The Cryosphere Discussions

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Reply on RC3/ Edward Bair

Elisabeth D. Hafner et al.

Author comment on "Automated avalanche mapping from SPOT 6/7 satellite imagery with deep learning: results, evaluation, potential and limitations" by Elisabeth D. Hafner et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-80-AC3, 2022

Dear Edward Bair,

thank you very much for the comments and suggestions regarding our manuscript. We will in the following discuss and attempt to answer the points you raised:

1) We are very well aware of the limitations of optical imagery and their dependence on clear sky during data acquisition. We will clearly point this out in the revised version of our manuscript.

2) Crowns, track and debris can usually be identified in the imagery. Texture, hue and hints of possible damage will probably also play a role. How different experts emphasize those in their search/mapping was not yet investigated.

As our model is trained on the manually mapped avalanches, it tries to identify patterns in this dataset to find avalanches independently later on. What exactly the network is focusing on we do not know, but tests indicate the model seems to be focusing on texture and therefore learning more from deposits than from release areas (see metrics in Table 2). We plan to further investigate how avalanches are recognized and mapped by experts in a follow up study.

3) Our first idea to be able to provide separate metrics for sun and shade has also been using solar geometry. Despite using a DSM with 2m resolution and exact information on image acquisition time, sun azimuth and sun altitude, we found the modeled shade does not represent reality well. As we wanted to avoid distorting our results for areas located at the border of sun and shade, we used SVM instead.

4) We did perform ablation studies using the different SPOT bands and investigated how performance changed with varying input data. We found overall metrics neither improved by additionally including the blue and the green band nor when using only the red, green and blue without the near-infrared band. We therefore concluded, that the near-infrared band possesses important information (in the sun) that by far outweighs the disadvantages (in shaded areas). A more in-depth analysis of this aspect is beyond the scope of our paper and would be interesting to investigate for future work.

In the following we will try to answer the specific comments noted in the provided supplement (the numbers correspond to the lines in our manuscript):

49: for completeness we will add the reference to our study (Bühler et al., 2019), in addition to the provided data citations in the revised manuscript

62/68: as already mentioned in the general comments we will add a short paragraph explicitly describing the limitations relying on optical data, including the inability to acquire data during an event (except for wet snow avalanche periods caused solely by warming during the day).

69: we intended to point out that spectral information is provided in the four bands specified. We will change the sentence to "SPOT 6/7 images have a ground sampling distance (GSD) of 1.5 m and provide information in four spectral bands, namely red, green, blue, and near-infrared (R, G, B, NIR), at a radiometric resolution of 12 bits." in the revised version of our manuscript.

70: In our previous publication (Bühler et al., 2019) we have found the following locational accuracy (sample of 11 GCPs) for the data acquired on 24.01.2018: The achieved accuracy (RMSE) of the GCPs was of 1.23 m in X, 0.83 m in Y and 0.16 m in Z.

72: Yes, we use top of atmosphere reflectance. As you rightly pointed out in the comment to line 76, we use it without correcting for atmospheric effects, because our main focus is texture and the absolute spectral values do not matter for avalanche identification. The description regarding low variability between the years was written with the conditions of the avalanche period (on/ close to the ground) in mind. We did not intend to make a statement about atmospheric conditions that influence the spectral values in the satellite imagery, which could be analyzed with independent data such as AOD. We will correct this information to make this clear to the reader in the revised version of our manuscript.

76: as proposed we will delete this sentence in the revised version

83: we have provided the equations for POD and PPV in section 4 where we introduce them for our work. We will add a reference to those formulas here as well in the revised version of our manuscript.

90: see general answer 2): we will add a sentence elaborating on this in the revised version

113/119: we will correct the language mistakes as proposed in the revised version

125: You are right, patch size is dependent on the spatial resolution as well as computational resources. In order to be more specific and make what we mean clear we will replace this sentence. It will be included in the proper introduction of the patch size, that we have already promised to RC2, in the revised version of our manuscript: "Given the proposed model architecture and the available computational resources, we are able to simultaneously process batches of 2 image patches per GPU of up to 512×512 pixels at training time, which translates into an area of 589'824 m^2 at the spatial resolution of SPOT 6/7 images."

127: we are sorry, but we do not know where you think the "/" is missing.

References:

Bühler, Y., Hafner, E. D., Zweifel, B., Zesiger, M., and Heisig, H.: Where are the avalanches? Rapid SPOT6 satellite data acquisition to map an extreme avalanche period over the Swiss Alps, The Cryosphere, 13, 3225–3238, https://doi.org/10.5194/tc-13-3225-2019, 2019