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Supporting Information for

Disentangling the regional climate impacts of competing vegetation responses to elevated atmospheric CO₂

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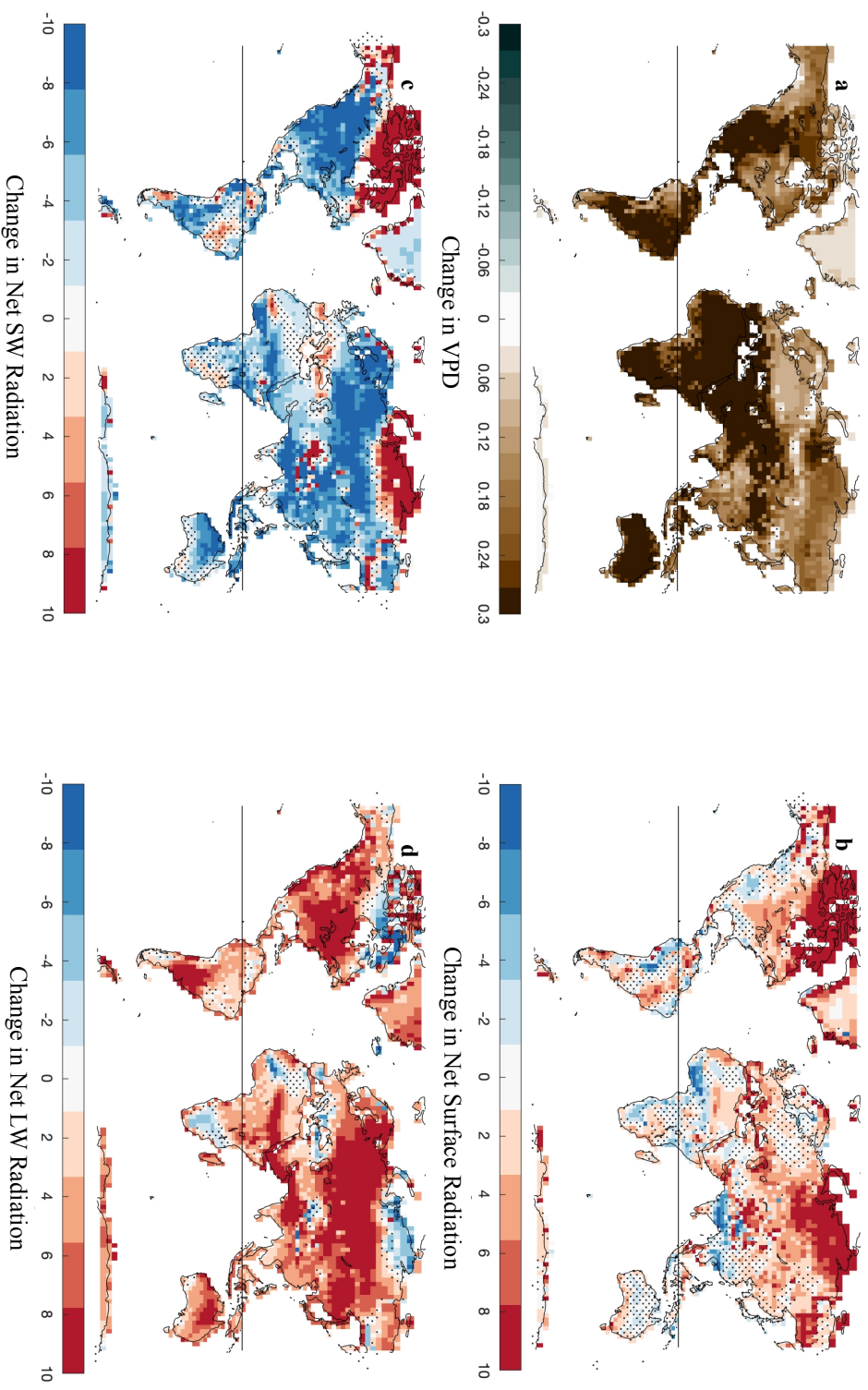
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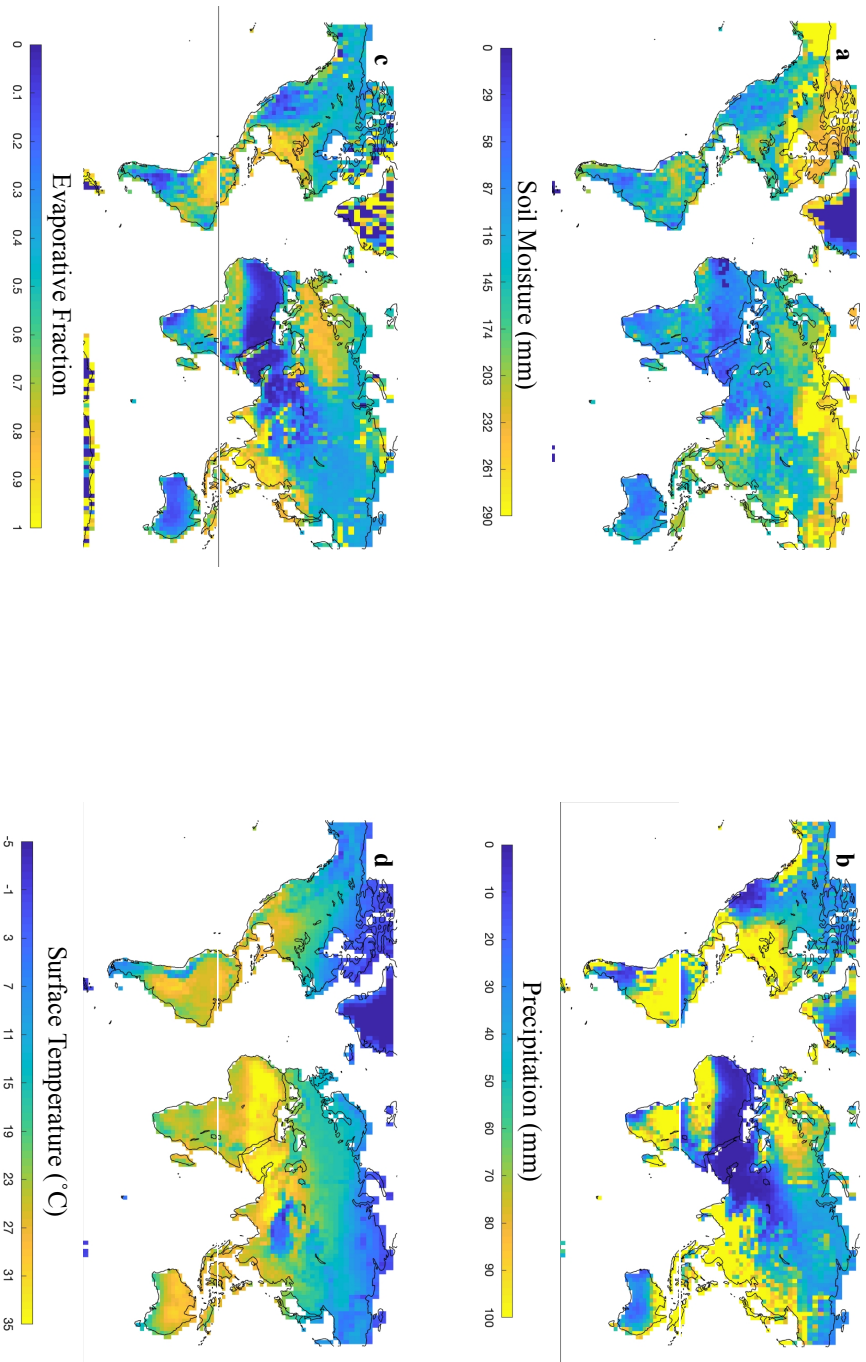
Introduction

The figures herein provide are intended to supplement the analyses provided in McDermid et al., “Disentangling the regional climate impacts of competing vegetation responses to elevated atmospheric CO₂”. These figures were created using the output of idealized sensitivity experiments performed with the NASA GISS ModelE global climate model as described in the Methods section (Section 2) and Tables 1 and 2 in the main manuscript. Unless otherwise specified, all sensitivity testing shown in these supplementary figures was performed using the methods described in Section 2.3 in the main manuscript. Results here are based on ModelE tag modelE_AR5_v2_branch, which is an intermediate version of the GISS ModelE2 and is not

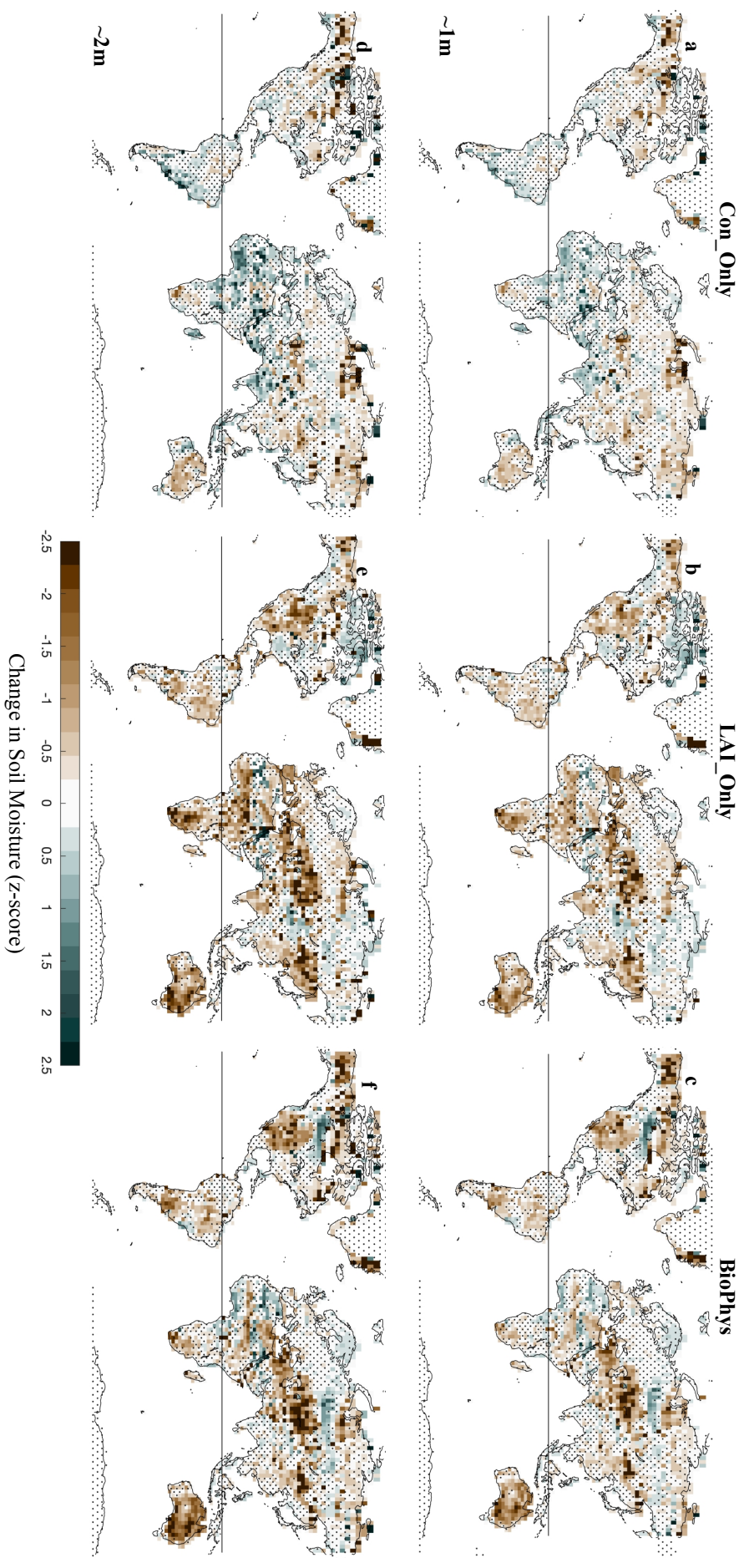
a publicly released version but is available in the developer repository. All the input files and simulation output used in this study are publicly available at:
<https://doi.org/10.5281/zenodo.3662573>



SI Figure 1. Growing season change in a) vapor pressure deficit (kPa), b) net surface radiation (W/m^2), c) net shortwave radiation (W/m^2), and d) net longwave radiation (W/m^2) due to Rad_Only effect. Stippling indicates responses are *not significant* via a Student's t-test ($p < 0.05$, sample size adjusted for autocorrelation where relevant).



SI Figure 2. Baseline growing season a) soil moisture (mm), b) precipitation, c) evaporative fraction, and d) surface temperature (°C)



SI Figure 3. Change in growing season soil moisture (z-score) down to ~1m (Row 1) for (a) Con_Only, (b) LAI_Only, and (c) BioPhys. Row 2 shows the same as Row 1, but for soil moisture changes down to ~2m. Growing season is defined as JJA for the northern hemisphere, and DJF for the southern hemisphere. Stippling indicates responses are *not significant* via a Student's t-test ($p < 0.05$, sample size adjusted for autocorrelation where relevant).

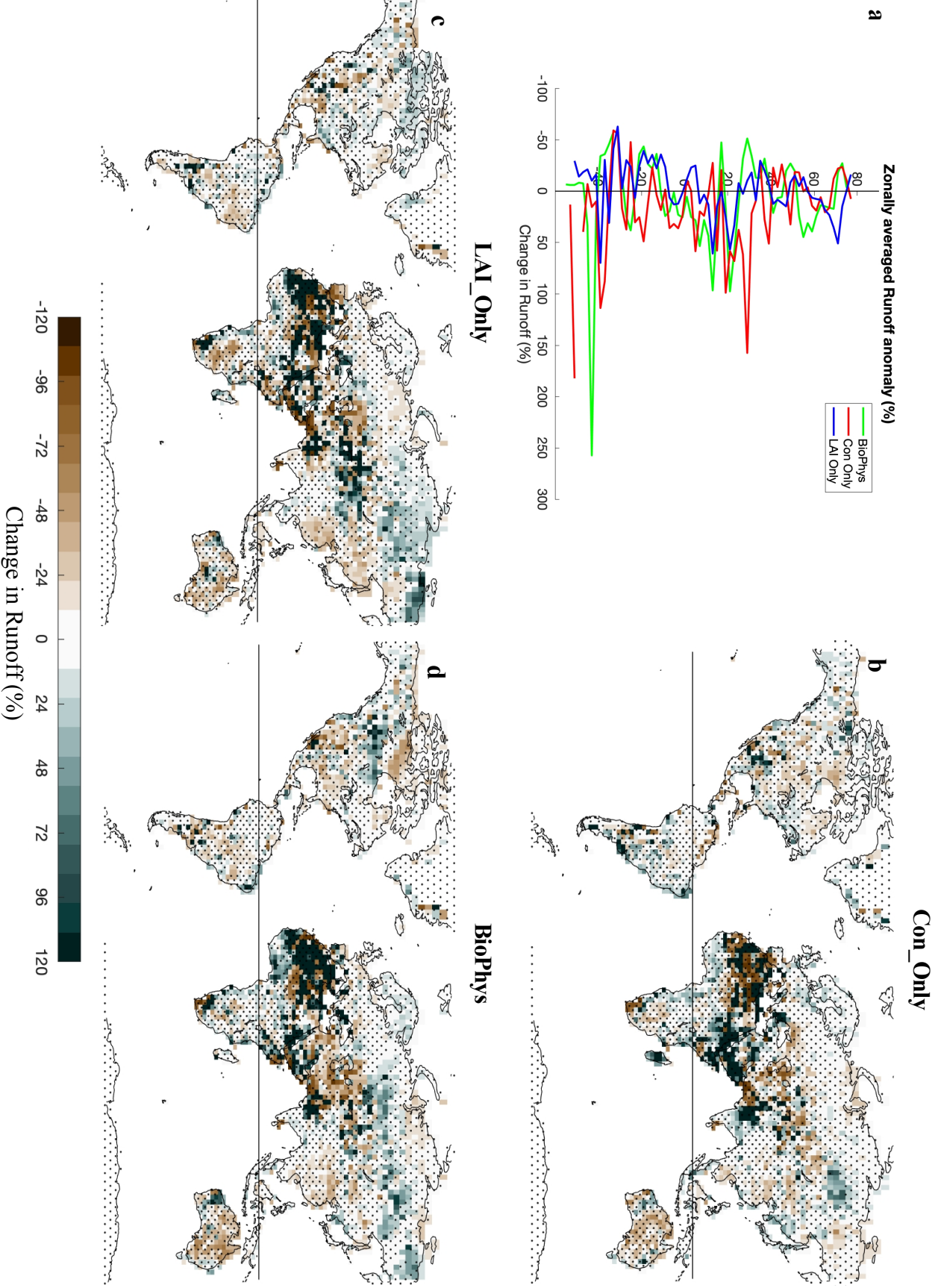
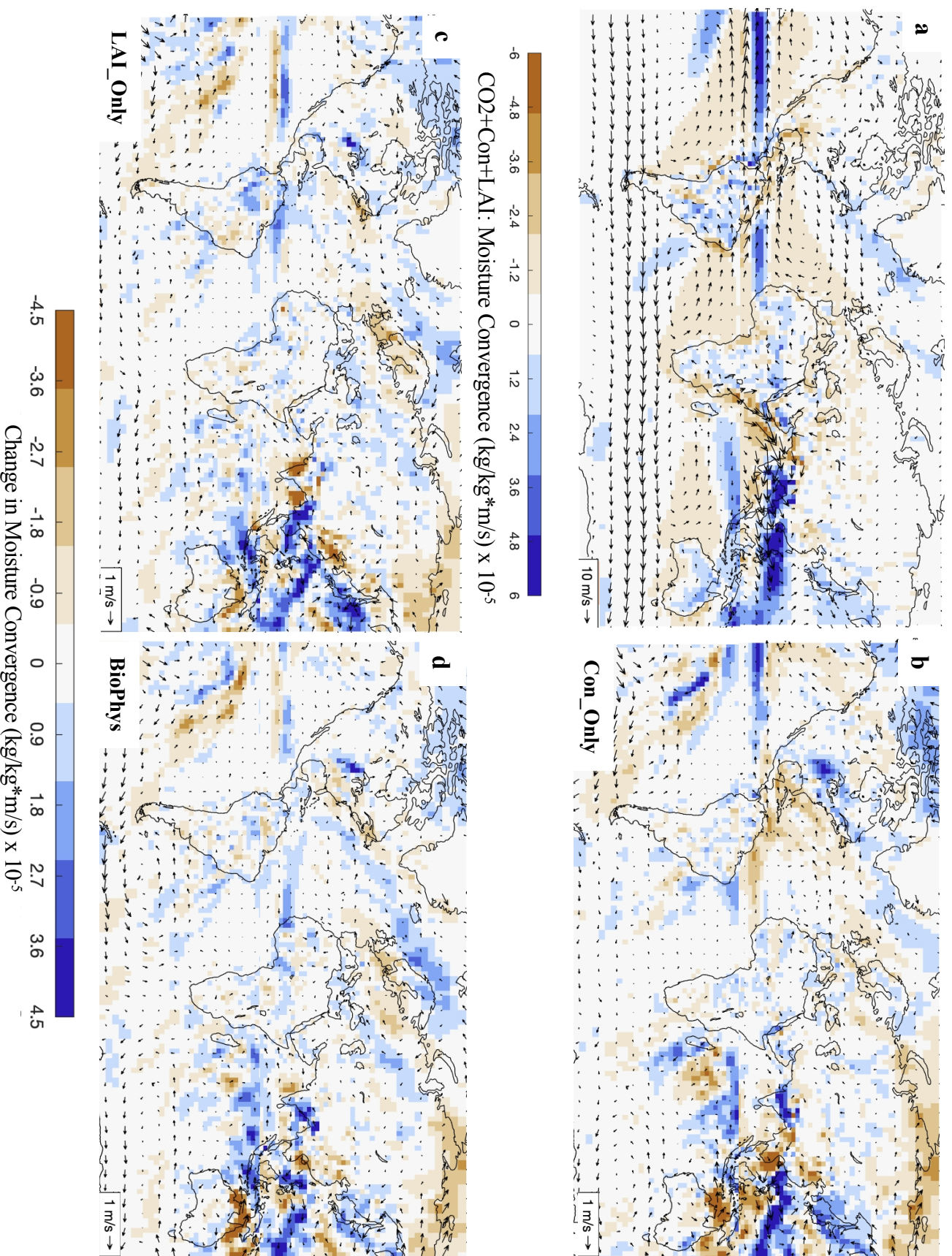
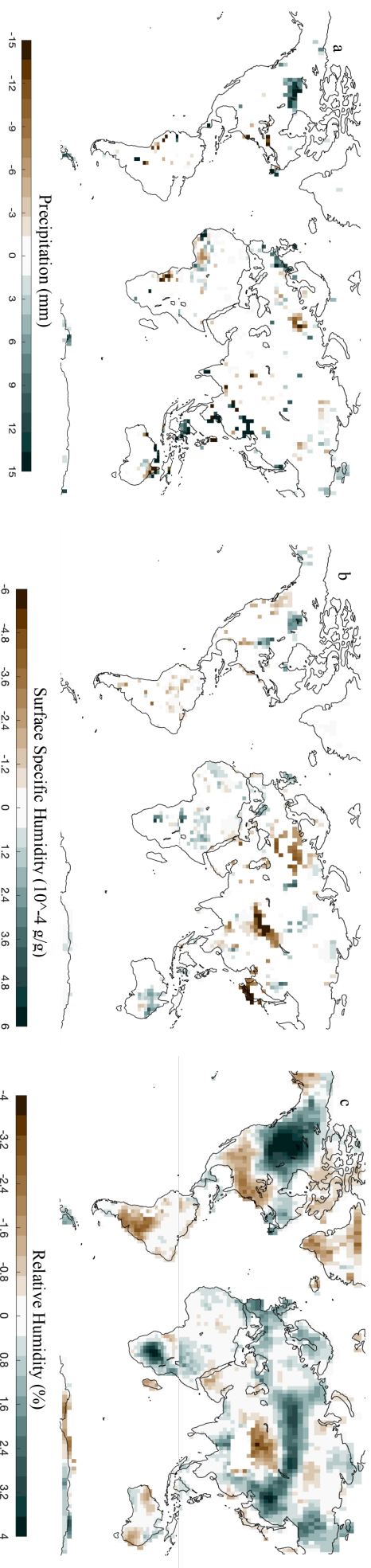


Figure SI 4. Combined under- and overground runoff (% change) for a) zonal averages for each of the vegetation biophysical effects isolated, b) Con_Only, c) LAI_Only and d) BioPhys. Changes shown for growing season in each hemisphere. Stippling indicates responses are *not significant* via a Student's t-test ($p < 0.05$, sample size adjusted for autocorrelation where relevant).

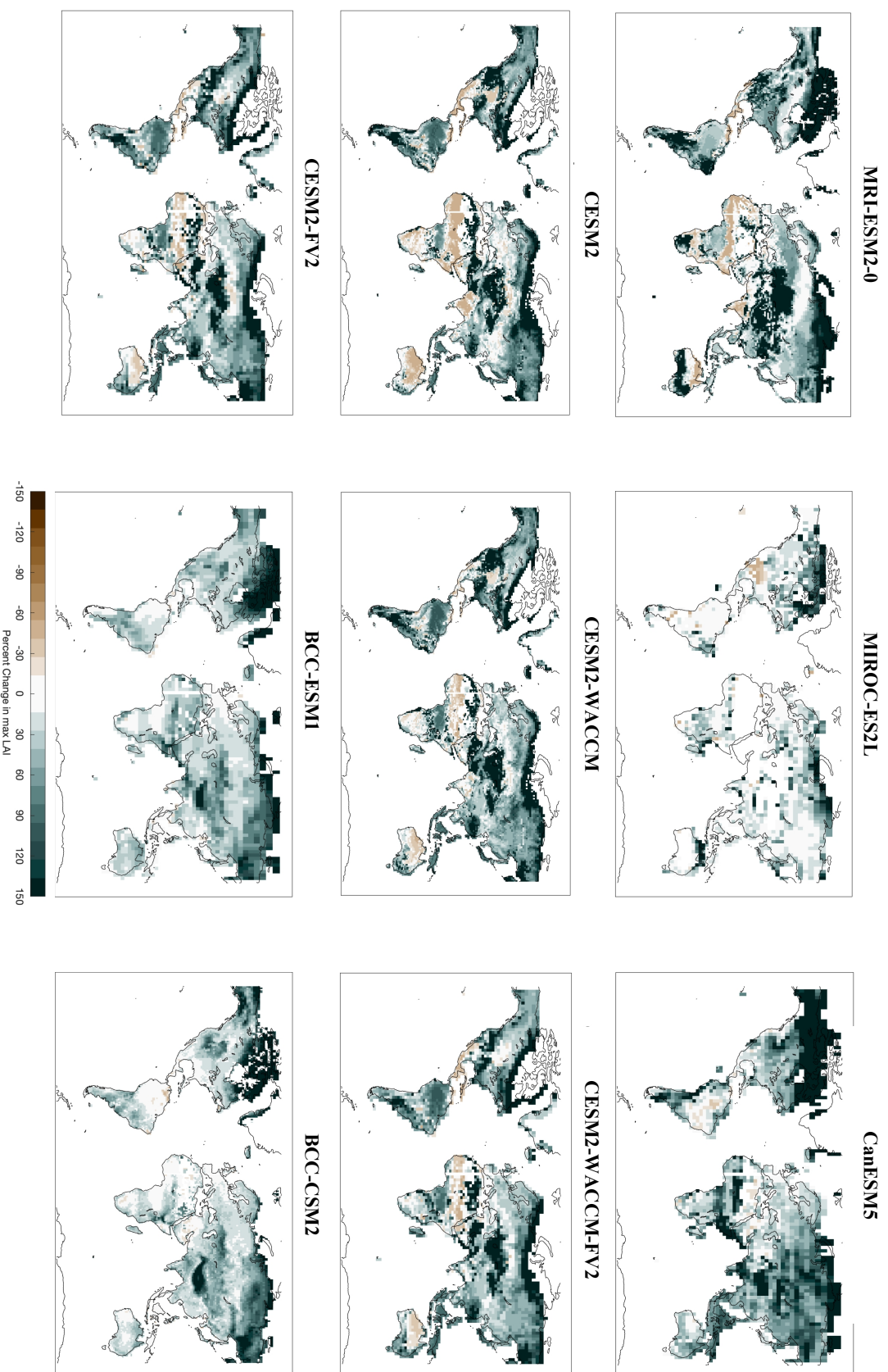
Vertically Integrated Moisture Convergence



SI Figure 5. Vertically integrated moisture convergence from surface to 514 mb for growing season a) the CO2+LAI+Con experiment (see Table 1), and the anomalies resulting from b) the Con_Only effect (see Table 2), c) LAI_Only effect, and d) the BioPhys effect. Shown for hemisphere-respective growing seasons.



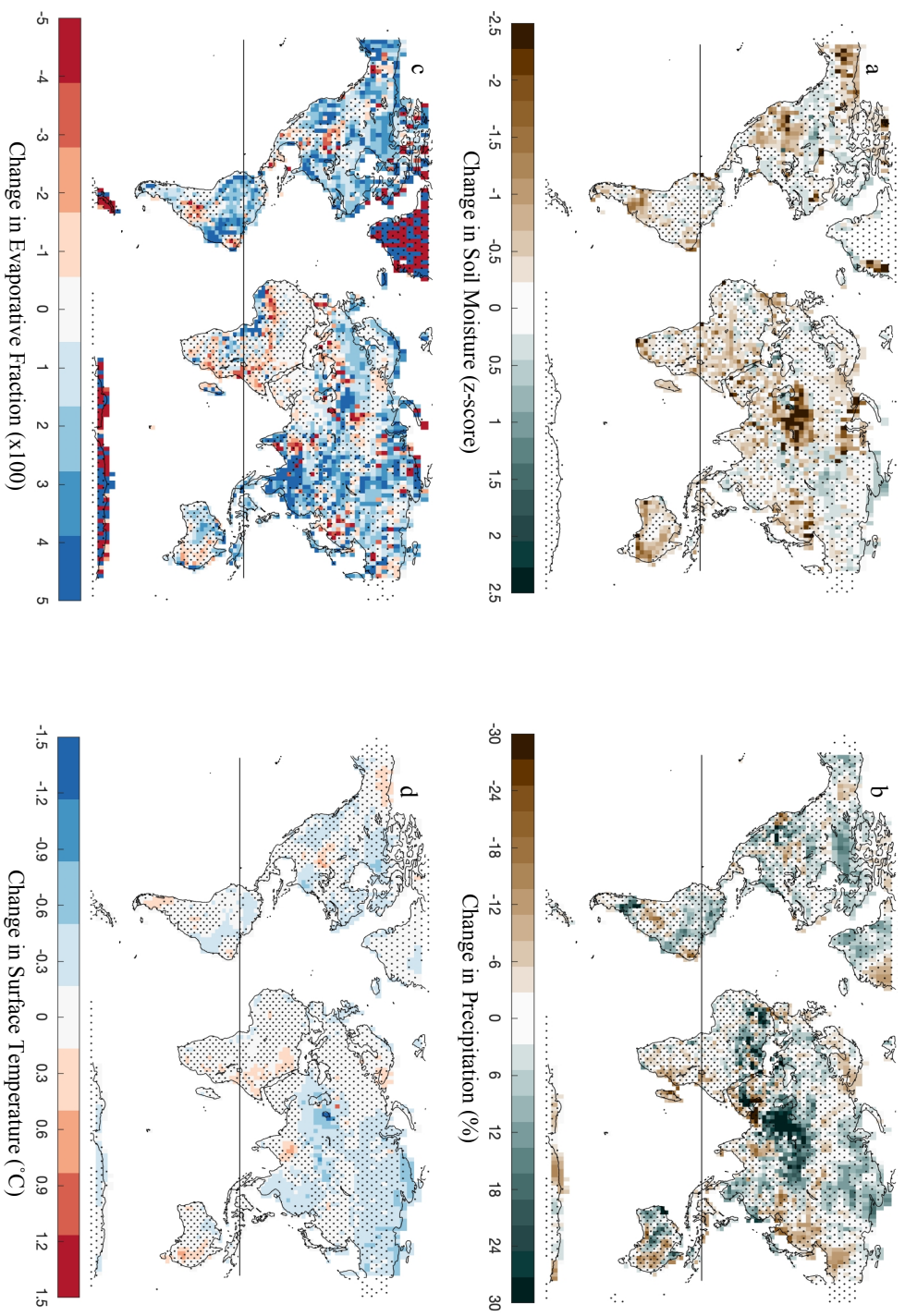
SI Figure 6. The geographic distribution of the nonlinear interaction term, taken as **AlIEffects** – (**RadOnly** + **LAIonly** + **ConOnly**), for a) precipitation, b) surface specific humidity, and c) low level (up to ~700 mb) relative humidity during the growing season



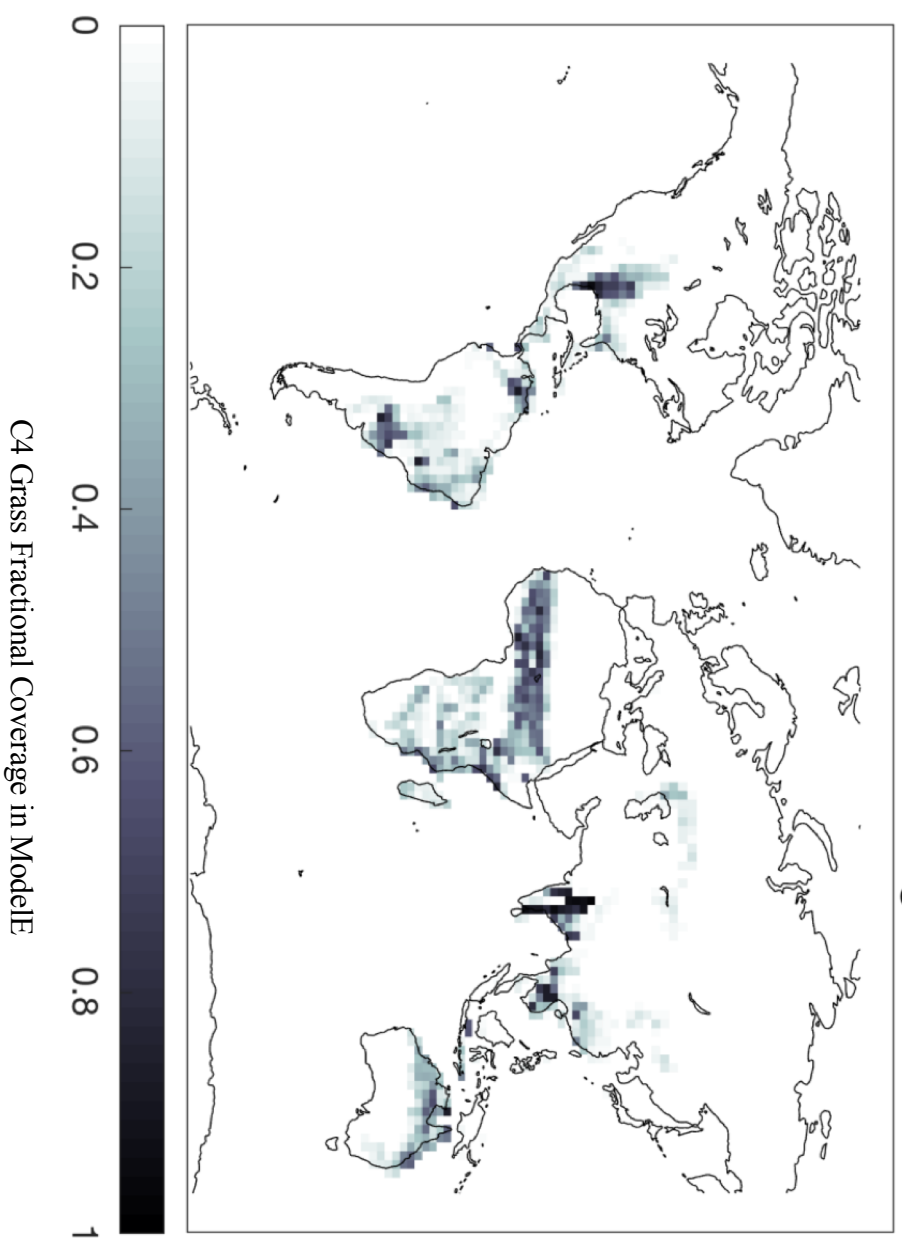
SI Figure 7. Percent change for maximum LAI across 9 CMIP6 models for “pseudo” $2\times\text{CO}_2$ experiment

Description of CMIP6 model responses to “pseudo” 2xCO₂ experiment

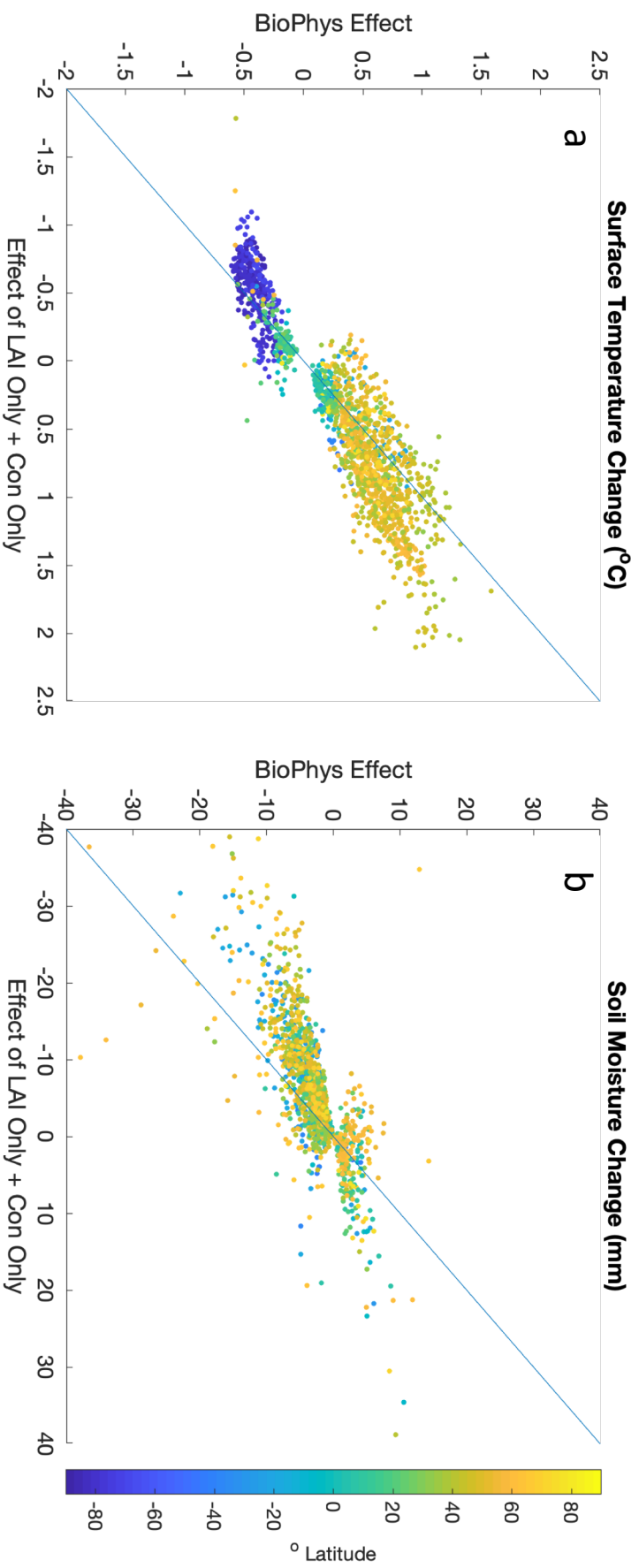
The sign of LAI change is generally consistent across the CMIP6 models used here and is generally positive globally and in regions displaying the strongest responses. Most models show the strongest positive LAI increases across the mid- and high-latitude regions (SI Figure 7). MRI-ESM2-0, MIROC-ES2L and the various CESM-based models also show small but significant LAI declines at lower latitudes, which are not accounted for in our idealized 50% increase model experiments. MIROC-ES2L shows the weakest responses globally, and its strongest increases occur at very high latitudes. In contrast, the largest responses, both positive and negative, exist in the MRI-ESM2-0 and CESM-based models (SI Figure 7). Regionally, however, some distinctions arise between these models' responses, particularly across the lower latitudes. For example, most models show LAI increases over the Amazon, which range widely from ~30% to upwards of 100%. In contrast, MIROC-ES2L and BCC-CSM2 show no significant changes while CanESM5 also displays grid cells with small declines. In the US Southwest, the responses are also more mixed: MRI-ESM2-0, BCC-ESM1, and CanESM5 all display moderate to strong increases in LAI, while MIROC-ES2L and the various CESM model configurations show varying extents of LAI decline. These declines extend into Central America in the CESM models, where they are also interspersed with grid cells of strong LAI increases. In further contrast to other models, the CESM models and MRI-ESM2-0 also produce moderate LAI declines across Sahelian Africa. There are similar mixed results in Australia. MRI-ESM2-0 and the CESM group of models show varying extents of LAI decline across northern and central Australia, respectively, while also producing strong LAI increases in the southeast. CanESM5, BCC-ESM1, and BCC-CSM2 however all display smaller to moderate LAI increases across much of central and eastern Australia with no significant declines. MIROC-ES2L produces the



SI Figure 8. 50-year climatological growing-season anomalies for: a) soil moisture (z-score); b) precipitation (% change); c) evaporative fraction (x100); d) surface air temperature ($^{\circ}\text{C}$). Anomalies shown for LAI. Only responses, where LAI has been prescribed per the “pseudo” $2\times\text{CO}_2$ experiment based on a CMIP6 ensemble. Northern hemisphere shown for JJA; southern hemisphere shown for DJF. Stippling indicates responses are *not significant* via a Student's t-test ($p < 0.05$, sample size adjusted for autocorrelation where relevant).



SI Figure 9. Fractional (0-1) coverage per gridcell of C₄ grass used in model E.



SI Figure 10. The BioPhys effect vs the combined, linearly added LAI_Only + Con_Only effect for a) surface temperature ($^{\circ}\text{C}$), and b) soil moisture (mm, down to 57 cm). A perfect correspondence between the BioPhys response and LAI_Only + Con_Only response would fall on the 1:1 line shown on the figures.