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Interactive comment on "Correction of albedo measurements due to unknown geometry" *by* U. Weiser et al.

Anonymous Referee #4

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1 Summary

Weiser and colleagues present a methodology to correct tilted albedo measurements over a non-flat snow/ice surface using nearby leveled shortwave incoming radiation. The method is based on the assumption of constant diurnal atmospheric conditions, constant diurnal albedo values and constant sensor tilts and surface slopes. They apply the methodology for some days by comparing the modeled albedo with the observed albedo, but never validate the retrieved tilt, slope angles.

2 Assessment

Although Weiser and colleagues present a study on a interesting topic for the TC community, the manuscript has too many issues in its current status (see major and specific comments) to warrant publication in TC. Therefore, I would recommend a resubmission where the authors can tackle the issues mentioned in this review and in the review reports of my colleagues which all raise valuable concerns.

3 Major comments:

- The manuscript is poorly written. The English needs a thorough revision and the structure of the paper is poor. For example, both the introduction and discussion lack a comprehensive overview and seem a collection of loose ideas without a clear rationale. Both sections also fail to put the methodology in a context in terms of applicability. Also the references lack a clear overview of the state of the art in the domain. The methodology section on the other hand is extremely technical and often difficult to follow.
- The results are based on some illustrations and examples, but fail to provide any idea on the accuracy of the method, applicability, etc.
- Although the methodology is interesting, it is based on some assumptions which are difficult to defend. Firstly, the methodology assumes a constant diurnal albedo and therefore does not account for diurnal variations in albedo, which can range above 0.1 depending on the solar zenith angle. Secondly, it does not account for any other physical condition that can have an effect on diurnal albedo (e.g. surface roughness; Lhermitte et. al.). Thirdly, the method fails to provide any correction of cloudy conditions and therefore still limits its use to calculate daily albedo values, etc.). Fourthly, the method assumes that the sensors only

'sees' the sky (upward sensor) or snow/ice (downward sensor), whereas this is often not the case for tilted surfaces: e.g. differences in skyview factors or a downward facing sensor which receives radiation from nearby mountains etc.

- Although the method is very interesting, it is, given its dependence on a 'third' leveled sensor nearby, very difficult to apply in real polar conditions, where the installation of an unattended leveled AWS is practically almost impossible. I think this drawback of the method should be clearly discussed.

4 Specific comments:

p2710 L20: automatic tilt meters can be installed to make such measurements in real-time (e.g. PROMICE data set)

p2710 L22: "changing physical conditions" What is meant by that? Does this include changes in diurnal albedo (e.g. Gardner and Sharp, doi:10.1029/2009JF001444.) and/or changes in roughness and homogeneity of snow cover in the surrounding of the measurement site (e.g. Lhermitte et. al., www.the-cryosphere.net/8/1069/2014/)

p2710 L25: 'ideally southwards': ideally a sensor is not tilted at all. On the other hand, the only reason to prefer a direction, has to do with the shadowing effect. Because all other tilt effects could theoretically be corrected for if the tilt is known. In this context, 'southwards' is only true for the northern hemisphere.

p2711 L1: the cosine law does not introduce the errors. The assumption of a flat surface/sensor when it is not flat, introduces the error and this error could be corrected using the cosine law.

p2711 L3: Many publications: true, but the introduction and discussion should benefit strongly of a more comprehensive overview of these publications. Some examples of publications worth including are: MacWhorter, M. (1991). Error in measurements of

incoming shortwave radiation made from ships and buoys. Journal of Atmospheric and Oceanic Technology. Van den Broeke, M., van As, D., Reijmer, C., van de Wal, R. (2004). Assessing and improving the quality of unattended radiation observations in Antarctica. Journal of Atmospheric and Oceanic Technology, 21(9), 1417–1431.

p2711 L28: 'measured tilts and directions': the words tilt, surface, angle, directions are often used confusingly. A sensor can have a tilt, which has a zenith angle and azimuth angle in a certain direction, whereas a surface can have a certain slope with corresponding slope angle and azimuth angle. In my opinion, a glacier/snow surface is not tilted.

p2713 L13: what about variations due to variations on solar zenith angle, cloudiness, etc. (Gardner and Sharp)

p2713 L19: Not all AWS's are drilled into the ice. Some setups use tri- or four-pods standing on the ice.

p2713 L20 "estimate reasonable diurnal mean albedo values". This is certainly true, but how is the proposed method going to change this without a valuable method that accounts for cloudy albedo values

p2713 L24: What is the slope of albedo variation?

The Method section 2.1 should clearly indicate how many times was measured etc.

p2715 L4: changes continuously? What is meant by continuously (every day, five minutes) and how much does it change? Moreover, if a data logger is connected to the inclinometer the sensor tilt can be logged over time.

eq. 2 is irrelevant for the rest of the story

Fig.2: Seems rather irrelevant

p2716 L16: 'are used from here on': Why aren't uniform symbols used from the start. It would certainly increase the readability of the manuscript. Moreover, I would recom-

mend to use clear subscripts. The subscript tilt for example can create confusion as both the pyranometer and surface can show a 'tilt' in the definitions that are given.

Eq. 9: this is not necessarily true as the downward facing pyranometer, might also be receiving radiation from other terrain parts within its field of view. For heavily tilted pyranometers, for example, the downward facing pyranometer might 'see' parts of the horizon or nearby mountains etc.,

p2718 L11: and how is the downward facing pyranometer leveled?

p2718 L12: This also assumes that the surface is completely flat and homogeneous (e.g. Lhermitte et. al)

p2718 L18: part: I assume this means fractions between 0 and 1? Part is very unclear and does not necessarily imply that the values are between 0 and 1.

Eq. 16: I don't understand the logic for Eq. 16 and I think it should be proven in this case. Normally the diffuse radiation is dependent on the sky view factor, the solar zenith angle (i.e. longer atmospheric path -> more scattering, etc)

p2719 L17: 'Irrelevant': this is not true, depending on the tilt angle, the sky-view factor (or perhaps better ground-view factor) will change, i.e. the pyranometer will see more of the surrounding mountains, horizon, etc.

Eq. 18: The derivation of Eq. 18 is very confusing as in Eq. 10 it is still defined based on solar zenith angle. Moreover, eq. 18 is only true for 100

Eq. 19: Where does the $cos\Theta_s$ come from

p2721 Assumption 3 is really problematic as the solar zenith angle, changing surface properties (Gardner and Sharp) as the surface properties (Lhermitte et. al.) will have an effect on the diurnal albedo which certainly cannot be neglected (i.e. variations of 0.1 on an albedo of 0.7 due to SZA alone)

p2721: Why a constant diffuse fraction is assumed if the diffuse fraction could be

expressed as a function of the solar zenith angle?

The workflow is often very unclear. E.g. p27222 L1 'for one specific day': so the sensor tilt is only determined once and assume it constant afterwards? Moreover, it is always guessing what has been performed exactly on what data. This should be clearly clarified.

p2722 L12: it is very unclear which equations to minimize.

p2723 L15: As constant as possible. First, it is physically wrong to assume a constant albedo (see previous comments). Second, what is 'constant as possible'? What is the range that is allowed? Is this based on some minimization?

p2723 last line: equation does not have a number

Eq. 27: how can you estimate errors in balance if the method does not allow to account for cloudiness?

p2725 L4-10: This should be in the method section. All these setups are now never explained in the method section and appear in the result section, where they don't belong

p2726 L4: So there is no diurnal variation in p_{diff}?

p2726 L16-20: Ok, but how certain are we that corrected one is effectively the correct one, when there is no correct measurement to compare it with?

p2726 L21-22: this is kicking in an open door as it is already the motivation of the article

p2727 L12 'Over the year 2011' how is this assessed when the method has no way to account for cloudy observations?

P2728 L1-3: True, but also for small angles (and even for all non-flat surfaces) the sensor can also 'see' neighboring mountains, etc...

p2728 L12: without reference measurement the method can indeed not be used and this completely limits the use of the method as getting such a reference measurement is practically impossible (e.g. no flat nearby terrain on large ice caps etc.)

p2728L17: adjusted parallel. This is practically impossible and I challenge the authors to perform such a setup. Installing a flat unattended sensor is already 'impossible'

p2728L21: 'High' or low etc.

p2728l9: Winter months: Sep and June are not a winter months. Moreover, this is hemisphere dependent. I also challenge the authors to apply this method in polar areas as it practically impossible to do a flat unattended reference measurement over ice caps etc.

Fig.9 is SWout, not albedo

Interactive comment on The Cryosphere Discuss., 9, 2709, 2015.