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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 #2

Comments: In this work the authors have used satellite data from MODIS Terra to study the aerosol trends over South Asia during the last decade. As other referees have also pointed out, it is not straightforward to use satellites alone to deïňĄne the aerosol trends. In addition, MODIS Terra is known to have issues with the instrument degradation, which is causing artiïňĄcial negative trend in aerosol optical depth on a global scale. The authors do not discuss how this might effect their results, which I

ïňĄnd as a weak point of this study.

Authors: Regarding the MODIS AOD retrievals over Indian sub-continent we have responded to the comments made by other reviewers, so our responses remain the same. On the other hand, MODIS as well as other satellite sensors (e.g. MISR) and ground-based measurements show an overall increasing trend in aerosols over south Asia as shown by numerous researchers. In the introduction section, we have cited numerous references regarding this issue. Note also that several studies published in well-cited scientific journals have used satellite retrievals for AOD trend analysis over the area, so we cannot understand why MODIS is incapable for such applications. Of course, satellite remote sensing exhibits some uncertainties, especially over land. All these are discussed in more detail in the revised version. However, note that the trends are discussed rather qualitatively and not quantitatively, since other sensors can conclude to different results regarding the trend values. On the other hand, our results agree with those recently observed from MISR over the area (Dey and di Girolamo, GRL, 2011) regarding the overall increasing trend in AOD over India and the declining trend over IGP region in late pre-monsoon and monsoon months. The same results were observed by analyzing Kanpur-AERONET data during the last decade, thus justifying at least qualitatively the MODIS-derived AOD trends. All the above are discussed in a separate section in the revised manuscript.

Comments: Hence, I would also suggest to include data from other satellite sensors, such as MODIS Aqua, MISR and/or SeaWiFS to support the ïňĄndings. In addition, as the authors point out in the conclusions, further investigations from ground-based measurements is needed.

Authors: MISR data has already been used over the studied region (Dey and di Girolamo, GRL, 2011). Analyzing the AOD trends by using Aqua MODIS will deviate the results, at least quantitatively, since the Aqua data series are two years less than Terra ones. The results of the present work clearly show that the year-to-year AOD variation is the main factor controlling the trend values. Thus, further limiting the studied period

the results would be not so accurate and the discrepancies would be increased. However, the Aqua-MODIS AOD trends are in general agreement with those obtained from Terra MODIS exhibiting larger AOD increasing trend in winter and neutral or even declining trends over northern India during late pre-monsoon and monsoon seasons. On the other hand, the present analysis can constitute the basis for further comparisons with other sensors in the future.

Referee: I would also suggest the authors to use MODIS L2 quality checked-data, so that they would be able to study more carefully e.g. the regional effects, or the effect of cloudiness. The L3-data is not the best possible dataset for this kind of study, where the results are mainly based on satellite retrieved AOD. By using the L2-data authors could explain in more detail the averaging procedure over the seasons, and if/how the sampling in each month is taken into account.

Authors: Regarding the use of L2 data we clearly responded to the other Referee. You can see our response there and the figures (1 and 2) provided using L2 Terra MODIS data over IGP. The L2 data were used over IGP where the data points are less compared to the other regions and the spatial distribution of the trends is more heterogeneous, especially in monsoon. Such retrievals can show the availability of data during monsoon cloudy season. However, analyzing the trends by using L2 data does not provide something new in the analysis, since the L3 data are spatially averaged L2 data. For this reason, we do not include L2 analysis in the revised manuscript, but we provide some figures which show the consistency of the trends as well as their spatial distributions with the L3 MODIS data.

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 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. 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.

Referee: As a minor comment I would suggest to include an additional ïňĄgure showing the four different study areas on a map. That would help the interpretation of the results.

Authors: In the area description section, we clearly defined all these sub-regions. Since the figures are so many in the manuscript, we decided not to include a new one just showing the borders of each sub-region.

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

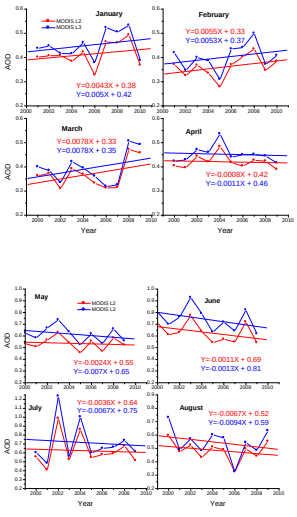

Fig. 1.

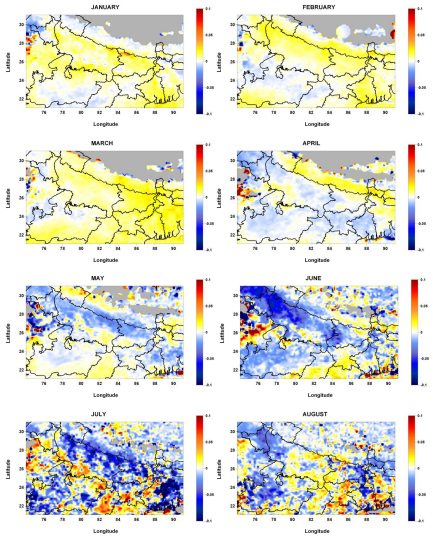
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Fig. 2.