

Russian collaboration loss risks permafrost carbon emissions network



While never overshadowing the dominant influence of human activities, additional greenhouse gas emissions from warming Arctic permafrost are expected to accelerate future climate change by 10–20%^{1–4}. The Russian Federation contains two-thirds of the northern permafrost area^{5,6} and the loss of access to permafrost carbon flux sites and data due to the Russian invasion of Ukraine threatens scientists' ability to detect this climate feedback.

Scientists are working to improve the Arctic carbon flux network, by increasing the number of sites and pushing the data processing and reporting towards real-time (annual) updates. Analogous to weather monitoring, real-time methane and carbon dioxide measurements do not slow emissions, but instead provide knowledge about the speed and strength of the permafrost carbon feedback to climate change. By 2100, the Arctic is expected to release permafrost carbon with the climate impact of a large, industrialized nation¹, and that must be accounted for as nations around the world determine their own greenhouse gas emission levels aimed at meeting specified temperature targets.

The disruption of science collaboration following the invasion of Ukraine threatens the Arctic carbon network in quantifiable ways. At present, the network comprises individual study sites that voluntarily contribute data to international databases. Site-based eddy covariance measurements of methane and carbon dioxide fluxes are combined with remotely sensed information about ecosystems to provide an integrated view of carbon emissions across the permafrost region. Previously published analysis⁷ used a suite of environmental information available across the region, combined with direct methane and carbon dioxide eddy covariance tower measurements, to understand the landscape-scale 'represented fraction' of the Arctic carbon network. This measurement (on a 0 to 1 scale) shows how well the carbon flux network observes the full distribution of Arctic ecosystems in the region, and here we outline what happens without access to Russian data.

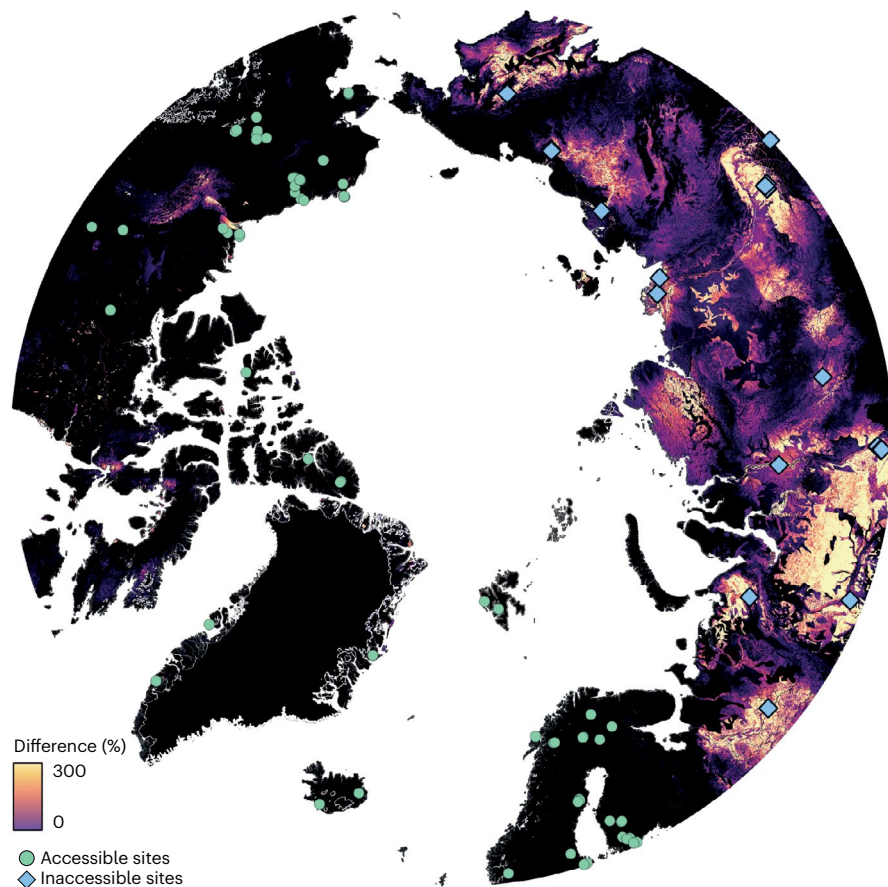


Fig. 1 | Regions of environmental space described by the Arctic carbon monitoring network that are affected by loss of Russian science collaborations. Colours represent proportional difference based on a network with Russian sites (inaccessible sites (blue symbols) + accessible sites (green symbols)) as opposed to without (accessible sites (green symbols only)), while black represents no change. This figure relies on methods and datasets detailed in ref. 7. Eddy covariance site data are available at <https://cosima.nceas.ucsb.edu/carbon-flux-sites/>; a snapshot of the eddy covariance component of this database used for this paper is retained and available on request.

The Arctic carbon network based on the existing entire patchwork of field sites has a combined ecosystem represented fraction of 0.55, meaning that it captures more than half of the landscape variability in carbon dynamics. Removing all 27 sites within the Russian Federation drops this represented fraction to 0.36, which means the entire network has about 50% more information about landscape carbon fluxes as compared to a more-limited

network without Russian collaboration (Fig. 1). This information loss estimate is robust even when using a more conservative approach with multiple towers required to accurately describe environmental controls over carbon fluxes. The network is already undersampling a vast region that covers millions of square kilometres – a diminishment due to loss of science collaboration is a critical blow towards observing Arctic carbon fluxes.

Using the same approach, we asked whether the loss of access to Russian sites could be compensated by building additional carbon flux sites elsewhere. Building 27 new sites in North America where sites are relatively sparse, mirroring the environmental space of lost Russian sites and tied to infrastructure already in place, can increase the landscape represented fraction from 0.36 to 0.43. This means that improving science infrastructure elsewhere can compensate in part for the loss of Russian collaboration at the cost of installing and maintaining new infrastructure. Compensation, however, is incomplete. The new network describes only about 80% of the environmental space previously monitored by the full network that included Russia. Furthermore, adding an even greater number of new sites cannot overcome this information loss. There are permafrost ecosystems in Russia that do not have environmental analogues in North America and so cannot be compensated.

Expanding North American infrastructure is a way forward for climate science, but other factors may also ameliorate the loss of Russian sites. Russian science collaborations with certain countries may continue to persist in some form, but it is difficult to see how the pre-invasion Arctic carbon flux network

would not diminish over time. Remote sensing can partially compensate for the loss of ground-based measurements, but greenhouse gas satellites have limited operation at high latitudes based on available sunlight and rely on models to indirectly infer changes in ecosystem carbon fluxes.

As the climate crisis unfolds, the Arctic remains a bellwether for change. The impact of science deglobalization is particularly profound for observations of permafrost methane and carbon dioxide emissions as they relate to climate change. We should compensate by expanding Arctic science infrastructure outside Russian territory. When the time is right, we also need to seek new ways to support science research across the Western-Russian divide for the benefit of science and global diplomacy.

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Author contributions

All authors contributed substantially to this work. Based on previous collaborative work by the author group, E.A.G.S. conceived the initial idea and wrote the draft, and M.P. and M.G. provided the analysis with the figure, and contributed to the written text.

Competing interests

The authors declare no competing interests.