A Survey of Biological Aerosol over the Continental United States during NASA SEAC^{4}RS

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Introduction

- Bioaerosols consist of fungal spores, bacteria, pollens, viruses, and leaf detritus that are derived from both continental and marine sources.
- Extensive laboratory testing has implicated bioaerosols as efficient ice nuclei (IN).
- Ambient measurements of bioaerosol IN behavior are very limited and results have been inconclusive (e.g., Creamean et al. [2013] and Cziczo et al. [2013]).
- Differing conclusions on the IN role of bioaerosol illustrate the complexity and sensitivity of ice formation to different cloud regimes and variable bioaerosol speciation.
- Thus, regional and global scale modeling efforts require quantifying the spatial and vertical extent of bioaerosol concentrations and speciation [Despres et al., 2012], especially in complex environments and in the presence of convective systems.

Objectives and Impacts

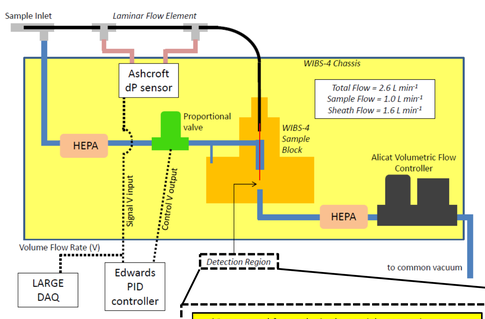
1. Assess the performance of the DMT Wideband Integrated Bioaerosol Sensor (WIBS) for airborne measurements of bioaerosol by fluorescence detection.
2. Explore spatial and verticel variability in bioaerosol properties in the biogenically-active SE region of the United States
3. Assess the vertical transport of bioaerosols by convective cells as a mechanism for free-tropospheric redistribution

Conclusions and Future Work

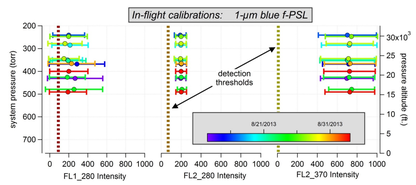
1. The WIBS showed stable performance for all SEAC4RS flights.
2. Extensive BL sampling yielded variable concentrations and fractional contributions by biological material.
3. Convective outflow sampling illustrated high concentrations of bioaerosol in updrafts into the free troposphere.
4. Transported SAL dust lacked presence of bioaerosol

- Vertical profiles indicate larger concentrations and relative contributions of bioaerosol in the SE-USA region compared to marine, western, and urban profiles.
- Filters were collected targeting areas of interest and will be analyzed for bacterial speciation and DNA sequencing.
- PALMS spectra will be assessed for biological signatures.

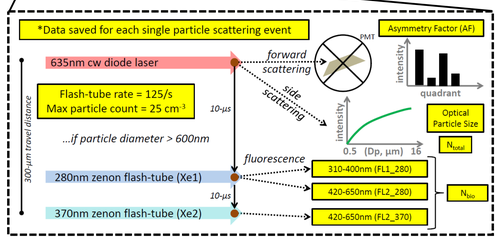
1. WIBS Operation and In-Flight Testing



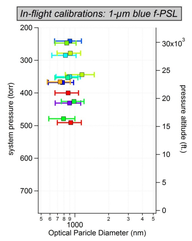
- A comprehensive suite of aerosol optical, chemical, and microphysical property measurements were made aboard the NASA DC-8 during SEAC^{4}RS, including bioaerosol measurements with a DMT WIBS.
- Modifications were made to the system for airborne use, including active sample-flow control using an in-line laminar flow element (LFE) (*left*).



- The WIBS measures single-particle size, asymmetry factor (AF) and fluorescence (FL) intensity at two excitation λ (280nm and 370nm) (*right*).



- The particle size-cut into the WIBS is primarily limited by transmission into the iso-kinetically controlled aircraft inlet at 5-6µm D_p (50%).
- Quantification based on Gabey et al. [2010].

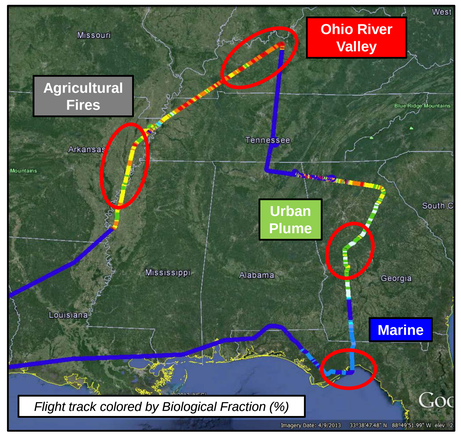


- In-flight calibrations using 1-µm diameter blue f-PSL showed stable FL detector performance (*top*) and sizing capability (*right*) over a wide altitude (and pressure) range during SEAC^{4}RS.

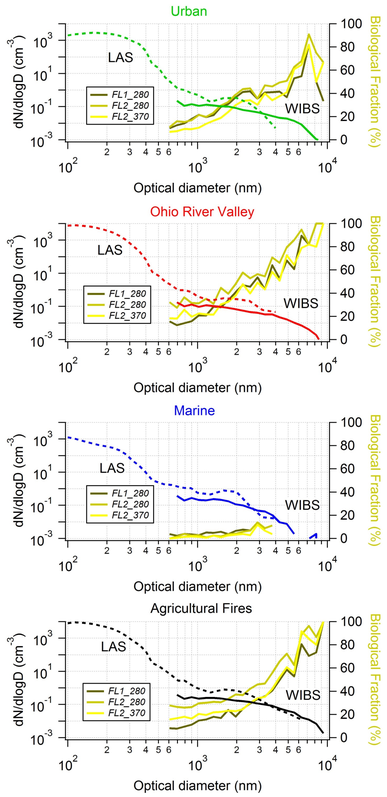
2. Spatial Variability

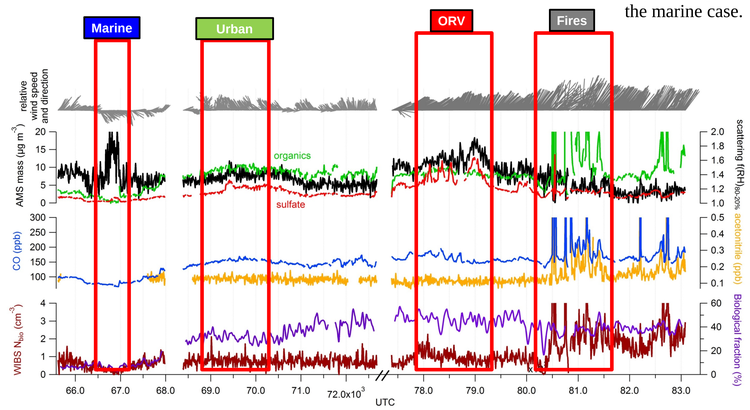
- The 9 Sept flight was chosen to assess bioaerosol spatial variability because several distinct regions were sampled (*right*):

1) Ohio River Valley (ORV),
2) Urban plume from Atlanta, GA
3) Marine aerosols on the Florida Gulf coast
4) MS-river agricultural fires

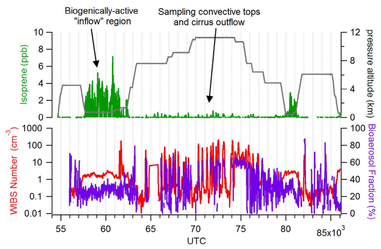


- Size distributions from the WIBS are compared to measurements from a LAS (TSI, laser aerosol spectrometer) (*right*) and show 1) a consistently present coarse mode and 2) reasonable instrument agreement for each region.
- Biological fraction approaches 100% at 10µm except for the marine case.



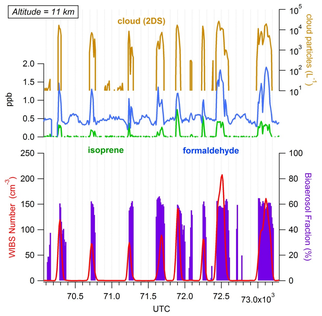


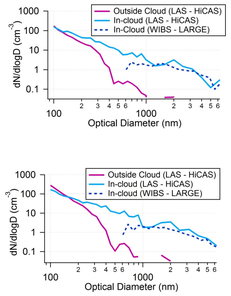
3. Convective Pumping



- The 2 Sept flight is shown (*above*) targeting a biogenically-active region of MS and high-altitude sampling of convective outflow.
- Stable concentrations of ~2 cm^{-3} were observed in the BL, ~30% of which were biological.

- Large enhancements of coarse-mode aerosol were observed at the tops of convective cells (identified with a SPEC 2DS probe) and were coincident with gas-phase BL tracers (*right*).
- The biological fraction was significantly enhanced during these events up to ~60% (right)



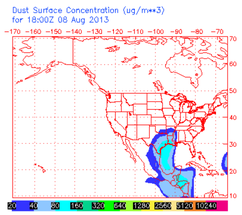


- While small particle concentrations (less than 300nm) remain unchanged inside the convective clouds, larger particles are significantly enhanced.
- Good agreement from each inlet, suggesting that the biological aerosols measured by the WIBS are likely interstitial and are not due to cloud shatter or residues.

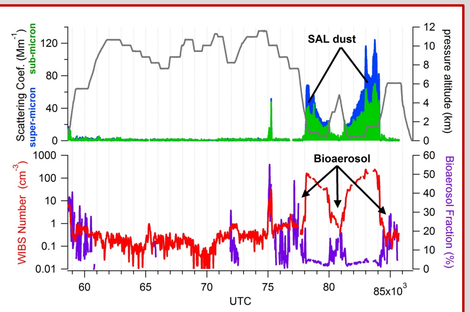
Acknowledgement: We would like to thank NASA for SEAC^{4}RS funding, the LaRC Science Directorate for SIF funding, the DC-8 crew, Gary Granger at DMT for help with the WIBS, and collaborators for use of data.

4. SAL Dust Sampling

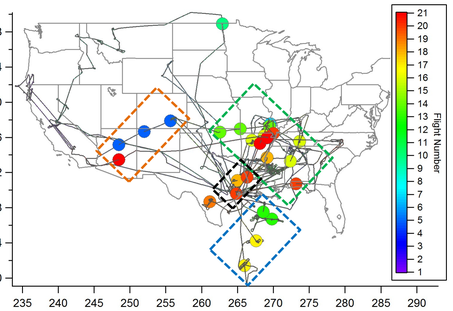
- During the 8 August transit flight from Palmdale, CA to Houston, TX, SAL (Saharan Aerosol Layer) dust was sampled off the Louisiana coast (*right*).
- Presence of transported SAL dust was corroborated by filter-based chemical composition, PALMS observations, and model predictions (*below*).

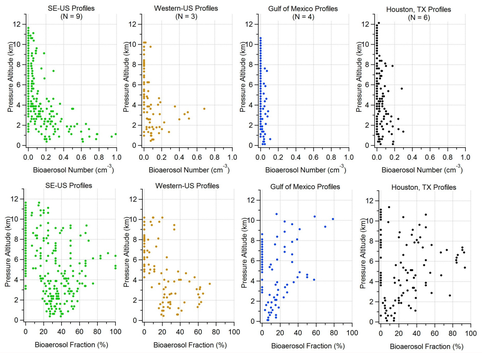


NRL-NAAPS model

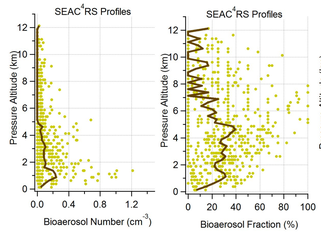


- Nephelometer measurements indicated up to 50% contribution from super-µm particles, indicating clearly the dust penetration that was sampled twice (*above*).
- WIBS measurements showed strong enhancements of coarse-mode number concentration but a distinct lack of biological contribution.
- These observations are contrary to numerous studies showing biological material transported long distances in dust plumes.

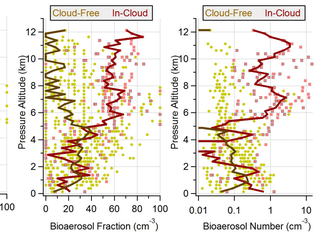




5. Vertical Profiles



- Profiles in the SE-USA region had higher concentrations and relative fractions than other regions



- In-cloud data was consistently enhanced above 5km altitude
- Artifact analysis is ongoing