ORGANIC AEROSOL COMPOSITION in YOSEMITE NATIONAL PARK
Results from the 2002 Yosemite Aerosol Characterization Study (YACS)

Guenter Engling, Pierre Herckes, Sonia Kreidenweis, and Jeffrey Collett

Department of Atmospheric Science, Colorado State University, Fort Collins, CO 80523

Overview

Physicochemical properties of the ambient aerosol in Yosemite National Park were measured for two months during the summer of 2002 in order to investigate sources of haze and the resulting visibility impact. In particular, the influence of wildfires on the regional haze was determined. In addition, secondary biogenic aerosol species were identified as important PM2.5 constituents. Size distributions of individual organic aerosol species were determined as well.

Introduction

Smoke, released from prescribed or wild fires, comprises a significant fraction of fine atmospheric particulate matter in many areas and thus contributes to regional haze and visibility degradation. Fine particle carbon can constitute more than half of total fine particle mass in parts of the western U.S., such as in Yosemite National Park. Therefore, it is important to investigate its sources.

Comparison of days with good and poor visibility

Sampling

The Yosemite Aerosol Characterization Study (YACS) spanned a period of approximately two months from July 14 to September 5, 2002. The primary sampling site was on Turtleback Dome in Yosemite National Park at an elevation of 1615 m. Samples for organic speciation were collected on pre-fired quartz fiber filters, using Thermo Andersen high-volume (Hi-vol) collectors. Size-selective inlets were used to obtain PM2.5, PM10 and size distributions over 6 particle diameters.

PM2.5 samples were collected over 24-hour periods. Shorter sampling (12 hours) was performed during intensive periods such as during regional or local fire influence. Multi-stage samples were collected over 72 hours or 24 hours during intensive smoke episodes.

Turtleback Dome Sampling Site

Hi-vol Collectors at Turtleback Dome

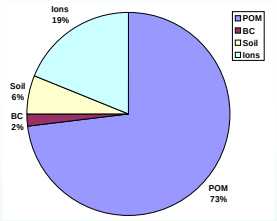
Analysis

Average compositions of particulate organic matter (POM) were determined for weekly composite samples in addition to daily (24-hour) and 12-hour samples.

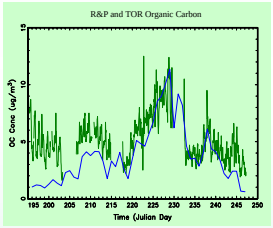
Speciation of the organic aerosol fraction was accomplished by solvent extraction, followed by separation, identification and quantification using gas chromatography with mass spectrometric detection (GC-MS). In addition, selected samples were analyzed by high-performance liquid chromatography (HPLC), following aqueous extraction.

Fine Particle Composition

Organic carbon (OC) dominated the PM2.5 mass during the entire study period, accounting for more than 70% of the total PM2.5 mass on average. Contemporary (i.e., non-fossil fuel) carbon constituted on average 94% of the total PM2.5, based on ^{14}C analysis. Average carbon preference indices (CPI) above 3 for alkanes and alkanoic acids indicate primarily biogenic sources. A large spectrum of POM constituents was identified and quantified, including n-alkanes, alkanols, carbonyls, carboxylic acids, PAHs, biogenic SOA species, and molecular tracer compounds for biomass burning.



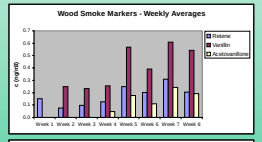
PM2.5 Average Composition

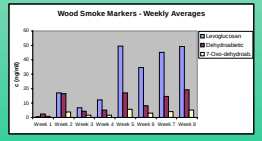


Timeline of OC

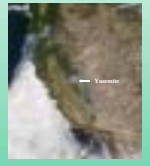
Wildfire Impact

Significant influence of wildfires on PM2.5 mass in Yosemite was illustrated by high concentrations of wood smoke markers during certain periods. Contributions of smoke from biomass burning to the total fine POM during these periods were estimated based on selected molecular markers, including resin acids, anhydrosugars and methoxyphenols. The highest source contributions from biomass burning were observed during week 5, when wood smoke appeared to be the dominant POM source. Additional data, including dual-channel (UV-vis) aethalometer black carbon (BC), soluble potassium concentrations, satellite images, and back trajectories, support the molecular marker observations.

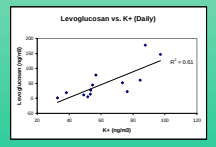




Wood Smoke Marker Concentrations



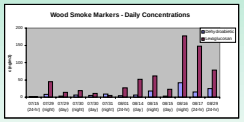
August 11, 2002 Satellite Image

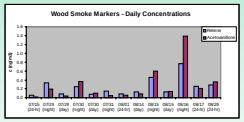


Correlation of Levoglucosan to K⁺

Wood Smoke Tracers

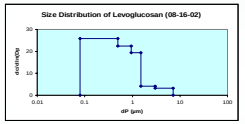
All wood smoke marker concentrations showed a diurnal pattern that coincides with the diurnal change in wind direction that was observed throughout the entire study period. During the day, air masses were carried up-slope to Yosemite from the West, while at night down-slope flow out of Yosemite Valley prevailed.

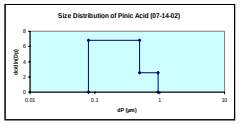




Size Distributions

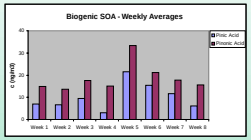
Certain compounds, including n-alkanes and n-alkanoic acids, were detected in particles of a relatively wide size range, while others were present only in sub-micrometer particles (e.g., hopanes, dicarboxylic acids, and selected pinene oxidation products). In addition, certain organic species, such as dehydroabietic acid, showed a bi-modal distribution.

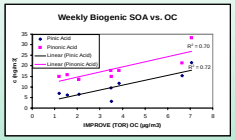




Secondary Organic Aerosol (SOA)

Secondary biogenic compounds constituted an additional important source of contemporary carbon, as indicated by relatively high concentrations of pinene oxidation products, such as pinonaldehyde, pinic acid and pinonic acid. The concentrations of the measured biogenic SOA species showed good correlation with organic carbon on a weekly average, yet they are relatively high throughout the entire study period.





Conclusions

Class 1 areas in the Western United States, such as Yosemite National Park, can be significantly impacted by haze due to high concentrations of fine aerosol particles, leading to poor visibility. The main component of the fine aerosol mass in Yosemite is particulate organic matter (POM). During the summer of 2002, POM in Yosemite was dominated by emissions from natural sources, in particular by wildfire smoke and secondary organic species from biogenic sources.

Acknowledgements

- This study was funded by the National Park Service (NPS).
- Thanks for the contribution of the Carbon-14 data to Graham Bench, LLNL, Livermore, CA.
- The author also thanks the other YACS team members, including Bill Malm, Jackie Carrillo, Kip Carrico, Taehyoung Lee, and Derek Day for their contributions.
- For logistic support we thank Air Resource Specialists (ARS), Fort Collins, CO.