How much SOA is formed from biomass burning (BB-SOA)?

- Shrivastava et al. [2015]
- Hodzic et al. [2016]
- Cubison et al. [2011]
- Spracklen et al. [2011]
- Bruns et al. [2016]
- Hallquist et al. [2009]

Chamber measurements are complex due to vapor/particle wall losses.

- Models vary in terms of BB-SIVOC emissions and their SOA yields.
Most aircraft observations following BB plumes show almost constant $\Delta$OA/ $\Delta$CO with aging: Net OA (SOA+POA) does not change with aging.

But degree of oxygenation of OA (O/C ratio) increases substantially with aging and results in formation of more oxidized OA (e.g., Jolleys et al. 2012).

How does $\Delta$OA/ $\Delta$CO remains constant across different fires even though OA becomes more oxidized?

Hypothesis: SOA formation is balanced by dilution and evaporation of POA in most ambient studies.
Insights from 3D Chemical Transport Models

Model predicts 60-80% of OA is SOA from biomass burning

Model configurations included semi-volatile organics (SIVOCs)

Shrivastava et al. 2015, JGR
Simulated BB-SOA burden is a factor of 3 to 5 higher than primary BB-POA

Similar factors over most other biomass burning regions, globally
Simulations show even if POA is assumed non-volatile, 3 to 5 times more BB-SOA needed to explain aircraft OA and AOD in biomass burning regions.

If $\Delta$OA/ $\Delta$CO is interpreted as no additional OA added during aging, can GFED/FINN fire POA emissions be too low by factors of 3 to 5?

POA has complex variation with fire type and dilution.

Unidentified low volatility organic gases are not represented in GFED fire estimates.
Measurements needed to characterize BB-SOA

- How do OA properties (volatility, hygroscopicity, optical properties, CCN) change with BB-SOA formation?

- OA loss processes need to be better characterized: Gas-phase fragmentation, heterogeneous loss, wet removal

- Difficult to deconvolve primary BB-POA and BB-SOA from AMS measurements

- Aqueous processing of biomass burning emissions can also form SOA

- Measurements also needed to constrain aqueous BB-SOA
Biomass burning is a large source of fine organic aerosols

Modeling suggests large BB-SOA formation needed to explain aircraft observed OA and satellite AOD in biomass burning regions

If actual BB-SOA formation were lower, semi-volatile POA emissions need to be much higher than current fire inventories

Wet removal is another source of modeling uncertainty

How can we reconcile constant $\Delta$OA/$\Delta$CO with large increase in degree of oxygenation across most fire types?
Satellite and E3SM model simulated AOD over South America

(a) MODIS AOD  ave=0.22

(b) Model AOD (Factor 4)  ave=0.22

(c) Model AOD (Factor 6.5)  ave=0.29