B02 Cross-seasonal Investigation Regarding the Composition of atmospheric trace matter Up to UTLS heights (CIRCUS)

TP CHANGE

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Motivation

1) In the upper troposphere/lower stratosphere (UTLS):
   - **spacecraft-induced particles (SiPs)**: from re-entry [1] or propulsion [2]
   - **meteoric particles (MPs)** found ubiquitously in the LS [3, 4, 5]
2) In the troposphere:
   - **particles form via NPF** at various altitudes [6, 7, 8, 9], e.g. from organic precursors [10], and **partly reach the stratosphere** [11]

⇒ All these are spatially/temporally limited observations.

B02-II research objectives:
- **cross-seasonal survey** of the presence /proportion **of MPs & SiPs in the UTLS** compared to particles of tropospheric origin
- **linking** observed **NPF to vertical** (frontal) **uplift of precursors**
- **composition** and **formation/conversion in the troposphere**

Role within TPChange – collaborations

Common measurements and analyses: A04 A05 A06 B01
Data from B02 and exchange of information: B07 C01 C09 (N)
Model study on tropospheric NPF persistence/events' ages: A03
Data exchange with: B06 B08 C07 C08 (N)

Contribution to TPChange synthesis

Z03
- synergy of model efforts and tools
- aerosol and chemistry enabled ICON–MESSy
- suitability of new modelling systems for UTLS
- gravity wave modelling MS-GWaM

synthesis
- source/origin by backward-trajectories
- microphysics & composition box modelling
  ⇒ regional (MECO(n))
  ⇒ global scale (ICON/MESSy)
- removal/modifications during uplift
- effects of GW activity
- exchange at TP folds

B02
- trace material characterization from ground to UTLS
- cross-seasonal cycle of UTLS aerosol material
- tropospheric NPF detection
- thermodynamic characterization of the atmosphere

References:

[1] Murphy, D. M., et al., PNAS, 2023.
[2] Brown, T. F. M., et al., Earth Space Sci, 2024.
[3] Curtius, J., et al., ACP, 2005.
[4] Weigel, R., et al., ACP, 2014.
[5] Schneider, J., et al., ACP, 2021.
[6] Größ, J., et al., ACP, 2018.
[7] Crumeyrolle, S., et al., ACP, 2010.
[8] Weigel, R., et al., ACP, 2021.
[9] Williamson, C. J., et al., Nature, 2019.
[10] Curtius, J., et al., Nature, 2024.
[11] Ueyama, R., et al., GRL, 2025.
[12] Moormann, L., et al., AMT, 2025.
[13] Moormann, L., et al., in prep.
[14] Weigel, R., et al., EGU gen. assemb., 2025.
[15] Jost, S., et al., AMT in press, 2025.

Results from phase I

1) **Proof-of-concept:** developed assembly of ground-based (MoLa), airborne (UAS), and balloon-based measurements and collocated observations with HALO (Fig. 1, [12])
   ⇒ B02-II: prospect of balloon & HALO/Learjet rendezvous
2) **Meteoric particles** (magnesium-rich silicate with iron) sampled **in the UT** at 7.2-11.4 km altitude during the IOP 2024 (Fig. 2; [14])
   ⇒ B02-II: observational survey over 18 months
3) **Increased aerosol load** at site during frequently occurring **inflow from Frankfurt** (Fig. 3, [13])
   ⇒ B02-II: Spielberg is preferred location for IOP
4) **Physico-chemical properties of Saharan dust** over Europe [14]
   ⇒ soundings flexibly available on short-notice
5) **Improved accuracy of concentration measurements** of a balloon-borne optical particle counter (UCASS) [15]
   ⇒ crucial for UCASS application, e.g., in B02-II

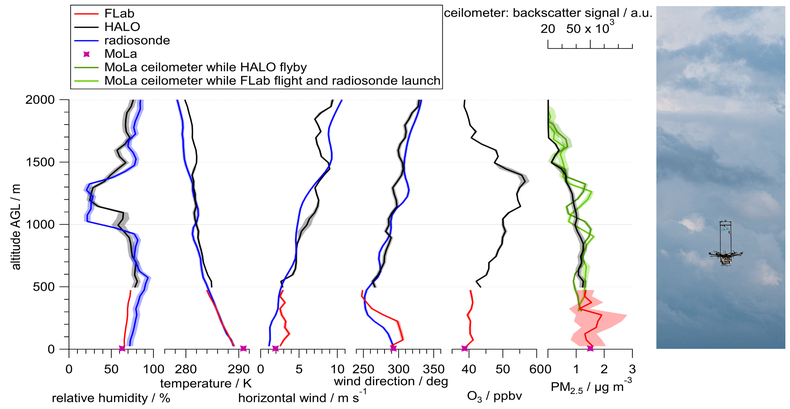

Fig. 1: Comparison of collocated observations during HALO flyover, IOP 2023.

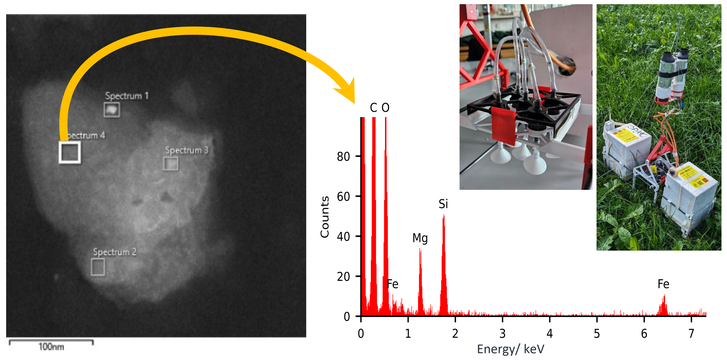

Fig. 2: Meteoric particle collected at about 7-11 km altitude, IOP 2024.

Research plan for phase II

First cross-seasonal survey of the proportion of MPs and SiPs in the UTLS in relationship to contributions lifted from the troposphere.

cross-seasonal view on MPs & SiPs in the UTLS

vertical (frontal) lifting of precursors & their formation/conversion from PBL to the UTLS

nano-particles: improved balloon-payload with Partector-2

18-month observational survey (Mainz) + **21 days IOP (Spielberg)**

- **RQ-C1:** temporal variability of trace gas and aerosol distributions on seasonal and multiannual time scales in the UTLS?
- **RQ-A2:** non-sulfur aerosol components (e.g. meteoric material, etc.): impact on aerosol properties and their effects in the UTLS?
- **RQ-B1:** small-scale microphysical processes and interactions with tropopause structure (from B02's continued *T*-, *RH*-, and O_3-profiling).
- **RQ-A3:** NPF in the UT? main source region for CCN in the extra-tropical lower troposphere?

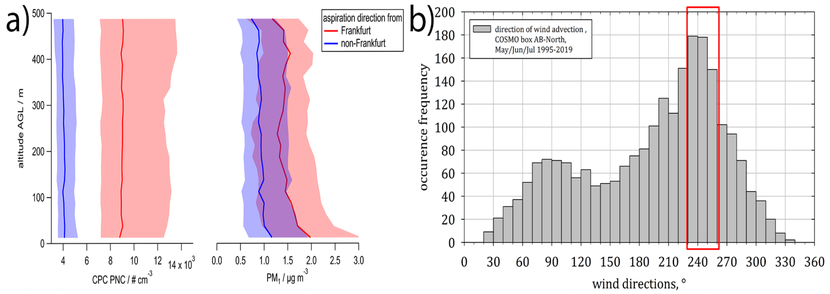

Fig. 3: Increased aerosol load at Spielberg launch site during inflow from Frankfurt (a) frequently occurring at this site during spring/summer (b, red frame).