4.17 Frequency Distribution of Rain Rate With Cloud Top Brightness Temperature, and near-real time calibration of GOES Multispectral Rainfall Algorithm

[1,2]Mamoudou B Ba*, [2,3]Arnold Gruber, and [2]Myeong-Jae Jeong
[1]Raytheon-ITSS, Lanham, MD 20706
[2]University of Maryland, College Park, MD 20742.
[3]NOAA-NESDIS, Camp Springs, MD 20720

Abstract

Biased corrected radar rain estimates and GOES observations are used to study the distribution of rain rate with cloud top brightness temperatures, and to calibrate a GOES Multispectral Rainfall Algorithm (GMSRA). First, radar estimates are used to select the actual raining clouds. The frequency of distribution is then computed using classes of 5 mm/hr of rain rate. Results for the summer months (May, June and July 2001) show interesting results characterized by two distinct classes of raining clouds for light to moderate rain rates: very cold cloud tops centered about 214°K, and a second warm cloud top about 260K. Very few raining clouds with cloud tops between 235°K and 253°K are observed for these three months of data. For rain rates greater than approximately 25 mm/hr, only one class with Guassian-like distribution is observed with the modal value centered around 212°K with a cut-off of rain at approximately about 225°K. The biased corrected radar rain rates and collocated instantaneous cloud top brightness GOES data are used to compute mean rain rate for a 2-°K bin. The resulting lookup table is used to re-calibrate GOES Multispectral Rainfall Algorithm.

1. INTRODUCTION

For satellite based rainfall algorithms, two fundamental problems need to be solved: 1) identifying raining cloud from satellite data, and 2) determining rain amount associated to these clouds. The GOES Multispectral Rainfall Algorithm (GMSRA) (Ba and Gruber, 2001) is an attempt to solve these two problems. However, it is found that GMSRA generally under-estimate heavy rainfall events and overestimate light rainfall. GMSRA was calibrated using data collected for only seventeen days in June and July 1998. This paper presents results for near real-time calibration of GMSRA using biased corrected radar, and an analysis of frequency distribution of rain as function of cloud top brightness temperature.

* Corresponding author address: Mamoudou B. Ba, Raytheon-ITSS, Lanham, MD 20706
e.mail: Mamoudou_b_Ba@Raytheon.com

2. DATA PROCESSING

The data used in this study include radar and satellite data collected during May-July 2001. The data consist of 15-minute US composite radar reflectivities from the Global Hydrology Resources Center (GHRC), and 15-minute of GOES imagery data obtained from NESDIS. The reflectivity data were converted to the radar rain rate estimates using Z-R relationship given in Eq. 1. The computed rain rate from Eq. 1 is multiplied by a factor of 0.4 representing a multiplicative bias obtained by the ratio of rain gauge estimates to radar ones (Jeong, personal communication 2002).

$$Z = 300RR^{1.4} \tag{1}$$

where RR is rain rate and Z radar parameter. Frequency of distribution of radar rain rate as function of cloud top brightness temperature is computed using classes of 5 mm/hr for the months of May, June and July 2001.

Figure 1 shows the distribution of rain rate as function of cloud top temperature. The distribution is characterized by two distinct classes of raining clouds for light to moderate rain rates; very cold cloud tops centered about 214°K, and a second warm cloud top about 260K. Very few raining clouds with cloud tops between 235°K and 253°K are observed for these three months of data. For rain rates greater than approximately 25 mm/hr, only one class with Guassian-like distribution is observed with the modal value centered around 212°K with a cut-off of rain at approximately about 225°K. Note that the infrared rainfall based techniques generally use a threshold of about 230°K as a cut-off of raining cloud. Figure 1 also shows that significant rain events are associated with warm clouds in the range of the freezing level. Another interesting result is that most of rain events for both warm and cold tops are associated with light to moderate rain rate. This is a serious problem for calibrating of visible/infrared based techniques using data of a limited rain events.

In the light of the above results, it seems the best way to calibrate satellite visible/infrared technique is to apply a refreshing calibration. This is not easy to do in the most part of the globe, but it can be done over USA where near real-time radar data exist. Using the 15-minute radar and GOES data, we develop a near real-time calibration technique for GMSRA. For each hour, biased corrected radar rain rates and collocated instantaneous cloud top brightness GOES data are used to compute mean rain rate for a 2-°K bin. The resulting lookup table is used for the next hour in GMSRA for estimating rainfall for that hour. It is assumed that the environmental setting of the weather is slowly changing so that the rain processes will be nearly identical within one hour for a given location.

Figure 2 presents 24-hour rainfall accumulation for radar estimates, and GOES estimates for real-time calibration, and the old GMSRA calibration. Table 1 shows statistics of the comparison between 24-hour radar and GMSRA estimates. Overall, GMSRA overestimates the mean spatial rainfall by 1.7 and 2 for near real-time calibration (New) and the static calibration (old), respectively.

3. CONCLUSION

Biased corrected radar are used to study the frequency of distribution of rain rate as function of cloud top brightness temperature. It is found that the distribution is characterized by two main classes with one class corresponding to very cold top centered about 214K, and a second class centered about 260K. Most of rain events for the three months studied correspond to light to moderate rain rate for both warm and cold tops. This indicates the difficulty in establishing a single relationship between rain rate and cloud top using a limited set of rain events. A near real time calibration may be the best solution for calibrating satellite rainfall algorithms. This is implemented for GMSRA and its performance will be tested in our future work.

4. REFERENCES

Ba, M. B., A. Gruber, 2001: GOES Multispectral Rainfall Algorithm (GMSRA), *J. Appl. Meteor.*, **40**, 1500-1514.

	N	Coefficient of correlation	rmse (mm)	Bias (mm)	Spatial Mean (mm)
New vs. radar	1,025	0.63	4.0	-1.6	3.6/2.1
Old vs. radar	1,025	0.63	4.0	-2.2	4.2/2.1
New vs. old	1,025	0.83	4.3	0.6	3.6/4.2

Table 1: Statistics of comparison between radar and GMSRA estimates for 0.5° x 0.5° boxes.

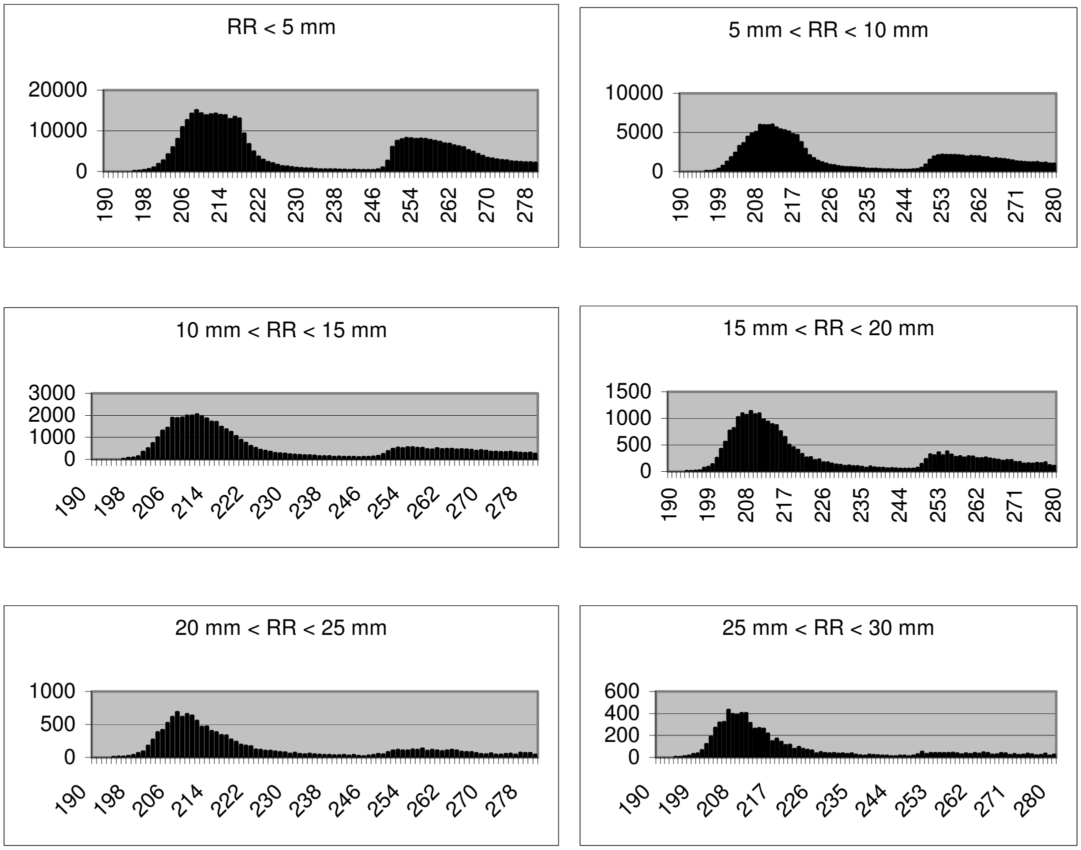

Figure 1: Frequency distribution of rainfall events with Satellite Observed Cloud Top Brightness Temperature.

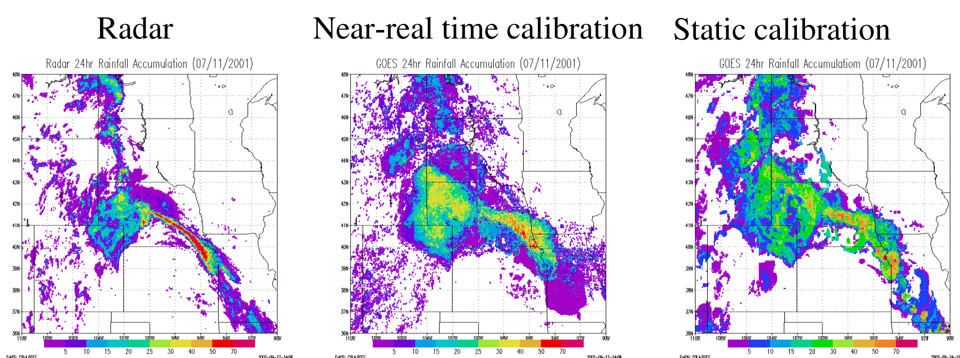

Figure 2: 24-hour rainfall accumulation (mm) as estimated from radar (left panel), GMSRA new calibration (middle panel), and GMSRA old calibration (right pane)