The Globalization of Air Pollution

Topics:

1) The Growing Reach of Air Pollution
Local, regional, global and back again

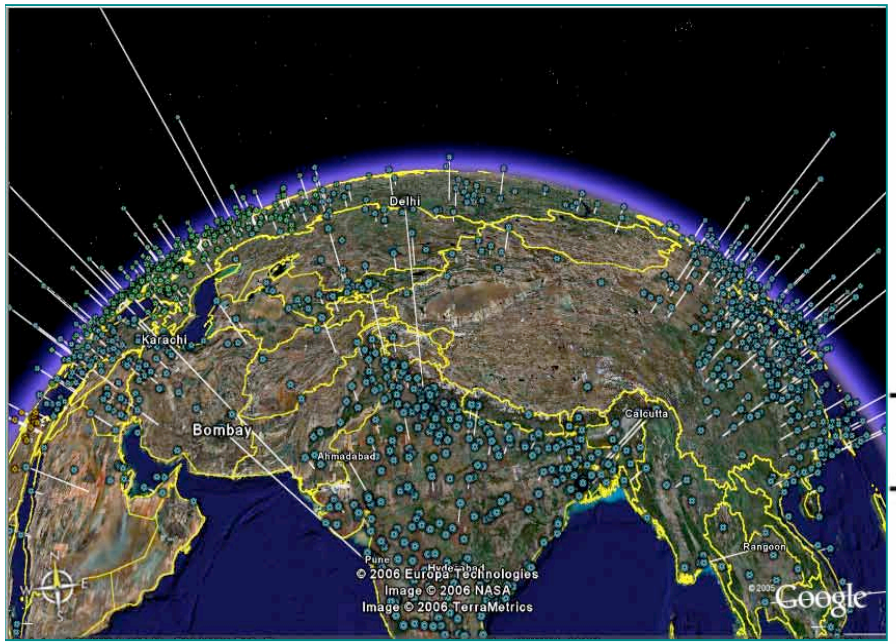
2) Links Between Air Pollution and Climate Change
A tale of 2 carbons (carbon dioxide and black carbon)

3) Regional Impacts
Human health, agriculture, water resources

4) Challenges for Weather Services
Defining roles and services in meteorology, climate and air pollution

Urban Environments Are Key Drivers Of Air Quality

We are learning that Megacities have large environmental footprints



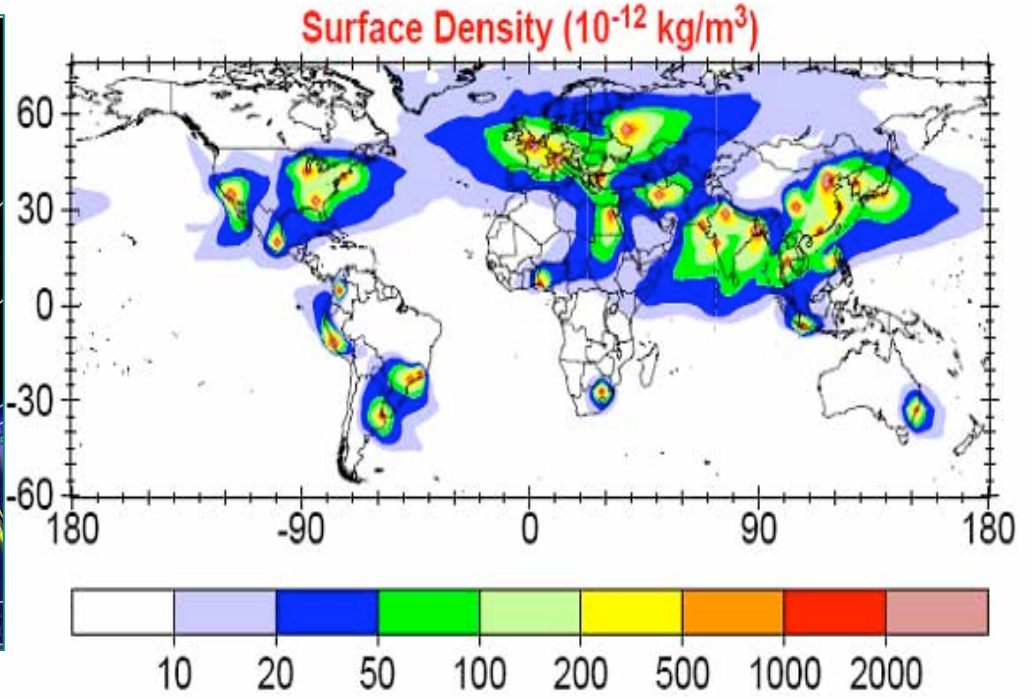
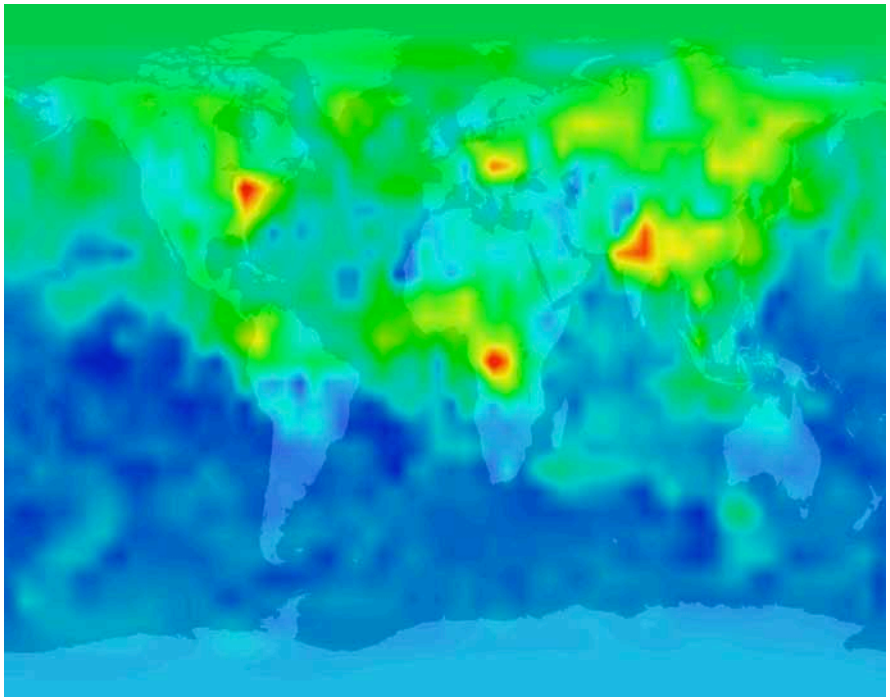


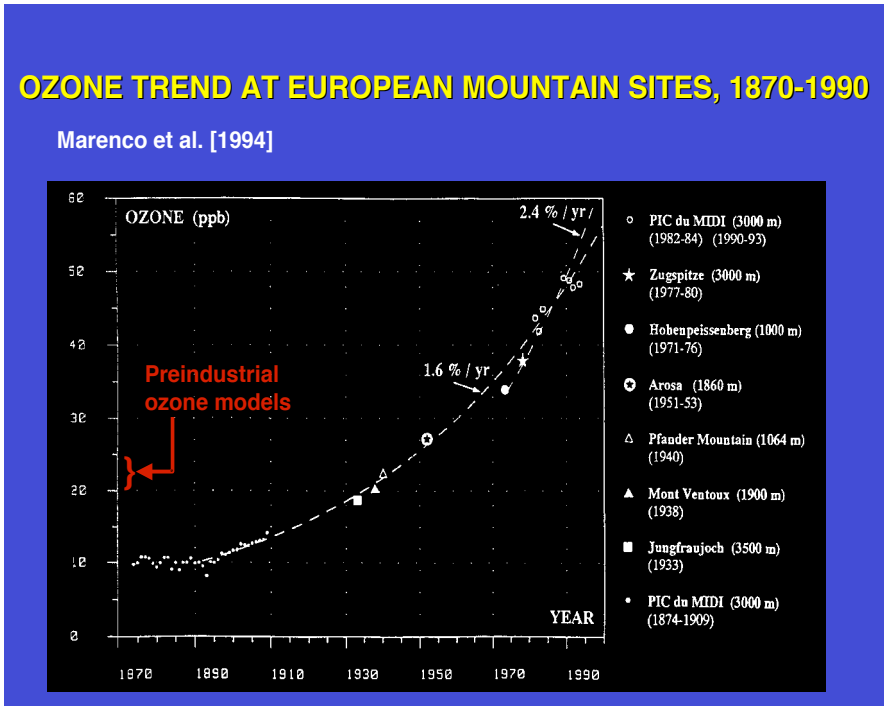
Fig. 5.1 Annual mean plots of the sum of all of the (10 d) MPC tracers for the model surface layer density (10−12 kg/m3) and the column above 5km (10−9 kg/m2). From *Lawrence et al.*, 2007.

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

There Is Growing Awareness That We Now Face Pollution At The Global Scale



Satellite Observations of CO (MOPITT)

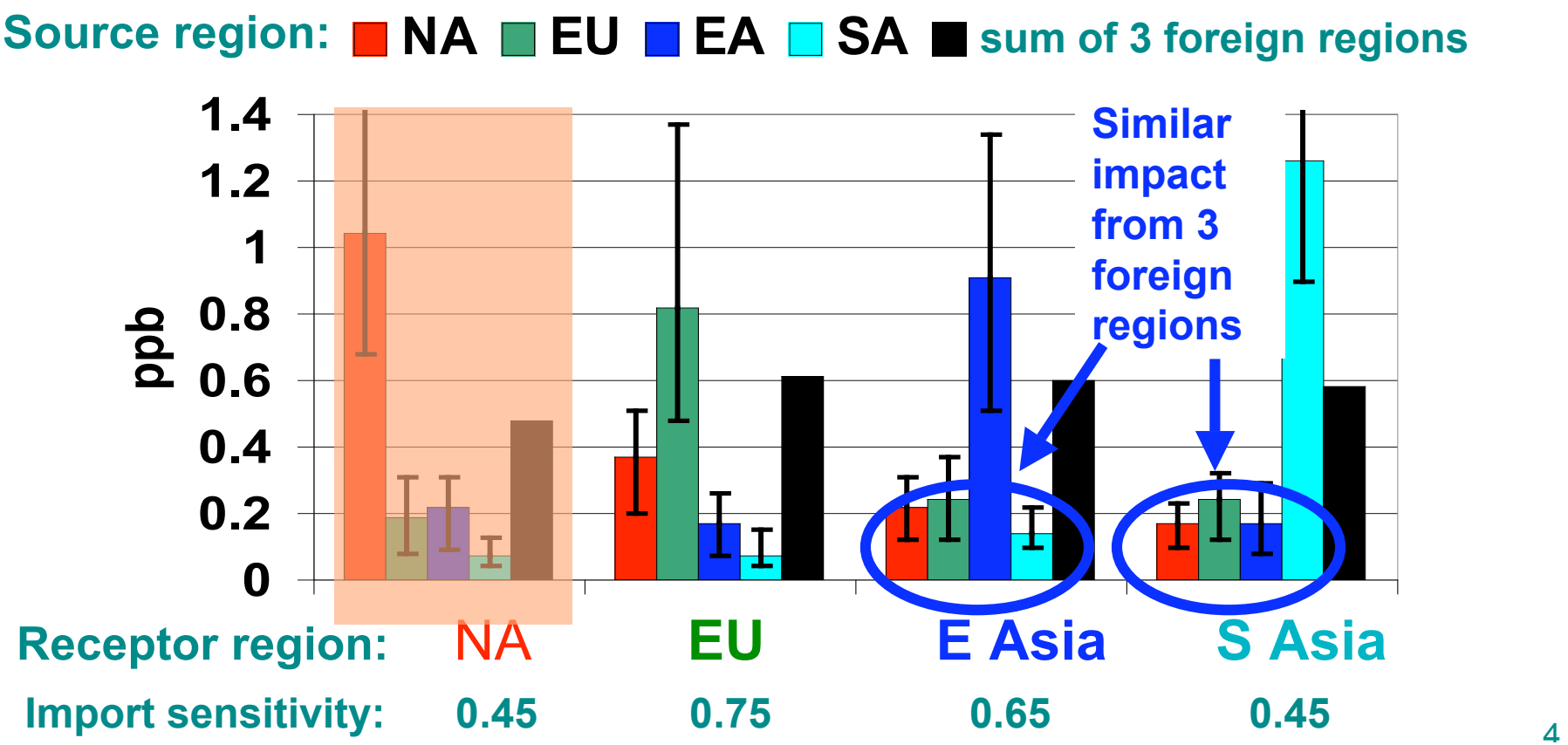


Growing Hemispheric Levels

How Important Are Distant Sources To Local Air Quality?

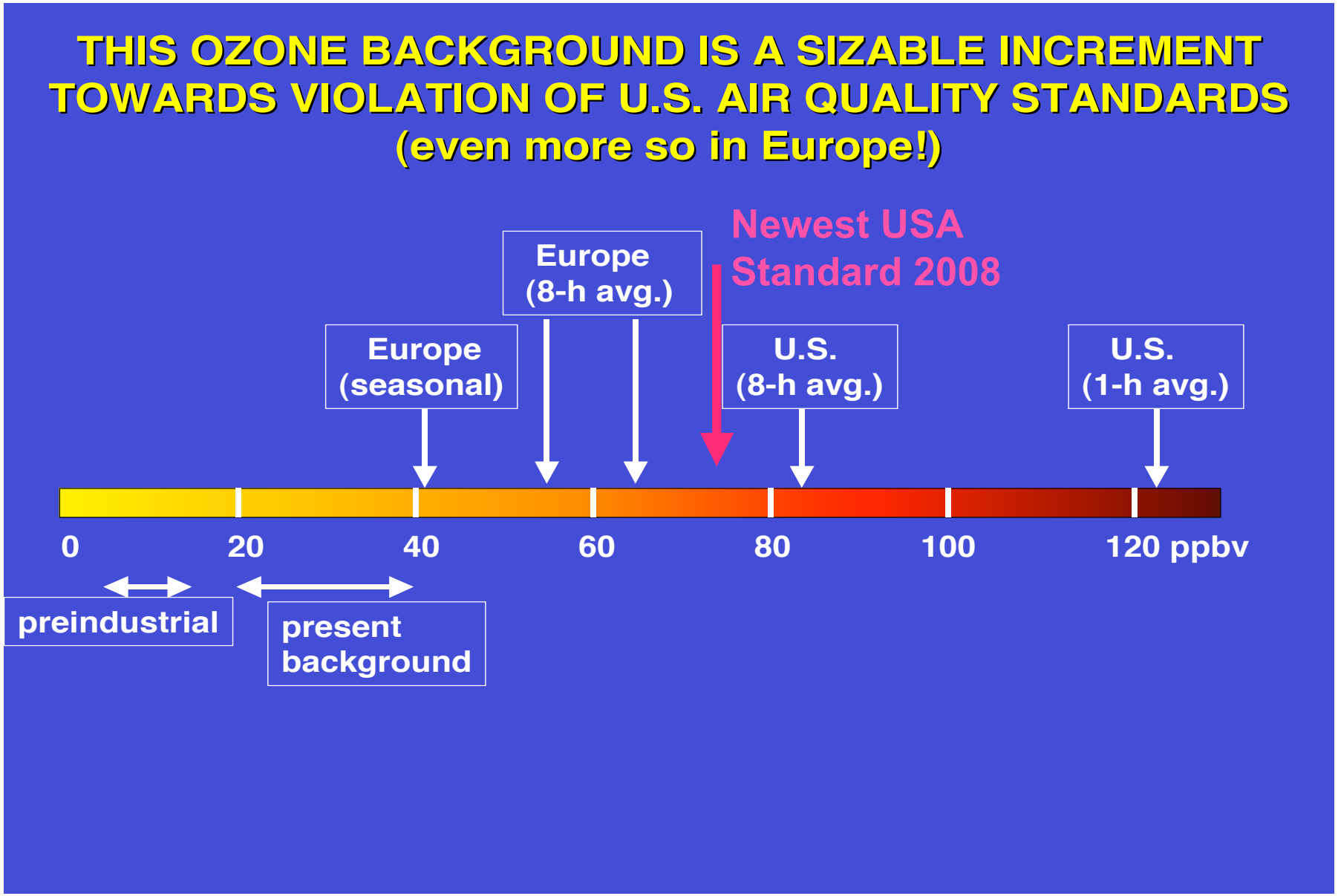
Model estimates for surface O_3 pollution

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



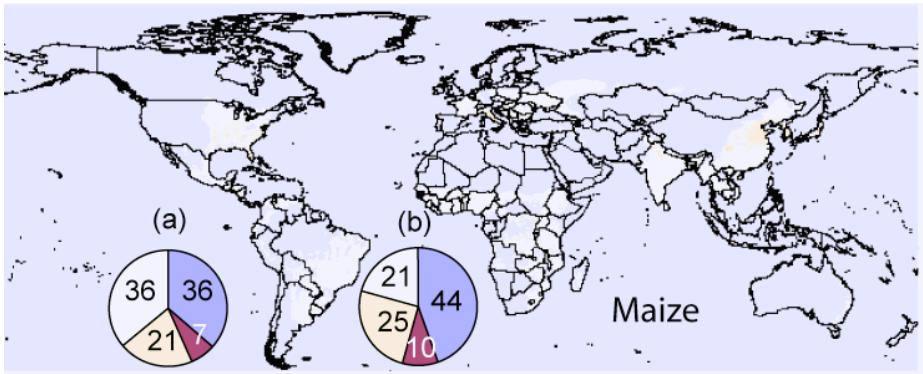
EU Task Force on Hemispheric Transport of Pollutants. Interim Assessment Report 2008
http://www.unece.org/env/eb/Air.Pollution%20Studies.No.16.Hemispheric%20Transport.pdf

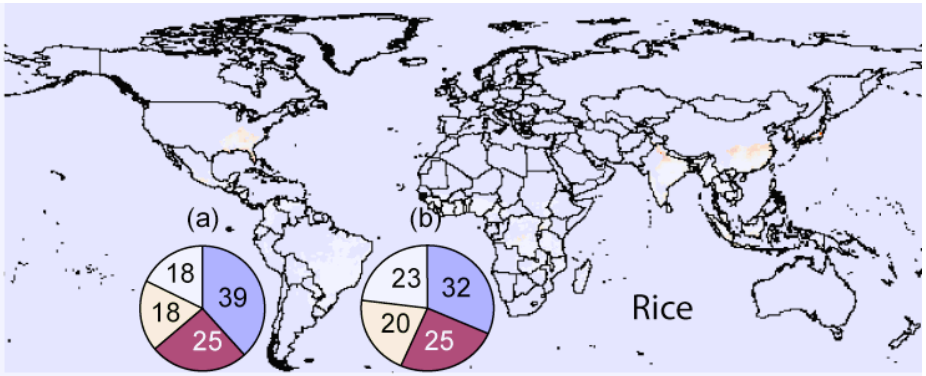
As Air Quality Standards Become More Stringent
The Importance Of Distant Sources Increases

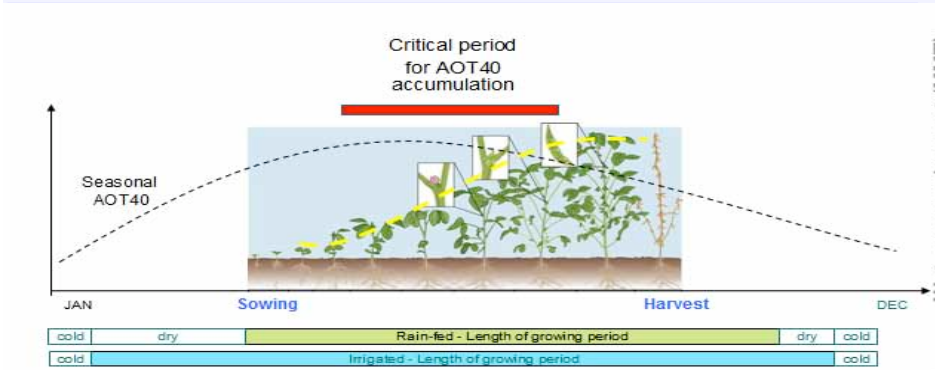


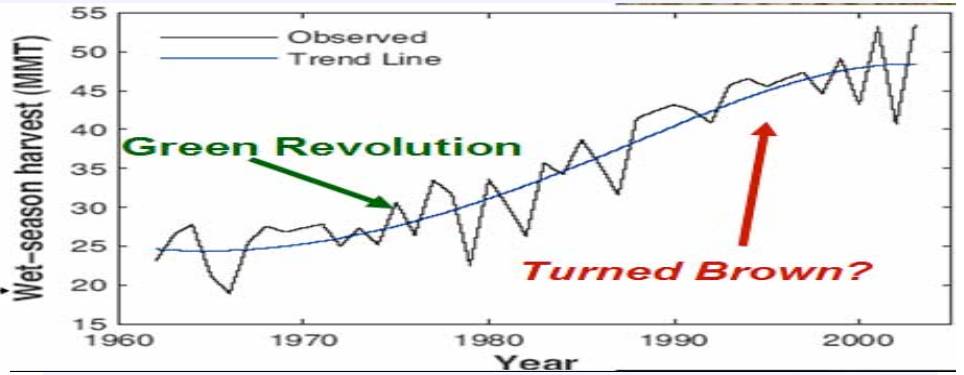
O_3 Damage To 'Potential' Production

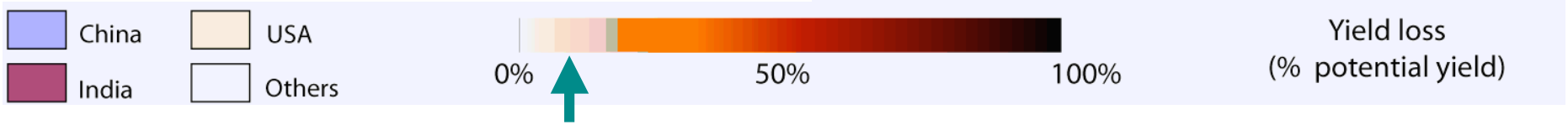
(rain-fed, 2000-CLE emissions)











Inset graphs:

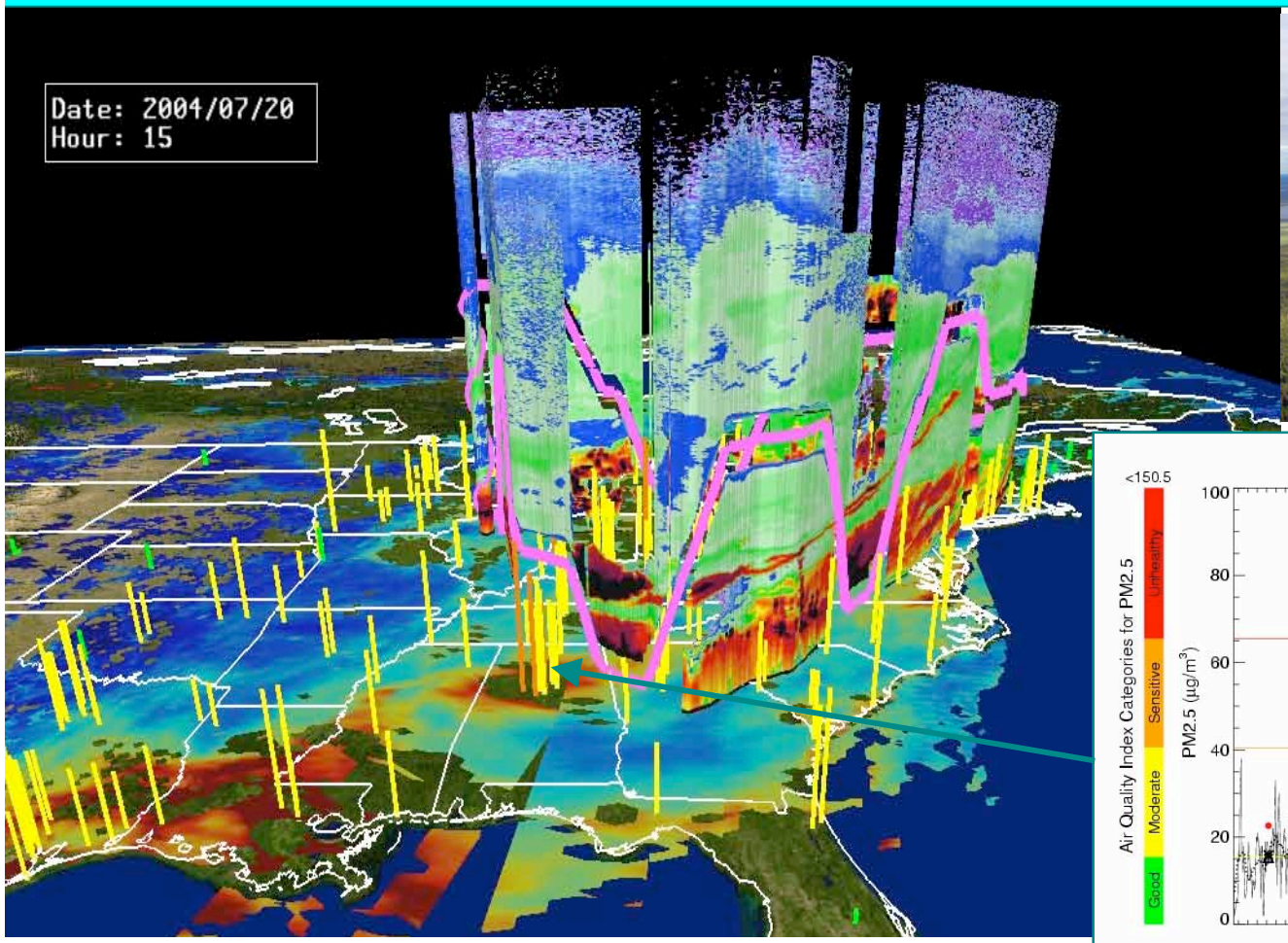
(a) Share of global threatened areas

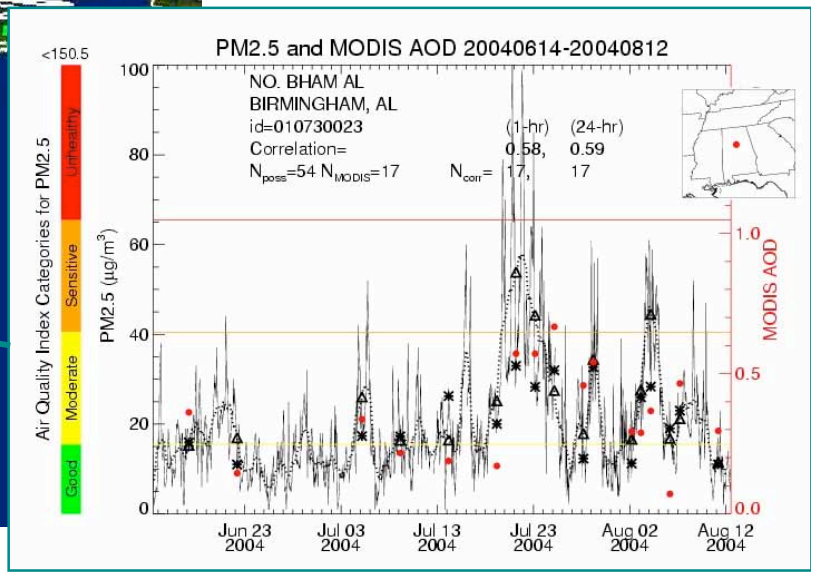
(b) Share of global losses

China, India and the USA bear nearly 75% of all global losses

Impacts of Global Composition On Regional Air Quality: The Role Of Fire

DC-8 LIDAR backscatter, MODIS AOD and EPA AIRNow PM2.5 on July 20, 2004



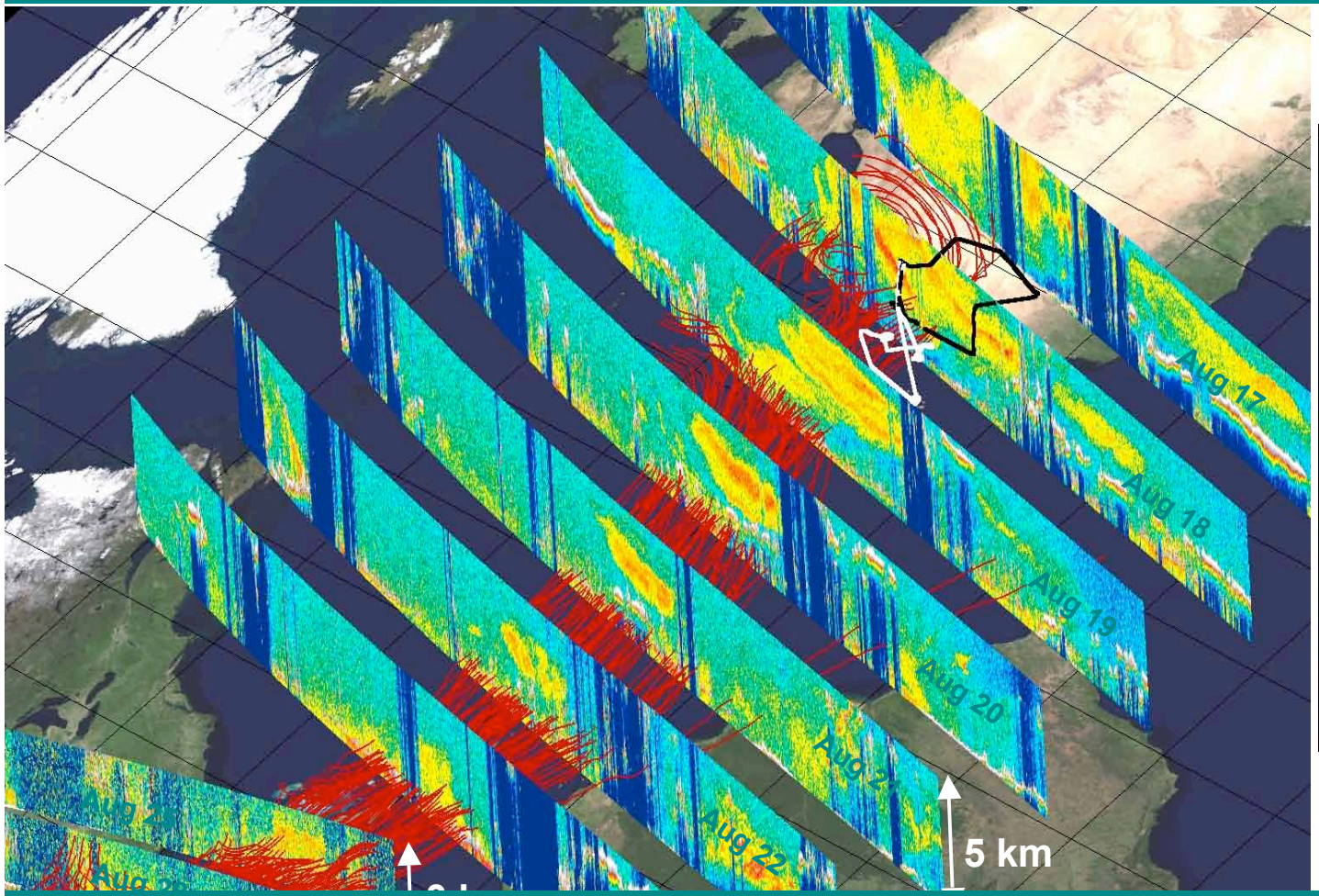


DC8 LIDAR shows that the high aerosols seen by MODIS were at several layers in the troposphere.

Dust Transport: Global Source/Receptor Studies

CALIPSO Observations Link Texas Dust event to Saharan Source region

NASA NAMMA Flight tracks shown in black (08/19) and white (08/20)

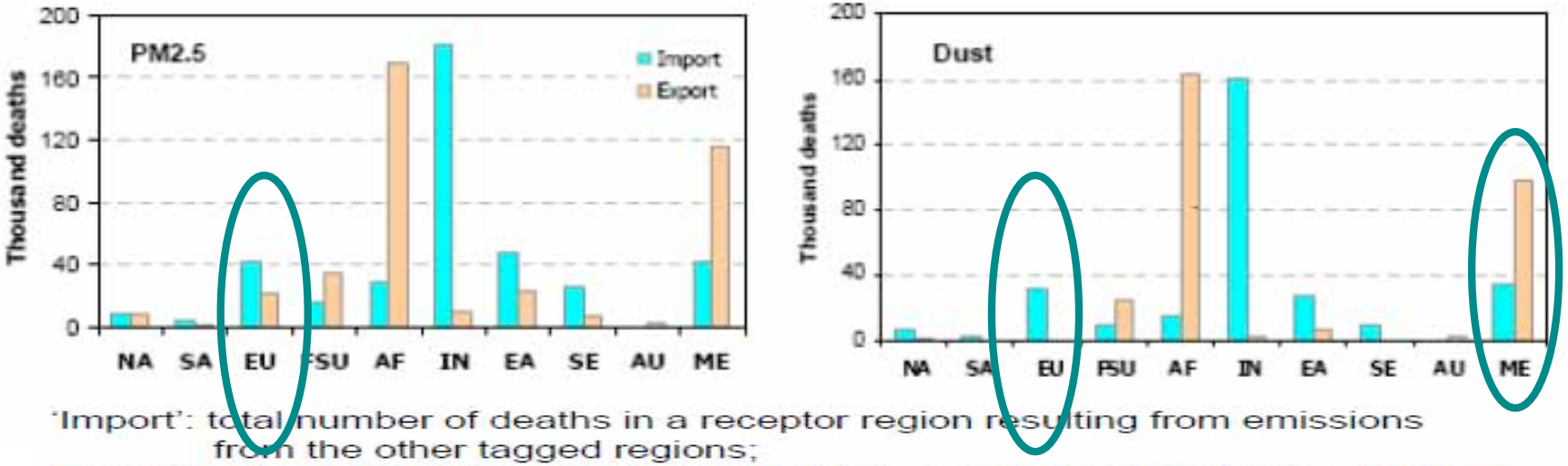


Boundary Layer back trajectories from August 28 CALIPSO track shown in red

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!!!)

Dust plays important role in weather and climate as well!



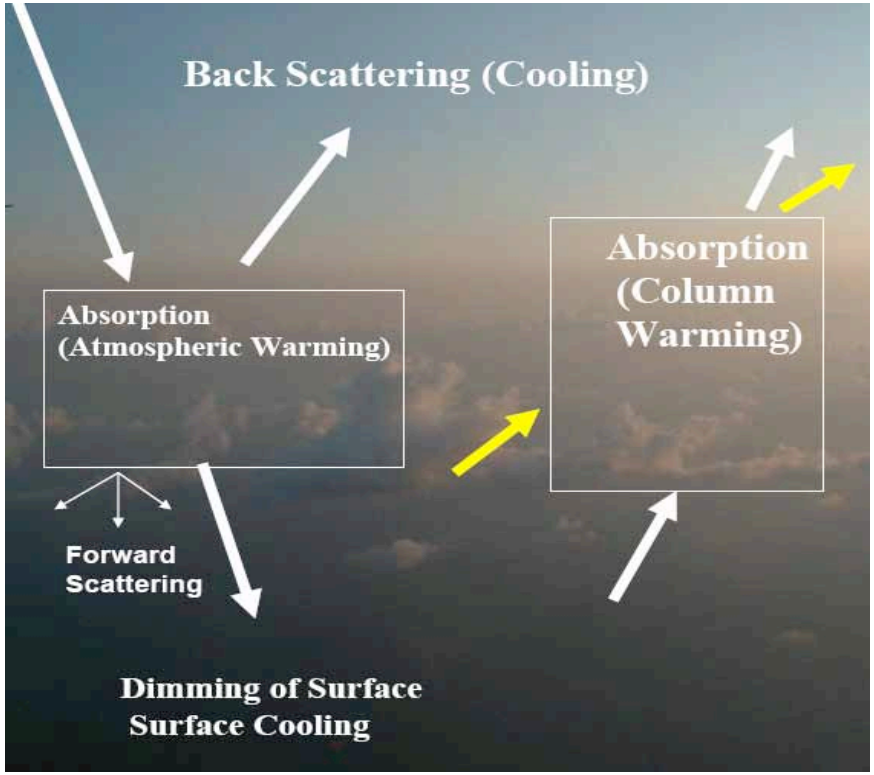
'Import': total number of deaths in a receptor region resulting from emissions from the other tagged regions;
'Export': total number of deaths in the other nine regions resulting from emissions from the given region.

Denise Mauzerall
Princeton University

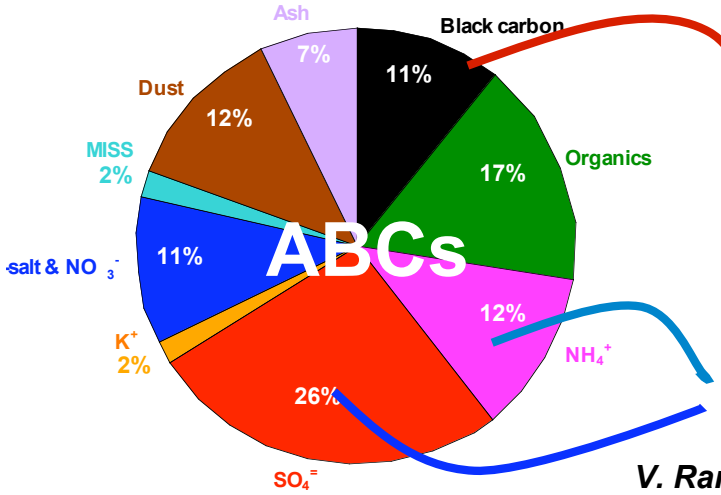
(in USA >50,000 excess deaths; $100B/yr)

Strong Motivator For Air Quality Forecasting Activities

How Do Aerosols Influence Climate ?



- Aerosols "mask" about 50% of the forcing of GHGs.
- BC acts like CO2 with about 50% of forcing as CO2, but with a much shorter atmospheric lifetime.



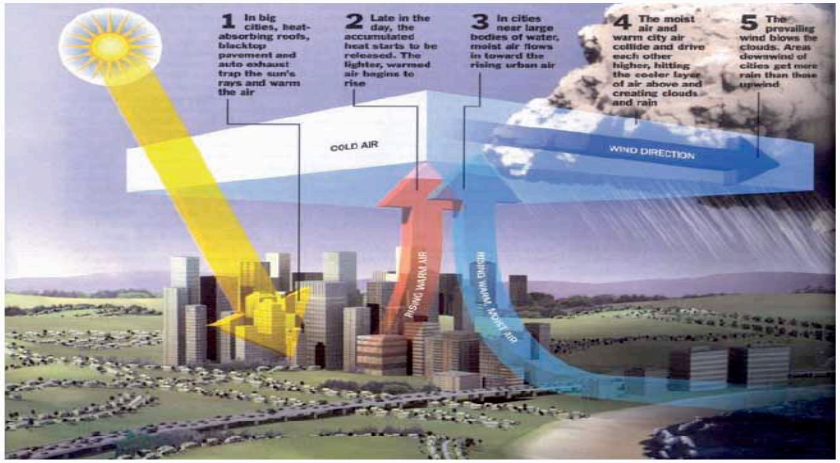
Traps sunlight and heats the air

Reflects sunlight like mirrors and cool

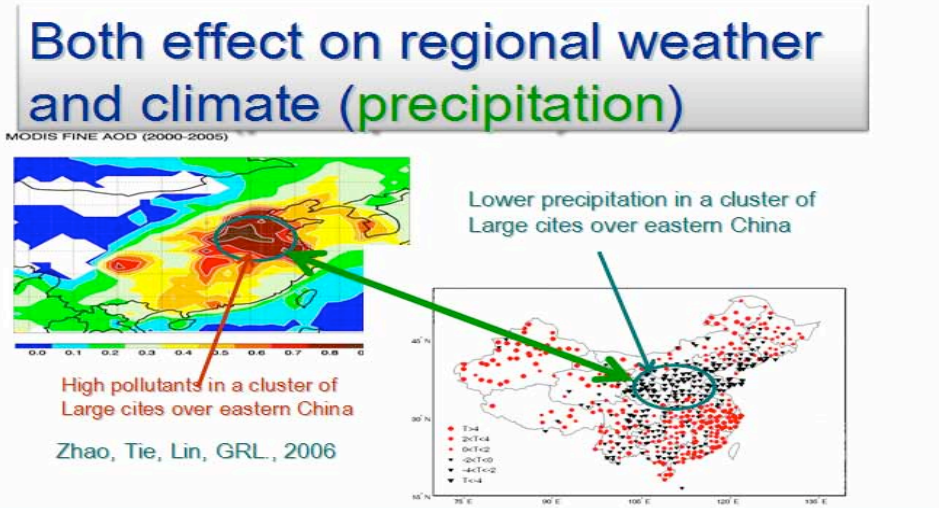
V. Ramanathan, and G. Carmichael, Nature Geos. 2008

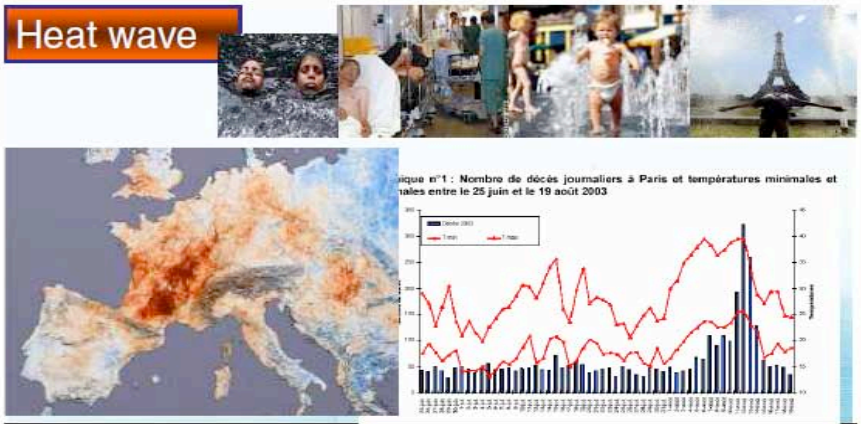
The Interactions Between Air Pollution, Weather And Climate Are Many And Complex

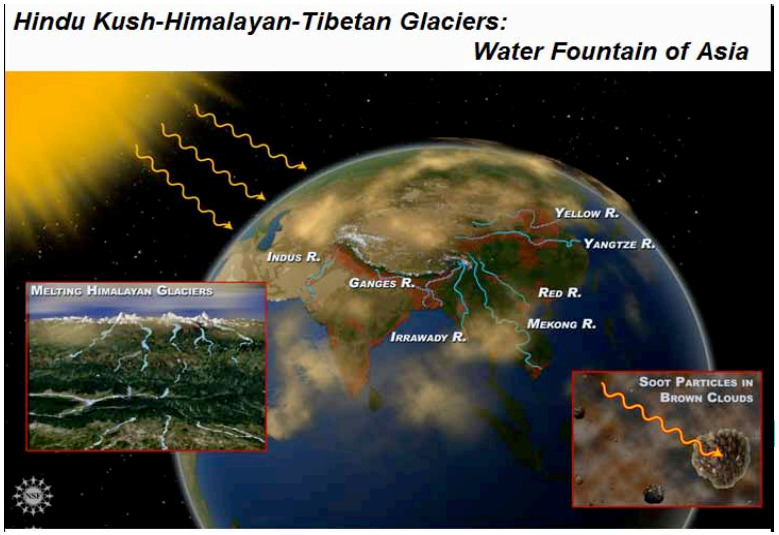
Weather Impacts AQ <----> AQ Impacts Weather !!



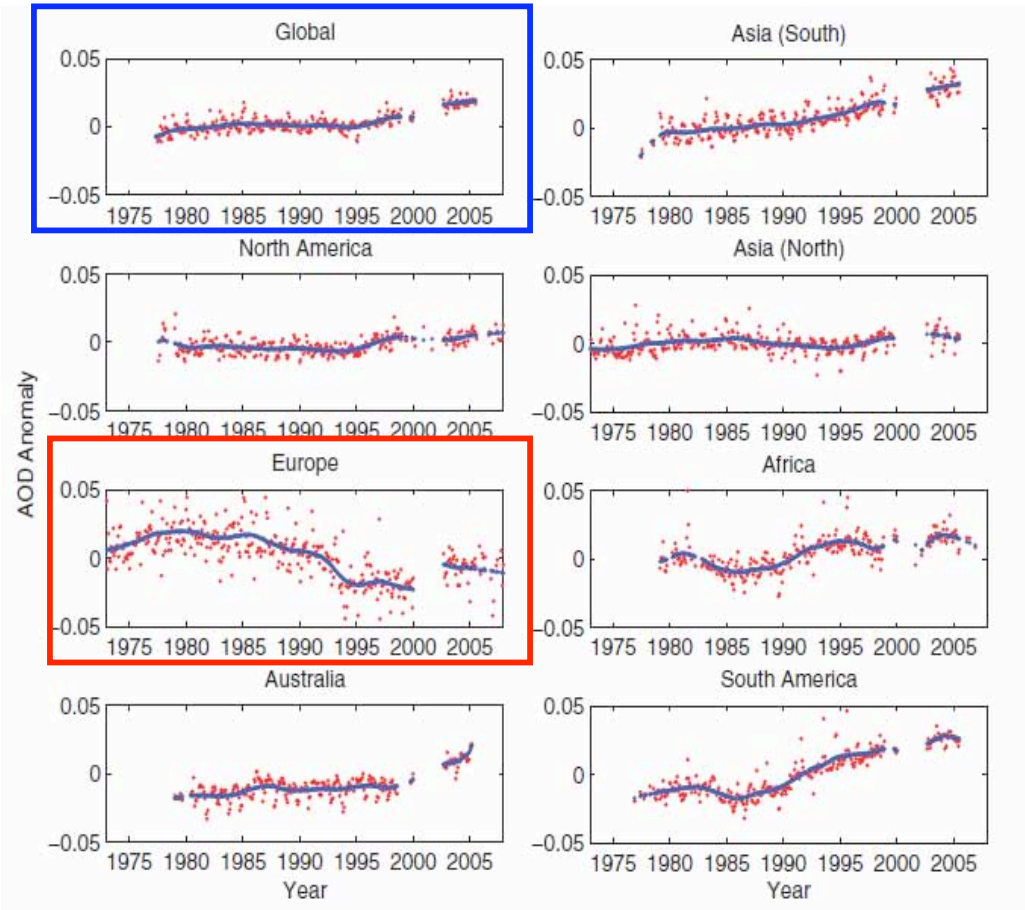
Urban Heat Island



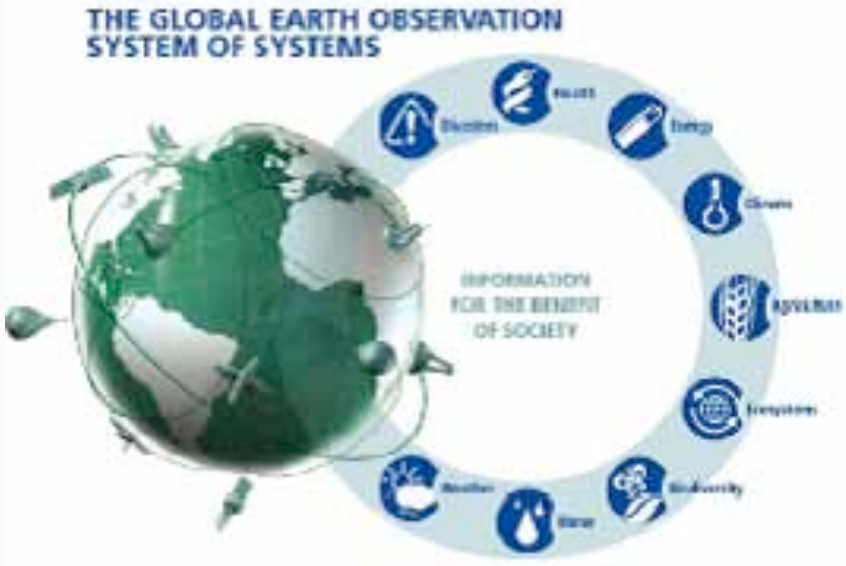




For Pollution And Climate Reasons We Need To Reduce Aerosols BUT It Is A Big Challenge

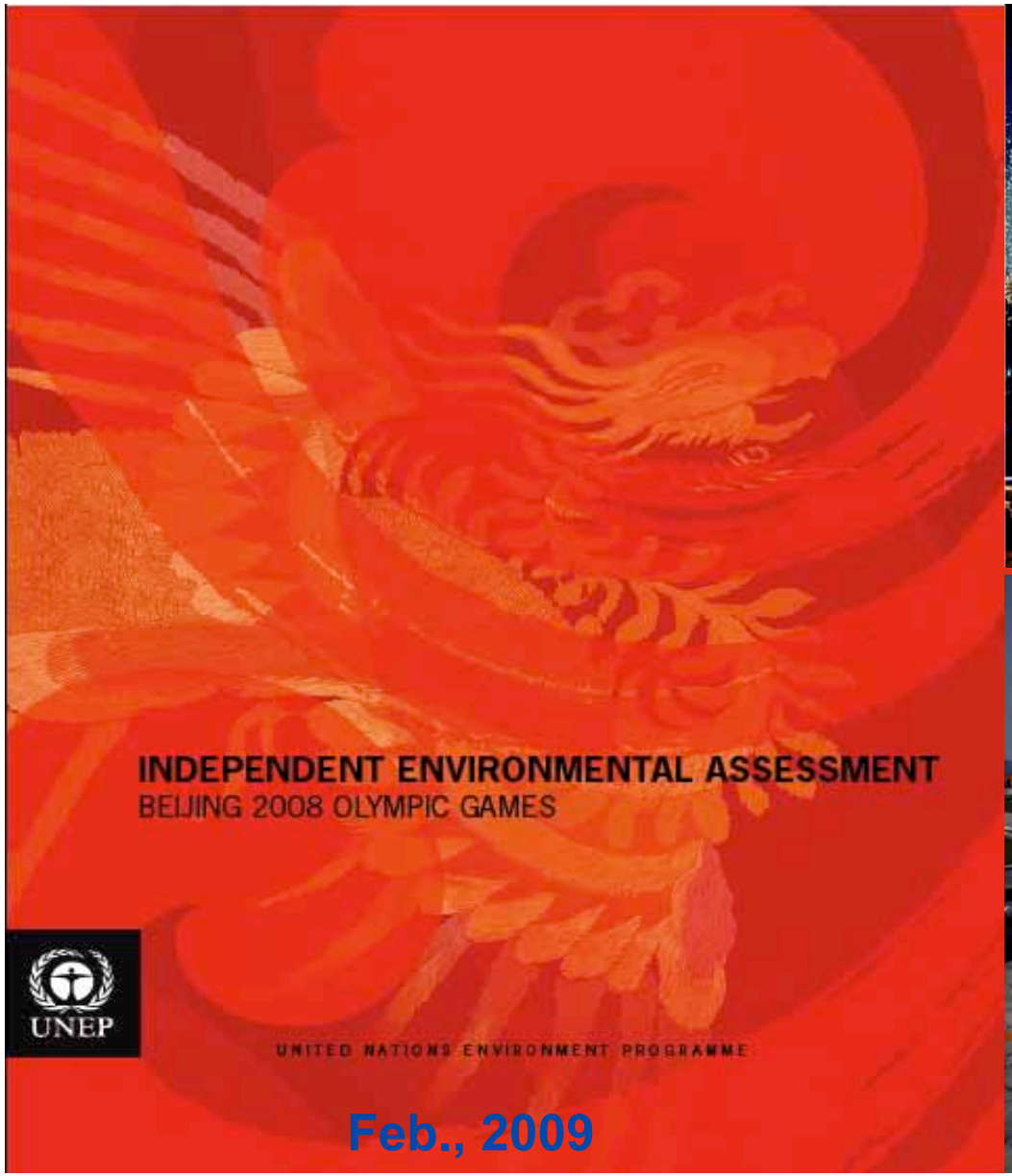


Wang et al., Science, 2009

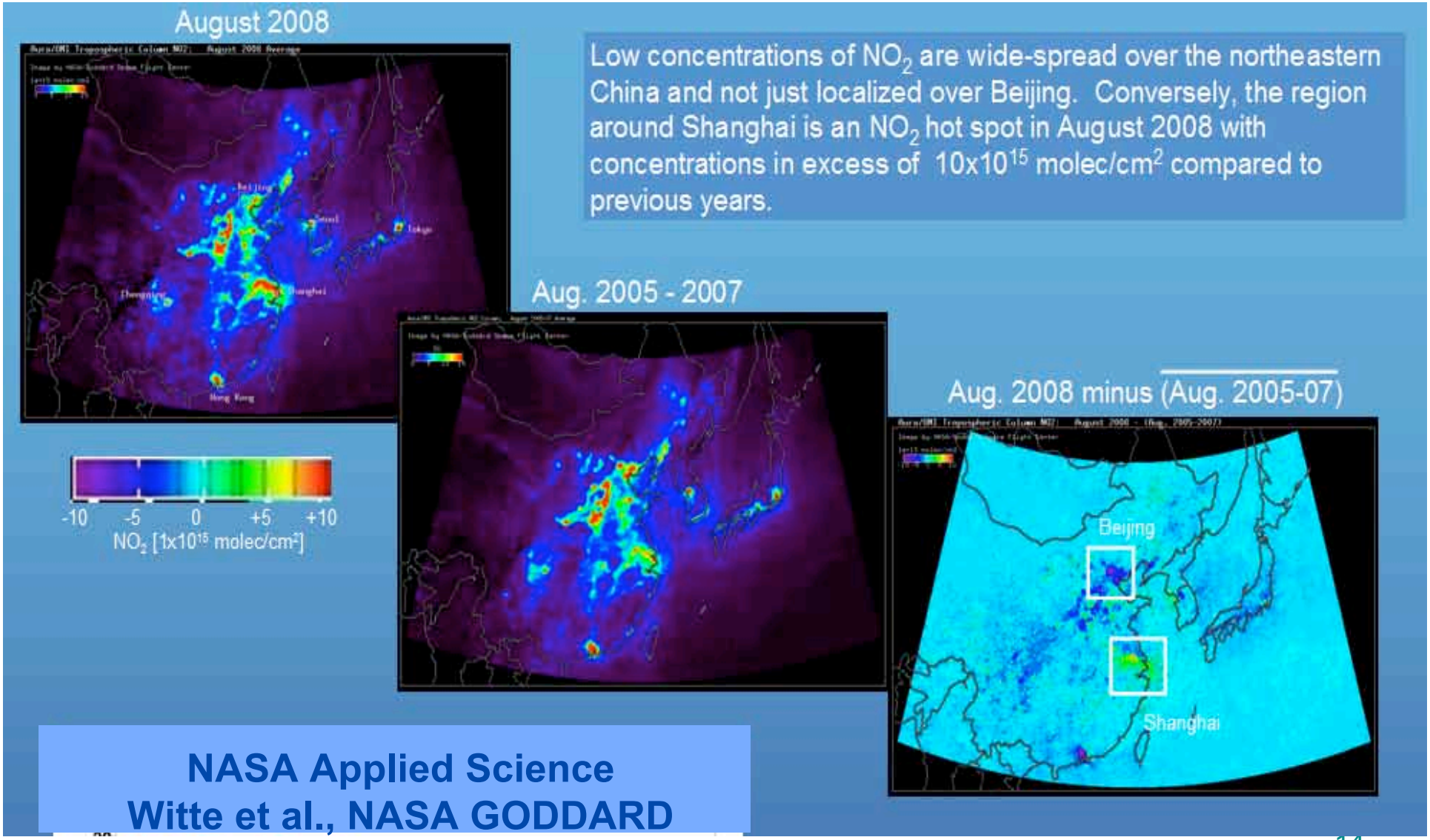


Through Improved Global Measurement Capabilities We Are Able To Better Observe Global Distributions And Detect Important Trends

Reducing Aerosols Is A Big Challenge BUT The Beijing Olympics Were An Important Example



OMI Satellite Analysis Of NO2 And SO2 Columns Were Able To Detect The Emission Changes



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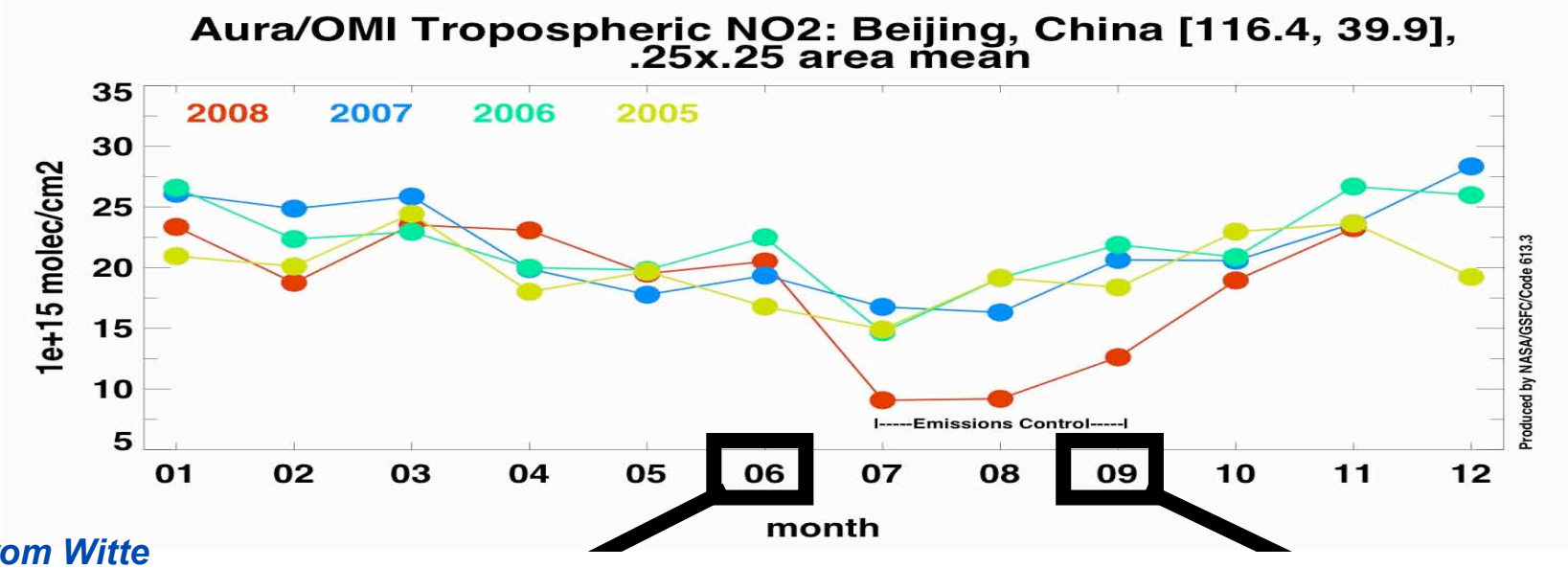
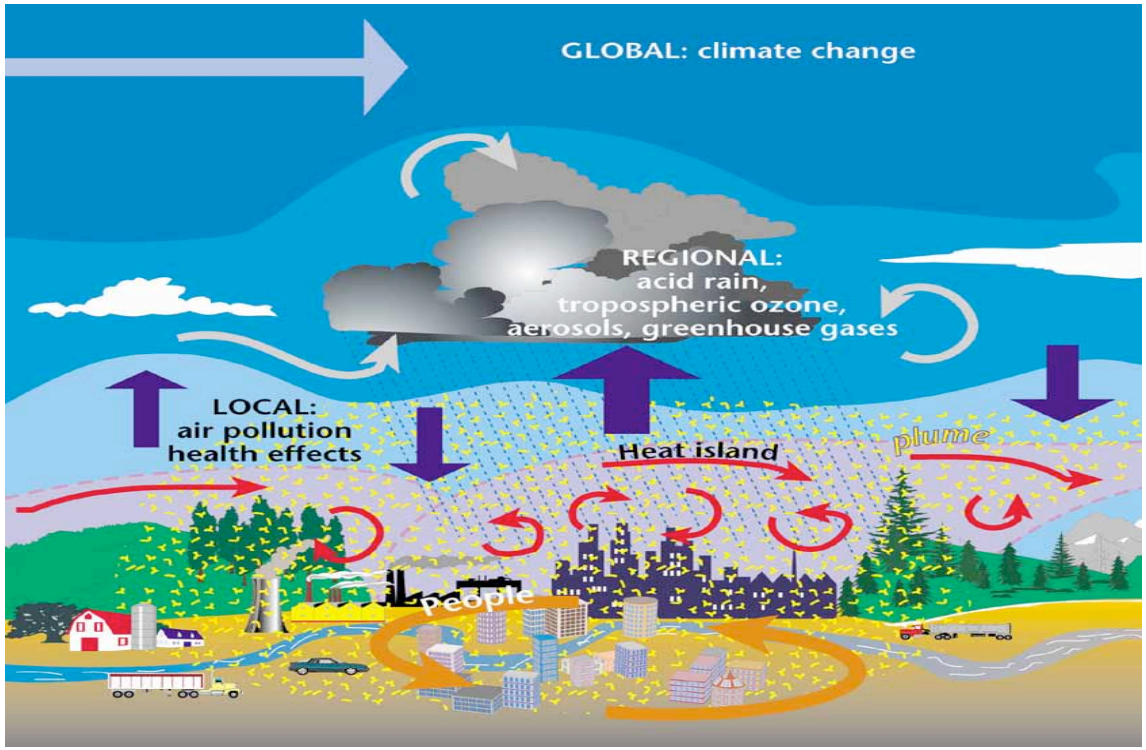


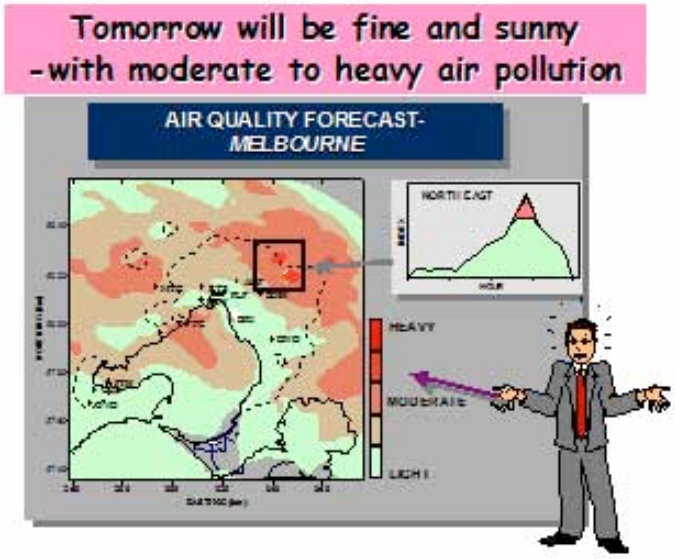
Figure from Witte et al., 2008.

Over what scales can we detect the signal?
To what extent can we attribute the signal to emissions vs meteorology?

New Challenges/Opportunities For Weather Services

Evolving complexity of observing systems, models, and applications.





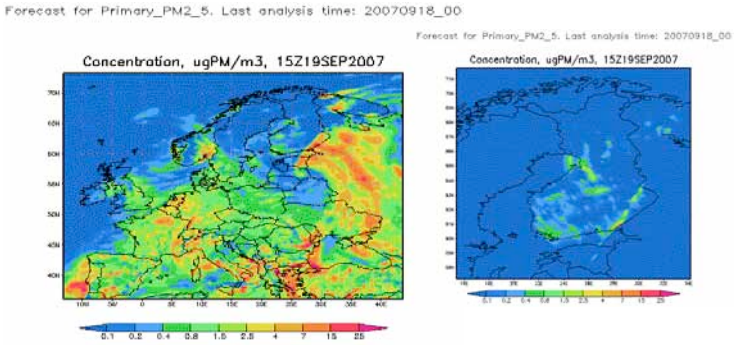
What air quality services can and should be provided?

WMO: GAW Urban Research Meteorology and Environment Project -- GURME

Many Meteorological Services Already Supply Operational Chemical Weather Products (e.g., FMI)

Satellite observations

Fire Assimilation System



Final AQ products

Phenological observations

Aerobiological observations

Physiography, forest mapping

Phenological models

SILAM AQ model

EVALUATION: NRT model-measurement comparison

Assimilation

HIRLAM NWP model

UN-ECE CLRTAP/EMEP emission database

Meteorological data: ECMWF

Aerobiological observations

Online AQ monitoring

Real-time data needs!

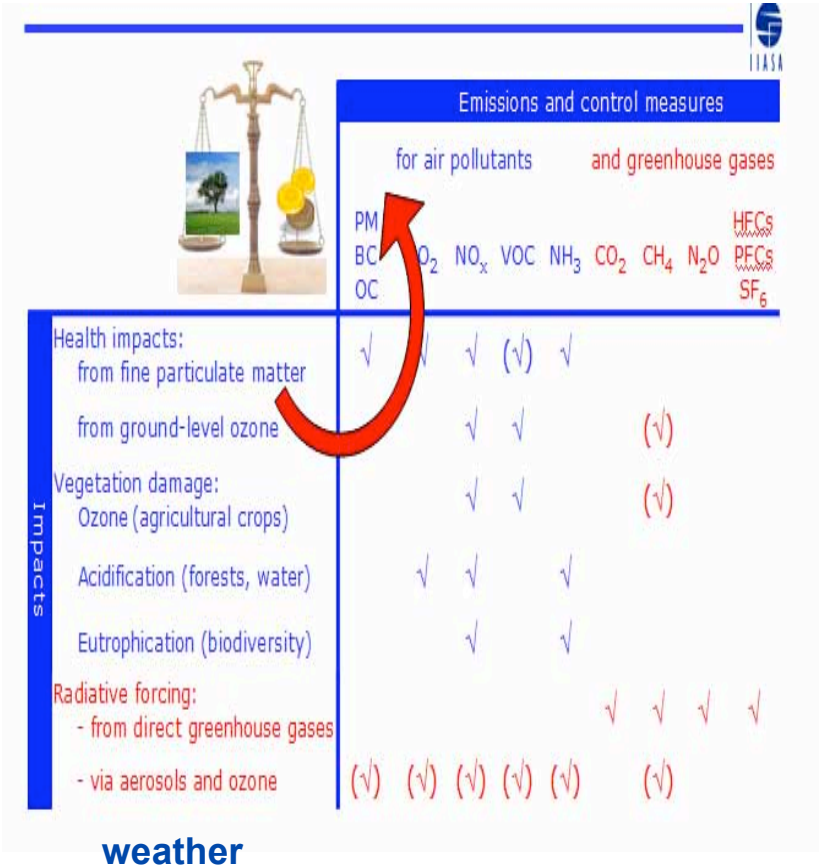
EXPO 2010 Better City Better Life

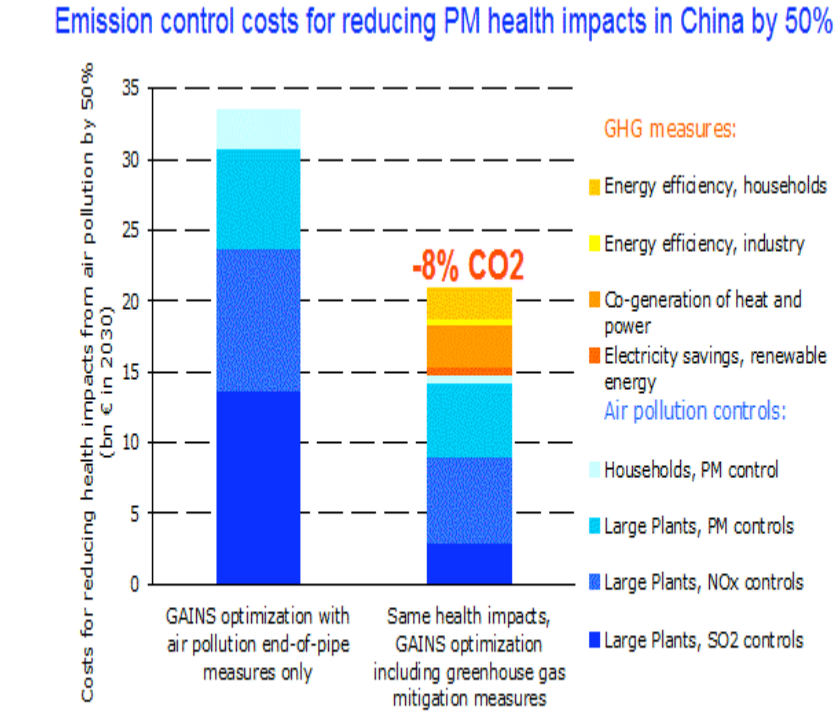
Shanghai Multi-Hazard Early Warning System

Multi-Hazard threats to Shanghai: frequently affected by natural hazards such as typhoons and associated marine hazards such as storm surge, heavy storms, heavy fog, heat-waves, and by atmospheric pollution episodes.

Shanghai GURME pilot project: air pollution, heat island, urban relevant meteorological measurements, air quality forecasting.

We Need To Harvest Synergies By Integrating Multiple Pollutants And Their Multiple Effects



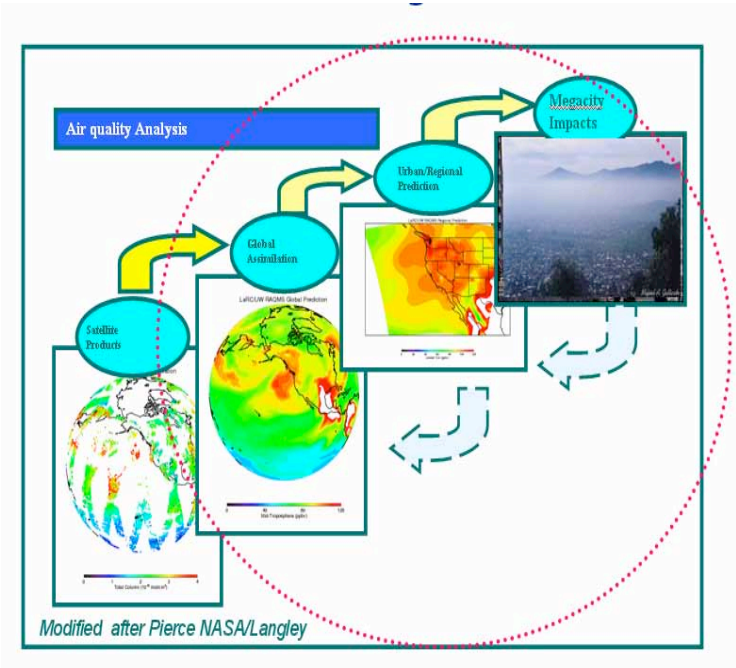


Full application of advanced emission control technologies can reduce health impacts in China by 43% in 2030; optimized saves 80% of costs. 31

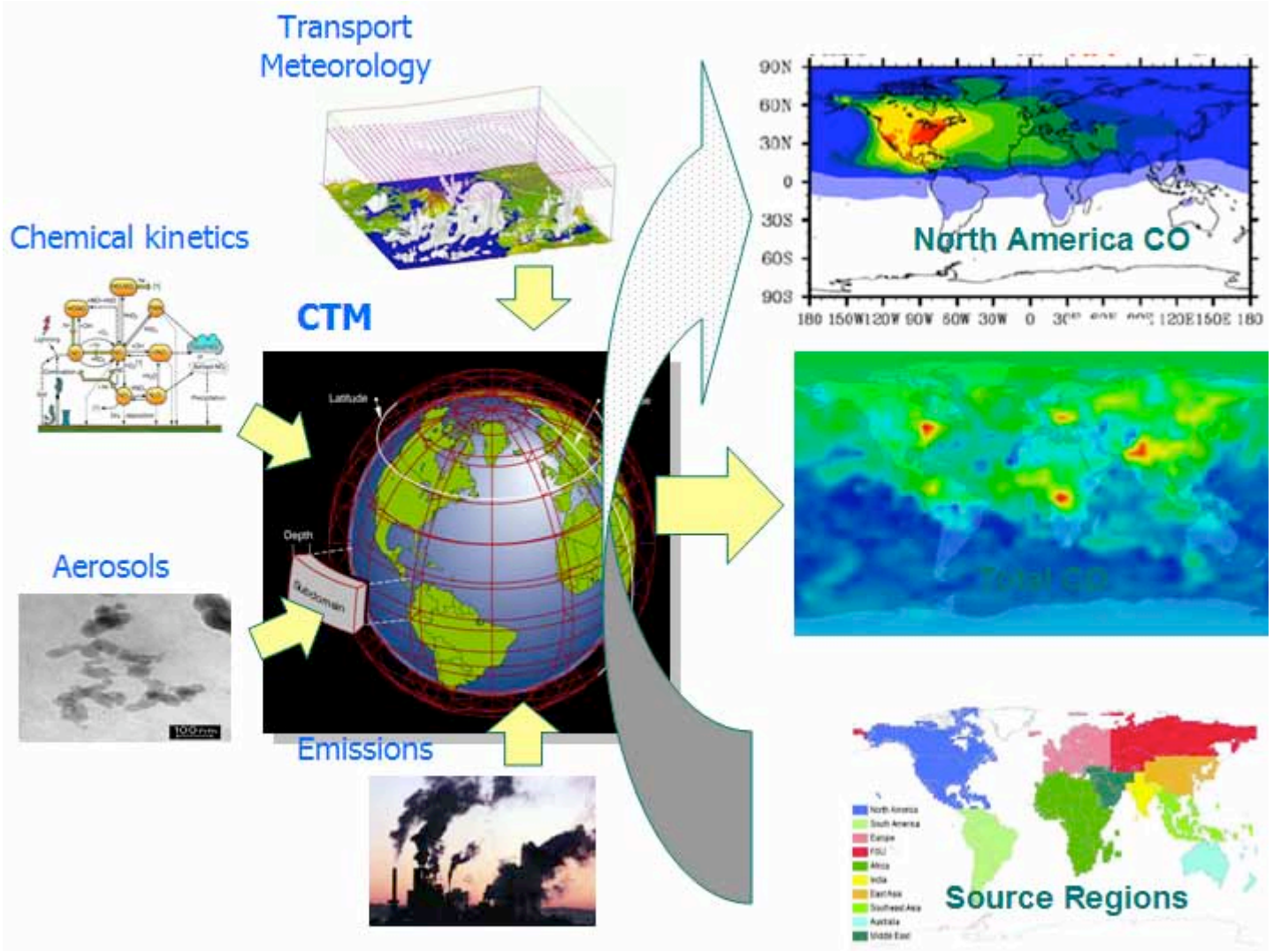
The Globalization of Air Pollution

- Important implications for the quality of the air we breathe, the water we drink, the food we eat, and our policies moving forward.
- Meteorological services have important roles to play, but it presents many challenges as well as opportunities.
- Need to:
  - further expand observing and modeling capabilities and
  - build stronger bridges within and between communities

  In order to develop a common understanding of issues and **better integrated services** related to pollution and its long reach and interactions with climate, weather and health.



Models Play Increasing Important Roles in Understanding Our *Chemical Weather*



Source/Receptor Relationships

Pollution Distributions

Air Quality Forecast Capability
End-to-End Operational Capability

Model Components: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

- *NCEP mesoscale NWP: **WRF-NMM***
- *NOAA/EPA community model for AQ: CMAQ*

Observational Input:

- *NWS weather observations; NESDIS fire locations*
- *EPA emissions inventory*

Gridded forecast guidance products

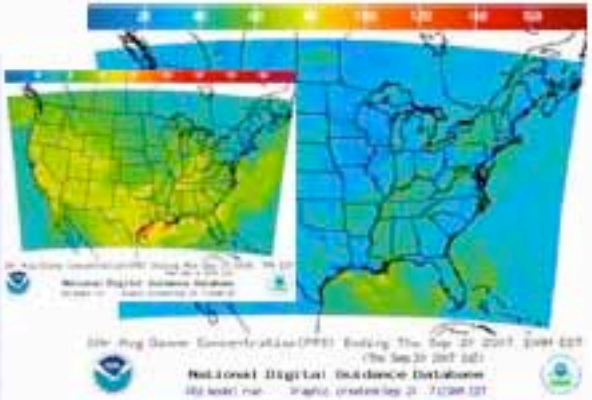
- *On NWS servers: www.weather.gov/aq and ftp-servers*
- *On EPA servers*
- *Updated 2x daily*

Verification basis, near-real time:

- *Ground-level AIRNow observations*
- *Satellite smoke observations*

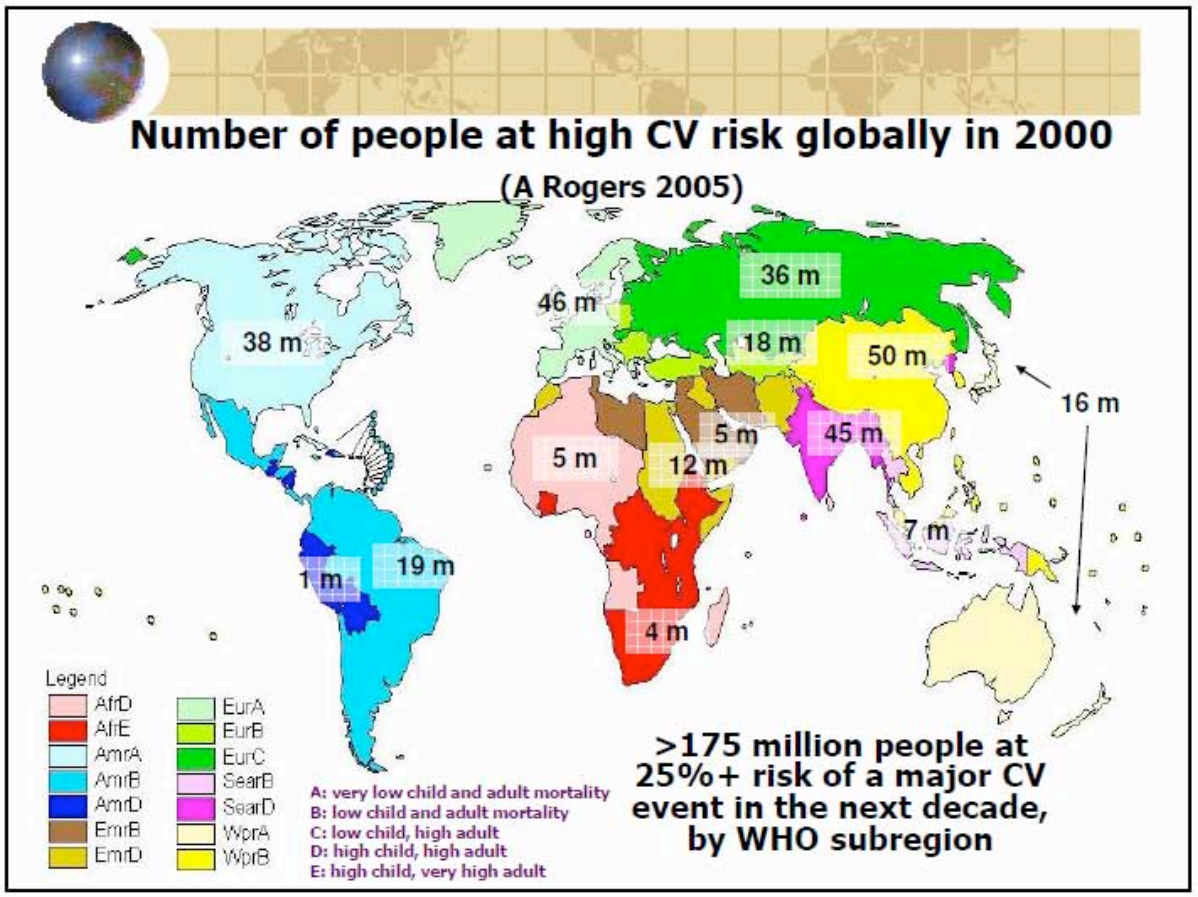
Customer outreach/feedback

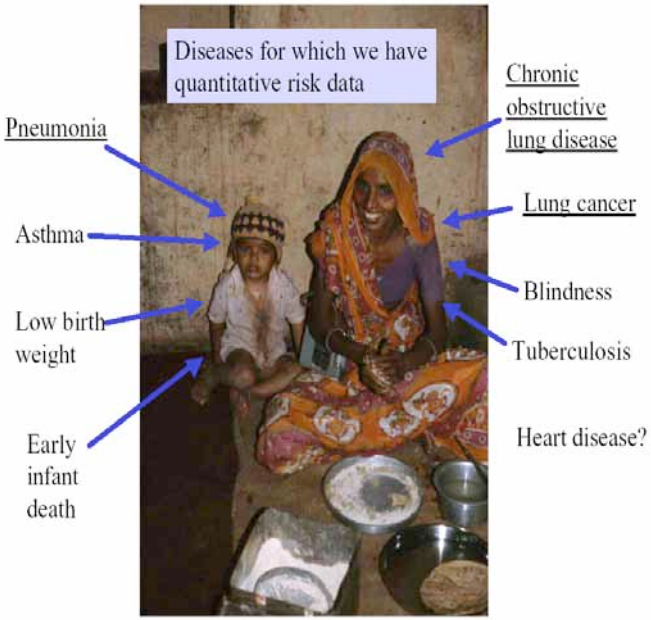
- *State & Local AQ forecasters coordinated with EPA*
- *Public and Private Sector AQ constituents*
- *Website monitoring*



Health Burdon Of Global Air Pollution Is Enormous

No region immune!





~800,000 excess deaths per year (in USA >50,000 deaths; $100B/yr)

Strong Motivator For Air Quality Forecasting Activities