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Thermal balance features in the Terelj valley (Mongolia)

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I Introduction

Estimating and foreseeing possible effects of climate changes and human activities on permafrost conditions, as well as developing appropriate strategies for monitoring critical parameters over long periods, are now vital part of long trem environmental and ecological stadies in permafrost zone in Mongolia.

The Khentei Mts. belongs to the mountain forest steppe zone of Mongolia and covers about 25% of Mongolia, and is one of the most heavily populated areas in Mongolia. Its pastures, wood, and water make it an important area for herders and their livestock. The zone is also the site of some densely populated urban areas.

In the Khentei mountain area the continuous distribution of permafrost occupied more than 85% or 14,853 km^2 of territory and discontinuous about 50-85%, sporadic 10-50%. In Gorkhi-Terelj area distributed a seasonal permafrost and occupied 282 km^2. (Sharhuu, 2002).

II Study area

The Terelj valley is located in the middle part of the Khentei Mts., about 45 and 90 km east of Ulaanbaatar, capital city of Mongolia.

The extreme continental climate, permafrost and modification of natural environment due to overgrazing are the fundamental factors affecting to the thermal and water balance of the particular landscape in Mongolia.

Based on the hydrothermal data collected in the Terelj and Nalaikh drainage basin, thermal regime in Khentei Mts. can be determined as extremely variable. The areas mentioned above are block fields with different vegetation cover where precipitation results very specific generation of surface flow and microthermal regime of surrounding areas. Water circulation in the studied areas plays important role into formation of thermal regime. Rates of water infiltration into various kinds of covers are as follows: over 25 mm/min in forest, 2mm/min on the woodless slopes and below 1 mm/min in the valley bottoms.

III Methodology

The radiation balance (R_n) at the ground surface (Fig. 1) can be divided into short-wave (R_t) and long-wave (L_n) radiation (solar and terrestrial radiation, respectively). The net radiation budget can be written as

$$R_n = (1-\alpha)(R_{dir} + R_{dif} + R_{ref}) + \varepsilon_s L_{in} - L_{out}$$
$$= (1-\alpha)R_t + L_n \qquad (1)$$

where R_{dir}, R_{dif}, R_{ref} are direct, diffuse and reflected short-wave radiation, L_{in}, L_{out} are incoming and outgoing longwave radiation, α is the surface reflectance (albedo), and ε_s is the emissivity.

Each component of the budget equation must be treated separately in order to get the most correct estimates. Values for latitude, date, atmospheric transmissions, scattering, ground reflectance, emissivity, temperature, lapse rate and cloud conditions should be known. Sufficient algorithms for slope, aspect, hillshading, and temperature extrapolation must also be incorporated. Here, only the potential short-wave radiation is estimated. Full radiation balance modelling will be provided when more information is available from the two meteorological stations in the study area.

IV Results

In average, the net radiation ranges (table 1) from 5,028 MJ/m^2 to 6,285 MJ/m^2 and an altitudinal gradient in summer time is 8.4-12.6 MJ/m^2, and in winter reaches upto 25.1 MJ/m^2. The peak value of net radiation registered in June month revealing 628.5-712.3 MJ/m^2, and it's minimum value occurred in winter, ranging 125.7-209.5 MJ/m^2.

As shows the long term research in forest steppe zone in Mongolia the radiation balance value in it varies from 1,047 to 1,257 MJ/m^2. The albedo (A_k) amount in the coniferous forest is ranges 0.10-0.15, and in the sedge-grass-forb meadow is 0.21.

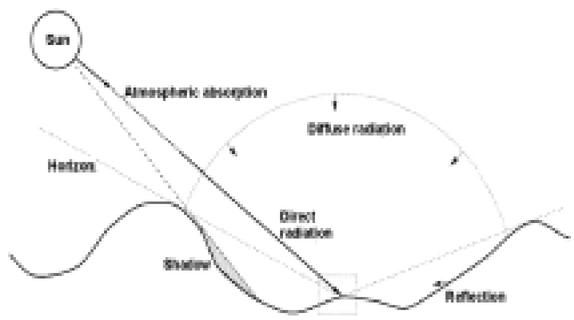

Fig. 1 Schema depicting the radiation balance (*R_n*) at the ground surface, divided into short-wave (*R_t*) and long-wave (*L_n*) radiation, in relation to surface topography. "Horizon" defines the view field from every point, "shadow" defines an area on the surface not directly receiving sun energy. Diffuse radiation is the backscatter of radiation within the atmosphere.

Table 1 Net radiation amount (Q_0) in case of clear sky, MJ/m^2.

Altitude	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
52°	155.0	318.4	532.1	741.6	879.9	963.7	900.8	758.5	595.0	398.0	196.9	125.7
50°	192.7	347.8	561.5	766.8	905.0	980.5	913.4	779.3	620.1	427.4	230.4	159.2
48°	230.4	381.8	590.8	791.9	926.0	993.0	926.0	800.3	645.3	456.7	264.0	192.7
46°	268.2	414.8	620.1	817.0	951.1	1005.6	938.6	821.2	670.4	486.0	297.5	226.3
44°	305.9	448.3	649.4	838.0	972.1	1014.0	946.9	838.0	691.4	515.4	331.0	259.8

Table 2 The climatic and heat balance characteristic near by Ulaanbaatar city.

Month	Climate characteristics									Monthly sum of heat balance components (MJ/m^2)			
	Air temperature,^{0}C	Absolute minimum	Absolute maximum	Wind velocity, m/s	Total cloud	Absolute vapour pressure, mb	Relative humidity, %	Precipitation, mm	Snow depth, cm	Radiation balance	Heat discharge for evapotransporation	Heat exchange with atmosphere	Heat fluxes into soil
1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	-27.4	-48	-4	1.0	3.4	0.6	75	2	5	-8.4	0.0	29.3	-37.7
II	-23.0	-46	4	1.4	3.5	0.8	73	2	5	50.3	-4.19	75.4	-20.9
III	-11.2	-41	18	2.3	4.5	1.8	66	2	2	150.8	25.1	113.1	12.6
IV	-0.5	-22	25	3.5	5.0	2.7	50	7		259.8	46.1	184.4	29.3
V	7.9	-16	31	3.9	5.4	4.6	47	17		297.5	88.0	134.1	75.4
VI	14.8	-5	34	3.4	5.8	8.6	56	49		381.3	130.0	176.0	79.6
VII	17.1	1	39	2.7	6.0	12.0	65	72		343.6	163.4	147.0	33.5
VIII	15.0	-4	37	2.5	5.5	10.5	65	49		326.8	151.0	163.4	12.6
IX	7.5	-14	30	2.5	4.9	6.2	64	27		201.1	25.1	176.0	0.0
X	-1.6	-30	24	2.0	4.2	3.3	65	7		88.0	-4.19	96.4	-12.6
XI	-15.3	-43	13	1.3	4.1	1.5	72	4	2	20.9	-12.6	58.7	-25.1
XII	-25.5	-49	1	0.8	3.8	0.7	75	2	4	-16.8	0.0	25.1	-4.19
Year	-3.5	-49	39	2.3	4.7	4.4	64	240	-	2095	612.0	1378	104.7

In around the Terelj rural area the radiation balance structure as follow:

The turbulent heat exchange between atmosphere and active ground surface is the major portion of the radiation balance and it's monthly values at beginning of April until September ranges 147-189 MJ/m^2. The heat discharge to evaporation is occupied about 29% from annual value of radiation balance. Annual sum of evaporation equal to mean annual precipitation (242 mm. Heat fluxes into soil horizon in spring and summer period reaches 63 MJ/m^2 which is 15-20% from annual radiation balance.

Direct radiation in the Khentei Mts. area varies strongly depending of the angle of incidence and shadowing effects. It also shows considerable annual and daily cycles.

We hope that our joint research collaboration in field of radiation and thermal balance will bring more interesting results.

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