

wcswatin: An R Package for Processing Multi-Source Weather and Climate Data for SWAT Hydrological Modeling

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Software

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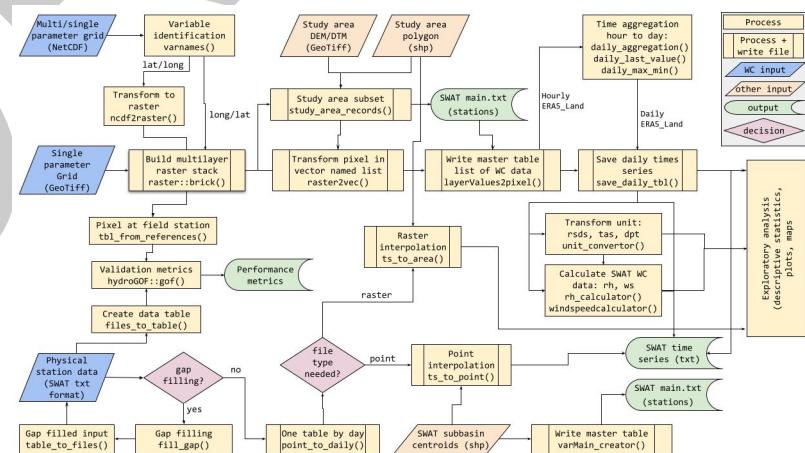
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Authors of papers retain copyright and release the work under a Creative Commons Attribution 4.0 International License ([CC BY 4.0](#)). The package provides integrated tools for extracting, cleaning, validating, and formatting Global Weather and Climate Grids (GWCG), as well as for processing measured station data through spatial interpolation. By supporting common data formats including NetCDF, GeoTIFF, and CSV, wcswatin enables consistent and reproducible preparation of weather and climate inputs for SWAT modeling. [Figure 1](#) illustrates the main processing pipelines implemented in the package.

Summary

Weather and climate variables constitute essential boundary conditions for hydrological modeling frameworks; however, the acquisition, harmonization, preprocessing, and quality control of heterogeneous datasets originating from multiple sources remain computationally intensive and susceptible to systematic and random errors. wcswatin is an R package developed to standardize and automate the preprocessing of multi-source weather and climate datasets, with a specific emphasis on generating rigorously formatted meteorological inputs for the Soil and Water Assessment Tool (SWAT), a globally established, process-based ecohydrological model.



²⁴ lowers methodological and technical barriers for hydrologists and environmental scientists,
²⁵ particularly in applications requiring the integration of multiple climate data sources.

²⁶ Statement of need

²⁷ The Soil and Water Assessment Tool (SWAT) (Arnold et al., 2012) is widely used for watershed-
²⁸ scale hydrological modeling worldwide (Tan et al., 2020) and requires accurate weather and
²⁹ climate inputs, including precipitation, temperature, solar radiation, wind speed, and relative
³⁰ humidity. While Global Weather and Climate Grids (GWCG) derived from reanalysis products,
³¹ satellite missions, and other modeled datasets provide increasingly high-resolution alternatives
³² to sparse station networks, their preprocessing for SWAT remains technically demanding.

³³ These datasets typically require multiple processing steps prior to model application, including
³⁴ temporal aggregation, unit conversion, spatial subsetting, validation against in situ observations,
³⁵ and conversion into model-specific input formats. Performing these steps manually or using
³⁶ multiple disconnected tools is time-consuming and increases the risk of errors, particularly
³⁷ when comparing alternative climate products or working with large spatio-temporal datasets.

³⁸ wccswatin addresses these challenges by providing a generalized and integrated workflow for
³⁹ preprocessing multisource weather and climate data for SWAT modeling. The package supports
⁴⁰ the processing of gridded datasets in common formats, offers specialized functionality for
⁴¹ compiling complete SWAT-compatible weather datasets from ERA5-Land, and includes tools for
⁴² gap-filling, spatial interpolation, and validation using measured station data. By consolidating
⁴³ these tasks within a single R-based environment, wccswatin facilitates reproducible and efficient
⁴⁴ preparation of weather and climate inputs for hydrological and ecohydrological studies

⁴⁵ Functionality

⁴⁶ The wccswatin package supports the extraction, preprocessing, exploratory analysis, spatial
⁴⁷ interpolation, and validation of weather and climate data from multiple sources, with a focus
⁴⁸ on generating SWAT-compatible inputs.

⁴⁹ For gridded datasets, the package provides functions to process Global Weather and Climate
⁵⁰ Grids supplied in NetCDF or GeoTIFF formats. This includes automated handling of temporal
⁵¹ resolution, aggregation of hourly data to daily values, unit conversion, and derivation of
⁵² additional variables required by SWAT, such as wind speed and relative humidity. These
⁵³ capabilities have been applied to multi-parameter reanalysis products including ERA5-Land.

⁵⁴ In addition to gridded data, wccswatin supports the use of measured in situ station data. Station
⁵⁵ observations can be imported in standard SWAT format, screened for missing values, gap-filled
⁵⁶ using regression-based approaches, and spatially interpolated using trend surface analysis.
⁵⁷ The resulting interpolated datasets can be generated as point-based or gridded outputs and
⁵⁸ subsequently converted into SWAT-compatible weather inputs. Figure 2 demonstrates an
⁵⁹ example of the spatial interpolation capabilities, showing a third-order trend surface interpolation
⁶⁰ for daily precipitation data.

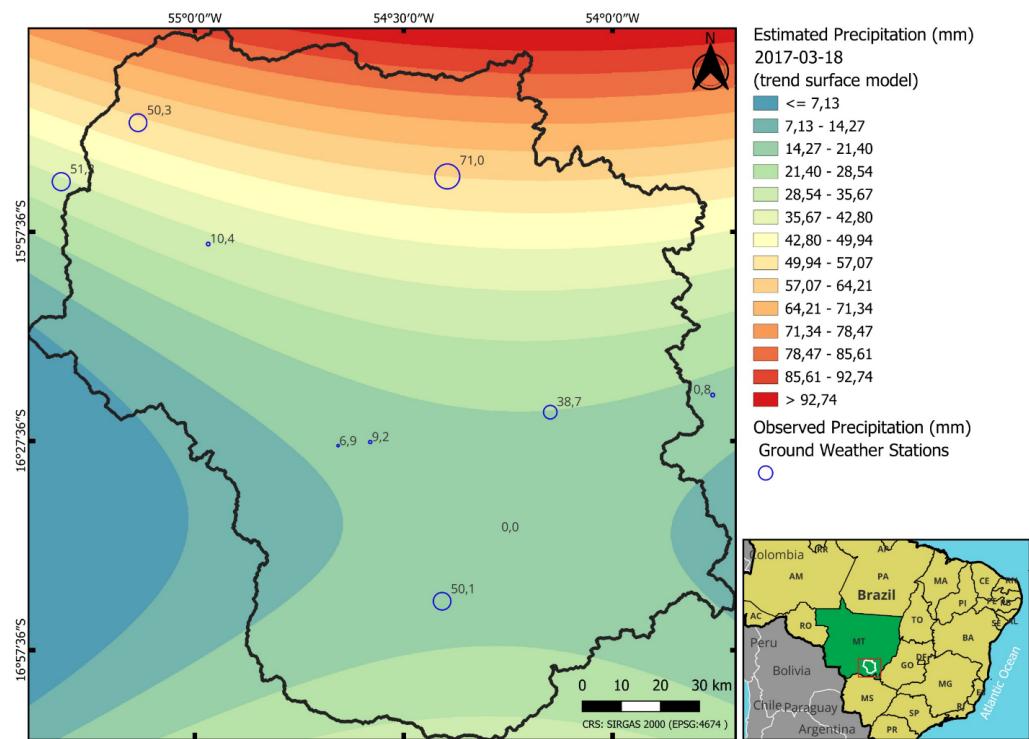


Figure 2: Example of third-order trend surface interpolation for precipitation data (March 18, 2017) using wcswatn's spatial interpolation function.

61 The package also includes tools for validating gridded climate products against station measurements
 62 through statistical metrics and visual inspection, enabling users to compare alternative
 63 weather and climate datasets prior to hydrological modeling. Performance optimizations,
 64 including parallel processing and reduced memory overhead, allow wcsWatn to handle large
 65 spatio-temporal datasets efficiently on standard computing systems.

66 Related work

67 Several existing tools partially support the preparation of weather and climate data for
 68 hydrological modeling. The NASAaccess R package ([Ibrahim, 2023](#)) provides functionality for
 69 downloading and reformatting selected NASA datasets for use in models such as SWAT, but
 70 is limited to a small number of variables and data sources. The pRecipe package ([Godoy &
 71 Markonis, 2023](#)) focuses on global precipitation datasets and visualization but does not offer
 72 comprehensive workflows for generating complete SWAT weather inputs.

73 Web-based tools like the NCEP Climate Forecast System Reanalysis portal (<https://globalweather.tamu.edu/>) are restricted to specific time periods (1979-2014) and have demonstrated
 74 weak performance in discharge simulations ([Senent-Aparicio et al., 2021](#)). In contrast, wcsWatn
 75 emphasizes integrated preprocessing, validation, and formatting of multisource weather and
 76 climate data, supporting both gridded and station-based inputs within a unified and extensible
 77 workflow tailored to SWAT modeling.

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 81 partially funding the software development under grant CEPF-104254.

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