



An Investigation on Arctic Precipitation

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Abstract

Important information on our changing climate can be found in Arctic precipitation. Measurements from the Parsivel Disdrometer OTT2 and the Micro Rain Radar over the Arctic location of Ny-Ålesund, Svalbard, reveal the occurrence of many forms of rain and snowfall with various growth mechanisms. Based on a year's worth of data, we give some case studies of various precipitation types with their characteristics and the related synoptic conditions in this study. This study will also include a variety of atmospheric phenomena, such as bright band and Virga. The findings are helpful in determining how climate change may affect arctic precipitation.

Keywords: Climate, Arctic, Precipitation, Remote Sensing, Virga, Bright band, Himadri

1. Introduction

Precipitation is a fundamental energy and hydrologic interaction between the Earth's atmosphere and its surface. Therefore, understanding where, when, and how much precipitation and snow falls is crucial for both scientific study and practical applications in society [7]. Precipitation in polar regions almost always takes the form of snow or rain. Changes in weather over a long period of time reveal the nature of climate change, Therefore Arctic precipitation may offer essential information about our changing climate, Since decades most long-term global climate change forecasts based on observational temperature and precipitation data have mostly concentrated on changes in mean values [1]. The Arctic is sometimes referred to as the "icebox of the Earth." Because Arctic cold the world and shapes its jet stream, What happens in the Arctic does not remain in the Arctic since circumstances in the Arctic are affected by global warming. Climate and weather in the Arctic are closely related to those in other parts of the world. Global circulation patterns in the atmosphere and water are significantly influenced by cold temperatures in both the Arctic and Antarctic [2].

Recent Studies states That Arctic is warming Three times as quickly as the world average. This is mostly due to the fact that melting snow and ice reveals a darker surface, which increases the quantity of solar energy absorbed in these regions (albedo effect) [4]. More precipitation will

change to rainfall in cryospheric regions as a result of global warming. Given that the kind of precipitation has an impact on surface energy and mass cycles, it is crucial to identify the distinct characteristics of the precipitation and appropriately categories it in significant regions [9]. Polar climatic systems are vulnerable to global warming and are altering accordingly. Based on daily data of precipitation and air temperature, we examined the monthly distribution, yearly day changes for each type of precipitation, and trends on the location of Arctic It has set up observation nodes in six Arctic Council nations (the US, Canada, Norway, Greenland (Denmark), Iceland, and Russia) to track the rapid changes in the region's ecology[8]. Numerous nations, including India, perform studies to determine the causes of climate change, forecast the future, and comprehend how the polar climate system influences global climate change.

2. Data and Methodology

India has it's own research station Himadri (78.91°N, 11.89°E) established in 2008 at Ny-Ålesund is situated on Svalbard's western shore. The distance to the North Pole is 1231 km. It is Near the fjord, the sea, and the mountains, Due to its location, its atmosphere is mostly impacted by the neighboring orographic features and warm ocean's diabatic heating. [3].

Therefor Measuring precipitation over the arctic area is a difficult task because of inherent experimental difficulties that affect both remote sensing and in situ approaches. Understanding the characteristics of snowfall and clouds over polar regions, especially over the Arctic, is the aim of this research. Disdrometer (Parsivel OTT2) and vertical pointing radar (MRR) data will make it possible to reconstruct lower precipitation layers, identify storm experiences with "drifting snow," and describe how the ice particle size distribution changed during the initial kilometers above the earth's surface. snowfall readings from MRR and Parsivel can be compared at the same time. Simultaneous snowfall observations from MRR and Parsivel allow distinct snow/ice behaviors to be distinguished in terms of radar equivalent reflectivity factor (Ze).

In This study we used year 2019 data collected by MRR and a disdrometer at the Himadri research station, it was made accessible in collaboration with NCAOR, Goa, India.

2.1 Instruments

At Himadri continuous measurements of precipitation microstructure are being performed using Micro Rain Radar and Parsival Disdrometer OTT2 along with other meteorological parameters.

2.1.1 Disdrometer

The OTT 2 Parsival is a sophisticated laser disdrometer that can measure all sorts of precipitation. Using the concept of light occlusion, parsival operate ($\lambda = 650 \text{ nm}$). When light is sent from the transmitter to the receiver, it forms a single horizontal sheet of light. It is possible to gauge the size of a drop by measuring how much output voltage is blocked as it passes through the laser beam. When a drop enters a light sheet and exits it again, its velocity is calculated.

It divides droplets into 32 different size (0.2–25 mm) and velocity (0.2–20 ms^{-1}) classes [5 13]. The raw data are utilized to calculate the precipitation's type, amount, intensity, and kinetic energy, as well as its visibility [11].

2.1.2 Micro Rain Radar

Micro Rain Radar is a compact vertically pointed radar that uses the Doppler principle to measure the vertical profile of rain drop size distribution. MRR antenna transmits Signal of 24.1 GHz(K-band) vertically into the atmosphere which get reflect from the droplets [10]. The backscattered reflected Signal Received by a parabola dish connected to MRR and then sent to RCPD (Radar Control and Processing Device) box where backscattered receiver signal is analyses, Doppler spectra are computed, and average power spectra, also known as "Raw data" are sent to the control and evaluation PC for interpretation [12].

Precipitation, which includes rain, snow, graupel, and hail, has a radar reflectivity factor (Z) that depends on the quantity (N_0) and size (D) of its reflectors [6]. Other Precipitation characteristics such as rate of Precipitation, LWC, and hydrometeor fall velocity can be computed using DSD. The Radar Reflectivity Factor $Z(\text{mm}^6\text{m}^{-3})$

$$Z = \int_0^{D_{max}} N_0 e^{-AD} D^6 dD \quad (1)$$

$Z_e(\text{dBZ})$ is the Logarithm of the Z which we using for our result because the value of $Z(\text{mm}^6\text{m}^{-3})$ vary greatly from drizzle to hail. Here Z_0 is the Reflectivity Factor of 1 mm drop.

$$Z_e = 10 \log_{10} \left(\frac{Z}{Z_0} \right) \text{dBZ} \quad (2)$$

3. Results

Examined the data of year 2019 from MRR and OTT2 Parsival Disdrometer and Discovered a variety of precipitation types throughout the years at location of Ny-Ålesund and temperature also varies, reaching a maximum average temperature of 5°C in the month of July and a minimum average temperature of -16°C in the month of February (Figure 1(top)). The fraction of various precipitation types that occur in the arctic is shown in Figure 1(bottom), including snowfall (SN), rain (RA), drizzling of rain (RADZ), grupel/small hail (GS), and a mixture of rain and snow(RASN). The majority of precipitation is snowfall, with liquid precipitation reaching its peak from July to September. The fraction for 'GS' and 'RASN' type of precipitation is less than 0.1.

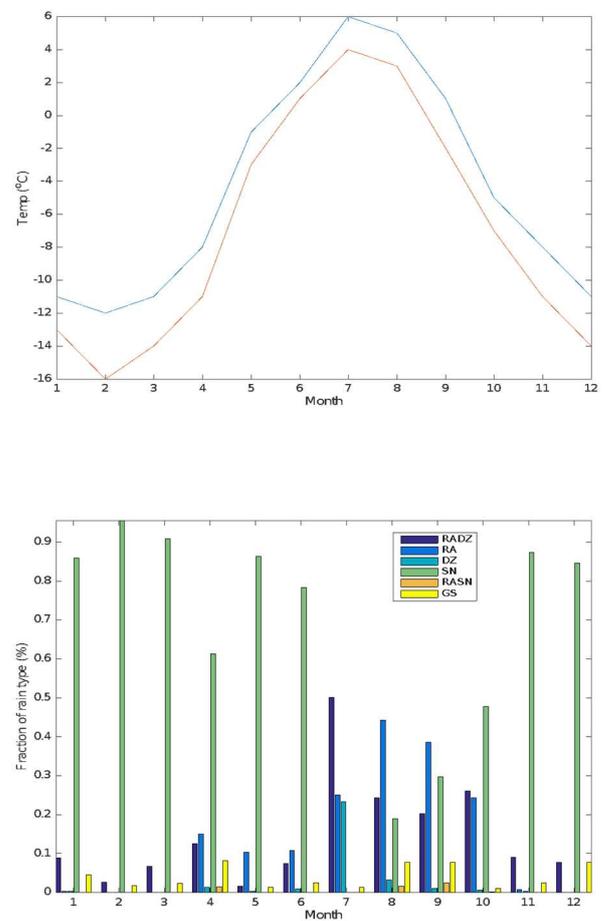


Figure 1. (top) Average monthly maximum and minimum temperature variations for the year 2019 show that the coldest month was Feb and the hottest was Jul. **(bottom)** Fraction of different type of precipitation for each month of 2019 indicates about domination snow precipitation.

Disdrometer determines the type of rain based on the diameter, intensity, and speed of the precipitation droplets. As many types of precipitation can be seen in a single day, this indicates a quick change in the weather. A time series visualization for precipitation rate using data from

disdrometer On April 16, 2019 (Figure 2), show many precipitation types were observed in a single day. It was a fully Precipitation day and all the form of precipitation of snow and rain took place according to change in temperature, Relative humidity, air velocity and other factors. The average rate of precipitation is about 1 mm per hour, thus there is a light moderate amount of precipitation.

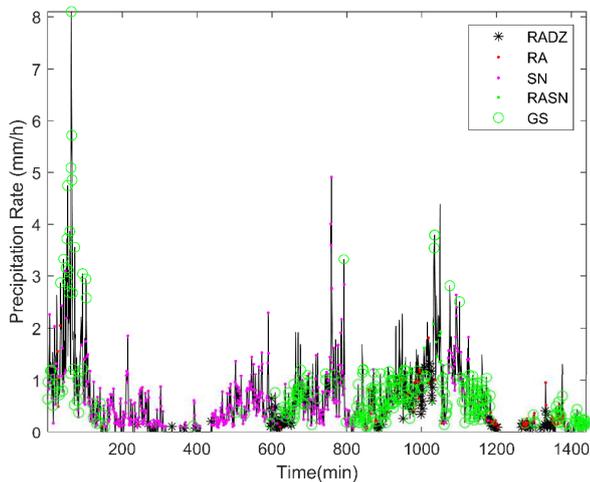


Figure 2. On the day of April 16, 2019, time series plot of the precipitation rate (mm/h), where a variety of colorful symbols indicate the types of precipitation that occur in a single day.

The result of changing Temperature, airflow, and relative humidity in the Arctic allowed us to examine numerous atmospheric phenomena, including virga and bright bands in the height profiles of reflectivity. Virga is an occurrence in which no precipitation touches the ground. The optical phenomenon, which is characterized by a rapid change in the brightness of a precipitation shaft beneath a cloud, is occasionally attributed to droplets evaporation [14]. Virga has been spotted numerous times throughout the year after snowfall, therefore it will happen during the winter. Snow that has fallen evaporates due to a dry wind blowing quickly from another area, low relative humidity, and high temperature.

The "bright band" signature in the radar reflectivity profile can be used to identify the stratiform rain type. Due to the existence of the melting layer, the brilliant band represents the amplified back scattered portion of the vertical radar reflectivity profile. Compared to a water droplet, the melting layer has a higher reflectivity. The radar reflectivity profile shows a bright area that gives the impression that heavy Precipitation is falling there[15].

This event mainly take place only when it is a liquid rain and this method has been used to classify the liquid rain type (stratiform/convective) using MRR data and time series of vertical radar reflectivity profile up to 1550 m [15].

4. Conclusion

In the Arctic, remote sensing is utilized to identify the characteristics of various types of precipitation at the Himadri research station in Ny-Ålesund, Svalbard. The average monthly temperature in the Arctic has been seen to change linearly from the winter season to the summer season and vice versa. It has been noted that February has the coldest temperature of the year 2019 (-16°C), while July has the highest temperature (5°C). Being the coolest month, July has the highest fraction of snowfall, while the summer months, including July, have higher fractions of liquid precipitation.

As a result of the influence of the sea and fjord on the site of Himadri, several types of precipitation, including SN, RASN, GS, RA, and RADZ, have been observed on June 16, 2019, leading to a rapid change in the weather. In snow and liquid precipitation, respectively, the Virga and bright band signatures have been seen. Where virga events predominately occur in winter (peaking in march) and bright band signature predominately occur in summer when we see more liquid rain. We will investigate the synoptic conditions virga and brilliant band in liquid rain in subsequent research to better understand arctic weather and climate.

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