Atmospheric
Chemistry
and Physics

Supplement of

Dependency of the impacts of geoengineering on the stratospheric sulfur injection strategy – Part 1: Intercomparison of modal and sectional aerosol modules

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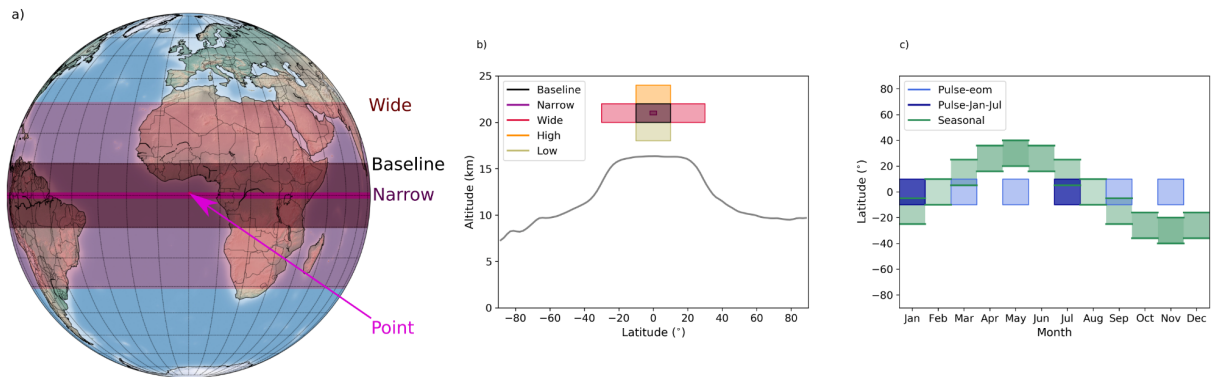
Supplement

Figure S1. Dependence of studied injection areas on a) latitude, b) latitude and altitude and c) latitude and month. Injection altitude in Pulse-eom, Pulse-Jan-Jul and seasonal is the same as Baseline scenario. Injections are done across all longitudes in all other scenarios than Point, where injections are done only in one grid box. Grey line in b) represents yearly mean tropopause altitude in CTRL simulation (simulated with SALSA).
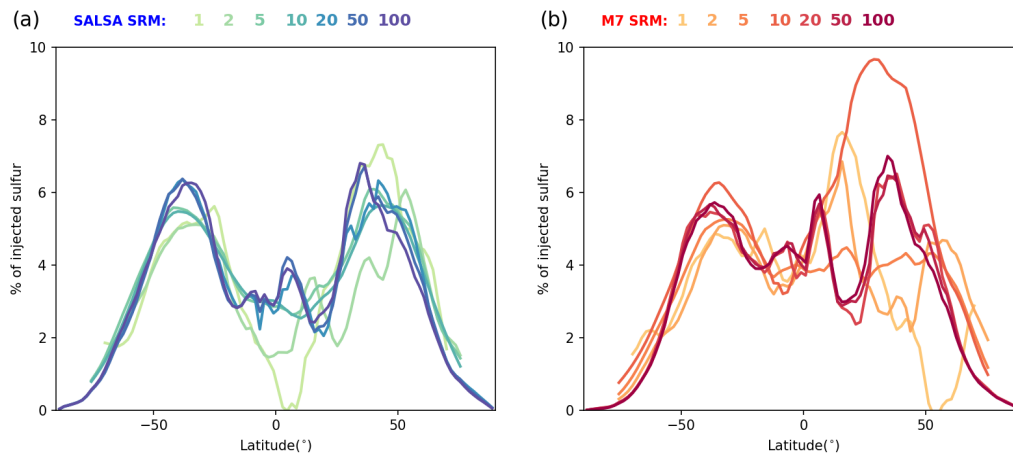

Figure S2: Relative zonal mean sulfate deposition in baseline scenarios simulated with a) SALSA and b) M7. Figure shows zonal running means of 21 latitudinal gridboxes for 1 Tg(S)yr injection rate and running mean of 15 latitudinal gridboxes for 2, 5, 10 Tg(S)yr injection rates.
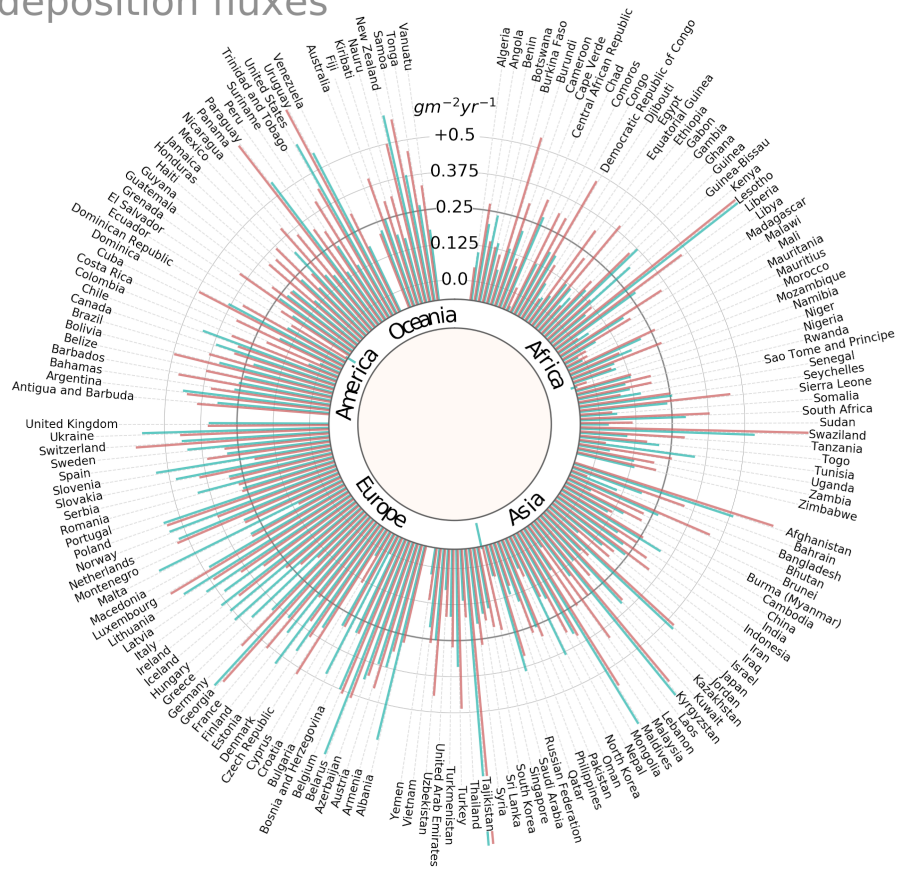
Sulfate deposition fluxes

Figure S3: Deposited sulfate per country in baseline scenario with 50 Tg(S)/yr injection rate. Blue bars show results simulated with SALSA and red bars are from simulations with M7.
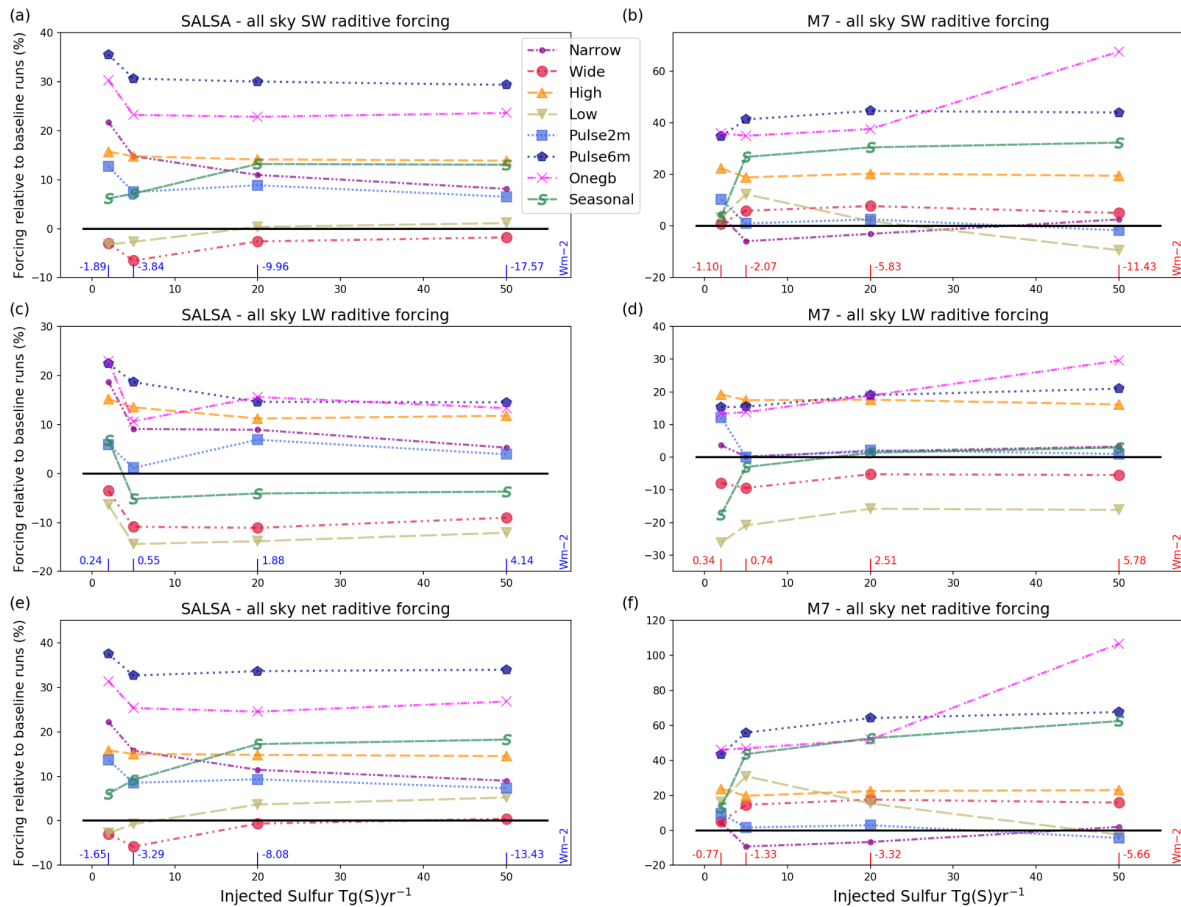
Figure S4. Relative global mean all-sky SW (a-b), LW (c-d) and net radiative forcing in sensitivity scenarios compared to baseline scenario with corresponding sulfur injection rate. Baseline values are shown at the bottom of each panel. SALSA results are shown in the left and M7 in right panels. Note different y-axes scale between the panels.
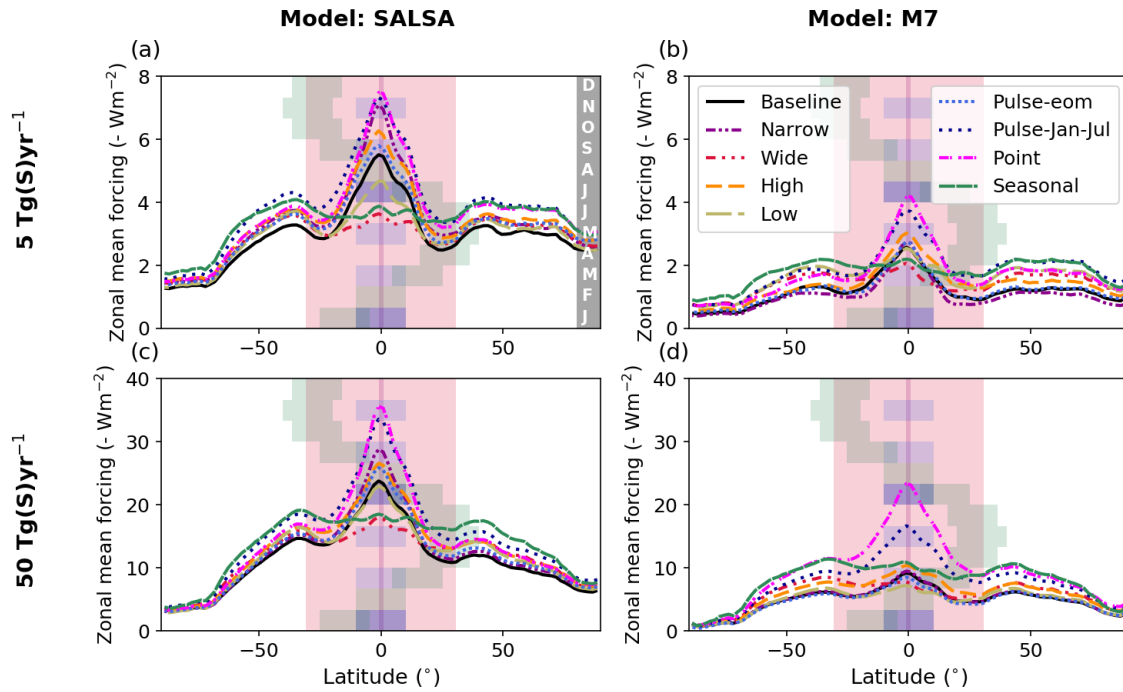
Figure S5. Zonal mean all sky net forcing with a-b) 5 and c-d) 50 Tg(S)yr^{-1} injection rates in simulated sensitivity scenarios. SALSA results are shown in the left and M7 results on the right panels. Note that y-axes scale shows negative (cooling) values. Shaded areas show latitudes of injection area at the time of year (y-axes, month shown in right edge of panel a)) in each injection scenario. Latitudes of injection area are same in Baseline, High and Low scenario (10° N - 10° S)

Figure S6. a) Global mean clear sky SW forcing and b) forcing efficiency, c) lifetime and d) effective radius of stratospheric aerosols (sulfate) in baseline and Point scenarios simulated with M7.
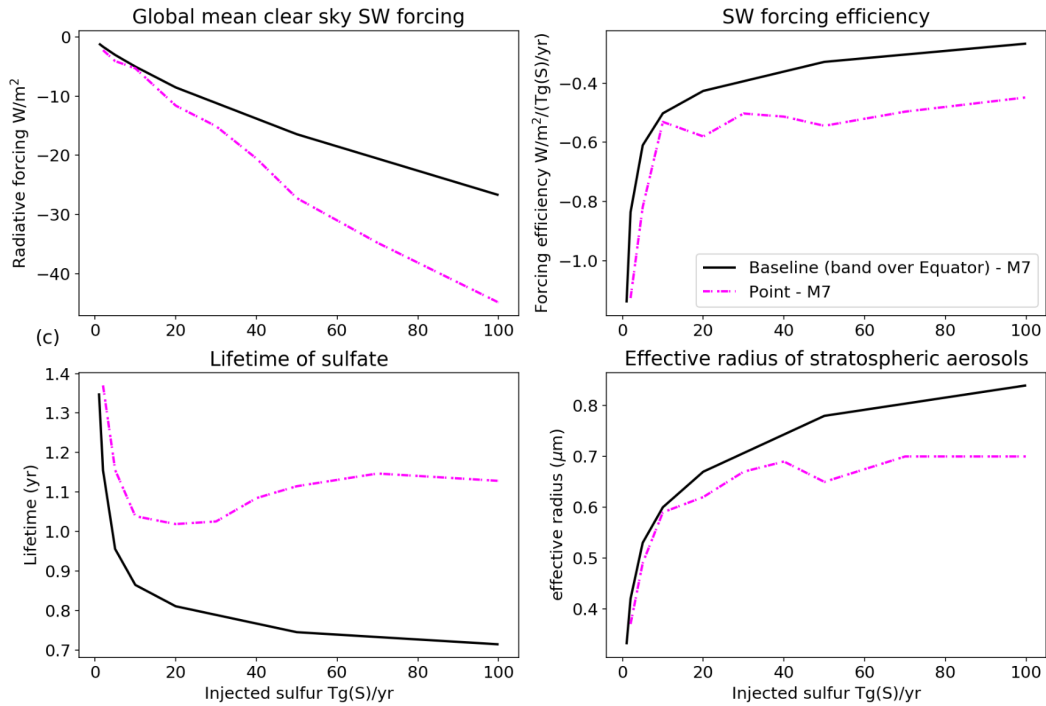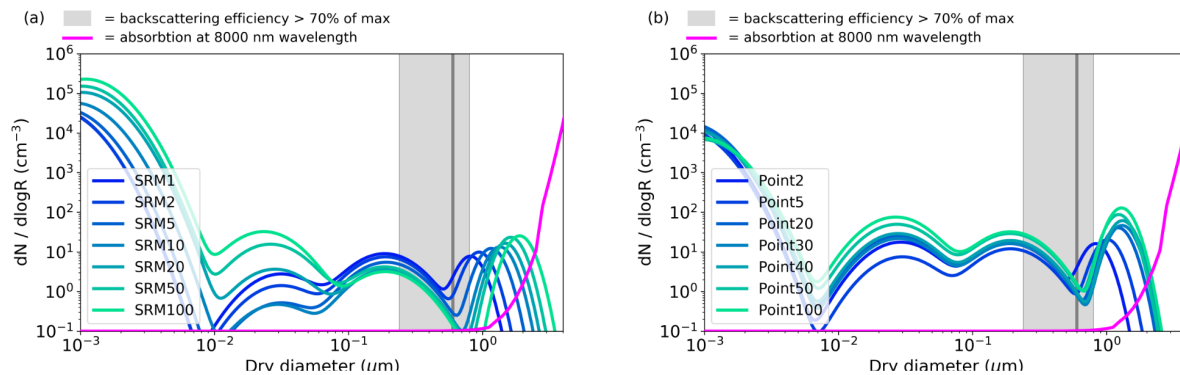

Figure S7. Average aerosol number size distribution at the Equator and at the 20-22 km altitude in a) Baseline and b) Point scenarios simulated with M7.
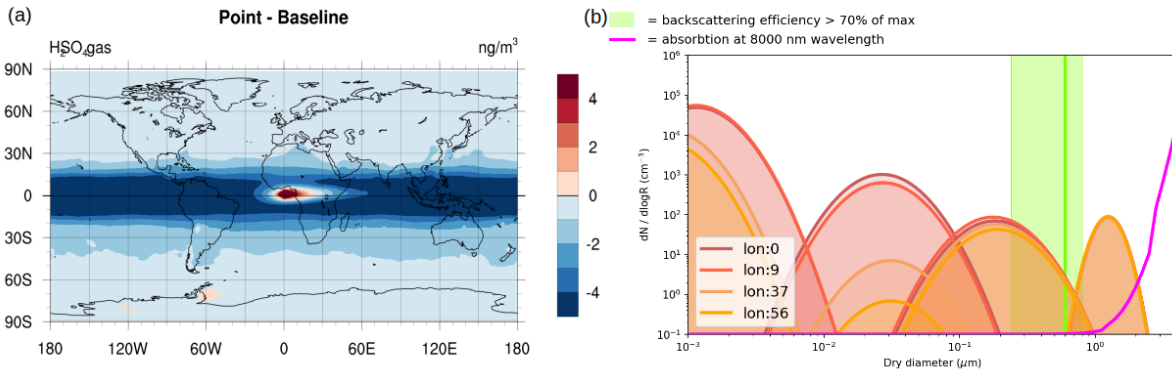
Figure S8. a) Difference in column sum of gaseous sulfuric acid concentration between Onegb and Baseline scenarios b) Number size distribution in Onegb scenario at the 20 km altitude over the Equator at different longitudes. Injections are taking place over the Prime meridian in Onegb scenario.
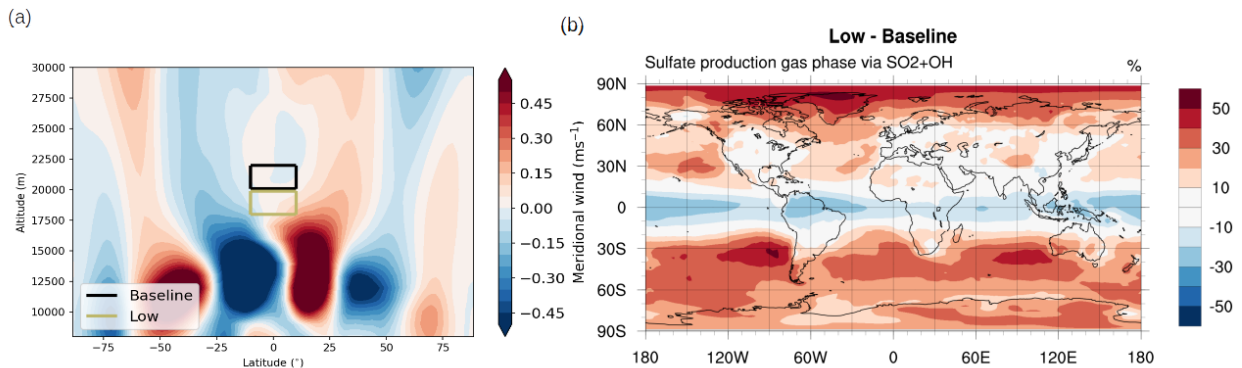
Figure S9. a) Mean meridional wind pattern in Baseline scenario with 5 Tg(S)/yr injection rate simulated with M7. b) Difference in Sulfate production via SO_2 and OH between Low and Baseline scenarios with 5 Tg(S)/yr injection rate simulated with M7.
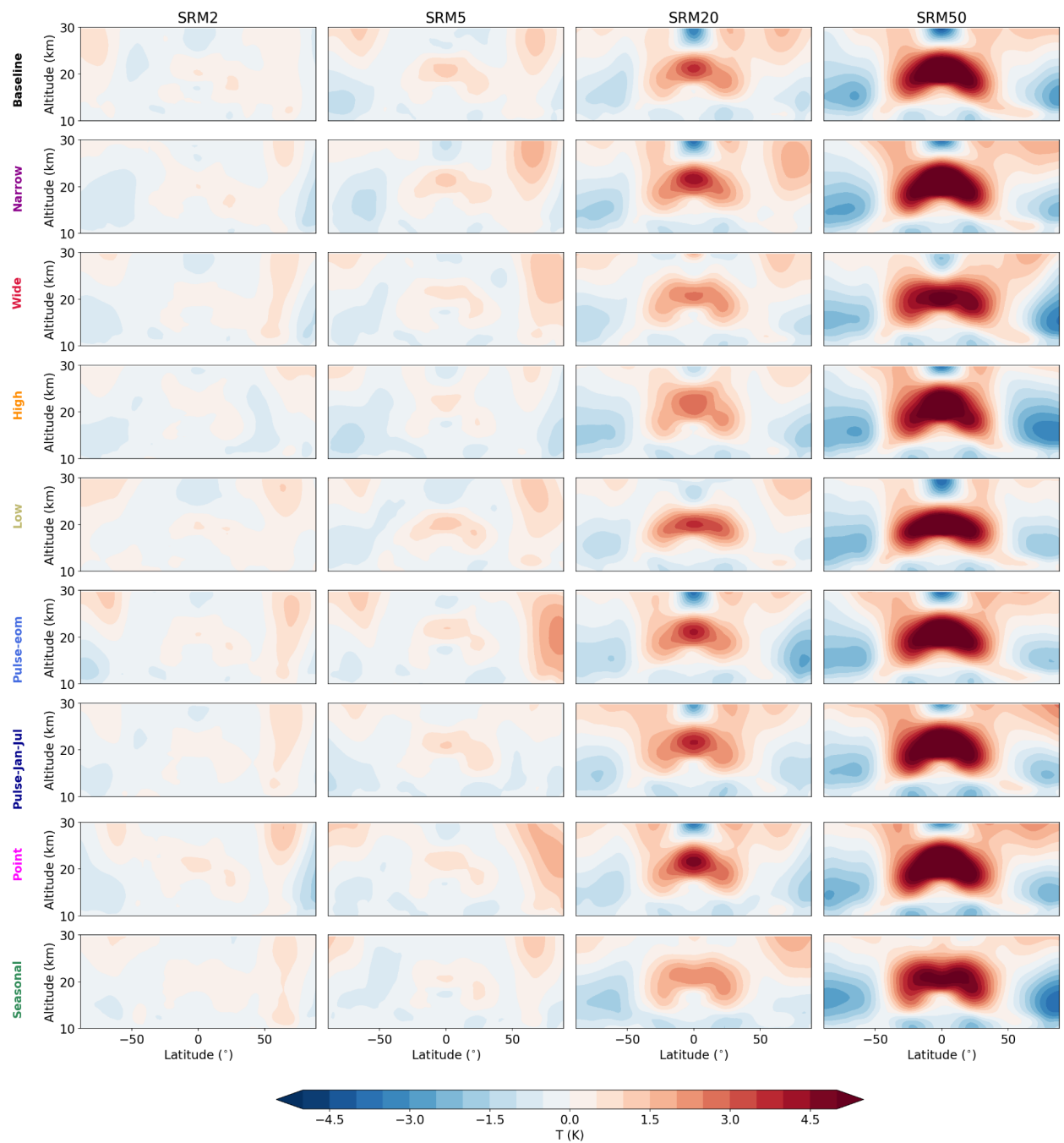
Figure S10. Temperature anomaly due to the stratospheric sulfur injection with different injection rates simulated with SALSA.
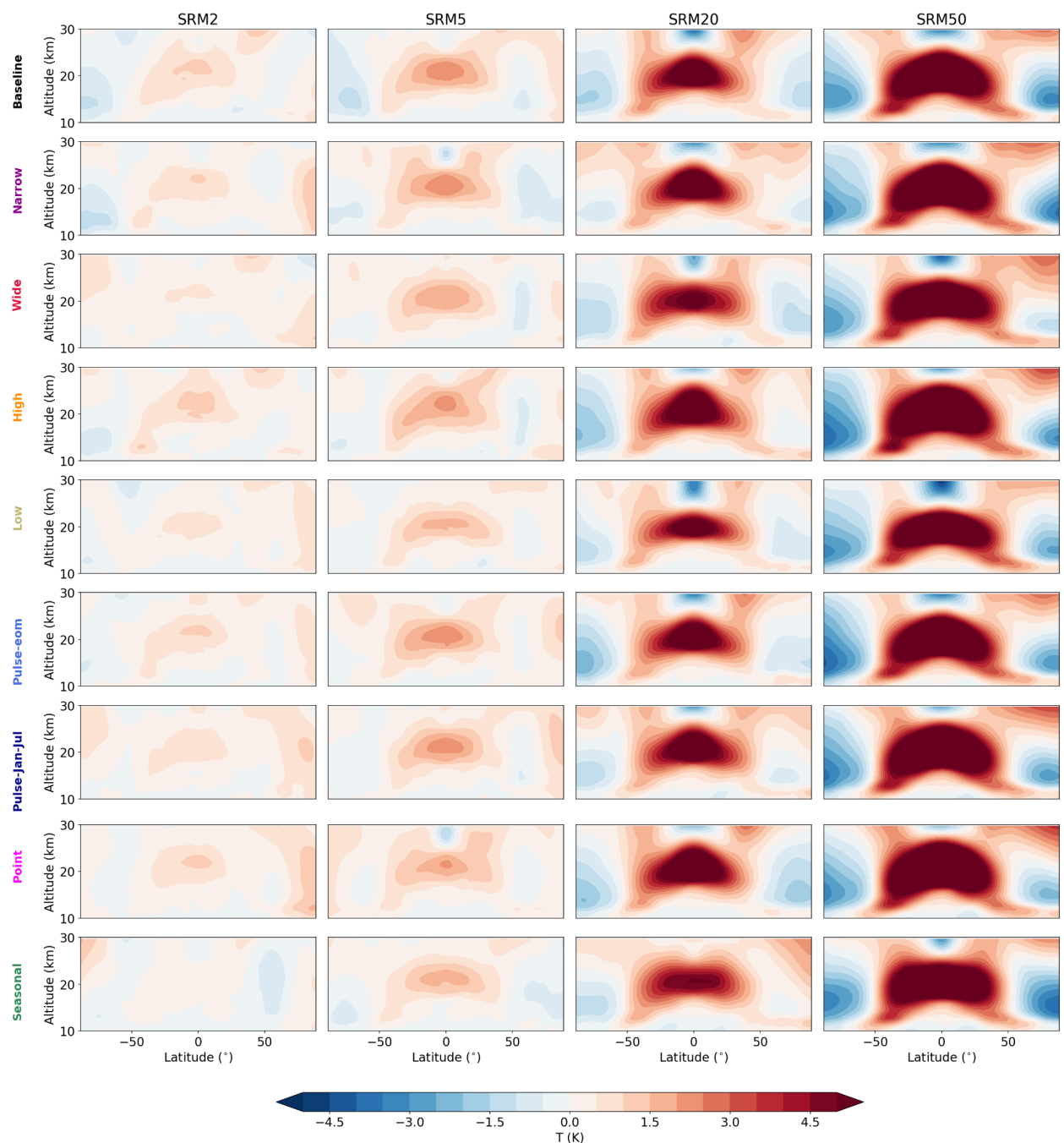
Figure S11. Temperature anomaly due to the stratospheric sulfur injection with different injection rates simulated with M7.
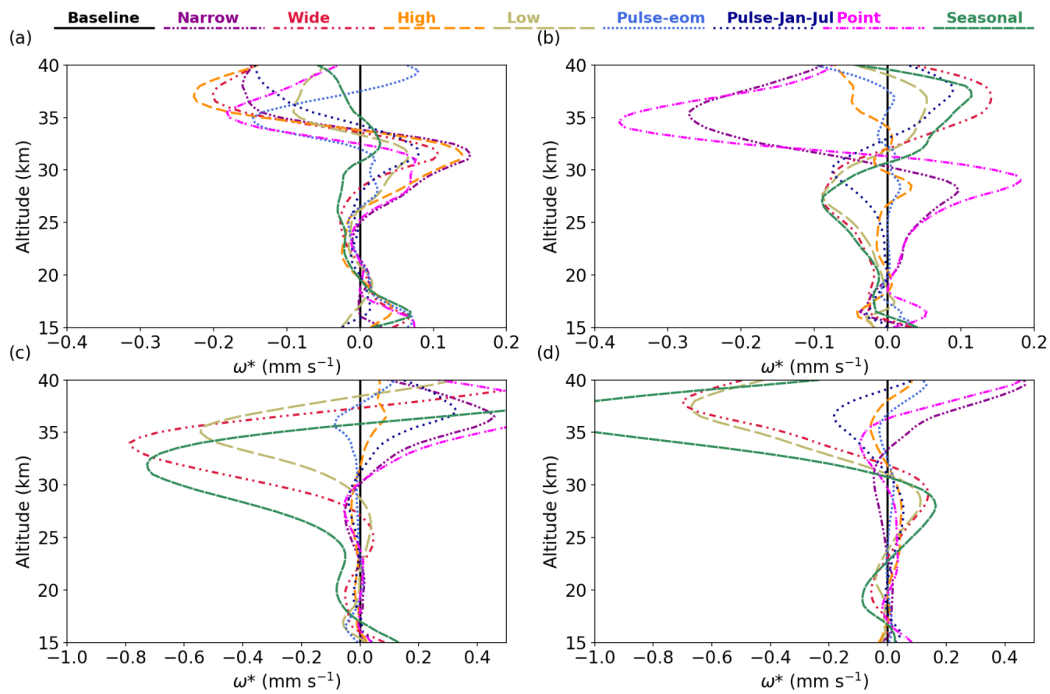
Figure S12. Residual vertical velocity in the tropics for different injection strategies compared to baseline scenario of corresponding injection rates (a-b 5 Tg(S)/yr and c-d 50 Tg(S)/yr) for SALSA (a,c) and M7 (b,d).
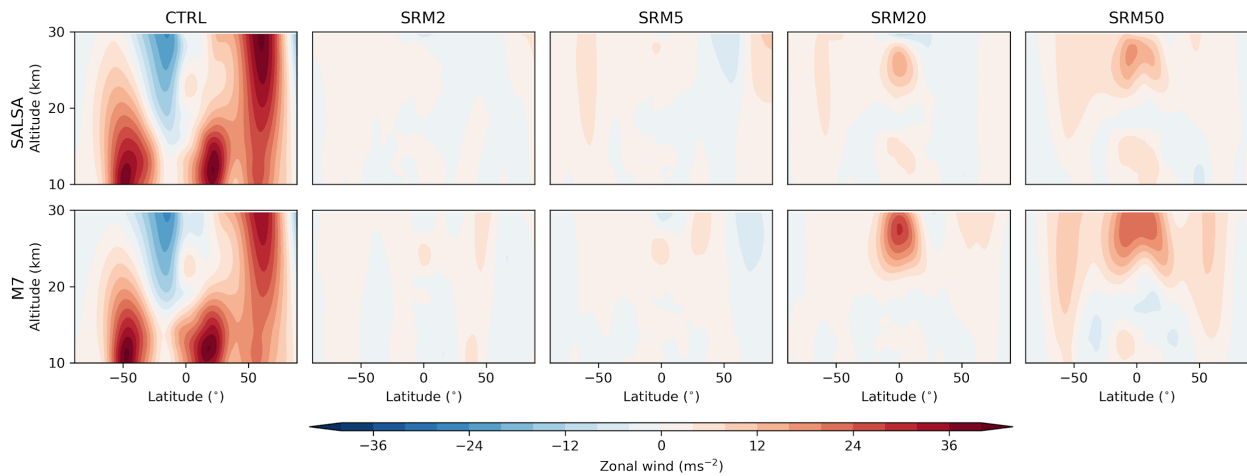
Figure S13. Zonal mean zonal wind (m/s) in CTRL scenarios and wind anomaly compared to CTRL in stratospheric sulfur injection scenarios in December-January-February
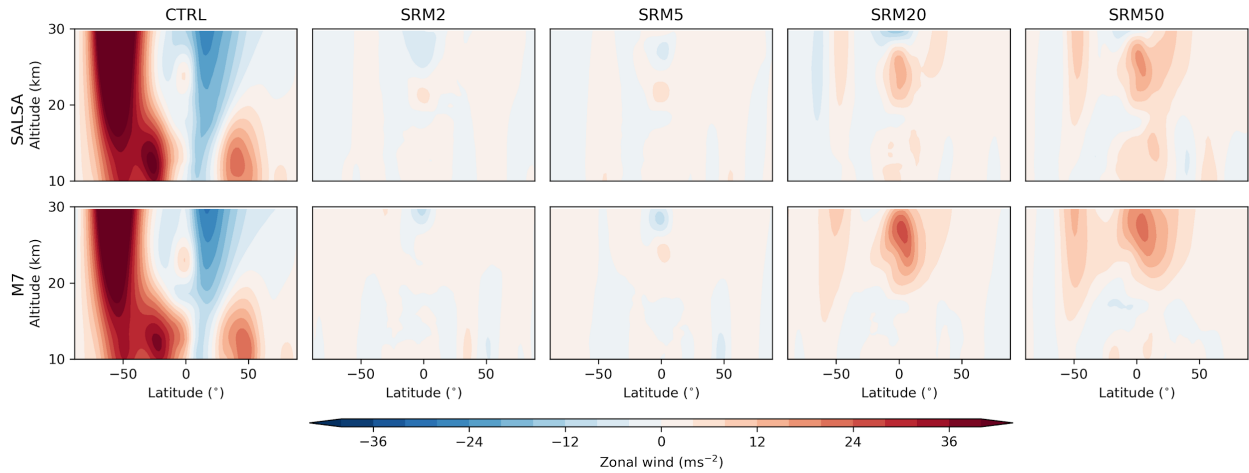
Figure S14. Zonal mean zonal wind (m/s) in CTRL scenarios and wind anomaly compared to CTRL in stratospheric sulfur injection scenarios in June-July-August
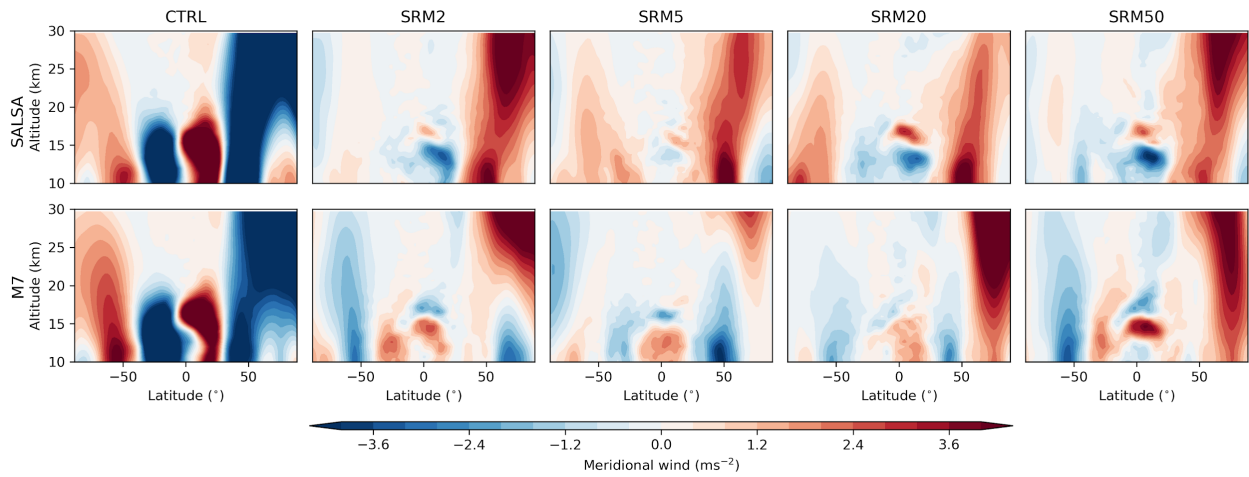
Figure S15. Zonal mean meridional wind (m/s) in CTRL scenarios and wind anomaly compared to CTRL in stratospheric sulfur injection scenarios in December-January-February
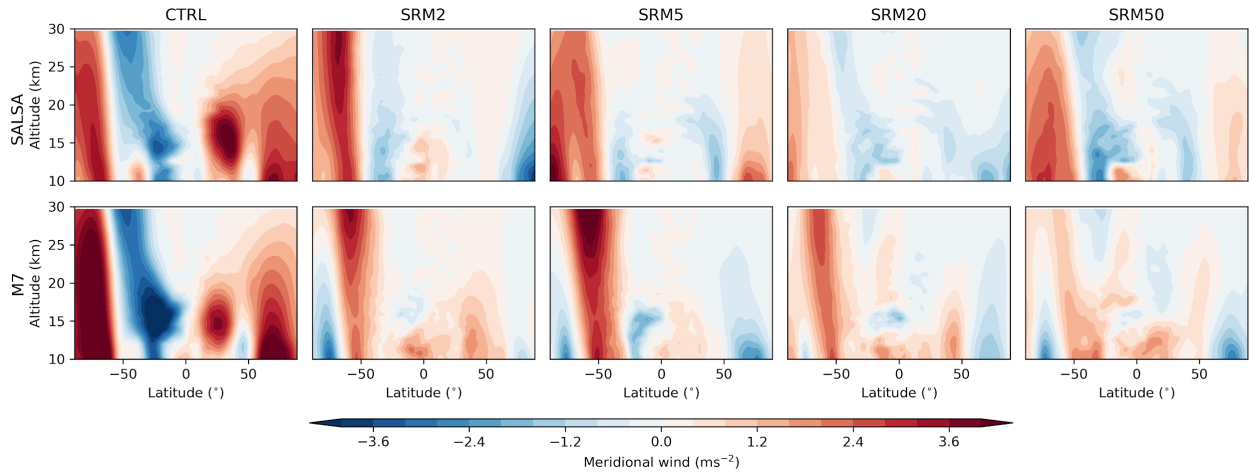
Figure S16. Zonal mean meridional wind (m/s) in CTRL scenarios and wind anomaly compared to CTRL in stratospheric sulfur injection scenarios in June-July-August
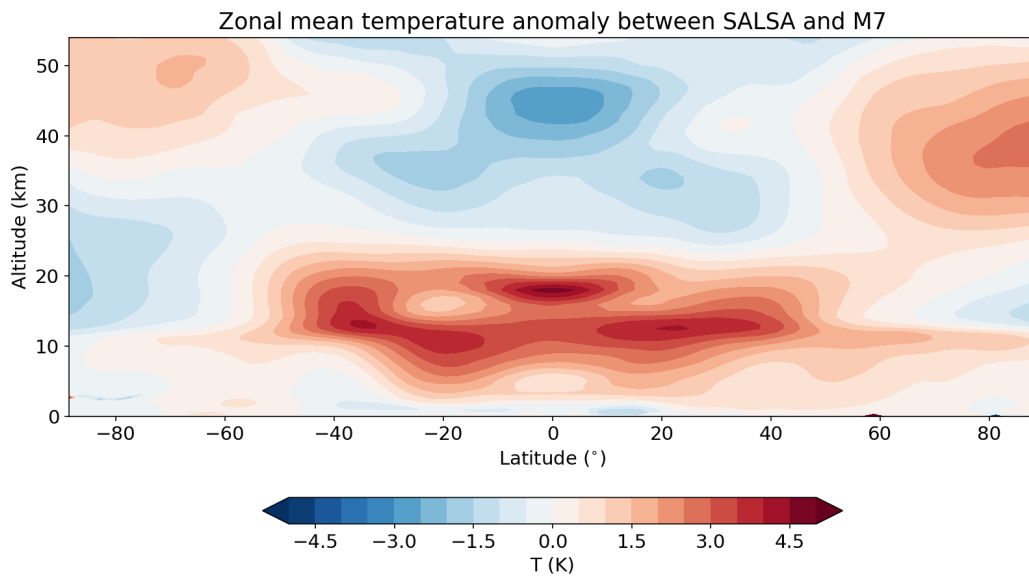
Figure S17. Zonal mean temperature difference between CTRL scenarios simulated with SALSA and M7.

Figure S18. Zonal mean zonal wind (m/s) at the Equator for simulated stratospheric sulfur injection scenarios with different injection rates.

Table S1: Global mean All-sky and Clear-sky radiative forcing in the simulated stratospheric sulfur injection scenarios.

All-sky

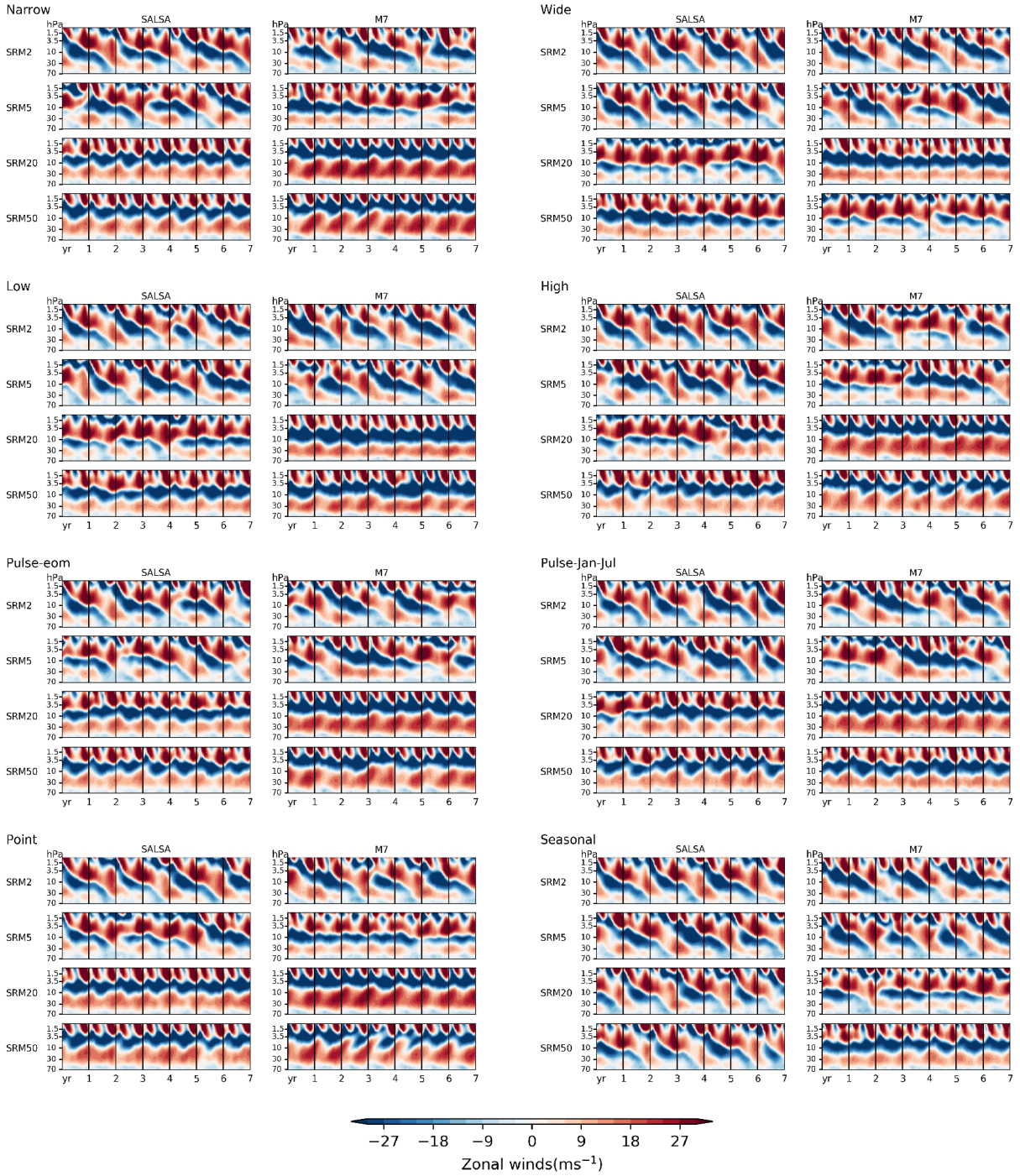| All-sky SW	TOA SW (W/m2)							TOA LW (W/m2)							TOA net (W/m2)						
Tg(S)/yr	1	2	5	10	20	50	100	1	2	5	10	20	50	100	1	2	5	10	20	50	100
SALSA Baseline	-1.17	-1.89	-3.84	-6.24	-9.95	-17.57	-27.27	0.12	0.24	0.55	01.01	1.88	4.14	7.55	-1.05	-1.65	-3.29	-5.23	-8.07	-13.43	-19.72
SALSA Narrow		-2.3	-4.41		-11.05	−19			0.28	0.6		02.04	4.36			-2.02	-3.81		-9.01	-14.64	
SALSA Wide		-1.83	-3.58		-9.7	-17.26			0.23	0.49		1.67	3.77			-1.6	-3.09		-8.03	-13.49	
SALSA High		-2.19	-4.41		-11.36	−20			0.27	0.62		02.09	4.62			-1.92	-3.79		-9.27	-15.38	
SALSA Low		-1.83	-3.73		-9.99	-17.77			0.22	0.47		1.62	3.64			-1.61	-3.26		-8.37	-14.13	
SALSA Pulse-eom		-2.13	-4.13		-10.84	-18.72			0.25	0.55		02.01	4.31			-1.88	-3.58		-8.83	-14.41	
SALSA Pulse-Jan-Jul		-2.56	-5.01		-12.94	-22.71			0.29	0.65		2.15	4.74			-2.27	-4.36		-10.79	-17.97	
SALSA Point		-2.48	-4.73		-12.23	-21.73			0.29	0.6		2.17	4.7			-2.19	-4.13		-10.06	-17.03	
SALSA Seasonal		-2.03	-4.11		-11.27	-19.86			0.26	0.52		1.8	3.99			-1.77	-3.59		-9.47	-15.87	
M7 Baseline	-0.76	-1.1	-2.07	-3.4	-5.84	-11.44	-18.78	0.2	0.34	0.74	1.34	2.51	5.78	10.78	-0.56	-0.76	-1.33	-2.06	-3.33	-5.66	−8
M7 Narrow		-1.16	-1.95		-5.66	-11.74			0.35	0.74		2.56	5.96			-0.81	-1.21		-3.1	-5.78	
M7 Wide		-1.12	-2.2		-6.3	-12.02			0.31	0.67		2.38	5.47			-0.81	-1.53		-3.92	-6.55	
M7 High		-1.35	-2.46		-7.03	-13.66			0.4	0.87		2.95	6.71			-0.95	-1.59		-4.08	-6.95	
M7 Low		-1.14	-2.34		-5.95	-10.38			0.25	0.59		2.12	4.85			-0.89	-1.75		-3.83	-5.53	
M7 Pulse-eom		-1.22	-2.1		−6	-11.24			0.38	0.74		2.57	5.83			-0.84	-1.36		-3.43	-5.41	
M7 Pulse-Jan-Jul		-1.49	-2.93		-8.45	-16.45			0.39	0.85		2.99	6.99			-1.1	-2.08		-5.46	-9.46	
M7 Point		-1.51	-2.8		-8.04	-19.19			0.38	0.84		2.99	7.49			-1.13	-1.96		-5.05	-11.7	
M7 Seasonal		-1.15	-2.63		-7.62	-15.15			0.28	0.72		2.54	5.95			-0.87	-1.91		-5.08	-9.2	

Clear-sky

Clear-sky SW	TOA SW (W/m2)							TOA LW (W/m2)							TOA net (W/m2)						
Tg(S)/yr	1	2	5	10	20	50	100	1	2	5	10	20	50	100	1	2	5	10	20	50	100
SALSA Baseline	-1.68	-2.72	-5.55	-8.97	-14.2	-24.88	-38.34	0.14	0.29	0.65	1.21	2.25	4.97	09.06	-1.54	-2.43	-4.9	-7.76	-11.95	-19.91	-29.28
SALSA Narrow		-3.32	-6.33		-15.67	-26.7			0.34	0.71		2.45	5.24			-2.98	-5.62		-13.22	-21.46	
SALSA Wide		-2.7	-5.28		-14.19	-25.33			0.28	0.58		2	4.54			-2.42	-4.7		-12.19	-20.79	
SALSA High		-3.14	-6.3		-16.22	-28.23			0.33	0.75		2.51	5.58			-2.81	-5.55		-13.71	-22.65	
SALSA Low		-2.74	-5.56		-14.5	-25.46			0.27	0.56		1.93	4.35			-2.47	−5		-12.57	-21.11	
SALSA Pulse-eom		-3.07	-5.98		-15.44	-26.48			0.3	0.66		2.41	5.17			-2.77	-5.32		-13.03	-21.31	
SALSA Pulse-Jan-Jul		-3.72	-7.23		-18.43	-31.96			0.35	0.77		2.59	5.72			-3.37	-6.46		-15.84	-26.24	
SALSA Point		-3.57	-6.83		-17.34	-30.47			0.35	0.72		2.61	5.67			-3.22	-6.11		-14.73	-24.8	
SALSA Seasonal		-3.02	-6.09		-16.52	-28.67			0.31	0.62		2.16	4.81			-2.71	-5.47		-14.36	-23.86	
M7 Baseline	-1.14	-1.67	-3.05	-5.02	-8.53	-16.43	-26.7	0.24	0.41	0.89	1.61	03.03	6.95	12.93	-0.9	-1.26	-2.16	-3.41	-5.5	-9.48	-13.77
M7 Narrow		-1.72	-2.85		-8.22	-16.89			0.43	0.9		03.07	7.2			-1.29	-1.95		-5.15	-9.69	
M7 Wide		-1.72	-3.31		-9.36	-17.57			0.37	0.81		2.88	6.6			-1.35	-2.5		-6.48	-10.97	
M7 High		-2.01	-3.61		-10.19	-19.6			0.5	01.05		3.58	8.12			-1.51	-2.56		-6.61	-11.48	
M7 Low		-1.74	-3.55		-8.85	-15.12			0.3	0.71		2.55	5.83			-1.44	-2.84		-6.3	-9.29	
M7 Pulse-eom		-1.8	-3.1		-8.79	-16.19			0.45	0.89		3.1	07.03			-1.35	-2.21		-5.69	-9.16	
M7 Pulse-Jan-Jul		-2.23	-4.34		-12.26	-23.42			0.47	01.03		3.62	8.46			-1.76	-3.31		-8.64	-14.96	
M7 Point		-2.25	-4.09		-11.6	-27.21			0.46	01.01		3.61	09.09			-1.79	-3.08		-7.99	-18.12	
M7 Seasonal		-1.78	−4		-11.33	-22.12			0.32	0.87		03.08	7.22			-1.46	-3.13		-8.25	-14.9	

Table S2: Effective radius, sulfate burden and lifetime of stratospheric sulfate aerosols in the simulated stratospheric sulfur injection scenario.

	Effective radius of stratos. aerosols (um)								Sulfate burden Tg(S)								Lifetime of injected sulfate						
Tg(S)/yr	1	2	5	10	20	50	100		1	2	5	10	20	50	100		1	2	5	10	20	50	100
SALSA Baseline	0.24	0.29	0.36	0.42	0.49	0.58	0.65		1.4	2.45	5.66	10.32	18.92	41.3	76.33		1.40	1.23	1.13	01.03	0.95	0.83	0.76
SALSA Narrow		0.28	0.36		0.51	0.6				2.82	6.25		20.82	44.33				1.41	1.25		01.04	0.89	
SALSA Wide		0.26	0.33		0.44	0.53				2.32	5.17		17.91	39.62				1.16	01.03		0.90	0.79	
SALSA High		0.29	0.37		0.49	0.59				2.84	6.43		21.46	47.22				1.42	1.29		01.07	0.94	
SALSA Low		0.24	0.3		0.42	0.51				2.24	05.07		17.04	37.99				1.12	01.01		0.85	0.76	
SALSA Pulse-eom		0.28	0.36		0.5	0.58				2.67	5.96		20.28	43.56				1.34	1.19		01.01	0.87	
SALSA Pulse-Jan-Jul		0.26	0.34		0.48	0.57				3.1	6.82		22.99	50.62				1.55	1.36		1.15	01.01	
SALSA Point		0.27	0.35		0.5	0.59				2.94	6.53		22.28	49.6				1.47	1.31		1.11	0.99	
SALSA Seasonal		0.24	0.31		0.42	0.52				2.54	5.76		19.96	44.28				1.27	1.15		1.00	0.89	
M7 Baseline	0.33	0.42	0.53	0.6	0.67	0.78	0.84		1.35	2.31	4.78	8.65	16.22	37.27	71.47		1.35	1.16	0.96	0.87	0.81	0.75	0.71
M7 Narrow		0.43	0.55		0.7	0.78				2.25	4.61		16.13	38.58				1.13	0.92		0.81	0.77	
M7 Wide		0.38	0.47		0.6	0.71				2.24	4.83		16.57	37.58				1.12	0.97		0.83	0.75	
M7 High		0.44	0.54		0.67	0.77				2.59	5.53		19.63	45.02				1.30	1.11		0.98	0.90	
M7 Low		0.3	0.38		0.56	0.71				02.01	4.42		14.4	31.2				01.01	0.88		0.72	0.62	
M7 Pulse-eom		0.42	0.53		0.67	0.79				2.34	4.84		16.46	37.3				1.17	0.97		0.82	0.75	
M7 Pulse-Jan-Jul		0.38	0.47		0.59	0.69				2.71	06.03		21.03	49.72				1.36	1.21		01.05	0.99	
M7 Point		0.37	0.49		0.62	0.65				2.74	5.78		20.38	55.74				1.37	1.16		01.02	1.11	
M7 Seasonal		0.35	0.42		0.54	0.62				2.43	5.43		18.99	44.74				1.22	01.09		0.95	0.89	