Challenges in the use of Space Applications for Monitoring Air Pollution-Experience from Pakistan

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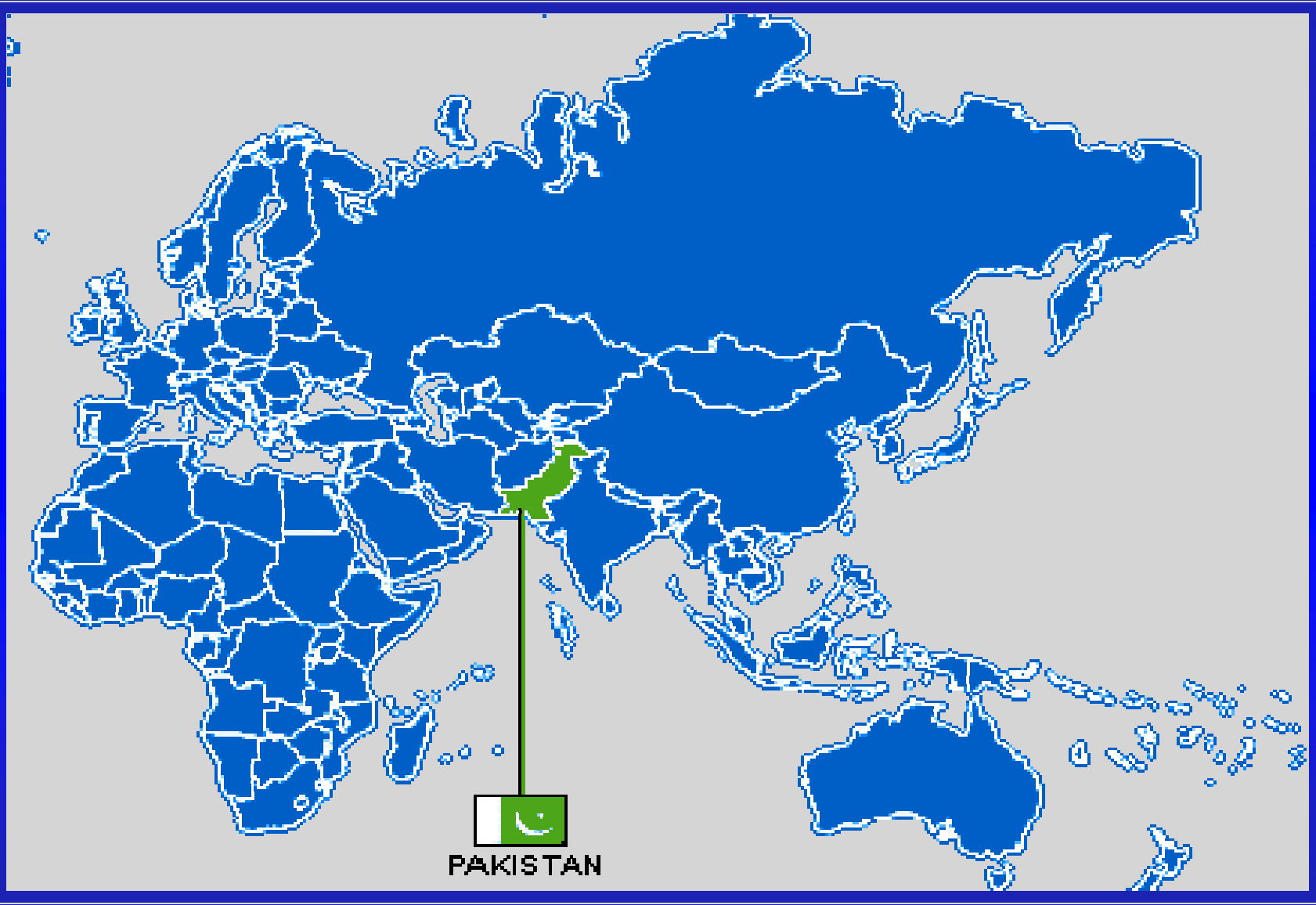
"Space Tools For Monitoring Air Pollution And Energy Use For Sustainable Development"

Contents of Presentation

- Need for Monitoring
- Measuring Instruments (Space & Ground)
- Air Pollution Monitoring through Space –Pakistan Experience
- Acquisition of Data with Ground Instrument
- General Urban Air Quality in Pakistan
- International Collaboration
- Challenges

Location of Pakistan on World Map



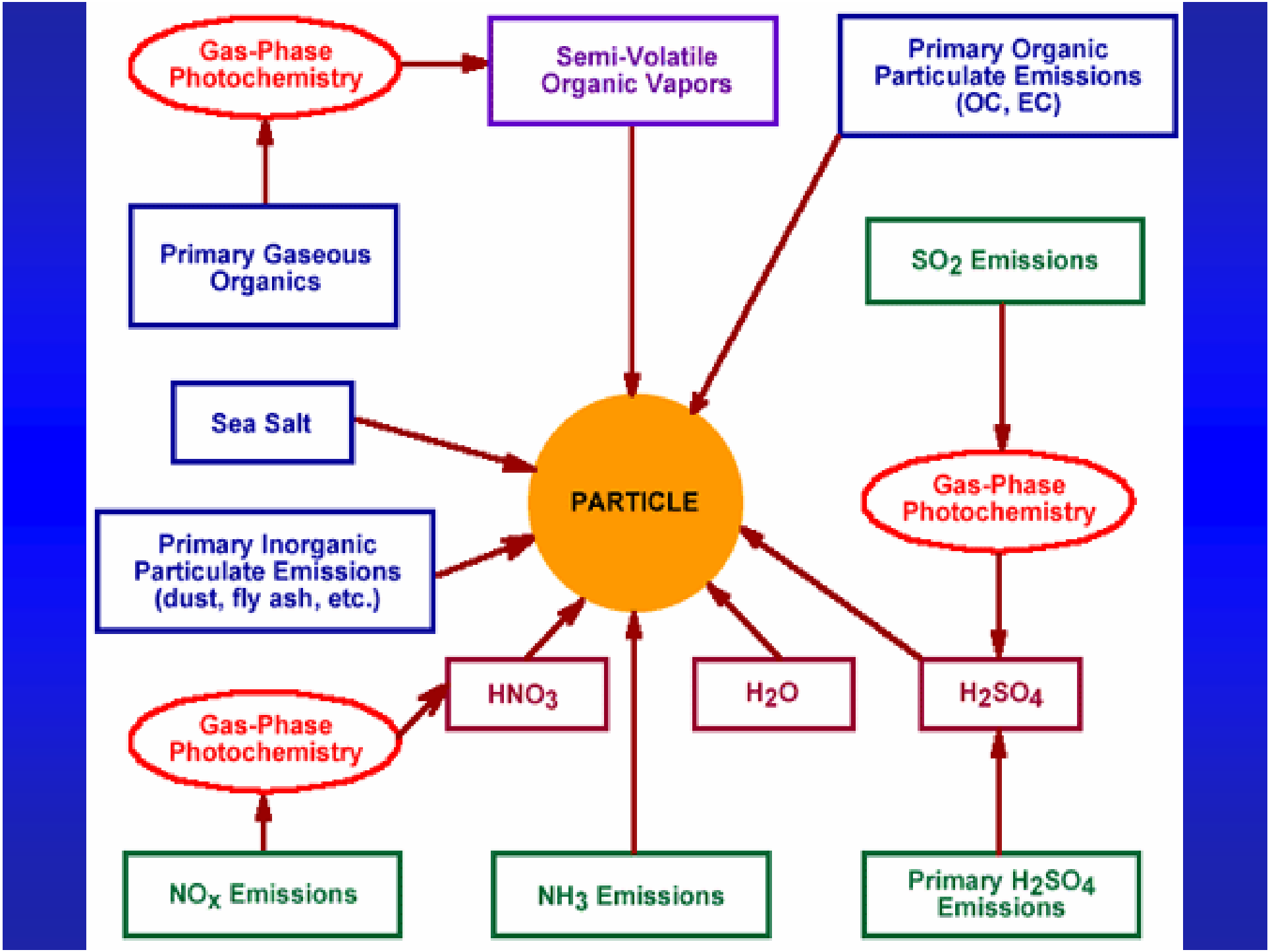
Air Pollution and Health: What we know about the effects

Air Pollution has Many Effects

- Health
  - Respiratory, cardiovascular morbidity
  - Mortality
- Heritage
  - Nitric Sulfuric Acid erosion
- Natural Resources
  - Acidification (lake and stream biology)
  - Mercury deposition (fish tissue)
  - Visibility
- Agriculture
  - Ozone crop effects

Many Sources of Air Pollution in Pakistan

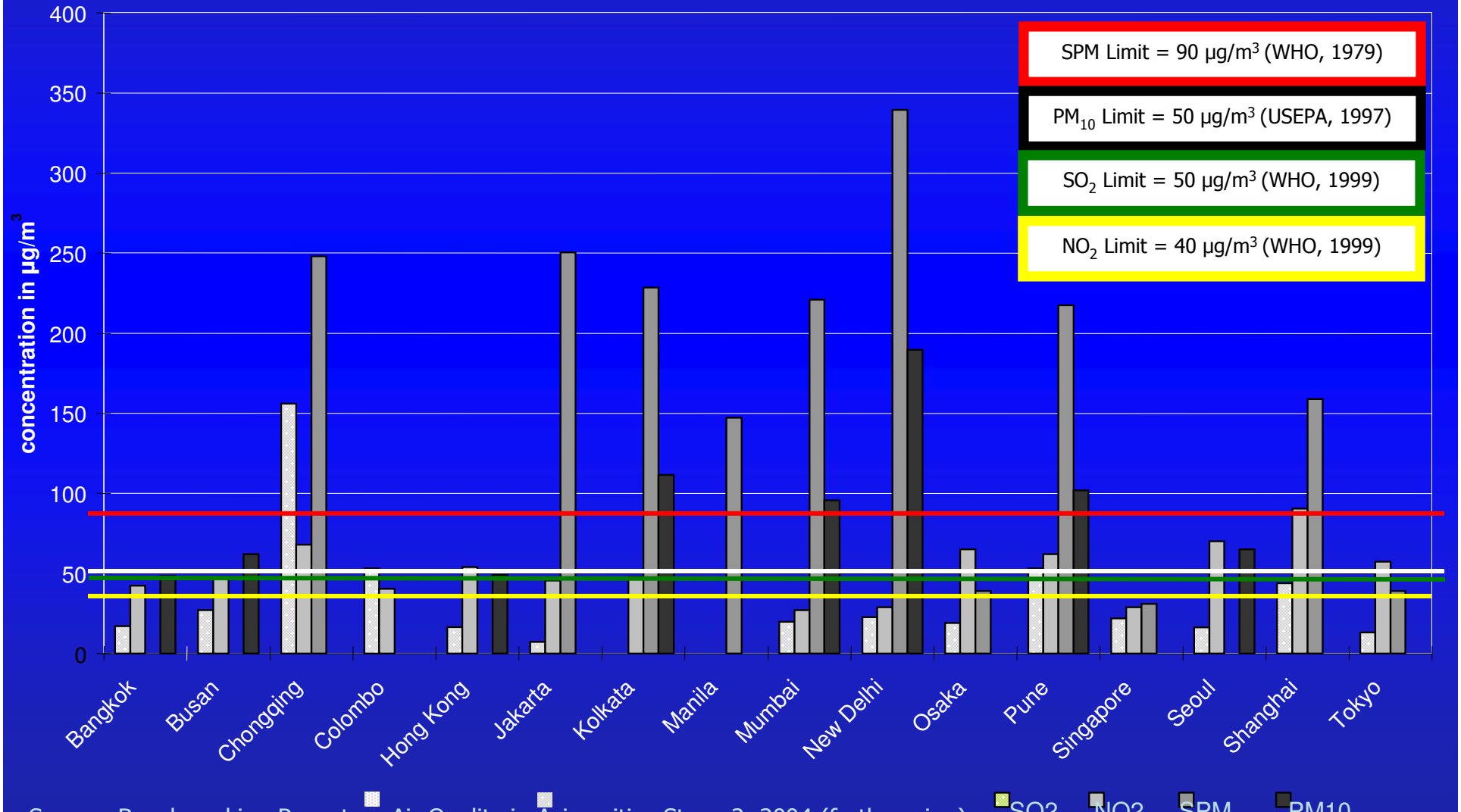
- Combustion
  - Open burning
  - Brick Kilns
  - Vehicles
  - Trash burning
  - Factories
  - Power generation
  - Cooking in slums
- Non-Combustion
  - Agricultural cultivation
  - Street sweeping
  - Windblown sand
  - Unpaved roads
  - Paved roads (asbestos, rubber etc)
  - Construction


Gas-Phase Photochemistry
Semi-Volatile Organic Vapors
Primary Organic Particulate Emissions (OC, EC)
Primary Gaseous Organics
SO_2 Emissions
Sea Salt
PARTICLE
Gas-Phase Photochemistry
Primary Inorganic Particulate Emissions (dust, fly ash, etc.)
HNO_3
H_2O
H_2SO_4
Gas-Phase Photochemistry
NO_x Emissions
NH_3 Emissions
Primary H_2SO_4 Emissions

Major Vehicle/Fuel Emissions

- Carbon Monoxide
- Diesel Exhaust
- Particulate Matter (PM)
- Lead
- Nitrogen Oxides (NOx) and Hydrocarbons (HC)
  - *Precursors to Ozone and PM*
- Nitrogen Dioxide
- Air Toxics
  - Aldehydes
    - formaldehyde
    - acetaldehyde
    - others
  - Benzene
  - 1,3-butadiene
  - Methanol
  - Polycyclic organic matter (e.g. PAHs)

The Problem: Air Pollution in Asia: High Levels in Many Cities (2000-2001)



Source: Benchmarking Report on Air Quality in Asian cities Stage 2, 2004 (forthcoming)

Environmental Burdens Premature Deaths

source: WHO Global Burdon of Disease

Environmental Risks	Global Estimate	Asian Estimate	Asia as a percent of Global
Unsafe Water	1,730,000	730,000	42%
Urban Outdoor Air	799,000	487,000	61%
Indoor Air	1,619,000	1,025,000	63%
Lead	234,000	88,000	37%

Need for Monitoring

- Protect and enhance the quality of the country's air resources
- Protect public health and welfare against any potential adverse effects that may reasonably be anticipated to accrue from air pollution
- Preserve, protect, and enhance the air quality in urban areas
- Ensure that economic growth will occur in a manner consistent with the preservation of existing clean air resources
- Assure that Pakistan's international obligations regarding the trans-boundary effects of air pollution are met

Measuring Instruments (Space & Ground)

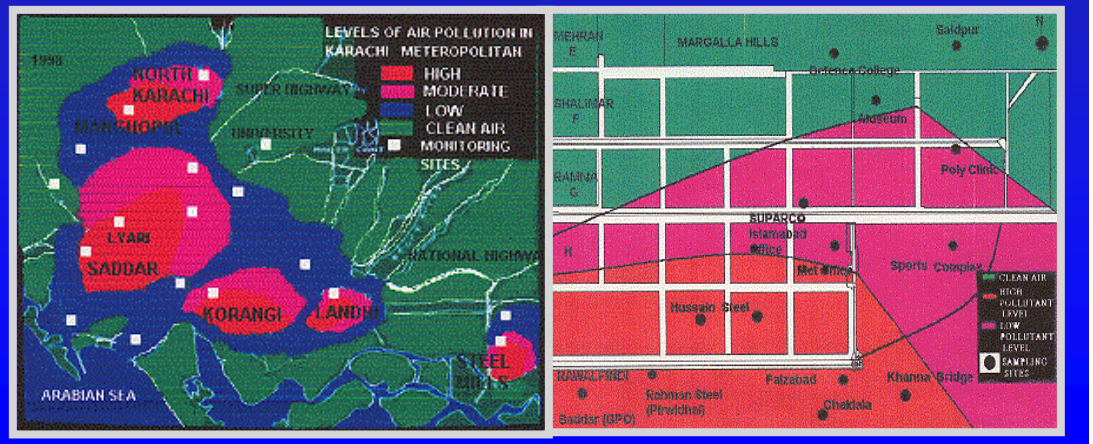
Satellite Based System

- **MODIS**
  (Moderate Resolution Imaging Spectroradiometer)
- **TOMS**
  (Total Ozone Mapping Spectrometer)
- **GOME**
  (Global Ozone Monitoring Eeperiment)
- **SCIAMACHY**
  (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY)
- **MOPITT**
  (Measurements of Pollution in the Troposphere)

Ground Measuring Instruments

Ground Based (Fixed)

POLLUTION MONITORING & ANALYSIS



Carried out pollution survey at Karachi, Lahore and Islamabad on the request of ministry of Environment, Local Government and NGO's

Establishing air pollution monitoring facilities at Karachi/Lahore and regular monitoring of SO_2, NOx, H-Cs and non-methane H-Cs, CO and CO_2, surface ozone, total suspended inhalable particulate matter, UV-B radiation.

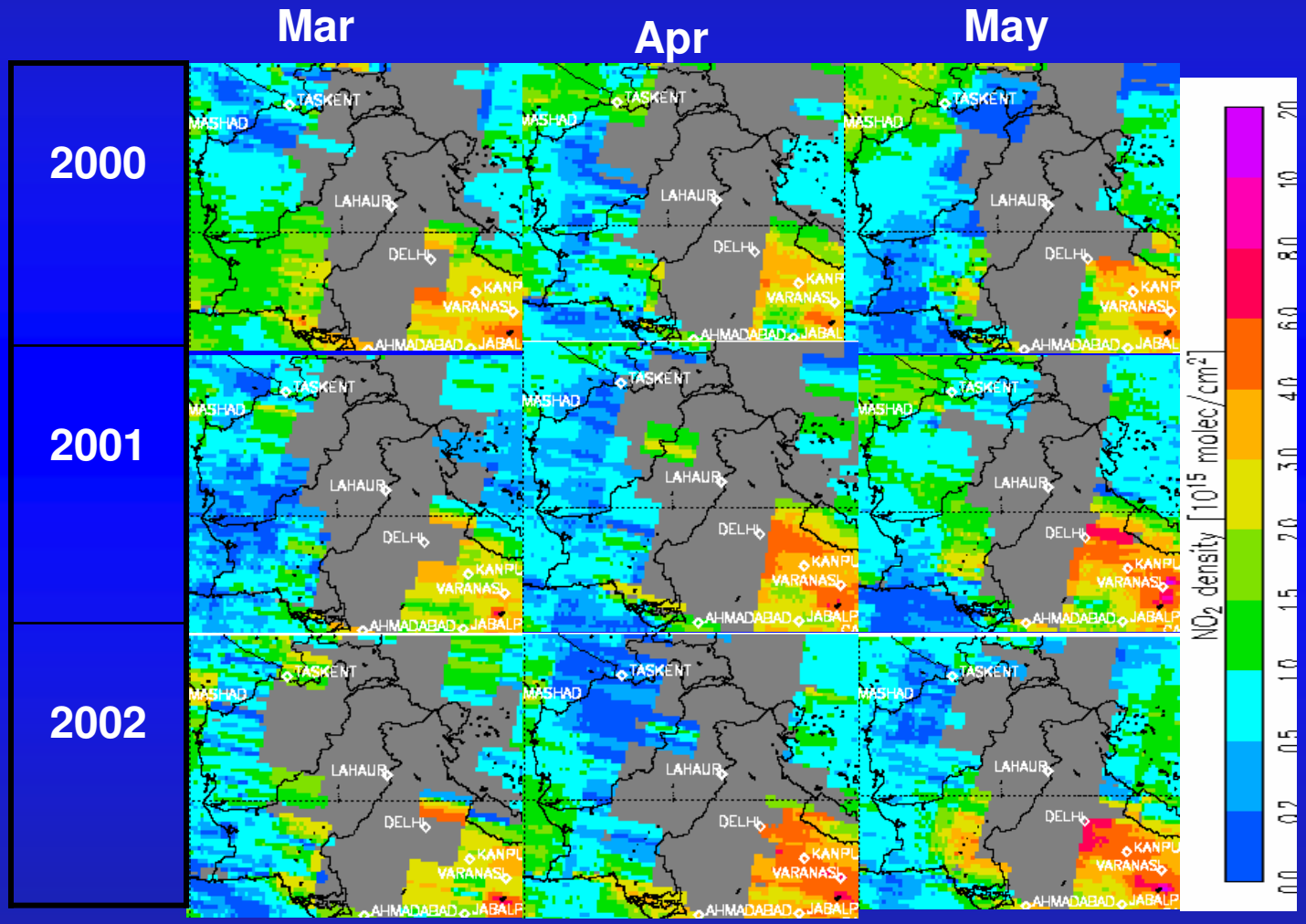
Mobile

Inner View of Mobile Lab.

Air Pollution Monitoring Through Space

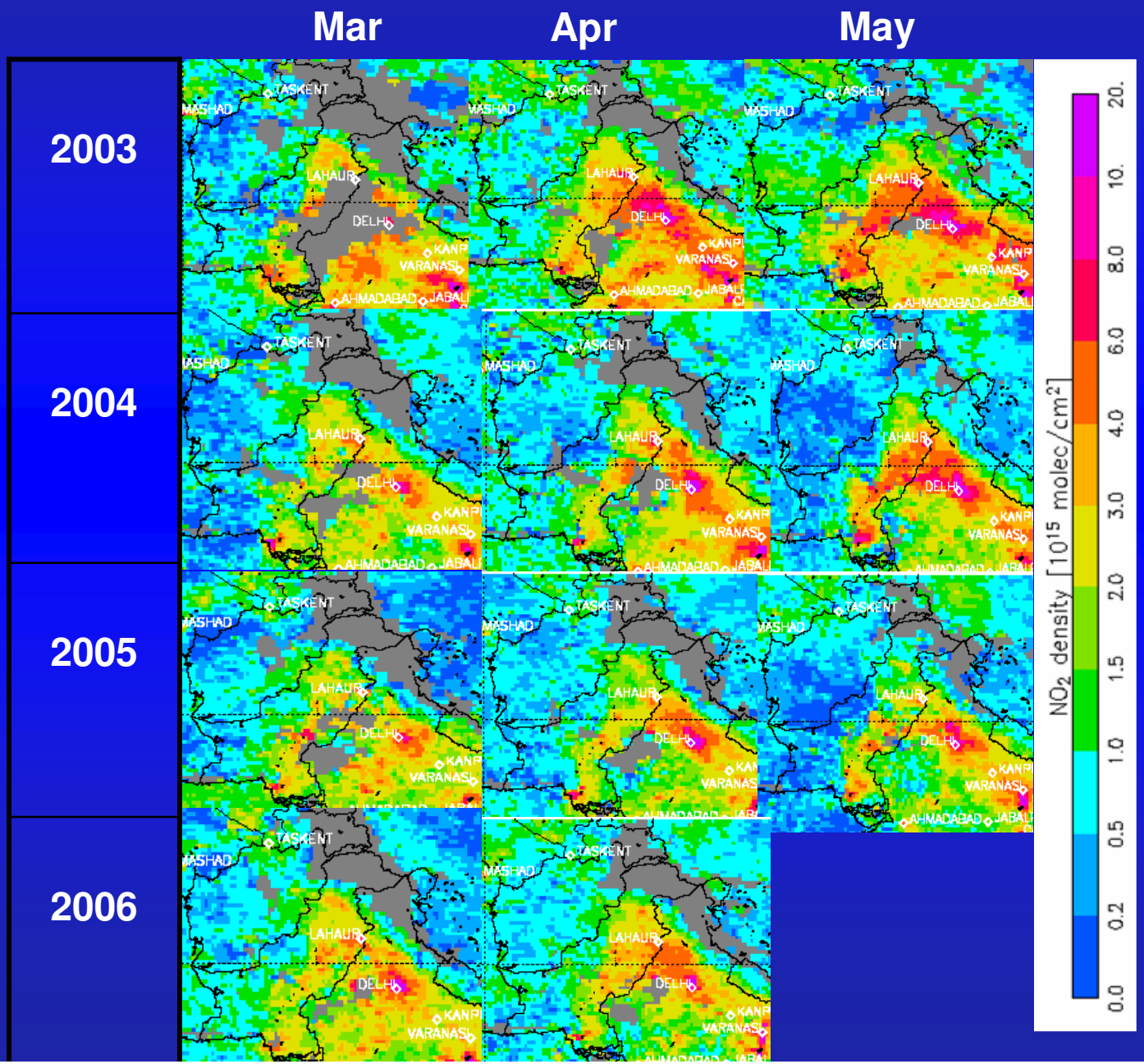
KNMI/IASB/ESA

GOME Trop. NO_2 Pre-Monsoon Over Pakistan



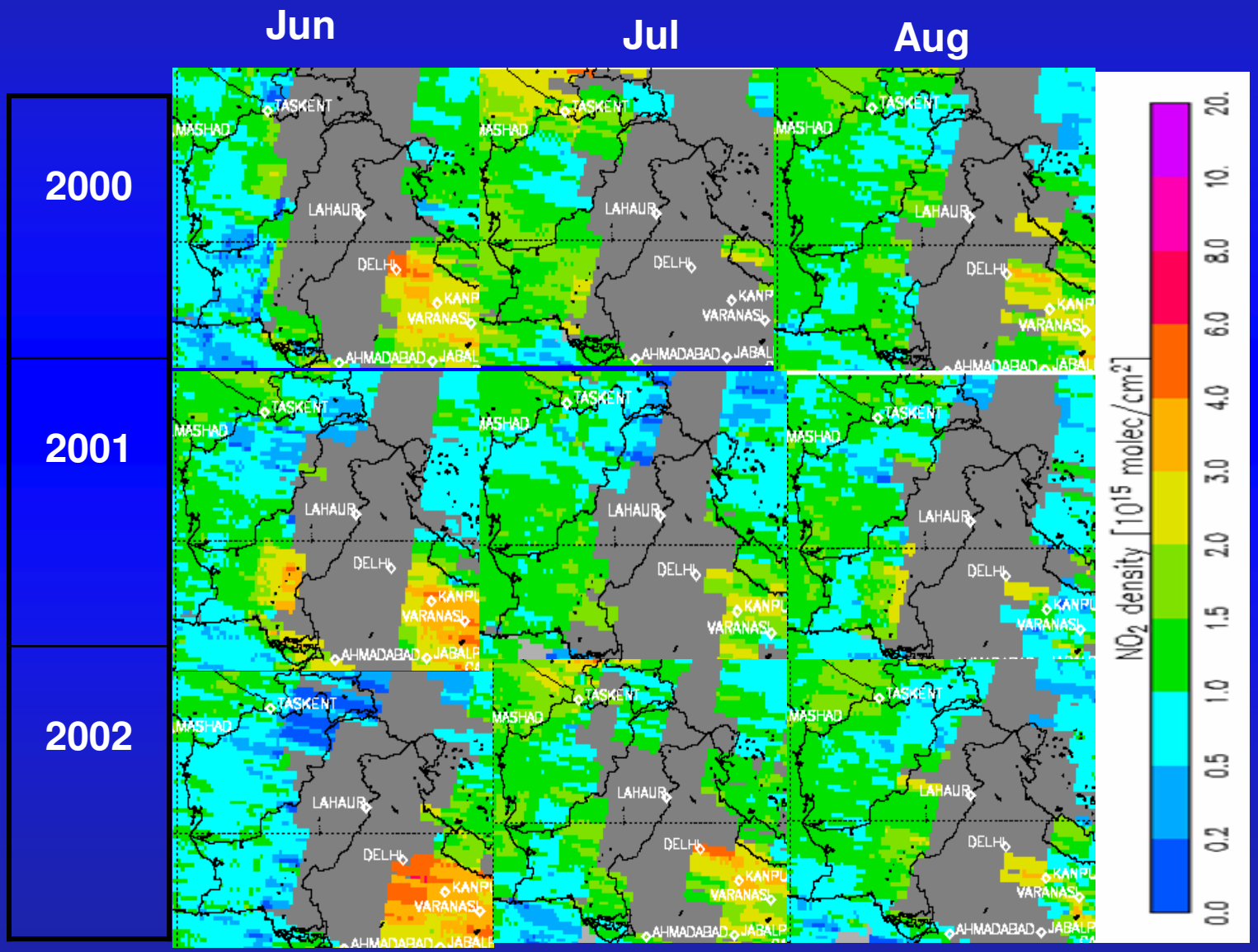
KNMI/IASB/ESA

Sciamachy Trop. NO_2 Pre-Monsoon Over Pakistan



KNMI/IASB/ESA

GOME Trop. NO_2 Monsoon over Pakistan



KNMI/IASB/ESA

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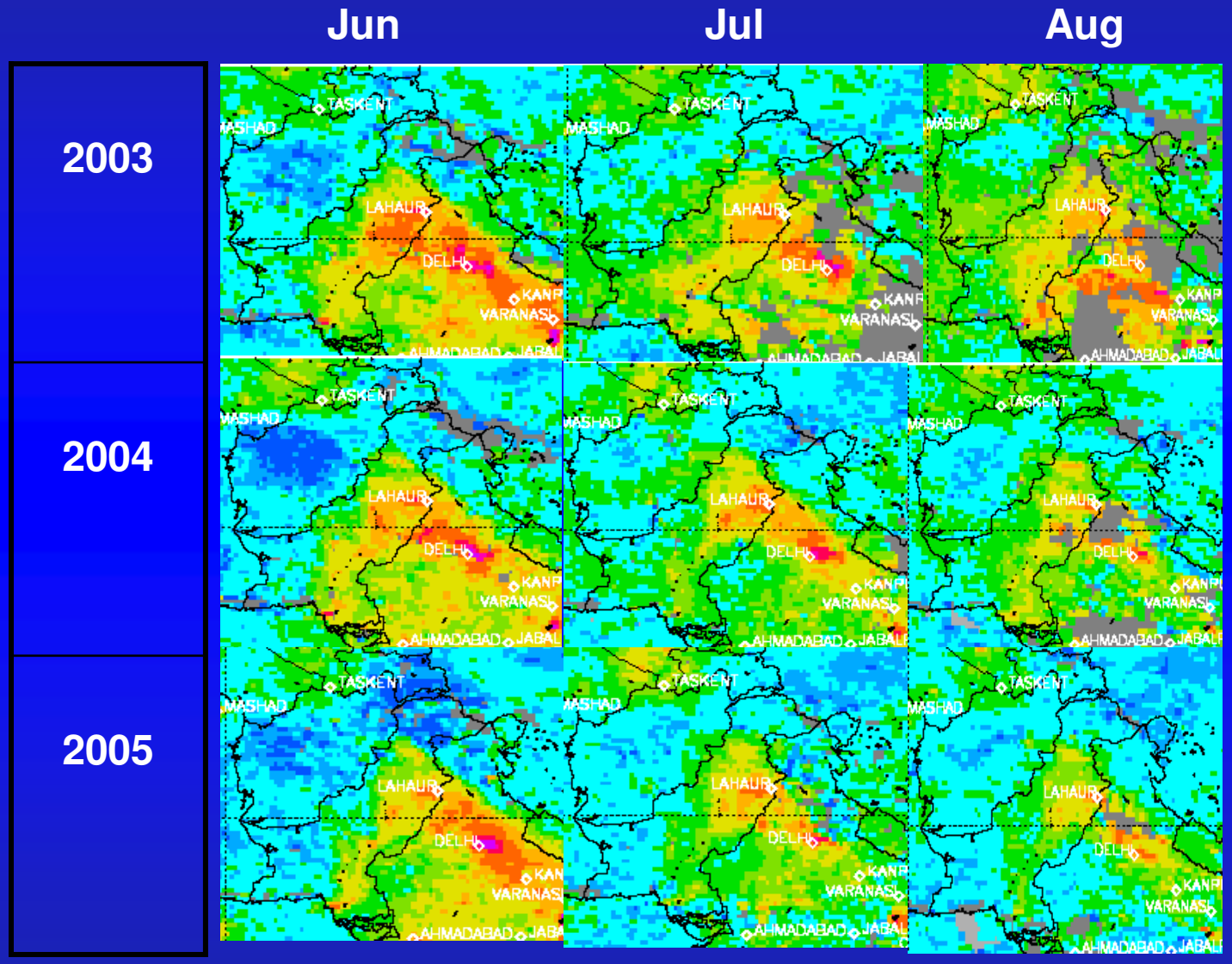
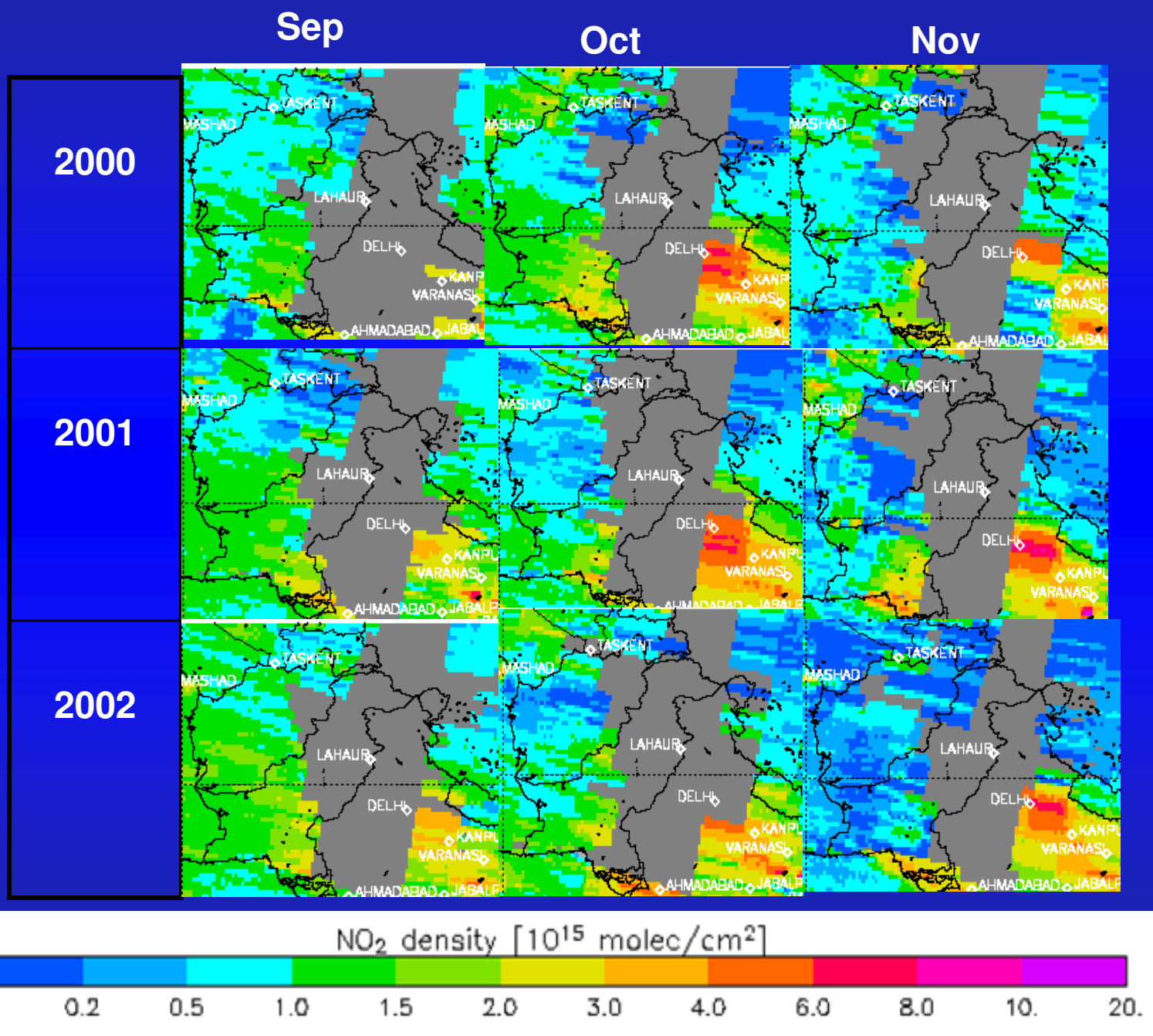


GOME Trop. NO_2 Post Monsoon over Pakistan KNMI/IASB/ESA



KNMI/IASB/ESA

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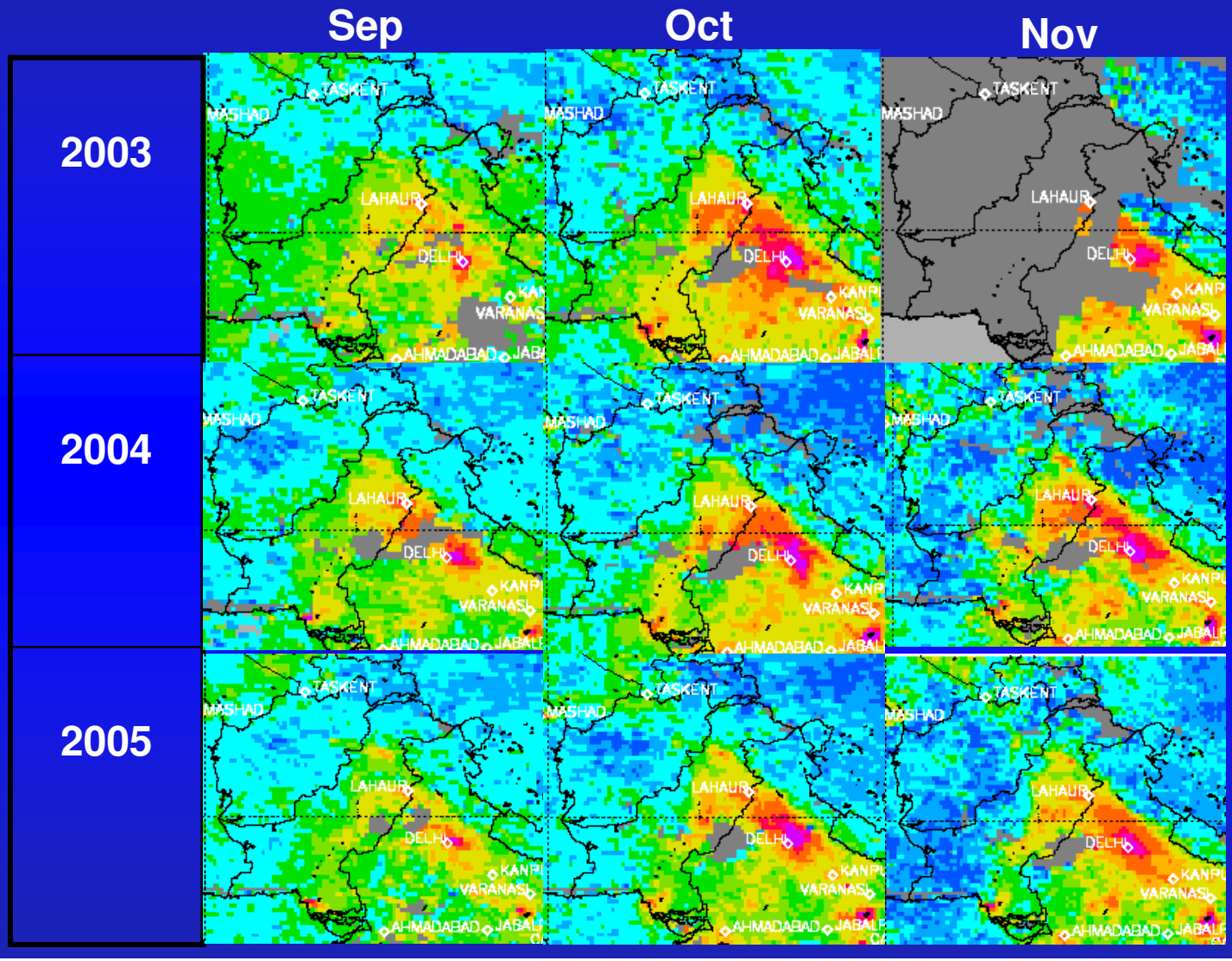
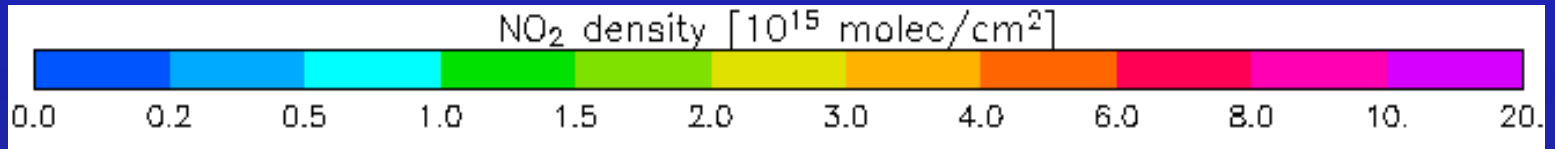
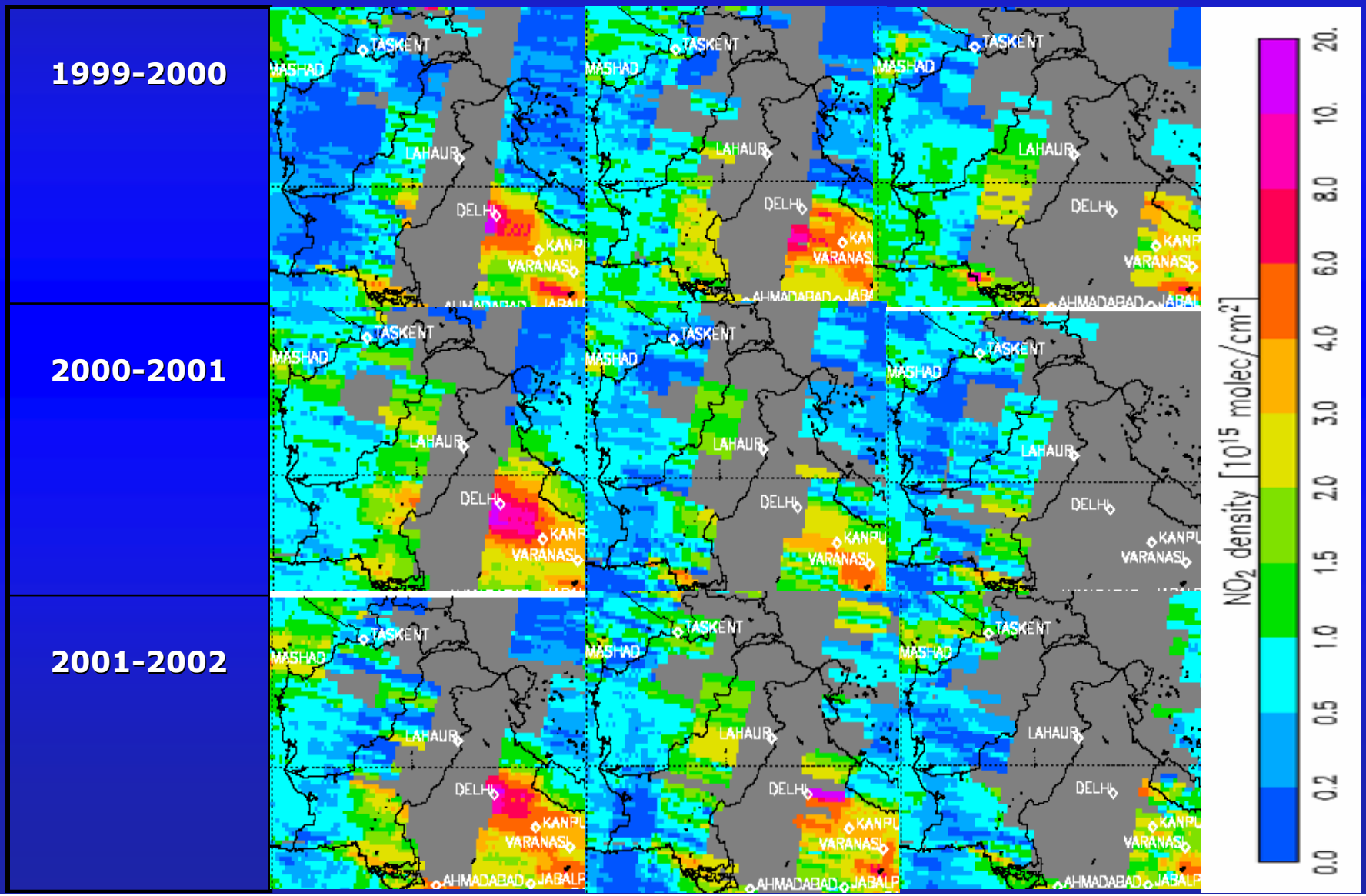




KNMI/IASB/ESA

GOME Trop. NO_2 Winter Over Pakistan



KNMI/IASB/ESA

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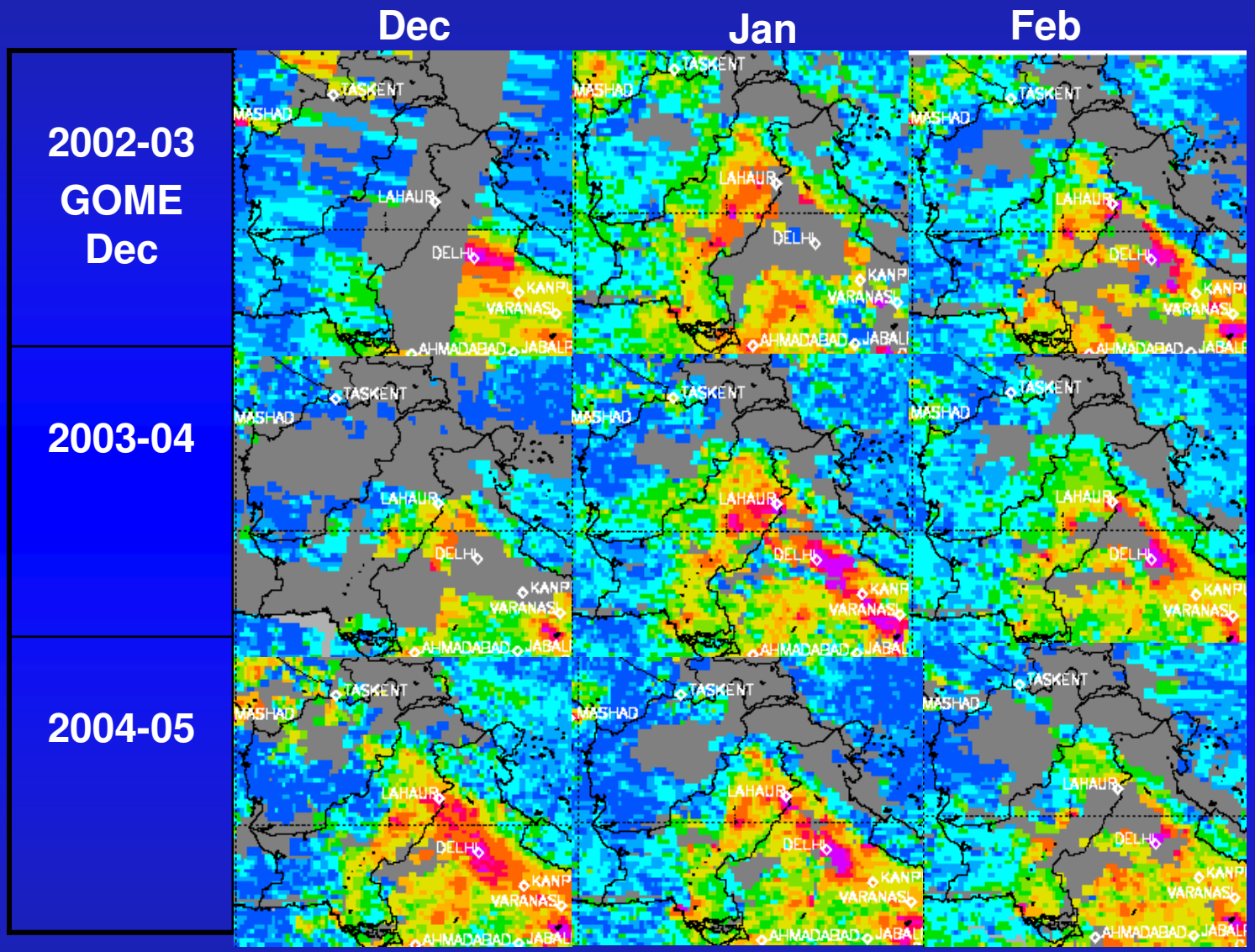
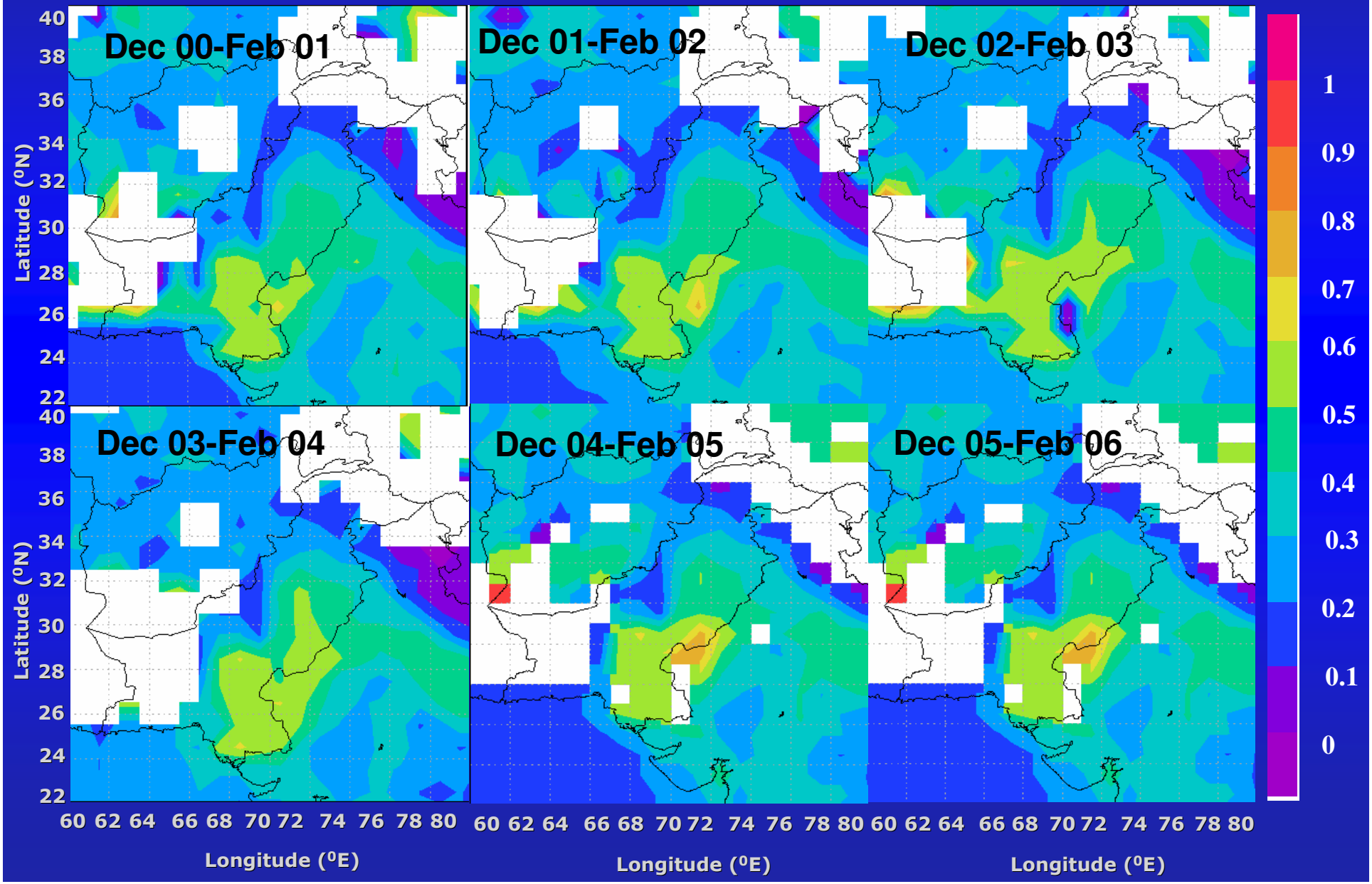


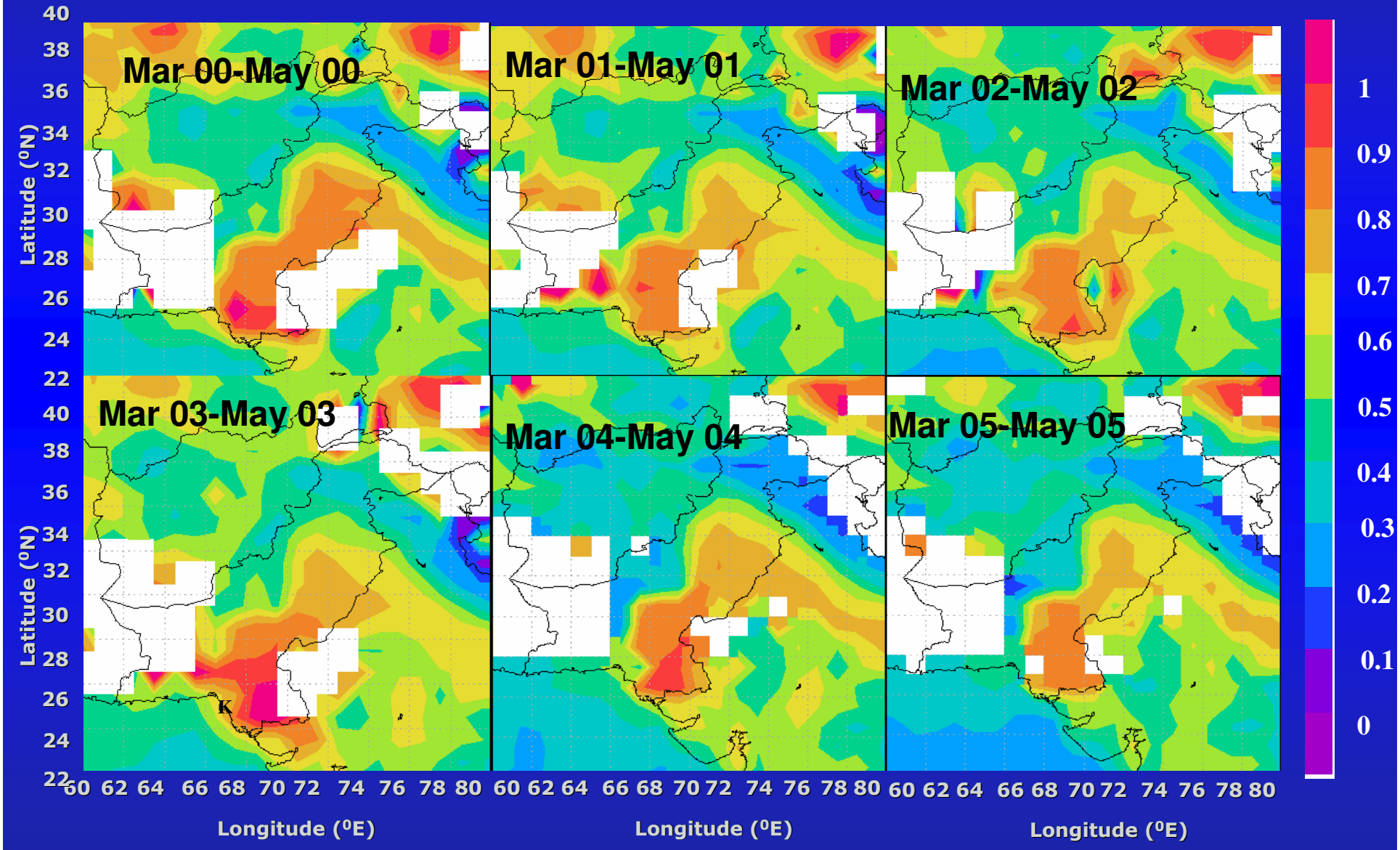
Aerosol Optical Thickness using MODIS Data

Winter Season



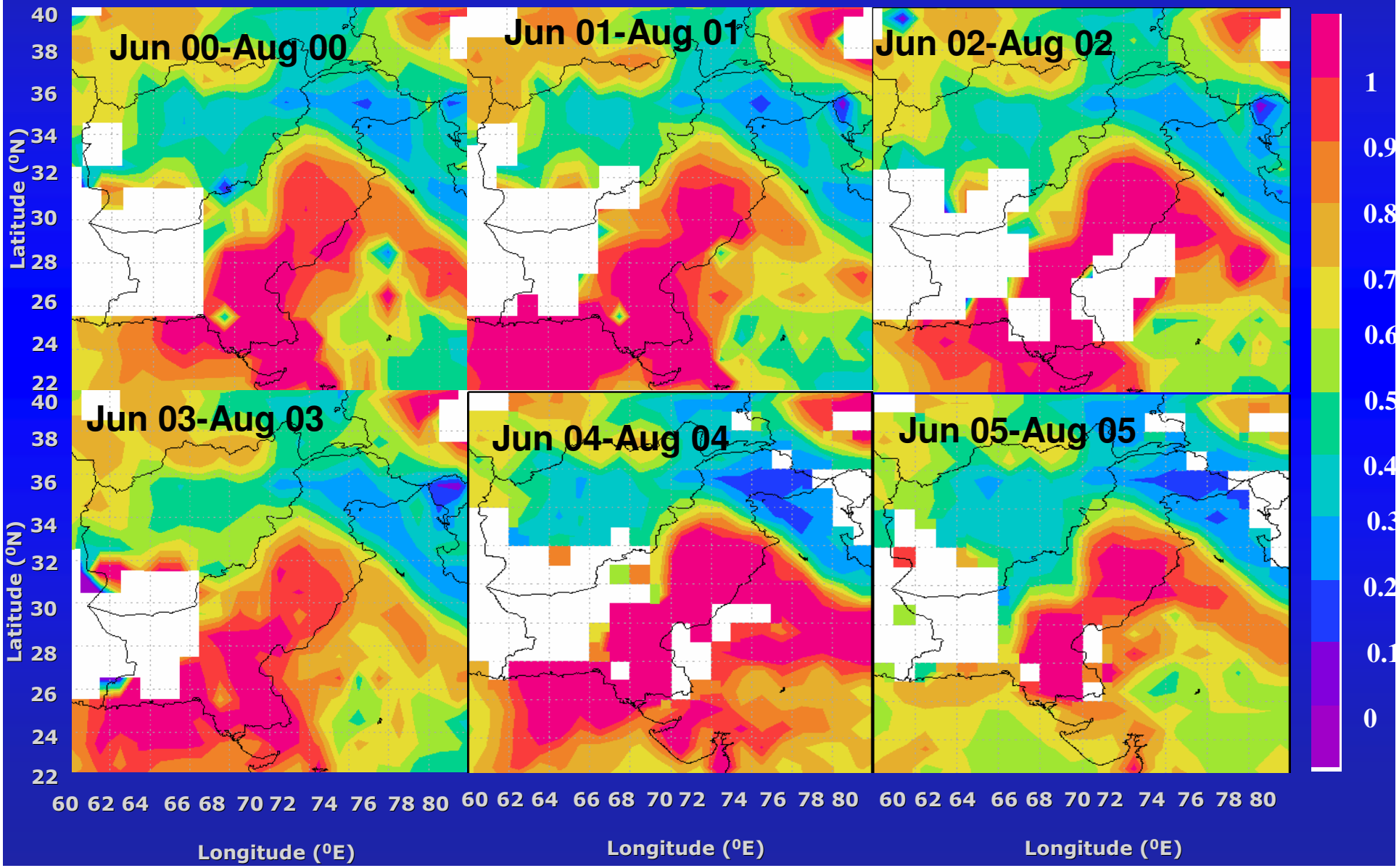
Aerosol Optical Thickness using MODIS Data

Pre-Monsoon Season



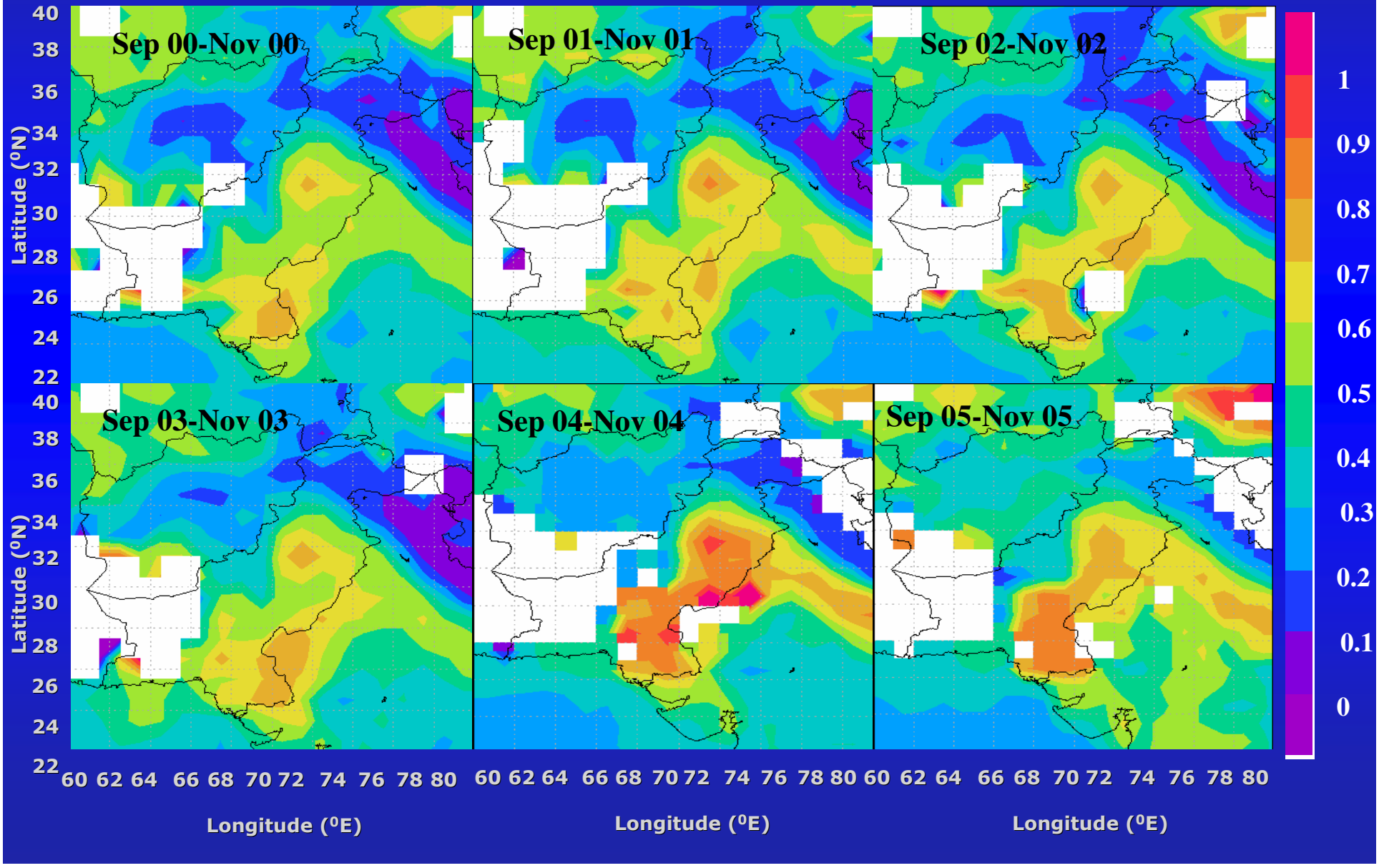
Aerosol Optical Thickness using MODIS Data

Monsoon Season

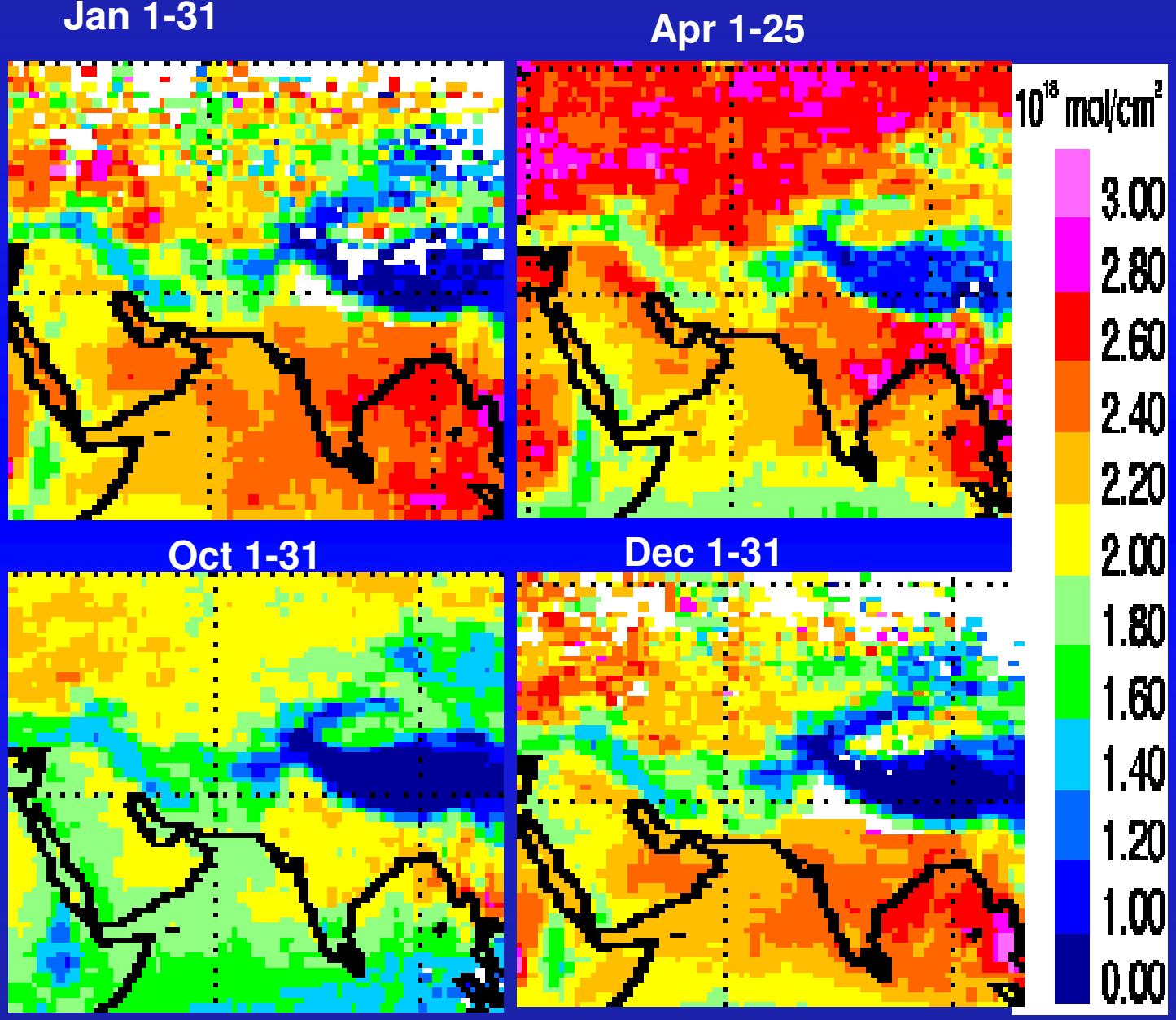


Aerosol Optical Thickness using MODIS Data

Post-Monsoon Season

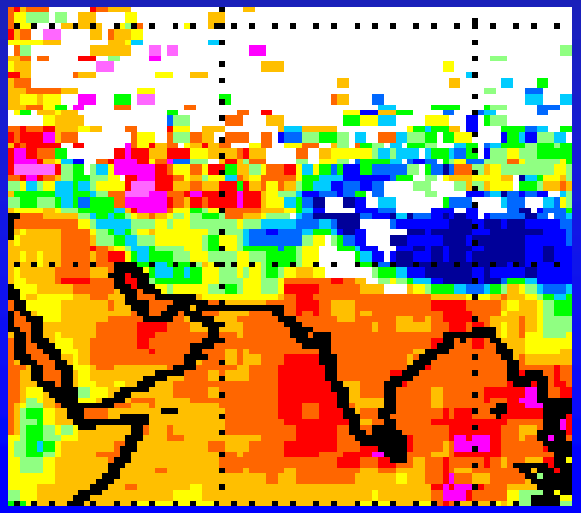


MOPITT CO (V3) Monthly Column , 2005

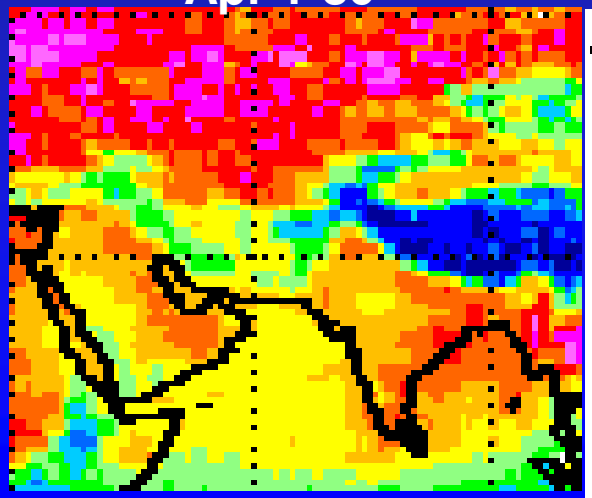


MOPITT CO (V3) Monthly Column , 2006

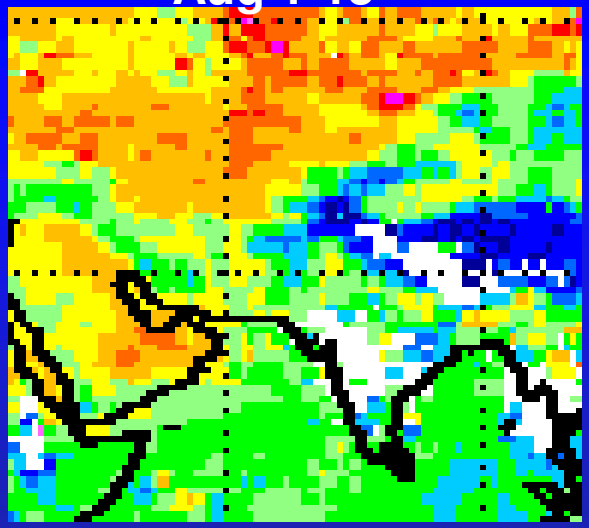
Jan 2-31

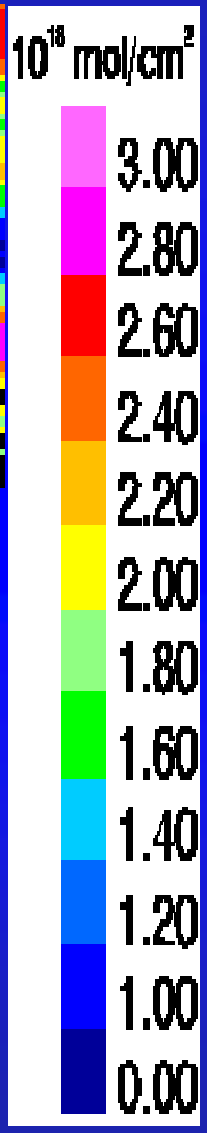


Apr 1-30

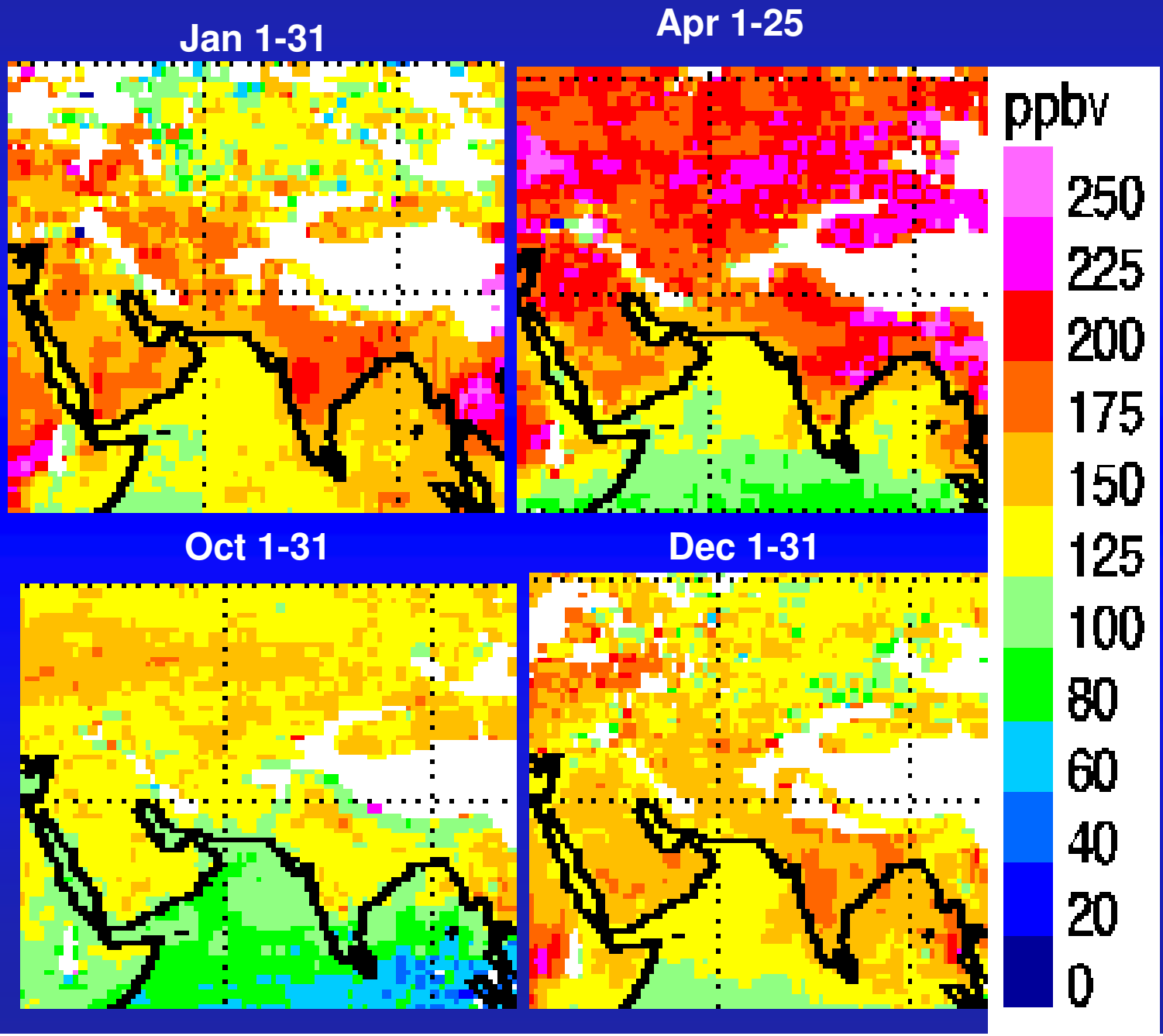


Aug 1-13





MOPITT CO (V3) Monthly 850 hPa, 2005



MOPITT CO (V3) Monthly 850 hPa, 2006

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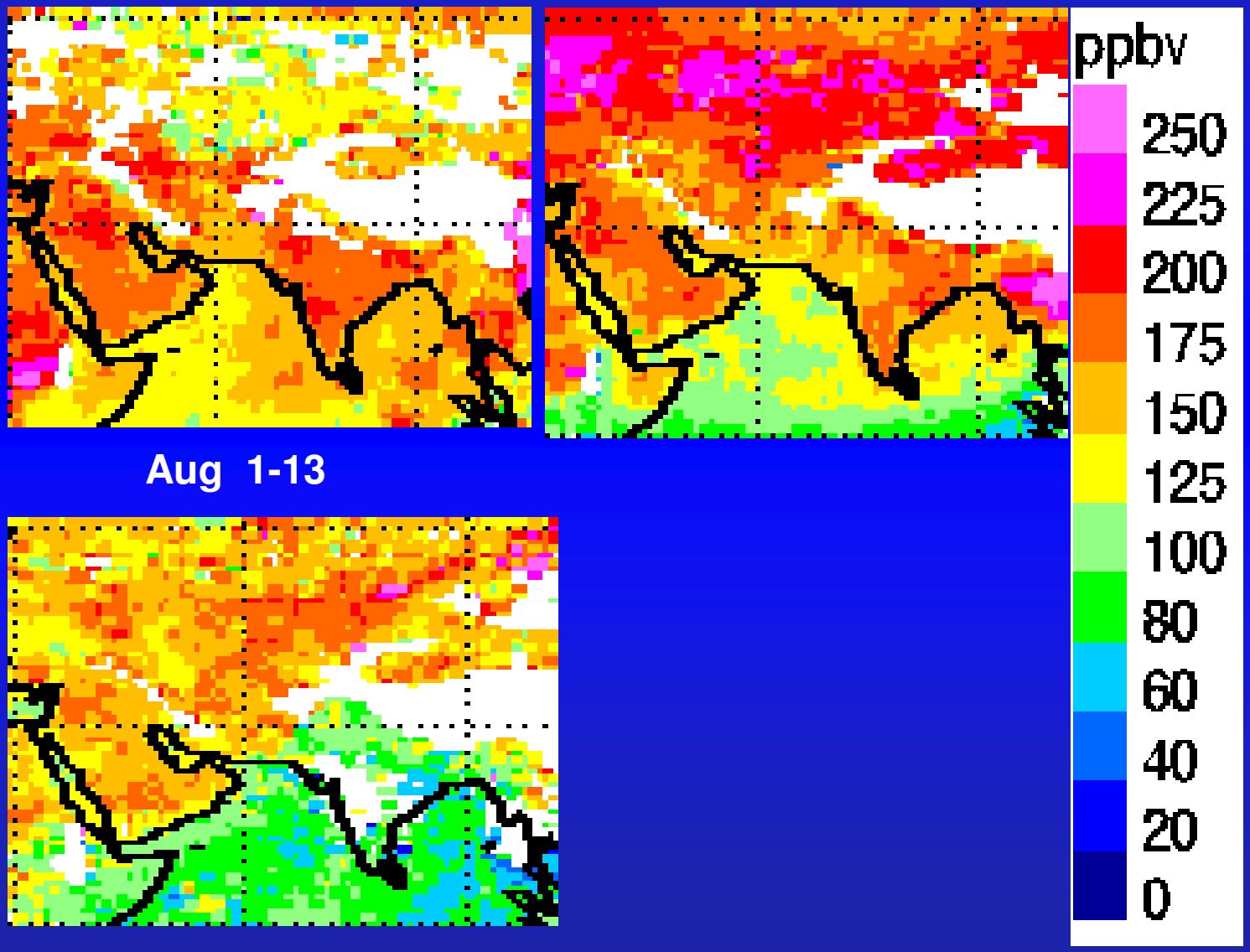
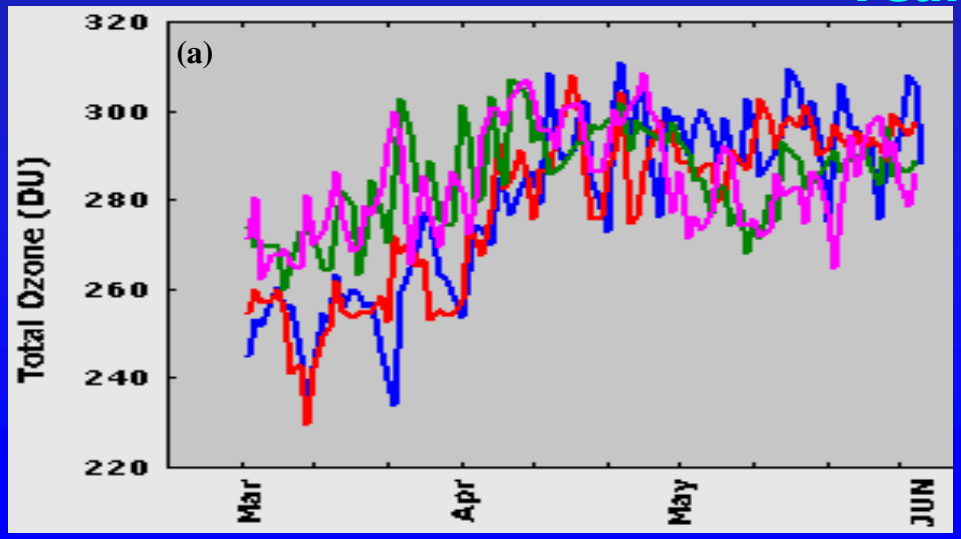
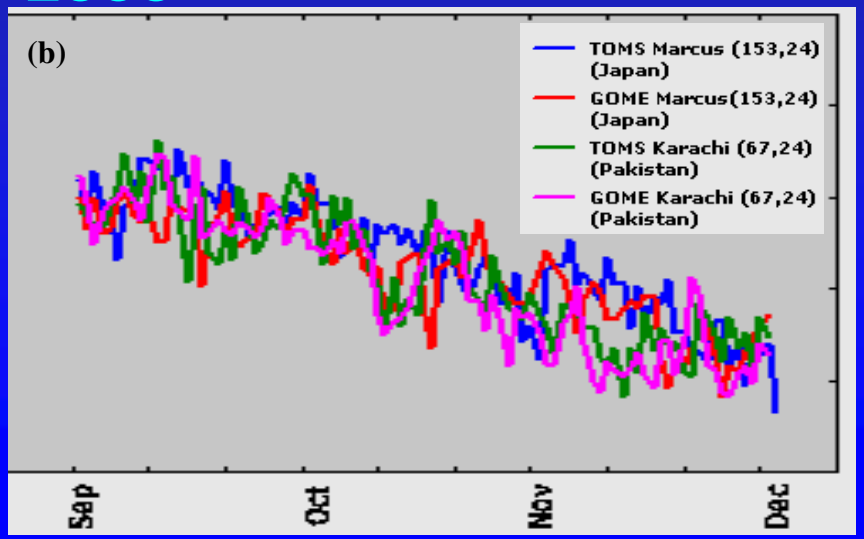


Aug 1-13

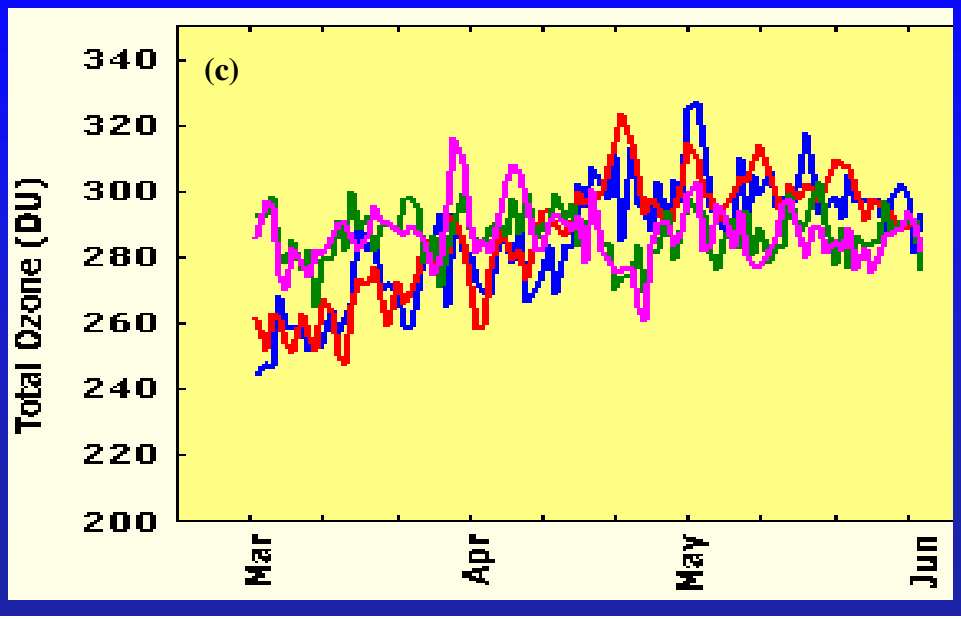
Seasonal Variation at 24° Latitude (TOMS & GOME)

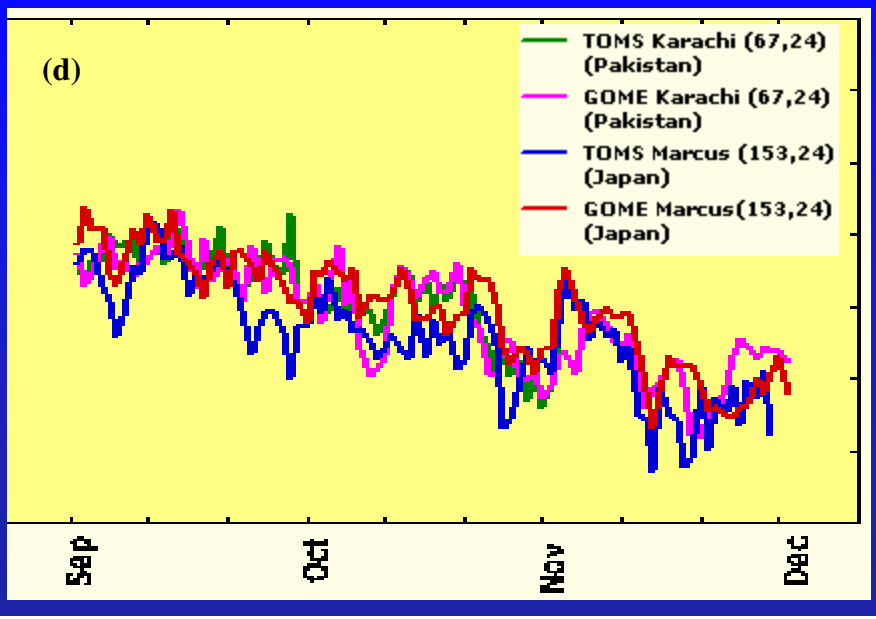
Year 2000





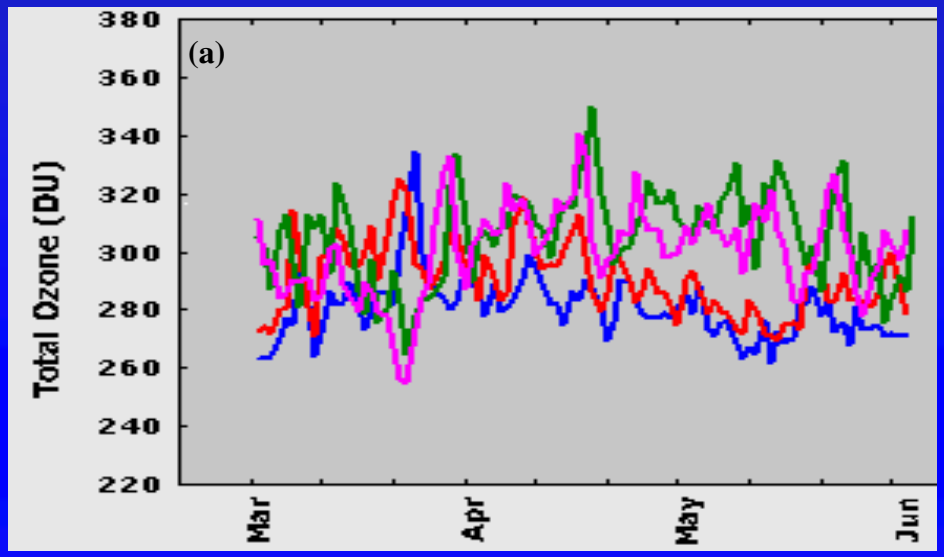
Year 2001

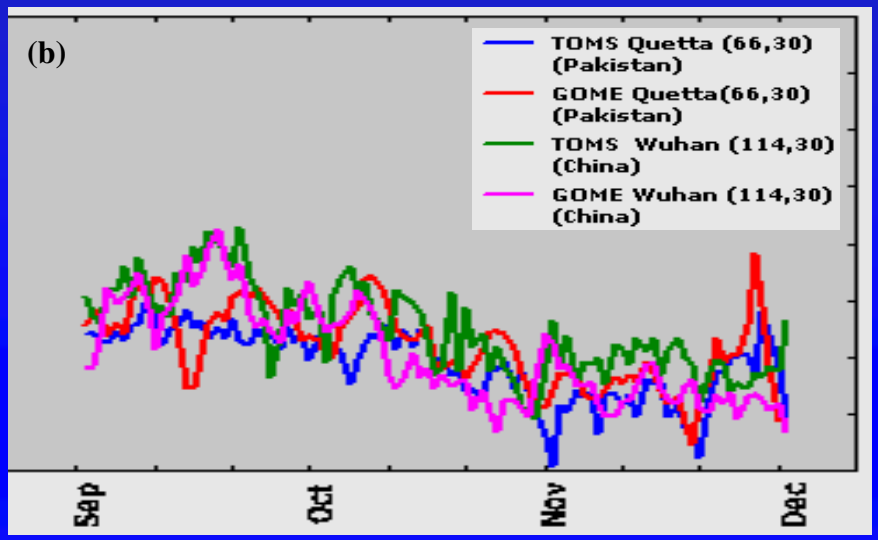




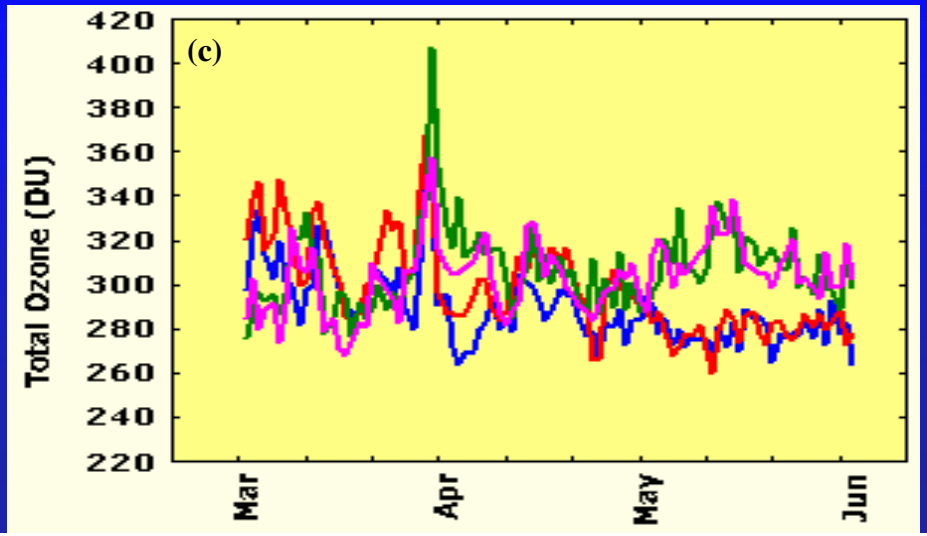
Seasonal Variation at 30° Latitude (TOMS & GOME)

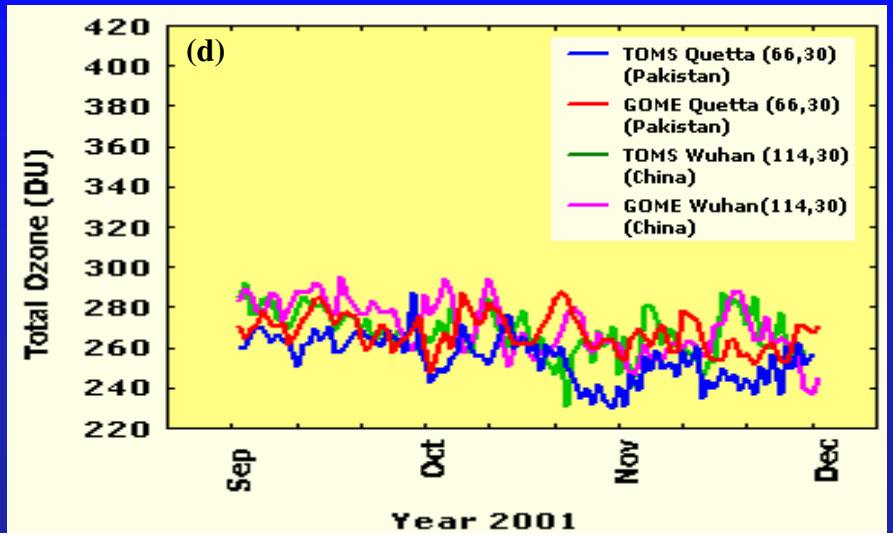
Year 2000





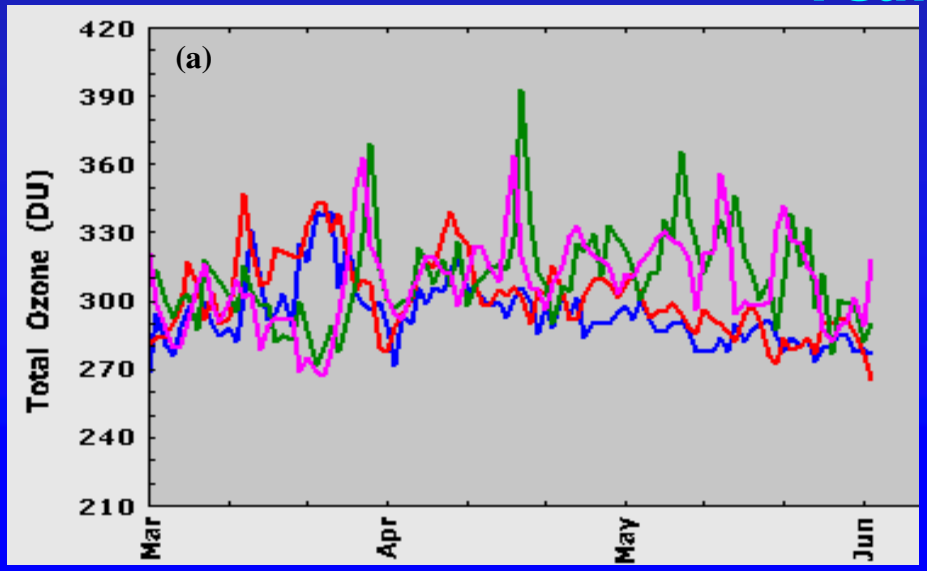
Year 2001

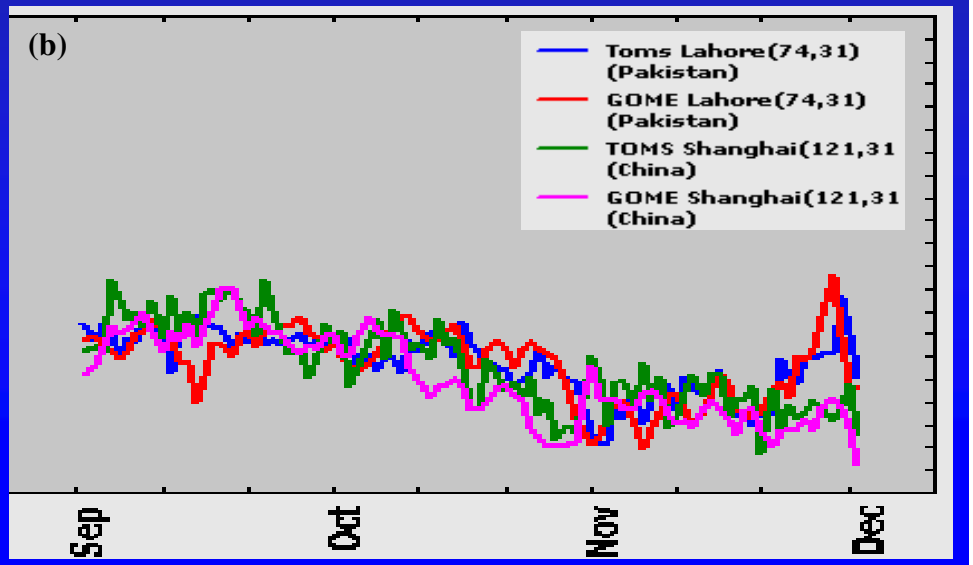




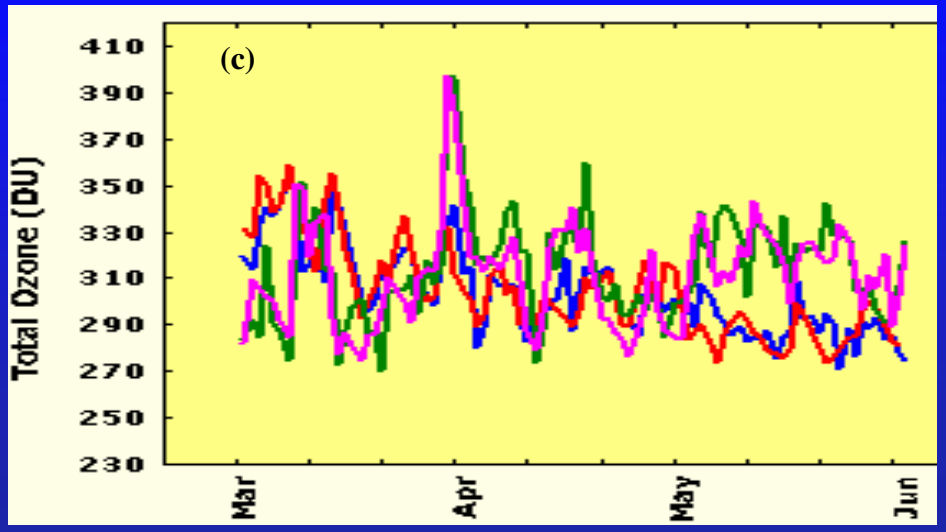
Seasonal Variation at 31° Latitude (TOMS & GOME)

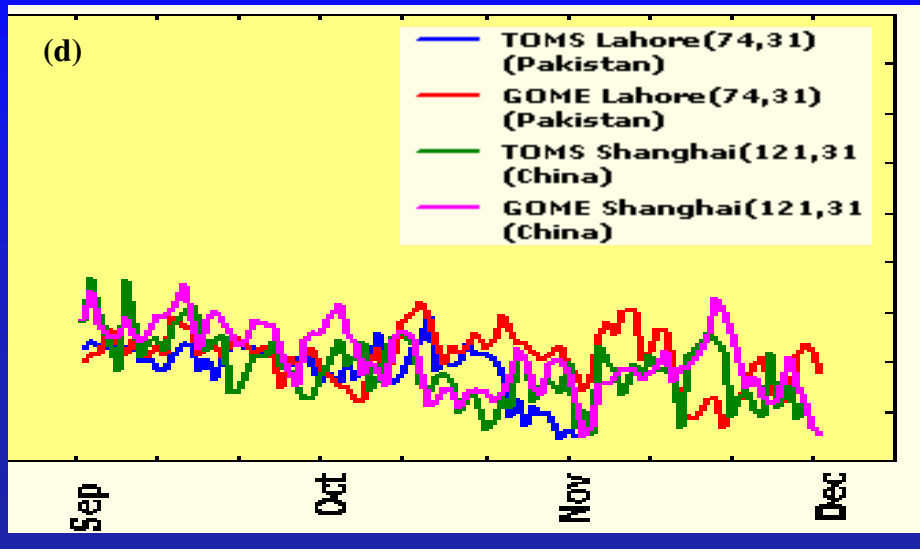
Year 2000





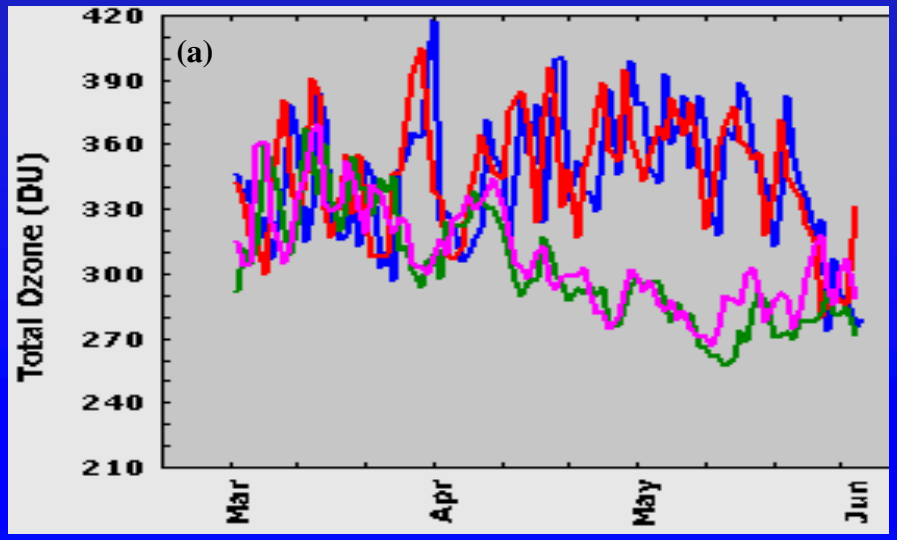
Year 2001

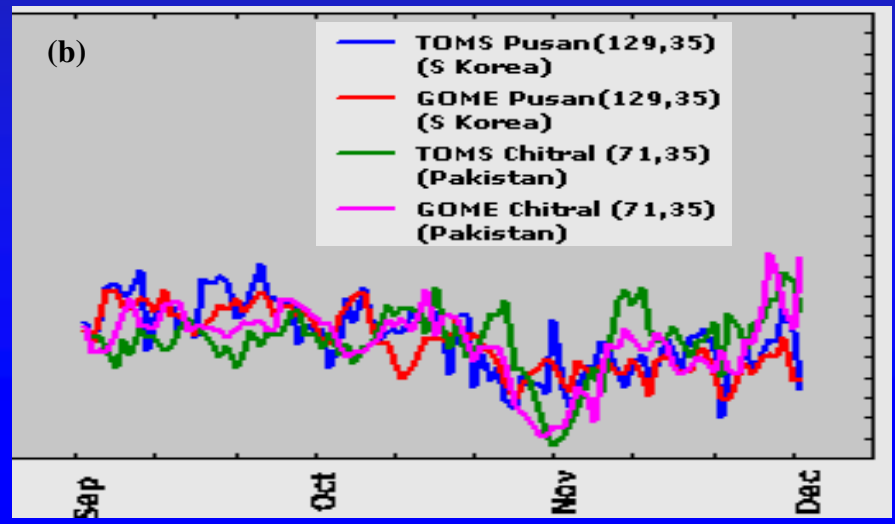




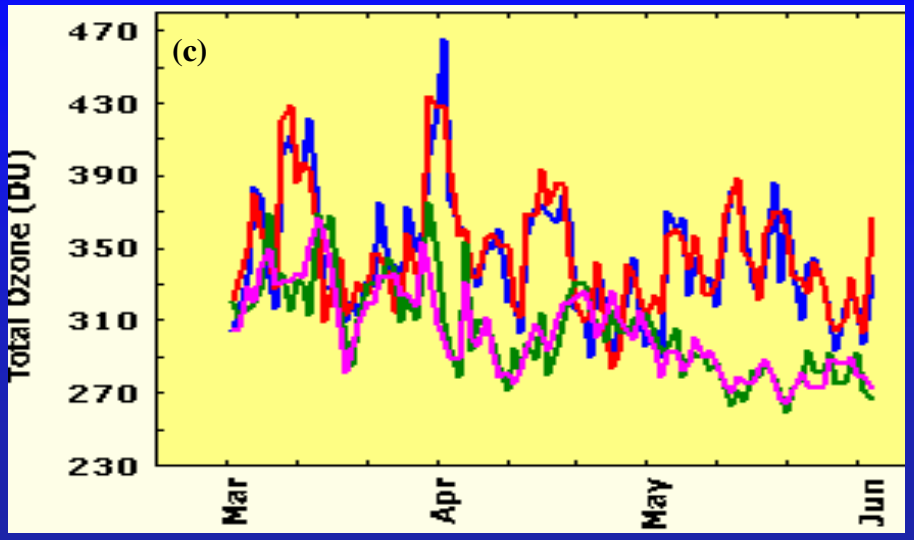
Seasonal Variation at 35° Latitude (TOMS & GOME)

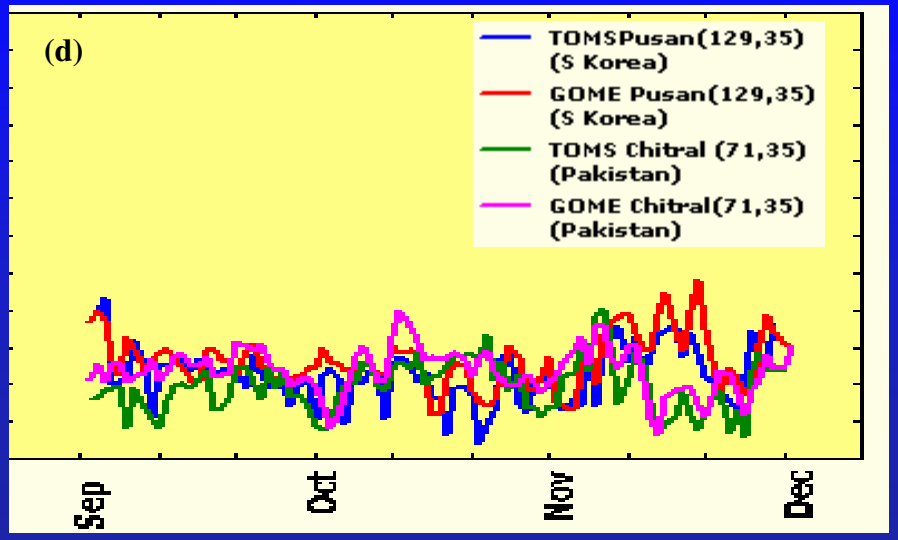
Year 2000



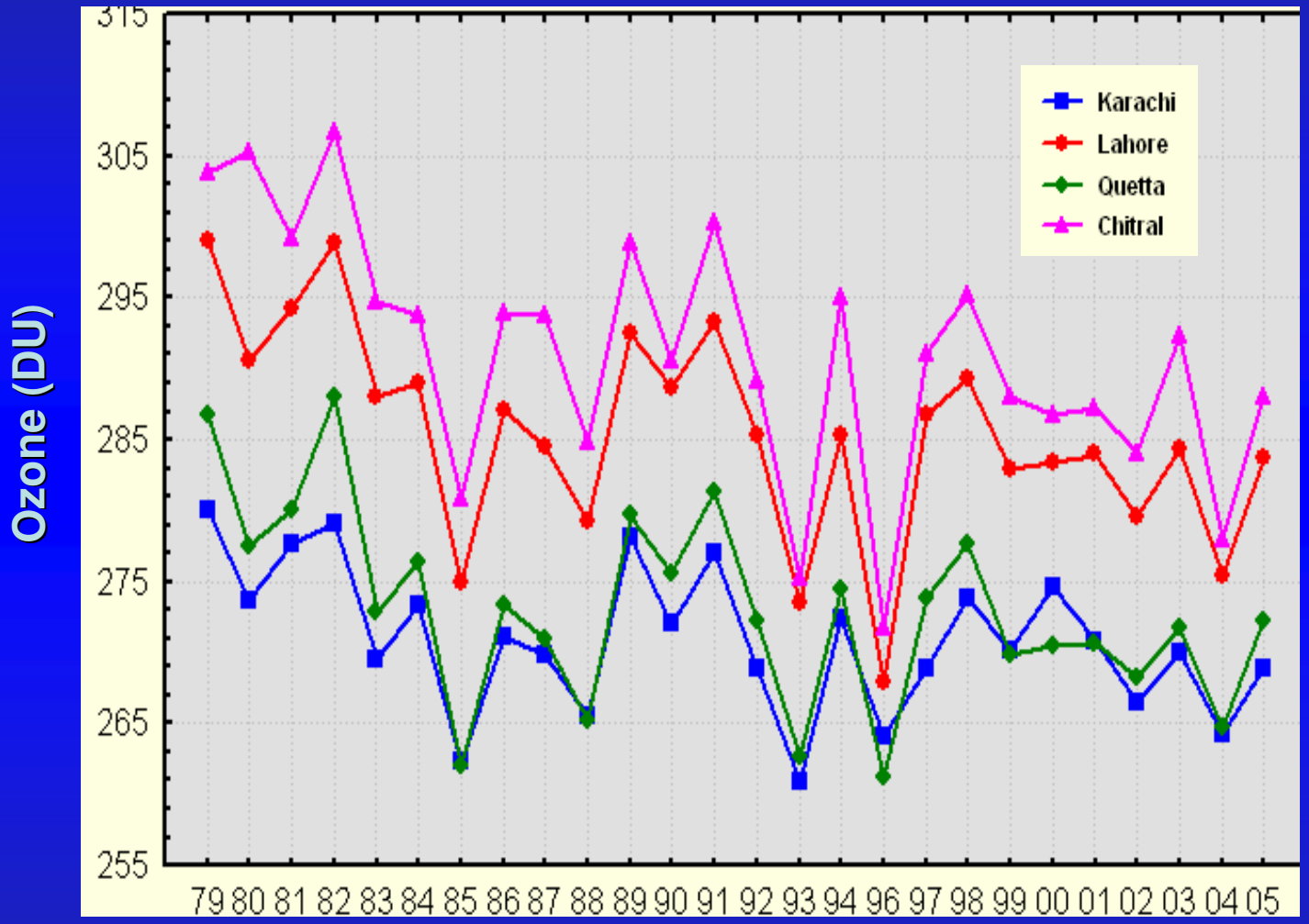


Year 2001

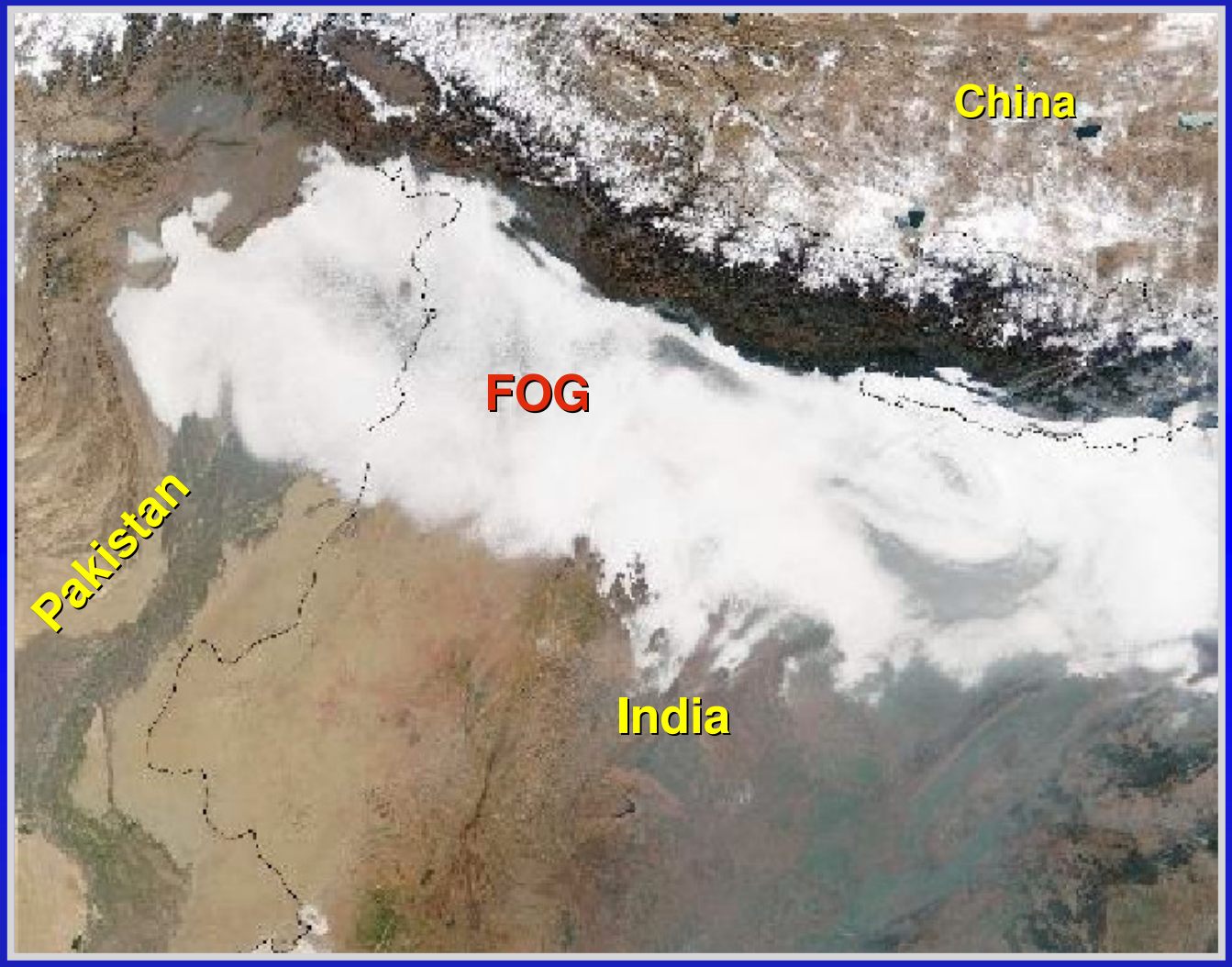




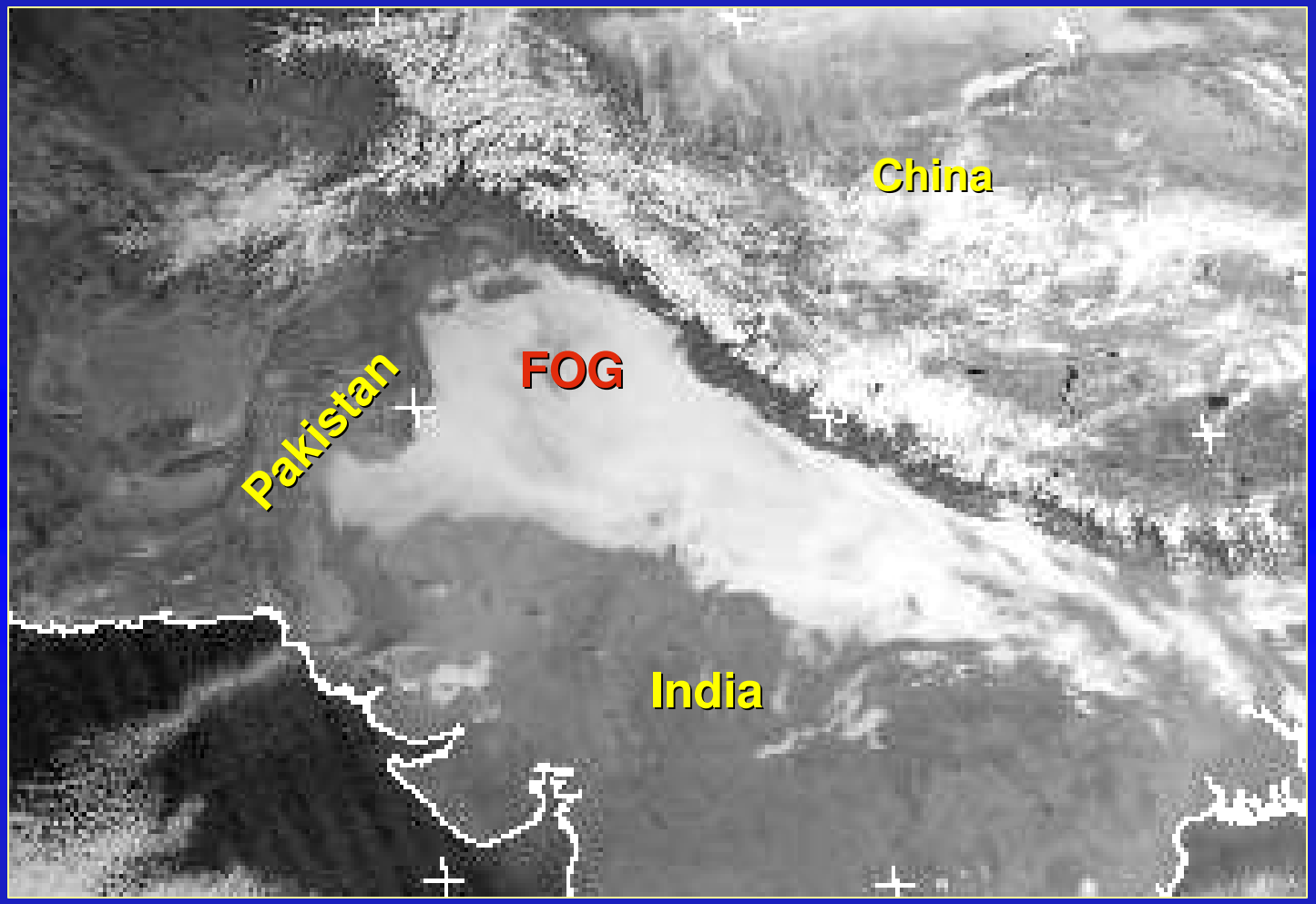
Latitudnal Variation of Yearly Mean of Total Ozone derived from TOMS Data



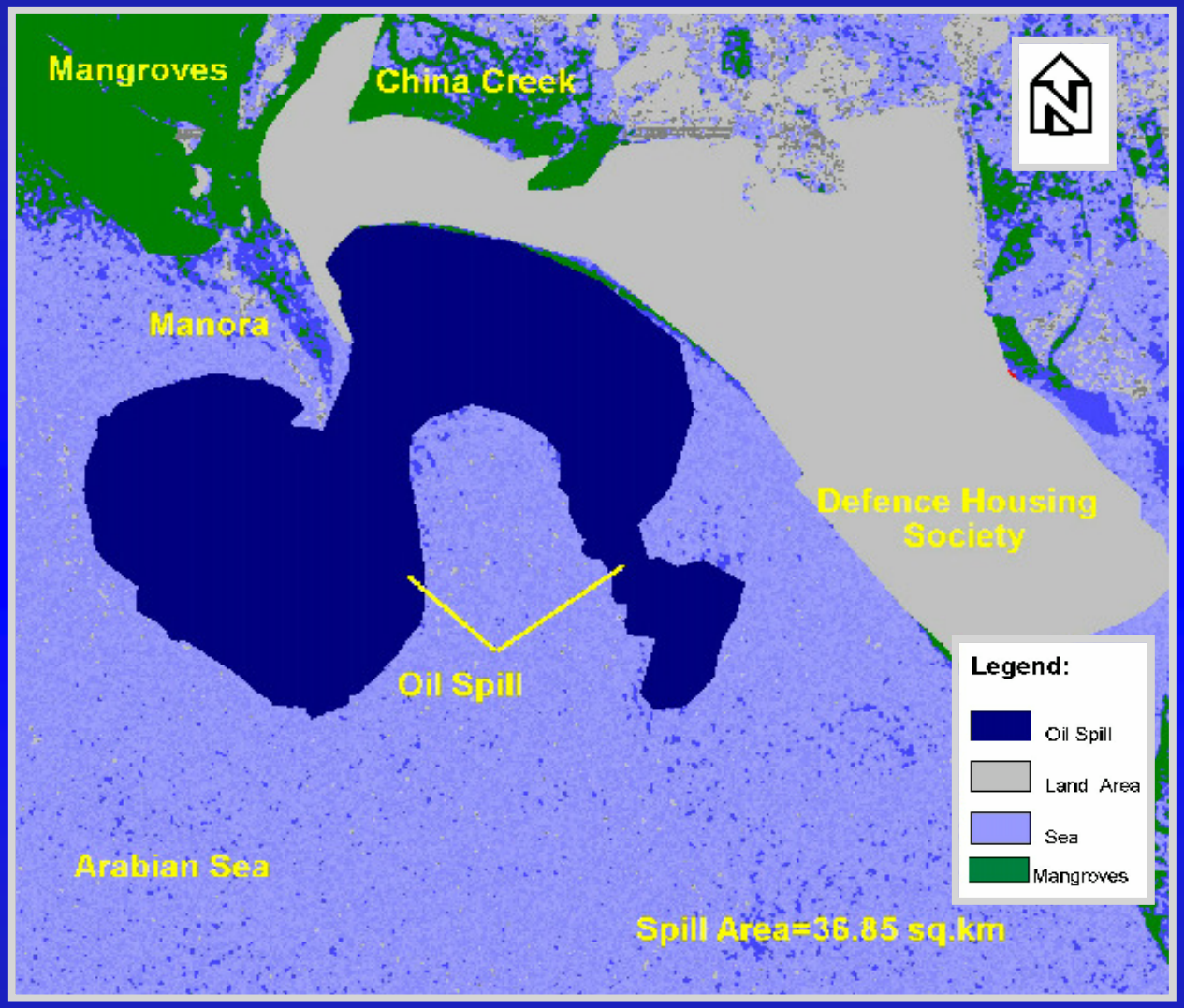
Winter Fog over India and Eastern Part of Pakistan Observed by MODIS on 07-01-2003



Fog as observed by Meteosat-5 on 04-01-2001



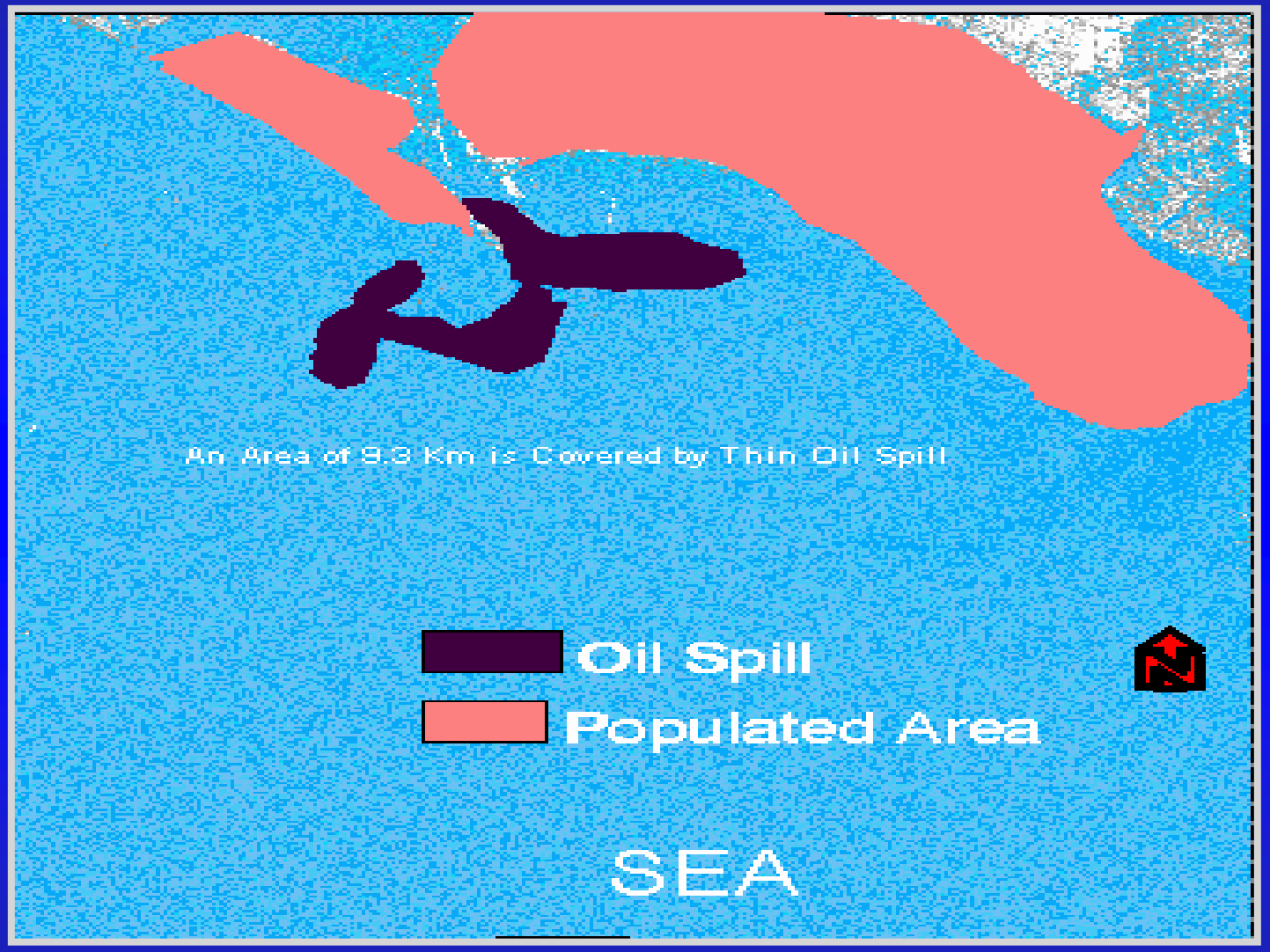
RADARSAT Image of August 19, 2003 (with oil spill)



Space and Atmospheric Science

Courtesy RADARSAT

RADARSAT Image OF December 12 , 2003



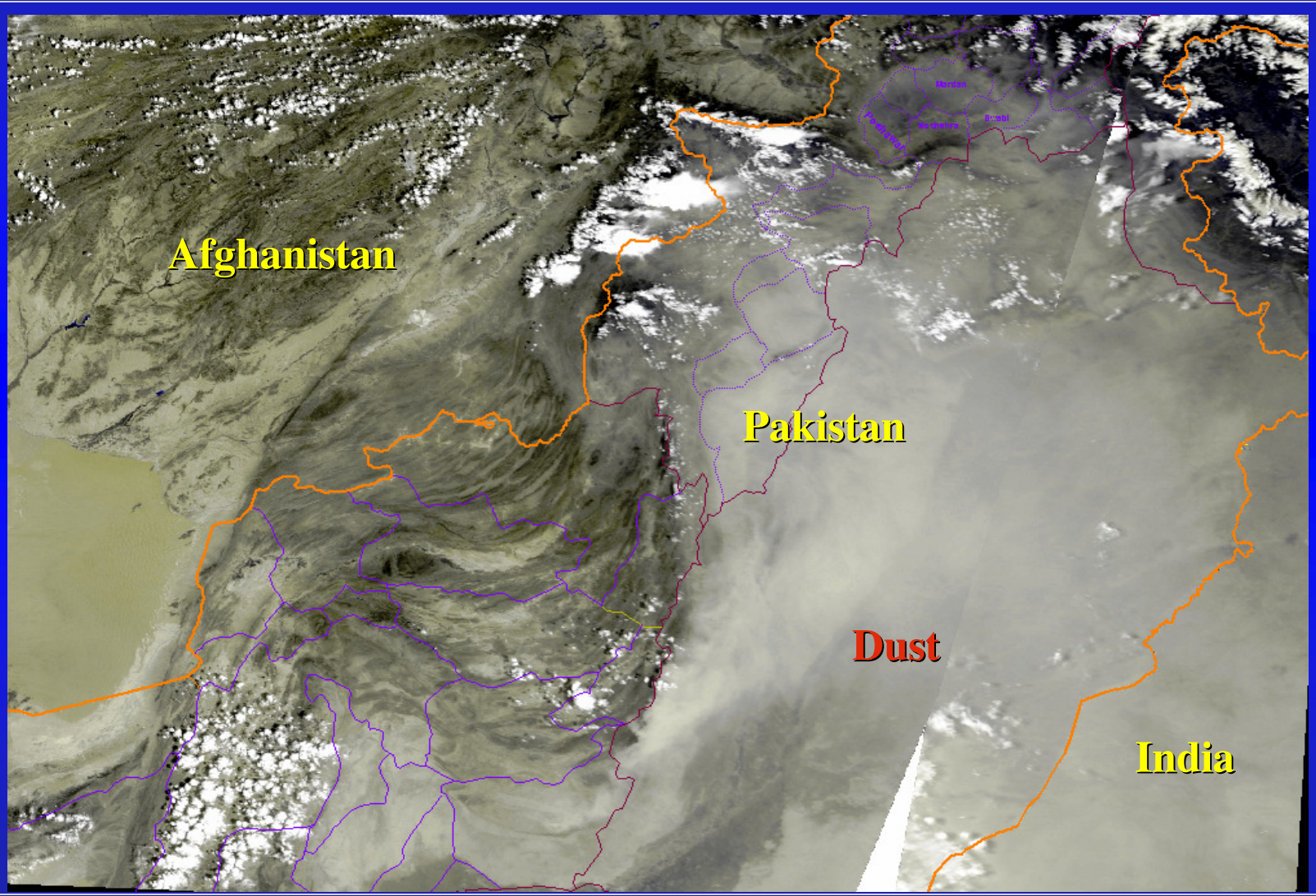
Courtesy RADARSAT

Space and Atmospheric Science

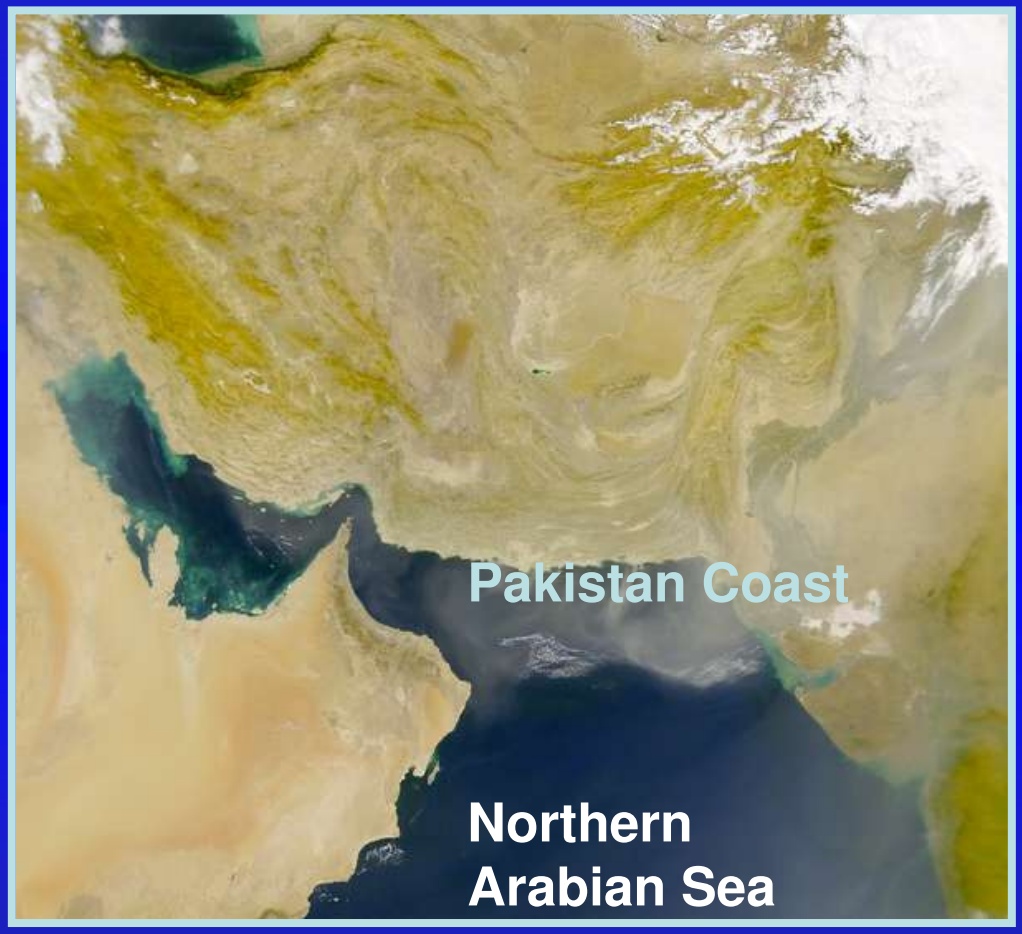
MONITORING DUST STORM

- Dust storms result from extremely hot & dry conditions
- Dust storm obscure land & input to sediment flux in the sea
- Dust storms carry infectious organisms
- Despite blown to height & exposed to Sun radiation, bacteria & fungi survived
- The dust storm sweep thru Pakistan
- MODIS image shows the dust storm in the region

MODIS image showing Dust Storm sweeping thru Pakistan on 22 May 2006

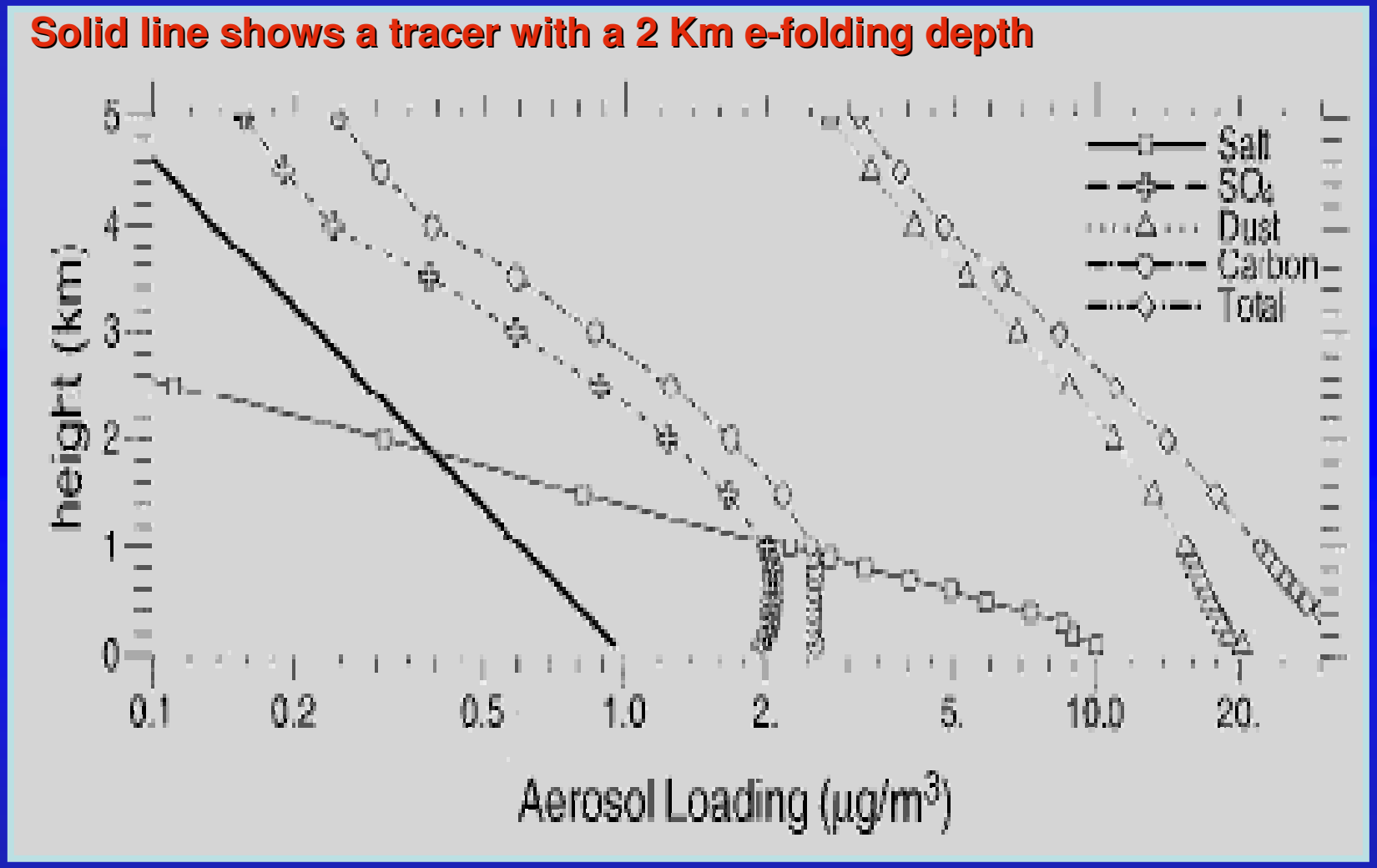


Atmospheric input to sediment flux in the northern Arabian sea - A dust storm transporting sediments through aerosols to the seawater



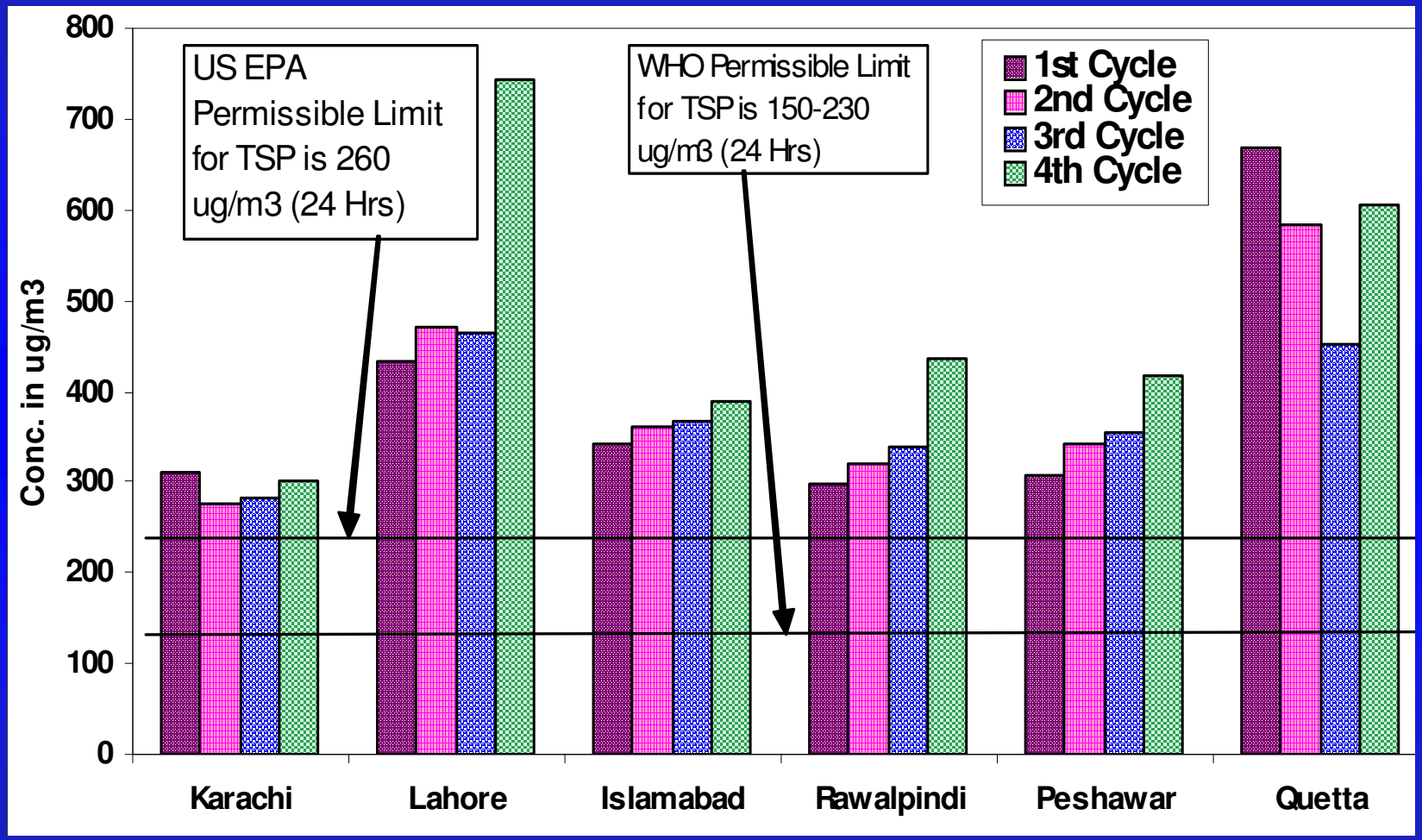
Average Vertical Profiles of Aerosol Constituents over entire INDOEX Region

Solid line shows a tracer with a 2 Km e-folding depth

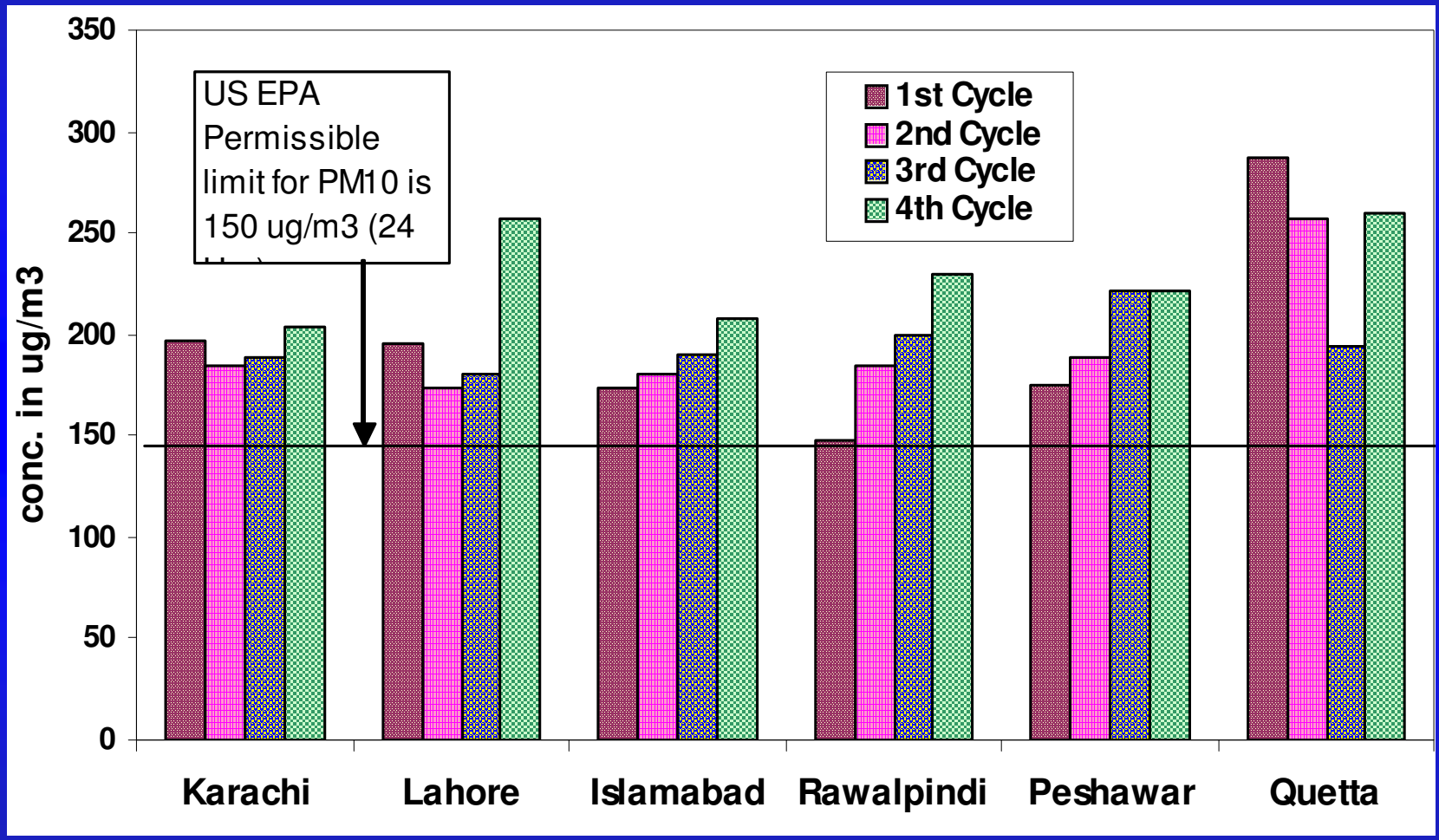


Acquisition of Pollution Data with Ground Instruments

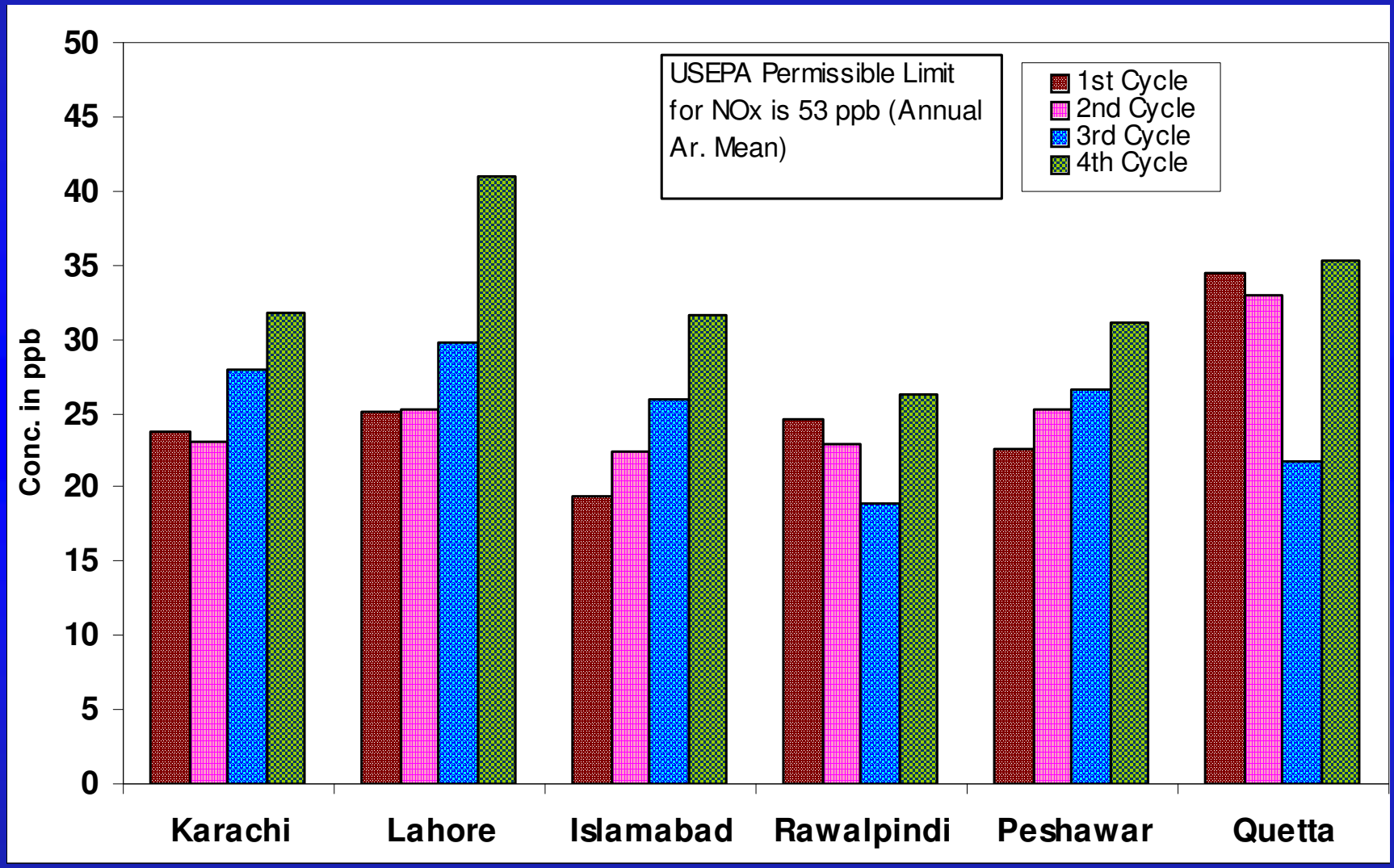
Mean concentration (48 hrs) of TSP in Six Major Cities of Pakistan



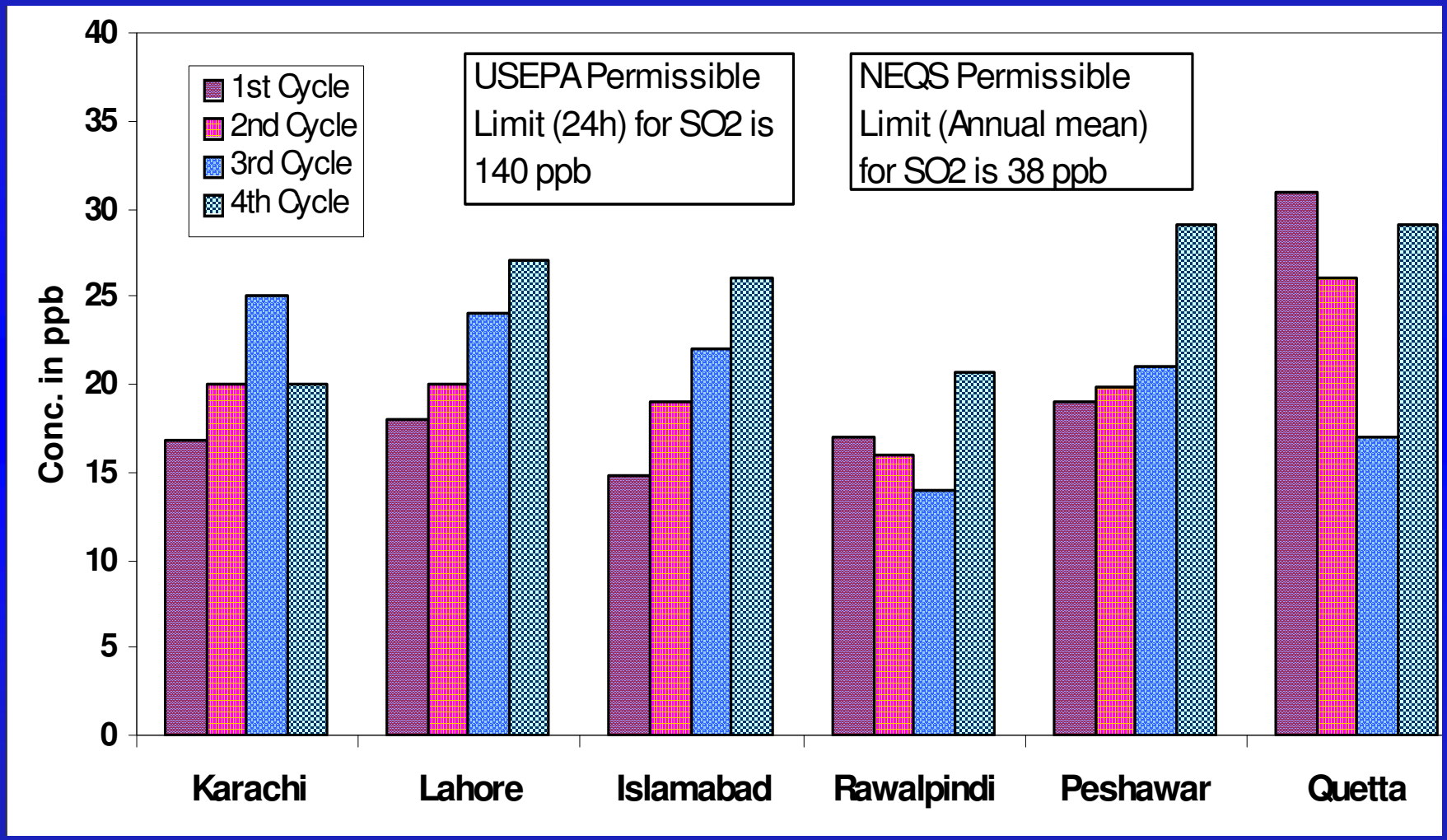
Mean Conc. of PM10 in Six Major Cities of Pakistan



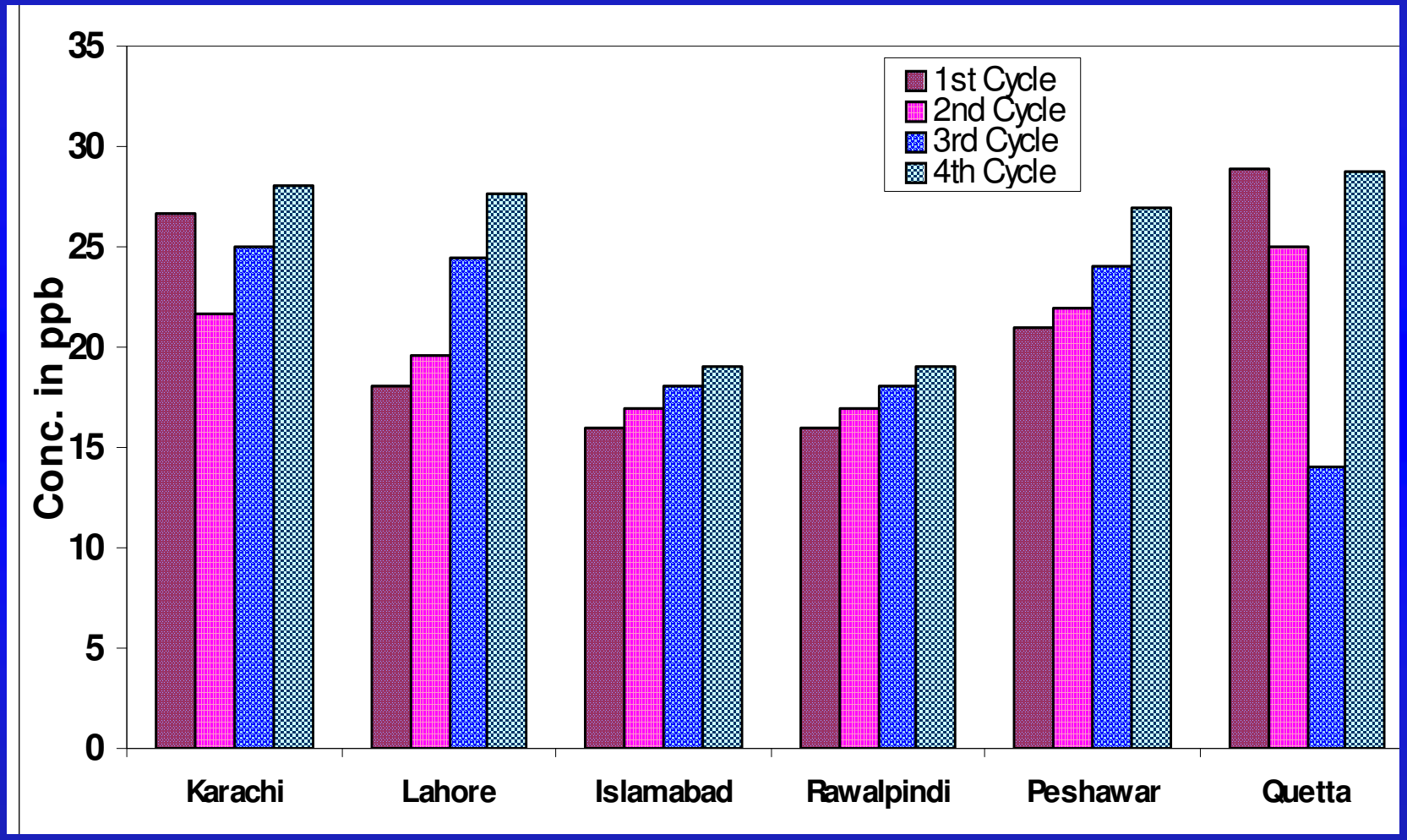
Mean Conc. of NOx in Six Major Cities of Pakistan



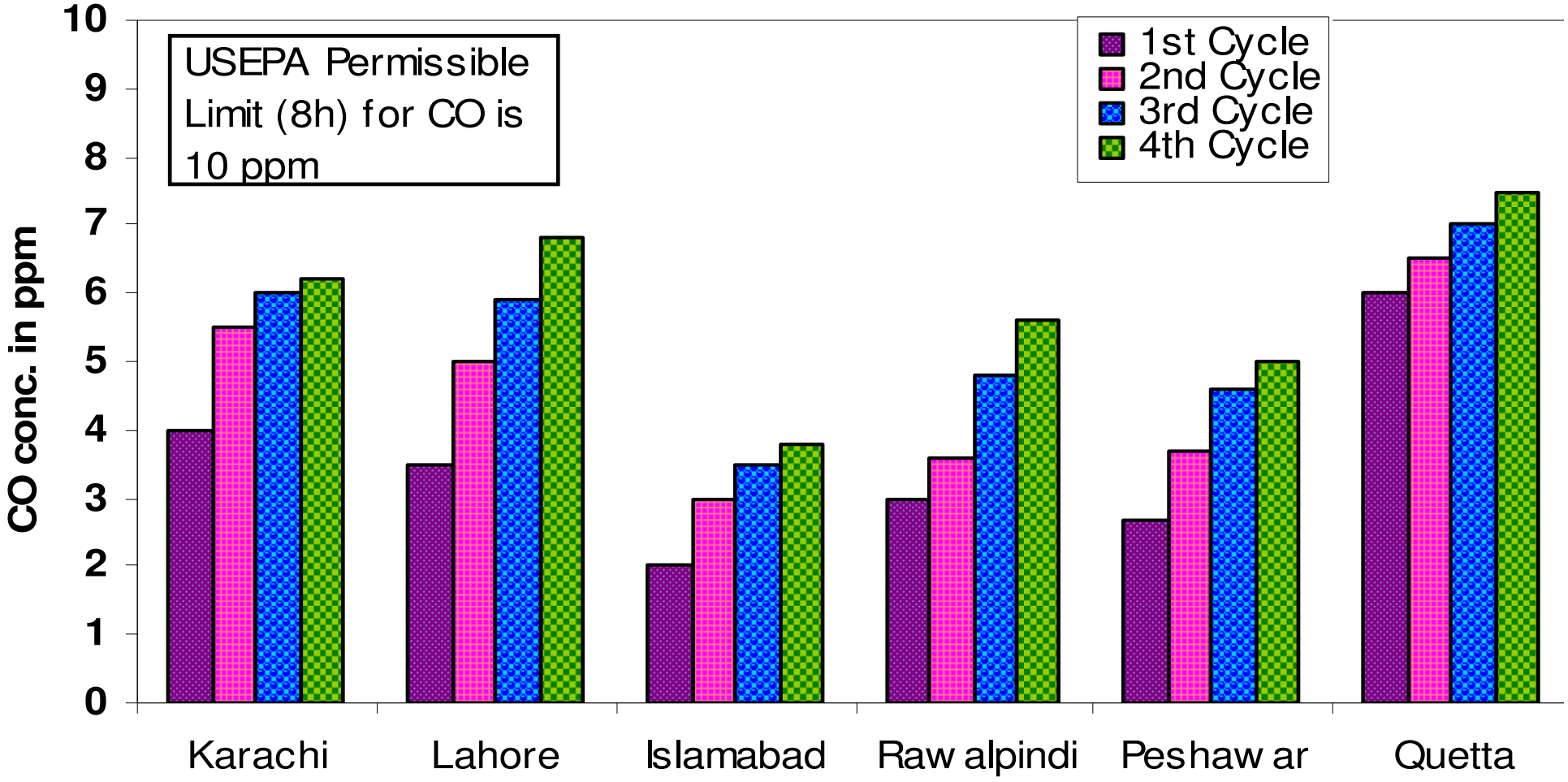
Mean (48hrs) Conc. of SO2 in Six Cities of Pakistan



Mean Average Concentration of Ozone in Six Major Cities of Pakistan



Mean Concentration of CO in Six Major Cities of Pakistan

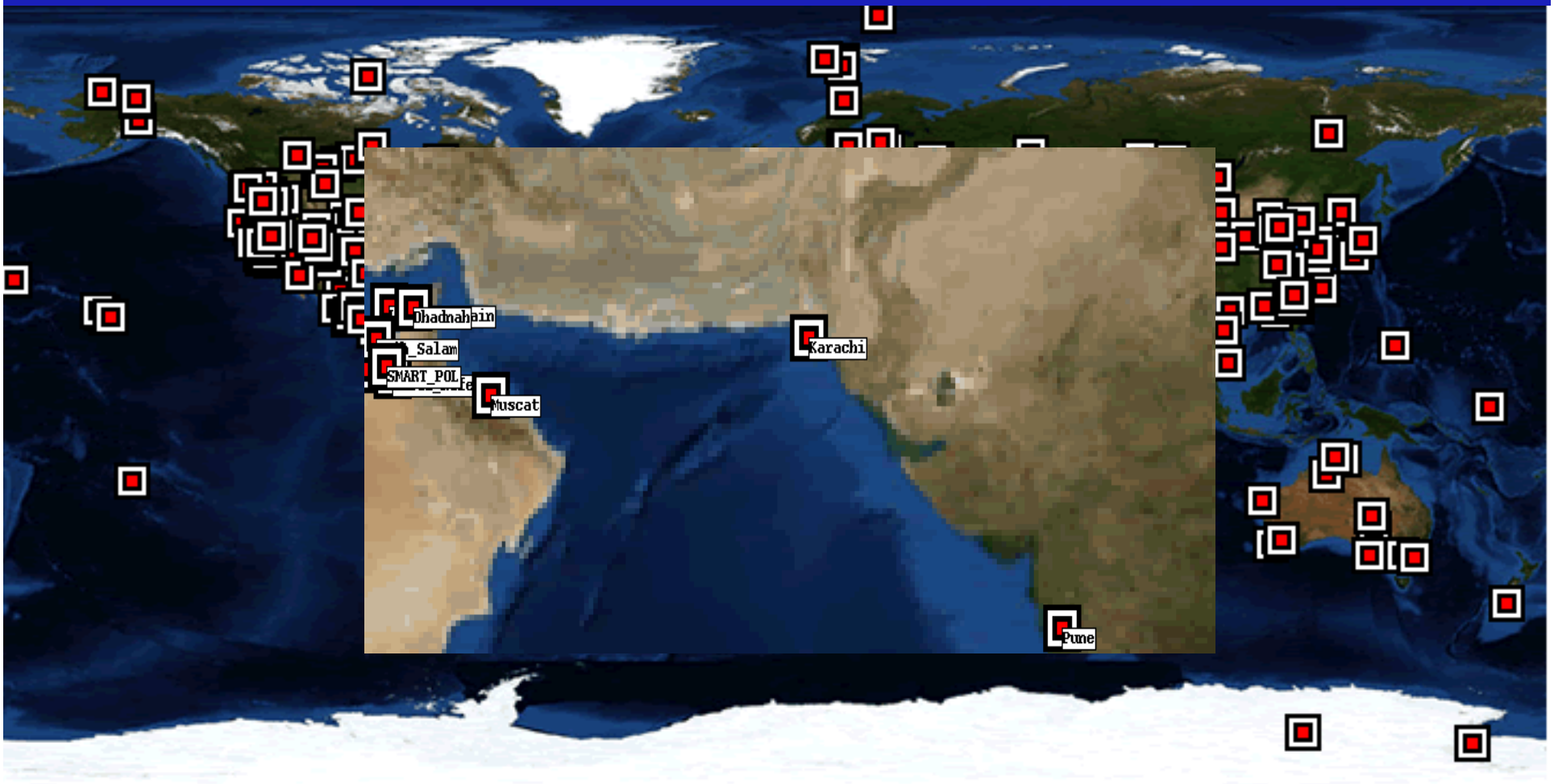


Urban Air Quality in Pakistan

- Air Pollution is major cause of acute respiratory disease, asthma and bronchitis
- Air pollution can also cause acidification of lakes and soils and impacts on crop productivity, forest growth, and biodiversity
- Air pollution directly injures trees by damaging living tissue, primarily foliage, and impairs photosynthesis
- Air pollution with airborne particles can block the sunlight reaches the surface hence tends to cool the surface. Through this cooling, there is a tendency for the surface to reduce its sensible and latent heat flux and also impact on the microphysical properties of clouds

International Participation

International Participation

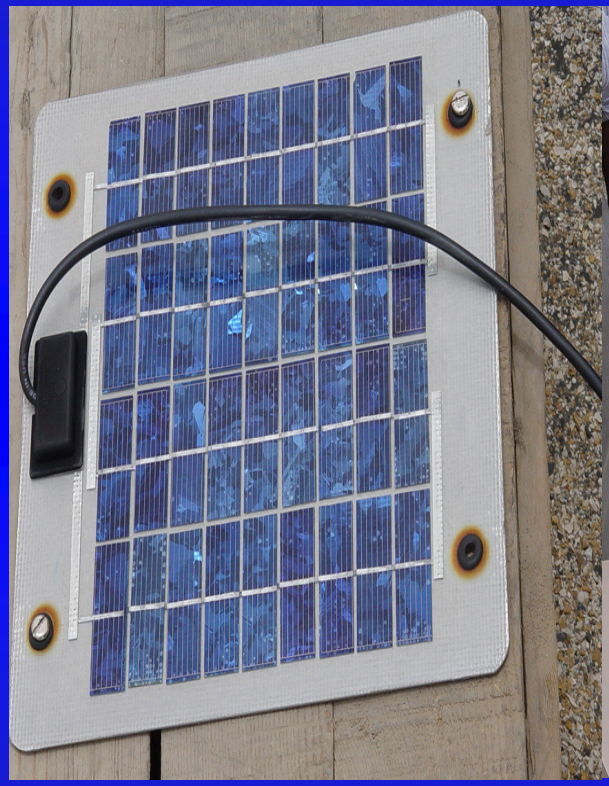


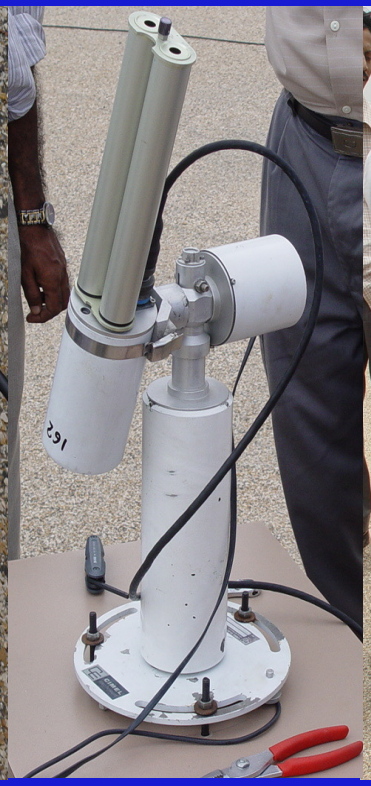
Objectives of Aerosol Robotic Network Program

- Investigate the potential of aerosol particles to influence cloud and turbulence properties of the marine boundary layer
- Significantly improve the understanding of the properties and concentration of aerosols and their relationship to aerosols on global and regional scales
- Validation of Satellite with Ground Data

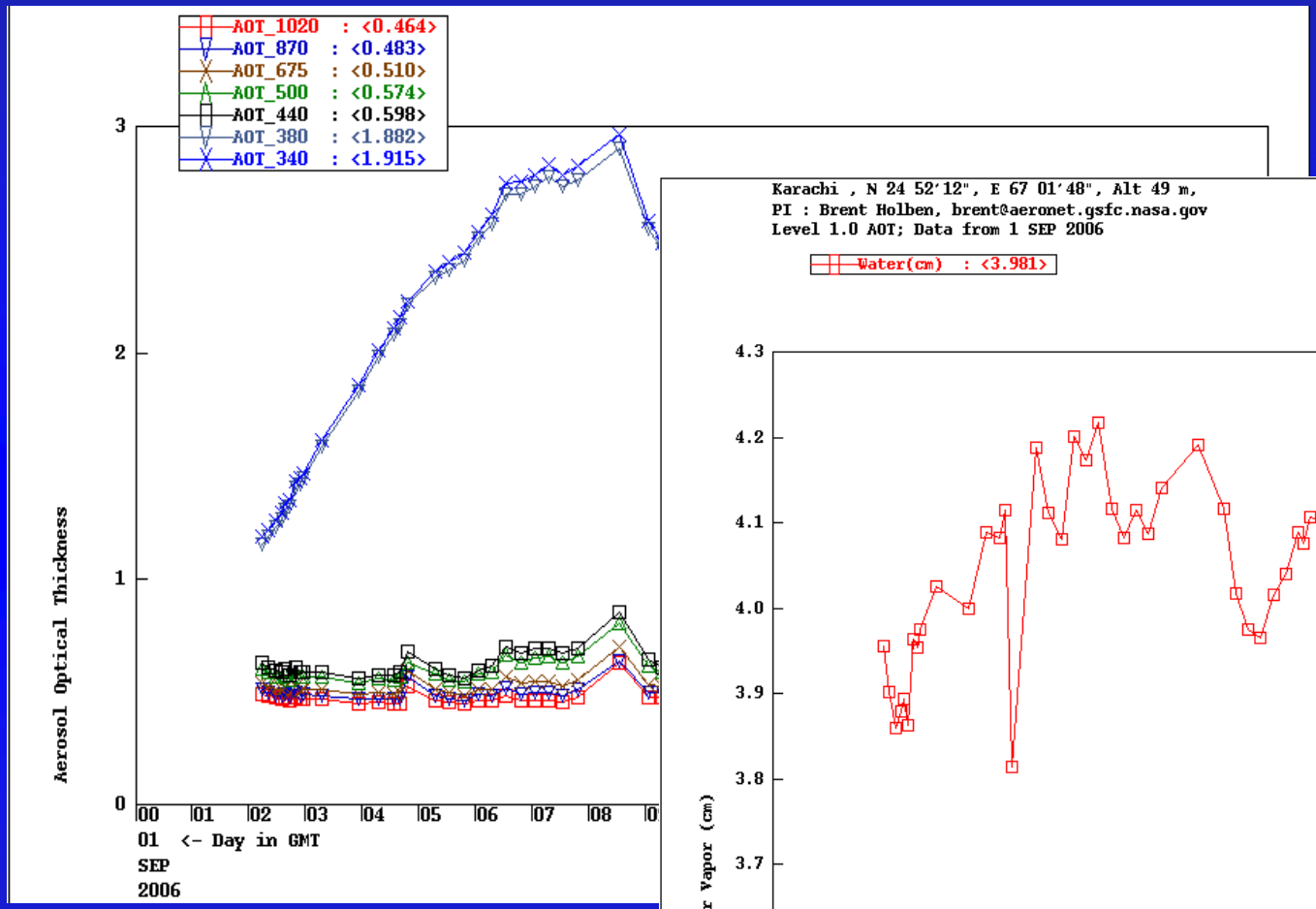
AERONET

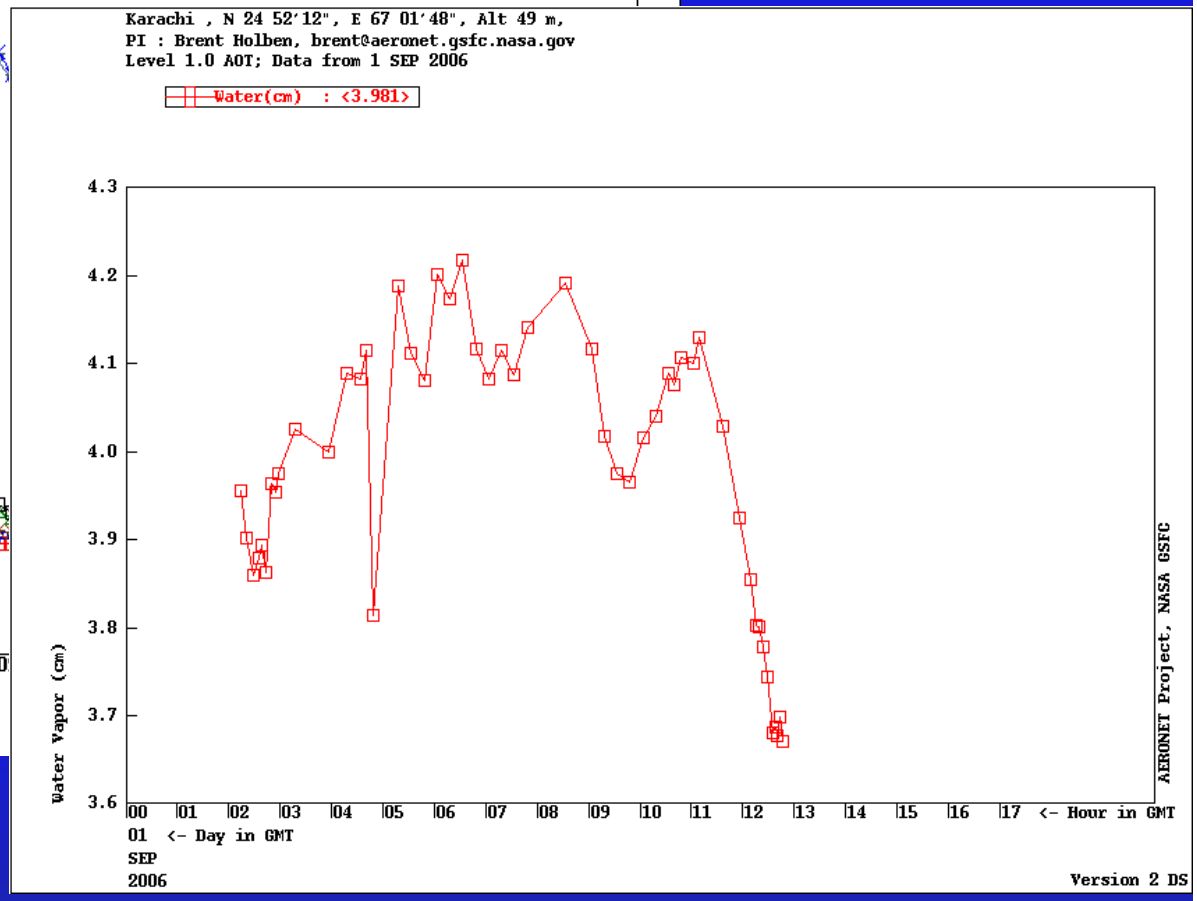
AEROSOL ROBOTIC NETWORK





AOT Unscreen Data from 01 SEP 2006 at Karachi





Challenges

- Lack of access to data
- Spatial and temporal gaps in data sets
- Data interoperability
- Uncertainty about data continuity
- Lack of data interpretation capacity in developing countries

Recommendations

- Encourage development of scientists and researchers that develop skills in the integrated use of remote and in situ observation systems
- Translation of technical data and products to tools that support decision-making related to societal needs by those who make these kinds of decisions
- Improve interactions between the technical elements and other aspects of societally-relevant decisions: social, economic, political, cultural

End of Presentation