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Variation of snow making hours on the slopes of Moscow region in recent years †

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Abstract: Ongoing climate variations and variation of winter weather conditions in recent years in Moscow region strongly influence on hill skiing industry. Conducted in the work calculations of possible snow making hours and theirs variations in recent years allows making conclusions about ongoing changes and possible consequences in future.

Keywords: winter temperature; winter precipitation; snow making hours; Moscow region

1. Introduction

In the recently published regular annual report of Russian Hydromet is stated the acceleration of climate change in Russia. Taking into account the data of 2020, the increase in temperature over ten years amounted to 0.51 degrees Celsius, with the world average of 0.18 degrees. According to this report, the estimates of the rate of climate change from the 1970s to the present were updated, which indicates an increase in change. So the winter season (November-March) 2020/2021 in Moscow was colder (-3.9°C) than the previous winter seasons 2013/14-2019/20 (-1.08, -1.96, -1, 88, -3.46 -3.6, -3.1, 1.24°C), but warmer than 2009/10-2012/13 (-5.66, -5.08, -4.3, - 5.1°C) (Fig. 1). For the winter period of 2020/21 the average amount of precipitation was 253 mm (Fig. 2). The average February snow cover thickness was slightly higher than its average value in recent years (44.9 cm) (Fig. 3). The snow cover onset in the winter season 2020/2021 was at the beginning of December and lasted until the end of March-beginning of April. During this time, cold waves with a drop in temperature to -10 - -20°C were replaced by thaws with a small positive temperature of about five times (Fig. 4).

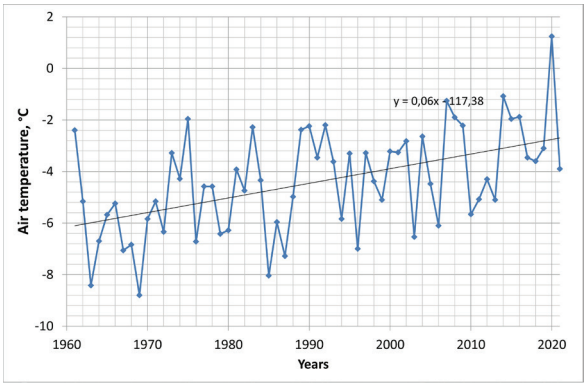

Figure 1. Variations of air temperature in winter months (November-March) in Moscow for 1961-2021.

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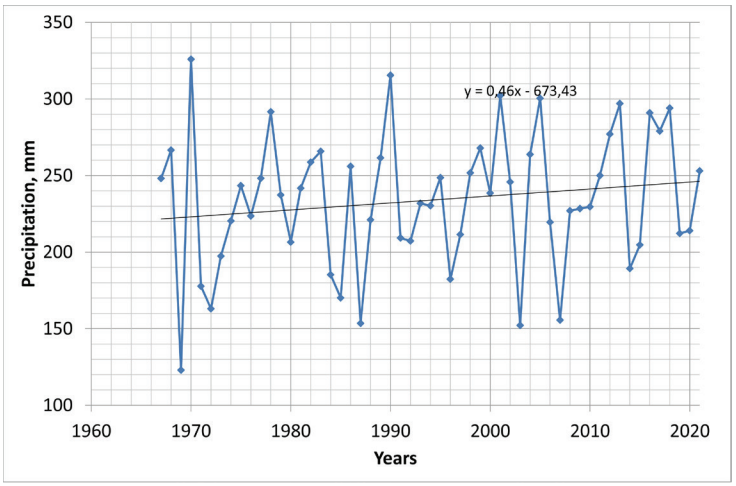

Figure 2. Variations in the amount of precipitation in winter months (November-March) in Moscow for 1961-2021.

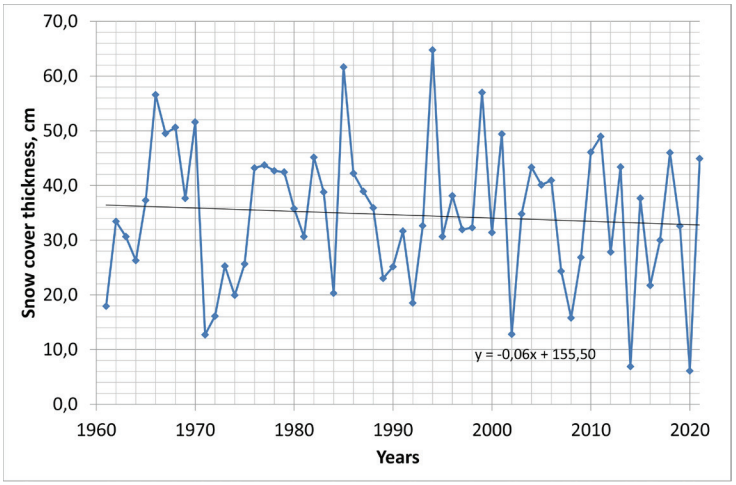

Figure 3. Variations in the average thickness of snow cover in February in Moscow for 1961-2021.

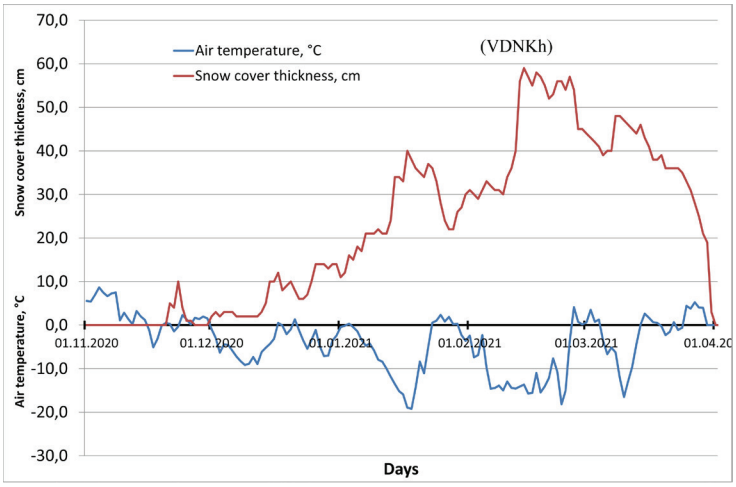

Figure 4. Variations in air temperature and snow cover thickness in Moscow in the winter season 2020/2021.

2. Materials and Methods

Due to the warming climate and redistribution of snow cover over the past decades [1], ski resorts in all parts of the world are faced with a lack of natural snow for preparing

slopes. In this regard, artificial snow production and snowmaking of ski slopes are increasingly used. However, climate warming also reduces the hours of possible operation of snowmaking devices (snow cannons) on slopes during winter periods [2]. In this work, the calculation of the possible number of hours of operation of snow guns and their change in the winter periods of the last decade for the slopes of the Moscow region is revealed.

According to earlier studies [3], the air temperature and the amount of precipitation in winter in Moscow have recently been increasing, and the thickness of the snow cover is decreasing. At the same time, many ski resorts have recently opened in the Moscow region, such as Latatrek in Krylatskoye, Kant on Nagornaya Street, complexes in Peredelkino, Khimki and others. These ski resorts use artificial snowmaking, which, according to [4], also harms the plants growing in the snow-covered area by the fact that artificial snow takes more time in spring to melt and thereby delays the beginning of the growing season of plants. And also for artificial snowmaking, it may be necessary to create large reservoirs with water reserves in the immediate vicinity for supplying snow cannons to the slopes, which will also greatly change the hydrological conditions of the area, including for plants. And potash and sodium salts used in preparing snow slopes for skiing competitions after snow melt and the beginning of the growing season affect the composition of the soil and vegetation. Salts of nitrate used to treat snow slopes can also serve as a fertilizer for plants later [5].

One snow cannon can produce between 5 and 90 cubic meters of snow per hour, depending on the model. So, according to the site [6], for the production of one cubic meter of artificial snow, up to one cubic meter of water and up to 6.8 kilowatts of electricity is required (depending on the ambient temperature and relative humidity).

The calculation of the number of hours suitable for the operation of snowmaking devices in the winter periods of the last decade was carried out on the basis of meteorological data from the site rp5.ru [7] on the basis of the rule from [2]. According to this rule, weather conditions with a wet bulb temperature not exceeding -4°C are suitable for snowmaking.

This means that in accordance with the hygrometric table of the temperature values of the ambient air thermometers with a wet and dry bulb and relative humidity, for the successful operation of snowmaking devices, conditions such as must be met:

$$Rh <- 16T + 32 \quad (1)$$

where Rh is the relative humidity of the ambient air in percent and T is the ambient temperature in degrees Celsius.

This condition means that snowmaking is potentially possible at a temperature of + 2°C, but at a relative humidity of 0%. Otherwise, snowmakers can work safely at temperatures of -4°C and below, at any relative humidity of the ambient air. Therefore, calculations according to this scheme were made in an Excel spreadsheet based on publicly available meteorological data for the Moscow meteorological station (VDNKh).

3. Results and Conclusions

The processing of meteorological data showed that over the past winter seasons, the number of potential hours for the operation of snowmaking devices to create snow cover on the ski slopes of Moscow in the periods from November 1 to December 24 has changed: 2014 - 1335 hours, 2015 - 99, 2016 - 660, 2017 - 204 , 2018 - 612, 2019 - 162 hours. These values show a tendency towards a decrease in potential snowmaking hours for Moscow in recent years, which, along with an increase in the temperature of winter seasons and a decrease in the amount of solid precipitation, create conditions for disrupting ski seasons for ski resorts. For example, the ski season of winter 2019/2020 was almost completely disrupted for ski resorts located inside Moscow.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

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Conflicts of Interest: The authors declare no conflict of interest.

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