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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Black carbon record based on a shallow Himalayan ice core and its climatic implications" *by* J. Ming et al.

J. Ming et al.

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Response to Referee 1

The authors wish to express their thanks to referee 1 for the helpful comments, which have assisted in the revision of this manuscript. Our response to these comments is addressed below by first briefly repeating the comments.

For important issues: - The title of the manuscript... The authors agree with the referee's concern. Yes, we alluded to import climate effects of BC in ice without quantifying radiative forcing in the previous version of the paper. In the revision, the radiative forcing of BC in ice was simulated by the SNICAR model covering 50 yrs of the core age.

- Use of English... The paper's use of English has been improved by careful check for

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the grammatical and spelling errors.

For other important issues: - Uncertainties in the qualification of BC concentration in ice should be mentioned, as well as how the reported range (uncertainty) was estimated. The ranges for the BC measurements were reported in the revised manuscript, and the detection limits and precisions of the instruments or techniques have also been presented.

- The derivation of atmospheric BC requires more explanation. Specifically, to justify your method you should discuss the importance of the relative magnitudes of wet- and dry- deposition. The measured ratio of wet/total removal has not been investigated at this extremely difficult site for technical reasons till now. Based on a mean result of models, wet/total removal of BC is about 80%. At this extremely high site with large average annual net water accumulation, we presumed nearly all the BC in this ice was wet-deposited. And for discussing this point, we added a paragraph into the text.

- Transport of BC: One of the main points of this article is that BC in this region originates from South Asia... From the BC record in the top sections of the ice core with relative higher time resolution, seasonal cycle can be observed, indicating that higher BC concentrations appeared in Indian summer monsoon seasons. We precluded the significant local source of BC. And some sentences were added in the revised manuscript for describing the distinction between "long distance" and "non-long-distance" transport.

For specific comments: - Mt. Qomolangma and Mt. Everest... "Mt. Qomolangma" is better known by nearly all Chinese than Mt. Everest. We put Everest in the parenthesis after Mt. Qomolangma in the abstract and at the first appearance of Mt. Qomolangma in the revised manuscript.

- P. 14414, line 25: McConnell et al. (2007) paper... We have put the work of McConnell et al. (2007) in the description for previous study.

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- P. 14415, line 3: "Up to now there are only two reports..." - This is no longer true. Again, McConnell et. al. report a record from Greenland. I realize that McConnell et al. may not have been published before this manuscript was submitted. We did not clarify this problem before. We tried to mention that there were two works on BC records in the ice cores reported in the mid-latitudes. The statement was changed in the revised manuscript.

- P. 14415, line 12-14: "Himalayas may be an effective barrier to..." - This may be true, but this comment appears to counter one of your main conclusions: that particles deposited on the glacier are coming from the other side of the Himalayas. Place this comment in the context of your conclusions. In the conclusions of the revised manuscript, we stated "BC from South Asia's emissions could penetrate into the high Himalayas, although the elevated Himalayas could block off the air masses transported from South Asia to some extent".

- P. 14416, section 2.1: You discuss the borehole temperatures. Is there ever surface melt at this location/elevation in the summer? If melt does occur, discuss any implications for dating and positioning of frozen particles. At this site with the elevation of 6500 m where several other deeper ice cores were drilled during the recent years, surface melt was rare.

- P. 14416, line 25: "The seasonality of delta-18O exhibits an amount effect" - This does not make sense. Please clarify. In the revised manuscript, we state "Amount effect in the precipitations near Mt. Qomolangma caused less negative delta-18O values in non-monsoon seasons and more negative delta-18O values in monsoon seasons as recorded in the ice cores of the ERG (Qin et al., 2002; Kang et al., 2002)".

- P. 14418, line 1: What is "100-class"? "100-class" is the standard of cleanness in ambient air of EPA in USA. It refers to "numbers of particles larger than 0.5 μm in 1 ft3 air are less than 100".

- Section 2.3: What is the pore size of the filter? ... The pore size of the filter is 1

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μm. And the fiber filter efficiency for the capture of particles was better than 97%.

- Section 2.4: Briefly mention sources of errors for these techniques and their potential magnitudes. Later, you report ranges for the measurements. How was the range quantified? As showed in the "other important issues" part and in the revised manuscript.

- Section 3.2: ...This would only seem to apply to BC that is wet-deposited, since dry deposition does not depend on the scavenging ratio. Describe how your derivation of atmospheric BC would be affected if a significant portion of the BC in ice was dry-deposited. ... Provide an estimate of uncertainty in deriving the atmospheric concentration from the ice concentration. As showed in the "other important issues" part and in the revised manuscript, based on a mean result of models, wet/total removal of BC is about 80%. We presumed nearly all the BC in this ice was wet-deposited. Estimated errors have been provided in the new plot.

- P. 14420, line 19: "No matter what season it is in, ERG is located in the downwind direction of South Asia." - Be more specific about source regions during different seasons, as the portions of South Asia downwind of the ice core location may be very different during the seasons. If westerlies dominate during the winter and monsoonal flow during the summer, there is presumably an intra-annual dependence. We deleted the sentence "No matter what season it is in, ERG is located in the downwind of South Asia". Based on the result of the simulation for backward trajectories, an intra-annual dependence that the westerlies dominated during the winter and monsoonal flows during the summer could be observed.

- P. 14420, line 20: Provide a reference for the HYSPLIT model. The citation of Draxler and Hess (1998) has been added in the text as a reference.

- Section 3.3, last 2 sentences: Here, you are demonstrating that there is co-variability between the number of "non-long-distance" trajectories and the estimated atmospheric BC concentration. First, describe in more detail what constitutes "long-distance" and

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"non-long-distance" transports. Second, expand on your analysis: Presumably air masses coming from the south (or southwest?) during the monsoon season will be more polluted. Do you see a seasonal cycle in your timeseries? Is atmospheric BC greater (statistically significant) during non-long-distance transport times? If so, what are the likely "non-long-distance" sources that cause this effect? Must these sources come from the other side of the Himalayas? Are there any potential local BC sources (say, within 100km)? In the text, the trajectories of "long-distance transport" refer to the trajectories via a relatively longer distance and a higher pathway drove by the westerlies, and the other trajectories originated from south Asia and Southeast Asia belong to non-long-distance transport. Seasonal cycle of BC concentrations in ice could be surveyed through the toper ice with higher time resolution. We could not attribute BC in ice to local sources (say, within 100 km), for previous glaciochemistry conducted in the ERG suggested the atmospheric environment over the high elevated glaciers in the Himalayas was little affected by boundary layer and reflected the deposition of particles of non-vicinity sources. Above consideration has been included in the revised manuscript.

- P. 14422, line 1-2: "ERG's BC concentration could not be neglected to consider its consequent climate effect after taking its enhancing atmospheric solar absorption over snow and ice surface into account" - Also mention the enhanced absorption by snow and ice, which may even be a greater source of warming over snow than the atmospheric BC, as supported by studies from Hansen and Nazarenko (2004), Jacobson (2005), and Flanner et al. (2007). While you do mention this effect later, it could be better tied in with this statement. We estimated the radiative forcing caused by BC in ice, thus the statement has been changed, and detailed descriptions can be read in the revised manuscript.

- P. 14422, line 6: "this level of BC concentration in atmosphere and therefore black carbonaceous particles deposited in snow and ice could be fatal to the Himalayan glaciers" - This is an extreme statement and not supported by any quantifications conducted in

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this study. As alluded to at the beginning of my comments, subjective inferences such as these, if included, must be supported by some sort of estimate of the radiative forcing or warming effects. This sentence was deleted, and new simulation result on radiative forcing caused by BC in the ice has been added into the text.

- Section 3.4: Needs grammatical and conceptual work to be more coherent... The grammatical problems have been carefully checked, especially for the proper use of the tense and words.

- Figure 2 caption: Describe the three variables plotted in this figure. The usage of three variables for dating the ice core has been explained in the revised manuscript.

- Figure 5: I do not understand the bottom portion of this figure. Describe it in the caption, including what the the x-axis is. The two curves seem to show a common point at 3666 meters. What does this altitude represent? The bottom portion of this figure refers to the vertical move of particles from the place 5 days ago to the drilling site. The necessary illustrative words have been added into the plot and also into the caption. The point refers to the drilling site, and "3666 m" is the relative elevation above the HYSPLIT model ground level at the drilling site.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 14413, 2007.