Authors' Response to Referee #1

UV-Indien Network ground-based measurements: comparisons with satellite and model estimates of UV radiation over the Western Indian Ocean, **K. Lamy, T. Portafaix, Earth System Science Data, essd-2021-55**

Introduction

We appreciate the time and effort put into this article by the referee and thank him for his detailed and thorough comments.

Before we start responding in detail, we would like to point out that we have taken into account the remarks of the two referees on the slight discrepancy between the objectives and scope of the ESSD and some sections of the article.

We have therefore prepared a new version of the manuscript with an updated structure that will include the suggestions and corrections proposed by the two referees.

The focus of the paper has now shifted from the presentation of the data (diurnal UV and cloud cycle) to the description of the instrumented sites, the instrumental characteristics (instrument type, protocols, calibrations and uncertainties) and the creation of the dataset (filtering method, post processing). This new version is provided with our final response and all answers to the questions raised during the discussion (step 5 of the revision as described here: https://www.earth-system-science-data.net/peer_review/interactive_review_process.html).

We hope that the restructuring and shifting of the focus of the paper has helped to realign the manuscript with the ams and scope of ESSD.

Below we provide detailed answers to the main questions raised by the Referee. Our response is structured in two parts. The first part concerns the Referee's general comment. As this general comment is very insightful and detailed, we have decided to divide it into several points. Our responses to these points form the first part of our response.

The second part of our response addresses the specific comments (as distinct from the general comments). We thank the referee for his specific comments that were helpful in improving this manuscript.

Part 1: Answer to the General Comments of the Referee #1 to the Author

---

Referee's Comment 1: *This article presents a new data set of UV index observations for an area of the world that generally lacks observations. A comparison is presented with UV indices derived from various satellite products. On the whole, these items are worthy of publication in some venue. However, based on the provided review guidelines as I understood them, I could not confirm that the submission meets the objectives of a data description article for the Earth System Science Data journal. Quoting from the aims and scopes of the ESSD (https://www.earth-system-science-data.net/about/aims_and_scope.html),*

"Articles in the data section may pertain to the planning, instrumentation, and execution of experiments or collection of data. Any interpretation of data is outside the scope of regular articles. Articles on methods describe nontrivial statistical and other methods employed (e.g. to filter, normalize, or convert raw data to primary published data) as well as nontrivial instrumentation or operational methods. Any comparison to other methods is beyond the scope of regular articles."

This article does describe how the data was gathered and processed, including calibration information, but this is actually a minor portion of the text and mostly references other sources. The bulk of article describes interpretation of the data, for example the presence of cloud enhancement, and comparisons of radiometer data with results determined by other methods (satellite and model-based products). The short summary states that the article concerns the validation of a new dataset from the measurement of ultraviolet radiation, but the validation described in the lines 110-115 is actually of the satellite and model based numerical products given the ground-based radiometric measurements.

Author's Response 1: We do not believe that the bulk of the article you refer to (we assume this is part 4 of the article?) can be considered solely as an exercise in data interpretation.

We do not deny that there are elements of explanation of the data, but these explanatory notes are used here to ensure the quality of the data set.

We consider that this allows us to provide key elements for the correct use of the data by the future user of the data. It is therefore about providing information about the data for the purpose of better understanding the instrument and the data but not for the sole purpose of understanding and studying the variability of a physical phenomenon although these two objectives are closely related.

Therefore, in this section we represent the instrumental measurement data and provide a quantitative description of the variability of these data across stations and thus across latitudes, longitudes or environmental situations. These descriptions are made without trying

to explain them. From these representations, we provide short elements to understand the variability of the data set.

The example of the increase in UV by clouds is very telling. This phenomenon, which is very common and can play an important role in the UV measurement, is observed for all measuring stations described in this article. It is therefore necessary to mention it. The article does not investigate the mechanisms and amplitudes associated with the phenomenon of UV enhancement by clouds, but this phenomenon is mentioned and its possible impact on the amplitudes of the observed values is reported. This assures the future user that the maxima observed in the dataset are not the result of poor data quality but the result of an existing physical phenomenon.

In lines 110-115 we only mention the objectives of this network and the possible uses of this network of instruments. Although one of the objectives of the network is to serve as a reference to validate future satellites, models or products. The quality and validity of the measurements of this network must first be ensured against instruments and models already validated and operational before the installation of this network, which is done in the rest of the paper, especially in section 3.2.

However, we agree that more detail is needed on the choice of instrumented sites, the environmental conditions associated with these sites, the characteristics of the instruments and the associated calibration and data processing protocols. As indicated in the introduction, we have therefore restructured the manuscript to focus on these issues. We have chosen to retain some elements of Section 4 because, as explained here earlier, we believe it is important to provide the future user with key information about the variability of the data set.

> ***RC 2:*** *Moreover, a stated criterium of a ESSD contribution is that it should be easy for any interested person to use the associated archived data, but the data available at https://zenodo.org/record/4572026#.YH8SL2gpC9Y doesn't quite meet that standard. The meta data should provide more information, including what zone is used for time (UTC? LT?), what is a UV index, and what is meant by an "Instant Reading". In one of the data sets, AnseQuitor, the same observation occurs in triplicate at each time point which appears to be an error. The files include data at "night" (SZA >90 but not reported) which are all zero and makes the files unnecessarily long (zero data is omitted for the St-Denis data). The cloud fraction data includes the red-blue ratio the derivation of which is not described in the article. Finally, the data doi only includes the radiometer (Kipp Zonen erythemal) data and not the other data referenced in the paper, including the Bentham spectroradiometer data, TOC and UVI derived from the satellite and model products.*
>
> ---

AR2: The data is accessible via 2 databases (zenodo and WOUDC). WOUDC specifies the timezone, which is not the case in the current version on zenodo database. This will be corrected in a version 2 soon available on this site, together with corrections concerning

triple data (Anse Quitor) and unnecessary night measurements (SZA >90). We thank the reviewer for his vigilance.

The ZENODO data d.o.i includes the radiometer (Kipp Zonen erythemal) and cloud fraction; it is not the case for the WOUDC repository. Indeed, only the UV and cloud fraction data are concerned by this article because of their originality.The other data mentioned in the comparisons are freely available on the websites of the organisations concerned. These elements are referenced in our articles so that a user can easily find them. These other data have their own doi (Bentham spectroradiometer, OMI TOC, UVI from satellite or model).

> ***RC3:*** Calibration procedures are mentioned in the article but details are omitted, in particular when calibrations were performed for the data presented. The article does mention plans for future operation and procedures for future calibrations. This information will be of interest to the reader but is not directly relevant to the archived data. The organization would be improved by segregating such information in a separate section on titled something like “future operations”.
>
> ---

AR3: We agree with the referee on this point. The calibration section is now more detailled in the newer version of the manuscript. Nevertheless, in order to answer your questions, more details concerning the calibrations are provided below in the specific commentary associated with the calibration (Part 2 Author’s Response 1).

> ***Referee #1 conclusions before specific comments:*** This is the first paper I have reviewed for ESSD and perhaps I have applied the criteria for publication too narrowly. For this reason, I have not recommended outright rejection and leave it to the editor to make the final judgement. Whatever course is taken, the mss and data sets with revisions should be appropriate for publication in this or some other venue for reporting geophysical results. In the revision, I recommend attending to the points made above and a number of specific issues as follows:

Part 2: Answer to the Specific Comments

> ***Referee's Comment 1:*** *3.1 Calibration – This section refers to results on Radiometer ADs and RDs relative to the Bentham spectroradiometer but only qualitative description is given. Comparing this section and the data section lines 95-109, I am confused about what calibrations were used and how they were done. Line 97 says that the radiometers will be calibrated every two years. How about the calibrations for the presented data? In section 3.1, differences are described between radiometer based and spectroradiometer based UVI for the "recent recalibration". What was the calibration of the radiometers for this comparison? Later in the paragraph, it is stated that "differences were used to recalibrate the radiometer". But isn't that what is usually done in a calibration against a reference instrument?*

Author's Response 1: We agree with the Referee that this section may be confusing for the reader. We are currently reworking a new version of this section separated into several parts with more qualitative and quantitative details on the calibration of UVS-E-T radiometers and on the calibration of SUV-E radiometers.

To briefly answer the questions raised by the Referee;:

The calibration of the data presented in the manuscript (Antananarivo, Anse Quitor, Mahe and St-Denis) is the manufacturer's calibration for the first three and the manufacturer's calibration followed by a calibration performed in Davos for the Saint-Denis radiometer.

Recent calibration using an intercomparison with the BENTHAM spectroradiometer measurements was done for the SUV-E Radiometers (installed in Fort Dauphin, Moroni, Diego Suarez and Juan de Nova Island), the BENTHAM is considered as the reference in this calibration process.

We plan to recalibrate all radiometers (SUV-E and UVS-E-T) every 2 to 3 years by re-deploying them for a few months on the same site as the Bentham (Réunion Island, Moufia site). This procedure requires the physical pick-up of the radiometer at each site and the exchange with a recalibrated instrument at La Reunion Island. Indeed, postal services are not efficient in this part of the world (risk of loss or theft) and for some sites we do not have local correspondents allowing a secure shipment. Unfortunately the current health situation has delayed this process since no commercial flights are operated between Reunion, Madagascar, Seychelles, or Comoro Island, since March 2020.

> ***RC2:*** *What are the criteria for determining which measurement are "clear-sky" and what is meant by a "clear sky day" Please specify. The text says, e.g., that there are 16% "clear sky days" at Antananarivo, but the data set AntananarivoSKYCAMVISION has < 1% of 30s resolution data with CF=0.*

AR2: This filtering was done manually for 1h intervals. The filtering process is as follows: each daily UVI and cloud fraction profile is plotted together with an estimate of the clear sky

profile using the Madronich analytical formula. To calculate the Madronich UVI estimate, we use the total ozone column from either the OMTO3d satellite product or a co-located ground-based instrument (the SAOZ for the St-Denis station).

An observer then selects the one-hour windows considered as clear sky according to the following criteria:

- Difference between observed and estimated UVI (according to the Madronich Analytical formula)

- Presence of clouds, a cloud fraction threshold of 0.25 is set. A UVI measurement performed

- Shape and regularity of the UVI curve during the day. A Gaussian (or semi-Gaussian) curve indicates a day (or half-day) not affected by the presence of clouds. As clouds generally have a high temporal variability, rapid development of clouds usually results in rapid variations of UVI over a few minutes.

- Cloud cover can also be quasi-homogeneous and quasi-constant over the day, which does not lead to sudden variations in UVI, and this case is also excluded from the filtering.

References:

Madronich, S. (2007), Analytic Formula for the Clear-sky UV Index. Photochemistry and Photobiology, 83: 1537-1538. https://doi.org/10.1111/j.1751-1097.2007.00200.x

These details have been added to the manuscript.

RC3: *Line 93 "on station Juan de Nova" Should read "one station at Juan de Nova"?*

AR3: Corrected. This sentence no longer appears in the new version of the manuscript.

RC4: *Line 95 "All stations are now equipped with a Kipp & Zonen UVS-E-T broadband radiometer."*

Table 3 and later text states that some of the radiometers are the SUV-E model

AR4: Corrected. This sentence no longer appears in the new version of the manuscript.

RC5: *Line 96 "The raw UV measurements obtained by the radiometers are reprocessed considering the calibrations and TOC measured simultaneously."*

Please describe and/or give reference for the reprocessing procedure. The reference given in Table 2 describes how the KZ radiometer was calibrated in Davos, but what is the current procedure?

AR5: See AR1

RC6: *Line 101 "on a smaller mesh size"*

Not clear what this means

AR6: Corrected, this sentence was a typo and no longer appears in the new version of the manuscript.

RC7: *Line 212 "Table 4 presents the different radiometers and their current locations, along with the date of the next calibration"*

This information is in Table 3

AR7: Corrected.

RC8: *Line 225 Figure 2 shows the period covered by each data set at these four stations.*

The figure only has one line covering data for the broad-band radiometers, does not show each station separately

AR8: Each station are now represented sepately in the new version of the manuscript. Timeline of every UV-Indien instrument are among the main figure (Figure 2). Timeline of satellite, models and Bentham and radiometer at St-Denis are in appendix.

RC9: *Line 315 – UV enhancement by cloud scattering is a well known and widely occuring phenomenom, would be appropriate to cite the Sabburg and Wong (2000) paper here, also see Badosa et al. (2014)*

AR9: Corrected.

RC10: *Line 347 "The density of the corresponding data set for each month of the year is represented in Figure 7b"*

Please define what is density in this context, proportion of what?

AR10: In this context, density is the ratio of the number of measurements for each month to the total number of measurements normalized between 0 and 1. This information is now included in the manuscript.

RC11: *Line 394 - The correlation coefficient between the satellite or model estimates and the ground-based measurements was greater than 0.9 at all stations except Mahel̀ and for all datasets except OMUVBG.*

Revise to state that correlation applies only for clear sky conditions

AR11: Corrected in the new version of the manuscript.

RC12: 6-Conclusions

Perhaps the authors can comment on why of the three stations at similar south latitude, Antananarivo, Anse Quitor, and St-Denis, the UV-index, even for clear sky, seems to be systematically lower at St-Denis. For example, the noon mean CS UVI is ~10 at St.-Denis but ~12 at Anse Quitor. The maximum CS UVI is ~18 at Anse Quitor and ~17 at Antananarivo, but <15 at St-Denis.

AR12: Although the stations of Antananarivo, Anse Quitor and Saint Denis are almost at the same latitude, the environmental conditions are very different. Total ozone variations do not exceed 10 DU between these 3 sites but other conditions influencing UV can vary considerably.

The Antananarivo station is located at more than 1370m a.s.l while Saint Denis and Anse Quitor are at 82m and 32m respectively. The maximum clear-sky UV index is expected to be higher at Antananarivo than at Anse Quitor but the UVI is affected by the very high presence of air pollution at Antananarivo.

The differences between Saint-Denis and Anse Quitor are also due to air quality. The agglomeration of Saint-Denis has about 200k inhabitants, the traffic is important and although this coastal city is under the trade winds, the presence of a thin aerosol layer can be measured all day long. Anse Quitor is part of the Plaine Corail district, the population of this district is about 3000 and there is very little traffic.

These elements are added to the descriptive part 2.2 of the new manuscript which includes details on the choice of sites, on the environmental conditions or on the available ancillary data for each station (AOD, total ozone, etc.), in accordance with the recommendations of reviewer #2

RC13 *Figure 1, Map – add Latitude and Longitude*

AR13: The map has been updated to show the presence or absence of a Bentham radiometer, camera or spectrometer.

RC14: *Figure 3 caption– What do the gray bars represent in the histogram sub figures? This also applies to the Appendix figures*

AR14: The grey bars represent the distribution of points by intervals of UVI values (for clear sky data only). The curves (blue and red) represent estimates of the probability density functions (for clear-sky and all-sky data respectively).

RC15: *Figure 5. The caption reads "Diurnal Cycle of UVI at ST-DENIS."*

The figure actually has all stations, not just ST-DENIS.

AR15: Corrected

RC16: *Figure 7 & 8 captions – Describe the data density subplots (b) and (d)*

Figure 7c and 8c – The annual mean difference CS-AS UVI seems to follow very closely the DJF mean – Is this correct? Seems like the mean should be approximately in the middle of all the monthly means, but this is not the case for much of the plot, especially in 8c.

AR16: There was an error in the legend and subtitle of figures 7 and 8. These are not averages but maxima.

In this figure, the difference in UVI maxima in clear and cloudy sky for the whole dataset (, and for the seasons (DJF, JJA, MAM and SON) is shown.

The fact that the DJF curve is quasi-confluent with the ALL curve for an instant t of the day (formerly 'mean' curve, the previous name was a typo) indicates that the differences in UVI maxima observed over the whole year at this instant t of the day are from December, January and February.

In other words, if we write in subscript the season associated with the UVI maximum at a time t1 and the caracteristic (CS: clear-sky or AS: all-sky), and let's take for example the JJA season, we can have the following cases::

1) The JJA seasonal curve is the same as the curve for the whole period (ALL), i.e:

   $\max(UVI_{JJA,CS})(t_1) - \max(UVI_{JJA,AS})(t_1) == \max(UVI_{ALL,CS})(t_1) - \max(UVI_{ALL,AS})(t_1)$

   In this case, the maxima observed at time t1 in CS and AS for the whole period are the same as those observed for the JJA season.

2) The JJA seasonal curve is above or below the curve for the whole period, i.e:

   $\max(UVI_{JJA,CS})(t_1) - \max(UVI_{JJA,AS})(t_1) > \max(UVI_{ALL,CS})(t_1) - \max(UVI_{ALL,AS})(t_1)$

   or

$max(UVI_{JJA,CS})\ (t_1) - max(UVI_{JJA,AS})\ (t_1) < max(UVI_{ALL,CS})\ (t_1) - max(UVI_{ALL,AS})\ (t_1)$

In this case, $max(UVI_{ALL,AS})\ (t_1)$ or $max(UVI_{ALL,CS})\ (t_1)$ are from another season.

Indeed, over the whole period, at t_1 $max(UVI_{ALL,CS})\ (t_1)$ could be observed in December while $max(UVI_{ALL,AS})\ (t_1)$ would be observed in June and the resulting difference could then be lower or higher than the difference of the two UVIs (CS and AS) from the same season (here JJA).

Typographical errors have been corrected on the figure and in the text.

RC17: *Table 1 – Region location for Juan de Nova station should be Ile Juan de Nova*

AR17: Corrected in the new version of the manuscript.

RC18: *Reference missing bibliographic information: Pastel, M., Pommereau, J.-P., Goutail, F., Richter, A., Pazmino, A., Ionov, D. V., and Portafaix, T.: Construction of merged satellite total O3 and NO2 time series in the tropics for trend studies and evaluation by comparison to NDACC SAOZ measurements, 2014.*

AR18: Corrected in the new version of the manuscript.

RC19: *References:*

Badosa, J., Calbó, J., Mckenzie, R., Liley, B., González, J.â A., Forgan, B. and Long, C.N. (2014), Two Methods for Retrieving UV Index for All Cloud Conditions from Sky Imager Products or Total SW Radiation Measurements. Photochem Photobiol, 90: 941-951. https://doi.org/10.1111/php.12272

AR19: Added in the new version of the manuscript.