Supplementary Information of

Stomatal responses of terrestrial plants to global change

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Table S1 | Global environmental change sensitivity of stomatal conductance across plant functional types. The weighted mean sensitivities (means [–95%CI, +95%CI]) under eCO_2 (% + 100 ppm^{-1}), eT (% + 1 $°C^{-1}$) , iP (% + 10%$^{-1}$) , dP (% – 10%$^{-1}$), eN (% + 1 g^{-1} m^{-2} yr^{-1}), and eO_3 (% + 10 ppb^{-1}) are reported. Sensitivities significantly different from zero at $P < 0.05$ are shown in bold, and the numbers of species (observation) are shown in italic. Q_B: between-group heterogeneity, significant Q_B at $P < 0.05$ are shown in bold and indicate that the sensitivities differ among plant functional types. eCO_2: elevated CO_2 concentration, eT: elevated temperature, iP/dP: increased/decreased precipitation, eN: elevated nitrogen deposition, and eO_3: elevated O_3 concentration.

Plant functional type	eCO2	eT	iP	dP	eN	eO3
Conifer	**–3.6 [–6.4, –0.7]**	–2.6 [–5.3, 0.3]	5.5 [–0.1, 11.3]	**–3.7 [–5.7, –1.6]**	**1.2 [0.1, 2.3]**	**–2.4 [–4.3, –0.6]**
	26(141),P=0.015	*24(81),P=0.078*	*5(10),P=0.052*	*10(86),P<0.001*	*16(63),P=0.027*	*15(126),P=0.010*
Deciduous broadleaf	**–7.1 [–9.2, –5.0]**	–2.7 [–5.5, 0.2]	2.0 [–2.8, 7.0]	**–3.4 [–6.6, -0.0]**	–0.1 [–0.8, 0.5]	–1.3 [–2.7, 0.2]
	66(406) ,P<0.001	*22(91),P=0.069*	*4(20),P=0.43*	*15(75),P=0.047*	*26(96),P=0.70*	*52(461),P=0.089*
Evergreen broadleaf	**–10.3 [–12.8, –7.7]**	–0.4 [–2.5, 1.6]	–3.6 [–7.7, 0.7]	**–4.8 [–7.6, –1.8]**	**1.7 [1.0, 2.3]**	**–2.1 [–3.9, –0.2]**
	47(114),P<0.001	*20(64),P=0.69*	*3(9),P=0.10*	*19(40),P=0.002*	*21(66),P<0.001*	*26(75),P=0.030*
Shrub	**–7.2 [–12.5, –1.6]**	1.3 [–0.8, 3.5]	**3.4 [0.8, 6.1]**	–1.6 [–3.7, 0.6]	0.9 [–0.4, 2.3]	–2.9 [–6.8, 1.2]
	17(161),P=0.013	*10(70),P=0.21*	*6(53),P=0.011*	*7(30),P=0.14*	*12(39),P=0.17*	*5(6),P=0.17*
C3 grass	**–10.4 [–13.0, –7.8]**	–0.1 [–1.7, 1.5]	3.1 [–5.8, 12.9]	**–3.8 [–6.0, –1.5]**	**1.4 [0.7, 2.2]**	**–3.1 [–5.8, –0.3]**
	35(267),P<0.001	*13(183),P=0.87*	*2(2),P=0.51*	*6(21),P=0.001*	*9(54),P<0.001*	*10(49),P=0.029*
C4 grass	**–8.8 [–13.8, –3.5]**	–1.3 [–4.0, 1.5]	0.9 [–6.6, 8.9]		**1.5 [0.3, 2.2]**	0.7 [–4.1, 5.7]
	17(56),P=0.001	*4(22),P=0.36*	*2(5),P=0.82*		*8(23),P=0.012*	*3(6),P=0.77*
Legume forb	**–11.3 [–14.1, –8.4]**	0.4 [–4.7, 5.8]	/	**–4.7 [–8.0, –1.2]**	0.4 [–1.9, 2.9]	–3.2 [–7.0, 0.8]
	18(109),P<0.001	*4(15),P=0.88*		*4(4),P=0.009*	*7(7),P=0.72*	*4(4),P=0.12*
Nonlegume forb	**–8.7 [–12.8, –4.5]**	**–1.9 [–3.4, –0.4]**	2.1 [–7.2, 12.4]	–2.6 [–5.4, 0.2]	0.3 [–1.8, 2.4]	–1.7 [–5.1, 1.8]
	36(97),P<0.001	*22(78),P=0.015*	*2(2),P=0.67*	*5(16),P=0.073*	*14(53),P=0.80*	*6(16),P=0.34*
Q_B	**21.8**	10.2	9.1	5.4	**18.9**	3.6
P	**0.003**	0.18	0.17	0.61	**0.008**	0.82

Table S2 | Source of spatial data of future changes in environmental factors

Factors	Sources	Models	Future scenarios
Atmospheric CO_2 concentration	Mauna Loa Observatory SSP Database		SSP1-2.6 SSP2-4.5 SSP5-8.5
Atmospheric temperature Precipitation	Worldclim v2.1	BCC-CSM2-MR CNRM-CM6-1 CNRM-ESM2-1 CanESM5 IPSL-CM6A-LR MIROC-ES2L MIROC6 MRI-ESM2-0	SSP1-2.6 SSP2-4.5 SSP5-8.5
Atmospheric N deposition	CMIP6 datasets	CESM2-WACCM MIROC-ES2L CMCC-ESM2 CMCC-CM2-SR5 MPI-ESM1-2-LR EC-Earth3-Veg ACCESS-ESM1-5	SSP1-2.6 SSP2-4.5 SSP5-8.5
Ground-level O_3 concentration	Sicard *et al*., 2017	CESM-CAM GFDL-AM3 GISS-ES2-R MIROC-CHEM MOCAGE UM-CAM	RCP2.6 RCP4.5 RCP8.5

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Sicard P, Anav A, De Marco A, Paoletti E. Projected global ground-level ozone impacts on vegetation under different emission and climate scenarios. *Atmos. Chem. Phys.* **17**, 12177-12196 (2017).

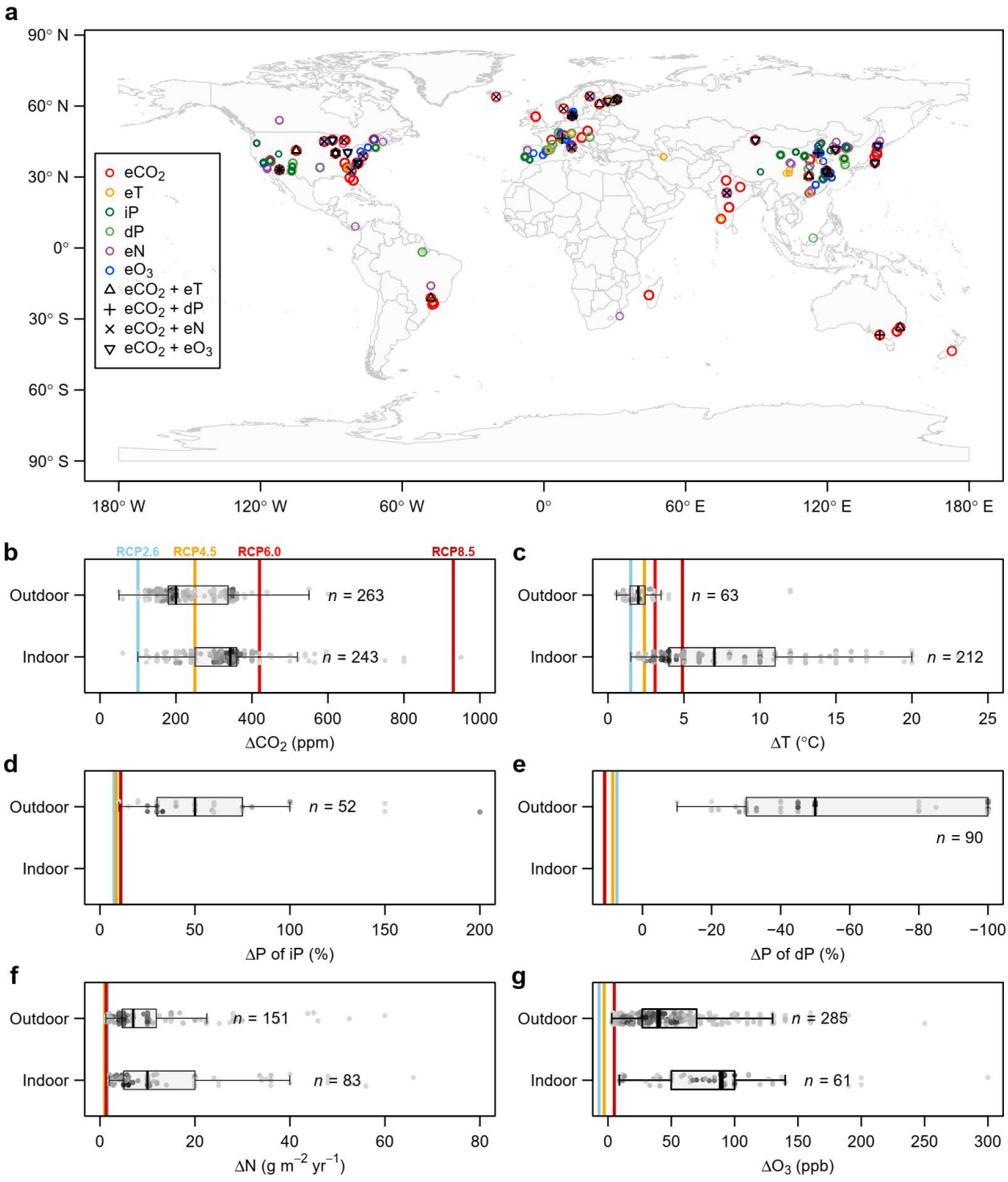

Figure S1 | Global distribution of study sites included in this meta-analysis and the magnitudes of experiments against model projections. a, The global distribution of study sites of single- and combined factor experiments, only outdoor experiments are shown. **b,** The increases in atmospheric CO_2 concentrations manipulated by eCO2 experiments and projected in all IPCC Representative Concentration Pathways (RCPs). **c,** The increases of Earth's land surface temperature manipulated by

eT experiments and projected in all RCPs. **d-e,** The changes in precipitation manipulated by precipitation experiments and projected in all RCPs. **f,** The changes in atmospheric nitrogen deposition manipulated by eN experiments and projected in different RCPs. **g,** The changes in atmospheric O_3 concentrations of eO_3 experiments and projected in different RCPs. In the box plots **b-g**, the centre line represents the median, the edges of the box indicate the 25th and 75th percentiles, and the whiskers indicate 1.5 × IQR (the interquartile range between the 25th and 75th percentiles).

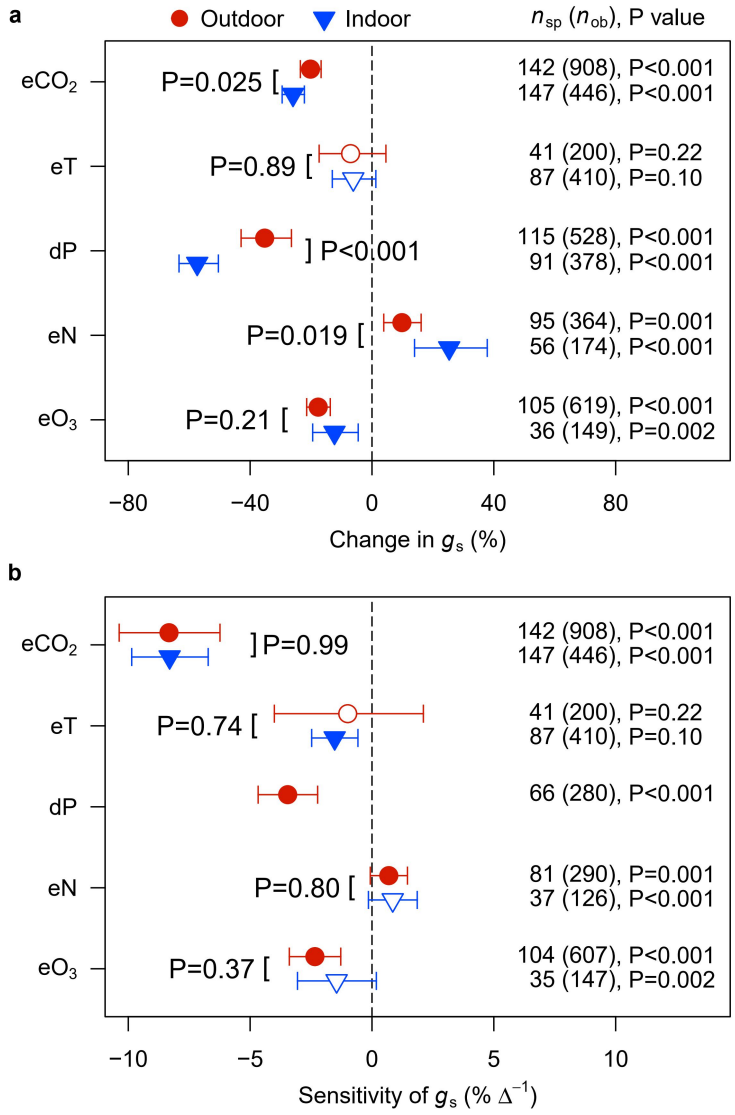

Figure S2 | Responses of g_s to global change factors in the outdoor against indoor experiments. **a,** The overall changes of g_s in response to global change factors. **b,** The g_s sensitivities in response to global change factors. The error bars represent the 95% confidence interval of the weighted means. Open and filled symbols represent insignificant ($P > 0.05$) and significant ($P < 0.05$) differences between the g_s response and zero, respectively. P values near the error bars indicate statistic significant levels for comparisons between indoor and outdoor groups. The numbers outside and inside parentheses represent the number of species (n_{sp}) and observations (n_{ob}), respectively.

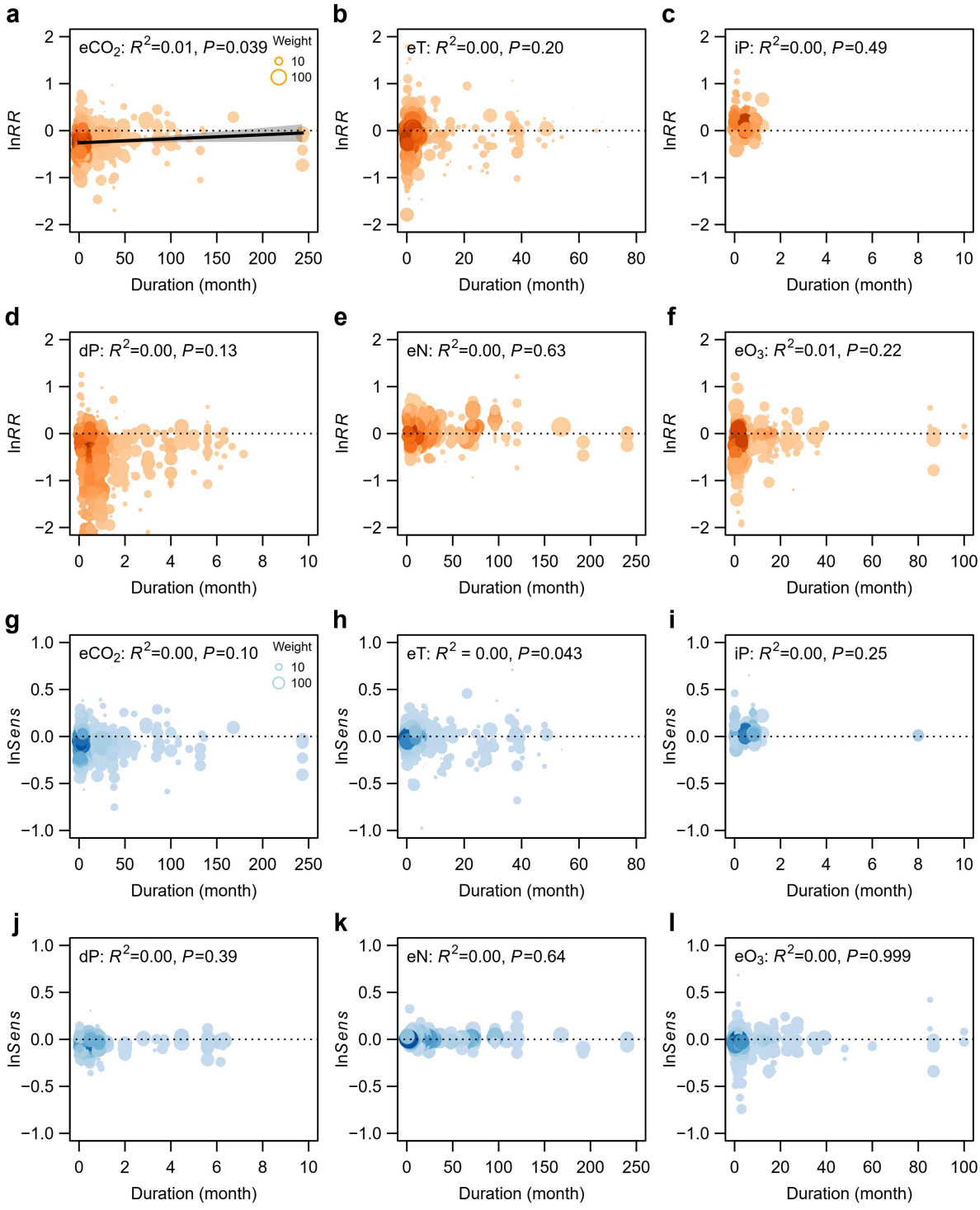

Figure S3 | Stomatal responses to global change factors in relation to experimental duration. ln*RR* and ln*Sens* represent natural log-transformed response ratio and sensitivity, respectively. The size of each point represents the adjusted weight of each data point, and the darker the color means the higher the point density. The error bands surrounding the regression lines represent the 95% confidence interval.

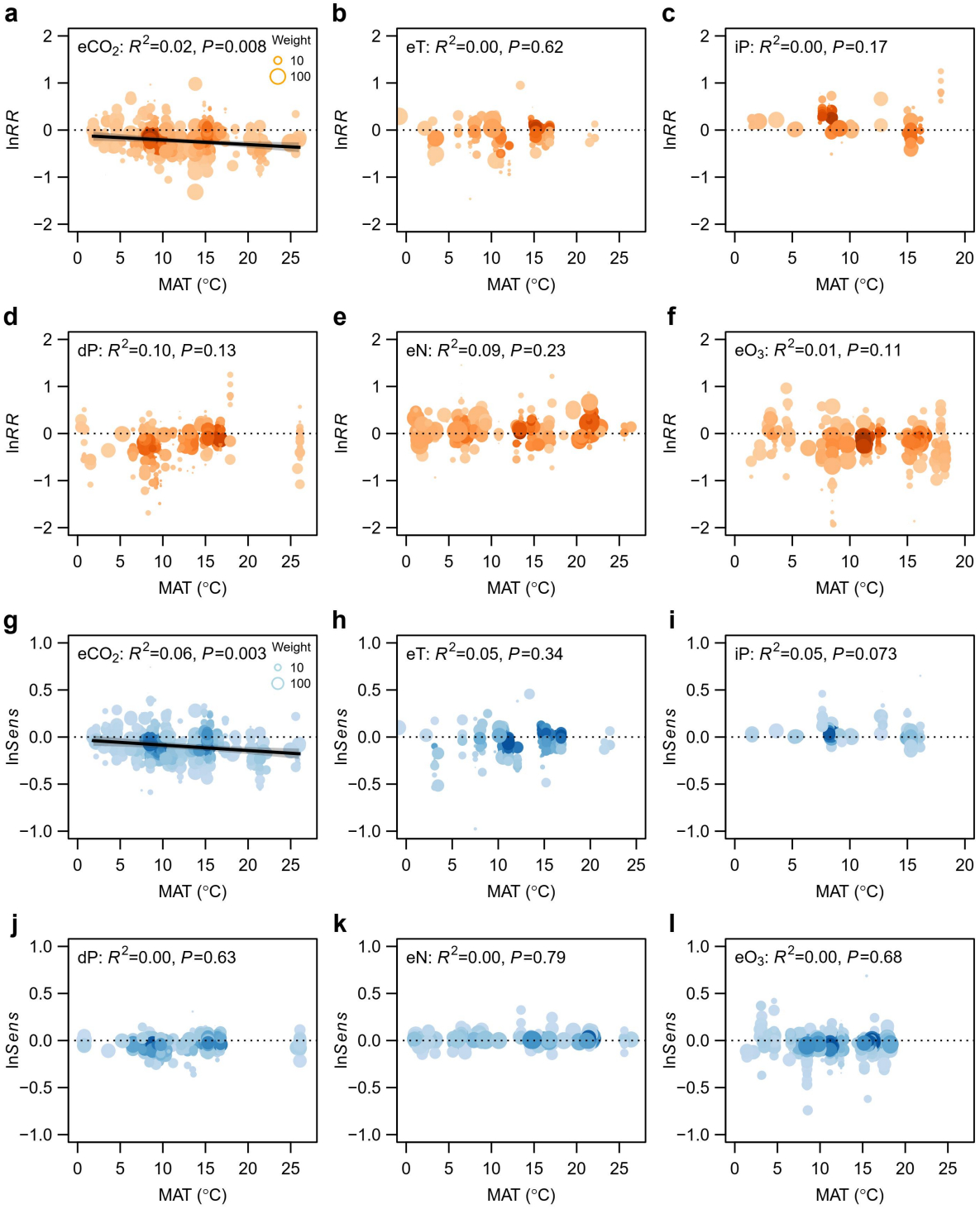

Figure S4 | Stomatal responses to global change factors in relation to mean annual temperature (MAT). ln*RR* and ln*Sens* represent natural log-transformed response ratio and sensitivity, respectively. The size of each point represents the adjusted weight of each data point, and the darker the color means the higher the point density. The error bands surrounding the regression lines represent the 95% confidence interval.

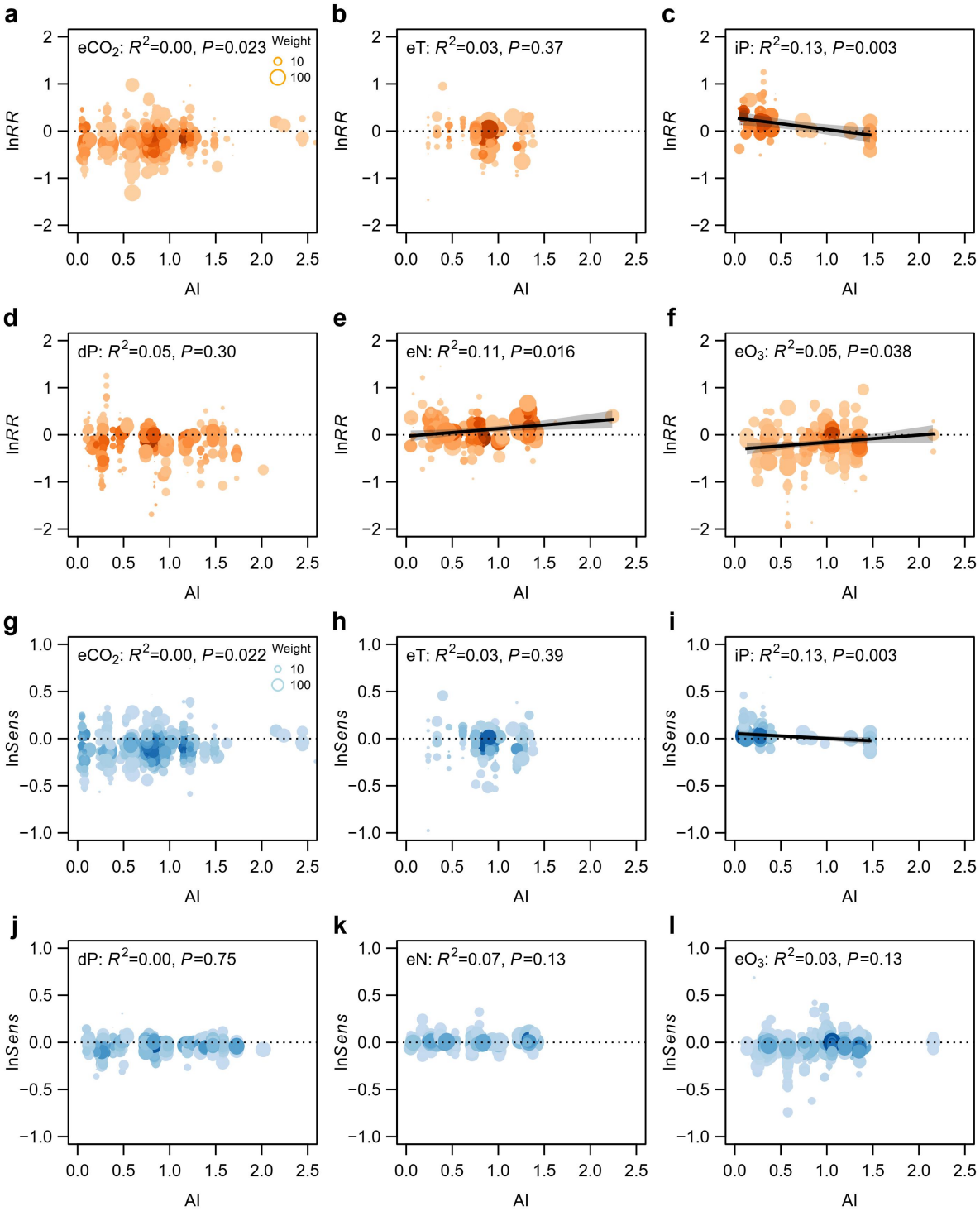

Figure S5 | Stomatal responses to global change factors in relation to aridity index (AI). ln*RR* and ln*Sens* represent natural log-transformed response ratio and sensitivity, respectively. The size of each point represents the adjusted weight of each data point, and the darker the color means the higher the point density. The error bands surrounding the regression lines represent the 95% confidence interval.

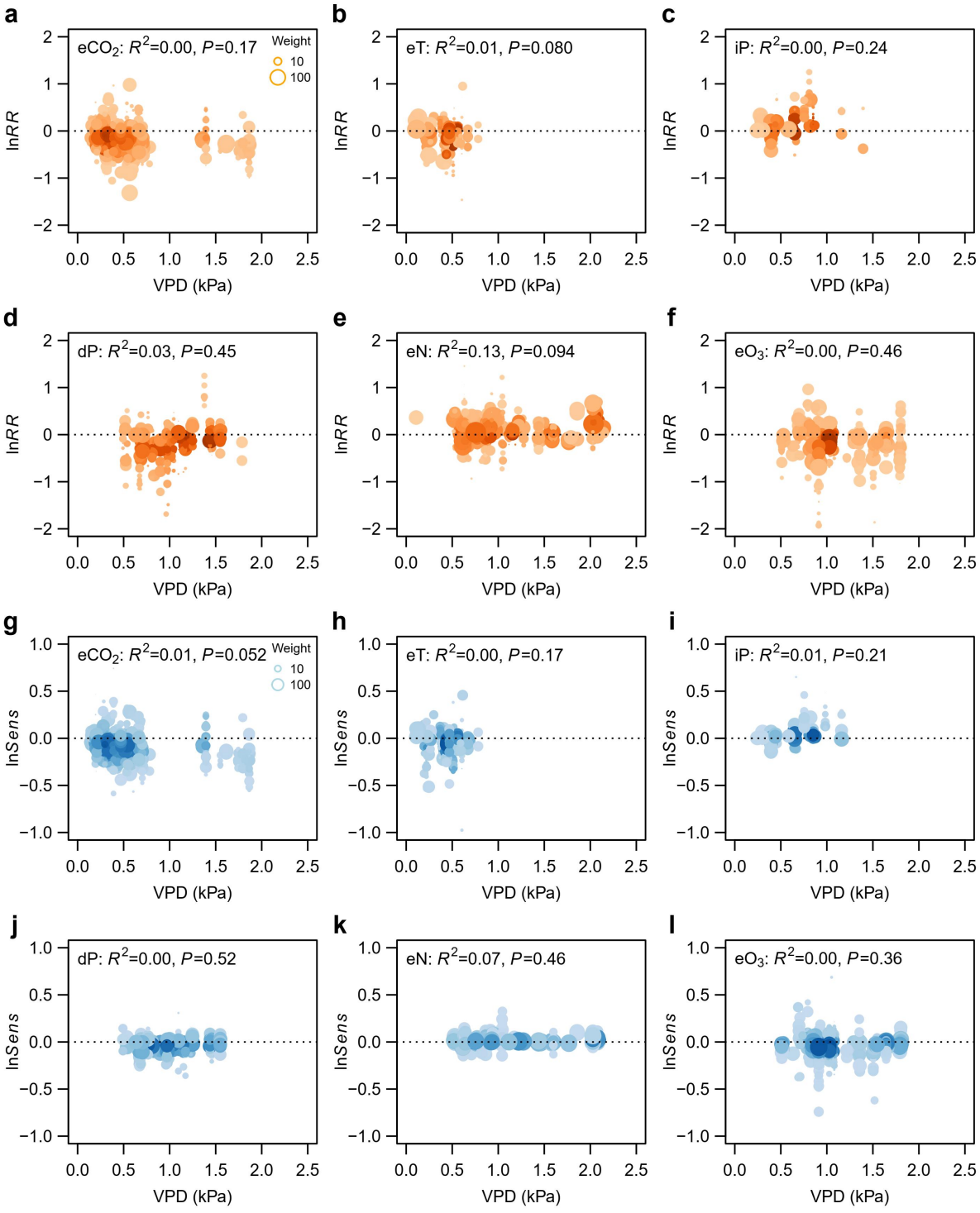

Figure S6 | Stomatal responses to global change factors in relation to vapor pressure difference (VPD). ln*RR* and ln*Sens* represent natural log-transformed response ratio and sensitivity, respectively. The size of each point represents the adjusted weight of each data point, and the darker the color means the higher the point density.

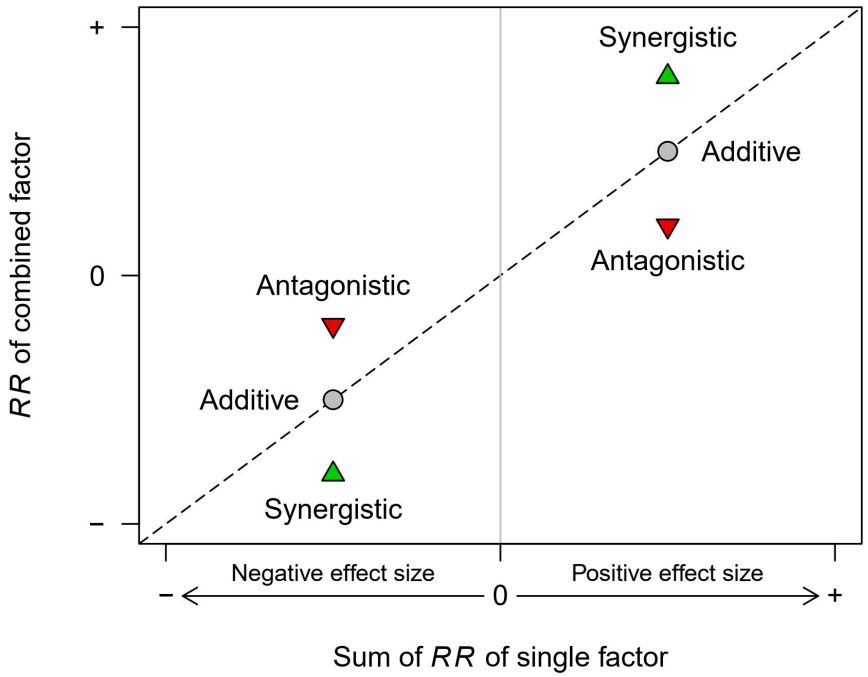

Figure S7 | The location of points that represent different interactive effects on the plot. Dashed line indicates 1:1 relation.

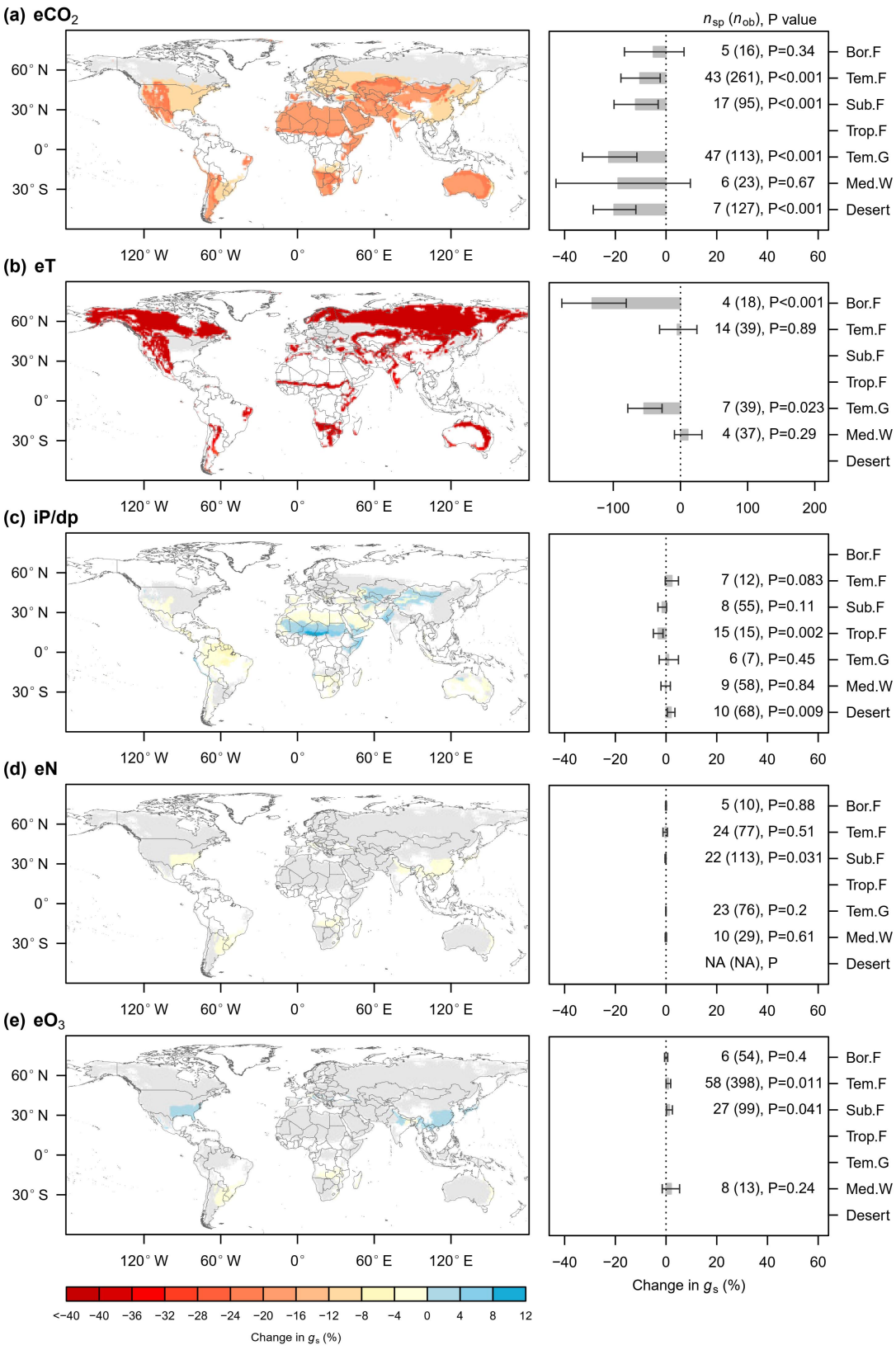

Figure S8 | Predicted changes in g_s across biomes by the end of the twenty-first century under SSP2-4.5/RCP4.5 scenario. The left panels display global maps depicting changes in g_s, with grey

and white land colors indicating areas where changes are statistically insignificant and where is a lack of data, respectively. The right panels depict biome-level predictions, with error bars representing the 95% confidence interval. The numbers outside and inside parentheses represent the number of species (n_{sp}) and observations (n_{ob}), respectively. Bor.F: boreal forest, Tem.F: temperate forest, Sub.F: subtropical forest, Trop.F: tropical forest, Tem.G: temperate grassland, Med.W: Mediterranean woodland.

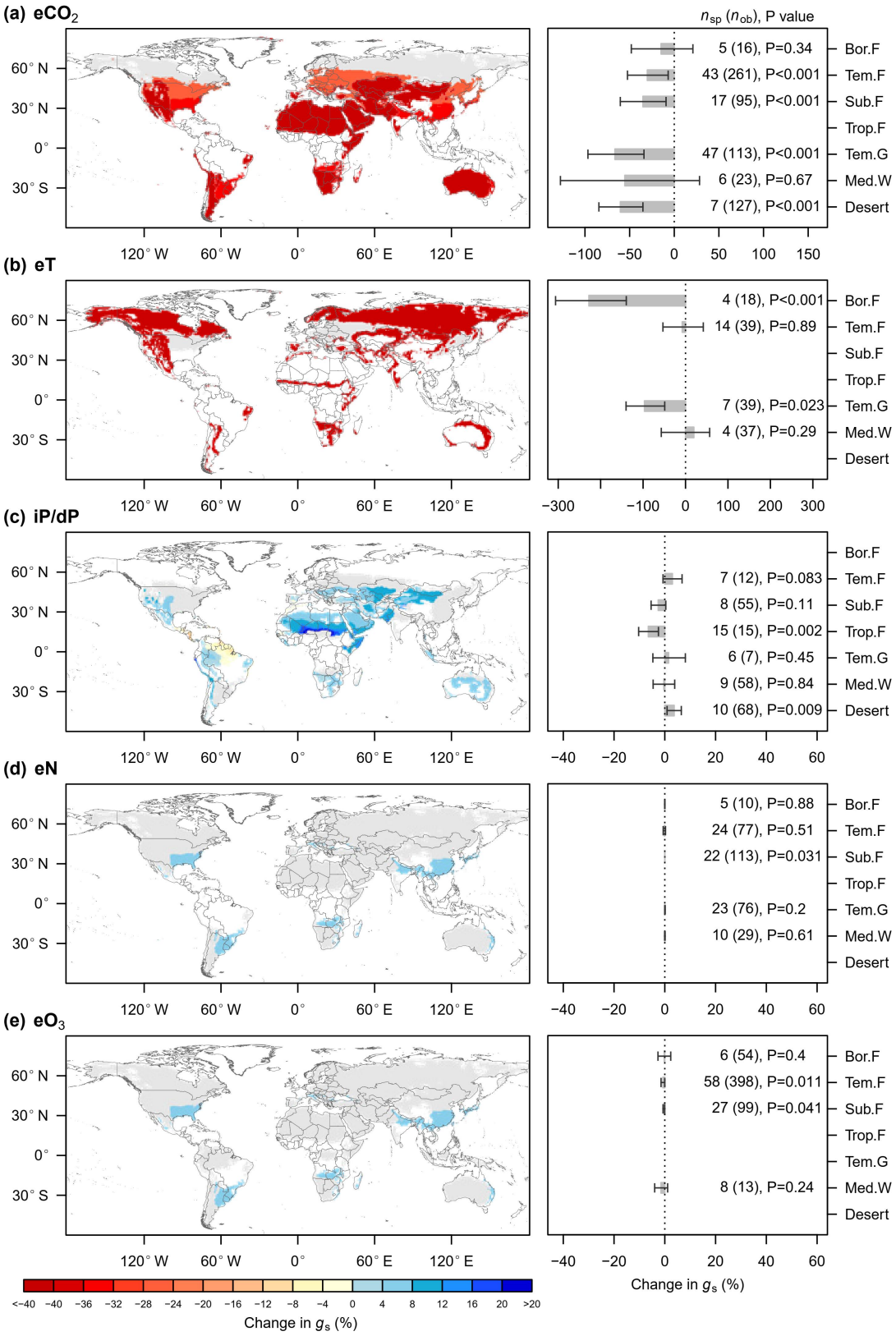

Figure S9 | Predicted changes in g_s across biomes by the end of the twenty-first century under SSP5-8.5/RCP8.5 scenario. The left panels display global maps depicting changes in g_s, with grey

and white land colors indicating areas where changes are statistically insignificant and where is a lack of data, respectively. The right panels depict biome-level predictions, with error bars representing the 95% confidence interval. The numbers outside and inside parentheses represent the number of species (n_{sp}) and observations (n_{ob}), respectively. Bor.F: boreal forest, Tem.F: temperate forest, Sub.F: subtropical forest, Trop.F: tropical forest, Tem.G: temperate grassland, Med.W: Mediterranean woodland.

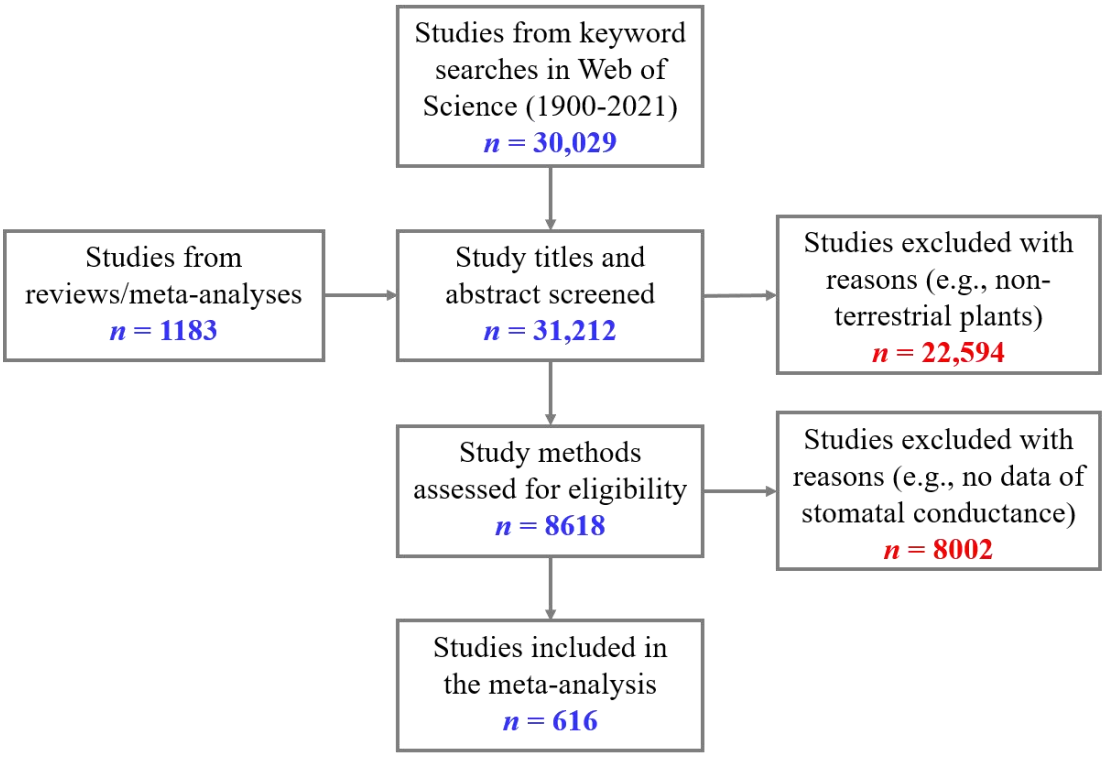

Figure S10 | PRISMA flow diagram depicting the literature search and study selection process.

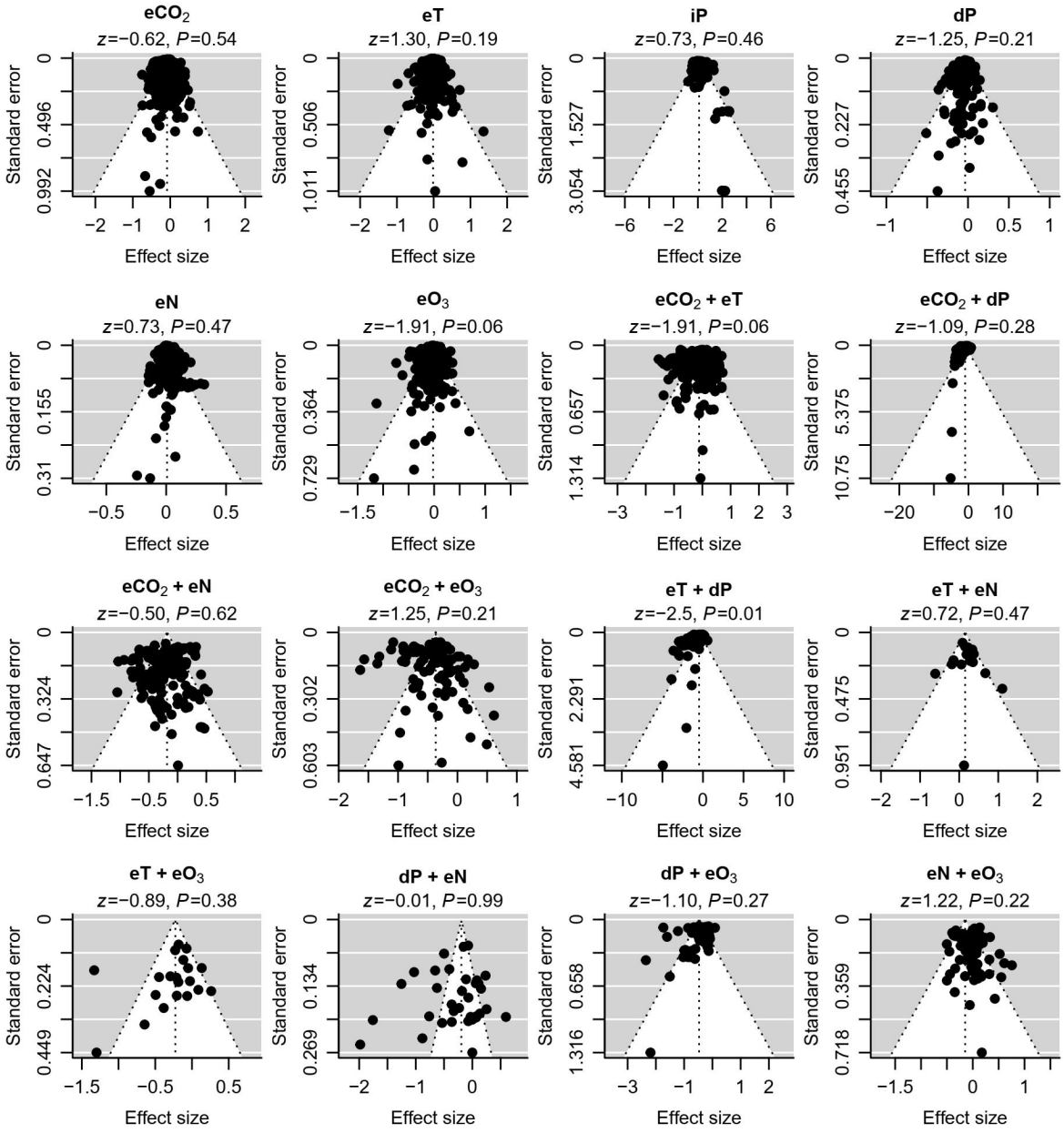

Figure S11 | Funnel plots for assessments of publication bias. Results of Egger's regression are given at the top to each panel, with *P* values > 0.05 indicate no publication bias.

Supplementary References

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