A Characterization of Arctic Aerosols as Derived from Airborne Observations and their Influence on the Surface Radiation Budget

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Airborne campaign: PAMARCMiP

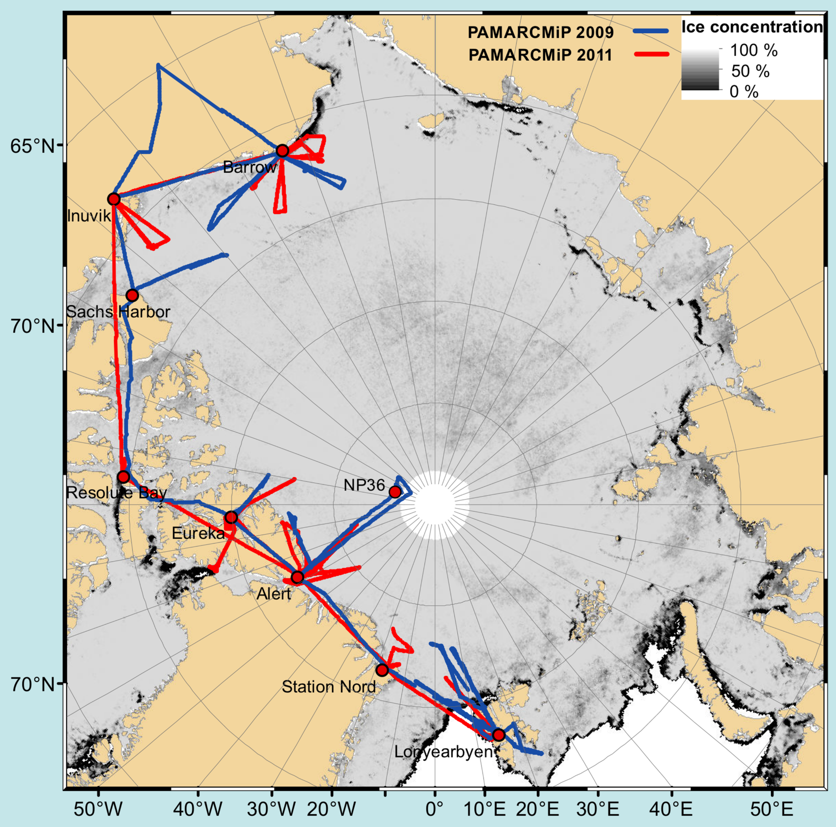
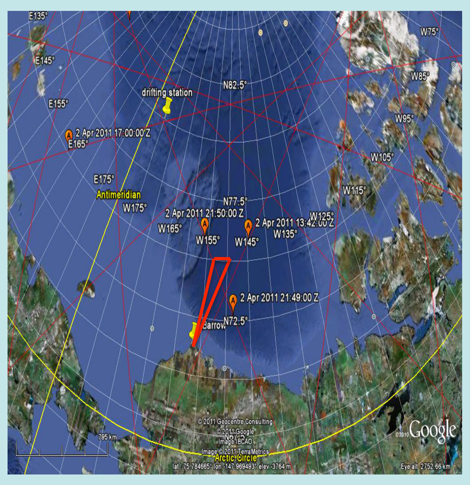


Figure 1: Flight Route of the POLAR-5 during PAMARCMiP 2009 (blue) and 2011 (red). The lines show tracks of ferry and science flights. Background shows here the sea-ice concentration from mid April from the AMSR-E satellite (Courtesy of G. Heygster, University of Bremen, Germany).

The Arctic is a key player in the climate system because of the strong modification of the surface energy budget through snow and ice cover, which is tightly coupled to the global circulation of the atmosphere and the ocean. AWI (Alfred Wegener Institute) initiated therefore together with EC (Environment Canada) a special airborne program, as the Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project (PAMARCMiP). The past two campaigns with POLAR 5 took place during April 2009 as well as April 2011. The Instrumentation, included a tethered electromagnetic (EM) sensor for sea ice thickness measurements [Haas et al, 2010], analyzers for ozone, gaseous elementary mercury, bromine monoxide, aerosol light scattering and aerosol light absorption and refractory black carbon, aerosol number concentration and aerosol size distribution, and aerosol optical depth (AOD). In addition, aerosol and ozone LIDAR were operated, and drop sondes were launched to characterize atmospheric state variables and to use it for combined LIDAR and aerosol data analysis [Hoffmann et al., 2012]. The traverses were completed within about a month, providing 3-D snapshots of aerosol, trace gases, atmospheric condition and sea ice thickness [Herber et al., 2011]. Participants from Germany (AWI, Jade HS, FIELAX) Canada (Environment Canada; University of Alberta; York University), Italy (ISAC Bologna), Russia (AARI St. Petersburg) and US (NOAA Boulder; NASA LaRC Hampton; Uuniversity of Alaska; NSF) conducted the surveys between Svalbard, Norway and Barrow, Alaska as indicated in the Figure 1.

Aerosol data set – April 2-3, 2011

During PAMARCMiP, many vertical profiles and extended horizontal transects were undertaken. The aerosol in-situ data indicated that the planetary boundary layer often contained high concentrations of aerosols, including black carbon. This gave rise to enhanced light extinction at low levels as derived from profiles of AOD and retrieved from the airborne LIDAR system [Stone et al., 2010, Lampert et al., 2012]. The Arctic atmosphere in 2011 was less perturbed, but on several occasions elevated layers of aerosols were observed. BC was observed at all levels sampled but at relatively low concentrations compared to historical values. Figure 2a-e exhibits an example for the science flight from Barrow on April 2, 2011. There are variations in the number concentrations, optical depth, aerosol scattering and absorption coefficients. The AOD profile shows a decrease in aerosols with increasing altitude.



Some aerosol measurements in 2011 were coordinated with CALIPSO satellite over-flights [http://www.nasa.gov/mission_pages/calipso/main], especially in Barrow, Inuvik, Eureka, Station Nord and Longyearbyen. Here you can find the science flight from April 2, 2011 with the related CALIPSO over flights. The analyses of the nineteen coordinated P5 flights is in progress.

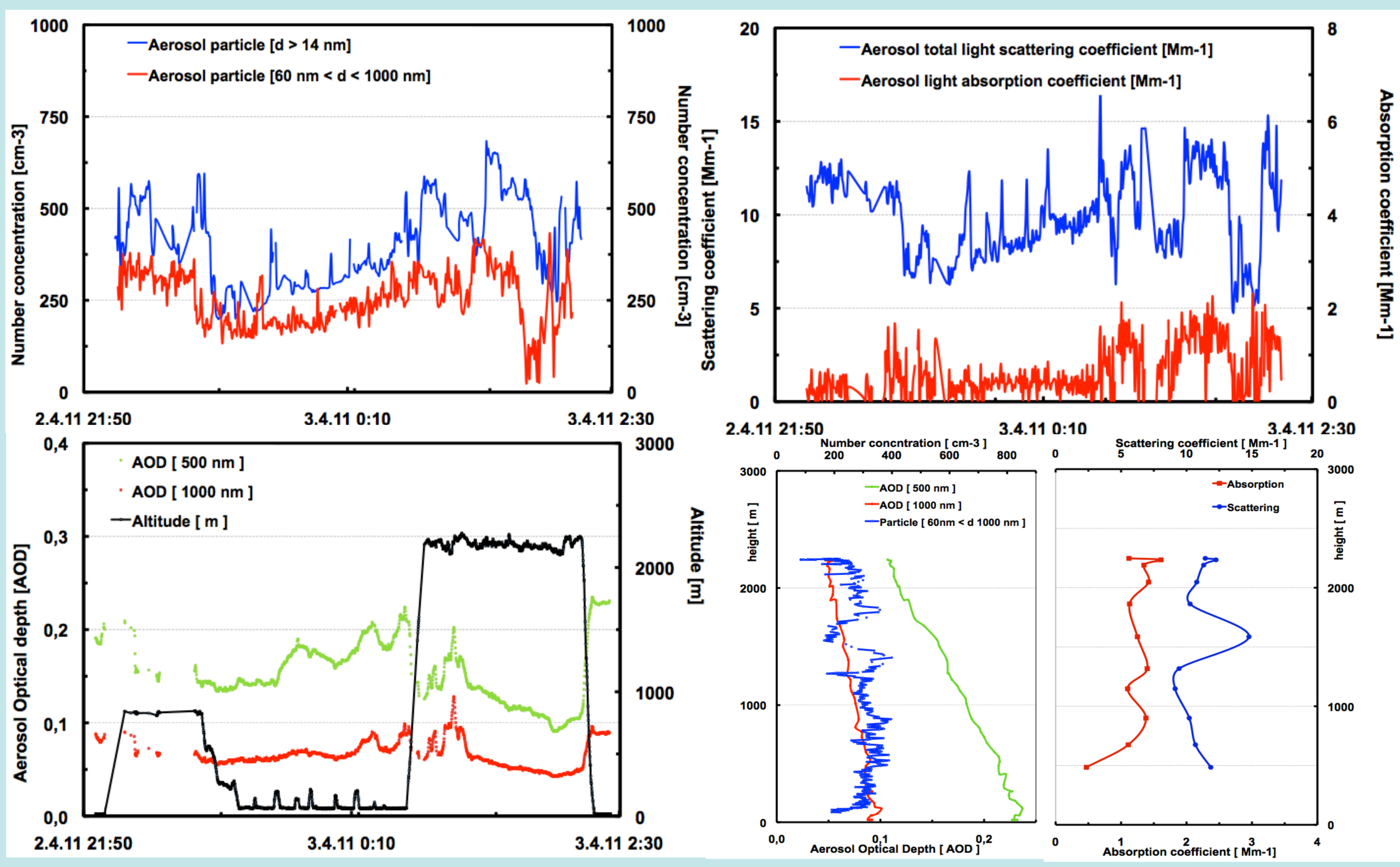


*Figure 2 a-e: Example of flight activity onApril 2, 2011 (*to refer to the flight track*) – long-range from Barrow up to 71.3° N - a) total aerosol number concentration from CN counter and from UHSAS spectrometer - b) Absorption and Scattering coefficient from CLAP and Nephelometer – c) Aerosol optical depth from SPTA airborne photometer and* altitude is shown on the right hand axis *– d) vertical distribution of AOD and number concentration from UHSAS – e) vertical distribution of Absorption and Scattering coefficient from CLAP and Nephelometer.*

Future activities / outlook

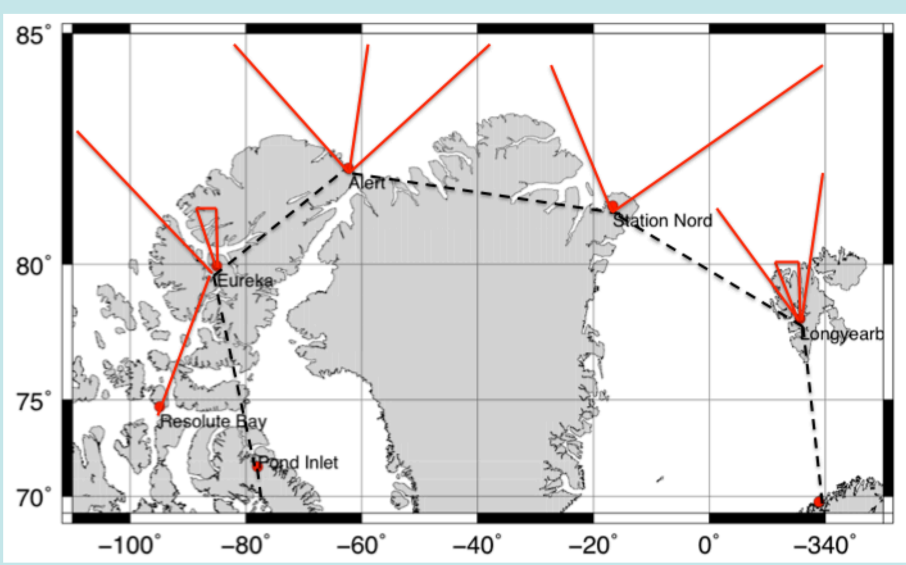


Figure 3: Route for PAMARCMIP 2012, with science flights between Longyearbyen and Eureka. The time window is from March 19, 2012 to April 10, 2012.

On the basis of two successful campaigns the plan is to undertake annual April missions in the next years to monitor inter-annual changes of surface and atmospheric properties at the time of sea ice maximum extent. April is also the period when atmospheric aerosols and trace gases show important, but poorly understood variations that influence the surface-atmosphere radiation balance. The further acquisition of aerosol and trace gas data (temporal and spatial variability) from the suite of instruments on board POLAR 5 will provide valuable data. The planned flight activity is shown in Figure 3.

Acknowledgements: PAMARCMiP was a success thanks to behind-the-scenes efforts by many individuals from the participating institutes and affiliates. Personnel at different ground stations across the Arctic provided for our needs. The highly demanding flying would not have been possible without the professionalism and commitment of the crew of EA I(Oshawa, ON, Canada) in 2009 as well as of the crew of KBAL (Calgary, AL, Canada) in 2011. We acknowledge John Ogren from NOAA for his help with the CLAP integration during 2011 campaign.

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