

## ***Interactive comment on “A 10 yr record of black carbon and dust from Mera Peak ice core (Nepal): variability and potential impact on Himalayan glacier melting” by P. Ginot et al.***

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### Overview

Manuscript by Ginot and others reveals a ten year record of impurities in an ice core drilled at high elevation accumulation site of Mera Glacier, Nepal Himalaya. The ice core well preserves seasonal signals of stable isotope, chemical compositions and impurities. Although effect of black carbon (BC) on glacier mass balance has been pointed out in some previous studies, this study evaluates both impact of BC and dust in terms of albedo, absorption of solar radiation and excess melt quantitatively. The record shown in this manuscript seems important and thus worth to be published in

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TC. In particular, it is meaningful that the authors successfully distinguished the impacts and seasonality of dust and BC because the impact of BC seems to have been overstated in previous studies. However, impacts of the impurities on absorption of solar radiation and excess melting are based on various and vulnerable assumptions. Considering use of these values by following researches, the manuscript seems to draw somewhat over-conclusion though the authors described limitation of their analysis.

### Major comments

A similar discussion paper

A similar paper is now under discussion in an open discussion journal, ACP. The paper by Kaspari and others deals with the same element, BC, taken at the same glacier. I recommend that both authors exchange their information not for competing each other, but for improving both manuscripts.

Kaspari, S., Painter, T. H., Gysel, M., and Schwikowski, M.: Seasonal and elevational variations of black carbon and dust in snow and ice in the Solu-Khumbu, Nepal and estimated radiative forcings, *Atmos. Chem. Phys. Discuss.*, 13, 33491-33521, doi:10.5194/acpd-13-33491-2013, 2013.

<http://www.atmos-chem-phys-discuss.net/13/33491/2013/acpd-13-33491-2013.html>

### Uncertainty in sample retrieval and analysis

Although the BC analysis is not my expertise, I have heard that BC particles could decrease during transportation and storage. Also heard was that refreezing could alter the analytical result significantly. The manuscript does not touch those technical points.

### Analyses of the ice-core records

Analysis and discussion of the ice core record are insufficient. Although many space is spent to explain general behavior and source of ammonium (P6010), for instance,

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the profile is not sufficiently analyzed. Consistency and inconsistency among different species and impurities may provide more information in terms of source, emission and transportation processes.

In particular, comparison with meteorological record has to be performed. I suppose that data at Lukla and Namche Bazar should be available together with the NCO-Pyramid. Onset of monsoon varied year by year and it will affect the assumptions that every 1st June is end of dry season, and that impurity concentrations linearly increased during every dry season toward their maxima on 1st June. I agree with that the winter accumulation is expected to have been eroded by wind though it will be negligibly small amount. But it will be meaningful to compare whether the ice-core derived accumulation is consistent with the observational precipitation records at the neighboring stations.

#### Description and discussion of stratigraphy

In addition to the analysis above mentioned, stratigraphy such as ice layers and grain size have to be described and discussed. The relevant descriptions are fragmentally shown through the manuscript.

#### Definition of seasons

Although pre-monsoon, post-monsoon, monsoon and winter seasons are surely defined in the manuscript, "inter-monsoon" suddenly appeared at the middle part (P6011L21), and then used through the latter part of the manuscript. Also undefined is "non-monsoon" season. I just imagined from Figure 4 that the inter-monsoon and non-monsoon are the season consisting of post- and pre-monsoon seasons excluding winter.

#### Linear assumptions

I do not agree with the authors' assumptions in which the surface concentrations in dust and BC have increased linearly toward 1st June because this directly affects the

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succeeding results and I feel that the authors overstated their estimates. At least, it is better to be assumed that the surface concentrations are distributed according to those in the ice core profiles.

#### Potential melting evaluation

The "potential melting evaluation" will mislead readers. Decreased albedo by dust and BC could warm up temperature of the snow pack, but no melt should have occurred in the cold snow condition as the authors mentioned. Under such condition, projection of "additional melt" is meaningless. Although the authors further evaluated the impact of dust and BC as additional melt by comparing the mass balance in the ablation zone, the surface condition should be completely different from that in the accumulation zone, at which the ice core was retrieved and albedo reduction was estimated. In addition to the complicated "mass balance" of impurities as the authors mentioned in the text, it is questionable that the impact of additional dust and BC would be "additive" on a surface condition in the ablation zone, on which mud like material is usually found (e.g. Takeuchi et al., 2001). Fujita et al. (2011) have demonstrated that the lowering of surface albedo could alter the mass balance around the equilibrium line altitude while no significant consequence was found at the accumulation zone and at the ablation zone. At the accumulation zone, additional meltwater caused by albedo reduction could be captured by refreezing, while the dirty surface could be exposed (almost) throughout the melting season at the ablation zone.

Takeuchi, N., Kohshima, S., and Seko, K.: Structure, formation, and darkening process of albedo-reducing material (cryoconite) on a Himalayan glacier: A granular algal mat growing on the glacier, *Arct. Antarct. Alp. Res.*, 33(2), 115–122, 2001.

Fujita, K., Takeuchi, N., Nikitin, S.A., Surazakov, A.B., Okamoto, S., Aizen, V.B., Kubota, J.: Favorable climatic regime for maintaining the present-day geometry of the Gregoriev Glacier, Inner Tien Shan, *Cryosphere*, 5(3), 539-549. doi:10.5194/tc-5-539-2011, 2011

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#### Deposition timing of impurities

The authors assumed that the surface was dirtiest on 1st June in every year. This assumption is not sufficiently discussed though the timing when the surface was dusted (BC added) is substantially important for the melt acceleration. Fujita (2007) has demonstrated this aspect.

Fujita, K.: Effect of dust event timing on glacier runoff: sensitivity analysis for a Tibetan glacier, *Hydrol. Process.*, 21(21), 2892–2896, doi:10.1002/hyp.6504, 2007.

#### Minor comments

Many abbreviations are used without spelling out. Many sentences are grammatically incomplete, probably because of position of parentheses. The manuscript must be checked by any native English speakers.

P6007L20 How did the authors know the site temperature? Need reference or description how it was measured or estimated.

P6011L8-18 The authors interpreted that the upper most part of the ice-core was accumulated during early winter. But in the profile of stable isotope (Fig. 2), I cannot identify any signatures of post-monsoonal precipitation which should show heavier values.

P6013L15- Nothing is explained why the authors can conclude that the principal component 1 is controlled by deposition processes.

P6013L23 Need evidence or reference for the emission source to be salt lake.

P6014L12 What are the 4 species?

P6014L16 Need any references for the limited transportation.

P6014L18- I totally agree with this description. Therefore it is important to analyze variability of the ice core signals.

P6015L6-10 Was dust either "in the snow" or "in the atmosphere" measured at the

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#### NCO-P?

P6020L6 Are solar radiation incident and solar irradiance different? If they are same meaning, use a single term.

Figure 1 Replace the Asian map (lower left panel) by close-up regional map, in which NCO-P, Ronbuk Glacier and other stations are shown. I think that the location of Mera Glacier (red star) is incorrect.

Figures 5 and 6 Labels and legends are too small to be seen.

Figure 6 Same scale of y axes is appreciated for two panels.

Figure 8 Is any different color used for "monsoon"?

Two important papers by Xu et al. (2009, 2012) are missed.

Xu, B., Cao, J., Hansen, J., Yao, T., Joswiak, D., Wang, N., Wu, G., Wang, M., Zhao, H., Yang, W., Liu, X., and He, J.: Black soot and the survival of Tibetan glaciers, *P. Natl. Acad. Sci. USA*, 106, 22114–22118, 2009.

Xu, B., Cao, J., Joswiak, D., Liu, X., Zhao, H., and He, J.: Post-depositional enrichment of black soot in snow-pack and accelerated melting of Tibetan glaciers, *Environ. Res. Lett.*, 7, 014022, 2012.

#### Misc

P6006L19-20 Why is February omitted? November is counted twice.

P6015L29-P0616L3 Definition of the ratio is unclear because of "between". Is this ratio dust against rBC?

P6019L15 I do not understand what "enhances" means.

P6020L5-6 I do not understand what "solar incident radiation incident". Is this just typo?

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P6022L21 Delete "and topographical – image of 2012" because the satellite image does not matter in terms of mass balance in the ablation zone.

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Interactive comment on The Cryosphere Discuss., 7, 6001, 2013.

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