Passive Microwave Precipitation Retrieval using TRMM/TMI: Comparison with TRMM/PR (2A25) and TRMM/TMI standard product (2A12)

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1. Intruction

The information about the global precipitation is necessary for the study of climatology, the prediction of a flood and the problem of the water resource. The observation from space crafts gives a lot of data about the precipitation. An useful observation is using radiation of microwave radiated from the Earth which is passive observation. The microwave has a good sensitivity to rainfalls. Several microwave radiometers observes the rainfall, for example, Special Sensor Microwave Imager (SSM/I) on board the Defense Meteorological Satellite Program (DMSP) of U.S.A. There are several retrieval programs to obtain precipitation from brightness temperatures observed satellites passively. The accurate of the precipitation data has not been well known, for example the variation with ground rain gauge data on ocean. The Precipitation Radar (PR) on board the Tropical Rainfall Measuring Mission (TRMM) satellite observes at the same time with the TRMM Microwave Imager (TMI) on board the TRMM. We can validate the precipitation data of a microwave sensor by comparing with the PR data.

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An algorithm to retrieve the precipitation from brightness temperatures (TBs) observed by the TMI is being constructed. The basic idea of the algorithm is to find the optimal precipitation that gives Radiative Transfer Model (RTM) -calculated TBs that fit best with observed TBs.

In this study the result precipitation of the retrieval algorithm is compared with standard precipitation named 2A12 (TMI standard product, the precipitation is processed by the GPROF algorithm [Kummerow, 2002], version 5) and 2A25 (Precipitation Radar (PR) observation, the rainfall is estimated by the algorithm made by Iguchi, et al. [2000], version 5) during 1998. Mainly the precipitation over ocean is compared.

In the future the algorithm will be developed by introductions of the rainfall area over the land (to reduce of the snow effect) and the precipitation profiles (to divide precipitation types). .

2. Data set

The TMI measured TBs at 10.7, 19.35, 21.3, 37.0 and 85.5 GHz (hereafter 10, 19, 21, 37 and 85 GHz) horizontal and vertical polarized microwave expect for the 21.3GHz. The level 1 product 1B11 version 5 is including those TBs which are used for the algorithm. The result precipitation of the algorithm is arranged to 0.25X0.25^{o} grid daily data set. The data set using the comparison are 2A12 and 2A25 version 5 which data are arranged to the same way of our result.

The methods to evaluate our result are:

1. Comparison of grid data of one day (1/1/1998 and 2/7/1998), the scatter plot is showed between the result and standard products, and calculated correlation coefficients.
2. Comparison of the zonal mean for one month over ocean for January, 1998 and July, 1998.

In this study, only the result over ocean is compared. The advanced version of our algorithm includes the sub routine for the distinction real rainfall area from snow coverage area. The detail is referred a presentation of Seto, et al., (in the same poster session,1P21).

3. Algorithm

The basic idea of the algorithm is to find precipitation that gives RTM-calculated TBs that fit best with TBs at 10, 19 and 85GHz vertical polarization.

The outline of the algorithm is:

1. The RTM of Liu (2002) calculates lookup tables between precipitation and TBs for homogeneous precipitation.
2. The lookup tables are corrected using the estimated precipitation inhomogeneity.
3. The first guess of precipitation is obtained from TMI TBs using the lookup tables.
4. The optimal precipitation is iteratively calculated from TBs calculated from fist guess of precipitation and TMI TBs.

The applied RTM is made by Liu (2002) that was advanced from Liu's RTM [Liu, 1998]. The information of surrounding atmosphere, for example, temperature profile of the atmosphere, Sea Surface Temperature (SST) , surface wind speed are given from the 12-hourly global analysis data (GANAL) provided by the Japan Meteorological Agency. Both raindrop and ice particle are assumed to follow the Marshall-Palmer size distribution.

The correction of look up tables for inhomogeneous precipitation is referred Aonashi and Liu [2000].

4. Results

4-1.*Scatter plots and correlation coefficient*

By the data set of 0.25X0.25^{o} of selected day (2/7/1998), scatter diagram between 2A12, 2A25 vs. the result and 2A12 vs. 2A25 shown in Figure 1(a), (b), (c). The relation between the result (axis named 'New') and 2A12, shows good coincidence but the slope of linear regression is small which means the precipitation of the algorithm is estimated lower than 2A12. The trend of the linear regression less than 1 is almost seen for all days calculated. The scatter plot between the result and 2A25 shows under estimate of our result. This relation is almost seen in the all days calculated.

From Figure 1(b) the correlation between the result and 2A25 is predicted well than 2A12 vs. 2A25 (Figure 1(c)). Actually the correlation coefficient between the result and 2A25 listed in Table 1 which is added results of April and October is better than those of between 2A12 vs. 2A25 expect January 1998.

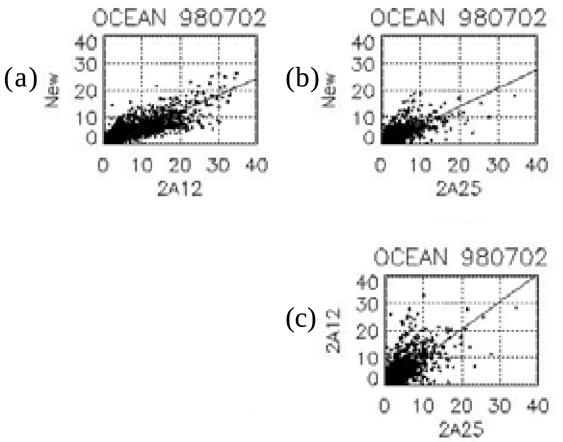


Figure 1. Scatter plot of precipitation (mm/h). (a) Our result v.s.2A12, (b) Our result v.s. 2A25 and (c) 2A12 v.s. 2A25 (for refer). About 2/7/1998.

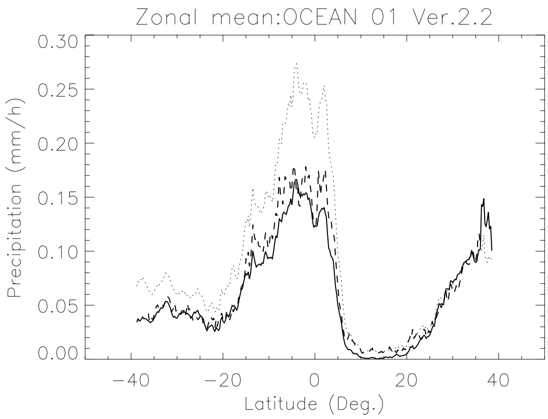
	Ver.2 vs. 2A12	Ver.2 vs. 2A25	2A25 vs. 2A12
January	0.79	0.77	0.82
April	0.92	0.83*	0.82
July	0.88	0.83*	0.72
October	0.92	0.85*	0.83

Table 1. Seasonal variation of correlation coefficient. 'Ver.2' means our result.

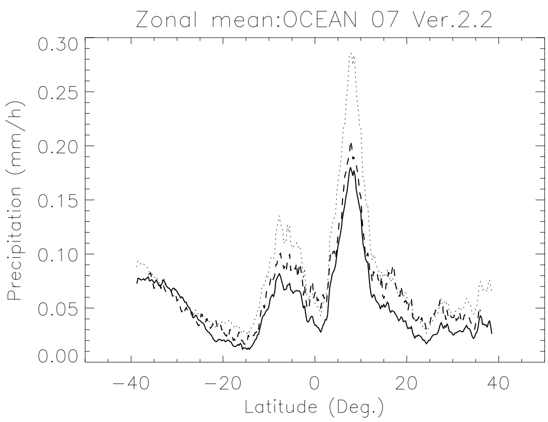
4-2.*Zonal mean rainfall*

Zonal averaged rainfalls are displayed in Figure 2(a) for January 1998 and (b) for July 1998. The zonal mean rainfall is important for evaluate averaged value. Three zonal mean values show that the result and 2A25 is well coincident for both months. For January, 1998, the stronger precipitation area is seen during 5^{o}N-15^{o}S. The result and 2A25 are well correlated. The 2A12 is generally higher than 2A25 and our result, especially around the equator. The period during January 1998 is in the midst of the strong El Nino, the estimated difference around the equator between 2A25 and 2A21 is quite larger between -20S^{o} and 5N^{o}. This difference may be caused the freezing height. The experimental calculation by using GPROF (2A12's algorithm) is presented by Hashizume in the same poster session 1P13.

The profiles of July, 1998 have twin peaks around the equator which is seemed the ITCZ and SPCZ. At these tops, 2A21 rainfall is greater than 2A25 and the result. The result and 2A25 profile are closely similar each other. Expected winter (south) hemisphere, our result is slightly lower than that of 2A25. If we regard the PR observation 2A25 rainfall is nearly realistic rainfall, the comparisons between the result and 2A21 and 2A25 show that our result is reproduced realistic rainfall trend (agree with



(a)



(b)

Figure 2: Monthly zonal mean precipitation. (a):January,1998, (b):July,1998. The solid line, dashed line and dotted line indicate our result, 2A25 (PR) and 2A12.

2A25 rainfall) and our result was somewhat underestimated.

The overestimation of 2A12 more than 2A25 (PR) was well known by data users. The data sets (2A12, 2A25) are under renewal to version 6, that the difference between 2A21 and 2A25 is expected to be small.

5. Summary

The result rainfall of the retrieval algorithm is compared with TRMM standard products data TMI (2A12) and PR (2A25). The result of our algorithm indicated the underestimation compared with 2A21 and 2A25, which results are common in one day grid data and the monthly zonal averaged data.

The correlation coefficient between the result and 2A25 was a few larger than that between 2A21 vs. 2A25. The zonal mean shows the same trend that the 2A25 latitudinal-rainfall profile of the zonal mean is closely of our result.

These characteristics are seen in all through 1998.

The next step is how to delete the effect of the snow coverage on land, the next version of the algorithm is including distinguish the rainfall area from higher Tb occurred on the snow. The algorithm will be developed by turning the freezing height, selecting precipitation vertical profiles, and so on by GSMap project.

ACKNOWLEDGEMENTS

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