Dynamics of active layer and spring icing at Terelj observation sites, Mongolia

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I Introduction

Long-term researches of Joint Japan – Mongolian IORGC project have been concentrated and conducted in discontinuous permafrost zone of Nalaikh and Terelj areas near Ulaanbaatar last over 2 years. One of the main topics of the project is to observe dynamics of active layer and spring icing at Terelj observation sites. The active layer is ground conditions of annually thawing and freezing in areas underlain by permafrost. Icing is a sheet-like mass of ice layers formed on the ground surface by freezing of successive flows of water that may seep from the ground, flow from a spring through fractures. Depending on source water, icing can be categorized into one of spring icing, ground icing and river icing. Icing observation is very important to consider winter active layer dynamics that influence land-surface hydrological processes and to predict their near-future changes under influence of current climate change and human activities.

II Observation sites

The observation sites are located in small Shijir valley near Terelj village. The observation for dynamics of icing has been conducted at Shijir spring site located in upper part of the valley bottom. Continuous and discontinuous permafrost is characteristic of the north-facing forested slopes of the valley. Isolated and sporadic permafrost is developed on north-facing low gentle slope without forest and at some swampy sites of the valley bottom. The freezing and thawing states of icing were represented by soil temperature records at site D located on north-facing forested slope of the valley.

Table 1 Dynamics of active layer.

Dates	2003								2004		
	15-Apr	15-May	15-Jun	15-Jul	15-Aug	15-Sep	15-Oct	15-Nov	15-Aug	15-Sep	15-Oct
Depths, m	0.1	0.7	1.4	2.1	2.24	2	2.3	2.2	2.35	2.42	2.48
Percent, %	4	29	58	88	92	91	96	92	92	95	97

Table 2 Dynamics of icing.

Dates		Area, m^2	Average thickness, m	Volume, l	Water discharge, l/sec
2003	15.Septemer	947	0.055	47719.49	
	17.December	1612	0.248	363967.24	0.39
2004	18. January	4809	0.346	1515183.67	4.16
	03.February	5647	0.633	3251126.06	12.56
	17.February	7372	0.600	4024444.06	6.39
	03.March	10042	0.664	6067451.39	15.76
	24.March	11602	0.685	7234537.31	6.43
	16.April	17745	0.560	9039798.95	9.08
	04.May	8056	0.421	3085886.44	
	18.May	1198.4	0.122	133278.60	

III Methods applied

Temperature sensors are set at the depths of 0, 20, 40, 80, 120, 240, 280 and 325 cm. The ground thermal condition of the active layer during last 2 years is shown in a graph of soil temperature isopleths. Discharge of spring water and area of spring icing in February of 2003 were estimated by means of using weir and making leveling measurement, respectively. Volume of spring icing during last winter and spring was studied on the basis of making leveling measurements twice per month in the points of the certain grid. The leveling points are distributed every 10 m along 14 parallel profiles. Distance between each profile was 20 m. Through this measurement, we could estimate area and thickness of icing and discharge of spring water depending on dates of the measurements (in graphs and tables).

IV Results

Materials of active layer at the site D are composed of debris with silt and sandy fill. Mean annual soil temperatures at a depth of 3.2 m were -0.94 °C, thickness of permafrost was estimated to be about 15 m and depth of active layer was 2.31 and 2.48 m in 2003 and 2004, respectively. According to Table 1, seasonal thawing of ground begins from 13th April, reaches 73% of active layer by 1st July and finishes in late September. Refreezing of the active layer starts from 22nd October and finishes in the beginning of December. Therefore, seasonal freezing and thawing of active layer in autumn and spring occurs with high rate or gradient.

Dates of beginning active icing processes have fixed on 10th December 2002 and on the 13th January 2004. Temperature of Shijir spring waters during winter and spring was about. 0.2-0.3 °C. Discharge of spring waters was 0.25 l/sec and 0.08 l/sec by 16th December 2002 and 13th February 2003, respectively. Discharge of spring waters during last winter and spring was very changeable and relatively high (see Table 2). Maximal spring icing was observed by mid April 2004. By this time area of icing is 17,745 m^2, average thickness 0.56 m, and volume of icing reaches 9,934 m^3.

Discharge of spring waters varies from 0.4 l/sec to 15.8 l/sec by 17th December, 2003 and 3rd March, 2004, respectively. Thickening of icing area occurs in transitional form from one to other side of brook channel depending on duration, climate condition and human activities for example, new thickening of icing or small aufeis are formed in the places where people drilled hole on icing for drinking waters.

V Conclusions

Thickness of active layer in areas of discontinuous permafrost is relatively higher than in areas of continuous permafrost. High rate of seasonal thawing of active layers occurs in May and June, and high gradient of its refreezing in November.

Shijir spring icing is related to small and middle size of icing formation. Spring icing processes start in December, active icing is formed from January to mid April, and degradation of the icing is observed in May. The most active spring icing has observed last winter.

Dynamics of active layer and spring icing is very changeable and different depending on climate and hydrological condition, soil freezing and temperature regime and also on human activities.