Answers to the Reviewer #3 comments concerning the manuscript "Validation of satellite-based noontime UVI with NDACC ground-based instruments: influence of topography, environment and satellite overpass time", by Brogniez et al.

In the following the comments of the reviewers are in italics and the answers and the changes made to the paper are in blue.

Anonymous Referee #3

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We thank the Referee for all his/her helpful comments and suggestions. The reviewer is also thanked for the proposed English language corrections.

General comments

The manuscript by Brogniez is a straightforward paper, describing the difference of satellite- and ground-based UVI measurements at three sites using various statistical quantities. As already pointed out by Referee #2, one important shortcoming of the paper is that the uncertainty of the ground-based measurements is not well quantified. I urge the authors to include a comprehensive uncertainty budget of their measurements when submitted a revised version of the manuscript.

As recommended by both referees we have given a reference for the estimate of the uncertainty budget (Bernhard and Seckmeyer, 1999).

We have also given the web site address where the QASUME reports can be viewed. In the modified manuscript we state that following the QASUME campaigns the raw measurements were reprocessed to account for the observed biases.

We have written: "During the QASUME campaigns, held for the three instruments, biases were observed: on average about 10% for VDA and OHP instruments and less than 3% at SDR (local instrument measurements lower than those of QASUME, reports available at http://www.pmodwrc.ch/wcc_uv/wcc_uv.php?topic=qasume_audit). Following these results, the VDA and OHP lamps have been recalibrated in July 2012 at the World Radiation Center, Davos, and all the data reprocessed. An intercomparison campaign held in July 2015 in Hanover, and further analysis have shown that the measurements are still 3-4 % lower than the reference measurements.

The SDR lamp irradiance has been adjusted to the QASUME irradiance (May 2013), and all the data reprocessed."

We have also given the uncertainty for each instrument separately: “The irradiance uncertainty leads to an UVI uncertainty for a coverage factor $k = 2$ of 5.3 % at VDA and OHP and 5% at SDR. The remaining biases observed at VDA and OHP are thus within these uncertainties.”

At least OMI provides the UVI also at the time of the satellite overpass (other data products include the UVI at local solar noon and the daily UV dose). Satellite- and ground-based measurements performed at the time of the overpass should agree better than the respective datasets for solar noon that are discussed in the manuscript. For example, changes in cloud cover between the time of the overpass and solar noon would not contribute to differences between the ground- and satellite datasets if the comparison had been based on overpass data. I suggest that the authors also consider a comparison of the difference of satellite- and ground-based observations at the time of the satellite overpass. This does not have to be lengthy.

We agree that a comparison would be interesting but as stated in the answer to Referee #1 GOME 2 does not provide data at satellite OP time.

Moreover many other works do exist for OMI data at OP time and not for noon, though noon UVI is important for public health.

The manuscript should be thoroughly copy-edited before publication in ACP is considered. For example, the article “the” is frequently missing and many other grammatical errors should also be addressed.

Specific comments

L22: The main difference between versions v1.2 and v1.3 (i.e., treatment of aerosols) should be mentioned here.

It has been mentioned: “The present study concerns the period 2009-September 2012, date of the implementation of a new OMI processing. The new version (v1.3) introduces a correction for absorbing aerosols that were not considered in the old version (v1.2). Both versions of the OMI UVI products are available before September 2012 and are used to assess the improvement of the new processing.”

L33: “that did not account for absorbing aerosols.” should be mentioned earlier (i.e.., L22)

Done

L65: It should also be discussed here that the ground-based UVI measurement and SDR may not be representative for the UVI of the satellite pixel because the majority of the area contributing to the satellite measurement is the UVI over the ocean. Cloud cover over the ocean may be quite different from that over the mountainous island of La Reunion!

We thank the reviewer for his/her suggestion because indeed this should be specified. We have included the following sentence in the revised manuscript: ¨ This site may be not representative of satellite pixel because a large part of the area contributing to the satellite measurement is over the ocean where the cloud cover is likely different from that over the mountainous island."

L50: Delete "Thus, GB measurements are essential for validation of finer scale satellite measurements". (I don't understand what's meant with "finer scale satellite measurements". At least such measurements are not discussed in the manuscript.)

We agree that since we did not study finer scale, this sentence is not necessary, so we have removed it.

L60: "All these OMI validations were conducted using data collected at the time of the satellite overpass." Please explain why your study is based on comparisons for local noon instead.

We choose to validate noon UVI because OMI and GOME-2 websites provide maps for noon and as mentioned few lines later, the UVI is generally maximum. We have rephrased as following:

"In the present study validations are conducted using data at noon, when the UVI is maximum for cloud-free conditions, over a more recent period at three French sites, including a new southern site."

And after : "OMI and GOME-2 websites make available UVI data and maps at solar noon, when values are generally close to the maximum and more risky for health, therefore comparison with ground-based UVI is carried out in this study at noontime. "

L72: Mention the websites here or point to the appendix where those are provided.

The websites are indicated in the section "Data availability".

L74: Regarding ". . .during about four years (January 2009-September 2012, date of the replacement of OMI version 1.2 by version 1.3). Both versions of OMI data are used to assess the effect of the absorbing aerosol correction that has been recently introduced (v1.3 available since end of March 2014)." The two sentences contradict each other. The first suggests that v1.2. was available up to September 2012 and was then replaced by v1.3. The second sentence suggests that v1.3. is only available from March 2014 onward. Please clarify. Ideally, comparisons of OMI versions v1.2. and v1.3 with ground-based data should be based on the same time period. Was this the case?

We have rewritten the text to clarify: "… during about four years, January 2009-September 2012, date of the implementation of a new OMI processing. The new version (v1.3) introduces a correction for absorbing aerosols that were not considered in the old version (v1.2). All the archive has been reprocessed with OMI v1.3, so both versions of the OMI UVI products are available before September 2012 and are used in this work to assess the effect of the absorbing aerosol correction."

L104: The period (full stop) in "25.10-3 Wm-2." is confusing. It should be 25 x 10-3 Wm-2.

Done

L105: MAJOR POINT: The uncertainty of the ground-based measurements needs to be discussed in much greater detail. What is the basis of the conclusion that "The irradiance uncertainty leads to an UVI uncertainty for a coverage factor k = 2 of about 5 %?" Is there a paper that could be cited? The results of the intercomparision with the QASUME instrument should also be discussed in detail. I assume that there is a QASUME report that could be cited.

As stated in the answer to the first General comment above, we give now more information (we give a reference for the estimate of the uncertainty budget (Bernhard and Seckmeyer, 1999) and the web site address where the QASUME reports can be viewed).

L194: Can the qualitative statement "variations around noon must be smooth" be quantified?

We cannot quantify because the examination of the diurnal variation plot is made subjectively by a visual inspection. It is the first criterion to detect cloudless sky. The second criterion based on the relative dispersion around the hourly mean is quantitative and checked automatically.

We have made few changes in the text: "the shape of the curve of the UVI diurnal variations around noon must be smooth (made by a visual inspection), and (ii) the UVI relative dispersion around the hourly mean must be less than 5 %, this value being an estimate of the UVI variation due to SZA variation around noontime (estimation derived from modelling). This second criterion is checked automatically."

L196: Explain "SEVIRI/MSG"

We have now written "the SEVIRI sensor on the MSG satellite".

L198: The sentence "One has considered two limits for the distance between the GB station and the cross track position (CTP) for OMI and the grid cell centre point for GOME-2." comes out of the blue. Do you mean "We have considered . . ." If so, what are the limits?

Yes, "one" was for "we", we have replaced it. We have also given here the distance limits (100 and 10 km) that were given later.

L206: The following recent paper could also be cited here: http://www.atmos-chem-phys.net/15/7391/2015/

It is added.

L220 and all figures with the exception of Figure 5: I don't see a need to use different colors for OMI-v1.3 and GOME-2 in the upper and lower panels of those figures!

It sounds to us practical to distinguish both instruments, so we keep the different colors.

L 455: Regarding "Due to the mountainous topography of. . ." Not only that. A good fraction of the satellite pixel covers the ocean rather than the land where the instrument is located. This must have some effect. For example, cloud cover over the ocean is likely different from that over land.

We agree with the reviewer, so we have written: "SDR site is difficult for spatial UV estimates because of (i) the mountainous topography of Reunion Island, and thus to the frequent formation of clouds and (ii) the satellite pixel covers both land and ocean, for which the cloud cover are likely different."

Language:

L13: "in very" > "at very"

Done

L21: Delete "date of the change of OMI data processing. UVI" (the phrase is more confusing than helpful considering that the differences in the processing method implemented after September 2012 are not discussed here).

We study the differences in the derived UVI from the two versions, so we have rewritten the text to clarify: "The present study concerns the period 2009-September 2012, date of the implementation of a new OMI processing. The new version (v1.3) introduces a correction for absorbing aerosols that were not considered in the old version (v1.2). Both versions of the OMI UVI products are available before September 2012 and are used to assess the improvement of the new processing."

L26: "Correlation" > The correlation"

Done

L27: "for both spatial instruments" > "for both space-borne instruments"

Done

L37: "as is a goal" > "which is the goal"

Done

L73: "confrontation"? Do you mean comparison?

Yes, we have made the change

L81: "are listed" > "are provided"

Done

L109: "to NDACC" > "with NDACC"

Done

L116: "on aura" > "on the AURA" ; "on July 2004" > "in July 2004"

Done

L120: "Thanks to Aura orbit and large OMI swath width" > "Thanks to the AURA orbit and the large OMI swath width"

Following the Reviewer suggestion we have added "the" in 2 places but we have kept Aura (according to the literature).

L134: "the high positive bias between OMI" > "a large portion of the high positive bias between OMI"L150: "on Metop-A platform" > "on the Metop-A platform" L167: "in the same grid." > "on the same grid."L189: "has been made." > "was calculated"

Done

L225 (and similar for OHP and SDR): "means (STD nearly 40., means nearly 21)" > "means (STD nearly 40%, means nearly 21%)" Please add "%" also to similar phrases in the OHP and SDR sections.

Done

L237: "in CS conditions." > "for CS conditions."

Done

L237 (and similar for OHP and SDR): "weak (STD<10., means<8.)" > "weak (STD<10%, means<8%)"

Done

L246: "are reliable." > "statistically robust".

Done

L250 (and other places): "weak UVI" > "small UVI"

Done

L255: Please rephrase. The sentence as it stands is confusing.

We have rephrased the sentence: "On the other hand, GOME-2 UVI relative differences exhibit seasonal variations, that is due to negative values related to small UVI and large SZA occurring mostly in winter rather than in other seasons."

L291: "As expected, v1.3 product is more reliable than v1.2 one." > "As expected, version v1.3 data are more accurate than version v1.2 data."

Done

L315: "in CS" > "for CS"

Done

L324, L361, L400: "The statistics results" > "Statistics of the results"

Done

L332: What do you mean with "previous study"?

We have specified it is the study for 100 km distance

L345: "than the site one" > " compared to the actual altitude of the site"

Done

L364: "that v1.3 product is more reliable than v1.2 one" > "that the v1.3 dataset if more accurate than the v1.2. dataset.

Done

L365: "black plots" > "datasets indicated by black broken lines"

We have written "black dashed lines"

L373: "on average much far from noon than OMI." could be deleted. also: "SDR site" > "SDR"

Done

L396: "One has checked". Do you mean "We have checked"?

Yes, we have made the change

L416: "weakly reliable" > " not statistically significant"

Done

L442: "Overall, these changes are weak and not significant. This could be understood because, as can be seen in Fig. 5 (blue plots). The aerosol content is small (small AOD (Fig. 5a)) and the aerosols are weakly absorbing (large SSA (Fig. 5b)). Thus the correction factor is close to unity (Fig. 5c), leading v1.3 products to be little improved compared to v1.2 at SDR." > "The small difference between the v1.2 and v1.3 datasets is due to the small AOD (Fig. 5a) and large SSA (Fig. 5b) at SDR. Correction factors are therefore close to unity (Fig. 5c), resulting in only small difference between the two versions."

We agree with the reviewer that this formulation is shorter and clearer. We have adopted it:

"The small difference between the v1.2 and v1.3 datasets is due to the small AOD (Fig. 5a, blue dashed line) and large SSA (Fig. 5b). Thus the correction factor at SDR is close to unity (Fig. 5c). "

L454: "to NDACC" > "with NDACC"

Done

L457: "these two latter sites are hindered by aerosols of pollutant origin" > "VDA and OHP are affected by aerosols caused by air pollution".

Done

L463: "is worth" > "is worth considering

Done