Hydrology and Earth System Sciences Discussions

Interactive comment on "Rainfall retrievals over West Africa using SEVIRI: evaluation with TRMM-PR and monitoring of the daylight time monsoon progression" *by* E. L. A. Wolters et al.

E. L. A. Wolters et al.

wolterse@knmi.nl

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We are grateful to reviewer1 for the thorough evaluation of the manuscript and suggestions for improvements. The comments are included in our response for clarity.

Reviewer 1

General Items.

It would be good, if possible, to have a deïňĄnitive reference that describes the CPP-PP technique. While a few references relate to the technique I didn't ïňĄnd a particular

one that adequately described the technique.

At the moment the CPP-PP retrieval algorithm is only presented in the paper of Roebeling and Holleman (2009). In our paper we refer to this paper several times. In order to clarify the point raised by the reviewer we describe the method is some more detail in section 2.1.

SpeciïňА̧c items

Abstract: Although this study focuses on Meteosat-9, of course, SEVIRI was also on Meteosat-8. Consequently the authors might want to change the reference to Meteosat-9 in the Abstract to Meteosat Second Generation (as noted on p6356).

Ok, modified as requested.

p6355, l27: I was unclear what the 11% 'accuracy' really meant – does this mean that

if a retrieval was made it would be within 11

The term 'accuracy' refers here to the bias in observed rain rates between CPP-PP and rain radar observations over The Netherlands. In the study of Roebeling and Holleman (2009), the bias was defined as the difference between the mean instantaneous CPP-PP-retrieved and rain radar observed rain rates. To clarify this point we have included the above sentence in the revised manuscript.

p6356, l19-21: I am surprised that the retrieval algorithm for a vis/IR technique was

based upon one used for passive microwave retrievals – in what way was it adapted?

The CPP-PP algorithm is for a large part based on the approach of Wentz and Spencer (1998). However, the original algorithm is only applicable to water clouds, as microwave radiometer radiation is only to a minor extent scattered by ice crystals. Roebeling and Holleman (2009) have extended the applicability to ice clouds by considering the Condensed Water Path. In other words, the CPP-PP algorithm is capable of retrieving rain rate for both stratiform ('warm' rain) and convective precipitation.

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p6357, general: although the technique appears very promising, a big gap is obviously the lack of nighttime retrievals. It would be good for the authors to make some comment upon this (e.g. can the Re be derived from other surrogate data, etc?).

It is recognized that a substantial amount of retrievals cannot be performed due to the dependency on visible/near-infrared reflectances. During nighttime, Meteosat provides only observations from the infrared channels. These channels cannot be used to estimate the cloud physical properties of optically thick precipitating clouds. Because these clouds have emissivities close to 1 at all infrared wavelengths it is impossible to retrieve the cloud microphysics. Thus, the cloud top temperature is the only source of information left during the night. If this information were used to estimate rain rates it would be merely a Cold Cloud Duration technique. However, to our opinion the advantage of permanently having rain rate retrievals does not compensate the disadvantage of retrieving rain rate from two types of satellite information (VIS/NIR and TIR). For example, there will be a discontinuity in rain rates when going from the daytime to the nighttime retrieval scheme and vice versa, which would have to be corrected for. In addition, although it has been proven in literature that Cold Cloud Duration techniques are quite accurate in estimating accumulated precipitation, which might indeed be of added value to the region of interest in this paper, for regions where convection is less prevalent we expect the retrieval results to be less accurate. To clarify this point in the manuscript, we have included a condensed version of the above in the conclusions section.

p6358, l21: the TRMM V5 PR data product is somewhat old now, and v6 has been around for many years (in fact v7 is due for release soon). Some of the issues noted in this paper are addressed in the v6 data, and certainly in the v7 data.

We have checked the version number of the TRMM-PR data we have obtained, and it is indeed a newer version, version 6. This has been corrected in the manuscript.

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P6359, l11: the authors should specify how the 0.1x0.1 degree resolution was actually derived: was the data averaged? (i.e. all PR 4.3x4.3 km resolution data was averaged to the 0.1x0.1 degrees?).

Both SEVIRI and TRMM-PR data were averaged to the common grid. This omission has been included in the manuscript.

P6359, l16: I understand why the authors chose to look at the mean/median rain rates rather than the spatial matches. However, it is critical to provide the rainfall in the correct place at the correct time, particular if dealing with large regions.

Complete matching is difficult due to resolution differences, collocation uncertainties and parallax shifts. Therefore, verifying the products in a deterministic sense will probably not give useful information on the applicability of the CPP-PP products for climate research. Because precipitation is a highly variable in space and time, deterministic comparisons are extremely sensitive to collocation uncertainties. This was demonstrated by Roebeling and Holleman (2009), who showed that shifting similar weather radar images of rain occurrence leads to a rapid decrease of the Probability Of Detection (POD) values and increase of the False Alarm Rates (FAR) See Figure 1 in this reply.

P6359, l27: I'm not sure why the authors downsized the number of samples from 14,000 to 10,000. Normally a bootstrapping technique would be used to improve the number of samples (or to seriously downsize a data set). A brief explanation might be useful.

Probably there is some confusion. To clarify the point raised by the reviewer, from a total number of observations of 14,000, there is a single original relative/cumulative distribution function. To obtain an indication on the uncertainty of the calculated rel-

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ative/cumulative distribution function, we applied the bootstrapping technique. So we have increased the number of distribution functions from 1 to 10,000. The text has been adapted to avoid confusion.

P6360, l13: the study accumulates the gauge data over a 15-minute interval to match the SEVIRI sampling. However, the SEVIRI data is an instantaneous snapshot of the cloud tops, not an integrated measurement. While vis/IR techniques beneïňĄt from some time-integrated (due to the longevity of the clouds), the instantaneousness of the imagery needs to recognised. This might explain some of the distributions found later in Figure 3.

We are aware of the fact that SEVIRI takes a snapshot of an area of 3x3 km. This means that CPP-PP retrieves an area-averaged rain rate from an instantaneous observation. In contrast, the rain gauges sample rain rate over a period of time at one location. One could assume that rain gauge observations taken over a period of time represents a transect through a cloud system. To minimize the sampling and collocation uncertainties one needs to apply a correction procedure. In our paper we assumed that a cloud system remains constant over the time period between two consecutive SEVIRI images, the averaging period of the surface observations to match the satellite pixel size is mostly a function of wind speed and wind direction. Schutgens and Roebeling (2009) and Greuell and Roebeling (2009) describe the underlying assumptions, uncertainties and averaging procedures for the validation of Liquid Water Path. However, we note that precipitation has a more intermittent character than LWP, hence we are not convinced that the approaches applied in the papers mentioned will work. Therefore we have chosen to simply aggregate the rain gauge observations over a 15-minute period. To give the reader some more background about this issue, we have included the above discussion in slightly adapted form in the manuscript. In addition, we added the two papers mentioned above to the reference list.

Greuell, W., and R. A. Roebeling, 2009: Toward a Standard Procedure for Validation of Satellite-Derived Cloud Liquid Water Path: A Study with SEVIRI Data. *J. Appl. Meteor.*

Climatol., **48**, 1575–1590.

Schutgens, N. A. J., and R. A. Roebeling, 2009: Validating the Validation: The Influence of Liquid Water Distribution in Clouds on the Intercomparison of Satellite and Surface Observations. *J. Atmos. Oceanic Technol.*, **26**, 1457–1474.

P6369, l3-16: The authors need to be careful here: the technique described here cannot be used for climatological work since it is daytime only – whereas data derived from TRMM can: comparison of the two is a bit of a mis-match.

We partly agree to the point made by the reviewer. Of course, the lack of nighttime data causes an observational gap to obtain a full-day climatology. However, in our opinion the CPP-PP products can be used for climatologic studies. The fact that SEVIRI provides about 40 observations during daylight hours which can be used for precipitation retrievals is a strong advantage. High-quality precipitation retrievals from low-earth orbiting satellites typically have much lower sample frequencies (∼2-4 observations per day per satellite); it is only by collecting observations from many different instruments that sufficient samples can be made available to derive accurate daily precipitation sums. Although our technique cannot be used for all types of climatic research, some example applications are: studying seasonal and annual changes in the daytime cycle as is shown Figure 9, or studying seasonal or inter-annual changes for daytime (between 9 and 15 hr) precipitation. The latter is much more difficult to obtain from low-earth orbiting satellites because a prerequisite is that the observation times need to be identical over the years. Due to possible drifts in the overpass time of such orbiters, it is not easy to prepare such a climatology. With the SEVIRI archive of almost 7 years, we believe that accurate information on precipitation characteristics during daytime will certainly augment the current climatologies based on e.g. TRMM, TAMSAT, and several merged low-earth orbiting satellites.

Introduction

p6353, l17: use of 'passive imagery', although technically correct, would also include

microwave radiometers, which are not what is really meant here. It would be better to specify vis/IR imagery.

We have included "VIS/NIR" before "passive imagery" as requested.

p6354, l12: ..."Therefore continuous rainfall monitoring is of great importance."

Text adapted as requested.

p6355, l2-3: replace "over too wet soils" with "over soils that are too wet"

Text adapted as requested.

p6357, l20-21: "ïňĆagged precipitation", maybe put "precipitation" in italics?

Text adapted as requested.

p6358, l9: TRMM is really a Low Earth Orbiting satellite, rather than a polar (orbiting) satellite.

Text adapted as requested.

P6359, l19: please include a note of what the minimum threshold of the CPP-PP algorithm is.

Normally, the retrieved rain rate from CPP-PP can be as small as 0.05 mm h-1. However, to make possible a proper comparison between SEVIRI and TRMM-PR, also for SEVIRI a threshold of 0.5 mm h-1 has been set. This has been included in the revised manuscript.

P6364, l19: TEJ = Tropical Easterly Jet (I presume). Also spell out 'SST'.

TEJ has already been written in expanded form at p. 6355, l. 8 of the original manuscript. SST has been spelled out at p. 6363, l. 9-10 in the original manuscript.

P6365, l27: Expand CWP.

This has already been done in the original manuscript at p. 6356, l. 21-22.

P6366, l19: Expand AEWs.

This has already been done in the original manuscript at p. 6354, l. 25.

P6368, l5: replace 'until' with 'up to'.

Done as requested.

P6368, l19: replace 'resolution' with 'sampling'.

Done as requested.

P6368, l27: AEJ – African Easterly Jet?

Indeed, but this was already expanded in the original manuscript at p. 6354, l. 26.

Figure 2: in the caption, replace 'clouds' with 'retrievals'

Done as requested.

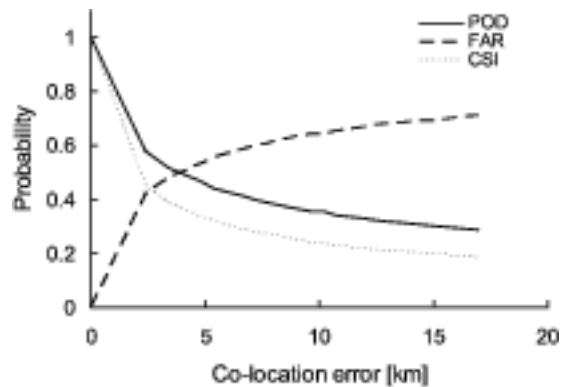Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 6351, 2010.

Fig. 1. Impact of collocation errors on POD, FAR, and CSI scores calculated from a dataset of perfectly collocated and shifted weather radar observations.