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Projected impacts of temperature and humidity on feedlot cattle in South Africa using temperature humidity index as an indicator of heat stress

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1 SUMMARY

In South Africa, feedlot industry accounts for about 75 % of beef produced and about 80 % of the country's cattle being farmed for beef and the remaining 20 % for dairy. It is hypothesized that increased climate conditions may lead to loss in livestock and its productivity, with unconditioned confined feedlot cattle losses being disastrous. The economic losses owning to cattle death losses may be exceeded several-folds by those associated with reduced cattle performance. In light of this, the aim of this paper was to assess the effects of projected future climate on feedlot cattle in South Africa. This information could be used to inform the process of developing animal production adaptation strategies and policies. Climate stations selected to represent the country's climate were used to extract the downscaled daily climate projections for A2 emissions scenario from various General Circulation Models, similar to those used in the Intergovernmental Panel on Climate Change 4th Assessment Report of 2007. The climate projections were used to compute an index combining temperature and humidity (THI). A classification scheme was used from literature to reclassify THI to show different degree of potential heat stress in cattle. The results from the projections of heat stress suggests that in the intermediate future [2046 - 2065] and distant future [2081 - 2100] feedlot cattle might experience more stress as compared to present climate scenario, mainly along the northern periphery. This information could be used to inform the process of developing animal production adaptation strategies and policies.

2 INTRODUCTION

The rising atmospheric carbon dioxide (CO_2) levels due to the increasing combustion of fossil fuels have potential to impact adversely on the global climate. Results from several studies suggest an increased likelihood of heat wave events in the future (Frank *et al*., 2001). According to IPCC (2007), particularly vulnerable regions include Africa, especially the sub-Saharan region because of current low adaptive capacity. There is growing evidence that climate changes will cause considerable damage to the livestock sector worldwide. According to Seo and Mendelsohn (2006), environmental warming will cause the net revenue from all animals to fall but the impact will be more pronounced in beef cattle. They found that changes in beef cattle net revenue in response to changes in climate were the only ones statistically significant compared to all other livestock net revenues. In South Africa, climate change impact assessments on agricultural sector have focused on main crops, such as maize and wheat. This assessment forms part of a few studies which focus on the

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direct impacts of climate change on animal production in the country. Animal production in South Africa contributes a significant amount of income into the economy compared to other agricultural activities, such as grain crops and horticulture. Additionally, according to Thornton *et al* (2008) livestock are a much better hedge than crops against extreme weather events such as heat and drought. The feedlot industry accounts for about 75 % of beef production, with approximately 80 % of cattle farmed for beef and the remaining 20 % for dairy production of the total number of cattle in South Africa (DoA, 2008). DoA (2008) documented the greatest number of cattle per province to be in Eastern Cape followed by KwaZulu-Natal and then North West in 2003 and 2007. Therefore, information on heat stress in feedlot cattle is of importance to the management of livestock welfare and performance. The aim of this study is to assess the impact of climate change on heat stress in feedlot cattle.

3 Methodology

3.1 Climate Modelling: Climate projections (scenarios) used in this study was the ECHAM5/MPI-OM, MRI-CGCM2.3.2 and GFDL-CM2.0/2 General Circulation Models (GCMS) at A2 emissions scenarios, documented in Intergovernmental Panel on Climate Change 4th Assessment Report of 2007. The downscaled temperature values derived from the GCMs were extracted at station level. The extracted climate projections were for the following time periods: Present [1971 - 1990], Intermediate Future, [2046 - 2065] and more Distant Future [2081 - 2100].

3.2 Thermal Heat Stress Model for Livestock: In this study heat stress on dairy cattle (*Bos taurus*) was assessed using a Thermal Heat Index (Temperature-Humidity Index) equation (Yousef. 1985):

$$THI = T_{db} +036Tdp + 41.2$$

Where, THI = Temperature-Humidity Index

T_{db} = Dry Bulb Temperature (^{o}C)

T_{dp} = Dew point Temperature (^{o}C)

Dew point temperature (T_{dp}) was computed. Daily temperature output generated from the ECHAM5/MPI-OM, MRI-CGCM2.3.2 and GFDL-CM2.0/2 GCMs were used to project Temperature-Humidity Index(THI) values at present (1971–1990), intermediate future (2046–2065) and distant future (2081–2100) climate conditions 21st century for South Africa. The heat stress index classification, adopted from a study by Mader *et al.* (2006),used in this study to indicate likely feedlot cattle stress are:

< 74 THI – Normal
74 to 78 THI – Alert
78 to 84 THI – Danger
> 98 THI – Emergency

3.3 Spatial Representation: Climate station locations, indicated in Figure 1, were used to extract the climate projections from the above mentioned GCMs. The station locations were selected to represent the climate over South Africa. The THIs were computed at each station location derived climate projections and spatial interpolated over the country using Inverse Distance Weighting techniques in ArcView 9.3.1 (ESRI, 2010).

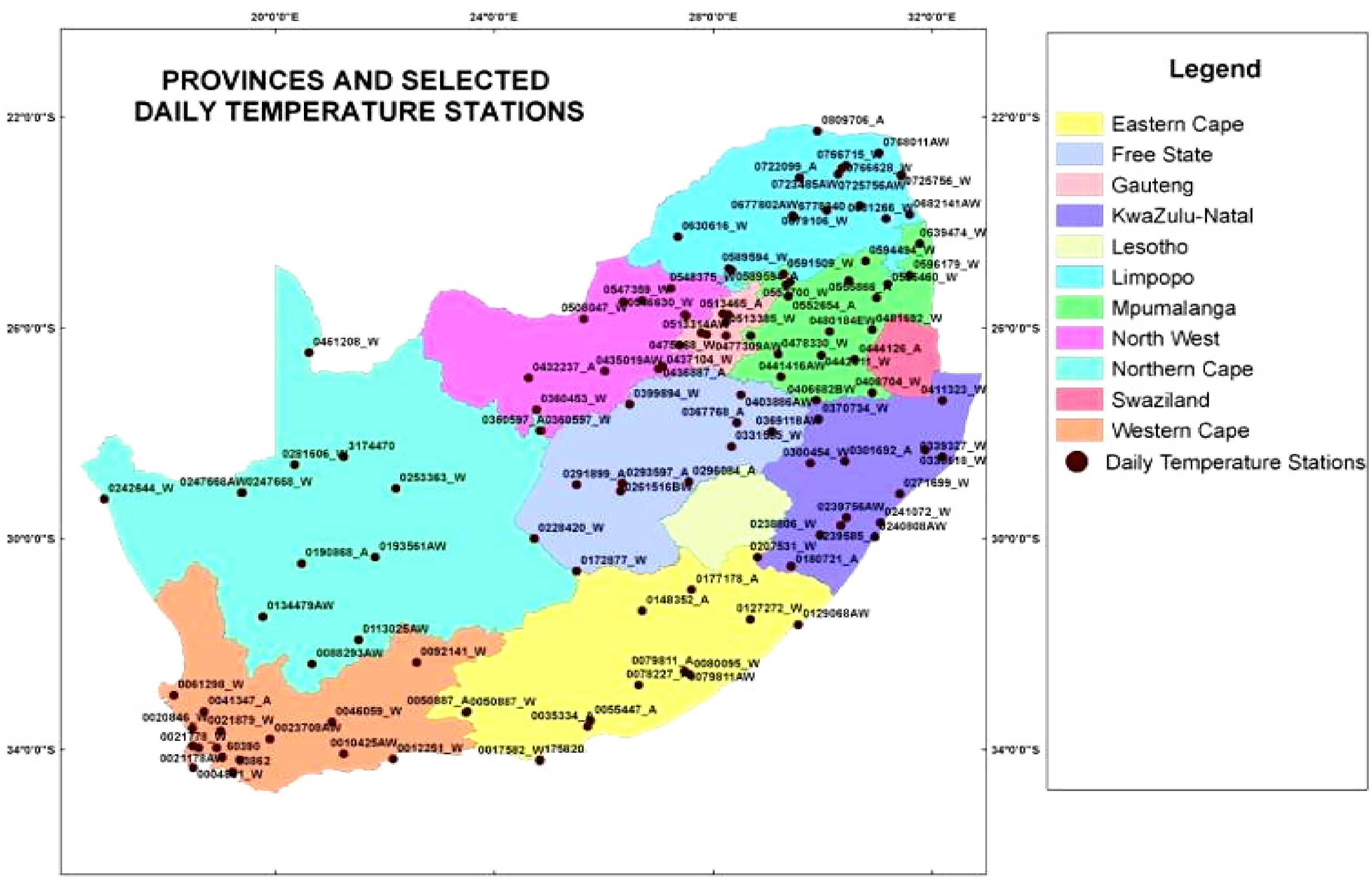

Figure 1: Study area's provinces and climate stations

4 RESULTS AND DISCUSSION

Figure 2 shows mean annual THI derived from ECHAM5/MPI-OM, MRI-CGCM2.3.2 and GFDL-CM2.0/2 GCMs over South Africa. The present climate map of THI under mean climate conditions indicate normal conditions, hence suggests no stress is likely to be experienced by feedlot cattle over all the country. In the intermediate future climate THI above normal (alert) conditions are projected across all GCMs to be in patches along the northern border of the country. The alert stress condition areas are projected in the distant future climate to further increase spatially along the northern border.

Figure 3 indicates maps of maximum annual THI for the ECHAM5/MPI-OM and MRI-CGCM2.3.2 projections over South Africa. For present climate conditions, a similar pattern is shown over all distribution in the THI of alert heat stress index in eastern interior of the country and emergency conditions in parts west and east border. The emergency conditions are projected to further expand towards the central interior of the country in the intermediate to distant future climate conditions. Hence, the projections suggest that production in Eastern Cape, KwaZulu-Natal and North West Provinces with the highest number of cattle compared with other provinces is likely to be affected by emergency heat stress index in future climate conditions.

The performance of animals under intensive feeding systems is highly dependent on voluntary feed intake and feed conversion efficiency. There is evidence that a marked increase in temperature can have a significant detrimental effect on voluntary feed intake (Nienaber *et al*., 1996, Quiniou *et al*., 2000; (Mader and Davis, 2004). Voluntary feed intake decreases curvilinearly with increasing environmental temperature resulting in reduced animal performance (Collin *et al*., 2001). Cattle are particularly vulnerable not only to extreme environmental conditions, but also to rapid changes in these conditions (Mader, 2007). If animals are not managed properly, heat stress in feedlots can cause decreased animal performance and may even lead to death (Crawford, 2007).

It is evident from the projections that heat stress will increase in the intermediate and distant future and this will necessitate measures to be put in place to reduce the adverse effects of increased temperatures. A number of measures (Mader, 2007) have been suggested to mitigate against effects of heat stress and these include: strategic use sprinklers or shade and manipulation of diet energy density. Genetic conservation of indigenous livestock which are more adapted to adverse heat conditions should be considered. Adaptation strategies through both natural and artificial selection should also be considered to enhance adaptation to continuing changes in climate.

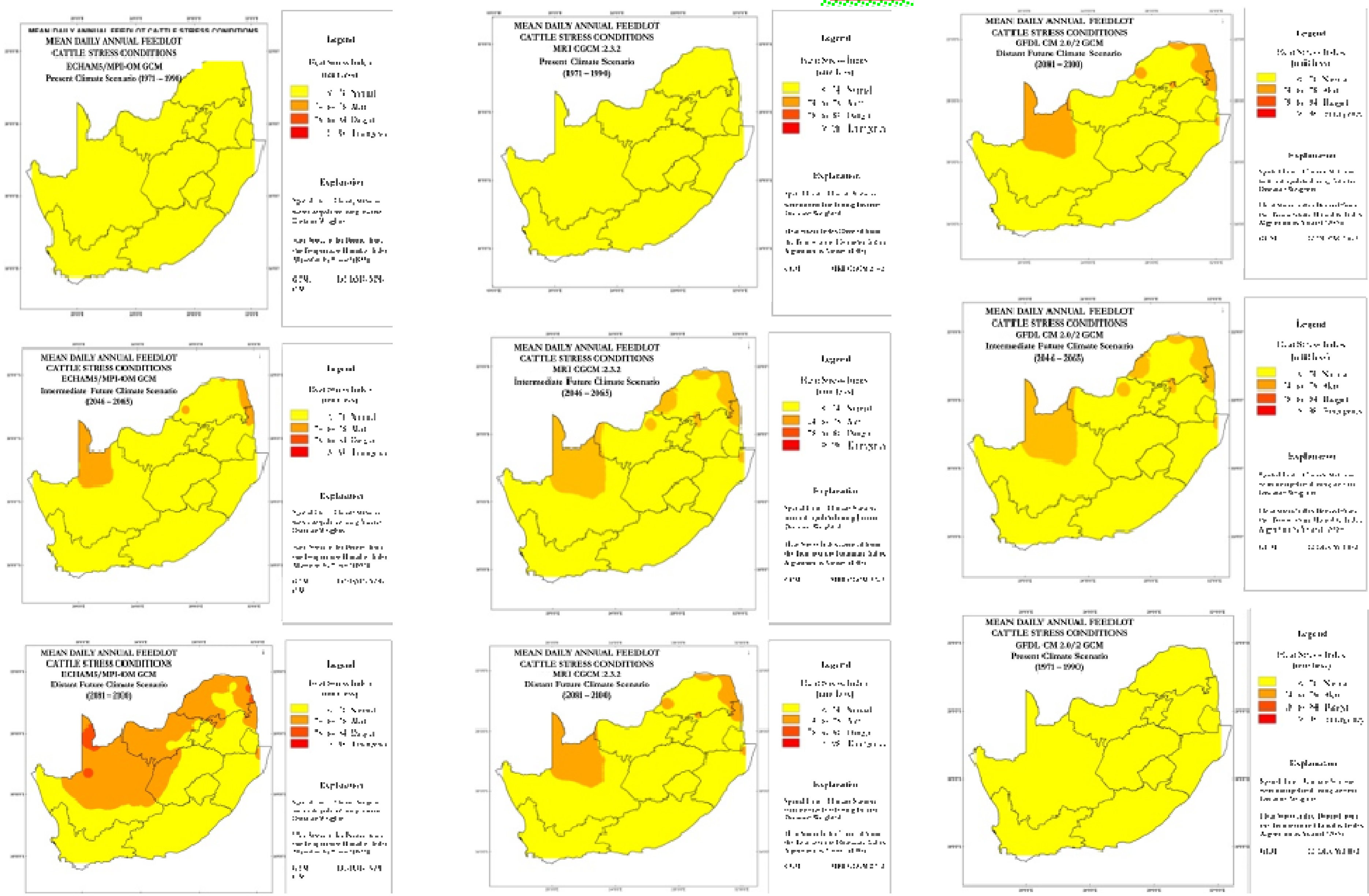

Figure 2: Mean annual thermal heat stress for feedlot cattle for present climate conditions derived from MRI-CGCM2.3.2, ECHAM5/MPI-OM and GFDL-

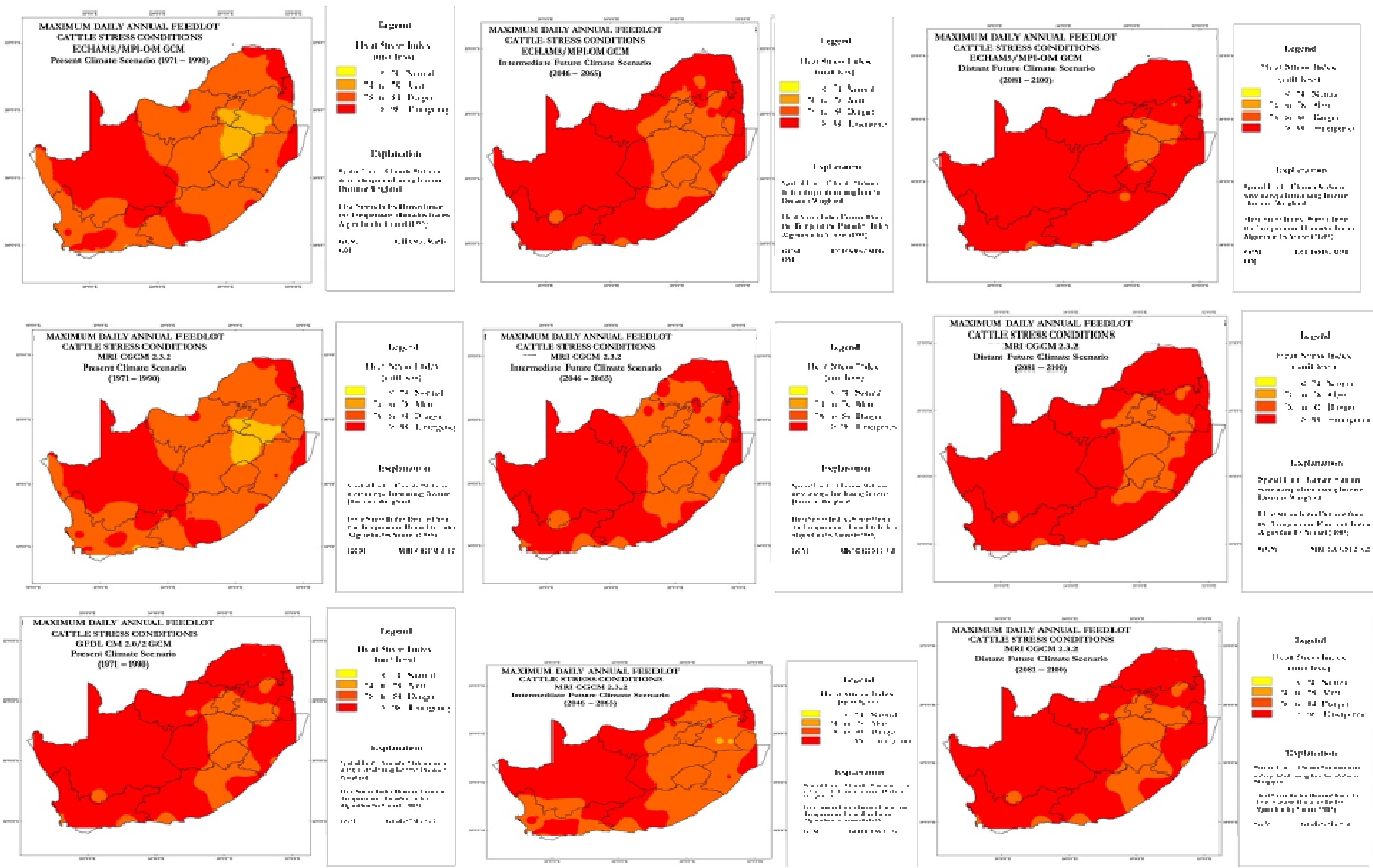

Figure 3: Maximum annual thermal heat stress for feedlot cattle for present climate conditions derived from MRI-CGCM2.3.2, ECHAM5/MPI-OM and GFDL-CM2.0/2.

5 CONCLUSION

Mean annual THI indicates normal conditions mainly along the southern part of the country and alert conditions along the northern parts in projected future climate. For maximum daily annual THI emergency conditions are projected to spread from the western and eastern parts of the country towards the central interior in future climate. The scenario depicted by these projections indicate that plans such as reducing overcrowding, maximizing shade, using of sprinklers for cooling, improving ventilation, construction of new building design and installation of thermo controlled air conditioning should be put in place to mitigate the likely incidence of heat stress in the intermediate and distant future.

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7 REFERENCES

Collin A, van Milgent, J. and Le Dividich, J. :2001. Modelling the effect of high, constant temperature on food intake in young growing pigs. Animal Science 72: 519 – 527.

Crawford G: 2007. Managing heat stress in feedlot cattle. University of Minnesota Extension Bulletin. www.extension.umn.edu/beef.

DoA: 2008. Department of Agriculture. Trends in the Agricultural Sector 2007. National Department of Agriculture, Pretoria, RSA.

ESRI Help Manual, Geostatistical Analyst: How Inverse Distance Weighted (IDW) interpolation works, software help files.

Frank KL, Mader, TL, Harrington, JA, Hahn GL. and MS Davis:2001. Climate change effects of livestock production in the great plains. In Livestock Environment IV, Proceedings of the Sixth International Livestock Environment Symposium. ASAE Publication 701P0201. 351-358.

IPCC (Intergovernmental Panel on Climate Change): 2007. Impacts, Adaptation and Vulnerability. Summary for policy makers. Online at http://www.ipcc.cg/SPM13apr07.pdf [Retrieved November, 12, 2010].

Mader TL, Davis MS. and Brown-Brandl T: 2006. Environmental factors influencing heat stress in feedlot cattle. Journal Animal Science, 84:712-719.

Mader TL. and Davis MS :2004. Effect of management strategies on reducing heat stress of feedlot cattle: feed and water intake. J. Anim Sci. 82: 3077-3087.

Mader, T.L., Davis, M.S., Gaughan, J.B. 2007: Effect of sprinkling on feedlot microclimate and cattle behaviour, International Journal of Biometeorology 51: 541-551.

Nienaber J A, Hahn GL, McDonald TP. and Korthals RL: 1996. Feeding patterns and swine performance in hot environment. Transactions of the American Society of Agricultural Engineers 39: 195-202.

Quiniou N, Dubois S. and Noblet J: 2000. Voluntary feed intake and feeding behaviour of group-housed growing pigs are affected by ambient temperature and body weight. Livestock Production Science 63: 245-253.

Seo S. and Mendelsohn R: 2006. The impact of climate change on livestock management in Africa: A structural Ricardian analysis. CEEPA Discussion Paper No. 23, Centre for

Environmental Economics and Policy in Africa, University of Pretoria.

Thornton PK, van de Steeg J, Notenbaert A. and Herrero M: 2008. The livestock-climate-poverty nexus: A discussion paper on ILRI research in relation to climate change. Discussion Paper No. 11. ILRI, PO Box 30709, Nairobi 00100, Kenya. Pp 76.

Yousef MK: 1985. Stress Physiology in Livestock. CRC Press, Boca.