



Improving Emission Profiles of Secondary Organic Aerosol Precursor gases from Biomass Burning

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NW-AIRQUEST meeting

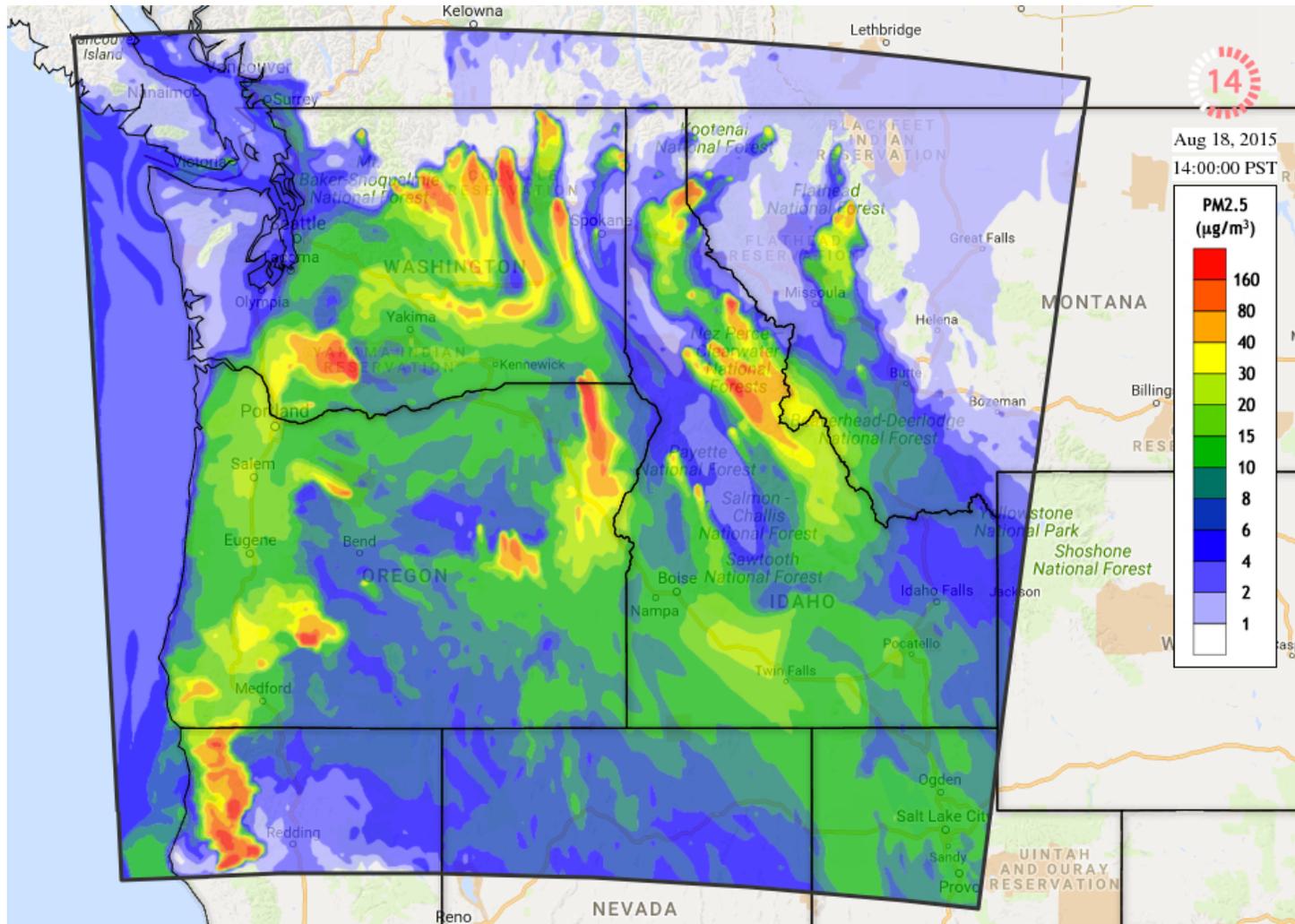
June 15, 2017



Laboratory for Atmospheric Research
Washington State University

Biomass burning affects air quality significantly.

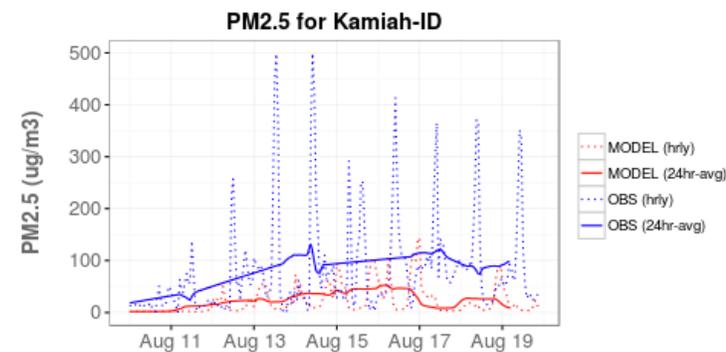
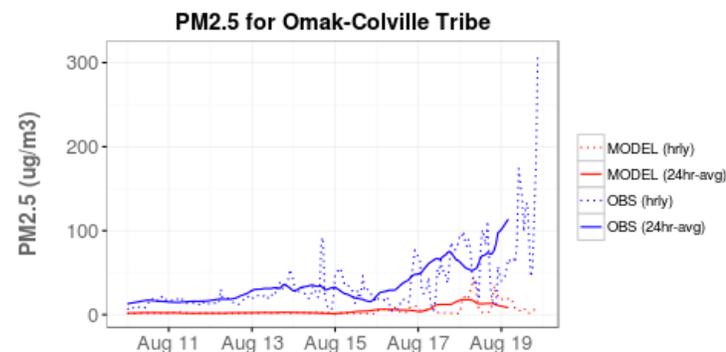
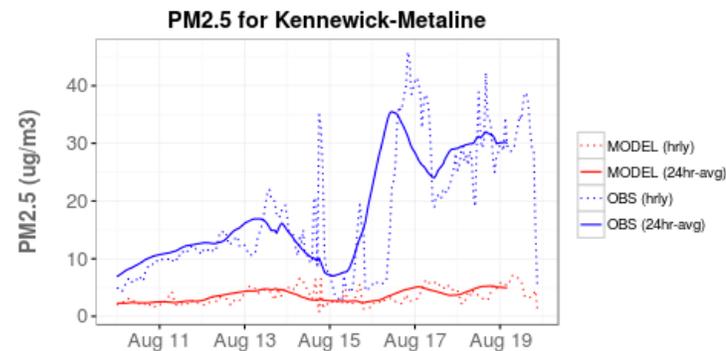
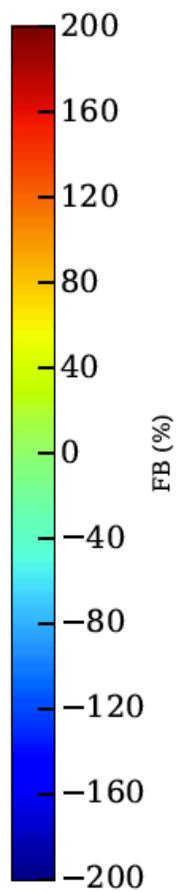
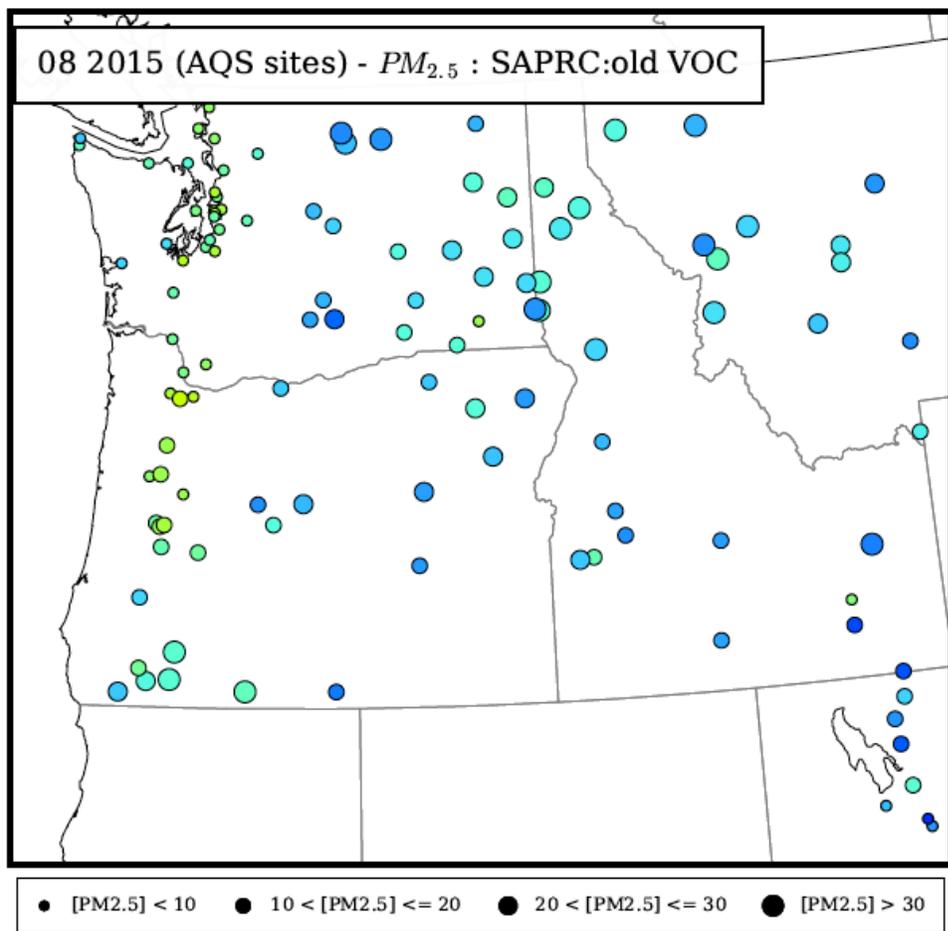
AIRPACT-5 PM_{2.5} 2pm August 18 2015





Challenges to modeling air quality resulted from biomass burning

AIRPACT-5 Fractional Bias PM_{2.5} August 2015





Uncertainty in 'net' Secondary Organic Aerosol (SOA) production from biomass burning

Two important parameters

- $\Delta\text{OA} / \Delta\text{CO}$ ratio \rightarrow net SOA formation
- OM:OC (O/C ratio) \rightarrow aging of OA

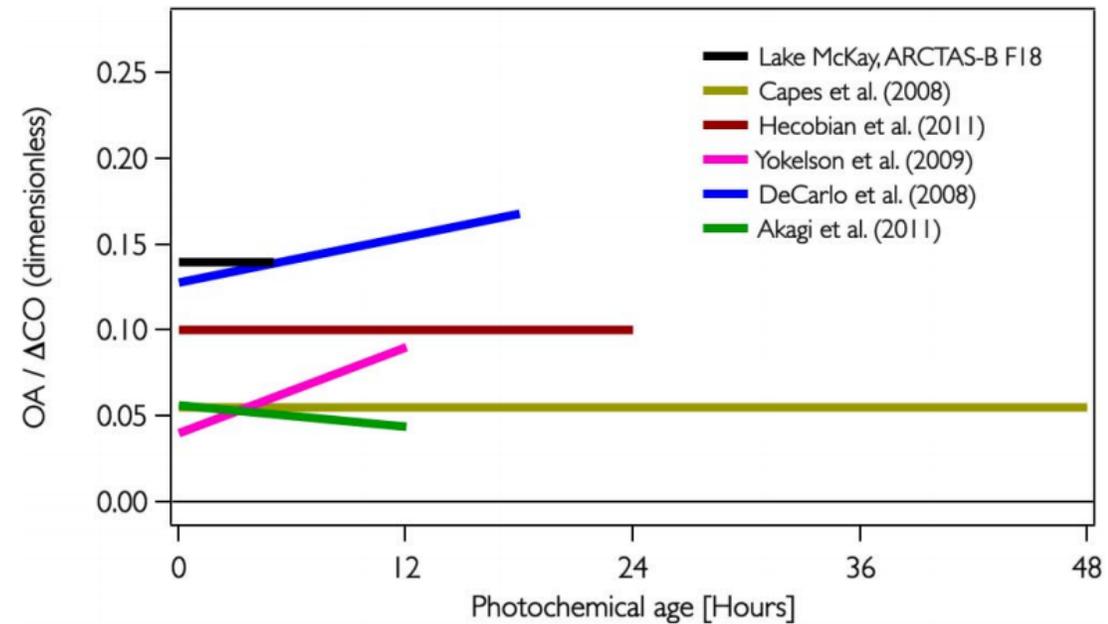
Out of 17 published aircraft studies on aging of Wildfire emissions

- 10: no detectable net addition of OA mass
- 3: a decrease
- 4: an increase

The findings imply that the OA mass from biomass burning remains roughly constant during aging

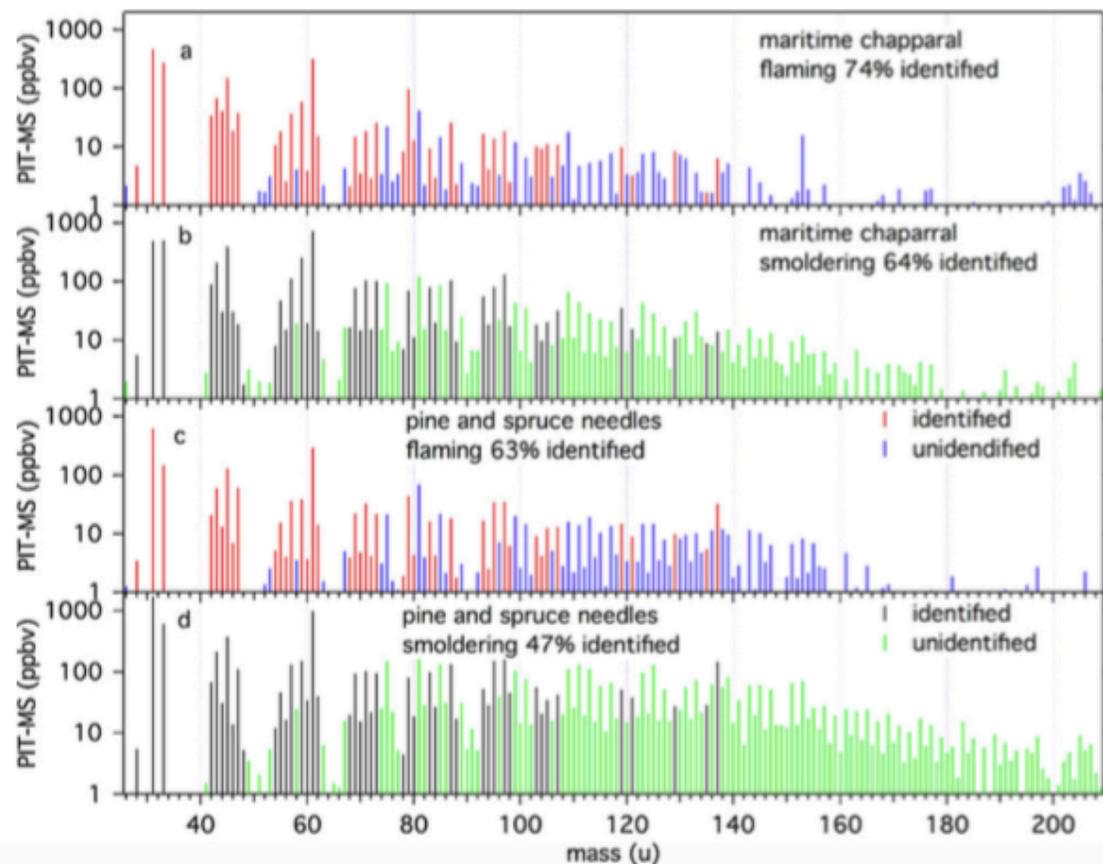
net OA = Dilution/evaporation of OA - SOA formation

M. J. Cubison et al.: Effects of aging on organic aerosol



This study: Uncertainty in SOA precursors from biomass burning emissions

Unidentified species (blue or green)



From: Warneke et al., *IJMS*, 2011

Goal 1: To improve the chemical speciation and emission factors of SOA precursors

- Use data from FLAME-4 (Fourth Fire Lab at Missoula Experiment) to calculate emissions factors and build an updated emissions inventory for 'boreal forest' land cover type

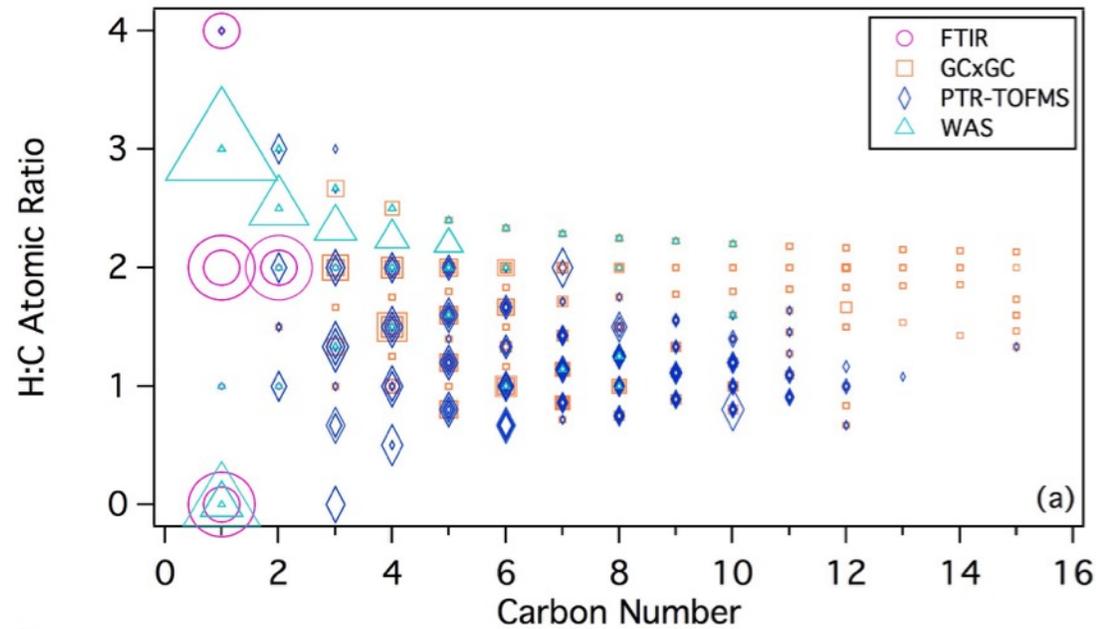
Goal 2: To assess the impact of improved SOA precursors emissions on air quality

- Run regional air quality model (CMAQ) with default and updated emissions
- Evaluate changes in SOA and $PM_{2.5}$ formation; compare model predictions with observations



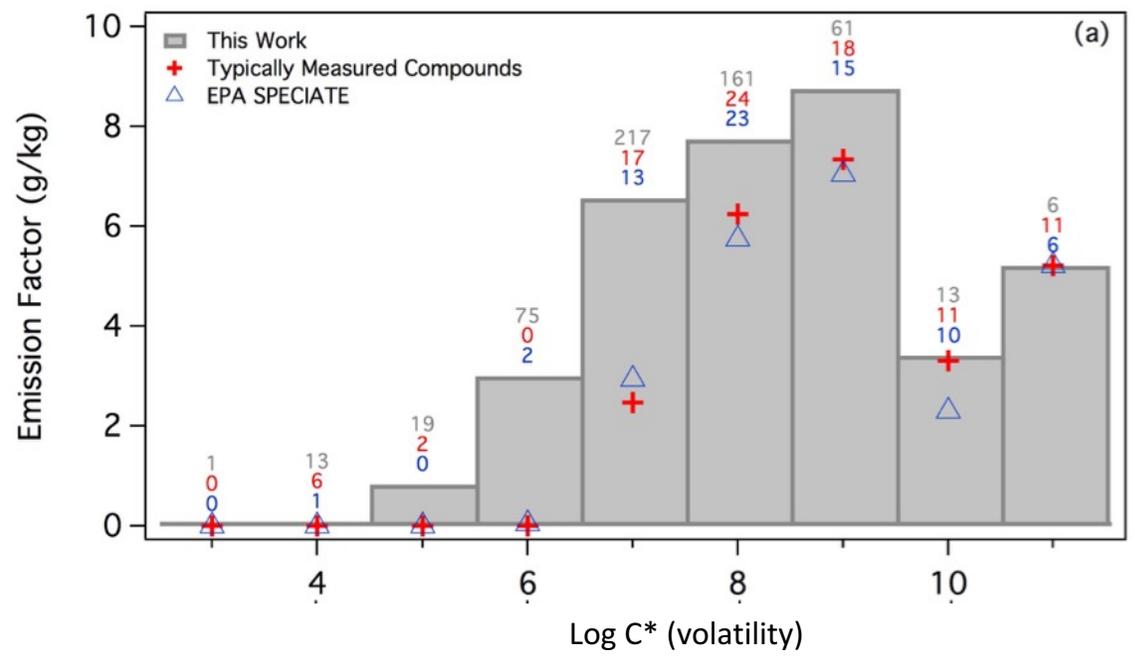
Uncertainty in SOA precursors from biomass burning emissions

Compositional Range of NMOCs



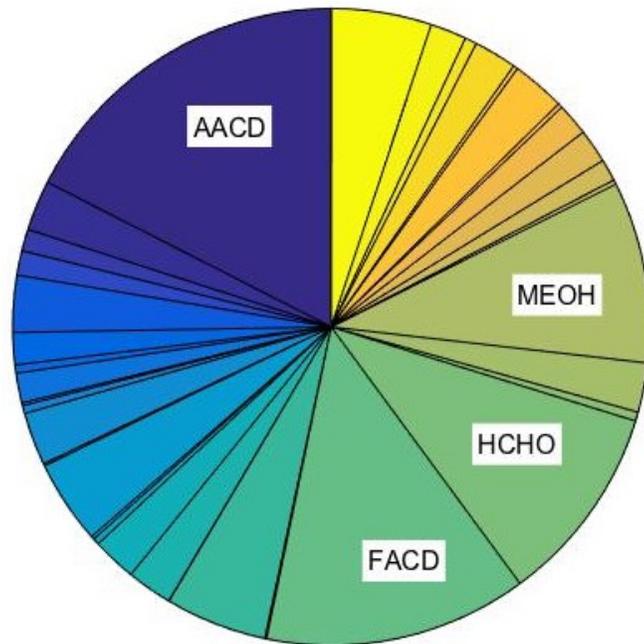
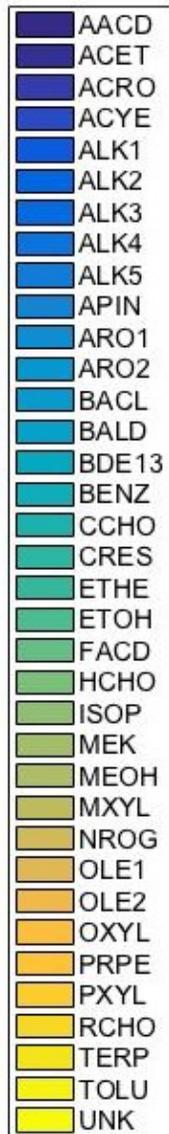
Chemical Composition,
Complimentary Analytical Approaches

Volatility Range of NMOCs



Volatility Distribution of Measured NMOCs
Less Volatile than Typically Captured

Surrogate SAPRC Profiles: Default vs. Updated



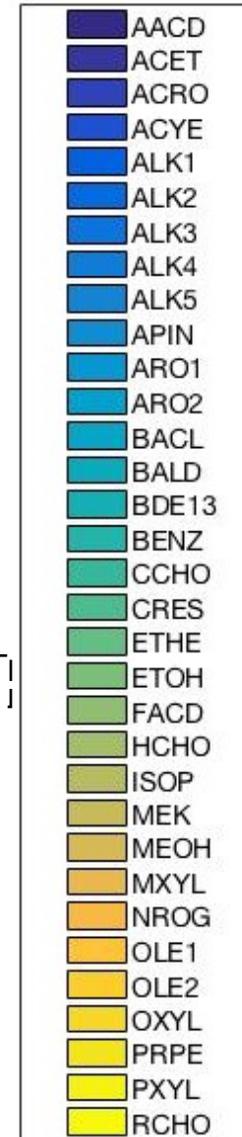
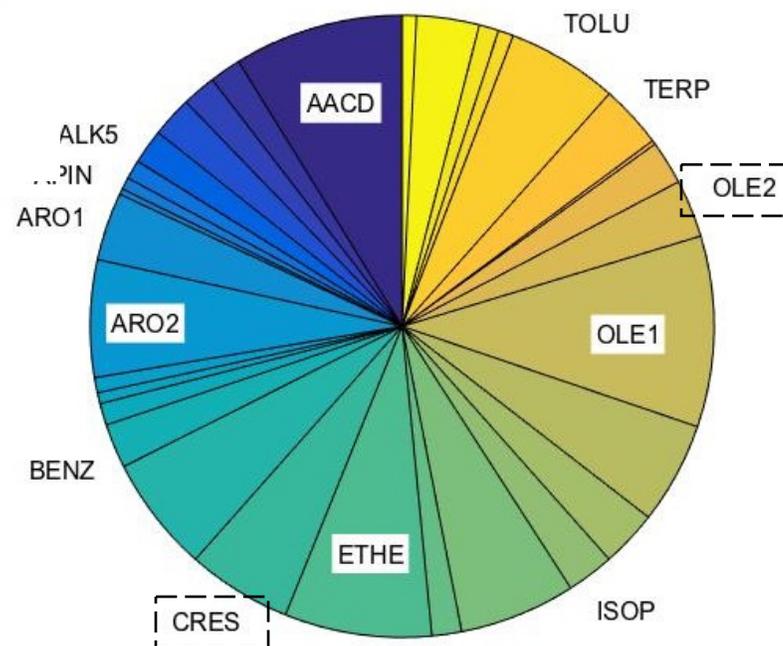
Default

SOA precursors: ALK5, ARO1 (incl. toluene), ARO2 (incl. xylene), BENZ, ISO, TERP (incl. a-pin.), SESQ

% EF by Mass

ALK5	0.1%	0.6%
ARO1	0.5%	0.9%
ARO2	0.1%	6.1%
BENZ	2.3%	2.3%
TERP	1.0%	3.6%
ISO	0.5%	2.5%

Updated



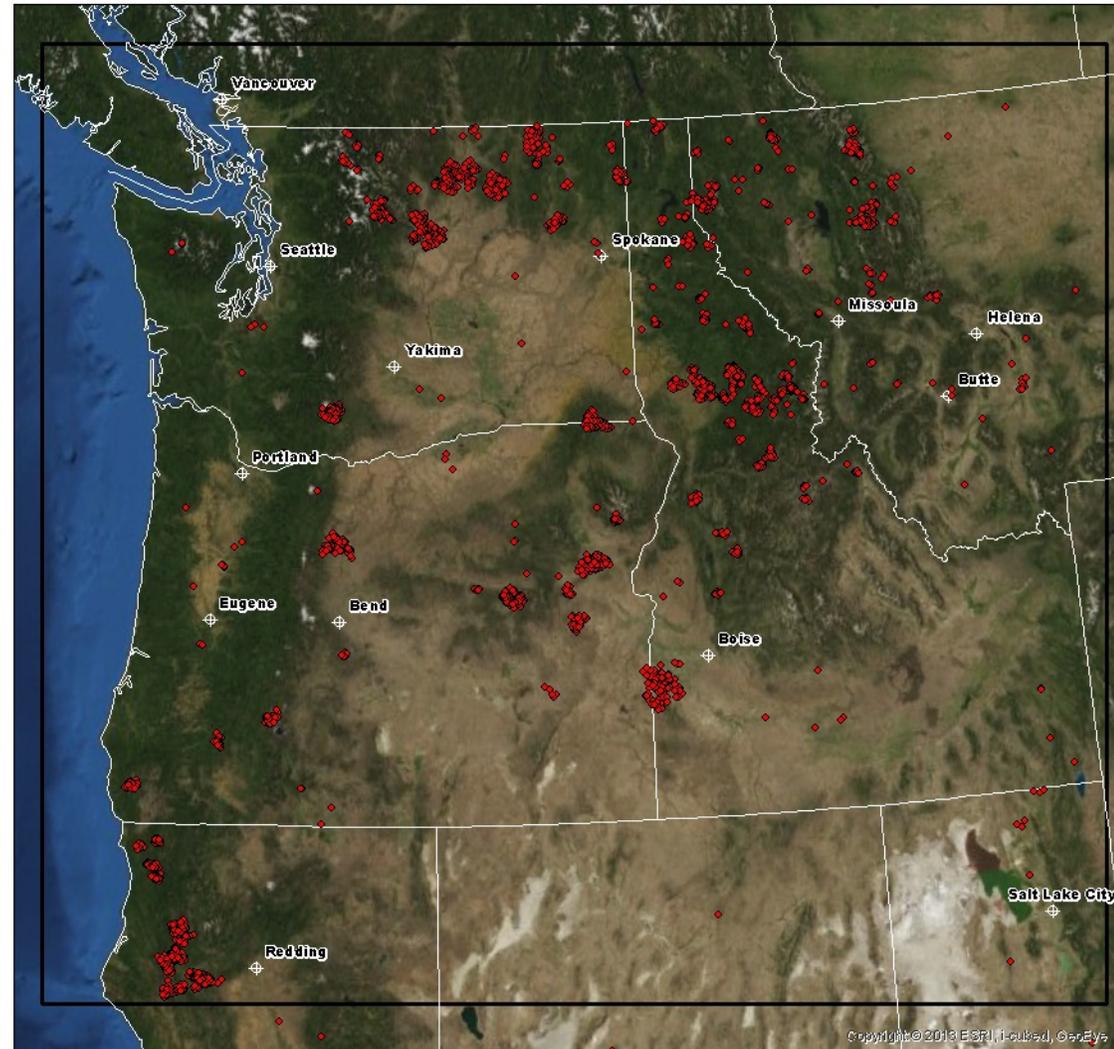


3-D Modeling Details

- AIRPACT-5 Domain (4-km x 4-km, 21 vertical layers)
- Simulation Period: 2015-08-10 to 2015-08-20
- Biogenic Emissions: MEGANv2.10
- Fire Emissions: BlueSkyv.2.5.1
- CMAQv5.0.2

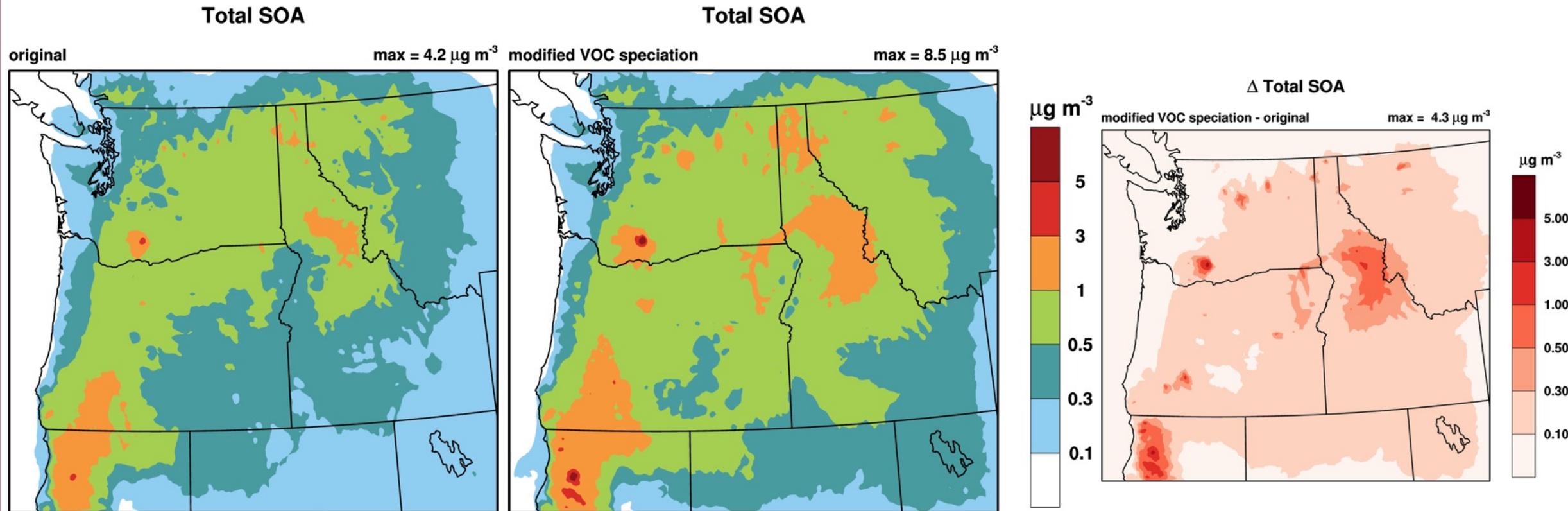
Gas chemical mechanism	SOA precursors Emissions
CB05	Original
SAPRC07	Original
SAPRC07	Updated

SMARTFire-Fire Activity Map

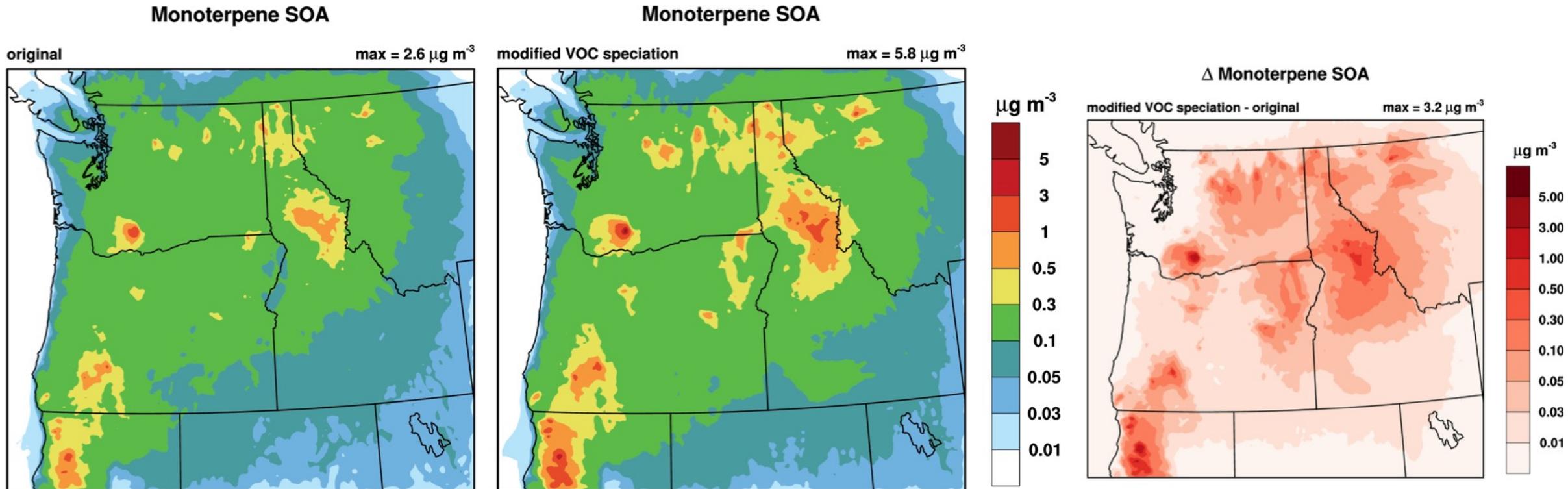




Model Results: Changes in Total SOA



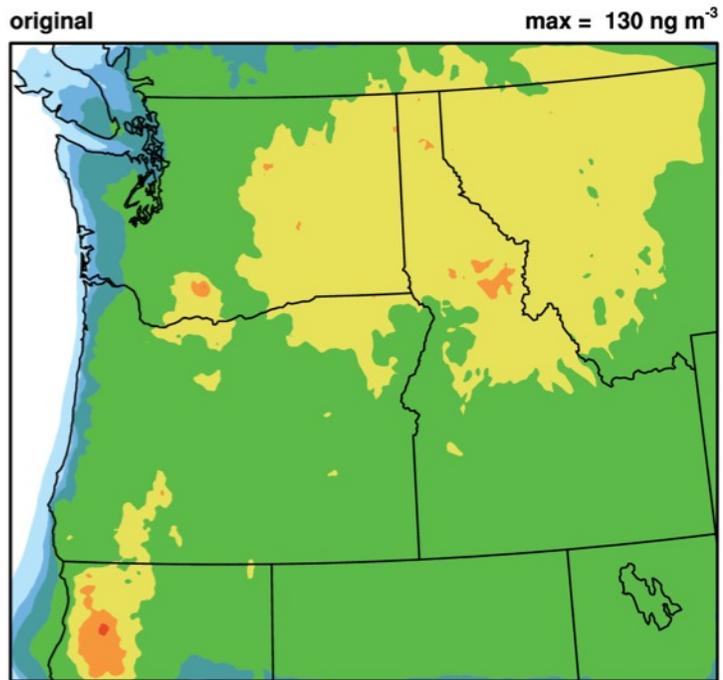
Model Results: Changes in Monoterpene SOA



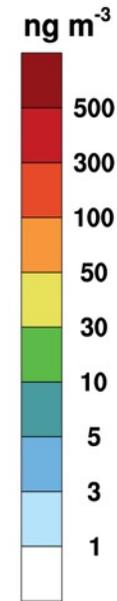
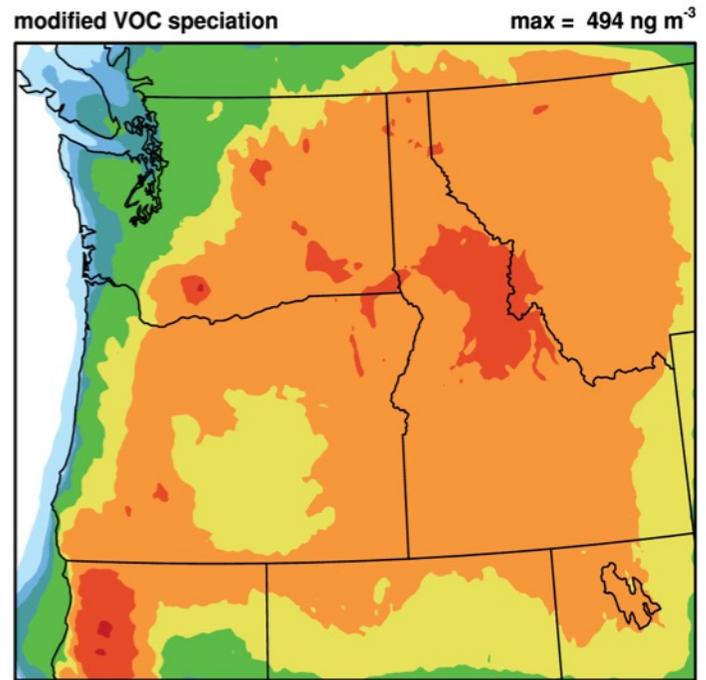


Model Results: Changes in ARO2 SOA

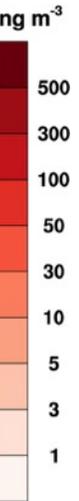
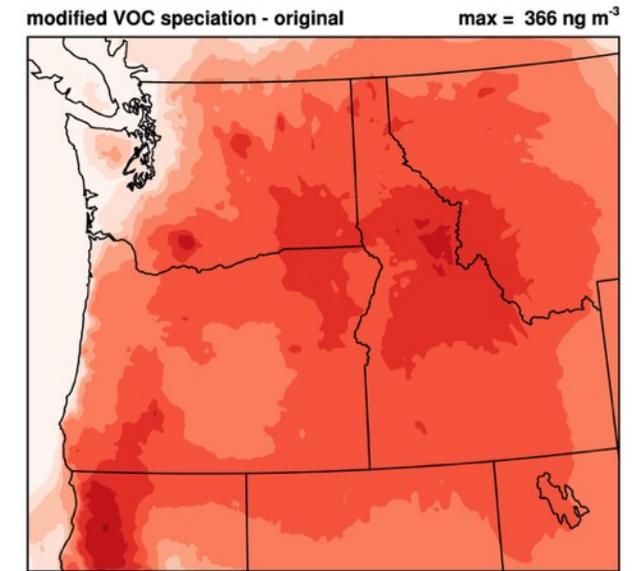
ARO2 (xylene) SOA



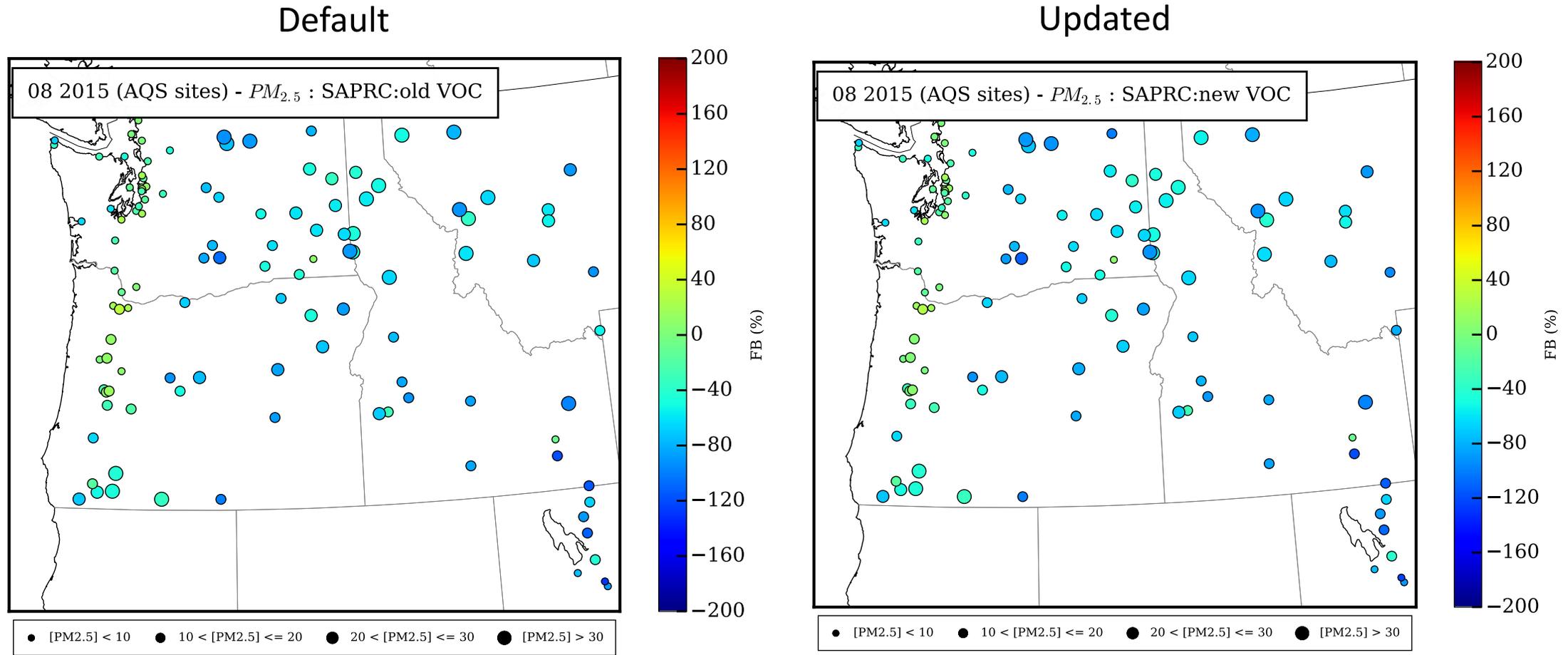
ARO2 (xylene) SOA



Δ ARO2 (xylene) SOA



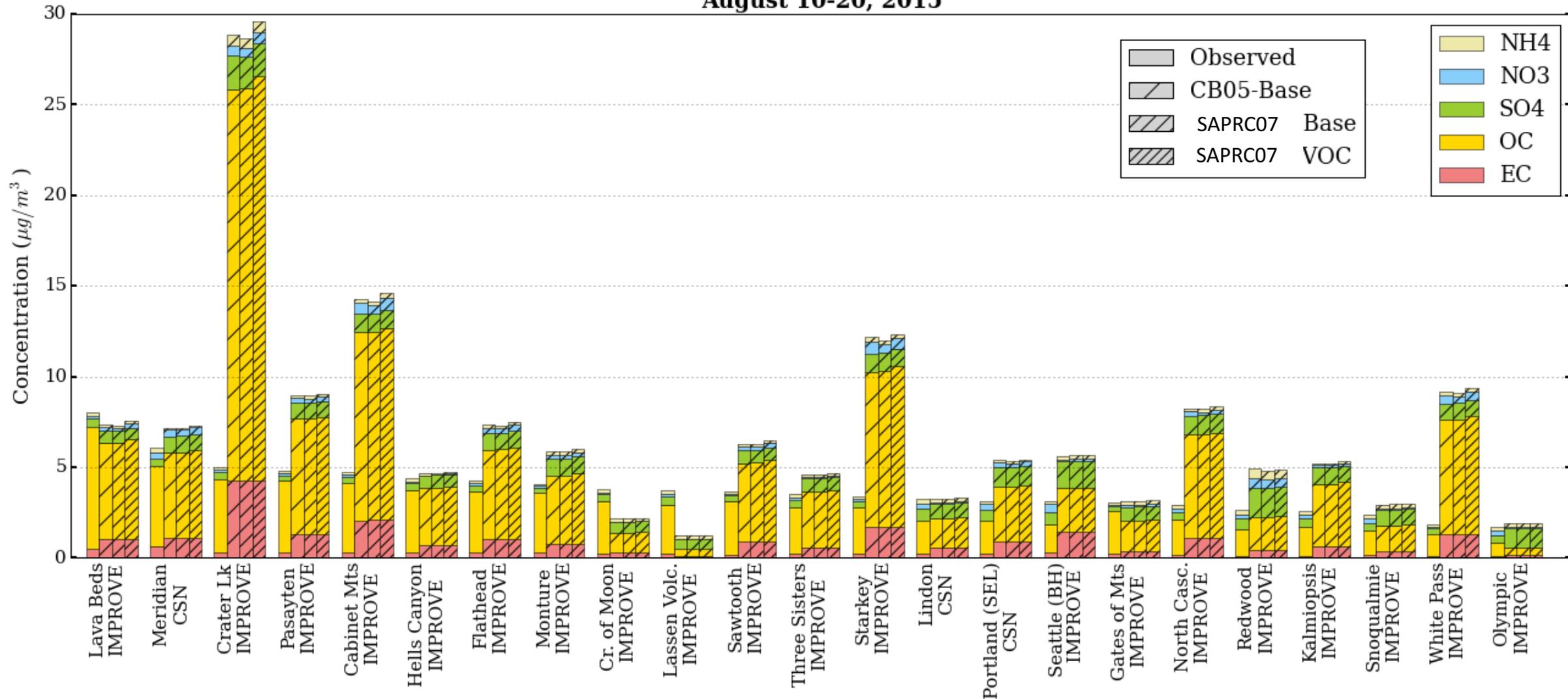
PM_{2.5} Fractional Bias Predictions vs. Observations



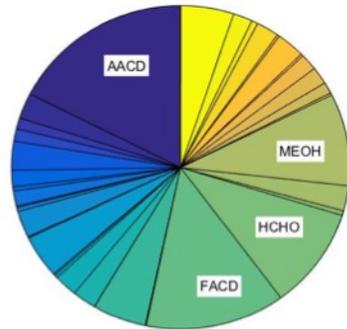
No Change in PM_{2.5}
Primary Emissions $\mu\text{g m}^{-3}$ >> Secondary Production $\mu\text{g m}^{-3}$

PM2.5 Speciation Predictions vs. Observations

August 10-20, 2015

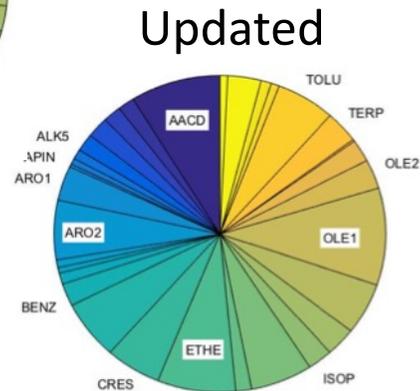


Conclusions



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1. New emissions data fundamentally changes lumped surrogate distribution

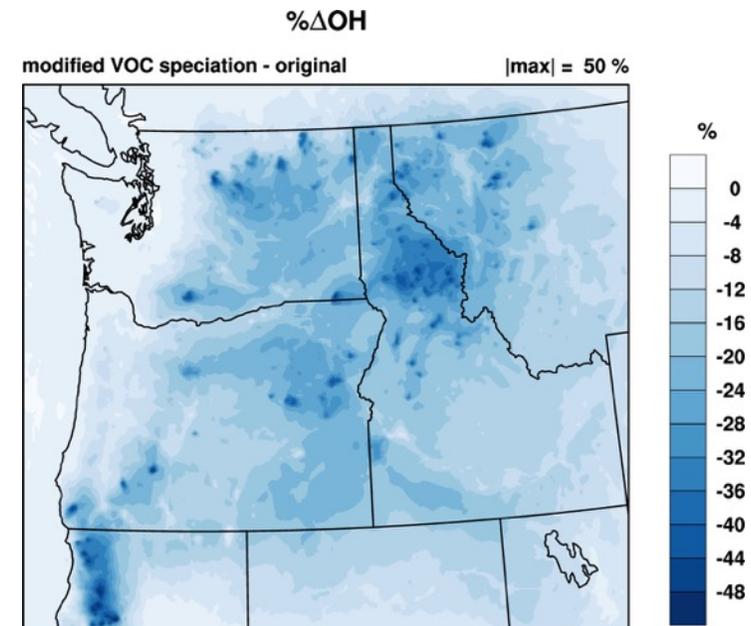


Updated

2. Changes in SOA/PM_{2.5} don't reflect emissions: Oxidant limited? Current SOA schemes insensitive (and arguably unrepresentative)?

3. Yet to Consider...

- compounds known yields not well represented by lumped surrogates (e.g., monoterpenes, alkanes/alkenes, PAHs)
- compounds with understudied SOA yields (see Hatch et al., *ACPD*, 2016)





Next Steps

- Update emission factors of organic gases and PM from biomass burning
- Use BBOP field campaigns and Mount Bachelor OA measurements to evaluate POA and SOA separately
- Account for POA evaporation
- Run a sensitivity run to test SOA parameters (e.g., volatility and partitioning)