Response to Reviewer #1
(Our response in blue)

Reviewer:
General Comments:
This manuscript reports on ground observations of aerosol, water vapor and radiation collected at several sites across northern India and Nepal over a 2.5 month period (April – June) in 2009, and it attempts to use this data to ascertain the radiative forcings from aerosol and water vapor across the region. Unfortunately, the manuscript provides no original conclusions, falls far short on scientific rigor and reporting, misses basic principles in radiative transfer, and is unfocused on the significance of the findings. Therefore, I am recommending rejection of this manuscript by ACP. Given the long list of coauthors, many of whom I know are well established scientist, I wish that they would have taken more time in reviewing this manuscript rather than leaving it up to reviewers like myself (who are also very busy) to provide feedback to the first author. After all, the coauthors are getting the credit, not the reviewers.

Response:
As the Reviewer notes in the opening statement, "This manuscript reports on ground observations of aerosol, water vapor and radiation collected at several sites across northern India and Nepal over a 2.5 month period (April – June) in 2009, and it attempts to use this data to ascertain the radiative forcings from aerosol and water vapor across the region."

Elaborating the Reviewer statement as follows:
This manuscript reports ground-based column integrated observations of aerosol loading and optical properties, water vapor and broadband surface solar flux at several sites (10 sites) over northern India and Nepal (covering the near-desert location, Indo-Gangetic Plains and foothills and elevated southern slopes of the Himalayas) over a 2.5 month period during the pre-monsoon season (April-June) to study the aerosol and water vapor dynamics across the region and associated radiative impact.

The above statement reflects the Introductory background of this manuscript and clearly justifies the potential of its publication in ACP, unlike the Reviewer's recommendation.

It is quite surprising and unfortunate that an ACP Journal Reviewer has given such improper and sweeping comments and has overlooked the findings of this manuscript based on a unified set of observational data aimed at improved understanding of the highly variable aerosol loading, water vapor dynamics, aerosol absorption and radiative effects, collectively over 9 locations in the complex environment of northern India and Nepal during the critical pre-monsoon period. The uniqueness of the paper also lies in the quality of data collected from same instrumentation protocol and calibrations applied for the AERONET sun photometers, Microtops and pyranometers used in the study. The paper reports aerosol related observations capturing the zonal gradient (from west to east) and the vertical transects from the IGP to the elevated mountain slopes – which has not been collectively reported during the course of pre-monsoon season in previous studies. This ground-based observational study focuses on better understanding and improved characterization of the highly variable aerosol loading, comprised of mineral dust, biomass burning and anthropogenic aerosols, and changes in aerosol optical/radiative properties, strongly influenced by the dynamic meteorological conditions, from

the desert/arid climate in northwestern India to the eastern parts of the IGP as well as along the southern slopes of the Himalayas. In the paper, we also highlight the aerosol and water vapor variability and dynamics during the important transition period from dry to monsoon onset conditions over the Gangetic-Himalayan region using column-integrated measurements carried out in a unified and consistent manner from 9 locations in northern India and Nepal.

We therefore strongly reject Reviewer's notion that "Unfortunately, the manuscript provides no original conclusions, falls far short on scientific rigor and reporting, misses basic principles in radiative transfer, and is unfocused on the significance of the findings." for the reasons listed below.

The current manuscript expands and advances the knowledge of aerosol loading in the Gangetic-Himalayan region as follows (and we therefore believe its potential publication in ACP):

- A focused characterization of aerosol optical properties and their distribution during pre-monsoon period from west to east and south to north of the Gangetic-Himalayan region, thus representing the spatial and vertical domain of the complex environment.
- Based on radiometric measurements from 2009, this manuscript provides insight into the aerosol loading and absorption distribution and highlights the gradients associated with greater dust loading and higher SSA in northwestern India (and western IGP). In contrast, lower SSA (more absorbing aerosol) is associated with reduced dust transport and more carbonaceous aerosols in the eastern IGP (Gandhi College), especially over Nepal transect associated with upslope transport of urban pollution and forest fire smoke activity.
- A dynamical perspective presiding the characteristic aerosol distribution is proposed such that the prevalent dust-laden westerlies strongly influence the aerosol properties in northwestern India, while the lack of a prevalent wind pattern due to a cyclonic flow in the eastern IGP and Nepal region impedes influx of dust leading to prevalence of a fine-mode dominated strongly absorbing haze.
- In the above dynamical context, the dust-laden westerly airmass, enriched with moisture, is characteristic to northwestern India during the course of the pre-monsoon period from April to June, leading to a strongly coupled regional aerosol-water vapor loading airmass, in contrast to the eastern regions.
- With ground measurements limited to one pre-monsoon season, we also attempt to highlight the aerosol solar absorption from IGP to Nepal Himalayas foothill/slope region, together with the impact of the moisture-laden airmass on the aerosol radiative forcing and provide comparisons with previous published studies.

In reference to the above points, the Reviewer states that the manuscript does not offer any original conclusions – which we believe is an erroneous evaluation.

Reviewer:
Specific Comments:
The manuscript provides no original contribution to knowledge. All findings in the abstract can be found in the literature. A couple of recent papers that provide reasonably good reviews and views on aerosol properties over India include Lawernce and Lelieveld (ACP 2010) and Dey and Di Girolamo (JGR 2010). The authors may find the exchange between Ramachandran and Satheesh (AE 2007) enlightening on issues pertaining to radiative forcing calculations. After carefully studying these papers and the references found within them, the authors will realize that they missed many important references that have made similar conclusions with greater scientific rigor, confidence, and context than what is presented in this manuscript.

Response:
Once again, too many sweeping statements are made by the Reviewer in the above paragraph related to originality of the paper that we rebutted in the above points. Regarding the two papers mentioned by the Reviewer, we will cite those recent studies in the paper. Though, it should be noted that Lawrence and Lelieveld (ACP 2010) presented a review focusing on outflow of South Asian aerosols towards the surrounding oceanic regions. On the other hand, the current manuscript is focused on the influx and accumulation of aerosols over northern India and Nepal during pre-monsoon period. Regarding Dey and Di Girolamo 2010 paper on seasonal aerosol climatology over India from satellite (MISR) data, we will refer to their findings in our revised submission. We would like to note here that during the time of preparation of the manuscript, few papers from the recent period (2010-11) were missed and therefore will be included in the revised submission.
Regarding the exchanges between Ramachandran and Satheesh (AE 2007) on issues pertaining to radiative forcing calculations, their correspondence focused on model simulations related to effects of internally mixed vs. externally mixed aerosol species on surface forcing estimates. Our paper utilizes ground-radiometric measurements to constrain solar flux calculations using external mixture of aerosols to derive radiative forcing estimates at surface and single scattering albedo (in close agreement with AERONET SSA). Similar methodology of aerosol radiative forcing estimation was followed in Gautam et al., 2010 over Kanpur and several other studies dealing with pyranometer measurements (in the absence of quantitative surface in situ chemical data). We will include the uncertainties associated with radiative forcing calculations in the revised submission, per the constructive commentary of Reviewer #2, as we show in our response for Review #2.

Reviewer:
There are too many technical problems (large and small) for me to cite. Since the lack of originality is enough to reject this manuscript, I'll only cite a couple of examples:

Response:
Reviewer's jittery comment on lack of originality is not justified as rebutted above.

Reviewer:
Discussions on "water vapor measurements" (not defined, but it looks like the authors mean precipitable water) and pyranometer details and uncertainties are completely missing. There's also no detail on MODIS retrieval uncertainties. [It is not even clear how Dark-Target and Deep-

Blue are combined to produce a final reporting of optical depth or angstrom exponent. It doesn't even say whether the data comes from Terra or Aqua or both (only from one image caption did I see Aqua). Why not use both Aqua and Terra? Why not place these satellite data on Figure 5?] In fact the treatment of measurement and sampling uncertainty is missing, as are the usual tests for significance when describing temporal and spatial changes in the face of such low independent samples. One cannot draw scientific conclusions without these basic scientific procedures. There are some +/- numbers that show up here and there throughout the text and in the tables, but they are never defined. I suspect they are simply the standard deviation of the data that went into producing the mean, which only speaks to the variability of the data.

Response:
The purpose of the Aqua/MODIS Aerosol Optical Depth (composite mean from Dark-Target and Deep Blue products) in Fig. 3 is to show, in a qualitative sense, the spatial distribution and extent of the progressive increase of aerosol loading from April to June over northern India. All the detailed discussions and figures related to AOD/Angstrom Exponent and other optical properties (SSA, size distribution) are based on sunphotometer measurements. On the details and uncertainties of forcing calculations, we agree with the Reviewer and the related discussions will be included in the revised submission as also presented in our response to Reviewer #2.

Reviewer:
The radiative transfer modeling and its "adjustments" for retrievals is missing a lot of details that makes these results irreproducible or even believable. Simple things, like the surface spectral albedo for the different sites, are not mentioned. Model results are presented on aerosol and water vapor radiative forcing without the recognition of something that is very basic: the forcing will depend on the vertical distribution of BOTH aerosol and water vapor properties (as extreme examples: aerosols overlying the water vapor; and water vapor overlying the aerosols), in addition to the underlying spectral albedo, etc. No mention of this is very troublesome. There is some mention that CALIPSO aerosol extinction profiles are used, but no details on how (e.g., were they averaged, day and night, etc.). The fact that such basic things are missing leads me to have no confidence that the scientific method was followed.

Response:

As mentioned in the previous point and in our response to Reviewer #2, we will include details associated with radiative forcing estimation (at surface with respect to the pyranometer observations) in the revised submission. On the Reviewer's comment related to surface albedo, we use CERES-derived broadband surface albedo (Rutan et al., 2009, JGR) as input for the calculations. However, contrary to Reviewer's emphasis on the surface albedo aspect, the sensitivity of calculated shortwave surface flux to broadband surface albedo is low – which is something basic in total surface solar flux calculations (< than ±1.5% for the surface albedo range of 0.15-0.25, refer to our response to Reviewer #2).

Regarding aerosol and water vapor vertical profile inputs, we separate the aerosol and water vapor radiative forcing in model calculations by minimizing the relative humidity-dependency

factor (aerosol humidification effect) in the forcing calculations and therefore the vertical distribution has small effect (as long as the column-integrated optical depth is constant) on the diurnally-averaged surface forcing values (< than ±1% by perturbing a Gaussian aerosol profile peaking between 1 and 5km in model calculations, refer to our response to Reviewer #2). Aerosol optical model is the most sensitive parameter with significant direct radiative effect at surface as we show in Table 1 of the response to Reviewer #2, along with other variables in the model sensitivity study.

As mentioned above, we will include details of the radiative forcing calculations (with CALIPSO aerosol extinction profile input) and related uncertainties in the revised submission as also discussed in our response to Reviewer #2 comments and Table 1.