



Water, gravity and trees: Relationship of tree-ring widths and total water storage dynamics

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27 Apr. 2012

Water resources



Observations of past are necessary to improve:

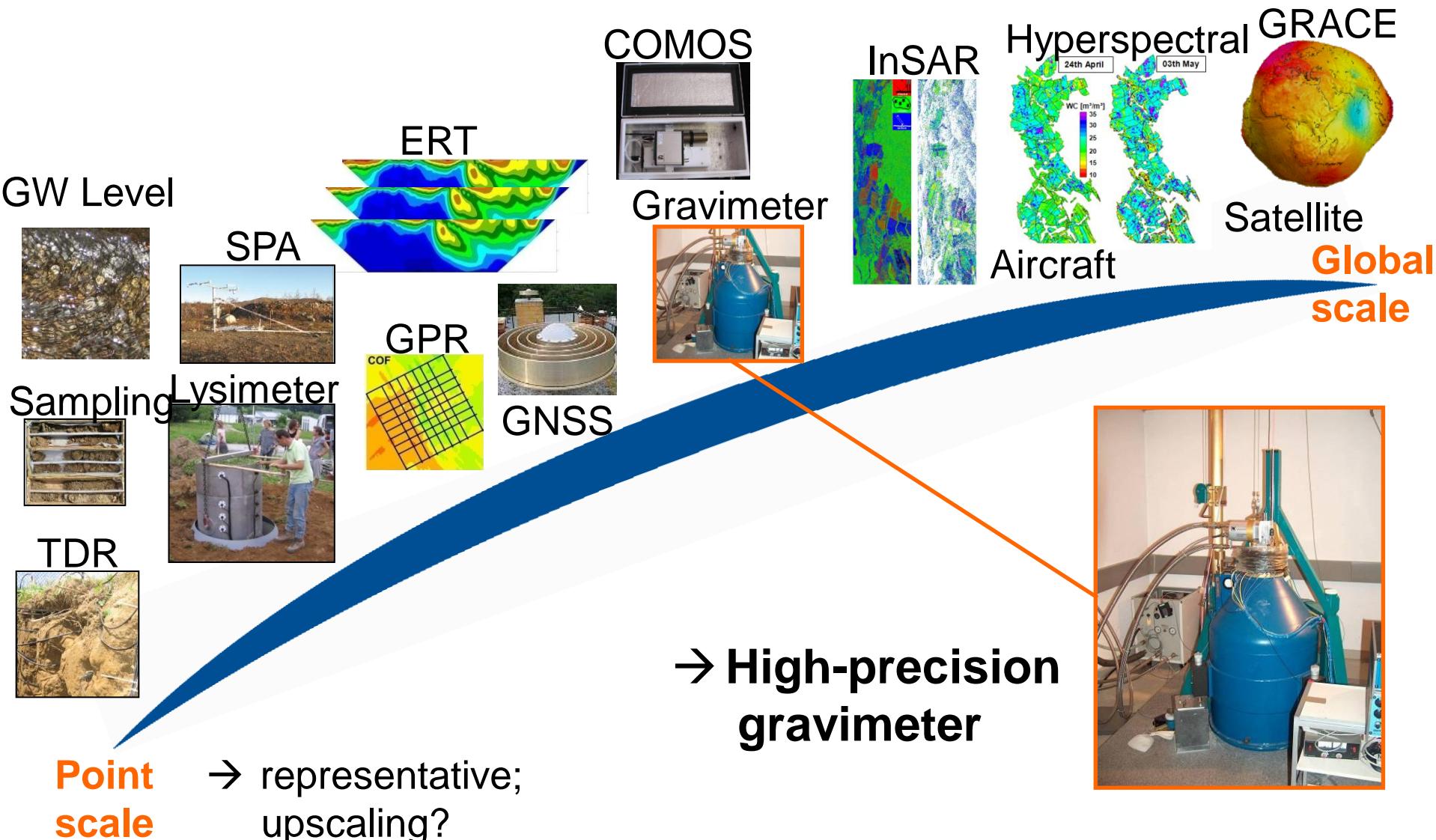
- the understanding of the **environmental system**
- the prediction of **future developments**
- more **efficient use** of the resource water

Water stored in the subsurface is an important fresh water source:

- drinking water
- food production
- natural vegetation

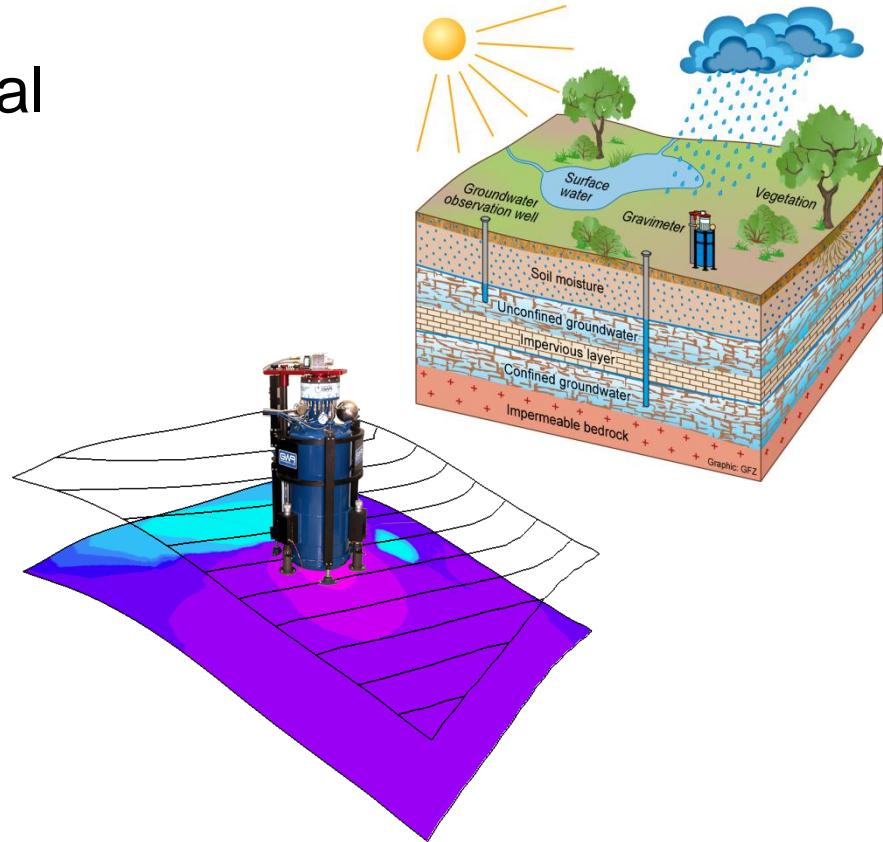


Estimation of (subsurface) water storage

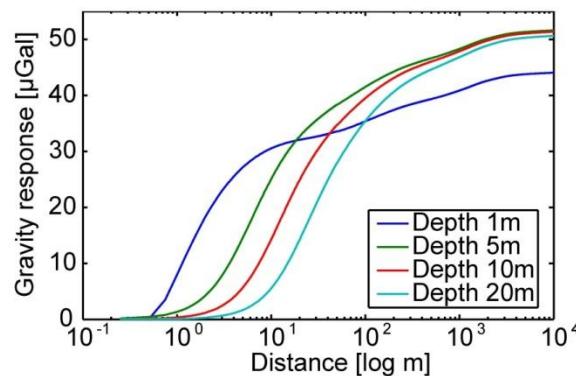


High-precision gravimeter

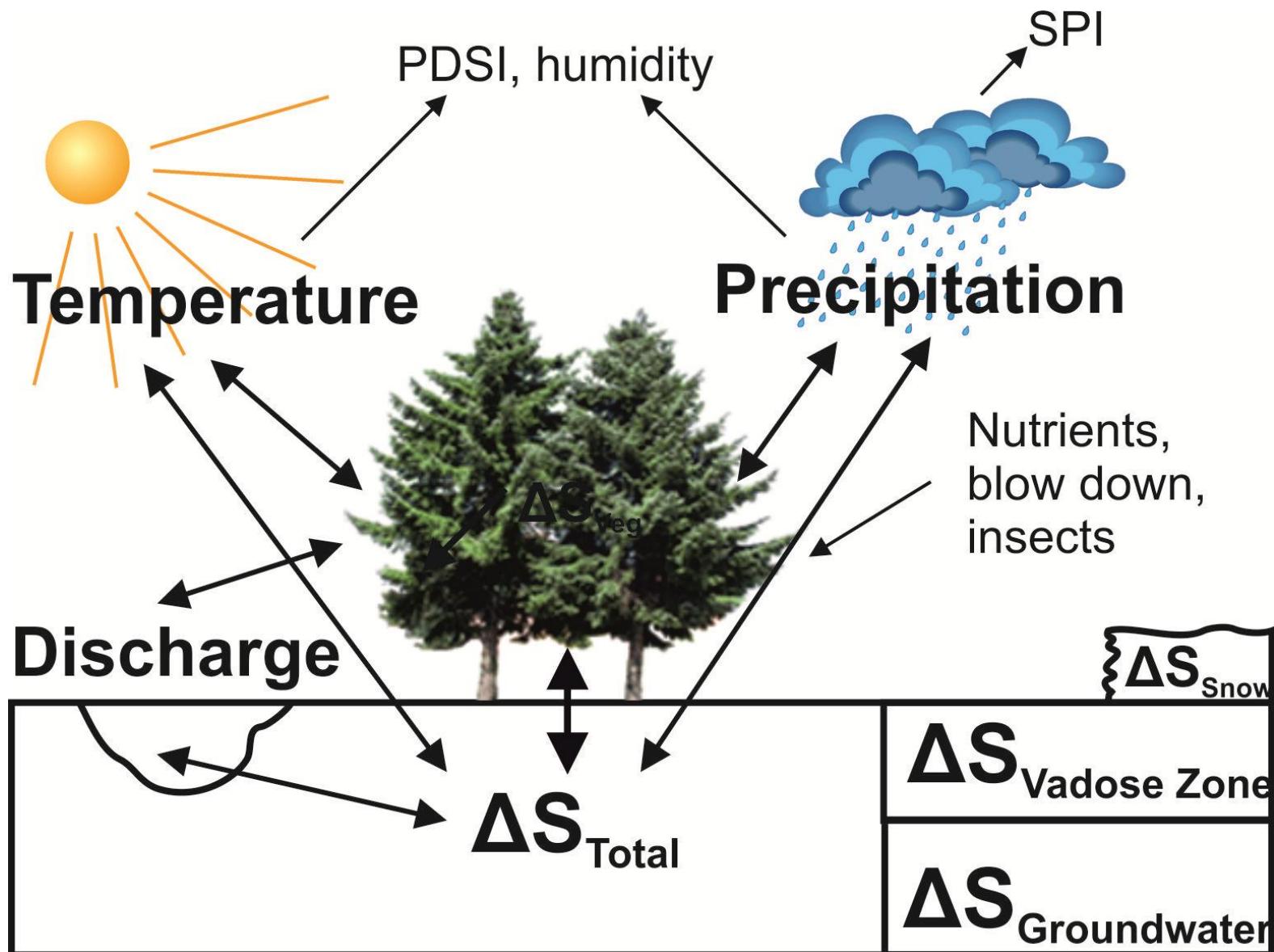
- integral signal of the hydrological system: snow, soil moisture, groundwater, ...
- the exploration of subsurface water storage change.
- intermediate scale



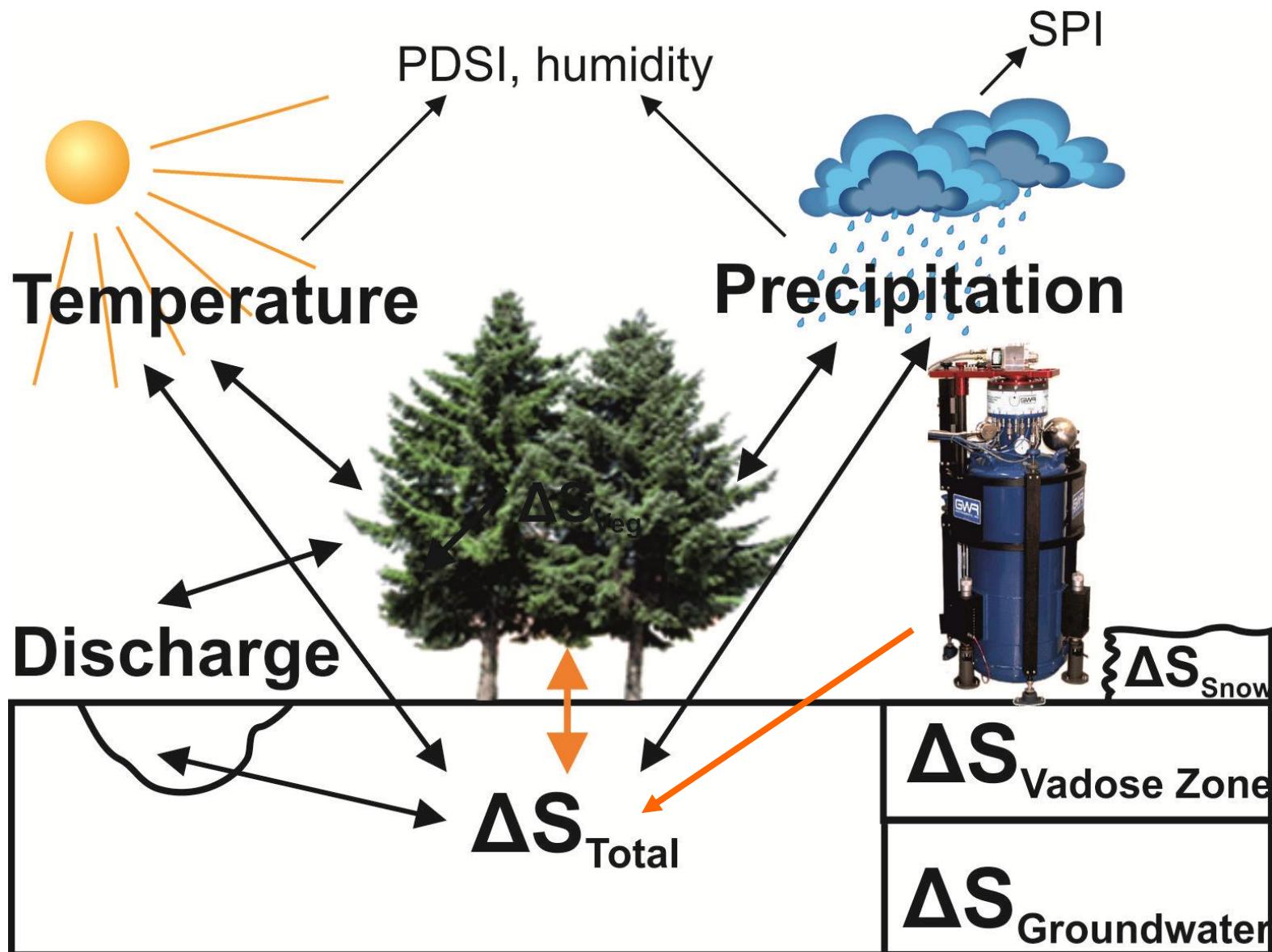
→ Relatively short time series available



Tree rings: archive of the environment



Tree rings: archive of the environment



Study site: Geodetic Observatory Wettzell

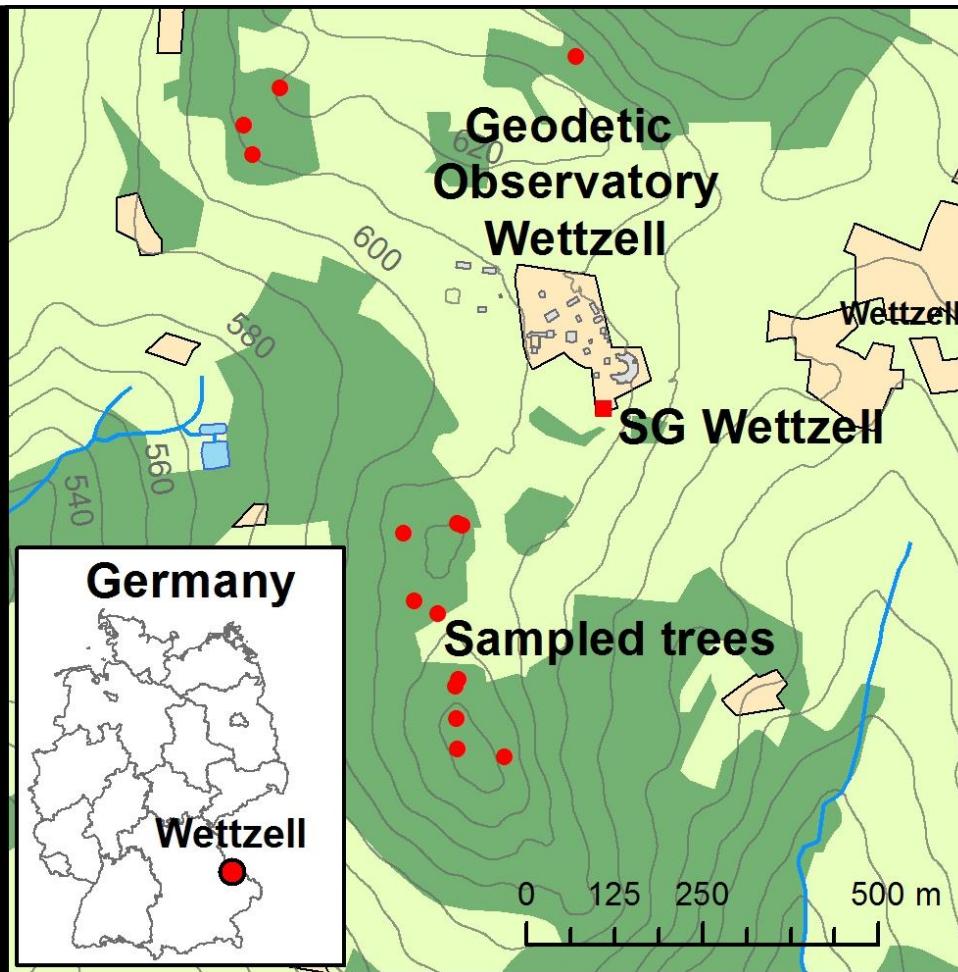
Location:
- Bavarian forest

Climate:
- MAP: 850 mm
- MAT: 7 °C

Landuse:
- Grassland

Soil:
- Cambisols

Geology:
- Gneiss

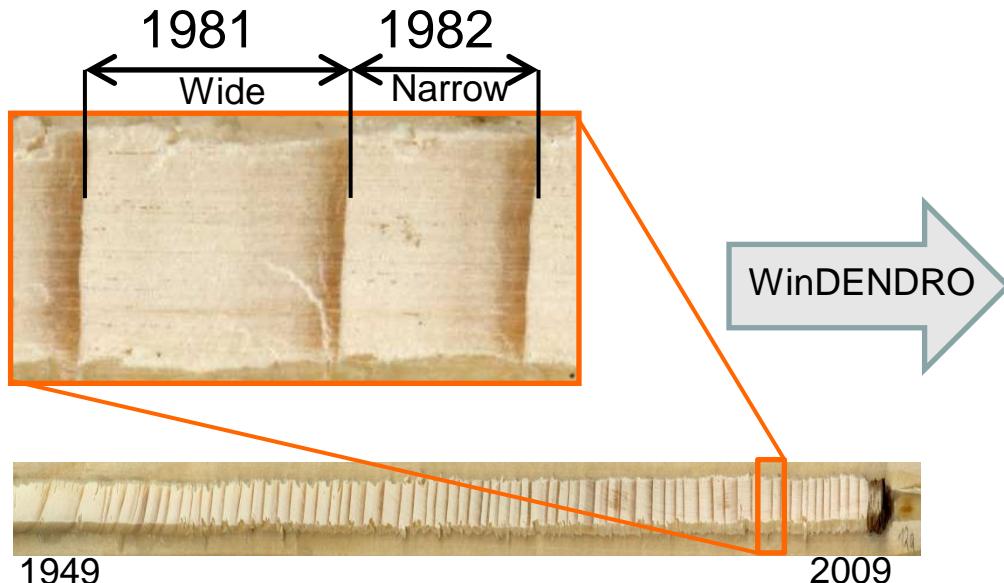


14 Spruces
26 core samples

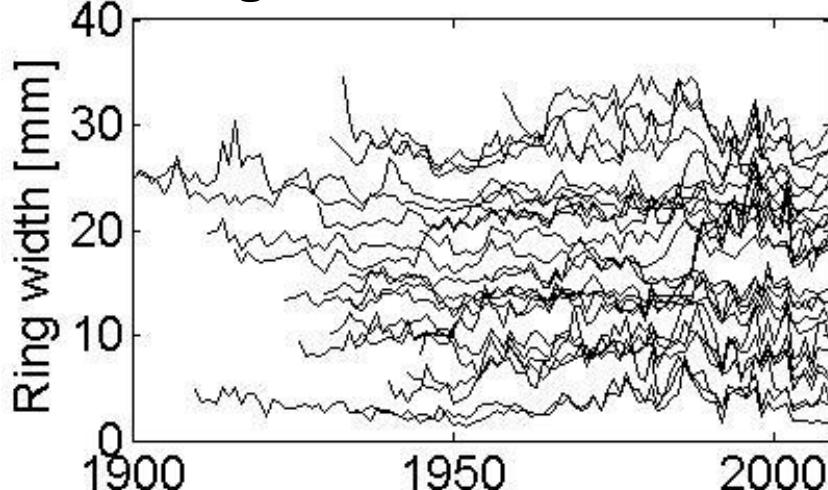


The Geodetic Observatory Wettzell is operated by the
Federal Agency for Cartography and Geodesy (BKG)

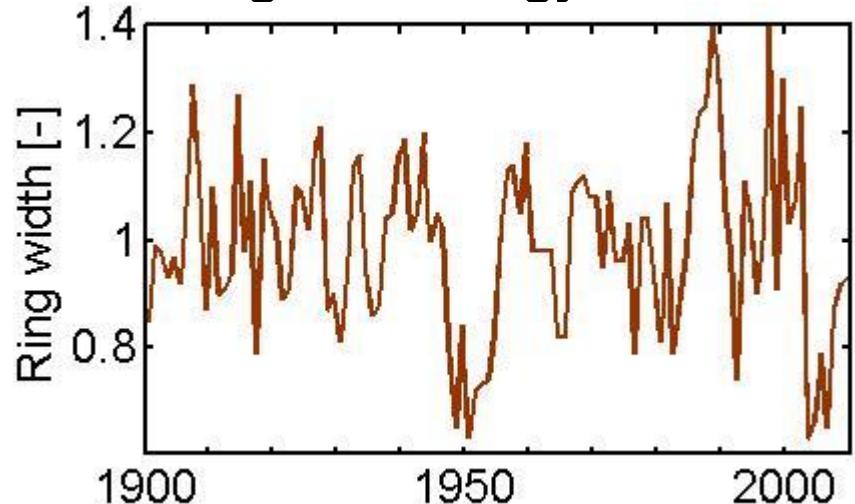
Tree ring processing



Tree ring width



Tree-ring chronology



Cross-dating/quality check:

- Series Intercorrelation: 0.57
- mean average sensitivity: 0.25

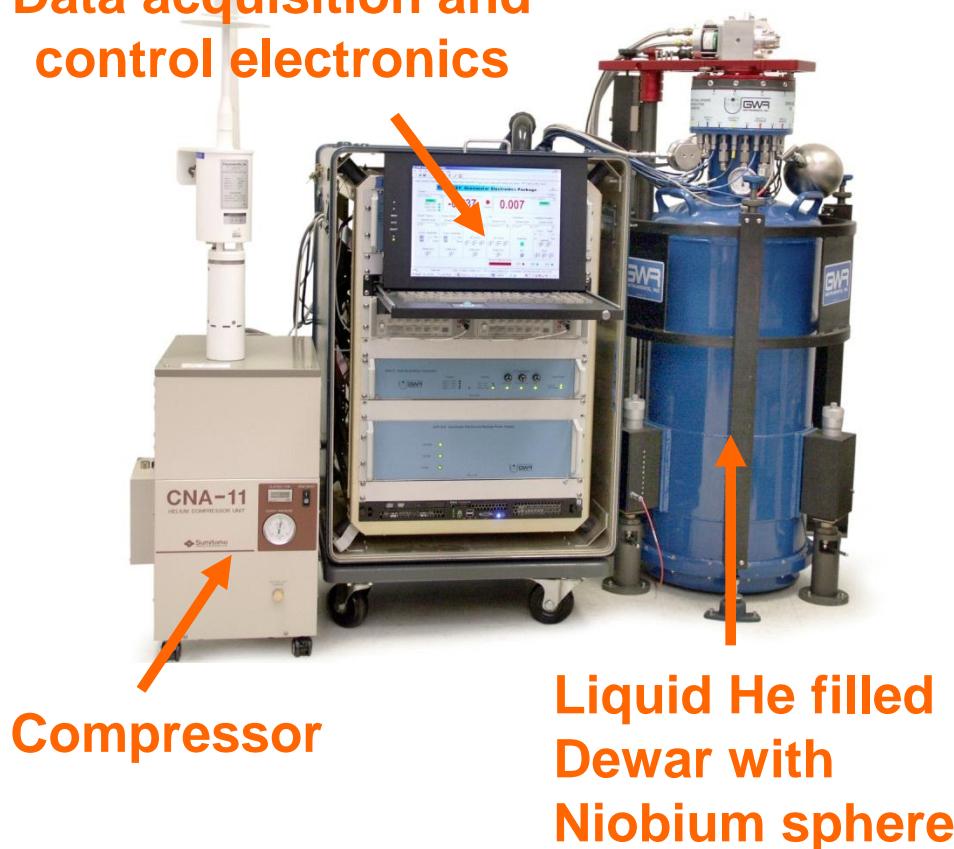
COFECHA and ARSTAN

Detrending, standardizing and removal of endogenous disturbances

Superconducting gravimeter (SG)

SG measure the variation of the Earth's gravity field [Gal]: $\rightarrow 1 \mu\text{Gal} = 10^{-8} \text{ m/s}^2$

Data acquisition and control electronics

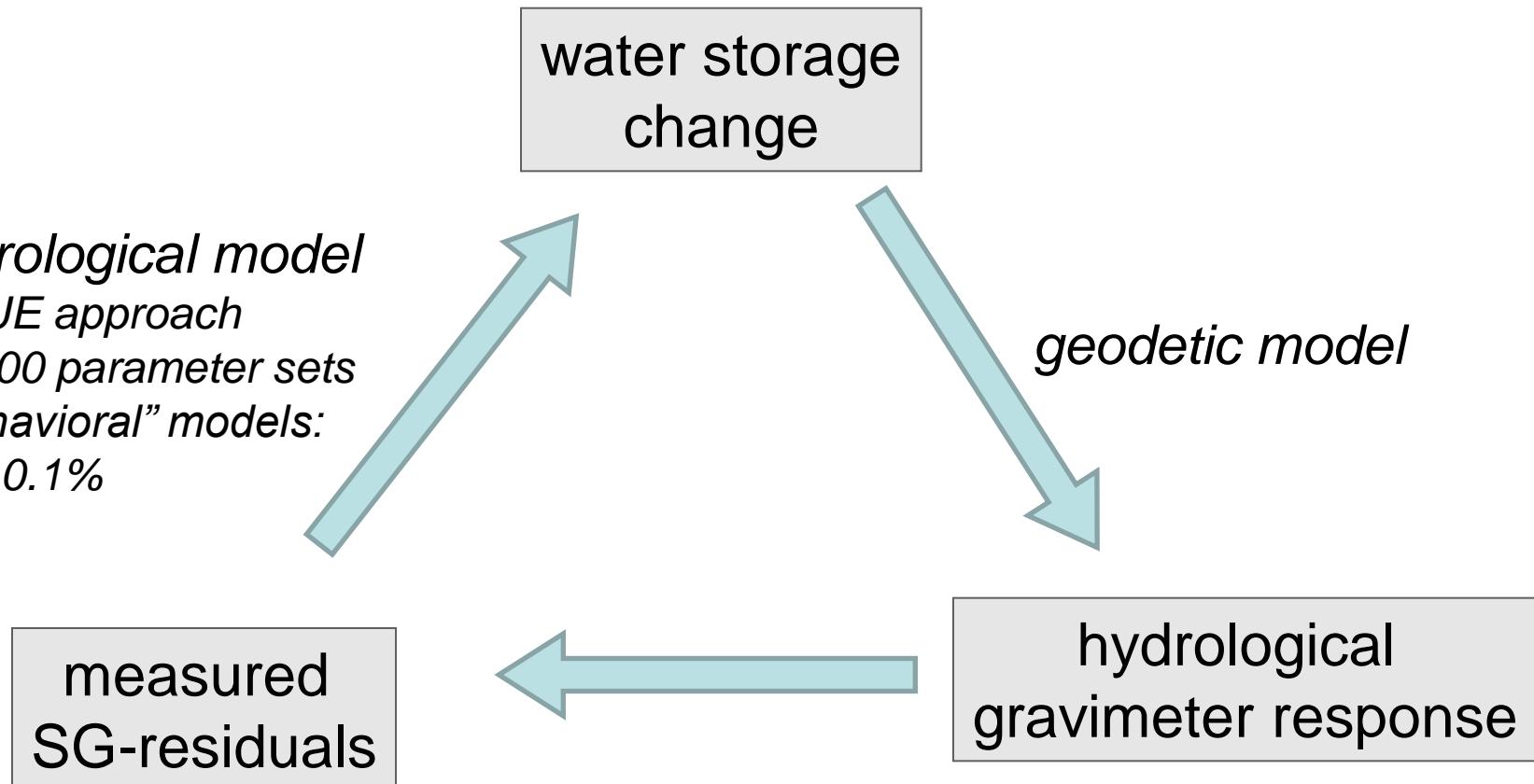


SG data processing:

- solid Earth tides
 - ocean tide loading
 - polar motion
 - atmospheric effects
- modelled and removed
- remaining signal: 'SG residuals'
- SG residuals mainly caused by water storage changes

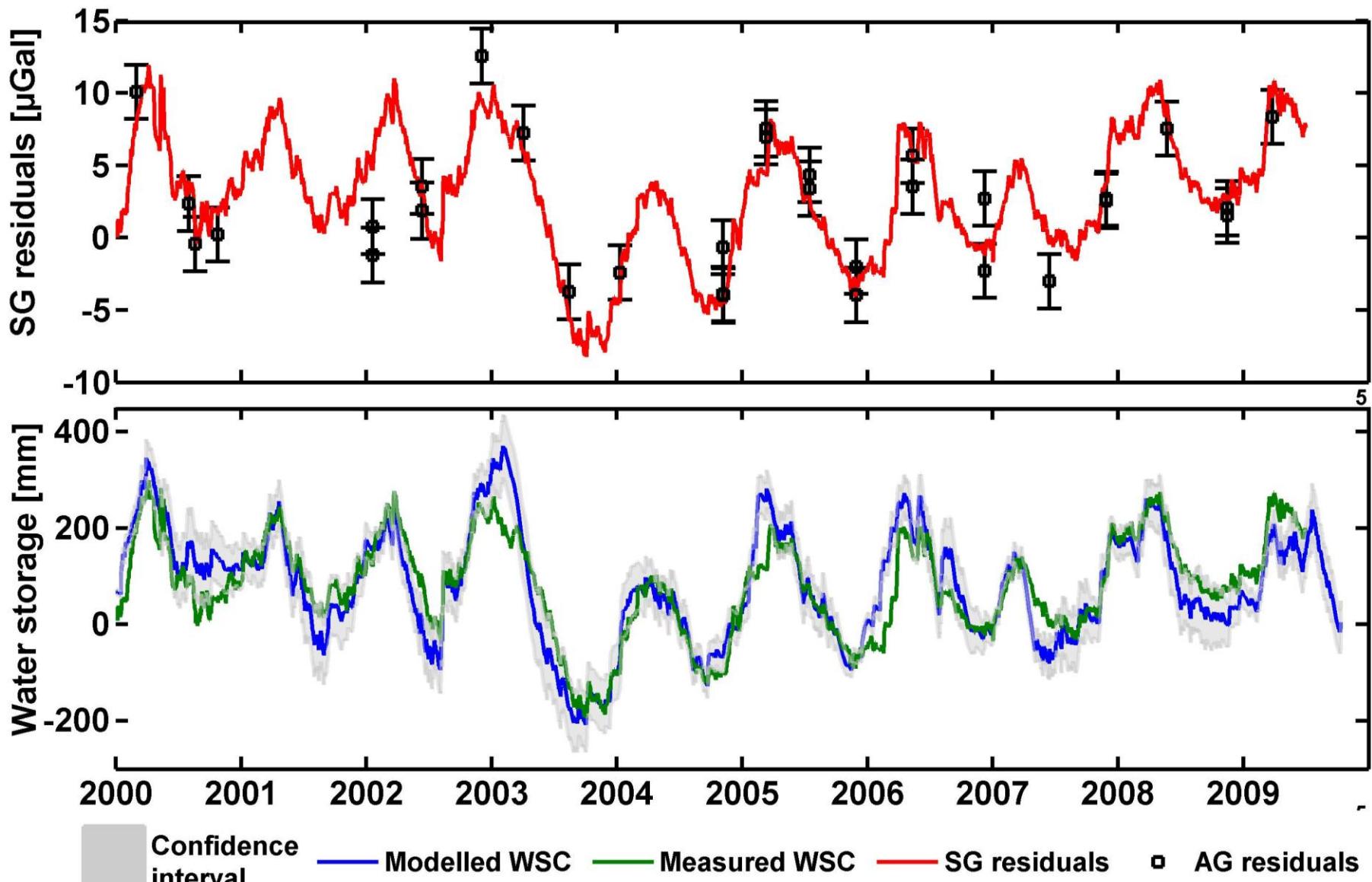
Interpretation of gravity measurements

→ Coupled hydrogeophysical inversion



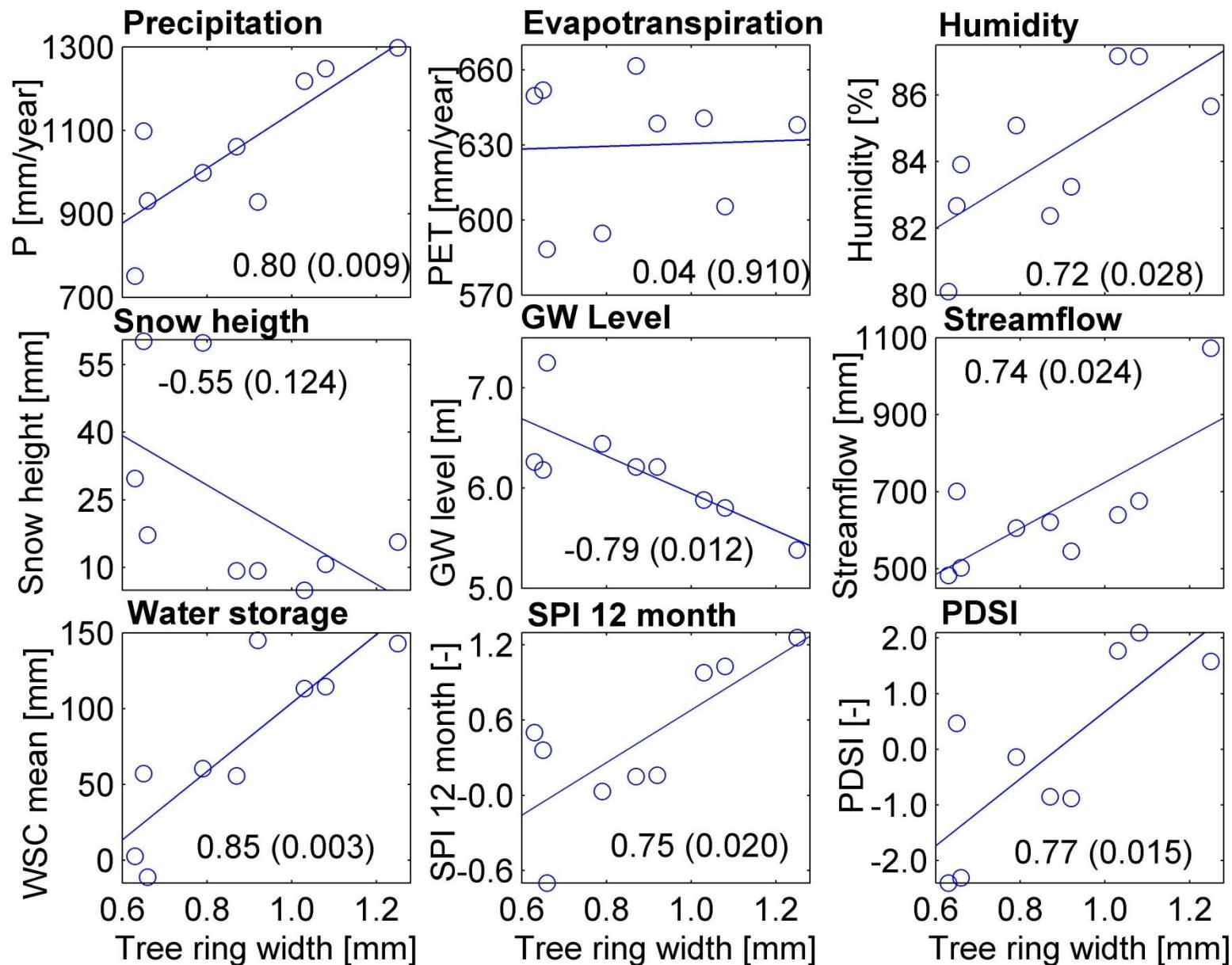
Creutzfeldt et al., 2010 (HESS)

Total water storage change

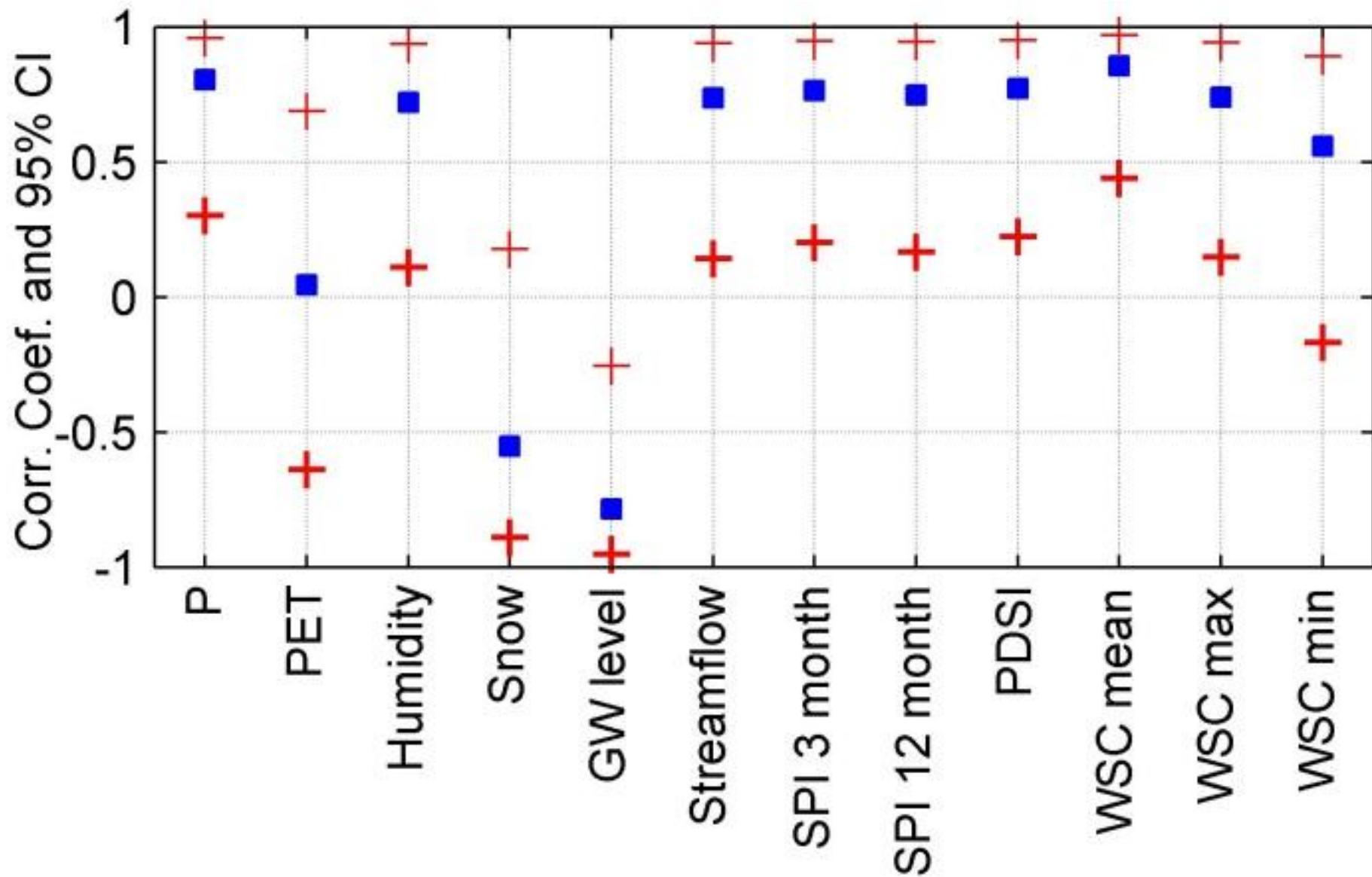


Creutzfeldt et al., 2012 (JGR)

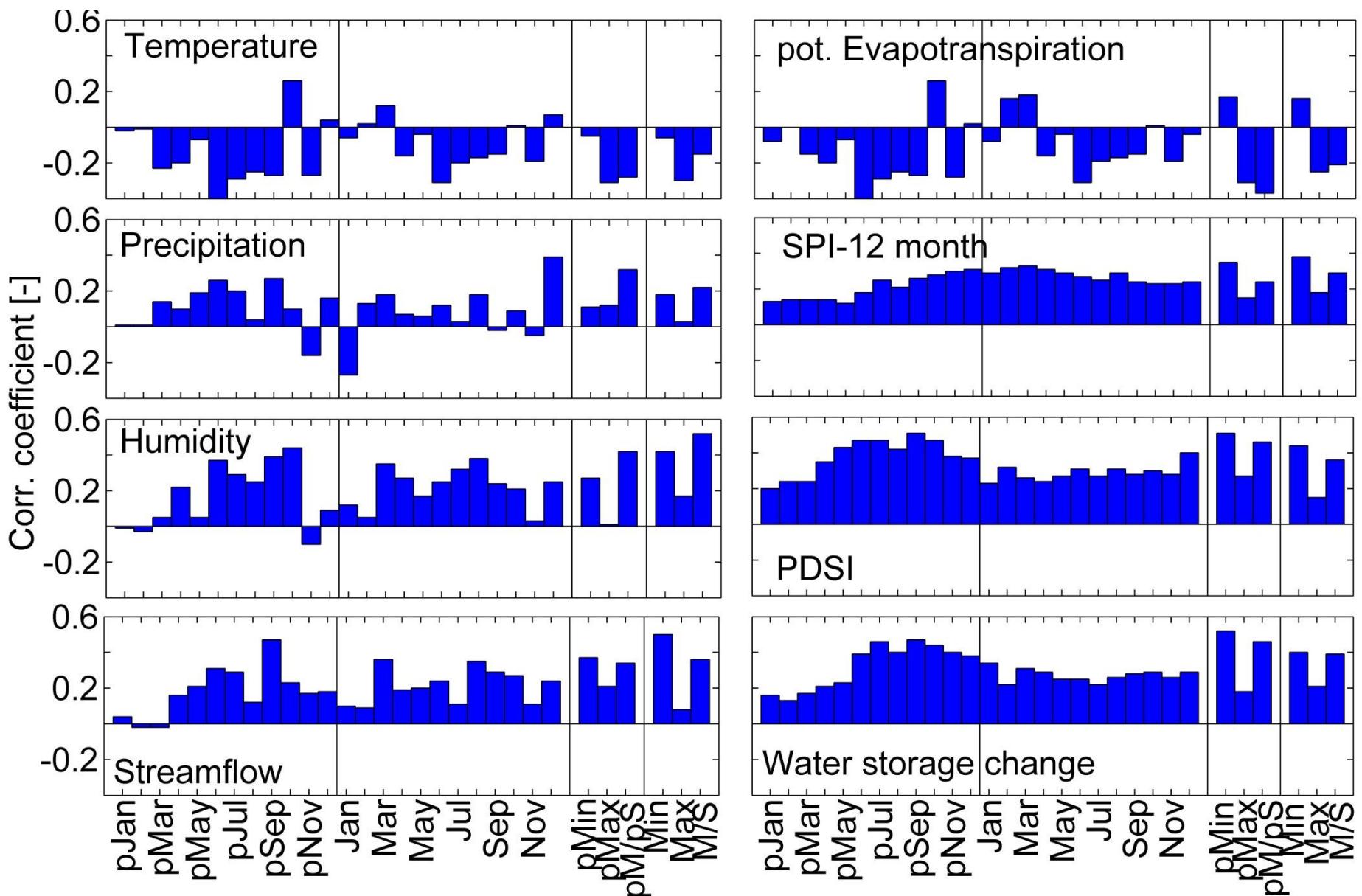
Relationship: 2000 - 2009



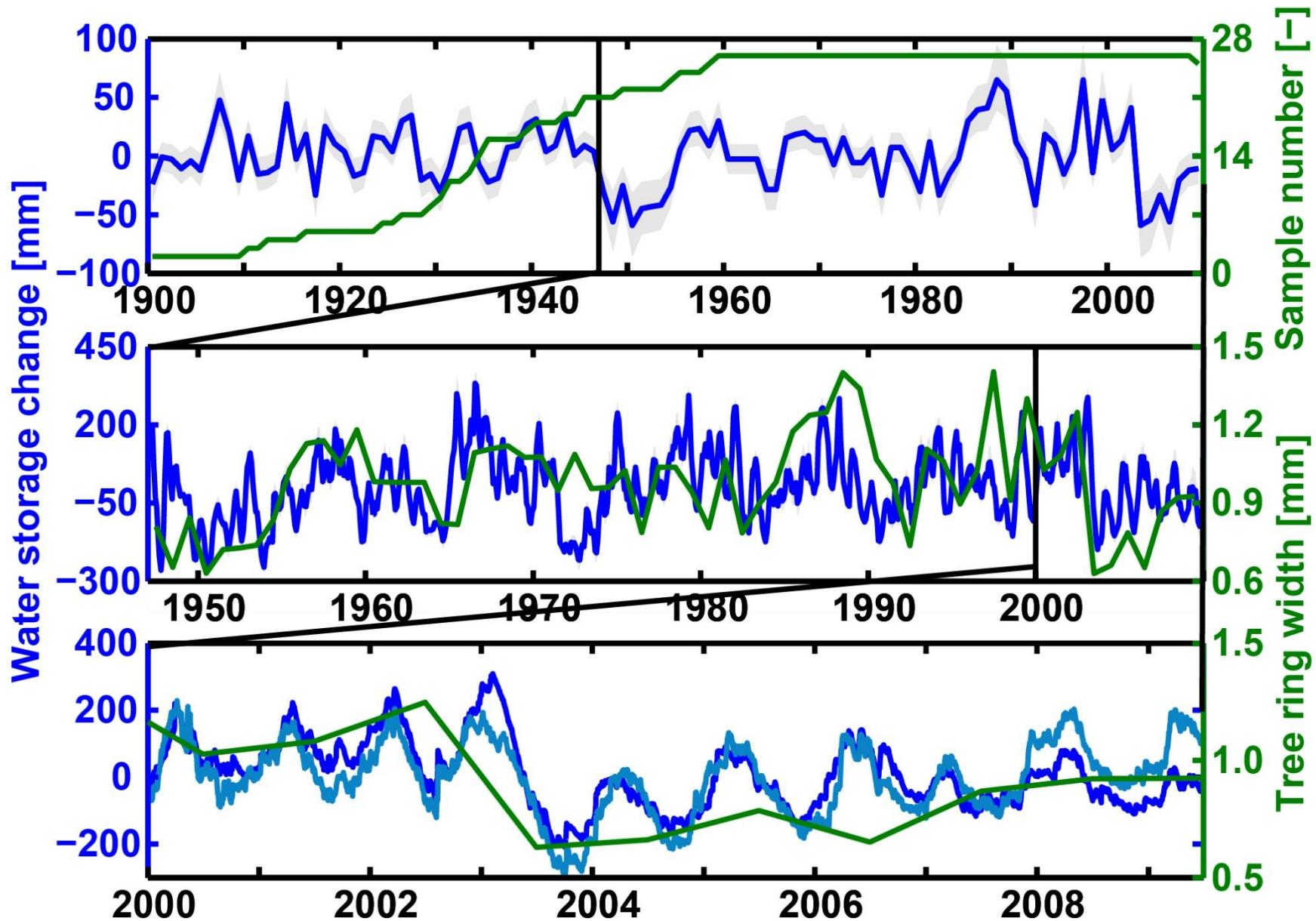
Corr. coefficient and confidence intervals



Relationship: 1947 - 2009



Water storage reconstruction



Conclusion

- Tree-ring growth is primarily controlled total water storage in the subsurface
 - High-precision temporal gravity measurements help to reveal the strong relationship
 - Tree rings allow the reconstruction of subsurface water storage variations
 - Longer time series (measurements) are needed
- multi-disciplinary study, combining the different scientific disciplines hydrology, dendrochronology and geodesy



I am happy to take your question



References

- Creutzfeldt, B., A. Güntner, T. Klügel, and H. Wziontek (2008), Simulating the influence of water storage changes on the superconducting gravimeter of the Geodetic Observatory Wettzell, Germany, *Geophysics*, 73(6), WA95.
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- Creutzfeldt, B., A. Güntner, H. Wziontek, and B. Merz (2010), Reducing local hydrology from high precision gravity measurements: a lysimeter-based approach, *GJI*, 183(1), 178-187.
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- Creutzfeldt, B., T. Ferré, P. Troch, B. Merz, H. Wziontek, and A. Güntner (2012), Total water storage dynamics in response to climate variability and extremes: Inference from long-term terrestrial gravity measurement, *J. Geophys. Res.*, 117, D08112.