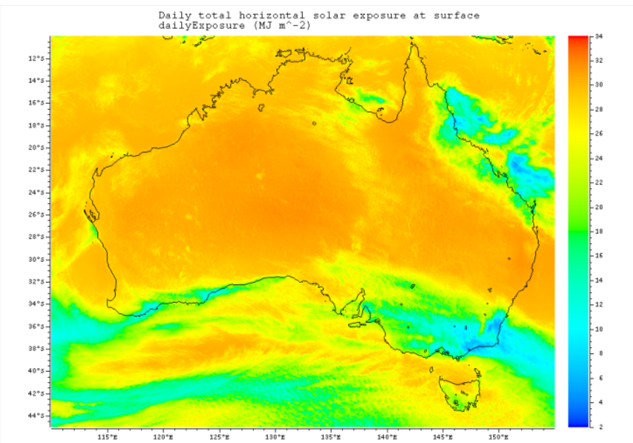
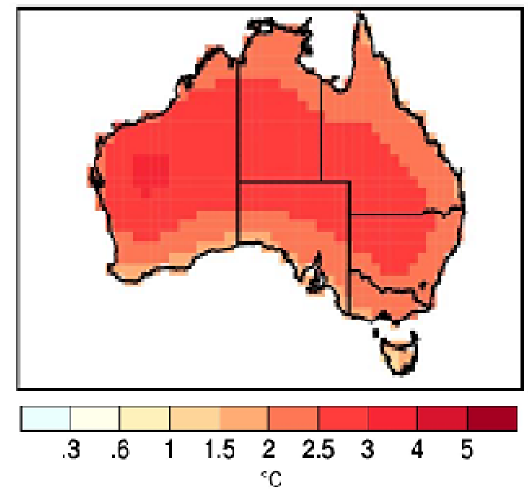
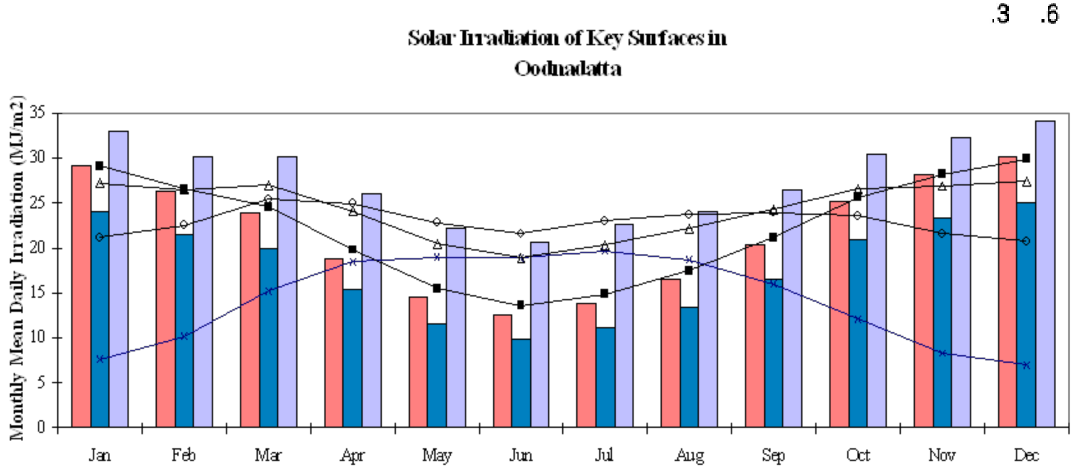
Climate Data for Building Optimisation and Energy Management



ENERGY
PARTNERS



Trevor Lee



Climate Data for Building Optimisation and Energy Management

The Australian Solar and Climate Resource

- **Australian Solar Radiation Data Handbook background and applications**

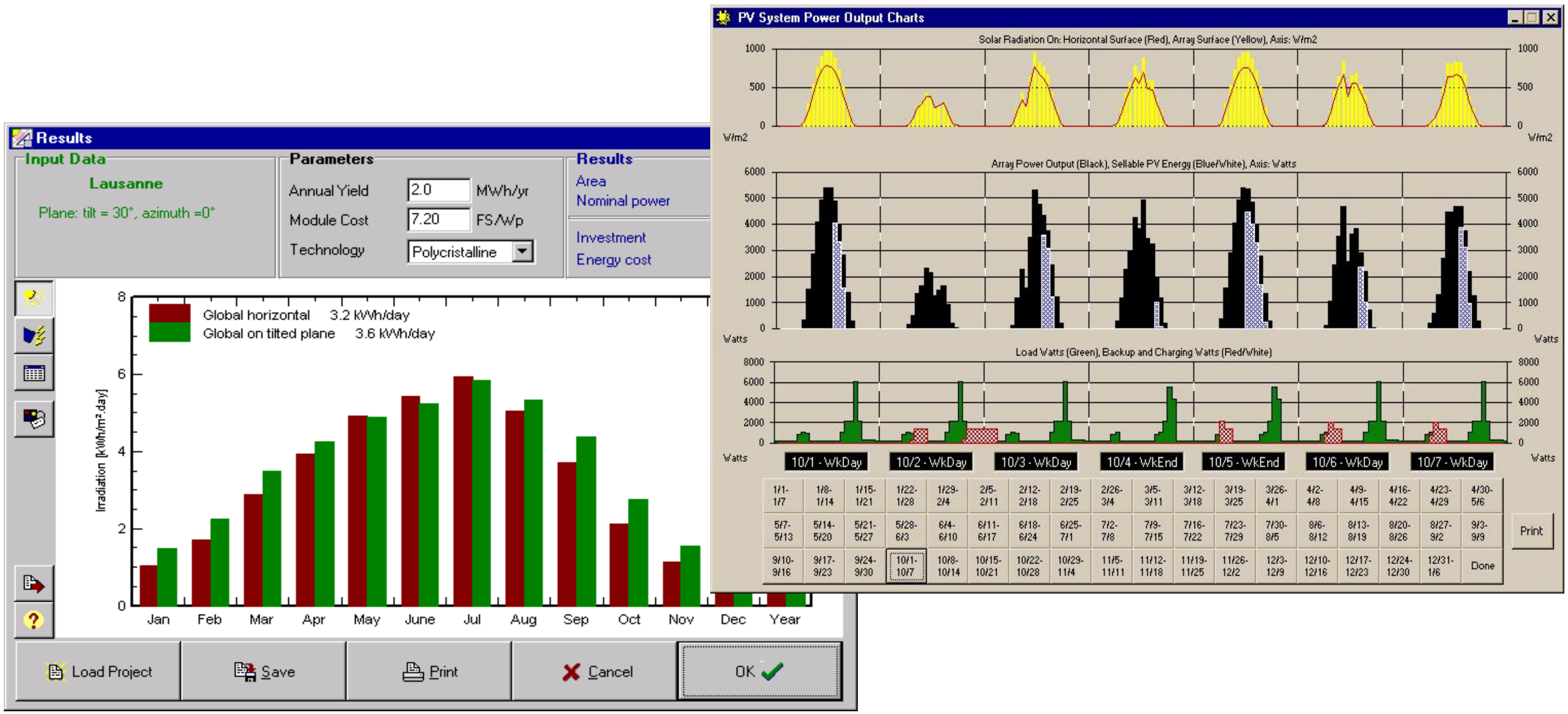
Beyond TMY: Climate Data for Specific Applications

- **Australian Climate Data Bank and using Reference Meteorological Years**

Creation of Ersatz Future Weather Data Files

- **Measuring energy performance of buildings under predicted future weather conditions**

The Australian Solar and Climate Resource



In association with Brett Stokes (Adelaide Applied Algebra)

ASRDH – Data Presentation

Australian Solar Radiation Data Handbook - AuSES

- **Table 1** — **Climate averages** (highest monthly mean, overall daily mean and lowest monthly mean) based on old ASRDH
- **Table 2** — **Clearness Index figures** (average hourly clearness figures for each month)
- **Tables 3** — **Solar radiation based on Horizontal Plane** (includes direct, diffuse, global and daily direct threshold percentages)
- **Tables 4** — **Vertical and Tracking Planes –** (Average total hourly irradiance (W/sq.m.) and daily irradiation (MJ/sq.m.) on a north-south axis tracking plane by hour for each month
- **Tables 5** — **Daily totals by month for inclined planes** (Plane azimuth versus plane inclination)
- **Tables 6** — **Vertical windows** – (eg. Average hourly (W/sq.m.) and daily (MJ/sq.m.) solar heat gain factor through a north facing vertical window for each month)
- **Tables 7** — **Sequences of days** (e.g. Proportional occurrence (%) of sequences of days for which the daily global irradiation is less than 10 MJ/sq.m.

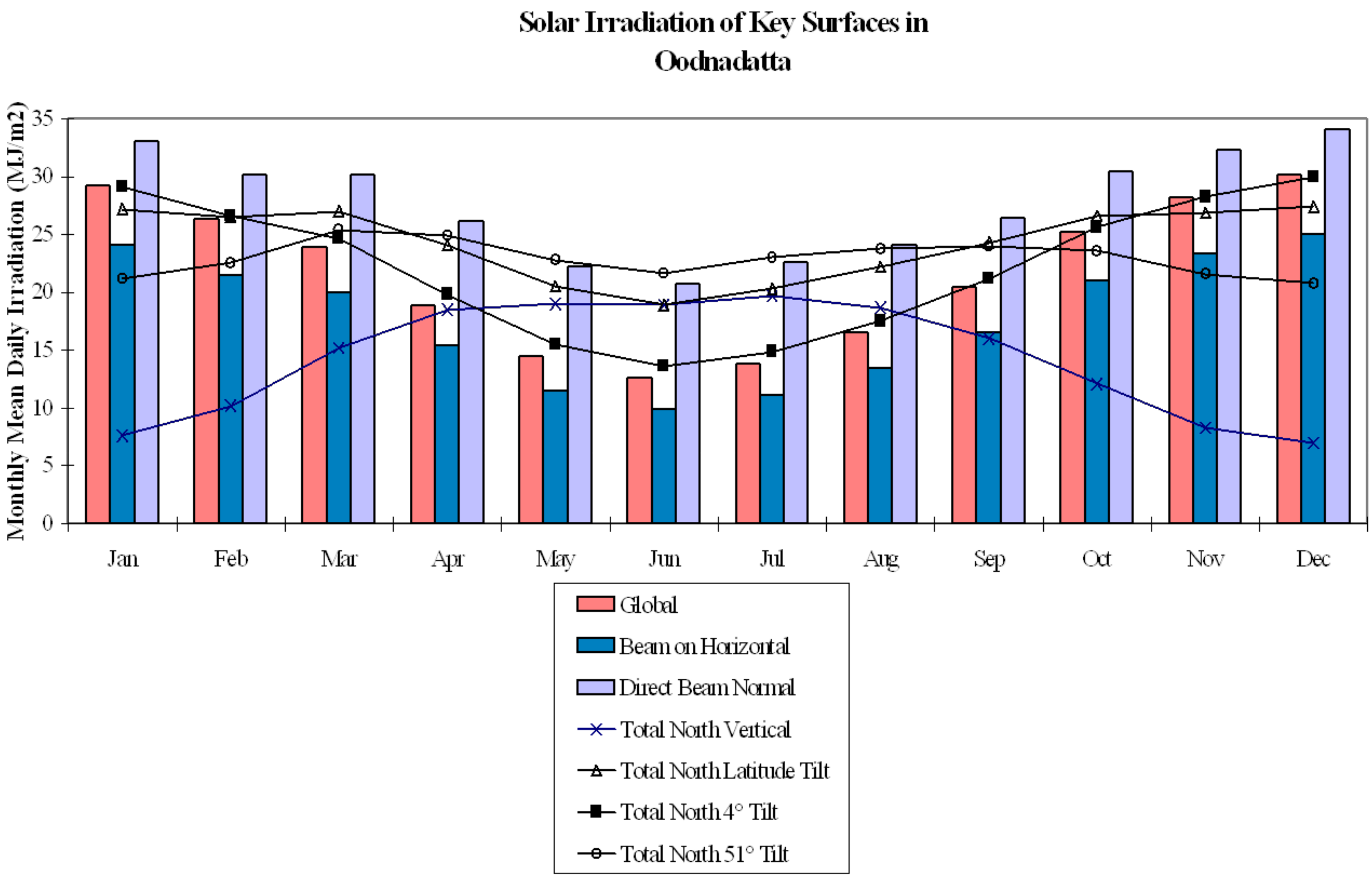
ASRDH - Sample Table

Table 4.5:

Average total hourly irradiance (W/sq.m.) and daily irradiation (MJ/sq.m.) on a north facing plane inclined at latitude angle for each month

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
5	1										1	3	
6	28	7							1	14	38	44	11
7	108	74	43	14	2			5	40	110	144	142	57
8	257	232	195	137	72	28	35	89	188	265	288	294	173
9	420	411	371	306	222	167	187	256	355	423	442	459	335
10	595	589	535	469	372	306	338	413	488	558	578	602	487
11	738	732	661	561	474	419	468	511	583	675	706	726	605
12	840	838	744	621	509	471	517	553	649	725	779	794	670
13	869	870	777	617	505	463	504	553	640	718	779	808	675
14	816	818	726	557	438	409	462	494	583	666	705	747	619
15	697	699	614	444	325	309	351	401	475	538	574	620	504
16	537	542	448	303	189	182	224	270	336	384	424	465	359
17	354	349	269	135	57	44	73	119	179	218	246	300	195
18	171	158	88	19	2		3	13	35	59	91	133	64
19	48	31	7							5	20	42	13
20	4	2										4	1
Daily	23.3	22.9	19.7	15.1	11.4	10.1	11.4	13.2	16.4	19.3	20.9	22.3	17.2

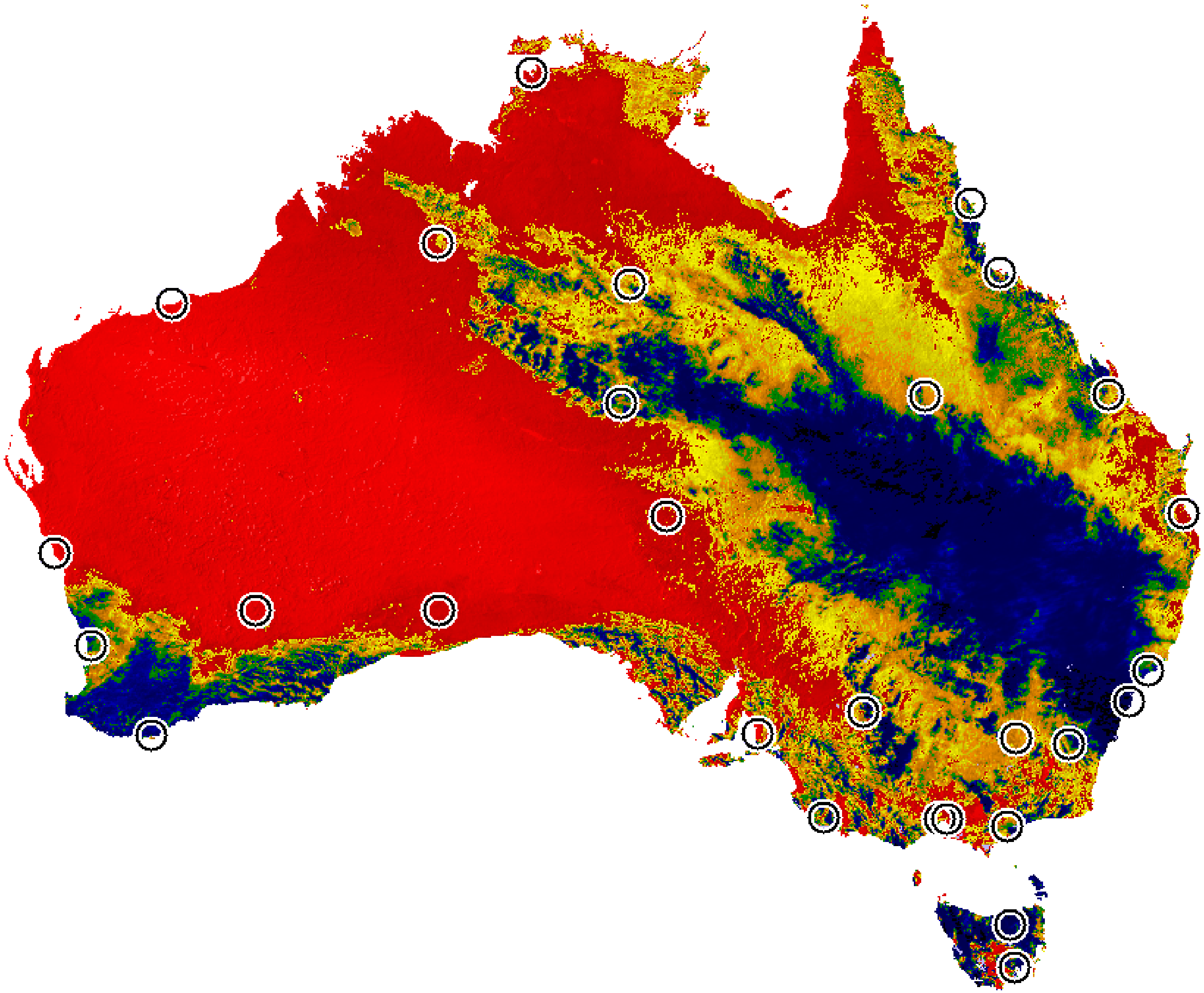
ASRDH - Sample Graph



Climate Data Source

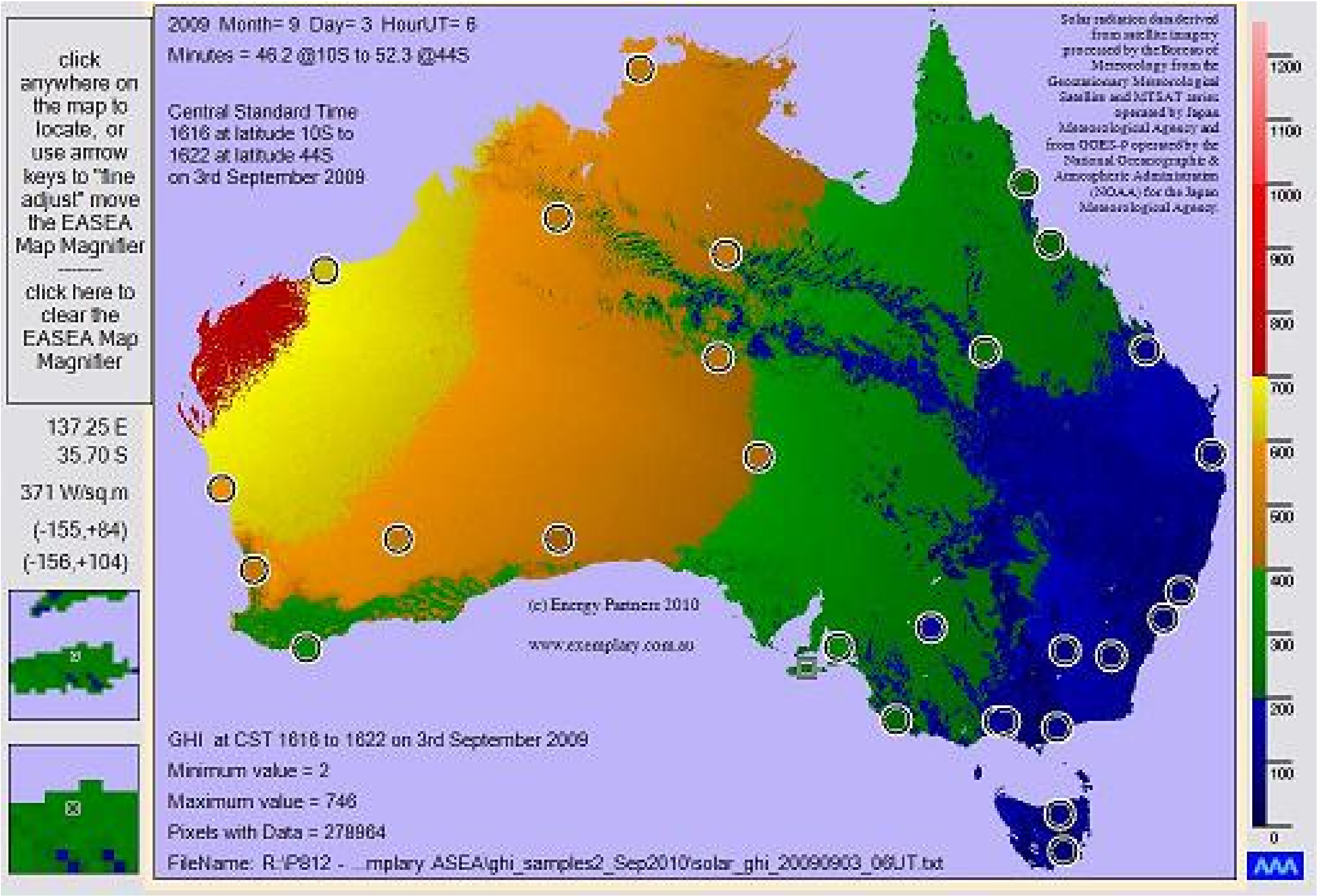
- The enhanced ACDB could be used as the data source for ASRDH 5.
  - 100 sites most with ersatz solar irradiation data inferred from satellite measurements of radiation being reflected back into space.
  - With simultaneous temperature, humidity, wind speed and direction and cloud cover (octas).
  - Impractical as a reference book so likely to be an enhanced version of AUSOLRAD.
  - Non-reference meteorological “years”

Climate Data - satellite measurement



Climate Data - satellite measurement

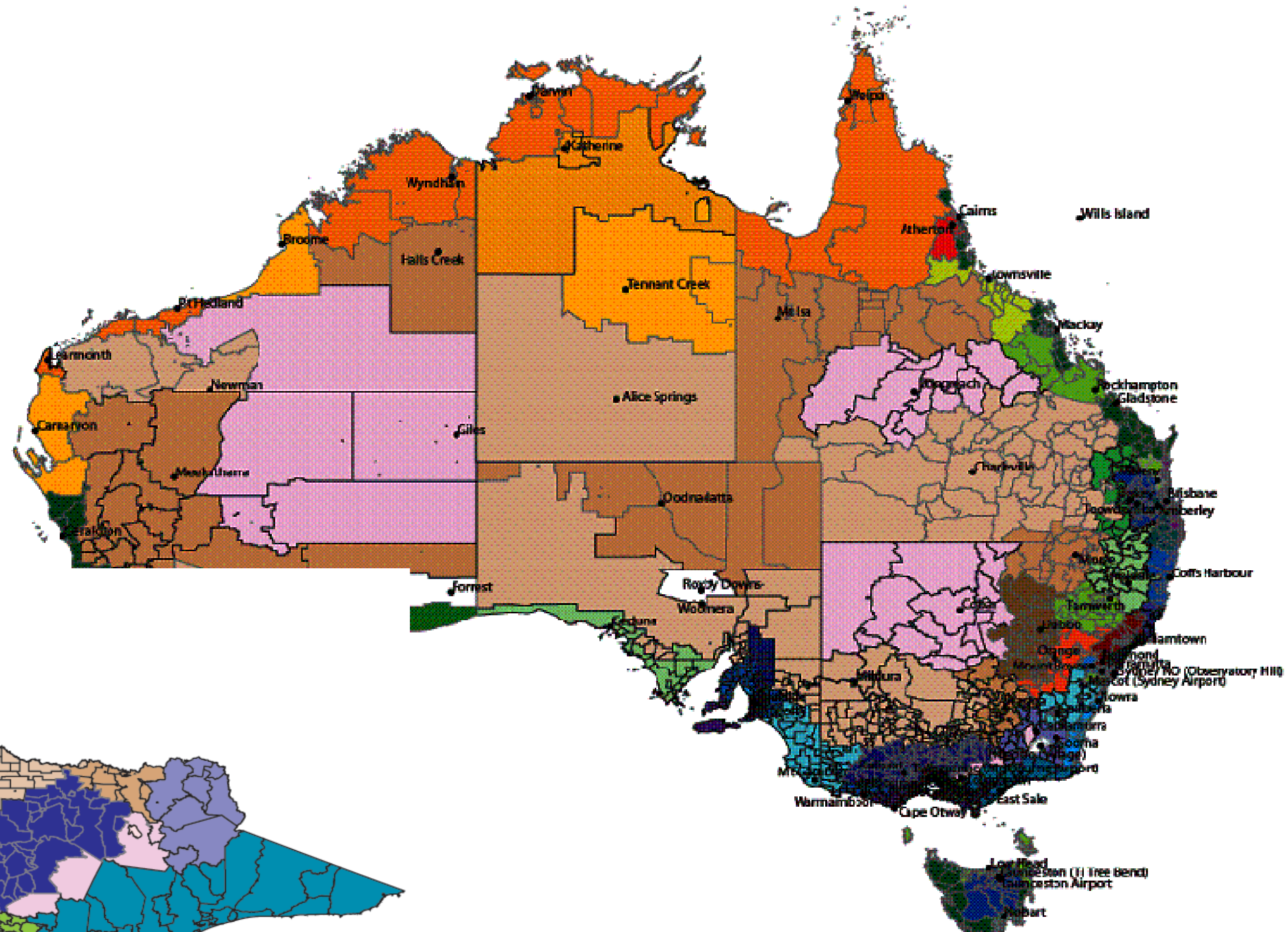
Exemplary Australian Solar Energy Atlas

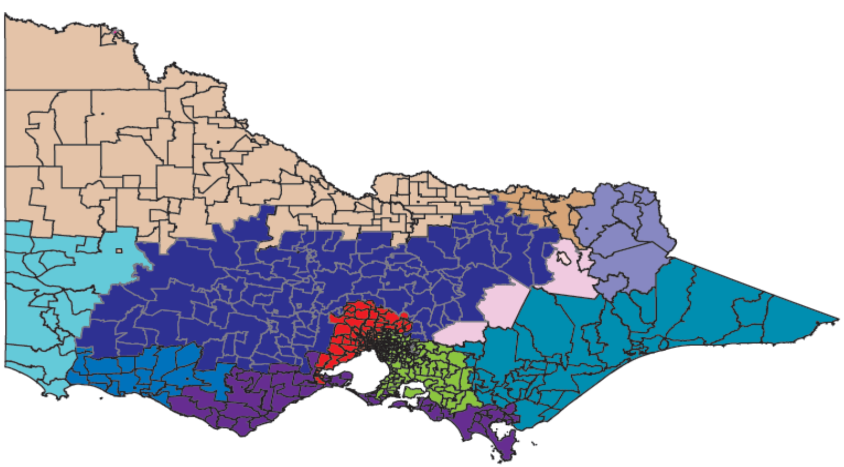


Solar Data Source - AUSOLRAD

- **User selects:**
  - orientation in 1° increments
  - tilt in 1° increments (including facing down)
  - Depth of overhang
  - Reflectivity of the “ground”
- **AUSOLRAD produces:**
  - Tables for all geometries of engineering and architectural interest including single and double axis tracking
  - NO frequency tables for storage design optimisation
- **Distributed by AuSES**

Beyond TMY: Climate Data for Specific Applications





Background

Weightings for RMY datasets

Weights for RMY with recorded diffuse irradiance

Weather Element	Weighting
Max Temp	1/20
Min Temp	1/20
Mean Temp	2/20
Max Wet Bulb Temp	1/20
Min Wet Bulb Temp	1/20
Mean Wet Bulb Temp	2/20
Max Wind Velocity	1/20
Mean Wind Velocity	1/20
Global Radiation	5/20
Diffuse Radiation	5/20

Weights for RMY without recorded diffuse irradiance

Weather Element	Weighting
Max Temp	1/15
Min Temp	1/15
Mean Temp	2/15
Max Wet Bulb Temp	1/15
Min Wet Bulb Temp	1/15
Mean Wet Bulb Temp	2/15
Max Wind Velocity	1/15
Mean Wind Velocity	1/15
Global Radiation	5/15
Diffuse Radiation	0/15

Further Enhancements

Using alternative RMY-month selection procedures

Weighted Mean calculations can be further modified to create:

- **Bias towards data from recent years to represent future climate expectations**
- **Weighting extreme conditions (eXtreme Meteorological Year: XMY)**

Modifying Weather Element Weights

meteorological data to meet any set of weightings

Examples include:

Potential weights for large office buildings		Potential weights for wind farms		Potential weights for solar-sensitive infrastructure	
Weather Element	**Weighting**	**Weather Element**	**Weighting**	**Weather Element**	**Weighting**
Max Temp	1/12	Max Temp	1/15	Max Temp	1/20
Min Temp	1/12	Min Temp	1/15	Min Temp	0/20
Mean Temp	2/12	Mean Temp	1/15	Mean Temp	1/20
Max Wet Bulb Temp	1/12	Max Wet Bulb Temp	0/15	Max Wet Bulb Temp	0/20
Min Wet Bulb Temp	1/12	Min Wet Bulb Temp	0/15	Min Wet Bulb Temp	0/20
Mean Wet Bulb Temp	2/12	Mean Wet Bulb Temp	0/15	Mean Wet Bulb Temp	0/20
Max Wind Velocity	1/12	Max Wind Velocity	5/15	Max Wind Velocity	2/20
Mean Wind Velocity	1/12	Mean Wind Velocity	5/15	Mean Wind Velocity	1/20
Global Radiation	2/12	Global Radiation	1/15	Global Radiation	10/20
Diffuse Radiation	0/12	Diffuse Radiation	1/15	Diffuse Radiation	5/20

Representative Extremes

eXtreme Meteorological Year (XMY) data sets still require full definition

Examples include

- **Performance during a hot, dry (El Niño) year**
- **Performance during a windy, wet (La Niña) year**
- **Amalgamation of ‘hottest summer’ with ‘coldest winter’ months**
- **Warmest months ever (changed warmer climate)**

Real-time Data

- Model Calibration
- Building or system monitoring
- Measuring actual output or consumption in the previous year relative to RMY

Real-time year-to-date data (RTY)

Results

Comparison of:

- **ACDB 2005 RMY**
- **ACDB 2008 RMYA**
- **ACDB 2008 RMYB**
- **ACDB 2008 RMYC**
- **RTY**
- **DTD (decade-to-date)**
- **40 year historical averages**

Using 11 house models with varying energy usage in the CSIRO thermal simulation software, AccuRate

Key Results

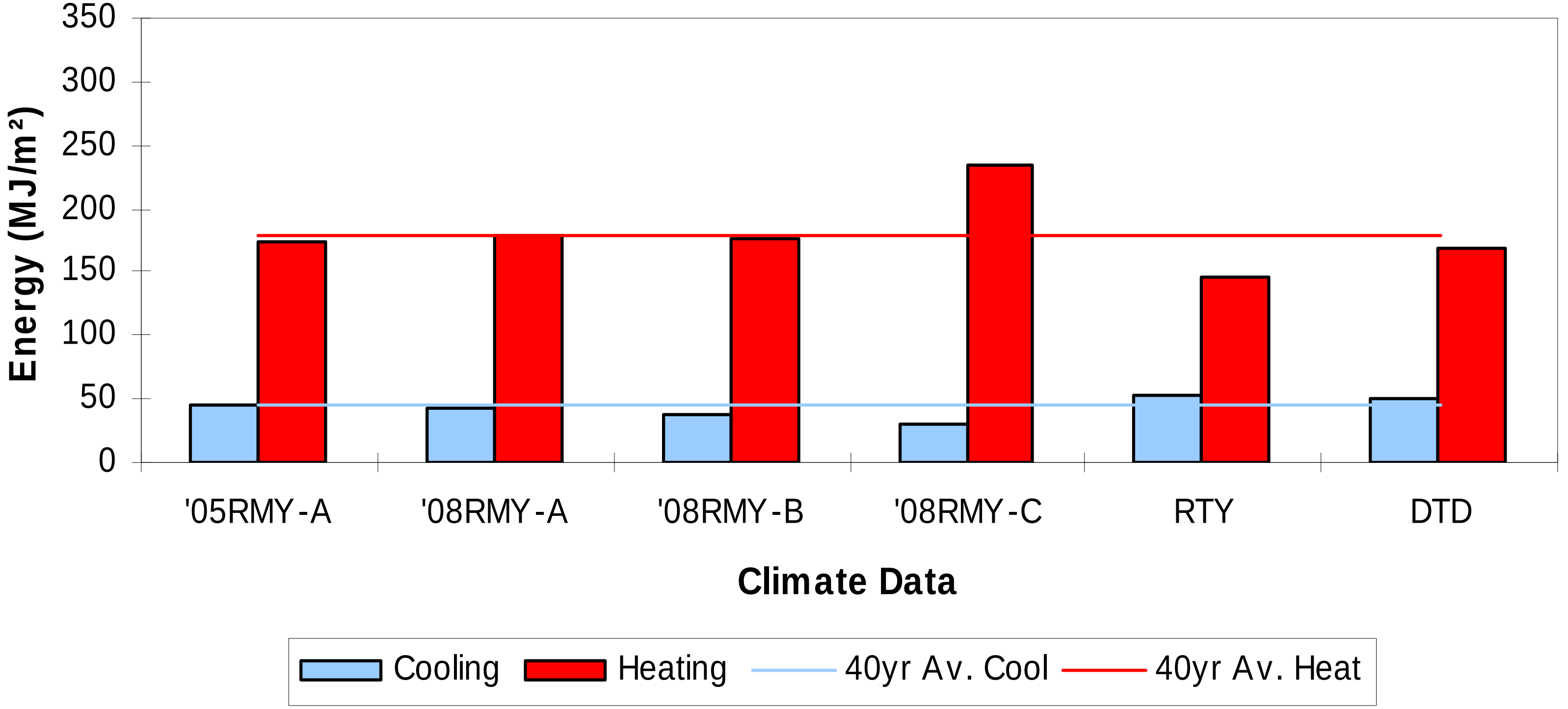


Figure 1: Simulated consumption of a 'lightweight' dwelling at 0º orientation

Key Results

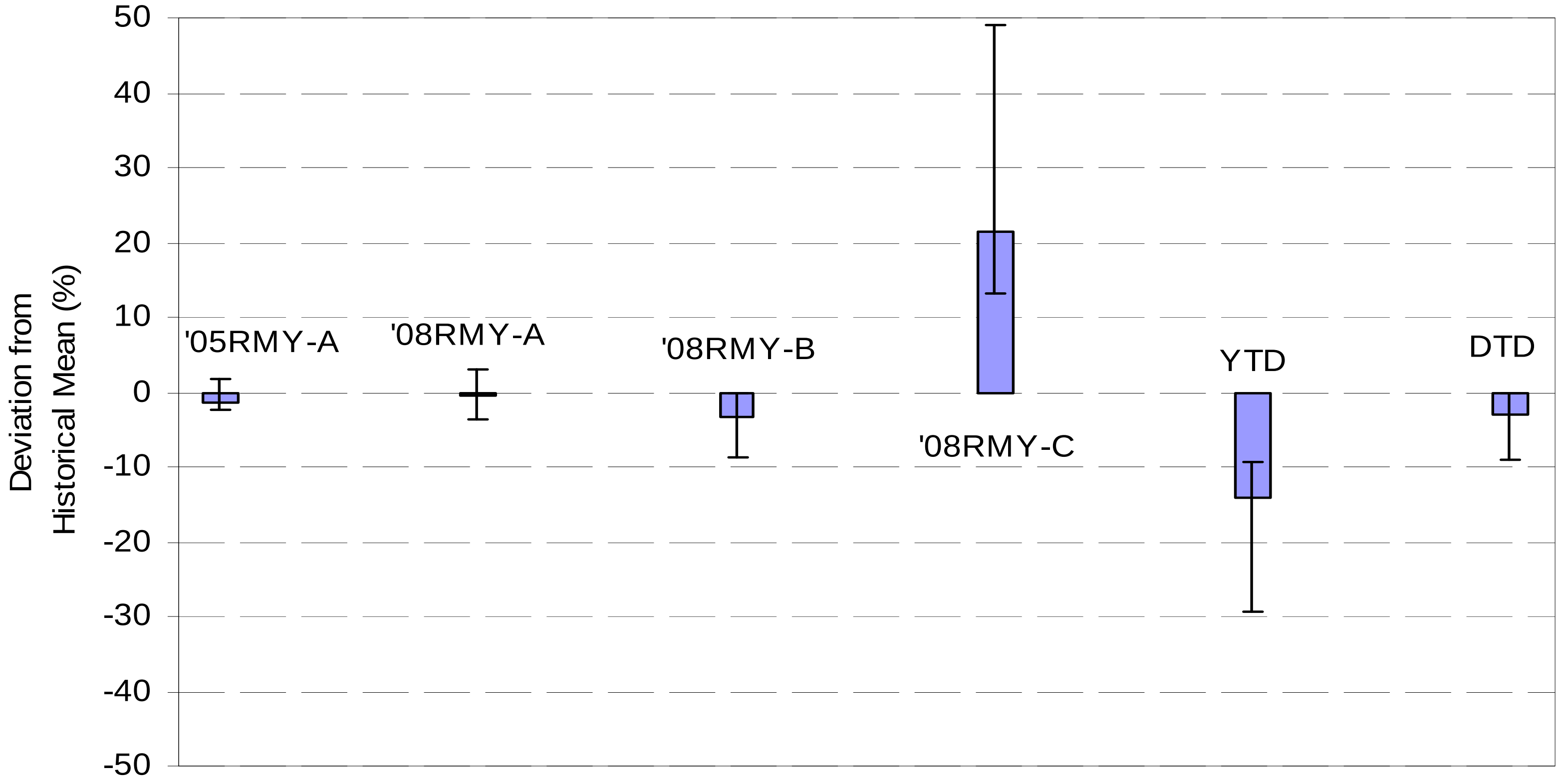


Figure 2: Average difference between simulation results using representative data and historical mean

Key Results

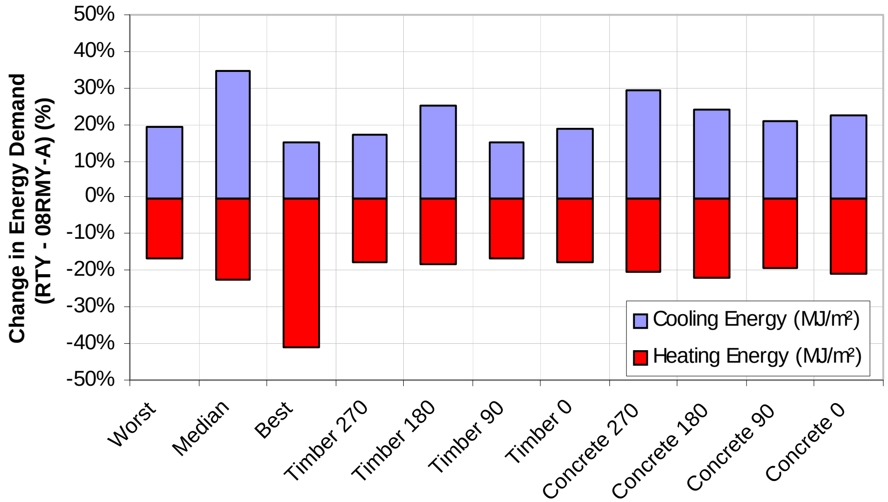


Figure 3: Total heating and cooling energy between RTY and 2008 RMY-A as a percentage of 2008 RMY-A

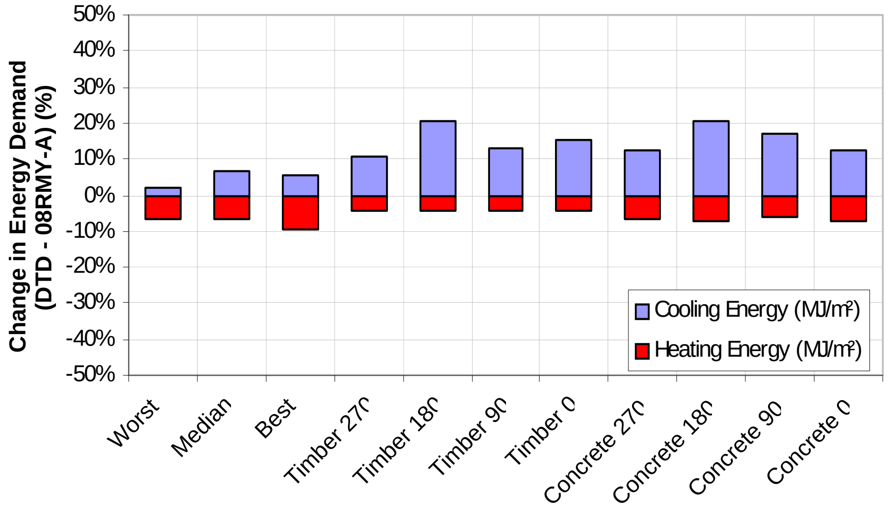
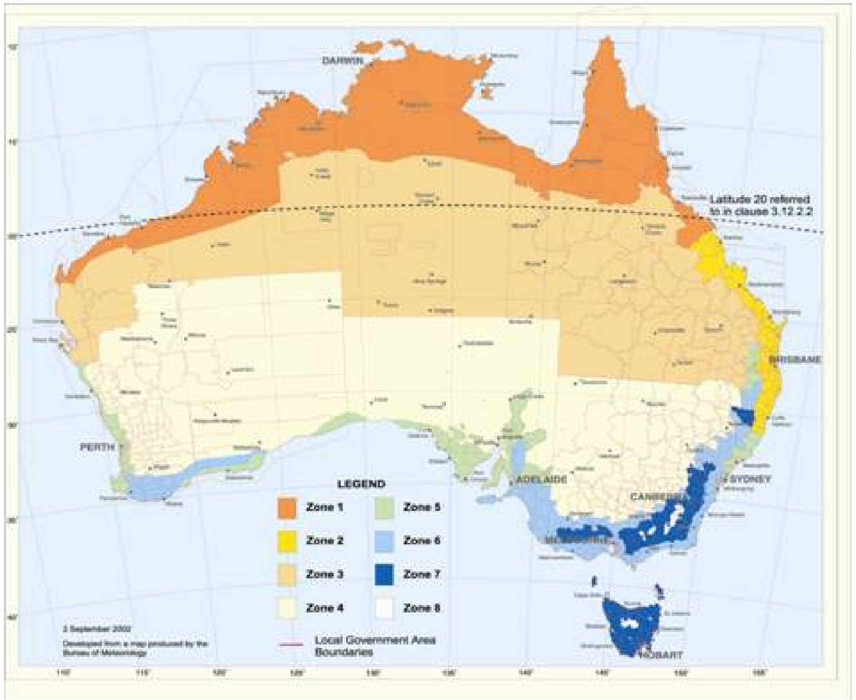


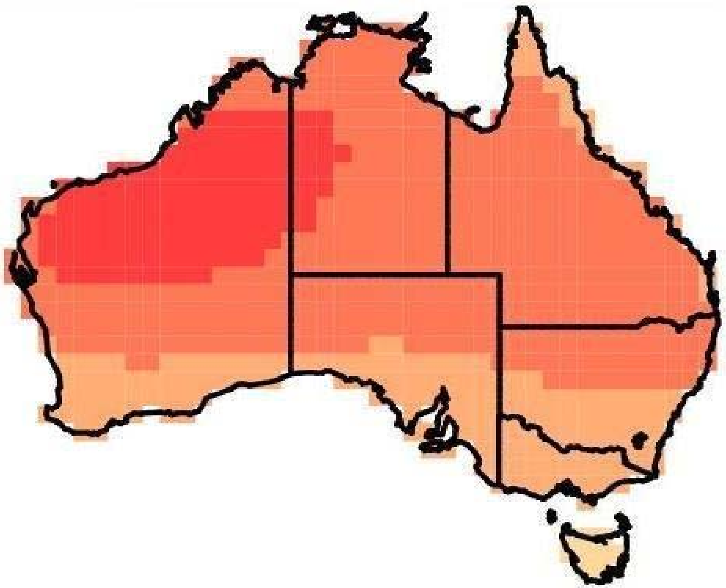
Figure 4: Total heating and cooling energy between DTD and 2008 RMY-A as a percentage of 2008 RMY-A

Heating energy demand of both the RTY and DTD relative to RMY-A is smaller while cooling energy demand has increased

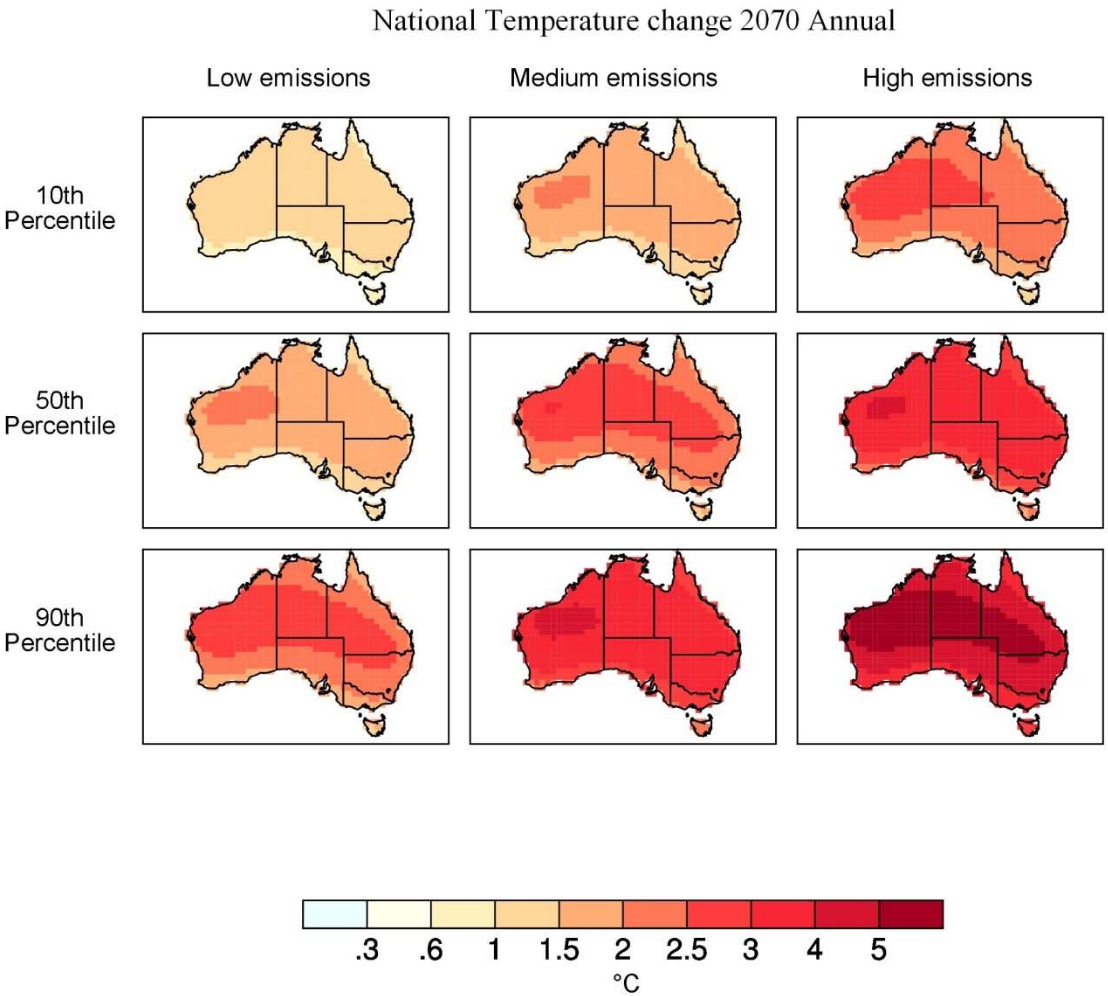
Indication of past climate change

CREATION OF ERSATZ FUTURE WEATHER DATA FILES



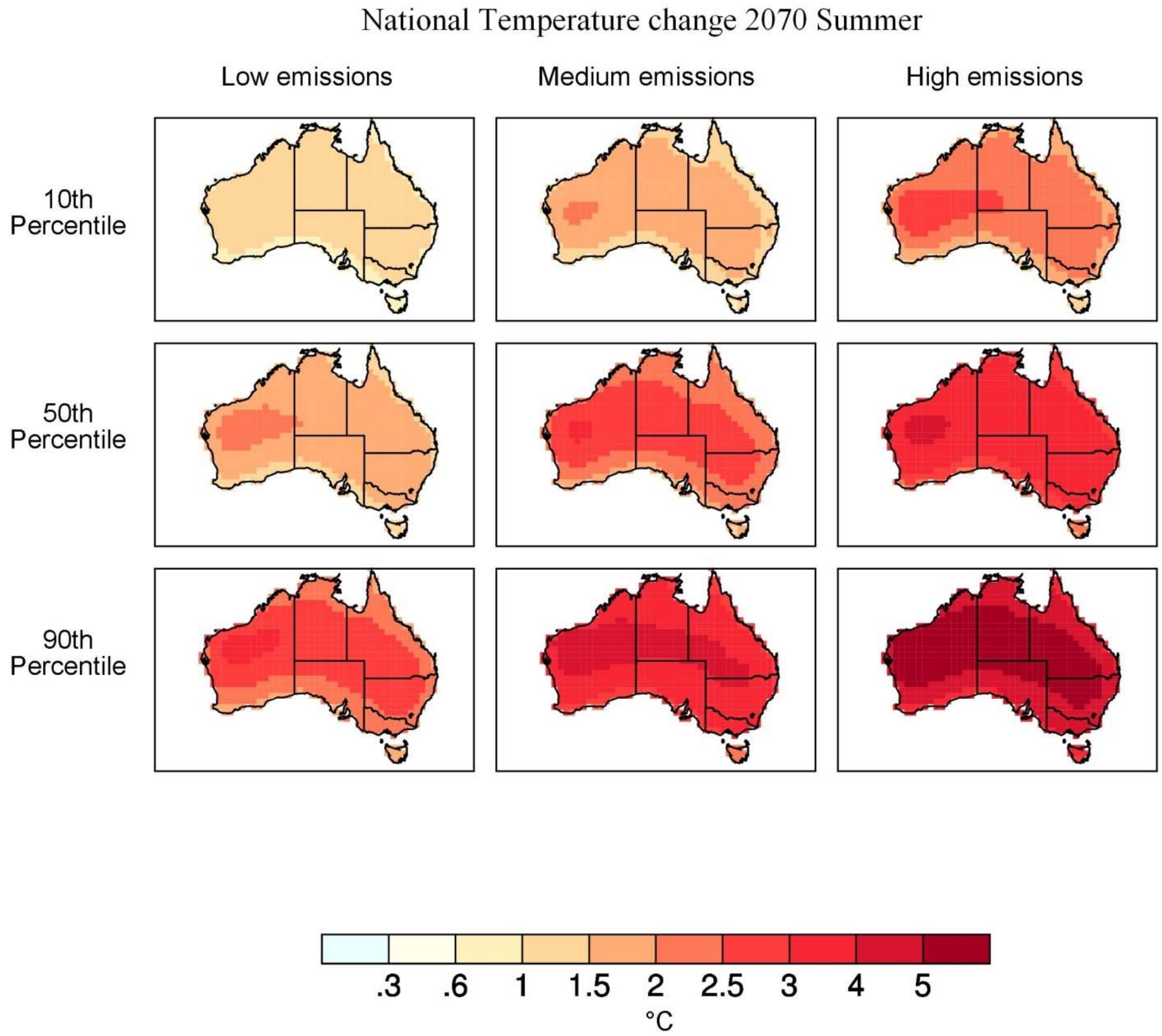


Climate “Forecast” (Overall)

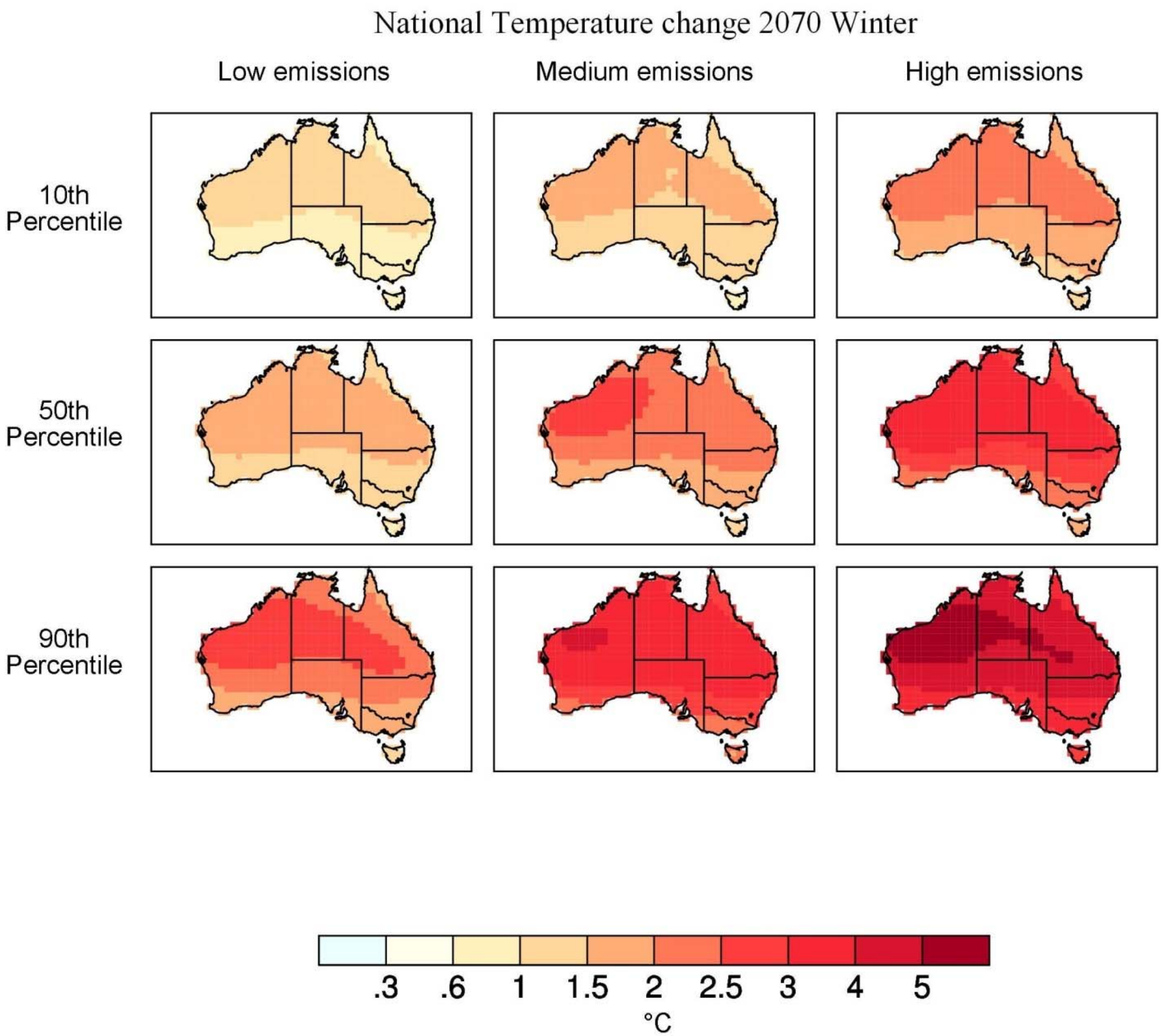


- Projections are presented relative to the period 1980-1999 (referred to as the “1990 baseline” for convenience).
- The 50th percentile (the mid-point of the spread of model results) provides a best estimate result.
- The 10th and 90th percentiles provide a range of uncertainty.

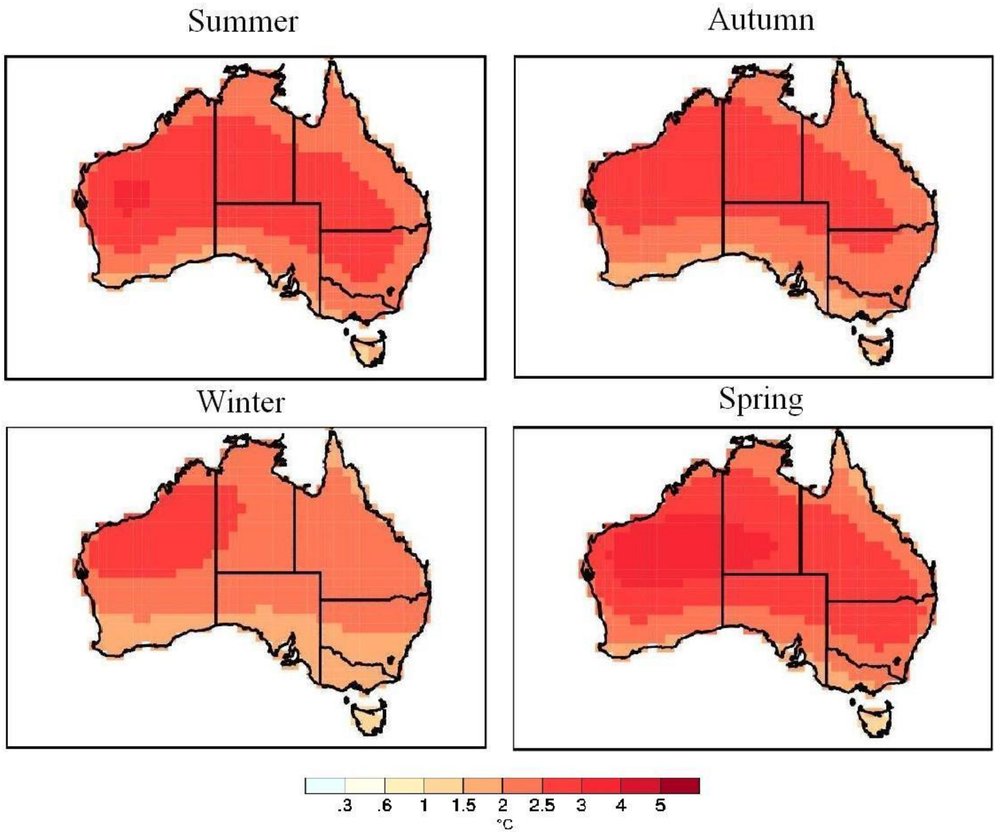
Climate "Forecast" (Seasonal)



Climate "Forecast" (Seasonal)

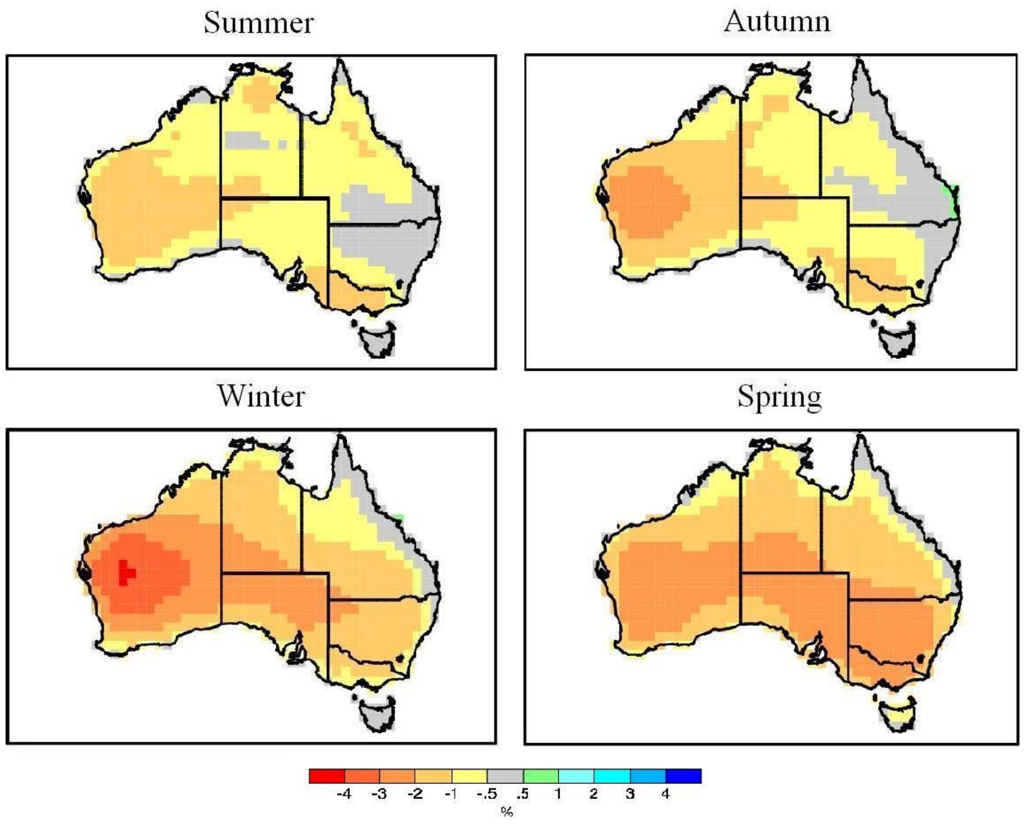


Climate “Forecast” (Seasonal)



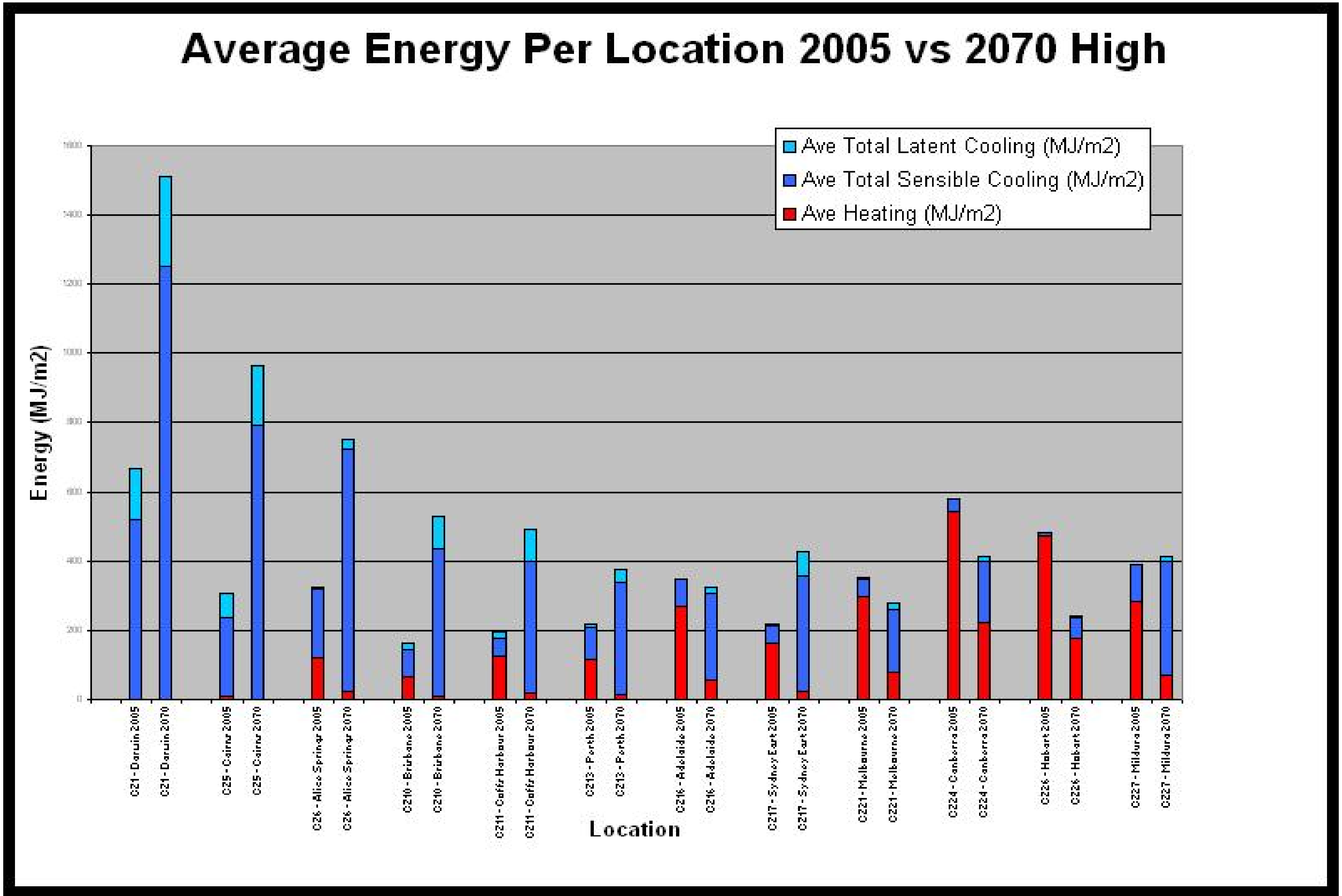
- 50^{th} percentile change in dry-bulb temperature

Climate "Forecast" (Seasonal)

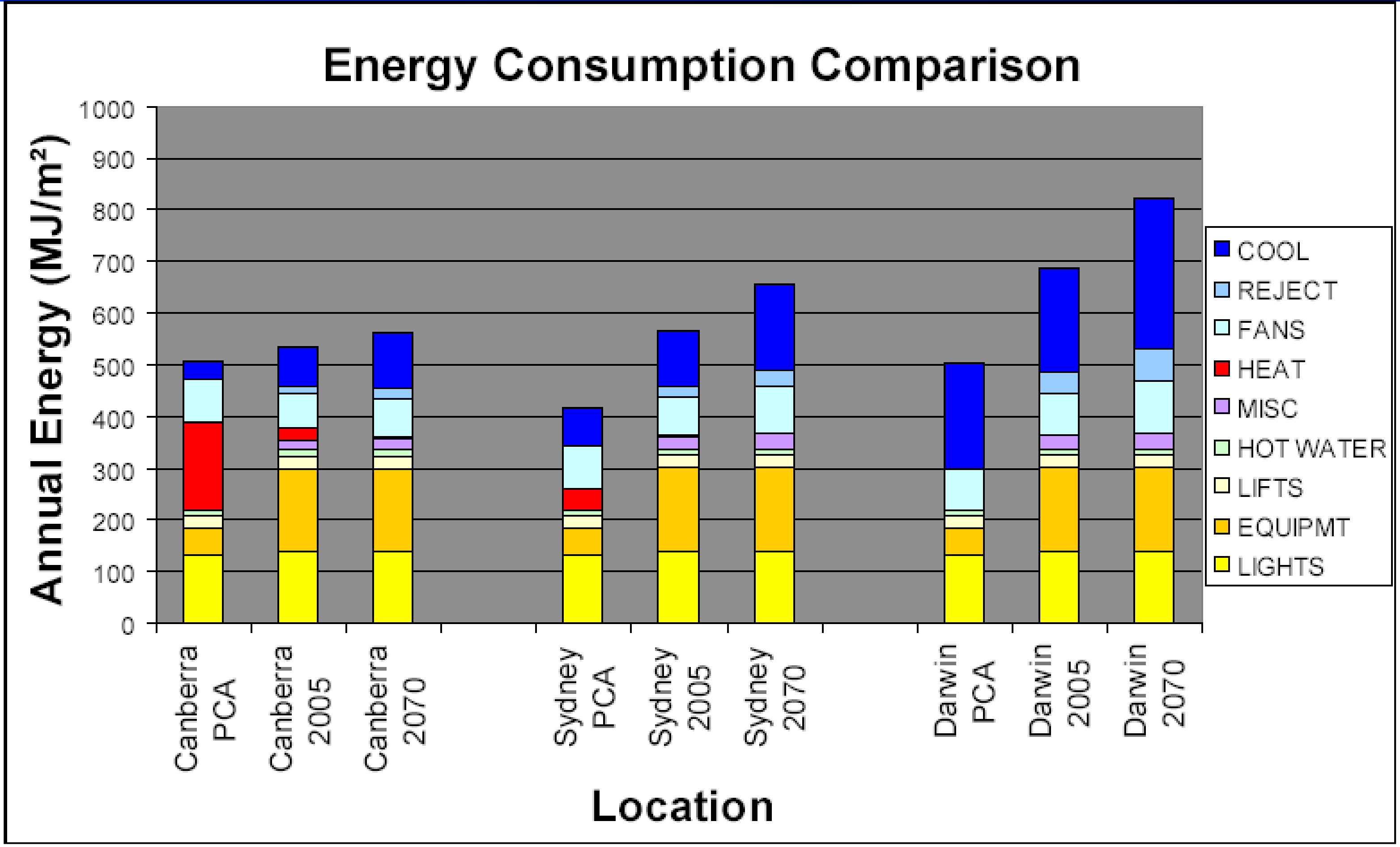


- 50^{th} percentile change in relative Humidity

Energy Impacts for Dwellings



Energy Impacts for Non-residential Buildings



Simulated end-use energy consumption of 10-storey office building

Future Work

- **Specific projection scenarios based on climate modelling are being produced to improve accuracy**
- **Re-setting the baseline**
  - **The 2008 update to the ACDB included improvements to calculations in several areas**
  - **New RMYs based on data up to the end of 2007 and using these techniques are available**
  - **Ideally, baseline RMYs would be created for the 1980-1999 period forming the baseline of specific CSIRO projections**
- **Other applications of these techniques may include estimation of the effect of urban heat islands, as in the upcoming paper:**

Crawley, D. *"Estimating the impacts of climate change and urbanisation on building performance".* Journal of Building Performance Simulation, yet to be published.

Conclusions

- Climate and weather data may be tailored to suit a wide range of renewable energy and energy conservation applications.
- ASRDH 4 and AUSOLRAD provide accurate irradiation data suitable for use in analysing building / thermal / PV energy performance. Soon to be supplemented and extended with Exemplary Australian Solar Energy Atlas.
- RMYs may be created to meet the specific requirements of an application based on the weighting assigned to the different weather elements.
- XMYs and YTDs can be created for system design and operational optimisation.
- Ersatz Future Weather Data based on “forecast” scenarios for climate change can predict energy performance in the future.

Climate Data for Building Optimisation and Energy Management

Questions?

ENERGY PARTNERS

Trevor Lee