



Supplement of

TermPicks: a century of Greenland glacier terminus data for use in scientific and machine learning applications

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Supplementary Material

A Google earth package

The TermPicks.kmz is a Google Earth KML (Keyhole Markup language) file and supporting images with the Landsat coverage for each glacier. Users can select their glacier of interest either in the side menu, or by navigating Google Earth to the glacier.

- 5 Clicking on the glacier ID gives an image pop up that is the same format as Figure 11. This can be used to get a overview of what the data coverage is for each glacier; however, it does not include other data sources, such as Sentinel data. This file can be found in the TermPicks GitHub repository.

B TermPicks reference polygons

The TermPicks polylines need to be converted into label polygons for the deep learning usage. The label polygon contains the glacier terminus, fjord boundary, and outer boundary that ensures the polygon covers the corresponding remote sensing image. To convert into polygons, we first prepare a reference label polygon for each glacier. The terminus position of the reference polygon should be at the furthest retreat position so that the fjord boundary is exposed to the most extent. Then, for any given terminus in TermPicks, we use it to replace the terminus part of the corresponding reference polygon to generate label polygons. A file containing reference polygons for the current TermPicks dataset is currently available on Zenodo (<https://doi.org/10.5281/zenodo.6557981>).

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C GEEDiT-TermPicks

GEEDiT-TermPicks is written within Google Earth Engine's (GEE) API (Gorelick et al., 2017). This bespoke version of GEEDiT (Lea, 2018) provides much the same functionality as the original, though represents a significant re-writing of its structure to allow for several improvements and TermPicks specific requirements, including:

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1. Changing the digitisation interface so it operates using the Google Earth Engine DrawingTools functions (Google, 2021, link: <https://developers.google.com/earth-engine/tutorials/community/drawing-tools>, last accessed 5/21/2021). This allows even more rapid digitisation due to data being temporarily stored 'client side', rather than in the original tool where vertices were submitted 'server side' for subsequent visualization (see Google, 2021, link: https://developers.google.com/earth-engine/guides/client_server for more information, last accessed 5/21/2021).
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2. User skipping of images by date as well as image number
 3. Inclusion of ASTER L1T Radiance image archive (https://lpdaac.usgs.gov/products/ast_11tv003/, last accessed 5/21/2021)
 4. Easy user access to imagery of glaciers that make up the TermPicks database and their respective locations.
 5. Automatic appending of glacier, imagery and digitisation metadata, allowing any future versions of TermPicks to be easily and quickly generated.
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6. Compulsory fields for user names and email addresses that are appended in metadata to ensure that those who digitize the data are properly acknowledged if and when they are subsequently shared/published, and (where necessary) to enable user inter-comparisons.

D GEEDiT-TermPicks walkthrough

Link to GEEDiT-TermPicks: <https://github.com/jmlea16/GEEDiT-TermPicks>

- 35 Step 1:

1. Define date range, months of interest, maximum image cloud cover limit, and satellites to visualise imagery from. Note that maximum image cloud cover limit uses the metadata values indicating cloud cover across the entire image that are provided with Landsat, Sentinel 2, and ASTER imagery. See Figure S1 for overview of menu screen.

2. Zoom to the glacier of interest and click on its blue dot.

40 Step 2:

1. The tool will automatically zoom to the selected glacier, and the blue dot will turn red. Imagery in the background is the standard Google Earth base imagery. If you have selected the incorrect glacier, click the 'Go Back' button and this will return you to the previous screen. See Figure S2.

45 2. Enter your name and email address in the boxes provided, and click the 'Go to images' button to continue. These are compulsory fields to ensure that data can be appropriately acknowledged where they are shared/published.

Step 3:

50 1. Imagery for the selected glacier, satellite and date is displayed. Zoom to the desired level to allow accurate digitisation of the terminus, and click on the screen to start digitising, and double click to end. It is possible for multiple lines to be digitized per image, though if users are seeking consistency with the TermPicks dataset this should be avoided. See Figure S3.

2. Four panels are included on this screen, including:

55 (a) Panel for adding/removing extra images for comparison, and modifying margins that have been digitized. Clicking 'Remove added images' will remove any images that have been added by the user, leaving only the original satellite image on the screen. The 'Edit' button can be used where a line has been finished, but needs to be subsequently modified or deleted. To do this, click the 'Edit' button and then click on the line that needs to be modified. This will allow its vertices to be moved, while the line can be deleted by pressing the delete or backspace key while the line is selected. To switch back to drawing mode, press the 'Draw new line' button. This will allow a line to be digitized by clicking on the screen as before. See Figure S4.

60 (b) Panel for assigning quality flags. Each of these flags can be manually assigned by the user as appropriate, though for SLC-off Landsat 7 imagery, and where the user uses panel 1 to compare to other imagery, the relevant check boxes will automatically be selected. If digitized margins fall in areas of SLC-off Landsat 7 images, or the user has added an extra image for comparison in error, these flags can be manually deselected. Values of all flags, and any text notes are automatically appended to margins as metadata when they are exported. See Figure S5.

65 (c) Panel displaying glacier name, TermPicks ID and satellite that collected the displayed image. Text boxes display the date of the displayed image in YYYY-MM-DD format, and the image number of the total available of the glacier. Users can also skip to different images, by date or image number. Where users choose to enter dates, they must be given in YYYY-MM-DD format, and the image shown will be the image that is the closest available in time to the entered date. If a user defined image number falls outwith the range of valid values the map will be cleared and a panel requesting the user to enter a valid number will appear. Once a date/image number has been entered, the user can skip to that image by pressing the enter key. See Figure S6.

70 (d) Panel that allows the user to skip to the next/previous image number, or export the entire set of digitized margins. By pressing any of these buttons, the user will log the digitized margins for export. Once any of these buttons have been pressed, subsequent modification of the data via the geometry imports bar will result in duplicate margins in the exported dataset. Pressing 'Export' will set up an export task that can be accessed through the 'Task Manager' tab in the top right of the screen (Google, 2021, <https://developers.google.com/earth-engine/guides/playground>, last accessed: 5/21/2021). To avoid the possibility of data loss through failure of internet connection and/or browser crashes, it is recommended that users regularly export their data. See Figure S7.

75 (e) By hovering the cursor over the Geometry Imports panel, users can view all previous termini that have been digitized. The name of each geometry is given in the format t_YYYY_MM_DD_HHmm, where the date and time are derived from the image. Margins from previous images are visualised in blue, and those for the current image in black by default. Note that any modifications to previous margins (*i.e.* blue lines) will not be logged. See Figure S8.

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Figure S1. Step 1 of GEEDIT-TermPicks walkthrough. Overview of the menu screen (Screenshot from Google Earth Engine © Google Earth 2021).

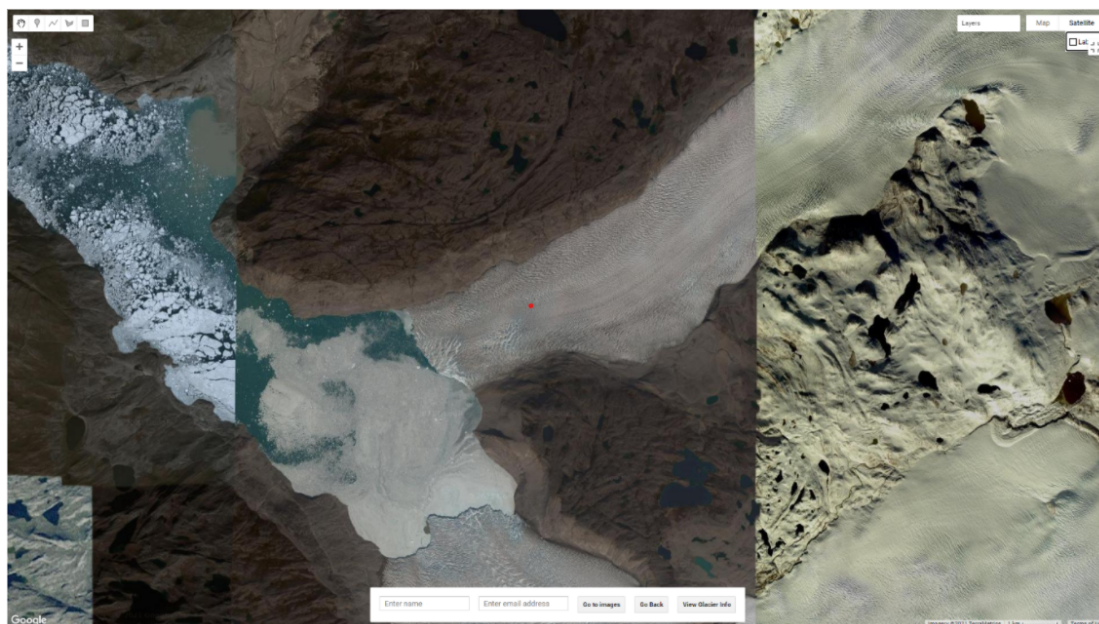


Figure S2. Step 2 of GEEDiT-TermPicks walkthrough. Zoom in of the individual glacier of interest menu (Screenshot from Google Earth Engine © Google Earth 2021).

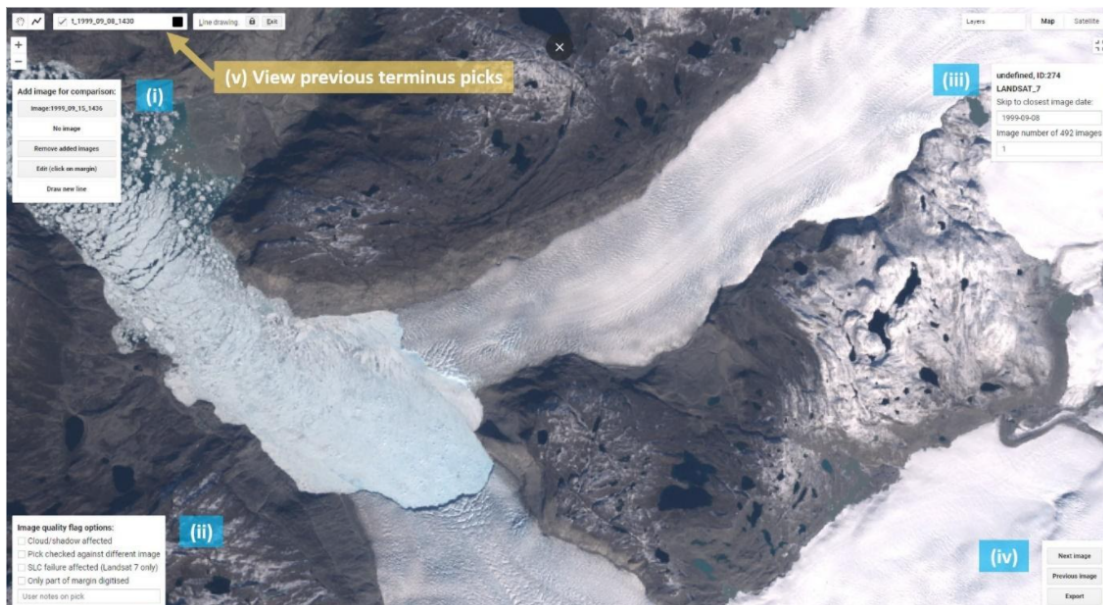


Figure S3. Step 3 of GEEDiT-TermPicks walkthrough. Zoom in of the individual glacier of interest menu and additional menus (Screenshot from Google Earth Engine © Google Earth 2021).

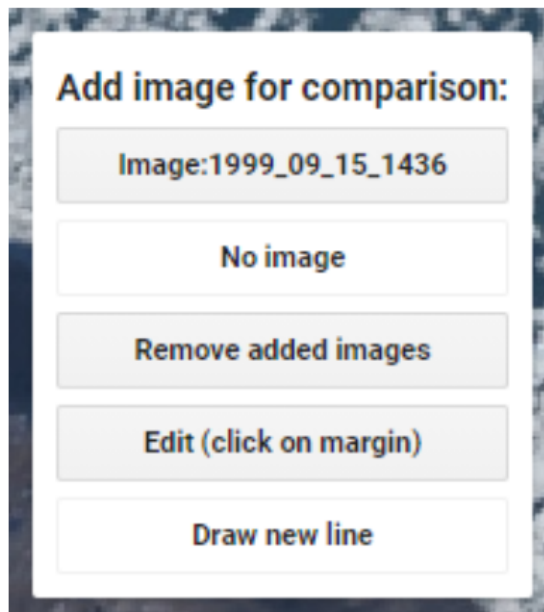


Figure S4. Step 3a of GEEDiT-TermPicks walkthrough. Panel for adding/removing extra images for comparison, and modifying margins that have been digitized (Screenshot from Google Earth Engine © Google Earth 2021).

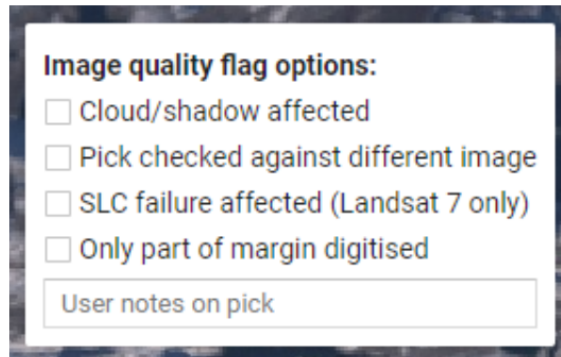


Figure S5. Step 3b of GEEDiT-TermPicks walkthrough. Panel for assigning quality flags (Screenshot from Google Earth Engine © Google Earth 2021).

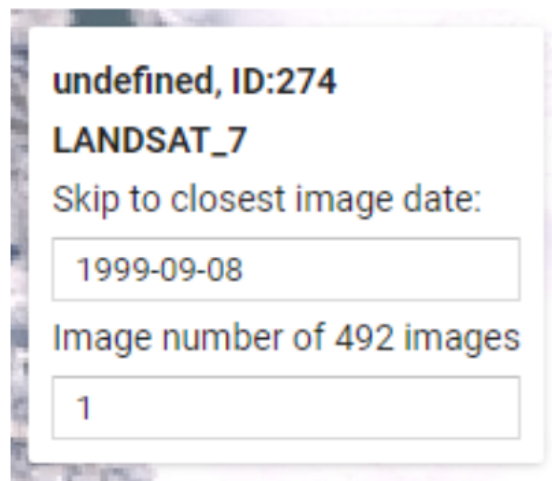


Figure S6. Step 3c of GEEDiT-TermPicks walkthrough. Panel displaying glacier name (Screenshot from Google Earth Engine © Google Earth 2021).

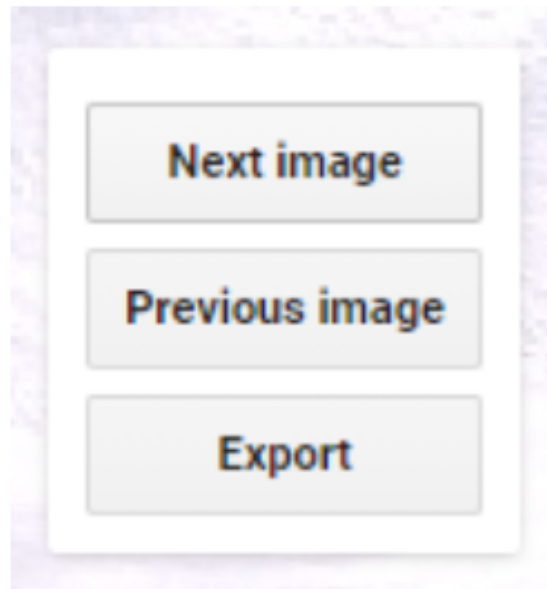


Figure S7. Step 3d of GEEDiT-TermPicks walkthrough. Panel that allows the user to skip to the next/previous image number, or export the entire set of digitized margins (Screenshot from Google Earth Engine © Google Earth 2021).

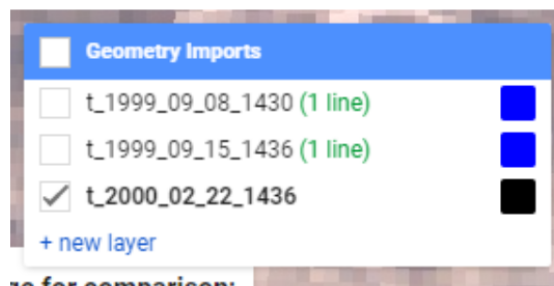


Figure S8. Step 3e of GEEDiT-TermPicks walkthrough. Panel of geometry imports to view previous termini (Screenshot from Google Earth Engine © Google Earth 2021).

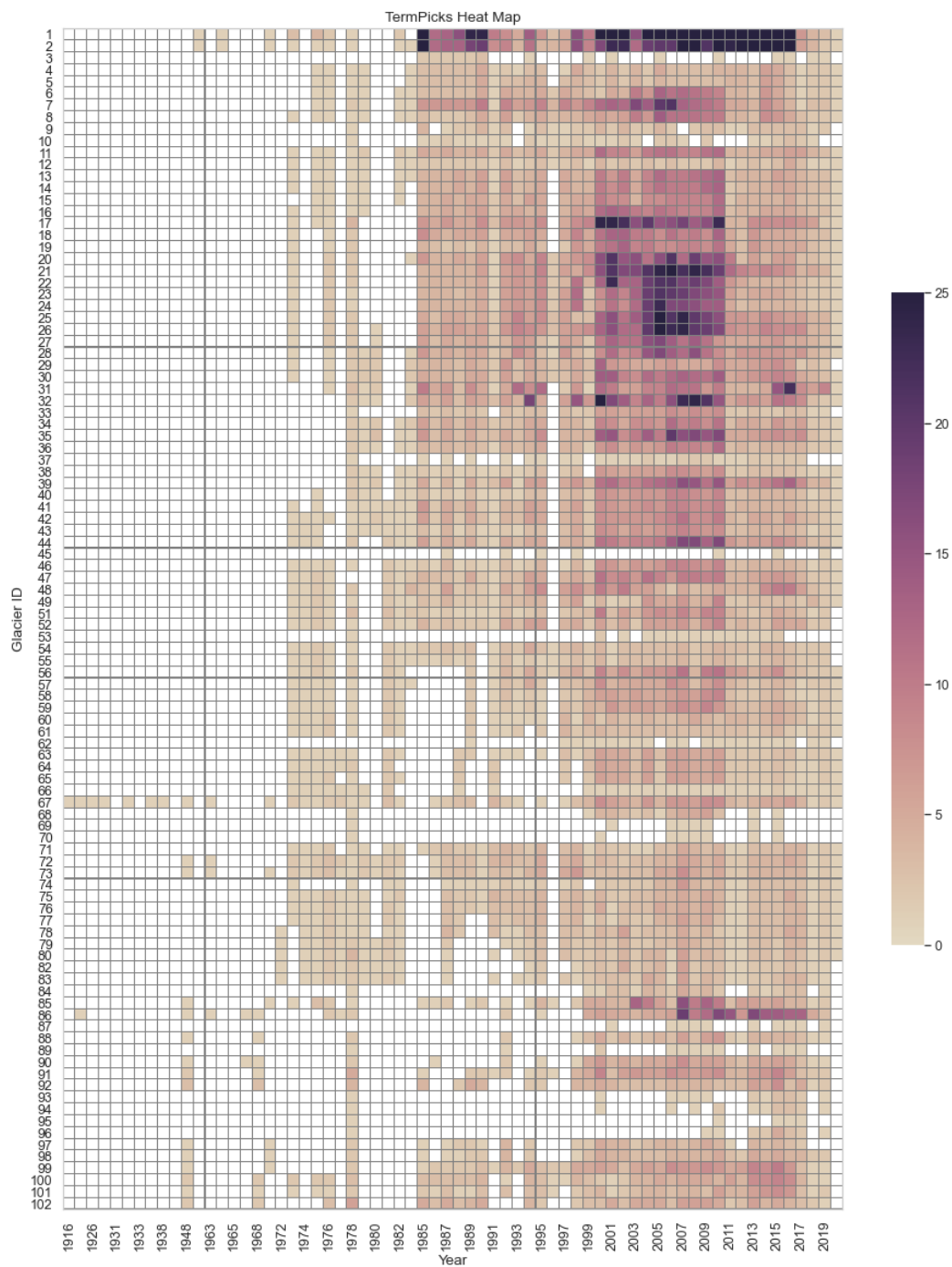


Figure S9. Heatmap of glacier traces for glaciers 1 to 102. The x-axis is year and the y-axis is the Glacier ID. The color corresponds to the number of traces for that basin's glacier per year, between 1 and >25. 0 traces are grey.

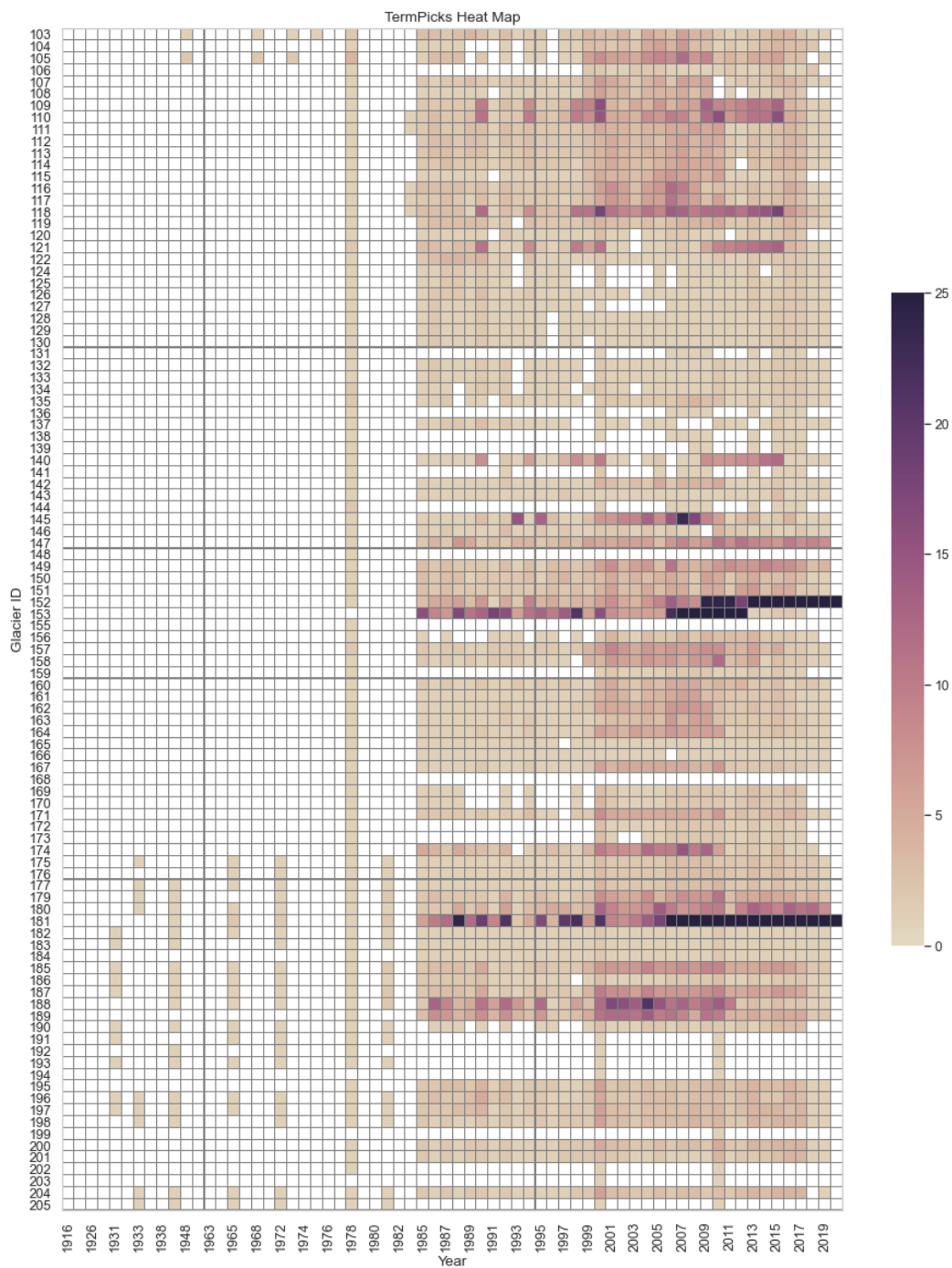


Figure S10. Heatmap of glacier traces for glaciers 103 to 205. The x-axis is year and the y-axis is the Glacier ID. The color corresponds to the number of traces for that basin's glacier per year, between 1 and >25. 0 traces are grey.

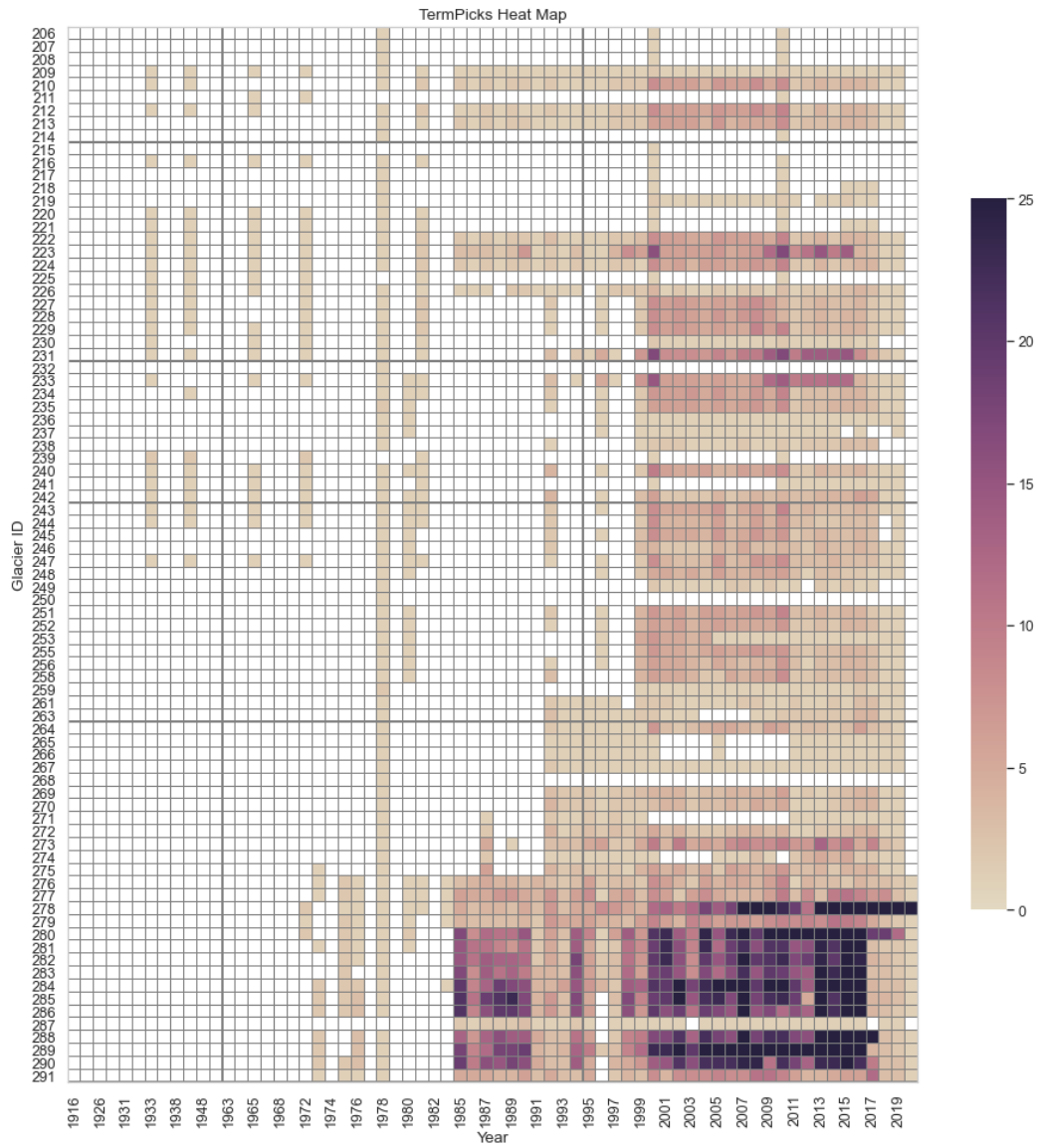


Figure S11. Heatmap of glacier traces for glaciers 206 to 291. The x-axis is year and the y-axis is the Glacier ID. The color corresponds to the number of traces for that basin's glacier per year, between 1 and >25. 0 traces are grey.

References

- 85 Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., and Moore, R.: Google Earth Engine: Planetary-scale geospatial analysis for everyone, *Remote Sensing of Environment*, 202, 18 – 27, <https://doi.org/10.1016/j.rse.2017.06.031>, 2017.
- Lea, J. M.: The Google Earth Engine Digitisation Tool (GEEDiT) and the Margin change Quantification Tool (MaQiT) – simple tools for the rapid mapping and quantification of changing Earth surface margins, *Earth Surface Dynamics*, 6, 551 – 561, <https://doi.org/10.5194/esurf-6-551-2018>, <https://www.earth-surf-dynam.net/6/551/2018/esurf-6-551-2018.pdf>, 2018.