Responses to Reviewer Comments on

Interactive comment on "Transport of regional pollutants through a remote trans-Himalayan valley in Nepal" by Shradda Dhungel et al.

We thank the two anonymous reviewers for their helpful comments on and recommendations for improvement of the subject manuscript. We have made major edits to the submitted version, which has helped improve the clarity of our presentation. The responses to Referee #1 and #2 are included in this document. Each comment is listed below followed by our response to that comment (in italics).

Referee #1

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GENERAL COMMENTS

This paper by Dhungel et al., 2016, provides a first characterization of the variability of ozone and equivalent BC at a measurement site located in a Himalayan valley. Until now only sparse continuous measurements are available in the Himalayas region. Thus the data presented in this work can be considered of high interest for the advancement of knowledge about SLCF (short-lived climate forcers) variability in the Himalaya and about the emissions and atmospheric processes able to affect them. Unfortunately, it is not clear from the paper, which data coverage is available over the whole (2.5-year long) investigation period.

However, the paper suffers of major deficiencies that prevent publication in this current form. Indeed, the paper only provides a basic characterization of typical seasonal and diurnal variability of O3 and BC: only a tentative attribution of the observed variability in terms of valley wind regime. No information about the role of synoptic-scale transport variability is provided. The data analysis is basic and lacking of statistical analysis. The possible impact of open fire emissions in the IGP and Himalaya foothills should be better assessed by carrying out a systematic analysis. At least, the three case studies presented in Figure 6 should be better explored (as an instance by investigating them by using air-mass transport modeling and a better use of satellite data) and extended (e.g. no information is provided about the frequency by which the three "regimes" were observed over the whole measurement period). The occurrence of open fires is a typical feature of the pre-monsoon season in the Himalaya foothills. Why the transport of fire emission along the valley is observed only in a few cases? Which are the factors triggering the transport of open fire emissions?

Some previous works already extensively investigated the role of thermal wind circulation and open fire emission in affecting atmospheric composition in Himalaya (e.g. Bonasoni et al., ACP, 2010; Dumka et al., ACP, 2015; Lüthi et al., ACP, 2015; Xu et al., ACP, 2015; Raatikainen et al., Atmos. Env. 2014; Hyvärinen, ACP, 2011a,b). It should be great if the authors can discuss their results as a function of these previous investigations even clarifying the scientific advance of their study in respect to these previous works. As an instance, the diurnal behaviors of BC and O3 are significantly different from those observed at other Himalayan site (e.g. NCO-P, or Naintal ,see Bonasoni et al., 2010; Dumka et al., ACP, 2015) which reports eqBC increase from early morning and peaking in the afternoon. The authors should better motivate these differences. Finally, as also admitted by the authors, a not negligible influence on the observed behaviors could relate to local emissions (see the BC peak observed in the morning). It should be important (and interesting) that this local contribution is isolated and quantified before discussing eqBc and O3 variability.

Moreover, I cannot able to find along the paper a real proof about the transport of pollution from IGP to TP: the paper only presents observations inside the Himalaya valley, thus the export of this pollution to TP is just a speculation at this stage. . .

Finally, I strongly suggest a language revision by a native-speaking English person.

> *In response to the reviewer's comment, we have: 1) added additional references to relevant previously published work; 2) added qualifications regarding interpretation of pollutant transport from the IGP; 3) statistically evaluated differences between the daytime and nighttime concentrations across seasons; 4) added seasonal flux patterns and calculated the net daily fluxes between different seasons with statistical analysis; 5)clarified characterization of the different types of transport episodes 6)added HYSPLIT back trajectories to the examples of transport episode.*

SPECIFIC COMMENTS

Page 3, line 101. Extensive investigation of the role of valley wind system in favoring the transport of SLCFs to Himalayas was presented by Bonasoni et al., 2010 and reference therein. These researches can be profitably cited at this point of Introduction other than reporting the (rather dated) works from Alpine region. Also this work can be profitably cited: Quantification of topographic venting of boundary layer air to the free troposphere. S. Henne, M. Furger, S. Nyeki, M. Steinbacher, B. Neininger, S. F. J. de Wekker, J. Dommen, N. Spichtinger, A. Stohl, and A. S. H. Prévôt. Atmos. Chem. Phys., 4, 497-509, doi:10.5194/acp-4-497-2004, 2004.

> *The references section has been revised as follows:*
>
> *"In the European Alps, prevailing wind systems in the mountain river valleys funnel polluted air from peripheral source regions to high elevations in a phenomenon known as "Alpine Pumping" (Weissmann et al., 2005). Under fair weather conditions during daytime, the upslope winds are capable of transporting significant pollutants and moisture into the free troposphere (Henne et al., 2004). Relative to air over plains, the*

air within the valleys heats and cools more quickly (Steinacker, 1984). The resultant differences in temperature create gradients in pressure and density, which in turn drive transport of air from the plains to higher-elevations during the daytime (Reiter and Tang 1984, Whiteman and Bian, 1998; Egger et al., 2000). Numerous studies have looked at the possibility of the transport of pollutants from the IGP to the Himalayan foothills (Pant et al., 2006; Dumka et al., 2008; Komppula et al., 2009; Hyvärinen et al., 2009; Ram et al., 2010; Brun et al., 2011; Gautam et al., 2011; Srivastava et al., 2012). Other studies show that pollutants have the potential to reach not only the foothills of the Himalaya but also higher elevations (Bonasoni et al., 2010; Decesari et al., 2010; Marinoni et al., 2010). In addition, studies have shown the obstruction of flow caused by the high Himalaya which intensifies the effect of pollution over the IGP that are visible in satellite imagery especially during pre-monsoon seasons (Singh et al., 2004; Dey and Di Girolamo, 2010; Gautam et al., 2011). Though there is evidence of existence of similar source pollutants, both regional and local, in the foothills and the higher altitude sites (Raatikainen et al., 2017; Raatikainen et al., 2014; Srivastava et al., 2012,), observational evidence of mechanisms and pathways facilitating such transport via Himalayan valleys is lacking. Our data fills this gap by characterizing the role of the wind system within a deep Himalayan valley in transporting pollutants from the IGP to the high mountains."

Page 4, line 133: actually, the intrusion of the haze is not so visible from Figure 1a.

The image in figure 1a has been zoomed in to better show the intrusion of haze.

Page 4, line 138: the description of the valley orientation is difficult to follow. Some of the described features (e.g. Eastward orientation at Jomstom) cannot be captured by Figure 1. I would suggest to add to Figure 1 a more detailed map of the measurement site.

We have replaced table 1 with a new figure 2, which includes a clear map of the valley.

Page 5, line 148: please add to Table 1 a column with measured parameters

The measured parameters are now included in the new figure 2.

Page 5, line 151: actually "equivalent BC" is measured by MAAP.

The text now reads:

"Equivalent black carbon (hereafter referred to as BC)…" is specified when first used and, for efficiency, the acronym BC is used thereafter.

Page 5, line 158: please substitute "attenuation" by "absorption". For O3 and eqBC, please provide indication about measurement uncertainty and QA/QC procedures.

We have *changed attenuation to absorption. Additional description on QA/QC procedures have been added.*

Page 5, line 161: please indicate the percentage of data available over the period January 2013 – August 2015. Please, remove the sentence "Measurements of carbon monoxide. . ." (no CO data were presented/discussed in the paper).

A data timeline has been added as supplementary table 1 and we have removed CO measurements from the sentence.

Page 5, line 164: no winter season has been identified?

Our analysis focused on variability in BC and O3 variability during wet (monsoon) and dry (pre-monsoon and post-monsoon) seasons. Consequently, identification and interpretation of variability during the winter season was not directly relevant.

Page 5, line 169: I would skip "about 10 meters above and"

We prefer to retain the clarification that meteorological parameters were measured 10 meters above ground to ensure that readers know that AWS were above the surface layer.

Page 5, line 175: I cannot understand this kind of normalization. Why did you not report actual eqBc and O3 values? You should simply report the averaged seasonal diurnal variation of O3 and eqBC obtained by subtracting averaged monthly values from hourly values.

The approach we employ here to characterize diurnal variability normalizes for day-to-day variability in concentrations, quantitatively captures the frequency distributions in normalized cycles, and is widely used in the literature (e.g., Sander et al., 2003, ACP; Fischer et al., 2006; JGR, Keene et al., 2007, JGR; Smith et al., 2007, JGR, Young et al., 2013, JGR; among others). Cycles derived from average values typically dampen the relative range of actual diurnal variability.

Figure 2: I would like to see the percentiles for each single month. This would provide also information about year-to-year variability.

Figure 2 in the submitted version of the manuscript depicts percentile distributions based on data binned into each month over the duration measurement period. These results were interpreted to evaluate seasonal variability. While we agree with the reviewer that it would be interesting to evaluate year-to-year variability, the limited duration of the measurement period , 2.5 years, is insufficient for a reliable analysis of this nature.

Page 6, line 189: please provide references. Possible reduced domestic emissions related to less domestic heating?

We have added the references and clarified the text. It reads as follows:

"We infer that the significantly lower concentrations during the monsoon reflect the influences of synoptic easterly airflow that transports cleaner marine air mass over the region, reduced agricultural residue burning (Sarangi et al., 2014), and more efficient removal via wet deposition (Dumka et al., 2010)."

Page 6, line 197: "Seasonal variability. . ..broad regional pattern". I do not agree. In the IGP, BC is maximized during winter months (December- January), while in Himalayas (and also at your station) the values are higher during pre-monsoon! (see also).

We agree with the reviewer and recognize that BC peaks during Dec-Jan in the IGP and during March- May in the Himalayan sites. We have clarified the language in section 3.1 as follows:

"Similar seasonal variability in BC concentration is evident across the IGP from urban to remote locations. For example, high concentrations of BC (~1.48 to 1.99 µg m-3) have been reported in near-surface air across the IGP as well as in layers of the atmosphere at ~900 m asl and ~1200 m asl during the post-monsoon over Northern India (Tripathi et al, 2005; 2007). Sreekanth et al (2007) reported BC concentrations in Vishkhapatnam, in eastern India, to be 8.01 µg m-3 in pre-monsoon and 1.67 µg m-3 during monsoon while Ramchandran et al (2007) observed BC concentrations in Ahmedabad, western India, of 0.8 µg m-3 during the monsoon in July to 5 µg m-3 during the post monsoon in January. Similar seasonable variability has also been reported in the high Himalaya. For example, the Nepal Climate Observatory-Pyramid (NCO-P) station at the 5079 m asl in the Himalaya has also shown high seasonal differences for BC (0.444 (±0.443) µ gm-3 during pre-monsoon and 0.064 (±0.101) µ gm-3 during monsoon season and ozone concentrations 61 (±9) ppbv during pre-monsoon season and 39 (±10) ppbv during monsoon (Cristofanelli et al., 2010, Marinoni et al., 2013) (Supplementary Table 2). Our results indicate that seasonable variability in BC and O3 within the KGV and presumably other deep Himalayan valleys is coupled with these larger regional-scale patterns."

Page 6, line 209: "These differences in. . .". Not clear: what differences?

This point is addressed in our response to the preceding comment.

Page 6, line 213: The works by Ratikainen et al., 2014 AtmosEnv can be cited here

We have added a citation to this study in the revised version.

Section 3.2: this discussion is mainly qualitative. No statistical analysis have been applied and it is difficult to discern if the observed features are statistically significant. I suggest to add a line describing the mean average values with statistical confidence level (this would help in understand if the observed peak and minima are robust features). I would add to these plots the analogous for wind direction and speed to clearly correlate wind regime with O3 and eqBc variability. In any case, the results are based just on the analysis of 3 single months of observations. A comment for taking into account the possible intra-seasonal and year-to-year variability should be added. Your measurement period is 2.5 year-long. Why you did not use all the available data?

> *Figure 2 of the original version of the manuscript (Figure 3 of the revised version) depicts monthly percentile distributions for both BC and O_3 over the entire measurement period. As indicated in the Section 3.2 (lines 190 to 192 of the original manuscript), "representative months from each season, April 2013 (pre-monsoon), July 2015 (monsoon) and November 2014 (post-monsoon), were selected based on data availability and quality to evaluate aspects of temporal variability in more detail." Normalize diurnal variability in concentrations of O3 and BC during these months is depicted in Figure 3 of the original version (Figure 4 of the revised version). The role of wind in the transport is discussed in section 3.4. As mentioned in response to a previous comment, a 2.5-year data record is insufficient to reliable characterize inter-annual variability particularly given the data gaps in our study.*
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> *In addition, we have added results from non-parametric statistical analysis that shows differences between up-valley and down-valley concentration and flux. For this analysis we have used all days during the measurement period when 24 hour data for all parameters measured were available. As the data is not normally distributed a mean average value, as suggested, are not appropriate to evaluate significant differences day and night.*

Page 7, line 219: "peaked in the early afternoon". I would say "at noon"! This can be an hint for local photochemical production. . .

> *The peak is too broad to assign specific time of the day. For this reason, we prefer to retain use of the term "early afternoon".*

Page 7, line 220. "Finally,. . .0 to 1 (Fig. 3)", I cannot be able to understand this sentence. . .Maybe you would suggest that diurnal variability account for the most part of the overall O3 variability? In the case, this is a point that should be better stressed. Can you quantify it?

> *We have clarified this sentence to read;" In contrast, based on median values during all three periods, BC concentrations increased rapidly in the early morning, decreased during late morning, and then rose through the afternoon and early evening hours (Fig. 5)."*

Page 7, line 223: "increased rapidly following sunrise". . .because later in the manuscript, you suggested that this peak can be related to local emissions, I would change with "increased rapidly in the early morning".

> *We have made the recommended change.*

Page 7, line 225-229: Again, this sentence is not clear to me. See the same comment for ozone.

We have clarified the text to read; "Notably, BC concentrations showed lower variability relative to that of O_3, particularly during pre-monsoon periods. These skewed distributions reflect infrequent periods of relatively high BC concentrations during all three seasons."

Page 7, line 230: you should also mention air-mass transport. At a remote site, if local emissions are really negligible (I'm not totally convinced about this for your site, see your following sentence about eqBC), I would expect that the contribution by transport is the most important one!

We have provided further clarification, the text now reads:

"Several factors contributed to differences in the diurnal variability of O_3 and BC. These include diurnal variability in emissions of BC versus O_3 precursors and/or production in source regions followed by regional transport, diurnal variability in the photochemical chemical production and destruction of O_3, and contributions of O3 from non-combustion sources. O_3 is produced photochemically and is lost via deposition to surfaces and chemical reactions. In contrast, BC is a primary emission product of combustion that may originate from both local and distant sources."

We have also added text as further evidence that these emissions are not local. (See response to following comment)

Page 7, line 236: the secondary peak (in the evening from 19 to 21) is visible only during the post-monsoon. Please comment. Does this peak be related with domestic emissions (e.g. domestic cooking or heating)?

The contribution from local pollutants dominate morning peaks while the influx of pollutants after the onset of up-valley flows suggest long-range transport. The absence of secondary peak during monsoon season supports the argument. The peaks are present both during pre-monsoon and post-monsoon seasons (old figure 6). This has been clarified in the text to read;

"The early morning peak during all three seasons suggests probable contributions from the local combustion of biofuels for cooking and heating, which are most prevalent during early morning. The secondary peak in the afternoon and early evening occur when the local anthropogenic sources are at minimum in the KGV."

Page 7, line 239: "Up-valley. . .Alpine pumping". As mentioned before, many works in Himalayas investigated the role of valleys as channel of anthropogenic pollution. Please consider them and comment your results as a function of these previous works.

We have included additional references to recent papers that have investigated pollution transport in the Himalaya throughout the manuscript. Some of these studies have examined this pathway through satellite imagery and remote sensing. Others have made field-based measurements in the IGP and TP. However, as stated in the manuscript, ours is the first study to directly measure air pollution transport within a trans-Himalayan valley. We have also added a table that compares our results with results from Bonasoni (2010)

Section 3.3: the expected outcome from this Section is not clear. Why did you show just 6 days of data at JSM_2, when more than two years of meteorological data are available at the "core" site where also O3 and eqBC data were available? You must show these data! Moreover, if I'm not wrong, JSM_2 is located 1000 m above the "core" site. Thus, which is the goal of showing these data?

In the original manuscript, the station names at Jomsom were in misplaced. These errors have been corrected and we apologize for any related the confusion.

We have updated the old wind rose figure with wind roses for JSM_2 for all seasons (new figure 6a) binned every three hours for the duration of the measurement period. The wind roses show the seasonality in wind direction and magnitude of wind speed at Jomsom.

Section 3.4: Legend is missed in Figure 6. I suspect that blue dots represent O3 but you have to add a legend! Basically, this section repeat the same concept about diurnal variability already reported by Section 3.2. . .

The legend has been added. Section 3.2 describes the diurnal variability in the BC and O3 concentrations. Section 3.3 describes the wind pattern in the valley. Building on these lines of evidence, section 3.4 describes how BC and O3 concentration variability correlates with wind variability. It is important to state this link explicitly before we describe the anomalies we observe in diurnal concentration (section 3.5).

Page 8, line 271: "This peak occurred about an (one) hour later during the post-monsoon period". Looking at Figure 3, this seems not true! eqBc peak at 8:00 AM during all the seasons. However, it is important to evaluate the robustness and origin of this peak. Looking at the eqBc time series reported in Figure 6, it looks that the early morning peak is related to "spiky" observations, very likely related to local emissions. This is particularly evident during post-monsoon, when these "spikes" where observed during the diurnal minima of eqBC. This feature can be of a certain interest to evaluate the local emissions to the "pristine" Himalayan environment, but I would neglect it for the analysis of transport processes affecting O3 and eqBC variability.

Please refer to the response earlier to the comment about secondary peaks.

Page 8, line 275: “. . ..decreasing concentration with increasing wind speeds are consistent with expectation based on dilution”. I think that the decrease on eqBC observed during midday can be associated not only to dilution in a more developed PBL of local emissions, but also to the fact that air-masses reaching the site from the lower valley are still not enriched in pollutant. . .Indeed, you observed eqBC (and O3) increase in the afternoon/evening (when both PBL height decrease and air-masses richer in pollution could reach the site from longer distance). You should roughly evaluate the distance of eqBC emissions by analysing wind speed at the measurement sites. . .

We have roughly calculated the maximum distance from which the secondary peak emissions could have originated during May 2015. We estimate that emissions could have traveled from as far as 70km away from Lete. This estimate was done by calculating the time it would take for the secondary peak occurring at Jomsom (1900 LST) to travel from Lete (1810 LST) to Marpha (1850 LST) to Jomsom. We then determined the difference in time (8 hours) between when emissions started to increase after the morning peak at Jomsom and the occurrence of the secondary peak at Jomsom. Finally, we used this 8 hour estimate combined with wind speed measurements at Lete to calculate the maximum distance from Lete from which secondary peak emissions could have originated. This poorly constrained estimate does not account for other factors that influence pollutant transport and its reliability cannot be evaluated based on objective criteria. Consequently, we choose not to include it in our paper.

Page 8, line 285. This detailed description of local wind regime needs a more detailed map on Figure 1!

The revised manuscript includes a more detailed map (new figure 2).

Page 9, line 294: “Nocturnal decupling of the boundary layer preserves the concentration of. . .”. Not clear: what do you mean with “decoupling PBL”? Decoupling from what?

Author: *We have removed the sentence.*

Section 3.4: I assume that this Section should be “Evidence of LONG-RANGE transport episodes. . .”. In this section you discuss three typical regimes of O3 and eqBC variability. However, I would like to see a more detailed description of the main features of each single regime (basically how are you able to distinguish among them?) and a systematic assessment of their occurrence and impact on eqBC and O3 variability E.g. which is the frequency of occurrences of these regimes on a seasonal basis? Are you able to objectively identify (by some selection criteria) the occurrence of that regimes? Can you able to compare your results with previous studies? (e.g. Putero et al., Environ. Poll. 2013)

We have changed the section title to "Evidence of regional transport episodes". We also updated the figure with wind data for the episodes shown as examples (new figure 8); have quantified the frequency of each transport pattern and included all the transport pattern observed in supplementary table ..

Page 9, line 304: actually you did not show any evidence of transport to TP! I think this is just a (reasonable) speculation. Maybe you can discuss this possibility in the conclusions Section.

We have added transport to TP in the conclusion as a potential transport to the TP.

Page 9, line 310: I think that the relationship between eqBc , O3 and fire emissions in the IGB is only qualitative and deserve more analyses. At least a correlation between the temporal variation of the fire number in the IGP and the eqBc and O3 at the measurement site must be showed. Moreover, air-mass transport analysis (i.e. backtrajectories or dispersion plume) corroborating the transport towards the measurement site region should be showed (the same is valid for case B). For case B and C, eqBc is maximized during night-time, when down-valley winds are expected in a mountain valley and cleaner air-masses from upper layers should be present (add the behaviors of wd and ws!). Please, comment. Moreover, the different co-variability (correlation) between O3 and eqBC should be better investigated and commented. During case B, the diurnal variability of O3 and eqBC appeared to be minimized. Can this indicate the role of far (fires?) emissions instead of regional/local ones? The increase of daytime minima value of eqBc and O3, would indicate a build-up of pollution. Is this build-up only limited to the valley or did it extend to the foothills? Maybe time series of satellite MODIS data can help. . .

The authors feel that back trajectories trying to relate surface sources to valley transport are unreliable in complex terrain so we used HYSPLIT back trajectories from the mouth of the valley in conjunction with the MODIS imagery. The back trajectories show transport of air mass from are with high biomass/ forest fires activity and/or haze over the IGP during the regional transport period examples. It supports the hypothesized source for the high concentration during regional transport episode. Dispersion models are beyond the scope of this paper.

Section 3.4.2 is confused and not provides important information: thus, it can be skipped. STE discussion at this point is a little bit out of the scope of the paper. A rigorous assessment of STE contribution to eqBC and O3 variability would deserve a specific investigation. Moreover, I would note that the focus on the monsoon season is of limited interest, since it is well assessed that summer monsoon is the season during which transport of stratospheric air-masses to the lower troposphere is minimized over the Himalayan region (see e.g. Putero et al., 2016, Ohja et al., , 2016).

We have removed discussion of STE from the paper.

The conclusions are not robust. Actually you did not demonstrate the transport of pollutant from IGP to TP but just the transport of pollution up to the valley. Your main results (seasonal and diurnal O3 and eqBC variability, influence of open fires) should be better commented in the framework of the most recent studies on the topic.

In response to the reviewer's comment regarding transport to the TP, we have revised the text to indicate that that our observational evidence suggests (but does not conclusively demonstrate) such a connection.

Referee #2

The manuscript reports data that is collected recently over a high altitude site and does not bring in any new insights or results. As the authors write, many results from the same group have been published recently.

Numerous studies have looked at the possibility of the transport of pollutants from the IGP to the Himalayan foothills (Pant et al., 2006; Dumka et al., 2008; Komppula et al., 2009; Hyvärinen et al., 2009, 2010; Ram et al., 2010; Brun et al., 2011; Gautam et al., 2011; Srivastava et al., 2012b). In addition, the obstruction of flow caused by the high Himalaya intensifies the effect of pollution over the IGP that are visible in satellite imagery especially during pre-monsoon seasons (Singh et al., 2004; Sarkar et al., 2006; Bollasina et al., 2008; Gautam et al., 2009; Dey and Di Girolamo, 2010). Other studies show that pollutants, with similar regional sources, have the potential to reach not only the foothills of the Himalaya but also higher elevations (Decesari et al., 2010; Marinoni et al., 2010; Sellegri et al., 2010; Gobbi et al., 2010). Though there is evidence of existence of similar source pollutants, both regional and local, in the foothills and the higher altitude sites (Raatikainen et al., 2016, Raatikainen et al., 2014, Srivastava et al., 2012,), observational evidence of mechanisms and pathways facilitating such transport is lacking. Our data fills this gap by characterizing the role of the wind system within a deep Himalayan valley in transporting pollutants from the IGP to the high mountains.

These data have not been previously published.

What is the relevance of connecting ozone and BC is not clear. Many aspects are very loosely dealt with and mentioned in passing. References are missing.

The rationale for investigating BC and ozone is explained in detail in the introduction. Briefly, both species are short-lived climate forcers (SLCFs) that originate from combustions sources over the IGP. We measured these species in conjunction with corresponding meteorological conditions and satellite imagery to understand the importance of deep valleys in their transport to the high Himalaya. Impacts on ice-albedo and temperature contributes to warming, which accelerated melting of glaciers with potential negative consequences for almost a billion people in the surrounding watersheds. Mitigation of SLCF emissions has the potential to slow the rate of future climate change. As indicated in our responses to comments by Reviewer 1, we have added references relevant to the analysis.

Lines 285 - how this phenomenon can occur? What about lifetime of BC aerosols?

As indicated above in our response to a similar comment by Reviewer 1, we roughly estimated the transport time required for an air mass from Lete to Jomsom (approximately 50 minutes) and the distance of the source from Lete (approximately 70km). Given the lifetime of BC and in the absence of substantial wet or dry deposition, emissions from IGP could reach Lete and up the KGV under suitable synoptic and local weather.

Conclusion - with the limited scope of the study the conclusions are far fetched.

While the reviewer was not specific regarding the nature of his/her concern, we have exercised greater caution in the statements regarding transport of pollutions from the IGP to the TP and revised the conclusion section. It now reads,

"This study provides in-situ observational evidence of the role of a major Himalayan valley as important pathway for transporting air pollutants from the IGP to the higher Himalaya. We found that:

- *Concentrations of BC and O3 in the KGV exhibited systematic diurnal and seasonal variability. The diurnal pattern of BC concentrations during the pre- and post-monsoon seasons were modulated by the pulsed nature of up-valley and down-valley flows. Seasonally, pre-monsoon BC concentrations of BC were higher than in post-monsoon season.*

- *The morning and afternoon peaks in the post monsoon season was more pronounced than those of pre-monsoon season likely due to the relatively lower wind speeds during post-monsoon.*

- *When compared to a high elevation site, NCO-P CNR in the Himalaya, JSM_STA consistently showed higher BC concentrations for all seasons whereas the corresponding O3 concentrations were higher at NCO-P CNR.*

- *Significant positive up-valley fluxes of BC were measured during all seasons.*

- *During episodes of regional pollution over the IGP, relatively higher concentrations of BC and O3 were also measured in the KGV.*

Further studies are needed to understand the vertical and horizontal distribution of particulate matter and ozone in the Himalayan region, and their impact on the radiative budget, the ASM and climate. Investigations using sondes, LiDar and air-borne measurements could help characterize the stratification of the vertical air masses."