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Trend analysis of aerosol particle physical properties at Villum Research Station, Northern Greenland

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Introduction

The Arctic region is particularly sensitive to global climate change, experiencing warming at twice the rate of the global average. Anthropogenic pollution (e.g. aerosols, black carbon, ozone, and greenhouse gases), which to a large extent originates from the mid-latitudes, is suspected to be partly responsible for this warming. Atmospheric aerosols can alter the planetary radiation balance directly through scattering and absorption and indirectly through modification of cloud properties. These interactions depend on aerosol physicochemical properties. The Arctic cryosphere and atmosphere has undergone significant changes in recent decades, accompanied by reductions in anthropogenic emissions, especially in Europe and North America. These changes have important ramifications for the ambient Arctic aerosol. Understanding the direction and magnitude of recent changes in the Arctic aerosol population is key to elucidating the implications for the changing Arctic, although this remains a scientific challenge. Here we report recent trends for aerosol particle physical properties, which will aid in this understanding of the changing Arctic.

Measurement Site & Methods

All measurements were obtained at Villum Research Station (Villum, N 81^{o}36′ W 16^{o}39′ 24 m a.s.l) in northeastern Greenland. Particle number size distributions (PNSD) were measured using a Scanning Mobility Particle Sizer (SMPS) from 2010–2018.

We have utilized mode fitting on daily averaged PNSDs to characterize three distinct modes (Nucleation, Aitken, and Accumulation) along with geometric mean diameters (GMD) and number concentrations (PN) for each mode.

The trends in these parameters were identified and quantified using the Mann-Kendal test and Theil Sen slope on the 90th % confidence interval. Trends in different months were analyzed using daily modal parameters.

Results

Statistically significant (s.s.) decreasing trends were detected for the Nucleation and Aitken modes GMDs in the winter, spring, and summer, with the only s.s. increasing trends occurring in the autumn. The Accumulation mode GMD showed a s.s. decrease in the spring and s.s. increase in

the summer. For the PN of each mode, large s.s. increasing trends were detected for Nucleation and Aitken mode PN in the spring and summer. The Accumulation mode PN showed a small s.s. increase in the summer and a large s.s. decrease in the autumn.

These results show that ultrafine modes (Nucleation and Aitken) are decreasing in diameter while simultaneously increasing in number concentration. These trends are most likely related to changes in sea ice extent, as previous research has indicated a negative correlation between new particle formation and sea ice extent. The decrease in Accumulation mode GMD in spring (during the peak of the Arctic Haze) is possibly related to decreases in anthropogenic emissions, while the increase PN during summer could signal an increase in primary biogenic aerosol emissions from the ocean surface. The large decrease in Accumulation mode PN during autumn requires further investigation.

This work will help confirm trends of other aerosol components observed at other High Arctic sites and can offer insight into the climatic implications (i.e., radiative balance and cloud properties) for a future Arctic climate.