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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Assessment of the Level-3 MODIS daily aerosol optical depth in the context of surface solar radiation and numerical weather modeling" *by* J. A. Ruiz-Arias et al.

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General comments

Seems, that the problem the authors deal with is not well posed. They use the term "error" not in a conventional way. They point out that "most of the validation efforts so far have focused on Level-2 products (10-km)". Validation of a product is usually attempted at scales that match in time and space the parameters that are being compared. Such match seems to be better at Level-2. The lack of agreement between the AERONET value and 1 deg box average is not an "error";

they should be different. In order to estimate the error in the larger grid there is a need to sample the AOD at several locations in the 1 deg box to establish to what extent the satellite estimates represents the ground observations. As such, what was done is not a "validation" of the Level-3 product but something else. Needs to be clarified.

Response: We agree in this point. The use of point-wise observations doesn't appear to be the best validation truth for 1 deg-resolution estimates. Strictly speaking, the result after this comparison shouldn't be categorized as error because it also encompasses differences regarding the coarser spatial aggregation of the satellite estimates, thus neglecting the natural variability of AOD at sub-pixel scale. We acknowledge this explicitly in Sect. 5, where we discuss to what extent the spatial representativeness is important and how it compares against the results of our validation against point observations. The results suggest that *"the spatial representativeness uncertainty contributes ≈50% to the total uncertainty of the L3 AOD"* where, once again, the total uncertainty is the resultant from the comparison of the L3-AOD estimates against point observations. The problem, therefore, seems to be our mis-use of the term *error*. Instead, we could term this as *apparent error*, for instance. We have added a new paragraph after the second paragraph in Sect. 1.2 where we discuss this point:

"In this respect, it is also important to note that the use of point-wise observations may not be the ideal validation reference for the 1°×1° L3-AOD values. Strictly speaking, the results of this validation should not be categorized as "errors" because they also encompass differences regarding the coarser spatial aggregation of the L3 AOD, thus neglecting the natural spatial variability of AOD at smaller scales than 1°×1° . However, from a large-scale application standpoint, the validation of the L3-AOD product with point-wise observations is sufficiently informative and convenient, and is the only practical global validation that can be done anyway. Therefore, although for the sake of language clarity we refer to the result of the validation in the present framework as error (including expected error), we explicitly acknowledge that it is only a first guess

ACPD

12, C8985–C8990, 2012

or proxy to the actual L3-AOD error."

The reason why we are using point observations in the validation of L3 AOD is that, for surface solar applications and, in particular, solar applications requiring direct irradiance, L3 AOD has more advantageous characteristics than the Level-2 AOD, as it is stated in the manuscript. From the point of view of these applications, the validation and control of the L3 AOD is necessary and the direct comparison against AERONET observations is convenient.

From a global perspective, due to the large number of ground-truth sites the bias should be quite correct because of large-scale cancellation of errors, albeit a substantial part of the observed rms (or noise) is due to the spatial issue already described and discussed in Sect. 5.

The "errors" in the aerosol optical depth seem to be quite high ("Overall, the mean error of the dataset is 0.03 (17%, relative to the mean ground-observed AOD), with a root mean square error of 0.14 (73%, relative to the same"). Yet, the authors claim that the Level 3 product is very useful. Raises questions as to the needed accuracy in estimating the AOD in order for it to be still useful for certain objectives. Perhaps, it would be more informative if the authors presented information on error limits that would still produce acceptable values for DNI.

Response: Even with the current level of uncertainty, the L3-AOD product is useful and informative because it represents a daily global support framework for the modeling of AOD, whereas most of the current modeling techniques in solar applications are forced to rely on monthly databases only, which miss the intra-monthly time variability. Gaps in daily data can be filled by using interpolation methods, while the bias can be reduced based, for instance, on some of the results presented in this work, such as those in Sections 4 and 5.

The uncertainty in GHI and DNI has been presented from a *what-we-have* point of

ACPD

12, C8985–C8990, 2012

view. The reason is that we wanted to stress the large regional differences regarding the uncertainty in solar radiation modeling even though we use a single AOD product. However, we deeply agree with your suggestion that the establishment of a maximum tolerance for the optimal usage of AOD is very useful. Thereby, we have added the next paragraph in Sect. 6 after Eq. (2):

"Just as a reference, if we assume a mean AOD value of 0.2 – referred to as mean global AOD value in Table 1- and request a maximum uncertainty of, say, 5% or 10% in DNI, due only to the uncertainty in AOD, the maximum acceptable uncertainty in AOD would be 6% or 12%, respectively, i.e., 0.012 or 0.024 in AOD unit. For GHI, the maximum tolerable uncertainty in AOD would increase to 17% or 34%, respectively. These values have been estimated with the REST2 model and assuming a solar zenith angle of 30°."

Specific comments

1. Listed are 4 affiliations:

Response: Fixed.

2. Abstract. The Level-3 MODIS aerosol optical depth (AOD) product offers interesting features for surface solar radiation and numerical weather modeling applications. Instead of "features" a different word needs to be used.

Response: Switched to *"characteristics"* (e.g., lower fraction of missing data)

3. In section "Motivations and objectives" stated: "We will focus here only on AOD because it is the most important aerosol optical property driving solar ex-

ACPD

12, C8985–C8990, 2012

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tinction, and thus the incident surface shortwave irradiance." This is not always so. Aerosol absorbing properties also play an important role.

Response: For solar energy applications, the absorbing properties are only second order. They actually do not even affect DNI at all. We have added the following to this sentence:

"We will focus here only on AOD because it is the most important aerosol optical property driving solar extinction, and thus the incident surface shortwave irradiance –most importantly the direct irradiance."

4. The Abstract is too long and needs to be of a general nature; no need for detailed results.

Response: The abstract has been shortened:

"The daily Level-3 MODIS aerosol optical depth (AOD) product is a global daily spatial aggregation of the Level-2 MODIS AOD (10-km spatial resolution) into a regular grid with a resolution of $1^\circ \times 1^\circ$. It offers interesting characteristics for surface solar radiation and numerical weather modeling applications. However, most of the validation efforts so far have focused on Level-2 products and only rarely on Level 3. In this contribution, we compare the Level-3 Collection 5.1 MODIS AOD dataset available since 2000 against observed daily AOD values at 550 nm from more than 500 AERONET ground stations around the globe. Overall, the mean error of the dataset is 0.03 (17%, relative to the mean ground-observed AOD), with a root mean square error of 0.14 (73%, relative to the same), albeit these values are found highly dependent on geographical region. We propose new functions for the expected error of the Level-3 AOD, as well as for both its mean error and its standard deviation. Additionally, we investigate the role of pixel count vis-à-vis the reliability of the AOD estimates and also explore to what extent the spatial aggregation from Level 2 to Level 3 influences the total uncertainty

ACPD

12, C8985–C8990, 2012

in the Level-3 AOD. Finally, we use a radiative transfer model to investigate how the Level-3 AOD uncertainty propagates into the calculated direct normal (DNI) and global horizontal (GHI) irradiances."

5. The opening statement of the Abstract should tell the reader first briefly what the Level-3 MODIS data are.

Response: Fixed.

6. It is stated: "Consequently, we propose new functions for the expected error of the Level-3 AOD, as well as for both its mean error and its standard deviation". Again, this is not a measure of error. Possibly, this value represents the area average better than the single AERONET site.

Response: See response to general comments.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 23219, 2012.