MEAT & LIVESTOCK AUSTRALIA

On farm

Operation of a Weather Forecasting Service for Several Locations for Excessive Heat Load Events Over Summer 2002/2003 For The Australian Feedlot Industry

FLOT.320

Final Report prepared for MLA by:

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FEEDLOTS

Contents:

TABLES:

FIGURES:

Final report - FLOT 313 – Operation of a weather forecasting service for several sites for excessive heat load events over Summer 2002/2003 for the Australian feedlot industry.

Abstract

To assist with warning feedlot operators of impending adverse weather conditions that could lead to excessive heat loads (and potential mortality) for feedlot cattle a weather forecasting system was developed. This forecasting system covered several locations near to cattle stations where Bureau of Meteorology automatic weather stations (AWS) are available.

The forecasts were made over a four month period in summer at 14 sites throughout Queensland, New South Wales and South Australia. Forecasts were made on meteorological parameters (wind speed, wind direction, temperature) necessary to calculate a heat load index.

Forecasts for all 14 sites were posted daily onto a website (www.katestone.com.au/mla) for easy access to all feedlot operators.

The forecasting system found a relatively high level of agreement between the forecast heat load index (HLI) and the observations out to 3 days ahead, with reduced strength in the relationship out to 6 days ahead.

Executive Summary

E1 Introduction

Last year Katestone Environmental developed a forecasting system for MLA to predict cattle heat stress out to 6 days ahead for 4 sites in Queensland and New South Wales (FLOT.313). This project aimed to assist cattle feedlot operators with managing upcoming potential cattle heat stress events. The study obtained data daily from on-site meteorological stations and the nearest Bureau of Meteorology automatic weather station (AWS) and conducted forecasts for all data. A comparison was made between the on-site forecasts and the AWS forecasts for cattle heat stress indicators. It was found that reasonable forecasts could be made using the closest AWS. This is significant as the majority of feedlot sites do not have on-site meteorological stations.

The forecasting study was expanded over the summer 2002/2003 period to cover more AWS sites that represent feedlot locations, specifically feedlots where heat stress in cattle is important. This study included the following 14 sites:

- Queensland – Amberley, Emerald, Miles, Oakey, Roma and Warwick;
- New South Wales – Albury, Armidale, Griffith, Hay, Moree, Tamworth and Yanco; and
- South Australia – Clare.

The forecasting system was designed to produce daily forecasts of the heat load index (HLI) recommended to MLA as having a more significant relationship to cattle heat stress than the previously used temperature-humidity index (THI).

E2 Key issues

The key issues in producing a viable feedlot weather forecasting system include:

(a) Identification of primary and derived meteorological parameters that indicate excessive heat load in cattle and cattle storage mechanisms.

(b) Selection of methodology for predicting primary and derived parameters at AWS locations over a suitable time horizon.

(c) Development of a forecasting software system for predicting feedlot conditions.

(d) Having the forecasting system available to all feedlot operators on a daily basis.

At the outset, the following constraints were identified:

- Forecasting using available Bureau of Meteorology AWS sites is limiting for a majority of the cattle stations. Most AWS's are situated near significant populations or industrial regions and as such only 14 sites were identified close to feedlot stations.
- The Bureau of Meteorology's model data (LAPS and GASP), necessary to be able to conduct a forecast, is only stored by the Bureau of Meteorology when requested. Therefore the models created for most sites were only based on a small amount of historical LAPS/GASP data. This can have a significant impact on the model performance.

- Initial concerns were raised as to how all feedlot operators could access the daily forecasts. It was decided that the best option was to have the information for each site uploaded to a webpage everyday and have the feedlot operators check the forecasts when necessary. The feedlot operators were more likely to have internet access rather than email or facsimile access.

E3 Selected methodology

The following methodology was adopted following discussions between MLA and Katestone Environmental on the most viable options:

- Utilise fully the information from the nearest AWS run by the BoM.
- Calculate the key parameters at a fine time resolution out to 6 days ahead.
- Forecasts uploaded daily on a website, including warnings on impending excessive heat load days.
- Software system to include automatic model retraining as more data becomes available.

The forecasts were based on the models generated during the previous study conducted by Katestone Environmental for MLA.

E4 Forecast performance

The forecast skill for each site and different forecast horizons was investigated for the daily maximum HLI, the number of hours per day that the HLI was predicted above 84 and the number of hours over a nighttime period where HLI was below 74.

The forecast HLI were found to have a high correlation with the HLI calculated from observations for most sites.

E5 Recommendations

If a future forecasting system is to include more sites, we would recommend ample warning of the sites of interest so we can request that the Bureau of Meteorology store the LAPS/GASP information for these regions. Having a larger database of information from which to conduct the forecasts would improve model performance in the initial couple of months of forecasts.

1. INTRODUCTION

Last year Katestone Environmental undertook a feasibility forecasting study for MLA (FLOT.313) for predicting excessive heat load in cattle. This forecasting system was for 4 sites where on-site meteorological stations were available at the cattle feedlots and was based on the calculation of a thermal-heat stress index (THI) derived from available forecast meteorological variables. Forecasts were conducted for on-site meteorological stations and for the nearest Bureau of Meteorology AWS. These forecasts were then compared to determine the accuracy of the forecasts. It was confirmed that suitable forecasts could be generated from the AWS stations for the feedlot sites. This forecasting system was expanded to include several sites around Australia for the 2002 to 2003 Summer period.

Recent studies on cattle heat stress (Gaughan et al (2002)) determined that the heat load index (HLI) was a better indicator of cattle heat stress than the originally used THI. These studies also found that, the number of hours the HLI were above a threshold (84) was also a good indicator for cattle heat stress. The studies also found that if the HLI was below 74 for a number of hours than the cattle would be able to recover somewhat from the heat stress. Each of these variables were therefore supplied in the forecasting system.

The study included the following sites:

- Queensland – Amberley, Emerald, Miles, Oakey, Roma and Warwick;
- New South Wales – Albury, Armidale, Griffith, Hay, Moree, Tamworth and Yanco; and
- South Australia – Clare.

Forecasts were to be conducted every day over the summer period.

2. STUDY DEFINITION AND OBJECTIVES

The MLA requested a forecasting system for feedlot sites around Australia that have suffered cattle heat stress events, to assist with identifying potential cattle heat stress events. The objectives of the study were to:

- Provide forecasts out to 6 days ahead for predicted maximum heat load, the frequency of hours above and below a threshold and forecast of rainfall. These forecasts were necessary for the summer period of 2002/2003.
- Allow the forecasts to be accessible on a daily basis to each of the feedlot operators.
- Retrain the models regularly to improve the forecasts.
- Examine the accuracy of the forecasts.

3. SHORT-TERM FORECASTING OF EXCESSIVE HEAT LOAD

3.1 Key forecasting parameters

Short-term forecasting is relatively well established for dry bulb temperature, dewpoint temperature or relative humidity and wind speed. These are the essential parameters from which many heat comfort indices can be derived. It is also highly desirable to include rainfall and solar radiation parameters in any feedlot forecasting scheme but there is currently less skill in producing such forecasts.

Regional rainfall forecasts are available from the Bureau of Meteorology which have been included in the daily forecasts. Solar radiation profiles can be calculated for each day based on site location and typical diurnal radiation profiles. The typical profiles do not account for cloud cover and therefore can overestimate solar radiation for cloudy days. The dependence of the HLI used in this assessment on radiation is relatively minor and as such the possible overestimation was not considered significant.

Each of these variables were combined to calculate the HLI for each site on a half-hourly basis.

3.2 Forecasting methodologies for fine spatial resolution

Most available forecast models give a regional forecast for areas up to usually 25 x 25 km. The forecasting system adopted for this project gives a forecast for the location of interest. This can be more beneficial in incorporating local influences on the meteorology such as terrain.

The forecast models for each site for the meteorological variables were produced using the same methodology as our previous forecasting as detailed in our report titled “Flot. 313 – development and trial operation of a weather forecasting service for excessive heat load events for the Australian feedlot industry”.

The only alteration to these models was that wind speed and wind direction are modelled and forecast for all sites except Griffith and Hay. For these sites it was necessary to model wind speed alone (as a scalar quantity) due to the large spatial separation between the physical surface site, and the upper-level input forecast region.

3.3 Bureau of Meteorology services

LAPS and GASP data were provided by the Bureau of Meteorology for each of the forecasting sites along with the AWS data on a daily basis. Details on this information can be found in our previous forecasting report (Katestone Scientific, 2002). The LAPS and GASP data were downloaded on a daily basis from a website specially arranged by the Bureau of Meteorology, along with the AWS data.

3.4 Key heat load indices

The forecast meteorological variables along with the solar radiation daily profiles were combined into a formula to calculate the heat load index. This formula, along with the equations necessary to calculate the variables, are defined below. Further details on these equations and assumptions made are listed in our recent report to the MLA (FLOT.321) titled “Development of statistics and a website for the display of the risk of excessive heat load events for several Australian sites for the Australian feedlot industry”.

3.4.1 Relative Humidity

The relative humidity used in the calculation of HLI was calculated from the temperature (Temp in ºC) and dew point temperature (DewPt in ºC) using the following equation:

$$\mathrm{Re}lHum = 100\left(\frac{1.8DewPt - 0.18Temp + 201.8}{1.62Temp + 201.8}\right)^8$$

Equation 1. Relative humidity calculated from temperature and dew point

3.4.2 Solar Radiation

Solar radiation (SolRad in w/m^2) is not recorded at any of the Bureau of Meteorology AWS sites. The following equations were used for the calculation of solar radiation, for each hour for each day based on the location of the sun throughout the day and year (Oke, 1987). The equation assumes no reduction in radiation due to cloud cover and therefore is conservative for this application:

$$\begin{aligned} localHr &= \frac{15\pi}{180}(12 - t) \\ declination &= \frac{-23.5\pi}{180} Cos\left(\frac{2\pi\,(day + 10)}{365}\right) \\ elevation &= Sin^{-1}\big(Sin(lat)Sin(declination) + Cos(lat)Cos(declination)Cos(localHr)\big) \\ SolRad &= 1050Sin(elevation) - 65 \end{aligned}$$

Equation 2. Solar radiation equation

where:
t is the time of the day expressed in hours
day is the Julian day of the year
lat is the latitude of the site.

3.4.3 Heat Load Index

To calculate the HLI for each hour of recorded data, the following equations were used:

$$\begin{aligned} BGT &= 1.33Temp - 2.65\sqrt{Temp} + 3.21\log(SolRad + 1) + 3.5 \\ HLI &= 1.4BGT + 0.09\,\mathrm{Re}lHum - 0.57WSpeed + 32.5 \end{aligned}$$

Equation 3. Heat Load Index equations

where
WSpeed is measured in km/hr.
Temp is measured in °C.
RelHum is measured in %.

SolRad is measured in W/m²
BGT is known as the black globe temperature (ºC).

The cattle heat stress thresholds used in the project were provided by the MLA and are as follows:

- Heat Load Index of 74 to 79
  ALERT phase - mild heat load effects especially on vulnerable cattle.
  Time to think about and implement heat load reduction strategies. Death not likely.

- Heat Load Index of 79 to 84
  DANGER phase - strong to severe heat load effects on cattle. Death unlikely but possible.

- Heat Load Index of 84 to 92
  EMERGENCY phase - severe to extreme heat load effects on cattle. Death possible in vulnerable cattle.

- Heat Load index over 92
  CRISIS phase – extreme heat load (EHL). Death possible EVEN with heat load reduction strategies.

3.5 Service delivery mechanisms

For this project, forecasts were automatically updated every morning and uploaded on the website www.katestone.com.au/mla. These forecasts were checked every day by Katestone Environmental staff. These forecasts were loaded to this website to ensure all cattle feedlot operators would have access to the latest heat load forecasts.

3.6 Overall methodology

The prototype system was based on the models developed in our previous forecasting system developed for the MLA. It consists of the following steps:

(a) Obtain upper-level forecast data from numerical weather prediction models via a special web-site provided by the BoM.

(b) Collect concurrent information from an automatic weather station close to the site of interest.

(c) Once a sufficient training set of information is collected, use proprietary Katestone software to develop statistical models that relate the surface measurement to a subset of the upper-level variables.

(d) Use these models and the most recent data to provide the necessary forecasts.

This MLA project was challenging as limited information was available for the forecasts as the Bureau of Meteorology only store LAPS information if requested. This meant that the accuracy of the forecasts was likely to be poor initially.

The forecasts for daily maximum heat load index, number of hours with HLI over 84 and number of hours with HLI to be less than 74 out to 6 days ahead were compared with the calculated HLI based on measurements. The Pearson Correlation Coefficient, index of agreement and the root mean square error were calculated for each of these variables for each site to give an indication of the accuracy of the forecast.

4. ACCURACY OF FORECASTING SYSTEM

4.1 Statistical measures for forecast accuracy

The Pearson Correlation Coefficient is a measure of the strength of the linear relationship between the predicted and observed measurements (defined in Equation 4). The closer this value is to 1 the stronger the relationship. The index of agreement (IOA) is defined in Equation 6 and gives an index from 0-1 (1 being a strong agreement index). The root mean square error (RMSE) defined in Equation 5 is an indication of the absolute error. The smaller the RMSE (i.e. the closer the value is to zero) the better the forecast.

$$r = \frac{N\left(\sum_{i=1}^{N} O_i P_i\right) - \left(\sum_{i=1}^{N} O_i\right)\left(\sum_{i=1}^{N} P_i\right)}{\sqrt{\left[N\left(\sum_{i=1}^{N} O^2_{i\ i}\right) - \left(\sum_{i=1}^{N} O_i\right)^2\right]\left[N\left(\sum_{i=1}^{N} P_1^2\right) - \left(\sum_{i=1}^{N} P_i\right)^2\right]}}$$

Equation 4. Pearson Correlation Coefficient

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(P_i - O_i\right)^2}$$

Equation 5. Root Mean Square Error

$$IOA = 1 - \frac{\sum_{i=1}^{N}\left(P_i - O_i\right)^2}{\sum_{i=1}^{N}\left(\left|P_i - O_{mean}\right| + \left|O_i - O_{mean}\right|\right)^2}$$

Equation 6. Index of Agreement

4.2 Forecasting results

As the number of hours per day that the HLI was predicted over 84 may be zero for several days at some sites, the Pearson Correlation Coefficient and Index of Agreement are not a good measure of model performance. For this case the RMSE should be viewed instead or inspection of the contingency table (Table 4).

For the number of hours where the HLI was predicted to be less than 74, the times were taken from midday to midday to give the number of hours overnight that were below 74. Cattle recovery is likely when the HLI is below 74, which is most likely to occur at night. Therefore, only a 5 day ahead forecast is available.

A summary of the statistics for forecasts (1 day and 3 days ahead) of the number of hours where the heat load index was less than 74 is shown in Table 1. The statistics for 1 day, 3 days and 6 days ahead forecasts for the number of hours the HLI was over 84 and the maximum daily HLI can be seen in Table 2 and Table 3 respectively.

Table 1. Statistics for forecast accuracy of the number of hours for the HLI <74 for 1 day and 3 days ahead.

Site	1 day ahead			3 days ahead		
	Pearson	IOA	RMSE	Pearson	IOA	RMSE
Albury	0.83	0.86	2.77	0.71	0.80	3.52
Amberley	0.56	0.66	3.15	0.56	0.62	3.47
Armidale	0.74	0.81	2.58	0.67	0.76	3.06
Clare	0.90	0.93	2.38	0.79	0.84	3.64
Emerald	0.72	0.83	1.97	0.30	0.54	2.94
Griffith	0.83	0.91	2.37	0.70	0.83	3.26
Hay	0.81	0.90	2.80	0.61	0.78	3.88
Miles	0.62	0.73	2.20	0.37	0.63	2.31
Moree	0.59	0.67	2.87	0.41	0.53	3.97
Oakey	0.83	0.91	2.16	0.71	0.82	3.06
Roma	0.65	0.72	2.87	0.47	0.61	3.46
Tamworth	0.84	0.90	2.37	0.56	0.73	3.72
Warwick	0.49	0.62	4.84	0.41	0.61	5.13
Yanco	0.82	0.88	2.76	0.77	0.83	3.44

For 1 day ahead forecasts the site for which the predicted number of hours with HLI less than 74 was most accurate was Clare and the least accurate was Warwick. Ten of the 14 sites had a relatively high Pearson Correlation Coefficient (0.65 or above) and index of agreement (0.72 or above) for 1 day ahead. The RMSE was smallest for Emerald, showing Emerald to have the least amount of error in the forecasts to actuals.

Table 2. Statistics for forecast accuracy of the number of hours for the HLI >84 for 1 day, 3 days and 6 days ahead.

Site	1 day ahead			3 days ahead			6 days ahead		
	Pearson	IOA	RMSE	Pearson	IOA	RMSE	Pearson	IOA	RMSE
Albury	0.69	0.73	3.61	0.59	0.64	4.29	0.42	0.59	4.25
Amberley	0.75	0.79	2.08	0.68	0.68	2.81	0.32	0.49	3.61
Armidale	0.11	0.14	0.95	0.33	0.31	0.89	0.00	0.07	0.38
Clare	0.63	0.71	3.12	0.64	0.70	3.32	0.40	0.54	3.97
Emerald	0.72	0.82	2.68	0.40	0.66	3.63	0.32	0.60	4.17
Griffith	0.71	0.83	2.51	0.45	0.68	3.28	0.31	0.60	3.30
Hay	0.71	0.84	2.68	0.52	0.74	3.22	0.36	0.65	3.48
Miles	0.77	0.85	2.66	0.57	0.77	3.27	0.30	0.61	4.22
Moree	0.73	0.77	3.20	0.57	0.72	3.50	0.43	0.64	3.81
Oakey	0.80	0.88	1.43	0.50	0.66	2.55	0.32	0.54	2.84
Roma	0.67	0.77	3.14	0.50	0.69	3.75	0.44	0.62	4.28
Tamworth	0.77	0.85	2.29	0.79	0.85	2.56	0.65	0.79	2.71
Warwick	0.56	0.70	1.67	0.54	0.72	1.76	0.41	0.62	1.87
Yanco	0.76	0.79	2.81	0.50	0.62	3.68	0.27	0.51	3.82

The forecast number of hours with HLI over 84 (Table 2) show Armidale to have a low Pearson Correlation and IOA although the RMSE is the best out of all of the sites. The relationship between the predicted and observed measurements is actually in good agreement for Armidale due to the infrequent number of times that the HLI was over 84 (which the Pearson Correlation Coefficient and IOA variables do not account for). A time-series of the predicted 1 day ahead forecast and measured for Armidale show the small amount of error with the models (Figure 1). For all other sites the Pearson Correlation Coefficient and IOA showed a strong relationship between the observed and predicted measurements.

Table 3. Comparison statistics for maximum daily HLI for predicted and observed measurements for 1 day, 3 days and 6 days ahead.

Site	1 day ahead			3 days ahead			6 days ahead		
	Pearson	IOA	RMSE	Pearson	IOA	RMSE	Pearson	IOA	RMSE
Albury	0.81	0.88	4.96	0.72	0.83	5.85	0.61	0.76	6.60
Amberley	0.77	0.86	3.24	0.66	0.79	3.80	0.46	0.67	5.11
Armidale	0.81	0.88	1.85	0.62	0.79	5.85	0.47	0.69	6.44
Clare	0.91	0.93	4.84	0.81	0.86	6.60	0.65	0.79	8.22
Emerald	0.77	0.87	3.36	0.52	0.71	4.99	0.33	0.58	6.68
Griffith	0.89	0.93	3.91	0.72	0.83	6.06	0.54	0.71	7.83
Hay	0.85	0.92	5.07	0.70	0.84	6.80	0.53	0.72	8.44
Miles	0.82	0.88	3.16	0.61	0.77	4.72	0.44	0.65	5.98
Moree	0.65	0.76	5.21	0.57	0.74	5.86	0.45	0.67	6.23
Oakey	0.90	0.94	3.43	0.75	0.84	5.34	0.48	0.66	7.54
Roma	0.76	0.84	4.38	0.59	0.75	5.64	0.41	0.62	7.15
Tamworth	0.84	0.91	3.65	0.69	0.83	5.10	0.47	0.70	6.46
Warwick	0.67	0.59	10.88	0.65	0.58	11.12	0.44	0.49	11.77
Yanco	0.89	0.93	4.31	0.78	0.87	6.01	0.56	0.73	7.83

The relationship between the maximum HLI predicted and observed in a given day (Table 3) is very high for almost all sites (over 0.76) for 1 day ahead except for Moree and Warwick. A time-series of observed and predicted measurements at Moree showed the HLI to be overpredicted on occasions but overall the measurements corresponded well (Figure 2). Visual analysis of the time-series of the Warwick forecasts and observations show the forecasts occasionally underpredicting within the first couple of months but showed better agreement throughout March (Figure 3). This is most likely a result of the insufficient data available initially to train the forecast models.

As the forecasting accuracy between the correlations and RMSE is difficult to interpret at times a contingency table comparing the forecasts was conducted for each classification index as shown in Table 4.

Table 4: Contingency table for number of observations within specified thresholds for predicted and measured for half-hourly average daily maximum HLI.

Site	Observed	Predicted 1 day ahead					Predicted 3 days ahead				
		<74	74-79	79-84	84-92	92+	<74	74-79	79-84	84-92	92+
ALB	<74	5	3	1	0	0	6	1	3	0	0
	74-79	0	7	7	3	1	1	3	7	10	1
	79-84	0	2	10	14	0	0	4	13	10	0
	84-92	0	0	6	27	5	1	2	7	19	11
	92+	0	0	0	0	8	0	0	0	1	6
AMB	<74	0	0	2	0	0	0	1	1	0	0
	74-79	0	8	11	1	0	0	6	14	1	0
	79-84	0	6	23	11	0	0	10	19	11	0
	84-92	0	1	4	25	5	0	3	7	20	4
	92+	0	0	0	0	1	0	0	0	1	0
ARM	<74	43	16	6	0	0	47	15	3	0	0
	74-79	2	11	6	0	0	9	6	6	2	0
	79-84	0	2	6	5	0	3	3	3	3	0
	84-92	0	1	2	2	0	0	0	1	4	0
	92+	0	0	0	0	0	0	0	0	0	0
CLA	<74	26	10	1	0	0	21	8	6	2	0
	74-79	1	9	6	2	1	3	3	8	5	1
	79-84	0	1	8	7	1	0	2	7	10	0
	84-92	0	0	3	12	5	0	0	3	9	7
	92+	0	0	0	1	5	0	0	0	1	4
EME	<74	0	1	0	0	0	0	0	1	0	0
	74-79	0	0	7	1	0	0	0	7	1	0
	79-84	0	4	10	6	0	0	5	7	6	0
	84-92	0	0	8	47	6	1	5	18	35	3
	92+	0	0	0	3	6	0	0	0	5	4
GRI	<74	8	3	0	0	1	9	2	0	0	1
	74-79	4	9	4	1	0	5	8	6	1	0
	79-84	1	7	14	1	0	4	10	4	5	0
	84-92	0	1	10	15	1	0	3	12	11	1
	92+	0	0	0	7	6	0	0	2	7	2
HAY	<74	14	6	1	0	0	12	5	2	2	0
	74-79	3	4	6	2	1	4	5	5	3	1
	79-84	1	3	10	6	0	1	11	9	2	0
	84-92	0	1	7	16	2	0	4	9	9	4
	92+	0	0	0	4	8	0	0	1	5	4
MIL	<74	0	0	1	0	0	0	1	0	0	0
	74-79	0	1	6	0	0	0	2	4	1	0
	79-84	0	1	16	13	0	0	9	11	11	0
	84-92	0	0	5	35	7	0	8	11	24	4
	92+	0	0	0	1	6	0	0	0	0	7
MOR	<74	0	0	2	1	0	1	0	1	1	0
	74-79	0	1	3	4	0	0	0	4	6	0
	79-84	0	3	13	10	1	1	4	12	9	0
	84-92	0	1	6	31	13	0	4	14	21	12
	92+	0	0	0	2	8	0	0	0	1	8
OAK	<74	22	2	1	0	0	11	11	2	1	0
	74-79	4	9	5	2	0	1	5	11	4	0
	79-84	2	7	16	7	1	2	3	10	15	0
	84-92	0	0	3	10	4	0	0	4	8	4

Site	Observed	Predicted 1 day ahead					Predicted 3 days ahead				
		<74	74-79	79-84	84-92	92+	<74	74-79	79-84	84-92	92+
	92+	0	0	0	1	2	0	0	0	2	1
ROM	<74	1	1	0	0	0	1	1	0	0	0
	74-79	0	3	4	0	0	0	2	3	2	0
	79-84	0	3	16	12	0	0	10	13	11	0
	84-92	0	0	7	33	10	0	5	15	19	10
	92+	0	0	0	0	6	0	0	0	0	6
TAM	<74	3	5	0	0	0	2	4	1	1	0
	74-79	2	9	5	2	0	3	5	8	2	0
	79-84	0	10	12	10	0	2	8	14	9	0
	84-92	0	0	6	20	1	0	3	8	9	5
	92+	0	0	0	2	6	0	0	0	2	6
WAR	<74	12	1	0	0	0	12	1	0	0	0
	74-79	19	4	3	0	0	18	5	4	0	0
	79-84	15	7	10	3	0	15	5	10	5	0
	84-92	3	3	4	9	2	3	2	3	10	1
	92+	0	0	0	1	0	0	0	0	1	0
YAN	<74	10	5	2	0	0	10	4	2	1	0
	74-79	3	8	5	2	0	1	7	7	5	1
	79-84	0	2	10	9	0	0	3	8	8	1
	84-92	0	0	2	23	5	0	0	5	15	9
	92+	0	0	0	1	6	0	0	1	0	4

The contingency table shows that at most sites the forecasts overpredict between the HLI range 74 to 84 but predict well for indices over 84 and less than 74. The 3-day ahead forecasts have a higher tendency to overpredict than the 1-day ahead forecasts. Griffith, Hay and Warwick were the only sites showing an underprediction which was mostly evident 3-days ahead. Almost all events greater than 92 were predicted, however at most sites (Griffith, Hay and Warwick the exceptions) almost twice the number of events greater than 92 were predicted than actually occurred. The forecast differences for Griffith and Hay may be due to the large spatial separation between the forecast site and the upper-level input forecast for the region.

Overall, due to the limited amount of data available to conduct the forecasts, the models produced very good results when compared to the calculated HLI based on observed measurements over a majority of the sites. These models could be improved as more data becomes available. This was evident from the visual inspections of the time-series between the observed and forecast measurements.

5. SERVICE DELIVERY AND UTILITY

Forecasts of the following parameters were posted onto the website www.katestone.com.au/mla on a daily basis and checked by the Katestone Environmental staff:

- Daily half-hourly average maximum predicted heat load index;
- Daily half-hourly average minimum heat load index;
- Total number of hours per day with HLI predicted to be over 84;
- Total number of hours with HLI predicted to be less than 74; and
- Total amount of rainfall from the Bureau of Meteorology regional forecast out to 6 days ahead.

These forecasts were uploaded to the website on a daily basis for access by all feedlot operators. The previous week's forecasts were also kept available if the feedlot operators needed to check an earlier forecast.

The utility of the forecasts is very flexible. As the models have been made, any future need for forecasting at these same locations will require a basic retraining of the models with more recent data. To arrange for new sites to be included would require correspondences with the Bureau of Meteorology to store the data. Katestone Environmental would then need to develop new models based on the existing model methodology. If the excess heat load formulas change then the models would only require a minor adjustment to the output equations.

6. RECOMMENDATIONS FOR FUTURE WORK

It is recommended that earlier advice is necessary on the need for any new forecasting sites to ensure an ample amount of concurrent upper-level and AWS data are available to train the models. This will improve the initial forecast accuracy of the models.

No allowance has currently been made for the difference between feedlot conditions and conditions at the AWS site, or for factors such as shading. These factors could readily be included when results of other studies are available.

7. CONCLUSIONS

A forecasting system developed for the summer 2002/2003 period for MLA has proved to provide relatively accurate forecasts out to 3 days ahead for cattle heat stress at a majority of the locations. The forecasts out to 6 days ahead are less accurate but are still very useful in determining whether the excessive heat load conditions are expected to continue.

The models should be more accurate in the future as more data becomes available for the models to be retrained with.

REFERENCES

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Katestone Scientific (2002), "FLOT. 313 – Development and trial operation of a weather forecasting service for excessive heat load events for the Australian feedlot industry."

Oke TR (1987), "Boundary Layer Climates", Second Edition, Routledge.

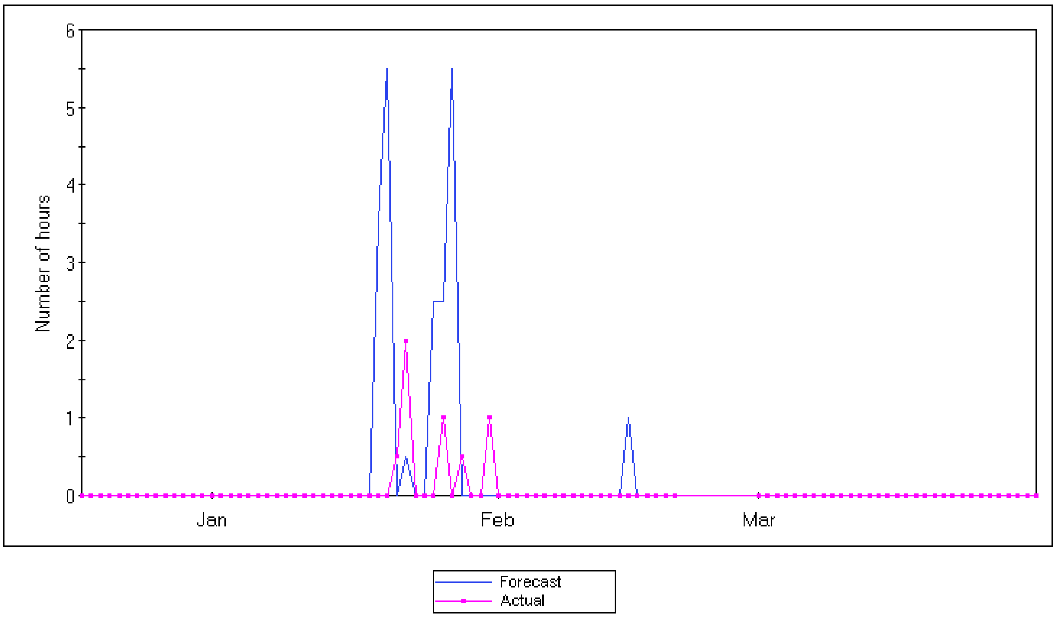

Figure 1. Time-series of predicted 1 day ahead forecast and measured number of hours where the HLI exceeded 84 for Armidale.

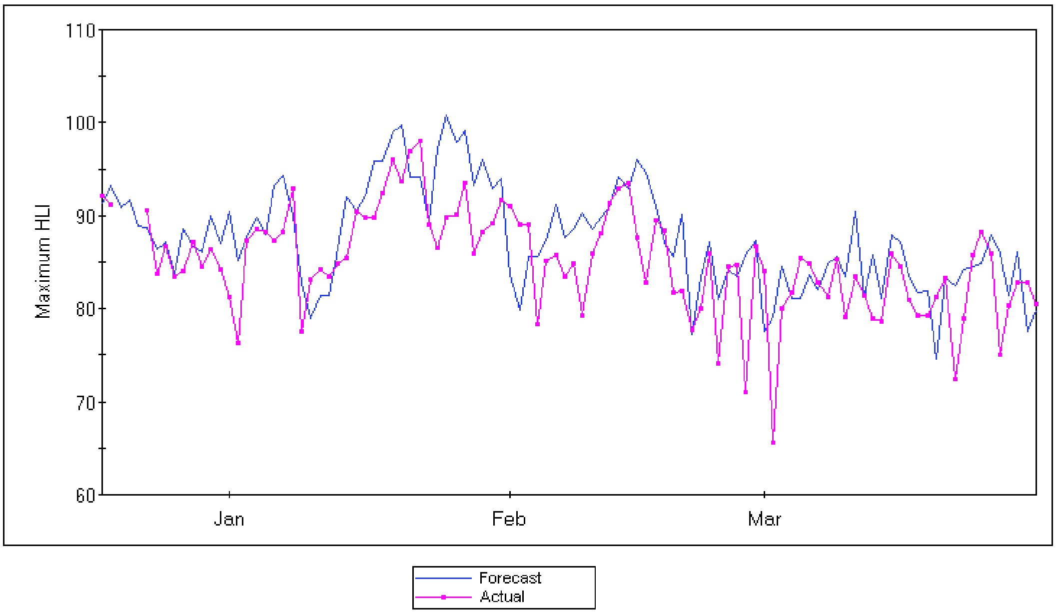

Figure 2. Time-series of maximum HLI for the 1 day ahead forecast and measured for Moree.

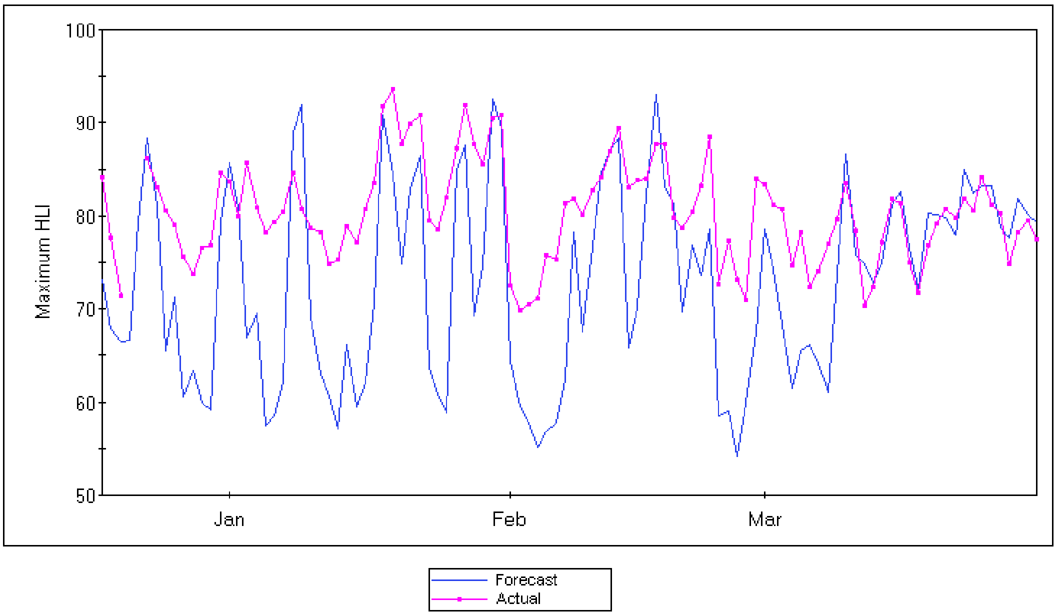

Figure 3. Time-series of maximum HLI for the 1 day ahead forecast and measured for Warwick.