The next generation GSMaP MWI precipitation algorithm: Improvement of the first guess of physical variables based on MWI TB statistical error analysis

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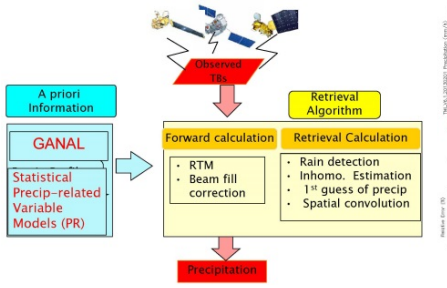
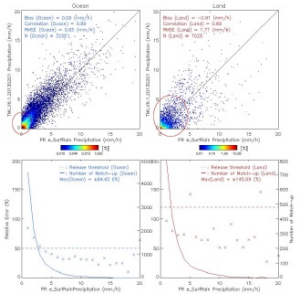
1. Introduction:

The current GSMaP Microwave Imager (MWI) precipitation retrieval algorithm uses a priori information as "the truth". We have been developing a next generation algorithm that assumes a priori information as the first guess and retrieves the physical variables including precipitation and precipitation types etc. from MWI TBs. The basic idea of this algorithm is to derive the statistically optimal values of the physical variables, based on Bayes' theorem. We assume multi-regime PDFs for precipitation profile and surface emissivity.

Basic Idea of the Current Retrieval Algorithm

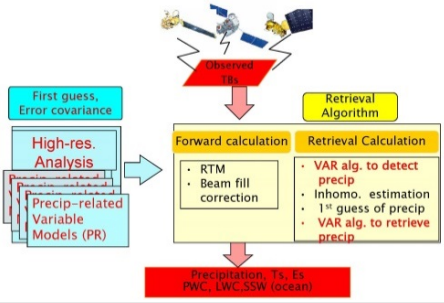




TMI Retrieval V6.1.20130201 vs. PR Estimated Surface Rain

Ave. over TMI 10GHzFOV

Basic Idea of the NEW Retrieval Algorithm



2. Retrieval using Multi-Regime PDFs:

We assume that a priori PDFs of physical variables are expressed as the mixture of different regimes:

$$\Pr(\overset{\vee}{X}^f) = \sum_{j=1}^{J} w^{f,j} \Pr(\overset{\vee}{X}^{f,j} : \bar{X}^{f,j}, P^{f,j})$$

Then, the conditioned (a posteriori) PDFs given observation Y, can be written as follows:

$$\Pr(\overset{\vee}{X}^a \mid \overset{\vee}{Y}) = \sum_{j=1}^{J} w^{a,j} \Pr(\overset{\vee}{X}^{a,j} : \bar{X}^{a,j}, P^{a,j})$$

Hence, the retrieval results in searching the conditioned regime probability $w^{a,j} = \Pr(r = j \mid \overset{\vee}{Y})$ and the analysis for each regime $\overset{\vee}{X}^{a,j}$

The conditioned regime probability is calculated as:

$$w^{a,j} = \Pr(r = j \mid \overset{\vee}{Y}) = \Pr(\overset{\vee}{Y} \mid r = j)\ \Pr(r = j) / \Pr(\overset{\vee}{Y})$$

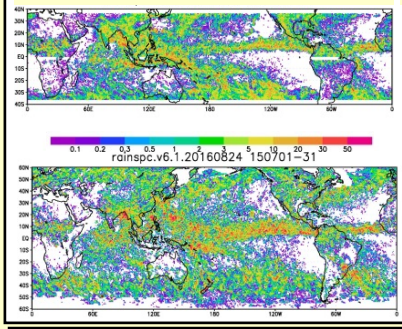
where $\Pr(r = j)$ is a priori regime probability and $\Pr(\overset{\vee}{Y} \mid r = j)$ is the model conditioned likelihood function (MCLF) which can be written using the innovation $d^j = Y - H(\bar{X}^{f,j})$

$$\Pr(\overset{\vee}{Y} \mid r = j) = \Pr(\overset{r}{d}^j : \bar{d}^j, S^j) = \exp\{-\frac{1}{2}(\overset{r}{d}^j - \bar{d}^j)' S^j (\overset{r}{d}^j - \bar{d}^j)\}$$

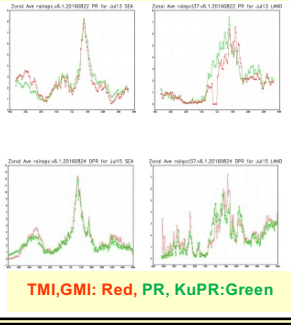
3. Data used for Statistical analyses of MWI TB 1st guess

We performed statistical error analyses of the forward-calculated MWI TBs of the conventional GSMaP algorithm (v6.1.20160824) using the TRMM (Apr.2013-Mar. 2014) & GPM (fJan.2015-Dec 2015) data.

Monthly mean Precip. Retrieval (mm/dy)
(up) TMI for Jul. 13
(dwn) GMI for Jul. 15



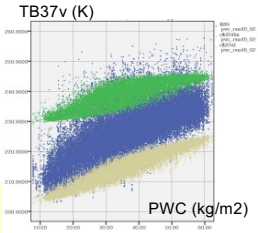
Zonal mean Precip. (mm/dy) over Sea (left) Land (right)
(up) TMI PR for Jul. 13
(dwn) GMI KuPR for Jul. 15



TMI,GMI: Red, PR, KuPR:Green

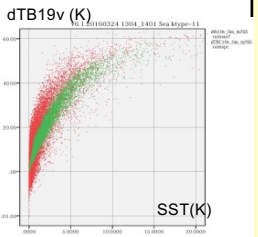
4. Results of the statistical Analysis

The forward calculation using the conventional first guess of CLWC overestimated TBs for most points with very weak precipitation.



GMI TB37v for Pr (0-0.2 mm/h) vs. PWC over Sea (prtype=8)
TBo: Blue, TBc (0.5 kg/m2) : Green, TBc (CLWC=0) : brown

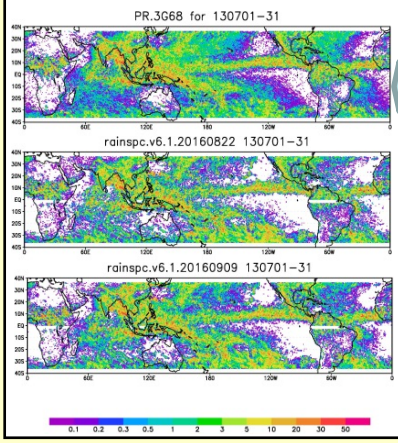
The forward calculation from the PR surface precipitation tended to underestimate subtropical TBs with large PWC.



PR Rainsurf vs. TMI (TB19v-TBc0mm) for SST (290-295 K) over Sea (prtype=11)
TBo: Red, TBc (CLWC=0.5 kg.m2):Green

5. Improvement of the first guess of physical variables

Based on the results, we set the CLWC first guess as a function of PWC and SST. This improved the precipitation retrieval by enlarging weak precipitation areas and reducing positive biases for subtropical precipitation.



Monthly mean Precip. (mm/dy) for Jul. 13
(up) TRMM PR 2A25
(mid) TMI conventional
(dwn) TMI improved

Zonal mean Precip. (mm/dy) over Sea for Jul. 13

(up) TMI conventional

(dwn) TMI improved

TMI: Red, PR:Green

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