ASIA-PACIFIC SOLAR RESEARCH CONFERENCE

5-7 Dec 2023, RMIT, Melbourne

Enhancing Australia's Weather and Climate Data for Benchmarking Simulations

Huey Jean Tan[1], Trevor Lee[1] and David Ferrari[1]

[1]Exemplary Energy, Canberra, Australia
trevor.lee@exemplary.com.au

Introduction

This paper discusses the latest progress in weather and climate data for engineering and architectural simulations. These data are are distributed in a range of formats suited to various applications, but all are based on meteorological observations data acquired from the Bureau of Meteorology (BOM) and other sources where needed for timely data provision.

The data include hourly values of meteorological elements including solar radiation such as Global Horizontal Irradiation (GHI), Direct Normal Irradiation (DNI), Diffuse Horizontal Irradiation (DIF), Humidity (RH etc.), Wind Speed, Wind Direction, Cloud Cover, Temperature, and Pressure. They are utilised in applications that include estimating future energy performance, building tuning and commissioning, performance monitoring and verification, peak load estimation and moisture modelling, presented as Real-Time Years (RTY), Reference Meteorological Years (RMY)[1], eXtreme Meteorological Years (XMY) and Ersatz Future Meteorological Years (EFMY).

The application of RTY data in benchmarking simulations is particularly valuable for monitoring systems, as it facilitates the comparison of recent weather-dependent energy performance with historical average climate conditions. This underscores the necessity of precise and timely RTY datasets for effective management and optimisation of thermal and hygrothermal systems. Previous work for the development of XMY datasets had shown a clear trend of increasing average cooling load and decreasing heating over a period of 30 years, which are indicative of a warming climate (Tan et al, 2022). It is imperative to incorporate the likely future increase in cooling loads due to climate change impact into building energy simulations, which further emphasises the need for accurate and up-to-date weather and climate files.

Datasets are available in at least three formats: Typical Meteorological Year (TMY2, TMY3), EnergyPlus Weather (EPW), and Australian Climate Data Bank (ACDB). The ACDB dataset was developed by CSIRO in partnership with BOM, which conforms to the specific format required for the Nationwide House Energy Rating Scheme (NatHERS) software. The EPW dataset was developed for compatibility with simulation software such as EnergyPlus and ESP-r and has since been adopted as a quasi-standard format by many other building and solar system simulation tools. Presented in a text-based, comma-separated value (CSV) format, the EPW data set is based on data present in other weather datasets such as TMY2, which contains time-series meteorological measurements and modelled or actual solar radiation values, with occasional inferred and/or interpolated data when satellite or ground-based observations are absent in the source data.

The enhancements presented here are over and above the data previously developed by the authors which corrected the gross errors in data that continues to be published by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Details of those key flaws were outlined in (Tarquini et al. 2022).

[1] The base period for defining "averages" in RMY data can be selected according to the application, but typically incorporate between 10 and 30 of the most recent years. A detailed discussion is presented in (Trewin, 2007)

Real-Time Data Sources

To provide the latest weather data to our clients and allow extension of the Exemplary Weather and Energy (EWE) Index to all 8 capital cities, we subscribe to several sources for terrestrial observations and solar satellite data. Solcast's global solar database is utilised for solar satellite data, which has been successfully integrated into our products since May 2022. Solcast produces irradiance and weather data using high-resolution (1-2km) imagery from a range of geostationary meteorological satellites in five different positions to provide global coverage.

The BOM's terrestrial observations and gridded solar data are accessed for other less time-sensitive applications, which allows us to produce weather data time series in various formats to cover the period 1990-2022 for over 250 Australian locations and to create Reference Meteorological Year (RMY) climate data files.

Exemplary Weather and Energy Index

The Exemplary Weather and Energy (EWE) Index is a monthly free public service that shows a comparison of the RTY weather with the long-term average and the medium-term future climates, highlighting noteworthy results for each of the 8 capital cities. The EWE Index has been published through a monthly e-newsletter since 2014 and was recently converted into a weblog with interactive graphical capabilities to give users more control over the information displayed, thus enabling a self-tailored analysis. Readers can easily access and compare specific weather elements and simulation results for a 5 kW solar PV array, archetype 3-storey office, 10-storey office or ground-level supermarket which comply with the Deemed to Satisfy provision of the National Construction Code (NCC) 2019 Section J.

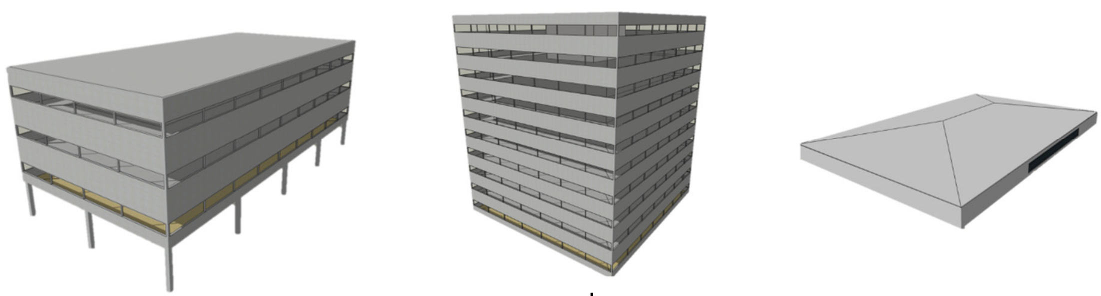

Figure 1. Graphical models of the archetypical buildings used in EWE simulations – a: 3-storey office building, b: 10-storey office building, c: Supermarket.

Recent Improvements: Precipitation and Cloud Cover

Accurate precipitation data is important across a wide variety of applications. In this context, the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) provides specifications for predicting, mitigating, or reducing moisture damage to buildings, requiring detailed consideration of wind-driven precipitation (AIRAH, 2020). Minimum condensation requirements were incorporated into the NCC in 2019, designed to control moisture impacts on occupant health, and these have been enhanced in the NCC 2022.

Several applications in the design and simulation of built environments require input of historical weather data, and the accuracy of these models increases proportionally with the resolution of the input weather data. Unfortunately, while verification by simulation is possible using accredited software such as WUFI®, there have been no reliable datasets which include precipitation in Australia in a recognised format and adequate temporal resolution – for example, while these tools require hourly or half-hourly datasets, observations were only reported as daily totals of precipitation by BOM prior to the early 2000s. The authors are collaborating with colleagues from University of NSW, University of Tasmania and AIRAH to estimate half-hourly precipitation data in our weather and climate datasets, which will greatly improve the ability to model moisture management in buildings and can also be applied to more accurately estimate the self-cleaning performance of renewable energy systems.

Further, we have enhanced our cloud cover estimates to provide more reliable cloud cover data for the whole range of weather and climate data services. While cloud cover data is already included in ACDB, TMY2 and EPW files, these are often inferred from satellite-derived solar data and the ASHRAE clear sky model. Our in-house software now utilises half-hourly ceilometer data from the BOM for cloud cover in eighths of the sky (oktas) and in Meteorological Aerodrome Reports (MetAR).

A rigorous QA process has been implemented to ensure the accuracy and reliability of our weather data. This process involves a close examination of the raw data we receive from various sources and code reviews of our in-house software “ClimateCypher”. To give an example, Figure 2 demonstrates a problem that was identified in the raw data during our QA procedure, and Figure 3 shows the improved output that is better aligned with the expected results after the code was adjusted to work around an issue originating in the raw data. Our QA process also allows for peer review and feedback to our data providers (in this particular case, the BOM).

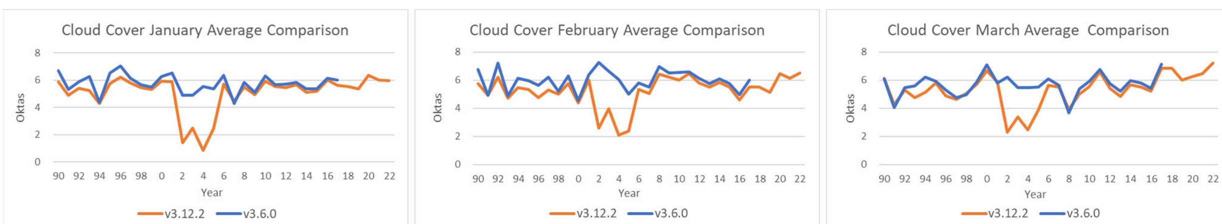

Figure 2. Comparison of cloud cover output data for Sydney from 1990-2022 with the version of our software used for the 2017 production run revealed aberrant cloud cover estimates originating from the raw data obtained by the BOM

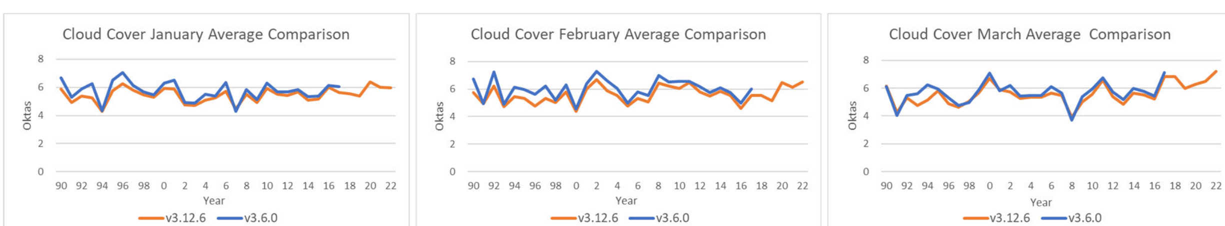

Figure 3. The improved cloud cover output for Sydney for the 1990-2022 period after adjustment to our code to work around the problem in the raw data

It is imperative to employ future weather data in building simulation to facilitate climate change adaptation. The advancements in weather and climate data provision outlined in this paper demonstrate a clear path forward for building and renewable energy system designers and facility managers. By improving the accuracy and relevance of the datasets through a combination of satellite-derived estimates and terrestrial observations, benchmarking simulations, refinement of cloud cover estimates and inclusion of precipitation data, the energy efficiency of buildings can be optimised and the risk of moisture damage can be reduced. These enhancements will be a valuable tool for making data-driven decisions about the performance of properties and systems, and guide the optimisation of commercial buildings and solar systems operation by owners and managers. Ultimately, these improvements advance the field towards more cost-effective, sustainable and energy-efficient practices.

References

AIRAH, 2020, *'DA07 Criteria for Moisture Control Design Analysis in Buildings',* Design Application Manual

Lee T., 2011, 'Climate data for building optimisation in design and operation in Australia', *Proceedings of Building Simulation 2011: 12th Conference of International Building Performance Simulation Association*, 14-16 November, Sydney

Tan H. J., Lee T. and Ferrari D., 2022, 'Extreme Climate Data Files for Design Resilience', *Asia-Pacific Solar Research Conference 2022,* 29 November – 1 December 2022, Newcastle, Australia.

Tarquini, D., Lee, T., and Ferrari, D., 2022, 'Quality Assurance of Available Meteorological Data', *Asia-Pacific Solar Research Conference 2022,* 29 November – 1 December 2022, Newcastle, Australia.

Trewin, B., 2007. 'The role of climatalogical normals in a changing climate', World Meteorological Association, Geneva. Edited by Baddour, O., and Kontongomde, H.