TRMM DATA APPLICATIONS ON RAIN MONITORING OVER AMAZONIA

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ABSTRACT

New released TRMM data have been made available to the scientific community since June 1, 1998. Through the limited case study by use of TMI, PR and VIRS data we anticipate its usefulness to rain monitoring and prediction over Amazonia. The study will be continued to gain the experience of utilizing TRMM data on LBA program as well as its effect on the improvement on daily rain rate forecasting.

1. Introduction

TRMM (Tropical Rainfall Measuring Mission) is a joint effort of NASA (National Aeronautics and Space Administration) and NASDA (National Space Development Agency of Japan). One of the mission objectives is to test, evaluate and improve the performance of satellite rainfall measurements and estimation techniques. The satellite was launched on Nov. 27, 1997 from Tanegashima, Japan. It has a circular orbit with altitude of 350 km ranging between 35 degrees north and 35 degrees south of equator. Aboard the TRMM there are five instruments. Among them the Precipitation Radar (PR), the TRMM Microwave Imager (TMI) and the Visible Infrared Scanner (VIRS) are the three primary instruments which constitute a rainfall measurement package. They work in a complementary manner.

TRMM level-1 data became available to the scientific community since June 1, 1998. The software to view the TRMM data is also available from web page. Here we use the software Orbit Viewer developed by the TRMM Science Data and Information System (TSDIS) to display the VIRS, TMI and PR data for showing an event of rain structure over Amazonia in various ways. One comparison between TRMM rain and operational rain estimate based on GOES IR image is carried out. Since the data for this case study was picked up arbitrarily from NASA/DAAC early release and June is the winter season for Amazonia the selected rain event is not a heavy one and the results are very preliminary. Further study of TRMM data on improvement of operational rainfall estimation over Amazonia should be conducted.

2. TRMM Instruments

The PR is the first space-borne instrument designed by NASDA to provide three-dimensional maps of storm structure. The measurements should yield invaluable information on the intensity and distribution of the rain, on the rain type, on the storm depth and on the height at which the snow melts into rain. The PR has a horizontal resolution at the ground of 4.3 kilometers and a swath width of 220 kilometers. It operates at 13.8 GHz with horizontal polarization. One of its most important feature is its ability to provide vertical profiles of the rain and snow from the surface up to a height of about 20 kilometers.

TRMM Microwave Imager (TMI) and Visible Infrared Scanner (VIRS) were developed by NASA Goddard Space Flight Center. TMI is similar to SSM/I on the DMSP (Defense Meteorological Satellite Program). Instead of 4 frequencies TMI has 5 channels (10.65 GHz, 19.35 GHz, 21 GHz, 37.0 GHz and 85.5 GHz) with dual polarization except channel 21 GHz. The additional 10.7 GHz channel is

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designed to provide a more-linear response for high rainfall rates common in tropical regions. The horizontal resolution of the TMI changes from 4.3 km at 85.5 GHz to 45 km at 10.65 GHz. A scan angle of 65 degrees provides a swath width of 760 km. The VIRS also has 5 channels (0.63, 1.6, 3.75, 10.80 and 12.0 microns) with a swath width of 720 km and a horizontal resolution of 2 km. The channels selected are similar to NOAA AVHRR and GOES imager. Thus the VIRS provides a link between measurements made by TRMM rain package and those made simultaneously by the visible and infrared radiometers on operational polar and geostationary satellites. The primary sensors PR, TMI and VIRS in combination constitute TRMM as a 'flying rain gauge' to correct or calibrate the rain estimates made by other instruments such as GOES/IR, NOAA/AVHRR etc.

3. Precipitation Measured by TRMM Instruments

The rain rate over land and ocean is based on the 85 GHz scattering index as defined by Ferraro et al. (1996). The 85 GHz scattering index SI85 over land is defined by:

$$SI85 = 451.9-0.44*TB19v-1.775*TB22v+0.00574*TB22v^{2}-TB85v$$

when $100<TB19v<300$ and $80<TB85v<300$. Here TB19v, TB22v and TB85v represent 19.35 GHz, 22.235 GHz and 85.5 GHz brightness temperature with vertical polarization respectively. The above equation has been used for SSM/I data. TRMM has similar channels as SSM/I plus one additional channel (10.65 GHz) and the location of channel 22.235 GHz for SSM/I was moved to 21 GHz for TMI. If TB22v is replaced by TB21v in the previous equation similar result should be expected.

The rain rate RR is calculated from SI85 as follows:

$$RR = 0.00513*SI85L^{1.9468}$$

where RR is in millimeters per hour. Since the resulting rain rates increase exponentially for higher SI85 values, RR above 35 mm/hr is set to 35 mm/hr. This represents a practical upward limit of rain rate as suggested by Ferraro et al. (1996). Currently, there is no rain rate product derived from TRMM TMI data available to public users. It will be released sometime in August after the algorithm is validated.

The daily TMI images can be viewed (starting from Nov. 30, 1997) from TRMM homepage: http://trmm.gsfc.nasa.gov/, by clicking 'Image/Movie Archive' and 'Quick Look'.

Figure 1 is the TMI 'Quick Look' image on June 24, 1998. The orbit passes through the equator at 15:02 GMT. There are some rain systems right over Central Amazonia. The color scheme for the images is derived from the 85 GHz vertical, horizontal and 19 GHz vertical channels in red, green and blue respectively (through RGB composite). The probable rainfall appears as the yellow and white areas (the white being most intense) from scattering by ice particles of convective cloud system. It is based on 85 GHz and works over both land and ocean.

Figure 2 and 3 are also the brightness temperature TMI images of 85 GHz vertical polarization (Ch.8) over Amazonia with the river system overlaid for geo-reference. It is a high resolution (4.3 km) channel with swath width of 760 km. The green/purple/brown areas delineate rain regions well.

Figures 4 and 5 are the VIRS IR (Ch. 4) image and its enlargement with swath width of 720 km, which is a little narrower than that of TMI. The resolution (2 km) is higher than that of TMI (4.3 km). The brown areas show the low values of radiance (cold temperature) indicating either deep convective cloud or high cloud. General agreement of rain areas delineated by TMI and VIRS are good. But TMI gives more details in intensity. Since high cloud (low temperature) does not necessarily produce rain the cold area in VIRS IR image does not always represent rain. If one uses only thresholds of IR radiance or brightness temperature to delineate rain regions, the result could not be accurate due to possible existence of high clouds. The rain area will be either smaller or larger than the actual one depending on which threshold value is chosen. If the brown region on VIRS image (Fig. 5) is considered as the rain area and green to brown region in TMI image (Fig. 3) contains precipitation the difference between them can be found through careful comparison.

Figure 6 shows the rain estimates which is based on GOES IR image using a technique developed by Oliveira et al. (1998). The GOES observation time is 15:00 GMT which is almost the same time as the TRMM measurement. The medium rain system in the middle of Figure 6 corresponds to one shown on Figures 3 and 5. Since the rain rate derived from TMI data are not available yet the quantitative comparison can not be done.

Figure 7 displays the PR reflectivity image of horizontal slice at 63 level (0 is the highest and 140 is the lowest) with 49 fields of view along the scan. Since the swath width of PR has only 220 km it is much narrower than one given by either TMI and VIRS. So only part of the rain system is shown on the image. From the overlaid rivers one can easily find the correspondent part. Despite of its narrow coverage PR is still the best instrument on the TRMM because it is able to provide the 3-dimensional rain structure and can calibrate the measurements made by the other two instruments. Figure 8 is a vertical cross-section along the track at field of view 12 and Figure 9 displays the vertical cross-sections across the track with scan numbers 2352. The software Orbit Viewer provides sliders for changing the slice position conveniently.

4. Conclusions

The importance of TRMM data is obvious for ecological and hydrological monitoring over Amazonia aimed by the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). Also, there is a tremendous potential to use these data for more accurate prediction of rainfall over southeastern economic area of Brazil. Through the practice of accessing the TRMM data via NASA's 'TRMM data search and order system' and data analysis by TSDIS 'Orbit Viewer' we found:

- the data quality is excellent,
- the data distribution system is efficient,
- the software Orbit Viewer is a nice tool to analyze the TRMM data and
- the TRMM data will play a key role on improving operational rainfall forecasting products and the success of LBA program.

5. Acknowledgements

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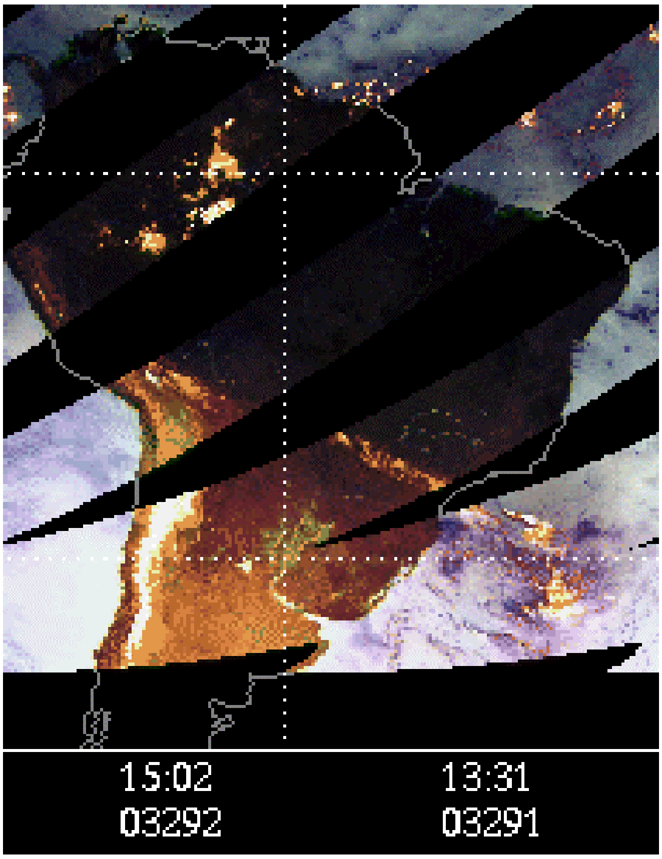

Fig. 1. TMI 'Quick Look' Image on June 24, 1998.

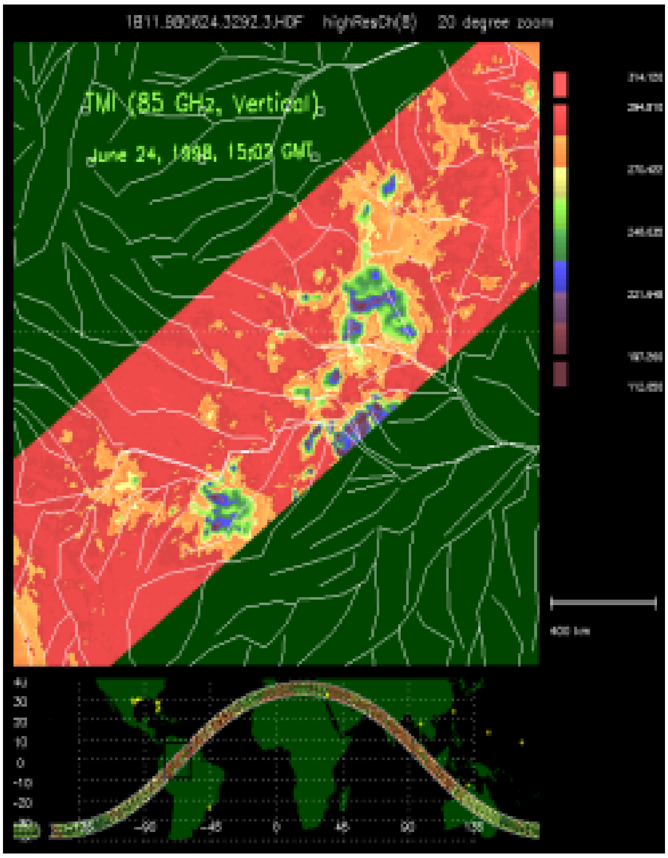

Fig. 2. TMI Image of 85 GHz Vertical Polarization.

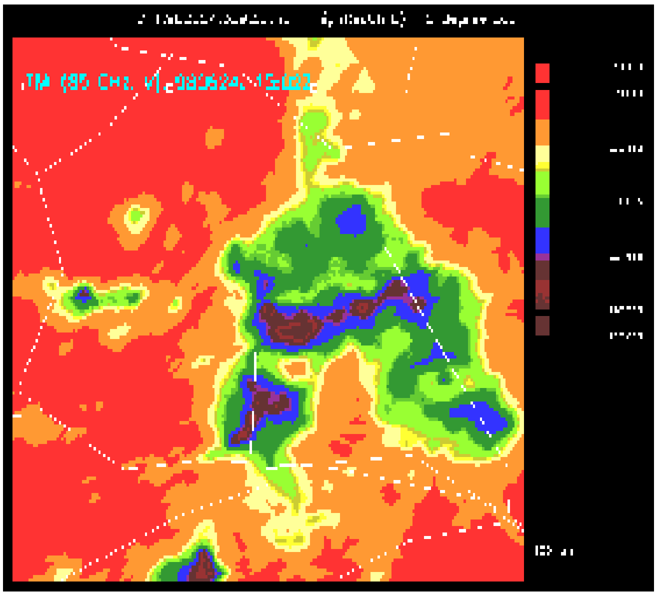

Fig. 3. Enlargement of TMI Image.

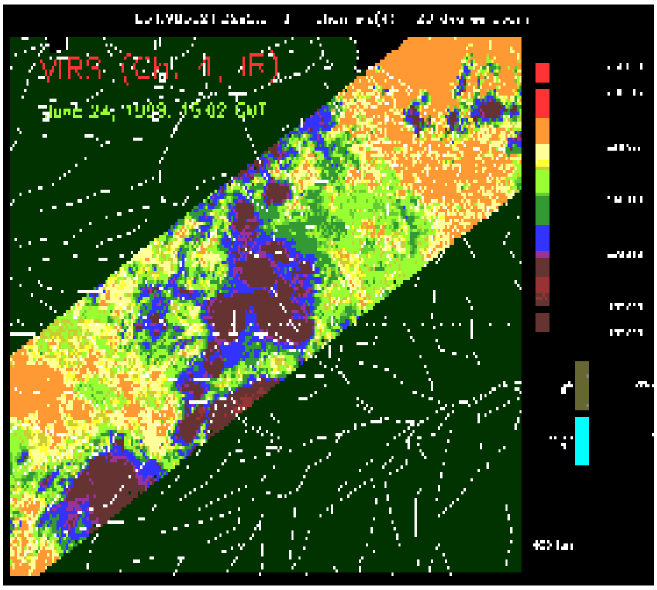

Fig. 4. VIRS IR Image (Ch. 4) over Amazonia.

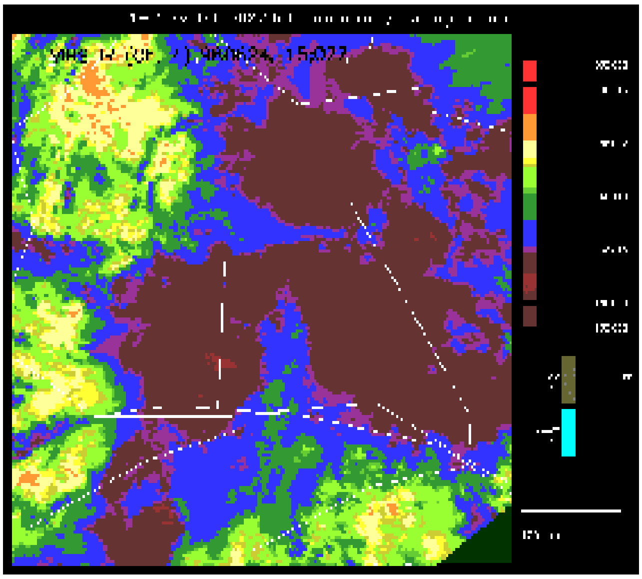

Fig. 5. Enlargement of VIRS IR Image.

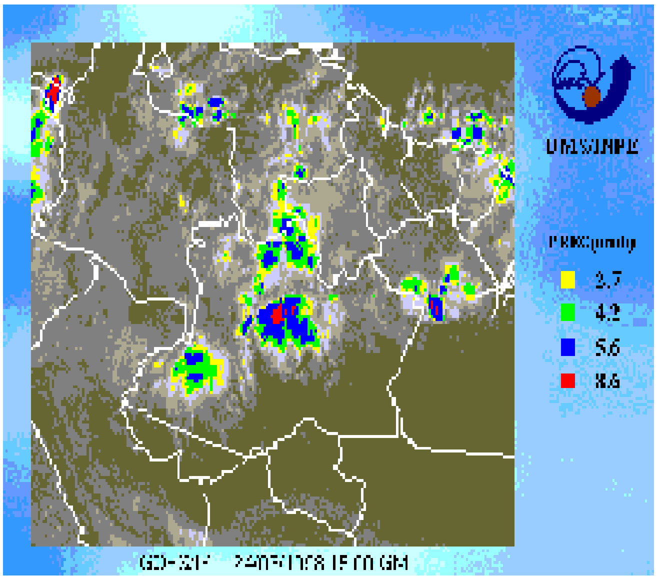

Fig. 6. Rain Estimates based on GOES IR Image.

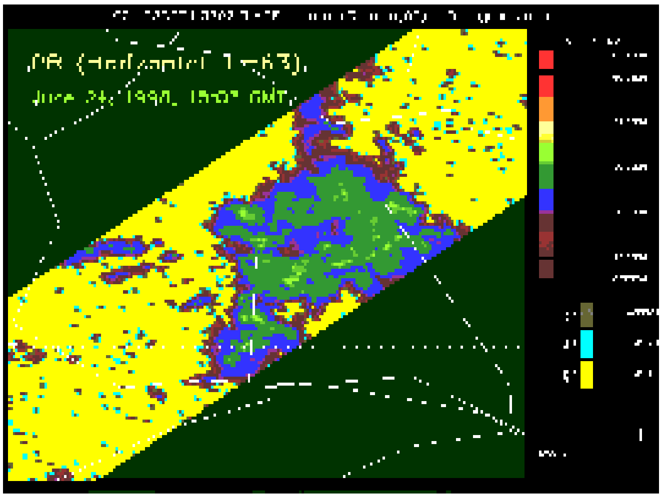

Fig. 7. PR Horizontal Sliced Image.

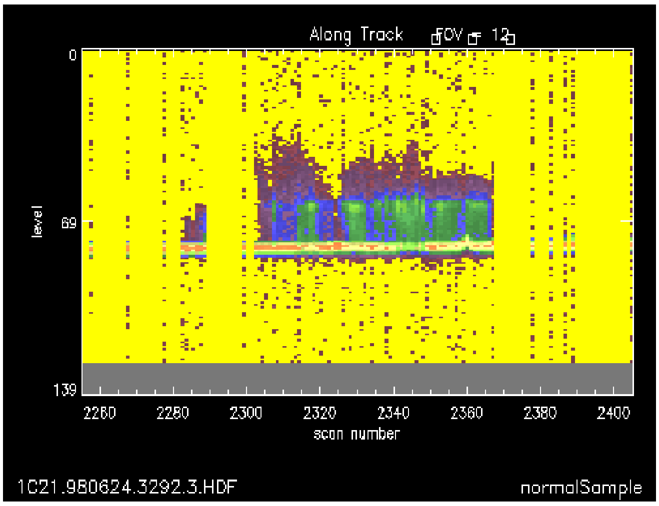

Fig. 8. PR Vertical Slice along the Track.

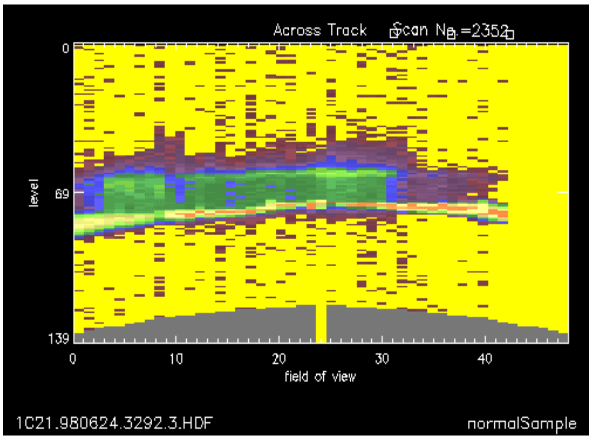

Fig. 9. PR Vertical Slice across the Track.