

Interactive comment on “Icelandic Snow Cover Characteristics derived from a gap-filled MODIS Daily Snow Cover Product” by Andri Gunnarsson et al.

Anonymous Referee #2 Received and published: 30 Apr 2019

Response to Anonymous Reviewer #2

Author response is in red

Reviewer #2 General comments:

Cloud cover and persistence is a substantial obstacle for monitoring snow presence/absence, especially in locales with abundant clouds. The manuscript describes a methodology for a gap-filling approach to remedy the issue. The resultant product is compared against ground observations (snow absence/presence) and coincident higher-resolution imagery. The product is analyzed for landscape characteristics and temporal trends. The manuscript presents an advance in analysis of snow duration and site characteristics, especially for such a heavily cloud-dominated Iceland snow pack. Analyses such as this, performed at moderate resolution, add insight into snow variability and temporal trends that are useful and creative. As presented, the conclusions reached are carefully supported by the methods and results, and the structure of the manuscript makes it relatively easy to follow the authors’ lines of thought. The paper is referenced well overall. The manuscript is hindered most by its writing, rather than its content. Substantial effort to make the writing efficient, precise, and concise throughout would go a long way to improve its clarity and make it accessible and elegant. In some places there is too much description that can be reduced. Scientifically, the paper is solid and informative. The manuscript can be improved by addressing important work done on published snow cover trends in the Northern Hemisphere and Iceland (e.g., Dietz et al.) in the Discussion.

We would like to thank Anonymous Reviewer #2 for very useful comments and a general positive feedback about our submitted manuscript.

The authors will review the manuscript carefully to make it more precise as suggested and address recent important work done by others.

Specific Comments

Reviewer #2 Comment #1

Pg. 1, line 20-21. “. . . and low thermal conductivity which is dominating for the growing season length of vegetation and plants (Keller et al., 2005).” How is snow’s thermal conductivity related to growing season length, let alone a dominant for determining growing season length? Thermal conductivity is indeed important for flora, fauna, and soils in winter; but what ties are there between thermal conductivity of snowpacks and growing season length? In addition, why “vegetation and plants” in the sentence? Isn’t vegetation comprised of plants?

Author response #1:

This is poorly worded. The authors suggest changing the text to:

“... and isolating properties which can influence the length of the growing season.”

Reviewer #2 Comment #2

The description of Icelandic land cover is especially relevant (Pg. 2, lines 12-14). The sparse and bare can be envisioned, but what is meant by “semi-natural” vegetation?

Author response #2:

This is poorly worded and translated wrong from Icelandic. It should say non-vegetated land classified at areas where vegetation cover is less than 10%

We will change the sentence accordingly.

Reviewer #2 Comment #3

Figure 2. By the time the reader arrives at this Figure, there has been no introduction of what size pixel is being referenced. Perhaps hectares or sq. km would be more useful as a y-axis variable.

Author response #3:

We will change this to square kilometers

Reviewer #2 Comment #4

Pg. 3, lines 9-11 is confusing: “A system of reservoirs and diversions store melt water during the spring freshet which generally consists of a seasonal snow melt period (April - June), a glacier melt period (June - September) and precipitation in the fall (August - October).” If you replace “spring freshet” with “year,” it makes sense, but I’m not sure if this captures the intended point.

Author response #4:

The following re-write is suggested for clarification:

“A system of reservoirs and diversions store melt water during melt season in the spring and summer which generally consists of a seasonal snow melt period (April - June) followed by a glacier melt period (June - September). As glacier melt recedes in the fall liquid precipitation is a large contributor to inflow (August - October).”

Reviewer #2 Comment #5

Pg. 5, lines 23-26. At times there is too much detail in the manuscript, and this is a good example of text that can be cut. “The data were downloaded from the United States Geological Survey (USGS) (<https://earthexplorer.usgs.gov/>) using bulk download utilities. Landsat scenes that cover Iceland are numbered from 224-13 to 216-13, 224-14 to 215-14, 223-15 to 215-15 and 219-16 to 216-16 in the

Worldwide Reference System 2 (WRS2), a total of 32 Landsat footprints (USGS, 2018).” Just referencing the source of the data and website in the previous sentences should suffice.

Author response #5:

The authors agree that this is too much detail. We will remove the above text as suggested. Also, similar details will be removed in the manuscript.

Reviewer #2 Comment #6

Organization. In Section 2 (Data), the ground observations are described first. In Section 3 (Methods), the Landsat/Sentinel data are described first. Perhaps 3.2 in-situ data processing, could be moved to 3.1 to maintain that structure? It goes back to ground observations first in Results (4.1.1)

Author response #6:

This has been suggested by reviewer 1 as well and we will change this

Reviewer #2 Comment #7

Pg. 6, lines 22-25. This part discusses resampling for sentinel data, but there is no corresponding parallel description of this for Landsat data in the first paragraph of Section 3.1. More important, what sort of resampling was used to shift the pixels from 30 and 20 m resolution to 500 m?

Author response #7:

We suggest the following edits in Pg.6 L22-25:

Data were processed at 20 m and 30 m spatial resolution for Sentinel 2, and Landsat 7 and 8, respectively. Data were then resampled to the Modis data grid at 500 m spatial resolution using GDAL utilities (reference) with an average resampling method.

Reviewer #2 Comment #8

What impacts are expected from the scale disparity going from 30/20 to 500 m?

Author response #8:

This is discussed in Pg. 9, lines 11-12: “The screening reveals that disagreement was mainly located at snow cover boundaries, i.e. where snow free land meets snow covered land as well as boundaries of clouds and land”. These are the main effect we observe during the resampling of the data.

Reviewer #2 Comment #9

Of the pixels resampled, how much snow-covered classifications went to snow-covered areas or vice-versa? To elucidate, does snow cover largely disappear at once, or do lingering drift areas remain?

Author response #9:

The GDAL average resampling method converts the higher resolution satellite data to snow if more than 50% of merged pixels are classified as snow within the MODIS pixel area. Lingering drift areas need to compromise more than 50% of the Modis pixel to be classified as snow.

Reviewer #2 Comment #10

What sensitivity is in the snow-classification developed from MODIS to how much pixel area is snow covered before that threshold of snow presence/absence is crossed for Iceland?

Author response #10:

This is based on the NDSI index. Various NDSI Snow Cover Quality test are applied during the calculation of snow cover and supplied with the MOD10A1 granule. The sensitivity has not been investigated here.

Reviewer #2 Comment #11

Some discussion of these scale issues and inherent differences would be appreciated. Later on in the manuscript, the line (Pg. 9, lines 11-12), “The screening reveals that disagreement was mainly located at snow cover boundaries, i.e. where snow free land meets snow covered land as well as boundaries of clouds and land,” is intriguing. It seems like more should be said about these boundaries and what is and isn’t captured in the approach and validation with higher-resolution data.

Author response #11:

Higher resolution data captures indeed more details while MODIS would see a more mixed pixel. Spectral unmixing for example could prove benefits to this problem but as the data is mostly used for validation purposes it is not further pursued.

Reviewer #2 Comment #12

Pg. 8, lines 3-5. “To classify the remaining unclassified pixels information about location (Latitude, Longitude), elevation and aspect to account for earlier melting of south facing slopes are derived to apply for a gap filling algorithm.” This is unclear.

Author response #12:

Suggested re-write to clarify:

“To classify the remaining unclassified pixels information about pixel location (Latitude, Longitude), pixel elevation and pixel aspect are derived to use for the gap filling algorithm.”

Reviewer #2 Comment #13

Figure 3. The color bars for the ratio of agreement aren't intuitive. Orange and Red bracket purple, blue, and green. The error magnitude would be better understood if the color scheme made a more natural color progression from high (warm/cold) to low (cold/warm).

Author response #13:

We will change this

Reviewer #2 Comment #14

Pg. 9, lines 3-4. "Pixel density range from 110, 30 and 90 for Landsat 7, Landsat 8 and Sentinel 2, respectively." This sentence is unclear.

Author response #14:

We suggest the following re-write for clarification:

Pixel density, i.e. number of overlapping pixel for the study period, range from 110, 30 and 90 for Landsat 7, Landsat 8 and Sentinel 2, respectively."

Reviewer #2 Comment #15

Pg. 9, lines 5-6. "Visually the agreement is good in all cases with R2 values 96 %, 92 % and 95 % for Landsat 7, 8 and Sentinel 2 respectively." This statement isn't in agreement with Figure 4B, where the R2 is listed as 0.72 and the MSE seems high.

Author response #15:

This is a typo. 0.72 in figure 4B should read 0.92

Reviewer #2 Comment #16

Pg. 11, lines 16. "After applying a temporal aggregation to the data unclassified pixels still remained in the dataset." Please tell us more about that here; how many? What percentage?

Author response #16:

As mentioned P11 L9 the improvement to pixel temporal aggregation ranges from 70% down to 14% depending on the number days selected to aggregate. This is shown in Figure 7 which is referred to in P11 L1.

Reviewer #2 Comment #17

Figure 8. Wait, on page 12 line 9 we learned Nov-January data were not there due to darkness, and the figure presents 12 months in a year on the X-Axis. Day of year on the X-Axis should be in DOY, not months. On the Y-Axis, why not use one tick per year instead of 0.5 year?

Author response #17:

This is an error at our end in the axis extent. We will change axis and change the minor tick markings.

Reviewer #2 Comment #18

It would be more useful if this work were placed in a similar context with published analyses of snow cover trends. There's no discussion on volcanic impacts on snow duration. There are no contrasts provided with other published results/trends for snow cover, even at Northern Hemisphere scales. Claiming that increased glacial mass balance in Iceland is interesting, but may not be identical to what is being observed/measured in this project.

Author response #18:

The authors will review the manuscript carefully to make it more precise as suggested and address recent important work done by others. Impacts of volcanic eruptions will be mentioned.

Reviewer #2 Comment #19

Figure 10 is interesting. It would be helpful to add a small black line to separate the Feb-Nov full dataset analyses from the bi-monthly comparisons comprising the top.

Author response #19:

This will be added

Reviewer #2 Technical Corrections

The paper could be shortened a bit with increased efficiency.

The authors will review the manuscript carefully to make it more precise.

"Modis" should be "MODIS" throughout.

We will change to MODIS

The manuscript has a comma shortage, and there are a number of single-sentence redundancies throughout where identical words are used repeatedly in the same sentence or adjacent sentences.

The authors will review the manuscript carefully to reduce redundancies.

Pg. 2 Line 20, "higher altitudes" could be "high-altitude"

We will change this

Figure 1. The green markers are hard to see on the dark gray background.

We will change this

Need a “growing” between “vegetation” and “season” (Pg. 13, line 2)

We will change this