Regional Methods for Computing the Mean Summer Temperature and Intra-annual Course of Global Radiation within Central Asia

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Abstract

The air temperature and incoming global radiation regularly figure in the models of hydrometeorological processes in mountain watersheds. The regional formulae for computing the total monthly global radiation and mean summer (June-August) temperature as functions of altitude, latitude, longitude, and time were received as a result of the present investigations. Practical recommendations based on a study of the spatial variability of total cloudiness are offered for extrapolating the data from a single meteorological point to whole basins. The results of calculations from these formulae agree rather closely with measured data including the spatial variation of the air temperature and global radiation within Central Asia.

Method for Computing Global Radiation

In the mathematical model of glacier melting elaborated by Konovalov (Konovalov 1985), the initial formula for determining daily sums of global radiation Q_s on clear days is as follows:

$$Q_s = J_s T_1 / \pi * \int_0^{\tau_s} \frac{\sin h_s}{\rho(z,t) + \sin h_s} \left[\sin h_s + 0.38 \rho(z,t) \right] dt_1 \qquad (1)$$

where,

J_s is the meteorological solar constant, T_1 is the duration of one day equal to 1,440 min, τ_s is the time of sunset, or sunrise, t_1 is the time of day expressed as a periodical angular function of the hour, ρ is the general transparency of the atmosphere, h_s is the angle of the sun´s height, and z is the altitude above sea level.

The intra-annual course of the general transparency of the atmosphere at different altitudes is described by the following expression (Konovalov 1985):

$$\rho(z,t) = 0.383 - 0.068z + \left(0.036 + 0.031z - 0.084z^2\right) * \\ * \cos\left[2\pi\left(t - 373 + 59.5z - 11.7z^2\right)/T_2\right] \qquad (2)$$

Here T_2 = 365 days. Analysis of formula (2) has shown that $\rho(z,t) > 0$ at $0 \le z \le 5.19$km. For practical applications it was assumed that at $z \ge 5.19$kmasl, ρ is constant and equal to its value at z = 5.19km.

It is not difficult to derive analytical formulae for determining the expression under the integral in the right part of (1) after some mathematical transformations. Those formulae were used for the calculation of $Q_s = Q_s(z,t,\varphi)$ within the Central Asian area by means of a special computer routine. The calculation of incoming Q_s on slopes of different inclination and exposition, taking into account the actual conditions of cloudiness, is also envisaged in this routine. The calculations of Q_s were confirmed for some points within Central Asia by measurements of global radiation. The relative deviations between measured and calculated values of Q_s are presented in Table 1.

Table 1: Relative Deviations (%) between Measured and Calculated Monthly Sums of Global Radiation

Points	Zkmasl	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Chardjou	0.188	-10	-9	-3	0	2	3	6	0	-4	-13	-14	-12
Ashgabat	0.227	-5	-6	1	4	7	9	11	8	5	-6	-7	-3
Termez	0.309	-9	-6	1	2	6	4	5	3	-2	-8	-11	-12
Kairak-kum	0.347	-8	-11	-3	1	3	7	8	5	-1	-10	-11	-9
Tashkent	0.478	-9	-10	-3	3	7	5	6	7	0	-8	-10	-9
Fergana	0.578	-1	-8	-7	4	7	7	8	4	0	-7	-11	-10
Samarkand	0.689	-5	-3	3	7	8	5	9	5	3	-6	-9	-7
Bishkek	0.756	-12	-10	0	3	7	9	8	6	1	-10	-12	-12
Alma-Aty	0.847	-6	-5	2	4	7	8	8	7	1	-9	-9	-12
Kyzylcha	2.076	-15	-18	-8	-10	-4	-3	-2	0	-3	-12	-14	-15
Big Almaty Lake	2.516	0	-11	-4	-3	1	5	6	6	2	-9	-11	-22
Tian-Shan	3.610	-7	-6	-3	-2	1	3	4	1	-2	-8	-12	-10
Lednik Fedchenko	4.169	-5	-5	-5	-2	-1	2	4	2	0	-8	2	-3

Method for Computing Mean Summer Temperature

To develop the regional method of calculating the mean summer temperature as a function of altitude, z, latitude, φ, longitude, λ, data of 198 meteorological points, located within an altitudinal range from 0.3km to 4.9km above sea level were used. Among this set of data were also 12 points on glaciers.

Ultimately, for calculations of the mean summer air temperature within Central Asian territory, the following expression was derived:

$$\Theta_s = 70.56 - 0.517 * 10^{-2} z - 0.407 * 10^{-6} z^2 - 1.102\varphi + 0.0409\lambda \quad (3)$$

where,

Θ_s is the summer mean temperature, °C; z is the altitude, masl; φ is the latitude; λ is the longitude.

The correlation relationship for (3) equals 0.98, and the root mean square error is 1.37°C. The quality of calculation according to (3) was estimated by comparing Θ_s values derived according to the proposed formula and the same characteristics determined by the well-known method of Krenke (Krenke 1982). These values are presented in Table 2. As may be seen, the correspondence between the compared characteristics is satisfactory enough to permit us to recommend our simple and effective method for wider applications.

Table 2: Comparisons of Θ_s Calculations by Formula (3) and the Method of Krenke, °C

Z,km asl	φ NL	λ EL	Θ_s by (3)	Θ_s by Krenke	Difference, °C	Z,km asl	φ NL	λ EL	Θ_s by (3)	Θ_s by Krenke	Difference, °C
3.96	39.0	66.8	3.6	3.4	0.2	3.98	38.2	65.3	4.0	4.1	-0.1
4.04	39.1	67.3	3.3	2.7	0.6	3.82	38.1	64.8	4.9	5.5	-0.6
3.89	39.3	67.3	3.9	3.7	0.2	3.76	38.1	64.5	5.4	6.0	-0.6
4.10	39.1	67.9	2.8	2.2	0.6	3.85	37.1	67.7	5.3	6.3	-1.0
4.10	39.2	68.8	2.6	2.1	0.5	3.83	37.8	65.3	5.1	5.8	-0.7
4.10	39.9	69.6	3.1	1.4	1.7	3.95	37.6	65.5	4.6	5.0	-0.4
4.26	39.5	70.4	1.9	0.5	1.4	3.95	37.8	65.6	4.5	4.8	-0.3
4.36	39.6	71.1	1.1	-0.5	1.6	3.77	38.0	66.1	5.6	6.1	-0.5
4.29	40.1	71.8	1.4	-0.4	1.8	3.91	38.0	67.0	4.9	5.0	-0.1
4.35	39.9	72.3	1.3	-0.7	2.0	3.67	38.5	68.8	6.1	6.5	-0.4
4.05	40.4	73.6	3.0	1.4	1.6	3.94	38.4	67.9	4.4	4.3	0.1
4.15	40.7	74.3	2.0	0.3	1.7	3.85	38.7	68.7	5.0	4.8	0.2
4.09	38.9	68.8	3.1	2.5	0.6	3.83	38.7	69.2	5.0	5.0	0.0
3.98	38.3	67.6	4.2	4.1	0.1	4.03	39.2	70.3	3.6	2.8	0.8
3.97	38.0	65.6	4.1	4.4	-0.3	4.23	39.3	70.4	2.1	1.0	1.1

References

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