Validating Rainfall Products from the Chinese FY-3B Satellite Microwave Radiometer

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Abstract

The Goddard Profiling Algorithm represents a Bayesian algorithm to retrieve rainfall and its vertical structure from passive microwave radiometers. It uses an a-priori database of cloud structures and its associated brightness temperature based upon TMRM Microwave Imager (TMI) and Precipitation Radar (PR) (Kummerow, et. al. 2011). The algorithm is applicable to additional microwave sensor as long as the appropriate sensor brightness temperatures are created from the original database. This project created a database for use by the recently launched FengYun-3B (FY3B) Microwave Radiometer Imager (MWRI) and implemented it in GPROF to calculate rain rates. The rain rate amounts calculated from one month of FY-3B MWRI data were the compared against the Kwajalein radar and the TMI for quality assessment. Scatterplots illustrate a linear trend between MWRI and TMI, with a correlation coefficient of 0.8406. The image comparisons between MWRI and TMI show similar shapes of the rain areas along with similar rain rates. The MWRI and Kwajalein rain rate comparisons have a small linear trend, but the image comparisons show the detection of rain in the same areas and general shapes with varying rain rates.

Methodology

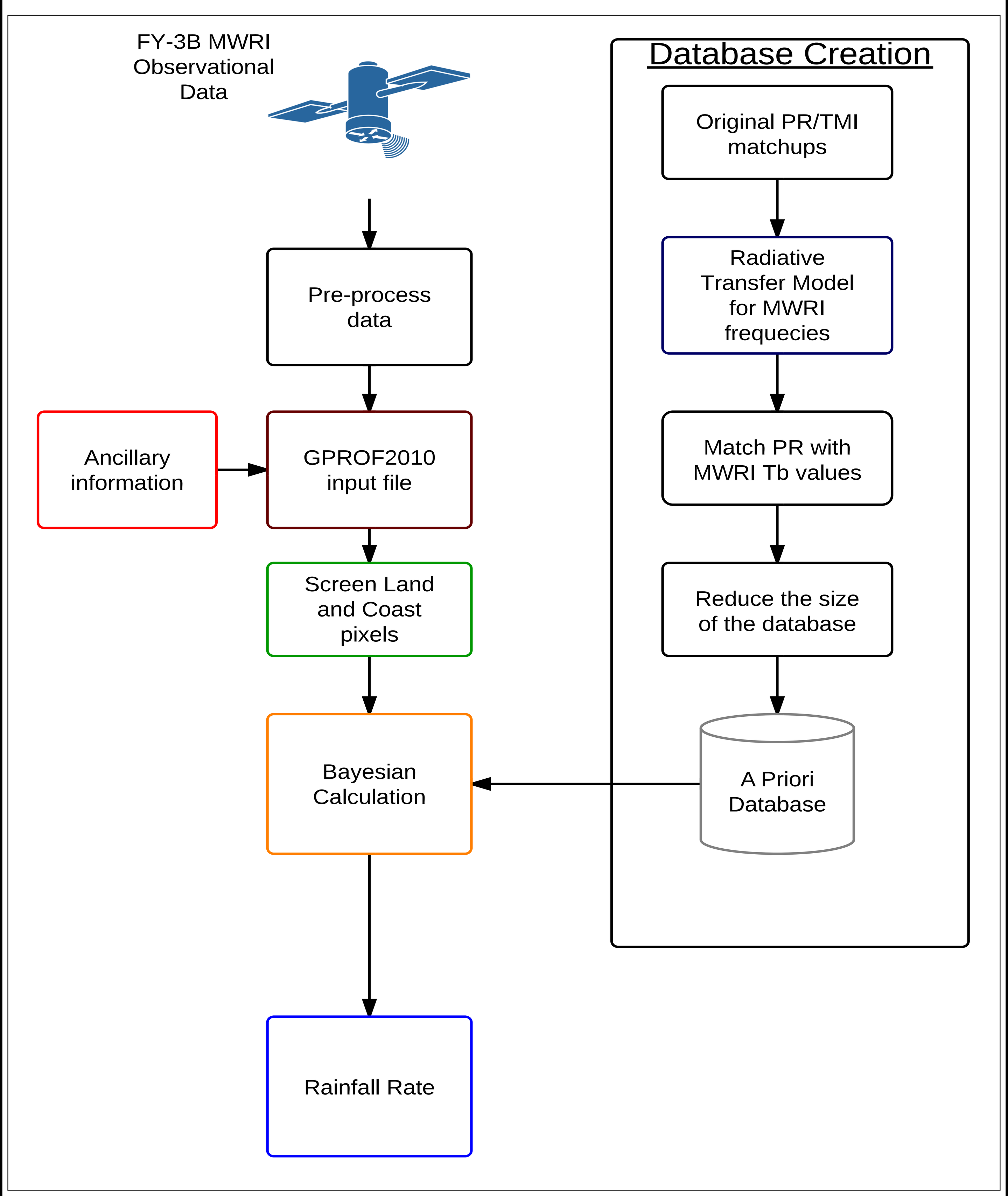
1)Using GPROF, calculate the rain rates from the MWRI observational data for the month of July, 2011

- Specific sensor modifications needed to be made to the original a-priori database of cloud structures and the associated brightness temperatures from Kummerow et. Al. (2011).

2)Compare GPROF rain rates for MWRI with the Kwajalein radar rain rates and the TMI GPROF rain rates when the MWRI crosses their path

- In order for that to occur, coincident latitude and longitude points needed to be calculated.
- Latitude Range for KWAJ comparison: 7° 20' N to 10° N
- Longitude Range for KWAJ comparison: 166° 12' E to 169° 24' E

Figure 1: Flow Chart of Rain Rate Calculation



FengYun-3B Microwave Radiation Imager (MWRI)

- Launched FengYun-3B satellite Nov. 5th, 2010 by the Chinese Meteorological Administration
- Sun-synchronous, polar orbiter
- Lifespan: 3 years
- MWRI observes the Earth's atmosphere and surface at: 10.65, 18.7, 23.8, 36.5, and 89.0 GHz with each frequency having dual polarization
- Major uses:
  - Rain rates
  - Cloud water content
  - Water Vapor
  - Sea Surface Temperature
  - Snow Cover

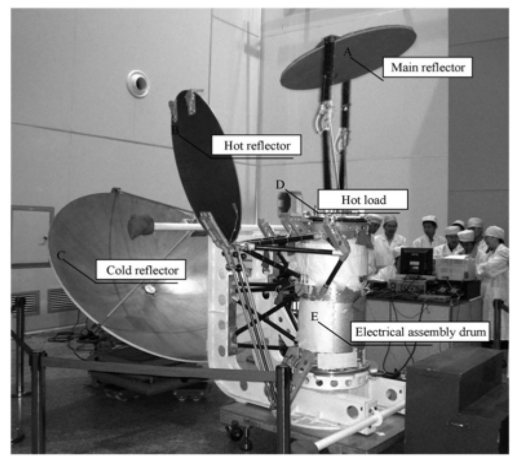
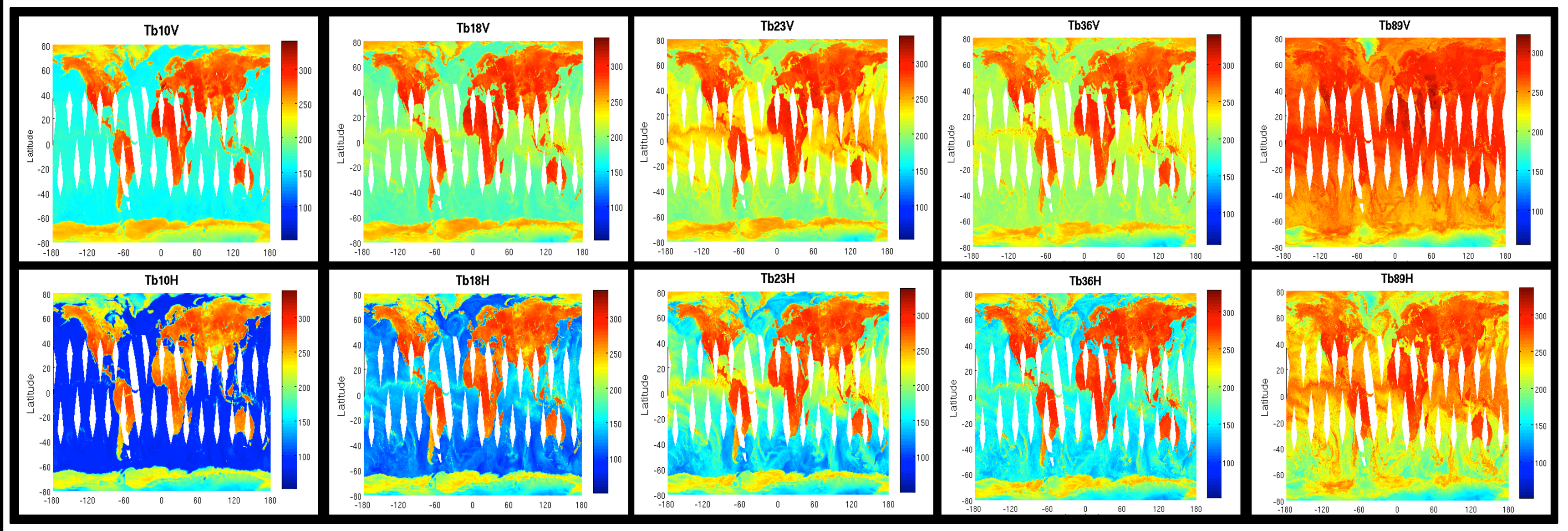


Figure 2: An actual photograph of the MWRI sensor from Yang et. Al. (2011).

Figure 3: The brightness temperatures of the MWRI at every frequency on 7/1/2011



Validation

- The data that was compared was the whole month of July, 2011.
- For MWRI vs. TMI, all the points where the two satellites crossover within an hour were recorded and compared. A total of 991 crossover points. Figure 4 shows the locations of the crossover points.
- The black star on figure 4 represents the location of Kwajalein.

Figure 4: Crossover Locations of the TMI and MWRI during July, 2011 Within an Hour

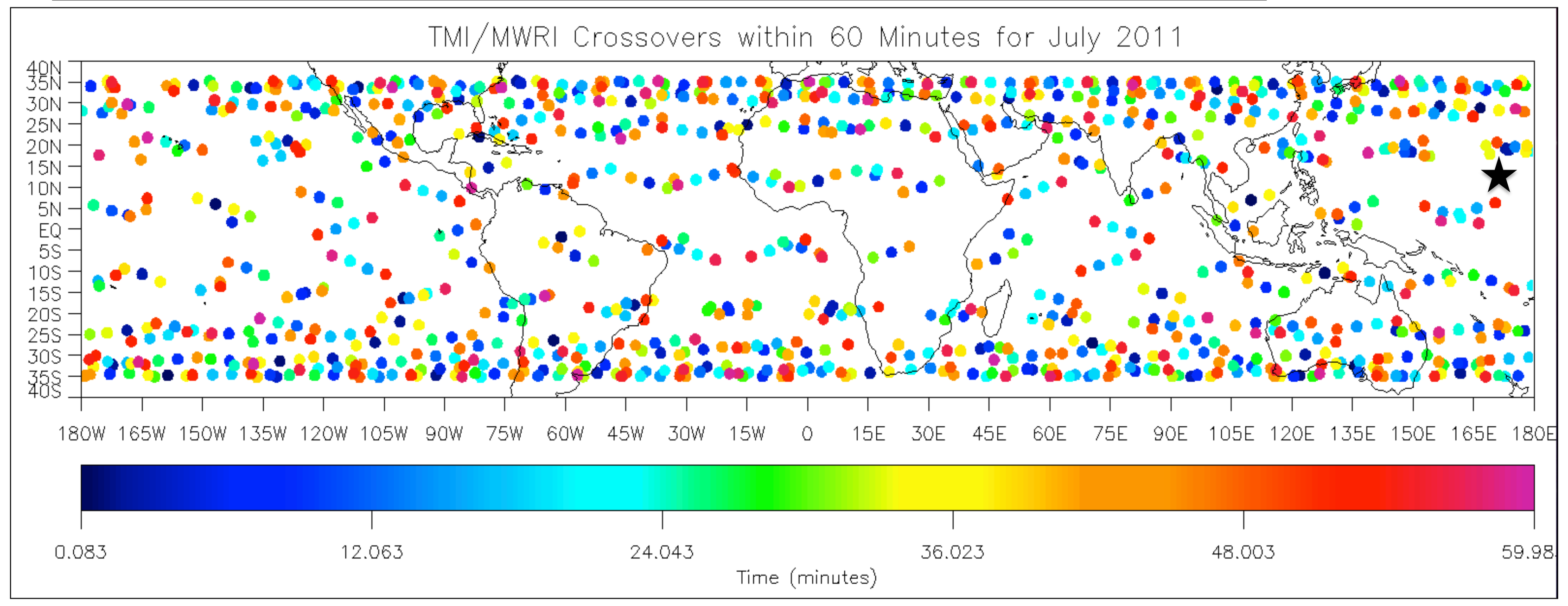


Figure 5a

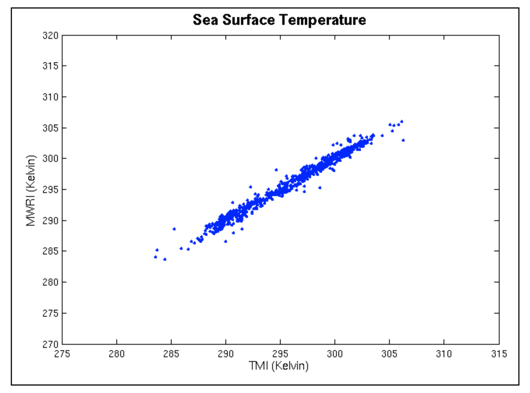


Figure 5b

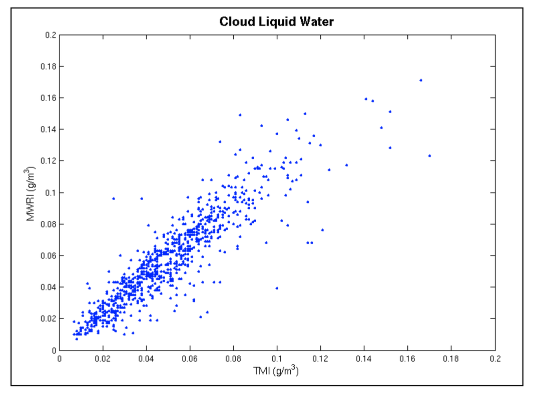


Figure 5c

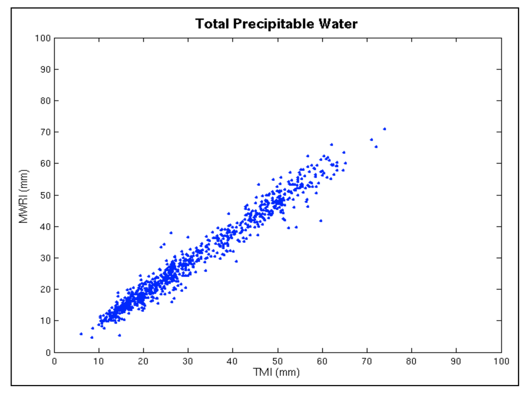


Figure 5: Comparison of sea surface temperature (a), cloud liquid water (b), and total precipitable water (c) between MWRI and TMI.

References

Kummerow, C., S. Ringerud, J. Crook, D. Randel, and W. Berg, 2011: An Observationally Generated A Priori Database for Microwave Rainfall Retrievals. *Journal of Atmospheric and Oceanic Technology,* **28**,113-130.

Yang, H., F. Weng, L. Lv, N. Lu, G. Liu, M. Bai, Q. Qian, J. He, and H. Xu, 2011: The FengYun-3 Microwave Radiation Imager On-Orbit Verification. *IEEE Transactions on Geoscience and Remote Sensing,* **49**, 4552-4560.

Wolff, D., and B. Fisher, 2008: Comparisons of Instantaneous TRMM Ground Validation and Satellite Rain-Rate Estimates at Different Spatial Scales. *Journal of Applied Meteorology and Climatology*, **47**, 2215-2236.

Verification

Figure 6: Rain Rate comparison between TMI vs. MWRI (a) and Kwajalein vs. MWRI (b).

- The rain rate scatterplots (Figure 6) show two different stories. The TMI vs. MWRI (Fig. 6a) has a correlation of 84.06% and a bias with respect to TMI of 9.35%.
- Figure 6b illustrates the relationship between the mean Kwajalein rain rate and the mean MWRI rain rate at 300 km x 300 km. It has a correlation of 91.92% and a bias with respect to Kwajalein of 51.11%.

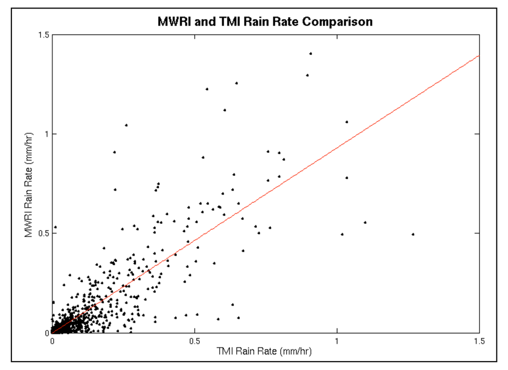


Figure 6a

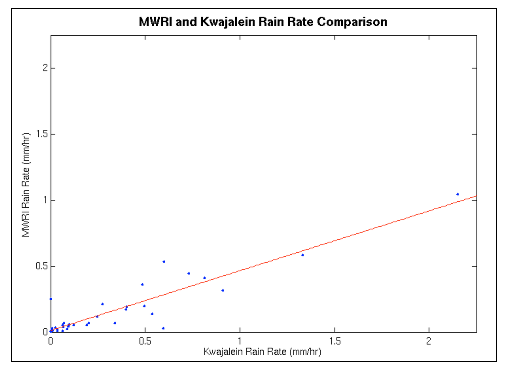
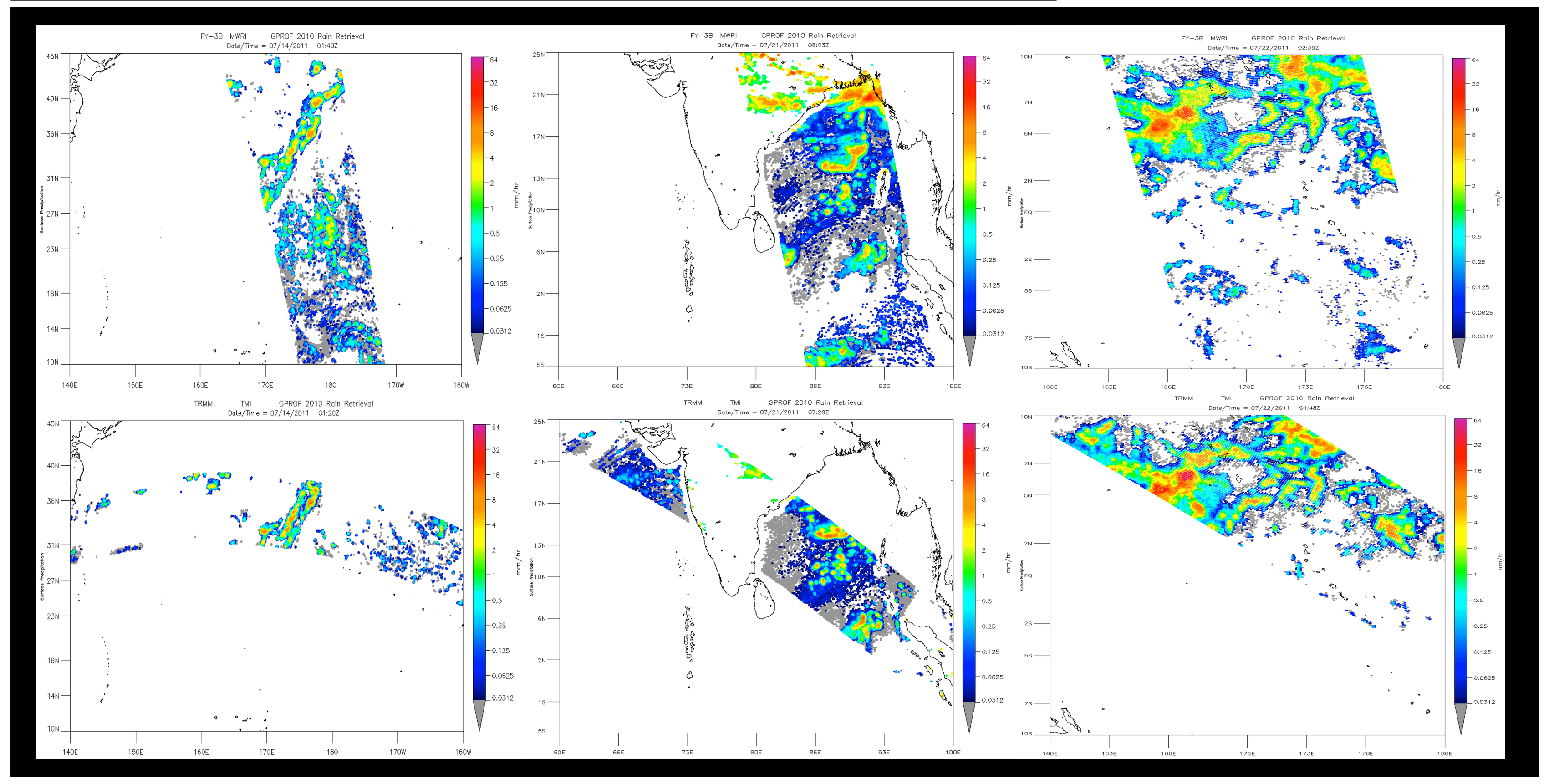


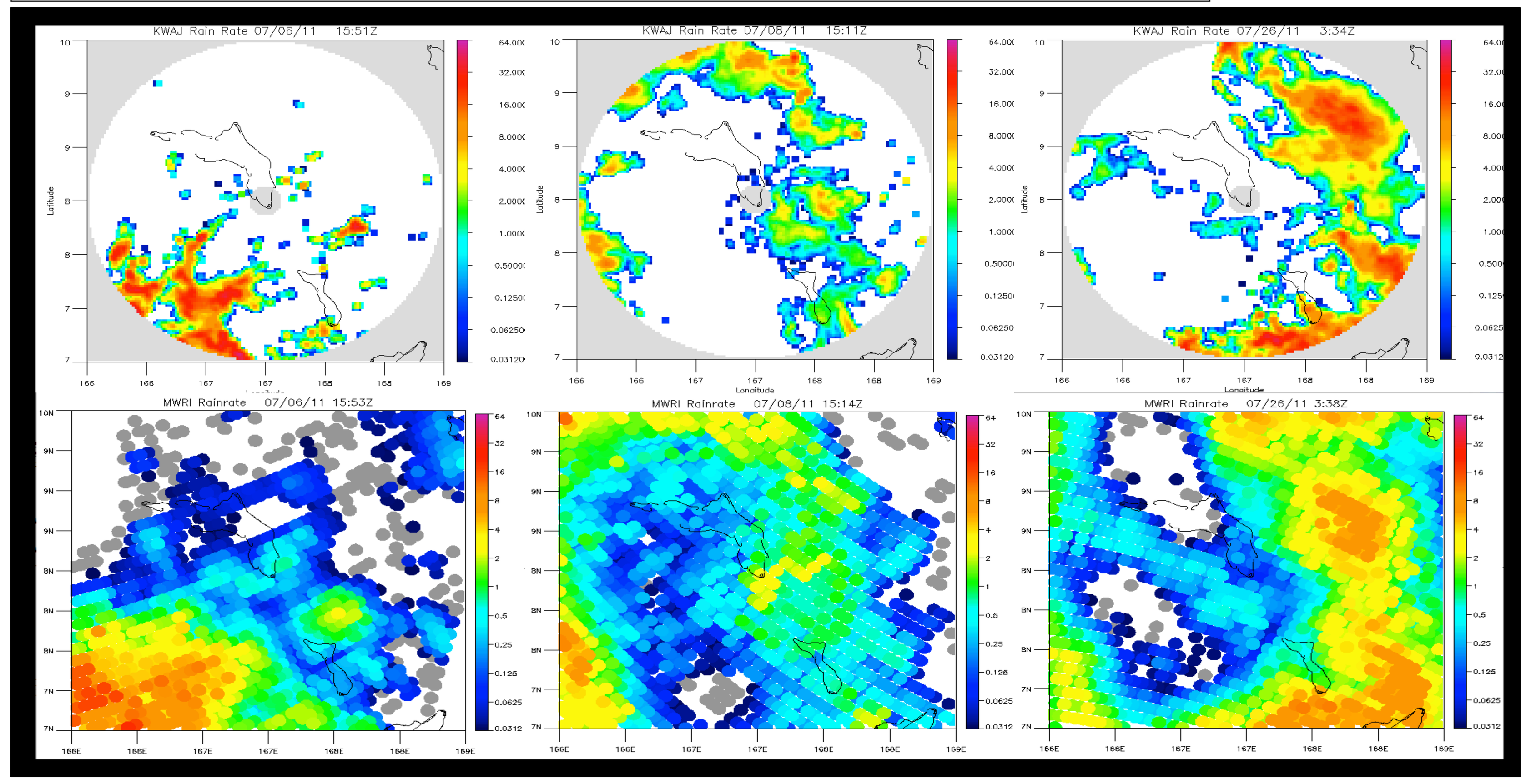
Figure 6b

Figure 7: Rain rate comparisons between MWRI and TMI for 3 separate days



- The MWRI and TMI rain areas look very close to each other. The shapes and rain rates look very similar.

Figure 8: Rain rate comparisons between Kwajalein radar and MWRI for separate 3 days



- The shapes of the rain rates in each of pairs of radar and MWRI images seem to match up, but the rain rates are not exactly the same.

Conclusions

- The conversion of the *a priori* database from the TMI to the MWRI was successfully created using the radiative transfer model in order for GPROF to work for the MWRI data.
- The MWRI rain rate and the TMI rain rate have a correlation of 84.06% with a bias of 9.35%. We expect this to do better than MWRI vs. Kwajalein because the two sensors are very similar to each other and have similar scanning processes.
- The MWRI rain rate and the Kwajalein rain rate have correlation of 91.92% with a bias of 51.11%. A study by Wolff and Fisher (2008) show that Kwajalein and TMI have a mean bias of 7.9% for 5 years. If we had run a years worth of data, the Kwajalein vs. MWRI bias should decrease.

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