

# Prudhoe Bay Oilfield Influences on Atmospheric Particulate Matter (PM) on the North Slope of Alaska

Kerri A. Pratt<sup>1</sup>, Matthew J. Gunsch<sup>1</sup>, Rachel M. Kirpes<sup>1</sup>, Katheryn R. Kolesar<sup>1</sup>,  
Claire E. Moffett<sup>2</sup>, Tate E. Barrett<sup>2</sup>, Rebecca J. Sheesley<sup>2</sup>

<sup>1</sup> University of Michigan, <sup>2</sup> Baylor University



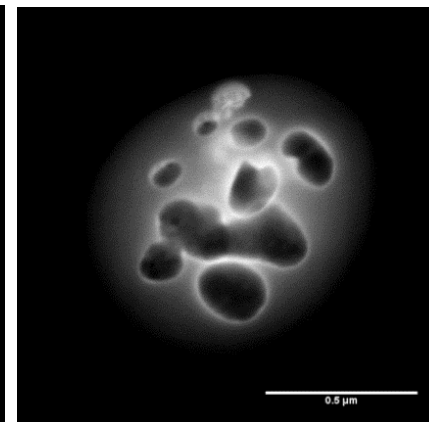
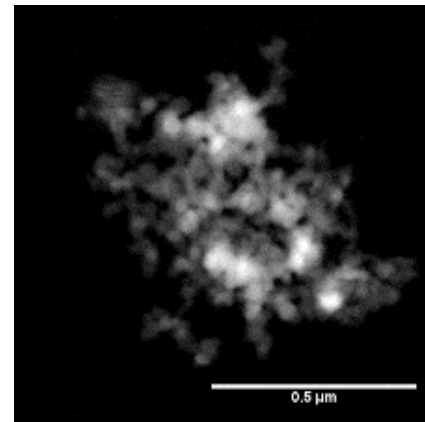
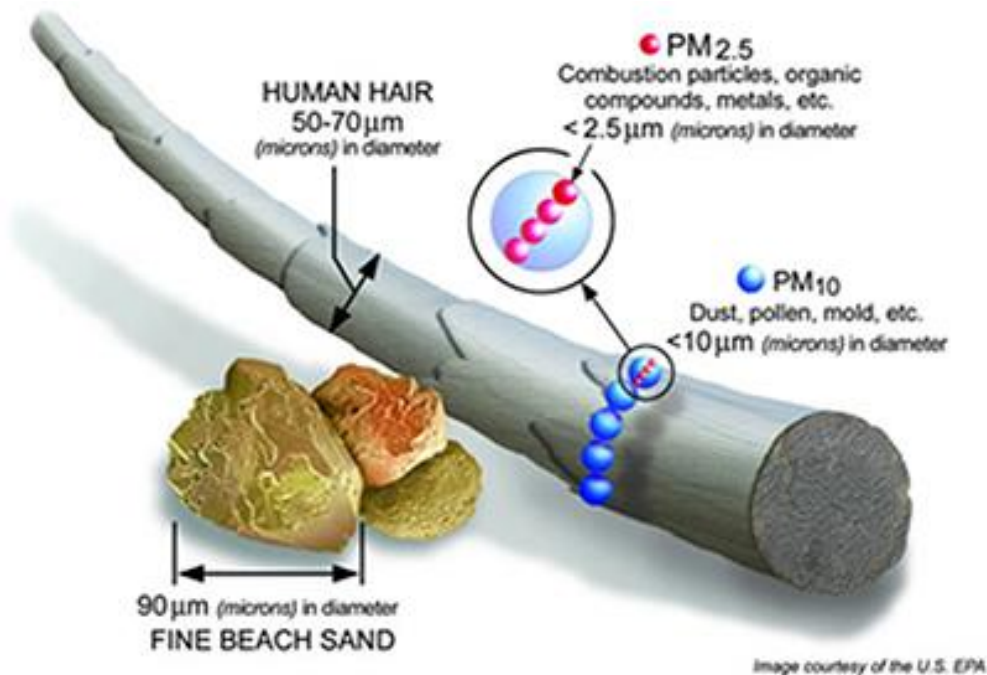
BAYLOR  
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Photo: David Oaks

# Project Goal: How do Emissions from the Prudhoe Bay Oilfield Impact Atmospheric Particulate Matter (PM) on the North Slope of Alaska?

## Particulate matter smaller than 2.5 $\mu\text{m}$ (PM<sub>2.5</sub>)



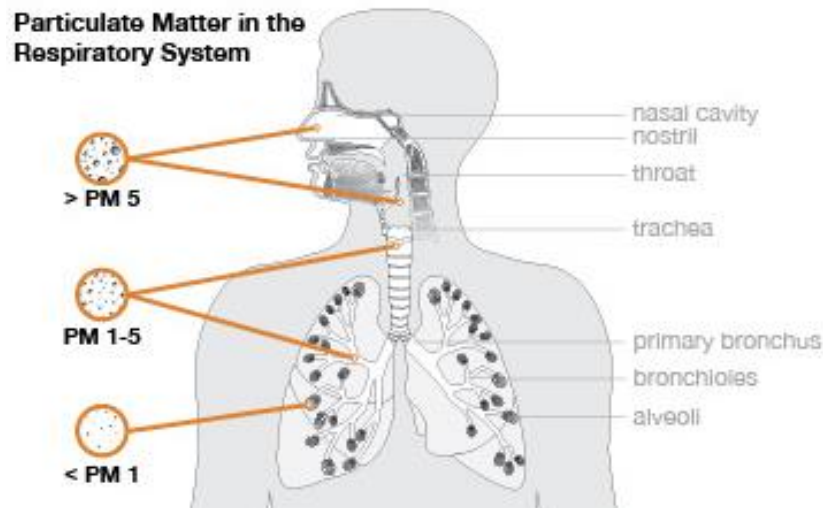
Regulated by the Clean Air Act through the National Ambient Air Quality Standards

# PM Impacts: Human Health, Climate, & Weather

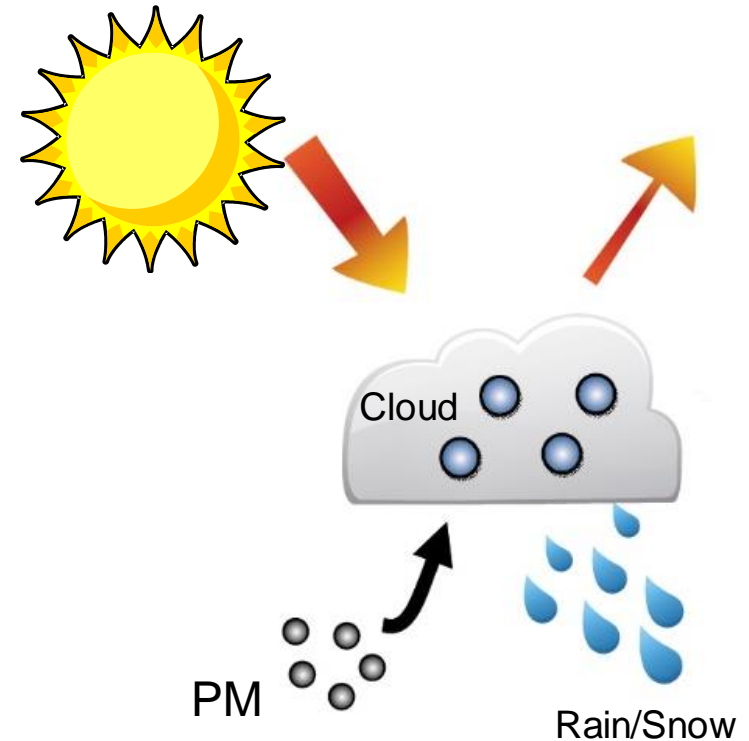
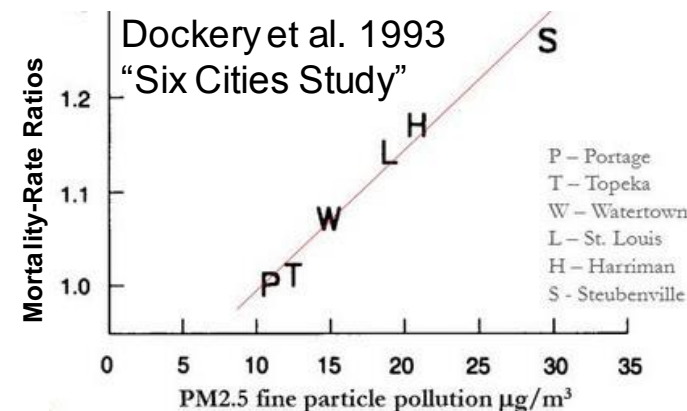
Top environmental risk factor  
for mortality worldwide

Impact Earth's energy budget &  
hydrological cycle:

- 1) Scatter or absorb solar radiation
- 2) Serve as 'seeds' for cloud formation, changing precipitation

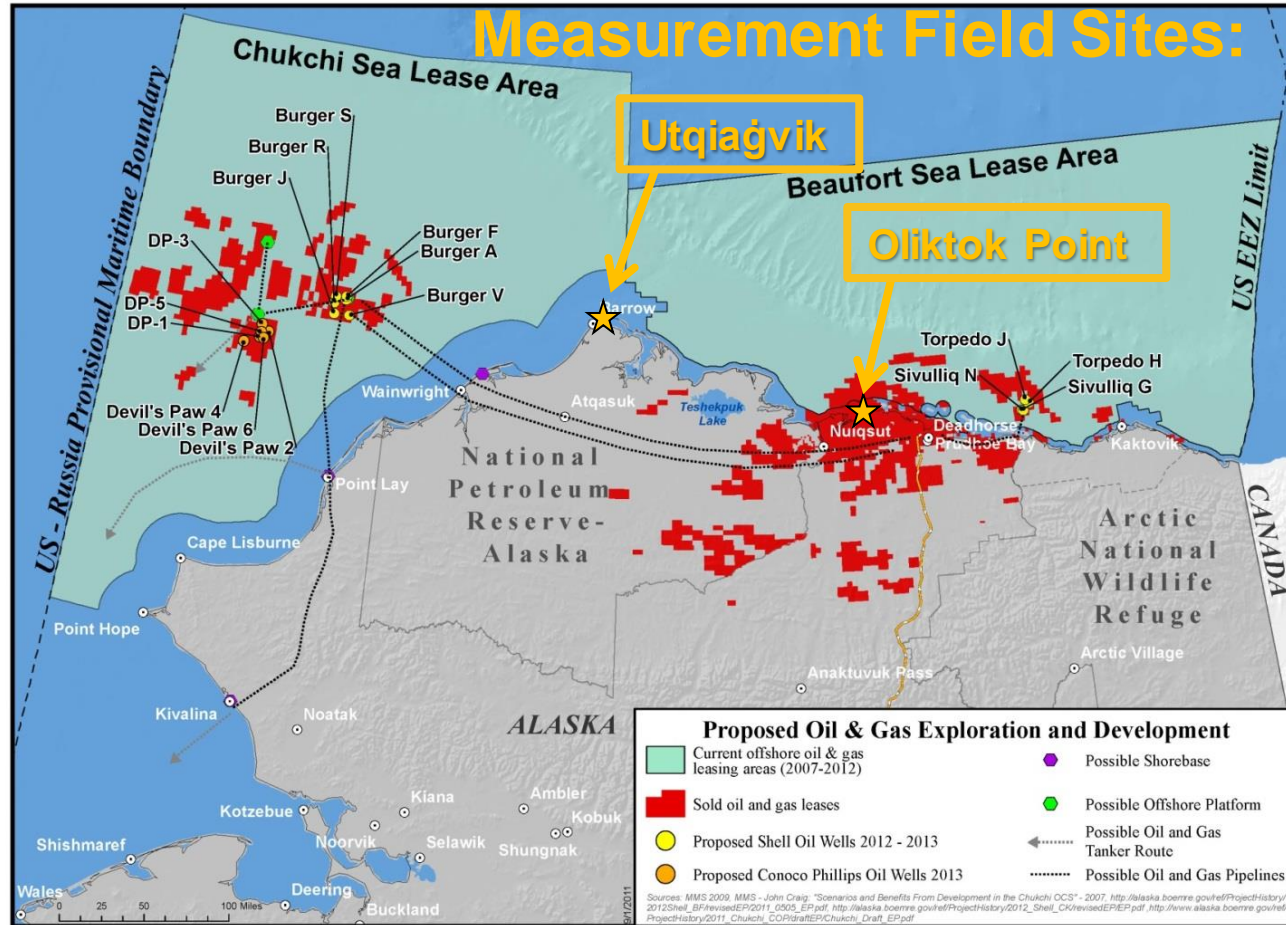


<http://www.aurametrix.com/topics/particulate-matter>



# Prudhoe Bay – 3<sup>rd</sup> Largest Oilfield in North America

## Measurement Field Sites:

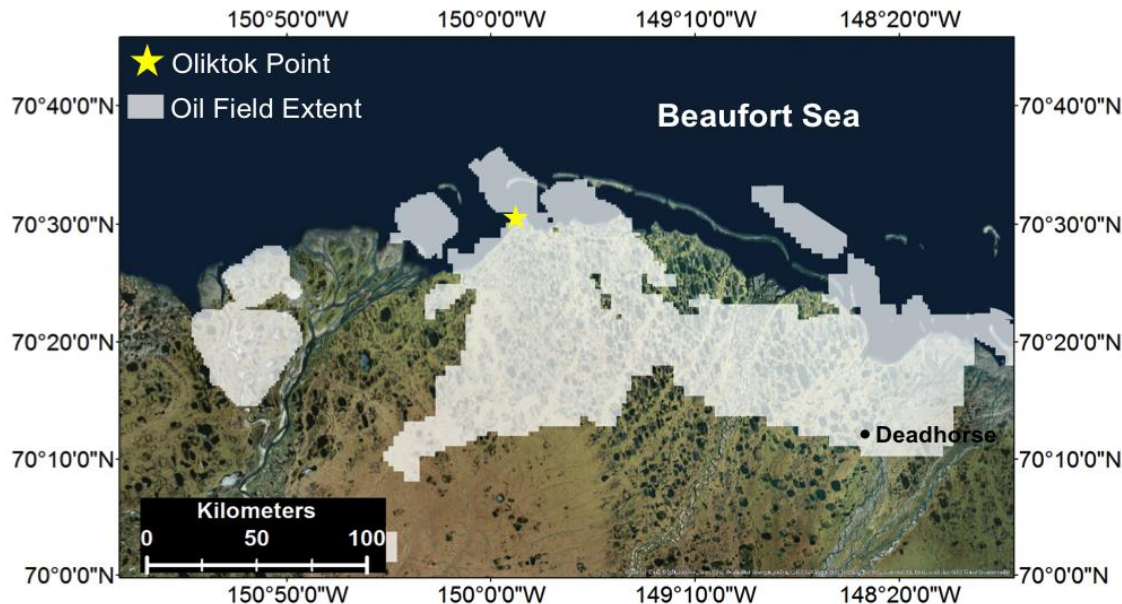


1976-present: Semi-continuous PM monitoring at NOAA Barrow Observatory & DOE ARM North Slope of Alaska Observatory

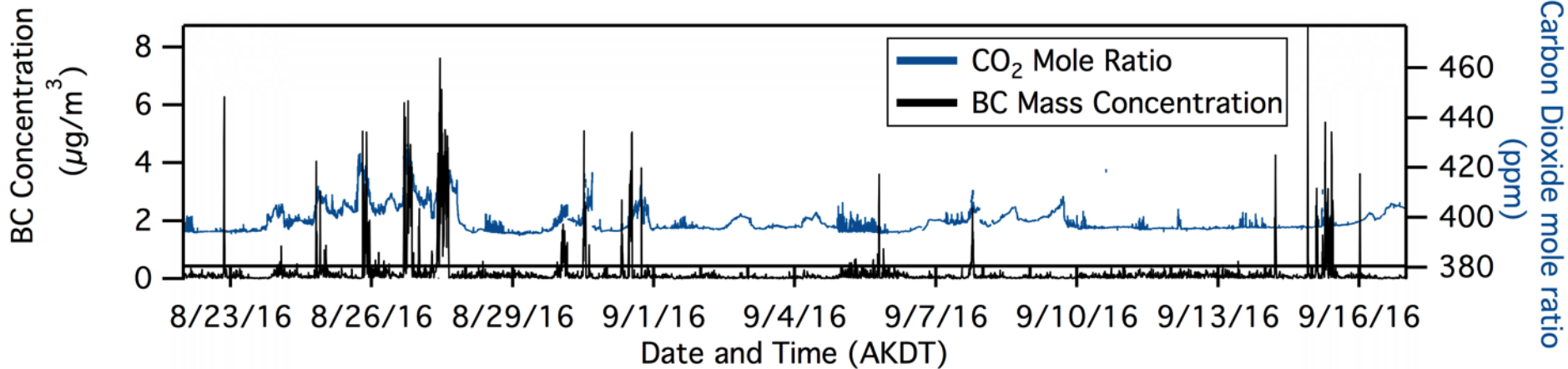
2016-present: DOE ARM Oliktok Point Mobile Facility

Aug.-Sept. 2015 & 2016: NOAA & DOE ARM-funded Field Campaigns in Utqiagvik & Oliktok Point (Collaboration with Rebecca Sheesley, Baylor Univ.)

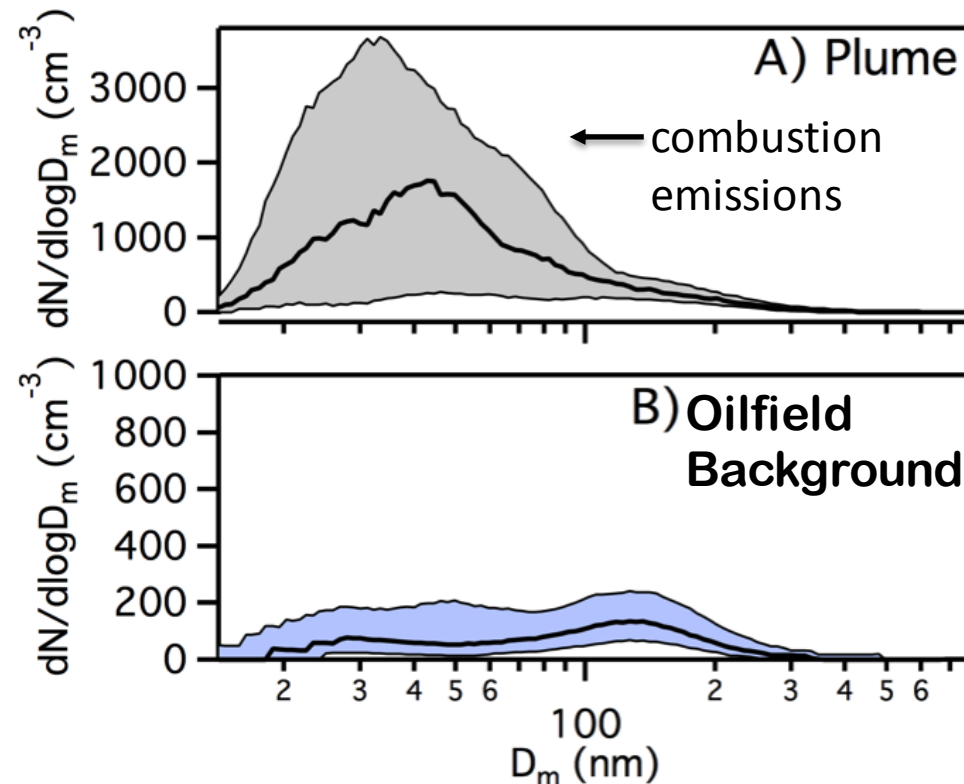
# Aug.-Sept. 2016 Measurements at Oliktok Point, within the Prudhoe Bay Oilfield



# Direct Combustion Plume Measurements

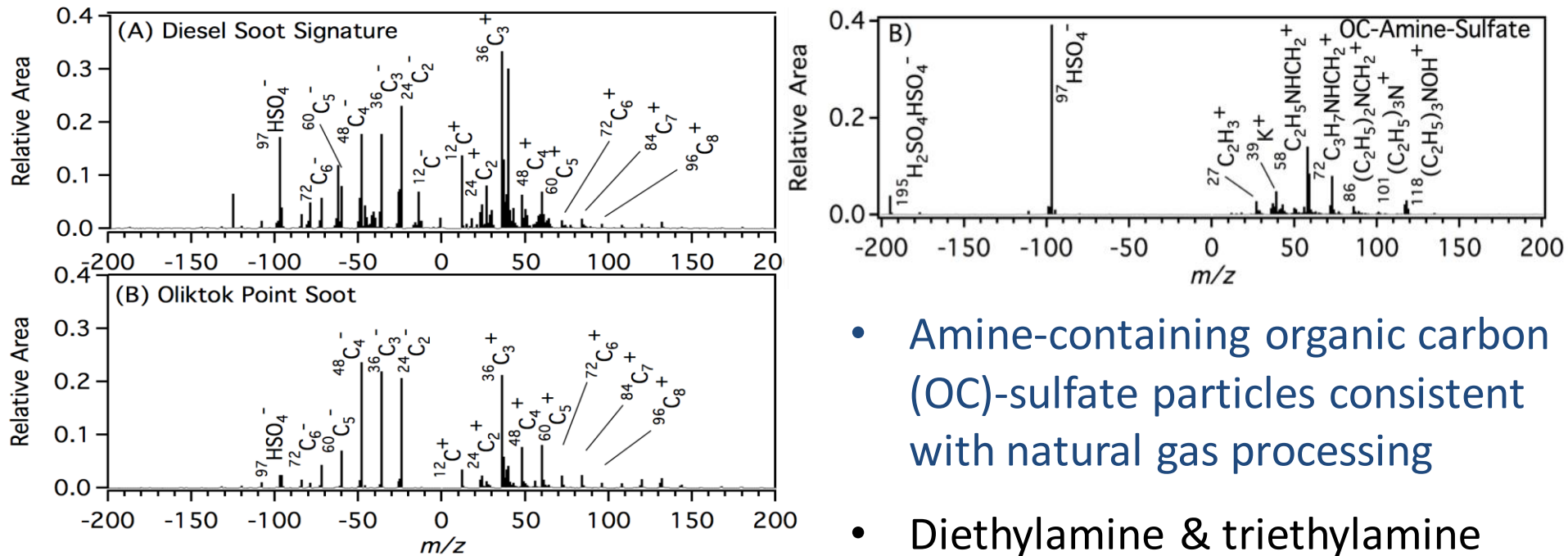


- Defined plume periods by elevated CO<sub>2</sub> (> 397 ppm) or black carbon (BC, or soot) (> 0.2 μg/m<sup>3</sup>)
- Increased particle concentrations, especially of <100 nm particles, in combustion plumes



# Mass Spectrometry of Individual Particles: Diesel Combustion & Natural Gas Processing

Custom single-particle mass spectrometer (Pratt et al. 2009, *Analytical Chem.*):  
Online analysis of individual 0.07-1.6  $\mu\text{m}$  particles



- Soot (elemental carbon, EC) particles consistent with diesel combustion soot (not gasoline combustion soot)
- Amine-containing organic carbon (OC)-sulfate particles consistent with natural gas processing
- Diethylamine & triethylamine used to treat sour (high sulfur content) natural gas; not emitted from marine sources

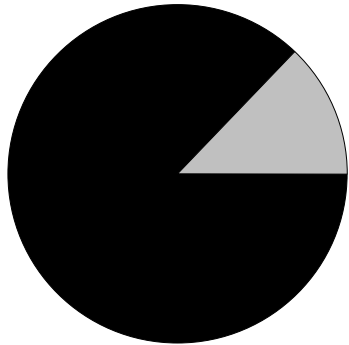
# Fossil Carbon & Contemporary (Marine, Terrestrial) Carbon PM Contributions

Atmospheric PM collected on filters, followed by radiocarbon ( $^{13}\text{C}$ ) analysis of organic carbon (OC) and elemental carbon (EC)

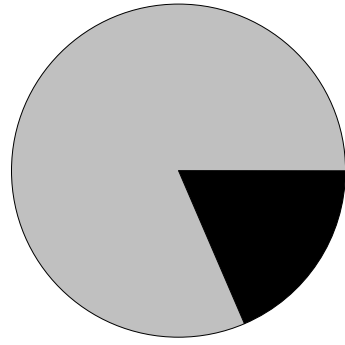
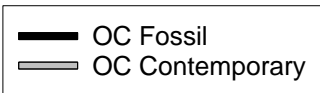
**Aug. 24-28, 2016**

OC:  $0.68 \mu\text{g}/\text{m}^3$  (mostly contemporary carbon)

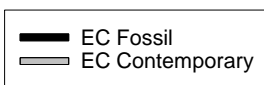
EC:  $0.19 \mu\text{g}/\text{m}^3$  (mostly fossil carbon)



8/24-8/28/16



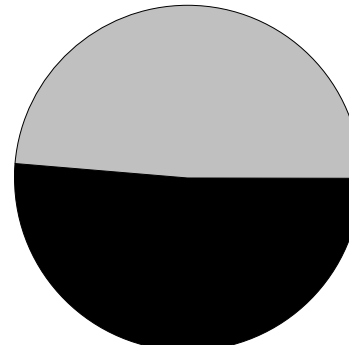
8/24-8/28/16



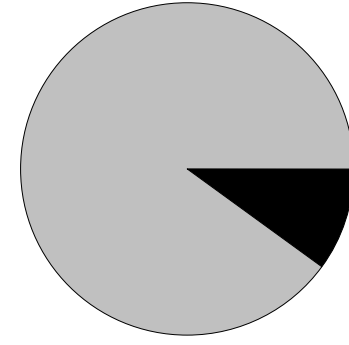
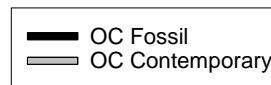
**Sept. 18-21, 2016**

OC:  $0.19 \mu\text{g}/\text{m}^3$  (~half contemporary carbon)

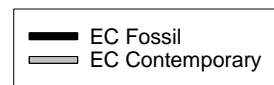
EC:  $0.24 \mu\text{g}/\text{m}^3$  (mostly fossil carbon)



9/18-9/21/16



9/18-9/21/16

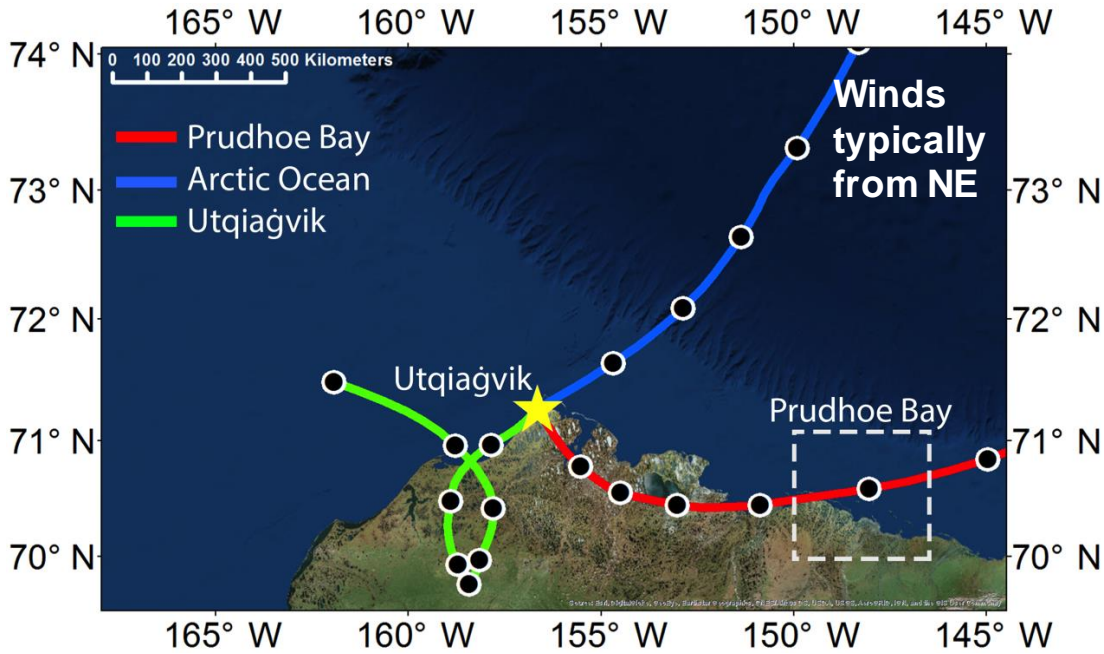


Greater contributions of marine/terrestrial OC emissions in August, compared to Sept.; EC consistent with diesel combustion

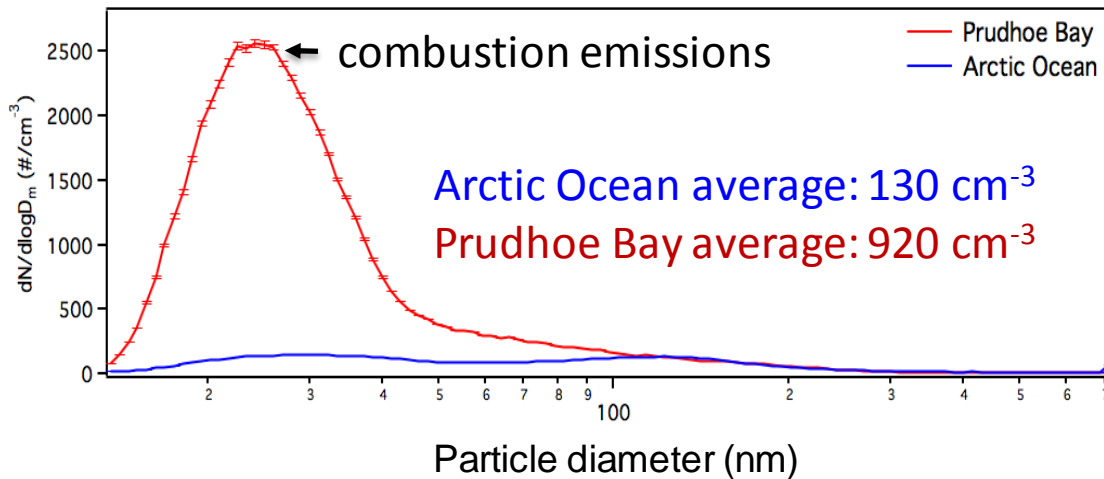
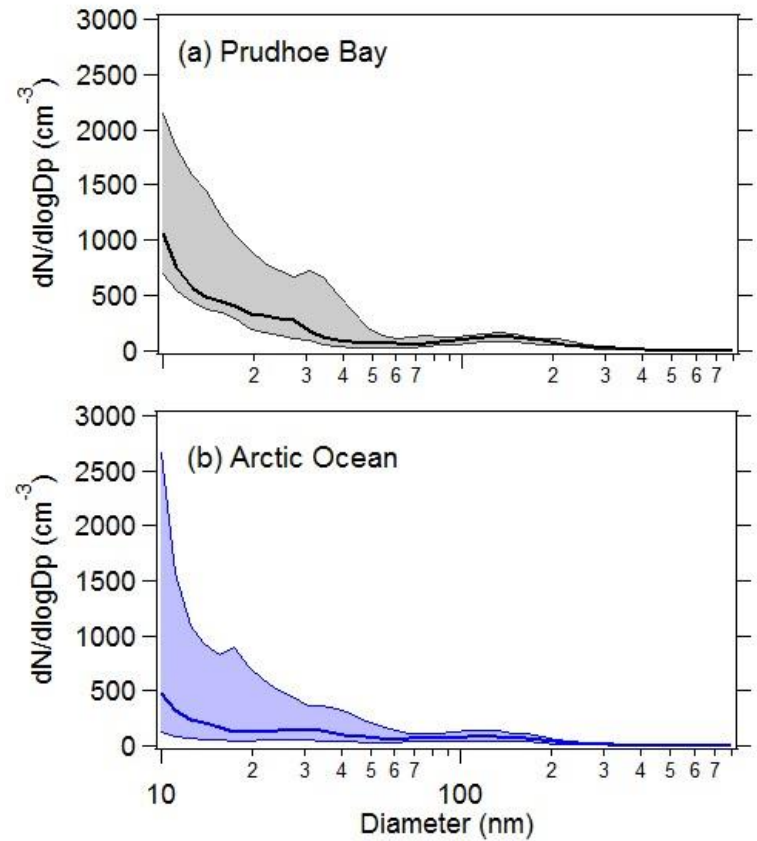
Results from  
Rebecca Sheesley



# Utqiagvik: Summer (Aug.-Sept.) 2015



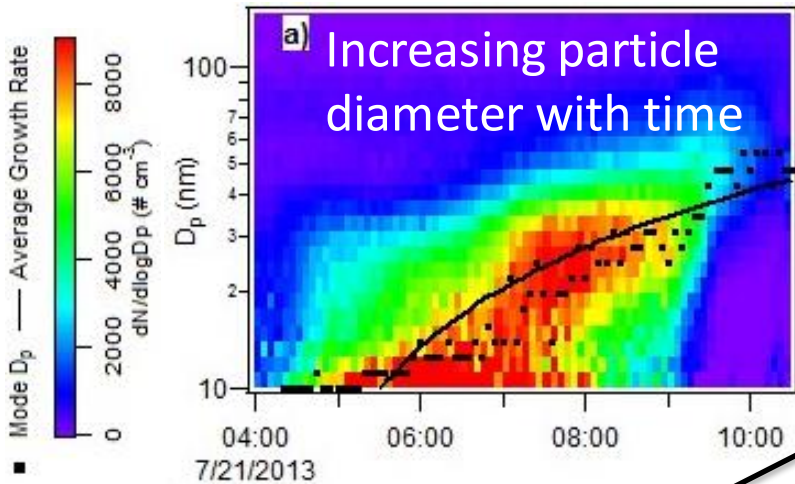
## Comparison: Aug.-Sept. 2008-2014



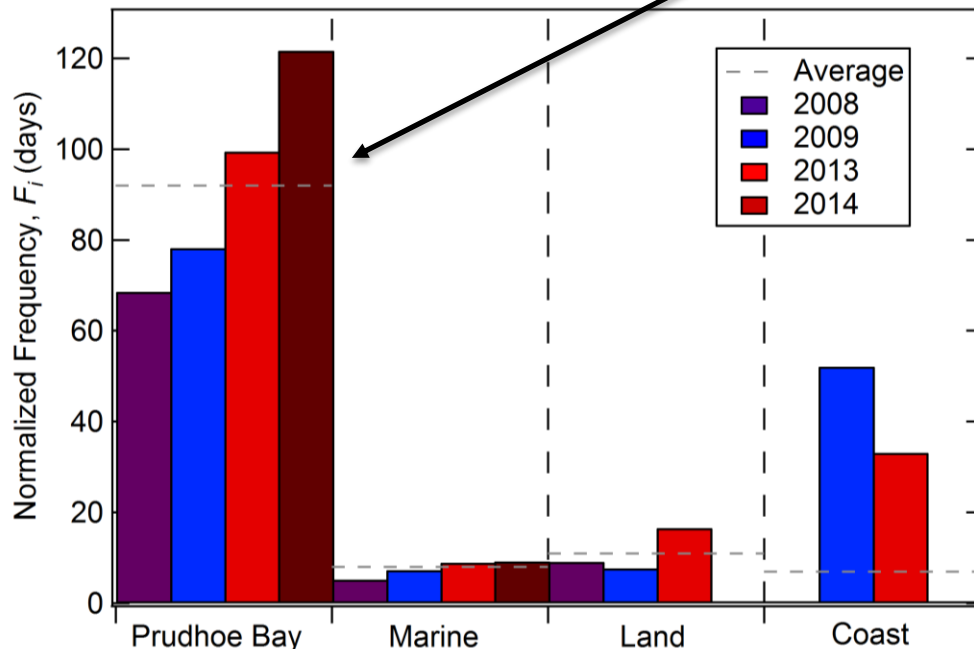
Increased particle concentrations under Prudhoe Bay influence

# Atmospheric Particle Growth

## Observed at Utqiagvik, Alaska (2008-2015)



Preferential occurrence of spring/summer particle growth at Utqiagvik for Prudhoe Bay air masses, compared to marine (Arctic Ocean) or land (tundra) air masses

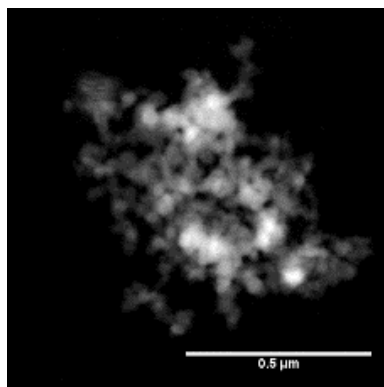
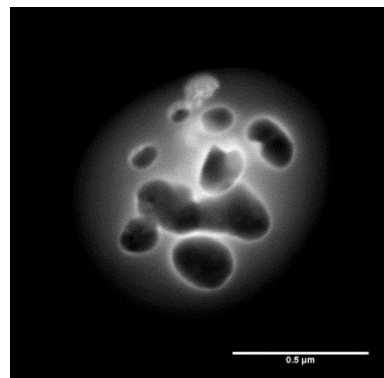
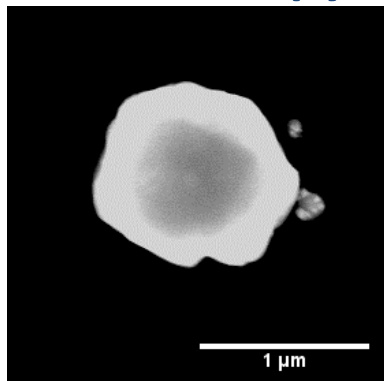


← Representation of the number of days of particle growth that would be expected if the wind direction observed at Utqiagvik, AK always came from the same location

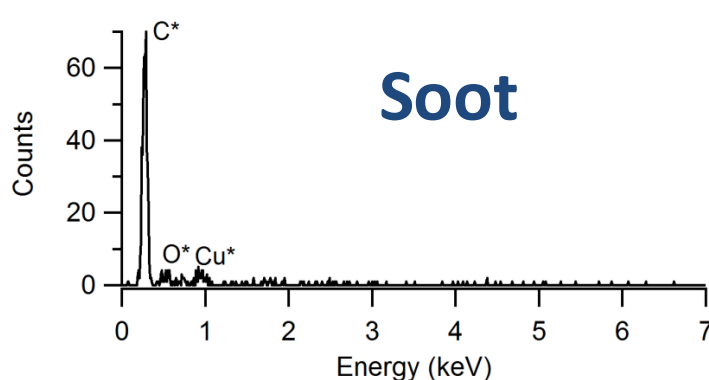
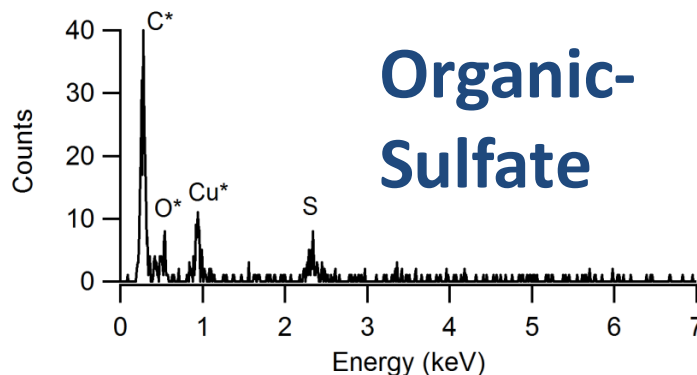
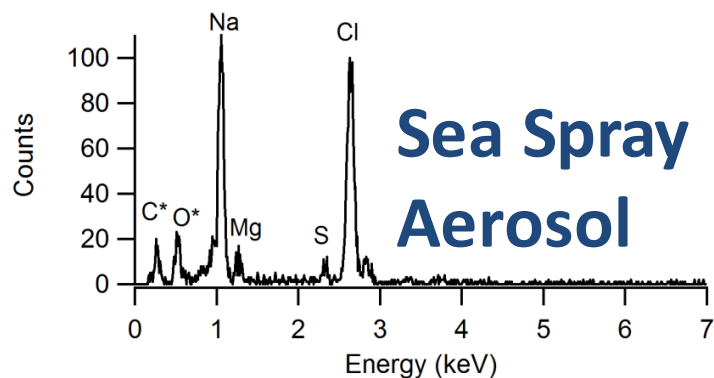
# Summer Particle Composition

Gunsch et al. 2017,  
*Atmos. Chem. Phys.*

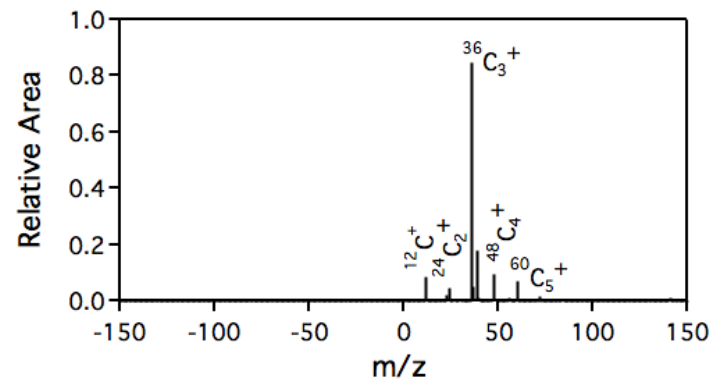
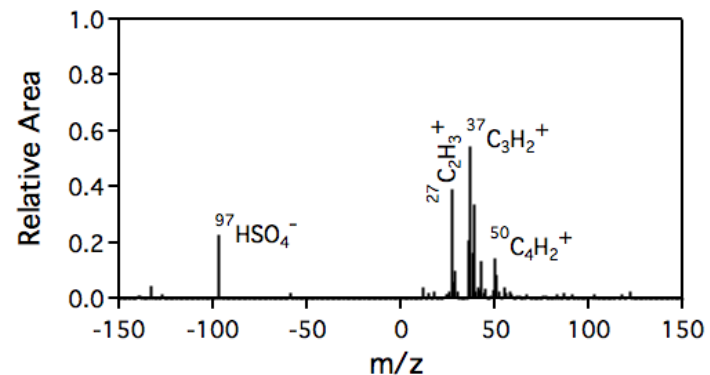
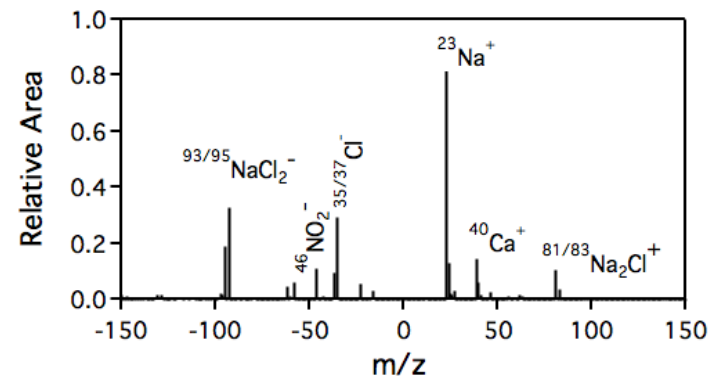
## Scanning Electron Microscopy



## Energy Dispersive X-ray Spectroscopy

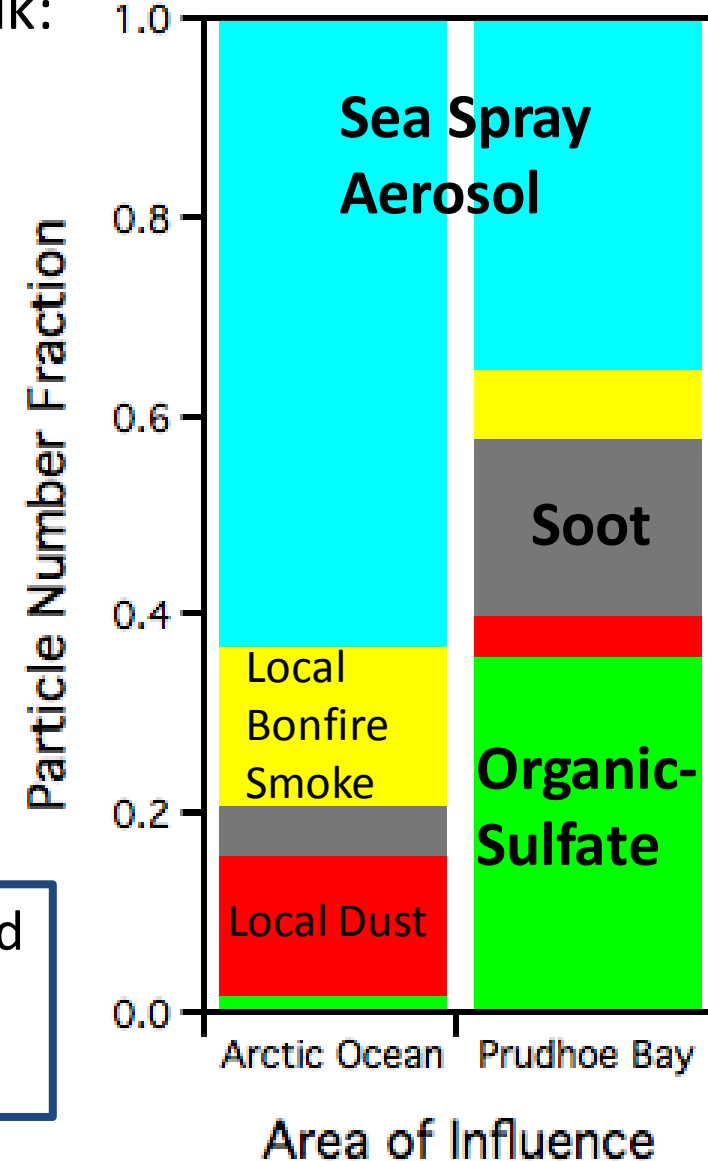
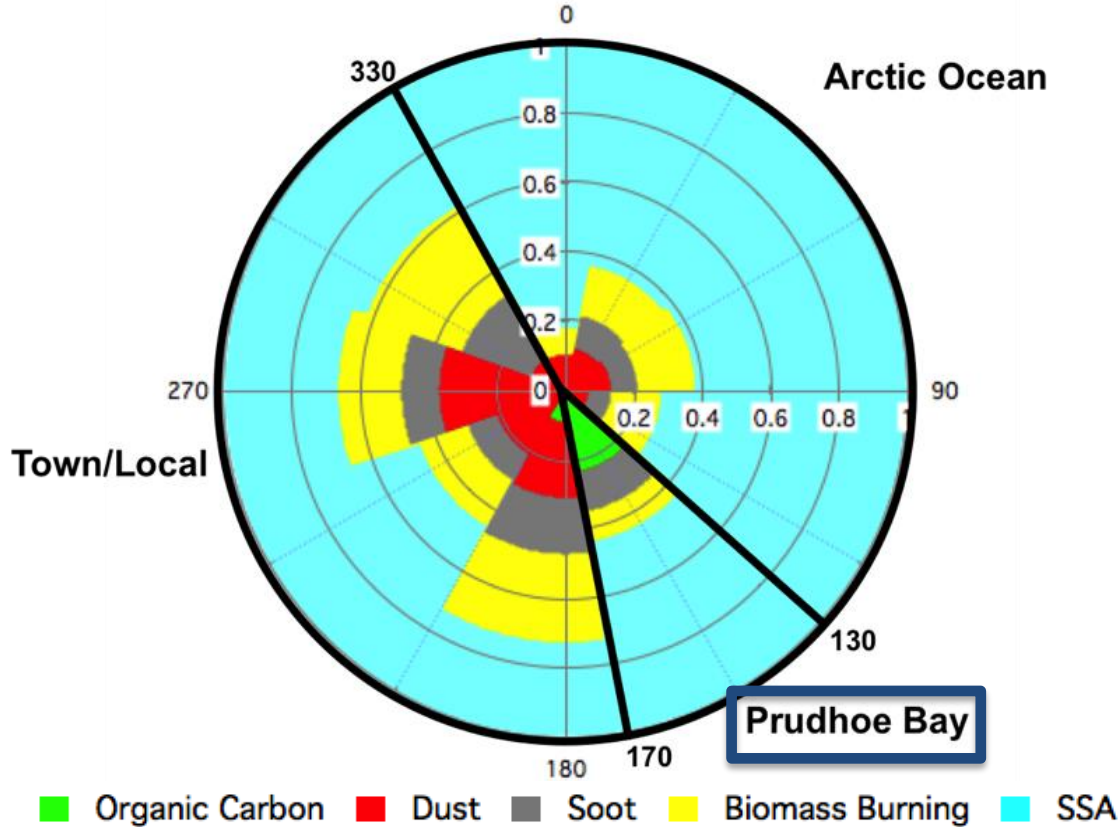


## Single-Particle Mass Spectrometry



# Transported Soot and Organic-Sulfate Particles from Prudhoe Bay Oilfield

Single-particle mass spectrometry at Utqiagvik:



Combustion emissions from Prudhoe Bay Oilfield impact Utqiagvik, AK over 160 miles away (particles can travel 100s-1000s of miles)

# Summary: Prudhoe Bay Influences on Alaskan Arctic Aerosol

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- **Increased particles, especially <100 nm**, from combustion sources impacting air within the Prudhoe Bay oilfield and downwind (even >160 miles at Utqiagvik)
- **Higher chance of particle growth** for Prudhoe Bay air masses (compared to Arctic Ocean)
- Single-particle mass spectrometry identified **diesel combustion and natural gas processing as major particle sources**

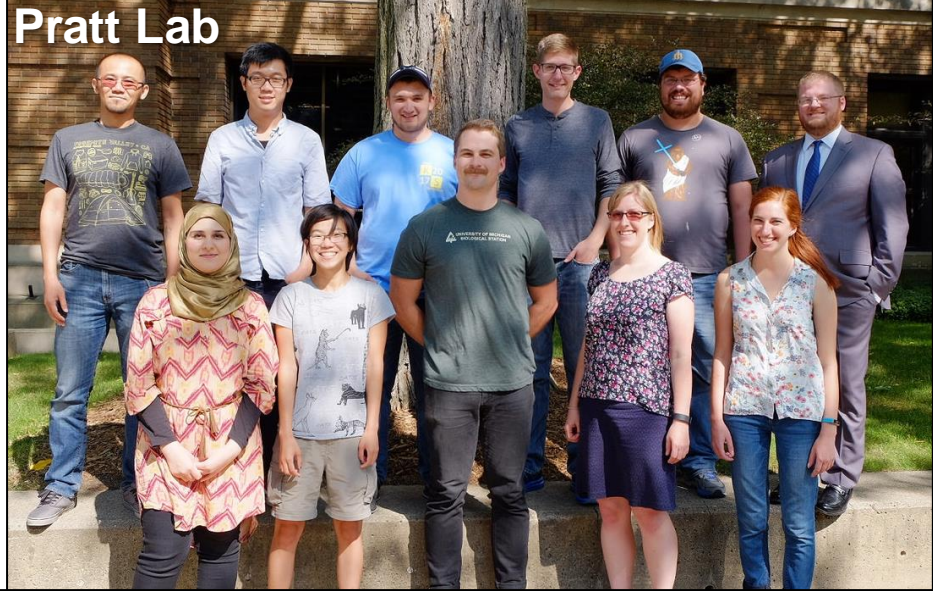


## Future Work:

- Modeling and aircraft studies of the air quality and climate impacts of Prudhoe Bay oilfield emissions on the greater Arctic region
- Air quality measurements in villages on the North Slope of Alaska (e.g., Nuiqsut)

# Acknowledgements

Pratt Lab



- Funding:
  - NOAA (NA14OAR4310149 and NA14OAR43101450)
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- Logistics:
  - DOE ARM
  - UIC-Science
  - AMF3 Operators
  - Sandia National Labs
  - U.S. Air Force



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