Ny-Ålesund column thermodynamic structure, clouds, aerosols, trace gases & radiative effects

E02

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1. Summary

- Comprehensive atmospheric observations at supersite Ny-Ålesund (NYA, Svalbard)
- Synthesis of the complementary data sets for the analysis of Arctic amplification related processes from event-based to inter-annual time scales

Research questions

Q1 How do water vapor, clouds, aerosols, trace gases, precipitation,and associated radiative effects at Ny-Ålesund vary on intra- and interannual time scales?

Q2 How do circulation weather types, along with advection of airmasses from lower latitudes, modify these properties of the Ny-Ålesund column?

Q3 What is the impact of long-term changes and trends in circulation weather type characteristics on the past, recent and potential future development of the Ny-Ålesund atmospheric state?

Hypothesis

Signatures of Arctic amplification along with their dynamic and radiative effects can be revealed in the extensive observations of the Ny-Ålesund column.

Contributions to CCA3 and CCA4 & SQ1, SQ2 and SQ3

2. Achievements phase II

Instrument operation, retrieval development and application

- Continuous operation of remote sensing instruments (e.g. cloud radar, precipitation sensors, emission infrared Fourier transform spectrometer (FTS))
- New retrieval methods and operational products to characterize the NYA column

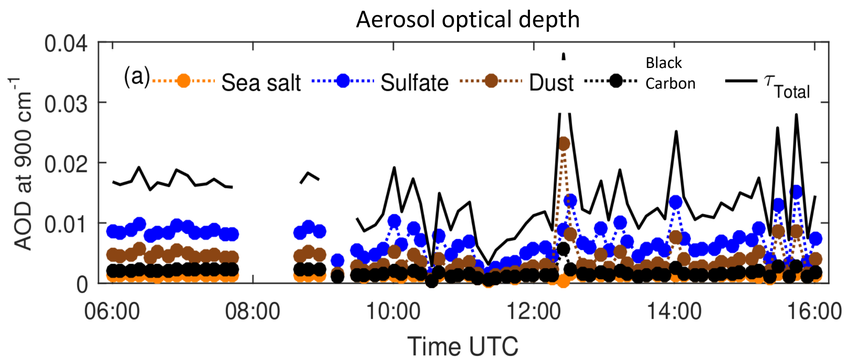


Fig. 1: Aerosol optical depth (AOD) and total AOD from emission FTS on 10 June 2020 at NYA.

Process understanding of clouds, water vapor, precipitation and radiative effect

- Characterization of low-level mixed-phase clouds & precipitation formation process
- Joint analysis of column observations with in-situ cloud and aerosol data
- Analysis of cloud radiative effect and of water vapor anomalies impacting clouds and their radiative effects at NYA

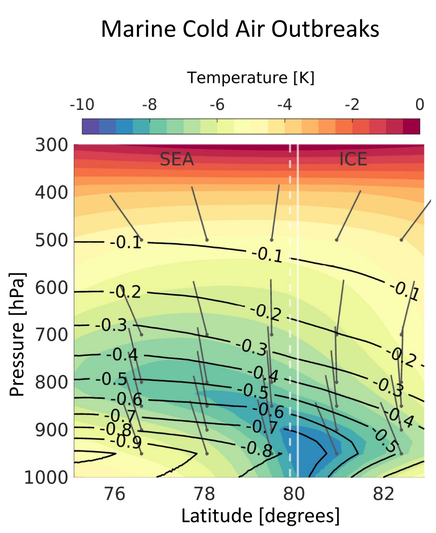


Fig. 2: 1991 – 2020 winter MCAO anomaly for temperature and specific humidity (contours, g/kg) at 6°E from CARRA reanalysis.

Process understanding on larger spatial scales

- Assessment of spatial and temporal variability of sea ice cover, surface meteorology and continentality of climate across Svalbard
- Analysis of marine cold air outbreaks (MCAOs) and their footprint in the NYA column, sea ice extent & surface fluxes

Synthesis of NYA observations and model & satellite data

- Analysis of NYA column obs. with local, high-resolution modeling
- Evaluation of limited-area model and reanalysis for moisture intrusion and associated precipitation patterns
- Assessment of water vapor and satellite cloud products in the Arctic
- Evaluation of satellite products and global maps for trace gases and aerosols

3. Research plan phase III

WP1 Continuous observations of thermodynamic state, clouds, radiation, precipitation, aerosols, and trace gases for process studies and modeling applications

- Extended data set of NYA column properties
  → study of inter- and intra-annual variability
- Relation of precipitation to thermodynamic and cloud conditions
- Long-term analysis of cloud radiative effect

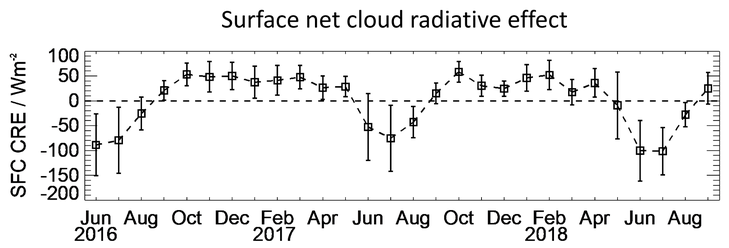
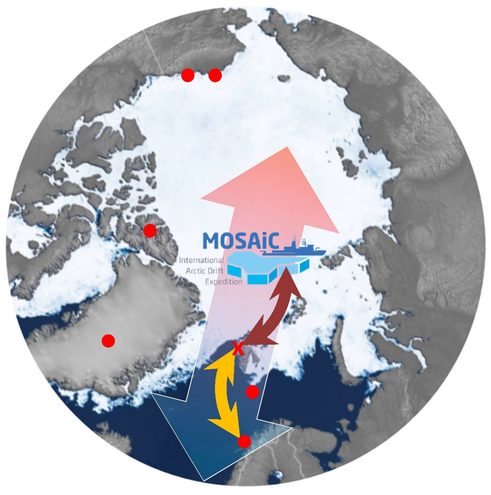


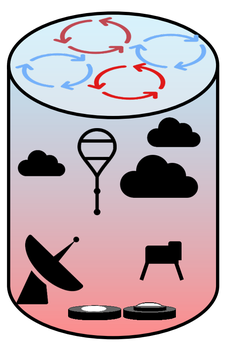
Fig. 3: Monthly mean surface net cloud radiative effect (CRE) at NYA. The error bars indicate the standard deviation of the daily mean values. Adapted from Ebell et al. (2020).

- Local spatial variability of clouds and water vapor
  → ICON-LEM (E03) & COMPEX/IOP4H2O campaigns

WP2 Linking NYA to the lower and central Arctic

- Dynamical transport and air mass transformation processes linking NYA with MOSAiC
- Impact of air mass transformations on atmospheric hydrological variables (with E04)
  → N-S transect Andenes-Bjørnøya-NYA
- Analysis of trace gas and aerosol measurements around the Arctic
- Stable water isotope measurements for airmass source attribution (with E06)





WP3 Attribution of NYA column properties to circulation weather types (CWTs)

- Systematic assessment of characteristic atmospheric CWTs (with D01) affecting the NYA column
- Derivation of statistical relations between NYA atmospheric state properties and CWTs
- Long-term variability and trends of CWTs and implications for NYA column

4. Legacy & Major expected results

Project Legacy

- High-quality data products for process studies and evaluation of model, reanalyses and satellite data (e.g. EarthCARE)
- Cloud data processing embedded in Aerosol, Clouds & Trace Gases Research Infrastructure (ACTRIS)
- Continuation of measurements of remote sensing instrumentation beyond (AC)³

Major expected results within phase III

- 10+ years of extensive observations of thermodynamic structure, clouds, aerosols, trace gases at NYA
- Integration of new retrieval methods for operational studies
- Quantitative assessment of Arctic amplification related processes in the NYA column, as well as their long-term variability and dependence on CWTs

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