The global hydrologic response to land evapotranspiration-driven warming

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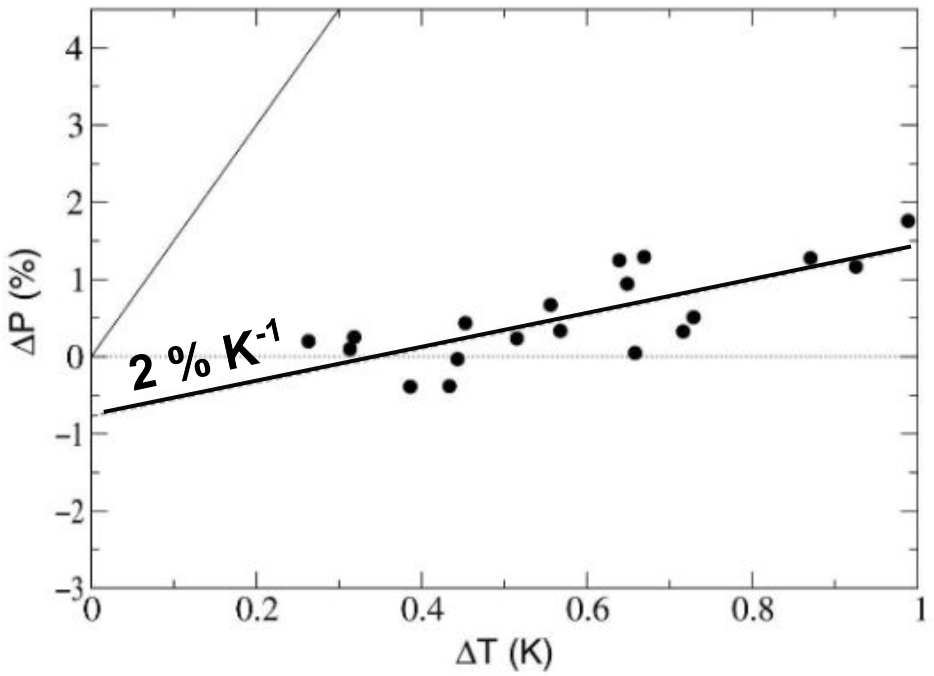
The hydrologic cycle amplifies with radiatively-driven warming

- The global mean hydrologic cycle is expected to amplify at 2 % K^{-1}



Held & Soden (2006)

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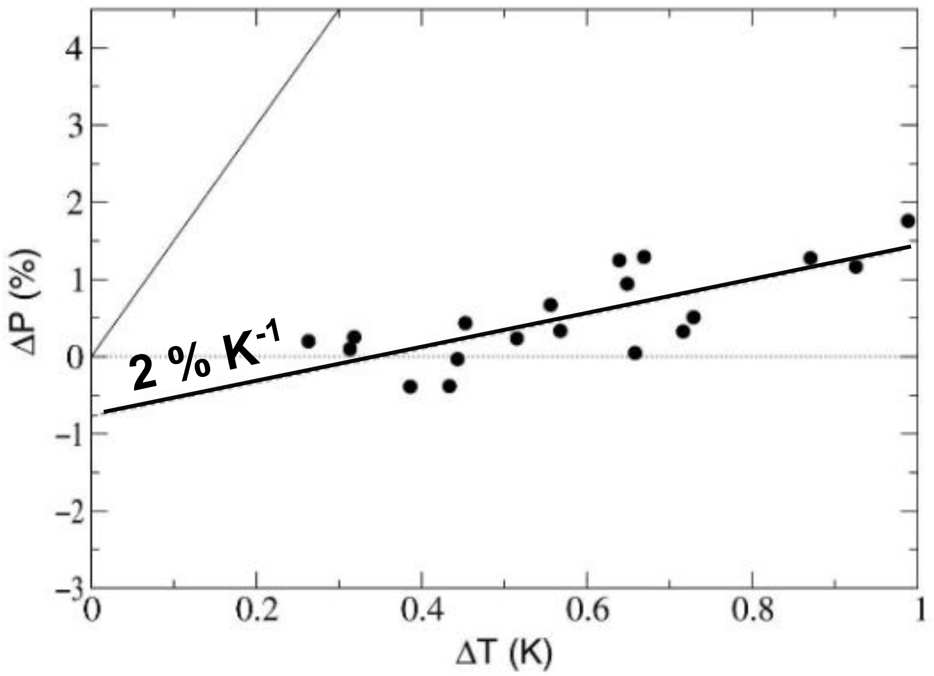

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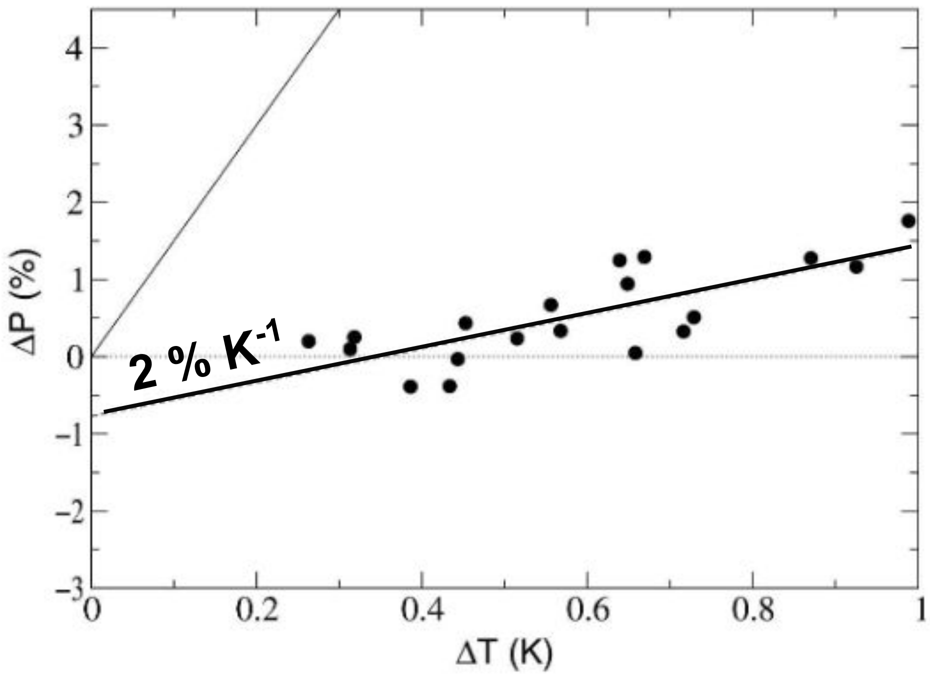
- Other papers extended this scaling to better represent the zonal pattern of $\delta(P - E)$
    - Pietschnig et al. (2019), Byrne & O'Gorman (2015), Roderick et al. (2014)



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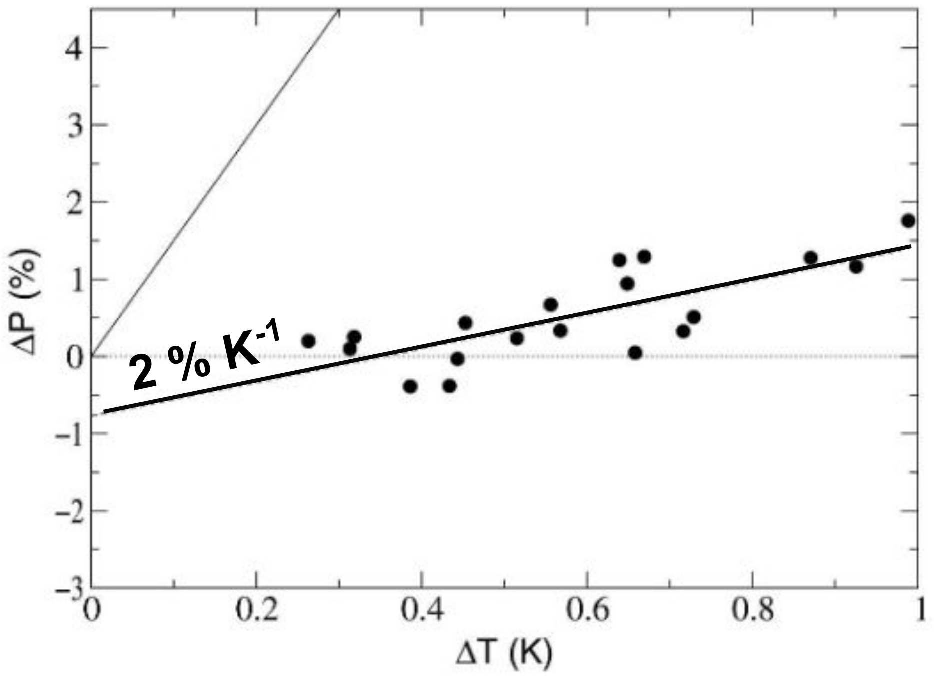
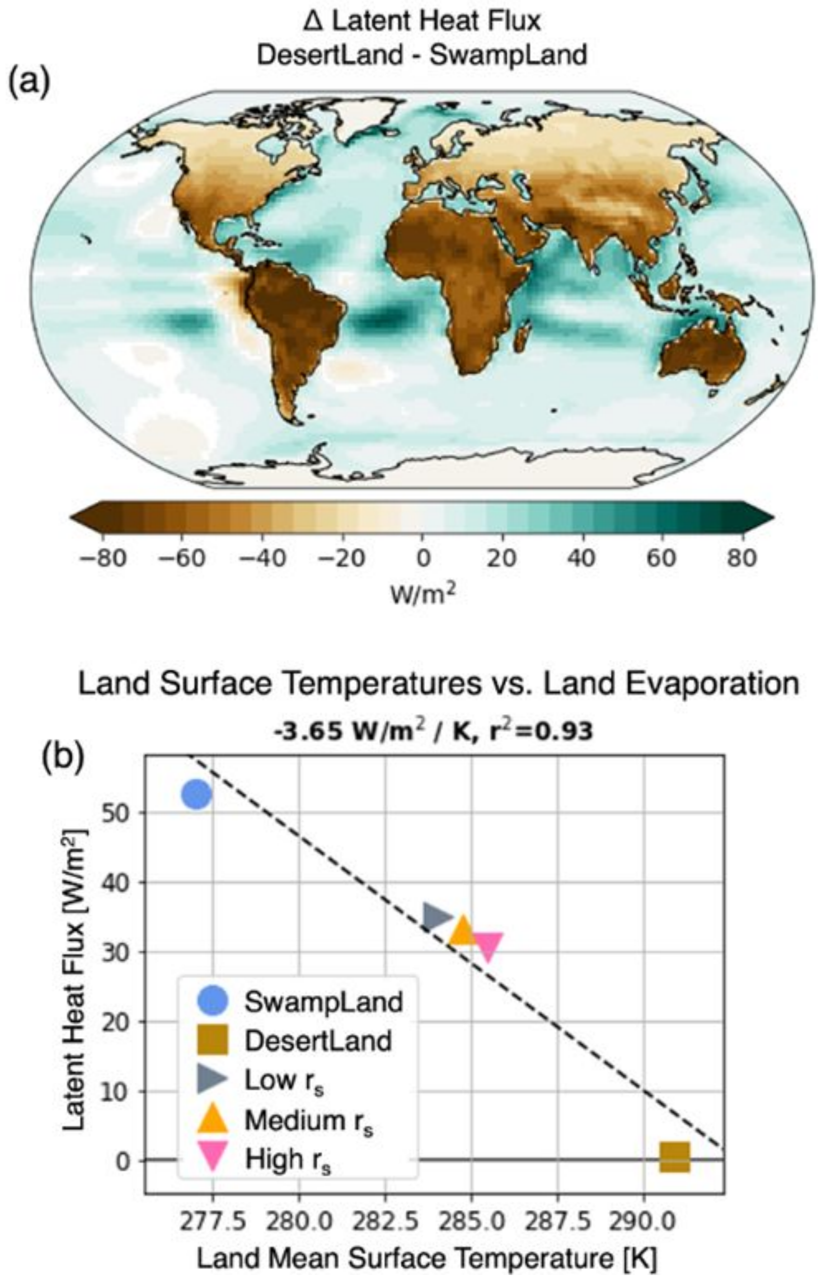
- **Is the hydrologic response to land ET-driven warming different than from CO_2 radiatively-driven warming?**



Held & Soden (2006)

Suppressing evapotranspiration alters the global hydrologic cycle

- Idealized simulations with **large-magnitude** ET changes (Laguë et al., 2023)
  - Suppressed ET induces surface warming
  - SW cloud response
  - Column water vapor and residence time increases



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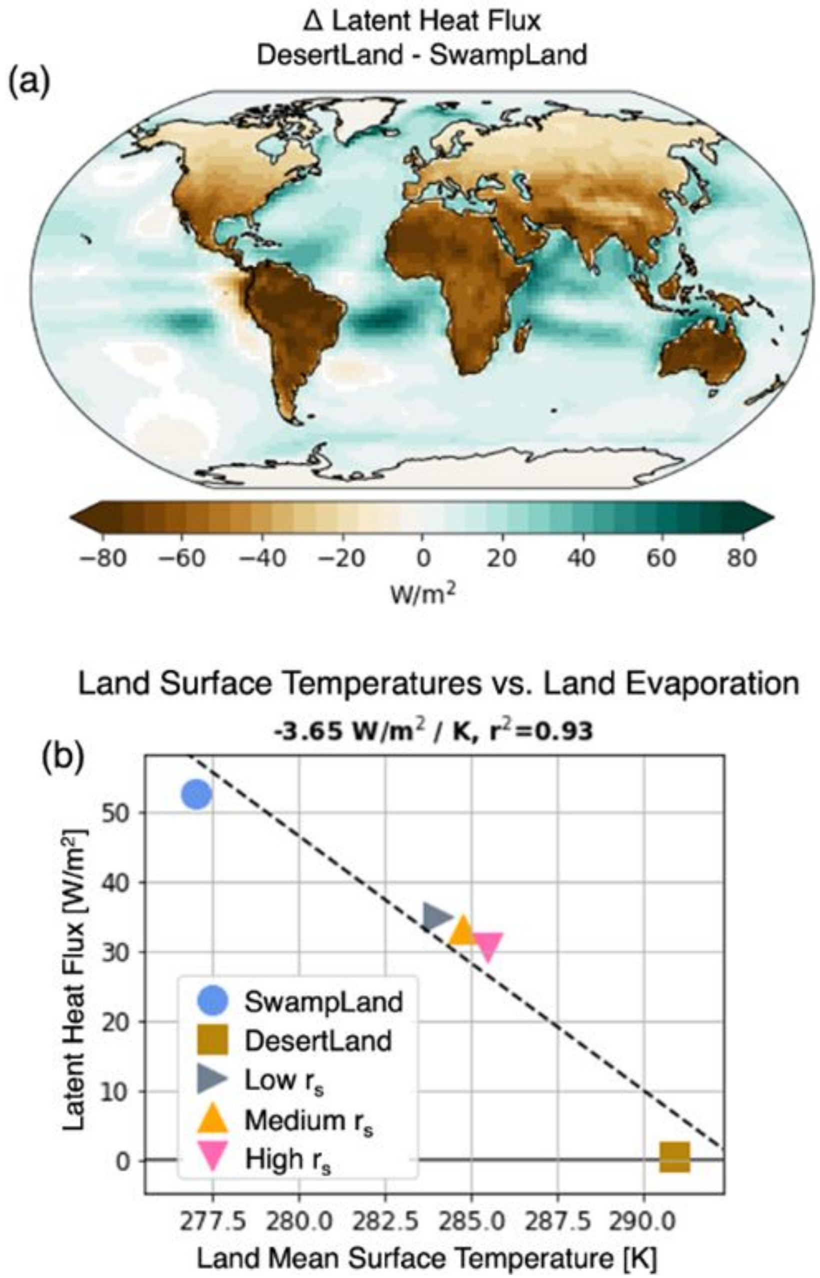
  - Column water vapor and residence time increases
- **Do these processes hold across a range of smaller ET perturbations?**



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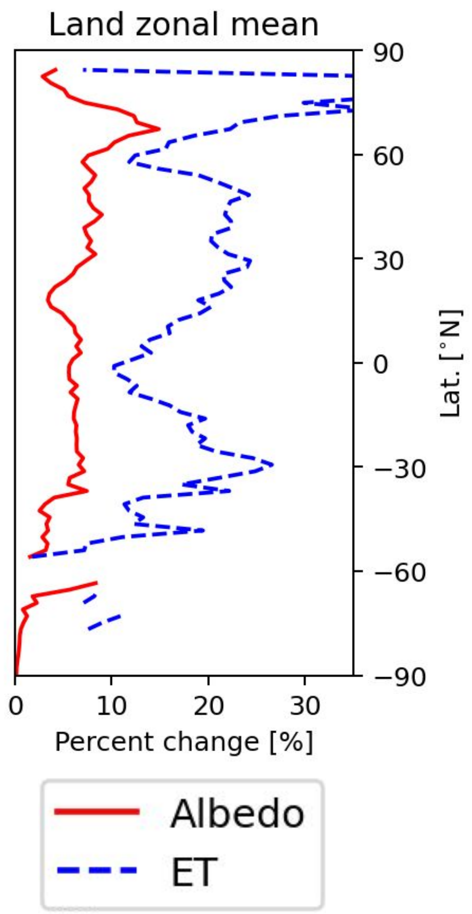
Leveraging the coupled PPE to examine small evapotranspiration perturbations

- Surface temperature change is driven by ET, not albedo



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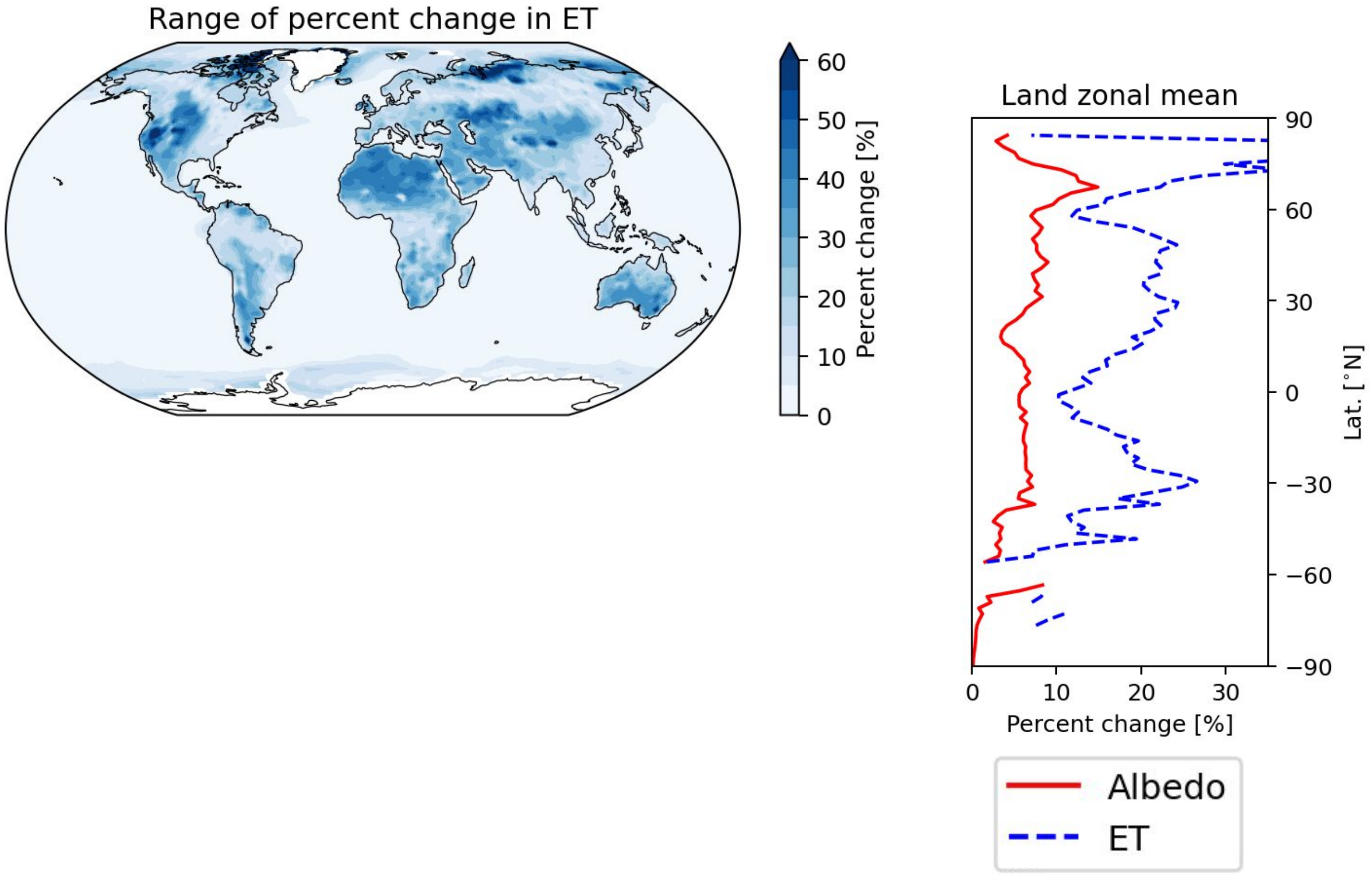

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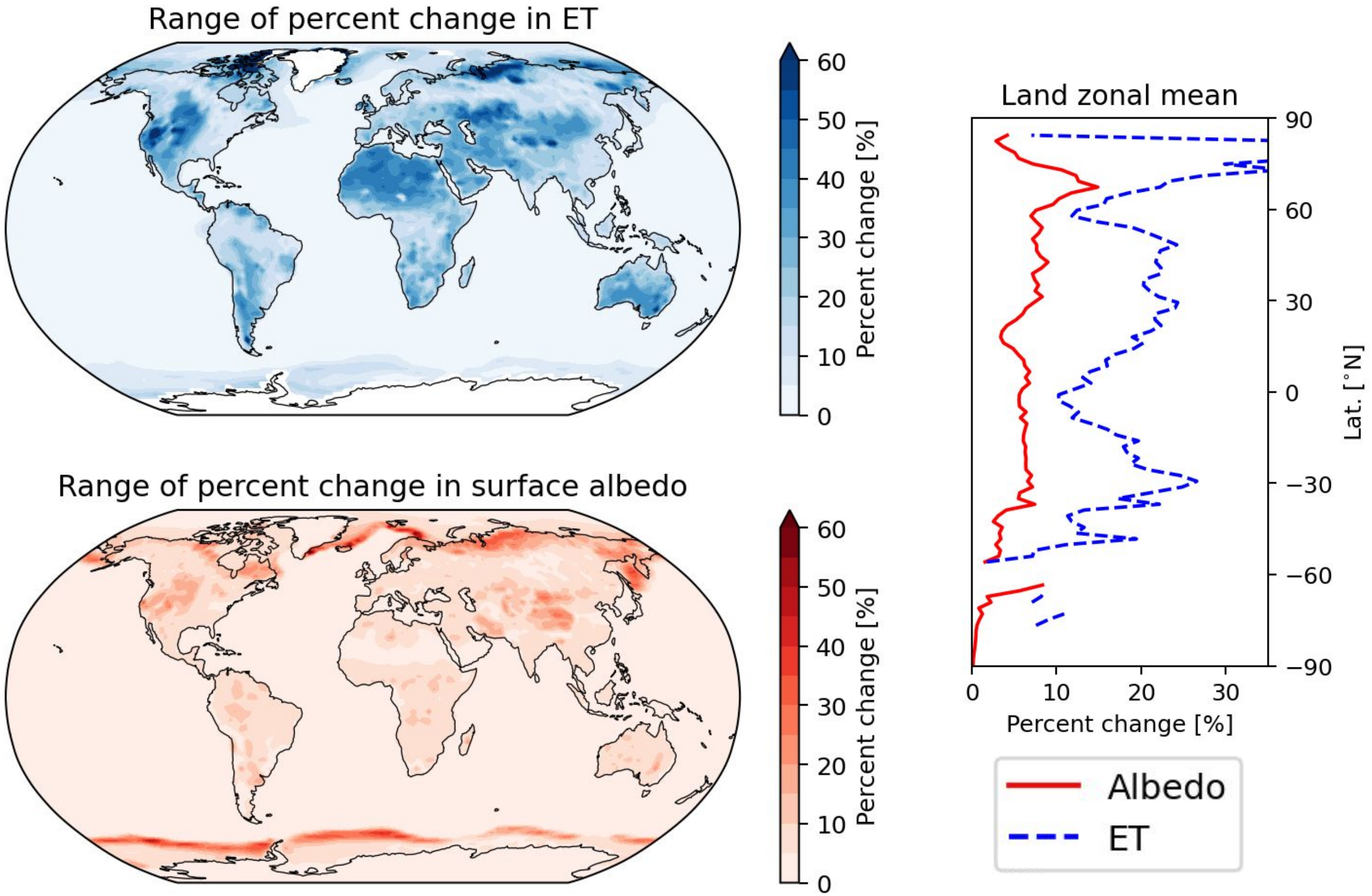
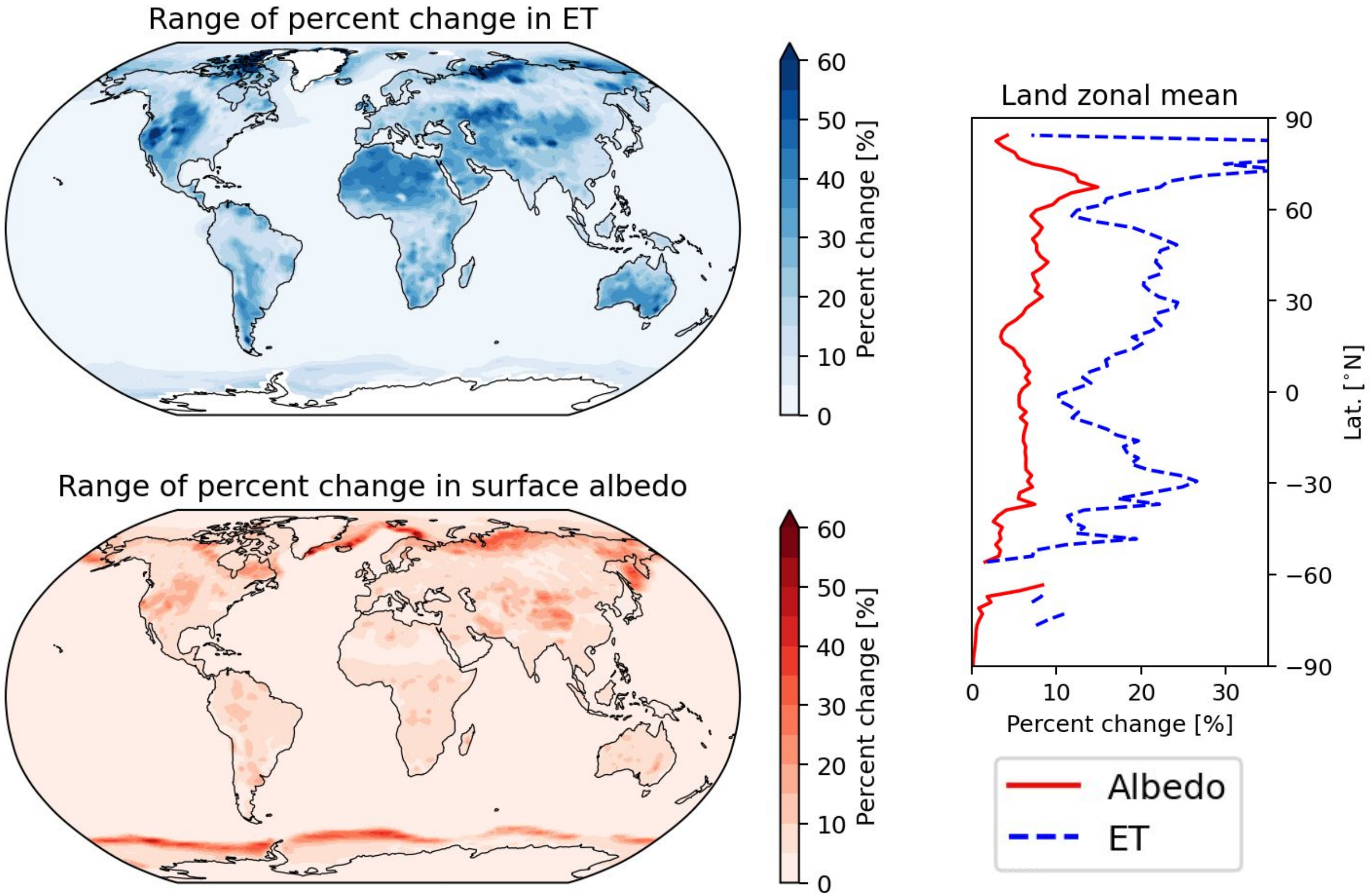


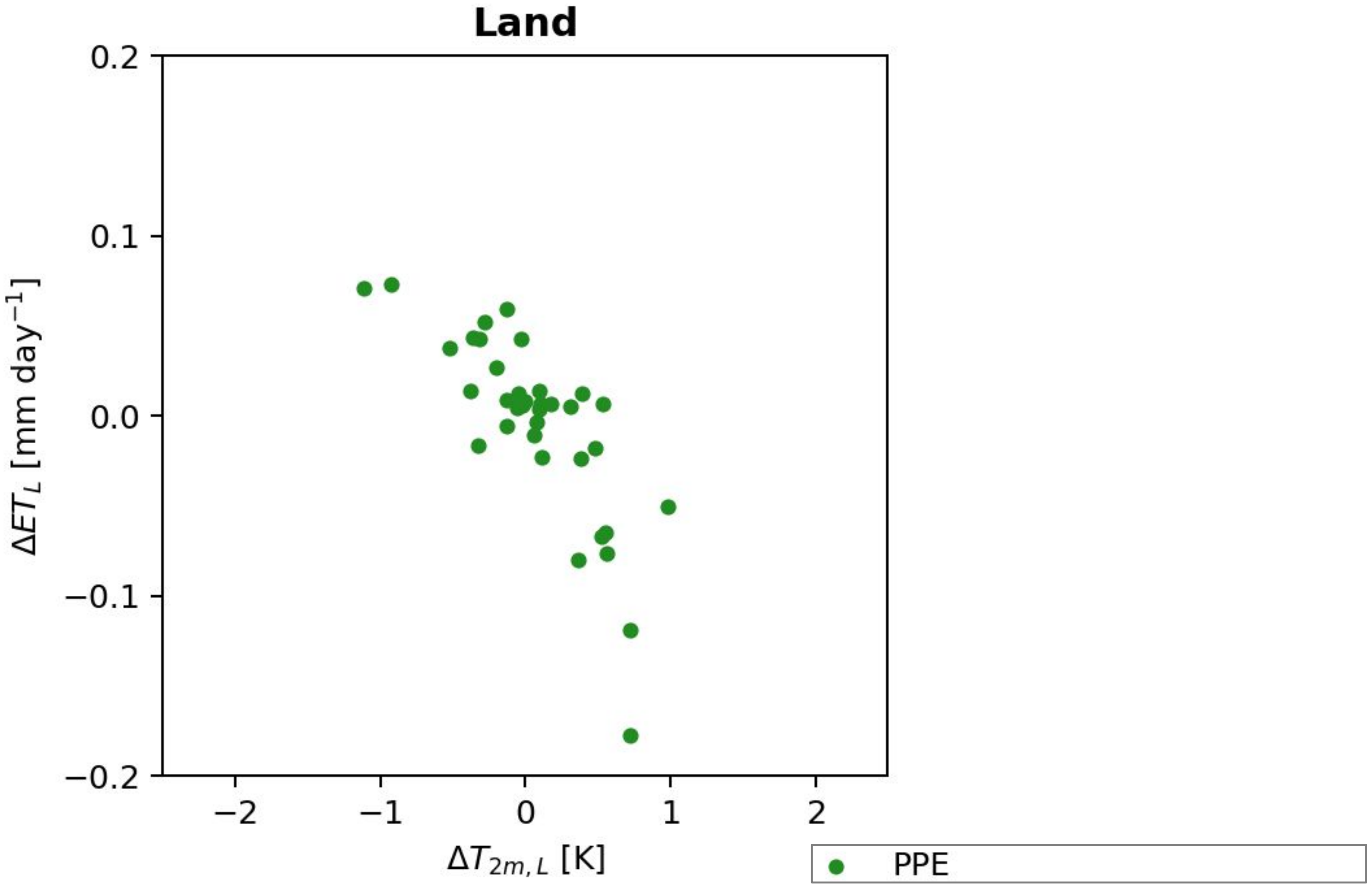
Leveraging the coupled PPE to examine small evapotranspiration perturbations

- Surface temperature change is driven by ET, not albedo
- This is an emergent feature of the PPE:

  greater parametric uncertainty in representing ET than representing albedo



Surface temperature and evapotranspiration are negatively correlated over land



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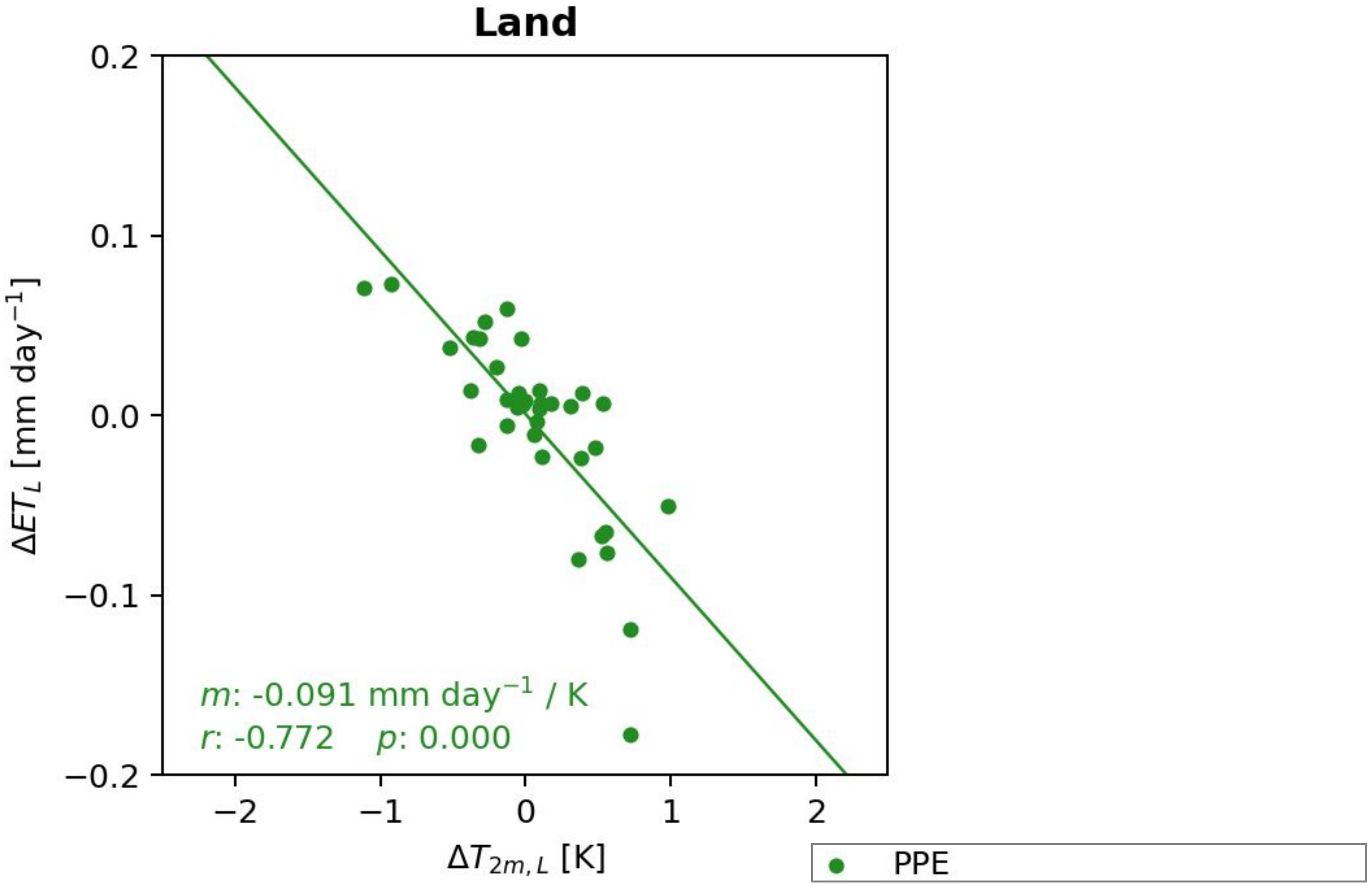

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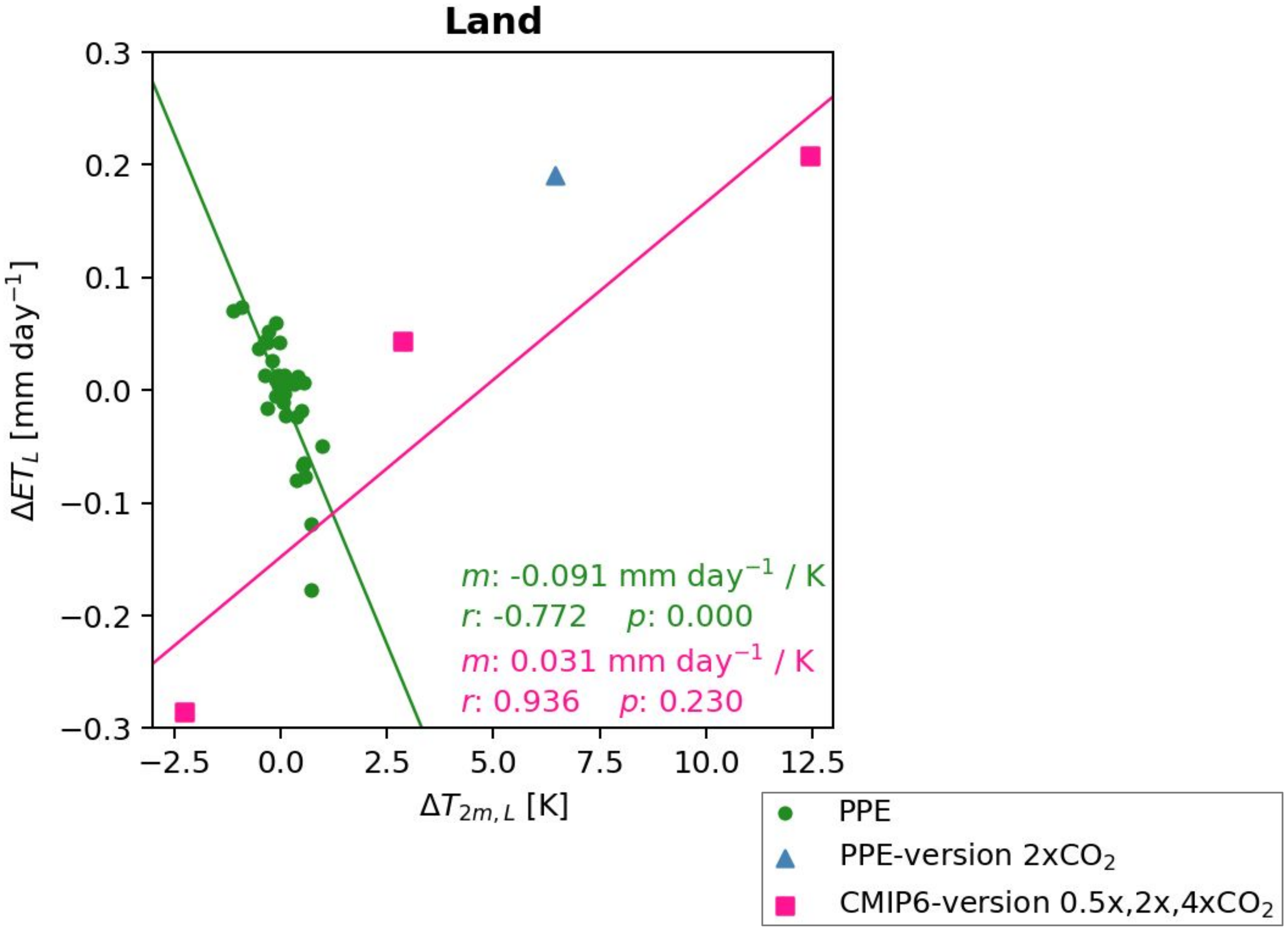

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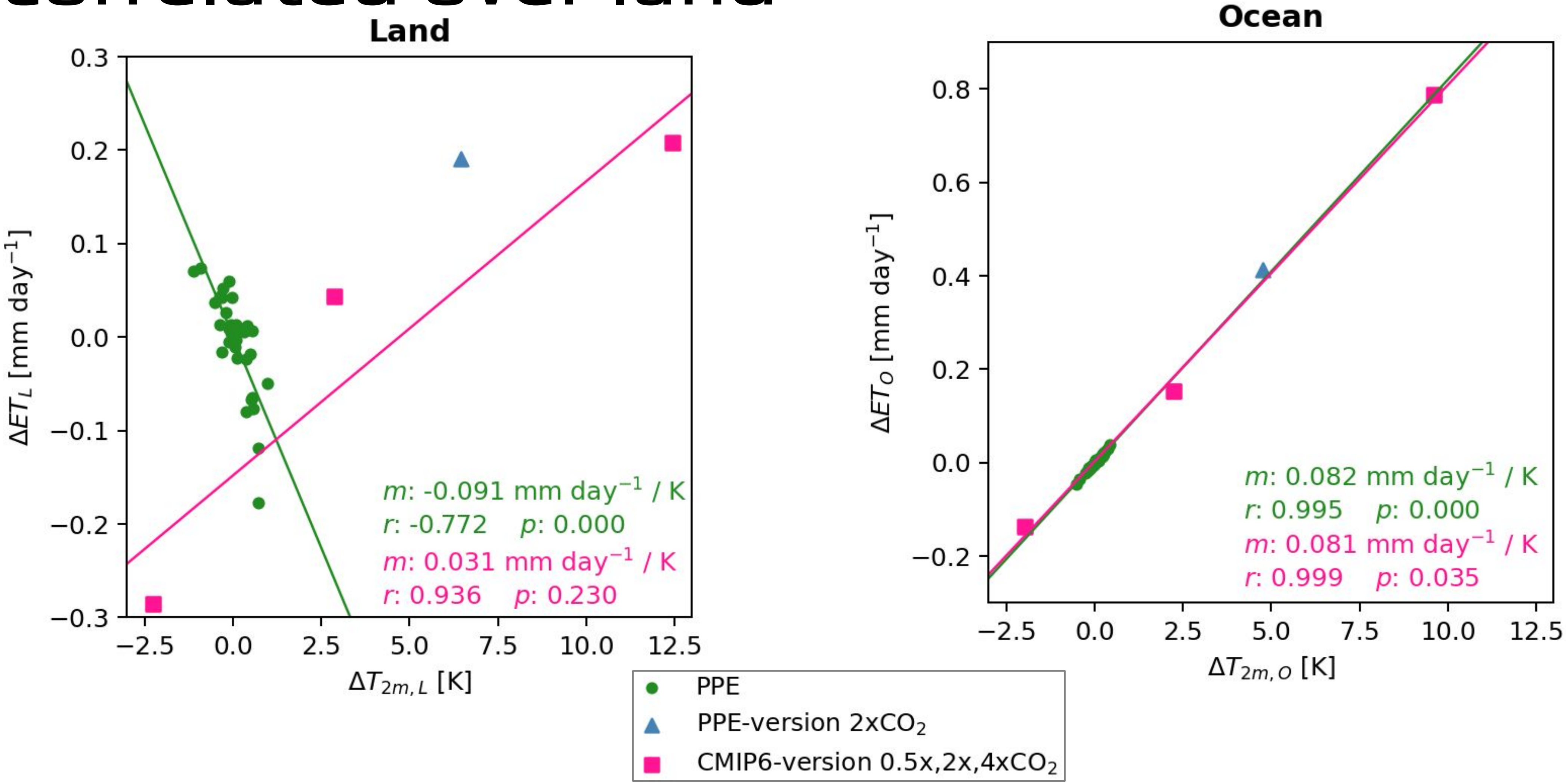

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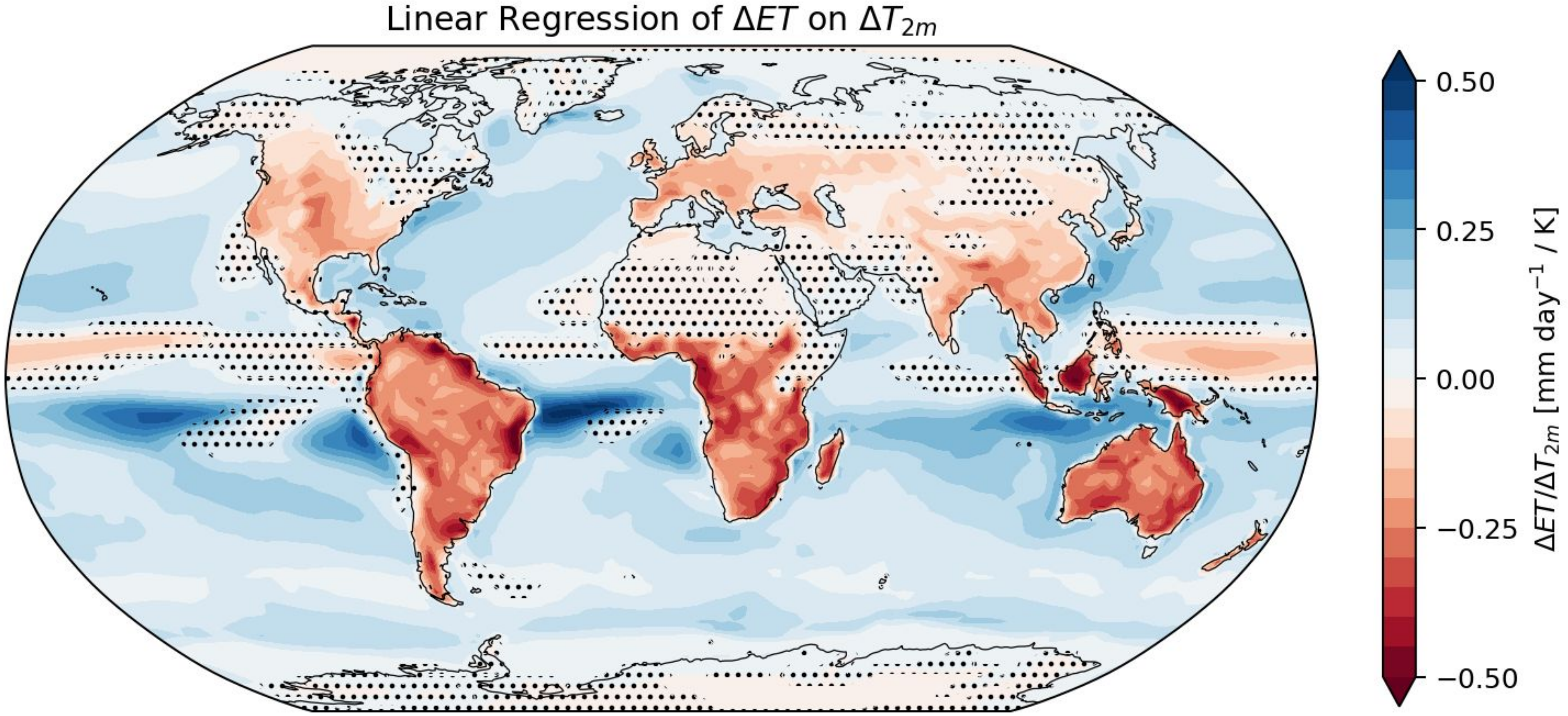
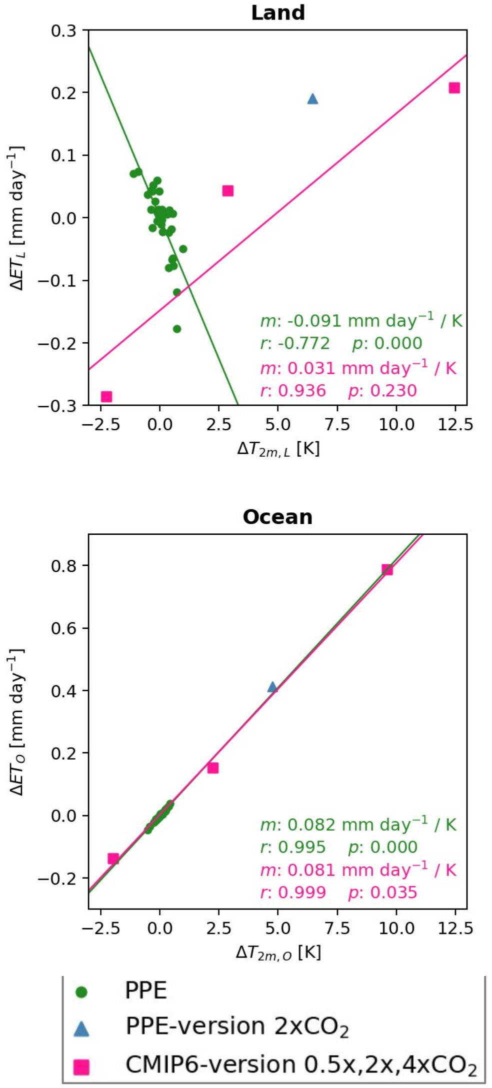
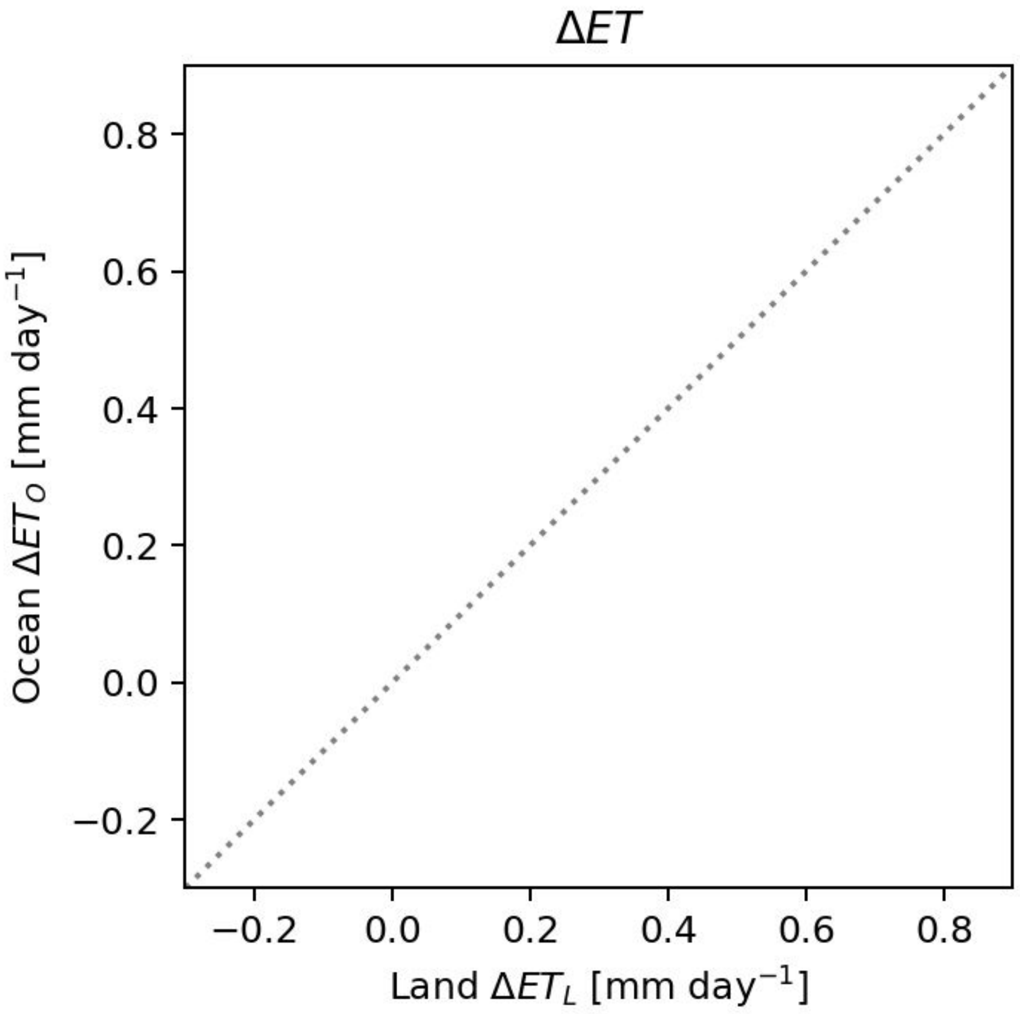




Land-ocean contrasts further display different regimes over land and ocean



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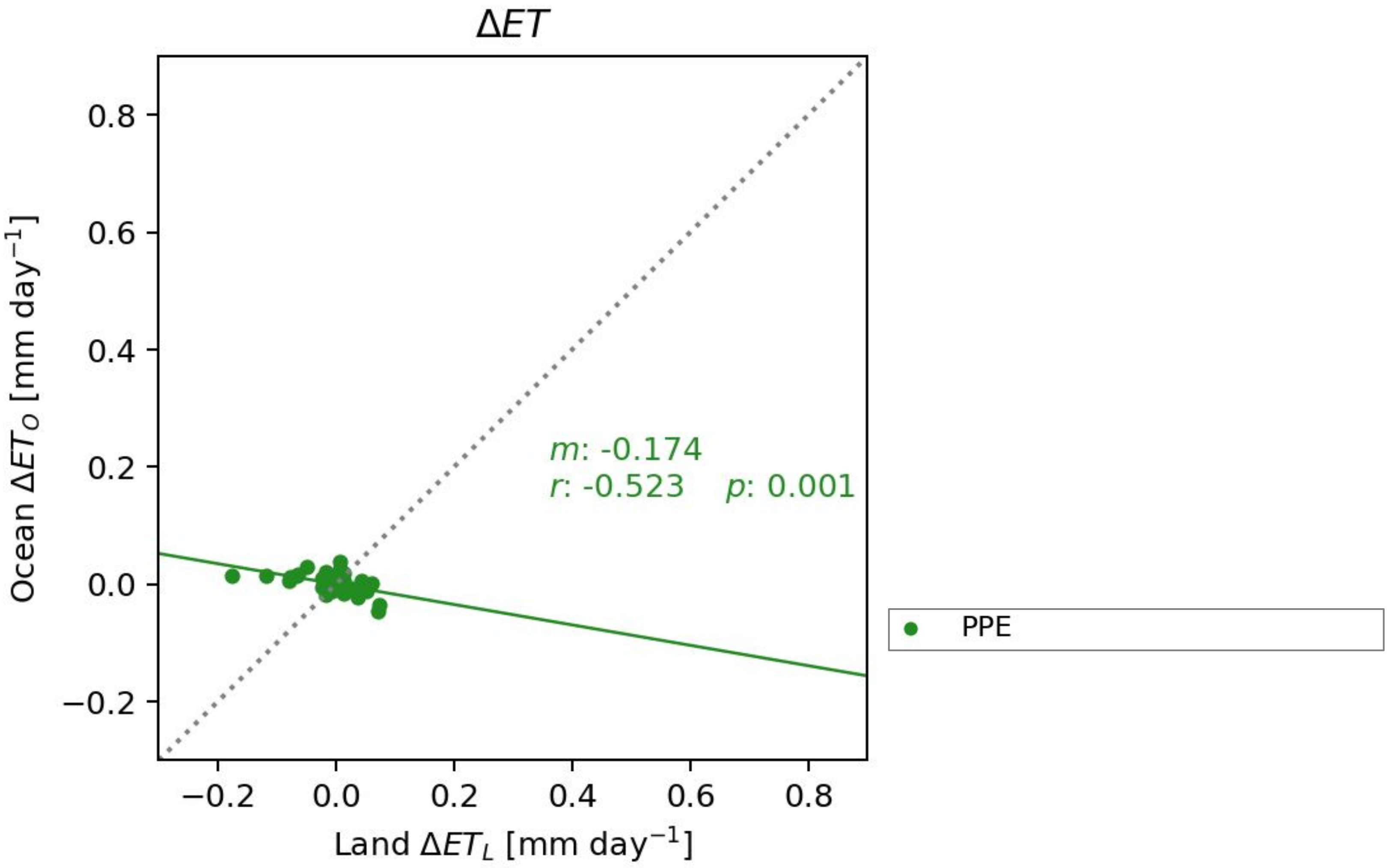

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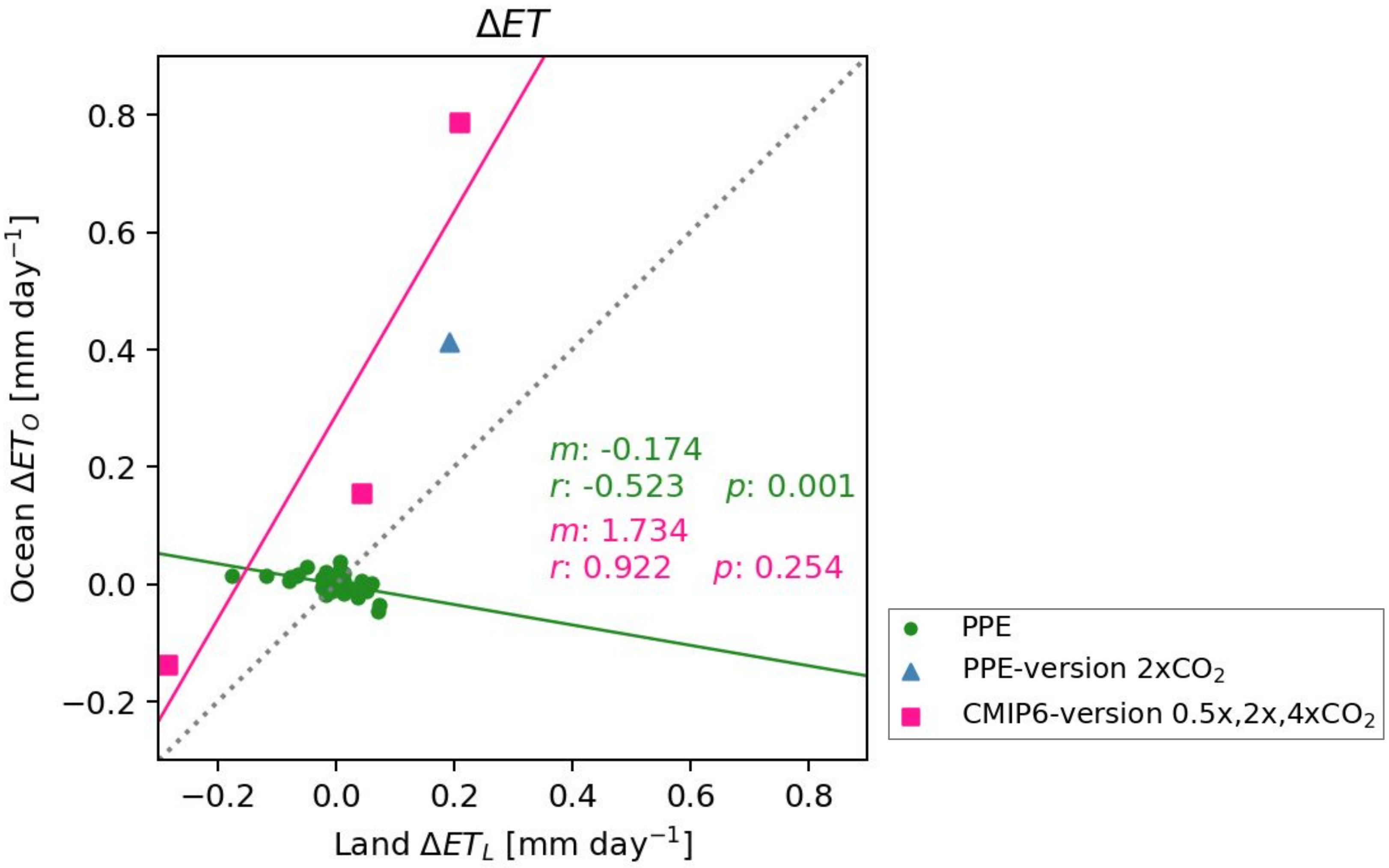
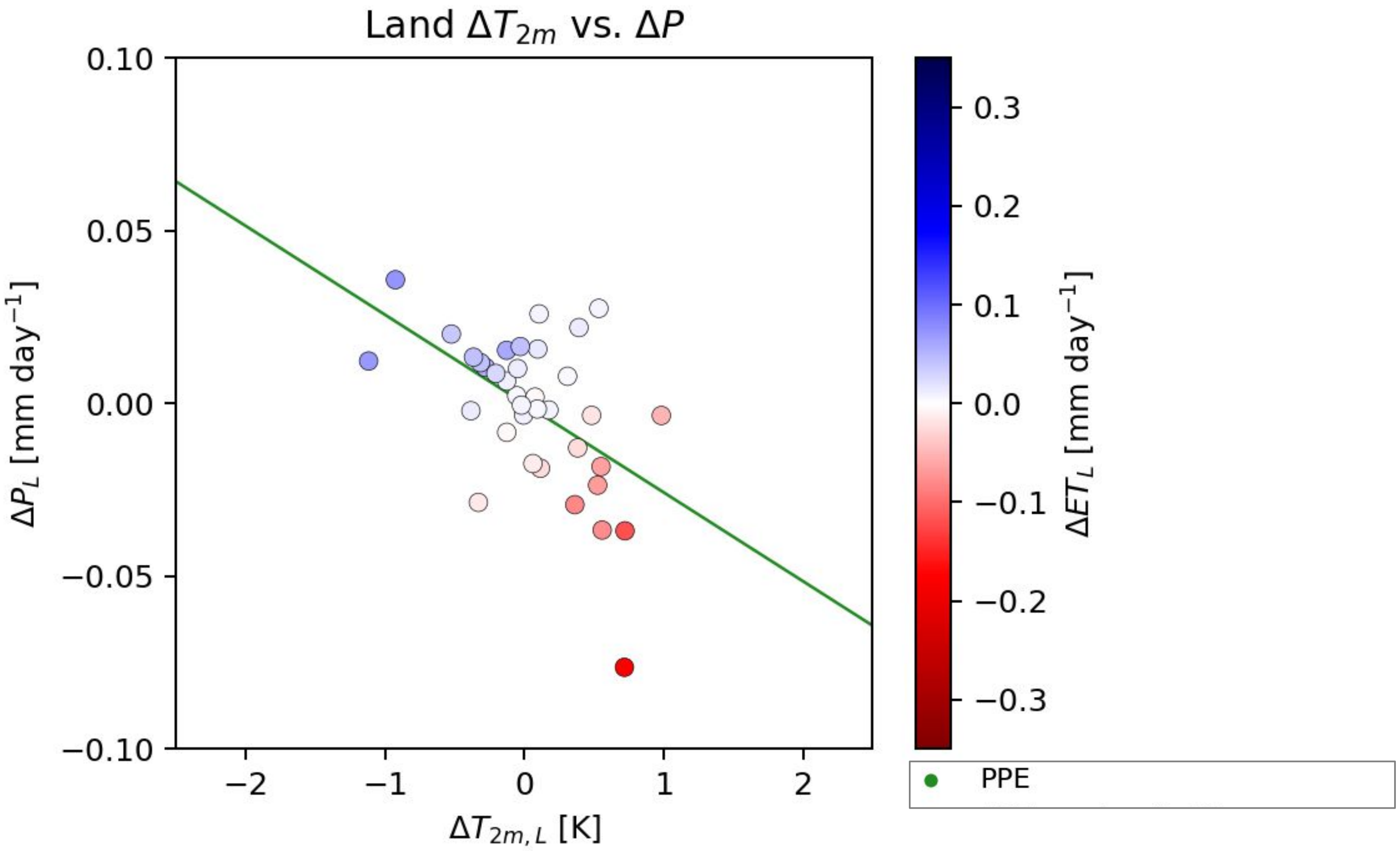


Precipitation responds oppositely over land



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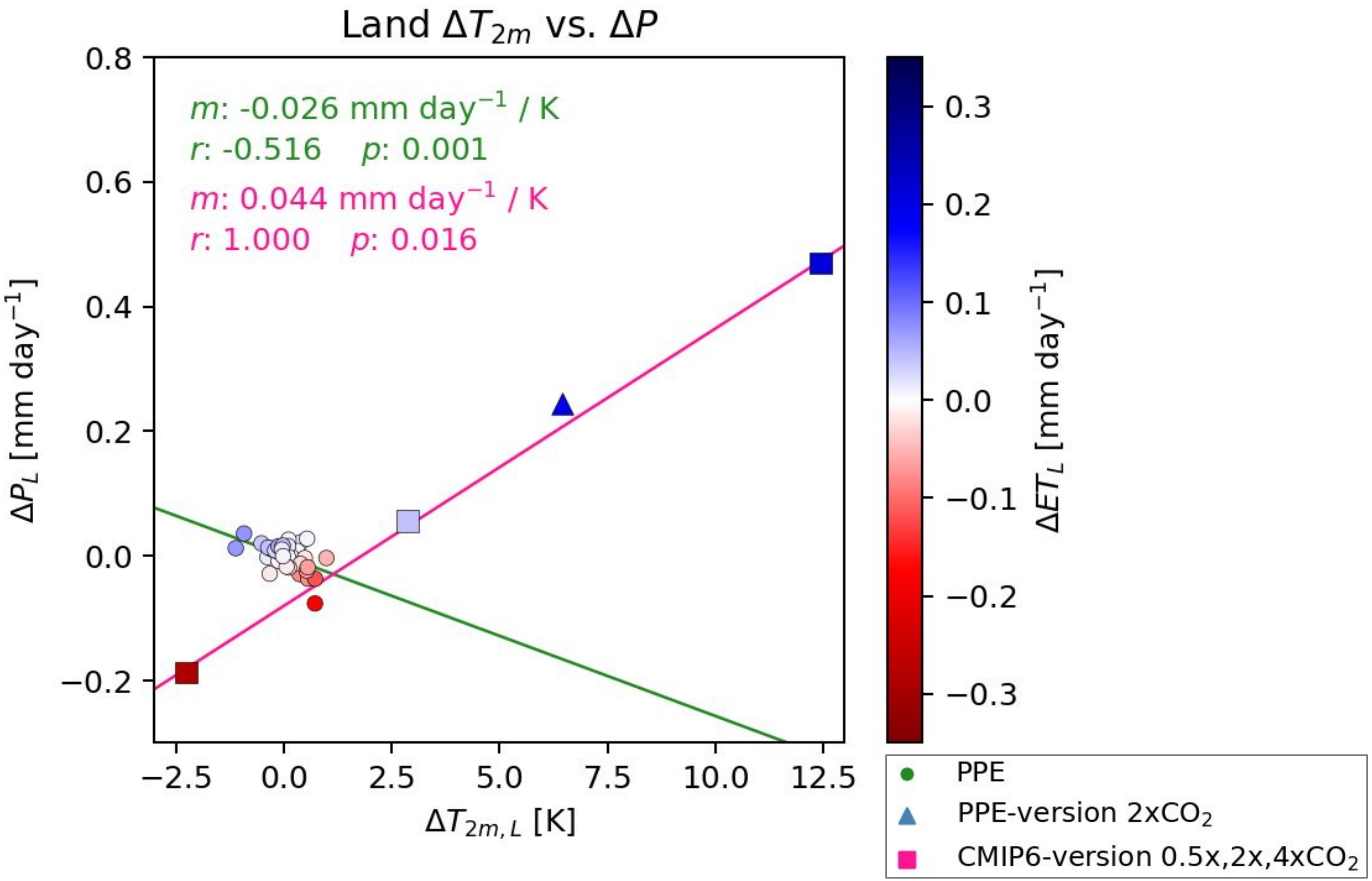
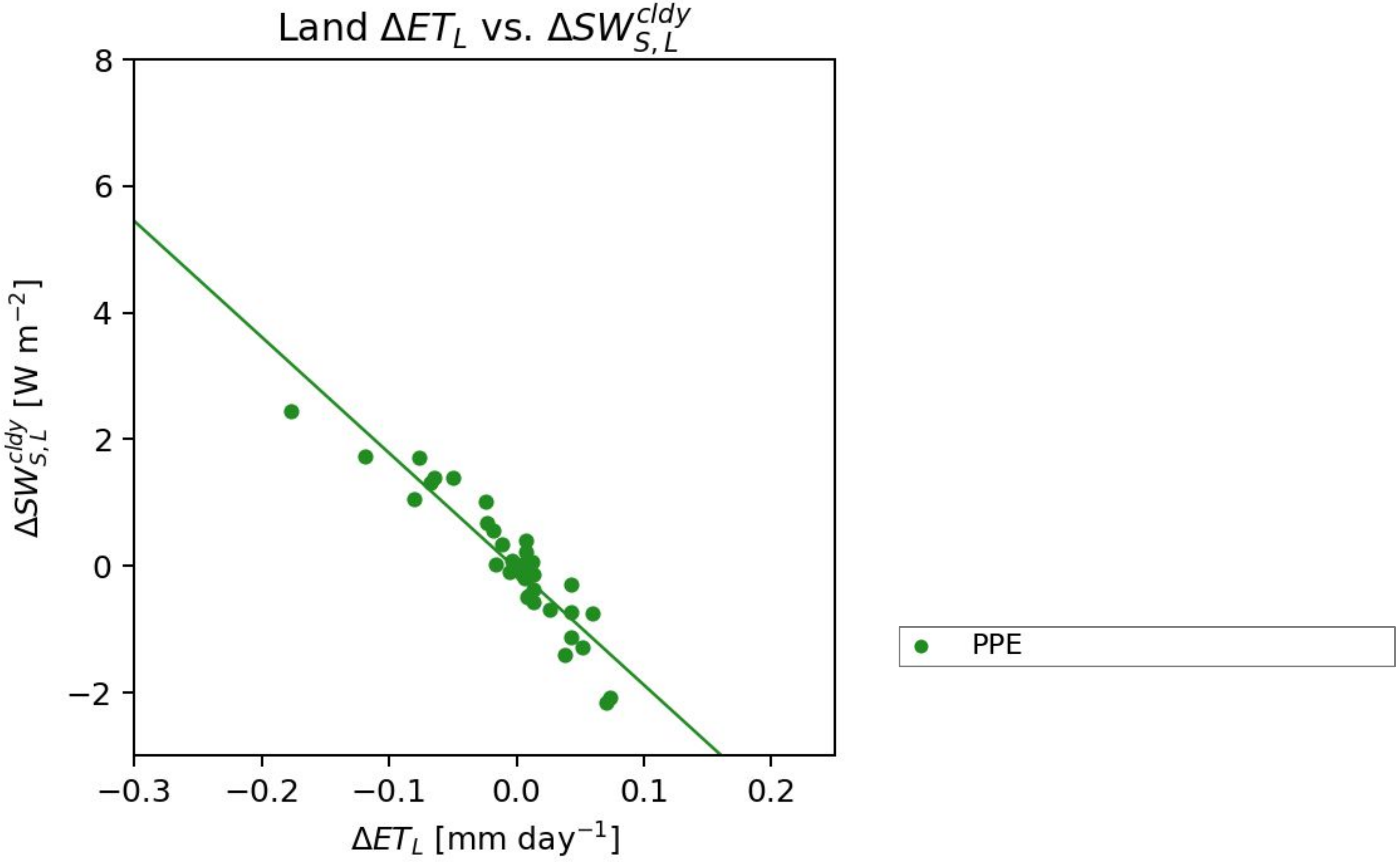


Shortwave cloud response contributes to land surface temperature change



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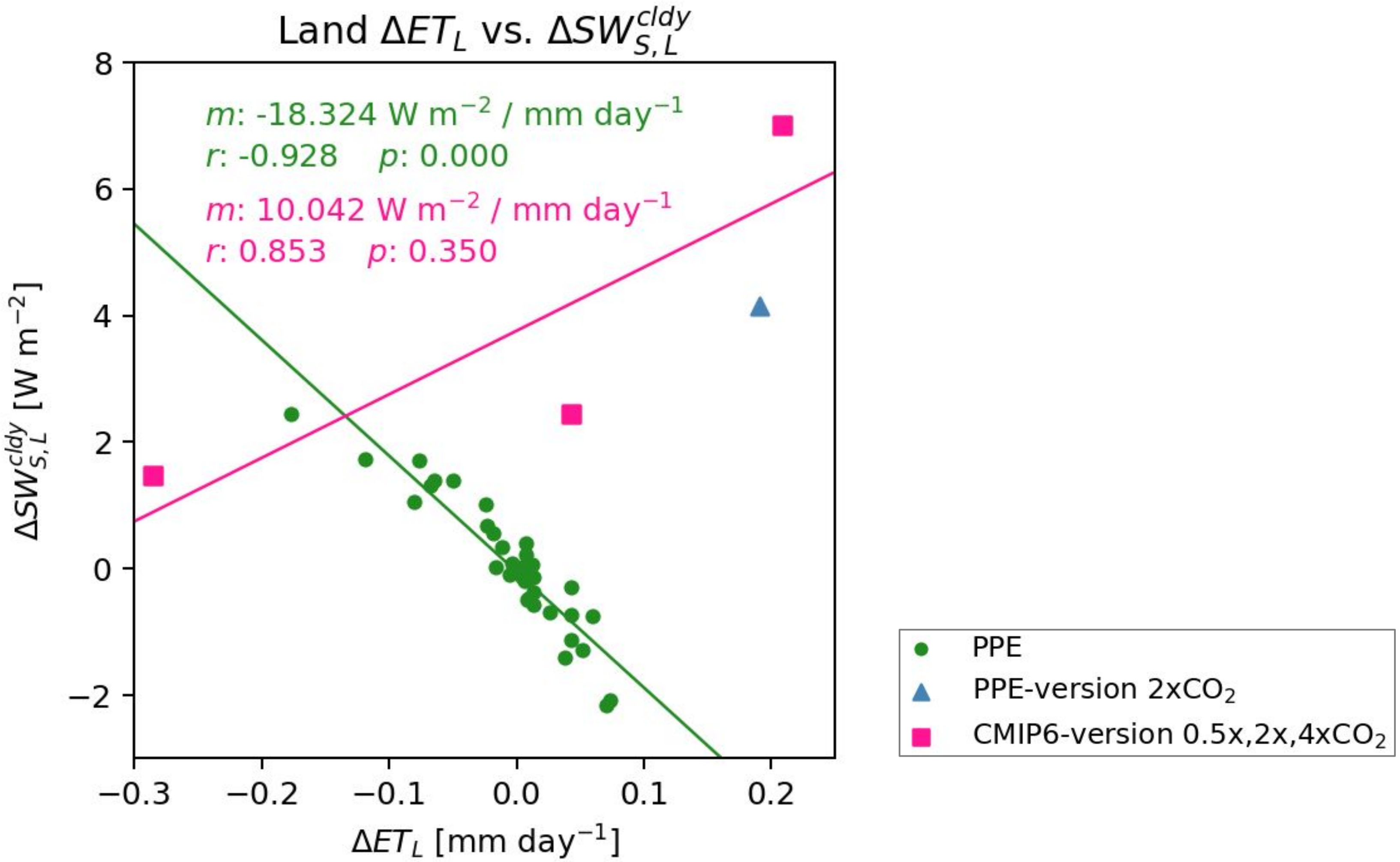

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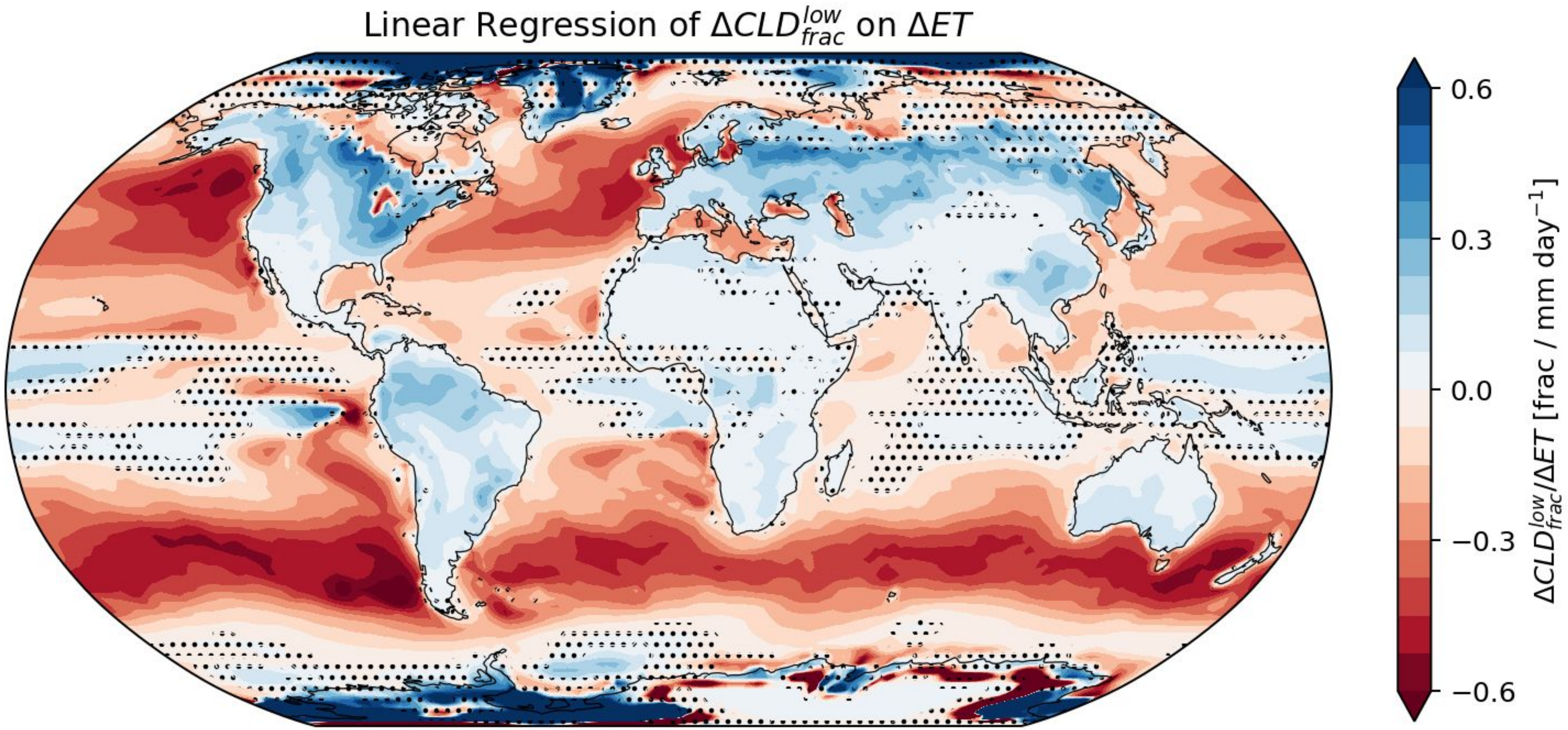
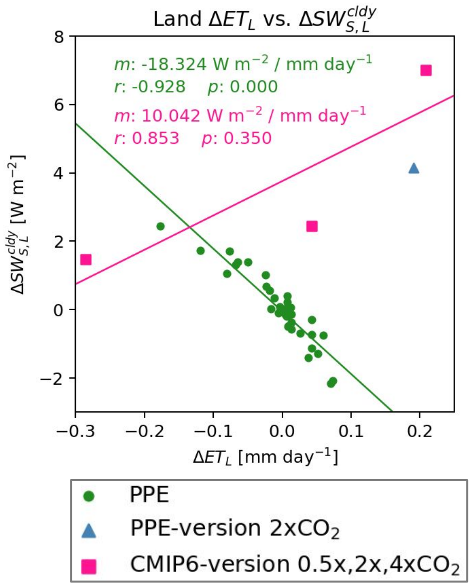


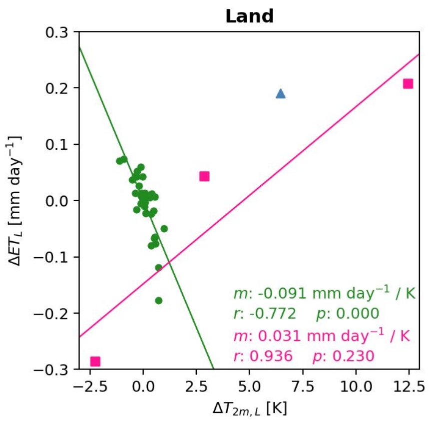


Take home points

1. **over land**

PPE **ET↓ causes T↑**

+ CO2 **ET↑ with T↑**



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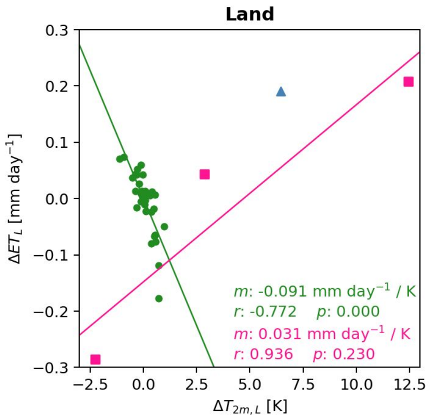

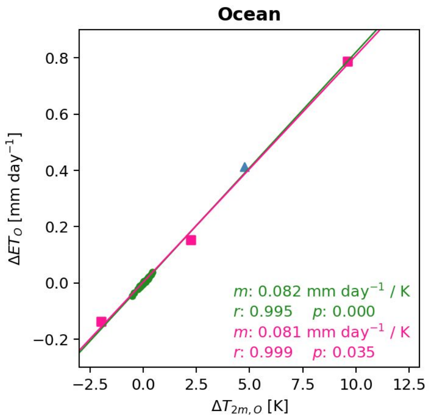

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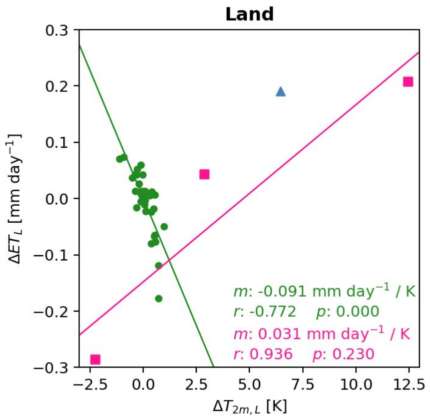
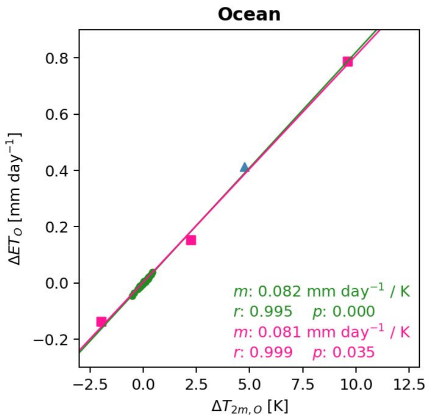
PPE	**ET↓ causes T↑**		**ET↑ with T↑**	
+ CO_2	**ET↑ with T↑**		**ET↑ with T↑**	

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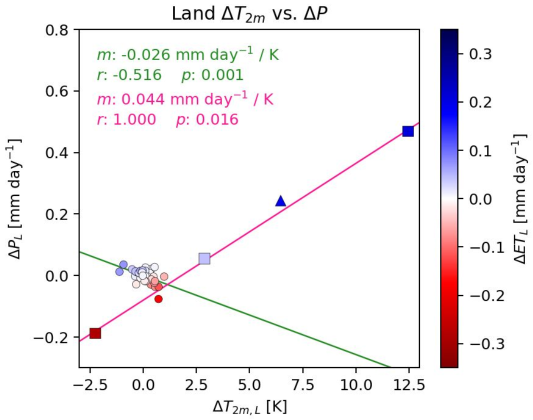
PPE	**P↓ with T↑**	
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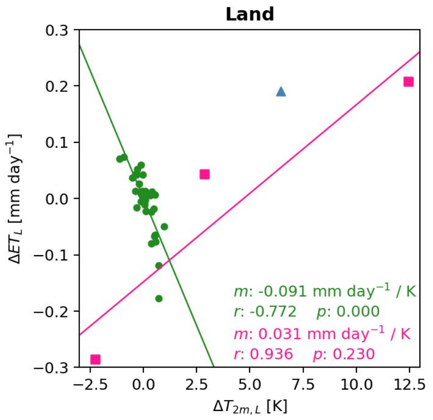
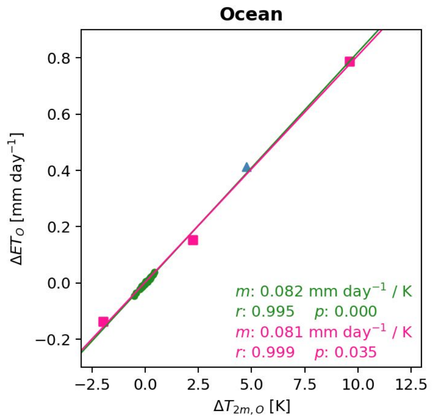


over ocean

ET↑ with T↑

ET↑ with T↑



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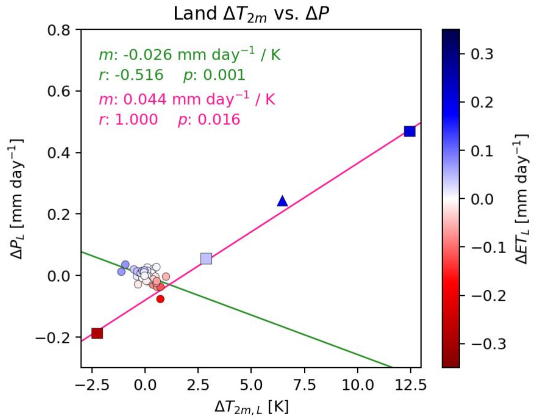
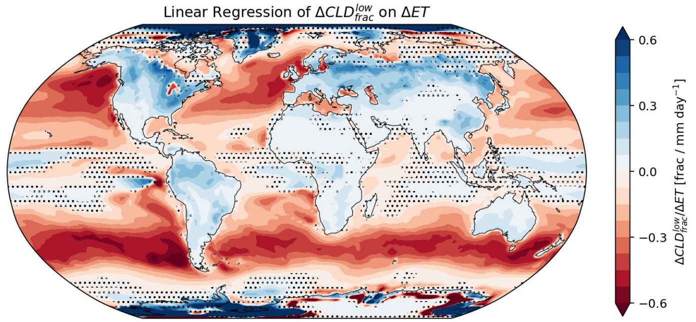


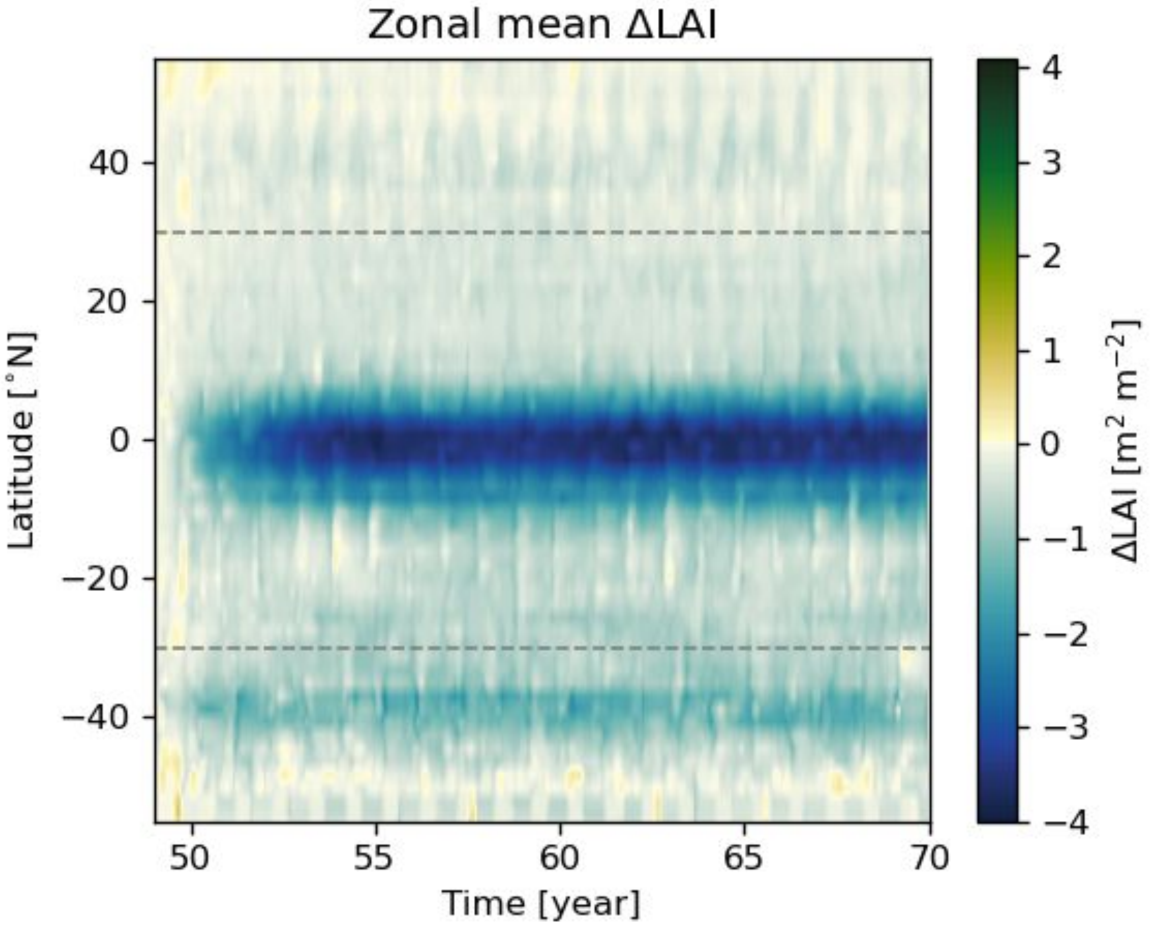
3. T↑ over land from SW



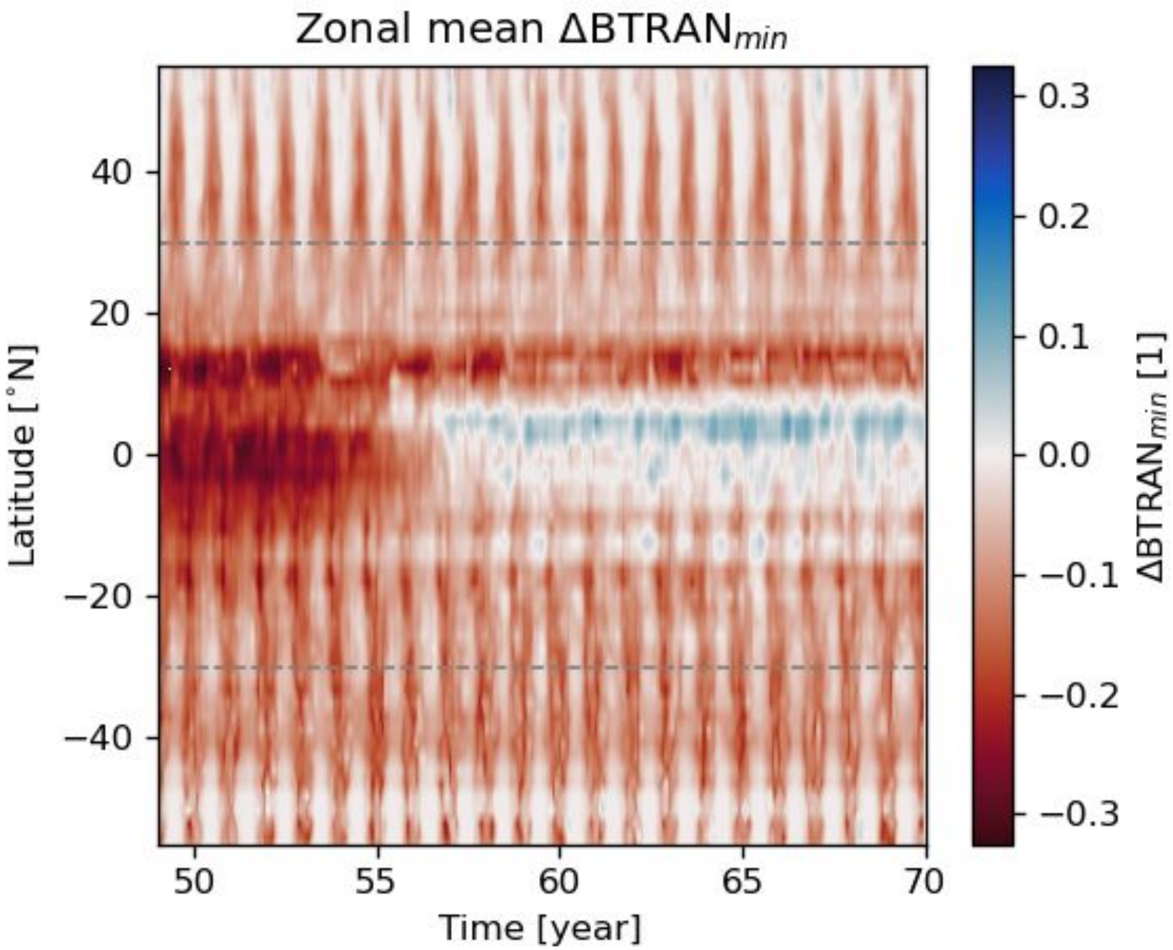
Other curious but unrelated results!

Fixing vapor pressure deficit near zero causes Amazon "die-off" and new vegetation stable state

Tropical leaf area decreases in first 5 years, then reaches new stable state



Decrease in leaf area driven by increase in water stress



Low VPD increases water stress causing a large decline of leaf area in tropical rainforests, which ***persists as a new stable state even when the water stress alleviates.***

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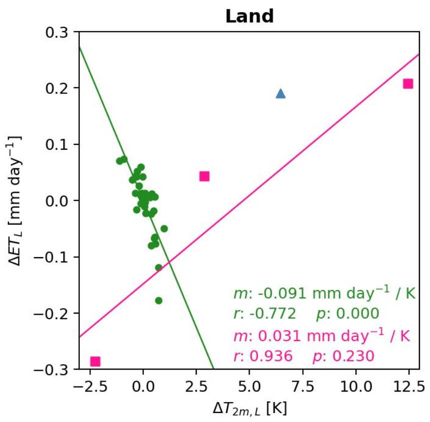

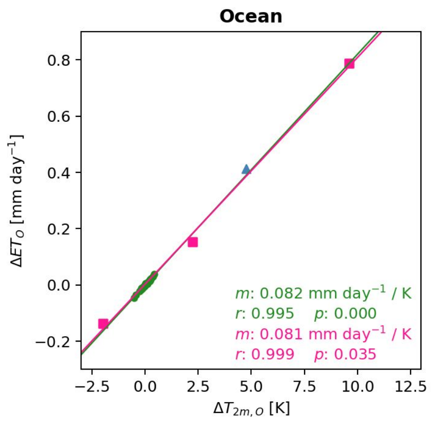

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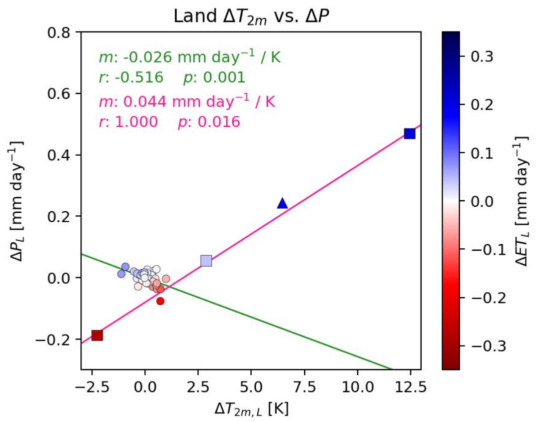

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