

Title: Countrywide Digital Surface Models and Vegetation Height Models from Historical Aerial Images

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Author's response related to the comments made in Report #1 received on the manuscript:
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We thank anonymous referee #2 for some remaining recommendations concerning clarity and presentation of our manuscript. After thoroughly evaluating the feedback and recommendations, we have revised our manuscript to further enhance the clarity and accuracy of our paper. .

The main changes we made to the manuscript are as follows:

- Incorporating the suggestions into the figures.
- Modifying certain formulations-within the text.

We are confident that the following point-by-point responses adequately address the remaining suggestions.

Point-by-point reply to reviewer comments: Reviewers' comments are in black, and the authors' response is in blue, with citations from the revised manuscript in green.

RC 2 – Report # 1:

- r128 "the images from epochs 1, 2 and 4 was derived by swisstopo"
--> "1, 3 and 4"

Response: Thank you very much for spotting this mistake. We have changed the wrong campaign numbers from “1, 2 and 4” to “1, 3 and 4” in the sentence.

R127-129: The exterior orientation information for the images from epochs 1, 3 and 4 was derived by swisstopo within the framework of the Swiss Land Use/Cover Statistics program around 2004.

- Fig. 3: I was a bit puzzled by the bold black corner markers. It took me some time to find out that they may enclose the two workflows for DSM and VHM. Maybe you could improve that? e.g. by surrounding them with slightly colored rectangles? And/or add to the caption that the DSM workflow involves the steps 2-5 and the VHM afterwards additionally 6-8.

Response: Thank you, we have improved the figure 3 as suggested.

- r183: Thanks for the added info regarding the "1200 regular grid cells". However, I still think there is room for improvement, because I do not think that the "number of cells" is the typical information regarding a grid layout, but the grid width. Thus I would suggest to replace "The number of regular grid cells was" by "The cell size of this regular grid (XXX m) was", where XXX is the grid width. (Is it around 418 m = $\sqrt{12 \cdot 17.5 / 1200}$?) And add this cell size also to the description in Fig 4, because currently the 1st legend entry "Grid" is difficult to link to the description in the main text.

Response: Thank you for this comment. We replaced the number of grid cells by the grid cell size and rephrased the caption for figure 4 correspondingly.

R 185-188: The cell size of this regular grid (418 m) was determined through an empirical approach, ensuring that each grid cell contained enough difference values to yield a valid median and that there were sufficient grid cells per map sheet to enable the interpolation of a continuous correction surface using spline interpolation.

R:1991-195: Figure 4: Illustration of the workflow to correct the elevation bias in the historical digital surface models (DSMs) for each map sheet. A correction surface is derived by a spline interpolation of the median height difference values (reference DTM – historical DSM at sample points “sealed surface” and “grass/herbs”) within regular grid cells (418 m).

Additionally, you could adapt the wording such that the outlier removal was not done only by the filtering part using mean $\pm$ 1 std, but also by considering the median in the 2nd step. Currently, it reads like the outlier removal was done only by the mean+std part (which as outlined in my 1st review is an odd way); e.g. "Outliers were dealt with in the following way: First, the height differences were filtered based on ... 50 x 50 pixels. Afterwards, the median of the remaining ..."

Response: We appreciate your recommendation for enhancement. We have incorporated your suggestion into the text, agreeing that this formulation supports that the outlier removal considers robust statistics, by calculating the median of the oddly filtered height differences.

R 182-185: The approach to handle outliers was as follows: In a first step, the height differences were filtered based on mean $\pm$ 1 standard deviation (Std), calculated within a moving window of 50 $\times$ 50 pixels. In a second step the median of the remaining elevation differences was calculated for each of the 1,200 regular grid cells per map sheet.

- r262: "such as the median and the normalised median absolute deviation (NMAD) were calculated, as biases in spatial datasets are often not normally distributed" --> I find that 2nd part confusing, because the valid application of the NMAD >>requires<< that the underlying distribution is in fact Gaussian. That's the reason why the factor from MAD to NMAD is 1.4826. For a different distribution a different factor would be needed. Perhaps, that 2nd part of the sentence is not referring to the applicability of the NMAD and really just means the "bias". But the bias itself has no distribution as it is just an (unknown) offset. Perhaps, you can reformulated (or drop that 2nd part).

Response: Thank you for this comment. We agree that a bias does not have a distribution. The formulation of the mentioned sentence is indeed confusing. We document the variation of the distribution with the NMAD, because the NMAD is an estimate of the standard deviation more resilient to outliers. We have omitted the 2nd part of our sentence, as we believe that it remains clear what we accomplished, and a detailed explanation would not be appropriate at this position in the text.

R 265-266: From the remaining differences, robust statistics, such as the median and the normalised median absolute deviation (NMAD) were calculated (Höhle and Höhle, 2009).

- Fig. 7: Note, that the limits for the histograms, probably, could/should be set to ± 5 m, instead of ± 10 m, in order to reveal some details.

Response: Thank you for this suggestion. We have changed the x limit to ± 5 m and updated the figure accordingly.

- Fig. 9: On the left we see that the profile runs diagonal through exactly 5 blue points. Also, the right side shows 5 blue points, however, the distance between them is not identical anymore.

Response: Thank you for spotting this mistake. We have corrected the plot and updated the figure accordingly.

- Fig. 10: Probably, the five colors of the VHMs could be changed to something more discernible?

Response: Thank you for your suggestion. We tested other colour maps; however, the visual appearance does not improve, and we prefer to maintain the current version. In this version, classes 0-1 are clearly visible, followed by a gradual transition to light and dark green representing vegetation height. In addition, by keeping the current colour scale, we are consistent with the VHM map displayed in Figure 11.