

Federated Activity HSAF_FA17_01

***Assessment of ground-reference data in Brazil and
validation of the H-SAF precipitation products in the
perspective of CDOP-3***

FINAL REPORT

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Abstract

The present Federated Activity was conceived during the second Continuous Operational Phase (CDOP-2) to set up a collaborative framework with extra H-SAF institutions in order to deal with the cumbersome task related to the validation of the H-SAF precipitation products on the MSG Full Disk, it being a crucial objective of the CDOP-3 phase started in march 2017.

In this perspective, a scientific collaboration was established with the Brazilian research center CPTEC/INPE managing a mobile X band radar deployed in Brazil for several measurements campaigns.

In addition, the French Research Institute for the Development (IRD) was also involved as it already collaborated with CPTEC/INPE to analyze the algorithms applied during the CHUVA Field Campaigns during 2011-2014 timeframe (<http://chuvaproject.cptec.inpe.br>).

The CHUVA project carried carry out six field experiments to investigate the different precipitation regimes in Brazil from April 2011 to October 2014. To study these precipitation regimes, the field campaigns used a dual-polarization X-band radar, a microwave radiometer, disdrometers, radiosonde and other instruments like automatic rain gauges.

Objectives

The proposed FA pursued the following two tasks:

1. **Task 1.** Review of the data processing chain currently applied during the CHUVA field campaign. Implementation and testing of an ad-hoc procedure to associate a quality information to the retrieved rainfall fields.

Details on this Task are provided in the report of the connected VS activity HSAF_CDOP2_VS17_01 entitled "Testing of dual-polarization processing algorithms for radar rainfall estimation in Tropical scenarios".

This activity was carried out by the selected Associated Scientist (VS1) Stefano Barbieri under the supervision of Gianfranco Vulpiani (DPC), Marielle Gosset (CNRS/IRD) and Daniel Vila (CPTEC/INPE) and with the active participation and collaboration of CNR-ISAC.

2. **Task 2.** Validation of the H-SAF passive microwave precipitation products H01, H02, and H18 using the CHUVA campaign data set as ground reference.

The mentioned products optimized for the Brazilian area were generated for the period of the CHUVA campaign.

Details on this Task are provided in the report of the connected VS activity HSAF_CDOP2_VS17_02 entitled "Validation of the H-SAF precipitation products over brazil using the CHUVA campaign dataset".

This activity was carried out by the selected Associated Scientist (VS2) Lia Amaral under the supervision of Silvia Puca (DPC), Daniel Vila (CPTEC/INPE) and Giulia Panegrossi (ISAC-CNR) with the active participation and collaboration of CNRS/IRD.

Results

The activity related to the Task 1 has been carried out mainly by Associated Scientist Dr. Stefano Barbieri (VS1) under the supervision of Gianfranco Vulpiani (DPC), Marielle Gosset (CNRS/IRD) and Daniel Vila (CPTEC/INPE) and with the active participation and collaboration of

CNR-ISAC. The activity related to the Task 2 has been carried out by Associated Scientist Lia Martins Costa do Amaral (CPTEC/INPE) (VS2) under the supervision of Silvia Puca (DPC), Daniel Vila (CPTEC/INPE) and Giulia Panegrossi (ISAC-CNR) with the active participation and collaboration of CNRS/IRD.

The Kick-off meeting was held via Teleconference on the 3rd of May 2017. The participants were Stefano Barbieri (VS1), Lia Amaral (VS2), Gianfranco Vulpiani (DPC), Silvia Puca (DPC), Giulia Panegrossi (CNR), Daniel Vila (CPTEC/INPE), Thiago Biscaro (CPTEC/INPE), Stefano Dietrich (Science Manager), Davide Melfi (former Science Manager), Romulo Augusto (CNRS/IRD). During the meeting, it was planned the overall working strategy, discussed the quality of the available dataset.

During the FA Gianfranco Vulpiani (DPC) lead the activity, defining the strategies for the fulfilment of the objectives, and prepared the work plan accordingly in agreement with CPTEC/INPE, CNRS. Dr. Vulpiani also provided support for the analysis and review of the CPTEC/INPE radar data processing algorithms, and for implementing and testing any processing module during the VS1. Dr. Silvia Puca and Dr. Marco Petracca (DPC) provided the support to implement the H-SAF validation strategy, and the common validation code, during VS2. DPC has provided support to the activity of VS1 and VS2 towards the fulfilment of Tasks 1 and 2. Teleconferences with CPTEC/INPE (Thiago Biscaro) were held to discuss the outcomes of the preliminary analysis concerning the processing of the radar observations with a special focus on some observational anomalies (radar beam shielding due non orographic obstacles, rain gauge data coding).

CNR-ISAC (Giulia Panegrossi and Paolo Sanò) has provided support during the FA to the fulfilment of the Tasks 2. In particular, it provided technical and scientific support to VS2 to: 1) run the passive microwave precipitation retrieval algorithms relative to H SAF products H01, H02 and H18 over the Brazilian area to cover the whole period of the CHUVA campaign; 2) interpret the results the retrieval in the different areas considered, in connection with specific aspects of the retrieval algorithms (see VS2 final report). CNR-ISAC has also coordinated the activity and interactions with CPTEC/INPE and CNRS/IRD, and DPC. A mid-term meeting was held in September 2017 at CNR-ISAC. The meeting has seen the participation of the key persons of each institution involved in the FA, in particular: Daniel Vila (CPTEC/INPE), Gianfranco Vulpiani (DPC), Silvia Puca (DPC), Marco Petracca (DPC), Giulia Panegrossi (ISAC), Paolo Sanò (ISAC), Stefano Dietrich (H SAF Science Manager), and VS1 and VS2 who presented their activities and preliminary results. A final Teleconference with the participation of the key persons of each institution involved in the FA was held on the 13 of October 2017 to presents the final results of the VS1 activity and analyze the latest results of the activity of VS2 in view of the completion of the activity.

CPTEC/INPE (Daniel Vila, Thiago Biscaro) has contributed to the definition of the activities for the fulfilment of the objectives of the FA. Its main role was the provision of the raw radar data, and rain gauge data, collected during the CHUVA campaign needed to the fulfilment of both Tasks. CPTEC/INPE has participated actively to VS1, by supporting the understanding of measurements issues related to the specific environmental and field-campaign conditions (W-Hardware malfunctioning, LAN interferences, ground-clutter), and to the discussions during teleconferences and mid-term meeting on limitations and cautions related to the use of the raw radar data (see VS1 mid-term and final report).

Finally, CNRS/IRD (Marielle Gosset and Romulo Augusto) has provided support in the analysis of the results of VS1 and VS2 based on the experience gained on the use of polarimetric X-band weather radars in Tropical scenarios, including previous works carried out on the CHUVA campaign data set (Koffi et al., 2014; Alcoba et al., 2015, Alcoba and Gosset, 2015).

A detailed description of the objectives, methodologies as well as of the outcomes of both the Associated Scientist activities VS1 and VS2 are described in the corresponding final reports.

A brief summary is described below. Please, refer to the HSAF_AS17_01 (VS1) Mid-term and Final Reports, and HSAF_AS17_02 (VS2) Final Report for further details.

Associated Scientist Activity 1: Testing of dual-polarization processing algorithms for radar rainfall estimation in Tropical scenarios

This activity concerned the use of X-Band polarimetric radar observations for the quantitative estimation of precipitation to be used as reference for the assessment of the H-SAF products in Brazil. As know, radar rainfall estimation is conditioned by several sources of uncertainty. Rain-path attenuation is certainly among the major at X-band, but not the unique.

The Associate Scientist has implemented and optimized some up-to-date methodologies described in literature applied in operational contest

The applied processing chain is composed by an complex set of modules dealing with the removal of non-weather returns, estimation and correction of Partial Beam Blockage (Bech et al., 2003), differential phase processing and specific differential phase estimation (Vulpiani et al., 2012), attenuation correction (Testud et al., 2000), polarimetric rainfall estimation (Vulpiani et al., 2015). In parallel, the data quality is evaluated and provided to AVS2 in order to be used as constraint in the assessment phase (Rinollo et al., 2013; Vulpiani et al., 2014).

As stated in the conclusions different polarimetric QPE algorithms were evaluated at the hourly time step using independent rain-gauges. Three days of observations, from the campaign at Fortaleza in 2011, were used for the evaluation.

Based on the comparative analysis with the available raingauge measurements, the positive impact derived by the use of specific differential phase for the estimation of precipitation is confirmed.

Despite, the available rain gauge data set was too limited to derive statistically significant conclusions, the results are in agreement with the outcomes of several investigators.

The major outcome of this activity is that it allowed to build a methodological framework to investigate the quality of the provided radar system and the feasibility to use its observations for the validation of satellite products.

Additional work is needed to further investigate some instrumental and phenomenological issue such as the radome interferences that reduce the visibility in some azimuthal sectors or radome attenuation that can, in some circumstances, drastically reduce the data quality.

In the perspective of CDOP-3, the possibility to use C- and or S- radar observations should be explored.

Associated Scientist Activity 2 – Validation of the H-SAF precipitation products over Brazil using the CHUVA campaign dataset

The work analyzed the data collected during two sub-campaigns held in Manaus (Amazon) and Vale do Paraiba (São Paulo region). Based on the VS2 results, it was evidenced that the

sample size, in all cases, was quite small and new verifications should be carried out over a larger and more comprehensive sample.

Regarding the Manaus campaign, it was found that

- H01 tends to have improvement on the statistical scores with increasing quality index, however tends to overestimate the light and heavy rain rate classes;
- H02 did not show improvements with the increase of quality index, presents better POD than H01, but also presents high FAR values.
- H18 presents lower overestimation of heavy rain rates compared to H02, probably due the different neural network used in H18.

In general, all algorithms showed high FAR values and larger areas of precipitation than the reference, due to the precipitation screening procedure which is affected by the high water vapor content characteristic of the Amazon region. Moreover, the variability of the surface in this region is not well represented in the a-priori (or training) database used in the retrieval algorithms. The surface is often flagged as “coastal area”, therefore subject to larger uncertainty in the retrieval.

Regarding the campaign held in Vale do Paraíba, it was found that both algorithms, H01 and H02, produce mean error values quite close to zero (or negative) and lower FAR values (from 0,21 to 0,49) than for Manaus. Differently from Manaus the precipitation patterns are well reproduced and the estimations are close to the reference. These results indicate that the cloud-radiation database used as priori or training information for the retrieval algorithm represents quite well the precipitation climatology of the Vale do Paraíba region.

The analysis carried out on Vale do Paraíba (São Paulo region) and Manaus (Amazon region), indicates pathways for future development in the retrieval algorithms to be optimally used over Brazil. It is suggested to:

- Perform new validations using a larger and more comprehensive sample of reference data for the different Brazilian regions.
- To improve the rain/no-rain screening procedure to be able to account for environmental conditions (atmospheric moisture and background surface, as observed in the Amazon region) that limit the rainfall detection capabilities of the current versions of the H-SAF precipitation products analyzed (H01, H02, H18).
- To improve the surface classification in the a-priori (training) database in order to reduce the impact of misclassification in the retrieval algorithms.
- Create an a-priori (or training) cloud-radiation database representative of the distinct precipitation systems in Brazil.

References

- Alcoba M and M Gosset, 2015 :Verification study over West Africa of PMW precipitation products using X-pol radar observations and rain gauges ; H-SAF ASSOCIATED SCIENTIST ACTIVITY SAF_AS15_03 ; FINAL REPORT.
- Bech, J., B. Codina, J. Lorente, and D. Bebbington, 2003: The sensitivity of single polarization weather radar beam blockage correction to variability in the vertical refractivity gradient. *J. Atmos. Oceanic Technol.*, 20, 845–855.
- Gosset, M., E. P. Zahiri, and S. Moumouni, 2010: Rain drop size distribution variability and impact on X-band polarimetric radar retrieval: Results from the AMMA campaign in Benin. *Quarterly Journal of the Royal Meteorological Society*, 136(S1), 243-256.
- Koffi, A.K., M. Gosset, E.P. Zahiri, A.D. Ochou, M. Kacou, F. Cazenave, and P. Assamoi, 2014: Evaluation of X-band polarimetric radar estimation of rainfall and rain drop size distribution parameters in West Africa. *Atmospheric Research* 143, 438–461. doi:10.1016/j.atmosres.2014.03.009.
- Rinollo, A., G. Vulpiani, S. Puca, P. Pagliara, J. Kaňák, E. Lábó, Ł. Okon, E. Roulin, P. Baguis, E. Cattani, S. Laviola, and V. Levizzani, 2013: Definition and impact of a quality index for radar-based reference measurements in the H-SAF precipitation product validation. *Nat. Hazards Earth Syst. Sci.*, 13, 2695-2705.
- Testud, J., E. L. Bouar, E. Obligis, and M. Ali-Mehenni, 2000: The rain profiling algorithm applied to polarimetric weather radar. *J. Atmos. Oceanic Technol.*, 17, 332–356.
- Vulpiani, G., M. Montopoli, L. Delli Passeri, A. Gioia, P. Giordano and F. S. Marzano, 2012: On the use of dual-polarized C-band radar for operational rainfall retrieval in mountainous areas. *J. Appl. Meteor and Clim.*, vol. 51, N. 2, 405-425.
- Vulpiani, G., A. Rinollo, S. Puca, M. Montopoli, 2014: A quality-based approach for radar rain field reconstruction and the H-SAF precipitation products validation. *Proc. Of the 8th European Radar Conference (ERAD)*, 1-5 sept. 2014, Garmish-Partenkirchen (Germany).
- Vulpiani, G., L. Baldini N. Roberto, 2015: Characterization of Mediterranean hail-bearing storms using an operational polarimetric X-band radar. *Atmos. Meas. Tech.*, 8, 4681-4698, doi: 10.5194/amt-8-4681-2015.