Initial Response to Referee #2:

We thank the reviewer for the helpful comments. Here we will provide quick responses to these comments for the purpose of interactive discussion and will update the paper text and supplement after the completion of the interactive discussion.

First of all, the Authors claim that their analysis has implications for improving the modelling of black carbon (BC) transport to the glaciated regions of Tibet (all the Introduction is dedicated to this topic). However, their approach is based on measurements (in situ and satellite retrievals) of aromatic HCs and of their degradation products (glyoxal). It is certainly true that aromatic hydrocarbons share with BC several emission and transport patterns, but only to a certain extent. For instance, the aromatic HCs are emitted by fossil fuel combustion, gasoline evaporation and solvent use (page 2, line 24), however only the first of these three sectors is of importance for BC. It follows that top-down methods for correcting the emissions of aromatic HCs (Section 2.4) has unclear implications for improving the representation of BC sources in the models. If the scope of the paper is really improving BC modelling in the Himalayan-Tibetan region, then the absence of BC observations poses a major caveat, even if the approach is conceptually valid and in principle it could be extended to experiments involving real BC measurements.

Authors' response:
The implications of this paper for BC are only on transport. As the reviewer pointed out that our work cannot directly address the accuracy of BC emission inventories, which we did not claim in the paper that we can either. We suggest that aromatics observations are good proxies for understanding transport processes of BC to the Tibetan plateau. The major pathway of transport is driven by the presence of a cut-off low system. Section 2.4 shows that the underestimates of aromatics transport are due to an underestimation of emissions, which can be improved using satellite observations.

To further demonstrate the link between transport of aromatics and BC to Tibet, we redistributed total aromatics emissions over China and other South Asia countries using the BC emission distributions. Therefore, the resulting aromatics emission distributions resembles that of BC. We conducted a sensitivity simulation using these emissions and compared the results to the original REAM simulation (Fig. S8). Transport of BC from South Asia (e.g., India) clearly dominates and it is strongly affected by the presence of a cut-off low system, as we discussed in the paper.

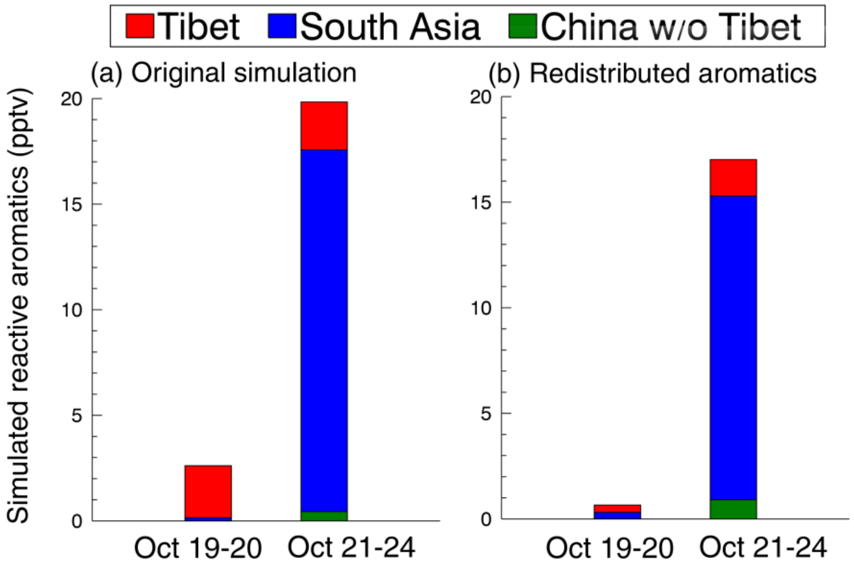

Figure S8: Averages of simulated reactive aromatics emitted from Tibet (red), India and nearby countries ("South Asia", blue) and China excluding Tibet ("China w/o Tibet", green) corresponding to in situ observations during Oct 19-20 and Oct 21-24. REAM simulations are conducted with original emissions (a) and the aromatics emissions redistributed to be the same as BC (b), respectively.

Specific comments: a. Biomass burning is ruled out from the possible explanations for the difference between observed and retrieved glyoxal concentrations over the IGP, because satellite fire counts show only spot fire occurrence over the Plain with little correspondence with the model-measurement gap (Page 5, lines 10 – 14). However, open burning accounts for only a fraction of biomass burning, which is normally practiced also indoor for cooking, heating etc., undetected by remote sensing. Therefore, I would not rule out the hypothesis of a direct emission of glyoxal from domestic biomass burning.

We calculate indoor biomass burning glyoxal emissions using emission factors from Pettersson et al. (2011) and Li et al. (2014). The Indian rural and urban population distribution from the NASA Socioeconomic Data and Applications Center (SEDAC) Network for year 2010 is used as spatial proxies. We adopt the energy consumptions for rural and urban inhabitants on the basis of the National Sample Survey Office of India (N.S.S.O., 2012a, 2012b). Simulated indoor biomass burning contribution to glyoxal VCDs is lower by a factor of about 15 than the glyoxal VCDs discrepancy between satellite retrieval and model simulation (Fig. 1). The uncertainty of the indoor energy consumption glyoxal emissions mainly results from the uncertainty of the emission factor. Even we assume this uncertainty to be 300%, indoor burning cannot explain the low bias of the simulated glyoxal VCDs. Thus, we consider that the underestimation of aromatics emissions is the main reason for the glyoxal VCD discrepancy.

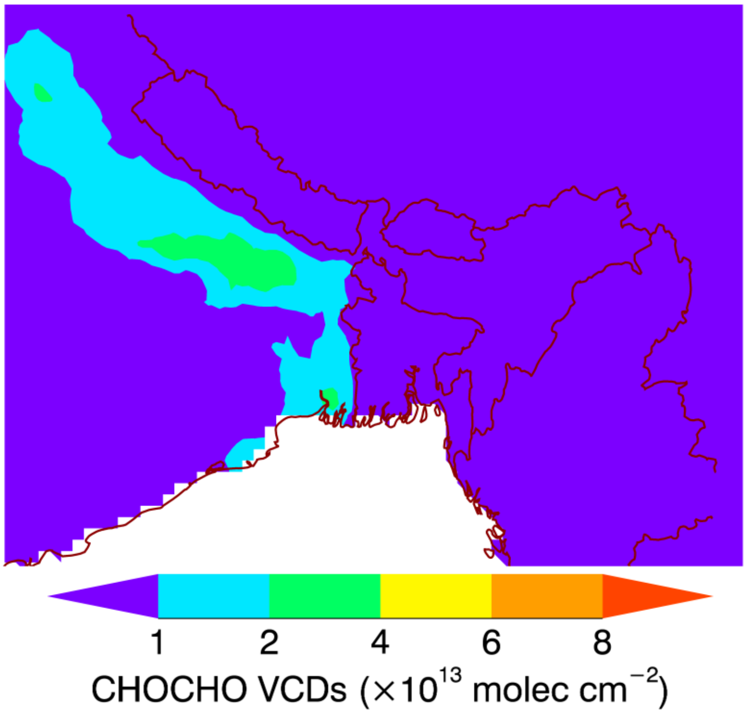

Figure 1: Simulated contribution of indoor burning to CHOCHO VCDs.

b. The Authors find a plausible explanation for the rise of aromatic HCs concentrations between 22 and 24 Oct 2010 in the synoptic meteorological conditions in central Asia showing an upper-level cut-off system triggering a southerly circulation from India to Tibet. However, minding that BC can be removed during transport by precipitations, the Authors should provide a more in-depth analysis of the meteorological conditions over the Himalayans during the approach of the low-pressure system. Apparently, on the 22 of October, frontal cloud systems travelled over the Tibet from west to east (http://www.ssec.wisc.edu/data/comp/ir/2010295M0000.gif). The presence of precipitations with possible losses of BC (and not necessarily of aromatic HCs) in the Himalayas should be checked carefully at local meteorological stations.

This is a good point for BC concentration distribution over the Tibet, which is not studied in this work. Our focus is on transport. BC still needs to be transported to the Tibetan region; scavenging can only reduce the BC amount. If BC is not transported to the region in the first place, scavenging cannot increase BC in this region.

Our study suggests that the cut-off low system is difficult to simulate with a regional model constrained by meteorological observations. It would be much harder for climate models to simulate correctly. Fig. 2 shows the precipitation distribution for Oct 19-20 and Oct 21-24. The cut-off system is to the northwest of Tibet. Precipitation south of the Himalayas is weak and hence the removed BC from precipitation during the inter-Himalayas transport is limited.

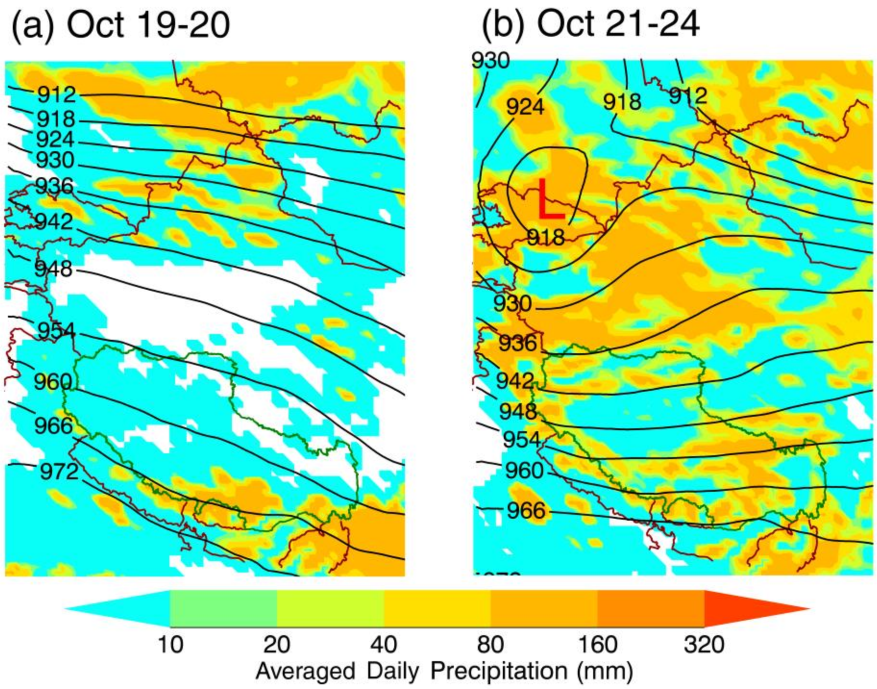

Figure 2: WRF simulated averaged daily precipitation for Oct 19-20 (a) and Oct 21-24 (b), respectively.

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