Modeling Atmospheric Aerosols

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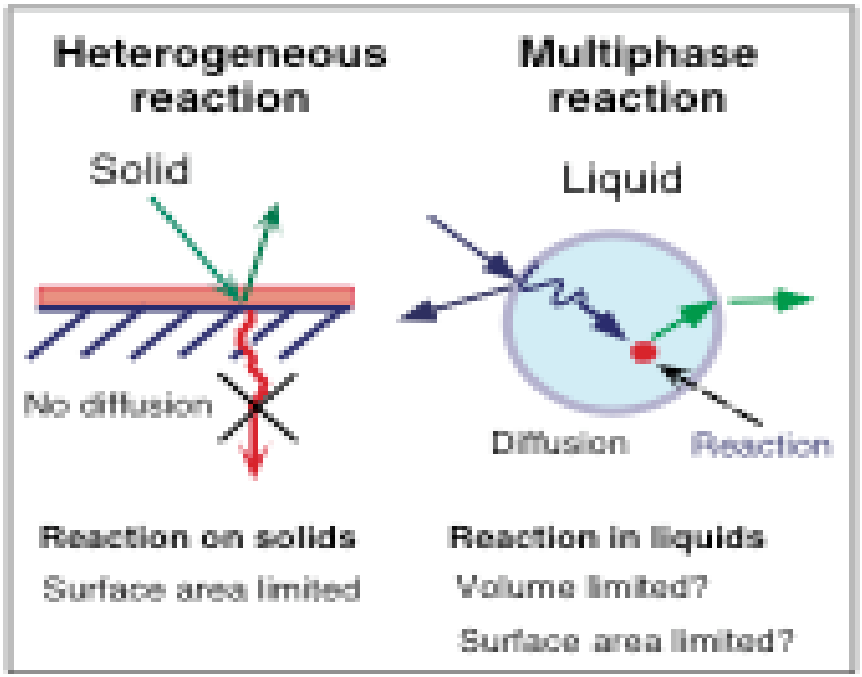
Outline

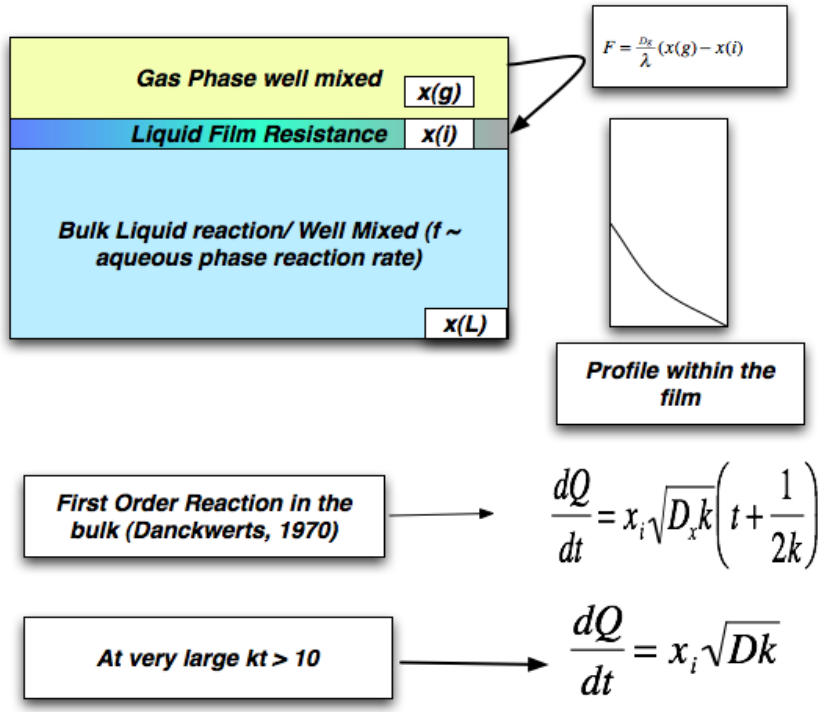
- Atmospheric Aerosols and gas phase heterogeneous reactions
- Regional Scales and Atmospheric Aerosols
- Regional Scale Aerosols: Ganges Valley Aerosol Experiment (GVAX)

Gas – Liquid Reactions – Heterogeneous /Multiphase Pathways

Aerosol mediated heterogeneous/multiphase reactions can speed up reactions compared to purely gas-phase and affect the steady state concentrations in the atmosphere



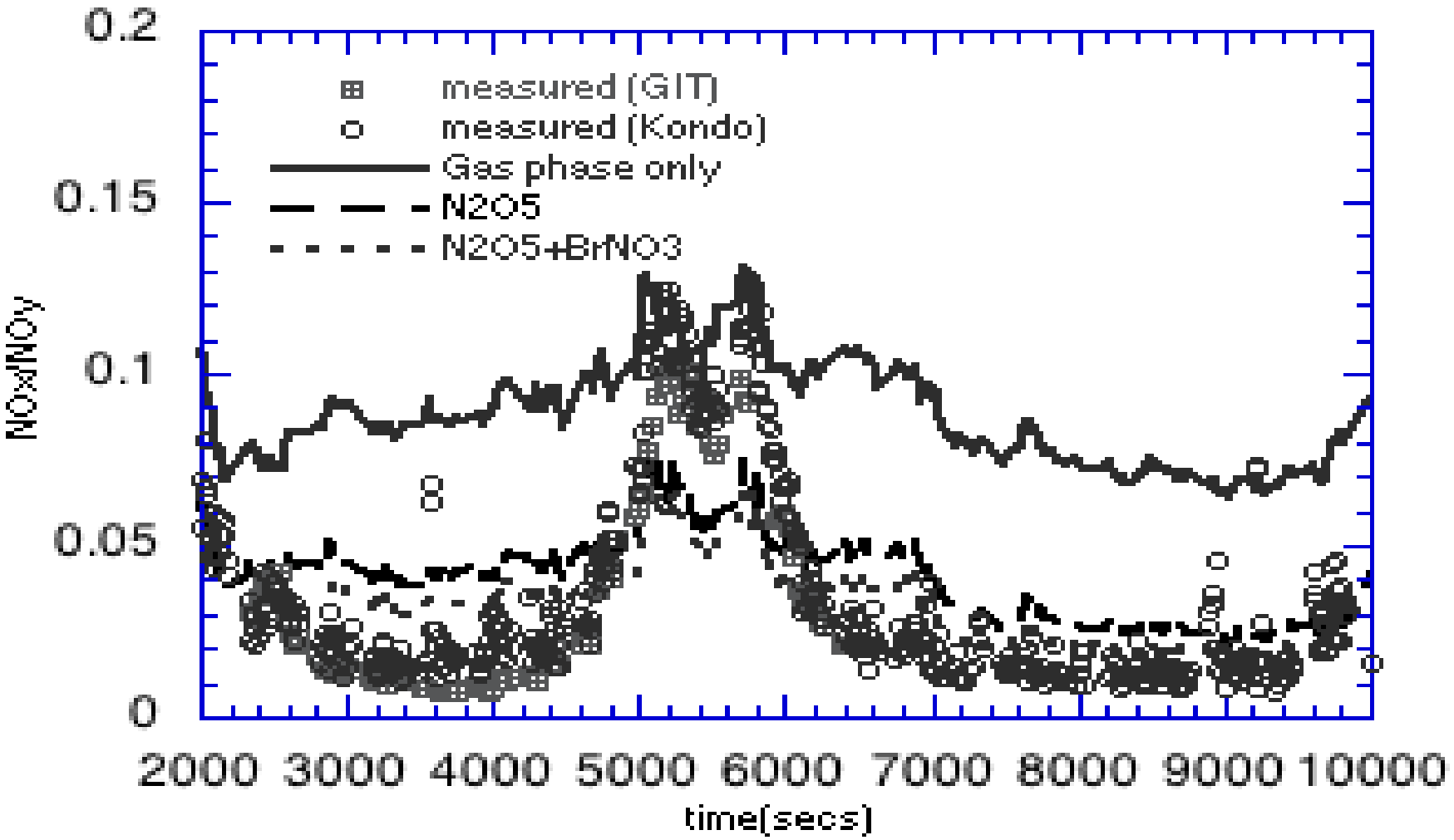
Ravishankara, Science, 1996



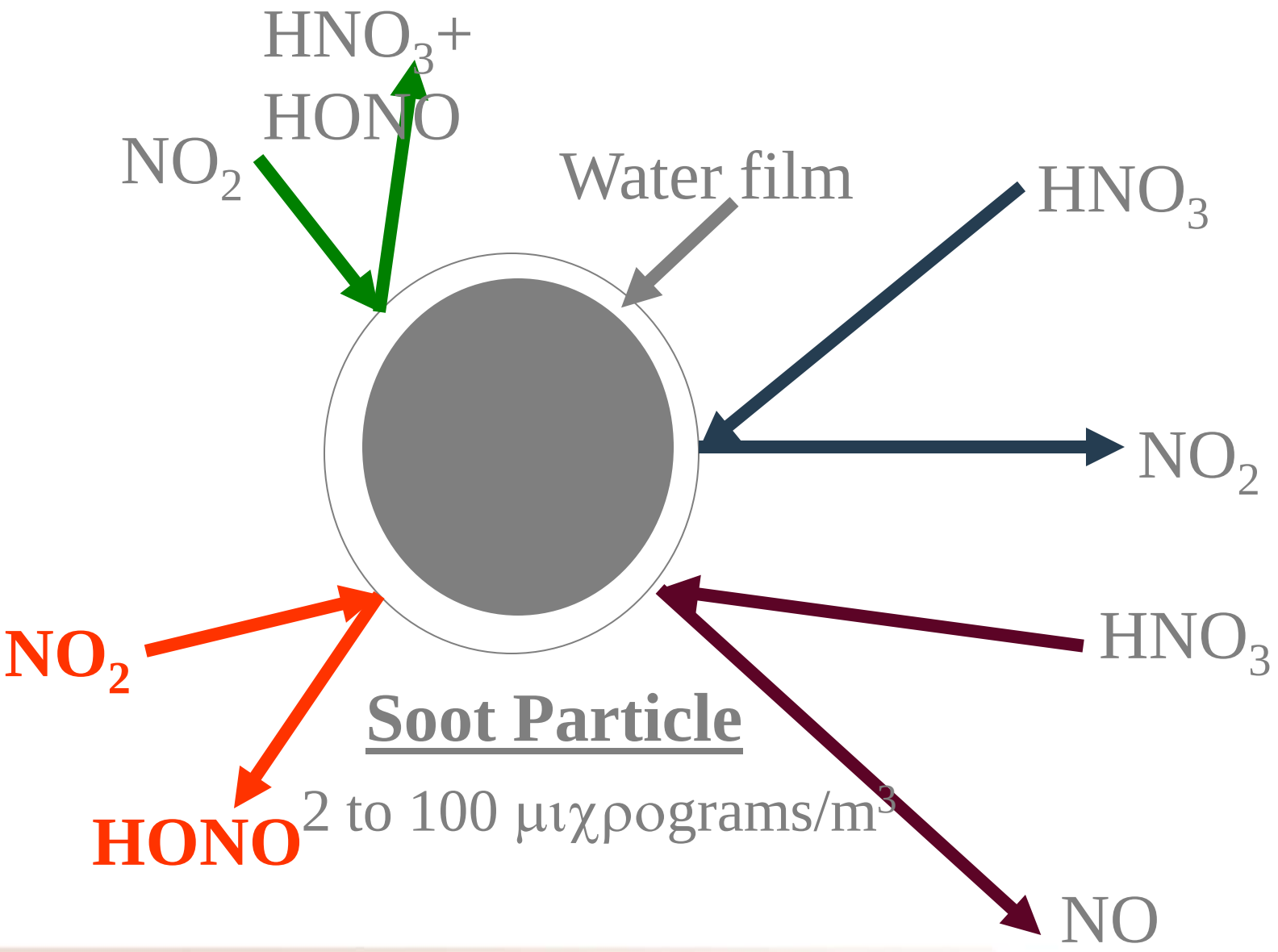
$$\frac{dx_g}{dt} = -kx_g \qquad k = \frac{\omega A \gamma}{4}; \qquad \gamma = \frac{4RT}{\omega} H\sqrt{D_x k}$$

over the surface area of the aerosol

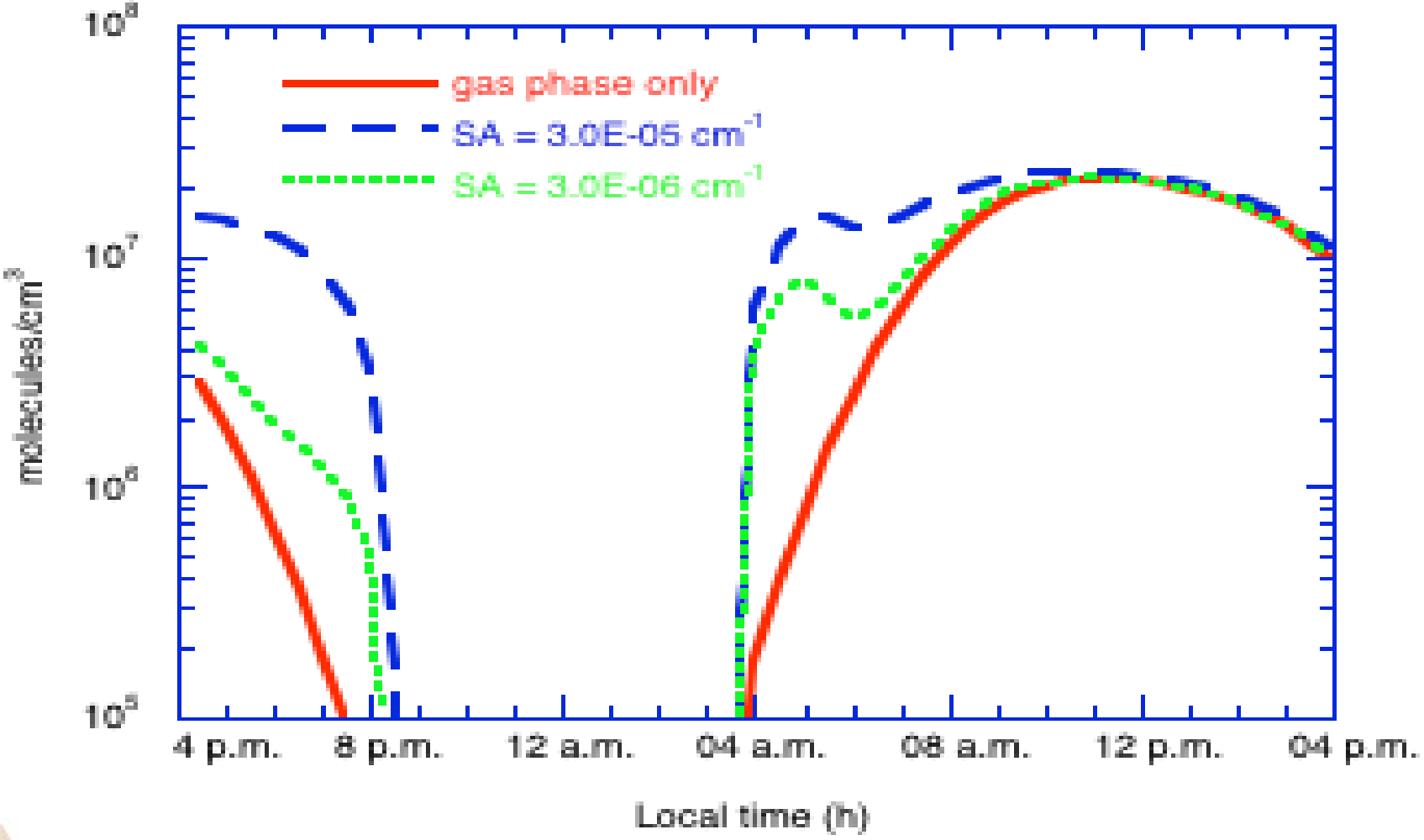
Sulfate aerosol in the upper troposphere – hydrolysis of N_2O_5



Night time/Dawn oxidant production Speedup



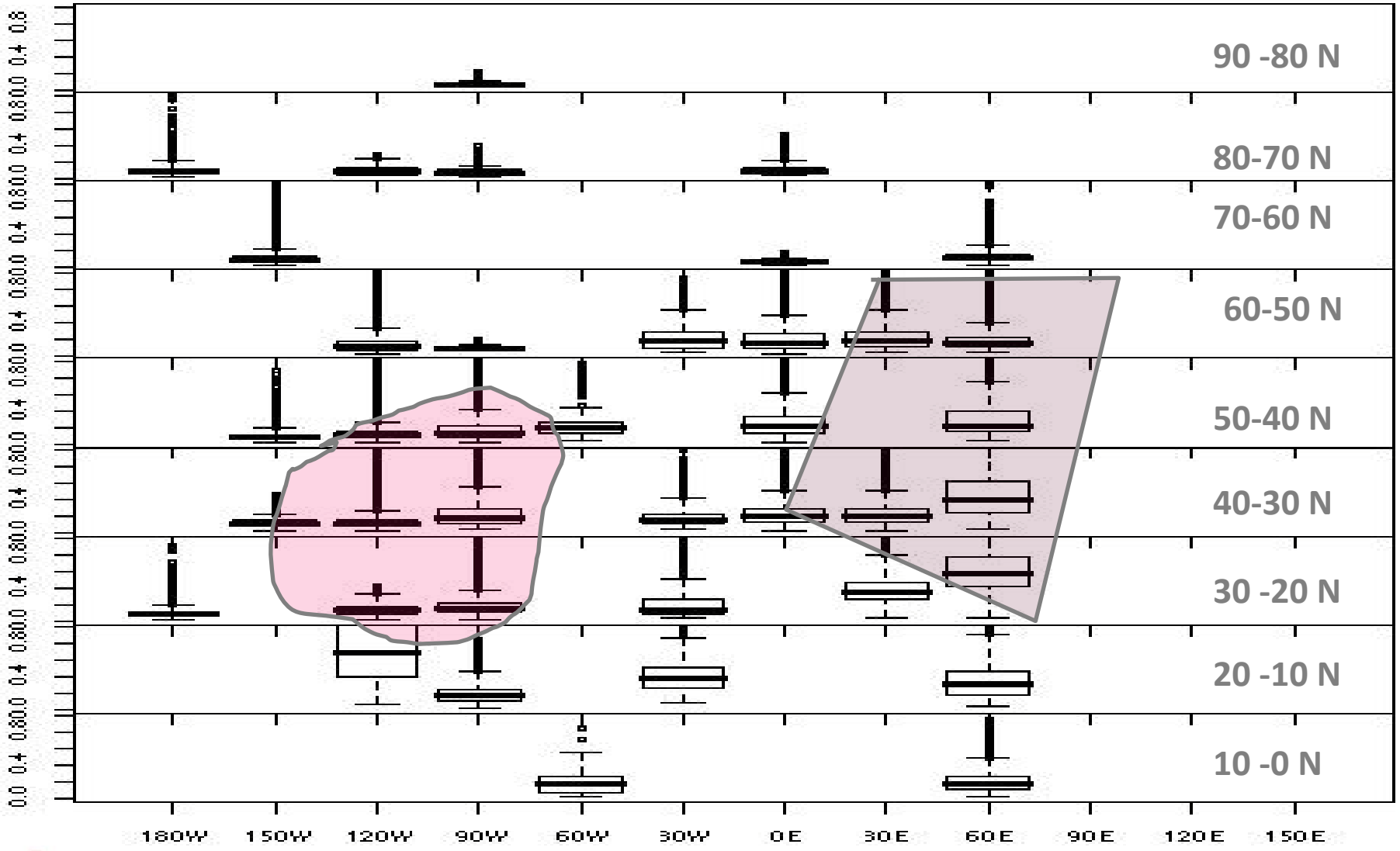
OH (molecules/cm^3)



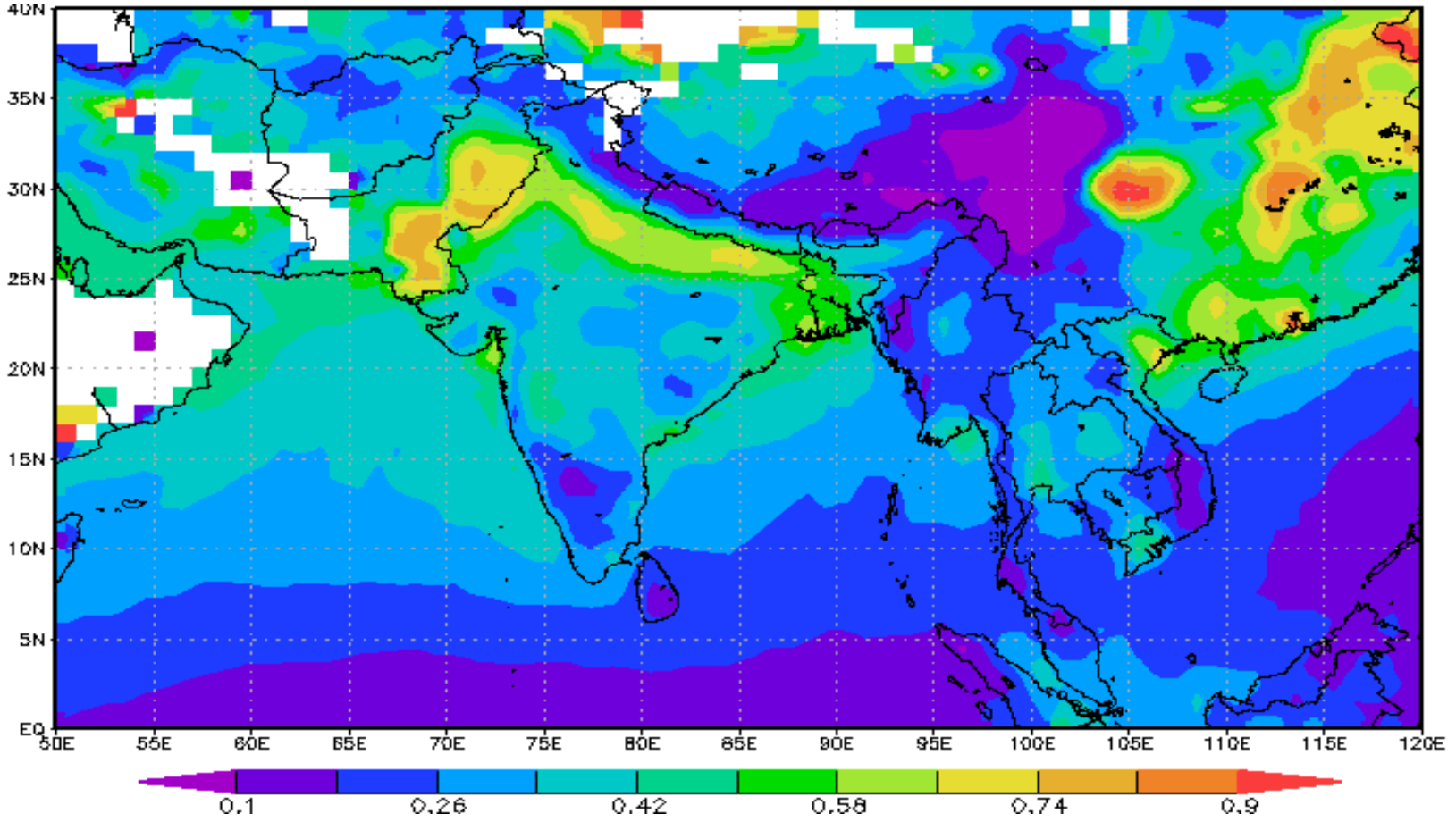
Gas Phase Chemistry and SOA formation

- Gas phase oxidation drives the formation of precursors that lead to SOA formation
- Volatility of these VOC degradation products and primary emissions is key for determining the aerosol mass.
- Oxidant levels, oxidant precursors in the gas phase thus will influence SOA formation.
- Several new studies indicate increasing SOA yields with increasing NO_x mixing ratios.
- The SOA cycle seems closely linked to gas-phase chemistry and would be interesting to see if there are any coupled systems in this SOA-Oxidant/heterogeneous reactions-SOA cycle.

AERONET Data (spring – 1992-2004) – v2 500nm (AOT)

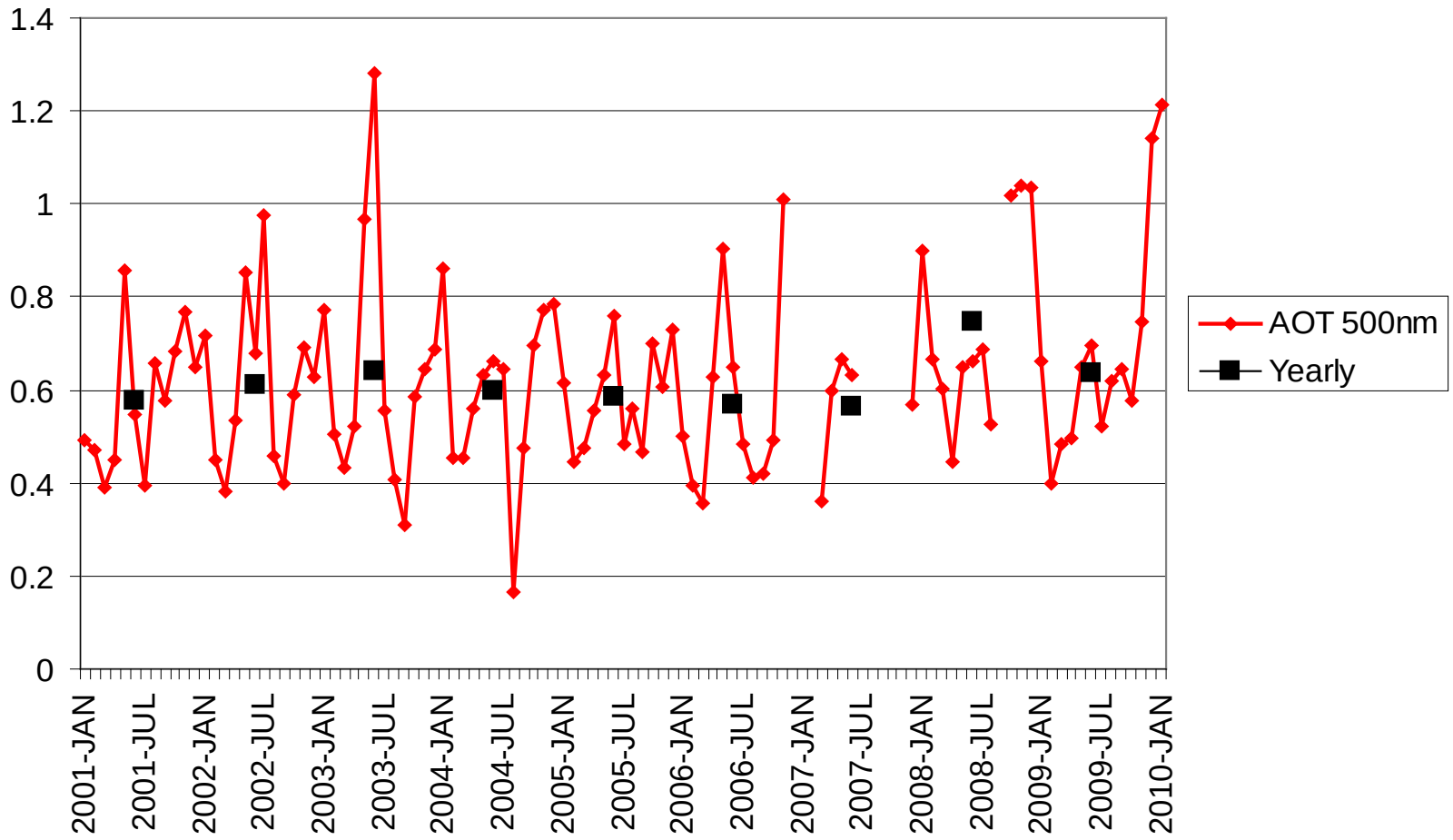


MODIS Data shows high AOD's in the Ganges Valley Region



Multi-angle imaging spectroradiometer AOD values at mid visible wavelengths (558 nm) averaged over the years 2005-2008.

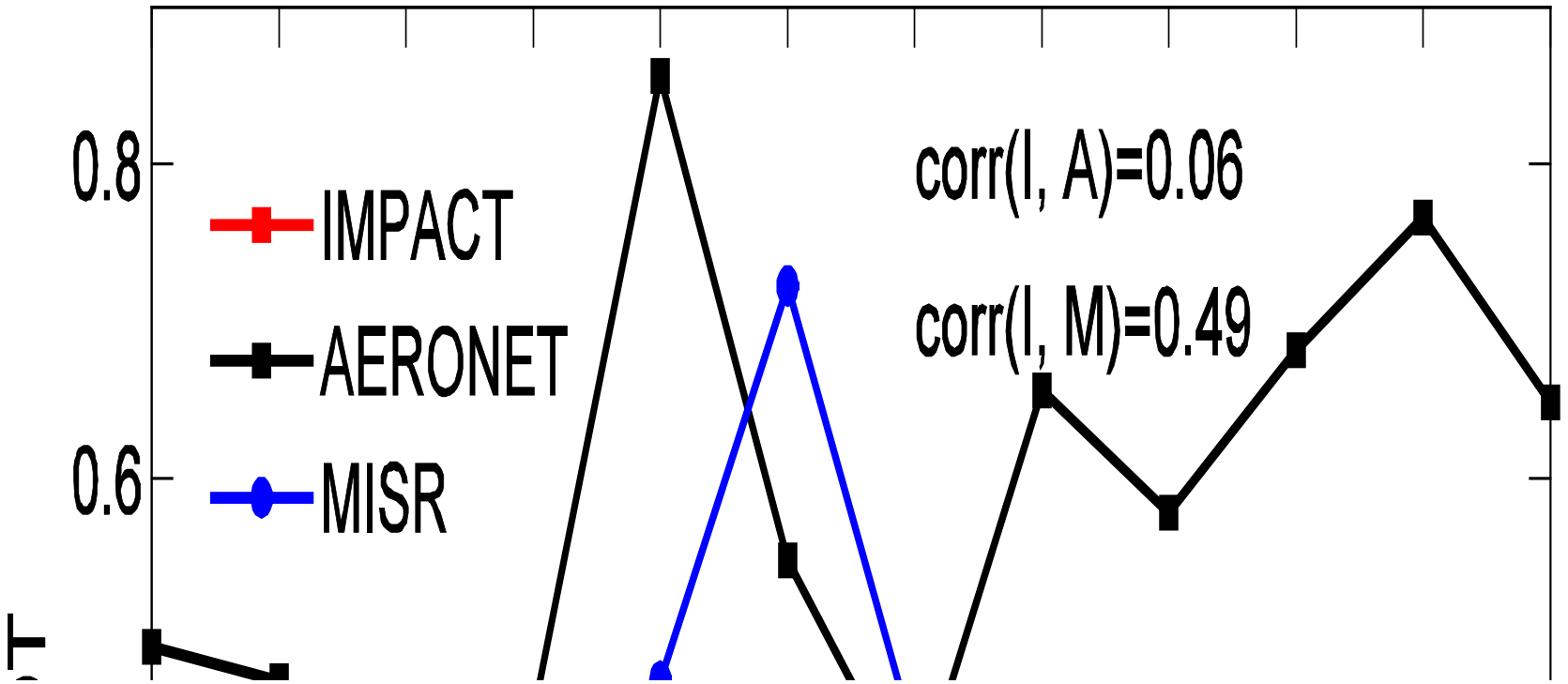
10-year AERONET AOT data at Kanpur



Comparison of Model (IMPACT) and Data (AERONET and MISR)

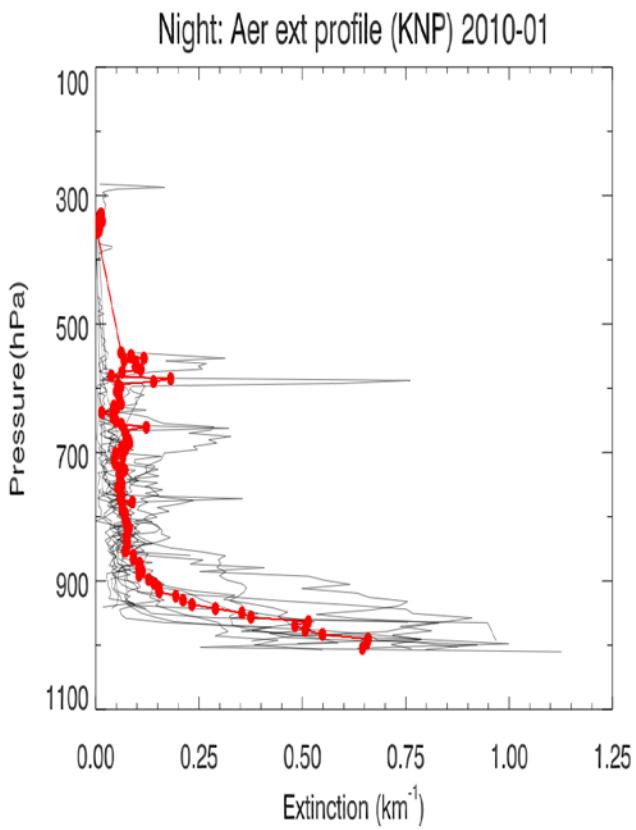
2001 Kanpur

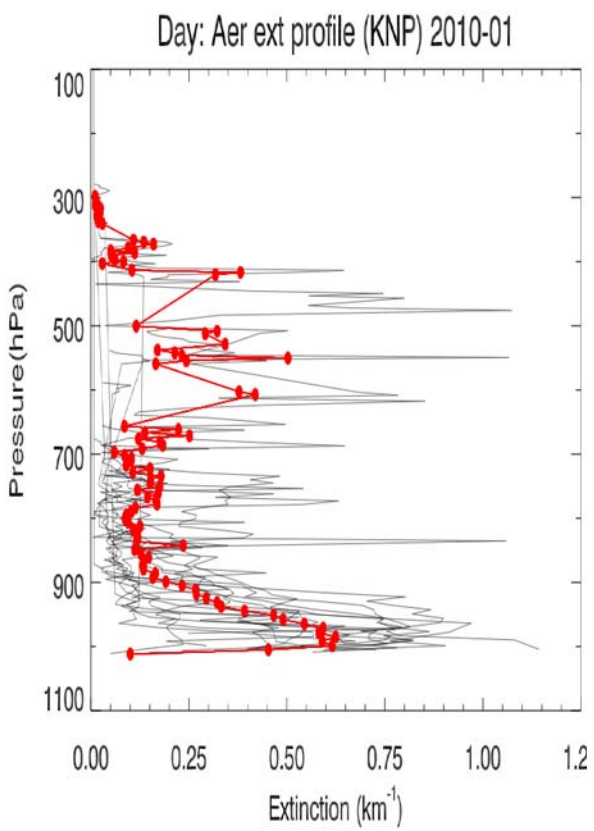
KANPUR



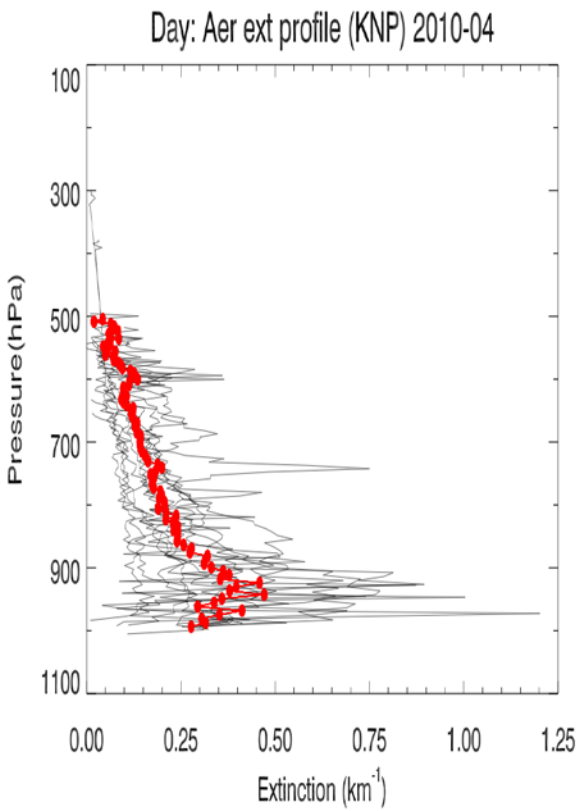
CALIPSO extinction Profiles

January

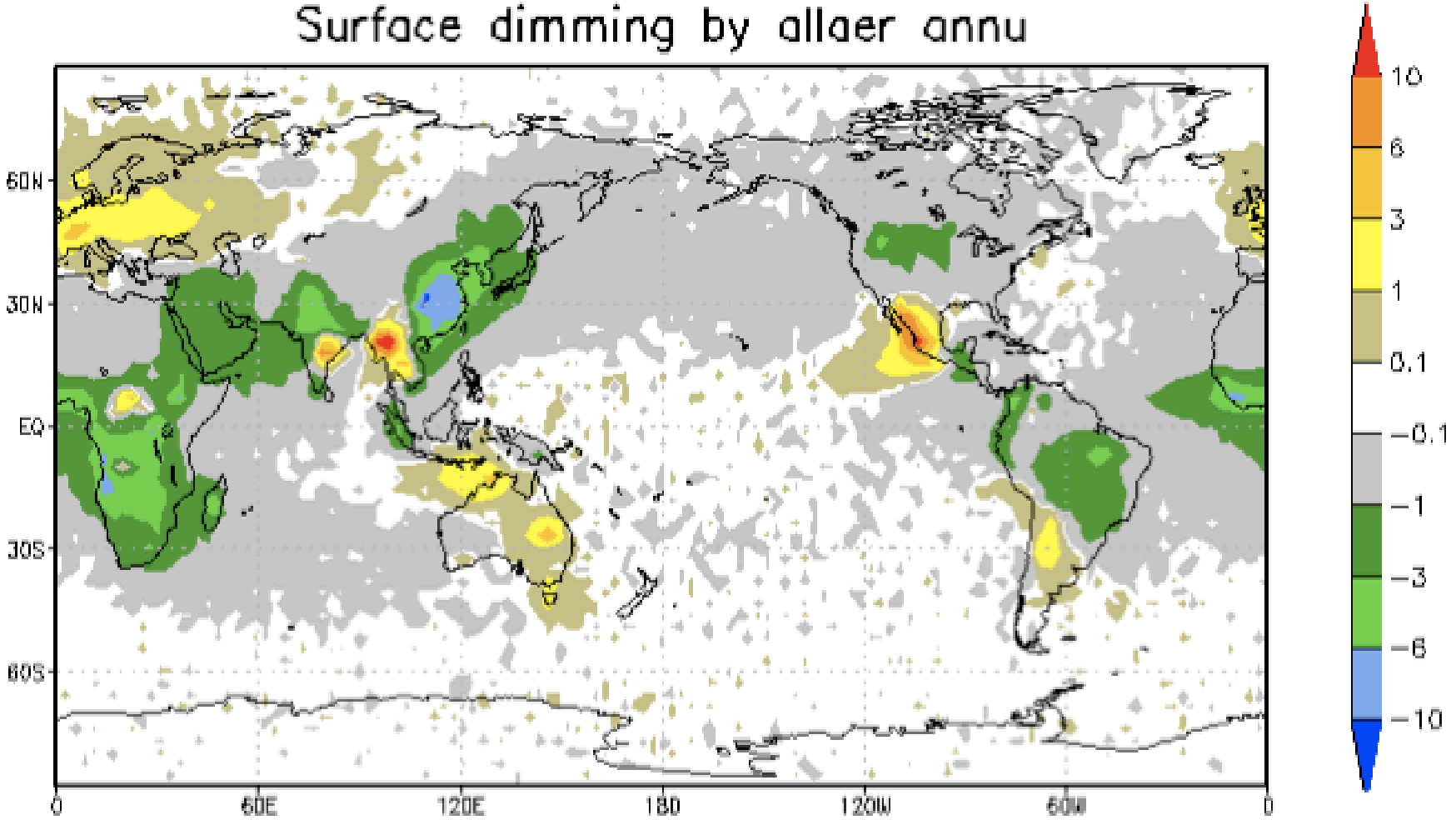




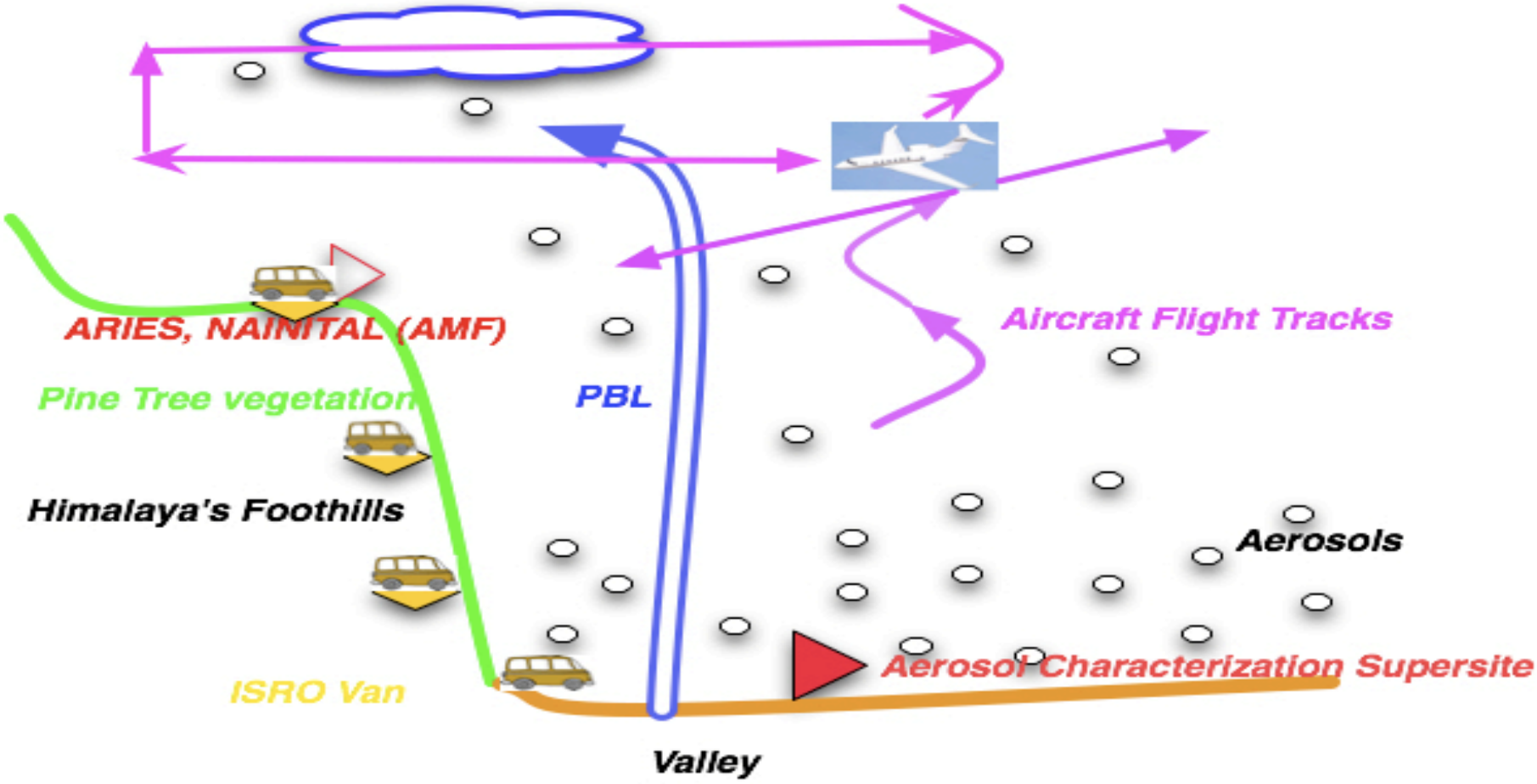
April



Estimated Changes in All-sky Surface Solar Radiation due to Anthropogenic Aerosols (1975 - 2000)

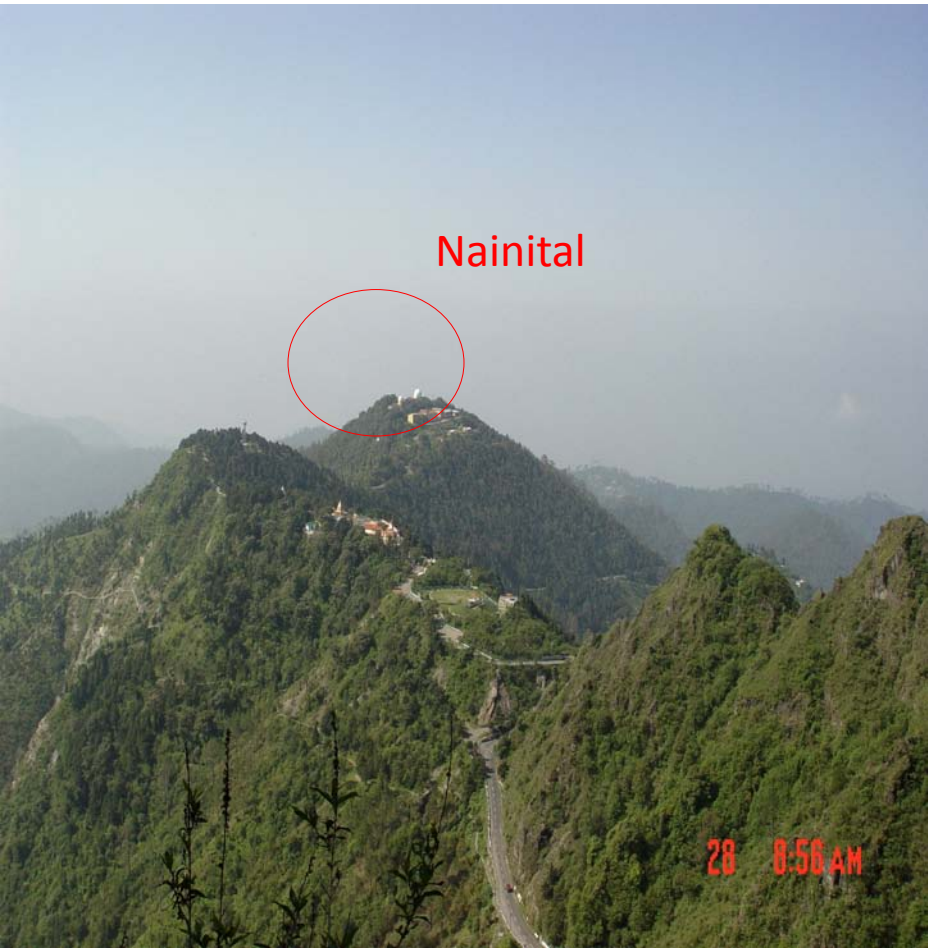


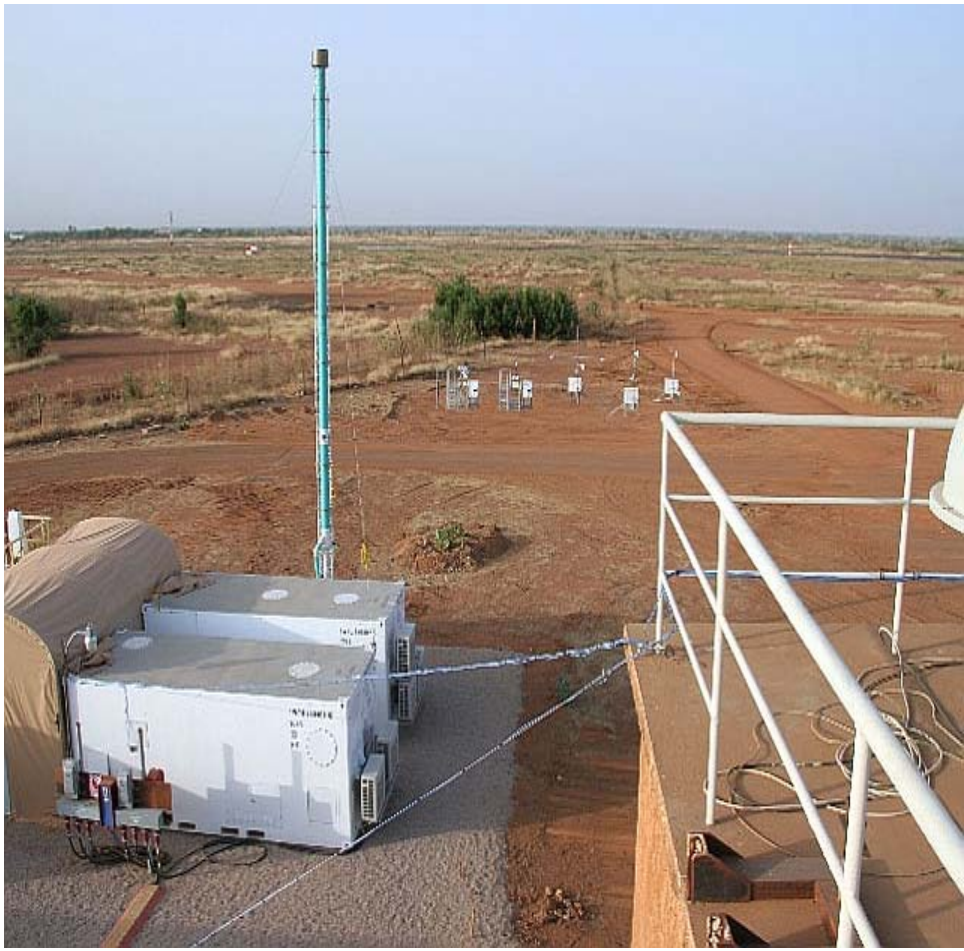
We Plan To Understand The Anthropogenic Aerosol Behavior, Aerosol Composition and its Affect on Heating Rates: (Winter)



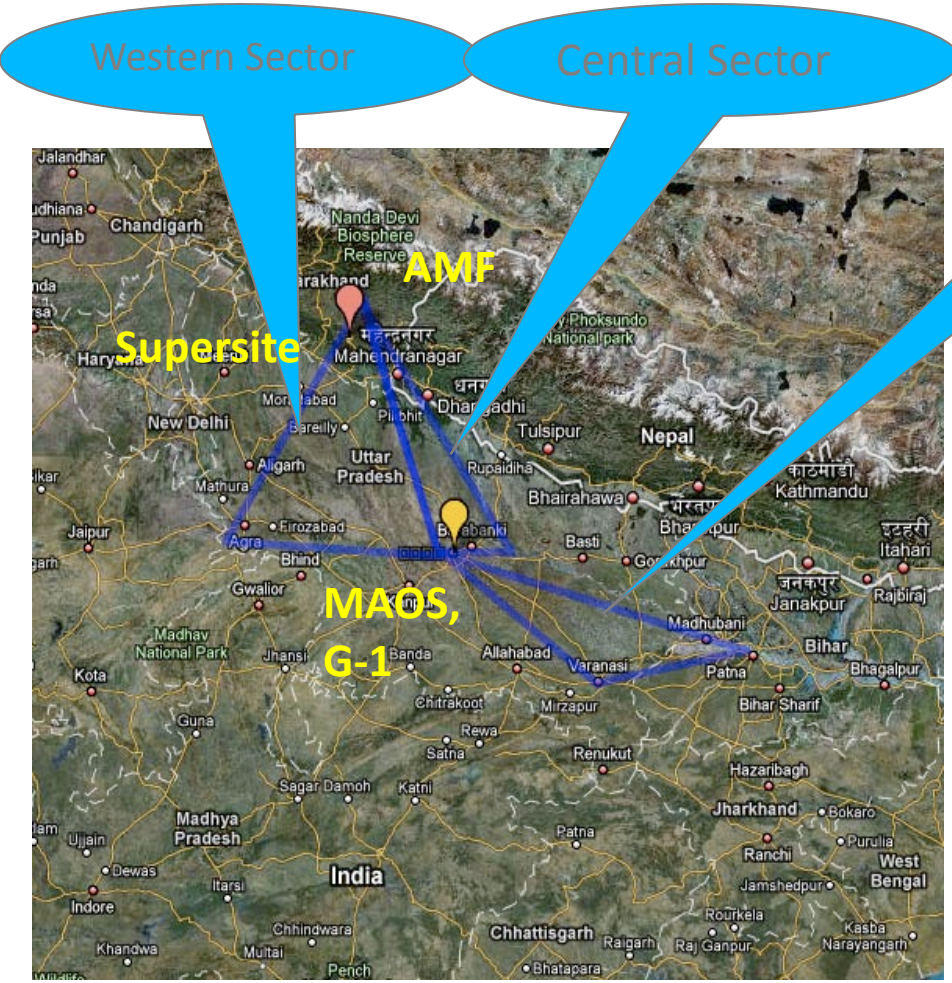
A conceptual diagram of the proposed study

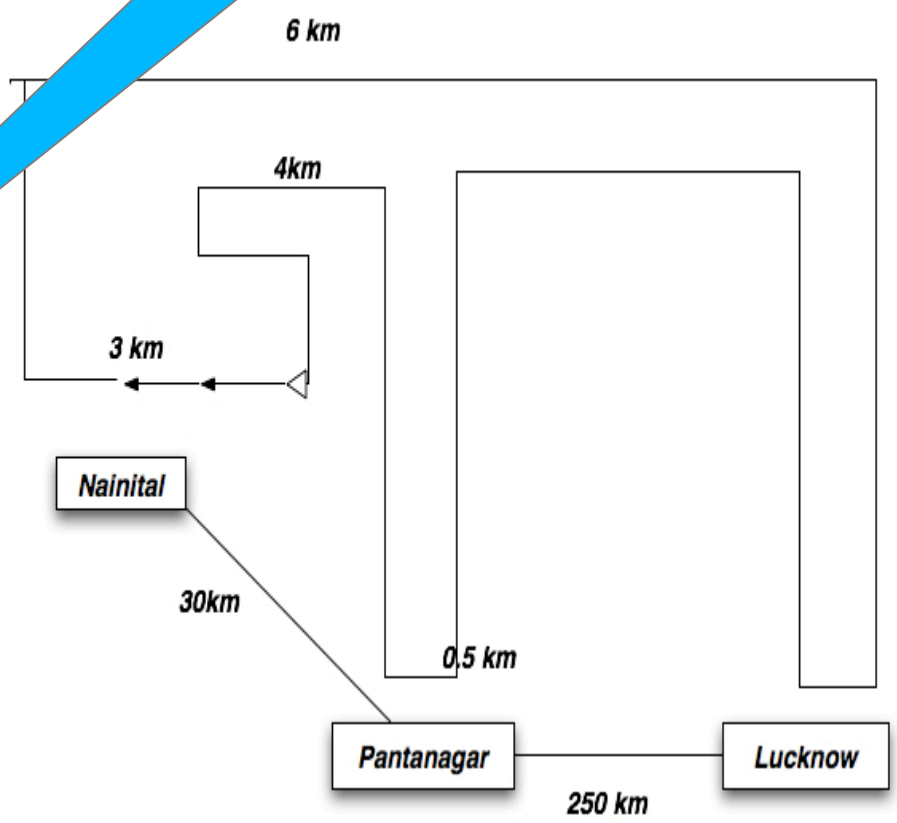
Typical Mobile Facility Setup





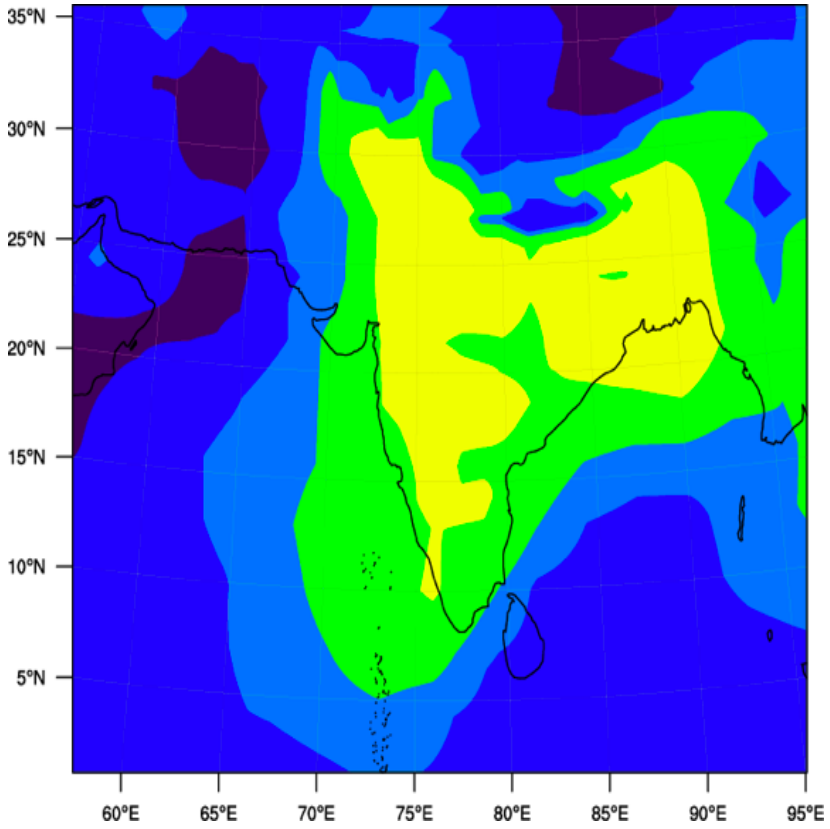
Winter Intensive will need G-1 to characterize the aerosol plume: Base of operations is Likely Lucknow



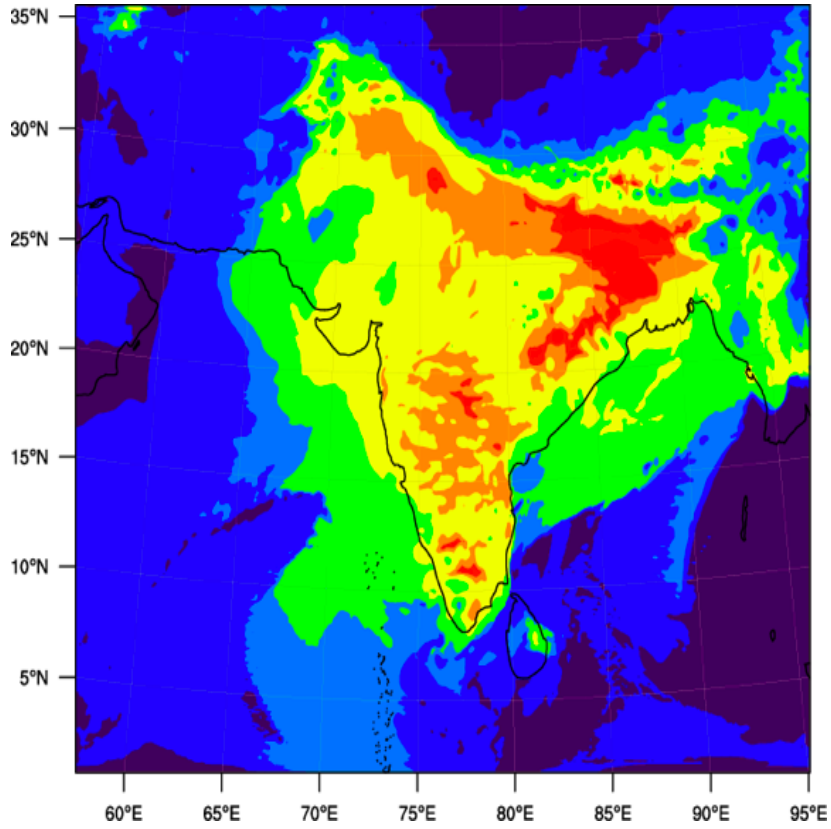


Flight Plan for the Central Sector

Regional Scale BC forecasting for GVAX: WRF-CHEM with MOZART gas phase chemistry and GOCART aerosols (12 km grid size)

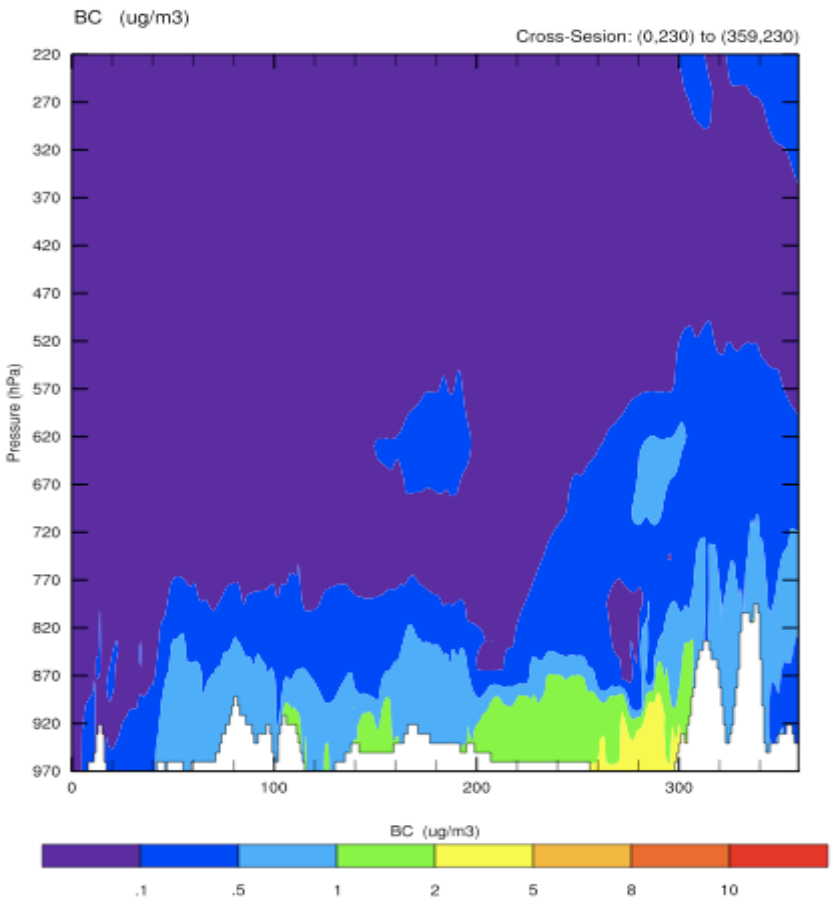


T=0; Initial conditions from GOCART model

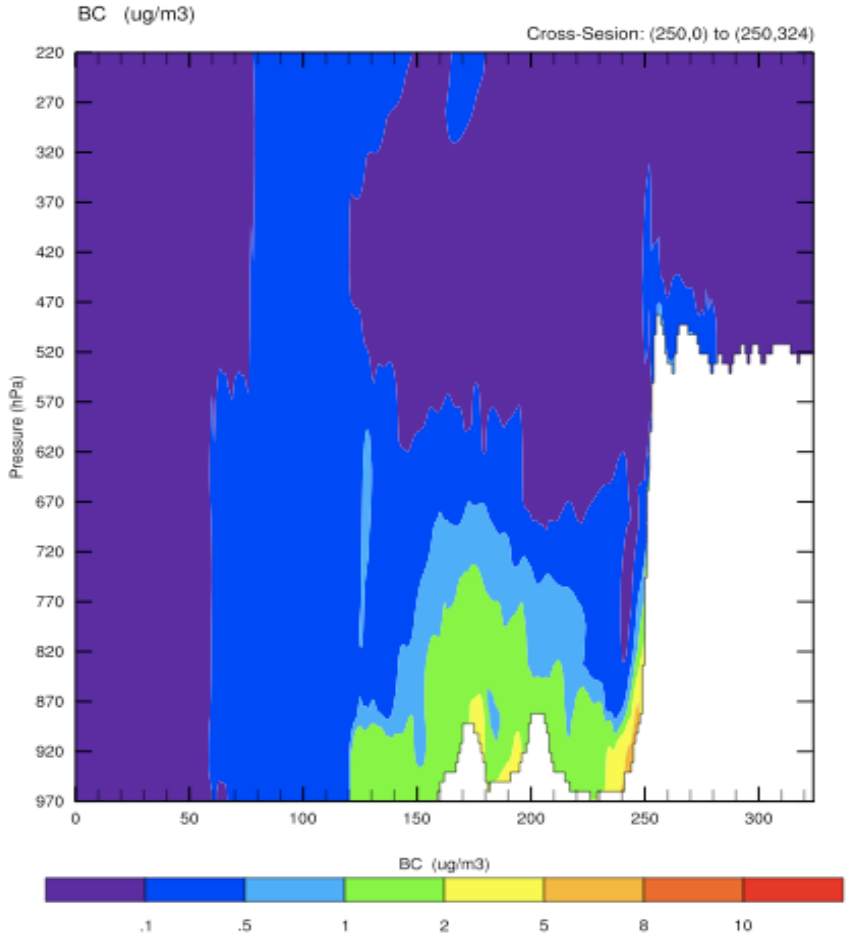


T=24, WRF-CHEM calculated

Regional Scale BC forecasting for GVAX: WRF-CHEM with MOZART gas phase chemistry and GOCART aerosols (12 km grid size)

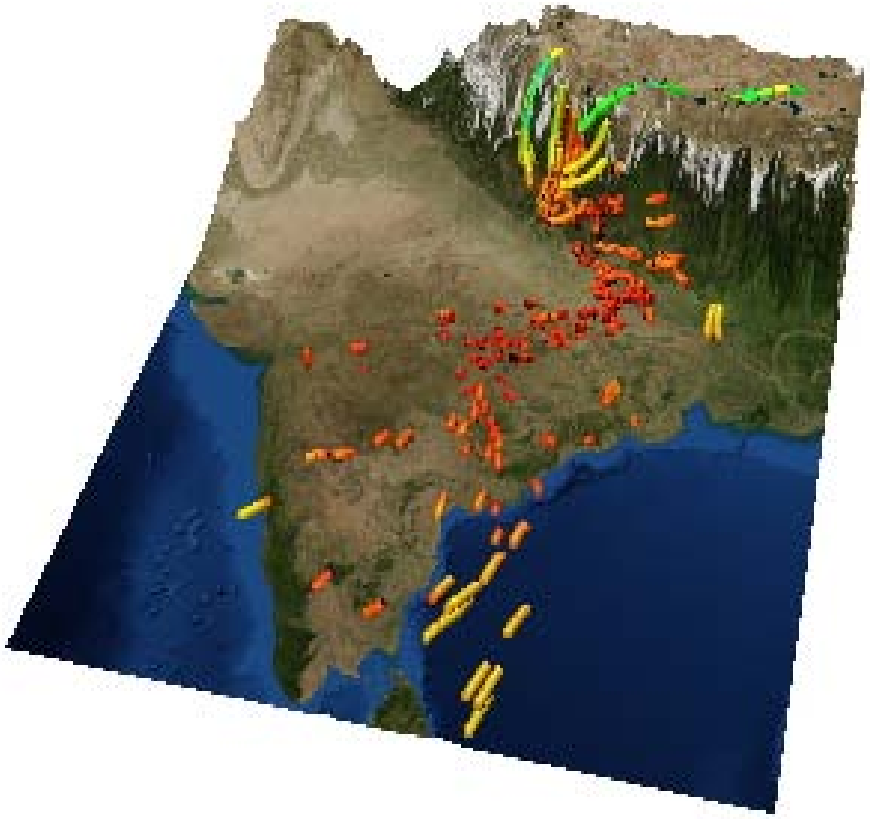


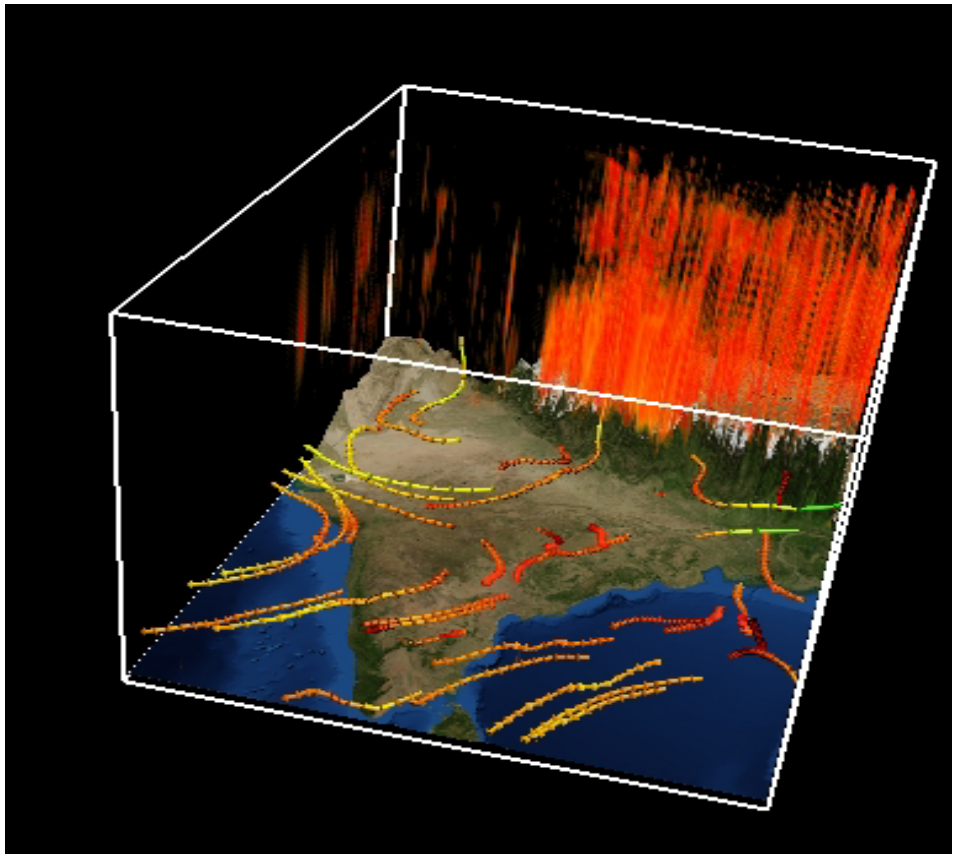
Longitude-Height cross section



Latitude-Height Cross Section

Transport of particles near Nainital/Pantnagar;
2008 January





Acknowledgement

- DOE ASR program for the support
- Many colleagues from DOE National Laboratories. ISRO , ARIES and IISc for collaborating on the GVAX experiment
- NOAA/NCAR WRF-CHEM developers for providing the support in our efforts to establish a forecasting system for GVAX
- ANL LCRC for computational support
- More information on GVAX, updates and progress at:

http://www.arm.gov/sites/amf/pgh/

BC instrumentation during GVAX (ground sites)

- Nainital (June 2011 - April 2012):
  - PSAP (Particle Soot Absorption photometer)
  - Other aerosol instrument (AERI, Nephelometer, MFRSR)
- Lucknow (January 2012 - March 2012)
  - SP2 (Soot Photometer)
  - PSAP (particle Soot absorption photometer)
  - PASS-3 (Photo acoustic Spectrometer)
  - Aethalometer
- Pantanagar (January 2012 – March 2012)
  - MAAP (Multiangle absorption photometer)
  - SP-AMS (soot particle aerosols mass spectrometer)
  - SP2 (soot photometer)
  - PASS-3 (photo acoustic spectrometer)