



Quantification of Cooking Organic Aerosol (COA) in the Indoor Environment

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AMS Users Meeting

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HR-AMS at HOMEChem

HOMEChem: House Observations of Microbial and Environmental Chemistry

→ 28 days of planned experiments

→ Replicate real indoor occupant activities (cooking, cleaning)



HR-AMS at ATHLETIC

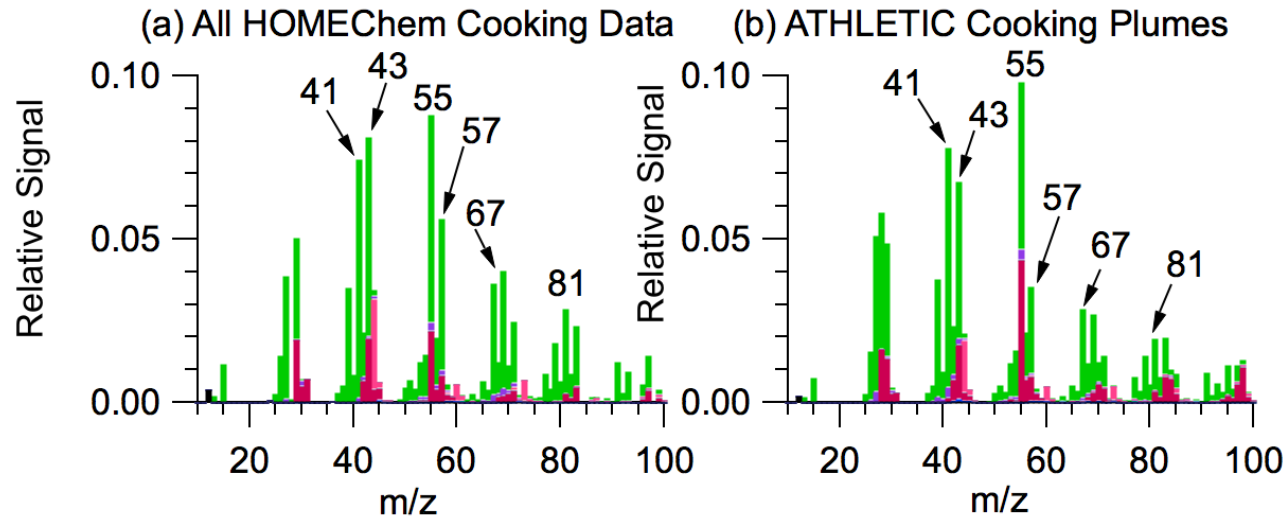
ATHLETIC: Athletic Center Study of Indoor Chemistry

- Human emissions sampled at a university athletic center
- COA introduced to the sampling site via building ventilation system (not planned)



COA Mass Spectra

Average Mass Spectra:

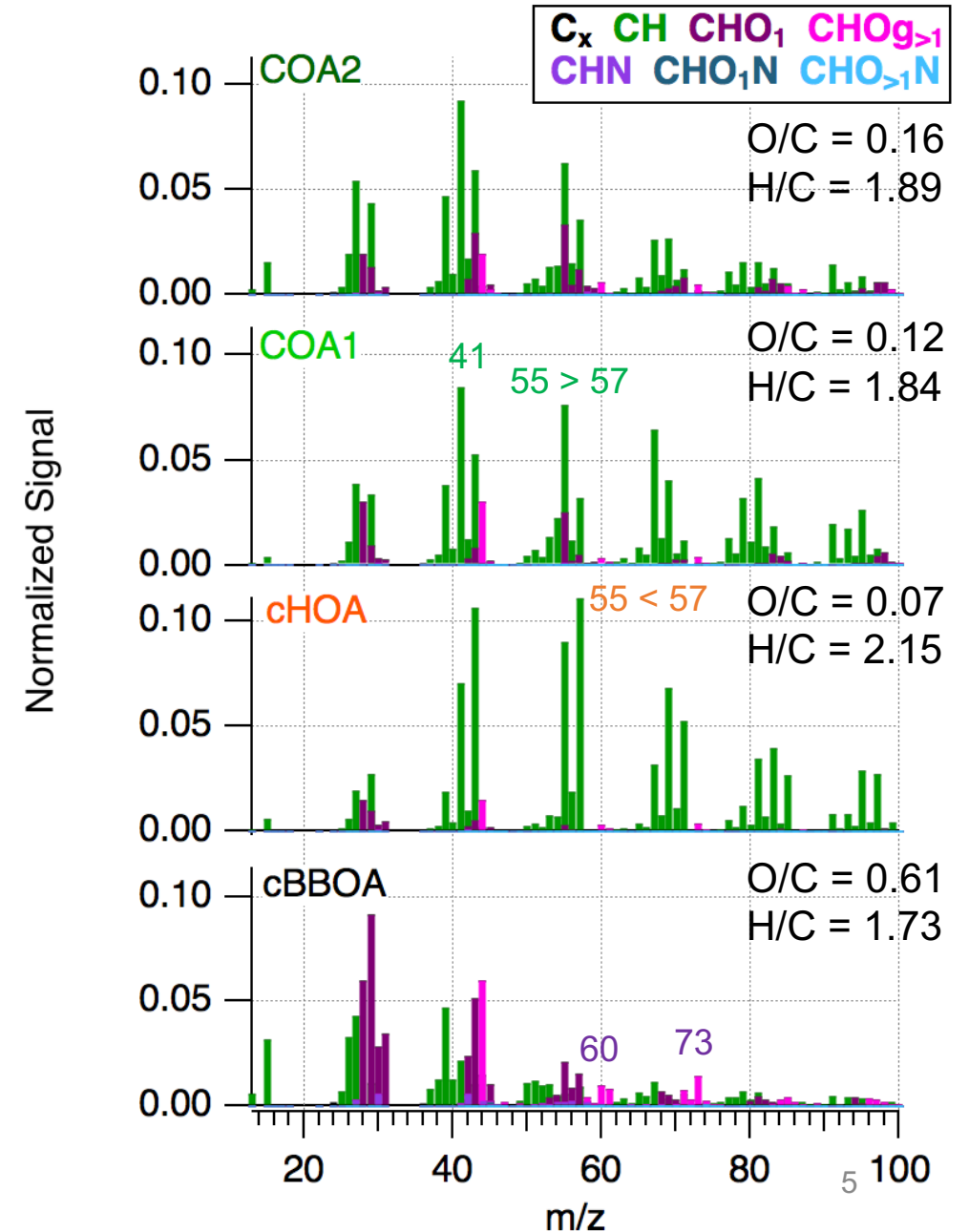


- Average COA mass spectra are similar ($R^2 = 0.97$)
- Typical COA ions identified
 - 55 > 57
 - High fraction of m/z 55 & 41
- PMF was run on HOMEChem cooking data

COA Mass Spectra

- **Cooking organic aerosol 2 "COA2"**
(oven emissions)
- **Cooking organic aerosol 1 "COA1"**
(stovetop sautéing)
- **Cooking associated hydrocarbon-like organic aerosol "cHOA"**
(bread toasting)
- **Cooking associated burning/browning organic aerosol "cBBOA"**
(burning, charring, caramelization events)

Four HOMEChem COA Factors Identified With PMF:



Quantification of Oxidized vs. Reduced OA

$$[OA] \propto \frac{1}{RIE_{OA} * CE}$$

Possibility for hydrocarbons & oxygenated hydrocarbons to have different RIE was suggested and utilized early on

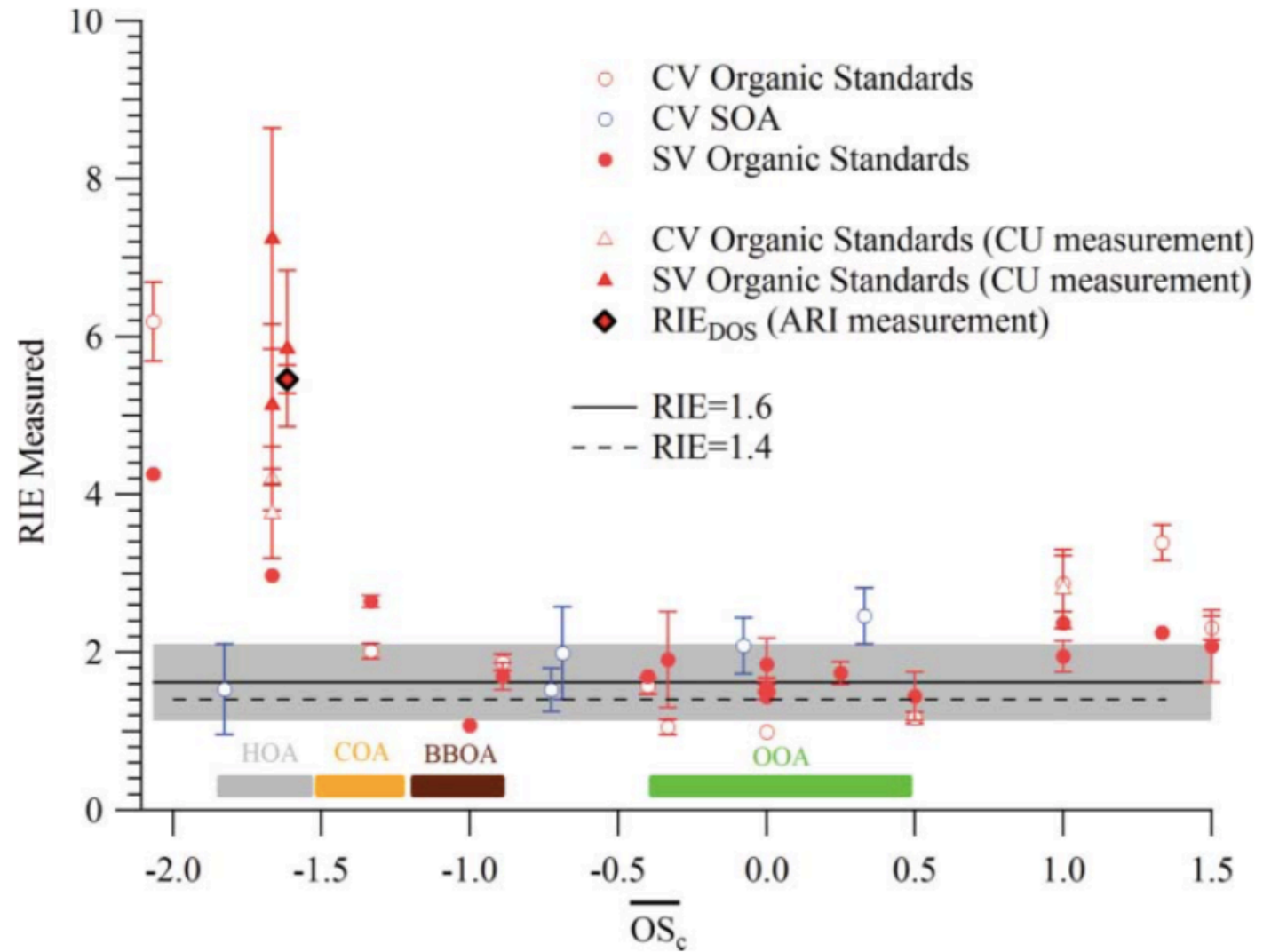
Jimenez et al. 2003 JGR

Reduced, pure component laboratory standards RIE > 1.4

Xu et al. 2018 AS&T

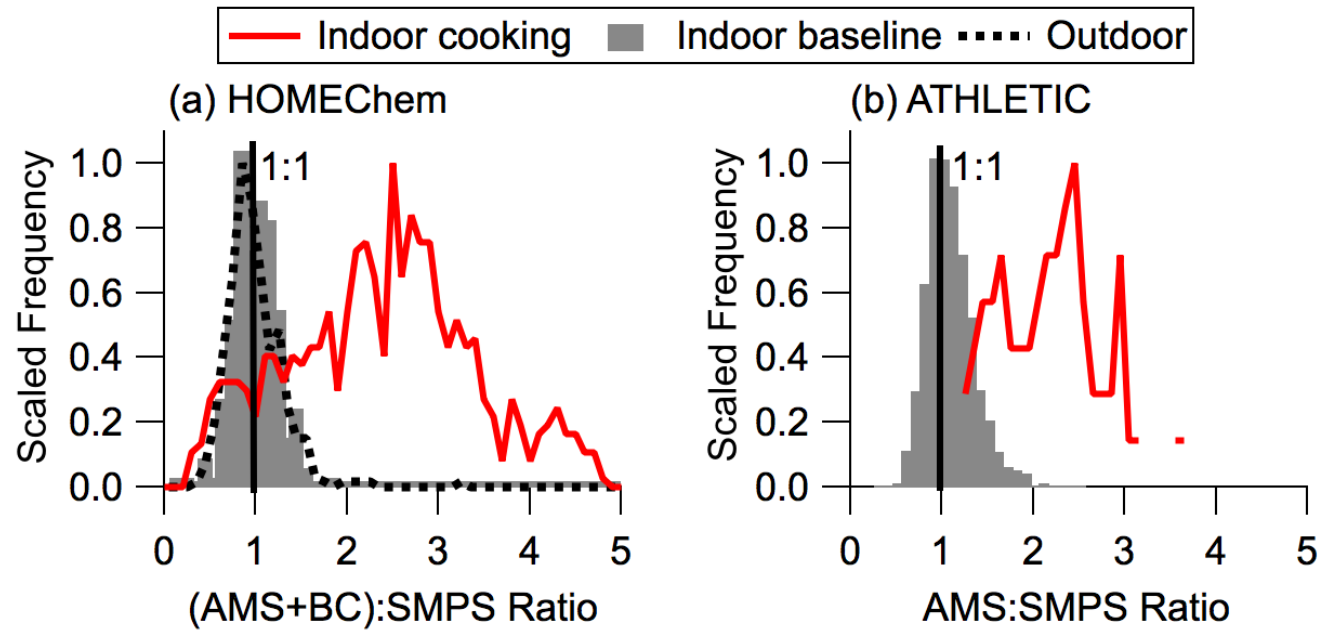
Laboratory cooking organic aerosol RIE = 1.56 to 3.06

Reyes-Villegas et al. 2018 ES&T



Xu et al. 2018 AS&T
Figure 6

Field Data Quantification with Typical Parameters



- $RIE_{OA} = 1.4$
- $CE_{\text{Baseline} + \text{Outdoor}} = \text{Middlebrook et al. (2012) parameterization}$
- $CE_{\text{Cooking}} = 1.0$

Factors contributing to HR-AMS over-estimation

1. Particle density
2. Size distribution differences between instruments
3. AMS transmission efficiency
4. RIE and CE

→ Most important factors

Factors Contributing to HR-AMS Over-estimation

1. Particle density

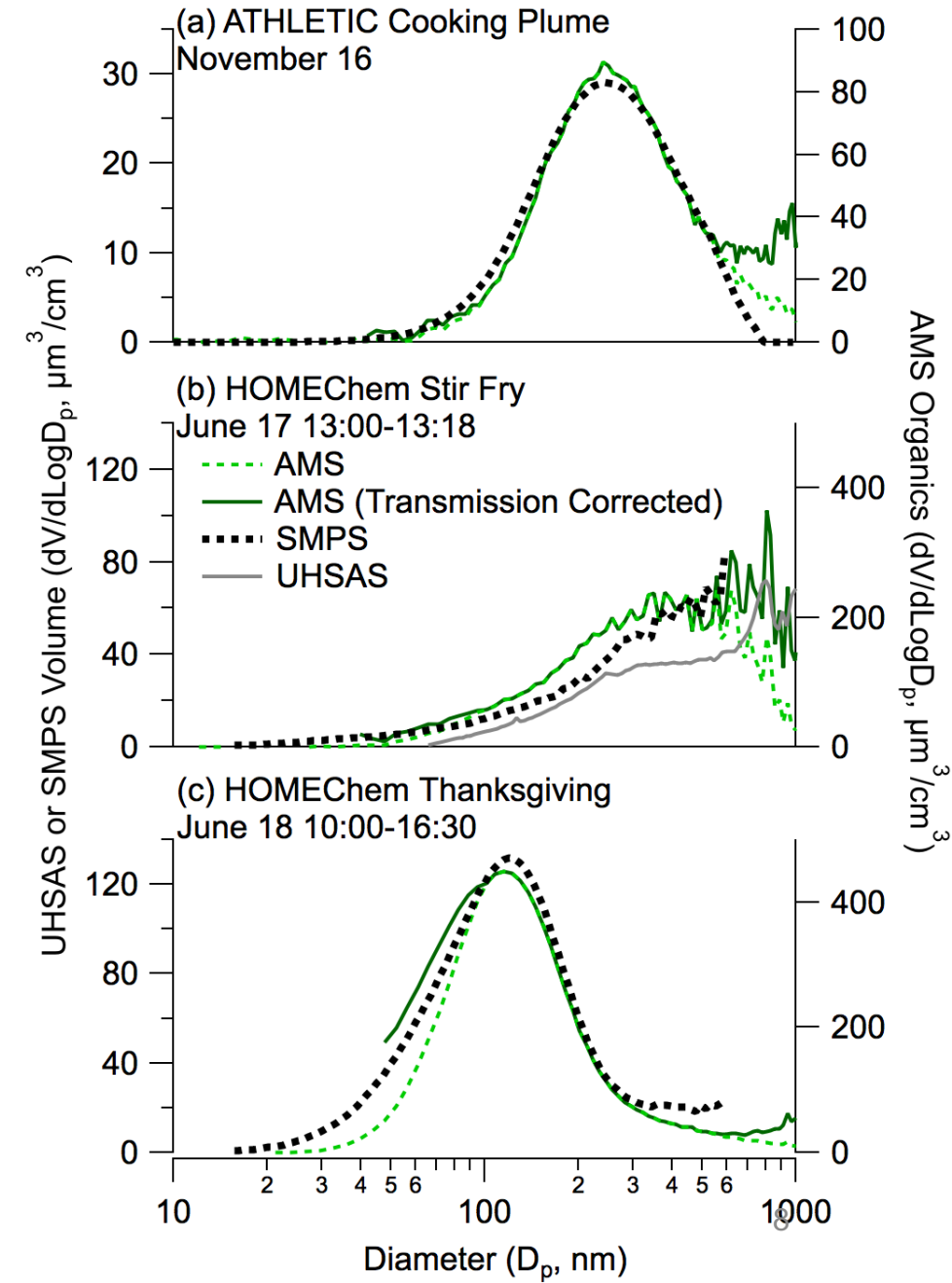
- Density via Kuwata et al. (2012) O/C, H/C parameterization
 - HOMEChem = 1.0 g/cm³
 - ATHLETIC = 0.95 g/cm³
- AMS & SMPS size distribution comparison
 - Agreement indicates 1.0 g/cm³

2. Size distribution differences between instrument

- UHSAS: compare during stir fry experiments
- SMPS: compare during other experiments

3. AMS transmission efficiency

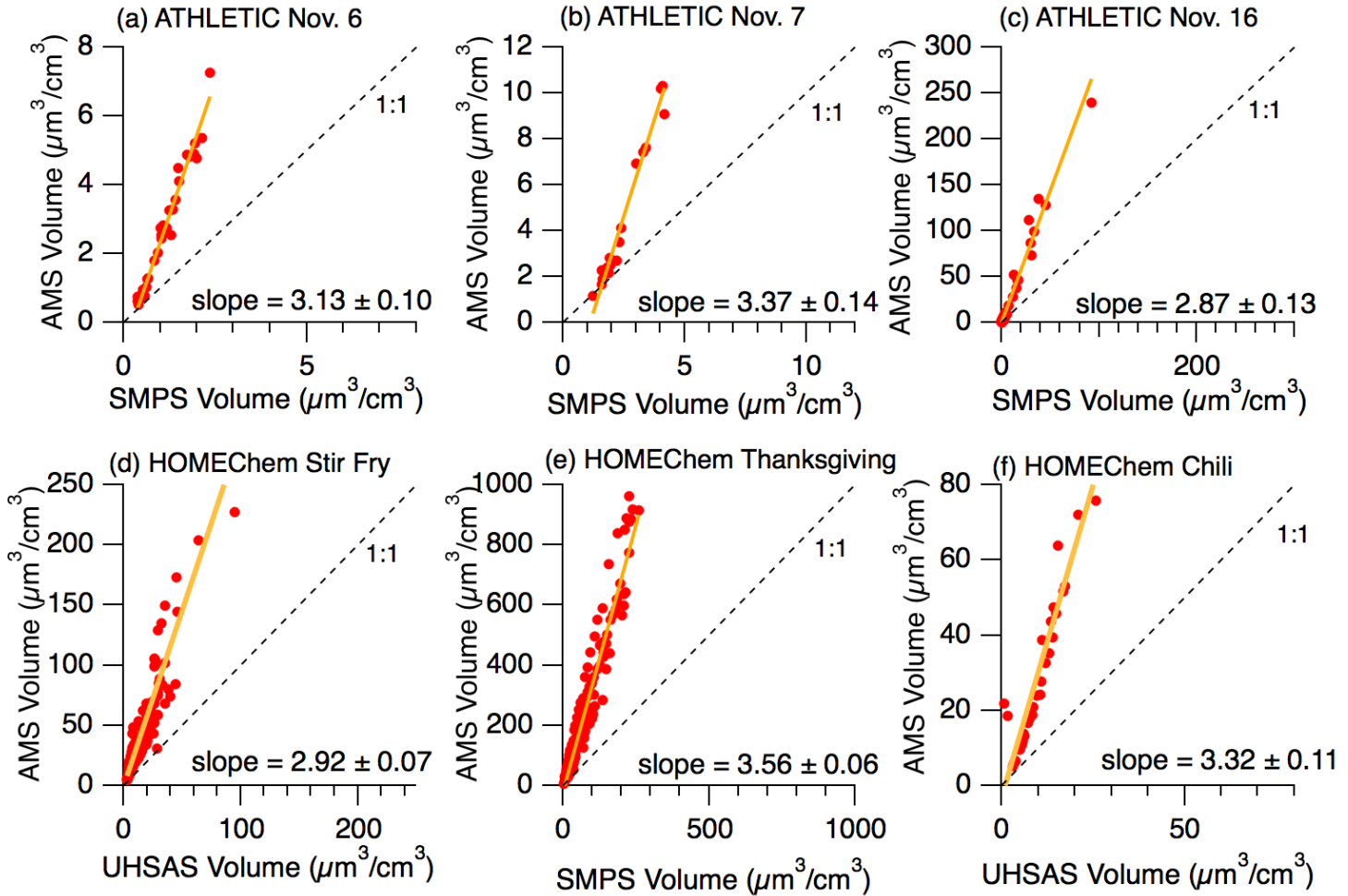
- Deviations in transmission considered in uncertainty analysis



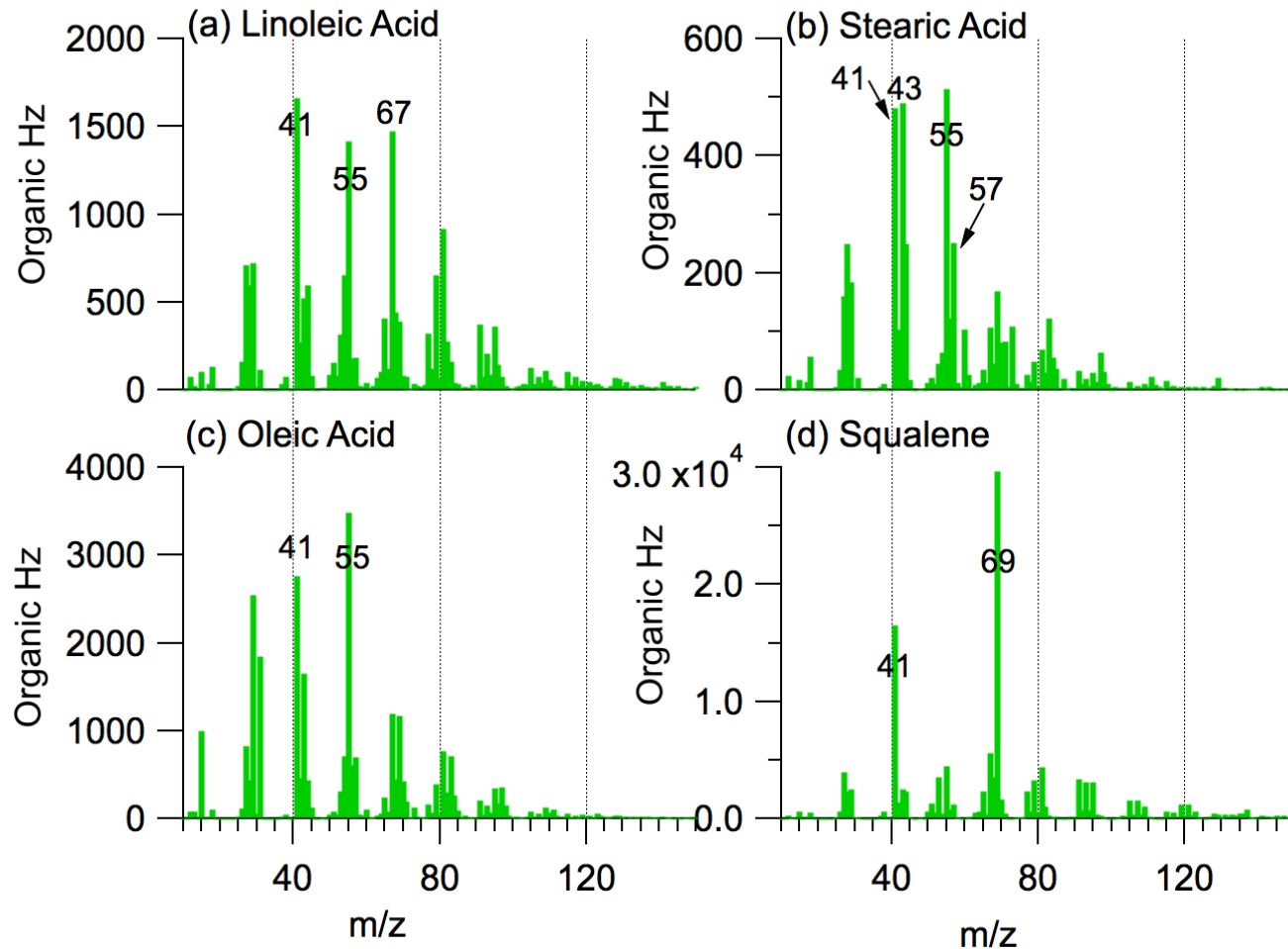
Calculating RIE for Field Data

1. Calculate AMS total volume considering previous factors
2. Compare AMS volume to appropriate instrument (SMPS or UHSAS)
3. Multiply slopes by 1.4 (RIE_{OA}) (Reyes-Villegas et al. 2018) and 1.15 (correction for mass > m/z 100)

	Avg. RIE_{COA}	2σ Uncertainty
ATHLETIC	4.15	33%
HOMEChem	5.57	



Validate Field RIE with Laboratory Calibrations



$$RIE_s = \frac{IE_s}{MW_s} * \frac{MW_{NO3}}{IE_{NO3}} * RIE_{NO3}$$

	RIE (CE = 1)
Stearic Acid	2.56 ± 0.76
Oleic Acid	3.18 ± 0.95
Linoleic Acid	5.77 ± 1.73
Squalene	6.98 ± 2.09

Field RIE_{COA} is within range of lab RIE
 (Field RIE_{COA} : 3.84 to 6.50)

Two Methods for Applying RIE_{COA} to Field Data

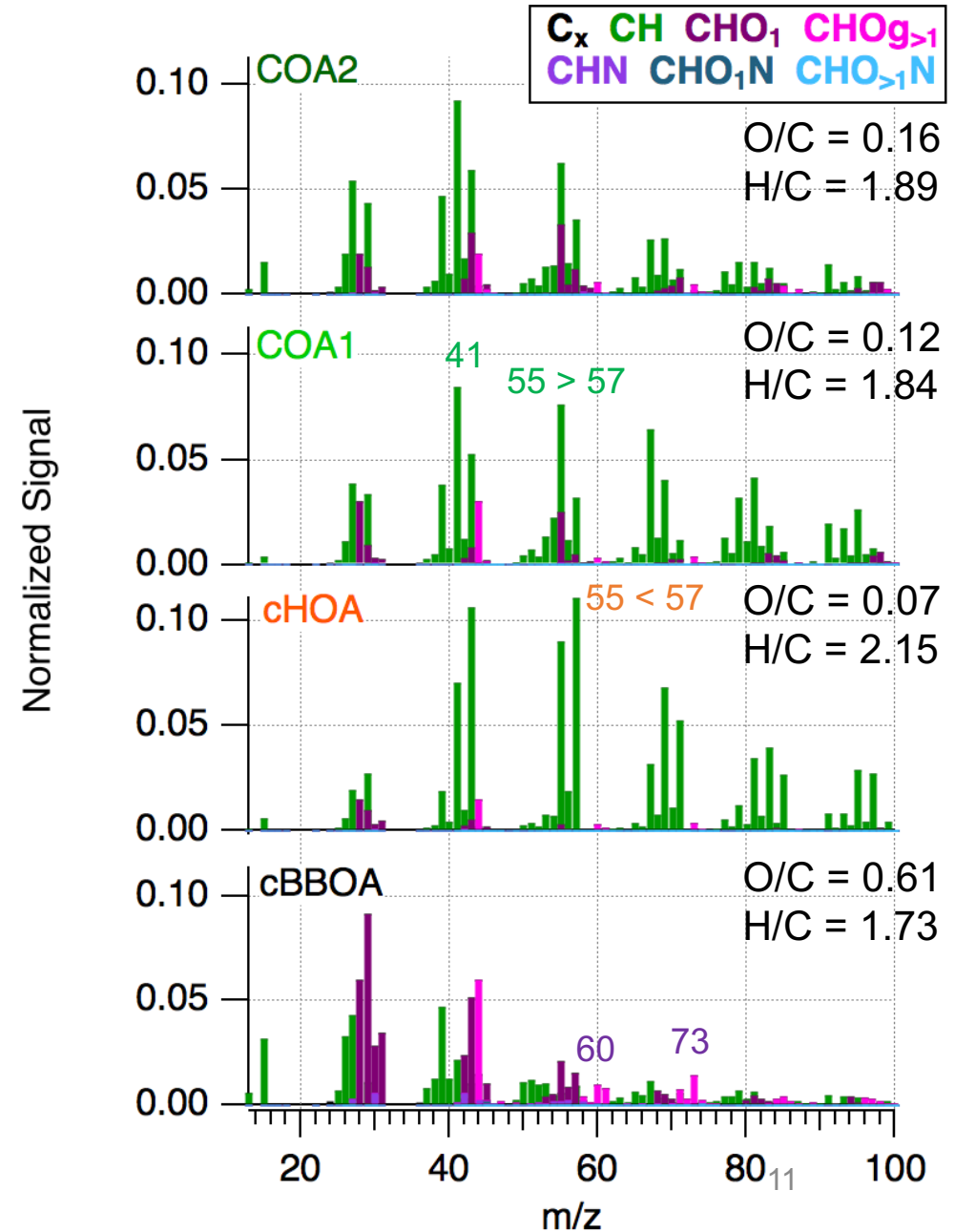
- cBBOA is oxidized (may not warrant use of $RIE > 1.4$) (Xu et al. 2018)

(1) Custom fit method

- Apply $RIE = 1.4$ to cBBOA
- Use Igor custom fit equation to calculate RIE for reduced factors (COA1, COA2, cHOA)

(2) Apply RIE_{COA} to all PMF factors

Use $RIE_{cBBOA} = 1.4$ with custom fit method for consistency with literature



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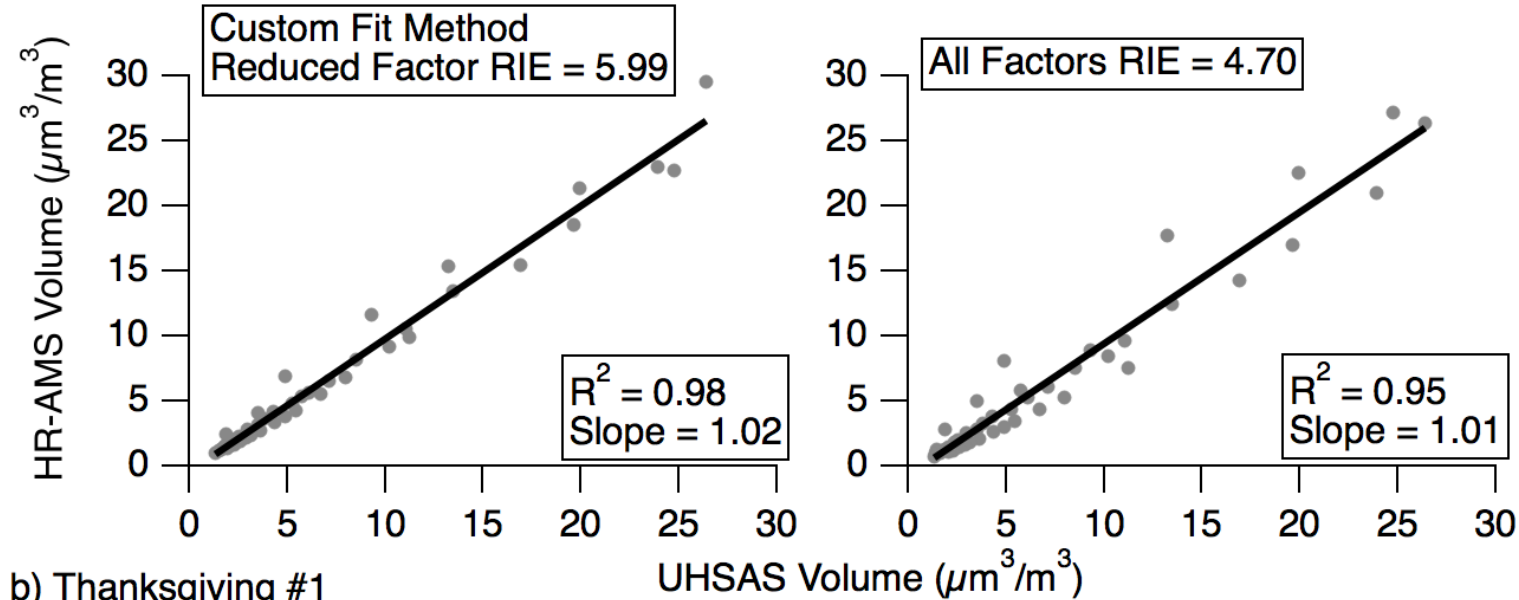
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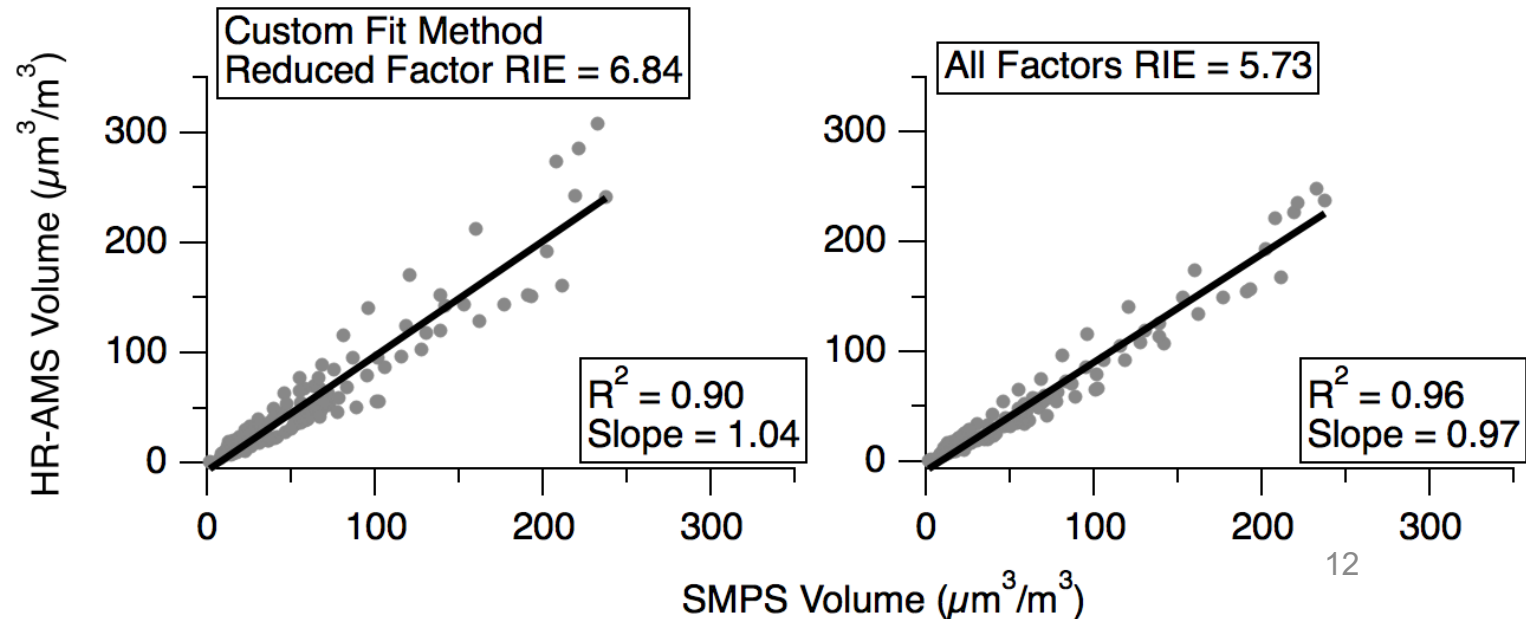
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a) Stir Fry June 17, 2018



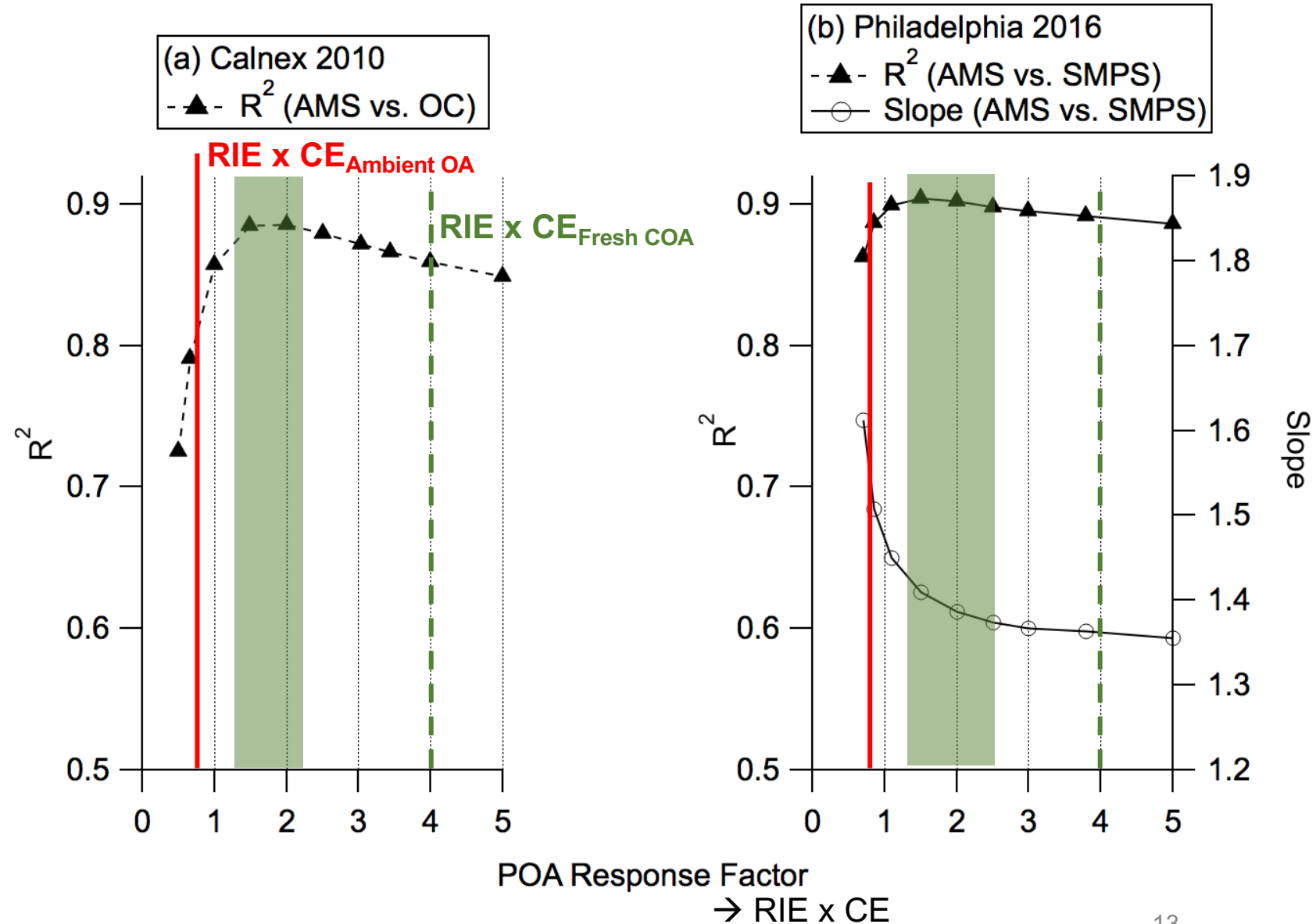
b) Thanksgiving #1



Is RIE_{COA} also important in urban ambient datasets?

- Calnex 2010: impacted by regional COA
 - Hayes et al. 2013 *JGR*
- Philadelphia 2016: near source of fresh COA
 - Avery et al. 2019 *ESPI*
- Varying response factors ($RIE \times CE$) were applied to primary OA ($POA = COA + HOA$) and compared to co-located instruments when POA fraction was high

Ambient POA response factor
 $> 1.4 \times 0.5$
 Not as high as fresh indoor COA



Conclusions

- RIE of fresh COA is greater than the value used for ambient organics
 - $RIE_{\text{Fresh COA}} \sim 4$
 - $RIE_{\text{Ambient OA}} = 1.4$
- Other reduced organics (ambient HOA & COA) may also have $RIE > 1.4$ (likely not as high as fresh COA)
- Applying higher RIE to urban POA factors improved consistency between AMS and co-located instruments
- Cooking style and ingredients may impact RIE_{COA}
 - HOMEChem: Soybean oil
 - Reyes Villegas et al. (2018): Rapeseed oil

Thank you!

