General answers to the Editor and to the two Referees

We want to express our sincere appreciation for all the comments and suggestion from the Editor and the two Referees. We have seriously examined all the suggestions from the Editor Dr. S. J. Munchak (i.e., impact of the parallax correction, and presentation of results in a more “physical” way, with a geographical map of the statistical scores and analysis of how the algorithm performs for different types of precipitating event). The comments on the readiness and organization of the results section have been particularly appreciated. The anonymous reviewer 2 has expressed some criticism on the need of a detection algorithm and on the possibility to have consistent detections from different sensors. Well argued criticisms like these makes it possible for an author to think about the real motivations of his work, and present them in a clearer form. Finally referee 1 comments have pointed out several issues on our manuscript that have been addressed, i.e. we particularly appreciated the comments on the minimum detectable rainfall from PR, the choice of using the same dataset for training and testing and the need of a more physical analysis. Moreover we acknowledge referee 1 for the “*labor limae*” (a patient, diligent, meticulous work) on our manuscript.

In order to address all the referees and editor comments we have made substantial changes in the manuscript. In detail, we have built an independent dataset of coincident observations relative to the year 2013 and used this dataset for the testing of the algorithm. As a consequence all the results section is now relative to this new test dataset. Moreover we have removed the SSMIS radiometer on board the DMSP-F18 satellite both from the training and the test datasets because of the presence of a corrupted channel at 150 GHz. As suggested by the Editor, we have made comparisons with the results obtained calculating the Canonical Variables (CVs) in log(RR) space (where RR is the rainfall rate) finding better performances of the algorithm. Therefore, we have decided to adopt a new discrimination function based on CCA in log(RR) space. Finally we investigated the impact of the parallax corrections on the results finding a very small impact and decided not to apply any parallax correction. In order to meet the suggestion of a more physical analysis of the results we have computed a table of the statistical scores divided by rain type as observed by TRMM-PR and by the background surface. Finally, we have analyzed the impact on the algorithm of the non uniform beam filling effect.

These main changes are hereafter briefly reported:

A. **Changes in the text relative to the dataset construction and partition, and to the change of the discriminant function:**
   1. P9243 L4 changed to “AMSU/MHS radiometers in the years 2011-2013”
   2. P9243 L24: changed to “and DMSP-F17 satellites (i.e. the DMSP-F18 has the 150 GHz channel malfunctioning since February 2012)”.
   3. P9246 L1 a sentence that describes the dataset partition in training and test will be inserted at the end of Section 2: “ The SSMIS and AMSU/MHS datasets have been divided into a training set (which includes all data from 2011 and 2012) and a test dataset (data from 2013)”.
   4. P9246 L2: a sentence describing the use of the training dataset at the beginning of section 3 will be inserted: “This section is dedicated to the training of the CCA algorithm done by using the training dataset relative to the years 2011-2012”.
   5. P9247 L2; the sentence “correlation with rainfall rate (RR)” will be replaced by “correlation with the logarithm of rainfall rate log(RR)”.
   6. P9249 L8: a sentence that describes the use of the test dataset at the beginning of section 4 will be inserted: “This section shows the results of the application of the algorithm to the test dataset relative to year 2013.”
   7. P9270: Figure 3 will show the results on the new training SSMIS dataset.

B. **Parallax corrections**:
   Descriptions and comments will be removed after the verification that there is a very small effect on the statistical scores due to the correction of the parallax effect (See answer to the Editor, E6, and to Reviewer 1, R1.5).

C. **Results Section:**

We have changed substantially the section “4. Results”. The full new results section with new figures and tables can be found in the attached document “new_results_section.pdf”. The main changes are listed below:

1. Figure 4-5 will be replaced with new figures, showing the results on the test and training datasets of the CCA algorithms and the comparison with other well known screening algorithms. The comments to these figures will be consequently modified, shortened and grouped into a sub section “4.1 Discussion of Skill Scores”.

2. Figure 7 will be removed and a new figure (Figure 5) has been added to section 4.1 The new figure shows the well known POD, FAR and HSS. The results are shown for rain/no-rain threshold (“truth” from PR 2A25) equal to 0.1 mm/h. Skill scores relative to CCA-GMI have been removed because they almost identical to CCA-SSMIS. A comment on this figure will be included in section “4.1 Discussion of Skill Scores”.

3. Figure 6 and Table 3 will be changed. The comments to this figure and table will be modified accordingly into a new subsection: “4.2 Minimum Detectable Rate”.

4. New tables will be inserted in the manuscript in a new subsection “4.3 Dependence on precipitation regime”.

D. Changes in the conclusions:

1. The conclusions have been updated with the new results.

Specific answers of the authors to the Anonymous Referee 1

We acknowledge the anonymous referee 1 for the valuable comments and for his/her meticulous work on our manuscript, that was particularly appreciated.

Overall quality of paper: The paper outlines the formulation and testing of a rain/norain methodology for use with passive microwave radiometers using the Precipitation Radar on the Tropical Rainfall Measuring Mission as the calibrator. The results indicate that the technique can usefully discriminate the rain/no-rain boundary between about 0.15 and 0.40 mmh-1 depending upon the sensor and surface type. The paper is generally well-structured and written, although there are a number of specific issues and technical corrections that require attention.

R1.1 I would note that the paper tackles the problem of rain/no-rain from largely a mathematical viewpoint. For many applications it is the spatial distribution of precipitation that is important and it would have been very useful to have seem at least a couple of figures that showed mapped precipitation – even if it was just this techniques occurrence of precipitation vs that derived from the TRMM PR data; that way the reader could easily discern how applicable the technique was to ‘global’ rainfall estimations and to their particular region.

We want to acknowledge referee 1 for this comment, which is closely related to one of the Editor’s comments (see E3 in the Answers to the Editor). We have considered the possibility of showing the geographical map of the statistical scores of the CCA algorithm. We have used the full SSMIS-PR dataset, i.e. years 2011-2013, for this analysis. The following figures show the map of the statistical scores obtained by re-gridding the SSMIS-PR dataset to a regularly spaced lat/lon grid with 1 degree spacing.
Figure A shows the population of each grid box in the regular grid, i.e., the number of SSMIS-PR coincidences in each grid box. The following four maps show: B) the fraction of precipitating counts (as observed by PR); C) the fraction of false alarms counts, and D) the fraction of misses counts, (all three fractions are computed respect to the number of samples in each grid box); E) shows the number of shallow rain counts within each grid box. There are some features in the false alarms map that can be easily related to mistakes in the definition of the coast/desert map, such as some small islands that are not detected as “coast” areas (Canaria, Azores, Sao Tomè, Comore, Socotra) producing false alarms, or the Namib desert that has

been incorrectly categorized as Vegetated Land. However, other false alarm features are not so easy to be explained, and require a more detailed analysis.

The map of the misses is more complex, some geographical features appear (e.g. a concentration of misses in South America near Guyana and Suriname, in some spot on the Western coast of the African continent and along the Eastern coast of Madagascar). However, except for these cases, the higher fraction of misses follows the distributions of the Shallow convective events over ocean and coast, as shown in figure E.

We believe that this results needs some more accurate analysis, the geographical dependence of the CCA algorithm and comparison with the other algorithms might be beyond the scope of the present paper (as suggested also by the Editor). It will be addressed in a future study, where we will apply the CCA detection algorithm to real GMI data.

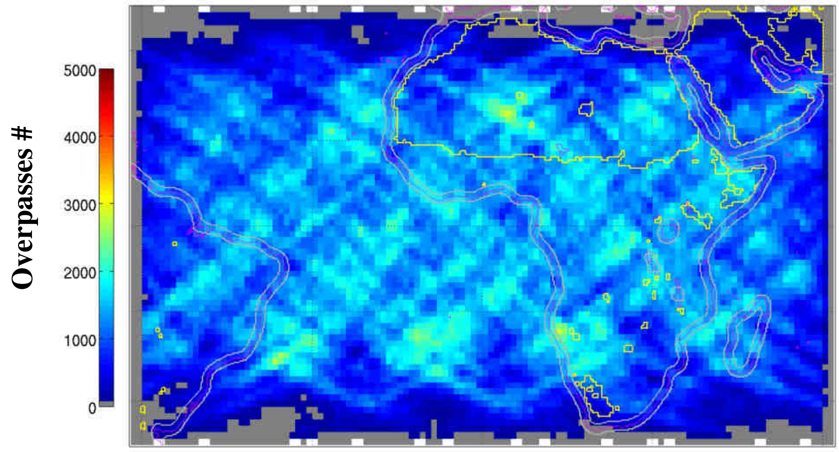


Figure A

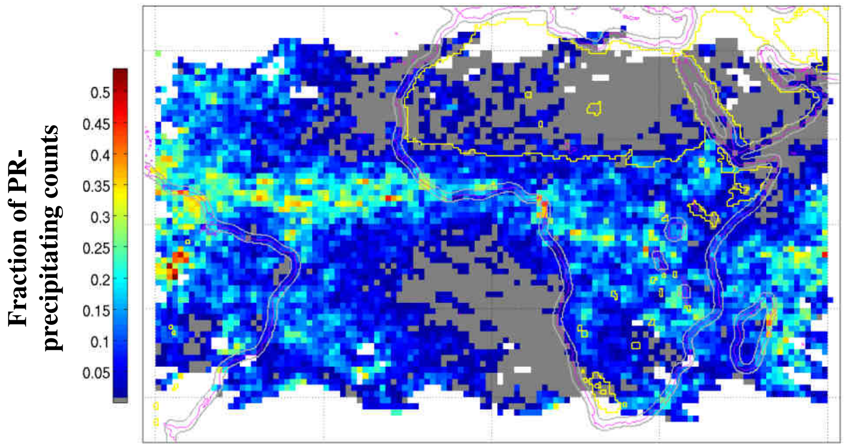


Figure B

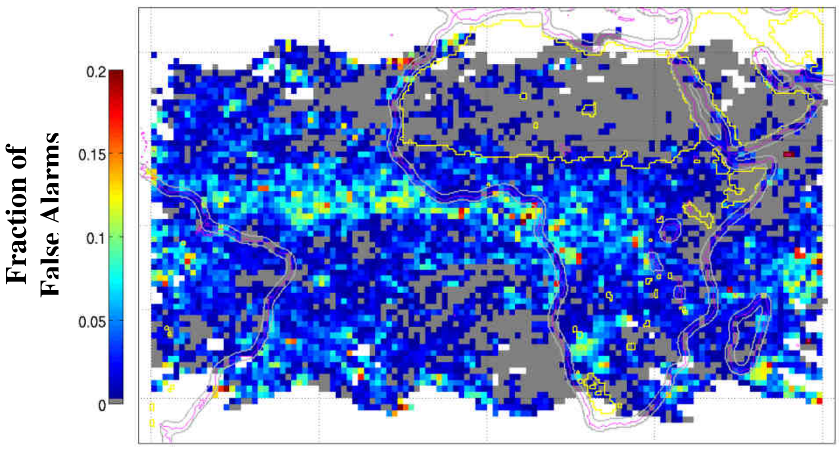


Figure C

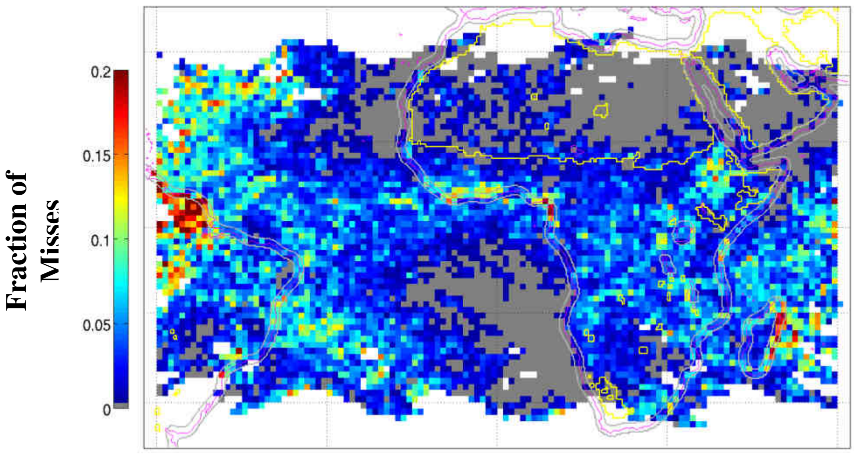


Figure D

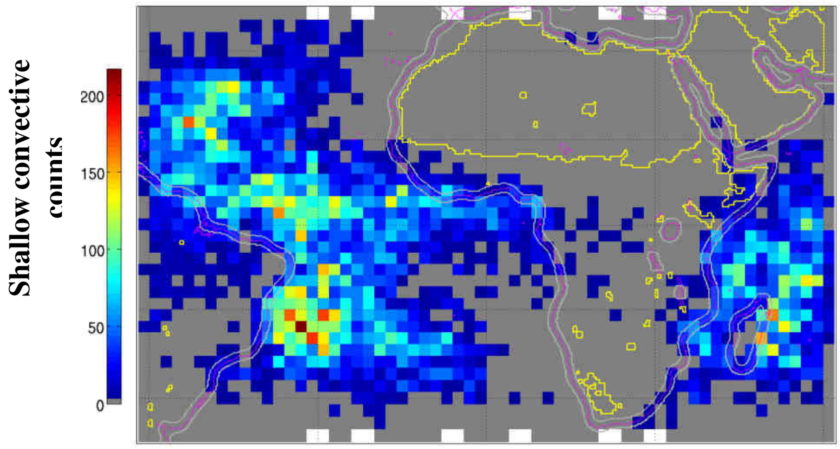


Figure E

Specific comments:

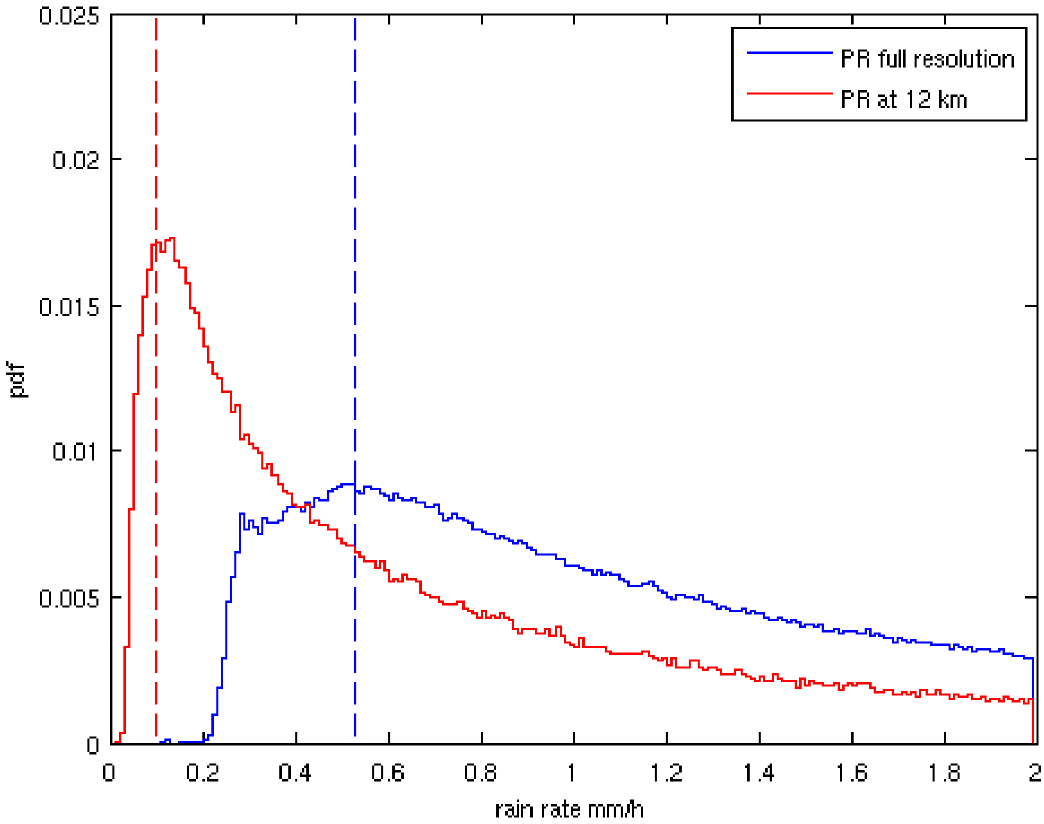
R1.2 calibration/training of technique: the authors use the Precipitation Radar on the Tropical Rainfall Measuring Mission as the high-quality precipitation calibrator. At no stage do the authors note/acknowledge that the nominal minimum detectable rainfall signal for this instrument is 0.7 mmh^{-1}. While this figure relates to a single footprint at 5 km resolution, and that resampling to the lower resolution of the current passive microwave radiometer footprints will allow a lower rain-rate 'observation', the author's choice of 0.1 mm/h^{-1} threshold is someone subjective. Of course, for the cross-track sensors, whose footprint size increases dramatically towards the edge of scan, this will be further complicated.

We agree with the referee, we have not discussed the choice of the minimum detectable rainfall signal for PR. In Iguchi et al. 2009, describing version 7 of the PR algorithm, the choice of the Z-R relationship is based on several parameters such as rain type, existence of the bright band, 0°C level height.

Kirstetter et al. 2014 determined the PR minimum detectable rain rate at 0.53 mm/hr. In the following figure you can see how the rain rate pdf for the PR changes downscaling the dataset to the SSMIS resolution and how our 0.1 mm/h rain rate threshold is reliable for this dataset.

We will change the manuscript in order to include a description of this results:

P9247 L13 after "(for each surface class).": The choice of 0.1 mm/h threshold for TRMM-PR can be justified taking into account that the minimum detectable rain rate of this instrument has been estimated by Kirstetter et al. (2014) as 0.53 mm/h at PR spatial resolution. However, as can be observed form the analysis of the rain rate pdf at full PR resolution and downscaled PR datasets, the downscaling to SSMIS and MHS (not shown), nominal resolution shifts the peak of the pdf (corresponding to about 0.53 mm/h in the high resolution dataset) to value lower or nearly equal to 0.1 mm/h."



References:
Iguchi, T., Kozu, T., Kwiatkowski, J., Meneghini, R., Awaka, J., & Okamoto, K. I.. "Uncertainties in the rain profiling algorithm for the TRMM precipitation radar." Journal of the Meteorological Society of Japan, Vol 87A: 1-30. (2009)
Kirstetter, P. E., Hong, Y., Gourley, J. J., Schwaller, M., Petersen, W., & Cao, Q. "Impact of sub-pixel rainfall variability on spaceborne precipitation estimation: evaluating the TRMM 2A25 product." *Quarterly Journal of the Royal Meteorological Society* (2014). doi: 10.1002/qj.2416

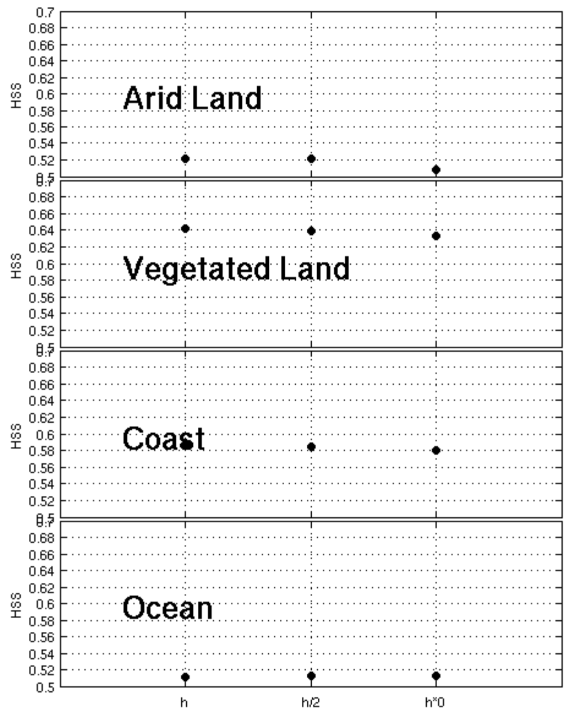
R1.3 Application/verification of results: these seem to be done using the same data as the calibration/training data – these should really be independent to ensure usability; applying the results to different time periods would provide a better understanding of the robustness of the technique over time.
We have seriously tackle this comment and we want to thank the referee for having pointed out this issue. Therefore we have built a new dataset of coincident overpasses in the same area during the year 2013. And we will show the results of the CCA algorithm applied to this test dataset and also some comparison with the results obtained from the training dataset. We believe that now the robustness of the technique is improved and well established. Please, see General Answers above, and the new Result section in the attached document: new_results_section.pdf

R1.4 Indeed, splitting the data between 'seasons' (although in the Tropics this might be more seasonal weather regimes, rather than climatological seasons), might also provide a better insight into whether, for example, the technique works well for monsoonal conditions as for semi-arid – two quite different regimes with quite different socio-economic issues
We agree with the referee. Also in the Editor's comments, a more physical analysis of the results was encouraged (see Answer to the Editor's Comments E3) In order to address both the Referee's and the Editor comments on this regard, we have analyzed the results considering both the surface background and the

rainfall regime and we have added a new discussion of results based on this analysis. We also believe that precipitation regime is strongly affected by the season and is more directly related to the CCA performances. See Section 4.3 of the new Result section in the attached document "new_results_section.pdf".

R1.5 parallax: is this really necessary? There might be some rational for applying a parallax correction where the correction is equal or greater than the sensor resolution (and maybe a large fraction of the resolution). However, this is not the case in this instance. First it should be noted that the passive instruments see an integrated total of the precipitation through the atmospheric column, not just that at the surface, or at the top of the precipitation column. Second, even at a viewing angle of 45 degrees the maximum parallax, assuming that all the signal is from the top of the precipitation column, will be about 4-5 km – but much less in shallow precipitation systems. Given the SSMIS sampling at 12.5 km, and MHS at 16 km (at nadir) this is only 1/3 to 1 4 of the actual footprint. If a parallax-correction is to be applied it should consider the full vertical profiles available from the TRMM PR, preferably using the original level 1A data to allow sub-footprint analysis to be done.

We want to thank the reviewer for this comment. We have performed some tests, as suggested by the Editor, in order to assess the effect of our parallax correction on the results. In detail we have checked the HSS over various surface types calculating the parallax shift based on a cloud height equal to *1*h, 0.5*h* and the *0*h* (with *h* defined in the original manuscript as the cloud top echo from the PR reflectivity profile). We have found a small impact on the results and we decided to remove the parallax correction from our dataset and from the manuscript. The following figure shows the test on parallax correction for SSMIS radiometer.



In Section 2 (" Instrument and dataset description ") of the revised version of the manuscript the part on the parallax correction will be removed (P9245 L9-25). In case the Referee recommends it, we will add a brief comment on the lack of a significant impact of parallax correction for this study based on the results of the test we have performed.

R1.6 acronyms: in the result section the authors make use of different 'detection' algorithms (or rather detection scheme within algorithms). However, the acronyms used within the text do not match up with the acronyms in the figures: these need to be consistent to enable the reader to interpret and understand the results.

Agreed. We will use the term “detection scheme” or “screening technique” instead of “detection algorithm” where needed, and the acronyms in the figures have been changed. New Figures 3 and 4 relative to the test dataset (2013) are shown in the attached document “new_results_section.pdf”.

R1.7 in the results mention is made to differences in the detection threshold between the different surface types, in particular that of arid surfaces. It should be noted that the different surface have fundamentally different rainfall regimes which would be reflected in the training dataset – indeed, it might be expected that the arid surface might have very little or no rainfall.

We agree with the first statement of the referee, we will include in the paper a discussion of the results based on both surface type and rainfall regime (expressed as rain type); details on this discussion are in new Section 4.3 of the attached document “new_results_section.pdf”.

About the assertion on very little or no rainfall over arid surface we want to point out that in our study for Arid Land detection we have considered the mean 19 GHz V and H channel difference, averaged over one year of observations. By doing that, we have considered not just desert areas but also semi-arid regions. Of course, rainfall is less frequent over Arid Land and concentrated in short periods of time, however in these regions it can have very important socio-economic impact. Moreover other screening techniques (or even precipitation retrieval algorithms) exclude arid regions from their analysis, as they are subject to a large false alarm ratios over these areas. CCA, instead, has relatively good scores over Arid Land (desert and semi-arid regions).

Technical corrections:

P9238, L2: insert ‘-orbiting’ after ‘polar’

Done

P9238, L4: remove ‘ly’ from ‘independently’

Done

P9238, L11: replace ‘and’ with ‘with’ and remove ‘was’

Done

P9238, L13: add ‘s’ to ‘algorithm’

Done

P9238, L14: add ‘s’ to ‘show’

Done

P9238, L17: add ‘s’ to ‘surface’

Done

P9238, L17: Question: does ‘total amount’ relate to occurrence or accumulation?

The analysis on total error has been removed from the manuscript (see Answer to the Editor E2) , therefore the last sentence in the abstract will be removed as well.

P9238, L23: remove ‘ly’ from ‘globally’

done

P9238, L24: replace ‘in’ with ‘over’

Done

P9238, L25: replace ‘in the’ with ‘over’ and remove ‘by 2015’

Done

P9239, L1: replace ‘France, India’ with ‘France/India’ (since Megha-Tropiques is a joint mission)

Done

P9239, L3: the DPR is the ‘Dual-frequency Precipitation Radar’

Done

P9239, L6-8:items need to be plural

Done

P9239, L12: SAPHIR needs to be spelt out in French (Sondeur Atmosphérique du Profil d’Humidité Intertropicale par Radiométrie); this is a crosstrack sensor so should not be included with the conical-sensors, but later with the other cross-track sensors.

Done. We have move it with the cross-track sensor description.

P9239, L13: ‘the last two: : :’ – no, AMSR2 is on GCOM-W; I suspect that the authors have originally mentioned MADRAS and SAPHIR. Please correct this section accordingly.

Done

P9239, L18-19: remove reference to JPSS since it has yet to be launched.
Done
P9239, L20: revise text to 'It is also worth mentioning the: : :'
Done
P9239, L29:revise text to ': : :the Bayesian-based Goddard PROFiling algorithm (GPROF2014): : :'
Done
P9240, L3-4: move 'also' from line 3 to line 4 between 'is' and 'of' P9240, L5: move 'to be' to after radiometers and P9240, L5: move 'detect' to after 'efficiently'
The paragraph has changed (see Answers to Anonymous Referee 2 (R2.3),). The new paragraph is:
However the inconsistencies in the precipitation detection deriving from the use of different radiometers also might affect significantly the rainfall estimates from such a heterogeneous constellation, as well as precipitation products derived from the combination of these estimates (i.e., IR/MW merging techniques). The differences in the available channels, spatial resolutions, and observation geometry have a strong impact on the possibility of separating the radiance due to the background surface from the signal related to precipitation. Therefore, the limits of each sensor in detecting precipitation should be carefully studied and established. However, as shown by our results, a certain degree of coherence between different sensors can be accomplished by developing common procedures to be applied to all the different radiometers and able to detect efficiently the presence of precipitation in different environmental conditions."
P9240, L15: add 's' to 'satellite'
We changed it to "from satellite observations"
P9240, L17: replace 'the ones' with 'that', remove 'type of' and add 's' to 'surface'
Done
P9240, L18: replace 'in' with 'at'
Done
P9240, L20: revise 'allows to detect the' to 'allows the detection of'
Done
P9240, L23: revise 'has still' to 'still has'
Done
P9240, L26: replace 'estimate' with 'estimation'
Done
P9240, L29: replace 'the algorithms estimating precipitation' with 'the estimation scheme'
Done
P9241, L3: replace 'unfrequent' with 'infrequent'
Done
P9241, L4: remove 'As a matter of fact, over' with just 'Over'
Done
P9241, L10-11: better reference than 'Barrett et al., 1988' would be 'Kidd, 1998' (reference would be: Kidd, C., 1998: On rainfall retrieval using polarization-corrected temperatures. International Journal of Remote Sensing 19, 981-996.)
We have used the Spencer 1989 formula for PCT calculation, however we have included this reference.
P9241, L19: remove 'large'
Done
P9241, L24: insert 'while' before 'Islam'
Done
P9241, L29: elaborate where the 'high quality precipitation measurements' are from.
This is a general statement, in this case we used TRMM-PR as "high quality precipitation measurements" whose limits in many conditions have been pointed out by several authors (e.g. Kirstetter et al. 2014) However, the methodology presented in this paper can be applied to any dataset of rainfall measurements, as far as it can be considered "high quality" for the region/time frame of interest, or as far as its limits are known. We will rephrase 'high quality precipitation measurements' as: '*Quality controlled precipitation measurements'*.
P9242, L2: replace 'to' with 'by'
We changed finalized with aimed
P9242, L3: replace 'estimate' with 'estimation'
Done
P9242, L6: replace 'compared' with 'compare'

Done

P9242, L7: replace 'for' with 'using'; also note that these techniques are not necessarily just detection techniques.

Accepted. However, we are referring here and in the previous paragraph to the screening technique that is "quite common in the framework of precipitation estimate", not to the precipitation estimate techniques. It will read as: *Different well known algorithms for precipitation retrieval using detection techniques*

P9242, L10: replace 'Europe' with 'European'

Done

P9242, L13: remove 's' from 'multi-channels'

Done

P9242,L17: replace 'are' with 'is'

Done

P9242, L29: add 's' to 'part', and remove 'part of the' and:P9243, L1: remove 'n' from 'American', remove 'continent and part of', and add 'the' before 'Indian'.

Done. These lines are now:

parts of the Arabian Peninsula, Southern America, the Atlantic Ocean, and the Indian Ocean.

P9243, L2: replace 'considering' with 'using'

Done

P9243, L14: replace 'in' with 'for'

Done

P9243, L4-5: TRMM was never officially an operational satellite, however its'data has been used operationally, and as such it is still providing data (and will do so for at least the next 3-4 months). Revise sentence.

Done

P9243, L4-5 will read as*: which has been providing publicly available data until October 2014*

P9243, L7: replace 'at' to 'to a'

Done

P9243,L8-9: need for clarity over the 'observation angle'; the scanning angle is 45 degrees, while the Earth incidence angle is 53.1 degrees.

Done. It will read as: *"…with a scanning angle of 45 degrees*

P9243, L9: the swath width is 1707 km.

Done

P9243, L11: the 22 GHz is vertically polarized (not horizontally). P9243, L13:the 50.3-60.8 GHz channels are vertically polarized or right-circular polarized.

Done. However as much as we know, Channels 1-7 are V-pol in F16 and H-pol in F17-F18. See Kunkee et al. 2008. It will read as:

…while the 22 GHz channel is present only in the vertical polarization and the 150 GHz in the horizontal polarization, as the channels in the water vapor absorption band (around 183.31 GHz). Finally, the channels in the oxygen absorption band (50.3-63.2 GHz) are horizontally polarized or right circular polarized (in the radiometer carried by DMSP-F16 channels 1-7 were incorrectly designed as V polarized).

P9243,L19: insert '183 GHz' before 'water vapor'

Done

P9243, L20: scan angles are -48.95 to 48.95 degrees (from nadir).

Done

P9243, L21: replace 'around' with 'about'

Done

P9243, L22: replace 'considering' with 'within'

Done

P9243, L24: replace 'considered' with 'analysed'

Done

P9243, L25: replace 'considering' with 'for the'

Done

P9243, L26: insert 'therefore' between 'have' and 'been'

Done

P9244, L12: replace 'considered' with 'used'

Done

P9244, L16: remove 'Then'

Done

P9245, L5: replace 'in' with 'over'

Done

P9245, L11-25: see above comment about the parallax correction.

See the above answer R1.5 about parallax correction.

P9246, L2-5: Some would question the use of the 50 GHz channels for precipitation retrievals since these are essentially oxygen absorption channels.

The channels considered in this paper in the 50-60 GHz absorption band have weighting functions peaks in the troposphere (see Kunkee et al. 2008). The 50.3 channels in particular, has a peak at the surface level in clear sky conditions, so radiation in this channel is influenced by scattering and absorption from clouds and precipitation, in principle there is no reason to ignore these channels. However, the comparison between the results of CCA-SSMIS and CCA-pseudo-GMI shows that the inclusion of the 50-60 GHz band has no impact on the detection scheme. This result has been discussed in the new Section 4.2 (see attached file new_result_sections.pdf).

Kunkee, D. B., Poe, G. A., Boucher, D. J., Swadley, S. D., Hong, Y., Wessel, J. E., and 5 Uliana, E. A.: Design and evaluation of the first special Sensor Microwave Imager/Sounder, *IEEE T. Geosci. Remote*, 46, 863–883, doi:10.1109/tgrs.2008.917980, 2008.

P9247, L12: As noted above, the TRMM PR has a minimum threshold of 0.7 mmh-1: the selection of a threshold of 0.1 mmh-1 will therefore be a function of the fraction coverage of the precipitation within the satellite footprint – overwhich the TRMM PR is averaged.

Agreed. See the above answer to Specific Comment R1.1. The minimum detectable rain rate of the TRMM-PR is about 0.1 in the downscaled SSMIS dataset and lower in the MHS dataset.

P9247, L18-19: replace 'an HSS equal to' with 'where'

Done

P9248, L1: replace 'trained using separately two' with 'trained separately for the two'

Done

P9248, L2-3: replace 'considering' with 'using'

Done

P9248, L18: replace 'It' with 'This'

Done

P9249, L18: replace 'following' with 'the scattering index'

Done

P9249, L19: replace 'considering also the' with 'with the'

We would like to keep the sentence as it is, because we want to stress that that we have calculated SI and also Q19 and Q37 over ocean (see Ferraro 1997 equations A3a-A3b).

Ferraro, R. R.: Special sensor microwave imager derived global rainfall estimates for climatological applications, J. Geophys. Res.-Atmos., 102, 16715–16735, doi:10.1029/97jd01210, 1997.

P9249, L20: remove 'following' ; P9249, L23: remove 'we have considered' P9249, L24: replace 'considers differences' with 'uses the difference' P9250, L2: remove 'following' P9250, L3-4: replace 'we have considered' with 'that uses' P9250, L7: replace 'shows a synthetic description of' with 'summarises' P9250,L9: replace 'shown' with 'evaluated' P9251, L10: revise 'the signal deriving from the surface' to 'the surface signal' P9251,L25: replace 'maximize the' with 'has a maximum' P9251, L26: remove 'threshold' P9251, L27: insert 'which' before 'maximizes' P9252, L7-16: As noted above, ensure that the reference to the detection schemes is consistent between the text and the figures. P9252, 21: replace 'conditions' with 'situation' P9253, L5-6: replace 'represent' with 'represents' P9253, L19: replace 'brings' with 'leads' P9253, L21: replace 'as' with 'while' P9254, L9: insert 'the' before 'HSS' P9254, L14: revise 'values of rain rate' to 'rain rate values' P9254, L15: replace 'considered detect' with 'are able to detect' P9254, L16: revise 'more efficiently high rain rates' to 'high rain rates more efficiently' P9254, L17: remove 'the' before 'low precipitation' P9254, L18: revise 'estimate' to 'estimation' P9254, L27: revise 'algorithm' to 'algorithms' P9254, L28: revise 'estimate' to

'estimates' and 'estimate' to 'estimation' P9255, L4-24: consider using more common terminology for 'fraction of precipitation due to hits' (e.g. 'hits') and 'fraction of precipitation due to false alarm (e.g. 'false alarms').

Thank you. We have made the suggested changes where possible. However, please, consider that this section has been significantly modified (see new_results_section.pdf).

P9256, L3-4: revise 'rainfall rate high quality estimates' to 'high quality rainfall rate estimates'

Done

P9256, L6-7: revise 'maximize' to 'maximizes'

Done

P9256, L14: insert 'by' after 'generated'

Done

P9256, L21: revise 'shows almost always' to 'almost always shows'

Done

P9256, L24: replace 'large' with 'high'

Done

P9257, L9-10: clarify whether 'total amount of precipitation' relates to occurrence or accumulation.

This sentence will be changed in the new version of the manuscript, as the analysis of the total error has been removed (see Answer E2 to the Editor and R2.6 to Referee 2).

P9257, L16-17: replace 'Lots of efforts are' with 'Lots of effort is'

Done

P9258, L3: The CloudSat radar is the Cloud Profiling Radar (CPR) not the CloudSat Precipitation Radar.

Done, we are sorry for the mistake.

P9263, Table2: Why are there asterisks in brackets?

As specified in the table caption the algorithms marked with an asterisk are the ones that have been applied to only SSMIS and pseudo-GMI dataset, we will remove the brackets.

P9271/9272 Figures 4/5: Caption acronyms need to match those in the text (or vice versa).

Done