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glenglat: a database of global englacial temperatures

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Abstract. Measurements of englacial temperatures have been collected since the earliest years of glaciology, with the first measurements dating back to the mid-19th century. Although temperature is a defining characteristic of any glacier – and is notoriously laborious to collect – no effort had been made yet to gather all existing measurements. In an attempt to make existing ice temperature data more accessible, we present glenglat, the **gl**obal **engla**cial **t**emperature database compiled from 316 literature sources and 12 data submissions and composed of 1 931 831 measurements of depth and temperature from 788 boreholes located on 213 glaciers outside the ice sheets. Alongside recent compilations for the ice sheets (Løkkegaard et al., 2023; Vandecrux et al., 2023), most published englacial temperature measurements are now readily available to the research community.

Here, we review the variety of glacier thermal regimes that have been measured and summarize the spatial, temporal, and climatic coverage of measurements relative to the global glacierized area. Measurements of cold and polythermal glacier ice greatly outnumber those of temperate ice. Overall, temperature has been measured in fewer than 1‰ of all glaciers, and only 27 % of boreholes have been measured more than once, highlighting the great potential to investigate changing temperature conditions by repeating past measurements. The database is developed on GitHub (https://github.com/mjacqu/glenglat, last access: 7 April 2024) and published to Zenodo (https://doi.org/10.5281/zenodo.11516611, Welty et al., 2025). It consists of four relational tables and detailed machine-actionable and human-readable metadata. The GitHub repository also provides submission instructions (including a spreadsheet template and validation tools), in the hope that investigators will help us keep glenglat complete and current going forward. We hope that glenglat will improve our understanding of glacier thermal regimes, refine glacier thermodynamic models, and give insight into hazardous glacier instabilities in a warming world.

1 Introduction

Englacial temperature is a defining characteristic of any glacier. It influences glacier flow dynamics and subglacial hydrology, it can be a decisive factor in glacier hazards, and it can serve as an archive of past climate. To illustrate this, ice viscosity and deformation rate depend directly on ice temperature (Deeley and Woodward, 1908; Glen, 1954; Cuffey and Paterson, 2010), only temperate (basal) ice permits glacier sliding over the bed (Cuffey and Paterson, 2010), and impermeable cold ice can serve as a barrier for water, controlling subglacial and englacial water flow and possibly contributing to the formation of hazardous water accumulations within the ice or in glacier sediment beds (Irvine-Fynn et al., 2011; Vincent et al., 2012; Gilbert et al., 2012; Kääb et al., 2018; Gilbert et al., 2018; Jacquemart et al., 2020; Kääb et al., 2021). Under cold conditions, the variations in temperature with depth are a window into the past evolution

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of atmospheric temperatures, making englacial temperature changes an important climate variable (e.g., Gilbert et al., 2010). Ice temperatures and glacier flow regimes also have implications for glacial archeology, defining how well artifacts can survive in ice (Pilø et al., 2023). Finally, ice temperature records also serve to validate thermomechanical glacier models, which are important tools for improving our understanding of glacier systems.

Glaciers are typically categorized as either temperate, cold, or polythermal. Temperate ice is at the pressure melting point, cold ice is below the pressure melting point, and polythermal glaciers contain both cold and temperate ice. The pressure melting point depends mostly on the ice overburden pressure (and, to a lesser extent, the presence of air bubbles and other impurities), such that under temperate conditions ice temperature decreases with depth at around 6.5×10^{-4} to $7.5 \times 10^{-4}\,°\mathrm{C\,m^{-1}}$ (Paterson, 1971; Harrison, 1972; Jania et al., 1996). More generally, the englacial temperature is determined by the complex interaction between the surface energy balance, the geothermal heat flux, and internal heating from ice deformation, basal friction, and refreezing of meltwater (Cuffey and Paterson, 2010). Available heat is transferred through the ice and firn via conduction and advection by ice and water flow. The superposition of these processes can lead glaciers to be fully cold or temperate or simultaneously contain cold and temperate ice in a wide variety of spatial configurations (Blatter and Hutter, 1991; Irvine-Fynn et al., 2011).

Ongoing human-driven climate change is leading to substantial changes in englacial temperatures, evidence of which is clear in (the few existing) repeat measurements. At Dôme du Gouter in the French Alps, for example, a warming of 1.5 °C was recorded at a depth of 50 m between 1994 and 2017 (Vincent et al., 2020). Long-term measurements at Golle Gnifetti (Swiss Alps) between 1991 and 2023 reveal the same amount of warming at a depth of 20 m (Marcus Gastaldello and Martin Hoelzle, personal communication, 2024a). This warming can have several consequences. For one, meltwater infiltrating cold firn can degrade or destroy the archive of past climatic conditions that can be stored in firn or ice cores (Mattea et al., 2021; Gabrielli et al., 2016). In steep terrain, warming at the glacier bed can lead to widespread sliding and destabilization of entire glaciers, increasing the probability of very large ice avalanches, similar to the one observed at Altels in Switzerland in 1895 (Heim et al., 1895; Faillettaz et al., 2011). Counterintuitively, warming can also lead some glaciers to cool, because their disappearing firn cover reduces the amount of englacial warming that stems from the latent heat release of refreezing meltwater (Gilbert et al., 2012; Huss and Fischer, 2016; Irvine-Fynn et al., 2011). A similar effect may also occur in areas still covered by firn if the refreezing meltwater creates impermeable ice layers that prevent water percolation into the firn, thereby (locally) limiting the latent heat release (Vincent et al., 2020).

Measuring englacial temperatures is a laborious process; (deep) ice temperature measurements are therefore comparatively rare. Those that exist were typically collected for one of several reasons: to gain an understanding of glacier dynamics and englacial temperatures directly (e.g., Agassiz, 1847; Blatter and Haeberli, 1984; Clarke et al., 1984; Copland et al., 2003; Ryser et al., 2013; Gilbert et al., 2010; Vincent et al., 2020; Troilo et al., 2021; Karušs et al., 2022), in connection with the retrieval of ice cores used to reconstruct past climatic changes (e.g., Thompson et al., 1990, 2018; Kinnard et al., 2006; Schwikowski et al., 2013; Kinnard et al., 2020), or as part of operational glacier monitoring efforts to document current climate change (e.g., Hoelzle et al., 2020). The data resulting from such efforts are largely hidden away in the scientific literature spanning more than a century and are therefore not readily available as a community resource. At the same time, there is an increasing need to understand how englacial temperatures – and their changes over time – relate to glacier dynamics, climate change, and glacier hazards (Gilbert and Vincent, 2013; Colgan et al., 2015; Gilbert et al., 2015; Kääb et al., 2018; Machguth et al., 2023b). In order to make englacial temperature data from glaciers around the world more widely available, we have compiled glenglat, the **gl**obal **engla**cial **t**emperature database, sourced – largely but not exclusively – from the published literature. In the following, we describe how englacial temperatures are measured in the field (Sect. 2.1), how we found and compiled these measurements (Sect. 2.2), and how the resulting glenglat database is structured and managed (Sect. 2.3). In Sect. 3, we present and discuss the content of glenglat (version 1.0) and close with instructions for how others can contribute additional data (Sect. 3.5). We hope that glenglat will serve as a community resource to help improve our understanding of ongoing changes in the cryosphere and that it will grow over time with the addition of past and future englacial temperature measurements.

2 Methods and data

2.1 Measurement methods

Englacial temperature measurements are typically made by placing one or more thermistors in a borehole (Fig. 1). Boreholes are drilled with either mechanical (reviewed in Talalay, 2016) or thermal (reviewed in Talalay, 2020) drills or a combination thereof. The advantage of mechanical drilling is that temperatures can be reliably measured after a short time. Thermal drilling (e.g., steam or hot water) significantly raises the temperature of the borehole, which subsequently needs time to re-adjust to the temperature of the surrounding ice – typically several days to a few weeks (Laternser, 1992; Miles et al., 2018). Depending on the measurement techniques and objectives, borehole temperatures are measured only once, or the thermistor chain is left in the hole (which is allowed to freeze up or is kept open with a casing or fluid) and is either remeasured manually or equipped with an automatic logger. A recent innovation replaces discrete thermistors with a fiber optic cable (distributed temperature sensing (DTS); Law et al., 2021), which can provide measurements with an unprecedented vertical resolution, especially in deep boreholes where the required number of thermistors would be prohibitively expensive.

2.2 Data compilation

Most data included in glenglat are sourced from published documents and datasets. Publications were initially found by searching Google Scholar (https://scholar.google.com, last access: 7 April 2024) and Google Dataset Search (https://datasetsearch.research.google.com, last access: 7 April 2024) for combinations of the English words “glacier”, “ice”, “temperature”, “thermal”, “regime”, “englacial”, “borehole”, “drill(ing)”, “measurement”, and “record”, together with 冰川温度钻孔 and скважина температуры ледника (“glacier borehole temperature” in Chinese and Russian, respectively). We then recursively sought out publications referenced in previously identified publications, striving to find the most complete and original data source for each measurement. Tracking down references was made more difficult by the practice of journals (primarily European and North American journals using Latin script, like this one) of not publishing references in their original script (e.g., “термический”) but only translations (“temperature”) or phonetic transcriptions (“termicheskiy”). Finding these often involved reconstructing the original reference, since the modified form did not appear in search results. When we were unable to find the full text of a publication online or in print in nearby libraries, we requested it from the Swiss Library Service Platform (https://slsp.ch, last access: 7 April 2024) document delivery (DocDel) service through the University of Bern (https://www.ub.unibe.ch, last access: 7 April 2024). In addition to extracting data from publications, we solicited data submissions on CRYOLIST (https://cryolist.org, last access: 7 April 2024) at the 2023 Alpine Glaciology Meeting in Birmensdorf, Switzerland, and through personal communications. All the data sources are listed within glenglat itself (Sect. 2.3) and in the references of this publication (see Appendix A for a list of the glaciers and the corresponding references). Unfortunately, since Copernicus Publications does not support non-Latin characters, the latter are Latin only; complete versions of the appendices and references are thus provided in Sects. S1 and S2 of the Supplement.

For this first version of glenglat, we selected only firn and/or ice temperature measurements with a well-defined depth. This means that we omitted measurements made in tunnels dug horizontally into glaciers. We also disregarded publications with measurements made exclusively in seasonal snow but included snow temperatures when they were provided alongside or as part of a profile reaching firn or ice. We also focused on glaciers and omitted measurements from the Antarctic and Greenland ice sheets, to a large degree because data from the ice sheets were already compiled by Løkkegaard et al. (2023) and Vandecrux et al. (2023).

For each measurement, we extracted depth, temperature, and associated metadata (see below). Submitted or published data in machine-readable formats were added directly to the database, data published numerically in text or tables were transcribed with the help of optical character recognition (OCR), and data represented graphically (e.g., as a plot of temperature versus depth) were digitized using the open-source software Plot Digitizer (Huwaldt, 2020). For plots that used points to indicate each measurement (Fig. 3a), we digitized the values at each point. For plots using a continuous line (Fig. 3b), such that the locations of the measurements along the line are unknown, we used a point density sufficient to reproduce the original line.

Metadata associated with the temperature measurements were compiled from one or more sources to the best of our abilities (see Tables 1–4). For example, borehole coordinates were either extracted directly from text, digitized from a map with defined axes (e.g., latitude and longitude) using Plot Digitizer, digitized from a map (without such axes) visually georeferenced to a global basemap using the QGIS Freehand Raster Georeferencer plugin (Vellut, 2021), or approximated on global basemaps with the help of terrain features, glacier morphology, or elevation information. Borehole elevation was published as text in most cases, though we did occasionally have to approximate elevation from provided contour lines or by comparison to an independent topographic map. Other metadata included the measurement and drilling dates, the drill type (mechanical, thermal, or combined), the depth of the firn–ice interface (i.e., whether the measurements are in firn, ice, or both), whether the borehole reached the glacier bed, and the uncertainty of the temperature measurements.

2.3 Data structure and management

glenglat is packaged and described following the Frictionless Tabular Data Package standard (Pollock et al., 2025a), version-controlled and tested on GitHub (https://github.com/mjacqu/glenglat, last access: 7 April 2024) and published to Zenodo (https://doi.org/10.5281/zenodo.11516611, Welty et al., 2025). Data and metadata (Tables 1–4) are stored using common text file formats to ensure that they are human-readable, machine-actionable, and compatible with line-based version-control systems like Git. The data are structured as a four-table relational database stored in comma-separated values (CSV) files. The `source` table (Table 1) contains a full reference to each data source that we used. Names in non-Latin scripts (Cyrillic, Hangul, and Chinese characters) are accompanied by a latinized form, and non-

Figure 1. Photographs illustrating methods for measuring glacier temperatures: **(a)** drilling a shallow borehole with a handheld mechanical auger on Griesgletscher, Switzerland (photo by Matthias Huss); **(b)** drilling a deep borehole with a hot-water drill and a large array of fuel drums and pumps to heat and pressurize the water on Rhonegletscher, Switzerland (photo by Raphael Moser); and **(c)** a typical string of thermistors used to measure temperature at different depths in a borehole (photo by Mylène Jacquemart).

English titles are accompanied by an English translation. The `borehole` table (Table 2) describes the drill site – including the location, elevation, drill method, and reported uncertainty of the temperature measurements. The `profile` table (Table 3) describes each temperature–depth profile – including the timing of the measurement and whether or not the measurement was made after the borehole was known to have reached thermal equilibrium. Finally, the `measurement` table (Table 4) contains the measurements of temperature with depth. To improve the manageability of the CSV data from boreholes with time series measurements (i.e., with thousands of profiles), the `profile` and `measurement` tables are stored in separate, source-specific CSV files. Supporting these tabular data are files that, for each source, document how and from where the data were extracted. For submissions, these include data files and email correspondence. For publications, these include the key text passages, tables, maps, or figures that served as the sources of the data. Additional files can be used to reproduce how numerical values were digitized from maps and figures using Plot Digitizer (`*.xml`) or georeferenced and digitized using QGIS (`*.pgw`, `*.{png|jpg}.aux.xml`, and `*.geojson`).

The tabular data are described in a single YAML (https://yaml.org, last access: 7 April 2024) metadata file (`datapackage.yaml`). This file lists general attributes of the database – like name, description, version, license, and contributors – and gives a detailed description of the structure and content of each tabular data file. The Table Dialect (Pollock et al., 2025b) specifies how exactly the CSV files are structured, while the Table Schema (Pollock et al., 2025c) specifies the name and data type of each column, the constraints on each column's values, and the foreign-key relations between tables.

This metadata architecture allows data maintainers and contributors to use Frictionless (e.g., for Python; Karev et al., 2024) to test whether the metadata are correctly structured and whether the data are consistent with the metadata. These tests are run automatically in a continuous-integration pipeline on GitHub, ensuring the integrity of the database whenever any file is modified. Additional custom tests, which cannot be expressed by the metadata, further verify the integrity of the dataset, e.g., that all people who contributed data (referenced as a personal communication in table `source`) are listed as contributors in `datapackage.yaml`. Using software (Welty, 2023) built on the Frictionless Tabular Data Package standard, we can also render the metadata as an interactive spreadsheet template with dropdown menus and real-time validation, lowering the bar for future data contributors.

We publish the database to Zenodo using a custom build process. The uploaded file archive and detailed Zenodo metadata are generated automatically from the contents of the GitHub repository and submitted using Zenodo's InvenioRDM REST API (https://inveniordm.docs.cern.ch/reference/rest_api_index, last access: 7 April 2024). Zenodo manages the DOIs for glenglat, registering a concept DOI encompassing all versions (https://doi.org/10.5281/zenodo.11516611, Welty et al., 2025) and a DOI for each new version. To keep the structure simple and the download small, Zenodo releases contain only the CSV files (`data/*.csv`), a license (`LICENSE.md`), simplified documentation (`README.md`), and a version of the metadata (`datapackage.yaml`) converted into JSON.

2.4 Errors from digitization and data reproduction

In addition to the uncertainty of the original measurements, errors are introduced when the measurements are reproduced

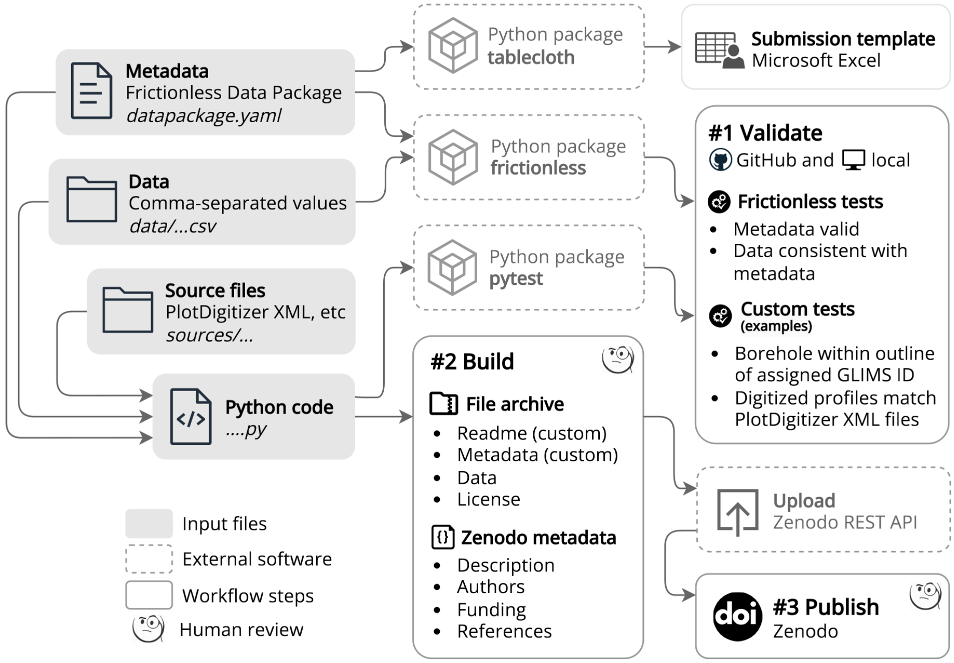

Figure 2. The glenglat testing and publishing workflow. The input files (in gray) are those version-controlled in the GitHub repository.

Table 1. Main columns of the `source` table (`data/source.csv`); a full description is provided in `datapackage.yaml`. Column names and categorical values closely match the Citation Style Language (CSL) 1.0.2 specification (Zelle et al., 2015). The primary key is indicated with *.

Column	Type/unit	Description
id*	String	Unique identifier, constructed from the author name and year (e.g., zagorodnov1981) and referenced from other tables either formally in a foreign key or informally within free-form text
author	String	Author names (optionally followed by their ORCID or contact email) as a pipe-delimited list
year	YYYY	Year issued (published, communicated, or last updated)
type	String	Type (e.g., journal article, book chapter, dataset, or personal communication)
title	String	Title of the work
url	String	URL (DOI if available)
language	String	Language as ISO 639-1 two-letter language code
container_title	String	Title of the container (e.g., journal, book, or data repository)

in tables or figures (henceforth "reproduction error"), and again when these reproductions are digitized (henceforth "digitization error"). Such errors can multiply if the data are shared between researchers or digitized from older publications and reprinted in subsequent publications. In 109 cases, we acquired the same temperature profile from two different sources (a published figure replaced by a data submission, table, or better figure), allowing us to assess the magnitude of reproduction errors (inclusive of digitization errors). In order to quantify the digitization error in isolation, 177 temperature profiles were digitized by two different people. This exercise also allowed us to refine our method by identifying avoidable human errors and software quirks (e.g., wrong scaling of an axis or misplaced points). We calculated both of these errors from profile pairs as the difference between their temperatures after interpolating (but never extrapolating) the temperatures of one to match the depths of the other.

3 Results and discussion

As far as we know, glenglat is the largest collection of englacial temperature measurements. It contains 1 931 831 measurements of depth and temperature, organized into 256 450 profiles from 788 boreholes (Fig. 4). We included

Table 2. Columns of the `borehole` table (`data/borehole.csv`). Primary keys are indicated with *, foreign keys with °.

Column	Type/unit	Description
id*	Integer	Unique identifier
source_id°	String	Identifier of the source of the earliest temperature measurements (and the source of all borehole metadata, unless otherwise stated in `notes`)
glacier_name	String	Glacier or ice cap name (as reported)
glims_id	String	Global Land Ice Measurements from Space (GLIMS) glacier identifier
location_origin	String	Origin of location (`latitude`, `longitude`): – submitted: provided in data submission; – published: reported as numbers in the original publication; – digitized: digitized from the published map with complete axes; – estimated: estimated from the published plot by comparison to a map; – guessed: estimated with difficulty (e.g., by comparing `elevation` to a map).
latitude	Degrees	Latitude in the EPSG 4326 spatial reference system
longitude	Degrees	Longitude in the EPSG 4326 spatial reference system
elevation_origin	String	Origin of `elevation`; same categories as for `location_origin`
elevation	m	Elevation above sea level of the drilling site
mass_balance_area	String	Mass balance area: ablation area, near the equilibrium line, or accumulation area
label	String	Borehole name (e.g., as labeled on a plot)
date_min	YYYY-MM-DD	Start date (or first possible date) of drilling (e.g., 2019: 2019-01-01)
date_max	YYYY-MM-DD	End date (or last possible date) of drilling (e.g., 2019: 2019-12-31)
drill_method	String	Drilling method: mechanical, thermal, or combined
ice_depth	m	Starting depth of ice. Infinity (INF) indicates that ice was not reached.
depth	m	Total borehole depth (not including drilling in the underlying bed)
to_bed	Boolean	Whether the borehole reached the glacier bed
temperature_uncertainty	°C	Estimated temperature uncertainty (as reported)
notes	String	Additional remarks as a pipe-delimited list. Quality concerns are prefixed with [flag].
curator	String	Names of people who added the data to the database, as a pipe-delimited list
investigators	String	Names of people and/or agencies who performed the work, as a pipe-delimited list
funding	String	Funding sources as a pipe-delimited list

39 366 profiles (for 80 boreholes) from 10 data submissions. The remaining data were extracted from 203 primary literature sources (see Table A1), with an additional 115 secondary sources helping to further populate the metadata. Non-English sources make up 20 % (60) of all primary sources but 48 % (48) of those published before the year 2000.

3.1 Thermal regimes and borehole depths

A variety of thermal structures can be identified in the temperature profiles (Fig. 5). The borehole from the Devon Ice Cap (Nunavut, Canada; data from Paterson and Clarke, 1978) is an example of fully cold conditions. At depth, the temperature increases at a rate largely determined by the geothermal heat flux (heat conduction from Earth's interior). In contrast to the fully cold conditions, profiles can be fully temperate, such as on Hansbreen (e.g., Svalbard; data from Jania et al., 1996), where the ice temperature decreases with depth in accordance with the lowering of the pressure melting point. Between these two endmembers, there is a lot of variety. At Grenzgletscher (Switzerland; data from Ryser et al., 2013; Hoelzle et al., 2011) and White Glacier (Axel Heiberg Island, Canada; data from Blatter, 1987), for example, the ice in the accumulation area is colder than the ice in the abla-

Table 3. Columns of the `profile` table (`data/profile.csv` and `data/**/profile.csv`), where ** indicates subdirectories that hold separate `profile.csv` and `measurement.csv` files from boreholes with many profiles (e.g., from automated loggers). Composite primary keys are indicated with *, foreign keys with °.

Column	Type/unit	Description
borehole_id*°	Integer	Borehole identifier
id*	Integer	Borehole profile identifier (starting from 1 for each borehole)
source_id°	Integer	Source identifier
measurement_origin	String	Origin of measurements: – submitted: provided as numbers in data submission; – published: numbers read from the original publication; – digitized-discrete: digitized from discrete points of depth versus temperature; – digitized-continuous: digitized from a continuous line plot.
date_min	YYYY-MM-DD	First possible date of measurement (e.g., 2019: 2019-01-01)
date_max	YYYY-MM-DD	Last possible date of measurement (e.g., 2019: 2019-12-31)
time	hh:mm:ss	Measurement time
utc_offset	h	Time offset relative to Coordinated Universal Time (UTC)
equilibrium	String	Whether and how reported temperatures equilibrated following drilling: – true: equilibrium was measured; – estimated: equilibrium was estimated (typically by extrapolation); and – false: equilibrium was not reached.
notes	String	Additional remarks as a pipe-delimited list. Quality concerns are prefixed with [flag].

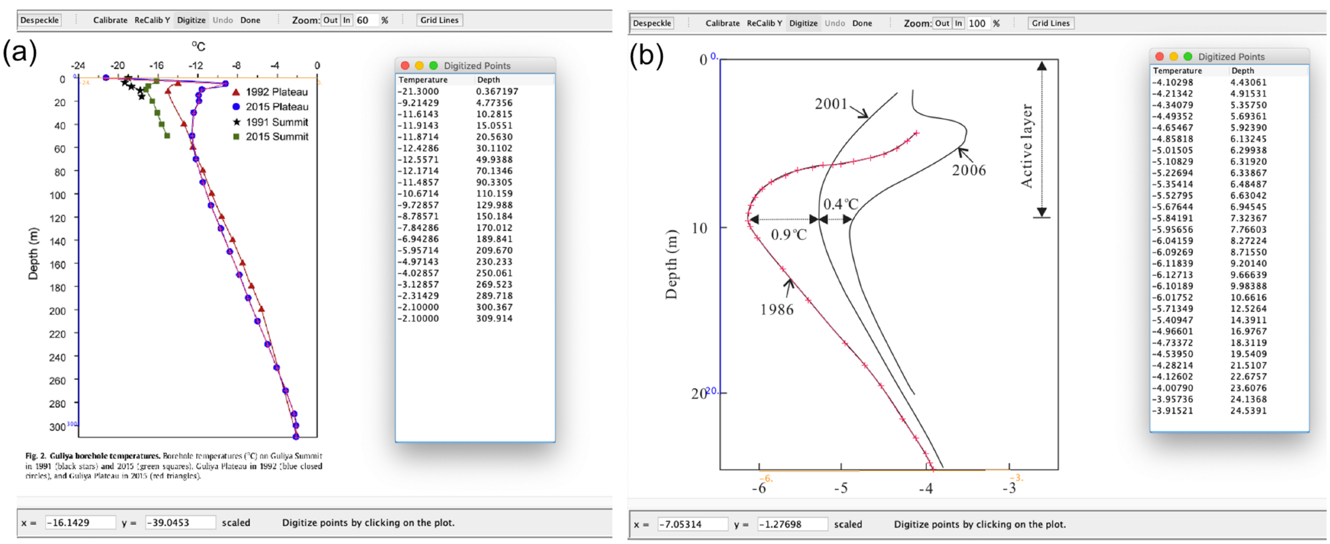

Figure 3. Screenshots of the digitization process with Plot Digitizer (https://plotdigitizer.sourceforge.net, last access: 7 April 2024), where temperature and depth are plotted either as **(a)** discrete points for each measurement or **(b)** a continuous line with unknown measurement locations. The data are from **(a)** 古里雅冰帽 (Guliya Ice Cap, GLIMS ID G081455E35226N) and **(b)** 天山1号冰川 (Urumqi Glacier No. 1, GLIMS ID G086810E43111N).

tion area, indicating that the cold ice is warmed (e.g., by shear heating and latent heat release) as it advects down from the accumulation area. The opposite is true at Kongsvegen (Svalbard; data from Björnsson et al., 1996), where the latent heat release of refreezing meltwater and precipitation is high enough to eliminate the winter cold wave and create temperate firn and ice in the accumulation area. In the ablation area lower on the glacier, meltwater and precipitation can run off,

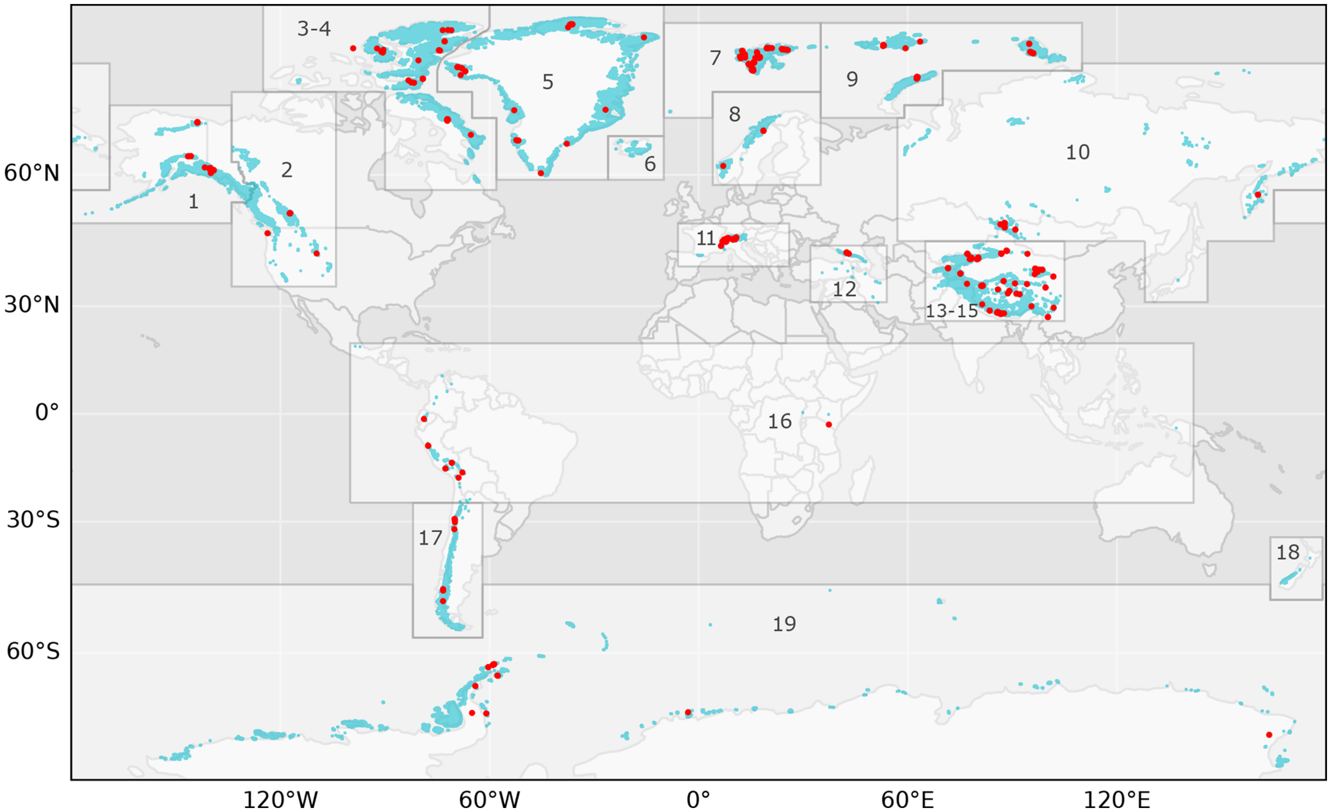

Figure 4. Spatial distribution of temperature measurements recorded in glenglat. Boreholes are plotted in red, glaciers (according to the Randolph Glacier Inventory (RGI) 7.0; RGI Consortium, 2023) in light blue. The Global Terrestrial Network for Glaciers (GTN-G) glacier regions (GTN-G, 2017) are shown in gray and are numbered; these correspond to the region numbers in Fig. 6.

Table 4. Columns of the `measurement` table (`data/measurement.csv` and `data/**/measurement.csv`), where ** indicates subdirectories that hold separate `profile.csv` and `measurement.csv` files from boreholes with many profiles (e.g., from automated loggers). Composite primary keys are indicated with *, foreign keys with °.

Column	Type/unit	Description
borehole_id*°	Integer	Borehole identifier
profile_id*°	Integer	Borehole profile identifier
depth*	m	Depth below the glacier surface
temperature	°C	Measured temperature

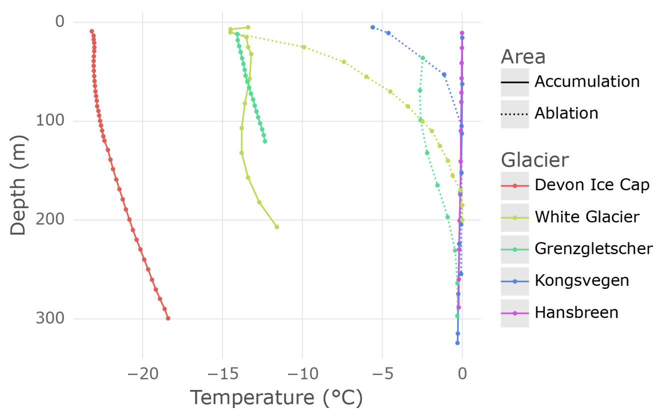

Figure 5. Measured profiles demonstrating the range of englacial temperatures and some typical profile shapes – from fully cold (Devon Ice Cap; Paterson and Clarke, 1978) to fully temperate (Hansbreen; Jania et al., 1996). Measurements from the accumulation areas are plotted with solid lines, those from ablation areas with dotted lines.

allowing the near-surface ice to cool into a layer of cold ice superimposed onto the temperate ice.

The temperatures measured in the boreholes range from temperate (i.e., at the pressure melting point) to −33.5 °C (the lowest temperature at 15 m depth is −31.7 °C). The majority (67 %) of boreholes deeper than 15 m are in cold or polythermal ice (defined as those where the maximum measured temperature is colder than −0.25 °C), with only 7 % of all boreholes deeper than 15 m showing fully temperate conditions (i.e., the coldest measured temperature at any depth below 15 m is warmer than −0.25 °C). This is not surprising. For one, temperate (or even partially temperate) ice is of little interest to ice core investigations because it does not retain a memory of past climatic conditions (though research for dating temperate cores is ongoing; see, e.g., Di Stefano et al., 2024). Secondly, temperate ice measurements are deemed less interesting. Therefore, englacial temperature measurements are rarely carried out on glaciers that are assumed to be fully temperate, and if temperate conditions are measured, the results are rarely published. However, such measurements would be very valuable for training and calibrating models that predict glacier thermal regimes at regional to global scales. At present, it may be possible to train a model to accurately identify cold or polythermal glaciers, but it would be harder to constrain the boundaries – in terms of elevation, latitude, mean air temperature, etc. – between cold and temperate ice.

The median of the maximum measured depths in all boreholes in glenglat is 20 m (see Fig. 6). A total of 508 boreholes (64 %) were measured at depths greater than 15 m, and 151 (19 %) were measured at depths greater than 100 m. Only 147 (19 %) are known to have reached the glacier bed, including the deepest one, a 724 m ice core borehole drilled on Ледник Академии Наук (Akademii Nauk Ice Cap, Severnaya Zemlya, Russia; Kotlyakov et al., 2004).

Of 224 boreholes with a reported ice surface depth (an attribute that was added later and thus likely incomplete with respect to the available literature), 131 actually reached ice, whether at 0 m depth (for 82 boreholes) or below a maximum of 80 m of snow and firn (at Col du Dôme, France; Gilbert and Vincent, 2013). Unfortunately, whether a borehole was drilled into snow, firn, ice, or a combination thereof is not always known. For applications where this is relevant, the stratigraphy can often be estimated – if not explicitly reported – from the depth of the borehole and its location on the glacier (e.g., ablation or accumulation area). Further complicating the borehole stratigraphy, repeat measurements in the same borehole typically define depth relative to the glacier surface at the time of the initial drilling or thermistor installation, despite accumulation and ablation that may occur in the interim. This can lead to spurious and above-zero temperature measurements if thermistors melt out over time. Only in very rare cases (e.g., in Harrison et al., 1975) are the changes in the surface elevation recorded in detail.

3.2 Climatic conditions

Compared to the average climatic conditions at the locations of all glaciers in the Randolph Glacier Inventory (RGI) 7.0 (RGI Consortium, 2023), the locations selected for englacial temperature measurements are biased towards cold and dry conditions (Fig. 7a). Most boreholes are in locations where the total annual precipitation is less than $1\,\mathrm{m\,yr^{-1}}$ and the mean annual air temperature is below $-5\,°\mathrm{C}$. This focus on regions with a continental climate is again not surprising, because the high accumulation rates and warmer air temperatures of maritime climates are more likely to lead to temperate ice – which is considered less interesting – or high ice fluxes – which are not desirable for ice core measurements (e.g., Vance et al., 2016; Bohleber, 2019).

To explore the controls on englacial temperatures, we take the 15 m temperature – the depth at which seasonal temperature variations have mostly disappeared (see Fig.8) – as an indicator of the local glacier thermal regime. Comparing borehole temperatures measured since 1960 to the mean annual air temperature (MAAT) (ERA5-Land from Muñoz Sabater, 2019) of the 10 years prior to the borehole measurement reveals that temperate ice can occur over a wide range of surface air temperatures (Fig. 7b). Englacial temperatures generally decrease with decreasing air temperature, but they are also consistently warmer than the temperatures at the surface. This is expected, given the numerous processes that can deliver heat into the glacier (latent heat release and geothermal, frictional, and strain heating). This warm bias is smallest at the coldest surface temperatures (presumably because there is little melt) but can still be up to $+10\,°\mathrm{C}$ at $-20\,°\mathrm{C}$. It reaches a maximum of $+15\,°\mathrm{C}$ at $-15\,°\mathrm{C}$ before gradually decreasing towards warmer temperatures only because ice cannot be any warmer than the melting point. Temperate ice does not seem to occur where the mean annual air temperature is below $\sim -15\,°\mathrm{C}$. It is unclear, however, whether the absence of temperate ice in colder climates is real or due to the undersampling of temperate glaciers.

The trends and boundaries in Fig. 7b need to be evaluated with respect to possible caveats of the chosen dataset and are only intended to show broad patterns. ERA5-Land (and other reanalysis products) may not be able to represent the true variability of temperature fields or precipitation patterns in complex alpine terrain. The observed "warm bias" could therefore partly be due to biases within this dataset, and the 2 m air temperature is in reality not the true surface boundary condition. Beyond this, the chosen lapse rate (in our case $-6.5\,°\mathrm{C\,km^{-1}}$) changes the relationship between air temperature and englacial temperature, though we found that it mostly affects the positions of the data points relative to the 1 : 1 line, while the overall shape remains stable. In reality, of course, englacial temperatures are controlled by much more than mean annual air temperature and precipitation, and the consideration of 15 m temperatures further ignores the facts that (i) temperate ice can exist at deeper locations within the ice even under very cold conditions (e.g., due to shear heating; Blatter, 1987), (ii) ice temperatures can be controlled by glacier dynamics more than by climate (e.g., emergence of cold ice in the ablation area of a glacier in a temperate climate; Ryser et al., 2013), and (iii) ice at depth has a memory of past surface temperatures, which can lead to complex patterns of englacial temperatures that are not reflected in the 15 m temperature. Despite these caveats, the large number of englacial temperature measurements available in glenglat makes it possible, for the first time ever, to investigate global patterns of englacial temperatures and hopefully find more

Region	Name	Glaciers	Boreholes (all)	Boreholes (>15m)
1	Alaska	12	70	30
2	Western Canada and USA	3	15	1
3–4	Arctic Canada	17	88	62
5	Greenland Periphery	14	24	4
7	Svalbard and Jan Mayen	31	88	51
8	Scandinavia	2	5	5
9	Russian Arctic	13	61	14
10	Asia, North	10	22	9
11	Central Europe	23	202	125
12	Caucasus and Middle East	5	14	9
13–15	Asia, South & Central	52	156	92
16	Low Latitudes	9	11	10
17	Southern Andes	10	11	5
19	Antarctic and Subantarctic	12	21	12

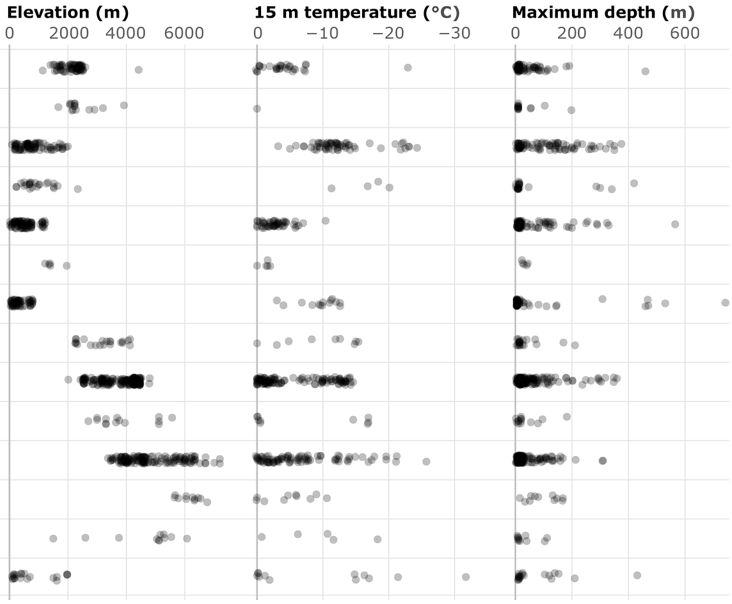

Figure 6. Overview of the borehole counts (all and those deeper than 15 m) and the surface elevation, the 15 m temperature, and the maximum measured depth for each borehole (each represented by a dot) by region (see Fig. 4).

robust ways of predicting the thermal regime of all glaciers in a region or worldwide.

3.3 Spatial, temporal, and elevation distributions

The 788 boreholes in glenglat are located on 213 individual glaciers (based on their GLIMS IDs) scattered across the world (see Figs. 4 and 6). This represents less than 1 ‰ of all glaciers worldwide, illustrating both how laborious englacial temperature measurements are (see Appendix A) and how interest in this glacier variable remains relatively limited. Two-thirds of all boreholes (68 %) are in Arctic Canada (88), Svalbard and Jan Mayen (88); central Europe (202 – albeit with 80 on a single glacier, Grenzgletscher); and South and Central Asia (156). Conversely, there are only 5 boreholes in Scandinavia and 11 in the southern Andes, with 0 in Iceland or New Zealand. If we envision using global or regional models to constrain thermal regimes by space, elevation, temperature, precipitation regime, or glacier dynamics, we ideally need measurements that span the transition and range of conditions where glaciers exist. In this context it is important to understand which data are present in a possible training dataset. In the following, we therefore briefly discuss the temporal and spatial patterns of the data in glenglat.

The surface elevations of boreholes in glenglat range from 14 m a.s.l. (Erikbreen, Svalbard; Ødegård et al., 1992) to 7200 m a.s.l. (Dasoupu Glacier, China; Yao et al., 2002). Compared to the elevation distribution of glaciers worldwide (as represented by RGI 7.0), elevations above 2000 m are oversampled and elevations between 750 and 1500 m are undersampled (Fig. 9). This sampling bias may have several causes. Topographic saddles and summits of very-high-elevation glaciers (> 4500 m) are of particular interest to ice core science because ice flow, accumulation, and melt are minimal and a maximum number of annual ice layers can be preserved. The middle elevations (2000 to 4500 m) are likely oversampled because they circumvent many of the challenges of work at very high elevations, allowing for simpler (helicopter) logistics and reasonable working conditions. Additionally, this is the elevation range of glaciers in central Europe (region 11; see Figs. 4 and 6), which are historically overstudied compared to other regions. Below 2000 m, most of the data come from Svalbard and Jan Mayen (region 7) and Arctic Canada (regions 3–4). Though there are many measurements from these regions, lower elevations remain undersampled, likely because (i) there is a very large glacierized area in this elevation band, (ii) there is a lack of interest in measurements from temperate ice (e.g., the large low-lying glaciers along the western coast of Alaska), (iii) the tongues of tidewater glaciers – which make up a large portion of this band – are notoriously difficult to access, and, (iv) when accessing land-terminating glaciers in these remote regions, working on their low-elevation tongues is easier than accessing the higher-elevation accumulation areas (750 to 1500 m).

The earliest measurement in glenglat stems from 1842, when Louis Aggasiz and colleagues drilled a 60 m borehole in temperate ice on Unteraargletscher (Agassiz, 1847) in Switzerland (see Fig. 10). With the exception of other early outliers (1911, Vallot, 1913; 1938, Hughes and Seligman, 1939; 1948, Sharp, 1951), widespread measurement did not begin until the late 1950s – in large part motivated by the 1957/1958 International Geophysical Year – when drilling

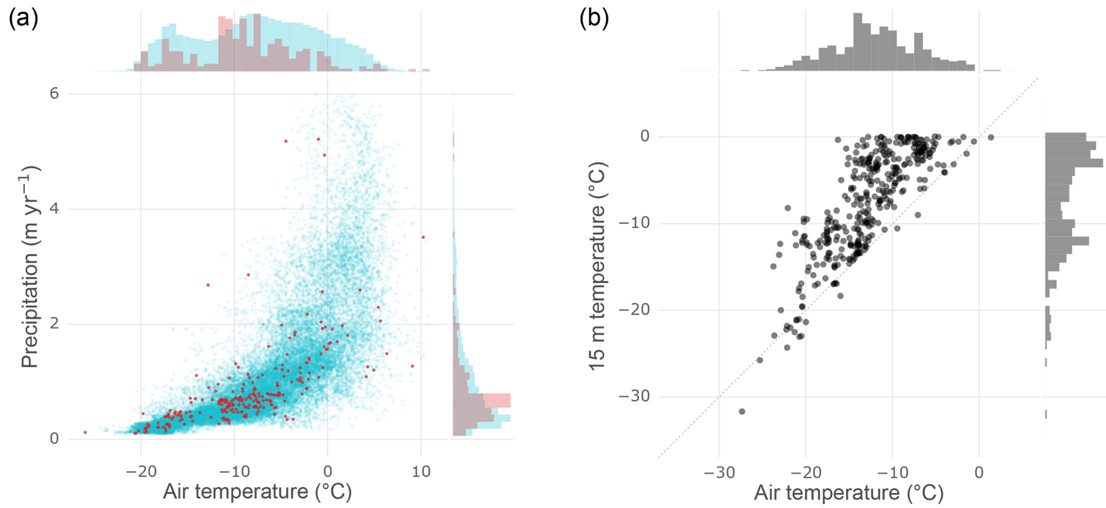

Figure 7. **(a)** Distribution of the 2000–2019 mean annual 2 m air temperature and total annual precipitation for the locations of glenglat boreholes (red) and the locations of all RGI 7.0 glaciers (blue). **(b)** Englacial temperatures (1960 to the present) at 15 m depth versus mean annual air temperature at the borehole locations for the 10 years prior to the borehole measurement. Air temperatures were adjusted to the elevation of the borehole using a lapse rate of $-6.5\,°\mathrm{C\,km^{-1}}$. The climate data are from ERA5-Land (Muñoz Sabater, 2019).

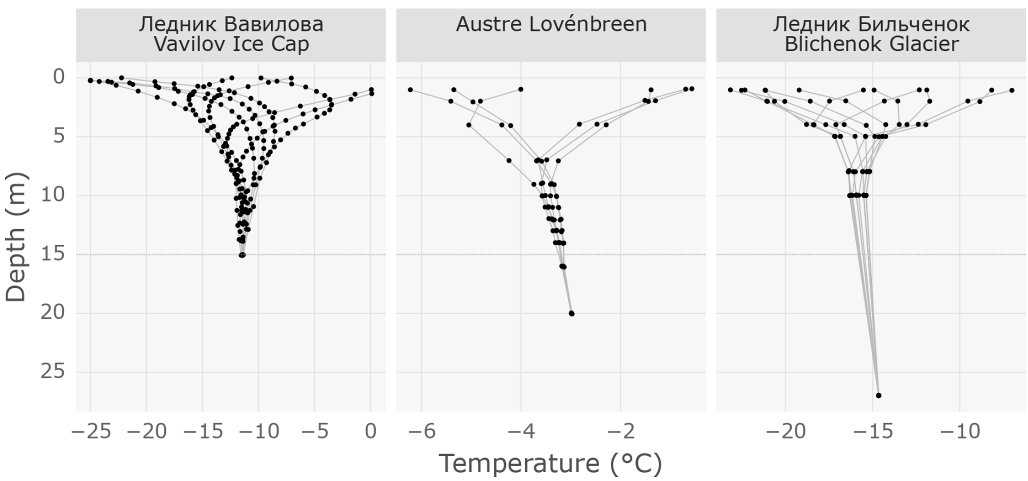

Figure 8. Examples of temperature profiles measured in the same borehole at different times of the year, showing the elimination of seasonal surface temperature variations at a depth of around 15 m. Data are from Vavilov Ice Cap (Barkov et al., 1988), Austre Lovénbreen (Sun et al., 2016), and Blichenok Glacier (Shiraiwa et al., 2001).

technology and motorized transport were developed enough to allow increasingly ambitious expeditions to remote areas. Mid-century measurements likely remain underrepresented in glenglat because of early and obscure publications that were never indexed nor published online. After sustained activity since the 1970s, measurements declined beginning in 2015, which may be the result of a lag between data collection and publishing, reduced interest and funding for complex field campaigns, a shift in focus from glaciers to ice sheets, or increased emphasis on modeling and remote sensing. The wide range of measurement dates in glenglat could present a challenge for training or calibrating numerical models, as it requires longer model runs and inputs (e.g., climate reanalysis) from earlier periods with fewer and lower-quality data.

Of all the boreholes in glenglat, 209 (27 %) have repeat temperature measurements. The most frequently measured borehole is on Hintergrat Glacier (Italy; Carturan et al., 2023a), with 5 years of hourly measurements (2011–2016). The longest monitored borehole is CG05-1 on Grenzgletscher (Switzerland; Hoelzle, 2014; Darms, 2009; Hoelzle, 2017), drilled in 2005 and measured four times over 8 years (2007–2015). The lifetime of a single borehole is limited by creep closure, internal deformation, and other forces that inevitably lead to equipment failure, so to achieve longer records, a new borehole is drilled and instrumented nearby.

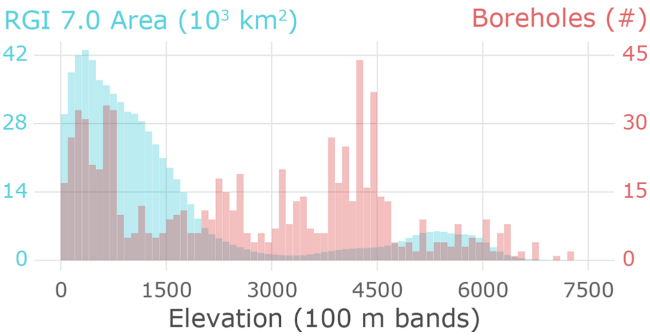

Figure 9. Elevation distribution of glenglat boreholes (red) compared to the elevation distribution of all RGI 7.0 glaciers (blue). Higher elevations, especially between 2000 and 4500 m, are oversampled, while low elevations are undersampled.

A cursory review of boreholes within 100 m reveals only a few locations with multiple comparable boreholes and temperatures spanning more than 20 years, all of which are the result of deliberate repeat studies (Vincent et al., 2020; Hoelzle et al., 2011; Thompson et al., 2018; Mikhalenko et al., 2005a; Rabus and Echelmeyer, 2002; Li et al., 2011). Clusters of more distant boreholes, however, suggest opportunities for retroactive comparisons.

The low percentage of locations that have been measured more than once indicates that there is a large potential for repeat measurements that would yield insight into how englacial temperatures have changed. Repeat measurements could focus on locations with deep boreholes (e.g., more than 30 m), predominantly cold englacial temperatures, high measurement accuracies (low reported uncertainties), and a last measurement dating back around 20 years or more. Ignoring surge-type glaciers, a search of glenglat reveals high-value repeat-measurement locations in many different regions and climates. Some examples that fall into this category include Nevado Illimani (Bolivia, 138 m, measured in 1999; Gilbert et al., 2010), Vavilov Glacier (Russian Arctic, up to 460 m, last measured in 1985; Morev et al., 1988), or Åsgårdfonna (Svalbard, 185 m, measured in 1993; Uchida et al., 1996).

3.4 Error analysis

In our analysis, we distinguish between three sources of uncertainty in the reported englacial temperatures: the reported uncertainty of the original measurements, errors introduced by their subsequent textual or graphical reproduction, and errors associated with the digitization of graphical reproductions.

The measurement uncertainty encompasses a wide range of instrumental, methodological, and environmental factors. The design and calibration of a thermistor determine the precision and accuracy with which it measures temperature. Whether the measured temperature differs from the temperature of the glacier is primarily determined by the extent to which the borehole reached thermal equilibrium following drilling and sensor installation or the method by which an equilibrium temperature is extrapolated from a sensor cooling curve. Secondary sources of thermal disturbance include "wind pumping" (air circulation within firn or snow caused by surface pressure changes; Clarke et al., 1987), sensor electronics (Ryser et al., 2013), and artificial thermal coupling with the surface (e.g., the black tubing used in Davis, 1967). Finally, the uncertainty in the measurement depth translates into an uncertainty in the temperature at that depth, especially in areas with steep temperature gradients (e.g., near the surface).

Temperature measurement uncertainty is reported for 64 % of the boreholes included in glenglat (0.01 to 1.0 °C; see Fig. 11). Which sources of error that the value represents are rarely specified, but sensor design and calibration are often the only factors discussed. Other glenglat attributes like drilling method, drilling and measurement dates, whether and how equilibrium was reported to have been reached, and repeat measurements from the same borehole are thus helpful for independently assessing measurement uncertainty. Contrary to the suggestion of Løkkegaard et al. (2023) that sensor accuracy has improved substantially since 1950, we found no significant change in reported temperature uncertainties over time. This could reflect increased caution in error reporting, an acknowledgement that sensor accuracy is only one component of the total uncertainty, or indeed that the accuracy of the typical englacial temperature measurement has not improved significantly.

Depth measurement uncertainty is so rarely reported that no provision was made to track it in glenglat. In many cases, the reference surface for the depth measurements is not specified, nor whether this reference changed over time (e.g., the upper glacier surface at the time of installation or the snow–ice boundary at the time of measurement). As the glacier surface changes, so do the depths of the sensors relative to this surface, and this can complicate the comparability of measurements through time.

Figure 11 presents the reported measurement uncertainties alongside errors introduced by data reproduction and digitization. For the sake of comparison, we describe each distribution by the 0.5 (median), 0.68, and 0.95 quantiles (of the absolute values). For measurement uncertainties, these are 0.1, 0.2, and 0.3 °C. Reproduction errors were calculated as the difference between temperatures for the same profile retrieved from a figure versus either a table or another figure (and they thus include digitization error). They are typically smaller than measurement uncertainties (0.05, 0.10, and 0.51 °C), especially at depths greater than 15 m (0.04, 0.09, and 0.31 °C). The largest of these are due to different measurements being included (the impact of which is greatest near the surface, where temperature gradients are steepest), actual differences in the reported temperatures, or poor figure quality (e.g., large °C/pixel size or non-square axes from hand drawing or bad scanning). Random digitization

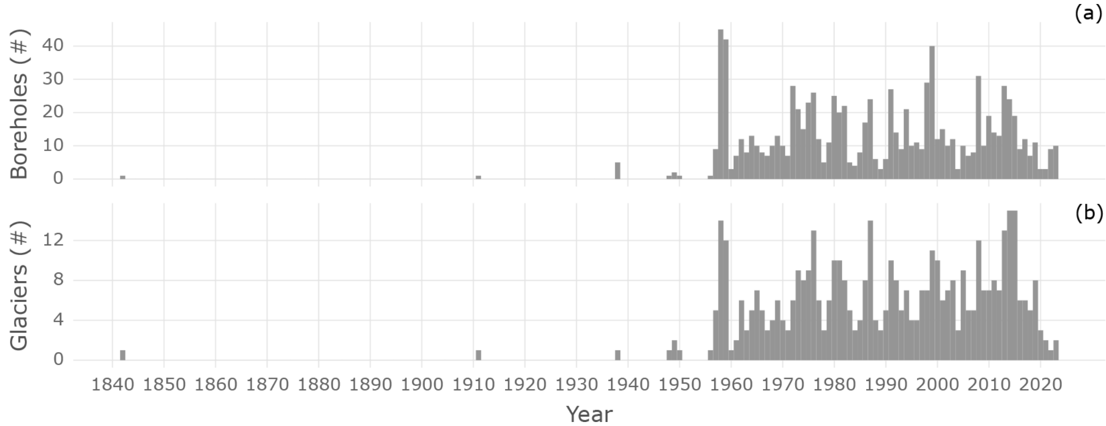

Figure 10. Number of measured boreholes **(a)** and number of measured glaciers **(b)** for each year. We assume that early measurements are still underrepresented, because publications were not archived. The drop-off towards more recent years may be due to the lag between drilling and publication or changes in research and funding priorities.

errors (isolated from reproduction errors) were calculated as the difference between temperatures for the same profile and figure digitized by two different people. They are smaller (0.03, 0.05, and 0.23 °C) and sensitive to the interaction between figure scale and temperature gradient. The °C/pixel sizes of the figures' digitized temperature axes – an imperfect proxy for their effective resolution – range from 0.002 to 0.109 °C (median 0.016 °C) and are weakly correlated with the digitization errors ($R^2 = 0.058$, slope = 1.29). However, the °C/pixel sizes of the depth axes – once converted to °C based on the local slope of the profile – range from 0.000 to 1.007 °C (median 0.007 °C) and explain the observations much better ($R^2 = 0.483$, slope = 1.26).

A full assessment of uncertainty would require a careful evaluation of each profile (e.g., Løkkegaard et al., 2023), including a review of the original sources, since these often contain more details than could be integrated into glenglat. However, we can provide some general guidance to users: favor data with low reported measurement uncertainties sourced from textual reproductions (`measurement_origin` "submitted" or "published"), inspect the source of digitized data (`measurement_origin` "digitized-discrete" or "digitized-continuous"), favor profiles known to have reached thermal equilibrium (`equilibrium`), and avoid interpolation at depths with steep temperature gradients.

Reducing and quantifying uncertainties will be crucial for detecting and correctly interpreting the long-term thermal evolution of glaciers and ice sheets, so we urge future campaigns to carefully assess uncertainties and thoroughly and precisely describe their measurements. To eliminate reproduction and digitization errors in the future, new and existing measurements should be published somewhere as text, e.g., by submitting them directly to glenglat (see Sect. 3.5).

3.5 Future additions

We hope that glenglat will serve not only as a valuable resource for glaciological research today, but also as a long-lived data repository for additional past and future englacial temperature measurements. The dataset is currently hosted at https://github.com/mjacqu/glenglat, last access: 7 April 2024. To encourage and facilitate submissions, we have included detailed instructions, a Microsoft Excel spreadsheet template, and a tutorial showing how to self-validate the data prior to submission using the Frictionless Python package. We have done our best to populate all fields of the database, but certain columns were added at a later stage of the database creation process, and we were not able to revisit every source every time. Therefore, not all columns are equally well populated. Additions to or refinements of existing entries are welcome any time, either by emailing the authors or by creating an issue at https://github.com/mjacqu/glenglat/issues, last access: 7 April 2024. Community members are also welcome to take on existing issues and contribute to the improvement of the dataset in this way. Anyone who submits data to glenglat will be invited to become a co-author of future releases of the dataset (see the detailed authorship policy at https://github.com/mjacqu/glenglat/tree/main?tab=readme-ov-file#authorship-policy, last access: 7 April 2024).

4 Code and data availability

Published versions of glenglat are released to Zenodo (https://doi.org/10.5281/zenodo.11516611, Welty et al., 2025). The database is maintained as a GitHub repository (https://github.com/mjacqu/glenglat, last access: 7 April 2024) which also contains all of the Python code for the tests, build process, and Zenodo publishing described above. It also contains a Jupyter notebook with tutorials on how to download

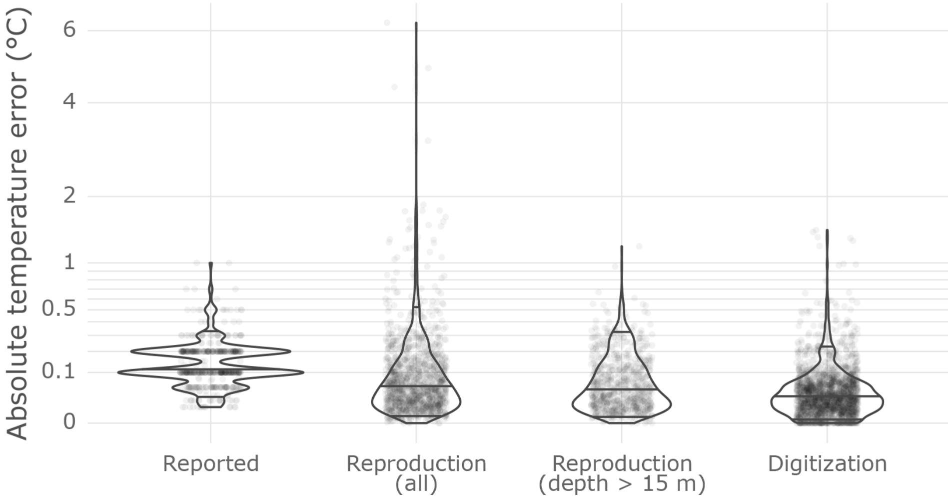

Figure 11. Distribution of the reported measurement uncertainties alongside distributions of the absolute values of the reproduction errors (comparing the same measurement from different sources) and digitization errors (comparing the digitization of the same measurement by two different people). The y axis uses square-root scaling to accentuate differences near 0 °C. For each distribution, horizontal lines are drawn at the 0.05, 0.5 (median), and 0.95 quantiles.

the data from Zenodo, read the data into Python, and produce statistics and plots similar to those in this paper. It can be run in Google Colab (https://colab.google, Google, 2025). This paper refers to version 1.0.0 (https://doi.org/10.5281/zenodo.15005624, Welty et al., 2025). glenglat is licensed under Creative Commons Attribution 4.0 International, though the repository's license does not extend to figures, tables, maps, or text extracted from publications. These are included in the `sources` folder for transparency and reproducibility. Full PDF files of the original sources will gladly be shared upon request. ERA5-Land climate reanalysis data (Muñoz Sabater, 2019) were downloaded from the Copernicus Climate Change Service (https://cds.climate.copernicus.eu, last access: 7 April 2024).

Dataset citation. When using glenglat, please cite both this publication (Jacquemart et al., 2025) and the version of the dataset that was used (Welty, Jacquemart et al. <year>. glenglat: Global englacial temperature database. <version>. Zenodo. <version doi>). We also recommend citing the original sources, especially when using only a subset. Finding and citing the original literature is facilitated by the bibliographic information that is provided in the `source.csv` file.

5 Conclusions and outlook

Based on an extensive literature search and data submissions, we have created glenglat, the first (to our knowledge) englacial temperature database for all glaciers outside of the ice sheets. Together with recent compilations of deep boreholes in Greenland by Løkkegaard et al. (2023) of shallow measurements for Greenland and Antarctica in the SUMup collaborative database (Vandecrux et al., 2023), most published englacial temperature measurements are now readily available to researchers. Depending on community needs, it may be worth combining these datasets into one, for lower maintenance overhead, for ease of use, and because the distinction between ice sheet and glacier will become increasingly arbitrary as glaciers detach from retreating ice sheet margins. Subsurface variables like density (as in SUMup) or stratigraphy (as in glenglat, but only for the depth of the snow–ice or firn–ice transition) may be worth adding, especially since these are often measured alongside temperature. Another enhancement would be to include qualitative temperature information, i.e., whether a borehole was measured as temperate (but no actual measurements were reported), together with the presence and depth of a cold–temperate transition surface (often extracted from ice-penetrating radar profiles as an indicator of the glacier thermal regime; Björnsson et al., 1996; Ødegård et al., 1992, 1997; Pettersson et al., 2003; Wilson et al., 2013).

We believe that glenglat can contribute to better modeling and understanding of englacial temperatures, their spatial distribution, and their changes in a warming world – most directly as an unparalleled source of observational data for model training and validation. For measurements to better reflect global glacier conditions, however, we see a general need for more measurements (or reporting thereof) from temperate glaciers, warmer climates, elevations between 750 and 1500 m, and underrepresented regions (e.g., Iceland, New Zealand, or Scandinavia). glenglat also presents new opportunities to investigate changes in englacial temperatures over time, both by making more evident the existence of repeat measurements and by documenting a century of early measurements that could now be deliberately repeated.

Appendix A: References by glacier and region

Table A1. Summary of englacial temperature measurements contained in glenglat – sorted by glacier region and grouped by glacier (as defined by boreholes with matching glacier names or GLIMS IDs) – with borehole count, profile count, maximum depth, minimum temperature (at all depths and at 15 m in depth, if available), range of years, and sources. Since Copernicus Publications does not support non-Latin characters, only the English translations of the glacier names are provided here. A complete version is provided in Sect. S1 of the Supplement.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
1	Black Rapids Glacier	G213683E63392N	3	6	12	−14.0		1973–1973	Harrison et al. (1975)
1	Fox Glacier Rusty Glacier	G219698E61200N G219665E61212N	14	15	84	−8.0	−7.5	1968–1970	Classen (1970); Classen and Clarke (1971); Collins (1972); Crossley and Clarke (1972)
1	Hyena Glacier Trapridge Glacier	G219646E61222N	13	19	88	−8.4	−7.3	1969–1980	Classen (1970); Jarvis (1973); Jarvis and Clarke (1975); Clarke et al. (1984)
1	Jarvis Glacier	G214333E63481N	2	2995	72	−8.2		2017–2018	Lee (2019); Lee et al. (2020)
1	Little Kluane Glacier	G220578E60873N	1	17 873	191	−0.3		2019–2021	Gwenn E. Flowers (personal communication, 2022)
1	McCall Glacier	G216152E69302N	27	56	180	−12.4	−4.8	1957–2008	Orvig and Mason (1963); Trabant et al. (1975); Rabus and Echelmeyer (2002); Weller et al. (2007); Delcourt et al. (2013)
1	North Glacier	G220859E60905N	1	1	70	−3.0	−3.0	2011–2011	Wilson (2012); Wilson et al. (2013); Gwenn E. Flowers (personal communication, 2022)
1	Russell Glacier	G218192E61498N	1	1	460	−23.1	−22.9	2002–2002	Thompson et al. (2004); Urmann (2009)
1	Seward Glacier	G219787E60289N	3	10	62	−13.0		1948–1950	Sharp (1951)
1	South Glacier	G220869E60822N	1	14 914	82	−2.4		2011–2014	Flowers et al. (2011); Wilson et al. (2013); Gwenn E. Flowers (personal communication, 2022)
1	Steele Glacier	G219819E61242N	4	5	114	−6.7	−5.0	1972–1974	Jarvis (1973); Jarvis and Clarke (1974); Clarke and Jarvis (1976)
2	Athabasca Glacier	G242719E52168N	13	16	198	−5.8		1967–1986	Paterson (1971, 1972)
2	Blue Glacier	G236316E47813N	1	2	104	−0.2	−0.0	1969–1969	Harrison (1972)
2	Upper Fremont Glacier	G250390E43132N	1	1	10	0.0		1990–1991	Naftz and Smith (1993)
3	Agassiz Ice Cap	G288743E80950N	3	3	335	−24.6	−24.3	1977–1984	Clarke et al. (1987); Vinther et al. (2008)
3	Devon Ice Cap	G278488E75058N G277553E75571N	3	3	299	−23.2	−23.1	1972–2000	Paterson and Clarke (1978); Kinnard et al. (2006); Mankoff et al. (2022); Mankoff (2022e); Løkkegaard et al. (2023)
3	Gilman Glacier	G288737E82174N	2	8	25	−22.3		1958–1958	Hattersley-Smith (1960)
3	Henrietta Nesmith Glacier	G286504E81978N	1	1	12	−25.9		1958–1958	Hattersley-Smith (1960)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
3	John Evans Glacier	G285646E79663N	4	4	15	−12.2	−12.2	1997–1999	Copland et al. (2003)
3	Laika Ice Cap	G280856E75887N	5	5	87	−11.2	−10.4	1975–1975	Blatter (1985); Blatter and Kappenberger (1988)
3	McGill Ice Cap	G266878E79842N G269900E79733N	2	2	38	−22.6	−22.0	1962–1962	Harrison (1963); Müller (1963a, b, 1976)
3	Meighen Ice Cap	G260810E79982N	1	3	121	−23.1	−17.1	1965–1967	Koerner (1968); Paterson (1968)
3	Prince of Wales Ice Cap	G279351E78361N	1	1	176	−21.3	−21.0	2005–2005	Kinnard et al. (2008); Mankoff et al. (2022); Mankoff (2022b); Løkkegaard et al. (2023)
3	Sverdrup Glacier	G276838E75498N	1	3	15	−19.6		1963–1963	Keeler (1964); Koerner (1970)
3	White Glacier	G269329E79672N	48	90	375	−20.4	−14.9	1959–1981	Müller (1961); Harrison (1963); Müller (1963a, 1976); Blatter (1985, 1987)
4	Barnes Ice Cap	G287731E69650N G287718E69797N G288059E69709N	16	16	281	−11.1	−10.9	1973–1977	Hooke (1976); Classen (1977); Hooke et al. (1980); Gilbert et al. (2016)
4	Penny Ice Cap	G294647E67092N	1	1	176	−12.8	−12.2	1997–1997	Fisher et al. (1998); Mankoff et al. (2022); Mankoff (2022c); Løkkegaard et al. (2023)
5	Flade Isblink Ice Cap	G344790E81287N	1	1	420	−17.4		2006–2006	Lemark (2010); Sheldon et al. (2014); Mankoff et al. (2022); Mankoff (2022d); Løkkegaard et al. (2023); European Space Agency (2024)
5	Hans Tausen Ice Cap	G323085E82488N	1	1	341	−20.8	−20.0	1995–1995	Hammer (1995); Reeh (1995); Steffensen et al. (2001)
5	Hare Glacier	G323403E82808N G322065E82674N	6	6	286	−21.0	−16.9	1994–1995	Thomsen et al. (1996); Reeh et al. (2001)
5	Hurlbut Gletscher	G292196E77316N	2	8	15	−18.2		1957–1957	Arktisk Institute (1959, 1960); Fristrup (1960a, b, 1961)
5	Mitdluagkat Gletscher	G322197E65696N	1	1	15	−1.0		1958–1958	Fristrup (1960a, 1961); Hasholt (1987)
5	Napassorssuaq Gletscher	G314725E60307N	1	1	7	−0.7		1957–1957	Arktisk Institute (1959, 1960); Fristrup (1960a, 1961); Weidick (1988)
5	Nunatarssuaq Ice Cap	G292408E76864N	2	343	2	−8.6		2017–2017	Abermann et al. (2020); Rainer Prinz, Jakob Abermann, and Jakob Friedrich Steiner (personal communication, 2022)
5	Qaanaaq Glacier	G290838E77522N	3	3	13	−11.9		2014–2014	Tsutaki et al. (2017)
5	Renland Ice Cap	G333444E71216N	1	1	300	−18.7	−18.4	1988–1988	Johnsen et al. (1992); Mankoff et al. (2022); Mankoff (2022a); Løkkegaard et al. (2023)
5	Sermikavsak	G307173E71231N	1	1	7	−3.2		1957–1957	Møller (1959); Fristrup (1960a, 1961)
5	Sukkertoppen Ice Cap	G307609E66296N G308051E66298N	4	4	12	−4.6		1964–1964	Rundle (1965)
5	Tuto Ramp	G291955E76463N	1	12	47	−22.1	−11.5	1961–1962	Davis (1967)
7	Amundsenisen	G015444E77229N	1	3	13	−9.5		1980–1980	Zagorodnov (1981)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
7	Austfonna	G024340E79634N G025297E79771N G023619E79932N G024143E79973N	14	15	565	−16.4	−4.5	1987–1999	Zagorodnov et al. (1990); Watts et al. (1997); Watanabe et al. (2001); Motoyama et al. (2008)
7	Austre Brøggerbreen	G011895E78886N	3	3	108	−4.2	−4.2	1990–1994	Hagen (1992); Björnsson et al. (1996); Motoyama et al. (2000, 2008)
7	Austre Grønfjordbreen	G014342E77910N	12	30	83	−8.5	−2.2	1966–2014	Singer and Mikhalev (1967); Zagorodnov and Zotikov (1981); Macheret et al. (1985); Kotlyakov et al. (2004); Chernov et al. (2015)
7	Austre Lovénbreen	G012161E78870N	3	17	20	−6.2	−3.2	2009–2011	Sun et al. (2016)
7	Bertilbreen	G016264E78699N	3	3	108	−11.5	−5.6	1980–1980	Zagorodnov (1981)
7	Bogerbreen	G015633E78130N	1	1	7	−7.3		1980–1980	Zagorodnov (1981)
7	Erikbreen	G012478E79621N	5	10	20	−8.7	−3.5	1990–1992	Ødegård et al. (1992)
7	Finsterwalderbreen	G015235E77463N	2	2	189	−4.5	−3.1	1994–1995	Nuttall et al. (1997); Ødegård et al. (1997)
7	Fridtjofbreen	G014442E77835N	1	1	115	−5.2	−3.9	1981–1981	Macheret et al. (1985)
7	Hans Glacier Hansbreen	G015592E77097N	9	42	330	−10.3	−3.6	1979–1994	Grześ (1980); Jania et al. (1996)
7	Holtedahlfonna	G013095E79037N	1	1	124	−3.2	−0.4	2005–2005	Beaudon et al. (2013)
7	Høghetta	G016639E79309N	1	1	86	−13.3	−10.4	1987–1987	Kawamura et al. (1991); Motoyama et al. (2008)
7	Irenebreen	G012138E78665N	1	12	10	−5.8		2008–2009	Sobota (2011)
7	Kongsvegen	G013044E78792N	2	2	324	−5.6	−4.3	1990–1992	Hagen (1992); Björnsson et al. (1996)
7	Lomonosovfonna	G018042E78675N G018391E78924N G017025E78797N	7	18	122	−11.4	−2.4	1965–2013	Singer et al. (1966); Zagorodnov and Zotikov (1981); van de Wal et al. (2002); Kotlyakov et al. (2004); Marchenko et al. (2017)
7	Midre Lovénbreen	G012039E78878N	2	2	133	−3.6	−3.3	1990–1992	Hagen (1992); Björnsson et al. (1996)
7	Nordenskiöldbreen	G017371E78745N	2	2	26	−7.1	−4.4	1965–1965	Singer et al. (1966)
7	Scott Turnerbreen	G015894E78097N	2	2	54	−11.1	−7.2	1993–1993	Hodgkins et al. (1999)
7	Snøfjellafonna	G013542E78988N	1	1	80	−3.4	−1.8	1992–1992	Kameda et al. (1993)
7	Vestfonna	G019951E79875N G020879E79901N G019797E80009N	6	11	200	−23.6	−2.6	1956–1995	Palosuo and Schytt (1960); Schytt (1964); Kotlyakov (1985); Palosuo (1987); Watanabe et al. (2001); Kotlyakov et al. (2004); Motoyama et al. (2008)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
7	Waldemarbreen	G012079E78681N	3	23	10	−7.6		2007–2019	Sobota (2009); Karušs et al. (2022)
7	Werenskioldbreen	G015442E77070N	4	4	15	−4.2	0.0	1970–1970	Baranowski (1975)
7	Åsgårdfonna	G017048E79443N	2	2	182	−7.9	−6.1	1993–1993	Kameda et al. (1993); Uchida et al. (1996); Motoyama et al. (2008)
8	Nigardsbreen	G007099E61715N	1	1	44	−0.8	−0.1	1987–1987	Kawamura et al. (1989)
8	Storglaciären	G018569E67903N	4	15	40	−9.0	−2.0	1965–2002	Schytt (1966, 1968); Pettersson et al. (2003)
9	Academy of Sciences Glacier Akademii Nauk Ice Dome	G096063E80433N	3	3	743	−14.7		1986–2001	Savatyugin and Zagorodnov (1988); Zagorodnov (1989); Zagorodnov and Arkhipov (1990); Savatyugin et al. (2001); Fritzsche et al. (2002); Kotlyakov et al. (2004)
9	Churlyanis Cupola Sedov Glacier	G053403E80271N G053047E80333N G053032E80282N G052977E80310N	31	134	82	−27.5		1958–1959	Razumeiko (1960, 1963)
9	Jackson Cupola	G053200E80194N	1	13	20	−22.3		1959–1959	Razumeiko (1963)
9	Salm Island Glacier	G059273E79977N	1	1	14	−18.0		2005–2005	Kubyshkin et al. (2006)
9	Shokalsky Glacier	G062464E75974N G062675E76121N	16	38	30	−29.0		1958–1959	Khmelevskoy (1963, 1964)
9	Vavilov Glacier Vavilov Ice Cap	G095294E79482N G096481E79287N G095612E79448N	8	21	470	−25.0	−12.6	1974–1985	Barbash et al. (1981); Morev and Pukhov (1981); Barkov et al. (1988); Morev et al. (1988); Kotlyakov et al. (2004)
9	Vetreniy Ice Dome	G063846E80729N	1	1	308	−11.4	−6.8	1997–1997	Kotlyakov et al. (2004)
10	Belukha Glacier	G086577E49799N	1	1	75	−17.2		2001–2001	Olivier et al. (2003)
10	Blichenok Glacier	G160474E56097N	2	14	211	−23.2	−15.5	1996–1999	Shiraiwa et al. (1997, 2001)
10	Halasi Glacier	G087783E49100N	3	6	8	−4.0		1980–1980	Wang et al. (1983); Liu et al. (2012); Guo et al. (2015)
10	Khukh Nuru Uul glacier	G090853E48651N	1	1	70	−13.8	−12.6	2009–2009	Herren et al. (2013)
10	Maliy Aktru Glacier	G087761E50048N G087720E50060N	10	15	30	−11.4	−8.4	1980–1982	Nikitin (1986)
10	Sofiyskiy Glacier	G087759E49791N	2	2	25	−0.3	−0.0	2000–2001	Fujii et al. (2000, 2002)
10	Tsambagarav Glacier	G090847E48595N	1	1	40	−13.4	−12.0	2008–2008	Liu et al. (2009); Davaa (2016); Khalzan et al. (2022)
10	Vodopadniy Glacier	G087789E50050N	1	2	12	−15.7		1981–1982	Nikitin (1986)
10	Western Belukha Plateau	G086544E49802N	1	1	170	−15.7	−14.8	2003–2003	Takeuchi et al. (2004)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
11	Altelsgletscher	G007671E46431N	3	22	21	−6.4	−0.4	1991–1991	Laternser (1992)
11	Breithornplateau Gorner-gletscher Grenzgletscher	G007908E45948N G007800E45965N G007875E45922N	82	115	359	−17.0	−14.6	1975–2021	Haeberli (1976); Oeschger et al. (1977); Gäggeler et al. (1983); Blatter and Haeberli (1984); Haeberli and Funk (1991); Laternser (1992); Lüthi (1999); Keck (2001); Lüthi and Funk (2001); Suter et al. (2001, 2002); Schwerzmann et al. (2006b); Darms (2009); Eisen et al. (2009); Hoelzle (2009); Hoelzle et al. (2011); Diez et al. (2013); Ryser et al. (2013); Hoelzle (2014); Mayewski (2014); Hoelzle (2017); Bohleber et al. (2018); Hoelzle et al. (2020); Mattea (2020); Swisstopo (2021); Hoelzle (2022); Marcus Gastaldello and Martin Hoelzle (personal communication, 2024a, b)
11	Fieschergletscher	G008144E46504N	3	3	153	−6.8	−2.0	2003–2003	Schwerzmann et al. (2006b, a)
11	Glacier de Taconnaz Glacier des Bossons Taconnaz Glacier	G006865E45868N G006844E45863N	41	43	126	−15.1	−14.2	1911–2017	Vallot (1913); Lliboutry et al. (1976); Jouzel et al. (1984); Suter et al. (2002); Vincent et al. (2007); Gilbert and Vincent (2013); Gilbert (2013); Gilbert et al. (2015); Vincent et al. (2020)
11	Glacier de Tête Rousse	G006819E45856N	19	41	70	−2.8	−2.7	2010–2023	Gilbert et al. (2012); Vincent et al. (2012); Olivier Gagliardini and Christian Vincent (personal communication, 2023)
11	Glacier du Pelvoux	G006408E44900N	1	1	13	−0.2		1983–1983	Jouzel et al. (1984)
11	Glacier du Sex Rouge	G007212E46327N	2	3	35	−1.2	−0.5	2013–2014	Signer (2014)
11	Grubengletscher	G007996E46168N	6	6	46	−2.3	−2.3	1974–1975	Haeberli (1976)
11	Hintereisferner	G010752E46802N	6	70	15	−4.7	−0.3	1972–1976	Markl and Wagner (1977)
11	Hintergrat Glacier	G010554E46507N	1	41 581	10	−8.9		2011–2016	Gabrielli et al. (2016); Carturan et al. (2023a, b)
11	Jungfraufirn	G008032E46504N	10	33	20	−13.6	−3.6	1938–1991	Hughes and Seligman (1939); Laternser (1992); Suter et al. (2001)
11	Lysgletscher	G007846E45906N	6	6	22	−10.0	−5.5	1999–1999	Suter et al. (2002); Marcus Gastaldello and Martin Hoelzle (personal communication, 2024a)
11	Mont Blanc	G006867E45829N	2	2	18	−17.1		1983–1998	Jouzel et al. (1984); Suter et al. (2002)
11	Sphinxgrat	G007985E46549N	1	1	10	−6.0		1981–1981	Haeberli and Alean (1985)
11	St. Annafirn	G008601E46597N	2	2	8	−1.3		2014–2014	Signer (2014)
11	Titlis-Gletscher	G008427E46774N	1	1	15	−0.7	−0.7	1979–1980	Haeberli and Alean (1985)
11	Unteraargletscher	G008187E46569N	1	1	60	0.0		1842–1842	Wild et al. (1842); Agassiz (1847)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
11	Vadret da Morteratsch	G009927E46382N	1	1	42	−2.8	−2.2	2002–2002	Schwerzmann et al. (2006b)
11	Vadret dal Corvatsch	G009822E46416N	10	41	18	−9.1	−2.6	1999–2002	Hager (2002); Haeberli et al. (2004)
11	Vedretta Alta dell'Ortles	G010536E46513N	4	62 324	75	−9.4		2009–2016	Gabrielli et al. (2010, 2012, 2016); Carturan et al. (2023a, b)
12	Bezengi Glacier	G043100E43030N	1	1	80	−0.6	−0.5	1966–1966	Psareva (1968); Khromova et al. (2022)
12	Djankuat Glacier	G042766E43192N	5	5	55	−19.5	−0.5	1971–1971	Yakor, I. S. (1978)
12	Garabashi Glacier	G042470E43307N	4	19	20	−13.0		1958–1988	Plam (1962); Zagorodnov et al. (1992)
12	Mount Elbrus	G042429E43293N G042488E43308N	4	4	182	−17.3	−16.9	2004–2020	Mikhalenko et al. (2005b, 2015, 2021)
13	Abramov Glacier	G071570E39610N	7	35 370	27	−20.0	−1.6	1969–2020	Kislov et al. (1977); Kislov (1980); Suslov (1980); Barandun (2018); Kronenberg et al. (2021, 2022a); Martina Barandun (personal communication, 2024); Machguth and Kronenberg (2024)
13	Ashu-Tor Glacier	G078182E42041N	1	1	20	−7.6		?–1962	Dikikh (1965); Kutuzov (2012); Van Tricht et al. (2021); Tsvetkov (2023)
13	Batysh Sook Glacier	G077749E41787N	1	5	15	−6.3	−0.6	2013–2017	Martina Barandum (personal communication, 2023)
13	Bogda Fan-Shaped Diffluence Glacier	G088313E43812N	1	4	20	−3.0	−1.5	1981–1981	Qiu and Deng (1983); Ren (1983); Liu et al. (2012); Guo et al. (2015)
13	Bogda Heigou No. 8 Glacier Heigou Glacier No. 8	G088356E43784N	7	11	19	−7.3	−4.9	1985–1986	Wang et al. (1989); Shao and Liu (1990); Wu et al. (2013)
13	Central Tuyuksu Glacier	G077080E43049N	5	119	52	−16.1		1957–1959	Vilesov (1961, 1962a, b, c); Tsykina and Vilesov (1963)
13	Chongce Ice Cap	G081119E35239N	7	13	130	−16.4	−16.0	1987–2012	Huang (1990); Shao and Liu (1990); Zhou (1990); Hou et al. (2018)
13	Crescent River Glacier No. 15	G087444E36402N	2	2	18	−8.2	−7.4	1988–1988	Su (1998); Liu et al. (2012); Guo et al. (2015)
13	Davydov Glacier	G078204E41844N	1	4	30	−5.8	−2.5	1985–1985	Vasilenko (1988)
13	Dunde Ice Cap	G096414E38091N	1	1	136	−7.3	−6.7	1987–1987	Thompson et al. (1990)
13	Geladandong Ice Cap	G091151E33199N	1	1	87	−12.1	−5.0	2004–2004	Wang and Pu (2005)
13	Grigoriev Glacier Grigoriev Ice Cap	G077894E41995N G077923E41963N	14	1900	87	−22.9	−6.1	1962–2023	Dikikh (1965); Mikhalenko (1989); Thompson et al. (1993, 1997); Arkhipov et al. (2004); Mikhalenko et al. (2005a); Takeuchi et al. (2014); Kronenberg et al. (2022b); Kronenberg (2022); Machguth et al. (2023a, b)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
13	Guliya Ice Cap	G081455E35226N G081480E35252N	7	7	310	−21.3	−17.8	1990–2015	Yao et al. (1992); Thompson et al. (1995a, 2018)
13	Guozha Glacier	G081064E35246N	1	2	12	−6.4		1987–1987	Shao and Liu (1990)
13	Halong Glacier	G099492E34764N	2	2	10	−7.3		1981–1981	Wang (1987); Su (1998); Liu et al. (2012); Guo et al. (2015)
13	July 1st Glacier Qiyi Glacier	G097755E39237N	6	9	10	-12.3		1959–2002	Dolgushin (1961); Huang et al. (1982); Matsuda et al. (2004)
13	Karabatak Glacier	G078269E42140N	1	1	10	−2.8		1948–1950	Dolgushin (1961)
13	Laohugou Glacier Laohugou No. 12 Glacier Laohukou Glacier No. 20	G096524E39457N	7	13	109	−24.7	−8.1	1959–2011	Dolgushin (1961); Huang et al. (1982); Wang et al. (2018)
13	Malan Glacier	G090770E35803N	1	1	100	−9.3	−4.7	1999–1999	Sun et al. (2021)
13	Meikuang Glacier	G094184E35669N	1	1	16	−7.0	−6.2	1989–1989	Su (1998); Liu et al. (2012); Guo et al. (2015)
13	Miaoergou Glacier	G094316E43053N	1	1	60	−8.3	−6.4	2005–2005	Liu et al. (2006); Takeuchi et al. (2008); Liu et al. (2009); Jiao et al. (2023)
13	Muztagh Glacier	G075086E38293N	5	5	78	−26.2	−25.8	2002–2003	Wu et al. (2003); Li et al. (2004)
13	Puruogangri Ice Cap	G089122E33894N	3	4	213	−9.9	−9.7	2000–2000	Pu et al. (2002); Thompson et al. (2006); Liu et al. (2016)
13	Qiangtang No. 1 Glacier	G088700E33291N	1	1	109	−11.4	−7.7	2014–2015	Li et al. (2017)
13	Qingbingtan Glacier No. 72	G079894E41774N	3	3	10	−1.7		2008–2008	Wang et al. (2017)
13	Shuiguan River No. 4 Glacier	G101752E37542N	2	2	10	−4.5		1963–1976	Huang et al. (1982); Liu et al. (2012)
13	Shule Nanshan Glacier	G097261E38695N	1	1	92	−9.9	−7.8	2007–2007	Liu et al. (2009)
13	South Inylchek Glacier	G079787E42137N	1	1	160	−12.0	−12.0	2000–2000	Aizen et al. (2001); Thompson (2022)
13	Urumqi Glacier No. 1 Urumqi River No. 1 Glacier	G086810E43111N G086801E43117N	27	29	107	−19.8	−7.4	1962–2006	Huang et al. (1982); Ren et al. (1985); Cai et al. (1988); Liu and Sharmal (1988); Huang (1990); Zhang et al. (1993); Li et al. (2011)
13	Xiao Dongkemadi Glacier	G092063E33082N	1	2	15	−11.0	−7.3	1992–1993	Pu et al. (1995)
13	Xiqiongtailan Glacier	G080111E41952N	3	5	18	−4.6	−3.3	1978–1978	Wang et al. (1985); Liu et al. (2012)
13	Yanglong River Glacier No. 5	G098570E39226N	3	27	16	−10.7	−8.2	1977–1977	Ren and Huang (1981)
13	Zangser Kangri Glacier	G085843E34297N	1	1	127	−12.4	-12.3	2009–2009	An et al. (2016)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	15 m	Year min–max	Sources
14	Singhi Glacier	G077054E35619N	1	1	10	−1.8		1987–1987	Su (1998); Liu et al. (2012); Guo et al. (2015)
15	Baishui Glacier No. 1	G100187E27104N	4	13	21	−2.8	−0.5	1982–2010	Huang (1990); Du et al. (2013)
15	Dagongba Glacier	G101855E29563N	1	1	15	-0.9		1982–1982	Huang (1990)
15	Dasuopu Glacier Yebokangjial Glacier	G085752E28395N	4	9	168	−14.4	−13.8	1964–1997	Shi and Liu (1964); Huang (1982); Thompson et al. (2000); Yao et al. (2002); Liu et al. (2012); Thompson (2022)
15	East Rongbuk Glacier	G086939E28060N	3	3	109	−10.9	−9.2	2002–2008	Hou et al. (2004, 2007); Zhang et al. (2013); Tong Zhang (personal communication, 2022)
15	Glacier No. 18	G087614E28094N	1	4	10	−5.6		1987–1987	Liu and Sharmal (1988)
15	Glacier No. 71	G086174E28297N	1	2	7	−4.7		1987–1987	Liu and Sharmal (1988)
15	Guxiang No. 3 Glacier	G095488E29960N	1	1	10	0.0		1965–1965	Yuan et al. (1982); Liu et al. (2012)
15	Gyabrag Glacier	G086633E28122N	1	1	69	−9.1	−7.7	2005–2005	Liu et al. (2009)
15	Khumbu Glacier	G086820E27978N	3	3	131	−3.3	−3.2	2017–2017	Miles et al. (2018, 2019); Hubbard et al. (2021)
15	Naimona'nyi Gacier	G081317E30454N	1	1	159	−9.6	−9.4	2006–2006	Thompson et al. (2018); Thompson (2022)
15	Nakeduola River No. 7 Glacier	G085817E28470N	1	1	5	−10.9		1964–1964	Shi and Liu (1964); Huang (1982)
15	Rikha Samba Glacier	G083488E28819N	3	6 134	10	−10.6		2014–2015	Gilbert et al. (2020); Tika Ram Gurung (personal communication, 2022)
15	Rongbuk Glacier	G086866E28050N	2	2	26	−12.2		1966–1966	Huang et al. (1982); Liu et al. (2012)
15	Trambau Glacier	G086537E27874N	1	1	78	−1.3		2019–2019	Tsushima et al. (2021)
15	Yala Glacier	G085612E28242N	2	2	60	−1.0	−1.0	1981–1982	Iida et al. (1984); Watanabe et al. (1984)
16	Chimborazo	G281173E01467S	1	1	55	−4.8	−4.7	2000–2000	Ginot et al. (2002); Schotterer et al. (2003); Bonnaveira et al. (2011)
16	Illimani Volcano	G292220E16653S	1	1	138	−9.0	−8.1	1999–1999	Gilbert et al. (2010)
16	Mount Kilimanjaro	G037352E03058S	1	1	51	−1.6	−1.1	2000–2000	Thompson et al. (2002); Thompson (2022)
16	Nevado Huascarán	G282414E09082S G282415E09115S	3	3	167	−9.0	−5.9	1993–2019	Thompson et al. (1995b); Thompson (2022); Thompson et al. (2023)
16	Nevado Sajama	G291113E18113S	1	1	132	−11.3	−10.6	1997–1997	Thompson et al. (1998); Vimeux et al. (2009); Thompson (2022)
16	Quelccaya Ice Cap	G289183E13941S G289167E13923S	2	2	168	−7.2	0.0	1976–2003	Thompson (1980); Zagorodnov et al. (2005); Vimeux et al. (2009); Thompson (2015, 2022)

Table A1. Continued.

Region	Glacier names	GLIMS IDs	Borehole count	Profile count	Depth [m] max	Temperature [°C] min	Temperature [°C] 15 m	Year min–max	Sources
16	Volcán Coropuna	G287357E15537S	2	2	147	−11.1	−9.0	2003–2003	Zagorodnov et al. (2005, 2006); Vimeux et al. (2009); Thompson (2022)
17	Glaciar Estrecho	G289987E29297S	1	10 125	10	−16.1		2014–2015	Bravo and Rivera (2015)
17	Glaciar Guanaco Guanaco Glacier	G289989E29347S	2	9 331	112	−19.4	−6.2	2008–2015	Bravo and Rivera (2015); Kinnard et al. (2020); Masiokas et al. (2020)
17	Glaciar La Ollada	G289889E31964S	1	1	104	−18.5	−18.3	2005–2005	Schwerzmann et al. (2006b)
17	Glaciar Nef	G286668E46885S	1	1	13	−0.1		1996–1996	Matsuoka and Naruse (1999)
17	Glaciar Ortigas 1	G289947E29388S	1	8 466	10	−13.4		2014–2015	Bravo and Rivera (2015)
17	Glaciar San Rafael	G286620E46550S	1	1	16	−11.9	−11.6	2005–2005	Vimeux et al. (2008)
17	Glaciarete Esperanza	G289964E29330S	1	8 363	10	−17.4		2014–2015	Bravo and Rivera (2015)
17	Glaciarete Ortigas 2	G289958E29393S	1	35 136	7	−16.2		2014–2015	Bravo and Rivera (2015)
17	Pío XI glacier	G286372E49263S	1	1	40	−0.9	−0.7	2006–2006	Schwikowski et al. (2013)
17	Tapado Glacier	G290072E30145S	1	1	36	−12.4	−10.7	1999–1999	Ginot et al. (2006)
19	Blåskimen Island Ice Rise	G356949E70424S	1	1	19	−16.4	−16.3	2012–2014	Goel et al. (2017a, b)
19	Bruce Plateau	G295982E66134S	2	6	431	−15.8	−15.1	2010–2010	Zagorodnov et al. (2012)
19	Collins Ice Cap	G301284E62099S G301112E62165S	7	16	30	−6.1	−2.0	1992–1992	Han et al. (1995)
19	Dolleman Island	G299288E70606S	1	1	128	−17.2	−17.0	1986–1986	Nicholls and Paren (1993)
19	Dyer Plateau		1	1	104	−21.8	−21.4	1989–1989	Nicholls and Paren (1993)
19	James Ross Island Ice Cap	G302228E64270S	2	2	10	−14.2		1976–1977	Aristarain and Delmas (1981)
19	Johnsons Glacier	G299645E62671S	2	2	153	−0.2	−0.2	2016–2016	Sugiyama et al. (2019); Shin Sugiyama (personal communication, 2022)
19	King George Island Ice Cap	G301226E62159S	1	3	15	−1.8		1986–1986	Ren (1990)
19	Nelson Island Ice Cap	G301002E62274S G300887E62269S	3	12	13	−1.6		1986–1986	Ren (1990)
19	Styx Glacier		1	1	210	−33.5	−31.7	2016–2016	Han et al. (2015); Yang et al. (2018)

Appendix B: Source authors

These are the authors of all the sources used to compile the data in glenglat. The list is sorted alphabetically by (Latin) family name, which is capitalized. The latinized form preserves the order of the original, which is family name first for Chinese, Japanese, and Korean names. Since Copernicus Publications does not support non-Latin characters, a version of this list that preserves the people's original names is provided in Sect. S3 of the Supplement.

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Supplement. Versions of the Appendices and references preserving non-Latin characters can be found in the Supplement. The supplement related to this article is available online at https://doi.org/10.5194/essd-17-1627-2025-supplement.

Author contributions. MJ and EW contributed equally to this project (manuscript and dataset). MJ conceived the project and, together with EW, designed, implemented, and populated the database. EW managed the testing and publishing pipelines, and MJ and EW wrote the manuscript. MG curated the Colle Gnifetti dataset, including a (re)evaluation of uncertainties for selected boreholes. GC re-digitized a large subset of figures from which data were sourced, providing the basis for the digitization error assessment. All the authors read, edited, and approved the manuscript.

Competing interests. The contact author has declared that none of the authors has any competing interests.

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