Linking Arctic Rain on Snow Events with Atmospheric Rivers

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Introduction

This study addresses the meteorology of Arctic Rain on Snow (ROS) events from two case studies. The first, occurring near Nuuk, Greenland, generated significant impacts, including slush avalanches. The second, less severe, occurred within the community of Iqaluit, Nunavut. Atmospheric blocking played a leading role in ROS initiation for these and other events (Omega and Rex type, respectively), with atmospheric rivers – narrow bands of high water vapor transport, typically originating from the tropics and subtropics – having both direct and indirect effects.

Data

- ERA5 reanalysis fields at 00Z (UTC) and 12Z files, which coincide with upper-air launch times
- Sounding data for Aasiaat, Greenland (north of Nuuk), and for Iqaluit
- Automated station data for Godthaab (Nuuk) and Iqaluit

Key Findings

- Atmospheric blocking played a leading role in ROS initiation, with direct (Nuuk) and indirect (Iqaluit) effects.
- Cyclone-induced low-level jets and resultant "warm noses" of higher air temperatures and moisture transport were other key features in ROS generation.
- Low temperatures following ROS events led to icy layers
- The meteorological drivers identified here find support from other studies on Arctic ROS events and are similar to weather features associated with Arctic precipitation events of extreme magnitude.

Acknowledgments

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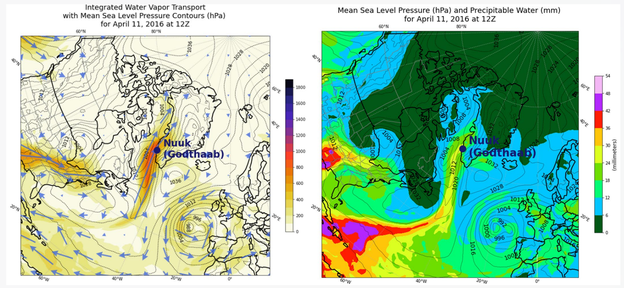
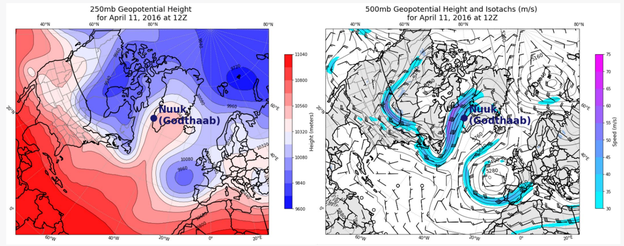
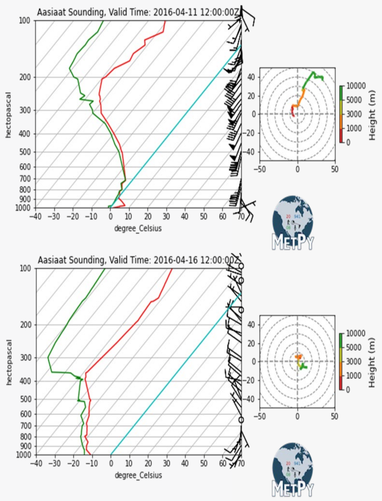
- ERA5 data was accessed from the Copernicus Climate Data Store API maintained by the ECMWF.
- We also appreciate the ECMWF and UCAR for their data and MetPy programming codes and Iowa State University for the AOS data.

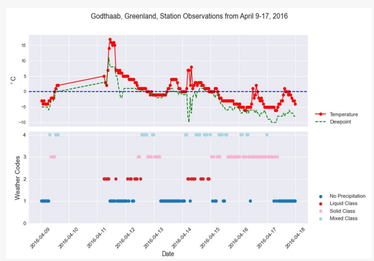


The 2016 Western Greenland case moisture variables. Integrated water vapor transport, with mean sea level pressure as black contours, is plotted on the left, and precipitable water, with mean sea level pressure contours, is plotted on the right. The vapor transport visualization includes magnitudes as filled contours, and vector arrows provide the direction. **Atmospheric river with direct effects!**



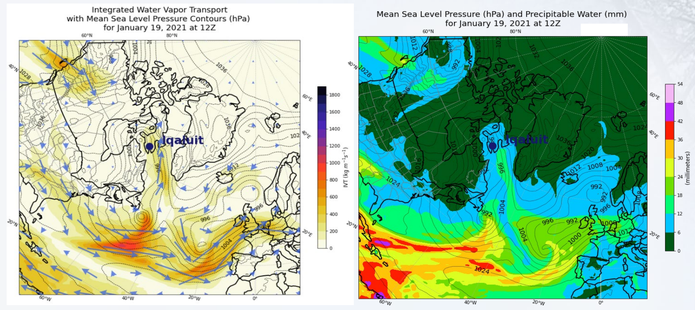
The 2016 Western Greenland case upper atmospheric levels. The 250-mb geopotential heights are plotted on the left, and the 500-mb heights and winds are plotted on the right. The 500-mb panel also includes isotachs (lines of constant wind speed) in m s^{-1} in filled contours, in addition to wind barbs that indicate both direction and speed. **Omega block!**



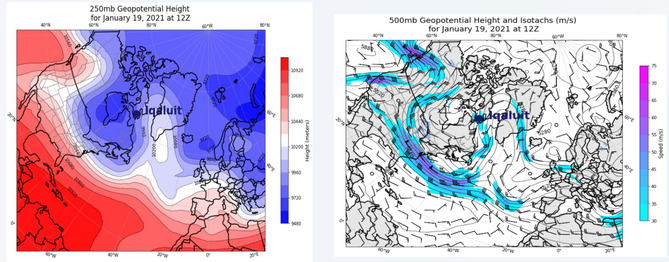


Godthaab (Nuuk), Greenland, surface station observations (April 9-17, 2016). Temperature and dewpoint temperature are plotted in the upper panel in °C, and the corresponding precipitation types are plotted in the lower panel. Rising temperatures pre-event, change from snow to rain, 15oC on April 11. Then it got colder.

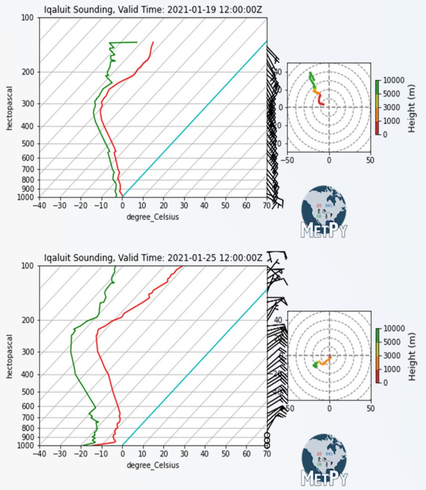
Aasiaat, Greenland (north of Nuuk), during and post rain-on-snow event soundings. The top sounding shows the atmospheric conditions on April 11, 2016. Note the "warm nose" at the surface. The bottom sounding shows the atmospheric conditions five days later. The red and green lines represent air temperature and dewpoint temperature plotted with height, respectively, and winds are plotted as both barbs on the sounding's right and as a hodograph on the right-hand side of the figure. Much colder!

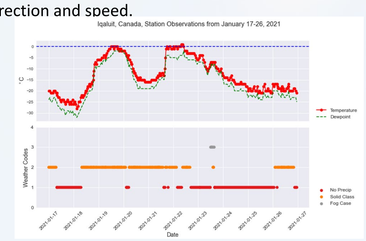


The 2021 Iqaluit case moisture variables. Integrated water vapor transport, with mean sea level pressure as black contours, is plotted on the left, and precipitable water, with similar mean sea level pressure contours, is plotted on the right. The vapor transport visualization includes magnitudes as filled contours, and vector arrows provide the direction. Part of an atmospheric river was "stripped off" to influence Iqaluit, **hence and indirect effect**



The 2021 Iqaluit case upper atmospheric levels. The 250-mb geopotential heights are plotted on the left, and the 500-mb heights and winds are plotted on the right. The 500-mb panel also includes isotachs (lines of constant wind speed) in m s^{-1} in filled contours, in addition to wind barbs that indicate both direction and speed.





Surface observations from Iqaluit (January 17-26, 2021). Temperature and dewpoint temperature are plotted in the upper panel in °C, and the corresponding precipitation types are plotted in the lower panel. Note the lack of liquid or even mixed precipitation types at the time of ROS occurrence. An eyewitness confirmed this ROS event, so this exemplifies a situation where the ASOS (usually collocated with an airport) may not have been representative of all regional conditions.

Iqaluit, Nunavut, during and post rain-on-snow event soundings. The top sounding shows the atmospheric conditions on January 19, 2021. No "warm nose". The bottom sounding shows the atmospheric conditions six days later. The red and green lines represent air temperature and dewpoint temperature plotted with height, respectively, and winds are plotted as both barbs on the sounding's right and as a hodograph on the right-hand side of the figure. No "warm nose" in this case, but again much colder post event