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ANALYSIS OF DIURNAL VARIATION OF LAND SURFACE TEMPERATURE FROM GEOSTATIONARY SATELLITE INSAT-3D

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Abstract: Land Surface Temperature is a key parameter in land surface processes and in climatological and environmental studies. For the retrieval of Land Surface Temperature (LST), many studies make use of polar orbiting satellite, but polar orbiting satellite can sample each location twice a day, therefor polar orbiting satellite cannot capture a strong diurnal variation existing in LST. Geostationary satellite has a capability of providing data every half an hour, so it provides a unique data source of the earth's diurnal variation of LST. LST retrieved from satellite will have missing data, so data gaps will be there due to cloud coverage. In this paper, modelling of LSTD profile, modelling of LSTD profile on basis of different land covers is described in order to fill the data gaps and get a smooth LST profile.
Keywords: LST, Modelling, INSAT-3D, Imager.

I. INTRODUCTION

Land Surface Temperature (LST) is a key parameter at the land atmosphere interface. Land Surface Temperature Diurnal cycle (LSTD) is a key element of a climate system and meteorology. LST is useful in wide range of areas that are related to land surface processes, including climatology, hydrology, meteorology and environmental studies. The LST data are retrieved from geostationary satellite for its capability of providing data every half an hour. The LSTretrieved from satellites contain missing LST data. Cloud coverage is the main problem for the generation of clear LST over large area. This paper gives a concise view of method for filling the data gaps and to obtainclear and smooth Land Surface Temperature over large area.

II. RELATEDWORK

Past and ongoing Satellites have provided the ability to retrieve Land Surface Temperature at high spatial resolution and temporal resolution. Spaceborne sensors offer the potential to better retrieve Land Surface Temperature Diurnal (LSTD) profile. In [1] author's main objective is to retrieve Diurnal variation of LSTD cycle retrieved from K1-VHRR geostationary satellite. Cloud cover is usually a problem for the retrieval of clear LST. Due to cloud cover there will be data gaps. To fill the data gaps, mathematical modelling of LSTD profile is done. With the help of mathematical modelling some important parameters such as bandwidth, time of maximum temperature, residual temperature, temperature amplitude is retrieved. Modelling of LSTD profile on the basis of different land covers is done with the help of retrieved parameters. Modelled LSTD and measured LSTD are validated on the basis of different land covers.

In [2] a main objective to retrieve LST from Kalpana-1 VHRR geostationary satellite using single channel algorithm. In this, LSTD is retrieved using single channel algorithm with the known surface emissivity and atmospheric water vapour from Kalpana-1 geostationary satellite. After obtaining LST, cloud removal from K1-VHRR thermal infrared observation is done. The retrieved LSTD is validated with in-situ data (desert and crop site) and with Modis data. In [3] the objective is to retrieve Land Surface Temperature from MODIS data using 4- parameters diurnal temperature cycle model. Diurnal cycle of LST is calculated at high temporal and spatial resolution from polar orbiting satellite. In this, authors have obtained diurnal cycle of LST using 4-parameters considering ts (start of attenuation) to be 1 hour before the sunset. Validation between 4-parameters retrieved Land surface temperature Diurnal profile and 5-parameters retrieved Land surface temperature Diurnal profile is carried out.

III. METHODOLOGY AND RESULTS

Mathematical Modelling:
Gottsche and Olesen (2001) developed a physics based model for cloud free LST, which is used to fill in the data gaps and to interpolate atmospheric correction. Mathematical modelling is done in two parts:-
1) A cosine term is taken which describes the effect of the sun.
2) An exponential term is taken which describes the decay of LST during night.
Equations used are:

$T_1(t) = T_0 + T_a*\cos((3.14/\square)*(t-T_m))$ -----------(B1) [1]

$T_2(t)=(T_0+\square T) + (T_a* \cos((3.14/\square\square)*(T_s-T_m))-\square\square T) * e^{-(t-T_s)/k}$---(B2) [1]

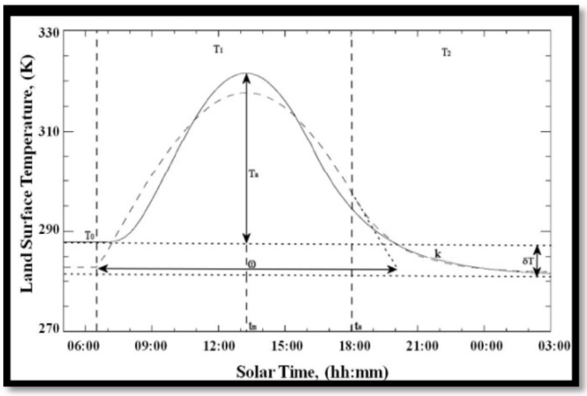

Figure 1. LSTD cycle model parameters[1]

T_1 (t) = LSTD modelling cycle
(Sunrise to start of attenuation function at ts)
T_2 (t) = LSTD modelling cycle Night time part T2 (ts to end)
T_0[C] = residual temperature,
δT[C] = T0 – T (t → ∞), wh re t is time, T_a[C] = temperature amplitude,
ω [hh:mm]= half period of oscillation of cosine, t_s [Solar time]= start of the attenuation function, T_m [Solar time] = time of the maximum,
k [hh:mm]= attenuation constant
The above parameters are obtained from mathematical modelling. Validation between measured LSTD and modeled LSTD is carried out for land cover crop for month December. The results obtained are:

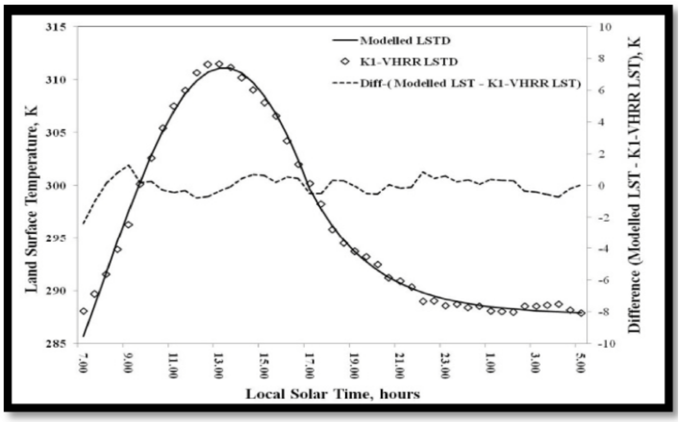

Figure 2. LSTD cycle over representative cropland locations over India for December 2013 derived from K1-VHRR LST and modelled LST derive using equation B1 and B2.[1] It can be seen that modelled LSTD fits very well with measured LSTD. The difference of 1 K was observed during sunrise, for the rest of the day it fits equally well.

Single Channel Method:
LST is obtained using Single channel function is calculated using Radiative method. Atmospheric transfer model. Water vapour and surface emissivity must be known.

The LST obtained is validate with in-situ data and with Modis data.
Results obtained are:-

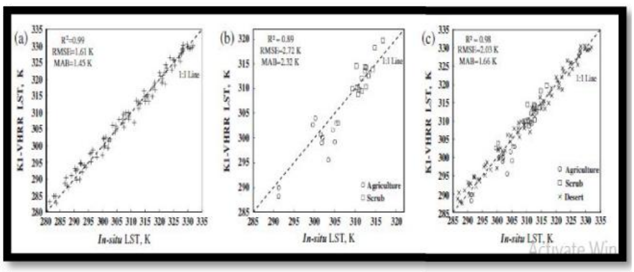

Figure 3. Comparison of Kalpana-1-VHRR LST retrievals with the in situ measurements at (a) desert site, (b) crop site and (c) both sites for the study period February 23–25Figure 2-6 Fitting 4- Parameter model over (a) forest, (b) shrubland, (c) woodland, (d) grassland, (e) cropland, and (f) unvegetated land [2]

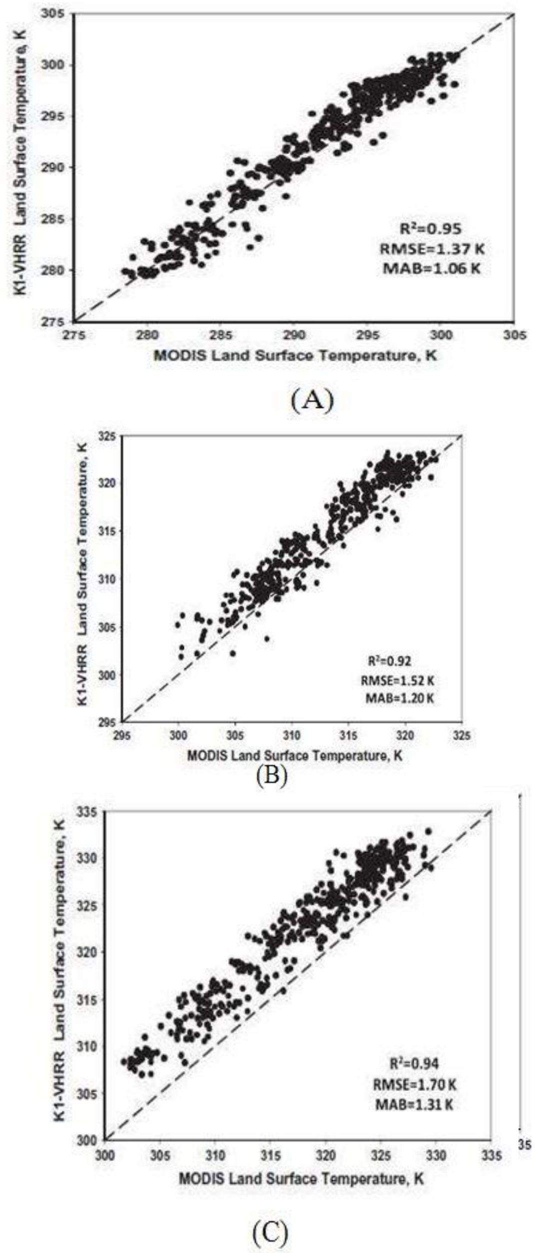

Figure 4. Comparison of Kalpana-1 LST and MODIS LST for (A) 22:30h night time data on March 23, 2011, (B) 11:00h day time data on March 26, 2011, (C) 14:30h day time data on March 24, 2011[2]
4-Parameters mathematical Modelling:
LST obtained from satellite will be having data gaps. For the removal of data gaps mathematical modelling is done. In this method modelling is done by using 4 parameters Diurnal temperature cycle (DTC) model. In this method author have assumed the value of Ts (start of attenuation) to be 1 hour before the sunset. The B1 and B2 equations are used for mathematical modelling.
The LST obtained from 4-parameters is validated with LST obtained from 5-parameters on basis of different land covers. The results are comparable with 5-parameter DTC model.

Results are:-

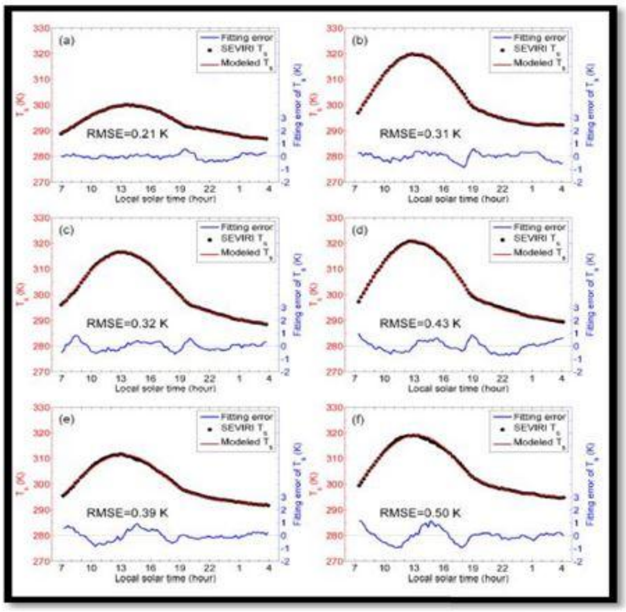

Figure 5. Fitting 4-Parameter model over (a) forest, (b) shrubland, (c) woodland, (d) grassland, (e) cropland, and (f) unvegetated land [3]

IV. CONCLUSION

LST is important in various application involving thermal inertia, generation of maximum and minimum LST and applications that are leading to climate change. This paper describes different available methodology for retrieving the LSTD. So, we can develop a method for retrieving LST from geostationary satellite on the basis of different land covers.

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