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Atmospheric Chemistry and Physics Discussions

Interactive comment on "TEMIS UV product validation using NILU-UV ground-based measurements in Thessaloniki, Greece" *by* Melina-Maria Zempila et al.

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Dear Reviewer,

Please find bellow our responses to your valuable comments regarding the manuscript entitled "TEMIS UV product validation using NILU-UV ground-based measurements in Thessaloniki, Greece".

Sincerely, Dr. Melina Zempila.

Reviewer #2: Comments and Suggestions

1. All-skies and clear-skies in figs 5, 6, 9: The scatter plots in figs 5 and 6 for the

case of all-skies are very different. Monthly variations and standard deviations are also very different. In fig. 5 I also note that the all-skies vs clear-skies scatter plots, and associated monthly variations and standard deviations, agree very well, something that is not seen in fig. 9. I understand that the UVB-1 and NILU data have been calibrated to a Brewer instrument before use, while the TEMIS data have not. Given that the Brewer favours measurements when the sun is not covered by clouds, can it be that this pre-calibration affects the measurements so that the all-skies in fig. 5 are not actually all-skies as in figs 6 and 9 but semi all-skies? Also, what filter do you use to define the clear-skies in fig. 5? Moreover, given that fig. 5 compares UVB-1 vs NILU data both calibrated to the same Brewer, while figs 6 and 9 compares TEMIS vs NILU data (NILU pre-calibrated to Brewer, TEMIS being not), would it make sense to calibrate also the TEMIS data to the Brewer for consistency? Potentially this pre-calibration reduces part of the variance in the original UVB-1 and NILU data, and as a consequence a better comparison is achieved between the two radiometers. I am not sure. Have you checked if the calibration to the Brewer affects the measurements denoted as all-skies? Overall I think that a clarification on the definition of all-skies and clear-skies conditions would help the reader.

Thank you for this comment. Here, we should notice that the UVB-1 data were not calibrated against the Brewer, but were only monitored and partially corrected for random incidences and occasional drifts caused by logging and/or electronic issues we have been experiencing during some short periods. Our intention was to prove that the NN originally applied to the NILU irradiances, results in reliable data firstly for CIE estimations, and secondly for vitamin D and DNA damage doses. We are aware that the UVB-1 data are not cosine corrected while a small overestimation of CIE takes place during the summer months. This behavior could explain the small seasonality seen in the two CIE datasets, UVB-1 and NILU (Figure 5(a)). We hope that the statement on page 13, lines: 14-16 adequately explains these aspects: "Even though the UVB-1 data were corrected for the degradation of its absolute response with B086 data, the validity of its measurements as absolute values can be used to evaluate the perfor-

mance of the NN used to derive all of the biological dose products based on NILU-UV measurements."

For the NILU calibration, you are correct, we used only cloud free cases to derive the final irradiances. A detailed explanation of the NILU calibration procedures was added to the text. "Specifically, for the calibration of NILU103 raw data, cloud free response weighted irradiances were derived from B086's measured spectra. Since B086 scans the UV solar spectrum within approximately 7 minutes, the time period needed to scan the spectral range of each NILU103's channel spectral response, is approximately 3 minutes. The coincidences of NILU103's raw data to B086's weighted spectra, were performed based on the time that B086 measured the wavelength at which each channel peaks. Subsequently, the time difference that can be introduced between the two datasets is normally less than ± 1 minute. To account for this time window, the mean values of 3 consecutive NILU103 measurements were analyzed, with the central one chosen to be the closest to B086's time scan of the peak wavelength of each channel. Then, NILU103's data were corrected for possible drifts in time via a time dependent smoothing spline fit. Furthermore, the drifts of the channels were monitored through monthly lamp measurements. Both methods resulted in the same patterns for the drifted channels. After correcting for time drifts, a time independent absolute calibration factor is derived through scatter plots based on linear regression through origin. To evaluate the validity of the calibration procedures, the NILU103 calibrated data were compared once again with B086 response weighted irradiances and the timeseries were checked for time drifts and SZA dependence. By calibrating the NILU103 measurements with the B086 coincident response weighted irradiances, we estimate that the uncertainties of the NILU103 measurements used in this study are 5.6% (Zempila et a., 2016a)." Based on these given details, NILU are considered to be valid for all skies cases and Brewer measurements do not affect the all skies measurements by means of implicitly excluding them. This is further testified by the fact that the agreement between UVB-1 and NILU derived CIE lies within the uncertainty of the latter, even for overcast days. Following your sequence of thoughts, we believe that now it is

more clear that UVB-1 and NILU CIE data are independent when compared in absolute values, since Brewer data served only for occasional drift correction in the UVB-1 while they were used for time drifts and absolute calibration of NILU raw data. We also agree that a pre-calibration of the TEMIS products based on Brewer measurements could take place, but the scope of this paper is to compare independent sources of estimations derived from satellite- and ground-based instruments, in our case NILU and TEMIS, in order to identify possible reasons of discrepancies between the two datasets. The comparisons performed for UVB-1 and NILU were meant to only evaluate the NN retrieval algorithm.

The filter we are using for defining the cloud free cases stated on page 13, line 22 is the same for all comparisons, apart from figure 9 were we evaluate the cloud influence on the TEMIS-NILU comparisons. We added the following sentence in order to clarify this selection criterion (Page 13, lines: 23-25) "This cloud classification criterion according to which days with more than 70% abundance of cloud free measurements are characterized as cloud free, is used throughout the study, unless stated otherwise." Again on page 17, lines: 10-11, we also emphasize on this detail. "At this point it should be mentioned that for the characterization of the cloud free one-minute data, the cloud screening detector proposed by Zempila et al. (2016a) was applied on the NILU103 Photosynthetically Active Radiation (PAR) measurements"

2. Page 19, line 2: The seasonality of the cloud-free cases is said to match the seasonality of all-skies but it is not shown. My suggestion is to show the seasonality of the cloud-free cases because later in fig. 10 you try to explain the cause of a seasonality which is not actually shown. The seasonality can be added in fig. 9 for the lines shown in fig. 9 accordingly. I expected that the seasonality of the cloud-free cases will match the seasonality of the clear-skies shown in fig. 5 not of the all-skies shown in fig. 6. Cannot understand why since we are talking about cloud-free data. A match between the two clear-skies seasonalities would strengthen the findings about clouds affecting the TEMIS data.

We thank you for the suggestion. We added the seasonality of the TEMIS/NILU comparisons for the 4 cloud classifications in the lower panel of Figure 9. Based on the findings, we cannot say that the seasonality seen in Figure 5 is the same with the one seen for the cloud free cases (Ncl>70%) in Figure 9. Although one could say that there are some similarities, when comparing these two seasonality patterns a solid conclusion is hard to be driven. We believe that these patterns are surely connected to the NILU data, but we also believe that the seasonality seen in the UVB-1/NILU comparisons is mainly due to the missing cosine correction of the UVB-1 data. On the other hand, the seasonality seen with the TEMIS/NILU comparisons can be attributed to both cosine inadequate treatment in the NILU data and/or satellite data and to the nature of the a-priori information used in the TEMIS algorithm. The pertinent paragraph was modified accordingly: "Table 3 shows that even under cloud-free days there is a scatter of almost $\pm$13% between the two datasets for all three UV doses. The seasonality seen in Figure 6 is also present when limiting the datasets to cloud-free days, as seen in the lower panel of Figure 10, implying that apart from the cloud effects, there are other factors affecting the agreement between the ground- and satellite-based UV data products. One of the causes could be variability of aerosol load over Thessaloniki which is neglected in the satellite-based retrievals."

3. Aerosol effect, p. 19 and fig 10: It is claimed that one of the causes for the seasonality seen in the satellite minus ground-based clear-sky differences (which is not actually shown) is variability in the aerosol load. The authors use fig. 10 to support this. Fig. 10 shows that there is a relation between the satellite minus ground-based clear-sky differences with increasing AOD (using 10-minute time intervals), revealing a positive correlation between them, but it does not straightforwardly show the link between their seasonal variations. What is the shape of the two seasonalities and how do they match? I suggest adding an extra plot in fig. 10 (below the existing plot) showing-explicitly the monthly variation of the differences vs the monthly variation of aerosols. This would strengthen the claim on p.19 line 4.

We again thank you for the suggestion. We added the seasonalities of all datasets shown in Figure 10 for the cloud free 10-minute doses. A description was also added into the text to further analyze the findings. "To further investigate the AOD impact on the comparisons, the monthly means were calculated for both AOD and relative differences. The pattern seen in the monthly means of the AOD values is in general agreement with the seasonality seen in the average monthly values of the relative percentage differences between the satellite- and ground-based 10-minute cloudless doses (Figure 10, lower panel), implying that there is a link between the two observed seasonalities."

4. Page 19, lines 8-12: According to section 2.2 (p.5 lines 29-30), for AOD>0.3 the satellite UV data products will overestimate the UV index and UV dose. Indeed, the negative differences in fig. 10 tend to become positive for AOD>0.3 (indicating the satellite overestimation), but it is not clear what you mean by mentioning that the slope changes for AOD>0.4. Do you imply that there is better agreement between the satellite and ground-based data in larger AOD? I think that mentioning about two slopes confuses, unless if you clarify what you mean.

To support this statement, the linear fits of each dataset were calculated, one for AOD<=0.4 and one for AOD>0.4. For all three daily doses, CIE, DNA damage and vitamin D, the slopes are significantly larger for AOD<=0.4 than those calculated for the cases where AOD was higher than 0.4. An additional paragraph provides this information into the text (page 20, lines:1-5). "To further testify on this aspect, linear fits were conducted for two datasets, one that comprised data with AOD$\leq$0.4 and the second with data with corresponding AOD>0.4. It was found that for all three UV effective doses, the slopes for the first imposed limitation on AOD were higher than those calculated for the second dataset. Specifically, the slopes for the two AOD limitations were found to be 44.5% and 11.7% for the CIE, 50.6% and 8.5% for the DNA damage, 46.1% and 8.3% for the vitamin D doses respectively."

5. Is there relation between the seasonality in aerosols and the seasonality in the

UVB-1 minus NILU clear-sky differences?

To further investigate this aspect, we used the cloud free cases for both TEMIS/NILU and UVB- 1/NILU comparison results. As seen in the figure bellow, it seems that there isn't any strong correlation between the seasonality of AOD and (UVB1-NILU)/NILU% data.

Minor comments: - Eq. 1: remove the unit (W/m2) from the UV index.

In the TEMIS processing the UVI(t) is computed in W/m2 with a time dependent SZA. As such it is used in the integration over time t to determine the daily UVD. Only when reporting the UV index at local solar noon UVI(t=12h) the scaling to dimensionless units is performed, as mentioned in the sentence at page 5 / line 6 (old numbering). Hence, we leave the unit in Eq. (1); the sentence at p5/l6 has been adapted slightly.

- Page 5, lines 6-8: Is it correct that the daily UV dose is calculated from the UV index?

Yes, the UVD is an integration over UVI(t) over time t from sunrise to sunset, with SZA(t) dependent on time, where UVI(t) is the UV index at time t. It sounds a little confusing perhaps, but calling the UV index at local solar noon (the quantity communicated to the public) just "UV index" is actually the confusing part of this.

- Page 6, line 30: It reads '...the total ozone column (TOC) and are used...'. Is it something missing from the sentence?

Thank you, we rephrased that to ". . .the total ozone column (TOC). These factors are used to. . .".

- Page 10, line 3: correct 'NILY' to 'NILU'.

Thank you, we did.

- Page 15, line 9: Usually the correlation values are usually re given by the correlation coefficient R, not the RËĘ2.

We thank you for the comment. R values were added to tables 3 and 4, while additional comments on these values were included in the text along with the discussion regarding the R2 values.

- Page 18, line 5: correct 'bellow' to 'below'.

Thank you, we did.

- Fig. 5: Please put (a), (b) and (c) to the left side of the titles of the plots, not below the plots.

Thank you, we did.

- Fig 6: Indicate that the figure refers to all skies.

Thank you, we did.

- Fig. 7: Indicate that the figure refers to all skies. Use thicker lines for the linear lines, and use dots or dashes for the y=x line.

Thank you, we did.

- Fig. 10: remove the three 'y=' inside the legend since these statistics are not equations. Also, indicate that the figure refers to the >90% cloudless instances, if so.

Thank you, we revised the legend and changed the caption to: "Relative differences of satellite-based and ground-based UV 10-minute doses as a function of AOD at 340 nm for cloudless cases at Thessaloniki in the period 2011-2014. The statistics are provided in the form of mean and standard deviation of the differences (upper panel). Monthly mean values of AOD at 340 nm along with the mean monthly values of the relative differences presented in the upper panel under cloud free cases (lower panel)."

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/acp-2016-1146/acp-2016-1146-AC2-supplement.pdf

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