

Water-use efficiency variability in trends and drivers in remote sensing and model data in Europe

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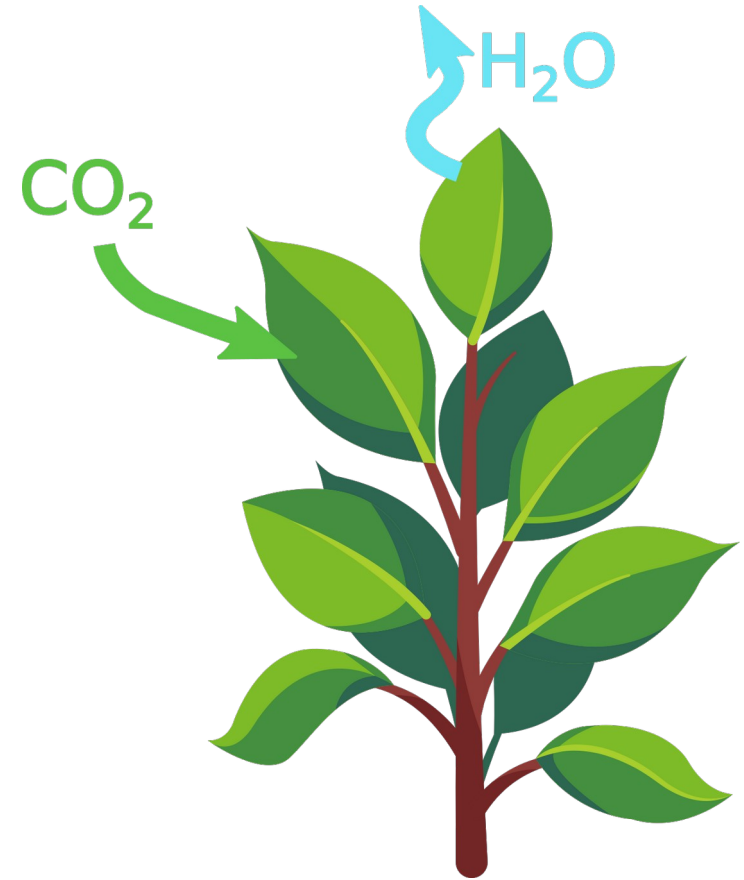


MOTIVATION

- Climate change is altering the variability of ecosystem processes
- Extent, direction and reasons for this variability is not yet thoroughly mapped.

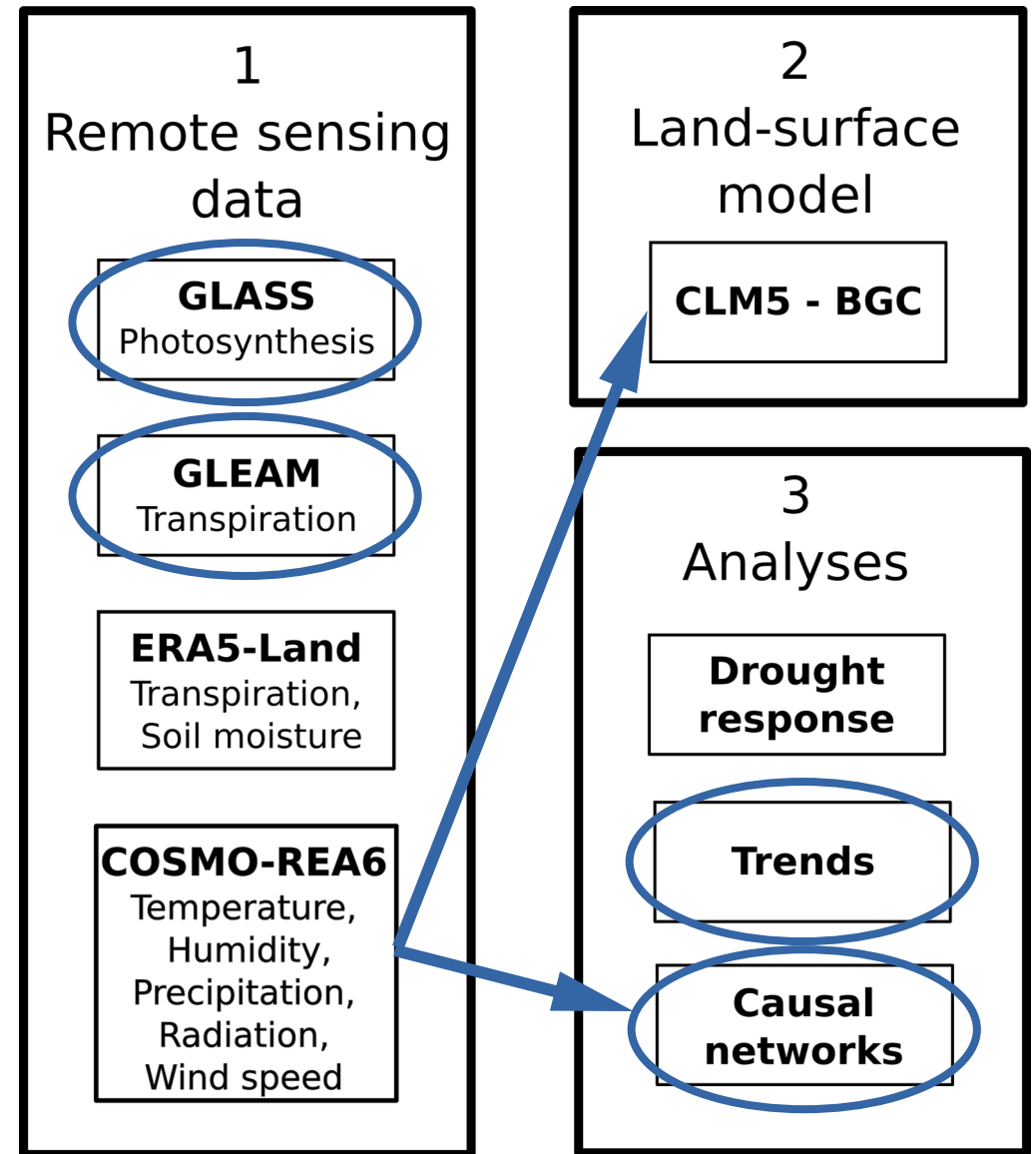
→ The water-use efficiency (WUE) is a key ecosystem function and variability

$$WUE = \frac{\textit{Photosynthesis}}{\textit{Transpiration}}$$

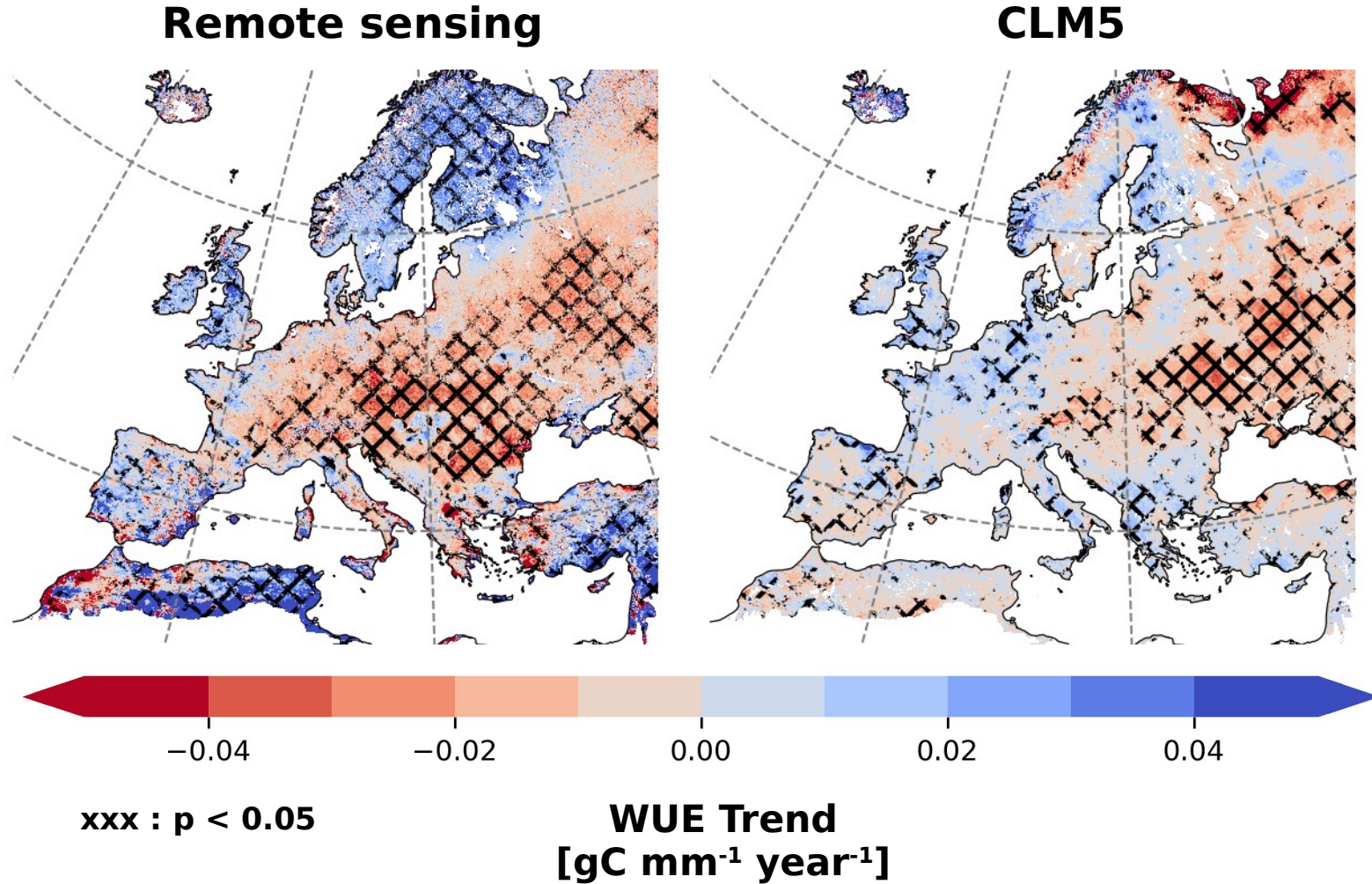


DATA-SETS AND METHODS

- **8 - day** temporal resolution
- Years **1995 - 2018**
- **3 x 3 km** pan European domain
- Remote sensing Photosynthesis includes effects of increased **CO₂** and **Vapour Pressure Deficit**
- Mann-Kendall **trend** analysis
- **PCMCI+** causal network analysis (Runge et al. 2020)



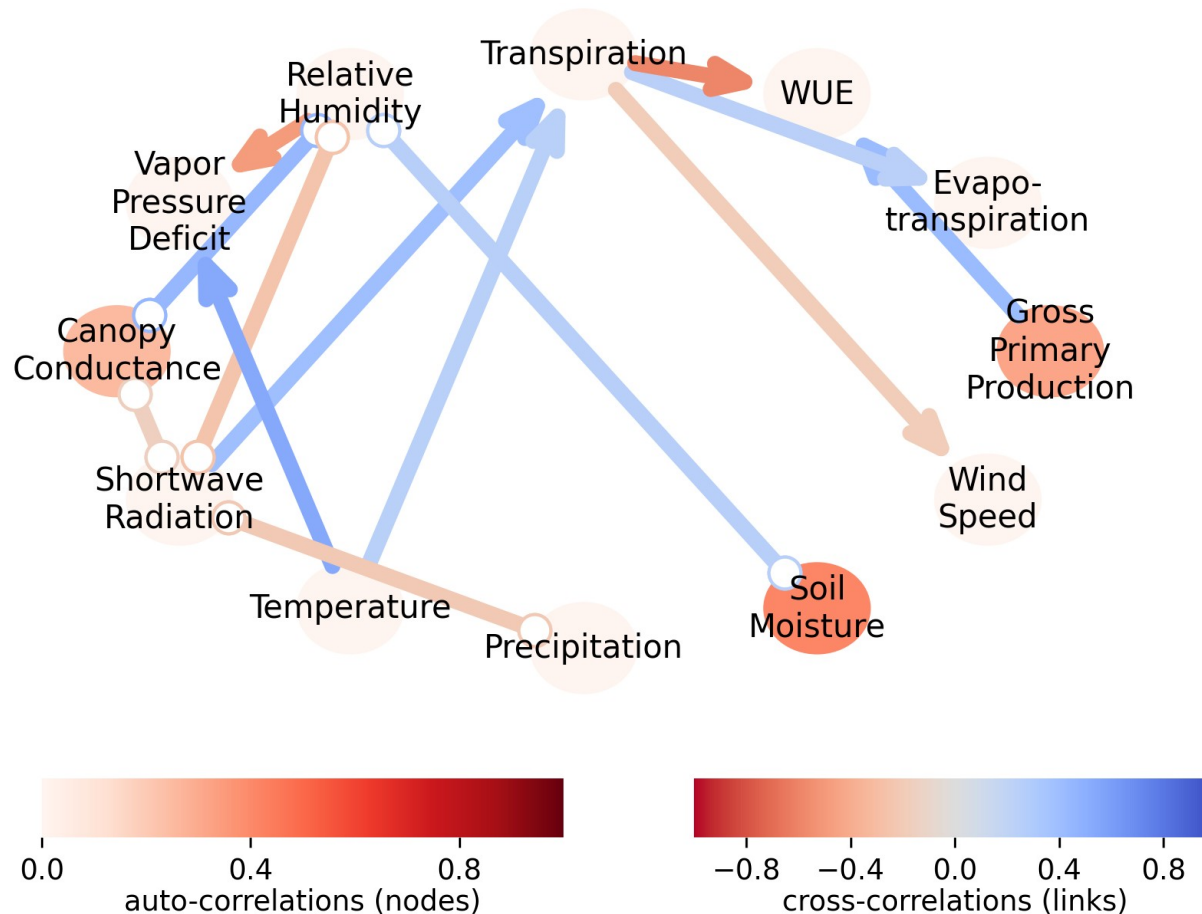
WATER-USE EFFICIENCY TRENDS



- Significant decreases in Eastern Europe
- Differences between remote sensing and CLM5:
 - No coherent increase in CLM5 in Northern Europe
 - Opposing trends in Central Europe

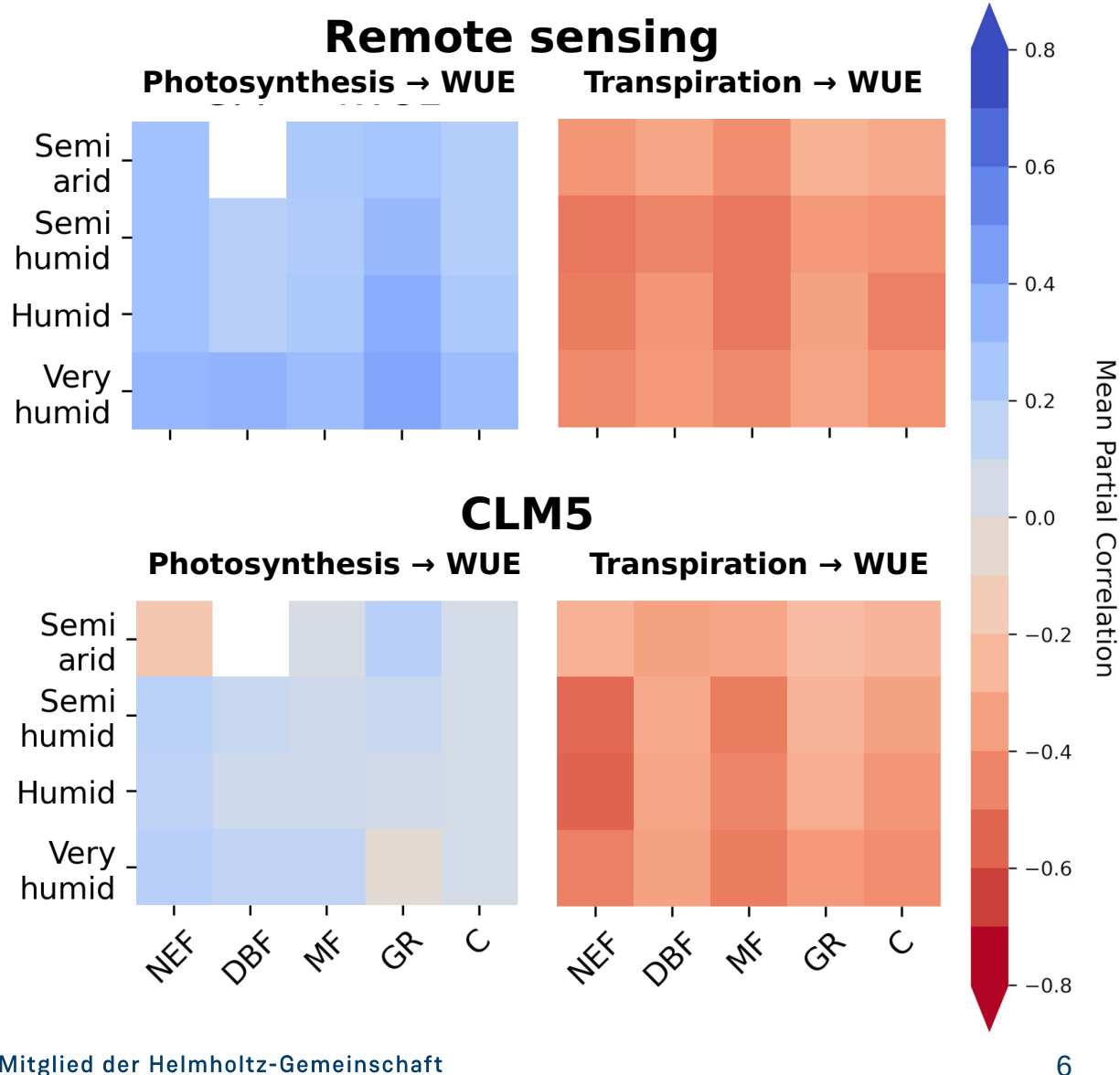
WATER-USE EFFICIENCY DRIVERS - LOCAL

Remote sensing



- Causal Network at TERENO Wüstebach site with PCMCI+ (Runge et al. 2020)
- Input time series of variables of each pixel and run algorithm
- High dimensional causal network data-set: One network for each pixel
- Aggregation over climates and ecosystem types

WATER-USE EFFICIENCY DRIVERS - AGGREGATION



- Strong link between transpiration and WUE in semi humid and humid Needleleaf Evergreen and Mixed Forests
- Differences between remote sensing and CLM5:
 - Weak links between photosynthesis and WUE in CLM5
 - Opposing gradients of partial correlations of Photosynthesis → WUE in Grasslands

NEF = Needleleaf Evergreen Forest, DBF = Deciduous Broadleaf Forest, MF= Mixed Forest, GR = Grassland, C = Cropland

SUMMARY

- The WUE ecosystem function varies with proceeding climate change
 - Extensive WUE decreases in Eastern Europe are evident in remote sensing and CLM5
 - Disagreement between model and remote sensing in Central and Northern Europe
- Causal networks around WUE are represented differently in remote sensing and CLM5
 - Less connections and lower mean partial correlations between photosynthesis and WUE in CLM5
 - Causality patterns of hydro-climates and ecosystem types are similar between transpiration and WUE in both

THANK YOU!

REFERENCES

Runge, Jakob. “Discovering Contemporaneous and Lagged Causal Relations in Autocorrelated Nonlinear Time Series Datasets.” In Proceedings of the 36th Conference on Uncertainty in Artificial Intelligence. Toronto: AUAI Press, **2020**. http://auai.org/uai2020/proceedings/579_main_paper.pdf.

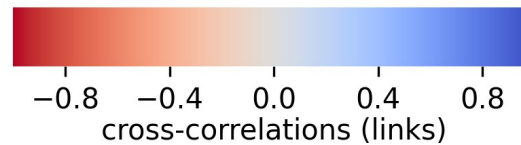
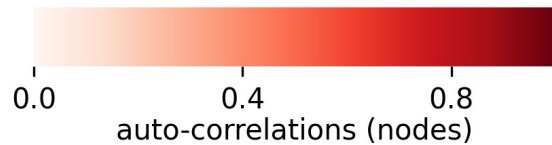
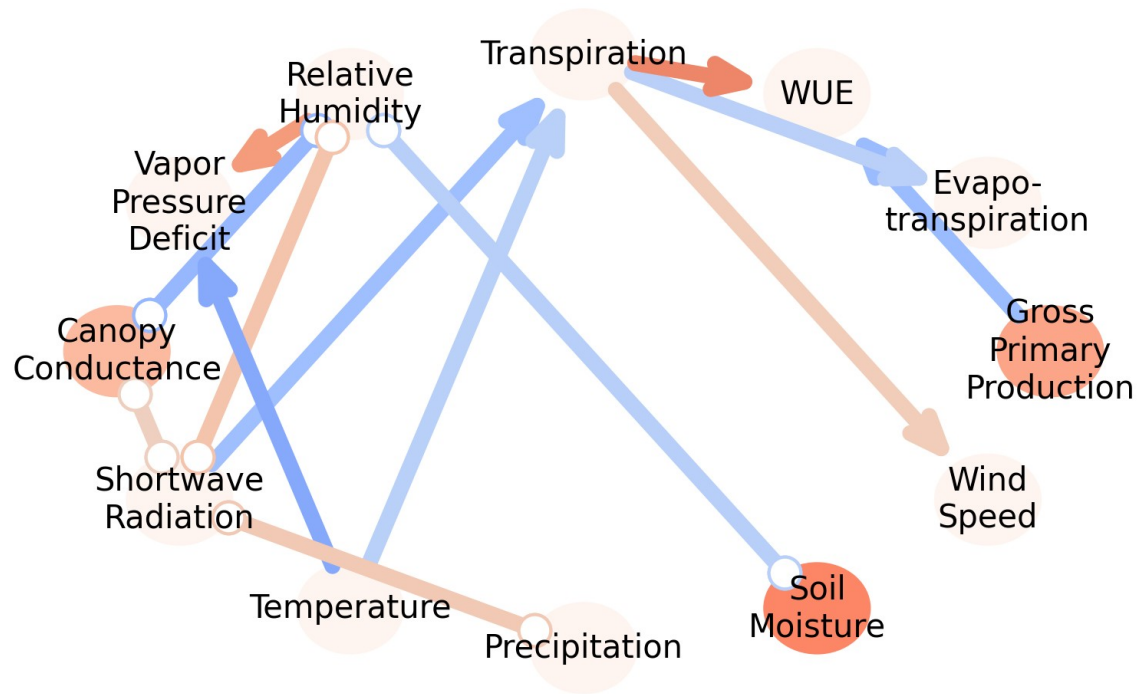
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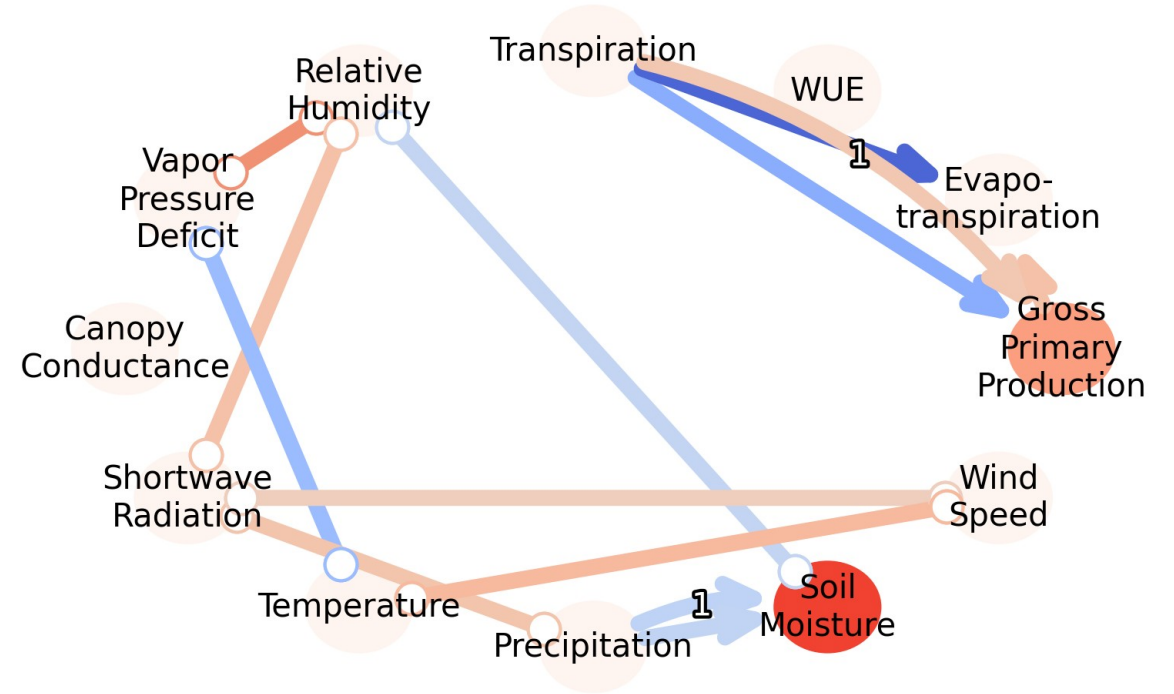
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WATER-USE EFFICIENCY DRIVERS - LOCAL

Remote sensing



CLM5



Causal Networks at TERENO Wüstebach site with PCMCi+ (Runge et al. 2020)

OUTLOOK

- Parameter uncertainty analysis in CLM5 - BGC
 - Plant functional type specific parameters on stomatal conductance and carbon assimilation
 - Data assimilation of soil moisture and vegetation states

→ Do more certain parameters improve the representation of causal relationships in CLM5?

- Comparison with in-situ data