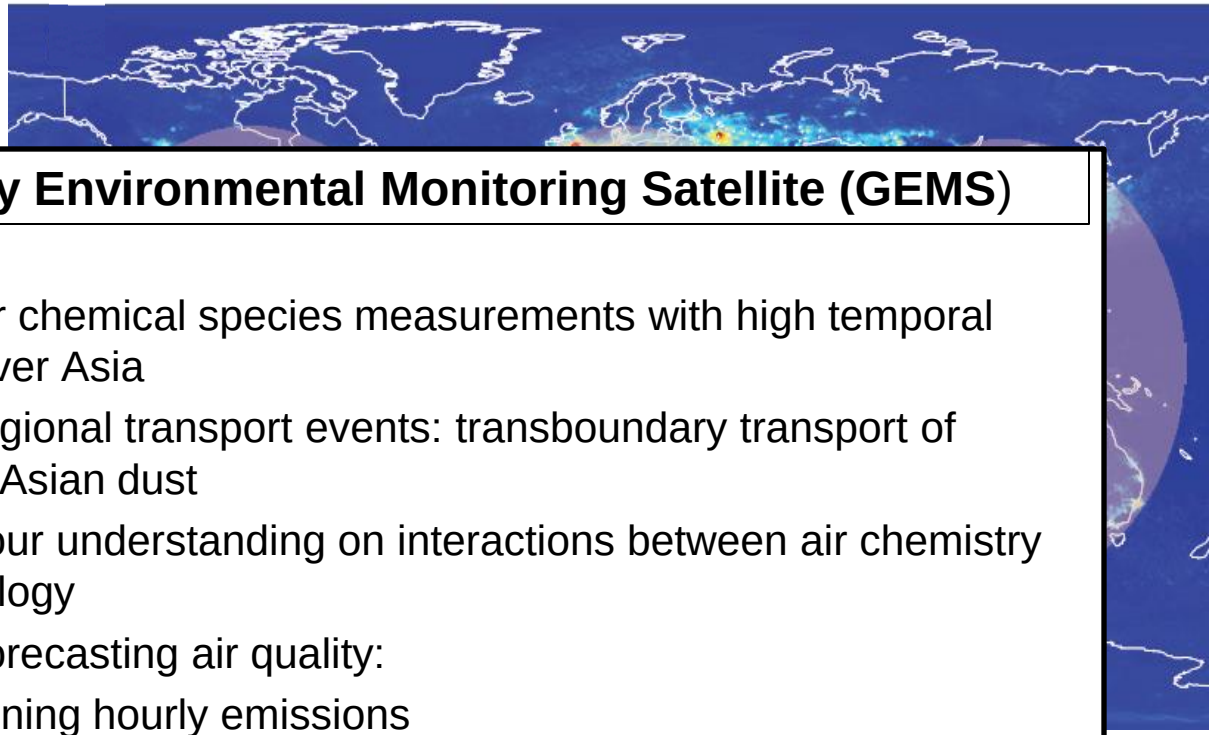
Science objectives of Geostationary Environmental Monitoring Satellite

- **Continuous, high-spatial-resolution, and high-temporal-resolution measurements for emissions and chemical transformations interacting with weather and sunlight including the rapidly varying PBL and continental-scale transport of pollution.**



Geostationary Environmental Monitoring Satellite (GEMS)

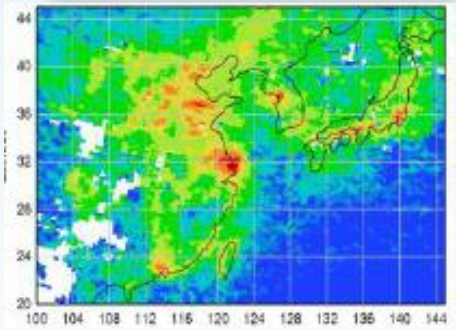
Objectives

1. To provide air chemical species measurements with high temporal resolution over Asia
2. To monitor regional transport events: transboundary transport of pollution and Asian dust
3. To enhance our understanding on interactions between air chemistry and meteorology
4. To improve forecasting air quality:
   - Constraining hourly emissions
   - Data assimilation of chemical observations

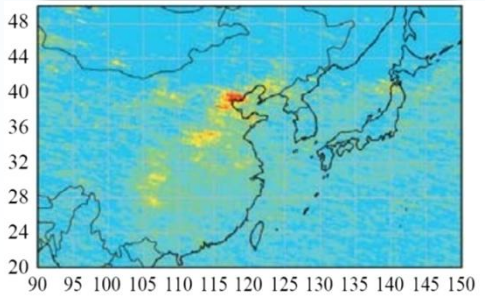
1. Monitoring atmospheric chemical environment

Monitoring NO_2, SO_2, O_3 , HCHO, Aerosol in East Asia – Emission/Distribution

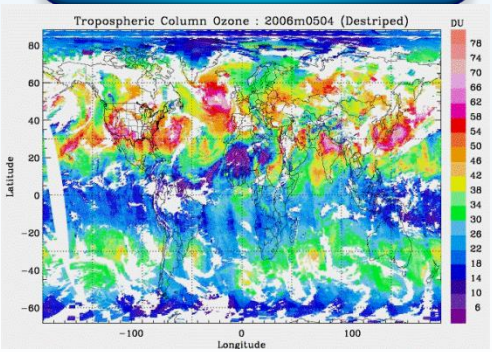
NO_2



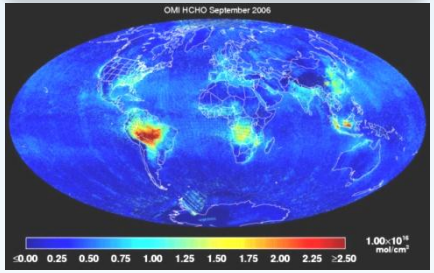
SO_2



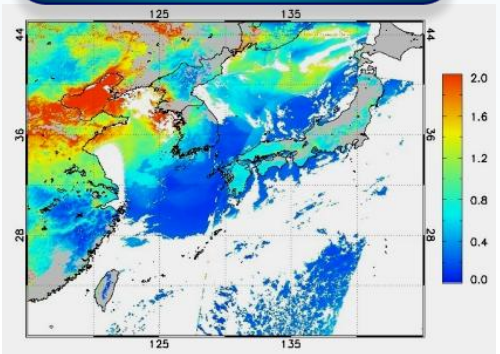
O_3



HCHO



Aerosol



from Bhartia, Richter from OMI and SCIAMACHY

Asia is an important source region for global tropospheric chemistry

Both Anthropogenic and Natural Sources throughout the year

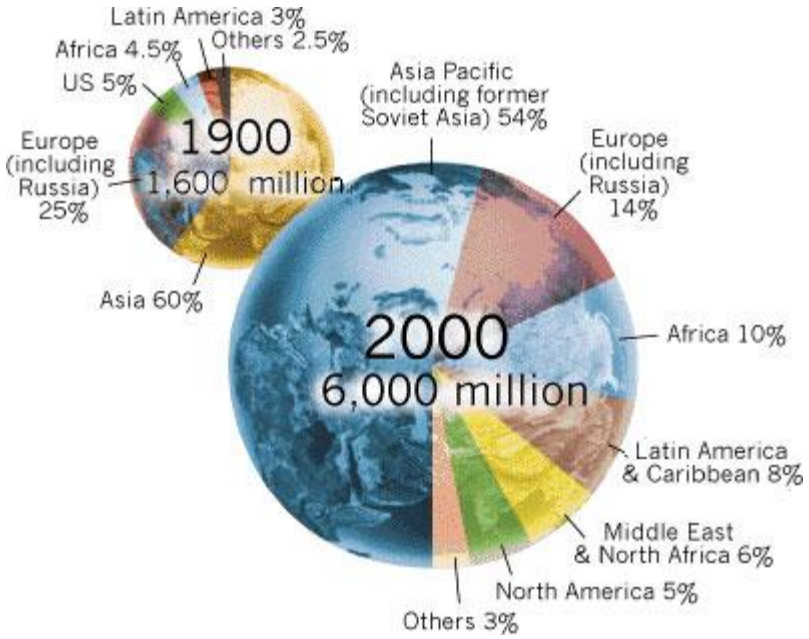
Anthropogenic	Geogenic	Biomass burning	Biogenic
			
Pollution	Asian dust	Wild fires	Sink change
Industry Transportation Developing Country	Land use change Monsoon Typhoon	Drought	Deforestation

Asia is the largest source region of anthropogenic emissions

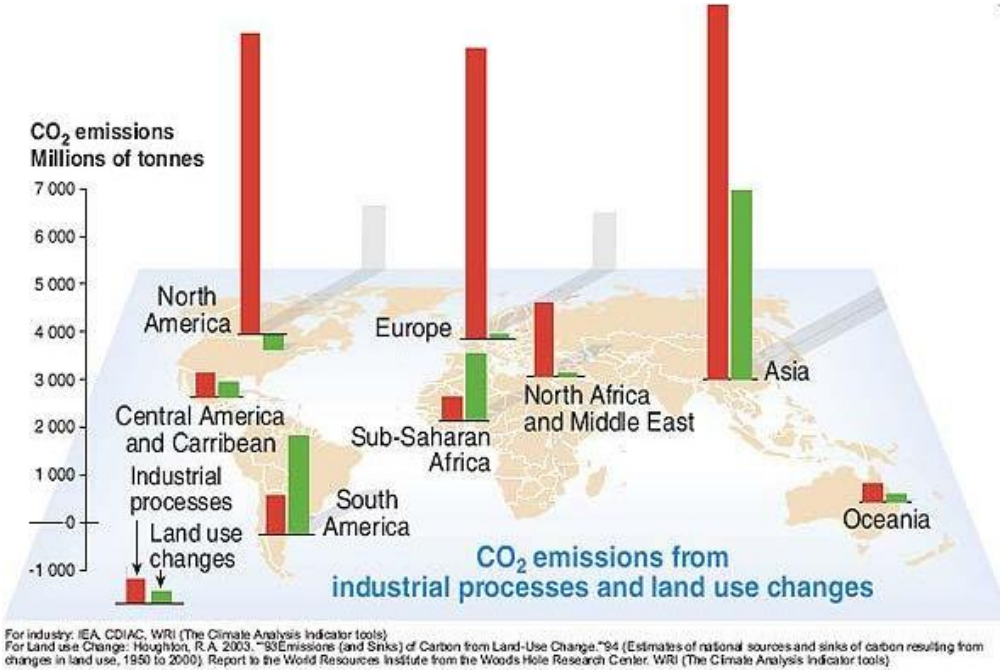
Large Asian population and its continuous growth

Many developing countries in Asia

Increase in the use of fossil fuels and in air pollution

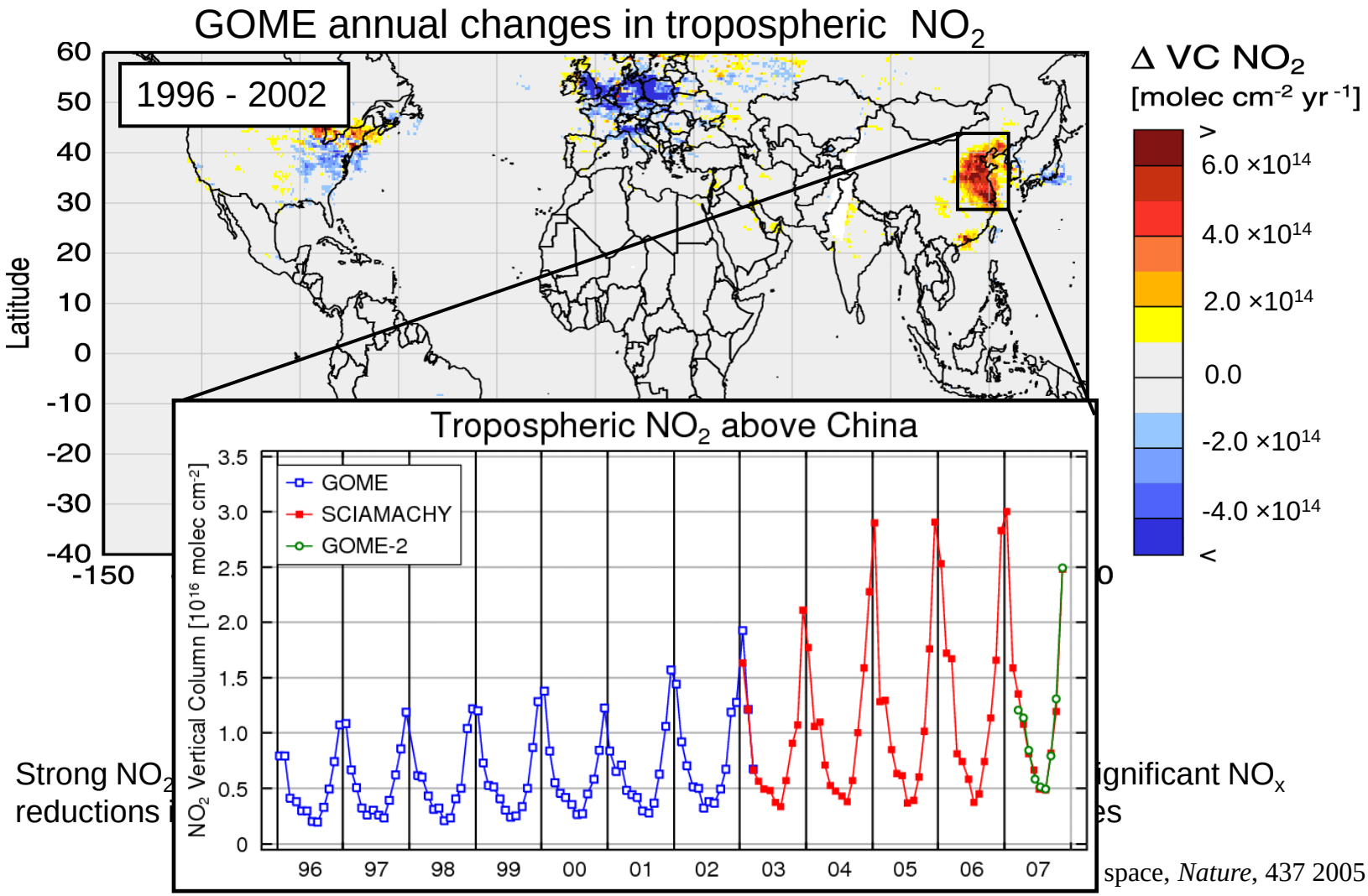


(http://www.newint.org/features)



(http://www.climateark.org)

Satellite OBS. of tropospheric NO_2 columns



- Strong NO_2
- reductions i

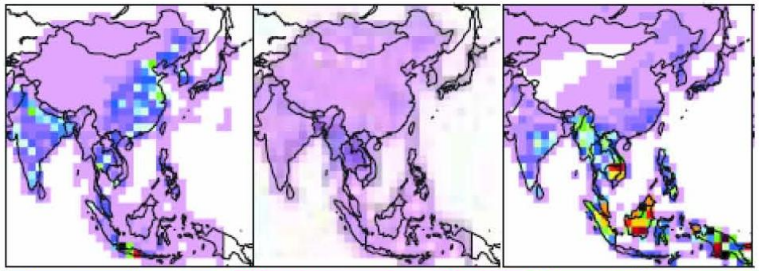
ignificant NO_x

es

space, *Nature*, 437 2005

Large discrepancy between simulated and satellite observed HCHO over East Asia

State-of-the-art "bottom-up"
Reactive VOC emission inventories



Anthropogenic 40 Tg	Biomass burning 12 Tg	Biogenic 80 Tg
Streets et al. [2003]	Streets et al. [2003]	Guenther et al. [2006]

GEOS-Chem

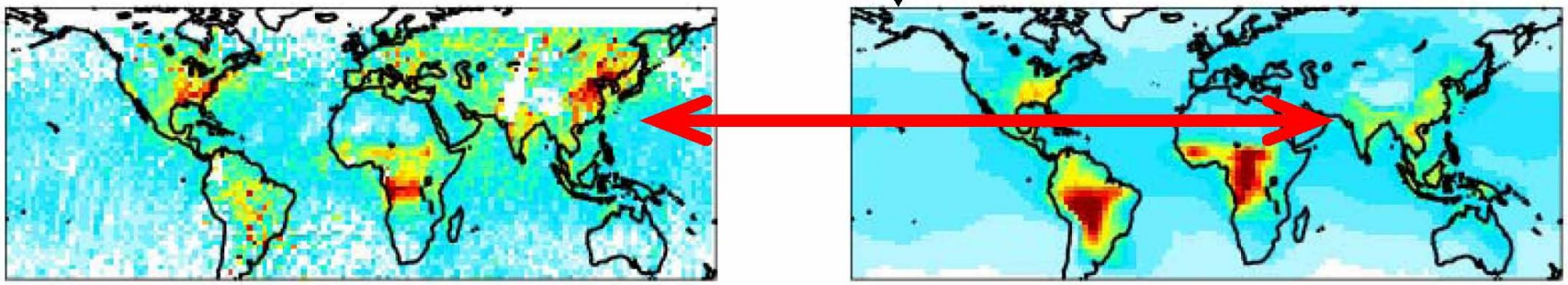
Global chemical transport model

Assimilated meteorology

Resolution: 2.5 longitude x 2 latitude

GOME HCHO column June 1996~2001

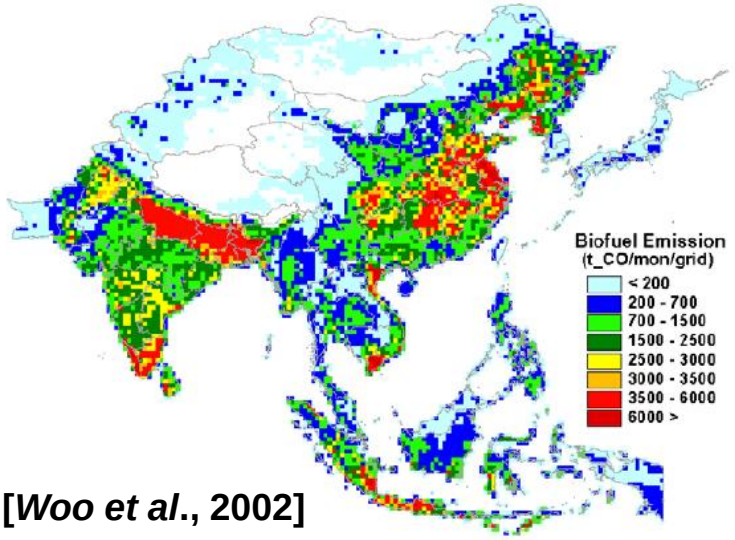
Model HCHO column June 2001



[10^{16} molec cm^{-2}]

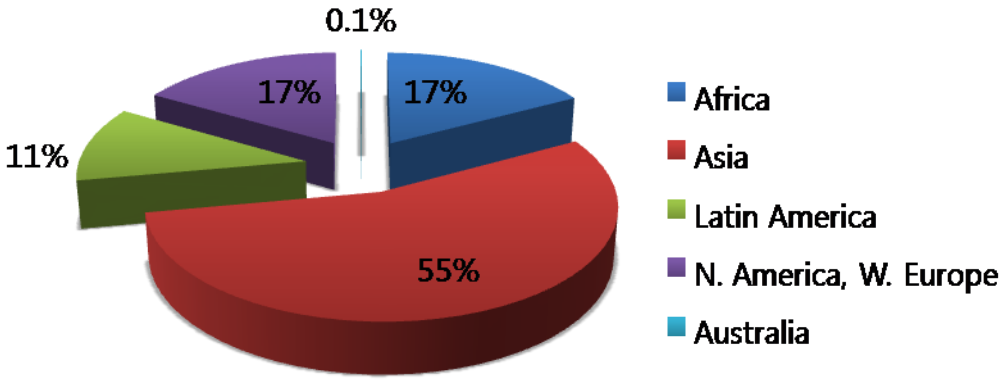
(Fu et al., 2007)

Highly uncertain biofuel emissions over Asia



[*Woo et al*., 2002]

Regional contributions to global biofuel uses



Asian biofuel uses account for over 50% of global biofuel uses. Biofuel is used mostly for household cooking and heating. Its emissions consequently are difficult to accurately assess.

Data from Yevich and Logan (2007)

2. Accurately monitoring transboundary transport of pollution in East Asia

Long-range transboundary transport of air pollutants in Northeast Asia (source-receptor regions)

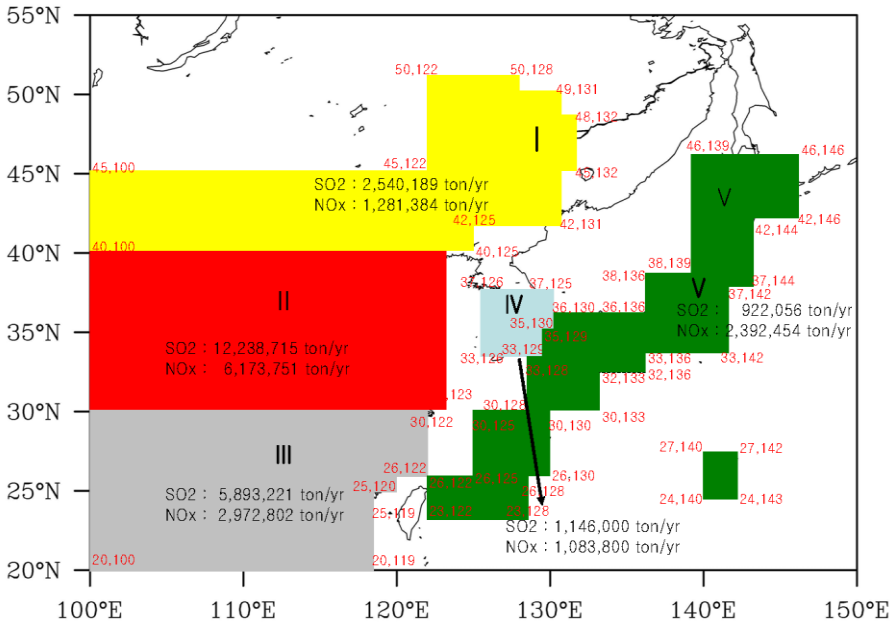
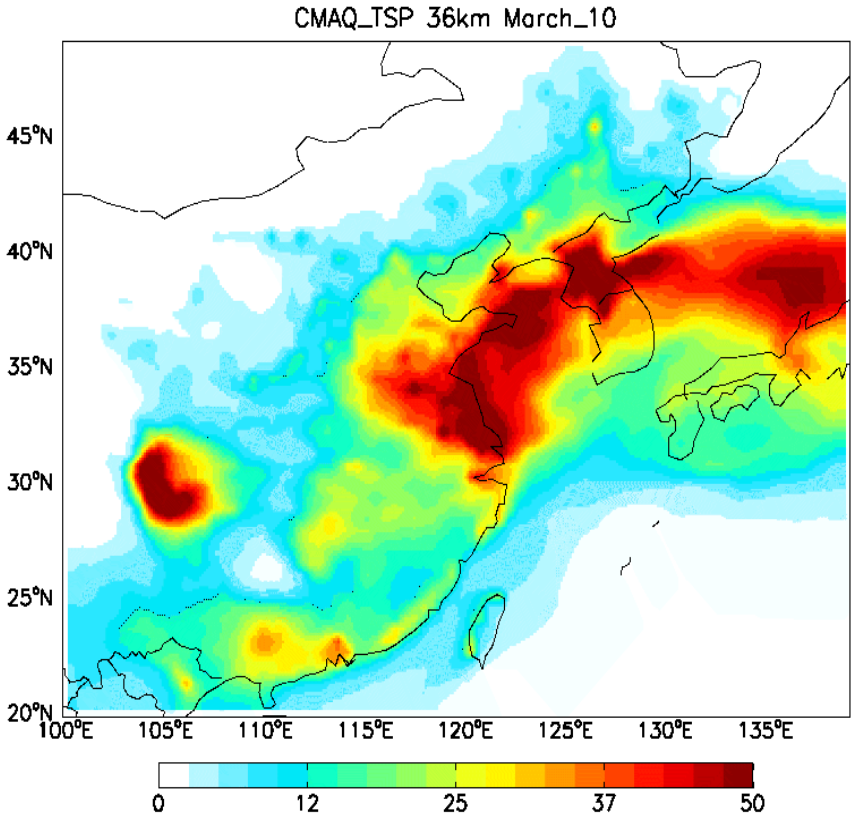


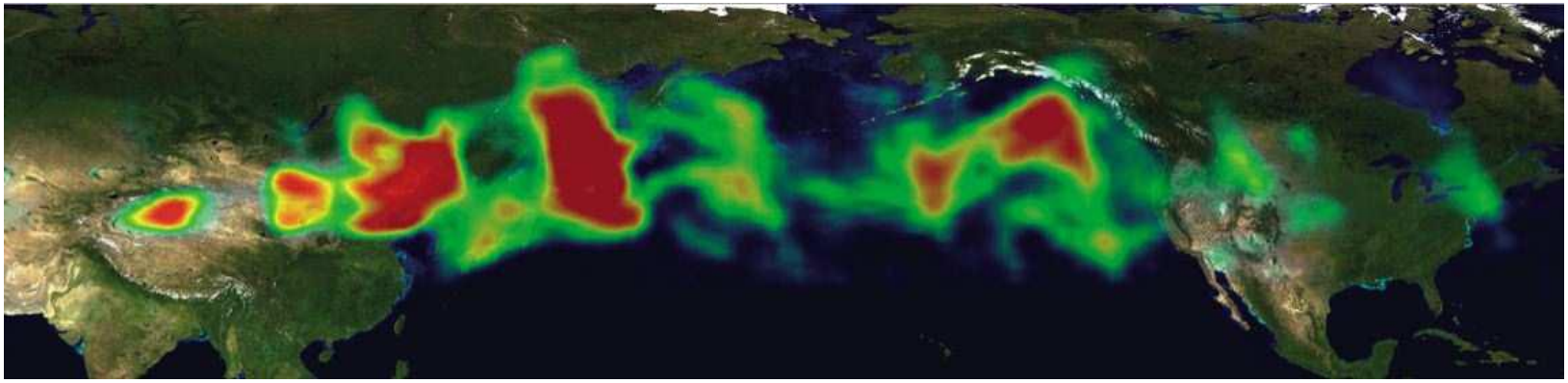
Fig. 8. Total emission amounts of SO_2 and NOx for each source/receptor region.



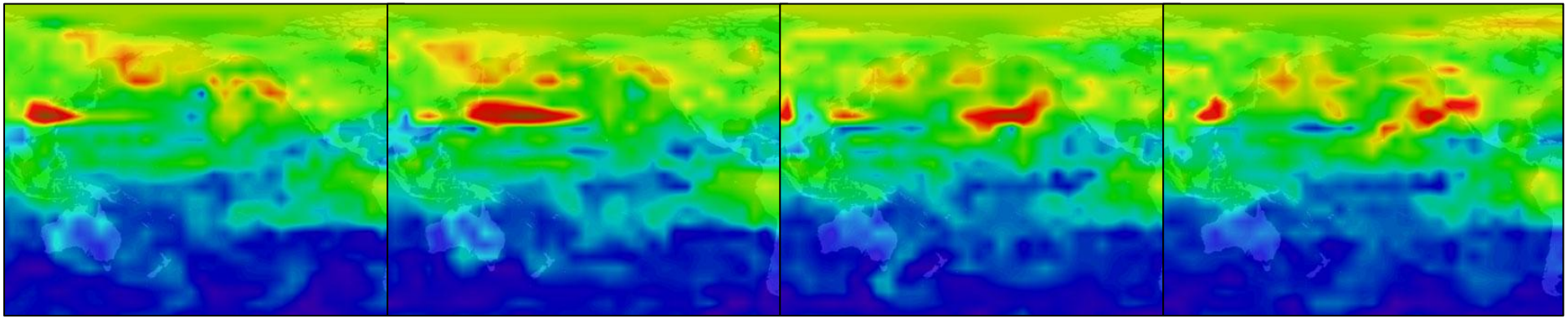
[*LTP project*, 2007]

Monitoring transpacific transport of pollution from Asia to NW pacific

Transport of Mongolian dust to N. America in April 2001.



This image was made by compositing several days of TOMS data. [courtesy, Bhartia]



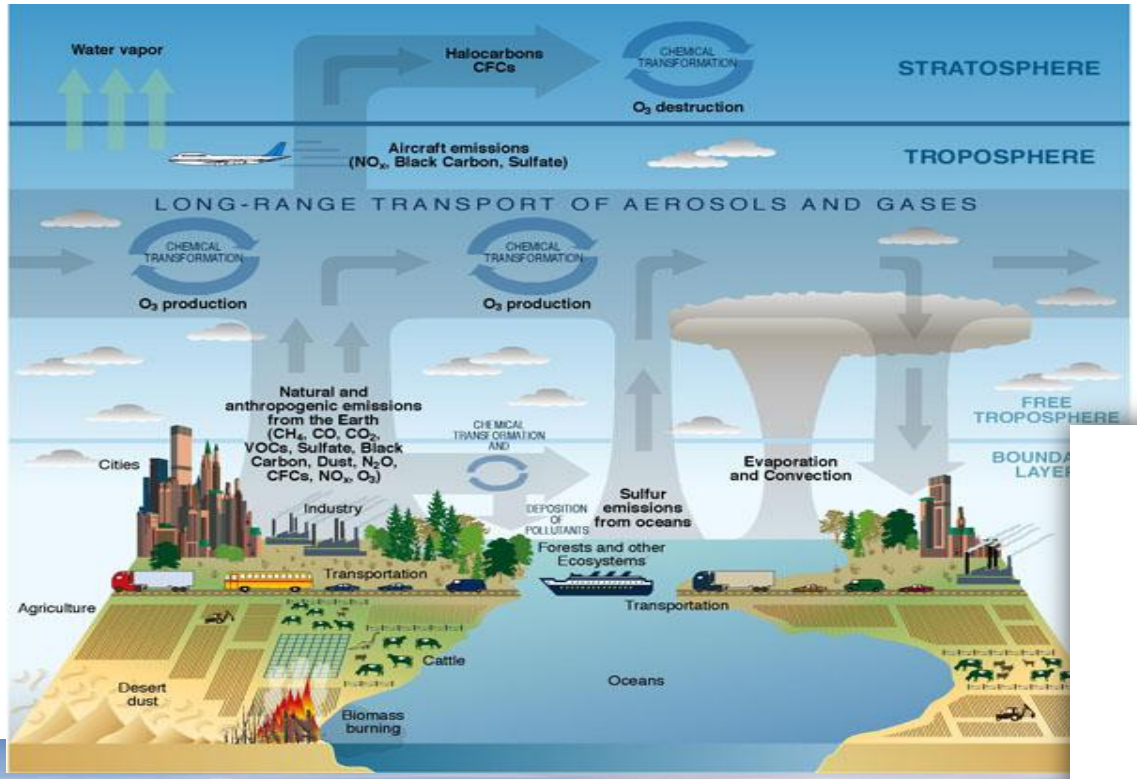
Terra detected strong sources of CO in Southeast Asia during April and May 2000.

(http://www.usgcrp.gov)

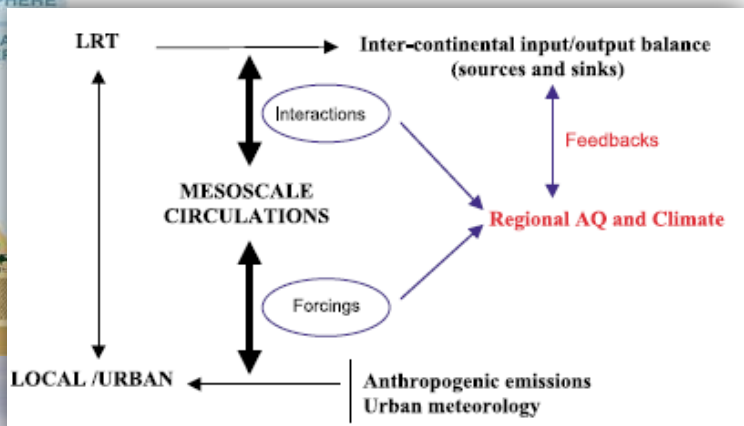
3. Study interaction between air chemistry and meteorology over East Asia

Through environmental (chem.+met.) measurements with high temporal and spatial resolution, the following interactions/feedback can be investigated:

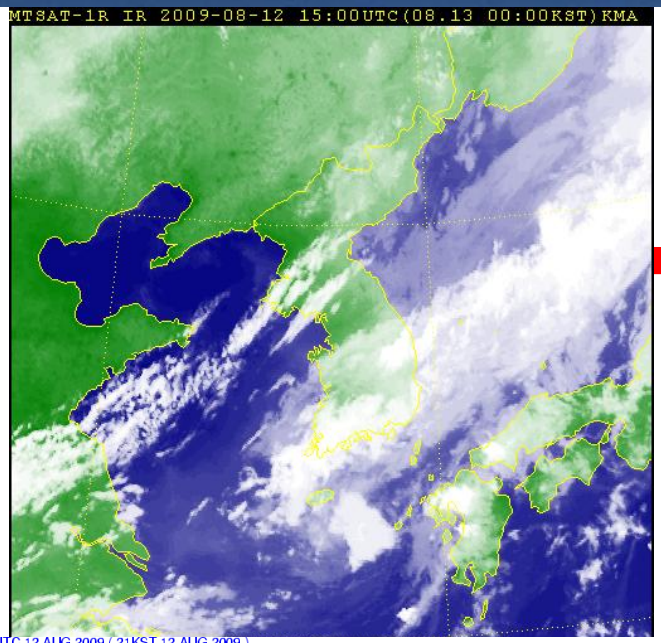
- Aerosol and cloud in short time scale
- Changes in temperature and biogenic VOC emissions (diurnal variation)
- Ozone and meteorological variables such as wind and temperature
- Convection and vertical transport of air pollution from the surface

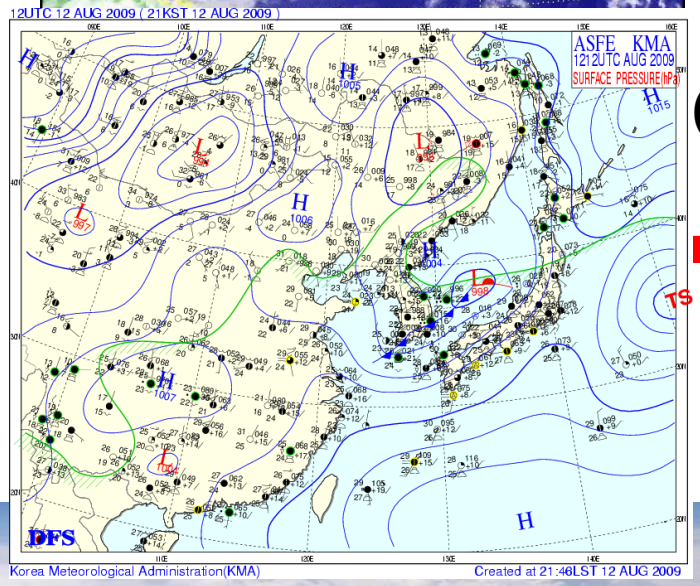


Credit: CCSP Strategic Plan (illustrated by P. Rekacewicz).

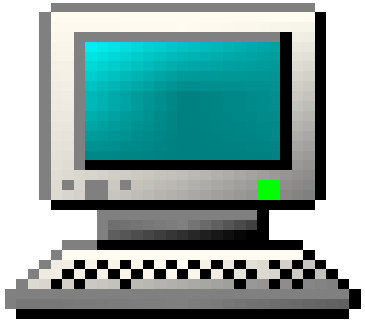


4. Air Quality forecasting along with weather forecasting





PM
Air quality



(Chemical Transport Model)

O3
Air quality

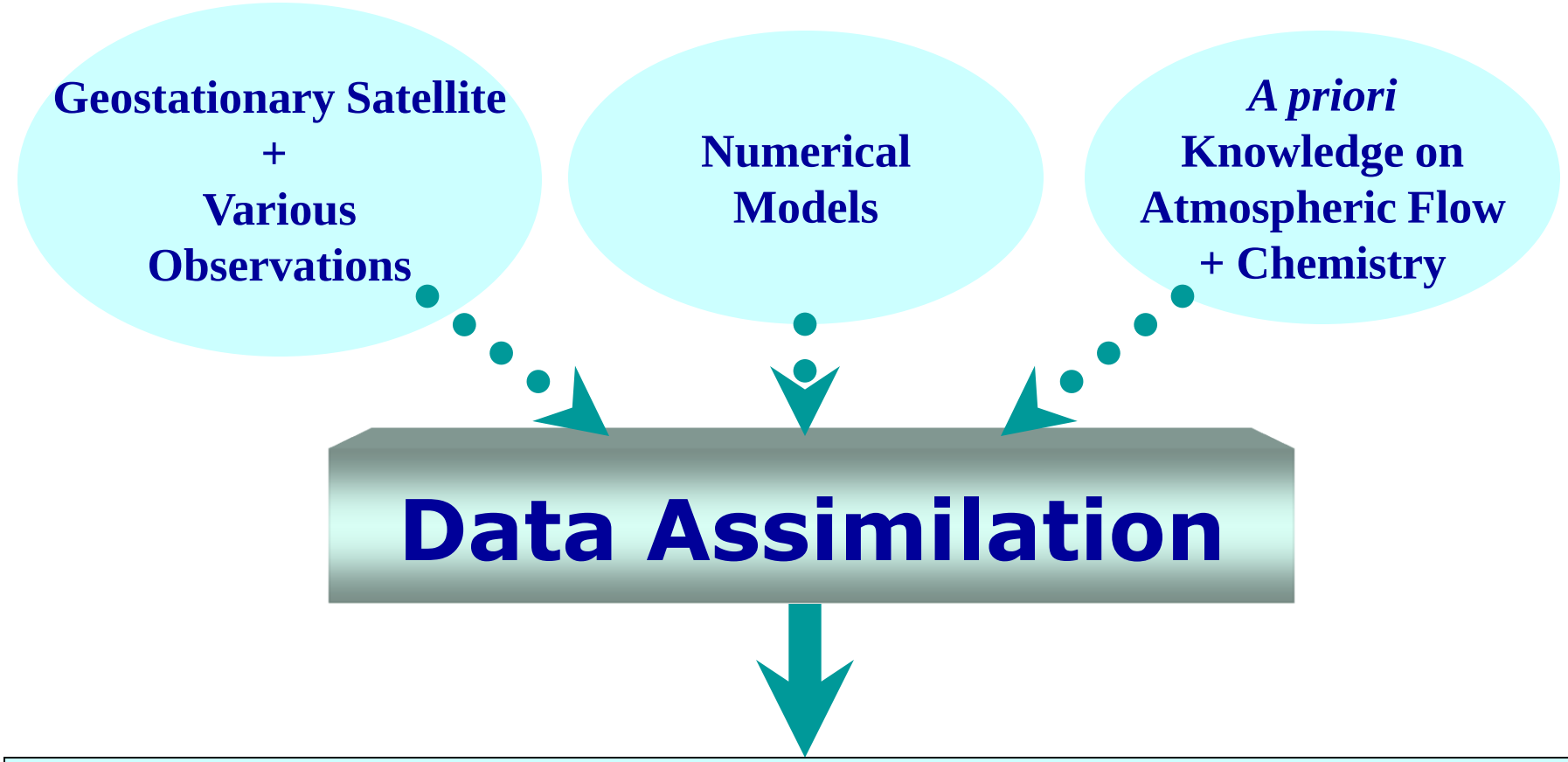
Table I. The U.S. EPA Air Quality Index for Particulate Matter.

Index Values	Category	Cautionary Statements	$PM_{2.5}$ ($\mu g\ m^{-3}$)	PM_{10} ($\mu g\ m^{-3}$)
0–50	Good	None	0–15.4	0–54
51–100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion	15.5–40.4	55–154
101–150	Unhealthy for sensitive groups	Sensitive groups should reduce prolonged or heavy exertion	40.5–65.4	155–254
151–200	Unhealthy	Sensitive groups should avoid prolonged or heavy exertion; everyone else should reduce prolonged or heavy exertion	65.5–150.4	255–354
201–300	Very unhealthy	Sensitive groups should avoid all physical activity outdoors; everyone else should avoid prolonged or heavy exertion	150.5–250.4	355–424

Source: US EPA, 1997

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

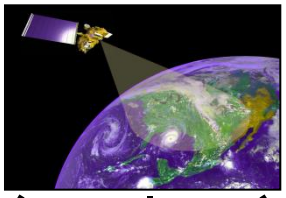
Using 3-D and 4-D VARs to constrain pollutant emissions with sufficient temporal resolutions

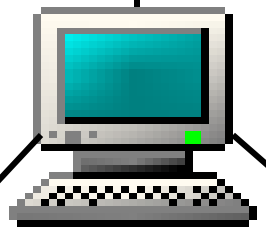


Most Complete and Accurate Description (Optimal States) of the Atmospheric Environment

OBSERVING SYSTEM FOR ATMOSPHERIC COMPOSITION MUST INTEGRATE SATELLITES, IN SITU MEASUREMENTS, AND MODELS

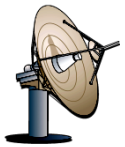
Satellites





Chemical transport models

Surface monitors



Aircraft, lidar

NEW KNOWLEDGE

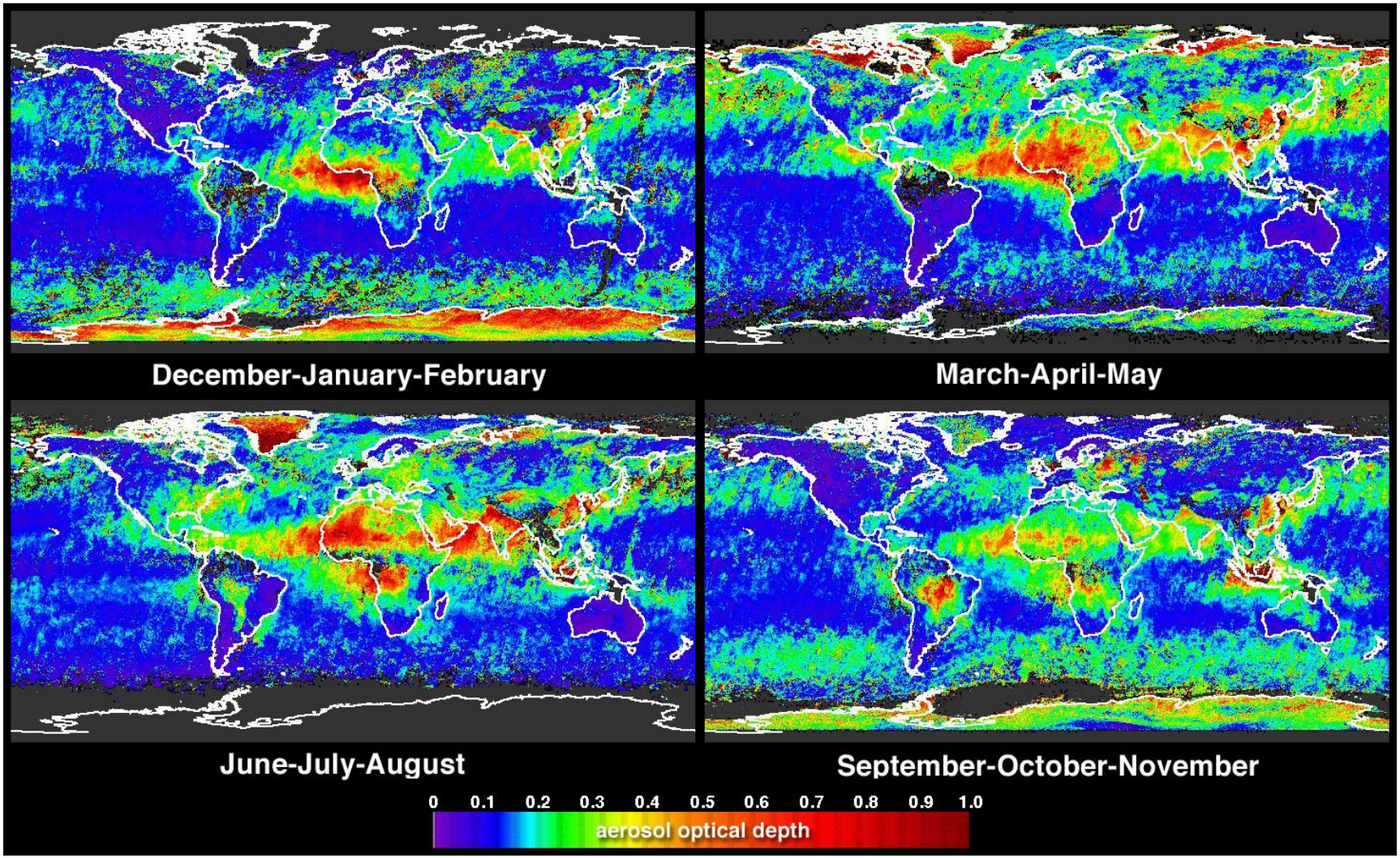
- Air quality monitoring & forecasting
- Source quantification, policing of environ-mental agreements
- Long-range transport
- Biogeochemical cycling
- Climate forcing
- Weather forecasting

Additional slides

Expected outcomes

1. Reduced uncertainties in East Asian emissions with high spatio-temporal scale observations
2. Quantification of East Asian pollution contribution to global tropospheric chemistry
3. Enhanced understanding of interactions between air chemistry and meteorology
4. Evaluation/validation of chemistry models
5. Continuous monitoring of transboundary and transpacific transport of air pollutants
6. Improve air quality forecasting using data assimilation techniques (3-D/4-D VARs)
7. …

Global and Seasonal Aerosol Distributions from MISR



(http://earthobservatory.nasa.gov)

1st HTAP MODEL INTERCOMPARISON

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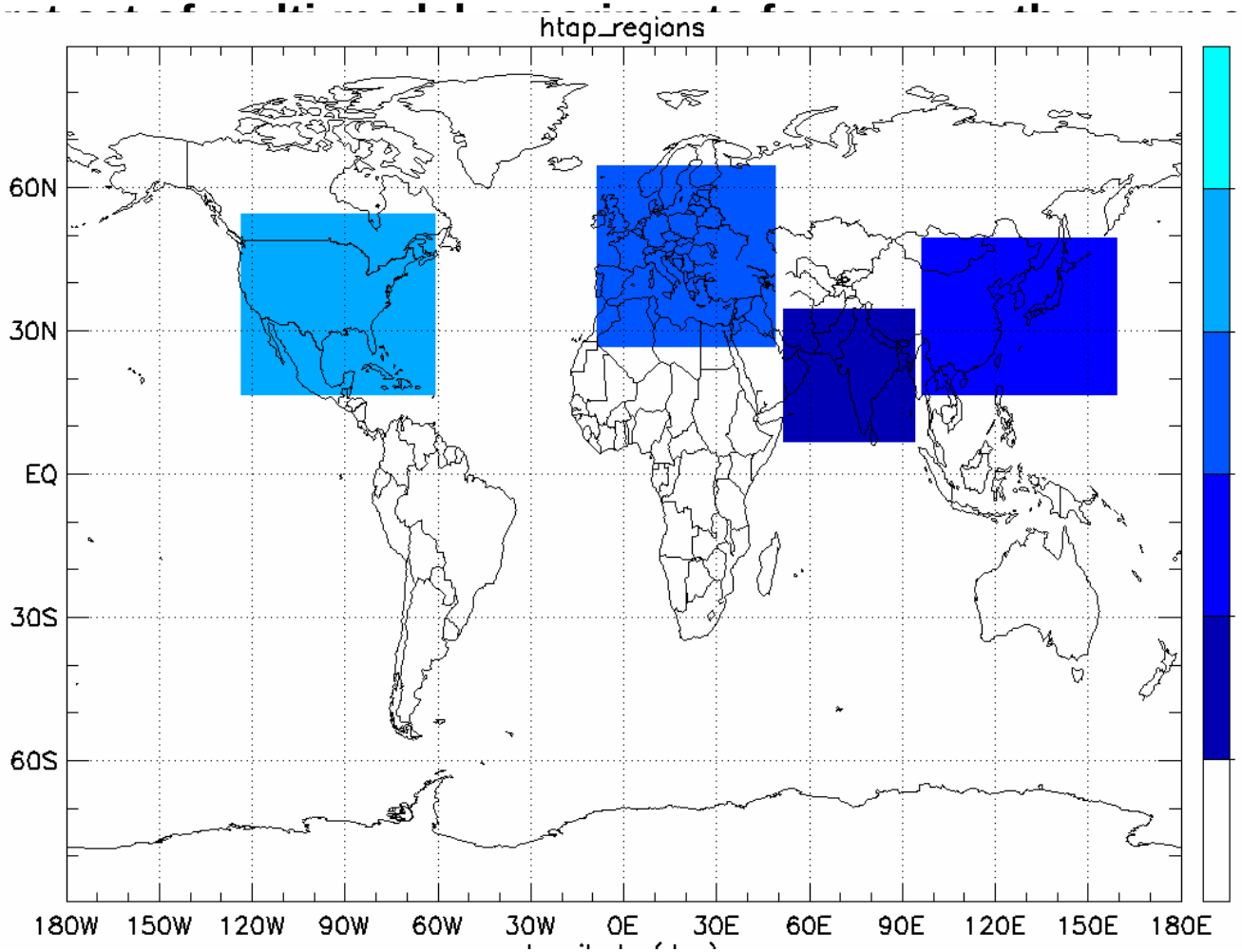

•Detailed information is given at http://aqm.jrc.it/HTAP/.