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Estimation and Modelling of Land Surface Temperature using LANDSAT 7 ETM+ Images and Fuzzy System Techniques

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ABSTRACT: Modeling of Land Surface Temperature is essential for short term and long term management of environmental studies and management activities of the Earth's resources. The objective of this research is to estimate and model land surface temperatures (LST). The most generally measured climate parameter is air temperature. air temperature estimation is valuable for different applications such as, environmental change examines, epidemic forecasting, assurance of different warmth and radiation fluxes vapor weight shortfall, climate gauging, urban warmth island, nature hydrology and air sciences and vital for necessary for the health of human being.

I. INTRODUCTION

In this study, LANDSAT 7 ETM+ images were applied to retrieve Land Surface Temperatures (LST) and Mamdani fuzzy inference system (MFIS) was applied to prepare models for LST values. Landsat 7 ETM+ images from 2007 to 2012 were chosen for retrieving LSTs and processed through MATLAB software using MFIS of year 2007 to 2012, which includes pre-monsoon and post-monsoon LSTs in the fuzzy model. The TVX (Surface Temperature Vegetation Index) and the empirical method have furnished assessed LST with an RMS error of 3 K [1] [2]. In this study, the Fuzzy model M4/7-19-1 (model 4, 7 fuzzy sets, 19 rules and 1 output) has been developed for Mangalore cityandhas provided more accurate results as compared to existing models (M1, M2, M3, M5).

Mangalore is located in Karnataka state of India between 12°-52'N latitude and 74°-49'E longitude. During the months of March and May when the region faces summer season, the weather in Mangalore remains hot and humid but still remains bearable. The temperature varies from 26° C to 35° C.

The Fuzzy logic technique has been applied to process control, image processing, pattern recognition, classification, management, economics and decisions making [3].FIS is the famous computing systems based on the concepts of fuzzy set hypothesis, which have been effectively connected in many fields viz. control, decision support, system identification, etc. [4]. The accomplishment of FIS is due to their intuitive, handling and simplicity, closeness to human recognition and reasoning[5]. In order to develop a fuzzy model for LST, seven fuzzy subsets, nineteen rules and one output are considered in the estimation of weekly mean air temperature. These are very low (VL), low (L), medium low (ML), medium (M), medium high (MH), high (H) and very high (VH), respectively (Fig. 1.)

Various statistical parameters are utilized to measure the strength of the statistical relationship between the assessed values and the reference values.

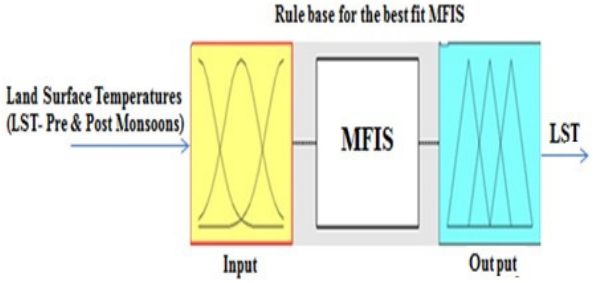

Fig. 1. The MFIS model.

Assume thatv_i, (i = 1,n) is the arrangement of n reference values and e_i, (i = 1,n) is the arrangement of the evaluation. $\overline{v}$and$\overline{e}$ are mean of reference and estimates values respectively. The bias, R and RMSE can be calculated by utilizing standard deviations of reference σ_v and estimate σ_e values, mean of reference and estimates values, assessed values and the reference values.The bias which is the difference between the mean estimate $\overline{e}$ and the mean reference value $\overline{v}$. The statistical formula of the linear correlation is defined as;

$$R = \sum_{i=1}^{n} \frac{(v_i - \overline{v})(e_i - \overline{e})}{n\sigma_v\sigma_e} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where *R* measures the proximity amongst estimate and reference. It is not sensitive to a bias [6]. RMSE measures the differences between anticipated values by a model and the actual observed values [7]. It can be expressed as;

$$\text{RMSE} = \left[\frac{1\sum_{i=1}^{n}(e_i - v_i)^2}{n}\right]^{\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

In this study, LST estimation results were compared with statistical criteria, it was seen that the optimum MFIS is 7-19-1 model called M4 were found in both cases as 0.966 and 0.963, that means MFIS got success up to 96.6% and 96.3% in estimating pre-monsoon and post-monsoon LST (Table 1& Table 2) and the retrieved pre-monsoon and post-monsoon LSTs from Landsat 7 ETM+ images are shown in Figure 2.and Figure 3 respectively.

Table 1: The R and RMSE statics of different MFIS models for pre-monsoon seasons LSTs.

Name	Model	Type	Defuzzification	R	RMSE (K)
M_1	4-10-1	trimf	centroid	0.794	1.850
M_2	5-13-1	trimf	centroid	0.872	1.728
M_3	6-16-1	trimf	centroid	0.916	1.653
M_4	**7-19-1**	**trimf**	**centroid**	**0.966**	**1.607**
M_5	8-22-1	trimf	centroid	0.754	1.920

Table 2: The R and RMSE statics of different MFIS models for post-monsoon seasons LSTs.

Name	Model	Type	Defuzzification	R	RMSE (K)
M_1	4-10-1	trimf	centroid	0.744	1.894
M_2	5-13-1	trimf	centroid	0.828	1.778
M_3	6-16-1	trimf	centroid	0.893	1.683
M_4	**7-19-1**	**trimf**	**centroid**	**0.963**	**1.623**
M_5	8-22-1	trimf	centroid	0.765	1.985

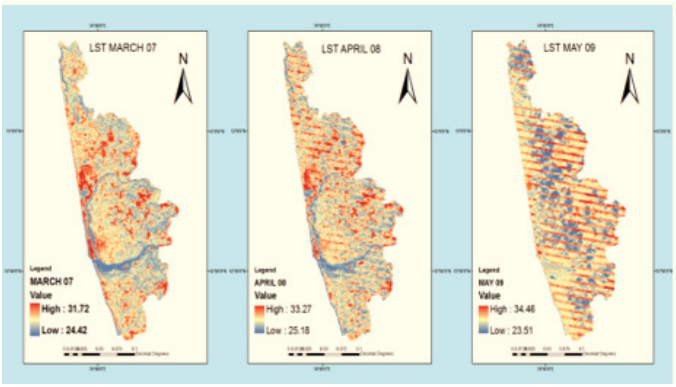

Fig. 2. LST maps of pre-monsoon images.

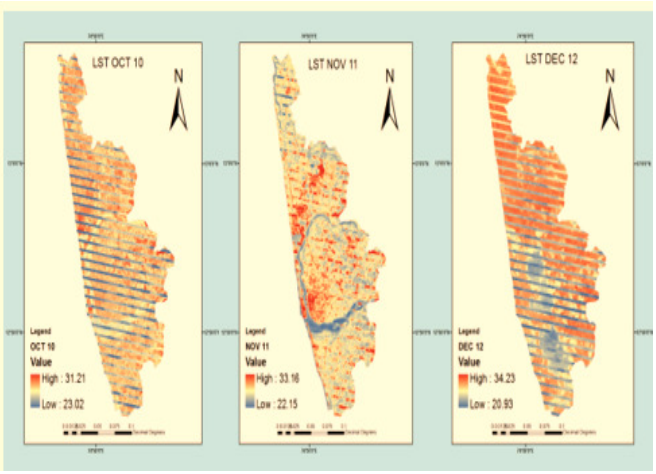

Fig. 3. LST maps of post-monsoon images.

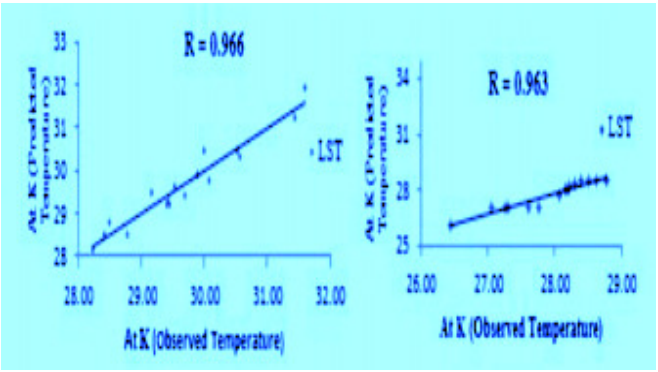

Fig. 4. Correlation between observed vs predicted of pre and post monsoons LSTs for model M_4.

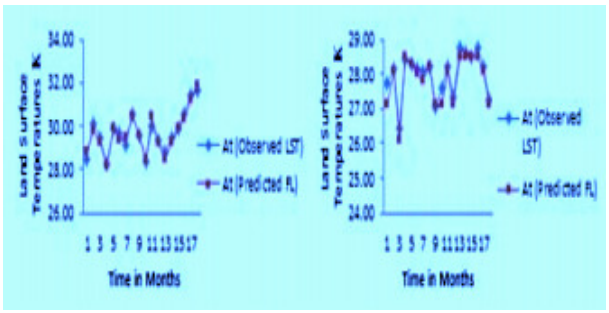

Fig. 5. Comparison of LSTs between observed (Landsat 7 ETM+) and predicted (MFIS) values.

This study describes the use of Landsat 7 ETM+ images to retrieve pre-monsoon and post-monsoon LST and MFI System used to model for retrievingLSTs in Mangalore City. The values were compared statically to the meteorological values. As per the literature, R and RMSE values were observed to be 0.975 - 2.581 K, respectively. Using retrieved LSTs values from Landsat 7ETM+ images, various MFIS models were employed to develop a better model for LST. Thus, in both cases pre-monsoon and post monsoon LSTs. The optimum outcomes were obtained through the model 7-19-1(M4). The results demonstrate that the present study is more accurate when thought about different studies in the literature.

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