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Impact of Atmospheric Rivers on Arctic climate: techniques for a better quantification of precipitation

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The Arctic has been experiencing significant warming and moistening with several potential factors at play. In general, the warming amplifies the Arctic hydrological cycle. There are two processes which could affect the water vapour content in the Arctic. These are the enhanced local evaporation due to the missing insulation effect of sea ice and the poleward moisture transport from lower latitudes. This poleward moisture transport is often associated with Atmospheric Rivers (ARs). Both processes could affect precipitation amounts and properties in the Arctic.

Snowfall and rainfall are critical components in the Arctic climate system. They influence the atmospheric thermodynamic due to phase changes and the surface characteristics like snow depth, mass balance and albedo. Snowfall has different effects over land and ocean. Over land it increases the albedo. However, over the ocean, snow enhances the thermal insulation which reduces the sea ice growth in winter. In contrast, rain on sea ice decreases the albedo and is related to sea ice melting. Recent studies have shown that an increase of precipitation have been observed over the last decades. Furthermore, the warming in the Arctic leads to a phase change with the consequence that the dominant type of precipitation is rain. Nowadays, it is still a challenge to quantify the frequency and type of precipitation in the Arctic due to the sparse observations in the Arctic – especially over the ocean and sea ice.

In this study, we analyse the relationship between the poleward moisture transport by ARs and the precipitation in the Arctic. For this purpose, we use comprehensive measurement campaigns conducted at Svalbard (ACLOUD May/June 2017, AFLUX March/April 2019) and analyse in detail several AR events.

For the detection of ARs, existing AR catalogues from global and polar-specific algorithms with the input of reanalyses data are used. For analysing the type and frequency of precipitation for the detected AR events, we analyse multiple parameters such as precipitation intensity and phase, particle number and size distribution, the liquid and total water content, the brightness temperature, and the radar reflectivity factor from different observational and model datasets (ERA5 reanalysis, satellite, in-situ measurements by research aircraft POLAR6, ground-based remote sensing measurements). To compare reanalysis with observational data, we apply the Passive and Active Microwave radiative TRAnsfer (PAMTRA) model. PAMTRA allows to calculate the brightness temperature as well as the radar reflectivity factor for different microphysics precipitation schemes. Furthermore, the radar reflectivity factor gives information about the vertical profile of hydrometeors and thus on the transition from snow to rain.

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