Aged Biomass Burning during LASIC: Understanding BC-dominated Absorbing Aerosol

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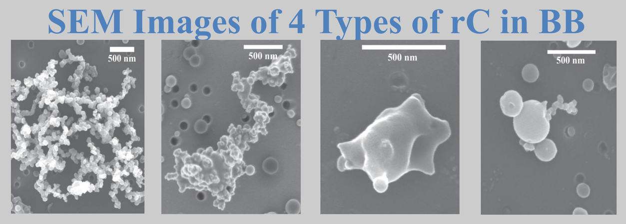
Climate Impacts of Biomass Burning (BB)

- Biomass Burning emissions: largest global source of Carbonaceous aerosols to the atmosphere
- BB aerosols have complex chemistries and optical properties

SEM Images of 4 Types of rC in BB

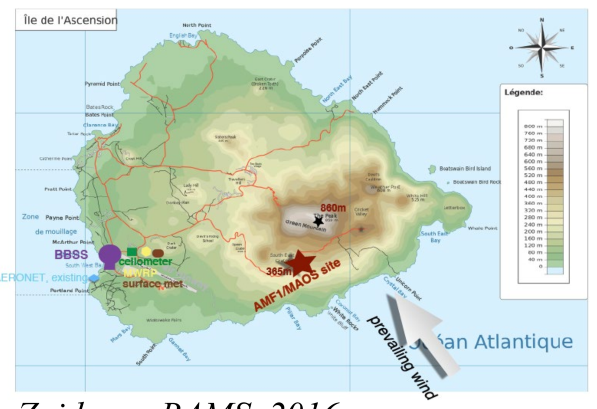


China et al., Nat. Commun., 2013

- Upon emission: internal and external mixtures with complex climate impacts (direct effects: radiation; indirect effects: clouds, precipitation)
- Atmospheric aging: aerosols undergo changes in their physical, optical and chemical properties due to processing in the atmosphere such as aggregation/agglomeration, condensation, oxidation, photochemistry, polymerization, vaporization
- Direct measurements by ARM AOS's can be probed in more detail under more controlled conditions to constrain atmospheric observations and atmospheric processing
  - ARM and Lab direct measurements: refractory Black Carbon (rBC), non-refractory Organic Carbon (OC) - *S. Liu, GRL, 2014; D. Liu, Nat Geo, 2017*
  - Larger uncertainties in measurements (mass quantification and optical properties) require targeted lab study: Brown Carbon (BrC; light-absorbing component of OC), Tar Balls - *Girotto et al., ES&T Letters, 2019*

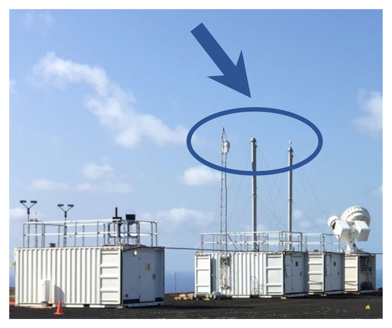
Layered Atlantic Smoke Interactions with Clouds (LASIC) – ARM Campaign

- Southern Africa: Largest BB source
  - Fuels: Land clearing wood and grassland fires
  - BB Season peaks from June – November

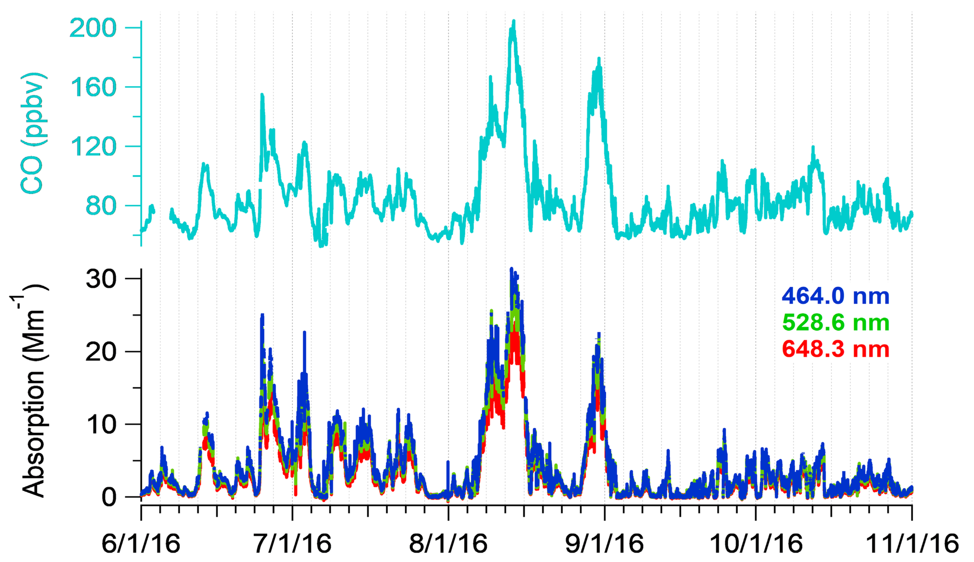


Zuidema, BAMS, 2016

- LASIC - ARM AMF1
  - Ascension Island is in the Southern Atlantic Ocean
  - June 2016 – October 2017 sampling 2 BB Seasons - *Zuidema et al., Geophysical Research Letters, 2018*



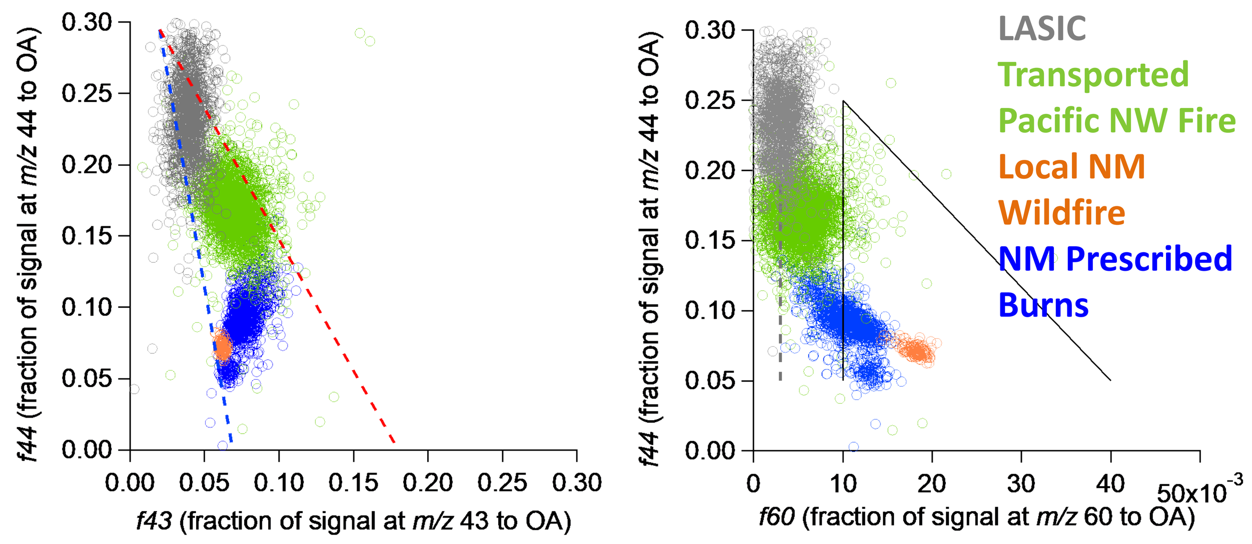
- Aerosol Observing System (AOS) aerosols within the MBL - *Uin, Springston, Aiken, et al., submitted to JTECH*
  - Submicron 1 minute average aerosol data (<1 µm diameter)
  - *In situ* aerosol number, CO, absorption of BB plumes
- 1 minute data - largest plumes during August 2016
  - Submicron number concentration of ~1000 #/cc
  - Absorption coefficients reach 30 Mm^{-1}
  - rBC concentrations > 1.5 µg m^{-3}, ΔCO > 120 ppbv



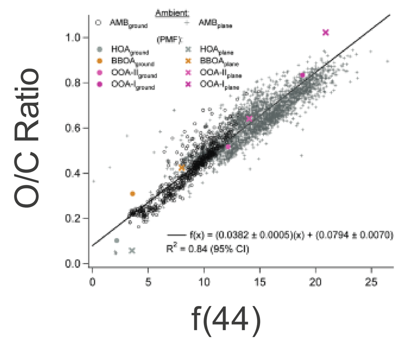
BB Chemical Composition and Optical Properties

Non-refractory Organic Carbon

- Non-refractory submicron aerosol mass is dominated by highly oxygenated Organics (OOA)
- LASIC Organic Aerosol (OA) chemical composition is contrasted with Ambient BB from 3 types of US Forest Fires sampled in 2017 (long range transported plumes, local BB and prescribed burns)
  - LASIC BB has the Highest Oxygen (f44) and lowest Hydrogen content (f43)
  - Typical of aged organics (LV-OOA; *Jimenez et al., Science 2009*) with little no primary BB signatures (f60)



- Elemental Analysis unit mass resolution approximation - *Aiken et al., ES&T, 2008*
  - O/C = 0.98 ± 0.12
  - OM/OC = 2.41 ± 0.16

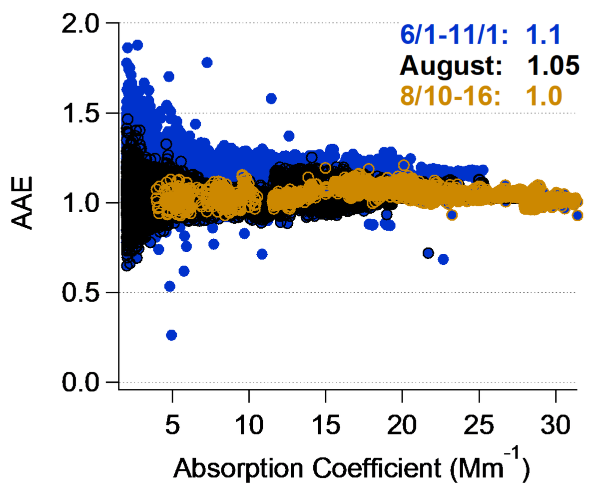


Refractory Black Carbon

- BB plumes are dominated optically by Black Carbon
- Absorption Angstrom Exponent (AAE)

$$\frac{\beta_{\lambda}}{\beta_{\lambda_0}} = \left(\frac{\lambda}{\lambda_0}\right)^{-AE}$$

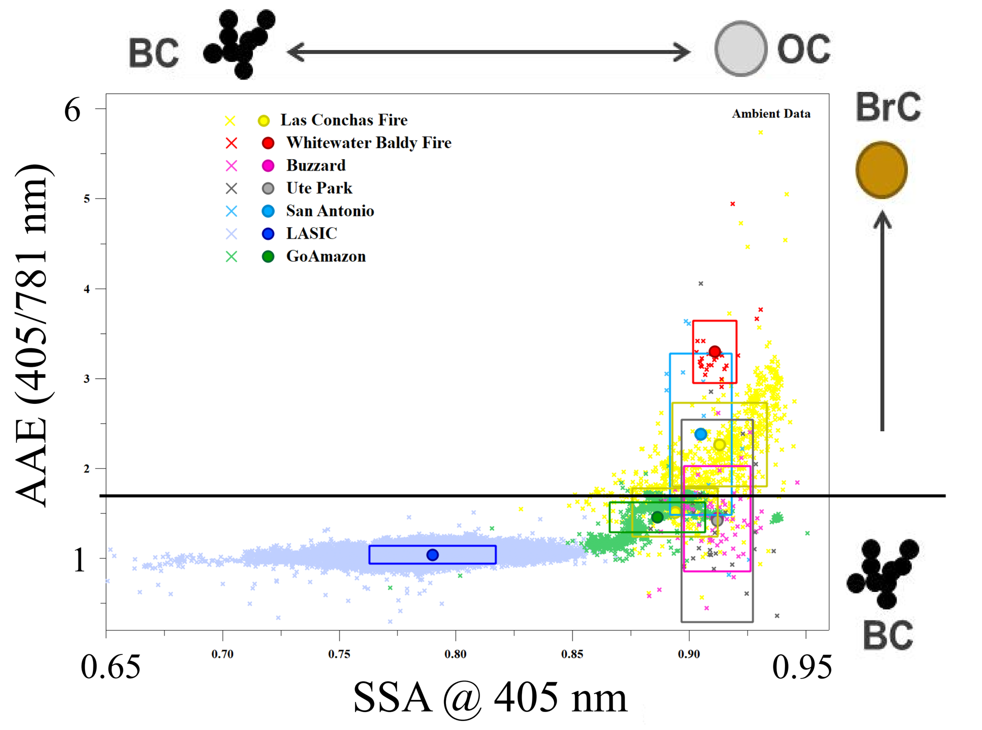
- AAE ~1.0 indicates absorption is dominated by rBC cores < ~200 nm d.



Optical Properties

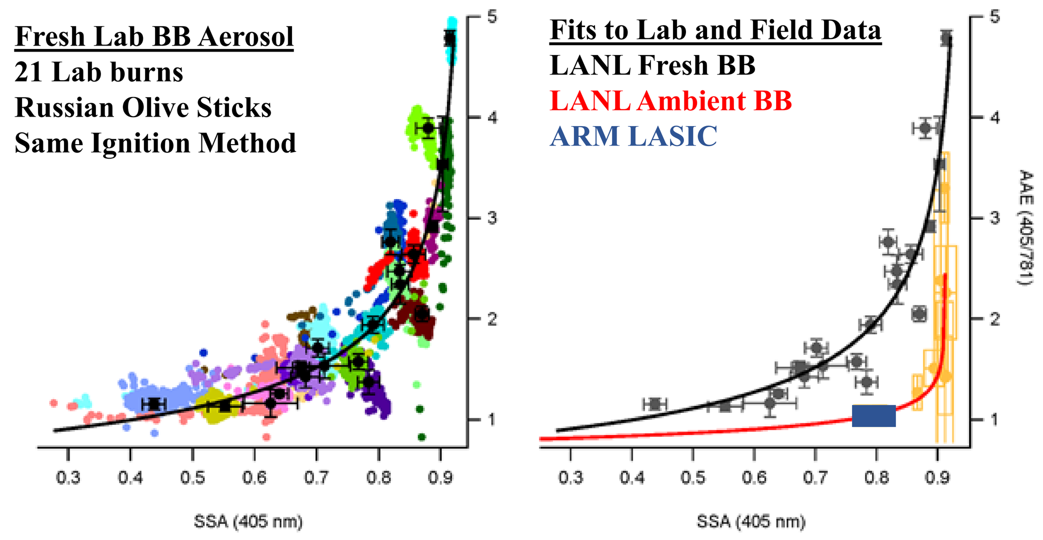
- Absorption Angstrom Exponent (AAE) and Single Scatter Albedo (SSA) from LASIC and other ambient BB events
  - AAE ~1 indicate most of the absorbance is from BC as is seen in the LASIC data
  - Higher observed values indicate BrC and is seen in the fresher BB plumes - *(Saleh R. et al., Nat Geo, 2014)*
- Single Scatter Albedo (SSA)
  - SSA ~1 for pure scattering particles
  - SSA ≤0.85 indicates a mixture (internal/external)

$$SSA = \frac{\beta_{sca}}{(\beta_{sca} + \beta_{abs})}$$



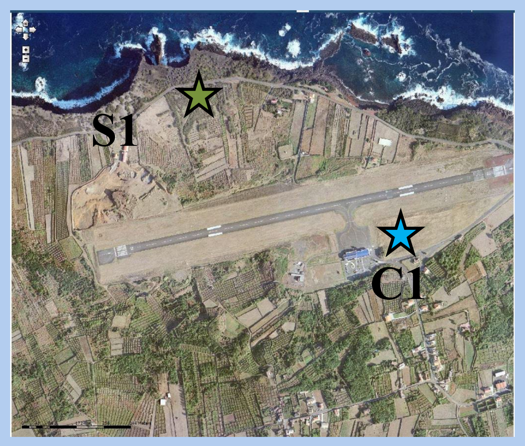
Laboratory Biomass Burning and Model Comparison

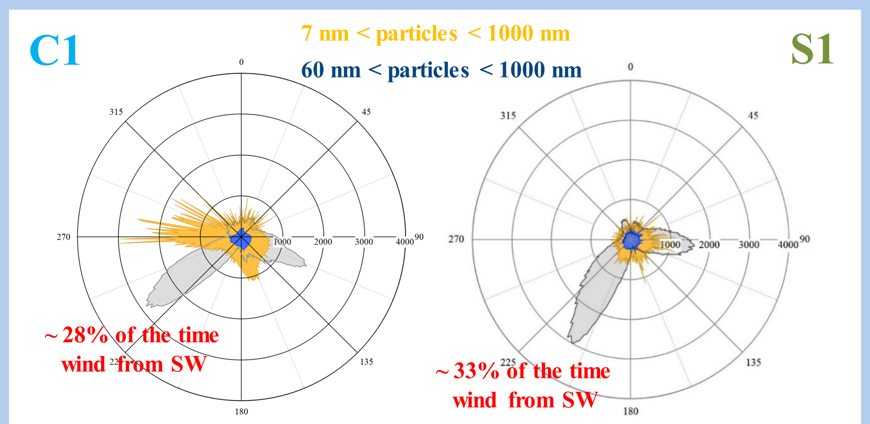
- A single fuel type can produce a range of aerosol optical properties – Russian Olive (SW US Invasive Species)
- LANL single fuel lab burns - *Gomez et al., JGR-A, 2018, Romonosksy et al., JGR-A, 2019*



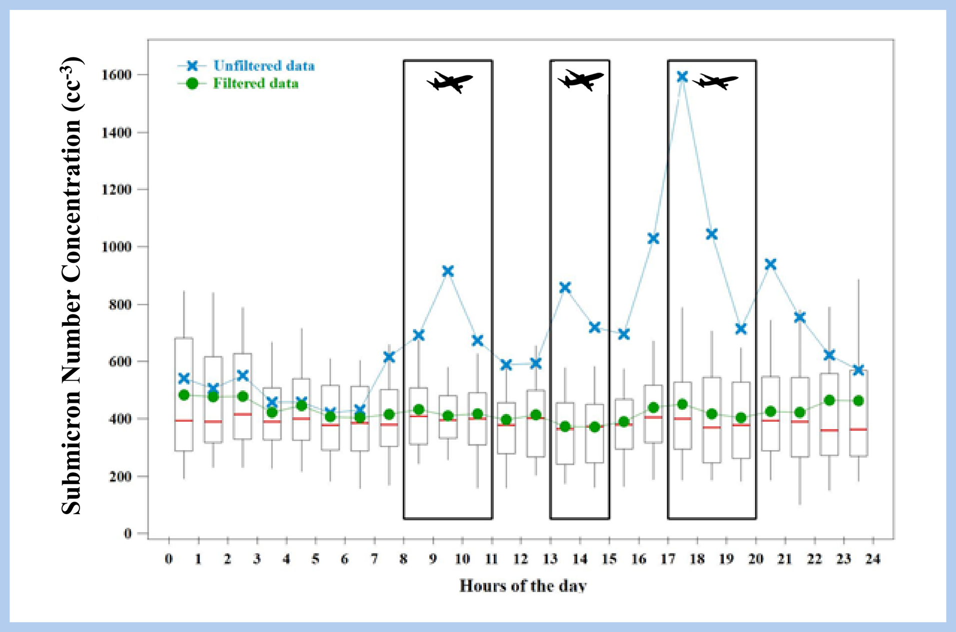
ENA Local Combustion: Supplementary Site (S1) and Aerosol Filter Development

- ENA AOS main facility (C1) is impacted by local sources due to the location – near a local airport and roadway
- An aerosol Supplementary Site (S1) was installed during ACE-ENA (July 2017 – April 2018) ~0.75 km from C1 to constrain sources
- Summer (shown below) and Winter dominant wind directions and particulate sources are compared at C1 and S1
  - CPC number concentration (7 nm - 1 µm)
  - UHSAS number concentration (60 nm – 1 µm)
  - Met Sensor (Wind Speed and Direction)
- **ARM ENA S1 Report - *Aiken, Gallo, Uin, et al. 2019***





- **Airport Operational Periods** dominate local sources at C1
- CPC number concentration can be used to flag local sources with a modified Standard Deviation Method to identify outliers
- Diurnal profile (shown below) and monthly averages of submicron concentrations from 2016 – 2018 are between 200 – 600 #/cc



- ACE-ENA Manuscript - *Gallo et al., in prep for AMT*
- Presentation at ACE-ENA Session (Thurs @ 1:50PM)