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

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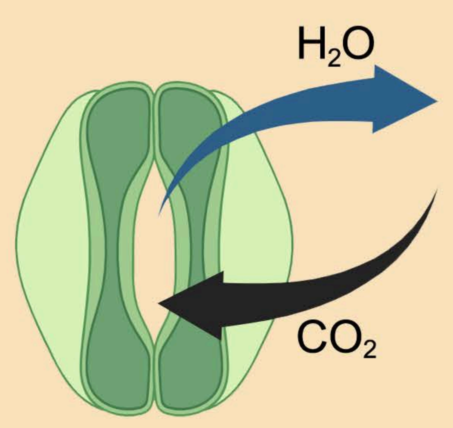
0. Background



- 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

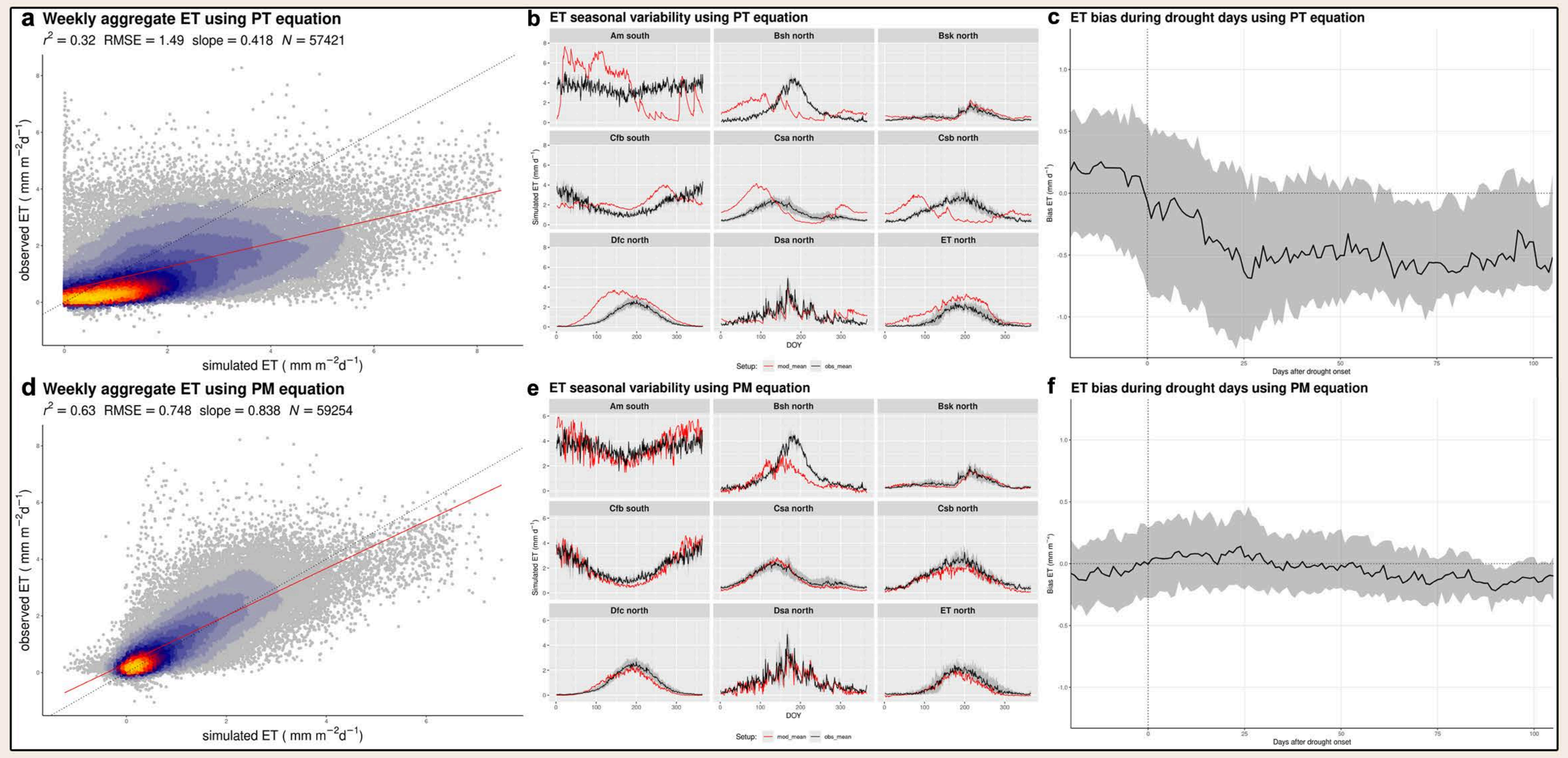
- Simulate carbon and water cycles without climate and plant-specific parameters.
- Improving the model simulation considering explicitly the vegetation activity.
- Upscaling the model from point to global scale simulation.

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.

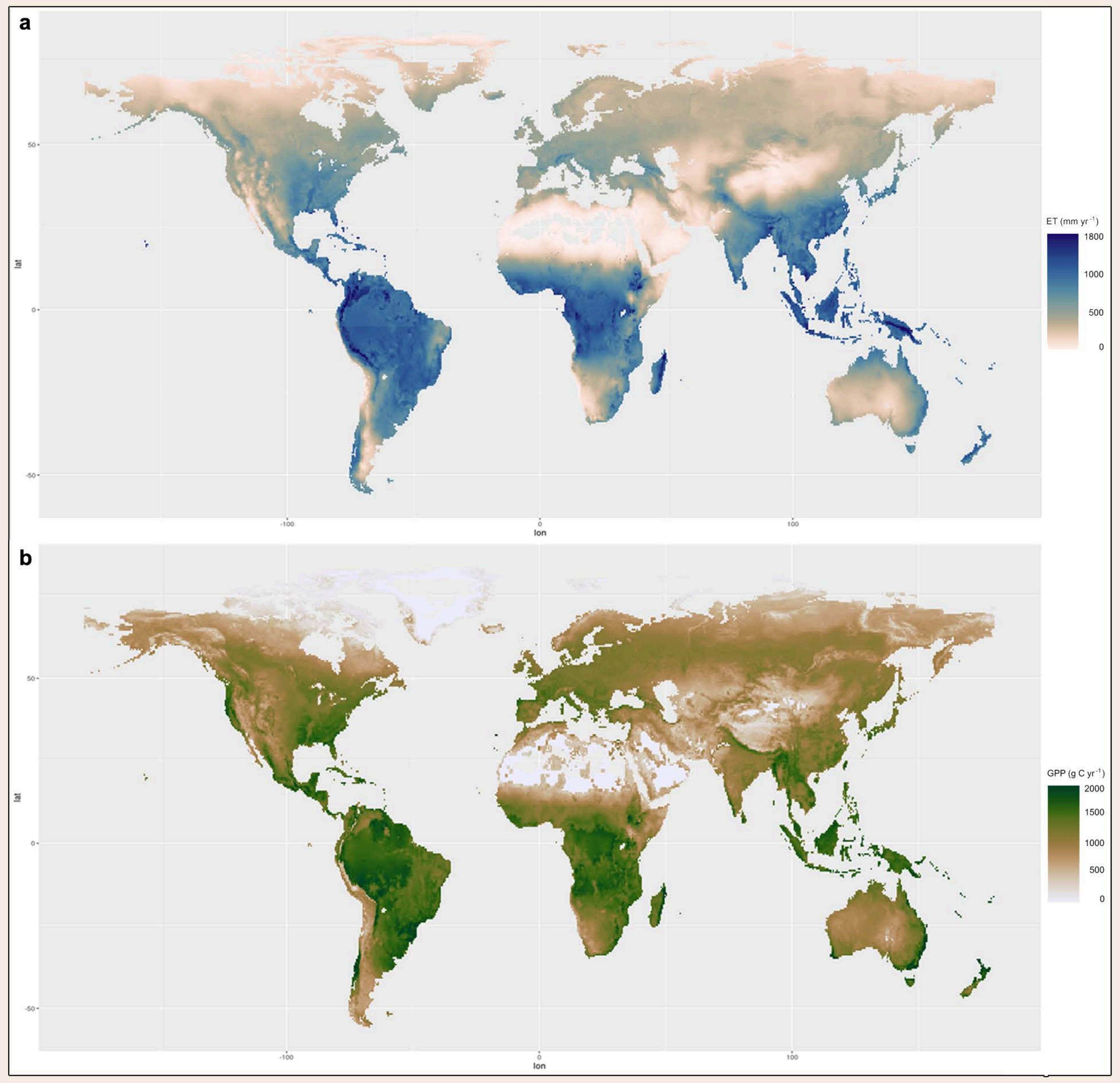
3. Results

Model improvement



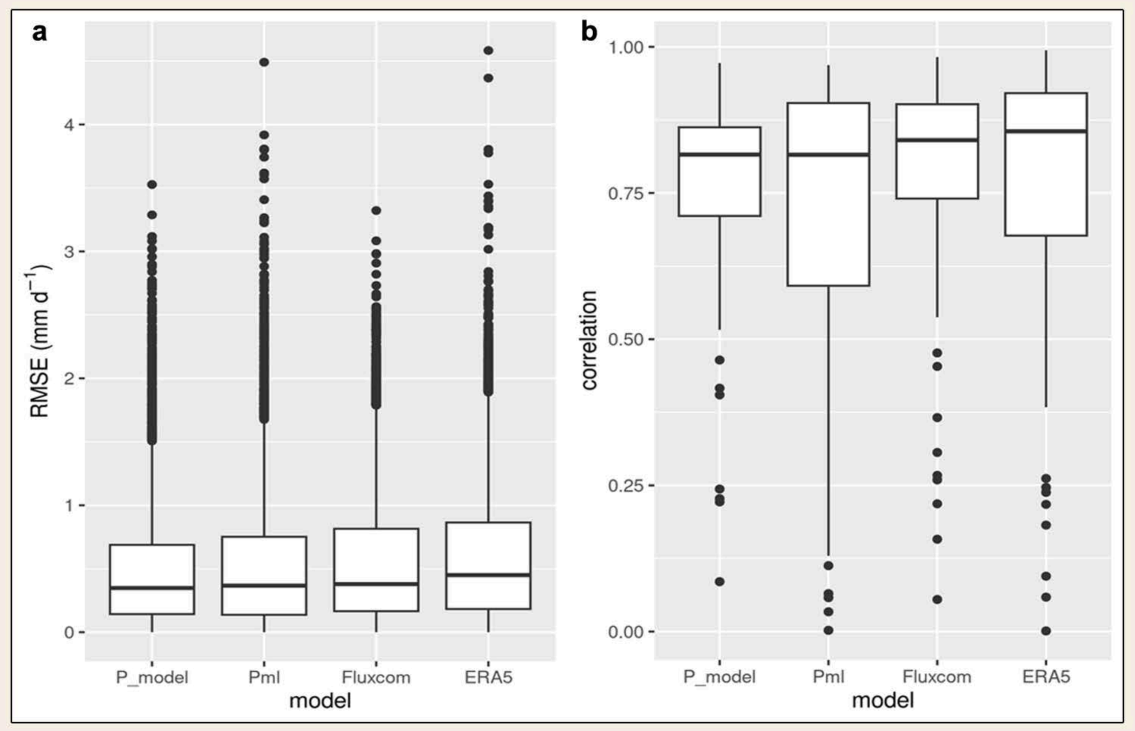
- **a,d.** ET is overestimated using PT equation. **Using PM equation ET is better represented.**
- **b,e.** The seasonal variability is well represented across all the climates using PM equation. **The largest differences in seasonal variability between PT and PM equations are found in water-limited 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

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[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.