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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "The decreasing albedo of Zhadang glacier on western Nyainqentanglha and the role of light-absorbing impurities" *by* B. Qu et al.

**Anonymous Referee #1**

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This study investigates changes in the surface albedo of the Zhadang glacier in the southern Tibetan Plateau, a topic of relevance for the special issue that the manuscript was submitted to. Three main issues are explored in this study: (1) trends in the albedo of the glacier during 2001-2010, determined from MODIS satellite observations, (2) the relationship between albedo anomalies and surface mass balance anomalies, and (3) the impacts of black carbon (BC) and dust on the albedo of different parts of the glacier, and under different snow and ice conditions. All of these issues are important and worthy of publication. The discussion of BC and dust impacts is somewhat disconnected from issues (1) and (2), because the in-situ measurements only occurred during July

and August of 2012. The study could have been more coherent if the decadal-scale changes in albedo had been linked to changes in dust and BC, but this does not appear possible because of the limited time extent of the ground measurements. Nonetheless, readers will likely be left wondering about the relationship between aerosols and the long-term changes in albedo, and consequently it would be helpful for the authors to comment more on this, perhaps leveraging findings from Ming et al (2012) and others. Such a discussion would help tie the different components of this study together. Aside from this, the issues described below relate mostly to need for justification or more detail on methods.

Issues:

Why does the MODIS albedo analysis (Figure 4) only extend to 2010? Presumably this could be extended through 2013. (Figure 3 includes 2011 MODIS data). Does the downward trend continue during 2011-2013? Including 2012 MODIS data would also allow a comparison between ASD-measured (in situ) albedo and MODIS albedo, similar to the comparison between AWS and MODIS albedo that is shown in Figure 3.

Abstract: Mention that the BC and dust albedo impacts only apply to measurements taken in 2012.

p.13111,11: The "darkening" referred to here probably relates to increasing grain size. I suggest being more precise.

p.13111,26-29: What are these albedo reductions relative to? Are these absolute albedo reductions relative to winter values, percentages of total impurity-induced albedo reduction, or something different? Please clarify.

p.13113,18-20: Wording here is unclear. Are these criteria applied by the authors, or are they "built in" to the product? Also, is the QA value binary or is it one of several possible values? If the latter, which threshold was applied?

p.13114,7: "mounted in a pistol-shaped unit" - Was this a tripod unit? How was leveling



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with respect to the normal conducted? Please include more detail here.

p.13115,7: "snow size" -> "snow grain size"

p.13115,12: "Snow grain effective radius is taken as the half of observed snow grain size shown in Table 1" - What is the justification for this factor? More generally, it should be pointed out, either here or in section 2.3, that the measure of grain size determined from a hand lens can be quite different from the optical (effective) measure that is relevant for radiative transfer modeling, and consequently uncertainty in snow grain size translates into substantial uncertainty in modeled albedo impacts of impurities.

p.13115,13: "The albedo of the underlying ground is taken as ..., based on observations" - For the radiative transfer modeling, these values should represent the albedo of whatever surface underlies the snow, which for a glacier is usually some sort of ice substrate. Do the "observed" values applied here represent bare glacier albedo or something different? Please clarify.

p.13116,13: "relative to" -> "related to"

Table 2 includes a useful comparison between modeled and observed albedo, but this is not discussed in the text. It would be helpful to include a brief statistical evaluation of the modeled vs. observed albedo (e.g., RMSE, correlation).

Discussion in section 3.2: Tables 2 and A1 indicate that the modeling work assumes thin snowpack (2-5 cm). Although these values are consistent with the measured snow thicknesses (Table 1), this configuration with the SNICAR model implies that impurities contained within the ice beneath the snow do not contribute to the radiative forcing calculations. It is unclear how important this assumption is, but it does contribute to a low bias in the RF estimates. This needs to be acknowledged in the manuscript.

Figure 3: Do the AWS measurements extend to 2012? If so, it would be very useful to also include a comparison between AWS and in-situ (ASD) measured albedos.

Figure 5: The caption should mention that these RF estimates represent mid-day RF



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(when the insolation measurements were conducted) rather than daily-mean RF.

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