THE INTERDEPENDENCE OF WATER AND TEMPERATURE REGIMES OF TAIGA-ALAS LANDSCAPES SOILS

Desyatkin R.V., Semenova T.N., Desyatkin A.R.
Institute for Biological Problems of Cryotithozone SB RAS, Yakutsk, Russia
677980, 41 Lenin Ave., IBPC SB RAS, Yakutsk, Russia
tel. +7 (4112) 33 64 71, fax +7 (4112) 33 58 12, e-мail: rvdes@ibpc.ysn.ru

The interdependence of the temperature and water regimes of soils on the zone of permafrost is much higher than somethere. This is conditioned by a several features: the development of soils in yearly thawing through layer, the presence of closely bedded moisture-proof aquiclude, the weak heat supply and small quantity of falling precipitations. In such conditions the heat exchange and moisture exchange occurs in thin active layer. The water regime dynamics of meadow soils during investigation period can be determined by fluctuations of weather conditions. During the investigation time the appropriate layers of meadow soils in Ulakhan Sykkhan alas contained significantly much more moisture reserves than meadow soils of Tungulu alas. The obtained results show great dependence between temperature regime and grounds moisture level.

Key words: permafrost, moisture regime, temperature, interdependence

Introduction

The interdependence of the temperature and water regimes of soils on the zone of permafrost is much higher than somethere. This is conditioned by a several features: the development of soils in yearly thawing through layer, the presence of closely bedded moisture-proof aquiclude, the weak heat supply and small quantity of falling precipitations. In such conditions the heat exchange and moisture exchange occurs in thin active layer. The integral index of intensity of heat and mass exchange of soil active layer on cryolithozone conditions is the maximum depth of seasonal thawing through. During years of observations depending on weather conditions of the season the capacity of active layer varies within 1.30 and 1.45 m. in forest; within 2.30 and 2.60 m. on tillage; from 0.80 to 1.30 m. on the edge of forest; from 1.00 to 1.15 m. on the layer of excess moistening; within 1.35 and 1.65 m. on the layer of normal moistening and between 2.50 and 3.30 m. on the layer of insufficient moistening.

Observations location and weather conditions

The interdependence study of water and temperature regimes of soils during 2002-2003 was conducted on two meadow soils of model alases Ulakhan Sykkhan and Tungulu located 4 km from each other. Both soil sites develop in the same natural and climatic conditions under the real meadows on the flat area of central part on aforenamed alases. The dominating species in meadow associations composition are Puccinellia tenuiflora with small mix of Glaux maritime and Polygonum sibiricum. The height of herbage equals to 35-45 cm., the productivity of these meadows in 2002 was 382 tons per km^2 and in 2003 about 404 tons per km^2.

Summer season of 2002 in Central Yakutia was warm and arid. The average temperature of season was 14ºC, while the long-term average equals to 12,2ºC. During the period between May and the end of October the precipitations level made only 90.2 mm, but normal quantity is about 174.9 mm, that is just a little bit higher than long-term average. Summer of 2003 was cooler for 1°C than the warm period of 2002, but it was warmer for 0,8°C than long-term normal average. During the period between May and the end of October the precipitations quantity was 153 mm, while the norm is 143 mm or for a bit higher than the long-term average quantity.

The dynamics of depth of thawing

During whole summer season on every site there is gradual growth in depth of seasonal thawing, that process continues until the third decade of September (see fig. 1).

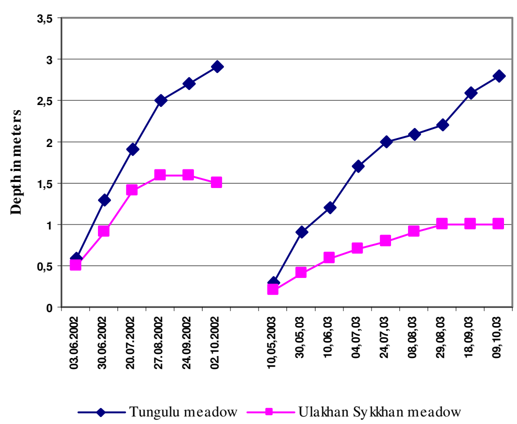

Fig. 1. The depth of soil thawing

The character of dynamics of thawing depth growth in both sites does not have difference, the distinction is only in tempo of thawed layer growth. Meadow soils of Ulakhan Sykkhan alas thawed considerably slower than the soils of Tungulu alas. By the end of season in 2002 the maximum depth of thawed layer in Ulakhan Sykkhan got 1.5 meters, while in Tungulu alas 2.9 meters. In the beginning of season in 2003 soils started to thaw slower than in the beginning of warm period in 2002. The maximum depth of thawed soils in 2003 in comparison with previous summer on Tungulu alas meadows was less for 10 cm and on Ulakhan Sykkhan alas was less for 50 cm. The reduction of thawing depth in 2003 can be explained by the dynamics of weather conditions: the lowering of air temperature and the increase of precipitations quantity in comparison with 2002 year.

Water regime

The initial reserves of moisture in meadow soils of studied alases at the beginning of summer 2002 were almost identical, total moisture reserves in thawed soils layer was about 90 mm (Table 1 and 2). By the opinion of Abolin R.I. (1929) in conditions of permafrost zone, during gradual thawing of frozen horizons get free new conserved moisture reserves, which in capillary way rise up and provide the requirements of plants. By the time of second term of observations became apparent the features of winter moisture reserves in soils. As far

Table 1

Moisture reserves in meadow soils of Ulakhan Sykkhan alas, 2002 (mm)

Depth in cm	04.06.02	29.06.02	20.07.02	26.08.02	25.09.02	2.10.02.
0-10	25,3	26,1	12,5	11,6	27,3	21,6
10-20	23,7	37,0	15,3	16,2	26,3	26,4
20-30	7,8	22,0	14,1	4,9	5,7	23,6
30-40	13,5	38,5	12,0	5,8	8,1	23,3
40-50	19,1	30,4	18,1	5,1	5,2	23,5
50-60		40,8	37,4	9,9	9,5	15,9
60-70		44,0	27,4	13,7	8,3	20,0
70-80		21,8	41,0	13,3	14,4	22,6
80-90		29,9	32,8	14,2	29,8	26,3
90-100		28,4	35,5	30,3	28,6	34,5
100-110		37,9	32,9	33,6	31,3	47,5
110-120			34,0	44,5	31,5	59,9
120-130			28,7	23,3	28,7	36,3
130-140			39,4	28,5	30,8	18,2
140-150			31,1	33,0	28,3	25,3
150-160			39,1	42,5	27,7	37,1
160-170				42,8	31,3	36,4
170-180				43,8	30,4	35,4
180-190				50,9	32,4	
190-200				59,5	33,5	
200-210				51,6	46,1	

Table 2

Moisture reserves in meadow soils of Tungulu alas, 2002 (mm)

Depth in cm	03.06.02	30.06.02	20.07.02	27.08.02	24.09.02	02.10.02
0-10	6,7	12,4	3,5	4,1	15,3	8,5
10-20	21,0	4,6	3,6	1,9	8,5	9,7
20-30	18,8	3,7	2,7	1,4	9,5	5,1
30-40	15,3	6,8	5,0	2,0	10,9	6,4
40-50	28,7	7,9	7,4	2,9	10,8	10,9
50-60		8,0	4,1	3,0	10,1	17,0
60-70		9,5	6,6	12,0	13,7	16,3
70-80		10,9	12,8	13,0	18,8	15,9
80-90		18,4	14,0	13,0	24,4	27,2
90-100		21,5	17,4	15,1	32,1	32,5
100-110		16,6	13,0	19,8	32,5	33,3
110-120			14,2	18,9	23,9	25,1
120-130			17,0	16,7	30,8	26,0
130-140			24,5	15,6	34,3	24,3
140-150			32,0	26,0	33,5	24,6
150-160			18,1	14,9	20,4	16,3
160-170				20,7	21,0	18,3
170-180				23,6	19,9	18,9
180-190				9,6	20,9	22,2
190-200				18,6	18,0	**358,7**
200-210				22,5	20,5	

as thawing the meadow soils of Ulakhan Sykkhan alas with large winter moisture reserves dehydrated less, while the soils of Tungulu alas having less winter moisture reserves dehydrated faster. On the whole the meadow soils of Tungulu alas during summer 2002 were provided by moisture insufficiently, the deficient reserves of mosture is not enough for optimal vegetation of meadow flora. Here takes place the fierce dehydration in the upper one-meter layer, and only at the third decade of September after precipitations during brief period of time the upper soils layers get saturated by the accessible type of soil moisture. During summer season of 2003 the thawed layer of meadow soils contained considerably more moisture reserve than in the same soil layer in 2002 (Table 3 and 4). The appreciable dynamics of water regime in meadow soils during the observation period can be explained by fluctuations of weather conditions.

Table 3

Moisture reserves in meadow soils of Ulakhan Sykkhan alas, 2003 (mm)

Depth in cm	30,05,03	10,06,03	04,07,03	08,08,03	29,08,03	09,10,03
0-10	46,9	56,2	46,5	22,6	37,6	53,0
10-20	59,6	70,2	43,4	29,0	41,3	51,6
20-30	34,0	47,9	40,0	27,3	32,5	30,4
30-40	49,4	66,4	46,8	33,3	39,5	27,8
40-50		57,5	56,0	37,1	47,2	29,0
50-60		72,5	53,2	51,4	55,7	25,4
60-70			74,8	23,0	67,3	8,6
70-80				7,8	10,1	6,2
80-90				8,4	25,5	8,2
90-100					18,6	

Table 4

Moisture reserves in meadow soils of Tungulu alas, 2003 (mm)

Depth in cm	30,05,03	10,06,03	04,07,03	08,08,03	29,08,03	09,10,03
0-10	22,9	15,6	15,6	3,9	20,1	18,8
10-20	21,4	12,9	9,9	11,8	13,8	18,8
20-30	10,8	19,2	21,6	9,5	9,4	11,3
30-40	9,2	15,0	12,0	16,2	12,7	13,2
40-50		14,7	22,1	14,0	7,7	15,8
50-60		15,3	14,0	14,1	12,5	13,2
60-70			10,0	15,7	12,9	15,9
70-80				15,7	13,5	14,0
80-90				31,8	21,6	13,4
90-100					15,1	

As is obvious from the mentioned actual data during the investigation time the appropriate layers of meadow soils in Ulakhan Sykkhan alas contained significantly much more moisture reserves than meadow soils of Tungulu alas.

The temperature regime

The moisture of landscapes's active layer plays important role in forming of the soil temperature regime. As Kononov K.E. noted (1978), in hydromorphous soils the main mass of incoming energy consumes for evaporation and only 10% consumes for thawing of frozen soil and it's heating. In soils with insufficient moistening the consumption of incoming solar energy for evaporation abruptly decreases and about 50% of radiation balance is consumed for thawing and heating of soil active layer.

After snow cover melting process in 2002 spring the investigated soils begin to slowly thaw through and heat up. In upper 0.2 meters-thick layer of Tungulu alas meadow soils the active temperatures were fixed as early as in the beginning of June and continued until the end of August (Fig. 2). Soil temperatures more than >10°C by the middle of July reached to the depth of 0.8 meters. Meadow soils of Ulakhan Sykkhan alas heated up considerably less, the active temperatures penetrated to the depth a bit more than 0.2 meters (Fig. 3).

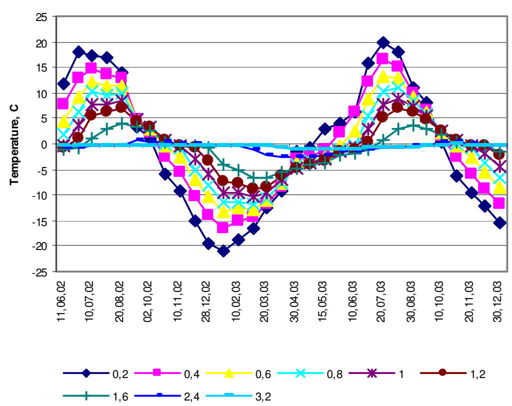

Fig. 2. The temperature regime of Tungulu alas meadow soils

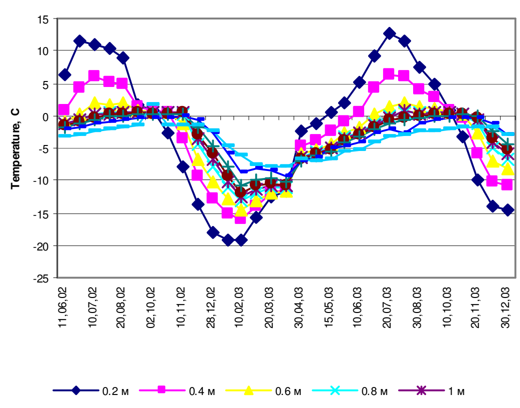

Fig. 3. The temperature regime of Ulakhan Sykkhan alas meadow soils

At both sites exists the dynamics of negative temperatures in the upper layers of permafrost. Thus, the temperature of permafrost upper layers in Tungulu alas meadow soils on the depth of 3.2 meters during all observation period remained nearly 0°C. The amplitude of negative temperatures fluctuations on upper permafrost layer amount -0.2°C. The insignificant temperature rise in upper permafrost layer on this site begins from September-October. Upper layers of permafrost in Ulakhan Sykkhan alas meadow soils are considerably colder than in Tungulu alas. Here temperature fluctuations in permafrost on the depth of 2.4 meters amount from –0,3 to –2,7°C, on 3.2 meters depth from –1,4 to –3,4°C. The maximal rise of negative temperatures in permafrost upper layer on this site noted in October.

Thawing process of surface soil layers in the beginning of warm season in 2003 started at the last decade of April. The summer of 2003 was cooler and more humid than summer of 2002, as the effect of this the soils accumulated less heat, that brought to reduction of thawing layer's thickness in Ulakhan Sykkhan akas meadow soils almost for 2 times less. The temperature regime of more moistened soils in Ulakhan Sykkhan alas meadows were also significantly colder than meadow soils of Tungulu alas. The difference of temperatures at the middle of summer in 0.2 meters thick layer reached more than 5°C. The Temperature in 0.2 meters layer of Ulakhan Sykkhan alas soils was about 9,2-12,6°C, and in soils of Tungulu alas was between 15,8-19,7°C (Fig. 2 and 3). The similar tendency remained in all depths and dates.

Thereby, the obtained results show great dependence between temperature regime and grounds moisture level.

The interdependence of regimes

It is determined that in forming of thermal regime of meadow soils the moisture reserves in soil active layer play a big role. At winter season all adsorbed moisture in soil turns into ice. When moistened soil freezes it requires more negative temperatures than freezing of dry soil. The specific heat capacity equals to 4.186 kilojoules (kilogram·K), so accordingly while freezing of each gram of soil required the corresponding quantity of heat. Hence, soils containing more moisture while conversion of water to ice during autumnal and winter period extract more heat for water crystallization. During winter such soils accumulate a big amount of coldness.

The reverse effect is observed while thawing of moistened soils, it requires more heat for melting of soil ice. The warmth of melting of ice equals to 249,9 joules per gram, consequently for thawing of moistened soil it needs according quantity of energy. For example, at autumn 2002 in active layer of Ulakhan Sykkhan alas meadow soils the content of moisture was 6337 tons per hectare, and in soils of Tungulu alas was 3587 tons per hectare. In 2003 correspondingly 2402 and 1345 tons per hectare. Accordingly for freezing and thawing processes of Ulakhan Sykkhan alas soils it needed in 2002 a 1.77 times more energy and in 2003 1.78 times. As a result of such case soils of Ulakhan Sykkhan alas thawed for less depth and heated up considerably slower than soils of Tungulu alas.

Thereby, on the zone of permafrost the moisture level of active layer presented as the determinative factor of soil temperature regime.

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