Weather Data and Climate Data Updates and Enhancements
This paper discusses the current situation with Australian weather and climate data availability, recent updates and projected enhancements in the foreseeable future:

- History of weather and climate data;
- Satellite estimation of hourly irradiation data;
- Real time weather data;
- Weather element weightings in climate data;
- Extreme weather and climate data;
- Ersatz future climate data; and
- Addition of hourly rainfall data for weather and climate files.
Early work in establishing climate files for building and renewable energy systems design and evaluation in Australia began with:

- Solar radiation tables by CSIRO in the 1970s inferred from 3-hourly cloud cover data based on manual observations from the ground.
- CSIRO and BOM generated the Australian Climate Data Bank (ACDB) in the mid-1980s.
- Test Reference Years (TRY) published and distributed by the Association for Computer Aided Design – Building Services Group (ACADS-BSG).
- TRYs were actual years of hourly data selected to not include any months of unusually warm or cool weather.
History of weather and climate data

Australian Greenhouse Office (AGO) late last century paid extra attention to bias error:

- 3-hourly records manually collected over the years since 1967 (adopted as the earliest start of reliable records for the then 28 NatHERS locations).
- Quasi-sinusoidal algorithm for non-linear interpolation removed the bias error in temperature and humidity data.
- Synthesised climate years concatenating the 12 calendar months of best fit using a weather element weighted cumulative difference function.
- Number of NatHERS sites was increased to 69.
- TMY2 format versions.
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Satellite estimation of irradiation

This paper discusses the current situation with Australian weather and climate data availability, recent updates and projected enhancements in the foreseeable future:

- History of weather and climate data production leading to the current needs and potentials;
- Real time weather data files for concurrent simulation with system operation and measurement;
- Weather element weightings in the production of climate files for design simulations; and
- Addition of hourly rainfall data for weather and climate files.
Weather Data - satellite estimation

single scan image with 28 sites of the Australian Solar Radiation Data Handbook overlaid
Satellite estimated hourly solar data begins at 1990 and assumes that:

- A cloud is vertically above the piece of ground that the satellite “sees” when the cloud is not there; and
- The cloud’s shadow falls on that same piece of ground.

This is a computationally convenient simplification.

This is obviously imprecise. Does it matter?

We looked at the theory and its implications when the data is applied in industry and commerce.
Satellite Parallax Error

Planar trigonometry (where the site lies close to the satellite meridian) and 3D trigonometry (below) for all other cases.

**Diagram:**
- **ρ:** satellite range
- **e:** satellite elevation
- **g:** great circle angle from observer to satellite sub-point
- **h:** satellite altitude
- **r:** satellite radius
- **R:** radius of Earth
- **C:** centre of Earth
- **EARTH:**
- **N:** North Pole
- **S:** South Pole
- **O:** Observer
- **T:** Satellite sub-point
- **W:** West
- **E:** East
- **P:** Observer Meridian
- **Q:** Satellite Meridian
- **Equator:**

**Formulas:**
- \( r = R + h \)
Parallax Error – satellite and solar
2014/12/27
4pm AEST
[Cloud Height 7688m]
Parallax Error – satellite view angle

Past GEO-Satellites Meridian

Current GEO-Satellite Meridian

Canberra

Wagga

Wagga
Weather Data - satellite estimation

Exemplary Australian Solar Energy Atlas
Conclusions

Satellite estimated solar data can be improved by:

- Applying cloud height estimates to locate the cloud above the piece of ground that it is actually above;
- Applying cloud height estimates with solar geometry to establish where the cloud’s shadow actually falls; and
- Applying the greater temporal and spatial precision of the Himawari satellite which has been the source of irradiation data since March 2016.

But building simulations indicate that when the improved data is applied in industry and commerce it makes little difference to the estimated peak loads and annual energy consumption calculations.
Real time weather data

CSIRO Black Mountain Automatic Weather Station installed for the monitoring of solar PV installation test
Real time weather data

CSIRO Black Mountain Automatic Weather Station
solar irradiation and cloud measurement equipment
## Exemplary Weather and Energy Index

**Perth – 12 months actual v RMY**

<table>
<thead>
<tr>
<th>Weather Energy Index</th>
<th>10-storey Office</th>
<th>3-storey Office</th>
<th>Supermarket</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooling</td>
<td>Heating</td>
<td>Cooling</td>
</tr>
<tr>
<td>Nov-15</td>
<td>6%</td>
<td>N.A.</td>
<td>7%</td>
</tr>
<tr>
<td>Dec-15</td>
<td>-11%</td>
<td>N.A.</td>
<td>-14%</td>
</tr>
<tr>
<td>Jan-16</td>
<td>-2%</td>
<td>N.A.</td>
<td>-2%</td>
</tr>
<tr>
<td>Feb-16</td>
<td>-6%</td>
<td>N.A.</td>
<td>-8%</td>
</tr>
<tr>
<td>Mar-16</td>
<td>-9%</td>
<td>N.A.</td>
<td>-10%</td>
</tr>
<tr>
<td>Apr-16</td>
<td>-8%</td>
<td>N.A.</td>
<td>-8%</td>
</tr>
<tr>
<td>May-16</td>
<td>-8%</td>
<td>50%</td>
<td>-10%</td>
</tr>
<tr>
<td>Jun-16</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Jul-16</td>
<td>1%</td>
<td>23%</td>
<td>0%</td>
</tr>
<tr>
<td>Aug-16</td>
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<td>29%</td>
<td>-10%</td>
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<tr>
<td>Sep-16</td>
<td>-4%</td>
<td>71%</td>
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</tr>
<tr>
<td>Oct-16</td>
<td>-3%</td>
<td>N.A.</td>
<td>-5%</td>
</tr>
</tbody>
</table>
Exemplary Weather and Energy Index – Perth PV

Perth Monthly Energy Delivered

- kWh


Legend:
- PE_RMY_A (1990 - 2012)
- Murdoch_RTY_Raw
## Weather element weightings

<table>
<thead>
<tr>
<th>Weather Element</th>
<th>Weighting</th>
<th>Weather Element</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Temp</td>
<td>1/20</td>
<td>Max Temp</td>
<td>1/15</td>
</tr>
<tr>
<td>Min Temp</td>
<td>1/20</td>
<td>Min Temp</td>
<td>1/15</td>
</tr>
<tr>
<td>Mean Temp</td>
<td>2/20</td>
<td>Mean Temp</td>
<td>2/15</td>
</tr>
<tr>
<td>Max Wet Bulb Temp</td>
<td>1/20</td>
<td>Max Wet Bulb Temp</td>
<td>1/15</td>
</tr>
<tr>
<td>Min Wet Bulb Temp</td>
<td>1/20</td>
<td>Min Wet Bulb Temp</td>
<td>1/15</td>
</tr>
<tr>
<td>Mean Wet Bulb Temp</td>
<td>2/20</td>
<td>Mean Wet Bulb Temp</td>
<td>2/15</td>
</tr>
<tr>
<td>Max Wind Velocity</td>
<td>1/20</td>
<td>Max Wind Velocity</td>
<td>1/15</td>
</tr>
<tr>
<td>Mean Wind Velocity</td>
<td>1/20</td>
<td>Mean Wind Velocity</td>
<td>1/15</td>
</tr>
<tr>
<td>Global Radiation</td>
<td>5/20</td>
<td>Global Radiation</td>
<td>5/15</td>
</tr>
<tr>
<td>Diffuse Radiation</td>
<td>5/20</td>
<td>Diffuse Radiation</td>
<td>0/15</td>
</tr>
</tbody>
</table>
Weather element weightings

meteorological data to meet any set of weightings

Examples include:

<table>
<thead>
<tr>
<th>Potential weights for</th>
<th>Weather Element</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>large office buildings</td>
<td>Max Temp</td>
<td>1/12</td>
</tr>
<tr>
<td></td>
<td>Min Temp</td>
<td>1/12</td>
</tr>
<tr>
<td></td>
<td>Mean Temp</td>
<td>2/12</td>
</tr>
<tr>
<td></td>
<td>Max Wet Bulb Temp</td>
<td>1/12</td>
</tr>
<tr>
<td></td>
<td>Min Wet Bulb Temp</td>
<td>1/12</td>
</tr>
<tr>
<td></td>
<td>Mean Wet Bulb Temp</td>
<td>2/12</td>
</tr>
<tr>
<td></td>
<td>Max Wind Velocity</td>
<td>1/12</td>
</tr>
<tr>
<td></td>
<td>Mean Wind Velocity</td>
<td>1/12</td>
</tr>
<tr>
<td></td>
<td>Global Radiation</td>
<td>2/12</td>
</tr>
<tr>
<td></td>
<td>Diffuse Radiation</td>
<td>0/12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential weights for</th>
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<th>Weighting</th>
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</thead>
<tbody>
<tr>
<td>wind farms</td>
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<td>1/15</td>
</tr>
<tr>
<td></td>
<td>Min Temp</td>
<td>1/15</td>
</tr>
<tr>
<td></td>
<td>Mean Temp</td>
<td>1/15</td>
</tr>
<tr>
<td></td>
<td>Max Wet Bulb Temp</td>
<td>0/15</td>
</tr>
<tr>
<td></td>
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<td>0/15</td>
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<td>5/15</td>
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<td>5/15</td>
</tr>
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<td></td>
<td>Global Radiation</td>
<td>1/15</td>
</tr>
<tr>
<td></td>
<td>Diffuse Radiation</td>
<td>1/15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential weights for</th>
<th>Weather Element</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>solar-sensitive</td>
<td>Max Temp</td>
<td>1/20</td>
</tr>
<tr>
<td>infrastructure</td>
<td>Min Temp</td>
<td>0/20</td>
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<tr>
<td></td>
<td>Mean Temp</td>
<td>1/20</td>
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<tr>
<td></td>
<td>Max Wet Bulb Temp</td>
<td>0/20</td>
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</tr>
<tr>
<td></td>
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<td>5/20</td>
</tr>
</tbody>
</table>
No consensus on the definition of extreme weather as it can be applied to climate files.

Continuing intention to generate such files based on actual weather experienced over 3 decades once that definition has been agreed.

As an interim measure, approximate P10 and P90 climate files have been generated based on Global Horizontal Irradiation (GHI) for use in PV system design and performance prediction (SAM).
Ersatz future climate data

- 2030 - two weather files for (high and most-likely temperatures).
- 2050 - four scenarios for (high and low emissions and high and most-likely temperatures).
- Created in ACDB and TMY2 formats.
- Monthly Projected Change Values (PCVs) provided by CSIRO on a coarse geographic grid.
- Interpolation used on PCVs near the boundary between two (or three or four) grid cells.
Separate PCVs for:

- Temperature – separate PCVs for Min, Mean and Max linearly interpolated for each day (treating the lowest hourly value as the Min and the highest hourly value as the Max)
- Humidity – applied the interpolated monthly CSIRO increment to the monthly mean RH and monthly mean dry bulb temperature (and atmospheric pressure) to derive the absolute humidity increment for ACDB format data
- Insolation and cloud cover
- Wind
Ersatz future climate data

Separate PCVs for:

- **Insolation and cloud cover**
  - Irradiance values were retained wherever zero octas (clear sky)
  - Monthly total (sum) of global irradiation to be the original level multiplied by the CSIRO increment factor (PCV)
  - Optimisation performed for estimation of “forecast” direct:diffuse ratio
  - For any one hour, direct irradiance was not permitted to increase over Clear Sky levels (ASHRAE, 2009), while diffuse irradiance was permitted to increase, but restricted to less than double RMY levels
  - Cloud cover not incremented due to absence of a technique, very coarse integer units and it being a second order effect on building energy performance

- **Wind**
  - Keep all wind directions unchanged
  - Increase all non-zero wind speeds by the same factor that CSIRO “forecast” for mean wind speeds
Ersatz future climate data - applied

Understanding the changing climate for building energy efficiency by Dr Anir Kumar Upadhyay UNSW Built Environment
Coincident rainfall data will be added to the weather and climate data files generated for the 30 years 1990-2019 early next year.

- Collector cleanliness and efficiency can be better estimated using coincident rainfall data.
- Other aspects of sustainability in systems can also be better estimated or simulated with that data.
- Dampness issues in buildings using proprietary software like WUFI in accordance with recent additional requirements of the National Construction Code (NCC) which incorporates the Building Code of Australia (BCA).
Summary

- History of weather and climate data;
- Satellite estimation of hourly irradiation data;
- Real time weather data;
- Weather element weightings in climate data;
- Extreme weather and climate data;
- Ersatz future climate data; and
References


• 2017, updated presentation Perth – WREC 2017, Murdoch University

• 2019, presentation to ABSA, *Understanding the changing climate for building energy efficiency*, Dr Anir Kumar Upadhyay, UNSW Built Environment

Acknowledgements

Dr Ian Grant (Satellite Specialist) and Ian Muirhead (Climate & Oceans Data & Analysis Services) both of the Australian Bureau of Meteorology, have assisted with the progress of this work.
Weather Data and Climate Data
Updates and Enhancements

Questions? Suggestions?

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