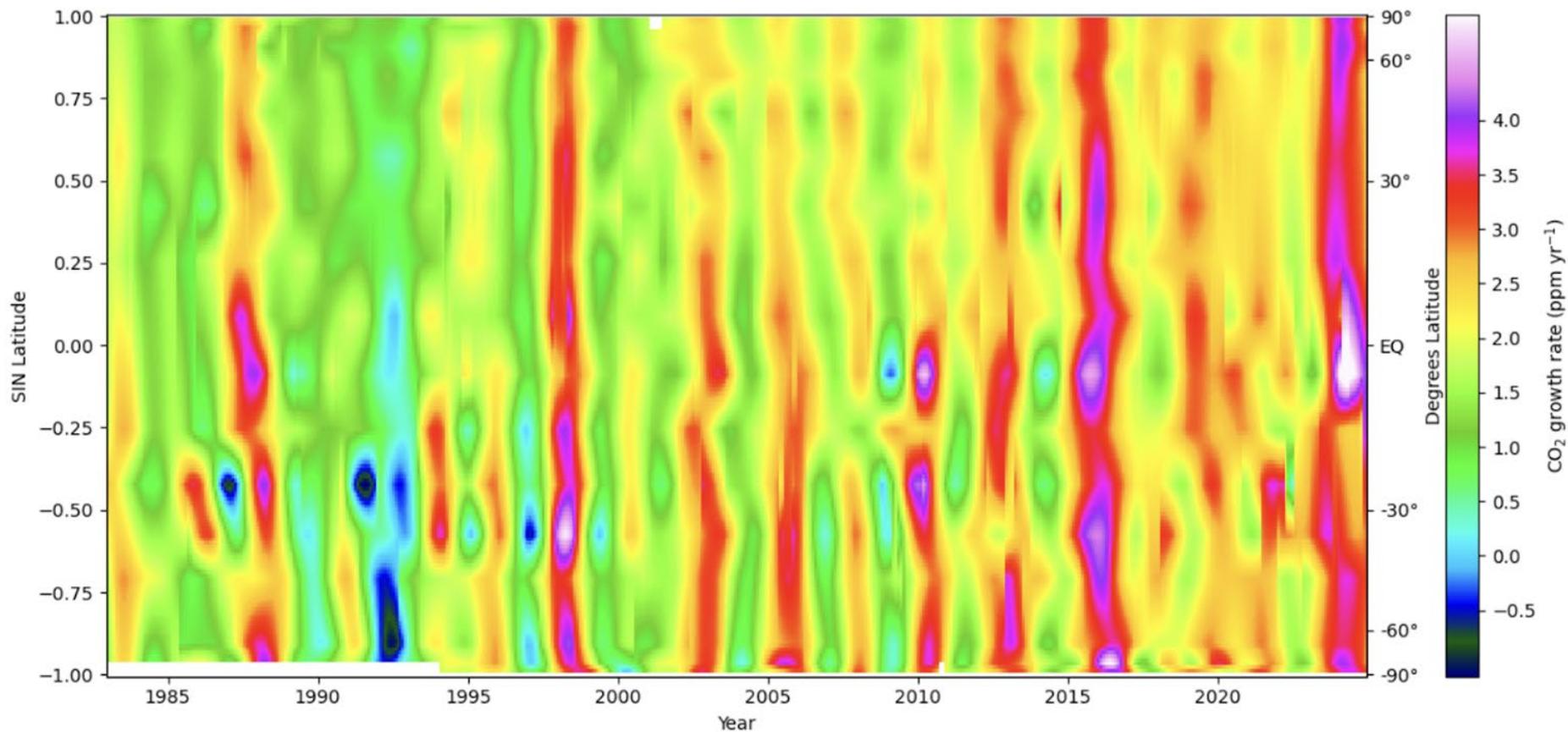# Regional Gross Primary Productivity Responses to ENSO across CMIP6 Earth System Models

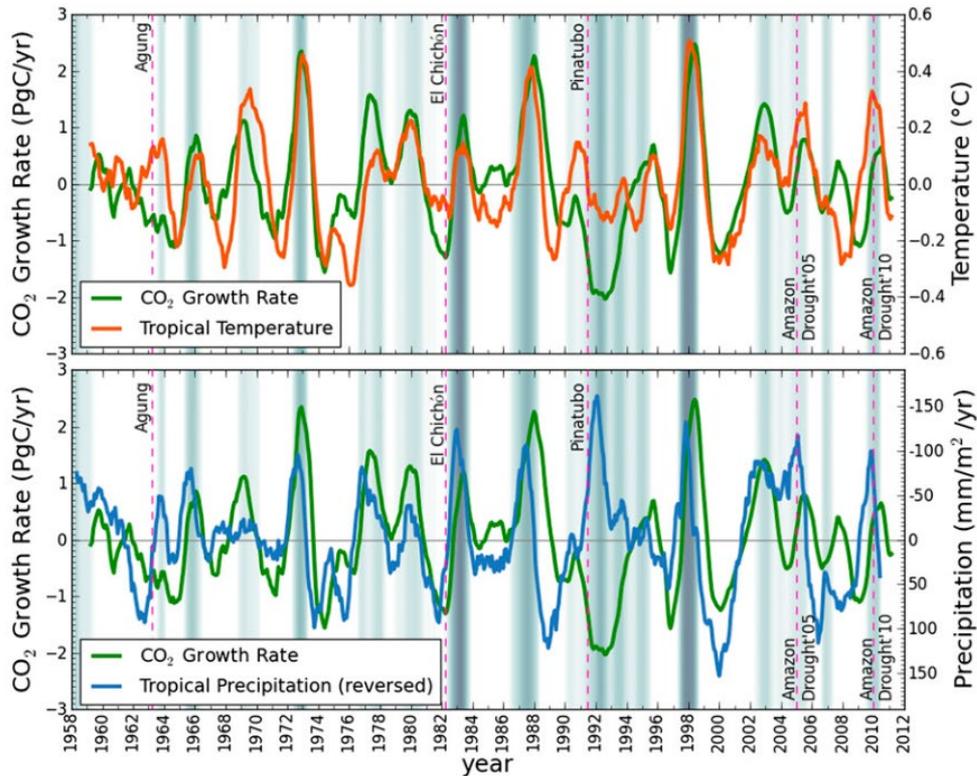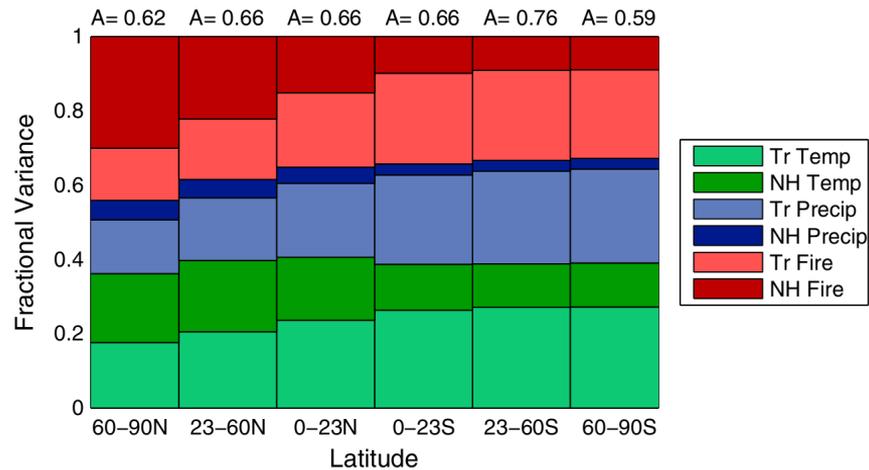**Maria Salazar,** Gretchen Keppel-Aleks, Allison Steiner

Atmospheric CO$_2$ growth rate increases during El Niño conditions

Empirical relationships show a role for several climate drivers across the globe in controlling this relationship
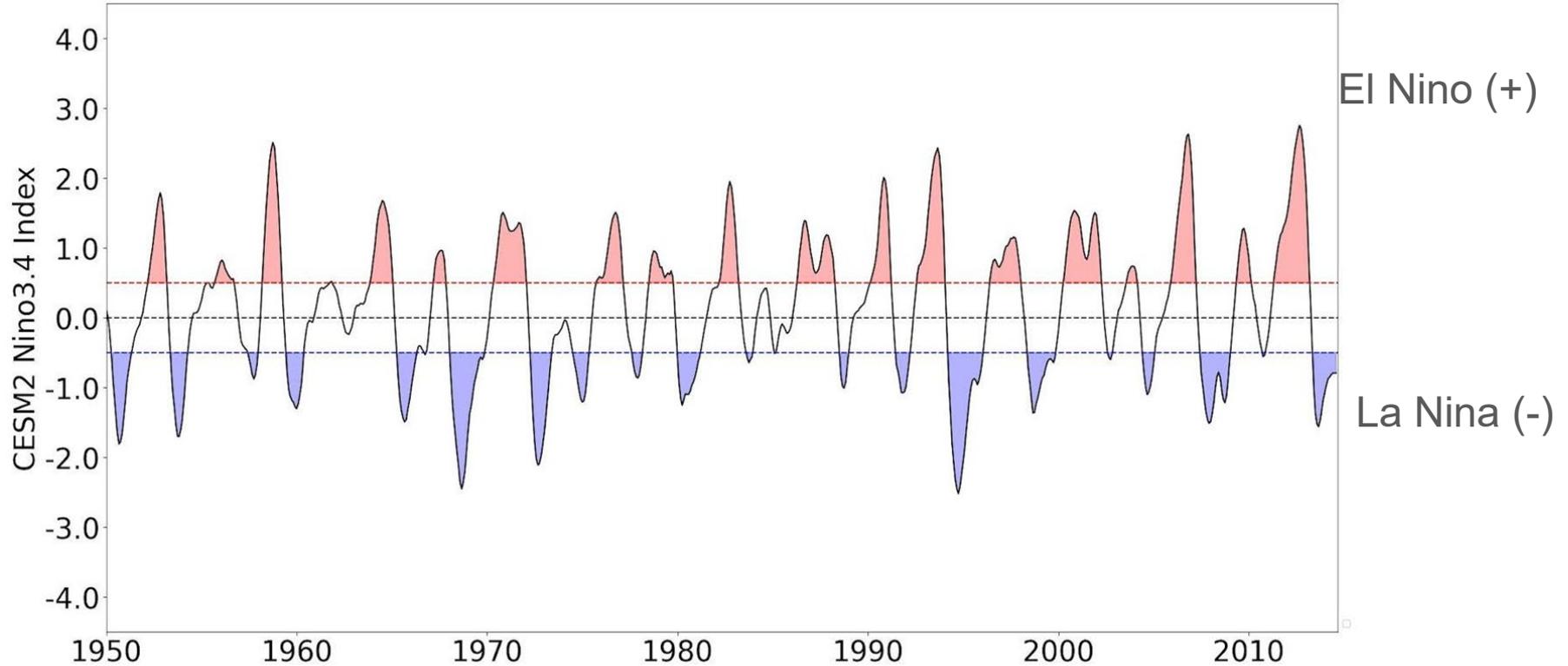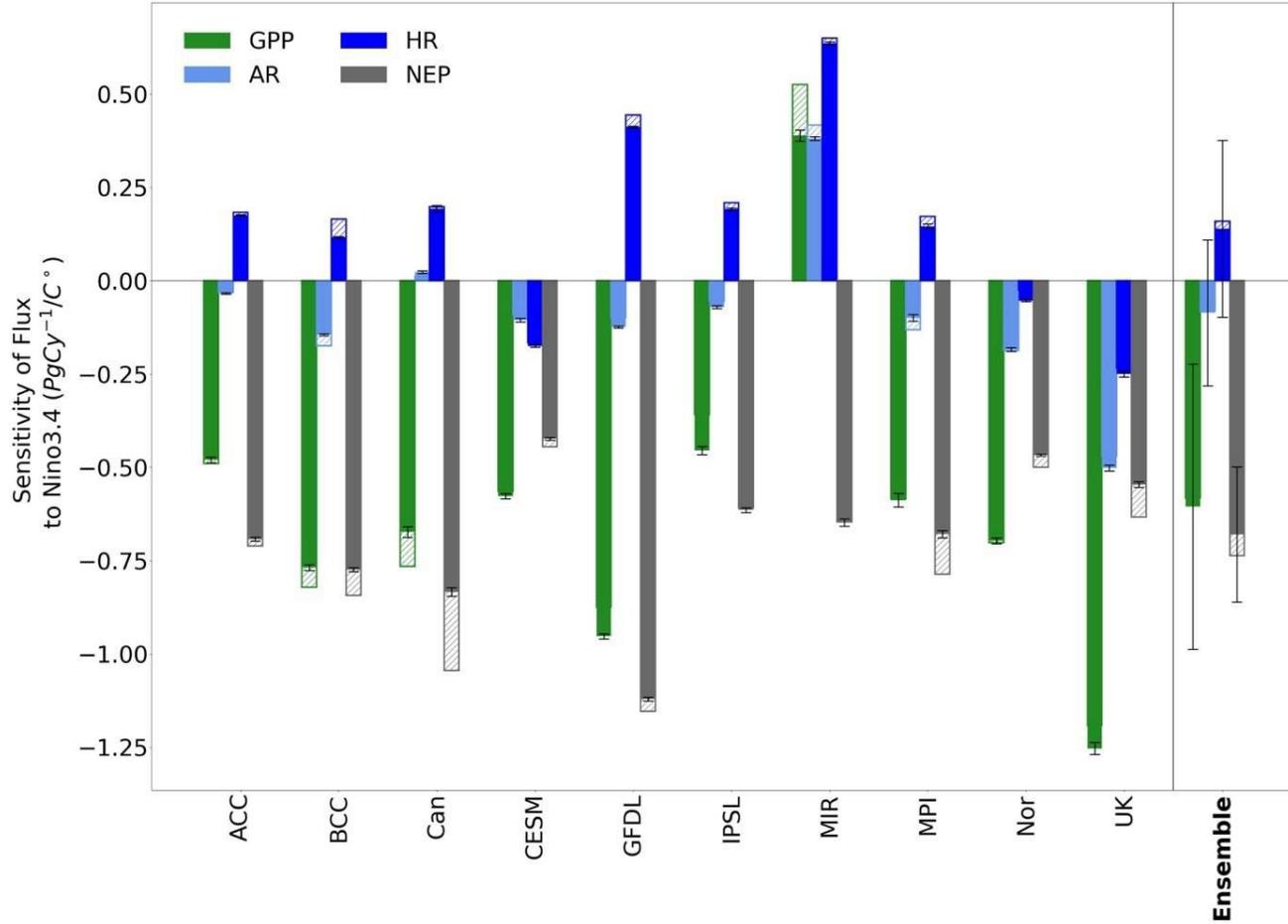

Wang et al., 2013
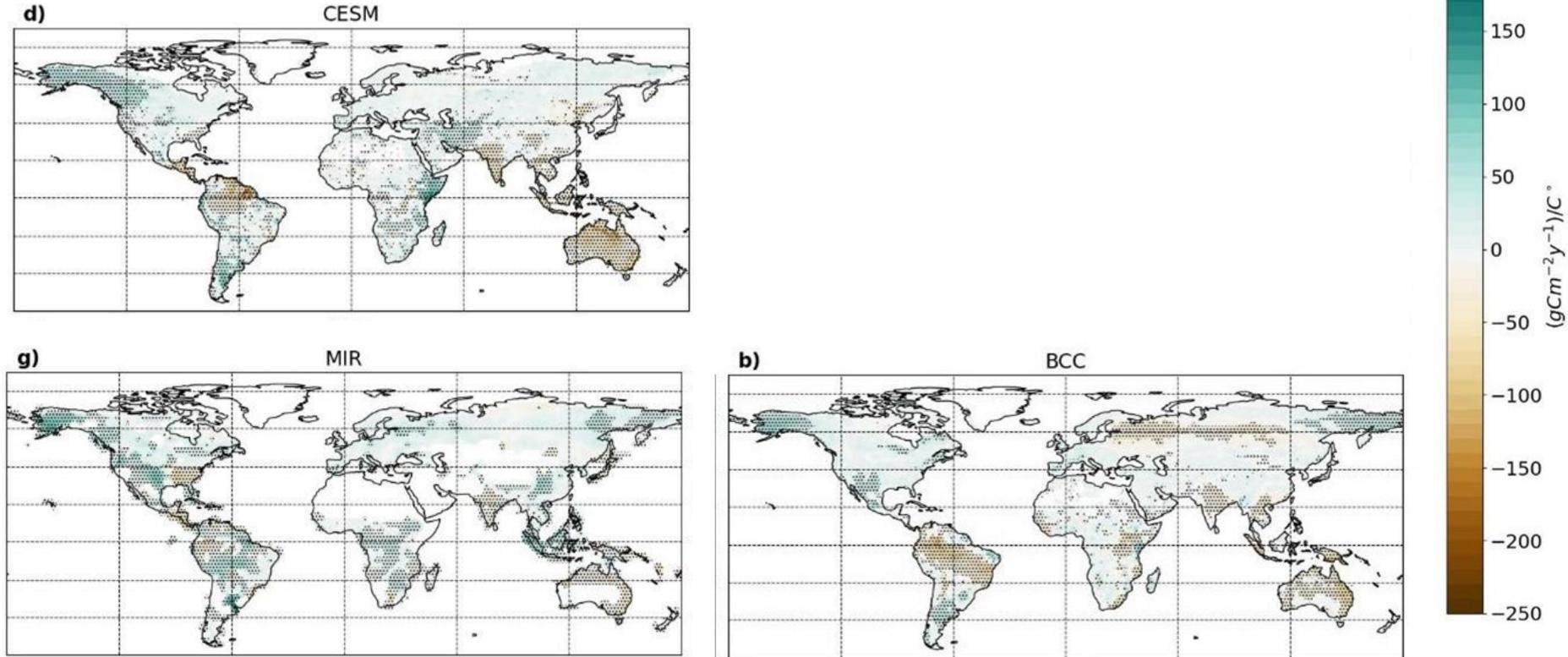
Keppel-Aleks et al., 2014

We assess ENSO across the CMIP6 historical ensemble to understand its impact on physical climate and terrestrial fluxes
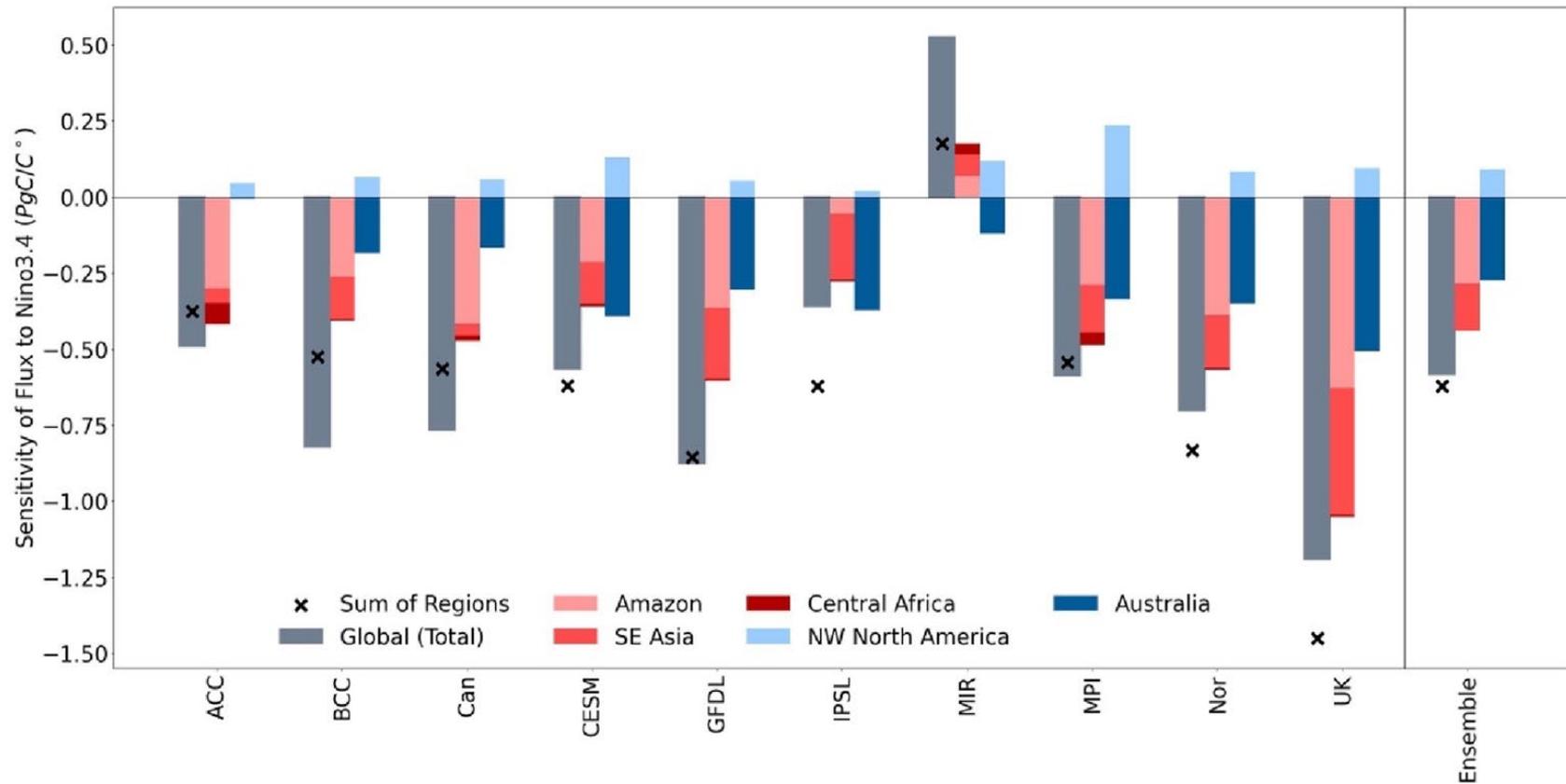
Across the CMIP6 ensemble, GPP is the flux most strongly affected by ENSO and generally shows reduced values during El Niño
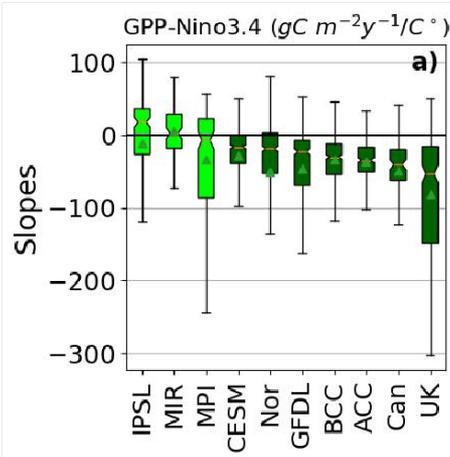
# Individual models show regional differences in response to ENSO conditions

Across the CMIP6 ensemble, four regions contribute to most of the ENSO-driven GPP variability

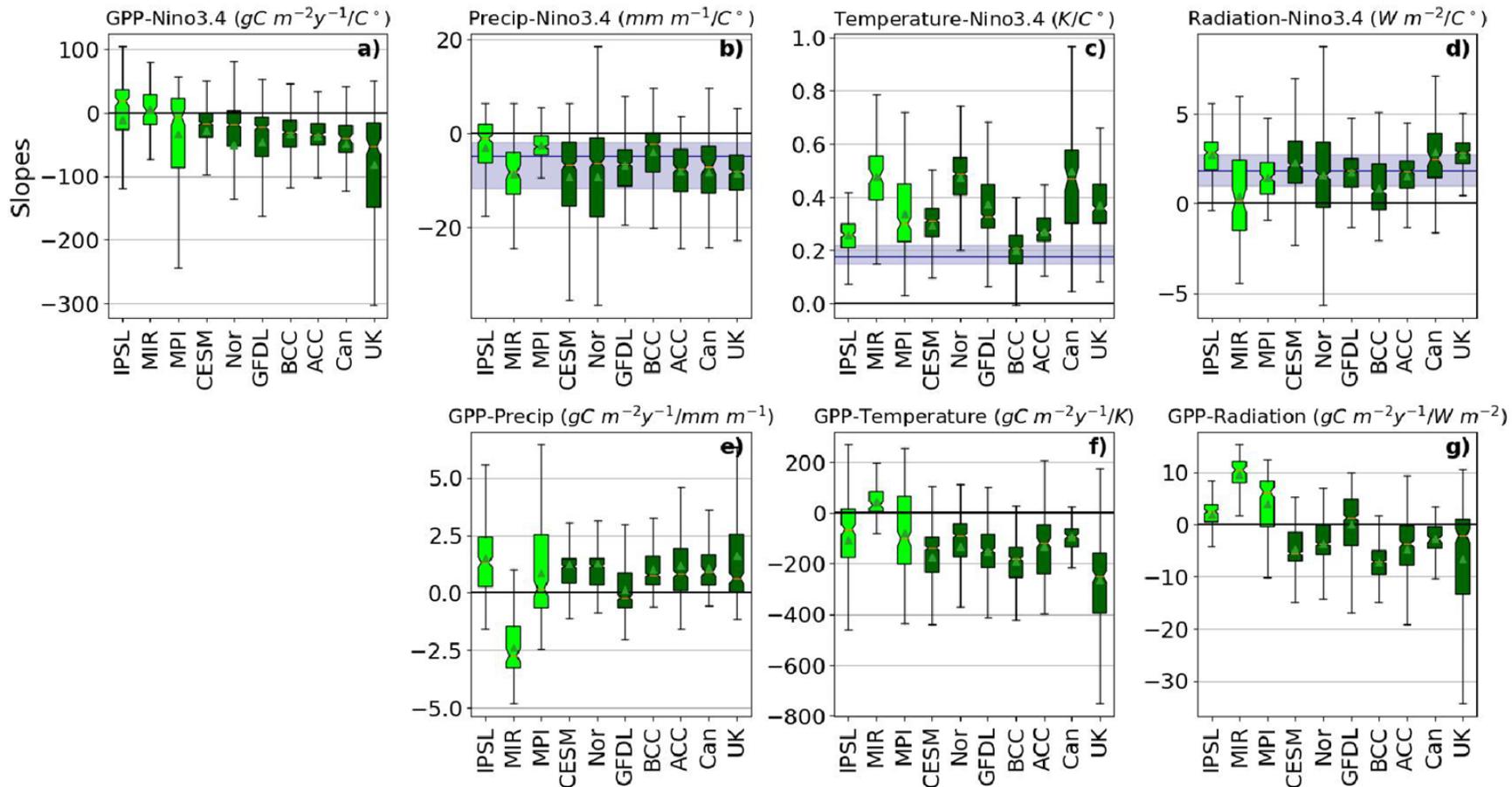# Within the Amazon, most models show a decline in GPP during El Niño, with a few models showing the opposite response


GPP-Nino3.4 ($gC\ m^{-2}y^{-1}/C°$)

There is spread in physical climate responses within the ensemble, but most show a consistent directionality
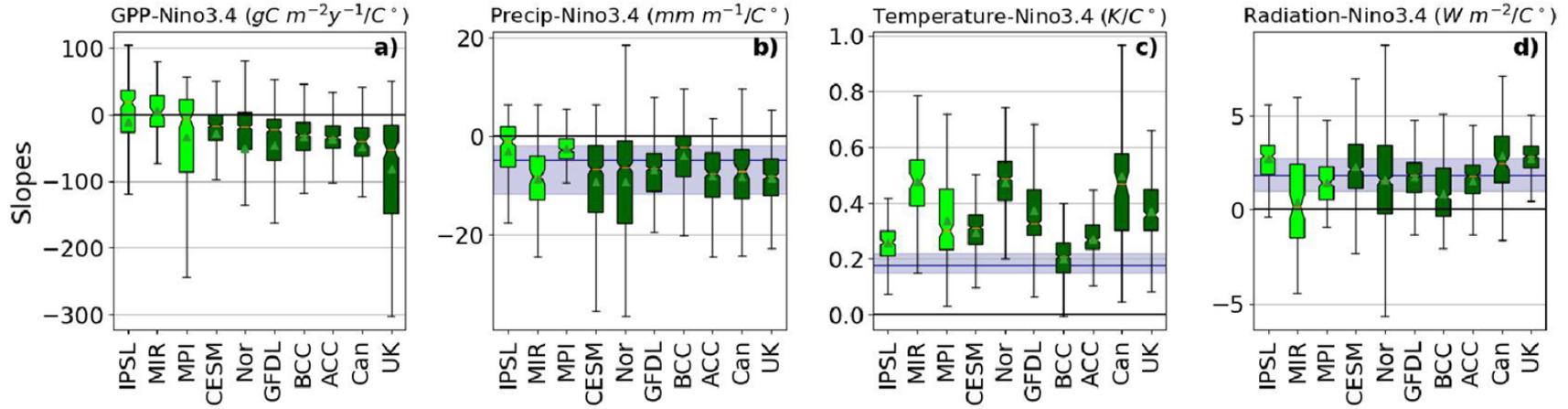
The models with the strongest GPP reduction during El Niño are the models with the biggest decline in precipitation…
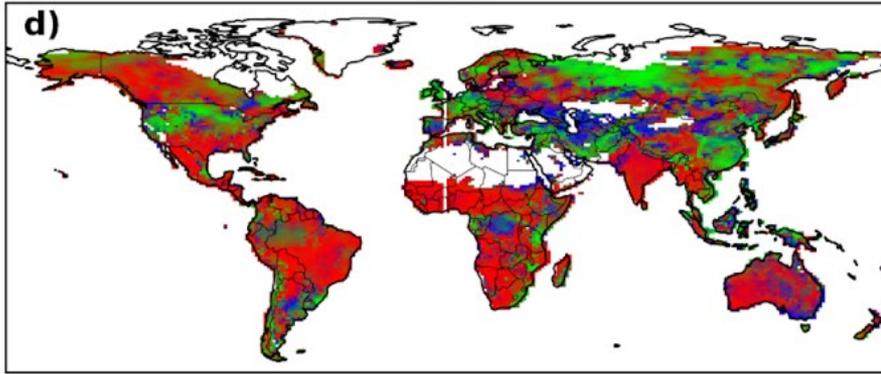
The models with the strongest GPP reduction during El Nino are the models with the biggest decline in precipitation…
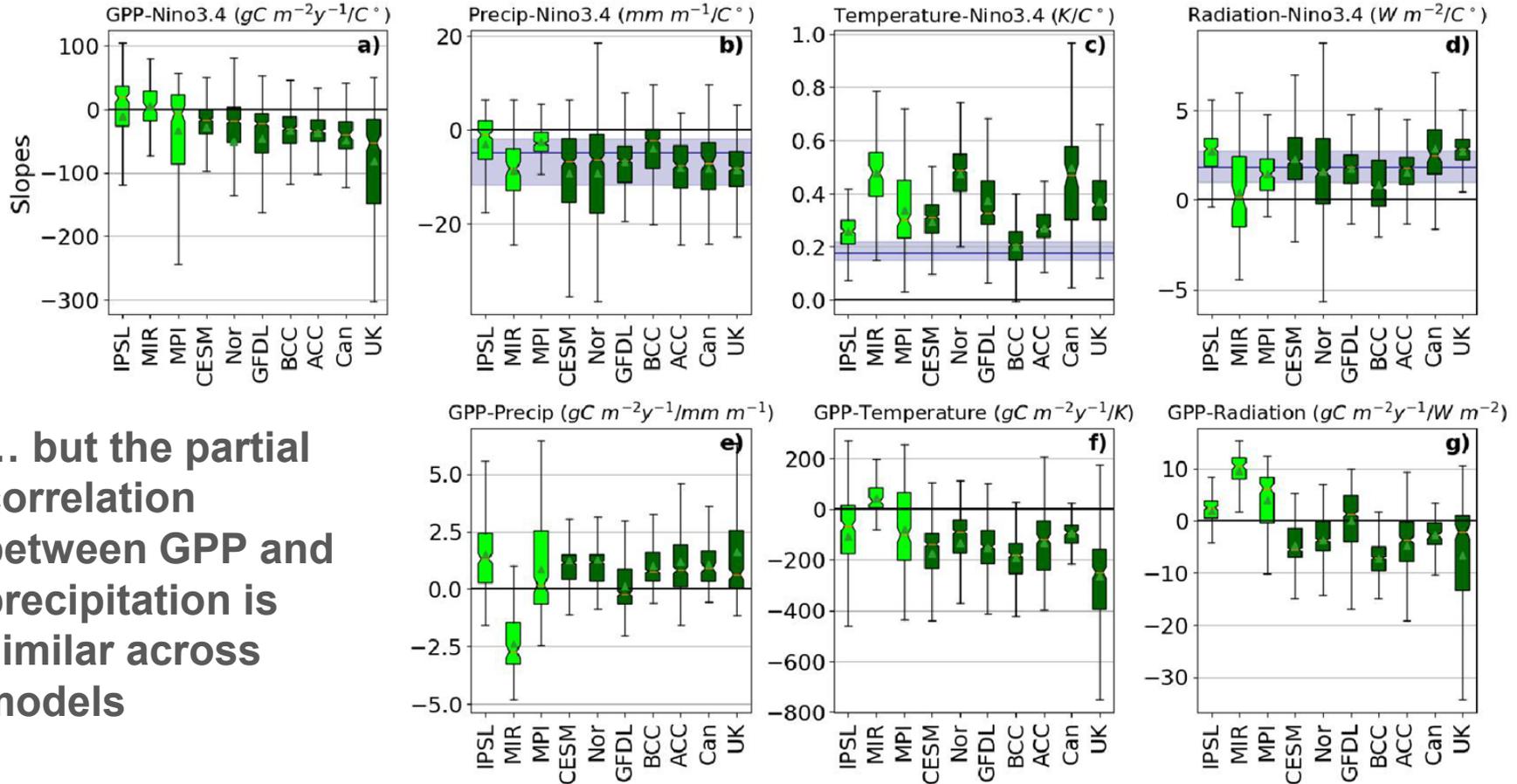
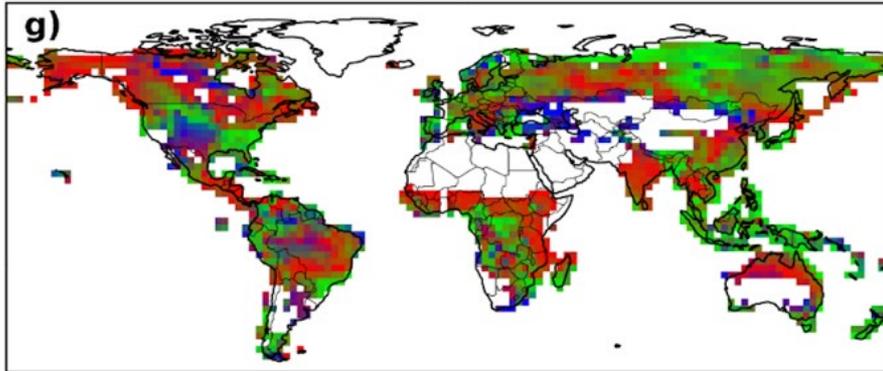… but the partial correlation between GPP and precipitation is similar across models

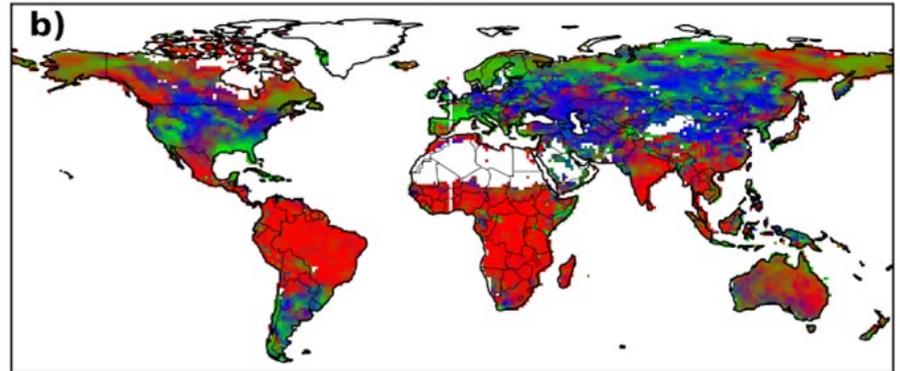# Accounting for covariances among three physical climate drivers reveals distinct spatial patterns

CESM

d)

Temperature
Radiation
Precipitation

MIR

g)

BCC

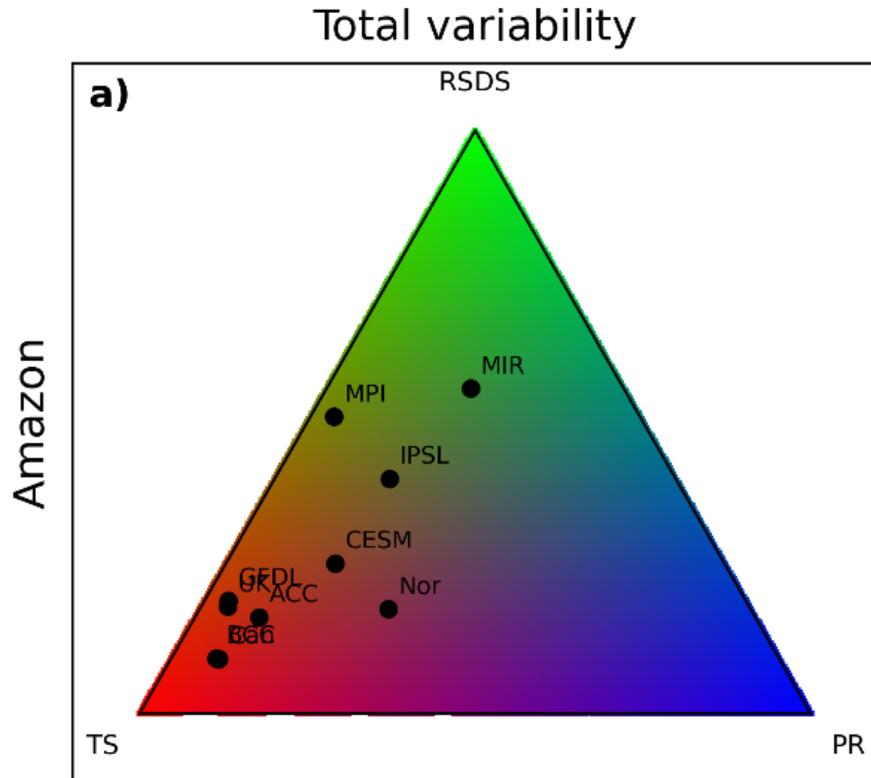b)
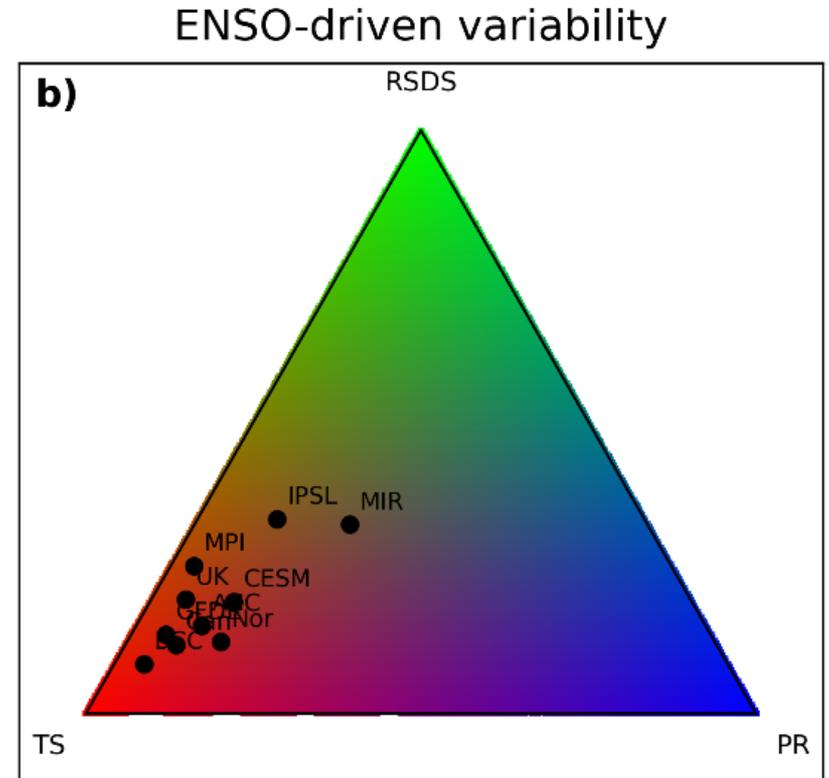
Within the Amazon, most models show that interannual variability is most highly correlated to temperature or radiation, NOT precipitation

When ENSO-driven variability is isolated from total IAV, temperature dominates over radiation impacts
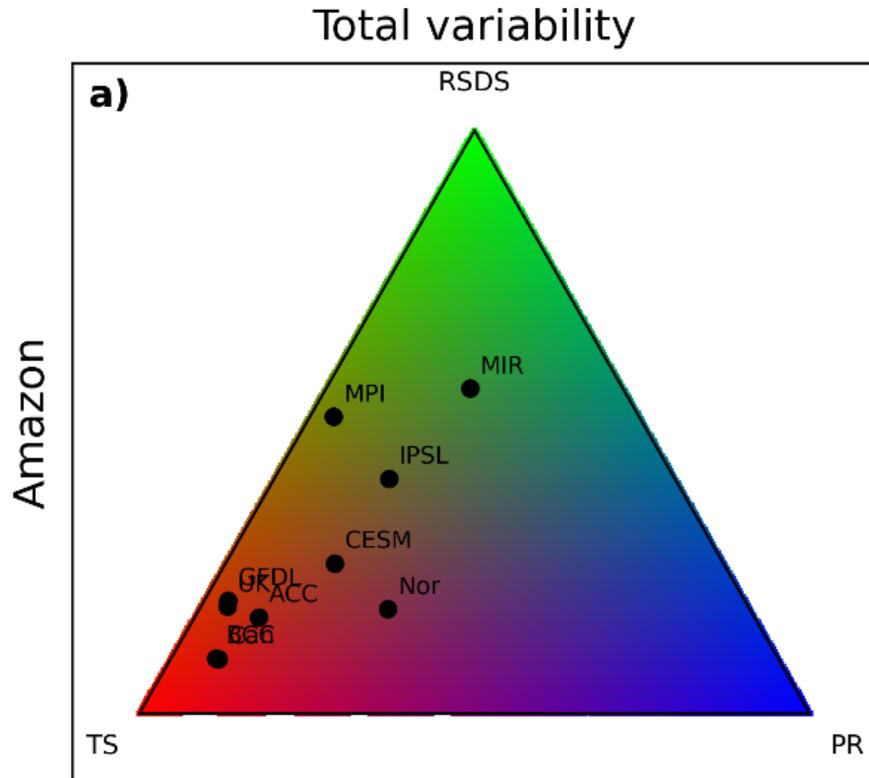
When controlling for regional moisture (relative to the global mean), models with wetter Amazons show a greater impact for radiation

All models show drying during El Niño, which pushes GPP response toward temperature dominance

Total variability

ENSO-driven variability
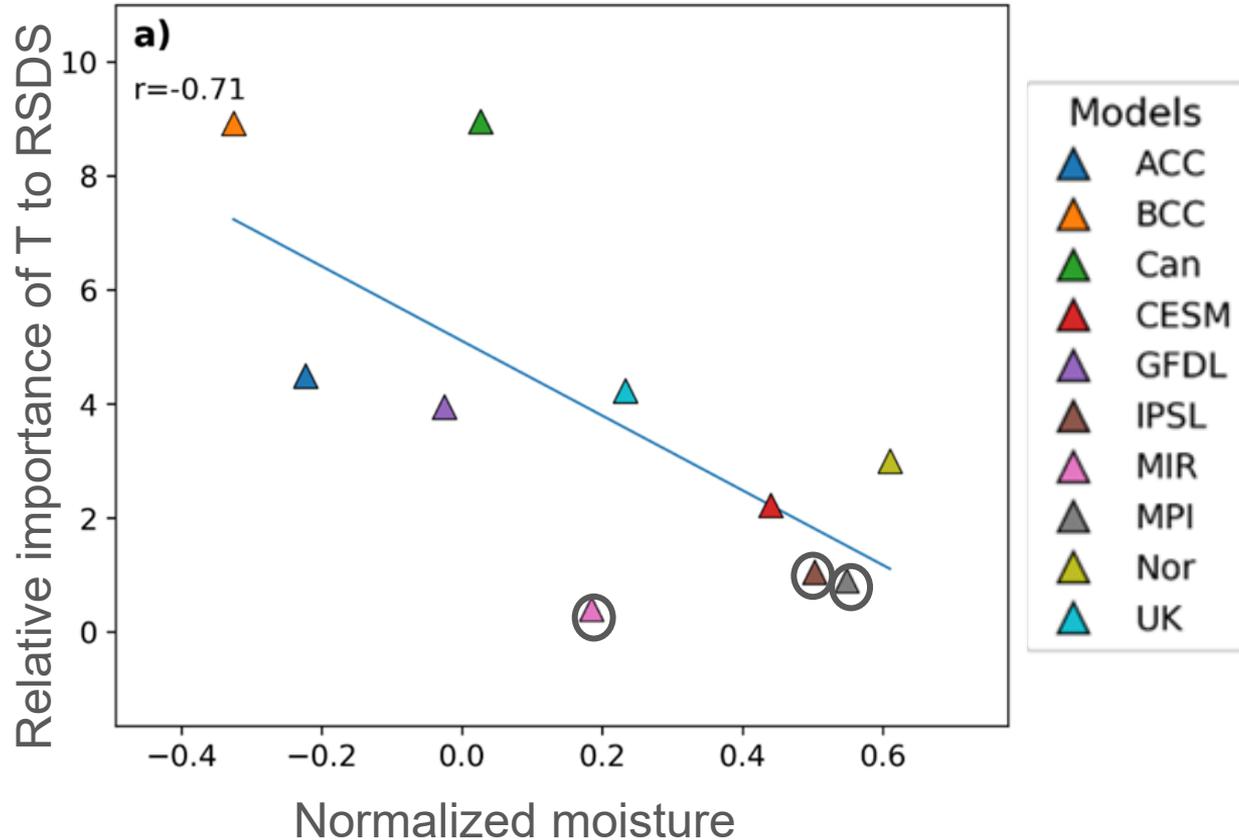
Regional GPP responses to El Niño are driven by a complex interplay between temperature, radiation, and moisture

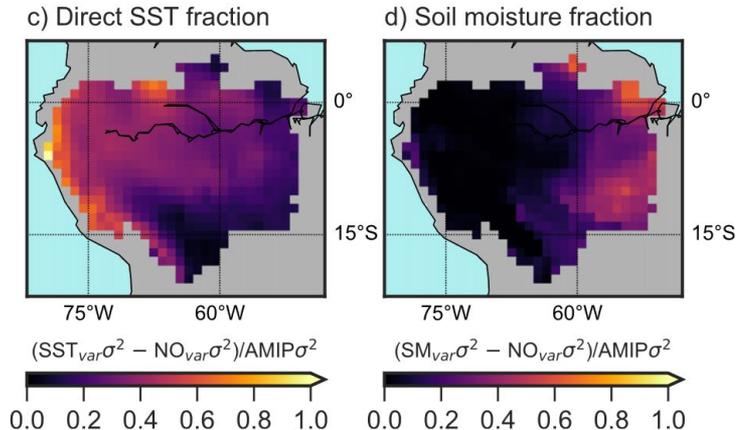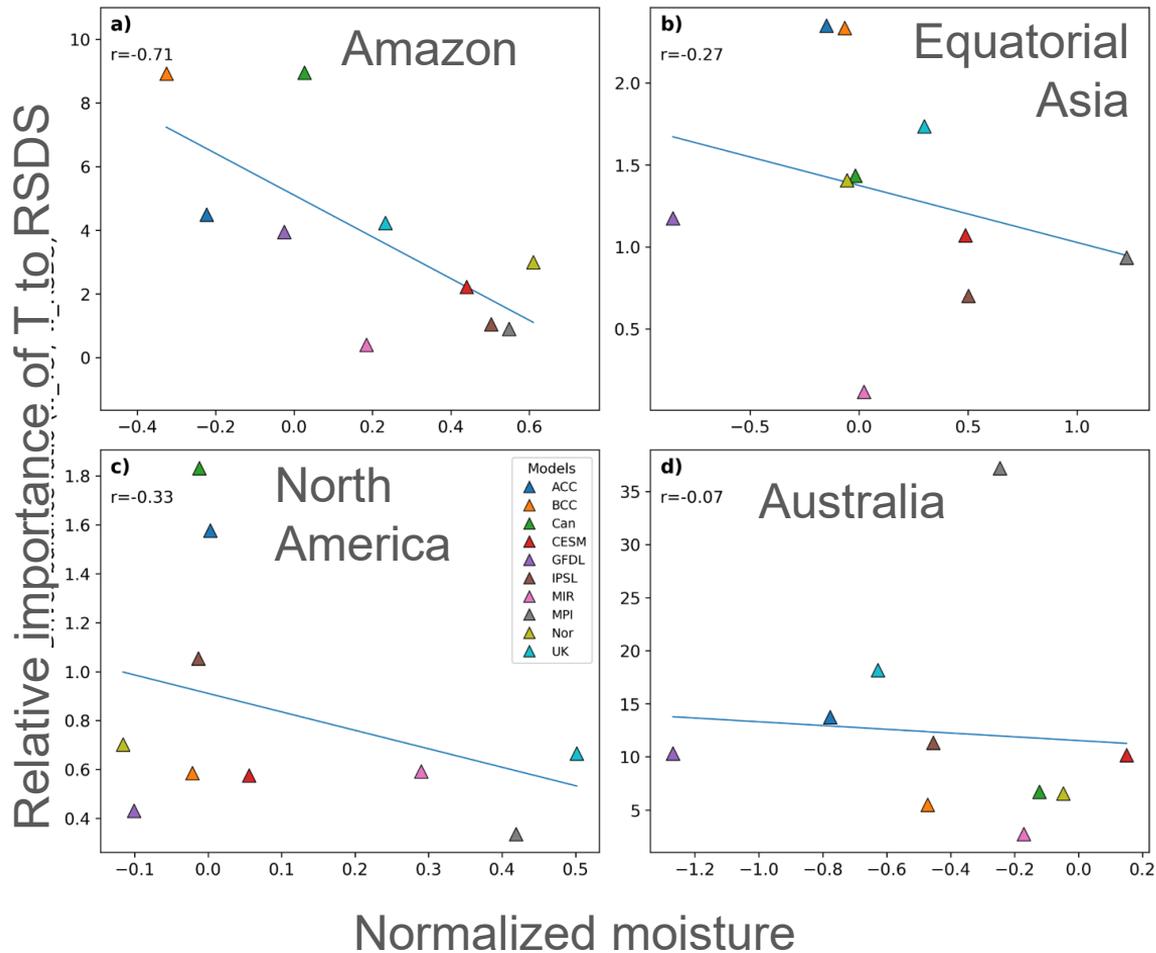**This interplay is a function both of mean climate state and interannual variations thereof: models with wetter Amazons in general show a greater sensitivity to radiation**

In models with dry Amazon, temperature stress can exacerbate existing moisture stress as evaporative cooling further reduces moisture

c) Direct SST fraction

d) Soil moisture fraction

$(SST_{var}\sigma^2 - NO_{var}\sigma^2)/AMIP\sigma^2$

$(SM_{var}\sigma^2 - NO_{var}\sigma^2)/AMIP\sigma^2$

0.0 0.2 0.4 0.6 0.8 1.0

0.0 0.2 0.4 0.6 0.8 1.0

Levine et al., 2019

Preconditioning by mean moisture is not as strong in other regions

Earth system models reveal key regional sensitivities that may be obscured by global correlations with the CO2 growth rate