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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Elevated large-scale dust veil originated in the Taklimakan Desert: intercontinental transport and 3-dimensional structure captured by CALIPSO and regional and global models" *by* K. Yumimoto et al.

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Dear Referee #2,

Thank you very much for your appropriate and adequate comments. We have deliberately confirmed and considered your comments. We believe that we have made sufficient revision to the revised manuscript after considering all comments and suggestions. Below we will provide a point-by-point response to the reviewer comments.

Specific comments

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Interactive Discussion

Discussion Paper

[Comment 1]14455, 17-19: “However, direct observational evidences of the Asian dust intercon-tinental transport to Europe...” This sentence does not make sense in the context. Consider rephrasing.

[Answer] We will improve the suggested points in the revised manuscript along [Comment 17] by Referee #1. “However, direct observational evidences of the Asian dust intercontinental transport to Europe are lacking, so there is little support for these previous studies.”

[Comment 2] 14455, 25-28: More recent works can be credited with regards to the aerosol direct and indirect effects.

[Answer] Thank you for your helpful suggestion. I will add recent references focusing the ice cloud formation and indirect and direct climate effect with dust (Sassen, K.: Indirect climate forcing over the western US form Asian dust storms, Geophys. Res. Lett., 29, 1465, 2002, and Sokolik, I.N. & Toon, O. B.: Direct radiative forcing by anthropogenic airborne mineral aerosols, Nature, 381, 681-683, 1996) in the introduction. Also see [Comment 1] by Referee #1.

[Comment 3] 14456, 2: Rephrase “..., which in turn can influence the plankton and dimethyl sulfide (DMS) emissions.”.

[Answer] We will delete "...can influence the dimethyl suplfide (DMS)..." in the revised paper. Also see [Comment 20] by Referee #1.

[Comment 4] 14457, 1: On what basis the occurrence of the dust storm was confirmed? SYNOP report?

[Answer] Yes. At Tazhong and Ruoqiang stations, sand storm was observed during 19-20 May. We also checked OMI Aerosol Index (figure 5) and found high AI level considered to be the dust storm in the Basin.

[Comment 5] 14457, 25-14458, 2 and 14458, 8-9: The logic behind the strategy to limit the dust sources to those over Taklimakan desert remains rather vague and not very

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convincing. Later in the paper, authors attribute the underestimation of dust loadings (with respect to CALIPSO measurement) in the model simulations solely to the limited horizontal and vertical resolutions. Can you entirely exclude the possibility that the underestimation results partly from other dust sources and aerosol types missing in the simulation? I presume that the models can keep a good track of dust particles emitted from different source regions. Wouldn't it be more convincing if you can also show that there was only minor contribution from the surrounding deserts (Gobi in particular)?

[Answer] We also perform an off-Taklimakan dust simulation in which we eliminate dust emission from the Taklimakan Desert and include all other aerosol sources (i.e., sulfate, sea salt, black carbon, and dust from non-Taklimakan Desert). The off-Taklimakan dust simulation cannot reproduce the long-range transport of the dust veil shown in CALIOP measurements and the Taklimakan dust only simulation. This fact means that dust from other sources (i.e. the Gobi Desert) and non-dust aerosols cannot be brought up to such a high altitude and contribute formation of the dust veil. Also see answer to [Comment 2] by Referee #1. We will add brief discussion as follows:

[line 10, page 14460] '. . . quite well. In addition, we also perform a preliminary SPRINT-ARS simulation in which dust emission in the Taklimakn Desert is eliminated and the other aerosol sources (sulfate, sea salt, carbonaceous, and dust from non-Taklimakan Desert) are included. The off-Taklimakan dust simulation cannot capture the dust veil measure by CALIOP (not shown). This fact indicates that dust from other sources (i.e. the Gobi Desert) and non-dust aerosols cannot be brought up to such a high altitude, and contribute formation of the dust veil. Figure 2b shows. . .'

[Comment 6] 14460, 2: Consider switching the order of sections 3.1 and 3.2 unless there is a good reason to show them in the current order. It would be more readable if dust emission from the source is proven, then the transport. When doing so, change the structure of the abstract and concluding remarks, as well as order of the figures accordingly.

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[Answer] We will reorganize. In revised manuscript, we will start from a brief explanation of the dust veil with figure 2 at the beginning of section 3, then discuss about emission and injection processes with figures 5, 6 and 7 in subsection 3.1, and finally show the inter-continental transport with figures 2, 3, and 4 in subsection 3.2. Figure 8 will be shown in the summary as the present manuscript. Also see [Comment 21] by Referee #1.

[Comment 7] 14462, 2: Is dust emission from Saharan desert taken into account in the SPRINTARS?

[Answer] No. In this paper, we show the simulation results in which only the emission of mineral dust from the Taklimakan Desert is taken into account.

[Comment 8] 14465, 4: Both “upper troposphere” and “free troposphere” appear in the paper but it is difficult to picture where exactly the authors are referring to. It would be very interesting to know the structures of the troposphere over these highly complex terrains. Authors may state more precisely how they define the free troposphere and its height range. This is especially important for the current work where it is supposed to show the detailed mechanism by which dust from the ground is transported into such high altitudes.

[Answer] To avoid readers’ confusion, we will replace “upper troposphere” to “free troposphere”. We estimate the tropopause is approximately 12-13 km from vertical gradient of modeled temperature (lapse rate tropopause: refer figure 4a). Therefore, in this study, we consider that the upper troposphere ranges about 9 to 12 km altitude where strong westerlies are dominant. Also see [Comment 7] by Referee #1. We will add the definition as follows:

[line 24, page 14467] ‘The strong updraft can inject the suspended dust to the free atmosphere (9-12 km), ’ We also improve figure 8 along the revision.

[Comment 9] 14465, 13-20: Perhaps another figure with a closer look on the cross sec-

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tions for 21 May-190843 path (both the CALIOP and RC4 dust extinction coefficients) can be added to help compare the two dust layers.

[Answer] We apologize that our complicated plots in figure 2. We will add a new figure to focus 21 May-190843 path.

[Comment 10] 14467, 2: Can you refer to other works making estimates on the amount of dust transported by major dust events? This would help readers to get a better idea on the significance of the dust veil in May 2007. Discussion on the uncertainty range is also missing with respect to the estimated dust loadings.

[Answer] There are a few estimates on the Taklimakan dust transport. Analyzing CALIPSO observations, Hara et al. (2008) estimated that summer-time horizontal dust flux over the Taklimakan Desert is 40-50 Gg/day. For the Taklimakan dust event, which caused one full circuit transport around the globe, Uno et al. (2009) estimated 75 Gg of dust was transported to the Pacific Ocean at 120E meridian using SPRINTARS model and CALIOP observations. We will revise as follows:

[line 4-14 page 14462] 'The SPRINTARS simulation estimates a dust inflow to the Pacific Ocean (at 130E) of 30.8 Gg. Hara et al. (2008) estimated that the horizontal dust flux over the Taklimakan Desert in summer is 40-50 Gg/day. Uno et al. (2009) tracked the Taklimakan dust transported one full circuit around the globe, and estimated that 75 Gg of dust amount is transported to the Pacific Ocean through 120E meridian. The SPRINTARS also evaluates that 65 % of the transported dust is deposited in the Pacific Ocean. . .'

We will add discussion about the underestimate of models along as follows (also see [Comment 3] by Referee #1):

[line 18, page 14446] 'though generally underestimate dust extinction coefficient: especially, in the North America and the North Atlantic Ocean, the model underestimates dust extinction coefficient by 1-2 order. This underestimate also leads a large uncer-

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tainty in the estimate of dust deposition amounts.'

[Comment 11] 14467, 4-7: It may not be within the scope of this work, but it is generally well accepted that such dust veil would more or less affect the global radiative budget. The question then is how much. It would be more informative if the estimates on the regional radiative effects are presented. Also, it would be very interesting to know if authors have any clue on the contribution of the Taklimakan desert (relative to other major sources) as the source of the global background dust.

[Answer] As referee mentioned, it is pretty interesting and important to estimate radiative effect of the dust veil (e.g. aerosol radiative forcing). However, that is quite difficult, because the dust veil is transported at high altitude with thin structure. Moreover, the models' underestimate makes quantitative estimates of the aerosol radiative forcing and the contribution difficult. It is next step of this study, including occurrence frequency of the dust veil.

Technical corrections

Thank you again for your careful review of our manuscript. We will improve the suggested points in the revised manuscript. Some suggestions require individual replies.

[Comment 12] 14454, 10: change "km / d" to "km / day". This should apply to the rest of the manuscript.

[Answer] We will improve.

[Comment 11] 14457, 6: "procedure" may not be the right word. Use "processes" instead. The word is misused elsewhere in the manuscript.

[Answer] We will replace procedure into process in revised manuscript. Also see [comment 14] of Referee #1.

[Comment 12] 14469, 6: Year is missing. 1984?

[Answer] You are right. We will improve.

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[Comment 13] 14469, 18: Is the work by Hara et al., (2008) cited in the paper?

[Answer] No. We will delete from the reference list.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 14453, 2009.

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