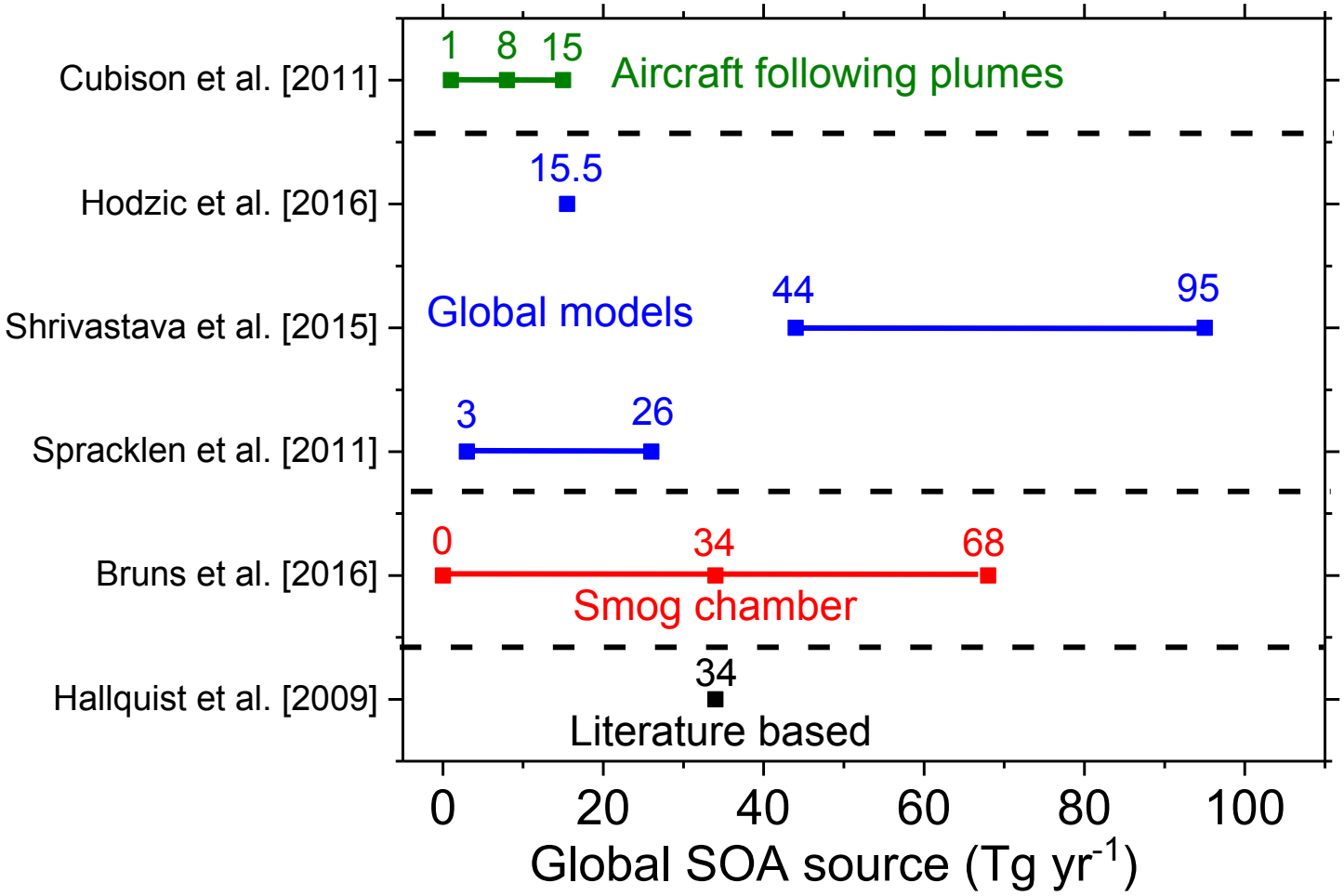
How much SOA is formed from biomass burning (BB-SOA)?



Shrivastava et al. 2017, Reviews of Geophysics

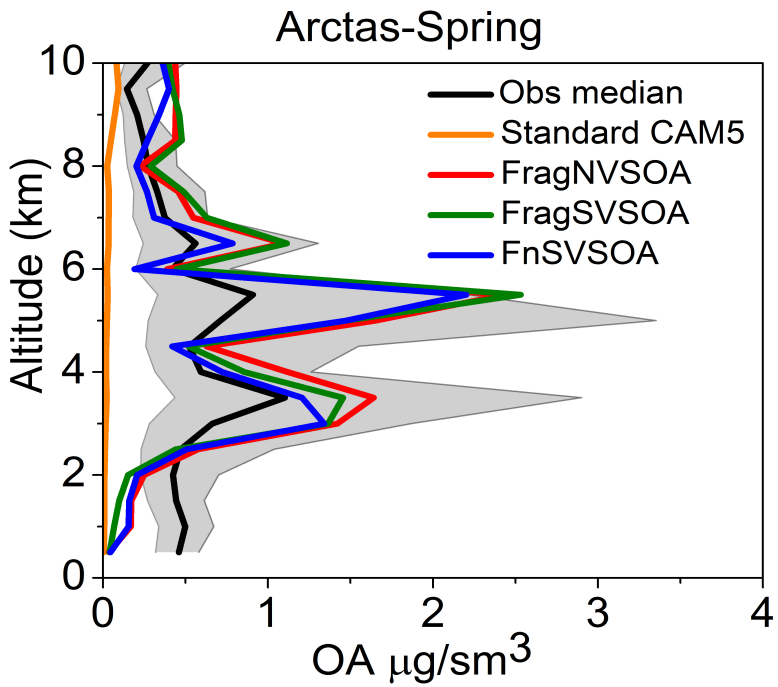
- Chamber measurements are complex due to vapor/particle wall losses
- Models vary in terms of BB-SIVOC emissions and their SOA yields

A big conundrum in BB-SOA

- Most aircraft observations following BB plumes show almost constant ΔOA/ ΔCO 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*) → SOA
- How does ΔOA/ ΔCO 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

Aircraft: Observed and Model



Shrivastava et al. 2015, JGR

- Model predicts 60-80% of OA is SOA from biomass burning
- Model configurations included semi-volatile organics (SIVOCs)

MODIS satellite and E3SM model simulated AOD over South Africa: 10-year means

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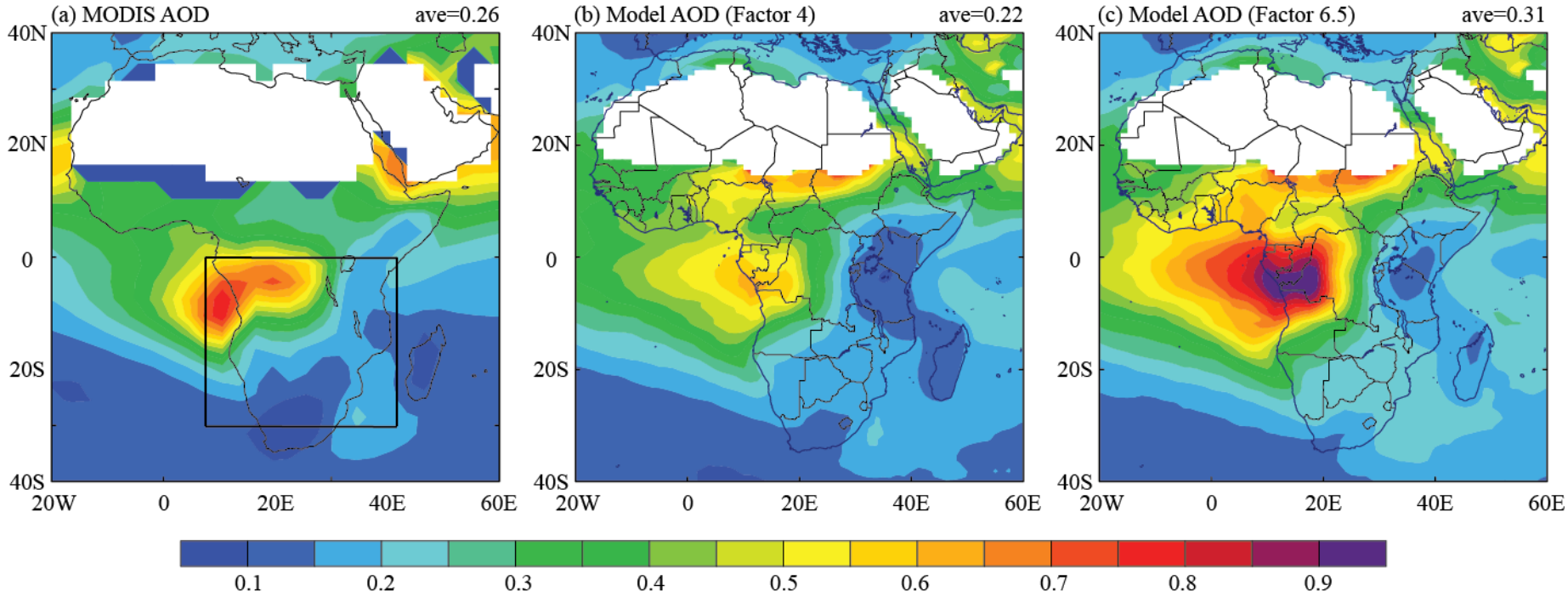

Lou et al. 2018, In preparation

- 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

Implications

- 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 ΔOA/ ΔCO 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

Summary

- 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?

Back-up Slides

Satellite and E3SM model simulated AOD over South America