HTAP2: Coordinated AeroCom III experiments - initial results

Reported by Mian Chin at AeroCom 2014 workshop

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Acknowledgement: Results from MODIS, MISR, OMI, AERONET, IMPROVE, HIPPO and funding from NASA

Background

- Hemispheric transport of air pollution (HTAP) is a UN TF HTAP coordinated international assessment activity
- Objectives include:
  - Examine the transport of aerosols, including anthropogenic, dust, and biomass burning, from source regions to downwind regions
  - Assess the emission and transport impacts on regional and global air quality, ecosystems, public health, and climate
  - Provide information on potential emission mitigation options

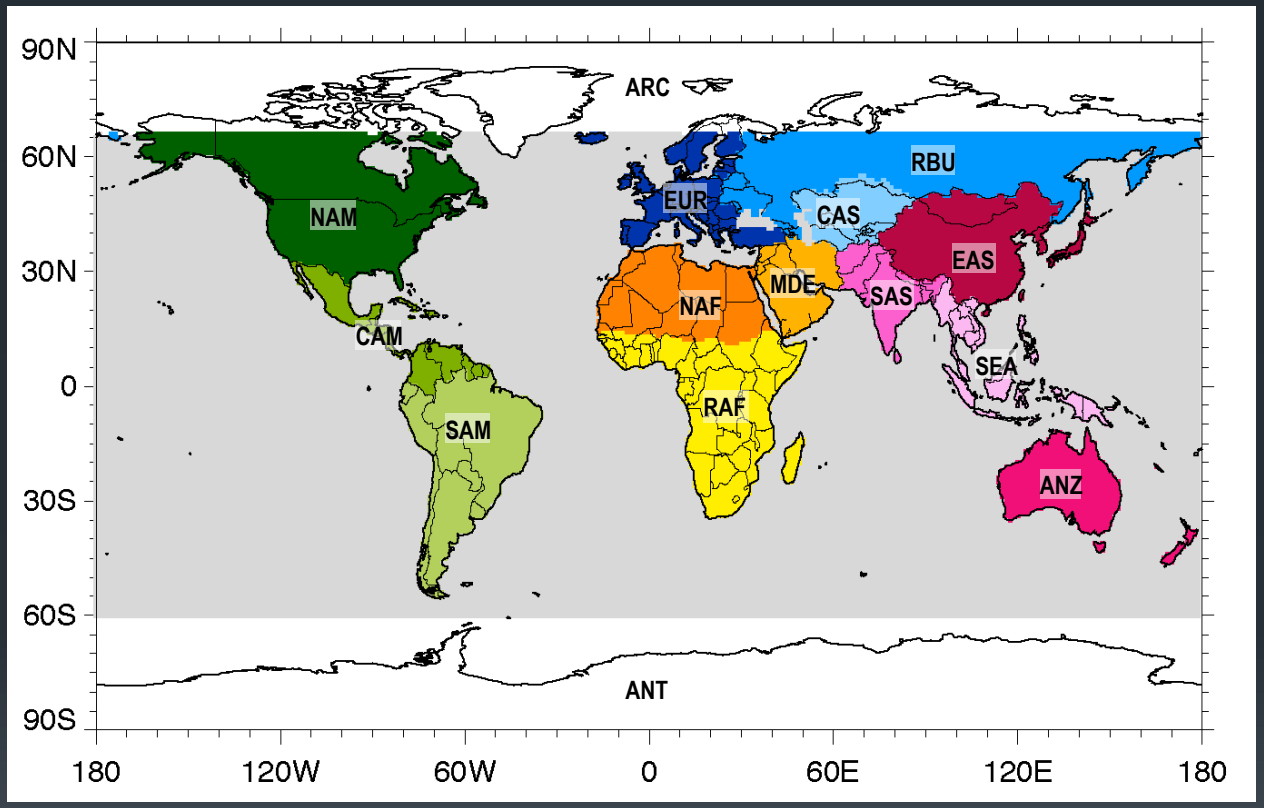
Why should AeroCom be involved

- AeroCom has been a major player in HTAP
- It provides multi-model well-coordinated experiments with expertise in aerosol related aspects (e.g., PM air quality from pollution, dust, and fire emissions, aerosol radiative effects, aerosol-cloud interactions, transport and deposition)
- It also benefitted from interacting with a wide community, documenting progresses in reducing/widening the model diversity over time, and moving forward
- Many analyses can be performed beyond HTAP objectives

Current status

- 3 models have done high priority simulations: GOCART, GEOS-5, and SPRINTARS
- 2 models will do high priority simulations: GISS, GFDL
- Please sign up!

Tier-1 source-receptor regions



12 land regions, ocean, and the polar regions

Anthropogenic source regions:
NAM, EUR, EAS, SAS, RBU, MDE

Dust source regions:
NAF, CAS, EAS, MDE

Fire source region:
GLO

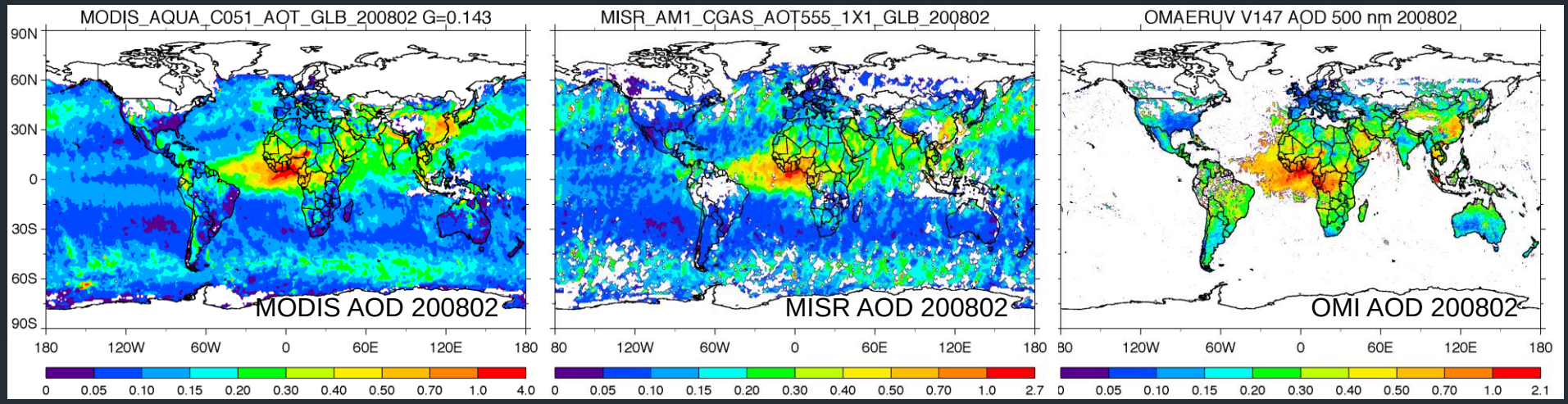
Model setup

- Emissions:
  - Anthropogenic: HTAP2, 0.1x0.1 deg, 4 sectors (energy, industry, residential, transportation)
  - Biomass burning: GFED v3 (recommended)
  - Volcanic: HTAP2/AeroCom-MAP (Thomas Diehl)
  - Dust and sea salt: Model calculated
- High priority runs:
  - BASE, 2008-2010
  - 20% reduction of anthropogenic emissions in GLO, NAM, EUR, EAS, SAS, RBU, and MDE
  - Zero-out dust emissions in NAF, CAS, EAS, MDE
  - 20% reduction of global fire emissions

Initial results - demonstrate the HTAP2 analysis with AeroCom simulations

- Global distributions - comparisons of AOD with MODIS, MISR, and OMI
- Comparisons with OMI and AERONET on AOD and AAOD
- Comparisons of surface concentrations and vertical profiles
- RERER
- Source attributions

AOD - 200802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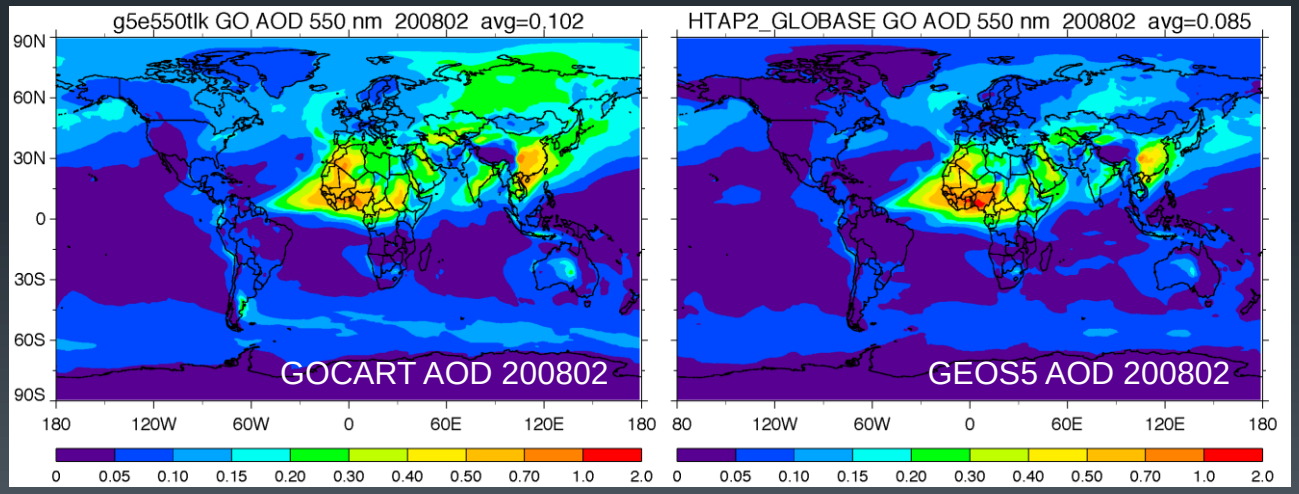
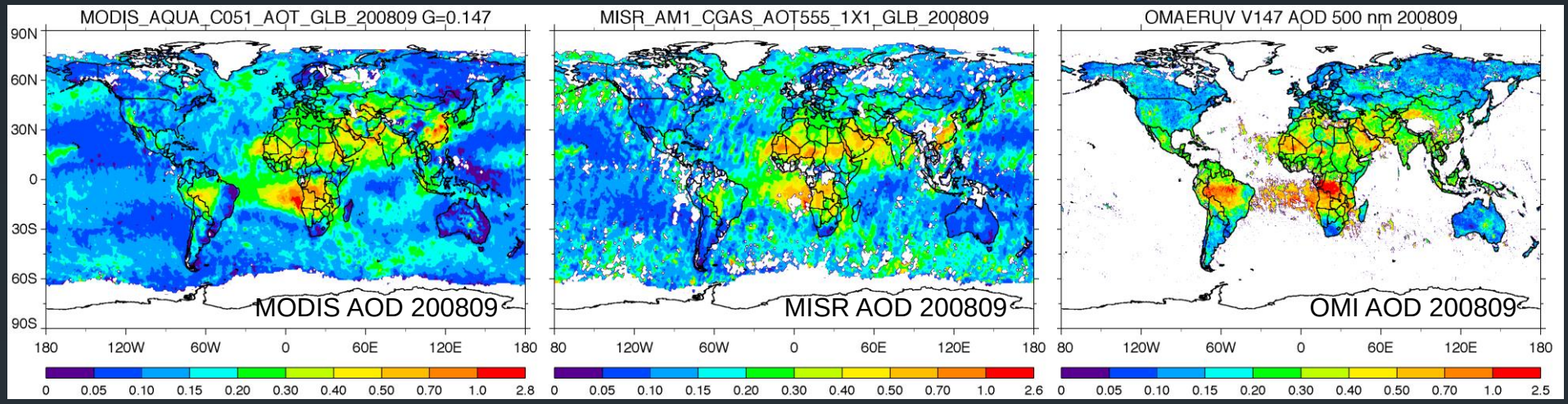
MODIS AOD 200802
MISR_AM1_CGAS_AOT555_1X1_GLB_200802
MISR AOD 200802
OMAERUV V147 AOD 500 nm 200802
OMI AOD 200802
90N
60N
30N
0
30S
60S
90S
180
120W
60W
0
60E
120E
180
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 4.0
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.7
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.1


g5e550tlk GO AOD 550 nm 200802 avg=0.102
GOCART AOD 200802
HTAP2_GLOBASE GO AOD 550 nm 200802 avg=0.085
GEOS5 AOD 200802
90N
60N
30N
0
30S
60S
90S
180
120W
60W
0
60E
120E
180
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.0
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.0

AOD - 200809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MODIS AOD 200809
MISR_AM1_CGAS_AOT555_1X1_GLB_200809
MISR AOD 200809
OMAERUV V147 AOD 500 nm 200809
OMI AOD 200809
90N
60N
30N
0
30S
60S
90S
180
120W
60W
0
60E
120E
80
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.8
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.6
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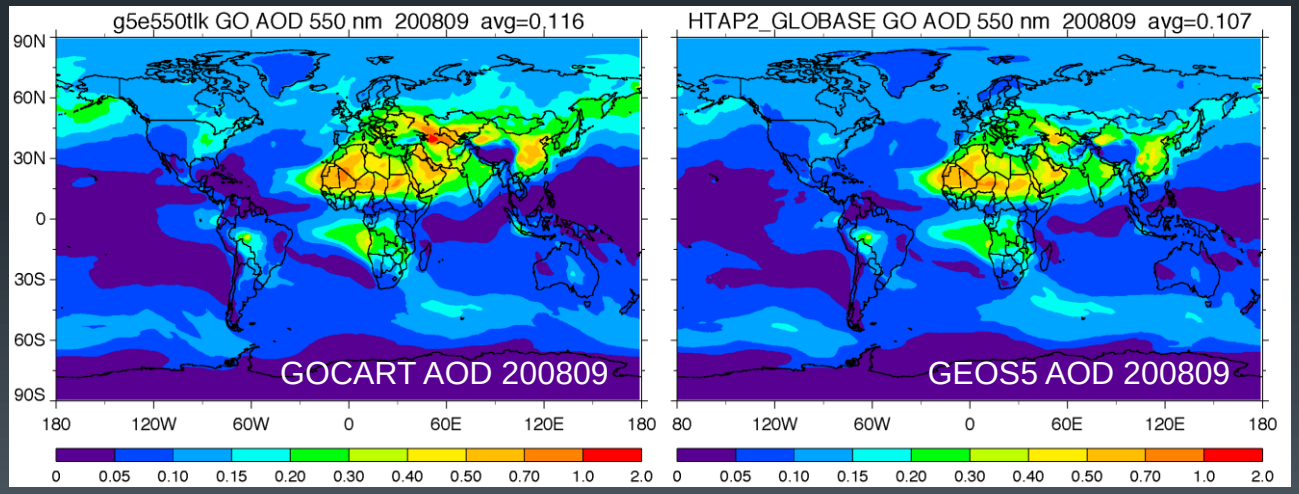
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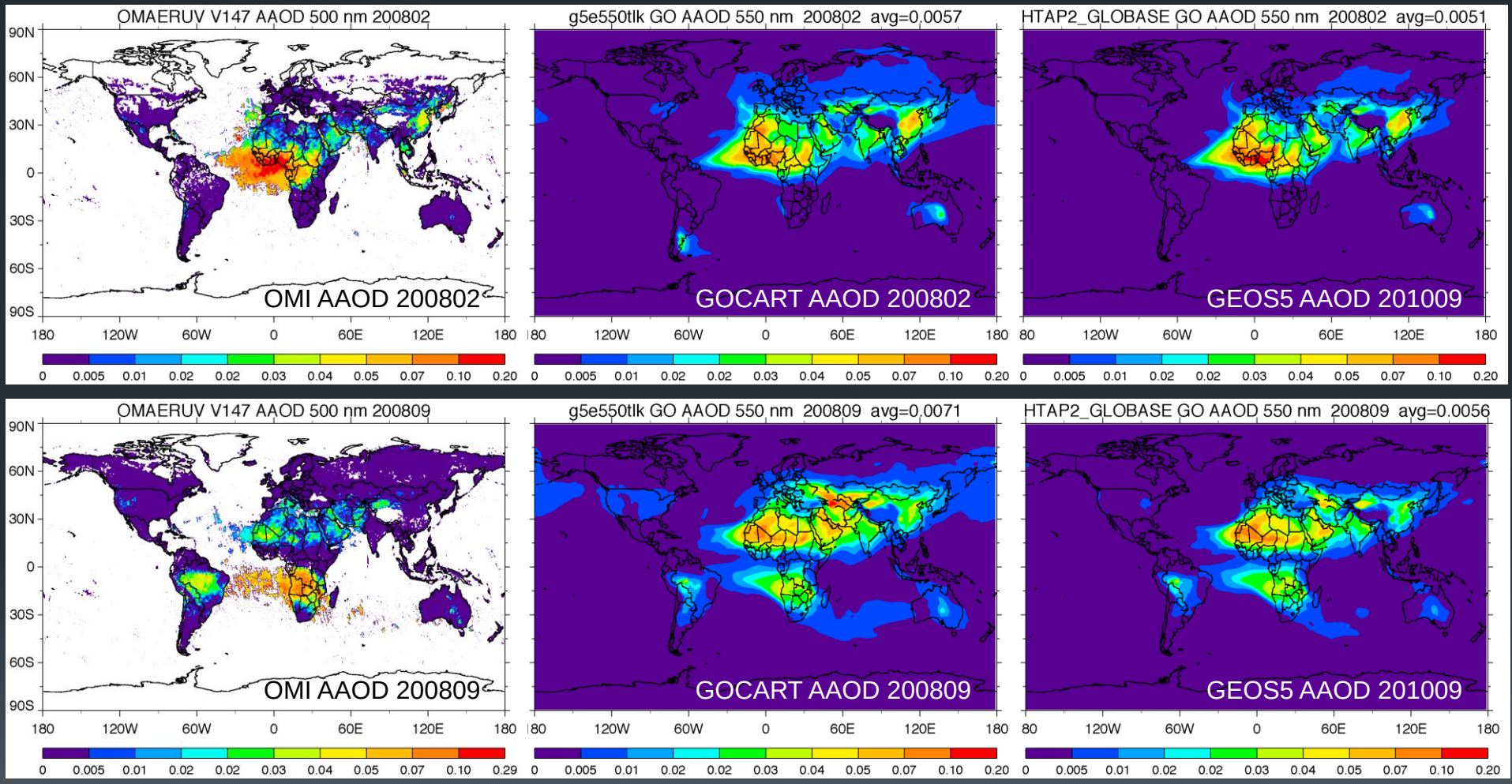
GEOS5 AOD 200809
90N
60N
30N
0
30S
60S
90S
180
120W
60W
0
60E
120E
80
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.0
0 0.05 0.10 0.15 0.20 0.30 0.40 0.50 0.70 1.0 2.0

AAOD


OMAERUV V147 AAOD 500 nm 200802
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OMI AAOD 200802
GOCART AAOD 200802
GEOS5 AAOD 201009
OMAERUV V147 AAOD 500 nm 200809
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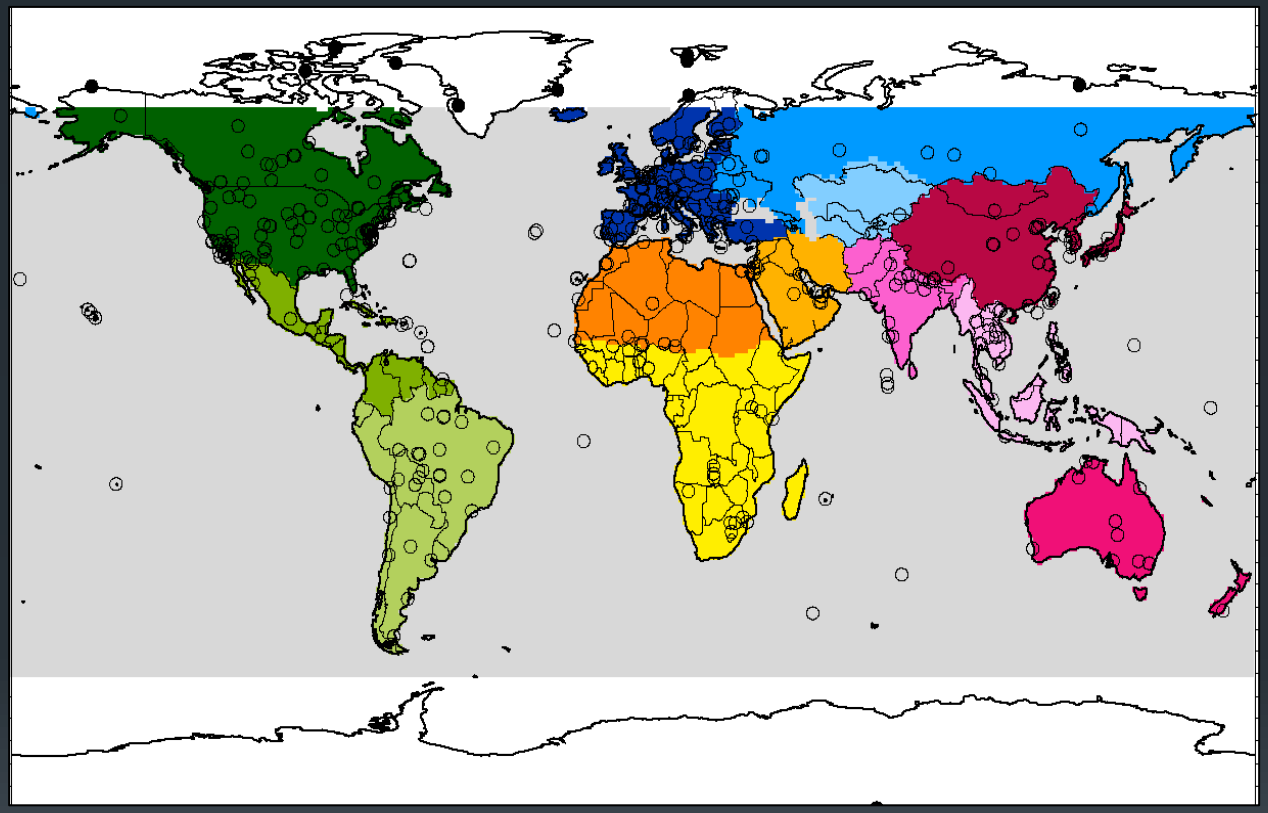
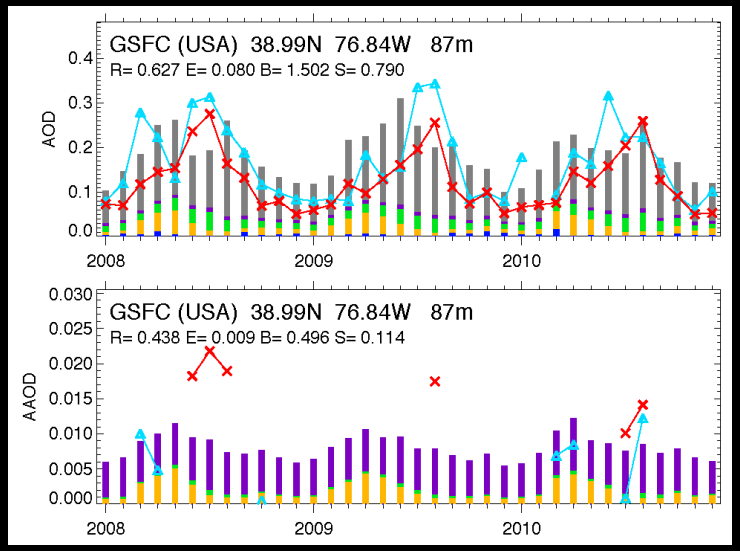
HTAP2_GLOBASE GO AAOD 550 nm 200809 avg=0.0056
OMI AAOD 200809
GOCART AAOD 200809
GEOS5 AAOD 201009

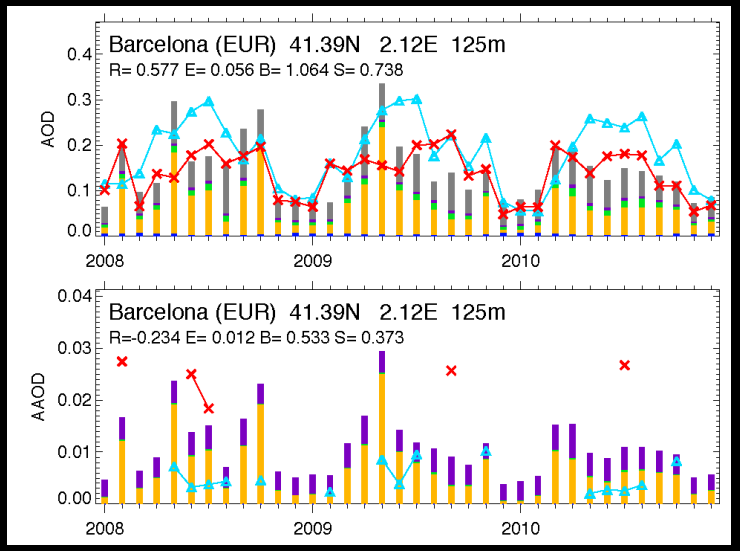
Comparisons with AERONET

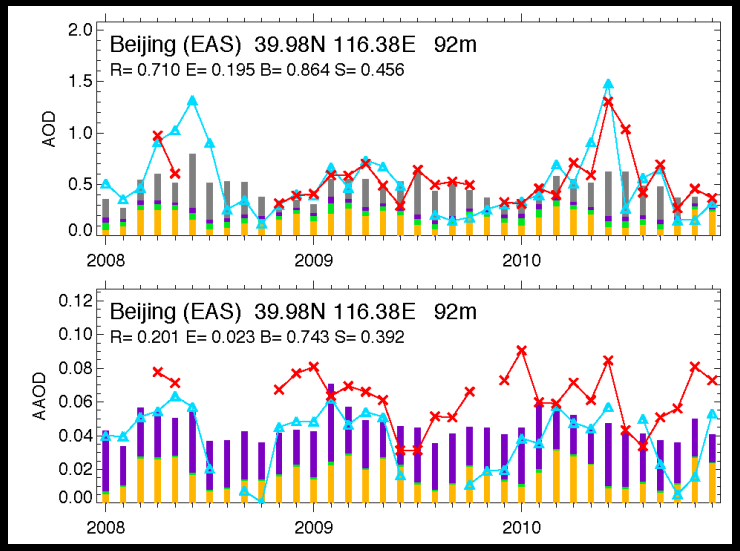


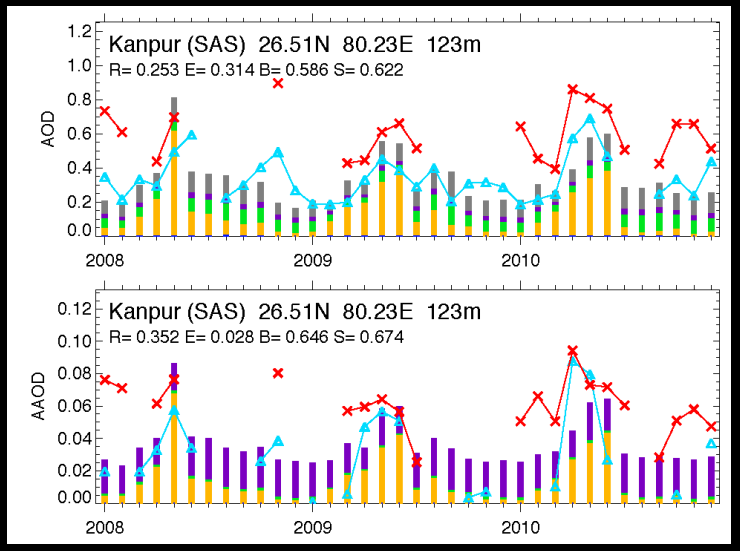
12 land regions, ocean, and the polar regions
(Circles: AERONET sites with data available in 2008-2010

Comparisons (GOCART) with AERONET AOD and AAOD – polluted regions

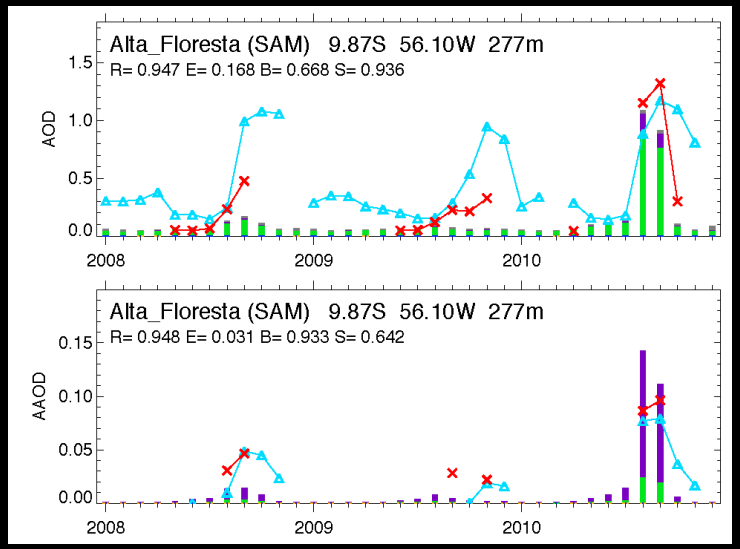


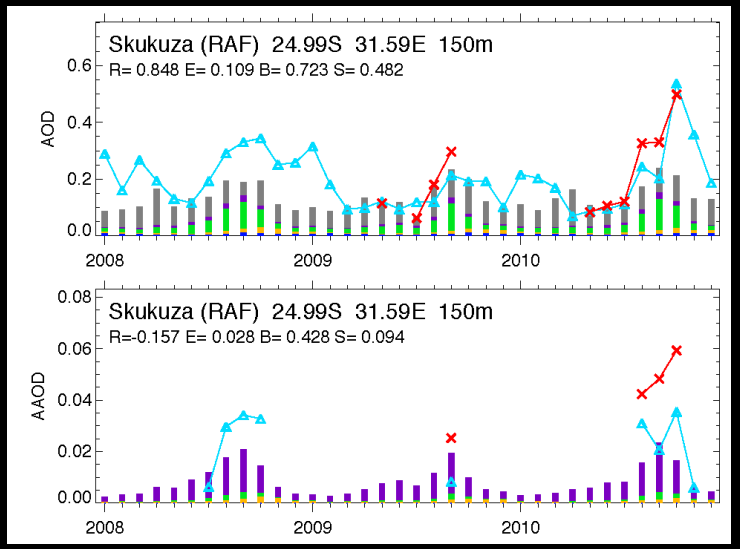


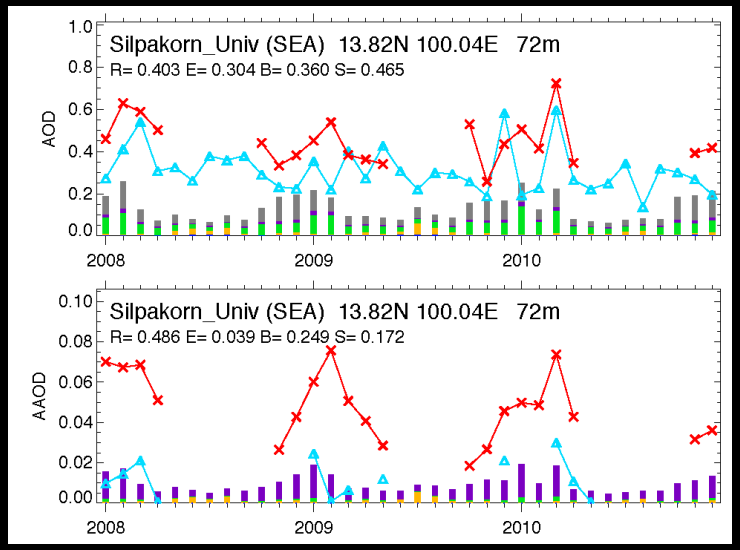


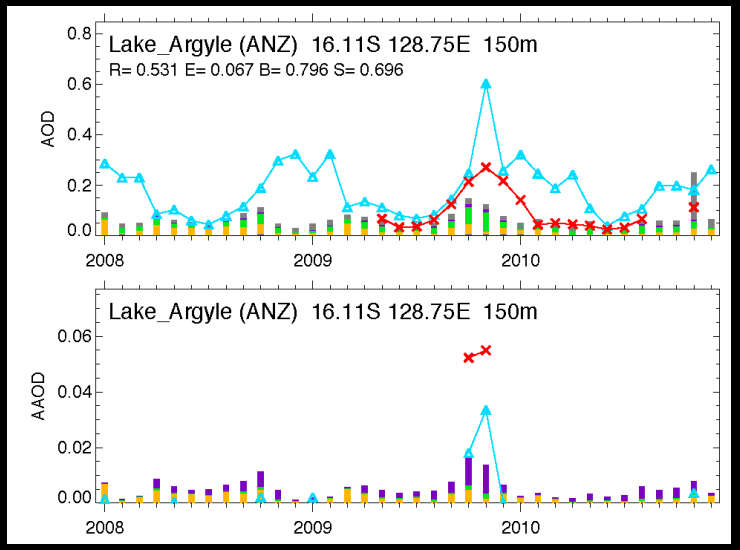


Comparisons with AERONET AOD and AAOD – biomass burning regions



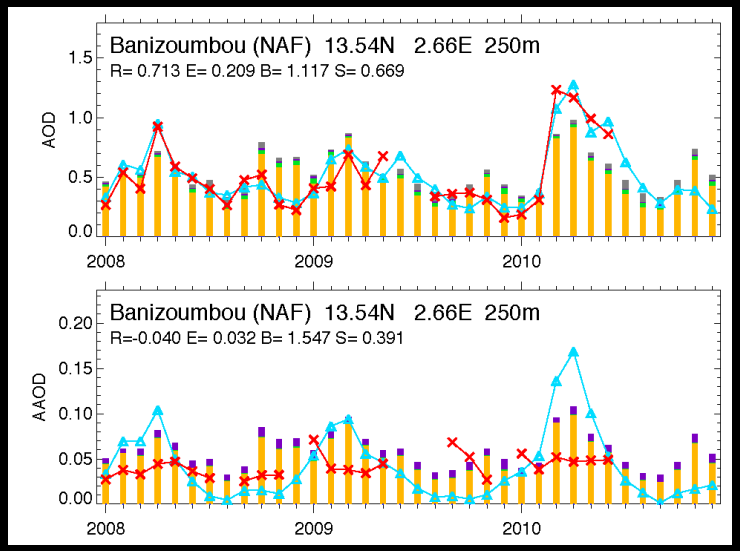


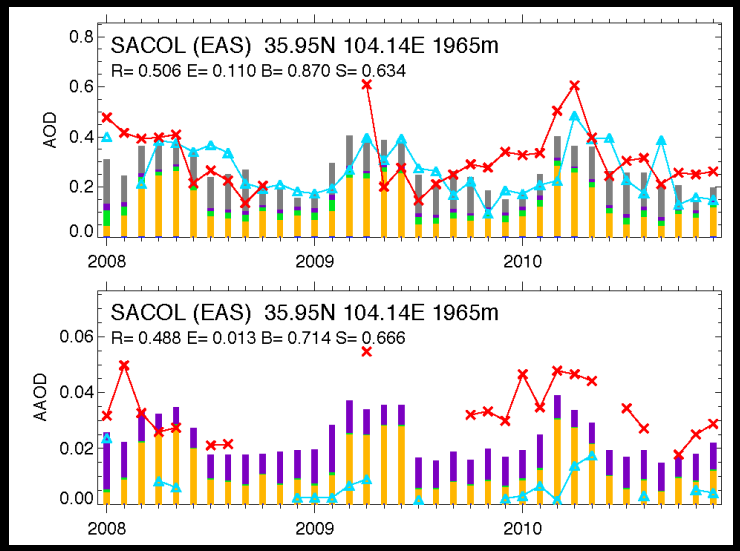


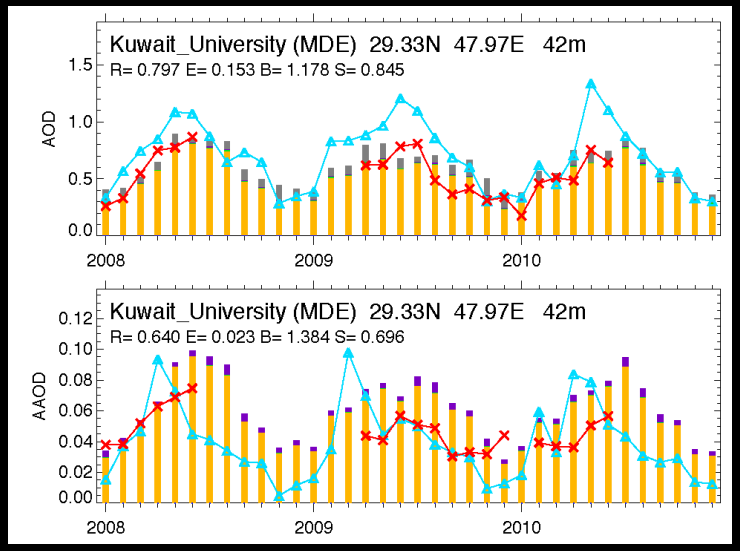


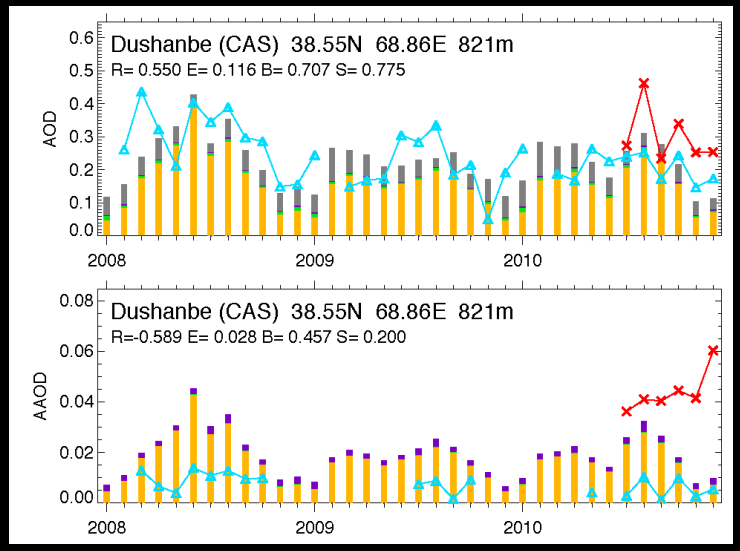
AERONET
OMI
GOCART
SU
BC
POM
Dust
Seasalt

Comparisons with AERONET AOD and AAOD – dust regions

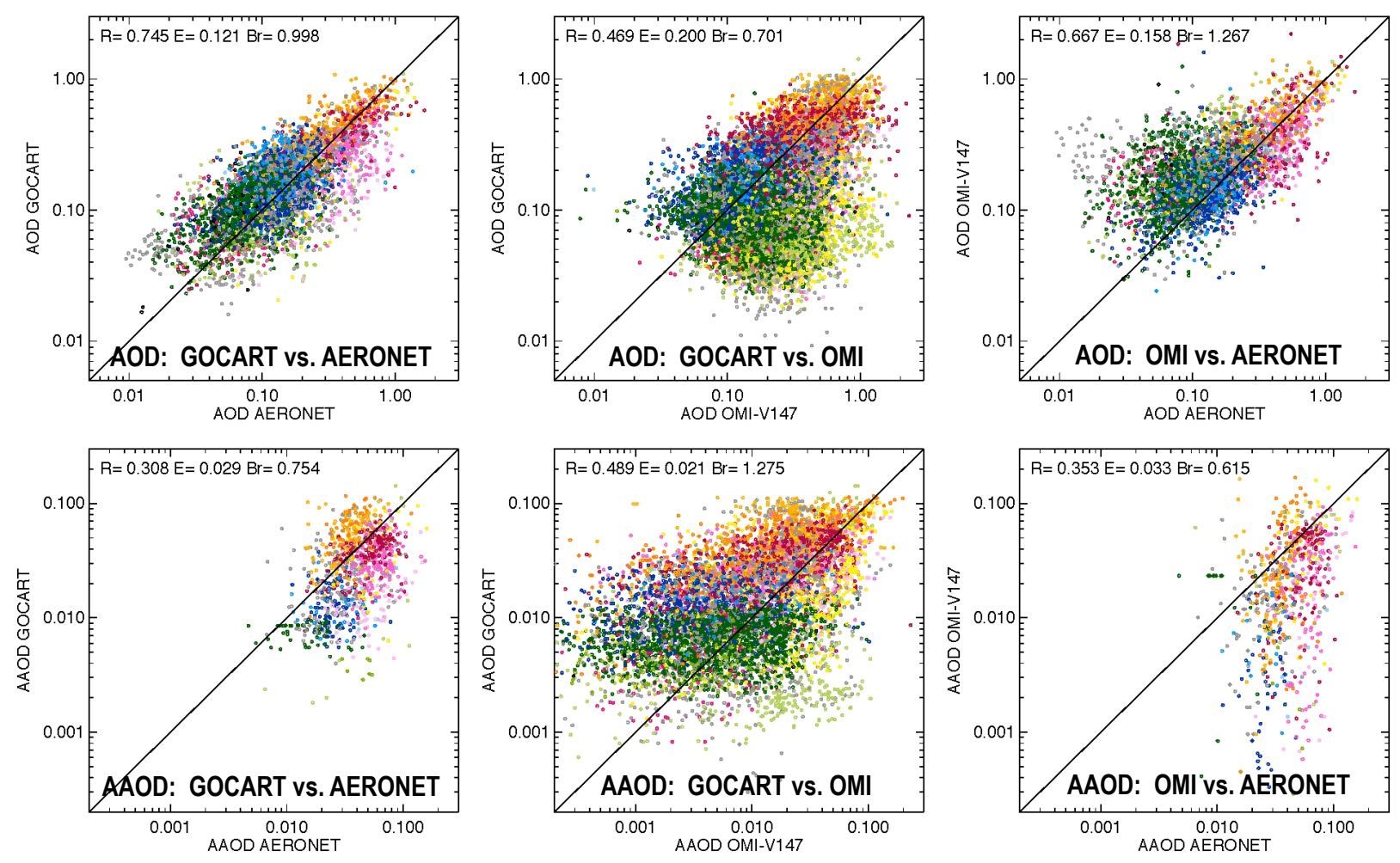




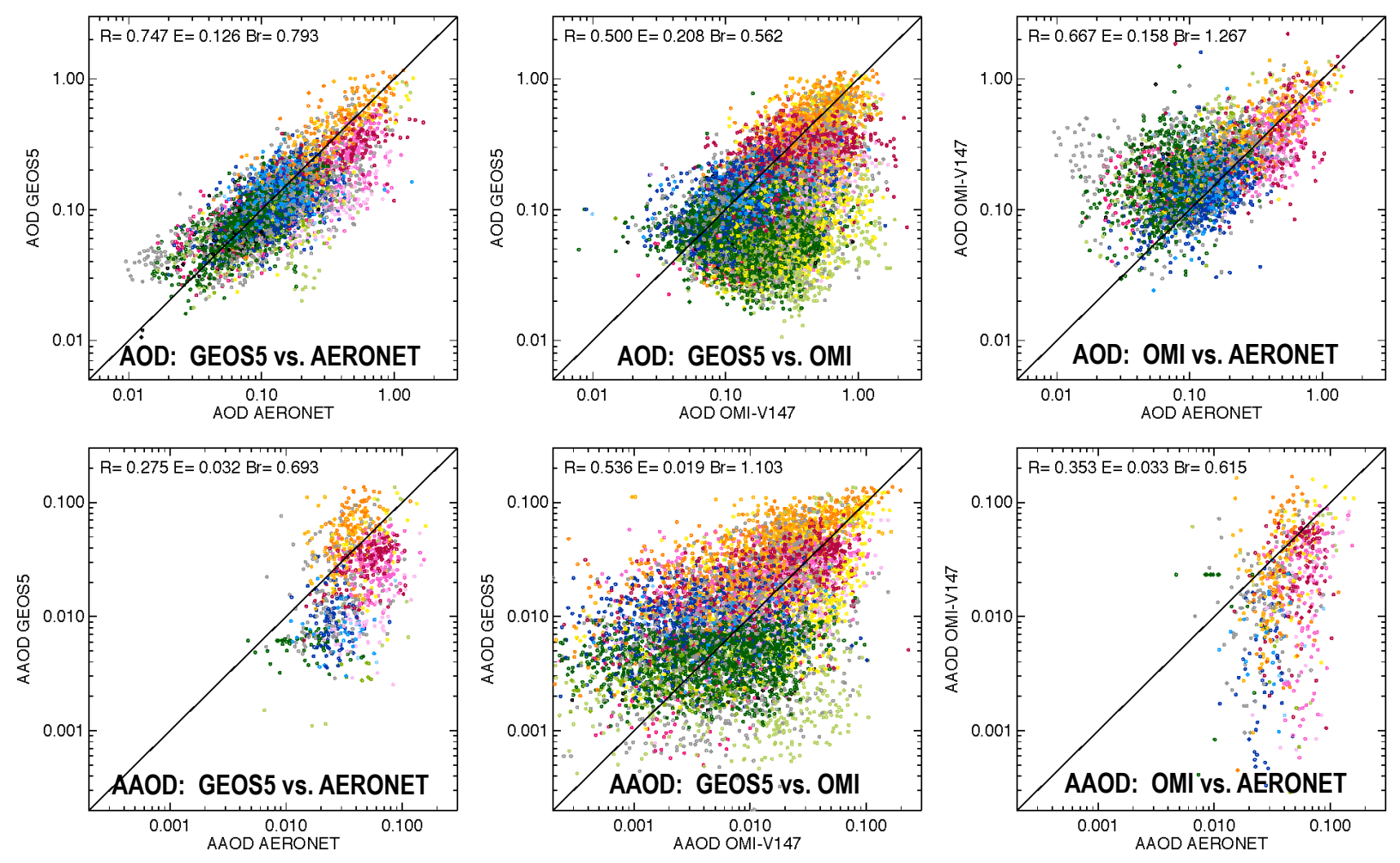




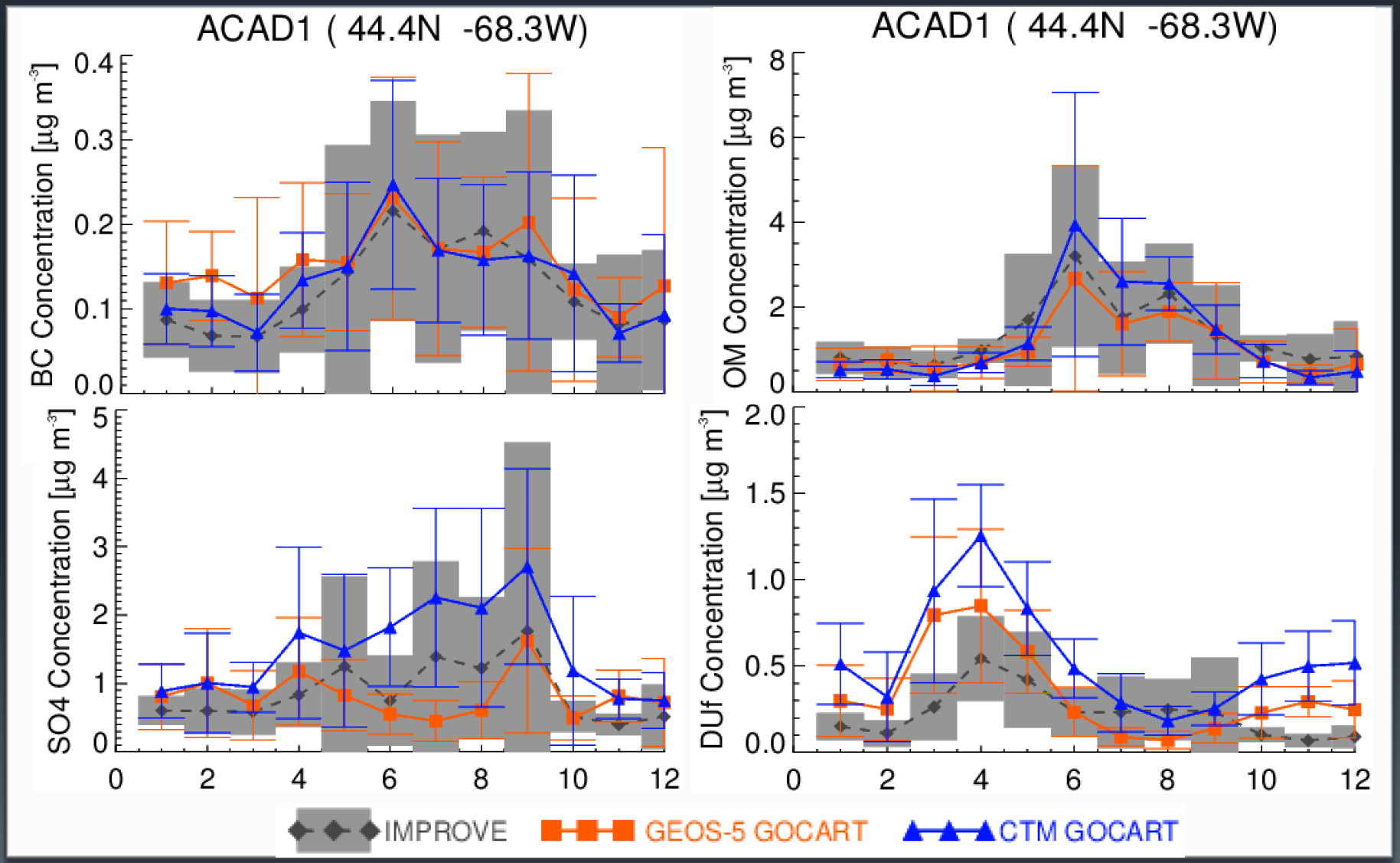
Overall correlation (monthly quantities), 2008-2010



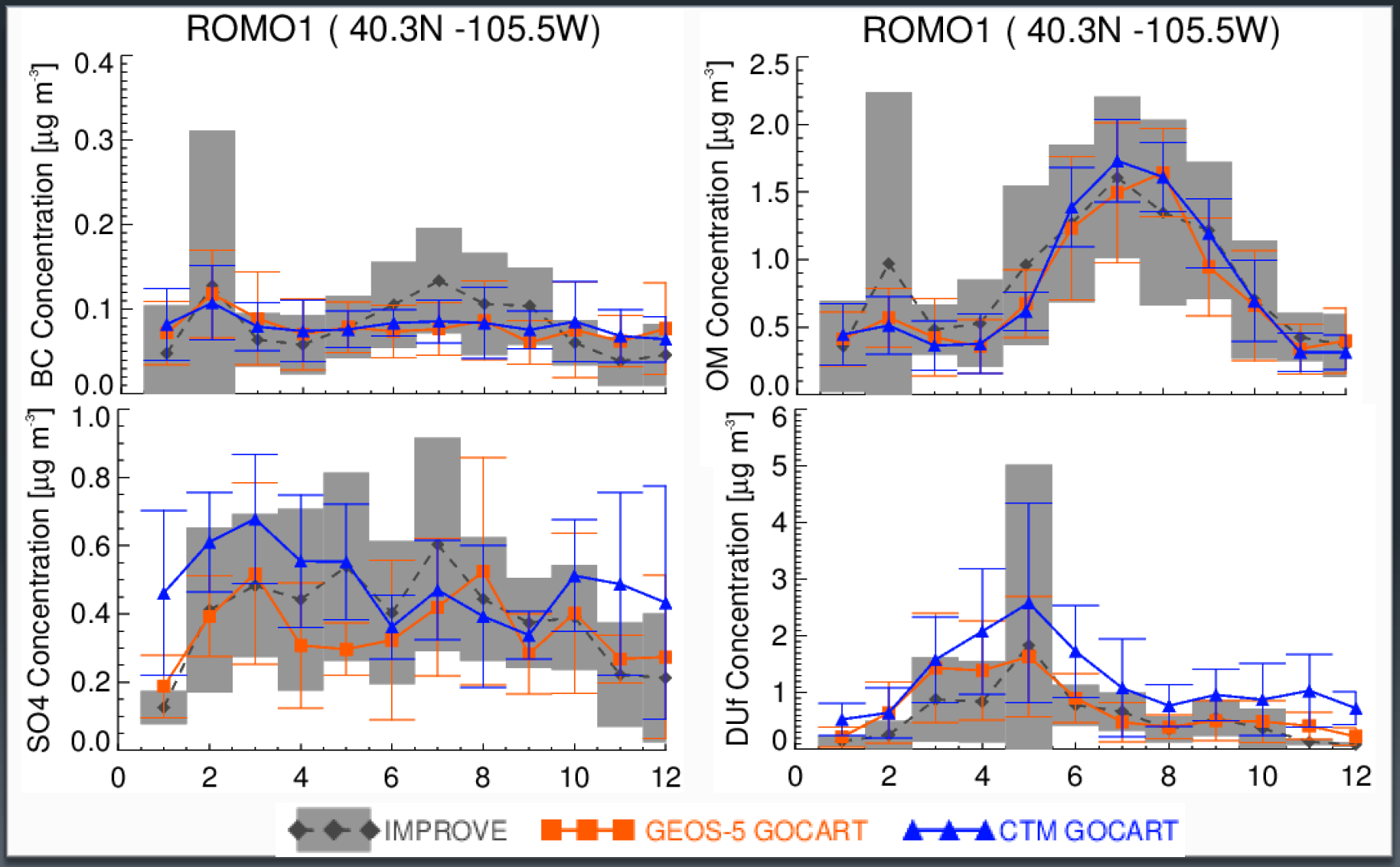
Overall correlation (monthly quantities), 2008-2010



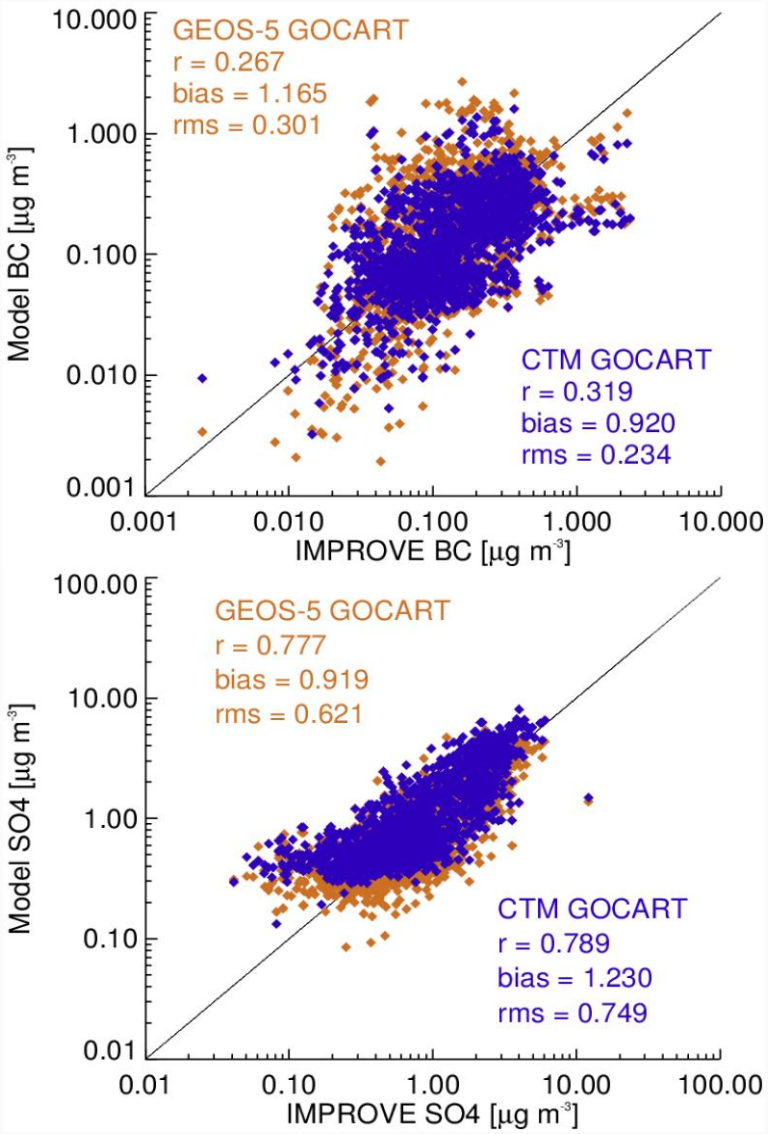
Comparisons of surface concentrations – IMPROVE site ACAD1

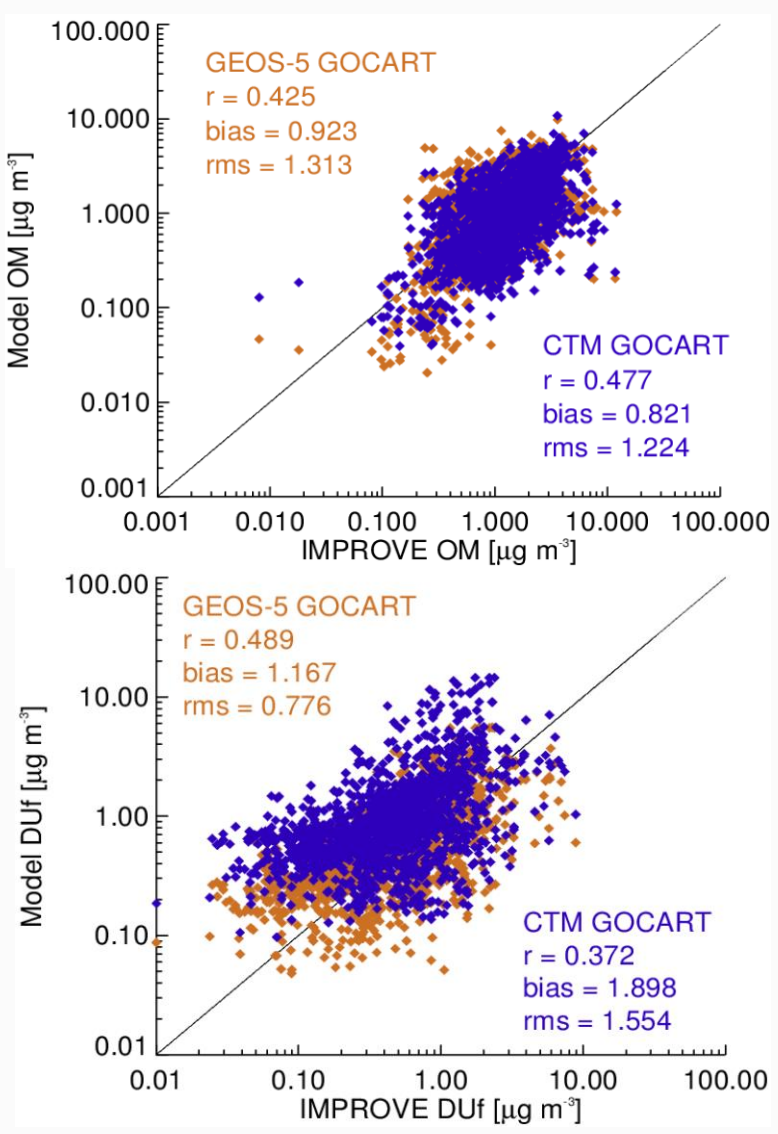


Comparisons of surface concentrations – IMPROVE site ROMO1



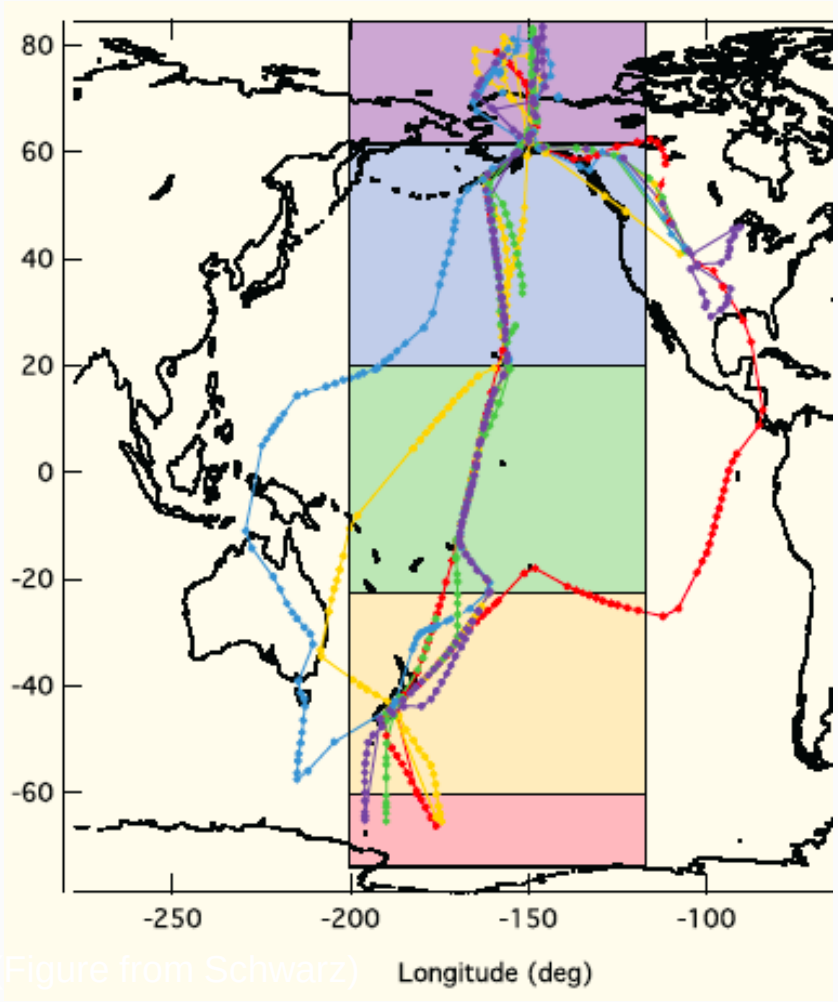
Overall Comparison with IMPROVE data





Comparisons with BC vertical profile from the HIPPO measurements – Still no good

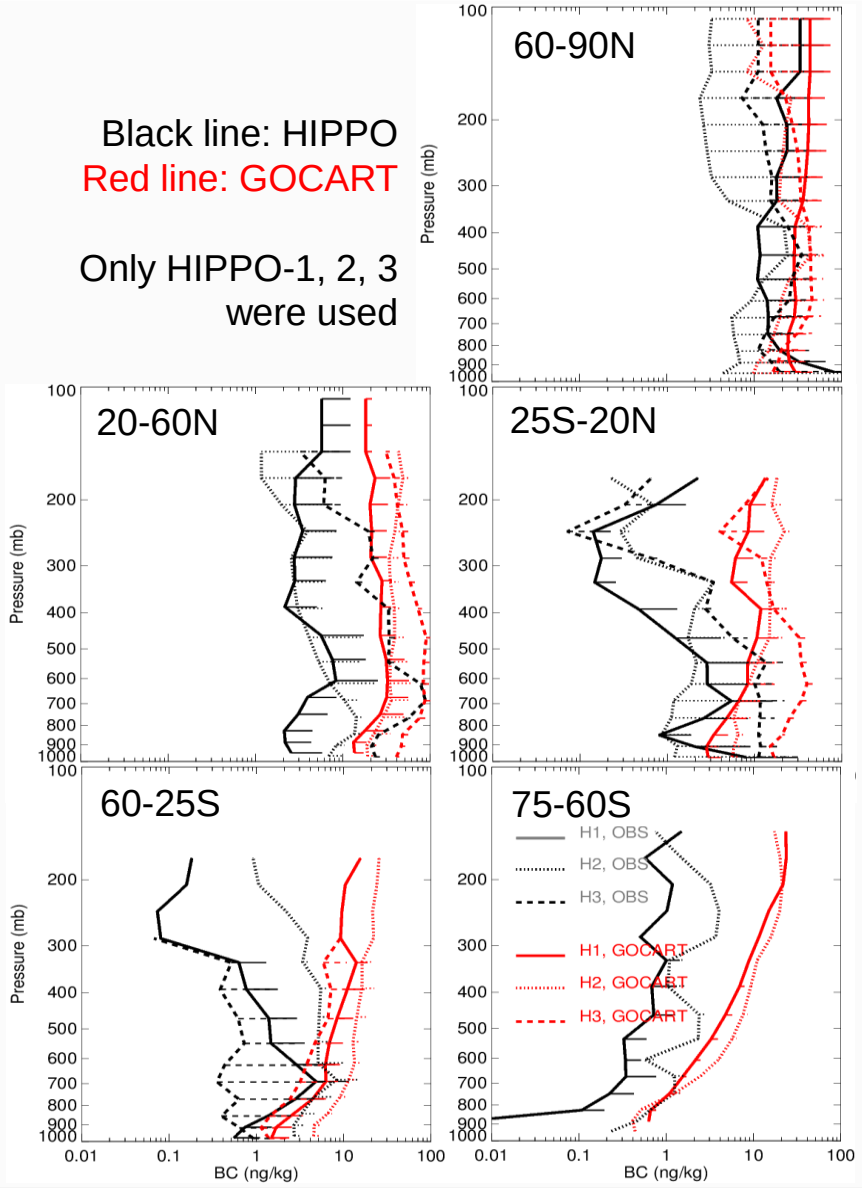
HIPPO flight tracks



(Figure from Schwarz)

Black line: HIPPO
Red line: GOCART

Only HIPPO-1, 2, 3 were used



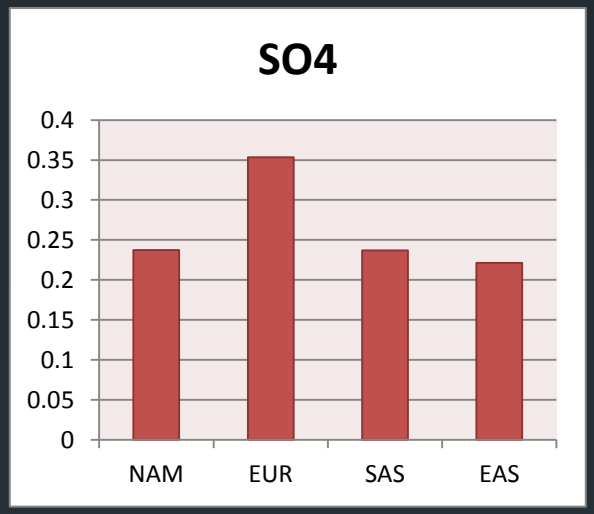
Response to extra-regional emission reduction (RERER)

- RERER (or *R*) for each region *i* is the regional concentration change due to the extra-regional emission reduction relative to that due to the global emission reduction (regional + extra regional), which can be written as

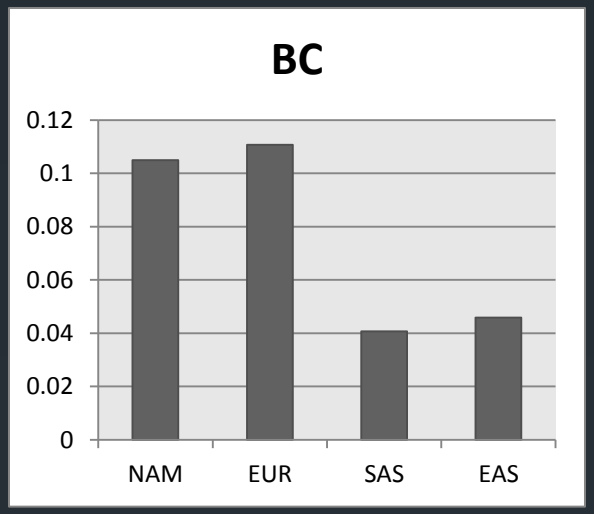
$$R_i = \frac{\Delta C_{i,glo} - \Delta C_{i,rgn}}{\Delta C_{i,glo}}$$

- The lower the R_i, the less sensitive the amount within a region to the extra-regional emission reduction (or the more sensitive to the emission reduction within its own region)

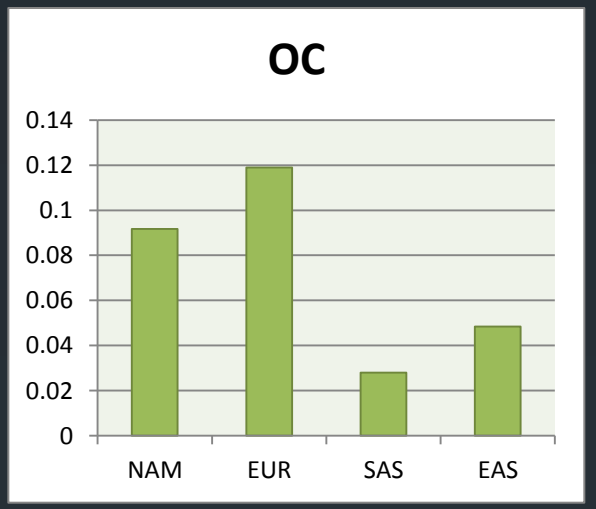
Surface concentration RERER (GOCART) in NAM, EUR, SAS, and EAS - anthropogenic



EUR is most sensitive to extra-regional SO2 emission change

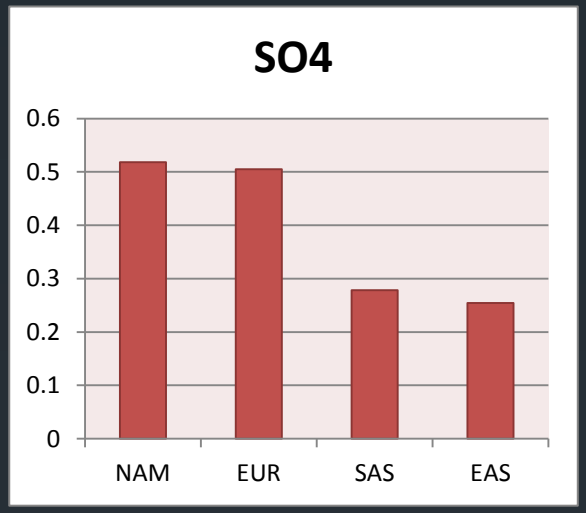


SAS and EAS are least sensitive to extra-regional BC emission change

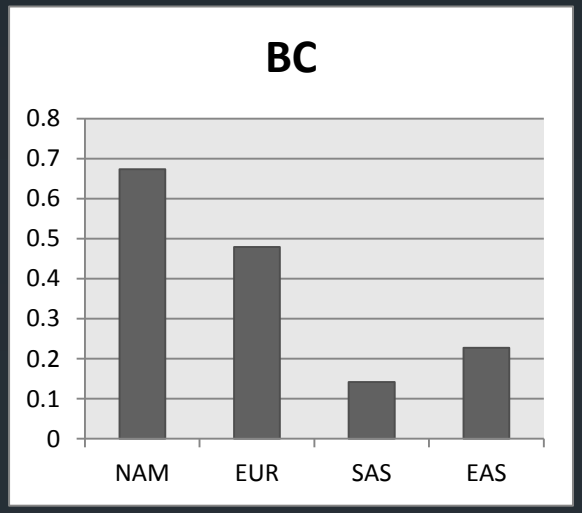


EUR is most and SAS is least sensitive to extra-regional OC emission change

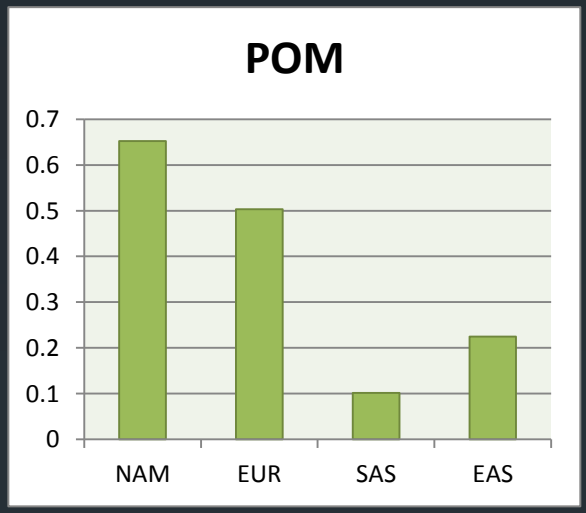
AOD RERER (GOCART) in NAM, EUR, SAS, and EAS - anthropogenic



NAM and EUR are much more sensitive to extra-regional SO2 emission change than SAS and EAS

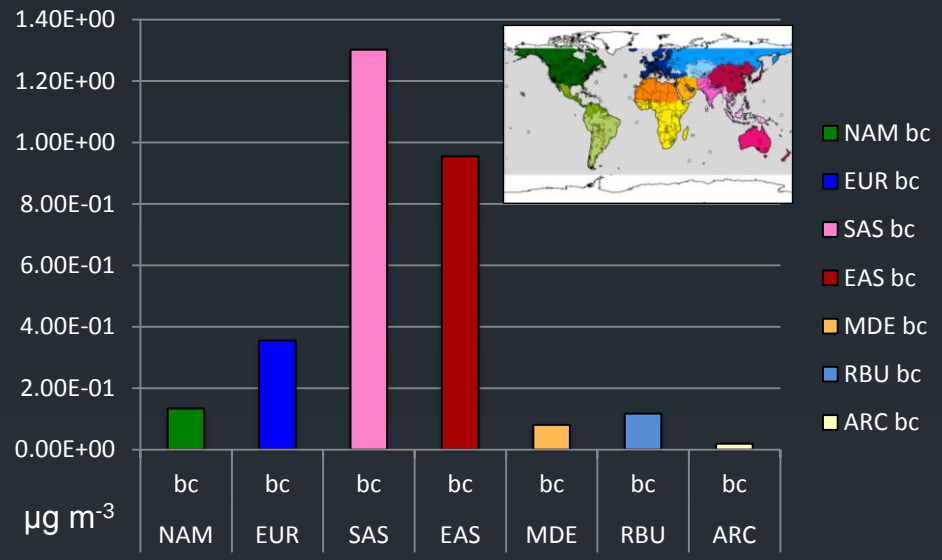


NAM is most sensitive and SAS is least sensitive to extra-regional BC emission change

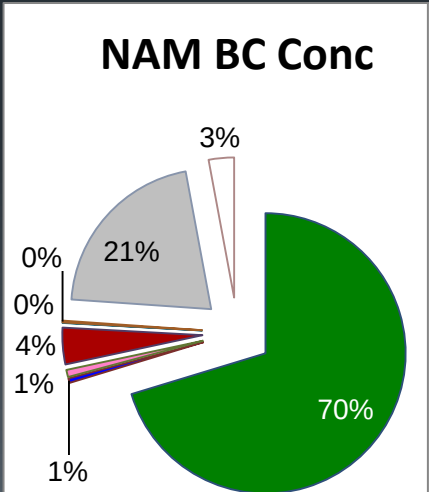


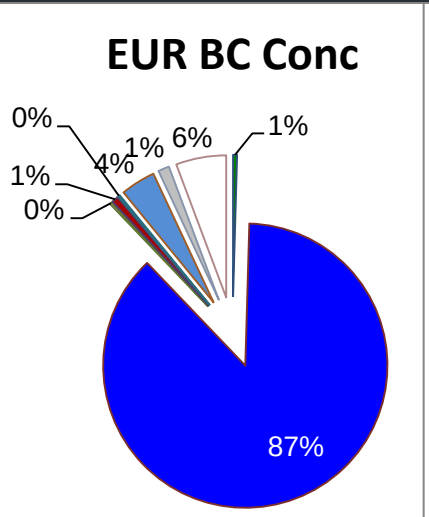
NAM is most sensitive and SAS is least sensitive to extra-regional OC emission change

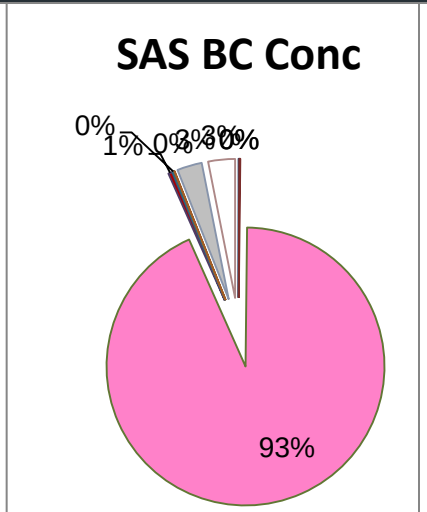
% of regional and extra-regional contributions to surface BC concentration

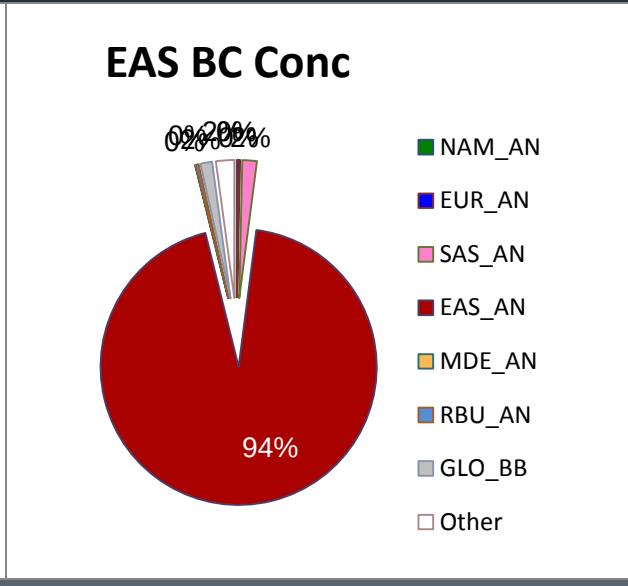


- On regional average, BC concentrations in SAS and EAS are much higher than that in NAM and EUR
- Over the source regions of NAM, EUR, SAS, and EAS, BC is predominantly from the regional pollution sources, especially in SAS and EAS

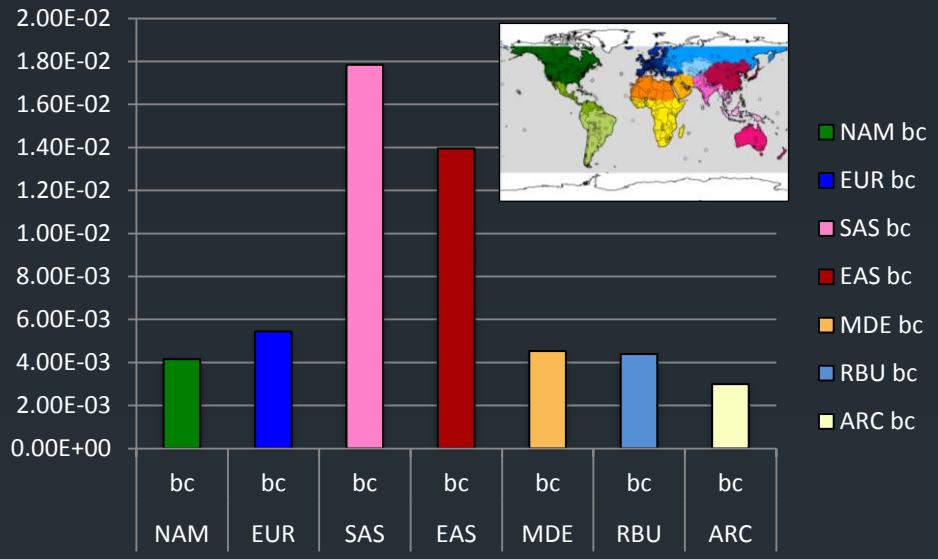




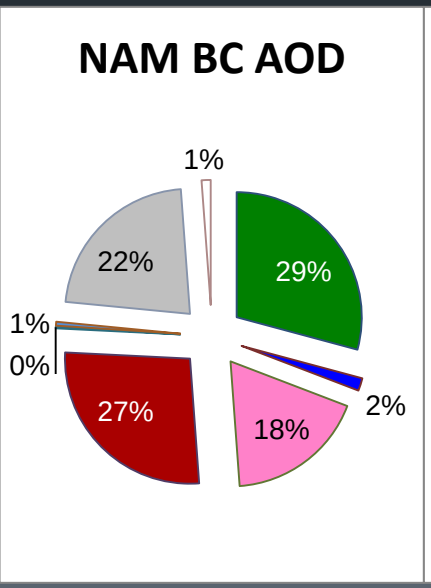


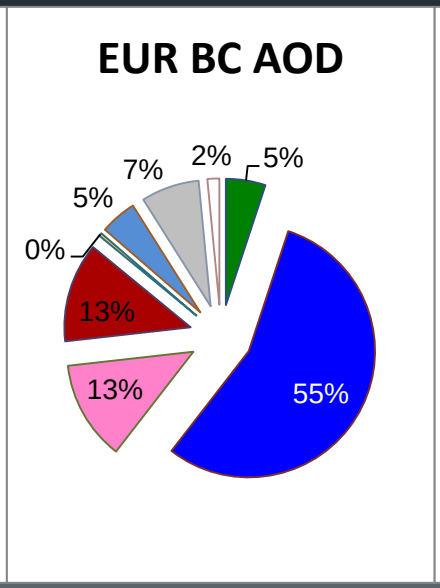


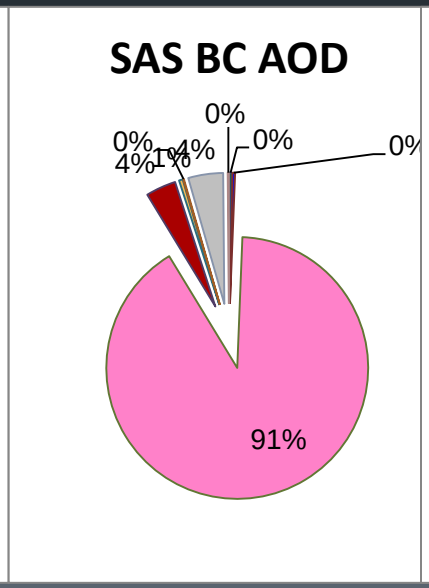
% of regional and extra-regional contributions to column BC AOD

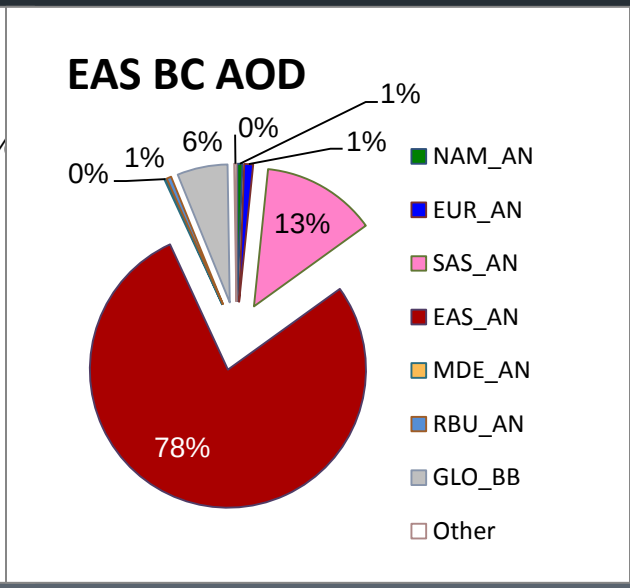


- In contrast to the surface, the atmospheric column over the pollution regions is much more affected by long-range transport especially NAM that is prone to pollution transported from Asia
- Meanwhile, regional pollution is still the dominant source of column BC over SAS and EAS

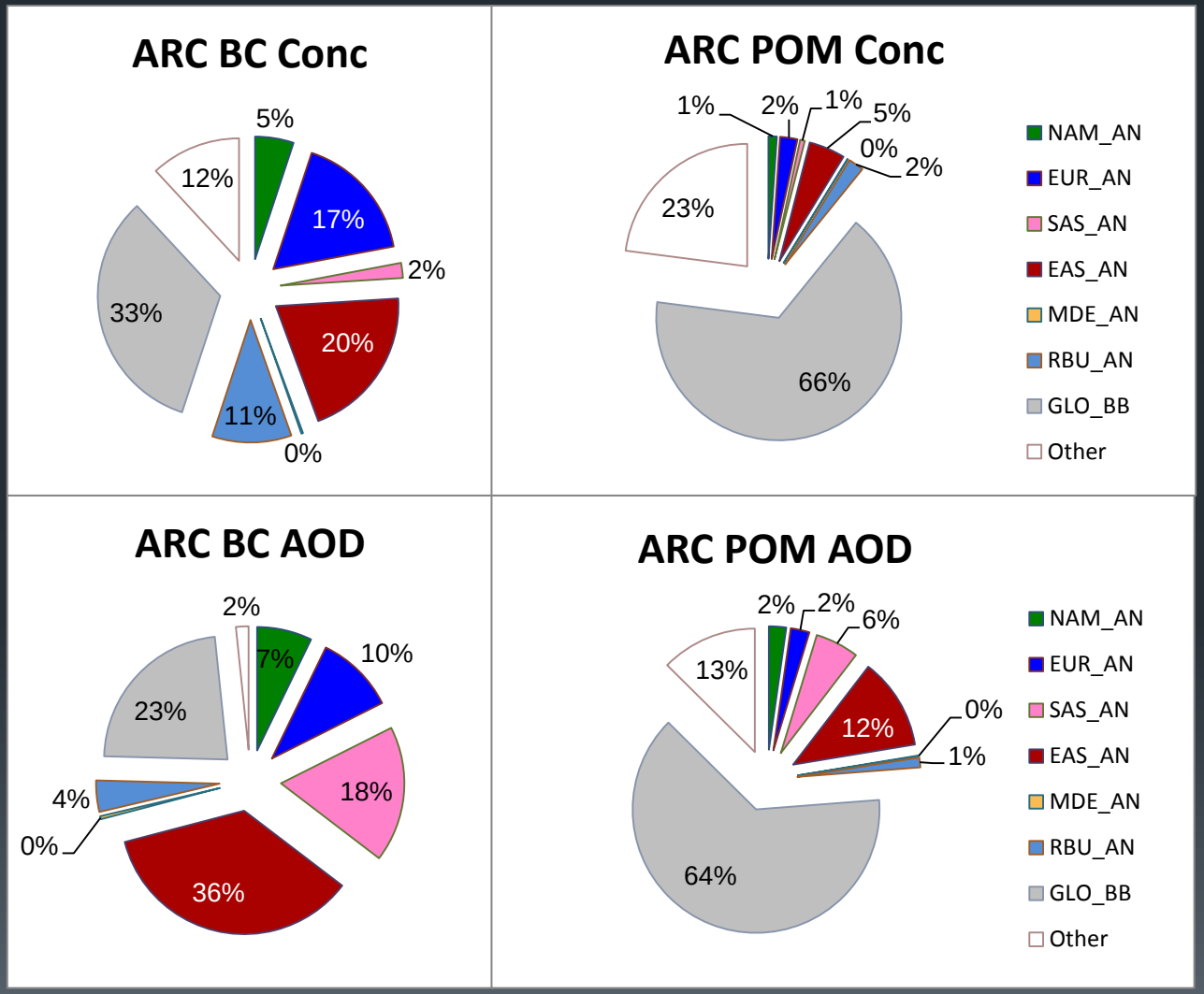








In the Arctic – where are the carbonaceous aerosols from?



- 2/3 of POM over the Arctic is from biomass burning in 2010
- Among the pollution regions, EAS now surpasses EUR to be the most influential region for the Arctic BC at both surface and column

Conclusions

- We have demonstrated the HTAP2 analysis with AeroCom III model runs
- We have targeted the model evaluations of AOD, AAOD, surface concentrations, and vertical profiles with satellite and suborbital observations
- We have shown the policy-relevant HTAP matric of impacts of regional vs. extra regional sources on regional air quality and column AOD
- We would like to have more models involved