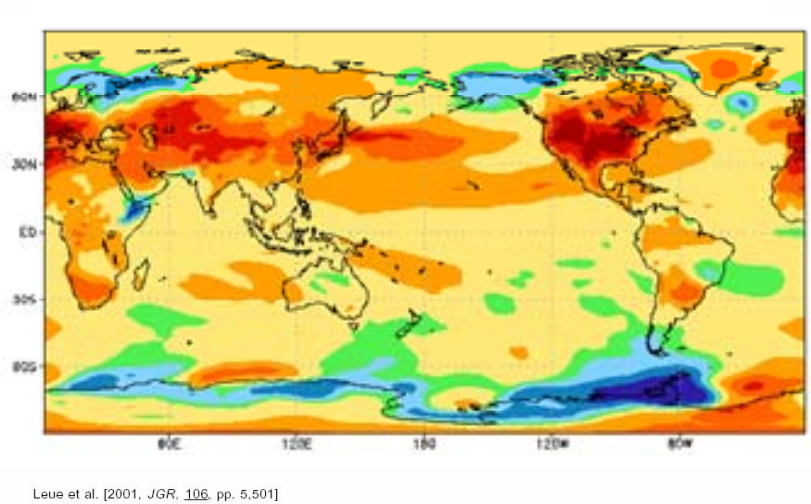
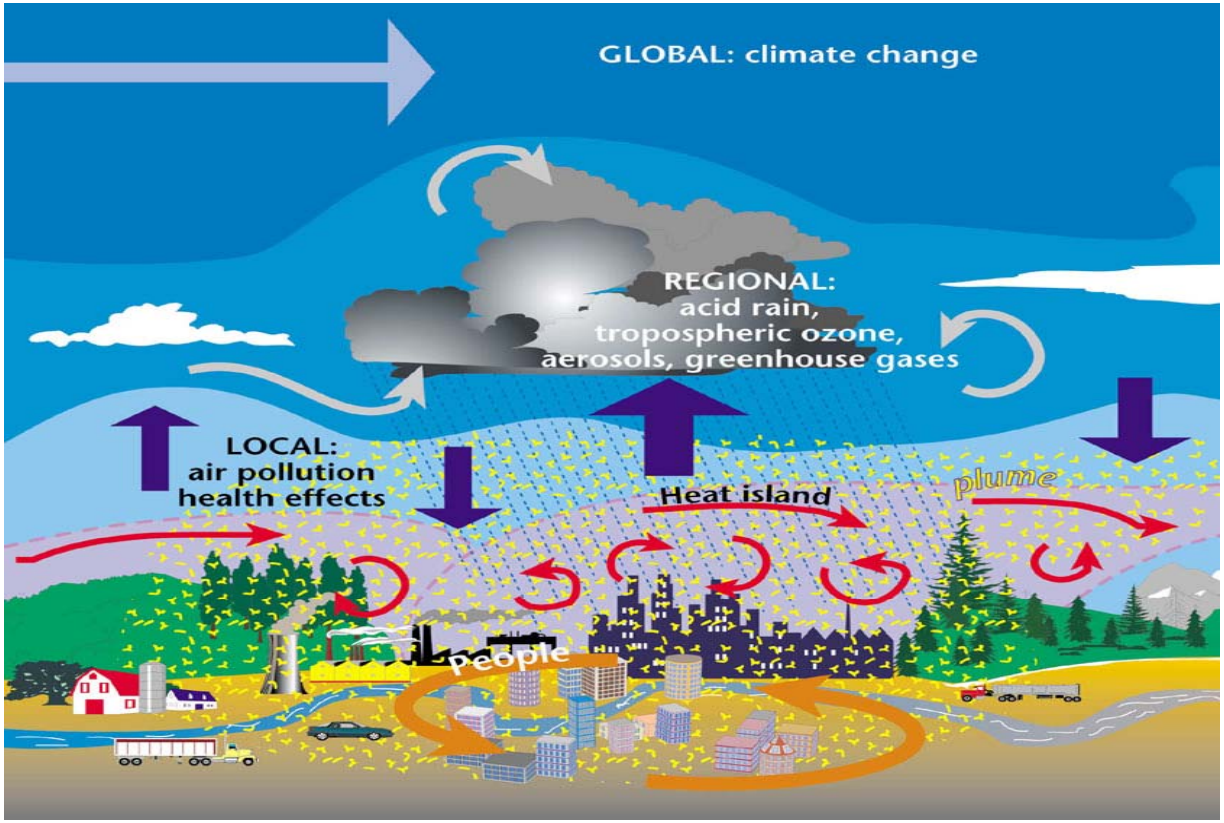
The Globalization of Air Pollution: Implications for Air Quality, Climate and Health



Leue et al. [2001, *JGR*, 106, pp. 5,501]

Regional and Global Perspectives of Air Pollution

Urban Environments Interactions involve Local to Global Scales



WMO GURME

Megacities Have Large Environmental Footprints

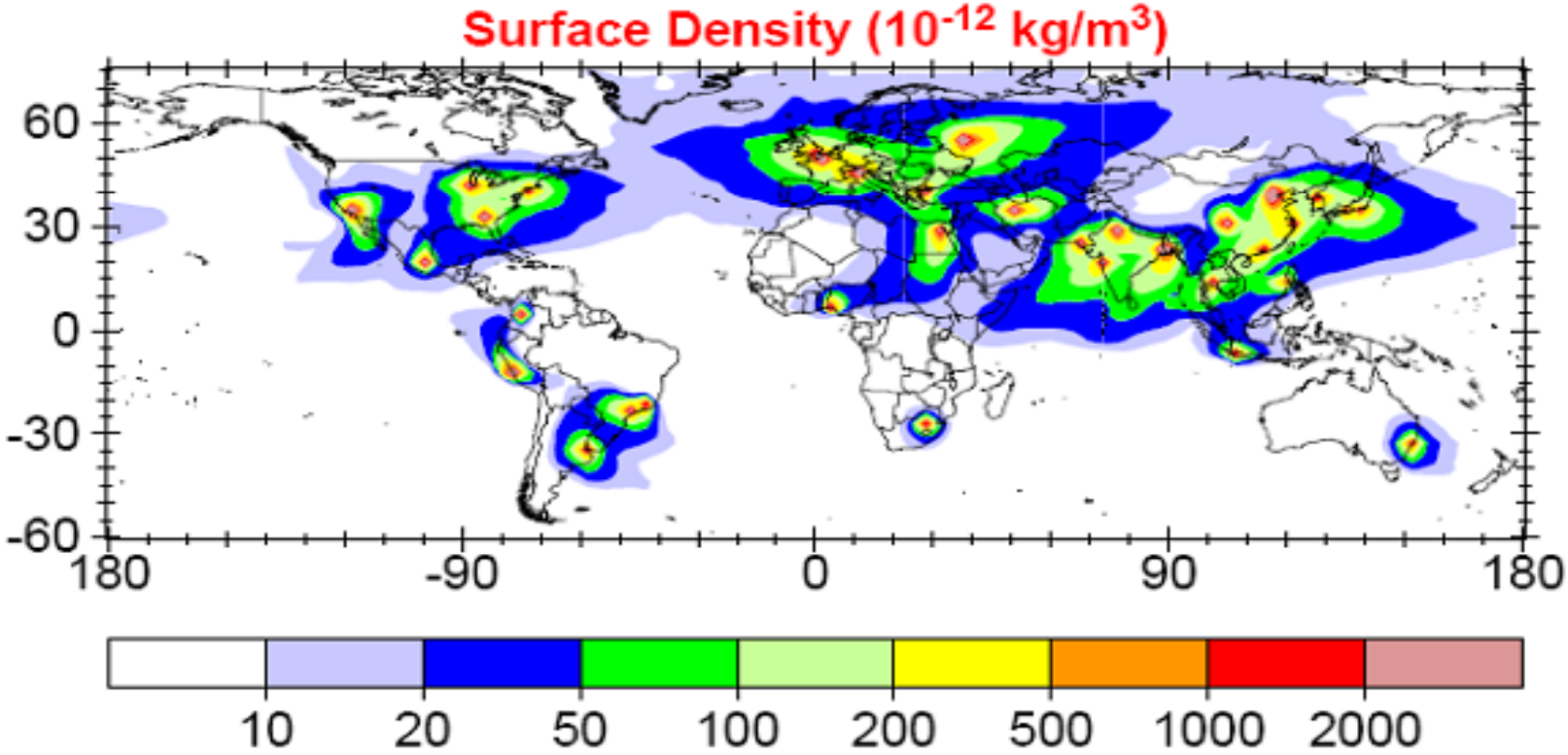
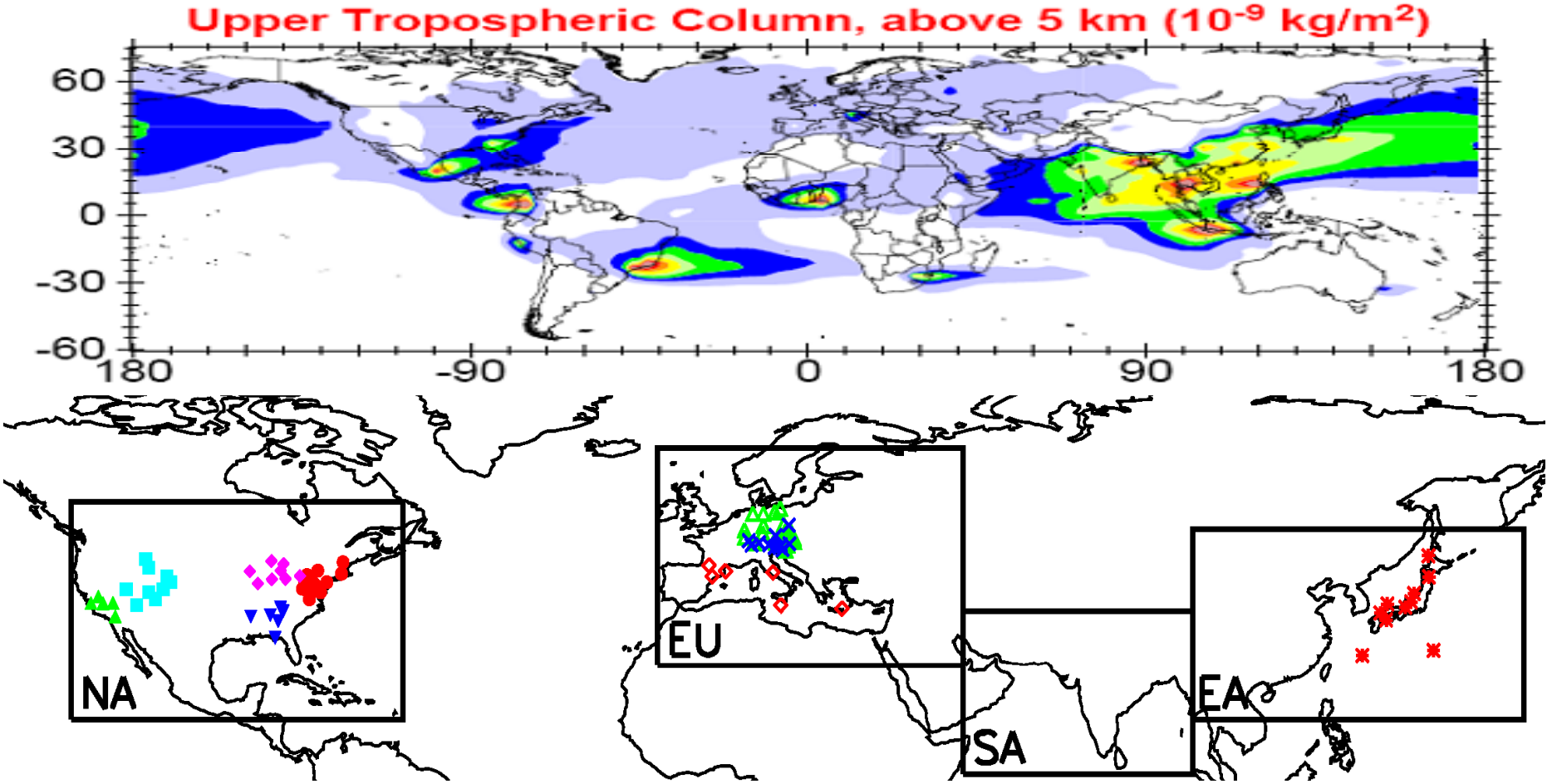


Fig. 5.1 Annual mean plots of the sum of all of the (10 d) MPC tracers for the model surface layer density (10−12 kg/m3) and the column above 5km (10−9 kg/m2). **From *Lawrence et al.*, 2007.**

We know that regional control strategies are needed to meet local air quality targets

We Are Learning That In Aggregate Air Pollution Impacts Extend Globally



Thirty models engaged in estimates of hemispheric transport of pollution.

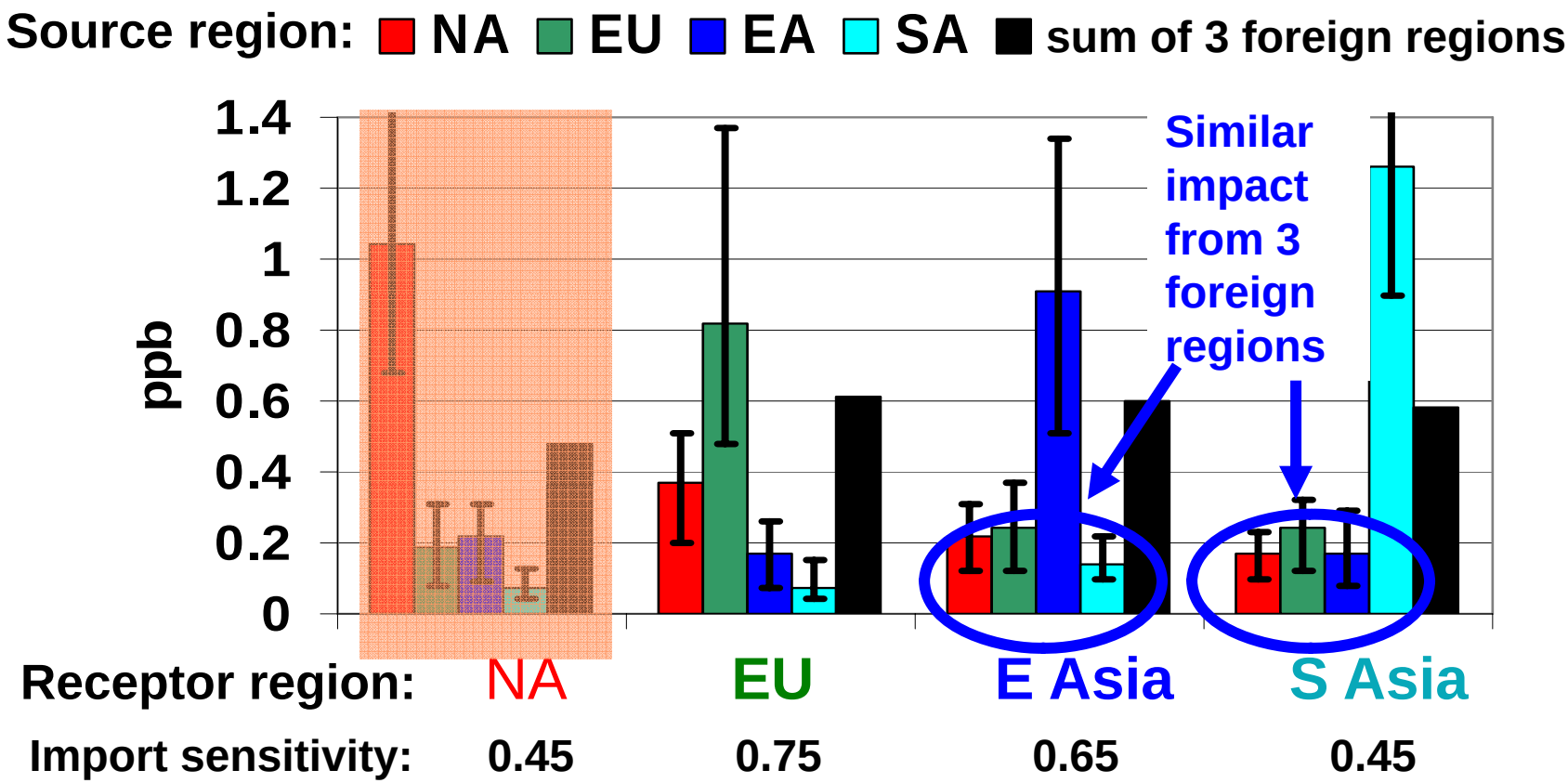
EU Task Force on Hemispheric Transport of Pollutants. Interim Assessment Report 2008

http://www.unece.org/env/eb/Air.Pollution%20Studies.No.16.Hemispheric%20Transport.pdf

Estimates of S-R relationships for surface O_3 pollution

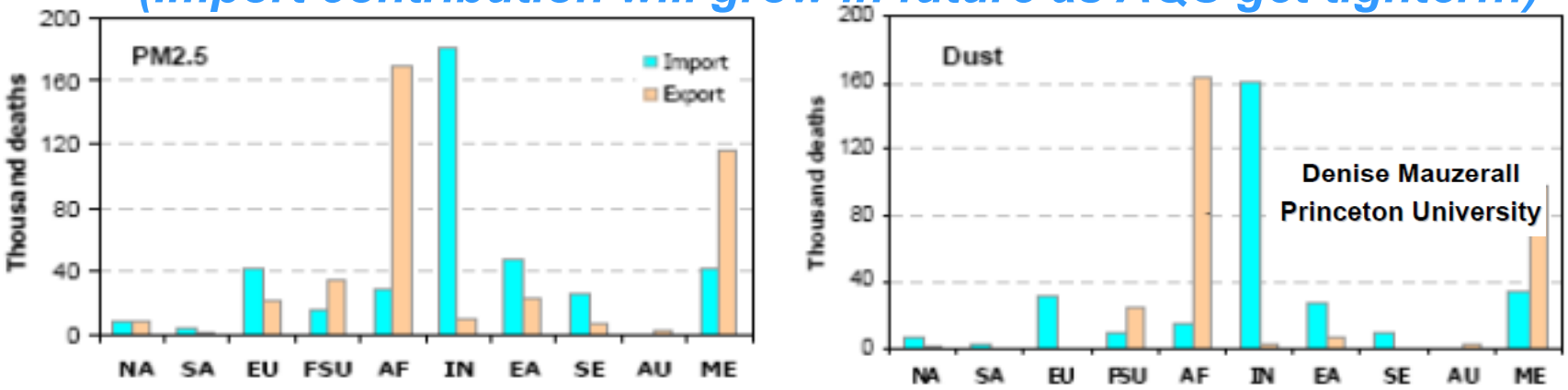
Annual mean surface O_3 change from
20% Perturbation in NOx+CO+NMVOC regional anthrop. emissions

(20% of Emissions Approximates Megacity Contributions)



Annual premature mortalities due to inter-continental "import" and "export" of total PM2.5 and fine dust alone.

(Import contribution will grow in future as AQS get tighter!!!)

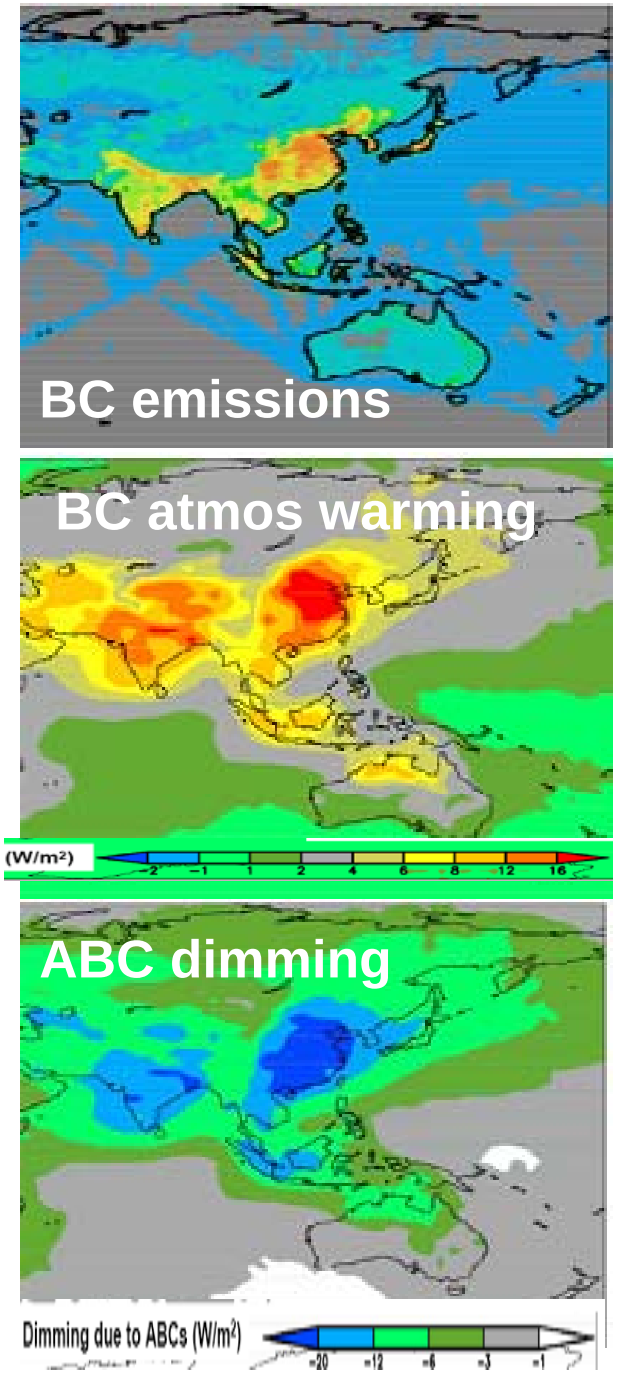


'Import': total number of deaths in a receptor region resulting from emissions from the other tagged regions;
'Export': total number of deaths in the other nine regions resulting from emissions from the given region.

✓**The majority of non-dust impacts are domestic, BUT Intercontinental transport of PM2.5) is associated with 400,000 premature mortalities (~100,000 from non-dust aerosols) of adults 30 years and older.**

✓***Intercontinental transport of PM2.5 may offset about 1/3 of the benefits from the new USA ozone AQ standard! (Tightening the U.S. 8-hour O3 standard from 84ppbv to 75ppbv, is annually projected to prevent 1,300 to 3,500 premature deaths in the United States at a cost of $7.6-8.8 billion USD each year [EPA, NAAQS RIA, 2008]).***

An Estimated 3 Billion Persons Live Under in Regions with High Aerosol Loadings – Implications for urban environments and beyond



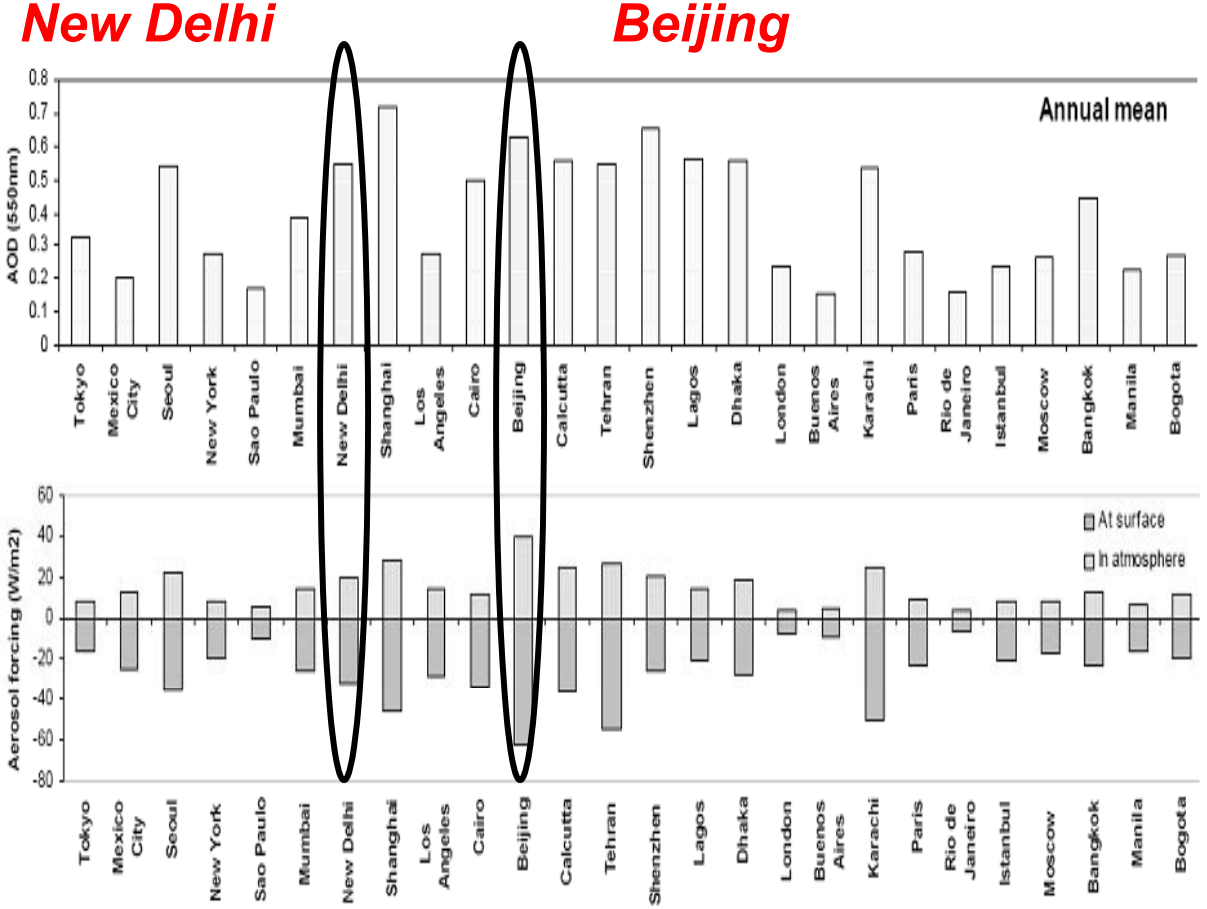


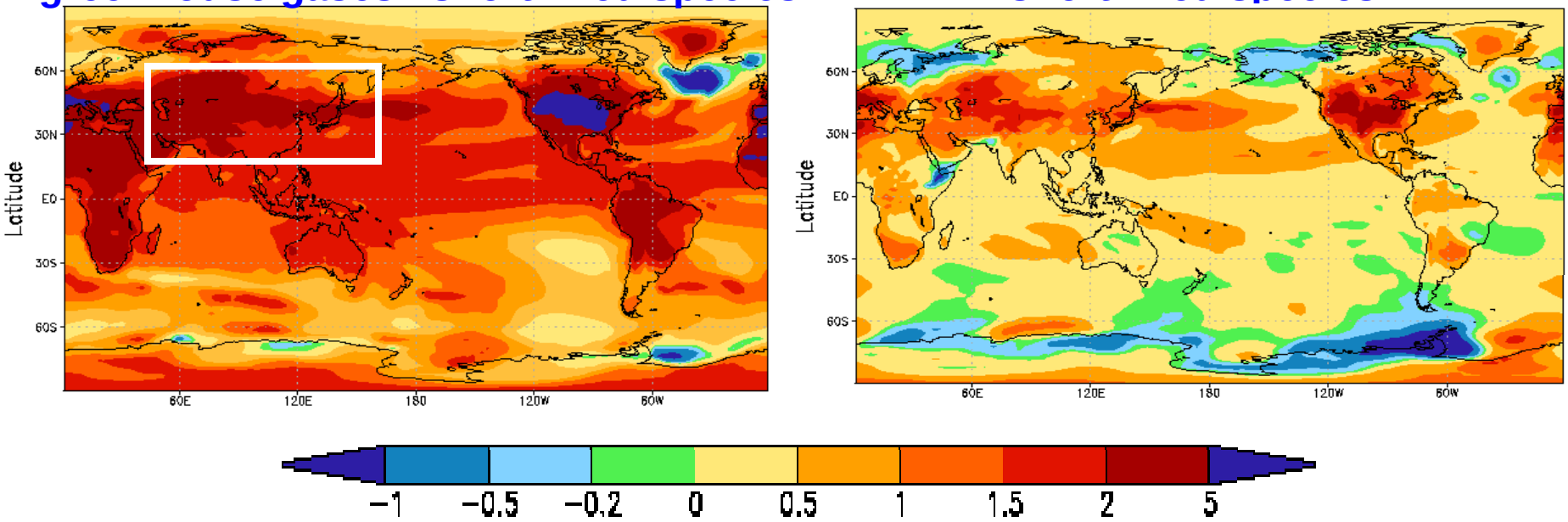
Figure Source: V. Ramanathan, and G. Carmichael, Nature Geoscience, 2008

Significant warming (up to 40%) in summer (2090s-2000s) may come from short-lived pollutants

Results from GFDL Climate Model [*Levy et al., JGR, 2007*]

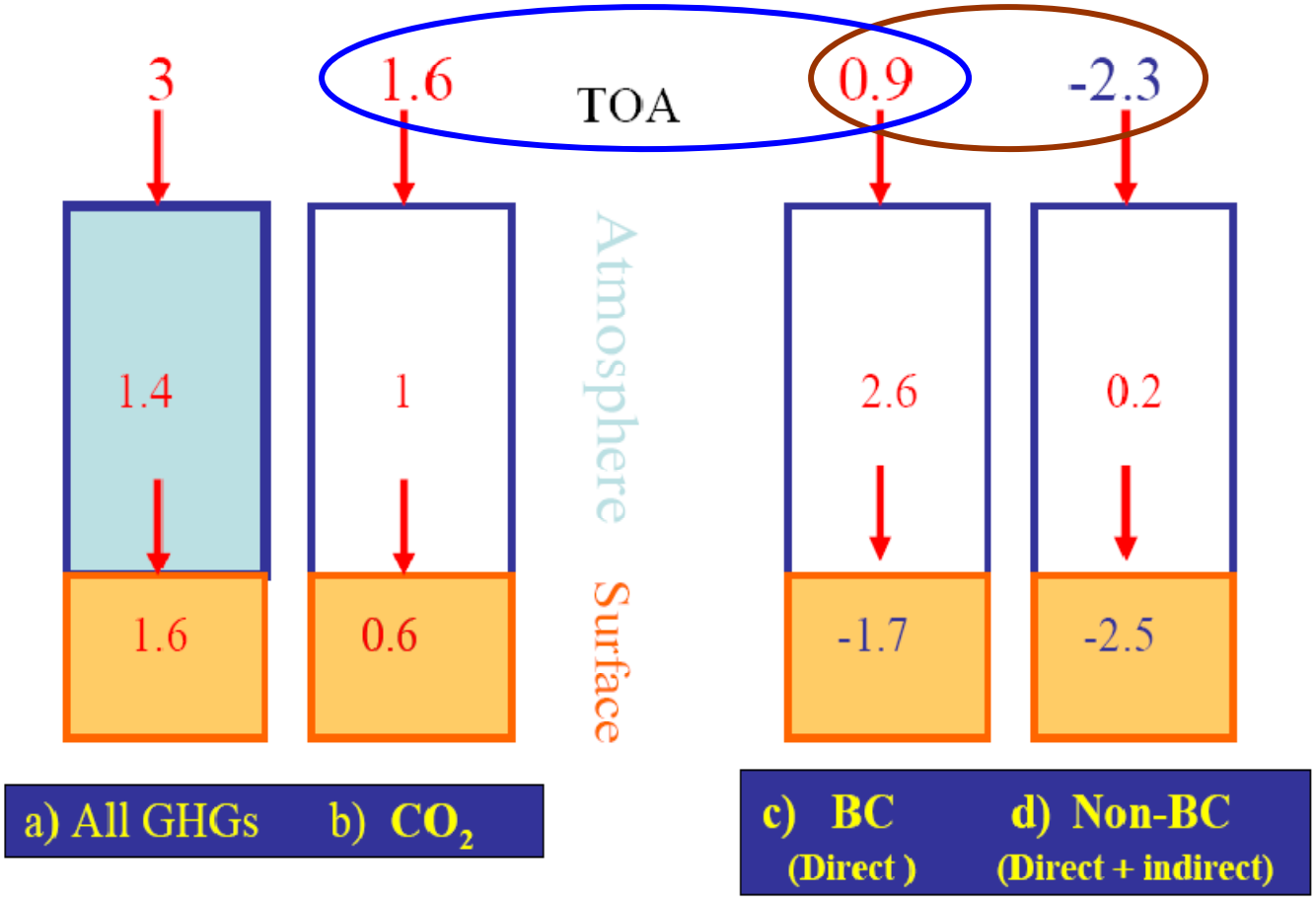
From changing well-mixed greenhouse gases +short-lived species

From changing only short-lived species



Large uncertainties associated with aerosol emission assumptions

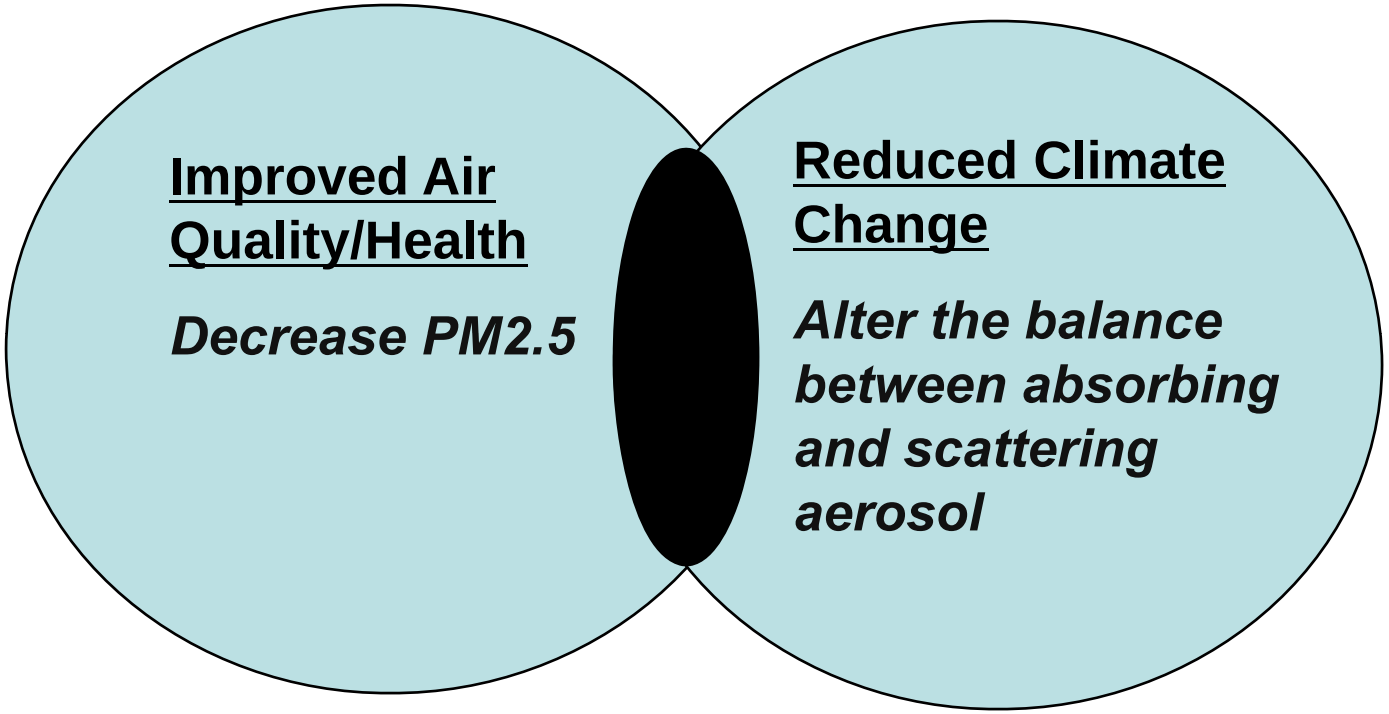
Aerosols Mask ~ 50% of Warming



- **BC is ~55% of CO_2 and has a much shorter lifetime**
- **Regional climate, hydrologic, agriculture, and health impacts of ABCs in Asia are summarized in a series of UNEP-ABC reports.**

Figure Source: V. Ramanathan, and G. Carmichael, *Nature Geos*. 2008

Reducing the Impacts of Aerosols on Air Quality and Climate



Win/Win Strategy

+ Decrease PM2.5

+ Decrease BC faster than Sulfate aerosol

BC Focused Controls Have Significant Health (and Climate) Benefits and Opportunities

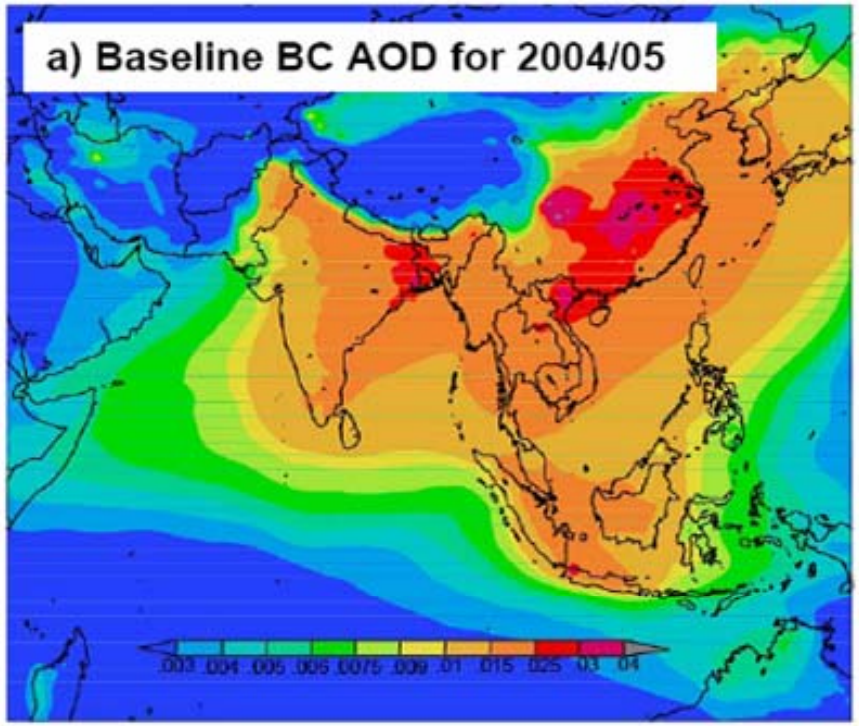
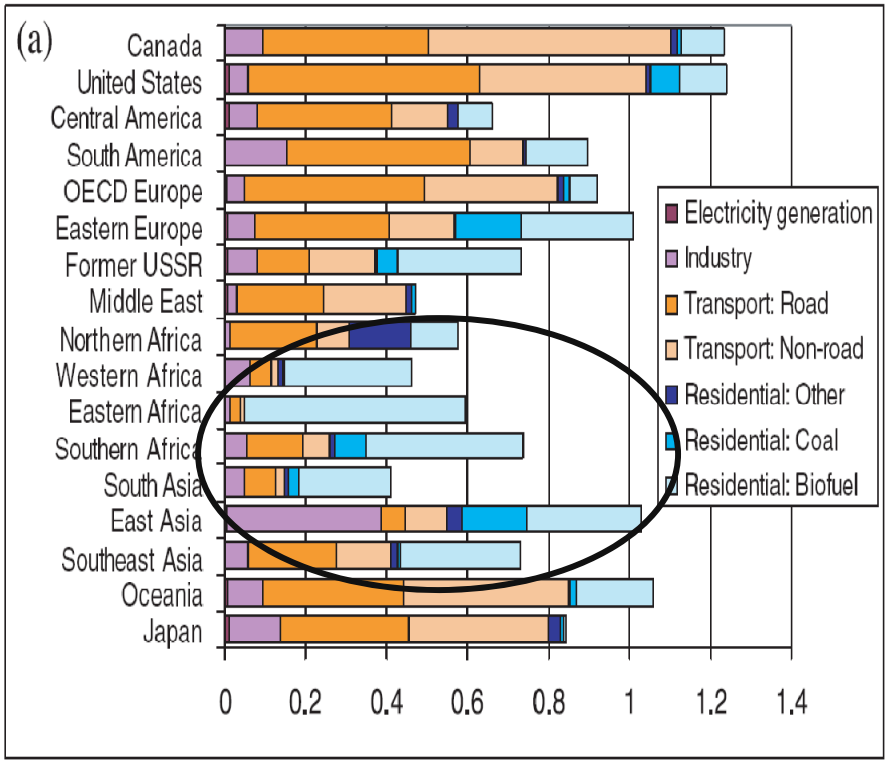
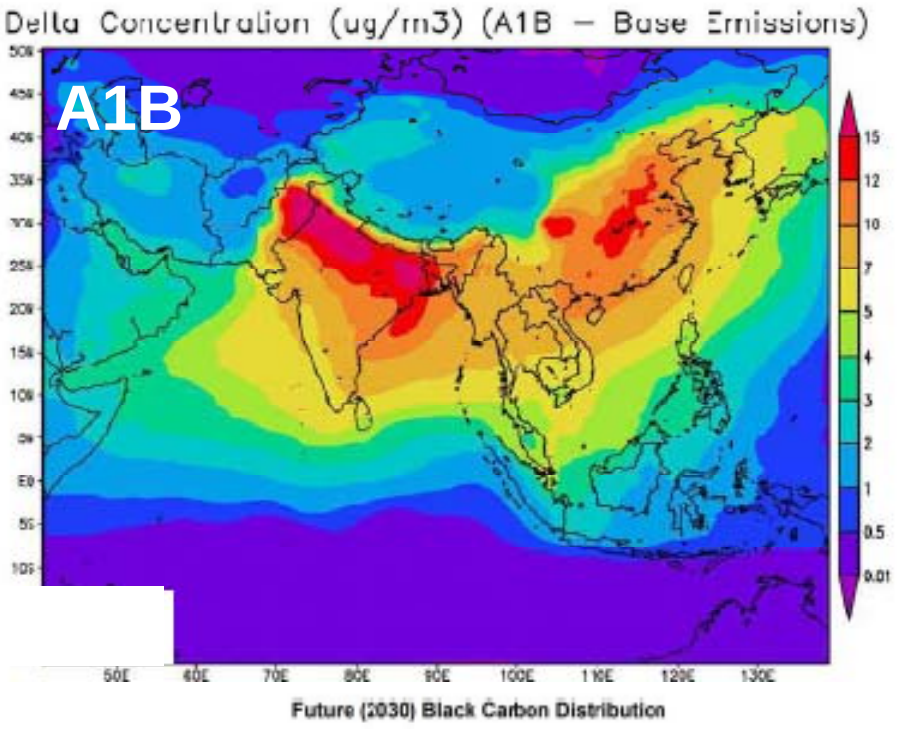


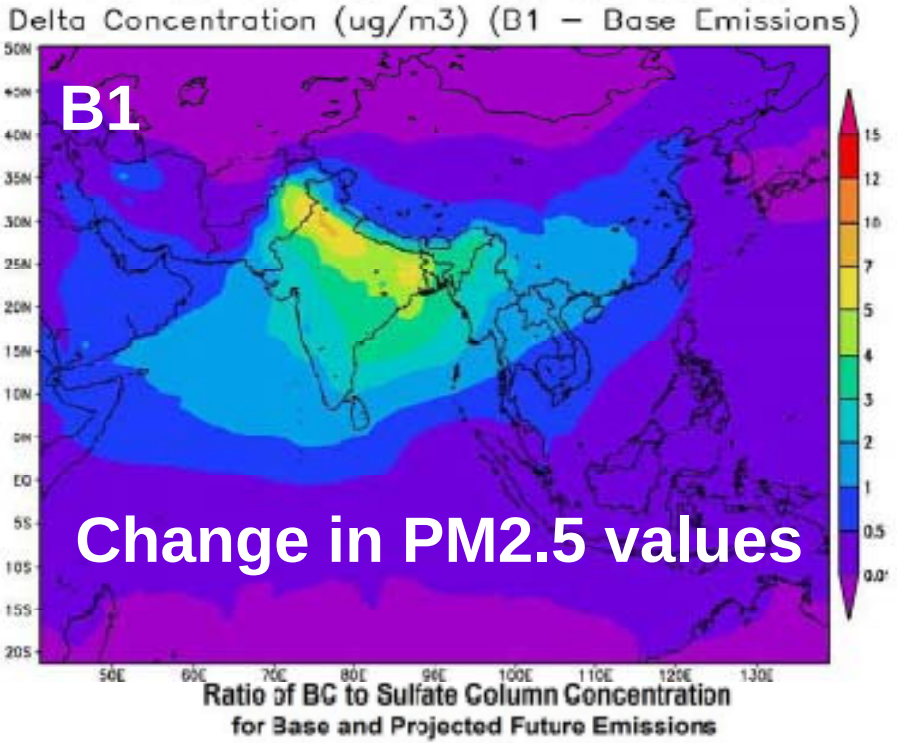
Figure Source: Adhikary et al., *JGR*, 2008

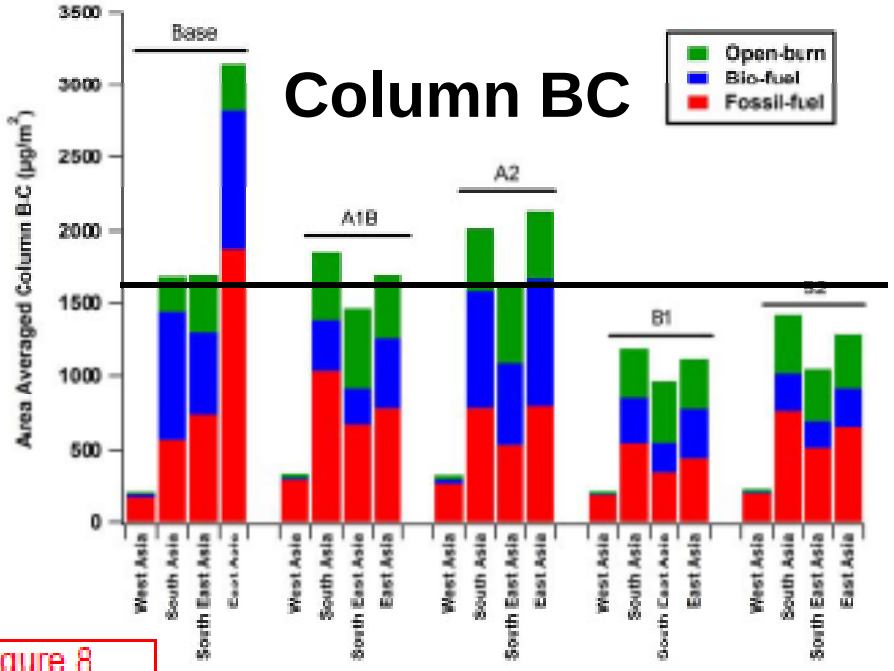


Bond et al., ERL, 2007

For BC its not just the megacities -- Biofuels are a significant source in many regions


Delta Concentration (ug/m3) (A1B – Base Emissions)
A1B
Future (2030) Black Carbon Distribution


Delta Concentration (ug/m3) (B1 – Base Emissions)
B1
Change in PM2.5 values


Column BC
Base
A1B
A2
B1
Open-burn
Bio-fuel
Fossil-fuel
Area Averaged Column BC (μg/m²)
West Asia
South Asia
South East Asia
East Asia

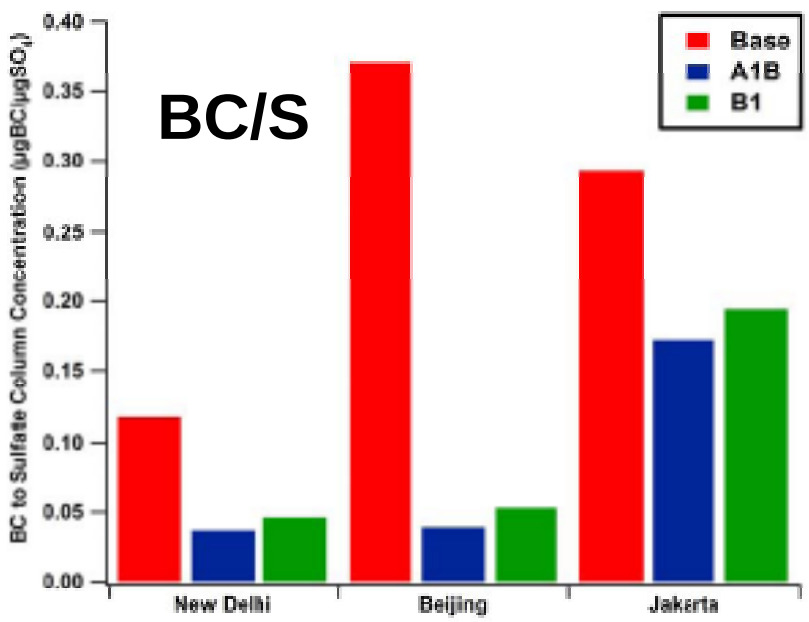
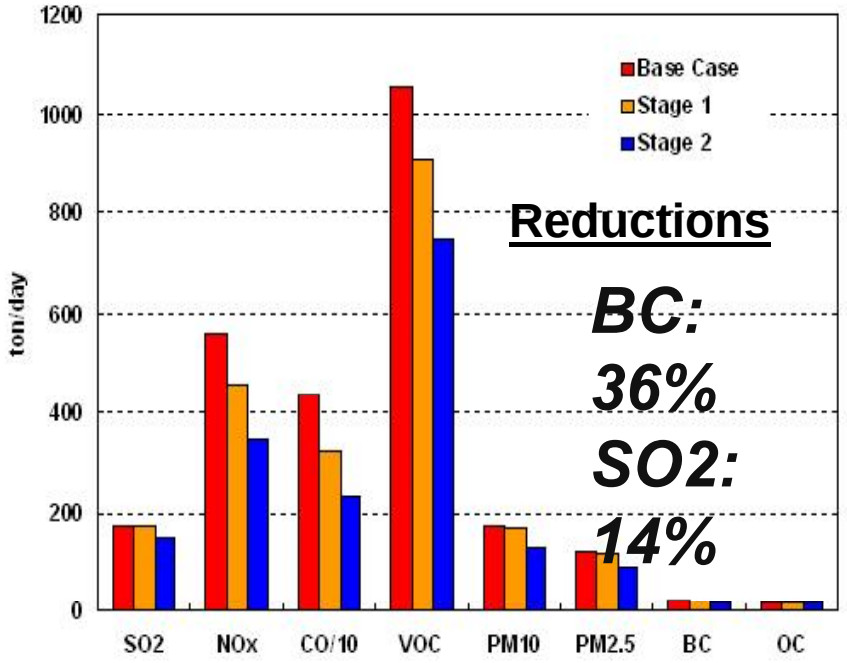

Ratio of BC to Sulfate Column Concentration
for Base and Projected Future Emissions
BC/S
Base
A1B
B1
BC to Sulfate Column Concentration (μgBC/μgSO4)
New Delhi
Beijing
Jakarta

Figure 8

Reducing Aerosols is a Big Challenge BUT

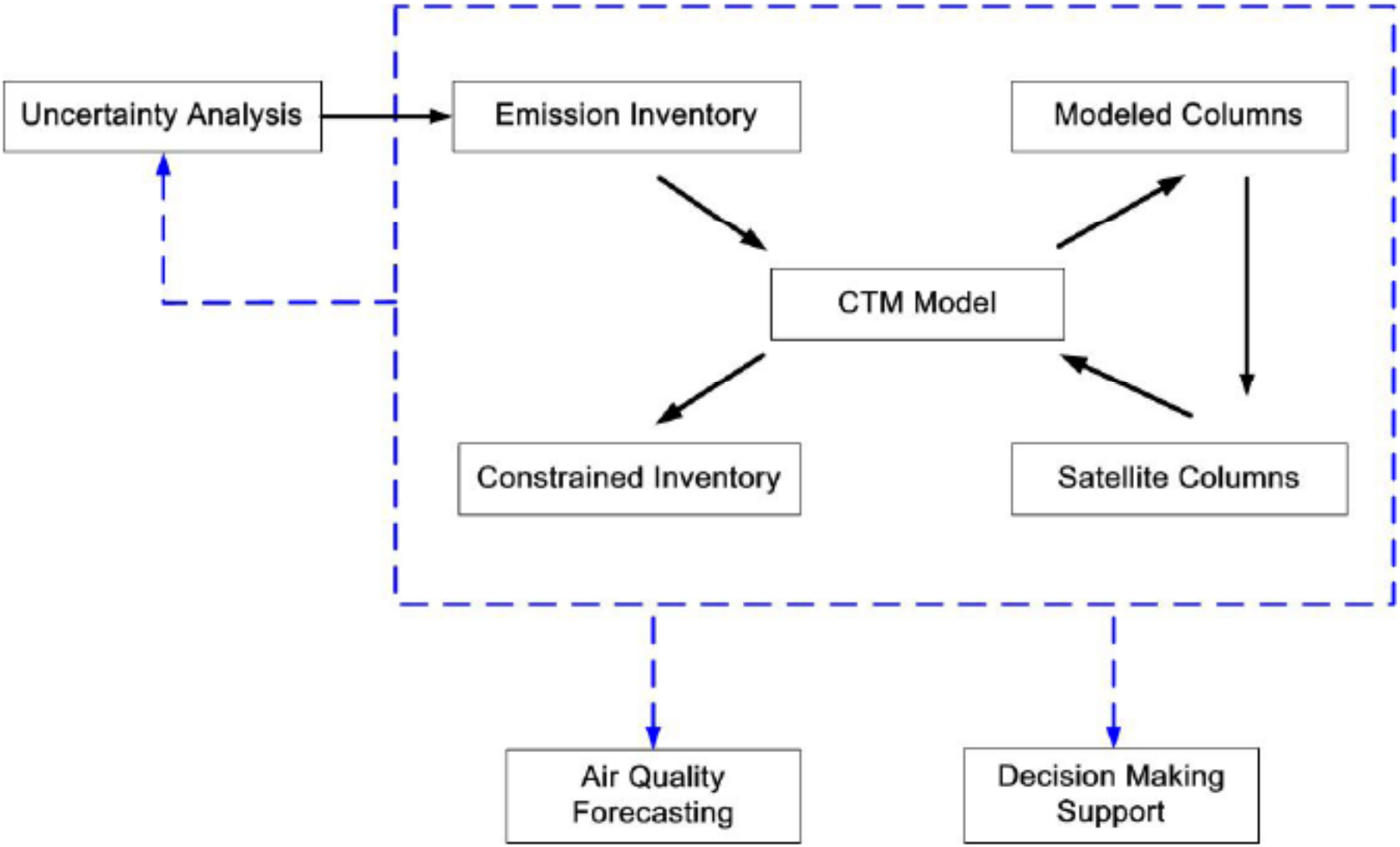
Beijing Olympics Were an Important Example

- Base Case: June 1-30
  - No special control measures
- Stage 1: July 1-19
  - 30% of "governmental owned vehicles" stop running in Beijing;
  - all "high emitters" were banned in Beijing.
- Stage 2: July 20 to now
  - reduce industrial production in Beijing;
  - stop construction activities in Beijing;
  - control VOC emissions from painting, gas stations, etc;
  - 70% of "governmental owned vehicles" stop running in Beijing;
  - all "high emit" cars and trucks were banned in Beijing;
  - 50% of private owned cars stop running on the same day in Beijing.
- Stage 3: August 6 to now (plus control measures in neighbor provinces)
  - reduce industrial production in Beijing;
  - stop construction activities in Beijing;
  - control VOC emissions from painting, gas stations, etc;
  - 70% of "governmental owned vehicles" stop running in Beijing;
  - all "high emit" cars and trucks were banned in Beijing;
  - 50% of private owned cars stop running on the same day in Beijing and Tianjin;
  - reduce iron, steel, and cement productions in Beijing surrounding provinces.



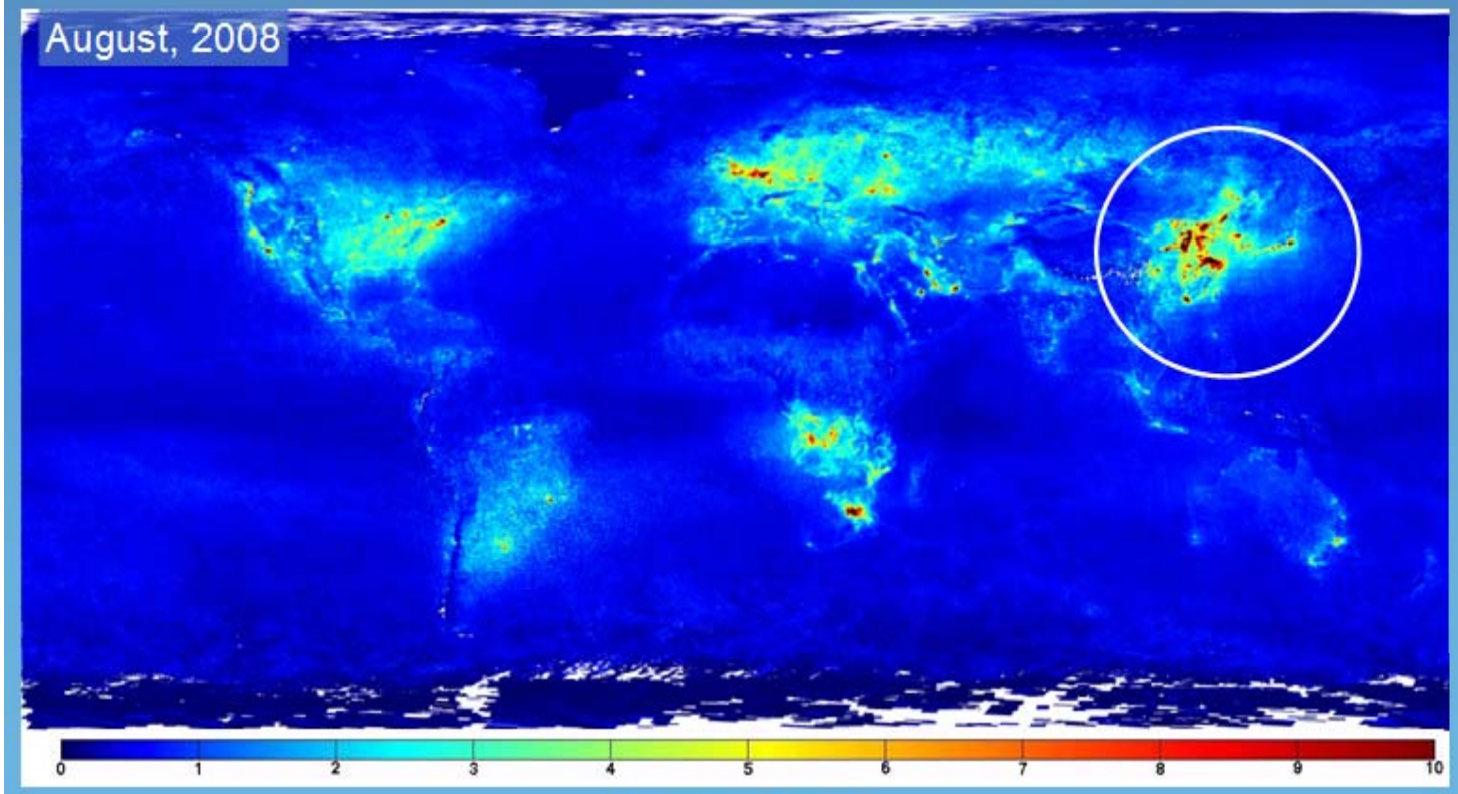
Daily Emission Scenarios for the Beijing Olympics

We are developing new approaches to integrate satellite data with chemical transport models and emission inventories for improved AQM



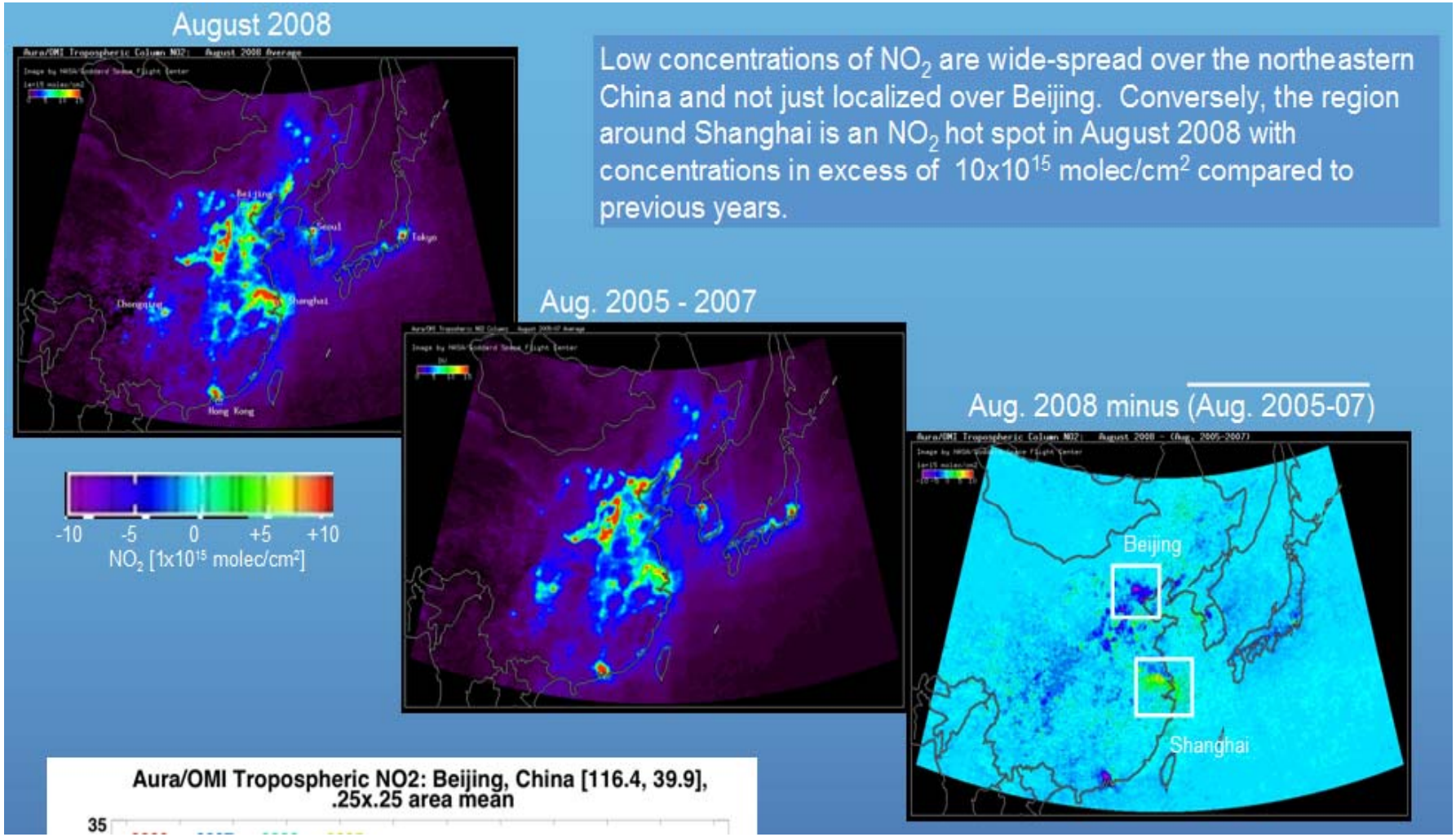
Satellites Offer Increasing Capacity to Monitor Air Pollution from Space

Tropospheric Nitrogen Dioxide (NO_2)



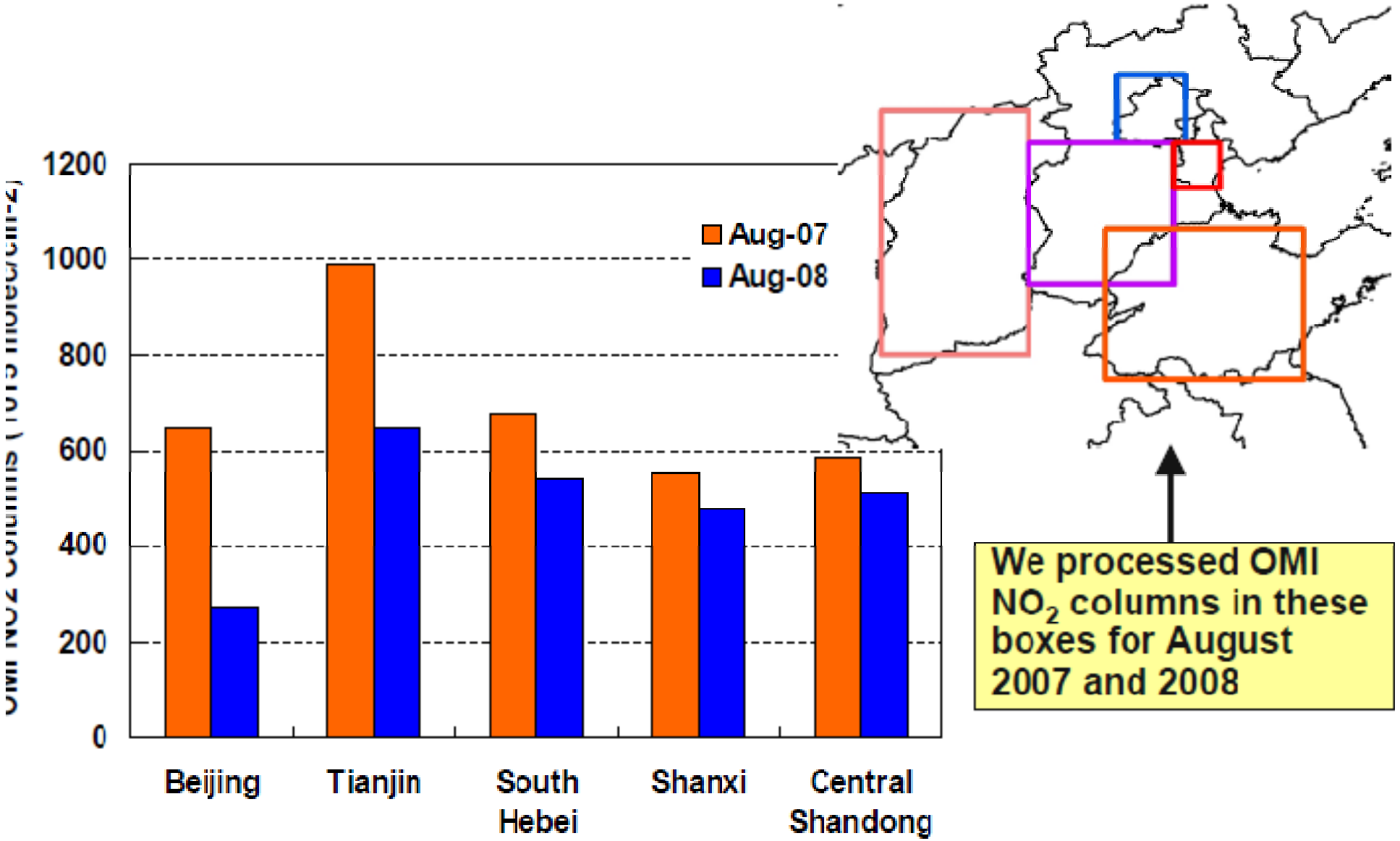
Eastern China stands out as one of the largest source regions of Tropospheric NO_2 (image source: http//:avdc.gsfc.nasa.gov). Anthropogenic sources of NO_2 are from vehicles and thermal power plants through combustion processes using air as the oxidant.

Detecting Changes in China

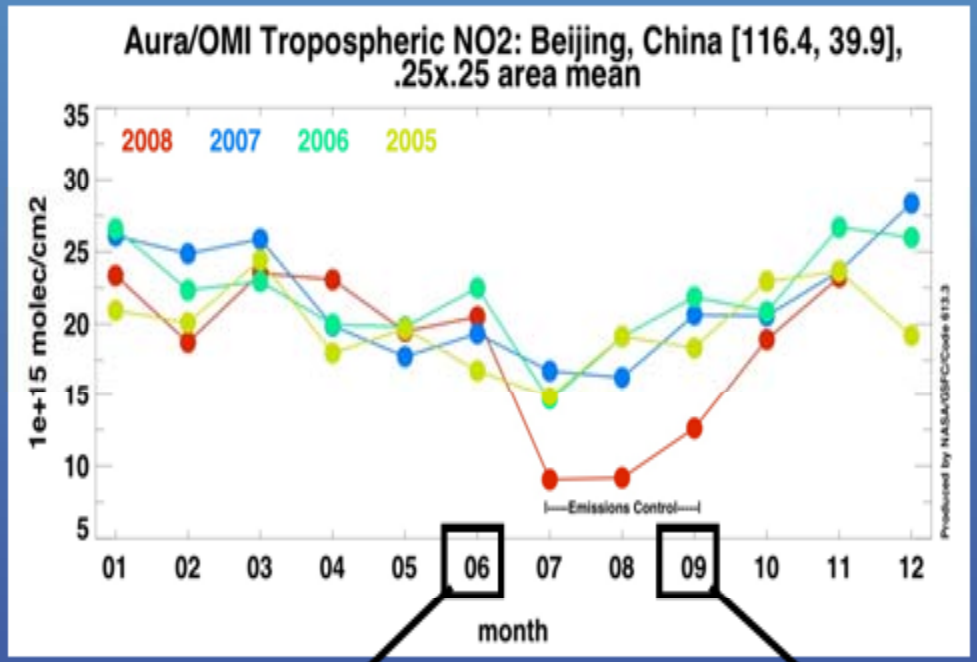


NASA Goddard, 2008

NO_2 decreases were observed in Beijing as well as all its neighboring provinces



The NO_2 Columns Over Beijing Reflected the Olympic Emission Reduction Measures



NASA Goddard, 2008

The monthly mean time-series show decreases of Trop. NO_2 by almost 50% during the emission controls, compared to previous months and years.

A blow-up of June - Sept 2008

Models are an Integral Part of Air Quality Analysis & Management

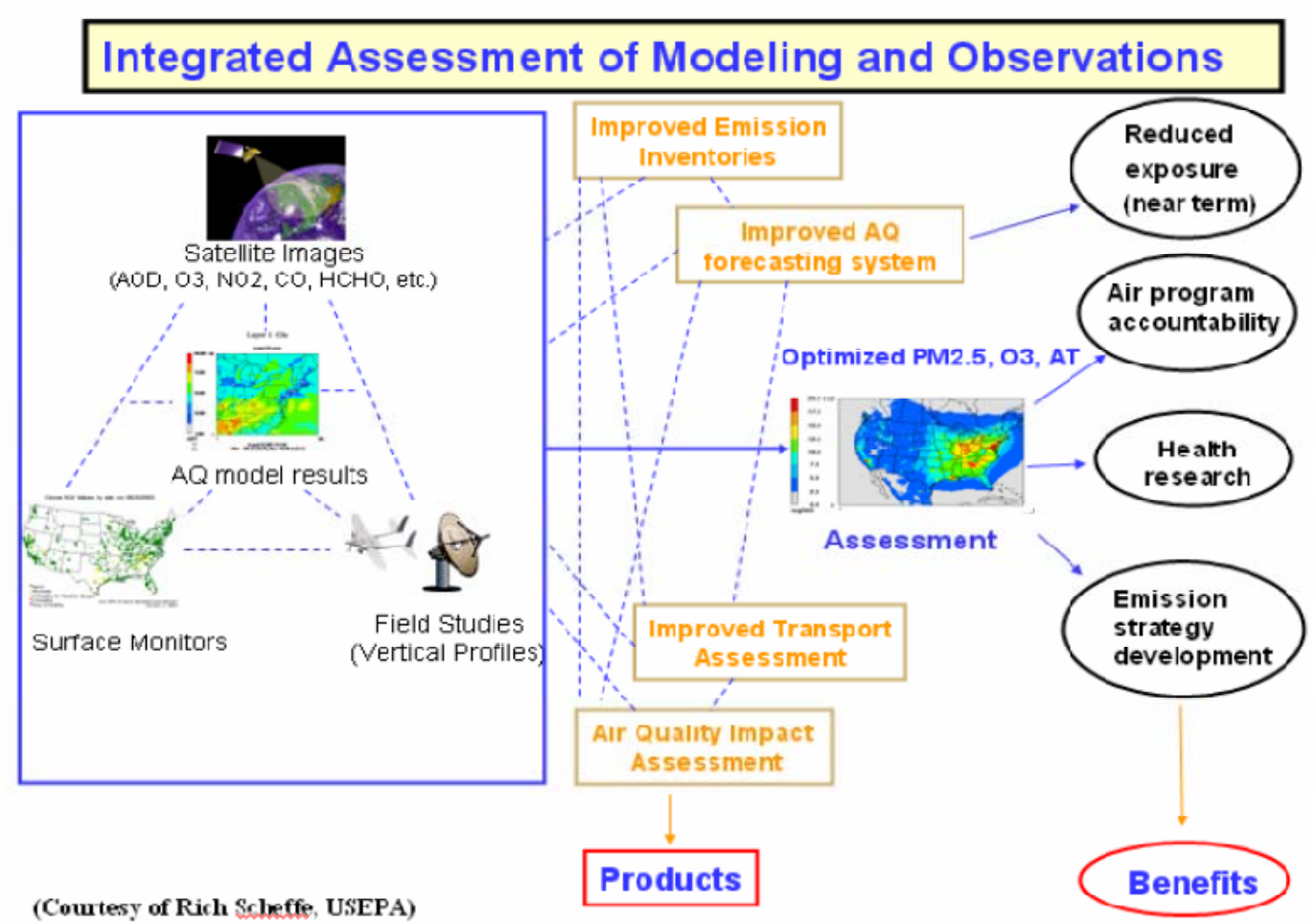


Figure 1