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: **2022-11-01 to 2023-10-31**

D01 is interested in dynamical contributions to Arctic amplification. In the reporting period, we conducted UA-ICON simulations. Data analysis focused on wave effects on the polar stratosphere (Karami et al., 2023)., as part of the AC3 investigations on coupling of middle and high latitudes in winter. The simulation data has been saved for further analysis. The climatologies of the stratopause height and temperature in the UA-ICON model were examined by comparing them to 17-years (2005–2021) of Microwave Limb Sounder (MLS) observations. In addition, the elevated stratopause (ES) event occurrence, their main characteristics, and driving mechanisms in the UA-ICON model are examined using three 30-year time-slice experiments. While UA-ICON reasonably simulates the large-scale stratopause properties similar to MLS observations, at polar latitudes in the Southern Hemisphere the stratopause is ∼8 K warmer and ∼3 km higher than observed. A time lag of about two months also exists in the occurrence of the tropical semiannual oscillation of the stratopause compared to the observations. ES events occur in ∼20% of the boreal winters, after major sudden stratospheric warmings (SSWs). Compared to the SSWs not followed by ES events (SSW-only), the ES events are associated with the persistent tropospheric forcing and prolonged anomalies of the stratospheric jet. Our modeling results suggest that the contributions of both gravity waves (GWs) and resolved waves are important in explaining the enhanced residual circulation following ES events compared to the SSW-only events but their contributions vary through the lifetime of ES events. We emphasize the role of the resolved wave drag in the ES formation as in the sensitivity test when the non-orographic GW drag is absent, the anomalously enhanced resolved wave forcing in the mesosphere gives rise to the formation of the elevated stratopause at about 85 km.

In project D02, we were interested in the role of cloud condensation nuclei (CCN) and ice nucleating particles (INP) on clouds in the Arctic. Trends in CCN and INP, due to remote or local sources, may lead to changes in the Arctic energy budget and thus modulate Arctic amplification. As already reported last year, in light of the observations-based studies from this project (Papakonstantinou-Presvelou et al., 2022), we decided to shift our method from the originally-planned ICON-HAM global (GCM) simulations to regional simulations with the kilometre-resolution ICON-NWP model (following also earlier experience, Kretzschmar et al., 2020).
In the reporting period, sensitivity simulations were carried out. These varied all relevant processes for ice crystal number concentrations. This included not only the ice nucleating particle concentrations (INP), i.e. heterogeneous nucleation, but also homogeneous nucleation and droplet freezing, as well as the sink processes and “articifial” processes such as sanity checks (finite ice number at ice mass > 0 etc.). So far, the results remained inconclusive, so that more work is required to draw valid conclusions.
For evaluation using aircraft observations, we further simulated a warm air intrusion in the Arctic, that was observed during the HALO-AC3 campaign on 12 March 2022. A result is shown in Fig. 1.

References

Karami, K., Borchert, S., Eichinger, R., Jacobi, C., Kuchar, A., Mehrdad, S., Pisoft, P. and Sacha, P., The climatology of elevated stratopause events in the UA-ICON model and the contribution of gravity waves. J. Geophys. Res. Atmos., 28, e2022JD037907, doi:10.1029/2022JD037907, 2023

Kretzschmar, J., J. Stapf, D. Klocke, M. Wendisch, and J. Quaas, Employing airborne radiation and cloud microphysics observations to improve cloud representation in ICON at kilometer-scale resolution in the Arctic, Atmos. Chem. Phys., 20, 13145-13165, doi:10.5194/acp-20-13145-2020, 2020.

Papakonstantinou-Presvelou, I., O. Sourdeval, and J. Quaas, Strong ocean/sea-ice contrasts observed in satellite-derived ice crystal number concentrations in Arctic ice boundary-layer clouds, Geophys. Res. Lett., 49, e2022GL098207, doi:10.1029/2022GL098207, 2022.

Figures

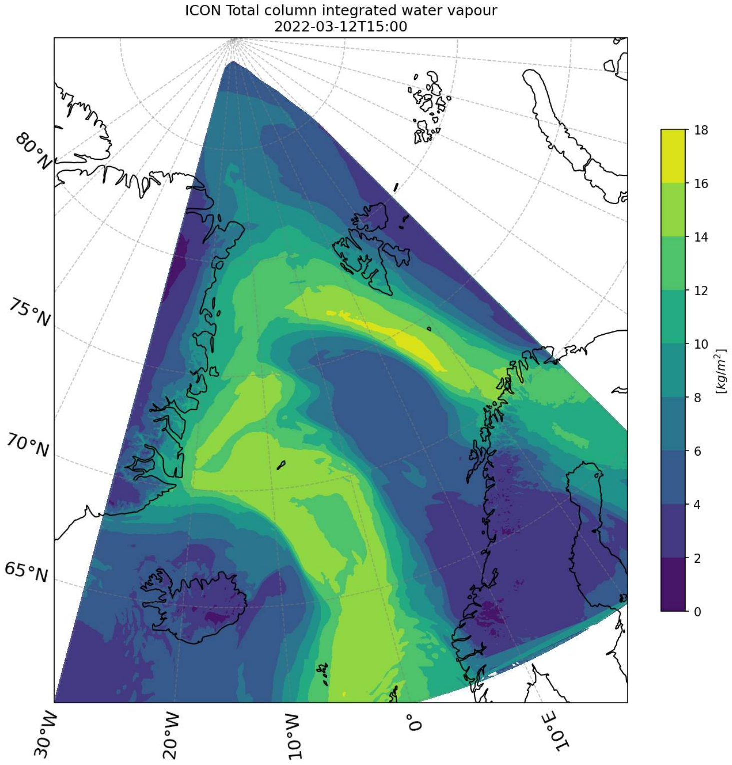

Fig. 1 Precipitable water (column water vapour, kg m^{-2}) from the ICON simulation for comparison to HALO-(AC)³ aircraft data. The interesting weather situatoin is a warm-air intrusion (visible through the moist air advected into the Arctic).