УДК556.555.2
DOI: 10.17816/edgcc34019

HYDROMETEOROLOGICAL CONDITIONS AND WATER REGIME OF THE LAKE KRASILOVSKOYE (ALTAI KRAI) IN 2013 2017

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Citation: Sutorikhin I.A., Samoilova S.Yu., Kolomeitsev A.A., K urakov S.A. 2020. Hydrometeorological conditions and water regime of the basinal freshwater lake Krasilovskoye (Altai Krai) in 2013-2017 // Environmental dynamics and global climate change. V. 11. N.1. P. 49-53

DOI: 10.17816/edgcc34019

Text of the article in English https://edgccjournal.org/EDGCC/article/view/34019

The paper presents the analysis of the data on monitoring the hydrological state of the basinal freshwater lake Krasilovskoye (Altai Krai) and hydrometeorological conditions in its catchment in 2013-2017. The data from the automated measuring complex developed at the Institute of monitoring of climatic and ecological systems of SB RAS as well as the data on snow surveys carried out by researchers from IWEP SB RAS in the catchment and water area of the lake are used. Observations of water regime in the basin lake in the years with contrasting hydro climatic conditions made it possible to identify the dominant factor determining its spring filling and to quantify its level dynamics. The magnitude and rate of level rise in spring mainly depend on hydro climatic conditions of air and soil of the previous cold period, which in turn determine the ratio of surface and underground runoff in spring.

It was found that in the winter of 2014 and 2016, hydro climatic conditions of the cold period contributed to the freezing of soil and the formation of a "locking" ice layer, which prevented vertical infiltration of melt water. Intensive surface runoff induced a drastic level rise up to 1-1.5 m. In 2015 and 2017, at the absence of soil freezing, the water rise was much lower, despite large snow reserves and intensive snowmelt. In the spring of 2017, the driven out to the water surface diluted near bott om layer enriched with hydrogen sulfide caused mass fish death after insignificant water inflow to the lake.

Keywords: basinal lake, monitoring, lake level, snow reserves, freezing, snowmelt

INTRODUCTION

In recent decades in Western Siberia a decline of lakes water availability is observed in forest steppeand steppe zones at Ishim, Barabinsk and Kulundid plains, the decline is involved with climate warming andaridization processes. The analysis of longstanding fluctuations of large lakes level has indicated its entwinement with climate aspects. Whereby, different lake systems react differently to climate changes [Shitnikov, 1950, 1957; Doganovski, 1978; Adamenko, 1985; Galahov, 2011; MeLanghin and Cohen, 2011; Harlamova, 2013]. Minor basinal lakes are frontier due to the lack of hydrometeorological information.

The basinal lakes hydraulic regime burgeons under a host of factors which determine a moisture entrance on the territories of lakes and water collection. We have used a measuring system MAAMF which had been produced at IMCES SBRAS (institute of monitoring of climatic and ecological systems of the Siberian Branch of the Russian Academy of sciences, Tomsk) and located on territory of academic training campus "The Lake Krasilovskoye" of Altai State University in 2013 year for solving the water body complex monitoring problems.

It allows getting information about main meteorological parameters of atmosphere and soil, snow cover height, lacustrine and groundwaterlevel in off line mode. Furthermore annual snow survey data is conducted by researchers from IWEPSBRAS (Institute for Water and Environmental Problems of the Siberian Branch of the Russian Academy of Sciences) upwards 2015. The monitoring and analysis of hydrometeorological conditions on the water collection of Lake Krasilovskoye and also estimating of its influence over the water level during a snowmelt period were the aim of present work.

THE TARGET OF RESEARCH

The basinal Lake Krasilovskoye is located on the southeast of West-Siberian plain. The datum level of region is about 220 m, the water collection and the face of lake areas are 46,11 and 0,8 km^2 respectively, the length of lake – 2,4 km, the average width – 0,33 km, the average depth – 2,7 m, maximum depth – 6,5 m. The lake has basinal regime, raven upon surface-and groundwater. In the recent decades a sizable lakes fall off occurred: thus in 1978 its maximum depth was 12 m, in 1998 – 8 m. The existence of terrace deposits betrays in the past Lake Krasilovskoye has had larger sizes. A tendency of lake evolution is silting and overgrowing [Lusgin, 1998; Sutorihin et al., 2014; Zuev et al., 2016].

METHODS OF RESEARCH AND PRIMARY MATERIALS

At a fundamental level were data from measuring system MAAMF (multiparametric automated agro-industrial measuring facility). It takes a measurement in online mode with regular intervals in convenient for researchers range (in our case -15 min) of the following parameters: the intensity of total and the diffuse solar radiation, an atmospheric pressure, the temperature and the relative humidity (at the height of 2-4 m), the amount of liquid precipitations, the snow cover height, the ground temperature (from surface to 3,2 meters), the lake level.

From 2015 researchers from IWEPSBRAS have been conducting an annual snow survey in three routes: at forest, on field and directly on a lakescape for parameters of snow cover analysis. The snow surveys are conducted during the second part of winter before a snowmelt starts, athickness, the density, the water content in snow are determined. Field surveys and laboratory investigations of observations are conducted within standard requests [Bykov and Popov, 2011]. Meteorological data of Troitskoye observation station from website “Weather and climate” and database IWEPSBRAS were used for estimating long-time annual average hydro-climatic parameters of this region and for verification of data of monitoring attendance.

THE MAIN RESULTS AND DISCUSSION

Authors have analyzed annual hydrometeorological data from the beginning of October till Match which represent the processes of snow accumulation, snowmelt and connected with two above mentioned spring running water (table 1). A number of retrieved in 2013–2015 data have been published previously [Zuev et al., 2016].

The behavior of daily-average atmospheric temperatures at the altitude of 2 meters and the ground temperatures at the altitude of 5 and 30 cm according to MAAMF is represented on picture 1. A dynamic of snow cover height, a summary of liquid precipitations and lake level are represented on picture 2. The height of water level is represented in terms of excess above hydrostatic device till 2015. Subsequently a device reinstallation and its orienteering to Baltic system of elevations were realized in summer 2015; the water level is represented in absolute elevations.

Authors had a capacity to see contrast hydrometeorological conditions during 4 years of investigations. The maximum water upraise which was more than over 1,5 m higher than winter one was seenin spring 2014 (table 1, fig. 2a). Whereby the summary of liquid precipitations, the height of snow cover and the snow reserves were essentially smaller than in the following years when water upraise didn’t rich the altitude of 1 meter. The main factor that determined high lake level in 2014 was wide soil freezing in winter 2013–2014 [Zuev et al., 2016].

Certainly the lower atmospheric temperatures are during a snow cover formation and the lower level of precipitations is themore intensive the process of soil freezing is [Burakov and Ivanova, 2010]. In a present year the quantity of precipitations in October-November was lower than long-time average annual standard over 20 %, a formation of stable snow cover took place in 22nd of December, the strong and longstanding frosts have been seen during the winter and the snow reserves were lower over 1,5 m than long-time average annual ones.The soil freezing reached the depth of 30 cm in the middle of February (fig. 1a).

Subsequently, during sizable thaw period in 20th-23rd of February 2014 glacial “blockade” layer was formed due to water soaking into the surface layers of freezing soil. An irriguous frozen soil becomes almost impermeable at a temperature of 2-3 subzero degrees [Popov, 1968]. Thus an intensive accumulated melt-water runoff occurred into the lake during the snowmelt period. During the autumn-winter period 2014-2015 the ground freezing absented (fig. 1, b) through tall snow cover and an abundance of precipitations during previous period. The speed and the height of water rise up in the lake were essentially fewer compared to last year (table 1, fig. 2b) in the result of intensive melt-water infiltration. In spring 2015 the snowmelt occurred much earlier compared to the average period of snowmelt due to early (8th of April) appearance above-zero daily average temperature and sudden warming. However it hasn’t affected the lake interpenetration: an intensive water rising began after 7 full days later on the snowmelt period.

In the beginning of winter 2015 the ground mercury pushed 0 degrees C in the layer depth to 5 cm. The reason of the ground freezing was little amount of precipitations in the autumn 2015 and also the height of snow cover was lower compared to annual average standard. The interchange of frost and thaw periods with exudation of liquid precipitations promoted “blockade” frozen horizon formation and melt-water runoff from the water collector without sizable infiltration wastage.

DOI: 10.17816/edgcc34019.

The hydrometeorological conditions differed from long-time annual average standard during 2016-2017. A rainy autumn took priority of winter: in October 2016 the summery of precipitations exceeded the long-time annual average standard in 2 times, that promoted water saturation of water collector and water rising to mark of 214,1 m (for reference in autumn 2015 the water level was 60-70 cm lower (fig. 2c) and arrived at 213,4-213,5 m). The snow cover formation occurred in unprecedented short period- in the second ten-day period of October. Even in below-freezing conditions (-34,5°C) in November the ground temperature continued to be above zero on 5 depth (fig.1d). The tall snow cover and snow reserves prevented ground from freezing during all winter. In these conditions a permanent infiltration of melt-water into the ground existed and land runoff was minimal. Despite tidemarks arrived at 214,4 m in 2016 and 2017 the speed of water rising was slowerand its size was only 40 cm.

It was discovered that near bottom layer is enriched by hydrogen sulfide during water sample collection in layer-by-layer subsequence by barometer in freeze-up period. The hydrogen sulfide is one of products of rotting in the silty layer which has a thickness of 50-70 cm and riches 120 cm in some regions accordingto our examination. In spring 2017 near bottom layer was supplanted to the surface due to temperature overturn in nature's way. The mass fish mortality has been occurred due to insufficient indraught of melt-water.

Thus primary focus of water rising is onthe ground freezing in the water collector.

The ground freezing and the formation of glacial "blockade" layer in 2014 and 2016 promoted the intensive runoff of melt-water and sudden water level rising on the height of 1-1,5 m before the snowmelt period. In years when freezing was absent (2015 and 2017) spring water indraught in lake occurred mostly by groundwater run while the water level rising proceeded after snowmelt period and was less intensive. Over the years of measurement the depth of freezing hasn't exceeded 30 cm.

CONCLUSION

The hydrometeorological parameters of water collector of Lake Krasilovskoye and the spring level regime were analyzed in different years by means of measurement data of system MAAMF and snow surveys.

The monitoring of basin al freshwater lake Krasilovskovoye regime in years with fundamentally different hydroclimitic conditions allowed us to reveal the main factors which determine the spring water rising. To the greatest extent the water indraught and the value of level rising depend on the ground condition at the water collector that determines a relation between ground and underground water runoffs during the snowmelt period.

The monitoring of hydroclimatical parameters of minor basinal lakes basins by means of automatic systems "MAAMF" type gives an opportunity to have more assessment and prediction of its water availability in changing climate conditions.

REFERENCES

1. Адаменко В.Н. 1985. Климат и Озера. Ленинград: Гидрометеоиздат, 264 с. [Adamenko V.N. 1985. Klimat i Ozera. Leningrad: Gidrometeoizdat. (In Russian)].
2. Бураков Д.А., Иванова О.И. 2010. Анализ формирования и прогноз стока весеннего половодья в лесных и лесостепных бассейнах Сибири // Метеорология и гидрология. № 6. С. 87–100. [Burakov D.A., Ivanova O.I. 2010. Analysis of formation and forecast of spring snowmelt flood runoff in forest and forest-steppe basins of Siberian rivers // Russian Meteorology and Hydrology. V. 35. P. 421–431. (In Russian)].
3. Быков Н.И., Попов Е.С. 2010. Наблюдения за динамикой снежного покрова в ООПТ Алтае-Саянского экорегиона. Красноярск: Город. 64 с. [Bykov N.I., Popov E.S. 2010. Nablyudeniya Za Dinamikoy Snezhnogo Pokrova v OOPT Altae-Sayanskogo Ekoregiona. Krasnoyarsk: Gorod. (In Russian)].
4. Галахов В.П. 2011. Оценка увлажнения юга Западной Сибири с помощью палеолимнологических реконструкций озера Чаны. Барнаул: Изд-во АлтГУ. 120 с. [Galakhov V.P. 2011. Otsenka Uvlazhneniya Yuga Zapadnoy Sibiri s Pomoshch'yu Paleolimnologicheskikh Rekonstruktsiy Ozera Chany. Barnaul: Izd-vo AltGU. (In Russian)].
5. Догановский А.М. 1978. Закономерности многолетних колебаний уровней оз. Кулундинского // Водные ресурсы Алтайского края, их рациональное использование и охрана. Барнаул. С. 109-112 [Doganovskiy A.M. 1978. Zakonomernosti mnogoletnikh kolebaniy urovney oz. Kulundinskogo // Vodnye Resursy Altayskogo Kraya, Ikh Ratsional'noe Ispol'zovanie i Okhrana. Barnaul. P. 109–112. (In Russian)].
6. Зуев В.В., Зуева Н.Е., Кураков С.А., Суторихин И.А., Харламова Н.Ф. 2016. Динамика весеннего подъема уровня бессточных озер (на примере озера Красиловское Алтайского края) // География и природные ресурсы. № 4. С. 126-134. [Zuev V.V., Zueva N.E., Kurakov S.A., Sutorikhin I.A., Kharlamova N.F. 2016. Dinamika vesennego pod'ema urovnya besstochnykh ozer (na primere ozera Krasilovskoe Altayskogo kraya) // Geography and Natural Resources. V. 4. P. 76–80.] doi: 10.21782/GIPR0206-1619-2016-4(76-80)
7. Лузгин Б.Н. 1998. Происхождение Красиловского озер // Изв. Алт. Ун-та. Сер. Химия, география, биология. № 4. С. 113-116. [Luzgin B.N. 1998. The origin of the Krasilovo lake // Izvestiya of Altai State University. V. 4. P. 113–116. (In Russian)].

DOI: 10.17816/edgcc34019.

8. Погода и климат. URL: http://www.pogodaiklimat.ru/ (дата обращения: 20.02.2019). [Weather and climate. URL: http://www.pogodaiklimat.ru/ (the data of access: 20.02.2019).
9. Попов Е.Г. 1968. Основы гидрологических прогнозов. Гидрометеоиздат, Ленинград: 294 с. [Popov E.G. 1968. Osnovy Gidrologicheskikh Prognozov. Leningrad: Gidrometeoizdat. (In Russian)].
10. Суторихин И.А., Букатый В.И., Харламова Н.Ф., Акулова О.Б. 2014. Сезонные изменения спектральной прозрачности и концентрации хлорофилла в разнотипных озерах // Оптика атмосферы и океана. № 27. С. 801-806. [Sutorikhin I.A., Bukaty V.I., Akulova O.B. 2014. Seasonal changes of water spectral transparency and concentration of chlorophyll a in different-type lakes // Atmospheric and Oceanic Optics. V. 27. P. 801–806. (In Russian)].
11. Харламова Н.Ф. 2013. Оценка и прогноз современных изменений климата Алтайского региона. Барнаул: Изд-во АлтГУ. 156 с. [Kharlamova N.F. 2013. Otsenka i Prognoz Sovremennykh Izmeneniy Klimata Altayskogo Regiona. Barnaul: Izd-vo AltGU. 156 pp. (In Russian)].
12. Шнитников А.В. 1950. Внутривековые колебания уровня степных озер Западной Сибири и Северного Казахстана и их зависимость от климата // Труды лаб. озероведения. С. 28-129 [Shnitnikov A.V. 1950. Vnutrivekovye kolebaniya urovnya stepnykh ozer Zapadnoy Sibiri i Severnogo Kazakhstana i ikh zavisimost' ot klimata // Trudy Lab. Ozerovedeniya. P. 28–129 (In Russian)].
13. Шнитников А.В. 1957. Изменчивость общей увлажненности материков Северного полушария // Зап. Геогр. о-ва СССР. Нов. серия. М.; Л.: Изд-во АН СССР. С. 264-266 [Shnitnikov A.V. 1957. Izmenchivost' obshchey uvlazhnennosti materikov Severnogo polushariya // Zapiski Geograficheskogo Obshchestva SSSR. Novaya Seriya., Moscow-Leningrad: Izd-vo AN SSSR. P. 264–266
14. MeLanghin D.L., Cohen M.J. 2011. Thermal artifacts in measurements of finescale water level variation // Water Resources. V. 47. W0901.

Table 1. Hydroneteorological conditions and water level rising in Lake Krasilovskoye in 2013-2017.

Indicator	Observations period		
	01.10. 2013 10.05.2014*	01.10.2014 10.05.2015*	01.10.2015 10.05.2016
The date of stable snow cover formation	22th of December	17th of November	9th of November
The quantity of liquid precipitations during snow cover formation period (October-November), mm	125,4	167,4	81
The average height of snow cover in the start of snow melt period, mm	750	825**	640**
The water storage in snow cover in the start of snow melt period, mm	~50	249**	187**
The period of intensive snow melt	12-30th of March (19 days)	6-14th of April (9 days)	23.03-08.04 (16 days)
The average atmosphere temperature during the period of intensive snow melt, ^{o}C	1,6	4,1	2,7
The quantity of liquid precipitations during the snow melt period, mm	0	41,6	14
The start of spring water rising	20th of March	20th of April	30th of March
The value of spring water rising, mm	1540	630	1000

Note: * data from previousl y published materials [Zuev et al., 2016];
** based on snow surveys data

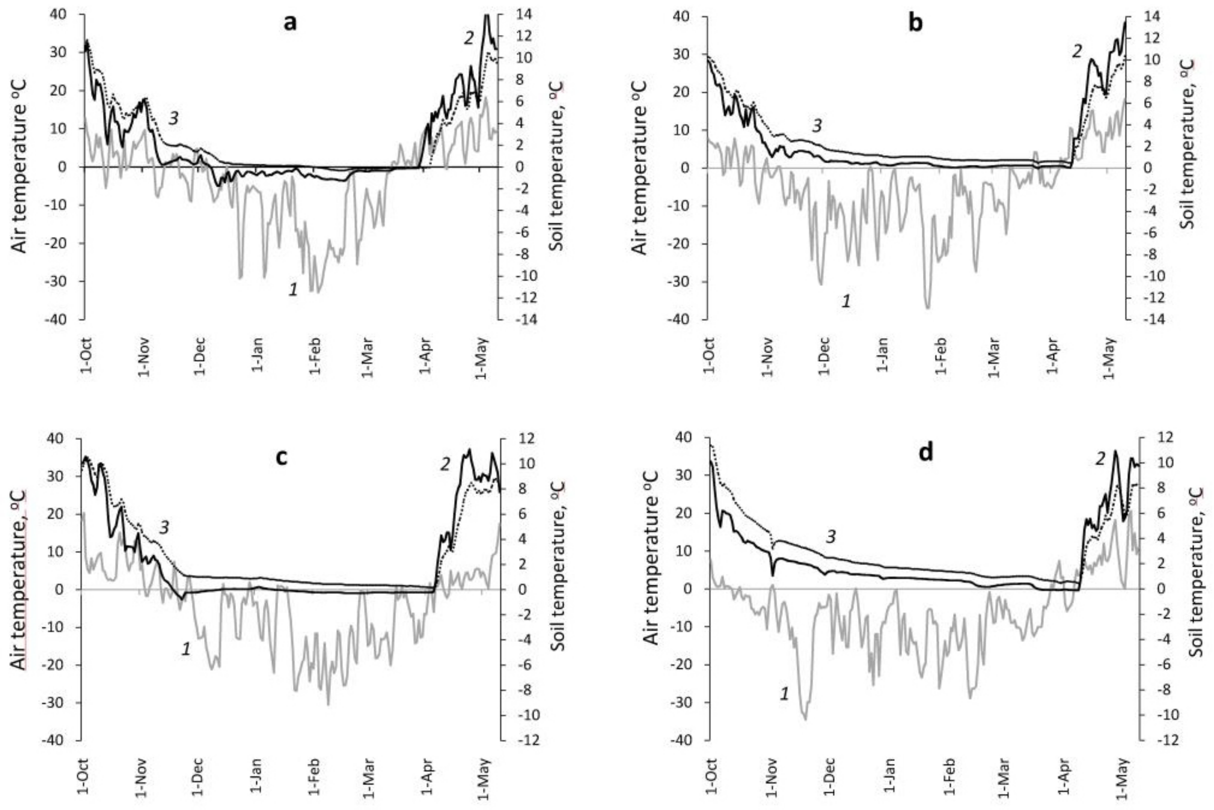

Fig. 1 Tha average daily temperatures of ground : **a** – in 2013-14, **b** – in 2014-15 , **c** – in 2015-16; **d** – in 2016-17. **1** – The atmosphere temperature at the altitude of 2 m; **2** – the ground temperature at depth of 5 cm; **3** – same but at depth of 30 cm.

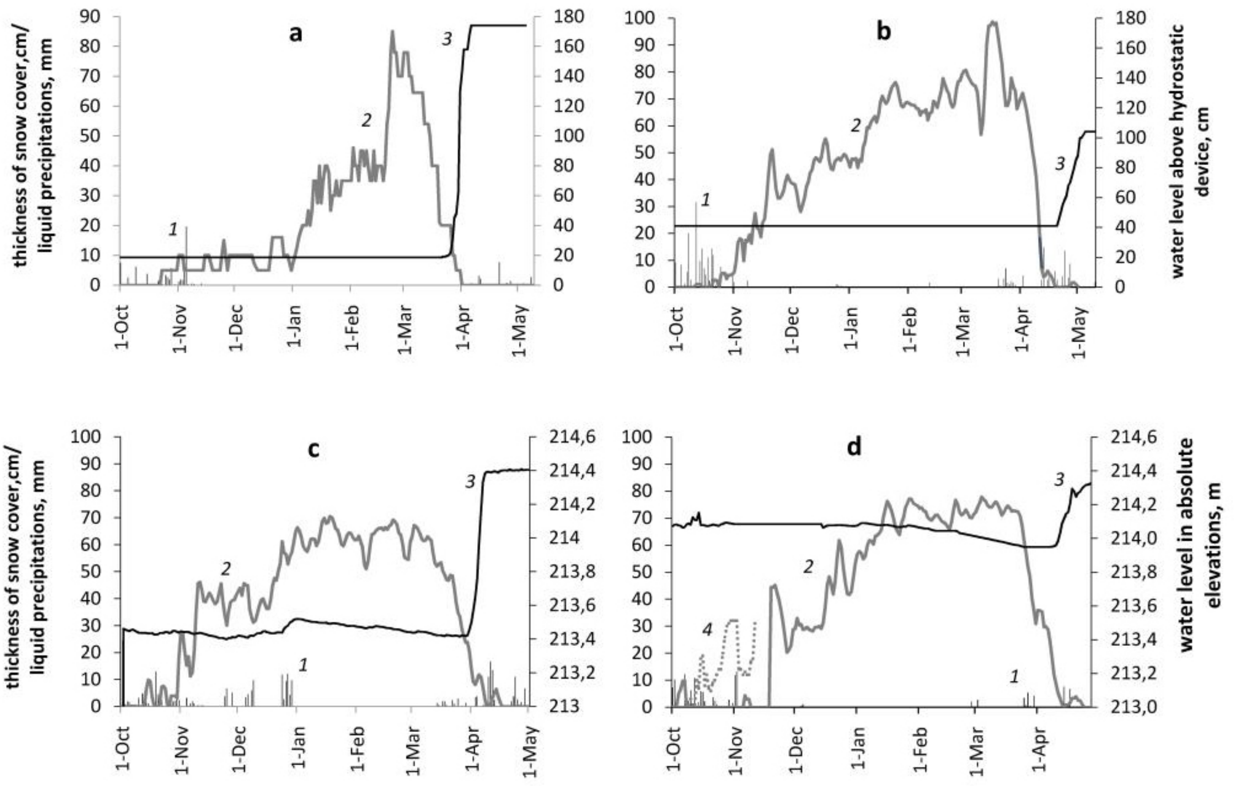

Fig. 2 – dynamics of snow cover height, the water level in lake and liquid precipitations according to MAAMF database: **a** – in 2013-14, **b** – in 2014-15, **c** – in 2015-16; **d** – in 2016-17. **1** – liquid precipitations, mm; **2** – thickness of now cover, cm; **3** – water level; **4** – thickness of snow cover (represented according to HC (hydrometeorological centre) Troitskoe due to faulty operation in snow cover sensor MAAMF)