

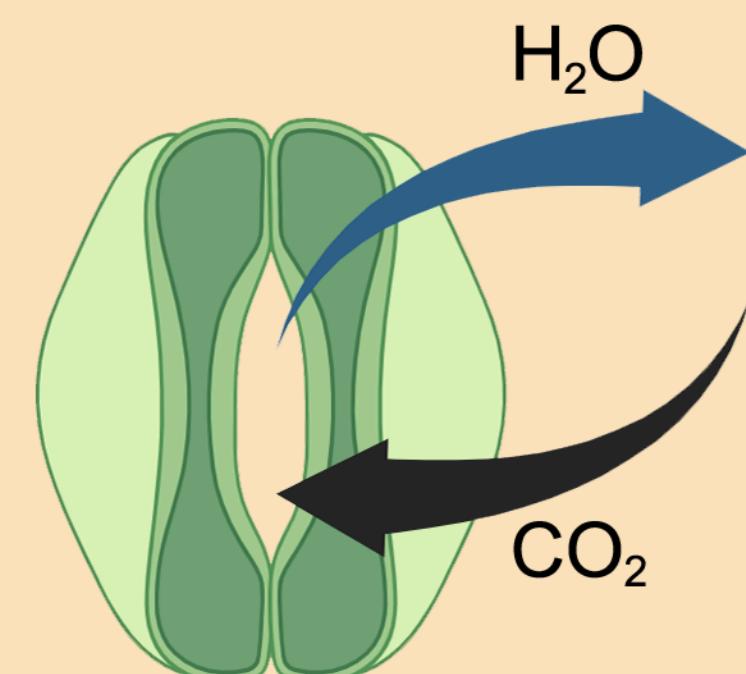
Improving coupled carbon-water cycle simulation from point to global scale

Francesco Grossi^{1,2}, Fabian Bernhard^{1,2}, Benjamin D. Stocker^{1,2}

¹ Institute of Geography, University of Bern, 3012 Bern, Switzerland

² Oeschger Centre for Climate Change Research, University of Bern, 3012 Bern, Switzerland

0. Background



- When the stomata open, CO_2 enters into leaves while H_2O diffuses out.
- When the soil is dry, plants close their stomata, thus limiting CO_2 assimilation.
- Correctly representing the vegetation activity is of key importance to face the incoming challenges due to climate change.**

1. Aim of the project

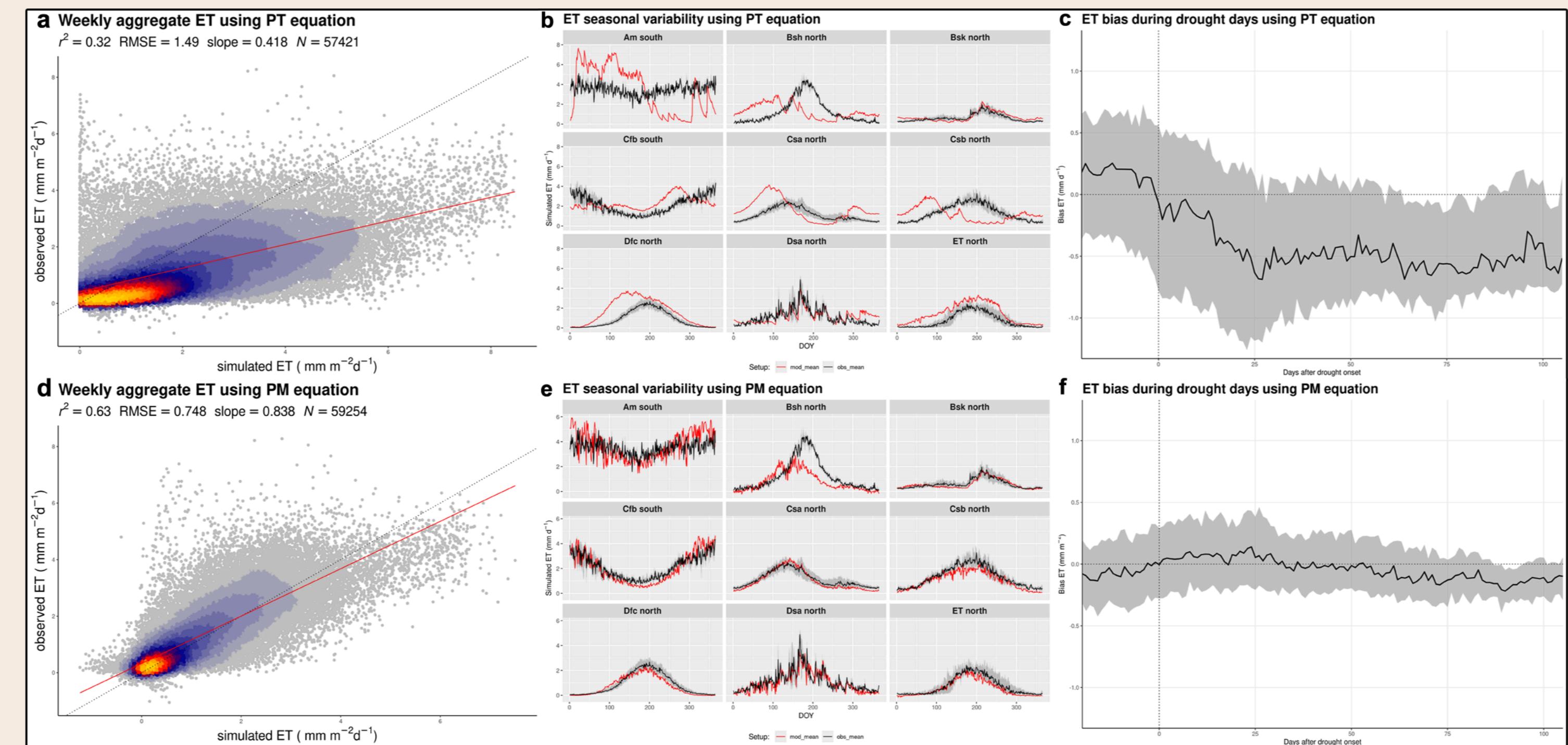
- Simulate carbon and water cycles without climate and plant-specific parameters.
- Improving the model simulation considering explicitly the vegetation activity.
- Upscaling the model from point to global scale simulation.

2. Model and method

- Use the P model to simulate the vegetation physiology [1].
- Simulate gross primary production (GPP) and evapotranspiration (ET) at 188 FLUXNET towers [2] using two different model setups.
 - Assuming the vegetation to be always active using the Priestly-Taylor equation (PT) [3].
 - Considering explicitly the vegetation activity with the Penman-Monteith equation (PM) [4].
- Upscaling the model to global simulation using different remote sensing data.

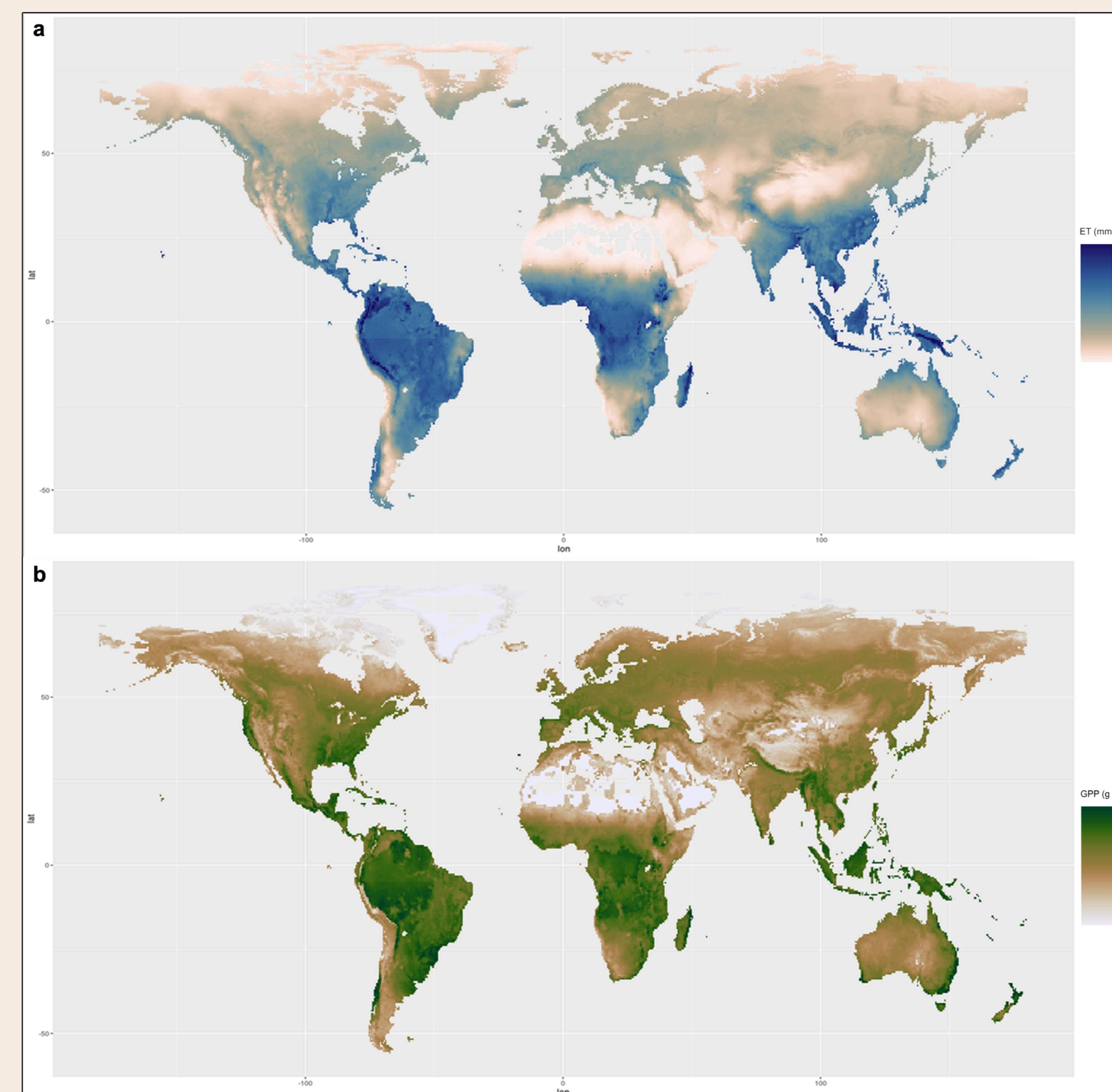
3. Results

Model improvement



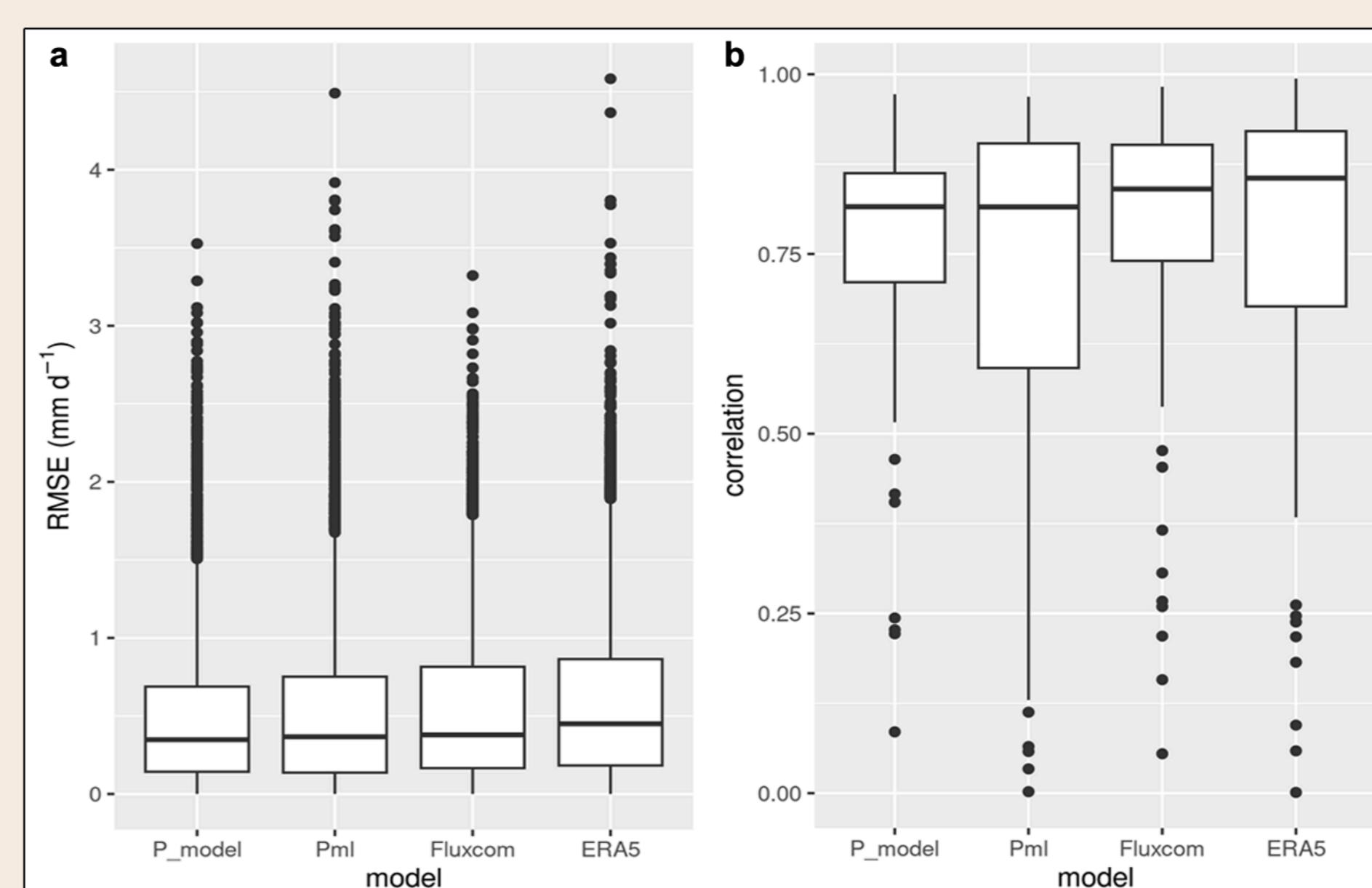
- a,d. ET is overestimated using PT equation. **Using PM equation ET is better represented.**
- b,e. The seasonal variability is well represented across all the climates using PM equation. **The largest differences in seasonal variability between PT and PM equations are found in water-limited climates.**
- c,f. Under drought conditions, the P model with PT equation severely underestimates ET.

Global scale simulation



- a,b. The P model in tandem with PM equation correctly simulates the multi-year average of water and carbon cycles from 1982 to 2011.

Validation



- a,b. The RMSE and correlation of ET using global data evaluated against FLUXNET is similar to the most relevant global model.

4. Conclusion

- Considering explicitly vegetation activity, the P model realistically represents the water and carbon cycles.
- The improvements in model simulation are mostly observed in water-limited climates and under drought conditions.
- The seasonal variability of ET is well-represented across all climates using PM equation.
- Using forcing data from remote sensing, the model's performance is similar to that of other global models.

5. Discussion

- It is possible to represent the limitation that the water cycle exerts on the carbon cycle by correctly simulating the vegetation activity.
- Due to increasing drought events, **simulating water and carbon cycles is crucial to assessing ecosystem balance.**
- Vegetation activity can be represented at global scale with a simple model** despite the incredible biodiversity.

References

- [1] Stocker, Benjamin D., et al. "P-model v1. 0: An optimality-based light use efficiency model for simulating ecosystem gross primary production." *Geoscientific Model Development* 13.3 (2020): 1545-1581.
- [2] Pastorello, Gilberto, et al. "The FLUXNET2015 dataset and the ONEFlux processing pipeline for eddy covariance data." *Scientific data* 7.1 (2020): 225.
- [3] Priestley, Charles Henry Brian, and Robert Joseph Taylor. "On the assessment of surface heat flux and evaporation using large-scale parameters." *Monthly weather review* 100.2 (1972): 81-92.
- [4] Penman, Howard Latimer. "Natural evaporation from open water, bare soil and grass." *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences* 193.1032 (1948): 120-145.