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Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Technical note: A low-cost albedometer for snow and ice measurements – Theoretical results and application on a tropical mountain in Bolivia" *by* Thomas Condom et al.

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We are grateful to the anonymous reviewer for the good feedbacks. We present below our detailed answer to each points. The reviewer's comments appear in black Times font and our responses appear in brown Arial font.

Specific Comments: The article would benefit from more background evidence of in situ snow and ice albedo measurement studies in the past, such as P. 4 L74-76 needs expanded. Maybe elaborate on previous techniques: Brock, B., Willis,

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Discussion paper

I., & Sharp, M. (2000). Measurement and parameterization of albedo variations at Haut Glacier d'Arolla, Switzerland. Journal of Glaciology, 46(155), 675-688. doi:10.3189/172756500781832675. We thank the reviewer for this comment and we added more background evidence of in situ snow and ice albedo measurement studies as those given by Brock et al. (2000). We added the following sentences into the introduction section: 'A study published by Brock et al. (2000) aimed to document the spatial and temporal variations of surface albedo on the Haut Glacier d'Arolla, Switzerland during the 1993 and 1994 ablation seasons (from the mid-May to the end of August). They used traditional Kipp and Zonen CM7B albedometer (that is expensive) and relied the temporal variations of albedo with surface conditions as snow depth, surface snow density and surface snow grain-size. One of their conclusions underlined the importance to conduct in-situ field measurements continuously at daily time scale across a glacier throughout the ablation season, as the measurements are crucial to develop albedo parametrization into hydro-glaciological models.'

The authors provide a comparison between simi-infinite diffuse albedo and the albedo index computed with the LCA for 10 different surface conditions, but it must be made clear that Figure 4 is comparing theory to theory, not theory to measurements by the LCA, rather it is a comparison to the expected albedo index based on the spectral response of the surface and the LCA. We agree with this comment, we changed the caption of figure 4 accordingly, you can now read: 'Figure 4: Comparison between the theoretical semi-infinite diffuse beam broadband albedo and LCA albedo index theoretically estimated based on spectral response of the LCA for 10 different surfaces calculated with two kinds of total solar irradiance (see the text for the calculation); on the right: cloudy sky and on the left: clear sky conditions (spectra are represented in Fig. 2) - 1: Ice air bubble 0.02; 2: Ice air bubble 0.05; 3: Ice air bubble 0.1; 4: Ice air bubble 0.2; 5: Ice air bubble 0.4; 6: Ice air bubble 0.7; 7: dusty snow SSA 5 m2 kg-1; 8: dusty snow SSA 40 m2 kg-1; 9: pure snow SSA 5 m2 kg-1; 10: pure snow SSA 40 m2 kg-1'

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If the authors had the means and resources, it would be much more convincing and valuable to compare the theoretical semi-infinite diffuse bean broadband albedo to actual measurements by the LCA over the 10 surface types in a controlled lab environment. We focused on the application of the LCA for a deployment in situ and the tests suggested by the reviewer are beyond the scope of this study.

Technical Corrections Suggestions: Hobo should be all upper case HOBO. We agree with this comment and we replaced “Hobo” with “HOBO” into the revised manuscript.

P2, L26: please describe the "classical" albedometer; it would be good if you could demonstrate that this is a secondary standard for albedo measurement or solar irradiance measurement, as this makes your comparison study more reliable. We agree with this comment and we added the description of the traditional albedometer. You can now read in the abstract of the revised version: ‘Then, the LCA values are compared with two “traditional” albedometers CM3 pyranometer (Kipp & Zonen®) in the shortwave domain from 0.305 to 2.800 μm over a one-year measurement period (2013) for two sites in a tropical mountainous catchment in Bolivia.’ As the LCA provides an albedo index that depends directly from the HOBO sensor, we don’t think that the albedo index could be a secondary standard. We decided to keep our definition of the albedo index in the revised version.

P2, L29: remove "right-hand side" and be more descriptive in terms of slope and azimuth direction of this location As suggested, we deleted the word “right-hand side” and the new sentence is the following: “One site is located on the Zongo Glacier (i.e. snow and ice surfaces) and the second one is found on the crest of the lateral moraine (bare soil and snow surfaces) which present a horizontal surface and a sky view factor of 0.98”.

P9, L158: for _longer_ wavelengths As mentioned, we replaced “for larger wavelengths” with “for longer wavelengths”.

P10, L171: Is there a formula to illustrate the calculation of the theoretical LCA albedo

that clarifies the method? We agree with this comment and we added the equations in order to be clearer. We can now read in the revised version: “The theoretical broadband albedo and LCA albedo indexes are calculated over the 0.205-3.9 μm range using the theoretical solar irradiance, the LCA spectral response from Figure 2, and the semi-infinite diffuse beam albedo from Figure 3. The total incident radiation flux for LCA, Sinc (in W m-2), is obtained by summing the theoretical incident radiation fluxes, Sinc-th(λ) (in W m-2 μm-1), weighted by the LCA response, Rλ (-), at each spectral increment of 5 μm for both cloudy and clear sky conditions (Eq. 1). S_inc=$\sum$_(λ=0.205)ˆ3.9âŰŠãĂŰS_(inc-th) (λ) R_λ dλãĂů (Eq. 1) Similarly, the reflected radiation flux for the LCA, Sref (in W m-2), is obtained by summing the theoretical reflected radiation fluxes, Sref-th(λ) (in W m-2 μm-1), weighted by the LCA response, Rλ (-), at each spectral increment of 5 μm for each snow or ice class considered (Eq. 2). S_ref=$\sum$_(λ=0.205)ˆ3.9âŰŠãĂŰS_(ref-th) (λ) R_λ dλãĂů (Eq. 2) Then, the LCA albedo index, Albedoindex (-),is the ratio between the reflected and incident LCA radiation fluxes for each type of snow and ice surface and for cloudy or clear sky conditions (Eq. 3). ãĂŰAlbedoãĂů_index=S_ref/S_inc (Eq. 3) Finally, this LCA albedo index is compared with the theoretical broadband albedo when we consider the spectral variations. Note that the results are presented with the incoming radiation corresponding to the total solar irradiances for clear sky and cloudy sky conditions and without testing the effect of the angular limitation of the LCA.”

P11, L 193: calculated with the LCA is vague. Do you mean theoretically estimated based on spectral response of the LCA? We agree, it was unclear and we changed the text as follows: ‘Comparison between the theoretical semi-infinite diffuse beam broadband albedo and LCA albedo index theoretically estimated based on spectral response of the LCA for 10 different surfaces calculated with two kinds of total solar irradiance (see the text for the calculation);’

P12, L205: What two sensors? There are no sensors involved (now direct measurements) in the theoretical estimations. Sensors are used in section 3. It was an error

and we changed the sentence as follows: ‘A better agreement between the theoretical albedos and the LCA albedo index is given in the cloudy case with an overall underestimation of 5% compared with 9% for the clear sky case.’

P14, L247: dividing the _sum_ of reflected by _sum_ of incident? We corrected the sentence and one can now read: ‘(ii) the calculation of the daily albedo index by dividing the sum of reflected values by the sum of incident illuminance values’.

P18, L309: numbers for the X axis, not Y axis? Yes, it is true and we changed the letter in the revised version of the manuscript.

P21, L379: be a little more explicit about the precautions that we need to consider when applying the Hobo albedometer We specified what should be the field visit frequency. You can read in the revised version: ‘In order to have good results for the albedo index calculated with the LCA, a certain degree of caution is required: for example, snow particles should not stay on the sensor and the sensor must be kept horizontal. Therefore, we recommend a frequency of about 15 days between each field visit and data download’.

You will find the revised manuscript in the supplement.

Please also note the supplement to this comment:
https://www.geosci-instrum-method-data-syst-discuss.net/gi-2017-55/gi-2017-55-AC2-supplement.pdf

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