Updating Australia's Reference Meteorological Years (RMYs) with the addition of Hourly Precipitation Data

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Abstract

This paper describes initial progress on method to allocate hourly precipitation (mostly rainfall) events based on recorded daily precipitation data. Analysis focussed on twelve representative locations across eight climate zones with a view to being able to update the weather and climate files for over 200 Australian locations for the three decades 1990-2019.

The availability of sub-daily rainfall event data is important for a wide range of engineering and modelling work in the built environment sector. While daily precipitation data are usually available, unfortunately, long series of recorded rainfall with hourly temporal resolution do not exist for all locations. The impetus for this work is to produce the input files for an anticipated version of NatHERS software used for modelling the energy performance of building[1].

Inclusion of hourly precipitation data will allow accurate prediction of condensation issues for enhanced building healthiness and durability. In their study 'Local Climate Models for Hygrothermal Building Component Simulations', Tanaka and Zirkelbach (2016) note that "concerning the hygrothermal performance evaluation of building components, the local climate influence can be crucial". Accordingly, updated energy modelling input files incorporating precipitation data will also allow demonstration of full compliance with the new National Construction Code condensation requirements (NCC 2019). Australian Climate Data Bank[2] (ACDB) weather and climate files are prepared for NatHERS software applications as part of the process of generating new Reference Meteorological Year (RMY) files for each of 69 climate zones. For maximum utility and compliance demonstration purposes, ACDB files might soon need to include data on hourly precipitation.

With respect to the generation of new RMY files, given that the point of this exercise is to provide building energy modelers with the best available inputs, mention must be made of the changes in heating and cooling demand due to climate change and/or urban heat island effects. Studies on metropolitan Sydney have shown that for currently complying dwellings, the increased heating-and-cooling energy demand simulated with current and future climate files could fail to comply with the BASIX[3] cooling energy threshold (Upadhyay, 2020). The changes in heating and cooling demand due to current and future climate change further underline the need to update the RMY files to as comprehensive and as recent a standard as practical.

Our analysis targeted the question: where there is some rain in the 24 hours to 9am, what other recorded meteorological events most correlate with the advent and duration of precipitation in those 24 hours?

[1] The Nationwide House Energy Rating Scheme (NatHERS) is administered by the Commonwealth on behalf of all Australian governments.

[2] Files in the same file format as the Australian Climate Data Bank (ACDB), developed by CSIRO (see Chen 2016)

[3] The Building Sustainability Index (BASIX) requirements apply to all residential dwelling types and are part of the development application process in NSW (www.planningportal.nsw.gov.au/basix).

We selected twelve representative locations from across the eight Australian climate zones that do have thirty (or close to) years of hourly precipitation data: the eight Australian capital cities and four other locations (Table I), to take into consideration all the climate zones defined in the Building Code of Australia as shown in Figure 2 at the end of this paper (Australian Building Codes Board, 2019).

Table I. Locations and Climate Zones

Climate Zone	Location	State	Climate Zone Description
1	Darwin	NT	High humid summer
2	Brisbane	QLD	Warm humid summer
3	Tennant Creek	NT	Hot dry summer, warm winter
4	Mildura	VIC	Hot dry summer, cool winter
4	Woomera	SA	Hot dry summer, cool winter
5	Adelaide	SA	Warm temperate
5	Perth	WA	Warm temperate
5	Sydney	NSW	Warm temperate
6	Melbourne	VIC	Mild temperate
7	Canberra	ACT	Cool temperate
7	Hobart	TAS	Cool temperate
8	Cabramurra	NSW	Alpine

Using hourly precipitation data from these locations, we performed correlations for precipitation events against other hourly metrological events recorded in the thirty-year record (see Table III in the Appendix for information on the ACDB weather and climate files). Table II below shows that the most plausible correlations appeared to be cloud cover, temperature change and moisture change. While the correlation *r* values shown are weak, highlighting the r values that fall in the top (pink) or bottom (green) 20% reveal those events with consistent associations.

Table II. Correlation Matrix: Onset and ongoing hourly precipitation

Precipitation Onset	AD res	BR res	CA res	DA res	HO res	ME res	MI res	PE res	SU res	SY res	TE res	WO res
Wind Speed	0.07	-0.02	0.03	0.11	0.05	0.04	0.03	0.05	0.04	0.01	0.09	0.02
Cloud Cover	0.09	0.10	0.09	0.10	0.05	0.10	0.09	0.12	0.06	0.09	0.10	0.06
Temp change tenths oC	-0.10	-0.09	-0.07	-0.19	-0.09	-0.11	-0.11	-0.07	-0.03	-0.08	-0.22	-0.11
Moisture change	0.15	0.07	0.12	-0.04	0.13	0.17	0.14	0.15	0.06	0.10	0.16	0.16
Pressure change	0.06	0.03	0.04	0.04	0.07	0.06	0.05	0.04	0.04	0.05	0.10	0.07
dif.to.median.rd.wd	-0.06	-0.01	-0.01	0.00	0.03	-0.02	-0.01	-0.07	-0.02	0.00	0.00	-0.01
dif.to.median.rh.wd	-0.06	-0.01	-0.01	0.00	0.03	-0.02	-0.01	-0.07	-0.02	0.00	0.00	-0.01
dif.to.median.rh.tod	0.01	0.02	-0.02	-0.01	-0.01	-0.02	-0.01	0.02	0.00	0.00	-0.03	-0.03
Hourly precipitation	**AD res**	**BR res**	**CA res**	**DA res**	**HO res**	**ME res**	**MI res**	**PE res**	**SU res**	**SY res**	**TE res**	**WO res**
Wind Speed	0.05	0.03	0.02	0.13	0.00	0.02	0.01	0.07	0.02	0.03	0.08	0.01
Cloud Cover	0.11	0.14	0.14	0.11	-0.01	0.06	0.10	0.15	0.07	0.15	0.10	0.04
Temp change tenths oC	-0.09	-0.13	-0.12	-0.27	0.04	-0.05	-0.08	-0.08	-0.05	-0.10	-0.21	-0.07
Moisture change	0.08	-0.02	0.06	-0.10	0.02	0.05	0.06	0.08	0.01	0.05	0.06	0.06
Pressure change	0.01	0.05	0.03	0.07	0.01	0.04	0.03	0.04	0.02	0.03	0.10	0.03
dif.to.median.rd.wd	-0.03	0.00	0.00	0.01	-0.01	0.01	0.01	-0.06	0.00	0.02	0.01	0.01
dif.to.median.rh.wd	-0.03	0.00	0.00	0.01	-0.01	0.01	0.01	-0.06	0.00	0.02	0.01	0.01
dif.to.median.rh.tod	0.00	-0.02	-0.04	-0.01	0.01	0.00	-0.02	0.02	-0.01	0.00	-0.03	-0.02

Given that the humidity, temperature change, pressure and cloud cover events only need to serve as a marker or guide, it was anticipated that these correlations will prove suitably robust as a basis for an algorithm to synthesise hourly precipitation events from existing daily precipitation data.

Outputs were cross validated by back testing our model on historical data. Initial results comparing our model and historical precipitation data for Adelaide, obtained a Pearson's correlation r = 3.6. This is better (though not by much), than dividing (and allocating), daily precipitation by 24 (r = 3.1).

We anticipate that the correlation would be higher if we allocated a lower weighing to night-time cloud cover. This is because we know that the reported values for night-time cloud cover are a linear interpolation of the values between dusk and dawn. Figure 1 below shows a distribution comparing BoM hourly and our modelled allocation for Adelaide.

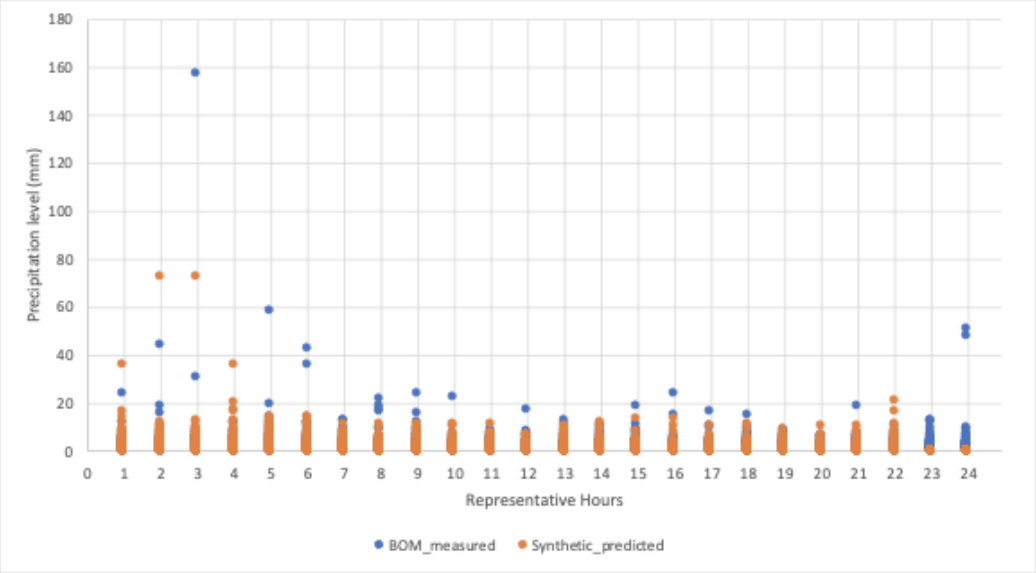

Figure 1. Comparative distribution of BoM and modelled precipitation for Adelaide

Conclusions and further work

As the BoM precipitation data was in the form of 30-minute precipitation accruing to 9am, a certain amount of data processing (parsing) was necessary to transform the data into hourly records. Initial analysis revealed more zeros and other anomalies than might be expected. While parsing was done in such a way to remove obvious errors, the outliers visible in Figure 1 above, revealed that the data quality of BoM 30-minute precipitation was poorer than anticipated. Subsequent work will first need to address the quality of the precipitation time series input data.

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References

Australian Building Codes Board, 2019, 'Climate zone map: Australia wide', https://www.abcb.gov.au/Resources/Tools-Calculators/Climate-Zone-Map-Australia-Wide

Brigandi, G., Aronica, G., n.d. 'Generation of Sub-Hourly Rainfall Events through a Point Stochastic Rainfall Model'. http://dx.doi.org/10.3390/geosciences9050226

Chen, D, 2016, AccuRate and the Chenath engine for residential house energy rating: https://www.hstar.com.au/Chenath/AccuRateChenathRepository.htm

Kossieris, P., Makropoulos, C., Onof, C., Koutsoyiannis, D., 2018. 'A rainfall disaggregation scheme for sub-hourly time scales: Coupling a Bartlett-Lewis based model with adjusting procedures'. J. Hydrol. 556, 980–992. https://doi.org/10.1016/j.jhydrol.2016.07.015

Lee, T, Ding, F, Davy, R, 2015, 'Satellite Estimated Solar cf Ground Based Measurement of Solar Irradiation', Proceedings of *International Conference on Energy and Meteorology*, Boulder CO, June 2015

Lee, T, Ding, F, 2015, 'Comparison of Satellite Estimated Hourly Solar Data with Coincident Ground Based Measurements and their Applications in Industry and Commerce', *APSRC*

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

National Construction Code (NCC) 2019, FP6.1 'Condensation and water vapor management' https://ncc.abcb.gov.au/ncc-online/NCC

Schöner, T, Zirkelbach, D, 2016, 'Development of Hygrothermal Reference Years for Germany', Fraunhofer Institute for Building Physics (IBP), Holzkirchen, Germany

Tanaka, E, Zirkelbach, D, 2016, 'Local Climate Models for Hygrothermal Building Component Simulations', Fraunhofer Institute for Building Physics, Germany

Upadhyay, A et al, 2020, paper in press, 'Impact of climate change in building energy efficiency: Efficacy of current Australian reference meteorological year climate file in Sydney Metropolitan Area'.

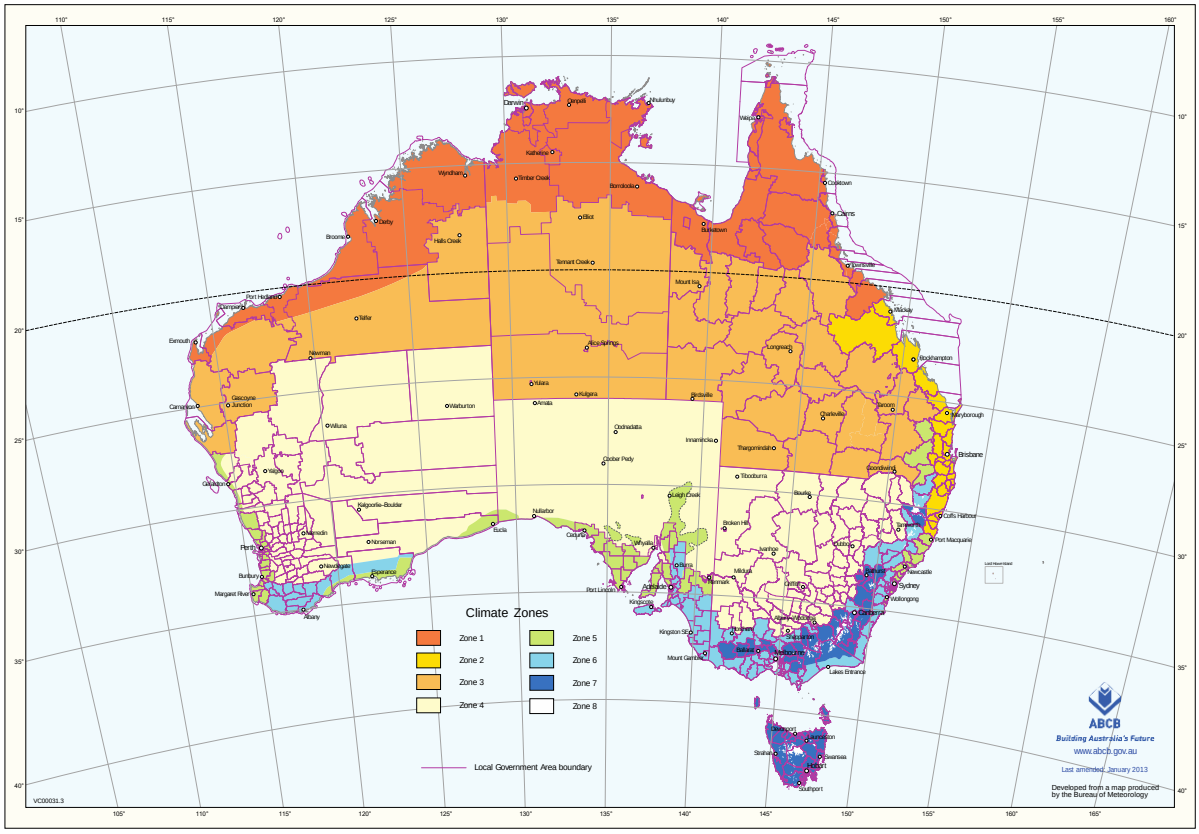

Figure 2. Climate zone map of Australia (NCC)

Appendix

Australian Climate Data Bank (ACDB) weather and climate files

The current ACDB files have 26 fields which hold metrological data including: location, date and time, temperature, moisture, pressure, wind speed and direction, cloud cover and solar radiation.

Table III. ACDB climate data file fields

ACDB field	Detail
Site	two letter code for the site (eg AD for Adelaide)
YY	last two digits of the year number eg 67 for 1967
MM	month number (zero-filled) eg 01 for January
DD	day number (zero-filled) eg 01 for first of the month
HH	hour number 0-23 (0=midnight, 1=1am etc)
Temperature	Dry Bulb (Air) temperature in tenths of degrees C
Moisture Content	Moisture Content in tenths of g per kg
Atmospheric Pressure	Atmospheric (Air) Pressure in tenths of kPa
Wind Speed	Wind Speed in tenths of metres per second
Wind Direction	Wind Direction 0-16 (0=CALM,1=NNE, …, 16=N)
Cloud Cover	Cloud Cover 0-8 (0= no cloud, …, 8= full cloud)
Flag for Dry Bulb Temp	Flag for Dry Bulb Temp. (0=Actual, 1=Estimated)
Flag for Moisture Content	Flag for Moisture Content (0=Actual, 1=Estimated)
Flag for Atmospheric Pressure	Flag for Atmospheric Pressure (0=Actual, 1=Estimated)
Flag for Wind Speed	Flag for Wind Speed (0=Actual, 1=Estimated)
Flag for Cloud Cover	Flag for Cloud Cover (0=Actual, 1=Estimated)
Flag for Wind Direction	Flag for Wind Direction (0=Actual, 1=Estimated)
Global Solar Radiation	Global Solar Radiation on a horizontal plane (Wh/m2)
Diffuse Solar Radiation	Diffuse Solar Radiation on a horizontal plane (Wh/m2)
Normal Direct Solar Radiation	Normal Direct Solar Radiation (Wh/m2)
Solar Altitude	Solar Altitude in degrees (0 to 90)
Solar Azimuth	Solar Azimuth in degrees (0 to 359, 0=N, 90=E, …)
Flag for Global Solar Radiation	Flag for Global Solar Radiation. (0=Actual, 1=Estimated)
Flag for Diffuse Solar Radiation	Flag for Diffuse Solar Radiation (0=Actual, 1=Estimated)
Flag for Normal Direct Solar Radiation	Flag for Normal Direct Solar Radiation (0=Actual, 1=Estim.)
Century digits	first two digits of the year number eg 19 for 1967

Precipitation data from the Australian Bureau of Meteorology (BoM)

The 18 fields in the BoM 30-minute precipitation data files hold data for location, date and time (standard and local) and precipitation in the preceding half hour.

Table IV. BoM 30-minute precipitation data file fields

Field label	Detail
hm	
Station Number	5 digit number for the weather station
Year Month Day Hour Minutes in YYYY	4 digit number for the year eg 1967 and 2013
MM	month number (zero-filled) eg 01 for January
DD	day number (zero-filled) eg 01 for first of the month
HH24	hour number 0-23 (0=midnight, 1=1am etc)
MI format in Local time	Half hour minute number eg 00 or 30 in local time
Year Month Day Hour Minutes in YYYY	The year, month, day, hour and minute fields are repeated

	for local standard time.
MM	month number (zero-filled) eg 01 for January
DD	day number (zero-filled) eg 01 for first of the month
HH24	hour number 0-23 (0=midnight, 1=1am etc)
MI format in Local standard time	month number (zero-filled) eg 01 for January
Precipitation in last 10 minutes in mm	number to one decimal place, minimum increment 0.2
Quality of precipitation in last 10 minutes	
Precipitation since 9am local time in mm	
Quality of precipitation since 9am local time	
AWS Flag	
#	