1. Introduction

A new algorithm for rainfall estimation from satellite data has been developed in the framework of the Megha-Tropiques mission. It aims to provide daily quantitative precipitation estimations at one-degree resolution over the Tropical Belt. The TAPEER-BRAIN (Tropical Amount of Precipitation with an Estimate of Errors) algorithm is a merging approach of passive microwave instantaneous rain retrievals and observations from geostationary cloud top sensitive infrared channels. A dedicated model error involving rainfall auto-correlation calculations is then used to characterize the associated sampling uncertainties. The algorithm error term of the error budget is derived from the microwave retrieval uncertainty analysis. A description of the TAPEER-BRAIN algorithm is provided in Section 2.

The TAPEER-BRAIN algorithm is applied for the summer (June 2009) and the winter (12011) using available conical scanning microwave imagers (TMI, SMI, AMSR-E). The distribution of rainfall estimates (including the associated errors) is first presented. This dataset is then compared in Section 3 with the recently released TRMM-3B42 V7 over the Tropical Oceans. Regions with consistencies/discrepancies are highlighted for future research.

In Section 4, we discuss an ongoing effort to set up a verification method of ensemble rain forecasts using TAPEER-BRAIN error bars.

2. The TAPEER-BRAIN algorithm for Megha-Tropiques

3.1 General functioning of the algorithm

The TAPEER-BRAIN approach aims to associate an error to the July rainfall accumulations, by deriving an estimate of each of the three error terms considered.

Rainfall accumulation estimation of TAPEER-BRAIN

- Adaptation of the UAGPI technique (Ou et al., 1999)
- BRAIN algorithm (Diniz et al., 2000)

provides rain rates from PMW

3.2 Error variance modeling strategy

Assuming the various error sources to be independent, the error budget of rainfall accumulation can be written as:

\[ s^2_{\text{error}} = s^2_{\text{rain}} + s^2_{\text{satellite}} + s^2_{\text{uncertainty}} \]

The methodology to estimate the error variance involves modeling the sampling error term and estimating the remaining terms of the error budget with a forward error propagation method. Indeed, these remaining terms are related to errors on the PM instantaneous rain retrievals and calibration of Level 1 datasets.

3.3 A simple sampling error model for satellite estimates

Uncertainty on the mean of a sampled random variable (Roca et al., 2010), over a surface A and period T:

\[ s^2_{\text{sampling}} = \frac{s^2}{N_{\text{independent samples}}} \]

where:
- \( s \) is the standard deviation of the variable under study
- \( N_{\text{independent samples}} \) is the number of independent samples

Computation of \( N_{\text{independent samples}} \)

\[ N_{\text{independent samples}} = \frac{A \times T}{\pi} \]

Local characteristic of \( s_{\text{error}} \), updated every 10 days to catch the intra-seasonal variability of \( s_{\text{error}} \) (Chambon et al., 2012)

Figure 7. Non-constant error budget in the inter-comparison of TAPEER-BRAIN

3.4 The TAPEER-BRAIN product

A qualitative overview of the total error magnitude for the TAPEER-BRAIN estimations was built from the error propagation results and the sampling error model. A best-case scenario of +20% bias and a worst-case scenario of +60% bias on medium rain rates were selected; for both of them, small and high rain rates are assumed to have low biases. Figure 7 on the right are previews of the corresponding best and worst total error maps of TAPEER-BRAIN.

3.5 Intercomparison of TAPEER-BRAIN and TMPA V7

June to September 2009

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<thead>
<tr>
<th></th>
<th>Mean Rain (mm)</th>
<th>Number of Rainy Days</th>
<th>Lower number of rainy days with low rain amount (0 to 1mm)</th>
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<tbody>
<tr>
<td>September 2009</td>
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<td>October 2011</td>
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Mean Rain (mm)

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<th>Mean Rain (mm)</th>
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<tr>
<td>0.5 mm</td>
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Number of Rainy Days

<table>
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<th>Number of Rainy Days</th>
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<tr>
<td>50 days</td>
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The sampling error model presented above was applied to TMPA V7 and compared with TAPEER-BRAIN taken their sampling errors into account (see Roca et al., 2010 for a full explanation of the comparison method).

4. Toward the use of TAPEER-BRAIN error bar for verification of ensemble forecasts

One of the application of the TAPEER-BRAIN product concerns the evaluation of Ensemble Prediction System (EPS). Indeed, the characterization of the EPS simulations and of the spread of the ensemble can be related to the uncertainty estimates provided along with the daily accumulation. A preliminary investigation is shown here where the ECMWF 50 members simulations are used for a day during the CINDY-DYNAMO experiment in November 2011 over the Indian Ocean.

Figure (a) and (b) show the TAPEER daily accumulation at 1°/1° resolution along with the error estimates at 1 sigma. The meteorological situation corresponds to the early part of an active inter-seasonal perturbation as witness by the large precipitation structure in the Southern Hemisphere. Smaller convergence lines yield to two other oceanic rain patches located respectively around 80°W in the southern oceans. Climatological features over Indonesia are also observed. The uncertainty reaches up to 15mm at the core of the maximum accumulated rain for that day and it otherwise smaller below 5mm. The two fields are rather smooth.

Figure (c) and (d) reveals the median and the standard deviation of daily accumulated rainfall for the EPSWRF EPS. The latter is used a metric of the spread of the ensemble. While the secondary maxima are well located in the simulations, the main rain features is smaller and less compact that in the observed field. The results field is more scattered with larger values than TAPEER. This is obvious when a single member of the ensemble is plotted which reveals intense rainfall in some grid points. The extent to which the variance of the ensemble and the error estimation at 1 sigma in TAPEER can actually be compared quantitatively requires further investigation.

5. Conclusion and perspectives

TAPEER-BRAIN estimates will be produced over the whole tropical belt at 1-degree/3-day resolution, using all available conical scanning PMW imagers. Because of both the low inclination of the Megha-Tropiques orbit and the large swath of the MIRAS instrument, one can expect the quality of the product to be enhanced in light of the encouraging performances of the TAPEER-BRAIN prototype presented in this paper over ocean and in Chambers et al. (2012) over land.

In the framework of the TAPEER-BRAIN project, the sampling error term is estimated through a variance computation technique, and the algorithm error term using an error propagation method with idealized error scenarios in (BRAIN) estimates. Plans are being made to apply the error propagation methodology using BRAIN error characterization derived from the data collected during the Megha-Tropiques Calibration/validation campaign over various rain regimes in Africa, India and Brazil.

6. References

Chambon et al., 2012

Roca et al., 2010

N. Viltard, C. Burlaud and C. Kummerow, “Rain Retrieval from TMI Brightness Temperature Measurements Using a TRMM PR–Based Algorithm.”


2. OMP/LEGOS, Toulouse, France

Figure 8. Variance of \( s_{\text{error}} \) at 30 km grid for the first 10-day period of July 2009.

Figure 9. Distribution of differences between TAPEER accumulations and ground truth rainfall for 10 days period (top panel)

Figure 10. Distribution of differences between TAPEER accumulations and ground truth rainfall for 10 days period (bottom panel)

Figure 11. Over-view of the ECMWF EPS ensemble of rain rates for the same period as (a) and (b).