# Reply to Referee#1

We thank you for your comments and suggestions to improve the paper. We have addressed your concerns as follows:

**Title and Abstract: I strongly suggest to replace the term 'Bihar Pollution Pool' with something like, IGB pollution or so. Authors state that high levels of pollution was seen over the state of Bihar, West Bengal as well as over Bangladesh. There are hundreds of satellite images of aerosol optical depth from MODIS, MISR, TOMS, and OMI show higher values of aerosol optical depth over the IGB compared to rest of India during winter. Attributing this to one particular state may not be justified. Author needs to be more technical here and should not adopt the terminology created by other authors.**

The term 'Bihar pollution pool' was coined by Di Girolamo et al. (2004) who had first reported the phenomenon from MISR data because the large AOD values were mostly seen within the state of Bihar. However we agree that the feature as seen in various datasets extends over a larger area and have accordingly changed the title of the paper as suggested by you as well as the second referee.

**Page 20890, line 1-2: "While the phenomenon was initially noted in the MISR aerosol optical depth data,...". The higher levels of aerosols were also noted in MODIS, TOMS, and AERONET data (Jethva et al., 2005,2007).**

The phenomenon is essentially a regional feature and is thus not possible to observe using the AERONET data at one location. We have modified the sentence as:

"While the phenomenon was initially noted in the MISR aerosol optical depth data and was also seen in Moderate Resolution Imaging SpectroRadiometer (MODIS) data (Jethva et al., 2005, Gautam et al., 2007), new height resolved aerosol data from CALIPSO have now become available, and these can provide further insight into the vertical distribution of the feature."

**Page 20892, line 24-25: "In absence of any significant biomass burning in this area in winter, these enhanced CO levels are generated by anthropogenic activities". What is rationale in stating that the higher levels of CO is generated by anthropogenic activities? Biomass burning also can anthropogenic in nature. I have seen plenty of MODIS RGB images during winter over many years which show that the haze seen from satellite is a result of widespread emission (vehicle, industrial, bio fuel) as well as biomass burning (those thick spots of smoke).**

We have deleted the words 'In absence of any significant biomass burning in this area in winter' and modified the sentence as:

"These enhanced CO levels are generated by various anthropogenic activities including industrial activity, vehicular emissions as well as biofuel and biomass burning."

**Page 20894, line 10-15: Provide reference on influence of biomass burning in South East Asia and within India during pre-monsoon months (Apr-May-Jun). In my opinion, authors may drop this figure from the manuscript as the spatial distribution of MOPITT**

**CO shown in Figure 2 is sufficient here.**

We have provided references as suggested (Duncan et al., 2003, Streets et al., 2003). However we believe Figure 5 provides valuable information since it shows that the phenomenon is robust and occurs every year and is not biased by one particular year. Referee 2 also feels that it is an interesting figure. We have therefore retained this figure.

**Page 20894, line 25: Jethva et al. (2005), their conclusion was based on the fact that TOMS Aerosol Index is less sensitive to the absorbing aerosol layer situated at lower levels of atmosphere, i.e., within boundary layer.**

We have deleted the relevant sentence, as it was not adding significant value to the discussion.

**Page 20895, line 5: How confident authors are here about the classification derived by CALIPSO? Any validation? Please justify and describe.**

We have added the following sentences to address the issue:

"Initial validation of the CALIPSO aerosol subtyping scheme has been conducted by Mielonen et al. (2009), who compared the CALIPSO aerosol subtyping results with corresponding aerosol types derived from the AERONET observations at 38 sites spread across the world. A good overall agreement (70%) was found between the aerosol types, with best agreement for coarse particles like dust and polluted dust and lower agreement for fine particles."

**Page 20895, last paragraph: How does CAD scheme define 'Polluted Dust' and 'Smoke'? Is polluted dust=smoke+dust? The maximum contribution of 'smoke' in the month of august is surprising. The concentration of smoke particle should be higher in winter (due to biomass burning)**

We have added the following sentences:

"It should be mentioned too that the CALIPSO subtype "smoke" represents aerosols from biomass burning while polluted dust represents a mixture of "dust" and "smoke" (Omar et al., 2009). Further, the subtypes "polluted continental" and "smoke" are distinguished primarily by the requirement that "smoke" layers be elevated (i.e., as opposed to being in contact with the surface), and so occasionally there might be partial overlaps between these two groups."

It is conceivable that some of the 'polluted continental' layers have been classified as 'smoke' instead, which might explain the large contribution of 'smoke' in August of 2007 as seen in Figure 8 of the discussion paper. We have examined the abundance of 'smoke' layers in August of other years. The fraction varies considerably from year to year ( 25% in 2006, 11% in 2008 and 37% in 2009) and we do not have any other information to discount this. In winter the dominant component is polluted dust which is a mixture of dust and smoke and should be quite reasonable.

**Page 20896 : I don't understand the significance of Figure 10 in this paper. Authors may drop this figure.**
**Page 20896, last paragraph : I don't understand the significance of Figure 10 in this**

**paper. Authors may remove this figure.**

Per your suggestion we have dropped this figure.

**Page 20897 : Author may also drop Figure 13, as it is an established fact that the pollution over the IGB is a persistent phenomenon with some temporal and spatial variability within region.**

Per your suggestion we have dropped this figure.

**References:**

Di Girolamo, L., Bond, T. C., Bramer, D., Diner, D. J., Fettinger, F., Kahn, R. A., Martonchik, J. V., Ramana, M. V., Ramanathan, V. and Rasch, P. J.: Analysis of multi-angle imaging spectro-radiometer (MISR) aerosol optical depths over greater India during winter 2001-2004, Geophys. Res. Lett., 31, L23115, doi:10.1029/2004GL0211273, 2004.

Duncan, B. N., Martin, R. V., Staudt, A. C., Yevich, R. and Logan, J. A., Interannual and seasonal variability of biomass burning emissions constrained by satellite observations, J. Geophys. Res., 108, D2, 4100, doi:10.1029/2002JD002378, 2003.

Gautam, R., Hsu, N. C., Kafatos, M. and Tsay, S.-C.: Influences of winter haze on fog/low cloud cover over the Indo-Gangetic plains, J. Geophys. Res., 1112, D05207, doi:10.1029/ 2005JD007036, 2007.

Jethva, H., Satheesh, S. K. and Srinivasan, J. : Seasonal variability of aerosols over the Indo-Gangetic plains, J. Geophys. Res., 110, D21204, doi:10.1029/2005JD005938, 2005.

Mielonen, T., Arola, A., Komppula, M., Kukkonen, J., Koskinen, J., de Leeuw, G., and Lehtinen, K. E. J., Comparison of CALIOP level 2 aerosol subtypes to aerosol types derived from AERONET inversion data, Geophys. Res. Lett., 36, L18804, doi:10.1029/2009GL039609, 2009.

Omar, A. H., Winker, D. M., Kittaka, C., Vaughan, M. A., Liu, Z., Hu, Y., Trepte, C. R., Rogers, R. R., Ferrare, R. A., Lee, K-P, Kuehn, R., and Hostetler, C. A. : The CALIPSO automated aerosol classification and lidar ratio selection algorithm, J. Atmos. Oceanic. Technol., 26, 1994-2014, 2009.

Streets, D. G., Yarber, K. F., Woo, J.-H. and Carmichael, G. R., Biomass burning in Asia: Annual and seasonal estimates and atmospheric emissions, Global Biogeochem. Cycles, 17(4), 1099, doi:10.1029/2003GB002040, 2003.