



A Pan-Arctic Database of Rain-on-Snow events and Associated Meteorological Conditions

Andrew P Barrett,

Jessica Voveris, Mark C. Serreze,

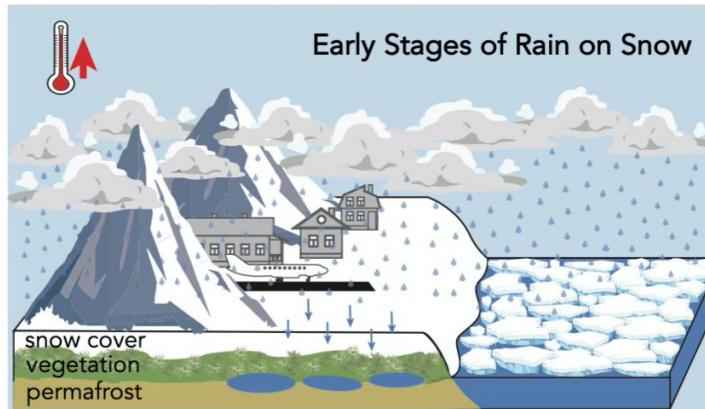


National Snow and Ice Data Center
Advancing knowledge of Earth's frozen regions



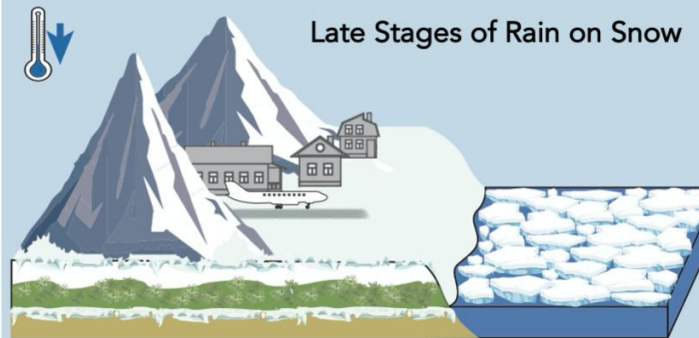
Warm moist air moves into region bringing a rise in temperature, overcast skies, and rainfall.

Water percolates snowpack and pools at permafrost surface.



Rainfall is followed by a rapid drop in temperature.

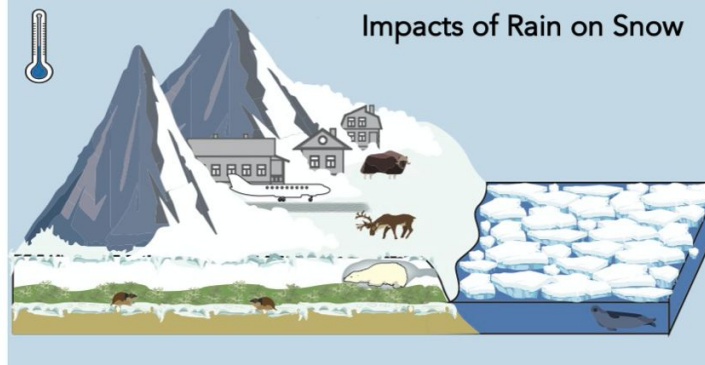
Water freezes on snow and ground surfaces. Freezing releases latent heat, warming underlying permafrost.



Temperature remains cold.

Rainfall can trigger avalanches and cause destruction to infrastructure.

Ice cover blocks animals from accessing vegetation and denning



Credit: Julia Gustavson and Matthew Druckenmiller



Arctic Rain on Snow Study (AROSS)

To better understand:

- Causes, frequency, and severity of ROS and extreme precipitation events in a warming Arctic
- Impacts on reindeer herding, wildlife, tundra, and Indigenous communities

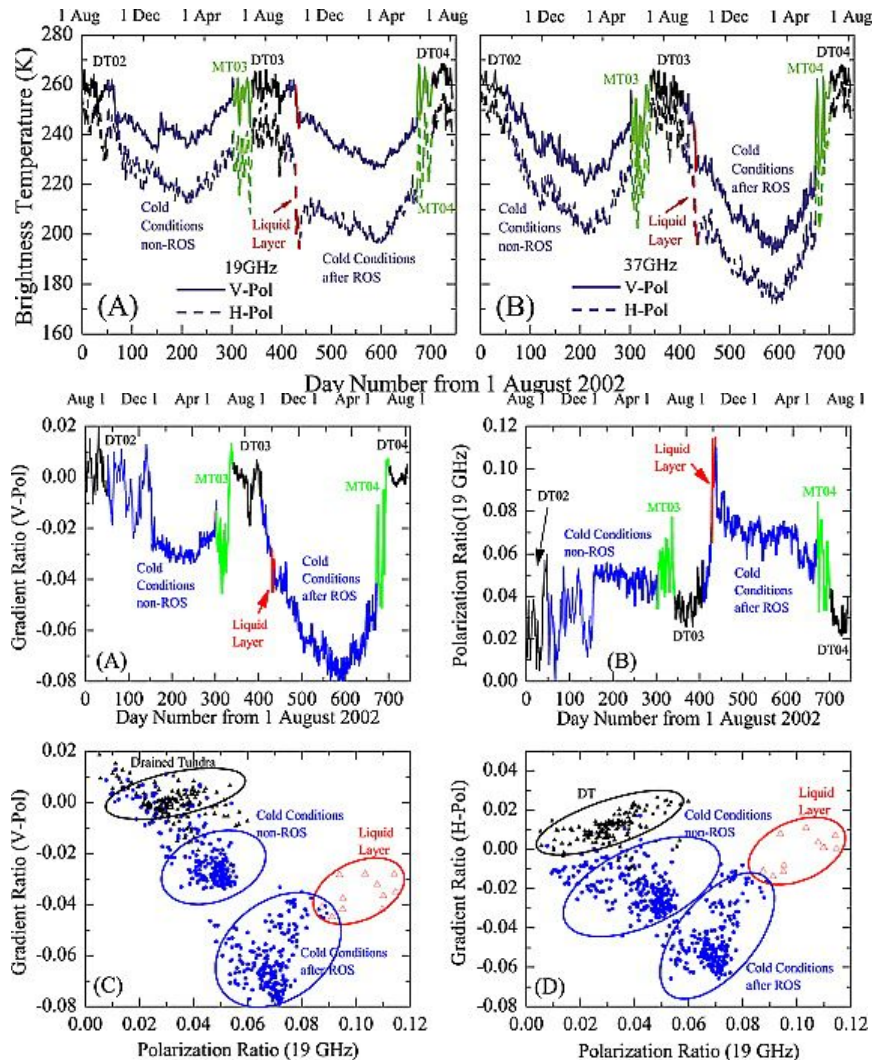
Observing assets:

- Atmospheric Reanalyses and Operational Models (NASA MERRA2 and ERA5)
- CMIP6 Model Output
- Satellite Microwave Data (SMMR, SSM/I, SSMIS, AMSR-E, AMSR-2)
- Validation data (e.g., met stations, SHEBA, MOSAiC, etc.)
- Local Observer Networks (reindeer herders in AK, Finland, and Russia; hunters in Canada)

Products:

- **ROS detection algorithm**
- **ROS and extreme event database**
- Expert system models to explore social-ecological impacts

ROS detection from passive microwave



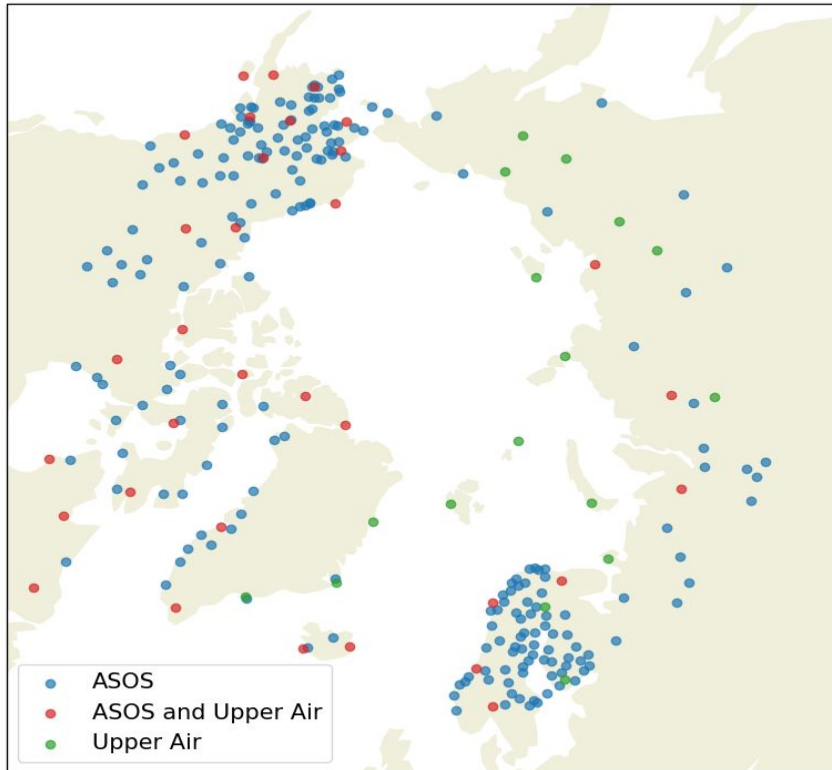
ROS over northern Banks Island, October 2003.

A week of on-off rain falling on a 15 cm snow pack.

Hunters report drizzly rain was enough to form cm thick ice at base of snow.

Grenfell and Putkonen 2008

Building a Database



Use data from ASOS - Automated Surface Observing System

2000 to 2020 period for September to March

ASOS provide data at fine temporal resolution (minutes).

Data downloaded from University of Iowa Mesonet site

- Quality Controlled
- Resampled to hourly
- Sampled for Rain, Freezing Rain and Solid Precipitation events

Events are combined with snow cover from IMS, and surface and upper air fields from ERA5.

Total Number of Winter Rain Events Detected at ASOS Stations



244 stations record events

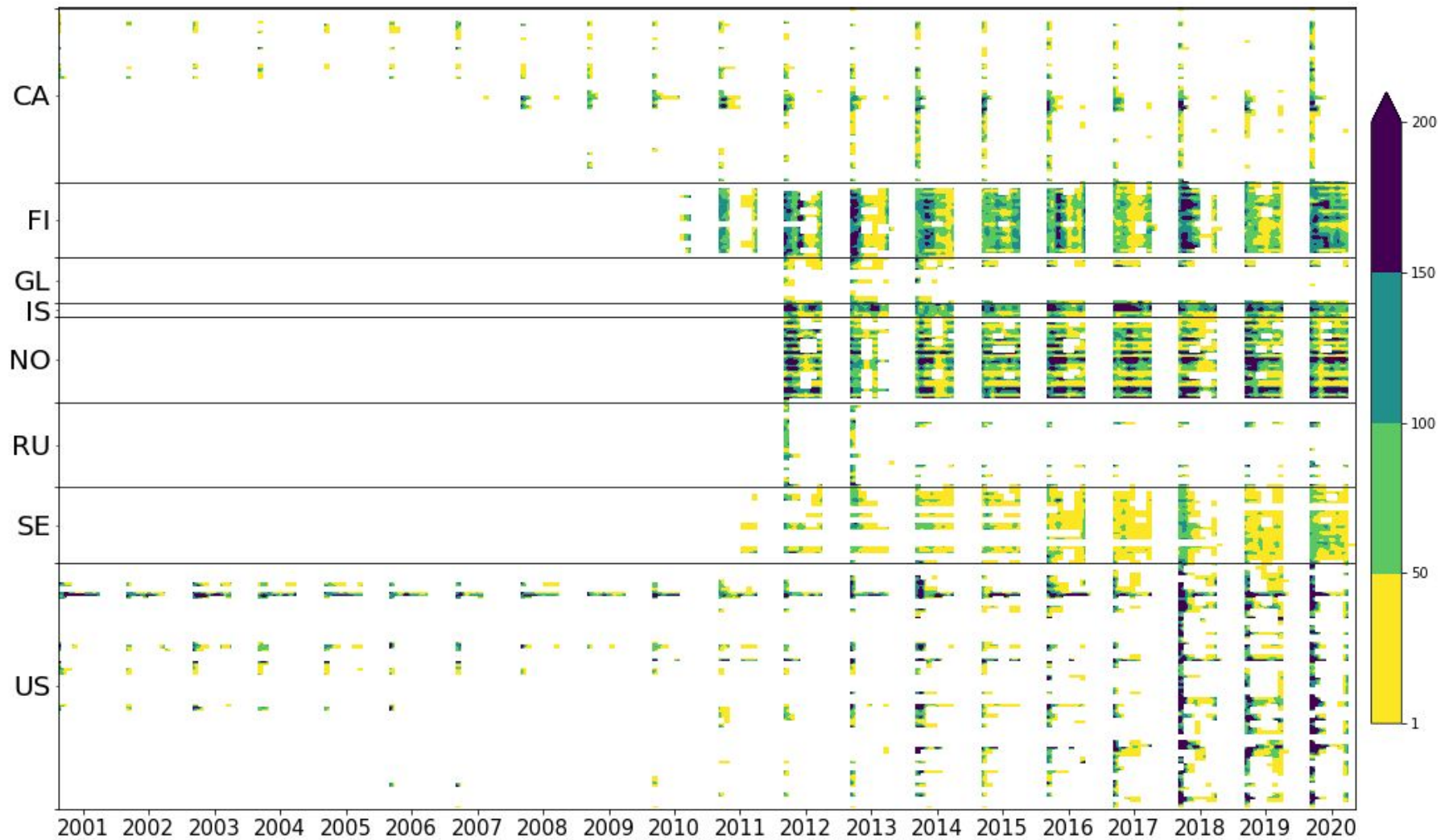
Total Events:

- Rain (RA) 765610
- Freezing Rain (FZRA) 18174

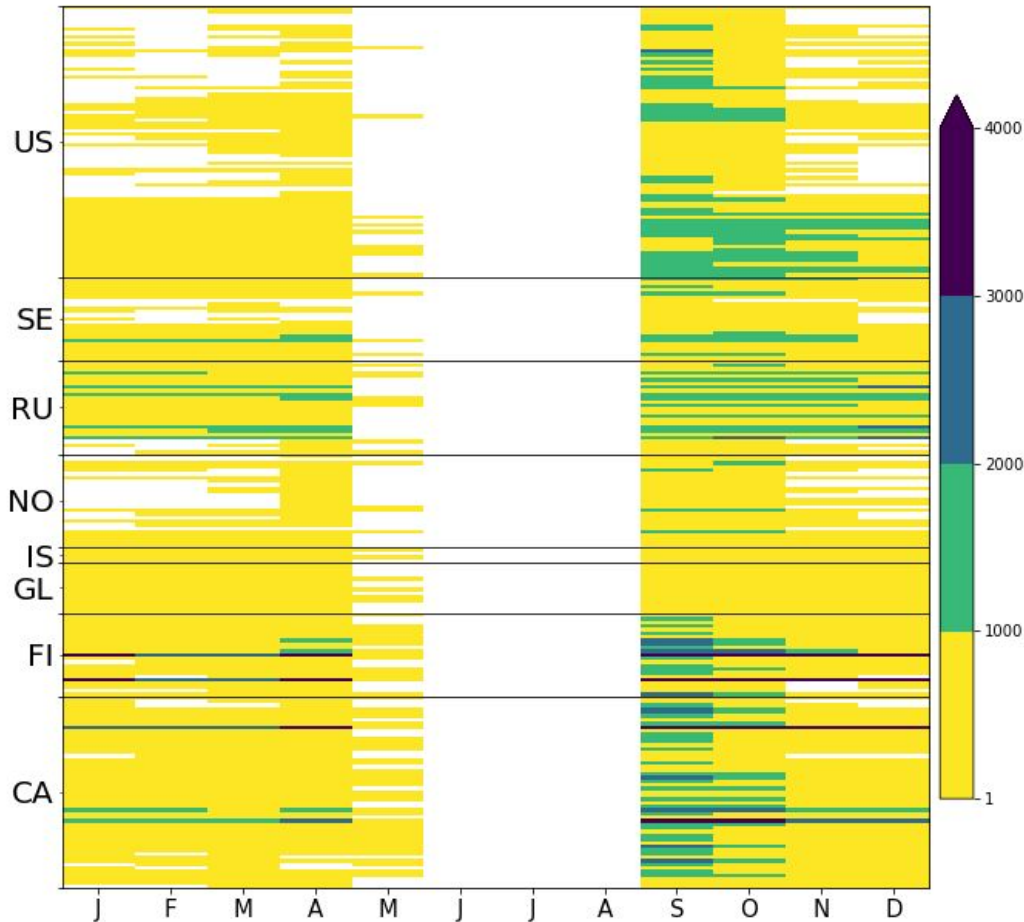
Largest circles ~ 30000 events.

Observing period different for each station

Heatmap of Winter Rain Events by Month



Distribution of Winter Rain Events By Month



Majority of events occur in shoulder months

However, for some stations, large numbers of events are recorded throughout the winter season

Next Steps...

We're finalizing the dataset.

First version of full dataset and processing code will be available from the Arctic Data Center in the next month.

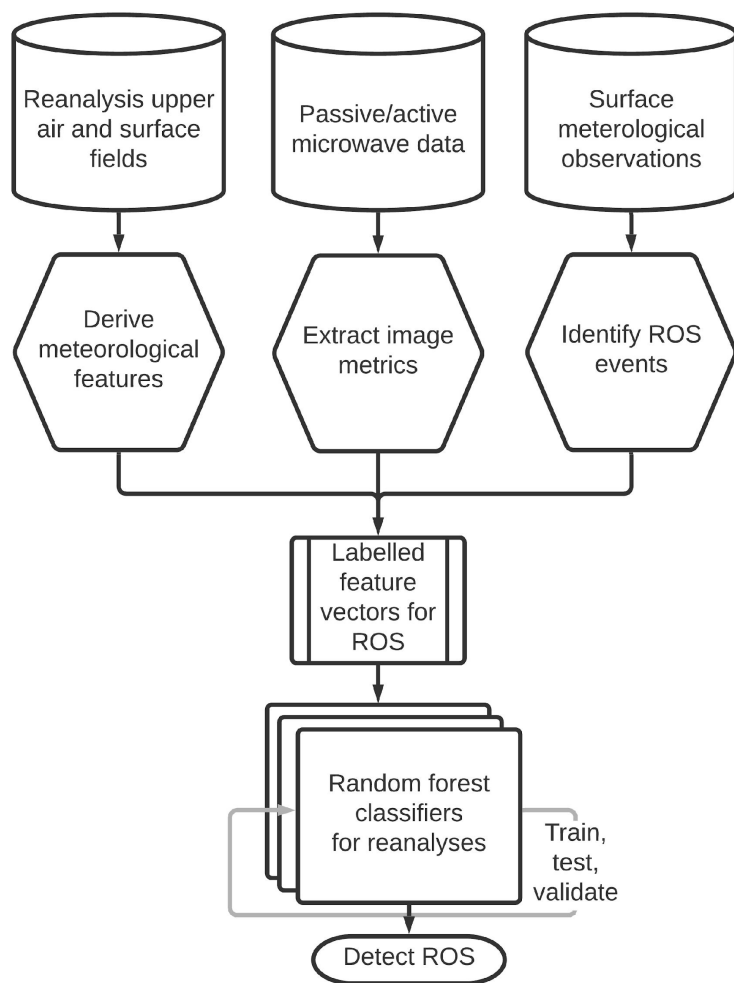
Data paper in the works.

Data will feed into Machine Learning rain on snow detection model.

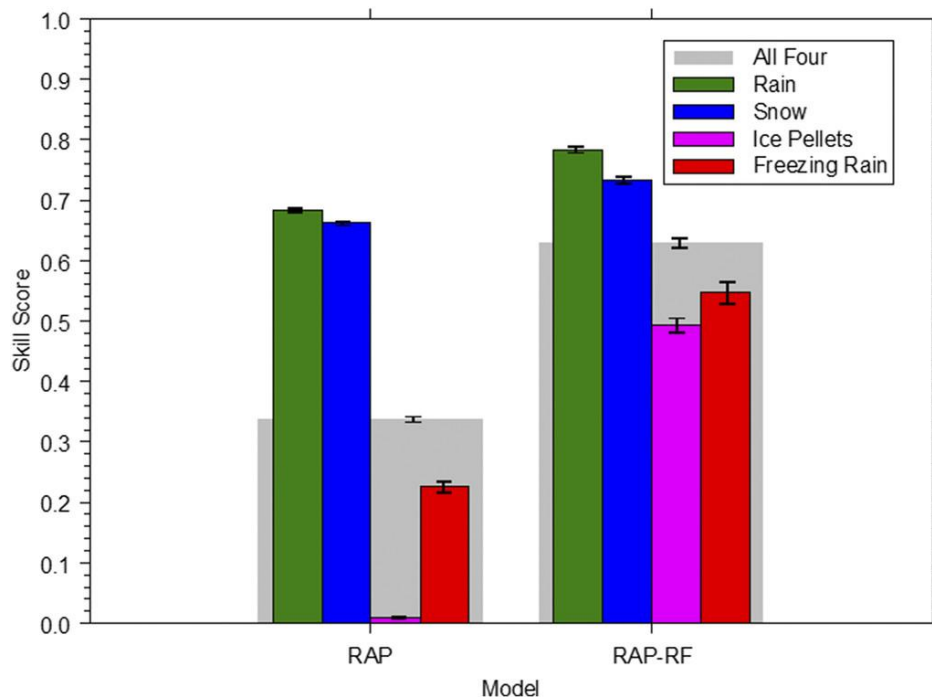
Questions?



AROSS Event Detection Algorithm



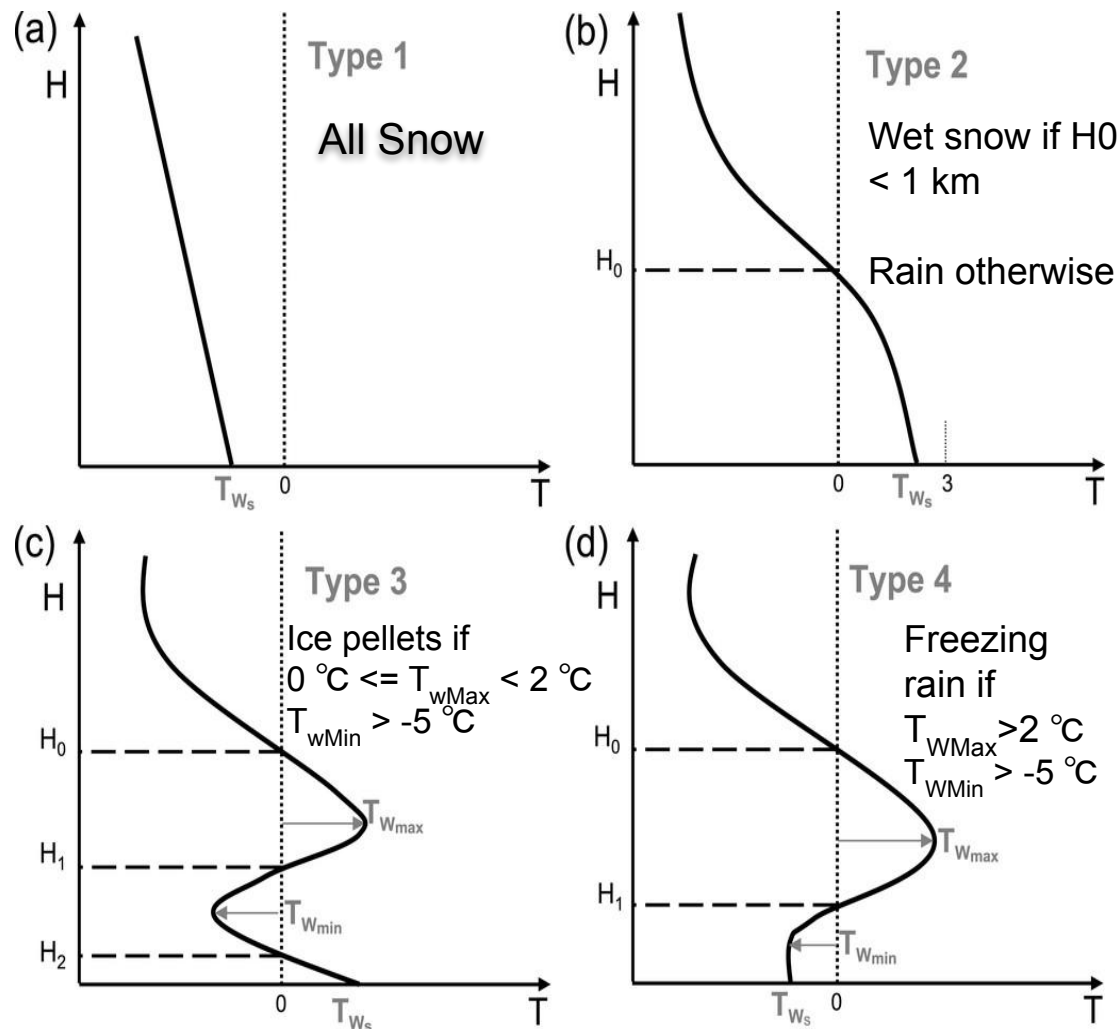
Random Forest Performance by Model



Using Peirce Skill Score: POD - POFD
McGovern et al, 2017, BAMS

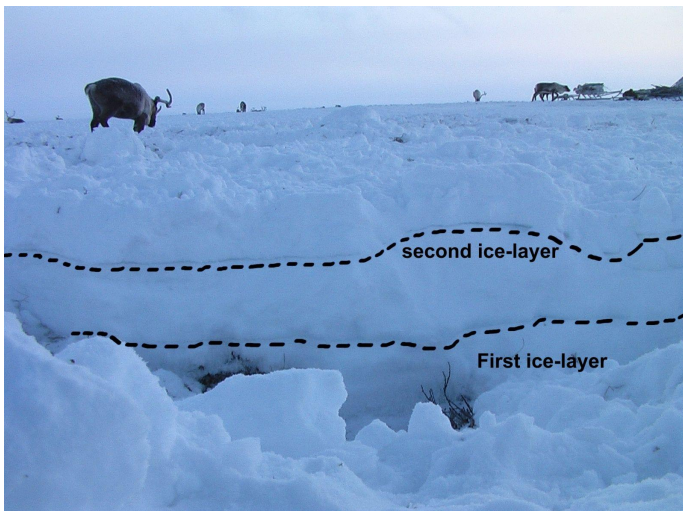
Heuristic approach to classification

Mid-west example after Schuur et al 2012



Classification based on thermodynamic information:

- Air temperature profiles
- Wet-bulb temperature profiles
- Pressure
- Layer thickness
- Min and max layer temperature
- Areas of warm noses and cold tails.

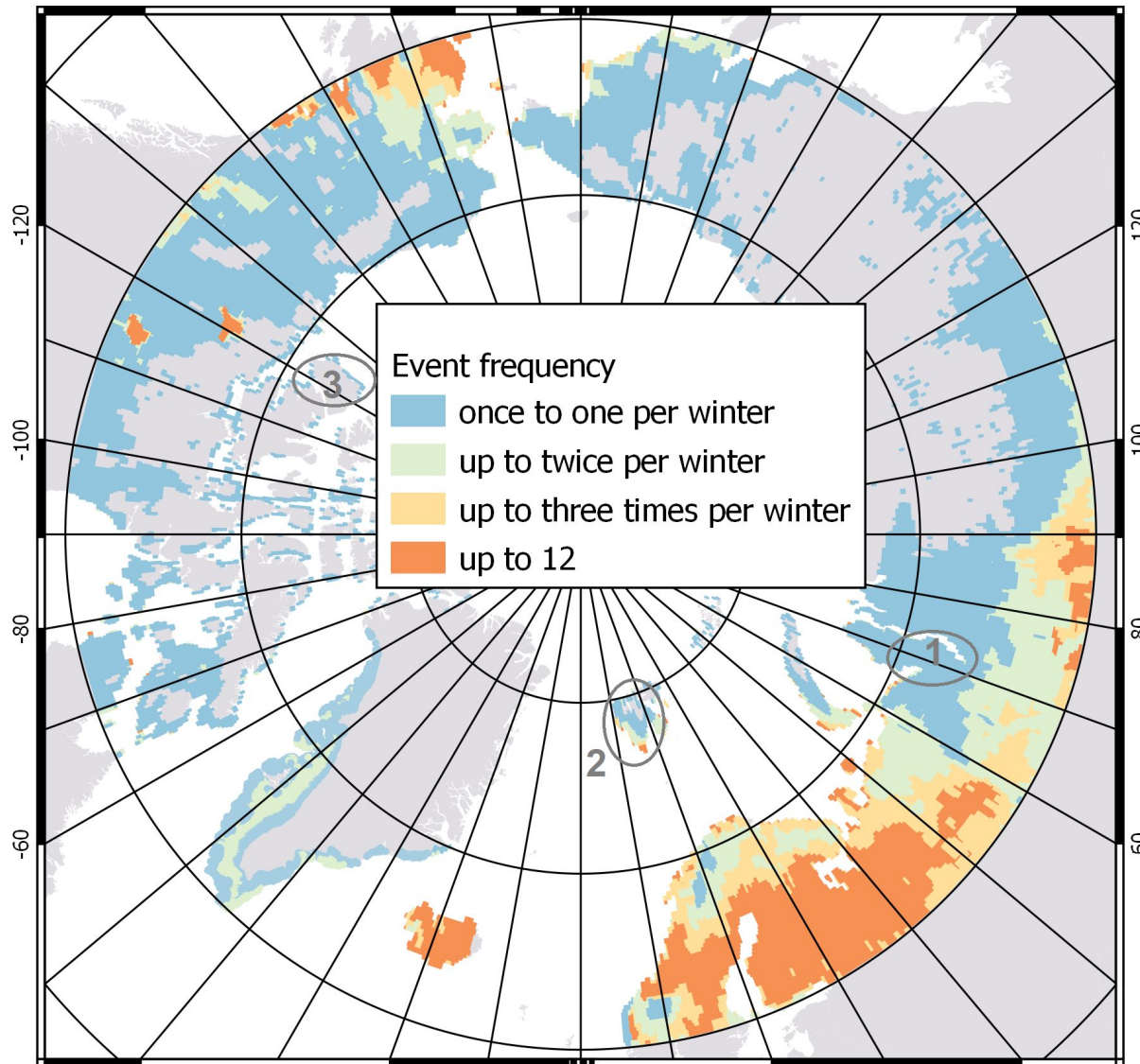


Multiple Ice Layers Layers

Mortality of Large Herbivores



Potential ROS events
November through
February for 2000 to
2009 from Ku-band
QuikSCAT backscatter



Observer Networks

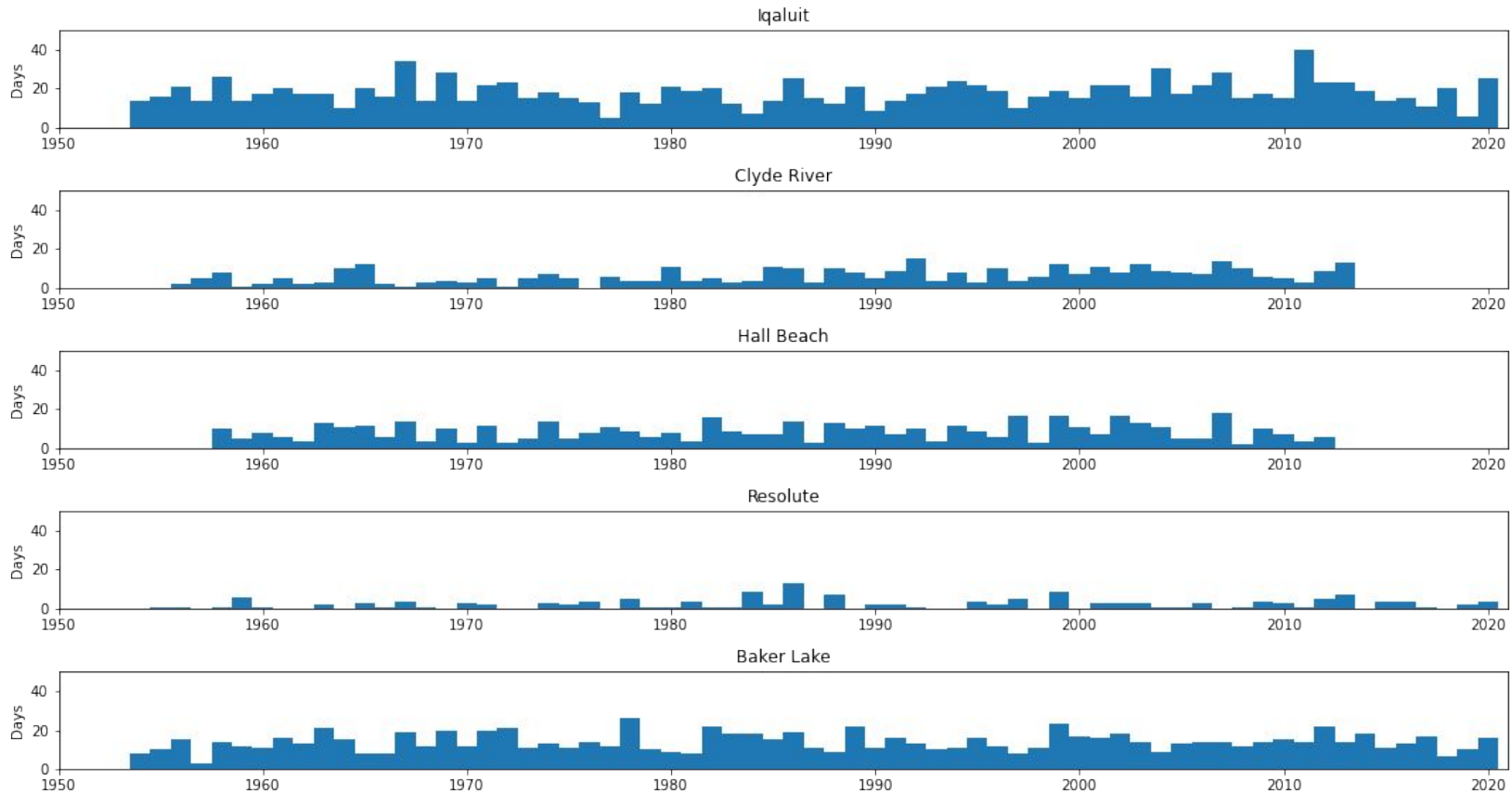


AROSS Rain on Snow observations map using reports from the LEO Network, Alaska Native Tribal Health Consortium

<https://nsidc.org/rain-snow/rain-snow-observations-map>, <https://www.leonetnetwork.org>

Mike Brubaker, Matt Fisher, Betsy Sheffield

Surface Station Winter Rain



Annual sum of September to April days with liquid precipitation.