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ClimDatDownloadR: Accessing Climate Data Repositories for Modelling

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Summary

Systematical accessing, downloading, and pre-processing climatological data from CHELSA (Karger et al., 2017, 2021; Karger et al., 2018) and WorldClim (Fick & Hijmans, 2017; Hijmans et al., 2005) remains a challenge in different environmental disciplines like Species Distribution Modelling (SDM) and climate studies. This package provides a set of functions that allow easy access and customized selection of climate data sets. Besides downloading the raw data, also functionalities to complete pre-processing steps like clipping, rescaling, and file management are available. The applications of the package range from one-time-use to implementing the functions in automatic processing of scientific workflows.

Statement of need

The climatology datasets CHELSA and WorldClim contribute as crucial data bases for studies in various scientific fields. Primarily used in studies with focus on ecology (~4,200 publications[1]), environmental sciences (>2,200 publications), and biodiversity conservation (>1,600 publications), usages extend to a wide variety of scientific disciplines. The main usage of the datasets, however, lies in Species Distribution Modelling (SDM) and Ecological Niche Modelling (ENM). Their free availability and frequent citation in widely referenced papers on SDM and ENM strategies (e.g., Randin et al., 2020; Zurell et al., 2020) have contributed to their widespread adoption, facilitating comparability between modelling studies at different spatial and temporal scales.

The high resolution global climatological datasets (30 arc-sec. ~ 1km) include downscaled and bias-corrected data from 30-year time-periods, providing always monthly mean, minimum, and maximum values of temperature and monthly precipitation sums for analysis[2]. Additionally, 19 bioclimatic parameters are accessible, which enable conclusions about seasonality.

Since their initial releases in 2018 (CHELSA V1.2), the CHELSA (Karger et al., 2017; Karger et al., 2018) datasets were cited in more than 2,800 peer reviewed papers, indexed on the Web of Science (source, Aug. 2025). The latest release of WorldClim 2 in 2017 (Fick & Hijmans, 2017) was cited more than 10,600 times (source, Aug. 2025).

[1] Following the Web of Science Categories, citations of Karger et al. (2018) (Data from CHELSA 2.1) had 1,155 citations in the field of Ecology. The WorldClim 2 data (Fick & Hijmans, 2017) has 3,044 citations in the same Web of Science category. Both numbers are of the date 17.05.2025. The "Web of Science Categories are assigned at the journal level", meaning the publishing journal defines the category (source).

[2] Function `Chelsa.timeseries.download` supports also the download of potential evapotranspiration (PET) from CHELSA 2.1 (Karger et al., 2018)

CHELSA and WorldClim datasets are commonly utilized in models predicting the potential past, current, and future distribution of species, particularly in studies on monitoring distribution shifts under climate change (e.g., Bobrowski et al., 2017; Twala et al., 2023; Werner et al., 2025), tracking endangered species and planning conservation strategies (e.g., Franklin, 2013; Muscatello et al., 2021), assessing the spread of invasive species (Srivastava et al., 2019), and management strategies in forestry and agriculture (e.g., Agbezuge & Balakrishnan, 2024; Pecchi et al., 2019).

Recent studies have also assessed the performance of these datasets in SDM/ENM approaches, highlighting their respective strengths and limitations (e.g., Bobrowski, Weidinger, & Schickhoff, 2021; Bobrowski, Weidinger, Schwab, et al., 2021; Bobrowski & Schickhoff, 2017; Datta et al., 2020; Rodríguez-Rey & Jiménez-Valverde, 2024). Given that dataset performance may vary depending on the research scope, it is recommended to test multiple datasets to to ensure their suitability for the research target and region.

For these applications, `ClimDatDownloadR` offers key advantages by enabling efficient retrieval from both dataset providers and pre-processing steps such as partial selection of parameters, months, and bioclimatic parameters, temporal subsets of timeseries, customized extent, and included file management as well as an output of the provider's respective citation file. In addition to time-saving aspects, the storage usage and management played a key role in the development of the `ClimDatDownloadR`.

The implemented data management creates a hierarchical, clear, and reproducible data structure for analyses during the processing. Downloaded data can be kept as is, deleted, or packed in a zip-archive file. All of raised *ease-of-use* add-ons contribute to the primary goal of `ClimDatDownloadR` to enable more scientists and other users or organisations to download and pre-process CHELSA and WorldClim data to gain more experience in geodata handling and applications.

Since the official release in 2023, the use of `ClimDatDownloadR` steadily increased (Bobrowski, Weidinger, & Schickhoff, 2021; Chen et al., 2025; Costa-Saura et al., 2025; Maitner et al., 2023; Santi et al., 2024; Twala et al., 2023; Werner et al., 2025). Further, the need of having software for downloading and pre-processing of freely available data is shown by the steady stream of interested visitors on ResearchGate (3,399 unique visits, 04.08.2025), Zenodo (>1000 views, > 150 downloads) (Jentsch et al., 2023), and citations in peer-reviewed papers.

The package implements the datasets CHELSA V1.2 , V2.1, WorldClim V1.4, and V2.1. More specifically the CHELSA Climatologies, Timeseries, CRU Timeseries (CHELSAcruts), and WorldClim Histclim datasets for present data. For past data, the CHELSA PIMP3 data from CHELSA V1.2 is also available. For future data, both CHELSA and WorldClim provide datasets incorporating various CMIP 5 and 6 global circulation models with various emission scenarios and reference periods. An overview as well as a introduction to the usage of the functions is provided in the Readme of the package on GitHub.

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