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Atmospheric Measurement Techniques Discussions

Interactive comment on "Role of coarse and fine mode aerosols in MODIS AOD retrieval: a case study" *by* M. N. Sai Suman et al.

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Responses to comments of Reviewer #2.

We thank Reviewer #2 for reviewing our manuscript and providing suggestions for improvements. Following is our responses to reviewer #2's comments and suggestions.

1. *We thank reviewer #2 for appreciating clarity of our presentation of results, need of this study and its importance for scientific community.*
2. *We thank reviewer #2 for suggesting inclusion of comparison with Jethva et al. (2010). In the revised manuscript, we have included comparison with Jethva et al. (2010).*

3. *Reviewer #2 has suggested that since we focus on aerosol properties over South India, title should reflect this.*

   We thank reviewer for this suggestion. In the revised manuscript we have changed the title to reflect this.

4. *Reviewer #2 has mentioned about lack of analysis about surface reflectance and its impact on retrieval of fine mode fraction from MODIS data.*

   Retrieval of surface reflectance is one of the crucial step in retrieving aerosol properties. In the revised manuscript we include discussion on this aspect. Since we do not have ground truth data for errors in surface reflectance, we restrict ourselves on analysing role of aerosol models. Though the sensitivity of retrieved fine mode AOD toward surface reflectance is high, role of aerosol models is undeniably important. Moreover, retrieval of surface reflectance also depends on aerosol model being used and hence indirectly aerosol model plays role even when attributing differences to errors in surface reflectance.

5. *Reviewer #2 has asked for inclusion of supporting data for our suggestion to have more absorbing aerosol model in MODIS.*

   In the revised manuscript we include data of single scattering albedo.

6. *Reviewer #2 has suggested to keep Introduction small and include details on previous studies in Results and Discussion section.*

   We thank Reviewer #2 for this suggestion. In the revised manuscript, we have moved some of the material from Introduction section to Results and Discussion section.

7. *Reviewer #2 has suggested that the description of the study site needs more information about aerosol field, dominance of fine or coarse aerosols, seasonal variations, etc.*

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Discussion on the aspect of aerosol field and seasonal variation of size and other properties of aerosol is very important and forms basis for establishing observatory and observations systems like MODIS in first place. In our earlier manuscript Kiran Kumar et al. (2013) we have provided many results related to aerosol field around the study site and its spatial variation over Southern India. The current manuscript is focused on validation aspect and hence we have kept other discussion minimal. We provide relevant citations where interested readers can find information on current state of knowledge.

8. *Reviewer #2 has raised concern that reported error 6% for sky-radiometer is high compare to other similar instruments like CIMEL and MICROTOPS II.*

   Holben et al. (2001) and Ichoku et al. (2002) have reported absolute errors in AOD in the range 0.01 to 0.02 for CIMEL and MICROTOPS sun-photometer, when best possible care is taken like very frequent calibrations and cleaning of optics. Even in the best case scenario (absolute error 0.01), values of relative error will be in range from 2% to 10% for a typical range of observed AODs (0.1 to 0.5) over Southern India. In case of 0.02 absolute error, the relative error will be in range from 4% to 20%. In this context, error reported by us is not significantly different from others.

9. *Reviewer #2 has asked whether this instrument has been used previously in any published work.*

   Some results using this sky-radiometer has been published in Gadhavi and Jayaraman (2010) and Kiran Kumar et al. (2013). In the revised manuscript we have mentioned this.

10. *Reviewer #2 has raised concerned that use of sky-radiances in place of direct radiation for AOD measurements is not described clearly.*

    We have used software based on Nakajima et al. (1996). It is well established and used around the world by several sky-radiometers under Skynet. We think

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that writing minute details of the algorithm that is established for nearly two decades is unnecessary. Let us write here answers to some of the questions that reviewer #2 has raised in this regard. Direct beam irradiance measurements are the solar radiation measurements when the instrument is pointing toward sun. Sky-radiance measurements are observations of radiation when sky-radiometer points away from sun at pre-decided angles. Retrieval of AOD from direct beam relies on fixed I0 values which in turn retrieved using Langley plot method. Estimation of I0 is usually infrequent. In our case it is done nearly on monthly basis whereas many researchers do it at the interval of 6 months or more. During these period instrument's optical characteristics can change and will result error in the AOD values. Whereas AOD retrieval from sky-radiances depends on ratio of radiation at certain angle to direct beam radiation. Since degradation in instrument's optical characteristics will affect both the beam in similar manner, retrieval of AOD is less sensitive toward optical degradation. Nakajima et al. (1996) have reported regression line between two methods as 0.985*AOD(dir) + 0.008 over Cagliari (Sardinia). We have also found similar comparison between two methods but since the method has been well established, we have not elaborated it in the manuscript.

11. *Reviewer #2 has raised concern over whether Level 3 data which have spatial resolution 1deg x 1 deg can be considered representative of the site, and ask for its justification for use when high resolution Level 2 data are available.*

    As mentioned in the manuscript, comparison study of ground vs satellite sensors has its own limitations. Based on following consideration, we chose to use Level 3 data.

    (a) In our earlier article (Kiran Kumar et al., 2013), we have done comparison of MODIS and sky-radiometer AOD at fine resolution. From regression point of view, we have not found any significant difference in earlier regression or current regression that is done for level 3 data.

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(b) Kiran Kumar et al., 2013 investigated spatial correlation of AOD and found that AOD displayed high correlation well beyond 200 km from Gadanki. Since fine mode fraction is expected to be less variable than AOD, it may also display similar characteristics in spatial correlation.

(c) From mathematics perspective, when coarse resolution data are used, variations of the parameter of interest (here AOD) in spatial domain affect the comparison (regression). If these variations are due to real geophysical reason then it is matter of concern, however if the fluctuations are due to noisy retrieval (random and non-geophysical) then the coarse resolution will help in removing the noise from data. This aspect is more evident in the analysis done by Kharol et al. (2011). Kharol et al. (2011) have found reasonable correlation for Level 3 Aqua and Terra AOD but they have found very poor correlation for Level 2 data set. Though some variability in AOD between two overpass time (10:30 and 1:30) is expected, not to have any significant correlation for Level 2 data is indicative of fact that fine resolution data are noisy.

12. *The reviewer has asked for inclusion of some discussion on why the regression is season dependent and include values of root mean square difference.*

    In the revised manuscript we include more discussion on this and also provide RMS difference values.

13. *The reviewer mentions that "the differences between AODs at shorter and longer wavelengths are also characteristic for the Angstrom exponent and aerosol type that is not referred. It would be in advance to provide the columnar size distributions in all seasons and discuss more the modifications on them due to different aerosol dominance. The large vertical bars especially for coarse mode during summer suggest large heterogeneity in the aerosol field. Is the aerosol field significantly influenced by dust plumes on that season? The differing air masses*

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controlling the FM values are not shown, so that, the statement cannot be justified from the present analysis and without any references".

As mentioned earlier, we try to keep current manuscript focused on validation part. We have provided size distribution number and AOD at two wavelengths to highlight scientific basis of size distribution retrieval from spectral AOD measurements. We have not included discussion of causes and implications of seasonal variations of aerosol size distribution and optical properties.

Specific Comment

1. *The study period has to be referred in the abstract.*

   In the revised manuscript we include study period in the abstract.

2. *Page 9112, line 26. Please check the R2 value between MODIS and AERONET. It seems too low.*

   The R2 value 0.248 is correctly mentioned in our manuscript. This number is taken from Figure 11 of Levy et al. (2007).

References

- Gadhavi, H. and Jayaraman, A.: Absorbing aerosols: contribution of biomass burning and implications for radiative forcing, Ann. Geophys., 28, 103-111, doi:10.5194/angeo-28-103-2010, 2010.
- Holben, B. N., Tanré, D., Smirnov, A., Eck, T. F., Slutsker, I., Abuhassan, N., Newcomb, W. W., Schafer, J. S., Chatenet, B., Lavenu, F., Kaufman, Y. J., Castle, J. V., Setzer, A., Markham, B., Clark, D., Frouin, R., Halthore, R., Karneli, A., O'Neill,

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N. T., Pietras, C., Pinker, R. T., Voss, K. and Zibordi, G.: An emerging ground-based aerosol climatology: Aerosol optical depth from AERONET, J. Geophys. Res., 106, 12067-12097, doi:10.1029/2001JD900014, 2001.

- Ichoku, C., Levy, R., Kaufman, Y. J., Remer, L. A., Li, R.-R., Martins, V. J., Holben, B. N., Abuhassan, N., Slutsker, I., Eck, T. F. and Pietras, C.: Analysis of the performance characteristics of the five-channel Microtops II Sun photometer for measuring aerosol optical thickness and precipitable water vapor, J. Geophys. Res., 107, 4179+, doi:10.1029/2001JD001302, 2002.

- Jethva, H., Satheesh, S. K., Srinivasan, J. and Levy, R. C.: Improved retrieval of aerosol size-resolved properties from moderate resolution imaging spectroradiometer over India: Role of aerosol model and surface reflectance, J. Geophys. Res., 115, D18213+, doi:10.1029/2009jd013218, 2010.

- Kharol, S. K., Badarinath, K. V. S., Sharma, A. R., Kaskaoutis, D. G. and Kambezidis, H. D.: Multiyear analysis of Terra/Aqua MODIS aerosol optical depth and ground observations over tropical urban region of Hyderabad, India, Atmos. Environ., 45, 1532-1542, doi:10.1016/j.atmosenv.2010.12.047, 2011. Kiran Kumar, T., Gadhavi, H., Jayaraman, A., Sai Suman, M. N. and Vijaya Bhaskara Rao, S.: Temporal and spatial variability of aerosol optical depth over South India as inferred from MODIS, J. Atmos. Sol.-Terr. Phys., 94, 71-80, doi:10.1016/j.jastp.2012.12.010, 2013.

- Levy, R. C., Remer, L. A., Mattoo, S., Vermote, E. F. and Kaufman, Y. J.: Second-generation operational algorithm: Retrieval of aerosol properties over land from inversion of Moderate Resolution Imaging Spectroradiometer spectral reflectance, J. Geophys. Res., 112, D13211+, doi:10.1029/2006JD007811, 2007. Nakajima, T., Tonna, G., Rao, R., Boi, P., Kaufman, Y. and Holben, B.: Use of sky brightness measurements from ground for remote sensing of particulate polydispersions, Appl. Opt., 35, 2672-2686, doi:10.1364/AO.35.002672, 1996.