‘weatherOz’, a unified interface to access and source Australian climate data

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Abstract

The ability to find, source and integrate weather data offers the potential to optimise resources improving crop management practices and support the agricultural industry to drive sustainable outcomes. Weather data underlies the planning and operationalisation of a range of farm practices (e.g., sowing opportunities, herbicide/fungicide applications, soil amelioration practices, harvest) and thus is central to data-driven decision-making in the agricultural industry. We introduce a software tool to facilitate access and retrieval of Australian climate data called ‘weatherOz’. This R package facilitates repeated and programmatic access and download of Australian climate datasets. ‘weatherOz’ consists of a unified interface providing standardised data access and retrieval from the Department of Primary Industries and Regional Development of Western Australia (DPIRD), the Queensland Government’s Scientific Information for Land Owners (SILO), and Australian Bureau of Meteorology (BOM). Here, we will cover an overview of the package's development, its functionality, showcase practical applications of the data in agricultural research as well as exemplify how these datasets can be leveraged to support agronomic planning and decision-making. This work provides insights into the value of climate data in agriculture, highlighting the ‘weatherOz’ package as a useful tool for agronomists, researchers, growers, and stakeholders in the agricultural industry.

Keywords

Climate data, information systems, data integration, sustainable agriculture, interoperability.

Introduction

Weather data plays a central role in various sectors, from agriculture to urban planning, renewable energy, and disaster management (Venäläinen & Heikinheimo, 2002; De Wolf et al., 2003). Readily accessible weather and climate data are indispensable for researchers, policymakers, and decision-makers (Cleugh et al., 2011; Leviäkangas. & Hautala, 2009). In Australia, this data is fragmented and repeated/ programmatic access is not streamlined. The ‘weatherOz’ package was designed to fill this gap by providing a single interface for querying and retrieving data from the DPIRD and SILO databases via application programming interfaces (API) (Jeffrey et al., 2001, DPIRD, 2024). ‘weatherOz’ incorporated the functionality from the ‘bomrang’ R package, which provided access to data from BOM’ public anonymous FTP server but faced limitations due to restrictive access policies leading to its archival (A. Sparks et al., 2017). The integrated interface of ‘weatherOz’ allows users to access a comprehensive range of weather and climate data without needing to navigate multiple systems, webpages, or data formats.

Australian-wide observations and data from SILO’s Patch Point and Data Drill datasets are available under Creative Commons Attribution 4.0 International (CC BY 4.0) license. BOM data, available under a Creative Commons Attribution (CC BY) licence, include Australian-wide data ranging from satellite and radar imagery to précis and coastal forecasts and agricultural bulletins. Data from DPIRD’s weather station network, available under a Creative Commons Attribution 3.0 (CC BY 3.0 AU) license, include station metadata, observations of extreme events (e.g., frost, heat, and wind erosion risk), and minute-to-annual summaries of various parameters from approximately 200 weather stations, largely located in the south-western part of Western Australia.

‘weatherOz’ was designed to be extended beyond data access. The package standardisation is beneficial for users who require consistent and reliable data for analysis, modelling and/or incorporation into other applications and software tools. In agricultural applications, for example, weather data is used for estimating crop yield, growth stages, physiological stress, and forecasting pest population levels or disease epidemics (A. Sparks, 2017). Urban planners use weather data to design infrastructure resilient to extreme weather events, while municipalities may use it for energy planning and disaster preparedness (Alcoforado et al., 2009; Svensson & Eliasson, 2002). Similarly, renewable energy projects rely on climate data to map potential sites for wind and solar power generation (Ramachandra & Shruthi, 2007). By facilitating easy access to these data, 'weatherOz' supports a wide array of applications, data driven decision-making and further development of innovative research applications. In this work, we provide an overview of the development of the R package, a description of its functionality and highlight uses cases of the tools available in the package.

Methods

Broadly, the development of 'weatherOz' R package consisted of i) standardisation of historical functionalities developed at DPIRD, ii) integration of capabilities from the 'bomrang' R package, iii) creation of an API client in the R programming language (R Core Team, 2023) and iv) design of user-friendly and informative documentation, providing instructions and examples on how to best use the package functionalities.

Incorporation of historical functionality

The initial step in developing 'weatherOz' was to assess and incorporate the historical functionalities available within the code base of the Systems Modelling/Farming Systems Innovation (SM/FSI) at DPIRD. A range of tools were developed and used across applications and models developed by the SM/FSI but these lack standardisation and structure, used deprecated or not current API endpoints, and documentation and usage examples were scattered or lacking. The infrastructure, data management practices and API access protocols of the eConnect team/DPIRD provided a reliable foundation for the development of initial versions of 'weatherOz' mostly aimed at accessing data from DPIRD's weather station network.

Leveraging the bomrang R package functions

The next phase involved evaluating and integrating the functionality from the archived 'bomrang' R package. The 'bomrang' package consisted of functions to fetch various datasets, including forecasts, agriculture bulletins, and satellite/radar imagery from the BOM's public anonymous FTP server. However, limitations in data accessibility and policies posed significant challenges to the continued development and maintenance of the package. The integration aimed to overcome these limitations by retaining functionality that was not restricted and by updating the features of 'bomrang' where possible. These included the updating of 'xml' parsing functions, internal functions to check BOM's products names and argument values, as well as printing relevant notes, warnings and additional information with the requested data as required by BOM's license agreement.

Development of a new API client interface

We focused on creating a unified set of functions that could handle the various formats and data types, such as querying and parsing functions, standardisation of variables names and output structure, so that users could retrieve data in a consistent and manageable way. This required understanding of BOM, SILO, and DPIRD databases structures, output types, access protocols, and licensing agreements. The API client's design also included error handling and testing to provide automated checks, transparency and troubleshooting support. Throughout the development process, we created documentation and user guides to assist users in setting up and utilising the package. Vignettes were included to demonstrate common tasks, such as fetching summary weather data, visualising station locations and outputting data in particular format (e.g., weather files with the '.met' extension ready to be used in APSIM simulations via the 'apsimx' R package; Miguez, 2024). Additional effort was placed in creating a function to source and unify station metadata for all data available via 'weatherOz'. The station metadata presented by 'weatherOz' offers more comprehensive information compared to SILO alone (Pires et al., 2024). This includes geographic coordinates (longitude, latitude, and state), elevation, availability dates, and operational status. For DPIRD stations, it also encompasses detailed uptime and hardware specifications of the stations.

Software and manuscript open peer-review

The 'weatherOz' package underwent a peer-review process through rOpenSci (Ram et al., 2018). The peer-review process involved initial package assessment, feedback from reviewers, and iterative improvement, all public and open via the rOpenSci review repository (https://github.com/ropensci/software-review/issues/598). Reviewers evaluated the package for its functionality, code quality, error handling, documentation, and adherence to best practices in open-source software development. We also submitted a manuscript to Journal of Open Source Software (https://joss.theoj.org) describing the gap 'weatherOz' was filling and briefly highlighting package features. The JOSS review and successful publication provided an additional layer of scrutiny, focusing on the scientific and technical contributions of the package (Pires et al., 2024).

Continuous development and testing

The development of the 'weatherOz' package incorporates continuous integration (CI) practices making it robust and ensuring compatibility across multiple operating systems and R versions. CI is used to automate building, installation and testing processes, allowing the package to be checked regularly and consistently on Windows, Linux, and macOS environments. The package is tested against several versions of R (i.e., current release, development, and older versions) to verify compatibility and catch any potential issues. By implementing CI, we maintain high standards of code quality and reliability and provide 'weatherOz' users with a dependable tool for accessing Australian weather and climate data.

Results

Near real-time management advice

DPIRD offers each year a subscription-based service where users are provided with forecasts and advice for Blackspot in field pea and Blackleg in canola (Figure 1). Each year, from April to June, 'weatherOz' is used to run the two spore forecast models, Blackspot Sporacle (for WA, NSW, SA, and VIC) and Blackleg Sporacle (WA-only). The service combines the spore forecast output (i.e., ascospore maturity and release) with location-specific agronomic advice tailored to the weather stations where subscribers are located. The outputs for subscribers include the percentage of spores released, agronomic recommendations, and rainfall summaries up to the current week, with projections of disease risk for the next two weeks. Additionally, a map indicating the current risk level for each location is generated, proving a visual aid of the current risk for each location in the subscriber service.

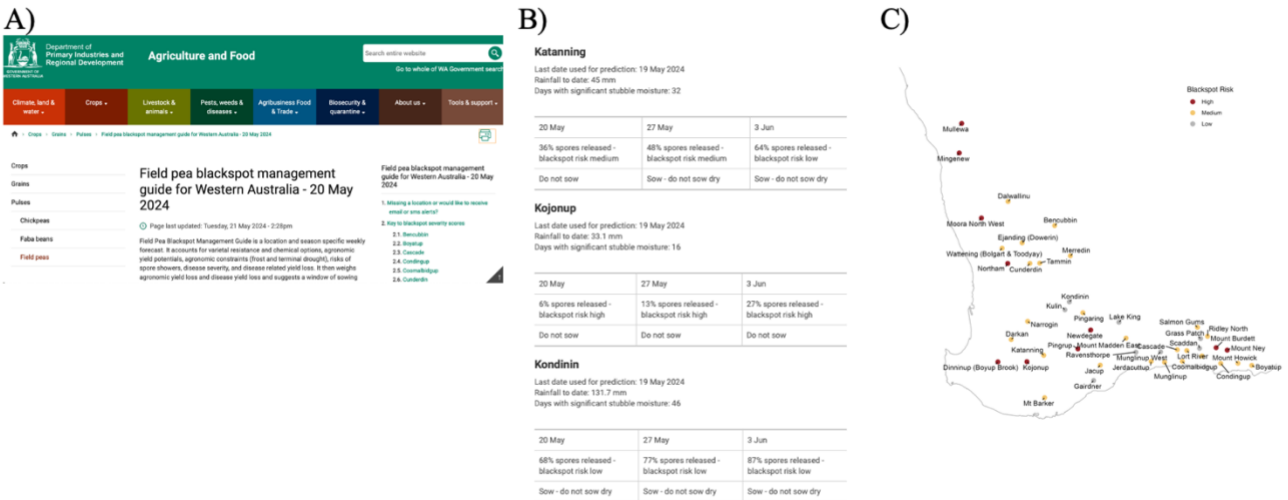

Figure 1. Overview of the field pea blackspot management guide using 'weatherOz' functionality. The online interface for blackspot in field peas where guides are published weekly each year (A), example of output for Katanning, Kojonup, and Kondinin, showing spore release percentages, agronomic advice, and location summaries (B) and a map with field pea blackspot risk levels for Western Australian subscribers (C).

Weather retrieval dashboard

We are developing dashboards for Farming System Innovation/DPIRD users to find, query, and download weather data through 'weatherOz'. The dashboards provide intuitive graphical interfaces for accessing the datasets offered by DPIRD and SILO. Users can select multiple stations at once (Figure 2A) or a single station with more detailed query for both SILO and DPIRD (Figure 2B), retrieving data points and downloading it for further analysis.

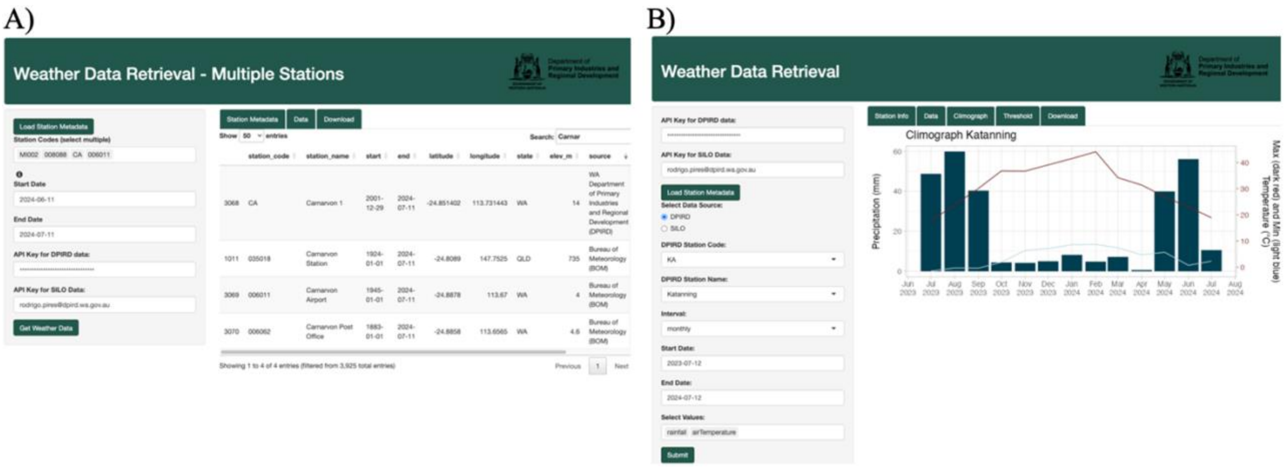

Figure 2. DPIRD weather retrieval dashboards to quickly view and download the data. Users can select multiple weather stations for daily data (A) or query a single station (B) by selecting custom variables and time intervals for DPIRD stations or custom daily data from SILO.

Conclusion

The ‘weatherOz’ R library described in this work offers R users with a single interface to access Australian climate and weather data sources providing a standardised way of easily querying and retrieving Australian climate and weather data. This package was developed with the intent to offer a unified interface that serves as a foundation to the development of other climate data tools such as web portals/dashboards, applications, and automated reporting functionality.

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