Project: **1036**
Project title: **ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms, (AC)³ – University of Leipzig contribution**
Principal investigator: **Johannes Quaas**
Report period: **2024-11-01 to 2025-10-31**

This project is about four sub-projects in which Leipzig University contributes to the (AC)³ collaborative research project.

D01: no contributions in reporting period.

D02: Recent studies suggested that air-mass intrusions bring large amounts of moisture and also aerosols into the Arctic, significantly impacting clouds and the Arctic climate system. Atmospheric Rivers (ARs) / Aerosol Atmospheric Rivers (AAR) are long narrow structures that carry an anomalously large amount of water vapor/aerosols across vast distances. We have utilized an atmospheric river detection algorithm to identify and analyze extreme aerosol and moisture transport events from mid-latitudes to the Arctic over a 43 year period. By examining the combined effects of aerosol and moisture intrusions, we aim to understand how the presence of aerosols alter the cloud properties compared to scenarios with only moisture. In order to evaluate the cloud properties, we used the active remote sensing product DARDAR-Nice dataset (Fig. 1), making use of DKRZ for data analysis.
The PhD thesis by Iris Papakonstantinou-Presvelou, building on the work in D02, was submitted and successfully defended in the reporting period (Papakonstantinou-Presvelou, 2025).

In D04, we conducted new FESOM2 simulations using the TRAC mesh (1.96M surface nodes, 4.5-60 km resolution) on DKRZ resources. The goal was to test a new methodology to simulate the atmospheric-equivalent partial pressures of CFCs and SF6 in the ocean directly, instead of mass concentrations (mol m^{-3}). In addition, the simulations aim to diagnose the cold halocline layer (CHL) thickness and occurrence frequencies following the method of Metzner and Salzmann (2023).
Current analyses focus on tracer-derived mean water ages and mixing indicators to quantify how ocean circulation regulates the redistribution of heat in the Arctic Ocean, as well as the trends in horizontal and vertical heat transport during Arctic amplification. The work combines FESOM2 output with observational tracer datasets and model results from CMIP6–OMIP-II to evaluate Arctic Ocean ventilation and mixing processes.

Project E01 is interested in the changing role of convection for Arctic amplification, but currently analyses available CMIP6 data.

In E06, we continued the test simulations using water isotopes as part of the ICON atmospheric model were conducted in collaboration with colleagues from FU Berlin (Stephan Pfahl et al.) and KIT (Roland Ruhnke et al.). The comparison to reference simulations improved, but issues are not yet fully solved.

References

Metzner, E. P. and Salzmann, M.: Technical note: Determining Arctic Ocean halocline and cold halostad depths based on vertical stability, Ocean Sci., 19, 1453–1464, https://doi.org/10.5194/os-19-1453-2023, 2023.

Papakonstantinou Presvelou, I., Impact of sea ice vs. ocean on Arctic mixed-phase clouds, PhD dissertation, Leipzig University, Faculty of Physics and Earth System Sciences, 91 pp., 2025.

Figures

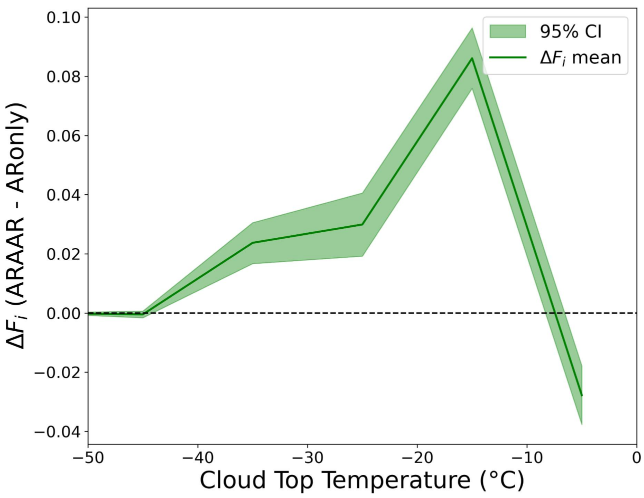

Fig. 1 Fraction of ice clouds vs. all clouds (F_i) as difference between aerosol-atmospheric rivers (ARAAR) and atmospheric rivers without specific aerosol transport (Aronly) as a function of cloud top temperature. The result is an indication of anomalous cloud glaciation in ARAAR, suggesting the conclusion that the aerosols serve as ice nucleating particles.