Polar “Opposites” in Aerosol Seasonal Cycles: Particle Chemical Composition in the Arctic and Antarctic

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McMurdo: Israel Silber, Jeramy Dedrick, Jun Liu, Dan Lubin.
Utqiagvik (Barrow): Patricia K. Quinn, Amanda A. Frossard, Dan Lubin.
Alert: Sangeeta Sharma, W. Richard Leaitch.

Three Polar Campaigns

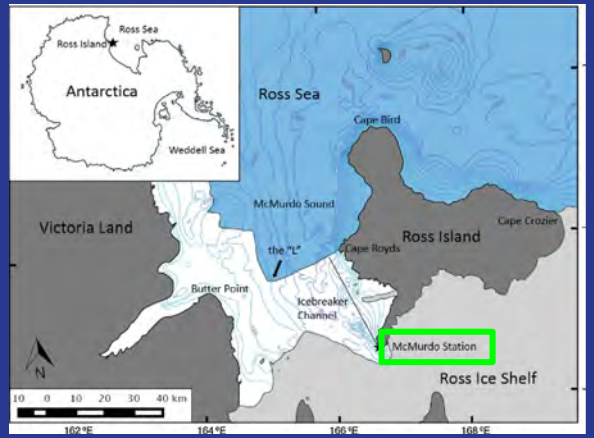
Submicron Aerosol Filters
Duration: 1-7 days
IC or XRF: Sulfate, NaCl, Dust
FTIR: Organic Mass

AWARE: ARM AMF (6 vans)

Barrow
(Utgiagvik)
2008-10

Alert
(Nunavut)
2012-14

McMurdo Station
(Antarctica)
2015-16



AWARE Highlights

A few recent publications;
And see breakout groups on:

- Observation-guided models
- High-latitude processes

AWARE: The ARM West Antarctic Radiation Experiment
Lubin D et al. 2020 *Bulletin of the American Meteorological Society*

Nonturbulent Liquid -Bearing Polar Clouds: Observed Frequency of Occurrence and Simulated Sensitivity to Gravity Waves
Silber I et al. 2020 *Geophysical Research Letters*

High summertime aerosol organic functional group concentrations from marine and seabird sources at Ross Island, Antarctica, during AWARE
Liu J et al. 2018 *Atmospheric Chemistry and Physics*

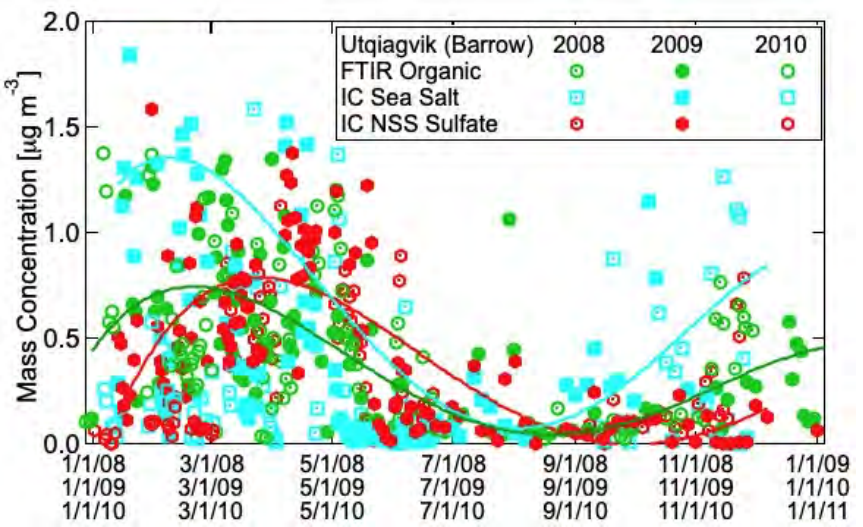
January 2016 extensive summer melt in West Antarctica favoured by strong El Nino
Nicolas J et al. 2017 *Nature Communications*

Persistent Supercooled Drizzle at Temperatures below -25°C Observed at McMurdo Station, Antarctica
Silber I et al. 2019 *Journal of Geophysical Research: Atmospheres*

Meteorological Drivers and Large-Scale Climate Forcing of West Antarctic Surface Melt
Scott R et al. 2019 *Journal of Climate*

Arctic Aerosol Chemical Composition

- Highest in winter-spring when mid-latitude sources contribute biomass and fossil fuel particles to episodic haze.
  - Utqiaġvik

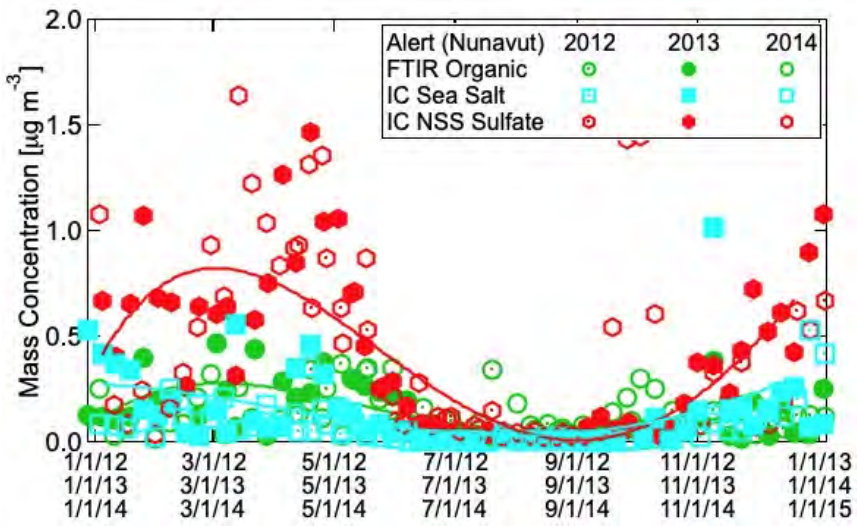


Frossard, A. A., Shaw, P. M., Russell, L. M., Kroll, J. H., Canagaratna, M. R., Worsnop, D. R., ... Bates, T. S. (2011). Springtime Arctic haze contributions of submicron organic particles from European and Asian combustion sources. *Journal of Geophysical Research -Atmospheres, 116*(D05205). doi: 10.1029/2010jd015178

Arctic Aerosol Chemical Composition

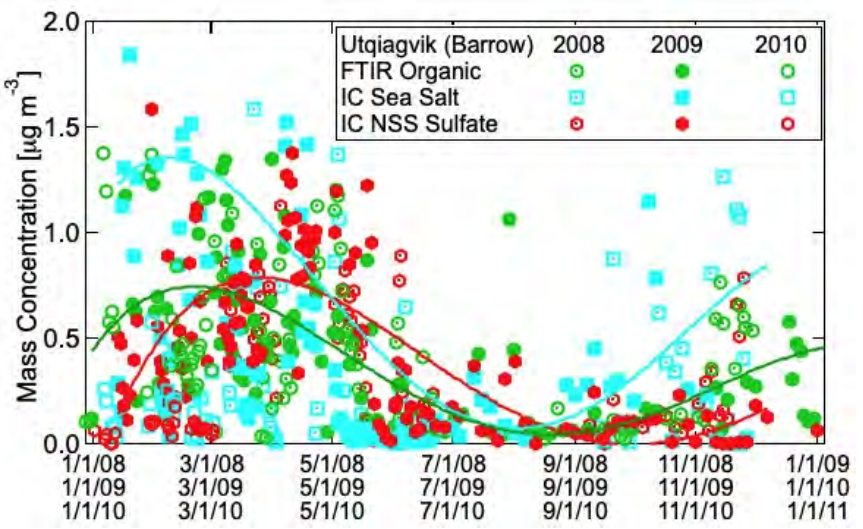
- Highest in winter-spring when mid-latitude sources contribute biomass and fossil fuel particles to episodic haze.
  - Alert

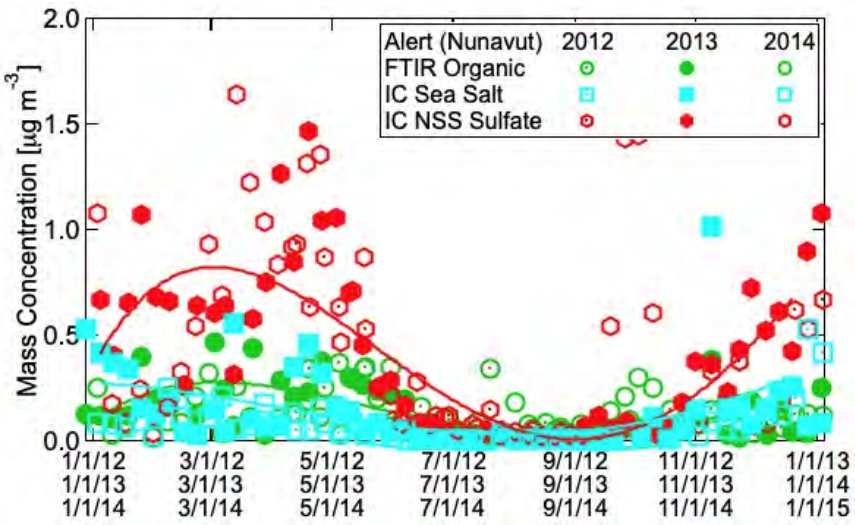
Leaitch, W. R., Russell, L. M., Liu, J., Kolonjari, F., Toom, D., Huang, L., ... Zhang, W. D. (2018). Organic functional groups in the submicron aerosol at 82.5 degrees N, 62.5 degrees W from 2012 to 2014. *Atmospheric Chemistry and Physics, 18*(5), 3269-3287. doi: 10.5194/acp-18-3269-2018



Arctic Aerosol Chemical Composition

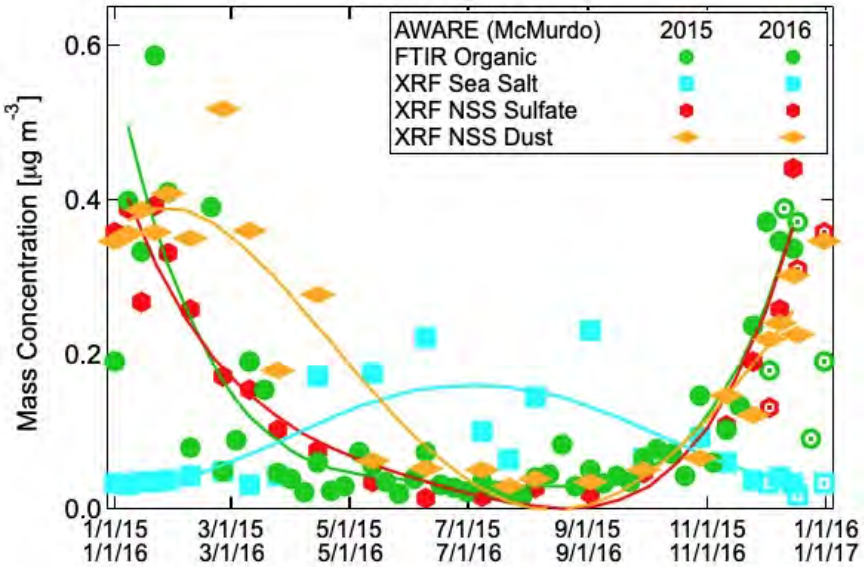
- Highest in spring when mid-latitude sources contribute biomass and fossil fuel particles to episodic haze.
  - Utqiaġvik has high sulfate and high organic mass (from coal and biomass burning).
  - Alert has lower organic than sulfate (less from biomass burning)





Antarctic Aerosol Chemical Composition

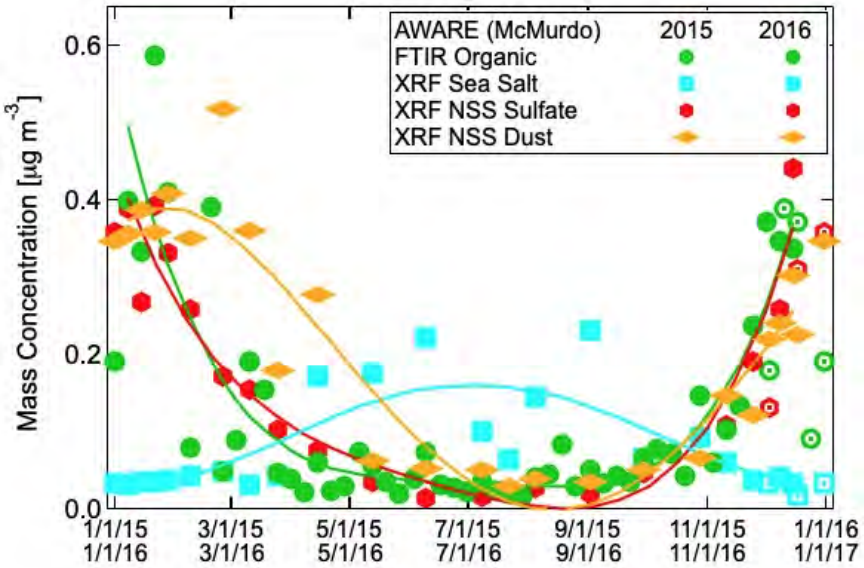
- Large biogenic contributions in summer but largely sea spray and frost flowers in winter.
  - McMurdo



Liu, J., Dedrick, J., Russell, L. M., Senum, G. I., Uin, J., Kuang, C. G., ... Lubin, D. (2018). High summertime aerosol organic functional group concentrations from marine and seabird sources at Ross Island, Antarctica, during AWARE. *Atmospheric Chemistry and Physics, 18* (12), 8571-8587. doi: 10.5194/acp-18-8571-2018

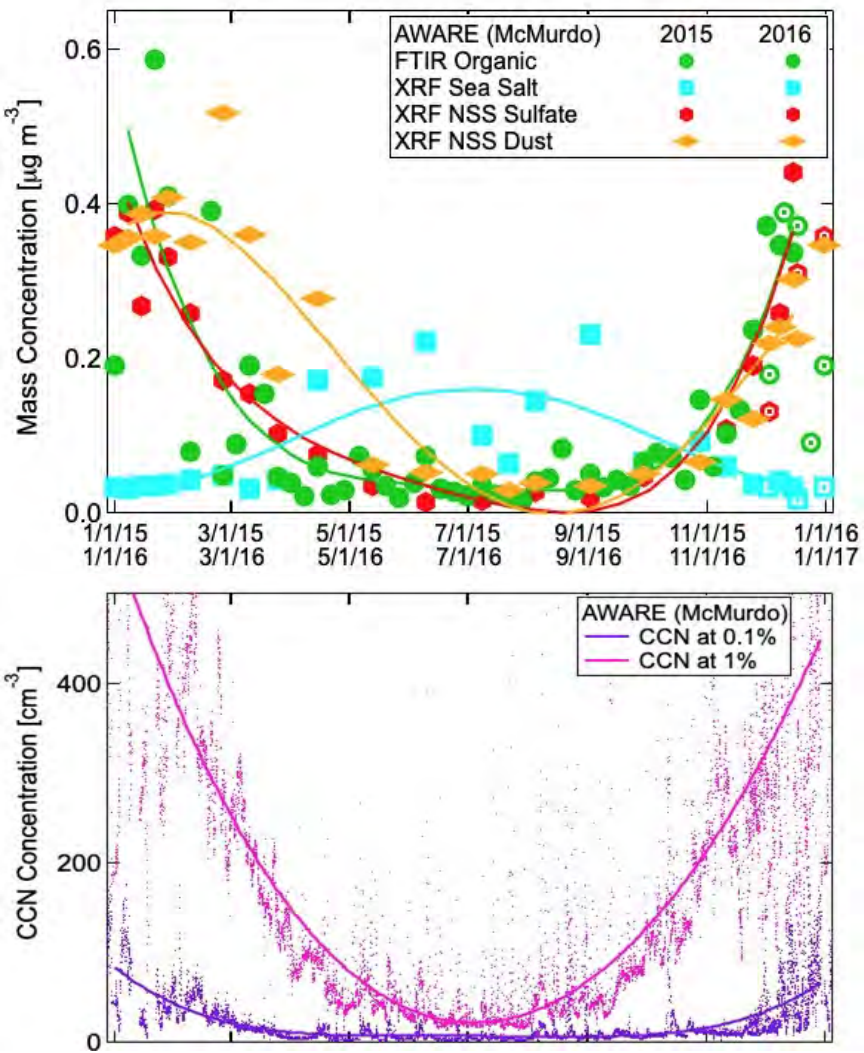
Antarctic Aerosol Chemical Composition

- Large biogenic contributions in summer but largely sea spray and frost flowers in winter.
  - McMurdo summertime has man-made contributions to organic and dust.
    - Most aerosol mass in summer is sulfate and organic, which is largely biogenic.



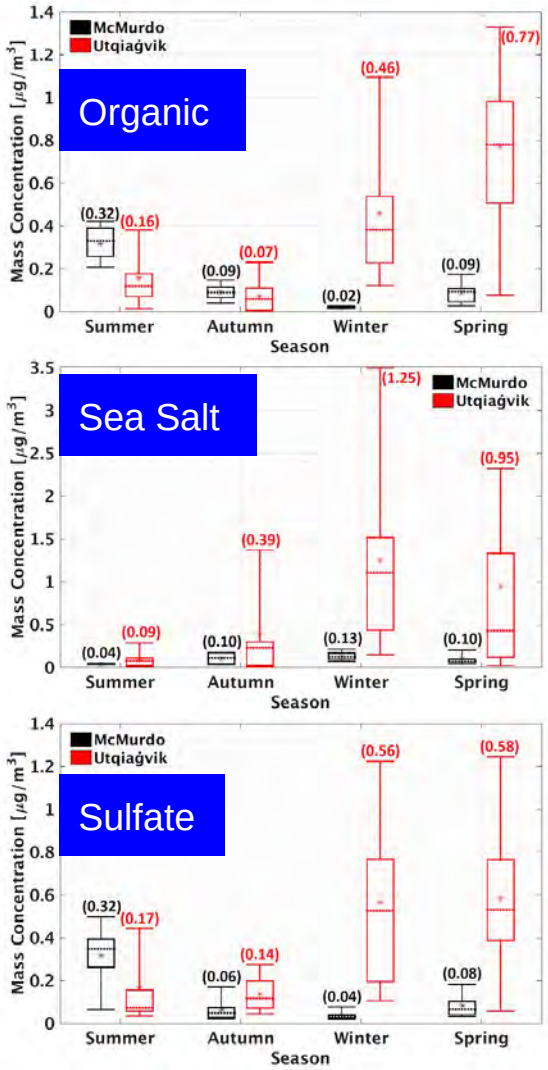
Antarctic Cloud Condensation Nuclei

- McMurdo CCN are highest in summer, tracking the seasonal increases in sulfate and organic submicron mass concentrations.
  - CCN at 1% are explained biogenic sulfate and possibly organic components.
  - CCN at 0.1% are largely sea salt in winter.



Comparison of Arctic and Antarctic Chemical Composition by Season

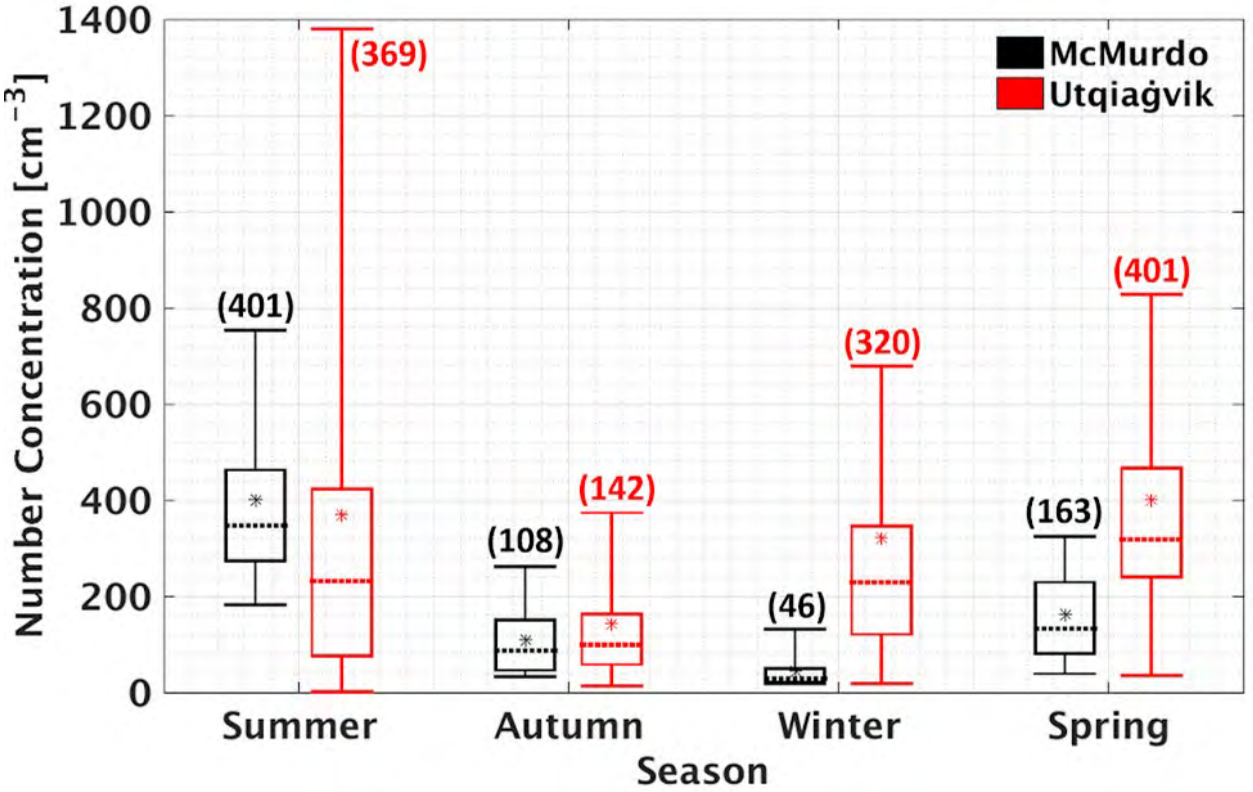
- Seasonal statistics at McMurdo and Utgiaġvik highlight differences
  - Utqiaġvik submicron sulfate and organic mass peak in winter-spring (due to transported haze).
  - McMurdo sulfate and organic mass are highest in summer (biogenic and some local pollution).



CCN Comparison

Utqiaġvik is highest in spring because of transported haze; difficult to see biogenic signal.

McMurdo is highest in summer because of biogenic sources; winter is “super” clean.



Conclusions

- Arctic aerosol submicron mass concentrations are highest in spring when mid-latitude sources contribute biomass and fossil fuel particles to episodic haze.
- Antarctic aerosol submicron mass concentrations have large biogenic contributions in summer but are largely sea spray and frost flowers in winter.
- Antarctic CCN are highest in summer, tracking the seasonal increases in sulfate and organic submicron mass.

The Next Questions...

Jeramy Dedrick (2nd yr PhD at SIO) analyzed AWARE data and proposes to study LASIC next.

- Can we quantify sea spray, DMS, and volatile organic contributions to CCN?
  - Can we tie sea spray to cloud properties?
- How are polar aerosol and marine aerosol different?
  - How do seasons and SST affect sea spray and clouds?
- How do clouds change in somewhat clean conditions?
  - For low clouds in tropical regimes?

Thank you!
Questions?

Acknowledgments

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