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| Project: | **1262** |
| Project title: | **Impact of Aerosol on Cloud Microphysics, Phase Partitioning and Precipitation Formation** |
| Project lead: | **Dr. Fabian Senf (TROPOS)** |
| Allocation period: | **1.1.2026 - 31.12.2026** |

## Overview on the Project

The DKRZ user project bb1262 supported research work carried out within the DFG project PolarCAP, which was part of the DFG priority program PROM[1]. PolarCAP ended at the end of May 2026. Within this framework, intensive collaboration took place with remote sensing scientists at TROPOS and with researchers from ETH Zurich. ETH led the renowned ERC research project CLOUDLAB[2], in which experiments were conducted on supercooled liquid water clouds to improve understanding of ice formation processes. This work makes an important contribution to weather and climate research, as the uncertainty of ice and liquid water in clouds leads to large uncertainties in the prediction of precipitation and climate sensitivities. In the CLOUDLAB experiments, drones were flown into supercooled fog, where ice formation was triggered via the burning of silver iodide flares (Miller et al., 2024). Downstream of the ignited flares, the properties of the formed ice were studied using a variety of in-situ and remote sensing devices (Henneberger et al., 2023). In order to infer process rates from the observables and to derive implications for atmospheric modeling, detailed cloud simulations with the spectral bin model SPECS were carried out by TROPOS to accompany the campaign.

## Overview on Planned and Realized Resource Use

In the utilization period, three tasks were planned: task A with high-resolution COSMO-SPECS simulations for the CLOUDLAB MIP (25.6k node hours), task B with ICON-SPECS simulations (15.4k node hours), and task C with extended post-processing including forward operations with PAMTRA and plume tracking with tobac (2.0k node hours). The original total request of 43.0k node hours was reduced by 45% to an approved allocation of 23.6k node hours. During finalization of the project paper, part of the granted resources had to be redirected to rerun earlier COSMO-SPECS plume seeding experiments. The reruns were required to output additional, spectrally resolved microphysical process diagnostics, enabling analysis of conversion rates such as immersion freezing, depositional growth, and riming. The project bb1262 had again six actively contributing members in 2026 of which 66% were Early Career Scientists. At the time of reporting, 19.2k node hours had been utilized, of which 8.2k node hours (42%) had expired.

## Results Achieved in the Reporting Period

The main production work in 2026 shifted from additional case expansion to targeted reruns of the 25 January 2023 CLOUDLAB plume-seeding simulations with COSMO-SPECS. These reruns were required during finalization of the project paper and were extended to output an advanced set of spectrally resolved microphysical diagnostics. In particular, the new output now allows process-wise analysis of conversion rates along the seeded plume pathway, including immersion freezing, depositional growth, and riming, together with consistent diagnostics of liquid and frozen condensate evolution

[1] https://gepris.dfg.de/gepris/projekt/359922472?language=en
[2] https://cloudlab.ethz.ch/

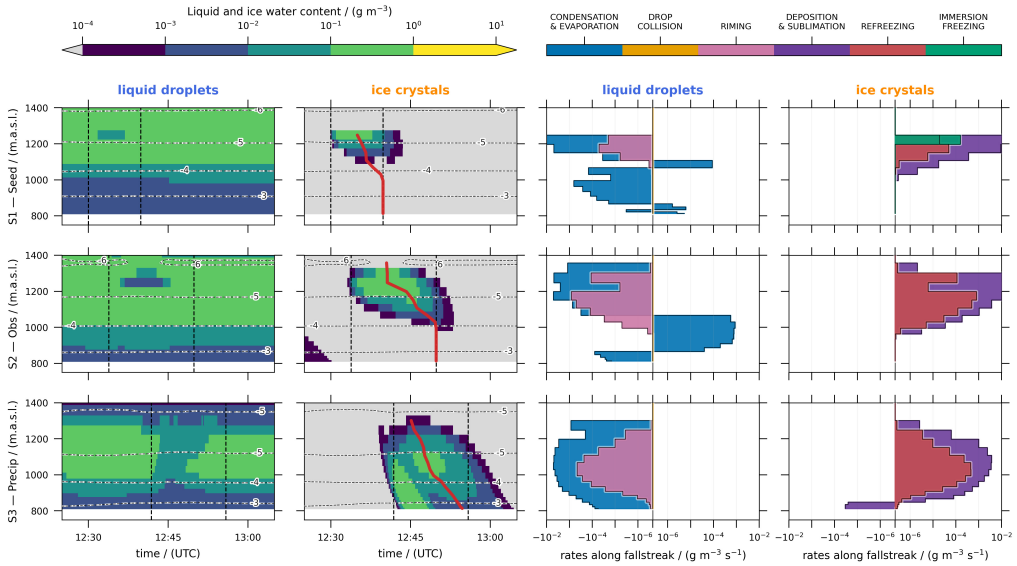



Figure 1: Time–height liquid water content (left) and frozen water content (second column) at S1 (flare), S2 (Eriswil), and S3 (downwind) for the 400-COL-S10 simulation, with ridge-sampled liquid and ice mass tendencies by SPECS process (right two columns; g m$^{-3}$ s$^{-1}$, symmetric-log axis). Dashed lines mark the station analysis windows, dotted contours indicate isotherms (°C), and the red curve marks the diagnosed ice ridge (column fallstreak). The figure illustrates the downwind transition from nucleation near the flare to depositional growth and sedimentation toward Eriswil and the downstream column.

at high temporal resolution. The rerun strategy was complemented by further development of the post-processing chain, including robust extraction of meteogram-based station columns and process-tendency diagnostics for flare, observational site, and downwind locations. This workflow enabled us to interpret the observed quantities in terms of the underlying simulated microphysical process rates.

Figure 1 summarizes this updated analysis for the reference ensemble member 400-COL-S10 (400 m horizontal grid spacing, columnar ice-habit setting, and AgI source strength of 10 particles cm$^{-3}$ s$^{-1}$) and documents the downwind process chain from S1 (flare) to S2 (Eriswil) and S3 (downwind column). The time-height panels show how the seeded ice signal forms near the flare, is advected toward Eriswil, and descends while frozen mass increases and liquid mass decreases along the diagnosed ice ridge. The process-tendency panels further indicate that immersion freezing initiates the perturbation close to the source region, while depositional growth dominates the subsequent ice-mass increase and riming contributes further downstream. The new analysis from our reruns therefore provides the central link between the highly resolved and quantitatively robust microphysical diagnostics and the physical interpretation used in our final manuscript. Overall, the 2026 reporting period delivered a substantially improved analysis basis for publication, despite reduced resources and the fact that further planned experiment extensions could not be executed.

## References

Henneberger, J., and Coauthors, 2023: Seeding of supercooled low stratus clouds with a uav to study microphysical ice processes - an introduction to the cloudlab project. *Bull. Amer. Meteor. Soc.*, doi:https://doi.org/10.1175/BAMS-D-22-0178.1.

Miller, A. J., and Coauthors, 2024: Two new multirotor uncrewed aerial vehicles (uavs) for glaciogenic cloud seeding and aerosol measurements within the cloudlab project. *Atmospheric Measurement Techniques*, **17 (2)**, 601–625, doi:10.5194/amt-17-601-2024, URL https://amt.copernicus.org/articles/17/601/2024/.