Nonlinear carbon feedbacks in CMIP6 and their impacts on future freshwater availability

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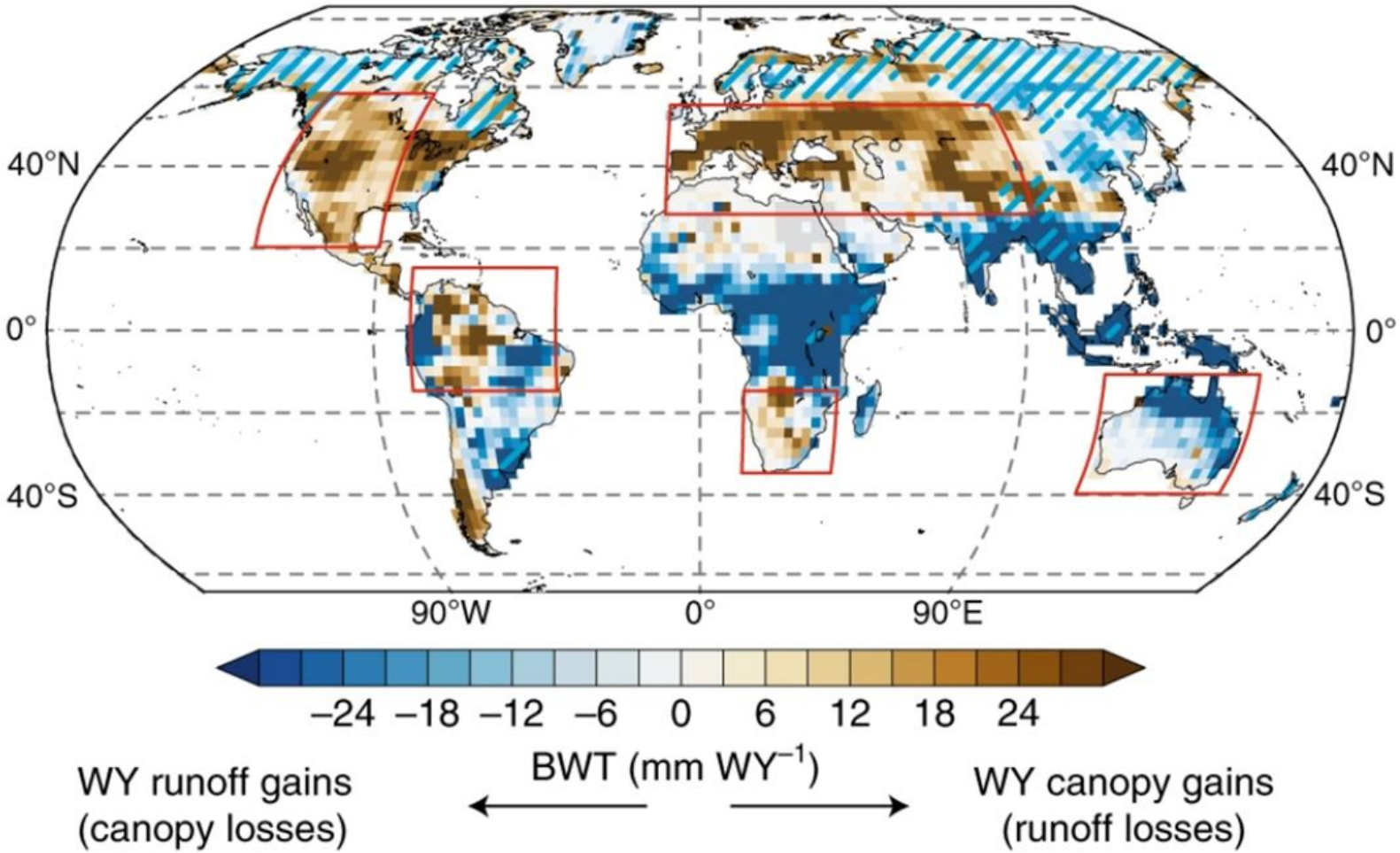
DOE Project:
The Role of Vegetation in Past and Future Global Hydroclimate Change

How will plants affect water availability at the land surface in the future?

Mid-latitude freshwater availability reduced by projected vegetation responses to climate change



Mankin, J.S., R. Seager, J.E. Smerdon, B. I. Cook, and A. P. Williams, *Nature Geoscience*, 12, 983–988, 2019.

13 CMIP6 Models

7 CMIP5 Models

COU ≈ BGC + RAD + NL

1pctCO2->140yrs
4XCO$_2$
Fully Coupled

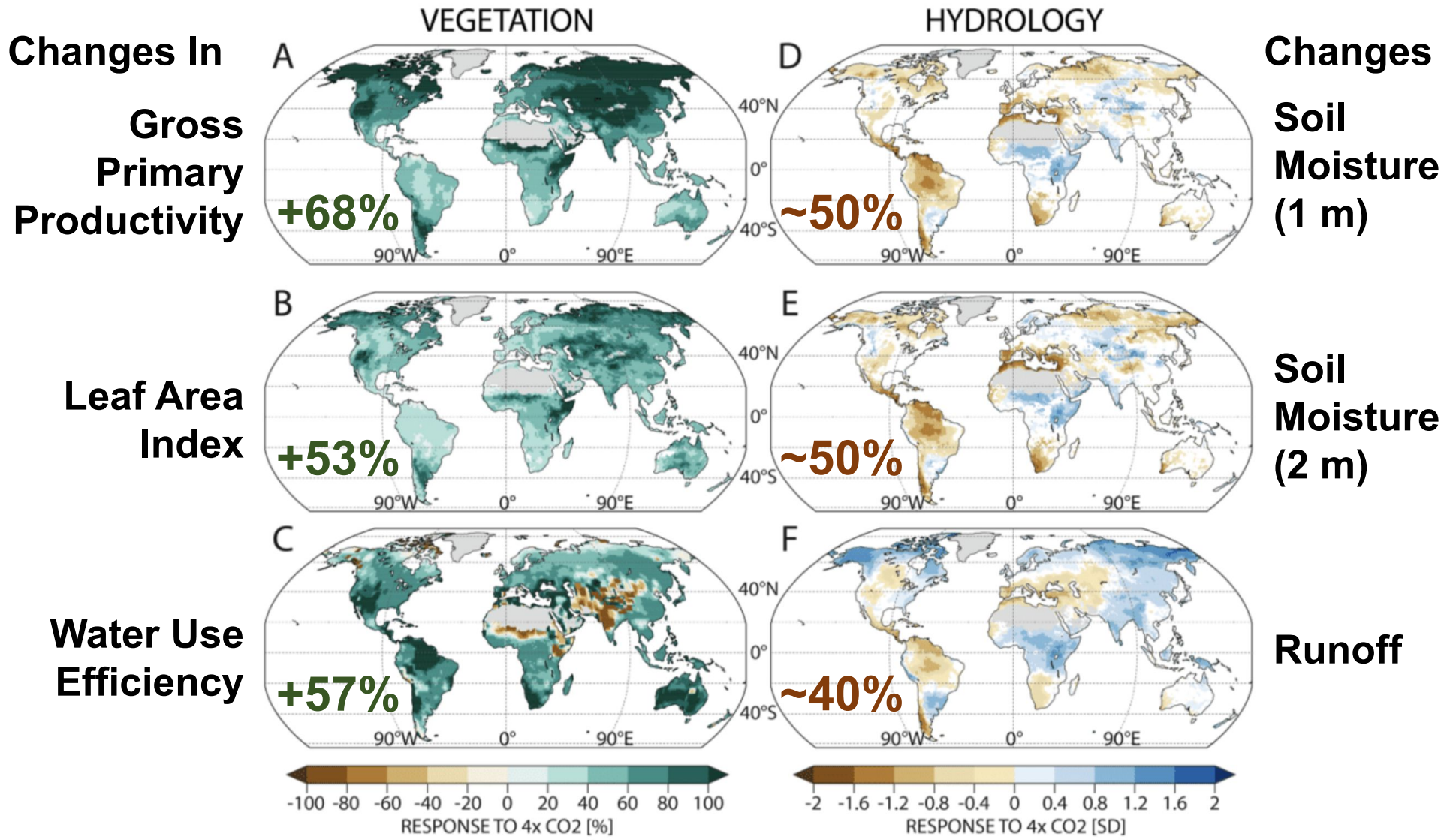
1pctCO2->140yrs
4XCO$_2$
Biochemical Scheme

1pctCO2->140yrs
4XCO$_2$
Radiative Scheme

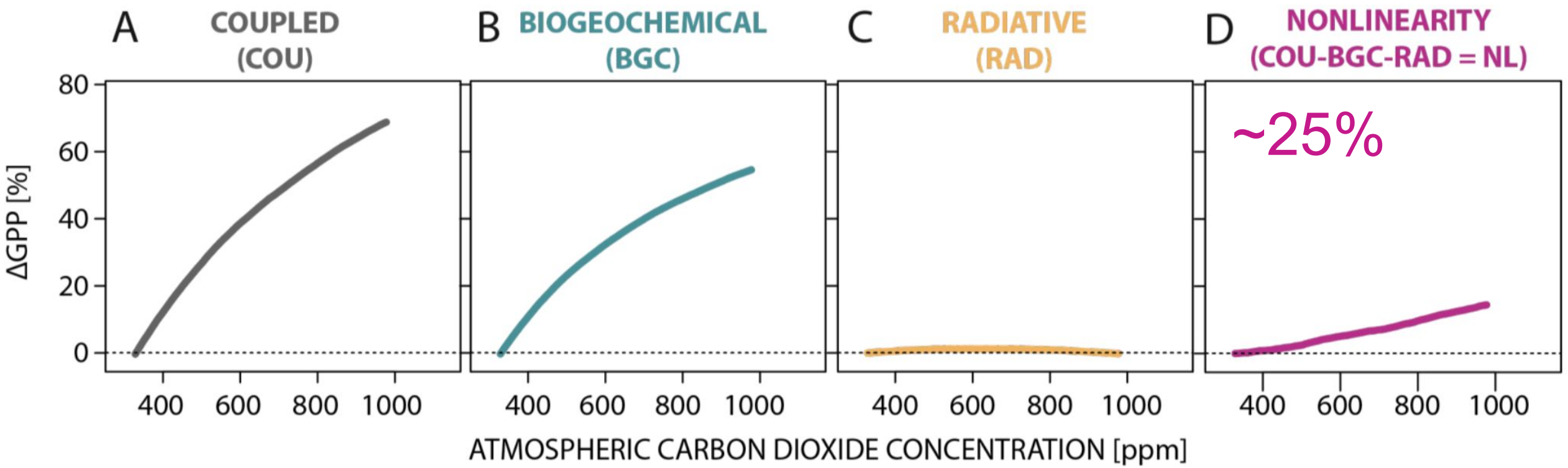
J. S. Mankin, N. Siegert, J. E. Smerdon, B. I. Cook, R. Seager, A. P. Williams, C. Lesk, Z. Li, H. Singh, and E. Martinez, Nonlinear carbon feedbacks in CMIP6 and their impacts on future freshwater availability, *Journal of Climate*, in review.

Simultaneous Greening and Drying

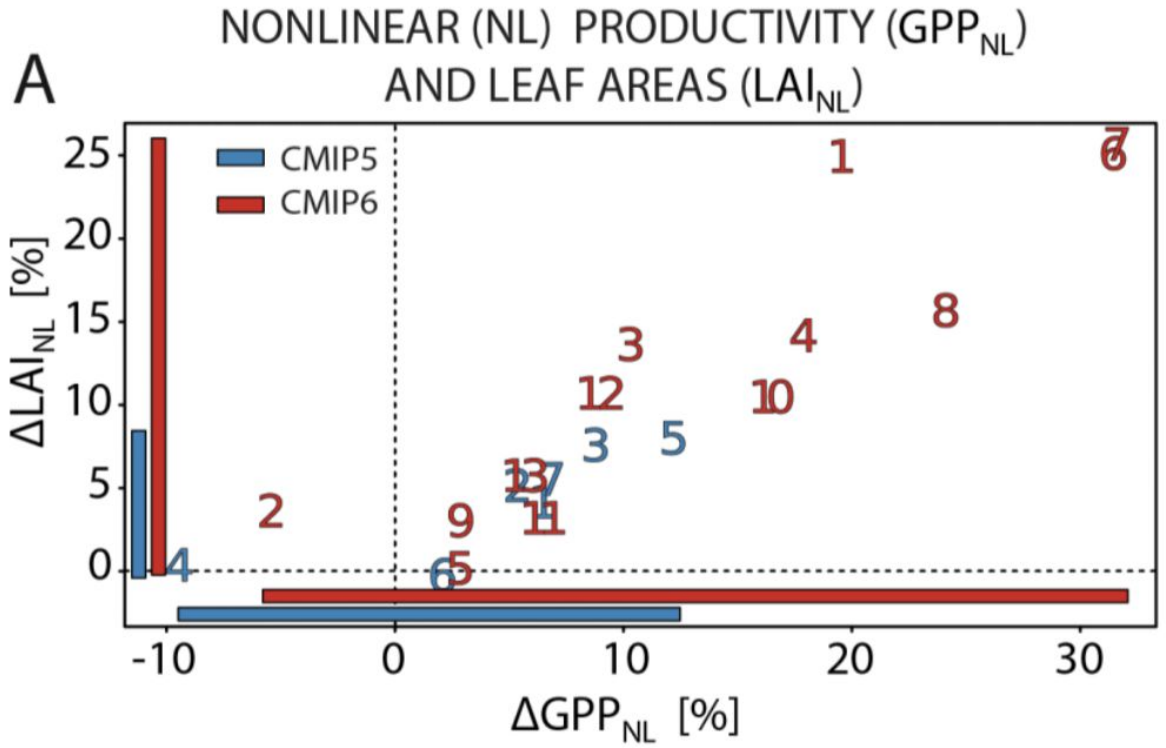
1st 30 yrs – Last 30 yrs



Emergent Nonlinear Term in Vegetation Productivity

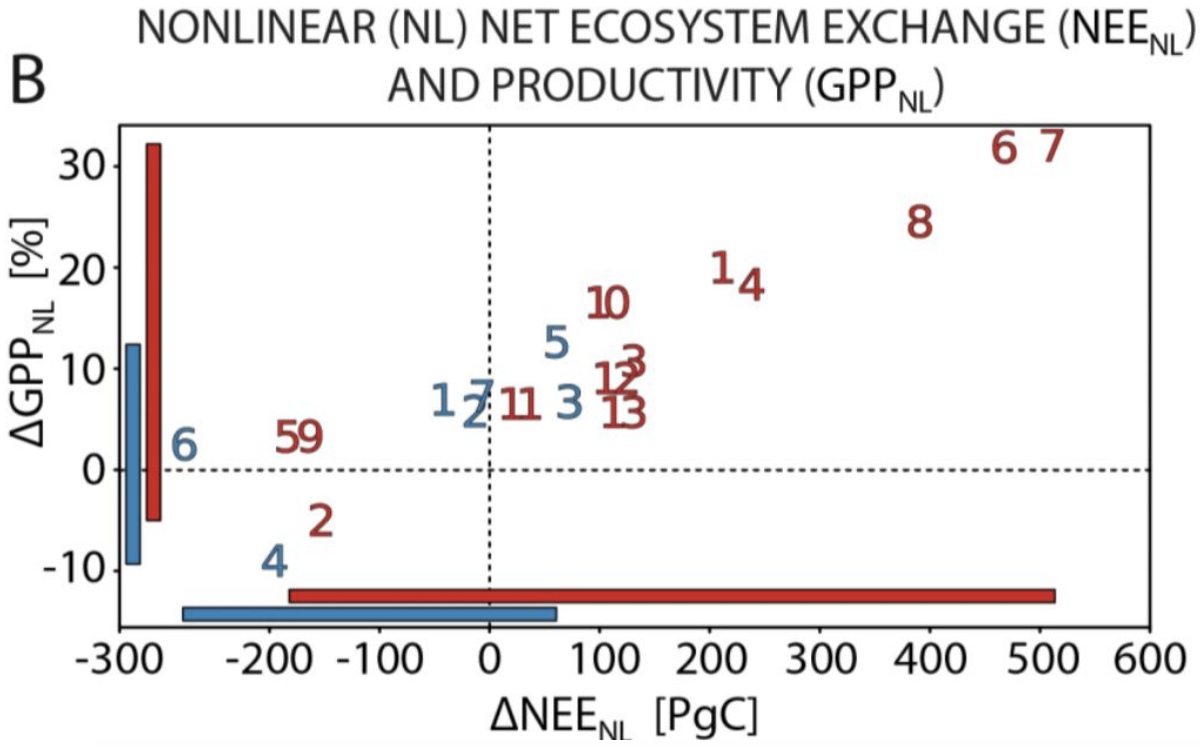


Model Uncertainties in Vegetation Productivity



CMIP5

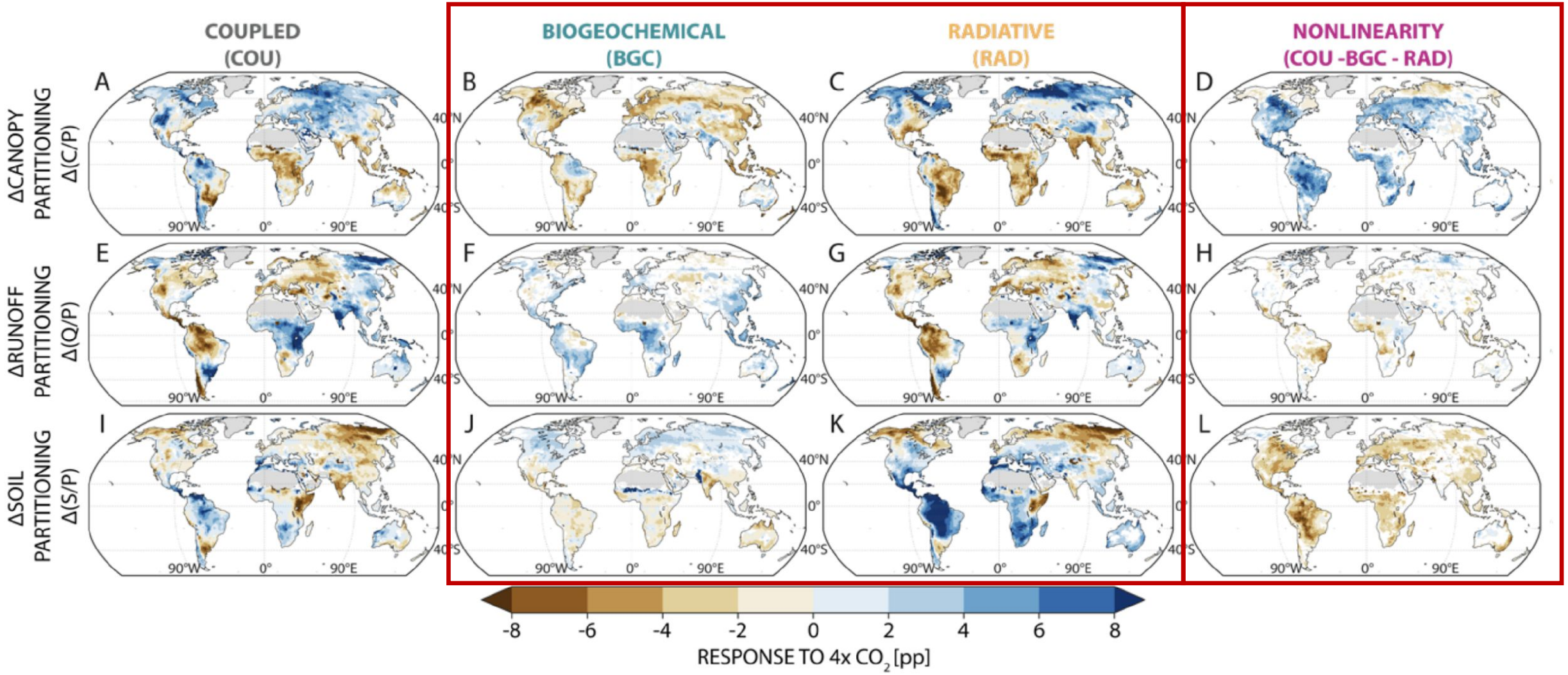
1 BCC-CSM 1-1 **5 IPSL-CM5A-LR**
2 CanESM2 6 MPI-ESM-LR
3 CESM1-BGC **7 NorESM1-ME**
4 HadGEM2-ES



CMIP6

1 ACCESS-ESM1-5 **6 CanESM5** 11 MIROC-ES2L
2 BCC-CSM2-MR 7 CanESM5-CanOE **12 NorESM2-LM**
3 CESM2 8 EC-Earth3-CC 13 UKESM1-0-LL
4 CMCC-ESM2 9 GFDL-ESM4
5 CNRM-ESM2-1 **10 IPSL-CM6A-LR**

Water Partitioning in the Future

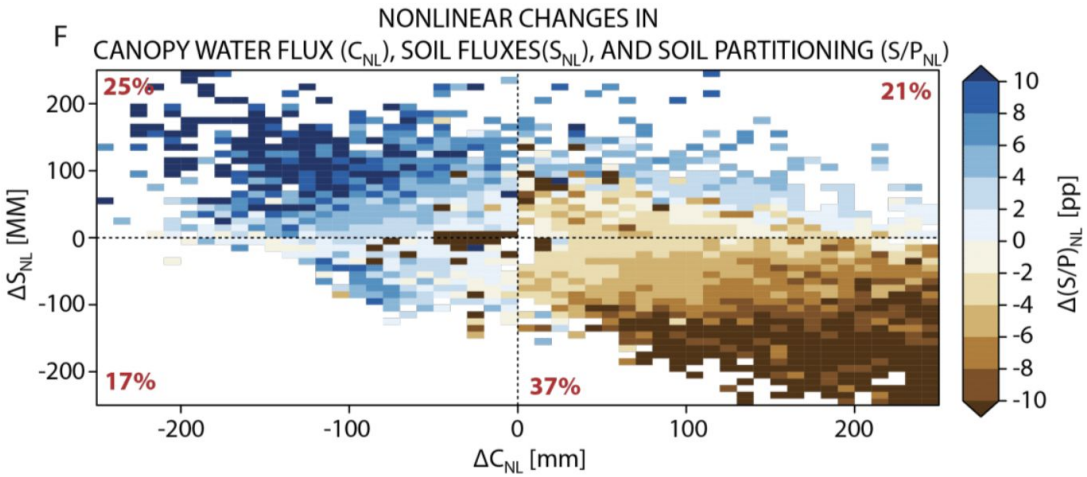


BGC → Reduced Stomatal Conductance
Increased LAI

RAD → Longer and warmer growing seasons

NL → Increased LAI + Longer Growing Seasons

Reduced Runoff and Soil Moisture



Is any of this correct and how do we know?

- Process-driven investigations across a hierarchy of models
- Perturbed parameter ensembles and global variance-based sensitivity studies
- Observations, observations, observations…