

Answer to comments (#2)

Evaluation of snow depth retrievals from ICESat-2

using airborne laser-scanning data

tc-2022-191

We thank the reviewers for their positive feedbacks on our revised version of the article. We took into account their comments as described below. We also included a number of stylistic and proofreading corrections from a co-author who is native English speaker.

Submitted on 21 Apr 2023 Anonymous referee #1

The authors have provided a manuscript that is strongly improved from the original iteration. I especially appreciate Section 6.1 - it is becoming clear from these ICESat-2 snow depth studies that accurate snow-off DEMs is necessary, and it is encouraging to see the results using Pleiades.

My comments at this point are minor and mainly highlight typos, but there are a few points worth addressing:

Page 1, Line 19: "taylored" --> "tailored"
Modified.

Page 2, Lines 63-64: Suggested rephrasing: "ATL08 snow depth retrievals were found to be reasonably accurate in regions of low slope, but uncertainties increased in mountainous terrain, as previously found by Hu et al., (2021)."
Modified.

Section 2: This section is fairly small. I suggest merging it with Section 3.

We added this section following a comment from the other reviewer suggesting to better structure the data, study site and methods sections. Instead of merging it with Section 3, we expanded it as follow:

«The upper Tuolumne river basin is part of the Sierra Nevada mountain range (California, USA) and is contained within Yosemite National Park (Figure 1). It is located above the Hetch Hetchy Reservoir which provides fresh water and produces hydropower for the San Francisco region (Painter et al., 2016). It consists of 1100 km² of montane forests and alpine zones spanning an elevation range of 1200 m to 4200 m. Tree cover is composed of deciduous broadleaf and needleleaf evergreens forests and its density varies greatly within the watershed. More than half of the precipitation of this region range falls as snow (Li et al., 2017; Lahmers et al., 2022) with large year-to-year variations of snow accumulation related to low precipitation during pluriannual droughts or strong precipitation events from atmospheric rivers (Hedrick et al., 2019; Pflug et al., 2022).»

Page 4, Line 104: Extra period after "(4% of the data)".
Corrected.

Page 4, Lines 104-105: The "n_fit_photons" variable is discussed in greater detail in Section 4, so I suggest removing this sentence.

Modified.

Page 5, Line 119: Should be Section 3.3 (not 2.3).

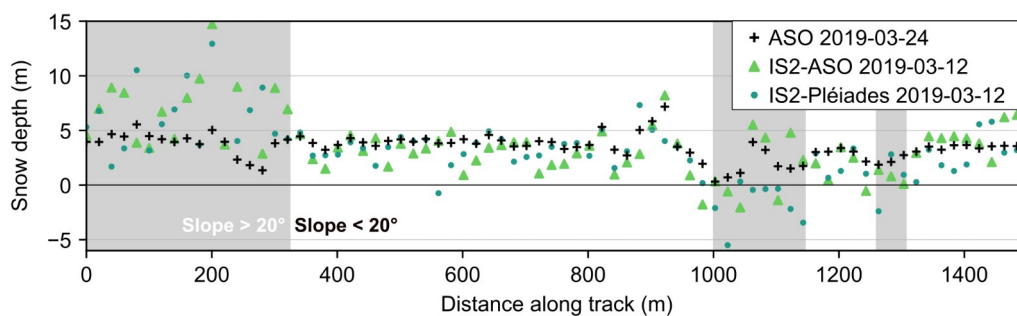
Modified.

Page 6, Line 148: "It can be used with *a* gridded product", or "It can be used with gridded product*s*"

Modified to «gridded products».

Figure 4: This is an interesting figure, though I suggest using shading or a bounding box to highlight the regions of high slope, rather than a black line.

We used a grey box to mark the regions of high slope and modified the caption accordingly.



Page 11, Line 221: Suggested rephrasing: "The IS2-ASO derived snow depths have a median bias of 0.00 m and a precision (NMAD) of 1.00 m."

We modified to:

«The IS2-ASO derived snow depths have a median bias of 0.00 m and a precision of 1.00 m (NMAD).»

Page 11, Line 235: 1.47 *m*

Corrected.

Page 14, Line 288: "...even with tree densities up to 60%..."

Modified line 278.

Page 14, Line 281: Suggested rephrasing: "Snow depths derived using the satellite photogrammetry DEM degrade rapidly when tree cover density increases and leads to marked bias."

Modified.

Page 17, Line 381: snow depth*s*

Corrected.

The authors did a thorough revision where they addressed all reviewer comments in a satisfying way. My only regret is that the authors didn't choose to correctly map the actual footprint of the 40m long ATL06 segments: it could have been very useful for the readers to see whether that yields better results than the simpler/faster approach of using the interpolated value of the DEM at 15m resolution, as presented in this study. Now this question stays open.

I only have a few technical correction suggestions that don't require another review.

Minor comments

--

Abstract, L16/L19: 0.5m or 1m? Following the review discussion, consider whether the readers will correctly understand "precision" here or whether you should describe what you mean by it. These terms are later introduced in the article but not in the abstract, where they are already used.

*We deleted «0.5 m» which was forgotten here and added the term «random error»:
«However, using airborne lidar elevation model as snow-off elevation source yielded an accuracy of ~0.2 m (bias), a precision of ~1 m (random error) across the basin and an improved precision of 0.5 m for low slopes, compared to eight reference airborne lidar snow depth maps.»*

Introduction, L68: I still suggest you write "...(ATL06) or _land surface_ and forest canopy height...". If "land surface" is not included here, it is not logical/unclear how the ATL08 product could be used for snow depths as referred to at L75ff.

Modified.

Discussion, L424ff: The double coregistration in this part can be a bit confusing for the reader. I suggest you help the reader to keep track on which coregistration round you are on, e.g.: The residual shift of this second coregistration is small with respect to the DEM resolutions of ... highlights the good agreement of the original co-registration to the ICESat-2 data.

Vertical coregistration shifts (L427): of the first or the second round? Clarify in the text.

We modified this part to clarify:

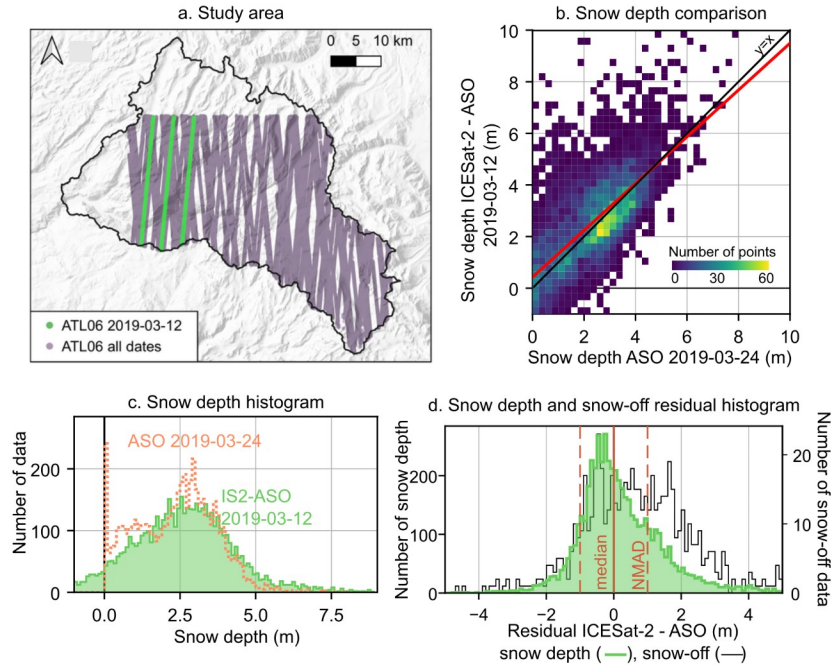
«We co-registered the Copernicus DEM and the Pléiades DEM to the ASO DEM after the original co-registration to the ATL06 snow-off points to evaluate the success of the co-registration processes (Table S3). The small horizontal shift obtained with the second co-registration, with respect to the DEMs resolution, of 0.70 m and 1.38 m respectively for the Pléiades and the Copernicus DEM highlights the good relative agreement of the original co-registration. The second vertical co-registration vectors were significant with 1.15 m for Pléiades DEM and -0.65 m for the Copernicus DEM and could lead, if applied, to changes in the accuracy of the snow depths.»

Figure 6 / caption: could be made easier to read - it is not immediately clear that these are four groups of two panels each, and "top" and "shown below" (in the caption) are thus a bit unclear terms. You may want to add some more white space between the panel groups and/or label panels (a,b,c...) you can refer to in the caption.

We added a title, modified the y-label (SCA (km²)) and added a.,b... to improve readability.

Colours in Fig. 3 and 6: Red/green with very similar intensity is an unfortunate choice (color-blindness, greyscale printouts). For example, red/blue with different intensity would be better readable.

We modified the line style to distinguish between these two colors.



Snow depth and snow cover area (SCA) distribution with elevation at four dates

