Supplement of Geosci. Model Dev., 11, 2581–2608, 2018
https://doi.org/10.5194/gmd-11-2581-2018-supplement

Supplement of

The Interactive Stratospheric Aerosol Model Intercomparison Project (ISA-MIP): motivation and experimental design

Claudia Timmreck et al.

Correspondence to: Claudia Timmreck (claudia.timmreck@mpimet.mpg.de)

Specifications	Reference
Greenhouse gases ODPs	As recommended for the SPARC CCMI hindcast scenario REF-C1SD (Eyring et al, 2013) http://www.met.reading.ac.uk/ccmi/?page_id=11
SST and SIC	Hadley Centre Sea Ice and Sea Surface Temperature data set (HADISST, Rayner et al., 2003) https://www.metoffice.gov.uk/hadobs/hadisst/

Table S1: Overview of background conditions.

Sulphur emission	Reference
SO_2 Anthropogenic	From MACC-CITY (Granier et al., 2011) for time period considered and as extended back to 1960 on ECCAD website http://eccad.sedoo.fr/eccad_extract_interface/JSF/page_login.jsf
SO_2 Biomass burning	Biomass burning: GFEDv4 (http://www.globalfiredata.org/index.html) From MACC-CITY (Granier et al., 2011) for time period considered and as extended back to 1960 on ECCAD website)
Continuously degassing volcanoes	"continuous_volc.1x1" from Aerocom-I (Dentener et al., 2006) based on Andres and Kasgnoc (1998) which presents an average estimate of the contribution of silent degassing volcanoes to the global sulphur budget, http://aerocom.met.no/download/emissions/AEROCOM_B-PRE/other_ascii/
DMS	Sea water concentration from Lana et al. (2011) is recommended ,https://www.bodc.ac.uk/solas_integration/implementation_products/group1/dms/ Biogenic modeller's choice
OCS	Concentrations are fixed at surface and equal to 510 pptv (Montzka et al., 2013; ASAP2006)

Table S2: Overview of sulphur emission.

Name	Description
nh_50	Passive tracer with fix surface concentration equal to 100 ppb between 30˚N and 50˚N and equal to 0 outside of this latitudinal band, e-folding decay time of 50 days
tr_50	Passive tracer with fix surface concentration equal to 100 ppb between 20˚S and 20˚N and equal to 0 outside of this latitudinal band, e-folding decay time of 50 days;
sh_50	Passive tracer with fix surface concentration equal to 100 ppb between 50˚S and 30˚S and equal to 0 outside of this latitudinal band, e-folding decay time of 50 days.
AOA	Passive tracer for the stratospheric mean age-of-air. Modelling groups can use their existing implementation or implement a tracer with a global fixed surface layer mixing ratio of 0 ppbv and a uniform unspecified fixed source (at all levels) everywhere else, which must be constant in space and time.
ST80_25	Passive tracer to estimate the exchange from the stratosphere to the troposphere. This is achieved by fixing the mixing ratio above 80hPa (200ppbv) to a constant value, and imposing a uniform fixed 25-day exponential decay in the troposphere only.
Volc	Passive volcanic tracer for the HerSEA experiments. The tracer is initialized in the same way as the volcanic SO_2 emission, with an initial value of 1.

Table S3: Suggested passive tracers mostly following the CCM protocol (Eyring et al., 2013).

Long name	**Variable name**	**Unit**	**Category**	**Comment**
grid-cell area	area	m^2	1	
land fraction	landf	1	1	Please express "X_area_fraction" as the fraction of horizontal area occupied by X.
surface altitude	orog	m	1	"Surface" means the lower boundary of the atmosphere. Altitude is the (geometric) height above the geoid, which is the reference geopotential surface.
Meteorology				
Precipitation	precip	kg m^{-2} s^{-1}	1	Includes all types: rain, snow, large-scale, convective, etc.
surface temperature	tas	K	1	
surface air pressure	ps	Pa	1	"Surface" means the lower boundary of the atmosphere.
Cloud fraction	clt	%	1	Cloud fraction as seen from top or surface
tropopause_air_pressure	ptp	Pa	2	2D monthly mean thermal tropopause calculated using WMO tropopause definition on 3d temperature
tropopause_air_temperature	tatp	K	2	See above
tropopause_altitude	ztp	M	2	See above
Budget				
Load of H2SO4 (aerosol)	loadso4	kg m^{-2}	1	Units of the particle-phase-sulphur should be using mass of H2SO4
Load of SO2(g)	loadso2	kg m^{-2}	1	
Load of H2SO4(g)	loadh2so4	kg m^{-2}	1	
Load of OCS	loadocs	kg m^{-2}	1	
Load of DMS	loaddms	kg m^{-2}	2	
Load of H2S	loadh2s	kg m^{-2}	3	
Load of CS2	loadcs2	kg m^{-2}	3	
Removal				
dry deposition of DMS	drysdms	kg m^{-2} s^{-1}	2	
dry deposition of SO2	dryso2	kg m^{-2} s^{-1}	1	
dry deposition of H2SO4(g)	dryh2so4	kg m^{-2} s^{-1}	1	
dry deposition of H2SO4(p)	dryso4	kg m^{-2} s^{-1}	1	
sedimentation of SO4	sedso4	kg m^{-2} s^{-1}	1	
dry deposition of H2S	dryh2s	kg m^{-2} s^{-1}	2	
dry deposition of C2S	dryc2s	kg m^{-2} s^{-1}	2	
wet deposition of SO2	wetso2	kg m^{-2} s^{-1}	1	
wet deposition of H2SO4(p)	wetso4	kg m^{-2} s^{-1}	1	
wet deposition of DMS	wetdms	kg m-^{2} s^{-1}	2	
wet deposition of C2S	wetc2s	kg m^{-2} s^{-1}	2	
wet deposition of H2S	weth2s	kg m^{-2} s^{-1}	2	
Emission				
total emission of SO2	emiso2	kg m^{-2} s^{-1}	1	
total emission of DMS	emidms	kg m^{-2} s^{-1}	2	
total emission of COS	emicos	kg m-2 s-1	1	If available
total emission of DMS	emih2s	kg m-2 s-1	1	
total emission of CS2	emic2s	kg m-2 s-1	3	
Fluxes				
So2 Flux to the tropopause	flxso2	kg m^{-2} s^{-1}	1	
H2SO4(p)Flux through the tropoause (total)	flxso4t	kg m^{-2} s^{-1}	1	
H2SO4 Flux (tropopause) per size class/modes	flxso4_	kg m^{-2} s^{-1}	3	
Flux H2SO4 (p) > 5nm	flxso4p150	kg m^{-2} s^{-1}	2	
Flux H2SO4 (p) >150nm	flxso4p150	kg m^{-2} s^{-1}	2	
Flux H2SO4 (p) >250nm	flxso4p250	kg m^{-2} s^{-1}	2	
Flux H2SO4 (p) >550nm	flxso4p550	kg m^{-2} s^{-1}	2	
Flux H2SO4 (p) >750nm	flxso4p750	kg m^{-2} s^{-1}	2	
Flux H2SO4 (p) >1000nm	flxso4p1000	kg m^{-2} s^{-1}	2	

Radiation				
AOD@386nm	od386aer	1	2	
AOD@453nm	od453aer	1	2	
AOD@525nm	od525aer	1	1	
AOD@750nm	od750aer	1	2	
AOD@870nm	pd870aer	1	2	
AOD@1020nm	od1020aer	1	1	
AOD@3460nm	od3460aer	1	2	
AOD@5260nm	od5260aer	1	2	
AOD@12660nm	od5260aer	1	2	
Surface downwelling SW radiation	rsds	W m^{-2}	1	
Surface upwelling SW radiation	rsus	W m^{-2}	1	
Surface downwelling LW radiation	rlds	W m^{-2}	1	
Surface upwelling LW radiation	rldus	W m^{-2}	1	
Surface downwelling SW flux clear sky	rsdscs	W m^{-2}	2	
Surface upwelling SW flux clear sky	rsuscs	W m^{-2}	2	
Surface upwelling LW flux clear sky	rldcs	W m^{-2}	2	
Surface diffuse SW flux	rsdsdiff	W m^{-2}	2	
Surface diffuse SW flux clear sky	rsdscsdiff	W m^{-2}	2	
TOA Incident	rst	W m^{-2}	2	
TOA downwelling SW radiation	rsdt	W m^{-2}	1	
TOA downwelling LW radiation	rldt	W m^{-2}	1	
TOA outgoing SW radiation	rsut	W m^{-2}	1	
TOA outgoing SW radiation clear sky	rsutcs	W m^{-2}	2	
TOA outgoing LW radiation	rlut	W m^{-2}	1	
TOA outgoing LW radiation clear sky	rlutcs	W m^{-2}	2	
Total photsynthtically FLUX (PAR)	tphotpar	W m^{-2}	3	
photsynthtically FLUX (PAR)	photpar	W m^{-2}	3	

Table S4: Overview of two-dimensional variables requested for ISA-MIP following mainly the AEROCOM protocols: http://aerocom.met.no/protocol.html. (1) indicates mandatory variables, which are in addition shaded, (2) important variables but not required, (3) values which are nice to have for special diagnostic. Monthly mean output is satisfactory except for the meteorological values, which should be provided in daily resolution.

Long name	Variable name	Unit	Category	Comment
Meteorology				
air temperature	ta	K	1	Air temperature is the bulk temperature of the air, not the surface (skin) temperature.
specific humidity	hus	1	1	Specific means per unit mass. Specific humidity is the mass fraction of water vapor in (moist) air.
air mass	airmass	kg m^{-2}	1	Vertically integrated mass content of air in layer
pressure	pfull	Pa	1	Air pressure on model levels
zonal wind	ua	m/s	1	
meridional wind	va	m/s	1	
vertical wind	wa	m/s	1	
geopotential height	Zg	m	1	
cloud fraction	clt3D	%	2	
cloud optical depth	cod3D	1	2	
aerosol water	mmraerh2o	1	3	
convective updraft mass flux	mcu	kg m-^{2} s^{-1}	3	The atmosphere convective mass flux is the vertical transport of mass for a field of cumulus clouds or thermals, given by the product of air density and vertical velocity. For an area-average, cell_methods should specify whether the average is over all the area or the area of updrafts only.
Sulfur Chemistry				
OCS	vmrocs	1	1	
SO2	vmrso2	1	2	
DMS	vmrdms	1	2	
H2S	vmr h2s	1	3	
H2SO4 (g)	vmrh2so4	1	2	
CS2	vmrcs	1	3	
SO3	vmrso3	1	2	
H2SO4 (p) total)	mmso4r	1	1	Mass mixing ratio of sulphate mass (total)
Mass mixing ratio of sulfate mass in each size class				
H2SO4 (p) > 5nm	mmso4r5	1	2	OPC
H2SO4 (p) >150nm	mmso4r15	1	2	OPC
H2SO4 (p) >250nm	mmso4r25	1	2	OPC
H2SO4 (p) >550nm	mmso4r55	1	2	OPC
H2SO4 (p) >750nm	mmso4r75	1	2	OPC
H2SO4 (p) >1000nm	mmso4r100	1	2	OPC
Microphysical processes				
number formation through nucleation	nucpn	m^{-3} s^{-1}	2	
sedimentation of SO4	sedso4	kg m^{-2} s^{-1}	2	Net downward (out-below minus in-above)
H2SO4 condensation flux	conh2so4	kg m^{-2} s^{-1}	2	Net transfer into the particulate phase
Chemistry				
N2O	vmrn2o	1	3	
OH	vmroh	1	1	
O3	vmro3	1	1	
HNO3	vmrhno3	1	3	
NO	vmrno	1	3	
NO2	vmrno2	1	3	
N2O5	vmrn2o5	1	3	
Bulk parameters				
surface area density	sad	m^2/m^3	1	
effective radius	reff	M	1	
Particle numbers				
N total	conccn	m^{-3}	1	number_concentration_of_ambient_aerosol_in_air
N> 5nm	conc5	m^{-3}	2	CPC
N>150nm	conc150	m^{-3}	2	OPC
N>250nm	conc250	m^{-3}	2	OPC
N>550nm	conc550	m^{-3}	2	OPC
N>750nm	conc750	m^{-3}	2	OPC

N>1000nm	conc1000	m^{-3}	2	OPC
Extinction				
Aerosol extinction @386nm	ec386aer	m^{-1}	2	SAGEII/III, (POAM, shipborne lidar)
Aerosol extinction @440nm	ec440aer	m-^{1}	3	
Aerosol extinction @525nm	ec525aer	m-^{1}	1	SAGE-II
Aerosol extinction @750nm	ec750aer	m^{-1}	2	OSIRIS
Aerosol extinction @870nm	ec870aer	m^{-1}	3	
Aerosol extinction @1020nm	ec1020aer	m^{-1}	1	SAGEII
Aerosol extinction @3460nm	ec3460aer	$m^{-}1$	2	HALOE
Aerosol extinction @5260nm	ec5260aer	m-1	2	HALOE
aerosol extinction @12660nm	ec12660aer	m^{-1}	3	ISAMS
Absorption				
aerosol absorption @386nm	abs386aer	m^{-1}	3	SAGEII/III, (POAM, shipborne lidar)
aerosol absorption@440nm	abs440aer	m^{-1}	3	
aerosol absorption @525nm	abs525aer	m^{-1}	2	SAGE-II
aerosol absorption@750nm	abs750aer	m^{-1}	3	OSIRIS
aerosol absorption @870nm	abs870aer	m^{-1}	3	
aerosol absorption @1020nm	abs1020aer	m^{-1}	2	SAGE-II
aerosol absorption @3460nm	abs3460aer	m^{-1}	3	HALOE
aerosol absorption @5260nm	abs5260aer	m^{-1}	3	HALOE
aerosol absorption @12660nm	abs12660aer	m^{-1}	3	ISAMS
asymmetry factor@525nm	asy525aer	1	1	

Table S5: Overview of three-dimensional variables requested for ISA-MIP following mainly the AEROCOM protocols: http://aerocom.met.no/protocol.html. All 3D data to be provided on either host model vertical levels or preferably (if resources allow) on the reference pressure levels 1000, 925, 850, 700, 600, 500, 400, 300, 250,200, 150, 100, 70, 50, 30, 20 & 10 hPa. If possible also on the additional pressure levels: 7, 5, 3, 2, 1 and 0.4 hPa. (1) indicates mandatory variables, which are in addition shaded, (2) important variables but not required, (3) values which are nice to have for special diagnostic. Monthly mean output is satisfactory except for the meteorological values, which should be provided in daily resolution.

Volcano	Lon	Lat	Time	Min Plume Height (km)	Max Plume Height (km)	Mean SO2 (kt)
Manam	145.04	-4.08	27 Jan 2005	18	24	154.67
Soufriere Hills	297.82	16.72;	19 May 2006;;	19	20	185.33
Rabaul/Tavurvur	152.20	-4.27;	7 Oct 2006	17	18	234.0
Okmok	168.10	53.43	12 Jul 2008	10	16	109.0
Kasatochi	175.50	52.18	7 Aug 2008	10	18	1363.33
Sarychev	153.20	48.09	15 Jun 2009	11	17	965.33
Merapi	110.44	-7.54	4 Nov 2010	14	17	282.67
Nabro	41.70	13.37;	13 Jun 2011	9.7	18	1307.0

Table S6: Overview of VolcDSUB, a subset of volcanic emissions, that were derived based on the average mass of SO_2 emitted using VolcDB1, VolcDB2, and VolcDB3. (http://isamip.eu/fileadmin/user_upload/isamip/volc_sub_v185.dat).

References

Andres, R. J. and Kasgnoc, A. D.: A time-averaged inventory of subaerial volcanic sulfur emissions, J. Geophys. Res., 103, 25251–25261, 1998.

Bingen, C., Robert, C. E., Stebel, K., Brühl, C., Schallock, J., Vanhellemont, F., Mateshvili N., Höpfner, M., Trickl, T., Barnes, J.E., Jumelet, J., Vernier, J.-P. ,Popp T, Gerrit de Leeuw, G., Pinnock, S.: Stratospheric aerosol data records for the climate change initiative: Development, validation and application to chemistry-climate modelling. Remote Sensing of Environment. https://doi.org/10.1016/j.rse.2017.06.002, 2017

Brühl, C., Lelieveld, J., Tost, H., Höpfner, M, and Glatthor, N.: Stratospheric sulphur and its implications for radiative forcing simulated by the chemistry climate model EMAC, J. Geophys. Res.-Atmos., 120, 2103–2118, doi:10.1002/2014JD022430, 2015.

Dentener, F., Kinne, S., Bond, T., Boucher, O., Cofala, J., Generoso, S., Ginoux, P., Gong, S., Hoelzemann, J. J., Ito, A., Marelli, L., Penner, J. E., Putaud, J.-P., Textor, C., Schulz, M., van der Werf, G. R., and Wilson, J.: Emissions of primary aerosol and precursor gases in the years 2000 and 1750 prescribed data-sets for AeroCom, Atmos. Chem. Phys., 6, 4321-4344, doi:10.5194/acp-6-4321-2006, 2006.

Eyring, V., J.-F. Lamarque et al., Overview of IGAC/SPARC Chemistry-Climate Model Initiative (CCMI) Community Simulations in Support of Upcoming Ozone and Climate Assessments, SPARC Newsletter No. 40, p. 48-66, 2013

Grams, G. and Fiocco, G.: Stratospheric Aerosol Layer during 1964 and 1965, J. Geophys. Res., vol. 72(14), 3523-3542, 1967.

Granier, C., Bessagnet, B., Bond, T. C., D'Angiola, A., Denier van der Gon, H., Frost, G. J., Heil, A., Kaiser, J. W., Kinne, S., Klimont, Z., Kloster, S., Lamarque, J.-F., Liousse, C., Masui, T., Meleux, F., Mieville, A., Ohara, T., Raut, J.-C., Riahi, K., Schultz, M. G., Smith, S. J., Thompson, A., Aardenne, J.,Werf, G. R., and Vuuren, D. P.: Evolution of anthropogenic and biomass burning emissions of air pollutants at global and regional scales during the 1980-2010 period. Climatic Change, 109, 163-190, DOI: 10.1007/s10584-011-0154-1, 2011.

Lana, A., Bell, T. G., Sinó, R., Vallina, S. M., Ballabrera-Poy, J., Kettle, A. J., Dachs, J., Bopp, L., Saltzman, E. S., Stefels, J., Johnson, J. E., and Liss, P. S.: An updated climatologyof surface dimethlysulfide concentrations and emission fluxesin the global ocean, Global Biogeochem. Cy., 25, GB1004,doi:10.1029/2010gb003850, 2011.

Montzka, S. A., Calvert, P., Hall, B. D., Elkins, J. W., Conway, T. J., Tans, P. P., and Sweeney, C.: On the global distribution, seasonality, and budget of atmospheric carbonyl sulfide and some similarities with CO2, J. Geophys. Res., 112, D09302, doi:10.1029/2006JD007665, 2007.

Rayner, N. A., D. E. Parker, E. B. Horton, C. K. Folland, L. V. Alexander, D. P. Rowell, E. C. Kent, and A. Kaplan, Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century, J. Geophys. Res.,108 14), 4407, doi:10.1029/2002JD002670, 2003.

SPARC: Assessment of Stratospheric Aerosol Properties (ASAP), SPARC Report No. 4, edited by: Thomason, L. and Peter, T., World Climate Research Programme WCRP-124, WMO/TD No. 1295, 2006.