Atmos. Chem. Phys. Discuss., 13, C13257–C13261, 2014
www.atmos-chem-phys-discuss.net/13/C13257/2014/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Seasonal and elevational variations of black carbon and dust in snow and ice in the Solu-Khumbu, Nepal and estimated radiative forcings" *by* S. Kaspari et al.

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Received and published: 1 April 2014

Anonymous Review #1

Note- this review was submitted prior to the article being posted online for interactive comment, and was never posted online. We've inquired with ACP about this, but have not received a response, so we are posting comments here.

This work focuses on the measurements of BC and Fe, as a dust proxy, deposited in snow from the south side of Himalaya. By analyses of seasonal and elevational variations in those impurities, it addresses albedo and radiative forcing implications for

Himalayan Glaciers, snowmelt and energy fluxes. This manuscript is well written, and the results are interesting and original. This paper provide a valuable insight into the contribution of impurities to the accelerated snow and ice melt in Himalayan region. It is a good supplemental and subsequent research of Kaspari et al. (2009) titled "Recent increase in black carbon concentrations from a Mt. Everest ice core spanning 1860-2000 AD" in the aspect of albedo and radiative forcing derived from BC and dust. However, I recommend the authors to consider the following comments. Comments: 1. The title of this article only including the variation information of BC and dust. However, âĂĺsince radiative forcing derived from those variations is one important aspect of this work, âĂĺmaybe the title should include this kind of information.

In response to this feedback, the title of the manuscript was modified to include estimated radiative forcing before the manuscript went online.

2. The sampling area should be described more specifically, including seasonality of âĂĺprecipitation, glacier mass accumulation, etc. This kind of data may be found from the weather station nearby or previous researches. These information can help us to understand the impurity enrichment process.

Section 2.1 (Site Description) has been added to the manuscript, providing more details on the site selection, climatology, and glacier: 2.1 Site Description Mera Glacier (27°43N, 86°53E) in the Solu-Khumbu region of Nepal was selected as the study site for this research because Mera glacier is: 1) located on the southern slope of the Himalaya; 2) a debris free glacier that has been monitored for glacier mass balance since 2007 (Wagnon et al., 2013); 3) located nearby (30 km south of) the Nepal Climate Observatory-Pyramid (NCO-P) in the Khumbu Valley, Nepal (27°56N, 86°49E, 5079 m asl) where atmospheric BC measurements have been made since 2006; and 4) relatively accessible (5-7 days walk from Lukla airport). During the summer months the climate at this site is dominated by the Indian monsoon, with air masses originating from the Bay of Bengal. During the winter, atmospheric circulation is dominated by the westerlies. Based on NCO-P station data, more than 80% of the precipitation falls

during the summer monsoon period (June-September), with the non-monsoon months relatively dry. Mera Glacier flows northwards from the summit of Mera Peak (6420 m a.s.l.) to the terminus at 4940 m a.s.l., and the equilibrium line altitude (ELA) is located at approximately 5550 m a.s.l.. Monitoring of Mera Glacier since 2007 indicates that the glacier is undergoing moderate mass loss (Wagnon et al., 2013).

3. About the seasonal layer of impurity in section 3.1, does the snow of sampling site melt remarkable during summer monsoon seasons? Could it be a possibility that the snow melt so seriously that the impurities enrich and form impurity layers? If it is the case, then the darker layers with high values of BC and Fe are likely formed during summers. According to Line 348-349, Page 8, as all the sampling sites below 7000 m asl, the impurities should be exposed. It seems to indicate the snow melt so remarkable during summer seasons that the impurity layer is re-exposed. According to this, the BC and dust could be concentrated and form impurity layer during summer seasons. âĂĺAs the seasonality of BC and dust is a key point in understanding the contribution of impurities to albedo and radiative forcing, I suggest the authors add oxygen isotope data to demonstrate the seasonality of impurity layers. If the impurity layers are shown in winter- spring seasons, when the isotope has higher values, the seasonality of impurities indicate relatively original atmosphere background. If the impurity layers are shown in summer seasons, when oxygen isotope has lower values, the impurity layers are likely derived from seriously melting during summer time.

We've addressed the reviewer's comments in the revised manuscript in section 3.1. Recently published glacier mass balance data from Mera glacier indicates that at Mera High Camp and Mera Summit the glacier balance is positive, and that accumulation occurs during the summer monsoon season (Wagnon et al. 2013). Additionally, the stable isotope data presented by Ginot et al. (2013 Cryosphere Discussions) confirm the seasonality of BC and dust deposition for Mera summit as presented in the original manuscript (peak BC and dust during the winter-spring), consistent with results we previously presented for a Mt. Everest ice core (Kaspari et al., 2011). We've added

this additional information into section 3.1. For the crevasse profile at Mera La we have modified our interpretation as the glacier monitoring conducted by Wagnon et al. indicates that Mera La is located below the equilibrium line altitude, thus multiple years of impurities may coalesce into a single layer. See paragraphs 2, 5 and 6 of section 3.1.

4. About the 54-cm-depth snowpit at the col below Mera Peak (6400 m asl), I'm wondering âĂĺwhy the authors only dig half meter depth? Is the snow only that thick? If deeper than 54 âĂĺcm it's ice, it may indicate great melt process at that location.

It would have been possible to dig a deeper snowpit, but difficult field conditions (high winds and one member of the party experiencing altitude sickness) resulted in only a 54 cm snowpit being sampled.

5. Authors use the snowpit data to demonstrate that summer monsoon season has lower âĂĺconcentration. Could the snowpit samples include the snow fall of spring and even winter? âĂĺIf they do, then it'll be better to show the vertical profiles of BC concentration of snowpits.

The snowpit at Mera La only consisted of summer monsoon precipitation (hit the super imposed ice layer and couldn't dig deeper). At Mera Summit it is possible that more than summer monsoon snow was collected, but due to the long storage of the snowpit samples this data is less certain and is better not presented. The recent results of Ginot et al. (2013) validate the seasonality we report in the manuscript.

6. All the impurities are treated as dust sounds reasonable. However, the reasons of this âĂĺassumption need more explanations and proofs. In the methods section (2.2) we stated that the impurities are treated as dust, and in section 3.3 we state that the dry mass may also contain organics. See the detailed response to referee #2 (our first response to referee #2) that provides further justification of the assumption that the impurities are dust.

7. Page 7, Line 316. “Figure 3” should be changed to “Figure 4”? The referee is correct- this change has been made.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 33491, 2013.