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Thawing of Permafrost Expected to Cause Significant Additional Global Warming, Not yet Accounted for in Climate Predictions

Policymakers and Climate Scientists Must Monitor and Prepare for Large Carbon Dioxide and Methane Emissions from Permafrost, Says UNEP Report

Doha, 27 November 2012 – Permafrost covering almost a quarter of the northern hemisphere contains 1,700 gigatonnes of carbon, twice that currently in the atmosphere, and could significantly amplify global warming should thawing accelerate as expected, according to a new report released today by the UN Environment Programme (UNEP).

Warming permafrost can also radically alter ecosystems and cause costly infrastructural damage due to increasingly unstable ground, the report says.

Policy Implications of Warming Permafrost seeks to highlight the potential hazards of carbon dioxide and methane emissions from warming permafrost, which have not thus far been included in climate-prediction modelling. The science on the potential impacts of warming permafrost has only begun to enter the mainstream in the last few years, and as a truly "emerging issue" could not have been included in climate change modelling to date.

The report recommends a special IPCC assessment on permafrost and the creation of national monitoring networks and adaptation plans as key steps to deal with potential impacts of this significant source of emissions, which may become a major factor in global warming.

"Permafrost is one of the keys to the planet's future because it contains large stores of frozen organic matter that, if thawed and released into the atmosphere, would amplify current global warming and propel us to a warmer world," said UN Under-Secretary General and UNEP Executive Director Achim Steiner.

"Its potential impact on the climate, ecosystems and infrastructure has been neglected for too long," he added. "This report seeks to communicate to climate-treaty negotiators, policy makers and the general public the implications of continuing to ignore the challenges of warming permafrost."

Most of the current permafrost formed during or since the last ice age and extends to depths of more than 700 meters in parts of northern Siberia and Canada. Permafrost consists of an active layer of up to two metres in thickness, which thaws each summer and refreezes each winter, and the permanently frozen soil beneath.

Should the active layer increase in thickness due to warming, huge quantities of organic matter stored in the frozen soil would begin to thaw and decay, releasing large amounts of CO_2 and methane into the atmosphere.

Once this process begins, it will operate in a feedback loop known as the permafrost carbon feedback, which has the effect of increasing surface temperatures and thus accelerating the further warming of permafrost – a process that would be irreversible on human timescales.

Arctic and alpine air temperatures are expected to increase at roughly twice the global rate, and climate projections indicate substantial loss of permafrost by 2100. A global temperature increase of 3°C means a 6°C increase in the Arctic, resulting in an irreversible loss of anywhere between 30 to 85 per cent of near-surface permafrost.

Warming permafrost could emit 43 to 135 gigatonnes of carbon dioxide equivalent by 2100 and 246 to 415 gigatonnes by 2200. Emissions could start within the next few decades and continue for several centuries.

Permafrost emissions could ultimately account for up to 39 per cent of total emissions, and the report's lead author warned that this must be factored in to the treaty to address global climate change expected to replace the Kyoto Protocol.

"The release of carbon dioxide and methane from warming permafrost is irreversible: once the organic matter thaws and decays away, there is no way to put it back into the permafrost," said lead author Kevin Schaefer, from the University of Colorado's National Snow and Ice Data Center.

"Anthropogenic emissions' targets in the climate change treaty need to account for these emissions or we risk overshooting the 2°C maximum warming target," he added.

Most of the recent climate projections are biased on the low side relative to global temperature because the models do not at this time include the permafrost carbon feedback, the report says. Consequently, targets for anthropogenic greenhouse gas emissions based on these climate projections would be biased high.

Ecosystems and Infrastructure under Threat

Warming permafrost also brings negative consequences in terms of ecosystem and infrastructure damage.

The dominant ecosystems in permafrost regions are boreal forests to the south and tundra to the north. Permafrost is impermeable to water, so rain and melt water pool on the surface – forming innumerable lakes and wetlands which are used by migratory birds as summer breeding grounds.

Ecosystem disturbances due to permafrost degradation will change species composition, and with it animal habitat and migration, according to the report.

Longer growing seasons due to higher temperatures favour the growth of shrubs and woody vegetation resulting in a northward migration of the tree line. Permafrost degradation and the resultant drying of the land can also result in disturbances such as fires. Fire in boreal forests has recently increased in intensity and frequency, and could become more common in tundra regions.

However, thawing permafrost is structurally weak, resulting in foundational settling that can damage or even destroy buildings, roads, pipelines, railways and power lines. Infrastructure failure can have dramatic environmental consequences, as seen in the 1994 breakdown of the pipeline to the Vozei oilfield in Northern Russia, which resulted in a spill of 160,000 tonnes of oil, the world's largest terrestrial oil spill.

Roads, buildings and other infrastructure in discontinuous permafrost, which tends to be warmer, and along the Arctic coast, where salt content means small temperature changes can turn ice to ground water, are most vulnerable to damage.

Climate change already could add up to US$6.1 billion to future costs for public infrastructure in the US state of Alaska between now and 2030, for example, and while there are only a handful of studies and reports evaluating the economic impacts of permafrost degradation, these indicate infrastructure maintenance and repair costs will increase.

"Thawing permafrost represents a dramatic physical change with huge impacts to ecosystems and human infrastructure," said Mr. Schaefer. "Individual nations need to develop plans to evaluate the risks, costs, and mitigation strategies to protect human infrastructure in permafrost regions most vulnerable to thaw."

Recommendations

The report issues the following specific policy recommendations to address the potential economic, social and environmental impacts of permafrost degradation in a warming climate:

- *Commission a Special Report on Permafrost Emissions*: The IPCC may consider preparing a special assessment report on how carbon dioxide and methane emissions from warming permafrost would influence global climate to support climate change policy discussions and treaty negotiations.

- *Create National Permafrost Monitoring Networks*: To adequately monitor permafrost, individual countries may consider taking over operation of monitoring sites within their borders, increasing funding, standardizing the measurements and expanding coverage. This applies particularly to countries with the most permafrost: Russia, Canada, China and the United States. The International Permafrost Association should continue to coordinate development and the national networks should remain part of the Global Terrestrial Network for Permafrost.

- *Plan for Adaptation*: Nations with substantial permafrost, such as those mentioned above, may consider evaluating the potential risks, damage and costs of permafrost degradation to critical infrastructure. Most nations currently do not have such plans, which will help policy makers, national planners and scientists quantify costs and risks associated with permafrost degradation.

Additional information

The report was written by, and in collaboration with, the following partners:

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The full report can be downloaded here: http://www.unep.org/pdf/permafrost.pdf

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