Aerosol, Cirrus and Radiation

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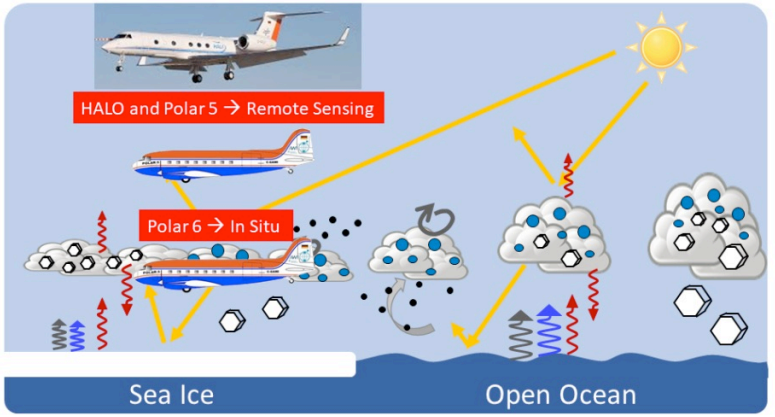
Activity during the HALO (AC)³ campaign (March - April 2022):

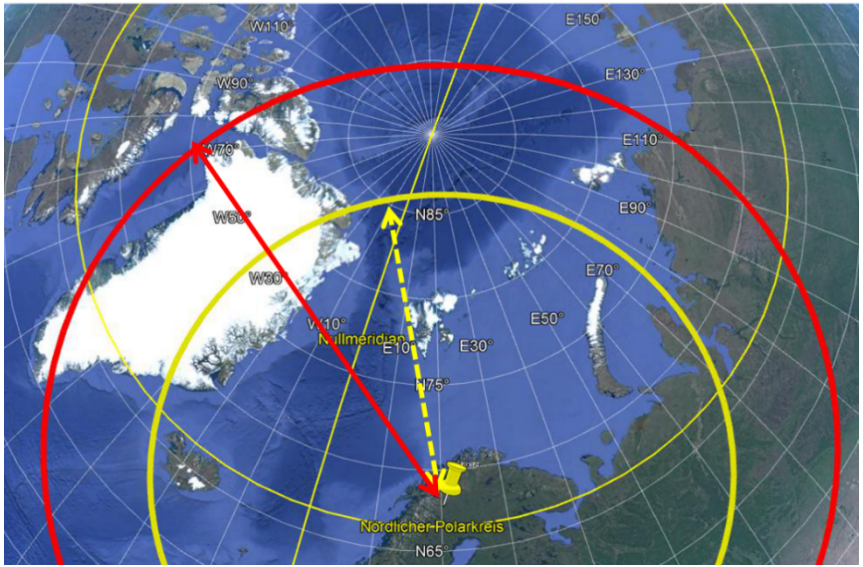
- **Operation of POLAR 5 & 6 from Longyearbyen**
- **Operation of HALO from Kiruna**
- **coordinated In-situ & remote sensing measurements**

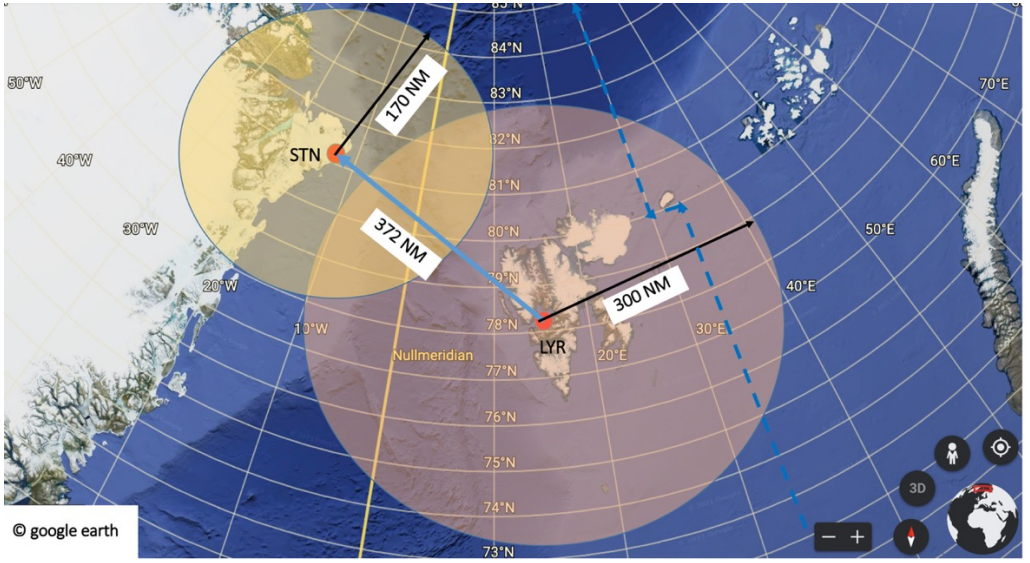


Operation area of HALO and P5/P6

max. range 3300 NM (10 km altitude, 400 kn)

realistic range including scientific flight pattern





Activity from our point of view

- Spatial distribution, Sources, and Cloud processing of Arctic Aerosol Particles

- Aerosol – Cloud Interaction

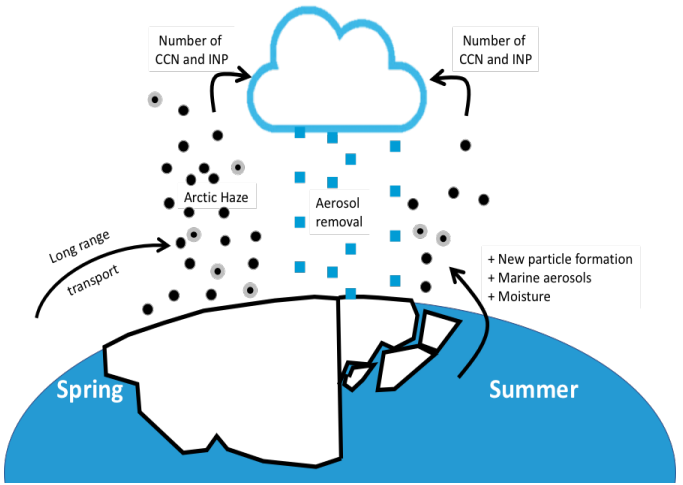
- Changes in ice cloud properties in the Arctic due to meridional transport of moisture

- Radiative Effects of Arctic cirrus

Spatial distribution, Sources, and Cloud processing of Arctic Aerosol Particles

Main scientific goals - Research questions

- What are the vertical and horizontal distribution, the physicochemical properties and sources of aerosols, CCN, INP, and BC.
- What is the link between INP and oceanic biology?
- How do clouds affect the vertical distribution and properties of aerosol particles, CCN, INP, and BC?



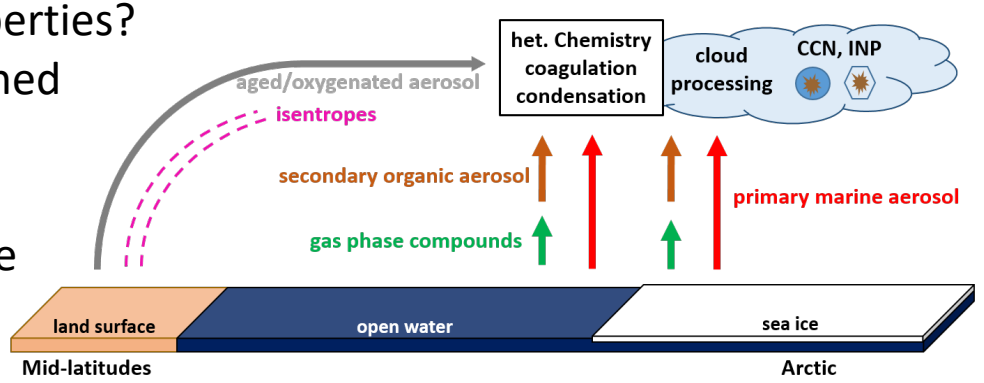
Specific Information on it

- **What measurement systems are necessary for this?**
  Aerosol number and size distribution, Filter Sampling for INP and chemical composition analysis, CCN concentration, BC mass concentration and size distribution, Single particle qualitative aerosol chemical composition
- **Are coordinated flight activities (HALO / P5 / P6) necessary?**
  For radiative properties of mixed-phase clouds remote sensing and in-Situ measurements are required
- **Are special flight patterns necessary?**
  Measurement below, above and in cloud. With the Counter-flow Virtual Impactor we will sample the cloud particle residuals inside clouds
- **What is expected from the modeling side (in both directions)?**
  Air mass trajectories, ECMWF / ICON weather prediction
- **What is the overlap or connection to the other topics?**
  -> Boundary Layer Processes (marine particle formation)
  -> Mixed-phase clouds (role of INPs, secondary ice formation)

Aerosol – Cloud Interaction

Main scientific goals - Research questions

- Sources and formation processes of marine aerosol particles in the Arctic (amines, sulfur compounds, sugars, etc…)
- Arctic marine particles: CCN and INP for Arctic cloud formation?
- Cloud processing → influence on CCN properties?
- Low level Arctic clouds: influenced/determined by particles from below (marine, sea ice, local pollution) or from above (long range transport)? ←→ Thermodynamic structure (coupled/decoupled)?



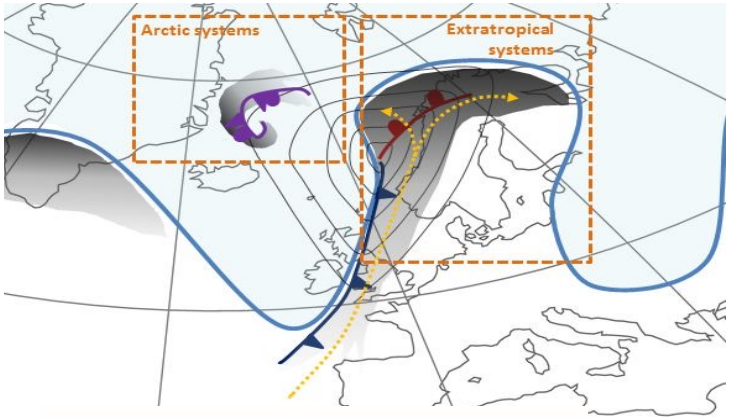
Specific Information on it

- **What measurement systems are necessary for this?**
  Aerosol and cloud residual composition, trace gases, cloud microphysics (ice water content)
- **Are coordinated flight activities (HALO / P5 / P6) necessary?**
  For radiative properties of mixed-phase clouds remote sensing measurements are required
- **Are special flight patterns necessary?**
  Flights crossing open water and sea ice, probing air below, in, and above cloud.
  No „sawtooth“ but short straight levels in cloud
- **What is expected from the modeling side (in both directions)?**
  Meteorology (trajectories, thermodynamic cloud structure
  Model calculation simulating marine particle formation (primary/secondary), transport to cloud height, and cloud activation
- **What is the overlap or connection to the other topics?**
  -> Boundary Layer Processes (marine particle formation)
  -> Mixed-phase clouds (role of INPs, secondary ice formation)

Changes in ice cloud properties in the Arctic due to meridional transport of moisture

Main scientific goals - Research questions:

- **What are the characteristics of air-masses in warm air intrusions, and how do they change during transition in the Arctic?**
  - → Measurements of the water vapor field (lidar) in the inflow region as well as during transport.
  - → Information on the overall amount of water vapor transported in the Arctic; focus on vertical structure and on vertical and horizontal dispersion during transport.
- **How does enhanced moist transport into the Arctic change the ice cloud optical and micro-physical properties; and thus, their impact on the radiation budget of the clouds?**
  - → Synergistic lidar and radar measurements provide information on cloud properties
  - → Cloud properties will be connected to the evolution mechanism and the surrounded water vapor field to investigate differences in the ice cloud properties due to enhanced water vapor.
  - → Derived ice cloud microphysics will be used as input for radiative transfer calculations



Specific Information on it

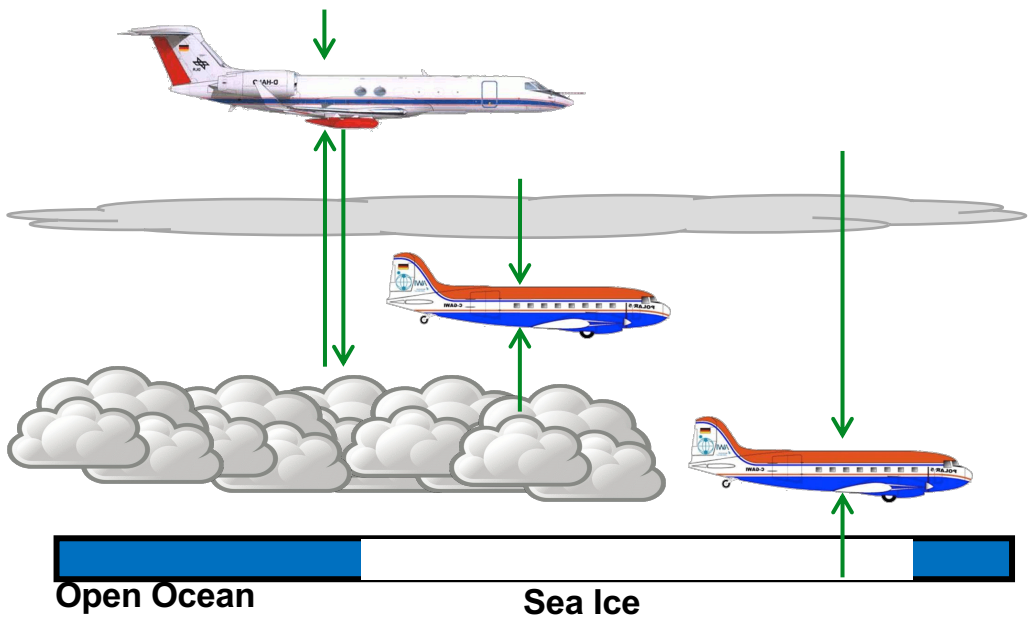
- **What measurement systems are necessary for this?**
  Lidar and radar measurements + SMART/specMACS (HALO), cloud microphysics (P5/P6) for single flights
- **Are coordinated flight activities (HALO / P5 / P6) necessary?**
  Coordinated flights of radar-lidar (HALO) and in-situ (P5/P6) would be welcome to validate retrieved ice cloud microphysical properties
- **Are special flight patterns necessary?**
  Flights along air mass trajectories (quasi Lagrangian) above cloud (with sufficient distance for lidar), flights crossing cloud systems (meridional transects after different steps of transport); for coordinated flights HALO/P5/P6 straight legs
- **What is expected from the modeling side (in both directions)?**
  Air mass trajectories, meteorology
- **What is the overlap or connection to the other topics?**
  Large scale transport (Arctic vs. extratropical air masses), mixed-phase clouds (icing conditions)

Radiative effect of Arctic Cirrus

Main scientific goals - Research questions

- Observations and representation in numerical weather prediction models (ECMWF IFS & ICON)
- Influence of the ice crystal properties
- Evaluation of the radiation scheme (ecRad)

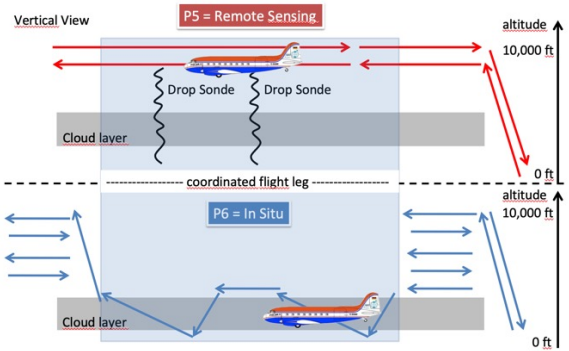
- Radiative energy budget above and below cirrus
  → Measured on all three aircraft, based on Remote sensing from above and below cirrus

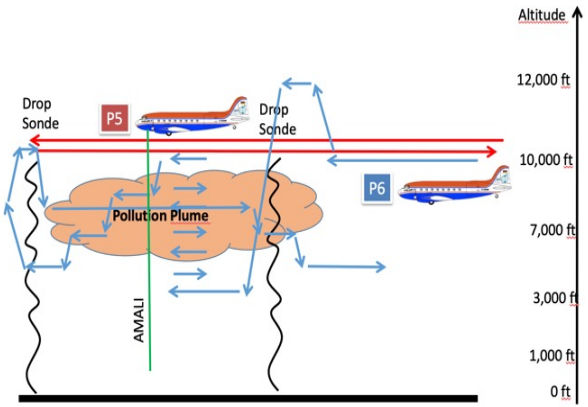


Specific Information on it

- **What measurement systems are necessary for this?**
  - Broadband irradiance – BACARDI + radiometer on P5/6,
  - Spectral irradiance/radiance – SMART/specMACs/VELOX (HALO, P5),
    – SMART, Sun photometer (P5)
- **Are coordinated flight activities (HALO / P5 / P6) necessary?**
  - Energy budget above (HALO) and below (P5/6) cirrus
  - radar-lidar (HALO) and in-situ (P5/P6) for ice cloud microphysical properties
- **Are special flight patterns necessary?**
  - Collocated flights: HALO above, P5 below cirrus but above low clouds, P6 below low clouds
- **What is expected from the modeling side (in both directions)?**
  - ECMWF / ICON weather prediction → input for ecRad
- **What is the overlap or connection to the other topics?**
  - Surface and low cloud properties influence on Cirrus radiative effects
  - Origin of cirrus - Large scale transport (Arctic vs. extratropical air masses)

Potential Flight pattern





Discussion tomorrow
24 November 2021