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Investigating seasonal and regional distribution of Arctic snowfall in regional climate model simulations: The model-to-observation approach

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Globally, precipitation acts as a significant coupling between Earth's water, energy and biogeochemical cycles. In the Arctic, snowfall by accumulating on sea ice affects its seasonal growth and decay, it contributes to the freshwater input into the ocean and modulates the surface albedo. To understand the seasonal dependent regional patterns of snowfall and to quantify the snowfall to total precipitation ratio, both comprehensive observations or rigorous modeling simulations are required. Bearing in mind the challenges to capture snowfalls with representative scales both in models and observations, we aim to investigate this in the Transregional Collaborative Research Centre – Arctic Amplification: Climate Relevant Atmospheric and Surface Processes and Feedback Mechanisms (AC)3.

In this study we evaluate how a state-of-the-art regional climate model (RCM) represents the seasonal and regional distribution of Arctic snowfall when compared to satellite observations. The utilized RCM is HIRHAM5, based on the High Resolution Limited Area Model (HIRLAM7, Unden et al. 2002) and the physical parameterizations of the atmospheric general circulation model (ECHAM5, Roeckner et al., 2003). For the satellite observations we employed the cloud radar observations (Cloud Profiling Radar, Stephens et al. 2002) by CloudSat, which provides nearly global coverage by a 16-day repeat cycle from 82°S to 82°N. The studied time period is between years 2006-2010. The Arctic region is divided to 10 different areas, covering the 66°-70° and >70° latitude rings and sectors of Nordic Sea, Russia, Chukchi Sea, Beaufort Sea and Baffin Sea.

We use the 3-hour HIRHAM5 output of the mixing ratios of hydrometeors, cloud ice and water, snow, and rain, at a horizontal resolution of ca. 0.25° (ca. 27 km) and 40 vertical levels. The mixing ratios are interpreted to particle size distributions and microphysical properties of the hydrometeors for the forward-simulator PAMTRA (Passive and Active Microwave TRAnsfer, https://github.com/igmk/pamtra) and the radar reflectivity is computed for the comparison with the satellite-observed reflectivity. Studying the CFADs (Contoured Frequency by Altitude Diagram) of CloudSat reflectivity, no significant regional differences are observed. Generally the lower height of the clouds and stronger reflectivity values closer to surface can be distinguished for the continental regions of Russia compared to oceanic regions. During winter months (DJF) increased reflectivity values are observed close to zero degrees Celsius in all the regions indicating the increased presence of snowfalls. We will present more detailed analysis of the regional differences between observed and modeled reflectivity distributions discussing also the seasonal behavior and importance of microphysical parametrizations.

Unden et al. (2002): HIRLAM-5 Scientific Documentation.
Roeckner et al. (2003): The atmospheric general circulation model ECHAM 5. Part 1. Model description. Report no.349, Max-Planck-Institute for Meteorology
Stephens et al. (2002): The CloudSat mission and the A-Train, BAMS, 83, 1771-1790.