

Interactive comment on “Operational surface UV radiation product from GOME-2 and AVHRR/3 data” by J. Kujanpää and N. Kalakoski

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We would like to thank M. van Weele for performing a thorough review and for the many helpful suggestions to improve the paper. We respond to each of the review comments below. For the sake of clarity, the review comments are given in italics whereas our response is printed in normal font.

General comments

The selection of operational products (maximum dose rates and UV index, daily integrated doses, and photolysis rates) seems well chosen given the observational

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constraints from polar orbiting platforms. However, I do not agree with the way the usefulness of combination with (e.g. cloud information from) geostationary satellites is somewhat downplayed for the UV product (P.4541, L5-7). Surface UV products are not only relevant in relation to ozone layer depletion, but as well in relation to ozone layer variability and, moreover, absolute UV variations are largest at low- to midlatitudes relevant for e.g. vitamin-D health studies and/or the impact of surface UV variability on atmospheric chemistry and biological processes. It is important that the authors acknowledge the limitation of the constellation of morning/afternoon polar orbiting satellites for some of the products which optimally would need information at high temporal resolution. Also, the authors acknowledge that accurate cloud information at solar zenith angles above 70 degrees is still a limiting factor for current polar orbiters, undermining the argument that the UV product would be most important at high latitudes. I suggest the authors explain and leave room for potential future improvements of (some of the) operational UV products, e.g. by combination with operational observations from geostationary platforms. The importance of time resolution for the daily integrated dose has been shown by e.g. the pioneering work by Jean Verdebout (as referenced).

We agree that the high temporal resolution of the geostationary data can improve the products at low- and midlatitudes. We are indeed studying possibilities to include geostationary cloud data over Europe from the SEVIRI/MSG and FCI/MTG instruments but it is bit too early days to promise anything in the paper. We added the following sentence to end of Summary and outlook: Finally, possibilities to improve the sampling of the diurnal cloud cover over Europe with measurements of geostationary satellites are being studied.

Further, the exact impact of missing cloud optical depth information for solar zenith angles larger than 70 degrees each of the products should be clarified. E.g. is the product not provided, is the product of lower quality, or is the product then

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available, though e.g. 'cloud-free'? What is the impact of missing cloud information for $sza > 70$ degrees on the integrated daily UV doses as a function of latitude and season? Maybe a figure could help to show the impact on some of the daily doses.

See our response to specific comment P4557, L9. If $sza > 70$ degrees during the whole day for a given grid cell, i.e. noon $sza > 70$, then there are no cloud observations available and the grid cell is flagged as missing data, except on the Greenland and Antarctic ice sheets where cloud-free conditions are always assumed.

Another general comment is the very limited results presented on validation/verification: partly this points is covered with figure 8 described in section 4.2.2 and further in section 4.2.3 Quality control), partly reference is made to future work on validation. Figure 8 provides an example which is outside the time period for which version 1.20 is available to users: 9/7/13 – 28/2/14 (Metop-A) and 1/3/2014 – present day (Metop-B) according to the O3MSAF UV product website : <http://o3msaf.fmi.fi/products/ouv.html> . It would be useful to add one or two exemplary figures of the some of UV products at mid or low latitudes, preferably with some validation to at least verify that the processing provides believable results for each of the products. To compensate for extra figures I suggest to move Figures 3 and 7 to supplementary material.

Initially, we planned to include the algorithm description and validation results in the same paper. However, the paper would duplicate in size, and therefore, we decided to keep the algorithm description paper separate from the validation results. We would like to keep this approach. We clarified in response to specific comment P4579, that the products for Figure 8 were reprocessed with the version 1.20 algorithm although the data are not available to users.

Finally, I miss a short perspective into the near(?) future for which AVHRR/3 will

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not be available anymore (at least no new NOAA version will be launched anymore).

We added the following sentence to Summary and outlook: As mentioned in Sect. 2.2.2, AVHRR/3 has been replaced by VIIRS in the NOAA side, and therefore, OUV processing is being adapted to use VIIRS measurements.

Specific comments

Please add the website <http://o3msaf.fmi.fi/products/ouv.html> and the time period of availability of the offline product version 1.20 to the manuscript, e.g. at the end of section 4.1

Agreed and added the following text to the end of section 4.1.: The version 1.20 is available from 9 July 2013. Latest information is given at the website <http://o3msaf.fmi.fi/products/ouv.html>.

Add Sun-Earth distance to the 'main factors' (P.4539, L 15-16). I assume that the variation in the Sun-Earth distance is taken into account in the product, please specify in the paper.

Agreed and added the Sun-Earth distance to the main factors. Specified that the modelled radiance depends on the Sun-Earth distance, see response to comment for P4548, L19 below.

Repetition of the word 'the' (P 4539, L22)

Corrected.

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'plays important role' (P4540, L5 and L8) ⇒ plays an important role

Corrected both instances.

P4540, L12: cloud field ⇒ cloud fields (plural)

Corrected.

P4540, L18: 'To capture the high UV dose rate region' ⇒ to capture the maximum UV dose rate

Changed as proposed.

P4541, L29: 'utilising measured satellite data' ⇒ utilising Level-2 total ozone columns

Changed as proposed.

P4542, L16: 'To capture the high UV dose rate region around the solar noon' ⇒ to capture the maximum UV dose rate around solar noon (without 'the')

Changed as proposed.

Section 2.3.1: please specify that in this way synoptic variations in surface pressure (High and low pressure systems) are neglected in the processing

Agreed and added the proposed sentence.

P4547, L12-13: please shortly explain HOW the results of Koelemeijer et al.(2003) are

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applied. Is it based on monthly mean spectral data?

Modified the text to: ...and the dependency of average MLER for different surface types on wavelength, obtained from 5.5 years of GOME observations covering the period June 1995 – December 2000 (Koelemeijer et al., 2003). For example, Figure 3 in Koelemeijer et al. indicates that over deserts the visible albedo (taken at 610 nm) is three times larger than the UV albedo (taken at 380 nm). Also added the word 'monthly' to the definition of MLER on P4547, L3.

P4548, L1: please specify for which time period the monthly AOD climatology is representative

Specified the time period as: ...combining aerosol products from various satellite instruments covering the time period from 1979 to 2006, including...

P4548, L19: add time-dependence on Sun-Earth distance. Please state that time variations in the solar spectrum are neglected (as implicitly acknowledged in section 3.1)

Agreed and changed the text to: It depends on time through the variation of the Sun-Earth distance during the year and solar elevation during the day, and also through τ . Time variations in the solar spectrum are neglected.

P4551, L17: please add here also a time stamp for the introduction in product version 1.20 P4552, L8: "is 1 up to 15 km" ⇒ is 1 km up to 15 km

Agreed and changed as proposed.

P4552, L10: Add after ...and ozone: (absorption by other minor trace gases

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such as SO₂ is neglected)”

Agreed and added this clarification.

P4554, L11: Please explain the impact of missing cloud optical depth for sza larger than 70 degrees each of the products (either here and/or in Section 4)

Agreed and added an explanation in section 4.2.2. See response to P4557, L9 below.

P4554, L19: I assume both the solar spectrum and the modelled spectrum are at wavelengths in air (and not in vacuum)?

Yes, they are in air. Added a clarification.

P4555, L3: Please clarify for the photolysis rate of ozone (up to 320 nm) if this is calculated also on coarse (5 nm) resolution as for the photolysis rate of NO₂, or at finer spectral resolution? (It should be calculated at a higher spectral resolution than 5 nm)

Agreed to clarify this. Changed the text to: ...model in the same wavelength grid but extended from 400 to 430 nm with 5 nm separation.

P4555, L9: “the input the near” unclear language P4555, L18: add reference to availability (time period) of version 1.20 as well as link to the <http://o3msaf.fmi.fi/products/ouv.htm> website with latest information

Agreed and removed the words “the input”. For the availability and website, see our response to the first specific comment above.

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P4555, L23-26: It is unclear what is done for 0.5x0.5 degrees pixel areas without total ozone data on a day (mainly at low latitudes, see figure 1), is this flagged as missing data?

Yes, it is flagged as missing data. Added the sentence: The grid cell is flagged as missing data if no ozone data are available.

P4557, L9: Here is it explained that discretization of the diurnal cycle extends to 88 degrees for solar zenith angle. How does this relate to missing cloud optical depth for solar zenith angles larger than 70 degrees?

The nearest neighbour (i.e. step-wise) interpolation (Eq. 13) is applied but only the cloud optical depth observations obtained for solar zenith angle < 70 degrees are available. Added the following sentences clarifying this: For cloud optical depth observations retrieved only for $\theta < 70^\circ$ (Sect. 3.2.), this means that a constant value for τ_c is assumed between $70^\circ < \theta < 88^\circ$, although the value can be different in the morning and evening. If no cloud observations are available, the grid cell is flagged as missing data, except on the Greenland and Antarctica ice sheets where cloud-free conditions are always assumed (Sect.4.2.3)

P4558, L3: improve the notation of dates in English: e.g. 1st of June or June 1 P558, L8-9: I do not understand the sentence: “..demonstrating the use of multiple overpasses during the day”, do you maybe mean usefulness instead of ‘use’?

The visual conventions for manuscript preparation specify the date format as: 25 July 2007. We understand that without the year the date should still be written as 25 July although it is not strictly specified in the guidelines. Agreed and replaced ‘use’ by ‘usefulness’

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P4560, L1-2: Are you sure that the AAI would be candidate product to replace the climatology? Maybe in combination with the AOD climatology or other AOD product? Please explain what is needed at minimum for the aerosol product in relation to the surface UV product

The AAI was used to correct for absorbing aerosols in the TOMS UV algorithm and a detailed discussion can be found in Krotkov et al. 1998. It is worth reconsidering this method because of its relative simplicity, and because AAI products are now available from GOME-2 PMD measurements with better spatial resolution. For surface UV product, aerosol products are needed to specify the concentration and the wavelength dependent absorption and scattering properties.

P4572, last line: what do you mean with "accepted"? This again relates to the unclear choices made for the different products when cloud optical thickness is missing for $sza > 70$ degrees.

Replaced the word 'accepted' with 'used'. This relates to text on lines 1-8 on page 4559 explaining why cloud-free conditions are assumed for Antarctic and Greenland ice sheets.

P4573, first sentence remove: "at the DLR"

Agreed and removed.

P4579, please clearly explain the OUV presented in this figure because either it is not version 1.20 or version 1.20 is identical to this product, or some reprocessing of version 1.20 has been done, true?

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The products for the dates in the example case were reprocessed with version 1.20 for the figure in the paper. The dates were found to be a good example case with an earlier version. Clarified this in the figure caption as: Intercomparison of the diurnal UV Index extracted from the products (reprocessed with the algorithm version 1.20) ...

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 4537, 2015.

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