Towards Improving Self-Consistency Between GPM Constellation Passive MW Precipitation Retrievals

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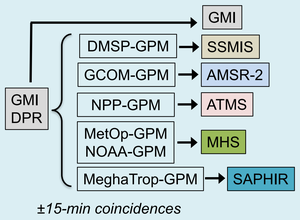
Summary
One of the key challenges for GPM is how to link the information from the single GPM core DPR across all passive MW sensors in the constellation, to produce a globally consistent precipitation product. With now 3.5 years of GPM data, there are abundant near-coincident (±15-minute) coincidences between GPM and each constellation radiometer. This affords an opportunity to examine the suitability of purely observational databases for building sensor-specific *a-priori* datasets appropriate for Bayesian-type precipitation estimation techniques.

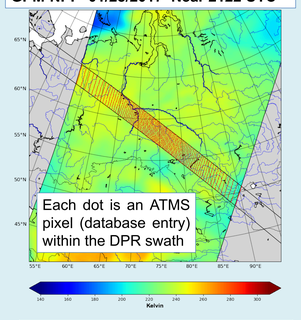


±15-min coincidences

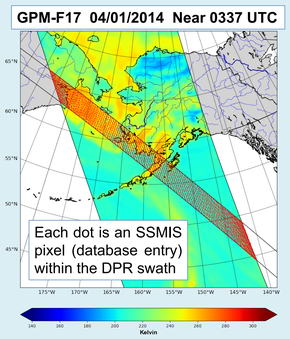
Observational Databases

Existing DPR Ku- and Ka-band uncorrected Z profiles and precipitation rate retrievals from ±15-min coincidences between GPM and each of the constellation radiometers are directly transferred into the databases. Four DPR-based retrievals are currently used: the NS- and MS-based estimates from the DPR-only and the CORRA combined (see **Nomenclature** below). This allows verification of not only conventional surface precipitation, but allows assessment of the the vertical structure of the DPR profiles that were selected by the radiometer-only retrieval.

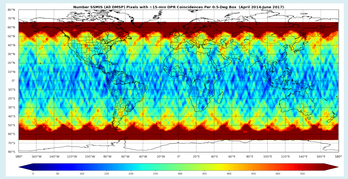
GPM-NPP 01/28/2017 Near 2122 UTC



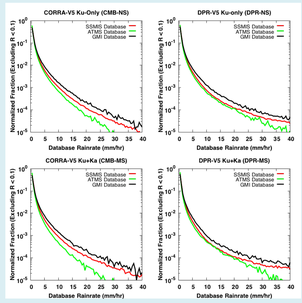
GPM-F17 04/01/2014 Near 0337 UTC



Density of SSMIS database (N per 0.5-deg box)



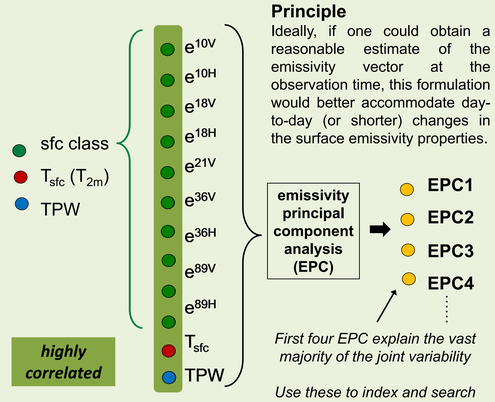
Database Sizes
N ATMS DB entries= 22M (04/2014-06/2017)
N SSMIS DB entries= 90M (04/2014-06/2017)
N GMI DB entries= 850M (09/2014-09/2015)
MHS, AMSR-2 in progress



Normalized histograms of raining entries, for each of the four DPR-based algorithms (panels) and three sensor databases (colors)

Surface-Based Indexing and Weighting

Since the constellation MW radiometers routinely observe many more non-precipitating conditions than precipitating, the information content within the 3.5 years of non-precipitating GPM observations is examined to characterize the global MW surface emissivity variability, (regardless of surface type), and use this information to design an indexing structure to search *a-priori* data and weight candidate solutions.



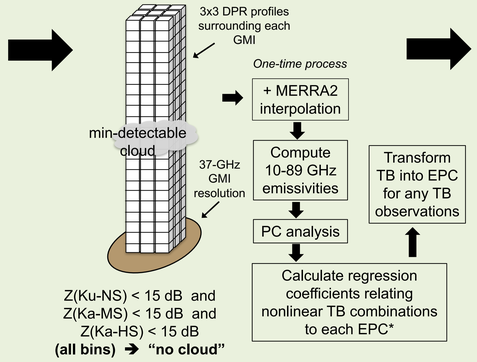
Principle

Ideally, if one could obtain a reasonable estimate of the emissivity vector at the observation time, this formulation would better accommodate day-to-day (or shorter) changes in the surface emissivity properties.

First four EPC explain the vast majority of the joint variability

Use these to index and search a-priori databases

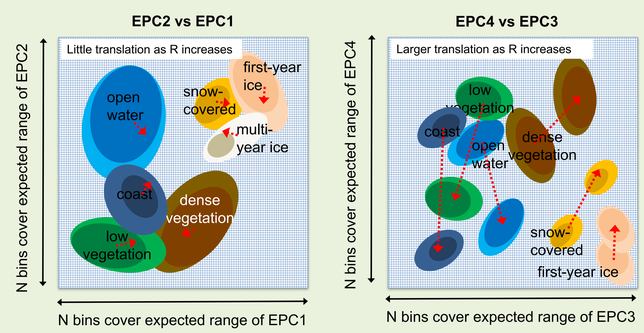
The transformation of TB into **emissivity principal component (EPC) space**, (from which the emissivity state vector can be reconstructed) to probabilistically separate "no-cloud" and increasingly cloudy and precipitating scenes is described in (*Turk et.al.* 2014; *Turk et.al.*, 2016*).



The method appears to identify self-similar surface types directly from the TB observations, without requiring any knowledge of geographical location, surface or environmental/temperature conditions.

*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, 1333-1353.

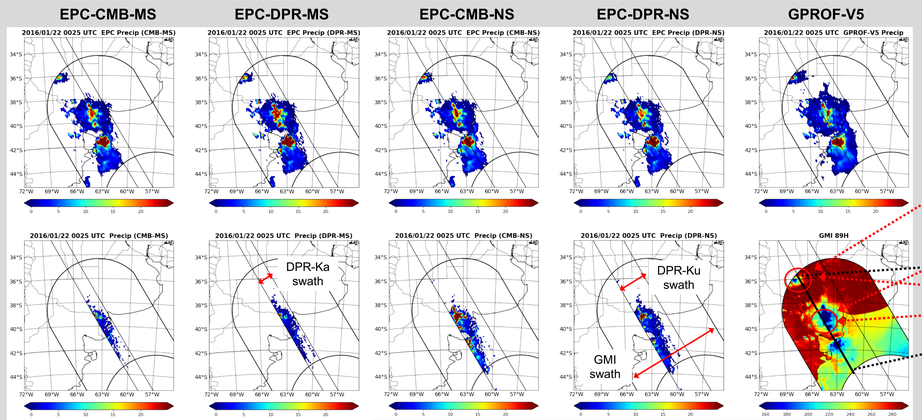
2-Dimension projection of an EPC-indexed database, binned by intervals of the first four EPC



The self-separation of the underlying surface types are mainly carried by the higher order terms (EPC1 and EPC2). The range (clusters) don't shift very much from their quiescent (no-precipitation) range as precipitation develops.

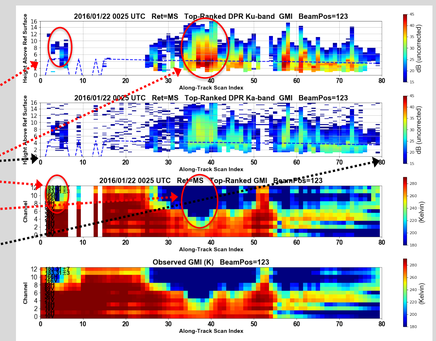
(not quantitative – for illustrative and conceptual purposes only)

As clouds and increasingly higher precipitation enters the radiometer field-of-view, the lower order terms (represented here by EPC3 and EPC4) display a more noticeable shift. This suggest the use of the EPC as a database indexing scheme, and also as a metric for searching and weighting Bayesian-based precipitation techniques.



Example: Argentina 2016/01/22 0025 UTC

The figure to the left depicts the four EPC-based precipitation retrievals for this GPM overpass, where (top, left-to-right) the CMB-MS, DPR-MS, CMB-NS and DPR-NS precipitation rates are weighted by their distance in EPC space, from the observations. Beneath each are the corresponding actual precipitation rates from these same four algorithms.



Ku-band top-ranked

Ka-band top-ranked

TB top-ranked

Actual TB GMI

Vertical cross section of the DPR Ku- and Ka-band measured reflectivity profiles from the top-ranked a-priori database candidate (minimum distance in EPC space), for the EPC-CMB-MS retrieval. The cross section is shown in the GMI 89H panel (left).

Trace of GMI TB 13 channels 10-183 GHz (bottom to top), from the top-ranked a-priori database candidate (minimum distance in EPC space), for the EPC-CMB-MS retrieval. Below are the actual GMI TB observations.

The radiometer-only retrieval has only the TB observations at its disposal, it has no knowledge of the vertical structure. The vertical profiles appear consistent with the TB spectrum.

Nomenclature

EPC-CMB-NS: EPC-based estimate, where the combined (CMB) radar-radar algorithm (CORRA) Ku-band normal scan (NS) retrievals were weighted by distance in EPC space

EPC-DPR-NS: EPC-based estimate, where the radar-only (DPR) Ku-band normal scan (NS) retrievals were weighted by distance in EPC space

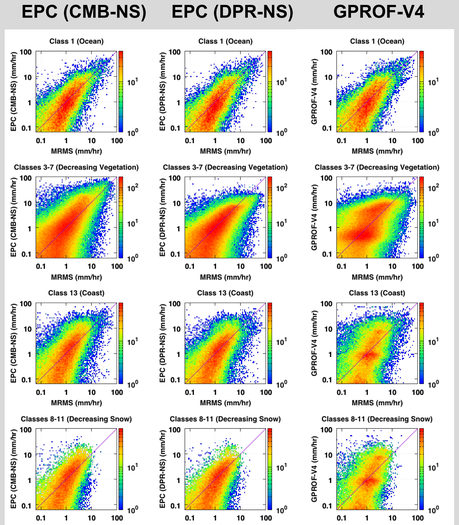
EPC-CMB-MS: EPC-based estimate, where the combined (CMB) radar-radar algorithm (CORRA) Ku+Ka-band matched scan (MS) retrievals were weighted by distance in EPC space

EPC-DPR-MS: EPC-based estimate, where the radar-only (DPR) Ku+Ka-band matched scan (MS) retrievals were weighted by distance in EPC space

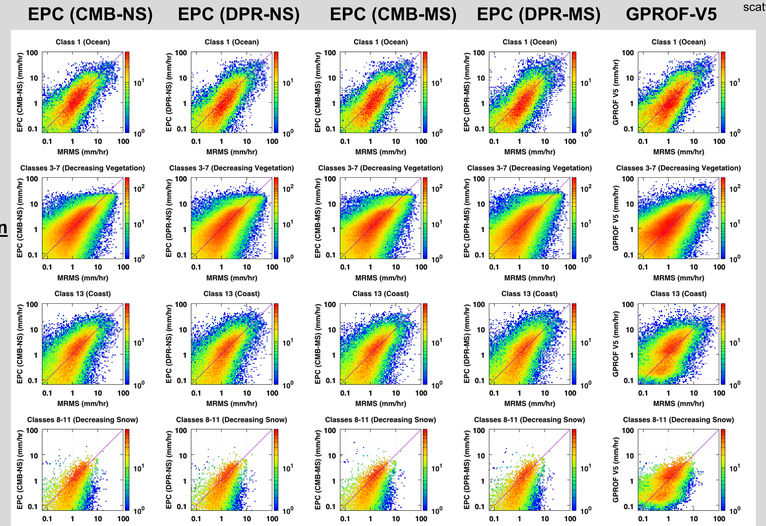
For Version-4 processing, only EPC-CMB-NS and EPC-DPR-NS retrievals used

For Version-5 processing, EPC-CMB-MS and EPC-DPR-MS retrievals were added (four EPC-based estimates)

EPC-Based Retrieval Overall Performance (Relative to GMI-Matched MRMS) Version 4 Datasets (seven months between Nov 2015 and Sep 2016)

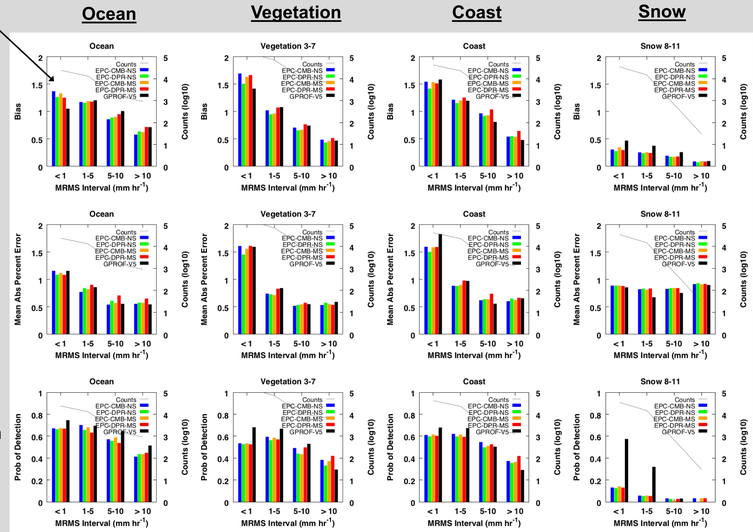


EPC-Based Retrieval Overall Performance (Relative to GMI-Matched MRMS) Version 5 Datasets (same seven months between Nov 2015 and Sep 2016)



Bar colors indicate the scores from each of the EPC-based retrievals, shown in the scatterplots

EPC-Based Retrieval Skill Scores by Rain Interval (Relative to GMI-Matched MRMS) (same seven months between Nov 2015 and Sep 2016)



Bias

Mean Absolute Percent Error (x 0.01)

Prob of Detection