Precipitation in Ny Ålesund :

Temperature dependence and synoptic patterns

Athulya R

Research Scholar

Arctic Ocean-atmosphere interaction group

MoES-National Centre for Polar and Ocean Research

Goa, India

Past and Ongoing studies from our group

- Precipitation studies
  - Extreme precipitation case studies
  - Tropospheric connection of precipitation
  - Vertical evolution of precipitation
- Arctic – tropics teleconnections
- Fjord studies – Observations and ROMS model
- Arctic large-scale ocean and atmospheric circulation studies
- Sea-Ice Ocean modelling studies using MOM.

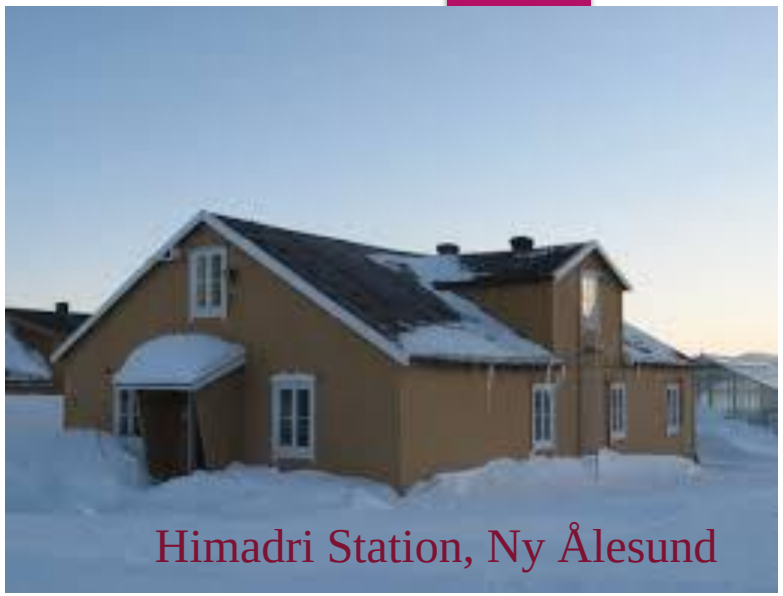
Atmospheric measurements of NCPOR in the Arctic

2013 to present

Instruments for precipitation-related measurements

Over The Top (OTT) Parsival disdrometer– ground – 1min

Micro Rain Radar (MRR) – up to 6km – 1 min data



Himadri Station, Ny Ålesund

Radiometer – up to 10km – 21 levels – 2 min data

Ceilometer – 15km- 6 sec data

Gruvebadet Observatory, Ny Ålesund

Foto di Marco Casula (CNR-ISP)

RiS ID 12263: Monitoring Arctic precipitation (MAP)

Available data

OTT-Parsivel (2018 – present)

- Precipitation intensity
- Precipitation type
- Radar reflectivity
- MOR visibility
- Number of particles detected
- Kinetic energy

Micro Rain Radar (2013 – present)

- Particle size
- Reflectivity
- Fall velocity
- Vertical Precipitation profile

Radiometer – up to 10km (2014 - present)

- Air Temperature profile
- Humidity profile
- Wind profile
- Pressure profile

Ceilometer – up to 15km (2015 - present)

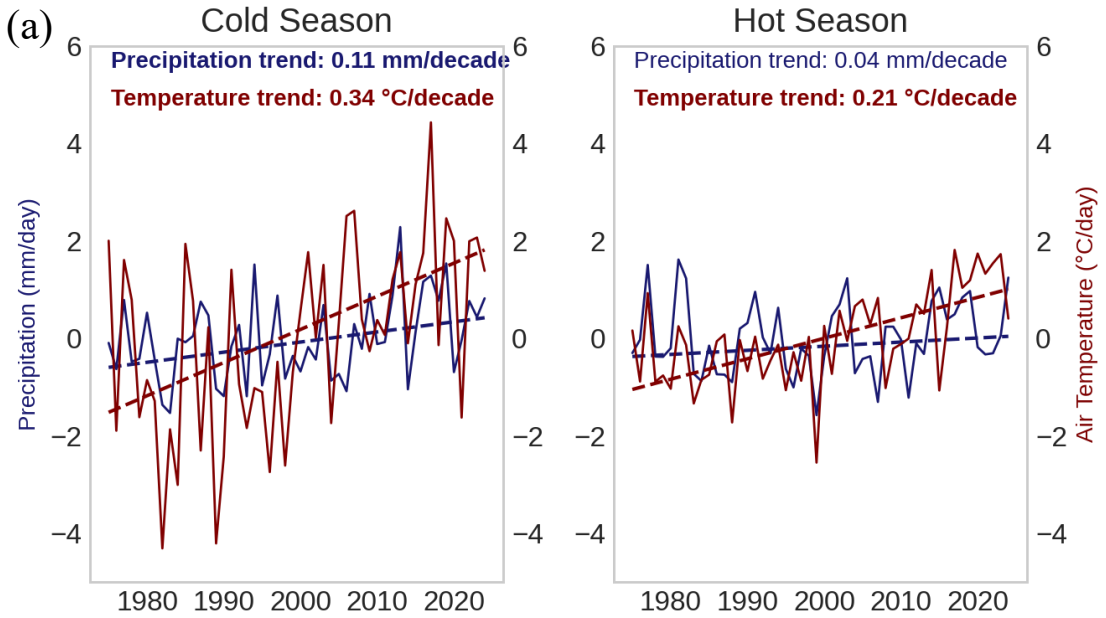
- Cloud base height

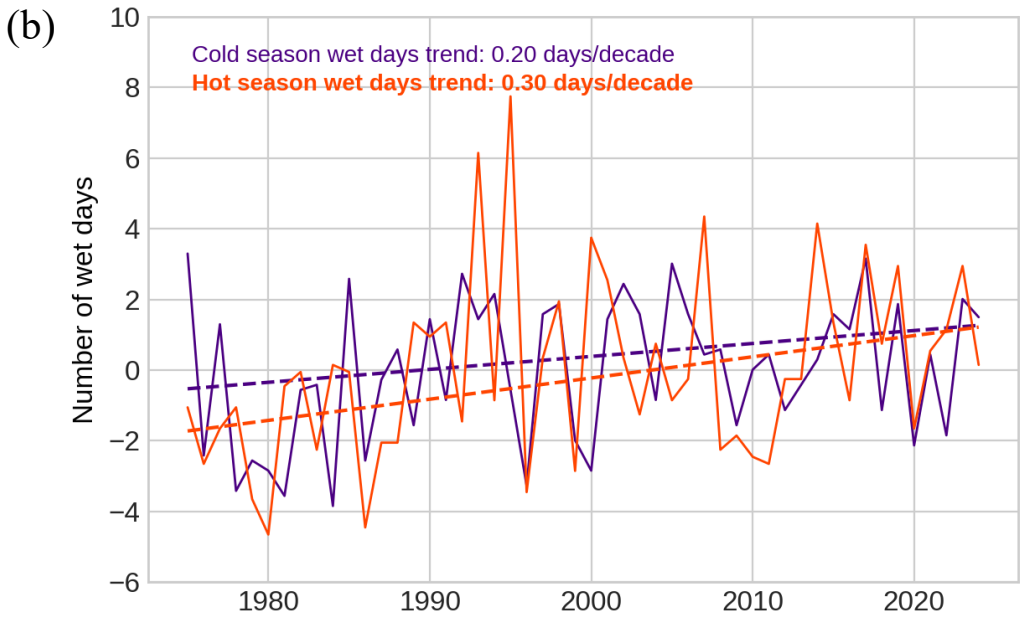
Acknowledgement

- Arctic logistics group - NCPOR
- Norwegian Polar Institute, NPI
- Alfred Weigner Institute AWI – PEV
- CNR, Italy
- Kingsbay, Ny Ålesund
- Norwegian Meteorological Institute – MET NORway

Arctic Amplification:

Long-term trend in Precipitation – Temperature in Ny Alesund





MET – NORway daily observations

- Cold season has increasing air temperature and precipitation.
- Hot season has increase in wet days

Clausius-Clapeyron Scaling in Ny Alesund

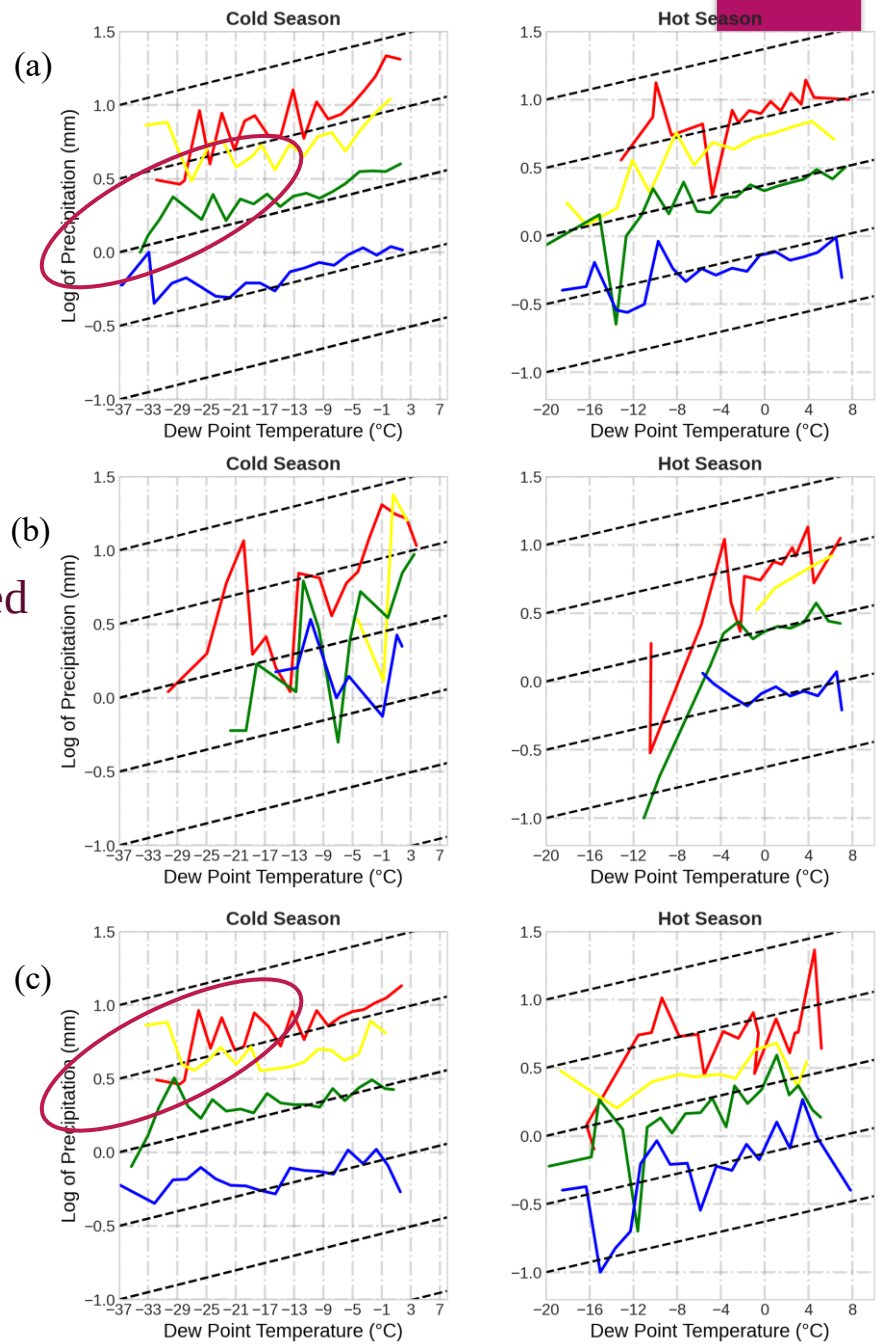
Temperature ↑ Saturation vapour pressure ↑ exponentially

1°C ↑ temperature 7% ↑ in precipitation

> 99th percentile	Extreme precipitation
80th to 99th percentile	Heavy precipitation
50th to 80th percentile	Moderate precipitation
10th to 50th percentile	Weak precipitation

20 bins of dew point temperature and precipitation are constructed and plotted

- Daily P-T relation for extreme events follow CC scaling in cold season
- Beyond 0°C there is a dip in precipitation in cold season and beyond 4 °C in hot season.
- For a small temperature range -4 °C to 4°C rain in hot season exceeds CC scaling
- Snow-DewT scaling follows P-T scaling pattern.



MET – NORway daily observations

1974-2023

> 99th percentile

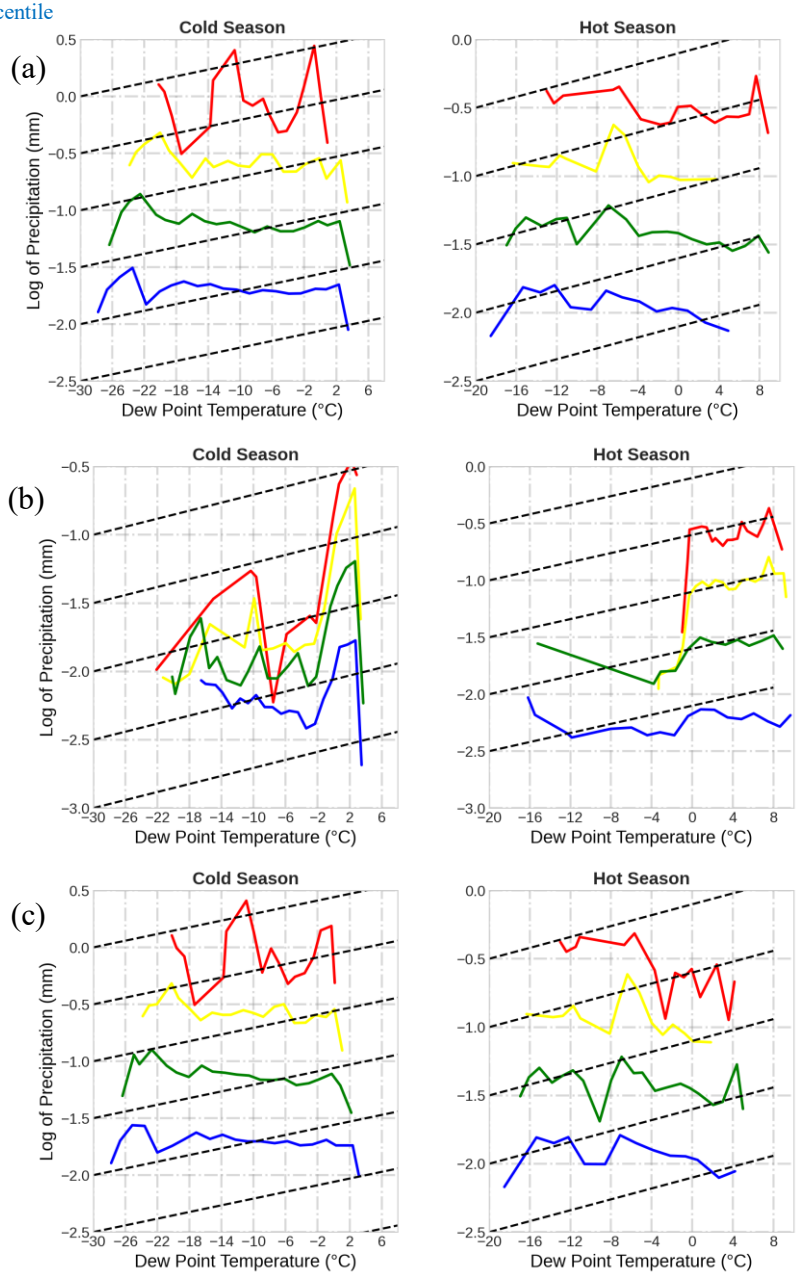
80th to 99th percentile

50th to 80th percentile

10th to 50th percentile

OTT – AWS 5min observations

2018-2023



Precipitation (Rain+Snow)

Rain

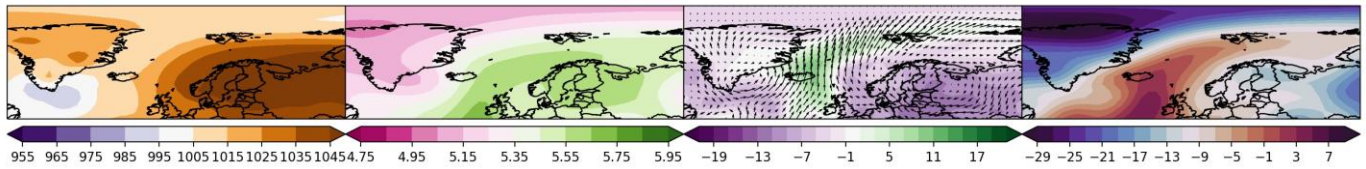
Snow

- For high resolution data in the past 6 years scaling is not observed in any season.
- The dip in precipitation is observed beyond 0 °C in the cold season and 8 °C during rain and 4°C during snow in the hot season

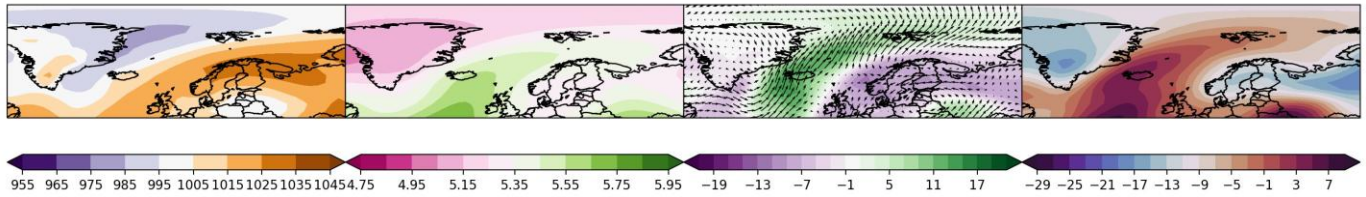
Case studies

(a) Cold Season extreme precipitation event synoptic conditions

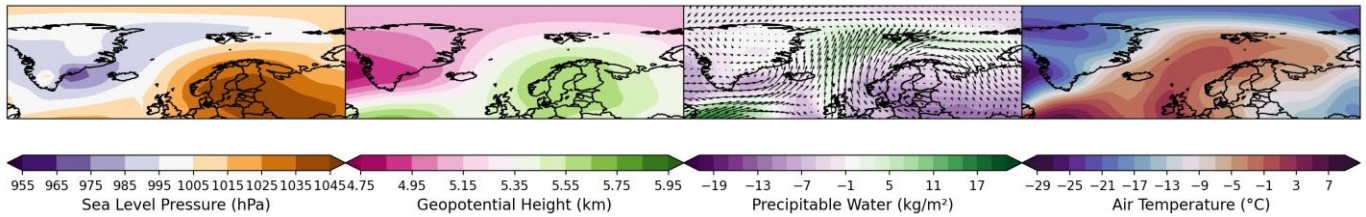
2012 Jan 29



2016 Nov 07

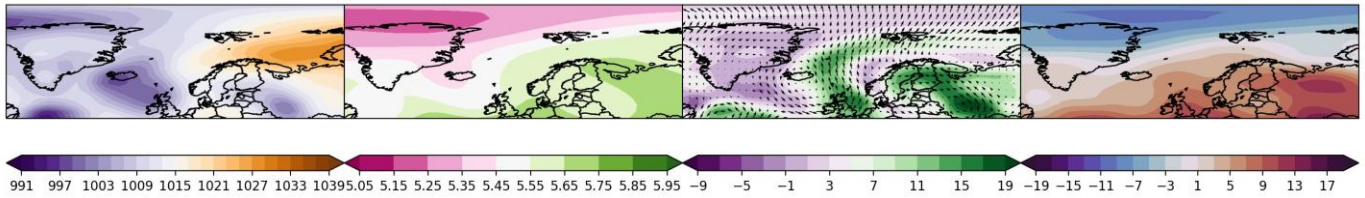


2018 Jan 13

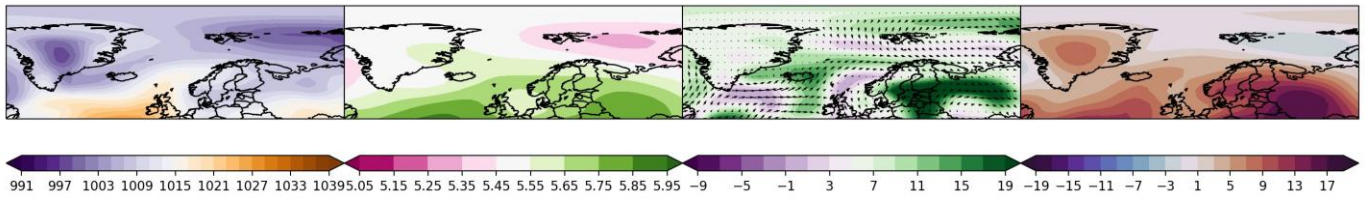


(b) Hot Season extreme precipitation event synoptic conditions

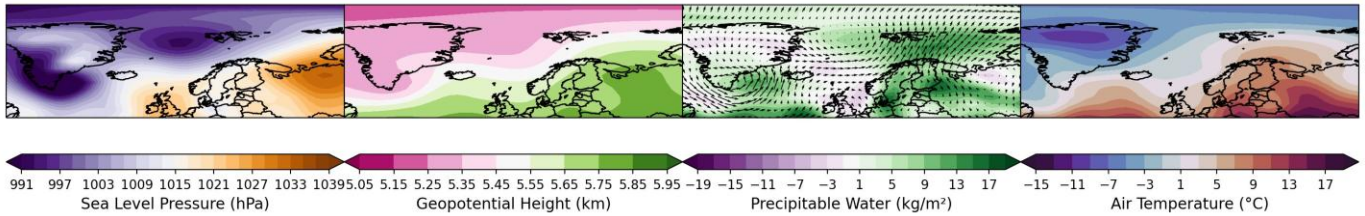
1980 Aug 11



2002 Jul 21



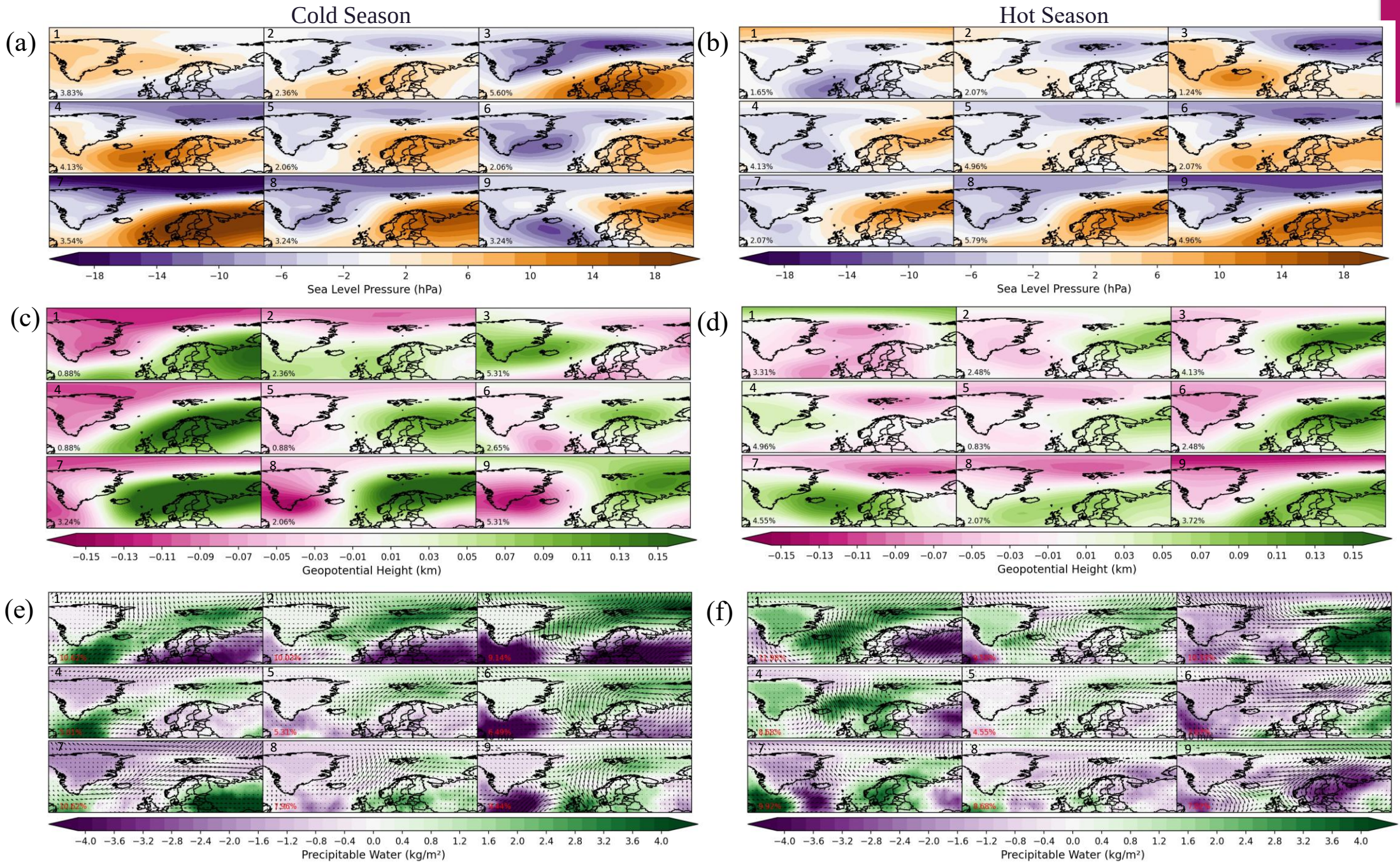
2018 Aug 30



Common Features

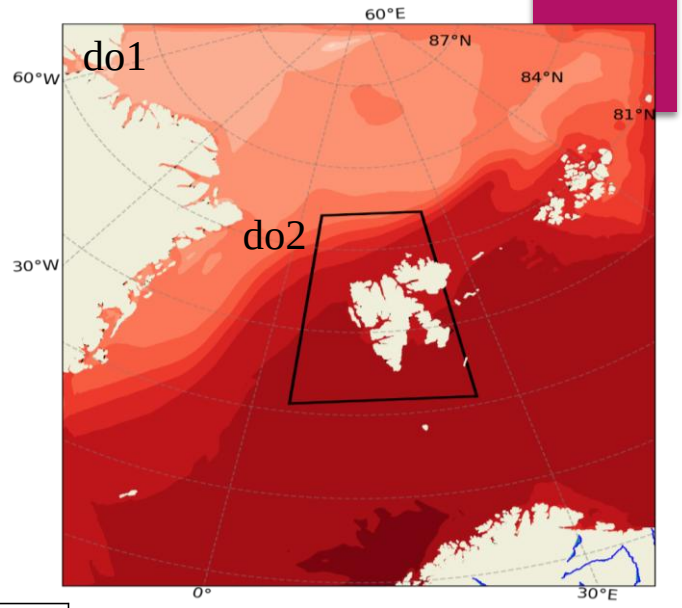
- Strong blocking over northern Europe
- Southerly Moisture/Temperature advection

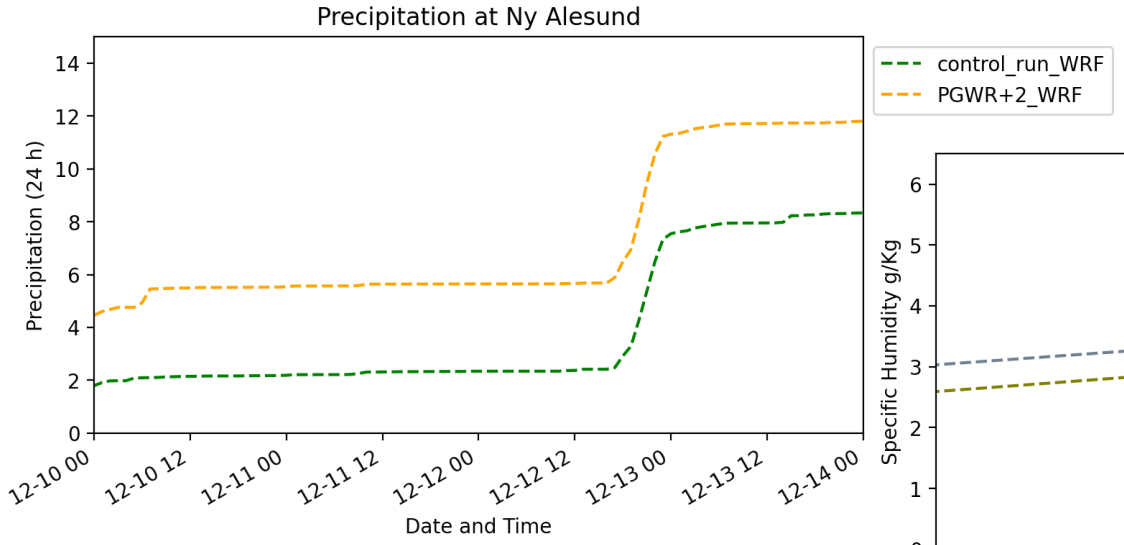
Self Organising Maps - Synoptic atmospheric patterns during extreme precipitation weather events

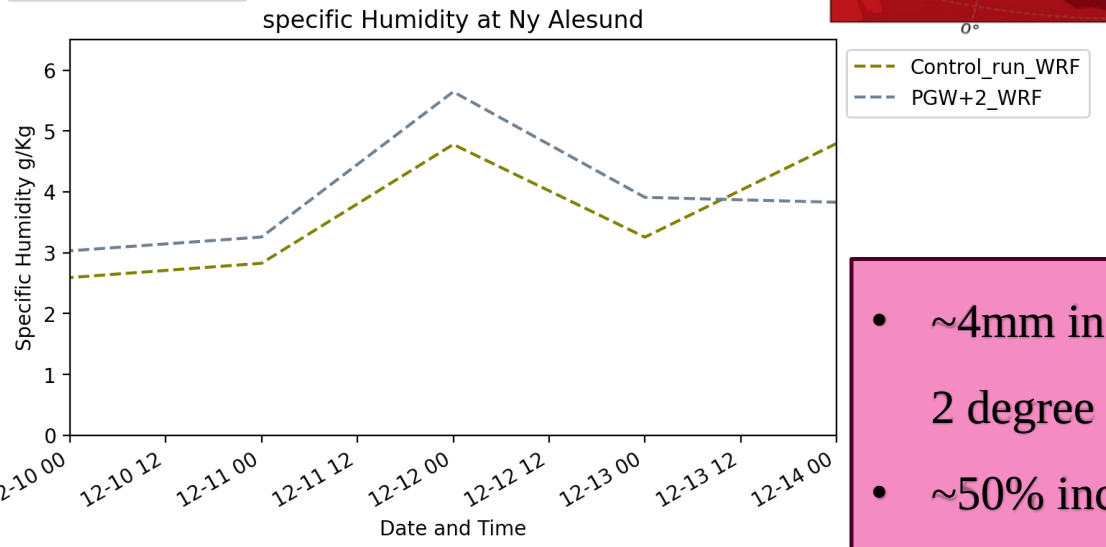


Studying Ny Ålesund using Polar WRF – Pseudo Global Warming Experiment

- For the Pseudo Global Warming (PWG) Experiment, the temperature fields of initial and boundary conditions are perturbed by +2°C (PGWR+2) (Schär et al, 1996).

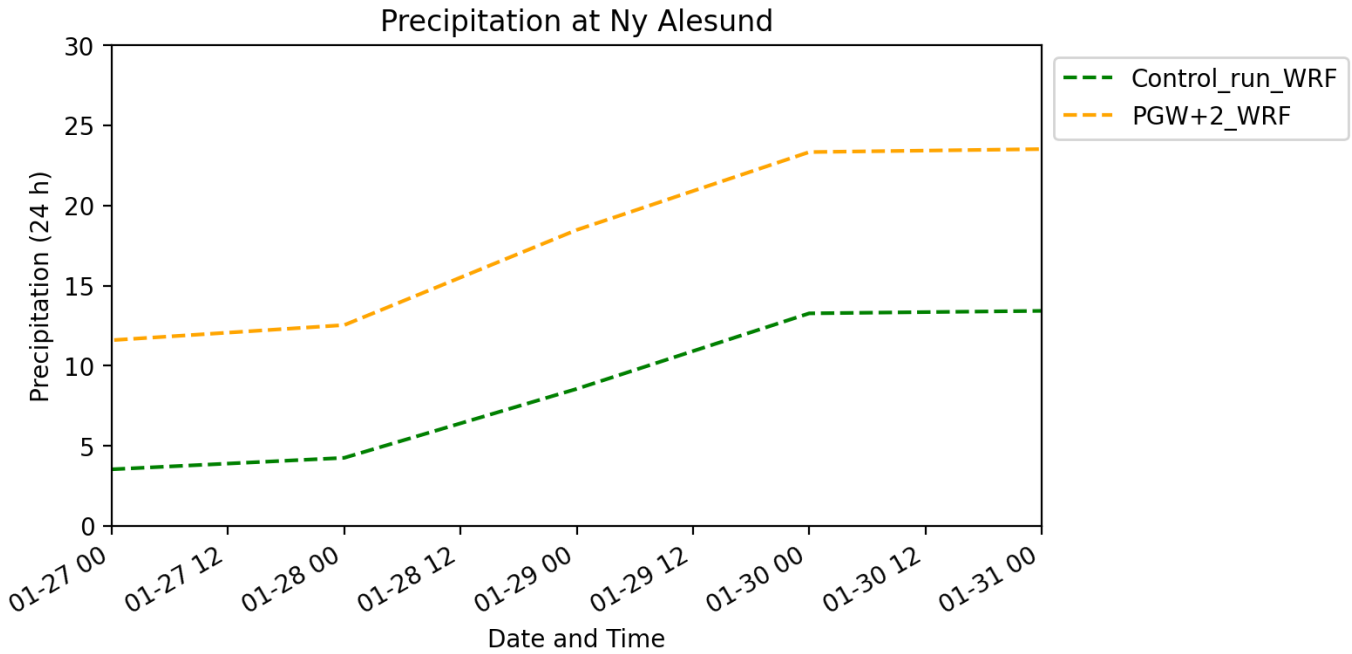






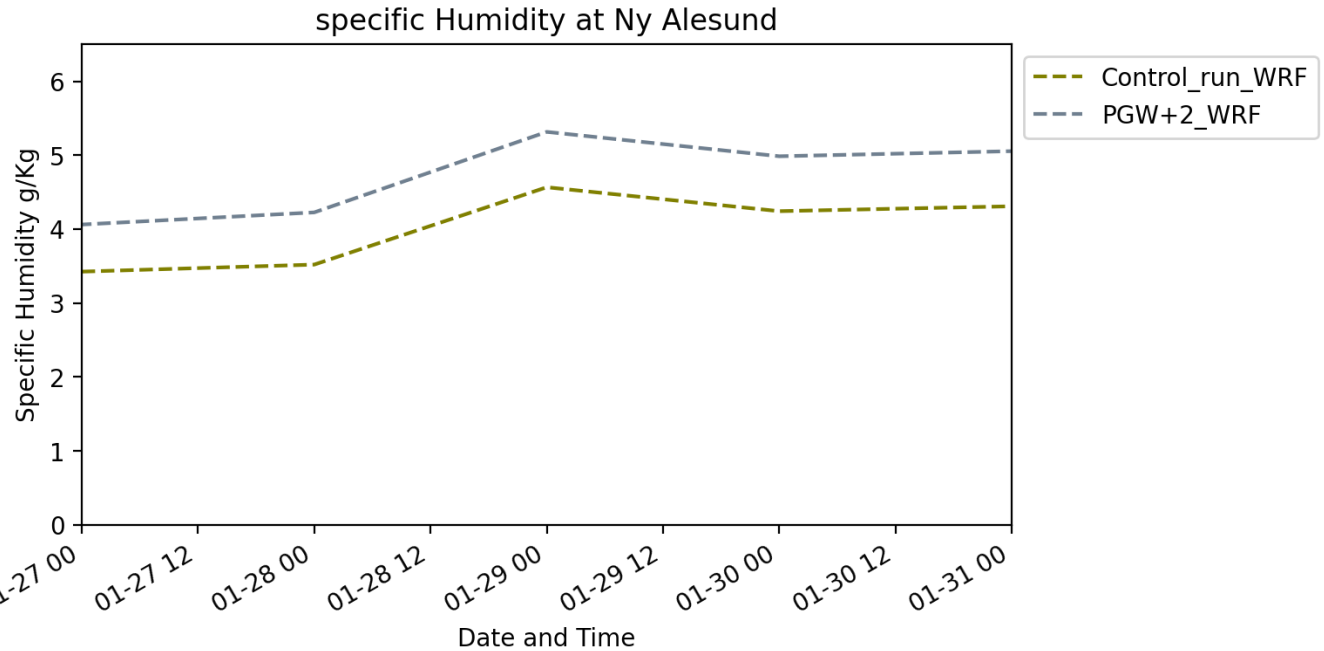
2018 December event

- ~4mm increase in precipitation with 2 degree increase in temperature
- ~50% increase in precipitation
- Surface air temperature < 0



- ~10mm increase in precipitation with 2 degree increase in temperature
- 71% increase in precipitation
- Surface air temperature > 0

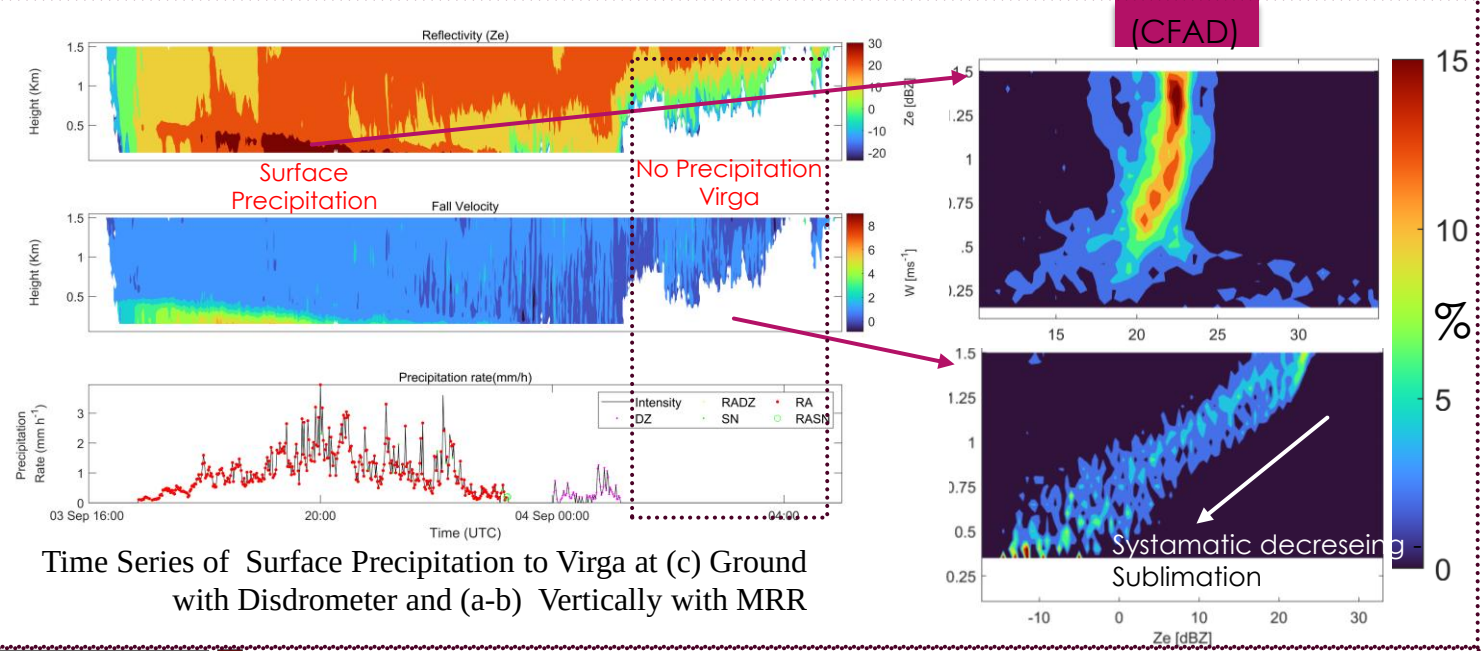
2012 Jan event – Top extreme precipitation event.



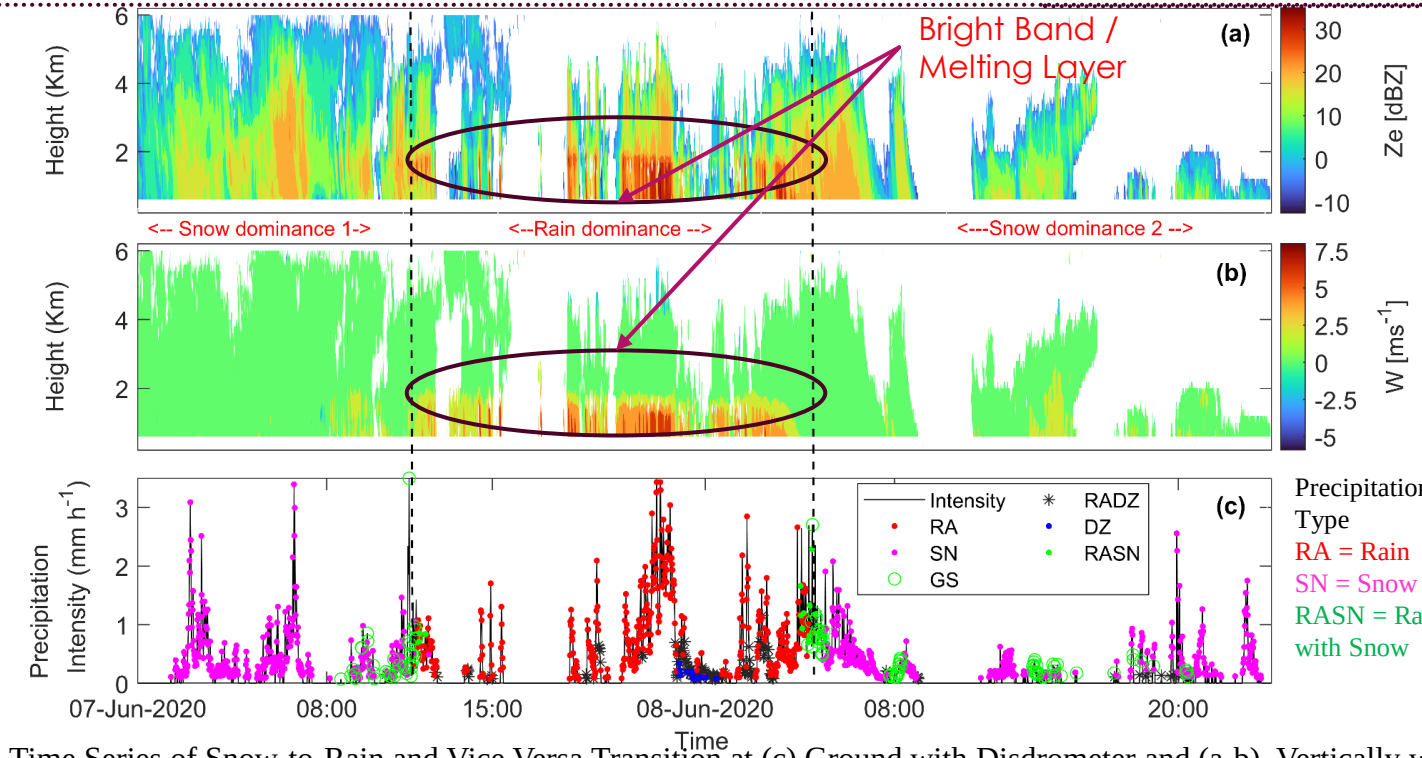
The precipitation observed by MET- NORway was **98mm** on this day but it was not represented in ERA5 data which was used as boundary conditions for PWRF run.

Micro rain radar (MRR)

Disdrometer

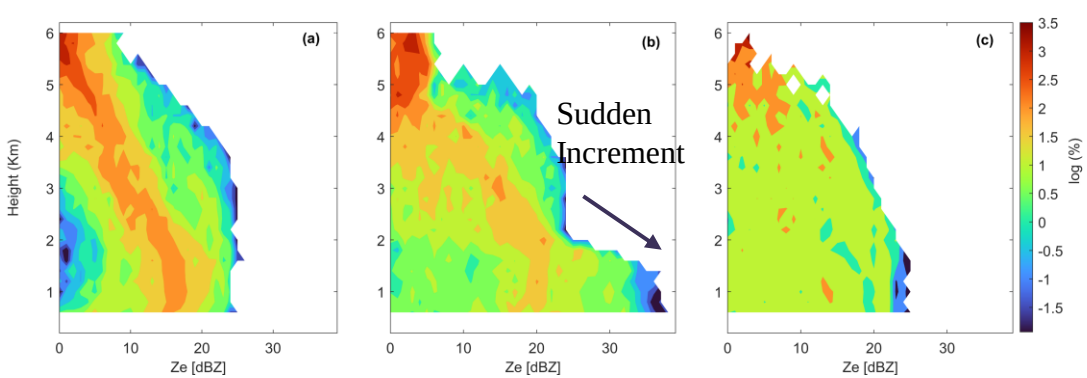


Time Series of Surface Precipitation to Virga at (c) Ground with Disdrometer and (a-b) Vertically with MRR



Precipitation Type
RA = Rain
SN = Snow
RASN = Rain with Snow

Contour frequency by Altitude Diagram (CFAD)



- Limiting within 25 dBZ
- Most frequent peak increases as coming to ground to a range 10-20 dBZ
- Near ground experience sudden increment in reflectivity - sign of melting layer
- Reflectivity equally scatter from 0 - 25 dBZ ,
- Uniform with height

Time Series of Snow-to-Rain and Vice Versa Transition at (c) Ground with Disdrometer and (a-b) Vertically with MRR

Prof Sourabh Das, IIT Indore

Concluding Remarks

- Long records of daily precipitation and temperature helps us to study the long trends in Ny Ålesund.
- CC scaling analysis is conducted extensively on P-T relationship in Ny Ålesund and scaling is observed in cold season extreme events daily data.
- Analysis of case-studies of extreme events identified distinct synoptic patterns – strong bocking over northern Europe and southwesterly moisture/temperature advection to Ny Ålesund.
- SOMs helped to identify the synoptic patterns similar to the composite analysis but at times different patterns during extreme precipitation.
- Polar WRF simulations help to quantify the increase in precipitation intensity w.r.t. temperature. For high intensity events happening in a warm atmosphere the increase in precipitation with 2℃ temperature perturbation is high.
- All the data from our instruments are available on NPDC site. Upon request we can provide you the required data.