Reply to Reviewer #1

We are thankful to Reviewer #1 for his/her comments and suggestions.

The comments from Reviewer #1 are in italics followed by our responses:

1. To the first part of the paper, regarding the comparison of models and observations:

- While the authors document significant difference between their model and observations for the chosen time period, it is hard to interpret the results without some knowledge of natural variation in aerosol loading in the region. A brief discussion on this, e.g. including some climatology of AODs from MODIS or AeroNet, would be beneficial to the reader her.

Following the reviewer's suggestions, we added a new paragraph describing the regional AOD climatology from MODIS as the new first paragraph of Section 3.1 after the first sentence "The model simulations of monthly mean AOD for March 2012 are compared with the MODIS/Terra satellite observations in Fig. 1" on Line 15, Page 16910, as follows:

"…During this time of the year, the Indo-Ganges Valley is impacted with locally emitted aerosols from urban and industrial sources as well as dust mainly from nearby arid agricultural lands and deserts (Giles et al., 2011). As shown in Fig. 1a, the MODIS retrievals of AOD are generally larger than 0.5 in these areas. Given the dry pre-monsoon conditions with small wet removal, these aerosols are transported in long distance by the northwesterly winds prevailing in the Valley. That leads to similarly high AODs (>0.5) over to the Bay of Bengal and the eastern India in the MODIS observations. Another aerosol hotspot is off the southwest coast of the Indian subcontinent, influenced by both nearby anthropogenic emissions in the western India and long-range transported pollutions from the northern India (Ramanathan et al., 2001). Dust dominates the AOD observed over the Arabian Sea with values about 0.3~0.5."

Some portion of the discussions on differences between the model results and MODIS AOD in the same paragraph of Section 3.1 (from Line 15, Page 16910 to Line 3, Page 16911) are revised accordingly to exclude the repetitions from the new additions above, as follows:

"The model-calculated AODs (shown in Fig. 1b) are lower than MODIS retrievals over most of the domain, while the overall geographic pattern of AOD distributions is simulated except for over the Arabian Sea. Large AODs are predicted in northern and eastern India and along the pathway that the aerosol plumes travel to southwestern India and the downwind as depicted similarly in the MODIS observations. But the maximum AOD values calculated by the model are much lower around 0.3~0.4. AODs less than 0.1 are predicted over most of northwestern India and the adjacent oceans, whereas MODIS has much higher values (> 0.3). …"

Additionally, we added a new sentence to the second paragraph of Section 3.1, on Line 14, Page 16911, to describe AOD climatology at two ground sites: Nainital and Kanpur, as follows:

"…nearby Kanpur (~390 km southeast; the two sites are marked in Fig. 1b). Being a relatively clean site, Nainital has a monthly mean AOD of 0.232 from MFRSR measurements, while the mean AERONET AOD is 0.583 at Kanpur. The discrepancies between the modeled and observed AOD are much smaller at the Nainital site in Fig. 1d…"

2. The authors provide some indication of the uncertainty on the CALIPSO data, but apart from this there is little evaluation of the significance of the differences found between models and data - e.g. in

Table 1 and Figure 2. An assertion that a significance test has indeed been performed should be added here.

The following statement on significance tests is now added to the end of the second paragraph of section 3.2, on Line 11, Page 16913, following the discussions on Table 1 and Figure 2:

"…available on the regional scale. Two-sample t-test of extinction time series suggests that the differences between the model calculations and observations (MPL data for Nainital and Kanpur; and CALIPSO data for South Asia) are significant below 2.5 km with p-values less than the significance level of 0.05."

Additionally, significance test results are provided below for Reviewer's reference. Figure R.1 below shows the calculated monthly mean and standard deviation of modeled and observed daily aerosol extinction profiles for Nainital, Kanpur, and South Asia, respectively. Since there are only 3 and 4 CALIPSO tracks with valid retrievals over Nainital and Kanpur in March 2012 (as given in Table 2; numbers in parentheses), the ground-based MPL profiles are shown for those two ground sites instead of CALIPSO retrievals and used in the t-test. This figure shows that the model means ± standard deviations are less than the observed means below 2.5km for all three locations.

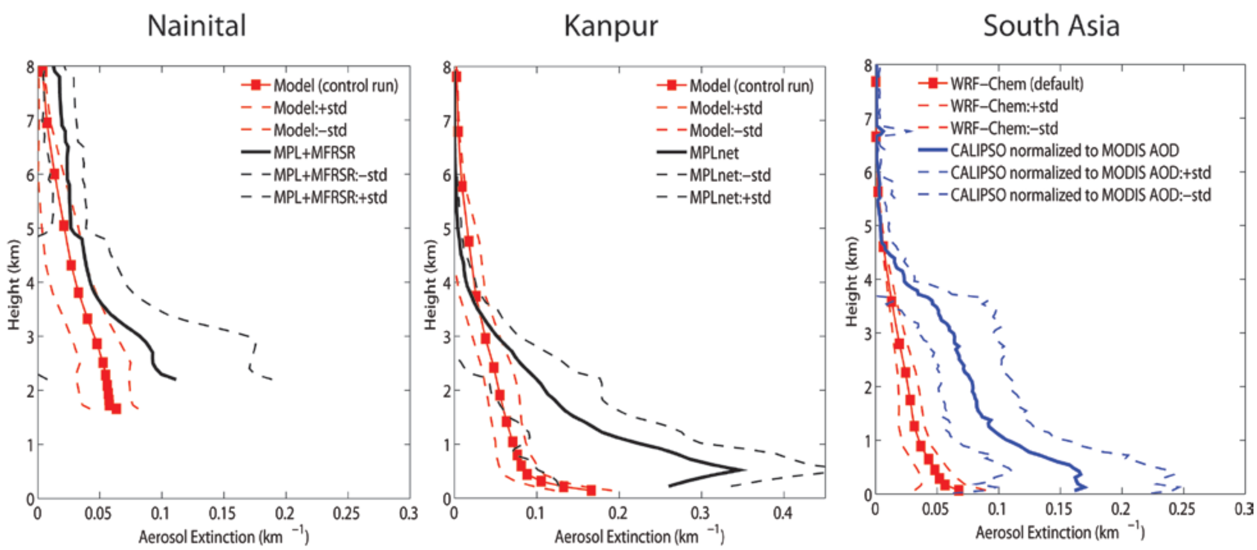

Figure R.1 Monthly mean and mean ±standard deviation of modeled and observed daily aerosol extinction profiles for Nainital, Kanpur, and South Asia, respectively

Furthermore, the p-values calculated in the t-test for a selection of altitudes are listed in the table below for each location. It suggests that below 2.5km, the model and observed extinctions are statistically different with a p-value less than 0.05.

Nainital Z(km)	2.3	2.5	2.9	3.3	3.8	4.3	5
P value	0.009	0.0489	0.112	0.128	0.188	0.115	0.207

Kanpur Z(km)	0.2	0.6	1.4	2.4	3.	3.7	4.8
P value	8e-8	1e09	1.9e-7	0.004	0.10	0.31	0.005

South Asia Z(km)	0.2	0.7	1.3	2.3	2.8	3.6	4.6
P value	0.	0.	0.	0.	0.	0.	0.06

3. To the second part, on the radiative and thermodynamic responses to the different aerosol profiles:

- For the results shown in Figures 5, 6 and 7, it is hard to assess whether the differences found are actually due to the changes to the aerosol profiles, or to internal variability in the modelled climate system. While the focus here is on the difference between the extinction profiles, under identical climate conditions, running e.g. three perturbed ensemble members for each profile for the selected month would greatly strengthen the impact of these figures. I would urge the authors to consider this, even if it means spending some extra computational time.

We would like to clarify that for the results shown in Figures 5, 6 and 7, differences found between the three cases (control run, case I, and case II) are due to the changes to the aerosol profiles, because they all deviate from the same base simulation without aerosols and the only difference between the three cases is the aerosol profile used. These differences, as also noted by the reviewer, are the focus of this study, and they are not directly related to the model internal variability.

The model internal variability may affect the results of each case (control run, case I, and case II), which represent the absolute aerosol effects simulated. While we agree with the reviewer that the ensemble mean is helpful to quantify the absolute aerosol effects (also a longer simulation period may be necessary), we do not think that it would help much on our focus on the differences between the absolute aerosol effects.

To account for this point raised by the reviewer, we revised the sentence in the Section 4, Summary and discussion, (Lines 28-29, Page 16923) from:

"…It would be desirable to conduct similar evaluations for longer times to better investigate the climate response to uncertainties in modeled aerosols…"

to:

"…It would be desirable to conduct similar evaluations for longer times and use ensemble members of perturbed meteorological conditions to better investigate the climate response to uncertainties in modeled aerosols..."

4. Page 16915, line 27: "Therefore, the largest warming is calculated for Case I". Given the almost vanishing temperature response over oceans here, and the closeness of the three curves in Figure 3, is this statement statistically valid?

Agreed that the differences in temperature responses over oceans are small between three cases in Figure 3, because of the fixed sea surface temperature. This sentence on Page 16915, line 27 is now removed.