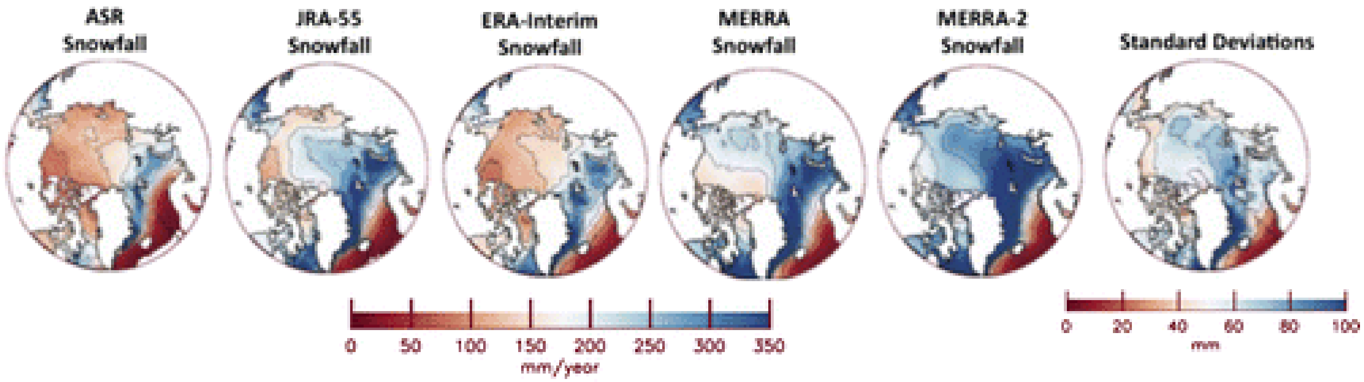
ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms (AC)³

Investigating seasonal and regional distribution of Arctic snowfall in regional climate model simulations: The model-to-observation approach

A. von Lerber, M. Mech and S. Crewell, University of Cologne
D. Zhang, Brookehaven National Laboratory
I. Gorodetskaya, University of Aveiro
A. Rinke, Alfred Wegener Institute

Snowfall in Arctic Region

- Critical climate variable
  - By accumulating on sea ice affects its seasonal growth and decay
  - Contributes to the freshwater input into the ocean
  - Modulates surface albedo



Boisvert et al. 2018

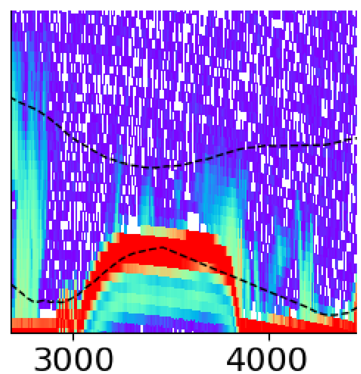
Challenges of quantifying snowfall

In-Situ observations

- Sparse
- Gauges and disrometers prone to wind-induced errors

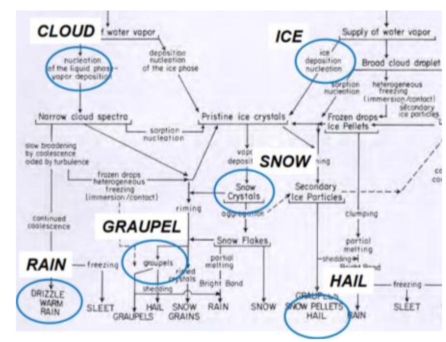
Satellite observations

- Retrieval
- Sensitivity
- Revisiting time
- Clutter
- Swath/Resolution



Modeling

- Microphysical parametrizations
- In climate models precipitation is diagnostic variable



How a regional climate model (RCM) represents the seasonal and regional distribution of Arctic snowfall when compared to satellite observations?

HIRHAM5

- High Resolution Limited Area Model (HIRLAM7) and ECHAM5
- Original resolution is ca. 27 km with 40 vertical levels reaching 30 km
- Utilize 3-hour output of the mixing ratios of cloud ice and liquid, snow and rain

PAMTRA (Passive and Active Microwave TRAnsfer)

- Mixing ratios are interpreted to particle size distributions (PSDs)
- Constant density is assumed for ice (500 kgm^{-3}) and snow (100 kgm^{-3})
- Model the reflectivity at 94 GHz: Mie-scattering for cloud liquid and rain, Self –Similar Rayleigh-Gans for cloud ice and snow.

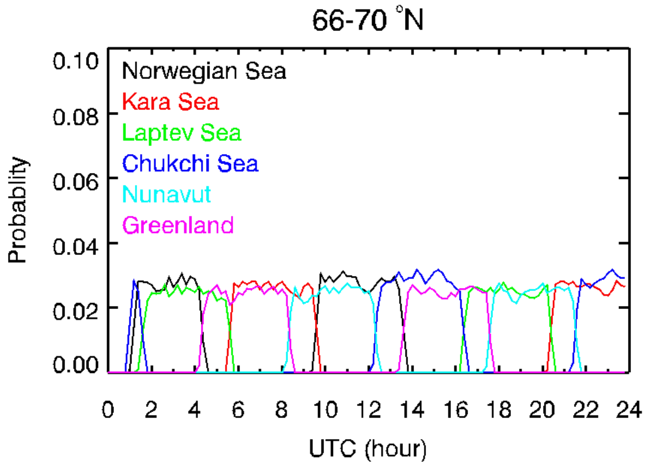
CloudSat

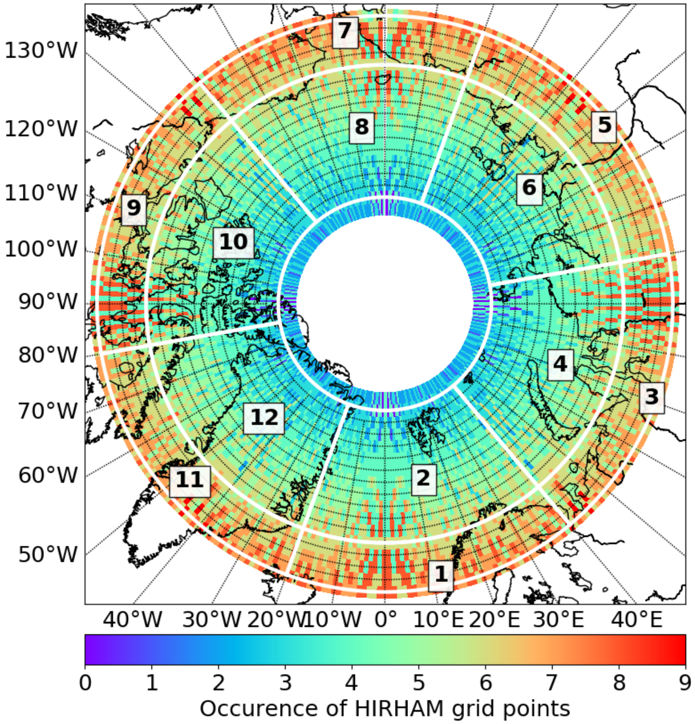
- CPR (Cloud Profiling Radar) at 94 GHz
- Provides coverage reaching 82 deg North with 16 – day repeat cycle
- Footprint of 1.4 km across by 2.5 km along track
- Two products are utilized 2C-PRECIP-COLUMN and 2C-SNOW-PROFILE

The studied regions

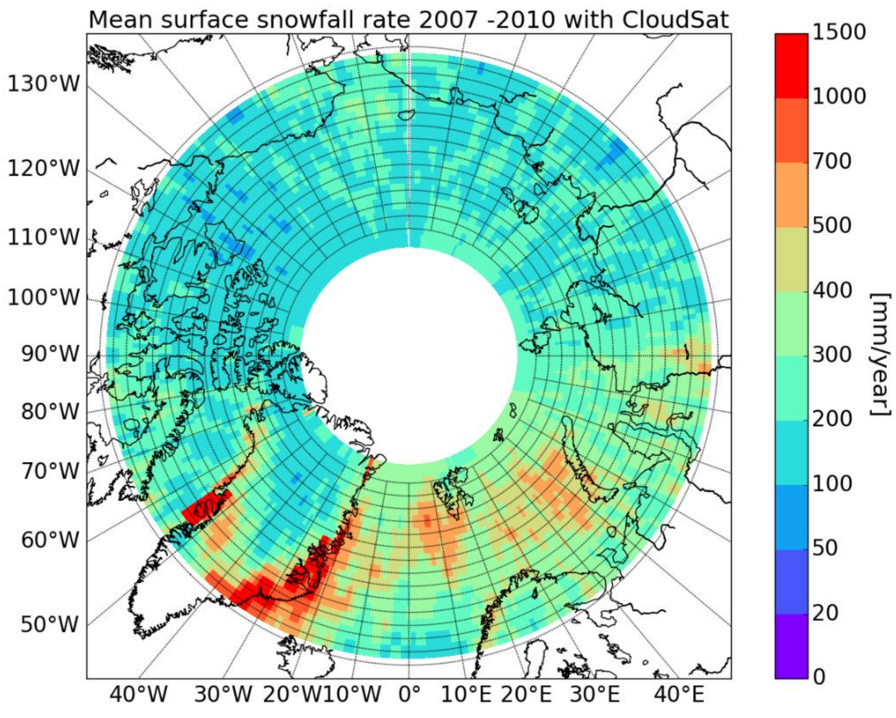
- The studied time period is 09/2006 – 12/2010
- The Arctic region is divided to 12 different areas, six longitude sectors and two different latitude bands
- The gridding is in 1° x 1 ° bins

Nr	Lon	Lat	Region
1 2	20°W - 40°E	66° - 70° 70° - 81°	Nordic Seas (Norwegian Sea)
3 4	40°E - 100°E	66° - 70° 70° - 81°	Kara Sea
5 6	100°E - 160°E	66° - 70° 70° - 81°	Laptev Sea
7 8	160°E - 140°W	66° - 70° 70° - 81°	Chukchi Sea and Beaufort Sea
9 10	140°W - 80°W	66° - 70° 70° - 81°	Canadian archipelago, (Nunavut)
11 12	140°W - 80°W	66° - 70° 70° - 81°	Greenland and Baffin Bay

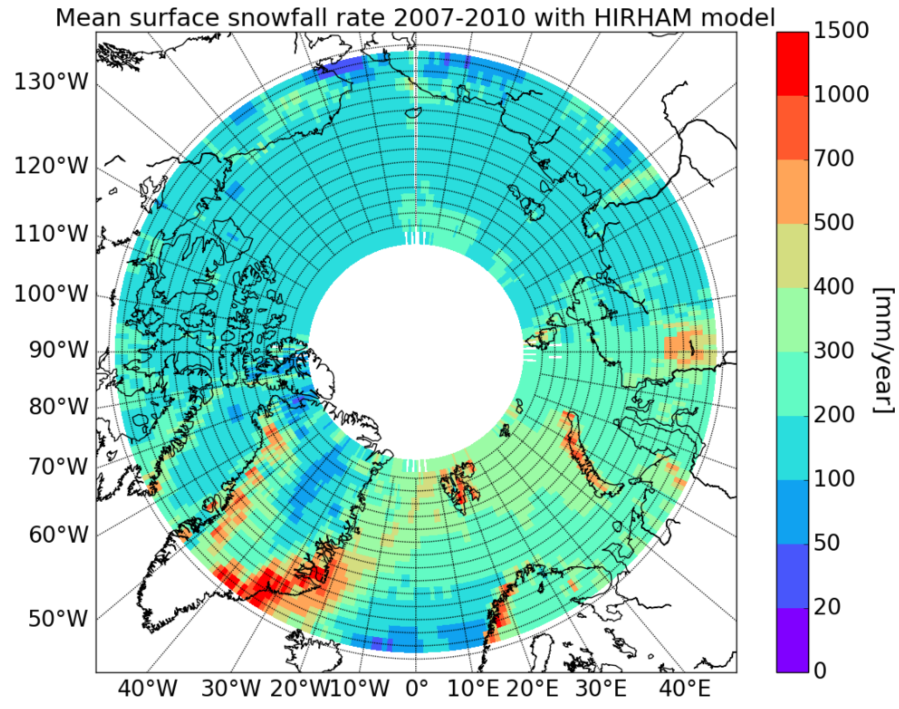




Mean yearly snowfall rate with HIRHAM/CloudSat



CloudSat

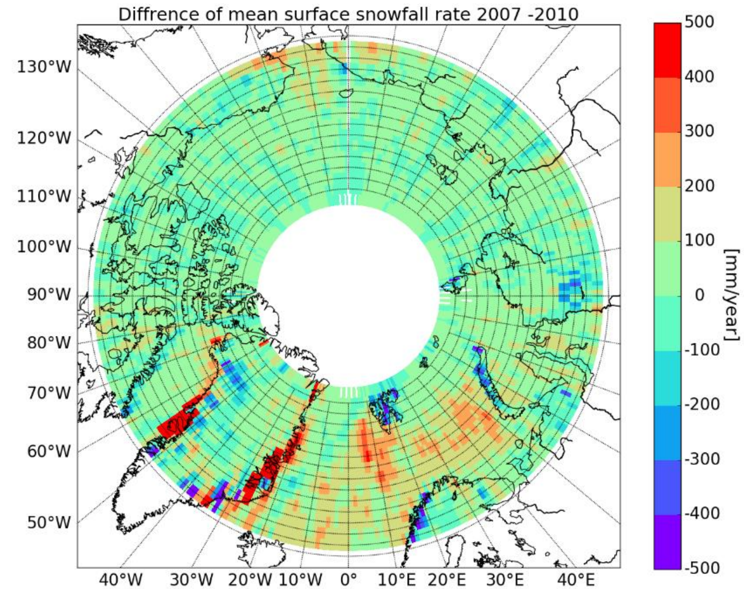


HIRHAM5

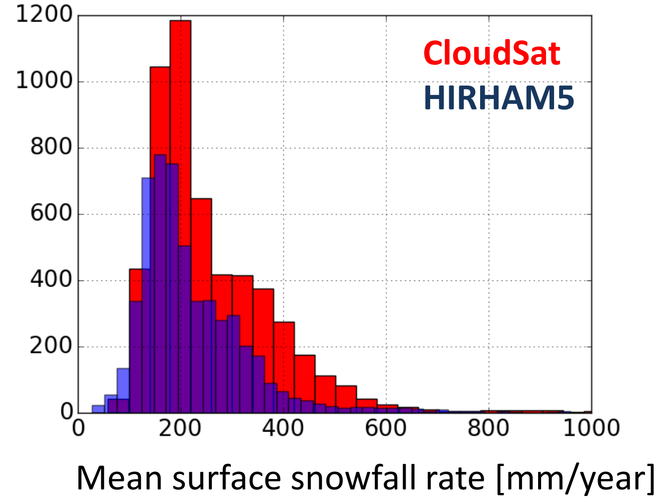
- Enhanced snowfall accumulation at the coast of Greenland, more pronounce at southeastern part and Artic North Atlantic
- Least accumulation in the Beaufort Sea, Canadian archipelago and Siberia
- Path of the cyclones

Mean yearly snowfall rate with HIRHAM/CloudSat

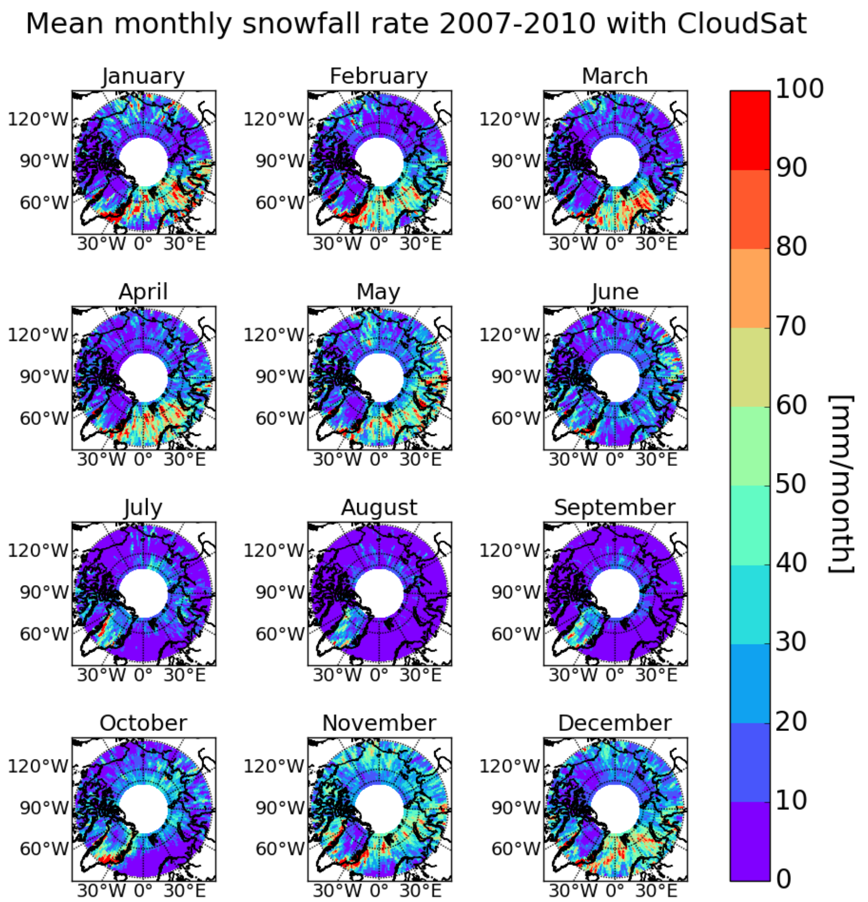
- Differences
  - Orographic effect
  - Overestimation of satellite observations because of the clutter
  - Mean difference is 52 mm/year (20% of CloudSat mean annual precipitation)
  - CloudSat observes higher snowfall rates

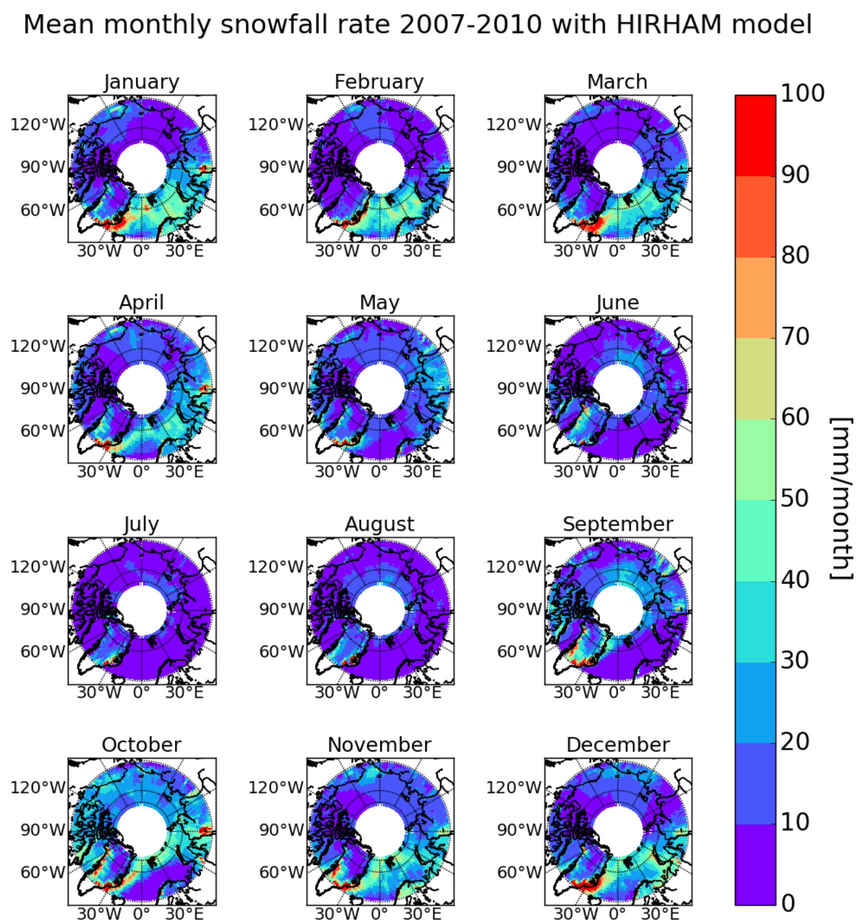


CloudSat – HIRHAM5



Monthly yearly snowfall rate with HIRHAM/CloudSat

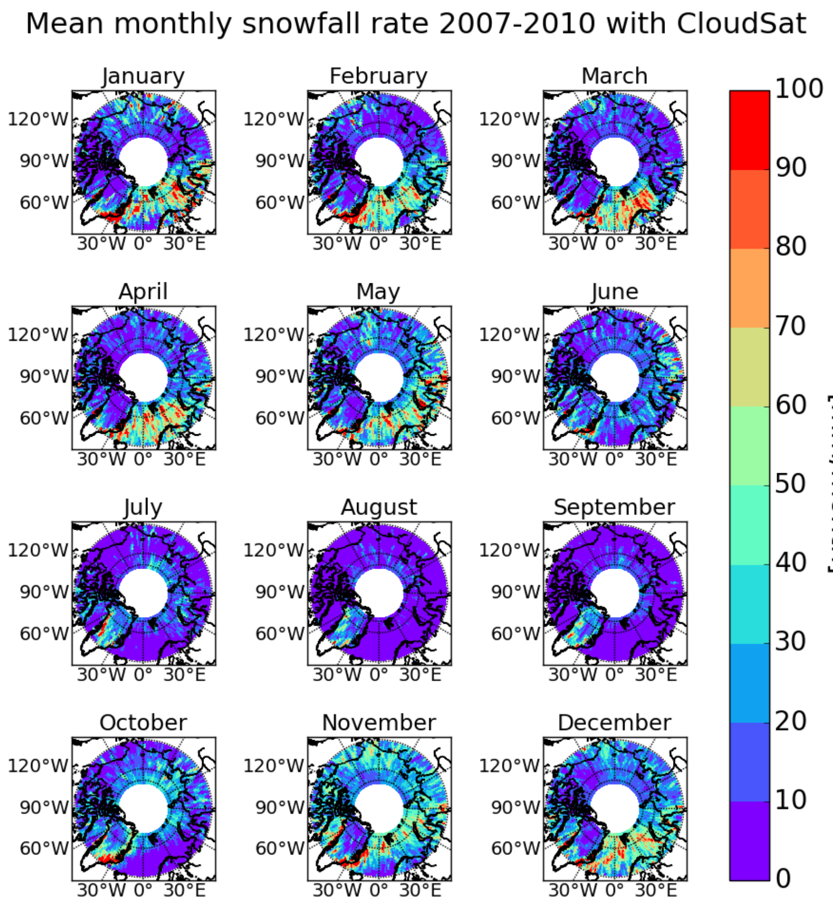




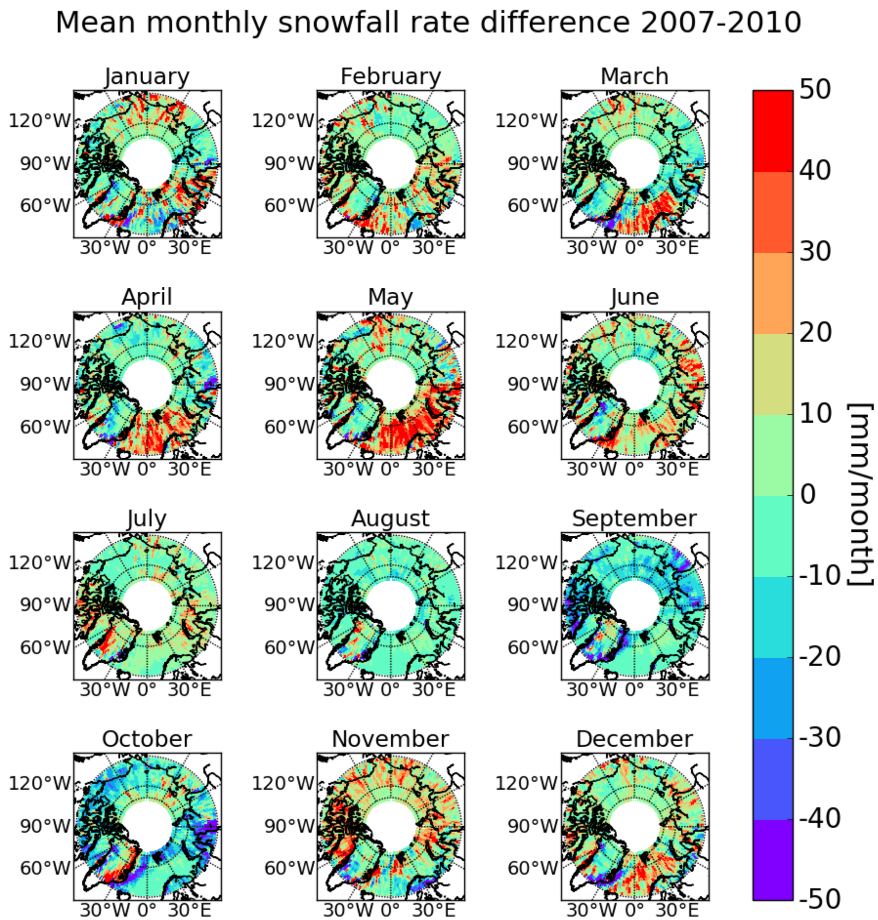
CloudSat

HIRHAM5

Monthly yearly snowfall rate with HIRHAM/CloudSat

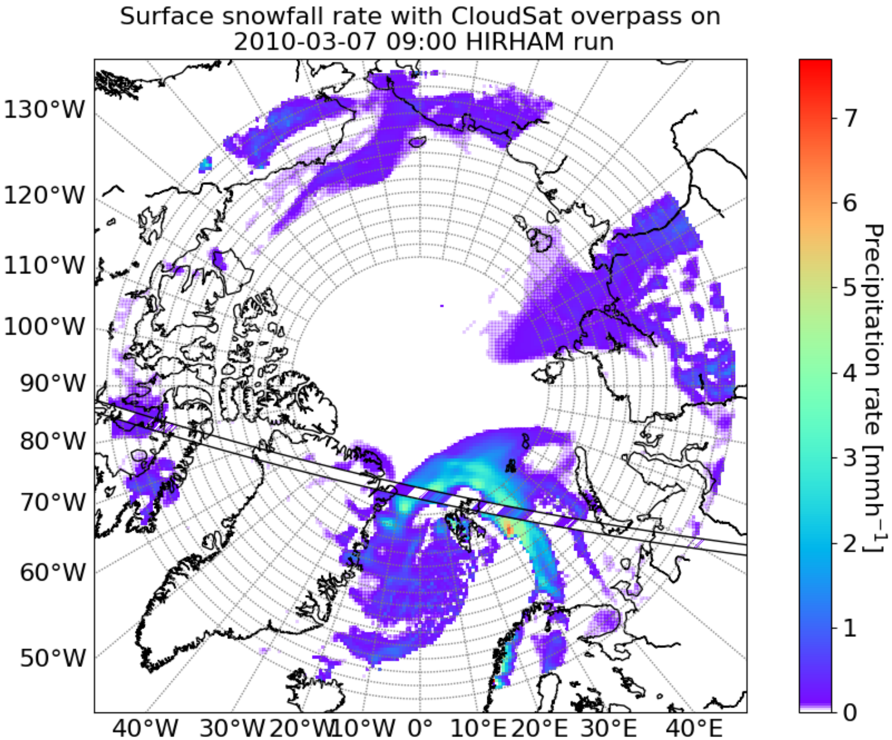


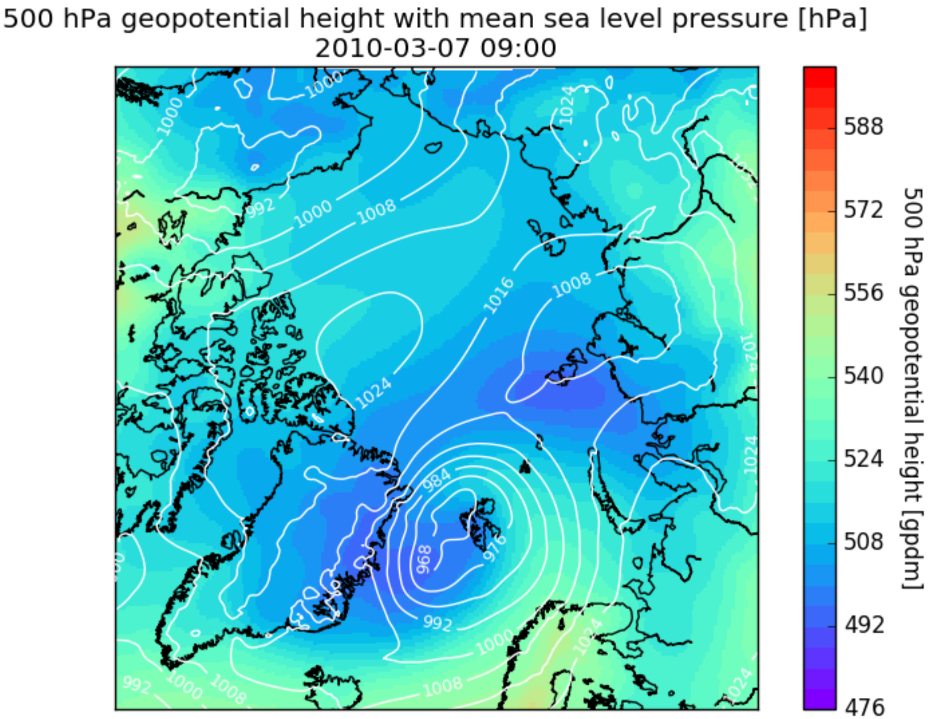
CloudSat



CloudSat – HIRHAM5

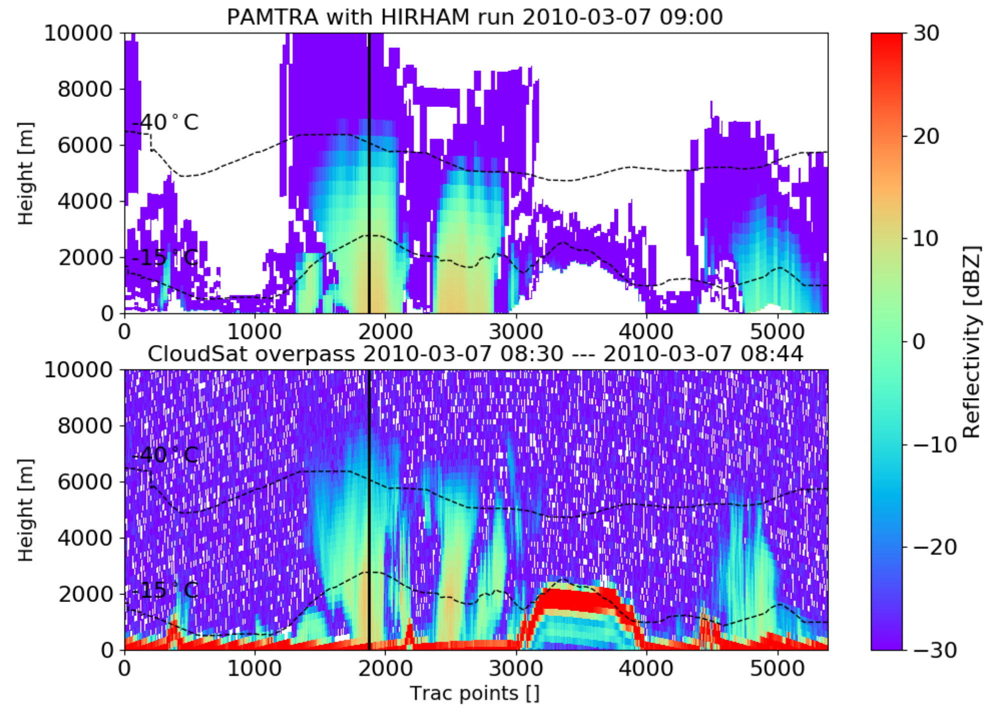
Case Study I: 2010 -03 -07

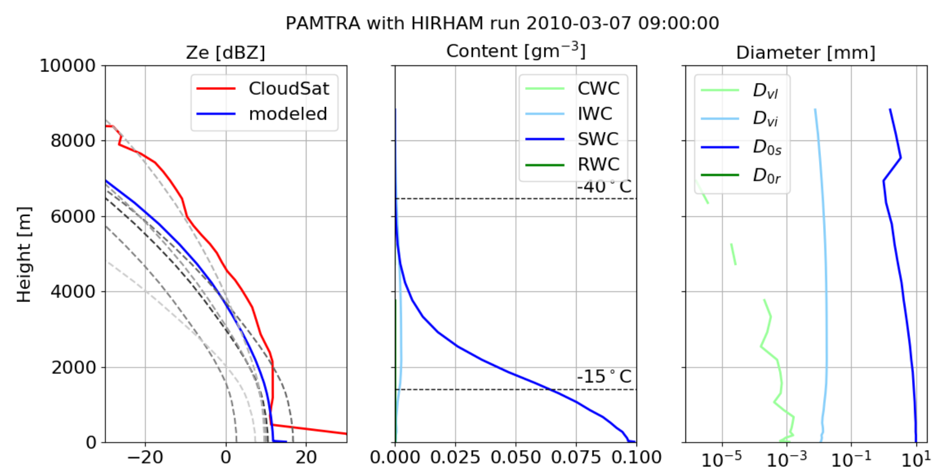




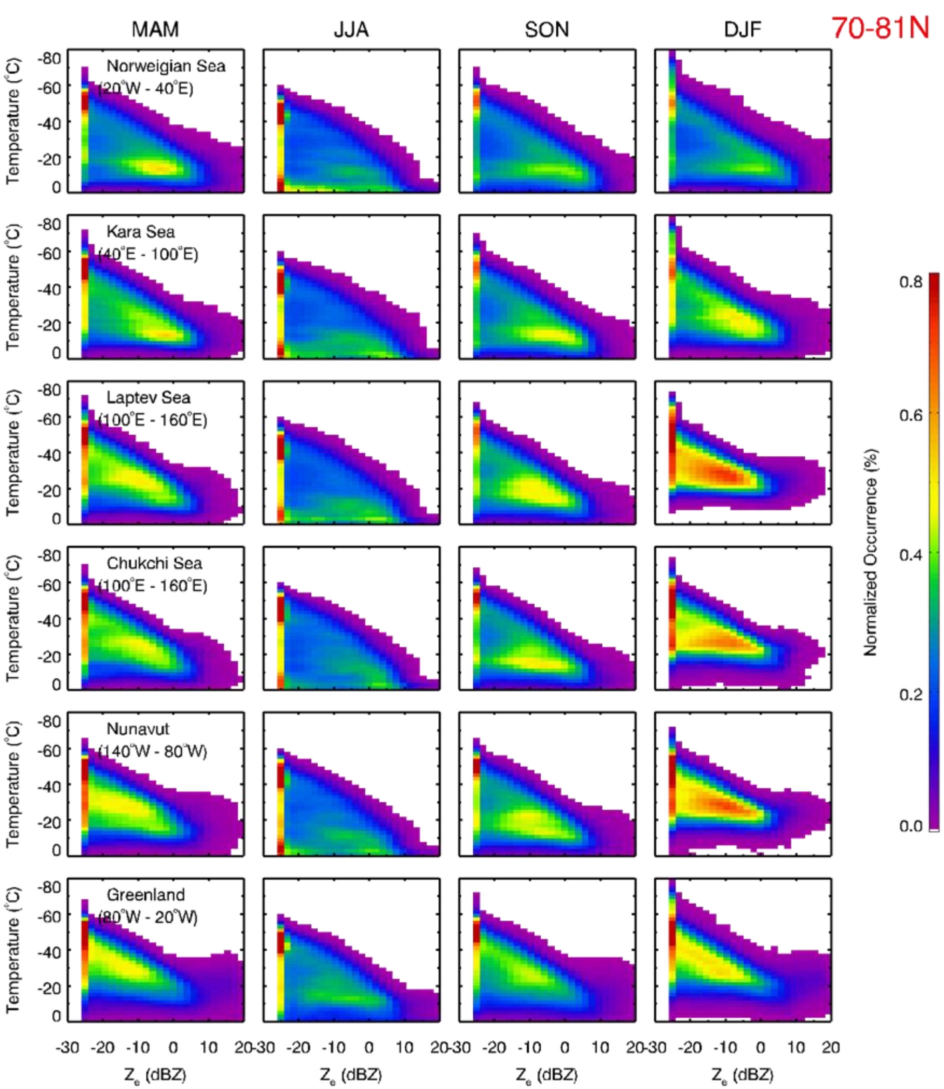
Case Study I: 2010-03-07

- Temporal and spatial correspondence is good (nudging)
- Reflectivity values are comparable in the snow
- Compared to literature values (Liu 2008, Matrosov 2007, Heymsfield et al. 2016)
- Modeled mean volume diameter of ice typically tens of microns

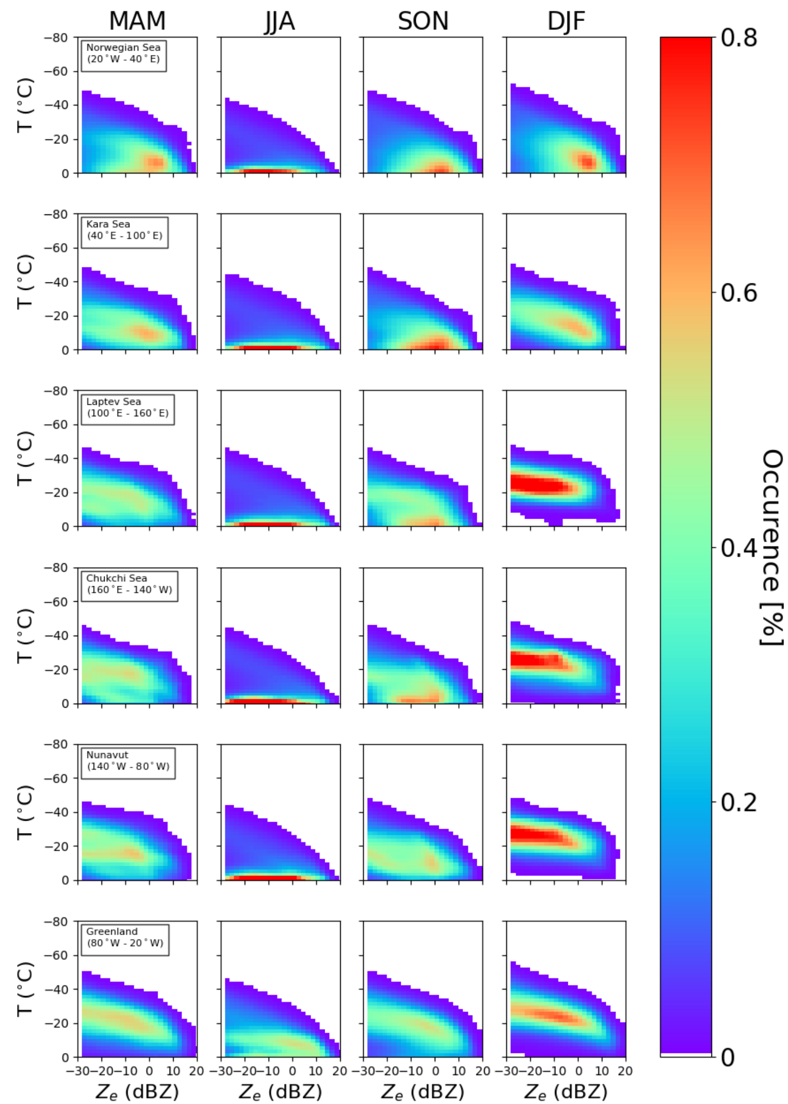




Contoured Frequency by Temperature Diagram (70°-81°)



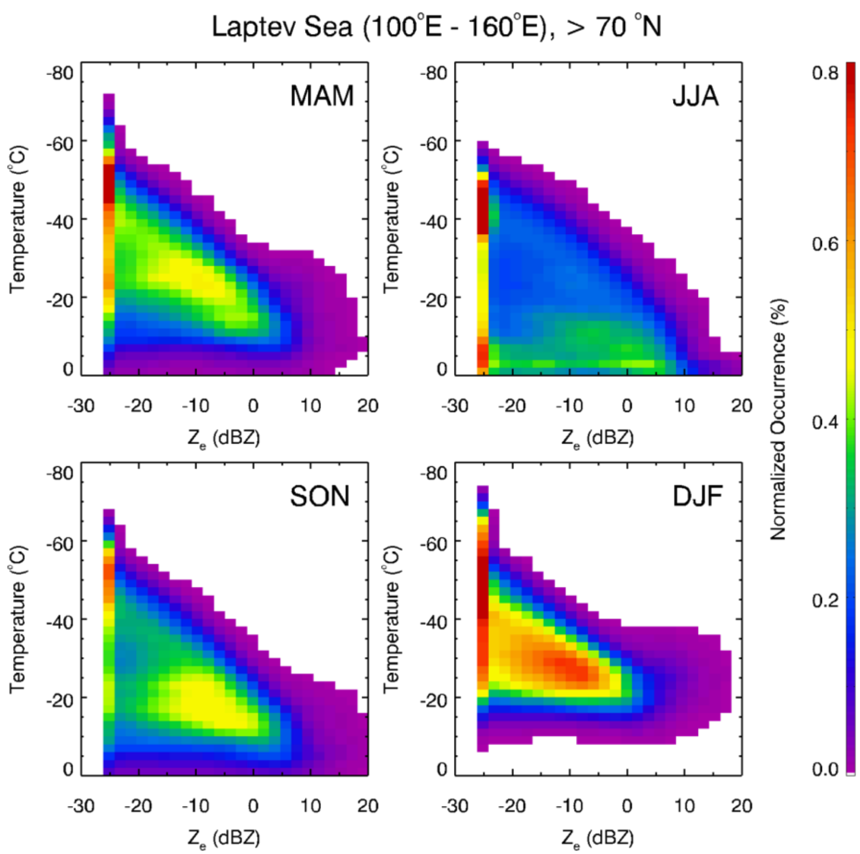
CloudSat



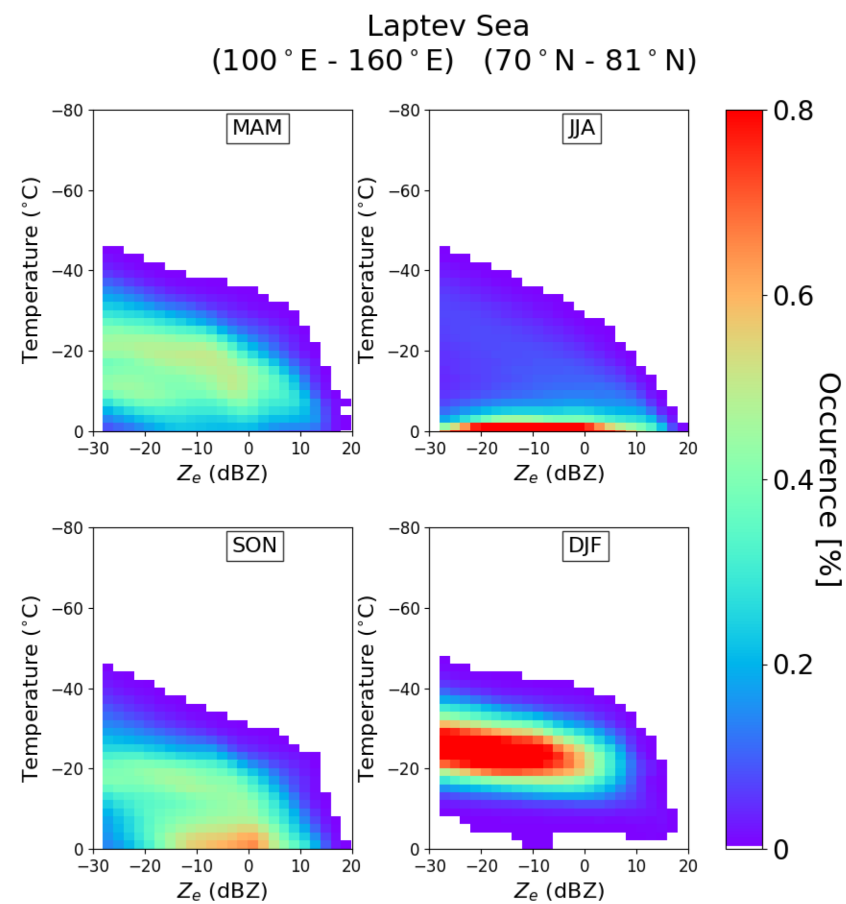
HIRHAM5

Contoured Frequency by Temperature Diagram (70°-81°)

Laptev Sea (70°-81°)



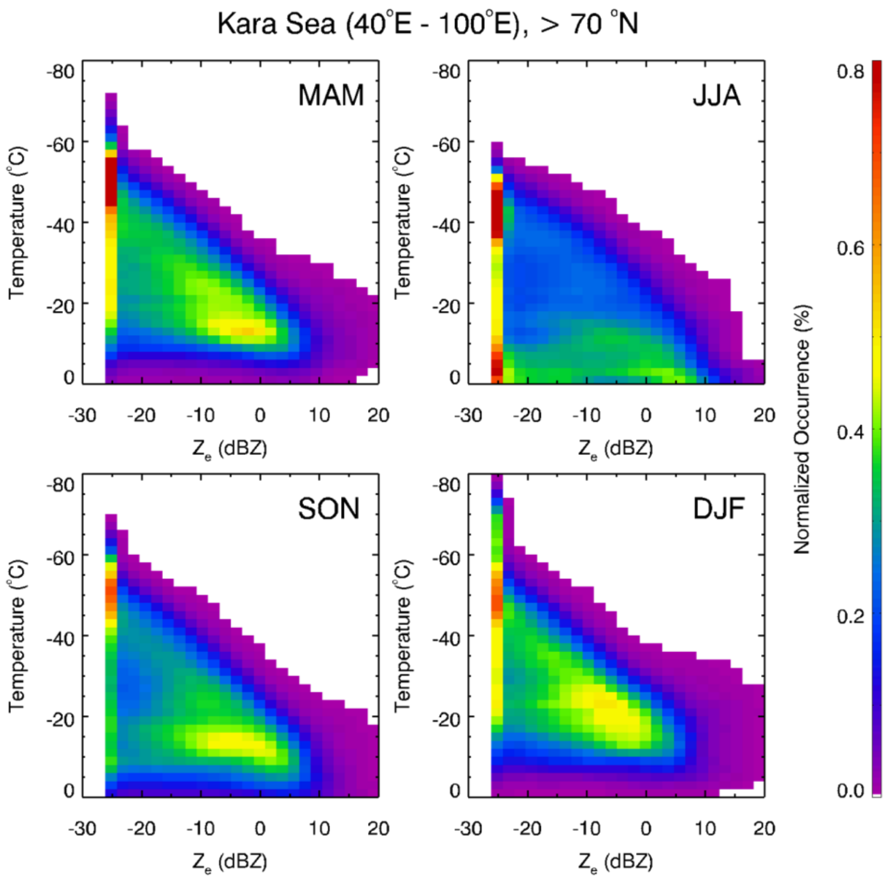
CloudSat



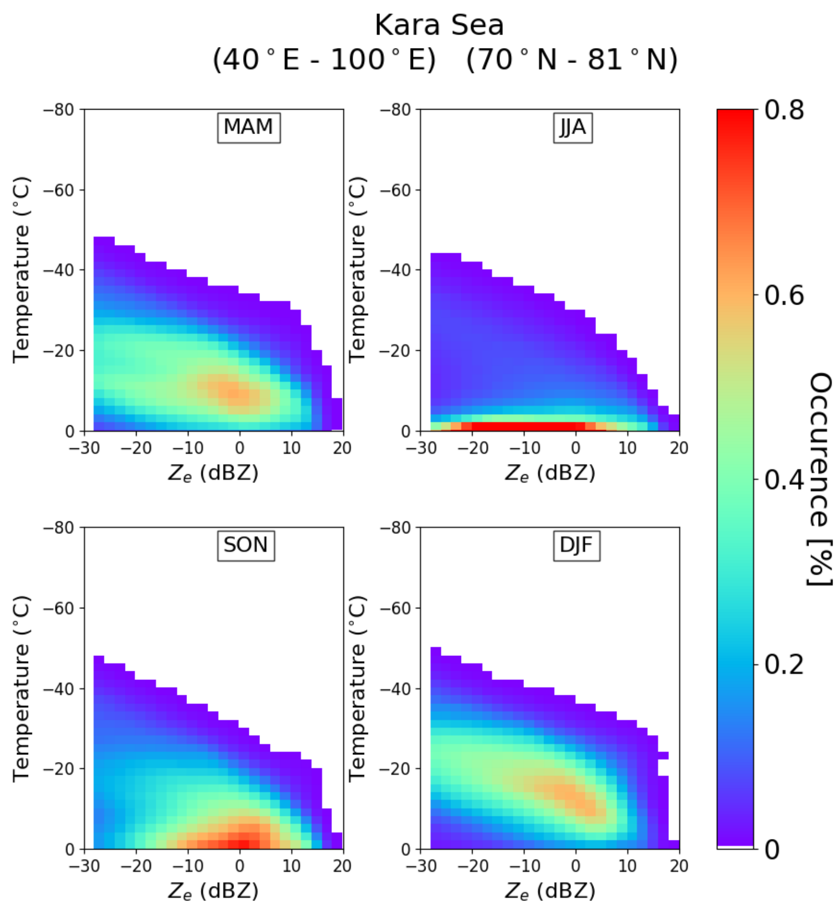
HIRHAM5

Contoured Frequency by Temperature Diagram (70°-81°)

Kara Sea (70°-81°)



CloudSat



HIRHAM5

Conclusions

- The focus on this study is how RCM represents the seasonal and regional distribution of Arctic snowfall when compared to satellite observations

- Modeled reflectivity values are comparable in the snow

- Cyclone driven seasonal changes are representative in the model, when compared to observations

- Requires more detailed study of the differences in respect to snowfall microphysical processes