Breakout Session Report
ARM/ASR User and PI Meeting
March 16-20, 2015

Session Title: Biomass Burning Observation Project (BBOP)
Breakout Session Date: Monday, March 16, 2015
Session Time: 7:00–9:00pm
Summary Authors: A.J. Sedlacek and L. Kleinman

Main Discussion

The goals of the 2015 BBOP Breakout Session were to: (i) provide researchers the opportunity to present their most recent work; (ii) provide these researchers the forum to discuss path(s) forward regarding the analysis and interpretation of these complex data sets; (iii) provide instrument mentors the chance to discuss remaining instrument issues and successes; and (iv) outline a publication strategy. The BBOP session was well attended and five 20-minute presentations were given.

The five presentations clearly indicate that the BBOP data set is both scientifically rich and complex. Examples of the richness includes the observation that there is precisely just enough NH_4 to neutralize NO_3 suggesting a unique and complex underlying chemistry within BB plumes; strong evidence for secondary organic aerosol (SOA) production associated with rapid aerosol aging and particle growth through the combined observations of rapid decreases in NO_x/NO_y ratio, increases in O:C ratio, and shift in particle size distributions; enhancement in the production of OA relative to the amount of fuel combusted; delta(OA)/(delta(CO)+delta(CO_2)) is found to varies within individual plumes while delta(PM)/(delta(CO)+delta(CO_2)) is reported to be anti-correlated with MCE (modified combustion efficiency); and evidence for the existence of brown carbon (BrC) along with an estimation of the mass absorption cross section for BrC (MAC_{BrC}) at 355 nm.

Examples of the complexity encountered in BBOP data analysis includes the observation that within some downwind transects the O:C ratio is found to modulate from high-to-low-to-high, suggesting localized sources of fresh emissions becoming entrained into the main (aged) targeted smoke plume. Another example is in the comparison of SSA values calculated using the *in situ* instruments (e.g., CAPS, PAS, and PTI) versus the filter-based measurements (PSAP). In a limited data set, it is found that the flight ensemble SSA for the 355 nm PAS is found to be ~0.85, ~0.88 for the 532 nm PTI, and 0.65 for the 522 nm PSAP. The discrepancy is thought to be due to artifacts in the scattering correction(s) applied to the PSAP measurement. This is consistent with literature reports of enhanced light absorption with the PSAP. However, using the 630 nm CAPS (Cavity Attenuated Phase Shift Extinction) monitor and the red scattering channel of the Nephelometer, a SSA of 0.75 is reported and represents a value falling between these the aforementioned limits.

Finally the BBOP session provided the opportunity for presentation of new analysis tools. Two of the most promising include the use of the CO/CO_2 ratio to identify an individual emission plume within a plume composed of two or more emission sources. The filtering methodology is expected to find immediate value in those downwind transects believed to be comprised of the targeted plume emission and localized 'hot' spots. The second technique takes advantage of using the 200-Hz particle-resolved UHSAS (Ultra High Sensitivity Aerosol Spectrometer) to identify spots within the plume that are characterized by highly inhomogeneous aerosol concentration by using Poissonian statistics and cluster index (ratio of the standard deviation(inter-arrival time) / mean(inter-arrival time)). Further work needs to be done and the utility of using this technique with the CO/CO_2 ratio method introduced above will be investigated. Finally, the benefit of using f_{60} ($C_2H_4O_2^+$; m/z = 60) with respect to the overall organic mass to subdivide the entire MBO-based BBOP measurement campaign into three major periods (no BB, BB influenced, and BB plume) was presented.

Key Findings

- It is found that that organic/CO and scattering/CO – where the CO corrects for plume dilution – increases by 20-35%, mainly in the first hour (volume and scattering give SOA because aerosol is > 90% OA)
- Ratio of number density/CO is found to change very little with plume age suggesting negligible coagulation. However, instrument limitations may alter this in the final analysis
- SOA production from condensation
- Using the SP-AMS data, it is found that there is just enough NH_4 to neutralize NO_3 – no more, no less. The puzzle is what about the sulfate
- Observation of organic enhancement = delta-Org/(delta-CO + delta-CO_2)
- There is a relation (negative slope) of delta-Organic/Delta-Carbon versus MCE
- Other species (nitrate, ammonia), scattering, etc. correlate well with MCE (but sulfate does not correlate at all); all decrease with increasing MCE
- 95% of biomass burning aerosol is found to be composed of organic aerosols
- Examination of the O:C ratio suggests that localized emissions [hot spots] are getting entrained into some downwind transects
- SP-AMS BC concentration estimates:
    - High [Org] generates C_N^+ ion signals (~1.2% total) that interfere with rBC C_N^+ ion signals (~50%)
    - After accounting for C_N^+ interferences good agreement found between SP-AMS and SP2 (20130726a)
    - [Non-refractory-particulate matter]/[refractory black carbon] >> 10
- Define Cluster index (CI) = standard deviation(inter-arrival time) / mean(inter-arrival time), for 1-sec data
    - CI = 1 => Poissonian; CI > 1 => clustered
    - CI > 1 found to correlate well with aerosol concentration – this may be useful for locating recent fire activity or 'hot spots' entrained in an aged plume.
- Optical Properties.
    - SSA derived from the PAS and PTI are higher (0.85 – 0.90) than those derived from the PSAP (~0.65).
    - MAC_{BC} (PSAP, 522 nm) = 43 m^2/g; MAC_{BC} (PTI, 532 nm) = 11 m^2/g – Discrepancies between *in situ* and filter-based instruments are likely due to limitations of scattering corrections for PSAP.
- Estimation of BrC Mass Absorption Cross Section (MAC_{BrC} (λ=355 nm)): ~ 1 m^2/g. (This is likely an underestimate in that it assumes that all organic is brown).

Issues

UHSAS data set. BNL and PNNL will be examining this data set to determine if it can be rescued and brought to a level that can be used.

Needs

Higher-level analysis of TEM samples and SP-AMS data (dependent on funding)

Future Plans

One manuscript is nearing completion – ground-based observations (Zhang et al.) – and a second is being drafted – evolution of optical properties for flight 20130821b (Sedlacek et al.)

Action Items

Aerodyne will provide BNL with BC concentration time series that take into account C_N^+ ion signals from Org. BNL will provide PNNL results on UHSAS and PCASP analysis.