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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Enhanced Trans-Himalaya Pollution Transport to the Tibetan Plateau by the Cut-off Low System" *by* Ruixiong Zhang et al.

Anonymous Referee #1

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Summary:

Zhang et al. use the REAM chemistry transport model simulation to investigate transport of aromatics to the Tibetan plateau. Their work shows that the INTEX-B 2006 emissions of aromatics do not produce sufficient glyoxal concentrations compared to the SCIAMACHY retrieval. The authors apply a top-down estimate to update the emissions of aromatics, which are glyoxal precursors. The REAM model results of aromatics were compared with observations taken at several ground locations over a 3-week period. Samples in central Tibet had the highest aromatic concentrations and were attributed to meteorological conditions that increased southwesterly surface winds bringing high concentrations of aromatics from the Indo-Gangetic Plain to Tibet.

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Discussion paper

The complex topography of this region makes for an especially challenging effort to represent transport into Tibet.

The investigation is important in terms of understanding transport of pollutants, especially black carbon, from population and industrial regions to the Himalayan glaciers. The results from this paper suggest the critical need to represent the airflow in complex terrain to predict black carbon transport accurately. While these conclusions are not unfamiliar, it is important to continue to highlight the role of meteorology on transport of pollutants. The presentation of the investigation is fair. One can understand the points being made, but it is not written as a compelling story. Several of the points below suggest ways to improve the paper.

Major Comments

1. Aromatics are good markers of transport that occurs over $\sim$1 day period because of their chemical lifetime. However, aromatics are not subject to wet deposition because of their low solubilities (Sander, 2015), while black carbon can be removed by storms. Therefore, it makes sense to use aromatics to analyze transport (isolating the one process), but they are not good proxies for black carbon. The authors should explain this caveat in the paper.

2. There is a lack of recognition of previous studies, especially of regional chemistry transport modeling in South Asia and western China. Some previous papers to consider are listed in the references.

3. When figures are discussed in enough detail, it is better to place them in the main part of the paper. In my opinion, the supplement should not contain information that is needed to support the conclusions of the paper. For example, Figure S2 should be part of the main paper because it supports the conclusion that the INTEX-A aromatics emission estimates are much lower than values determined from a top-down estimate. Please write the paper so that the reader can easily understand the main points of the study.

Minor Comments:

1. Page 4, Line 1: How does one choose α for use in the uncertainty equation? Is this even necessary information for the reader?

2. I suggest rearranging the model description paragraphs. How would you describe the model to someone who has never worked with regional transport models? I suggest beginning with the CFSR dataset because it is used to provide initial and boundary conditions for the WRF model. Then the WRF model should be described, citing what version, resolution, and parameterizations are used. Next, it should be stated how REAM takes information from the WRF simulation. Does it take WRF output every hour, every 3 hours, etc.? Finally, the REAM model should be described. Do not rely on the reader to go to the cited references to get needed information, but instead to go to the cited references to get more details.

3. It is important to include what the model top is because of the high surface elevation of Tibet that is prone to have stratospheric intrusions (perhaps falsely if the model top is too low).

4. Has the REAM model been evaluated for the region simulated? In this paper we see comparisons with SCIAMACHY and ground-based observations. How does the model perform in terms of meteorology and chemical constituents, such as CO, O3, NOx, and particulate matter?

5. The model domain is shown in Figure 1, allowing the reader to recognize that the region of interest is mostly away from the model boundaries. Is the Tibet region affected by the composition outside the model boundaries (especially the western boundary), or outside the subdomain shown in Figure 2?

6. When comparing the REAM model results with the SCIAMACHY satellite retrieval of glyoxal, is the model sampled the same way as SCIAMACHY sees the atmosphere? For example, I assume that the missing data in Figure 2a from the satellite data is due

to clouds. Are cloudy grid points removed from the model analysis (it doesn't appear so since there are no "missing data" from the model results).

7. Page 5, Line 21. It would be helpful to see a MEGAN emissions map of isoprene for the region.

8. Page 5, Lines 16-24. It may be helpful to include the glyoxal chemistry in the supplement.

9. Section 2.4. Why is the INTEX-B emissions inventory, which is appropriate for year 2006, being used for the model simulation for year 2010? MACCity emissions (appropriate for 2010) or EDGAR-HTAP emissions may have been better suited for these simulations. Could the authors discuss the differences between the emissions inventory that they used and these more recent emissions inventories?

10. Section 3.1. It would be interesting to learn in more detail what the surface elevation is at the observation points and at the matching REAM model grid cells. Could there be discrepancies between model and observations because the model does not adequately represent the surface elevation?

11. Page 7, Line 6. How are the source attributions computed?

12. Page 7, Lines 15-17. Could the "cutoff low system" be described in more detail? Would "closed low" be a more appropriate term? (see the NWS definition at http://forecast.weather.gov/glossary.php?word=cutoff%20low) How long did the cutoff low remain in the region? Was there precipitation associated with the cutoff low?

13. Page 7-8. It would be helpful to see Figure S5 showing both Period 1 and Period 2. From what is presented, it is unclear whether WRF simulates the cutoff low pressure system (unless these are WRF results, which is not clear from the figure caption).

14. Page 8, End of section 3. There should be a section added, discussing the results found in this study with previous papers (such as those listed in the references). For example, the Kumar et al. (2015) study also mentions the challenges of modeling

pollutant transport in the Himalayas. Ji et al. (2015) also discuss aerosol transport from the IGP to Tibet.

15. Figure 5. What is the source of the information plotted in Figure 5? Is it from the model (WRF + REAM) simulation? Please clarify. Why are the surface winds and simulated reactive aromatics shown only for Tibet?

Technical Comments:

1. Page 1, Line 16: verb agreement: Long-range transport followed by deposition of black carbon on glaciers of Tibet is one of the key issues

2. Page 1, Line 17: → impacting the melting of glaciers

3. Page 1, Line 28: Remove “Furthermore”

4. Page 2, Line 2: The Menon et al. (2002) paper should be cited.

5. Page 2, Line 5: Insert “altitude” or “surface elevation” after “4 km”

6. Page 2, Line 14 is an orphan sentence and is not really needed.

7. Page 2, Line 19: “aerosols” may be a better word than “condensation nuclei”

8. Page 2, Line 20: “large-scale westerlies from East Asia” does not make sense. East Asia is east of Tibet, so it must be an easterly wind if the air moves east to west.

9. Page 3, Line 20: Shouldn’t Fig. 1a be cited before Fig. 1b?

10. Page 3, Line 23: I think it should be “overpass time” and not “overpassing”.

11. Page 4, Lines 4-8: Are all these references needed? It is sufficient to just cite 1-2 example references per topic.

12. Page 4, Line 24: It would be good to cite Figure S1a.

13. Page 5, Lines 2-4 is a long sentence. Please break it up into 2 sentences.

14. Page 5, Line 2: I think it should be “overpass time” and not “overpassing”.

15. Page 5, Line 28: I think it should be “overpass time” and not “overpassing”.

16. Page 5, Line 29: Insert “did” before “for eastern China”.

17. Page 7, Line 15: I would suggest using “promote” instead of “provide”.

18. Page 7, Line 24: Are the histograms for wind speed for at the surface (or 10-m winds)? Please clarify.

19. References: Could the references be written so that they are easier to read? Either adding a “hanging indent” or a line space between references would help immensely.

20. Figure 4b: The black and dark blue colors are quite similar. Could a different color be plotted?

21. Figure S3: To emphasize the differences between the panels, it may be better to plot using the same scaling. The gradients can still be appreciated if a “log type” scaling is used, e.g. 1, 2, 3, 5, 7, 10.

22. Figure S7: The legend mistypes “original”. The original winds line does not look like the black line in Figure S4d.

References

These are mostly for BC studies for South Asia region, but do include other papers cited above.

Dumka, U. C., et al. (2010), Characteristics of aerosol black carbon mass concentration over a high altitude location in the Central Himalayas from multi-year measurements, Atmos. Res., 96 (4), 510–521.

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Yasunari, T. J., et al., (2010), Estimated impact of black carbon deposition during preâĂŘmonsoon season from Nepal Climate Observatory-Pyramid data and snow albedo changes over Himalayan glaciers, Atmos. Chem. Phys., 10, 6603–6615, doi:10.5194/acp-10-6603-2010.

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