From little things, BIG things grow

Two years of misleading HVAC simulations exposed[i]

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On 7 July, under the guise of the insignificant heading “CSIRO weather files for building energy modelling – update”, the CSIRO Data Shop notified users of an “update” to its “weather files” (sic)[iii]. The email described in detail changes to the way in which timestamps are mapped from NatHERS climate files to the .epw format for use in non-residential building energy simulations, a change in how the irradiation data is timestamped and an update to the User Guide which reflects these changes. Unhelpfully, the “update” advises that “some of these datasets” have been corrected (without saying which ones)[iv]. Even now, the CSIRO source describes them as ‘old’ and ‘new’ rather than the explicit and helpful ‘skewed’ and ‘corrected’. There is nothing new about the ‘new’ data.

The title of an “update” is grossly misleading, at best, but the detail confirms what has been known by scientists, engineers, industry and professional associations and bureaucrats for over two years: the original data contains gross errors which we estimate are responsible for 100,000 misleading simulations with serious implications for developers, building operators and the renewable energy and HVAC industries.

Background

Since August 2021, the CSIRO has distributed three important weather and climate datasets for use by building energy modellers:

- Typical Meteorological Year (TMY) – a collation of selected meteorological measurements, listing data at 8,760 hourly intervals to describe a ‘typical’ year of weather for a specific location. This data is published in the EnergyPlus (.epw) format and is available at https://acds.csiro.au/future-climate-typical-meteorological-year.
- Reference Meteorological Years (RMY) – conceptually representing the same information as TMY but presented in an amended version of the fixed record format of the Australian Climate Data Bank (ACDB). This data is the basis for climate information in the Nationwide House Energy Rating Scheme (NatHERS) software tools and is distributed with the CSIRO’s AccuRate software and its competitors (all using the same CHENATH computation “engine”).
- Predictive weather files – CSIRO’s predictive weather files are based on a typical meteorological year of historical weather data drawn from 1990 to 2015 and can be used to investigate the likely impact of climate change on building energy consumption. These are available in .epw and NatHERS-compatible formats at https://acds.csiro.au/future-climate-predictive-weather.

As the basis for NatHERS, the CSIRO’s RMY dataset is arguably the most commonly-applied pathway to demonstrate compliance with the residential energy efficiency requirements of the National Construction Code (NCC). With its transcription to the .epw format, closely related data is commonly used for simulations of commercial buildings that

are used to demonstrate compliance with section JV3 of the NCC, as well as simulations for other purposes.

A litany of major errors

We undertook a detailed review of the CSIRO data sets shortly after they were published in 2021. Our work revealed three major shortcomings:

1. Reliance on old weather data which fails to characterise recent trends in a warming climate;
2. Blatant timing errors across most weather elements in the .epw format; and
3. A lack of coincident precipitation data despite the .epw format expressly inviting it.

Old data

The first issue is well-known: The CSIRO files are derived from historical data to December 2015. This was a conscious choice made in the interests of aligning the .epw data to data used in the NatHERS scheme.[v]

In a warming climate, this decision means that the data fails to account for the hottest years, resulting in a dataset that is representative of a cooler climate than what future buildings should be designed to expect. It is imperative for the NCC to accurately reflect real weather conditions. In a changing climate, this can only be achieved using regular updates that incorporate recent observations.

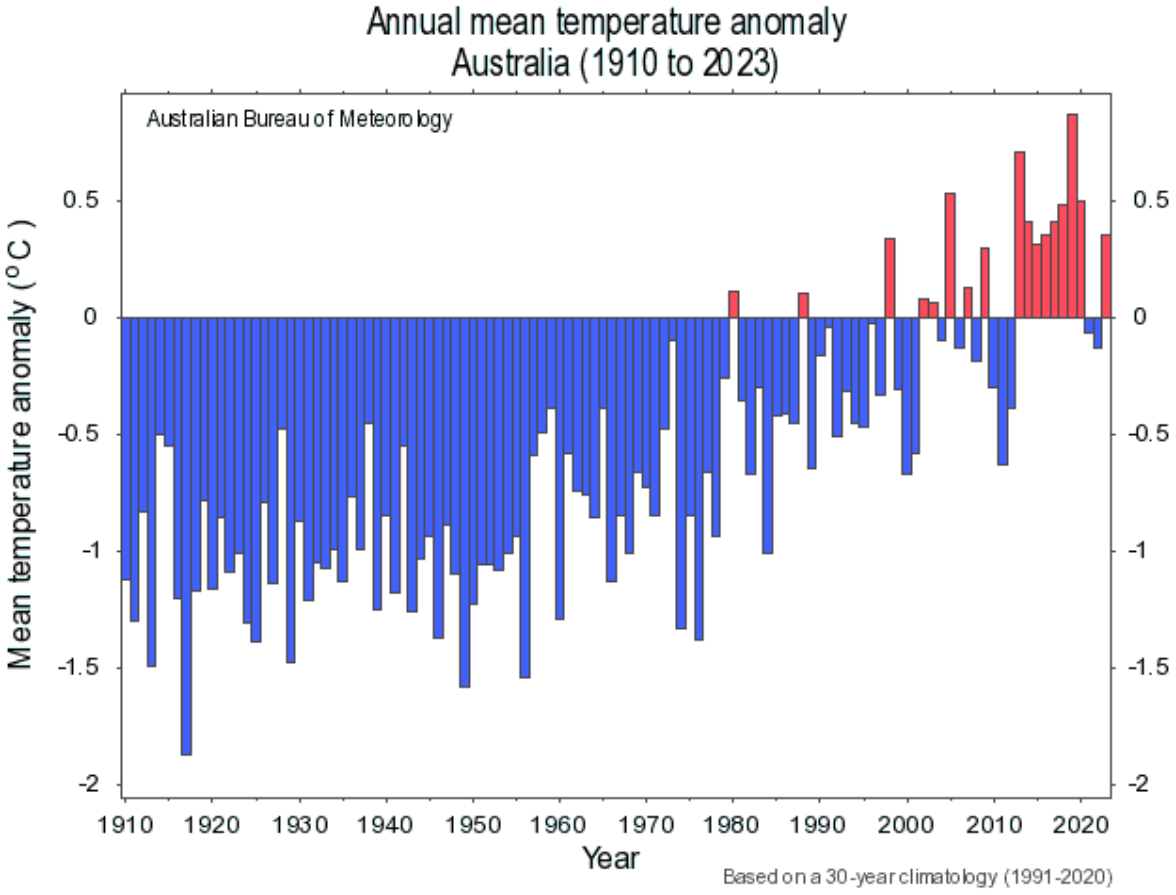


Figure 1: Source http://www.bom.gov.au/cgi-bin/climate/change/timeseries.cgi?graph=tmean&area=aus&season=0112&ave_yr=1&ave_period=9120

There is no reason for the accuracy of commercial building modelling to be held in the past on the basis of perceived administrative challenges in the NatHERS system

Timing errors

One of the key differences between the .epw and NatHERS formats relates to the timestamp applied to solar irradiation data: the .epw format requires that the solar irradiation data represents the period prior to the timestamp, whereas the NatHERS format specifies that the solar irradiation represents the hour centred on the timestamp. Failure to adjust to this time convention most notably affects the time of peak loading, and has major impacts on evaluations which incorporate on-site renewable energy generation. The differences between formats mean that the transcription is non-trivial and is grossly flawed regardless of the method.

On the other hand, the transcription of instantaneous elements such as dry bulb temperature, dew point and wind speed should be straightforward as it only involves an adjustment of the timestamp. However, CSIRO had introduced a 60-minute offset error[vi] in all non-solar weather elements including dry bulb, dew point, atmospheric pressure and wind.

When we applied these data to a simulation of a 3-storey office building in Canberra, the corrected data resulted in increased cooling by 4.4% and increased peak cooling load by 3.3%, along with a 30-minute timing offset in the peak cooling load. A full annual analysis was presented to the AIRAH/IBPSA *Australasian Building Simulation 202*2 Conference, Brisbane, 20-21July 2022, but seems to have been universally ignored when this sort of sensitivity analysis should have been applied by the CSIRO to all 69 locations to establish the magnitude of the error. Exemplary even devised a workaround interim measure of tweaking the operating hours of the building model to bring them into line with the non-solar weather elements but that ‘fix’ remained off the radar.

This information was expanded in scope and published through the Asia Pacific Solar Research Conference and the World Renewable Energy Forum later that year.

Lack of precipitation data

Precipitation data is important for a wide variety of applications. Since 2019, minimum performance requirements for managing condensation have been incorporated into the NCC, designed to minimise impacts related to moisture on the health of the occupants in the building. AIRAH DA07, Criteria for Moisture Control Design Analysis in Buildings, provides specifications for predicting, mitigating, or reducing moisture damage to buildings, and requires detailed consideration of precipitation.

One challenge is that, until recently, many sources of precipitation data are reported at inadequate temporal resolutions. However, a number of commercial providers including Exemplary Energy are now able to supply the hourly data needed for simulation purposes using tools such as WUFI.

Moving forward

The issues outlined herein need to be considered by policymakers and modellers alike.

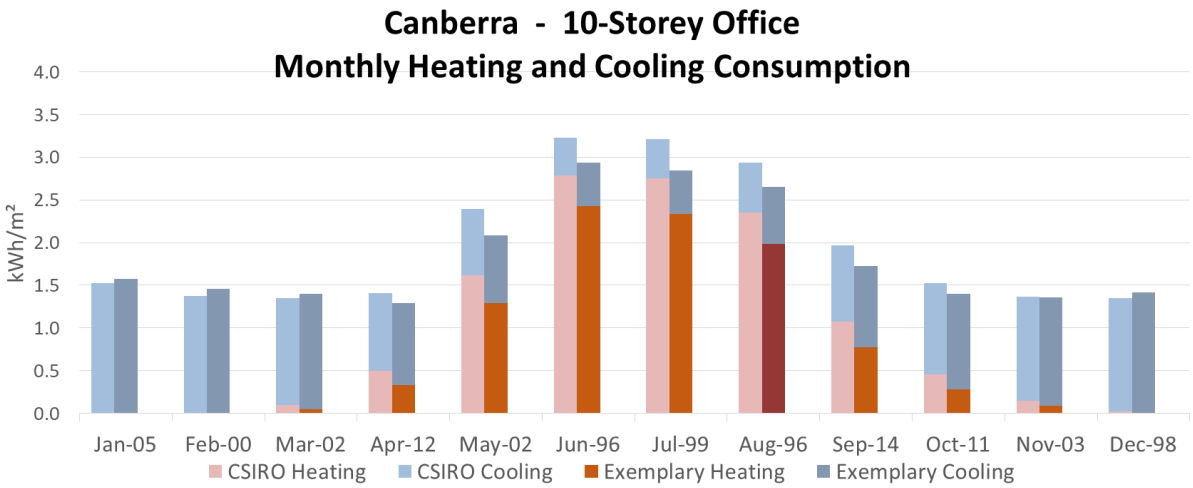
However, it is not the errors themselves that are most worrisome, it is the fact that we had advised our colleagues at CSIRO, ABCB and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) and its predecessor DISR of these

findings well over two years ago, warning of the risks of propagating the errors and offering our support to improve the data going forward. Our appeals appeared to fall on deaf ears. When it became apparent that we were being ignored within the bureaucracy, we elected to publish our concerns both on our blog and in peer reviewed forums.[vii]

The erroneous data was used as the basis for the *CSIRO Projected Weather Files* (again, actually climate files) which were applied in simulations for the Consultation Regulation Impact Statement (CRIS) for the J1V3 proposal for NCC 2025, making the simulation results potentially misleading and counterproductive. Clearly, this creates an urgent need for a sensitivity analysis to establish the effect of the errors on the conclusions of the CRIS and we said so during the public consultation stage of the draft NCC 2025.

It is a positive move for the corrections to have now been published, but to describe them as an "update" suggests an attempt at hiding the significance of the errors two years after the fact. We estimate that 1,000 simulations were undertaken each week using this data, so the errors are now responsible for 100,000 misleading simulations with serious implications for developers, building operators and the HVAC industry.

We chose our own Canberra climate for parochial reasons. Because the error has the building nominally being conditioned for an extra hour in the cool/cold of the morning and one hour less in the warmth/heat of the afternoon, warmer places should get underestimations of energy consumption, mostly cooling, instead.



This Figure was presented by the author at the AIRAH/IBPSA *Australasian Building Simulation 2022* Conference, Brisbane, 20-21July 2022, but seems to have been universally ignored.

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[i] First published by "Climate Control News" (CCN) 13 August 2024 with the title 'Misleading HVAC data' accessible here.

[ii] In the interests of full disclosure, we note that Exemplary Energy offers high quality climate and weather data, including ersatz future climate data and quasi-real-time recent weather data that have always avoided the issues of the CSIRO datasets. These are available for modellers demonstrating compliance through the JV3 pathway under the current NCC, along with non-regulatory applications in design and optimisation and resilience testing of buildings and energy systems.

[iii] Here, the CSIRO Data Shop makes another error: **Weather** is what you actually get, got or are forecast to get. **Climate** is what you expect to get, inferred from a long enough record of actual

weather. The data available through the service is all Climate data, but CSIRO have given their products the erroneous title “weather data”.

iv The notice even shows scientific semi-literacy by referring to Global Horizontal Radiation when the correct jargon is GHI Global Horizontal Irradiation

[v] Bureaucrats in the NatHERS system believe this data cannot be updated without undertaking a major regulatory impact study; rather than just tweak the NatHERS starband thresholds (MJ/m^2) to keep the stringency of the design and construction requirements unchanged.

[vi] NatHERS files allot the day into 24 hours from 0 to 23 with 0 being midnight. EPW files allot the day into 24 hours from 1 to 24 with 24 being midnight. Both are correct, but transposing the data in the first line of a NatHERS file to the first line of its EPW equivalent makes every value wrong by one hour. Sadly, that is what CSIRO did.

[vii] References:

Mahmoodi, M., Kodagoda , C., Hameed, N. A., Lee, T., Anderson, G. (2022) Disaggregation of Precipitation Data and the Importance of Data Time Convention. Australasian Building Simulation 2022 Conference, July 20-21 2022, Brisbane Australia

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