Carbon Research Update

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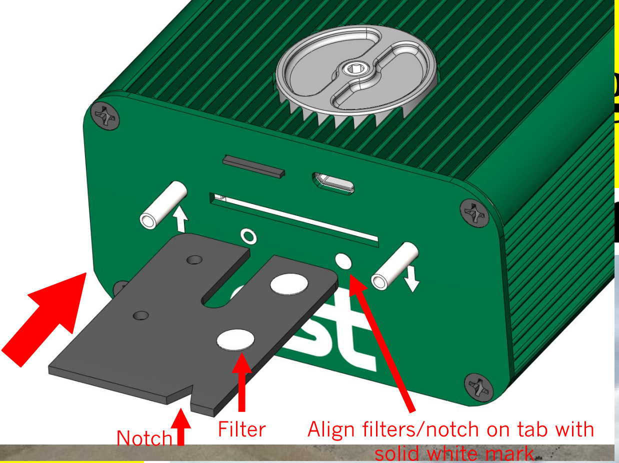
Topics

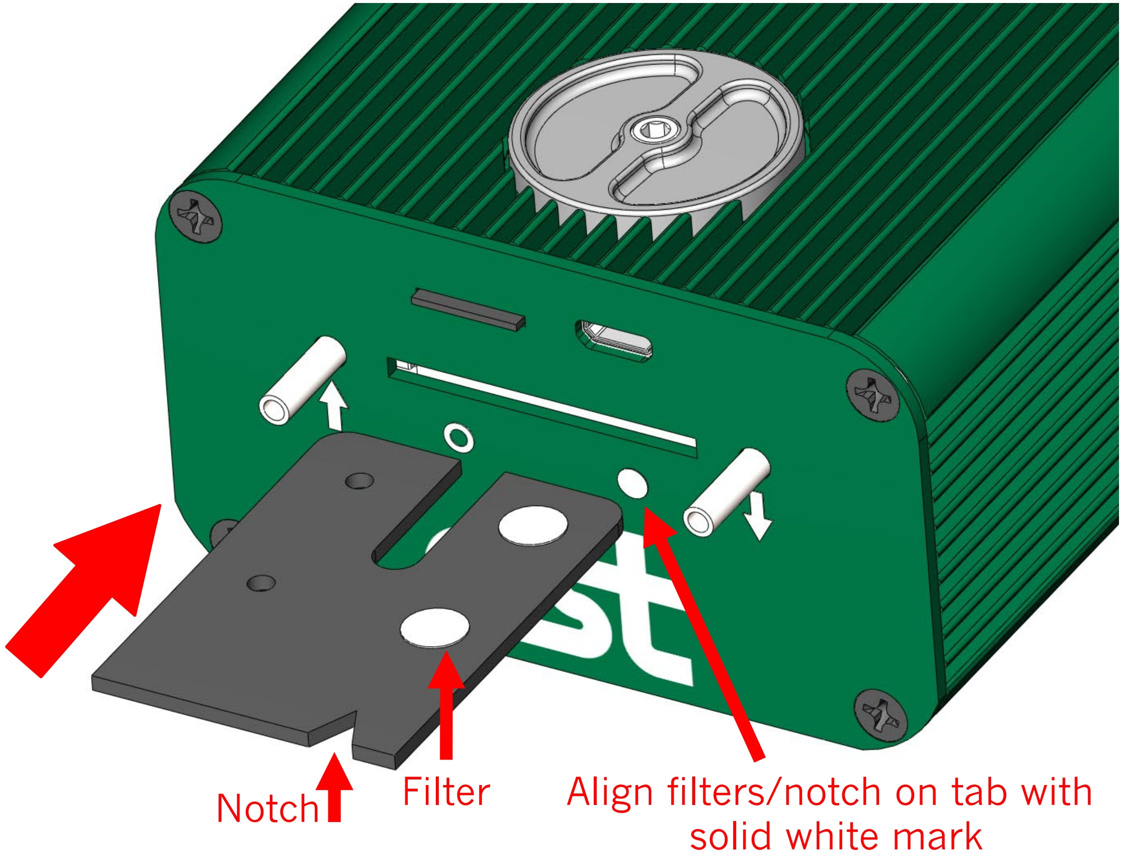
- DST BC and BrC and ARA performance tests
- TC and OC/EC short thermal/optical program comparisons
- f_{Abs}/EC follow-up
- Carbon characterization with PI-TOFMS

…gth tests have continued



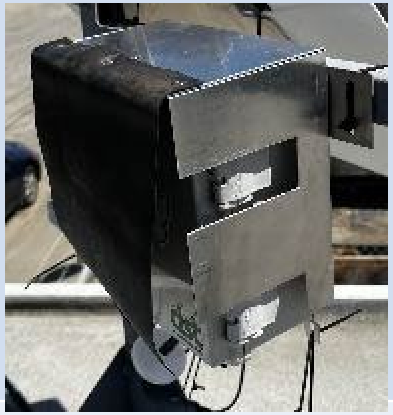
…ler configuration

2. DST BrC monitor



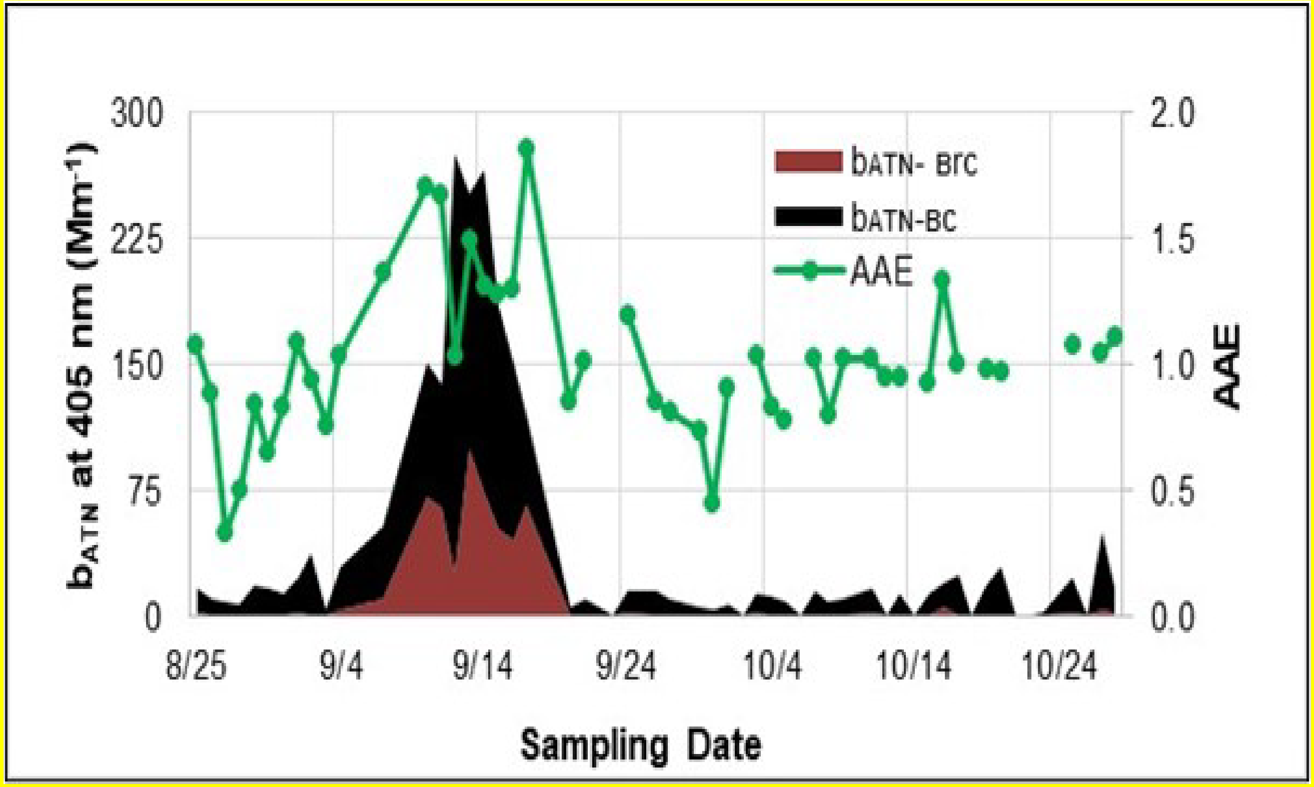
880 nm and 405 nm Attenuation: BC=7.8ATN(880), BrC=18.49[ATN(405)-ATN(880)[λ880/(λ405)][1]]

DST Problems and Solutions

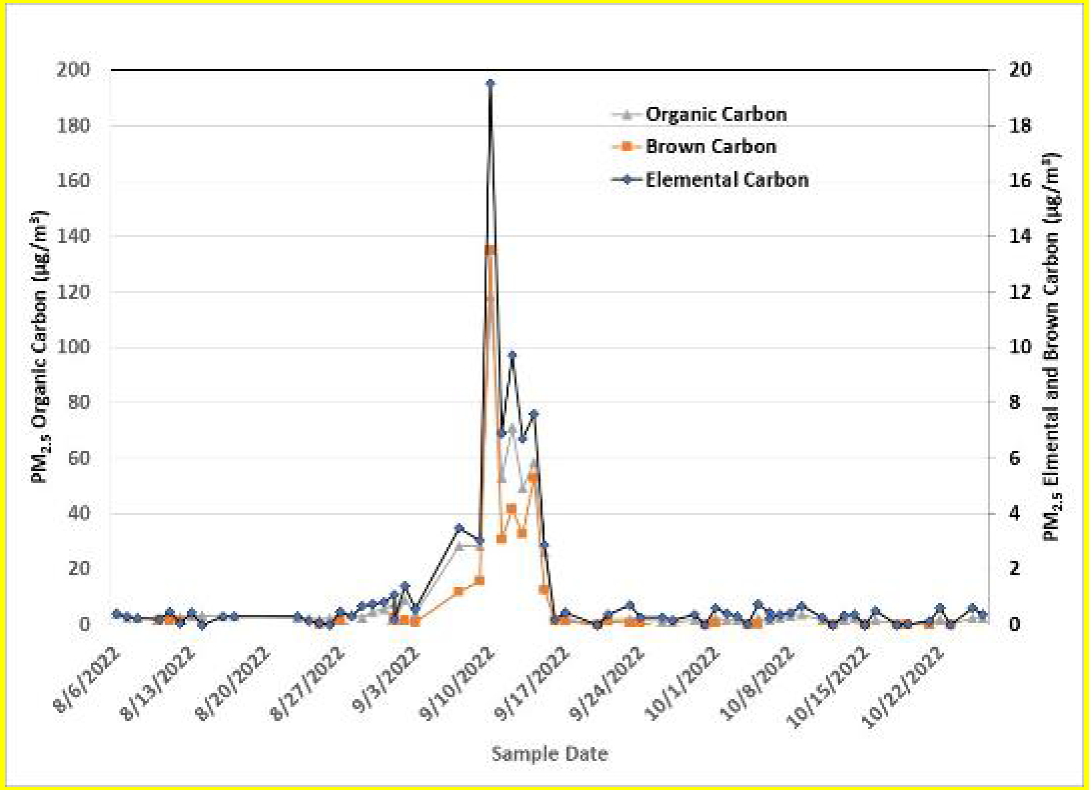
Problem	Solution
High temperatures affect short wavelength laser	Keep monitor in shade 
Short wavelength reference drifts	Test alternative lasers
Comparisons show consistent bias	Traced to inconsistent tightening of filter clamp. Use a torque disk
Company is in hiatus	Seeking investors

ARA samplers operate well on solar

Quartz filters are submitted to multiwavelength IMPROVE_A



Light attenuation by black carbon and brown carbon for daily samples collected before and after the 2022 Mosquito fire.

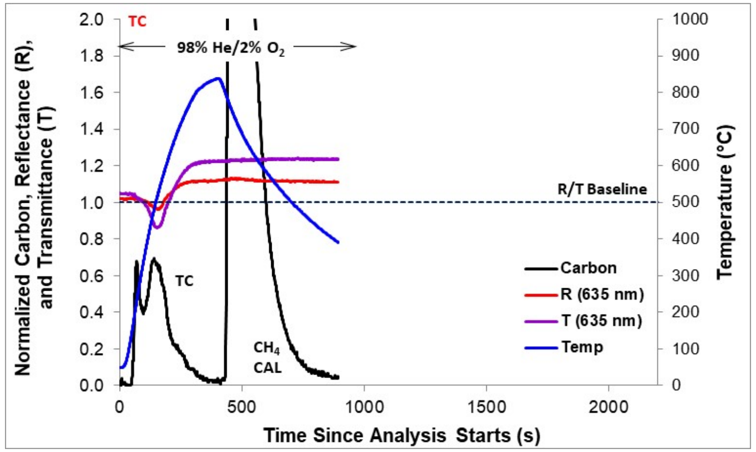


Organic, elemental, and brown carbon concentrations in Reno during the Mosquito fire. Brown carbon is estimated as the difference between the EC split for 405 nm and 980 nm.

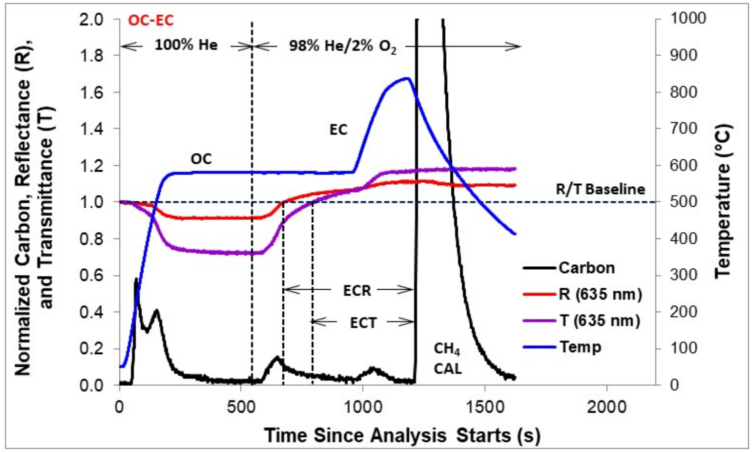
TC and OC/EC protocols reduce analysis times by ~50% and ~25%, respectively

This results in ~20% cost savings for the TC protocol and ~10% cost savings for the OC/EC protocol

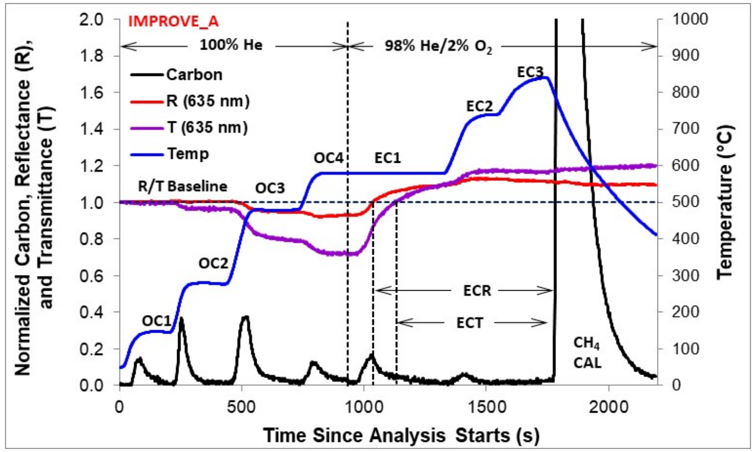
TC Protocol



OC-EC Protocol

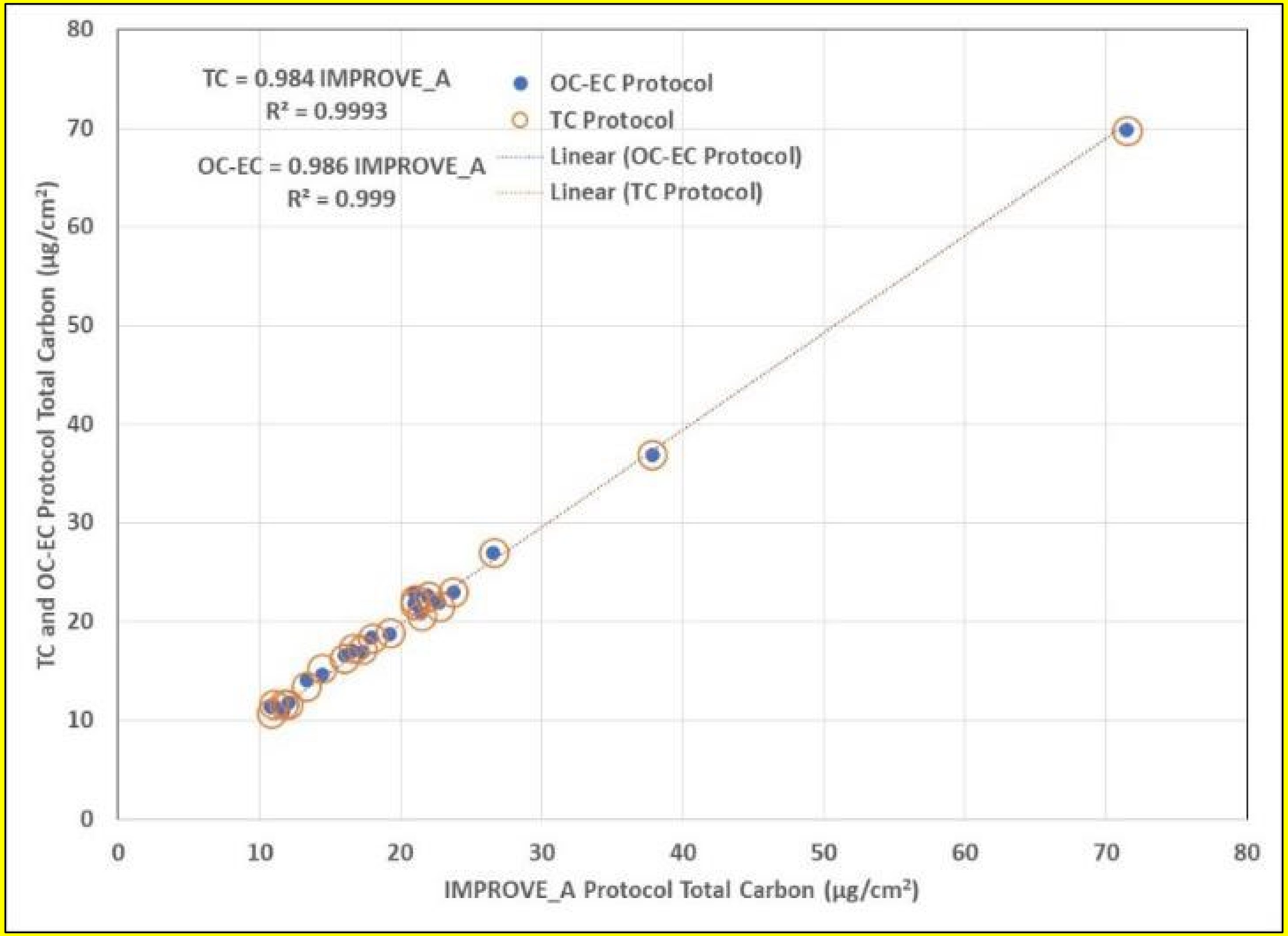


IMPROVE_A Protocol

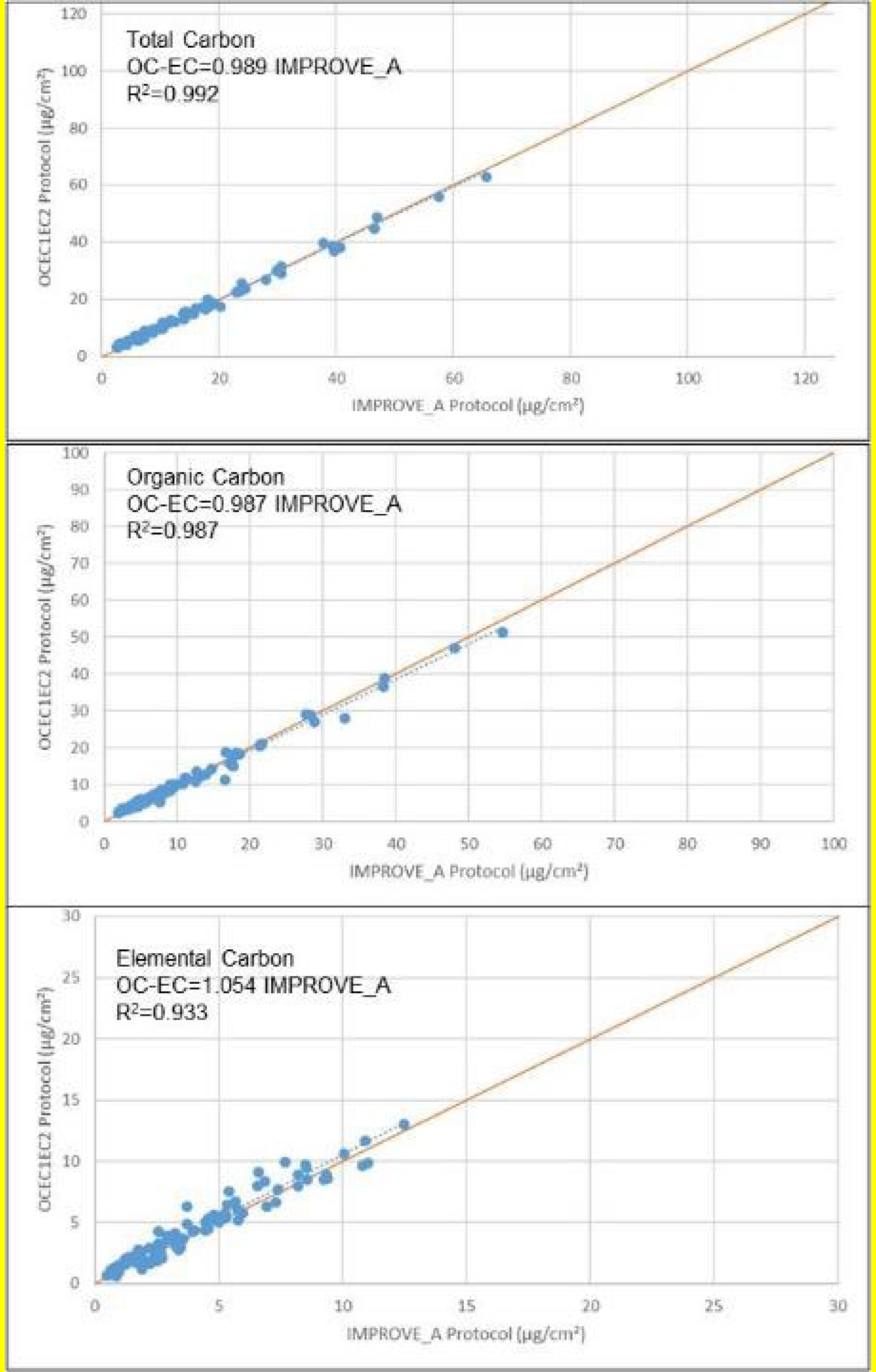


TC concentrations are the same for the TC, OC/EC, and IMPROVE_A protocols

Fresno supersite samples

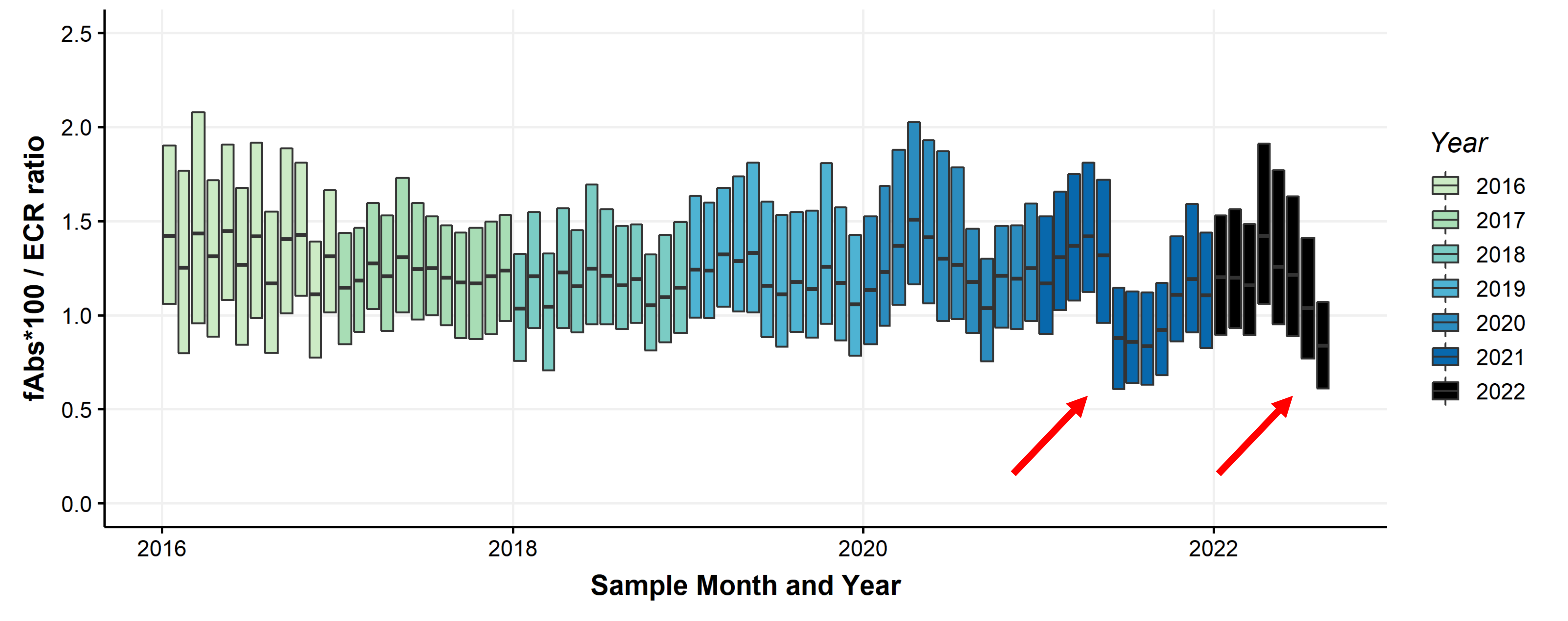


TC, OC, and EC are equivalent to IMPROVE_A for the OC/EC protocol for 100 collocated IMPROVE samples



f_{Abs}/EC ratio showed differences around June 2021 and July 2022

Is this due to f_{Abs} or EC changes?



Hyslop et al., 2023 IMPROVE Spring Meeting

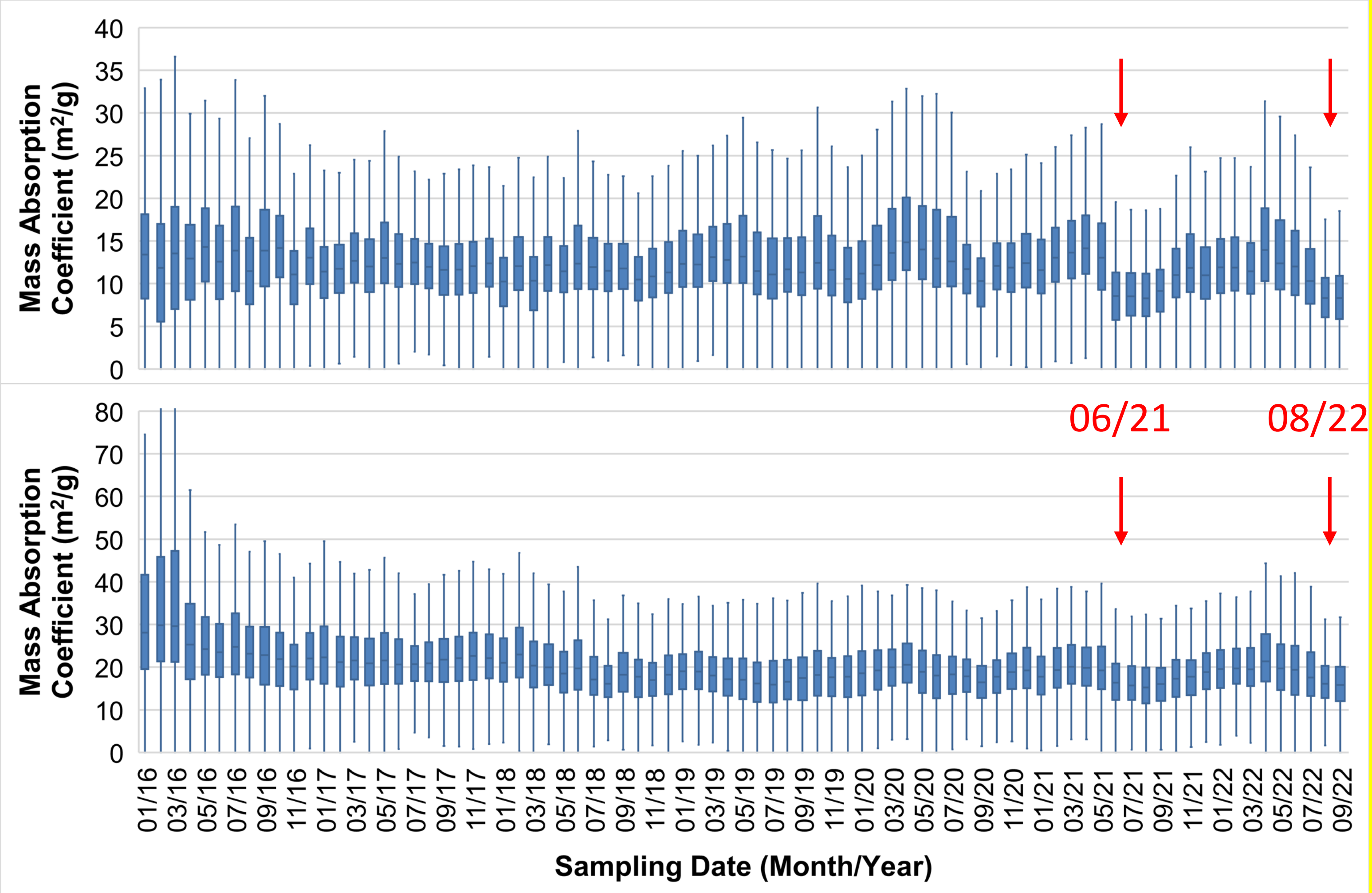
b_{Att}/EC derived from IMPROVE_A (quartz) analysis does not show similar changes from the longer-term patterns

Teflon, f_{Abs} / EC

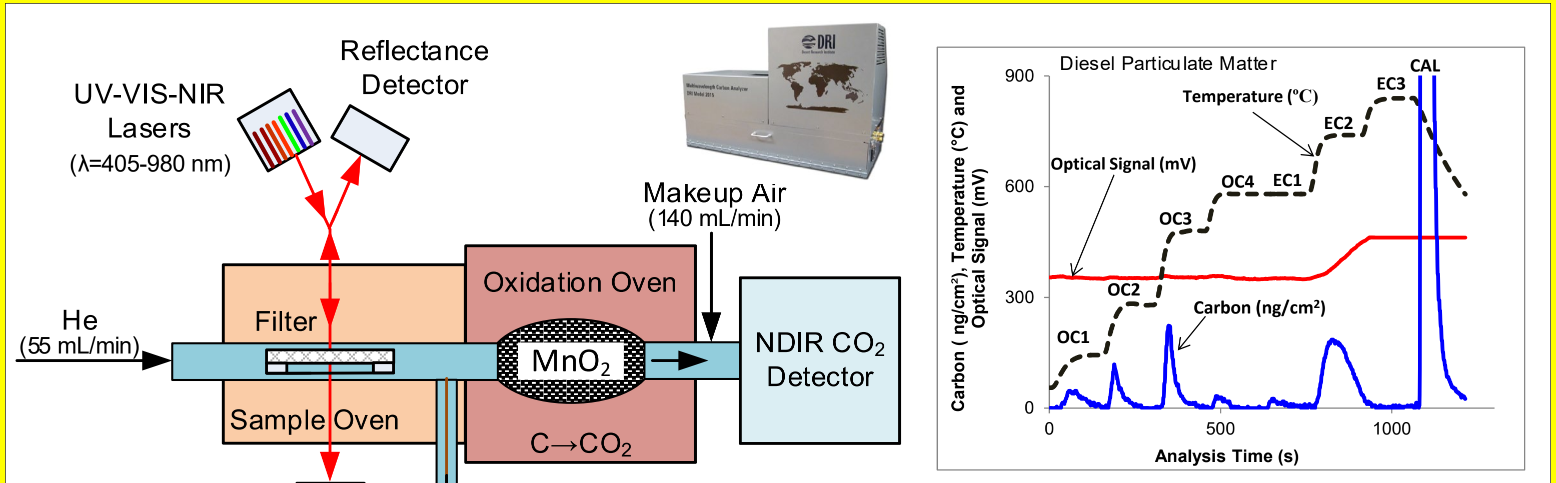
The 6/21–9/22 data seem to have a different pattern from previous years

Quartz, b_{Att} / EC

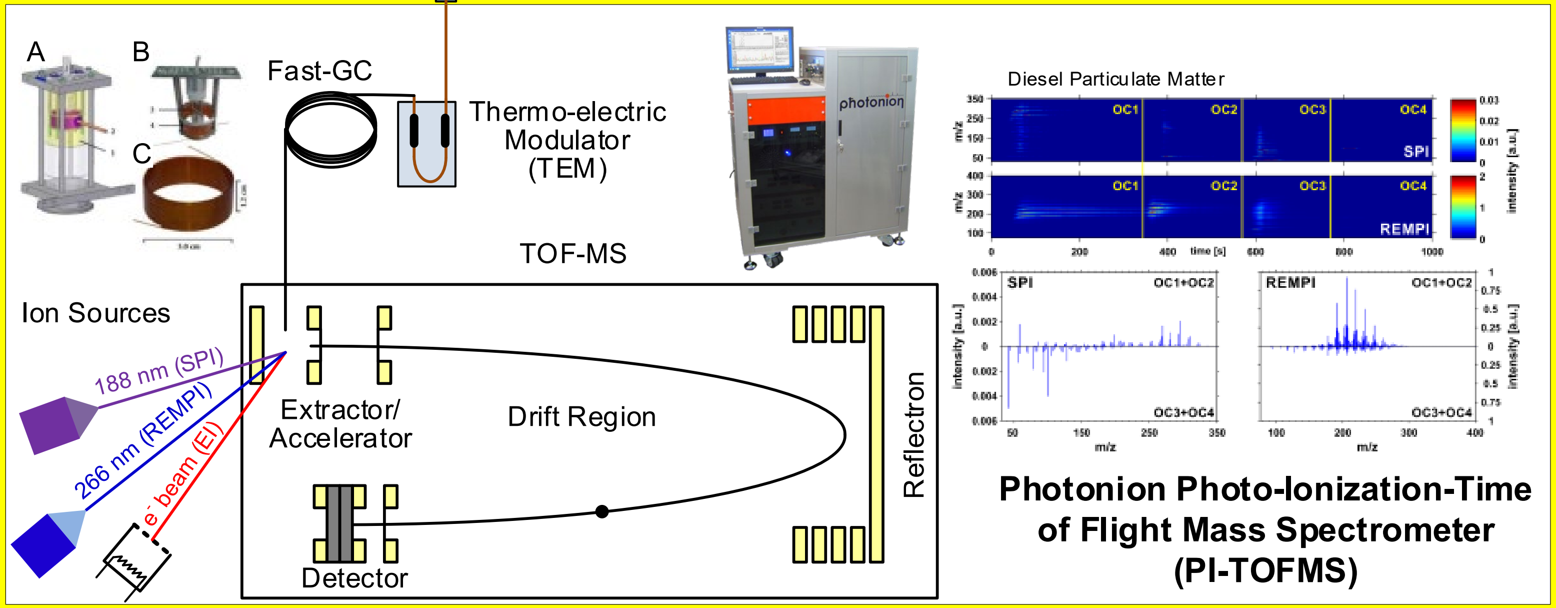
The 6/21–9/22 data have a similar pattern as previous years



NSF has approved DRI acquisition of a Photoionization-Time of Flight Mass Spectrometer (PI-TOFMS) coupled to a Model 2015 Multi-wavelength Carbon Analyzer



DRI Model 2015 Multiwavelength Thermal/Optical Carbon Analyzer (MWCA)



Photonion Photo-Ionization-Time of Flight Mass Spectrometer (PI-TOFMS)

Fast GC unit includes: A) gold-coated glass cylinder; B) inner framework with halogen lamp; and C) 3 m column stack. Particles are first collected on a filter and undergo thermal desorption. Part of the flow goes to an oxidizer and converts all carbon to CO_2, and a fraction of the flow goes to the PI-TOFMS.

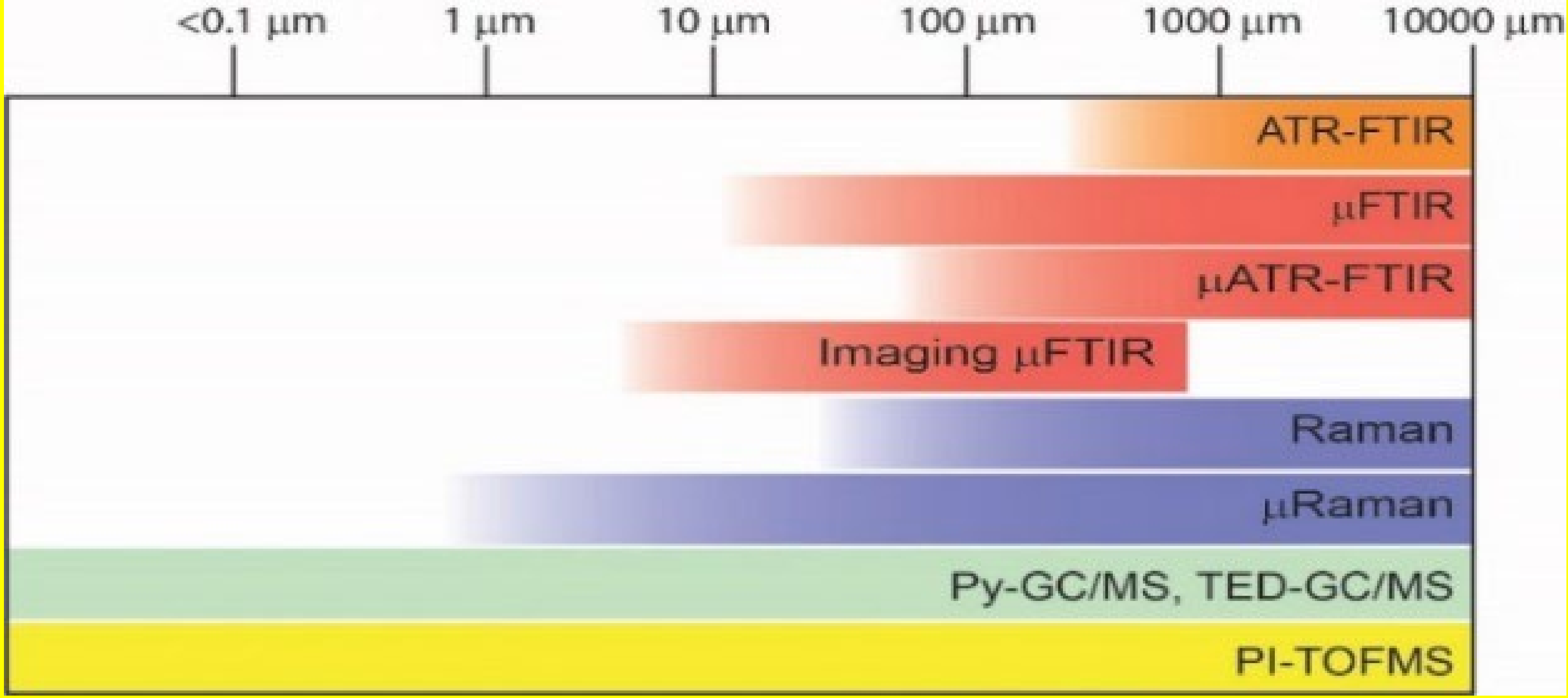
Advantages of PI-TOFMS

- Measures particle (with thermal desorption) and gas (VOC) organic compounds
- Resonance Enhanced Multiphoton Ionization (REMPI) quantifies aromatic compounds, including PAHs
- Single photon ionization (SPI) coupled to a fast gas chromatograph allows additional detection of aliphatic and oxygenated compounds
- Electron Impact (EI) ionization creates molecular fragments corresponding to those of the Aerosol Mass Spectrometer (AMS)
- Low detection limits allow for small sample sizes
- Temporal resolution of several seconds permits monitoring of changes with combustion conditions and aerosol aging

Current and proposed projects

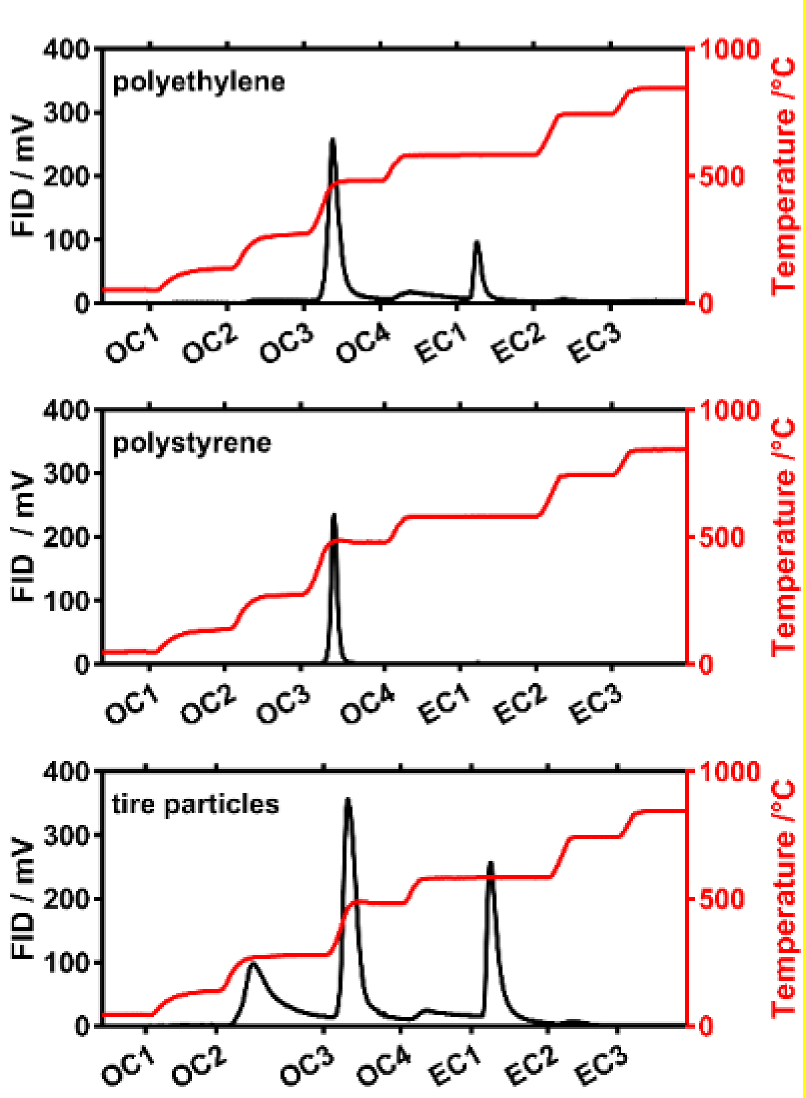
- Evolution of smoke in wildfires (NSF/EPSCOR)
- Micro- and Nano-plastics in air, water, soil, and ecosystems (NSF)
- Emission characterization of spacecraft fires (NASA)
- More specific source markers (DRI carbon research grant using archived samples)
- Brown carbon (BrC) components in thermal carbon fractions (proposed)

Microplastics (>~1 to 5 µm) are more commonly measured than nanoplastics ((<~1 µm)

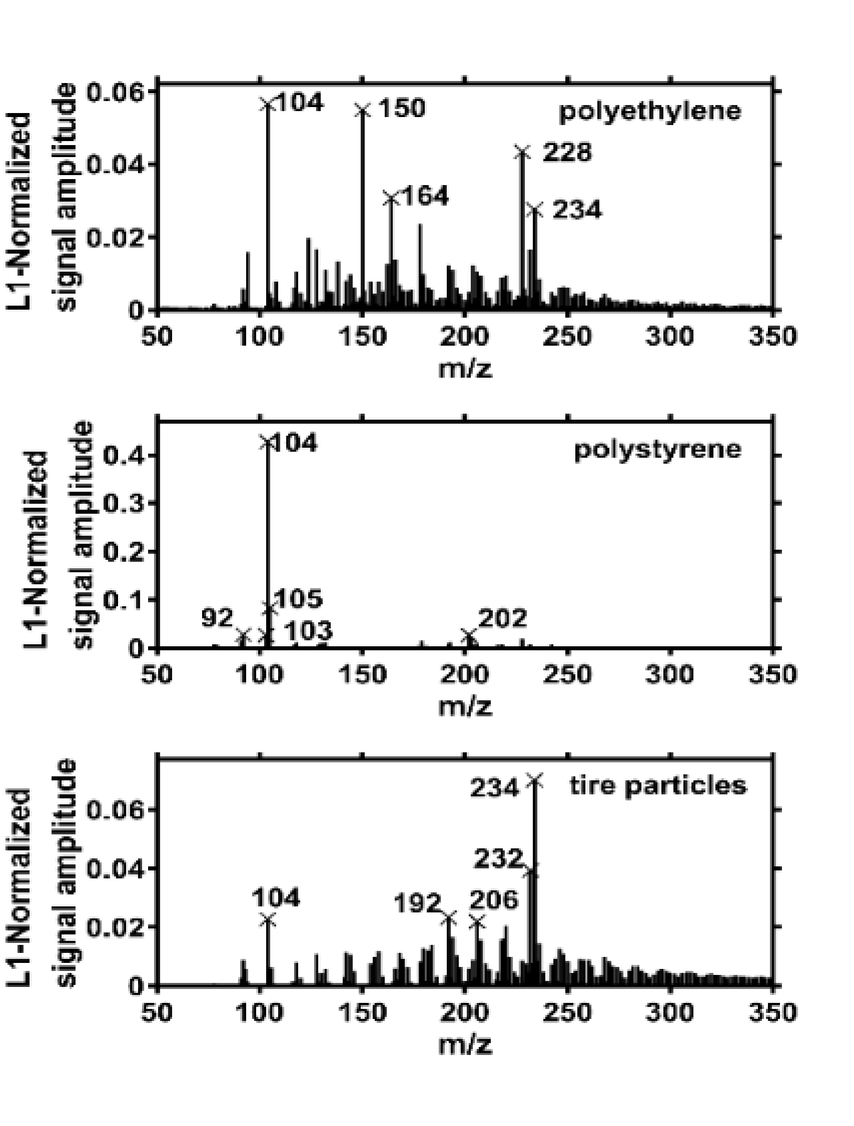


Attenuated total reflectance (ATR)-FTIR, µFTIR, and Raman (orange, red, blue) enable identification of plastic particles, while GC/MS (green) enable mass related quantifications with no size limitations. The PI-TOFMS (yellow) complements these standard methods, enabling mass related quantifications with no size limitations

IMPROVE_A thermal fractions have different patterns for different plastics



Thermal patterns for different plastics



OC4 fraction shows distinctive chemical fingerprints different

IMPROVE Observations

- **IMPROVE program has made major contributions to aerosol measurement technology and visibility**
- **IMPROVE data and archived samples have been leveraged for purposes far beyond visibility science**
- **Testing and evaluation of emerging technologies will benefit the long-term success of the program**
- **The collegial nature and broad participation of researchers and policy-makers has been a major contributor to the program’s success**