Response of Passive Microwave Wave Frequencies in Snow

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Abstract— Seasonal snows cover in NW-Himalaya plays an important role in hydrological and avalanche studies. Snow is an important natural water resource, which strongly affects the human life in high altitude areas and also to the national economy. However, snow may also cause avalanches and thus acts as a hazard. Mostly initiation of any avalanche depends on the condition of the snow pack, which is governed by some snow pack parameters i.e. snow depth, snow water equivalent, snow density etc. In Himalaya due to the ruggedness and inaccessibility of Himalayan terrain, it is very difficult to monitor the snowpack and also to collect these snow pack parameters using manual methods. Remote sensing satellite data (Optical and Microwave) has the potential to monitor the snow cover. Again in Himalaya, most of the area remains under clouds during winter period and optical satellite data will not be able to retrieve the snow cover information. However, due to its large wavelength, microwave satellite sensor data has capability to retrieve snow cover information in all-weather condition. In Microwave satellite data, Passive microwave data can be used to monitor the snow pack on regular basis, as this passive microwave satellite is having daily receptivity over the area under investigation. In the present study we have used, Passive microwave AMSR-2 (Advanced Microwave Scanning Radiometer-2) remote sensing data. We have estimated the Brightness Temperature (TB) data for Great Himalaya and Pir-Panjal Range at different frequencies i.e. 6.93, 7.3, 10.6, 18.7, 23.8, 36.5 and 89 GHz. The monthly Brightness Temperature (TB) maps were generated for year 2017. These maps at different frequencies were analysed to study the response of different passive microwave frequencies in snow.

Key words: AMSR-2, Himalaya, Brightness Temperature (TB)

I. INTRODUCTION

Seasonal snow cover plays an important role in hydrological cycles and climate processes. About 46.5 million km^2 is snow covered for northern hemisphere in January, and 3.8 million km^2 even in August [1]. In the Himalaya large area is covered by snow during winter and snow cover changes significantly due to melting in summer. Approximately 40–50%of the Northern Hemisphere is covered with snow during midwinter [2,4]. In the Himalaya snow cover areas are generally located at high altitude in remote and inaccessible regions and thus very difficult to monitor [5]. Remote sensing techniques are useful tool for gathering information of vast area and it is also used for study of snow properties and global water cycle [6].

A remote sensing technique is useful tool for gathering information of vast area. Different researcher have used optical and microwave satellite data for monitoring of snow cover information. Optical data is useful to retrieve the snow surface properties but optical data has major problem in winter most of the area is under clouds. Due to lower wavelength of optical data, it will not penetrate the clouds. Microwave satellite data has the capability to provide the snow cover information in all weather conditions [7]. In the present study we have used, Passive microwave AMSR-2 (Advanced Microwave Scanning Radiometer-2) remote sensing data at i.e. 6.93, 7.3, 10.6, 18.7, 23.8, 36.5 and 89 GHz. The monthly Brightness Temperature (T_B) maps were generated for year 2017. These maps at different frequencies were analysed to study the response of different passive microwave frequencies in snow.

II. DATA USED

The Advanced Microwave Scanning Radiometer 2 (AMSR-2) data has been used in the present study. AMSR-2 is a multi-frequency microwave radiometer. It measures weak Microwave emission (6.9-89.0GHz) from the surface and the atmosphere of the Earth. Orbit from the South Pole to the North Pole is called ascending path, and that from the North Pole to the South Pole is called descending path. The GCOM-W1 satellite orbit is a sun-synchronous sub-recurrent, which is a combination of Sun-synchronous orbit and sub-recurrent orbit. In a sun-synchronous orbit, positioning between the satellite and the sun is always the same. Ascending path observes the day scene and descending path observes the night scene.

AMSR-2 aboard Global Change Observation Mission - Water 1 (GCOM-W1), provides global passive microwave measurements of terrestrial, oceanic, and atmospheric parameters for the investigation of global water and energy cycles. Both AMSR2 and GCOM-W1 are built and operated by Japan Exploration Agency (JAXA).

The AMSR instruments are dual-polarized and passive microwave radiometers. Each is placed in a near-polar orbit which allows for up to twice daily sampling of a given Earth location.

	AMSR-2
Satellite Platform	GCOM-W1
Altitude	700 km
Equator Crossing Time (Local time zone)	1:30 PM Ascending 1:30 AM Descending
Antenna Size	2 m
Swath Width	1450 km

Table 1: Brief of AMSR-2

III. STUDY AREA

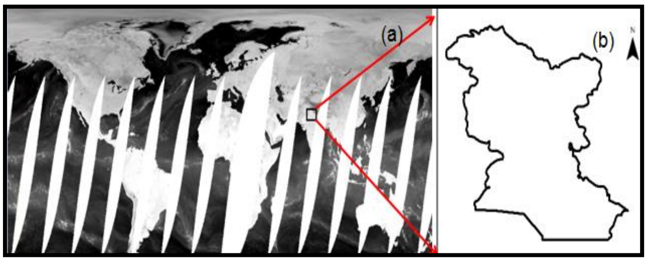

Fig. 1: Study area (a) AMSR-2 data (b) NW Himalaya Region

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Present study is concentrated in Indian Himalayan region shown in Figure 1, NW Himalaya has been categorized into different ranges shown in Figure 2, such as lower Himalaya as (Pir-Panjal range), middle Himalaya (Great Himalayan range) and upper Himalaya as (Karakoram Range) [3].

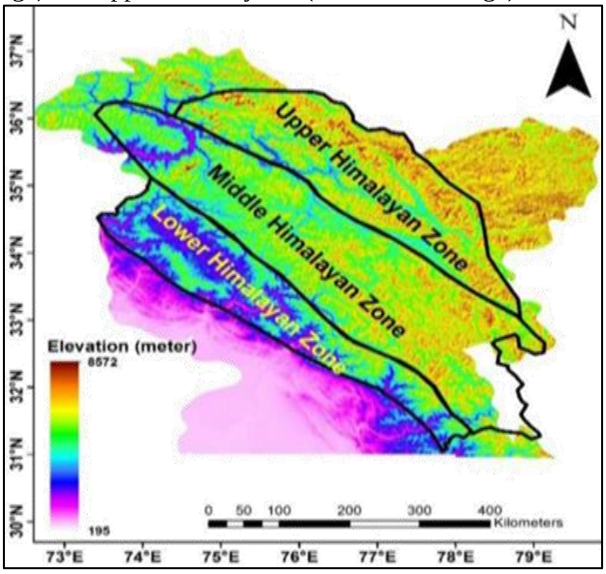

Fig. 2: Different Himalayan ranges of North West Himalaya

IV. METHODOLOGY

The methodology used in present work is shown in figure 3. First the AMSR-2 satellite data was downloaded from GCOMW-1 (Global Change Observation Mission Water).The processing of data was carried out using ArcGIS and ERDAS IMAGINE software's. The brightness temperature (T_B) maps were plotted using ERDAS IMAGINE software. T_B at different frequencies (i.e. 6.93, 7.3, 10.6, 18.7, 23.8, 36.5 and 89 GHz) were estimated for different snow metrological observatory locations of SASE

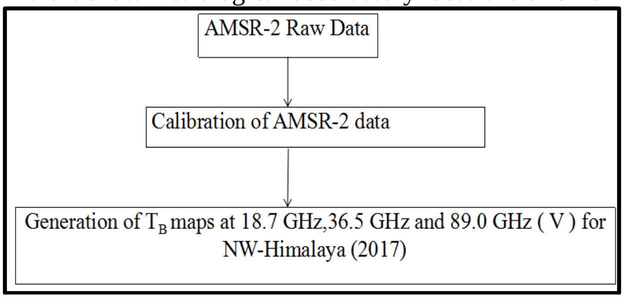

Fig. 3: Flow Chart of Methodology

V. RESULTS

Brightness temperature is highly dependent on frequency and snow properties such as snow depth, density and moisture content. The T_B is product of surface temperature (T_S) and emissivity (ε).Figure 4 (a, b, c) shows temporal and spatial variation of monthly average T_B at 18.7, 36.5 and 89 GHz (vertical polarization) frequencies for NW Himalaya during year 2017. It is observed from the figure that T_B shows significant variation from month to month and this variation is due to variation in snow pack/snow surface temperature in respective months. T_B is observed high in October and November month due to high ambient and snow pack temperature in case of the presence of the snow. From December onward till the March decrease in T_B has been observed due to lesser ambient temperature values. April onwards the T_B values higher, this may be attributed due to start of melting of the snow.

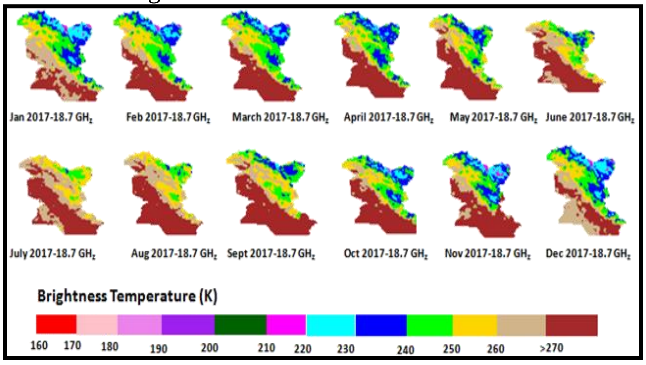

Fig. 4(a): Temporal & Spatial Variation of T_B at 18.7GHz (V) for NW Himalaya (Year: 2017)

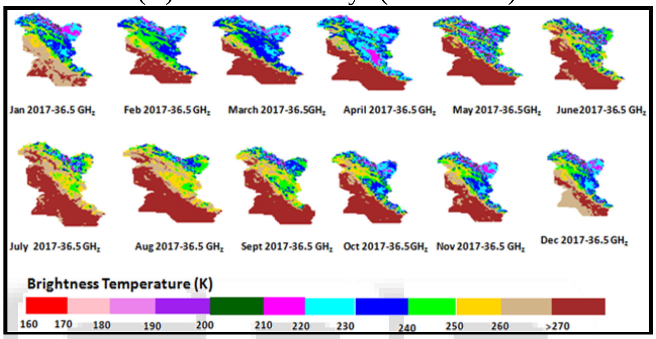

Fig. 4(b): Temporal & Spatial Variation of T_B at 36.5 GHz (V) for NW Himalaya (Year: 2017)

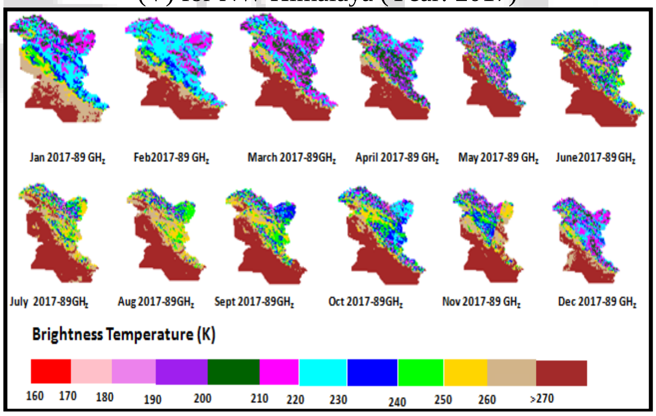

Fig. 4(c): Temporal & Spatial Variation of T_B at 89 GHz (V) for NW Himalaya (Year: 2017)

Further from the figure it is also observed that lower Himalaya (Pir-Panjal) range is showing higher T_B values in comparison to middle (Great Himalaya range) and upper Himalaya (Karakoram range).This variation is because in Pir-Panjal range the ambient temperature generally remains higher in comparison to other ranges, thus its T_B is also observed higher. While in Karakoram Range due to very low ambient temperature low T_B values were observed. However, the range of T_B values in Greater Himalaya is observed in mid of Karakoram and Pir-Panjal ranges.

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VI. CONCLUSIONS

It has been observed that brightness temperature (T_B) to identify snow covered areas. The trend shows temporal and spatial variation of monthly average T_B at 18.7, 36.5 and 89 GHz (vertical polarization) frequencies for NW Himalaya during year 2017. T_B shows significant variation from month to month and this variation is due to variation in snow pack/snow surface temperature in respective months. Father it also observed that lower Himalaya (Pir-Panjal) range is showing higher T_B values in comparison to middle (Great Himalaya range) and upper Himalaya (Karakoram range). Remote sensing satellite data (Optical and Microwave) has the potential to monitor the snow cover. Again in Himalaya, most of the area remains under clouds during winter period and optical satellite data will not be able to retrieve the snow cover information. However, due to its large wavelength, microwave satellite sensor data has capability to retrieve snow cover information in all-weather condition. Passive microwave remote sensing is currently the best method to monitor temporal and spatial variations in snow cover on hemispheric to global scales.

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