An Observationally-Based Method for Stratifying *a-priori* Passive MW Brightness Temperature Observations in a Bayesian-based Precipitation Retrieval Framework

Joe Turk, Ziad Haddad, Pierre Kirstetter, Yalei You, Sarah Ringerud
With due credit and acknowledgement to many others within the LSWG

PMM Land Surface Working Group
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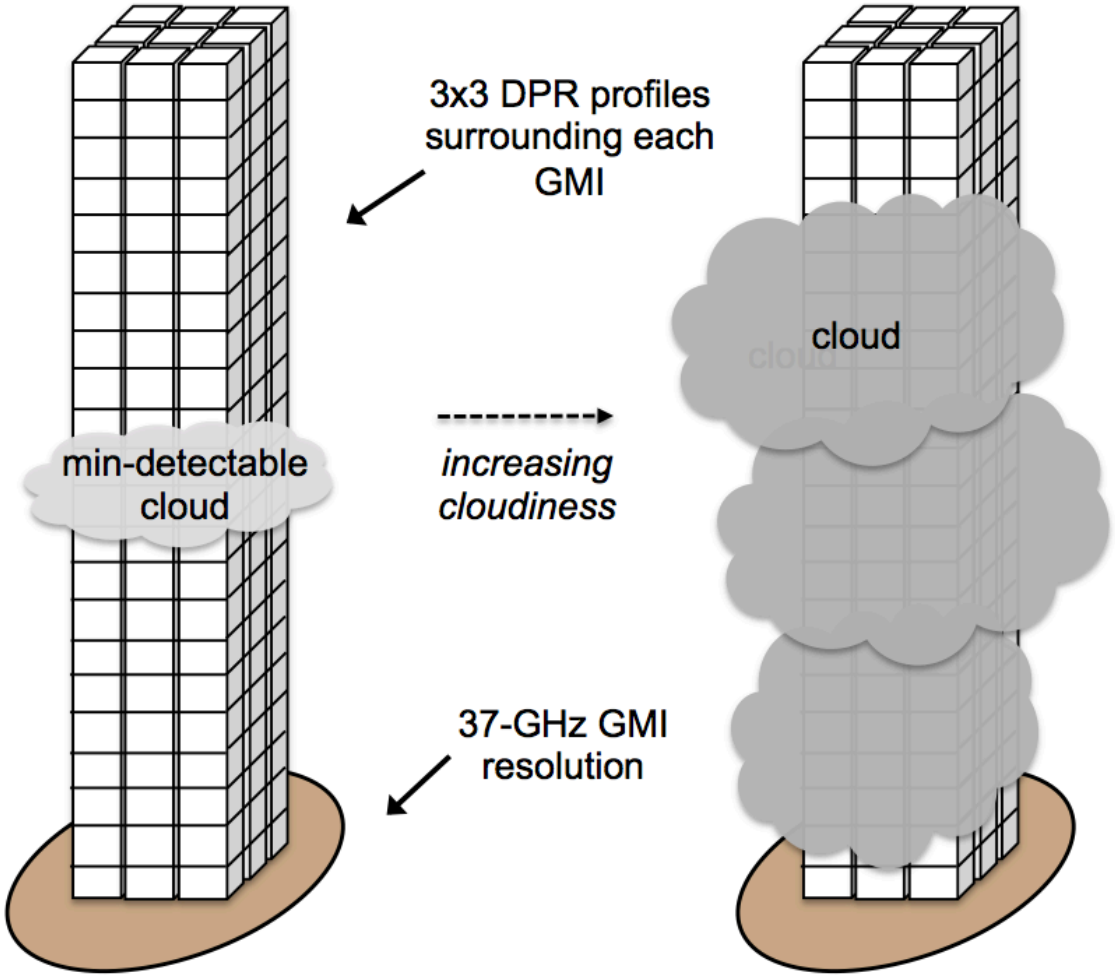
Previous Studies

- A main constraint on the interpretation of passive microwave TB is the “background” – the surface emissivity, or more generally, the joint surface and atmospheric state (e.g., water vapor).

- Previous publications demonstrated that a the emissivity principal component (EPC) structure could be fairly well estimated by nonlinear combinations of all TB.

- From this, the emissivity (10-85 GHz), column vapor and Tsfc can be reconstructed from TB and is fairly accurate under ”cloud-free” conditions.

- Exploits low-end DPR sensitivity to separate “no-cloud” GMI TB observations



Z(Ku-NS) < 15 dB and
Z(Ka-MS) < 15 dB and
Z(Ka-HS) < 15 dB
(all bins) ➔ "no cloud"

Total N of bins where Z(Ku-NS) > 20 dB as a proxy for increased likelihood of heavy clouds and precipitation

Turk, F.J., Haddad, Z.S. & You, Y., 2016, Estimating Non-Raining Surface Parameters to Assist GPM Constellation Radiometer Precipitation Algorithms, *J. Atmos. Oceanic Technol.*, 33(2016), pp. 1333-1353.

Extension to All Scenes, not just “no-cloud”

- The previous work suggests that the emissivity PC structure (EPC) can classify self-similar surface conditions around the world, jointly with the associated variability in the total column vapor and surface temperature, directly from the TB observations.

- As clouds and precipitation enter the TB scenes, the EPC structure is displaced from its no-cloudy range. EPC then begins to carry more information on clouds; with more clouds, surface becomes more opaque (i.e., emissivity less important).

- Suggests an alternate way to cluster a large database for efficient Bayesian-based inversion techniques for GMI and other sensors (GMI= 650K TB pixels/orbit). After initial EPC transformation established, no model data, surface class or land/ocean algorithm separation required.

- The a-priori dataset should be extensive enough to capture the full range and frequency of occurrence of all underlying variability in nature…surface, rain, weather systems, etc.

One-Year (Sept 2014-Oct 2015) Matched DPR-GMI

- One full year of pixel-matched GMI and DPR data was created from the 1-year database provided by S. Ringerud. Each orbit was written to a file as sequential binary record structures with GMI TB, Ku/Ka profile, EPC, MERRA2 data, various precipitation estimates from the current DPR, GMI and CMB (DPR+GMI; CORRA) algorithms.

- From this, the histograms of the first four EPCs were determined, and divided into ten equal-density spaced bins. Defines a data "cube" indexed by N=10x10x10x10= 10000 clusters.

- Each record (850M total/yr) was appended to its associated index file. 2% overlap was used for computational efficiency.

- **Nothing is lost here**….simply a reorganization of the dataset to make the search in EPC space much faster.

- In practice, the required index files are first identified, then only these files are opened one time (all pixels for index file 1, all pixels for index file 2, etc).

Weighting of Candidate Solutions

Distance in EPC space

$$d_{EPC} = \frac{1}{N}\sum_{i=1}^{N}\left(\left(u_i^{obs} - u_i^{DB}\right)/\sigma_i^{DB}\right)^2 \quad N = 11$$

$$d_{TB} = \frac{1}{N}\sum_{i=1}^{N}\left(\left(TB_i^{obs} - TB_i^{DB}\right)/\sigma_i^{DB}\right)^2 \quad N = 9 \text{ or } 13$$

Distance in TB space

TPW search
Weighting done by proximity to column water vapor, Ts (or T2m) values, the same TELSEM class index, and distance in TB space. Other properties (CAPE) being tested for GPROF (V. Petkovic et al, 2017)

EPC search
Weighting done in EPC space only

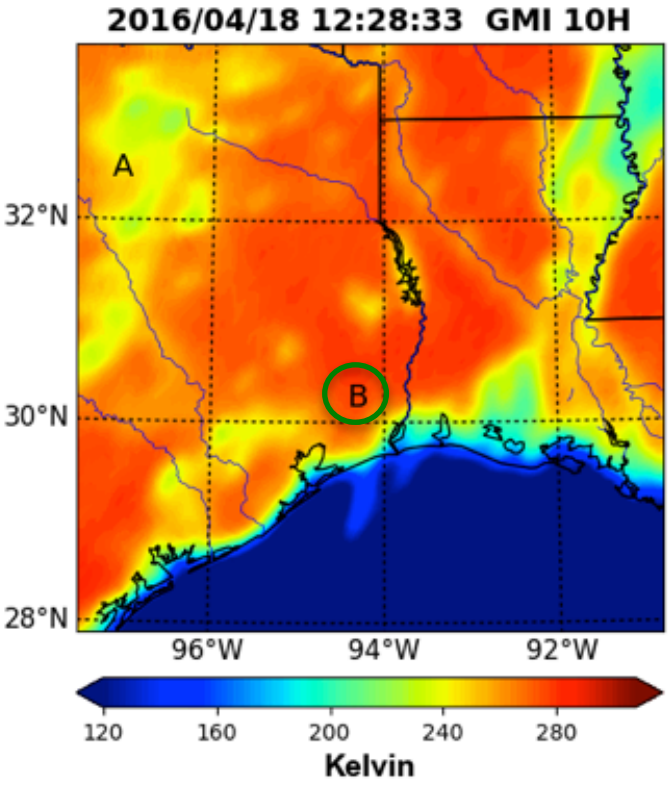
Both search methods interrogate the identical database

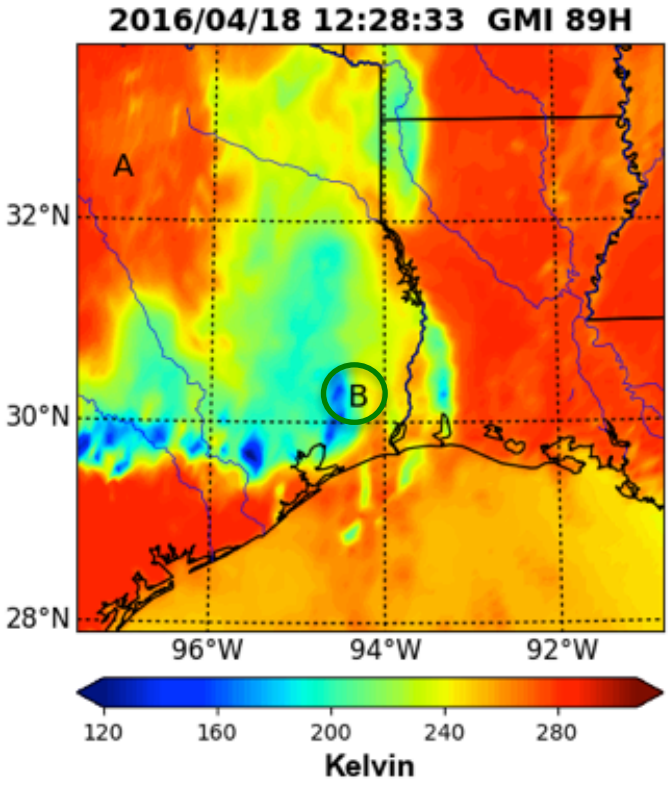
Use the TELSEM index for evaluation purposes

$$\hat{R}_{EPC} = \sum_{i=1}^{N} w_i R_i^{DB} \Big/ \sum_{i=1}^{N} w_i$$

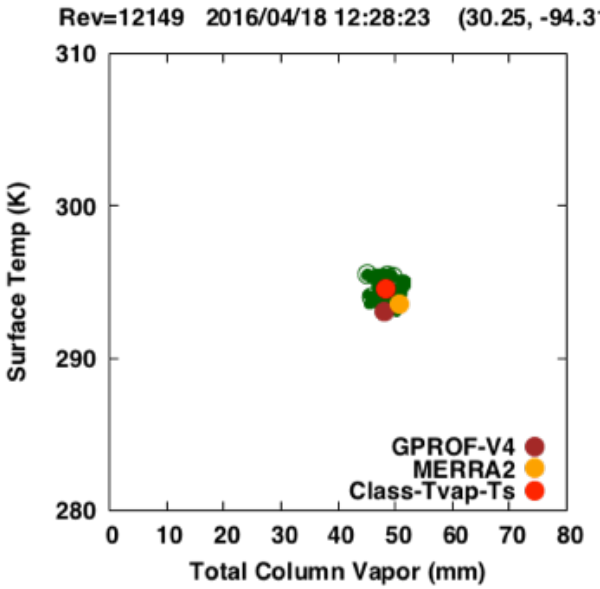
GPM overpass near the Texas-Louisiana border

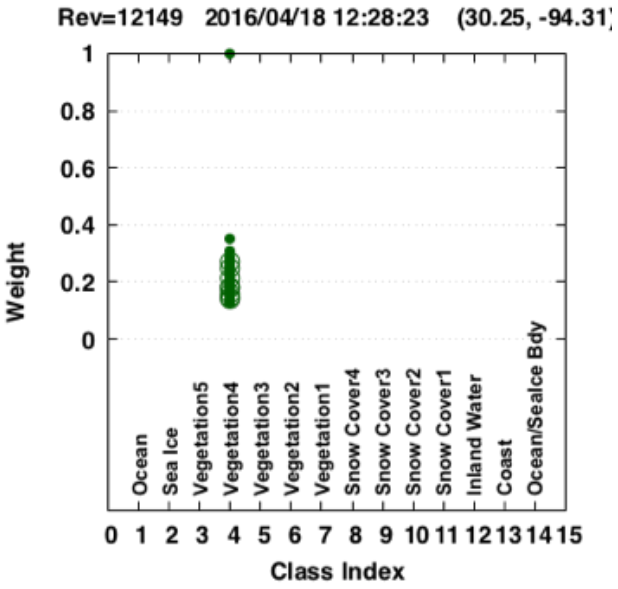
18 April 2016, near 1228 UTC

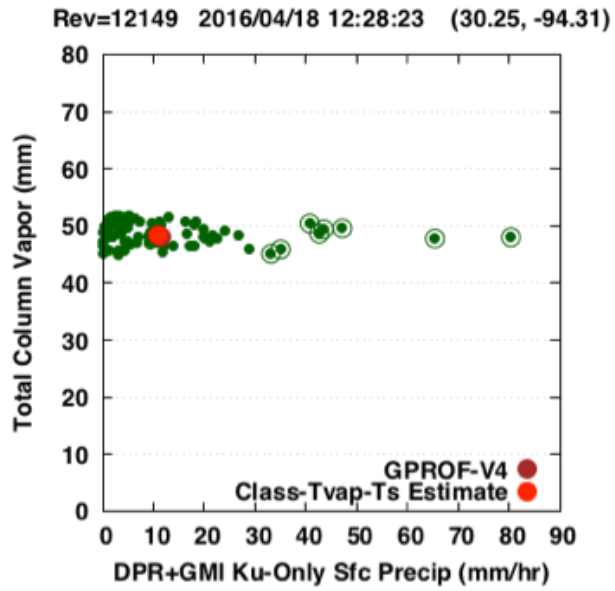


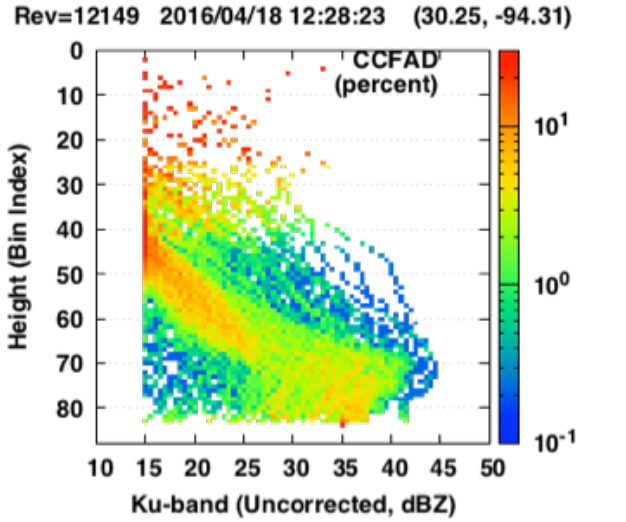


GMI Pixel at Location “B” (TPW-based search)

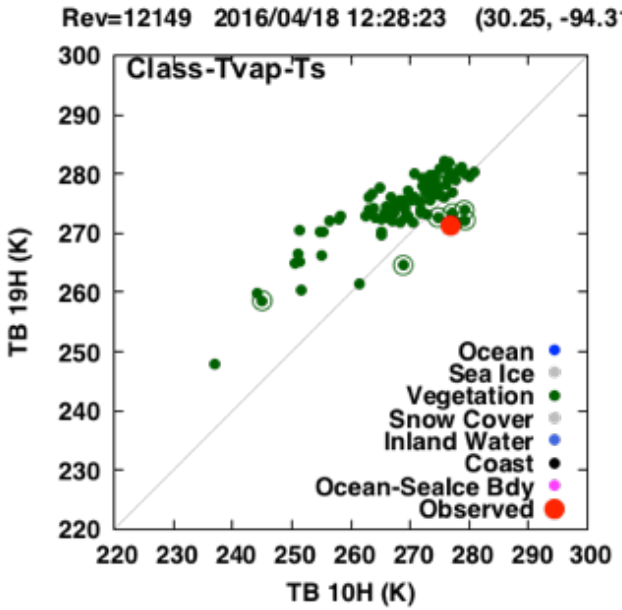


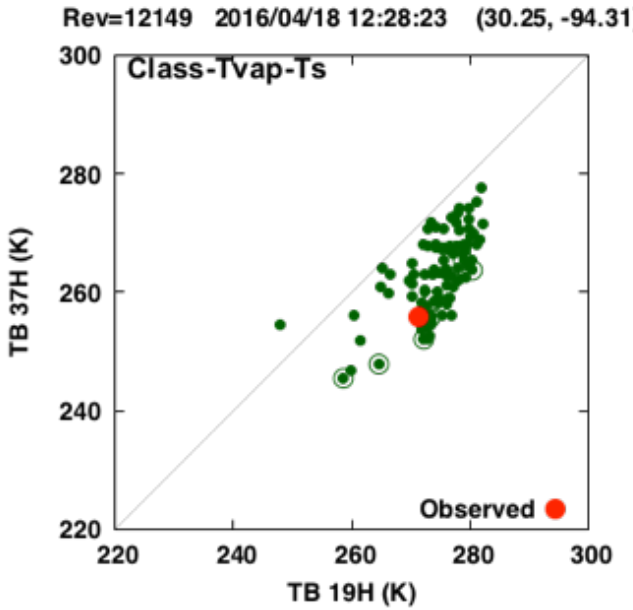


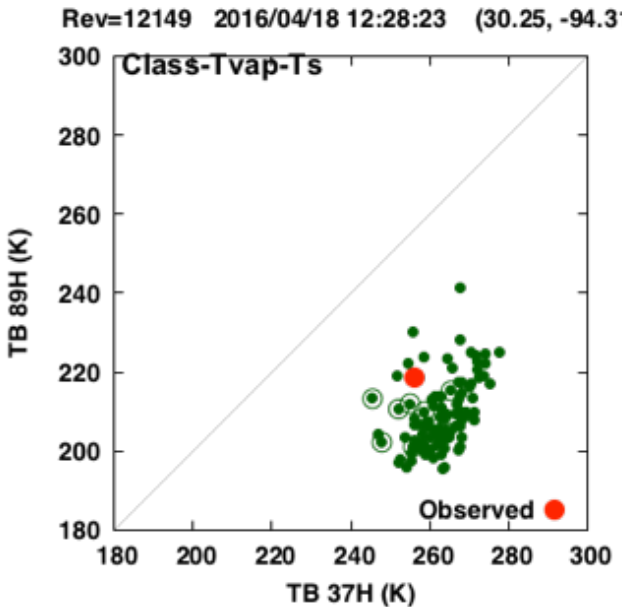


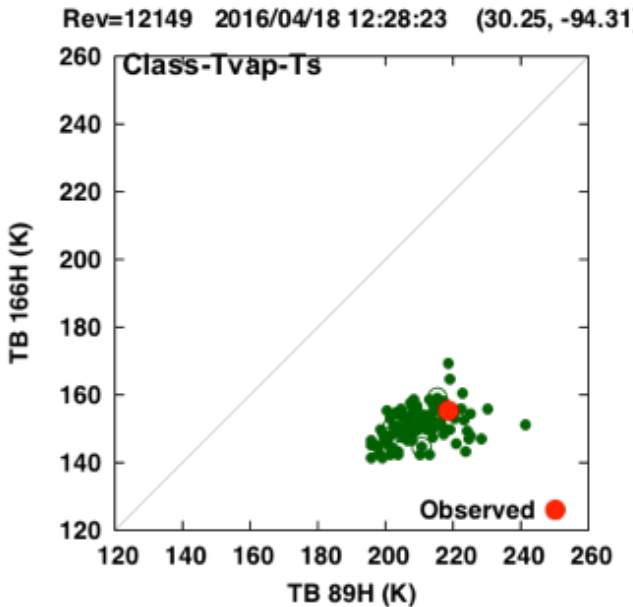


GMI Pixel at Location “B” (TPW-based search)
TB from top 100 candidates in search

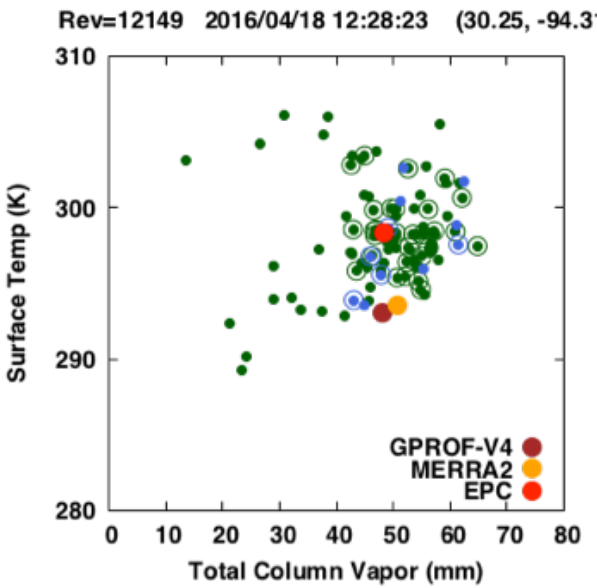


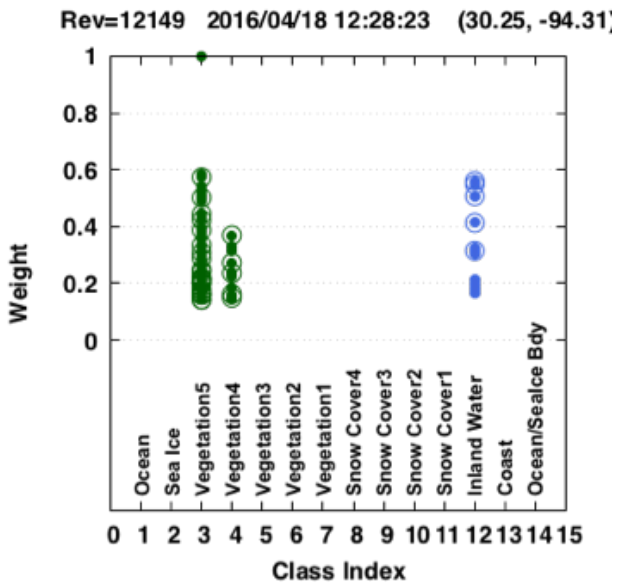


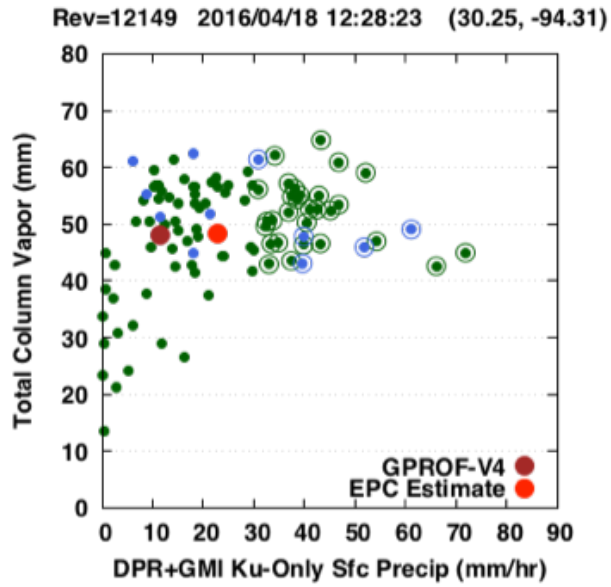


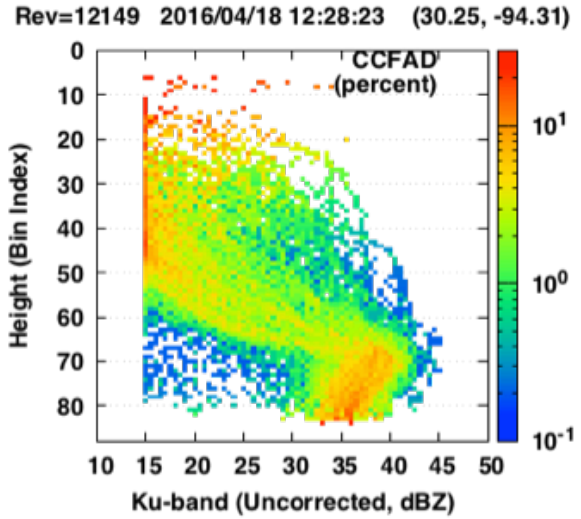


GMI Pixel at Location “B” (EPC-based search)

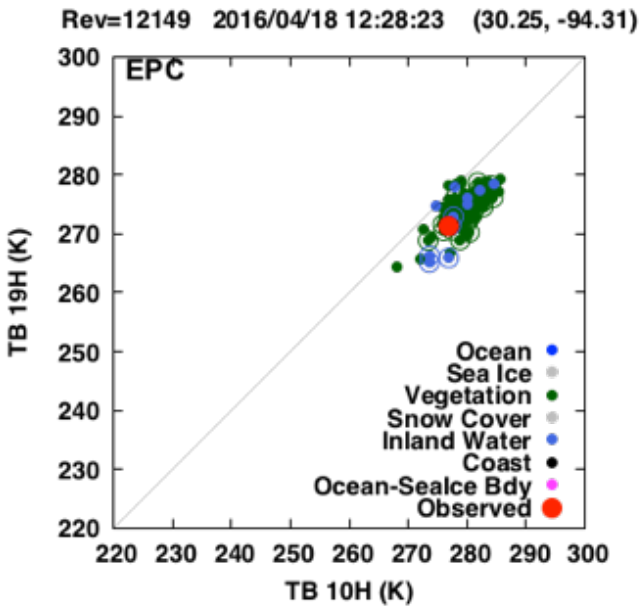


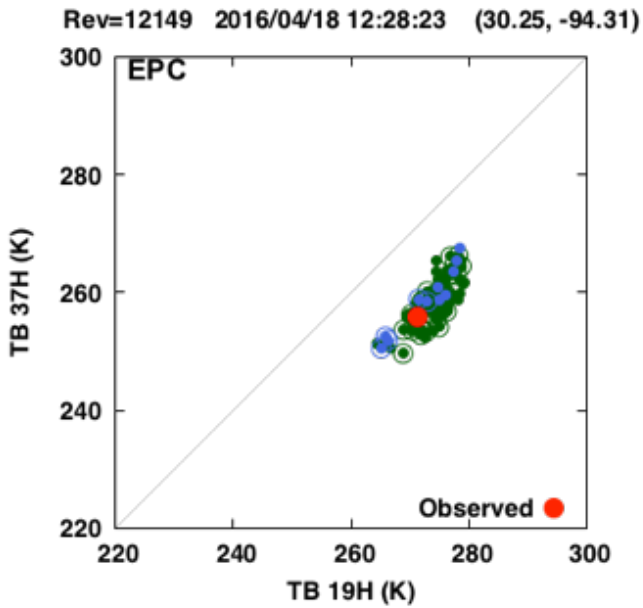


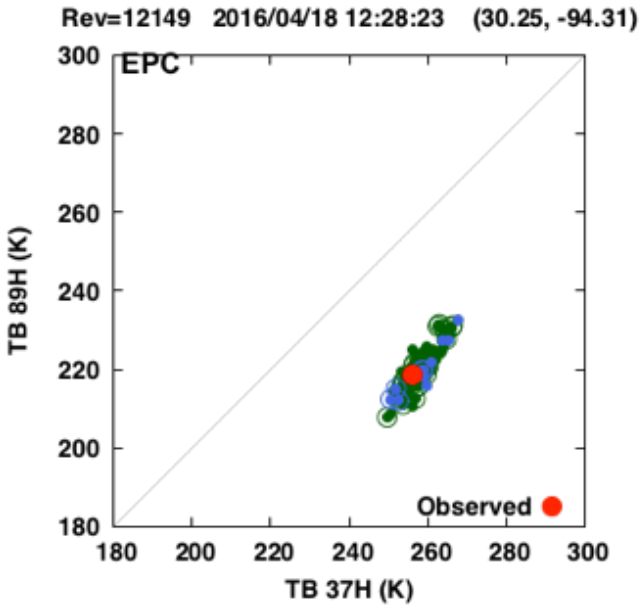


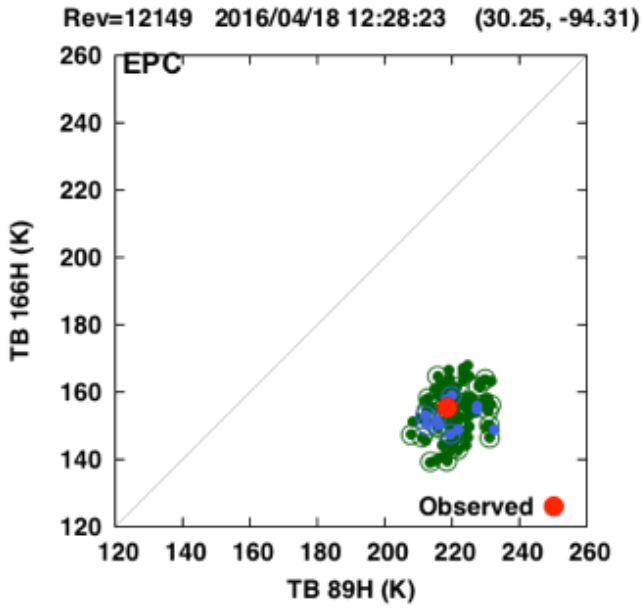


GMI Pixel at Location “B” (EPC-based search)
TB from top 100 candidates in search



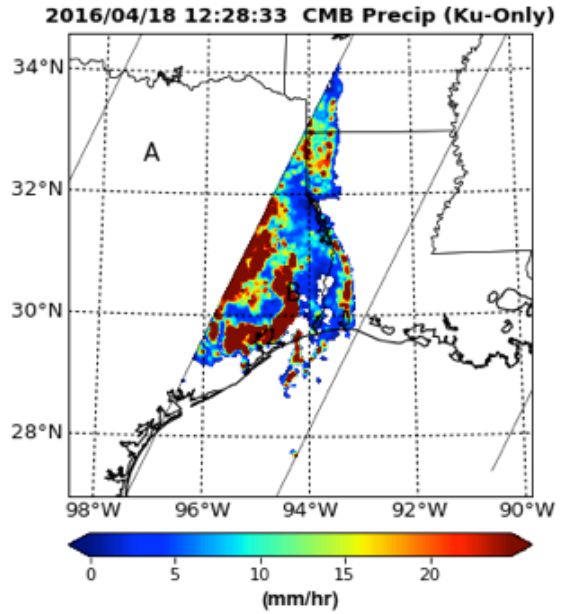


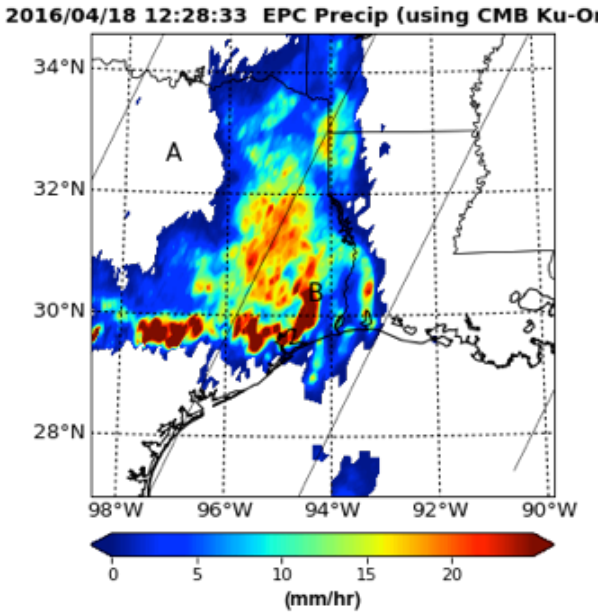




Comparison of TPW and EPC (using CMB precip)

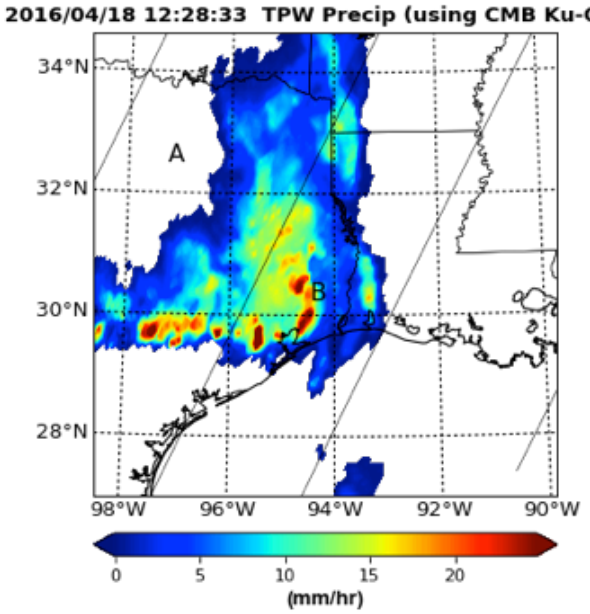
GPM CMB

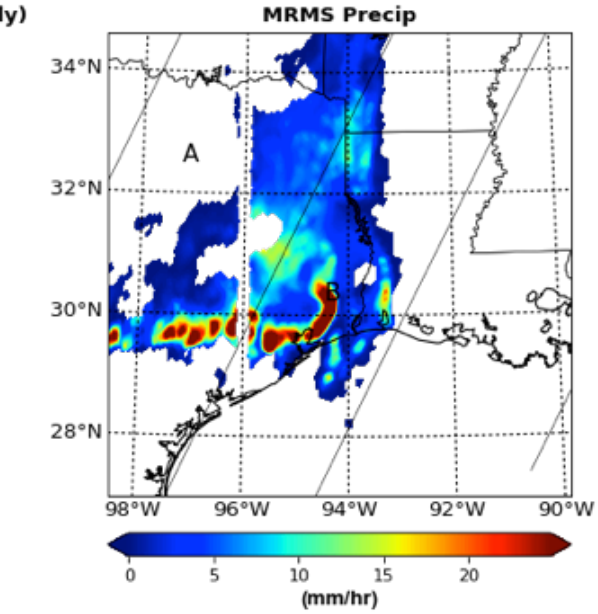




GMI, EPC-based weighting GPM CMB

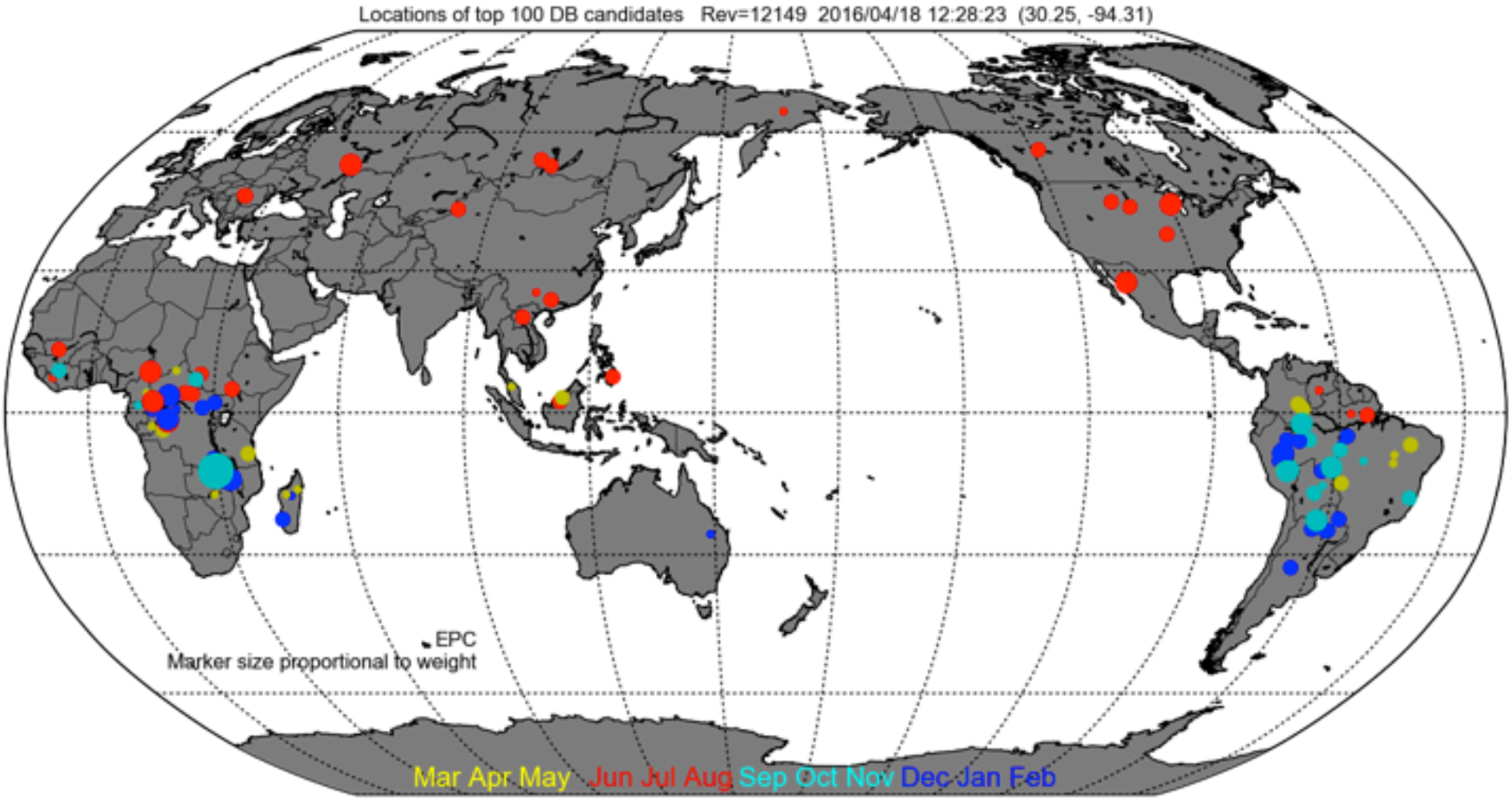
GMI, TPW-based, weighting GPM CMB



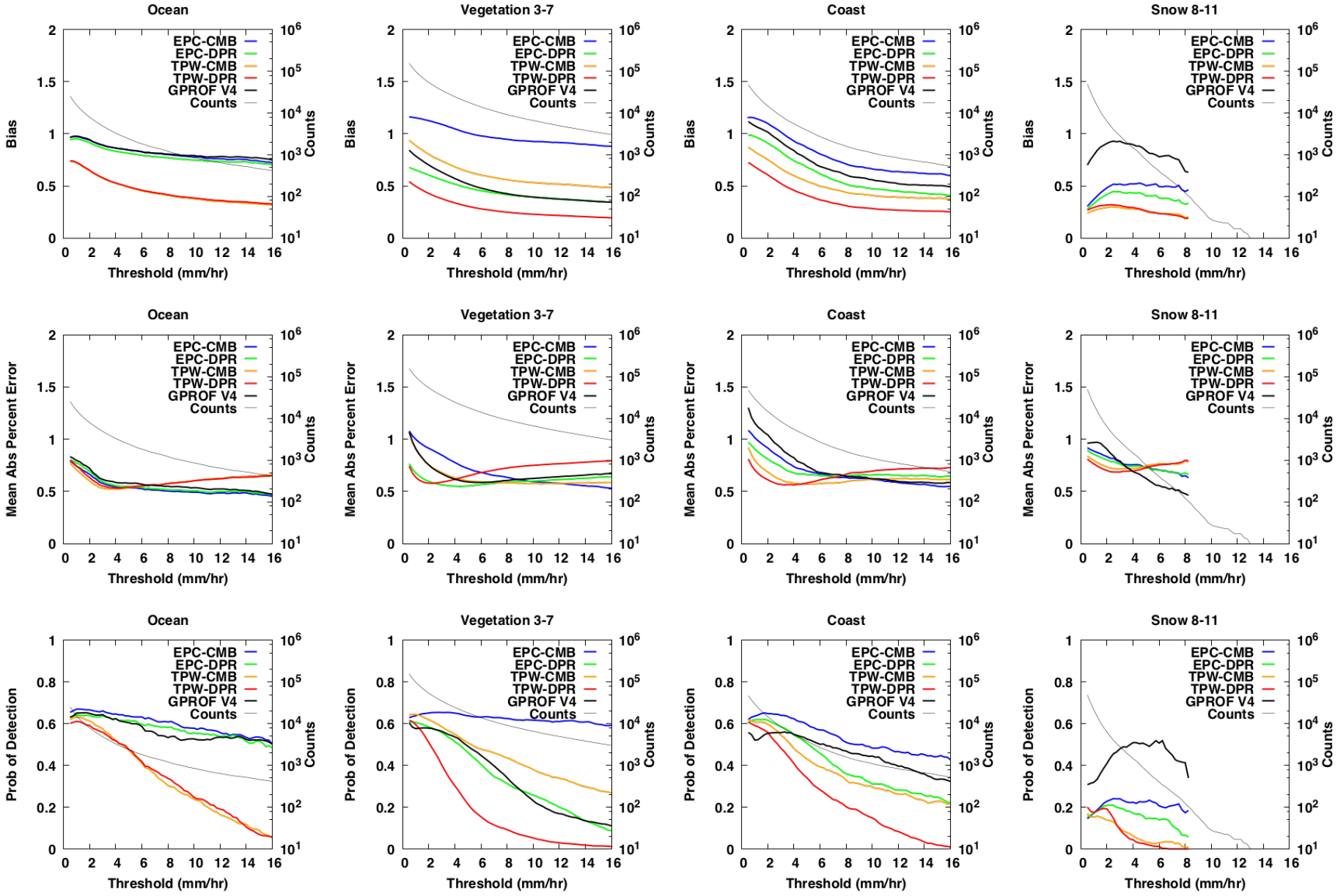


MRMS (nearest 2-min)

GMI Pixel at Location “B” (EPC-based search)
Locations of top 100 candidates in EPC search



Performance by Rain Threshold (Relative to GMI-Matched MRMS) (seven months between Nov 2015 and Sep 2016)



Performance by Rain Interval (Relative to GMI-Matched MRMS) (seven months between Nov 2015 and Sep 2016)