Rain-on-snow (ROS) events are gaining attention in research worldwide due to their wide-ranging impacts during the seasons with snow cover and climatic zones. In particular, ROS on Svalbard can lead to the formation of layers of ice at the ground-snow interface after a ROS event, which can both damage vegetation and restrict access to forage by reindeer, which has in some years led to large starvation-induced die-offs. CHORUS was originally motivated by anecdotal evidence of changing ROS characteristics in Svalbard, raising questions about potential spatially heterogeneous consequences for Svalbard reindeer populations. Moreover, most ROS studies until now have typically utilized single-source datasets, despite ROS being a multidisciplinary research topic. This highlighted the need for collaboration across disciplines to address the questions: how are the spatiotemporal characteristics of ROS events in Svalbard changing, and what aspect(s) of ROS is, or are most influential for changes in the cryosphere?

We have analyzed and integrated a diverse set of field, model and remote sensing observations from contrasting inland (Nordenskiöld Land) and coastal sites (Ny Ålesund) in Svalbard. These include a previously unanalyzed decadal temperature data set for the snowpack-ground interface, in-situ ground ice and meteorological observations, multi-layer snowpack model simulations, high resolution regional reanalysis (CARRA) and a remote sensing wet snow dataset. The long time series provided by gridded data has allowed us to quantify how the timing, frequency, extent, intensity, and duration of ROS events has changed over climate-relevant timescales.

Our initial correlation and trend analysis showed significant and positive trends in the bottom-of-snowpack temperature at Ny-Ålesund and across Nordenskiöld Land sites between 1991 and 2023 while only ROS duration was found to have significant and positive trend since 1991 at all of the Ny-Ålesund sites studied. Such trends add to knowledge on diverging Svalbard reindeer population trends from differences in climate impacts in the two core study regions. ROS event frequency and duration exhibited positive and significant correlations with bottom-of-snowpack temperature and were also the variables found to be most influential and consistently amongst the highest scoring models for explaining the variability in the snowpack variables. We also found strong and significant positive correlations between ROS total precipitation and intensity and ground ice thickness. Snowpack temperature and ground temperature were found to follow each other very closely but exhibit a nonlinear relationship. This suggests that factors influencing variations in the bottom-of-snowpack temperature will likely influence variations in ground temperature. Lastly, our analysis of a single downscaled global climate projection indicates that from 2030 to 2070, the greatest changes relative to present day conditions in all ROS characteristics are expected in the mountainous and glaciated areas in the north and northeast of the archipelago, while low lying western coastal areas will experience a decrease in all characteristics, most likely attributable to the result of fewer days with snow and thus a shorter period when rain can fall on a snowpack. The projections of Svalbard's future climate feature an increase in ROS events across all months, but most substantially in April for the 2050-2070 period, a month which currently experiences very few, if any, ROS events. This shift in ROS timing towards the end of the winter may have a cascade of impacts for both terrestrial and marine ecosystems that are dependent on snow and timing of snowmelt for accessing forage resources.