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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 #2

Received and published: 10 June 2014

The manuscript entitled "The decreasing albedo of Zhadang glacier on western Nyainqentanglha and the role of light-absorbing impurities" by Qu et al. discussed the influences of LACs (light-absorbing constituents, e.g., BC and dust) on the snow/ice albedo and mass balance of glacier based on in-situ measurements and satellite data. Authors found a good correlation between the decreased glacier mass balance and its surface albedo derived from MODIS. The BC and dust are suggested as two dominant factors driving the glacier albedo reduction. From both the science and societal impact perspectives, Tibetan Plateau is a very sensitive and important region in regulating Asian monsoon and hydrological cycle, which would potentially affect the water resources,

ecosystem, cryosphere change and even national securities in Asian countries. This study provided some very valuable in-situ measurement data over Zhadang glacier in Tibetan Plateau. While this is an interesting and appropriate topic for ACP, especially this SOAR-TP special issue, the analysis procedure of the data and presentation of the article can be greatly improved. Authors failed to present the data in a context that would logically support the major findings. For example, a good correlation between the glacier mass and surface albedo doesn't necessarily mean it must be the snow/ice impurities that caused the surface darkening. Other factors, such as the warming of atmosphere, no matter from whatever reasons, could reduce the snow surface albedo by increasing the snow gran size thought snow aging process, resulting in a glacier mass lose. The lack of long-term measurements of LACs (impurities) in snow/glacier (so no way to support your conclusion in a stronger way) is a serious flaw in this study. Also the presentation needs to be improved. The paper may need more work in improving the writing by a native English speaker. There are quite several grammatical errors or inappropriate use of English. This reviewer suggests that following comments and suggestions should be addressed before the manuscript can be considered for formally publication in ACP.

Major comments

1. Surface albedo inferred from satellite measurements have typical errors of a few percent, the bias could be even larger in mountainous area like Tibetan Plateau, so a signal of reduced or increased albedo will be difficult to detect. So how you can detect the albedo trend or change shown in Figure 4 is significant and reliable? The inference of albedo from a nadir radiance measurement can be biased low because of undetected thin clouds, multiple reflectances in the mountains or blowing snow altering the angular reflectance pattern (Warren, 2013). But even if the albedo could be measured perfectly from satellite, its attribution would be ambiguous because of the vertical variation of snow grain size, absorbing aerosol in the atmosphere above the snow, and especially because of sub pixel heterogeneity of the thin and patchy snow

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cover of the treeless regions. The spectral signature of thin snow resembles that of BC in snow. For these reasons, Warren (2013) suggests that attempts to use satellite remote sensing to estimate the variability of albedo by BC are unlikely to be successful. Authors suggested a downward trend of albedo in Zhadang glacier as shown in Figure 4. However, it would appear an upward trend if last two years of data are removed. This is a critical issue that should be more carefully addressed.

2. To justify the validity of using MODIS data to look at the trend or variability of glacier albedo, authors tried to use in-situ AWS albedo data to evaluate the MODIS albedo data, see Figure 3. This figure shows an overall positive correlation between these two datasets, but also a remarkable scattering and discrepancy can be seen. Especially, if the 5 points at lower albedo end are removed, the correlation would be much smaller. The in-situ AWS observation is point measurement but the MODIS albedo represents an average of 500 $\times$ 500 m2 pixel, which could contribute to the discrepancy, especially over mountainous area with complex terrain like Zhadang. This part of discussion should be more carefully revised.

3. Authors failed to present the data in a context that would logically support the major findings. For example, a good correlation between the glacier mass and surface albedo doesn't necessarily mean that it must be snow/ice impurities that caused the surface darkening. Other factors, such as the warming of atmosphere, no matter from whatever reasons, could increase the snow gran size (through snow aging process) thus reduce surface albedo, resulting in a glacier mass lose. The lack of long-term measurements of LACs in snow/glacier is a serious flaw in this study. This reviewer would suggest more measurement data that can link the snow albedo and impurities should be added in this study to support your conclusions.

Minor comments

1. Page 13131, Figure 5. How did you calculate the RF driven by BC and dust in the S-I condition? I think the SNICAR model only applies to the impurities in snow rather

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than glacier.

2. Page 13112, line 14. “Dust” -> “dust”.

3. Page 13113, line 4-5. “The surface conditions are typical in Alpine glaciers all around the year” means those conditions are typical all the time in Tibetan too?

4. Page 13116, line 3-4. The albedo increases with elevation, could it also due to lower BC and dust contained in the snow/ice?

5. Page 13116, line 17-18. N=6? Or 5?

6. Page 13116, line 23-26. The BC is accumulates greatly in aged snow/ice, so the concentration in the S-I condition is much higher than the ice core records or fresh snow. The BC concentration in aged snow should not be directly compared with the BC concentrations in ice core or fresh snow.

7. In calculation of albedo using SNICAR, please make sure the “MAC scaling factor (experimental)” is not MAC. In SNICAR model, the factor of BC in broadband is 1. If the authors just input “11” in the “factor (experimental)”, that’ll make the results of albedo reduction higher.

8. Page 13114, line 10, at sites A and B, it was bare ice. So when sampling, the ice just been picked up? Or chop one piece off from the bare ice? I suggest making the sampling procedure clear.

9. Page 13114, line 18, “clean hands-dirty hands”, what that means?

10. Page 13126, Table A1. “10. Dust concentration (ppm, 5.0–10.0 μm diameter)” How get the dust grain size (5.0-10.0 um in diameter)? The concentration is based on the different weights of filters before and after filtration? How get the dust diameter?

11. Reference format and arrangement should be corrected.

12. The paper may need more work in improving the writing by a native English

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speaker. There are quite several grammatical errors or inappropriate use of English.

13. Introduction: the first paragraph seems too long.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 13109, 2014.