Arctic Ocean and Prudhoe Bay Influences on Aerosol Mixing States on the North Slope of Alaska

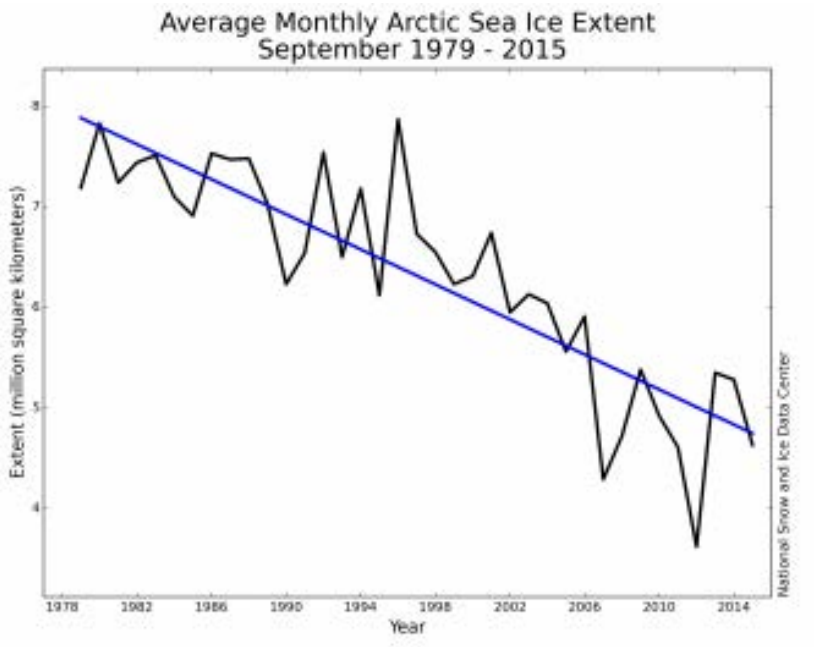
Kerri Pratt, Matthew Gunsch, Rachel Kirpes
University of Michigan
Rebecca Sheesley, Tate Barrett, Claire Moffett
Baylor University

ARM CLIMATE RESEARCH FACILITY

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

Changes in Aerosols in the "Future" Arctic

- Complete summertime sea ice loss predicted by 2050, possibly even within the next decade or two (Overland & Wang, 2013)



- ↑ sea spray aerosol emissions – *complex* Arctic climate feedback response due to cloud-precipitation interactions (Browse et al. 2014)

- ↑ Oil & gas development and shipping
- ↑ Emissions of absorbing soot and secondary aerosol precursors (Peters et al. 2011)
- Radiative forcing impacts: CCN, IN, particle optical properties, snow albedo

ARM Field Campaigns: 2012-2017

Real-time Aerosol Measurement Intensives:

- **Barrow:** Aug.-Sept. 2015
- **Oliktok Point:** *Aug.-Sept. 2016*

Particle Sampling for Off-line Analysis:

- **Barrow:** Jul. 2012-May 2013, Aug.-Sept. 2015, *Jun. 2016-Aug. 2017*
- **Oliktok Point:** Aug.-Sept. 2015, *Jun. 2016-Aug. 2017*

ARM NSA Barrow

UIC-Science Barrow

AMF3 Oliktok Point

2015 & 2016 Intensive Deployments

Goal: Detailed source and mixing state characterization of atmospheric aerosols on the North Slope of Alaska

Real-time Aerosol Instrumentation:

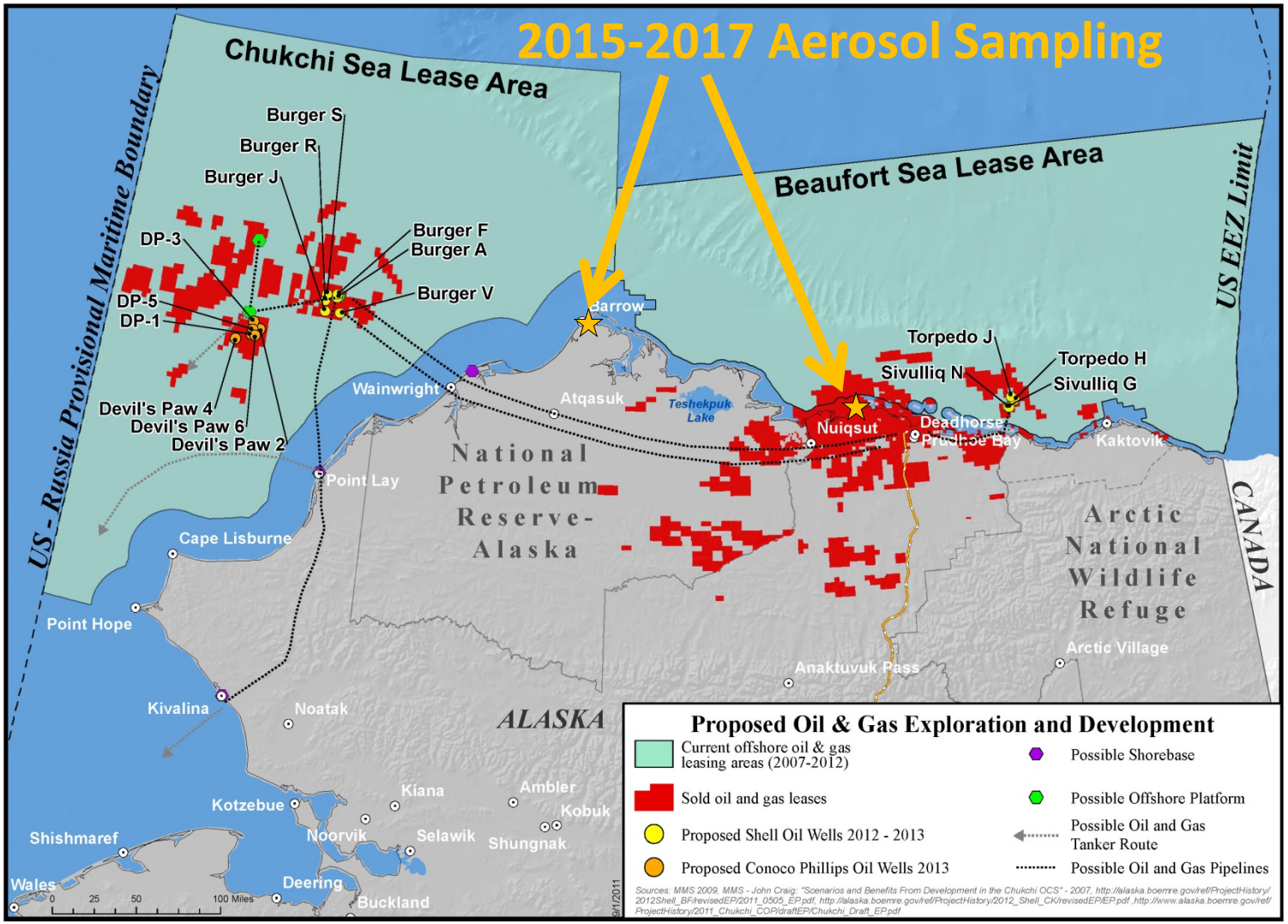
- Single-particle mass spectrometer (individual particle size & chemical composition & source identification, Pratt Lab aircraft-ATOFMS)
- SMPS & APS (aerosol size distributions)
- Aethalometer (black carbon)

Particle Sampling for Off-line Analysis:

- Organic carbon, elemental carbon
- Inorganic ions
- Radiocarbon analysis (modern vs. fossil carbon)
- Organic molecular tracers
- Computer-controlled scanning electron microscopy with energy dispersive X-ray spectroscopy (CCSEM-EDX, single-particle elemental composition)

  *PNNL EMSL user facility grant with Alex Laskin

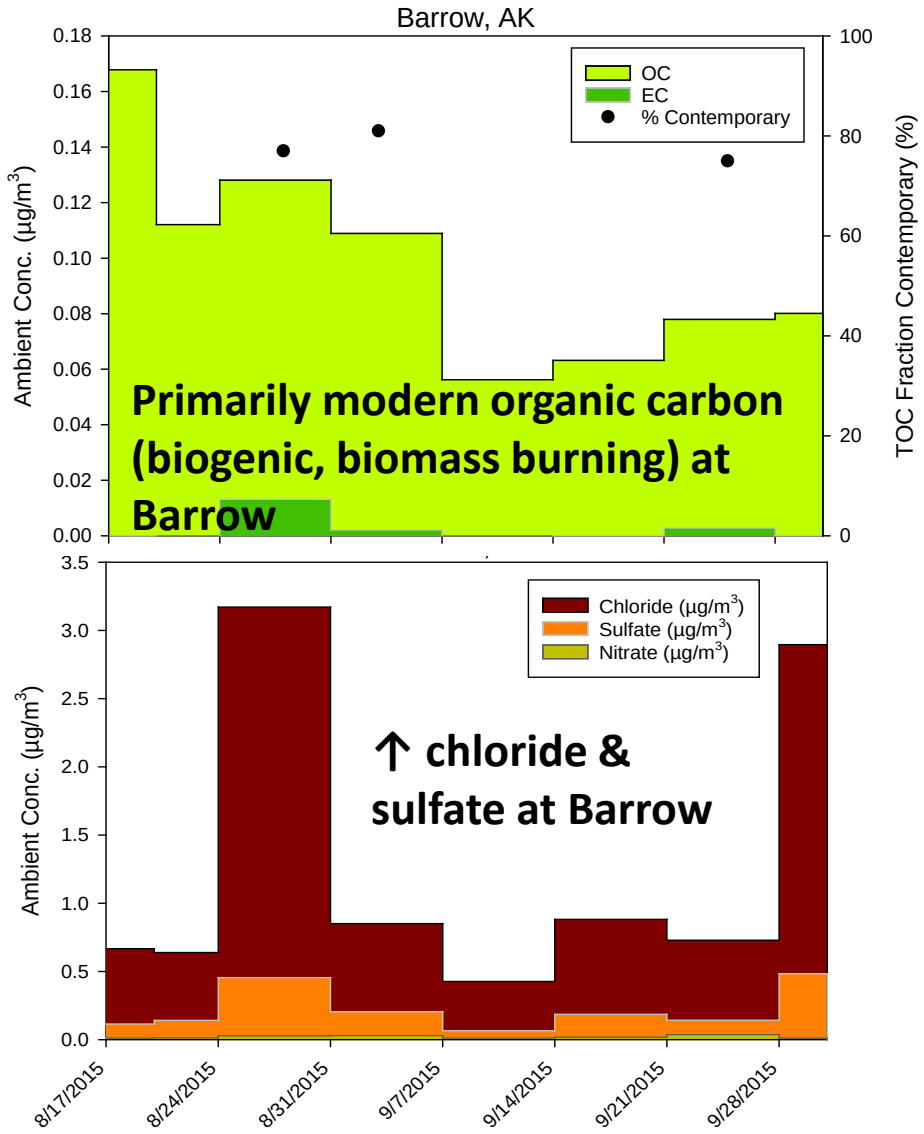
Prudhoe Bay – Largest Oilfield in North America

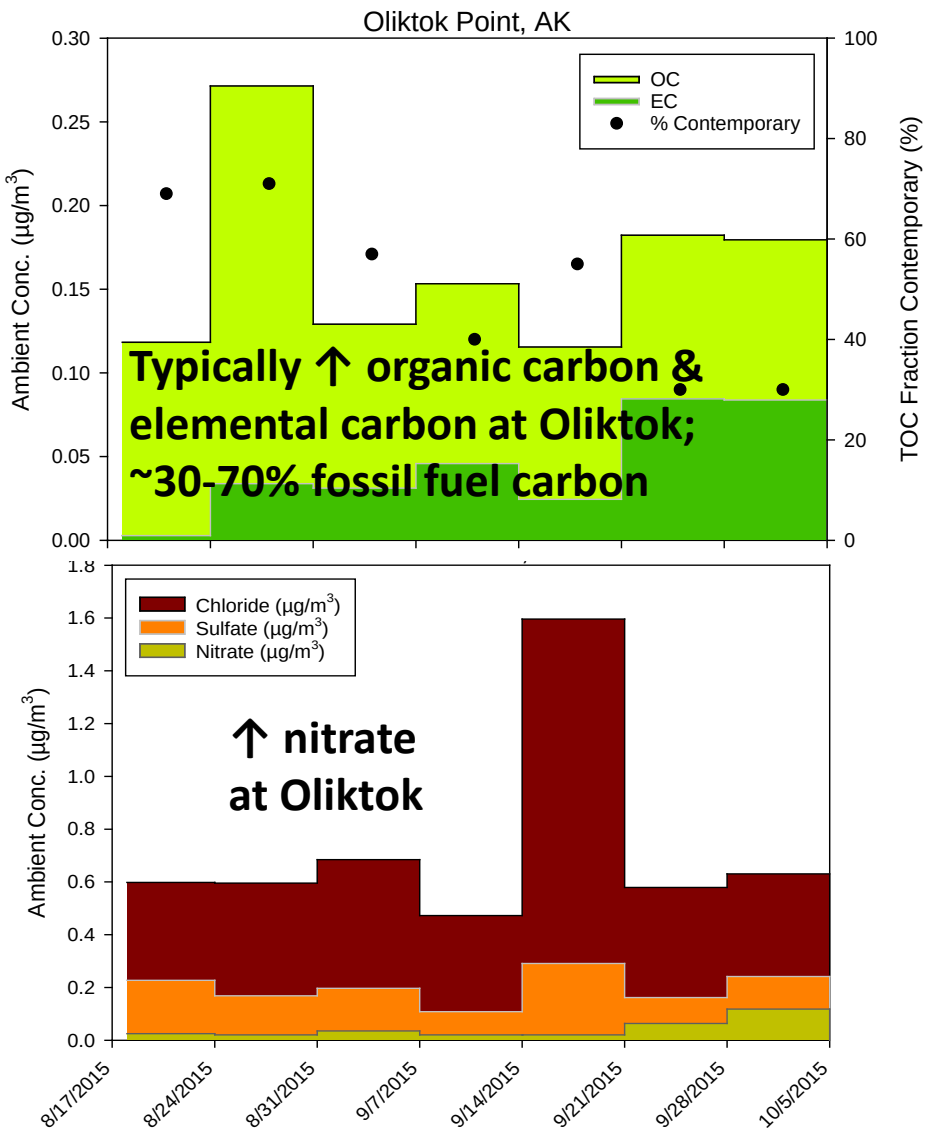


Impacts on Arctic aerosol mixing state: Emissions of primary absorbing aerosol (soot) and secondary aerosol precursors (SO_2, NO_x, volatile organic compounds)

2015 Barrow-Oliktok Comparisons

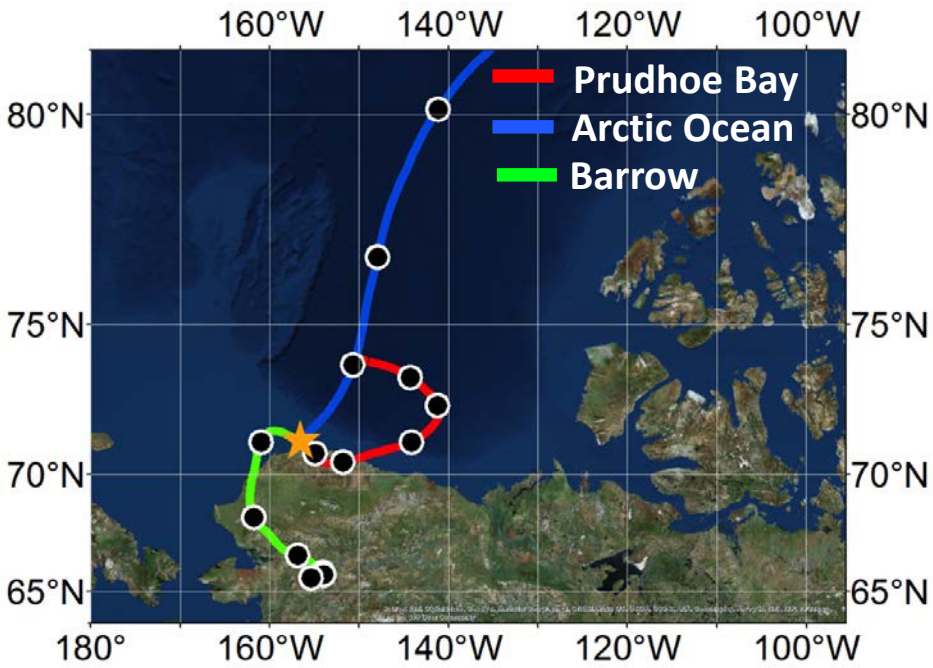
First aerosol chemical composition measurements at Oliktok Point!





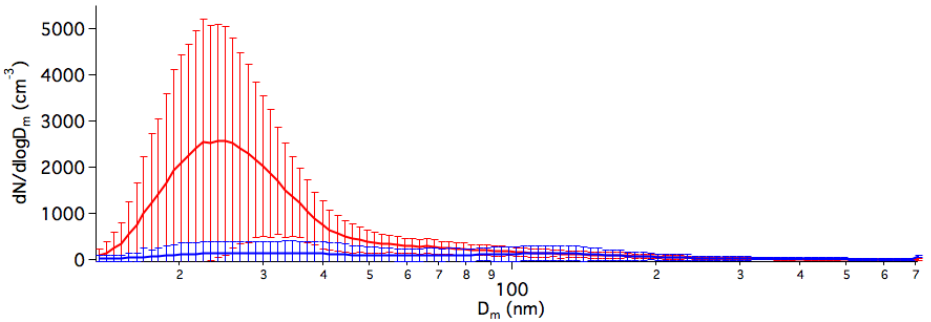
Barrow 2015 Summer Intensive

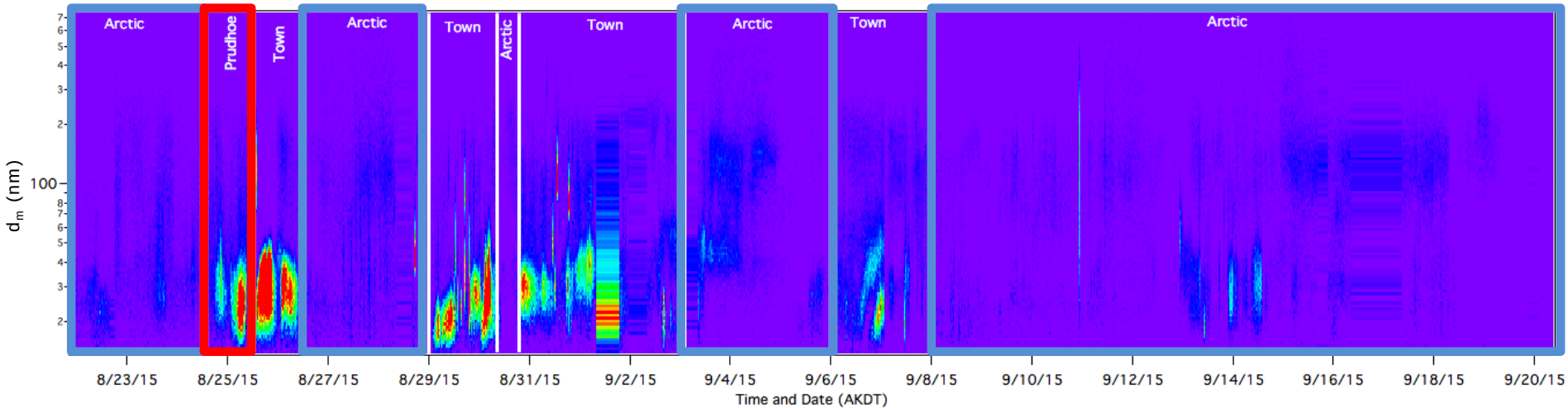
Preliminary Results!



Representative 72 h NOAA HYSPLIT backward air mass trajectories

- Particle number concentration enhancement with air mass influence from Prudhoe Bay
  - Arctic Ocean average: 130 cm^{-3}
  - Prudhoe Bay average: 920 cm^{-3}



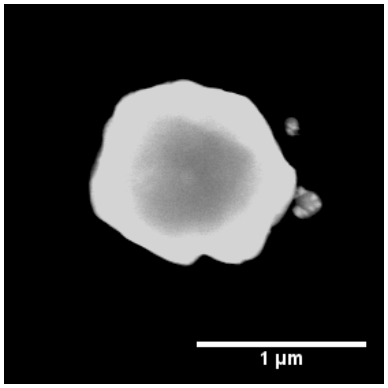


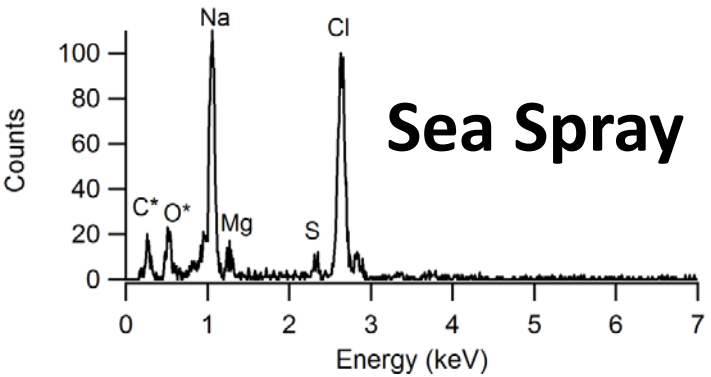
Individual Particle Types Observed (>0.2 µm)

Scanning Electron Microscopy

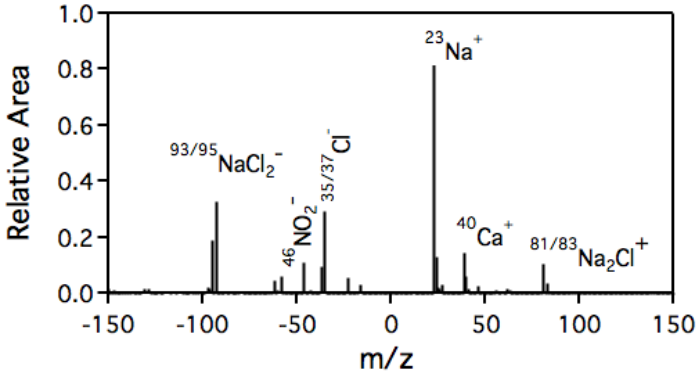
Energy Dispersive X-ray Spectroscopy

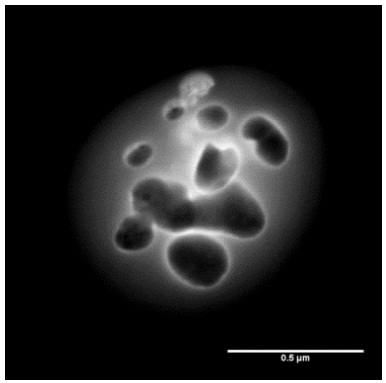
Single-Particle Mass Spectrometry

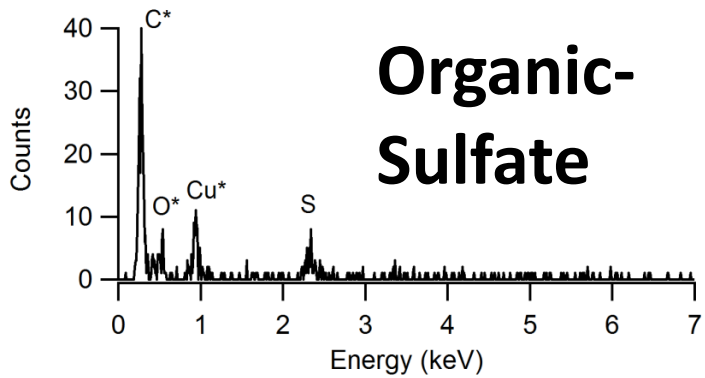




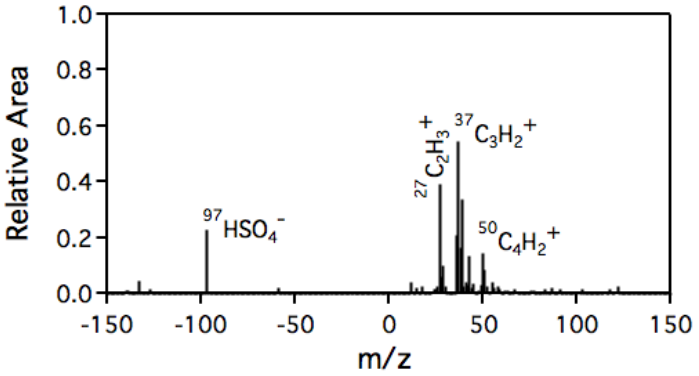
Sea Spray

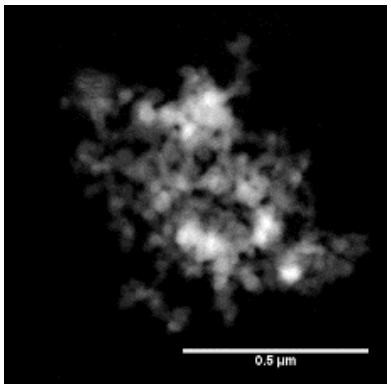


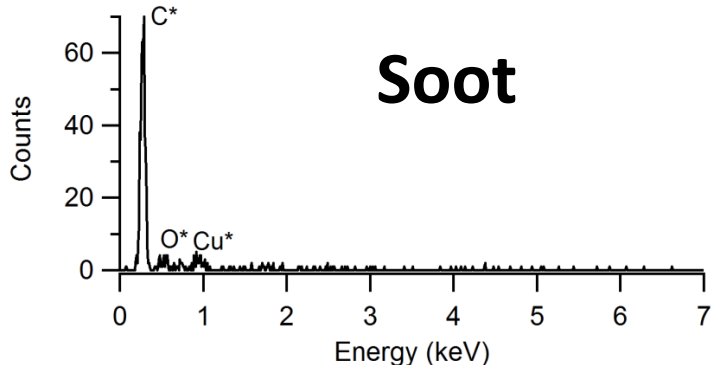




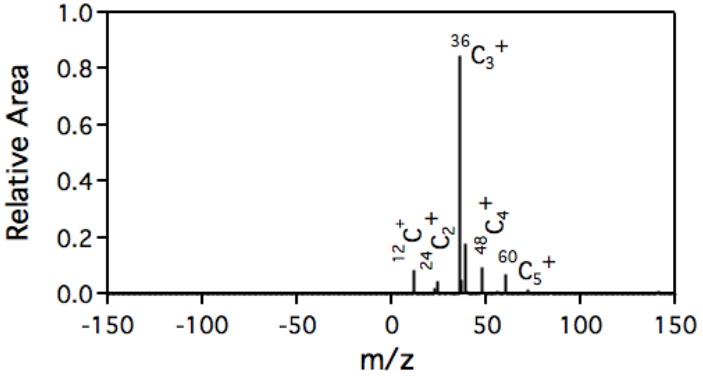
Organic-Sulfate



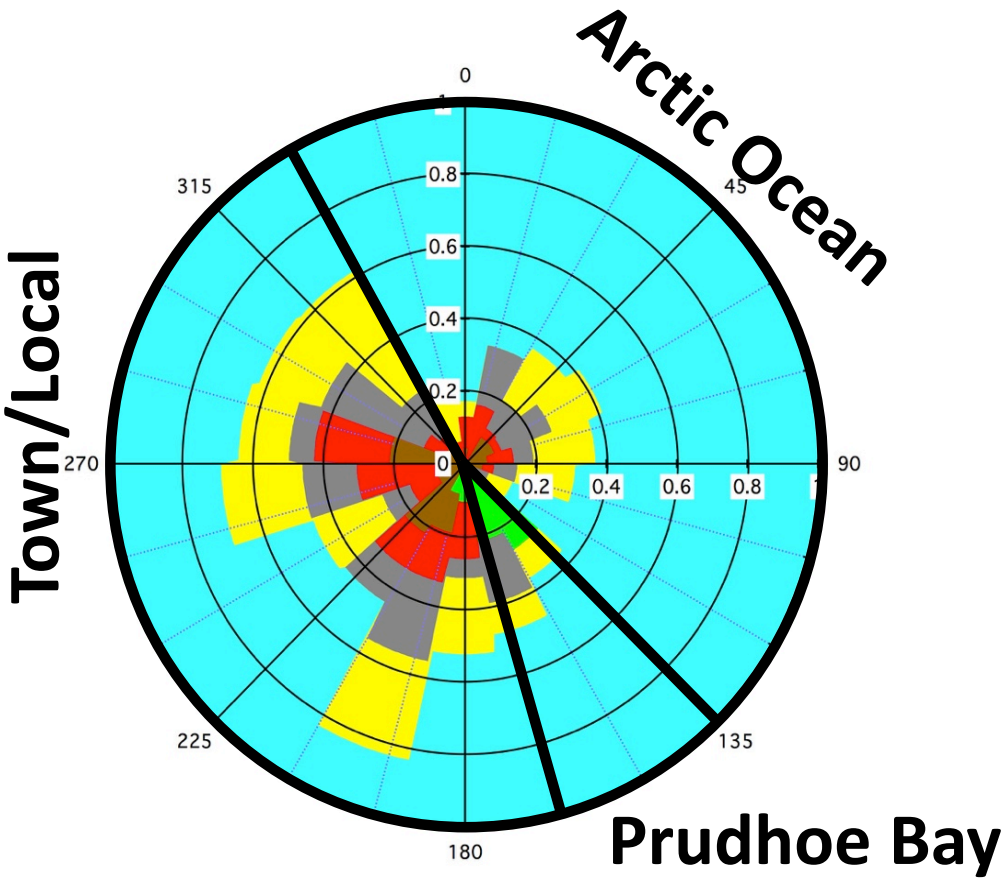


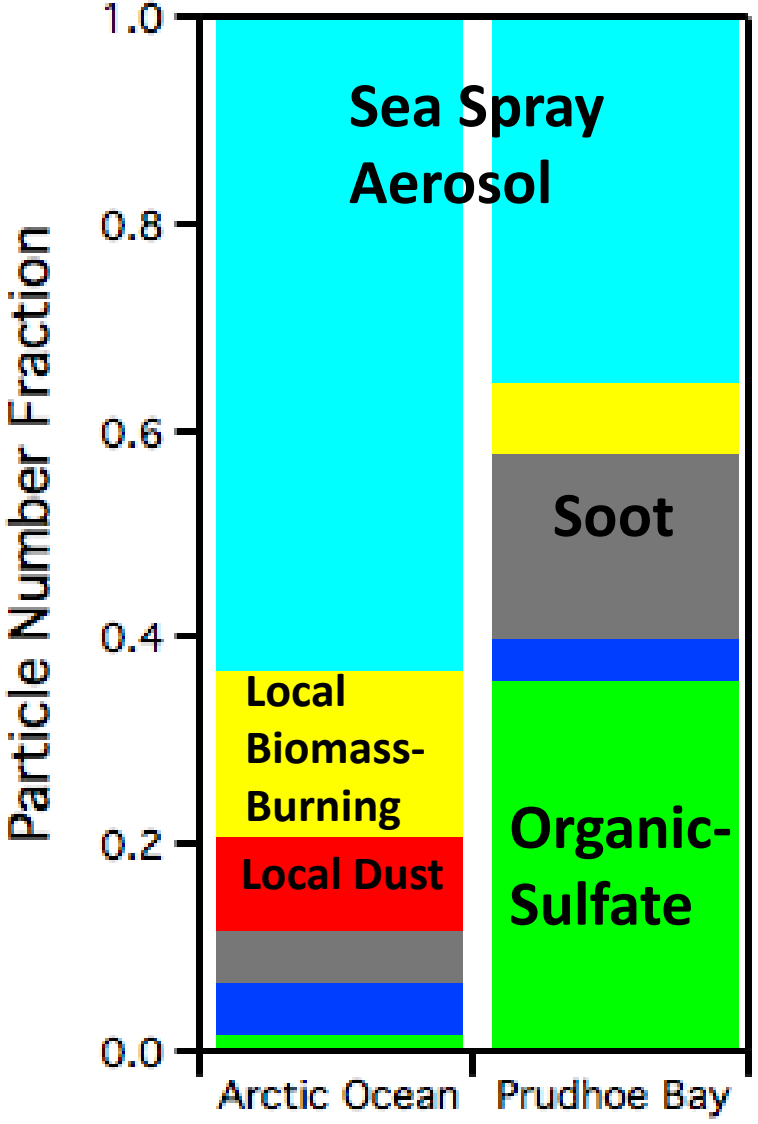


Soot



Real-time Aerosol Chemical Composition assists Source Identification

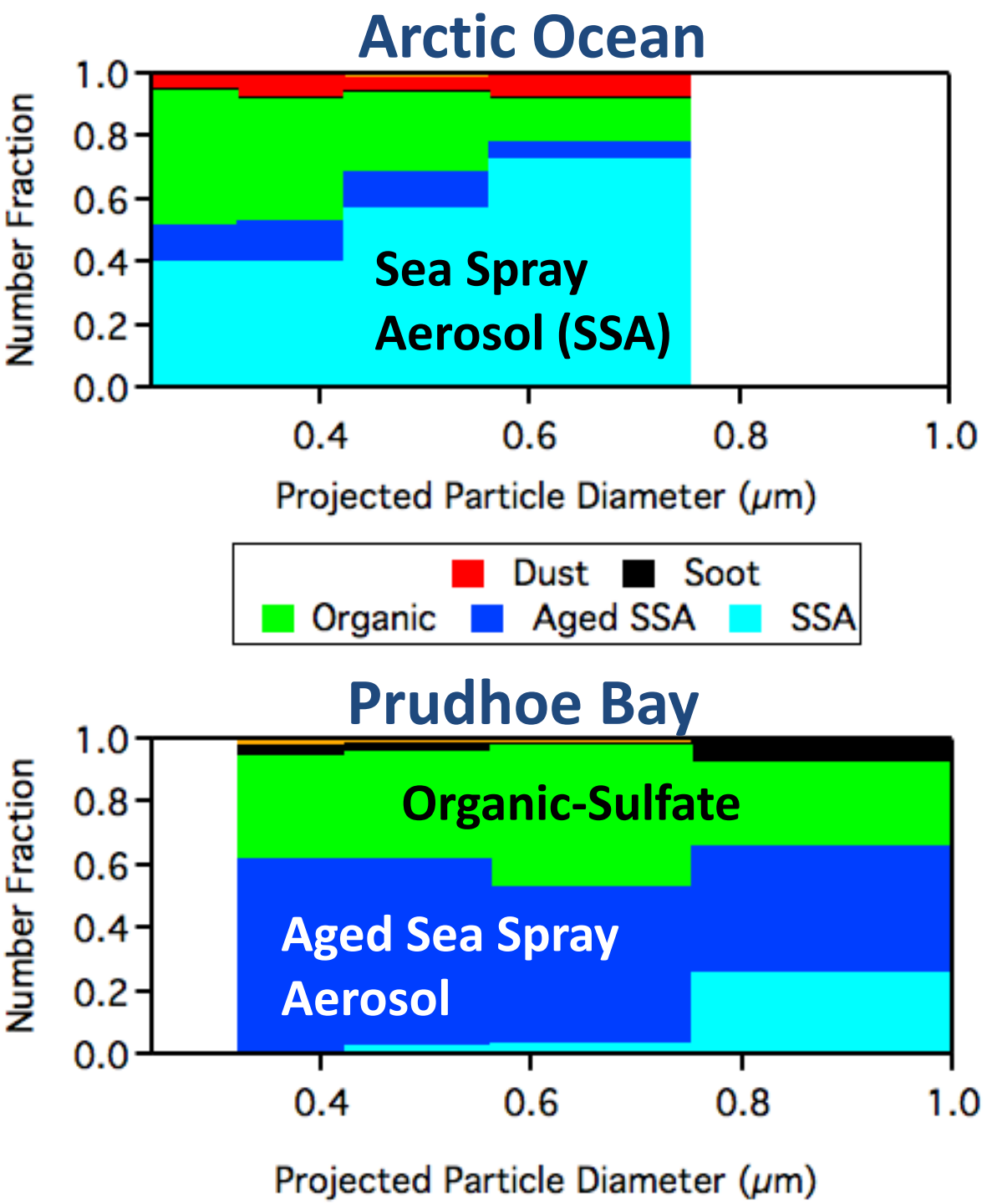




A-ATOFMS

Size-Resolved Single-Particle Mixing States

- **Over 50% of submicron particles were SSA, even at 0.2 µm**
- **Arctic Ocean Influence:** Greater fraction of "fresh" SSA, by number
- **Prudhoe Bay Influence:** Greater fractions of "aged" SSA, organic-sulfate particles, and soot, by number

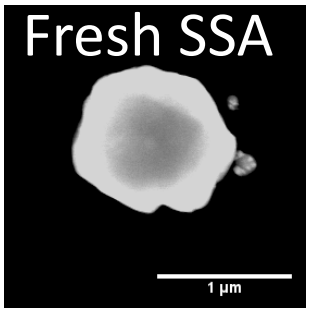


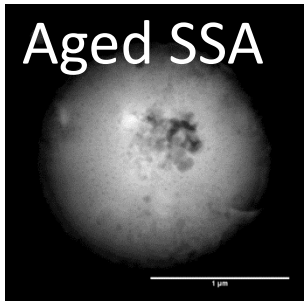
CCSEM-EDX

Sea Spray Aerosol (SSA) Mixing States

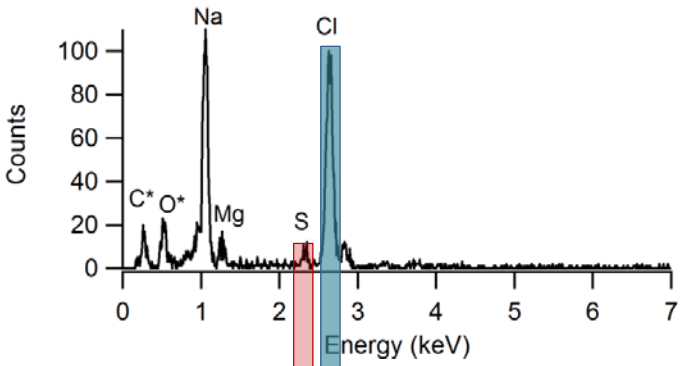
- **Arctic Ocean Influence:** Fresh SSA
- **Prudhoe Bay Influence:** Aged SSA
  - 60% of SSA by number internally mixed with sulfate
  - 80% of SSA by number internally mixed with nitrate
  - Decreased chloride, increased sulfate and nitrate mass

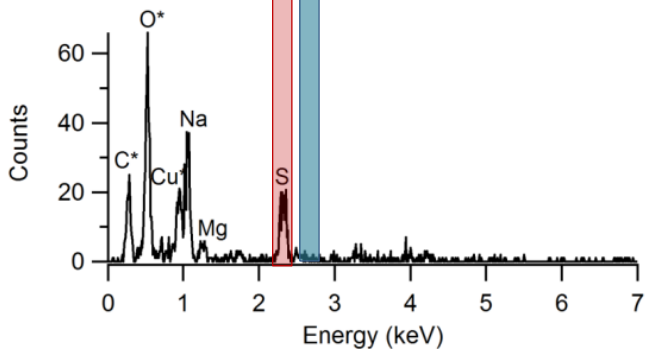
Scanning Electron Microscopy



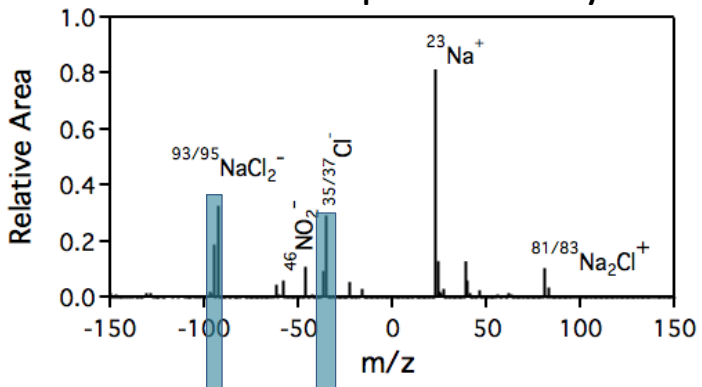


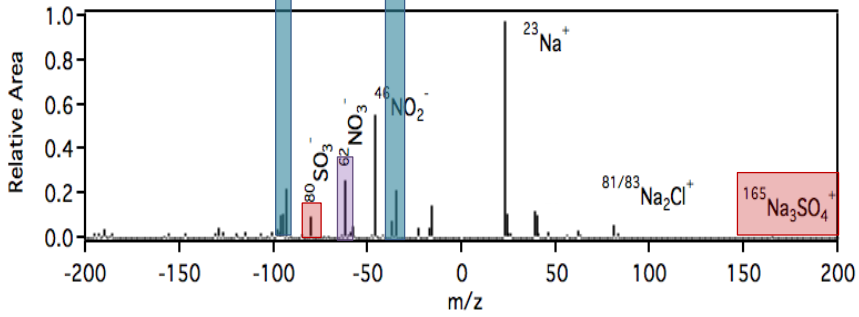
Energy Dispersive X-ray Spectroscopy





Single-Particle Mass Spectrometry





ARM Field Campaign Highlights

- 2015-2017 ARM field campaigns at Barrow & Oliktok Point, AK
- Increased aerosol number concentrations at Barrow when under Prudhoe Bay air mass influence
- Distinguished aerosol mixing state differences at Barrow between Arctic Ocean vs Prudhoe Bay air mass influences
  - Increased aged sea spray, soot, and organic-sulfate particles under Prudhoe Bay influence
  - Sulfate internally mixed with sea spray aerosol & organic particles
- Radiative forcing implications:
  - Increasing Arctic development will impact atmospheric aerosols
  - Aerosol mixing state impacts cloud formation (CCN, IN) ability and optical properties
- Summer 2016 intensive at Oliktok Point, simultaneous with AOS deployment

"Summer" in Barrow