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Temperature and rainfall extremes data for CoastAdapt - Methods

Methods used to develop projections of temperature and rainfall extremes for use on the NCCARF CoastAdapt website

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March 2017

Contents

1 Introduction

The National Climate Change Adaptation Research Facility (NCCARF) has developed a user-friendly website for dissemination of information relating to coastal inundation (Figure 1) at local government scale. In 2016, NCCARF contracted CSIRO’s Climate Science Centre to develop some simple measures of future temperature and rainfall extremes that would be suitable for incorporation into CoastAdapt.

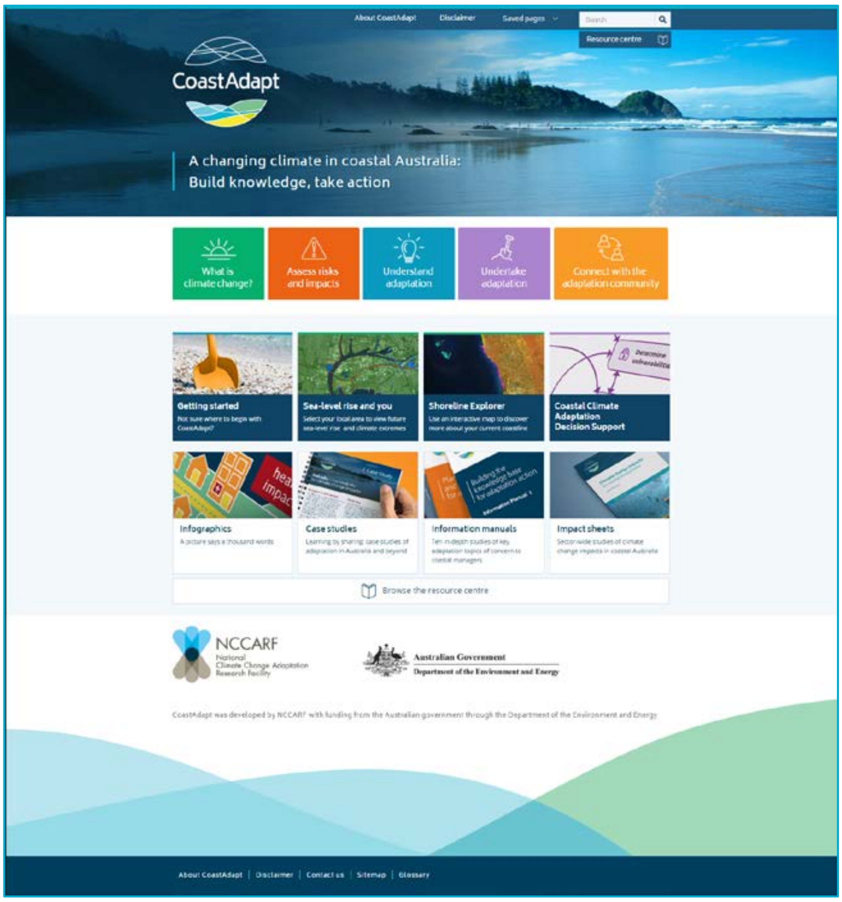


Figure 1 NCCARF CoastAdapt website (https://coastadapt.com.au/).

Following consultation with NCCARF, five indicators of extreme climate (Table 1) were produced for 241 locations. Although it is possible to develop these measures as averages calculated across each Coastal Council, such data would be difficult for users of CoastAdapt to relate to. Location-specific data, on the other hand are more readily understandable. Accordingly, NCCARF chose one location for each Coastal Council. The full list of locations with latitude and longitude information is provided in Appendix 1.

This report details the methods used to develop these datasets.

Table 1 Extremes metrics developed for CoastAdapt.

Extreme of interest	Metric developed	Notes
Hot Days	Average annual number of days where maximum temperature exceeds 30°C (days/year)	Historic and future values
Hot Nights	Average annual number of days where minimum temperature exceeds 25°C (days/year)	Historic and future values
Heatwaves	Average annual maximum run of days where maximum temperature exceeds 30° (days)	Historic and future values
Very Wet Days	Average annual number of days where daily total rainfall exceeds the historic 99.9th percentile.	Historic and future values; historically, such an event is expected once in every 1000 days on average.
Annual Dryness	Average number of months per year with total rainfall below the 10th percentile (0-12)	Historic and future values

2 Methods

2.1 Time periods and emissions scenarios

Each extremes metric was calculated for one historic period (1981-2010), four future time-periods (2016-2045, 2036-2065, 2056-2085 & 2075-2104) and two emissions scenarios (RCP4.5 & RCP8.5).

The emissions scenarios are shown in Figure 2.

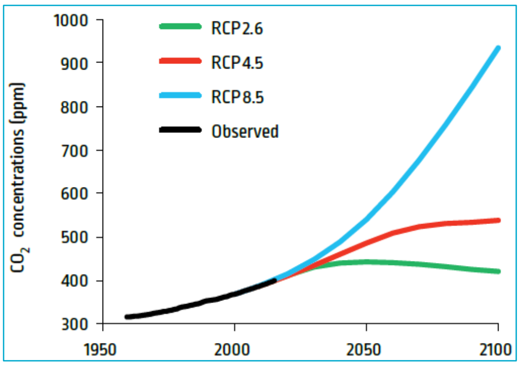


Figure 2 Emissions of carbon-dioxide (CO_2) corresponding to each of the four Representative Concentration Pathways (RCPs). For this work, only RCP4.5 (red) and RCP8.5 (blue) were used. SOURCE: Adapted from van Vuuren *et. al.* (2011).

The low-mid scenario (RCP4.5, red line) describes a future where global emissions peak around 2040 and CO_2 concentration reaching 540 ppm by 2100. The high emissions scenario (RCP8.5, blue line) describes a future with little curbing of emissions, with CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100 (van Vuuren *et al.* 2011).

2.2 Underpinning data sources

All the CoastAdapt datasets described here were developed using the 5 km gridded 'application-ready' datasets produced for Climate Change in Australia (CCIA; CSIRO & BoM 2015). These datasets have been produced using a representative sub-set of eight global climate models in combination with 5 km gridded observational data. Hot days, hot nights and heatwaves data were derived from the (mean-scaled) 30-year daily maximum and minimum temperature time-series datasets. Very wet days were calculated from the (quantile-scaled) 30-year daily rainfall time-series (quantile-scaling improves the representation of extreme rainfall events). Annual Dryness was calculated using the (mean-scaled) monthly rainfall time-series. These datasets were created using the Australian Water Availability Project (Jones *et al.* 2009) gridded observational dataset. Further information is provided in section 3 and full details of the 'application-ready' datasets are described at:
https://www.climatechangeinaustralia.gov.au/en/support-and-guidance/using-climate-projections/application-ready-data/scaling-methods/

For each CoastAdapt extreme measure, the data were calculated across the entire Australia-wide 5 km grid prior to extraction for the locations of interest. A small number of locations fell outside the spatial extent of the 5 km gridded dataset. In such cases, data were extracted from the nearest available grid (see Section 3.3).

The steps for production of each dataset are described in the following sub-sections.

2.3 Hot Days

Counts of hot days were calculated as follows:

1. For the historic (1981-2010) 30-year time-series
   (AWAP gridded daily maximum temperature)
   A. For each 5 × 5 km grid square
      i. Count the number of days where maximum temperature exceeded 30°C
      ii. Compute the annual average number (i.e. days/year)
   B. Extract the values for each location from the nearest grid square
2. For each of the four future time periods and two emissions scenarios
   (AWAP gridded observed daily maximum temperature time-series scaled by the relevant mean monthly change factor from the climate models)
   A. For each of the eight-model datasets
      i. For each 5 × 5 km grid square
         a. Count the number of days where maximum temperature exceeded 30°C
         b. Compute the annual average number (i.e. days/year)
      ii. Extract the values for each location from the nearest grid square
   B. Compute the mean, minimum and maximum of the eight models

2.4 Hot Nights

Counts of hot nights were calculated as follows:

1. For the historic (1981-2010) 30-year time-series
   (AWAP gridded daily minimum temperature)
   A. For each 5 × 5 km grid square
      i. Count the number of days where minimum temperature exceeded 25°C
      ii. Compute the annual average number (i.e. days/year)
   B. Extract the values for each location from the nearest grid square
2. For each of the four future time periods and two emissions scenarios
   (AWAP gridded observed daily maximum temperature time-series scaled by the relevant mean monthly change factor from the climate models)
   A. For each of the eight-model datasets
      i. For each 5 × 5 km grid square
         a. Count the number of days where minimum temperature exceeded 25°C
         b. Compute the annual average number (i.e. days/year)
      ii. Extract the values for each location from the nearest grid square
   B. Compute the mean, minimum and maximum of the eight models

2.5 Heat Waves

Average longest run of consecutive days above 30°C was calculated as follows:

1. For the historic (1981-2010) 30-year time-series
   (AWAP gridded daily maximum temperature)
   C. For each 5 × 5 km grid square
      i. Find each unique run of two or more consecutive days with maximum temperature greater than 30°C
      ii. Count the number of consecutive days in each run
      iii. Find the highest 'consecutive days' count for each calendar year
      iv. Calculate the average for the 30-year time period (i.e. days)
   D. Extract the values for each location from the nearest grid square
2. For each of the four future time periods and two emissions scenarios
   (AWAP gridded observed daily maximum temperature time-series scaled by the relevant mean monthly change factor from the climate models)
   A. For each of the eight-model datasets
      i. For each 5 × 5 km grid square
         a. Find each unique run of two or more consecutive days with maximum temperature greater than 30°C
         b. Count the number of consecutive days in each run
         c. Find the highest 'consecutive days' count for each calendar year

d. Calculate the average for the 30-year time period (i.e. days)
ii. Extract the values for each location from the nearest grid square
B. Compute the mean, minimum and maximum of the eight models

2.6 Very Wet Days

Counts of days with rainfall in excess of the historic 99.9th percentile were calculated as follows:

1. For the entire AWAP historic dataset (1900-2010)
   (AWAP gridded daily rainfall time-series)
   A. For each 5 × 5 km grid square
      i. Calculate the 99.9th percentile daily rainfall value
2. For the AWAP historic reference (1981-2010) 30-year time-series
   (AWAP gridded daily rainfall time-series)
   A. For each 5 × 5 km grid square
      i. Count the number of days where daily total rainfall exceeded the 99.9th percentile for that grid square
      ii. Compute the annual average number (i.e. days/year)
   B. Extract the values for each location from the nearest grid square
3. For each of the four future time periods and two emissions scenarios
   (AWAP gridded observed daily rainfall time-series scaled by the relevant quantile change factor from the climate models)
   A. For each of the eight-model datasets
      i. For each 5 × 5 km grid square
         a. Count the number of days where daily total rainfall exceeded the 99.9th percentile for that grid square
         b. Compute the annual average number (i.e. days/year)
      ii. Extract the values for each location from the nearest grid square
   B. Compute the mean, minimum and maximum of the eight models

2.7 Annual Dryness

Counts of months per year with monthly total rainfall below the corresponding 10th percentile were calculated as follows:

1. For the entire AWAP historic dataset (1900-2010)
   (AWAP gridded monthly rainfall time-series)
   A. For each 5 × 5 km grid square
      i. Calculate the 10th percentile monthly total rainfall value, month by month
2. For the AWAP historic reference (1981-2010) 30-year time-series
   (AWAP gridded monthly rainfall time-series)
   A. For each 5 × 5 km grid square

i. Count the number of months where monthly total rainfall was less than the 10th percentile for that grid square
ii. Compute the average number for each May to April period (i.e. months/'ENSO-year'; note that this reduces the total number of complete ENSO-years to 29)

B. Extract the values for each location from the nearest grid square

3. For each of the four future time periods and two emissions scenarios (AWAP gridded observed monthly rainfall time-series scaled by the relevant mean monthly change factor from the climate models)
   A. For each of the eight-model datasets
      i. For each 5 × 5 km grid square
         a. Count the number of months where monthly total rainfall was less than the 10th percentile for that grid square
         b. Compute the average number for each May to April period (i.e. months/'ENSO-year'; note that this reduces the total number of complete ENSO-years to 29)
      ii. Extract the values for each location from the nearest grid square
   B. Compute the mean, minimum and maximum of the eight models

3 Notes on the data

It is important to understand certain aspects of the daily and monthly time-series data from which the CoastAdapt data have been derived. As described in detail on the Climate Change in Australia website, the future time-series data are produced by applying future projected changes to historic daily or monthly time-series.

3.1 Climate change trend

The historic time-series data are 30-years in duration (1981-2010) and therefore include a mean climate change trend within that 30 years. The warming signal is applied to this historic period to generate a realistic future time-series. As a consequence, the future time-series reproduces the historic trend in mean climate, and does not contain the modelled trend within the future 30 year time series (which may be greater or less than the historic trends). This is necessary in order to avoid double-counting the historic trend. This means that the time series represent a difference in the climate between two periods, and should not be used as a time series of trends within a future period – this is important context for their use.

3.2 Natural variability

The historic time-series data reflect natural variations in the climate that occurred in that period, and since the future temperature time-series data are a scaling of this historical data, they retain this same variability (e.g. the same standard deviation) and the same sequence of events (e.g. a relatively hotter month followed by a relatively cooler month). For the rainfall data, the projected change values derived from the global climate models are applied at various quantiles, so there is some change in the rainfall distribution as simulated by the global climate models (e.g. in some cases the rainfall on very wet days will increase even if the mean is projected to decrease). The sequence of rainfall events (e.g. the sequence of no-rain days and heavy rainfall days in a month) will be the same as in the historical observed data.

The extent to which any projected changes to natural variability are represented in the future data varies with the dataset, as described in Table 2.

Table 2 Extent to which the extremes datasets produced for CoastAdapt reflect projected changes in natural variability

Metric	Natural Variability
Hot Days, Hot Nights & Heatwaves	The historic daily temperature time-series data were scaled by the future monthly mean changes. This will represent changes to the annual mean temperature and the mean annual cycle due to climate change, but not changes in daily, monthly or multi-year variability that climate change may cause.
Very Wet Days	The historic daily rainfall time-series is scaled with a quantile-scaling method. Because of this, projected changes in the wettest days (which are expected to be different to changes in daily mean rainfall) are better reflected in the future datasets. The timing of rainfall events, including the frequency of very wet days will be the same as in the historical observations. Some rainfall days can become no-rain days but dry days cannot become wet days.
Annual Dryness	The historic monthly rainfall time-series is scaled by the future average monthly mean changes. The mean change and change in the mean annual cycle will be represented, which then has an influence on the prevalence of dry years. Changes to inter-annual variability in rainfall due to climate change will not be represented.

3.3 Limitations of the AWAP spatial domain

The historic temperature and rainfall time-series data are obtained from the Australian Water Availability Project (AWAP) 5 km gridded dataset (Jones *et al.* 2009). This dataset is based on the

Bureau of Meteorology's (BoM) extensive observation station network and uses statistical techniques to interpolate between stations.

The data cover the land areas of continental Australia, extending to some of the continental islands. However, a small number (three) of the CoastAdapt locations fall outside the AWAP spatial domain. In these cases, the data were obtained from the nearest AWAP grid cell. The list of locations in Appendix 1 shows the locations along with the latitude and longitude of the AWAP grid cell used and (where relevant) the distance from the target location.

In an attempt to evaluate any differences between the historic climate of the target location and the surrogate grid cell used, we examined the low-resolution ERA-Interim 'reanalysis' (global, approximately 75 km grid) along with any available BoM station data. Unfortunately, the large grid size of the ERA-Interim dataset meant that the target location and the surrogate AWAP grid cell fell within the same ERA-Interim grid, thus precluding any like-for-like comparison.

It was, however possible to use limited station data to make a meaningful comparison (comparing like with like) for the target location "Torres Strait Islands (inner)"; the location for which corresponds to Thursday Island. The BoM stations "Thursday Island Township" (ID 027021) "Cape York Post Office" (ID 027004) have adequate data for different lengths of time, however there is an overlap from 1931 to 1960. A comparison of monthly climatological averages for this time period is shown in Table 3. Based on these data, Cape York has slightly lower maximum daily temperatures than Thursday Island. Since the location of the Cape York station approximates that of the AWAP grid cell used to produce the projections data, the counts of days above 35°C and nights above 25°C given for "Torres Strait Islands (inner)" may be a slight underestimate.

In the case of rainfall, the projections data produced are based on percentiles of the historic. Thus, there is little that can be said by comparing the Thursday Island and Cape York stations. However, it is encouraging that the historic decile 1 and maximum daily rainfall values are reasonably similar.

Overall, in the absence of better data to facilitate more meaningful comparisons, we can say the projections data provided for Torres Strait Islands (inner), Torres Strait Islands (outer) and Palm Island are likely to be indicative only. The projections are provided with lower confidence than those that fall within the AWAP spatial domain.

Table 3 Monthly and annual averages for three climate statistics for Thursday Island Township (BoM ID 027021) & Cape York Post Office (BoM ID 027004) for the period 1931-1960.

Month	Max. Temperature (°C)		Decile 1 Rainfall (mm)		Highest daily rain (mm)	
	Thursday Is	Cape York	Thursday Is	Cape York	Thursday Is	Cape York
January	30.8	30.0	164.4	172.8	220.2	233.7
February	30.2	29.7	221.0	210.7	133.4	119.4
March	30.6	29.7	184.9	201.9	176.5	251.7
April	30.5	29.6	58.6	58.1	188.2	208.3
May	29.9	28.7	9.1	17.6	197.1	135.9
June	29.0	28.1	3.4	4.1	94.7	64.0
July	28.3	27.6	4.0	8.1	16.8	20.8
August	28.6	27.7	0.8	0.0	58.4	8.9
September	29.4	28.6	0.0	0.0	18.8	31.0
October	30.7	30.0	0.0	0.0	93.5	87.6
November	32.1	31.0	1.6	4.8	165.6	98.3
December	31.9	31.1	10.9	12.8	238.3	279.4
Annual	30.2	29.3	1446.9	1320.4	238.3	279.4

3.4 Limitations of AWAP observations

The gridded AWAP dataset is created using statistical modelling techniques to interpolate results between Bureau of Meteorology stations (Jones *et al.* 2009).

Due to the interpolation methods used, AWAP data do not always match corresponding station data. The interpolation also means that some extreme events may be underestimated (Avila et al. 2015).

3.5 Scaling methods

As described in section 2.2, the underpinning *Application-Ready Data* were produced using one of two 'scaling' methods. In essence, 'scaling' approaches use knowledge of projected future changes to modify historic datasets to produce plausible future equivalent datasets. The mean and quantile scaling methods of relevance to this report are described in detail on the Climate Change in Australia website but are briefly described here.

3.5.1 Mean-scaling

The mean-scaling approach takes an historic daily or monthly time-series and applies the future monthly mean change value for the corresponding month as obtained from a global climate model (GCM). This was done using eight-model subset of all available GCMs, selected on the basis of representativeness, model skill and model independence. The resultant time-series is then checked against the original change quantities, and any error (bias) corrected.

Figure 3 shows an example of this approach for one GCM.

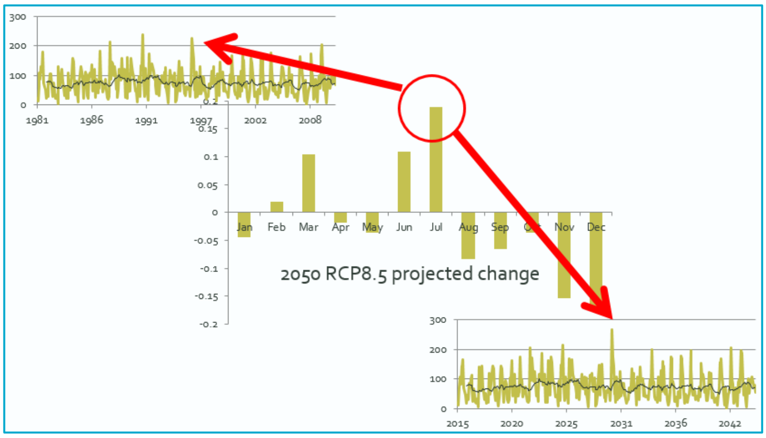
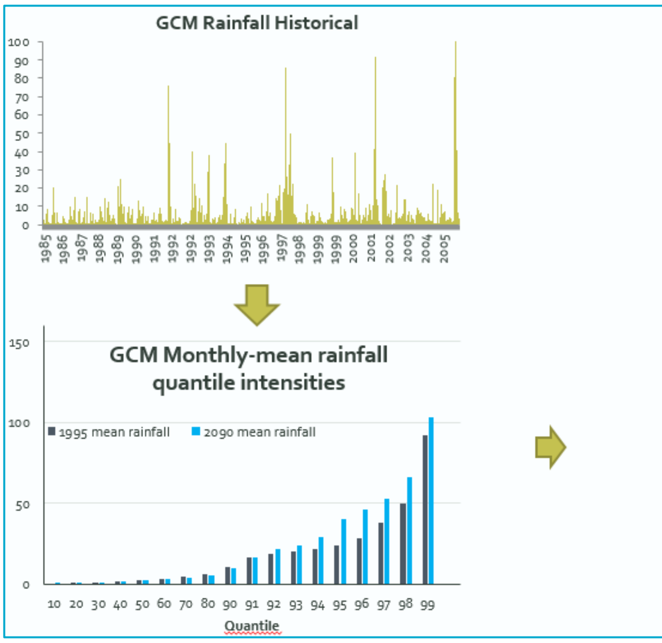


Figure 3 An example showing a daily time-series (top left) being scaled by the appropriate monthly mean change (middle) to produce a plausible future daily time-series (bottom right). The arrows show a July day from the observations being scaled by the July change value to produce the corresponding future daily amount.

3.5.2 Quantile-scaling

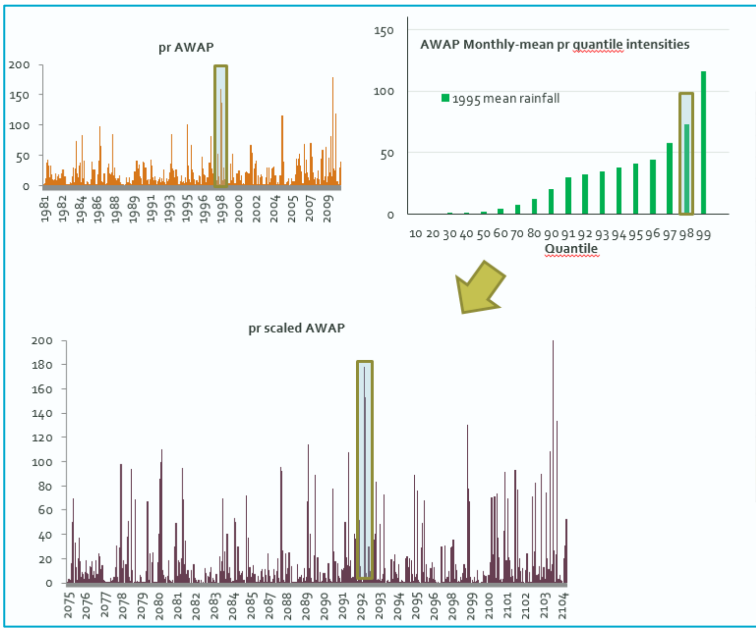
The quantile-scaling approach is a more sophisticated method whereby for each month, the historic data are separated into quantiles before being scaled by the projected change for the corresponding future quantile. In this case, the quantiles used were deciles 1 to 9 then every percentile from 91 to 99. This approach was only used to scale daily rainfall data and has the advantage of better capturing projected changes in high intensity rainfall events. The resultant time-series is then checked against the original change quantities, and any error (bias) corrected.

Figures 4 & 5 summarise the main steps in producing quantile-scaled data.



Quantile	Change ratio
Percentile 10	-1.0025
Percentile 20	0.0661
Percentile 30	-0.0850
Percentile 40	-0.0859
Percentile 50	-0.0537
Percentile 60	-0.1446
Percentile 70	-0.1378
Percentile 80	-0.1179
Percentile 90	-0.0700
Percentile 91	0.0084
Percentile 92	0.1410
Percentile 93	0.1864
Percentile 94	0.3394
Percentile 95	0.6722
Percentile 96	0.6175
Percentile 97	0.3931
Percentile 98	0.3305
Percentile 99	0.1222

Figure 4 Step 1 of quantile-quantile scaling. GCM simulated historic daily rainfall data (top left) are 'binned' into 20 quantiles. The same is done for the model's future projected times series (bottom left). The change from historic to future is calculated for each 'bin' or quantile (right).



Quantile	Change ratio
Percentile 10	-1.0025
Percentile 20	0.0661
Percentile 30	-0.0850
Percentile 40	-0.0859
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Percentile 70	-0.1378
Percentile 80	-0.1179
Percentile 90	-0.0700
Percentile 91	0.0084
Percentile 92	0.1410
Percentile 93	0.1864
Percentile 94	0.3394
Percentile 95	0.6722
Percentile 96	0.6175
Percentile 97	0.3931
Percentile 98	0.3305
Percentile 99	0.1222

Figure 5 Step 2 of quantile-quantile scaling. Observed daily rainfall time-series (top left) 'binned' into quantiles (top middle). The quantiles are scaled by the corresponding change ratios (right) and applied to the observations to produce the scaled future time-series (bottom left).

4 References

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Appendix 1 Location details

Table of locations and latitude/longitude of AWAP grid cell used for data extraction along with target latitude/longitude where these fell outside the AWAP spatial domain.

Location	AWAP Latitude	AWAP Longitude	Target Latitude	Target Longitude	Distance
Albany	-35.00	117.90			
Alexandrina	-35.50	138.80			
Ashburton	-22.70	117.80			
Ashfield	-33.90	151.10			
Auburn	-33.85	151.05			
Augusta-Margaret River	-33.95	115.05			
Aurukun	-13.35	141.75			
Ballina	-28.85	153.55			
Bankstown	-33.90	151.05			
Barunga West	-33.60	137.95			
Bass Coast	-38.40	145.20			
Bassendean	-31.90	115.95			
Bayside	-37.95	145.00			
Bayswater	-31.90	115.90			
Bega Valley	-36.70	149.85			
Bellingen	-30.45	152.90			
Belmont	-31.95	115.95			
Botany Bay	-33.95	151.20			
Break O'Day	-41.30	148.25			
Brighton	-42.75	147.30			
Brisbane	-27.45	153.00			
Broome	-17.95	122.25			
Bunbury	-33.35	115.65			
Bundaberg	-24.85	152.35			
Burdekin	-19.60	147.40			
Burke	-17.75	139.55			
Burnie	-41.05	145.90			
Busselton	-33.65	115.35			
Byron	-28.55	153.5			
Cairns	-16.95	145.75			
Cambridge	-31.95	115.80			
Canada Bay	-33.85	151.15			
Canning	-32.00	115.95			
Capel	-33.55	115.55			
Cardinia	-38.05	145.40			
Carnamah	-29.70	115.90			
Carnarvon	-24.90	113.65			
Carpentaria	-17.65	141.10			
Casey	-38.00	145.30			

Location	AWAP Latitude	AWAP Longitude	Target Latitude	Target Longitude	Distance
Cassowary Coast	-17.95	145.90			
Ceduna	-32.10	133.70			
Central Coast	-41.15	146.15			
Chapman Valley	-28.50	114.80			
Charles Sturt	-34.90	138.55			
Circular Head	-40.85	145.15			
Claremont	-32.00	115.80			
Clarence	-42.85	147.35			
Clarence Valley	-29.45	153.20			
Cleve	-33.70	136.50			
Cockburn	-32.10	115.80			
Coffs Harbour	-30.30	153.10			
Colac-Otway	-38.75	143.65			
Cook	-15.50	145.25			
Coorow	-29.90	116.05			
Copper Coast	-33.95	137.70			
Corangamite	-38.25	143.15			
Cottesloe	-32.00	115.80			
Dandaragan	-30.30	115.05			
Darwin	-12.45	130.85			
Denmark	-34.95	117.35			
Derby-West Kimberley	-17.30	123.65			
Derwent Valley	-42.80	147.05			
Devonport	-41.20	146.35			
Doomadgee	-17.95	138.85			
Dorset	-41.15	147.50			
Douglas	-19.25	146.80			
Dundas	-32.20	121.80			
East Arnhem	-12.35	134.95			
East Fremantle	-32.05	115.75			
East Gippsland	-37.85	147.65			
East Pilbara	-23.35	119.75			
Elliston	-33.65	134.90			
Esperance	-33.85	121.90			
Eurobodalla	-35.90	150.10			
Exmouth	-21.95	114.10			
Flinders	-40.10	148.00			
Franklin Harbour	-33.70	136.90			
Frankston	-38.15	145.20			
Fraser Coast	-25.30	152.85			
Fremantle	-32.05	115.75			
George Town	-41.10	146.85			
Geraldton-Greenough	-28.80	114.65			
Gingin	-31.35	115.90			

Location	AWAP Latitude	AWAP Longitude	Target Latitude	Target Longitude	Distance
Gladstone	-23.85	151.25			
Glamorgan/Spring Bay	-42.50	147.90			
Glenelg	-38.35	141.60			
Glenorchy	-42.85	147.30			
Gold Coast	-28.00	153.35			
Gosford	-33.45	151.35			
Grant	-37.80	140.75			
Great Lakes	-32.20	152.50			
Greater Geelong	-38.15	144.35			
Greater Taree	-31.90	152.45			
Gympie	-26.20	152.65			
Harvey	-33.10	115.90			
Hinchinbrook	-18.65	146.15			
Hobart	-42.90	147.30			
Hobsons Bay	-37.85	144.85			
Holdfast Bay	-35.00	138.55			
Hope Vale	-15.30	145.10			
Hornsby	-33.65	151.15			
Hunters Hill	-33.85	151.15			
Huon Valley	-43.35	146.50			
Hurstville	-33.95	151.10			
Irwin	-29.25	114.95			
Isaac	-22.80	147.65			
Jerramungup	-33.95	118.9			
Joondalup	-31.75	115.75			
Kangaroo Island	-35.65	137.60			
Kempsey	-31.10	152.85			
Kiama	-34.65	150.85			
King Island	-39.90	143.85			
Kingborough	-43.00	147.30			
Kingston	-37.95	145.05			
Kingston	-36.85	139.85			
Kogarah	-33.95	151.15			
Kowanyama	-15.45	141.75			
Ku-ring-gai	-33.75	151.15			
Kwinana	-32.25	115.80			
Lake Macquarie	-33.10	151.65			
Lane Cove	-33.80	151.15			
Latrobe	-41.25	146.40			
Launceston	-41.45	147.15			
Leichhardt	-33.90	151.15			
Litchfield	-12.55	131.05			
Livingstone	-23.40	150.50			
Lockhart River	-12.80	143.35			

Location	AWAP Latitude	AWAP Longitude	Target Latitude	Target Longitude	Distance
Lower Eyre Peninsula	-34.25	135.75			
Mackay	-21.15	149.20			
Mallala	-34.45	138.50			
Mandurah	-32.55	115.70			
Manjimup	-34.25	116.15			
Manly	-33.80	151.25			
Mapoon	-12.05	141.90			
Marion	-35.00	138.55			
Melbourne	-37.80	144.95			
Melville	-32.05	115.85			
Moreton Bay	-27.10	152.95			
Mornington	-16.50	139.40			
Mornington Peninsula	-38.40	144.90			
Mosman	-33.80	151.25			
Mosman Park	-32.00	115.80			
Mount Remarkable	-32.85	138.20			
Moyne	-38.35	142.25			
Murray	-32.65	115.85			
Nambucca	-30.70	152.90			
Nannup	-34.00	115.75			
Napranum	-12.65	141.90			
Nedlands	-32.00	115.80			
Newcastle	-32.95	151.75			
Noosa	-26.40	153.05			
North Sydney	-33.85	151.20			
Northampton	-28.35	114.65			
Northern Peninsula Area	-10.90	142.40			
Onkaparinga	-35.10	138.55			
Palm Island	-18.70	146.30	-18.73	146.58	*ca.* 27 km
Palmerston	-12.50	131.00			
Parramatta	-33.80	151.00			
Peppermint Grove	-32.00	115.80			
Perth	-31.95	115.85			
Pittwater	-33.70	151.30			
Playford	-34.70	138.65			
Pormpuraaw	-14.90	141.65			
Port Adelaide Enfield	-34.85	138.50			
Port Augusta	-32.50	137.75			
Port Hedland	-20.35	118.60			
Port Lincoln	-34.70	135.85			
Port Macquarie-Hastings	-31.45	152.90			
Port Phillip	-37.85	145.00			
Port Pirie City and Dists	-33.20	138.00			
Port Stephens	-32.75	151.75			

Location	AWAP Latitude	AWAP Longitude	Target Latitude	Target Longitude	Distance
Queenscliffe	-38.25	144.60			
Randwick	-33.90	151.25			
Ravensthorpe	-33.60	120.05			
Redland	-27.55	153.25			
Richmond Valley	-28.85	153.05			
Robe	-37.15	139.80			
Rockdale	-33.95	151.15			
Rockhampton	-23.35	150.50			
Rockingham	-32.30	115.75			
Roebourne	-20.80	117.15			
Roper Gulf	-16.05	136.30			
Ryde	-33.80	151.10			
Salisbury	-34.75	138.65			
Shark Bay	-25.90	113.55			
Shellharbour	-34.55	150.85			
Shoalhaven	-34.85	150.60			
Sorell	-42.75	147.55			
South Gippsland	-38.50	145.95			
South Perth	-32.00	115.85			
Stirling	-31.90	115.80			
Streaky Bay	-32.80	134.20			
Subiaco	-31.95	115.80			
Sunshine Coast	-26.65	153.05			
Surf Coast	-38.30	144.30			
Sutherland Shire	-34.05	151.05			
Swan	-31.90	116.00			
Sydney	-33.85	151.20			
Tasman	-43.10	147.75			
The Coorong	-35.25	139.45			
Tiwi Islands	-11.75	130.65			
Torres Strait Islands (inner)	-10.75	142.45	-10.58	142.22	*ca.* 28 km
Torres Strait Islands (outer)	-10.75	142.6	-10.05	143.07	*ca.* 90 km
Townsville	-19.25	146.80			
Tumby Bay	-34.35	136.10			
Tweed	-28.20	153.55			
Unincorp. Other Territories	-25.25	131.00			
Unincorporated NSW	-31.20	142.75			
Unincorporated NT	-12.65	132.85			
Unincorporated Vic	-38.95	146.30			
Victor Harbor	-35.55	138.60			
Victoria Park	-31.95	115.90			
Victoria-Daly	-14.10	129.70			
Vincent	-31.95	115.85			
Wakefield	-34.15	138.40			

Location	AWAP Latitude	AWAP Longitude	Target Latitude	Target Longitude	Distance
Wanneroo	-31.75	115.80			
Waratah/Wynyard	-41.00	145.75			
Waroona	-32.85	115.90			
Warringah	-33.70	151.30			
Warrnambool	-38.35	142.55			
Wattle Range	-37.60	140.35			
Waverley	-33.90	151.25			
Weipa	-12.65	141.90			
Wellington	-38.55	146.65			
West Arnhem	-12.65	132.85			
West Coast	-42.10	145.55			
West Tamar	-41.20	146.80			
West Torrens	-34.95	138.55			
Whitsunday	-20.00	148.25			
Whyalla	-33.05	137.55			
Willoughby	-33.80	151.20			
Wollongong	-34.40	150.90			
Woollahra	-33.90	151.25			
Wujal Wujal	-15.95	145.30			
Wyndham	-37.90	144.65			
Wyndham-East Kimberley	-15.80	128.75			
Wyong	-33.30	151.40			
Yankalilla	-35.45	138.35			
Yarrabah	-16.90	145.85			
Yorke Peninsula	-34.35	137.70			

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