Permafrost thawing faster than expected due to extreme summer rainfall

March 23 2022

Using a motor pump and sprinklers, researchers of the Plant Ecology & Nature Management group simulated the effect of extreme summer rains on the Siberian tundra ecosystem. Credit: Rúna Magnússon

In the past 50 years, the Arctic region has been warming three times faster than the average rate of global warming. This warming thaws the

permafrost, the permanently frozen Arctic soil. New research published in *Nature Communications* has revealed that extreme summer rainfall is accelerating this process. As extreme rainfall events become more frequent thanks to a warmer climate, the permafrost may thaw even faster than under the influence of rising temperatures alone.

Permafrost forms the foundation of Arctic ecosystems and the settlements of humans who live on it. When the permafrost thaws, the soil loses its load-bearing capacity. In addition, the organic carbon stored in the frozen soil decomposes more easily into greenhouse gases, such as CO_2 and methane, which contribute to global warming. The release of greenhouse gases through permafrost thaw causes what is known as a positive feedback loop, a self-reinforcing process.

But in addition to the temperature, the precipitation in the Arctic region is also increasing. In winter, this has a negative impact on the permafrost. A thicker layer of snow in winter has an insulating effect and protects the permafrost from extremely cold air, so it does not cool as much. But little was known about the effect of precipitation in summer.

Rain experiment

Researchers from Wageningen University (WUR)'s Plant Ecology & Nature Management chair group carried out an irrigation experiment on the Northeast Siberian tundra to study the effects of extreme summer precipitation on permafrost. Ph.D. candidate Rúna Magnússon selected 20 monitoring sites and used sprinklers to give half the sites extra water. The experiment simulated the effects of a single, extremely wet summer. The sites were monitored for several years for permafrost thaw depth and other soil and vegetation characteristics.

A crumbling permafrost bank on the shores of a lake reveals man-sized ice structures hidden in the frozen ground. The dark color of the soil is due to the presence of organic material such as decomposed plant remains. Credit: Rúna Magnússon

On average, the permafrost thawed 35% faster in the irrigated sites, leaving a larger amount of soil susceptible to the decomposition of soil carbon into greenhouse gas. An important finding was that the effect of an extremely wet summer lasted for several years; even two years after the sprinkler test, the permafrost under the irrigated sites was still thawing faster. An additional model analysis in cooperation with researchers from Stockholm University revealed that permafrost thaws particularly rapidly during periods of combined high rainfall and high air temperatures. "We were not surprised that the permafrost thawed to a greater depth during wet summers, but that the effect would be so extreme and last for several years was really unexpected," says Magnusson.

Risk of underestimating climate change

As rainfall is expected to increase and precipitation extremes will become more frequent in warming Arctic regions, these results are bad news for the permafrost. "If we only take warmer temperatures into account, we will underestimate how much permafrost is thawing as a result of climate change, and how much extra CO_2 and methane is being released," explains Magnusson. "But it is difficult to realistically represent the effect of such precipitation extremes on permafrost thaw and greenhouse gas emissions in climate models. This could lead us to underestimate future greenhouse gas emissions caused by permafrost thaw, and therefore our emissions targets to stay within the one-and-a-half or two degrees of global warming may turn out to be too optimistic."

Future research will hopefully reveal the extent to which the sensitivity of permafrost to rain varies regionally, so that more reliable estimates of future permafrost thaw can be made.

More information: Rúna Í. Magnússon et al, Extremely wet summer events enhance permafrost thaw for multiple years in Siberian tundra, *Nature Communications* (2022). DOI: 10.1038/s41467-022-29248-x

Provided by Wageningen University