Increasing water-limitation of global ecosystems in a changing climate

Rene Orth
Jasper Denissen, Wantong Li, Sungmin O
and many others

Max Planck Institute for Biogeochemistry
Jena, Germany

Good morning!

Good morning!

Many thanks
for inviting me

Increasing water-limitation of global ecosystems in a changing climate

1) Ecosystem energy vs. water-limitation

2) Implications of ecosystem water limitation

3) Trends in ecosystem water limitation

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Ecosystem
energy-limitation vs. water-limitation

telegraph.co.uk

dreamstime.com

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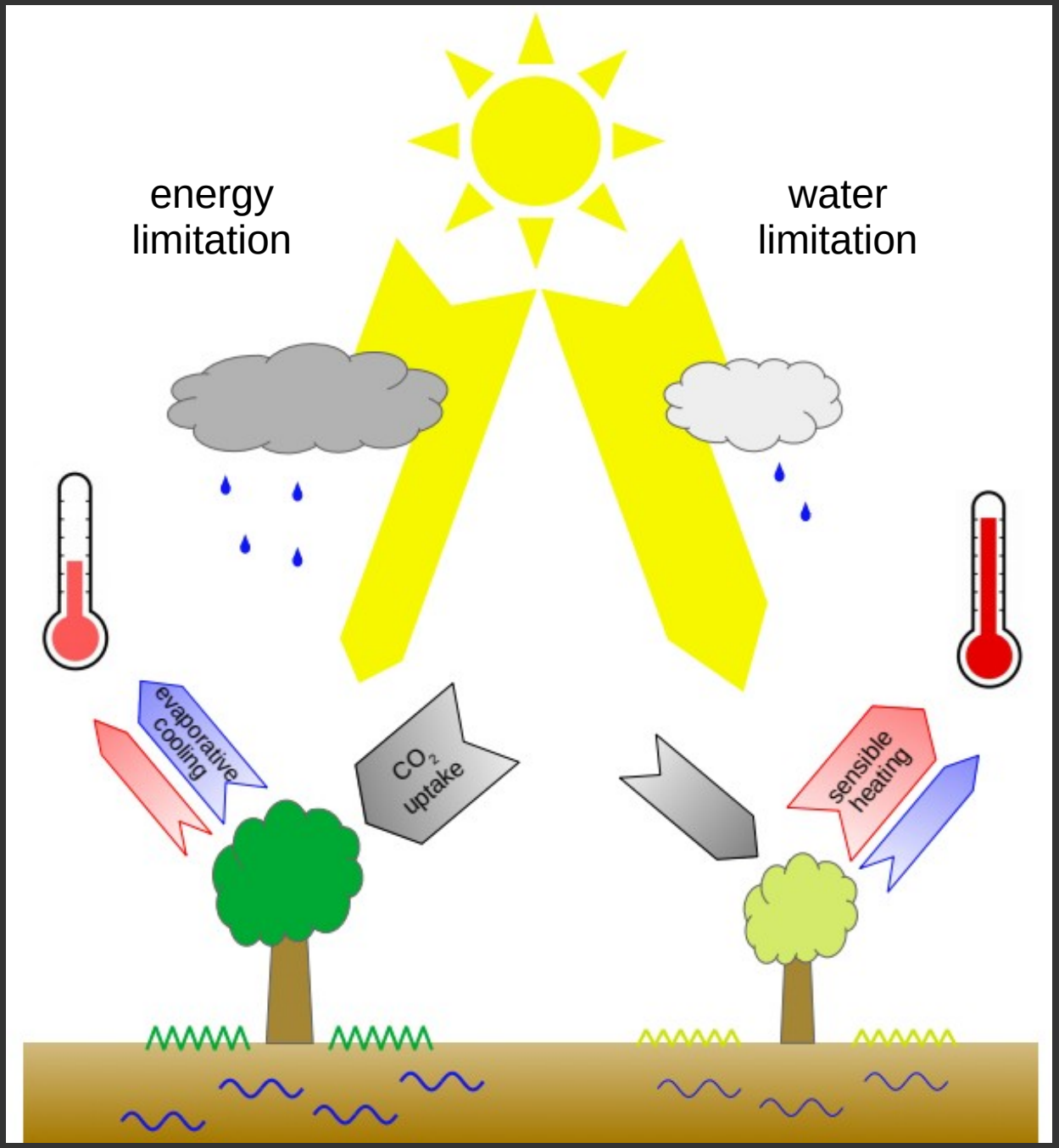
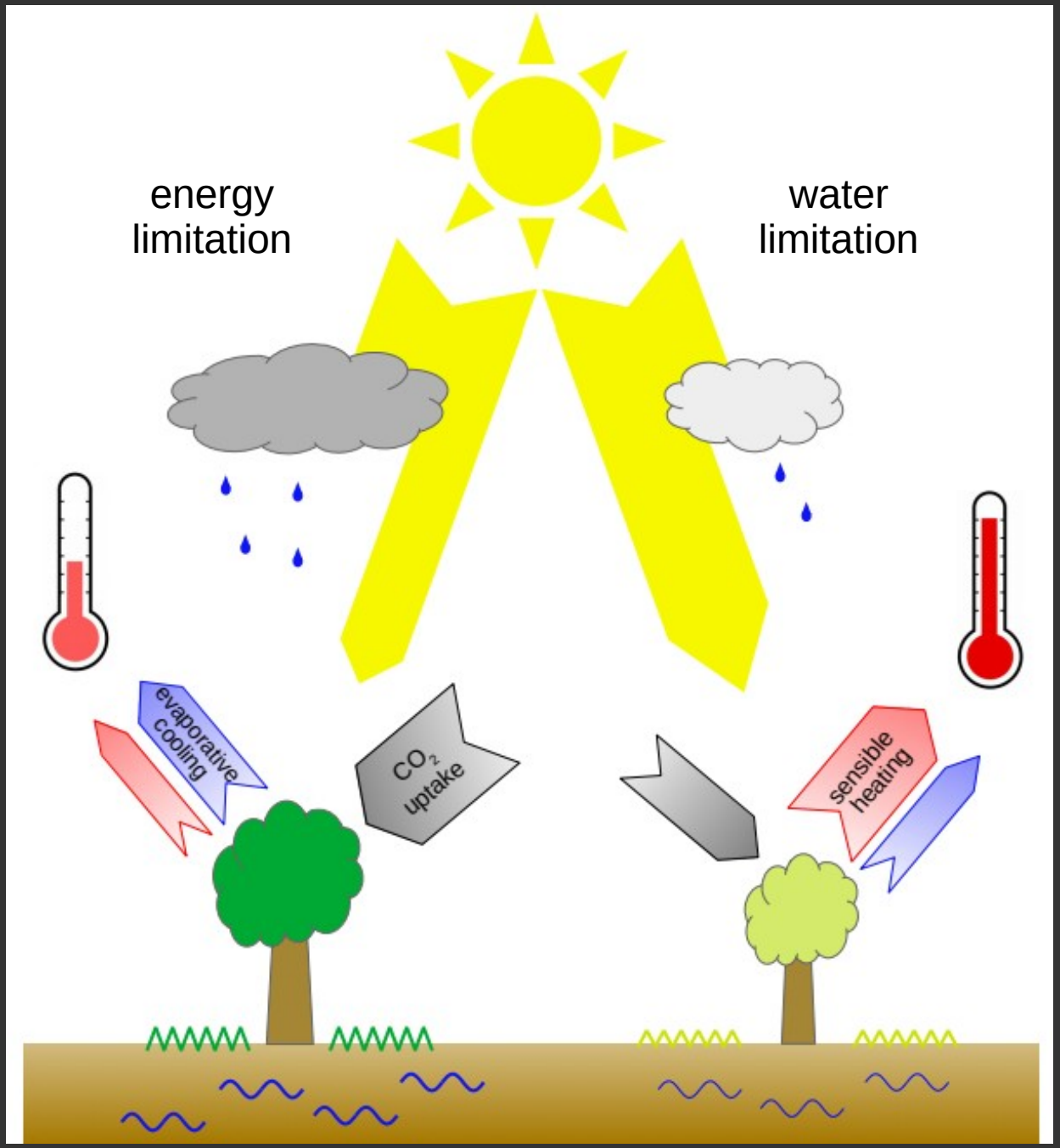
Here we consider the entire globe!

Ecosystem energy-limitation vs. water-limitation



Orth 2021, *AGU Adv.*

Ecosystem energy-limitation vs. water-limitation



Limited water supply affects ecosystem services

Orth 2021, *AGU Adv.*

Quantifying ecosystem water limitation

Ecosystem limitation index (ELI) =
corr(vegetation functioning, energy availability) – corr(vegetation functioning, water availability)

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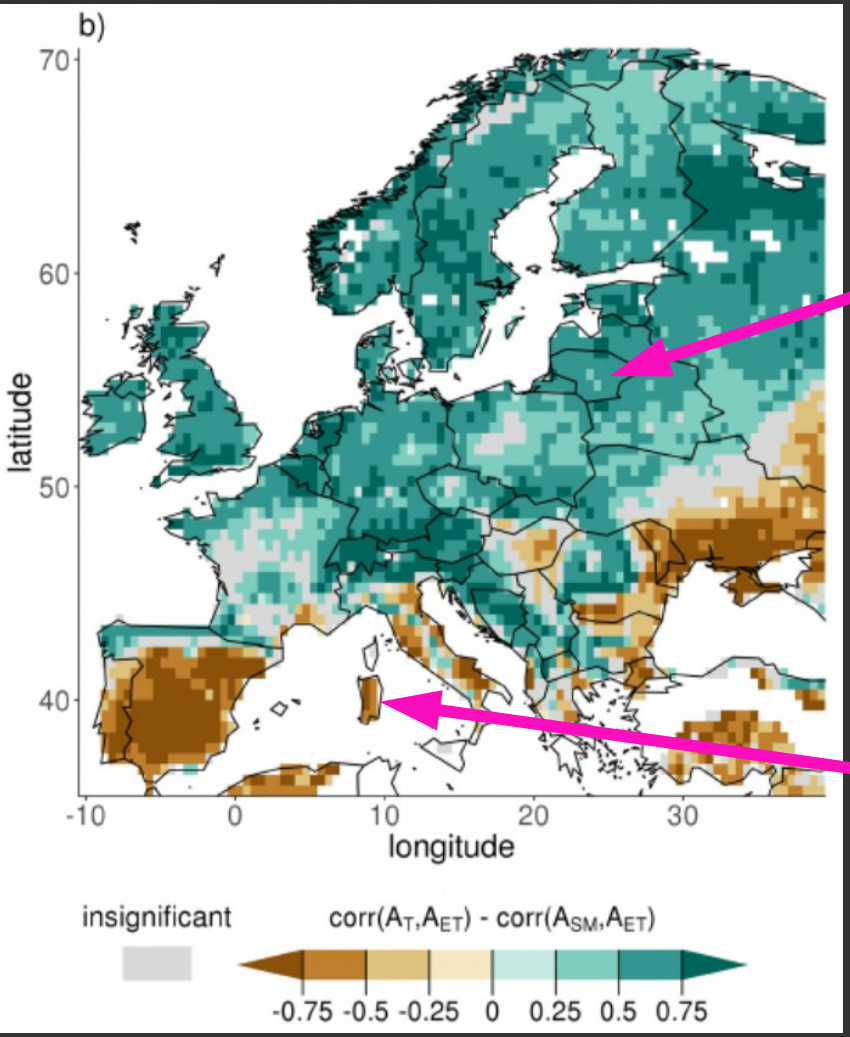

energy-control

water-control

Denissen et al. 2020, *JGR Atmospheres*

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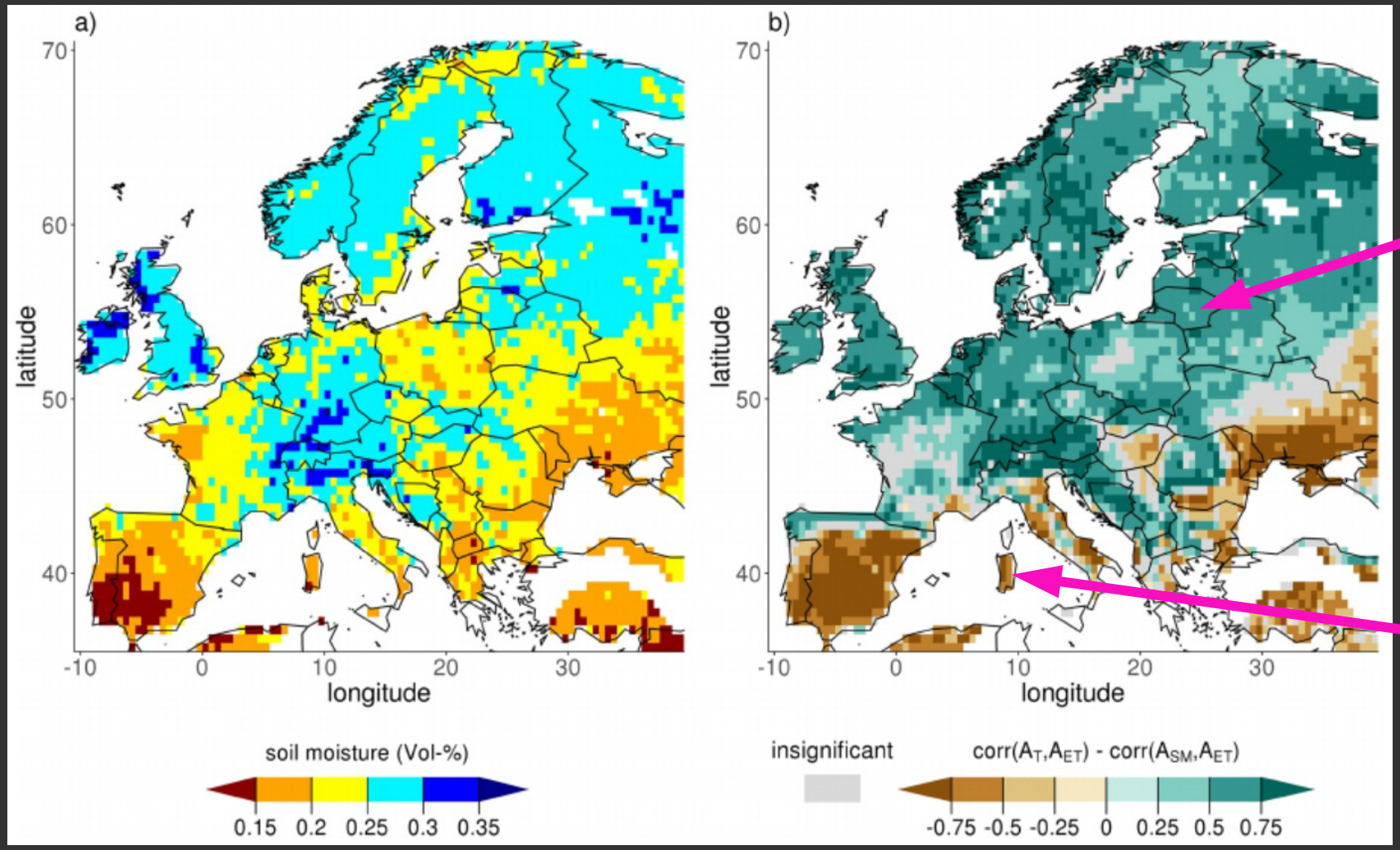

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Sensitivity of photosynthesis to water

Fitting random forest model *SIF ~ climate*

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Evaluate and isolate sensitivity to individual climate variables

Determine the main SIF controls

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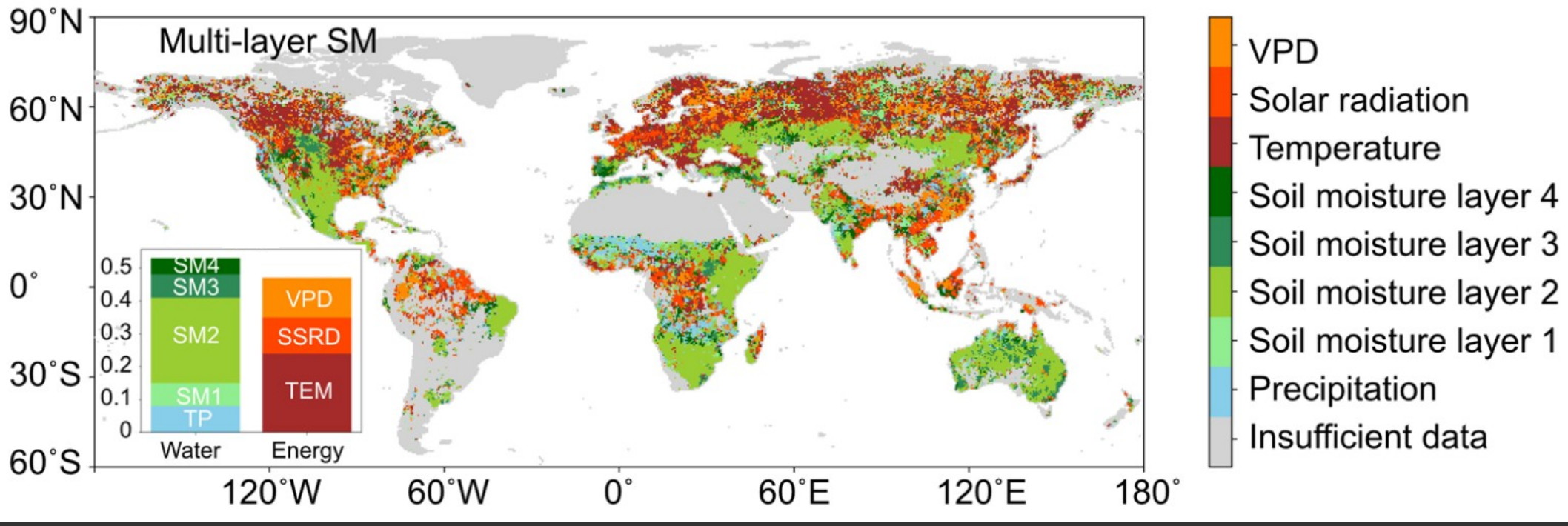

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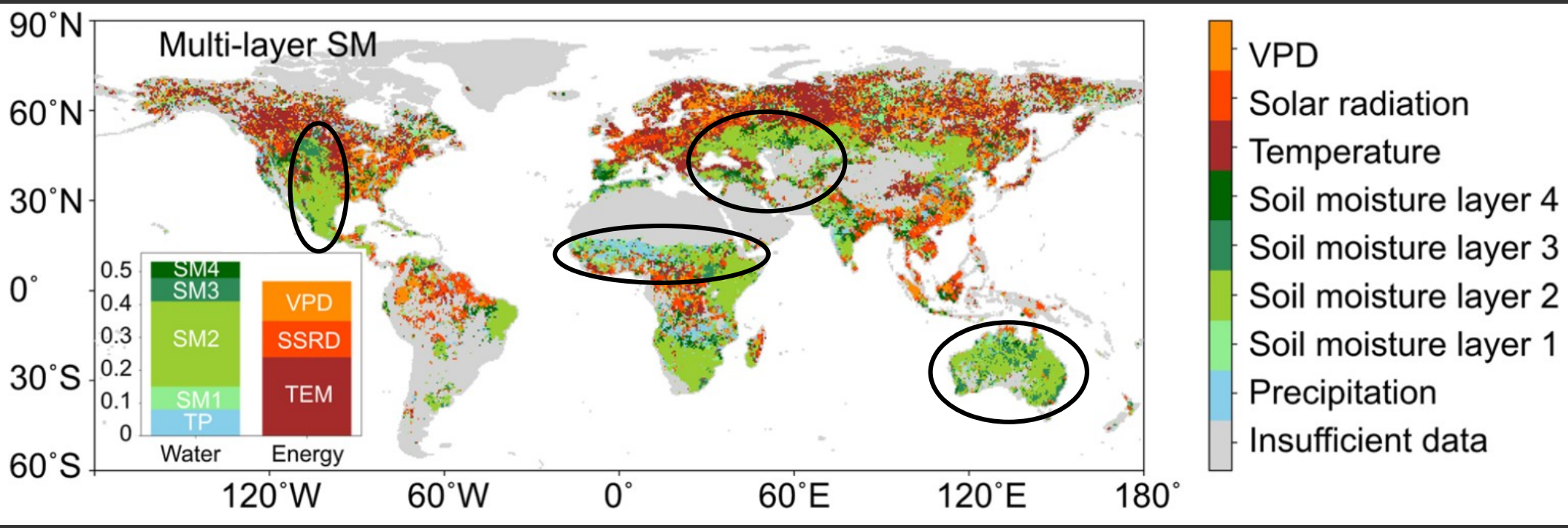

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Water-limited vegetation across more than half of the globe

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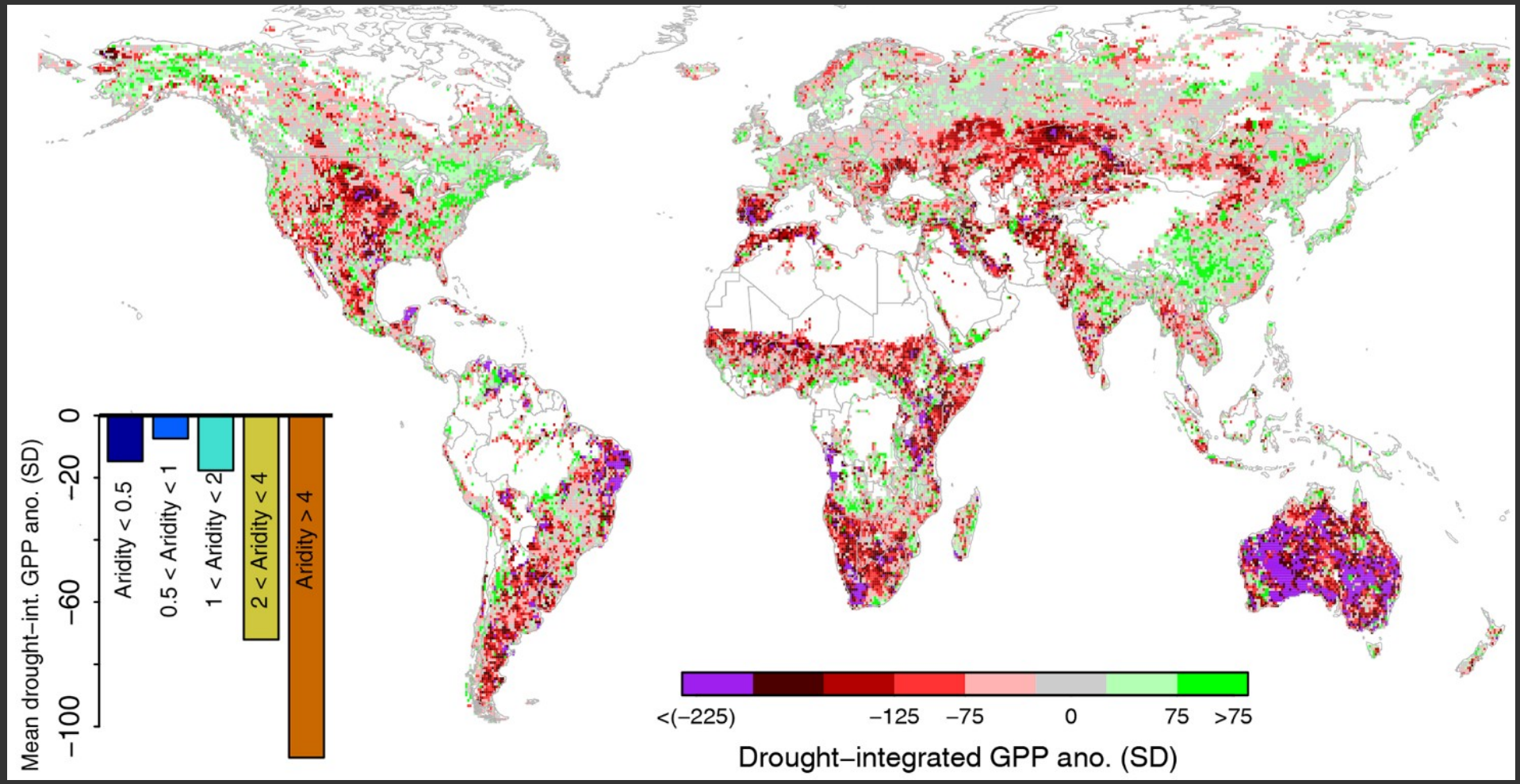

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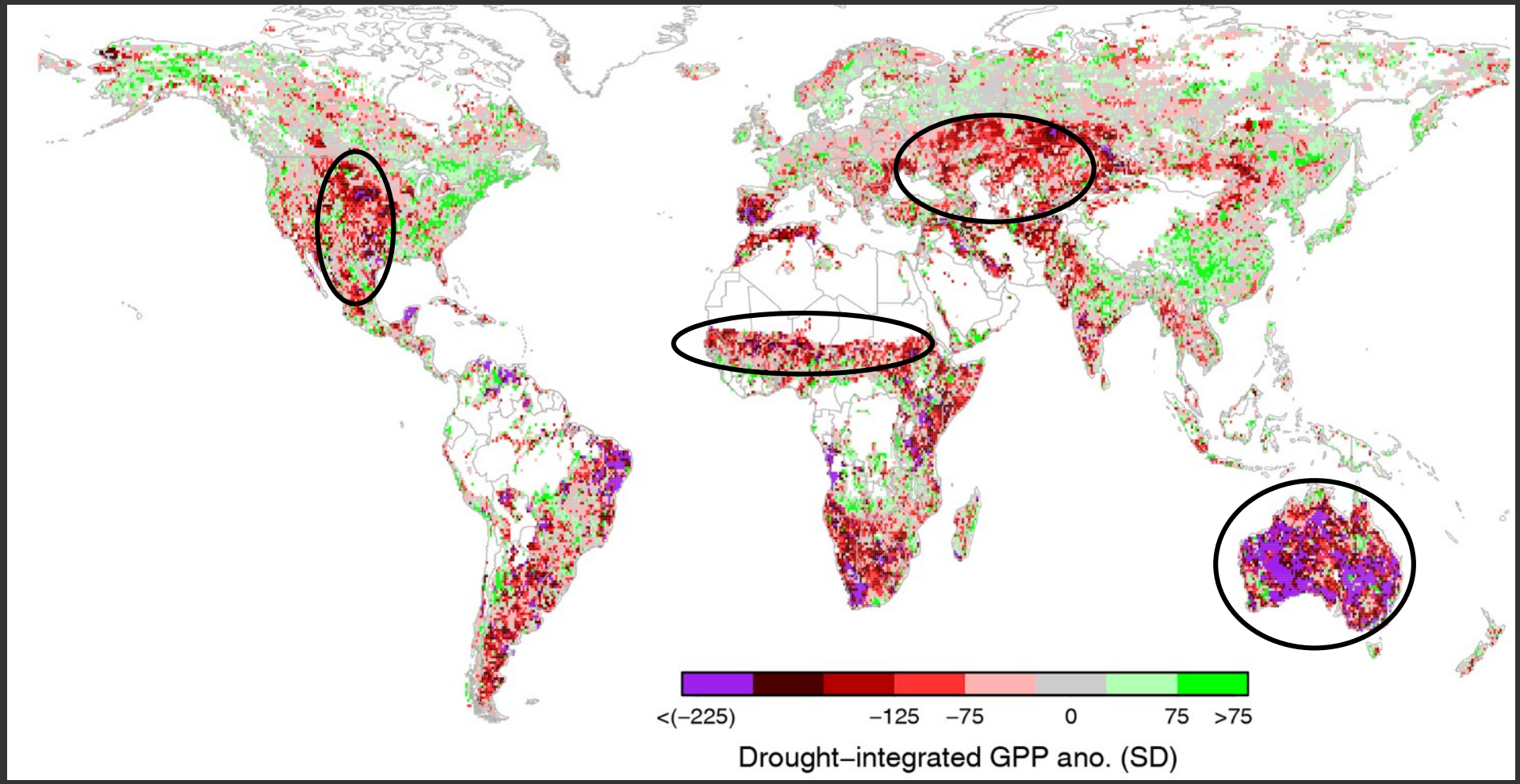

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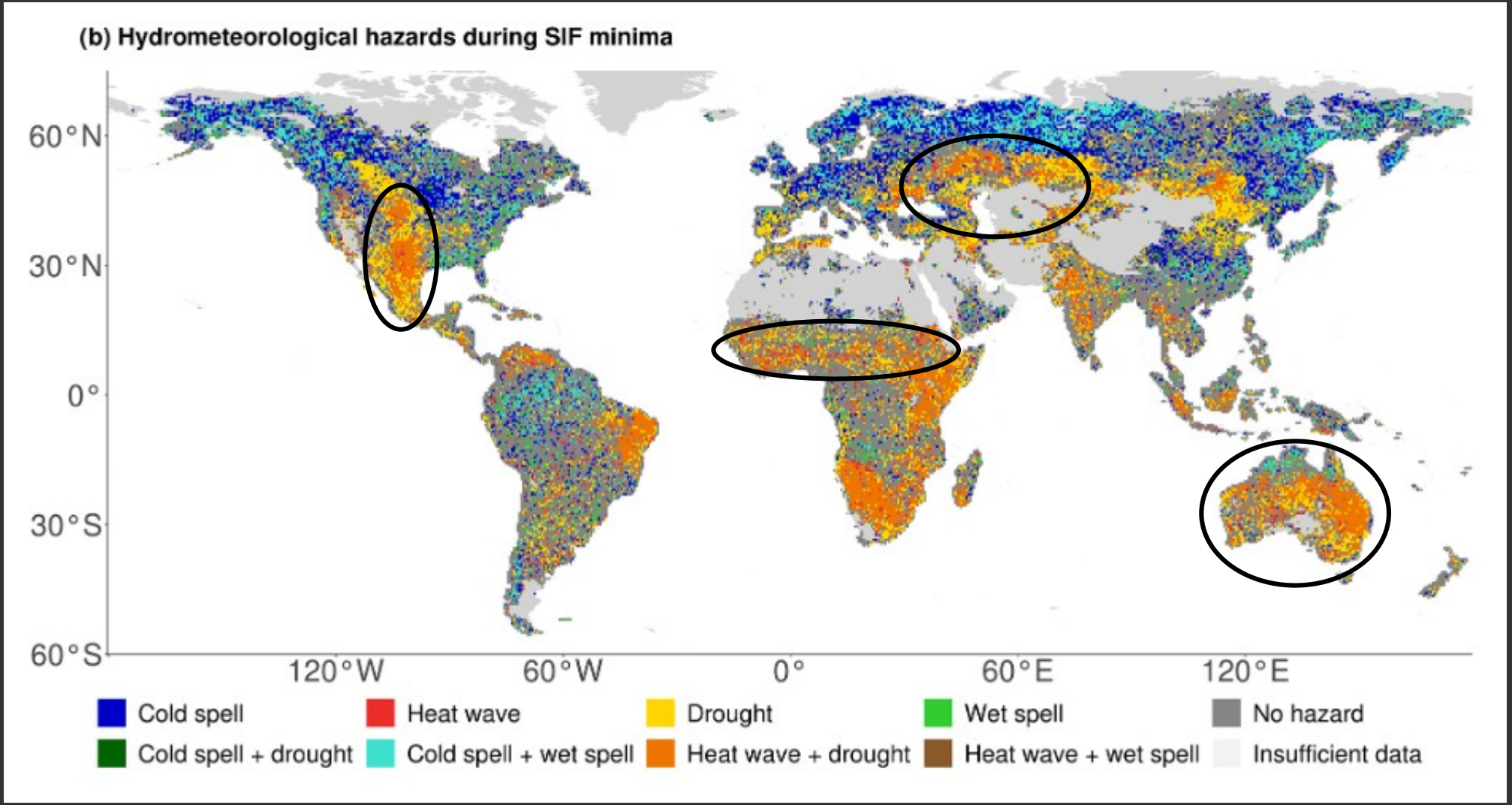
Drought predominantly harms water-limited ecosystems

Similarly for Sun-Induced Fluorescence

Hydro-meteorological extremes associated with SIF minima



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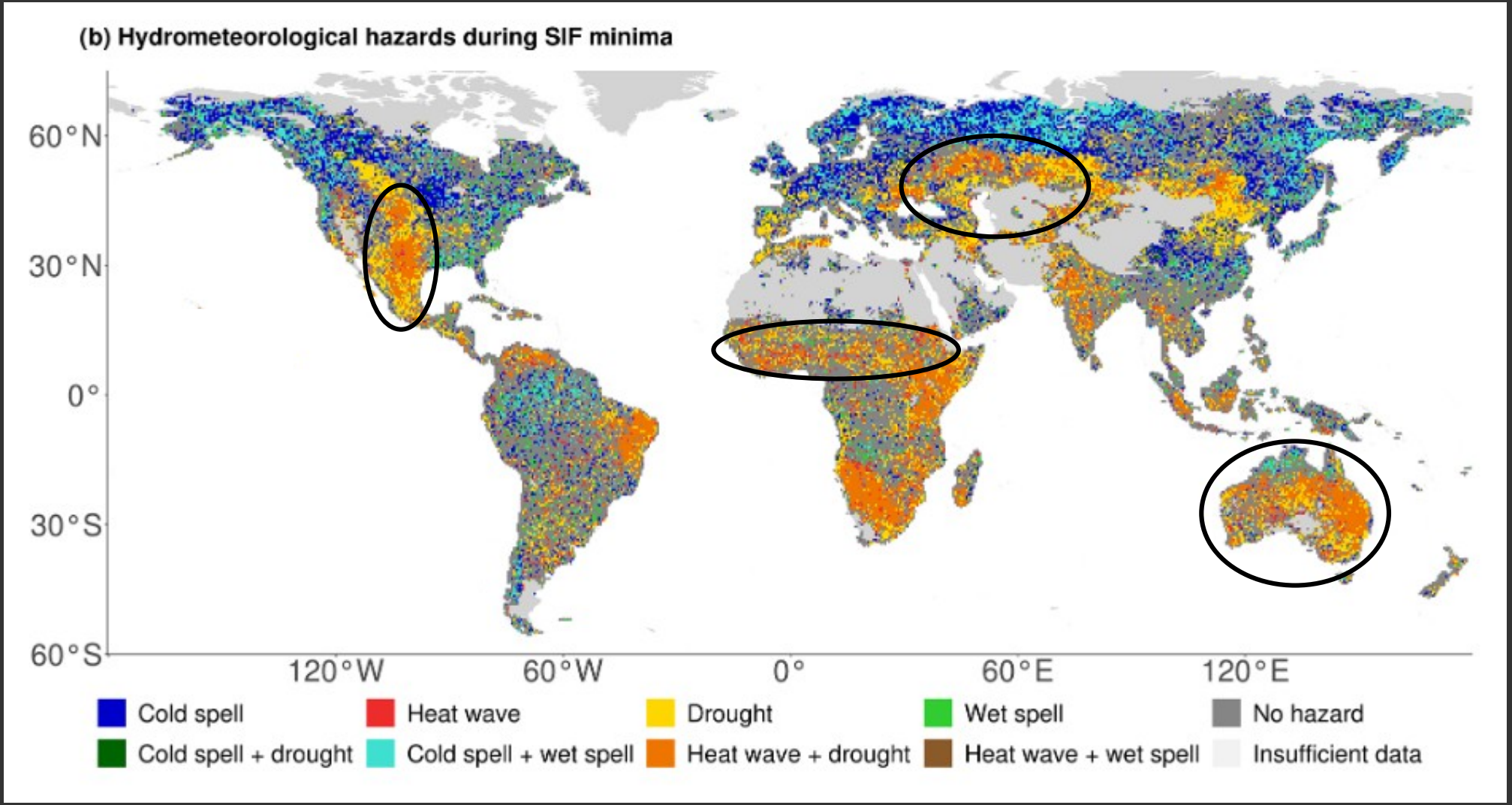

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Implications of ecosystem water limitation robustly seen across data products

Drought impacts on the water cycle

ET & runoff anomalies during the driest soil moisture month

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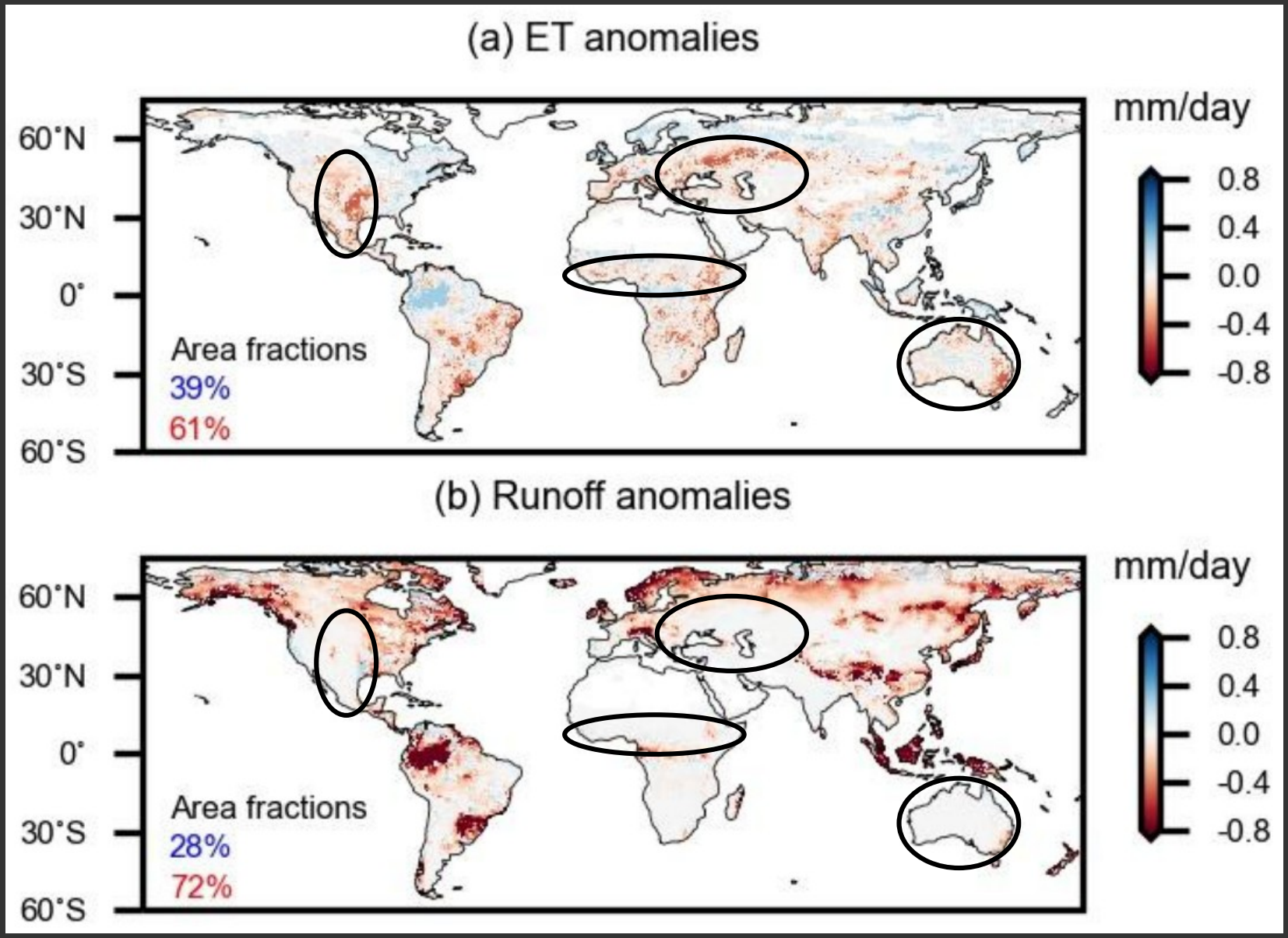

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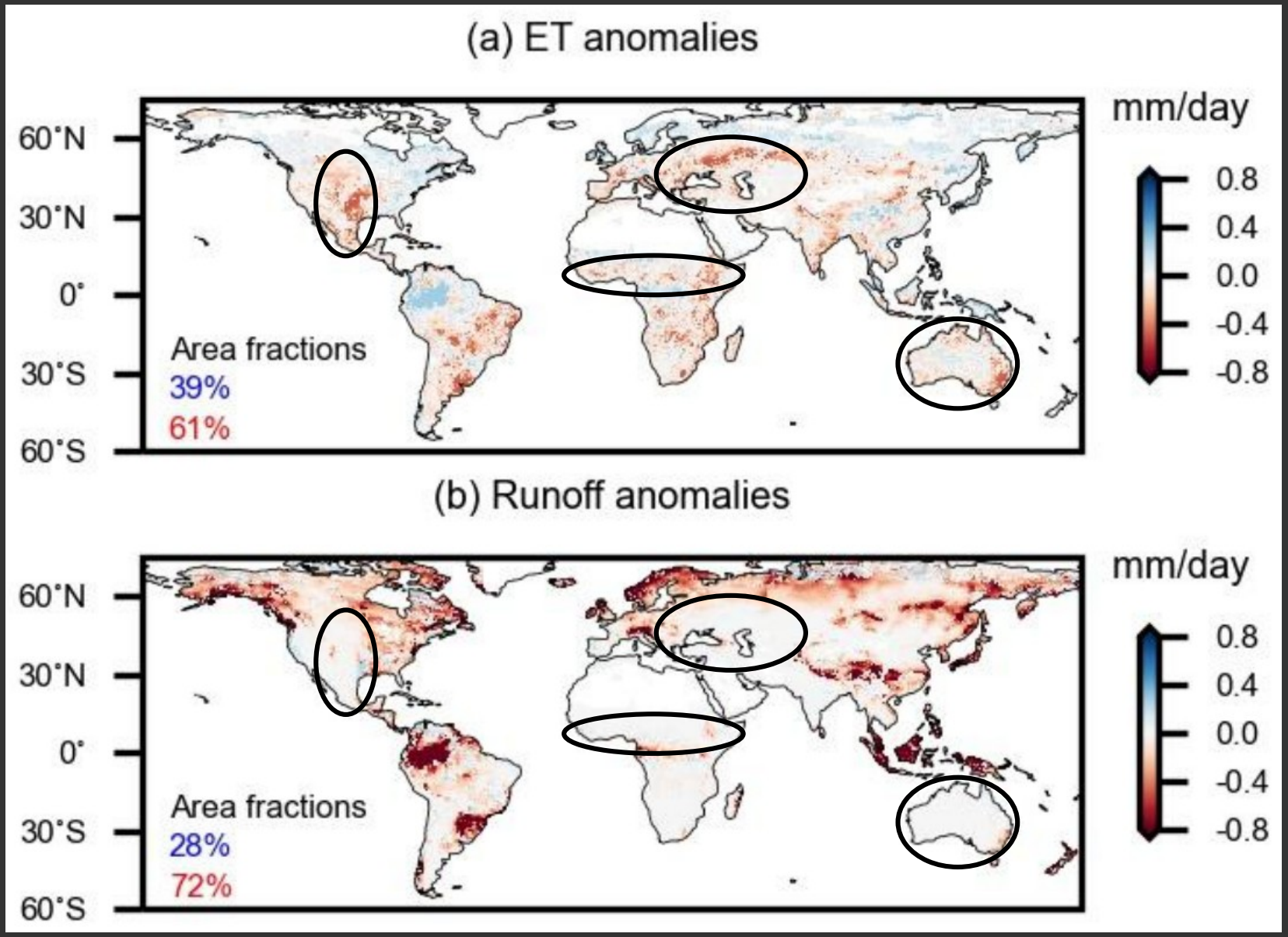

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Ecosystem water limitation mitigates runoff decreases (=saves water)

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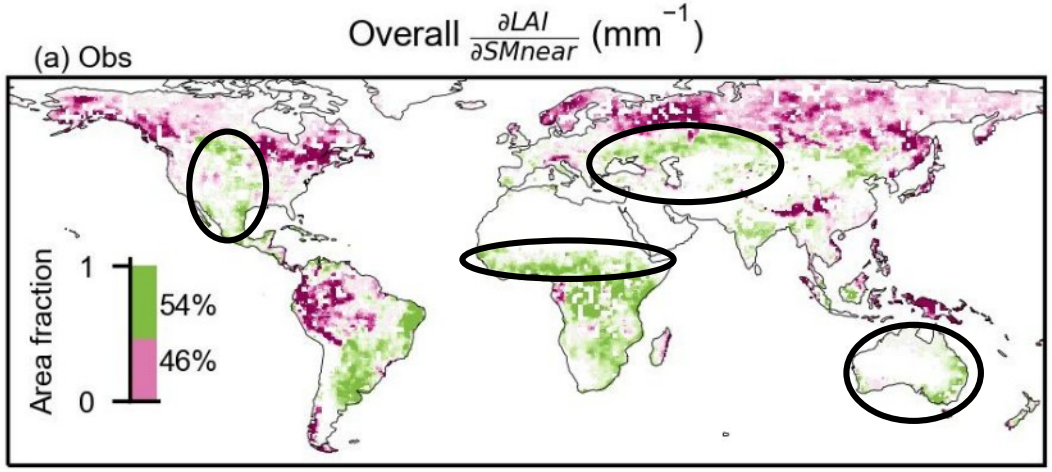

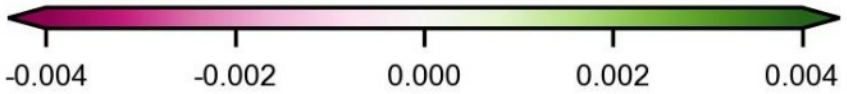

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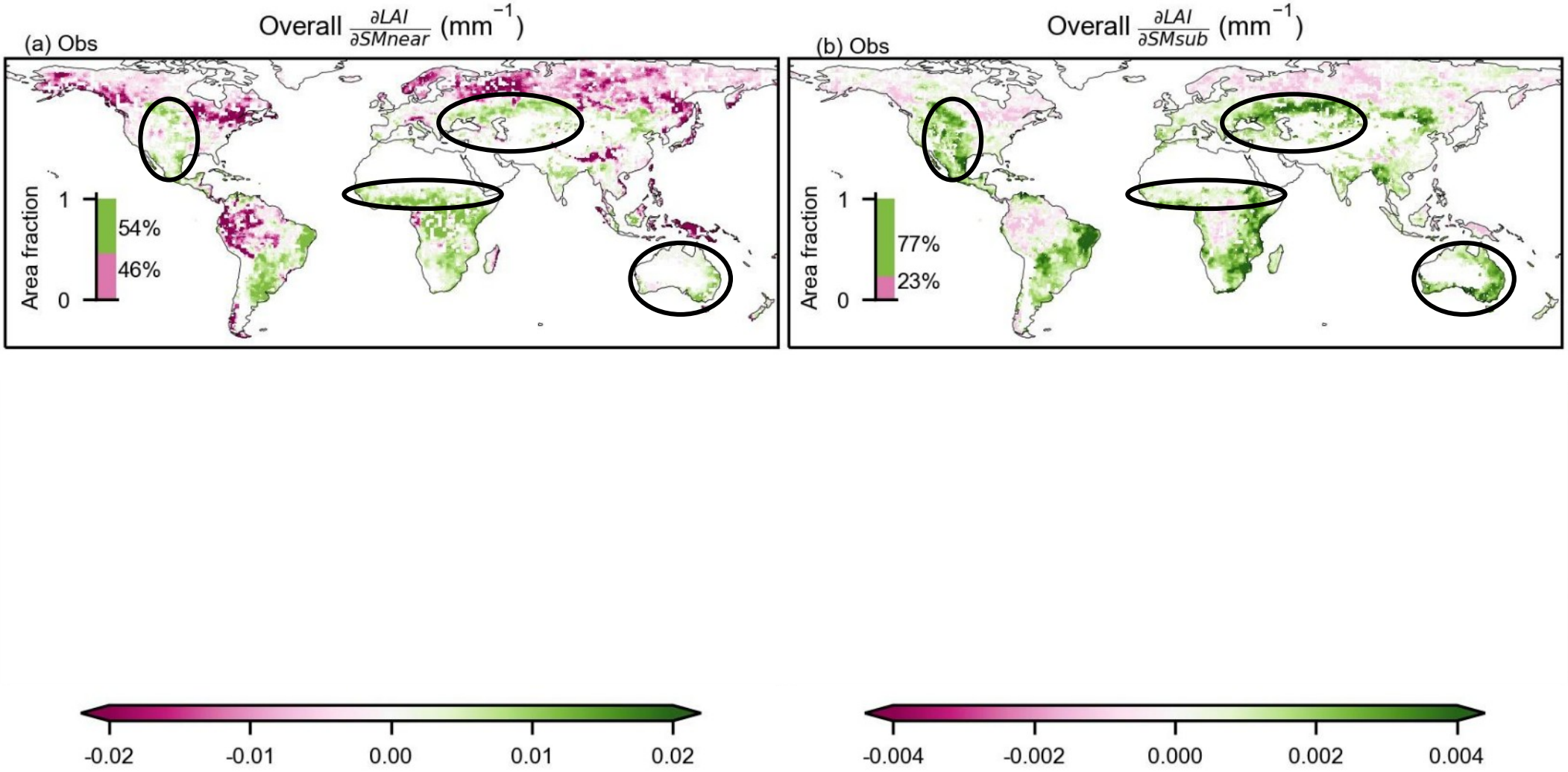

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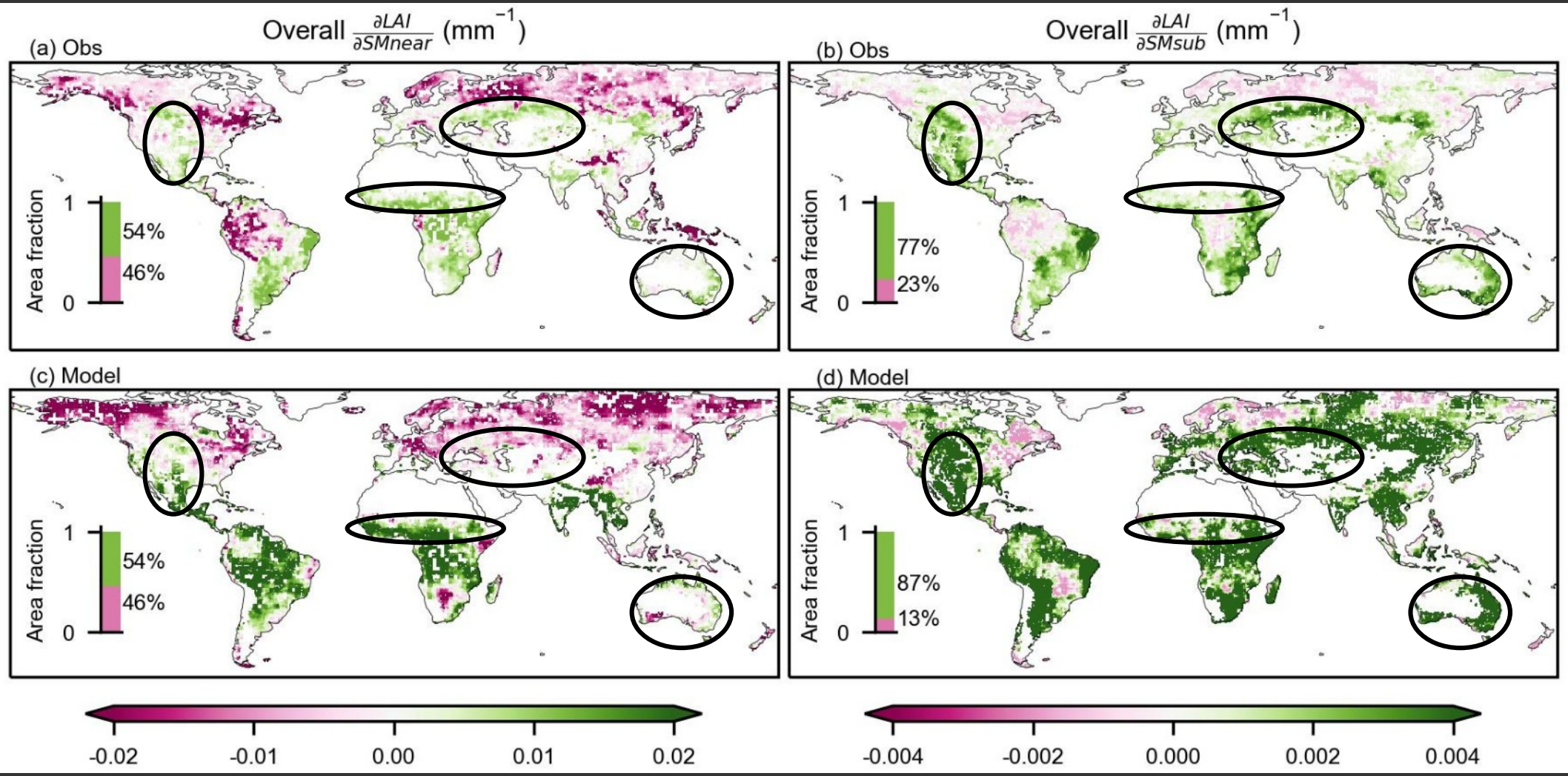

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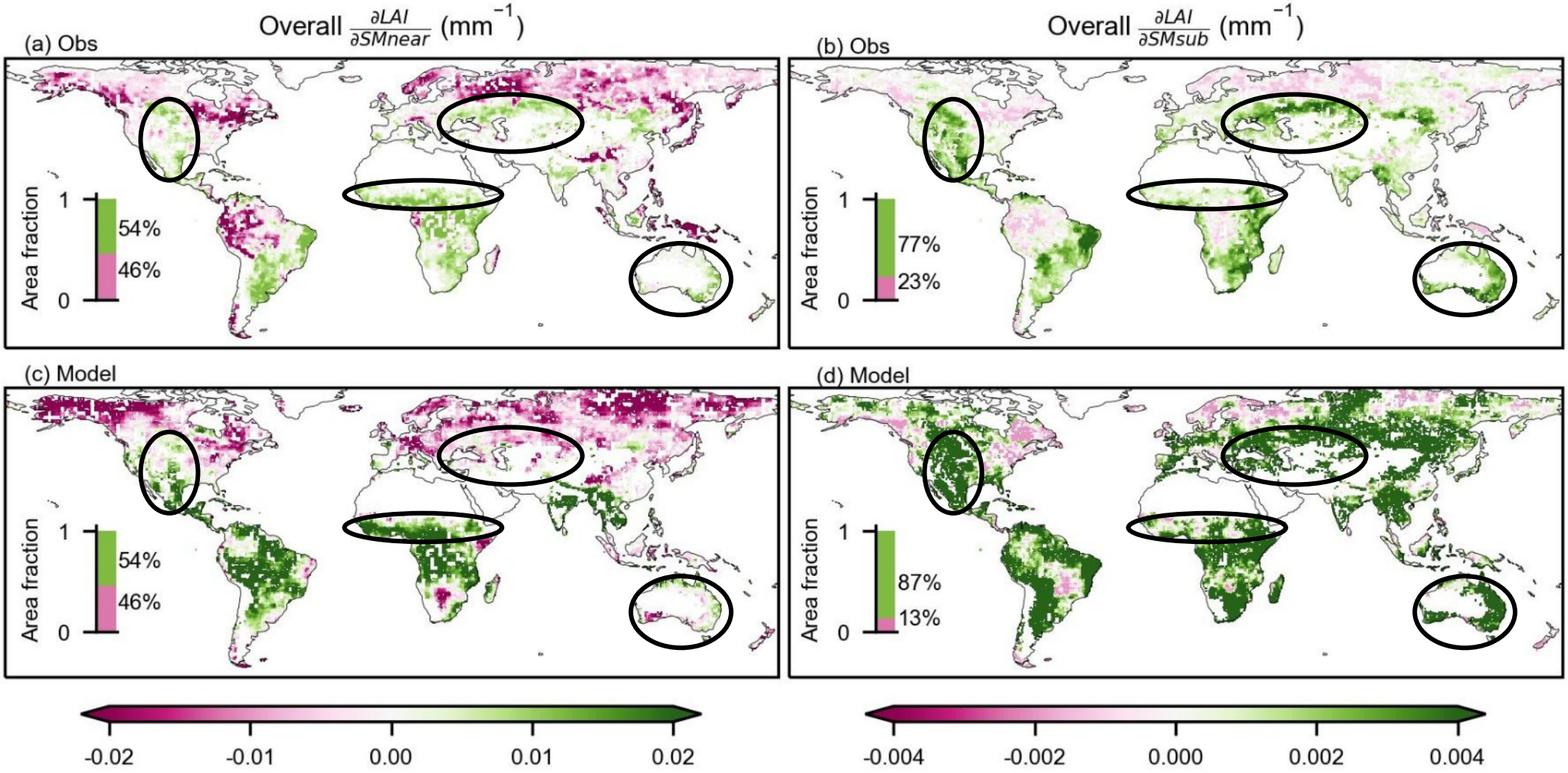

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Informative separation between surface and root-zone soil moisture

TRENDY models have difficulties to represent observed sensitivity patterns

Trends of sensitivity of leaf area to soil moisture

Long-term leaf area observations can be used to study trends

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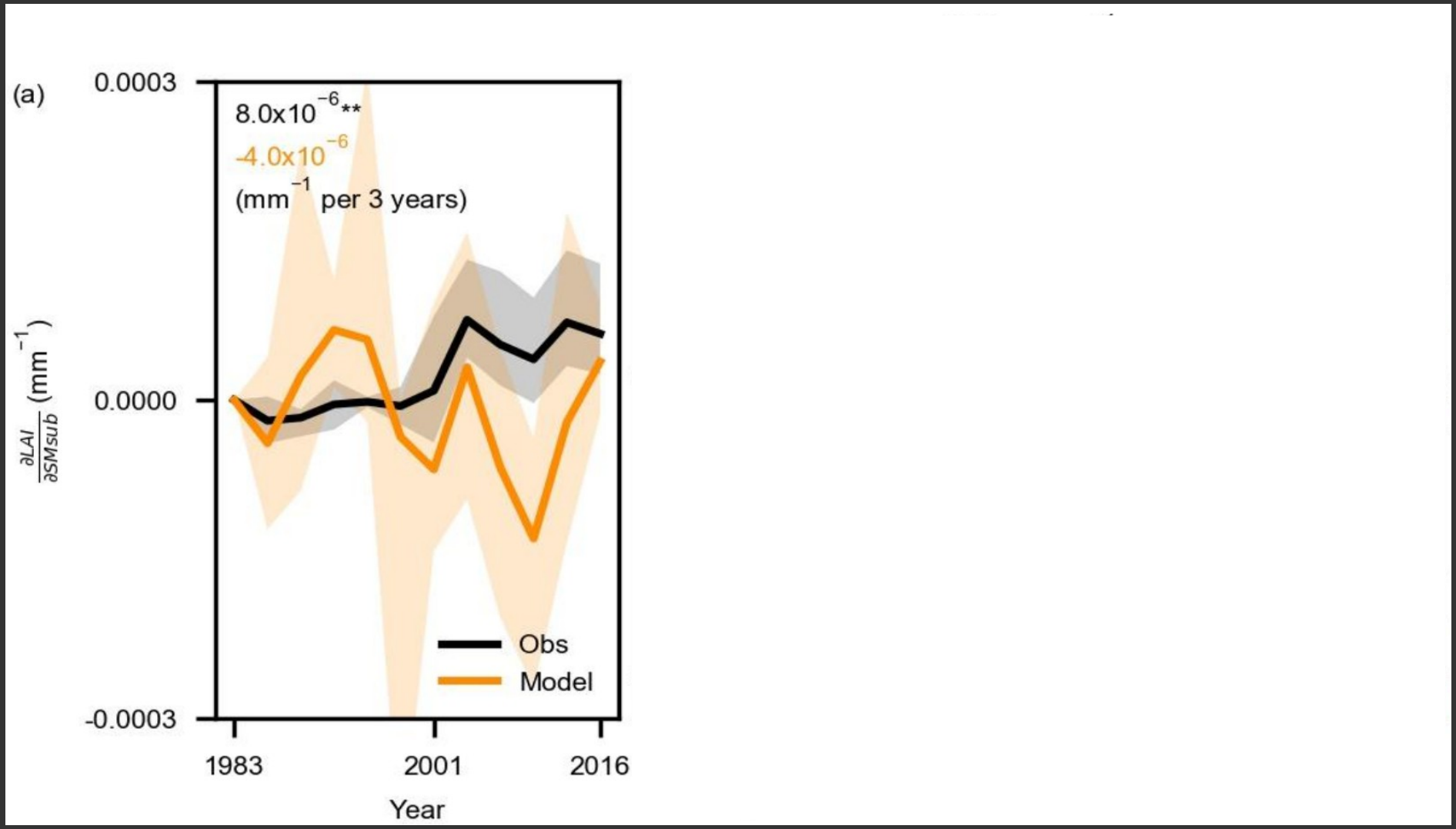

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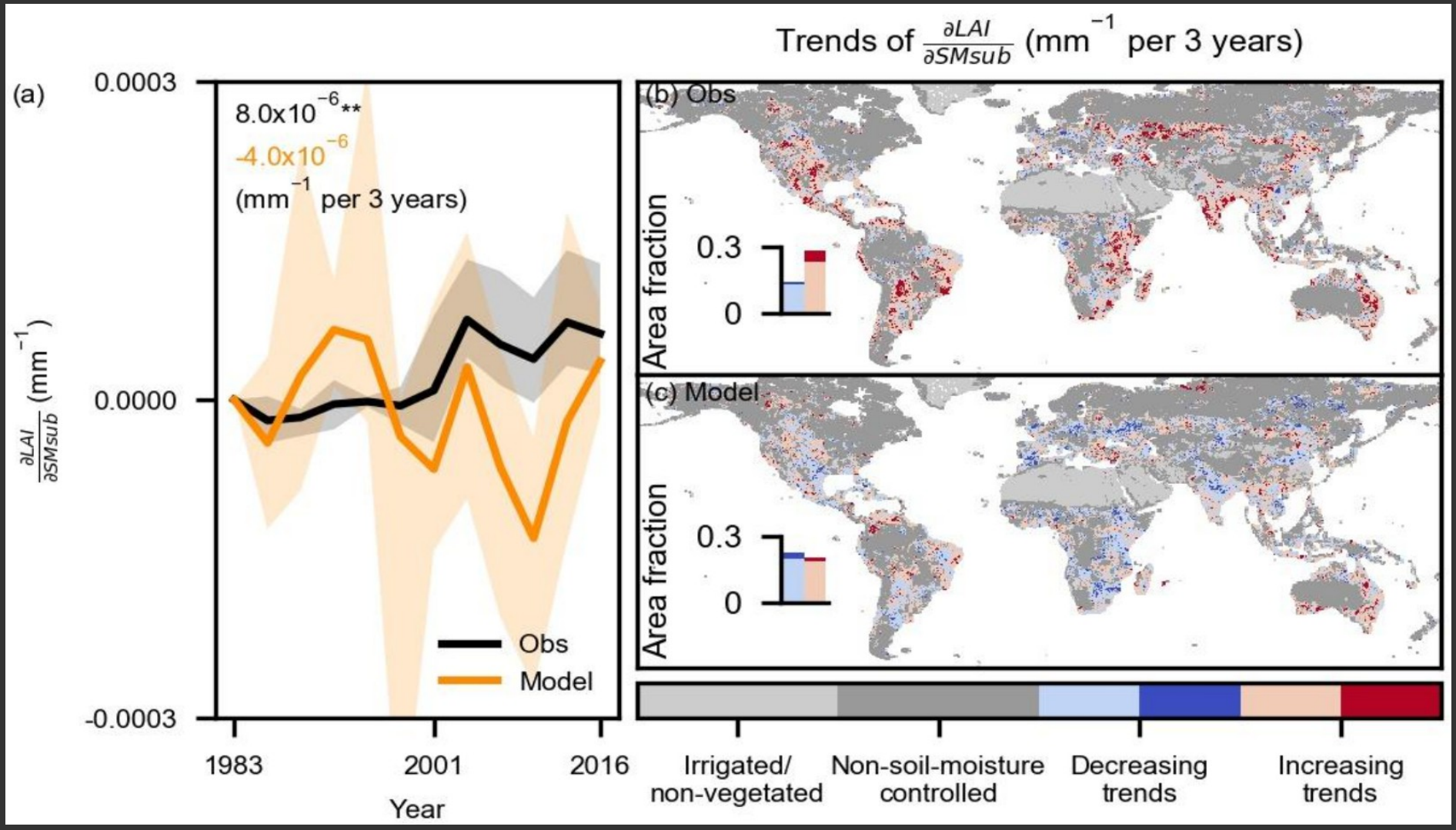

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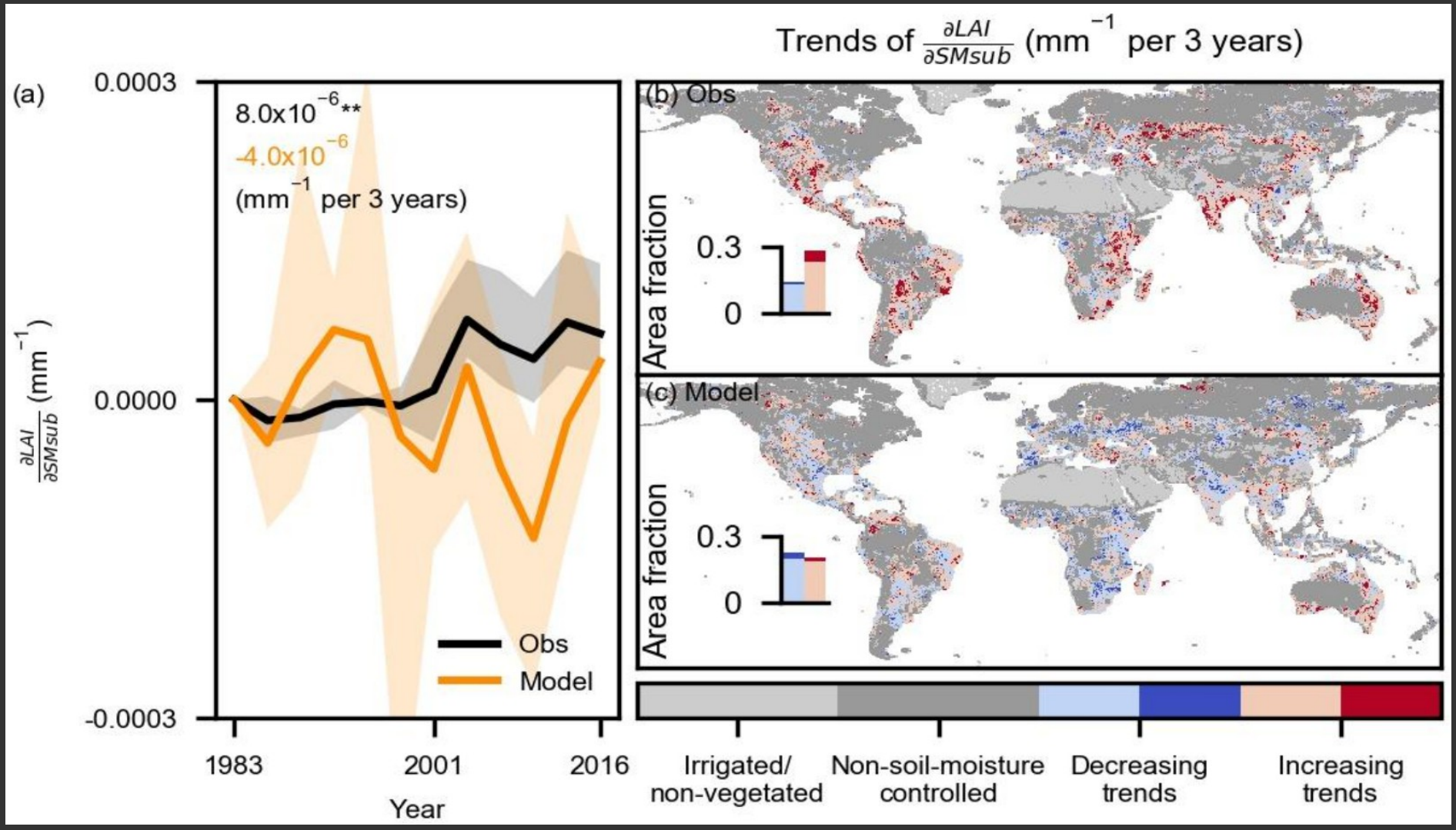

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Increasing sensitivity of leaf area to soil moisture

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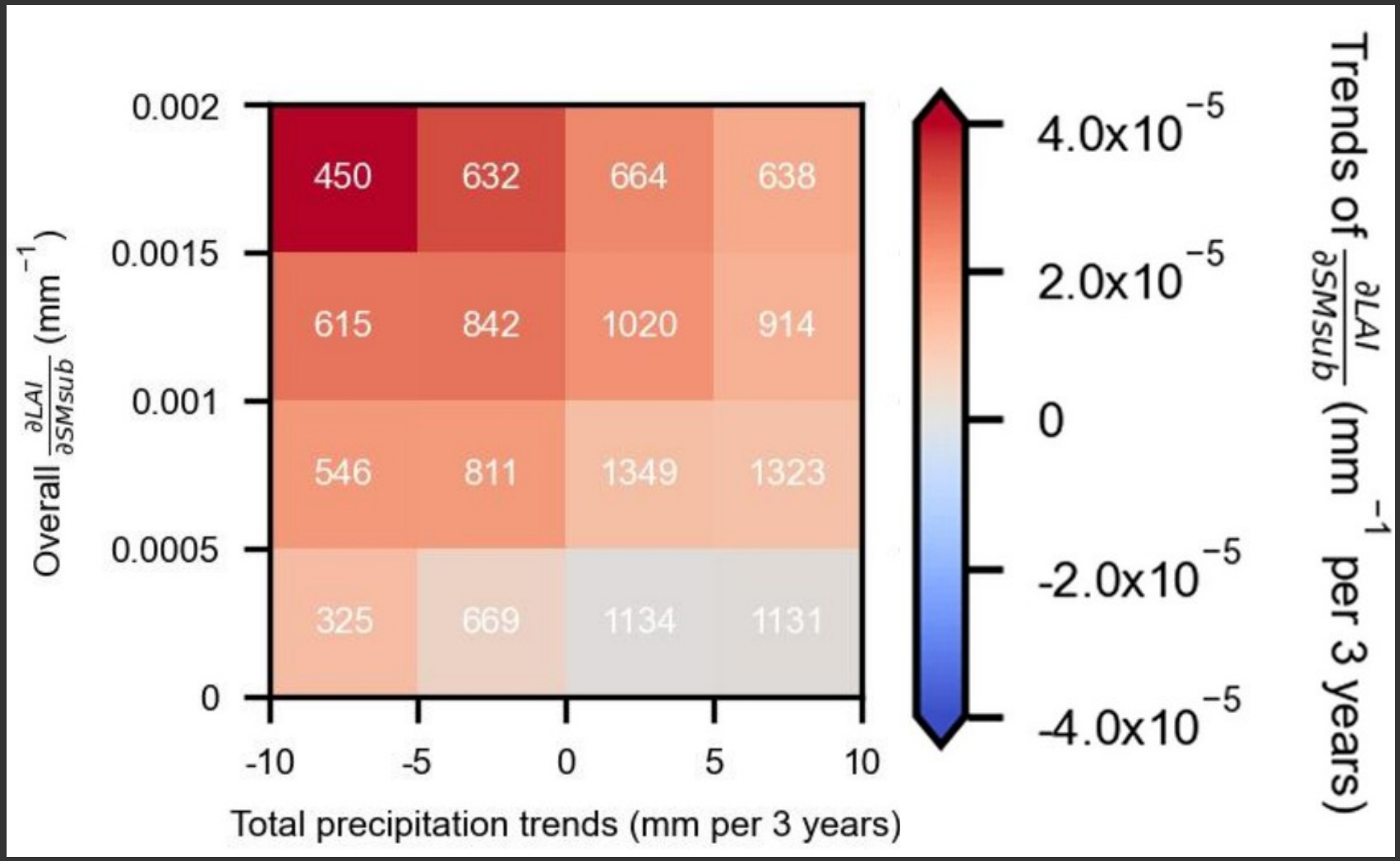

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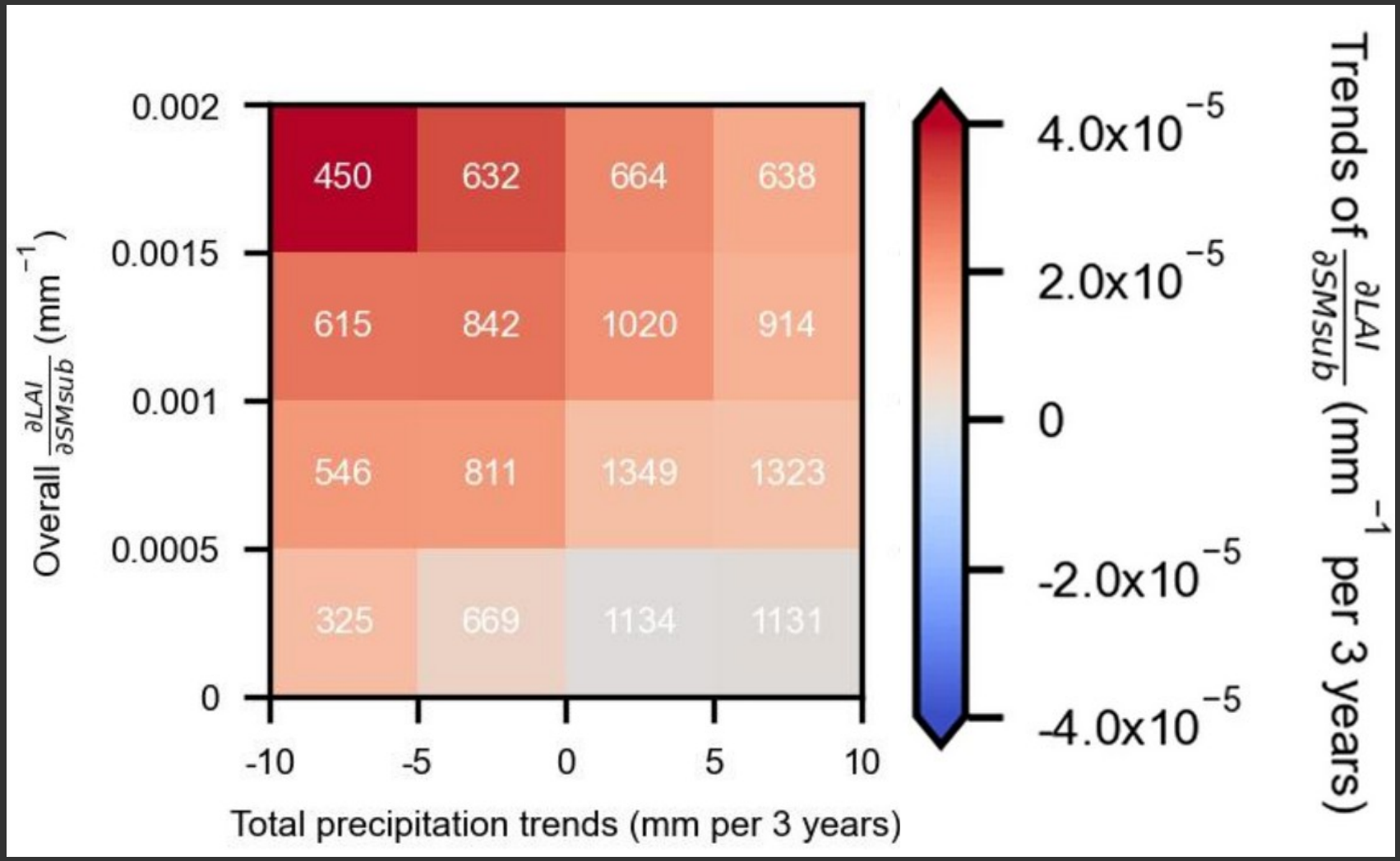

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Precipitation trends and actual sensitivity explain observed trends

Future trends in energy vs. water limitation

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Analyzing ecosystem limitation index in CMIP6 model simulations

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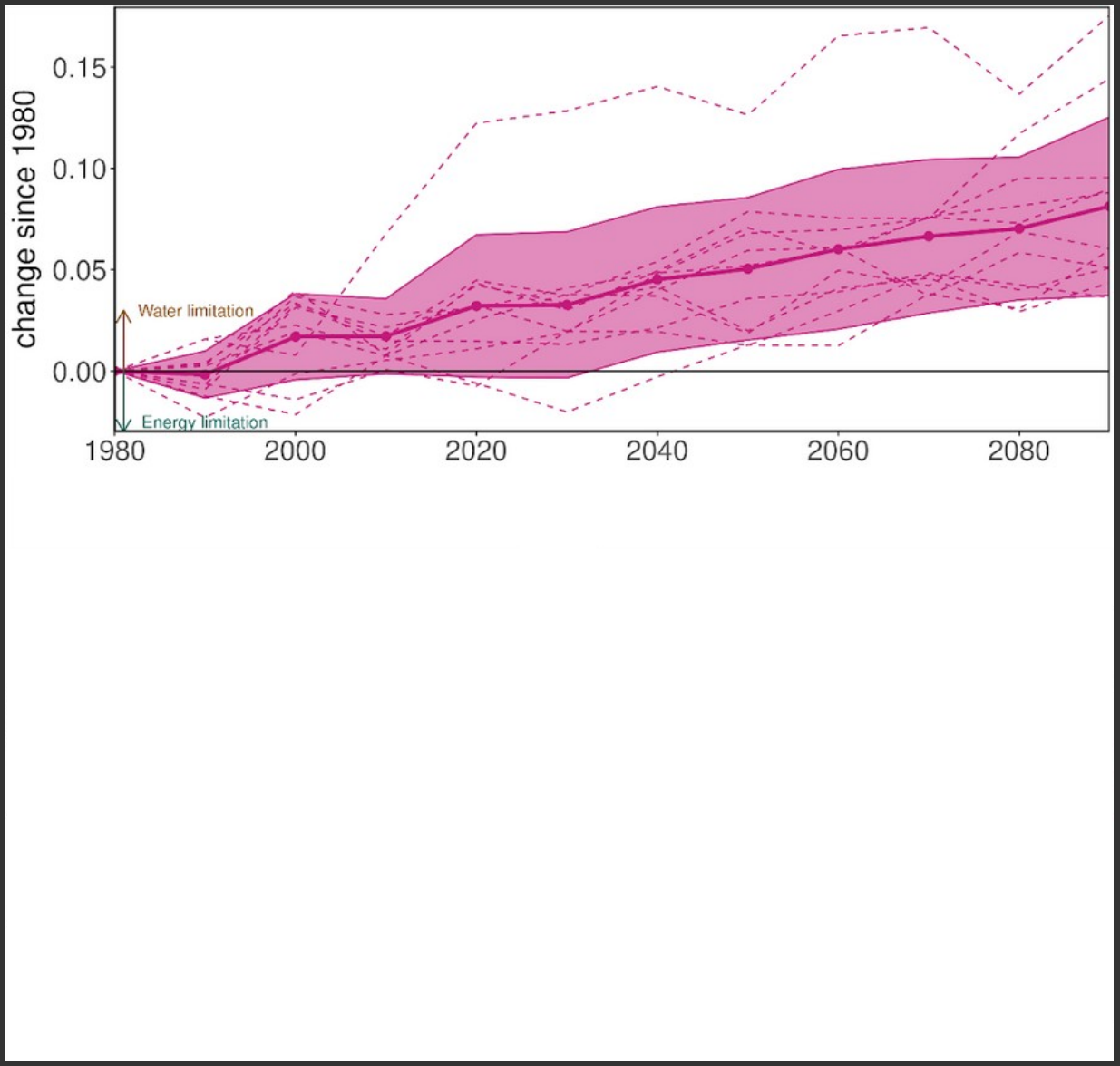

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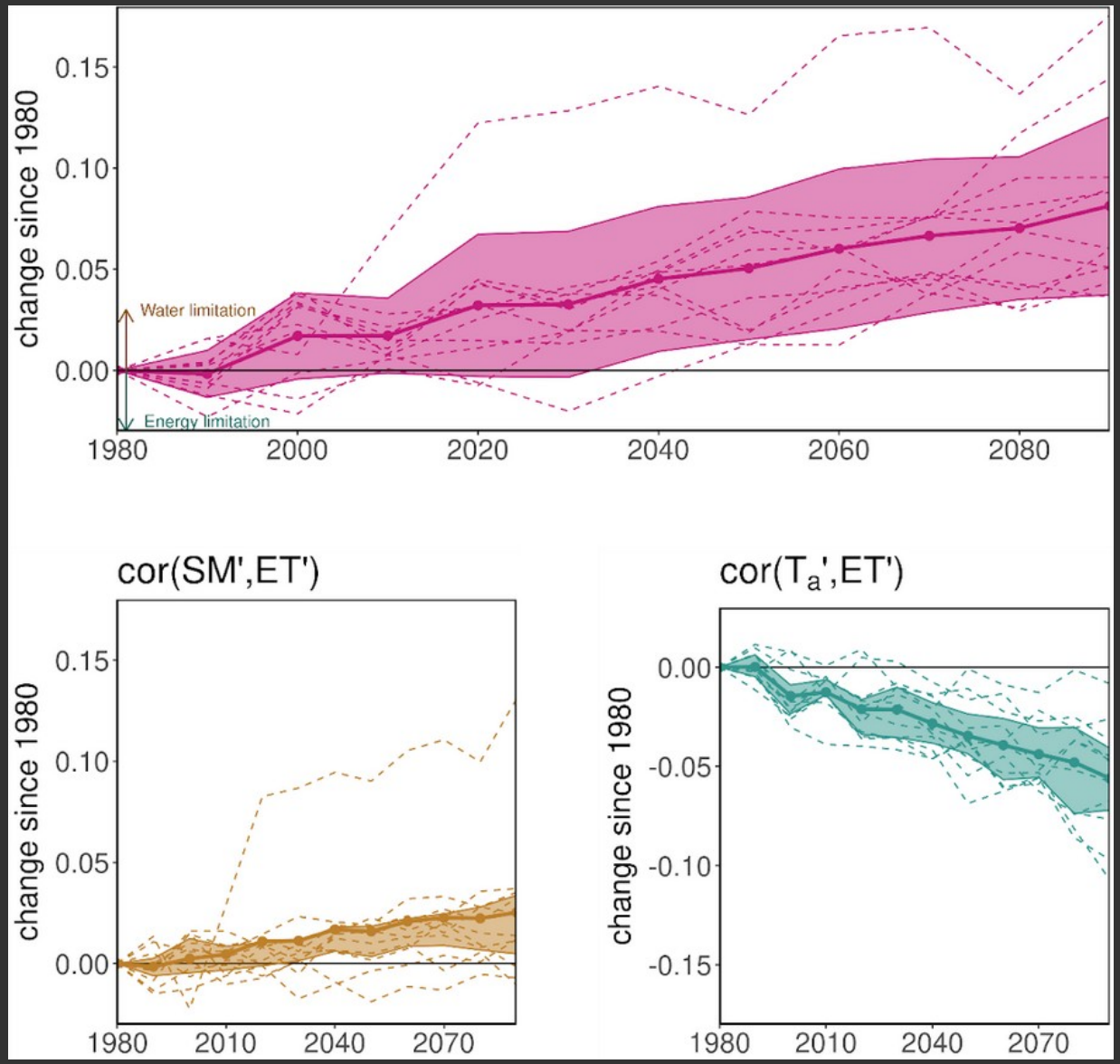

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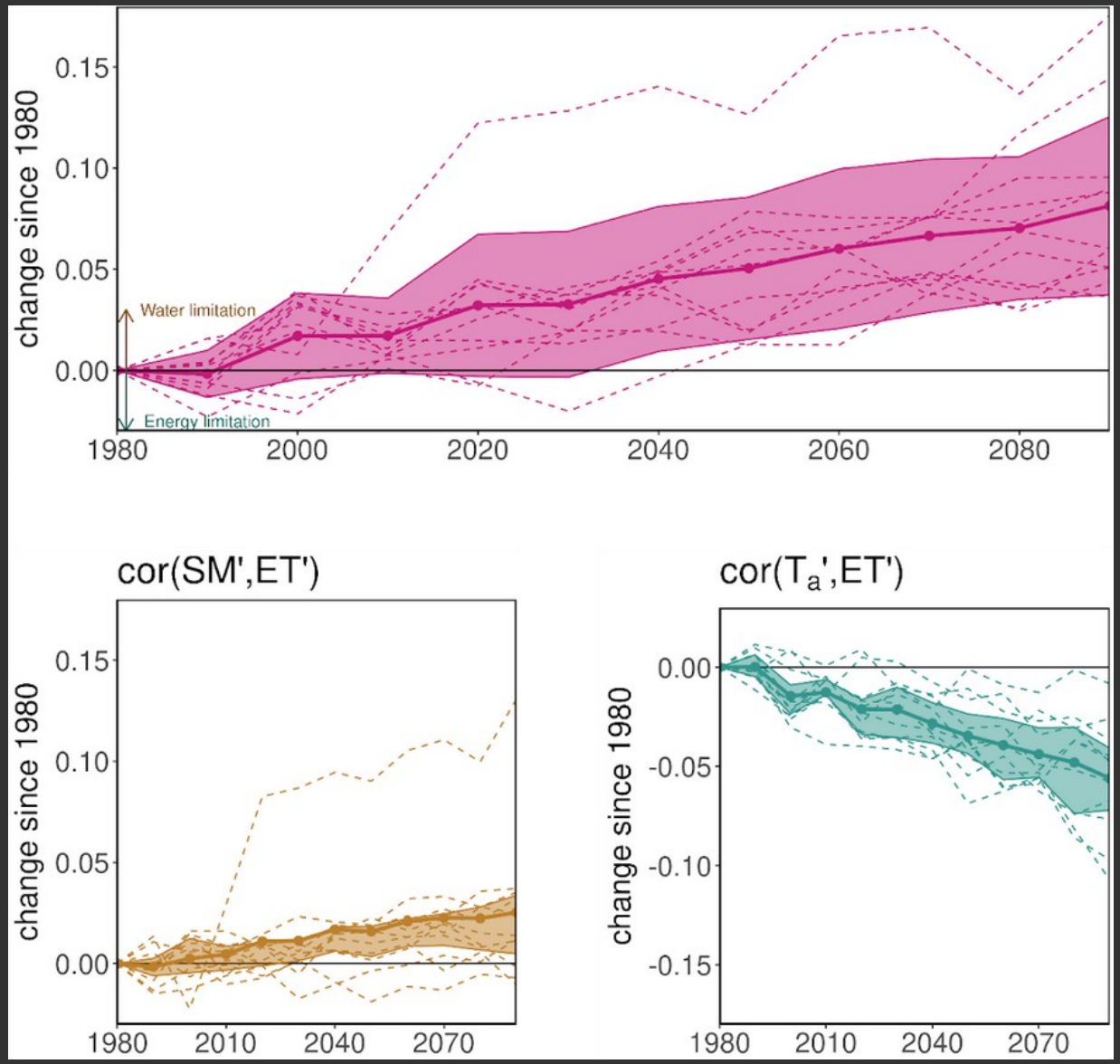

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Combined changes in ecosystem energy and water limitation

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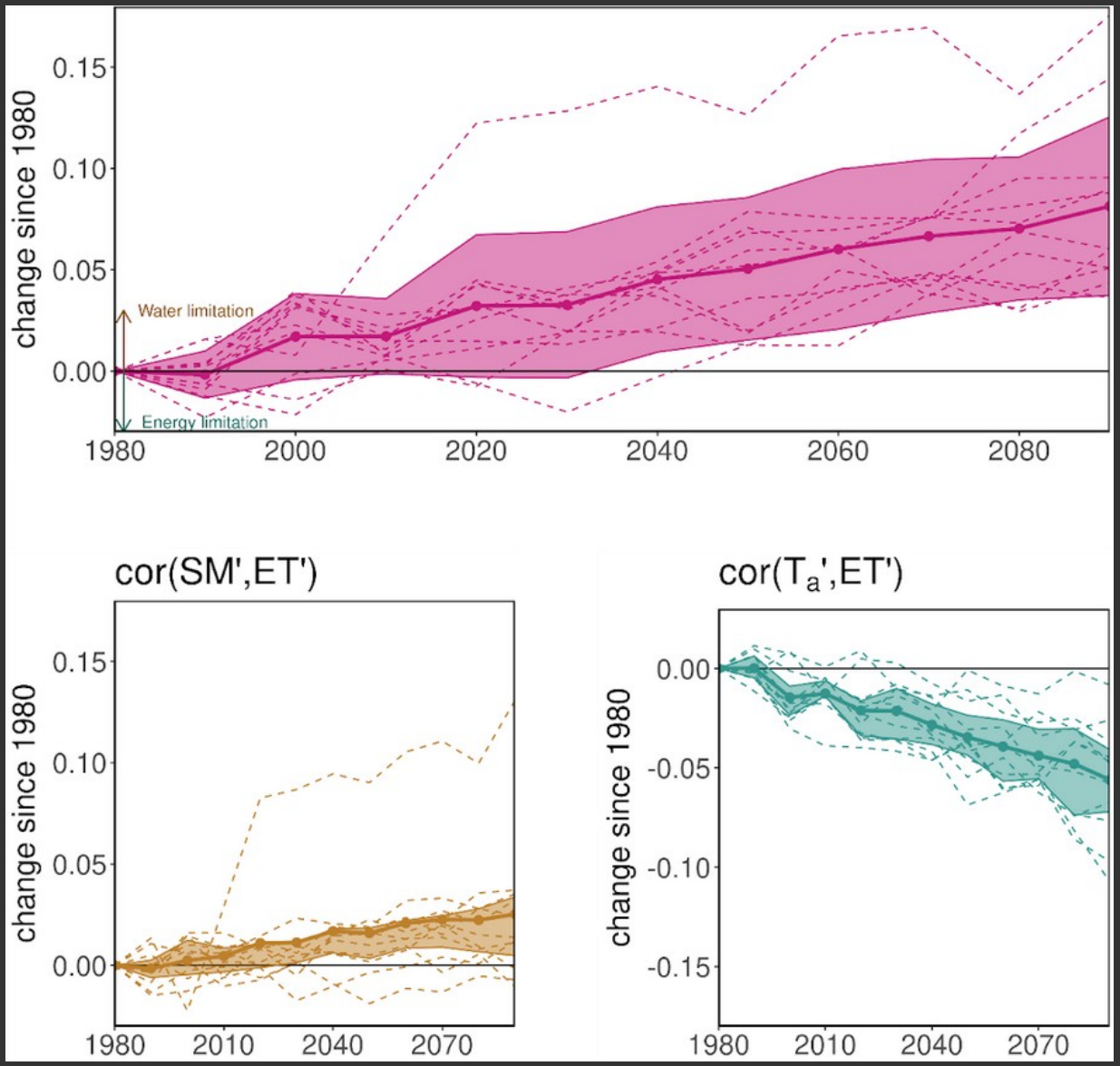

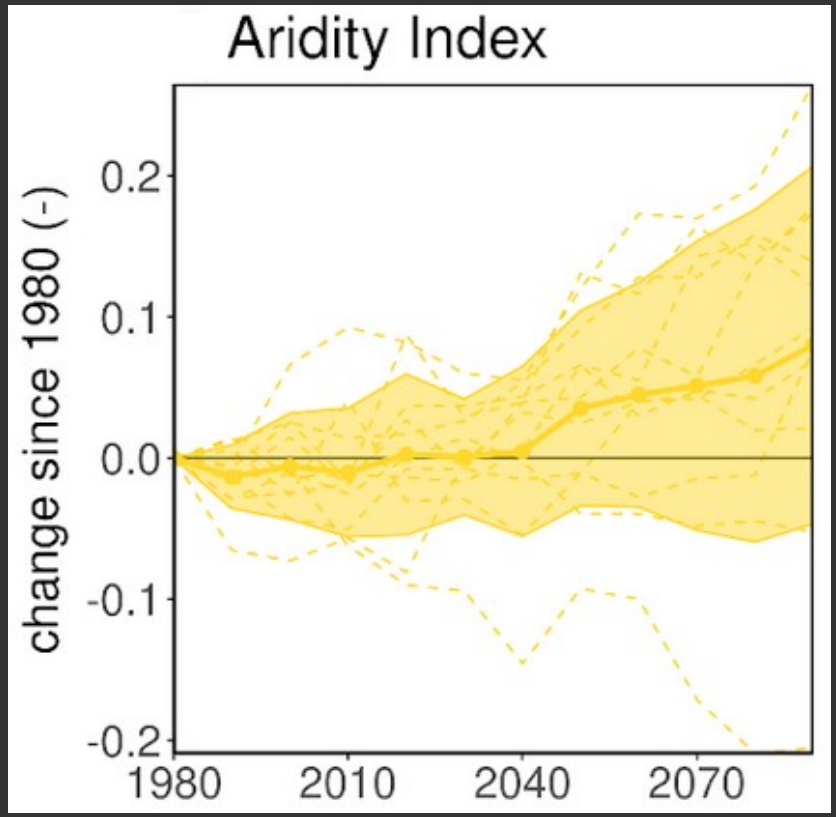

atmospheric dryness ≠ ecosystem dryness

Denissen et al. 2022, *Nat. Clim. Change*

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Emergence of water-limited regime

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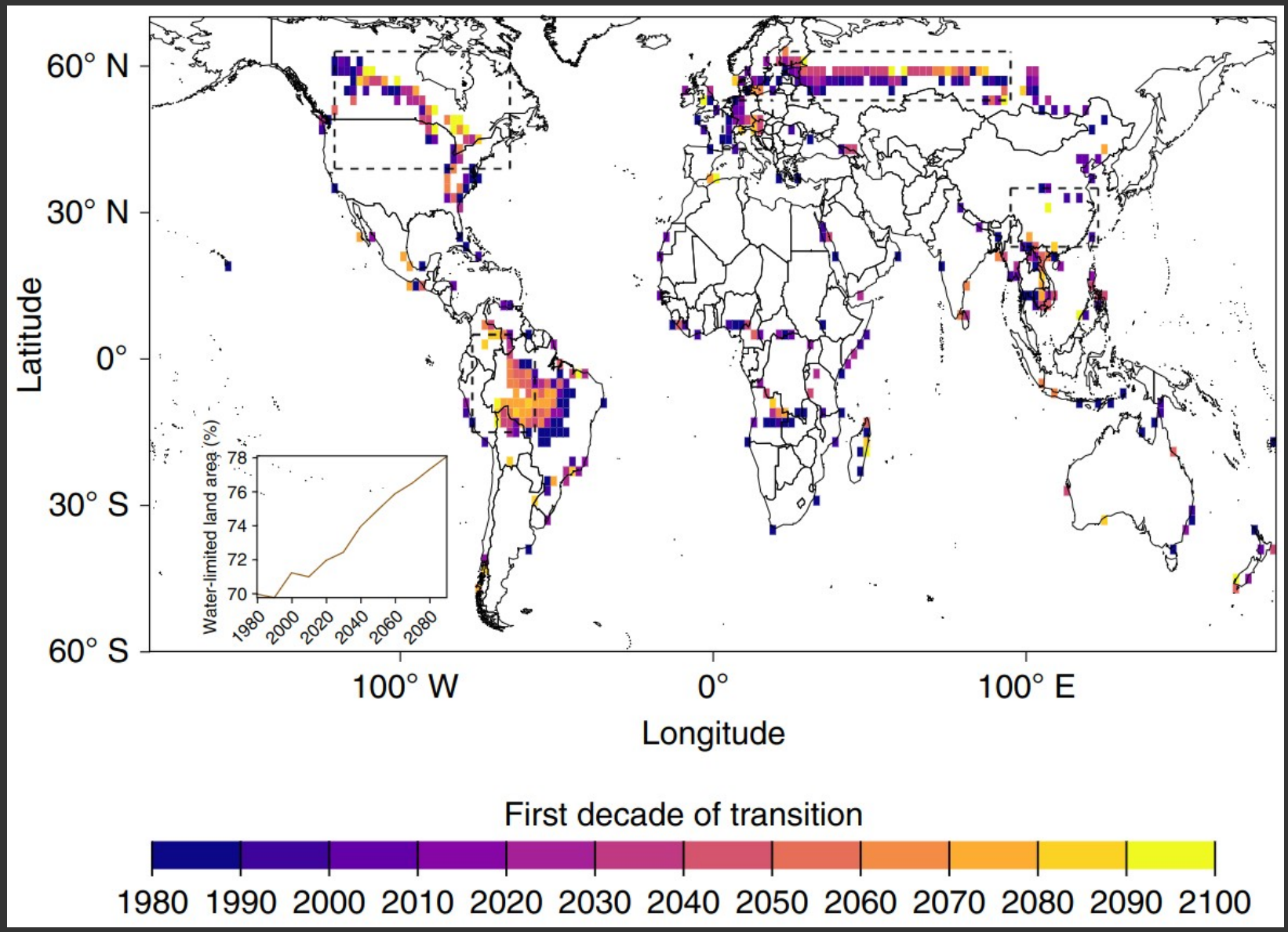

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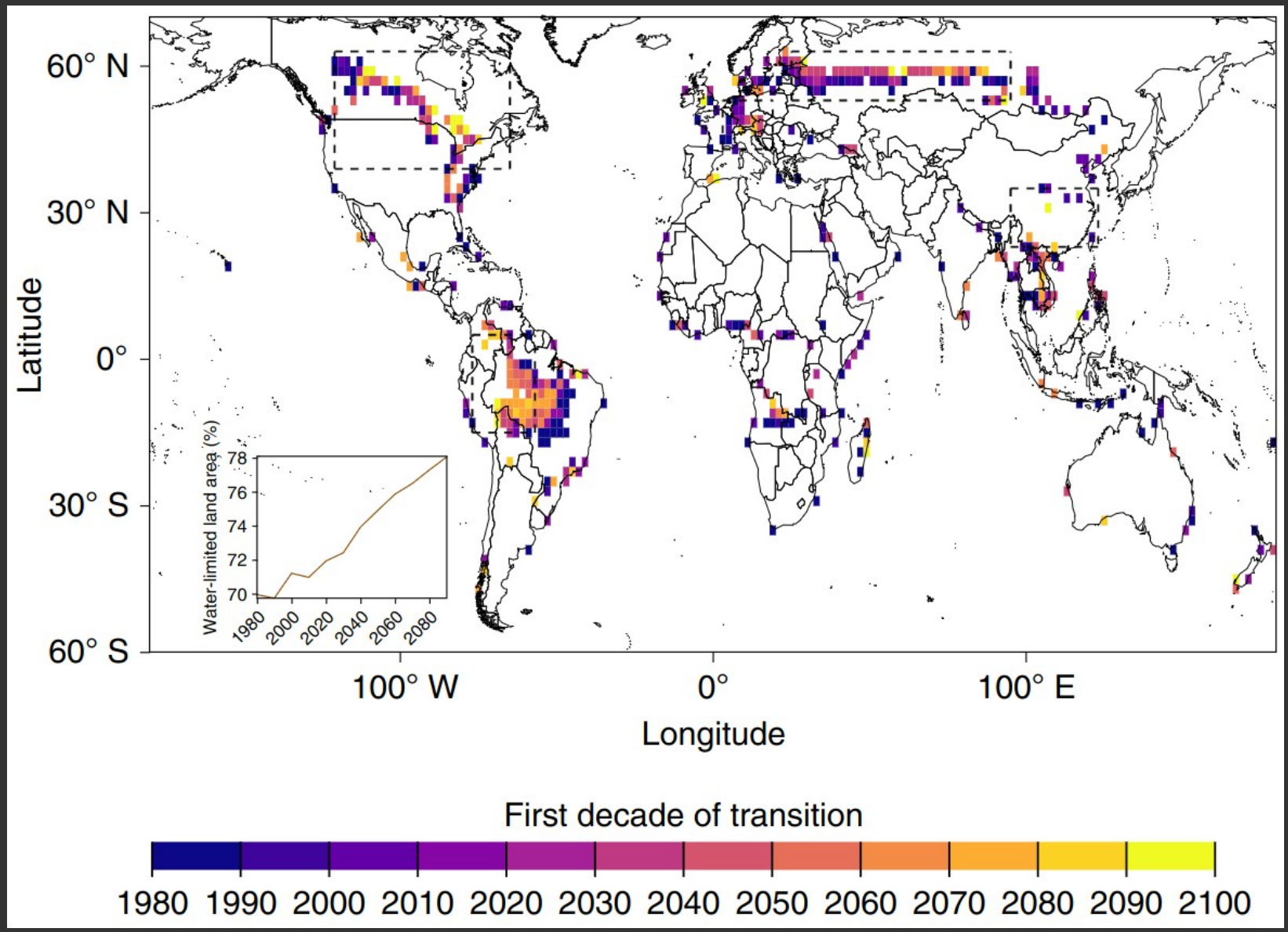

Denissen et al. 2022, *Nat. Clim. Change*

Regions across latitudes switch from energy to water control

Summary

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- Characterization of water-limited regions across the globe

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Thank you!

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Twitter: @hydrOrth_lab