Improving Over Land Precipitation Retrieval by Brightness Temperature Temporal Variation

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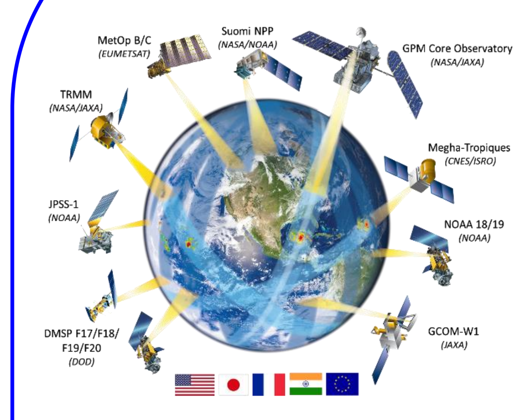
1. Background

- The primary precipitation signal over land is the brightness temperature (TB) depression at high frequency channels caused by the ice scattering.
- To augment existing retrieval algorithms, this study proposes to use TB temporal variation (ΔTB), which is derived from 8 polar-orbiting satellites, including GPM, F17, F18, S-NPP, NOAA-18, NOAA-19, Metop-A and Metop-B.
- The first motivation of using ΔTB is to account for differences in TB depression starting values (background emission).
- Another common and serious issue is the cold land surface contamination (e.g., snow-covered land), which is particularly problematic for rainfall/snowfall retrieval in winter.
- We show later that ΔTB can significantly improve the retrieval results by mitigating the surface and environmental contamination.

2. Data and Methodology



GPM satellite constellation

- We use all high frequency channels (≥ 85 GHz) from each sensor of these 8 radiometers.
- We first use Simultaneous Conical Overpass (SCO) technique and Principal Component Analysis (PCA) to "convert" TBs from other sensors to GMI frequencies.
- By doing so, it is as if that we have eight sensors measuring TBs at GMI frequencies, which are 89.0 (V/H) 166.0 (V/H), 183.3±3 (V), and 183.3±7 (V).
- Precipitation observations are from ground radar observations (MRMS).

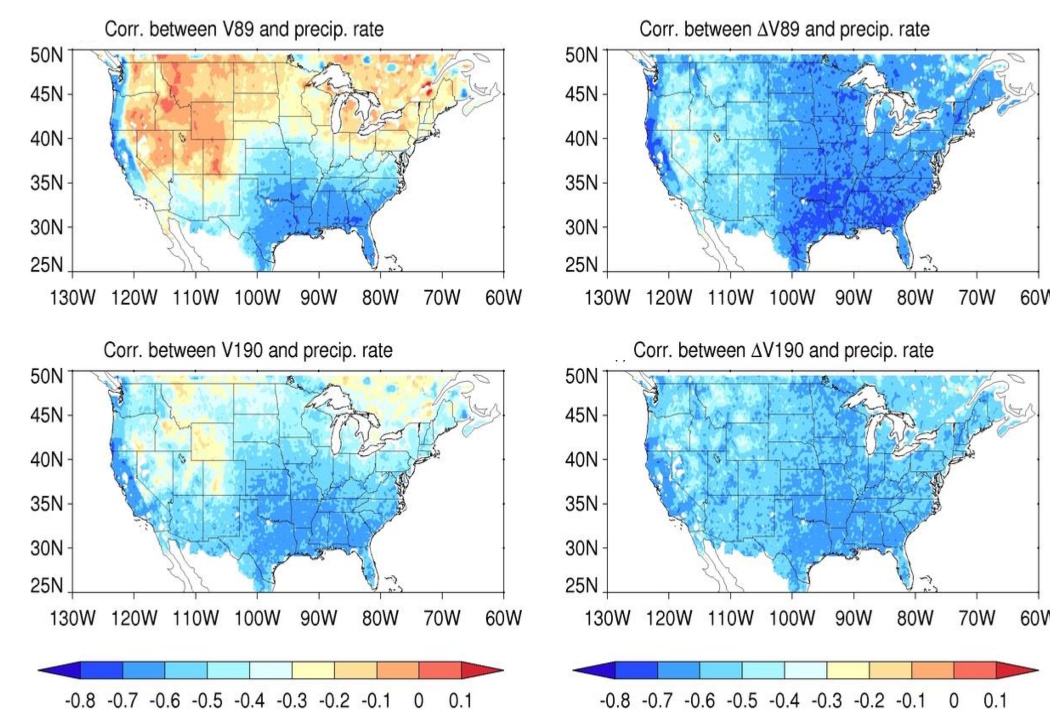
- All data are from 03/2014-12/2016, over 25N-50N, and 60W-130W.

- **TB temporal variation (ΔTB) is defined as:**

$$\Delta TB = TB_{t_0} - TB_{t_{-1}}$$

Where TB_{t_0} is the current TB associated with precipitation, and $TB_{t_{-1}}$ is the preceding TB at the same location without precipitation.

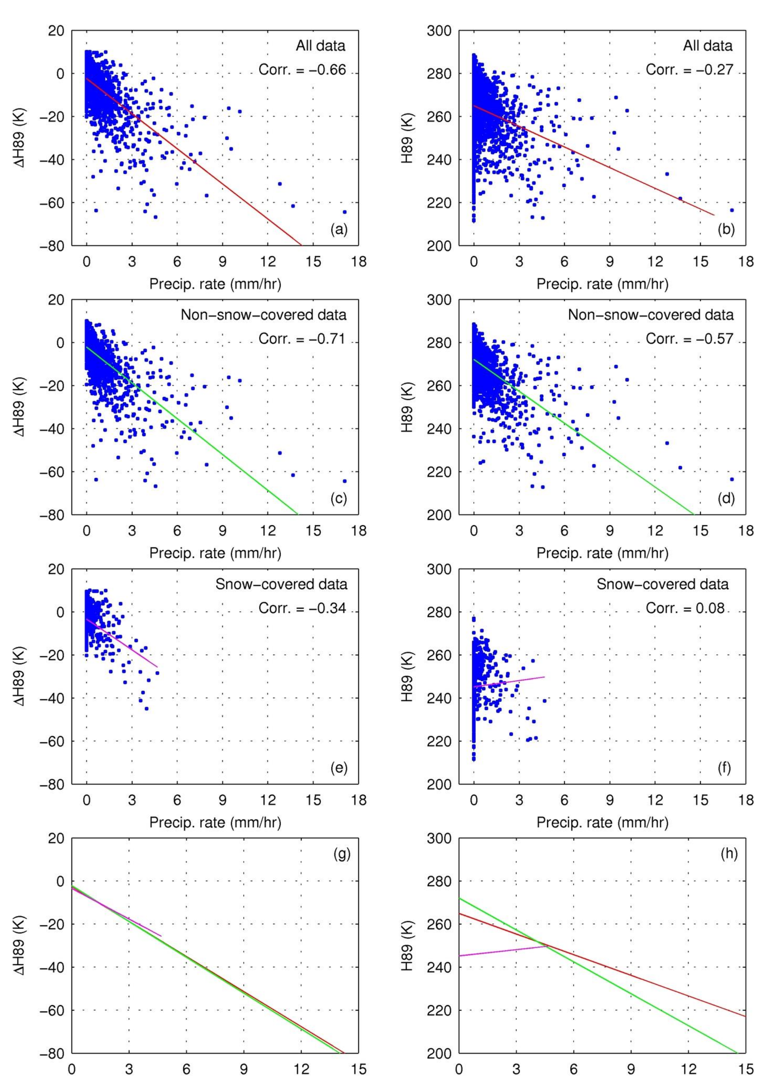
3. Correlation from TB vs. from ΔTB



(left) Correlation between the instantaneous TB and precipitation rate. (right) Correlation between ΔTB and precipitation rate at the corresponding channels.

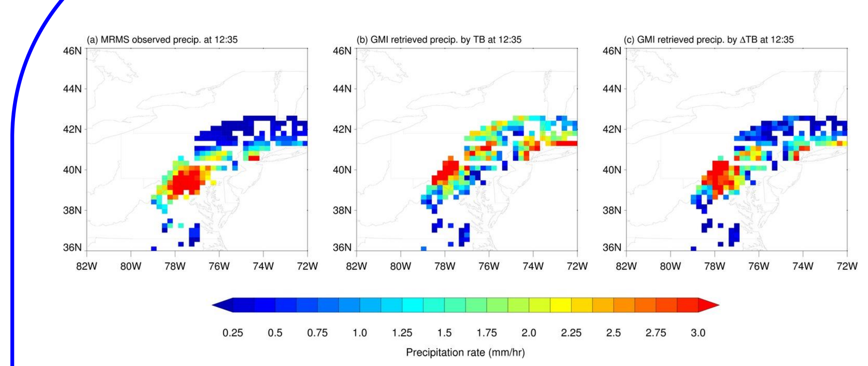
- **ΔTB correlates more strongly with precipitation rate.**
- Stronger correlation is especially evident over Rocky Mountains and Northeast of United States.

4. Why ΔTB?

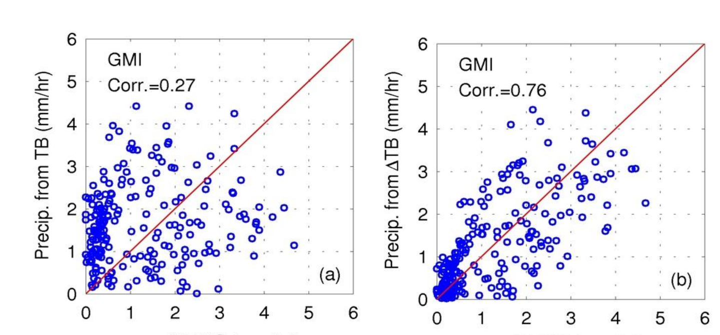


- Scatter plot between precipitation rate and H89, and between precipitation rate and ΔH89 over the grid box at (74W, 43.5N) in New York.
- Emissivity at high frequency channels is difficult to model at the global scale.
- Although we cannot model the emissivity accurately at the high freq., it likely does not vary significantly in the short period of time (~3hr) from these 8 satellites.
- Therefore, surface contamination from snow cover is greatly mitigated by ΔTB due to the frequent re-visit (every ~3hr) from these eight satellites over CONUS.

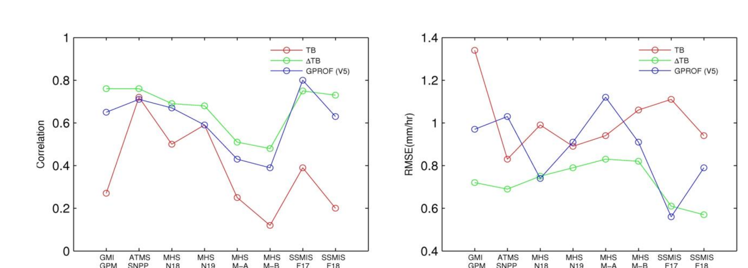
5. Blizzard Case on January 23 2016



(Left to right): Geospatial distribution of the blizzard case from MRMS, GMI TBs and ΔTBs.



Scatter plots between MRMS and precip. rate retrieved from GMI TBs, and from ΔTBs.



Statistics (correlation and RMSE) from retrieved precip. rate based on TBs and ΔTBs. The GPROF (V5) is also shown, as comparison.

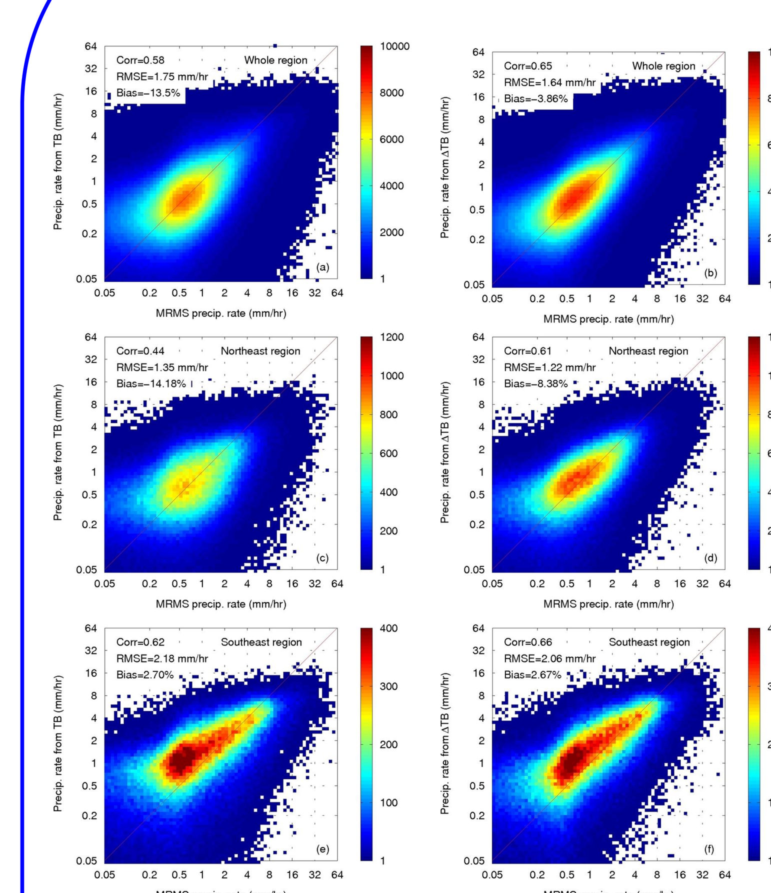
- **As a proof-of-concept**, we compare the retrieval result from TBs and ΔTBs, using a simple linear regression model.
- TBs are from a specific satellite, while ΔTBs are derived from all 8 satellites.

The most striking feature is that: the over-estimation for precipitation rates less than 2 mm/hr is greatly alleviated for all sensors, due to the mitigation of the surface contamination.

The correlation and RMSE based on the results from ΔTBs are clearly better those from TBs.

The simple linear regression results from ΔTBs are comparable to GPROF (Version5).

6. Retrieval Results from TB vs. ΔTB



- Retrieval results from TBs (V89, …, V190) vs. ΔTBs (ΔV89, …, ΔV190).
- Training data: 03/201 4-12/2015;
- Validation data: 2016.

- ΔTB greatly improves the light precipitation retrieval performance, especially over the snow-covered regions (e.g., Northeast CONUS).
- Over relative uniform land surface (e.g., Southeast CONUS), instantaneous TB performs as well as ΔTB due to the relative constant surface emissivity and environments.
- Over frequently snow-covered region (Northeast CONUS), ΔV89 performs very well (not shown), this opens new opportunities to use sensors with highest frequency at 89 GHz (e.g., AMSR2 and AMSU-A) to retrieve precipitation at high latitudes in the winter season.

7. Conclusions an Discussion

- TB temporal variation from satellite constellation correlates more strongly with precipitation rate than the instantaneous TB from a single satellite, because TB temporal variation greatly mitigates the surface contamination.
- This study highlights the importance of maintaining the current microwave constellation. It also implies that increasing the temporal resolution of microwave radiometer in the future mission (either from a geostationary microwave or a satellite constellation) can significantly improve the precipitation retrieval in the cold season and over the complex terrain, by capitalizing on the surface and atmosphere "background" information in TB temporal variation.

- **You, Y., C. Peters-Lidard, J. Turk, S. Ringerud, and S. Yang, 2017: Improving over land precipitation retrieval with brightness temperature temporal variation. *J. Hydrometeor.* doi:10.1175/JHM-D-17-0050.1.**
- **You, Y., C. Peters-Lidard, J. Turk, S. Ringerud, and S. Yang, N. Wang, R. Ferraro, 2017: Retrieving precipitation rate by brightness temperature temporal variation at 19 GHz over land. *J. Geophys. Res.* (submitted).**