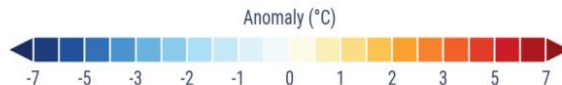
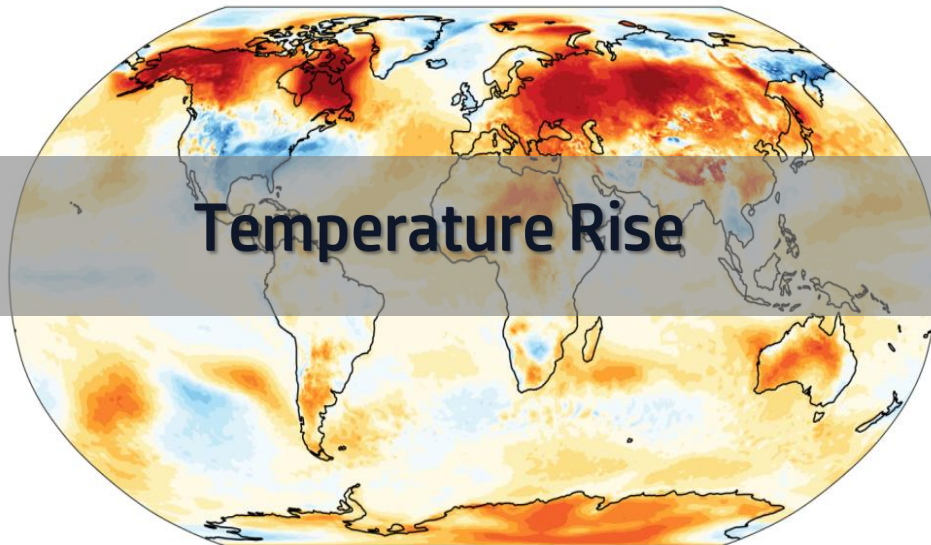




# Surface air temperature anomaly in January 2025

Reference period: 1991–2020 • Data: ERA5 • Credit: C3S/ECMWF



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# Temperature Rise

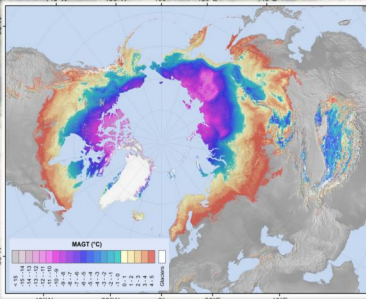
The WMO State of the Climate 2024 Update once again issues a Red Alert at the sheer pace of climate change in a single generation, turbo-charged by ever-increasing greenhouse gas levels in the atmosphere. 2015-2024 will be the warmest ten years on record; the loss of ice from glaciers, sea-level rise and ocean heating are accelerating; and extreme weather is wreaking havoc on communities and economies across the world.

The January – September 2024 global mean surface air temperature was  $1.54^{\circ}\text{C}$  (with a margin of uncertainty of  $\pm 0.13^{\circ}\text{C}$ ) above the pre-industrial average, boosted by a warming El Niño event, according to an analysis of six international datasets used by WMO.

<https://wmo.int/news/media-centre/2024-track-be-hottest-year-record-warming-temporarily-hits-15degc4>



# Melting of Permafrost



Picture comes from: [www.thearcticinstitute.org](http://www.thearcticinstitute.org)

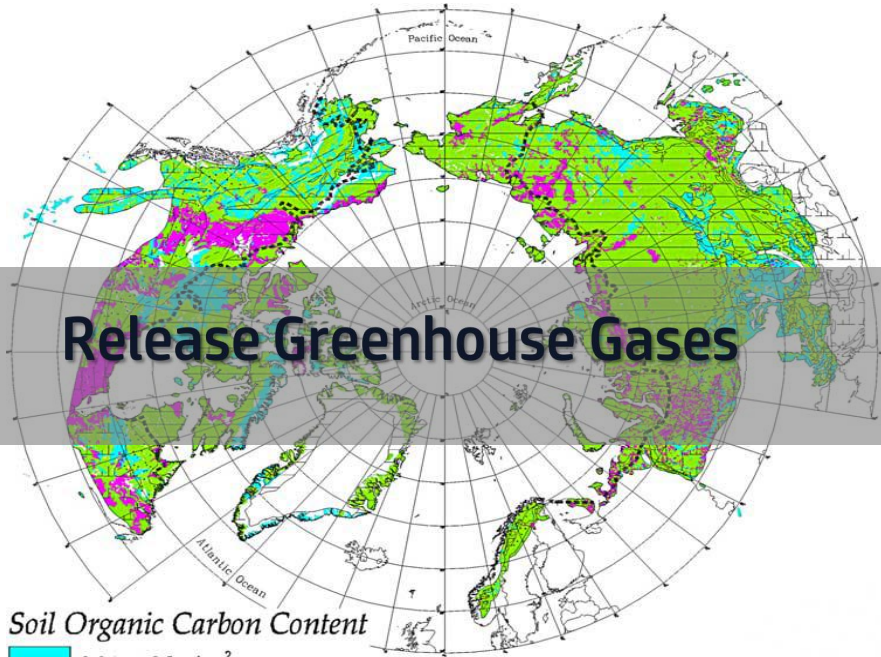
# Melting of Permafrost

Permafrost is soil or underwater sediment which continuously remains below  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ) for two years or more: the oldest permafrost has been continuously frozen for around 700,000 years. Whilst the shallowest permafrost has a vertical extent of below a meter (3 ft), the deepest is greater than 1,500 m.

Globally, permafrost underlies approximately 22 million  $\text{km}^2$  (15% of the exposed land surface), with 85% concentrated in the Northern Hemisphere. Recent satellite-based estimates indicate a 10-15% reduction in permafrost extent since the 1970s, primarily driven by ALT increases ( $0.5 - 1.5\text{ cm/yr}$  in Siberia) and MAGT warming ( $0.3 - 0.6^{\circ}\text{C/decade}$  in Alaska)

(ALT-Active Layer Thickness, represent the extend of melting. MAGT - Mean Annual Ground Temperature.)

Obu, J., et al. (2021). Permafrost Mapping and Metrics: A Global Synthesis. Earth-Science Reviews, 220, 103735. and Wikipedia



# Release Greenhouse Gases

Soil Organic Carbon Content



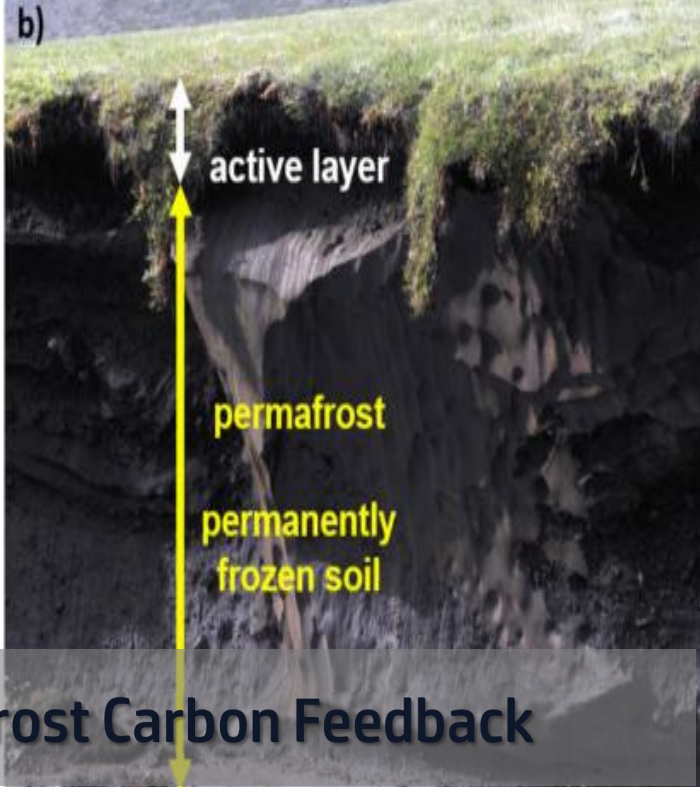
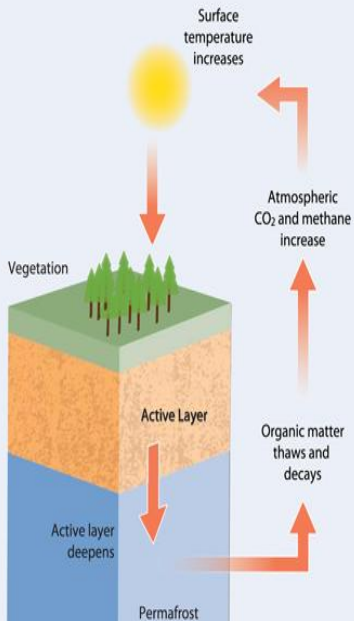
Tree line

# Release Greenhouse Gases

Plant remains and other organic material were buried and frozen into permafrost during or since the last ice age by dust deposition, sedimentation in flood plains and peat development on time scales of decades to millennia. Decay essentially stops once the soil is frozen, so this organic matter has been preserved, frozen in permafrost, for thousands of years.

Perennially frozen ground (permafrost) of the northern hemisphere contains about 800 Pg organic carbon. Another 500 Pg organic carbon are stored in the active layer of permafrost soils and perennially unfrozen sediments. The active layer receives a regular input of fresh organic matter (OM) from the surface vegetation, which is decomposed by microorganisms during the summer thaw period. The observed permafrost thaw, caused by rising atmospheric temperature unlocks formerly frozen OM, which may thereupon be decomposed to the greenhouse gases (GHGs) carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>).





# The Permafrost Carbon Feedback

# The Permafrost Carbon Feedback

The permafrost carbon feedback (PCF) is the amplification of anthropogenic warming due to carbon emissions from thawing permafrost. The CO<sub>2</sub> and CH<sub>4</sub> will amplify the warming due to anthropogenic greenhouse gas emissions, especially the CH<sub>4</sub> is 33 times more effective a greenhouse gas than CO<sub>2</sub>, and further accelerate permafrost degradation. Warmer conditions and increased atmospheric CO<sub>2</sub> will enhance plant growth that will remove some CO<sub>2</sub> from the atmosphere (Friedlingstein et al 2006), but this may only partially compensate for the much greater carbon losses from thawing permafrost. The PCF is irreversible on human time scales because in a warming climate, the burial mechanisms described above slow down or stop, so there is no way to convert CO<sub>2</sub> into organic matter and freeze it back into the permafrost.

Schaefer, K.; Lantuit, H.; Romanovsky, V. E.; Schuur, E. A. G.; Witt, R. The Impact of the Permafrost Carbon Feedback on Global Climate. *Environ. Res. Lett.* 2014, 9 (8), 085003.





## Infrastructure Crumbling

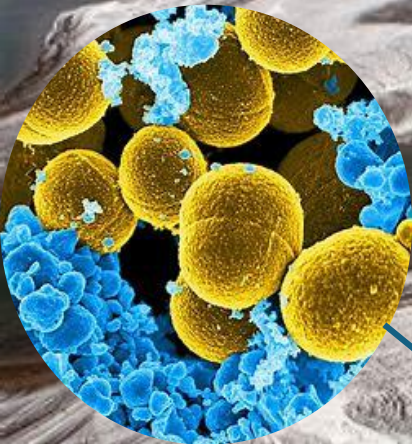


# Infrastructure Crumbling

In northern Russia, city buildings are crumbling. In Alaska, roads are turning into rollercoasters. When water turns into ice underground, it expands and the ground swells. When water thaws, the ground contracts, which can make the earth crack or cave in—as exemplified by potholes that form in the spring. About 35 million people live in a permafrost zone, in towns and cities built on top of what was once considered permanently frozen ground. But as that solid ground softens, the infrastructure these communities rely on grows increasingly unstable.

In Canada, disappearing permafrost is estimated to cause tens of millions of dollars in damage to public infrastructure across Northwestern Territories each year.

What is Permafrost, Melting Effects, and How to Stop it.  
<https://www.nrdc.org/stories/permafrost-everything-you-need-know> (accessed 2025-05-13).



**Release Pathogen**

# Releasing Pathogen

Thawing permafrost is reviving ancient pathogens. In 2016, anthrax spores released in Siberia's Yamal Peninsula killed 2,500 reindeer and infected humans, proving 75-year-old pathogens remain viable. Scientists have resurrected the 30,000-year-old giant virus *Mollivirus sibericum*, which can still infect amoebae. The UN Environment Programme warns that smallpox and plague viruses may lie dormant in permafrost, with rising human activity in the Arctic increasing exposure risks. Additionally, antibiotic-resistant bacteria (e.g., *Paenibacillus* strains) discovered in permafrost could challenge modern medicine.

Could microbes, locked in Arctic ice for millennia, unleash a wave of deadly diseases?  
<https://www.unep.org/news-and-stories/story/could-microbes-locked-arctic-ice-millennia-unleash-wave-deadly-diseases> (accessed 2025-05-13).