Australian Journal of Basic and Applied Sciences, 5(8): 1269-1272, 2011
ISSN 1991-8178

# Surface Temperature Calculated By Using An Analytical Method

[1]Iraj Ramezani, [2]Mohammad Taghi Zamanian and [3]Sayed Roholla Mousavi

[1]University of Payam e Noor, Iran
[2]Islamic Azad University, North Tehran Branch, Tehran, Iran
[3]Aligoudarz Branch, Islamic Azad University, Aligoudarz, Iran

**Abstract:** A computer program was prepared using analytical method to calculate surface temperatures, and then we compared the surface temperature calculated by the computer and the actual surface temperature obtained from Aligoudarz meteorological stations (Iran). Result showed that in most cases there was little difference between the output model and monitoring of meteorological stations.

**Key words:** Actual temperature, analytical method, surface temperature, meteorological

## INTRODUCTION

Basis of energy conservation is balance between total return and received thermal energy by the surface of earth that possible by radiation measurements, Therefore the principle of conservation of thermal energy in the Earth's surface, can be wrote as a following formula (Arya, 1988):

$$R_N = R_S \downarrow + R_S \uparrow + R_L \downarrow + R_L \uparrow = H_S + H_L + H_G$$

In the above formula: $R_N$ is net radiant flux that assumes to positive down; $R_S \downarrow$ is shortwave radiant flux from the sun and sky, including effluence radiation; $R_S \uparrow$ is shortwave reflected flux from the earth, which are considered as $R_S \uparrow = -\alpha R_S \downarrow$ (in this formula $\alpha$ is surface albedo); at night $R_S \uparrow$ is much smaller than $R_S \downarrow$, as well $R_S \uparrow$ and $R_S \downarrow$ at night are not zero, therefore we do not consider them because of their low value. For example, the moon light is the shortwave length of sun reflected and when reaches on the earth and reflected again the flux of reflection is too small; $R_L \downarrow$ is long wave radiant flux that incoming from the atmosphere, including clouds radiation; $R_L \uparrow$ is long wave radiant flux from the Earth's surface; $H_S$ is Sensible heat flux; $H_L$ is latent heat flux of evapotranspiration; $H_G$ is heat flux from soil surface to soil depth. To determine the sign of all radiations flux, we contract all radiant flux toward the earth are positive. In fact, earth surface temperature at a specific location can be determined by heat energy balance which depends to level of radiation, processes of heat exchange in the atmosphere near the earth, presence of trees and other vegetation and other heat emissions factors such as thermal properties on under level of environment. Depths soil temperature depends on many factors such as latitude, season, net radiation at the surface, soil material, soil roughness and softness, soil moisture content, soil cover and atmospheric conditions. To measure the net flux we must first calculate the radiation flux incoming above the atmosphere, flux of solar radiation on vertical landing at an average distance is 1367 $Wm^{-2}$ (solar constant) that it defined by $S_0$ (Byers, 1959). In the ascendant, the flux of solar radiation is calculated by following equation:

$$R_S = S_0 \left( \frac{r_m}{r} \right)^2 \cos Z$$

In the above equation $\left( \frac{r_m}{r} \right)^2$ is squared of ratio of the sun mean distance to distance of sun to place. Also, Z is the angle of the sun ridge, and calculated by following equation:

$$Z = \cos^{-1}\left(\sin\phi \sin\sigma + \cos\phi \cos\sigma \cos H\right).$$

$\phi$ = local Latitude

**Corresponding Author:** Sayed Roholla Mousavi, Aligoudarz Branch, Islamic Azad University, Aligoudarz, Iran.
Tell: +98-664-223-4731,
E-mail: rr_mousavi@yahoo.com

$\sigma$ = Current Sun declination

H = Hour angle ($H = (t - noon) \times 15$), the hour angle of a point is the angle between the half plane determined by the Earth's axis and the zenith (half of the meridian plane) and the half plane determined by the Earth's axis and the given point. Significant amount of power radiated reduced by the atmosphere when the input radiation passes through the atmosphere and reaches to the Earth. The amount of this reduction depends on the optical path lengths, which are determined by latitude, date and time, the nature and amount of reflected and dispersed particles and absorbent material in the atmosphere. Also reflect and scatter radiation by clouds is considered as one of the most important factors in reducing radiation. The input radiation flux formula to Earth's surface is shown to the follows:

$$R_S = S_0 \Psi \left( \frac{r_m}{r} \right)^2 \cos Z$$

$\Psi$ in the above formula is calculated as follows:

$$\Psi = \exp\left[ 0.089 \left( \frac{p}{p_0} M \right)^{0.75} - 0.174 \left( \frac{W.M}{20} \right)^{0.6} - 0.083 (C.M)^{0.9} \right]$$

In the above formula:

M is optical mass and is calculated by $M = \frac{1}{\cos Z} \frac{p}{p_0}$ , $p$ is station pressure (hectopascal) and $p_0$ is normal atmospheric pressure and is equal to a 1000 hectopascal.

$W$ is rain available water from the clouds and is calculated by $W = 10^{\left(0.247 \times e^{0.5} + 0.421\right)}$ $e$ is vapor pressure of water.

$C$ is a constant factor that its value in the clear blue sky and sky with suspended particles is 0.6 < C < 1 and 1 < C < 2 respectively.

Thereupon the formula of shortwave radiation flux and shortwave reflected flux from Earth is shown as follows:

$$R_S = R_S \downarrow + R_S \uparrow = R_S \downarrow (1 - \alpha)$$

In the above formula $\alpha$ is surface albedo and its value in the dry soil is 0.25 < $\alpha$ < 0.35.

long wave radiant flux from the Earth's surface and long wave radiant flux that incoming from the atmosphere is calculated by following formula:

$$R_L = R_L \uparrow + R_L \downarrow$$

$$R_L \downarrow = \sigma \left( 0.66 + 0.039 \times e^{0.5} \right) (T_a)^4$$

In the above formula $\sigma$ is Stefan–Boltzmann constant $(\sigma = 5.670400(40) \times 10^{-8} Wm^{-2} K^{-4})$ and $T_a$ is air temperature (Calvin).

Also $R_L \uparrow = -\sigma \varepsilon T_S{}^4$ that $\varepsilon$ is surface emission coefficient and its value for soil is 0.95; $T_S$ is soil temperature (Calvin).

Finally, long wave radiant flux from the Earth's surface and long wave radiant flux that incoming from the atmosphere is calculated by following formula:

$$R_L = \sigma \left[ \left( 0.66 + 0.039 \times e^{0.5} \right) (T_a)^4 - \varepsilon (T_S)^4 \right]$$

Also sensible heat flux is calculated by:

$$H_S = \frac{\rho c_P (T_S - T_a)}{r_a}$$

In the above formula, $\rho$ is air density, $c_p$ is specific heat capacity of air at constant pressure and $r_a$ is aerodynamic resistance that calculated by following formula:

$$\frac{\left( \ln\left( \frac{z}{z_0} \right) \right)^2}{k^2 U}$$

z = 10m

$z_0$ = 0.04m (for soil)

k (Von-Karman constant) = 0.4
U = the average wind speed in 10 meters height.
Latent heat flux is calculated by following empirical formula:

$$H_L = \frac{\Delta \times R_N + \rho c_P (e_s - e) / 10 r_a}{\Delta + \gamma \left(1 + \frac{r_e}{r_a}\right)}$$

In the above equation:

$\Delta$ is Penman–Monteith equation (following) (in below equation $T_a$ is air temperature)

$$\Delta = 4098 \times \frac{\left[0.6108 \exp\left(\frac{17.27 T_a}{T_a + 237.3}\right)\right]}{(T_a + 237.3)^2}$$

$\gamma$ is psychrometric constant and calculated by $\gamma = 0.665 \frac{p}{1000}$

$r_e$ is constant factor that its value for semi-desert areas is 150.

Heat flux determination into the Earth is difficult and depends on the soil material and aggregation, shape and size of soil grain, content of soil moisture and other factors. Consequently, for convenience we use the below approximate and average equivalent (Pielke, 2002):

$$H_G = 0.2 R_N$$

## MATERIAL AND METHODS

For numerical simulations of mountain – plains and plains – mountain wind in Aligoudarz region (Iran), we collected data in cooperation with Aligoudarz meteorological office in Lorestan province for 10 days on Earth's surface. We use of a dry thermometer, wet thermometer and maxima and minima thermometer to record the ground temperature, humidity, thermometers were placed 5cm above the soil surface, thermometers were protected from sunlight direct by using cover. Before we entering this data into the computer simulation program, the other computer program was prepared that could calculated Earth’s surface temperature with respect to solar radiation, terrestrial radiation and thermal conductivity of soil analytically, the process was as follows

1- We entering the air temperature ($T_a$), station pressure ($p$) and relative humidity ($r_h$) and the wind speed ($U$) into the computer program according to the data station.
2- We entering a hypothetical Earth’s surface temperature ($T_S$) into the computer program.
3- We consider $T_S$ with the condition that $\left|R_N - (H_S + H_L + H_G)\right| \le 1$ .
4- If the condition was not established we added 0.05 to $T_S$ and run the program again, and it continued until the condition is established, then consider $T_S$ .
5- It work was conducted for later steps.

The surface temperature recorded at the Aligoudarz station and calculated surface temperatures are compared in table 1.

## RESULTS AND DISCUSSION

Results showed that there was more than 1C$^0$ difference between calculated temperature and recorded temperature of the weather station at 10 am to 16 pm in local time, as maximum difference between calculated temperature and recorded temperature was obtained at 14 pm in local time, and minimum difference was obtained at 19 pm and 2 am in local time (Figure 1). Difference between calculation values and recorded values of weather station can cause by some cases such as: selection coefficients, soil type, nature and amount of particles, absorbent, reflected and scattered material in the atmosphere and carefully commands. Software and calculation errors can be important reasons that the calculation values were different with the recorded values of the weather stations. Earth’s surface temperature of the calculation method was equal with the recorded surface temperature of weather stations at 8 am in local time; it was due to the maximum speed mixing in this time, and thus difference temperature was less than surface temperature.

Since the calculation of Earth's surface and soil temperature is very useful in weather and agricultural research it recommended that be given more importance to this issue.

Table 1- data of Earth's surface temperature record of Aligoudarz weather station and calculated Earth's surface temperatures in the November 18, 2002.

| Local time | Relative humidity (%) | Air temperature ($C^0$) | Pressure (hectopascal) | wind speed (m/s) | Surface temperature (Actual value) ($C^0$) | Surface temperature (Calculated value) ($C^0$) |
|---|---|---|---|---|---|---|
| 7 | 79 | 0.0 | 807.3 | 5 | -1.0 | -1.28 |
| 8 | 58 | 4.0 | 807.5 | 8 | 4.8 | 4.80 |
| 9 | 57 | 5.0 | 808.1 | 7 | 7.0 | 7.95 |
| 10 | 47 | 7.0 | 807.9 | 7 | 10.0 | 11.55 |
| 11 | 38 | 9.0 | 807.6 | 5 | 14.0 | 16.52 |
| 12 | 34 | 9.4 | 80.74 | 7 | 14.2 | 15.26 |
| 13 | 34 | 10.0 | 806.2 | 6 | 14.8 | 16.28 |
| 14 | 34 | 10.0 | 806.0 | 4 | 14.0 | 17.21 |
| 15 | 33 | 11.0 | 806.0 | 4 | 12.5 | 15.40 |
| 16 | 35 | 10.0 | 806.0 | 7 | 11.4 | 10.60 |
| 17 | 33 | 10.0 | 806.1 | 7 | 8.2 | 8.84 |
| 18 | 31 | 8.0 | 806.2 | 6 | 6.8 | 6.65 |
| 19 | 36 | 7.2 | 806.2 | 6 | 6.0 | 5.88 |
| 20 | 40 | 5.8 | 806.2 | 5 | 4.1 | 4.28 |
| 21 | 45 | 1.8 | 806.3 | 6 | 3.2 | 3.54 |
| 22 | 49 | 4.2 | 806.3 | 5 | 2.5 | 2.73 |
| 23 | 54 | 2.8 | 806.3 | 5 | 1.2 | 1.36 |
| 0 | 56 | 2.0 | 806.4 | 6 | 1.0 | 0.77 |
| 1 | 60 | 1.8 | 806.4 | 5 | 0.6 | 0.38 |
| 2 | 65 | 1.6 | 806.4 | 6 | 0.4 | 0.32 |
| 3 | 70 | 1.2 | 806.5 | 6 | 0.3 | 0.00 |
| 4 | 72 | -0.8 | 806.5 | 5 | 0.0 | -0.57 |
| 5 | 68 | -0.2 | 806.6 | 6 | -0.8 | -1.37 |
| 6 | 66 | -0.6 | 806.6 | 5 | -1.2 | -1.98 |

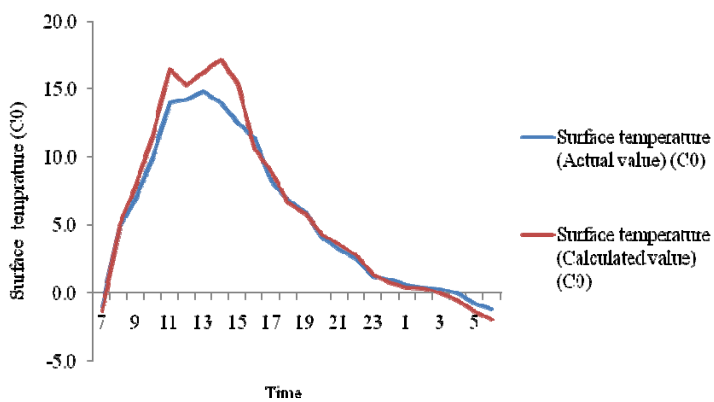


**Fig. 1:** Comparison of Earth's surface temperature record of Aligoudarz weather station and calculated Earth's surface temperatures in the November 18, 2002.

## REFERENCES

Arya, S.P.S., 1988. Introduction to micrometeorology. Academic Press, San Diego.

Byers, H.R., 1959. General meteorology. McGraw-Hill.

Pielke, R.A.S., 2002. Mesoscale meteorological modeling. 2nd Edition, Academic Press, San Diego, CA