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Interactive Comment

Interactive comment on "PRACTISE – Photo Rectification And ClassificaTIon SoftwarE (V.2.0)" *by* S. Härer et al.

S. Härer et al.

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Dear Stefan Pohl,
We thank you very much for your very helpful general and specific comments and are pleased that you think that our study is a valuable contribution to the modelling science community. We will answer all your comments and will also present the changes to our manuscript for all comments where the changes are not already obvious from our response:

General comments:
Comment from Referee:
I only have one general comment regarding the processing of snow cover maps from

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satellite images. A large portion of the paper deals with introducing a new objective approach of determining the NDSI threshold. This is very important as the procedure of setting this threshold has often been one of the major weaknesses of studies. The authors find in their example some substantial deviations of this threshold from the traditionally used literature value. I would appreciate some more discussion of what these deviations mean for the produced snow cover maps. A short section at the very end of the results section is devoted to this analysis but since this is one of the major innovations of the study, I feel this could be expanded. This would also maybe shed some light on earlier studies that have used the literature value. A suggestion would be to show "old" and "new" snow cover maps side by side and maybe discuss where differences in snow or no snow areas are especially apparent. In this respect, I appreciate the authors plan to focus future research on analyzing the NDSI threshold variability.

Authors' response:

We agree with the referee that the discussion of the effects of NDSI threshold changes on the produced snow cover maps could be extended. We will add and discuss a figure where the spatially distributed snow cover change at the Zugspitzplatt is shown for the three dates (see attached figure). However, we also think that three dates are not enough to analyse and discuss the topic in detail. Hence, we will only perform a visual analysis as well as present some descriptive statistics of the lower elevation snow cover in the investigation area in the revised version. But as we know that the topic is of interest and worth an extensive analysis we are preparing another publication at the moment where we will focus on the NDSI threshold variability and the resulting change in snow cover maps for a complete time series of several years.

Authors' changes in manuscript (p. 8500, line 24 to p. 8501, line 4):

At last, the changing NDSI thresholds of 0.18 on 17 November 2011, 0.35 on 1 July 2013 and 0.23 on 7 April 2014 calibrated with the SLR camera need to be discussed. All thresholds are below the value of 0.4 from Dozier (1989) and Hall et al. (1995) and the increases of snow cover extent in the Zugspitzplatt catchment are

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between 3.7 % on 1 July 2013 and 26.7 % on 17 November 2011 using the calibrated NDSI threshold values instead of the literature value of 0.4. Consequently, larger differences between the optimised and the standard NDSI threshold value lead to a higher percentage change of snow cover.

Figures 12a to c chronologically display the optimised snow cover maps (light blue) superimposed with the standard snow cover maps (dark blue) in the Zugspitzplatt for the three investigated dates. The visual comparison of the snow cover maps clearly shows that especially the edges of the snow cover become reclassified to snow whereas no new large snow patches are detected. This demonstrates that on the one hand the core snow cover areas are already correctly classified using the standard threshold. But on the other hand this finding also highlights that Landsat snow pixels at the snow cover edge and hence, probably mixed pixels represent a substantial portion of snow cover in alpine areas which have to be classified correctly for optimum results.

Additionally to the visual analysis, we analysed the changes in elevation of the snow covered pixels in the Zugspitzplatt area, in particular the snow line. As the lowest elevation where snow cover is detected is not necessarily representative for the current snow cover distribution in the investigation area, the 10 percent quantile of the elevation values of snow covered pixels was calculated. The resulting elevations for the 10 percent quantile are for the literature NDSI threshold 2390.6 m on 17 November 2011, 2261.4 m on 1 July 2013 and 1948.8 m on 7 April 2014, respectively for the optimised NDSI thresholds 2352.1 m, 2251.5 m and 1938.6 m. The elevation differences between the standard and the optimised method consequently range between 9.9 m for the July date and 38.5 m for the November date. The increase of snow covered areas in lower elevations using the lower optimised NDSI threshold values might be expected but about 10 m and in an extreme case about 40 m elevation change in lower elevation snow cover can make a huge difference, for example, when applied in climate change studies.

The presented values and findings underline that the strong temporal variations found in NDSI thresholds transfer to large uncertainties in the derivation of snow cover extents and studies relying on these snow cover products. A spatial and temporal adjustment of NDSI thresholds is therefore important to ensure optimum results in the snow cover mapping of specific areas, for example of the studied alpine catchment.

Specific comments:

Comment 1 of Referee (p. 8482, line 19):

"The results have shown..." I wouldn't use past tense here as the results are still valid.

Authors' response:

The reviewer is right, we will correct this within the revision.

Comment 2 of Referee (p. 8483, line 13):

Remove the "And" at the start of the sentence.

Authors' response:

Yes, we will skip the "And" here.

Comment 3 of Referee (p. 8487, line 12):

I think it would be very useful to provide some further explanation as to what a "camera target position" is, and how it can be determined. The authors used GCPs, but I think there are other methods. A reader that's not (yet) familiar with photo processing might benefit from such an extended explanation.

Authors' response:

Thanks for pointing this out. We will extend the explanation what the "camera t8arget position" is in this general input data section (sect. 2.1) and further clarify how we determined it in the study-specific input data section (sect. 2.2).

Authors' changes in manuscript:

p. 8487, line 11-15: PRACTISE V.2.0 requires a digital elevation model (DEM) and the exterior orientation parameters of the camera, i.e. the camera position *C*, the camera

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target position T and the roll ζ of the camera, as input. By definition, the camera target position T is the location that is shown in the centre of the photograph. The latitude and longitude positions of C and T are suffcient as input as the altitude is taken from the corresponding DEM pixel during the computing process.
p. 8489, line 3-12: The inputs given for the georectification of the SLR and webcam photographs are presented in Table 1. Camera dependent parameters were taken from the user manual of the camera systems. The focal lengths have been adjusted according to the used image. The location and target position of the camera, as well as the GCP locations have been identified combining photographs, DEM data, topographical maps and official orthophotos with a submeter spatial resolution. The camera location and target position could nevertheless only be estimated. The camera parameters in Table 1 except the camera sensor and photograph dimensions thus need to be optimised. A separate estimation for each photograph in this study using GCPs is further necessary as the locations and orientations of the cameras are changing in between the photographs due to either weather effects like wind, for maintenance reasons or a new camera location at the UFS.

Comment 4 of Referee (p. 8490, line 2 and 16):
I'm not sure about the term "disposes over". I would replace it with "provides" or "includes".
Authors' response:
We will replace "disposes over" by "provides" (p. 8490, line 2) and by "includes" (p. 8490, line 16).

Comment 5 of Referee (p. 8491, line 21):
The authors state that "shaded snow pixels normally have higher PC 2 values than PC 3..." Can you maybe quantify this a little more precisely? Approximately, what percentage is "normally"?

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Authors' response:

Thank you for making us aware that this sentence is formulated in an unclear way. We probably misused the term "normally" here. The point is that the PCA-based classification method was developed empirically and did work in conservatively estimated at least 95 % of our shadow-affected test photographs when classifying pixels as "snow" for PC2 values larger than PC3 values. The word "normally" should express that as with every method, there are situations where the PCA-based classification method is not the best option and the automatic blue band (or in some cases the manual) classification routine should be used. This is the case when the photographed area is free of shadows. Then, the second PC is often not connected to the snow cover distribution and the assumed relationship between PC2 and PC3 values for snow pixels is no longer valid. We will change this sentence and state the described point, clearly and concisely, in the revised version.

Authors' changes in manuscript (p. 8491, line 15-26):

Frequency histograms of the normalised PC score matrix ($\vec{PC}_{\mathsf{sc},n}$) for the columns 1 to 3 are illustrated in Figures 5a to c. The shape of the frequency histogram of $\vec{PC}_{\mathsf{sc},n}1$ in the PCA space (Fig. 5a) is essentially identical to the blue band DN frequency histogram in the RGB space. Hence, $\vec{PC}_{\mathsf{sc},n}1$ is not analysed further as the first classification step already utilises this information. But the frequency histograms of $\vec{PC}_{\mathsf{sc},n}2$ and $\vec{PC}_{\mathsf{sc},n}3$ are used and play a major role in the separation of shaded snow from other surfaces. Empirical analyses of numerous photographs have shown that shaded snow pixels have higher $\vec{PC}_{\mathsf{sc},n}2$ than $\vec{PC}_{\mathsf{sc},n}3$ values (Fig. 5b and c). For the used example, this means that shaded snow cover is grouped in the local maximum around 0.7 in the frequency histogram of $\vec{PC}_{\mathsf{sc},n}2$ (Fig. 5b). As a consequence, pixels are classified as snow where

$\vec{PC}_{\mathsf{sc},n}3 < \vec{PC}_{\mathsf{sc},n}2 \quad and \quad DN_{\mathsf{b},th} \geq DN_{\mathsf{b}} \geq 63.$

We want to note here that the observed relationship was found valid for conservatively estimated at least 95 % of our shadow-affected test photographs. For shadow-free situations, it is still recommended to use the existing classification routines presented in Härer et al. (2013).

Comment 6 of Referee (p. 8492, line 3):
This may be semantics, but the area of snow derived from the PC analysis in Figure 4 looks more green rather than yellow to me.
Authors' response:
The reviewer is right, we will rename the colour in Figure 4 to yellowgreen.

Comment 7 of Referee (p. 8492, line 18):
What happens to the pixels labeled as "unsure" if the user wants a final map that only shows "snow" or "no snow"? During the description of the calibration procedure on p. 8494 it is stated that the user can either exclude them or use them in weighted form according to their probability value. I assume that this is also the case when just processing a terrestrial photograph into a snow cover map, but I'm not sure. Please clarify.
Authors' response:
Thank you for highlighting the need for clarification here. It is correct that the pixels labeled as "unsure" in the photograph snow cover map can be excluded or used in weighted form for the calibration of the NDSI threshold in the satellite image. But the photograph snow cover map is unchanged by this user's decision. The photograph snow cover map hence returns probability values between 0 for "no snow" and 1 for "snow" for the PCA-based classification routine and binary classifications for the other two classification routines. If the user wants to have a binary photograph snow cover map utilising the PCA-based classification, we recommend post-processing the map using a simple conditional statement in Matlab or any geoinformation system. This allows the user to decide on a case-by-case basis if and how the probability values are taken into account. We will clarify this in the revised version.
Authors' changes in manuscript (p. 8494, line 1-6):

Subsequently, overlapping areas of terrestrial photography and the satellite image are detected. The results of the photograph snow cover maps are used as baseline. It is a user's decision if pixels classified as "unsure" in the photograph are excluded or used in weighted form according to their probability value. The user's selection does however only affect the NDSI threshold calibration of the satellite image while the photograph snow cover map is kept unchanged.
Now, the DDS optimisation routine which is also implemented in the framework of the GCP optimisation (cf. Härer et al., 2013) is used to optimise the NDSI threshold value.
...

Comment 8 of Referee (p. 8498, line 5 ff):
The authors state that they made a detailed visual analysis of the pixels in the two April photographs and discuss the "probably" and "unsure" pixels in detail. However, no information is given, whether they found any misclassifications in the pixels identified by the software as "snow" or "snow free" in the SLR photos. Since (the very few) misclassifications are discussed for the webcam photos, it can be assumed that there were no misclassifications at all for those two categories in the SLR photos. I would appreciate some info on this matter. (And if there were no evident misclassifications at all in the SLR photos, I would definitely mention that as this is a rather remarkable show of how good the software is working).
Authors' response:
We agree with the reviewer that some additional information on the classification accuracy of the categories "snow" and "snow free" in the discussed April photographs could be helpful. Misclassifications in these two categories amount to less than 0.3 % of pixels in the SLR photograph. Almost all of these misclassifications are due to the light-coloured bare rock (limestone) in the Zugspitzplatt area which is mistakenly classified as "snow". This is a weakness of the blue band classification method and has already been discussed in detail in Härer et al. (2013, PRACTISE V.1.0). As the blue band classification also represents one of the classification steps in the

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PCA-based classification routine the issue remains.

For the webcam photograph, less than 1 % of classified pixels can be identified as misclassifications in the categories "snow" and "no snow". Approximately one-half of misclassified pixels can thereby be attributed to georectification problems due to infrastructure. The other half is mainly located in shaded areas where even for the human eye the classification becomes increasingly difficult and where the problems are thus hardly surprising. We will add the mentioned points to the results section.

Authors' changes in manuscript (p. 8497, line 25 to p.8498, line 15)

Figure 10a to d show the superimposed snow classifications (snow in red, no snow in blue) on the SLR and webcam photographs of 1 July 2013 and 7 April 2014. The July photographs in Fig. 10a and b do not show strong shadowing effects due to the high sun angle at this date. Hence, the automatic blue band classification algorithm was utilised. The resulting classification visually indicates a high quality and will not be further discussed here as the method was evaluated before in Salvatori et al. (2011) and Härer et al. (2013).

For the photographs of 7 April 2014 the PCA-based classification algorithm was applied to reduce shadow-related misclassifications (Fig. 10c and d). The detailed visual analysis of pixels in the two April photographs confirmed a high quality of the new classification routine for pixels identified as "snow" and "free of snow" as well as for pixels classified as "probably snow", "highly unsure", and "probably no snow".

Misclassifications in the main classification categories "snow" and "free of snow" are very rare with less than 0.3 % of classified pixels in the SLR photograph and less than 1 % in the webcam photograph. The reasons for misclassifications are however different in both photographs. In the SLR photograph, the issues can mainly be attributed to the light-coloured bare rock (limestone) in the Zugspitzplatt area which is mistakenly classified as "snow". This issue has already been discussed in detail in Härer et al. (2013, PRACTISE V.1.0) and is a weakness of the blue band classification method which represents one of the classification steps in the PCA-based classification routine. The misclassifications in the webcam photograph have two main reasons,

the georectification problem due to infrastructure which has already been mentioned above and shaded areas, in particular in the valley below the Zugspitzplatt, where due to the large distance and the image quality even the human eye has problems to correctly classify "snow" and "no snow".
Additionally to the main categories "snow" and "free of snow", the three "unsure" categories need to be discussed for the April photographs. 1.9 % of classified pixels in the SLR photograph and 7.8 % in the webcam image are assigned probability values. The low percentages underline that the assignment rules in the PCA-based classification routine seem to describe the RGB characteristics of the different surfaces well. In addition, most pixels classified as "unsure" in the SLR photograph are exactly located at the transitional area between snow patches and snow-free areas in the photographs, and can therefore be seen as mixed pixels (Figs. 10c and 11a). The classification of the SLR photograph on 17 November 2011 (Fig. 6) has also attested this finding.

Comment 9 of Referee (p. 8499, line 29):)
I might have missed it, but how large is the Zugspitzblatt catchment over which the analysis for the satellite images was carried out?
Authors' response:
We mention the size of the investigated Zugspitzplatt area in section 3.2 (Threshold calibration for optimal NDSI-based snow cover maps): It amounts to about 13.1 km^2. However, we will also add a short sentence to the test site and data section (sect. 2).
Authors' changes in manuscript (p. 8487, line 2-6)
PRACTISE (V.2.0) was developed and tested in the Zugspitze massif, Germany. The investigated Zugspitzplatt area amounts to 13.1 km^2. A common single lens reflex camera (SLR, Canon EOS 550D, Canon EF 17–40 mm f/4l USM objective lens, 17.9 Mpx) directed towards the north east facing slope of the Schneefernerkopf and a webcam (Mobotix M10 L43, 1.2 Mpx) observing the south-eastern area of the Zugspitzplatt are used (Fig. 1). ...

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Figures

Comment from Referee:

I find the legends in the top right corner of Figures 3b/4/6/9/10/11 too small and therefore very hard to read.

Authors' response:

We agree with the referee here and will enlarge the legends in the mentioned figures (not attached).

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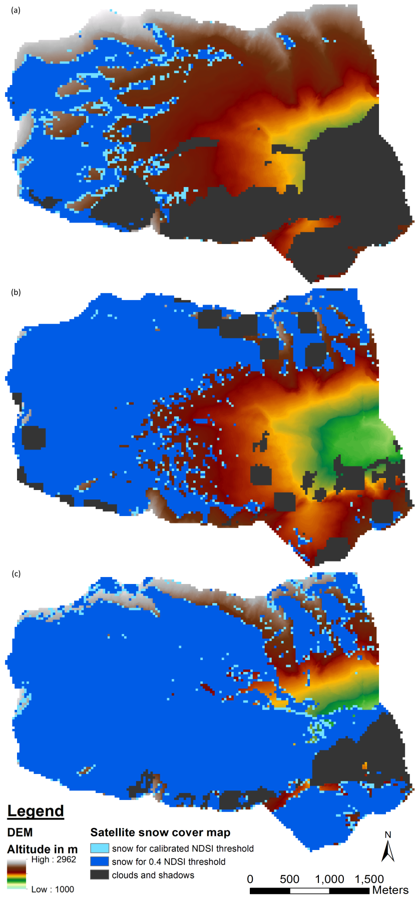

Fig. 1. Figures a to c chronologically display the optimised snow cover maps (light blue) superimposed with the standard snow cover maps (dark blue) of the Zugspitzplatt for 17/11/11, 1/7/13 and 7/4/14.