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Interactive comment on “High spatial resolution aerosol retrievals used for daily particulate matter monitoring over Po valley, northern Italy” by B. Arvani et al.

Anonymous Referee #2

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Title: High spatial resolution aerosol retrievals used for daily particulate matter monitoring over Po valley, northern Italy.

The authors used MODIS standard (10-km) and high-resolution (1-km) MAIAC AOD products to correlate with surface PM₁₀ in order to monitor PM over Po Valley in northern Italy. The manuscript described the correlation of MODIS AOD with PM₁₀ from 126 locations in 2012. The comparison between MODIS 10-km and 1-km products, along with assimilated PBL heights, is constructive. The approach, however, has a few holes.

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First, the approach doesn't show how does Eq. (1) lead to the normalization of AOD by PBL height? Second, the approach does not take into account $f(\text{RH})$ effect when correlating ambient AOD with dried PM₁₀ mass concentration. Thirdly, these results lack the evaluation of uncertainties of estimated PM₁₀ derived by AOD (MODIS vs. sun photometer). Finally, the bin-averaged results would not represent daily variation. Details are elaborated in major comments. In summary, the title of using monitoring is not accurate based upon the correlation resulted from MODIS. Evaluating AOD-PM₁₀ relationship would be more appropriate than daily monitoring for the manuscript. In recent years, research on AOD-PM relationship has progressed significantly, including airborne and regional sunphotometer measurements. Spatial variability based upon satellite AOD products may be biased because of retrieval errors. As a result, the interpretation of correlation as function of distance is questionable. The authors need to revise the manuscript before it can be accepted for publication.

Major comments:

- 1) The interpretation of AOD normalized by boundary layer depth is not included. Eq. (1) only expressed the definition of AOD equal to integration of extinction with height. How does Eq. (1) lead to the normalization of AOD by boundary layer depth? Tsai et al. (2011) elaborated the derivation of haze layer height as constrained by AOD in the atmospheric column that normalizing AOD by haze layer height is equal to the normalization of AOD by boundary layer depth if no aerosols aloft above boundary layer. What are the aerosol vertical distributions in different conditions (e.g., seasons) in Po Valley?
- 2) The authors didn't address the role $f(\text{RH})$ in the analysis. AOD is ambient measurements while PM₁₀ mass concentration data are dehumidified, which is important.
- 3) Multiple data sets of 2012 were used in the analysis. However, it cannot stop me thinking about associated seasonal characteristics. Mostly importantly the Po valley would reveal unique seasonal characteristics compared to other regions.

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4) Satellite AOD retrievals inherited uncertainties including instrument calibration, look-up table, and surface albedo estimation. Therefore, any results based upon satellite retrievals would be questionable. The argument of best results from distance ~ 12 km is doubtful. Spatial variability of AOD can be derived by sunphotometer network measurements (Chu et al., 2015). In other words, higher correlation will only be shown with smaller distance. The sunphotometer stations at Ispra, Modena, and Venice could at least verify the results obtained by MODIS.

5) The sole use of Aqua MODIS data in corresponding to daily mean PM₁₀ could be biased. What is the reason excluding Terra MODIS in the analysis? Both MODIS standard and high-resolution (MAIAC) AOD are produced according to Terra and Aqua daily overpasses. The comparison of mean MODIS AOD (Terra and Aqua) with daytime mean sunphotometer AOD is more important to understand the potential uncertainties attributed to MODIS retrievals and subsequently introduced in the analysis of AOD-PM₁₀ relationship.

6) The authors used 10 bins of PM₁₀ in the analysis of AOD-PM₁₀ relationship. Although the correlations derived are very high, the results of bin averages would not represent daily variation of both AOD and PM₁₀ since the bin averages are most likely involving both monthly and seasonal variations. What is the meaning of the relationship between bin-averaged PM₁₀ and AOD? Is this approach suitable for daily monitoring as the authors tried to do?

Minor Comments:

1) GDAS boundary layer data should be described in the data section 2) The MODIS standard 10-km AOD image is clearly smoothed but the MAIAC 1-km AOD image is not in Figure 3. What is the reason for the authors to state substantial spatial variability shown in MAIAC image? Also, what is the reason for areas without AOD retrievals in both 10-km and 1-km images of Figure 3? 3) Figure 5 x-axis is Julian day but ZPBL monthly mean was plotted. The actual data points are 12. Therefore “Month” is better

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used for x-axis. Figure caption should also change to “Monthly PBL height trend.”
4) Please add N (number of samples) in deriving statistics in Figures 5, 7, 8. 5) The N values in Figures 9 and 11 are not consistent with the data points plotted. 6) Why the authors did not include Modena sunphotometer in MODIS AOD validation (Figure 6)? 7) The behavior of coincidence of MAIAC in Figure 13 is strange for the “Average” results. 8) Suggested citations regarding aerosol mixing height for PM estimation to include in the manuscript

Barnaba F., Putaud, J.P., Gruening C., dell’Acqua A., Dos Santos S., 2010. Annual cycle in collocated in situ, total-column, and height-resolved aerosol observations in the Po Valley (Italy): implications for ground-level particulate matter mass concentration estimation from remote sensing, *J. Geophys. Res.*, 115, D19209, doi:10.1029/2009JD013002.

Boyouk, N., J. F. Léon, H. Delbarre, T. Podvin, and C. Deroo, 2010. Impact of the mixing boundary layer on the relationship between PM_{2.5} and aerosol optical thickness, *Atmos. Environ.*, 44, 271-277.

Chu D. A. et al., 2015. Regional Characteristics of the Relationship between columnar AOD and surface PM_{2.5}: Application of lidar aerosol extinction profiles over Baltimore-Washington Corridor during DISCOVER-AQ, *Atmos. Environ.*, 101, 338-349, DOI: 10.1016/j.atmosenv.2014.11.034.

Recommendation: Major revision.

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 15, 123, 2015.

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