Dear Dr. Fettweis,

thank you very much for reviewing our manuscript.

General remark

In the discussion paper, we used m^2/kg for the unit of the specific surface area of ice. However, the parameterisation by Gardner and Sharp (2010) used cm^2/g, and we overlooked the different units when we prepared the discussion paper. Our apologies for this mistake!

The value for the specific surface area we now use (2 cm^2/g; see Table 1) is based on Dadic et al. (2013). As a result, the clean ice albedo is higher, and the albedo reduction due to BC is less (Figure S4a). The conclusions of the paper are still the same, although the numbers have changed and will be corrected throughout the text. Also, Figures 5, 6, 7, 8, 9, 10 and S2, S3, S4 will be redone.

Response to the comments (referee's comments are repeated in red)

…However, as the authors use conceptual simulations and as everything is not linear, the absolute values of the impact of BC/dust to the GrIS depletion should be less highlighted. The uncertainty is too high.
For example, the sentence (in the abstract):
The effect of aerosols in the year 3000 is up to 12 % of additional ice sheet volume loss in the warmest scenario.

The last sentence in the abstract will be changed accordingly, and it will include the new numbers due to the change in specific surface area:

"The effect of aerosols depends non-linearly on the temperature rise due to the feedback between aerosol accumulation and surface melt. According to our conceptual model, accounting for BC and dust in future projections of ice sheet changes until the year 3000 could induce an additional volume loss of 7%. Since we have ignored some feedback processes, the impact might be even larger."

In addition to the remarks of reviewer 1, I notice that nothing is said about rainfall. With warmer climates, rainfall events over ice sheet should increase and could become dominant in summer over the ablation zone. If such events favour a cleaning of the ice sheet surface, could they reduce the impact of BC/dust? What is the impact of heavier rainfalls to dust/BC retention by the ice sheet?

Normal ablation rates at the margin are in the order of a few metres up to 10 metres yearly, whereas annual precipitation is around 500 mm. If the summer constitutes of four month of melt, this would result in not more than 300 mm of rain; in other words, a magnitude of some 3% compared to ice melt. We therefore believe that, even though rainfall intensity may increase, this only constitutes a small fraction of water running off the margin that can potentially remove dust/BC from the ice sheet.

The 2012 melt event produced an all-time observed water discharge from the ice sheet, and albedo of the ablation zone has not increased due to removal of dust/BC to our knowledge. So, we believe that the intensity of discharge is not the controlling factor for impurity removal.

We will add the following sentences in section 5.2: “Under warming scenarios, the daily reduction might increase with increased surface runoff due to meltwater and rainfall, which would have a stabilising effect that is currently not captured. Under recent conditions, the amount of meltwater runoff is typically one to two magnitudes higher than summer rainfall. Therefore, even with more rainfall during summer in the future, the potential increase of the daily reduction will most likely be determined by the meltwater runoff.“

Sincerely,

T. Goelles, C. E. Bøggild and R. Greve

Reference

Dadic, R., Mullen, P. C., Schneebeli, M., Brandt, R. and Warren, S. G.: Effects of bubbles, cracks, and volcanic tephra on the spectral albedo of bare ice near the Transantarctic Mountains: Implications for sea glaciers on Snowball Earth, J. Geophys. Res. Earth Surf., 118(3), 1658-1676, doi: 10.1002/jgrf.20098, 2013.

Gardner, A. and Sharp, M.: A review of snow and ice albedo and the development of a new physically based broadband albedo parameterization, J. Geophys. Res., 115, F01009, doi: 10.1029/2009JF001444, 2010.