Elemental Analysis of Oxygenated Organic Coating on Black Carbon Particles using a Soot-Particle Aerosol Mass Spectrometer (SP-AMS)

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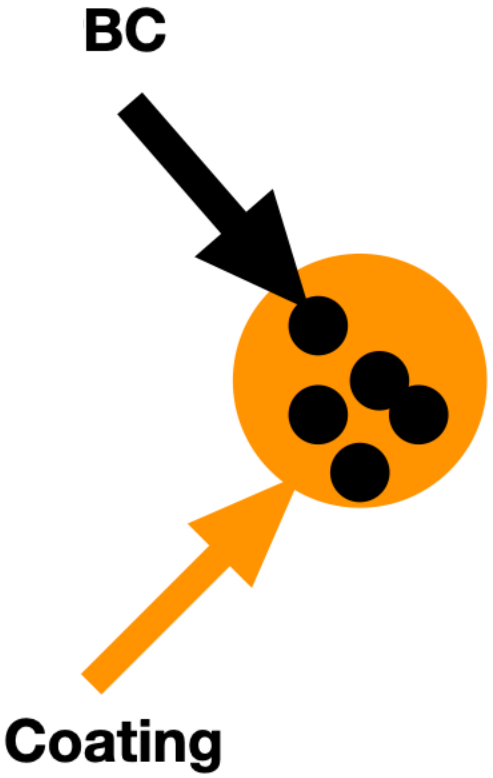
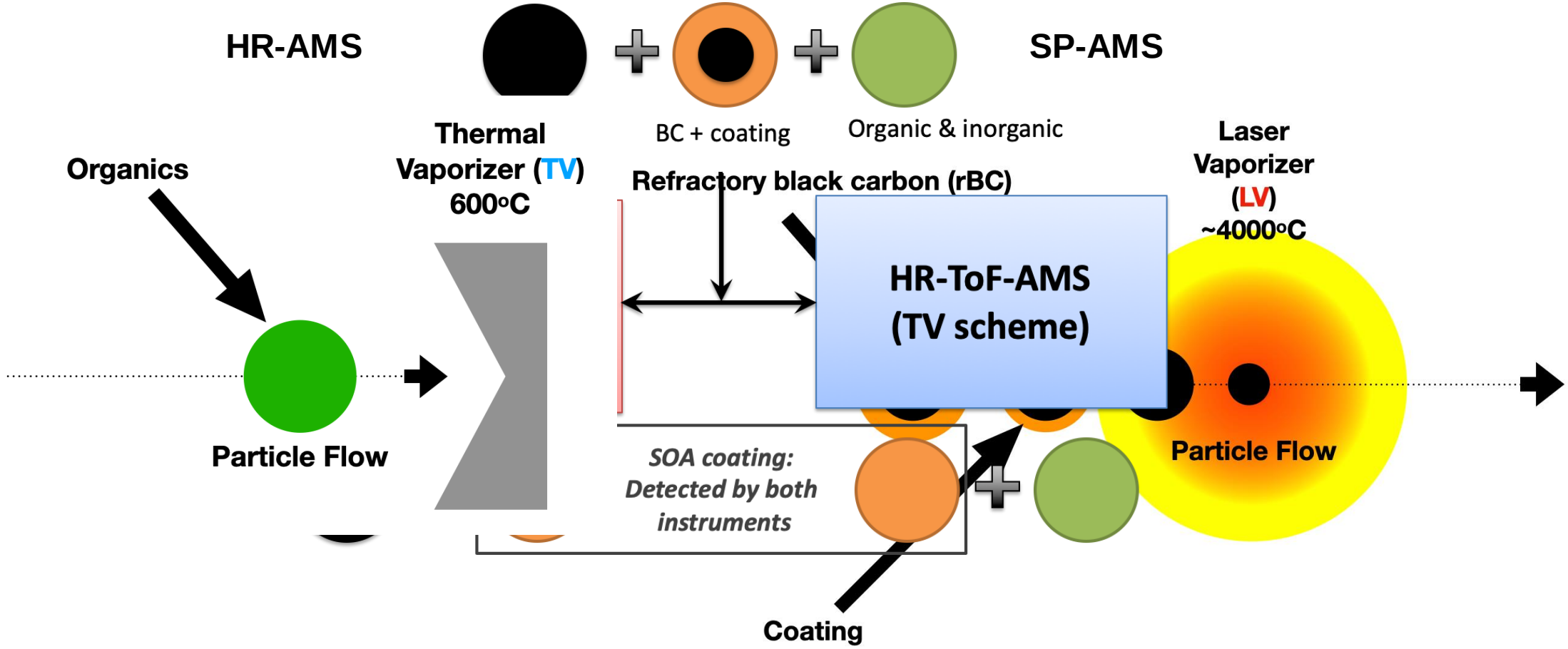
Importance of Black Carbon (BC) Coating Characterization

- BC have significant climate and health impact
- Organic coating can alter BC properties
- Characterization remain challenging



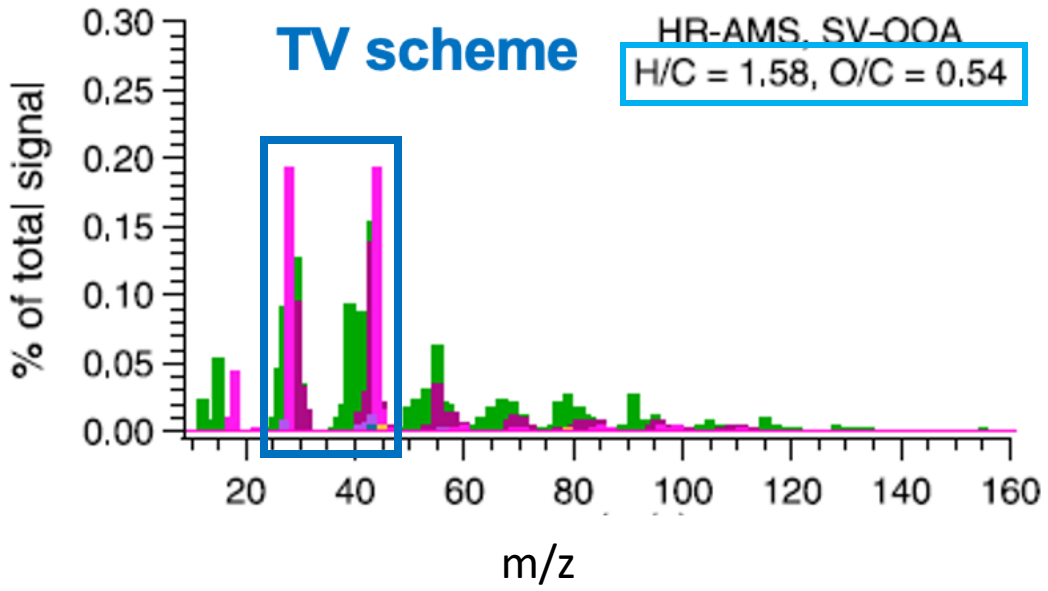
High-resolution Aerosol Mass Spectrometer (HR-AMS) vs. Soot-particle AMS (SP-AMS)

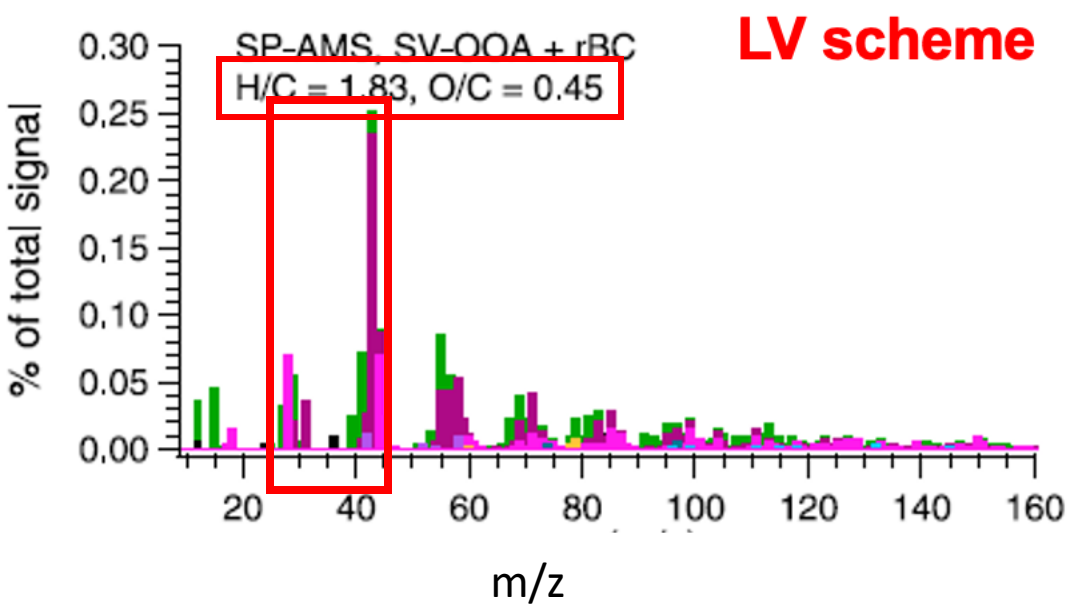
- *The laser vaporization scheme of SP-AMS can detect refractory black carbon (rBC).*



Mass spectral characteristics

Significant difference between OOA and OOA coated on rBC





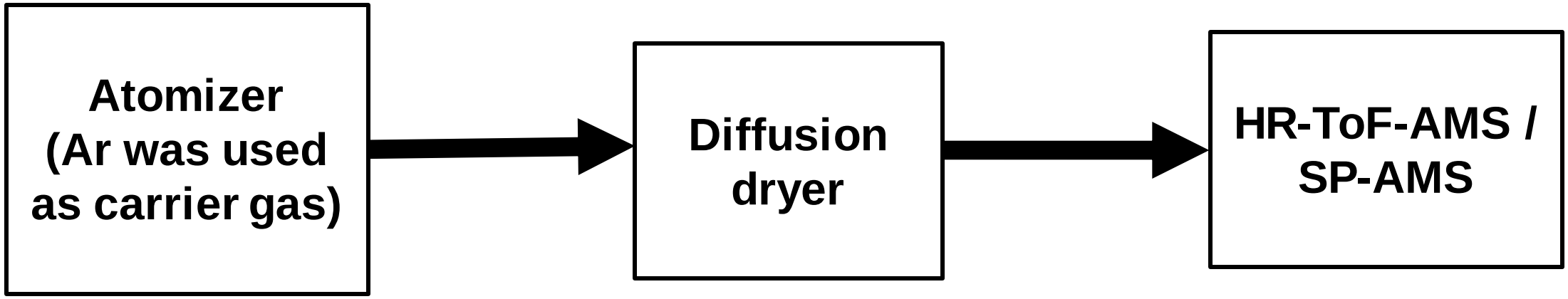
Massoli et al. 2015

Objectives

- Improve our understanding on the impacts of vaporization schemes on investigating atmospheric processing of OA coatings

- Reduce uncertainties of elemental analysis (H:C and O:C) for OA coatings (i.e., Standard HR-ToF-AMS vs. SP-AMS data)

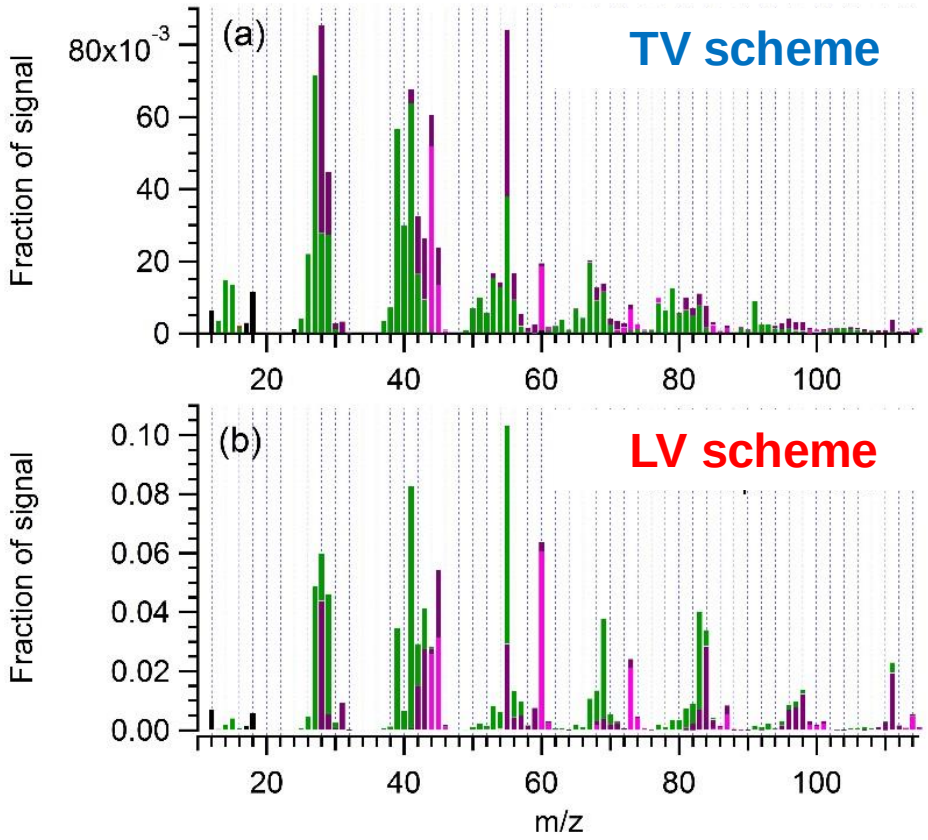
Experiment Setup



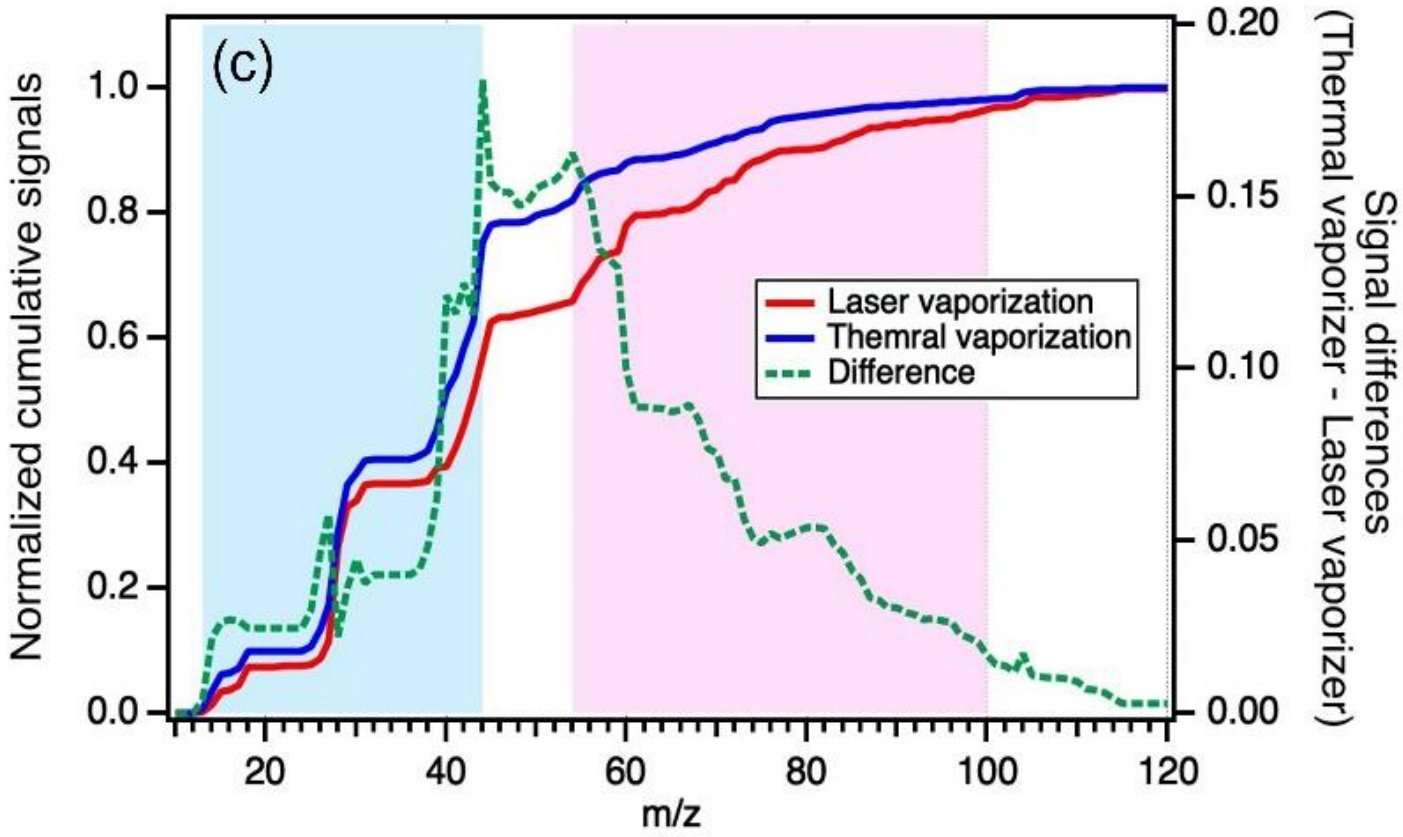
- HR-AMS (i.e. TV scheme) → Pure organic aerosol (OA)
- SP-AMS (i.e. LV scheme) → OA coatings on rBC core
- 30 oxygenated organic species (i.e., acids, alcohols, multifunctional species)
- 3 independent SP-AMS operated by different researchers (National University of Singapore / Aerodyne Research / University of Toronto)

Less fragmentation for OOA Coatings Vaporized by LV Scheme

Example: Azelaic acid



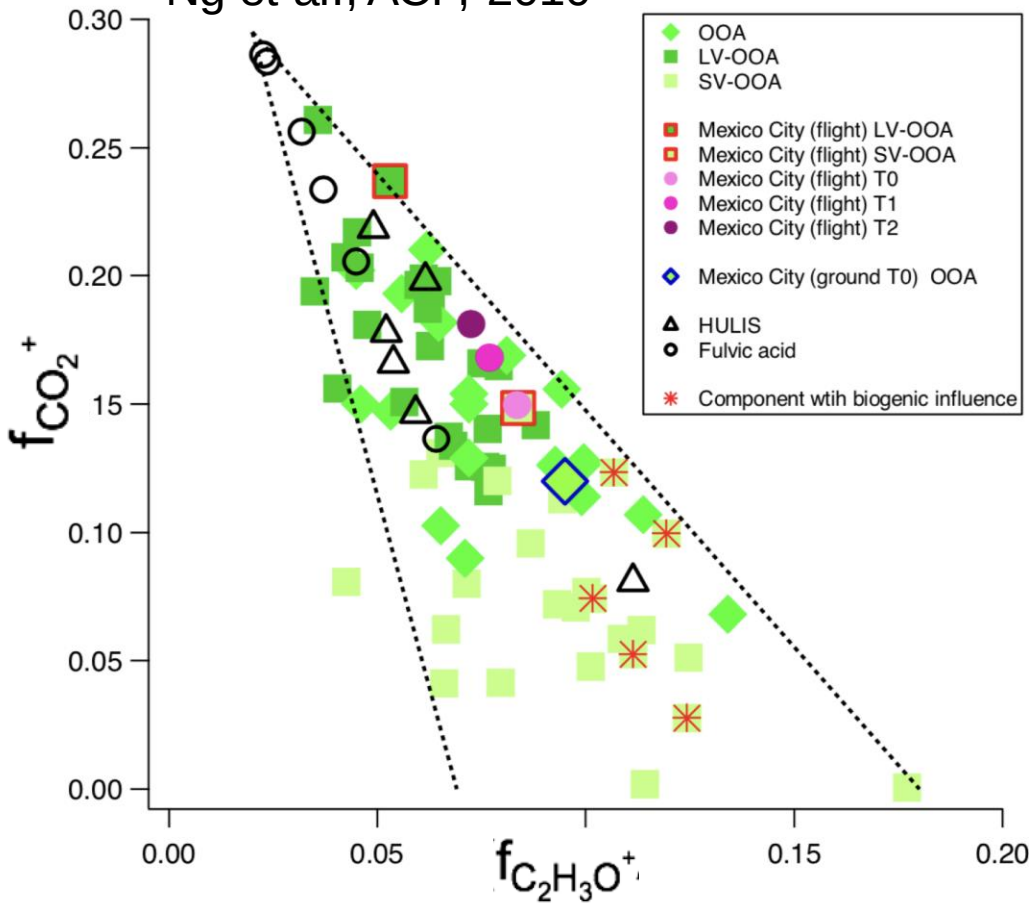
Difference between the two vaporization schemes (Averaged data)



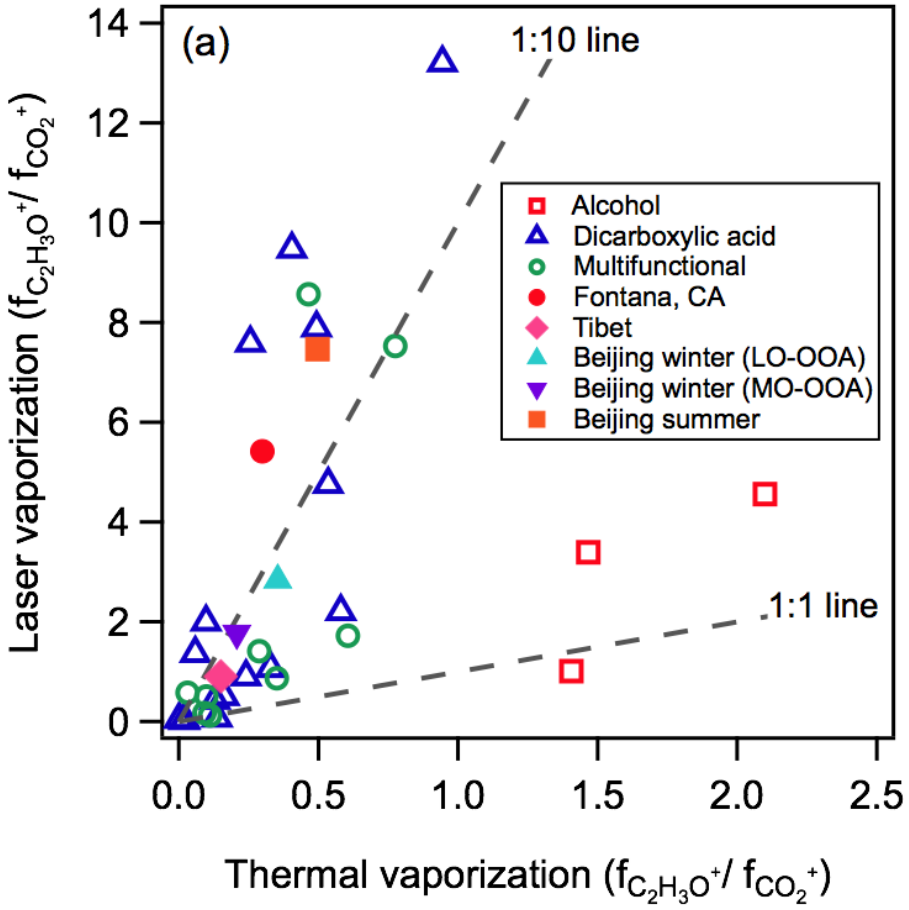
Impacts on Investigating Atmospheric Processing of Secondary Organic Aerosol (SOA) Coatings

Observational-framework based on f_{CO2+} and f_{C2H3O+}

Ng et al., ACP, 2010



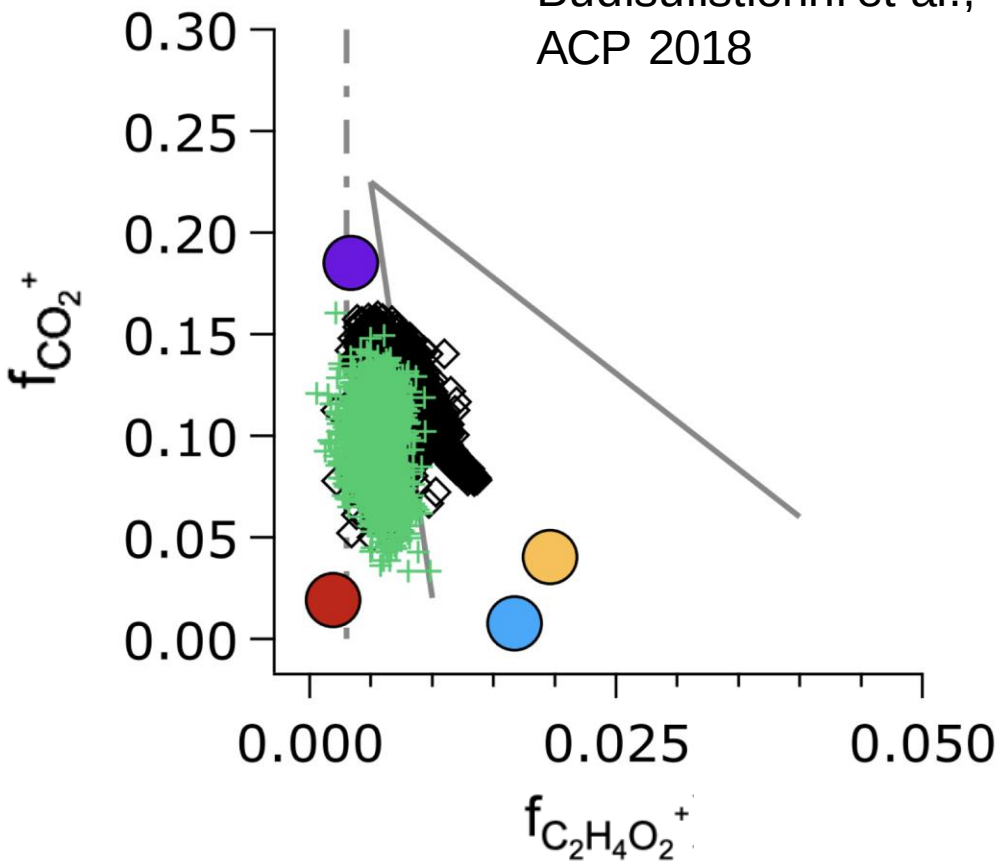
Enhancement of f_{C2H3O+}/f_{CO2+} ratio for data observed from LV scheme



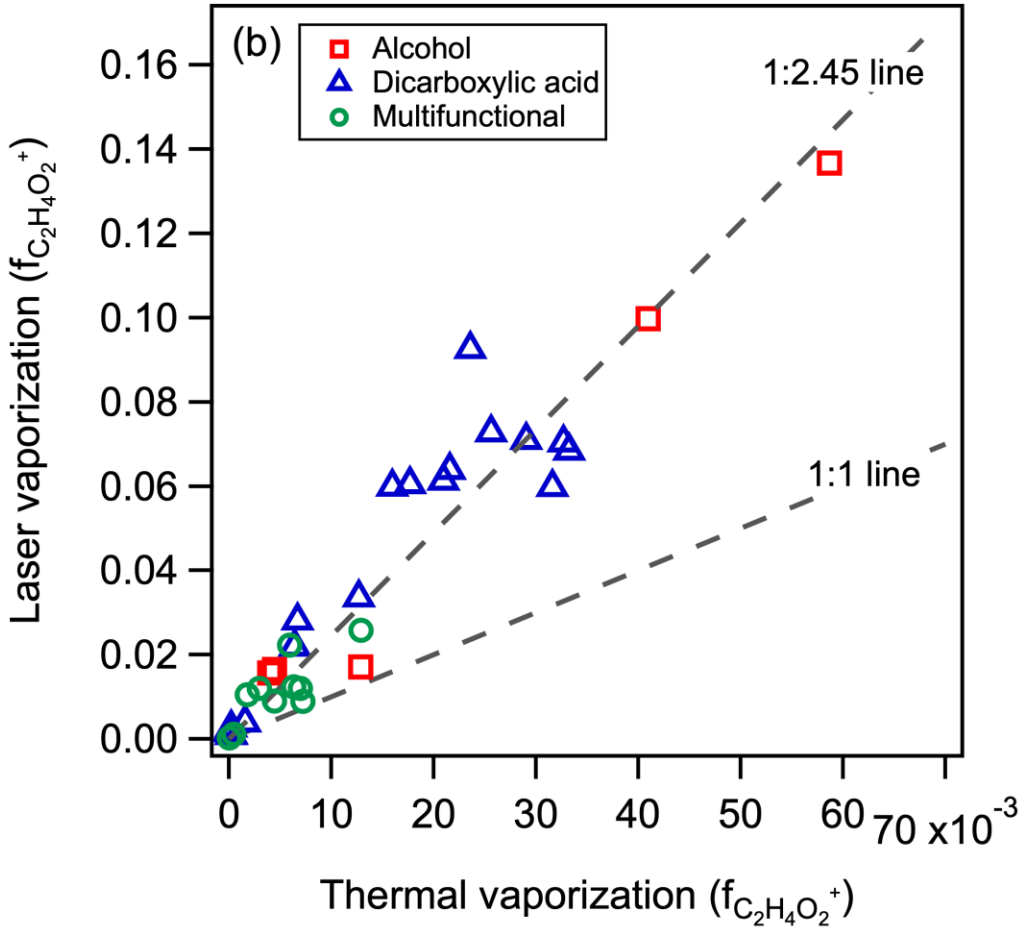
Impacts on Investigating Atmospheric Processing of Biomass Burning Organic Aerosol (BBOA) Coatings

Observational-framework based on f_{CO2+} and $f_{C2H4O2+}$

Budisulistiorini et al., ACP 2018



Enhancement of $f_{C2H4O2+}$ for data observed from LV scheme



Elemental analysis of OA for Standard AMS

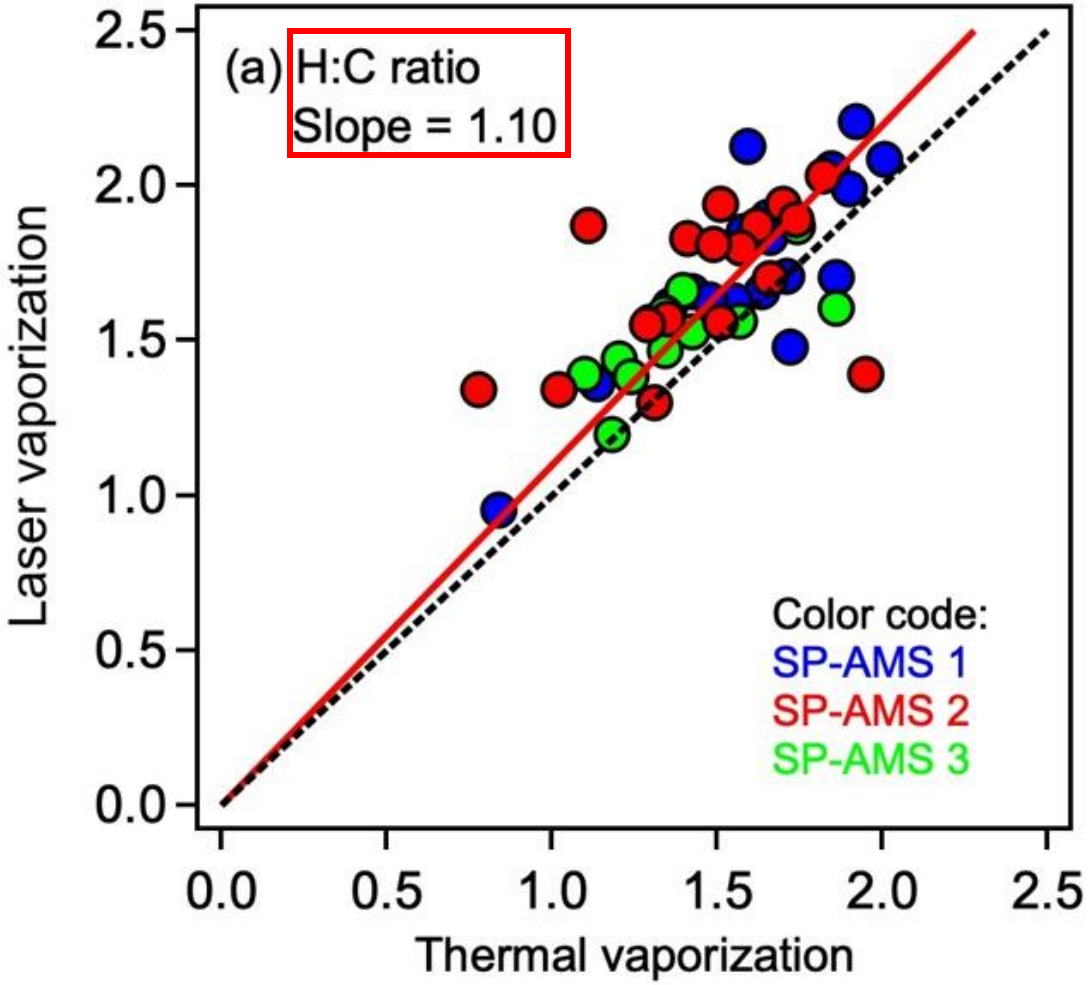
Aiken-Ambient (A-A) and Improved Ambient (I-A) methods are developed based on observations from TV scheme (Canagaratna et al., ACP 2015)

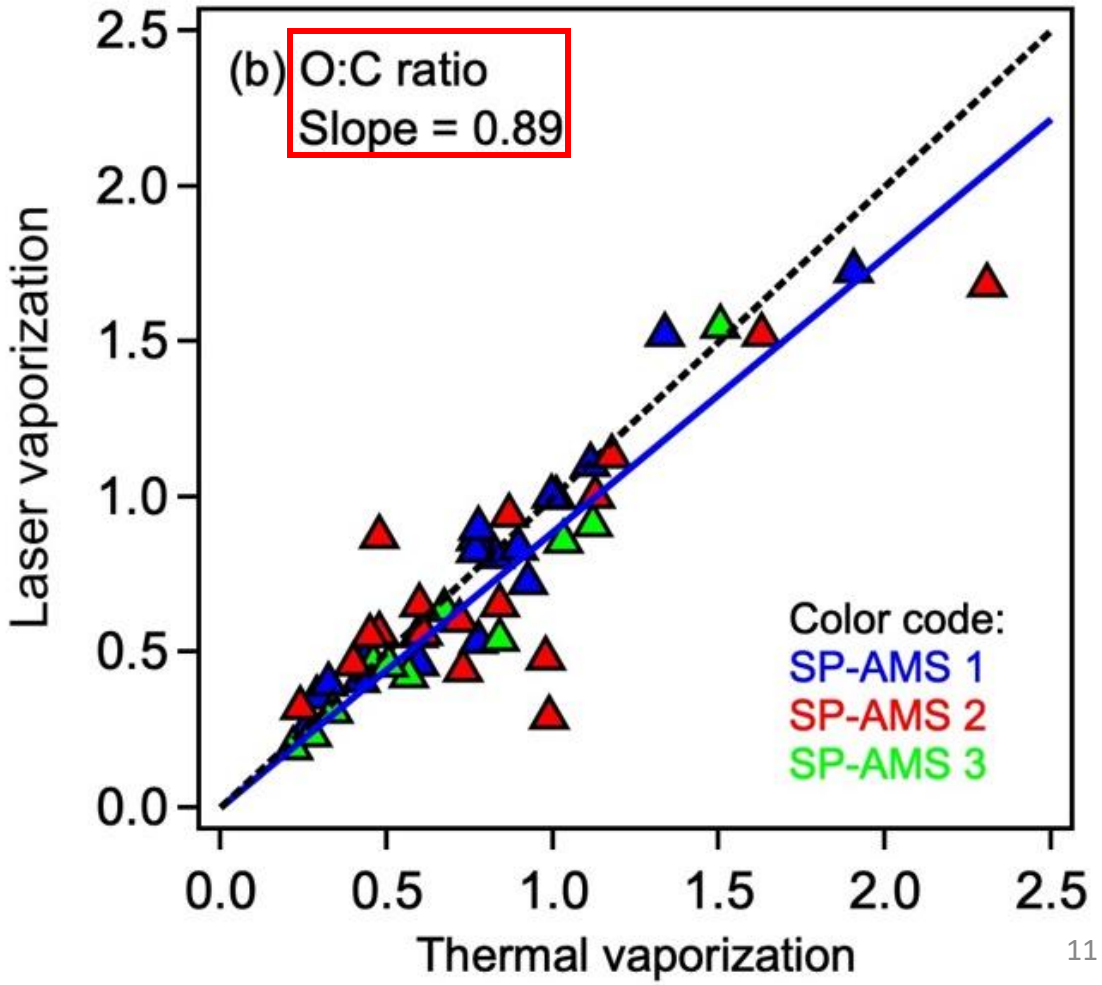
$$H{:}\,C_{I-A} = H{:}\,C_{A-A} \times [1.07 + 1.07 \times f_{CHO^+}]$$
$$O{:}\,C_{I-A} = O{:}\,C_{A-A} \times [0.87 - 2.00 \times f_{CHO^+} + 2.31 \times f_{CO_2^+}]$$

Question: Can we use the I-A method to analyze data observed by LV scheme?

I-A method: LV (Coatings) vs. TV (Pure OA)

Scaling factors were determined for H:C and O:C ratios (±10%)

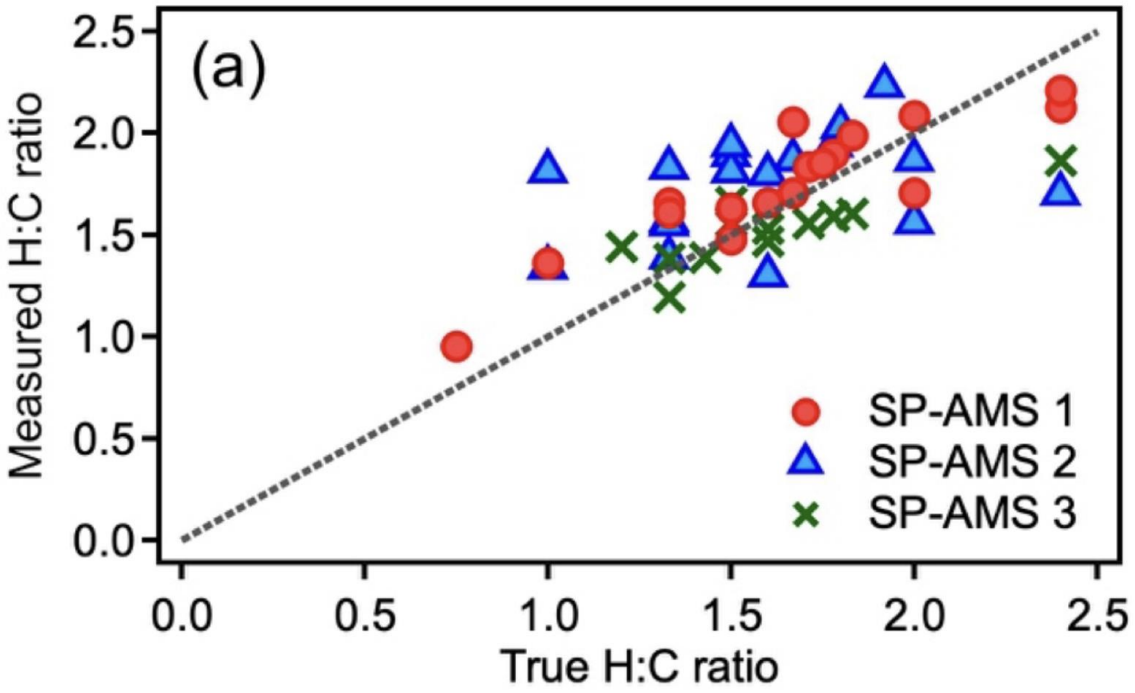




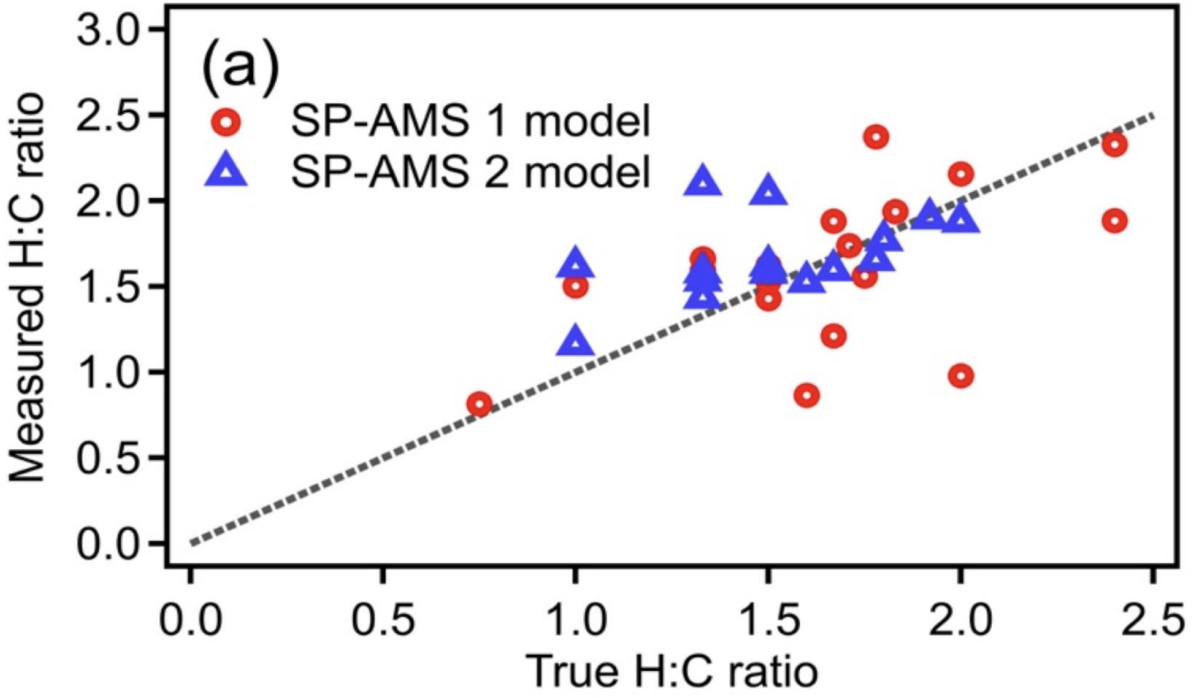
New parameterization for I-A method for characterizing OA coatings (I-A_{sp}) – H:C

$$H{:}\,C_{I-A_{SP}} = H{:}\,C_{A-A} \times [0.90 + 1.02 \times f_{CHO^+} + 2.78 \times f_{CO_2^+}]$$

I-A method (Error: 7%)



I-A_{sp} method (Error: 6%)

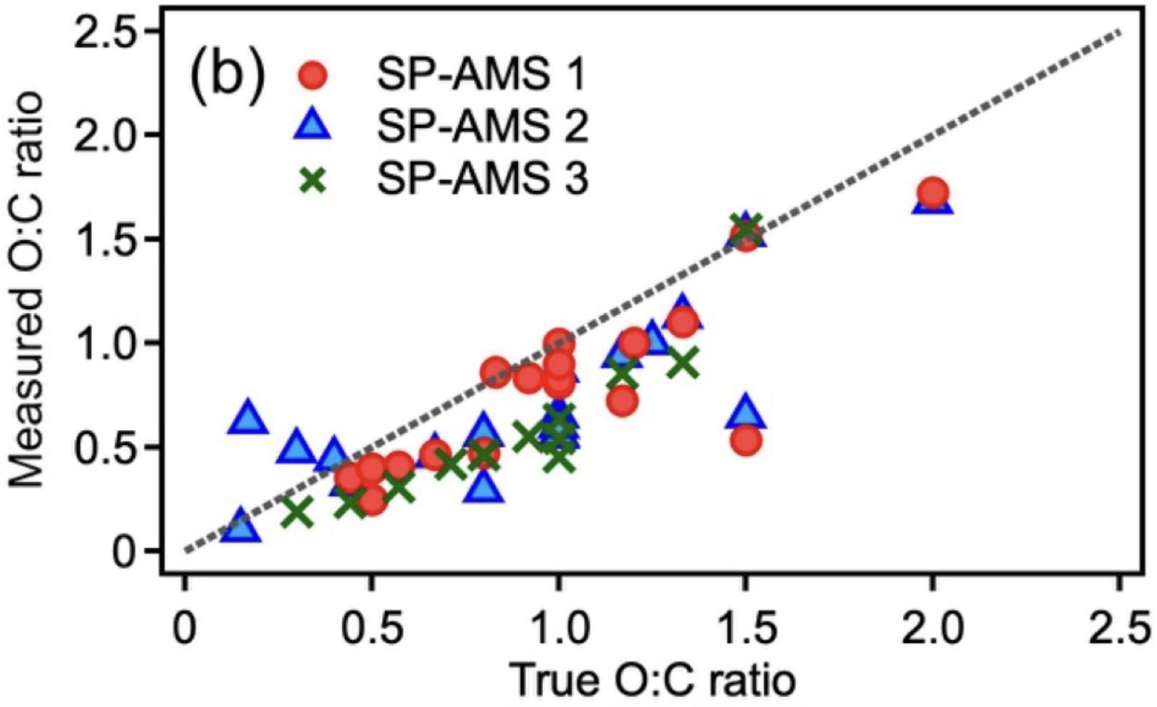


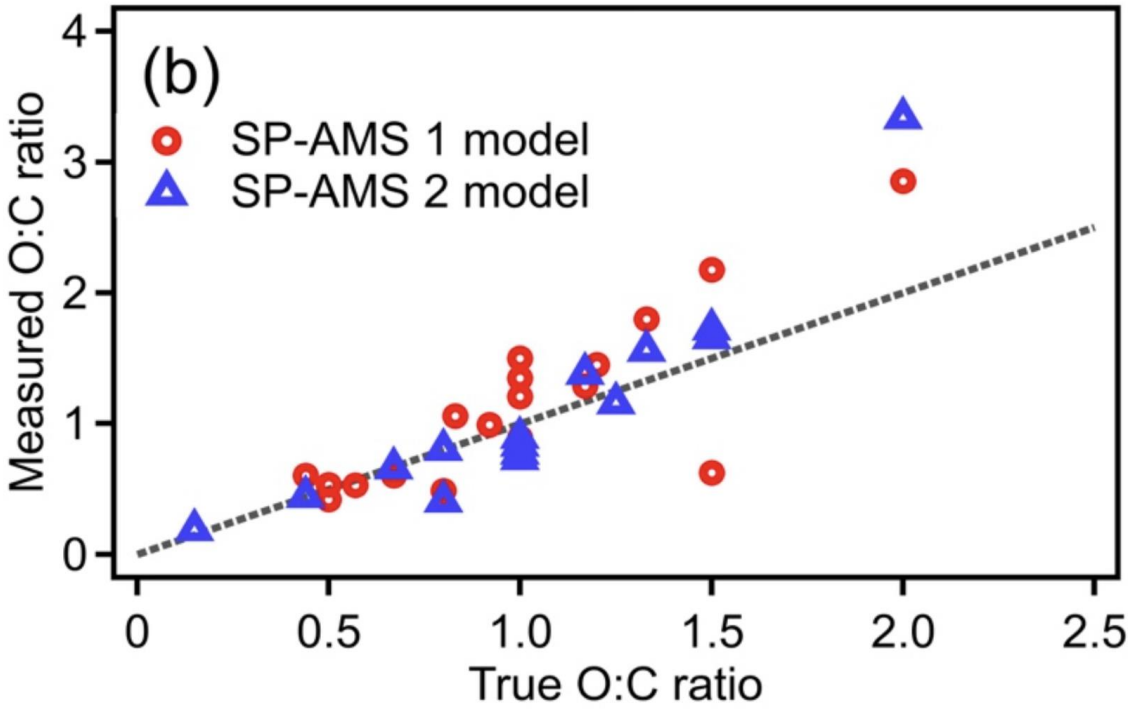
New parameterization for I-A method for characterizing OA coatings (I-A_{sp}) – O:C

$$O{:}\,C_{I-A_{SP}} = O{:}\,C_{A-A} \times [1.74 - 2.50 \times f_{CHO^+} + 1.93 \times f_{CO_2^+}]$$

I-A method (Error: 26%)

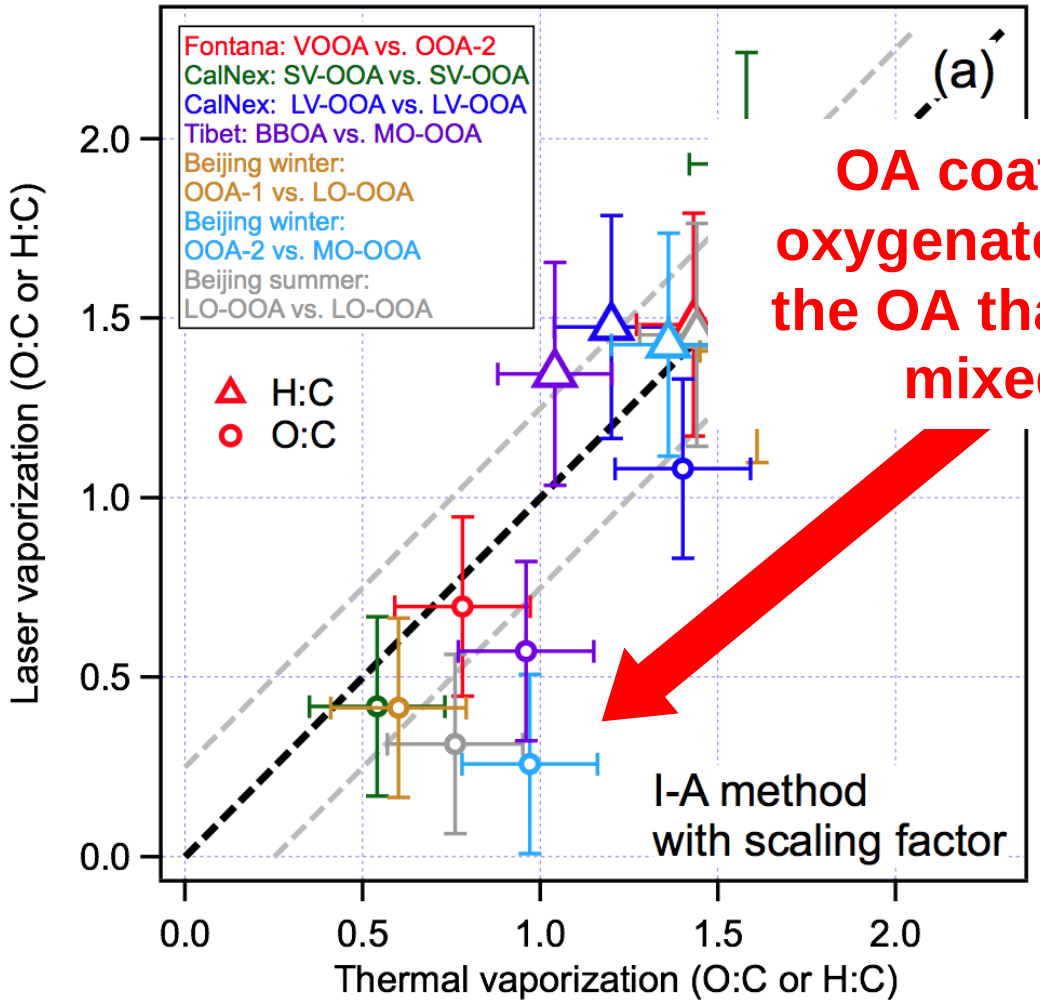
I-A_{sp} method (Error: 6%)



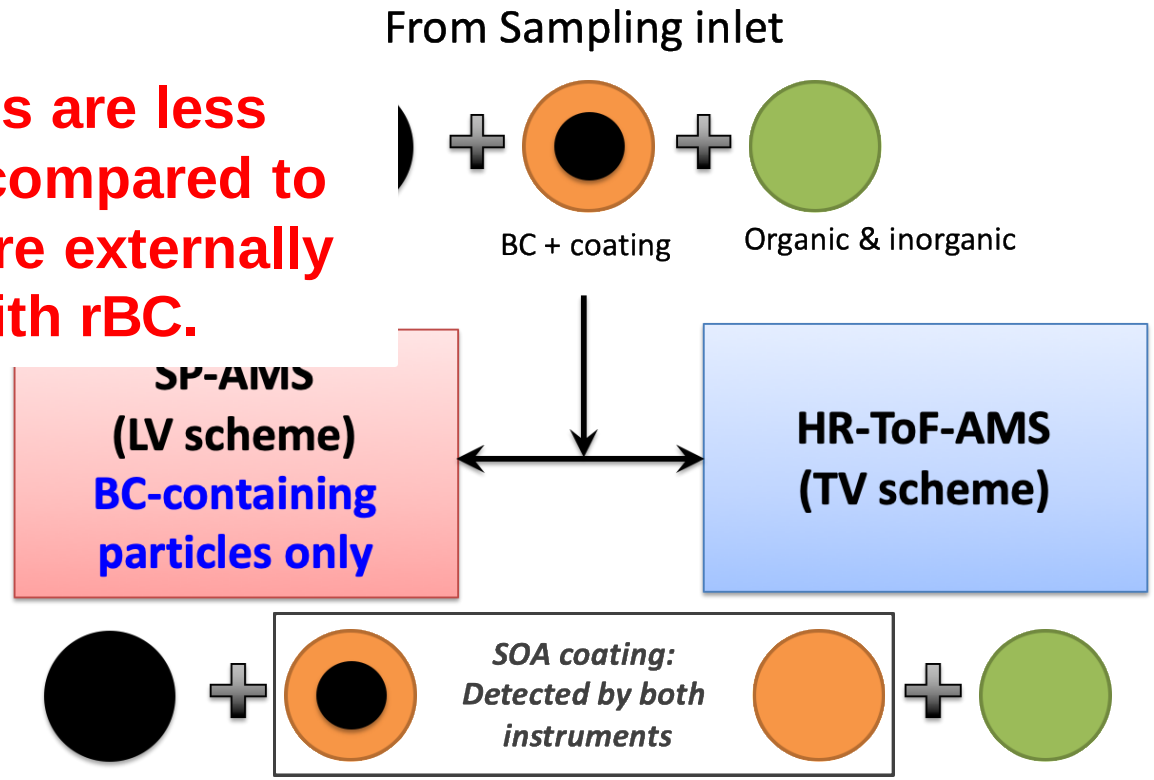


Field data: TV scheme vs. LV scheme

Comparison of OA factors determined by TV and LV scheme (R > 0.85)

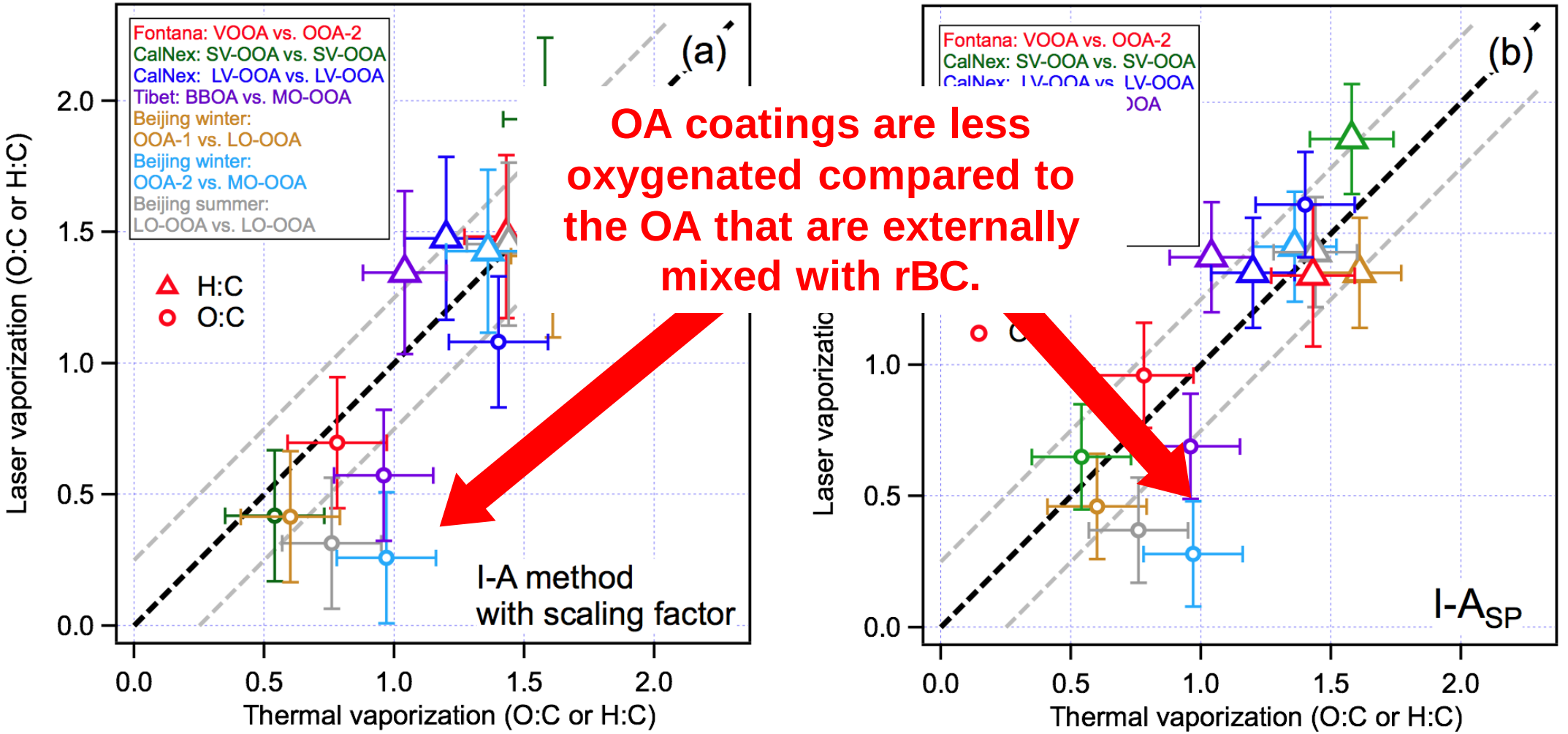


OA coatings are less oxygenated compared to the OA that are externally mixed with rBC.



Field data: TV scheme vs. LV scheme

Comparison of OA factors determined by TV and LV scheme (R > 0.85)



OA coatings are less oxygenated compared to the OA that are externally mixed with rBC.

Summary and Implications

- Reduced uncertainties of elemental analysis for OA coatings on black carbon (i.e., LV scheme data)

- Interpretation of atmospheric processing of SOA and BBOA coatings should be cautious when LV scheme is used for measurements

- SOA coating observed at highly polluted regions can be chemically different to those OA that are externally mixed with rBC

Acknowledgement

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The content does not represent NEA's view.