Resubmission of Manuscript ESSD-2023-349 – Response to reviewers
Hörður B. Helgason and Bart Nijssen, LamaH-Ice: LArge-SaMple Data for Hydrology and Environmental Sciences for Iceland

Original reviews in black
Responses in blue and bold

RC1: Comment on essd-2023-349 by Referee #1 (Alexa Hinxman):
General comments:
First of all, congratulations on your effort for this manuscript. It is well written and the care put into the document is apparent. This manuscript's main goal is to introduce the reader to a new dataset called LamaH-Ice. It goes into depth on the data was collected, the different attributes of the catchments, analysis of hydrologic signatures and the uncertainties within the data. It is through and rigorous in describing all aspects of the dataset. This could be very intriguing for Arctic hydrologists who do not have many long term datasets to work with. This paper gives confidence to the validity of the data collected and the various datasets utilized.

Specific comments:
While well written, the manuscript does suffer from being excessively wordy. I would suggest shortening some sections, especially Catchment attributes (section 5).

We have reduced the text in the following way:

- **Lines 322-332 were moved to the supplement**
- **Lines 338-340 were moved to the supplement**
- **Lines 474 and 475 were shortened**
- **Lines 494-497 were moved to the supplement**
- **Lines 510-513 were deleted**
- **Lines 524 and 525 were moved to the supplement**

Between lines 275-287: The authors stated that there is an underestimation of precipitation due to the use of ERA5-Land dataset, and that the decision to continue with the ERA5-Land dataset comes from consistency with other LSH datasets. If CARRA pr Rav-II datasets provide better estimations of data, should those not be used? Rather than less-accurate data even if it matches with other LSH datasets?

Referee #2 posted a similar comment regarding the decision to continue using precipitation from ERA5-Land. We have addressed this issue by adjusting the manuscript and the dataset. We now use precipitation data from the more appropriate RAV-II dataset in the main attribute table, as well as in the water balance file. For a more detailed response, see below (first response to Referee #2).

Technical corrections:
Suggestions are added into the pdf as comments.

The pdf included 13 suggestions to shorten sentences or refine the wording in the manuscript. We have incorporated these suggestions into the revised manuscript (with minor changes).

RC2: Comment on essd-2023-349 by Referee #2 (Anonymous):
This manuscript presents an LSH dataset for Iceland. I believe it is a valuable addition to the discipline – the presence of glaciers and snow cover in the basins makes it very valuable to evaluate hydrological processes in cold regions and related to glacier hydrology, a component often neglected in LHS due to their region of interest. I believe this dataset will be very helpful to the hydrology community.
I enjoyed reading the manuscript and thought it was well-organized and clearly laid-out the attributes and organization of the data. My main concern relates to the precipitation – after showcasing that the ERA-5 product is underestimating precipitation, and providing alternatives, the climate attributes using precipitation are still done using the ERA-5 data. While I understand the need for consistency with other LamaH datasets, I think providing basin attributes that are likely to be erroneous is problematic. Despite the disclaimer in the manuscript, I fear people will use the existing dataset anyway, which will result in flawed conclusions. I suggest providing the attributes that use precipitation using the more appropriate Carra or RAV-II datasets in the main attribute table and adding the ERA-5 one as a comparison with the existing LamaH dataset. I see that this is somewhat already done by adding P_RAV in the water balance attribute and in the meteorological timeseries, but I think it should also be done in the catchment attribute. Another option would be to add a comparison of ERA-5 precipitation and CARRA/RAV-II to justify if climatic indices that are based on precipitation values (as shown in Table A4) are reasonable. For example, despite the total amount of precipitation of ERA5 being too low, is the seasonality preserved? Overall, I look forward to using this dataset and appreciate the efforts put into compiling it in a consistent manner. Below are minor comment about the text and dataset.

In response to the referee's comments regarding our use of the ERA5-Land precipitation (also raised as a problem by Referee #1), we have adjusted the manuscript and the dataset. We now use precipitation data from the higher resolution RAV-II dataset in the main attribute table, as well as in the water balance file. The attributes and indices using precipitation from ERA5-Land are still included in the dataset for consistency with other large sample hydrology datasets that use ERA5-Land, denoted with a "_ERA5L" suffix. We now use the RAV-II precipitation in Figure 5 (showing the spatial distribution of climate indices) and in Figure 6 (showing hydrological signatures). We also calculated reference ET from the RAV-II data to replace the PET from ERA5-Land in the Budyko curve analysis. For details, see below in our response to a related comment from Christoph Klingler.

Detailed about the dataset and text:
In the text, the specific labels (for example, "aridity" or "frac_snow") of the attribute is added directly in the text for climate indices. It would be helpful to include those for the glacier attribute and topographical attributes as well. It makes finding the description and discussion of the attribute in the text when looking at the data easier. For example, the "fsca_full_watershed in section 4.3.

We have added the specific labels of every attribute in the manuscript.

L25: There are more up-to-date references about the importance of snow and ice water resources.

We have added more up-to-date references.

L51: About the application of machine learning in hydrology: could you add a citation here?

The citations regarding the application of machine learning are in the next sentence, we have connected the two sentences in a better way.

L102: Could you mention the average elevation of these glaciers? Potentially in the glacier attribute section?

The average elevation of the glaciers has been mentioned (at the end of section 5.8: Glacial characteristics).

L111: Could you add a citation about the categories of river classification in Iceland?

We have added a citation.

Fig1: Could you also show the delineation of the basins A in the map?

We now show the delineation of Basins A in the map.

L181: 51 catchments out of how many are classification A?

There are 107 catchments in basin delineations A and B. For clarity, we have updated this sentence from: "A total of 51 catchments in basin delineation A are located within other catchments." To "Fifty-one out of the 107 streamflow gauges in LamaH-Ice are located within catchments from of downstream gauges."

Fig 2: The labelling of subfigure is inconsistent – here is it upper right, upper left, but the rest is (a) (b) (c). Could the letter system be implemented throughout the manuscript?

We have implemented the letter numbering system throughout the manuscript.

L224: The line looks green to me.

The line is indeed green, we have corrected this in the text.

L313: The data has consistent gaps for Nov-Jan-Feb due to lack of light (I assume). This would be good to mention.

Correct, we have now mentioned this in the paragraph.

L329: outlier removal which causes some additional gaps in the dataset?

The outlier removal caused additional gaps in the MODIS dataset before it was temporally aggregated. We use a temporally aggregated dataset, so these additional gaps do not affect the usage of the data in LamaH-Ice. As mentioned, the temporal aggregation does however limit the applicability of the data in some use cases.

L441 "water bodies" is missing the attribute label ("wat_frac")

Inland water bodies have the short name "lake_fra" in the attributes table, "wat_frac" is not used.

Fig 11: the colour between no impact and B is hard to distinguish. If these colors are to be consistent with the Lamah dataset, I understand, but if not, I suggest changing it to a colour with more contrast.

For improved readability, we changed the plot markers of "no impact" to a dashed black circle (with no fill).

About the dataset:

Attribute elev_ran is missing from table A3.
The attribute elev_ran has been added to table A3.

Attribute “degimpact” in Table A1 is also named “degree” in the catchment attribute table.

The “degimpact” and “typimpact” attributes have been removed from the catchment attribute table (they should only be in the Gauge_attributes.csv file).

In the annual timeseries/glacier timeseries, the headers are missing the YYYY values **“,a**nnual_net_MB,summer_MB,winter_MB,glac_area_perc,glac_area_km2” instead of ” **YYYY (or date_time)** ,annual_net_MB,summer_MB,winter_MB,glac_area_perc,glac_area_km2).

This has been fixed.

In the attribute table in the dataset, I could not find g_lon, g_lat, g_frac_dyn and g_area_dyn.

These attributes have been added to the dataset.

Is there a reason why the columns in the manuscript tables and in the catchment attribute tables in the dataset are not in the same order? For example, in the Topographical attributes, in Table A3, it goes area_calc, elev_mean, elev_med, elev_std, slope_mean, m_vert_dist, nvert_dist, nvert_ang, asp_mean, elon_ratio, strm_dens, but in the catchment attribute table : area_calc,elev_mean,elev_med,**elev_ran,**slope_mean,elev_std,asp_mean, strm_dens,mvert_dist, ,elon_ratio , mvert _ang – with geological attributed inserted between the columns. Is there a reason to not group the attributes of specific categories together as presented in the manuscript tables? It would make navigating the datasets easier.

The attributes of specific categories have been grouped together in the catchment attribute table for improved readability.

CC1: Comment on essd-2023-349 by Christoph Klingler:

1. General

Dear authors, I was asked to act as a reviewer but declined because of a possible conflict of interest. I really appreciate your work and think that LamaH-Ice will become an important part for large-scale analysis, especially in the cold and glaciated region. The variety of static and dynamic attributes related to snow and ice cover are a novelty within LSH datasets and therefore of great value for the scientific community. You described the executed steps precisely in the article, the attached supplements are also a great support. The dataset is clearly structured and the attached text files give a nice orientation. I didn't do a detailed review, but for a start, I noted a few points that I picked up while reading the preprint and browsing in the dataset:

2. Comments preprint

L180: Can you plot the size of your circles depending on the catchment size in Figure 1?

In response to a comment from Referee #2, we have added the basin outlines to the map. We decided that would be clearer.

L224: On my site the line is more green than blue.

The line is indeed green, we have corrected this in the text.

L244: What is WRF?

We have added an explanation.

L267: Can you add a plot (like Figure 3d) between ERA5-L and CARRA at least in the supplements?

We have added a 1:1 plot showing the precipitation between ERA5-L and CARRA in the supplements (Figure S1).

L268: What is with the snow, that was blown away? The influence of wind can be huge – at least in the Alps.

Good point, it is a possibility that wind redistribution of snow would affect the snow depth measurements on the glaciers. We have mentioned this in the text (Section 5.8). It is also a possibility that this could be a contributing reason for the measured average runoff being larger than the precipitation for some catchments, especially given the lack of trees to constrain snow redistribution. We have also mentioned this in the text.

L269: Beside thaw events, sublimation and wind are also important factors.

Correct, we have mentioned this in the text.

L303: Note that the Budyko curve represents a reference condition for the water balance and meets not the variability on the whole globe. Deviations from the curve are therefore not always measurement errors. I think that in your case too low P or PET values can´t explain the deviation from the Budyko curve solely. Perhaps you can do a more detailed investigation here or explain the Budyko curve more clearly. Otherwise, most readers will think that the deviation is a big error.

We thank you for this insightful comment. The large deviation from the Budyko curve stems from the fact that the PET in ERA5-Land seems to be overestimated. The PET in ERA5-Land is

calculated as an open water (pan) evaporation. For the Budyko analysis, we calculated reference ET for well-watered agriculture land using the Penman-Monteith equation as recommended in the FAO manual, using atmospheric data from RAV-II. This alternate PET estimate is lower than the ERA5-Land PET, and the catchments fall closer to the Budyko curve. In the paper, we show the Budyko curve for meteorological data from ERA5-Land and RAV-II, and show that the reference ET calculated from RAV-II data is more plausible. The RAV-II reference ET is thus used in the climate indices computation.

L304: I think "higher ETA" is more sufficient than "high ETA".

We have changed the wording to "higher ETA".

L305: Do you mean Figure 3c?

Yes, we have corrected this typo.

L307: What is with glacier melt? 68 of the 107 catchments are partly covered by glaciers.

In an earlier paragraph, we do mention glacier melt being a possible contributing factor to the negative mean $P - R$. However, the glaciers gained mass between 1980-1993. We discussed that omitting the basins with >5% glaciation resulted in insignificant changes in mean $P - R$.

L342: Do you have the positions, where the glacier measurements are done? A plot with the sites on the glacier and the intersecting 32 catchments would be nice (maybe for the supplements).

We have added a map showing the glacier measurement sites in the supplement.

L371: Can you explain the high variability of PET especially in the south? Following Figure 5b) there are neighbouring basins with mean PET values of 0,5 and 3 mm/day within in a very short distance.

The locations of the markers in Figure 5 correspond to the locations of the streamflow gauges. The catchment index values are calculated for the full catchment area of these gauges. There are indeed high contrasts between some neighboring gauges, especially noticeable in the south. The reason is that the catchments with high PET values are small and located in low elevations. The neighboring catchments with low PET values extend over much larger areas in the highlands and on glaciers, where PET is lower. In the updated Figure 5, which shows mean daily reference ET (calculated from RAV-II), the variability is lower. As a result, the contrast between neighboring basins is less pronounced.

L461: I would refer to the supplement in all your subsections. The reference to S3.3 in the subsection 5.4 (land cover) is missing, for example.

We have added references to the supplement in all subsections where applicable.

L481: Sometimes there is Lamah instead of LamaH.

We have changed all occurrences of "Lamah" to "LamaH".

L596: Would it be possible to calculate an attribute indicating the deviation of the area from your basin delineation to those given by the data provider (IMO, NPC)?

We thought of this initially, but catchment delineations from the data providers were not available for all catchments. It was thus decided to omit this attribute. Instead, we performed a thorough check to see if our delineations matched with delineations from the providers (where applicable) as well as hydrologic information from a digital map database of Iceland (as discussed in the Supplement, S1).

3. Comments dataset
a. There are two files in D_gauges/1_attributes/ for the gauge attributes (Gauge_attributes.csv and Gauge_attributes_.csv). In the readme file is no explanation for that.

The latter file was included by mistake and has been removed.

b. Can you add the attribute "area_calc" in the file "Gauge_attributes"?

The catchment area is different between catchment delineations A, B and C. We thus prefer to include "area_calc" only the "Catchment_attributes" file for each delineation method.

c. I would add the quality codes (including the code 250) in the readme file for the gauge attributes and add the code 250 (gap) in the supplement table S1.

We have added information about the quality codes in the readme file and added the 250 code in the supplement table S1.

d. The separator in your csv files is sometimes comma (e.g. gauge attributes) and sometimes semicolon (e.g. runoff time series). I suggest using solely semicolon as a separator.

We now use a semicolon as a separator for all .csv files in the dataset.

e. Some special characters (e.g. æ) will certainly cause display problems for some users. This is just a hint.

In the readme file for the gauge attributes, we have raised this comment and suggested an encoding to use in the file reading.

f. Can you add at least the most important attributes to your Basin shapefiles?

We have added all the catchment attributes to the basin shapefiles.

g. Can you create metadata for your shapefiles that include at least a reference to your paper and a note that the units are described there in the tables? This will ensure the connection.

We have created metadata files for the shapefiles in the dataset.

h. I imported your shapefiles in a GIS and saw that they all have the coordinate system EPSG 3057. In contrast, the text file "Folder_structure" and the readme files state that Basins_C.shp and gauges.shp have EPSG 3035.

This is an error in the text files, the coordinate system used for shapefiles in LamaH-Ice is EPSG:3057. We have corrected the "Folder_structure" and readme files.