Geoscientific
Model Development

Supplement of

A new simplified parameterization of secondary organic aerosol in the Community Earth System Model Version 2 (CESM2; CAM6.3)

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Table S1. Global annual budgets and statistics for simulated SOA. Results are based on one year nudged simulation in 2013. The table also includes sensitivity simulation results that demonstrate the effect of excluding a specific aspect of the SOA scheme developed in this study. Three statistics are calculated against CAM-chem results: Normalized Mean Bias (NMB), the fraction of grid cells within a factor of 2 (FO2) and 5 (FO5). Statistics are calculated based on monthly mean grid cell points.

| Simulation case	Burden (Gg)	All Loss (Tg yr^{-1})	Dry dep. (Tg yr^{-1})	Wet dep. (Tg yr^{-1})	Photo. loss (Tg yr^{-1})	Lifetime (days)	NMB (%)	FO2 (%)	FO5 (%)
CAM-chem	1022	132	10.1	66.0	55.9	2.83	-	-	-
CAM6	948	80	11.9	68.2	0.0	4.32	-7.2	24	44
CAM (this study)	1027	133	7.8	67.5	57.3	2.83	0.5	62	82
This study (with CAM6 SOAG emissions)	318	37	2.4	15.7	18.8	3.14	-68.9	32	70
This study (without photolytic loss)	2997	116	10.5	105.3	0.0	9.45	193.2	14	27
This study (with CAM6 saturation vapor pressure and enthalpy)	1057	138	7.9	70.8	58.8	2.81	3.4	60	82
This study (without deposition of SOAG)	1367	194	11.3	109.0	74.2	2.57	33.7	61	86
This study (with the assumption of 10% of POA as oxygenated)	1126	149	9.2	77.6	61.9	2.77	10.2	63	83
This study (without intermediate tracer SOAE)	714	117	13.6	69.8	33.9	2.22	-30.1	16	39
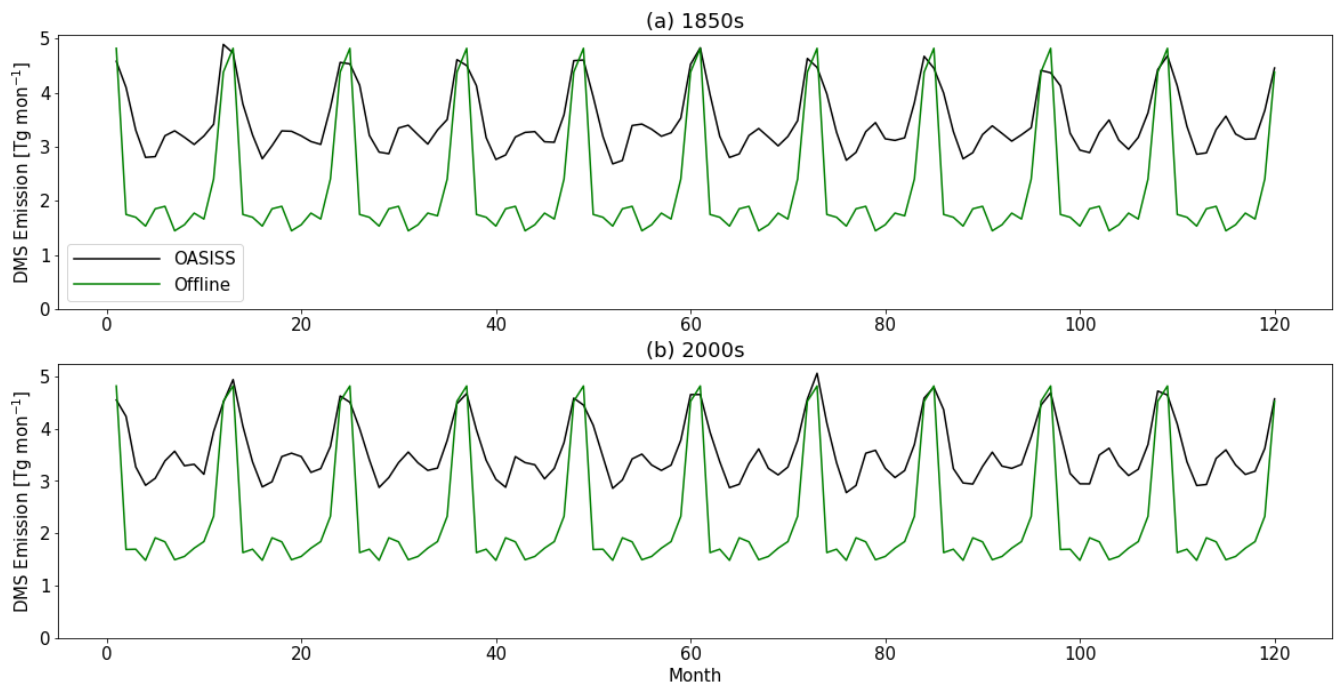
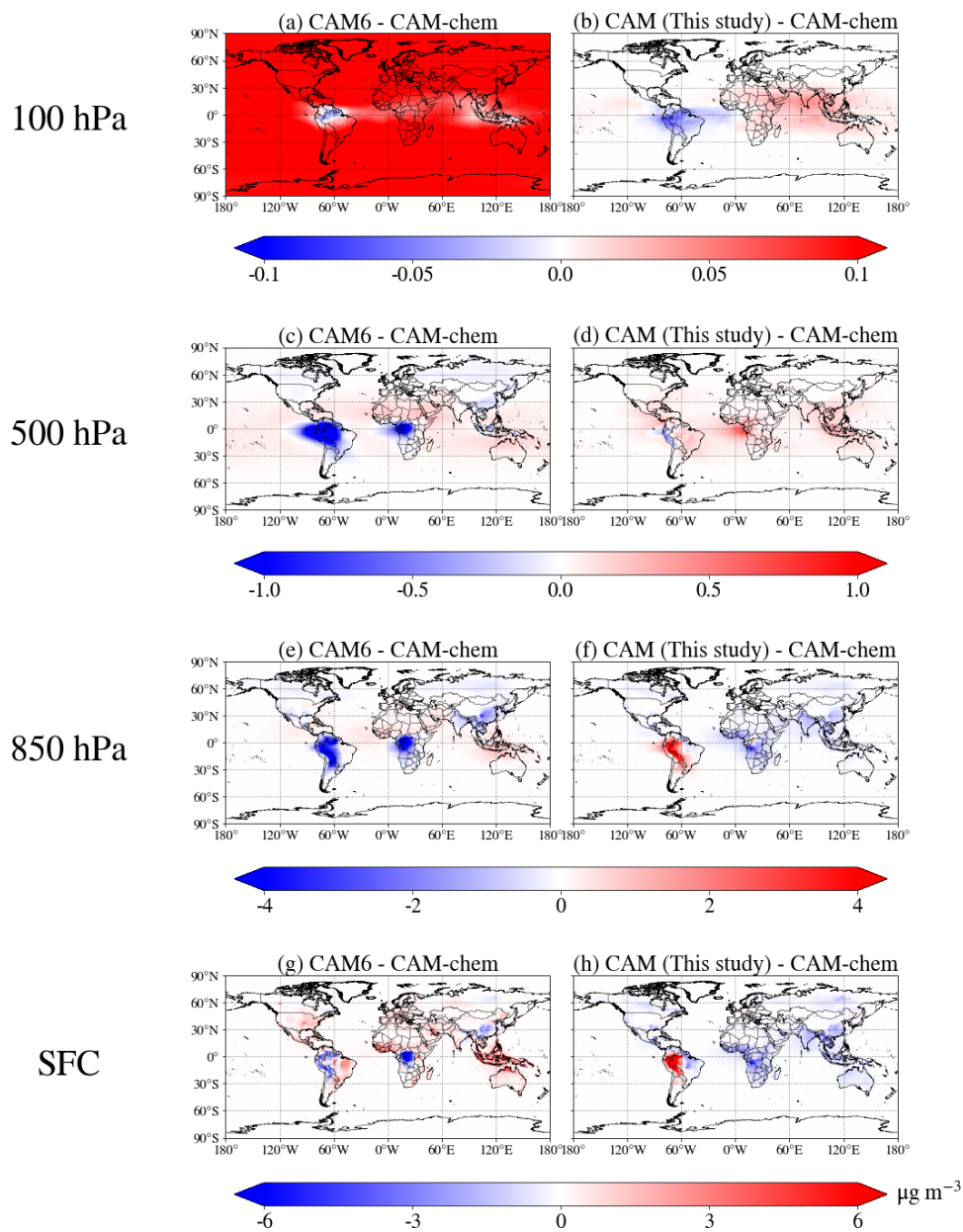**Figure S1.** Simulated (OASISS) and offline DMS emission timeseries in the 1850s and 2000s.

Figure S2. SOA concentrations difference between CAM and CAM-chem, for the current CAM SOA scheme (left column) and new CAM SOA scheme (right column), respectively.
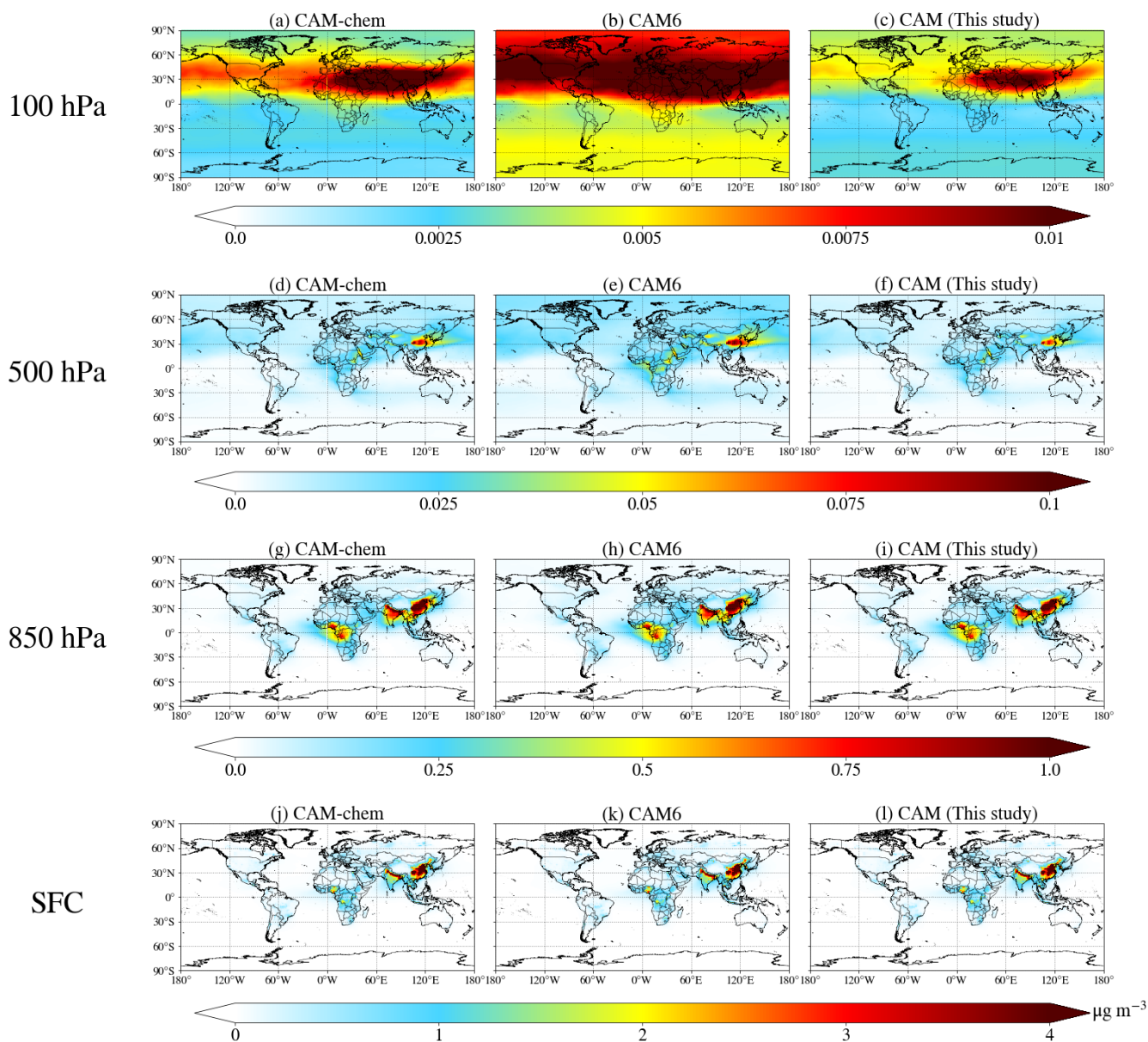
Figure S3. Global maps of BC in 2013 simulated by CAM-chem (first column), CAM (second column), and CAM (NEW) (third column) at four different vertical levels (surface, 850 hPa, 500 hPa, and 100 hPa). The difference maps between CAM and CAM-chem are available in Fig. S3.
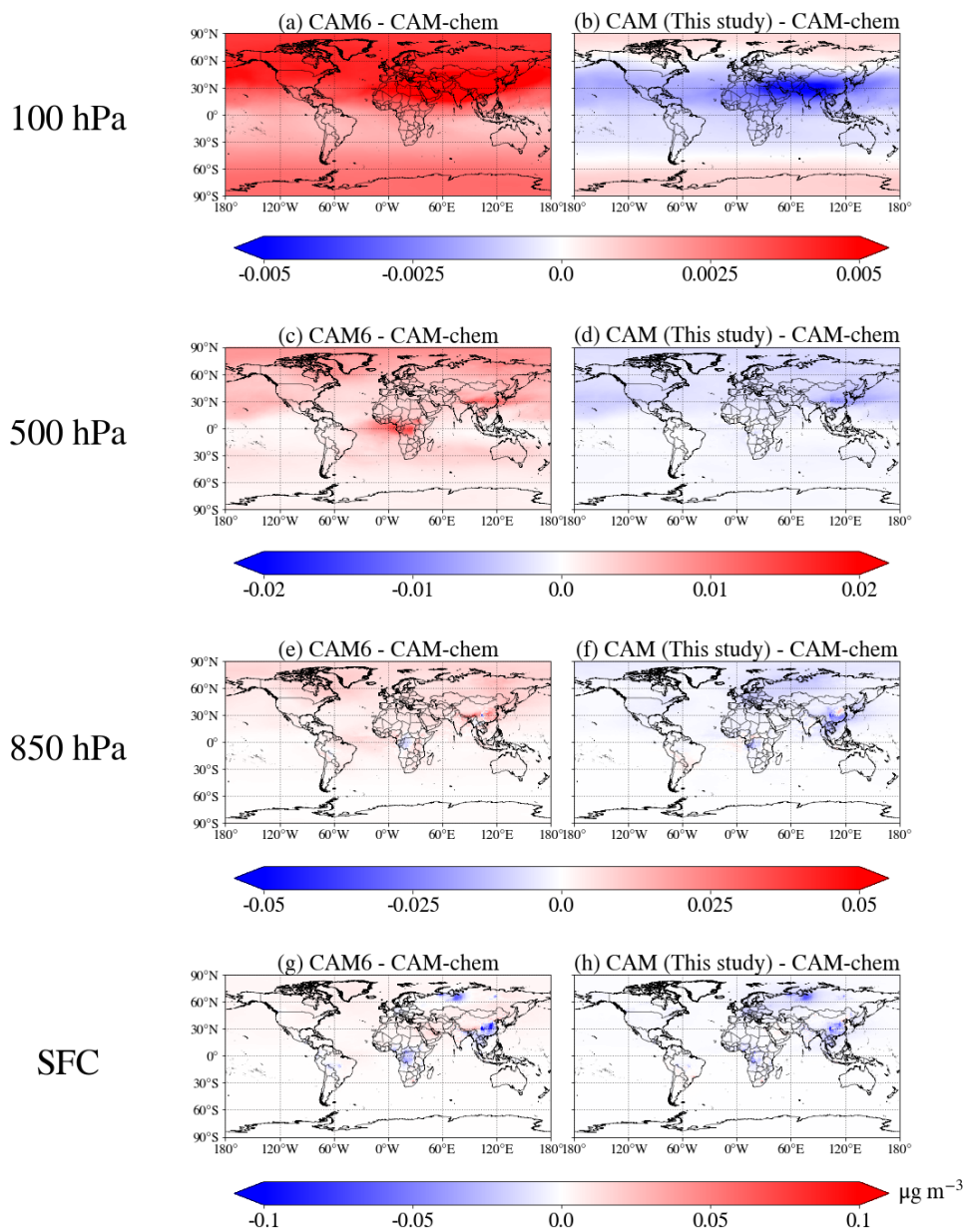
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Figure S4. BC concentrations difference between CAM and CAM-chem, for the current CAM SOA scheme (left column) and new CAM SOA scheme (right column), respectively.
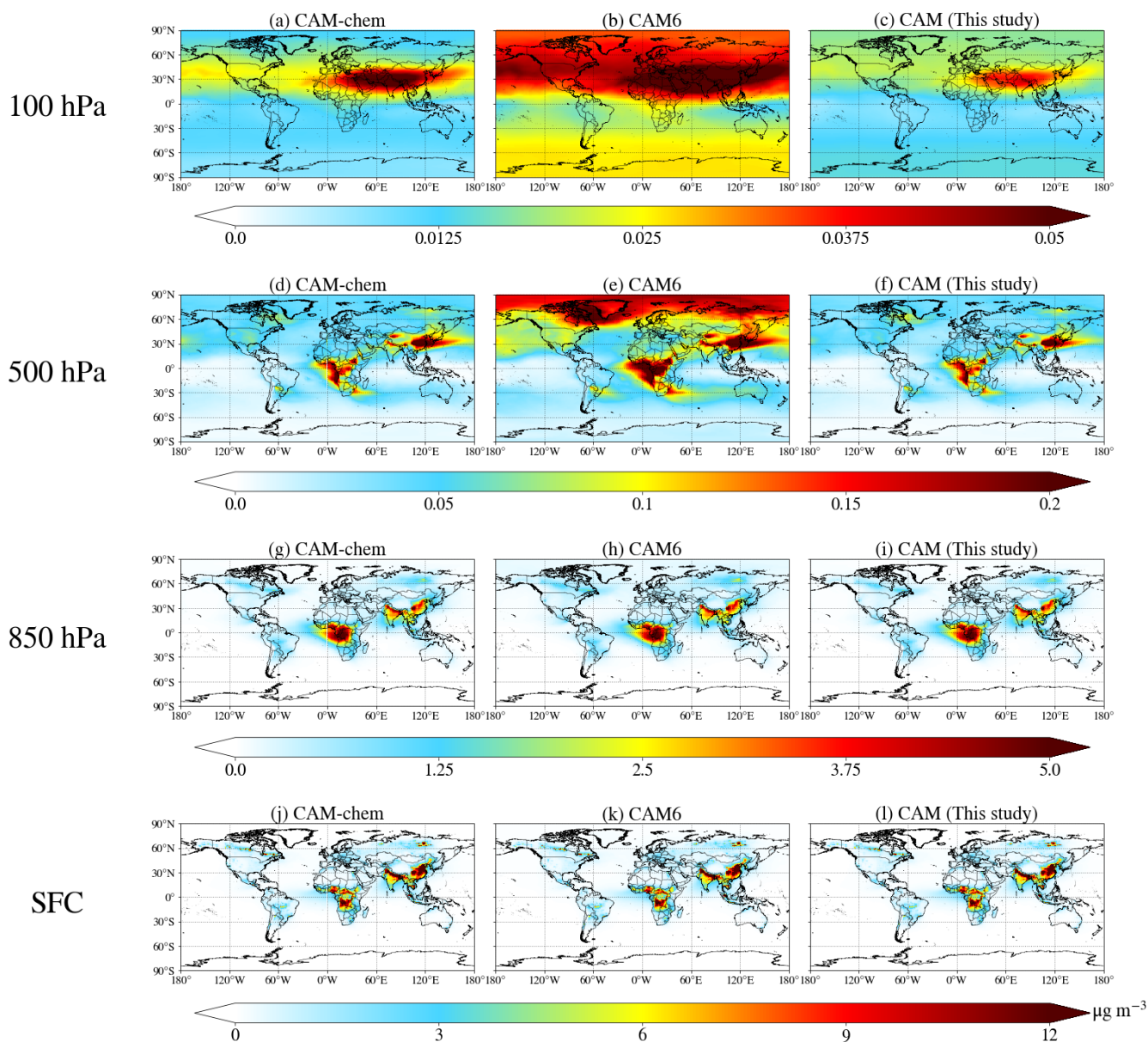
Figure S5. Global maps of POA in 2013 simulated by CAM-chem (first column), CAM (second column), and CAM (NEW) (third column) at four different vertical levels (surface, 850 hPa, 500 hPa, and 100 hPa). The difference maps between CAM and CAM-chem are available in Fig. S3.
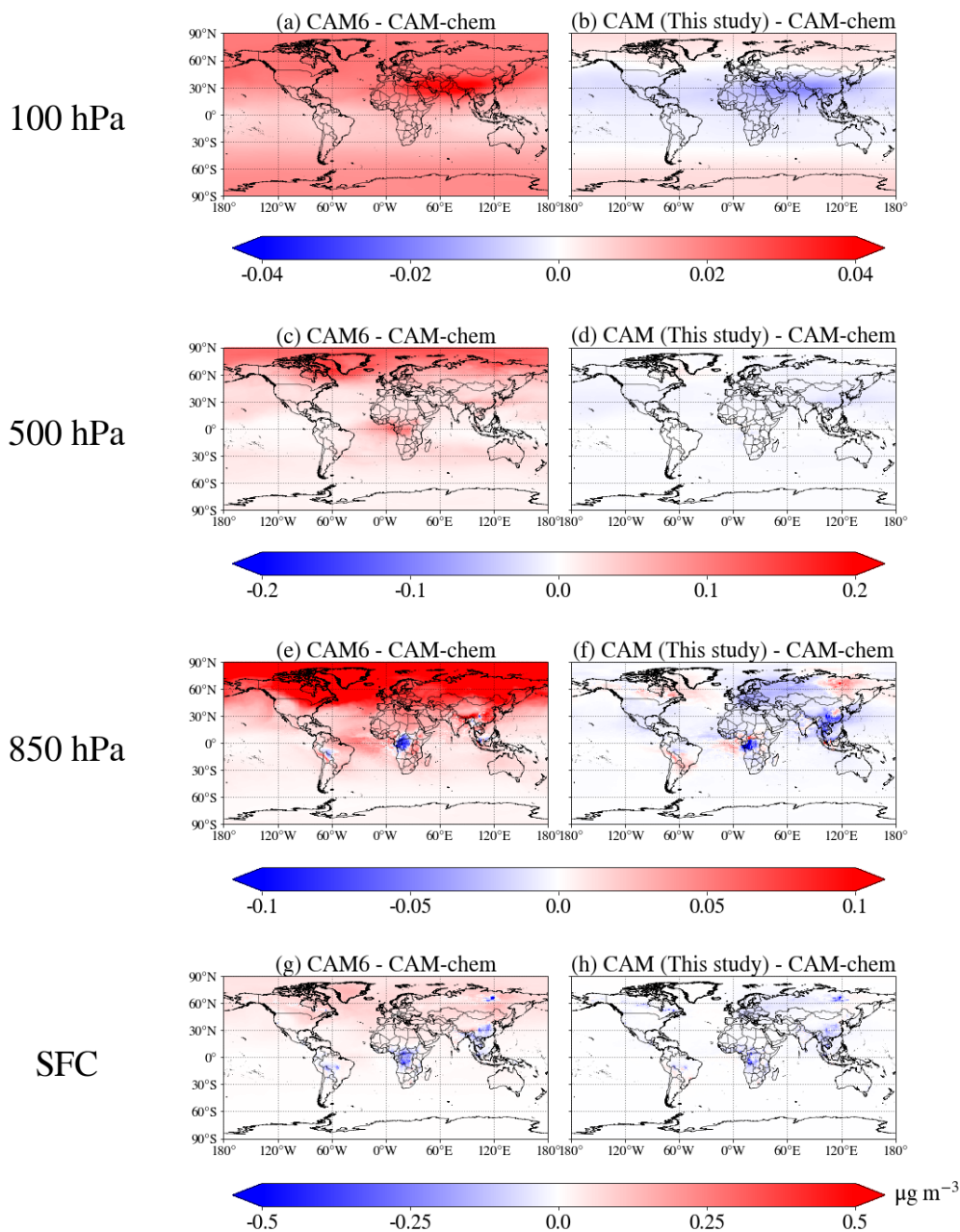
Figure S6. POA concentrations difference between CAM and CAM-chem, for the current CAM SOA scheme (left column) and new CAM SOA scheme (right column), respectively.
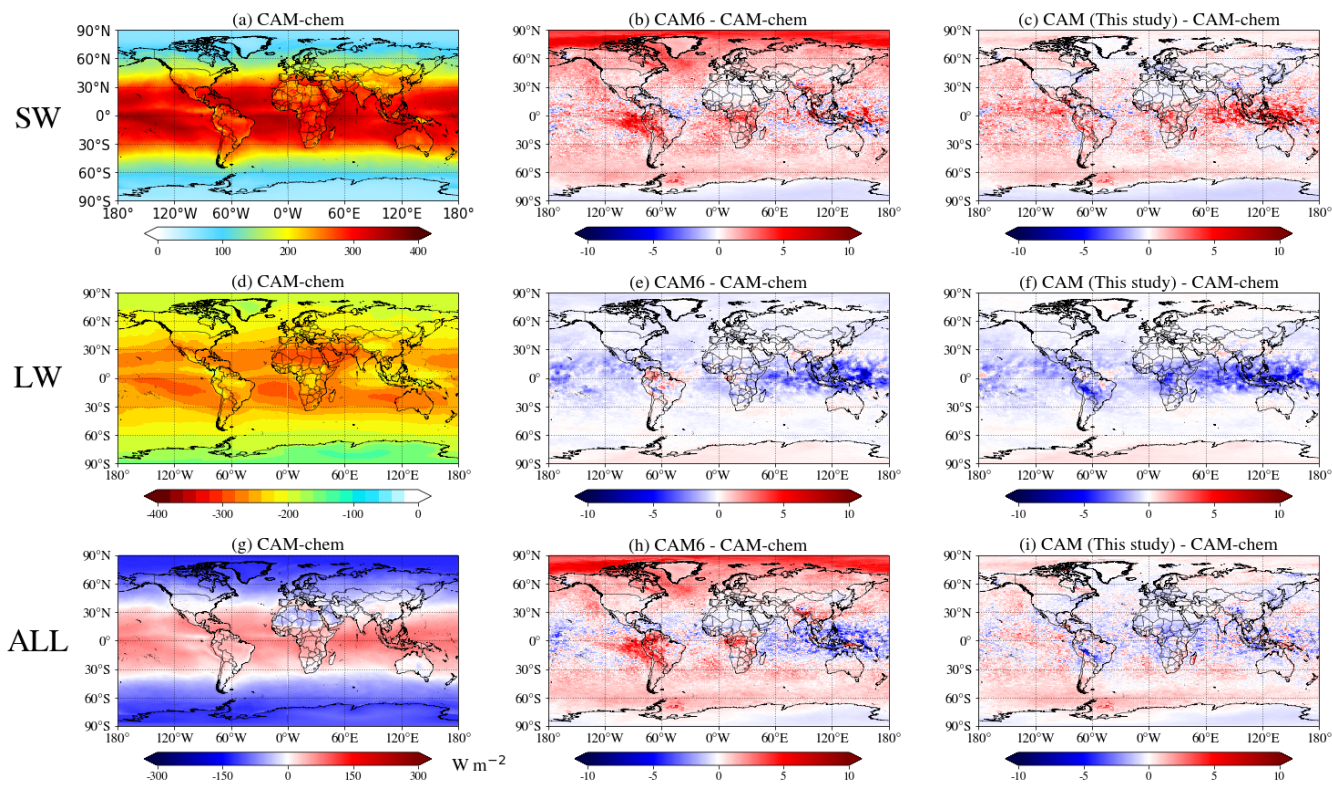
Figure S7. Global maps of net radiative fluxes (SW, LW, and ALL) at the top of the model in 2013. CAM-chem results are shown in the left column. The differences between CAM and CAM-chem are shown in the middle (CAM) and the right column (CAM (NEW)).
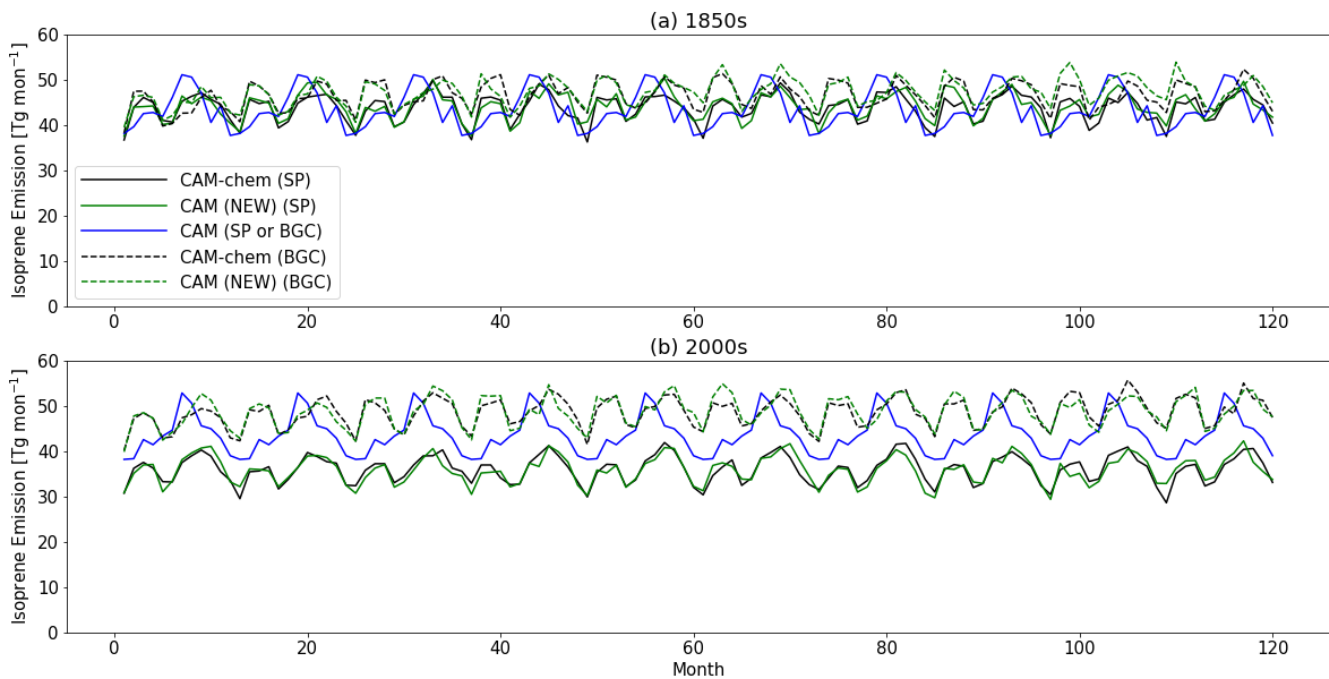
Figure S8. Simulated (CAM-chem and CAM (This study)) and offline (CAM6) isoprene emission timeseries in the 1850s and 2000s.