Peculiarities of weather and ground freezing conditions in Siberia and Russian Arctic in winter and spring period of 2019/2020

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Abstract. As a reason of anomalous warm winter 2019/2020 in Russia, as well as in Europe and USA along with the global warming is considered a non-typical situation in Arctic, where the extremely stable area of low pressure in the vicinity of North Pole was present during long time period and which does not let the cold air masses to move away from its borders. Such situation lead to the consequence, that on the most of the territory of Russia, USA, Northern Europe and Eastern Canada the temperature of winter months was on a few degrees more than usual. Due to these warm winter months 2019/2020, largely increasing in recent decade’s amount of snow and snow cover thickness and hot spring months 2020 in Siberia and Russian Arctic the winter ground freezing was not very intensive and active layer thickness at the beginning of the summer was rather high. This led to the oil tank construction damage in Norilsk on 29 May 2020 due to the instability of the basement and catastrophic oil spill into the river happened.

1. Introduction

The climatic factors, such as temperature conditions and snow cover thickness undergo a change and variations. Variations of climatic conditions, snow cover thickness and coupled with it ground freezing depth also leads to permafrost thawing and the damage of constructions and pipelines, the landslides on the slopes. In particular in relation to recent decade’s climate alteration at least in the Arctic, the growth of ground temperature and increase of seasonal thawed layer is observed. Summary effect from alteration of air-temperature and snow cover thickness can result in additional few degrees heating (+2+3°C). It is not critical for permanently frozen ground with the temperature of -8-10°C, but for the permanently frozen ground with the temperature of -3-5°C and higher this may lead to thawing and increase of seasonal active layer.

As a reason of anomalous warn winter 2019/2020 in Russia, as well as in Europe and USA, is considered non-typical situation in Arctic, where the extremely stable area of low pressure in the vicinity of North Pole was present and which does not let the cold air masses to move away from its borders. Such situation lead to the consequences that on the most of the territory of Russia, USA, Northern Europe and Eastern Canada the temperature of winter months was on few degrees more than usual (figure 1). And the spring months 2020 in west and central Siberia and in the Russian Arctic was also very hot (figure 2).
2. Materials and methods

According to measurements of the temperature in the borehole in the vicinity of Norilsk, the temperature of the permafrost at a depth of 6 to 18 meters is -2°C. This means that temperature of permafrost there is rather high and the permafrost there is rather vulnerable.

Average annual air temperature according to the nearby Igarka weather station (http://meteo.ru [3-4]) for 1931-2020 was -8°C and had a positive trend in the last 1970-2020. The average air temperature of the warm months (May-August) for 1931-2020 was 10.4°C and the cold months (September-April) -17°C, respectively (figure 3).

Also at the CALM polygon (Talnah) (according to [5]) there the active layer for the time interval from 2005 to 2019 had an average value of 95 cm with an average trend of 1.3 cm increase per year amounting to 90 cm at the beginning of the period and more than 100 cm on average at the present time (figure 4).
Figure 3. The average air temperature of the warm months (May-August) and the cold months (September-April) for 1931-2020.

Figure 4. Active layer thickness at CALM polygon (Talnah).
According to [6], particularly the thickness of the active layer at CALM polygon (Talnah) varies from 45-50 cm to 125-150 cm, depending on landscape-specific conditions. The maximum thickness of active-layer is observed at landscapes represented by sparsely-vegetated patterned ground and dry hillocks. The minimum ALT was found in the polygonized peatlands. The maximum three-year grid average ALT is 87.3 cm, with minimum 50 cm, maximum 126.5 cm, and standard deviation is relatively small and does not exceed 15 cm.

According to the Igarka weather station data [3, 4], the air temperature in Igarka in November of the winter-spring period 2019/2020 was -20.6 °C, with an average norm for 1981-2010 value -20 °C. In December, it was -20.9 °C (with an average norm of -25.36 °C), in January -20.9 °C (with -26.9 °C), in February -16.1 °C (with -25.5 °C), in March -13.8 °C (with -17.9 °C), in April -0.3 °C (with -11.1 °C) and in May 6.2 °C (with -1.4 °C) (Figure 5).

![Figure 5](image)

**Figure 5.** Mean air temperature in the winter-spring months of 2019/2020 and average, maximum and minimum monthly values for 1981-2010.

The sea ice area in the Laptev Sea was also at an all-time low for the end of June 2020, as it was in the entire Arctic sector of Russia. The area of sea ice in the Arctic Ocean for the end of June 2020 was 260,000 km² less than in the 2010s, 930,000 km² less than in the 2000s, 1,540,000 km² less than in the 1990s, and 2,150,000 km² less than in the 1980s [7].

3. Results and conclusion

The air temperature in the winter-spring months (November-May) in west and central Siberia and Russian Arctic exceeded the long-term 1981-2010 averaged values on 4-6°C. Due to such warm winter months 2019/2020, largely increasing in recent decade’s amount of snow and snow cover thickness [8] and hot spring months of 2020 in West and Central Siberia and Russian Arctic the winter ground freezing was not very intensive and active layer thickness at the beginning of the summer was rather high. This led to the oil tank construction damage in Norilsk on 29 May 2020 due to the instability of the basement and catastrophic oil spill into the river happened.

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