Next Generation GSMaP MWI Precipitation retrieval algorithm

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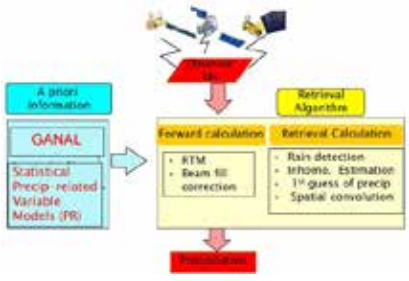
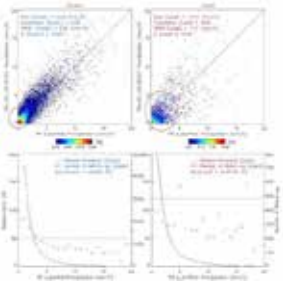
1. Introduction:

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

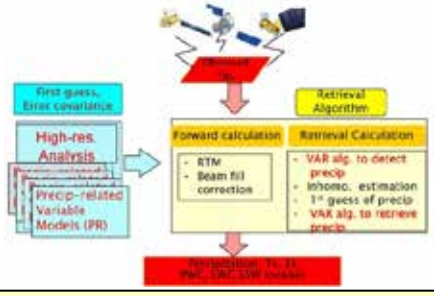




TMI Retrieval V6.1.20130201 vs. PR Estimated Surface Rain

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:

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

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

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

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

The conditioned regime probability is calculated as:

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

where $\Pr(r = j)$ is a priori regime probability and $\Pr(\vec{Y} \mid r = j)$ is the model conditioned likelihood function (MCLF).

A priori regime probability can be estimated from various a priori information (statistic, NWP outputs, etc.).

The MCLF can be written using the innovation $\vec{d}^j = \vec{Y} - H(\bar{X}^{f,j})$:

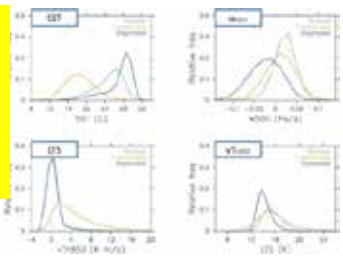
$$\Pr(\vec{Y} \mid r = j) = \Pr(\vec{d}^j : \bar{d}^j, S^j) = \exp\{-\frac{1}{2}(\vec{d}^j - \bar{d}^j)^t S^j (\vec{d}^j - \bar{d}^j)\}$$

3. Outline of the algorithm

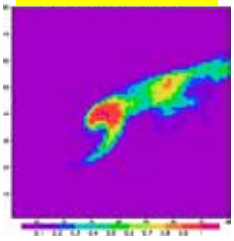
(1) Prescribe PDFs of each regime and estimate a priori regime prob.
(2) Estimate a posteriori probability of clear areas
(3) Retrieve Ts, Es etc from MWI TBs in clear-certain areas
(4) Estimate a posteriori regime probabilities
(5) Retrieve precipitation rates (and other variables) for each regime from MWI TBs in cloudy areas

Statistical prob. of over-ocean precip types in terms of env. Condition

From Hamada and Takayabu (2015)



POP cal from Ens Fcst



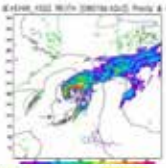
OSSE: a posteriori probability of clear areas

Typhoon CONSON (T0404) for 2004/6/9/22UTC

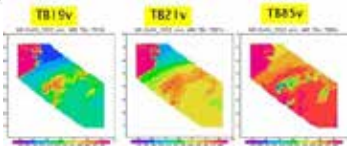
JMANHM(Saito et al, 2005) 5 km res.

Ensemble forecast (04/6/9/15) : 100 members started with perturbed initial data

Regard one member as the "truth"

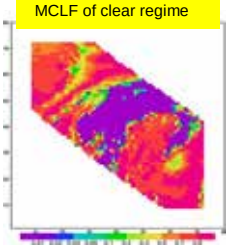


Simulated Observation for TMI TBs

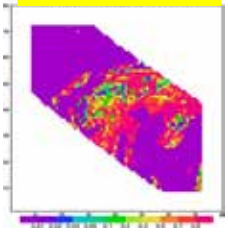


We assumed 2 regimes, clear and cloud-precip regimes, and derived MCLFs for the regimes using TMI TBo and TB calculated from Xf.

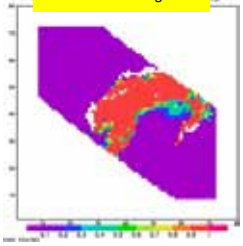
MCLF of clear regime



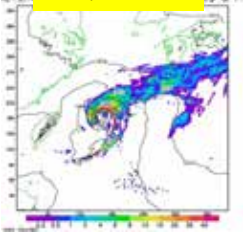
MCLF of CP regime



Prob. of CP regime



Precipitation Truth



Acknowledgements:
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