Present Temperature, Precipitation and Rain-on-Snow Climate in Svalbard

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Abstract

The Svalbard Archipelago has undergone rapid warming in the recent decades leading to warmer and wetter winter conditions. This study relates the present (2013-2018) 2m temperature, precipitation and rain-on-snow (ROS) climate in Svalbard to different atmospheric circulation (AC) types utilizing the high resolution numerical weather prediction model AROME-Arctic. We find that the 2m median temperatures vary most across AC types in winter and spring and in summer they vary the least. In all seasons the 10th percentile 2m temperatures are above 0 °C with southwesterly AC types over Svalbard. In comparison, the relationship between AC type and precipitation varies more spatially, with most accumulated precipitation and highest median precipitation intensities with onshore flow over open water. Our results suggest that sea ice explains a large part of the local variability in both 2m temperature and precipitation. In the studied period ROS is a frequent phenomenon below 150 m above sea level (ASL) on land, with most events in the southwestern parts of the archipelago (57 cases during 5 winter seasons). ROS events in winter occur predominantly with AC types from the southerly sector or during a low pressure center/trough passage. The southwesterly cyclonic AC type, with a low pressure center west of Svalbard, is the most frequent AC type for ROS events. In addition to being the most frequent, the southwesterly AC has the largest spatial coverage of ROS.

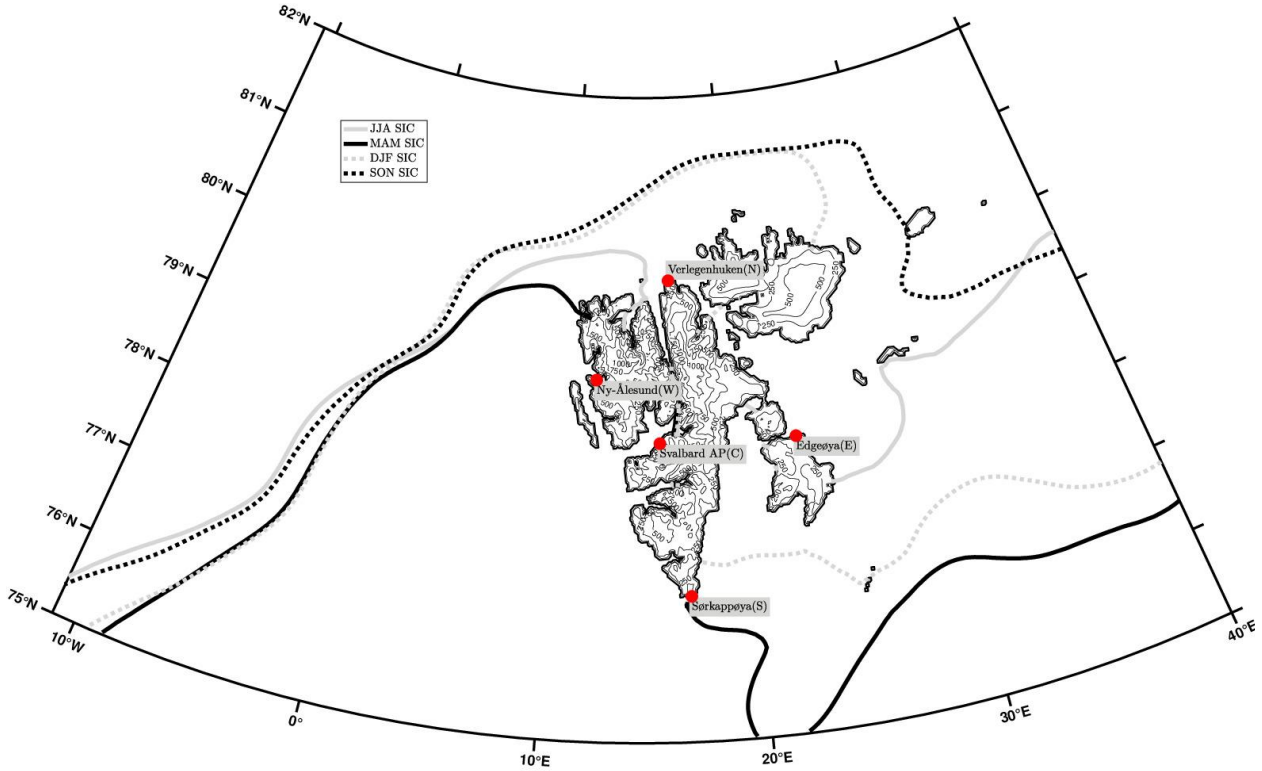

Figure 1. The Svalbard archipelago with the five AWS sites and the mean seasonal sea ice edge (15% concentration) for summer (JJA), spring (MAM), winter (DJF) and autumn (SON) for the years 2013-2018. Svalbard AP refers to the Svalbard Airport station.

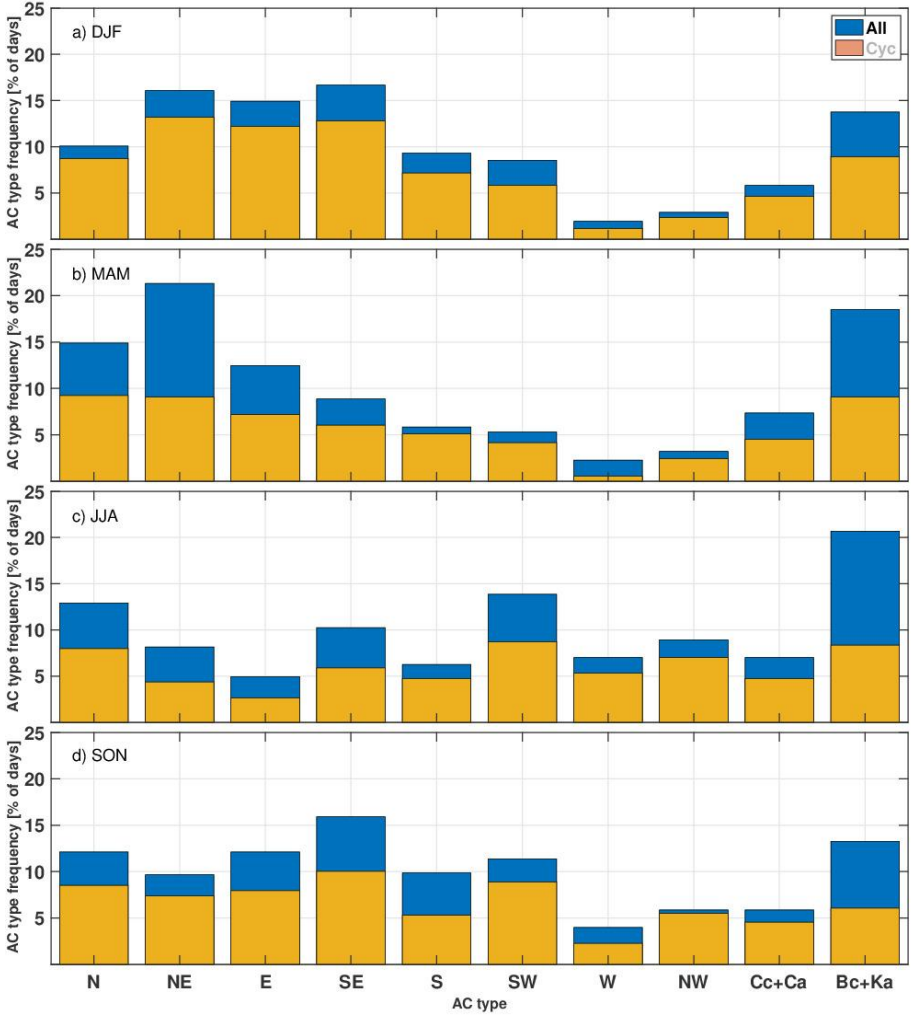

Figure 2. Seasonal atmospheric circulation (AC) type frequencies (% of days/season) for the years 2013-2018.

The circulation types/flow directions are:
N = north
NE = northeast
E = east
SE = southeast
S = south
SW = southwest
W = west
NW = northwest
Cc = cyclone over Svalbard
Ca = high pressure over Svalbard
Bc = cyclonic trough over Svalbard
Ka = high pressure ridge over Svalbard

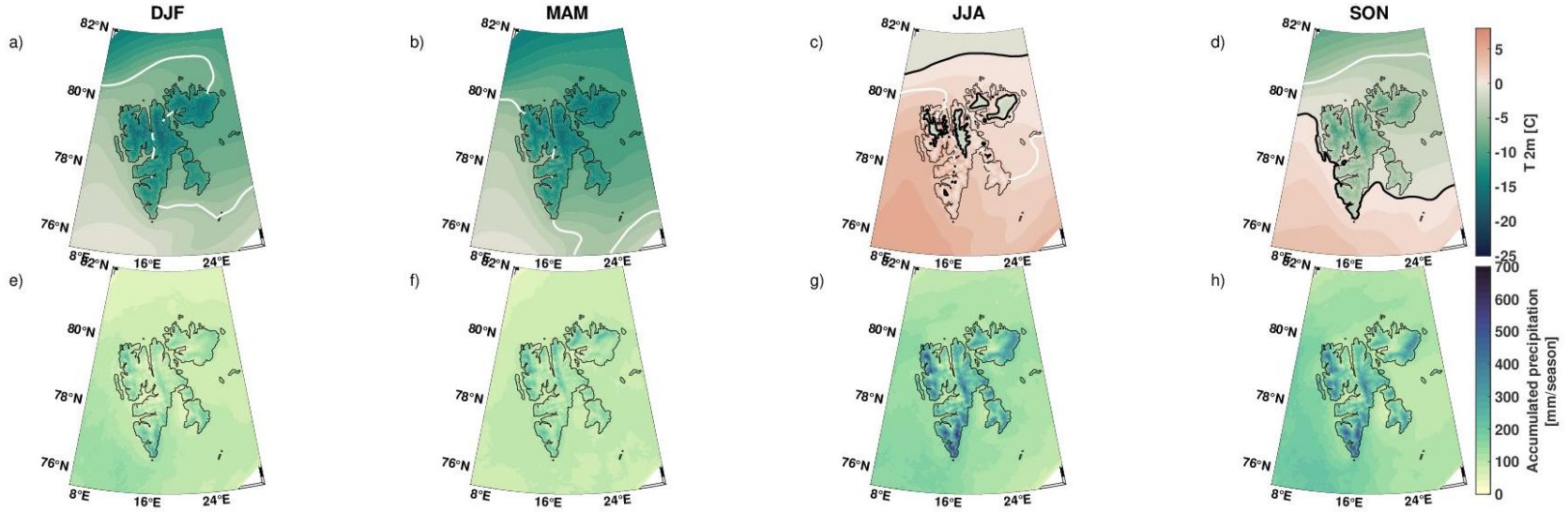

Figure 3. Maps of a-d) seasonal mean 2 m temperatures (°C) and e-h) accumulated precipitation (mm) for the period 2013-2018. The mean seasonal sea ice edge (15% concentration) is indicated with a white, solid line and the 0°C isotherm is indicated with a black, solid line (JJA and SON, only).

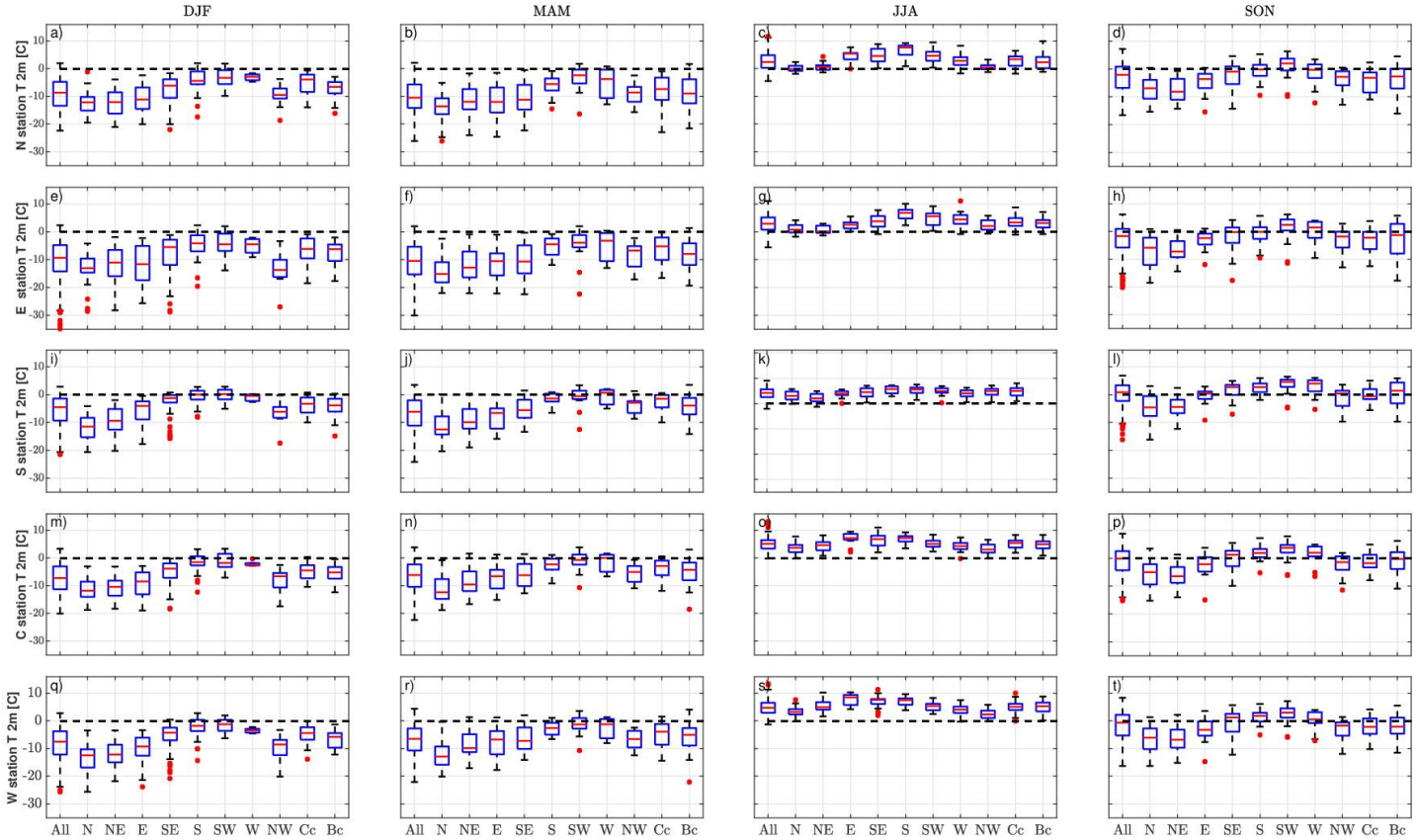

Figure 4. Seasonal box and whisker plots of 2-m air temperature (T 2m) for the cyclonic atmospheric circulation (AC) types 2013-2018 for all 5 stations (Figure 1). The solid, red line marks the median, the upper and lower edges of the blue box the 75th and 25th percentiles, the whiskers the 90th and 10th percentiles, and the red crosses are outliers.

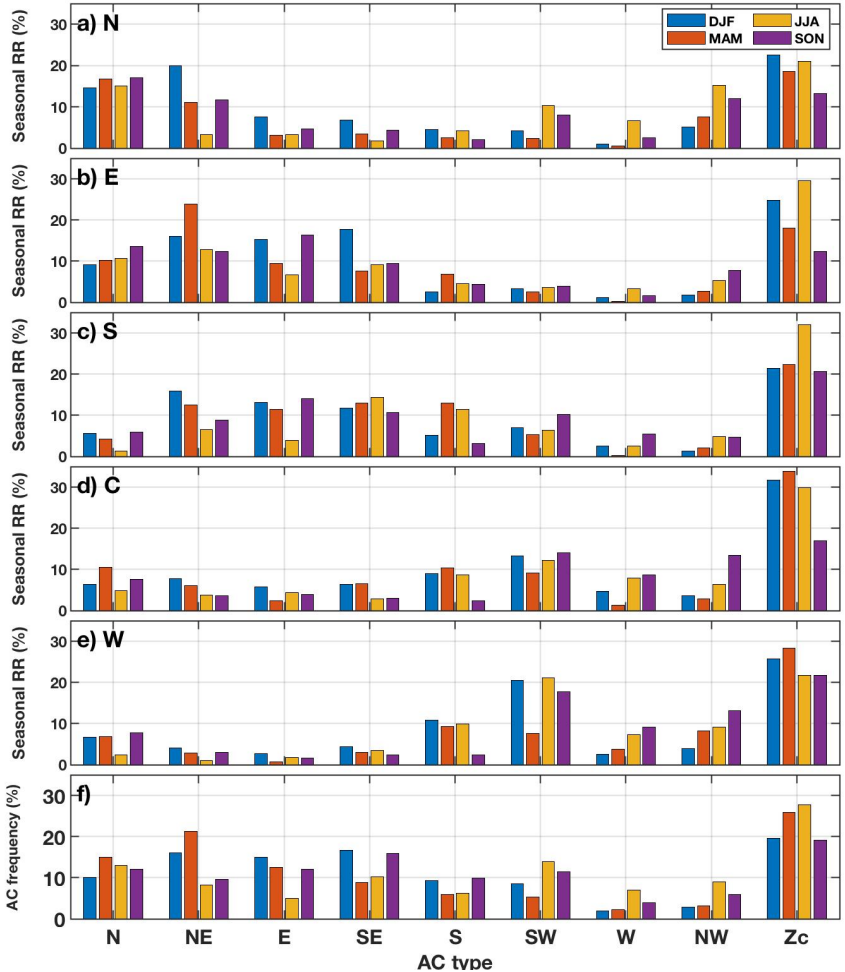

Figure 5. Bar plot of mean seasonal precipitation intensity (RR) with the given AC type at the 5 stations a)-e) and f) the seasonal AC distribution in the period 2013-2018 for all 5 stations.

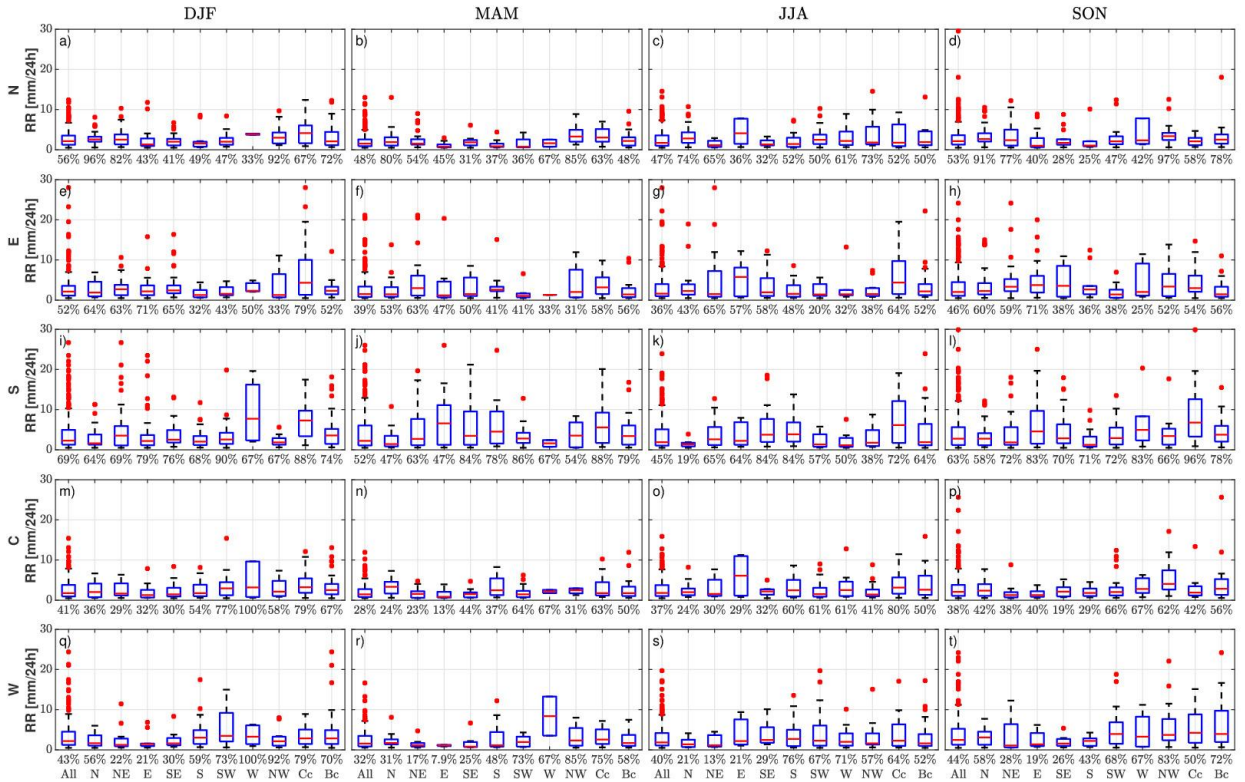

Figure 6. Seasonal box and whisker plots of precipitation intensity, RR [mm/24h], for the cyclonic atmospheric circulation (AC) types during 2013-2018 for all 5 stations. The solid, red line marks the median, the upper and lower edges of the blue box the 75th and 25th percentiles, the whiskers the 90th and 10th percentiles, and the red crosses are outliers. The percentages below the boxes indicate how large of a fraction of the days with a given AC type precipitate (more than 0.5 mm/24 h).

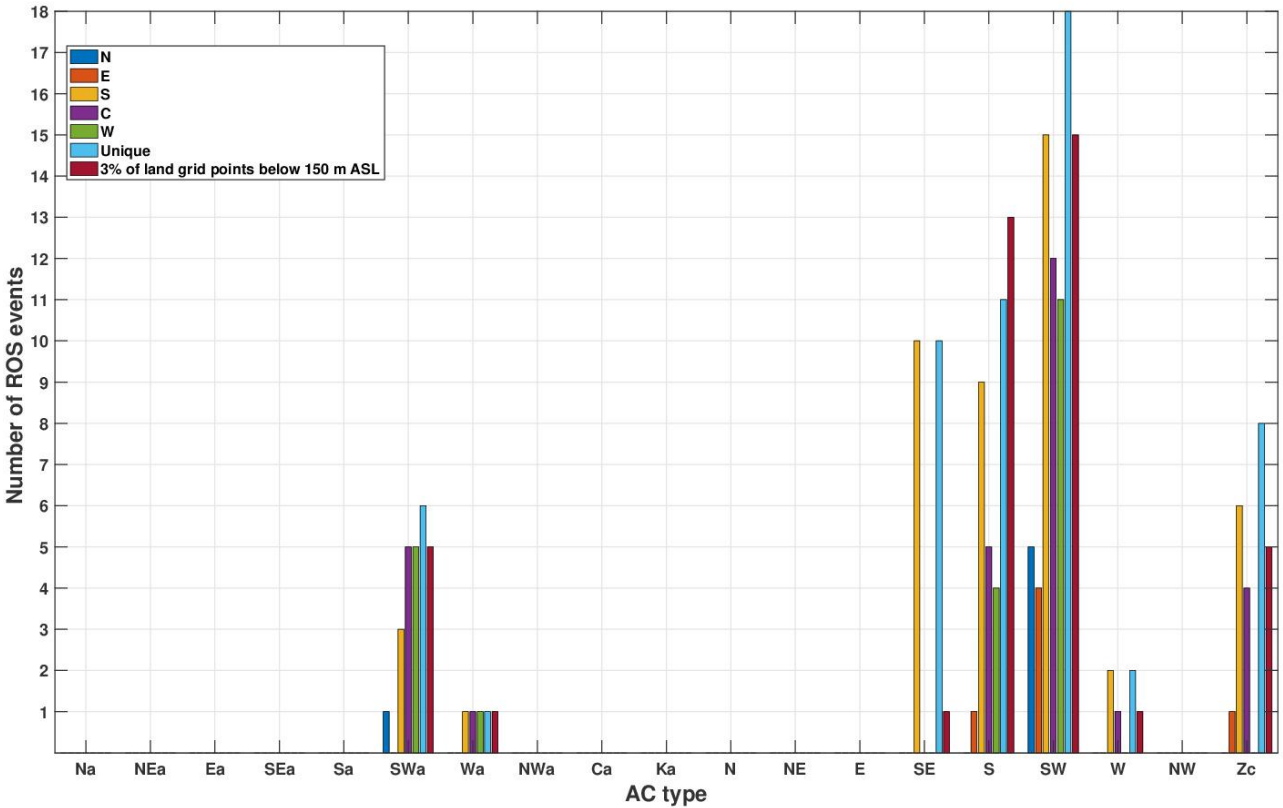

Figure 7. Bar plot showing the number of ROS events (defined in section 2.4) with the different atmospheric circulation (AC) types at the 5 different stations (presented in Figure 1). The light blue bar labelled unique refers to cases where a ROS event is calculated only once regardless of being found at several stations. The bar labelled 3% of grid points below 150 m ASL refers to the extensive events where 3% or more of the land grid points below 150 m ASL experience a ROS event.

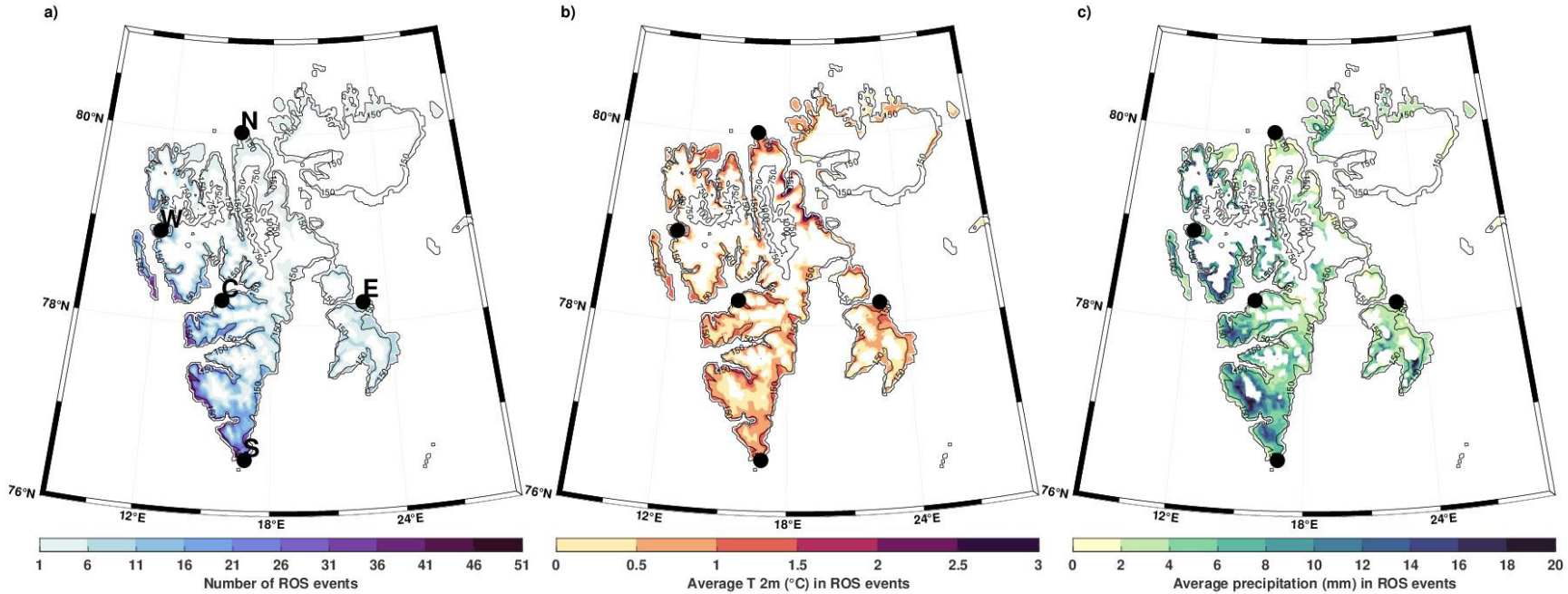

Figure 8. a) Average frequency of ROS events over land, defined as daily mean 2m air temperature (T 2m, °C) above freezing and more than 1 mm of precipitation, divided by the number of DJF seasons (5), b) average T 2m for ROS events and c) average daily precipitation (mm) for ROS events. The 150 m ASL terrain height contour is indicated as well in each of the panels.

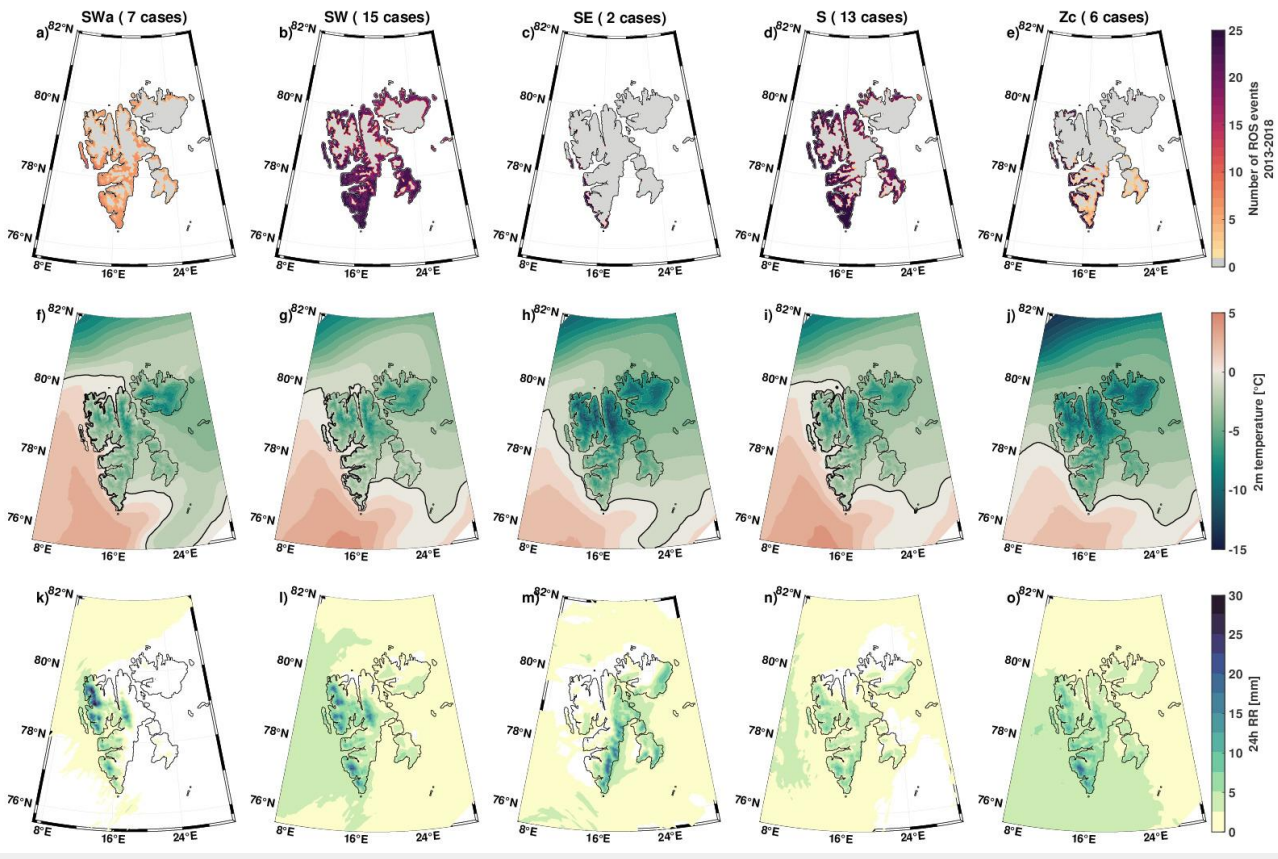

Figure 9. Average frequency of winter (DJF) rain-on-snow events (daily mean 2m air temperature above 0 °C and more than 1 mm of precipitation) divided by the number of seasons for a) SWa b) SW c) SE d) S d) Cc AC types and the composites of f-j) 2m air temperature (°C) and k-o) precipitation (mm/24h) produced as described in the text.

Main conclusions

- The temperature and precipitation conditions in Svalbard are most sensitive to synoptic flow direction during winter and spring.
- At the northern and eastern parts of Svalbard the precipitation intensity appears to depend on upstream sea ice conditions.
- Rain-on-snow events in Svalbard have the largest spatial coverage under southwesterly synoptic flow.

Acknowledgements

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The AROME-Arctic data is available at https://thredds.met.no/thredds/catalog/aromearcticarchive/catalog.html