LAND SURFACE TEMPERATURES FROM METEOSAT-9 SATELLITE IN MINAS GERAIS STATE, BRAZIL

A. A. A. Dantas
E. Ferreira

Universidade Federal de Lavras, Lavras City, Minas Gerais State, Brazil, email: auau@deg.ufla.br

1. INTRODUCTION

The Meteosat-9 is a geostationary meteorological satellite of the EUMETSAT. It has the Spinning Enhanced Visible and Infra Red Imager (SEVIRI) that collects data in eleven bands at a nominal ground resolution of 3 km, as well as 1 km resolution panchromatic band. One of the simplest applications that the versatile satellite offers is the estimation of the land surface temperatures (LST) from brightness temperatures data have been taken by the SEVIRI. This temperature is the first step to initiate estimations of other meteorological variables from meteorological satellites data. In this work the goal was to estimate the surface temperatures from Meteosat-9 images, in corresponding to the data of the automatic weather stations of CPTEC/INPE, used to validate these temperatures in Minas Gerais State, Brazil.

2. METHODOLOGY

2.1. Land surface temperature

Several studies use the temperature of the land surface as a starting point for other determinations and weather applications. Many of the algorithms used for the estimation of continental surface temperature (LST) from orbital sensors use Split Window technique. Originally the method was widely employed for the AVHRR sensor, NOAA series, based on channels 4 and 5 [1]. Concerning to SEVIRI, Meteosat-9 imager, the surface temperature is a simple linear relationship of brightness temperatures data obtained by thermal channel 9 (10.8 μm) and thermal channel 10 (12.0 μm), corrected for atmospheric contribution. The problems related to LST estimate from satellite data are the atmospheric effects and the unknown surface emissivities under the conditions in which the imagery were obtained. In addition, the algorithms are valid only for clear sky. Methods to estimate emissivity values and LST [1, 3, 4, 5] were used the Equations (1) to (4):

$$\varepsilon = 1,0094 + 0,047\ln(NDVI) \tag{1}$$

Where:

ε: emissivity,

NDVI: normalized difference vegetation index.

$$LST = 1,274 + \frac{P(T_9 + T_{10})}{2} + \frac{M(T_9 - T_{10})}{2} \qquad (2)$$

P and M are empirical coefficients and depend on the emissivity:

$$P = 1 + \frac{0,15616(1-\varepsilon)}{\varepsilon} - 0,482(\frac{\Delta\varepsilon}{\varepsilon^2}) \qquad (3)$$

$$M = 6,26 + 3,98\frac{(1-\varepsilon)}{\varepsilon} + 38,33(\frac{\Delta\varepsilon}{\varepsilon}) \qquad (4)$$

In the calculations of NDVIs were used a 3 pixels window, with a ground resolution of 3.7 km. To assess whether 3 pixels were contaminated with clouds [6] it was made two conditions which are based on the brightness temperature data of channel 9 (Tb9) and brightness temperature data of channel 10 (Tb10). If Tb10>278 K (presence of clouds), or if 0.4 K<(Tb9-Tb10)>3 K (presence of clouds). The results were analysed by comparing LST values obtained from the Meteosat -9 images with the values of temperatures in PCDs.

2.2. The EUMETCast Reception Station

The images from Meteosat-9 satellite have been receiving from 05/13/2009 to 05/31/2009 by the EUMETCast Reception Station located in the Department of Engineering of the *Universidade Federal de Lavras* (DEG/UFLA). These images have been receiving in the level 1.5 data format broadcasted by the EUMETCast. The *Tellicast* software was used to process the raw images. The *MSG Data Manager, MSG to Geotiff* and *ENVI ITT* softwares were used for processing data.

2.3. The CPTEC/INPE Automatic Weather Stations (PCDs) in Minas Gerais State, Brazil

The LST estimations were done for *Minas Gerais* State, Brazil, located between the latitudes of 14° S and 23° S and between the longitudes of 39° W and 51° W. The locations of the PCDs are indicated in Figure 1.

3. DISCUSSION

The data of *Honorópolis* PCD was chosen to illustrate the variables considered in estimations. In Table 1 are showed days, brightness temperatures data for 9 and 10 channels, presence of clouds (identified by *), NDVIs, emissivities, air temperatures data in PCDs, estimated LST and the differences between the air temperatures data and the temperatures estimated data (PCD-LST). The same was made for other localities (not showed here).
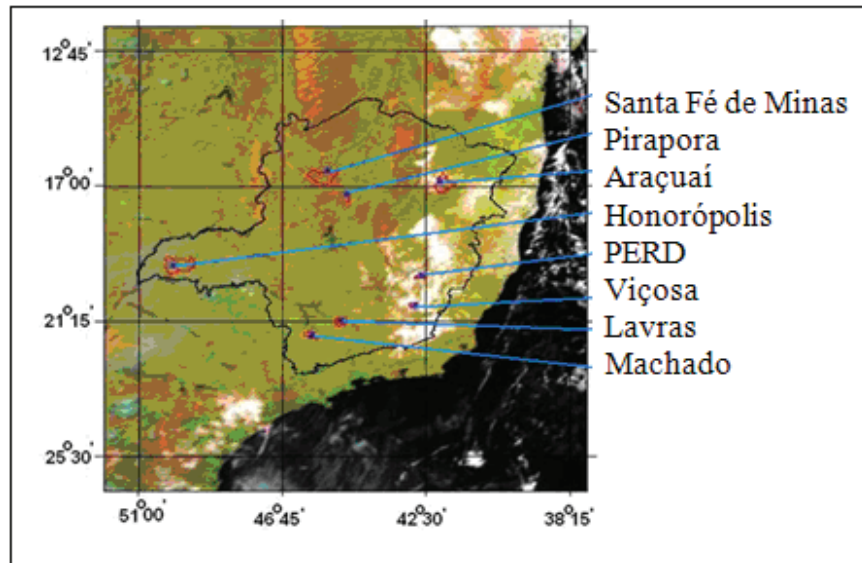
Figure 1. The Automatic Weather Stations CPTEC/INPE (PCDs) in *Minas Gerais* State, Brazil.

Table 1. Major variables involved in estimations of LST for *Honorópolis* locality.

Date	T_{b10} (K)	T_{b9} (K)	Clouds (*)	NDVI	Emissivity	PCD (K)	LST (K)	PCD-LST (K)
13/5/2009	265,6	269,3	(3,72*)	0,2806	0,949	-	-	-
14/5/2009	290,0	293,1	2,99	0,4317	0,969	298,5	303,8	-5
15/5/2009	229,1	231,0	(2,93*)	0,0635	0,879	-	-	-
16/5/2009	288,7	289,8	1,12	0,4680	0,973	291	295,3	-4
17/5/2009	290,9	292,3	1,36	0,4532	0,972	292,5	298,5	-6
18/5/2009	285,7	287,1	1,38	0,4159	0,9681	293,5	293,6	-0,1
19/5/2009	267,9	271,0	(3,13*)	0,2441	0,943	-	-	-
21/5/2009	292,4	293,0	0,58	0,4706	0,973	294,5	297,1	-2
22/5/2009	292,5	293,5	1,00	0,4706	0,973	295	298,7	-3
23/5/2009	292,5	293,5	0,98	0,4548	0,972	295,5	298,7	-3
24/5/2009	292,3	294,0	1,73	0,4343	0,970	297,5	301,4	-3
25/5/2009	291,0	293,0	2,00	0,4185	0,968	298,5	301,1	-2
26/5/2009	291,5	293,6	2,11	0,4287	0,969	298	302,0	-3
27/5/2009	283,8	287,4	(3,55*)	0,3051	0,953	-	-	-
28/5/2009	288,4	291,7	(3,33*)	0,4094	0,967	-	-	-
29/5/2009	289,5	292,2	2,70	0,4706	0,973	296	302,0	-5
30/5/2009	290,0	293,7	2,73	0,4147	0,968	297,5	304,0	-6
31/5/2009	248,8	250,8	(2,03*)	0,1837	0,929	-	-	-

It was observed for 18 days data that only was possible to estimate the temperature for 12 days, because in this period, 6 days were contaminated with clouds. In some cases the presence of clouds was not detected, but the NDVI values were low. In these cases, the maximum NDVI value was used to perform the calculations of emissivities. It is necessary to note that the PCDs temperatures data were not the real surface temperatures data,

so it must be consider an approximation. In Table 1 it can be seen that estimated temperature by Meteosat 9 satellite was always greater than temperature data of the PCD, ranging from 0.1 K to 6 K. Table 2 shows the regression equations and determination coefficients obtained only for the places that have acceptable values: *Honorópolis, Lavras, PERD and Santa Fé de Minas.*

Table 2. Regression equations and determination coefficients for places that have acceptable values.

Honorópolis	*Lavras*	*PERD*	*Santa Fé de Minas*
Y = 1,12x-27,73	Y = 1,61x-174,2	Y = 1,91x-261,1	Y = 1,32x-92
$R^2 = 0,70$	$R^2 = 0,64$	$R^2 = 0,82$	$R^2 = 0,61$

4. CONCLUSIONS

The land surface temperature values generated from Meteosat-9 images presented limitations due to the presence of clouds that prevent a perfect adjustment of brightness temperature values. In cases of absence of clouds, for some sites, images can be used for the estimation of LST. Studies must be developed in other seasons testing also other methods of estimation.

5. REFERENCES

[1] F. Becker; L. Z. LI, "Towards a local split window method over land surfaces", *Int. J. Rem. Sens.,* Taylor and Francis Ltd, London, vol. 11, no. 3, pp. 369 – 393, 1990.

[2] A. A. Van de Griend, M. Owe, "On the Relationship between Thermal Emissivity and the Normalised Difference Vegetation Index for Natural Surfaces", *Int. J. Rem. Sens.*, Taylor and Francis Ltd, London , vol. 14(6), pp. 1119-1131, 1993.

[3] Y. H. Kerr, J. P. Lagouarde; J. Imbernon, " Accurate land surface temperature retrieval from AVHRR data with use of an improved split window", *Rem. Sens. Environ.,* Elsevier, New York, vol.41, pp. 197-209, 1992.

[4] J. A. Sobrino, Z. L. Li; M. P. Stoll, F. Becker, "Improvements in the local split-window technique for land surface temperature determination", in *IEEE Trans. Geosci. & Rem. Sens.*, 1994, vol. 32, pp. 243-253.

[5] E. Valor, V. Caselles, "Mapping land surface emissivity from NDVI: application to European, Africa and South American areas", *Rem. Sens. Environ.*, Elsevier, New York, vol. 57, pp. 167-184, 1996.

[6] G. B. França, A. P. Cracknell, "Retrieval of land and sea surface temperature using NOAA-11 AVHRR data in north-eastern Brazil", *Int. J. Rem. Sens.,* Taylor and Francis Ltd, London, vol. 15, pp. 1695-1712, 1994.