First look of aerosol components using ATom measurements and GEOS5 model: Implications for sources and removal and suggestions for ATom-AeroCom analysis

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15th AeroCom meeting
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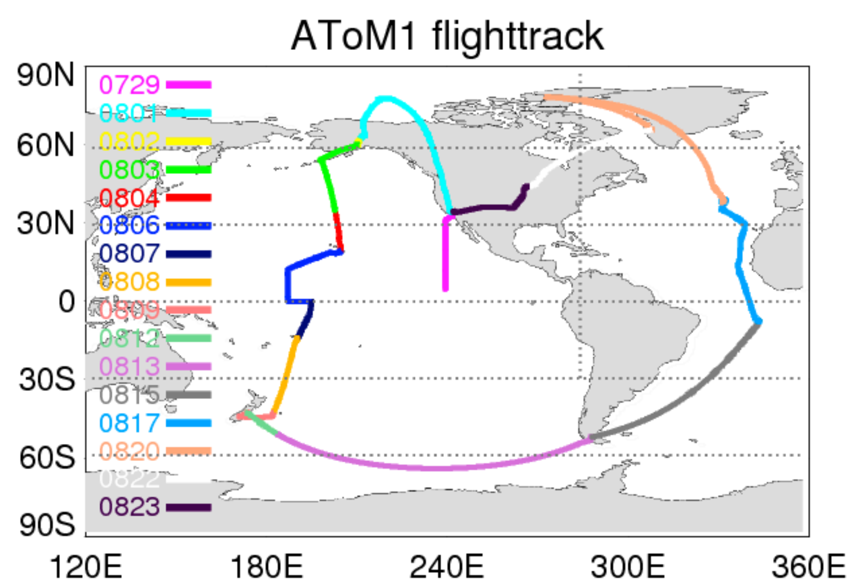
What's the AToM mission

A 5-year mission funded by NASA Earth Venture Suborbital-2 (EVS2) program

(i) use ~20 instruments on the NASA DC-8;
(ii) four deployments in each of the 4 seasons over a 3-year period (starting 2016);
(iii) flight routes over the Pacific, Atlantic, Southern Ocean, North America, and Greenland from 85°N to 65°S to establish a comprehensive, global-scale dataset;
(iv) profiling continuously from 0.2 to 12 km altitude.

ATom fills the following aerosol observational gaps relevant to this study:

(i) aerosol size distributions from 0.004 µm through 50 µm diameter, spanning newly formed, CCN-active, and larger particles;
(ii) organic and inorganic aerosol composition data;
(iii) gas-phase tracer data to provide source and transport information.



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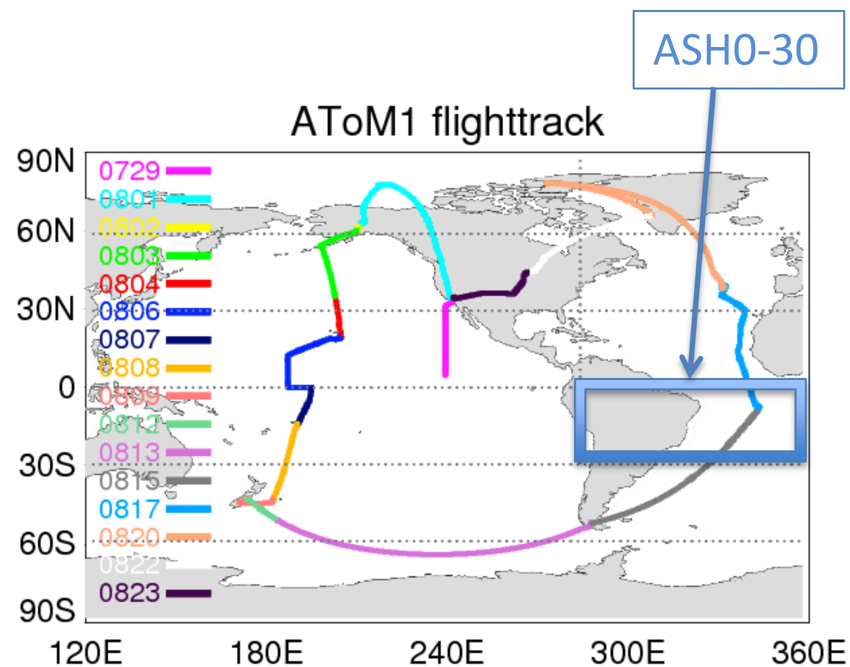


Aerosol and related species from ATom measurements

Species	Instrument*
Aerosol composition and microphysics:	
Particle distribution (4-1000 nm)	AMP
Cloud droplet size distribution (2-50 μm)	AMP
BC mass concentration and coating state	SP2
SO_4^{2-}, NO_3^-, NH_4^+, Cl^-	HR-AMS
OA, particle O/C, H/C, and OM/OC ratio	HR-AMS
Single particle composition (200-4000 nm), particle type fractions for SO_4^{2-}/OA/ NO_3^-, EC, sea salt, dust, biomass burning	PALMS
Particle type volume concentration	PALMS
MSA/ SO_4^{2-} ratio	PALMS
SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Na^+, Ca^{2+}, K^+, Mg^{2-}	SAGA filters
^{7}Be, ^{210}Pb	SAGA filters
Precursor gases and related species:	
SO_2	CIT-CIMS
DMS	WAS, TOGA
OCS	WAS, PANTHER, PFP
CO	HTS, PANTHER/UCATS
CO_2	HTS
Other:	
Pressure, temperature, winds, turbulence	MMS
Spectrally-resolved actinic flux (280-650 nm)	CAFS

ATom1 and GEOS5 GOCART data

ATom1:

PALMS BB MassFrac for GFSC 20170711.txt ------ PALMS biomass burning mass fraction
PALMS-duss-20170621.txt ------ PALMS dust and sea salt
PALMS-MSA-SO4-ratio-20170611.txt ------ PALMS MSA and SO4 ratio
AMS-MSA60s_DC8_20170729_R0.ict ------ AMS MSA
Mor.all.2017-06-02.tbl ------ all other measurements

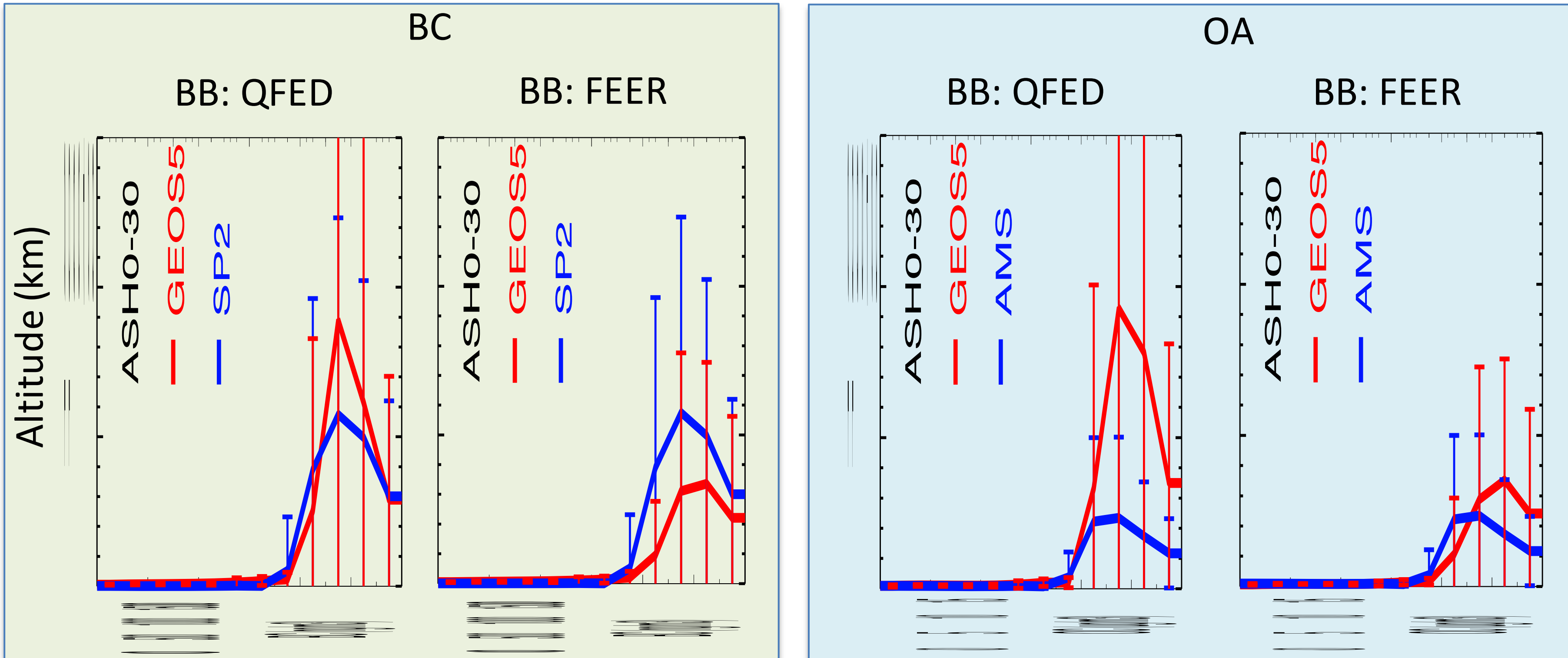
GEOS-5 GOCART (Icarus-1_0_p1):

1. Run in half degree horizontal resolution and 72 layers (576x361x72) and replayed with MERRA2 assimilation fields.
2. Simulation includes major aerosol/precursor components (SU, MSA, SO2, DMS, NI, NH4, NH3, BC, OC, DU, and SS), some gas pollutions (CO), and tracers (SF6, Rn, Pb210, and Be7).
3. Run tag tracers to emission types and source regions

What we can learn about source, wet removal and more in GEOS5 by using ATom1 data

EMISSIONS : Biomass Burning Emission QFED vs FEER

Vertical profiles between AToM and GEOS5 along flight track over Southern tropical Atlantic



- Individual component comparison between measurement and model helps understanding
- The simulated BC (and OA) is more than double when using QFED than FEER

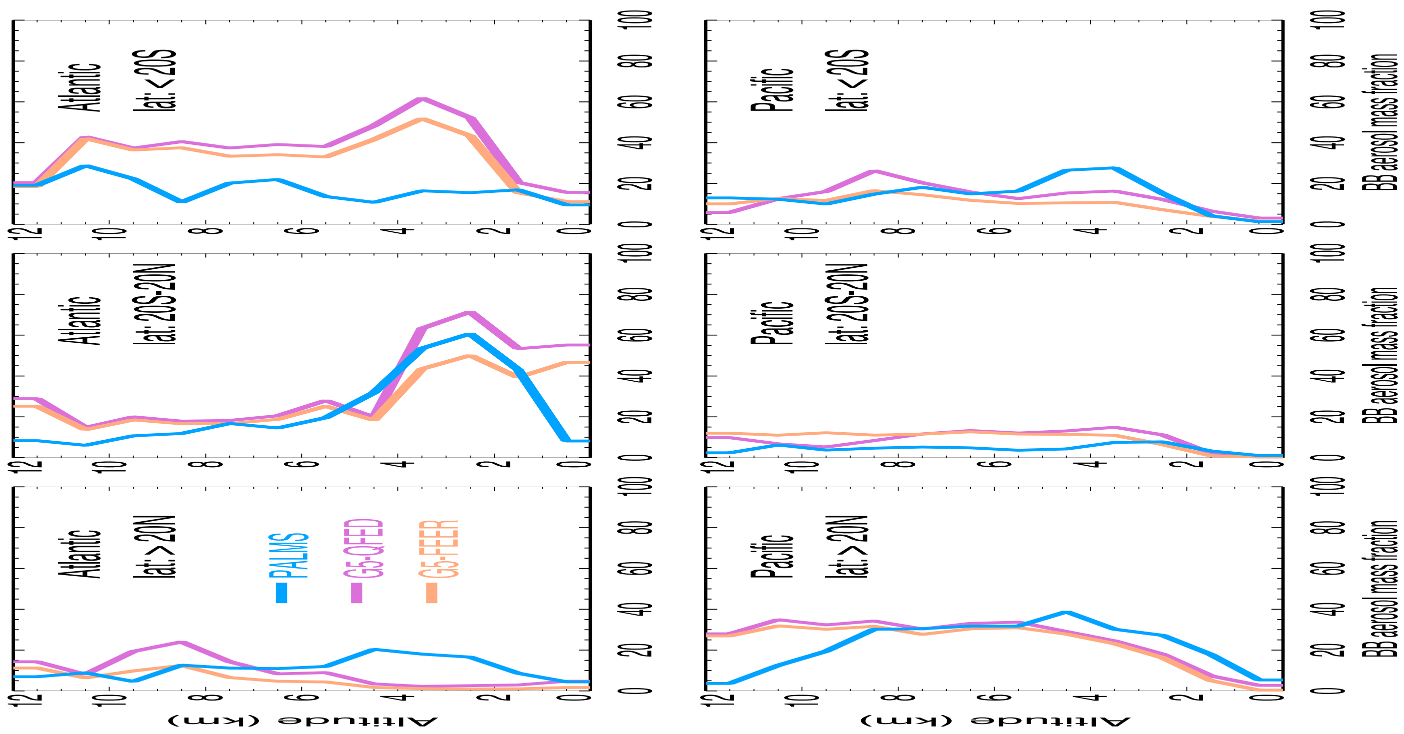
SP2: Shuka Schwarz

AMS: Jose Jimenez & Pedro Campuzano-Jost

GEOS5: Huisheng Bian & Pete Colarco

EMISSIONS : Biomass Burning Emission QFED vs FEER

fine mode BB aerosol mass fraction along flight tracks during ATom1

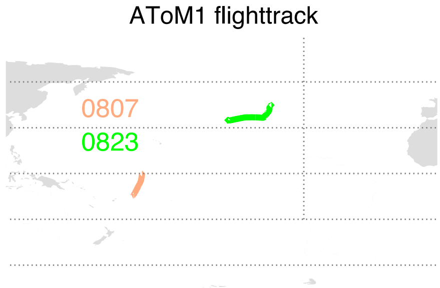


- BB aerosol dominates the particles over tropical Atlantic free troposphere
- Noticeable difference of the GEOS5 BB contributions when using two BB emissions, but less than the difference between model and observation

PALMS: Karl Froyd

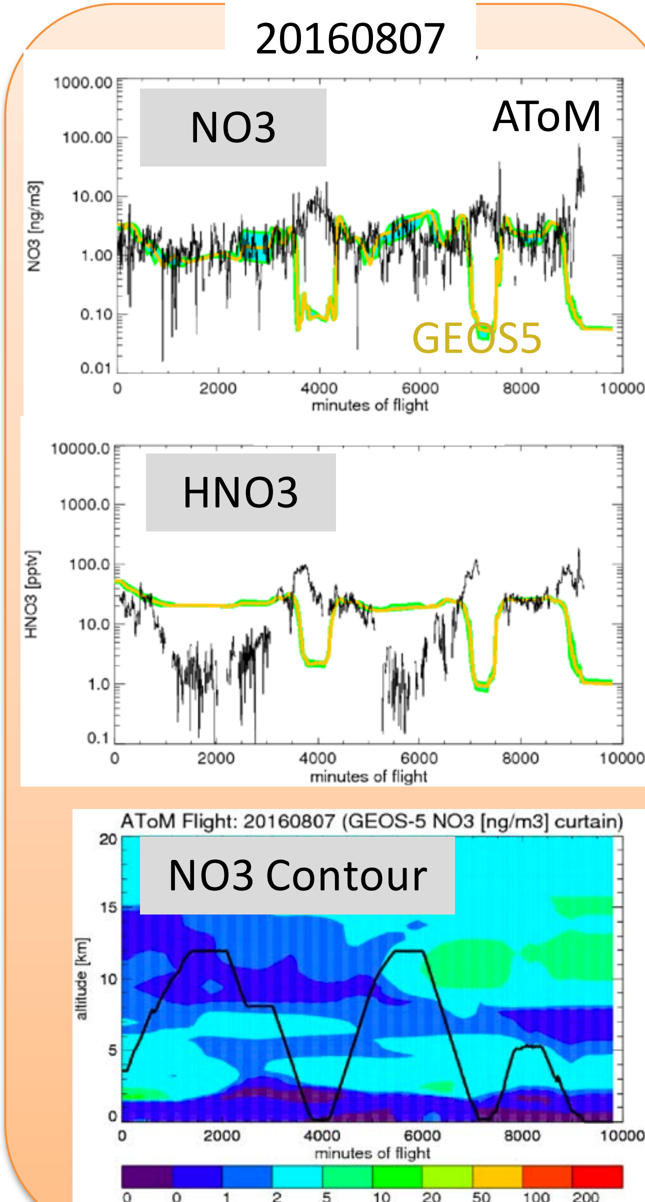
GEOS5: Huisheng Bian & Pete Colarco

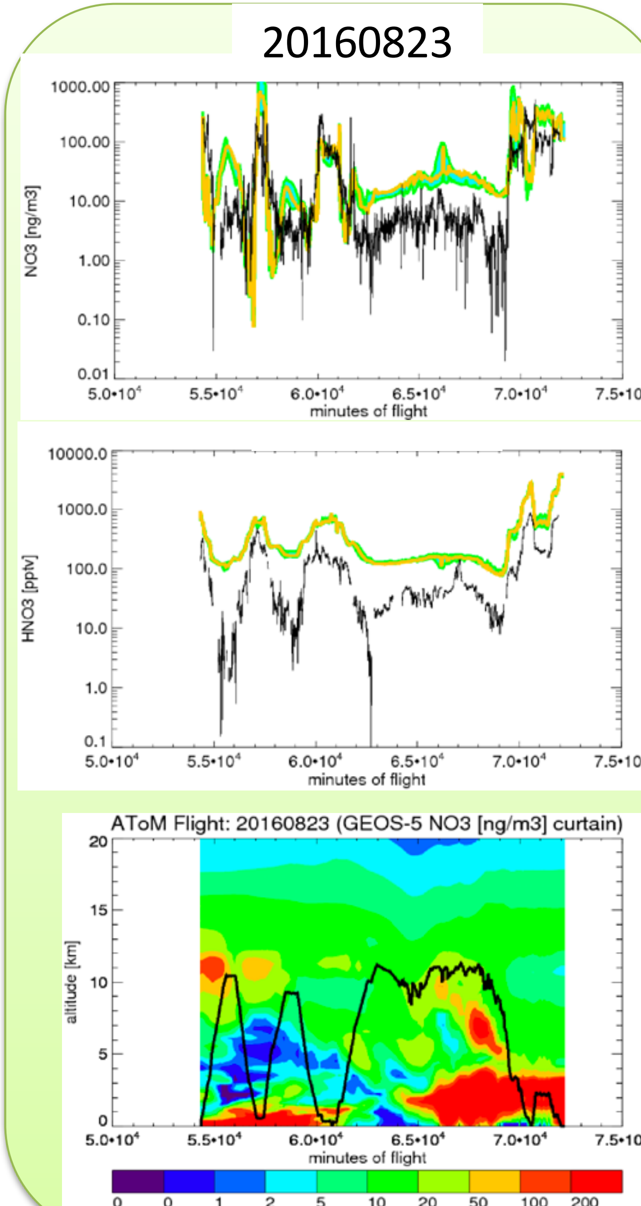
Emission: Missing oceanic nitrogen emission ?



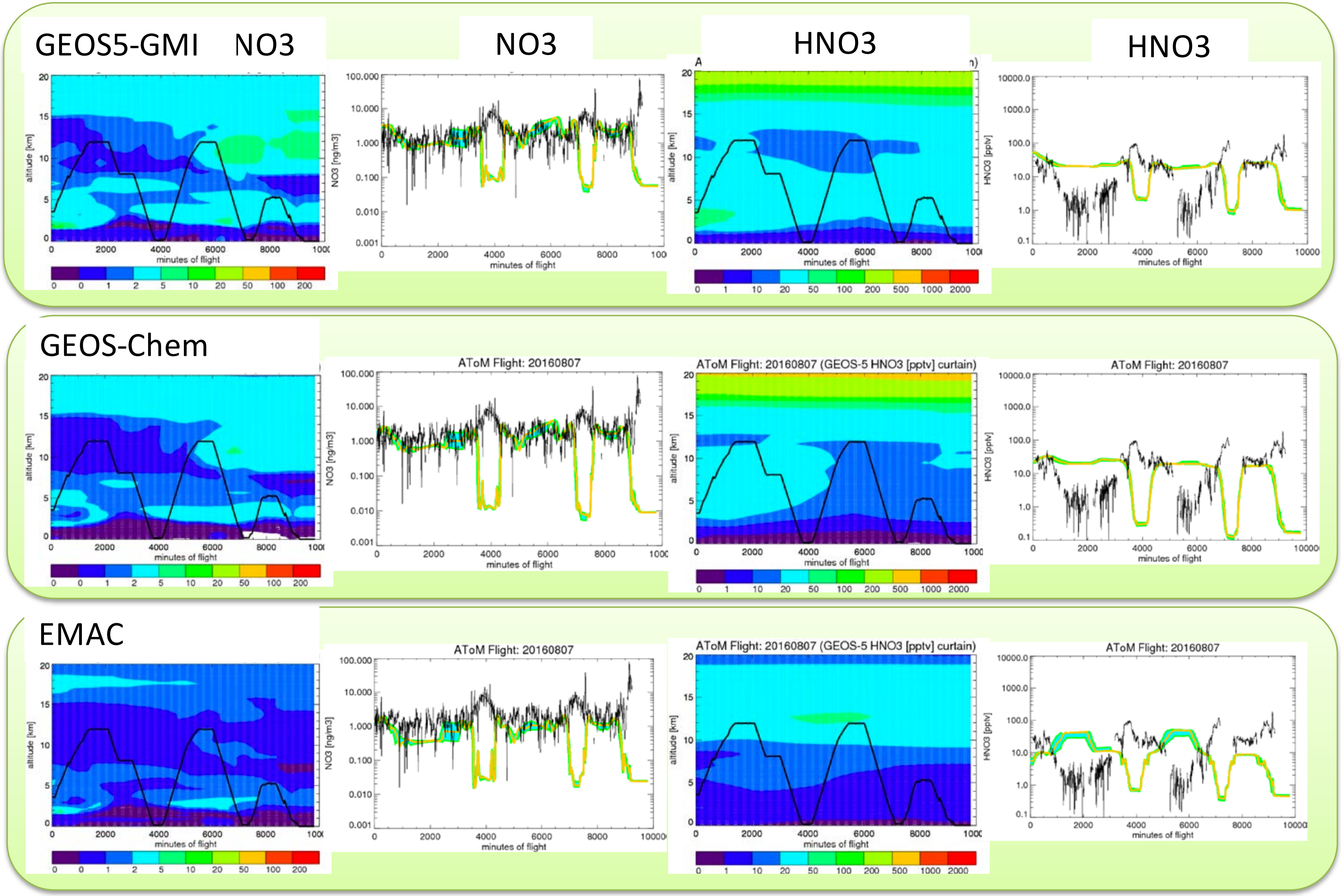
20160807: over southern tropical Pacific ocean =>NO3 and HNO3 within PBL are opposite between AToM and GEOS5

20160823: over USA =>NO3 and HNO3 within PBL agree between AToM and GEOS5

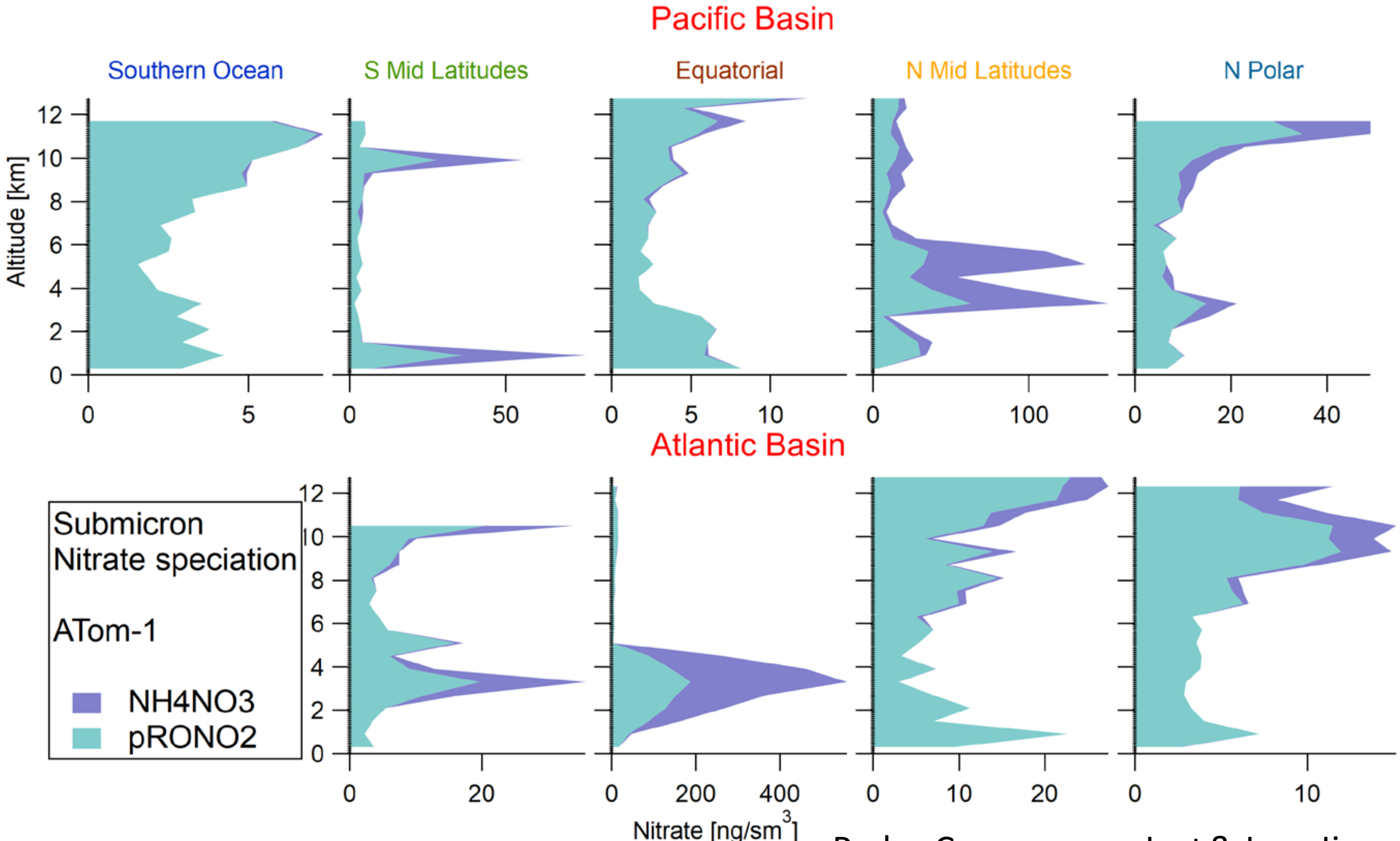




20160807 (over Southern Hemisphere tropical Pacific)



What forms of nitrate: inorganic or organic?
Where nitrate come from: primary and/or secondary?



Pedro Campuzano_Jost & Jose Jimenez

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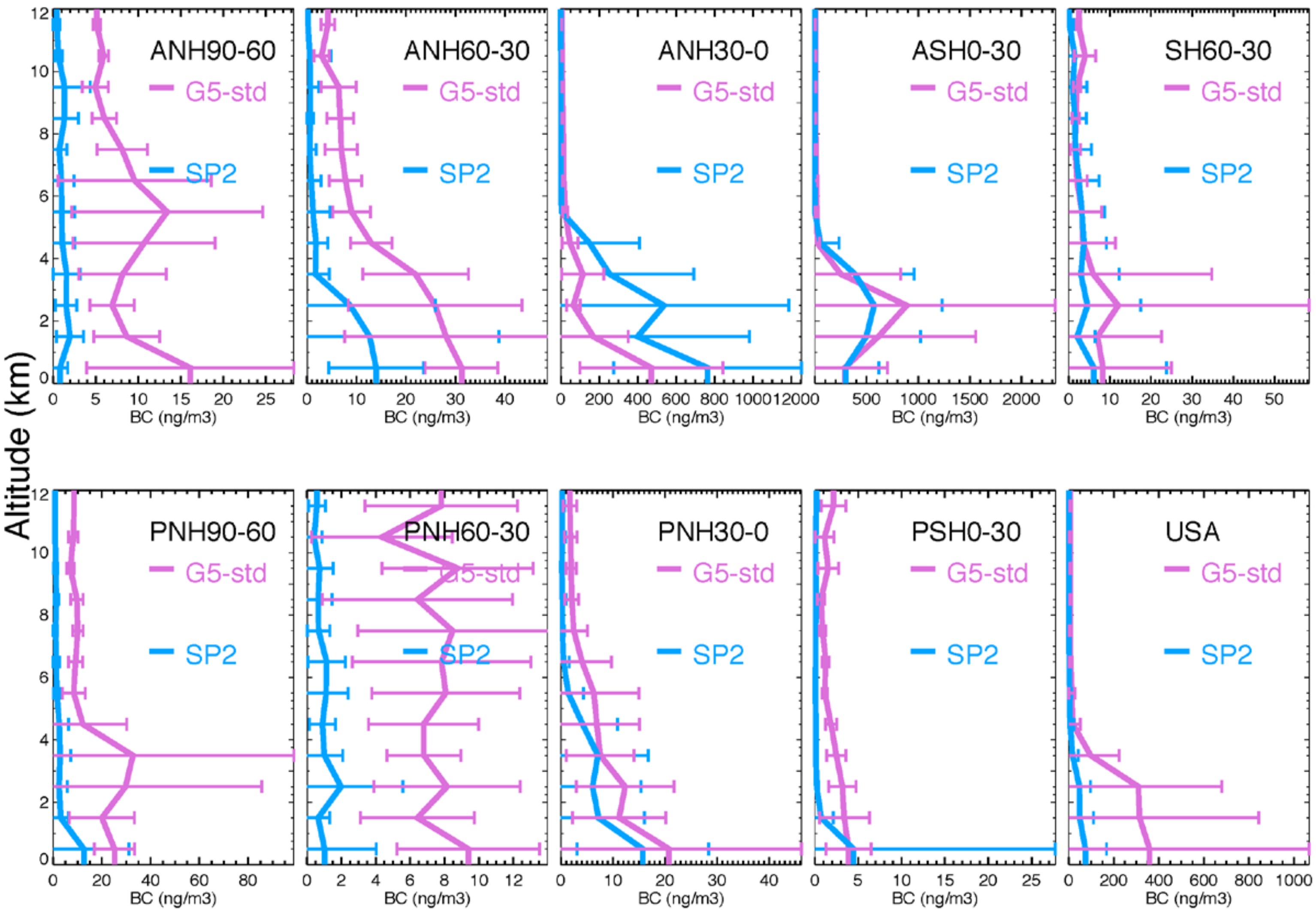
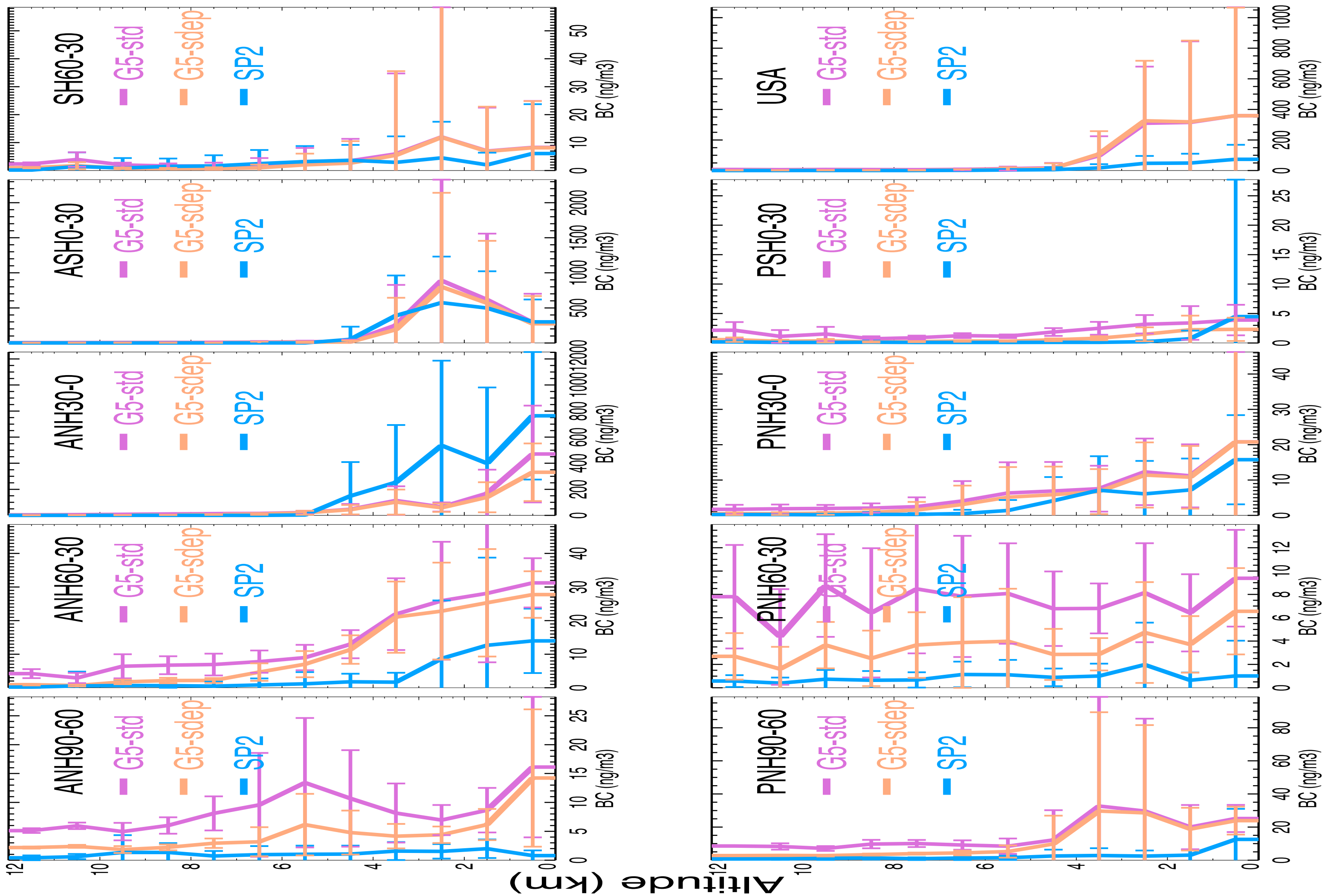
Wet Scavenging

G5-std:
BC1 (hydrophobic): rain+snow scavenging
BC2 (hydrophilic): No wet scavenging



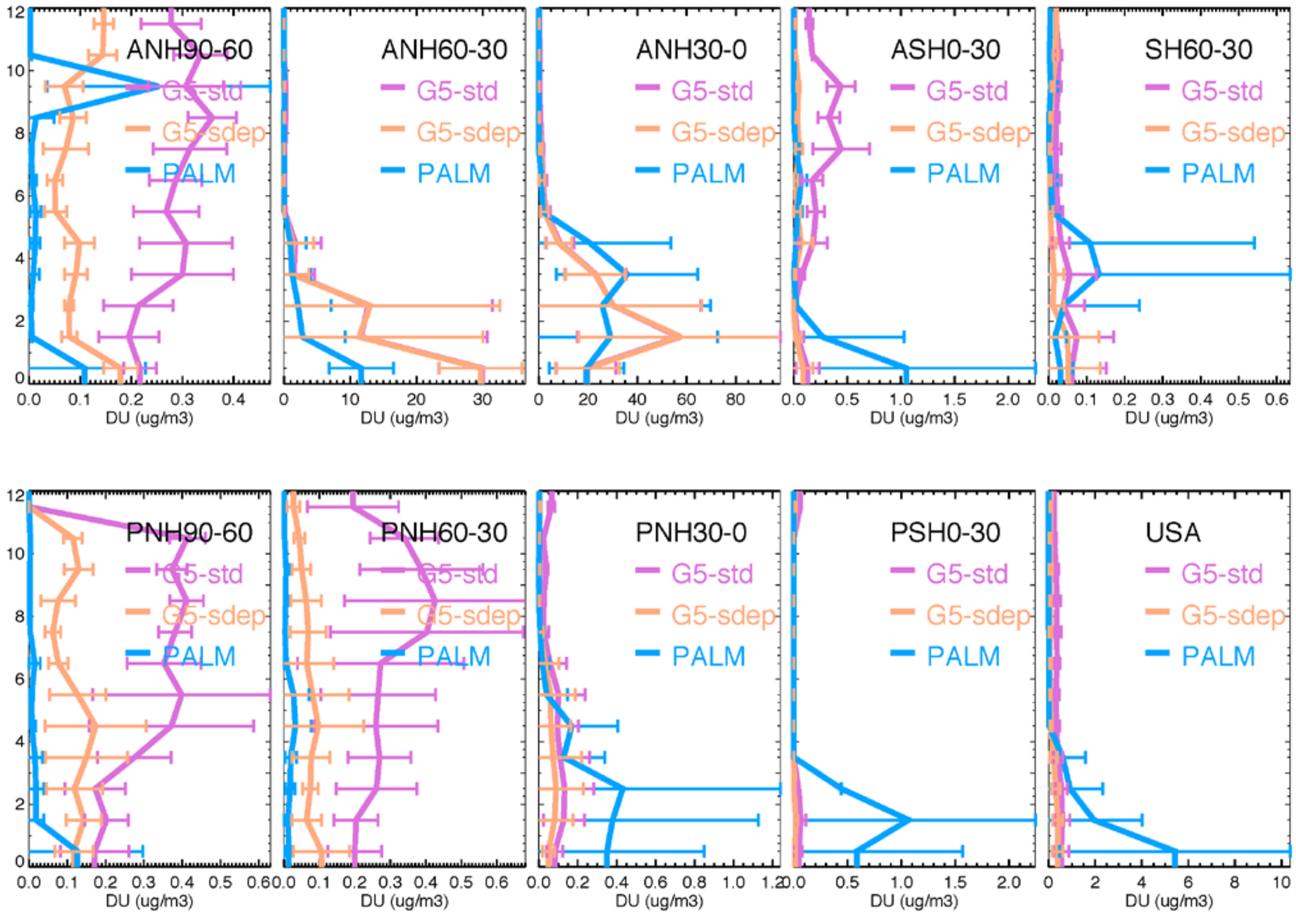
Wet Scavenging

Snow Scavenging for hydrophobic BC

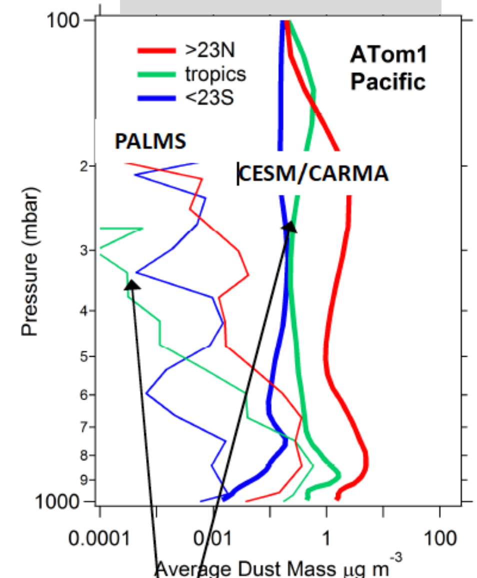


Wet Scavenging

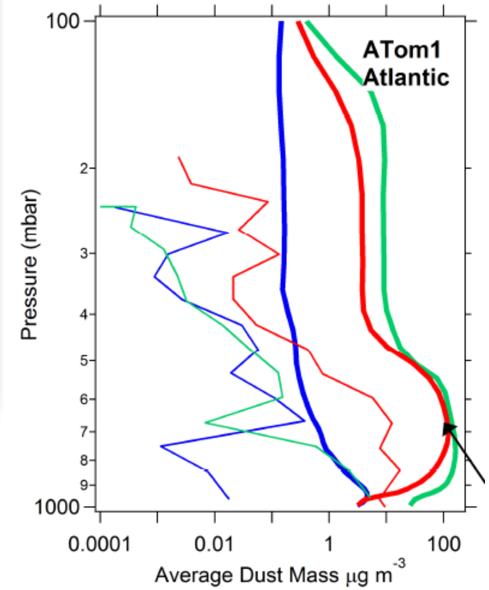
GEOS5: Snow Scavenging for Dust



CESM/CARMA

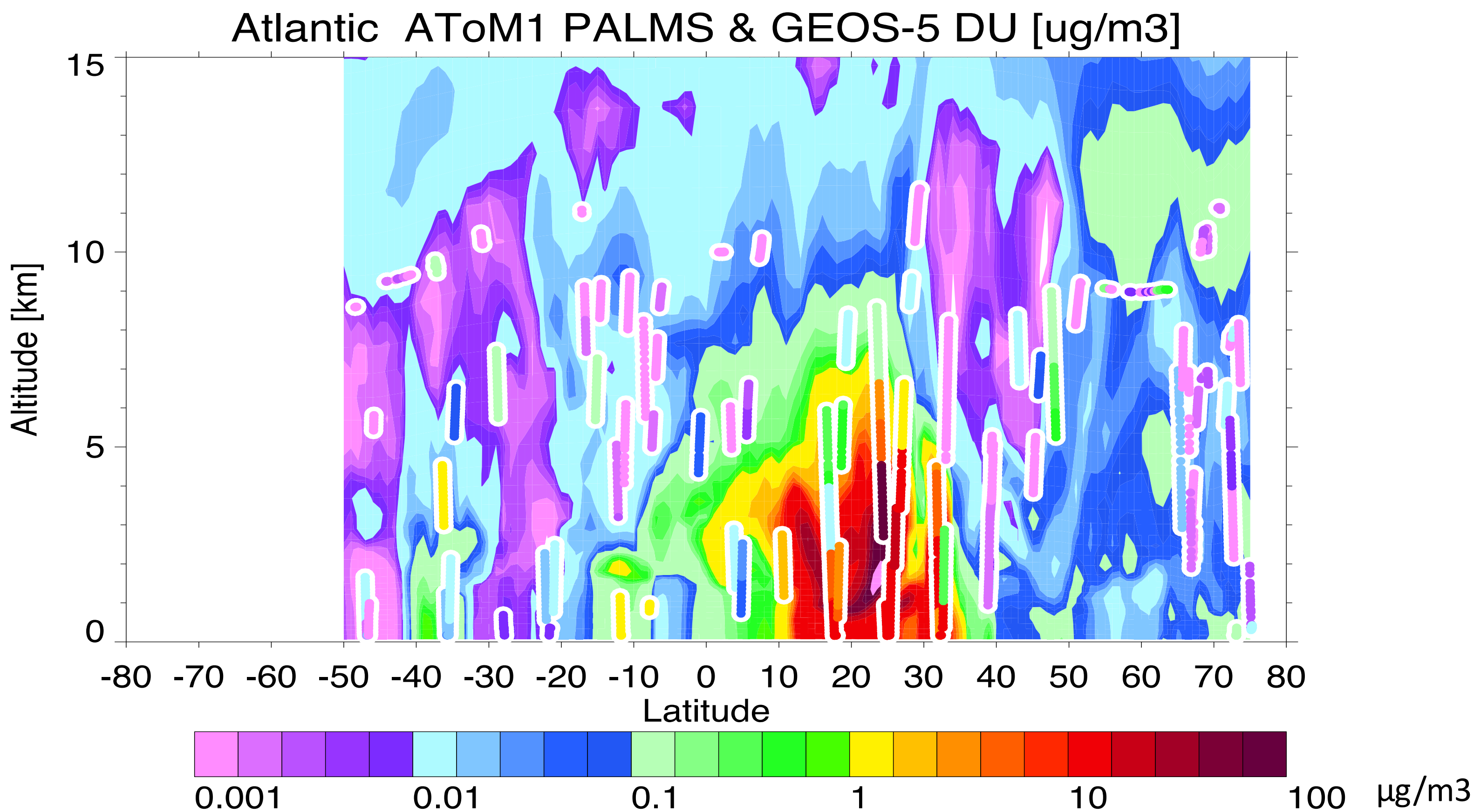


Tropical UT overestimated X100



(Pengfei Yu and Karl Froyd)

atmospheric circulation ???



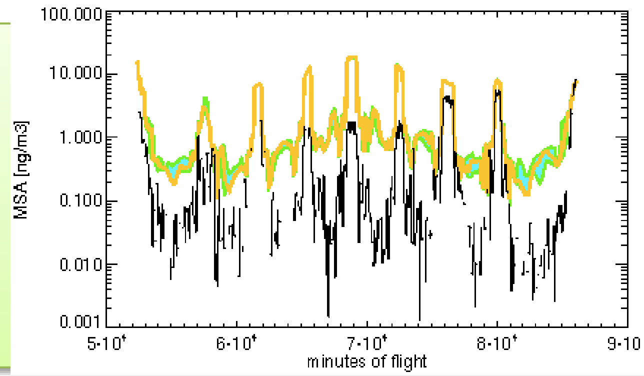
Size effect on MSA?

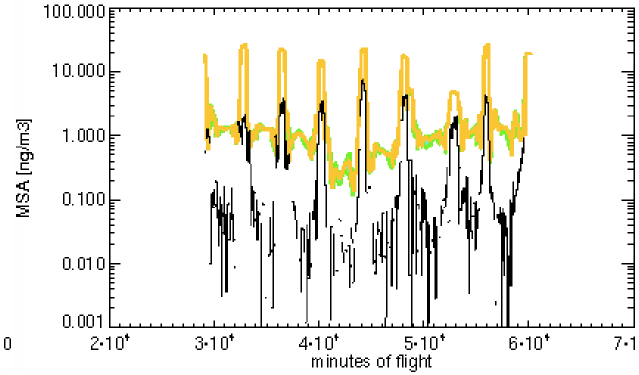
0729

0817

MSA

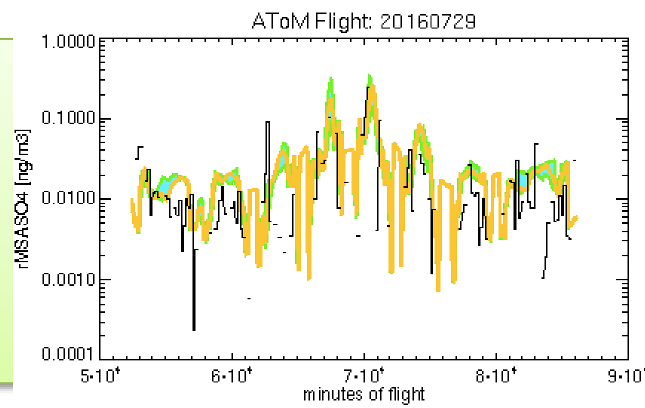
AMS: < 1µm

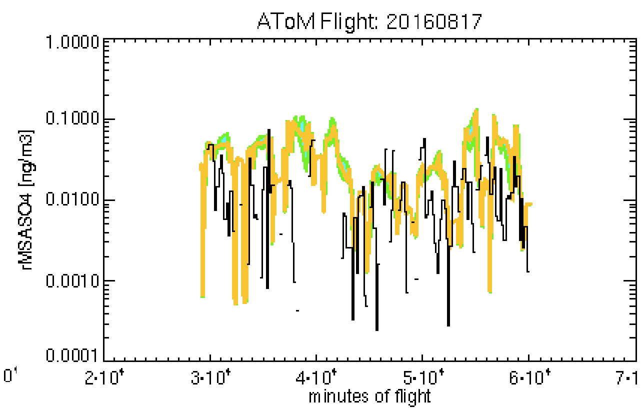




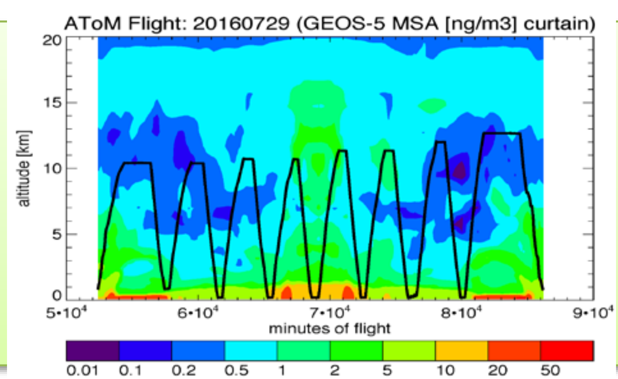
Ratio of MSA/SO4

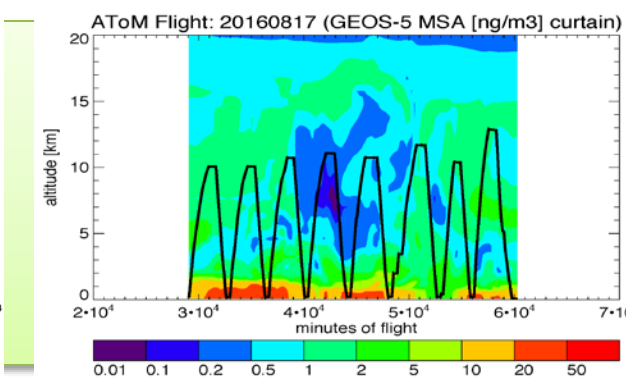
PALMS: < 3µm





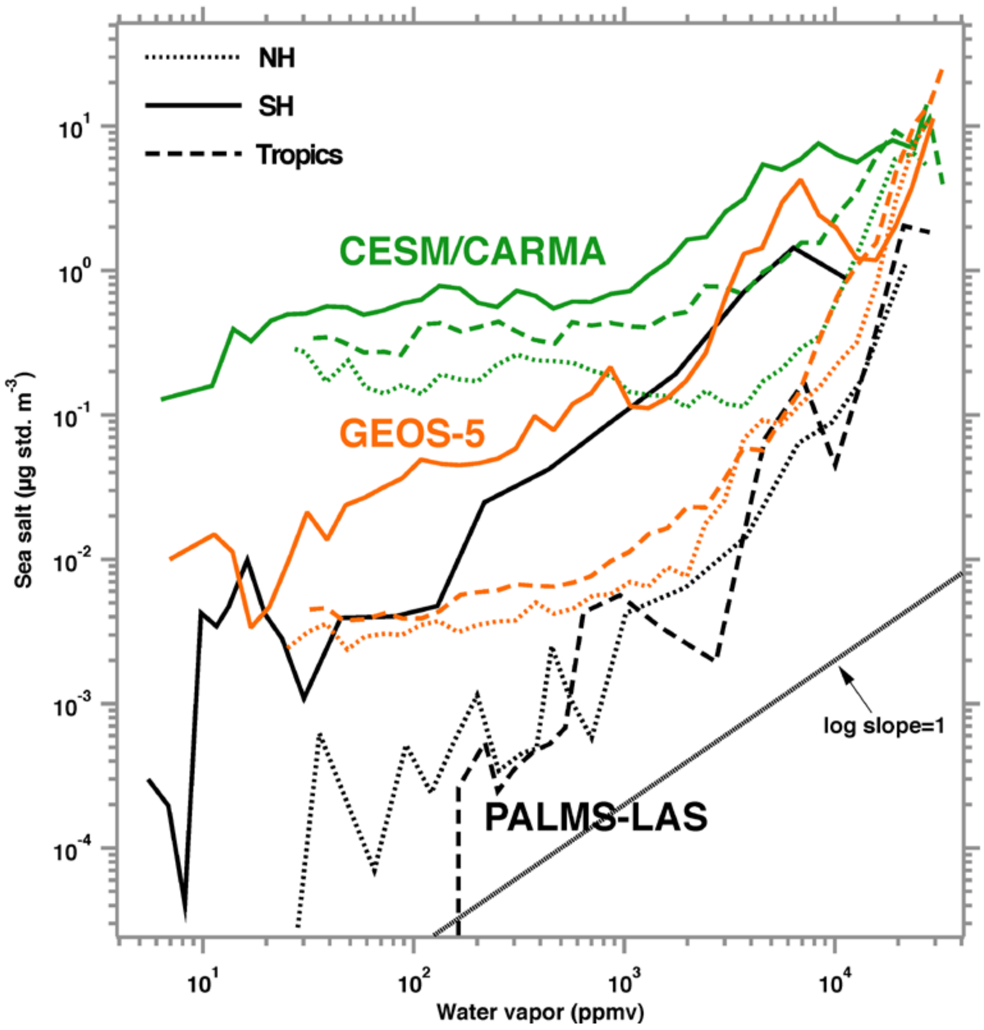
MSA curtain





Why does Sea Salt differ so large at low water vapor ?

Sea Salt vertical profiles of ATom1 and GEOS5



Daniel M. Murphy

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A proposed AeroCom-ATom study/analysis

Objectives

1. Evaluate model --- ATom mission provides unprecedented comprehensive measurements over remote oceans from near surface up to low stratosphere.
2. Improve the processes in models to best represent the ATom observations.
3. Investigate the sources (anthropogenic, natural, transported from land, emitted from ocean) of aerosols in the remote oceans and the processes of chemistry, transport, and removal that determine the composition and vertical distributions of aerosols in different seasons and locations.

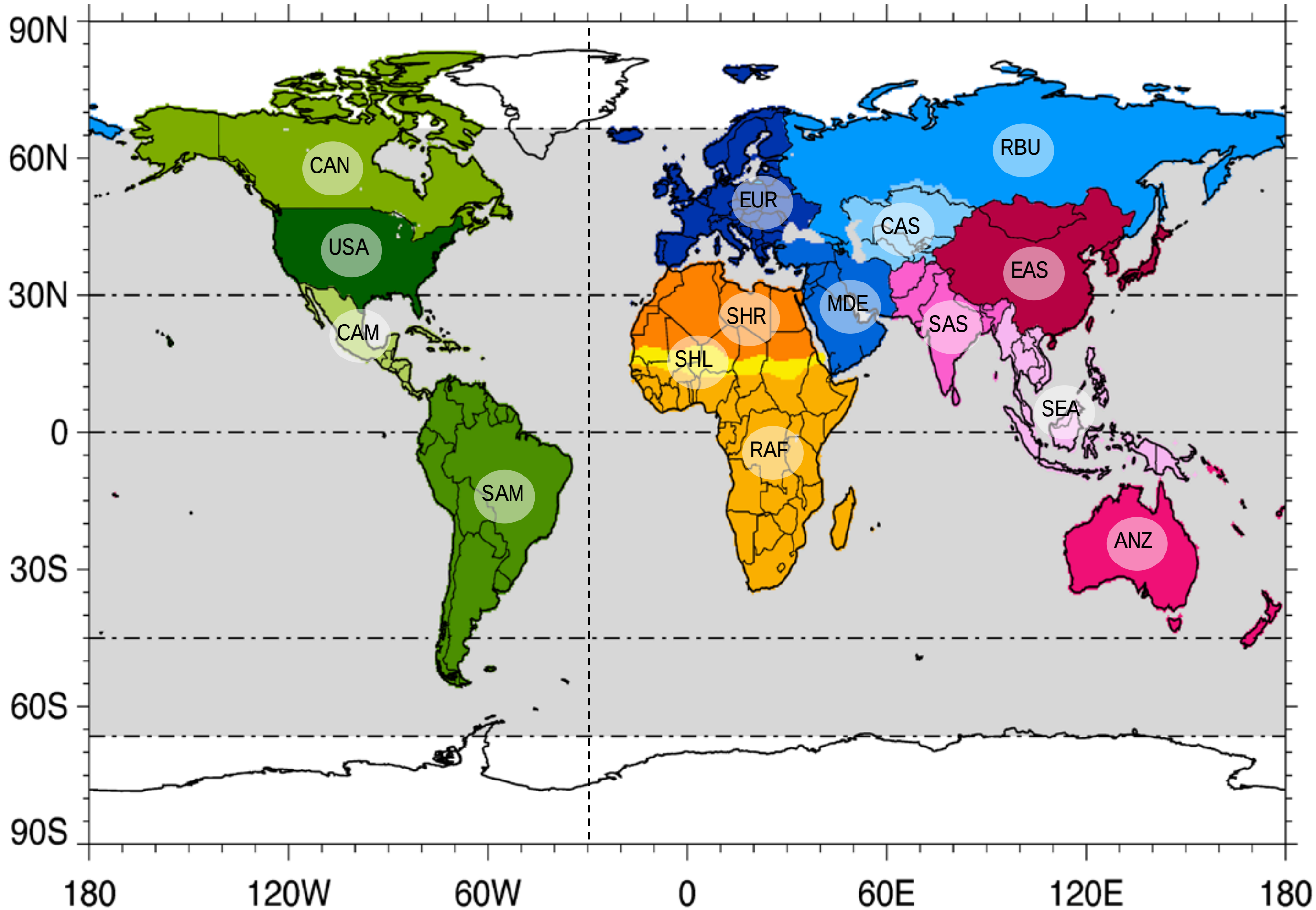
Themes of analysis

- Origin of aerosols in continental outflow and remote ocean regions
- Atmospheric sulfur cycle; natural vs. anthropogenic sources of nss-SO_4^{2-} over the Pacific, Atlantic, and Southern Ocean
- Vertical profiles of BC, OA, SO_4^{2-}, NH_4^+, NO_3^-, and dust – evaluating and constraining model removal processes
- Maritime aerosol – composition and origins in different regions and seasons
- New particle formation and CCN activation mechanisms
- Aerosol radiation interaction (calculating aerosol radiative effects)

Planned model experiments

Model run	***Emission***
BASE	All emissions
GLOAN0	No fossil fuel/biofuel burning emissions
GLOBB0	No biomass burning emissions
REGAN0	No fossil fuel/biofuel burning emissions from selected regions (EAS, SAS, EUR, NAM)
REGBB0	No biomass burning emissions from selected regions (WH, EH)
GLOOCN	Ocean emission only

Land regions



Anthropogenic source regions:
GLO
NAM (CAN+USA),
EUR
EAS
SAS

Fire source regions:
GLO
WST (180-75W)
EST (75W-180)

Model output

- Aerosol and related gas species concentrations:
  - Sulfur species: DMS, SO_2, SO_4^{2-}, MSA
  - Nitrogen species: NH_3, NH_4^+, NO_3^-
  - Carbon species: BC, OA (total), POA, SOA (optional)
  - Dust
  - Sea salt
  - CO, ^{7}Be, ^{210}Pb (optional)
- Aerosol optical parameters:
  - 550 nm extinction, absorption
- Transport tracer:
  - CO with prescribed source and 50-day decay time
  - CO_2 tracer with prescribed surface concentration (optional)
- Age of air