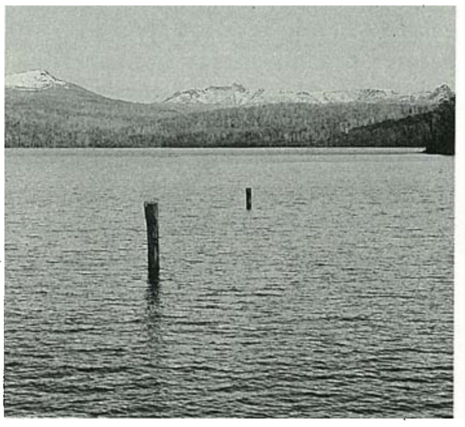
Comfort maps of Australia

In 1916 an Australian meteorologist, Griffith Taylor, divided the continent into four climate zones: scorching, muggy, keen, and raw. Although crude, this effort at classification did express the notion that people are strongly interested in describing the nature of the climate where they live; indeed, climate in many ways determines where people live and what sort of livelihood can be followed there.



Lake St Clair in July. You would feel colder here than at any other place in Tasmania, and quite possibly in Australia.

Marble Bar's postmaster records the town's weather data. By the researchers' reckoning, this place scores the highest heat stress for January afternoons.

Basically, people would like to know how comfortable they will be at a certain place. Many different ways of putting a measure on the climatic side of human comfort have been proposed. The United States Quartermaster General's clothing zones are based on wind chill and air temperature. The complication is that this scheme assigns two-thirds of the Australian continent, including the east coast, to a hot dry desert regime. Other misleading measures have included the number of days with a mean wet bulb temperature in excess of 21°C — this gives the erroneous impression that little discomfort is experienced in the major population centres south of 30° latitude.

In general, though, few climate maps drawn up in human comfort terms have been drawn for Australia. Cold stress has usually been neglected and only fairly basic and generalized measures of heat stress have been computed.

In the quest for scientific precision in this matter, two researchers have recently developed a new scheme in which the thermal equilibrium between a person and the atmosphere is calculated. Dr Jetse Kalma of the CSIRO Division of Land Use Research and Dr Andris Auliciems of the Geography Department of Queensland University believe their approach offers a way to specify, in physically meaningful numbers, the degree of comfort experienced by people living anywhere in Australia.

The pair used theoretical and semi-empirical approaches to calculate, for any time of day, the heat load on a naked person standing outdoors facing north. The expressions used take into account air temperature, humidity, radiation, and wind speed.

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The advantage of the scheme is that it eliminates differences caused by physiological adaptation or clothing preferences.

Calculations were made for 144 locations at 9 a.m. and 3 p.m. local time in mid January and mid July. The results for 3 p.m. are shown in the two maps — heat stress is shown by positive values and cold stress by negative ones.

The measures of heat and cold stress are expressed in watts, and this becomes more meaningful if we look at the amount of metabolic heat produced by a number of activities. Thus, when sitting we generate about 110 watts; walking, 220 W; golfing, 650 W; and sawing, 1000 W or more. This heat production adds to any heat stress brought about by the environment, and it must be dissipated by sweating.

The human body can pump out a maximum of about a litre of sweat per hour; if heat lost by this process is less than the total gained from the environment and metabolic exertion, then the temperature of the body rises and danger of heat stroke arises.

Metabolic heat can of course lessen cold stress, or we can put on more clothing to do the same. Putting on a substantial overcoat (with a wind speed of 1·5 metres per second) will reduce heat loss by about 300 W.

The greatest cold stress evidenced was for a station at Lake St Clair in central Tasmania (in the absence of data for the Australian alps), with a figure of minus 1462 W for 9 a.m. in July. This cold stress could be countered by wearing street clothing and producing 200–300 W of metabolic warmth (by a brisk walk, for example).

As for heat stress, high levels may be reached during summer, but if clothes can be freely discarded, enough heat can be lost by sweating to allow all but the most strenuous of activities. The highest 3 p.m. January heat stress was calculated for Marble Bar, where the thermal stress reached 651 W, permitting only moderate activity to be undertaken before the maximum sweat rate is reached.

Often, of course, sweating is impeded by custom or the necessities of protection against sunburn. Take into account too that average January figures have been used; in exceptionally hot weather it may be all a person can do to sit in the shade drinking a favourite cold liquid.

An interesting feature of the January map is that cold stress can occur at 3 p.m. along the southern coast, in the Australian alps, and in Tasmania.

As an extra detail, the maps show those areas where the 9 a.m. heat balance figure fell short of the 3 p.m. figure by more than 400 W. In other words, the temperature of those areas fluctuated a lot because of their continental climate and clear skies.

From outdoors to indoors

If our naked person is uncomfortable outdoors, our natural response is to go inside. We are usually more comfortable there, if for no other reason than that at least a heater, or a fan, is usually available.

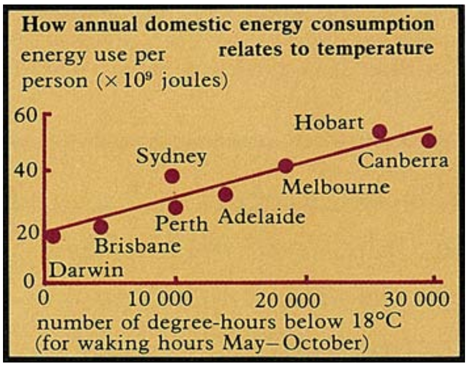
It is well known that air temperature is the most important factor in determining indoor comfort, while humidity, air speed, and radiation are of secondary importance. This makes comfort calculations relatively easy, and in fact many of the comfort maps drawn decades ago give us quite satisfactory indications of indoor thermal comfort.

Dr Kalma and Dr Auliciems were able to go one step further, however, and calculate the amount of fuel energy needed to keep people comfortable at 163 stations across Australia — a useful guide for people who take energy conservation seriously.

This work was based on two scientific findings. The first was that a temperature of 18°C is the balance temperature at which natural heat gains are just sufficient to provide indoor comfort without space heating. The second is that for the eight Australian capital cities there is an excellent linear relation between, on the one hand, the annual per capita energy use and, on the other, the annual total of 'degree-hours' below 18°C. This relation is shown in the graph.

From this graph we can extract a conversion factor relating degree-hours below 18°C to energy consumption. Using this factor, the two researchers applied it to all the Australian climate stations and came up with a map showing energy used for space heating.

Maximum values are of course found in the Australian alps and central Tasmania, with values exceeding 34 gigajoules per person per year. Most of the Tablelands and the Snowy Mountains districts of New South Wales, as well as the whole of Tasmania, also exceed 29 gigajoules.



The straight line of the graph suggests that residents of the eight Australian capital cities are inclined to turn their heaters on, or up, when the (indoor) temperature drops below 18°C.

In a similar fashion, a map of degree-hours above 25°C was obtained, which incorporated a correction for intensity of solar radiation. To give an idea of maximum cooling requirements across the country, some figures on electricity consumption of fully air-conditioned houses were used to achieve a conversion to energy needed for cooling. This map then shows that the highest figures are found in the Kimberley Ranges and around Marble Bar. Most of the coastal regions south from Brisbane and around to Perth show small cooling energy requirements.

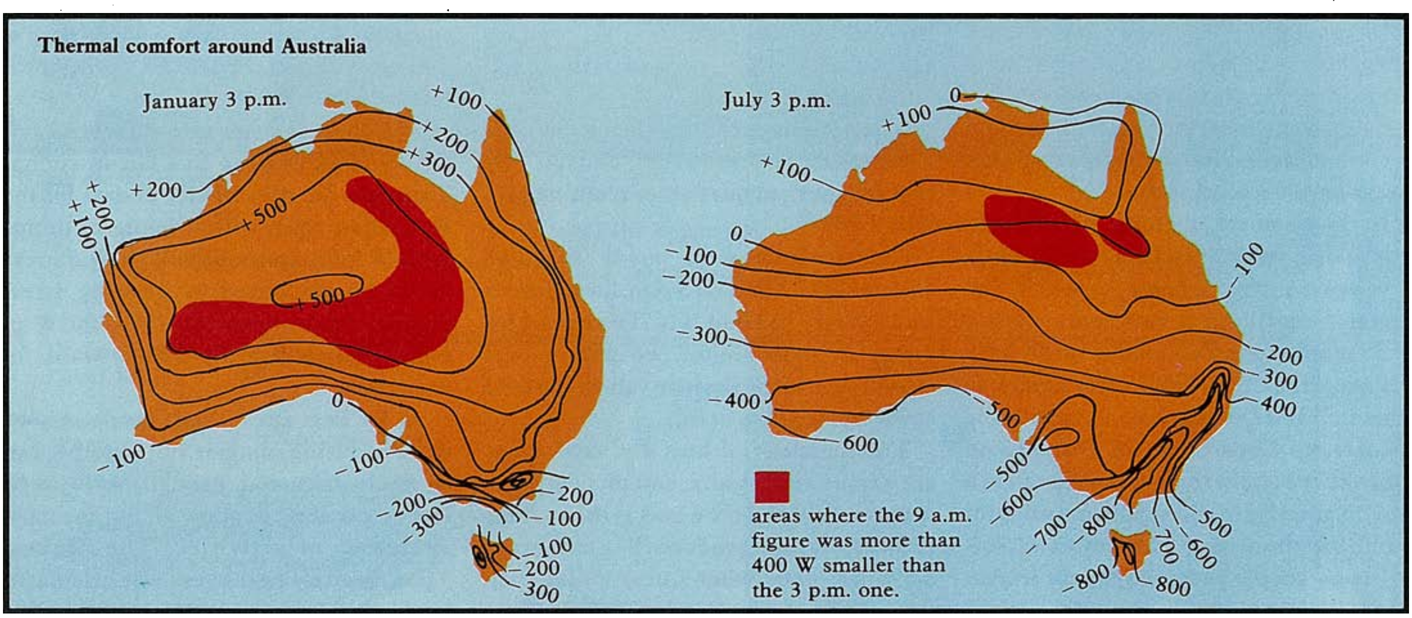
Combining the maps of actual energy used in space heating and maximum energy needs in space cooling gives an idea of how much energy would be needed to make us all comfortable. This shows that all the mainland capitals (except Darwin) would need something less than 40 gigajoules per person per year. Minimum values are found near Bunbury in Western Australia and along the east coast between Maryborough and Taree. This confirms what quite a number of alternative-lifestyle practitioners have hit on already.

Andrew Bell

More about the topic

Climate in relation to human comfort. J. D. Kalma and A. Auliciems. In 'Land and Water Resources of Australia', ed. E. G. Hallsworth and J. T. Woodcock. (Australian Academy of Technological Sciences: Melbourne 1979.)

A climatic classification of human thermal stress in Australia. A. Auliciems and J. D. Kalma. *Journal of Applied Meteorology*, 1979, 18, 616–26.



The figures give the heat stress, in watts, on a naked person outdoors. Negative values indicate cold stress.