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

\[
\frac{dx_g}{dt} = -k x_g \\
k = \frac{\omega A \gamma}{4} ; \\
\gamma = \frac{4RT}{\omega} H \sqrt{D_x k}
\]

over the surface area of the aerosol
Sulfate aerosol in the upper troposphere - hydrolysis of $\text{N}_2\text{O}_5$
Night time/Dawn oxidant production Speedup

Soot Particle

HNO₃ + HONO

NO₂

HNO₃

HNO₃

NO₂

HONO

Water film

2 to 100 μg/m³
OH (molecules/cm³)
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\textsubscript{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

AOT 500nm
Yearly

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

2001 Kanpur

KANPUR

corr(l, A)=0.06
corr(l, M)=0.49
CALIPSO extinction Profiles

January

Night: Aer ext profile (KNP) 2010-01

April

Day: Aer ext profile (KNP) 2010-01

Day: Aer ext profile (KNP) 2010-04
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 Effect on Heating Rates: (Winter)
Typical Mobile Facility Setup

Nainital
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
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– 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)