RAINFALL FROM TRMM-RADAR AND RADIOMETER

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Abstract: We present here, some of the studies carried for estimation of rainfall over land and oceanic regions in and around South Korea. We use active and passive microwave measurements from TRMM – TMI and Precipitation Radar (PR) respectively during a typhoon even named – RUSA that took place during 30 Aug. 2002. We have followed due approach by Yao at. all (2002) and examined the performance of their algorithm using two main predictor variable, named as Scattering Index (SI) and Polarization Corrected Brightness Temperature (PCT) while using TMI data. The rainfall fnus estimated using PST and SI shows some Under-estimation as compared to the 2A25 rainfall products from the PR in common area of overlap. A larger database thus would be used in future. To establish a new rain rate algorithm over Korean region based on the present case study.

Keywords: TRMM, TMI, SI, PCT

1. Introduction

The satellite retrieval of precipitation information from passive microwave radiances is important for the understanding of the hydrological cycle from regional to global scale. Rainfall is a highly discontinuous process both in space and time. Accurate and reliable measurements of rainfall over extensive areas of oceans present a formidable challenge to meteorologists. With best efforts, the ground based measurements cover only a small fraction of the globe. In addition to large uncertainties in the derived estimates, there are problems related to nonuniformities of coverage, quality and logistics of operations etc. The observations and monitoring of clouds from space using remote sensing techniques, has the potential of providing rainfall information on desired time and space scales. Assessment of precipitation contributes to improve weather forecasting, in small and large spatial scales, and a study of rainfall leads to better understanding of climate variability. For the retrieval of rainfall from passive microwave radiometers, a variety of theoretical approaches have been utilized. Earlier Katsaros et al (1989) and Gairola et al. (1992, 1994) have used SSM/I, Nimbus and Seasat SMMR data for locating the deep depressions, cyclonic storms and atmospheric fronts using satellite derived parameters like perceptible water, liquid water, rainfall rate, sea surface temperature and surface wind speed. Spencer(1986, 1989) proposed two algorithms using the combinations of the different polarized channels, for 37GHz and 85GHz. Grody(1991) suggested the scattering index as aprecipitation retrieval algorithm.

Based on the above rational the present study is taken up for examing a must recent rain algorithm over the South Korea region a typhoon RUSA in recent past at 30 August 2002. The algorithm by Yao et al(2002) and spencer et al (1989) is used for rainfall estimation. Final comparisons are made with PR rain fields and the results are assessed for development of a new algorithm in the area of our study.

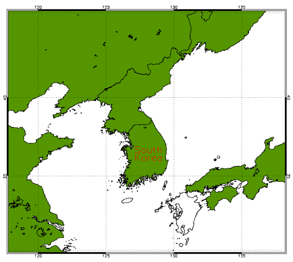

Fig. 1. Study of area

2. Study of area

Region of study is around Korea peninsula. The Korea region is surrounded by sea, located in eastern Asia(Figure 1). Longitude is 118-138E. TRMM is designed 40 latitude. TRMM can scan Korea region sufficiently for present study case study about Typhoon. Named as RUSA is selected. Figure 1 show the track of RUSA and demonstrate a cloud chart from channel (10.5-11.5um) of Geostationary Meteorological Satellite GMS-5 at 1530UTC at 21utc 30 August
2002. Typhoon center is at 30.7 N, 127.7E. The central pressure is 950hpa and that characterize & a very strong Typhoon. The Maximum wind speed was 38m/s. As one of the rare events, this typhoon went through Korea and dissipated in further north-east.

3. Data

1) TRMM TMI and PR data

The TRMM satellite was launched jointly by the United States and Japan in November of 1997 with the primary purpose of observing tropical rainfall from space. It scans for 15.77 orbits daily between 40N and 40S latitude. TMI is a 9-channel, 5-frequency, linear polarized passive Microwave radiometer that measures at 10.7, 19.35, 21.3, 37, and 85GHz. In comparison with the Special Sensors Microwave Imager(SSM/I) on the satellites series of the U.S. Defense Meteorological Satellite Program, TMI has higher spatial resolution because of the lower orbit of the TRMM satellite. Thus, it has a better capacity to monitor mesoscale and small-scale precipitation systems. The addition of 10.65GHz dual polarization channels allows for more penetration to the earth's surface. In this study, we use TMI 1B11 version4 as the TMI TB data.The PR is an active 13.8-GHz radar, measuring backscatter from precipitation. The horizontal and vertical resolutions of PR are 4.3km and 250m, respectively. Although PR has a swath width of 215km, low-level atmospheric echoes near boundaries of the swath are contaminated by ground clutter. PR 2A25 is a level-2 product for PR that includes rain intensity profile. Rain flags indicating the rain types(stratifrom, convective, bright band, etc.), and range bin numbers of various quantities of precipitation(top level, brightband level, etc.). For the validation of precipitation retrievals, we mainly use rain intensity data at 2-km height that give uncontaminated, near-surface precipitation measurements for the whole swath.

4. Result

Figure 2(a), (b), shows the scatter plot of H and V polarization at 10 and 85GHz. The emission effect due to rain increases the brightness temperature to a larger dynamic range. Figure 2(b) shows 85GHz H-V polarization TB and larger contribution from scattering is clearly evident compared to all other channels. The TB first increase due to water vapor, liquid water etc. But in the presence of precipitation there is a sharp decreasing branch of scattering below the emission signal

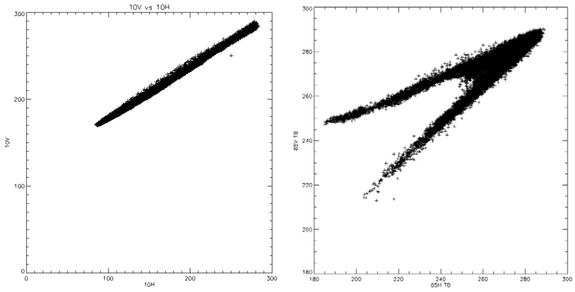

Fig. 2. Scatter plot of 10GHz and (b) 85GHz for V & H polarization on August 30, 2003

The scattering index is used to estimate the scattering intensity by presence of the ice crystals in the atmosphere. Usually, the brightness temperature at high-frequency channels that are highly affected by ice-crystal scattering, while the brightness temperature at low-frequency channels are not. Based on the dataset of rain-free areas, we used a formula, Yao et al(1989) of E(10V, 19V, 21V)$_{85v}$ as follows, which was used to estimate the value of TB$_{85v}$:

$$\mathrm{E(10V, 19V, 21V)}_{85v}$$
$$= -65.487 - 0.1862TB_{10V} - 0.45456TB_{19V} + 1.86047TB_{21V}$$

We named SL_L as the atmospheric scattering index over land, and SL_L is defined as this formura.

$$SL_L = \mathrm{E(10V, 19V, 21V)}_{85v} - TB_{85V}$$

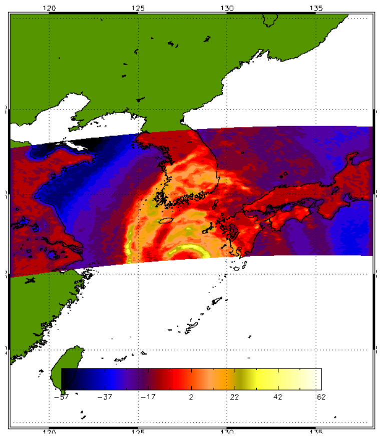

Fig. 3. Scatter Index(SI) for land and ocean area

Further the scattering index images were also plotted using the SI algorithm. The image is placed at figure 3. Now we must remember SI is negatively correlated to TB_{85V} when it is raining and hence is positively correlated to the surface rain rate. Hence for no rain areas the value of SI should be zero. The expected range should extended from zero(Corresponding to no rain) to some positive value(Corresponding to rainy areas). However the values of SI ranges from -57 to 62. Another factor sensitive to surface precipitation is polarization-corrected brightness temperature(PCT) at 85 GHz. Spencer et al. (1989) gave a formula of PCT_{85} as follows:

$$PCT_{85} = 1.818 TB_{85V} - 0.818 TB_{85H} .$$

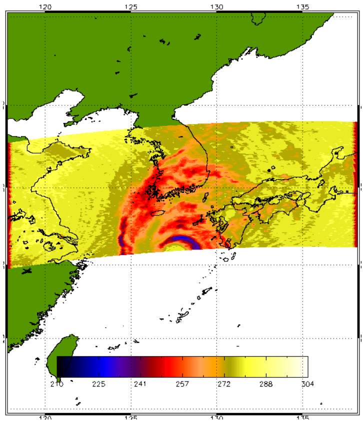

Fig. 4. Polarization-Corrected Brightness temperature (PCT) on August 30, 2003

The polarization corrected brightness temperature at 85 GHz was also calculated using Spencer algorithm are the image to plotted as shown in figure. 4. The values range from 210-304K. We know that since PCT_{85} is positively correlated to TB_{85V} when it is raining and since TB_{85V} is negatively correlated to rain rate hence PCT_{85} is negatively correlated to the surface rain rate. This is clearly seen in areas with lower value of PCT_{85} ad non rainy areas show higher values.

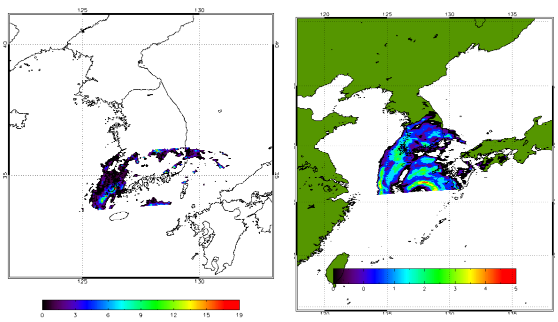

Fig. 5. (a)PR 2A25 rain intensity and (b)Precipitation using SI algorithm

Figure 5(a) shows PR 2A25 rain intensity at 2.5-km height over the Korea region. Southwest region was covered by an intense convective cloud cluster, which lead to a heavy surface rain. From figure 5(b), we can see that the rain intensity range is 0-19mm/h. Figure 12 presents precipitation retrieved from TMI TB using Yao et al(2002) SI and PCT algorithms. This figure shows heavy precipitation cells to the south of Jejudo Island. The rain rate using SI and PCT algorithm show underestimation comparison to 2A25 rain intensity. However the present case cannot be taken to generalize our observations. A larger number of such studies would be carried out to establish a new rain estimation procedure in the area of our study.

3. Conclusions

Present study has been taken up as an initiative to establish a new rain retrieval algorithm over the Korea region. The TRMM-channel characteristics are studied and an insight has been developed in order to make use of the some of the predictor variables that are clearly relation to rainfall equation SI and PCT. To examine the performance of an over land and ocean precipitation Yao et al(2002) algorithm using SI and PCT. We applied this algorithm to TMI data during RUSA Typhoon event 30 August 2002. The rain rate using SI and PCT algorithm show underestimation comparison to 2A25 rain intensity.

First time the TMI results based on an algorithm by Yao et al (2002) has been used in conjunction with precipitation radar observation. A larger data base of TMI and PR is envisaged in our one-year project. So as to have a full proof rain retrieval algorithm over Korea region. The ground based measurements from rain gauges and Doppler weather radar data would be used for validation and fine tuning the algorithm in near future.

Acknowledgement

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