

Heat and cold waves in the Arctic: threshold temperatures and their spatial and temporal variability

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Nowadays the climate is changing globally; climate change in the Arctic has widespread implications for indigenous and non-indigenous people, causing direct and indirect consequences for economic development, livelihoods and health implications (Kukarenko, 2011; Richter-Menge and Druckenmiller, 2020; Petrov et al., 2021). Climate change is manifesting itself in increase of ambient temperature, which may decrease the incidence of hypothermia and associated morbidity and mortality among Arctic residents. The thermal load of the environment on the human body is an important indicator of climate discomfort, especially the extraordinary conditions of the Arctic's extreme cold temperatures, combined with the strong wind. On the other hand, higher ambient temperatures at summer time may increase the effect of hyperthermia, with children, pregnant women and elderly people, as well as people with cardiovascular and respiratory disease, being the most vulnerable parts of the population (Grigorieva and Revich, 2021). Extreme weather events, including both heat waves and cold spells, can seriously change subsistence hunting and fishing of indigenous population. This short statement aims to identify and describe spatial and temporal changes in temperature thresholds for definition of extreme thermal events in the Far North of the Russian Far East. Cold spells and heat waves are calculated using quantitative metrics such as the periods with extreme temperatures below 3% and higher 97% percentile of the seasonal distribution of mean air temperature, respectively.

Materials and Methods. Daily mean air temperatures from World Data Center in Obninsk (<http://meteo.ru/data>), 110 weather stations (WS) at the Far North of the Russian Far East (latitude 50° N to 72° N, longitude 108° to 175°E), are used for the period from 2000 to 2019. This zone is adjacent to the most thermally extreme climate region in the world. Climate here varies from tundra to continental subarctic climate with extreme continental regime of annual temperatures at the continent and maritime – near the shore of the seas. Temporal and spatial range of mean, 3%- and 97%-percentiles of the year distribution of daily temperatures are examined.

Results and discussion. Mean annual air temperatures at the Far North of the Russian Far East vary between -14.0°C and $+5.7^{\circ}\text{C}$. Twenty-year spatial distribution of 3%-percentile is: -33.5 -40.8 -23.2°C , and for 97%-percentile is: 18.3, 20.0, and 15.9°C for all weather stations, continental and maritime WS, respectively. Annual differences between 3%- and 97%-percentile temperatures range over 60°C at the continent and near 40°C in maritime WS. All temperatures depend on the latitude: the further to north, the lower temperatures: the correlation is less obvious for 97%-percentile, especially at the continent, and more visible for the maritime climates, and especially for the 3%-percentile. And there is almost no causality between temperatures and longitude, which can be found only for weather stations located close to the seas. The fig. 1 demonstrates the detailed information for these dependences.

In the context of the problem of modern climate change, the most important thing is to know how these temperatures vary over time. The twenty-year (2000–2019) dynamics of daily temperature, 3%- and 97%-percentile of the annual distribution of the mean air temperature for all weather stations, continental and maritime at the Far North of the Russian Far East show the significant positive trend for the 3%-percentile, and almost no change and even slow growth for the 97%-percentile. Table 1 gives the details on these tendencies.

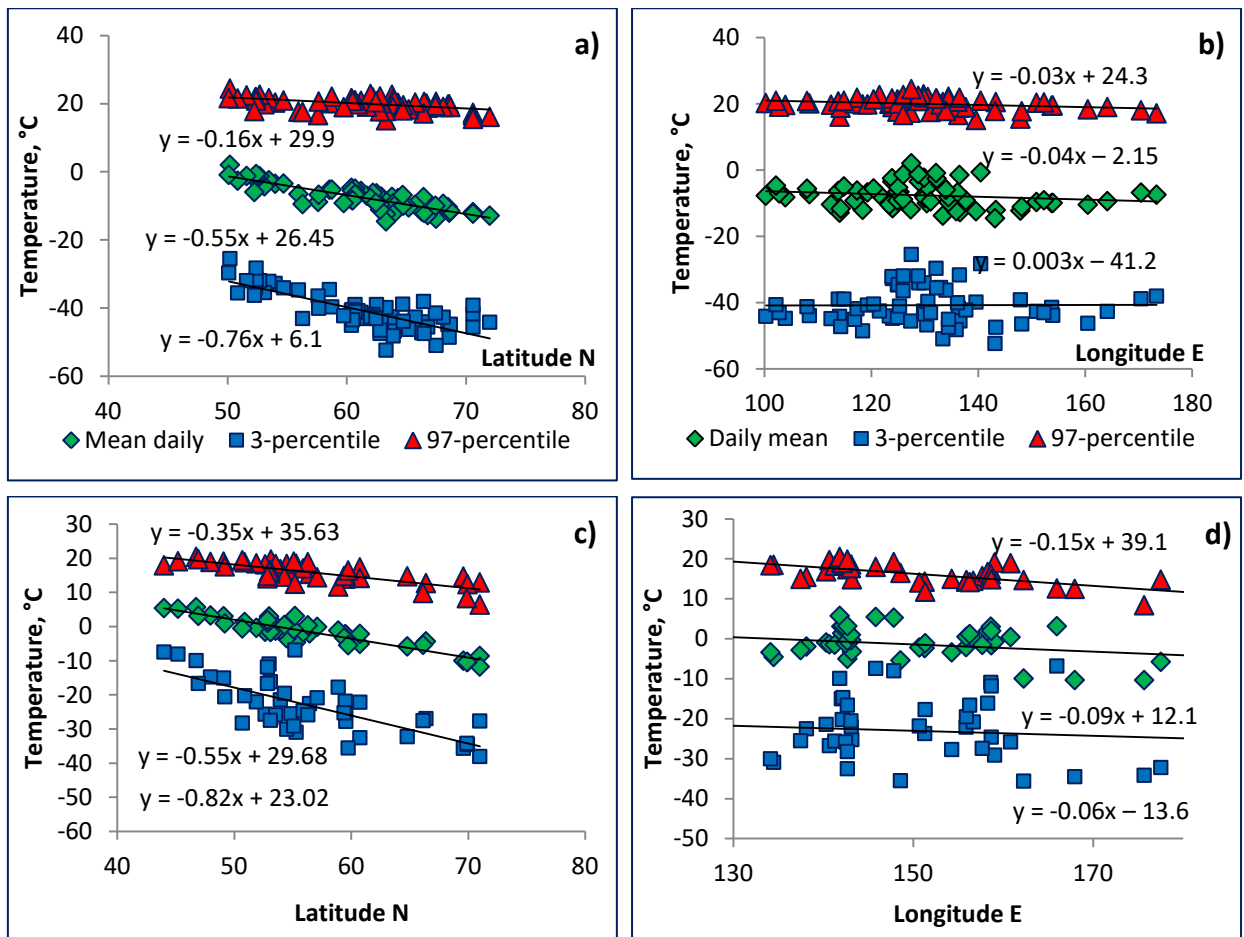


FIG. 1. Daily mean temperature, 3%- and 97% percentiles for continental (a, b) and maritime (c, d) stations: dependence on latitude (a, c) and longitude (b, d).

TABLE 1. Twenty-year (2000–2019) dynamic of mean daily temperature, 3%- and 97%-percentile for all weather stations, continental and maritime at the Far North of the Russian Far East, °C/year

Weather stations	3%-percentile	Temperature	
		Daily mean	97%-percentile
All weather stations	0.105	0.079	0.013
Continental	0.120	0.076	-0.010
Maritime	0.081	0.083	0.047

Conclusion. The results show that at the Far North of the Russian Far East mean air temperatures range between -14.5 and $+5.7$ with mean -5.2°C . Lower temperatures are found in continental weather stations (-7.6°C), higher (-1.6°C) – in maritime WS. 3%-percentile is lower at the continent, higher near seas; and vice versa, 97%-percentile is higher at the continent and lower in maritime climates; differences between 3% and 97% range near 60°C at the continent, near 40°C in maritime climates. Trend analysis of these threshold temperatures highlights the ongoing climate changes. Trend for daily air temperature for the period from 2000 to 2019 is near $0.7^{\circ}\text{C}/10$ year. Significant trend is found for 3%-percentile: $1.05^{\circ}\text{C}/10$ year for all WS, $1.2^{\circ}\text{C}/10$ year at the continent and $0.8^{\circ}\text{C}/10$ year for maritime WS. No significant trend is shown for 97%-percentile, with negative trend at the continent.

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