Australia's National
Science Agency

Projected weather files for building energy modelling

User Guide

Zhengen Ren, Zhi Tang, Melissa James

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Important disclaimer

Contents

Figures

Tables

Document History

DATE	VERSION NO	DESCRIPTION
2024-06-26	7	Change in way time mapped from NatHERS to .epw format; Change in how base radiation data obtained for .epw dataset; Addition of this document history table
2024-08-21	8	New .epw dataset published to fix formatting issues in .epw dataset: year format ‘yy’ changed to ‘yyyy’; ‘DAYLIGHT SAVING’ in header changed to ‘DAYLIGHT SAVINGS’

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1 Introduction

This report describes the development of projected weather files suitable for use by building energy simulation software. These files were created in response to growing demand for weather data suitable for exploring the impact of climate change on the built environment.

In 2020, Chen et al. developed projected weather files suitable for use in non-regulatory residential building energy simulations which use Nationwide House Energy Rating Scheme (NatHERS) software (Chen et al. 2021). Projected changes under three future climate change scenarios were applied to Reference Meteorological Year (RMY) weather data. To make these files suitable for use by software such as EnergyPlus, ESP-r and IESVE some parameters were added, and the file was converted to the format (.epw) required by the software. Figure 1 gives an overview of the process used to create the projected weather files.

Section 2 of this report describes the projected weather datasets. Section 3 describes the CSIRO methodology for constructing projected weather data. Section 4 describes the transformations necessary for converting the projected weather files suitable for NatHERS software to the format and content required by software such as EnergyPlus, ESP-r, and IESVE (in .epw format).

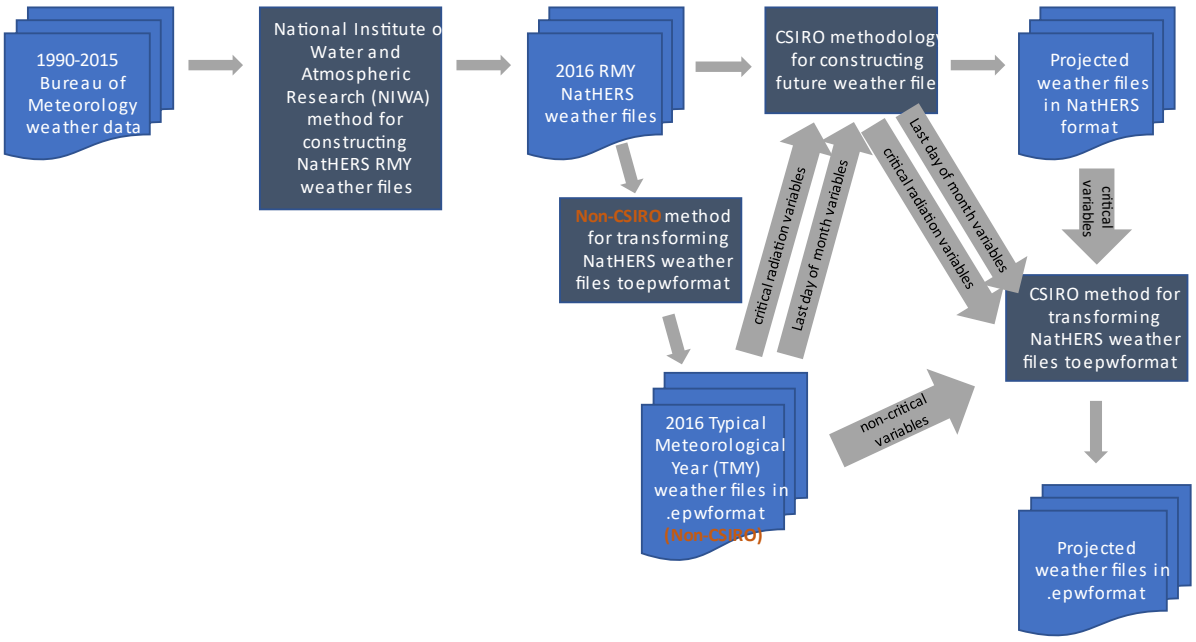

Figure 1 Overview of creation of weather files

2 The datasets

There are 2 projected weather datasets: 'Projected weather files in .epw format' and 'Projected weather files in NatHERS format'. Each dataset consists of 996 text files in a single zip file. Each text file contains one year of weather data in hourly intervals.

Each text file contains hourly weather data for one of 83 Australian locations, under one of 3 future climate scenarios (RCP2.6, RCP4.5, or RCP8.5), for one of 4 future years (2030, 2050, 2070, or 2090).

The Representative Concentration Pathway (RCP) climate projections reflect a range of possible climate futures with varying levels of anthropogenic greenhouse gas and aerosol (hereafter collectively referred to as GHG) emissions, atmospheric GHG concentrations, and the resultant increase in radiative forcing (Figure 2). In RCP2.6, atmospheric GHG emissions peak around 2020 then rapidly decline in line with strong emission reduction measures and active removal of GHGs from the atmosphere. In RCP4.5, GHG emissions peak in 2040, while RCP8.5 reflects a future with increased reliance on fossil-fuelled energy and little curbing of overall GHG emissions (van Vuuren et al. 2011).

The projected weather data are based on a typical meteorological year of historical weather data drawn from the years 1990 to 2015. Global Climate Models and morphing were applied to this data to project the future values under each climate scenario at each location.

The data are available in two text-based file formats:

- As .epw files that can be used by building simulation software such as EnergyPlus, ESP-r, and IESVE
- In a weather file format suitable for building simulations using NatHERS software such as AccuRate, BERSPro, FirstRate5, and HERO in **non-regulatory** mode. **Note that these files are NOT for use in a regulatory setting.**

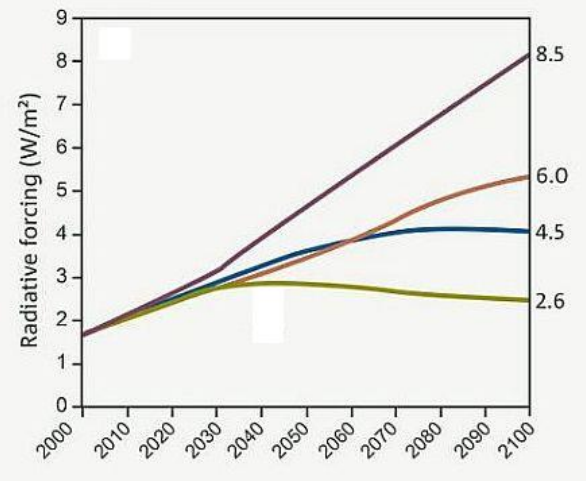

Figure 2 Resultant radiative forcing change under different RCP scenarios. SOURCE: CSIRO and Bureau of Meteorology, Australia (2015)

2.1 Accessing the datasets

The projected weather datasets are available in the CSIRO AgData Shop at this URL address: https://agdatashop.csiro.au/future-climate-predictive-weather.

2.2 Zip file structure

The text files in the zip file are arranged under the following directory hierarchy:

Location (83 locations)

Climate Scenario (RCP2.6, RCP4.5, & RCP8.5)

Future Year (2030, 2050, 2070, & 2090)

2.3 File naming

Each of the 996 files in the dataset has a unique name of the form:

*nn*_CZ*mmmm*_*aa*_NH16_*b*MY_RCP*rr*_*yyyy*_*ggg*.*ccc*

For example:

60_CZ0607_TU_NH16_TMY_RCP26_2030_Cnr.epw

Where:

nn = NatHERS climate zone

mmmm = Australian Climate Data Bank (ACDB) climate zone

aa = Location name code

b = 'T' (if .epw format) or 'R' (if NatHERS format)

rr = RCP number (without decimal point)

yyyy = future year

ggg = Global Climate Model used for projection

ccc = 'epw' (if .epw format) or 'txt' (if NatHERS format)

2.4 Locations

Projected weather files exist for 83 locations around Australia (Table 1).

Table 1 Locations

NATHERS CLIMATE ZONE	ACDB CLIMATE ZONE	LOCATION NAME CODE	LOCATION NAME	POSTCODE	STATE	LONGITUDE	LATITUDE
1	CZ0101	DA	Darwin	800	NT	130.9	-12.4
2	CZ0110	HE	Pt Hedland	6721	WA	118.6	-20.4
3	CZ0304	LO	Longreach	4730	QLD	144.3	-23.4
4	CZ0307	CR	Carnarvon	6701	WA	113.7	-24.9
5	CZ0109	TO	Townsville	4810	QLD	146.8	-19.3

NATHERS CLIMATE ZONE	ACDB CLIMATE ZONE	LOCATION NAME CODE	LOCATION NAME	POSTCODE	STATE	LONGITUDE	LATITUDE
6	CZ0306	AL	Alice Springs	870	NT	133.9	-23.8
7	CZ0202	RO	Rockhampton	4700	QLD	150.5	-23.4
8	CZ0404	MO	Moree	2400	NSW	149.9	-29.5
9	CZ0206	AM	Amberley	4306	QLD	152.7	-27.6
10	CZ0205	BR	Brisbane	4000	QLD	153.1	-27.4
11	CZ0207	CH	Coffs Harbour	2450	NSW	153.1	-30.3
12	CZ0503	GE	Geraldton	6530	WA	114.7	-28.8
13	CZ0505	PE	Perth	6000	WA	115.9	-31.9
14	CZ0701	AA	Armidale (old Tamworth)	2350	NSW	151.7	-30.5
15	CZ0509	WE	Williamtown	2300	NSW	151.8	-32.8
16	CZ0514	AD	Adelaide	5000	SA	138.6	-34.9
17	CZ0512	SY	Sydney RO (Observatory Hill)	2000	NSW	151.2	-33.9
18	CZ0604	NO	Nowra	2541	NSW	150.5	-35
19	CZ0310	CV	Charleville	4470	QLD	146.3	-26.4
20	CZ0414	WA	Wagga	2650	NSW	147.5	-35.2
21	CZ0609	ME	Melbourne RO	3000	VIC	145	-37.8
22	CZ0612	SE	East Sale	3852	VIC	147.1	-38.1
23	CZ0707	LT	Launceston (Ti Tree Bend)	7250	TAS	147.1	-41.4
24	CZ0703	CA	Canberra	2600	ACT	149.2	-35.3
25	CZ0801	CM	Cabramurra (old Alpine)	2629	NSW	148.4	-35.9
26	CZ0709	HO	Hobart	7000	TAS	147.5	-42.8
27	CZ0413	MI	Mildura	3500	VIC	142.1	-34.2
28	CZ0602	RI	Richmond	2753	NSW	150.8	-33.6
29	CZ0102	WP	Weipa	4874	QLD	141.9	-12.7
30	CZ0104	WY	Wyndham	6740	WA	128.1	-15.5
31	CZ0105	WS	Willis Island	4871	QLD	150	-16.3
32	CZ0106	CN	Cairns	4870	QLD	145.8	-16.9
33	CZ0108	BM	Broome	6725	WA	122.2	-18
34	CZ0111	LM	Learmonth	6707	WA	114.1	-22.2
35	CZ0201	MK	Mackay	4740	QLD	149.2	-21.1
36	CZ0203	GL	Gladstone	4680	QLD	151.3	-23.9
37	CZ0301	HA	Halls Creek	6770	WA	127.7	-18.2
38	CZ0302	TE	Tennant Creek	860	NT	134.1	-19.6
39	CZ0303	IS	Mt Isa	4825	QLD	149.2	-21.1
40	CZ0305	NE	Newman	6753	WA	119.7	-23.4
41	CZ0401	GI	Giles	6438	WA	128.3	-25
42	CZ0402	MT	Meekatharra	6642	WA	118.5	-26.6

NATHERS CLIMATE ZONE	ACDB CLIMATE ZONE	LOCATION NAME CODE	LOCATION NAME	POSTCODE	STATE	LONGITUDE	LATITUDE
43	CZ0403	OO	Oodnadatta	5734	SA	135.5	-27.6
44	CZ0406	KA	Kalgoorlie	6430	WA	121.5	-30.8
45	CZ0408	WO	Woomera	5720	SA	136.8	-31.2
46	CZ0409	CO	Cobar	2835	NSW	145.8	-31.5
47	CZ0410	BI	Bickley	6076	WA	116.1	-32
48	CZ0411	DU	Dubbo	2830	NSW	148.6	-32.2
49	CZ0412	KT	Katanning	6317	WA	117.6	-33.7
50	CZ0501	OA	Oakey	4401	QLD	151.7	-27.4
51	CZ0504	FO	Forrest	6434	WA	128.1	-30.8
52	CZ0506	SW	Swanbourne	6010	WA	115.8	-32
53	CZ0507	CE	Ceduna	5690	SA	133.7	-32.1
54	CZ0508	MD	Mandurah	6210	WA	115.7	-32.5
55	CZ0510	EP	Esperance	6450	WA	121.9	-33.8
56	CZ0513	MA	Mascot (Sydney Airport)	2020	NSW	151.2	-33.9
57	CZ0603	MJ	Manjimup	6258	WA	116.1	-34.2
58	CZ0605	AB	Albany	6330	WA	117.8	-35
59	CZ0606	ML	Mt Lofty	5240	SA	138.7	-35
60	CZ0607	TU	Tullamarine (Melbourne Airport)	3020	VIC	144.9	-37.7
61	CZ0610	MG	Mt Gambier	5290	SA	140.8	-37.8
62	CZ0611	MR	Moorabbin	3189	VIC	145.1	-38
63	CZ0613	WR	Warrnambool	3280	VIC	142.4	-38.3
64	CZ0614	OT	Cape Otway	3220	VIC	143.5	-38.9
65	CZ0702	OR	Orange	2800	NSW	149.1	-33.4
66	CZ0705	BA	Ballarat	3350	VIC	143.8	-37.5
67	CZ0706	LD	Low Head	7253	TAS	146.8	-41.1
68	CZ0708	LU	Launceston Airport	7120	TAS	147.2	-41.5
69	CZ0802	TH	Thredbo (Village)	2625	NSW	148.3	-36.5
70	CZ0502	TW	Toowoomba	4350	QLD	151.9	-27.6
71	CZ0107	AT	Atherton	4880	QLD	145.5	-17.3
72	CZ0405	RX	Roxby Downs	5725	SA	136.9	-30.5
73	CZ0204	MN	Maleny	4552	QLD	152.9	-26.8
74	CZ0103	KN	Katherine	853	NT	132.3	-14.4
75	CZ0515	AC	Adelaide Coastal (AMO)	5950	SA	138.5	-35
76	CZ0407	TA	Tamworth	2340	NSW	150.8	-31.1
77	CZ0511	PA	Parramatta	2200	NSW	151	-33.8
78	CZ0704	SU	Sub-Alpine (Cooma Airport)	2630	NSW	149	-36.3
79	CZ0601	BL	Blue Mountains	2785	NSW	149	-21.5

NATHERS CLIMATE ZONE	ACDB CLIMATE ZONE	LOCATION NAME CODE	LOCATION NAME	POSTCODE	STATE	LONGITUDE	LATITUDE
80	CZ0608	CS	Coldstream	3770	VIC	145.4	-37.7
81	CZ0516	BU	Busselton	6280	WA	115.4	-33.7
82	CZ0208	GM	Glasshouse mountains	4519	QLD	153	-27
83	CZ0112	XI	Christmas Island	6798	WA	96.8	-12.2

2.5 EnergyPlus weather file (.epw) format

The EnergyPlus weather file format (.epw) is a comma separated values (CSV) text format where variable values are separated by commas. The file structure is shown in Table 2. A sample of the data is shown in Figure 3.

The format is based on TMY2 which is a strict, position-specific format, with missing data filled with nines. SI units were used for all the data. Each weather file has basic (header) information followed by time step data.

The first eight lines provide basic information, including longitude, latitude, time zone, elevation, annual design conditions, monthly average ground temperatures, typical and extreme periods, holidays/daylight savings periods, and data periods.

The remaining lines provide time step data, including Dry Bulb Temperature, Dew Point Temperature, Relative Humidity, Atmospheric Station Pressure, Radiation (Extraterrestrial Horizontal, Extraterrestrial Direct Normal, Horizontal Infrared Radiation from Sky, Global Horizontal, Direct Normal, Diffuse Horizontal), Illuminance (Global Horizontal, Direct Normal, Diffuse Horizontal, Zenith), Wind (Direction, Speed), Sky Cover (Total, Opaque, Visibility, Ceiling Height), Present Weather (Observation, Codes), Precipitable Water, Aerosol Optical Depth, and Snow (Depth, Days Since Last Snowfall).

2.6 NatHERS weather file format

The NatHERS weather file has a position-specific text format. The file structure is shown in Figure 4. A sample of the data is shown in Figure 5

Weather data includes dry bulb temperature, absolute humidity, atmospheric pressure, wind (speed, direction), solar radiation (global, direct, diffuse), cloud cover, solar altitude, and solar azimuth.

Table 2 EnergyPlus (.epw) weather file format (adapted from Crawley, Lawrie and Hand, 1999)

LOCATION, A1 [City], A2 [State Province Region], A3 [Country], A4 [Data Source], N1 [WMO Number], N2 [Latitude {+N –S: -90.0 to +90.0: degrees minutes in decimal}], N3 [Longitude {-W +E: -180.0 to +180.0:degrees minutes in decimal}], N4 [Time Zone {-12.00 to +12.00: GMT-12 to GMT+12: partial hours in decimal}], N5 [Elevation {m: -1000.0 to +9999.9}],

DESIGN CONDITIONS, N1 [Annual Extreme Daily Mean Maximum Dry Bulb Temp {C}], N2 [Annual Extreme Daily Mean Minimum Dry Bulb Temp {C}], N3 [Annual Extreme Daily Standard Deviation Maximum Dry Bulb Temp {C}], N4 [Annual Extreme Daily Standard Deviation Minimum Dry Bulb Temp {C}], N5 [99.6% Heating Dry Bulb Temp {C}], N6 [99% Heating Dry Bulb Temp {C}],N7 [98% Heating Dry Bulb Temp {C}],N8 [0.4% Cooling Dry Bulb Temp {C}], N9 [0.4% Mean Coincident Wet Bulb Temp{C}], N10 [1.0% Cooling Dry Bulb Temp {C}], N11 [1.0% Mean Coincident Wet Bulb Temp {C}], N12 [2.0% Cooling Dry Bulb Temp {C}], N13 [2.0% Mean Coincident Wet Bulb Temp {C}], N14 [0.4% Cooling Dew Point Temp {C}], N15 [0.4% Mean Coincident Dry Bulb Temp {C}], N16 [0.4% Humidity Ratio {g/kg}], N17 [0.4% Relative Humidity], N18 [1.0% Cooling Dew Point Temp {C}], N19 [1.0% Mean Coincident Dry Bulb Temp {C}], N20 [1.0% Humidity Ratio {g/kg}], N21 [1.0% Relative Humidity], N22 [2.0% Cooling Dew Point Temp {C}], N23 [2.0% Mean Coincident Dry Bulb Temp {C}], N24 [2.0% Humidity Ratio {g/kg}], N25 [2.0% Relative Humidity], N26 [Daily Range of Dry Bulb Temp {C}], N27 [Heating Degree Days Base Temp {C}], N28 [Heating Degree Days], N29 [Cooling Degree Days Base Temp {C}], N30 [Cooling Degree Days]

TYPICAL/EXTREME PERIODS, N1 [Number of Typical/Extreme Periods], A1[Typical/Extreme Period 1], A2 [Period 1 Start Day], A3 [Period 1 End Day], A4 [Typical/Extreme Period 2], A5 [Period 2 Start Day], A6 [Period 2 End Day], A7 [Typical/Extreme Period 3], A8 [Period 3 Start Day], A9 [Period 3 End Day], A10 [Typical/Extreme Period 4], A11 [Period 4 Start Day], A12 [Period 4 End Day], A13 [Typical/Extreme Period 5], A14 [Period 5 Start Day], A15 [Period 5 End Day], A16 [Typical/Extreme Period 6], A17 [Period 6 Start Day], A18 [Period 6 End Day], A19 [Typical/Extreme Period 7], A20 [Period 7 Start Day], A21 [Period 7 End Day], A22 [Typical/Extreme Period 8], A23 [Period 8 Start Day], A24 [Period 8 End Day]

GROUND TEMPERATURES, N1 [Number of Ground Temp Depths], N2 [Ground Temp Depth 1 {m}], N3 [Depth 1 Soil Conductivity {W/(mK)}], N4 [Depth 1 Soil Density {kg/m3}], N5 [Depth 1 Soil Specific Heat {kJ/(kgK)}], N6 [Depth 1 January Average Ground Temp {C}], N7 [Depth 1 February Average Ground Temp {C}], N8 [Depth 1 March Average Ground Temp {C}], N9 [Depth 1 April Average Ground Temp {C}], N10 [Depth 1 May Average Ground Temp {C}], N11 [Depth 1 June Average Ground Temp {C}], N12 [Depth 1 July Average Ground Temp {C}], N13 [Depth 1 August Average Ground Temp {C}], N14 [Depth 1 September Average Ground Temp {C}], N15 [Depth 1 October Average Ground Temp {C}], N16 [Depth 1 November Average Ground Temp {C}], N17 [Depth 1 December Average Ground Temp {C}], N18 [Ground Temp Depth 2{m}], N19 [Depth 2 Soil Conductivity {W/(mK)}], N20 [Depth 2 Soil Density {kg/m3}], N21 [Depth 2 Soil Specific Heat {kJ/(kgK)}], N22 [Depth 2 January Average Ground Temp {C}], N23 [Depth 2 February Average Ground Temp {C}], N24 [Depth 2 March Average Ground Temp {C}], N25 [Depth 2 April Average Ground Temp {C}], N26 [Depth 2 May Average Ground Temp {C}], N27 [Depth 2 June Average Ground Temp {C}], N28 [Depth 2 July Average Ground Temp {C}], N29 [Depth 2 August Average Ground Temp {C}], N30 [Depth 2 September Average Ground Temp {C}], N31 [Depth 2 October Average Ground Temp {C}], N32 [Depth 2 November Average Ground Temp {C}], N33 [Depth 2 December Average Ground Temp {C}], N34 [Ground Temp Depth 3 {m}], N35 [Depth 3 Soil Conductivity {W/(mK)}], N36 [Depth 3 Soil Density {kg/m3}], N37 [Depth 3 Soil Specific Heat {kJ/(kgK)}], N38 [Depth 3 January Average Ground Temp {C}], N39 [Depth 3 February Average Ground Temp {C}], N40 [Depth 3 March Average Ground Temp {C}], N41 [Depth 3 April Average Ground Temp {C}], N42 [Depth 3 May Average Ground Temp {C}], N43 [Depth 3 June Average Ground Temp {C}], N44 [Depth 3 July Average Ground Temp {C}], N45 [Depth 3 August Average Ground Temp {C}], N46 [Depth 3 September Average Ground Temp {C}], N47 [Depth 3 October Average Ground Temp {C}], N48 [Depth 3 November Average Ground Temp {C}], N49 [Depth 3 December Average Ground Temp {C}]

HOLIDAYS/DAYLIGHT SAVINGS, A1 [Day of Week], A2 [Daylight Savings Start Day], A3 [Daylight Savings End Day], N1 [Number of Holidays, A4 [Holiday 1 Name], A5 [Holiday 1 Day], … , Ax [Holiday N Name], Ay [Holiday N Day]

COMMENTS 1, A1 [Comments 1]

COMMENTS 2, A1 [Comments 2]

DATA PERIODS, N1 [Number of Data Periods], A1 [Data Period 1 Name/Description], A2 [Data Period 1 Start Day], A3 [Data Period 1 End Day], A4 [Data Period 2 Name/Description], A5 [Data Period 2 Start Day], A6 [Data Period 2 End Day], A7 [Data Period 3 Name/Description], A8 [Data Period 3 Start Day], A9 [Data Period 3 End Day], A10 [Data Period 4 Name/Description], A11 [Data Period 4 Start Day], A12 [Data Period 4 End Day], A13 [Data Period 5 Name/Description], A14 [Data Period 5 Start Day], A15 [Data Period 5 End Day], A16 [Data Period 6 Name/Description], A17 [Data Period 6 Start Day], A18 [Data Period 6 End Day], A19 [Data Period 7 Name/Description], A20 [Data Period 7 Start Day], A21 [Data Period 7 End Day], A22 [Data Period 8 Name/Description], A23 [Data Period 8 Start Day], A24 [Data Period 8 End Day], A25 [Data Period 9 Name/Description], A26 [Data Period 9 Start Day], A27 [Data Period 9 End Day], A28 [Data Period 10 Name/Description], A29 [Data Period 10 Start Day], A30 [Data Period 10 End Day], A31 [Data Period 11 Name/Description], A32 [Data Period 11 Start Day], A33 [Data Period 11 End Day], A34 [Data Period 12 Name/Description], A35 [Data Period 12 Start Day], A36 [Data Period 12 End Day]

N1 [Year], N2 [Month {1-12}], N3 [Day {1-31}], N4 [Hour {0-23}], N5 [Minute {0-59}], A1 [Data Source and Uncertainty Flags], N6 [Dry Bulb Temp {C}],N7 [Dew Point Temp {C}], N8 [Relative Humidity {0.0 to 1.0}], N9 [Atmospheric Station Pressure {mb}], N10 [Extraterrestrial Horizontal Radiation {Wh/m2}], N11 [Extraterrestrial Direct Normal Radiation {Wh/m2}], N12 [Horizontal Infrared Radiation from Sky {Wh/m2}], N13 [Global Horizontal Radiation {Wh/m2}], N14 [Direct Normal Radiation {Wh/m2}], N15 [Diffuse Horizontal Radiation {Wh/m2}], N16 [Global Horizontal Illuminance {lux}], N17 [Direct NormalIlluminance {lux}],N18 [Diffuse Horizontal Illuminance {lux}], N19 [Zenith Luminance {Cd/m2}], N20 [Wind Direction {degrees}], N21 [Wind Speed {m/s}],N22 [Total Sky Cover], N23 [Opaque Sky Cover], N24 [Visibility {km}], N25 [Ceiling Height {m}], N26 [Present Weather Observation], A2 [Present Weather Codes], N27 [Precipitable Water {mm}], N28 [Aerosol Optical Depth {thousandths}],N29 [Snow Depth {cm}], N30 [Days Since Last Snowfall]

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LOCATION,Mascot (Sydney AP),NSW,Australia,NatHERS-TMY2 BoM 66037 CZ0513,947670,-33.94,151.17,10.0,5
DESIGN CONDITIONS,0
TYPICAL/EXTREME PERIODS,0
GROUND TEMPERATURES,0
HOLIDAYS/DAYLIGHT SAVING,No,0,0,0
COMMENTS 1,TMY2 months selected from 1990-  2016 out of 26 years of data; after Marion & Urban (1995), US National Renewable Energy Lab, NREL/SP-463-7668. Data reliability GOOD.
COMMENTS 2,Weights: T_dry 0.20, T_dew 0.20, Wind 0.10, R_glob 0.25, R_dir 0.25. Details in NIWA Client report 2019175WN, Ben Liley <Ben.Liley@niwa.co.nz>, Apr 2020.
DATA PERIODS,1,1,TMY2 Year,Sunday,1/1,12/31
2070,01,01,01,60,E8E8E8E8?0?3?3?3I4I4I6I5B8B8E8E8?0?0E8?0?0?0,20.7,12.5,59,101800,0,1407,9999,0,0,0,0,0,0,0,315,2.4,1,99,9999.,99999,9,999999999,23,0.999,99,99
2070,01,01,02,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7E8E8?0?0A7?0?0?0,20.8,12.4,58,101600,0,1407,9999,0,0,0,0,0,0,0,337,2.5,1,99,9999.,99999,9,999999999,23,0.999,99,99
2070,01,01,03,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7E8E8?0?0A7?0?0?0,20.9,12.4,58,101600,0,1407,9999,0,0,0,0,0,0,0,337,2.9,1,99,9999.,99999,9,999999999,23,0.999,99,99
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2070,01,01,07,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,19.6,12.5,63,101700,293,1407,9999,176,637,42,32735,68628,6235,76,337,2.9,1,99,9999.,99999,9,999999999,23,0.999,99,99
2070,01,01,08,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,21.0,12.4,57,101700,572,1407,9999,416,933,37,58640,92780,7410,121,315,2.9,1,99,9999.,99999,9,999999999,21,0.999,99,99
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2070,01,01,10,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,25.1,11.0,40,101700,1056,1407,9999,862,1106,42,98685,101725,14038,279,360,3.4,0,99,9999.,99999,9,999999999,21,0.999,99,99
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2070,01,01,18,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,27.9,11.5,36,101400,600,1407,9999,426,927,31,30087,71823,7243,122,45,7.9,3,99,9999.,99999,9,999999999,23,0.999,99,99
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2070,01,01,21,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,24.9,14.1,50,101600,0,1407,9999,0,0,0,0,0,0,0,22,6.9,1,99,9999.,99999,9,999999999,27,0.999,99,99
2070,01,01,22,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,24.3,14.5,54,101700,0,1407,9999,0,0,0,0,0,0,0,45,4.5,2,99,9999.,99999,9,999999999,28,0.999,99,99
2070,01,01,23,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,24.2,15.0,56,101700,0,1407,9999,0,0,0,0,0,0,0,45,4.5,2,99,9999.,99999,9,999999999,28,0.999,99,99
2070,01,01,24,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,23.3,15.5,61,101700,0,1407,9999,0,0,0,0,0,0,0,45,4.5,2,99,9999.,99999,9,999999999,29,0.999,99,99
2070,01,01,02,01,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,23.1,15.6,62,101700,0,1407,9999,0,0,0,0,0,0,0,45,2.4,1,99,9999.,99999,9,999999999,29,0.999,99,99
2070,01,01,02,02,60,A7A7A7E8?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,23.0,15.8,63,101600,0,1407,9999,0,0,0,0,0,0,0,22,2.4,1,99,9999.,99999,9,999999999,29,0.999,99,99
2070,01,01,02,03,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,21.9,15.6,67,101600,0,1407,9999,0,0,0,0,0,0,0,337,1.8,1,99,9999.,99999,9,999999999,28,0.999,99,99
2070,01,01,02,04,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,21.9,15.3,65,101600,0,1407,9999,0,0,0,0,0,0,0,360,1.3,1,99,9999.,99999,9,999999999,28,0.999,99,99
2070,01,01,02,05,60,A7A7A7A7?0?3?3?3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,20.9,15.3,70,101600,0,1407,9999,0,0,0,0,0,0,0,315,2.1,1,99,9999.,99999,9,999999999,28,0.999,99,99
2070,01,01,02,06,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,20.9,15.3,70,101700,13,1407,9999,4,1,4,7750,2154,4258,23,315,2.4,1,99,9999.,99999,9,999999999,28,0.999,99,99
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2070,01,01,02,08,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,23.8,15.0,57,101800,569,1407,9999,396,849,52,56934,90188,7128,119,337,2.4,1,99,9999.,99999,9,999999999,26,0.999,99,99
2070,01,01,02,09,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,25.4,14.2,49,101800,829,1407,9999,632,994,45,79744,99804,8701,162,360,4.8,1,99,9999.,99999,9,999999999,24,0.999,99,99
2070,01,01,02,10,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,26.5,12.6,41,101800,1054,1407,9999,834,1045,50,97193,102142,11042,243,22,5.5,1,99,9999.,99999,9,999999999,22,0.999,99,99
2070,01,01,02,11,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,27.9,11.8,36,101800,1228,1407,9999,985,1052,65,108747,102994,11958,376,45,7.9,2,99,9999.,99999,9,999999999,20,0.999,99,99
2070,01,01,02,12,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,28.3,10.5,32,101800,1340,1407,9999,1077,1041,85,114034,102750,12317,605,22,8.2,1,99,9999.,99999,9,999999999,20,0.999,99,99
2070,01,01,02,13,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,29.3,10.3,30,101700,1381,1407,9999,1104,1020,102,114414,103691,11487,763,22,7.9,0,99,9999.,99999,9,999999999,22,0.999,99,99
2070,01,01,02,14,60,A7A7A7A7?0A3A3D3I4I4I6I5A7A7A7A7?0?0A7?0?0?0,29.9,11.3,31,101700,1348,1407,9999,1081,1043,80,108524,103569,11195,585,45,8.8,1,99,9999.,99999,9,999999999,23,0.999,99,99
```

Figure 3 Sample of .epw format data

```
                DATA FORMAT FOR AUSTRALIAN CLIMATIC DATA BASE

Characters              Item

 1 - 2  location identification (e.g.ME represents Melbourne)
 3 - 4  year (e.g. 67)
 5 - 6  month (i.e. 1 - 12)
 7 - 8  day (i.e. 1 - 31)
 9 - 10 hour standard (i.e. 0-23, 0 = midnight)
11 - 14 dry bulb temperature (10-1 °C)
15 - 17 absolute moisture content (10-1 g/kg)
18 - 21 atmospheric pressure (10-1 kPa)
22 - 24 wind speed (10-1 m/s)
25 - 26 wind direction (0-16; 0 = CALM.  1 = NNE ,...,16 = N)
27      total cloud cover  (oktas, 0 - 8)
28      flag relating to dry bulb temperature
29      flag relating to absolute moisture content
30      flag relating to atmospheric pressure
31      flag relating to wind speed and direction
32      flag relating to total cloud cover
33      blank
34 - 37 global solar irradiance on a horizontal plane (W/m2)
38 - 40 diffuse solar irradiance on a horizontal plane (W/m2)
41 - 44 direct solar irradiance on a plane normal to the beam (W/m2)
45 - 46 solar altitude (degrees, 0-90)
47 - 49 solar azimuth (degrees, 0-360)
50      flag relating to global and diffuse solar irradiance
51      flag                                  }
52 - 56 Australian Met Station Number         } Some locations only
57 - 61 wet bulb temperature (10-1 °C)        }
62 - 81 Station name (first line only)        }

Values for flags relating to standard surface meteorological data (columns 28 - 32)

0  means that the value is measured value
1  means that the value is estimated to replace a missing measurement
2  means that the value is an interpolating between three-hourly measurements
3  missing value

  Values for flag relating to solar radiation data (column 50)

0  means that both global and diffuse irradiance values are based on measurements
1  means that both global and diffuse irradiance values are estimated to
   replace a missing measurement
2  means that the global irradiance value is based on measurement but the
   diffuse irradiance value is estimated to replace a missing measurement
3  missing value or estimated value from cloud cover data
4  interpolated value from three hourly data
```

Figure 4 NatHERS weather file structure

```
MA120101 0 207 951018 24141000010   0  0   0 018131320
MA120101 1 208 951016 25151111210   0  0   0 016531320
MA120101 2 209 951016 29151000010   0  0   0 015031320
MA120101 3 203 941016 29151000010   0  0   0 013731320
MA120101 4 190 931016 24141000000   0  0   0 012731320
MA120101 5 192 951016 24161000000   5  5   4 111800020
MA120101 6 196 951017 29151000000 176 42 6371211000020
MA120101 7 210 951017 29141000000 416 37 9332410300020
MA120101 8 234 871017 55161000000 655 32105636 9500020
MA120101 9 251 871017 34160000000 862 42110649 8700020
MA12010110 265 871017 401600000001007 49109861 7600020
MA12010111 270 871016 40 210000001104 61109372 5600020
MA12010112 279 861016 58 200000001135 72108179  400020
MA12010113 284 861015 79 200000001107 5910947330700020
MA12010114 290 881015 82 200000001011 4910976228500020
MA12010115 284 841014 79 20000000 862 4210925027400020
MA12010116 283 921014 82 20000000 664 3310563826600020
MA12010117 279 921014 79 21000000 426 31 9272525800020
MA12010118 266 971015 74 23000000 172 49 5351325100020
MA12010119 2561041016 64 27000000   0  0   0 224300020
MA12010120 2491071016 69 11000000   0  0   0 023400020
MA12010121 2431101017 45 21000000   0  0   0 022431320
MA12010122 2421131017 45 22000000   0  0   0 021231320
MA12010123 2331161017 45 22000000   0  0   0 019731320
MA120102 0 2311171017 24 22000000   0  0   0 018131320
MA120102 1 2301191016 24 11000000   0  0   0 016531320
MA120102 2 2191171016 18151001000   0  0   0 015031320
MA120102 3 2191151016 13161000000   0  0   0 013731320
MA120102 4 2091151016 21141000000   0  0   0 012731320
MA120102 5 2091141017 24141000000   4  4   1 111800020
MA120102 6 2171131017 21151000000 162 52 5311211000020
MA120102 7 2381131018 24151000000 396 52 8492410300020
MA120102 8 2541081018 48161000000 632 45 99436 9500020
MA120102 9 265 981018 55 11000000 834 50104549 8700020
MA12010210 279 931018 79 21000000 985 65105261 7600020
MA12010211 283 851018 82 120000001077 85104172 5600020
MA12010212 293 851017 79 1000000011041102102079  400020
MA12010213 299 911017 88 200000001081 8010437330800020
MA12010214 296 961016 98 21000000 994 5510596228600020
MA12010215 2931001016 98 20000000 845 4110495027400020
MA12010216 2841031015 93 20000000 641 36 9913826600020
MA12010217 2781111015 98 21000000 401 50 8212525800020
MA12010218 2771171015 98 24000000 157 62 4171325100020
MA12010219 2651161016109 27000000   0  0   0 224300020
MA12010220 2591181016 88 11000000   0  0   0 023500020
MA12010221 2541171017 82 11000000   0  0   0 022431320
MA12010222 2521171017 79 11000010   0  0   0 021231320
```

Figure 5 Sample of NatHERS weather file data

3 CSIRO methodology for constructing projected weather data

The dataset 'Projected weather files in NatHERS format' is based on the dataset 'NatHERS 2016 Reference Meteorological Year (RMY) weather files' (NIWA 2017). Projected changes in critical weather variables due to climate change have been applied to the RMY files (Chen et al. 2021). Critical weather variables are those which have a major impact on the thermal performance of a building.

The 'NatHERS 2016 RMY weather files' contain hourly weather data for a typical meteorological year in 83 Australian locations. The typical meteorological year is drawn from historical weather data from 1990 to 2015 using the method described by the New Zealand National Institute of Water and Atmospheric Research (NIWA 2017).

Future weather projections were made under 3 different GHG emissions scenarios (RCP2.6, RCP4.5, and RCP8.5). The 3 selected Representative Concentration Pathways (RCP) describe future scenarios of anthropogenic GHG emissions, the associated atmospheric GHG concentrations, and the resultant increase in radiative forcing (in W/m^2) (Figure 2). In RCP2.6, atmospheric GHG emissions peak around 2020, then rapidly decline in line with strong emission reduction measures. In RCP4.5, GHG emissions peak in 2040, while RCP8.5 reflects a future with little curbing of GHG emissions. Further RCP details are described by van Vuuren et al. (2011).

Projected changes in monthly means from a single selected Global Climate Model (GCM) were used to modify the RMY critical variables for each of the 3 RCPs at each of the 83 locations for each of the 4 future years. The GCMs selected were drawn from the Climate Change in Australia eight-model subset of representative models for Australia (Hennessy et al. 2015). These eight models have been drawn from the Coupled Model Intercomparison Project 5 (CMIP5) and have been thoroughly evaluated for their abilities to simulate the historic climate and climate processes of relevance to Australia (Moise et al. 2015) against multiple metrics for the Australian context. Table 3 describes selected characteristics of the eight-model subset.

Table 3 Characteristics of the eight selected Global Climate Models (modified from Hennessy et al. 2015)

SELECTED MODEL	MODEL CODE	INSTITUTE	CHARACTERISTICS
ACCESS1.0	Acc	CSIRO-BOM, Australia	Maximum consensus for many regions.
CESM1-CAM5	Ces	CCCMA, Canada	Hotter and wetter, or hotter and least drying
CNRM-CM5	Cnr	NSF-DOE-NCAR, USA	Hot /wet end of range in Southern Australia
GFDL-ESM2M	Gfd	CNRM-CERFACS, France	Hotter and drier model for many clusters
HadGEM2-CC	Had	NOAA, GFDL, USA	Maximum consensus for many regions.
CanESM2	Can	MOHC, UK	the hot/wet mode
MIROC5	Mir	JAMSTEC, Japan	Low warming wetter model
NorESM1-M	Nor	NCC, Norway	Low warming wettest representative model

For each location/RCP/future year combination, the model simulating a change in mean surface temperature that was closest to the mean of all eight models was selected for use for all variables (to ensure internal consistency, in accordance with Hennessy et al. 2015). Models selected are shown in Table 4.

Table 4 Model selected for each location/RCP/year

	RCP2.6				RCP4.5				RCP8.5			
NATHERS CLIMATE ZONE	2030	2050	2070	2090	2030	2050	2070	2090	2030	2050	2070	2090
1	Mir	Mir	Cnr	Cnr	Mir	Ces	Gfd	Can	Mir	Can	Ces	Ces
2	Ces	Ces	Cnr	Cnr	Can	Ces	Can	Can	Ces	Ces	Ces	Ces
3	Ces	Ces	Ces	Ces	Acc	Can	Can	Can	Had	Can	Acc	Ces
4	Ces	Ces	Cnr	Ces	Acc	Can	Can	Ces	Had	Acc	Acc	Ces
5	Mir	Mir	Cnr	Cnr	Had	Ces	Mir	Can	Mir	Can	Ces	Ces
6	Ces	Ces	Ces	Ces	Acc	Ces	Cnr	Ces	Had	Acc	Acc	Ces
7	Mir	Mir	Mir	Cnr	Gfd	Gfd	Cnr	Ces	Ces	Ces	Ces	Ces
8	Mir	Mir	Mir	Cnr	Mir	Ces	Can	Ces	Ces	Ces	Ces	Ces
9	Mir	Ces	Cnr	Cnr	Ces	Ces	Can	Ces	Ces	Ces	Ces	Ces
10	Mir	Mir	Cnr	Cnr	Ces	Ces	Can	Ces	Ces	Ces	Ces	Ces
11	Mir	Ces	Mir	Mir	Mir	Ces	Can	Ces	Ces	Ces	Ces	Ces
12	Mir	Cnr	Mir	Mir	Acc	Mir	Ces	Ces	Ces	Acc	Had	Had
13	Cnr	Cnr	Cnr	Mir	Ces	Acc	Had	Had	Ces	Acc	Had	Had
14	Mir	Ces	Mir	Cnr	Mir	Can	Can	Ces	Ces	Can	Ces	Ces
15	Mir	Ces	Mir	Cnr	Mir	Ces	Can	Ces	Ces	Ces	Ces	Ces
16	Cnr	Cnr	Mir	Mir	Mir	Acc	Ces	Had	Ces	Acc	Had	Had
17	Mir	Mir	Mir	Mir	Mir	Mir	Can	Can	Ces	Can	Ces	Ces
18	Mir	Mir	Mir	Mir	Mir	Mir	Cnr	Ces	Ces	Ces	Ces	Ces
19	Ces	Ces	Ces	Ces	Acc	Can	Ces	Ces	Had	Acc	Acc	Ces
20	Cnr	Can	Mir	Nor	Acc	Had	Ces	Had	Ces	Acc	Had	Had
21	Cnr	Cnr	Mir	Mir	Acc	Acc	Ces	Had	Ces	Acc	Had	Had
22	Cnr	Can	Cnr	Mir	Acc	Acc	Ces	Had	Ces	Acc	Had	Had
23	Cnr	Cnr	Cnr	Mir	Acc	Mir	Ces	Ces	Ces	Acc	Had	Had
24	Cnr	Mir	Mir	Cnr	Acc	Acc	Ces	Had	Ces	Acc	Had	Had
25	Cnr	Cnr	Cnr	Nor	Acc	Mir	Ces	Had	Ces	Acc	Had	Had
26	Cnr	Cnr	Cnr	Mir	Acc	Mir	Ces	Had	Ces	Acc	Had	Had
27	Cnr	Cnr	Cnr	Mir	Acc	Acc	Ces	Acc	Ces	Acc	Had	Had
28	Mir	Ces	Mir	Cnr	Mir	Ces	Cnr	Ces	Ces	Ces	Ces	Ces
29	Can	Mir	Cnr	Cnr	Mir	Ces	Mir	Can	Mir	Can	Ces	Ces
30	Ces	Mir	Ces	Cnr	Mir	Ces	Mir	Gfd	Mir	Can	Ces	Ces
31	Ces	Mir	Cnr	Cnr	Mir	Ces	Mir	Can	Mir	Can	Ces	Ces

	RCP2.6				RCP4.5				RCP8.5			
NATHERS CLIMATE ZONE	2030	2050	2070	2090	2030	2050	2070	2090	2030	2050	2070	2090
32	Ces	Cnr	Cnr	Cnr	Ces	Ces	Mir	Can	Mir	Can	Ces	Ces
33	Mir	Mir	Cnr	Cnr	Mir	Ces	Gfd	Can	Ces	Can	Ces	Ces
34	Ces	Ces	Ces	Mir	Acc	Can	Ces	Ces	Had	Acc	Acc	Ces
35	Mir	Ces	Cnr	Cnr	Gfd	Ces	Can	Can	Ces	Ces	Ces	Ces
36	Mir	Ces	Cnr	Cnr	Can	Ces	Cnr	Ces	Mir	Ces	Ces	Ces
37	Mir	Mir	Cnr	Cnr	Mir	Ces	Gfd	Can	Mir	Can	Ces	Ces
38	Ces	Ces	Ces	Cnr	Acc	Can	Ces	Ces	Ces	Acc	Acc	Ces
39	Mir	Mir	Cnr	Cnr	Can	Ces	Gfd	Can	Mir	Can	Ces	Ces
40	Ces	Ces	Cnr	Cnr	Acc	Can	Ces	Ces	Ces	Acc	Acc	Ces
41	Ces	Ces	Cnr	Ces	Had	Can	Ces	Ces	Ces	Acc	Acc	Ces
42	Ces	Ces	Cnr	Cnr	Acc	Can	Ces	Ces	Ces	Acc	Acc	Ces
43	Ces	Ces	Ces	Cnr	Had	Can	Ces	Ces	Ces	Had	Acc	Ces
44	Ces	Ces	Cnr	Cnr	Acc	Can	Ces	Ces	Ces	Acc	Acc	Ces
45	Ces	Ces	Cnr	Mir	Can	Can	Ces	Ces	Acc	Acc	Acc	Ces
46	Ces	Ces	Ces	Cnr	Acc	Can	Ces	Ces	Ces	Acc	Acc	Ces
47	Mir	Cnr	Cnr	Mir	Acc	Acc	Ces	Ces	Ces	Acc	Had	Had
48	Mir	Ces	Cnr	Cnr	Mir	Gfd	Cnr	Ces	Ces	Ces	Ces	Ces
49	Mir	Cnr	Mir	Mir	Acc	Acc	Ces	Acc	Ces	Acc	Had	Had
50	Mir	Ces	Cnr	Cnr	Can	Ces	Can	Ces	Ces	Ces	Ces	Ces
51	Can	Ces	Can	Mir	Ces	Ces	Ces	Ces	Ces	Acc	Acc	Ces
52	Cnr	Cnr	Cnr	Mir	Ces	Acc	Ces	Ces	Ces	Acc	Had	Had
53	Cnr	Can	Cnr	Mir	Can	Can	Cnr	Ces	Ces	Cnr	Ces	Had
54	Cnr	Cnr	Mir	Mir	Ces	Acc	Ces	Ces	Ces	Acc	Had	Had
55	Cnr	Cnr	Cnr	Mir	Acc	Acc	Ces	Ces	Ces	Acc	Had	Had
56	Cnr	Can	Mir	Mir	Acc	Can	Ces	Had	Ces	Acc	Had	Had
57	Mir	Cnr	Mir	Mir	Acc	Acc	Ces	Acc	Ces	Acc	Had	Had
58	Mir	Cnr	Mir	Mir	Acc	Acc	Ces	Ces	Acc	Acc	Had	Had
59	Cnr	Cnr	Mir	Mir	Mir	Acc	Ces	Had	Ces	Acc	Had	Had
60	Cnr	Cnr	Mir	Mir	Mir	Mir	Ces	Had	Ces	Acc	Had	Had
61	Cnr	Cnr	Cnr	Mir	Can	Acc	Ces	Ces	Ces	Acc	Had	Had
62	Cnr	Cnr	Mir	Mir	Acc	Mir	Ces	Had	Ces	Acc	Had	Had
63	Cnr	Cnr	Cnr	Mir	Ces	Acc	Ces	Ces	Ces	Acc	Had	Had
64	Cnr	Cnr	Mir	Mir	Mir	Cnr	Ces	Ces	Ces	Acc	Had	Had
65	Mir	Cnr	Cnr	Cnr	Mir	Cnr	Cnr	Ces	Ces	Ces	Ces	Ces
66	Cnr	Cnr	Mir	Mir	Mir	Mir	Ces	Ces	Ces	Acc	Had	Had
67	Cnr	Cnr	Cnr	Mir	Mir	Acc	Ces	Ces	Ces	Acc	Had	Had

	RCP2.6				RCP4.5				RCP8.5			
NATHERS CLIMATE ZONE	2030	2050	2070	2090	2030	2050	2070	2090	2030	2050	2070	2090
68	Cnr	Cnr	Cnr	Mir	Acc	Mir	Ces	Had	Acc	Mir	Ces	Had
69	Cnr	Can	Mir	Cnr	Acc	Acc	Ces	Had	Ces	Acc	Had	Had
70	Mir	Ces	Cnr	Cnr	Can	Ces	Can	Ces	Ces	Ces	Ces	Ces
71	Mir	Mir	Cnr	Cnr	Mir	Ces	Mir	Can	Mir	Can	Ces	Ces
72	Mir	Cnr	Cnr	Mir	Acc	Mir	Had	Had	Ces	Acc	Had	Had
73	Mir	Ces	Cnr	Cnr	Can	Ces	Can	Ces	Ces	Ces	Ces	Ces
74	Can	Mir	Cnr	Cnr	Can	Ces	Gfd	Can	Ces	Can	Ces	Ces
75	Cnr	Cnr	Mir	Mir	Mir	Acc	Ces	Had	Ces	Acc	Gfd	Gfd
76	Mir	Ces	Mir	Cnr	Mir	Ces	Cnr	Ces	Ces	Ces	Ces	Ces
77	Mir	Mir	Mir	Mir	Mir	Mir	Cnr	Ces	Ces	Ces	Ces	Ces
78	Cnr	Can	Mir	Cnr	Acc	Acc	Ces	Had	Ces	Acc	Had	Had
79	Mir	Ces	Cnr	Cnr	Gfd	Ces	Can	Can	Ces	Ces	Ces	Ces
80	Cnr	Cnr	Mir	Mir	Mir	Mir	Ces	Had	Ces	Acc	Had	Had
81	Mir	Ces	Cnr	Mir	Can	Cnr	Cnr	Can	Ces	Can	Acc	Ces
82	Gfd	Mir	Cnr	Cnr	Ces	Ces	Can	Ces	Ces	Ces	Ces	Ces
83	Ces	Ces	Mir	Mir	Mir	Ces	Can	Can	Can	Can	Can	Can

Projected monthly mean changes in critical weather variables were applied to the hourly data in the 'NatHERS 2016 RMY weather files' using the 'morphing' methodology developed by Belcher et al. (2006). For building energy simulations, the critical weather variables are ambient dry-bulb air temperature, relative humidity, solar radiation (global, direct and diffuse), and wind speed. Projected hourly values were estimated using equations 1-5 below.

Ambient dry-bulb air temperature

$$T = T_0 + \Delta T_m + \alpha_{Tm}\,(T_0 - \langle T_0 \rangle_m) \quad (1)$$

$$\alpha_{Tm} = \frac{\Delta TMAX_m - \Delta TMIN_m}{\langle T_{0max} \rangle_m - \langle T_{0min} \rangle_m} \quad (2)$$

Where:

- T is the ambient dry-bulb temperature at a particular date and hour in a future year that we wish to calculate (e.g. temperature at 8:00 am 2nd January 2030)
- T_0 is the ambient dry-bulb temperature at the same date and hour in the baseline weather data (e.g. temperature at 8:00 am 2nd January in the 'NatHERS 2016 RMY weather files')
- ΔT_m is the change in mean ambient dry-bulb temperature for this month as projected by the GCMs (e.g. the difference between the mean temperature for January 2030 and the mean temperature for January in the 'NatHERS 2016 RMY weather files')
- $\langle T_0 \rangle_m$ is the mean ambient dry-bulb temperature for the month in the baseline weather data (e.g. mean temperature for January in 'NatHERS 2016 RMY weather files')

- $\Delta TMAX_m$ is the change in mean maximum ambient dry-bulb temperature for the month as projected by the GCMs
- $\Delta TMIN_m$ is the change in mean minimum ambient dry-bulb temperature for the month as projected by the GCMs
- $\langle T_{0max} \rangle_m$ is the monthly mean value of daily maximum ambient dry-bulb temperature from the baseline weather data
- $\langle T_{0min} \rangle_m$ is the monthly mean value of daily minimum ambient dry-bulb temperature from the baseline weather data

Relative humidity

$$RH = RH_0(1 + \alpha_{Hm}) \quad (3)$$

Where:

- *RH* is the relative humidity at a particular date and hour in a future year that we wish to calculate (e.g. 8:00 am 2nd January 2030)
- RH_0 is the relative humidity at the same date and hour in the baseline weather data (e.g. 8:00 am 2nd January in the 'NatHERS 2016 RMY weather files')
- α_{Hm} is the fractional monthly mean change of relative humidity as projected by the GCMs

Wind Speed

$$U = U_0(1 + \alpha_{Um}) \quad (4)$$

Where:

- *U* is the wind speed at a particular date and hour in a future year that we wish to calculate
- U_0 is the wind speed at the same date and hour in the baseline weather data
- α_{Um} is the fractional monthly mean change of wind speed as projected by the GCMs

Solar Radiation

$$I = I_0(1 + I_{Rm}) \quad (5)$$

Where:

- *I* is the solar radiation at a particular date and hour in a future year that we wish to calculate
- I_0 is the solar radiation at the same date and hour in the baseline weather data
- α_{Rm} is the fractional monthly mean change of solar radiation as projected by the GCMs

Note

The 'NatHERS 2016 RMY weather files' (used as the starting point for constructing future weather data) contain the variable Absolute Moisture Content instead of Relative Humidity. Relative Humidity was derived from the variables Atmospheric Pressure, Dry Bulb Temperature, and Absolute Moisture Content using Equations 6-10 (see section 4). Projected future values for Relative Humidity were then calculated as described above. Future values for Absolute Moisture Content were then derived from the future values of Relative Humidity and Dry Bulb Temperature together with the (unchanged) Atmospheric Pressure according to the same equations, but in reverse.

3.1 Important considerations for using the datasets

Climate projections are inherently uncertain due to three main factors:

1. Natural climate variability including fluctuations in daily weather, seasonal/annual climate (e.g. El Niño Southern Oscillation) and decadal climate (e.g. Pacific Decadal Oscillation).
2. How greenhouse gas and aerosol concentrations may change in response to socio-economic change, technological change, energy transitions, and land-use change. This is described using 'pathways' such as the Representative emissions pathways.
3. How regional weather and climate respond to changing greenhouse gases and aerosols. This information is derived from climate models, each of which provides a different simulation of future weather and climate at a given location.

While climate models can produce plausible representations of the state of the future climate, they are not predictions. The climate model data used to produce the datasets described here represent a middle of the range future. Hotter, drier, cooler and wetter futures are also possible.

Users of these datasets are encouraged to be mindful of the wider context of plausible future climates. Information describing these can be found in the reports and tools available from the Climate Change is Australia website[1].

[1] See for example the Summary Data Explorer tool at https://www.climatechangeinaustralia.gov.au/en/projections-tools/summary-data-explorer/

4 CSIRO methodology for converting weather files in NatHERS format to .epw format

The EnergyPlus (.epw) format requires some variables that are not contained in the NatHERS format. The critical variables are derived from variables contained within the NatHERS format. Other values are filled with values from a version of the 2016 TMY weather files created by a third party.

Relative Humidity and Dew Point Temperature are calculated using the NatHERS variables Dry Bulb Temperature, Absolute Humidity, and Atmospheric Pressure as described in Equations 6-10 (Snyder 2005, Buck 1981).

$$RH = \frac{P_v}{P_s} \times 100 \quad (6)$$

$$P_v = \frac{AH \times (T + 273.16)}{2165} \quad (7)$$

$$P_s = (1.0007 + 3.46 \times P \times 10^{-6}) \times 6.1121 \times e^{17.502T/(240.97+T)} \quad (8)$$

$$T_d = \frac{237.3 \times b}{1 - b} \quad (9)$$

$$b = \frac{ln\left(\frac{RH}{100}\right)}{17.27} + \frac{T}{237.3+T} \quad (10)$$

Where:

- *RH* is the relative humidity (%)
- P_v is the vapour pressure of the air (mbar)
- P_s is the saturation vapour pressure of the air (mbar)
- *AH* is the absolute humidity (g/m^3)
- *T* is the dry-bulb temperature of the air (°C)
- *P* is the absolute pressure of the air (mbar)
- T_d is the dew point temperature (°C)

Some variables have different units and conversion is necessary to account for this (e.g. conversion from kPa to mb for Atmospheric Pressure).

Table 5 summarises the origin of each variable value in the EnergyPlus (.epw) format.

Table 5 Origin of weather variables in .epw files

ENERGYPLUS (.EPW) VARIABLE	ORIGIN
Dry Bulb Temp	NatHERS Dry bulb temperature with change of unit
Dew Point Temp	Calculated using NatHERS Dry Bulb Temperature, Absolute Moisture Content, and Atmospheric Pressure (Eq 6-10)
Relative Humidity	Calculated using NatHERS Dry Bulb Temperature, Absolute Moisture Content, and Atmospheric Pressure (Eq 6-8)
Atmospheric Station Pressure	NatHERS Atmospheric pressure with change of unit
Extraterrestrial Horizontal Radiation	As per 2016 Non-CSIRO TMY
Extraterrestrial Direct Normal Radiation	As per 2016 Non-CSIRO TMY
Horizontal Infrared Radiation from Sky	As per 2016 Non-CSIRO TMY
Global Horizontal Radiation	As per 2016 Non-CSIRO TMY with projected changes applied
Direct Normal Radiation	As per 2016 Non-CSIRO TMY with projected changes applied
Diffuse Horizontal Radiation	As per 2016 Non-CSIRO TMY with projected changes applied
Global Horizontal Illuminance	As per 2016 Non-CSIRO TMY
Direct Normal Illuminance	As per 2016 Non-CSIRO TMY
Diffuse Horizontal Illuminance	As per 2016 Non-CSIRO TMY
Zenith Luminance	As per 2016 Non-CSIRO TMY
Wind Direction	2016 RMY NatHERS Wind direction with change of unit
Wind Speed	NatHERS Wind speed with change of unit
Total Sky Cover	As per 2016 Non-CSIRO TMY
Opaque Sky Cover	As per 2016 Non-CSIRO TMY
Visibility	As per 2016 Non-CSIRO TMY
Ceiling Height	As per 2016 Non-CSIRO TMY
Present Weather Observation	As per 2016 Non-CSIRO TMY
Present Weather Codes	As per 2016 Non-CSIRO TMY
Precipitable Water	As per 2016 Non-CSIRO TMY
Aerosol Optical Depth	As per 2016 Non-CSIRO TMY
Snow Depth	As per 2016 Non-CSIRO TMY
Days Since Last Snowfall	As per 2016 Non-CSIRO TMY

4.1.1 Time period

The NatHERS format uses hours 0, 1, 2, 3, …, 23, whereas the EnergyPlus (.epw) format uses hours 1, 2, 3, …, 24.

In the previous versions of the projected weather files in .epw format, when NatHERS data was converted to .epw format, NatHERS hour values were mapped to .epw hour values as follows: 0->1, 1->2, 2->3, …, 23->24.

In the current version of the dataset, when NatHERS data is converted to .epw format, NatHERS hour values are mapped to .epw hour values as follows: 0 not used, 1->1, 2->2, …, 23->23.

For the last hour of each month (.epw hour 24), instead of using a value from the NatHERS RMY dataset (e.g. from hour 0 of the following month), critical variable values have been taken from the third party (non-CSIRO) 2016 TMY dataset. This avoids any potential problems in cases where consecutive months in the RMY/TMY datasets contain data which have been selected from the BOM weather data from different years.

These changes result in a better alignment of variable values with the .epw time period.

4.1.2 Radiation

In the previous versions of the projected weather files in .epw format, values for the three radiation variables Global Horizontal Radiation, Direct Normal Radiation, and Diffuse Horizontal Radiation were based on values from the NatHERS RMY files. The current version of this dataset takes these values from the third party (non-CSIRO) 2016 TMY dataset.

The reason for this change is that for the NatHERS RMY files, the radiation values are calculated centred around the hour. For example, radiation at hour 9 relates to radiation for the period 8:30AM to 9:30AM. Whereas the .epw format defines radiation values as relating to the hour preceding the stated hour. For example, radiation at hour 9 relates to radiation for the period 8:00AM to 9:00AM.

The radiation values in the third party (non-CSIRO) 2016 TMY dataset are consistent with the .epw understanding of radiation values.

5 QA and feedback process

5.1 QA process

The projected weather files were converted to the .epw format using the methodology described in this user guide by the CSIRO, who then reviewed the files and found that they worked on EnergyPlus.

All projected weather files were then provided to an independent consultant with access to IES-VE who reviewed them. The consultant found that the files were usable in IES-VE and identified errors. The errors found were:

- External relative humidity over 100%
- Incorrect wet bulb temperature
- Incorrect dewpoint temperature
- Incorrect absolute humidity

The CSIRO addressed these errors by:

1. Replacing negative values with the data derived from the two hours before and after these three points using a linear approach
2. Replacing estimated relative humidity greater than 100% with 100%
3. Replacing estimated relative humidity less than 1% with 1% for .epw files
4. Leaving dew point temperature found to be less than -30°C as it was, since there was no reliable data on which to base modification.

The independent consultant re-checked a sample of five representative files and found that the errors in the sample had been corrected and the files were usable in IES-VE.

5.2 Feedback process

Please provide feedback on the usability and functionality of this weather data to the CSIRO via the contact details on the Data Shop website. If you are happy to be approached for your advice on how the weather files could be improved, please provide your contact details.

The projected weather files have undergone checking and testing and were found to be generally suitable for use on EnergyPlus and IES-VE for modelling commercial buildings in Australia. However the CSIRO and the Department of Industry, Science, Energy and Resources (the department) welcome feedback on the usability and functionality of this weather data for the purposes of testing commercial building performance for resilience against potential future climate conditions when conducting:

- HVAC sizing
- Building fabric design
- Thermal comfort assessment

In 2022 the department will set up a technical working group to review the success of this project.

The group will be asked to provide feedback on the ease of access to the weather data, its suitability for use by commercial building modellers and the level of awareness of how to access and use the weather data. The group will also be asked to provide suggestions for improvement.

The department will collate the feedback and liaise with the CSIRO to implement improvements which are agreed by the department.

6 Data version control

The datasets are likely to be updated from time to time. This could be due to fixing errors discovered in the data, incorporating new weather data, or other reasons. Older versions of the datasets will still be available if required. The superseded versions will be available in the Data Shop on the same page as the current version, but clearly marked as archived versions.

Table 6 lists all versions of the dataset 'Projected weather files in .epw format' that have been available in the Data Shop, the date they were added, and the changes made.

Table 7 lists all versions of the dataset 'Projected weather files in NatHERS format' that have been available in the Data Shop, the date they were added, and the changes made.

Table 6 Data version control - Projected weather files in .epw format

DATASET ZIP FILE NAME	DATE ADDED TO DATA SHOP	CHANGES
PredictiveWeatherFilesEpw_20210712.zip	2021-08-13	First version of dataset publicly available
ProjectedWeatherFilesEpw_20220201.zip	2022-03-31	Data unchanged. Names of text files within zip file updated to include global climate model used for projection. Name of zip file updated to use 'Projected' rather than 'Predicted'.
ProjectedWeatherFilesEpw_20240531.zip	2024-07-10	Change in way time mapped from NatHERS to .epw format; Change in how radiation data obtained
ProjectedWeatherFilesEpw_20240820.zip	2024-08-05	Formatting issues fixed: year format 'yy' changed to 'yyyy'; 'DAYLIGHT SAVING' in header changed to 'DAYLIGHT SAVINGS'

Table 7 Data version control – Projected weather files in NatHERS format

DATASET ZIP FILE NAME	DATE ADDED TO DATA SHOP	CHANGES
PredictiveWeatherFilesNatHERS_20210628.zip	2021-08-13	First version of dataset publicly available
ProjectedWeatherFilesNatHERS_20220322.zip	2022-03-31	Data unchanged. Names of text files within zip file updated to include global climate model used for projection. Name of zip file updated to use 'Projected' rather than 'Predicted'.

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Contact us

1300 363 400
+61 3 9545 2176
csiroenquiries@csiro.au
csiro.au

For further information

Energy
Zhengen Ren
+61 3 9545 2430
zhengen.Ren@csiro.au
csiro.au/energy