A06 Composition and Variability of UTLS refractory aerosol and ice-nucleating particles

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Motivation

There is limited understanding of the sources and composition of fine aerosols and ice-nucleating particles (INPs) at high altitudes.

- The composition of aerosols is poorly constrained, yielding an uncertain impact on radiation.
- There is a lack of knowledge about the contribution of INPs to cirrus cloud formation.
- There are emerging concerns about the impact of space debris-derived particles.
- The efficiency of transport pathways and contributions from the troposphere are understudied.

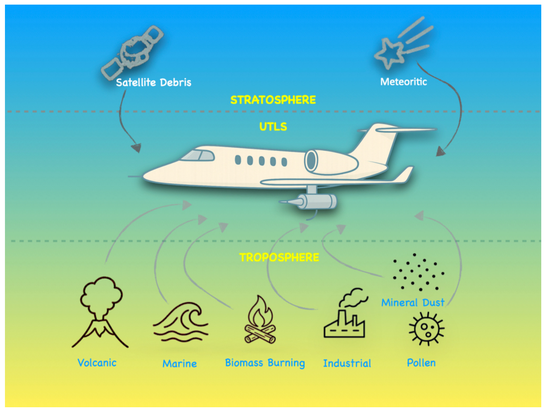


Figure 1: Sources of refractory UTLS particles.

Collaborations within TPChange

- **A04** Complementary analysis of refractory particles (in addition to the volatiles) from the same aerosol, yielding a more complete dataset.
- **A05** Joint sampling for HALO campaigns and parallel sampling for TPEx II provides complementary information on inorganic particles (in addition to the organic compounds).
- **B02** Sharing the analysis technique, delivery of a comparable result with different spatial information (sounding vs. flight, UTLS vs. boundary layer to stratosphere).
- **Z01** Using central infrastructure for joint INP experiments with A04 and A05.
- **Z02** Participation in TPEx II campaign and joint data use.
- **Z03** Using high-resolution trajectory information for interpretation of campaign results.

Results from phase I

Aerosol sampling for source apportionment

Development and deployment of three aerosol sampling devices (Fig. 2): a filter-based system for bulk aerosol sampling (SPAFiS), a thermophoretic sampler optimized for capturing ultrafine particles smaller than 100 nm (NanoPS) and a two-stage impactor designed for size-resolved aerosol collection (MultiMINI8).

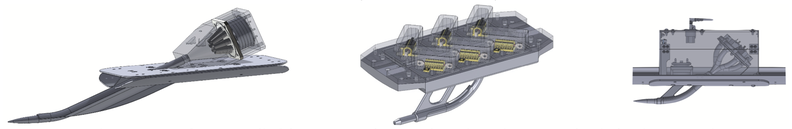
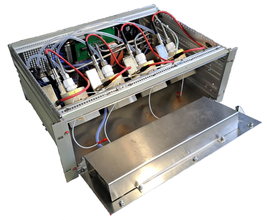


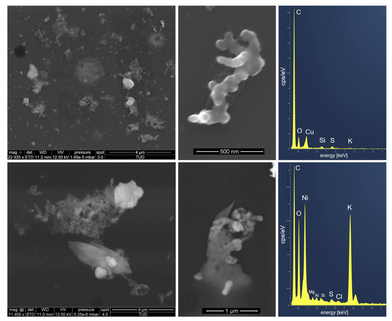
Figure 2: Schematics of SPAFiS (left), NanoPS (center) and MultiMINI8 (right). The samplers were built in the Wingpod of a LearJet during TPEx I.



Development and use of a new electrostatic aerosol collector version for airborne sampling and subsequent offline analysis to determine INP concentrations (FRIDGE) and physico-chemical properties of individual INPs (SEM-EDX).

Figure 3: electrostatic aerosol collector. Schneider et al., EGUsphere (AMT), 2024

Particles from Canadian wildfires over Europe



The presence of soot and K-rich biomass burning particles (Fig. 4) has been detected in the UTLS region over Europe. These particles originate from Canadian wildfires.

Joppe et al., EGUsphere (ACP), 2025

Figure 4: SEM images and EDX spectra of soot (upper row) and biomass burning particles (lower row) sampled during TPEx I with MultiMINI8 (17 June 2024).

Physico-chemical properties of ice-nucleating particles

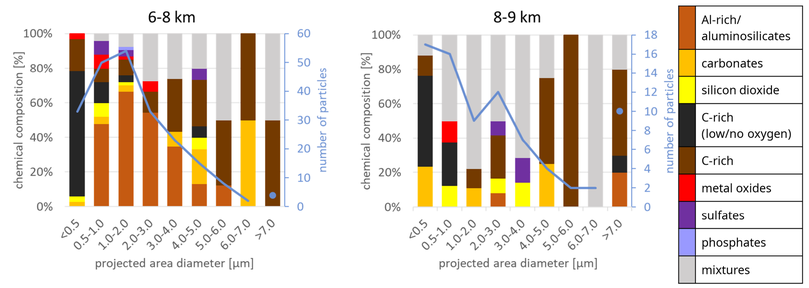


Figure 5: INP chemical composition and size distribution from different altitudes (sampled during TPEx I (11 June 2024), activated at -35°C).

Research plan phase II

Main goal: UTLS aerosol composition for source apportionment and transport process assessment with additional focus on INP composition and processing

Sampling

- TPEx II
  - Co-sampling of UTLS aerosols with phase I instruments
  - Minor instrument upgrades for higher accuracy
  - Collection of 200 samples (size range: few nm to 10 µm)
- HALO CONTANGO-FIRE
  - Joint use of HERA sampler (A05)
  - Ground test before deployment
  - Collection of 70 samples

Aerosol analysis by SEM-EDX

- TPEx II
  - Insight into midlatitude UTLS aerosol composition by well-characterized uplift processes
  - Systematic sources and transport assessment with detailed modelling (Z03)
- HALO CONTANGO-FIRE
  - Compositional characterization of large-scale fire-impacted atmosphere
- PHILEAS
  - 140 remaining samples from extratropical UTLS aerosol
  - Insight into sources of late-summer extratropical aerosol

INP observations

- TPEx II
  - Determination of INP activity with FRIDGE
  - SEM-EDX analysis of activated INPs
  - relative efficiency of different INP classes
  - relevance for the UTLS region
- Laboratory measurements with FRIDGE
  - Multiple INP activation cycles in acoustic levitator under simulated day/night cycles
  - SEM-EDX INP analysis provides insight into relevant INP modifications