SoilTemp: the global microclimate database

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Abstract

Traditional ecology has primarily relied on macroclimate data derived from standard weather stations, model outputs, or remote sensing. However, these datasets often have coarse spatial and temporal resolutions, failing to capture fine-scale processes. In contrast, microclimate data offer detailed and realistic climate information that is crucial for accurately assessing the effects of climate change on organisms and ecosystems, as well as for species distribution modeling. The SoilTemp project aims to address the global scarcity of microclimate data, providing researchers worldwide with the necessary tools and datasets to enhance ecological and biogeographical studies and predictions. With this poster, we aim to provide an overview of the current content of the rapidly growing SoilTemp database, on its way to open access publication. Here, we present summary statistics of approximately **19,000** unique locations currently in the database, show the structure of the emerging SQL database, and summarize the potential for data applications.

SoilTemp data submission

- Georeferenced microclimate time series of >1 month.
- Time series with maximum 4-hour interval.
- Observational and experimental data, above- and belowground: temperature, moisture, and any other microclimate parameters.
- Optionally: associated species (plants, other taxa) composition or trait data from the same location.
- One or several sensors per logger.

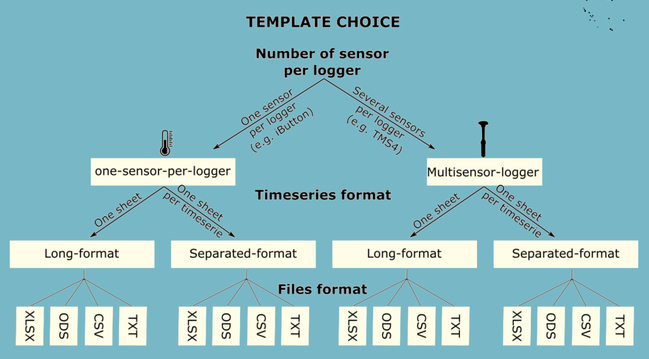

Fig. 1: SoilTemp submission template choice.

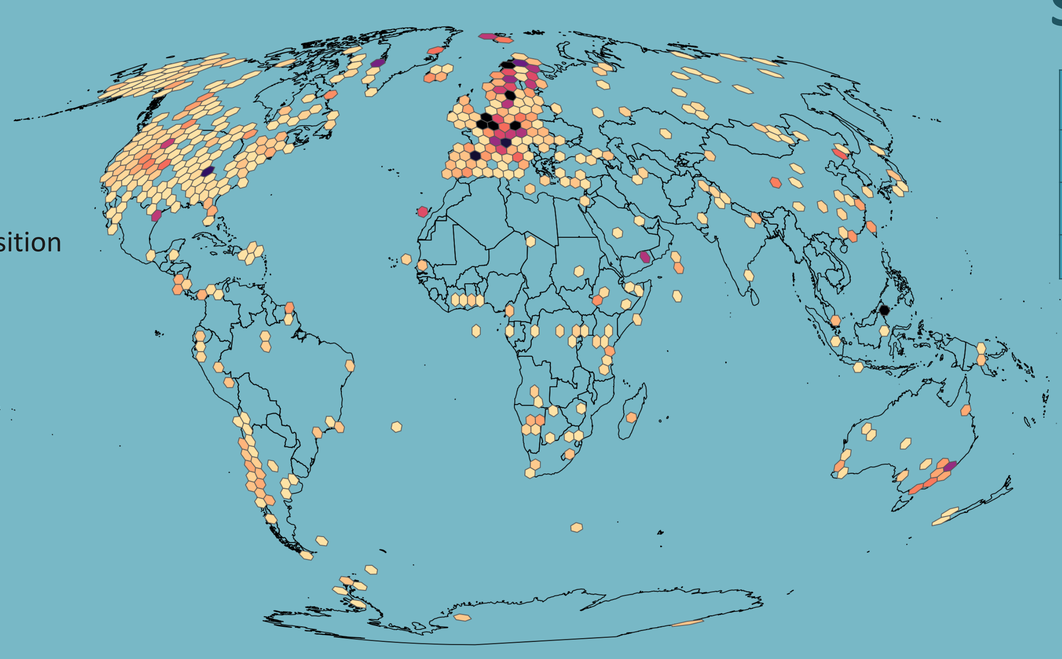

Fig. 2: Global density map of microclimate measurement distribution.

Summary of SoilTemp data

Number of	SoilTemp 1.0	SoilTemp 2.0
Observations	64,572	53,909
Unique locations	9,084	10,036
Countries	73	82

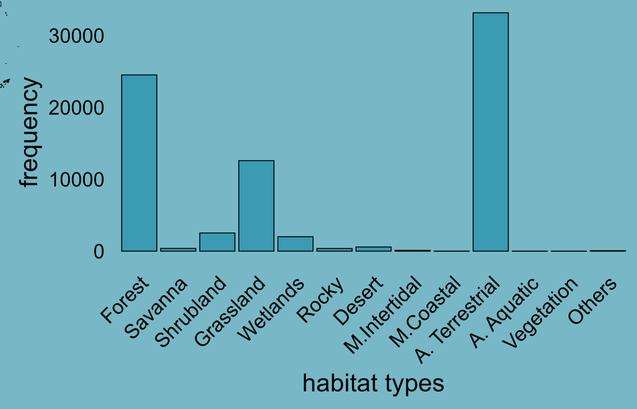

Fig. 3: Distribution of habitat types in the SoilTemp.

Microclimate measurements

SoilTemp collects a multitude of microclimate variables in its mission to create the first global and high resolution microclimate database. Through time, the database has been growing steadily (Fig. 4), with **soil and air temperatures** presenting the largest proportion of data submissions. Additionally, microclimate data were most commonly collected from **forest and grassland habitats** (Fig. 3), and were most often measured at **15-minute intervals** (Fig. 6).

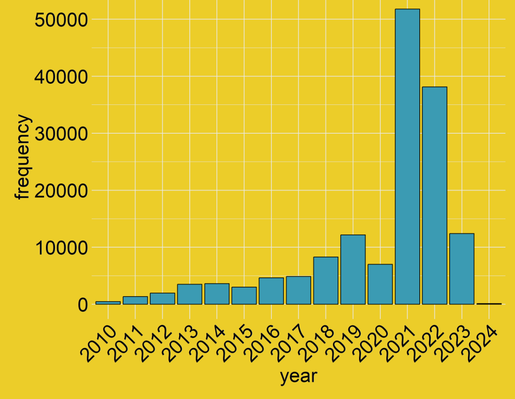

Fig. 4: Frequency of yearly microclimate measurements in SoilTemp.

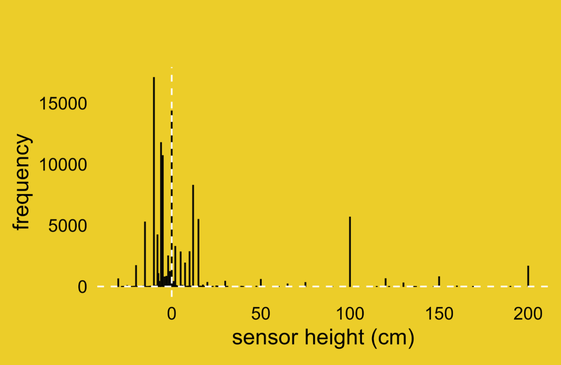

Fig. 5: Distribution of sensor heights.

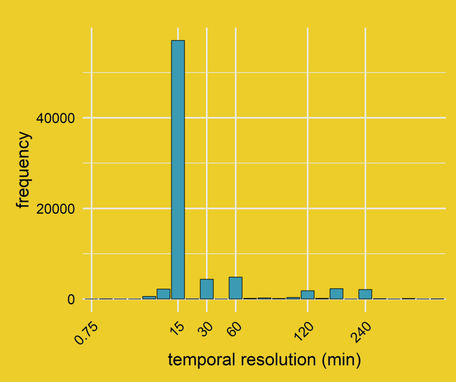

Fig. 6: Frequency of temporal resolutions.

SoilTemp database workflow

Traditional XLSX and CSV files are not practical for storing and processing large datasets. To overcome the limitations presented by such file formats, a **relational SoilTemp database** (Fig. 7) was developed. Prior to storage, **all data submissions will be validated** using an **R Shiny app**. Specifically, this Shiny app **checks all submitted data sheets and columns**, and automatically generates a **summary of the validated data**. Once all data have been processed, and discrepancies solved by the original data owners, data are uploaded to the SoilTemp SQL database.

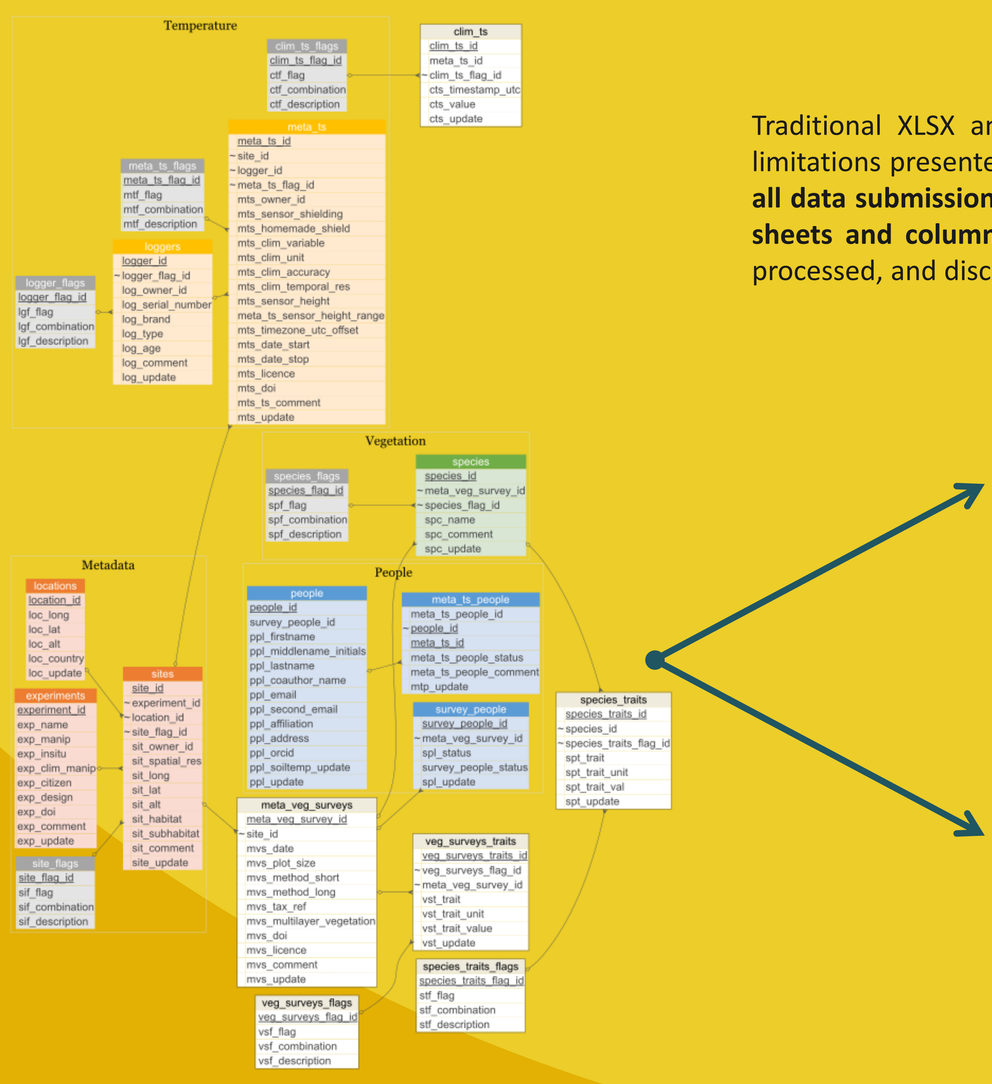

Fig. 7: SoilTemp database structure.

App design and publication

In addition to a Shiny app for data validation, a separate app is under development which will provide a streamlined, user-friendly experience for researchers, contributors and stakeholders. The app will feature a **dashboard** that presents **general summary statistics of the SoilTemp database**. Users will see key metrics such as the number of locations, geographic coverage, and data trends over time. Additionally, **the app will allow users to filter, explore, and extract metadata and measurement information**, including microclimate measurements, vegetation, and species (e.g. traits) data.

Potential applications

- Creation of the **first high-resolution gridded global microclimate dataset**.
- **Historical** and **projected climate change** data at the microclimate scale.
- Application in **ecology** and **biogeography**.
- Apply in situ microclimate measurements to **improve** the **mechanistic understanding** of microclimate across biomes.

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