

The Cryosphere Discuss., author comment AC1
<https://doi.org/10.5194/tc-2022-80-AC1>, 2022
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Reply on RC1/ Ron Simenhois

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-AC1>, 2022

Dear Ron Simenhois,

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

We are aware of the cost of data, the dependency on good acquisition conditions and lower reliability in shaded than illuminated regions for SPOT 6/7 data. Nevertheless, we have chosen to push and forward the use of optical SPOT 6/7 data because we see several major advantages of using optical data over SAR images:

- optical imagery is easier to interpret than SAR imagery.
- in our previous work (Hafner et al., 2021) we have shown that mapping from SPOT6/7 is overall more complete compared to Sentinel-1, which is especially true for avalanches of size 3 and smaller. This is (amongst others) related to the underlying spatial resolution of 1.5m for SPOT 6/7 and approximately 10-15m for Sentinel-1.
- in the same work we investigated which part of an avalanche can typically be identified using Sentinel-1 and found (in accordance with previous studies) that it is mostly the deposit, but may include patches from track and release area. When only using Sentinel-1 data it is therefore neither possible to derive the number of avalanches occurred (several unconnected patches for one avalanche), nor the size of the occurred avalanches (size of patches detected does usually not correspond to avalanche size).
- in conjunction with the above point, unless unambiguous with respect to the terrain the origin and release area of avalanche deposits detected in SAR remain unknown.
- several authors have suspected SAR to be less reliable for detecting dry snow avalanches. Eckerstorfer et al (2022) investigated this in more detail, and they were able to only identify 5.9% of all occurred dry snow avalanches in Sentinel-1 imagery employing manual and automatic detection.
- from optical SPOT data we can therefor get a more complete picture of an avalanche period and with whole outlines give something (more) useful to practice.

We will integrate a summarized version of the above arguments for optical imagery into the revised manuscript.

We have already greatly reduced the details concerning the technical specifications of our model but we will try to make those sections more reader friendly and expand the manuscript with a short non-technical description of a DeepLabV3+.

In the following we will address the specific comments:

Line 78: we refer to the person who manually mapped as expert because the mapping required knowledge on remote sensing, avalanches and the generation of a suitable mapping methodology in order to have comparable results over a large area. The detailed procedure is described in our previous work (Bühler et al., 2019). We will correct this sentence and rephrase it in such a way that what we mean becomes clear to the reader.

Line 84/86: Probabilities may generally also be written in percent with 1 equaling 100%. To avoid confusion, we will still change this passage and use 0.74 instead of 74% in the revised manuscript.

Line 101a: We have added the reference to the ResNet when we first mentioned it in line 42, but we will add it here as well in the revised manuscript.

Line 101b: Resnet is a well-established backbone which is why we went with it. We did test the effect of using a ResNet18, ResNet34 and ResNet50 and found the ResNet34 worked the best. Newer and more sophisticated backbones keep being proposed. Testing multiple other backbones would have been beyond the scope of this paper. For the future this would be an interesting aspect to investigate.

Line 110: the reference to Figure 3 is correct as we want to illustrate where in the network the deformable convolutions are implemented. As Figure 2 explains how deformable convolutions work in detail we will additionally add this reference here in the revised manuscript.

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

Eckerstorfer, M., Oterhals, H., Müller, K., Malnes, E., Grahn, J., Langeland, S., and Velsand, P.: Performance of manual and automatic detection of dry snow avalanches in Sentinel-1 SAR images. *Cold Regions Science and Technology*. 198. 103549. [10.1016/j.coldregions.2022.103549](https://doi.org/10.1016/j.coldregions.2022.103549), 2022.

Hafner, E. D., Techel, F., Leinss, S., and Bühler, Y.: Mapping avalanches with satellites – evaluation of performance and completeness, *The Cryosphere*, 15, 983–1004, <https://doi.org/10.5194/tc-15-983-2021>, 2021.