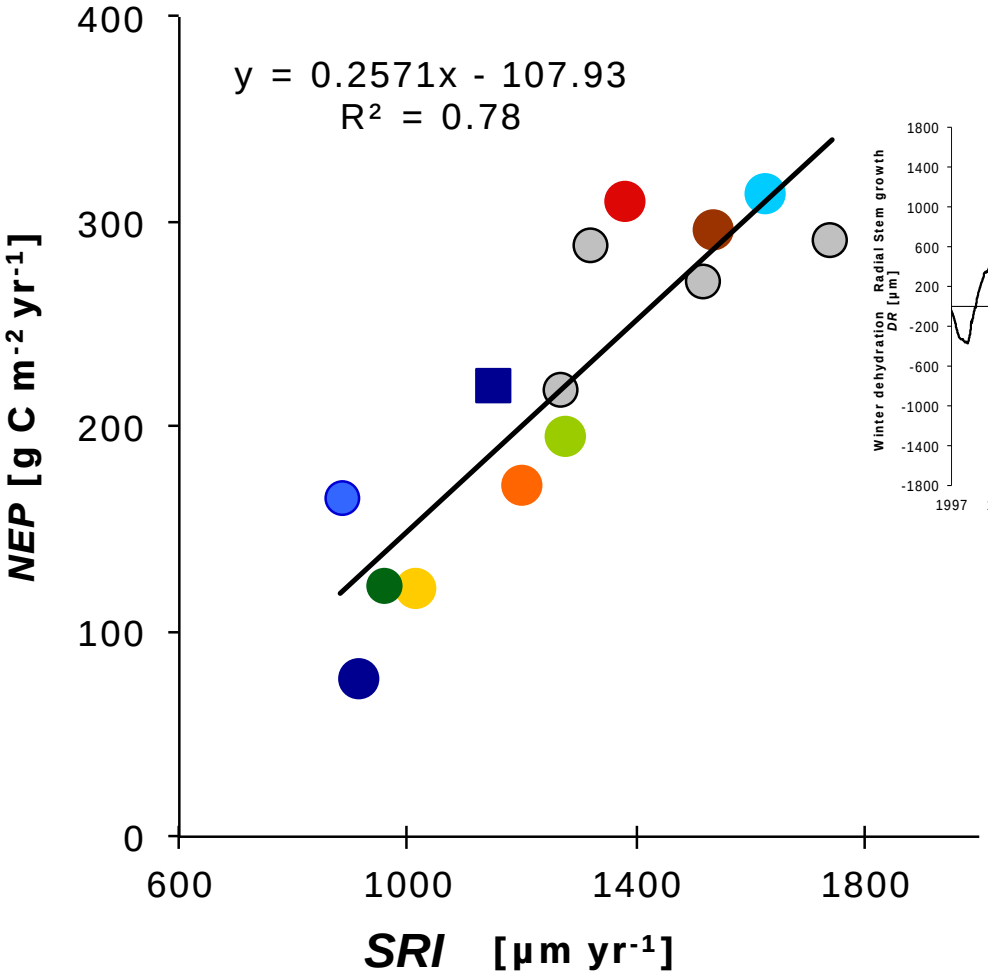
Seehornwald Davos, CH (Norway spruce forest, 1650 m asl)

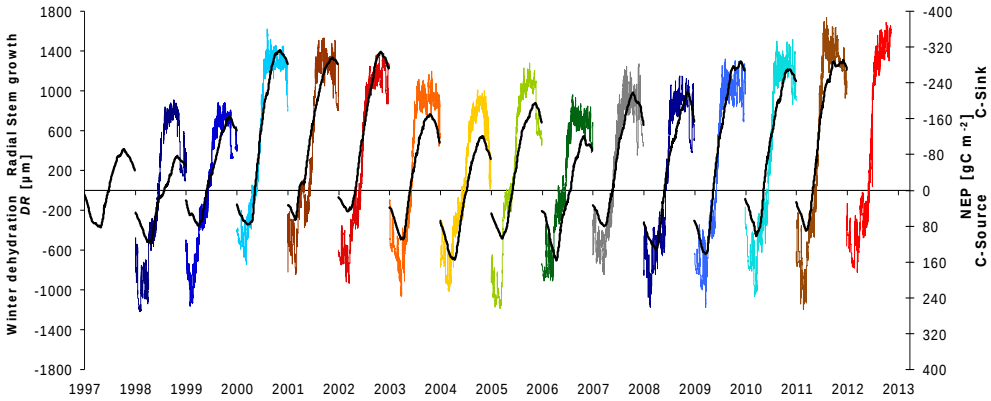


adapted from Zweifel et al. (2010), New Phytologist

Linking stem radius fluctuations (SRI) to net ecosystem productivity NEP (eddy covariance)





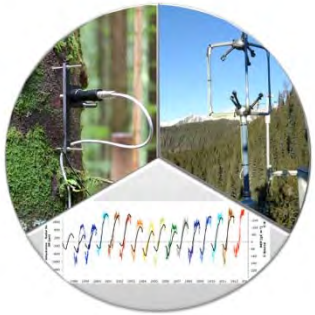


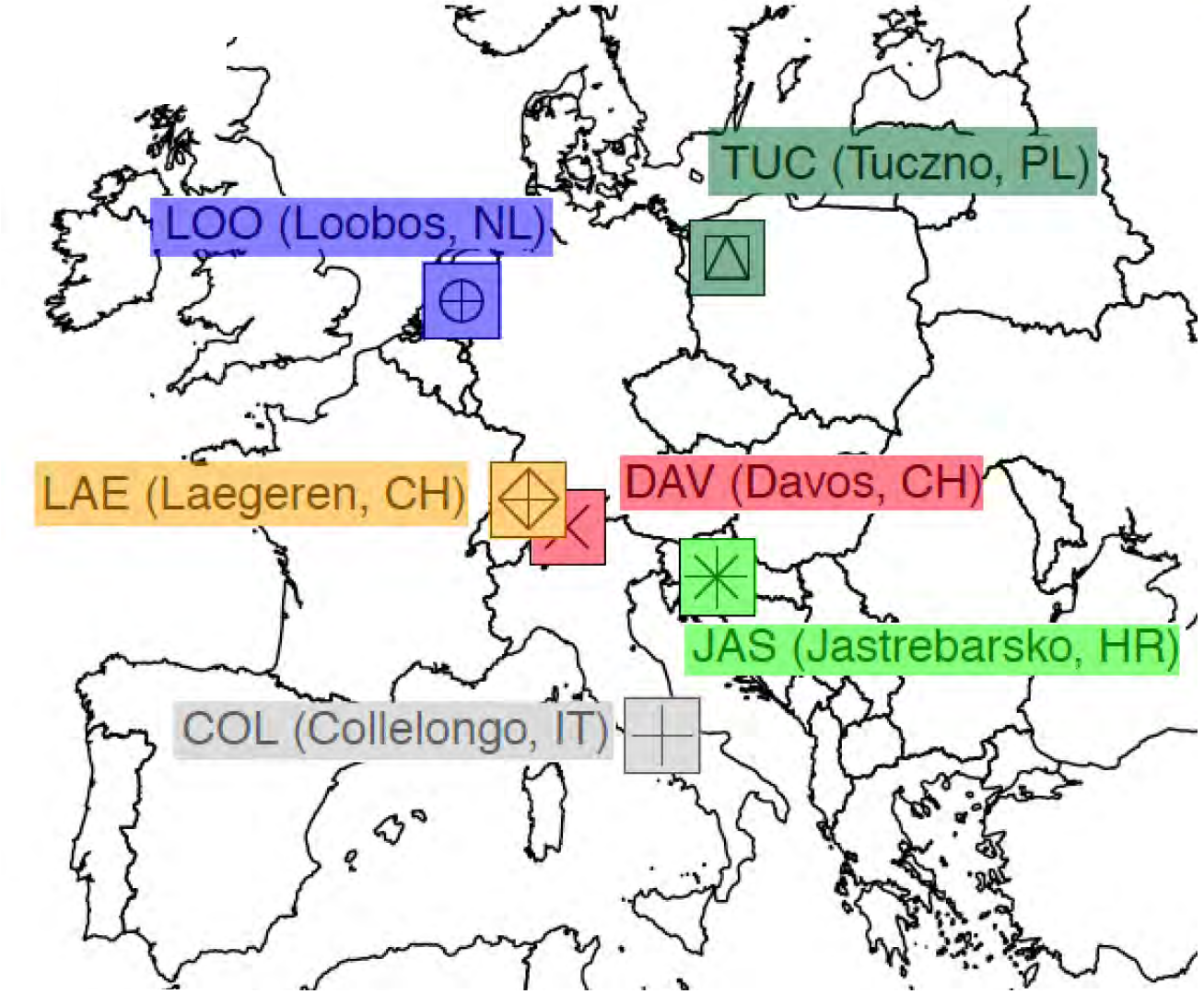
High correlation between annual values of SRI and NEP (Davos, Norway Spruce)

Potential of TreeNet to extrapolate Eddy data from two measurement points over entire CH

Zweifel et al. (2010), New Phytologist

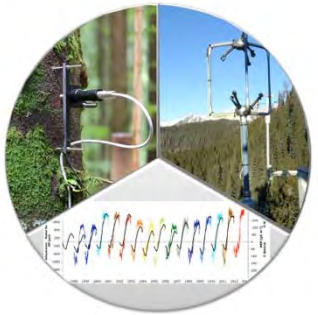
Linking stem radius fluctuations (SRI) to net ecosystem productivity NEP (eddy covariance)





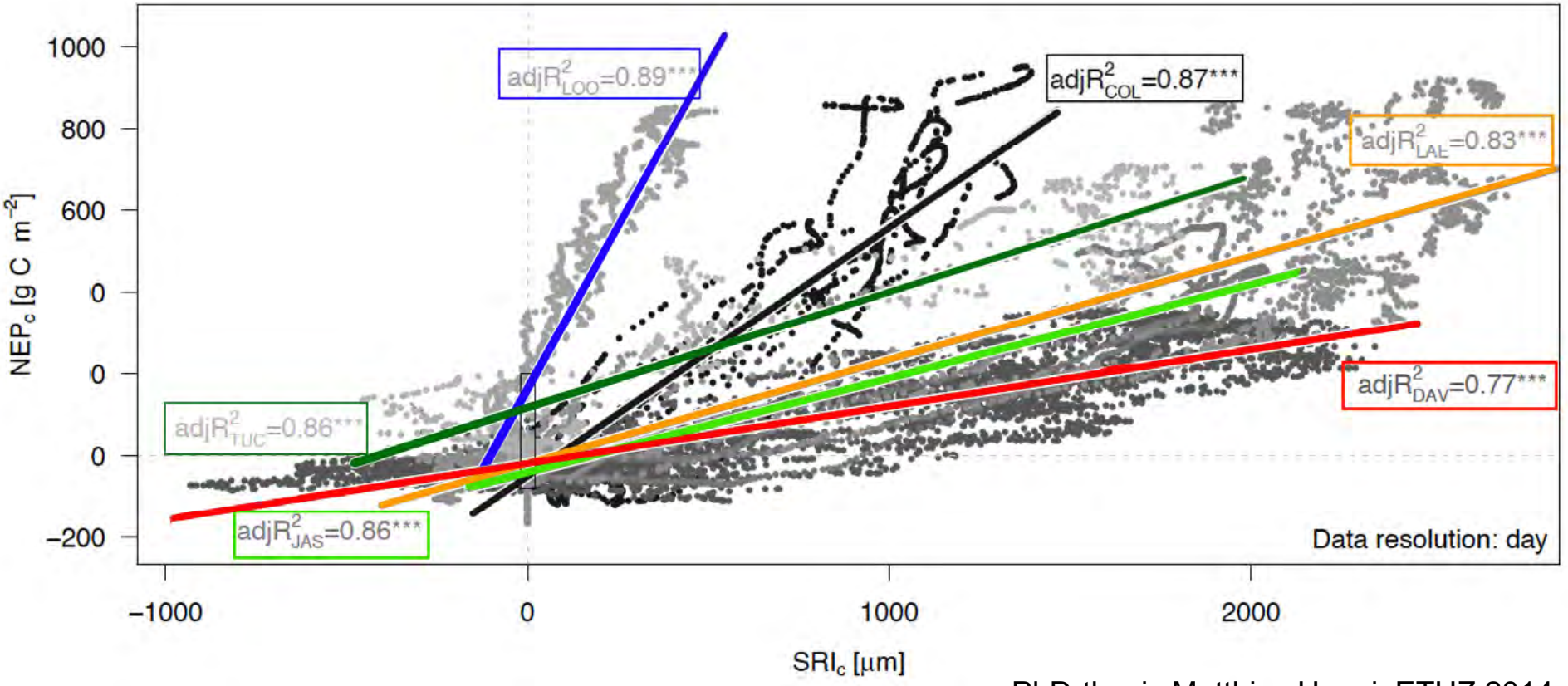
PhD-thesis Matthias Haeni, ETHZ 2014

Estimating net ecosystem productivity (NEP) from dendrometer measurements (SRI)



-> Very close relationship for all sites

-> Site-specific slope

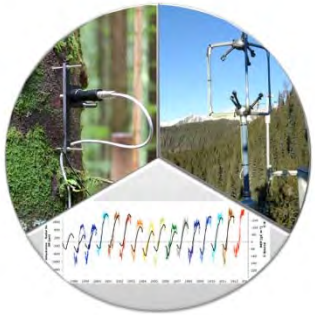


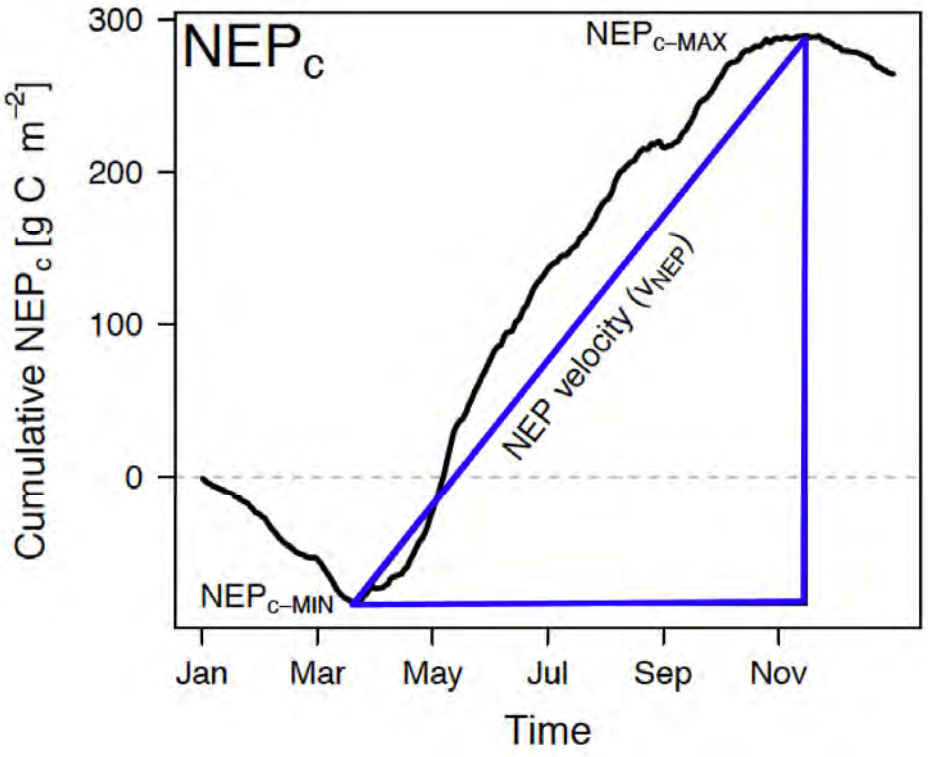
PhD-thesis Matthias Haeni, ETHZ 2014

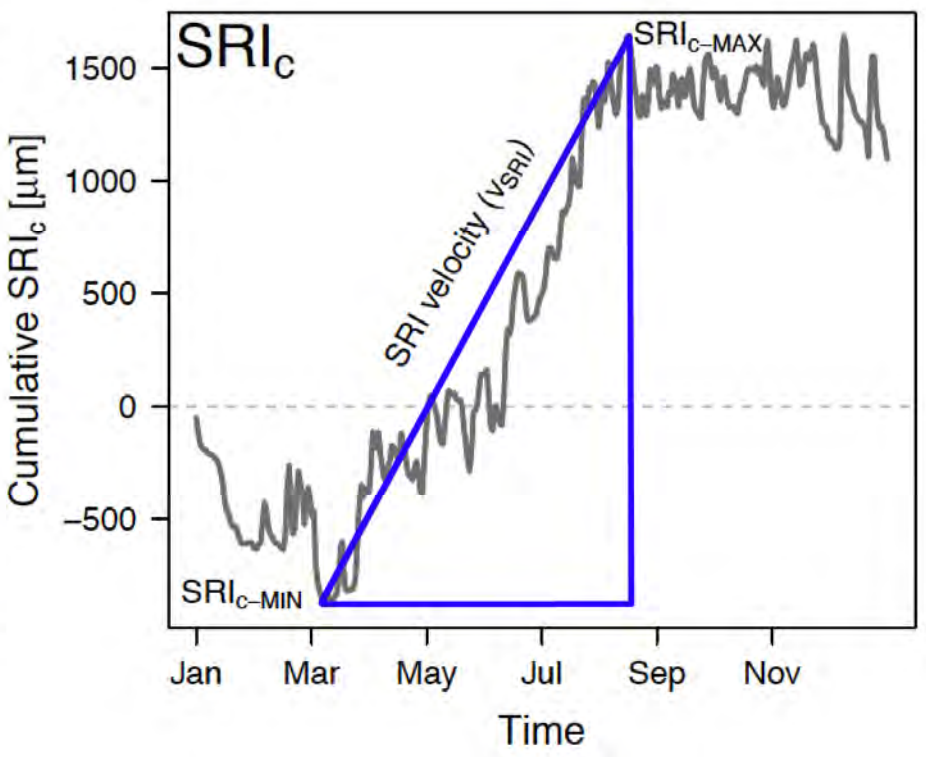
Estimating net ecosystem productivity (NEP) from dendrometer measurements (SRI)

-> Site-specific slope determinable from SRI data

-> time to grow (tg)



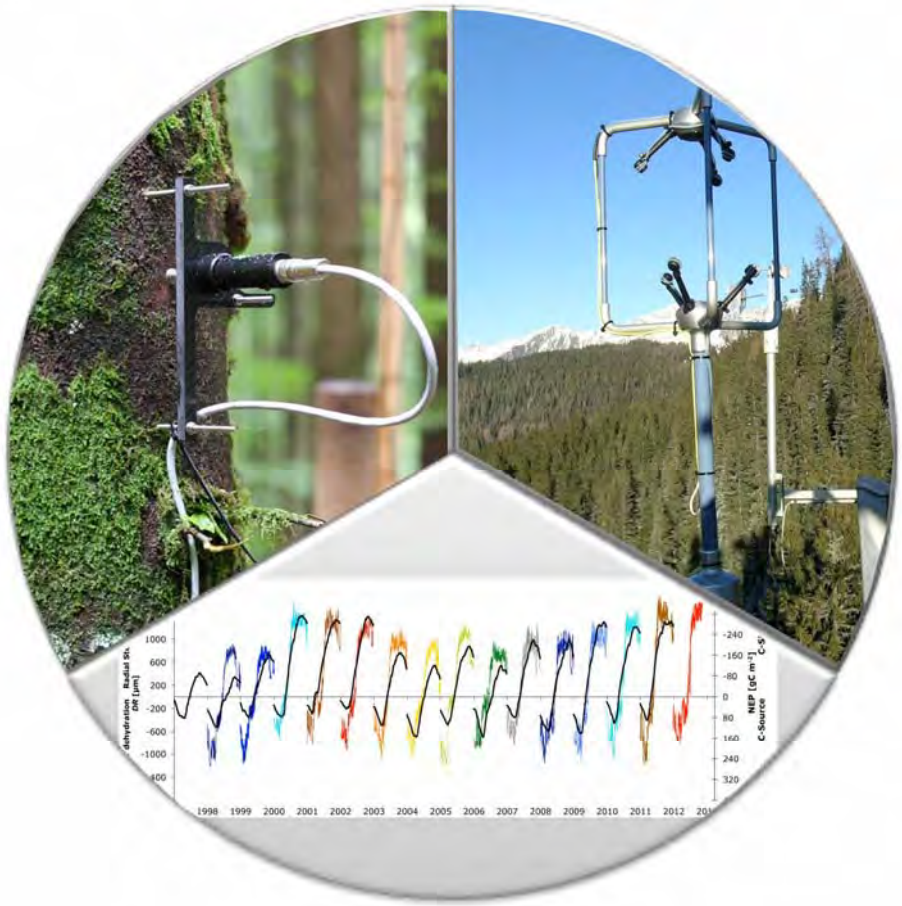




NEPc (i) = tg (SRIc) * SRIc (i)

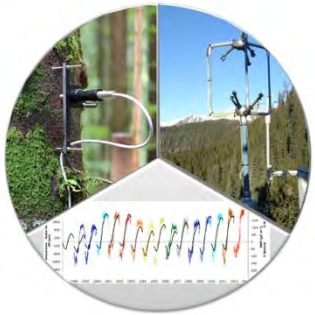
PhD-thesis Matthias Haeni, ETHZ 2014

The generally close relationship between SRI and NEP ...

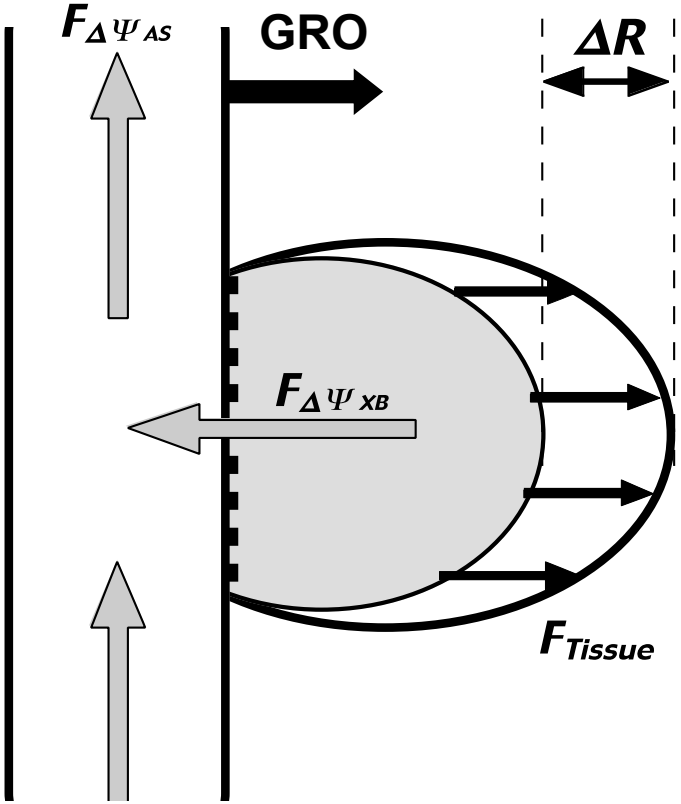


... leaves us with the question: why are some adult trees producing a (dendrometer) signal that explains the net gas exchange of the entire forest ecosystem?

Analysing stem radius fluctuations (SRI) data

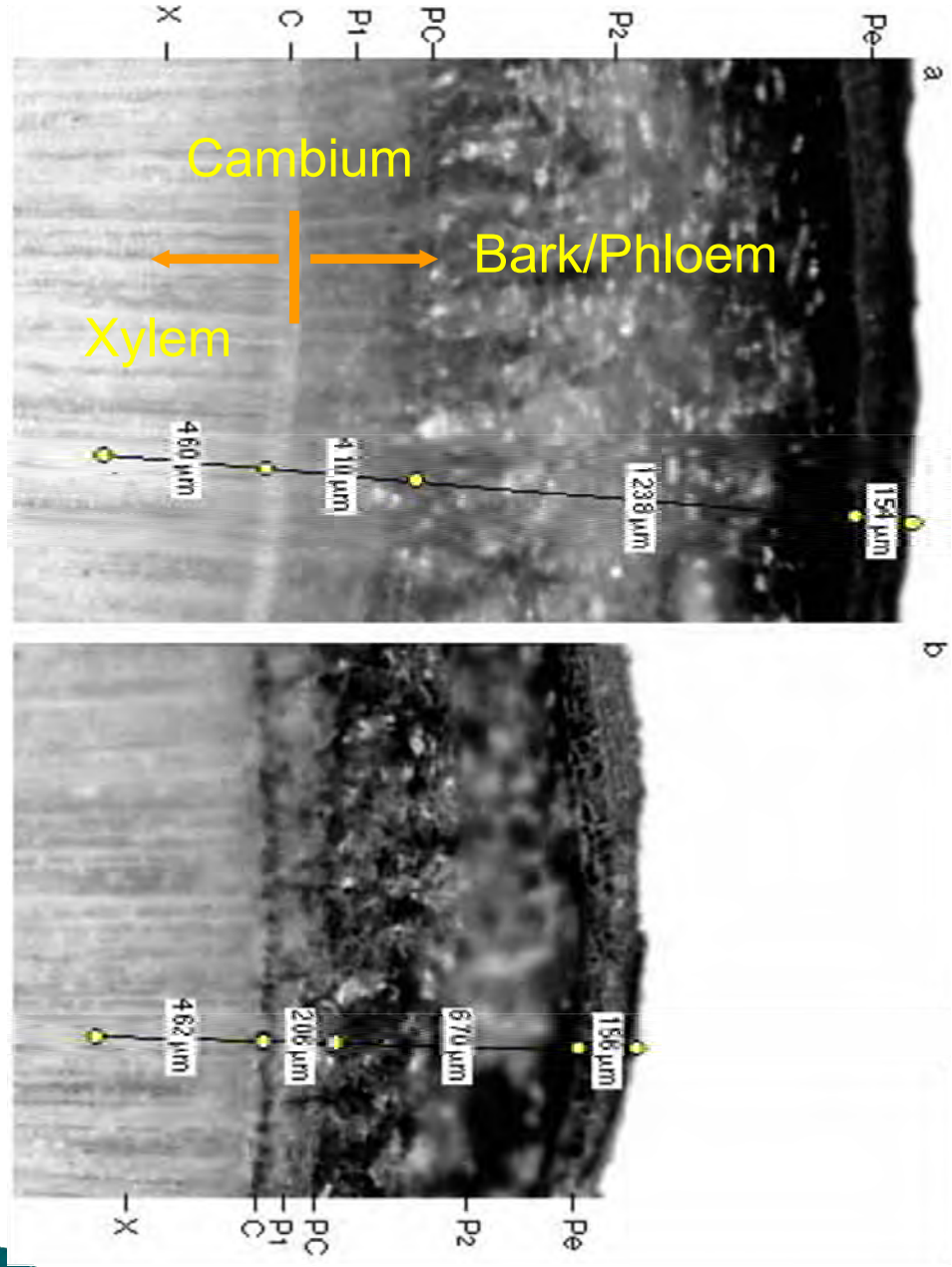


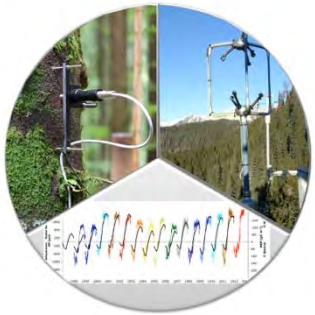
Water flow **Growth (irreversible)** **Water storage (reversible)**



Saturated tree stem

Dry tree stem



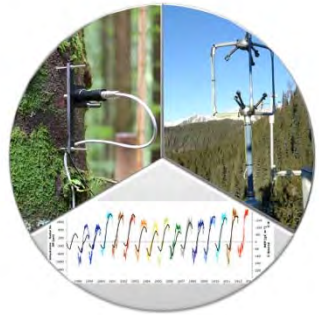


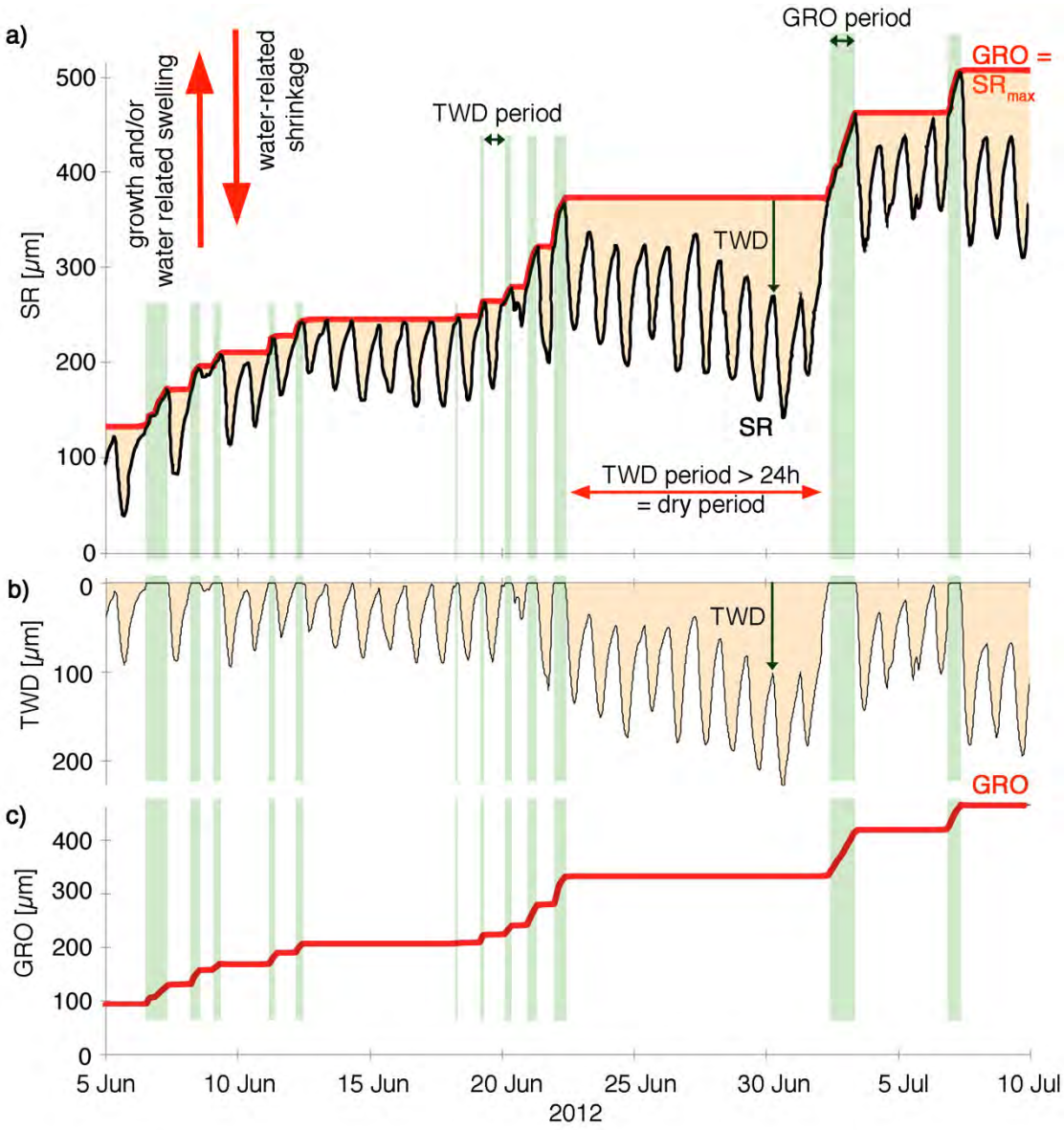
Point dendrometers measure:

- **water related shrinkage and expansion of stem (reversible)**
- **stem growth: cell division and elongation leading to new (irreversible) biomass in the wood and new (temporary) biomass in the bark**

Zweifel et al. 2000, Trees

Stem radius changes (SRI) = Growth (GRO) - Tree water deficit (TWD)



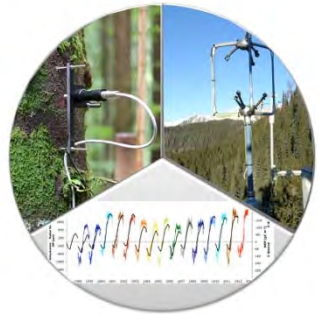


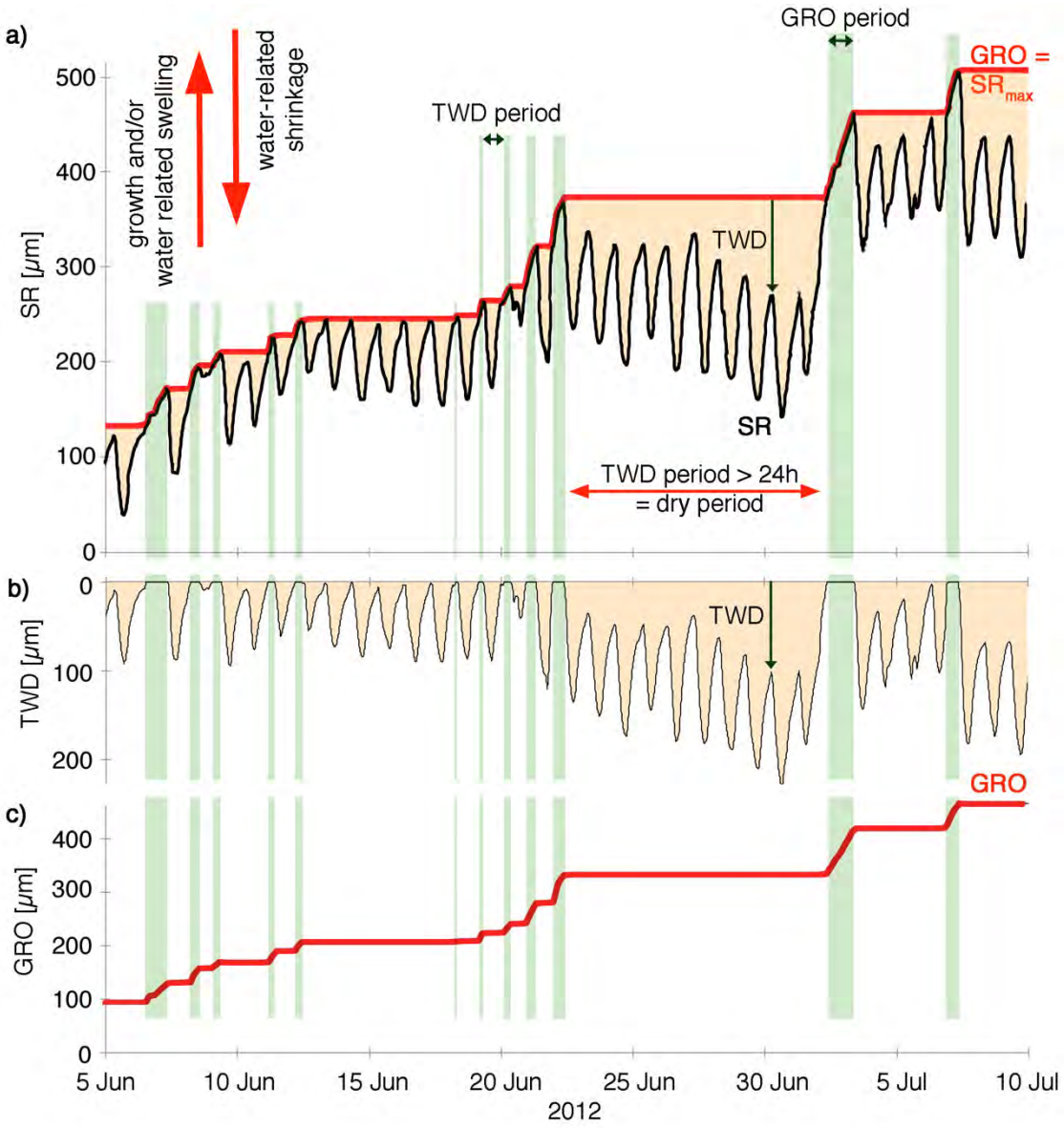
TWD is the missing water of a tree to fully saturate its tissues

Growth = cell division and cell expansion

Zweifel 2015 PCE,
Zweifel et al. 2016 New Phytologist

Stem radius changes (SRI) = Growth (GRO) - Tree water deficit (TWD)



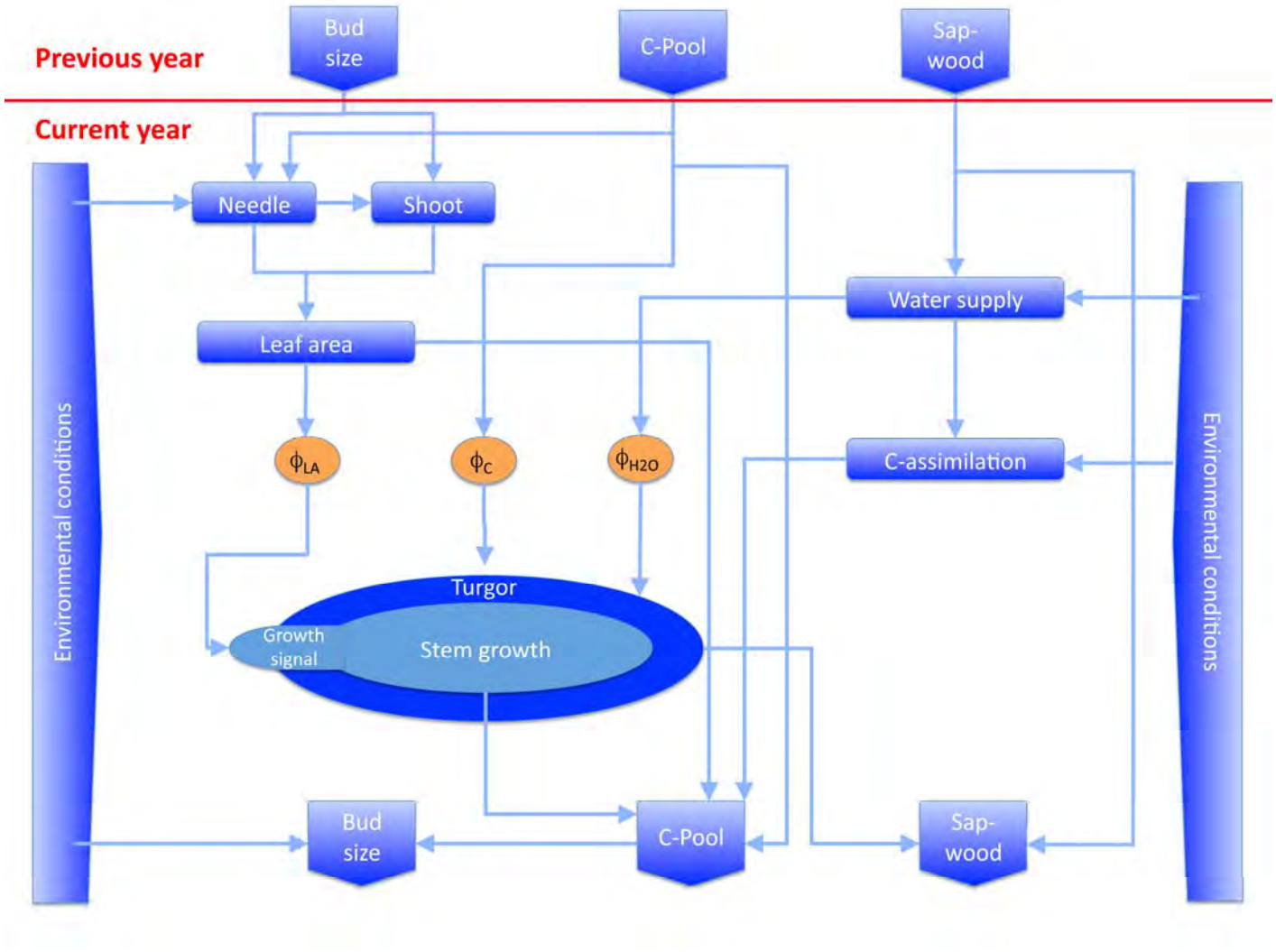


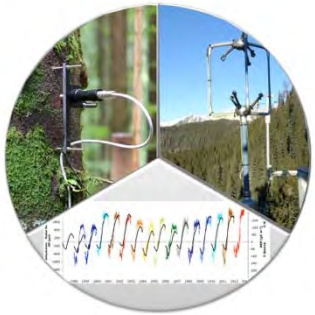
Tree rings alone explain less of NEP then SRI

(Rocha et al., 2006)

The secret lays in the bark (growth and reversible shrinking processes)

Timing of growth





Current year conditions are not fully explaining SRI and NEP

Carry-over effects (time lags) play an important role in determining SRI and NEP

Zielis et al., 2014
Gough et al., 2008



Take home message ...

... consistently close link between stem radius increments (SRI) and net ecosystem productivity (NEP)

... SRI consists of growth and tree water relations

... both seems to be important for the close relationship between SRI and NEP -> the secret lays in the bark

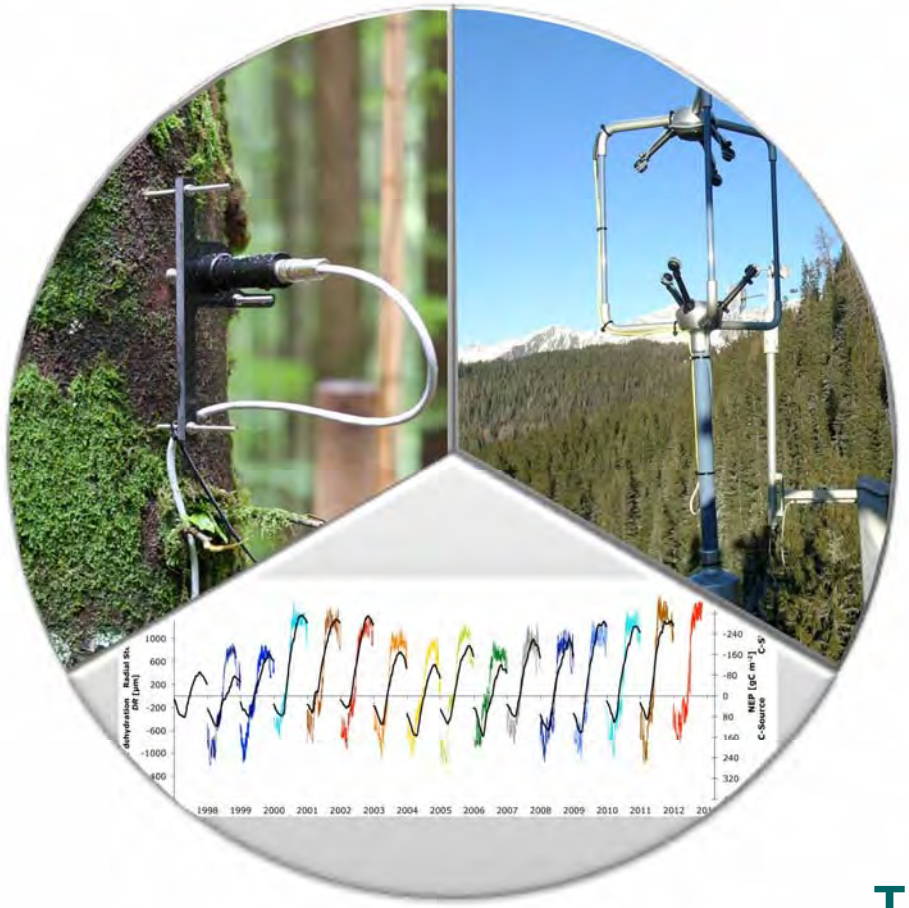
... carry-over effects determine SRI and NEP -> indirect coupling

... underlying mechanisms not fully understood yet

... great chance to up-scale results from carbon flux sites to entire landscapes with the help of SRI

... visit www.treenet.info

Do you offer data sets combining NEP and SRI?



Thank you for the attention

Table 1 Regression analyses for stem radius changes (DR) vs net ecosystem productivity (NEP), gross primary production (GPP) and total ecosystem respiration (TER) on three different time scales

	NEP	NEP	GPP	GPP	TER	TER	DR	DR
	adj. R^2	P	adj. R^2	P	adj. R^2	P	adj. R^2	P
Analyses on a half-hourly time scale								
$DR_{hh}(I)^a$	0.59	< 0.0001***	0.65	< 0.0001***	0.01	0.21	–	–
$DR_{hh}(II)^a$	0.43	< 0.0001***	0.52	< 0.0001***	0.00	0.28	–	–
$DR_{hh}(III)^a$	0.25	< 0.001***	0.31	< 0.001***	0.00	0.28	–	–
$DR_{hh}(IV)^a$	0.12	0.008**	0.15	0.003**	0.00	0.28	–	–
$DR_{hh}(V)^a$	0.00	0.30	0.00	0.35	0.00	0.31	–	–
Analyses on a monthly time scale								
DR_m	0.35	< 0.0001***	0.47	< 0.0001***	0.30	< 0.0001***	–	–
$DR_{m\ (without\ May)}$	0.53	< 0.0001***	0.53	< 0.0001***	0.31	< 0.0001***	–	–
Analyses on an annual time scale								
DR_{yr}	0.85	< 0.001***	0.35	0.03*	0.04	0.27	–	–
Analyses comparing specific periods and dates with annual measures								
MSC	0.27	0.06	–0.03	0.41	0.04	0.26	0.40	0.02*
DOY_{comp_MSC}	0.39	0.02*	0.01	0.32	0.08	0.21	0.37	0.03*
WRES	0.51	0.01**	–0.02	0.38	0.22	0.08	0.38	0.03*
DOY_{comp_WRES}	0.88	< 0.001***	0.51	0.01**	–0.08	0.65	0.76	< 0.0001***
CSP	0.18	0.1	0.57	< 0.001***	0.25	0.05*	0.04	0.25
RWG period	–0.08	0.64	–0.09	0.72	–0.11	0.9	–0.10	0.73

Data of half-hourly time scales are grouped into five classes of days: I, sunny summer days; II, cloudy summer days; III, rainy summer days; IV, winter days with average temperature > 0°C; V, winter days with average temperature < 0°C. Maximum stem contraction (MSC), maximum cumulative winter respiration (WRES), day of year when MSC (DOY_{comp_MSC}) and WRES (DOY_{comp_WRES}) are compensated, carbon sink period (CSP), radial wood growth (RWG) period. Significant negative correlations are marked in grey (*$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$). [a]Adj. R^2 and P were calculated separately for each day, and the median of the frequency distribution of all adj. R^2 and P per class for the years 1998–2008 is shown.

Seehornwald Davos (CH-DAV)