

Summary and recommendation

This paper presents a study of the evolution of the albedo of penitent. First the authors investigate the evolution of penitent measured albedo as a function of the sensor height. Then they compare the temporal evolution of the albedo measured in the field and by two satellite sensors.

I think this study presents very original results and measurements that might be useful for the community but the paper deserves some modifications, as detailed below, before it can be published.

Main comments

1/ The first comment is about the definition of the albedo. If I understood correctly, you measured the outgoing radiation from different heights above the ground and you divide it by the incoming radiation measured above a flat surface nearby. I completely agree that while doing that you will get the albedo as soon as the downward sensor is above the tip of the penitent but it is not true when the sensor is below the tip since in this case, the incoming radiation would also be modified. Consequently, it seems to me that you are not studying the evolution of albedo below the tip of the penitent but only the evolution of the outgoing radiation. I think this point deserves clarification in the paper.

2/ The second main comment is about the objectives of the paper. I think they should be more clearly stated in the introduction, abstract and conclusion. In the abstract, you are for example writing that the albedo is lower than the albedo of a smooth surface. You have some data to quantify this difference. I think this point is important in a mass balance perspective and should be more thoroughly developed in the paper. I think that the important questions raised by this paper are : what is the albedo of penitent ? How does it vary with the penitent and sun geometries ? At which height should be placed a pyranometer to measure an effective albedo ? What are the implications of penitent on glacier surface albedo ? Are satellite sensors capable of monitoring the albedo of such fields ?

3/ The last comment is on the discussion. There is a lot of interesting things there but you need to help the reader in following it. You are treating a lot of different points. I think that you have to carefully put only one subject per paragraph (see for example last paragraph of page 3834). Maybe using title for each subsection would also be useful.

Specific comments

Page 3825, second paragraph . There have been a lot of other studies on the evolution of albedo as a function of surface roughness such as : Leroux and Fily, 1998, Hudson and

Warren, 2007, Zhuravlela and Kokhanovky, 2011. Perhaps, some of these studies might be useful for the paper discussion.

Section 3.1. In my opinion the albedo of penitents should also change with the sun azimuth if they are tilted ? Are the penitent in your cases completely vertical or are they tilted ? Did you investigate this effect ?

Page 3828 line 10-15. Could you please quantify the correction ?

Section 4.1. Please take into account main comment 1/

Discussion. Please take into account main comments 3/ and 2/

Page 3820, lines 19-21 and below. You are referring to albedo anomaly that induces vertical changes of measured albedo. Maybe it would be more rigorous to refer to albedo spatial heterogeneity.

Page 3834, lines 8-10. The sentence is a bit confusing. What do you mean by between 2 and 8 m ? What happens if you are above 8 m ?

Page 3836, lines 15-16. The main reason for albedo vertical changes is the spatial heterogeneity of the surface not the sensor. The sentence thus looks a bit weird...

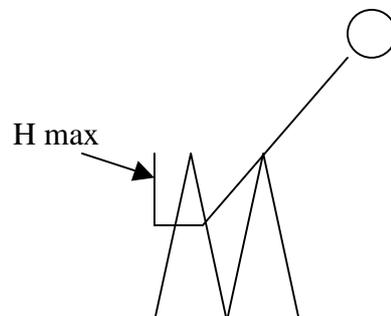
Conclusion, please take into account main comment 2.

Minor issues

Page 3824, line 16 penitent without s I guess

Page 3825 line 1, shortwave ? (maybe not short-wave)

Page 3831 and Figure 3. I think that naming Hmax penetration depth is a bit misleading but maybe I did not understood correctly. Hmax seems to be wrong in Figure 3 (see graph below) . The penetration depth is something else for snow (see for example Libois et al., 2013 TCD).



Page 3831. The notation here are a bit difficult to follow. D is both the tip distance of the penitent and an experiment. I would also prefer the sun zenith angle to be referred as θ .

Page 3833. It would help the reading to add that $z=H+z_p$.

Page 3835, lines 9-12. I think the sentence on Box et al. results is a bit confusing. It needs to be rephrased.

Page 3835, lines 15-19. I think I understand what you mean here by the anisotropic reflection factor but maybe this sentence would need to be also rephrased.