Nonlinear drought response to anthropogenic forcing in CESM

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Uni-directional drought evolution?

"Regional changes in extreme temperature and precipitation […] **scale robustly** with global temperature across scenarios."
Seneviratne et al. (2016, *Nature*)

"… human-induced change is **uni-directional** as long as the responsible changes in forcing (e.g. greenhouse gases) do not reverse in sign."
Seager (2015, *Climate Change*)

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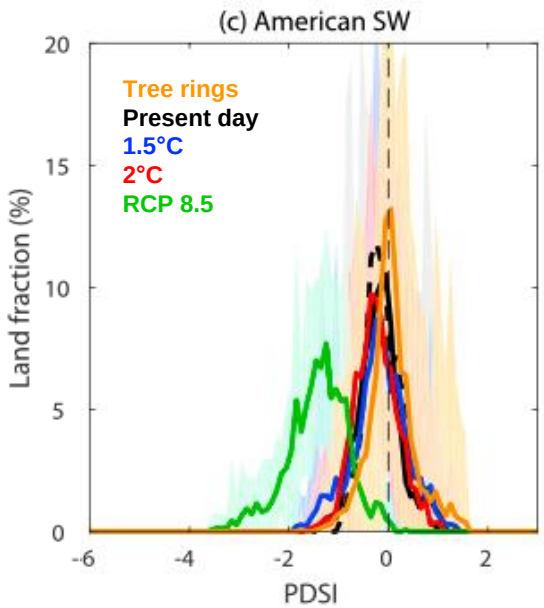

Nonlinear scaling of drought with warming.
Lehner et al. (2017, *Geophys. Res. Let.*)

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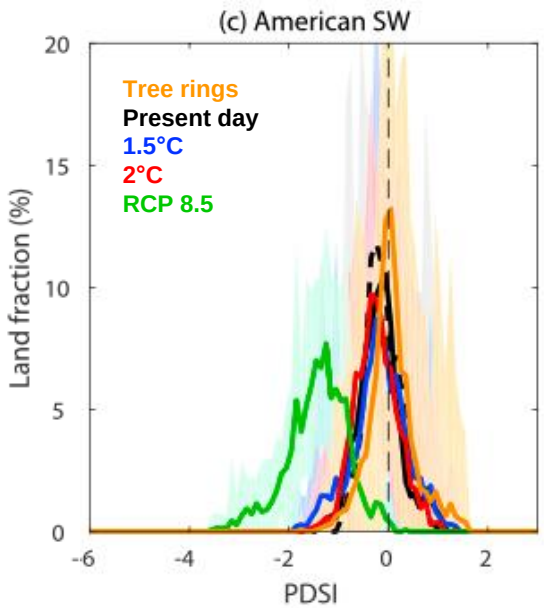

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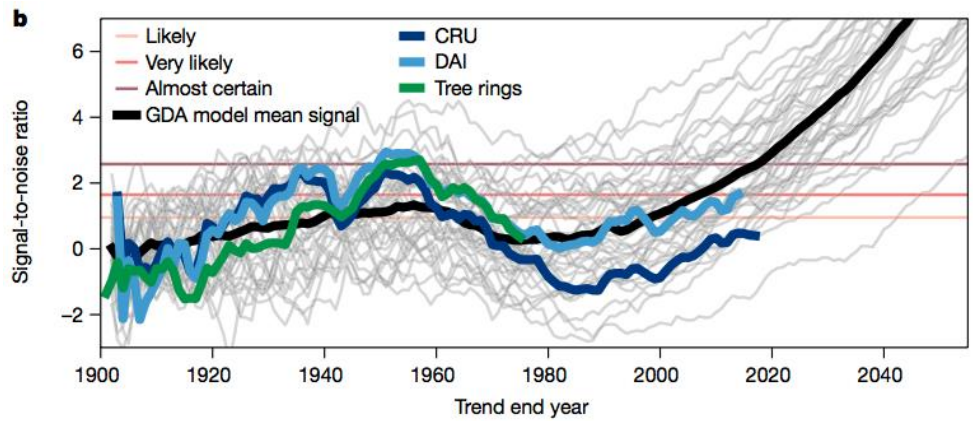
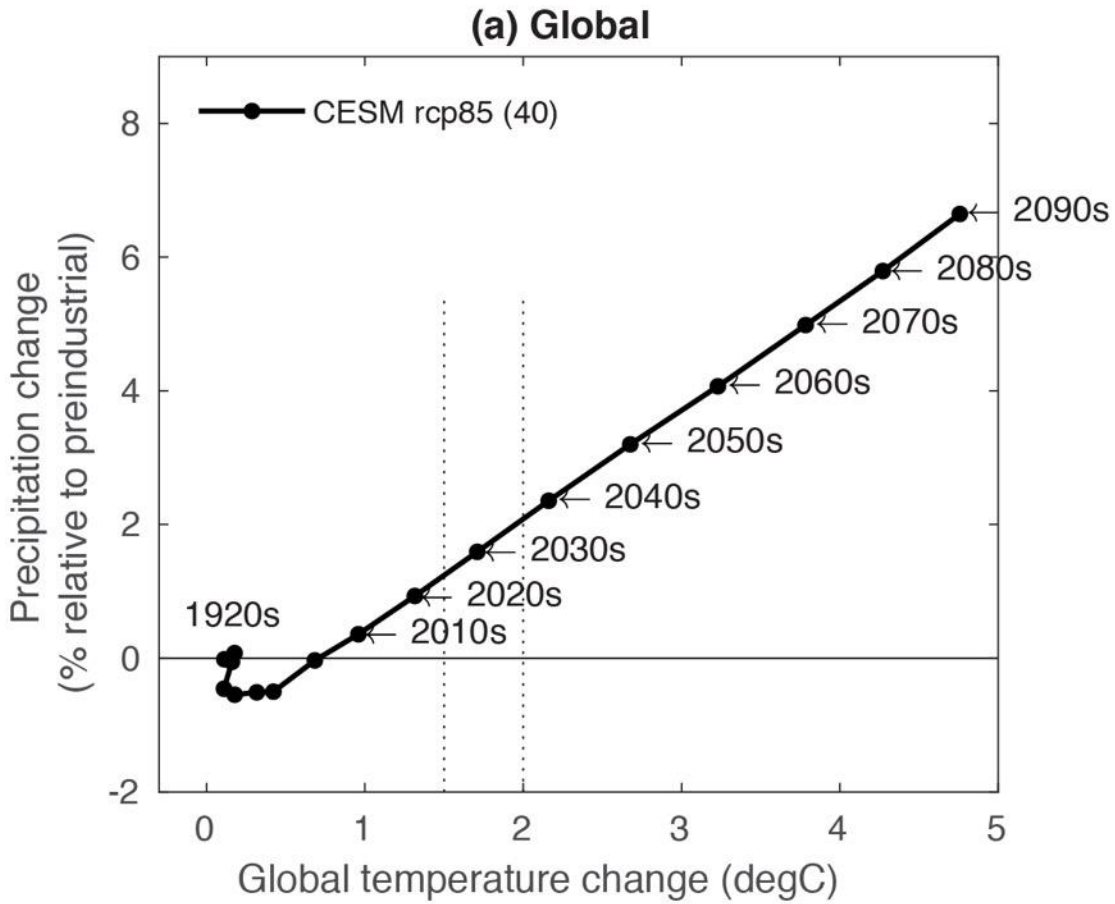


Detection of anthropogenic forcing (GHGs and aerosols) on global drought.
Marvel et al. (2019, *Nature*)

Scaling with global temperature



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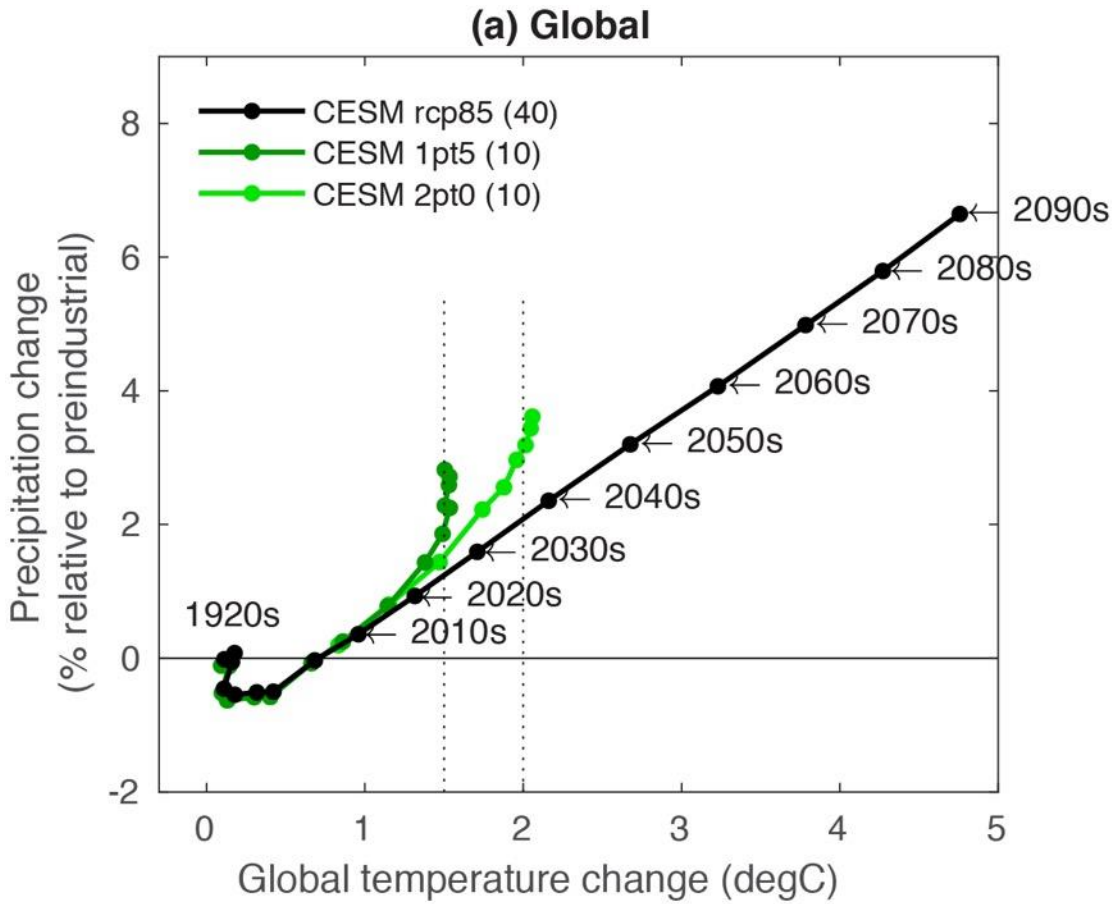

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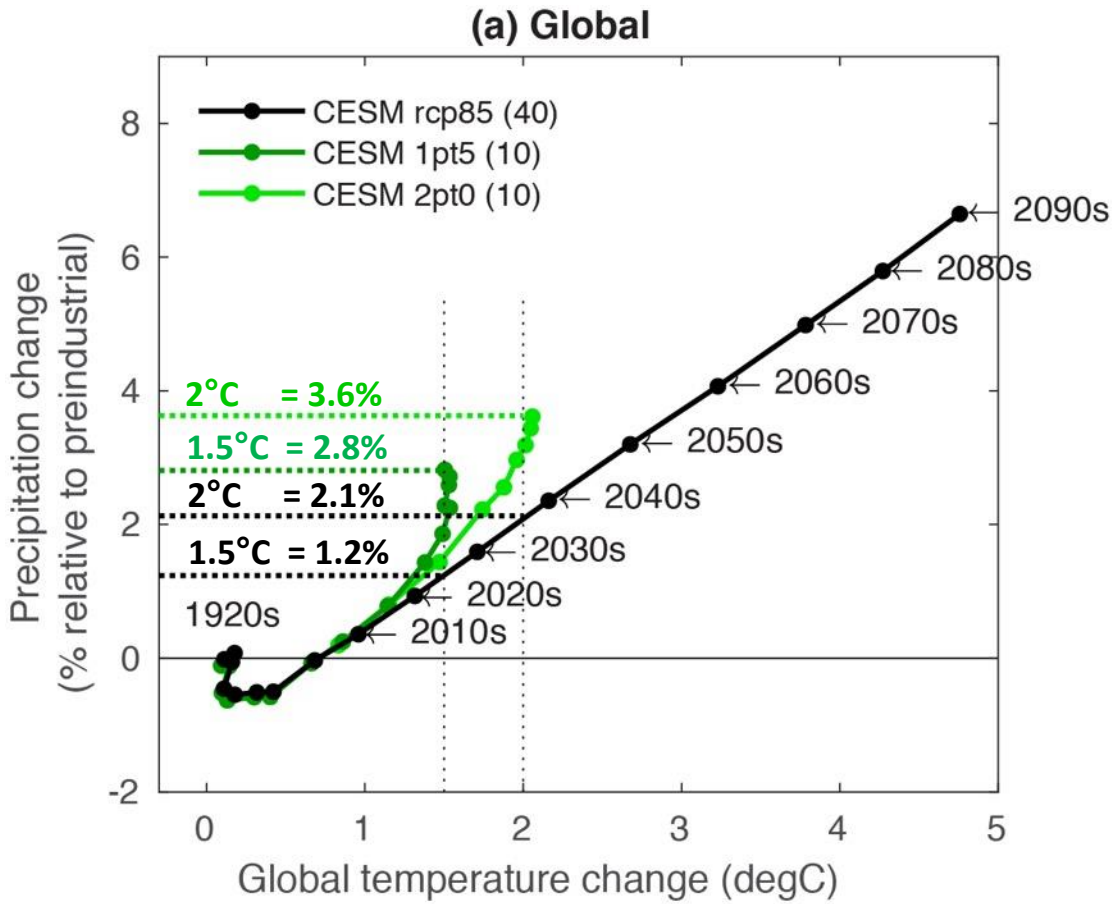

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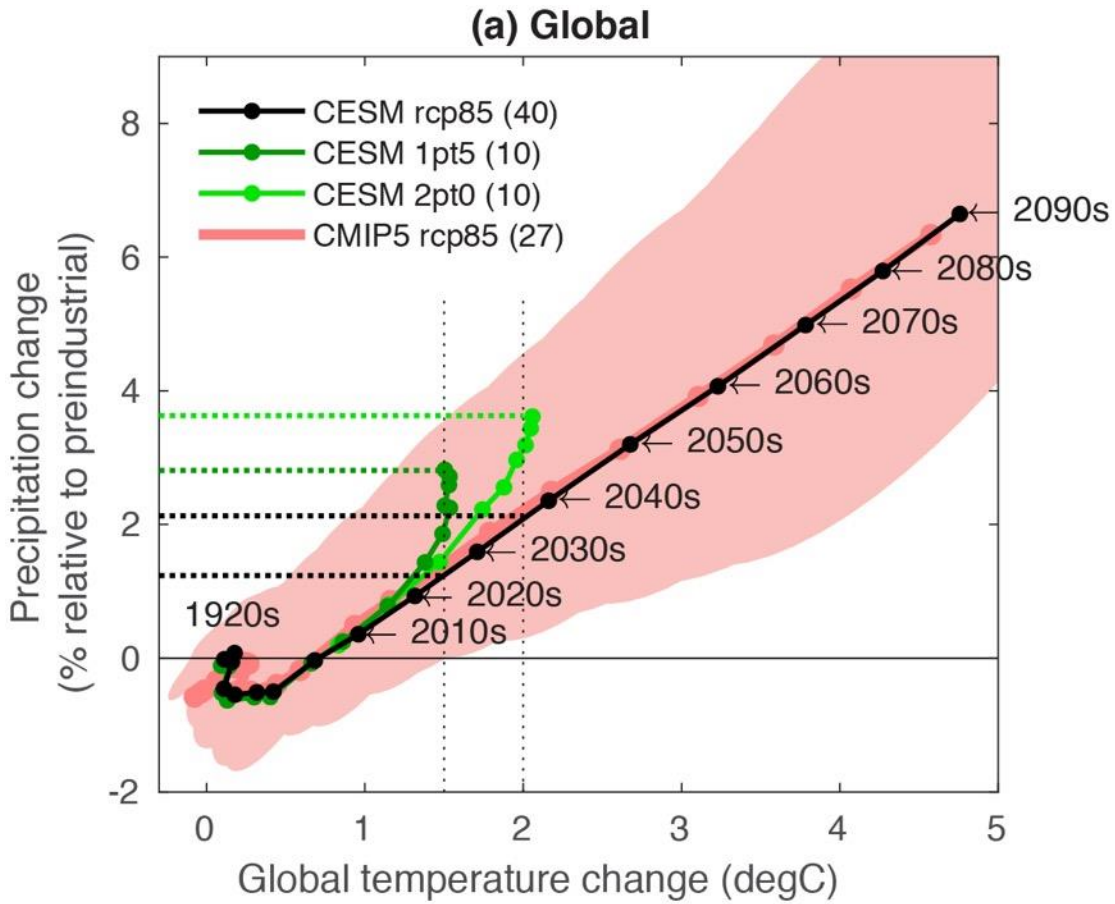

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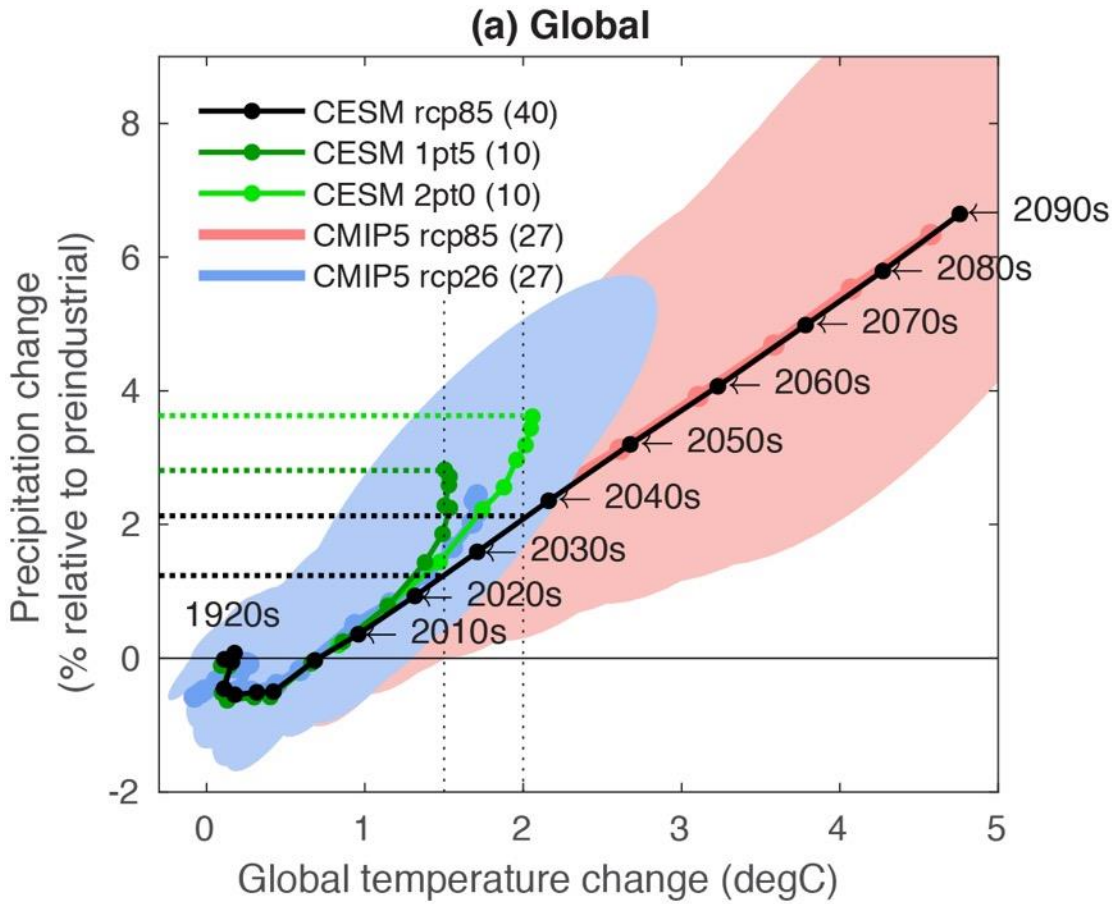
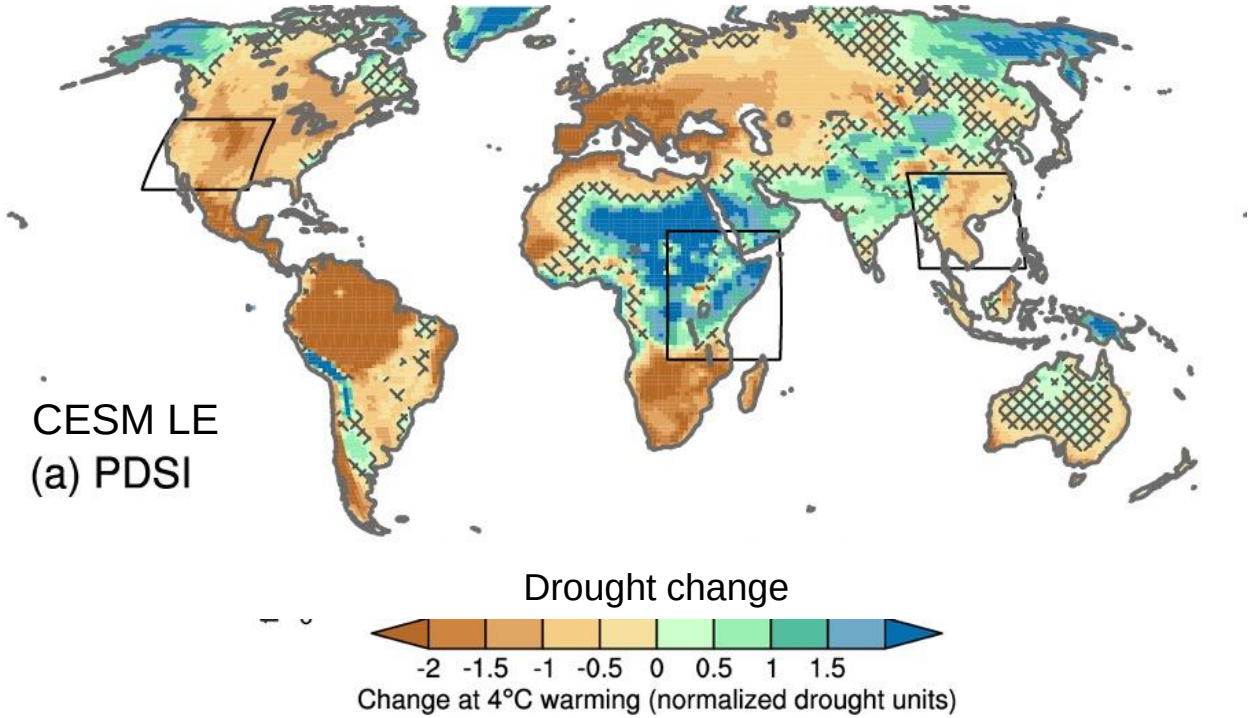


Drought changes in CESM



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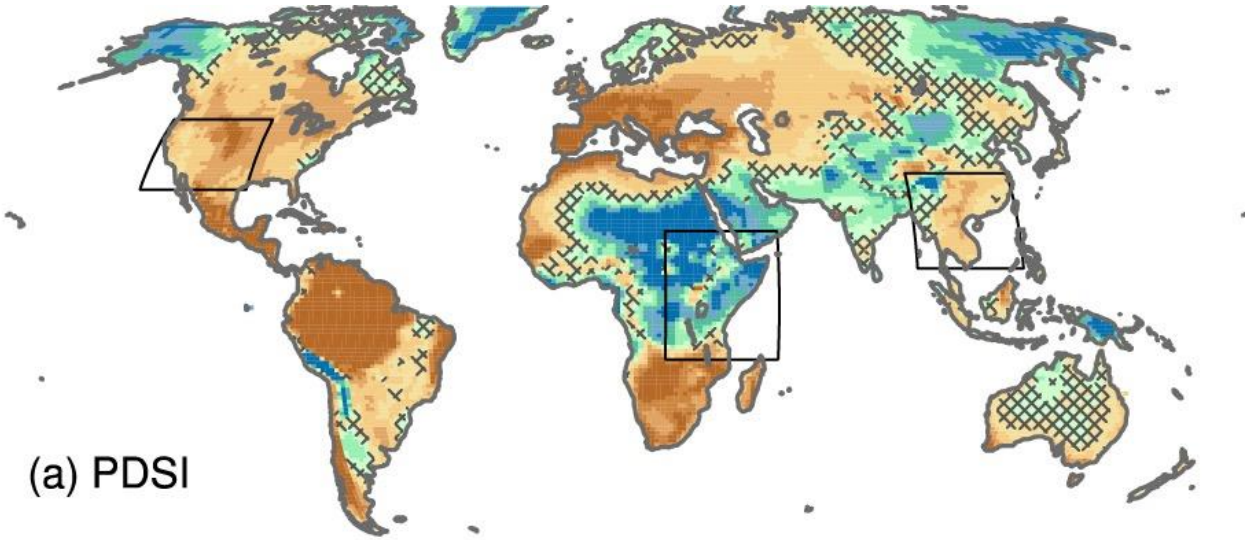

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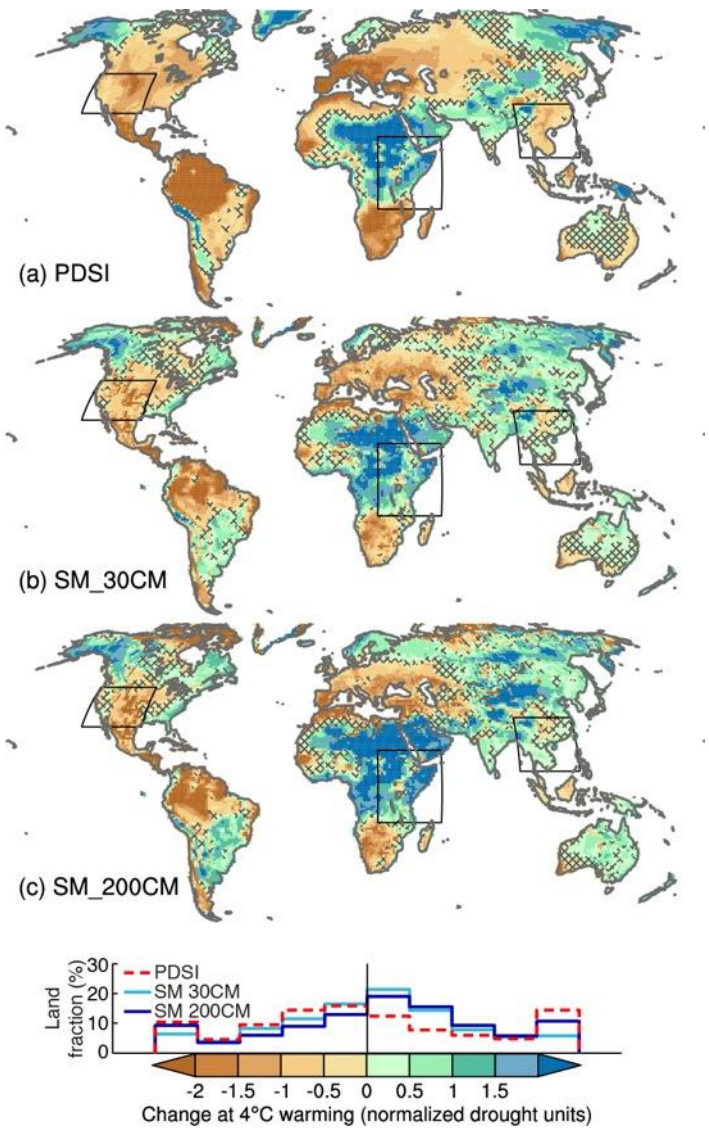

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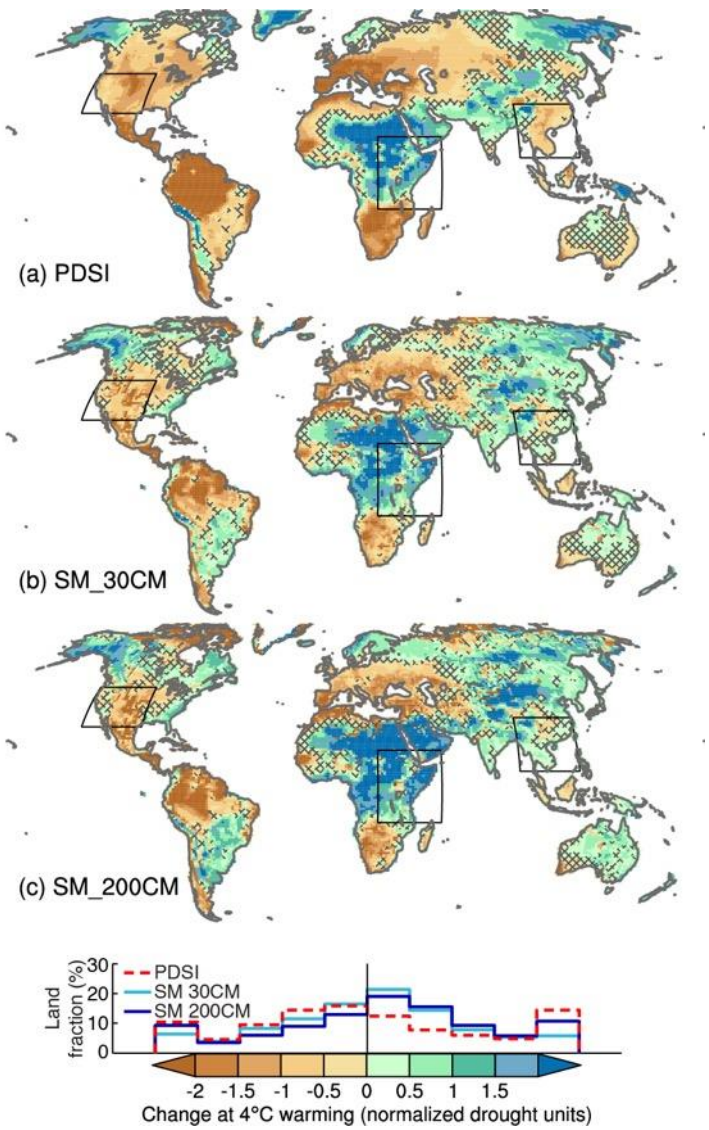
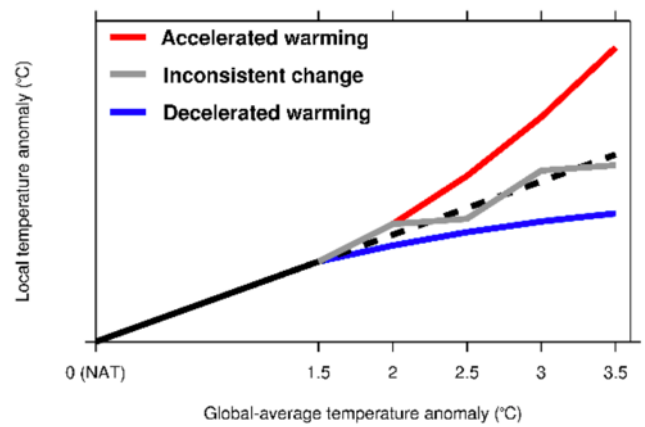


Departure from linear scaling

$$D_{\Delta T} = \Delta Q_{\Delta T} - \frac{\Delta T}{\Delta T - 0.5} \Delta Q_{\Delta T - 0.5°\mathrm{C}}$$



King (2019, *Env. Res. Let.*)

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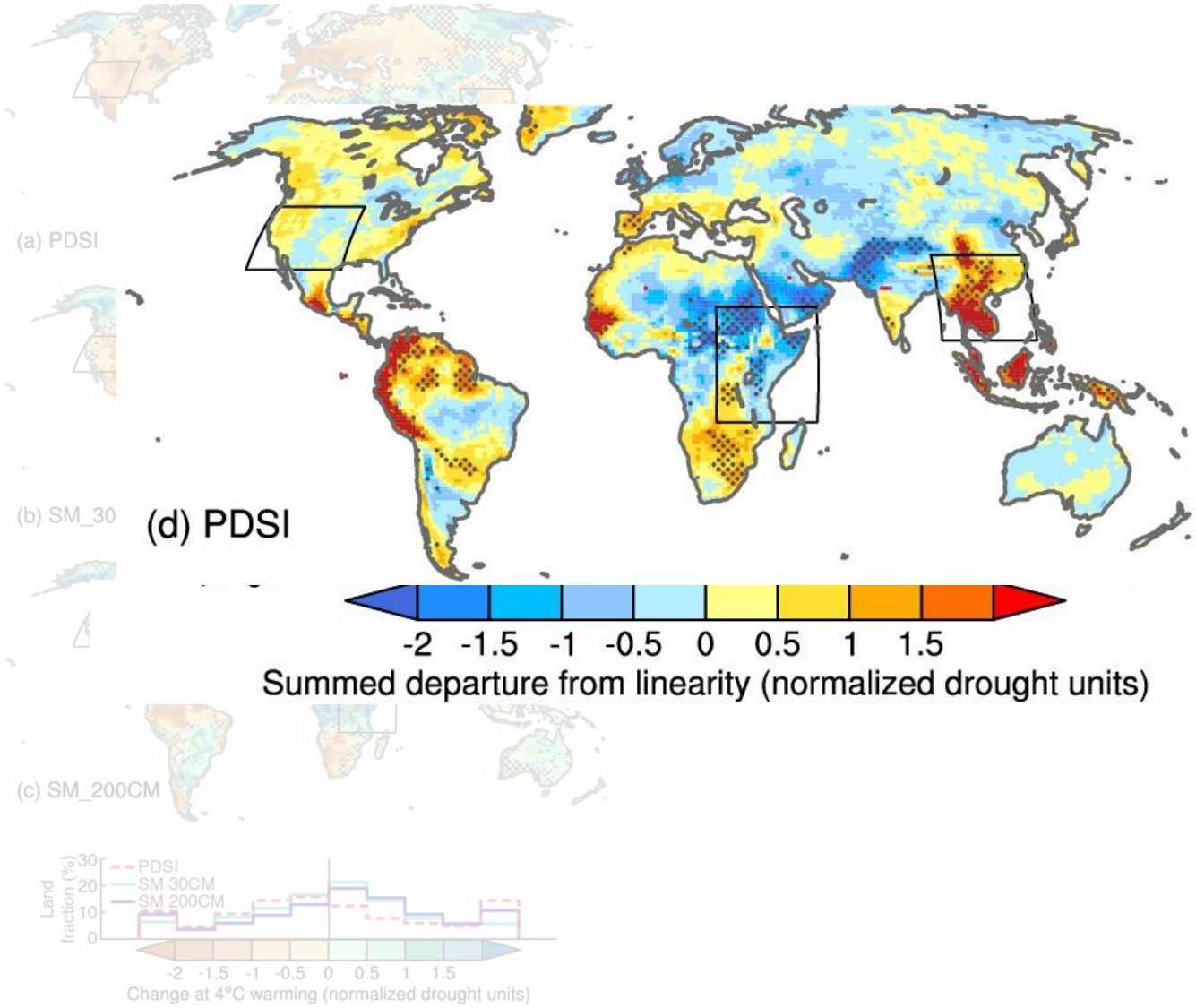

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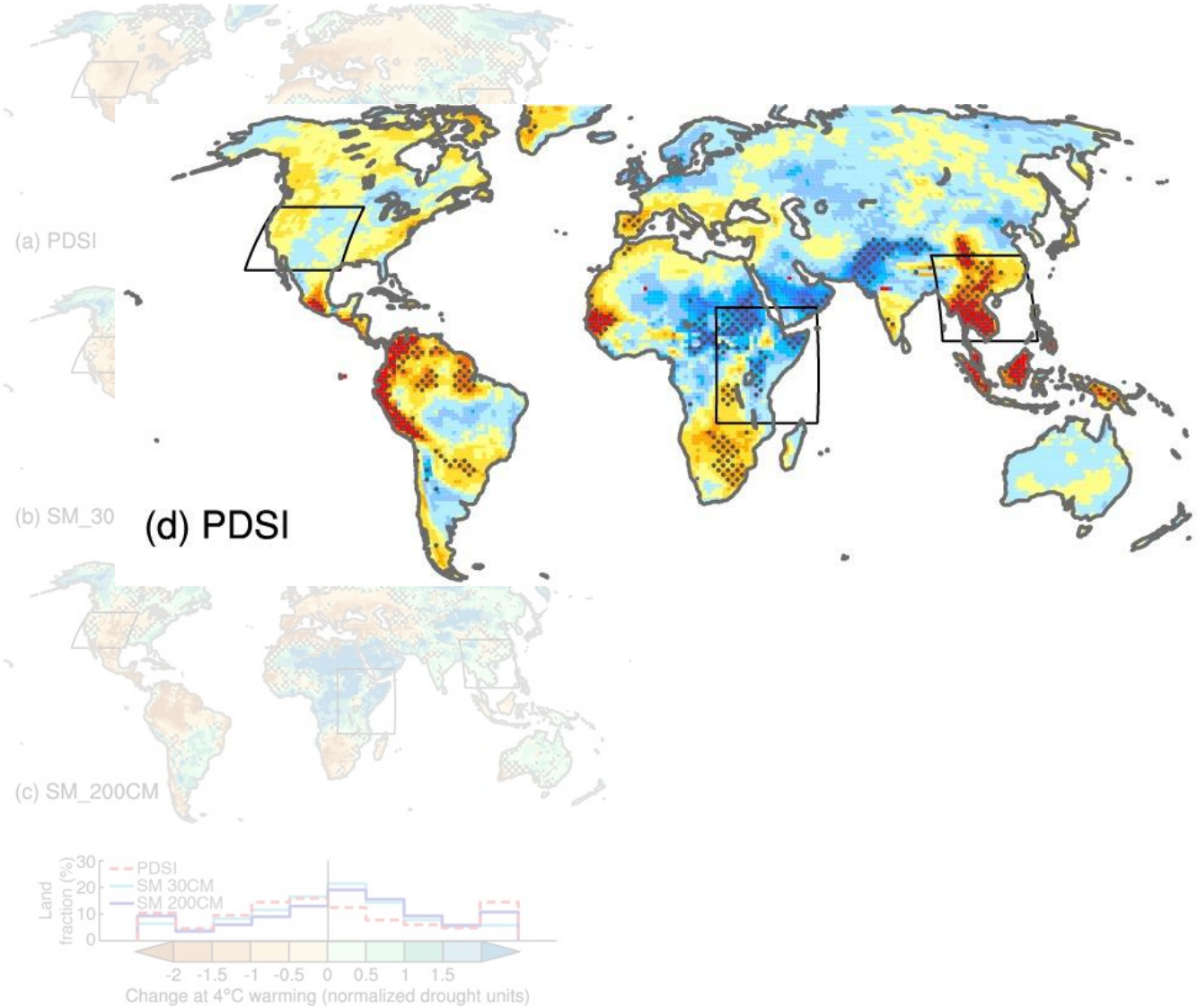

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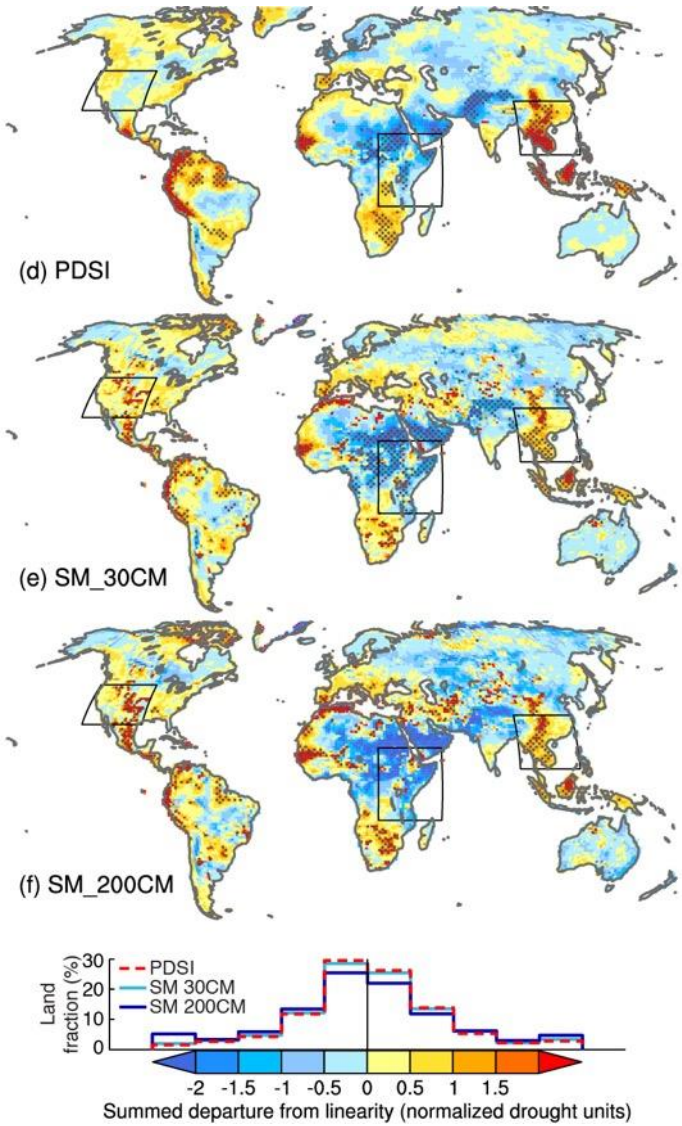

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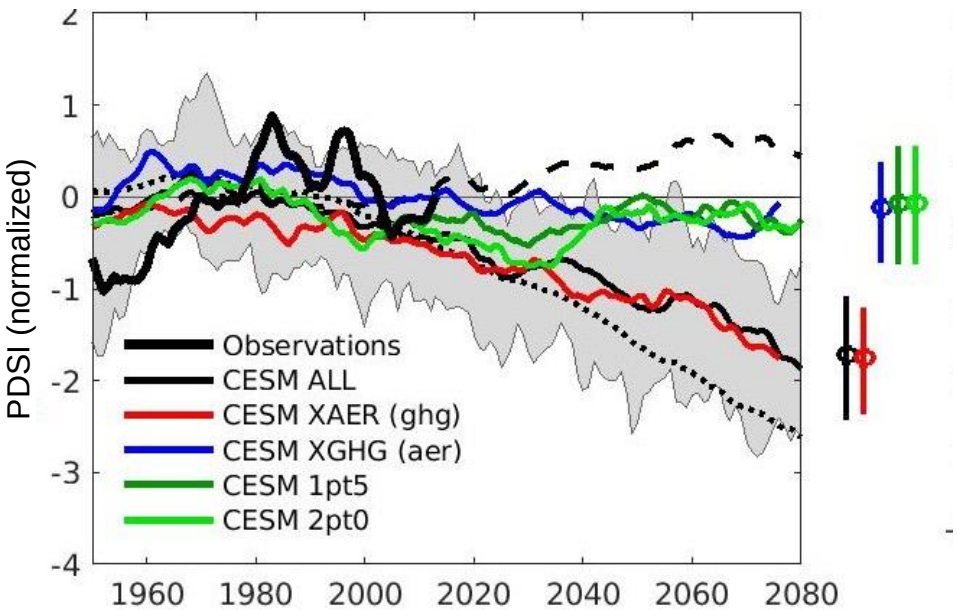
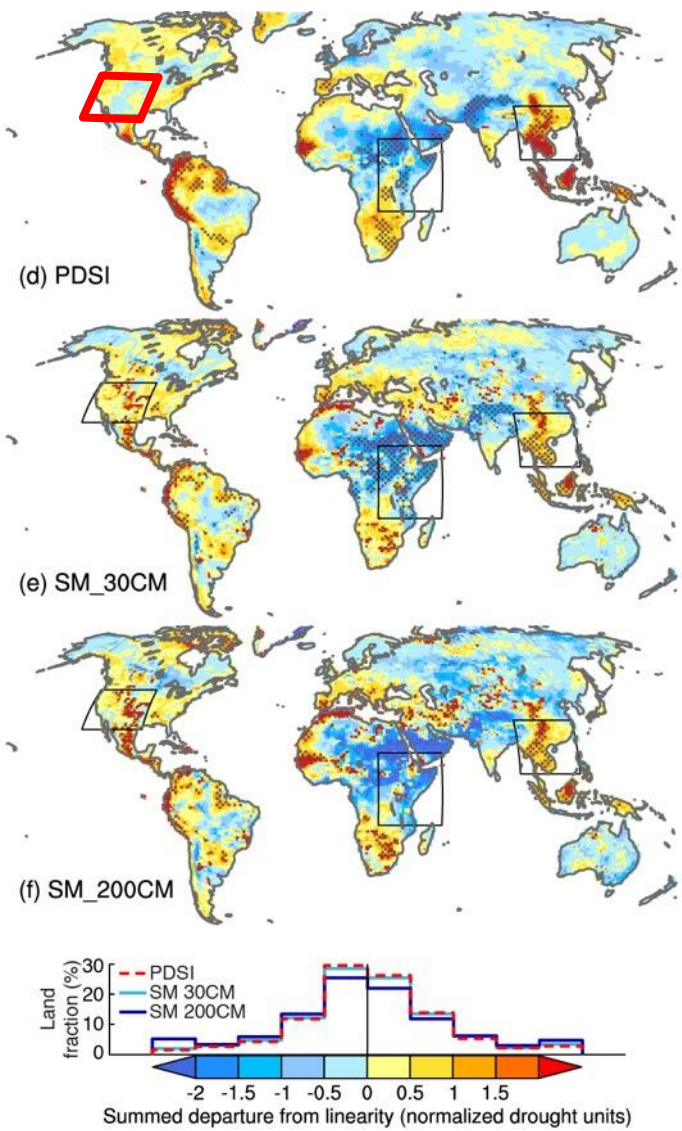


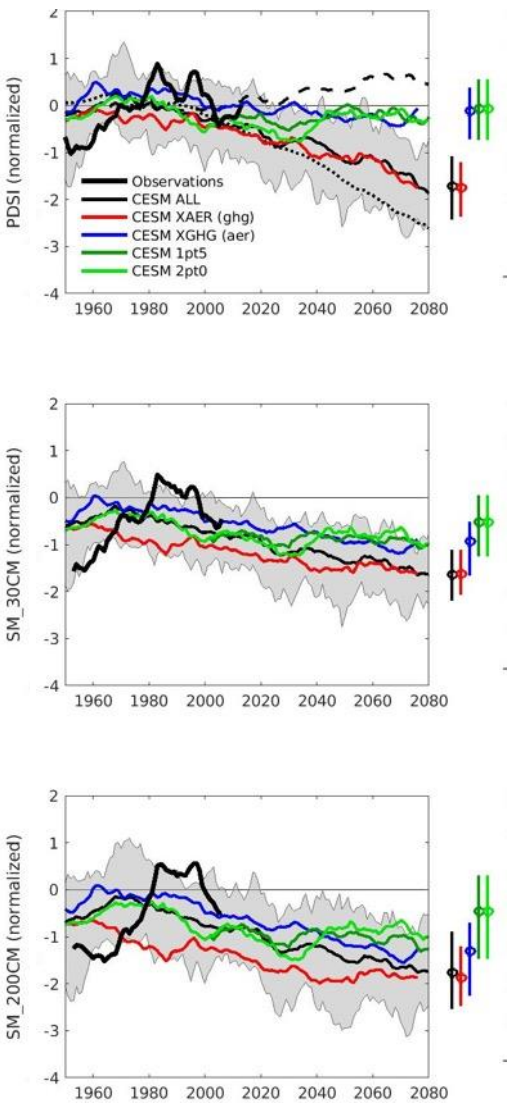


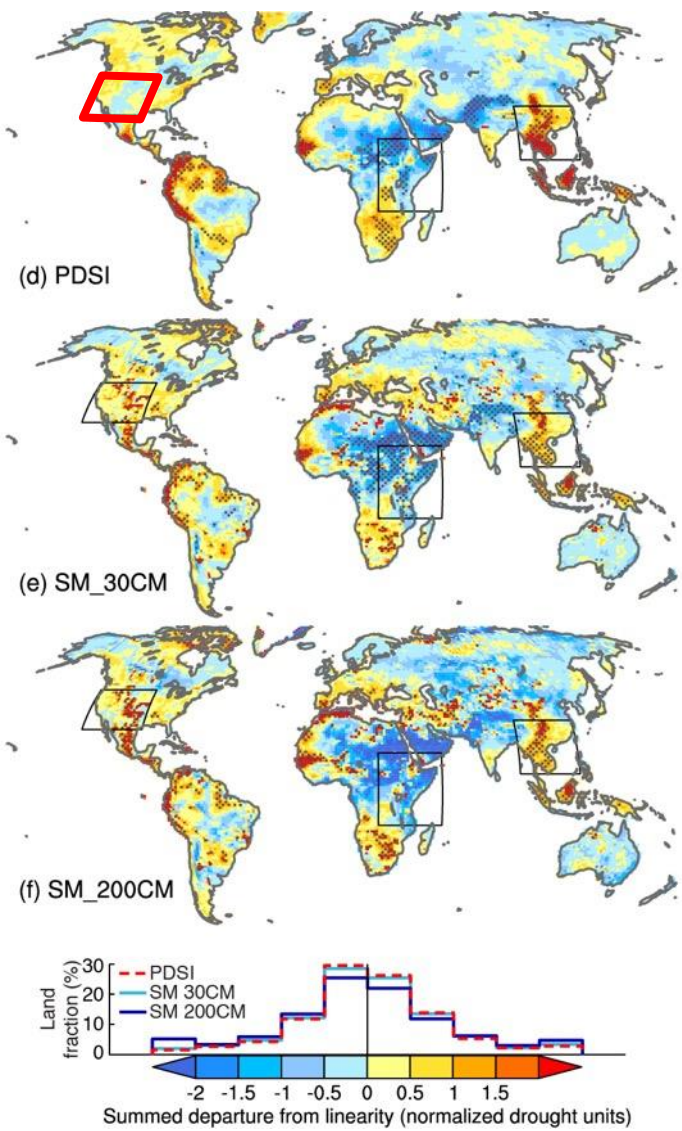
20 simulations each:

XAER = aerosols fixed at 1920 (~GHG)

XGHG = GHGs fixed at 1920 (~AER)

Drought changes in CESM





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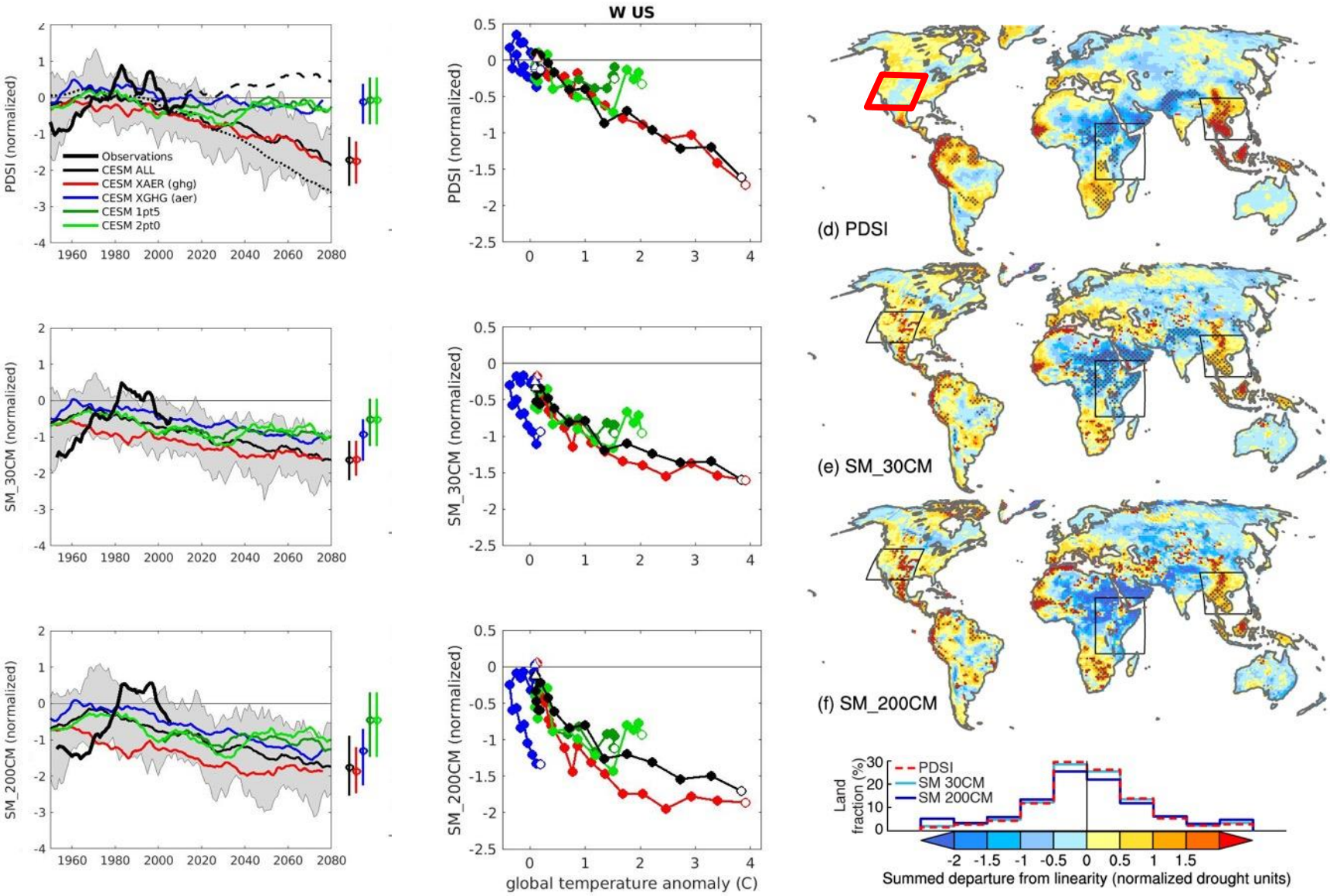

Summary and conclusions

- **Nonlinearities** with temperature exist, challenging the robustness of warming targets alone to inform about climate change impacts and their possible mitigation

- **Emission scenario composition** can have important regional impacts, with **aerosols** being the dominant factor → this complicates interpretation of the observational record

- Some results depend on **drought metric** used

- **Good/bad news:** CESM likely overestimates aerosol forcing on precipitation in some regions (not shown)

Thanks!

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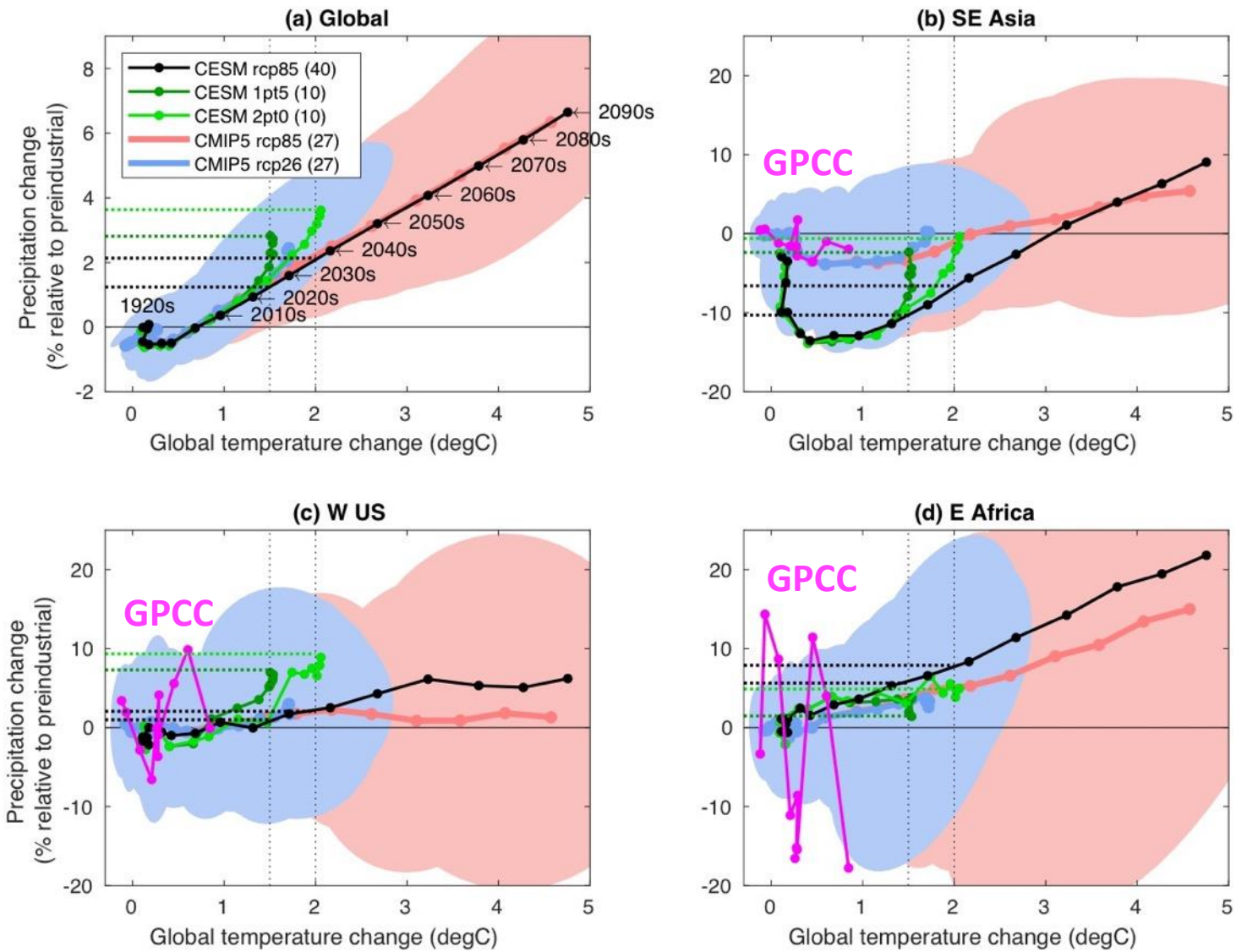
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