Revised as a *Short Communication* to ***STOTEN***, 21st July 2023

Global change research needs international collaboration

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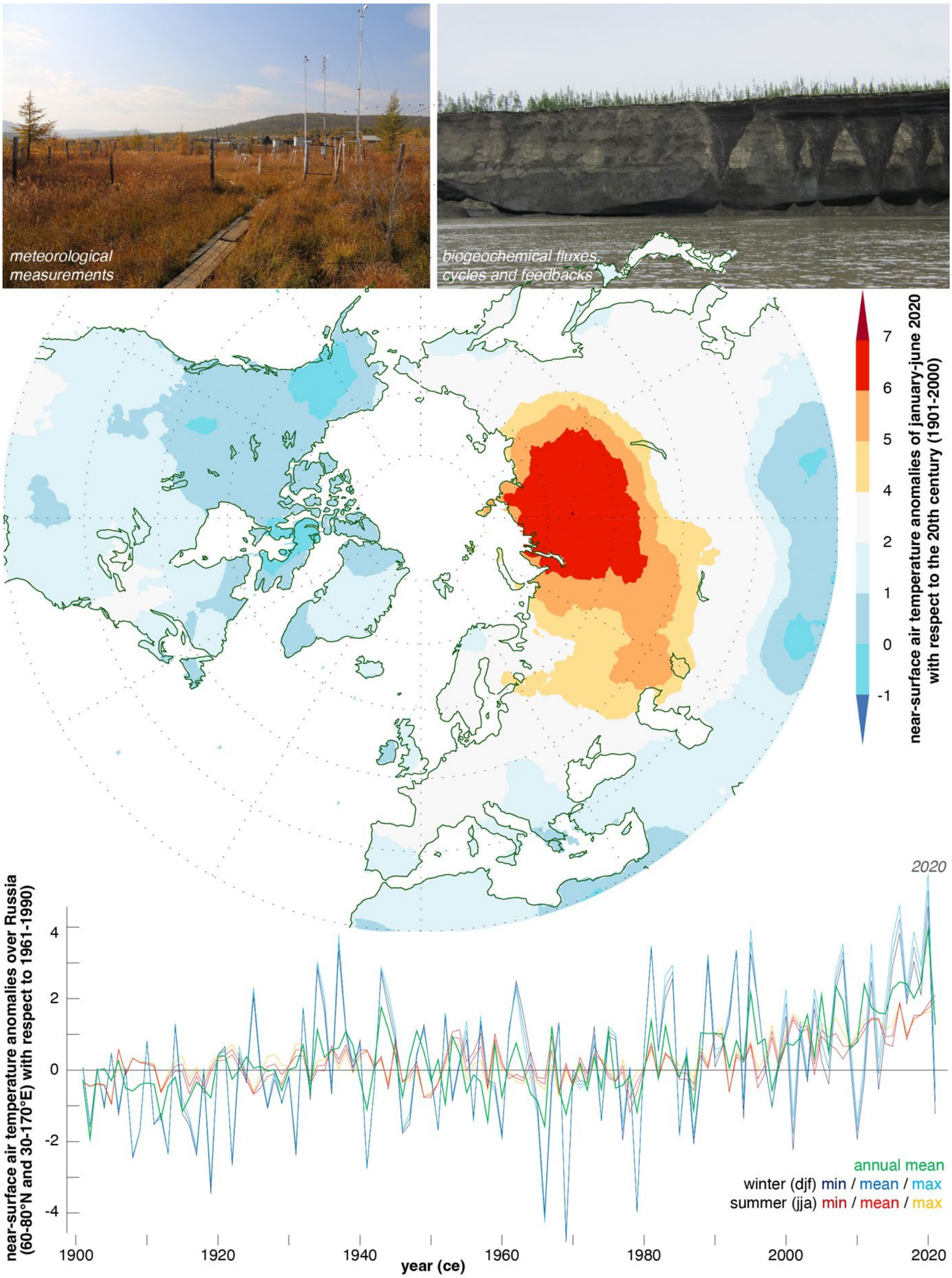
Keywords

Arctic Council, boreal forest, climate change; diplomatic soft power, global crises, open science

Abstract

Tackling the grand challenges of global climate change for the sustainability of ecological and societal systems requires data and expertise from Russia, the world's largest country that has the longest Arctic shoreline and the largest forest biome, peatland and permafrost zones. Academic relations and scientific collaborations with Russian scholars and institutions must continue despite the ensuing geopolitical crisis since 2022.

Graphical Abstract



1. Collapsing scientific networks

It is impossible to understand, forecast or mitigate the grand challenges of global climate change by ignoring the geographical entity and intellectual capacity of the world's largest country. However, international communication networks with scholars from Russia have recently started to collapse (Rees et al., 2023). While geopolitically justifiable as part of the response to Russia's military invasion of Ukraine, policy-driven constraints on open science are academically alarming because sustainability research into ongoing ecological and societal entanglements of anthropogenic climate change requires rapid action within and between all countries and NGOs. Despite their geopolitical relevance, the current sanctions affect peer-to-peer and institutional interactions, and further degrade Russian, and ultimately also international research infrastructure and knowledge.

Here, we advocate the continuity of ecological and meteorological observations and experiments, especially, but not exclusively, across Russia's high-northern latitudes. We argue that the Earth's biosphere and climate system cannot be understood, and protected, without data from the terrestrial (and marine) Arctic and sub-Arctic, of which more than half lies within Russian territory. We therefore emphasise the importance of uninterrupted, in situ, high-resolution investigations into the productivity and functioning of the boreal forest for understanding the causes and consequences of global warming to ensure the well-being of current and future generations.

2. International research tasks

With approximately 812×10^6 ha, Russia accounts for circa 22% of all forested area on our planet, contains the world's biggest peatland, overlaps with the largest permafrost zone, and includes the widest taiga-tundra transition. Although a myriad of slow growing and very old trees in Siberia contribute to the world's main terrestrial carbon pool (Büntgen et al., 2019), it is unclear whether the boreal forest will switch from a carbon sink to a net source (Kruse et al., 2022), due to remaining uncertainties about warming-induced permafrost thawing and vegetation-permafrost interactions. The ability to derive accurate, satellite-based, estimates of above-ground carbon storage in boreal locations is compromised by the scarcity of field-based calibration sites that are particularly rare in Russia (Schepaschenko et al., 2021). Further, anthropogenically-induced and herbivory-mediated disturbances of short- to long-term linkages between climate and vegetation are at least arguably stronger in Russia than elsewhere in the Arctic (IPCC, 2022). State-of-the-art Earth system models suggest that the active permafrost layer will become thinner across the terrestrial Arctic, where wildfires are likely to become more frequent under global warming (IPCC, 2022). Models also predict that the largest loss of permafrost over the 21st century will occur in northwest Russia (Karjalainen et al., 2019). In addition to unprecedented greenhouse gas emissions (Knobloch et al., 2018), thawing permafrost also releases subfossil wood, remains from the mammoth fauna, and possibly even ancient pathogens, as evidenced by the 2016 anthrax outbreak on the Yamal peninsula in northwest Russia (Hueffer et al., 2020). All these concerning issues emphasise the urgency for ongoing in situ data collection and continued access to previously acquired data. Risks to the comprehensiveness and integrity of datasets are posed both by limited access to existing records, and restricted prospect to maintain collaborations and develop new ones, undermining the ethos of sustainability.

For instance, annually resolved and absolutely dated reconstructions of Northern Hemisphere summer temperature variability significantly depend on tree-ring chronologies from Russia (Büntgen et al. 2020, 2021). Long-lasting and well-experienced laboratories in Krasnoyarsk, Ekaterinburg, Moscow, Abakan and Irkutsk have produced some of the world's longest and best replicated dendrochronological datasets. These laboratories also store unique proxy archives for advanced biochemical analyses that can be performed only in larger research projects. Resuming scientific collaborations is further motivated by another 450–500 not yet freely available tree-ring chronologies that remain under researched. There are also about 70,000 forest inventory sites, 18 ‘Eddy Covariance’ flux towers that measure carbon, water and energy fluxes between the biosphere and atmosphere (www.fluxnet.org), and 15 ‘Carbon Supersites’ from the Ministry of Education and Science of Russia that measure CO_2 exchanges and budgets (www.carbon-polygons.ru). The expected launch of four new flux towers and seven new carbon supersites is likely to be affected by the current sanctions, and there is a severe risk to lose access to the invaluable measurements of almost 500 official meteorological stations that have operated continuously, at least since the collapse of the Soviet Union (www.meteo.ru).

Due to significant warming since the 1990s, in tandem with the occurrence of extreme heatwaves (Figs. 1–2), boreal vegetation is likely to expand further into the tundra zone (Rees et al., 2020). This circumpolar trend underscores the relevance of continuous investigations into the complex relationship between climate and vegetation. Spatiotemporal quantification of Arctic ‘greening’ and/or ‘browning’ requires remote sensing measurements and ground validation of phytomass estimates (Callaghan et al., 2021; Schepaschenko et al., 2021). In situ field observations are also needed to disentangle the role natural (e.g., volcanoes and wildfires) and anthropogenic (e.g., mining, oil and shipping industries) forcing factors play for Arctic warming trends and carbon cycle dynamics (Kirdyanov et al., 2020; Rantanen et al., 2022).

The rate at which climate and vegetation in Siberia change is a powerful argument for continuing collaborative research with Russian scholars, as well as for supporting their challenging long-term monitoring networks across the vast taiga and tundra biomes. Climatic extremes and logistic constraints in many of the remote and often isolated parts of Siberia, and particularly the Russian Arctic, demand international partnership to ensure accurate and uninterrupted operation of high-precision ground measurements (Rees et al., 2020). Together with the development and application of advanced processing algorithms, field data are essential to underpin satellite imagery and expand process-based understanding beyond local scales, though they have relied increasingly on international efforts (Schepaschenko et al., 2021). For example, physical and digital access to research stations in, and data from, the Russian Arctic has until recently been facilitated by the international INTERACT network (www.eu-interact.org). Restrictions on the use of all twenty-one bases in Russia since March 2022, however, severely affect the integration of local expertise and indigenous knowledge into our understanding of the impacts of global climate and environmental change on the functioning and productivity of ecosystems and the well-being of societies. The situation is particularly alarming since the latest generation of climate models predicts the most significant rise in surface air temperatures and associated changes in precipitation regimes over parts of Siberia and the Russian Arctic (IPCC, 2022).

Not only aboveground vegetation dynamics, but also belowground soil properties, permafrost thawing and peatland degradation, must be included in an interdisciplinary (and international) approach to unravel the complex spatiotemporal interplay of biotic and abiotic responses to rapid warming (Figs. 1–2). The world's largest peatland in the West Siberian Lowlands exhibits a substantial carbon sink that probably stores as much as 10% of the amount of CO_2 currently comprised in the atmosphere (Dise, 2009). Like many other ecosystems in Russia, peatlands are chronically understudied (Kirpotin et al., 2021), and secured access to places such as the Mukhrino carbon supersite (www.carbon-polygons.ru) is currently at risk. Over the last few decades, in situ measurements of Arctic and sub-Arctic environmental processes in Russia have become increasingly collaborative and international. Exchanges of expertise and people, as well as data and equipment, including chemical reagents and grant money, have become essential to the conduct of basic and applied research. All this, however, has changed since the Russian invasion of Ukraine in 2022. The resulting deterioration of

Russian research infrastructure and lessening of Russian engagement with international peer-reviewed research will ultimately also affect the international scientific community.

3. Diplomatic soft power

Though scientific projects in Russia have always been challenging for political, organisational and cultural reasons (Büntgen, 2016), peer-to-peer and higher-level interactions are most important for the continuity of observations, experiments and datasets in the realm of global change research. The relevance of maintaining and fostering international relations has been recognised for several decades. The International Science Initiative in the Russian Arctic (ISIRA) was established for this purpose by the International Arctic Science Committee (IASC) three decades ago (Pavlenko et al., 2021). Joint research may also facilitate diplomatic soft power. For instance, Norway will shortly take over chairmanship of the Arctic Council from Russia (Rees et al., 2023). Since its establishment in 1996, the Arctic Council is a leading intergovernmental forum that promotes cooperation, coordination and interaction among states and peoples towards sustainable development and environmental protection. Its activities are currently suspended (www.state.gov/joint-statement-on-arctic-council-cooperation-following-russias-invasion-of-ukraine), as are those of the Arctic Ministerial Meeting process. However, and associated with some sort of diplomacy, the transfer of Arctic Council chairmanship could be an opportunity to reset international relationships and to highlight the status of open science in an increasingly uncertain world. As the scientific community begins to prepare for the 5th International Polar Year, now only a decade away, this reset is increasingly urgent. Moreover, we encourage the agreement to, and establishment of international contracts to ensure scientific collaboration for tackling the grand challenges of global climate change – over environmentally relevant timescales and jointly across all nations.

4. Resuming scientific collaboration

While national and institutional economic embargoes in responses to Russia's invasion of Ukraine are justified in a wider geopolitical context, the need for scientific cooperation is higher now than at any previous time, and we cannot afford these links to remain paralysed in a rapidly warming and increasingly unstable world. Understanding and mitigating ecological and societal effects of anthropogenic global warming and its potential effects on tipping points in the Earth's climate system are impossible without the inclusion of data and expertise, and action, from the world's largest country. We therefore advocate maintaining sensible scientific discourse with Russia despite the current political disorder. While this is still happening to some extent at personal levels with doubt and ambiguity, an exertion of upward pressure on international institutions and organisations is needed to resume dialogue with Russian scholars. Furthermore, we plead for an open attitude and long-term vision of funding agencies to rethink their current restrictions and restart the support of collaborative research in Russia to understand and mitigate the causes and consequences of global warming. It is a tragic irony that the 'Arctic Exceptionalism', in which the region has been effectively maintained as a zone of peaceful cooperation for at least the last quarter century (Kornhuber et al., 2023), is now threatened by the aggressive behaviour of an Arctic member state. We urge action to protect globally essential science from this risk.

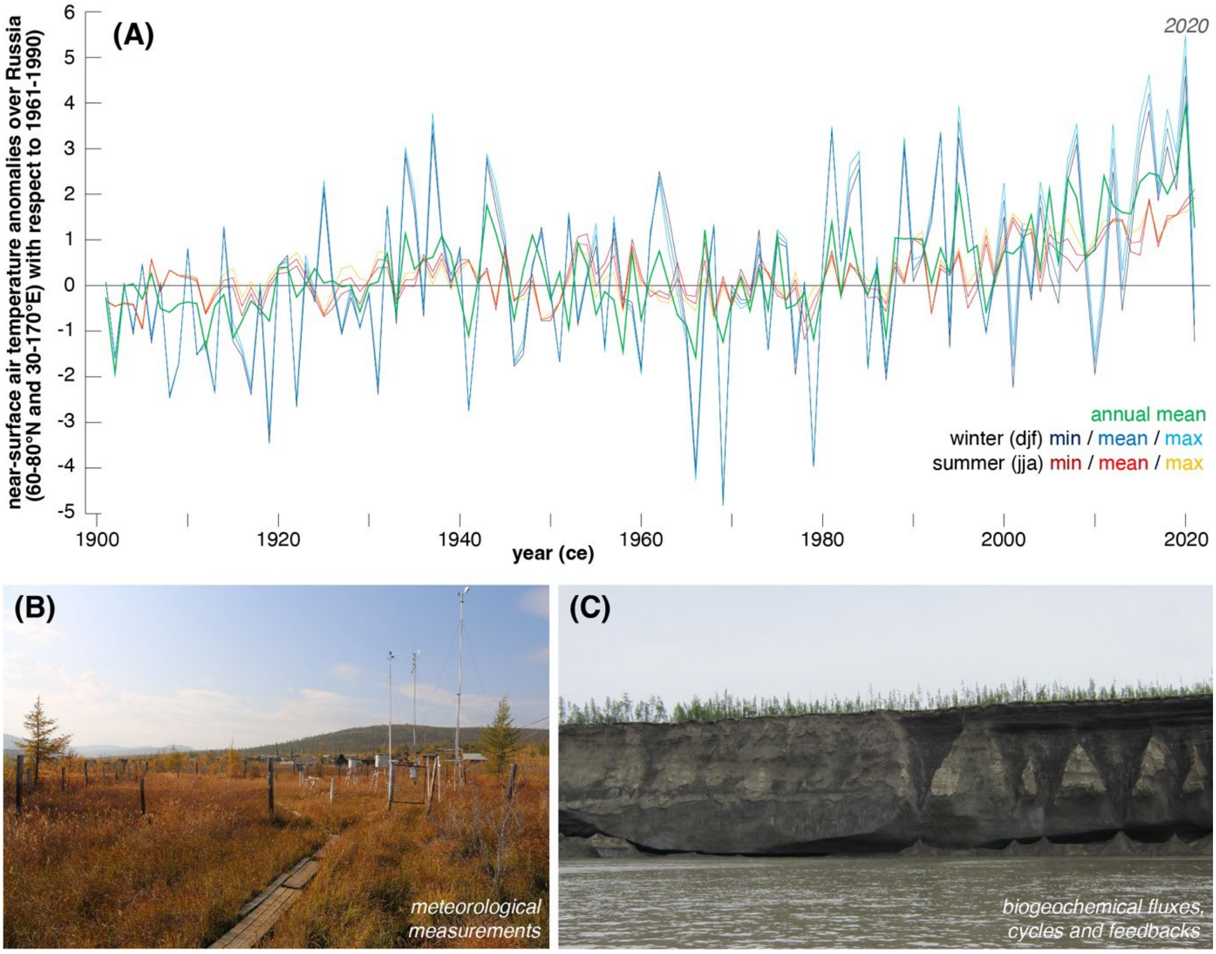


Fig. 1. (**A**) Near surface, air temperature anomalies with respect to the 1961–1990 period calculated for annual, winter and summer mean, minimum and maximum values over the 60–80°N and 30–170°E Russian landmass using 0.5° gridded CRU TS 4.06 data reveal the strong warming trend since around the 1990s. (**B**) A meteorological station near Bilibino in northern Chukotka, where instrumental weather measurements are rare. (**C**) Exposed carbon-rich soils from the mammoth steppe-tundra along the Indigirka, one of the largest rivers in eastern Siberia that drains yet undefined amounts of depleted organic matter and driftwood into the Arctic Ocean. The annual temperature amplitude in northern Yakutia reaches almost 100° Celsius, where slow growing larch trees (*Larix cajanderi*) can exceed ages of 1000 years, and where warming-induced permafrost thawing affects biogeochemical fluxes, cycles and feedbacks.

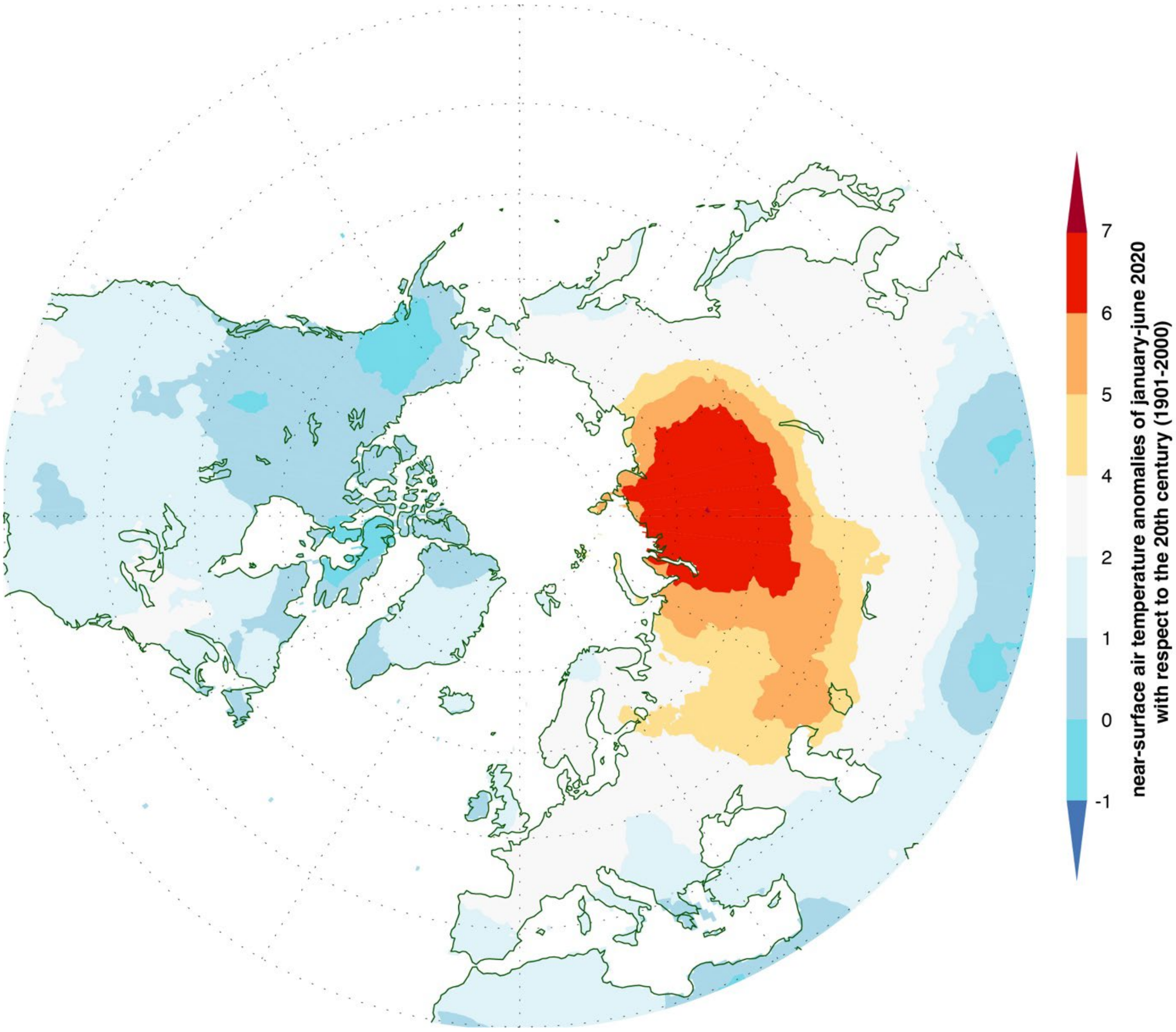


Fig. 2. Air surface temperature anomalies of January–June 2020 with respect to the 20th century and plotted over the Northern Hemisphere extra-tropics using 0.5° gridded CRU TS 4.06 data show the extreme 2020 heatwave over central Siberia.

Acknowledgements

U.B. received funding from the SustES project (CZ.02.1.01/0.0/0.0/16_019/0000797), and the ERC Advanced grant MONOSTAR (AdG 882727).

Author contributions

U.B. and G.R. conceived the study and wrote the paper.

Declaration of competing interests

The authors declare no competing interests.

Data availability

No data have been used.

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