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Atmospheric Measurement Techniques Discussions

Interactive comment on "Contrasting aerosol trends over South Asia during the last decade based on MODIS observations" *by* D. G. Kaskaoutis et al.

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Reply to the Comments made by Referee #1

Comments: I agree with the ïňĄrst reviewer that satellite data products are not the most reliable in studying aerosol trends as algorithm and sampling biases could signiïňĄcantly affect results. If use of satellite data is desired and justiïňĄes, as the paper attempts to study the spatial trend distribution, then more than one satellite sensor should be used, and ground-based measurements should be incorporated if possible.

Authors: We do agree with the Referee that for trend analysis, more than one sensor

and ground observations should be used. In our paper we have compared our results with MISR (which is recently carried out by Dey and di Girolamo, (2011) and Kanpur AERONET data. We do agree with the Referee that the satellite remote sensing data still suffers with larger uncertainties in aerosol retrievals over land compared to ocean, although the significant improvement that has been made recently in the aerosol models and reflectances used in the model algorithms after comparison with ground observations. However, this is a standard "problem" when using satellite retrievals over land. In the revised manuscript all these aspects are fully discussed based on the detailed comments made by Reviewers.

Comments: Currently the data during their study's time period is available from MISR in addition to MODIS Terra, and almost 9 years of observations are available from MODIS Aqua. It should be noted that globally, MODIS Terra is currently showing artiïňĄcial negative aerosol optical depth (AOD) trends over land as reported by a number of MODIS team presentations (see for example, Steve Platnick and Rob Levy, MODIS Atmosphere Solar ReïňĆectance Issues, MODIS 2011 Meeting). Therefore trends derived from MODIS Terra alone might not reïňĆect realistic decadal aerosol changes and variability. The paper results should be re-examined with additional satellite and ground-based data.

Authors: The present manuscript uses the Terra-MODIS AOD retrievals during the period 2000-2009 also aiming to explain the declining trend observed over northern India during late pre-monsoon and monsoon months. For the latter, we tried to be as analytical as possible and, for this reason, the manuscript is long enough without any possibility to further expand it by using additional analysis from other sensors or ground-based retrievals. Such analysis can constitute the basis for a new research. However, a new research using MISR retrievals for the AOD trends over India has been recently published (Dey and di Girolamo, 2011) and the findings are compared with the present results in the revised version. Furthermore, we have analyzed the Kanpur-AERONET data during the period 2001-2010 and these results are also discussed in

AMTD

4, C2163–C2170, 2011

the revised manuscript. Note, that both MISR and Kanpur AERONET agree with the MODIS observations regarding an overall increasing trend in AOD over Indian subcontinent as well as in the declining trend over northern India during late pre-monsoon and monsoon seasons; all these results support our findings, although these comparisons are only qualitatively and not quantitatively. Aqua MODIS has now about 9-year data series, but the present study covers 2000-2009 period. So, the use of Aqua MODIS data will further limit the study period. The results of the present study show that the large year-to-year variation of the monthly mean AOD values (see also Fig. 1 in the response) is the main factor that controls the trends and its influence is much larger than any uncertainties in the AOD retrievals. So, further limiting the studied period to two years we will conclude to some discrepancies regarding the AOD trends, which will cause more confusion in the results. However, since we have also analyzed the Aqua MODIS trends we found general agreement regarding the overall increasing trend of AOD over India. On the other hand, Aqua MODIS does not provide data during monsoon 2002, which is a very critical period regarding the enhancement of dust activity and AOD values over northern India and significantly influences the overall AOD trend. For the above reasons, the Aqua MODIS results are not included.

General comments: 1. The 1-degree grid is too large for the regional study over South Asia. The quality checked and 0.25-degree gridded Level 2 data should be used as the Level 3 products produce smoother appearing maps that can easily mask large point sources (e.g., industrialization, large metropolitan areas).

Authors: The main scope of the present study is not to present an AOD trend analysis over specific areas surrounding densely populated regions or urban centers where the L2 data should be used. The L3 data were retrieved from L2 and present more smoothed values which are capable for analyzing AOD trends over the whole Indian sub-continent. Note that the spatial domain is composed of 1110 data pixels, large enough for such retrievals. Note also that during the monsoon period, when the data availability is lower, the influence of the year-to-year AOD variations is much larger as

AMTD

4, C2163–C2170, 2011

observed from the spatial distribution figures. The use of L2 data will cause much larger spatial heterogeneities considering the outcome of any result quite difficult. A recent study over Hyderabad (Kharol et al., Atmos. Environ. 2011) show large differences in the L2 and L3 values around the spatial domain covering the urban area (in this point reviewer has absolutely right), but the results shown that on monthly and seasonal scales the variations and trends either concerning L2 or L3 data were similar. In the present manuscript, we clearly state that the AOD trend analysis can be considered rather qualitatively and not quantitatively; note that the declining trends over northern India during late pre-monsoon and monsoon seasons are not statistically significant at 95% confidence level. On the other hand, we have also checked the AOD trends by using the daily AOD values from the Kanpur-AERONET station. The results were in agreement with those using the monthly-mean AODs, although some differences found in the slope of the regressions and in the % variations. However, as noted above any quantitative analysis over the region, especially using satellite retrievals with the known larger uncertainties over land, must be avoided. On the other hand, we analyzed the L2 Terra-MODIS AOD550 over IGP covering the area 21.05-31.05oN, 74.05-91.05oE (Fig. 2). The area-averaged monthly mean variations of the L2 AODs are found to be similar to that observed by using L3 Terra MODIS AODs (see Fig. 1). The trends of the two datasets are in excellent agreement for each month, while the slight higher L3 AOD values are attributed to the fact that in L3 analysis we excluded the pixels over Nepal and Himalayas. Note also the significant year-to-year variability in the monthly mean AOD values, which defines the trends in the 10-year period. The satisfactory agreement in the regression analysis shows that L3 can be used for obtaining AOD trends over south Asia with satisfactory accuracy.

Comments: 2. The decreasing trend explanation related to dust activity should be examined with MODIS Deep Blue and MISR data over the Thar Desert.

Authors: This has been done and we provide the following graphs (Fig. 3a, b) for your perusal. Following suggestions of the Referee, we have carried out MODIS Deep

AMTD

4, C2163–C2170, 2011

Blue and MISR data over the Thar Desert as shown in Figs. 2a, b. The results of the Terra MODIS Deep Blue algorithm over Thar desert (6 – 29o N, 70 – 74o E) during the months April-July show increased values for 2002 and 2003, which are in agreement with the present results showing increase in dust activities during the late pre-monsoon and early monsoon seasons. Concerning the dust trend over the last decade, the Terra Deep Blue retrievals cannot give a clear view since the dataset is available only up to 2007.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 5275, 2011.

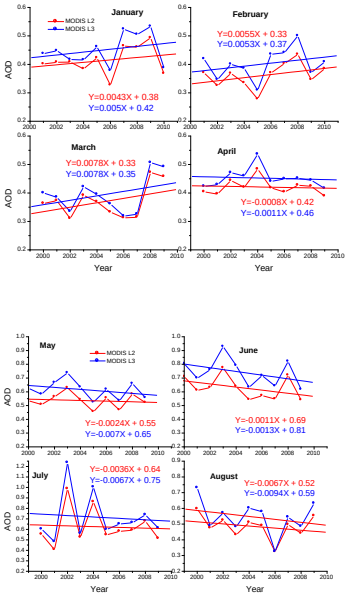

Fig. 1. Figure 1

AMTD
4, C2163–C2170, 2011

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Interactive Discussion
Discussion Paper

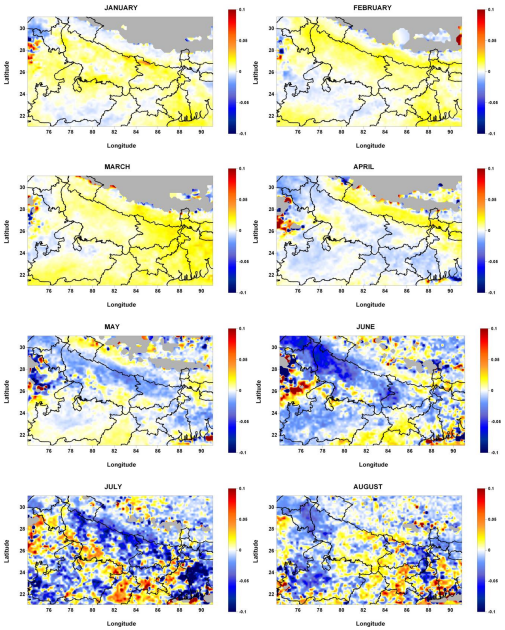

Fig. 2. Figure 2

AMTD
4, C2163–C2170, 2011

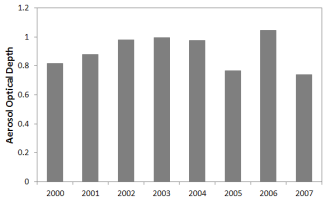

Fig. 3a. Yearly variations of the Deep Blue Terra-MODIS AOD over Thar desert (6 – 29° N, 70 – 74° E) averaged for the months April-July.

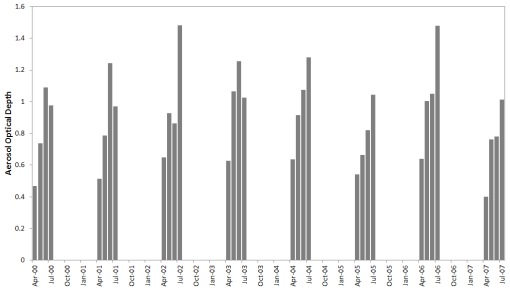

Fig. 3b. Monthly variations of the Deep Blue Terra-MODIS AOD over Thar desert (6 – 29° N, 70 – 74° E) during the period 2000-2007.

Fig. 3. Figure 3

AMTD
4, C2163–C2170, 2011

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