Oliktok Point Site Science: Aerosols

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Introduction

- Evaluating Arctic aerosol properties has implications for cloud formation, resulting in impacts on cloud lifetime, precipitation processes, and radiative forcing (Quinn et al., 2008; McFarquhar et al. 2011)
- Further, many remaining uncertainties exist regarding modeled and observed Arctic aerosol properties, thus, a better understanding of aerosol properties and sources in the Arctic is needed.
- Here, we present a comprehensive climatology of aerosol physical, chemical, and optical properties along the North Slope of Alaska at the joint NOAA and DOE ARM Barrow facility. We also investigate the potential for aerosol type (i.e., mineral dust) to influence cloud ice formation using in situ and remote sensing measurements (DeMott et al., 2003).

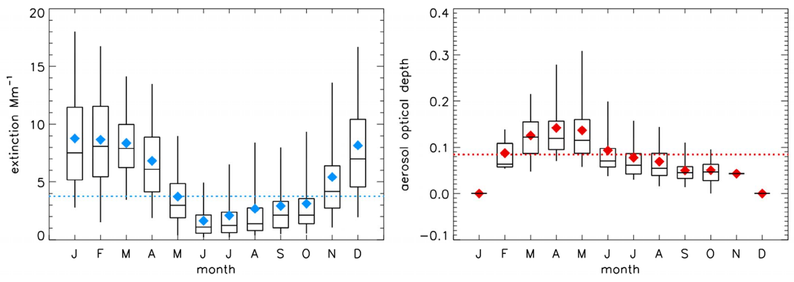
Aerosol Observations at Barrow

- Aerosol observations at Barrow extend back to 1976. See Table 1 for the complete list of aerosol measurements and where data were accessed.

Measurement	Instrument/ Method	λ (nm)	Size cut (μm)	Agency	Data source	Years available[1]
Particle number concentrations (CN)	Scanning Mobility Particle Sizer (SMPS)	*N/A*	1	TROPOS	GMD	2007 – 2009, 2012 – pres.
	Condensation particle Counter (CPC)	*N/A*	10	GMD	GMD	1976 – pres.
				ARM (AOS)	ARM	1998 – pres.
Particle size distributions	SMPS	*N/A*	1	TROPOS	GMD	2007 – 2009, 2012 – pres.
Absorption coefficient (σ_a)	Particle Soot Absorption Photometer (PSAP)	470	1	GMD	GMD	2006 – pres.
			10			2006 – pres.
		550/ 528	1		GMD	1997 – pres.
					ARM	1998 – pres.
			10		GMD	1988 – pres.
					ARM	1998 – pres.
		660	1		GMD	2006 – pres.
			10			2006 – pres.
Scattering coefficient (σ_s)	Nephelometer	450	1	GMD	GMD	1997 – pres.
					ARM	1998 – pres.
			10		GMD	1976 – pres.
					ARM	1998 – pres.
		550	1		GMD	1997 – pres.
					ARM	1998 – pres.
			10		GMD	1976 – pres.
					ARM	1998 – pres.
		700	1		GMD	1997 – pres.
					ARM	1998 – pres.
			10		GMD	1976 – pres.
					ARM	1998 – pres.
Aerosol optical depth (AOD)	Multi-Filter Rotating Shadowband Radiometer (MFRSR)	500	*N/A*	ARM	ARM	1998-pres.
Total mass concentrations	Gravimetric analysis	*N/A*	1	PMEL	PMEL	1998 – 2009[2]
			10			
Soluble ion concentrations	ion chromatography (IC)	*N/A*	1	PMEL	PMEL	1998 – 2009[2]
			10			
Submicron metal concentrations	x-ray fluorescence (XRF)	*N/A*	1	PMEL	PMEL	2003 – 2008[2]

[1]Some years do not have data from all months. Includes quality controlled and validated data only.
[2]Filter samples have been collected up to the present, currently available analysis ends in 2009 for IC and 2008 for XRF.

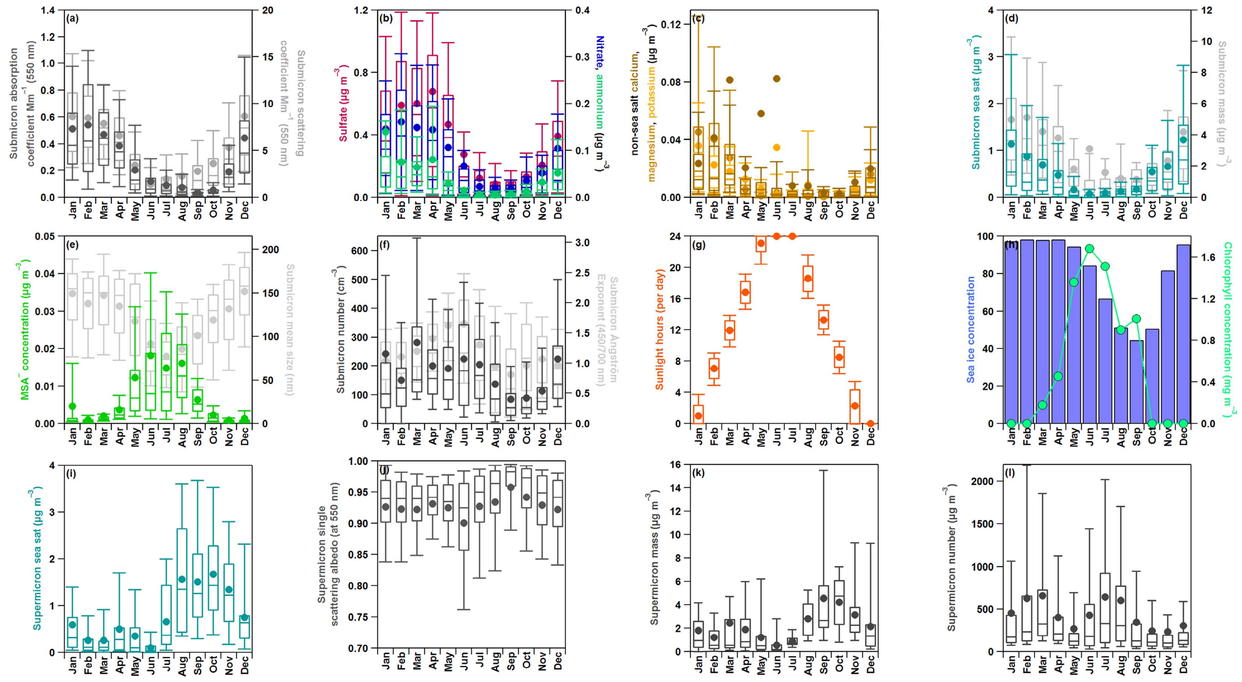
Seasonal Disconnect between Surface and Column Aerosol Optical Depth



- In situ surface aerosol measurements can provide a continuous and detailed record of variability in physical, chemical, and optical properties and the relationships among them. However, in the stratified Arctic atmosphere, significant effects from aerosols aloft may be overlooked.
- The blue plot shows the seasonal cycle of aerosol light extinction at the surface and reflects the pattern of mass concentrations in sulfate and ammonium shown above right.
- The red plot is the seasonal cycle of the column aerosol optical depth. The peak in light extinction is shifted to later in the season which is likely due to long-range transport of biomass burning aerosol that remains aloft. These aerosol might be more representative of those available to interact with cloud than what is measured at the surface.

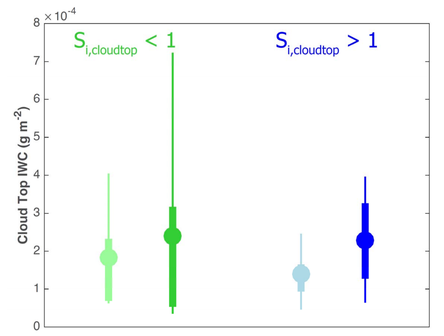
Climatology of Surface Aerosol Properties

- Extension of previous work by Quinn et al. (2002; 2009) using entire record of aerosol chemical, physical, and optical properties.
- The figure below shows the inter-monthly variations and relationships between all aerosol measurements at Barrow.



Evaluating the Impact of Atmospheric Dust on Cloud Ice

Here we combine information from NOAA filter samples with ARM remote sensors and NWS and ARM radiosondes to evaluate whether there is a noticeable increase in in-cloud ice amount for time periods with dust loading. Dust loading is based on the mass concentration of non-sea salt magnesium and non-sea salt calcium. Cloud top ice super saturation is determined using radiosonde data, and cloud top height and ice water content are derived from MMCR measurements. Cases are limited to those with cloud tops lower than 2 km and cloud top temperatures below 270 K. The distributions illustrate cases with no dust (lighter colors) and those with dust loading (darker colors), and are separated into times when the cloud top ice supersaturation was found to be lower than 1 and times when cloud top supersaturation exceeded 1. Next steps involve ensuring that all radiosonde measurements are dry-bias corrected and including the maximum in-cloud ice supersaturation instead of only the cloud-top value.



Summary

- The properties and sources of aerosols at the surface varied each month, indicating seasonally disparate aerosol impacts on surface radiation and cloud formation effects.
- **Winter/spring:** long-range transported submicron sea salt, mineral dust, industrial metals, pollution, and biomass burning, concurrent with higher concentrations of total submicron mass, number, and enhanced extinction
- **Summer:** relatively clean air, with influences from small, regionally-generated biogenic aerosols concurrent with availability of sunlight and open water.
- **Fall:** relatively clean air persists, but now with influences from regionally-generated supermicron sea salt, supporting the highest single scattering albedos.
- However, the seasonality of aerosols above the boundary layer is shifted, indicating different sources aloft versus at the ground.
- Preliminary results suggest cloud ice amount is potentially correlated to mineral dust observed at the surface under similar atmospheric conditions, although more work is needed.
- Results such as these could be used to constrain models by providing detailed information on the types of aerosols present in the Arctic.

References

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Acknowledgements

ASR Atmospheric System Research

This work was supported by the US Department of Energy, Atmospheric Systems Research (ASR) Program under award number DE-SC0013306.