Review of manuscript AMTD-180 by Jääskeläinen et al

Summary

This paper describes a procedure to create a climatological representation of aerosol optical depth over the continents for the period 1982-2014 using the OMI and TOMS aerosol index (AI), via an AI-to-AOD conversion procedure that involves the use of MODIS and OMI AOD satellite products.

The main purpose of the analysis is to replace a constant AOD value of 0.1 currently used in the CLARA-A2-SAL project with an estimate derived from the analysis in this paper, which, in the opinion of the authors, is a more realistic value.

Review

Although the authors have made an effort to develop a sound methodological approach, I do not believe they have achieved their proposed goal of deriving a realistic quantitative representation of the background atmospheric aerosol load over land which over most of the world is associated with sulfate-based industrial aerosols and biological particles, which is precisely what the AI is not. Since the AI represents only a partial description of the global aerosol load, I do not believe their goal of deriving a realistic product is actually achievable. For that reason, I do not think this work is publishable in its current form. In the review below I offer a few recommendations mostly on the correct interpretation of the AI data to arrive at more realistic representation of the AI in terms of AOD only in the regions where the AI may indeed be used as proxy of most of the atmospheric aerosol load.

Main comments

My main criticism of this work is this work has to do with the over-interpretation of the AI as a proxy of the total column AOD, as well as its miss-interpretation in conditions where the residual quantity is associated with other non-aerosol related effects. As it has been well documented the AI is only sensitive to elevated aerosol layers (about 2km and higher above the surface) of smoke, desert dust, and volcanic ash. Thus, the AI cannot be interpreted as a proxy of the total AOD column everywhere, and neither can it be interpreted as being representative of aerosol types other than optically thick layers of dust and smoke. As the residual quantity it is, the AI is a representation of any wavelength dependent process unaccounted for by a simple radiative model representation of the Earth's atmosphere where molecular scattering and ozone absorption are the only radiative transfer processes explicitly included. Positive AI values larger than about 1.0 are generally associated with the absorption effects of layers of smoke, dust or volcanic ash located at least 2.0 km above the surface. AI values less than 1.0 over land are undistinguishable from those associated with non-aerosol related effects such as wavelength dependent surface reflection effects (especially over the arid and semi-arid regions of the world) and scattering effects of clouds. Thus, in the analysis carried out in this manuscript AI values lower than 1.0 should not be used.

Special care should be exercised to avoid anomalous positive AI values (often larger than unity) that are commonly observed at high latitudes in the late fall and winter seasons in both hemispheres. The nature of these anomalous AI values is not well understood, but it appears to be related to a breakdown at high solar and satellite zenith angles of the Lambertian approximation used in the AI calculation.

Based on the above stated considerations the AI signal can be considered a reasonable proxy of the total columns aerosol load only over regions where either dust, smoke or a dust-smoke combination account for most of columnar aerosol content yielding AI values larger than 1.0. Those regions include the well-known tropical and sub-tropical regions of Africa and both South and Central America where the AI signal is associated with the presence of optically thick smoke layers as well as the so-called dust belt that contains the world's major dust sources.

The description of the different data sets presented in Table 2 is confusing and misleading. The authors seem very unfamiliar with the AI data sets they are using. The TOMS v8 algorithm using the 331 and 360 nm channels is applied uniformly to both Nimbus-7 and Earth Probe observations. The earlier version (v7) made use of 340-380 nm for Nimbus7 and 331-360 nm for Earth Probe. According to the tabulated information the authors may actually be using v7 data for both sensors. The v8 data sets should be used. Otherwise, a scaling factor should be applied to the 331-360 AI which is about 25% lower than the 340-380 nm AI definition due to the wavelength separation.

Earth-Probe TOMS AI data after 2001 should not be used. A serious degradation issue affecting the sensor diffuser produces anomalously high AI values that must be ignored in any kind of trend analysis [Kiss et al., 2007].

Other comments

The reported wavelength-pair (342.5-388 nm) used for the calculation of the OMAERO AI parameter is at odds with the 354-388 nm pair reported in the literature [Torres et al., 2007].

It is not clear why the authors have chosen to work with the OMAERO AI. The obvious choice should be the OMTO3 AI product that uses the same wavelengths and the same algorithm as the TOMS V8 products. The V8 AI algorithm applied to Nimbus7 TOMS, Earth-Probe TOMS and Aura OMI (OMTO3) uses an algorithm that accounts for the presence of clouds at realistic location above the surface (MLER model). OMAERO AI uses a simple approximation (LER model), in which clouds are placed at surface level. These algorithmic differences produce significant AI difference in the presence of clouds and cloud-aerosol mixtures (Penning de Vries and Wagner, 2010).

The authors make use of MODIS and OMAERO AOD retrievals to transform the AI into the AOD space. More information on this procedure is needed. Which MODIS data is used? If the Dark Target MODIS (DTM) data is used, how do the authors handle the lack of DTM data over most of the world's arid and semi-arid areas? Please include key references to MODIS AOD validation studies. A justification for the use of the OMAERO product in this analysis should be provided. I am not aware of any comprehensive validation analysis of this product under different of aerosol conditions to support its application in a global product as intended in this analysis. Limited multi-sensor comparisons to AERONET observations

[Ahn et al., 2014; Carboni et al., 2014], shows significantly poorer OMAERO statistics relative to other satellite data sets.

The representativity of the resulting monthly long-term AOD record should be evaluated by comparison to other available multiyear records such as MODIS and MiSR (2000-present), SeaWIFS (1997-2010) and TOMS (1979-2001).

References

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