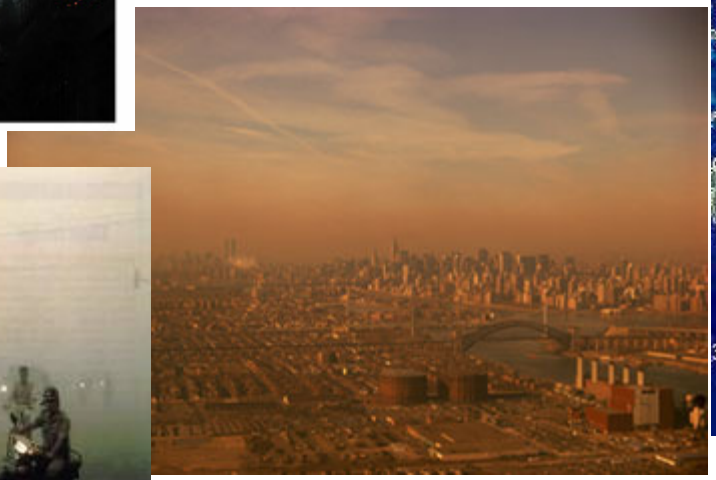
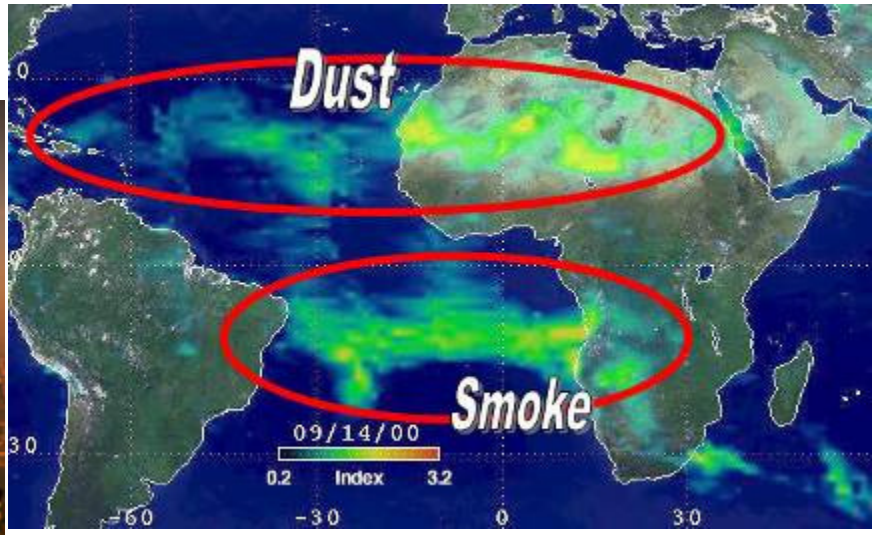
Who's Air Do We Breathe?

Dr. Sundar A. Christopher
The University of Alabama in Huntsville
Huntsville, Alabama
USA



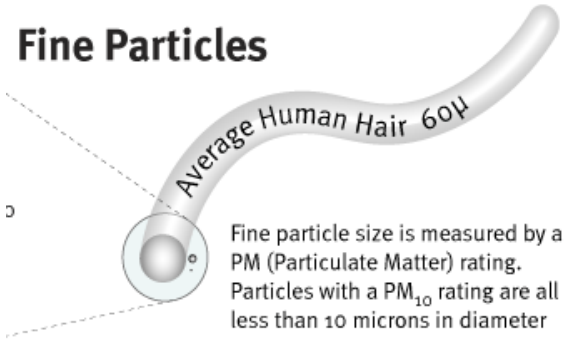


UN/Austria/ESA Symposium

"Space Tools and Solutions for Monitoring the Atmosphere in Support of Sustainable Development"
Graz, Austria, 11 - 14 September 2007

Introduction

- Pollution is a global problem with no boundaries
- Space-based tools are the best way to map global distribution of air pollution
- This talk will highlight satellite remote sensing of regional and intercontinental aerosol pollution



All Pollution is not equal!

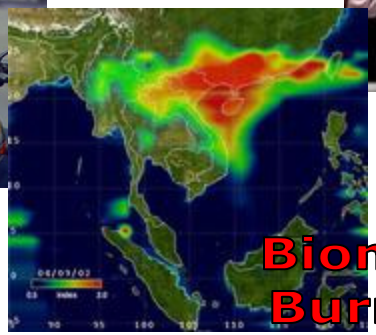
Forests fires

Dust

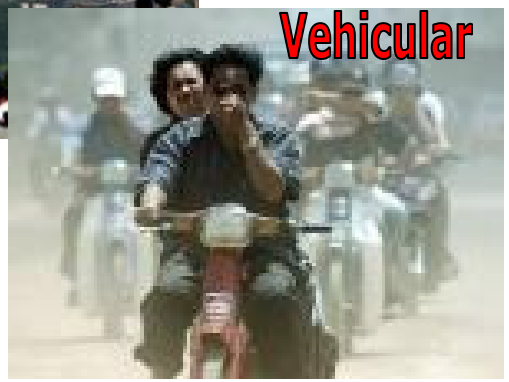
Natural versus Anthropogenic

Mt. Pinatubo

Industrial



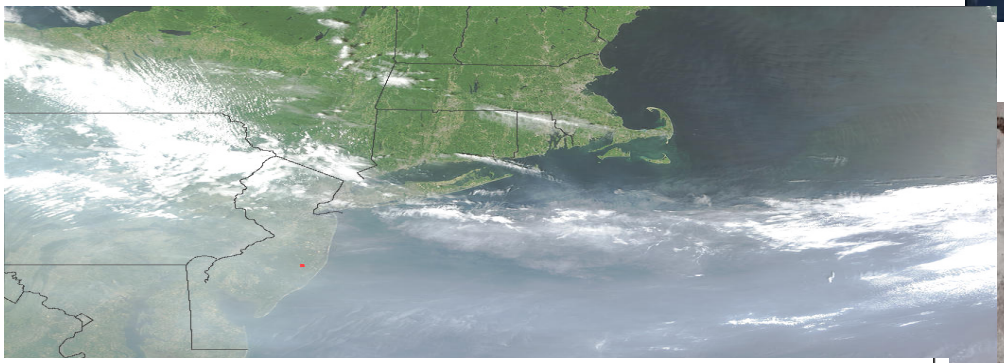
Biomass Burning

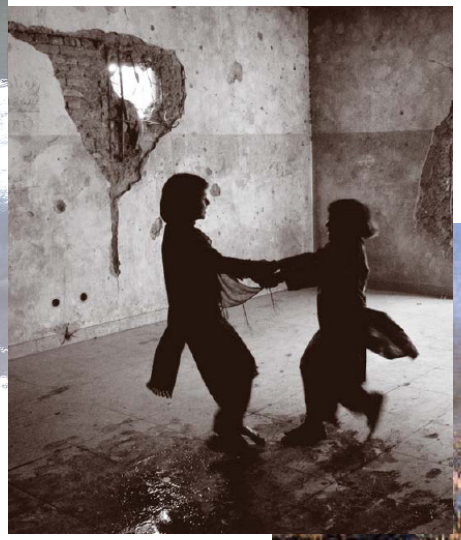


Vehicular

Messy Problem

- Climate
- Visibility
- Health
- Hydrology

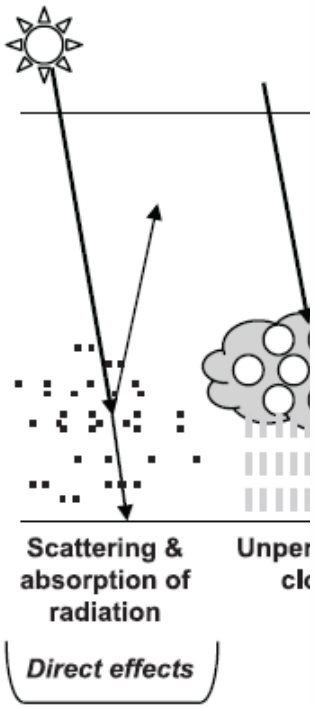


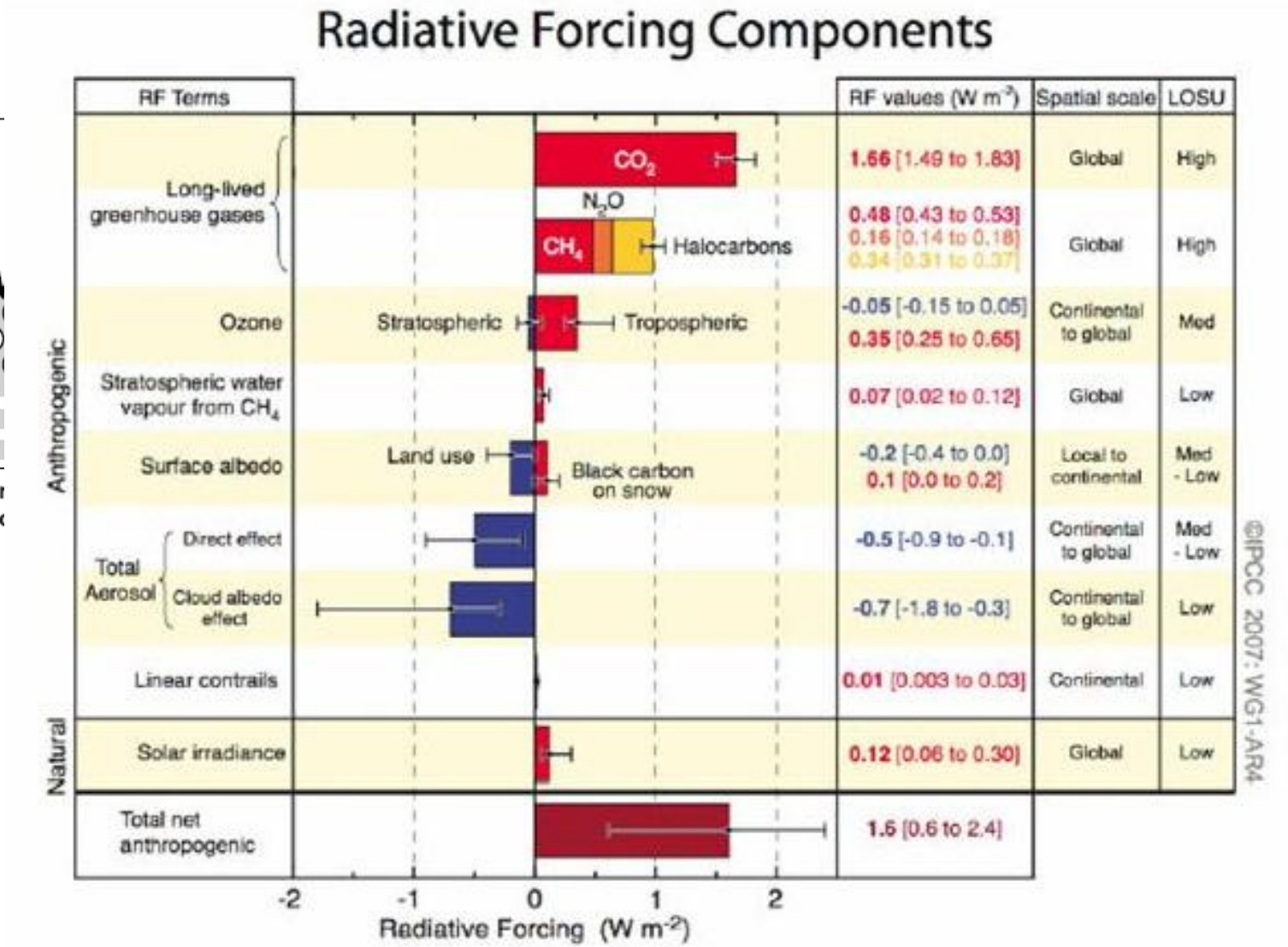


Visibility

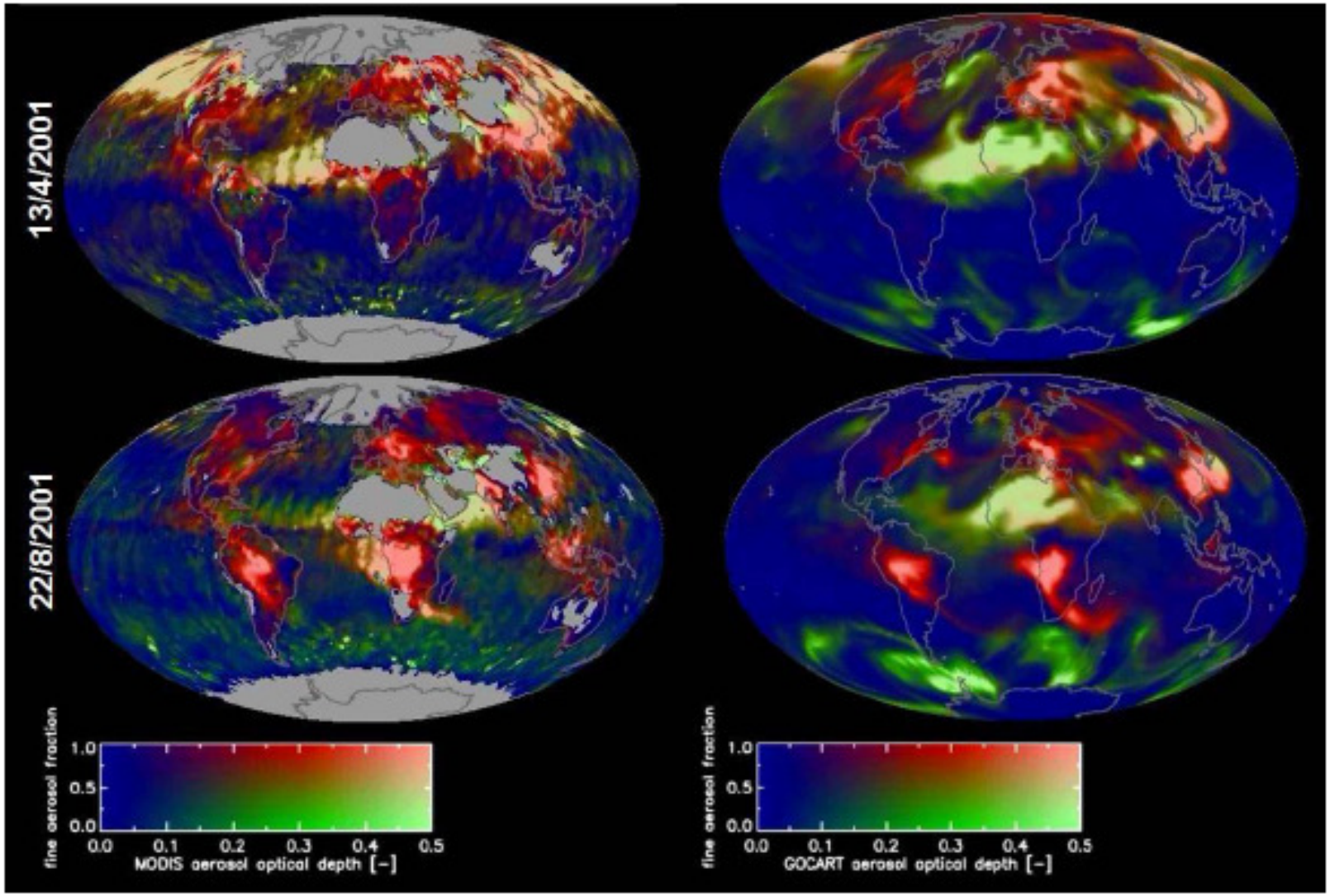
Pictures taken from a same location at same time of day, on two different days

Aerosols/Clouds

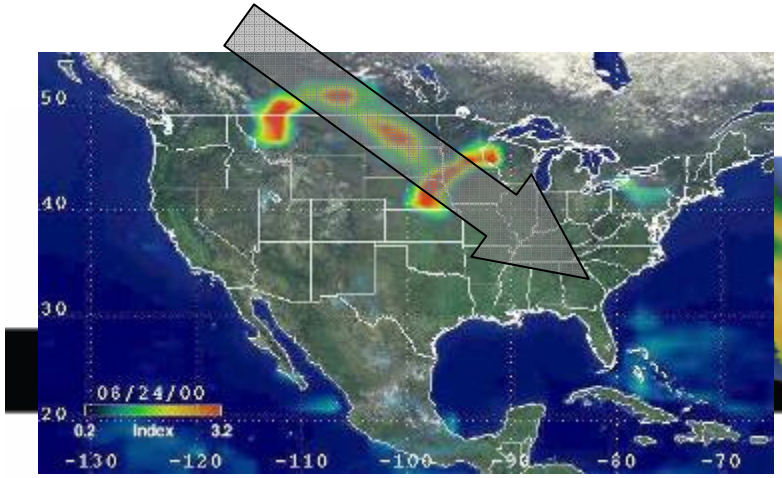


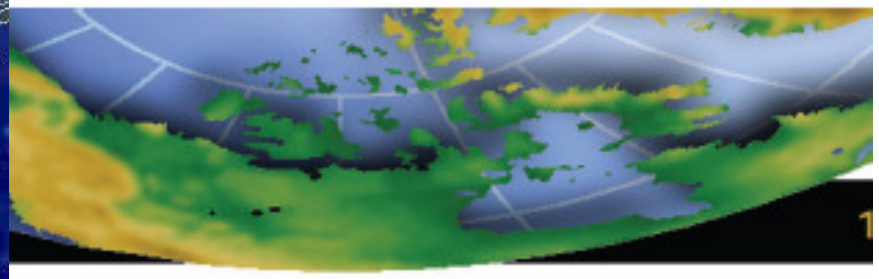


Emissions


13/4/2001
22/8/2001
fine aerosol fraction
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
MODIS aerosol optical depth [-]
fine aerosol fraction
1.0
0.5
0.0
0.0
0.1
0.2
0.3
0.4
0.5
GOCART aerosol optical depth [-]

From one country to another





Climate

Health

Agriculture

Ecosystems

Intercontinental transport

Global Air Quality and Pollution

Hajime Akimoto

The impact of global air pollution on climate and the environment is a new focus in atmospheric science. Intercontinental transport and hemispheric air pollution by ozone jeopardize agricultural and natural ecosystems worldwide and have a strong effect on climate. Aerosols, which are spread globally but have a strong regional imbalance, change global climate through their direct and indirect effects on radiative forcing. In the 1990s, nitrogen oxide emissions from Asia surpassed those from North America and Europe and should continue to exceed them for decades. International initiatives to mitigate global air pollution require participation from both developed and developing countries.

remote areas,
30 ppbv over
cific Ocean.
tent of globa
average conc
areas of East
jeopardize ag
tems there (*I*-
the elevation
by long-range
tion of ozone

Research Studies

21 August 1970, Volume 169, Number 3947 SCIENCE

The Effect of Air Pollution on Human Health

In no area of the world is the mean annual level of air pollution high enough to cause continuous acute health problems. Emitted pollutants are

Pollution and halth links not well established

Pollution – 30 years later

News Focus

Particle air pollution clearly causes substantial deaths and illness, but what makes fine particles so toxic—the size, the chemical compound, or both?

Mounting Evidence Indicts Fine-Particle Pollution

At risk. Studies with elderly volunteers have shown that slight changes in outdoor particle levels can change heart rate variability.

Industrial Air Pollution: Possible Effect on Lung Cancer

Abstract. *Higher lung cancer mortality rates occurred in males living in cer heavily industrialized areas of Los Angeles County, California. These areas v characterized by elevated concentrations of benzo*[a]*pyrene and other polynuc aromatic hydrocarbons of primarily industrial origin in the soil and air.*

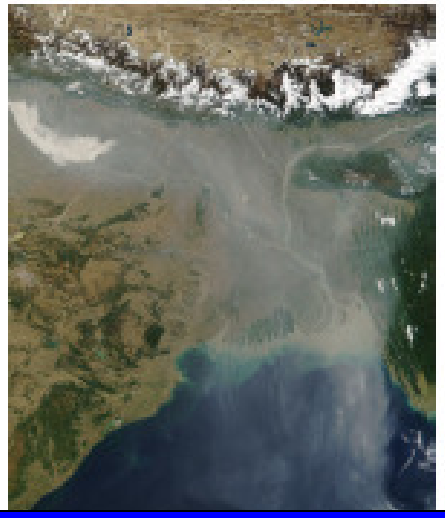
Industrial pollution linked to lung cancer

Pollution affects rice harvest

Air pollution and climate change both reduce Indian rice harvests

Wolfgang Cramer*
Department of Global Change and Natural Systems, Potsdam Institute for Climate Impact Re
D-14412 Potsdam, Germany

An ever-changing mix of anthropogenic pollutants alters the chemical and physical properties of the atmosphere and thereby causes potentially negative impacts on human society. To establish a robust cause-and-effect chain, all the way from a particular kind of emission to its economic and/or social impacts, remains a transdisciplinary tour de force with several risks of failure along the way. The first major link along such a chain, that between increased aerosol loads ("atmospheric brown clouds," or ABC) over the Indian subcontinent, globally increasing greenhouse gas (GHG) concentrations, and regional changes in temperature, rainfall, and surface-near radiation, requires consideration of chemical and physical

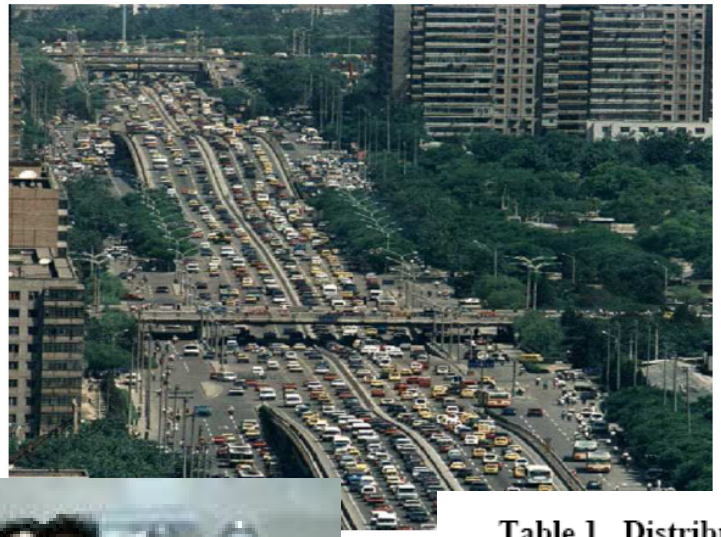


Despite remaining open questions, the basic mechanisms linking regional climatic conditions in South Asia to ABC are known from a combination of measurement campaigns and model simulations (7). First, the radiation budget is strongly affected by the presence of haze (Fig. 1), which reduces direct radiation at the surface (land or ocean, approximately −10 to −15 W m^{-2}, during the 1990s) and warms the troposphere by approximately

Pollution reduces sunlight and rainfall

11% drop in yields

GLOBAL AIR POLLUTION



- **Half of world's population now lives in urban areas**
- **Continues to grow at 2% per year**

Table 1. Distribution of Global Population by Size of Settlement (1950-2030)

	Population (in billions)				
Major area	**1950**	**1975**	**2000**	**2003**	**2030**
Total population					
World	2.52	4.07	6.07	6.30	8.13
More developed regions	0.81	1.05	1.19	1.20	1.24
Less developed regions	1.71	3.02	4.88	5.10	6.89
Urban population					
World	0.73	1.52	2.86	3.04	4.94
More developed regions	0.43	0.70	0.88	0.90	1.01
Less developed regions	0.31	0.81	1.97	2.15	3.93
Rural population					
World	1.79	2.55	3.21	3.26	3.19
More developed regions	0.39	0.34	0.31	0.31	0.23
Less developed regions	1.40	2.21	2.90	2.95	2.96

Source: United Nations Population Division, World Urbanization Prospects, The 2003 Revision.

MEGA CITIES

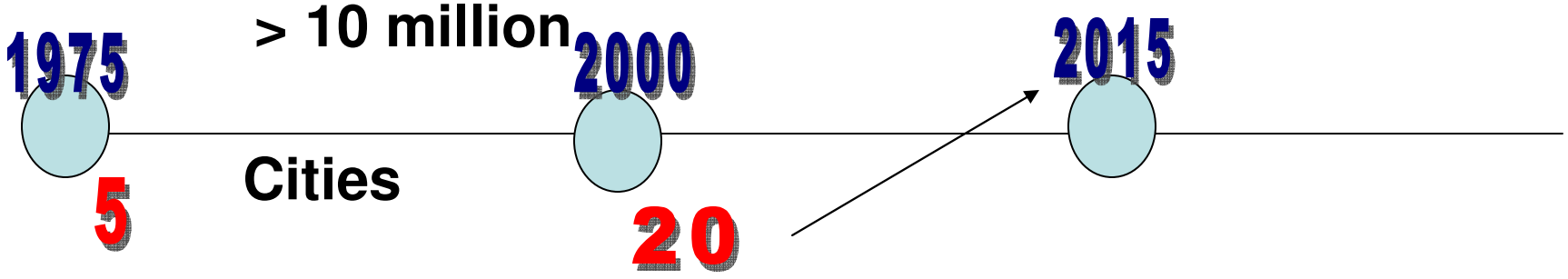
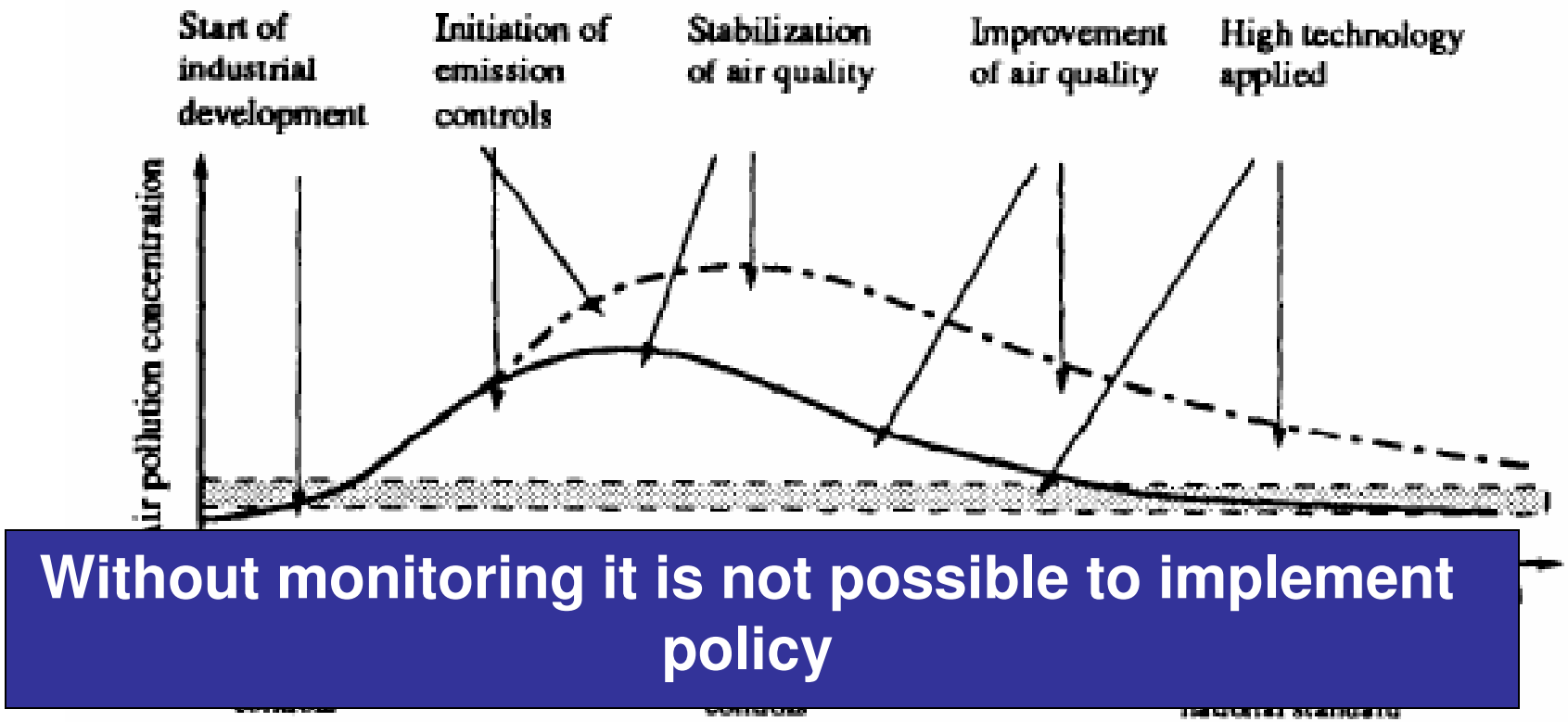


TABLE 1: WORLD MEGACITIES 1975, 2000 AND (PROJECTED) 2015: POPULATION IN MILLIONS

1975	2000	2015
Tokyo (19.8), New York (15.9), Shanghai (11.4), Mexico City (11.2), and São Paulo (10)	Tokyo (26.4), Mexico City (18.1), Mumbai (18.1), São Paulo (17.8), Shanghai (17), New York (16.6), Lagos (13.4), Los Angeles (13.1), Kolkata (12.9), Buenos Aires (12.6), Dhaka (12.3), Karachi (11.8), Delhi (11.7), Jakarta (11), Osaka (11), Metro Manila (10.9), Beijing (10.8), Rio de Janeiro (10.6), and Cairo (10.6)	Tokyo (26.4), Mumbai (26.1), Lagos (23.2), Dhaka (21.1), São Paulo (20.4), Karachi (19.2), Mexico City (19.2), New York (17.4), Jakarta (17.3), Kolkata (17.3), Delhi (16.8), Metro Manila (14.8), Shanghai (14.6), Los Angeles (14.1), Buenos Aires (14.1), Cairo (13.8), Istanbul (12.5), Beijing (12.3), Rio de Janeiro (11.9), Osaka (11.0), Tianjin (10.7), Hyderabad (10.5), and Bangkok (10.1)

Environmental stress due to urbanization

Awareness is first step?



Without monitoring it is not possible to implement policy

Problem identification → **Policy Formulation** → **Policy implementation** → **Continued monitoring**

No boundaries for pollution

Global Air Pollution Crossroads over the Mediterranean

J. Lelieveld,[1*] H. Berresheim,[2] S. Borrmann,[1,3] P. J. Crutzen,[1,4] F. J. Dentener,[5] H. Fischer,[1] J. Feichter,[6] P. J. Flatau,[4,7] J. Heland,[8] R. Holzinger,[1] R. Korrmann,[1] M. G. Lawrence,[1] Z. Levin,[9] K. M. Markowicz,[4,10] N. Mihalopoulos,[11] A. Minikin,[8] V. Ramanathan,[4] M. de Reus,[1] G. J. Roelofs,[12] H. A. Scheeren,[12] J. Sciare,[13] H. Schlager,[8] M. Schultz,[6] P. Siegmund,[14] B. Steil,[1] E. G. Stephanou,[11] P. Stier,[6] M. Traub,[1] C. Warneke,[15] J. Williams,[1] H. Ziereis[8]

The Mediterranean Intensive Oxidant Study, performed in the summer of 2001, uncovered air pollution layers from the surface to an altitude of 15 kilometers. In the boundary layer, air pollution standards are exceeded throughout the region, caused by West and East European pollution from the north. Aerosol particles also reduce solar radiation penetration to the surface, which can suppress precipitation. In the middle troposphere, Asian and to a lesser extent North American pollution is transported from the west. Additional Asian pollution from the east, transported from the monsoon in the upper troposphere, crosses the Mediterranean tropopause, which pollutes the lower stratosphere at middle latitudes.

From the N-E-W-S and at various heights pollution influx into Mediterranean

Intercontinental transport

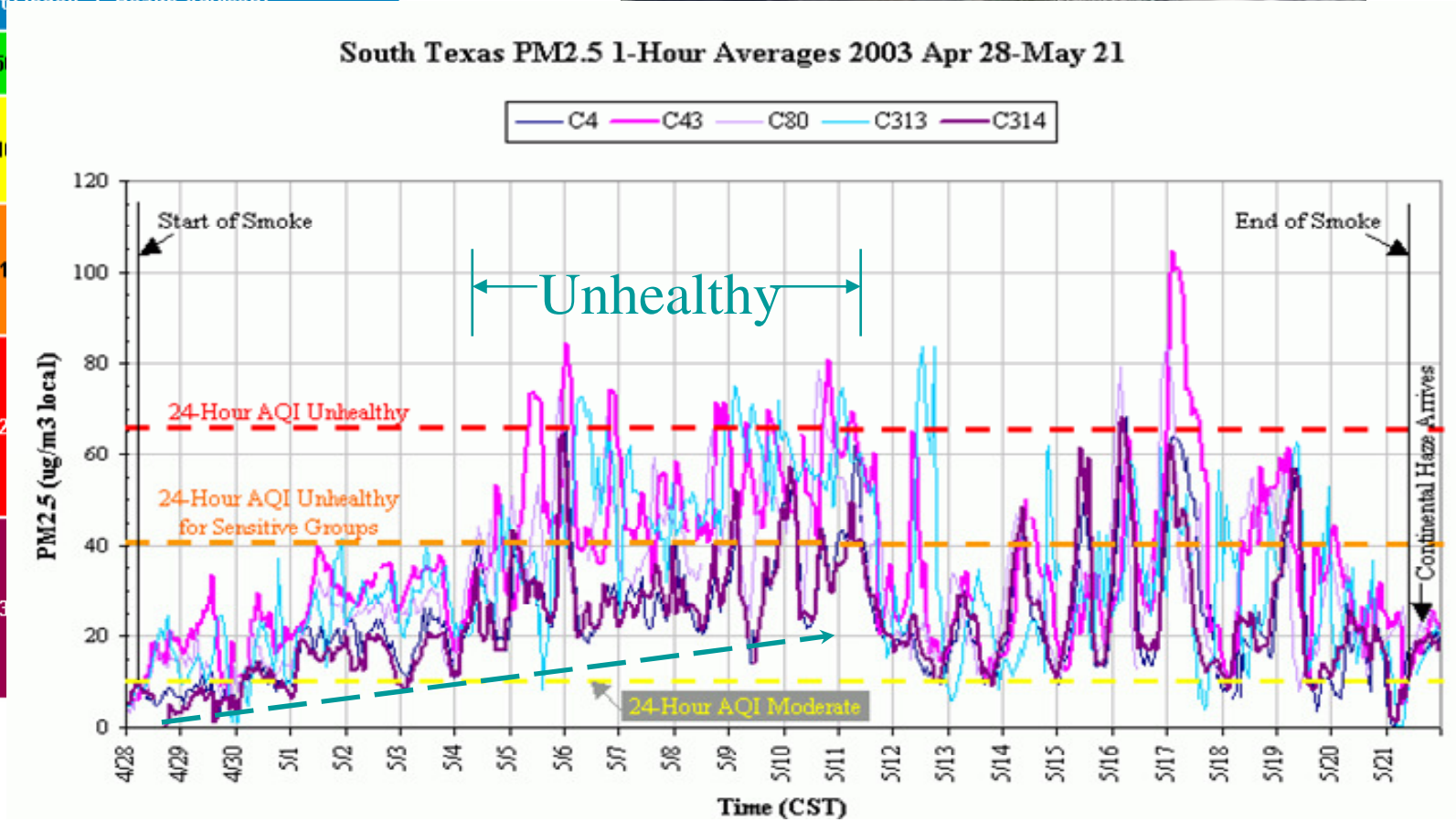
Measurements can help policy

EPA United States Environmental Protection Agency

AQI AIR QUALITY INDEX

Air Quality Guide for Particle Pollution

Air Quality	Air Quality Index	Health Advisory
Good	0-5	
Moderate	51-1	
Unhealthy for Sensitive Groups	101-1	
Unhealthy	151-2	
Very Unhealthy (Alert)	201-3	



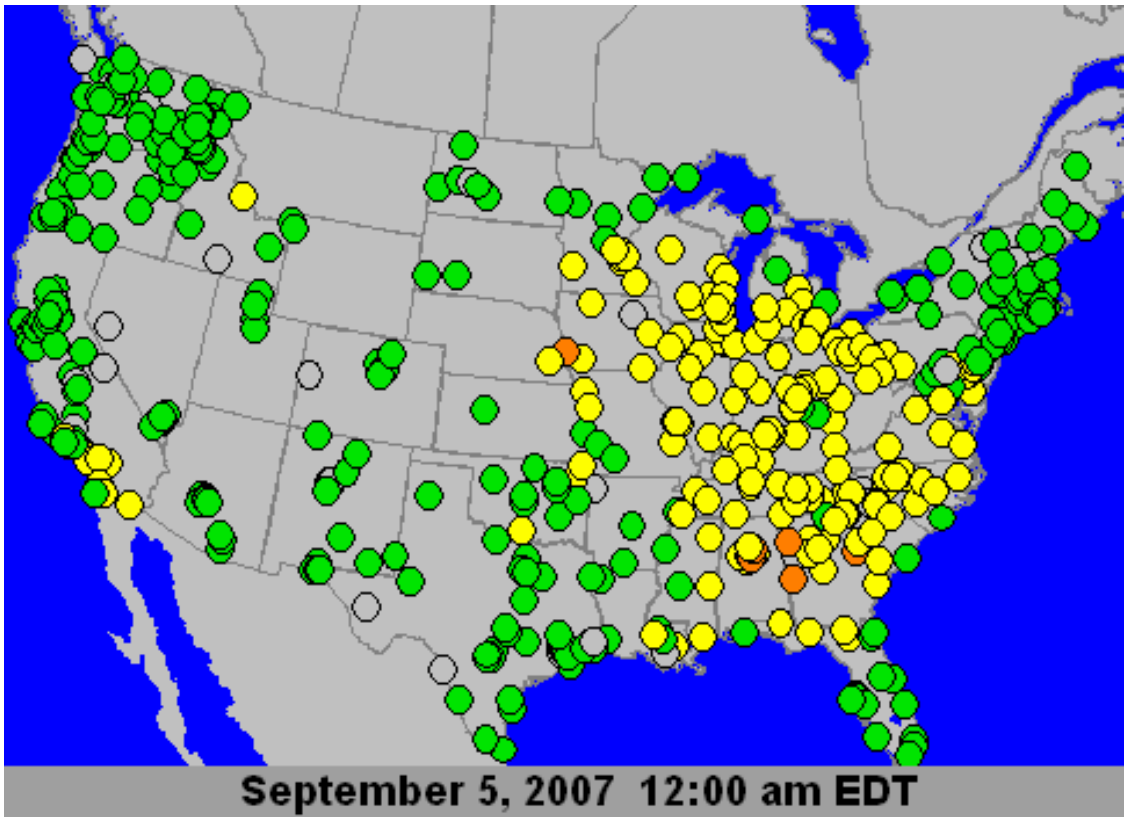
How do we monitor air pollution today?

Ground measurements of particulate matter mass microgram per cubic meter.

Developed countries have multiple measurement stations

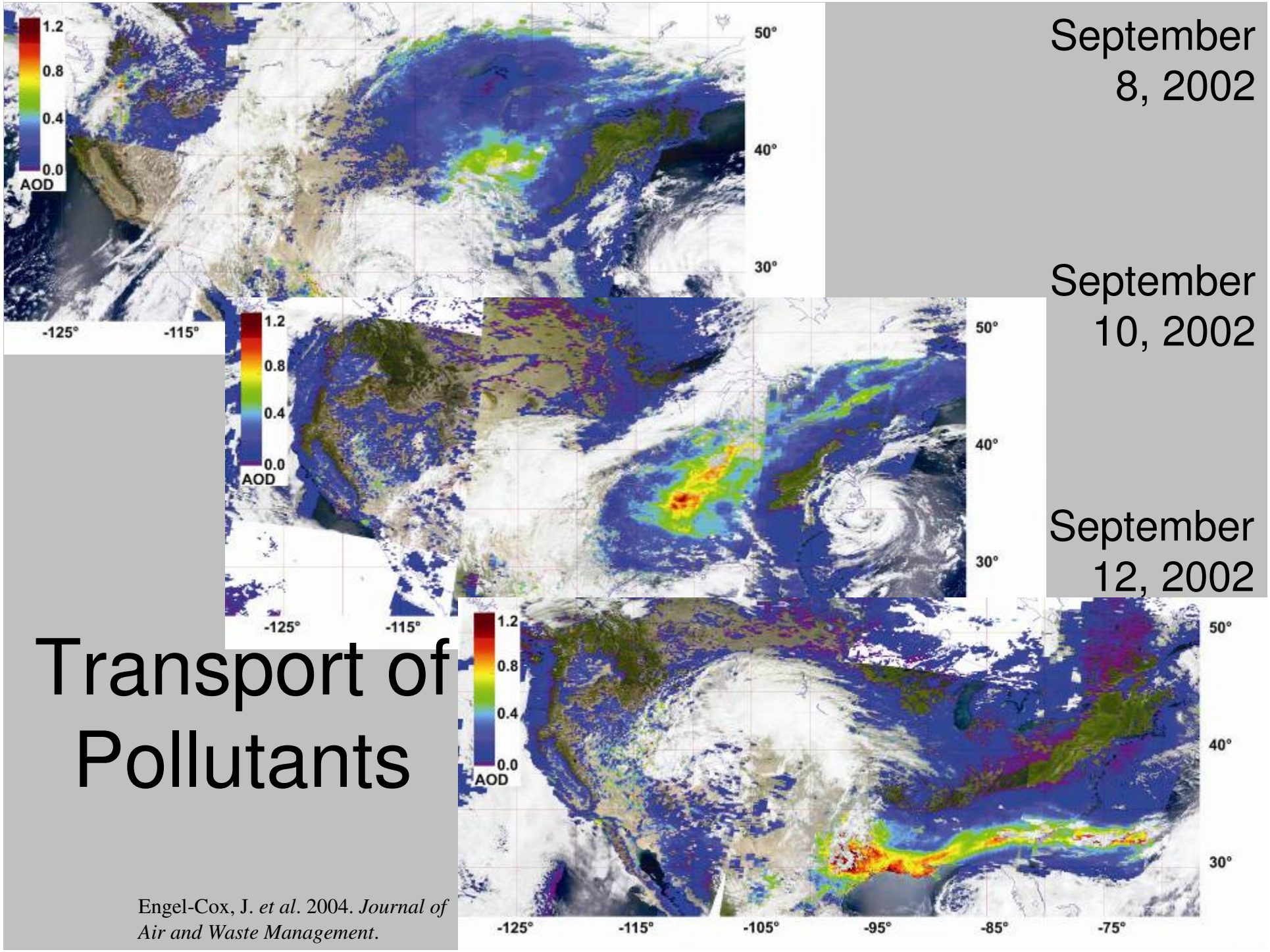
Developing countries have very few - even in urban areas

Even if we had a lot of ground-based measurements?



It is difficult to know where Pollution originates from With only ground Measurements

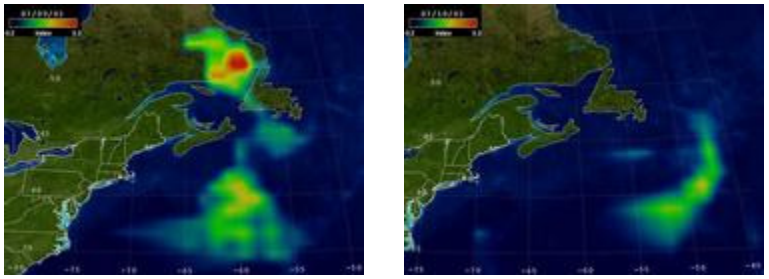
Hard to measure every square mile



Transport of Pollutants

Engel-Cox, J. *et al*. 2004. *Journal of Air and Waste Management*.

Canadian influx



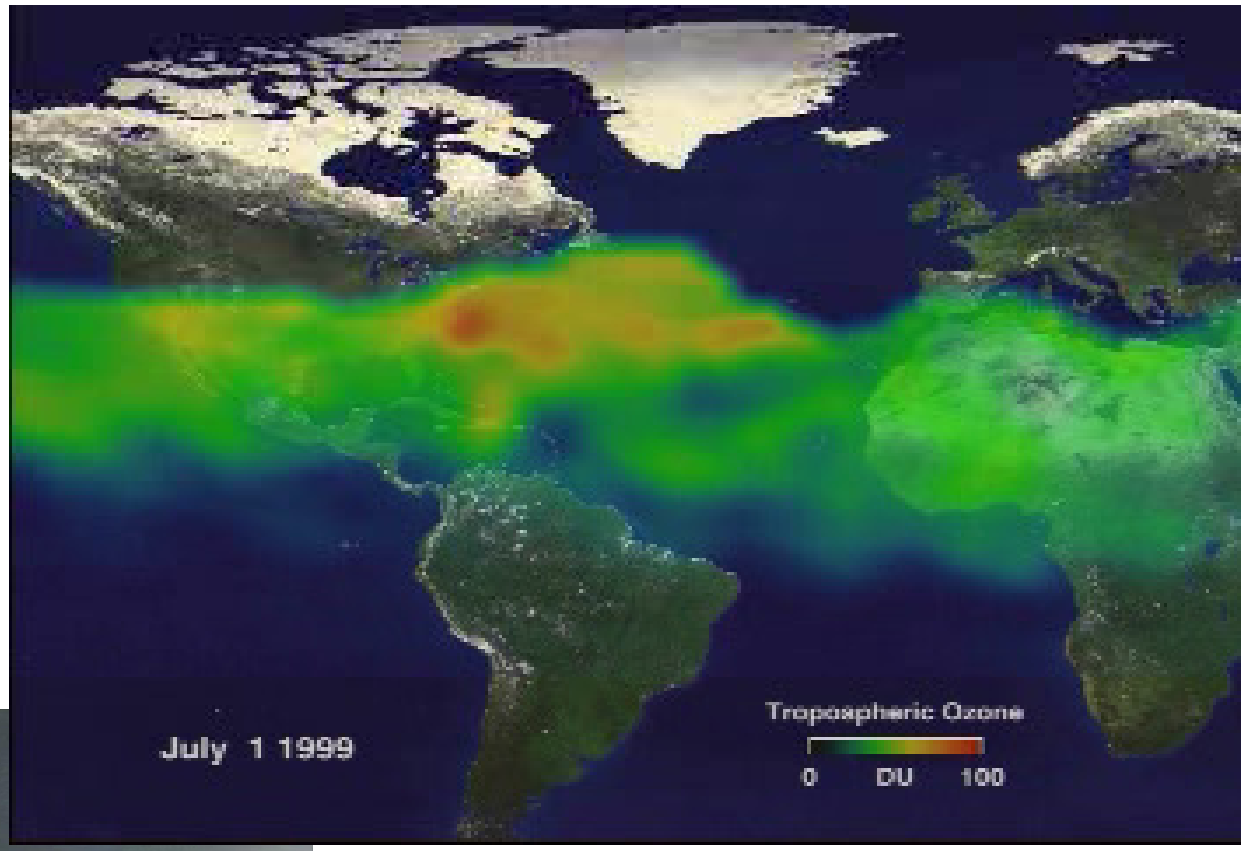
Satellites provide information that other measurements cannot

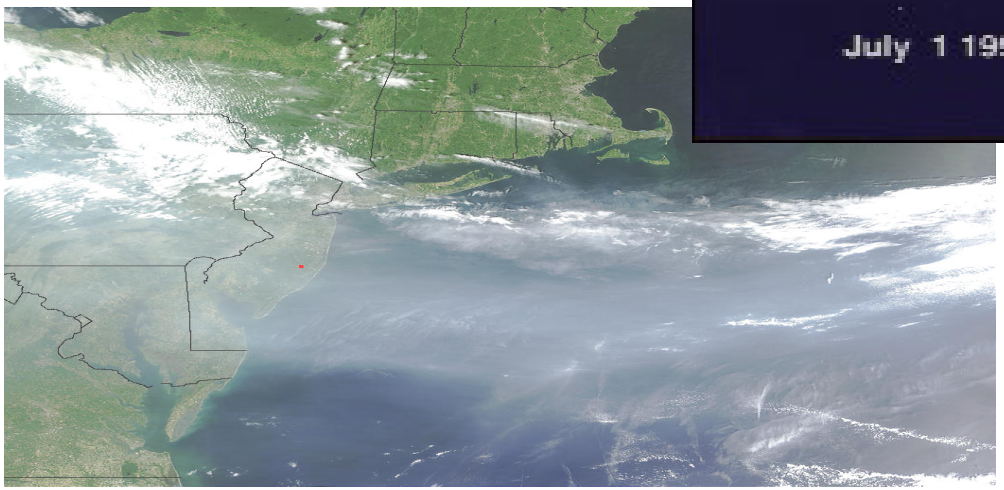
Fires in Canada started smoke transport through Eastern USA

Atlantic Transport

Smoke, pollution transport across the Atlantic

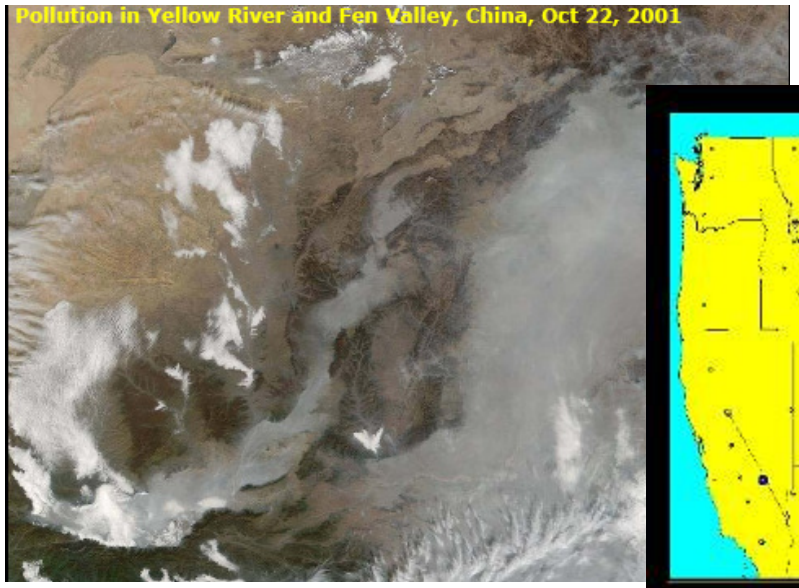
USA – Europe/Africa interchange

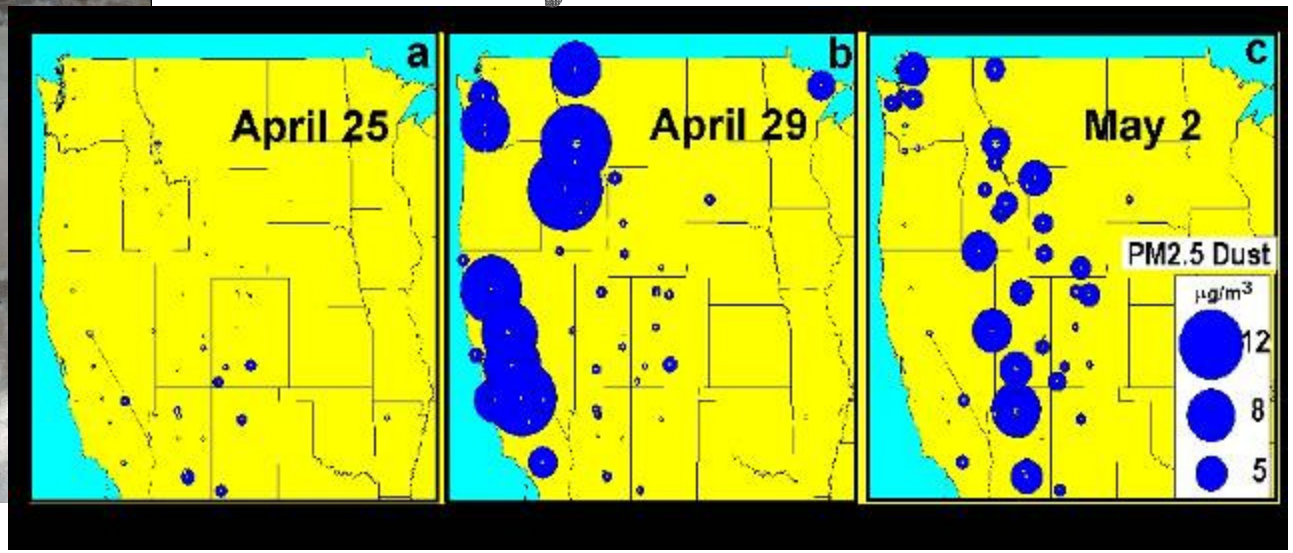


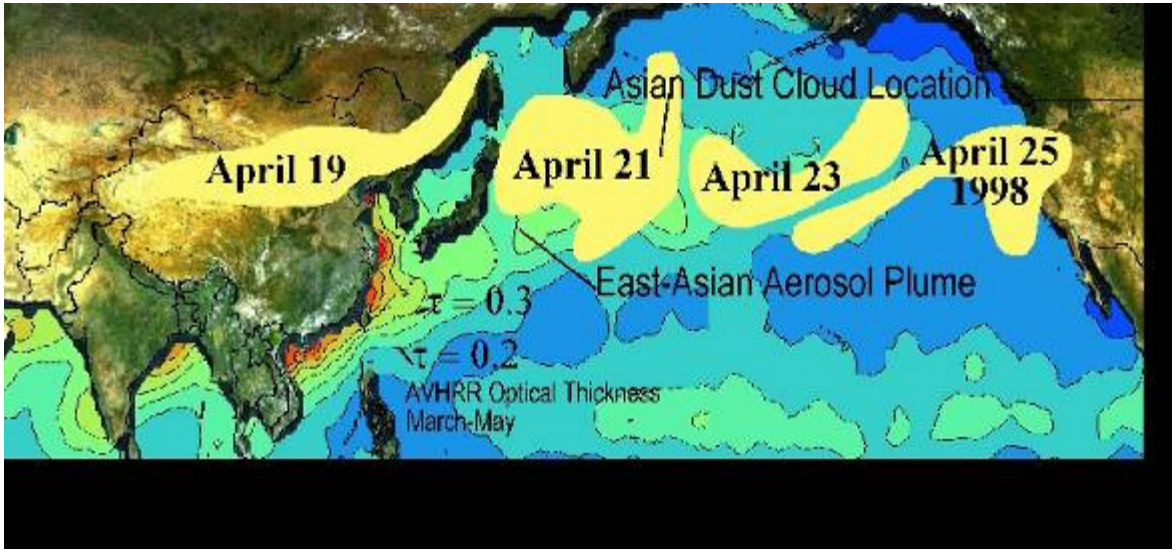


Asian-American Express

5-10 day transit times



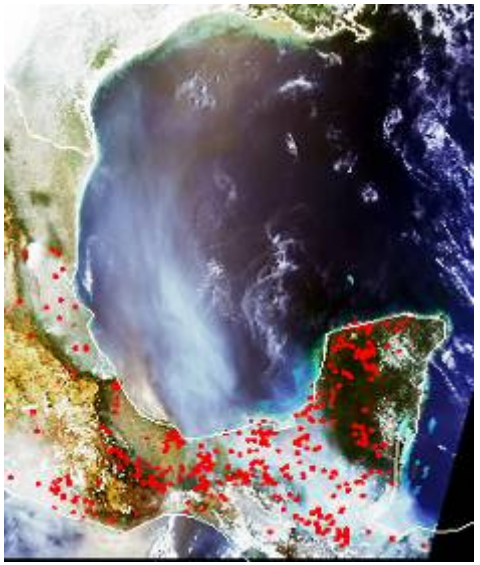




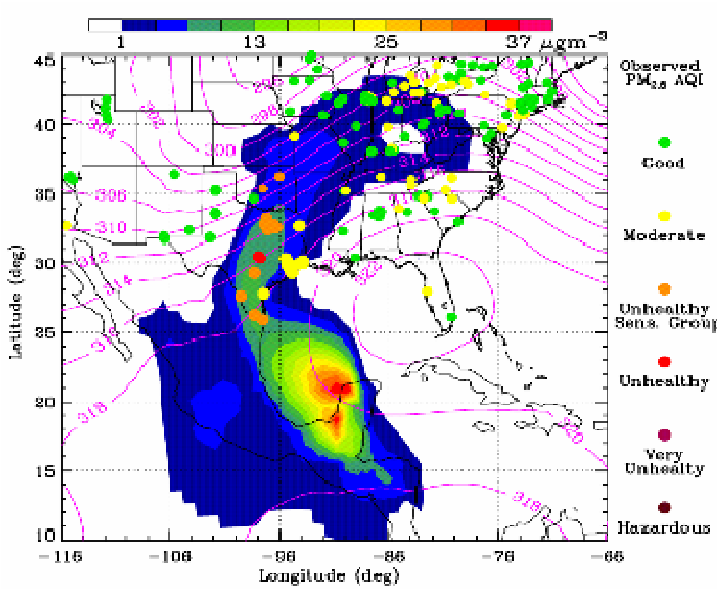
Gains in domestic control Strategy offset by Long range transport of pollution

Central America

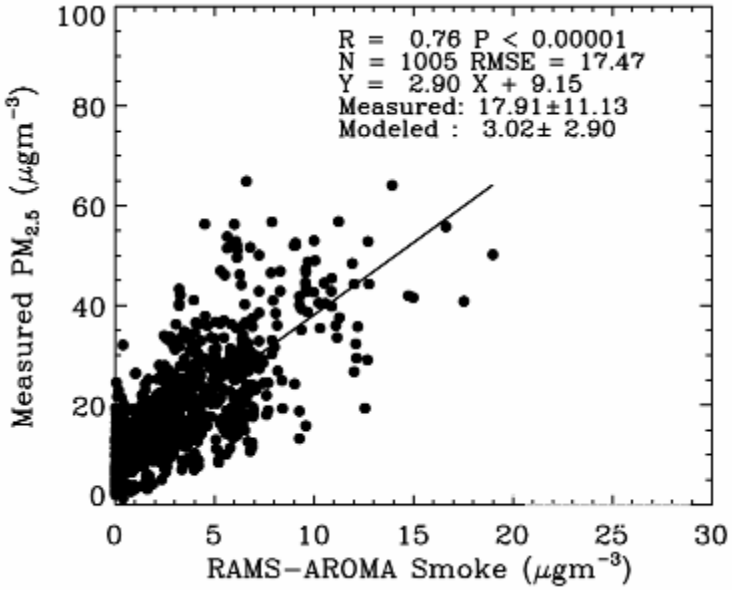
May 10, 2003 MODIS



RAMS-AROMA

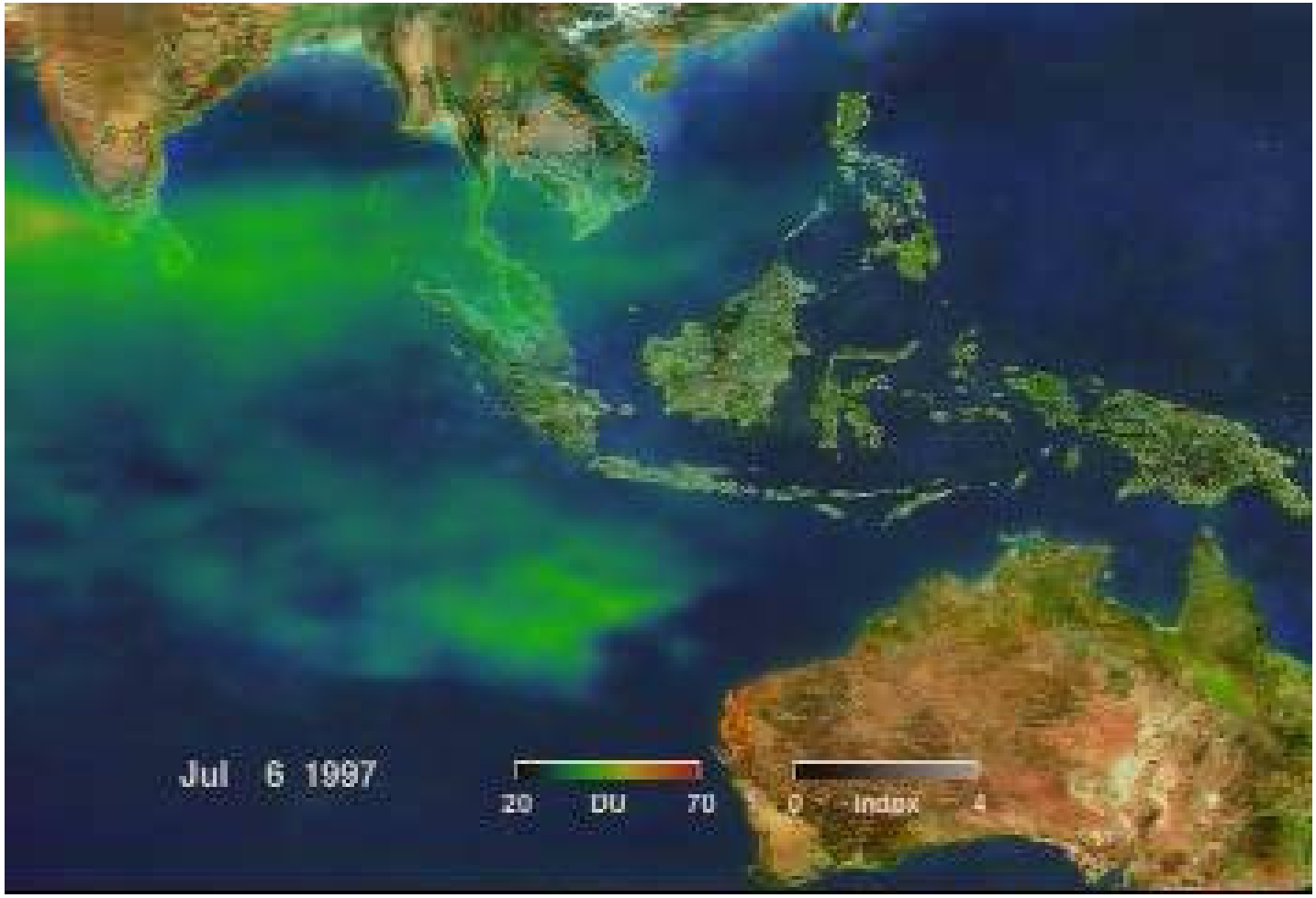


How good is the model?



Air quality worsens in USA due to smoke transport from Mexico

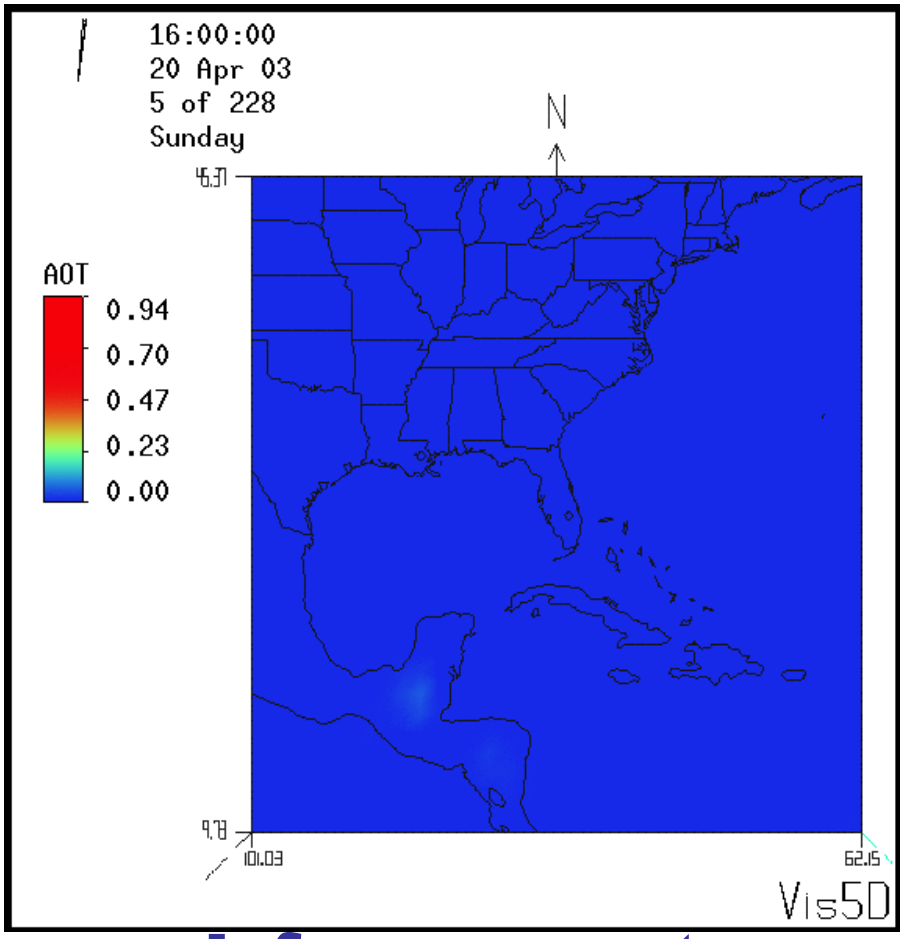
Asia - Australia



The best of both worlds
Satellite AND Ground-based

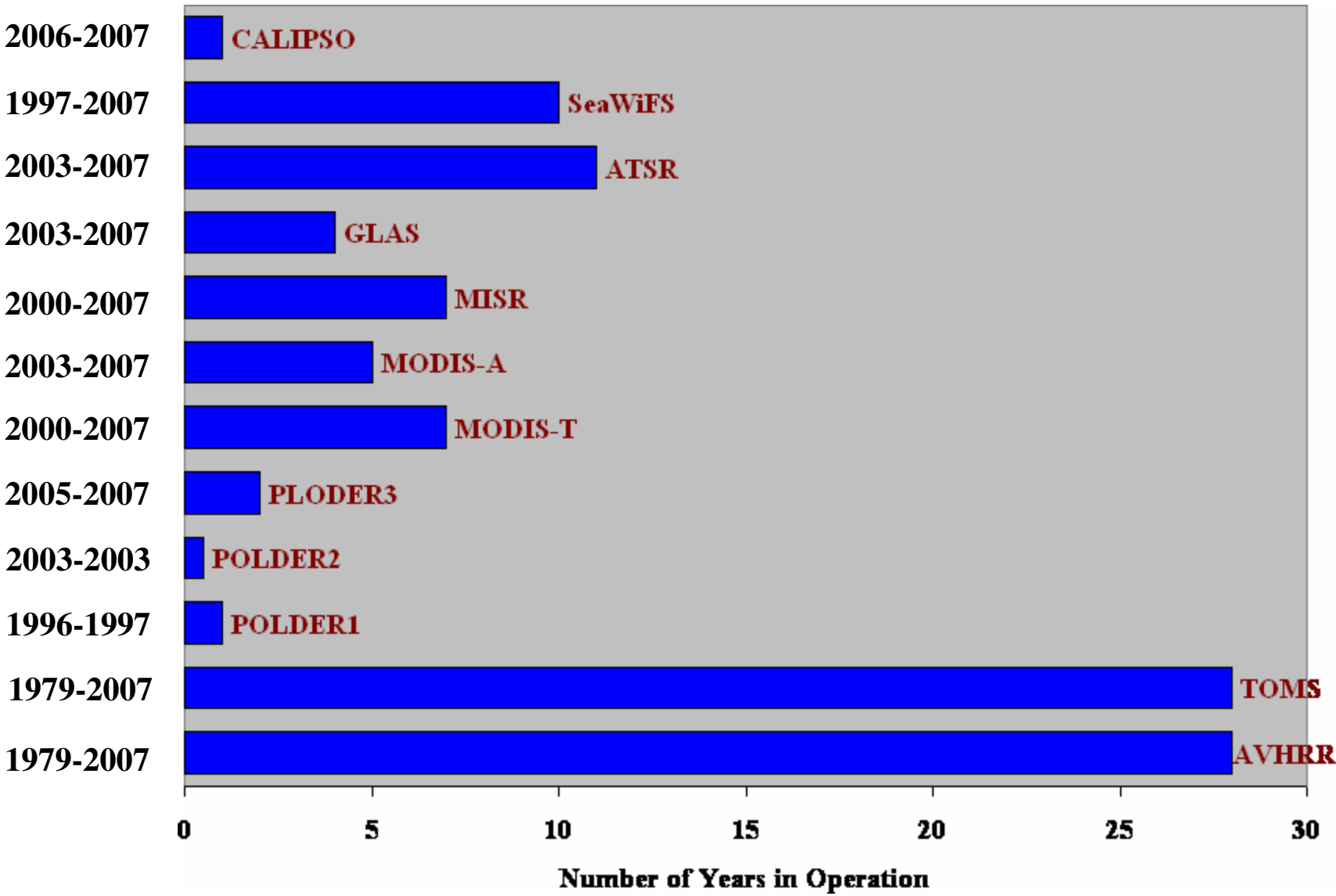
Satellites cannot cure all problems

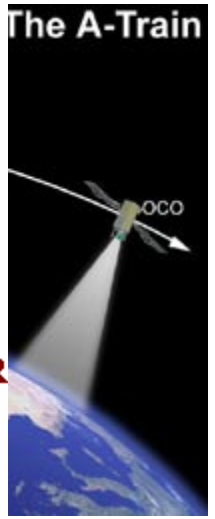
- Satellite images are only snap shots
- Satellite-information in models are the best way to “forecast” events



Example of aerosol forecast

What do we have now for Aerosol Remote Sensing





Summary

- Monitoring air pollution is critical
- Ground-based information is limited
- High quality satellite measurements are now available to monitor air pollution
- Our hands-on workshop tomorrow will demonstrate how participants can access and analyze satellite data
- Satellite information in combination with measurements and models can provide forecasts of air pollution events
- Data sharing is important among nations