# Passive Microwave Precipitation Detection for the GPM Constellation and Convective/Stratiform Classification for the Imagers – the PMW_CLASS


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## Imagers: Passive Microwave Precipitation Detection and Convective/Stratiform Classification – PMW_CLASS

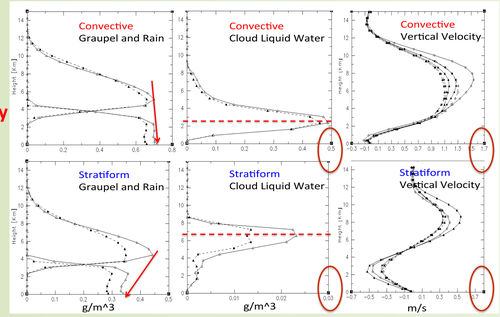
### Motivation

Physically-based retrievals are critically dependent on the assumptions that went into building the retrieval database (the relationship between the observables and the parameters of interest).

The critical assumptions that affect rain retrievals from microwave observations vary significantly as a function of the rain type.

Precipitating regions can be classified into two basic types – convective or stratiform – with very different properties.

- Convective and stratiform regions are characterized by different:
  - dynamics,
  - microphysical processes
  - spatial variability.




A critical step toward improving rain estimation from passive microwave observations requires:

i) developing the ability to distinguish the dominant type within each satellite Field-Of-View (*PMW_CLASS*)

ii) the design of appropriate retrieval databases that reflect these basic differences.

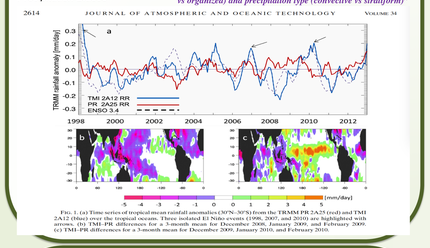
- The next step is to adapt the GMI passive microwave rain retrieval algorithm to work with the variety of existing LEO passive microwave instruments, by modifying it to properly account for the observing characteristics of different imager instruments.
- Such instrument-specific adaptation of the rain retrieval algorithm will assure that it can be successfully applied to a number of different passive microwave instruments.
- The main goal is to produce high-quality rain estimates that are equally accurate regardless of the specifics of the different observing instruments. Combining these rain retrievals, estimated from observations from different passive microwave instruments, should then result in a seamless product with wide coverage.

### Importance

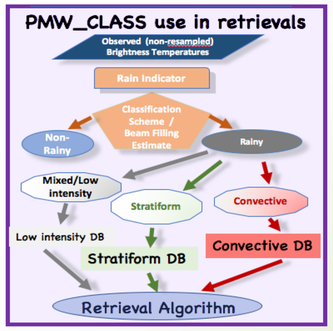
Henderson and Kummerow, 2017 "A Regime-Based Evaluation of TRMM Oceanic Precipitation Biases"

*"Throughout the TRMM mission, research employed various efforts to validate the TRMM rainfall retrievals; however, we still lack an understanding of the sources of bias. This issue is particularly pertinent during El Niño and La Niña events, where regional differences between the TRMM retrievals lead to large discrepancies when averaged over the tropical oceans."*

*"Through the evaluation of multiple case studies, biases in rain-rate estimates from the TRMM radar (PR) and radiometer (TMI) are best explained when derived as a function of precipitation organization (e.g., isolated vs organized) and precipitation type (convective vs stratiform)"*

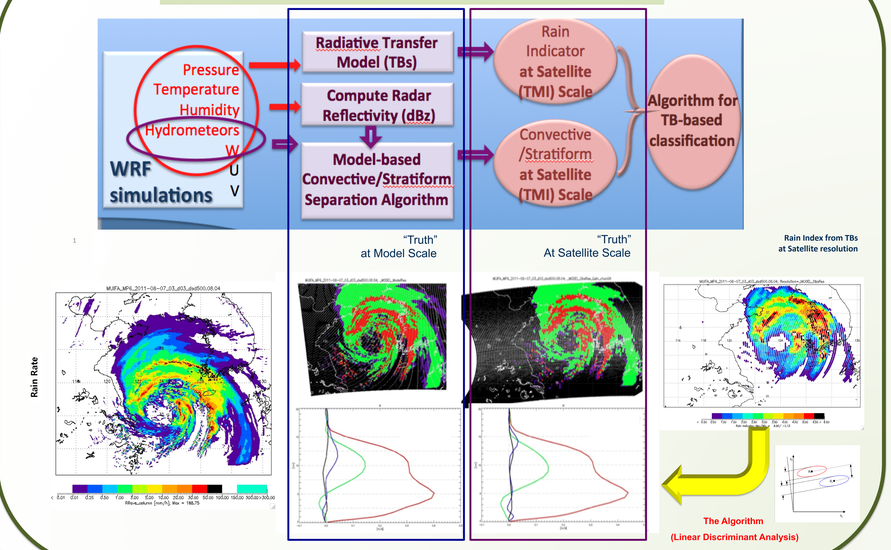



### PMW_CLASS use in retrievals

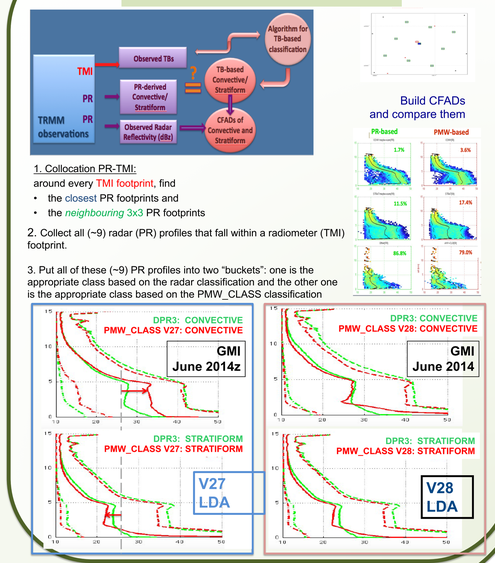



## GMI-specific PMW_CLASS

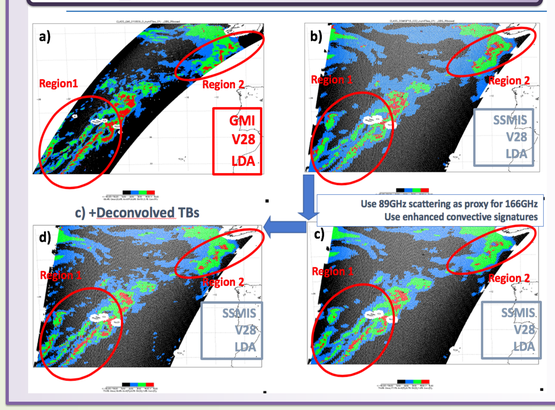
### Development




### Validation




### ➢PMW_CLASS: GMI vs SSMIS - A Squall Line




Expected degraded performance of the PMW_CLASS precipitation classification when using SSMIS observations, for two reasons:

i) spectral insufficiency of the observation, as the SSMIS instrument does not have the high frequency channel (166 GHz) that is very efficient in depicting ice scattering which, in turn, is characteristic of deep convective clouds;

ii) spatial resolution insufficiency, as the SSMIS low frequency observations have lower spatial resolution than that on GMI, resulting in smearing of the horizontally very inhomogenous convective signatures.

Panel c) depicts the much improved performance of the SSMIS-based PMW_CLASS, which we obtained after accounting for the two deficiencies described above

Panel d) presents the results after implementing our next approach to dealing with low resolution of the low-frequency SSMIS observations.

- first perform enhancement of the spatial resolution of the different low-frequency channels (deconvolution).
- The deconvolution is performed on the TBs.
- These de-convolved brightness temperatures are then used as inputs to the PMW_CLASS algorithm.

### PMW_CLASS: GMI vs SSMIS

PMW_CLASS with GMI and SSMIS-specific adaptations;

Large number of tropical cases;

500km domain (from intersection); within 15min;

**PMW_CLASS: Precipitation Type**

| | GMI: v28 | SSMI: v28 |
|---|---|---|
| anvil | 6.34 | 5.98 |
| stratiform | 5.56 | 6.71 |
| Convective | 3.51 | 2.49 |

**Detection: GMI**

| | GPROF | v28 |
|---|---|---|
| clear | 77.94 | 84.59 |
| rain | 22.06 | 15.41 |

**Detection: SSMI**

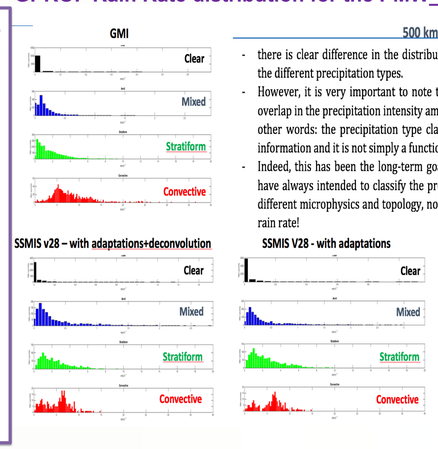
| | GPROF | v28 |
|---|---|---|
| clear | 60.42 | 84.82 |
| rain | 39.29 | 15.18 |

Very similar statistics!!

### GPROF Rain Rate distribution for the PMW_CLASS types

Squall Line:

500 km domain from intersection




- there is clear difference in the distribution of precipitation among the different precipitation types.
- However, it is very important to note that there is also significant overlap in the precipitation intensity among the different classes. In other words: the precipitation type classification caries additional information and it is not simply a function of the rain rate!
- Indeed, this has been the long-term goal of our methodology. We have always intended to classify the precipitating systems by their different microphysics and topology, not simply as a function of the rain rate!

Comparing the histograms obtained when using GMI-based, SSMIS-based or SSMIS-based plus deconvolution, we see generally similar histograms of the precipitation rates for a given precipitation type (say, stratiform).

## Sounders: Passive Microwave Precipitation Detection

- Imagers use conical scanning to achieve:
  - Frequency-dependent FOV BUT this FOV is constant across-track
  - Constant incidence angle
  - Also the imagers have both H and V pol observations at each observation point, allowing to use the H/V differences to detect precipitation easily
  - All this allowed us to develop the Rain Index. The precipitation detection and classification algorithm (PMW_CLASS) was then developed to take advantage of the value and the spatial variability of the Rain Index

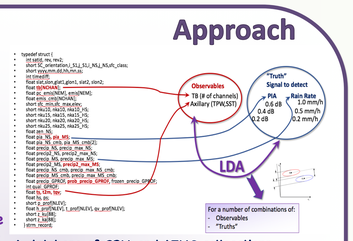
| | | Instrument / Mission (s) | Frequency [GHz] | Polari-zation | Scanning / FOV | Period |
|---|---|---|---|---|---|---|
| | | TMI / TRMM | IM - 10.7, 19.4, 21.3, 37, 85.5 GHz | H and V | Conical Scanning; Constant FOV; Constant Incidence angle; | 1997 - 2014 |
| Imager (IM) | | GMI / GPM | IM - 10.7, 19.4, 21.3, 37, 85.5 + 166 + 183 | H and V | | 2014 ~ |
| | | AMSR-E and AMSR2 / Aqua; GCOM-W | IM - 6.9, 10.7, 18.7, 23.8, 36.5, 89.0 | H and V | | 2002 ~ |
| | | SSMIS / DMSP-F16, F-17, F-18 | IM - 19, 22, 37, 91 | H and V | | |
| | | | SO - ~50; ~183; ~60 | V; H; Circ. | | |
| Sounder (SO) | | AMSU-A + AMSU-B / NOAA-15, 16, 17 | **AMSU-A**: 15 channels from 23 to 89; **AMSU-B**: 5 channels from 89.9 through 183 | Single Polarization; Variable across the scan | Cross-track scanning; Variable FOV across-track; Variable incidence angle cross track; | 1998 - 2013 |
| Sounder (SO) | | AMSU-A + MHS / NOAA-18; 19; MetOp A and B Series | **MHS** – very similar to AMSU-B, with some altered frequencies | | | 2005 ~ |
| Sounder (SO) | | AMSU-A + HSB / NASA-Aqua | **HSB** – like AMSU-B but with 4 channels - no 89 | | | 2002 |
| Sounder (SO) | | ATMS (AMSU-A + MHS) / Suomi NPP; Upcoming JPSS (NOAA-20) | 22 bands from 23 GHz to 183 GHz; AMSU-A + MHS with improved coverage | | | 2011 through 2038 |

- Sounders use cross-track scanning. This results in:
  - Variable FOV across the scan
  - Variable incidence angle across the scan
  - The sounders use single polarization observations at each observation point
  - All this indicates that we
    - cannot compute the Rain Index, developed for the imagers,
    - cannot use its value and spatial variability to detect the precipitation and develop the precipitation classification
  - Required is the development of more specialized precipitation detection/classification algorithms

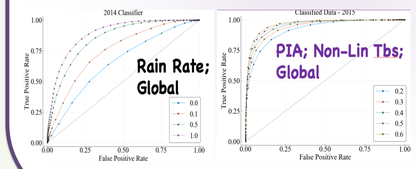
### Approach

The precipitation detector for the sounders is being developed using

- linear discriminant analysis (LDA) with a database of coincident radar/radiometer observations.
- The database provides the observables (the radiometer brightness temperatures) and the "Truth" regarding the existence of precipitation as determined by the radar




A database of GPM and ATMS collocations *developed by Dr. F. Joseph Turk*



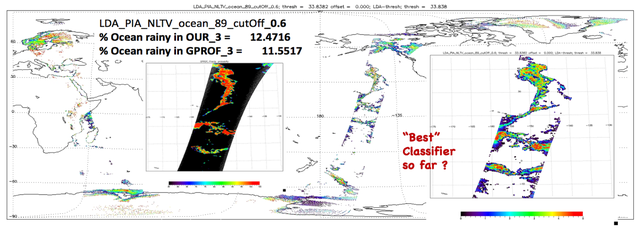

Note- The performance improves when:

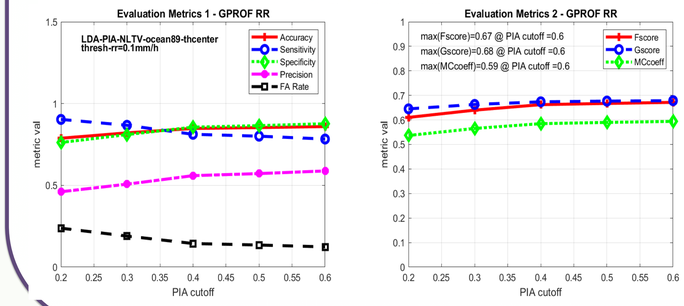
- using the PIA as truth versus using the surface Rain Rate
- Using non-linear combination of TBs!!!
- Using ocean-only data and with higher PIA.

"Truth": the PIA; PIA > 0.6 dB

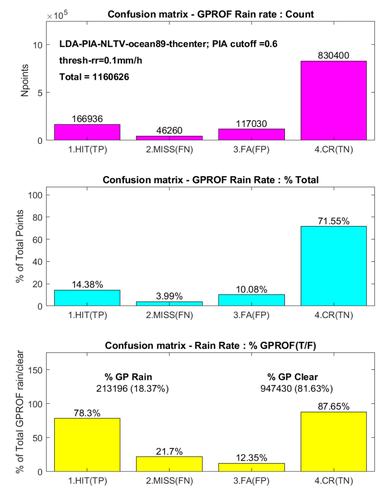
Observables: Non-linear combination of Tbs; Include T2m and TPW

Ocean collocations only were used 89 GHz is included




### Detection: ATMS vs GPROF

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