Permafrost Response to Dynamics of External Heat Exchange: Comparison of Observed and Modeled Data (Nadym-Pur-Taz Region)

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Introduction

The study of thermal state permafrost dynamics in connection with climate conditions has became topical in recent years.

Besides the air temperature, the amount of precipitation and the temperature of permafrost have increased in some areas since the 1960s (Israel et al. 2006, Pavlov et al. 2005). The problem of permafrost state forecast became significant for industrial companies. It requires the organizing of temperature permafrost monitoring. Most measured boreholes are located near industrial and civic constructions that disturb the ground temperature regime dynamics. It is difficult to consider the climatic role in permafrost temperature dynamics by using this data because the influence of construction and business activities is greatly powerful in local aspect. This problem impedes efficient permafrost forecasting because of the difficulty of model accuracy estimation.

Methods

The authors used mathematical modeling for the diagnosis of the man-caused disturbances factor that influences the permafrost temperature regime. We supposed that the codirectionality of modeled and observed temperature trends at low depths proves the weakness of anthropogenic influences in a short time period.

The forecast was done for the Nadym-Pyr-Taz region where climate warming is evident. The air temperatures have been increasing 0.05°C per year in the observed period 1960–1995. We modeled the ground temperature for a one-dimensional system, using the one-layer loamy silt configuration and observed mean monthly values of air temperature and snow cover depth (Fig. 1). We used the meteorological data from the Salekhard met-station, adding constant monthly average corrections in considering microclimatic features of the investigation site. Other climate characteristics were used as long-term average monthly values.

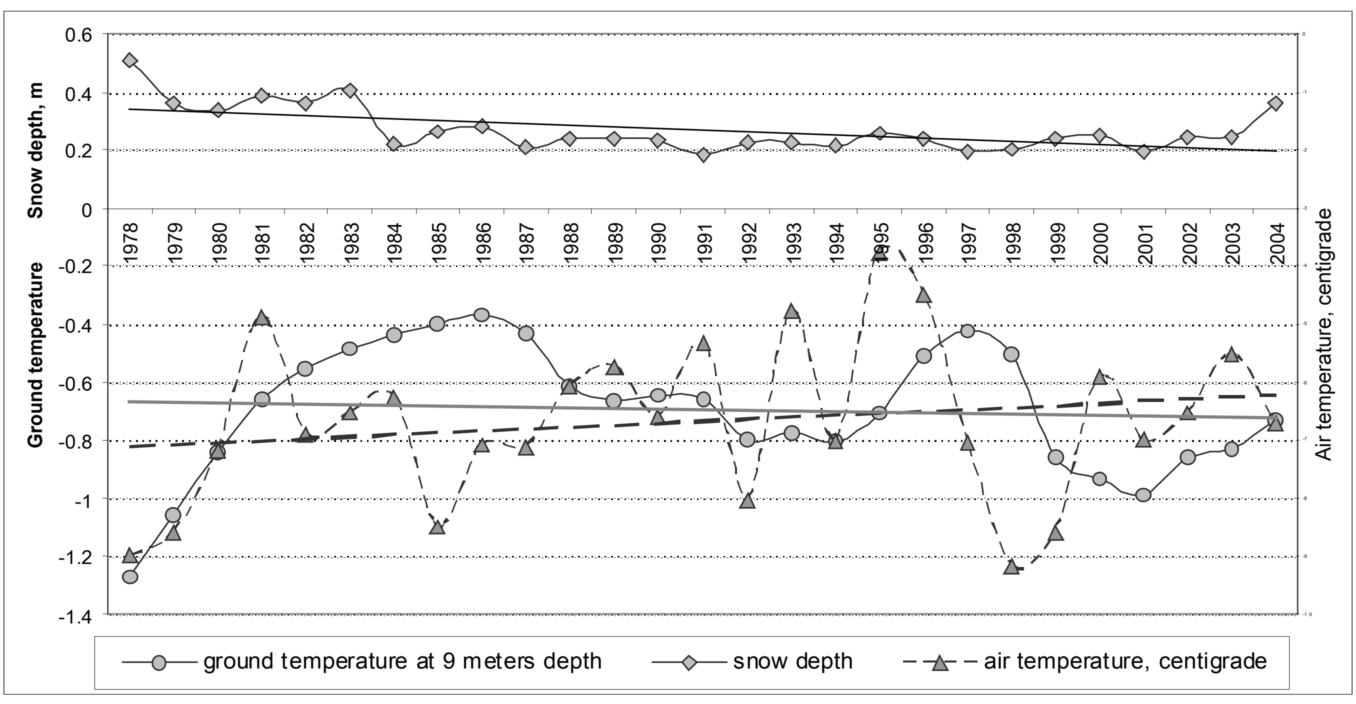

Figure 1. Long-term course of climate characteristics (air temperature and thickness of snow cover) and calculated ground temperature at 9 m depth.

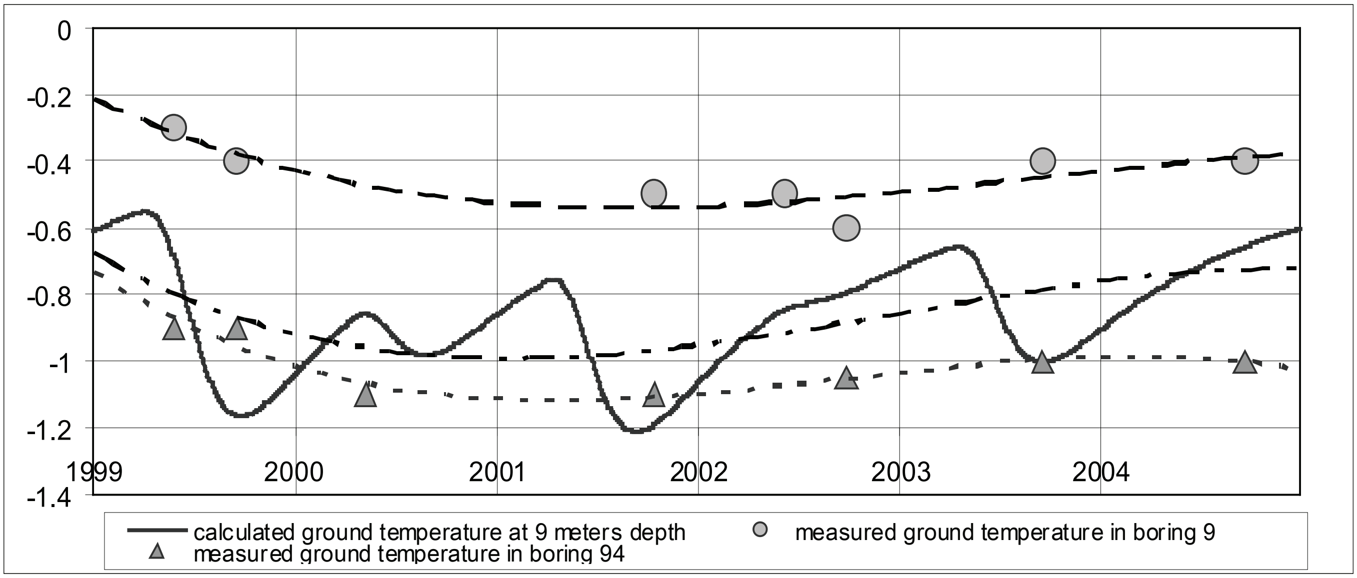

Figure 2. Comparison of measured and modeled ground temperature at 9 m depth.

The mathematical realization of the model was determined by G.S. Tipenko. The calculated values of ground temperature at 9 m depth was obtained and compared with the climate trend.

Results

The course of the modeled ground temperature is conformable to the measured temperature trend in boreholes #9 and #94.

We supposed that boreholes #9 and #94 are located in undisturbed conditions in the industrial area. The disagreement in the absolute value of the ground temperature in these boreholes is determined by the variability of snow cover. The data in detail of snow cover are not available; however, the interannual course of ground temperature at low depths is probably defined by climate dynamics, especially by the snow cover trend.

It is seen that the course of snow cover dynamics in long-range aspect has a stronger influence on ground temperature at low depth when compared with the course of air temperature.

To generalize, the framed and calibrated model of dynamic ground temperature allowed us to forecast the permafrost dynamics, depending not only on air temperature change but also on other factors of surface heat exchange. The model calibration criterion was the agreement fact of the trends rather than the desired accuracy of model parameter. Comparing the model of boreholes in undisturbed and disturbed conditions, the influence of technogenesis cannot be allowed. Thus, the data of climate contribution in the dynamics of permafrost temperature can be obtained. The boreholes that have the different tendency are strongly influenced by building and other man-caused factors.

References

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