Regional Climate Forcing by Carbonaceous Aerosols: Relating Optical Properties to Chemical Composition to Improve Predictions

Manvendra Dubey[1], Bradley Flowers[1], Claudio Mazzoleni [2], Alla Zelenyuk[3], James Schauer[4], V. Ramanathan[5]

[1]Los Alamos National Laboratory; [2]Michigan Tech. Univ.; [3]Pacific Northwest National Laboratory, [4]Univ. of Wisconsin, [5]UC-San Diego

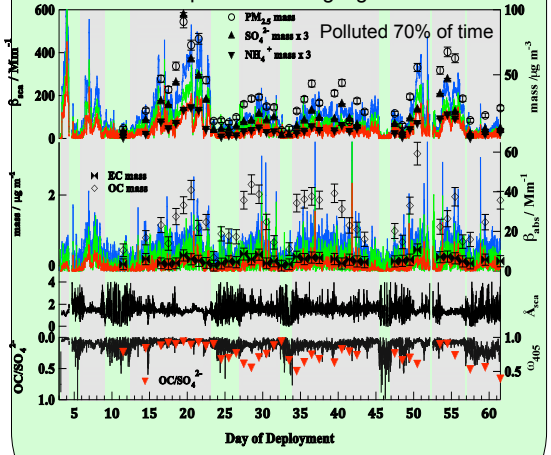
We are developing an empirical framework for models to predict aerosol optical properties from chemical and size information

Objectives

- Radiative forcing by carbonaceous aerosols is a largest sources of uncertainty in climate model
- They absorb and scatter sunlight to warm or cool the atmosphere depending on their Single Scatter Albedo, SSA = Scattering/(Scattering+Absorption)
- SSA is a complex function of the chemical composition and size of these aerosols. Models compute it from transport and chemistry of emissions with very idealized assumptions of optical properties. Unfortunately, these approximations are un-validated.
- We use our Arctic and Asia field data to relate aerosol chemistry to their optical properties
- Aerosol optical properties measured by our 3-wavelength photoacoustic spectrometer-PASS3

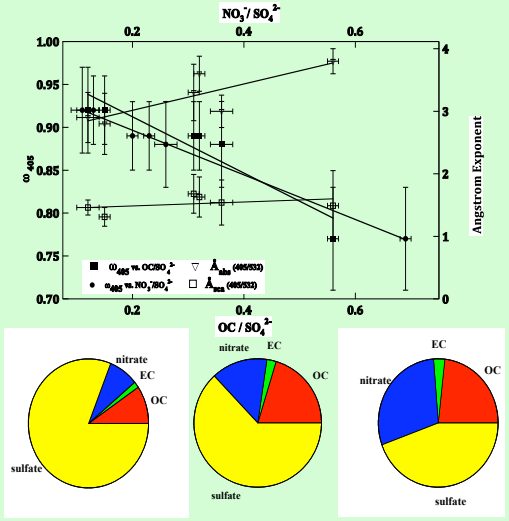
CAPMEX: Cheju, Korea 2008

Ground deployment of PASS3 and filter collection for chemical analysis in Aug/Sep 2008 downwind of China to study Beijing Olympics impacts. Pollution Episodes are highlighted below



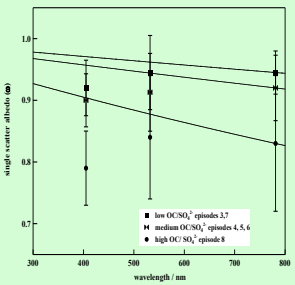
Temporal profile of optical properties (10 minute) and chemical composition (1 hour) for 60 days

Chemical-Optical Relations

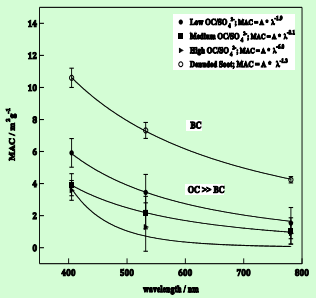


SSA (405 nm) vs. OC/sulfate ratio and nitrate/sulfate ratio for pollution episodes 3-8. The composition charts are for high, medium, and low OC/sulfate pollution episode. High OC/sulfate results in low SSA at 405 nm implying "brown carbo-nitrate"

Brown carbon absorbs more light in Blue-UV than soot



SSA for high, medium, and low OC/sulfate episode. The darkening observed at 405 nm is due to enhanced absorption by OC or brown carbon

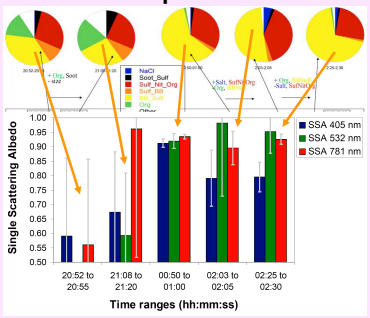


Wavelength dependence of the Mass Absorption Coefficients (m^2/g) for black carbon (open circle) from laboratory studies and brown carbon (BC + OC)

ISDAC: Alaska 2008

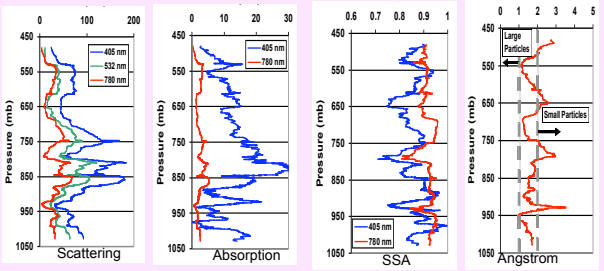
PASS3 and Single Particle Laser Ablation Spectrometer (SPLAT) deployed on CONAIR in April 2008. On 19 April we interrogated a large biomass burning plume

Chemical Optical Correlations



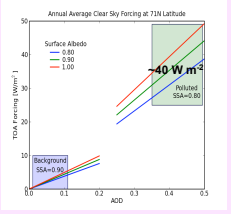
SSA at 405, 532 and 781nm in blue, green and red bars (PASS3) at various times in bottom. Chemical composition (SPALT) on pie charts for same periods. High soot (and OC) lowers SSA (in blue). Salt increases SSA.

Vertical Distribution of Optical Properties 4/19/08



Vertical distribution of optical properties show pollution layers twith alternating in high and low SSA. The extinction Angstom exponent, measures its wavelength dependence and is high for small (combustion) and low for large particles (dust)

Arctic Radiative Forcing Estimate



Large transient (weeks) forcings fromArctic haze and long range pollution transport needd to be included in climate models

We gratefully acknowledge DOE-ASR funding; Ashley Williamson, Program Manager