

# CHANGES IN AEROSOL PROPERTIES DURING SPRING-SUMMER PERIOD IN THE ARCTIC TROPOSPHERE

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## INTRODUCTION

The Arctic environment has become a focus of international scientific investigation during the last several decades as the potential delicacy of its climate system with respect to anthropogenic influence. Unlike many other regions there are only a few local human-derived sources of pollution. As a result, transport of aerosols and its gaseous precursors from industrialized mid-latitude regions in Europe, Asia, and North America are important and during springtime even dominating component of the Arctic aerosol budget. It is suspected that interactions among solar radiation, high albedo surface and the aerosol particles and clouds magnify the radiative impact of atmospheric aerosols. Thus, for a given aerosol distribution the specific optical impact is most likely increased in the high latitude regions.

Previous experiments conducted over the last 40 years have mainly focused on the Arctic Haze phenomenon that occurs during late winter and spring [e.g., Heintzenberg, 1989; Bodheine and Dutton, 1993]. Long-term ground-based measurements from Zeppelin station Ny-Ålesund, Svalbard and point Barrow, Canada show an annual variation with a clear transition between spring and summer for the chemical composition as well as physical properties of the Arctic aerosol [Quinn et al., 2002, Ström et al., 2003]. Remote sensing within the Stratospheric Aerosol and Gas Experiment SAGE II and SAGE III observed similar change between spring and summer for the optical properties of the Arctic aerosol in the upper free troposphere [Treffeisen et al., 2006].

The airborne field campaign ASTAR 2004 was therefore designed to study evolution of the aerosol physico-chemical and optical properties during transition between Arctic spring and summer periods. First results of this campaign showed that change in observed aerosol distribution from spring to summer conditions happened abruptly within period of a week, and was observed in boundary layer as well as in free troposphere. The consecutive analysis of the ground

based observations from Zeppelin station at Ny-Ålesund, Svalbard together with extensive air mass back trajectory analysis for Spitzbergen region covering period from year 2000 to 2005 shown that: 1) obtained results from the ASTAR 2004 intensive campaign are representative for the transition period, 2) abrupt change in atmospheric constituents distribution in the Arctic troposphere between spring and summer periods happens annually and it is most likely linked to a change in large scale circulation in the Arctic.

## DATABASE AND METHODS

During the ASTAR 2004 aerosol measurements was carried out on board of the Dornier 228 airplane covering altitudes from 50 m up to 7500 m in altitude and region of approximately 300 km around Longyearbyen airport. Observed aerosol number density, size distribution, covering range from 0.004  $\mu\text{m}$  up to 20  $\mu\text{m}$  and aerosol volatility properties were used in this study. More details about the campaign, instrumentation, measured parameters can be found at <http://www.awi-bremerhaven.de/www/pot/astar/public/astar2004.html>

Three-dimensional four and ten-day back trajectories provided by the Royal Netherlands Meteorological (KNMI) were used to study possible influence of the air mass origin and history on observed aerosol properties. The trajectories were calculated along the flight tracks of individual flights for ASTAR 2004 campaign, as well as once a day at several altitudes from 250 up to 8000 meter in a regular grid centered at Ny-Ålesund (78.9°N, 11.9°E) for period April – June during last 6 years (2000 – 2005). A statistical method was developed to investigate the temporal evolution of the air mass history and it has been used to detect exact time span when transition between Arctic spring and summer take place. The long-term measurements from the Zeppelin station, Ny-Ålesund (474 m a.s.l) were used to support the airborne observations as well as to evaluate temporal evolution

of the rapid spring-to-summer change on multi-annual basis. The Norwegian Institute for Air Research (NILU), and the Institute of Applied Environmental Research (Air Pollution Laboratory) (ITM), Stockholm University, provides the aerosol data from Zeppelin station.

## RESULTS

Aerosol microphysical measurements from the ASTAR 2004 campaign showed a clear change in aerosol loading between the first part of the campaign (late spring) and end of the campaign (early summer) for the whole vertical column up to 7 km altitude. To investigate and understand the mechanism behind the fast transition between spring and summer Arctic aerosol distribution we statistically analyzed the air mass history for the region of Ny-Ålesund for the time period from 2000 to 2005. We also connected these results to ground-based chemical aerosol data, trace gases and aerosol number concentration in order to demonstrate the quality of our statistical method.

We will present that the transition in aerosol properties observed in the tropospheric column in 2004 is reoccurring on annual basis and similar pattern can be observed in distribution of other atmospheric constituents and not only aerosols. The first preliminary results from the trajectory study suggest that the change over the vertical column in aerosol properties comes from a systematic change in air mass history. This in it self is perhaps not so surprising, but the fact that it appears to occur not only in the boundary layer gives new in-sight to mechanisms that might control particle formation and transformation in the Arctic atmosphere.

The significance of our results is that even though the Arctic summer atmosphere is among the cleanest, in terms of aerosol loading and other trace gases, anthropogenic pollution may still play an important role in controlling the summer time aerosol properties over a large vertical depth.

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**Keywords:** *Aerosol, Arctic, Troposphere*

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