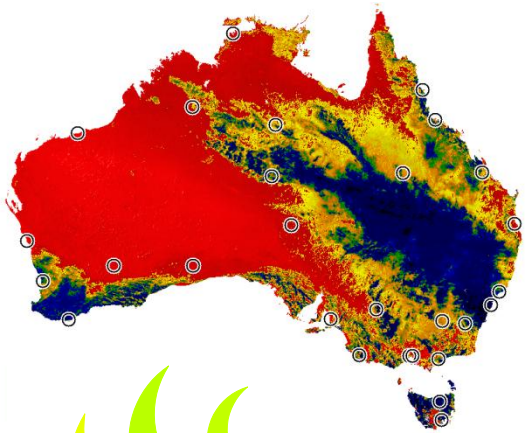
Real time solar and coincident weather data

for solar deployment and building optimisation and energy management



exemplary ENERGY

50 YEARS STILL DIFFERENT

MACQUARIE UNIVERSITY
SYDNEY ~ AUSTRALIA

Trevor Lee
Director, Buildings

Grant Edwards PhD
Department of Environment and Geography

Real time solar and coincident weather data for solar deployment and building optimisation

The Australian Solar and Climate Resource

- Australian Solar Radiation Data Handbook background and applications

Beyond TMY: Typical Meteorological Year

Climate Data for Specific Applications

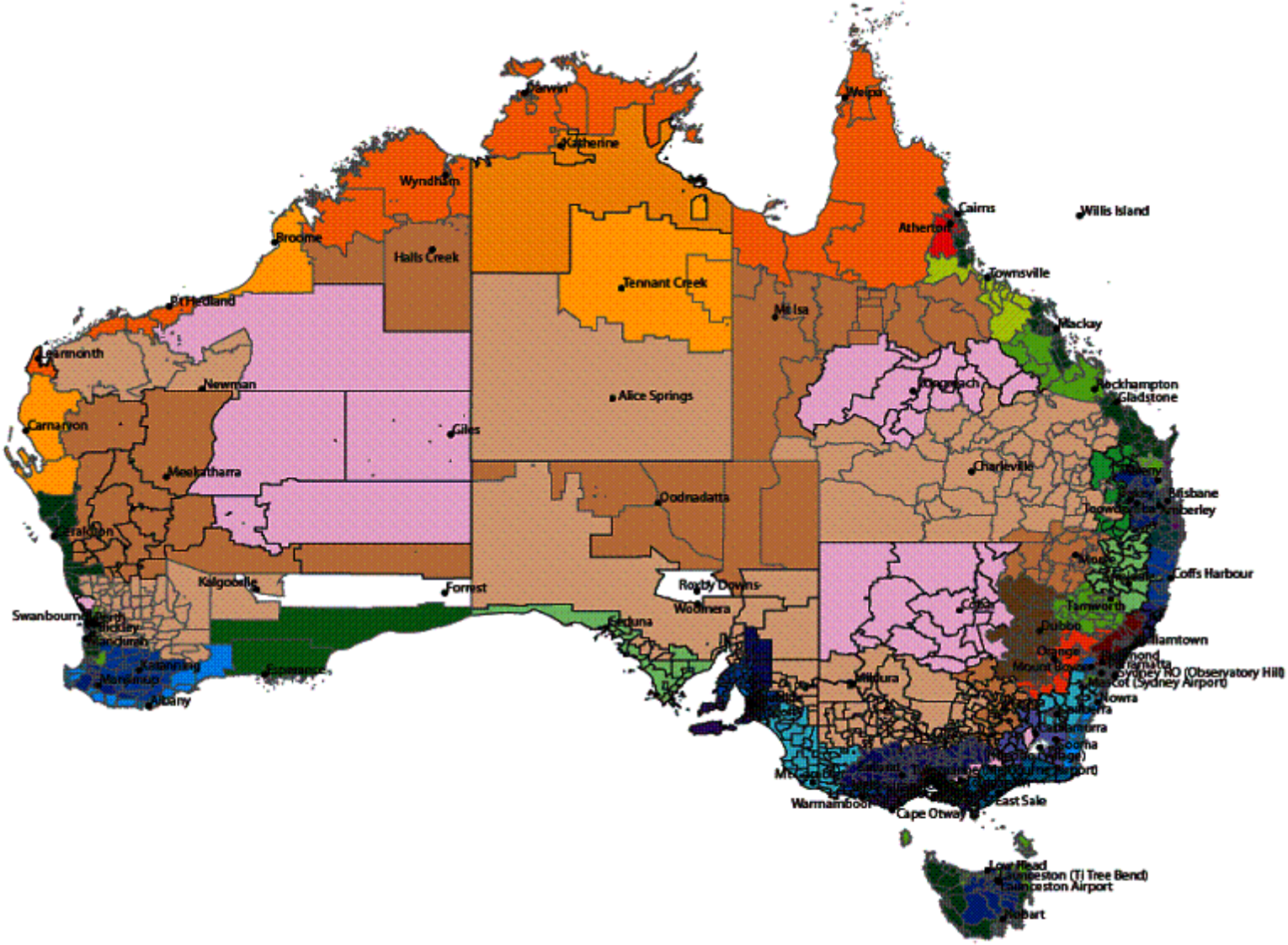
- Australian Climate Data Bank and
- using Reference Meteorological Years (RMY)

Creation of Ersatz Future Weather Data Files

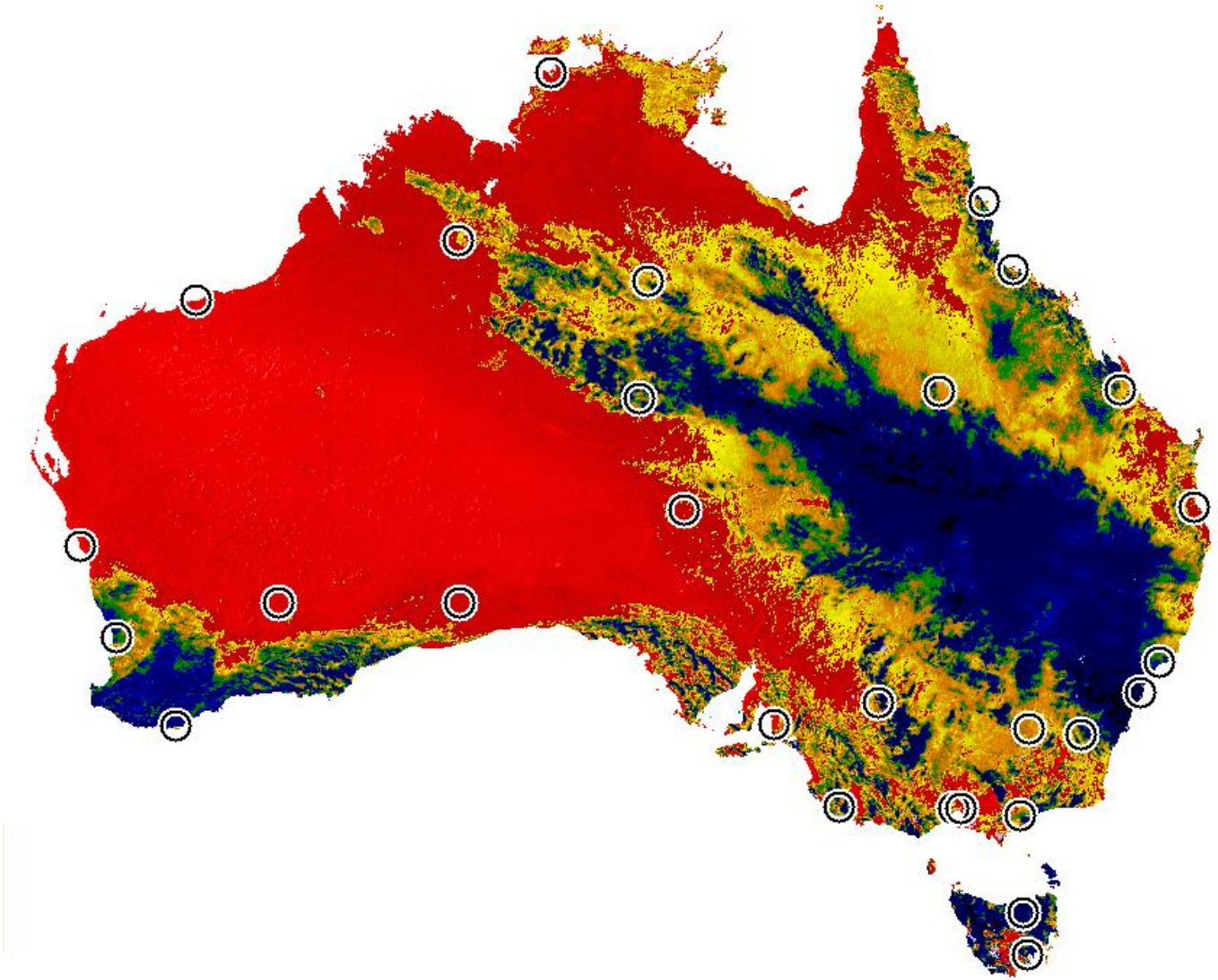
- Measuring energy performance of buildings under predicted future weather conditions

Team members: Zhong Ran “Talent” Deng and Chun Yin Wu
Adelaide Applied Algebra, Global Sustainable Energy Solutions

Beyond TMY: Climate Data for Specific Applications

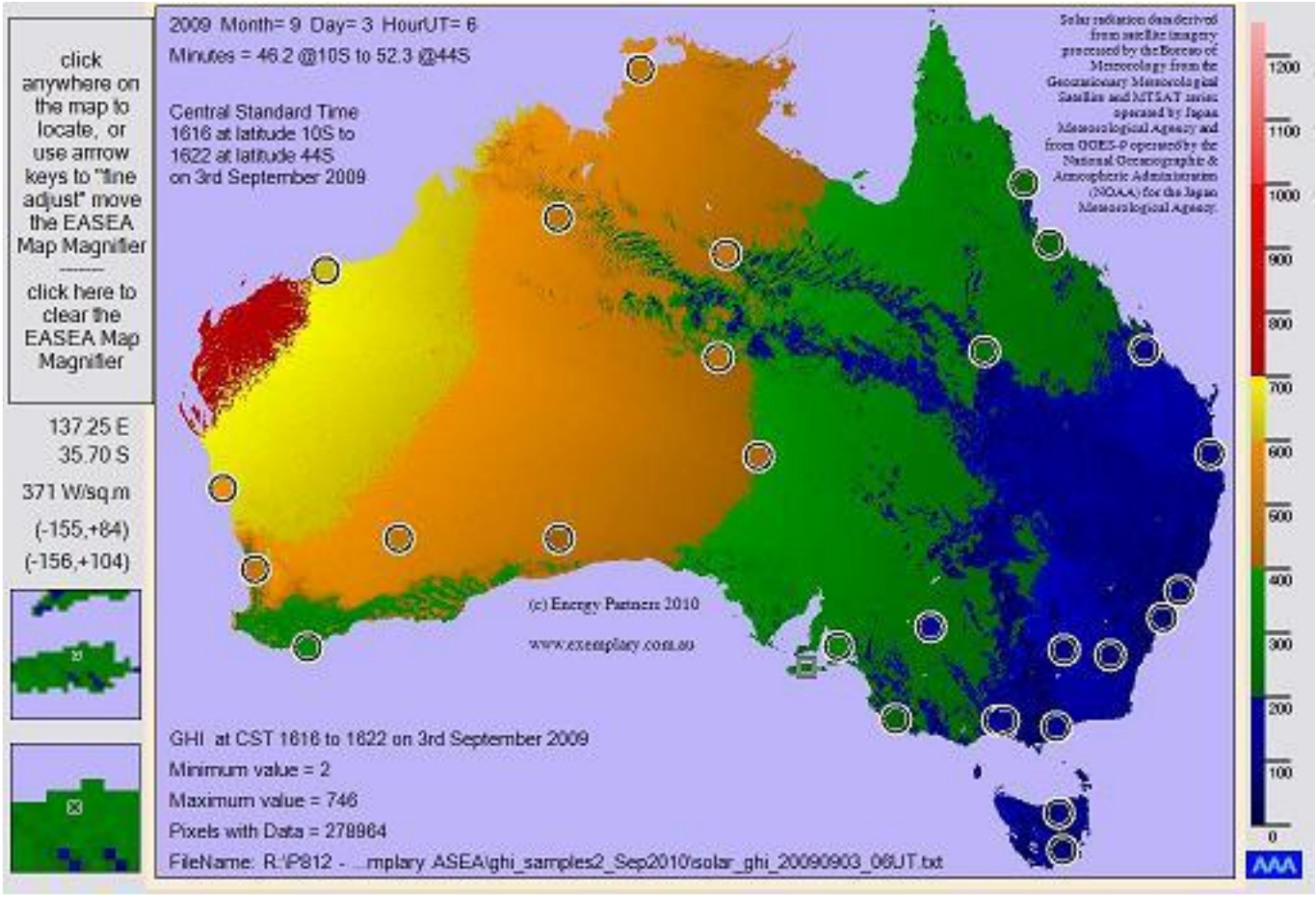


Weather Data - satellite measurement



Weather Data - satellite measurement

Exemplary Australian Solar Energy Atlas



Representative Extremes

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

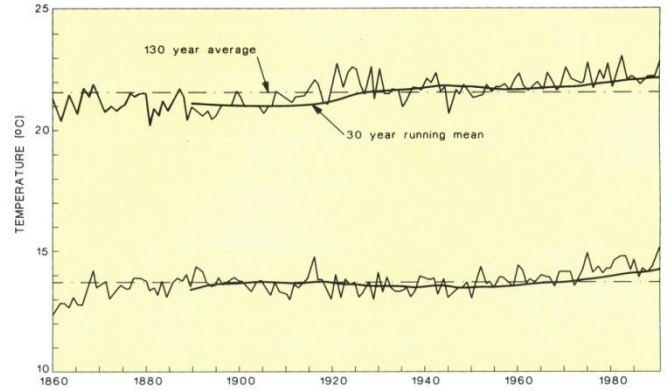
Examples include

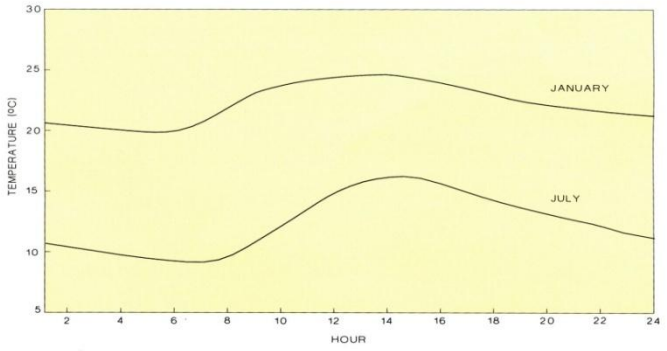
- **Performance during a hot, dry (El Niño) year**
- **Performance during a windy, wet (La Niña) year**
- **Amalgamation of ‘hottest summer’ with ‘coldest winter’ months**
- **Warmest months ever (changed warmer climate)**

Real-time Data – Weather not Climate

- **Simulation Model Calibration**
- **Building or system monitoring**
- **Renewable energy system monitoring**
- **Measuring actual output or consumption in previous year or month relative to RMY**

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



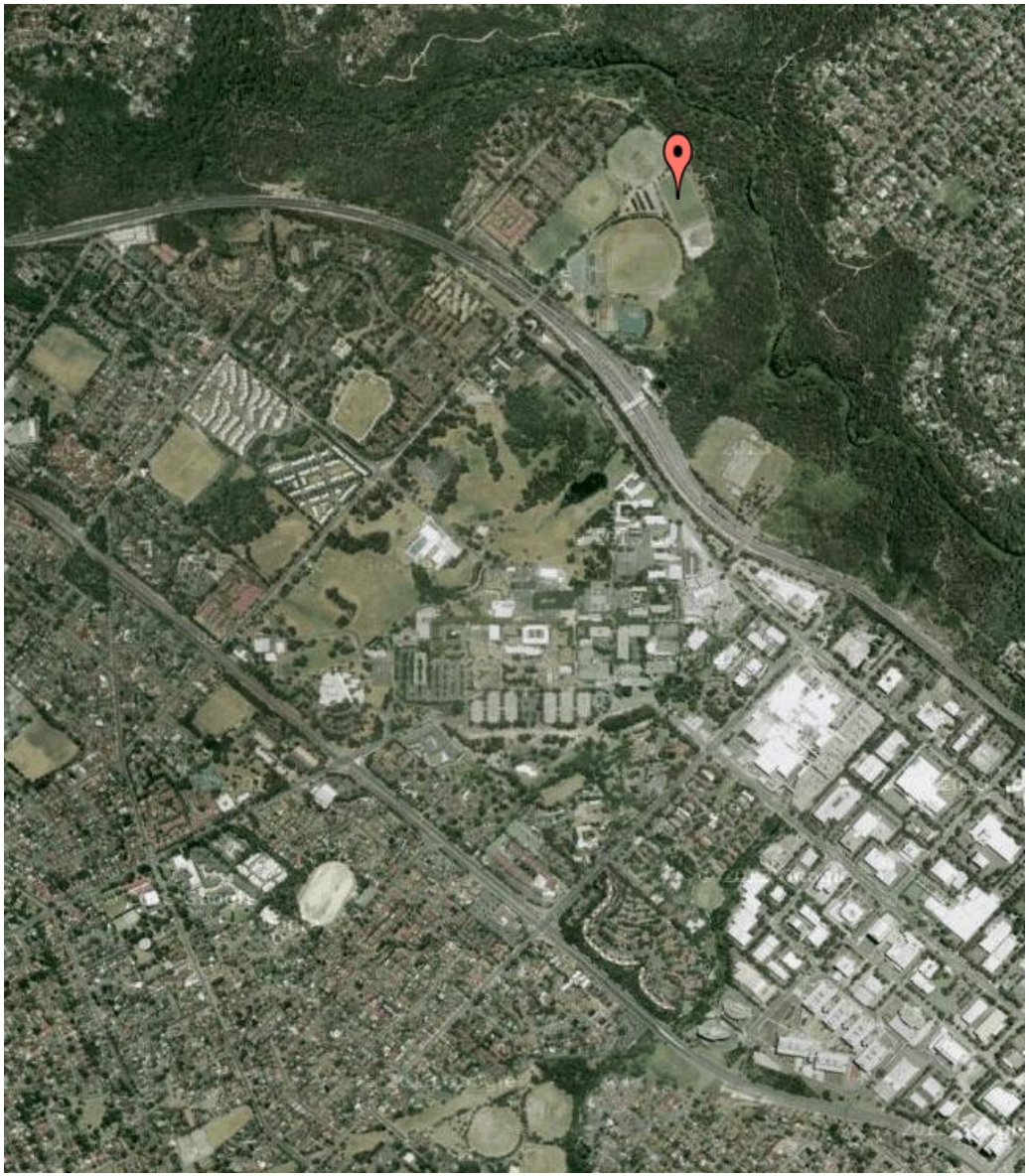


- **Weather is the state of the atmosphere at a given time and place. It is constantly changing hour to hour, or day to day.**
- **Climate is the aggregate of weather conditions, the sum of all statistical weather information that helps describe a place or region.**
- **Both Weather and Climate are typically expressed in terms of key parameters: Solar radiation (direct, diffuse and global), air temperature, humidity, speed and direction of the wind, air pressure, precipitation, cloud type and amount.**
- **Climate and weather data are key to the design of energy efficient buildings, human comfort, and management of energy systems on local and regional scales.**

Climate Examples;

- **Top Graph: annual mean max. and min. temperature record for Observatory Hill, CBD.**
- **Bottom Graph: mean hourly temperature for January and July at Observatory Hill, CBD.**

Macquarie University Automatic Weather Station



- The Automatic Weather Station since 1998 has been located within the sports grounds of Macquarie University at North Ryde, Sydney, Australia, denoted on the map by
- Its latitude and longitude are 33º 45' 55.1" South and 151º 7' 3.2" East.
- Its elevation is 66.8 m above mean sea level (accurate to 4.4 m).
- From 1992 to 1998 the AWS was located on the NW side of the main campus

Macquarie University AWS - Brief History

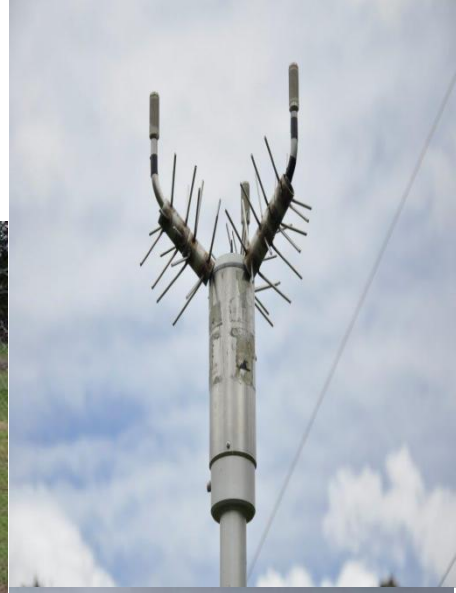
- 1992 - First site (AWS1) established at Macquarie University (Main Campus).
- 1997-1998 - Second site (AWS2) established nearby at Macquarie University sports fields.
- Late 2004 - Major upgrade to AWS2 including upgrade of communications from phone line to radio modem, replacement of cup and vane anemometer with sonic anemometer, installation of several new sensors and replacement of a significant portion of underground wiring.
- Mid 2007 - Vaisala WS425 Ultrasonic Anemometer installed for wind measurements, replacing Met One 50.5 Ultrasonic Anemometer.
- January 2011 - Automatic QA/QC checks implemented in datalogger program.
- August 2011 - Cynet 405U Radio modems replaced with Netcomm NTC-6908 Cellular modem due to tree growth blocking radio signal.

Macquarie University AWS - Specifications

Dry Bulb Temperature	Modified Vector Instruments H301 Psychrometer - Dry Bulb RTD
Wet Bulb Temperature	Modified Vector Instruments H301 Psychrometer - Wet Bulb RTD
Dew Point Temperature	Derived by the datalogger
Pressure	Vaisala PTA-427 Pressure Transducer
Vapour Pressure	Derived by the datalogger
Saturation Vapour Pressure	Derived by the datalogger
Relative Humidity	Met One 083c Relative Humidity Probe
Precipitation	Hydrological Services TB3 Tipping Bucket Rain-Gauge
Wind speed and direction	R.M. Young 05103 Wind Monitor
Standard Deviation of Wind Direction	Derived by the datalogger
Sunshine Duration	Middleton RS-6 Sunshine Duration Detector
Global Shortwave Radiation	Kipp & Zonen CNR1 Net Radiometer
Diffuse Shortwave Radiation	Kipp and Zonen CM5 Pyranometer
Reflected Shortwave Radiation	Kipp & Zonen CNR1 Net Radiometer
Net (All Wave) Radiation	Kipp & Zonen CNR1 Net Radiometer
UVB Radiation	Middleton UVR1-B Solar Ultraviolet Pyranometer
Sky Longwave Radiation	Kipp & Zonen CNR1 Net Radiometer
Soil Temperature at 1, 5, 10, 20, 50 and 100cm	Omega 44032 Thermistors encased in epoxy housed in stainless steel tube
Soil Heat Flux at 5cm and 50cm soil depth	Huxeflux HFP-01 Soil Heat Flux Plates

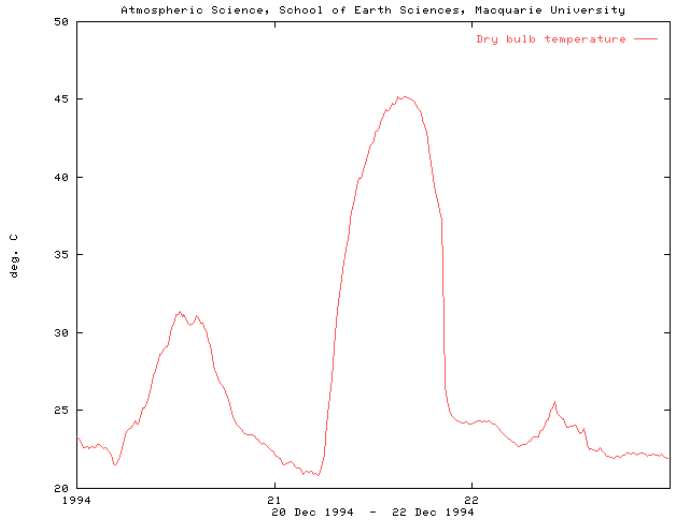
Macquarie University
Automatic Weather Station

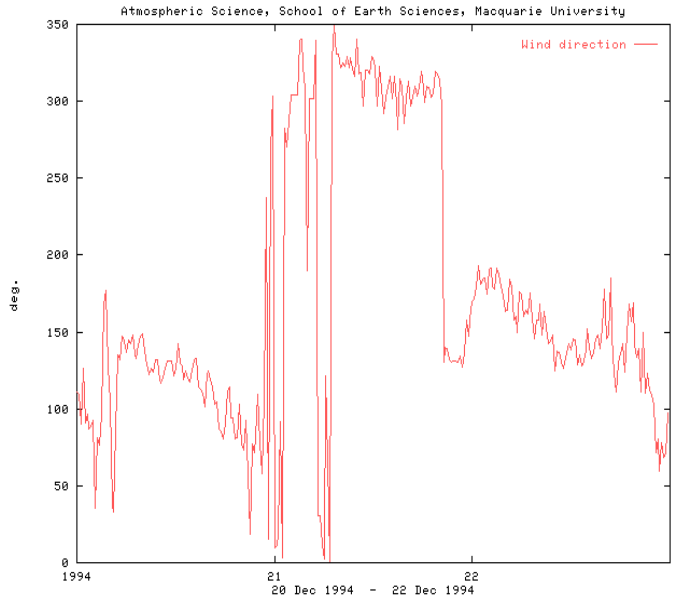




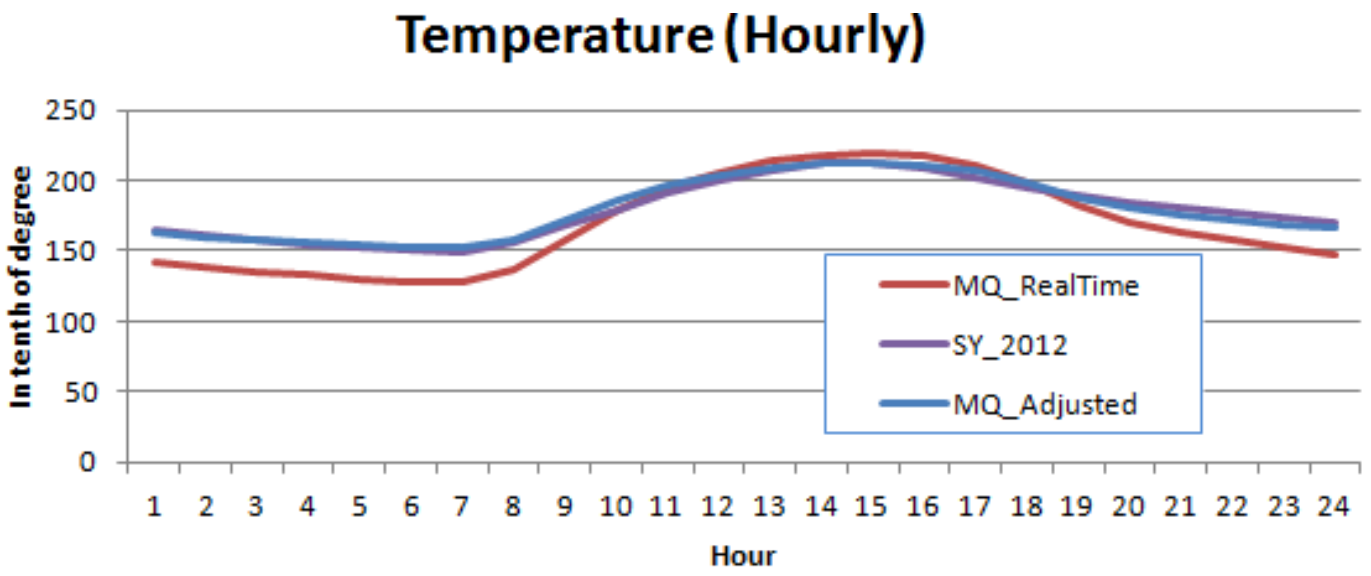
Macquarie University AWS – Uses and Applications

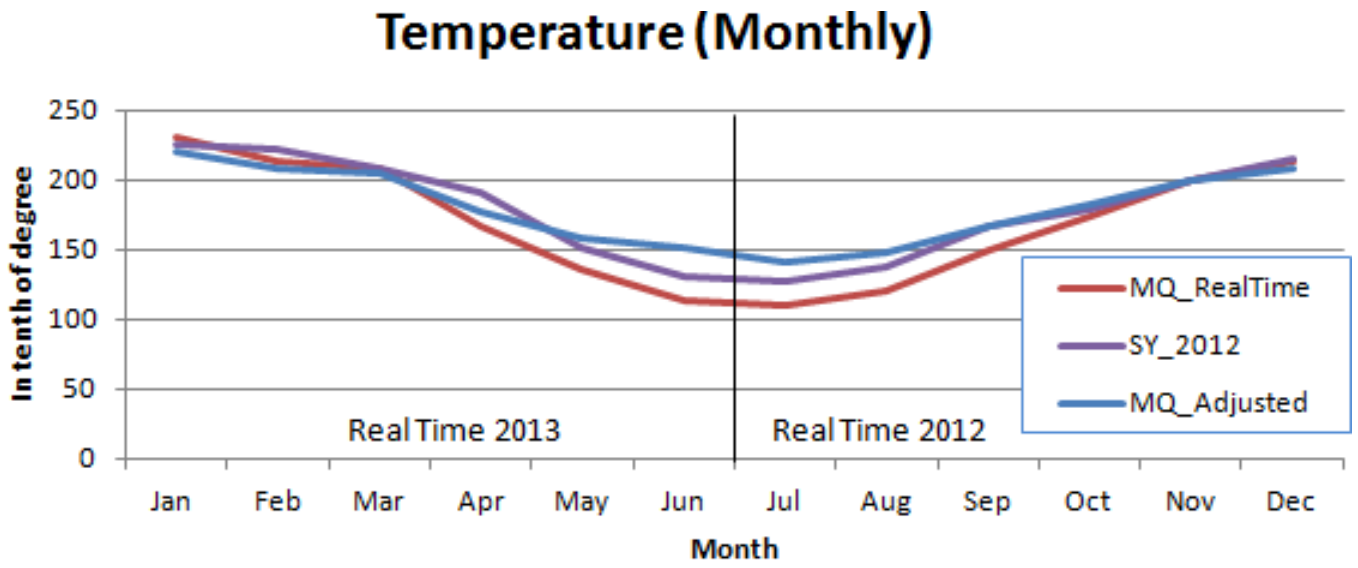




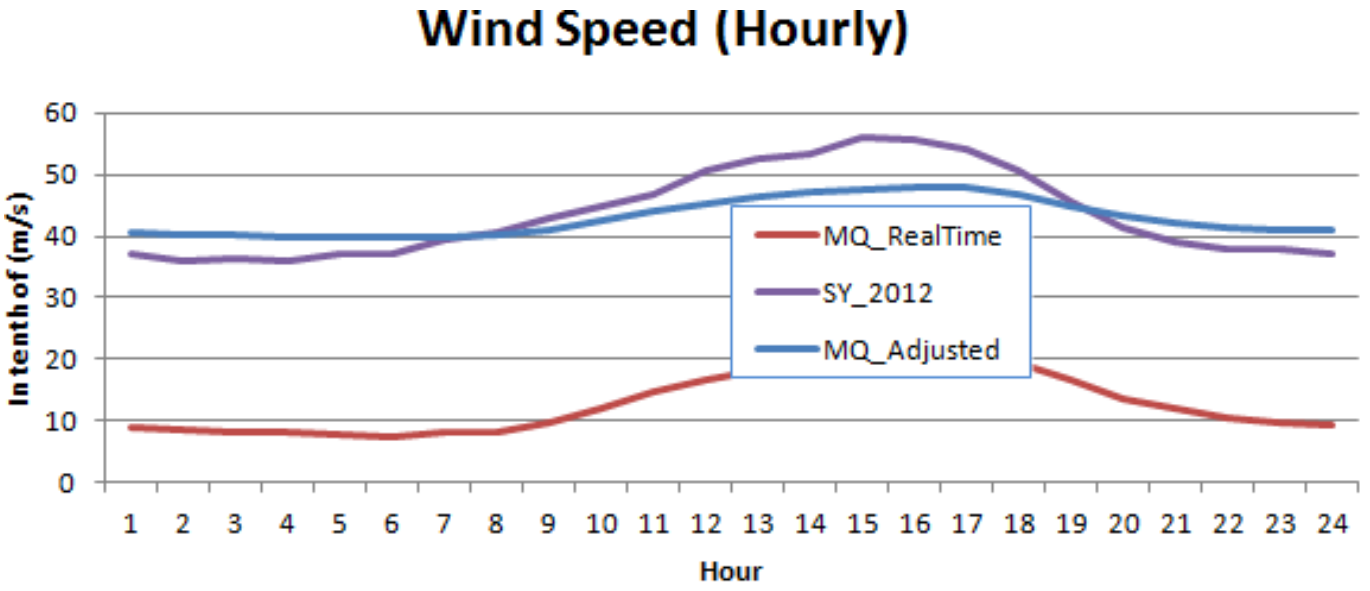
- Within the Department of Environment and Geography, the AWS is used for both teaching and research.
- Climatic studies
- Study of interesting weather events such as depicted here where the temperature was above 40 degrees Celsius from 10:30 am to 7:15 pm at which time there was a dramatic temperature drop of more than 10 degrees Celcius. The wind direction plot below tells us why.
- Provide data to outside users for energy management and other uses such as;
  - Local weather data during the construction of the M2
  - a study of the shelf life of food
  - assessment of the air conditioning requirements for a new animal house at Macquarie
  - in-filling missing radiation data for a study at Manly Reservoir
  - estimating maximum rainfall intensities during severe storms
  - estimating maximum wind speeds during gales
  - studying relationships between various radiation variables
  - estimating sunshine hours and solar energy available

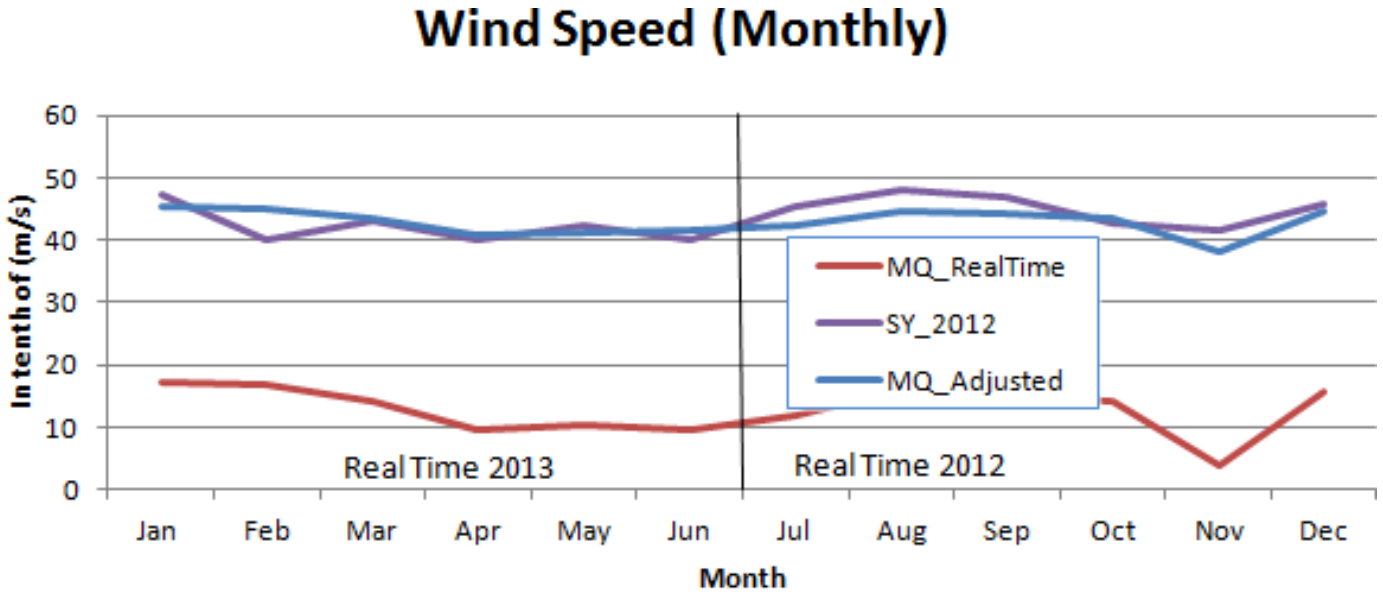
Macquarie University AWS – Normalisation to CBD





Macquarie University AWS – Normalisation to CBD





Real-time Data – Weather vs Climate

Exemplary Weather and Energy Index

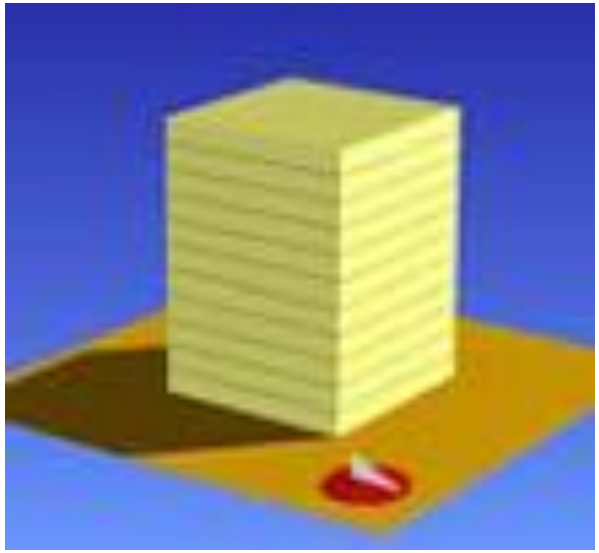
http://www.exemplary.com.au/EWE%20indices.php

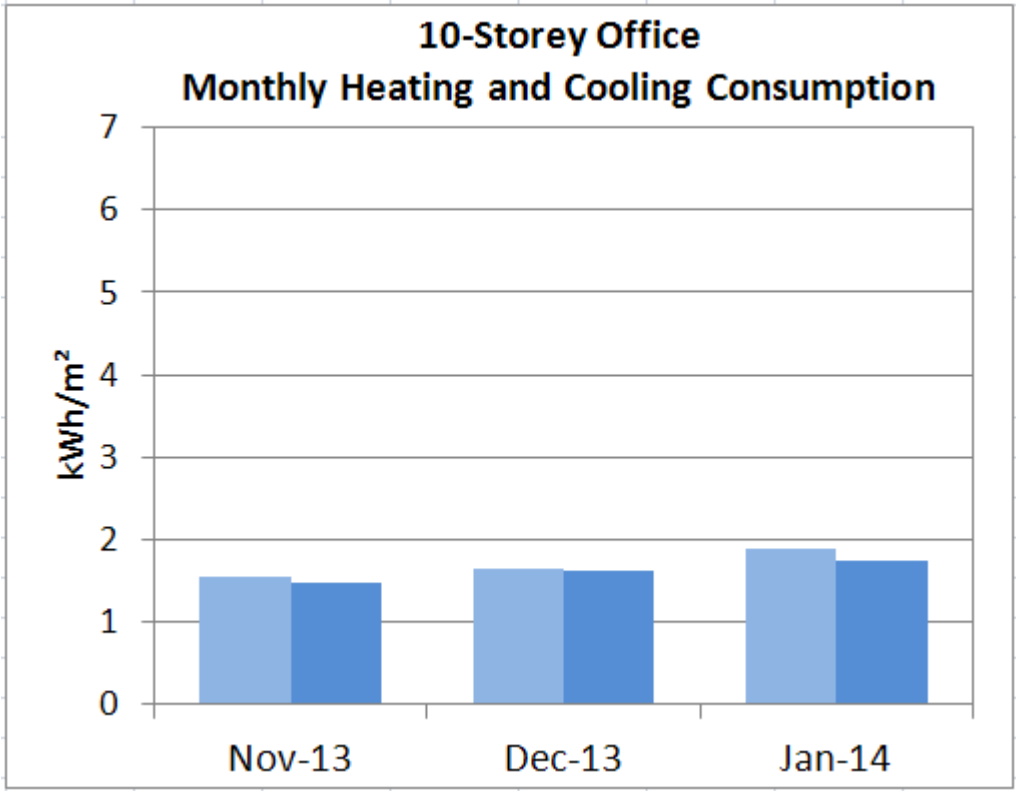
- **Monthly Graphs** (last updated 6 Feb 2014)
- **Canberra** (using CSIRO data)
- **Sydney** (using Macquarie Uni data)
  - Archetypical 10 storey office building
  - Archetypical 3 storey office building
  - Archetypical 1 storey supermarket building
  - Typical 3 kW domestic solar PV system

Exemplary Weather and Energy Index Sydney – 12 months actual v RMY

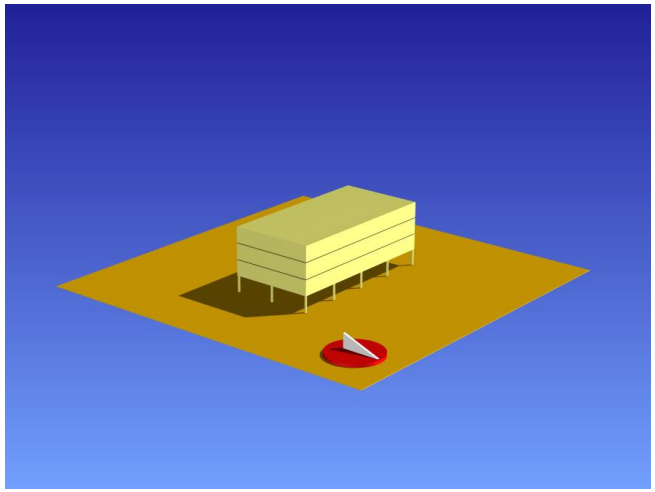
Weather Energy Index						
	10-storey Office		3-storey Office		Supermarket	
	Cooling	Heating	Cooling	Heating	Cooling	Heating
Feb-13	-23%	N.A.	-25%	N.A.	-11%	N.A.
Mar-13	-14%	N.A.	-17%	N.A.	-9%	N.A.
Apr-13	-10%	N.A.	-13%	N.A.	-33%	N.A.
May-13	-3%	-4%	-1%	3%	-3%	-46%
Jun-13	1%	-60%	4%	-100%	89%	-90%
Jul-13	15%	-37%	18%	-37%	110%	-75%
Aug-13	10%	-58%	16%	-55%	115%	-84%
Sep-13	7%	-84%	11%	-83%	137%	-100%
Oct-13	8%	N.A.	10%	N.A.	41%	N.A.
Nov-13	-4%	N.A.	-6%	N.A.	-11%	-100%
Dec-13	-1%	N.A.	-1%	N.A.	9%	N.A.
Jan-14	-8%	N.A.	-8%	N.A.	-3%	N.A.

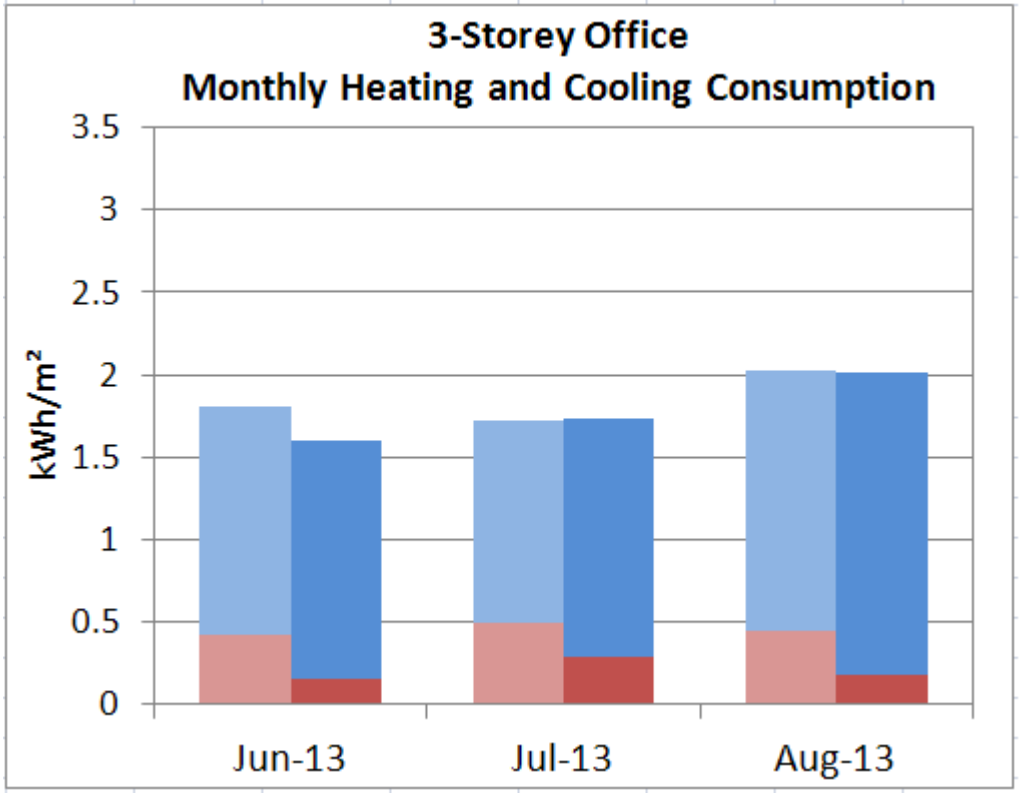
Exemplary Weather and Energy Index - Sydney



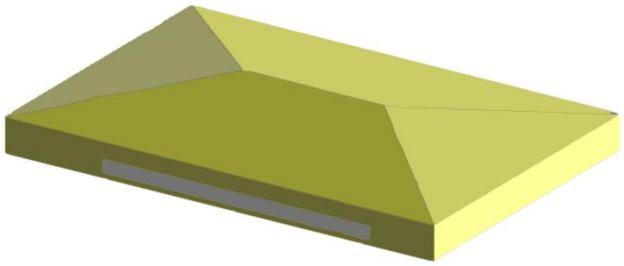


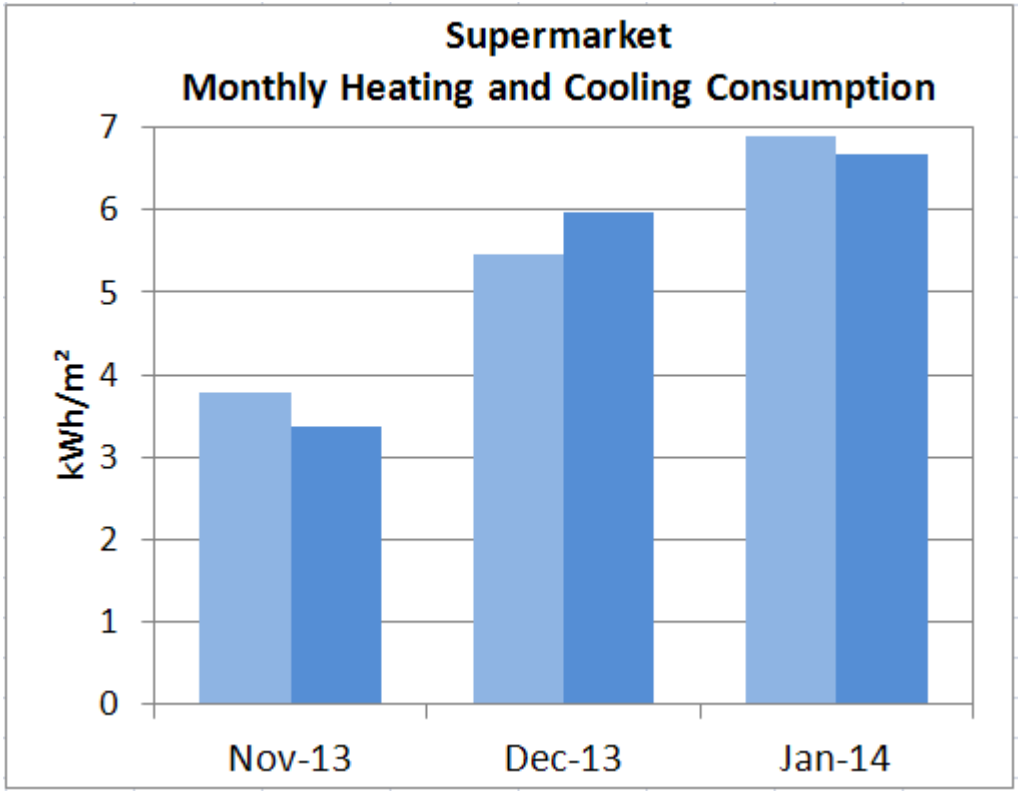
Exemplary Weather and Energy Index - Sydney



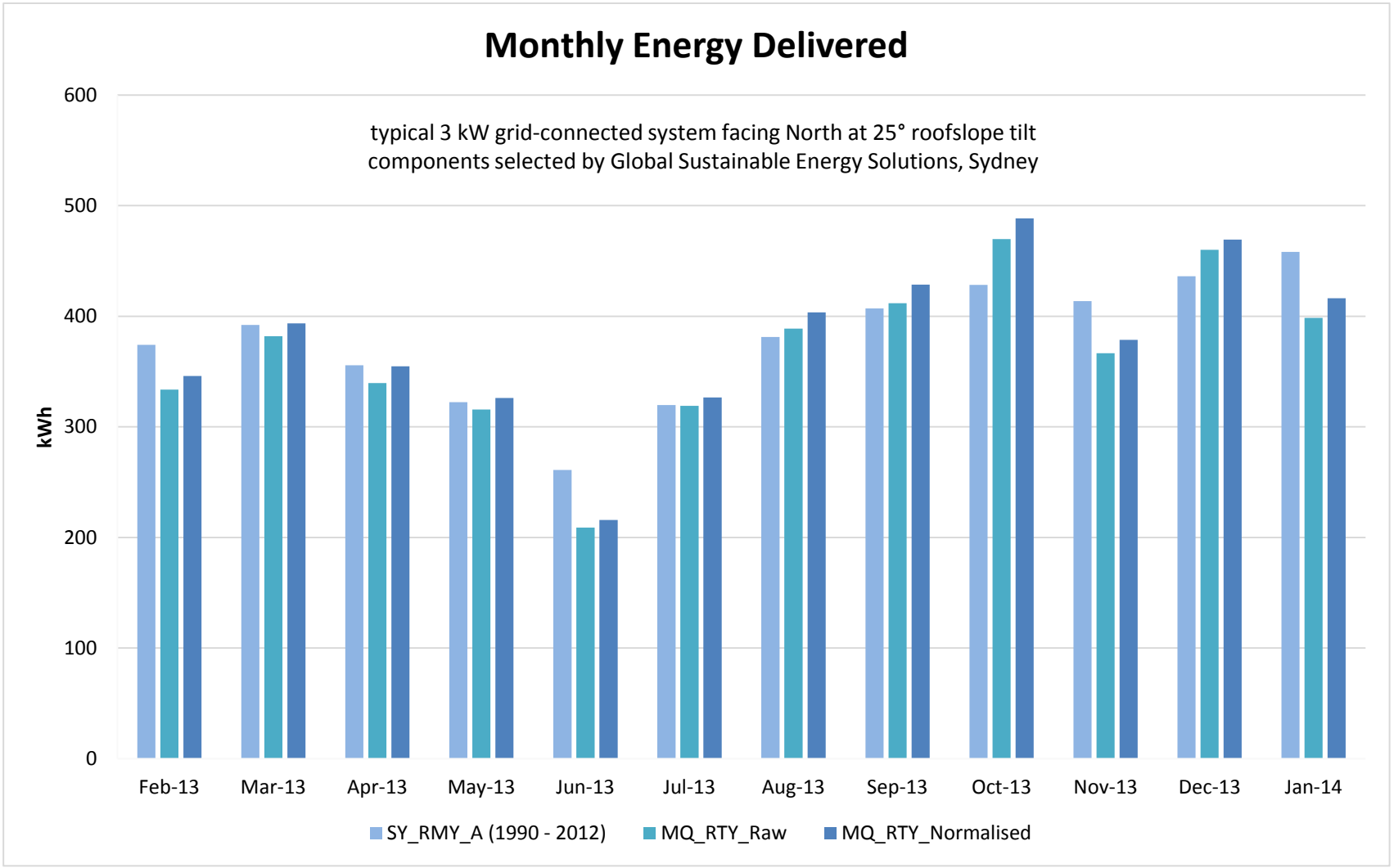


Exemplary Weather and Energy Index - Sydney

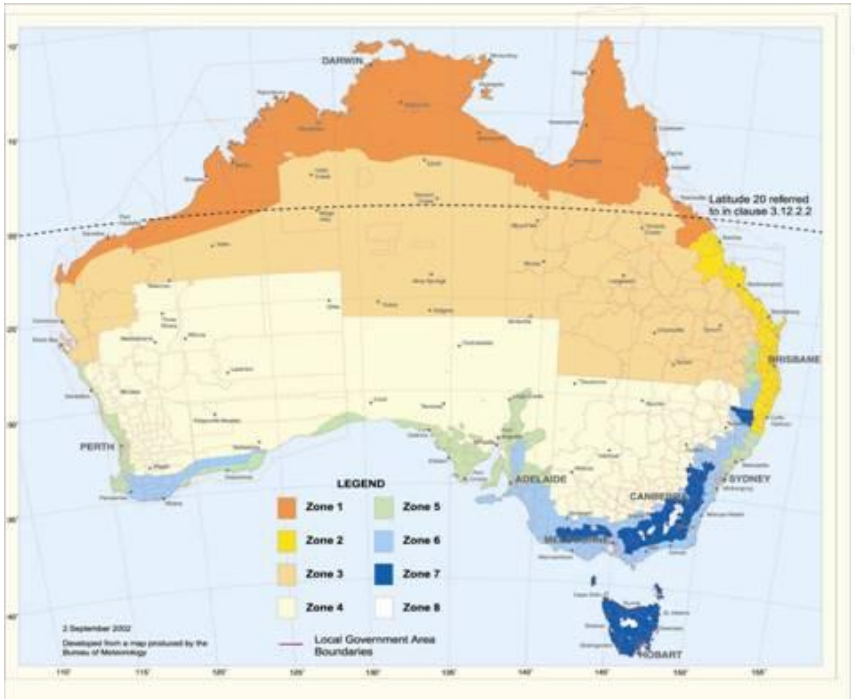


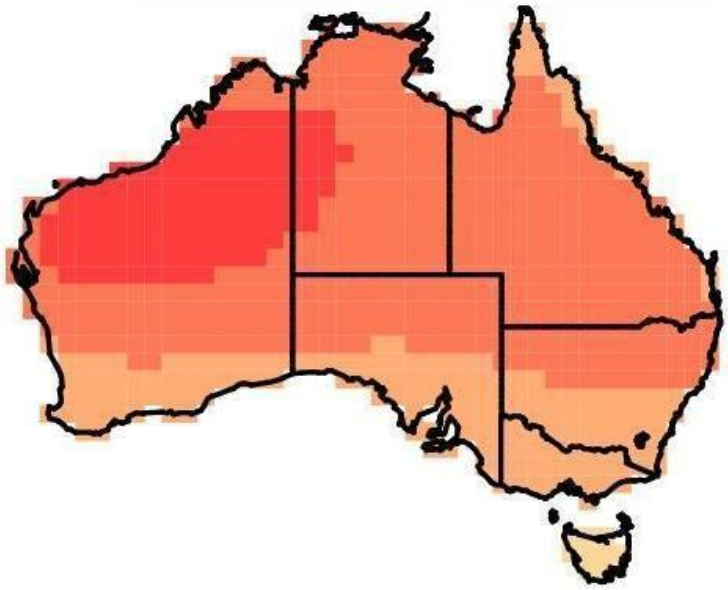


Exemplary Weather and Energy Index - Sydney PV

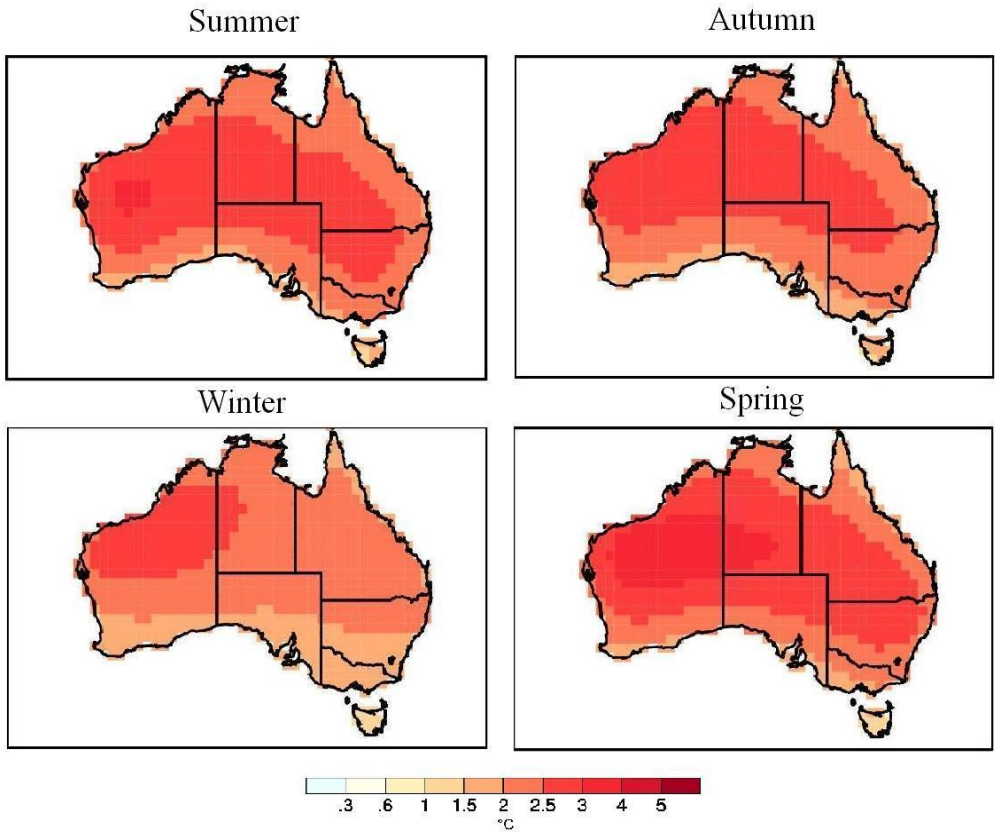


Creation of Ersatz Future Weather Data Files



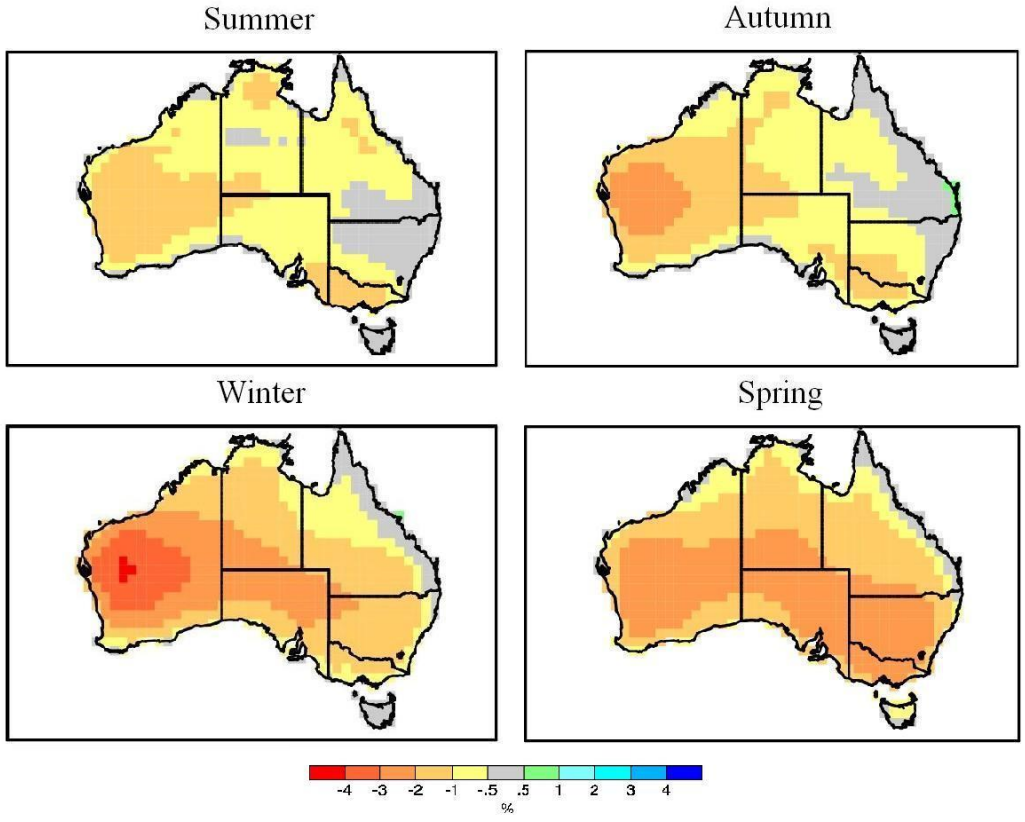


Climate "Forecast" (Seasonal)



- 50th percentile change in dry-bulb temperature

Climate "Forecast" (Seasonal)



- 50th percentile change in relative Humidity

Conclusions

- Climate and weather data may be tailored to suit a wide range of renewable energy and energy conservation applications.
- XMYs and RTYs 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.
- Weather data collected by institutions like CSIRO and Macquarie University can be applied with building and renewable energy system simulation techniques to maintain systems in optimal working order commensurate with designs
- That same data can be applied to publish a Weather and Energy Index based on archetypical systems as an indicator of variation in weather (compared with long term climate)

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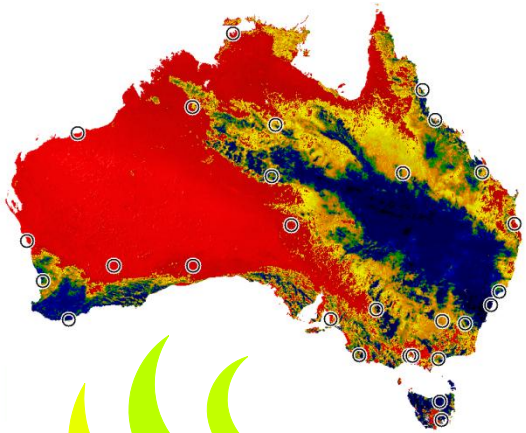

Questions?

Trevor Lee ARAIA
trevor.lee@exemplary.com.au

Grant Edwards PhD
grant.edwards@mq.edu.au