Anonymous Referee #1

Review of the manuscript by Tan et al. submitted to ACPD
Tan et al. have studied the optical properties of aerosols in Malaysia and developed a regression model to estimate AOD in cloudy cases. The prediction of AOD is a very interesting topic but, unfortunately, the manuscript is really hard to read. The grammar and the structure of the manuscript need a lot of work before this work can be published. In addition, several figures are hard to read, especially from a printed version of the manuscript.
RESPONSE: First of all, thanks for the comments which can be used for improving the article.

The grammar and the structure of the manuscript were edited according to the Referee #2.

Meanwhile, there will have new analysis added into this manuscript. The original figures submitted are qualified.

I don't understand why aerosol typing is discussed in this paper. Apparently, it has nothing to do with the AOD model. Furthermore, I'm skeptical on aerosol typing based only on AOD and Angstrom exponent. AOD provides information only on the amount of aerosols and Angstrom exponent gives some idea on the size. For a more reasonable typing you would need information on the absorption capability of the aerosols (which AERONET provides). See for example Lee et al. (2010) for more information. In my opinion, aerosol typing makes sense only if the results are used somewhere.
RESPONSE: That is a very good question. The purpose of performing the discrimination of aerosol typing is to check whether or not the aerosol type will influence our AOD prediction model. We have stated our purpose in p 19752, l 6-7. In our result, we observed the accuracy of our AOD prediction model is qualitatively related to aerosol type. The details can be referred to the answer in RESPONSE to the specific comment on "p 19757, l 5: Please clarify why this discrimination is done".

Actually, your doubt on the aerosol typing based only on AOD and Angstrom exponent could be right. However, many papers have recognized this method and this method is conveniently to be used. For my way, I did a comparison for several researchers who have using this method to identify the aerosol type. We observed that the threshold values suggested by Toledano et al. (2007) were given the best and reasonable aerosol typing result. The extra information can refer to the answer in RESPONSE to the specific comment on "p 19758, l 1: Why didn't you use Single Scattering Albedo (SSA) in the classification?" and on "p 19758, l 16: the indistinguishable aerosol types in the study sites were large."

The description of the AOD model is confusing. I couldn't understand which data set was used where and why. For example, the subsetting of the data makes sense but I'm not sure if I was able to follow how it was done and how the different subsets were used. I assume that the first subset was used in the calculation of the coefficients for the equation 2 but these values for the coefficients were not presented anywhere. The section 3.5 is really confusing but I assume that here the predicted AOD values were compared with the corresponding AERONET AODs. I don't understand why this was done because in the next section (3.6) is the validation of the predictions using the second subset of data which makes sense.

RESPONSE:

Your assumption is correct.

We have explicitly presented the coefficients in the answer for the "RESPONSE in Section 3.5".

The section for the description of the AOD model has been edited according to the recommendation proposed by Referee #2. Meanwhile, we have also edited a sentence to clarify the confusion raised by Referee #1 in the RESPONSE to "p 19753, l 5: sourced from alternatively selected data".

Section (3.6) is written with the purpose to check whether the large fluctuations appearing in the AOD prediction model were caused by outliers. Therefore the approach proposed by Lee et al. (2012) was applied. By using this approach, we have filtered out approximately 20 % data points. Then, the procedures to generate AOD prediction model were repeated. We realized that the fluctuations are genuine and not caused by outliers. Following this, we further examine the predicted AOD values by using an independent method (i.e., data from Lidar) to check the AOD variation. A more detailed discussion on this point is provided in the answer to the RESPONSE in "p 19765, l 11: The small group of highly underpredicted results (Fig. 5) …".

Finally, the usage of lidar data in the evaluation of the model performance is a good idea but a single measurement is just not enough. Moreover, for a proper comparison with the lidar, you should use extinction profiles from which you could integrate AOD. Of course, there are no extinction measurements during the day but you could select a suitable lidar ratio and use that to calculate the extinction profile from the backscatter profile. Furthermore, the comparison with other linear regression models is also superficial.

RESPONSE: As our response to the "single measurement" issue, please refer to the RESPONSE in "p 19764, l 18: A single comparison with LIDAR data does not provide enough data to support your conclusions."

As suggested, we have re-analyzed the LIDAR data. We refer the details to the RESPONSE for "p 19766, l 21: This lidar comparison is superficial. You should calculate AODs from the backscatter profile by assuming suitable lidar ratios."

We have added the necessary information such as RMSE and scatter plot in the RESPONSE for "Section 3.8: The comparison with other models is superficial. You only discuss R2 values. What about RMSE and biases?"

Specific comments:

The manuscript has several grammar issues. For example: p 19749, l 6: "are hardly quantifiable" p 19749, l 10: "conveniently analyzes air quality/pollution" p 19753, l 5: "sourced from alternatively selected data" p 19754, l 7: "were hardly quantifiable" p 19755, l 5: "the lowest AOD ranged from" p 19759, l 25-28: the whole sentence p 19761, l 16: "in clearing atmospheric conditions"

The following responses to Referee #1 are made after taking into consideration of the comment and suggestion of Referee #2.

RESPONSE: Thank you for spotting and pointing out our grammatical mistakes. We have corrected these mistakes. Below is a list of our correction:

p 19749, l 6: "are hardly quantifiable"

RESPONSE: are only coarsely quantifiable (the correction was suggested by Referee #2)

p 19749, l 10: "conveniently analyzes air quality/pollution"

RESPONSE: the sentence was deleted (as suggested by Referee #2)

p 19753, l 5: "sourced from alternatively selected data"

RESPONSE: p 19753, l 3-5 was rewritten to avoid unnecessary confusion:

"The data for each seasonal monsoon were further divided into two subsets for cross-validation purpose."

p 19754, l 7: "were hardly quantifiable"

RESPONSE: We have replaced the above phrase by "were difficult to quantify".

p 19755, l 5: "the lowest AOD ranged from"

RESPONSE: We replaced p 19755, l 3 – 6 by new sentences:

The climatological results derived from AERONET (http://aeronet.gsfc.nasa.gov/new_web/V2/climo_new/USM_Penang_500.html) for USM Penang is tabulated in Table 1. The monthly AOD (referred to as AOD_500, second column) shows that the two lowest AOD values are 0.18 and 0.19 during the inter-monsoon period (October–November and May).

p 19759, l 25-28: the whole sentence

RESPONSE: We have corrected the sentence based on the suggestion proposed by Referee #2. The sentence now reads:

During the northeast monsoon period, air parcels flow southwestward from the northern part of southeast Asia (Fig. 4a), including Indochina, transported through the South China Sea to reach Penang.

p 19761, l 16: “in clearing atmospheric conditions”
RESPONSE: We have corrected the sentence based on the suggestion proposed by Referee #2. The sentence now reads: “The insensitivity of the aerosol models *to clear* atmospheric conditions was also previously observed (Zhong et al., 2007).”

p 19750, l 5: Why is continuous retrieval of AOD difficult? Satellite instruments and sun photometers do it continuously.
RESPONSE: It is true that both satellite instruments and sun photometers do it continuously. However, the data often have to be discarded due to the presence of cloud. Second, the polar orbiting satellites can only acquire data at limited time window. For example, MODIS acquired data only twice per day. Furthermore the satellite data cannot be used if cloud exists during the acquisition period. As such, the data in practice are often rendered discontinuous.

p 19750, l 21: Explain here what is API and how it is calculated.
RESPONSE: Please refer to p 19752, l 16-20.

p 19751, l 23: What do you mean with the optical properties? Precipitable water is not an optical property, it isn’t even an aerosol property. It describes the amount of water in the atmospheric column.
RESPONSE: Thanks for pointing this out. We have corrected the sentence. It now reads:

“The optical properties of aerosols such as AOD and Angstrom exponent were analyzed to identify the aerosol characteristics in Penang during each period. Meanwhile, the precipitable water (PW) which is used to show the total water content in the atmosphere is in dry or moist condition.”

p 19751, l 26: What is the value in seasonally discriminated aerosol types?
RESPONSE: I am not exactly sure what you refer to by this question. I assume that the “value” is that reported in Table 2. The characteristics of each aerosol type are defined in Table 2. The definition of each aerosol type is independent of monsoon season. The main message we wish to convey in p 19751, l 26-27 is that we want to know what the dominant aerosol type are in each monsoonal season.

p 19752, l 8/13: Be more specific in the description of the data sets. What parameters (AOD, Angstrom?) from AERONET data were used? What parameters (visibility, API?) from NOAA data were used?
RESPONSE: AERONET in p 19752, l 8 should be replaced by “AOD”. The word of “in situ” in p19752, l 9 is now changed to “Vis”. We have also removed p 19752 l 11 – 14, as suggested by Referee #2. After these changes, the description of the data sets should now become more specific and less ambiguous.

Section 3: In the text you talk about monsoon periods but in the plots you have monthly ranges. Therefore, it is hard to link the plots with the text. Use the same nomenclature through out the paper.

RESPONSE: We have clearly defined each monsoon periods with corresponds months range in p19751, l 19-22 in our original manuscript. I agree that the nomenclature should be standardized when referring to monsoonal seasons. We will use the nomenclature "northeast", "pre-monsoon" etc. instead of referring them as "Dec - Mar", "Apr - May" etc. We shall correct the nomenclature in the captions of related figures and tables.

p 19755, l 11-14: How is precipitable water linked to aerosol size? What does the limit 4.1 mean here?

RESPONSE: In p 19755, l 11-14, we do not intent to analyze "how is the precipitable water linked to aerosol size". We merely report the climatology in Penang. Basically, if PW > 4.0 it means the atmosphere is in humid or moist condition. Please refer to (Okulov et al., 2002).

p 19756, l 2/5: What are Fig 1a(i) and (ii)?

RESPONSE: Thank you for pointing out this. The is actually no Fig. 1a(ii). As a correction, we have removed "Fig. 1a(ii)" in p 19756, l 2/5 by "Fig. 1a".

p 19756, l 9: Based on Fig 1. I couldn't say that Angstrom exponent has noticeable trends.

RESPONSE: I have rephrased the sentence. The sentence now reads: "The frequency distributions as function of Angstrom exponent displays a trend (Fig. 1b), in which approximately 95% of the total occurrence fall within the range of 1Å to 2Å."

p 19756, l 11: In other parts of the text you mention that the site is affected by marine aerosols. Usually, marine aerosols are thought to have coarse particles.

RESPONSE: You are right. Marine aerosol can also be referred to the coarse particles. The coarse particles in p 19756, l 11 are referred to dust particles but not marine aerosol.

Fig. 1b shows that approximately 95% of the total occurrence falls within the range of 1Å to 2Å, indicating the dominance of fine (i.e., non-course) particle (please refer to the threshold values for marine and dust aerosol in Table 2). The high relative frequency for MA in Fig. 3 also supports the fact that the marine aerosol is likely to be comprised of fine particle. To further support our statement, we refer to (O'Dowd et al., 1997). They shows that sea salt (marine aerosol in our context), which is defined to have a size between 1-10 µm, is mostly found below 2 µm. Whereas the mineral dust particles (we refer them as dust aerosol) can be extremely large. Majority of them are > 10 µm over the source origin. However, over the ocean region dust particles can become as small as only a few µm (Duce, 1995). Therefore, in our case we prefer to describe the coarse particle as "dust".

p 19756, l 25: How can you say that you have biomass burning aerosols from Indonesia just on the basis of Angstrom exponent that varies between 1.4 and 1.8? Doesn't sound plausible.

RESPONSE: We modify p 19756, l 25 so that it now reads: "During and before southwest monsoon, the Angstrom exponents in Penang ranged between 1.4 and 1.8, indicating the likely presence of biomass burning aerosols (Holben et al., 2001; Gerasopoulos et al., 2003; Toledano et al., 2007). They are likely to originate from local and neighboring countries. Indonesia is known to be very active in open burning during this season. Furthermore, southwest monsoon wind is likely to have transported these biomass burning aerosols to Penang."

p 19756, l 29: Why are you considering only the cases with PW < 4.0?

RESPONSE: I am not only considering the cases with PW < 4.0 BUT I also have mentioned the cases of PW < 3.5 and PW value between 5.0 – 5.5 (please refer to p 19757, l 1 - 4). Actually, PW < 4.0 is an indicator of dry atmosphere, whereas PW > 4.0 for humid atmosphere, as suggested by Okulov et al., (2002).

p 19757, l 5: Please clarify why this discrimination is done.

RESPONSE: For the purpose of this paper, we first need to obtain the knowledge of the distribution of dominant aerosol type over Penang region in each seasonal monsoon change. The knowledge of the discrimination of aerosol type is then used to countercheck the AOD prediction model. In fact p 19752, l 6-7 has already implied such intention. In this regard, the investigation of the aerosol type over Penang in each seasonal monsoon serves as an independent piece of information that provides support for the AOD prediction model.

The aerosol type discrimination result is as tabulated in Fig. 3. It is supposed to be used to compare against AOD prediction (as in Table 3). However, we have left out an extensive comparison between these two in the text. To make up for this, we have modified p 19762 l 20 – 24 to the following:

"By comparing the types of dominant aerosol in each monsoon, we observed that the results as obtained in Table 3 coincide with the information from Fig. 3. Fig. 3 shows that the dominant aerosol type BMA (MA and UIA) during pre-monsoon and southwest monsoon period is (are) higher (lower) compared to post-monsoon and northeast monsoon. Such observation implies that the aerosol types are possibly related to the AOD prediction model. However, the relationship between the predicted AOD and aerosol type as observed in our model is qualitative and preliminary. Further study is needed. In addition, as mentioned in Lee at al 2012, Gupta et al 2013, the relationship between AOD to air quality at ground surface depends also on environmental factors. Environmental factors that are disregarded in an AOD model may lead to deviations in the predicted values."

p 19757, l 18: I'm not sure if all of the references are appropriate here. For example, Smirnov et al. (2011) didn't have any AOD-Angstrom scatter plots. A lot of references are given in various places, so please check that all of them are in proper places.

RESPONSE:

In p 19757, l 18, Smirnov et al. (2011) should be replaced by Smirnov et al., (2002b).

We have checked the references are in proper places.

Meanwhile, since Smirnov et al., (2011) does not provide or discuss in great length about AOD-Angstrom scatter plot, therefore we decide to remove this citation for the related part of AOD-Angstrom, such as (p 19758, l 14 and p 19767, 25). These citations will be replaced by Smirnov et al., (2002b, 2003).

p 19757, l 24: "The AOD values at 500nm are normally used to indicate the turbidity condition." I don't understand what is meant by this.

RESPONSE: Actually I have cited several references which have suggested this idea. It means the wavelength at 500 nm is suitable for studying turbidity condition. In addition, this wavelength is also very suitable for aerosol study, as pointed out by Stone, (2002).

p 19758, l 1: Why didn't you use Single Scattering Albedo (SSA) in the classification? You have that data from AERONET and it would improve your classifications significantly, at least for the cases with high AODs.

RESPONSE: As a matter of fact, we did attempt to incorporate SSA into our analysis in the beginning. However, due to the relative scarcity of SSA data point at Level 2, incorporation of SSA data into our present work results in an overall reduction of data points available for statistical analysis. The total number of AOD and Angstrom data points at Level 2 for the period of study is approximately 2800, whereas only approximately 120 SSA data is available for the period from 2012 – 2013.

p 19758, l 7: Where is the reference to Table 1?

RESPONSE: Please refer to the RESPONSE for p 19755, l 5.

p 19758, l 16: "the indistinguishable aerosol types in the study sites were large "This is no surprise. The method you use in the classification is not sensitive to different aerosol types.

RESPONSE: We refer this issue to p 19758, l 15-25. In p 19758, l 15-25, I have mentioned that the thresholds suggested by Kaskaoutis et al. (2007) and Pace et al. (2006), and Smirnov et al. (2002b, 2003) are not sensitive enough to distinguish aerosol type. But threshold suggestions by other researchers were tested, and finally the threshold values suggested by Toledano at al., (2007) give best results in aerosol type discrimination, in which only a very small percentage (< 5%) of aerosol type is not distinguishable. This proves that the method is good for this case.

Note: the citation to Smirnov et al. (2002, 2003, 2011) should be replaced by Smirnov et al. (2002b, 2003), as mentioned in the RESPONSE in p 19757, l 18.

p 19759, l 5: Isn't marine aerosols coarse?
RESPONSE: Our response to this question is bundled in the RESPONSE for p 19756, l 11 (see above), as the issue raised is effectively the same.

p 19760, l 11: You mention "several sources from Indochina" but couldn't the mixed aerosols be from marine origin?
RESPONSE: Yes, mixed aerosols indeed could also be from marine origin. However, such a fact is not emphasized because marine aerosol is constantly present in Penang in every monsoonal season. Therefore MA cannot explain the bimodal pattern in Fig. 1 (b) during northeast monsoon season. We suspect that the biomass burning aerosol is different for northern and southern SEA because of different types of burning process. The aerosols from northern southeast Asia is likely to be transported by the northeast monsoon wind and ultimately mixes with local aerosols. Therefore, we suspect that the aerosol that causes this (bimodal pattern in Fig. 1 (b) is most likely from northern southeast Asia.

p 19760, l 19: "MA was the major aerosol during the post-monsoon and northeast monsoon". Based on Fig. 3 this is true for post-monsoon but for northeast monsoon the major aerosol was urban/industrial.
RESPONSE: To make our point clear we have modified the sentence to the following: "The occurrence frequency of MA was higher during the post-monsoon and northeast monsoon compared to southwest and pre-monsoon period."

Section 3.4: All the other seasons are analyzed except southwest monsoon. Why?
RESPONSE: The analysis on southwest monsoon is mentioned in p19760, l 2-3, 25-26, and 28.

p 19761, l 9: "AOD_500, Angstrom440–870, and PW clearly distinguished the dominant optical properties of aerosol for each monsoonal season". I have to disagree with this statement.
RESPONSE: The issue is very similar to that in p 19751, l 23 (already responded above). We have revised the sentence as below:
"The optical properties of aerosol for each monsoonal season are obtained by analyzing the relative frequency occurrence of AOD_500 and Angstrom440–870. The relative frequency plot of PW value also shown each monsoonal season has different water amount in the atmosphere column."

p 19761, l 26: Could the number of points used explain the smaller bias in the overall dataset?

RESPONSE: The number of points used in the "overall" dataset is not related to smaller bias. Below we list down the number of data points used in the statistical analysis and the corresponding R^2, RMSE and %MRE.

Seasonal monsoon months	Number of data point	R^2	RMSE	% MRE
Northeast monsoon	257	0.41	0.110	8.34×10^{-4}
Pre-monsoon	132	0.64	0.114	8.33×10^{-4}
Southwest monsoon	235	0.77	0.172	-1.50×10^{-3}
Post-monsoon	166	0.42	0.061	-7.50×10^{-4}
Overall	790 (= 257 + 132 + 235 + 166)	0.72	0.133	-1.11×10^{-4}

From the data provided in the table above, a larger number of data point does not necessary result in small bias.

Section 3.5: There are a lot of information missing from this section. For example, what are the coefficients for the model? How was the model performance tested, what was the data used? It would be good to show the comparison in a figure.

RESPONSE: The coefficients for the model are provided below. BUT be reminded that different location should have its own coefficients due to different environmental and meteorological factors. These numbers are supposed to be generated using the latest available measured data and based on our algorithm each time one wants to use the model for AOD prediction.

Seasonal monsoon months	a_0	a_1	a_2	a_3	a_4	a_5	a_6
Northeast monsoon	-5.258258	1.430235	-0.186205	0.007749	0.144008	-0.003414	0.000027
Pre-monsoon	-8.410274	5.187873	-0.618050	0.023880	-0.442305	0.011303	-0.000090
Southwest monsoon	-1.784069	0.703384	-0.121808	0.005852	0.079780	-0.001641	0.000011
Post-monsoon	-1.114879	0.000000	0.019906	-0.001603	0.100698	-0.003488	0.000038
Overall	-0.102516	0.306677	-0.061396	0.003092	0.015541	-0.000356	0.000004

The performance of the model was quantified by referring to the values of R^2, RMSE, and %MRE in Table 3, which clearly shows the comparison results for each monsoon season. The way the data was used for AOD data generation has been explicitly explained in the Methodology section (Section 2). We opine that Table 3 is sufficient to represent the comparison of the predicted data for each season.

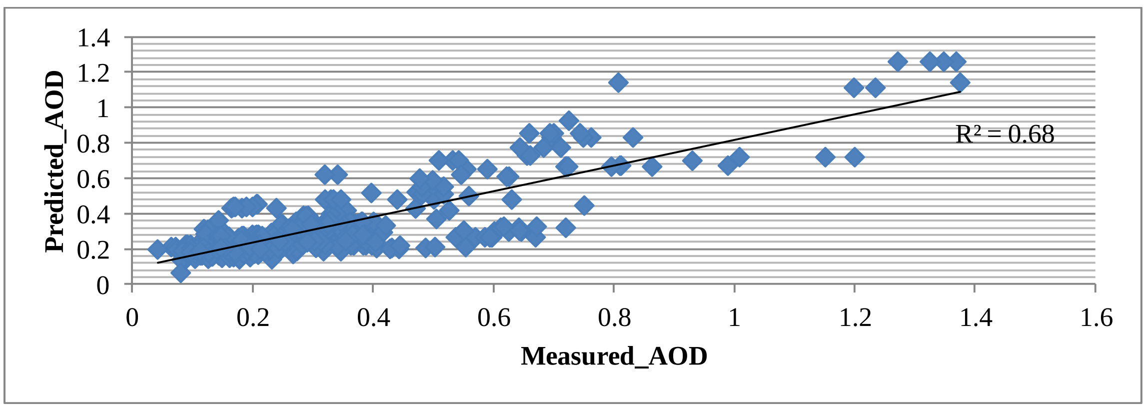
p 19762, l 14: "The accuracy of the prediction of the AOD model was moderate" Based on what?

RESPONSE: The sentence was edited as below:

"The accuracy of the prediction of the AOD model in post-monsoon and northeast monsoon is moderate when the aerosols in Penang were locally mixed with those from foreign sources because of the wind flow pattern during these two seasons (Fig. 4a and d)."

p 19764, l 8: "good AOD prediction" This seems to be conflicting with the previous point (p 19762, l 14). I suggest that you make a scatter plot of the measured and predicted AODs to show how well the values match.

RESPONSE: This issue is directly related to the one we have just responded above. p 19762, l 14 is referring to post-monsoon and northeast monsoon. Based on the data for these two monsoonal seasons alone, the predictions are moderate. However, the coefficients used for final AOD prediction are based on the "overall" data (average of all four monsoonal seasons) which results in a better AOD prediction. In our opinion, we think that line plot is more useful to show the variation of AOD as a function of time (Fig. 5). Anyway, we include here a scatter plot to fulfill the request of Referee #1.



p 19764, l 18: A single comparison with lidar data does not provide enough data to support your conclusions.

RESPONSE: Due to the fact that Lidar data points that coincide in time with measured from API, Vis, and AOD in level 2 are very limited in number, we are left with no choice. Despite the insufficiency in the amount of Lidar data, we can still derive much useful information about the un-well mixed aerosol layer in the atmosphere. The correctness of this information remains valid despite the time-coincident Lidar data point is limited in number. According to the literature review, we understand that the real atmosphere is not always in well mixed condition. And from our results in Fig. 5 we observed that small amount of the predicted AOD was highly bias (but from the test suggested by Lee et al., (2012), we knew that these points are not the actual bias but might be due to other reasons). In addition, majority of the predicted AOD were quite matched to the measured AOD, and the small deviation was matched for the case we discuss in the only Lidar measurements. We can assume that the highly deviated predicted AOD were due to the residue layer (the aerosols distributed beyond the planetary boundary layer) (Tan et al., 2014b, c). Additionally, particles propagating within the free troposphere is the factor sometimes cannot be ignored (Toth et al., 2014) when predicting columnar AOD in the atmosphere using near-surface measurement, or vice versa. Therefore, if a significant number of elevated aerosol plumes (equivalent to aerosol residual layer) occurred over the region, then a large deviation of the prediction value will be produced.

p 19764, l 28: You claim that there is a difference between the two predicted AOD values of 0.039 and 0.044. I don't believe it. The accuracy of the AERONET AODs is around 0.01 for 550 nm so I would say that the accuracy of your prediction (which is based on AERONET AOD) cannot be smaller. So it doesn't make sense to present the values with three decimals. If you use two decimals, the values are identical, 0.04. Therefore, I think that is analysis does not prove anything. Furthermore, you claim in the text that 0.044 is lower than 0.039.
RESPONSE: I strongly believed that you have misunderstood my point here. Please read again p 19764, l 20-21, 26-29, and p 19765, l 1-2.

We never claim that 0.044 is lower than 0.039. The value of 0.039 and 0.044 are the different between predicted AOD (from our model) and measured AOD (from AERONET) at 10 a.m. and 11 a.m. at local time, respectively. My point is that the predicted AOD at 10 a.m. is higher than the measured AOD as many as 0.039, whereas it is lower than measured AOD as many as 0.044 at 11 am.

To be clearly delivery our massage here we have rephrased p 19764, l 27-29 and p 19765, l 1-2, as suggested by Referee #2.
The aerosols had accumulated near the ground at 10:00 a.m., which was consistent with a slightly increased value in the predicted AOD of about 0.039. By contrast, most aerosols at 11.00 a.m. were at a higher level. This result corresponds with the lower value in the predicted AOD of approximately 0.044.

p 19765, l 11: "The small group of highly underpredicted results (Fig. 5) was attributed to the significant heterogeneity of aerosols in the atmosphere (e.g., aerosol residual layers) and the large amount of high-level transported aerosol (Tan et al., 2014b, c)" This statement has to backed up with data. Previously, you mentioned that you had only one lidar measurement from this period so I don't understand what data has been used here.
RESPONSE: Please refer to p 19764, 20-21. The only one data I meant to be the Lidar data must be coincide with AOD from AERONET, API and Vis from in-situ measurement.
Besides that, according to the literature review, we understand that the real atmosphere is not always in well mixed condition. And from our results in Fig. 5 we observed that small amount of the predicted AOD was highly bias (but from the test suggested by Lee et al., (2012), we knew that these points are not the actual bias but might be due to other reasons). In addition, majority of the predicted AOD were quite matched to the measured AOD, and the small deviation was match for the case we discuss in the only Lidar measurement. Therefore, we inferred that the highly deviated of the predicted AOD were seem like what have been discuss in (Tan et al., 2014b, c) who suggested about the residue layer (the aerosols distributed beyond the planetary boundary layer) should be the

possible reason to cause this deviation. Additionally, particles propagating within the free troposphere is the factor sometimes cannot be ignored (Toth et al., 2014), for near surface or ground based measurement correlate to columnar AOD in the atmosphere, and vice versa. Therefore, if a significant number of elevated aerosol plumes (same meaning to aerosol residual layer) occurred over the region, then a high deviation of the prediction value will be produced.

p 19766, l 21: This lidar comparison is superficial. You should calculate AODs from the backscatter profile by assuming suitable lidar ratios. You could verify the selected lidar ratios by comparing the calculated lidar AODs with AERONET AODs. If the AODs match, your lidar ratios are ok.

RESPONSE: As already mentioned in the manuscript (refer p 19766, l 21 - 23), our predicted AOD is well correlated with the temporal plot of the backscatter profile. Therefore we opine that the LIDAR comparison should be retained in the manuscript as it is.

As a response to the request of Referee #1, we have further analyzed the LIDAR signal to derive AOD values to compare against the AOD predicted from our model.

Our LIDAR uses a laser pulse of wavelength 355 nm, whereas the AERONET data are taken at a different wavelength. To obtain AOD data from AERONET at 355 nm, we have to perform a conversion, which will be described in the following:

Eq. (3) is derived from Angstrom power law showed by Ångström (1929). It is used for Angstrom exponent estimation ($\propto$) in terms of AOD (τ_a) measured at wavelength λ = 340 nm and λ =380 nm. In principle, if AOD and Angstrom exponent at one wavelength are known, AOD at a different wavelength can be computed, within the range of validity of Eq. (3).

$$\propto = -[(\ln \frac{\tau_{a_2}}{\tau_{a_1}}) \div (\ln \frac{\lambda_2}{\lambda_1})] \tag{3}$$

Therefore, AOD at wavelength 355 nm can be calculated as

$$\tau_{a_{355}} = \tau_{a_{340}} \times (\frac{\lambda_{355}}{\lambda_{340}})^{-\propto} \tag{4}$$

After the conversions, we repeat the procedure in Section 2 to obtain a new set of coefficients at 355 nm for the AOD predicting model.

Next, we need to obtain AOD value from the LIDAR signal. A Lidar ratio (L) is a constant, defined as the ratio of aerosol extinction coefficient (α_a) and backscatter coefficient (β_a), see Eq. (5). R in Eq. (5) is the range or altitude. α_a can be obtained once β_a and L are known. The value of L has to be assumed if the LIDAR system is elastic. In our case we set L = 70sr, because this period is common affected by the biomass burning aerosol (as is shown Fig. 3) (Tesche et al., 2011;Lopes et al., 2012). AOD value (τ_a) can be obtained using Eq. (6), where R_{max} is the maximum height of aerosol distribution, and R_0 (=1) is the overlap function.

$$L(R) = \frac{\alpha_a(R)}{\beta_a(R)} \quad (5)$$

$$\tau_a = \int_{R_0}^{R_{max}} \alpha_a(R)dr \quad (6)$$

If the LIDAR signal is affected by cloud, the AOD data calculated from the LIDAR signal will be removed. Then the time between the predicted AOD from our model and that calculated from LIDAR signal was compared so that coincidental AOD data are picked out. The result of comparison between the predicted AOD (by our model) and that derived from LIDAR is shows in Fig. 10. The correlation between these two sets of data is strong, as R^2 obtained is 0.86 with RMSE = 0.18. Via this independent check, we have further validated the robustness of our AOD prediction model.

NOTE: The content of this response, which is relatively lengthy, will be inserted into p 19766 l 26.

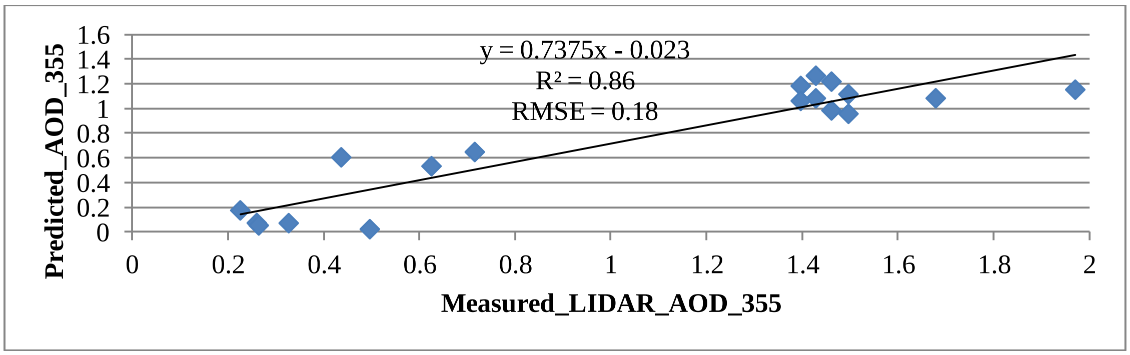


Figure 10. A scatter plot for AOD_355 predicted from our model versus the AOD calculated from Raymetrics LIDAR system.

Section 3.8: The comparison with other models is superficial. You only discuss R2 values. What about RMSE and biases? I would suggest to use scatter plots to show how well the models match the measurements. Moreover, present the coefficients used in the equations.

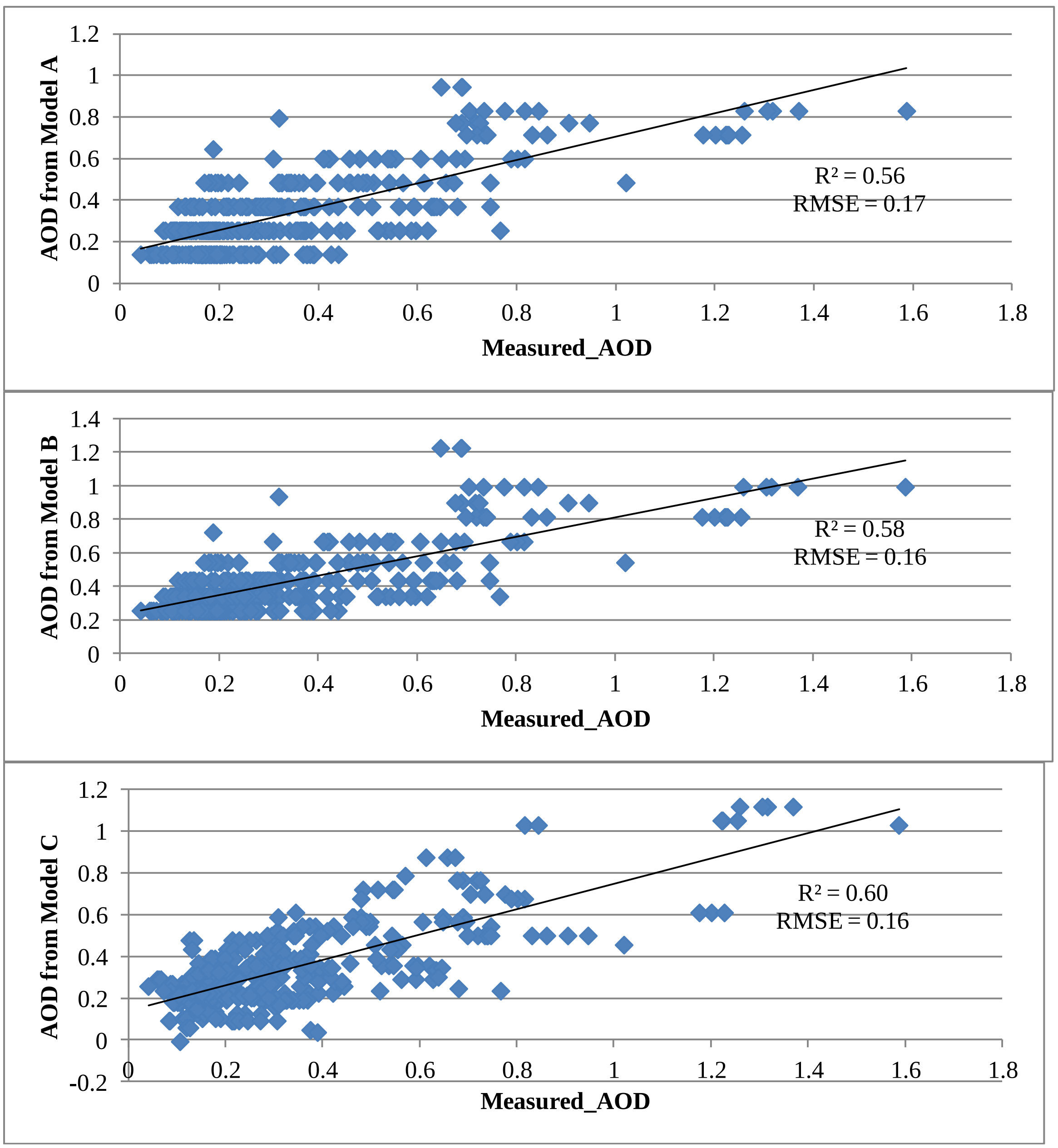
RESPONSE: We have added the coefficients and RMSE to Table 4. We would like to modify the sentence for p 19767, l 15-19 as below:

"The obtained PM_{10} values were inputted into the linear regression formula to predict AOD. The linear regression yielded $R^2 \leq 0.6$ with RMSE approximately 0.16 and above, which was much lower than that of our model (≥ 0.72 with RMSE = 0.13) based on the comparison of R^2 values for the "overall" dataset in Table 3 against those in Table 4. This result implied the dominance of the proposed model in terms of R^2 and RMSE."

We also showed the scatter plot for each of them. Actually, we believe that Table 4 is enough for the purpose of making comparison. The scatter plot is not really necessary.

Table 4. R^2 values of the AOD predicted by selected linear regression models from the literature.

Model	Author(s)	R^2	RMSE
A) AOD = 1.286 + (-0.115 (Vis))	(Retalis et al., 2010)	0.56	0.166
B) AOD = 2.106 + (-0.804 (b_{ext}))	(Mahowald et al., 2007)	0.58	0.162
C) AOD = -0.184 + 0.011 (PM10)	(Gao and Zha, 2010;Chen et al., 2013)	0.60	0.159



p 19768, l 10: Do you consider marine aerosols to be pollutants?
RESPONSE: Marine aerosols can be either clean or polluted. Since we are unable to determine this in our study, we will tone down the sentence to be "UIA and MA were the major aerosols in Penang throughout the year."

p 19768, l 19: If RH didn't play a role in the model, why was it there in the first place?
RESPONSE: I have already mentioned that Eq. (1) was proposed by Tan et al. (2014a). In our case, we analyzed our data and observed that RH did not contribute significantly to our AOD prediction (refer to p 19754, l 1-3). Therefore, we only decide to remove the RH term and form Eq. (2).

Section 4: I would suggest that you present the conclusions with values so it is easier for the reader to see how well the model performed and such.
RESPONSE: Thanks for the suggestion. We have revised the sentence in p 19768, l 28 and p 19769, l 1-2 as below:

"The R^2 and RMSE values in our model are ≤ 0.72 and 0.13. These figures are to be compared with the results of other relevant work which obtained $R^2 \leq 0.60$ and RMSE approximately 0.16 and above (see Table 4). The comparison indicates that the quality of our AOD prediction is statistically better than those simple models."

Since we have added a new analysis to compare AOD calculated from LIDAR to AOD predicted from our model (as shown in RESPONSE for p 19766, l 21), we would like to add a new sentence into Section 4 in p 19768, l 21. The sentence to be added in reads:

"In addition, we also validate our predicted AOD by an independent method using data derived from LIDAR system. The values of R^2 and RMSE from the comparison between our model and LIDAR-derived data at wavelength 355 nm are 0.86 and 0.18 respectively. This has added additional weight the robustness of our AOD prediction model."

References: Check the references for typos. For example, Smirnov (2002b) and Tan (2014c) have them.
RESPONSE: Checked and corrected.

Table 1: This isn't mentioned in the text.
RESPONSE: Table 1 will be inserted into p 19755, l 3 (as shown in RESPONSE for p 19758, l 7).

Fig. 1: Printed version hard to read. Consider leaving the columns out. They don't provide much information.
RESPONSE: The columns in the plot of Fig. 1 were left out. Additionally, the line of "overall" in Fig. 1a to 1c were changed to square dotted line. The new version of Fig. 1 is shows as following:

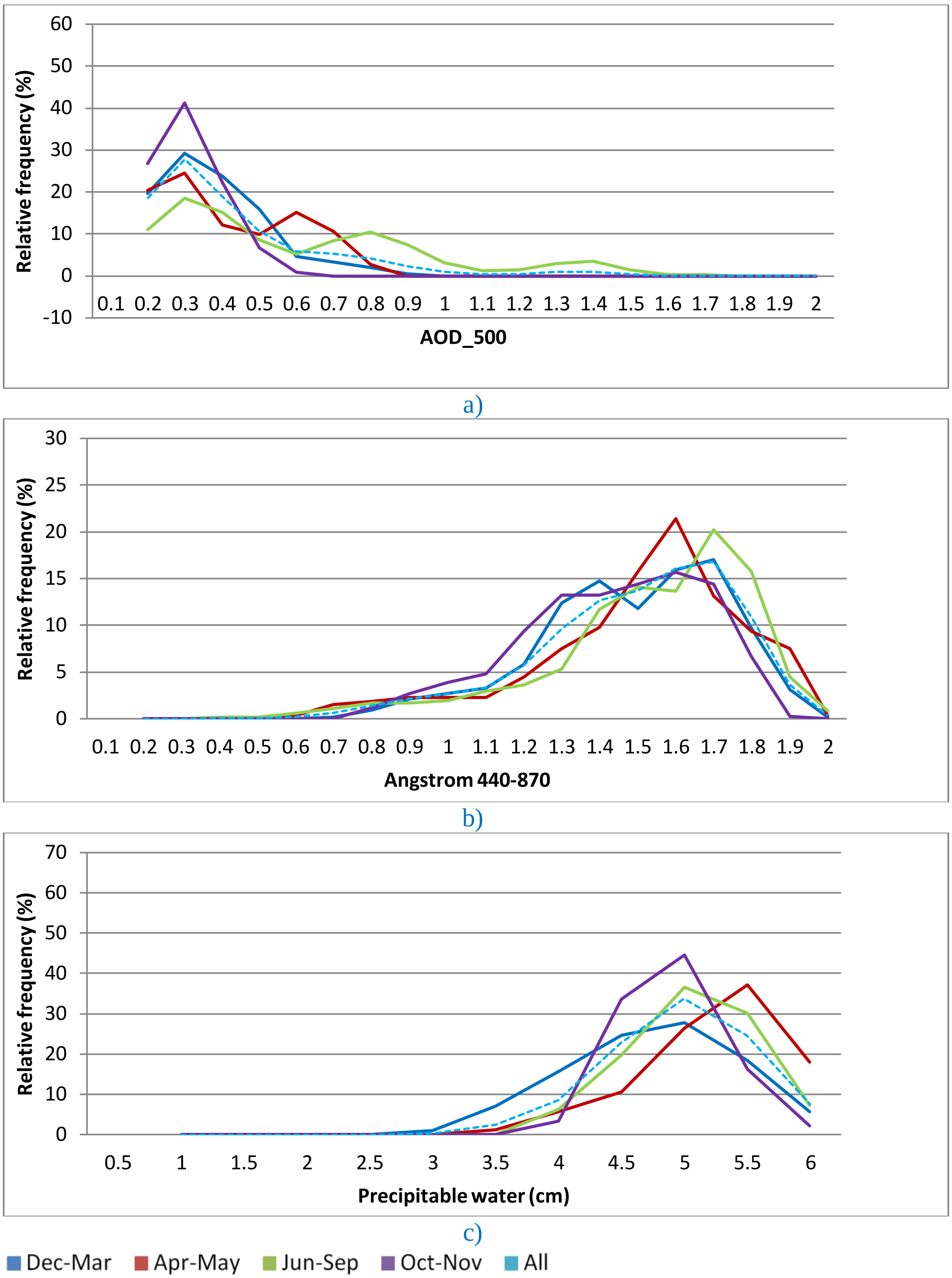


Figure 1. Seasonal relative frequencies of occurrences of **(a)** AOD_500, **(b)** Angstrom440–870, and **(c)** PW in Penang for February 2012 to November 2013.

Fig. 4: Printed version is impossible to read. You should have the same region in all of the plots. That would help the comparison. Why plot a) has a different scale than the others and what is the e) plot. It isn't mentioned anywhere.
RESPONSE: The original submitted figure is qualified.

The scale of Fig. 4 is not necessary to change, because the frequency density of the air flow pattern can be clearly seen in each monsoonal season. We opine that the scale does not provide any useful information for this case.

Thanks for notifying about the Fig. 4e. We replaced the words "The Fig. 4a-e" in p 19761, l 2, by "Fig. 4e".

Fig. 7: Printed version hard to read. What is the difference between figures 5 and 7?
RESPONSE: The original submitted figure is qualified.
Fig. 5 and Fig. 7 are absolutely different. Please refer to p 19762, l 27-28 for Fig. 5, and refer to p 19765, l 15-23 for Fig. 7.

Fig. 8: This figure could be left out.
RESPONSE: We opine that Fig. 8 should be included because it is useful for showing that the application of the AOD prediction model. Detail can be found in p 19766, L 3-15.

Fig. 9: Hard to draw any conclusions from this figure.
RESPONSE: We refer the details to the RESPONSE for "p 19766, l 21: This lidar comparison is superficial. You should calculate AODs from the backscatter profile by assuming suitable lidar ratios."

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