SENSITIVITY OF THERMAL CONDITIONS FOR TOURISM TO CLIMATE CHANGE AND VARIABILITY: A COMPARISON OF REGIONAL SCALE CASE STUDIES

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ABSTRACT

Many tourist destinations rely heavily on thermal environmental assets and a generally agreeable climate to attract visitors. Climate change, whether natural or anthropogenic, could modify these assets. Yet the topic of future climate is plagued with uncertainty. In addition, climate change impact assessment often relies on a greatly simplified picture of climate, mainly because it usually deals with change in terms of single, secondary climatic variables. Here a body-atmosphere energy balance is used to assess the significance of change using a sensitivity analysis. Two well-tested schemes for integrating thermal bioclimatic variables are used to assess sensitivity to climate change in a variety of regions of the world well known tourist locations globally. The approach produces integrated output indices in the form of the Predicted Mean Vote (PMV) and Physiologically Equivalent Temperature (PET). High resolution gridded data for the period 1961–1990 was used to produce monthly maps. Response surface are used to show sensitivity to change in two regions that are the focal point for tourism in the Southern Hemisphere. Overall the results show that the quantification of the thermal impact of changed climate cannot be adequately assessed using temperature alone. The generalised mapped results are useful for identifying areas of high sensitivity to climate change as well as the extent to which potential impact on thermal climate appeal for tourism is likely to be negative or positive.

KEYWORDS: *Predicted Mean Vote, Physiologically Equivalente Temperature, Thermal Sensitivity, Australia, New Zealand*

INTRODUCTION

Many tourist destinations rely heavily on thermal environmental assets that create a generally agreeable climate to attract visitors. Climate change, whether natural or anthropogenic, could modify these assets and result in significant impacts, posing both risks and opportunities. There are two ways assessing the effect of these changes on tourism climate, these are the so called top down or bottom up approach. The top down method is by far the most common. In this approach, a future climate state is identified using global climate models and impacts evaluated. But this method is hampered by the unreliability of climate models. The fact is that there are no dependable predictions of future climate, especially at the regional scale; consequently the topic of future climate and possible impacts is plagued with uncertainty (de Freitas and Fowler, 1989). Another problem is that there is often an implicit assumption that a specific changed climate condition is predicted. This is reinforced by the fact that global climate models are limited to calculating a single equilibrium response condition. Clearly, the consequences of models being ‘wrong’ could have serious planning implications. To make matters worse, there are large discrepancies between predictions from different global climate models, especially when model output is transformed into impacts at the regional scale, the very scale at which planners and policy-makers typically operate.

An additional problem is that top down climate change impact assessment often relies on a greatly simplified picture of climate, mainly because it usually deals with change in terms of single climate variables that allow for only elementary statistical connections to be made with impacts.. This approach is of limited use since the significance of change will depend on the net effect of the changed variables. Clearly, thermal climate in terms of human comfort is a function of the combined effect of several atmospheric variables, including air temperature, humidity, solar radiation and wind, as well a the body’s metabolic rate and clothing.

The alternative bottom up approach, circumnavigates many of these problems. First sensitivity of a tourism activity to climate is assessed, and then the question asked: What is the net effect of change on the tourism activity or tourism-related socioeconomic exposure unit? By identifying its sensitivity to climate and evaluating this in terms of the adaptive capacity of the exposure unit, vulnerability of tourism to change may be determined and assessed. With this information, planning decisions would be possible without knowing precisely what future climate will be like.

In the current study bottom up approach is used to assess the sensitivity to change of the thermal environmental assets that create a generally agreeable climate to attract visitors. Two regions that are heavily used for outdoor tourism activities are considered together for comparative purposes. The Southern Hemisphere is used as this part of the global often neglected in regional climate assessments. To overcome the deficiency caused by using a single climate variable, typically air temperature, a body-atmosphere energy balance approach is employed. This approach deals with thermal climate in terms human comfort as a function of the combined effect several atmospheric variables as well as the individual's activity level, posture and clothing. Thus he information provided is an expression of the integrated effect of all thermal aspects of climate. From here the significance of change can be related to overall sensitivity of the climate condition to those aspects of climate that do change. For example, an average 1°C air temperature rise may be of little consequence where high temperatures, high solar heat loads, high relative humidity and low wind speeds are commonplace. On the other hand, marginal tourism climates may be highly sensitive and respond dramatically to even the smallest change in thermal conditions in an already short tourist season. Also, more subtle changes in climate can be assessed, such as those due to changes in cloud cover, which affects the solar heat load on the human body and thus the body net thermal state.

METHOD

Two refined and well-tested schemes for integrating thermal bioclimatic variables are used to assess sensitivity of the climate of Australia and New Zealand generally to climate change. The tourism focus in both cases is outdoor recreation. In addition, two of regions that are well heavily used tourist locations, namely the Auckland region of the North Island of New Zealand and the Sunshine and Gold coasts of southeast Queensland Australia, are the subject of more in depth analysis. Detailed assessment of data from the climate stations at Auckland and Brisbane Australia are used as indicative of the climate of these important tourist regions.

Two refined and well-tested schemes for integrating thermal bioclimatic variables are used to assess sensitivity to climate change in a variety of regions of the world well known tourist locations globally. The approach produces integrated output indices in the form of the Predicted Mean Vote (Fanger, 1972, VDI, 1998) and Physiologically Equivalent Temperature (Höppe, 1999, Matzarakis et al., 1999). Predicted Mean Vote (PMV) or its equivalent the ASHRAE Temperature Sensation Scale (TSN) quantifies comfort/discomfort based on human-assessed response to thermal stress. PMV and TSN one of the most widely used thermal indices (McGregor et al., 2002). Physiological Equivalent Temperature (PET) integrates all thermal variables relevant to the body-atmosphere energy balance and expresses the result in terms of an "effective air temperature" (Höppe, 1999, Matzarakis et al., 1999).

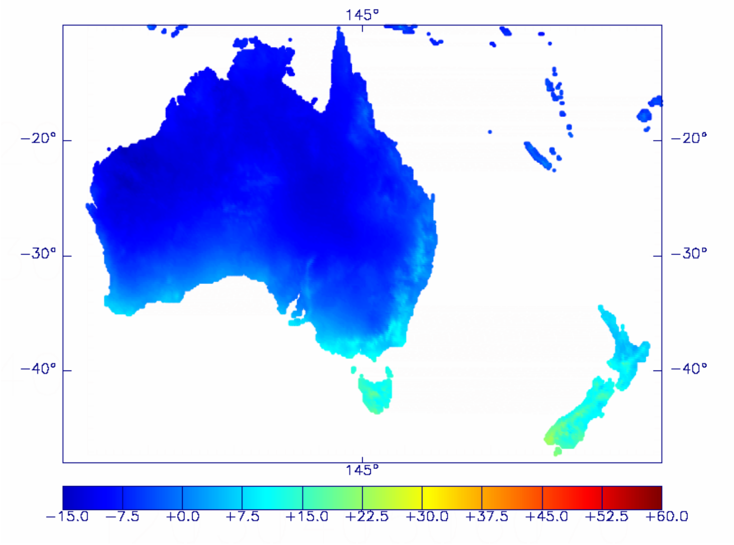

Figure 1: Conditions for January showing change in air temperature (deg C) required to bring PMV (TSN) to zero. Calculations are based on conditions at solar noon (Brisbane -8; Auckland +1). Activity and clothing level are 80 W/m2 and 0.5 clo, respectively

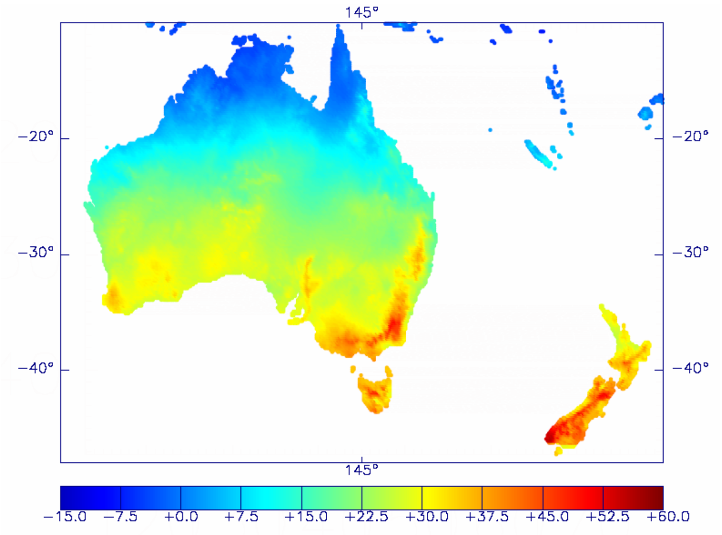

Figure 2: Conditions for July showing change in air temperature (deg C) required to bring PMV (TSN) to zero. Calculations are based on conditions at solar noon (Brisbane +5; Auckland +13). Activity and clothing level are 80 W/m2 and 0.5 clo, respectively

Two approaches are used. The first assesses broad regional or spatial sensitivity to climate change. High resolution gridded data for the period 1961–1990 (New et al., 1999, 2002) was used to produce monthly maps that show change in air temperature required to bring PMV (TSN) to zero. Calculations are based on conditions at solar noon, using an activity of humans of 80 W m^2 (equivalent to standing still) and clothing 0.5 clo (equivalent of light summer clothing). Figure 1 shows sensitivity to change during January, which is the mid-summer month. Figure 2 shows sensitivity during mid-winter (July). Figures 3 and 4 show sensitivity to full sunshine or shade for both mid winter and mid summer months. Computations for both months are based on mean monthly values of air temperature, relative humidity, wind and cloud cover at 12 noon local time for 15 January and 15 July for the period 1961-1990 using, as before, an activity level of 80 W m^2 and the insulation provided by 0.5 clo of clothing. Figures 3 and 4 show the maximum effect of cloud cover on the solar heat load on the human body during winter and summer, respectively.

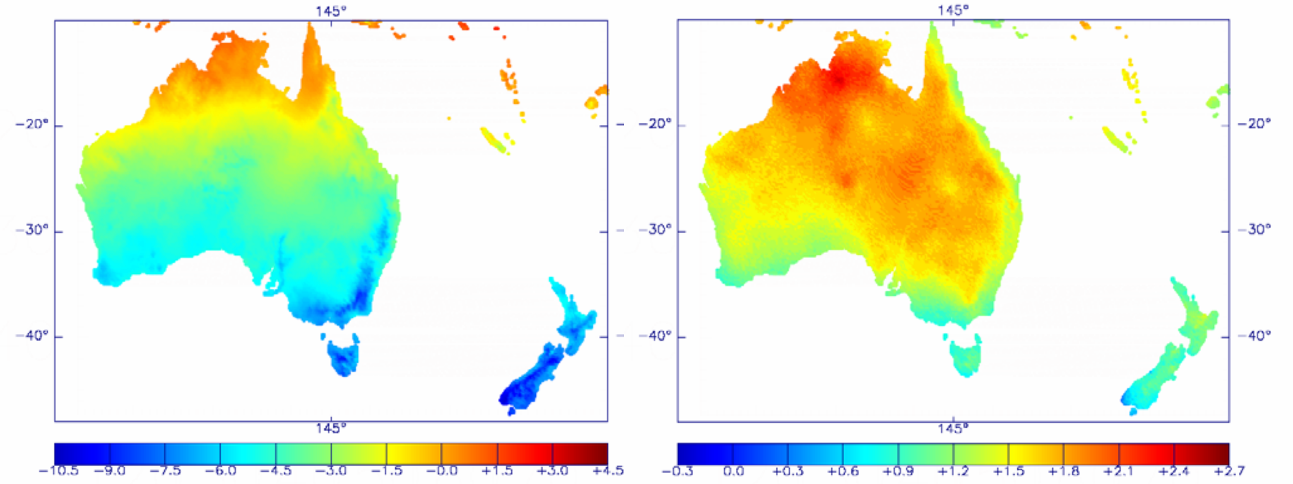

Figure 3: TSN (PMV) for the mid-winter month of July demonstrating the maximum effect of changes in cloud cover on the heat load of the human body. Figure on left is person standing in sun and on right in full shade. Data are based on mean monthly values of air temperature, relative humidity and wind at 12 noon local time for 15 January for the period 1961-1990. Activity and clothing level are 80 W/m2 and 0.5 clo, respectively

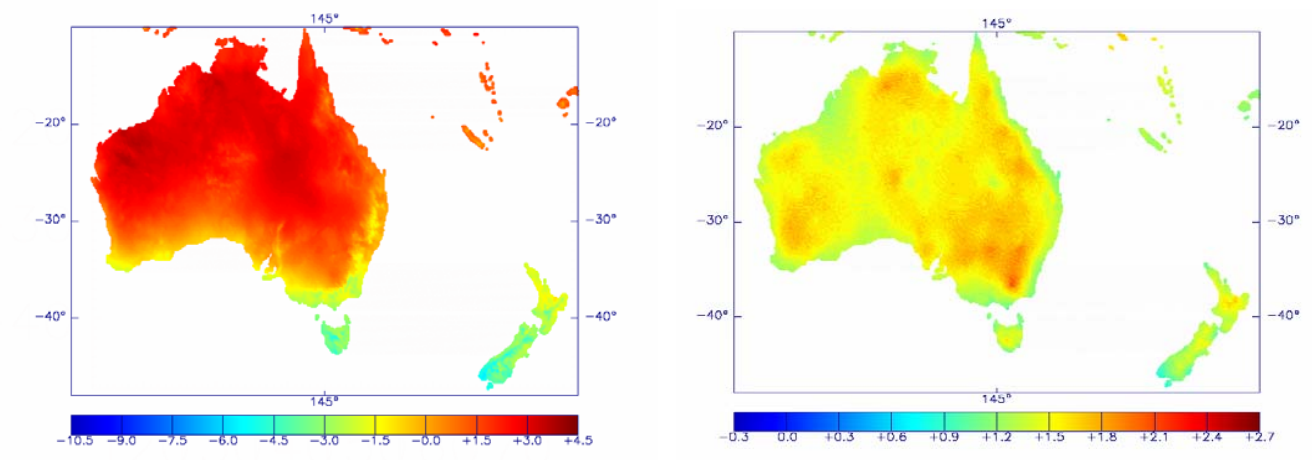

Figure 4: TSN (PMV) for the mid-summer month of January demonstrating the maximum effect of changes in cloud cover on the heat load of the human body. Figure on left is person standing in sun and on right in full shade. Data are based on mean monthly values of air temperature, relative humidity and wind at 12 noon local time for 15 January for the period 1961-1990. Activity and clothing level are 80 W/m2 and 0.5 clo, respectively

The second approach is by way of response surfaces, which are two-dimensional representation of the sensitivity of a specific response variable (PMV or TSN for example) to change in the two controlling features of climate (for example, temperature change and change in sunshine/cloudiness as it affect the solar heat load on the body). The relationship between the response variable and climate is determined from a pre-tested set or relationships, usually in the form of an empirical model, called a transfer function, such as is in the case for PMV presented by Fanger (1972).

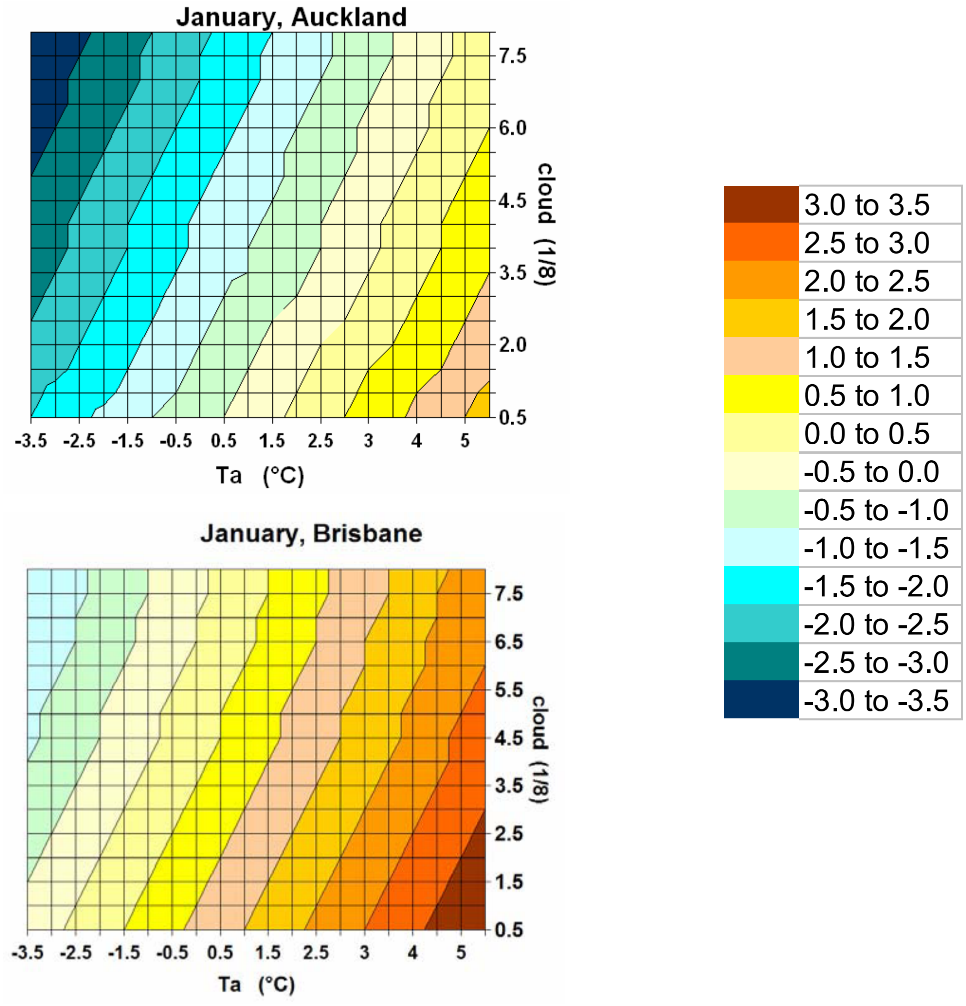

Figure 5: Sensitivity of PMV or TSN to changes in air temperature (deg C) and cloud cover. Mean cloud for Auckland is 3.9. Mean cloud for Brisbane is 3.1. PMV is calculated from an integrated human body-atmosphere energy budget holding relative humidity, wind and solar radiation constant at mean January values. Calculations consider conditions at solar noon. Activity and clothing level are 80 W/m2 and 0.5 clo, respectively

The output from the groups of determinants can be plotted using values relative to a baseline representing no climate change (Fig. 5 and 6). The latter representation is a step removed from absolute input and output but does have the advantage of providing a direct measure of sensitivity. For example, a 20 % response to a 10 % change in a controlling climate variable is clearly an example of impact amplification. Response surface isolines are a summary of a matrix of response points associated with various combinations of changes to the two groups of driving climate variables (Fig.s 5 and 6). The required data are derived from repeated runs of the transfer function with the prescribed changes to the input. The slope and closeness of the isolines are an indicator of sensitivity and discontinuities an indicator of change in response. Plotting climate change scenarios on the response surface enables it to be used for impact analysis. A scenario of say a 10 % increase in temperature and a 20 % increase in the cloud, for example, can be plotted on the response surface to assess the anticipated impact on the response variable, say change in the PMV or TSN (Fig.s 5 and 6).

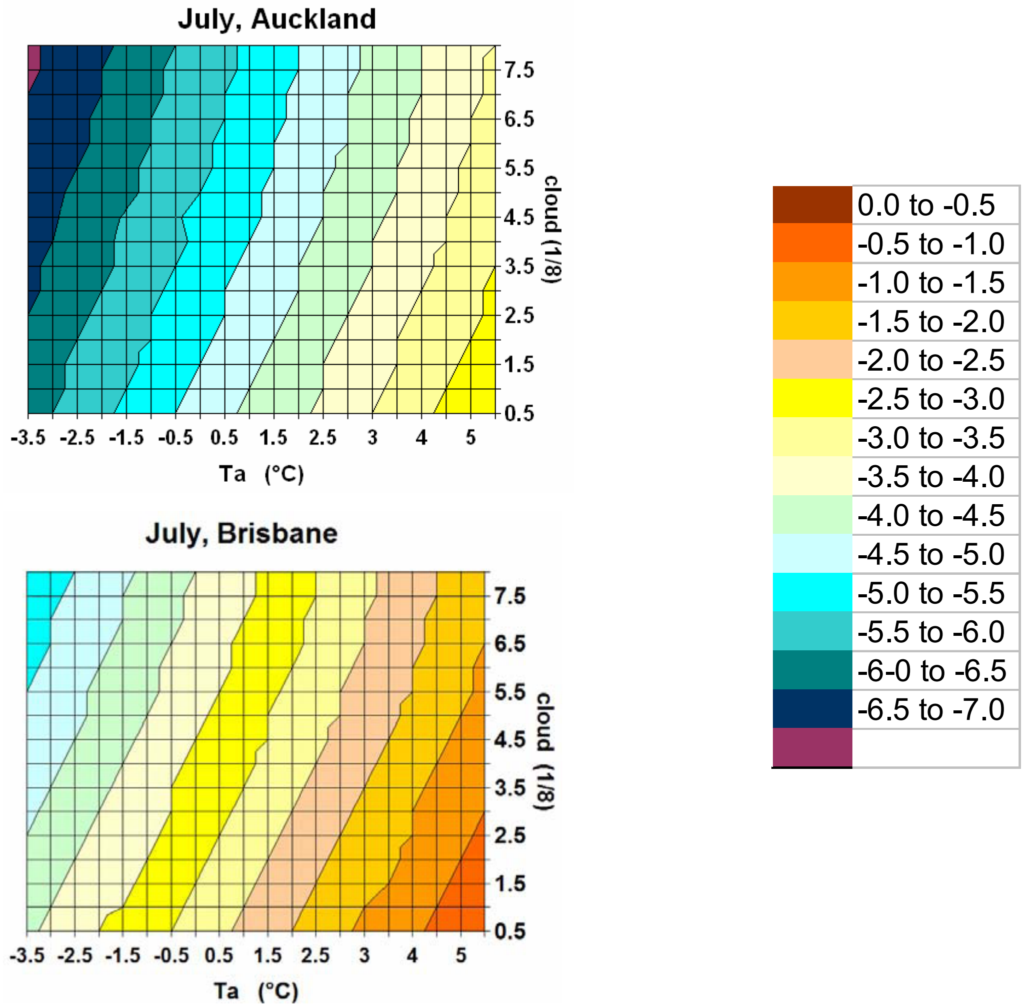

Figure 6: Sensitivity of PMV to changes in air temperature (deg C) and cloud cover. Mean cloud for Auckland is 4.5. Mean cloud for Brisbane is 3.2. PMV is calculated from an integrated human body-atmosphere energy budget holding relative humidity, wind and solar radiation constant at mean July values. Calculations consider conditions at solar noon. Activity and clothing level are 80 W/m² and 0.5 clo, respectively

CONCLUSION

The results can be used to describe the net effects of various IPCC scenarios and show that the changes in thermal conditions will be greater than implied by using air temperature alone, especially during summer. The changes for the winter result in net increases one to two PMV stress levels or about 5°C PET. Overall the results show that the quantification of the thermal impact of changed climate cannot be adequately assessed using temperature alone. The generalised mapped results are useful for identifying areas of high sensitivity to climate change as well as the extent to which potential impact on thermal climate appeal for tourism is likely to be negative or positive.

Given that, for many regions, climate is the main impetus for attracting visitors, it forms an important part of the natural resource base for tourism. Any change in climate will affect not only the resource but also demand for the resource. The capacity of society to respond will depend on tourism's sensitivity to changing climate. This will vary from region to region. An advantage of the response surface method is that it less likely to obscure inherent sensitivities to change that can occur in top down approach. Another is its flexibility. A wide range of new or changed scenarios can be easily handled by plotting them on the response surface. This avoids the need to rerun the transfer function, thus facilitating use by non-climate specialists such as planners and policy makers wanting to reassess impacts. In the top down approach the impression is given that a future climate state will occur at a particular time. This may not be particularly useful since a variety of planning time frames may be required. In contrast, the response surface method has an additional advantage of allowing, through interpolation, both longer and shorter term impacts to be assessed by way of response envelopes.

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