**hoboR: An R package to summarize and manipulate weather station data.**

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**Summary**

Meteorological records captured by weather stations and data loggers can accumulate large amounts of digital information. Local and regional efforts to create weather station networks, as well as projects oriented to the study of microclimates and smart agriculture, have increased the use of weather stations (Estévez et al., 2011; Lembrechts et al., 2021; Hachimi et al., 2022). These large and complex datasets can be difficult to analyze for non-expert users. HOBO data (ONSET, United Kingdom) loggers are among the most popular weather stations because they are relatively inexpensive and easy to use. A HOBO graphic user interface exists but is incompatible with post-process data analysis and large data sets. As a result, we have developed a series of algorithms to combine and manipulate CSV files. These algorithms allow the removal of redundant data, meteorological summaries by time, date, identification of sensor failures, out-of-range values, and the calculation of summary statistics (i.e., max, min, mean, and standard deviation).

**Statement of need**

HoboR is an R package (R Core Team, 2024) for efficiently processing large datasets obtained from weather stations and data loggers. We developed multiple tools designed to import, curate, and summarize weather data in a CSV file format. Packages to analyze weather data exist in Turbo Pascal (Pickering et al., 1994) and R packages have been developed to analyze weather data captured by satellites including NASA Power and rnoa (Sparks 2018, Chamberlain and Hocking, 2023). In contrast, hoboR automates these tasks by loading the CSV files into a data frame adaptable to HOBO sensor inputs, significantly reducing the time and effort required for data handling and management, and increasing the accuracy and reproducibility of the analysis. HoboR removes duplicate entries, summarizes the data by time intervals (minutes, hours, and/or days), and subsets files by user-determined ranges. The package can also identify and address common data quality and accuracy issues related to sensor failures, out-of-range entries, time zone discrepancies, and data formats.

Developing software to automate the processing of data collected by weather stations and data loggers can facilitate the analysis of local weather and microclimate patterns. Typically this data is used to correlate meteorological measurements with epidemiological processes, species composition, and a variety agricultural applications (Hachimi et al., 2022, Dahl et al., 2023; Nikolauo et al., 2023; Wu et al., 2023 ). Conversely, traditional spreadsheet interfaces pose an inherent challenge when handling data from large and complex studies, making managing and curating these datasets time-consuming and error prone. In many cases, the spreadsheet-based interfaces may be unable to handle an entire dataset and/or cannot simply remove redundant data. The integration of advanced algorithms and user-friendly software makes hoboR accessible to researchers and programmers with differing levels of experience. Facilitating the implementation of meteorological data in plant pathology and disease ecology to improve management (Garrett et al., 2023). To our knowledge, no R packages are available for collecting and analyzing large meteorological data sets collected from HOBO weather stations.

Weather station data can be logged at various time intervals for different types of sensors, including rain gauges, temperature, relative humidity (RH), leaf wetness, and solar radiation. The main functions of hoboR implement dynamic interpretation programming, which enables the independent processing of spreadsheets for any number of sensors and allows data to be transposed into a range of initial column structures. Among the challenges in recording meteorological data are the various errors that occur during data collection. For example, these errors could include damage to the logger, debris blocking the sensors, battery replacement, and malfunctioning sensors or loggers. These issues can result in multiple entries that might be challenging and time-consuming to detect, correct, and curate in tabular format. The package output includes the summary statistics of the minimum, maximum, mean, and standard deviation and can be rounded to the nearest minute, hour, or day. Other functions were developed to help summarize the data by time intervals and different ranges of dates. Additionally, hoboR can help identify and replace unrealistic values. We have also developed a framework to calibrate and correct the variation among data loggers (Fig. 1).

A diagram of a computer

Description automatically generated

Fig. 1) A workflow illustrating the steps recommended for the hoboR package: data parsing and summary. subset of entries, quality checking, and summary statistics. Optional calibration steps for HOBO data loggers. Discontinuous lines are optional; solid lines represent the recommended pipeline for HOBO data analysis.

**Example**

A test dataset is provided with the hoboR package. This data set was collected in Brookings, Oregon, between August to December 2021 (Fig. 1). We tested the package using partial datasets from different weather stations and data loggers. A full dataset consists of millions of

entries. The code is reproduced below.

```R

library(hoboR)

# Standard Analysis

# Add the PATH to your sites for weather data (from HOBO)

path = ("./site\_12")

files <- hobinder(path, header = T, skip = 1) # loading all hobo files

cleaned <- hobocleaner(files, format = "ymd") # remvoe duplicate entries

sum <- hobotime(cleaned, summariseby = “5 mins”, na.rm = T) # rounds data every 5 minutes

summa <- hoborange(sum, start = "2022-08-04", end = "2022-08-10") # select a time range

summary <- meanhobo(summa, summariseby = "1 day", na.rm = T) # get the summary statistics by "24 h"

# Quality check

impossiblevalues(cleaned, showrows = 3) # show impossible values

sensorfailures(cleaned, condition = ">", threshold = c(50, 3000, 101), opt = c("Temp", "Rain", RH) # flag impossible values to NA

timestamp(cleaned, stamp = "2022-08-05 00:01", by = "24 hours", days = 100, na.rm = TRUE, plot = TRUE) # shows the trends by time range .

```

This package requires R version 4.3.0 or later. It also requires the following packages:

data.table, lubridate, dplyr, plyr, reshape, and ggplot2. These dependencies should be installed automatically when dependencies = TRUE is set in the command used to install the

package.

```R

> if (!require("devtools"))

> install.packages("devtools")

> devtools::install\_github("leboldus\_lab/hoboR", dependencies = TRUE)

```

**Authors contributions**

Ricardo I. Alcalá Briseño developed and maintained the package, wrote the documentation, debugged the code, and wrote the manuscript. Adam R. Carson collected the data, wrote code implemented in the package, and debugged the code. Sky Lan collected the data, wrote code implemented in the package, and assisted in the user-functionality of the code functions. Ebba Peterson assisted in best practices for post-processing weather stations and data loggers. Niklaus J. Grunwald participated in manuscript preparation and funding. Jared M. LeBoldus supervised the project, manuscript preparation, and funding.

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Authors declare no conflict of interest.

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