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Atmospheric Measurement Techniques Discussions

Interactive comment on "Correcting spaceborne reflectivity measurements for application in solar ultraviolet radiation levels calculations at ground level" *by* P. N. den Outer et al.

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Reply to Referee 2

The authors thank the referee for carefully reading our manuscript. However, the main objection put forward ("I suggest rejecting the paper for publication in AMT.") does not coincide with our perspective of the subject. We are supported by the other referees that value the work described in the manuscript and that it should be published "The topic is relevant and of interest to those attempting to estimate CMF at UV from satellite data" (#1), The work is highly relevant in at least 3 respects:"(#3), "I however think that this manuscript includes results that are innovative and worth being published:"

(#4), and "This paper should definitely be published..... Of particular interest is the suggestion that an optimal size for estimating LER is 1 x 1 degrees." (#5).

We are fully aware of the fact that the current version evoked issues that need clarifications.

We present in this paper an extensive comparison of satellite-derived cloud effects on UV-radiation with ground-based measurements. The study includes data from three consecutive operating instruments spanning 30 years. The comparison comprises UV-radiation measurements from eight European UV stations and global solar radiation measurements from over eighty meteorological stations.

We focus on cloud effect proxies and on daily UV sums. The daily sums are the building block for health and environmental assessment studies. UV-induced effects are related to contracted exposure from years to a lifetime, therefore, long-term assessments are required, and thus long-term data records. To facilitate the use of daily sums, UV-research needs cloud effect proxies that can be implemented as cloud modification factors for daily sums of UV-radiation. Various action spectra/weighting functions are involved, making a single product based on erythemal UV not sufficient to fully serve the UV-community. NASA provides gridded, daily cloud-related products, now all under the 'Radiative Cloud Fraction Tab' on http://ozoneaq.gsfc.nasa.gov. We assess the practical use by implementing them in UV algorithm and make a comparison with ground-based measurements. For convenience, we use the erythemal action spectrum, other action spectra (e.g. skin cancer induction or Vitamin D production) could have been used as well. Other interesting topics, e.g. variability due to aerosols, ozone (profile), where not taken into account to limit to size of the paper.

We conclude that the use of uncorrected LER data to account for cloud effects, will lead to shifts in long-term UV radiation budgets. This shift is artificial, mainly due to the transition from the TOMS platform to the OMI-platform. RCF data, available through the same web-entry as LER-data, can perform the same task (account for clouds) although major rescaling is required. Results using RCF-data, however, are at their best comparable to the results derived using LER. Part of the dynamics in the rather large subset of the clipped RCF-data (18%) can be restored.

Itemized reply to the objections. "The subject is hardly new, since the pioneering paper of Eck et al [1995] first proposed using TOMS LER to estimate surface UV irradiance. Since then, the TOMS UV algorithm has been extensively discussed, improved and validated with ground UV measurements as documented in peer-review literature.",

Reply: To our knowledge a validation study on this scale, both in number of sites and in number of years, has not been done previously. Furthermore, the TOMS UV algorithm has NOT been the subject of our study. This is for several reasons mentioned in the paper and above. The paper addresses the optimal field of view for estimating daily UV-sums, the use of RCF-data and a comparison with pyranometers across Europe.

"It was shown in early 2000s that the LER method cannot account for spectral and ozone dependence of CMF. Therefore, current operational versions of the TOMS and OMI surface UV algorithms are not using LER, but are based on a model of homogeneous plane-parallel Mie cloud layer, embedded in a multiple scattering Rayleigh atmosphere with realistic ozone profiles: (http://eospso.gsfc.nasa.gov/eos_homepage/for_scientists/atbd/docs/OMI/ATBD-OMI-03.pdf). Therefore, discussion of LER in connection with the satellite UV algorithms is not relevant. "

Reply: We must admit that we do not fully understand the purpose of this remark. LER has been used and validated in UV algorithms (first by Eck et al.,), and we present an extensive comparison with ground-based UV measurements showing that LER can be used in UV algorithms, so we do not understand the last remark. Furthermore, in any modeled description of the actual situation, measured input should enter. In the case of the plane-parallel Mie cloud layer implemented in the TOMS-UV algorithm, we indeed read (ATBD-OMI-03.pdf) 'The (UV) irradiance product is the result of a radiative

transfer model calculation, using the following input parameters: the OMI total ozone column and the scene reflectance at 340 and 380 nm.'

We have accurate and validated algorithms to calculate the ground-level UV-irradiance using advanced radiation transfer models, and, either empirical methods or radiation transfer calculations, to take into account the effect of clouds on the UV-irradiance. It has been shown that the major source of uncertainty and variability is due to clouds. Or to put it differently: when cloud effects are tackled, the use of climatological values for aerosols, aerosol profile and ozone profiles will be often sufficient form the perspective of health and environmental impact of UV-radiation. Of course, snow cover that has a rather large impact on the actual UV-irradiance, needs additional attention. It is straightforward to include the, so-called albedo effect in UV-algorithms. In the paper, the full albedo effect (including multiple scattering between ground and cloud layer) has been included when spaceborne UV-radiation is compared with ground-based measured.

The (stratospherical) ozone dependence of CMF is a small effect compared to induced variability of clouds on the effective UV-radiation, both in spatial and temporal domain. We will add a discussion on tropospherical ozone on the influence on the CMF.

The spectral dependence of CMF has been tackled and presented in several papers including our own.

We do not see directly how the use of MIE-formalism will lead to a better understanding of multiple scattering properties of clouds while at the same time a plane-parallel geometry is assumed. The phase function and a value for the average scattering (cosine of the) angle of the individual cloud droplets (if assumed spherical) can be easily derived using MIE-formalism. However, effects of the phase functions will be scrambled by the extremely rough "surface boundaries" of clouds.

"The main goal of the paper: 'to improve on the spaceborne UV sums, and not understanding the optimal mathematical description of the correlations.' - p74, l25 , is not clear and is not justified. "

Reply: We made this remark at the point where we discus the fitting of the obtain correlations between satellite and ground-based derived CMFs. To us, it did not seem appropriate to list the 80 fit parameters. In our view it is sufficient to state that the curves in fig. 5 can be fitted with a polynomial function.

"Improvements in retrieval algorithms can be achieved through better understanding of the atmospheric radiative transfer leading to better forward models and inversions."

Reply: We fully agree with this statement. Again it should be noted that our needs to understand the UV-induced health and environmental involve UV weighting function of different type, and not only the Erythemal UV as supplied by the UV algorithm of TOMS or OMI. We are so-called data users and do not have access or the resources to handle the orbital scans needed to develop new retrieval algorithms. We write "The time scales of UV radiation-related health effects ...exceed, however, the life span of spaceborne instruments,...", combined with "The reason to focus on the LER-product is twofold. First, it is the longest and readily available data record for a cloud effect proxy, and secondly, non-radiative cloud parameters like cloud octas and cloud fraction are less suitable to infer cloud effects on UV irradiance ..." explains our interest in the LER-data set. By an extensive comparison with broad-band measurements and with UV-radiation measurements, we show that the LER data set serves as a good cloud effect proxy, although OMI-LER needs a scaling and doubt exist on the calibration of EP-TOMS set. The latter, however, does not emerge from our analysis.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 61, 2012.