

Assessing the Impact of Uncertain Brightness Temperatures on the Goddard Profiling Algorithm

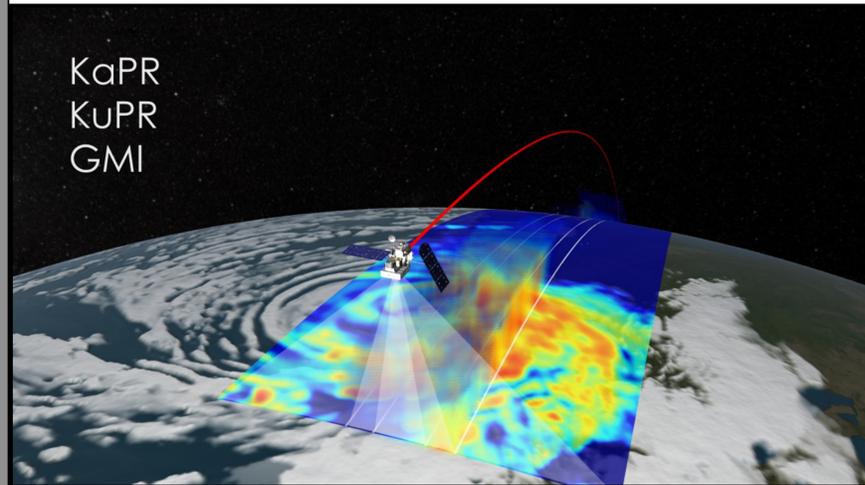
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Introduction

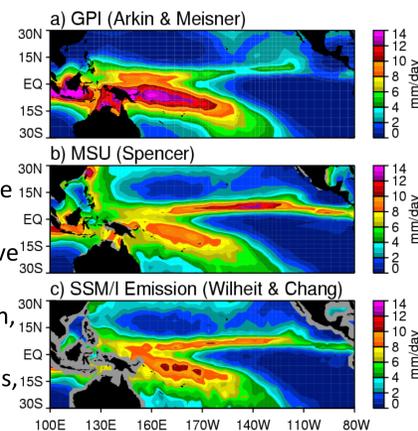
Measuring precipitation through satellites not only provides precise global rainfall data, but satellites also grant substantial coverage of weather patterns compared to just surface observations. Because of this, the algorithms utilized to compute rainfall data from the instruments on board the satellites are constantly undergoing improvements for more accurate representations of the atmosphere. This research assesses the impact of uncertain brightness temperatures on the Goddard Profiling Algorithm, the algorithm used to compute rainfall rates from the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Mission (GPM).



Motivation

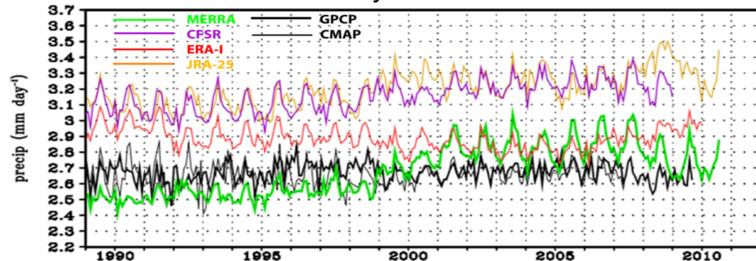
Before the TRMM and GPM era, estimates from satellite varied greatly. The image to the right shows estimates from three different satellites each with contrasting mean rainfall rates for the same observation area. The top shows an IR estimate that tends to overestimate in the Western Pacific. The center graph shows lesser intensities from a microwave sounder but with a more defined inter-tropical convergence zone. Bottom graph, from a microwave imager, shows characteristics of the top two estimations, no rainfall rates estimated near land.

Satellite Rainfall Biases
Mean DJF Rainfall (1987 – 1996)



Rainfall uncertainties are also evident in recent reanalysis data. Satellite observations (black) are relatively constant while different models show strong variability over the past two decades.

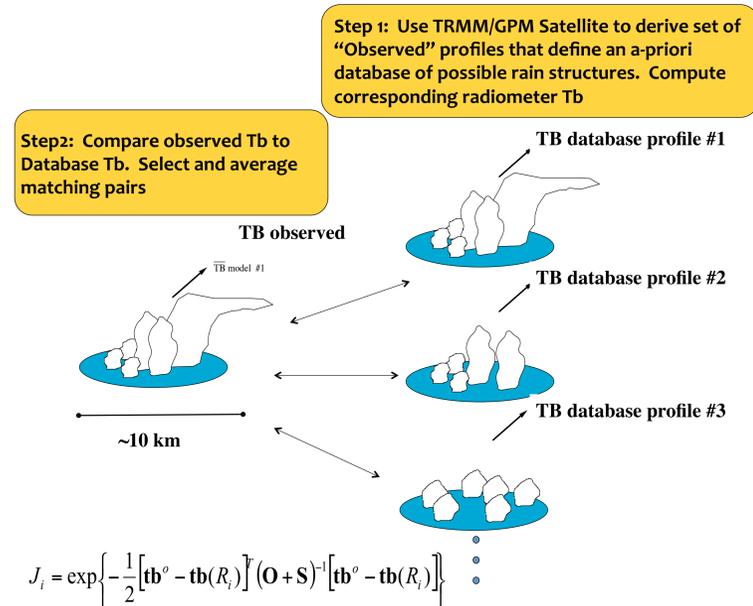
Reanalysis Data



Methodology

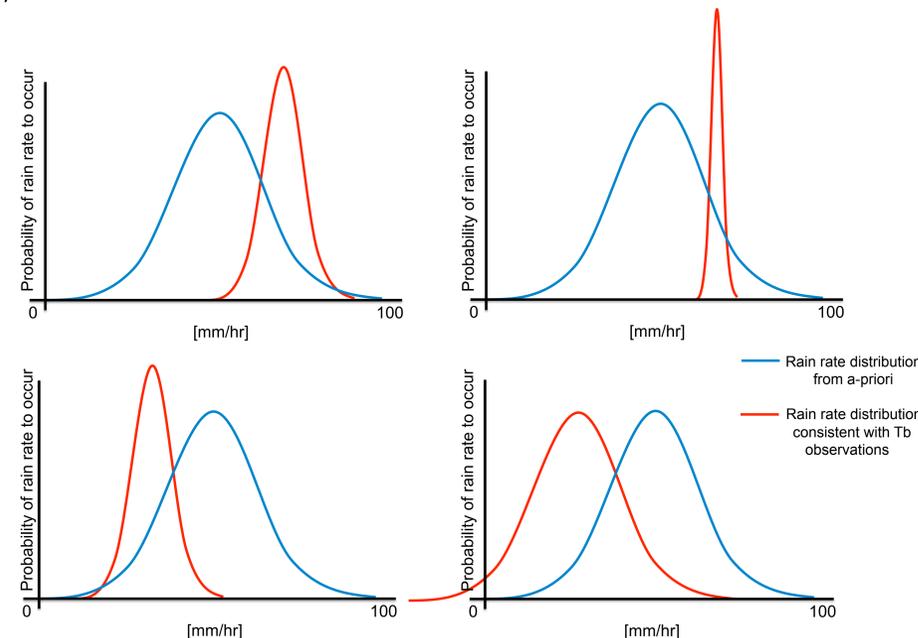
The most notable satellites used to obtain global precipitation data are the TRMM and GPM satellites. In order to obtain data from the instruments onboard these satellites, first the observations must go through a series of data retrieval algorithms. The Goddard Profiling Algorithm (GPROF) is applied to derive rain data from observations. The structure of the algorithm is as follows:

The GPM radiometer algorithm



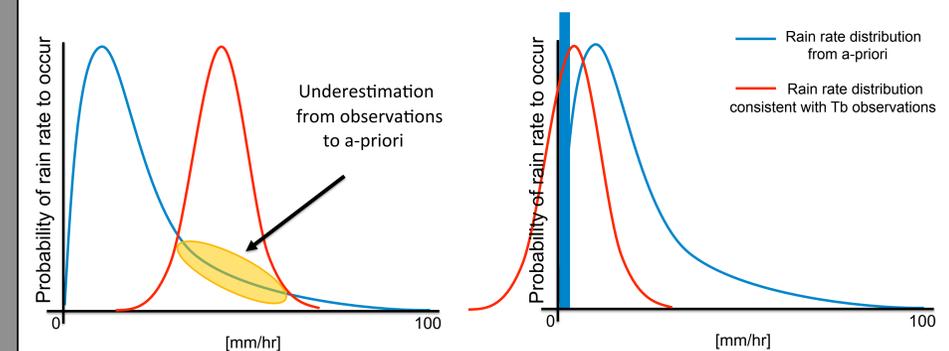
A simplified conceptual framework:

If the blue line below represents the a-priori distribution of observed rainfall, and the red is the distribution of rainfall that is consistent with the observed Tb, then the overlap represents the areas of consistency from where the expected value (retrieval) can be obtained. Retrievals can be biased if the a-priori is not linear within the overlap region. This depends upon the uncertainties (red curve). Curves below, for 4 gaussian rain rates distributions, show typical over- and under-estimates by retrieval with different Tb uncertainties.



Methodology (Continued)

Log-Normal:



Global mean rain rates follow a log-normal distribution, suggesting that there is a greater probability of rain rates to be near 0.00 [mm/hr] compared to 100 [mm/hr]. To test the impact of uncertain brightness temperatures, an increasing amount of noise and realistic 0.00 [mm/hr] rain rates will be added to a synthetic a-priori and observations, symbolically shown on the plot to the right.

Conclusions

		Channel Uncertainty							
		0.0 [K]	0.5 [K]	1.0 [K]	2.0 [K]	5.0 [K]	10 [K]	20 [K]	40 [K]
0%	Zeros	0.0%	-0.0069%	-0.0229%	-0.0598%	-0.2538%	-0.8285%	-2.7039%	-9.1763%
50%	Zeros	-0.0125%	-0.0637%	-0.1009%	-0.1141%	-0.4420%	-1.2124%	-3.6867%	-13.499%
80%	Zeros	-0.0125%	-0.0836%	-0.1653%	-0.3273%	-0.6133%	-1.6404%	-4.8630%	-20.944%
90%	Zeros	-0.0125%	-0.0940%	-0.1860%	-0.3715%	-1.0020%	-1.9352%	****	****

**** denotes large computational costs.

The results from running GPROF show an increase of negative bias with noise due to the lognormal nature of the a-priori. Furthermore, as realistic zero rain rates are added, the problem becomes exacerbated.

Future Research

What is happening at the low end of the rain rate distribution is not fully understood. Further investigations will allow negative rain rates to be computed in GPROF. Although not realistic, allowing negative rain rates to be computed might give a clearer demonstration of the behavior of the interacting means from the a-priori and the observed pixel.

Acknowledgements

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