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Integrating ozone–vegetation damage schemes into SSiB4/TRIFFID: evaluation of six parameterizations and refinement of ozone decay process across plant functional types

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1. Tables

Table S1 Implementation of six O_3-vegetation damage parameterizations in SSiB4/TRIFFID.

Scheme	O_3 impact factor for photosynthesis implemented in SSiB4/TRIFFID
L2015	$F_{O_3} = \begin{cases} 0.8752 & EBF, DBF \\ 0.8390 & ENF \\ -0.0009CUO + 0.8021 & C3, C4, Shrub, Tundra \end{cases}$
Li2024	$F_{O_3} = \begin{cases} 0.943e^{-0.0085CUO} & EBF, DBF \\ 1.005 - 0.0064CUO & ENF \\ 1.000 - 0.074\ln(CUO) & Shrub \\ 0.997 - 0.016CUO & C3, C4, Tundra \end{cases}$
S2007	$F_{O3} = 1 - \alpha_{PFT} \times \max\{f_{O3} - y, 0\}$
CS2007	$F_{O3} = 1 - \alpha_{PFT} \times \max\{f_{O3} - y, 0\}$
LMAgrid	$F_{O3} = 1 - \alpha \times \max\left\{\frac{f_{O3}}{LMA} - x, 0\right\}, \alpha = 3.5$
LMApft	$F_{O3} = 1 - \alpha \times \max\left\{\frac{f_{O3}}{LMA} - x, 0\right\}, \alpha = 2.82$

Table S2. PFT-specific parameters for O_3-vegetation damage parameterizations.

PFT	EBF	ENF	C3	C4	Shrub	Tundra	DBF
α_{PFT} for S2007	0.095	0.1475	0.4325	0.825	0.065	0.065	0.095
α_{PFT} for CS2007	0.023	0.017	0.041	0.041	0.03	0.015	0.042
y $(nmol\ m^{-2}\ s^{-1})$ for L2015	-	-	0.8	0.8	0.8	0.8	-
y $(nmol\ m^{-2}\ s^{-1})$ for Li2024	1.0	0.8	1.6	1.6	6.0	1.6	1.0
y $(nmol\ m^{-2}\ s^{-1})$ for S2007	1.6	1.6	5.0	50	1.6	1.6	1.6
y $(nmol\ m^{-2}\ s^{-1})$ for CS2007	1.0	1.0	1.0	1.0	1.0	1.0	1.0
x $(nmol\ g^{-1}\ s^{-1})$ for LMAgrid	0.019	0.019	0.019	0.019	0.019	0.019	0.019
x $(nmol\ g^{-1}\ s^{-1})$ for LMApft	0.019	0.019	0.019	0.019	0.019	0.019	0.019
LMA $(g\ m^{-2})$ for LMApft	83.9	158.1	47.7	47.7	68.8	68.8	53.9
l_{leaf} (year) for $Li2024_{modify}$	1.296	3.764	0.289	0.214	1.149	0.541	0.479

Table S3. The full list of datasets that used in this study.

Category	Description	Coverage	Resolution	URL
Climate	ERA5-Land	China	0.1 degree	https://cds.climate.copernicus.eu/datasets/reanalysis-era5-land?tab=overview
O_3	Hourly Surface Ozone Data (HrSOD)	China	0.1 degree	https://zenodo.org/records/7415326
	China National Environmental Monitoring Center (CNEMC) network	China (Station)	/	https://air.cnemc.cn:18007/
LAI	GLASS	China	0.05 degree	https://www.glass.hku.hk/download.html
GPP	GOSIF	China	0.05 degree	https://globalecology.unh.edu/data/GOSIF-GPP.html
	FLUXCOM	China	0.5 degree	https://www.bgc-jena.mpg.de/geodb/projects/Home.php
LMA	TRY database	Global	3 km	https://www.try-db.org/TryWeb/Data.php#59
Eddy-Covariance	Harvard forest (US-Ha1) from FLUXNET network	Station	/	https://harvardforest1.fas.harvard.edu/exist/apps/datasets/showData.html?id=HF066
	Hyytiälä forest (FI-Hyy) from FLUXNET network	Station	/	https://www.helsinki.fi/en/research-stations/hyytiala-forest-station/research/open-data

2. Figures

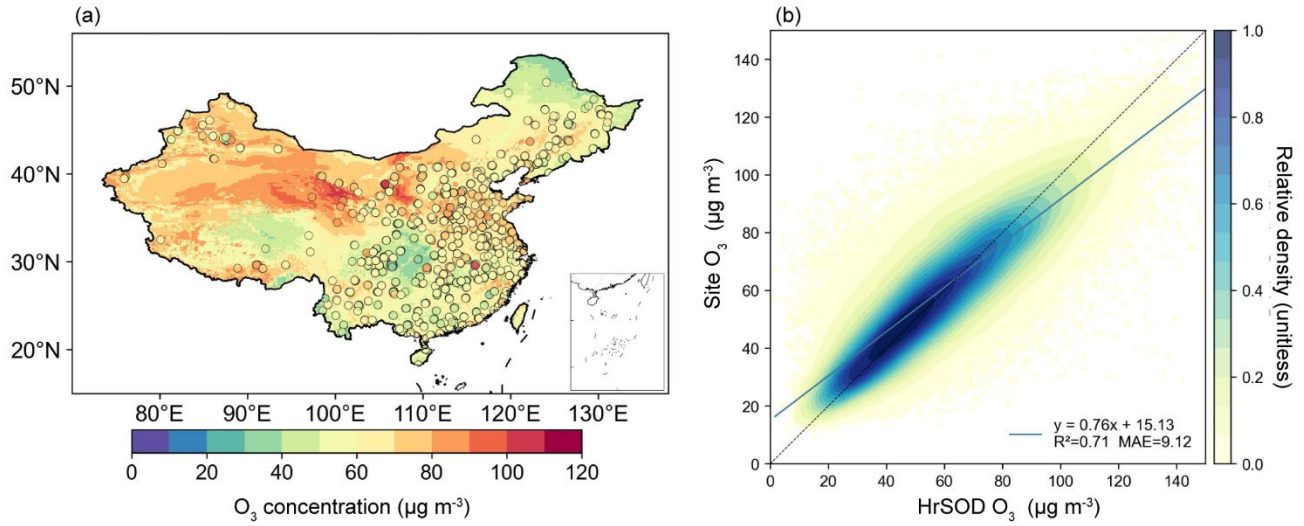

Figure S1. Evaluation of HrSOD O_3 against site observations for 2015–2020. (a) Annual mean HrSOD O_3 concentrations compared with site observations. (b) Monthly mean comparison between site observations and HrSOD.

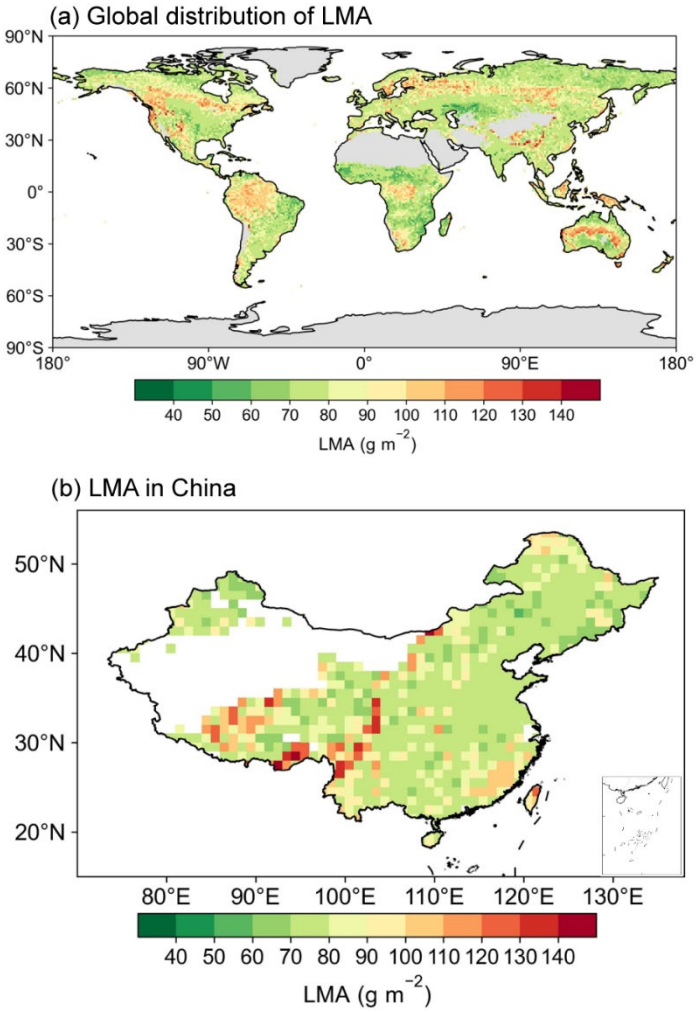

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Figure S2. Global and China distributions of leaf mass per area (LMA) used as input for the mass-based O_3 damage scheme (LMAgrid experiment).

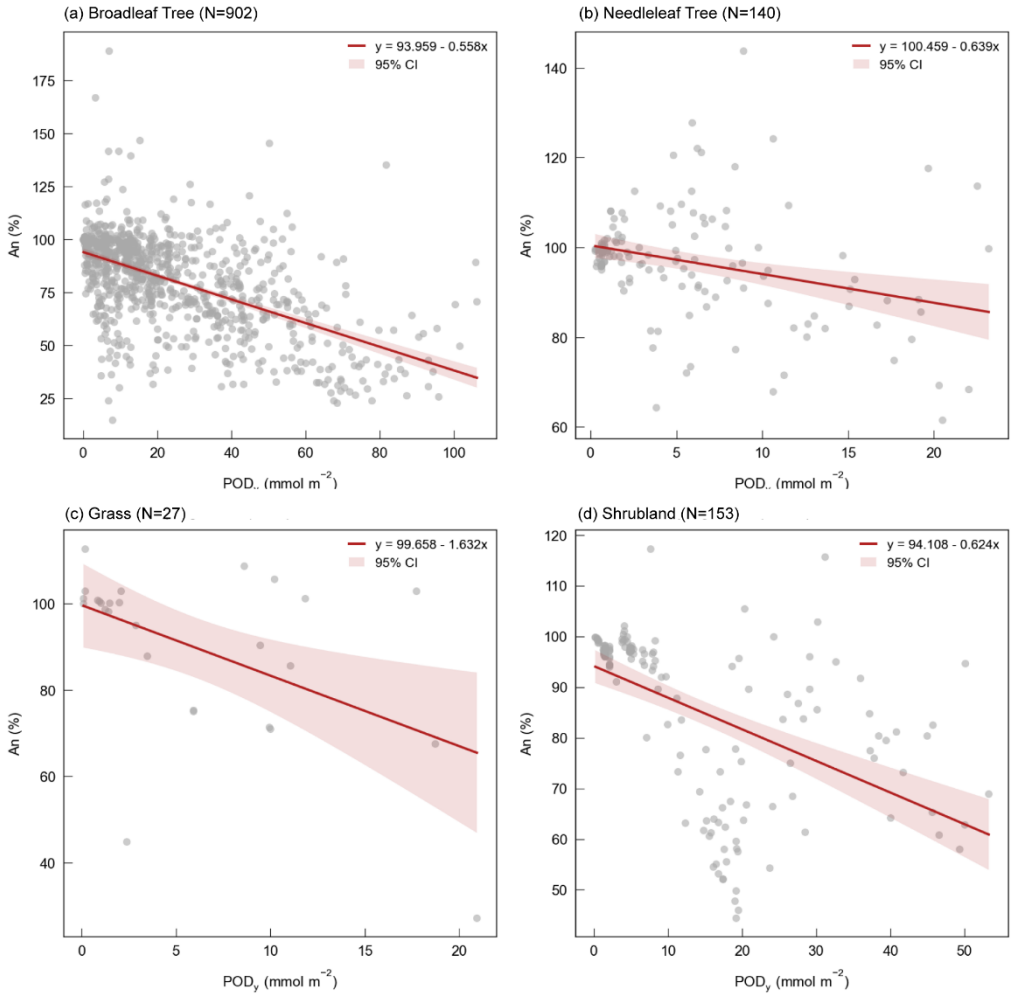


Figure S3. Observation-based dose–response relationships between net photosynthesis (An) and cumulative O_3 uptake (POD_y) for different vegetation types. Linear regressions are fitted for (a) broadleaf trees (BT), (b) needleleaf trees (NT), (c) grasses, and (d) shrubs. The slope of each regression is used to quantify O_3 sensitivity for the corresponding vegetation type. Shaded areas represent the 95% confidence intervals derived from 1000 bootstrap resamples (2.5th–97.5th percentiles).

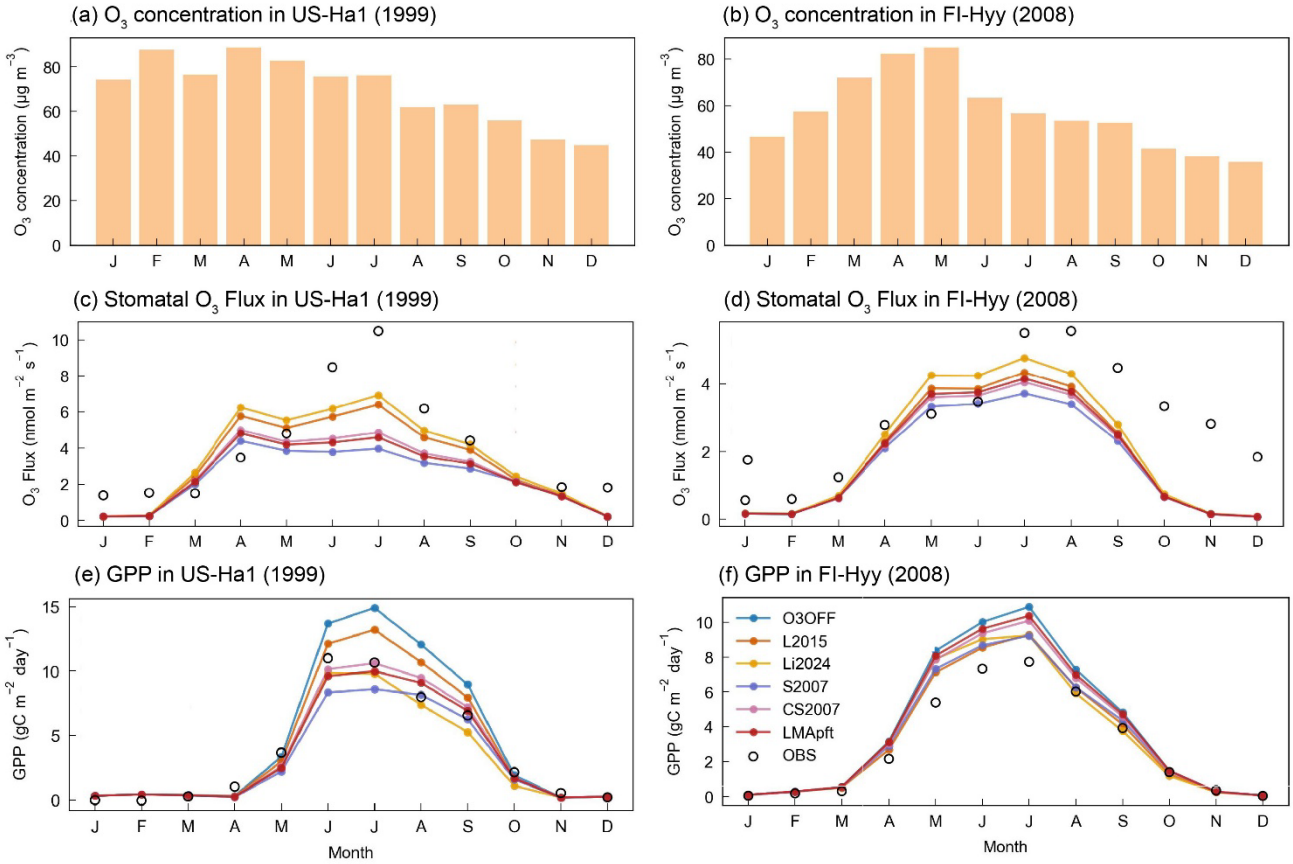
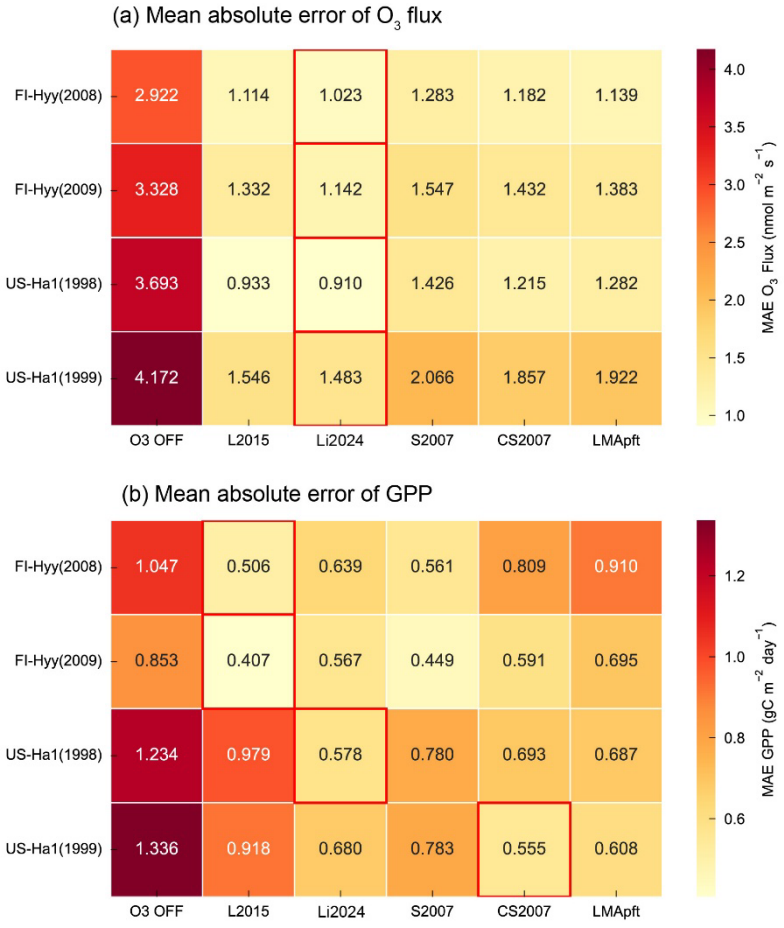


Figure S4. Same as Fig. 1, but for US-Ha1 (1999) and FI-Hyy (2008).



40 **Figure S5.** Mean absolute error (MAE) of simulated stomatal O_3 flux (top) and gross primary productivity (GPP; bottom) for six O_3 damage parameterizations across four site-years (US-Ha1: 1998 and 1999; FI-Hyy: 2008 and 2009). Red boxes indicate the scheme with the lowest MAE for each site-year.

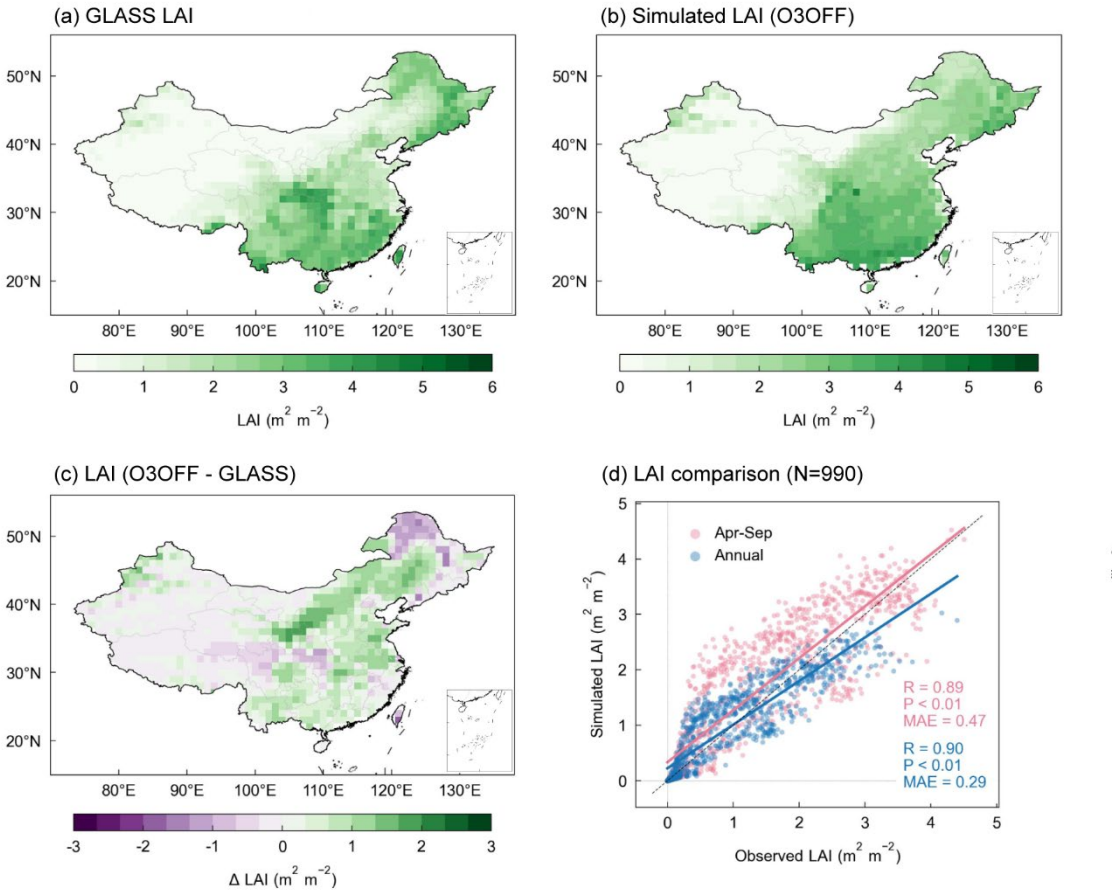
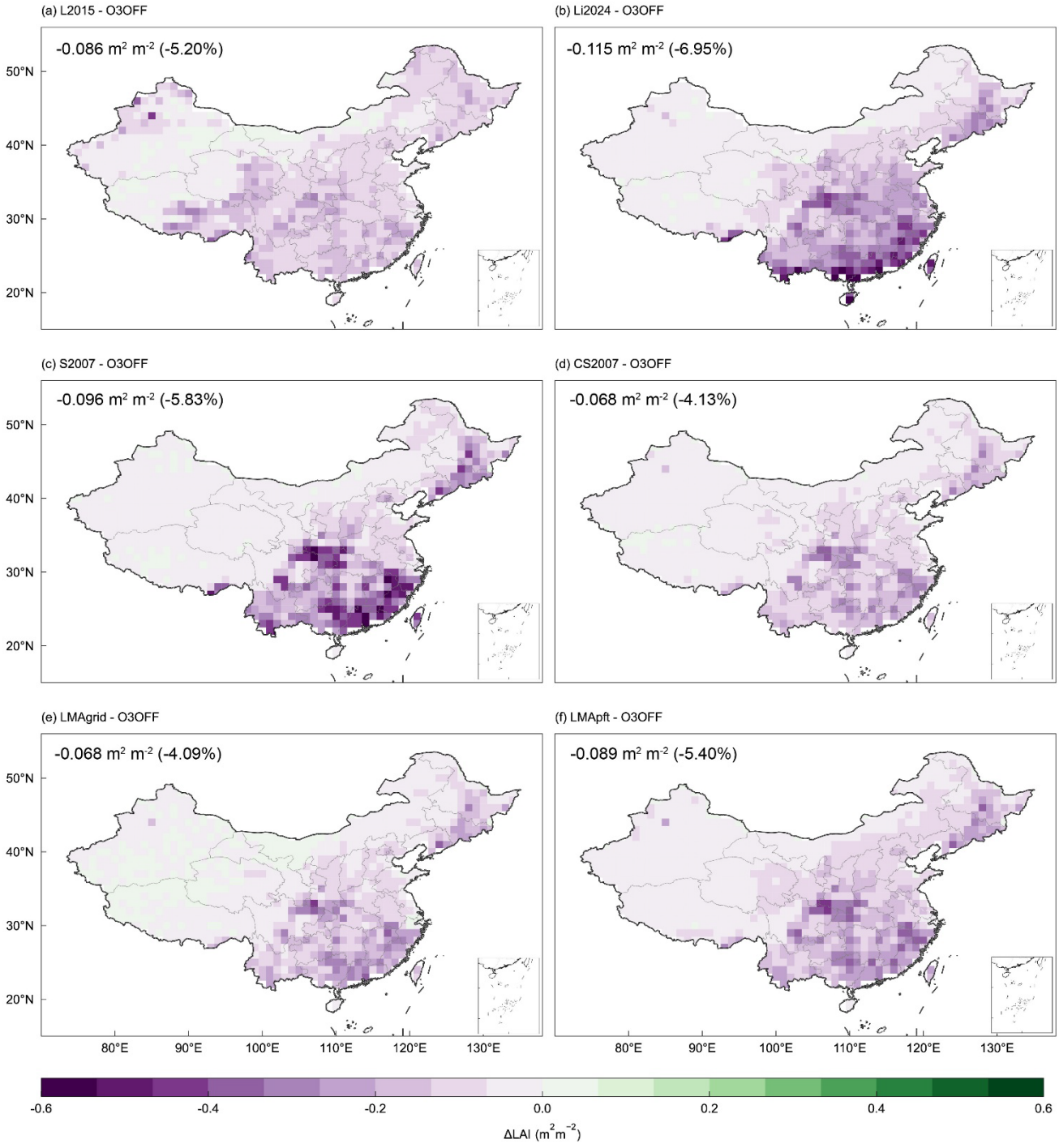


Figure S6. Same as Fig. 2 but for leaf area index (LAI).



50 **Figure S7.** Same as Fig. 4 but for leaf area index (LAI).

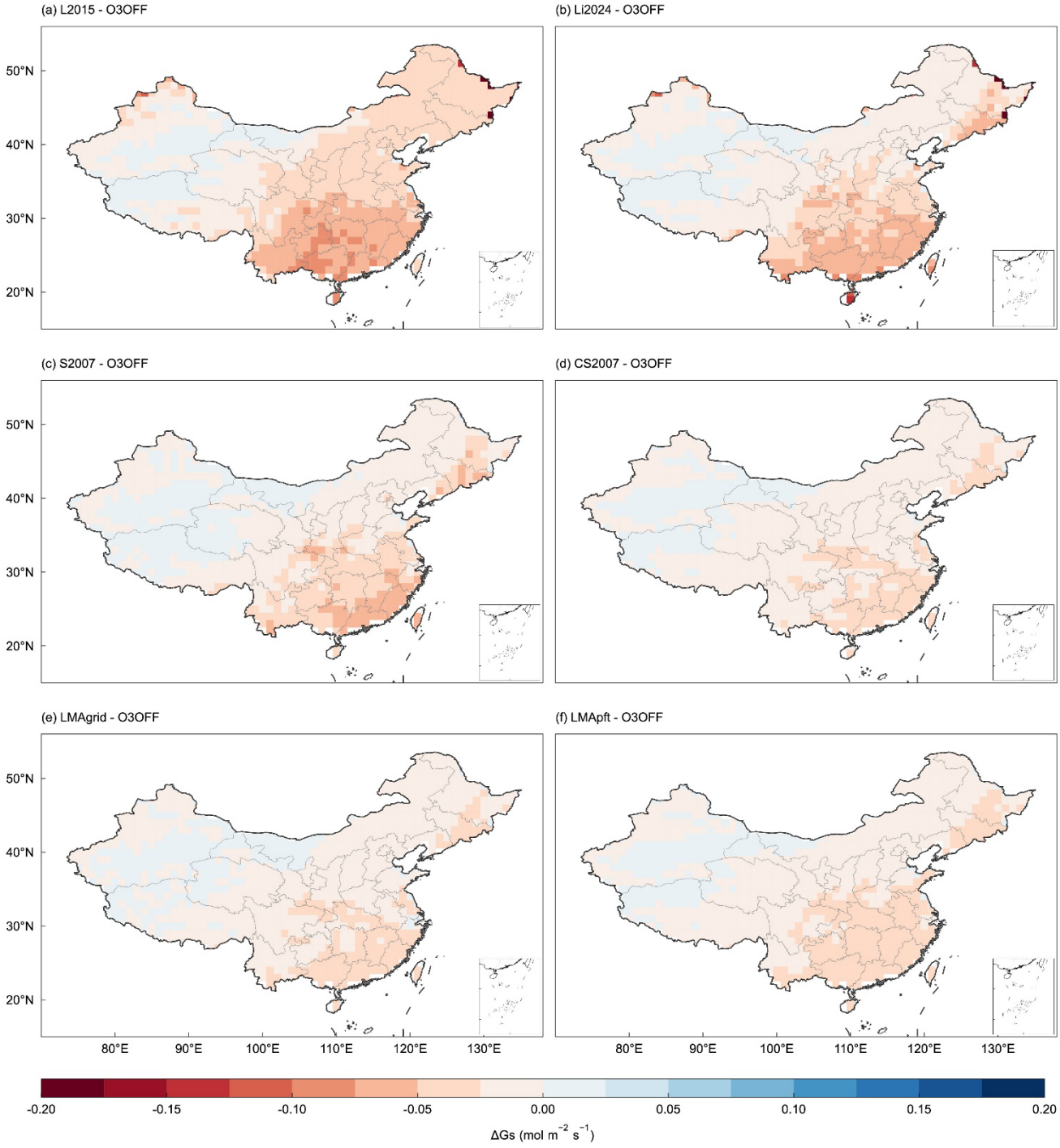


Figure S8. Same as Fig. 4 but for stomatal conductance (Gs).

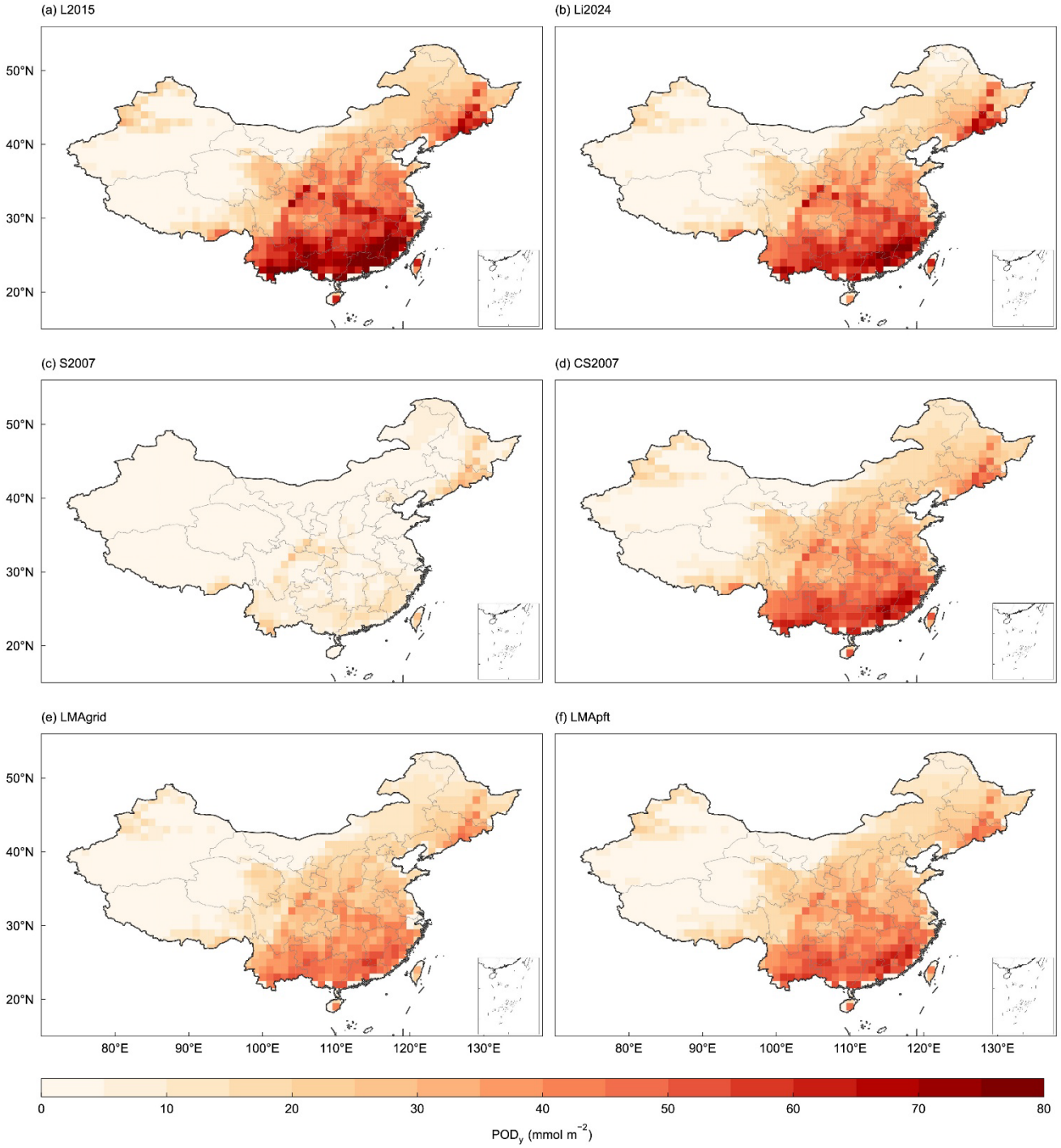


Figure S9. Same as Fig. 4 but for stomatal O_3 uptake represented by POD_y.