

Comment on **essd-2021-76**

Anonymous Referee #1

Referee comment on "Unlocking archival maps of the Hornsund fjord area for monitoring glaciers of the Sørkapp Land peninsula, Svalbard" by Justyna Dudek and Michał Pełlicki, Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2021-76-RC1>, 2021

Dudek & Pełlicki digitize and georeference three topographic map sheets covering the western portion of Sørkapp Land, Svalbard. They clearly outline the steps they took to digitize the contour lines, generate a raster digital elevation model (DEM), use triangulation points to co-register the historical map to a more modern (1990) DEM of the area, and assess the uncertainty in the final historical DEM using elevation differences to the reference DEM over non-glaciated terrain. A notable contribution of this paper is that it establishes that the contour lines in the IGF PAN map sheets represent the 1961 glacier elevations, rather than the elevations from the 1980s, which is when the maps were updated and published.

In my view, there are two categories of shortcomings in this work. The first pertains to the question of whether this paper presents a substantial new dataset to the community—a question that the Topic Editor raised some skepticism about. In lines 97-100, the authors explain that they digitized three of the ten sheets in the IGF PAN topographic map. But they don't provide an explanation for why they didn't digitize the other seven. Since Dudek & Pełlicki reconstruct the historical (1961) geometry of just a handful of the ~1,600 glaciers in Svalbard (König et al., 2014), this manuscript reads more like a nice recipe for digitizing historical topographic maps for analysis of geodetic glacier change, rather than presenting a large new dataset.

If this paper is going to be a template to help others digitize and georeference historical topographic maps, it becomes especially important that the methodology in the paper is careful and robust. That brings me to the second potential shortcoming of this work. In my view, there are three ways that the others could generate improved 1961 elevation reconstructions from the data already available to them. First, the authors use a TIN interpolation of the contour lines to create a DEM directly from the contour map. They could get more accurate glacier change observations by differencing just the contour lines to the reference DEM, and then interpolating the difference map. The reason is that glacier elevation change between two time points (Δh) varies in space more smoothly than the topography at any one time point. This kind of problem is discussed tangentially in McNabb et al. (2019). Second, the final co-registered map (Fig. 14) still has large regions

of positive dz and large regions of negative dz over ice-free land areas. Figure 14 suggests that the authors could still improve the georeferencing of the map by correcting for regional warping (see comment #3 below for some ideas how to do this). Finally, the authors cite Mertes et al. (2017) and Midgley and Tonkin (2017), two papers that use historical aerial imagery and Structure-from-Motion (SfM) photogrammetry to create historical DEMs. Lines 135-139 of the manuscript make it sound as though the authors already have the aerial imagery over their study area. Why not create a DEM from those photographs, following the methods of Mertes et al. (2017) and Midgley and Tonkin (2017) and many others (see references), and compare those results to the hand-drawn topographic maps?

In summary, although I think that the digitization of historical datasets is an important and worthwhile task, the small coverage of the digitized maps presented here, and the fact that the digitization could be done in better ways given the methods already described in published literature, makes me question whether the manuscript warrants publication in ESSD. However, I think that digitizing more of the map sheets, and following some or all of the 3 suggestions mentioned in the paragraph above, would substantially improve this contribution.

Specific comments:

1. If I recall correctly, the 1990 NP DEM for Sørkapp Land has a spatial resolution of 20 m. That relatively low resolution means that the DEM elevation at the pixel location of mountain peaks will consistently underestimate the peak elevation. How do your georeferencing results compare when you only georeference to steep mountain peaks vs. only georeference to flatter terrain? Also, now that Norsk Polarinstitutt (NP) has released a 5 m regional DEM (2010) for Sørkapp Land (geodata.npolar.no), you might want to experiment with the georeferencing results when you use the 5 m reference. Finally, for your discussion, you might consider evaluating the two time periods (1961-1990 vs. 1990-2010). Were thinning rates and retreat rates similar over those two periods? Have they increased/decreased?

2. You say in lines 135-139 that you analyze the original 1961 aerial photographs from the Norwegian Polar Institute. Can you use structure-from-motion to make a 3D model from those images? This has been done successfully for Svalbard glaciers numerous times. See, for example, Mertes et al. (2017), Midgley & Tonkin (2017), Girod et al. (2018), Kavan (2020), Holmlund (2021).

3. You do the co-registration based on the few dozen "triangulation points" listed in Tables 2-4. How would the co-registration differ if you instead applied the Nuth & Kaab (2011) procedure using all DEM pixels in stable ice-free areas? The reason I ask is that, in Figure 14, there remains a considerable amount of spatial structure in the dz map over land

areas (i.e., large regions that are consistently blue, transitioning to large regions that are consistently red). That suggests that you might want to change the way you do the co-registration. For example, you could compute the dx, dy, dz offsets using the Nuth & Kaab (2011) method for individual patches of ~ 2 km \times ~ 2 km (and you should explore the sensitivity to that window size), then unwarped the map using the vector field you generate, where the "vector field" is the $\langle dx, dy, dz \rangle$ vectors at the grid of locations where you extracted co-registration chips).

Below are some line-by-line comments, which mostly focus on clarity, language, and style. Feel free to ignore any suggestions that you disagree with.

Line comments:

Line 2: you might consider changing "reliable comparative" to "quantitative"

Line 9: change "from" to "on"

Lines 13-15: this first sentence needs a citation. Also, the word "dynamic" connotes ice dynamics (e.g., the flow of ice, surge behavior, etc.). But it seems like you are trying to say that melting is happening more rapidly in Svalbard than other places in the world. Perhaps you could start by saying that Svalbard is warming more rapidly than elsewhere (Nordli 2020), and then relate that warming trend to negative mass balance (e.g., Nuth et al., 2010; Morris et al., 2020). Or, you could skip straight to the negative mass balance.

Line 26: What is "this scientific field" referring to? Glaciology or remote sensing?

Lines 54-55: Clarify what you mean about aerial images being "more competitive" than terrestrial photographs, and why.

Table 1: Should you clarify in the caption that these mapping campaigns were done by the Norwegian Polar Institute, since, in the main text, you just discussed the Polish mapping efforts?

Table 1 (a more general comment): I wonder if the information in this table would be

conveyed more effectively by having a series of 8 simple line maps of Sørkapp Land, lined up side by side and colored to show the regions covered by each photogrammetric mapping campaign?

Line 60: replace "first decade of the 21st century" with "2000s"

Lines 65-74: These two paragraphs would benefit from a little more clarity. Is the IGF PAN topographic map for Sørkapp Land the result of analyzing the Norwegian 1960/1961 photos in a stereoplanograph?

Line 76: Missing a space at the end of the sentence.

Lines 76-77: Perhaps you should cite Ziaja & Ostafin (2015) here? Is it correct to call Sørkapp Land an island if it is still connected to Spitsbergen via the isthmus?

Line 79: why do you say "as many as 14 land-terminating glaciers," rather than simply "14 land-terminating glaciers"?

Line 97: clarify which topographic map.

Lines 97-100: where are the other 7 sheets? Is there a reason you chose not to digitize those ones?

Line 103: cite Fig. 2 again at the end of this sentence for clarity.

Line 112: what does "made in desk research" mean?

Line 121-122: tell the reader here what the answer is, rather than saying "the question was answered." Do the contour lines represent the glacier elevations in 1960s or the 1980s? You get to that in lines 131-134, but you might improve clarity by telling the reader up front that the glacier contour lines represent the 1961 surface, and then go into the paragraph of how you determined that (lines 123-130).

Lines 141-144: I suppose you began this research before NPI had released the 2010 DEM

for Sørkapp Land. Would that be a better reference dataset, since it is 5 m resolution rather than 20 m resolution?

Figure 4: Readers will see that this dz map resembles a hillshade map, due to delta-x and delta-y offsets between the two DEM datasets (i.e., poor co-registration--Nuth & Kaab, 2011). You should explain that in the caption. You already explain it nicely in the main text (lines 174-176), so just add a brief explanation in the caption, too.

Lines 172-173: You don't need to say how you subtracted one raster layer from another (i.e., which GIS module you used).

Figure 5: Reference Figure 2 so people know where sheet 8 comes from. Also, in Figure 2, you might consider adding (a), (b), and (c) and clearly labeling which sheet is which.

Lines 177-179: You don't need to tell the reader which of the 3 sheets you worked on first.

Lines 180: Add "elevation points" after "195"

In Figures 5, 6, and 8 (the maps showing triangulation points for the 3 sheets), it would be helpful if you plotted vector arrows pointing in the direction of the dx, dy offset to the NPI reference map. That would let readers see if there are consistent patterns of warping across the map sheets.

Lines 214-216: Rather than referring to "visual assessment" of the model accuracy, can you give a quantitative metric of the elevation accuracy. For example, the root mean square error (RMSE) between the 2 DEMs on ice-free land?

Lines 224-226: This sentence will be more compelling if you provide some stats. For example, use the NPI DEM to say XX% of the glaciated area in Sørkapp Land has slopes < 20 degrees."

Line 230: remove "for obvious reasons"

Line 242: to improve clarity, you could say "The mean elevation difference (the bias) between..."

Line 291: Missing space after "zone"

Line 308: You might want to cite Nuth et al. (2013) here, since it investigates similar datasets across Svalbard.

Lines 310, 312: replace "overflight" with "survey"

Line 313: Be specific: say "structure-from-motion (SfM) photogrammetry" or "structure-from-motion (SfM)-multi-view stereo (MVS)" rather than "modern methods"

Line 341: remove "very"

Line 343: what does it mean for an air mass "to be in effect"?

Lines 367-369: Rephrase this sentence for clarity and remove the word "ignorance." Make it clear that you are saying that, even though the map sheet is labeled as 1984, the glacier contour lines reflect the 1961 elevations.

Lines 384-386: You could remove this final sentence of the manuscript.

References

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