Atmospheric Composition and Asian Monsoon (ACAM) – A coordinated modeling and analysis project

Wiki website: https://wiki.met.no/aerocom/phase3-experiments#atmospheric_composition_and_asian_monsoon_acam_analysis
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Updated on March,8, 2020

Motivation:

The Asian monsoon system is a major component in Earth's climate. Given rapid population and economic growth across the Asian monsoon region, serious concern has emerged that coupling between the monsoon system and surface emissions is having increasingly significant effects not only on regional air quality but also on global atmospheric composition. This proposed activity represents a coordinated modeling and analysis effort among the AeroCom, CCMI, and ACAM communities to study interactions between Asian air pollution and the monsoon system.

Objectives:

- Compare and evaluate model-simulated aerosol and related species in the Asian monsoon region with observations from remote sensing and recent ground-based and aircraft measurements
- Identify and examine pathways of trace gases and aerosols in the UTLS above the Asian monsoon with respect to the monsoon anticyclone, large-scale transport, and atmospheric chemistry
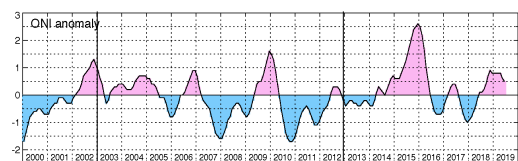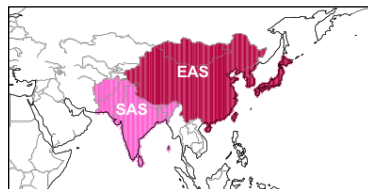- Investigate interactions between Asian pollution and monsoon meteorology

Type of Simulations:

The following model experiments and outputs are proposed for ACAM. Note that these model experiments are the same as AeroCom Phase III UTLS Tier 2 experiments except for a shorter simulation period. Thus, modelers participating in the UTLS experiment with Tier 2 simulations do not need to repeat the model simulations, and the UTLS experiment results will be used for the ACAM analysis (and vice versa).

Model experiments:

Simulation period:	2008-2017 (10 years)
Experiments:	
▪ BASE	Model simulation with all emissions
▪ FIR0	Same as BASE but without fire emissions globally
▪ ANT0	Same as BASE but without fossil fuel/biofuel emissions globally
▪ EAS0 (use region mask)	Same as BASE but without East Asian fossil fuel/biofuel emissions
▪ SAS0 (use region mask)	Same as BASE but without South Asian fossil fuel/biofuel emissions
Region mask:	https://tropo.gsfc.nasa.gov/gocart/products/xchange/aerocom/aerocom3/region_code/
	file name = region-code_htap2_tier1_mod_0.5x0.5.nc (0.5 deg resolution)

Emissions (see AeroCom Phase III wiki for access to [the emission files](#)):

Emission amount
  ▪ Anthropogenic:
  ▪ Biomass burning:
  ▪ Volcanic:
  ▪ Natural (dust, seasalt, biogenic):
	CMIP6
	CMIP6
	Carn dataset, SO_2 from eruptive and degassing volcanoes
	Model-calculated or specified

Emission height
  ▪ Anthropogenic:
  ▪ Biomass burning:
  ▪ Volcanic:
	
	Surface layer
	Boundary layer
	Eruptive: top listed in Carn dataset. Degassing: crater to 1km above

Met. field	CTM or free run
Transport tracer:	CO with prescribed sources (will be provided) and 50-day lifetime (see description in "Tracer for transport" on AeroCom Phase III wiki page)
Wet/dry deposition tracer:	Pb-210 produced from Rn-222 decay (5.5-day lifetime) with removal (dry and wet deposition) processes prescribed as for sulfate (see description in "Tracer for removal" on the AeroCom Phase III wiki page)
Model Output:	See below; more information can be found in the file specification document on the AeroCom Phase III [wiki page](#) under the "UTLS" experiment heading

Model output:

> Notes:
> - ▪ Your AeroCom file name (one variable per file) should look like this:

aerocom3_⟨ModelName⟩_ACAM-⟨PerturbationName⟩_⟨VariableName⟩_⟨VerticalCoordinateType⟩_⟨Year⟩_monthly.nc

> Examples:
> > 2-D: aerocom3_GEOS-i33p2_ACAM-BASE_ps_Surface_2008_monthly.nc
> > 3-D: aerocom3_GEOS-i33p2_ACAM-EAS0_rho_ModelLevel_2009_monthly.nc

> Where the ⟨VariableName⟩ is in lower case, and the ⟨VerticalCoordinateType⟩ for each set of variables is varying and listed in the tables below (Mixed with Upper and lower cases).
> - Please submit the essential variables listed below. These are "priority 1" variables listed in the AeroCom III Excel sheet. You can refer to AeroCom III-UTLS output specifications for detailed information and requirements there (the required diagnostic fields are listed under column "UTLS"). You are also encouraged to submit the "priority 2" variables if they are available.

> a) 2-D fixed:

Variable	Variable name [+]	Variable Unit [+]
Surface altitude (relative to the sea level)	orog	m
area of each grid	areacella	m2
Land area fraction	sftlf	1

> b) 2-D variables:

Variable	Variable name [+]	Variable Unit [+]	Temporal frequency	Evaluation Datasets
Met. fields	VerticalCoordinateType: Surface			
Surface air pressure	ps	Pa	Monthly	
Tropopause air pressure	ptp	Pa	Monthly	
Tropopause altitude	ztp	m	Monthly	
Tropopause air temperature	tatp	K	Monthly	
Sea surface temperature	tos	K	Monthly	
Near-surface air temperature	tas	K	Monthly	
Precipitation	pr	kg m-2 s-1	Monthly	
Atmospheric boundary layer thickness	bldep	m	Monthly	
Total cloud fraction	clt	1	Monthly	
Convective cloud area fraction	convclt	1	Monthly	
Radiation	VerticalCoordinateType: Surface			
TOA outgoing shortwave radiation	rsut	W m-2	Monthly	
TOA incident shortwave radiation	rsdt	W m-2	Monthly	
TOA outgoing clear-sky shortwave radiation	rsutcs	W m-2	Monthly	
TOA outgoing longwave radiation	rlut	W m-2	Monthly	
TOA outgoing clear-sky longwave radiation	rlutcs	W m-2	Monthly	
surface downwelling shortwave radiation	rsds	W m-2	Monthly	
surface upwelling shortwave radiation	rsus	W m-2	Monthly	
surface downwelling longwave radiation	rlds	W m-2	Monthly	
surface upwelling longwave radiation	rlus	W m-2	Monthly	
TOA outgoing shortwave radiation without aerosol radiative effect	rsutca	W m-2	Monthly	
TOA outgoing clear-sky shortwave radiation without aerosol radiative effect	rsutcsca	W m-2	Monthly	
TOA outgoing longwave radiation without aerosol radiative effect	rlutca	W m-2	Monthly	
Emission	VerticalCoordinateType: Surface			
Emission rate of black carbon aerosol mass	emibc	kg m-2 s-1	Monthly	
Primary emission rate of dry aerosol organic matter	emioa	kg m-2 s-1	Monthly	
Emission rate of anthropogenic organic matter	emiaoa	kg m-2 s-1	Monthly	
Chemical production of dry anthropogenic secondary organic matter	chepasoa	kg m-2 s-1	Monthly	
Total emission rate of SO2	emiso2	kg m-2 s-1	Monthly	
Total direct emission rate of SO4	emiso4	kg m-2 s-1	Monthly	

Total emission rate of DMS	emidms	kg m-2 s-1	Monthly		
Total emission rate of NH3	eminh3	kg m-2 s-1	Monthly		
Total emission rate of sea salt	emiss	kg m-2 s-1	Monthly		
Total emission rate of dust	emidust	kg m-2 s-1	Monthly		
Emission of artificial CO with 50-day lifetime	emco50	kg m-2 s-1	Monthly		
Emission of Rn-222 with 5.5 day lifetime	emrn	kg m-2 s-1	Monthly		
Deposition and concentration	VerticalCoordinationType: Surface				
Dry deposition rate of black carbon aerosol mass	drybc	kg m-2 s-1	Monthly		
Dry deposition rate of organic matter	dryoa	kg m-2 s-1	Monthly		
Dry deposition rate of SO2	dryso2	kg m-2 s-1	Monthly		
Dry deposition rate of SO4	dryso4	kg m-2 s-1	Monthly		
Dry deposition rate of NH3	drynh3	kg m-2 s-1	Monthly		
Dry deposition rate of NH4	drynh4	kg m-2 s-1	Monthly		
Dry deposition rate of sea salt	dryss	kg m-2 s-1	Monthly		
Dry deposition rate of dust	drydust	kg m-2 s-1	Monthly		
Wet deposition rate of black carbon aerosol mass	wetbc	kg m-2 s-1	Monthly		
Wet deposition rate of organic matter	wetoa	kg m-2 s-1	Monthly		
Wet deposition rate of SO2	wetso2	kg m-2 s-1	Monthly		
Wet deposition rate of SO4	wetso4	kg m-2 s-1	Monthly		
Wet deposition rate of NH3	wetnh3	kg m-2 s-1	Monthly		
Wet deposition rate of NH4	wetnh4	kg m-2 s-1	Monthly		
Wet deposition rate of sea salt	wetss	kg m-2 s-1	Monthly		
Wet deposition rate of dust	wetdust	kg m-2 s-1	Monthly		
Wet deposition rate of Pb-210	wetpb	kg m-2 s-1	Monthly		
Dry deposition rate of Pb-210	drypb	kg m-2 s-1	Monthly		
Surface concentration of BC	sconcbc [#]	kg m-3	Monthly		
Surface concentration of OA	sconcoa [#]	kg m-3	Monthly		
Surface concentration of SO4	sconcso4 [#]	kg m-3	Monthly		
Surface concentration of $PM_{2.5}$	sconcpm25 [#]	kg m-3	Monthly		
Load	VerticalCoordinateType: Column				
Column black carbon mass load	loadbc	kg m-2	Monthly		
Column organic aerosol mass load	loadoa	kg m-2	Monthly		
Column secondary organic aerosol mass load	loadsoa	kg m-2	Monthly		
Column dust mass load	loaddu	kg m-2	Monthly		
Column PM1 dust mass load	loadlt1d	kg m-2	Monthly		
Column sea-salt mass load	loadss	kg m-2	Monthly		
Column PM1 sea-salt mass load	loadlt1ss	kg m-2	Monthly		
Column PM2p5 sea-salt mass load	loadlt25ss	kg m-2	Monthly		
Column sulfate mass load	loadso4	kg m-2	Monthly		
Column methanesulfonic acid mass load	loadmsa	kg m-2	Monthly		
Column sulfur dioxide mass load	loadso2	kg m-2	Monthly		

Column dimethyl sulfide mass load	loaddms	kg m-2	Monthly		
Column nitrate mass load	loadno3	kg m-2	Monthly		
Column ammonium mass load	loadnh4	kg m-2	Monthly		
Column ammonia mass load	loadnh3	kg m-2	Monthly		
Column nitric acid mass load	loadhno3	kg m-2	Monthly		
Column Rn-222 mass load	loadrn	kg m-2	Monthly		
production of Pb-210 from Rn-222 decay	prodpb	kg m-2	Monthly		
Optical depth	VerticalCoordinateType: Column				
Cloud optical depth	dtau	1	Monthly		
ambient aerosol optical thickness at 550 nm	od550aer	1	Monthly		AERONET, MODIS, MISR
ambient aerosol optical thickness at 550 nm in clear sky	od550csaer	1	Monthly		AERONET, MODIS, MISR
sulfate aod@550nm	od550so4	1	Monthly		
black carbon aod@550nm	od550bc	1	Monthly		
Organic matter aod@550nm	od550oa	1	Monthly		
SOA aod@550nm	od550soa	1	Monthly		
Nitrate aod@550nm	od550no3	1	Monthly		
Sea salt aod@550nm	od550ss	1	Monthly		
Sea salt aod@550nm	od550ss	1	Monthly		
PM1 Sea salt aod@550nm	od550lt1ss	1	Monthly		
PM2p5 Sea salt aod@550nm	od550lt2p5ss	1	Monthly		
Dust aod@550nm	od550dust	1	Monthly		
PM1 dust aod@550nm	od550lt1du	1	Monthly		
PM2p5 dust aod@550nm	od550lt2p5du	1	Monthly		
ambient aerosol absorption optical thickness at 550 nm	abs550aer	1	Monthly		AERONET
ambient BC absorption optical thickness at 550 nm	abs550bc	1	Monthly		
ambient OC absorption optical thickness at 550 nm	abs550oc	1	Monthly		

c) 3-D variables (vertically in your model level):

Note:
- Output variables vertically in your model level (VerticalCoordinateType: ModelLevel), but make sure to provide layer height information, i.e., pfull (or phalf) or dh, one variable per file as an independent variable along with the information of longitude and latitude. Example of file name: aerocom3_GEOS-i33p2_ACAM-BASE_dh_ ModelLevel_2008_monthly.nc.

Variable	**Variable name** [+]	**Variable Unit** [+]	**Temporal frequency** [$]		**Evaluation Datasets**
Met. fields	VerticalCoordinateType: ModelLevel				
air pressure	pfull	Pa	Monthly		
air pressure at interfaces	phalf	Pa	Monthly		
air temperature	ta	k	Monthly		
Specific humidity	hus	kg kg-1	Monthly		
Relative humidity	rh	1	Monthly		

Eastward wind	ua	m s-1	Monthly		
Northward wind	va	m s-1	Monthly		
Upward air velocity	wa	m s-1	Monthly		
Shortwave heating rate	tntrs	K s-1	Monthly		
Longwave heating rate	tntrl	K s-1	Monthly		
Air density	rho	kg m-3	Monthly		
Layer thickness	dh	m	Monthly		
Cloud area fraction	clt	1	Monthly		
Convective cloud area fraction	convclt	1	Monthly		
Mass fraction of cloud liquid water	clw	kg kg-1	Monthly		
Mass fraction of cloud ice	cli	kg kg-1	Monthly		
Extinction	VerticalCoordinateType: ModelLevel				
aerosol_extinction_at_550nm	ec550aer	m-1	Monthly		CALIOP, SAGEII, OSIRIS, OMPS LP
Mixing ratio, production	VerticalCoordinateType: ModelLevel				
PM2.5 mass mixing ratio	mmrpm2p5	kg kg-1	Monthly		
PM10 mass mixing ratio	mmrpm10	kg kg-1	Monthly		
PM1 mass mixing ratio	mmrpm1	kg kg-1	Monthly		
CO mixing ratio	mmrco	mole mole-1	Monthly		MLS, StratoClim
Elemental carbon mass mixing ratio	mmrbc	kg kg-1	Monthly		
Organic matter mass mixing ratio	mmroa	kg kg-1	Monthly		
Secondary organic aerosol mass mixing ratio	mmrsoa	kg kg-1	Monthly		
Sulfate mass mixing ratio	mmrso4	kg kg-1	Monthly		
NO3 mass mixing ratio	mmrno3	kg kg-1	Monthly		
NH4 mass mixing ratio	mmrnh4	kg kg-1	Monthly		
Sea salt mass mixing ratio	mmrss	kg kg-1	Monthly		
dust mass mixing ratio	mmrdust	kg kg-1	Monthly		
SO2 mass mixing ratio	so2	mole mole-1	Monthly		MIPAS, MLS, OMO
DMS mass mixing ratio	dms	mole mole-1	Monthly		
Gas-phase production rate of SO4	chegpso4	kg m-2 s-1	Monthly		
Aqueous-phase production rate of SO4	cheaqpso4	kg m-2 s-1	Monthly		
Aerosol water mass mixing ratio	mmraerh2o	Kg kg-1	Monthly		
Artificial CO with 50-day lifetime	mmrco50	mole mole-1	Monthly		
Chemical decay of artificial CO with 50-day lifetime	dkco50	kg m-2 s-1	Monthly		
artificial CO with 50-day decay time produced by CH4 oxidation	co50pch4	kg m-2 s-1	Monthly		
Rn-222 mixing ratio	mmrrn	mole mole-1	Monthly		
Pb-210 mixing ratio	mmrpb	mole mole-1	Monthly		
chemical decay of Rn-222	dkrn	kg m-2 s-1	Monthly		

[superscript]+ Name required by AEROCOM III

$^\$$ Model output resolution. In all situations, monthly outputs from January to December are required.

[superscript]# variables not listed in the [AeroCom III Excel sheet](.).

Observations:

Satellite:		
Column SO$_2$	OMI	2004 (later half) – present
UTLS SO$_2$ (with vertical information)	MIPAS MLS	2003 – 2012 2004 (later half) – present
UTLS CO	MLS	2004 (later half) – present
Stratospheric aerosol vertical profile	SAGE II OSIRIS SCIAMACHY GOMOS CALIOP OMPS LP	1998 – 2005 2001 – present 2003 – present 2003 – 2012 2006 (later half) – present 2012 – present
Aircraft observation:		
UT aerosol (S, C) concentration	CARIBIC	2004 – 2012
SO$_2$, sulfate vertical profiles	OMO	2015 (July-Aug)
Aerosol vertical profiles	StratoClim	2017(July-Aug)

Model output submission:

Please refer to [Aerocom wiki page](.).

Considerations:
- The proposed activity is also in coordination with the CCMI subgroup on ACAM-related studies
- This is an opportunity to engage the extended international modeling and observation communities to study aerosol-chemistry-weather-climate interactions
- We now have plenty of remote sensing and in-situ observations over Asian monsoon regions for thorough model evaluations and uncertainty assessments

Timetable (tentative)
05.2020 – submit multi-model results to AeroCom server
08.2020 – circulate the first data analysis among co-authors
10.2020 – update the results at the annual AeroCom meeting
06.2021 – update the results at the biennual ACAM meeting
10.2021 – circulate the first draft among co-authors
06.2022 – submit the manuscript to the peer-reviewed journal