An evaluation of global hydrological models using functional relationships

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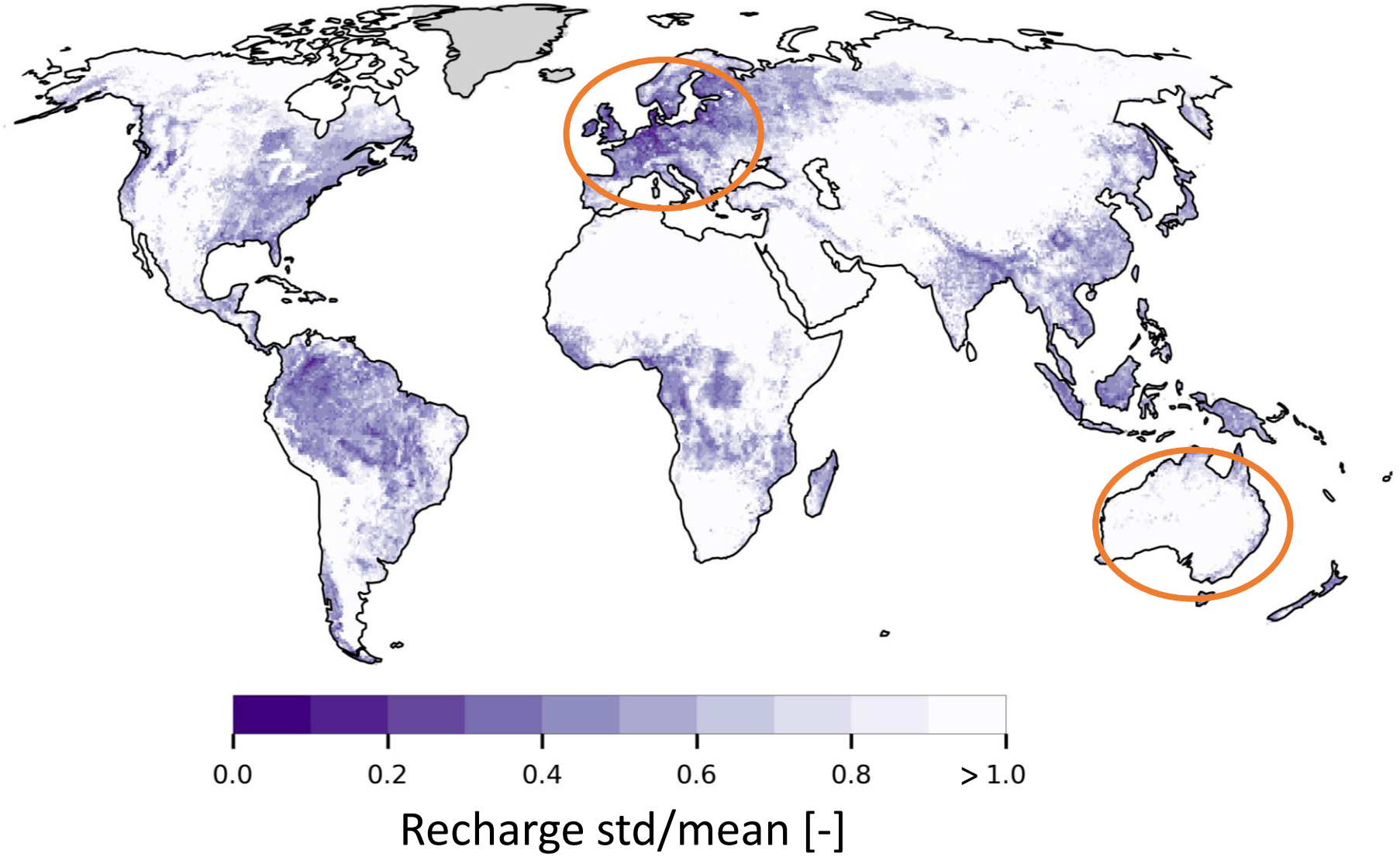
Global models differ and this difference varies spatially



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So how should we evaluate global models?

- Data are imperfect: data are scarce, uncertain, spatially biased, and often observed at different scales
- Some of these problems can be alleviated by
  (1) Comparing models to each other to learn from their differences
  (2) Using functional relationships

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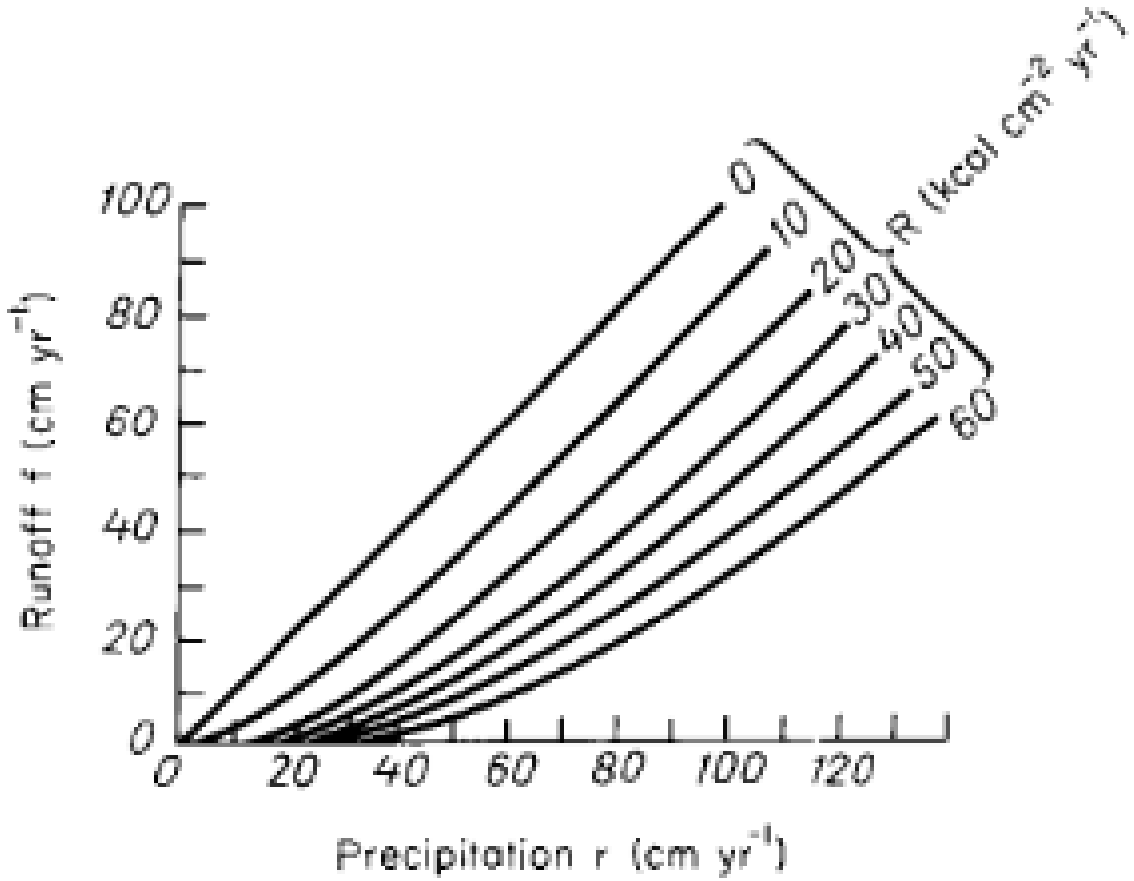
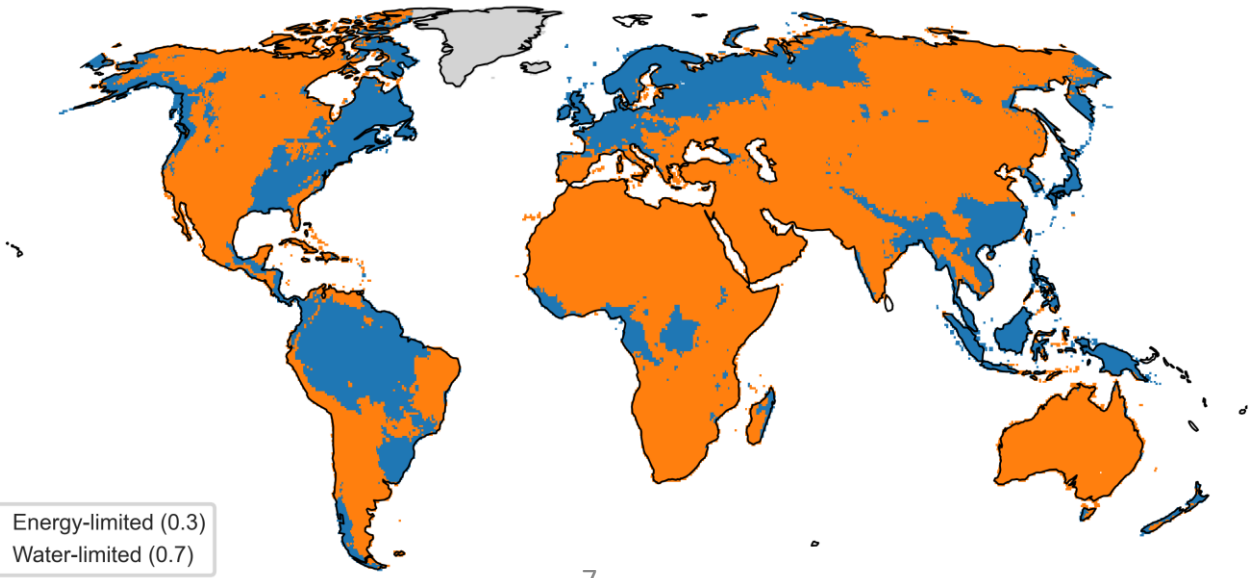
What do we mean by functional relationships?

- Budyko (1974) postulated that runoff is a function of the available water and energy



We will use functional relationships to explore how different models represent the water balance

- We use 8 global models from ISIMIP 2b
- We compare multiple input variables with multiple output variables, averged over 30 years (today: **recharge**)
- We also split the world into water-limited and energy-limited places



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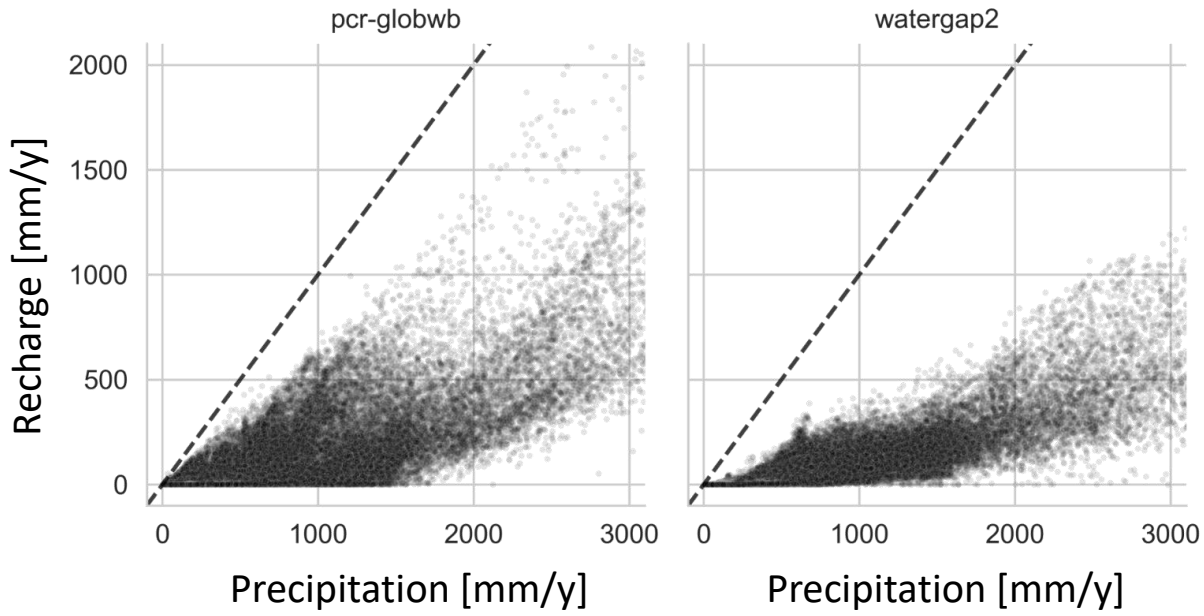
Scatter plots show how strongly recharge is controlled by precipitation



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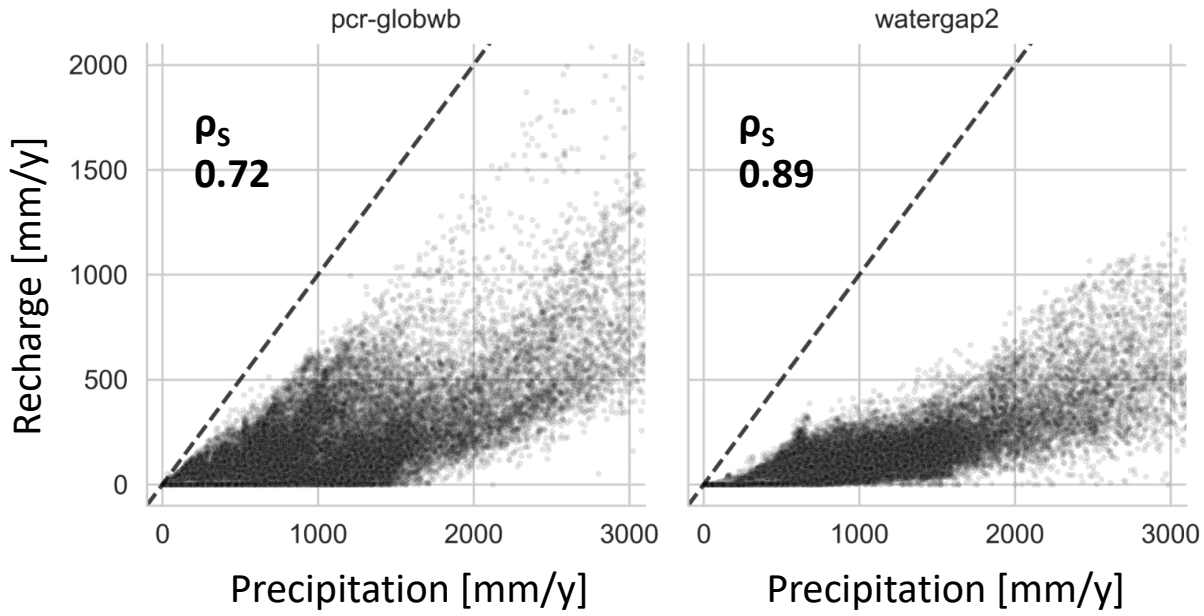
Rank correlations quantify how strongly recharge is controlled by precipitation



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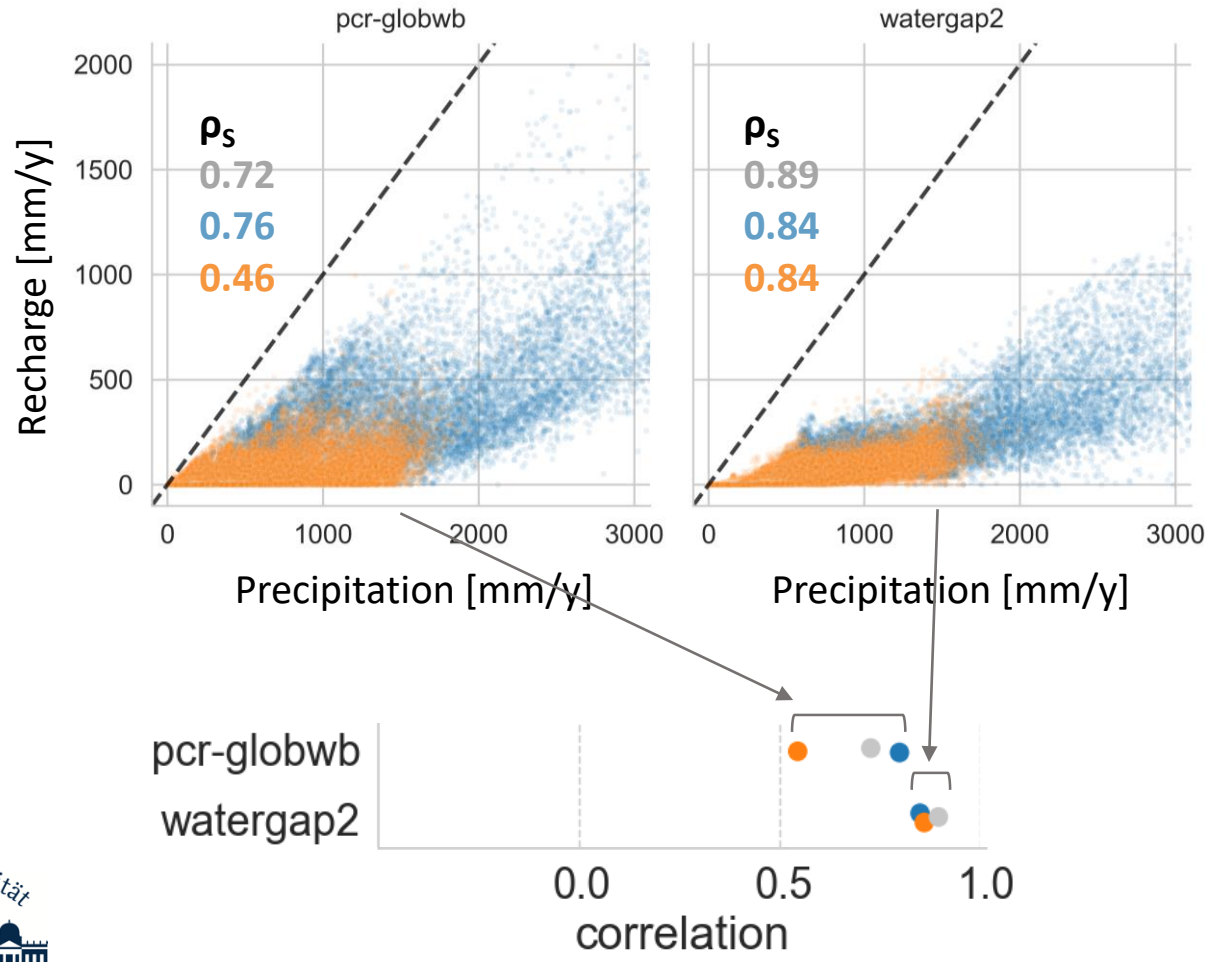
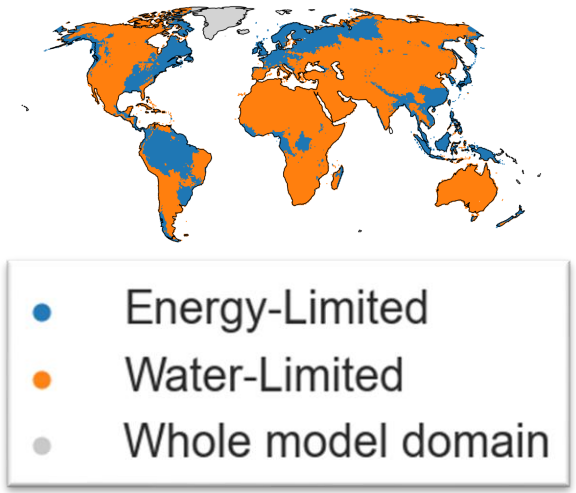
Rank correlations show how strongly recharge is controlled by precipitation





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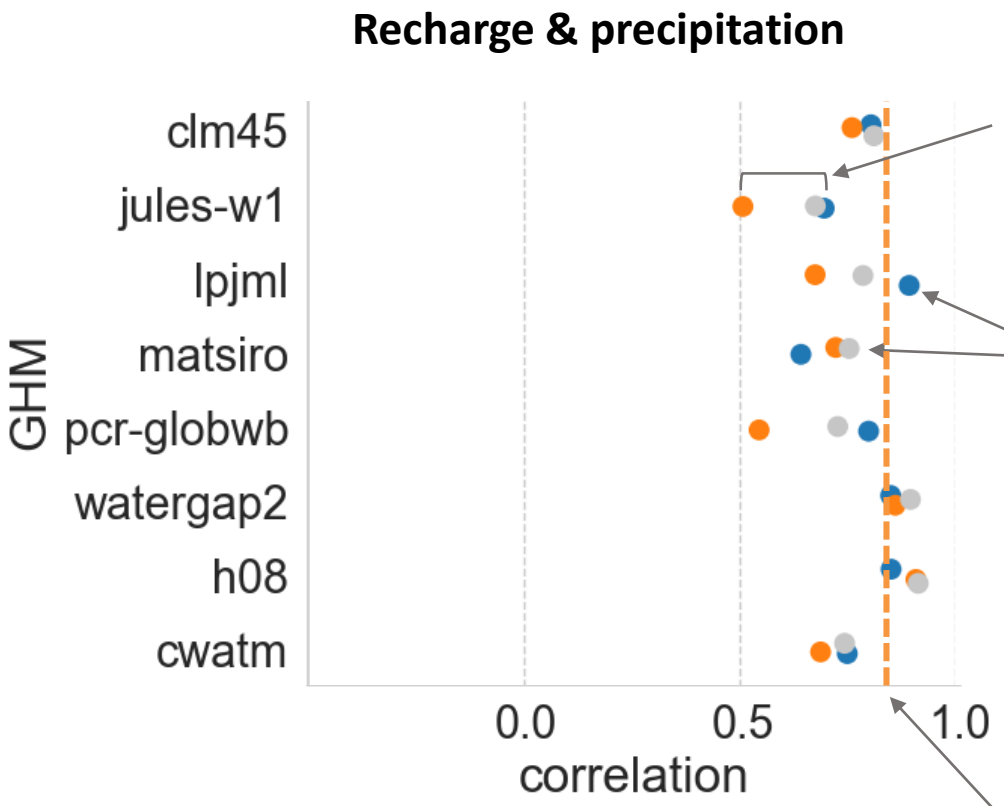
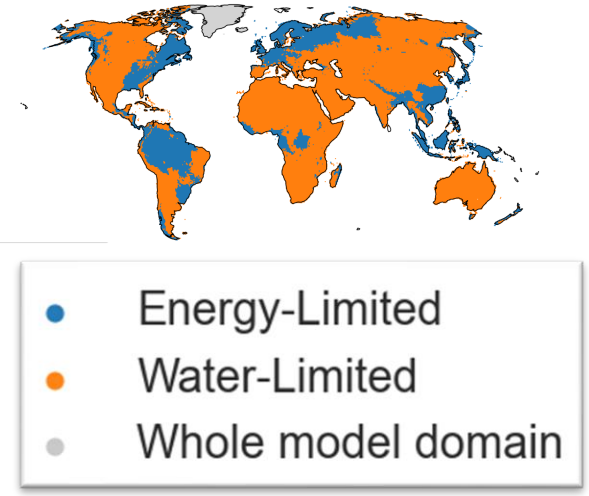
Rank correlations differ between different models, indicating different functional relationships



Difference between water- and energy-limited regions.

Difference is reversed.

MacDonald et al. (2021) ERL



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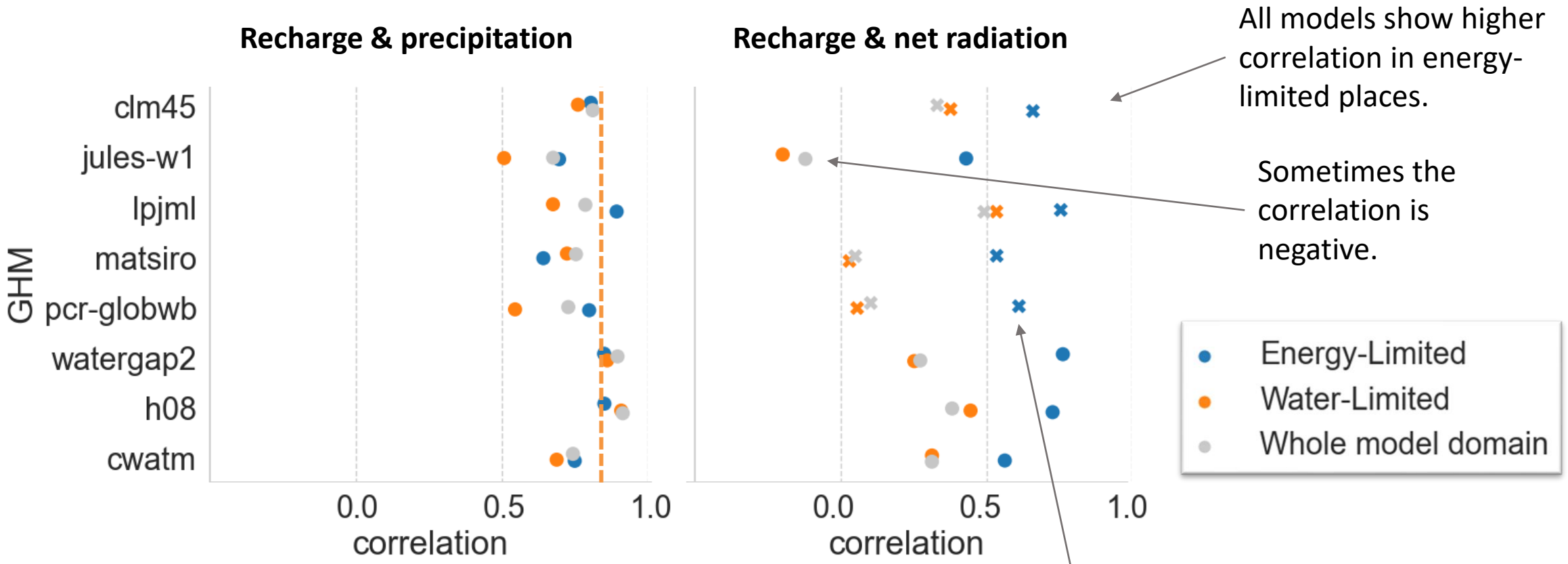
The functional relationships between net radiation and recharge show even more variability



All models show higher correlation in energy-limited places.

Sometimes the correlation is negative.

Crosses indicate that we do not have the data and use the ensemble mean instead.

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Functional relationships show that models translate forcing differently into recharge

- Differences suggest that we should use more than one model to get more robust results
- We cannot only rely on past observations to evaluate our models, so we have to think of alternative ways of model evaluation

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