Atmos. Chem. Phys. Discuss., 14, C11721–C11734, 2015
www.atmos-chem-phys-discuss.net/14/C11721/2015/

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "The regime of aerosol asymmetry parameter over Europe, Mediterranean and Middle East based on MODIS satellite data: evaluation against surface AERONET measurements" *by* M. B. Korras-Carraca et al.

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Received and published: 31 January 2015

We would like to thank A. M. Sayer for his helpful comments regarding trends and Terra/Aqua differences. We carefully read through them and also the reported papers (Levy et al., 2010; 2013, Lyapustin, AMT, 2014) in his comment and took all of them into account in the revised version of our paper.

- Since the analysis was done with Collection 5 data, I expect that the trend in Terra data will be influenced (possibly quite strongly) by the calibration drift in that sensor. The

differences between Terra and Aqua may likewise be a result of calibration differences. (combination of different absolute calibrations, and different drifts in various spectral channels in the two sensors). It is known that Collection 5 has an offset between Terra and Aqua in AOD, which changes through the mission. The asymmetry parameter information essentially depends on which aerosol modes are picked by the solution, and the relative weights between the two (i.e. it is more a derived quantity than the retrieved quantity). As this is largely a function of the spectral shape of reflectance, it is likely to be even more sensitive than AOD to calibration uncertainties.

Indeed, we were aware in our original document that there are calibration issues with the spectral channels of MODIS and that there is an optical sensor degradation, with the Terra suffering more than Aqua with regards to this. We acknowledge that these calibration drift issues and changes between Terra and Aqua are known to produce offsets between the two sensors and that, thus, may also generate similar differences in Terra and Aqua aerosol asymmetry parameter. Consequently, basically we tried to refrain from analysing the physical causes for the differences between the Terra and Aqua slopes of asymmetry parameter (Fig. 5, sect. 3.2.2) and to only refer to different time overpass time of the two platforms. However, we acknowledge that some statements made in the original manuscript may have been misleading with regards to this. Therefore, in order to avoid confusion, we have removed these statements in the revised version of the paper. Also, based on this A. M. Sayer comment, we made specific and extended reference to the MODIS calibration issues and its possible impacts on aerosol asymmetry parameter trends. In this sense, the results of Terra and Aqua aerosol asymmetry parameter trends presented in this paper (Fig. 5) are not to be taken as truth but rather they are given as a diagnostic of a problematic situation with MODIS aerosol asymmetry parameter. In line with this, inter-annual changes of asymmetry parameter are neither attempted nor derived based on the time-series of asymmetry parameter for the seven sub-regions of Fig. 6. All these are now stated in sect. 3.2.2, lines 366-377.

- I expect the new Collection 6 data will have resolved some of these issues, thanks to the work of the MODIS Calibration Science Team and Ocean Biology Processing Group in improving and maintaining the quality of MODIS calibration (both absolute and correction of drifts). Because of this, I would not try to interpret the Collection 5 Terra (and possibly Aqua, given the possibility of drift in later years) for trends, or to assign an Earth-related basis for differences between Terra and Aqua. My feeling is that calibration effects cannot be discounted here; repetition of the analysis with Collection 6 may be better (although I can't say for sure if calibration effects can be discounted entirely in C6). Levy et al., AMT (2013). See Figure 15 for Ångström exponent changes between MODIS C5 and C6 (which, as it is also size-related information, may indicate changes in asymmetry parameter, although I don't know if anyone has looked at this in C6 yet). Note this is for Aqua data.

Accordingly to this comment, we have made a relevant statement (sect. 3.2.2, lines 377-382) referring to a possible, at least partly, solution of these calibration problem in the new Collection 006 MODIS product.

We would like to clarify that on the occasion of this important comment of A. M. Sayer, we tried to make a quick assessment of how aerosol asymmetry parameter inter-annual trends change in the new C006 data product (from C005). As of now, only the Aqua database is available while the corresponding one of Terra is in preparation. Nevertheless, no aerosol asymmetry parameter product was found in C006 data, which prevented us from making such a direct assessment. Therefore, we tried to use another aerosol size parameter and therefore we computed the Angstrom exponent (AE), which is the most common, using spectral aerosol optical depth data. The results given below are obtained from the performed analysis using the MODIS C005 and C006 AE at 550-865 nm wavelength pair, with data spanning the period 2002-2010.

First, emphasis is given on how the C005 and C006 AE data themselves (not their trends) compare to each other. From Fig. 1 and Fig. 2 a similarity is apparent in the main geographical patterns, which are also in line with those of asymmetry param-

eter in our paper (Fig. 2). For example, note the high AE values in the Black Sea (yellowish-reddish colors), indicative of fine aerosols, the relatively high values in the Mediterranean Sea (greenish-yellowish colors) and the low values (deep bluish colors) off the western African coasts corresponding to exported Saharan dust. The similarity between C005 and C006 AE data is also depicted in the computed correlation coefficients (Fig. 3), exceeding 0.8, and biases (in absolute and relative percentage terms, Figs 4 and 5, respectively) which are smaller than 0.1 or 10% in most areas of the study region and 0.2 or 20% almost everywhere. It should be noticed that our AE results are in line with those of Levy et al. (2013, Fig. 15) which refer, however, only to year 2008 (ours are for 2002-2010).

Figure 1. MODIS C005 Angström exponent at 550-865 nm for the period 2002-2010.

Figure 2. MODIS C006 Angström exponent at 550-865 nm for the period 2002-2010.

Figure 3. Correlation coefficient values between MODIS C005 and C006 Angström exponent data at 550-865 nm over the period 2002-2010.

Figure 4. Biases between MODIS C005 and C006 Angström exponent data at 550-865 nm over the period 2002-2010.

Figure 5. Percent (%) biases between MODIS C005 and C006 Angström exponent data at 550-865 nm over the period 2002-2010.

In a next step, we attempted to compare the computed trends of C005 and C006 AE data over the common period 2002-2010 in order to assess whether changes are detected, which (as stated above and by A. M. Sayer) could be an indication of possible changes in corresponding asymmetry parameter trends. Below, in Figure 6, we show the computed deseasonalized trends of slope values for both C005 and C006.

Figure 6. Computed deseasonalized trends of MODIS Aqua C005 Angström exponent (550-865 nm) slope values for years 2002-2010.

Figure 7. Computed deseasonalized trends of MODIS Aqua C006 Angström exponent

(550-865 nm) slope values for years 2002-2010.

The results reveal similar patterns again between C005 and C006. First of all, small trends are found in both of them, in agreement with the small trends of asymmetry parameter reported in our paper (sect. 3.2.2, line 354). Then, it is obvious that the sign of AE trends mainly does not change from C005 to C006. This might be a signal that no changes of aerosol asymmetry parameter are expected in C006. Although this cannot be certified, unfortunately, due to the unavailability of asymmetry parameter in C006, it puts some confidence on the C005 results given in our paper. A short note relevant to the performed analysis has been made in sect. 3.2.2, lines 373-378, whereas the results are more extensively presented in a new section 2.3.3 introduced in the revised manuscript.

- I also would not place much importance on correlation coefficient between asymmetry parameter from MODIS and AERONET. The data range is quite small and the uncertainties on both datasets (AERONET too) can be non-negligible in this case. So I would not expect a high degree of correlation. I think bias and RMS are probably more useful metrics to emphasise.

We can understand the worries of A. M. Sayer regarding the comparison between MODIS and AERONET asymmetry parameter, especially as to the use of correlation coefficient as a metric. Nevertheless, we would like to note that what may be problematic is not the small asymmetry parameter data range per se, but the possibly large AERONET and MODIS errors compared to the data range. The range is constrained by the physical limits of the asymmetry parameter encountered in nature and deciding that it is too small is essentially accepting that meaningful validation for aerosol asymmetry parameter cannot be performed. This in our opinion is not what A. M. Sayer meant. He probably meant on the other hand, that there may be a problem with the uncertainties of both AERONET and MODIS asymmetry parameter and more specifically, with the uncertainty of the AERONET one, which is the independent variable in our comparison. It is known that existing errors in the independent variable result in "regression

dilution", i.e. underestimation of the correlation coefficient and of the regression slope. It would be possible to account for this underestimation by using Deming regression, if we had an estimate of the standard error of both sensors. In its absence, R and slope values have to be left uncorrected, while mentioning that their true values are actually larger than the ones reported in the paper.

Finally, we would like to note that we consider that the comparison shown in Fig. 9 (Figure 7 of original manuscript) can be still taken as a valid predictive model, which given a measured value of gaer from AERONET can predict with 95% confidence where the respective MODIS value falls (based on the definition of the prediction bands). These bands are now shown in Fig. 9.

Relevant notes to the above issue were made in the revised paper (sect. 4, lines 478-492). Moreover, taking into account the comment of A. M. Sayer, we toned down the importance of correlation coefficient, giving more emphasis in the discussion on biases and RMSE values.

References Levy, R. C., Remer, L. A., Kleidman, R. G., Mattoo, S., Ichoku, C., Kahn, R., and Eck, T. F.: Global evaluation of the Collection 5 MODIS dark-target aerosol products over land, Atmos. Chem. Phys., 10, 10399-10420, doi:10.5194/acp-10-10399-2010, 2010. Levy, R. C., Mattoo, S., Munchak, L. A., Remer, L. A., Sayer, A. M., Patadia, F., and Hsu, N. C.: The Collection 6 MODIS aerosol products over land and ocean, Atmos. Meas. Tech., 6, 2989-3034, doi:10.5194/amt-6-2989-2013, 2013. Lyapustin, A., Wang, Y., Xiong, X., Meister, G., Platnick, S., Levy, R., Franz, B., Korkin, S., Hilker, T., Tucker, J., Hall, F., Sellers, P., Wu, A., and Angal, A.: Scientific impact of MODIS C5 calibration degradation and C6+ improvements, Atmos. Meas. Tech., 7, 4353-4365, doi:10.5194/amt-7-4353-2014, 2014.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/14/C11721/2015/acpd-14-C11721-2015-supplement.pdf

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 22677, 2014.

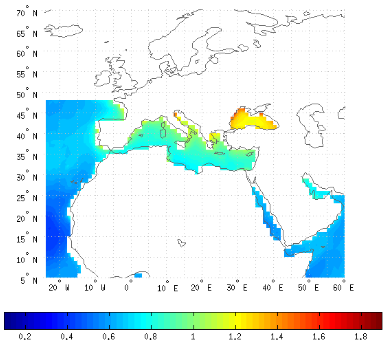

Fig. 1.

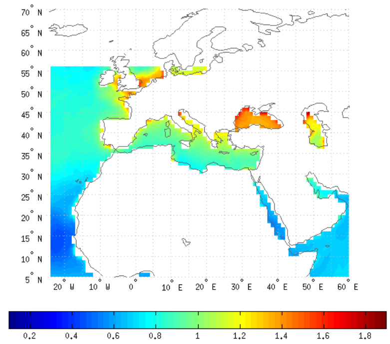
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Fig. 2.

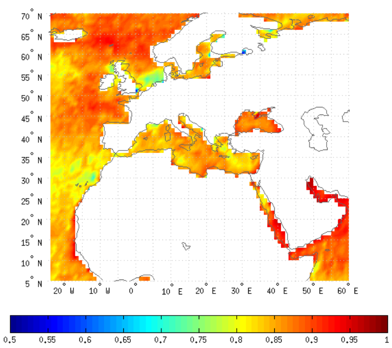
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Fig. 3.

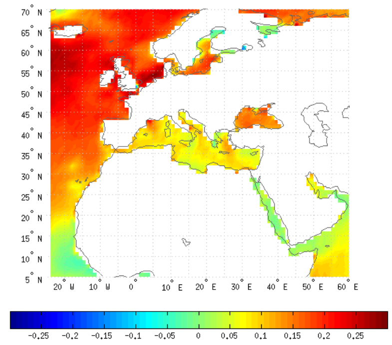
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Fig. 4.

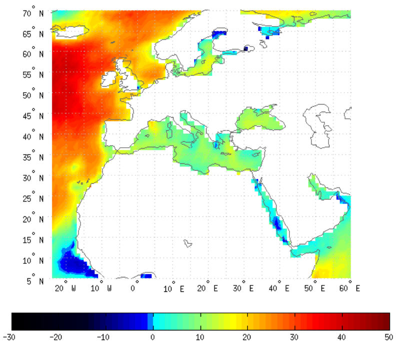
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Fig. 5.

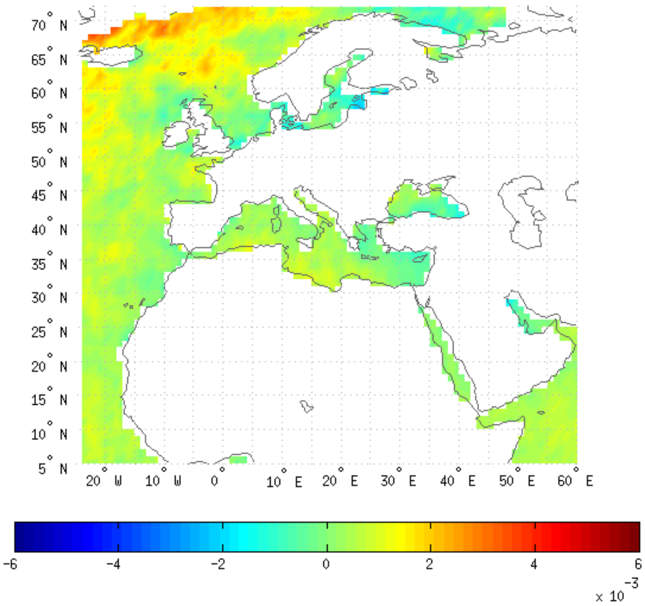
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Fig. 6.

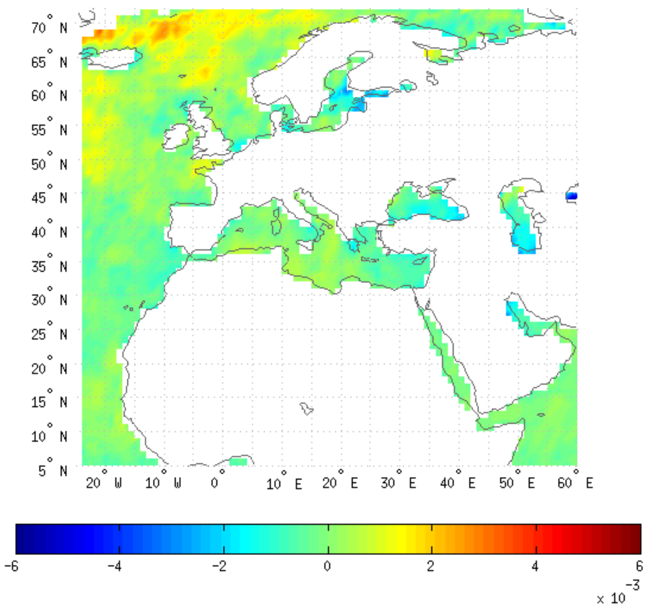
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Fig. 7.