Study of MSMR retrieved data using map generation and representation methodology over Rajasthan, India

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The microwave radiometer MSMR (Multi-frequency Scanning Microwave Radiometer) data available in the months of June 1999-2001 have been studied. These data have been represented on the map of Rajasthan. The map has been generated using layered approach. The data available at 6.6 GHz for both horizontal and vertical polarization have been used for this study. The brightness temperature \( T_B \) within 150 km diameter circle is displayed on the map of Rajasthan at the longitude and latitude obtained from the data set. The longitudes and latitudes are grouped in three zones A, B and C, depending on the geophysical parameters of the different sites.

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1 Introduction
Remote sensing\(^1\) is a scientific methodology that can be used to measure and monitor important geophysical characteristics and human activities on earth. The microwave remote sensing is done by two types of sensors — passive and active. The passive sensor here in the present paper is the microwave radiometer MSMR. The brightness temperature obtained from 6.6 GHz microwave radiometer in both horizontal and vertical polarization has been used. These data have been obtained from Space Application Centre (SAC), ISRO. They provided the FORTRAN programme along with data and this is used for retrieving satellite data. Maps are generated using layered approach\(^2\) to show variability of brightness temperature at various longitudes and latitudes of Rajasthan.

The data are studied with regard to variations in geophysical conditions in the month of June 2000 with respect to \( T_B \) at different locations, in three zones A, B and C, in which the sites of different longitudes and latitudes are clubbed together.

2 Description of MSMR IRS-P4
The Indian remote sensing satellite IRS-P4 was launched on 26 May 1999 to collect data for different coastal and atmospheric applications. It carried a microwave radiometer MSMR\(^3\) operating at frequencies 6.6, 10.65, 18 and 21 GHz, with dual polarization. The MSMR is basically a Dicke receiver wherein the receiver input is switched between the reference source and the antenna. The salient features are given in Table 1.

3 Methodology
3.1 Data retrieval
A `C` programme is developed at ICRS and used for filtering the data from SAC, for different longitudes and latitudes of Rajasthan. This filtered microwave remote sensing satellite data contain five fields. These fields are as follows:

(i) Date (yyyy mm dd)
(ii) Time (hh min ss)
(iii)Longitude
(iv)Latitude
(v) Brightness temperature (vertical and horizontal polarization on 6.6 GHz)

These data are displayed on the map generated using layered approach and the representation of brightness temperature on Rajasthan map is done for the study.

3.2 Map generation
Map generation\(^4\) as the term implies involves generating maps with given data to depict information graphically and geographically. The programme for map generation is developed in C utilizing it’s graphics library functions. This programme is divided
into three layers. These layers work in such a manner that a layer starts working after the previous layer has finished its work.

### 3.2.1 Layer 1

For layer 1, first the map of Rajasthan is taken and display area is decided for putting the image on the screen. The reference area available for this purpose on computer screen is 560 (X-direction) by 420 (Y-direction) pixel. Then using a graph paper a rectangle with a length of 560 mm and width of 420 mm is marked. This rectangle is similar to the size of the screen of the monitor. Each small unit in the graph paper represents 1 pixel of the screen. Horizontal axis is divided into 10 parts and the vertical axis into 7 parts to display the longitude and latitude of Rajasthan, which is 69°E to 79°E (horizontally) and 23°N to 30°N (vertically).

Now the pixel values corresponding to these points are taken with the help of the graph and plotted on the screen. Finally the lines between consecutive points are drawn and thus 1° × 1° grids are displayed on the screen. The pixel value for a particular longitude and latitude is calculated by a software code. This code determines the x, y position on the screen for a location. The pixel value calculation has been done by two functions. First function getx() takes lon-lat value as parameter and returns x position for that lon-lat. Second function gety(), also takes lon-lat as parameter and it returns y position on the screen. Then point (x, y) is plotted on the screen.

### 3.2.2 Layer 2

In second layer the map of Rajasthan is drawn on the display area of the screen. First a map of Rajasthan is taken and with the help of that map latitude and longitude values at the boundary of Rajasthan is determined. Thus latitude and longitude values at boundaries are obtained. After that an algorithm is developed for calculating the pixel positions against the values of the longitudes and latitudes, which are then plotted on the screen. Thus on completion of second layer, map of Rajasthan is generated as shown in Fig. 1.

### 3.2.3 Layer 3

Third layer represents the brightness temperatures at different sites of Rajasthan for all 28 months (June 1999-August 2001) individually and at particular time (7, 8, 9 AM). This is done for the entire temperature range (120-300 K) with the difference of 10 K and to differentiate between the temperature values, different line styles are assigned to each temperature range value.

Brightness temperature values are plotted on the screen at each site in the form of a circle. Each circle shows area with 150 km diameter, which is the footprint of MSMR satellite. The temperature ranges are represented using legend onto the map corresponding to different line style.

### 3.3 Zones of Rajasthan

Map of Rajasthan has been divided into three zones as per their geographical conditions. Zones are named as A, B and C. Here zone A ranges from 69.5°E to 72°E (longitude) and from 23°N to 30°N (latitude). This zone is the most arid part of the state. The climate is generally dry. It is characterized by large extremes of day and night temperature. This has only sand and no other geophysical elements like mountain and water body, etc. Zone B ranges from 72°E to 76°E (longitude) and 23°N to 30°N (latitude). The climate of this zone is marked by the large variation of temperature with extreme dryness, because the northern part of this zone is sandy, whereas southern part of this zone is surrounded by hills, with presence of water bodies. Zone C ranges from 76°E to 78.5°E (longitude) and 23°N to 30°N (latitude). The climate of this zone is dry, so this zone becomes extremely hot during summer.

Table 2 shows various longitude and latitude with their corresponding site numbers for Zone A, B and C. These site numbers are used to differentiate various longitudes and latitudes of Rajasthan in the maps according to zonal distribution. The satellite pass is from south to north as shown in Fig. 2. This pass covers most areas of Rajasthan. Zone A covers the site number 2, 3, 5, 6 and 7 where brightness temperature is almost constant. Most of the areas of zone A show that the brightness temperature ranges from 250 K to 260 K.
Results and discussion

The data retrieved and represented on the map of Rajasthan have been done for 6.6 GHz (both H and V polarization) for 28 months. The data recorded at 7, 8 and 9 AM for the month of June 2000 at 6.6 GHz and horizontal polarization, are shown in Figs 2, 3 and 4.

Area comprising zone A is almost sandy and dry. Sand takes less time to get hot and also less time to subsequently cool down. Due to this property of sandy soil, geophysical parameter like temperature is also affected. As the soil is sandy, the temperature changes taking place with time is extremely important. Thus observed $T_B$ is low at 7 AM, because the data are of morning time when sand is not too warm.

In the month of June, at 7 AM, most of the parts of northern side of zone B show $T_B$ between 250 K and 260 K, same as that for Zone A, because this area of zone B is also a desert area and follows the property of sand. The rest of the area which covers site numbers 9, 16, 17, 22, 30, 31 and 32 show brightness temperature range from 260 K to 270 K, without any variation as seen in Fig. 2. This area of zone B is surrounded by hills and having high population density. Due to this reason the observed $T_B$ of remaining area of zone B is high as compared to zone A and upper part of zone B.
Fig. 2—$T_B$ (h) of 6.6 GHz frequency for June 2000 (7 AM) on the map of Rajasthan

Fig. 3—$T_B$ (h) of 6.6 GHz frequency for June 2000 (8 AM) on the map of Rajasthan
Zone C covers site numbers from 35 to 39 as shown in the map in Fig. 2. Most areas of this zone show brightness temperature ranging from 260 K to 270 K, whereas site number 38 shows high brightness temperature ranging from 270 K to 280 K, which can be expected, because this site covers the area of Bharatpur. The climate of the district being dry becomes extremely hot during summers and extremely cold during winters. The satellite pass is at 8 AM from north to south direction as shown in Fig. 3. It scans most areas of the zone B and zone C of Rajasthan. In the month of June at 8 AM, zone B shows more variations in $T_B$ from 230 K to 270 K. The observed $T_B$ is not consistent and not according to geophysical properties of this zone.

In the zone B site numbers 14, 16, 17 and 27 show the variation from 230 K to 240 K of brightness temperature, which shows there has been some rainfall. Remaining locations of this zone also show more variation in brightness temperature as compared to what is observed in Fig. 2. Zone C covers the site numbers 37, 38 and 39. Here brightness temperature ranges from 220 K to 280 K, which shows maximum variation. Site number 38 shows brightness temperature range from 220 K to 230 K, which shows possible rainfall because at the same place at 7 AM $T_B$ was very high and suddenly after 1 hour $T_B$ has come down.

It can be observed from Fig. 4 that the satellite passes at 9 AM from north to south direction. It covers most of the areas of zone A and zone B of Rajasthan. In the month of June at 9 AM most of the areas of zone A which cover site numbers 1-3 again show constant $T_B$ from 240 K to 250 K. It is seen from the map that this area and specially the site 3 of zone A has always constant $T_B$, so this site can be used for calibration of Space Borne Passive Sensor. Rest of the areas of this zone at this time which are covered by site number 10-12 are having brightness temperature ranging from 240 K to 260 K.

Map in Fig. 4 illustrates that few areas of zone B, having site numbers 20 and 22 show 240-250 K brightness temperature range. Rest of the areas of this zone continues to have brightness temperature range 250-260 K. The maps show that in the month of June, brightness temperature in zone A of Rajasthan is 250 K. Meanwhile in zone B and zone C, brightness temperature changes and has large variation. Zone B and zone C show brightness temperature ranging from 250 K to 260 K at 7 AM and then brightness
temperature goes low to 220 K in few areas of zone B at 8 AM. This variation shows possibility of low rainfall, because at 9 AM brightness temperature at these locations again ranges from 240 K to 260 K.

5 Conclusions
The data obtained from MSMR have been studied for some areas of Rajasthan. The data have been retrieved and methodology for representation of the data using layered approach has been developed. It can be concluded that in Rajasthan, for all the three zones brightness temperature remains high for the month of June 2000 because the rainfall during that period is very low.

Using the above maps and it’s generation methodology, the maps for 28 months (June 1999 - August 2001) have been developed. Using the same approach maps for any geographical area can be drawn and the data for that area can be displayed on the map and studied and then correlated with geophysical parameters as well as atmospheric conditions.

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References