Solar Radiation Data for Australia and New Zealand
A Proposal for Enhanced Knowledge Dissemination

Trevor Lee
Energy Partners
PO Box 4170, Manuka ACT 2603
AUSTRALIA
Email: Energy.Partners@exemplary.com.au

ABSTRACT

The Australian Solar Radiation Data Handbook (ASRDH) was first published in 1985 but incorporating a gross error in its algorithm for solar position that made it highly inaccurate for high tilt surfaces. This error was corrected in 1992 and a fully revised third edition published by the Energy Research and Development Corporation (ERDC) in 1995 incorporating the best available anisotropic sky algorithms for interpreting global, diffuse and direct solar measurements into the required architectural and engineering design tables for a wide range of fixed and sun-tracking surfaces.

The ownership of the ASRDH edition 3 was passed to ANZSES upon the demise of the ERDC and, shortly after, ANZSES produced its software companion AUSOLRAD in 1997.

This paper builds on the recent project to update and enhance the ASRDH and its companion software AUSOLRAD. That project commenced in July 2002 under a grant from the Australian Greenhouse Office's Renewable Energy Industry Development program and was completed by the end of 2005. It was published by ANZSES in April 2006.

During its progress, an associated project to update and enhance the Australian Climate Data Bank (ACDB) was initiated and opportunities to further enhance the ASRDH as a result of that work are now canvassed in detail. Similar advances in the publication of New Zealand climate data suggest an expansion of the ASRDH and AUSOLRAD to be a trans-Tasman set of documents is fully feasible. Addressing its full capability, that would allow the production of tabulated data for 96 locations in CD-ROM with only a handful of selected sites published in hard copy with the Handbook itself.

Keywords – solar radiation, system simulation, weather data, climate

BACKGROUND

The Australian Solar Radiation Data Handbook (ASRDH) was first published in 1988 (Frick et al, 1988) following the pioneering work of Paltridge and Proctor (1976) and its preparation for wider use by Roy and Miller (1980).

Although it also calculates the irradiation of a range of engineering and architectural surfaces, each edition of this Handbook is different from their simpler predecessors the so-called "Spencer Tables" (Spencer, 1974 and later) that use completely clear skies to calculate irradiation levels. The "Spencer Tables" provide equivalent information for architectural surfaces for the specific case of a cloudless sky. By contrast, the data used for this Handbook are all statistical values (means and frequencies of occurrence) that account for the reduction, particularly in beam radiation, caused by actual cloud conditions. Similarly, in the early years, solar position and shading design was tackled with no explicit detail on the irradiation energy involved, as in Spencer and Philips (1983).

Alas, that first edition 1988 of the ASRDH incorporated a gross error in the algorithm for solar position that made it highly inaccurate for high tilt surfaces. The error was first revealed by Lee (1991) in *"Solar Progress"*, the quarterly journal of the Australian and New Zealand Solar Energy Society (ANZSES) and subsequently explained (Frick and Leadbeater, 1992). The error was corrected later in 1992 with an interim 5¼ inch floppy disk ASRDH 2nd edition (an early example of electronic publication) and a fully revised third edition subsequently published by the Energy Research and Development Corporation (ERDC), Canberra, (Lee et al, 1995). That edition incorporated the best available anisotropic sky algorithms for interpreting global, diffuse and direct solar measurements into the required architectural and design tables for a wide range of fixed and sun tracking surfaces.

That edition also built on the pioneering work of the Bureau of Meteorology (BOM) in its incorporation of isorad (contour) maps of capital city hinterlands prepared from satellite measurements of reflected radiation used to infer how much was reaching the ground anywhere over the Australian land mass (Nunez, 1990).

The ownership of the ASRDH edition 3 was passed to ANZSES upon the demise of the ERDC and, shortly after, ANZSES produced its software companion AUSOLRAD in 1997. However, that 3rd edition was forced to re-use the pre 1986 data from within the old Australian Climate Data Bank (ACDB) (Delsante, 1989) by the then priorities of the BOM - in process of changing all its data systems across to a new and better mainframe computer it had just acquired.

Industry and ANZSES pressure eventually convinced the Australian Government that this was unsatisfactory - especially for Adelaide, Brisbane, Canberra and Sydney which each had only three years worth of solar records in 1986. Subsequently, substantial inroads were made into the enhancement of the accuracy of solar measurement at the BOM despite constrained funding support (Forgan, 1996 and 1999).

A major enhancement project for the ASRDH commenced in July 2002 under a grant from the Australian Greenhouse Office's Renewable Energy Industry Development program and was completed by the end of 2005 (Lee, Snow and Stokes, 2005). The resultant publications were completed in the early months of 2006 at which point the current (4th) edition of the ASRDH and 2nd edition of AUSOLRAD became commercially available in hard copy and CD-ROM.

GEOGRAPHIC SCOPE

The current edition has data for only 28 sites[1] – six of which had no terrestrial irradiation data but were inferred from a combination of historical records for cloud

[1] Coincidentally, the Nationwide House Energy Rating Software (NatHERS) of the time had weather data for 28 sites, too, but only 18 of those coincided with the ASRDH sites.

cover, sunshine hours and latterly satellite estimation. These were included for spatial completeness in addition to the 22 sites in the first two editions. A list of those 28 sites and their data qualities is included in Tab. 1 and shown in Fig. 1.

By contrast, the 80 Australian sites (Fig. 2, after Lee and Snow, 2008 and Energy Partners, 2008) and 16 New Zealand sites (Fig. 3, after NIWA, Liley et al, 2007) represent a huge potential improvement in the spatial accuracy of the solar data. To gain some appreciation of this, see Fig. 5 which shows a seasonal snapshot of the variation around Hobart as an example.

PORTRAYAL OF TYPICAL YEARS

The currently available graphical portrayal of 28 solar energy climates (as in Fig. 4) can now be applied to almost 100 sites across Australasia. Additionally, this can be done with some improved accuracy for sites lacking separate terrestrial measurement of global, diffuse and direct irradiation (Boland, Brown and Ridley, 2008).

ANALYSIS OF ATYPICAL YEARS

Tapping the two National CDBs allows also the analysis of atypical years such as a typical El Nino year or even the sunniest year ever (in up to 42 years) to cite just two examples. The scope of such analysis has been dealt with elsewhere (Lee and Stokes, 2006), (Ferrari and Lee, 2008) and (Lee and Snow, 2008). In essence, any targeted selection of data that is possible for the full climate data sets is capable of generating an equivalent solar data tabulation.

Ersatz Future Climates

Lee and Ferrari (2008) described a method for producing RMY data sets for future climate scenarios by combining CSIRO climate projections with *baseline* data representative of current climate.

Such work can now be adapted to produce Ersatz Future Irradiation data based on these same forecasts.

Real-time Data

Real-time data can be applied to create real-year-to-date and other actual-year data sets which can be applied to:

- Model calibration using real time weather data coincident with other empirical measures like solar system output or building energy consumption or temperature (especially if unconditioned);
- Building or system monitoring for underperformance to indicate early restorative action; or
- Adjustment of actual output or consumption in a real year to reflect reasonably anticipated outcomes in the actual year relative to the RMY.

CONCLUSIONS

The 2008 update to the Australian Climate Data Bank (ACDB) and the 2007 creation of the New Zealand Climate Data Bank (NZCDB) presents an unprecedented opportunity for enhancing the accuracy and pertinence of solar radiation data available to researchers, educators and practitioners alike.

As such, it represents a key underpinning of the expansion of solar and other renewable energy infrastructure investments now being planned with the financial and legislative backing of the Australian Government through its recently passed Renewable Energy Target (RET) legislation.

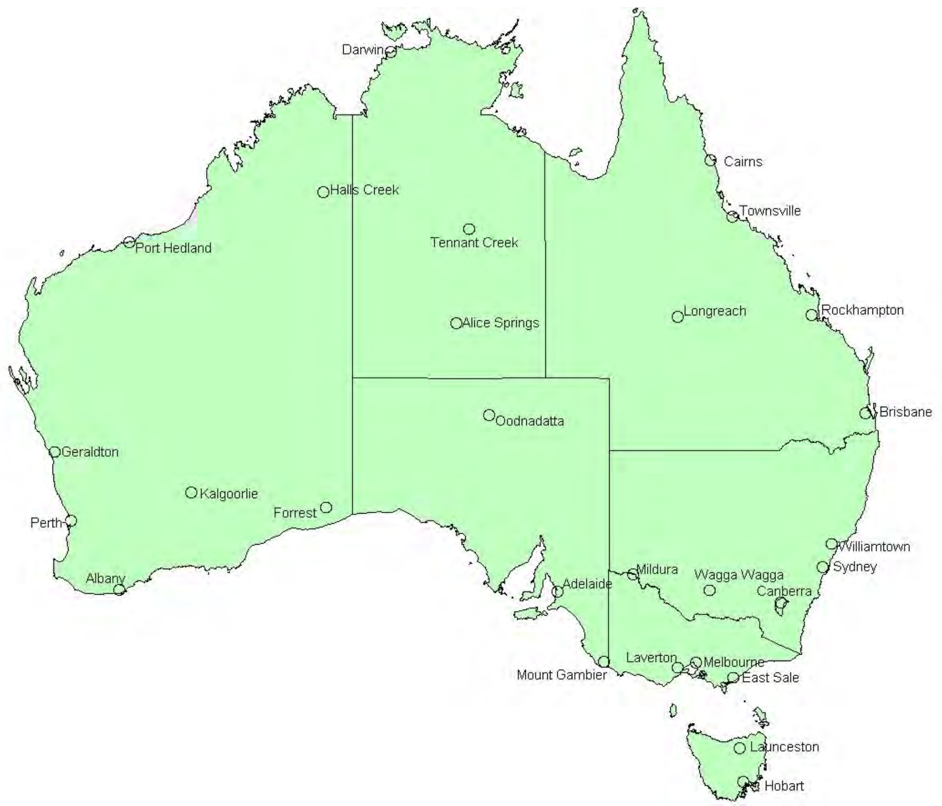

Fig. 1 Geographic Spread of the 28 Sites of the ASRDH Edition 4

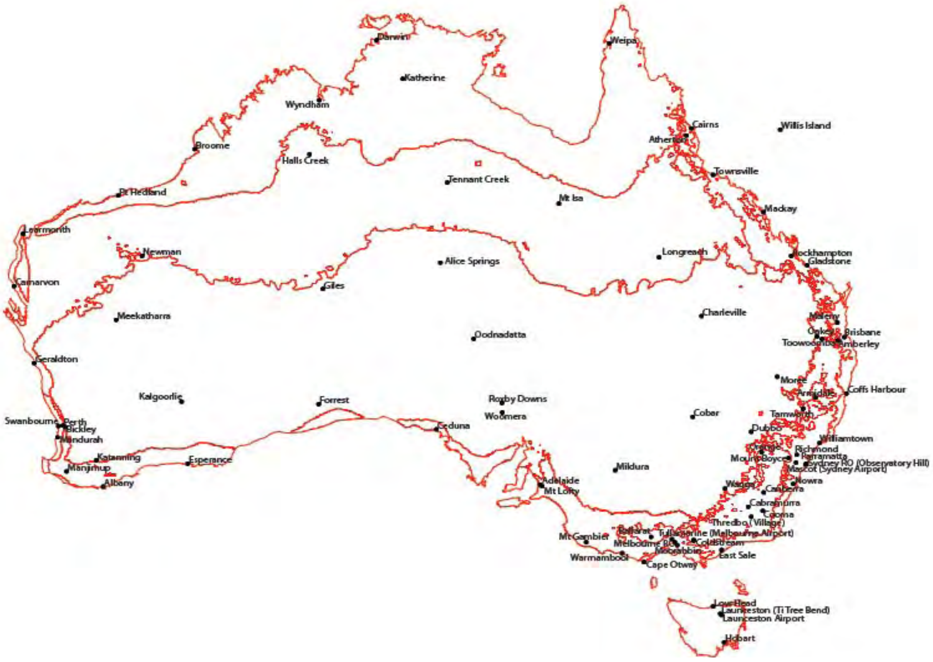

Fig. 2 Geographic Spread of the 80 Sites of the ACDB 2008 (showing the extents of the 8 BCA climate zones before harmonisation with state and local government boundaries)

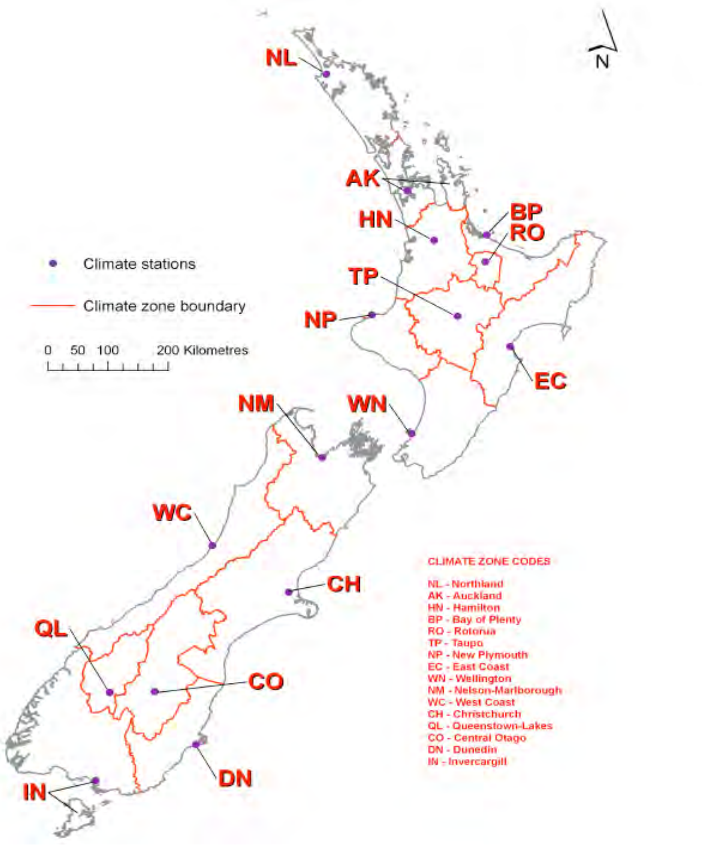

Fig. 3 Geographic Spread of the 16 Sites of the NZCDB 2007

Tab. 1 Data collection sites used in 2006 Handbook with various details

State Terr	Location	Elevation	Data type	Radiation data start date to May 2004	No. of days	% of days with estimated data only
NSW ACT	Canberra City	571 m	G&D	Mar 1976	10,301	24.2%
	Sydney RO	4 m	G&D	Aug 1983	7,604	29.4%
	Wagga Wagga AMO	224 m	G&D	July 1968	13,111	13.1%
	Williamtown AMO	12 m	G	Dec 1968	12,960	28.8%
QLD	Brisbane AMO	6 m	G&D	Jan 1983	7,805	22.2%
	Cairns AMO	3 m	EST	Oct 1990	4,962	28.9%
	Longreach	195 m	G	July 1968	13,093	23.9%
	Rockhampton AMO	8 m	G&D	Feb 1973	11,437	11.6%
	Townsville	4 m	EST	Mar 1971	12,128	21.7%
SA NT	Adelaide AMO	11 m	G&D	Jan 1983	7,816	16.2%
	Alice Springs AMO	547 m	G&D	July 1968	13,112	4.1%
	Darwin AMO	35 m	G	Oct 1968	13,021	9.8%
	Mt Gambier AMO	63 m	G&D	July 1968	13,108	5.2%
	Oodnadatta AMO	113 m	G	May 1969	12,798	42.5%
	Tennant Creek	375 m	EST	Oct 1990	4,962	6.1%
VIC TAS	East Sale AMO	14 m	EST	Oct 1990	4,962	51.8%
	Hobart RO	8 m	G&D	Oct 1967	13,367	18.3%
	Launceston AMO	171 m	EST	Oct 1990	4,962	51.9%
	Laverton AMO	14 m	G&D	Feb 1968	13,258	17.1%
	Melbourne HO	123 m	G&D	Jan 1967	13,660	25.6%
	Mildura AMO	53 m	G&D	Jan 1969	12,929	3.0%
WA	Albany AMO	71 m	G&D	June 1968	13,143	27.0%
	Forrest AMO	157 m	G	Nov 1969	12,623	29.6%
	Geraldton AMO	35 m	G&D	June 1968	13,124	6.5%
	Halls Creek AMO	423 m	G	May 1969	12,809	22.0%
	Kalgoorlie	360 m	EST	Feb 1979	9,240	4.9%
	Perth RO	11 m	G&D	Feb 1973	11,437	17.5%
	Port Hedland	8 m	G&D	Sep 1968	13,048	22.8%

Legend for Data Sources (listed in descending order of accuracy):

AMO indicates that the station is an Airport Meteorological Office

HO indicates that the station is Head Office of the Bureau of Meteorology, 150 Lonsdale Street, Melbourne

RO indicates that the station is Regional Office

G&D Locations using both global and diffuse measurements

G Locations using global radiation measurements only, with the diffuse radiation estimated.

EST Locations using only estimated data from cloud cover records

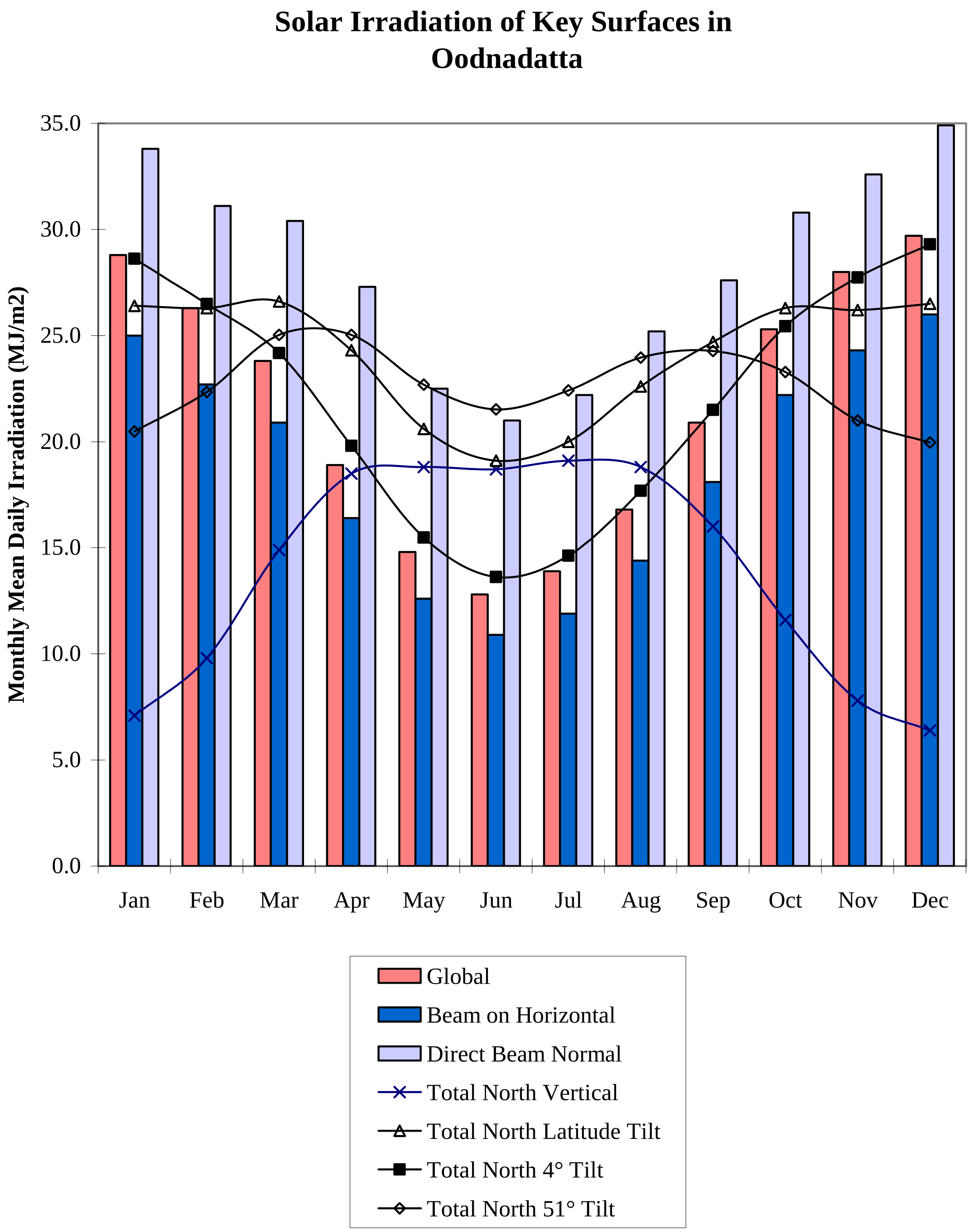

Fig. 4 Sample Graphical Summary from ASRDH Edition 4

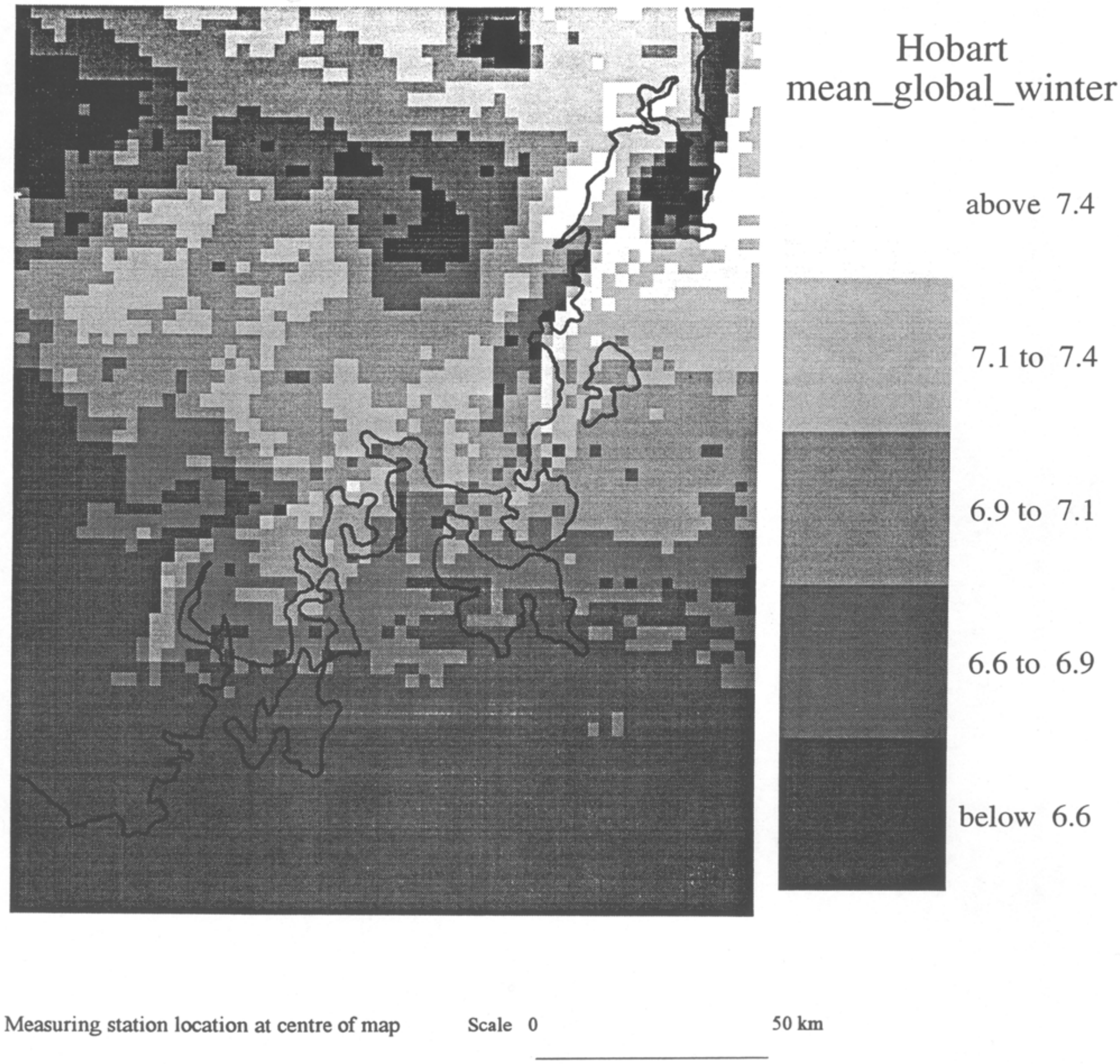

Fig. 5 Sample of the Spatial Variation Mapped for Capital Cities

REFERENCES

Boland J., Ridley B. and Brown B. (2008). *Models of diffuse solar radiation*, Renewable Energy, 33, 575-584.

Delsante, A.E. (1989). *Extension of Australian Climatic Data Bank and Outdoor Design Data* (NERDDC Project 984, Final Report), CSIRO, Division of Building, Construction and Engineering, Melbourne.

Energy Partners (2008), *Development of Climate Data for Building Related Energy Rating Software*, Report to the Australian Department of Environment, Water, Heritage and the Arts, Canberra (unpublished at the time of this conference)

Ferrari, D. and Lee, T.R. (2008), *Beyond TMY: Climate Data for Specific Applications*, Proceedings of the ANZSES Solar '08 Conference, Sydney

Frick, RA. et al (1988), *Australian Solar Radiation Data Handbook*, NERDDP/EG/88/714, Dept of Primary Industries and Energy, Canberra.

Frick, RA. and Leadbeater, M. (1992) *Sunless Springs and the ASRDH*, Solar Progress, Vol 13 No 1.

Forgan, B.W. (1996) *A New Method for Calibrating Reference and Field Pyranometers*, Journal of Atmospheric and Oceanic Technology: Vol. 13, No. 3, pp. 638–645.

Forgan, B.W. (1999) *Application of WCRP/BSRN minute data to satellite exposure uncertainty*. Bureau of Meteorology, Melbourne Australia

Lee, T.R (December 1991) *Defining the Solar Resource ... Just when we thought we had arrived*, editorial, Solar Progress, Vol 12, No 3&4

Lee, T.R., Oppenheim, D. and Williamson, T. (1995) *The Australian Solar Radiation Data Handbook (Edition 3)*, Energy Research and Development Corporation, Canberra

Lee, T.R, Snow, M. and Stokes, B. (2005) *The Australian Solar Radiation Resource Updated*, in proceedings of ANZSES Solar 2005, University of Otago, Dunedin

Lee, T.R, Snow, M. and Stokes, B. (2006) *The Australian Solar Radiation Data Handbook*, Energy Partners for ANZSES, Canberra

Lee, T.R. and Ferrari, D., (2008) *Simulating the Impact on Buildings of Changing Climate - Creation and Application of Ersatz Future Weather Data Files*, Simbuild Conference, Berkeley CA, USA

Lee, T and Stokes, B (2006), *"Producing New and Specialised Data Files for Australian Sites"*. In proceedings of IBPSA, Adelaide, 2006

Liley, J.B., Shiona, H., Sturman, J., Wratt, D.S., 2007. *Typical Meteorological Years for the New Zealand Home Energy Rating Scheme*. National Institute of Water & Atmospheric Research Ltd, Central Otago.

Nunez, M. (February 1990) *Satellite estimation of regional solar energy statistics for Australian capital cities*, Bureau of Meteorology Study No 39.

Paltridge, G.W. and Proctor, D. (1976*), Monthly Mean Solar Radiation Statistics for Australia*, Solar Energy Journal, Volume 18 No 3, pp 235 243, Pergamon Press.

Roy, G.G., and Miller, S.G., (1980) *Data Handbook for Australian Solar Energy Designers*, University of WA

Spencer J. W. and Phillips R O. (1983) *Sunshine and Shade in Australasia*, fourth edition, Department of Transport and Construction Bulletin No 8, AGPS.

Spencer J. W. (1974) *Melbourne Solar Tables: Tables for Solar Position and Radiation for Melbourne in SI Units*, CSIRO, Division of Building Research Technical Paper (Second Series) No 7, (and other capital cities subsequently).

ACKNOWLEDGEMENTS

The authors would like to thank the Australian and New Zealand Solar Energy Society for their continued support of the development and dissemination of the ASRDH and its potential expansion into the New Zealand context. The in principle support of the recently formed New Zealand Solar Energy Society (as a new Section of the International Solar Energy Society) is also much welcomed.

Similarly, the contribution of DEWHA and BOM in Australia and EECA and NIWA in New Zealand in making this expansion possible is gratefully acknowledged.

BRIEF BIOGRAPHY OF PRESENTER

Trevor Lee, ARAIA

An architect by initial training, Trevor is a consultant on energy conservation in the built environment through his multi-disciplinary firm Energy Partners. He is the lead author of the Australian Solar Radiation Data Handbook (ASRDH, 2006) and team leader for developing the current Australian Climate Data Bank (ACDB, 2008), the basis of all building and energy system simulation programs in current use in Australia. Subsequently, he worked on a project for the then Australian Greenhouse Office to project the impact on the built environment of “inevitable climate change”.

His interests include solar energy applications and ethical investment and, in pursuit of these, he has served as the Chairman of the Australian and New Zealand Solar Energy Society (ANZSES) and as a director of the Sustainable Energy Industry Association (forerunner of the Clean Energy Council (CEC) and of the Canberra-based funds manager Australian Ethical Investment Ltd.