NASA Modeling Activity Relevant to Air Quality

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NASA's Earth Science Modeling Programs *(that I know of…)*

- Modeling, Analysis, and Prediction (MAP) Program
  - Supports model development and simulations for climate and weather (GISS, GMAO, GMI, GOCART, GEOS-Chem, etc.)
- Atmospheric Chemistry Modeling and Analysis Program (ACMAP)
  - Supports model analysis of satellite and suborbital data
- Radiation Sciences Program (RSP)

non-RAQMS

A few current modeling activities for AQ

(I am involved in ...)

- Participating in the United Nation's Task Force on Hemispheric Transport of Air Pollution (HTAP)
- Analyzing how the satellite aerosol optical depth data can (or cannot) be used for PM2.5 prediction/monitoring
- Working with NOAA (in our spare time) to develop GFS aerosol capability and improve weather/air quality forecasts

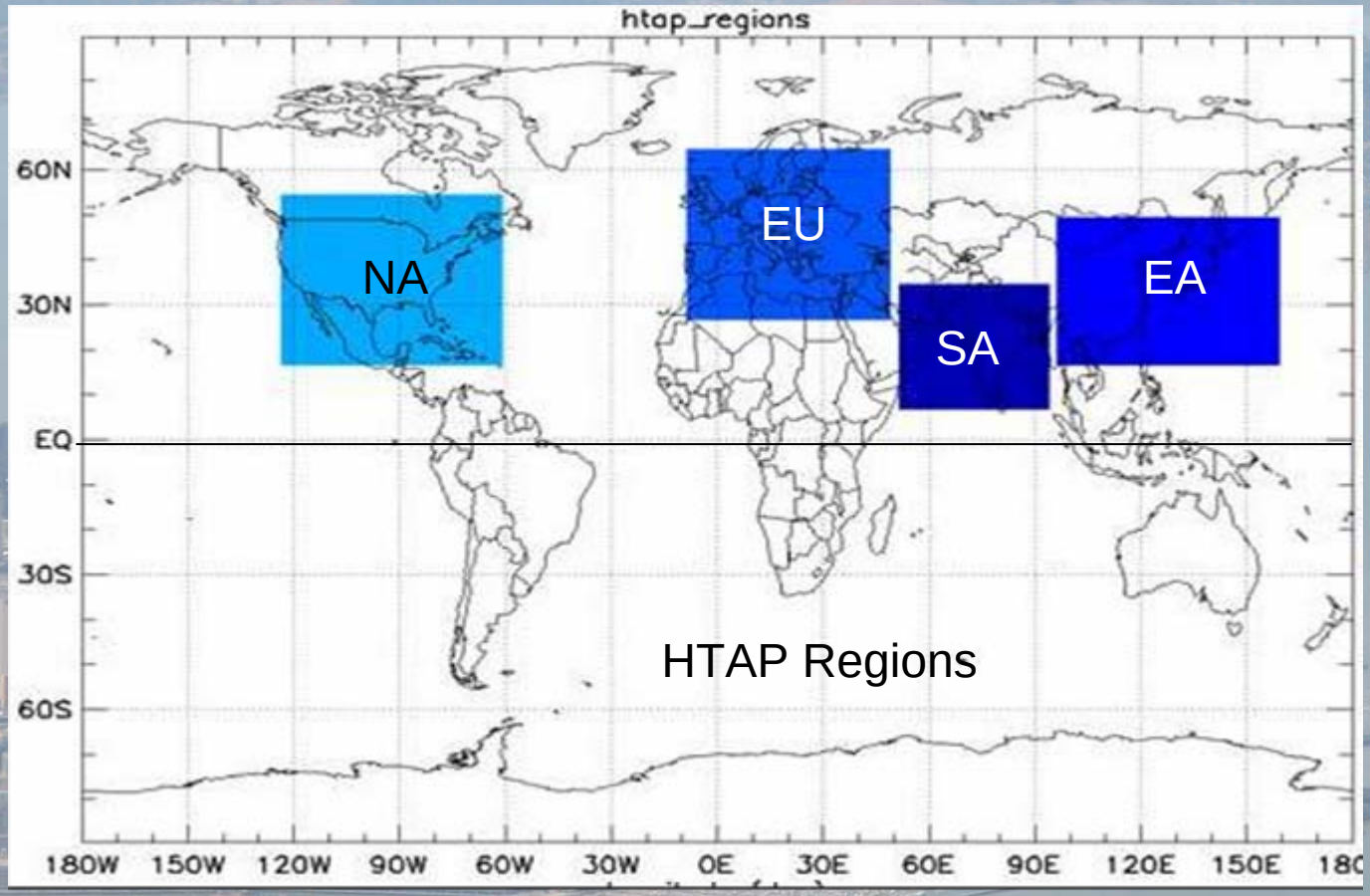
(1) HTAP

- The UNECE CLRTAP Task Force on Hemispheric Transport of Air Pollution (TF HTAP) has initiated a comprehensive modeling study to assess the importance of intercontinental transport of air pollution

- Coordinated experiments with global and regional chemical transport models have been carried out with participation from many research groups, including NASA models GOCART, GMI, GISS

- In the “standard” experiments, pollutants emissions in the four major pollution source regions (NA, EU, SA, EA) were kept at 100% or 80% levels and the differences were used to access the impact

Initial results from HTAP for PM

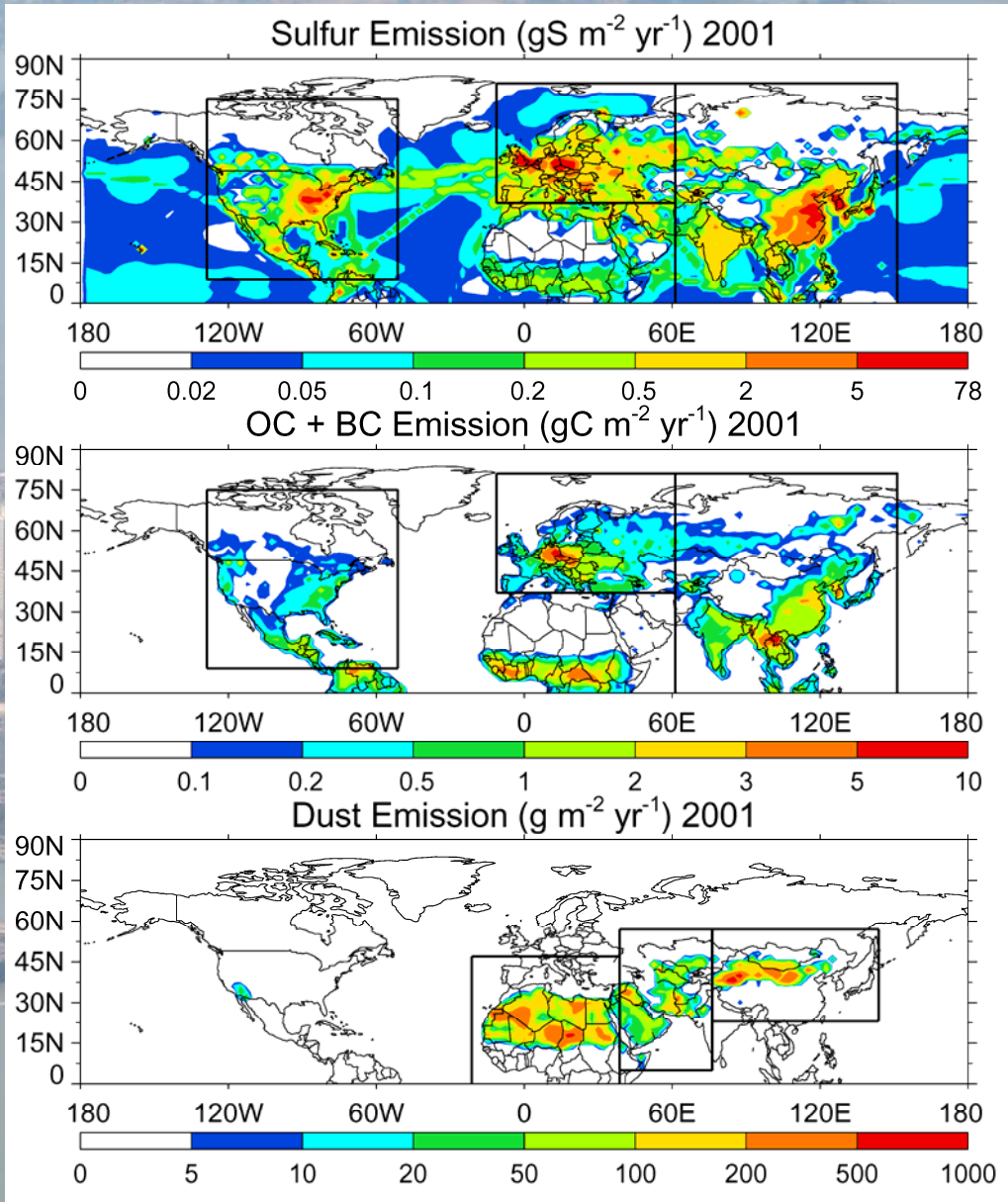


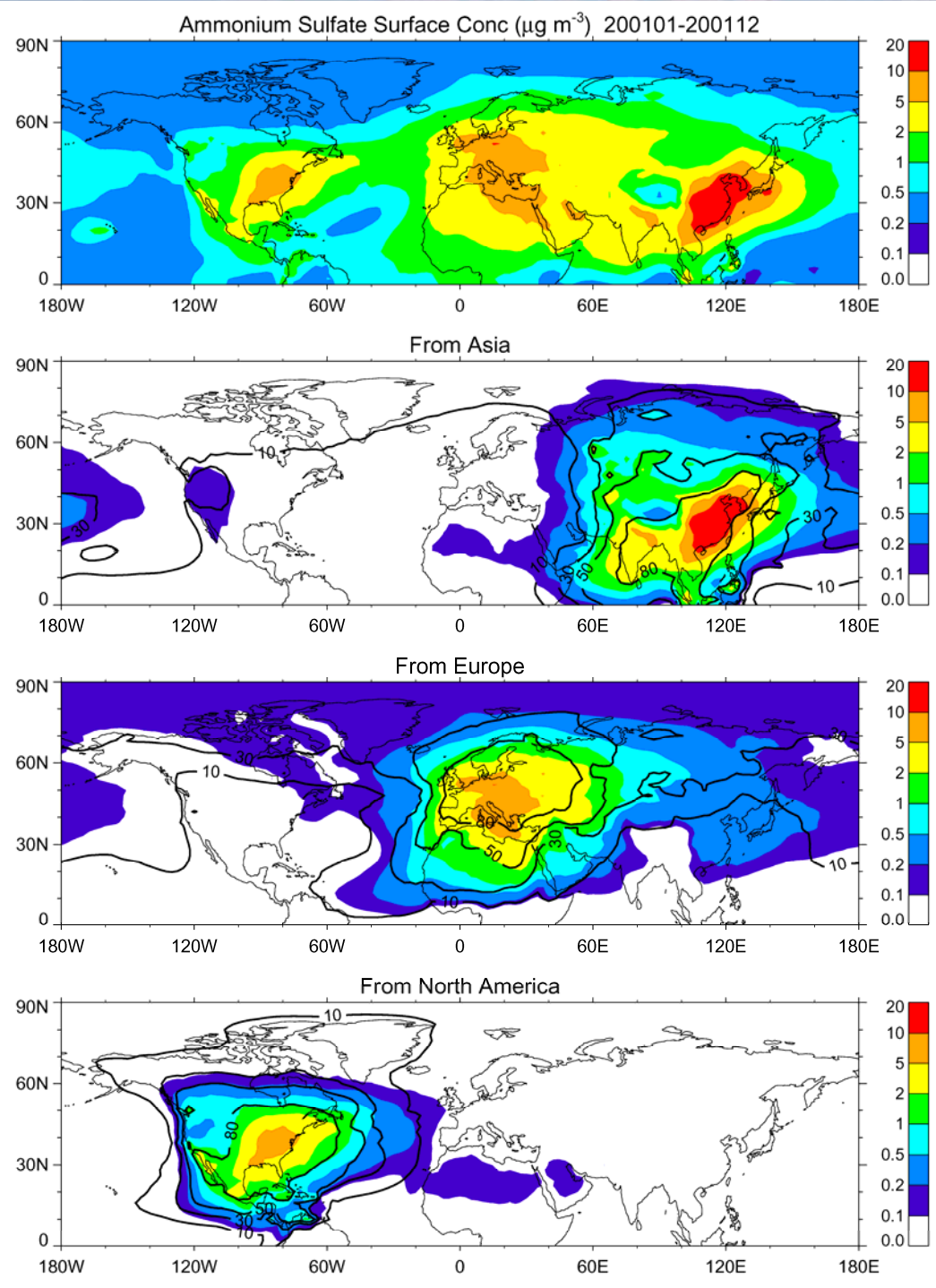
Results from 9 models	NA	EU	SA	EA
% of pollution PM imported to the region	7% ± 6%	5% ± 4%	25% ± 12%	10% ± 9%

Pre-HTAP study on intercontinental transport of aerosols and implication on PM air quality

- GOCART model, 2001 scenario
- Three major pollution source regions (NAM, EUR, ASA)
- Three major dust source regions (AFR, MDE, ASA)
- Emissions from each region were kept at 100% or 0% to assess maximum impact

Chin, M., Diehl, T., Ginoux, P., and Malm, W.: Intercontinental transport of pollution and dust aerosols: Implications for regional air quality, ACPD, accepted, 2007.





Intercontinental transport of pollution – $(NH_4)_2SO_4$ as a surrogate

Asia:

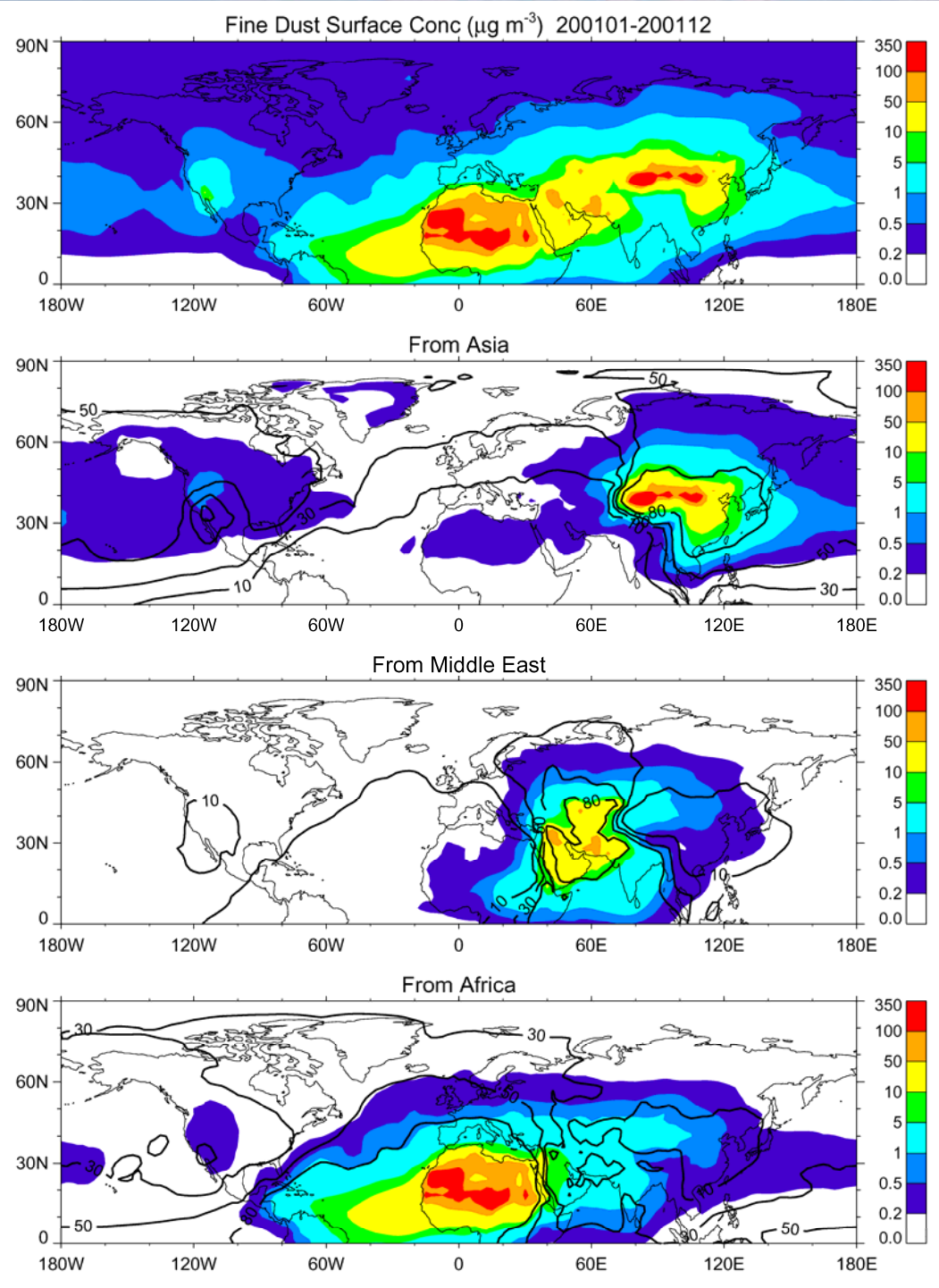
- Eastward transport, efficient removal during transport
- 0.1-0.2 µg/m3 to W.US and N.Afr, more to E.Afr and E.Eur
- < 10% increase to all continents

Europe:

- Pollution widely spread
- Largest impact on N. Africa with 0.5-5 µg/m3 increase
- 0.2-0.5 µg/m3 to E.Asia

North America:

- Relatively regionalized
- Amount to N.Africa/Saudi = Amount from Asia to W.US



Intercontinental transport of fine dust

Asia:

- Efficient eastward transport, less removal than sulfate during transport
- 0.2-0.5 µg/m^3 to US, N.Afr, MidE, 50% over Arctic
- Widespread in NH

Middle East:

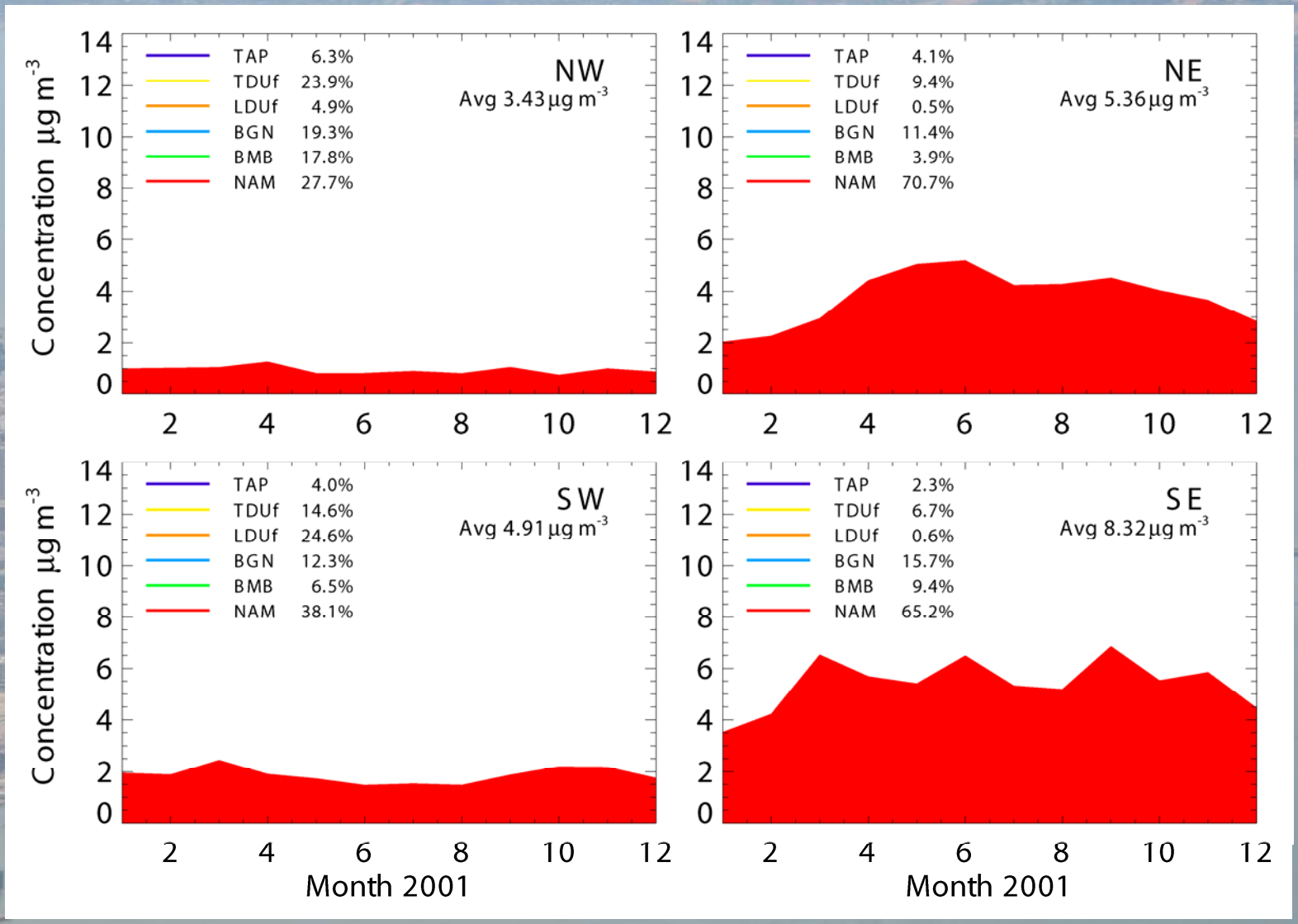
- Limited effects, mostly to neighbors
- Largest impact on N. Indian Ocean
- 0.2-0.5 µg/m^3 to E.Asia!

Africa:

- Westward to C.Am, northward to Europe, eastward to Asia-Pacific-……-North America!!

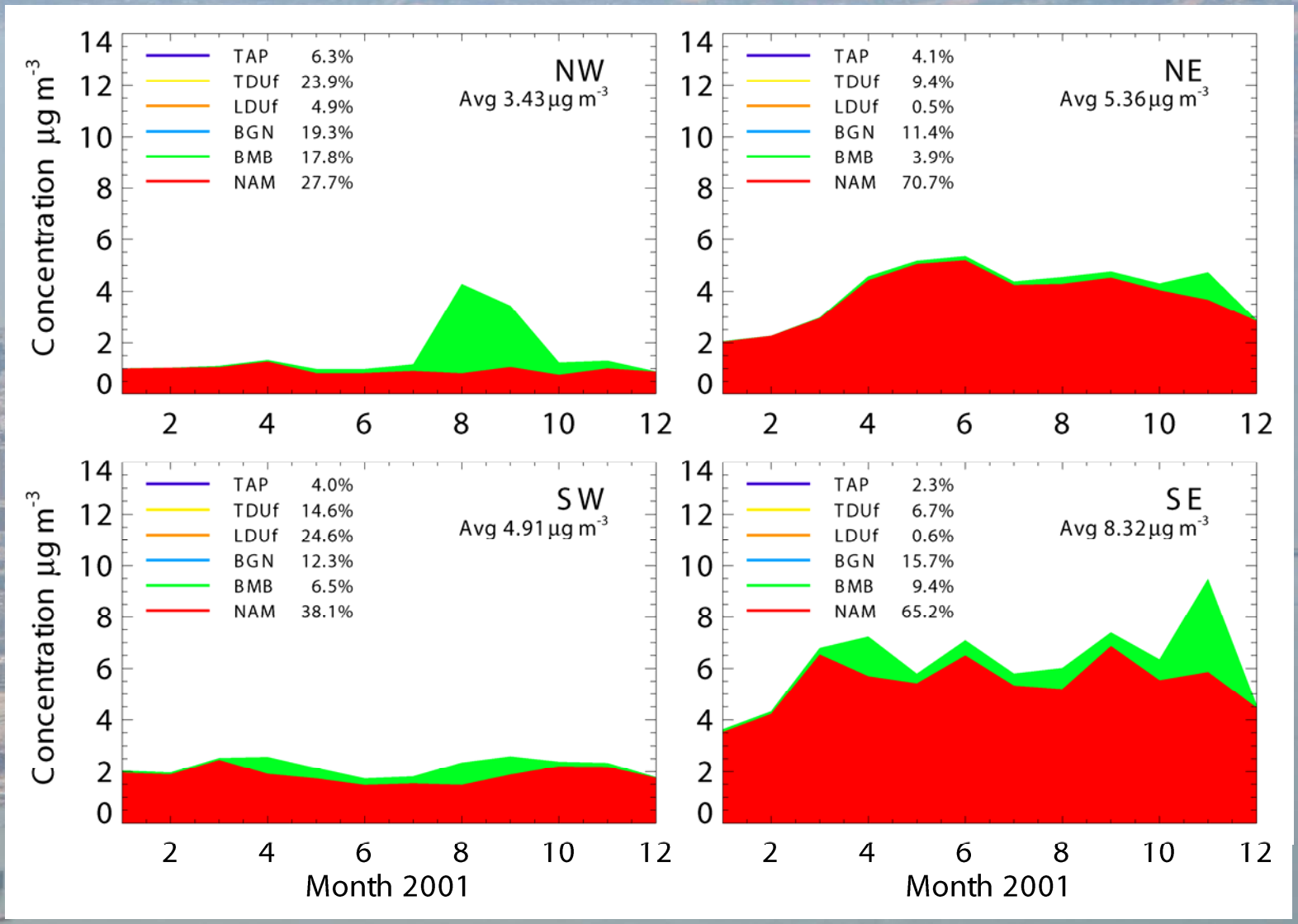
Impact on US (PM) air quality

North America pollution



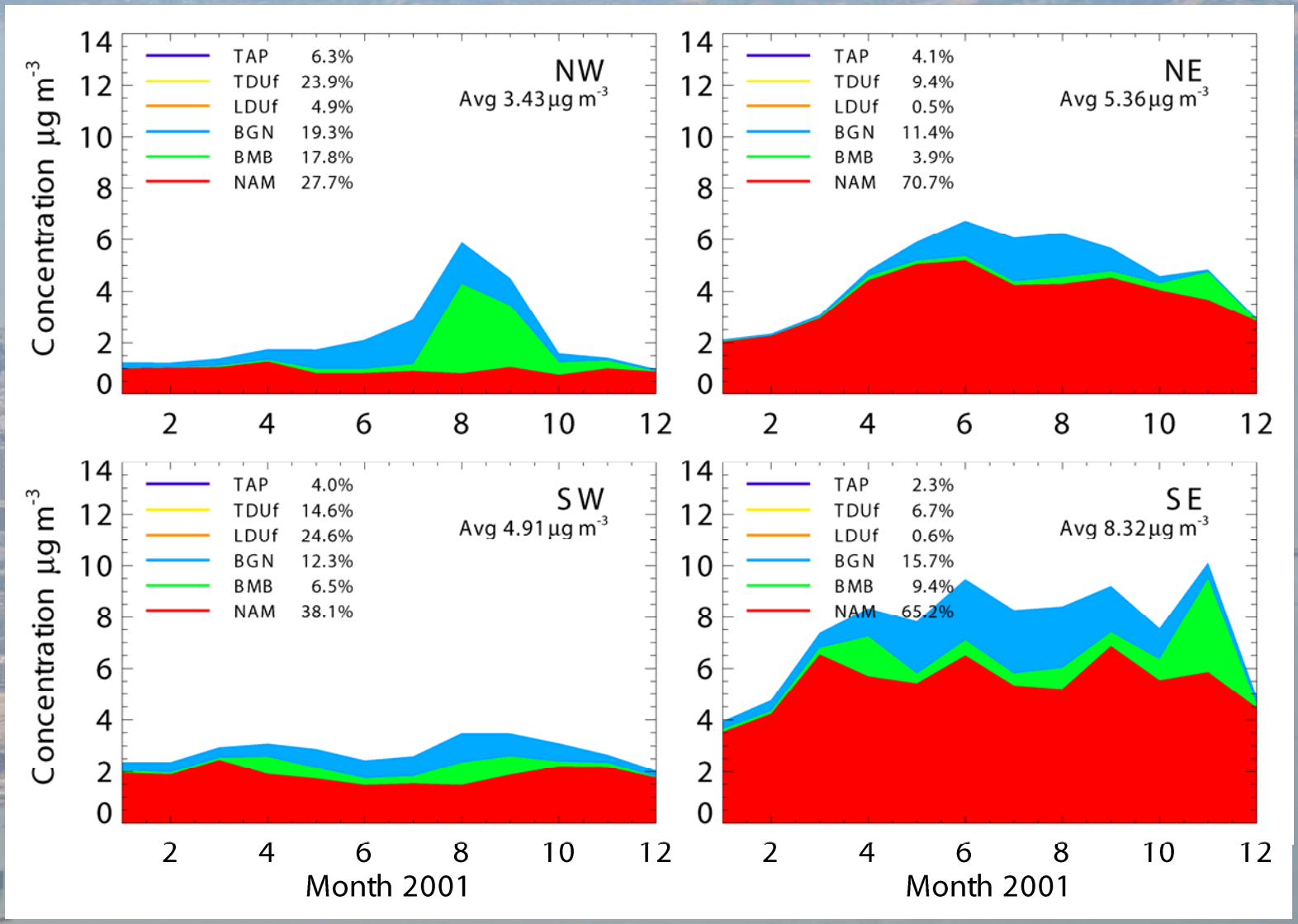
Impact on US (PM) air quality

North America pollution + biomass burning



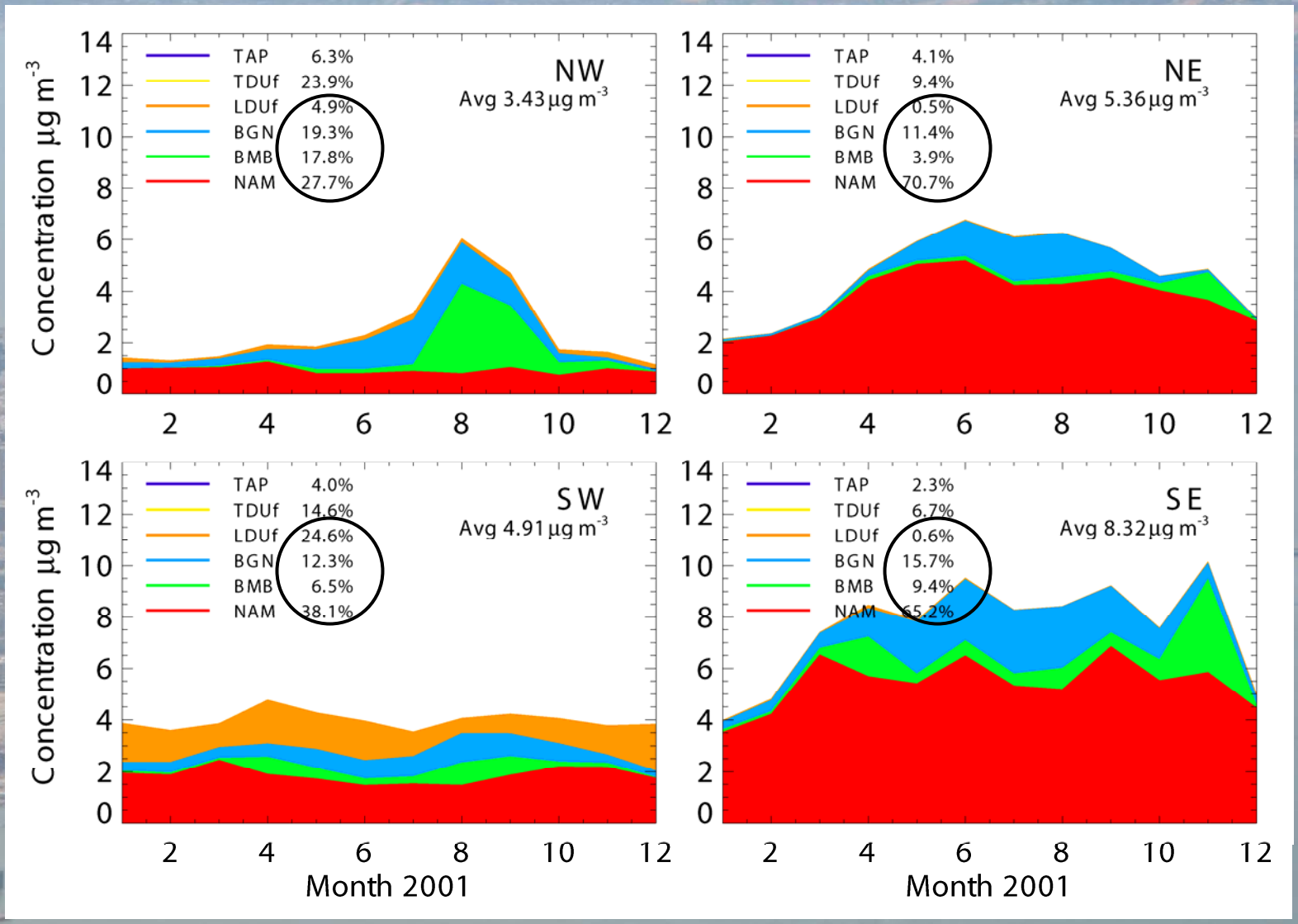
Impact on US (PM) air quality

North America pollution + biomass burning + biogenic



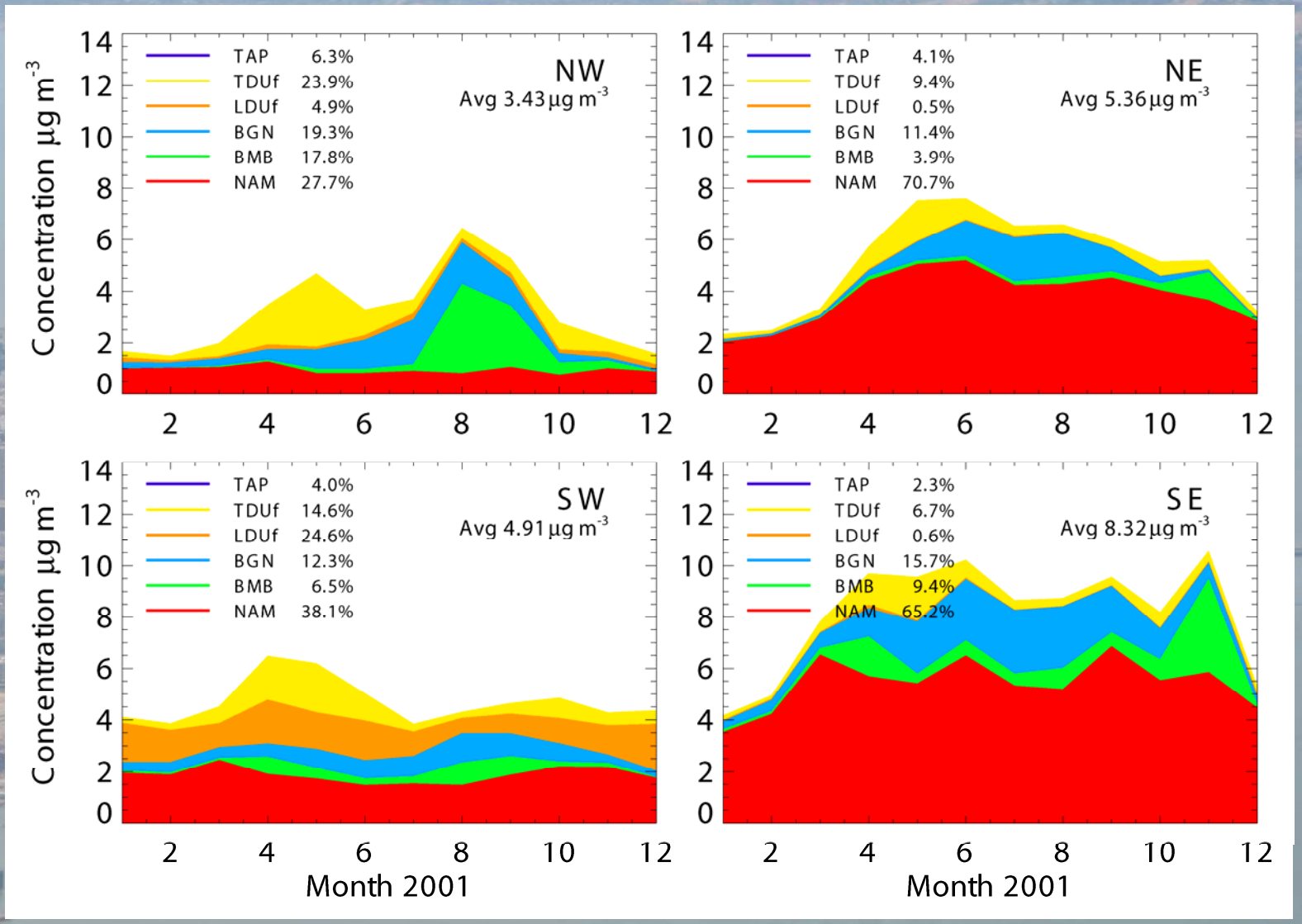
Impact on US (PM) air quality

North America pollution + biomass burning + biogenic + local fine dust = Total local RCFM



Impact on US (PM) air quality

North America pollution + biomass burning + biogenic + local fine dust + imported fine dust

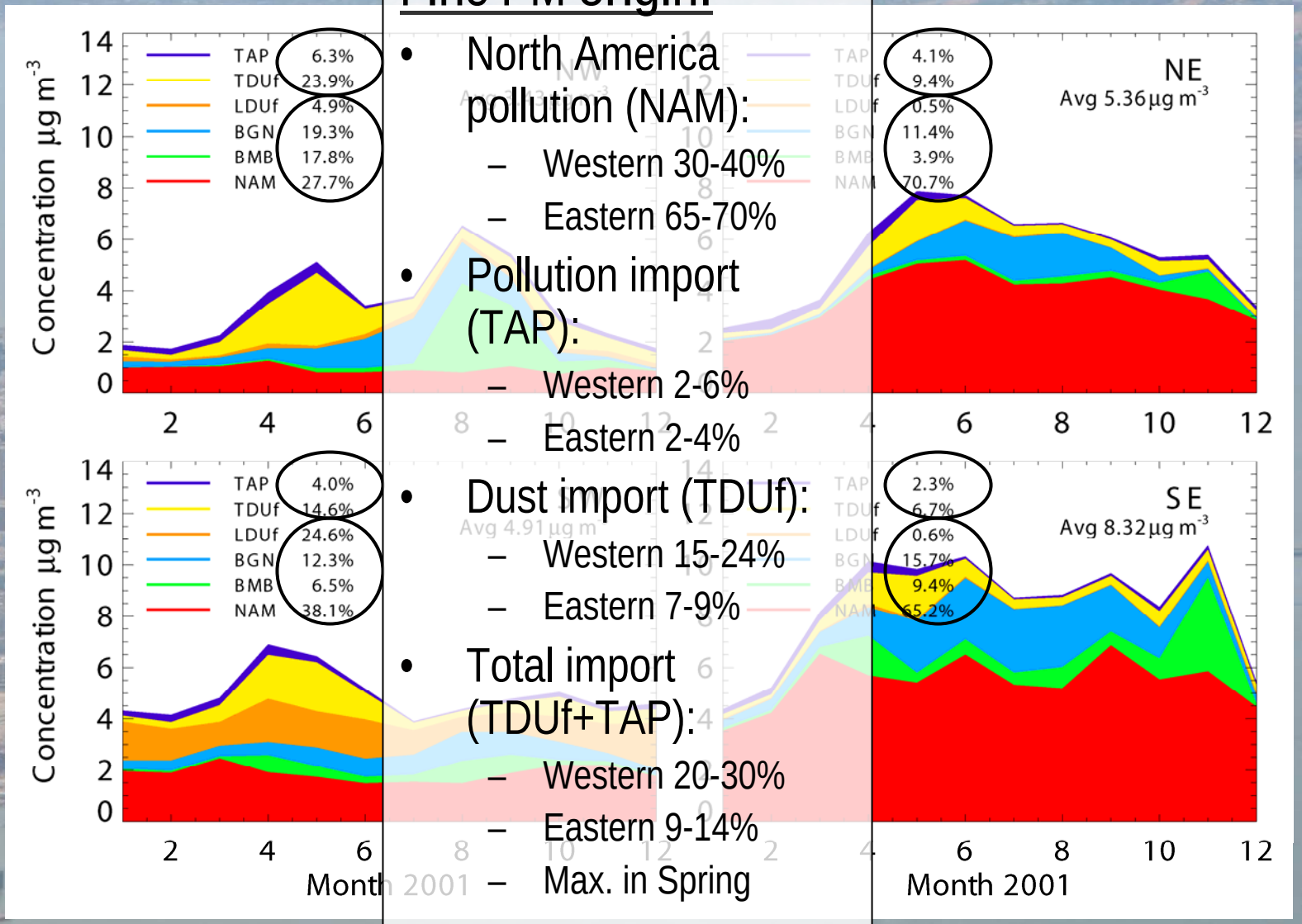


Impact on US (PM) air quality

North America pollution + biomass burning + biogenic + local fine dust + imported dust + imported pollution

Fine PM origin:

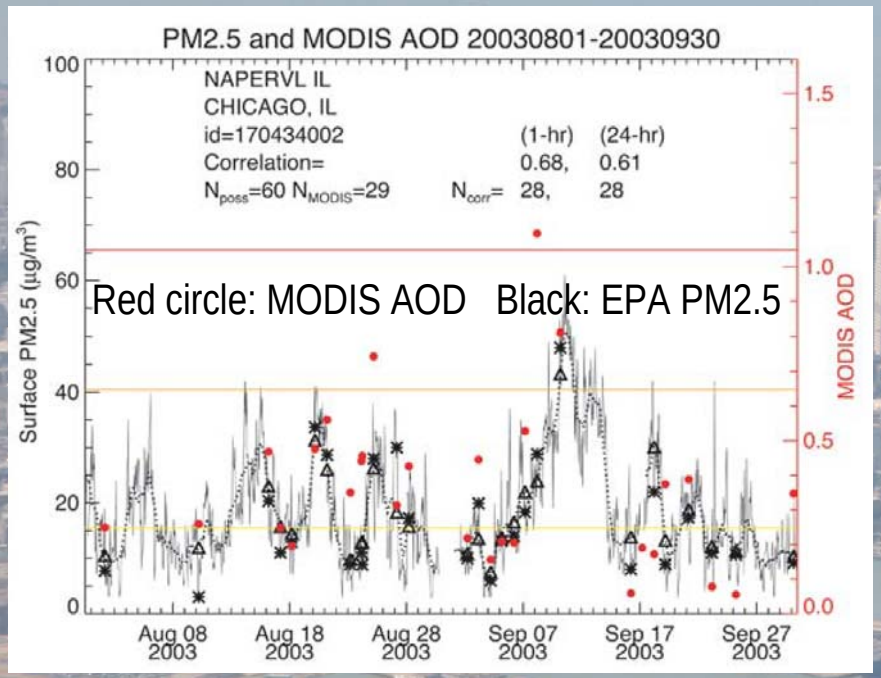
- North America pollution (NAM):
  - Western 30-40%
  - Eastern 65-70%
- Pollution import (TAP):
  - Western 2-6%
  - Eastern 2-4%
- Dust import (TDUf):
  - Western 15-24%
  - Eastern 7-9%
- Total import (TDUf+TAP):
  - Western 20-30%
  - Eastern 9-14%
  - Max. in Spring



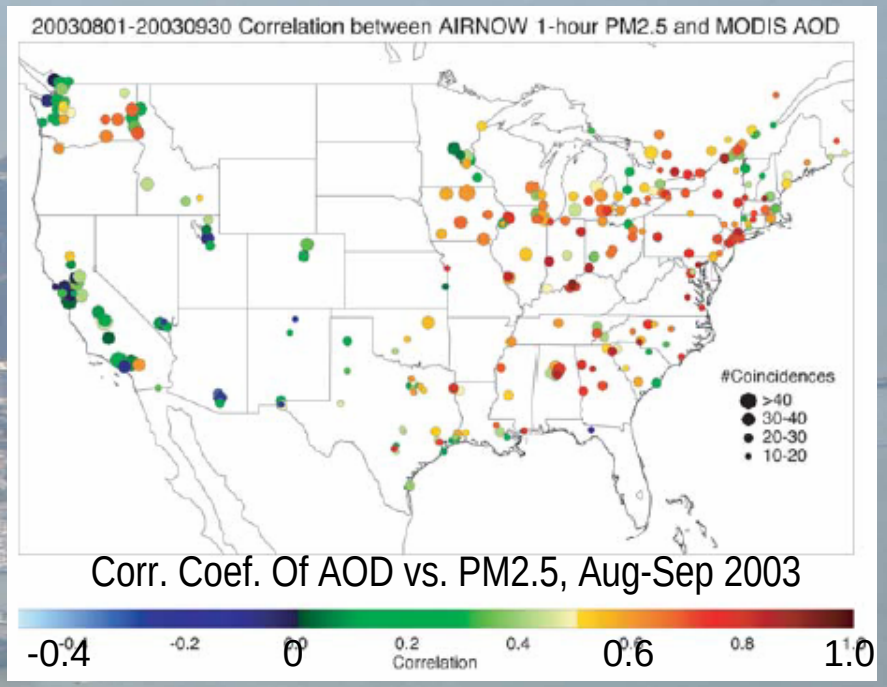
Red: local pollution (may control) Other: background (hard to control)

(2) Using AOD for PM monitoring

- Possible, since AOD and PM2.5 often track with each other



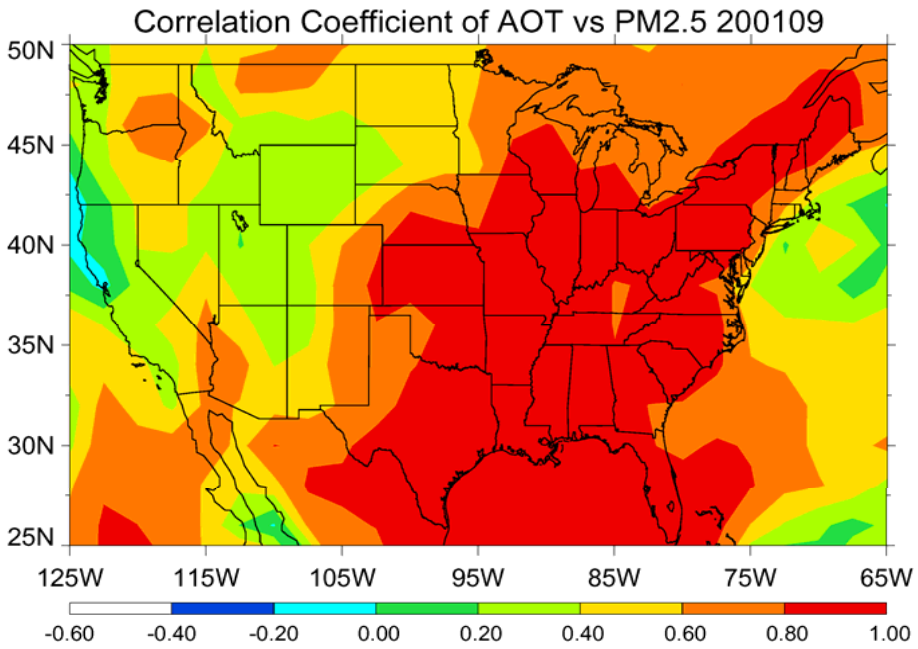
- Difficult, since AOD and PM2.5 don't always track with each other



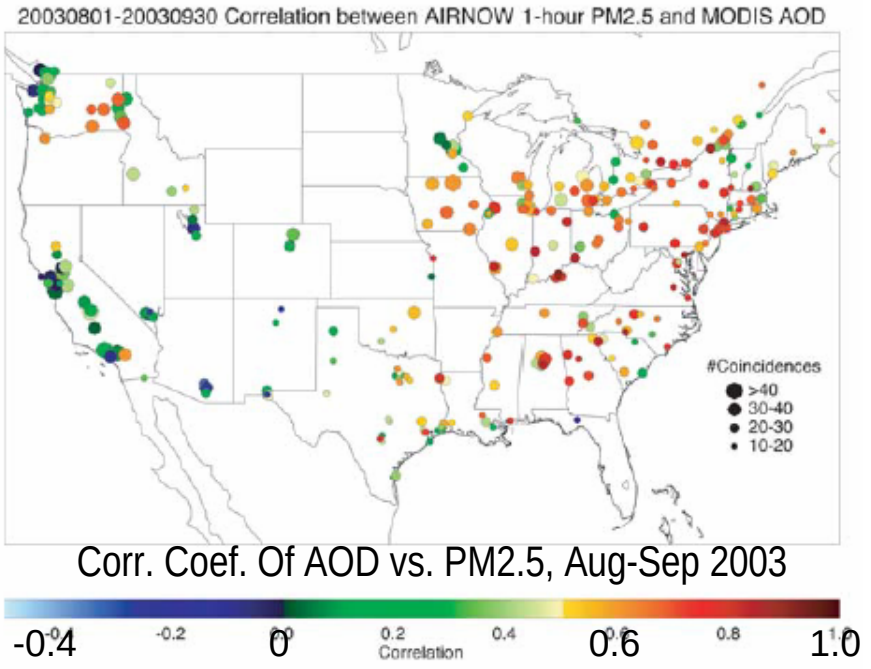
Figures from Al-Saadi et al., BAMS 2005

Model shows similar AOD-PM2.5 relationship

GOCART AOD vs GOCART PM2.5



MODIS AOD vs EPA PM2.5



The relationship depends on <u>vertical distribution</u> and <u>composition</u>, both are much less variable in the east than in the west.

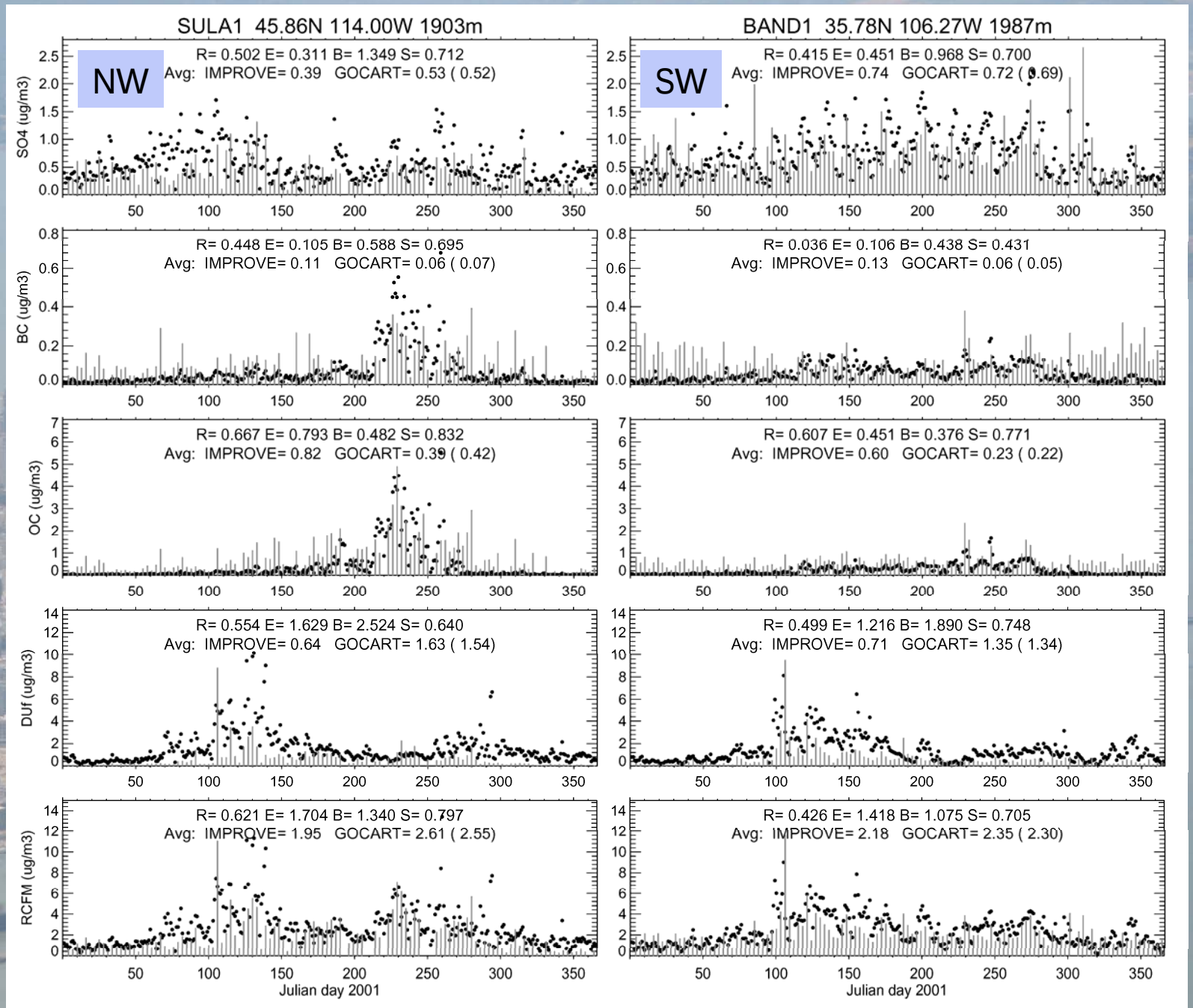
(Chin et al., Possibilities and challenges in using satellite AOD data for surface air quality monitoring, manu. in preparation, 2007)

Summary and conclusions

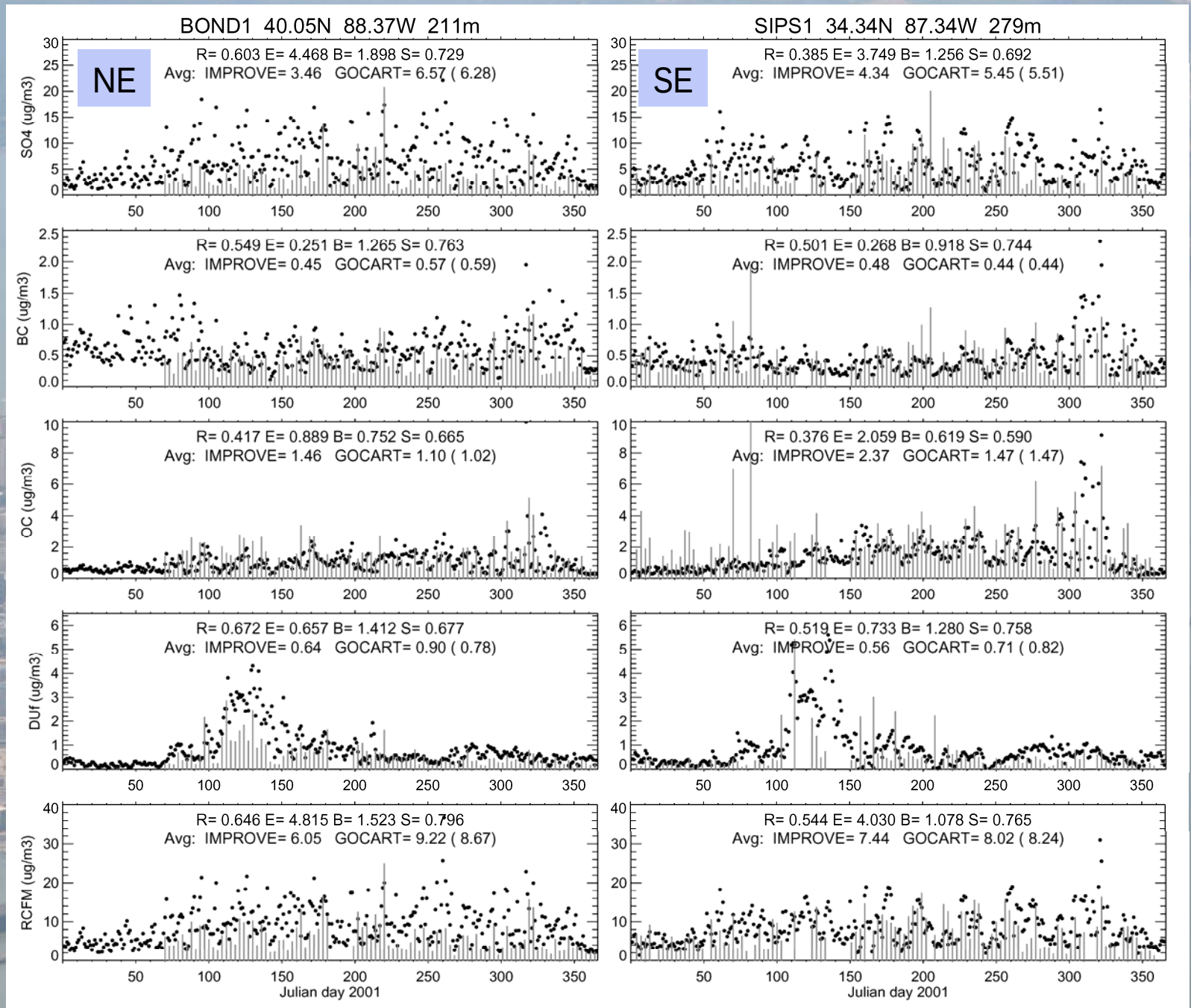
- Supported by NASA Earth Science programs, NASA global models can be readily applied to AQ applications
- Column AOD and surface PM2.5:
  - Their relationship varies with location and time, depending on vertical profile and composition of aerosols
- Regional air quality:
  - Pollution region is mostly responsible for its own PM air quality
- Intercontinental transport of pollutants:
  - Europe has the largest “impact potential over land”
  - Asian pollution impact on North America is … “not much”
- Intercontinental transport of dust:
  - Asian dust has the largest “impact potential over land”
  - African dust is most intense and can travel around globe


Backup slides

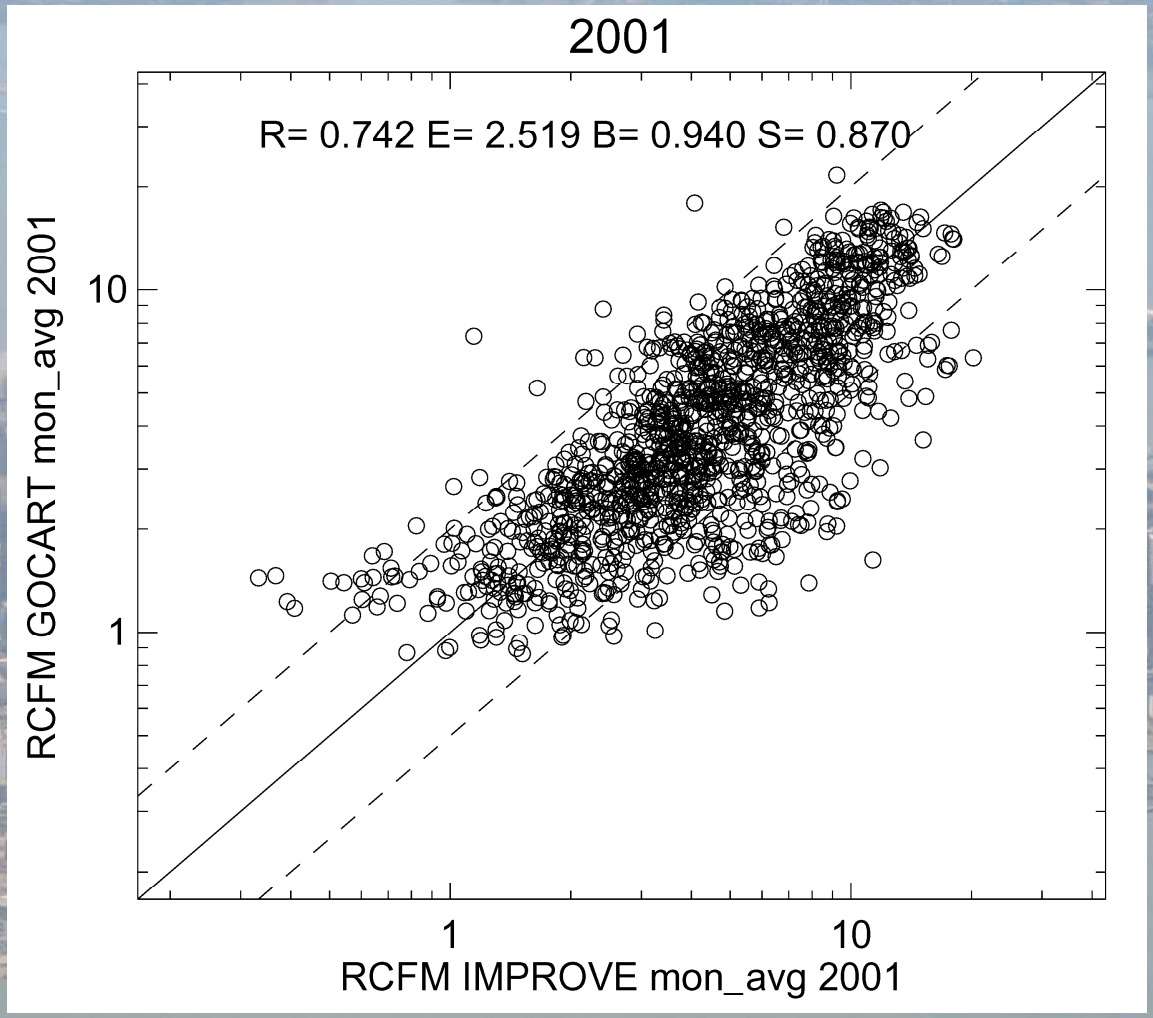
Daily variations of RCFM and its components. Line: data Dots: model



Daily variations of RCFM and its components. Line: data Dots: model



Comparison of RCFM (mon avg):



Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.

– Box and Draper, *Empirical Model-Building*, p. 74, 1987