Rain-on-snow events, ecology and community recording

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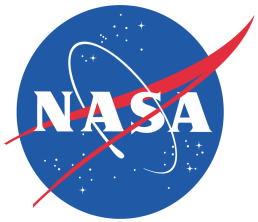



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Context – Extract from the IPCC (2013)

"The rapid rate at which climate is changing in the Polar Regions will impact natural and social systems."

"More frequent rain-on-snow events caused by warmer winters may restrict access to vegetation and may have profound negative influences on the population dynamics of Arctic ungulates."

Web of Science: 135 articles on rain on snow since 1985,
including 53 (40%) published since 2010

Context – Extract from SWIPA (2011)

"Rain falling on snow-covered ground will become more common."

"[...] animals grazing through snow, such as reindeer/caribou, suffer if winter rainfall creates an ice-crust over the snow. This is already happening more often in northern Canada and Scandinavia."

"In 2003, ∼20 000 muskox died on Banks Island in the Canadian Arctic because they could not break through the ice crust to graze."

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We already observe impacts on ecosystems and wildlife critical to the livelihood of communities of the North

Why monitoring rain-on-snow events?

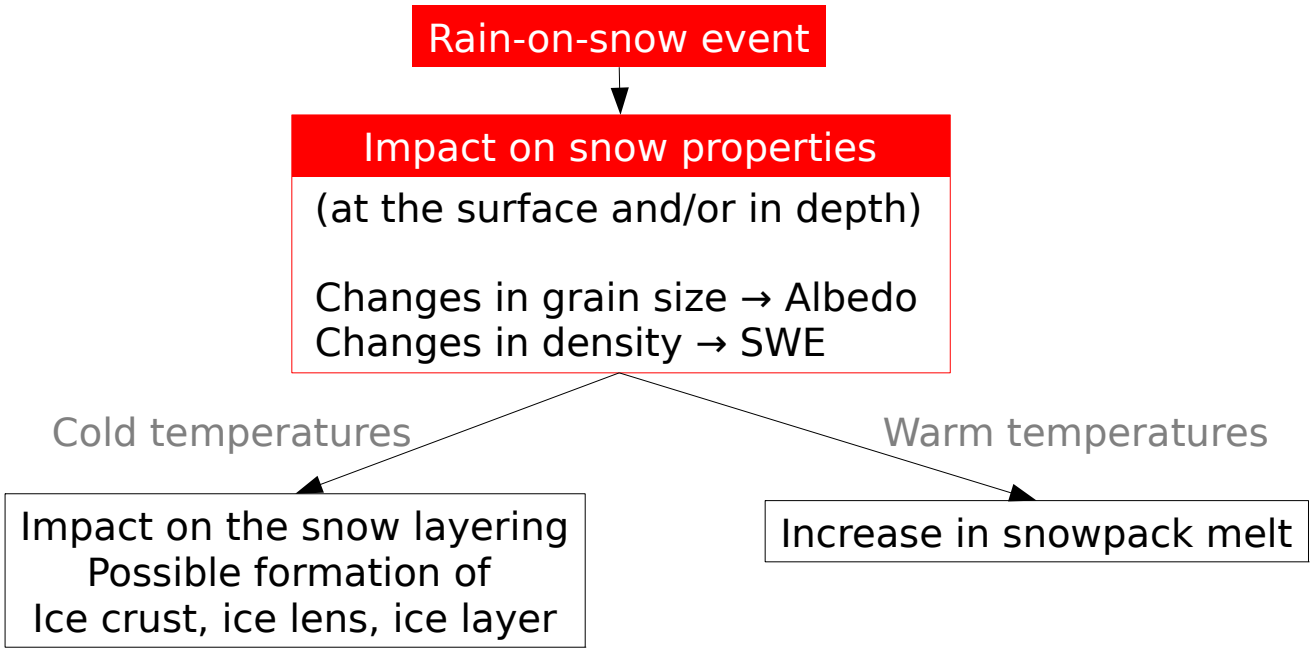
Relevant for:

- Wintertime climate change monitoring

- Climate adaptation to improve decision-making (e.g. herd management)

- Increasing our knownledge about rain-on-snow events, and their cumulative impact on:
  - surface energy balance
  - soil physical state/permafrost
  - snow melt
  - hydrological processes (including flash flood)

Why monitoring rain-on-snow events?



Impacts on the hydrosphere

Modification of percolation runoff

Impacts on the ecosystem

Modifications of the grazing conditions (e.g. pasture "lock-out" condition)

Impacts on the energy fluxes

How to monitor rain-on-snow events?

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- Community reportings and field campaigns

Community reportings and field campaigns

Two ways of knowing

e.g. Sami reindeer herders

(Eira et al., 2012)

e.g. local communities campaigns with latest sensors

Outstanding data sets for satellite algorithm validation

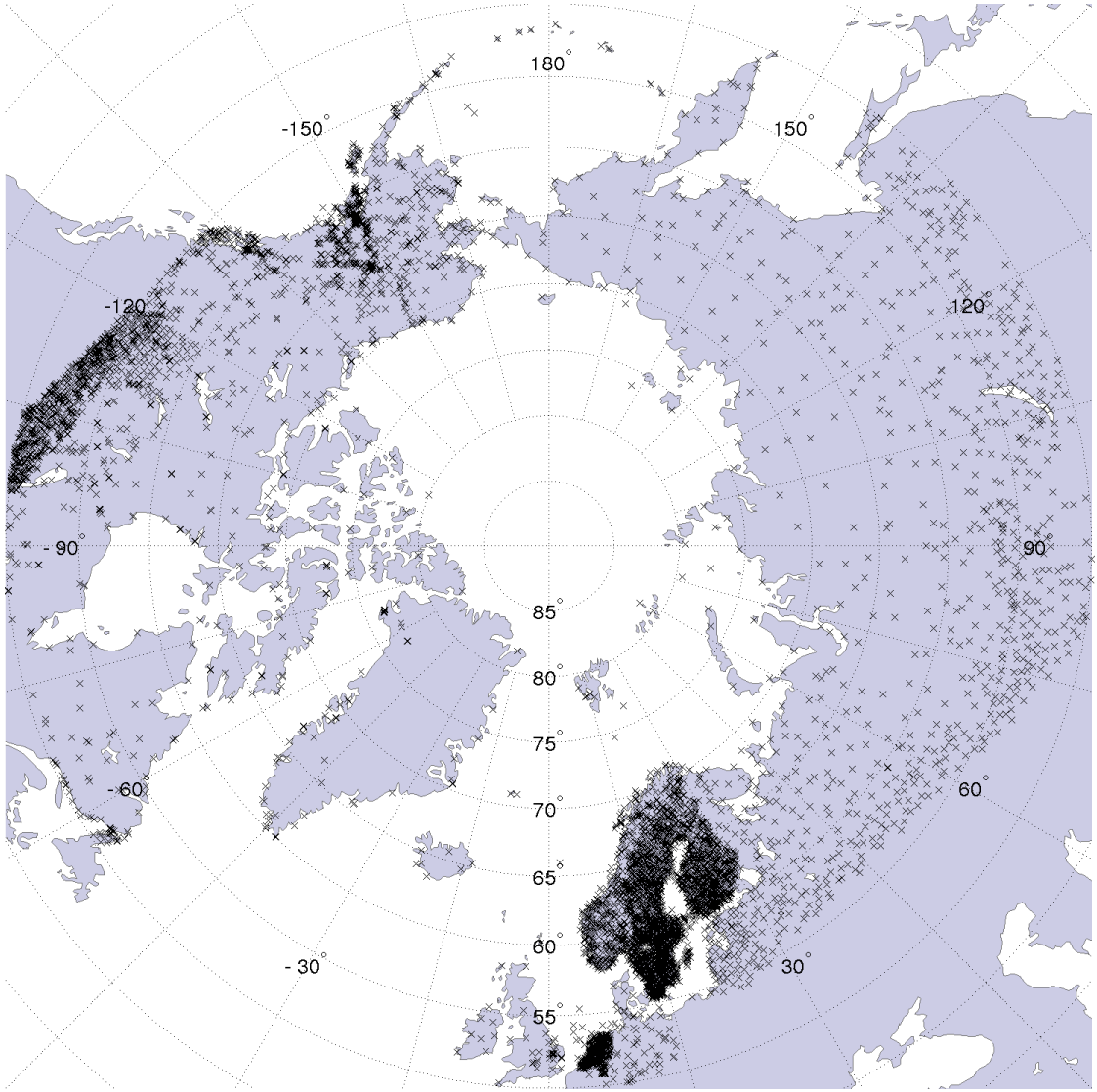
How to monitor rain-on-snow events?

- Community reportings
- Weather stations

Weather stations

e.g. Global Historical Climatology Network GHCN weather stations

...challenging...

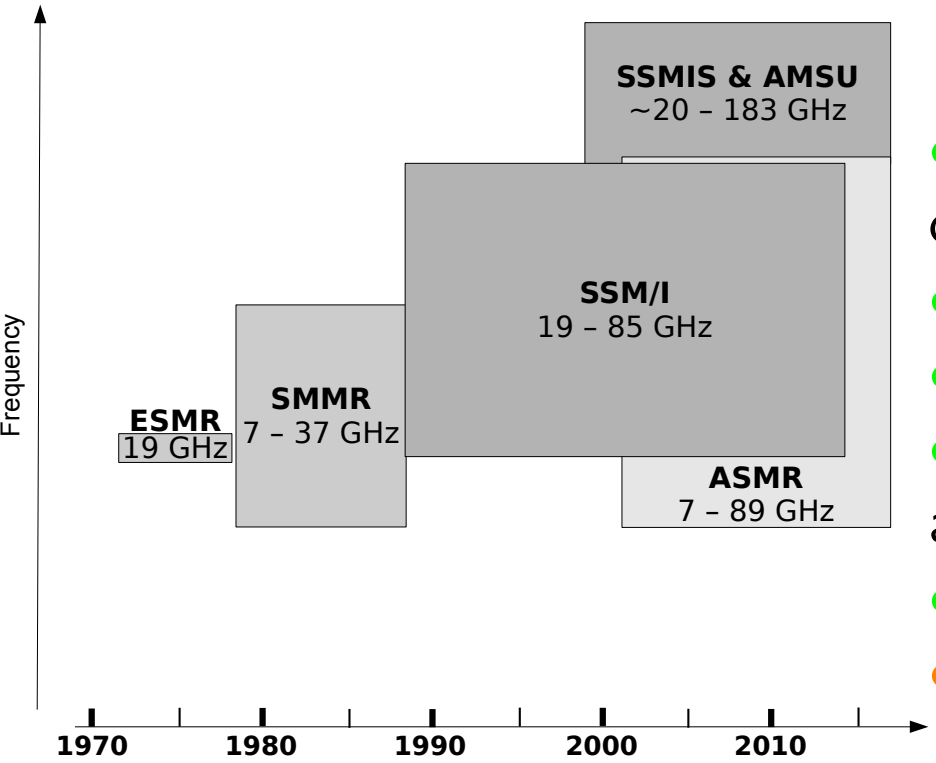


Only within a particular satellite grid

How to monitor rain-on-snow events?

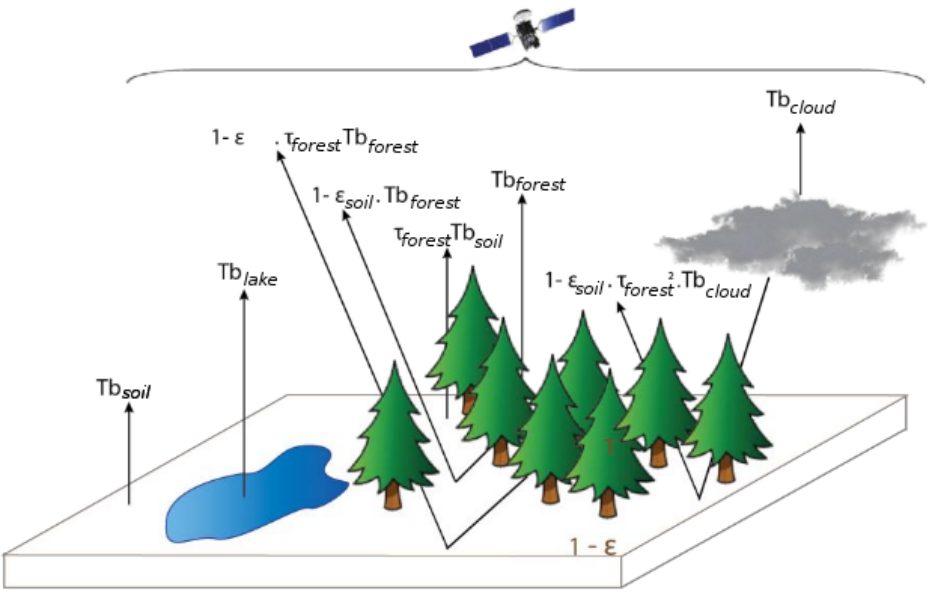
- Community reportings
- Weather stations
- Satellite microwave remote sensing

Satellite passive microwave remote sensing



- Good spatial & temporal coverages of the Arctic
- Long timeseries (since Oct. 1978)
- Multi-frequency and dual-polarization
- Channels weakly affected by the atmosphere
- ⇝ Sensitive to snow properties
- Limited spatial resolution (5–50 km)

Satellite passive microwave remote sensing



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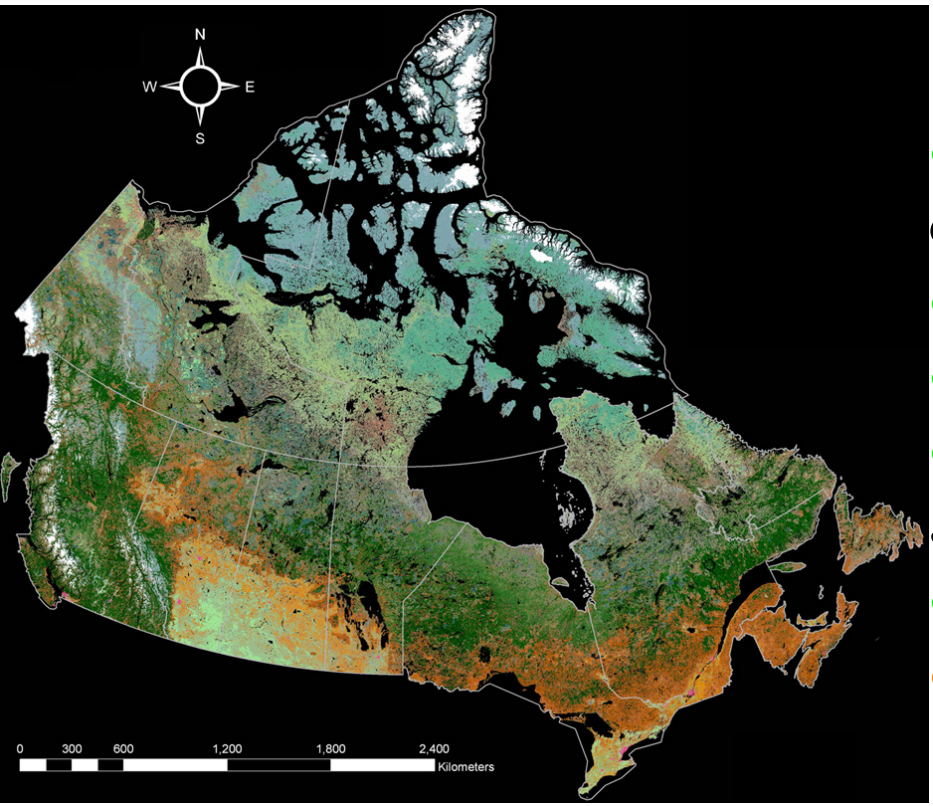

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Rain-on-snow event detection based on pmw observations

A **prototype** algorithm exists:

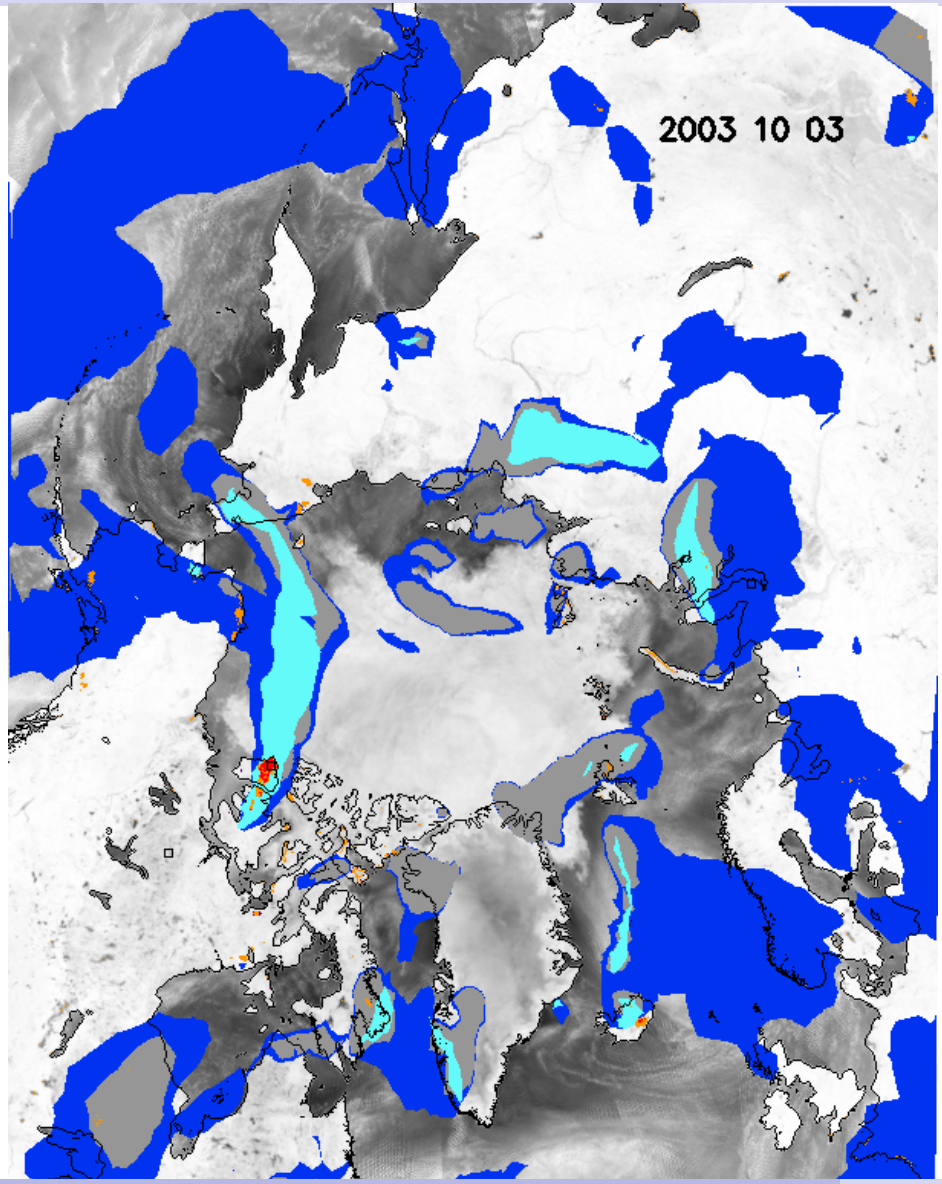
- It is an empirical algorithm
- Leveraged Grenfell and Putkonen's (2008) spectral detection
- Added a temporal detection

It is not validated (yet)

But, it shows encouraging spatial and temporal detections of known ROS events

Rain-on-snow event detections

Banks Island, 2003



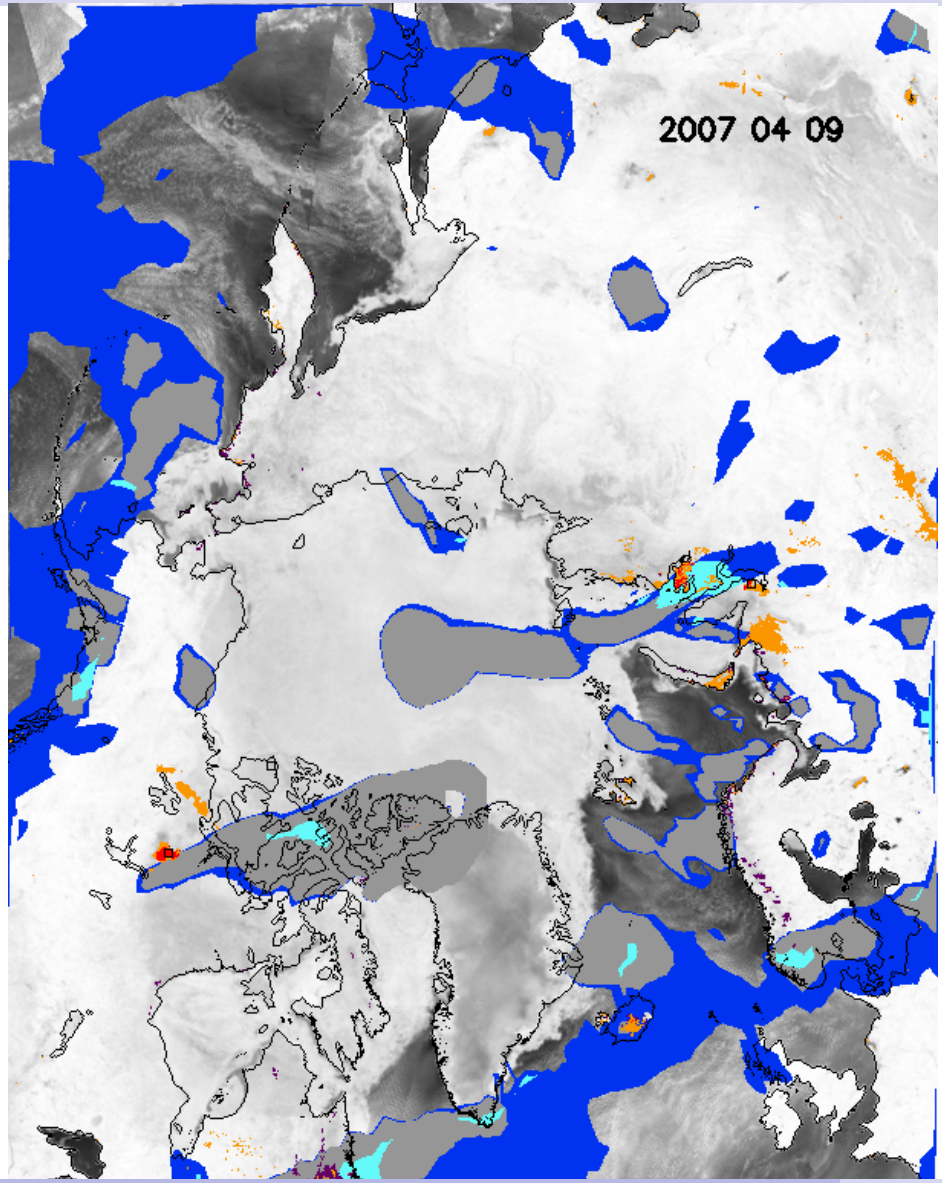
ROS with both spectral & temporal signatures

ROS with either spectral or temporal signatures

The other colors are not from the algorithm

Rain-on-snow event detections

Daring Lake, 2007



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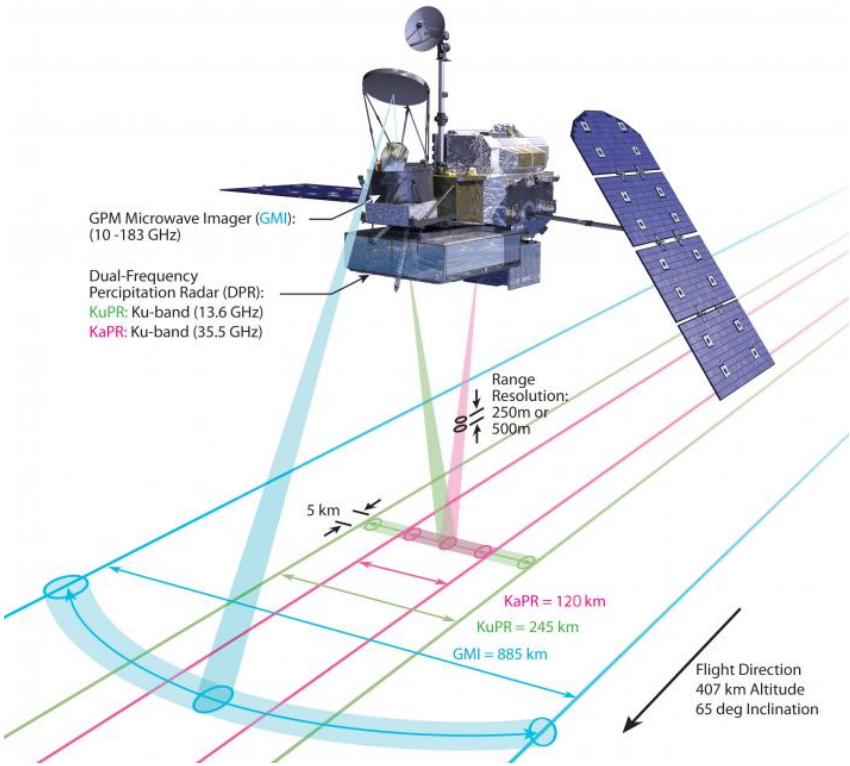
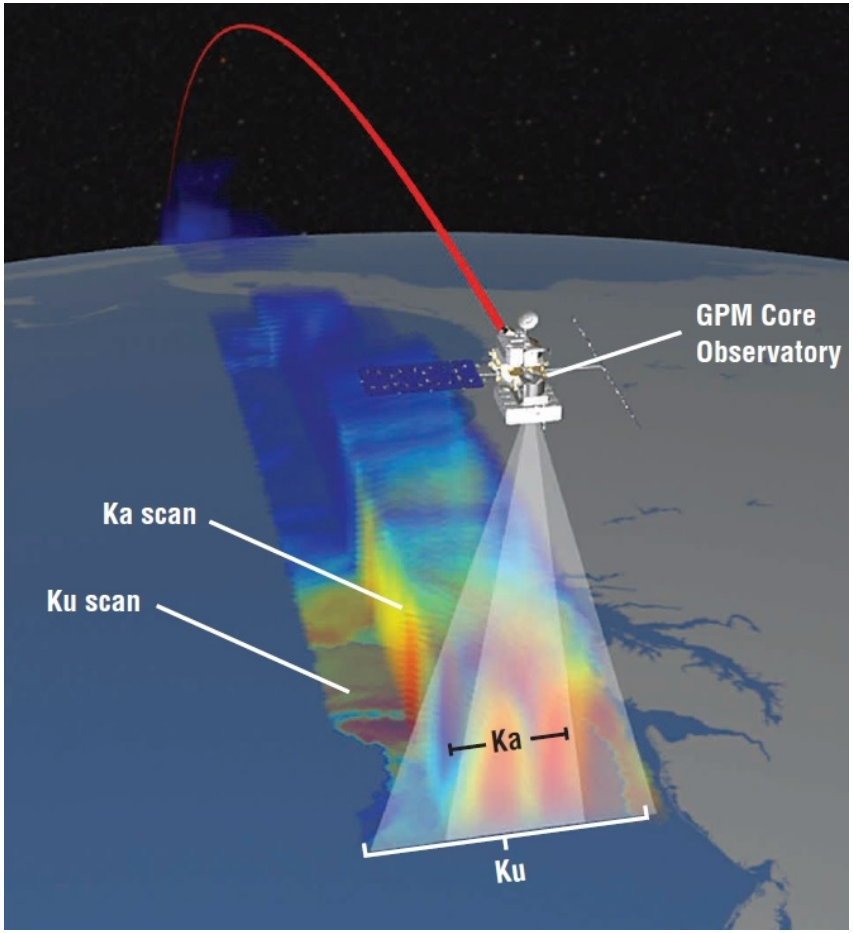
Global Precipitation Measurement (GPM)

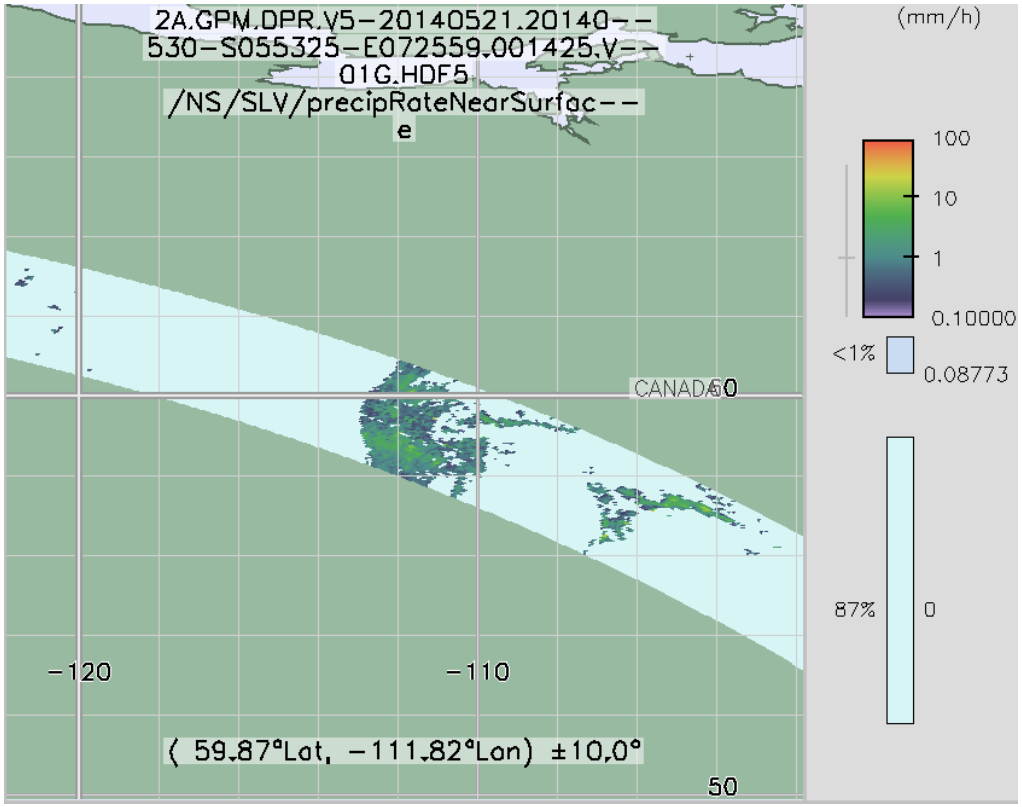




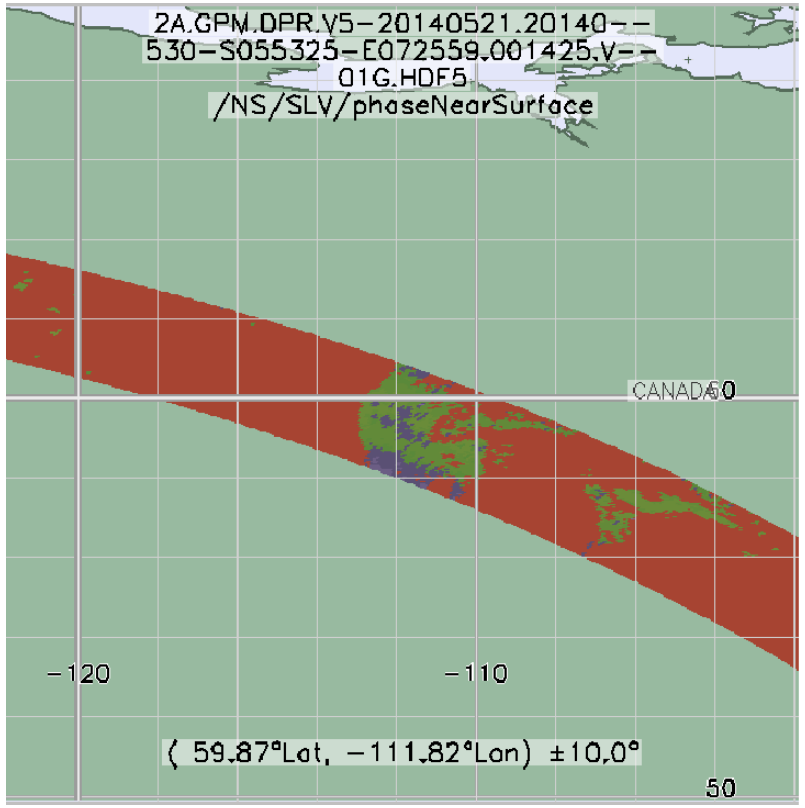
Since March 2014, GPM operates microwave radiometers & radars

GPM Dual-frequency Precipitation Radar (DPR)

Precipitation rate



Precipitation phase



(Data processed by J. Munchak)

It is thus possible to monitor rain on snow directly with GPM, but only up to ∼65N

Conclusion

- Increasing relevance of the impacts of rain-on-snow events
- Motivated for . wintertime climate monitoring
  . supporting climate adaptation

- Developing a rain-on-snow event detection algorithm, especially those leading to the formation of ice layering

- Already very high interests from Sami reindeer herders
- Reward expected by combining traditional & scientific knowledges

- On-going field activities (e.g. Quebec, CHARS, northern Norway) for satellite algorithm and snow evolution model assessments

* Bongo et al., 2012: Eurasian Reindeer Herding, Traditional Knowledge and Adaptation to Climate Change. In: UNESCO.Indigenous Peoples and Climate Change: Vulnerability, Adaptation and Traditional Knowledge. Report of workshop on Indigenous Peoples, Marginalized Populations and Climate Change: Vulnerability, Adaptation and Traditional Knowledge. UNESCO, Paris.

* Callaghan et al., 2013: Ecosystem change and stability over multiple decades in the Swedish sub-Arctic: complex processes and multiple drivers. Philosophical Transactions of the Royal Society B, 368(1624:20120488).

* Eira et al., 2012: Traditional Sami Snow Terminology and Physical Snow Classification – Two Ways of Knowing. Cold Regions Science and Technology, Cold Regions Science and Technology 85 (117-130), doi: 10.1016/j.coldregions.2012.09.004.

* Hansen et al., 2013: Climate events synchronize the dynamics of a resident vertebrate community in the high Arctic. Science, 339(6117), 313-315.

* Maynard et al., 2011: Impacts of Arctic Climate and Land Use Changes on Reindeer Pastoralism: Indigenous Knowledge & Remote Sensing. In: Eurasian Arctic Land Cover and Land Use in a Changing Climate. [Gutman, G. (ed.)]. Springer, pp. 177-205.

* and many other interesting papers on the topic of rain-on-snow events