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AMAP POLICY BRIEF
METHANE EMISSIONS TRENDS AND THE ARCTIC CLIMATE RESPONSE

ARCTIC MONITORING AND ASSESSMENT PROGRAMME



ARCTIC COUNCIL | AMAP

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POLICY RELEVANCE

Rapid reductions in methane emissions are vital to slow short-term warming in the Arctic. Because methane's atmospheric lifetime is much shorter than that of carbon dioxide (CO_2), reductions in methane emissions translate relatively rapidly into reduced atmospheric concentrations, and reduced warming.

The IPCC has stated that reductions in anthropogenic methane emissions of around one third, alongside cuts in other greenhouse gases (GHGs), are needed to keep warming below 1.5°C this century.[1] As noted in the AMAP Policy Brief: Black Carbon as a Climate Forcer,[2] mitigating short-lived climate forcers (SLCF) like black carbon and methane could have a significant impact on Arctic temperatures over the coming decades. Achieving the goals of the 2021 Global Methane Pledge (GMP), to cut anthropogenic methane emissions by 30% below 2020 levels by 2030, would reduce global warming by at least an estimated 0.2°C by the middle of the century.[3] Assessments undertaken for AMAP indicate that reductions would reduce Arctic warming by up to 0.5°C, due to Arctic amplification.[4] They would also lead to positive co-benefits to human and ecosystem health.

Although projections of global anthropogenic methane emissions are now lower than before the GMP was signed, the world is not on track to meet the GMP target. Prior to the introduction of the GMP, global methane emissions were expected to rise to 9% above 2020 levels by 2030. If policies in place and planned as of January 2026 are fully implemented, methane emissions are on track to fall 11% by 2030, still short of the 30% goal.[5]

Increasing greenhouse gas emissions, and the warming they cause, will give rise to climate feedbacks in the Arctic. These feedbacks, for example thawing permafrost, further exacerbate natural carbon emissions. This raises the risk of passing critical climate tipping points, although considerable uncertainty persists on this issue.

Reductions in methane emissions should be understood in the wider context of the urgent need to rapidly reduce all greenhouse gas emissions. While methane reductions can slow near-term warming, CO_2 emissions play a more significant role in longer-term climate change. On current emissions trends, average global temperatures will exceed the 1.5°C temperature ceiling set out in the Paris Agreements, and they will not stop rising until we achieve net-zero GHG emissions.

Recent research into the impacts on the Arctic from methane emissions in the context of the GMP, plus uncertainties in the Arctic's contributions to future methane emissions, for example from permafrost thaw, prompted AMAP to produce this policy communication.



John Bakator / Unsplash

1 IPCC, "The evidence is clear: the time for action is now. We can halve emissions by 2030.", press release, 4 April 2022.

2 AMAP, 2025. AMAP Policy Brief: Black Carbon as a Climate Forcer.

3 Global Methane Pledge website.

4 AMAP, 2021. AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health, page 226.

5 Höglund-Isaksson, L., et al. 2026. IIASA-GAINS model: Global database on anthropogenic methane emissions, future mitigation potentials and costs.

KEY MESSAGES

The key messages of this communication regarding the impacts of methane emissions trends on the Arctic climate are:

1 THE WORLD IS NOT ON TRACK TO REDUCE EMISSIONS IN LINE WITH TARGETS IN THE GLOBAL METHANE PLEDGE

Countries committing to the 2021 GMP pledged to contribute to a goal of reducing global human-caused (anthropogenic) methane emissions to at least 30% below 2020 levels by 2030. Meeting this target would avoid an estimated 0.2–0.3°C of warming globally by 2050 and would avoid up to an estimated 0.5°C of warming in the Arctic by 2050.

By the end of 2025, 159 governments had signed the GMP. If governments implement all measures planned as of January 2026 to reduce methane emissions, global emissions would fall to 11% below 2020 levels by 2030.

2 REDUCING METHANE EMISSIONS WOULD HELP MITIGATE WARMING IN THE ARCTIC IN THE NEAR TERM

Methane (CH_4) is a powerful greenhouse gas that has been responsible for around a third of global warming to date. As a short-lived climate forcer, it persists in the atmosphere for considerably less time than carbon dioxide (CO_2).

This means that reductions in methane emissions quickly lead to lower atmospheric concentrations of the gas. Methane emissions reductions can therefore reduce projected temperature increases over a much shorter timeframe, of decades rather than centuries, compared with reductions of CO_2. However, both are critical to stabilise global temperatures, with CO_2 reductions substantially more so over the longer term. The importance of reducing methane does not mean that efforts to reduce CO_2 emissions can be delayed.

3 RISING GLOBAL TEMPERATURES WOULD CONTRIBUTE TO POTENTIALLY SIGNIFICANT INCREASED CARBON EMISSIONS FROM THE ARCTIC

The Arctic is a small but growing source of methane emissions from natural sources, particularly wetlands and thawing permafrost. Some studies have found this to be driven by rising temperatures.

There are vast amounts of carbon trapped in permafrost, beneath glaciers and in Arctic Ocean sediments. Rising temperatures in the Arctic are thawing this permafrost, allowing organic material it contains to decompose, creating methane emissions.

Warming-induced northward migration of vegetation, combined with possible increases in lightning, may also increase wildfire CO_2, black carbon and methane emissions in the Arctic.

4 PURSUING MAXIMUM FEASIBLE METHANE REDUCTIONS HAS THE POTENTIAL TO MEET GMP TARGETS

Alternative scenarios exist that would enable the GMP target to be met. Were countries to implement maximum technically feasible reductions of methane, anthropogenic methane emissions could be reduced by up to 34% globally by 2030. UNEP estimates that, were all mitigation options implemented that cost less than US$1,000 per tonne of methane – equivalent to US$36 per tonne of CO_2 – methane emissions could be reduced by 26% by 2030.

In 2015, the Arctic Council members committed to take "enhanced, ambitious, national and collective action … to significantly reduce [their] overall methane emissions". Between 2013 and 2022, they collectively reduced anthropogenic emissions by 8%.

5 UNDERSTANDING FUTURE ARCTIC METHANE EMISSIONS REQUIRES ENHANCED MONITORING AND FURTHER MODELLING

As Arctic permafrost thaws and sea temperatures rise, the Arctic could become an increasingly significant source of natural methane emissions. Challenges in monitoring Arctic methane concentrations makes modelling of projected methane emissions increasingly important, although it is not without its own limitations.

Modelling and understanding future Arctic methane emissions requires enhanced monitoring, such as the strategic placement of observation sites, more sensitive remote sensing methods, and the integration of multi-source data into advanced process-based models.

SUPPLEMENTARY TECHNICAL EXPLANATION

The following pages provide additional technical detail that inform the key findings and recommendations in the policy-relevant summary above. They are intended for technical advisors to policy makers.

A METHANE PRIMER

Methane is a powerful greenhouse gas.[6] It has been responsible for around 30% of the global temperature rise since the Industrial Revolution and is the second most important contributor to global warming, after carbon dioxide (CO_2).[7] It is also a precursor to ground-level ozone (O_3) a harmful air pollutant that has negative impacts on human and ecosystem health.

Methane is produced primarily by the breakdown of organic matter in the absence of oxygen. Globally, natural sources, including wetlands and freshwaters, account for 40% of methane emissions. Anthropogenic sources, primarily agriculture, fossil fuel production and use, and waste, account for the other 60%.[8]

As a gas, it disperses throughout the atmosphere, although not as uniformly as CO_2, given its shorter lifetime in the atmosphere of only 10-12 years. As a consequence, atmospheric concentrations of methane, and thus its warming effect, respond more quickly to emissions reductions than do concentrations of CO_2, most of which persists in the atmosphere for hundreds of years.

Tonne for tonne, methane has a much greater warming effect than CO_2. Measured over 100 years – which is the conventional way of comparing the warming effect of greenhouse gases – methane has a global warming potential (GWP) 28 times that of CO_2. However, because methane is broken down rapidly in the atmosphere, its short-term warming impact is much greater than that of CO_2: measured over 20 years, methane's GWP is 81 times that of CO_2.[9]

Deep reductions in all emissions of GHGs and SLCFs over the next two decades, but particularly of methane, will reduce the warming we can expect this century.[10] Although methane reductions anywhere decrease the rate of warming everywhere, reducing methane emissions could have a relatively large impact on the Arctic climate. Arctic amplification mechanisms mean that the region is warming more than three times faster than the mid-latitudes.[11] Those same mechanisms mean that global emissions reductions will have a similarly large effect in slowing Arctic warming.[12]

AMAP's 2021 assessment of SLCFs, including methane, concluded that: "Global anthropogenic emissions of methane and levels of methane in the Arctic continue to increase."[6] Since that assessment, international policy efforts to address methane emissions have accelerated, including with the signing of the Global Methane Pledge (GMP) in 2021.

This policy brief provides an update on the realised and projected effects of policy developments on emissions of methane, methane concentrations in the atmosphere, and the expected climate and human impacts of methane in the Arctic.

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6 AMAP, 2021. AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health.

7 IEA, 2025. Global Methane Tracker 2025.

8 NASA, 2026. Methane - Earth Indicator, web page.

9 IPCC, IPCC Sixth Assessment Report, 2021. Climate Change 2021: The Physical Science Basis, chapter 7, Table 7.15, page 1017.

10 IPCC, 2023. Climate Change 2023 Synthesis Report.

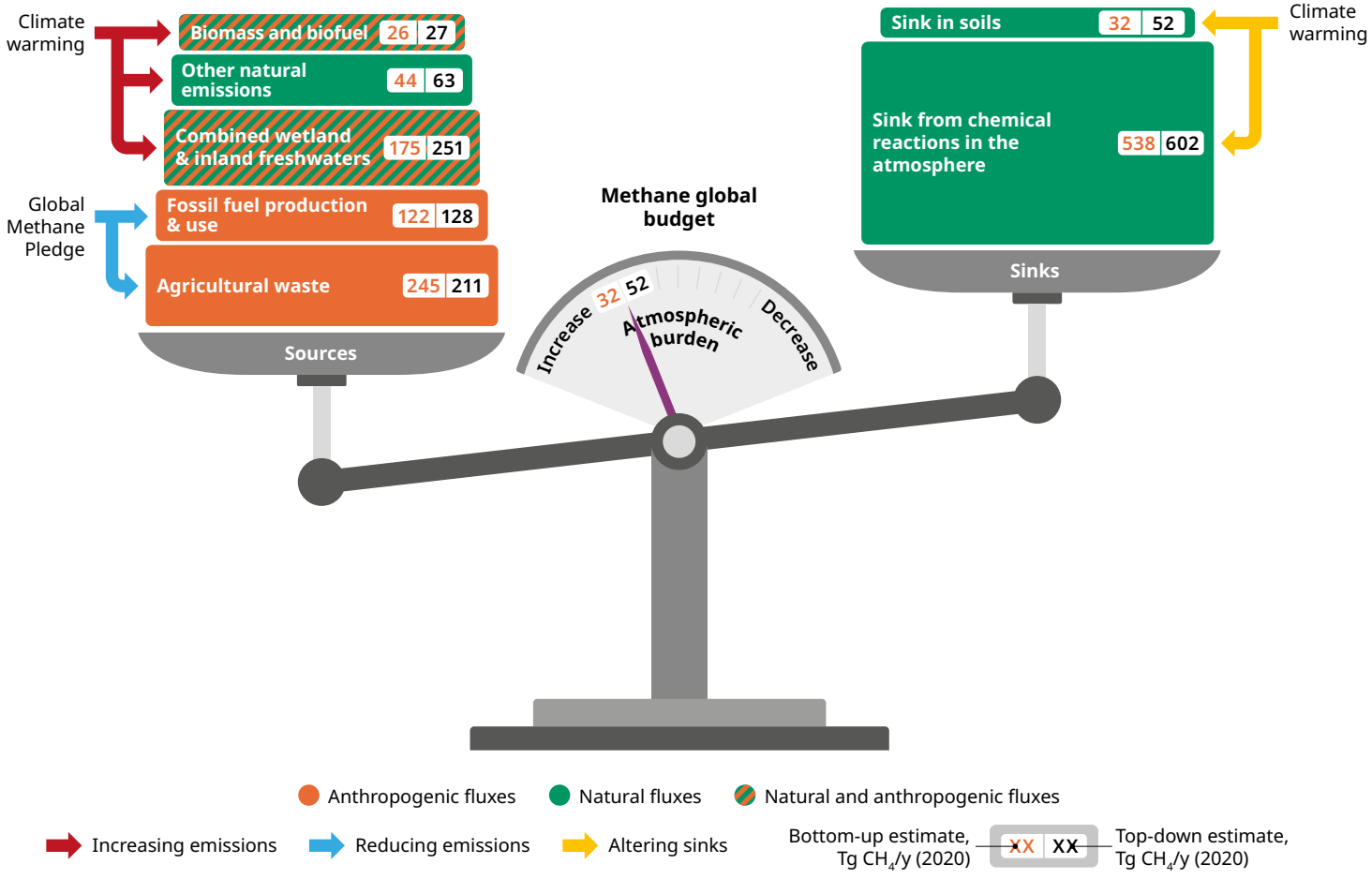
11 AMAP, 2021. Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health. Summary for Policy-makers; and AMAP, 2025. Arctic Climate Change Update 2024: Key Trends and Impacts. Summary for Policy-makers.

12 Im et al, 2026. Evolution of Near-Term Atmospheric Methane and Associated Temperature Response Under the Global Methane Pledge: Insights From an Earth System Model, page 6.

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Global anthropogenic and natural sources and sinks of methane. The Global Methane Pledge targets anthropogenic emissions reduction. Climate warming will influence natural processes that can lead to increased or decreased emissions of methane and other carbon species over different timescales.[13] 1 Tg = 1000 kt.

13 Source of data: The Global Carbon Project, Global Methane Budget webpage.

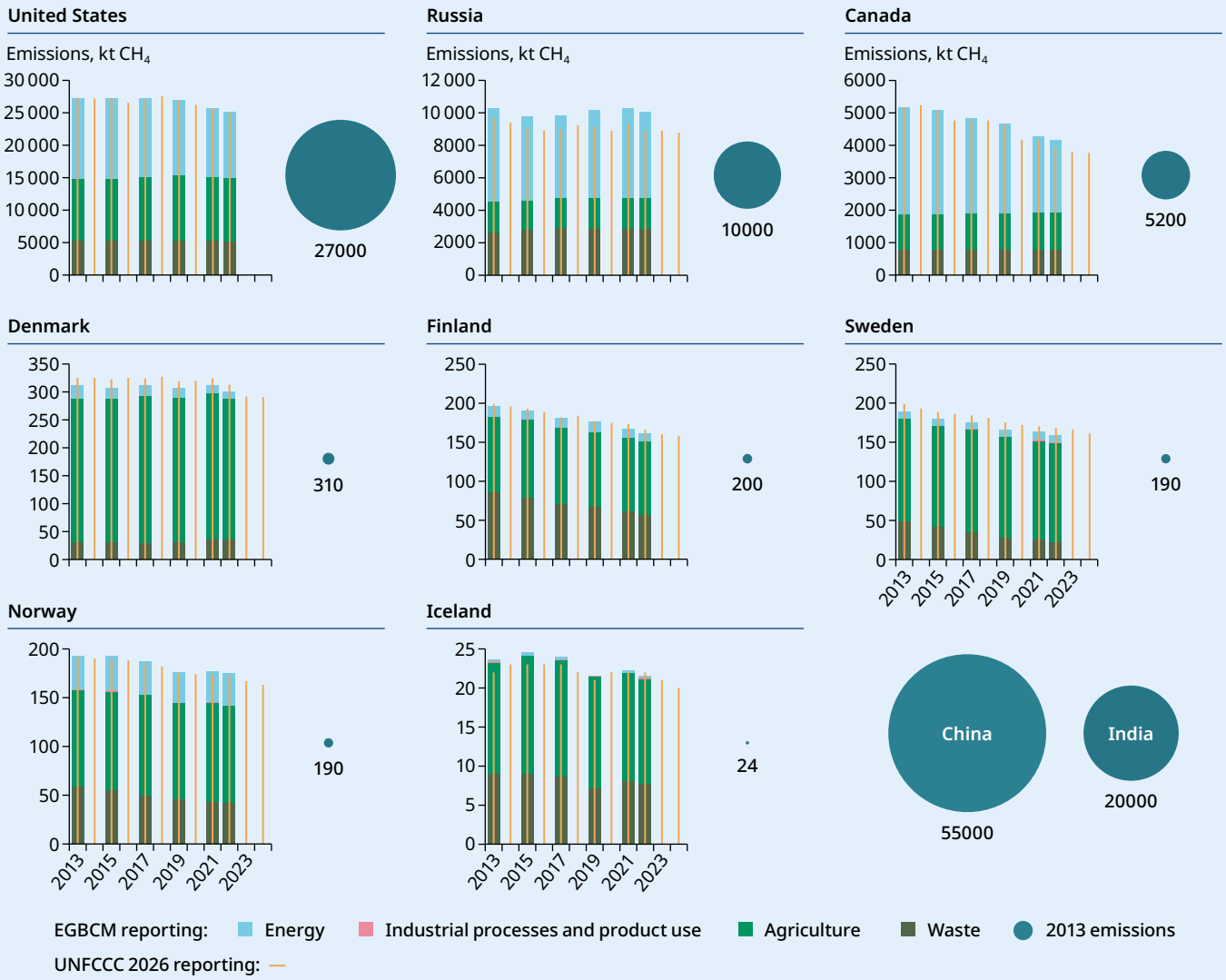
RECENT TRENDS IN METHANE EMISSIONS

ANTHROPOGENIC EMISSIONS

Around 42% of anthropogenic emissions of methane come from agriculture, 38% from energy production and use, and 20% from waste.[14] Emissions totals are calculated by bottom-up inventories, such as those submitted by signatories to the UN Framework Convention on Climate Change (UNFCCC), and through top-down atmospheric measurement, using monitoring stations and satellite observations.

Globally, anthropogenic emissions of methane have increased by around 40% between 1970 and 2020, reaching approximately 350 million tonnes (Mt) by that year.[15]

The eight Arctic States accounted for 20% of global anthropogenic emissions in 2020.[16] Methane emissions from Arctic States, as reported to the UNFCCC, collectively decreased 8% between 2013 and 2022.[17]



Recent trends in methane emissions (excluding land-use and land-use change) from Arctic Council member states show declining trends, largely in response to reduced emissions from the energy and waste sectors. Circle area scaled to total national emissions (in 2013) reflect the relative differences in methane emissions from Arctic Council member states and selected observer countries.[16] Also showing UNFCCC reported emissions.[18]

14 UNEP, 2025. Global Methane Status Report 2025, page 31.

15 Ibid, page 33

16 EGBCM, 2025. 4th Summary of Progress and Recommendations, page 13.

17 Ibid, page 7

18 UNFCCC National Inventory Submissions 2026.

The main source of anthropogenic methane emissions in the Arctic is the oil and gas sector. The four Arctic States with significant oil and gas production – Canada, Norway, the Russian Federation, and the United States – collectively report reduced methane emissions from that production by 14% between 2013 and 2021.[19] However, studies suggest that methane emissions from this sector tend to be underestimated where reporting relies on bottom-up methodologies alone.[20]

Although the eight Arctic states each report total anthropogenic methane emissions, they do not generally report data covering only their Arctic regions.

NATURAL EMISSIONS

Wetlands and inland freshwaters account for the majority of natural methane emissions, with other natural sources including geological emissions, oceans, termites, wild animals, and permafrost. Wildfires and other biomass burning account for significant volumes of methane emissions. The extent to which these should be attributed to human activities as opposed to natural processes is debated, as human-induced climate change is leading to increases in wildfire frequency. Near the Arctic, smouldering peat and Boreal forest fires can contribute a larger fraction of methane emissions than other types of fires, due to the low-oxygen and lower temperature fire environment. Long-lived underground peat fires have occurred in the Arctic, e.g. in southwest Greenland and Alaska.[21]

Compared with anthropogenic emissions, estimates of total natural methane emissions are subject to large ranges. One study estimates global natural emissions in 2020 at 314 Mt (with a range of 195–457 Mt) using bottom-up methods and 216 Mt (193–241 Mt) using top-down methods.[22]

In the Arctic, the vast majority of methane emissions are from natural sources, particularly wetlands and thawing permafrost. According to one study, methane emissions from Arctic wetlands and lakes averaged 34 Mt/y between 1988 and 2019, or around 5–6% of total global methane emissions.[23] Another study gave an estimate of 48.7 Mt of annual methane emissions from terrestrial and freshwater Arctic-Boreal sources, with a range of 13.3 to 86.9 Mt, with an additional 4.9 Mt (with a range of 0.4 to 19.4 Mt) from the Arctic marine environment.[24]


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Researchers have estimated that those emissions increased by around 9% from 2002 to 2022, driven by rising temperatures, changes to the hydrological cycle, and related increased ecosystem productivity.[25]

As well as contributing to gradual increases in methane emissions, large-scale permafrost thaw, and diminishing sea ice could potentially lead to releases of vast quantities of methane over short periods (see text box on next page).[26] Emissions from thawing ground beneath glaciers could represent a locally important source.[27]

There are considerable challenges to calculating natural methane emissions, particularly in the Arctic, where ground-level observations are limited.[28]

19 EGBCM, 2025. 4th Summary of Progress and Recommendations, page 37.

20 Chan, E., et al., 2024. Hybrid bottom-up and top-down framework resolves discrepancies in Canada's oil and gas methane inventories; MacKay, K., et al., 2024. A Comprehensive Integration and Synthesis of Methane Emissions from Canada's Oil and Gas Value Chain.

21 McCarty et al, 2020. Arctic fires re-emerging

22 Saunois, M. et al., 2025. Global Methane Budget 2000-2020.

23 Kuhn, M. et al., 2025. Current and future methane emissions from boreal-Arctic wetlands and lakes.

24 Parmentier, F-J. W. et al., 2024. Vulnerability of Arctic-Boreal methane emissions to climate change.

25 Yuan, K. et al., 2024. Boreal–Arctic wetland methane emissions modulated by warming and vegetation activity.

26 Wittig, S., et al., 2024. Surface networks in the Arctic may miss a future methane bomb.

27 Kleber G.E. et al., 2023. Groundwater springs formed during glacial retreat are a large source of methane in the high Arctic.

28 Pallandt, M. M. T. A., et al., 2022. Representativeness assessment of the pan-Arctic eddy covariance site network and optimized future enhancements.

SUDDEN METHANE RELEASES

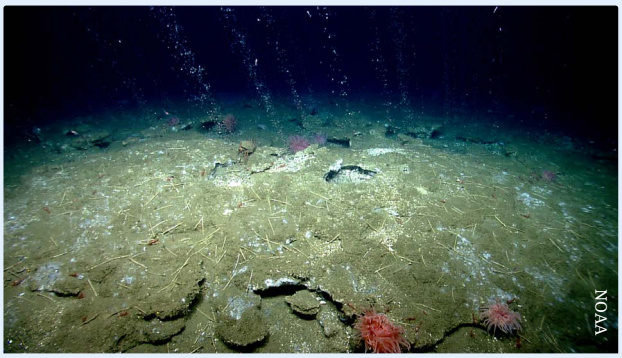
Arctic terrestrial and sub-sea permafrost contains vast reservoirs of frozen organic matter that, as it thaws, decomposes to produce methane. In addition, the Arctic Ocean contains large volumes of methane hydrate, an ice-like compound of water and methane, which is stable under pressure and at low temperatures.[29]

Some scientists have raised concerns that Arctic warming could lead to the rapid release of methane from these sources, creating a climate 'tipping point'.[30] The IPCC has warned that near-surface permafrost is projected to significantly decrease under future global warming scenarios, releasing CO_2 and methane to create positive carbon-climate feedbacks.[31]

Terrestrial permafrost: Recent studies have suggested that natural methane emissions from terrestrial permafrost have only increased marginally.[32] Other research notes that changes to Arctic hydrology are likely to counteract increased methane emissions from permafrost thaw to some extent, as dry soils consume atmospheric methane.[33]

Sub-sea methane: Some recent research also suggests that concerns about dramatic increases in sub-sea Arctic methane emissions may not be warranted.

Anoxic oxidation in sulphate-rich sediments, and the rapid dissolving of methane bubbles into ocean water where it is oxidized into CO_2, mean that relatively small amounts of methane from subsea sediments reach the atmosphere.[29]



Considerable uncertainty also persists around the possibility of large-scale emissions from sub-sea permafrost and methane hydrates, although those emissions are unlikely to be rapid: current modelling of the likely behaviour of sub-sea methane hydrates indicates that emissions will most likely occur over centuries or millennia.[34]

The wider context: Furthermore, some scenarios suggest that the volumes of methane released from natural terrestrial, freshwater and marine sources in the Arctic are likely to be lower than the reductions achievable from anthropogenic sources.[35] Nonetheless, when accounting for both methane and CO_2, model simulations suggest that annual permafrost emissions could reach or exceed the current total annual emissions of a high-emitting nation such as the USA by the end of the century.[36]

ISOTOPIC ANALYSIS OF METHANE EMISSIONS

The carbon and hydrogen atoms that make up the methane molecule come in a number of different isotopes – slightly lighter or heavier versions of the same element. The different processes that generate methane create an isotopic 'fingerprint' on each molecule, allowing scientists to distinguish between biological methane, fossil methane and methane produced by wildfires and other forms of biomass burning.

Biological methane is produced by microbes that favour lighter carbon isotopes. Fossil methane is produced under pressure and over a long period, resulting in methane enriched in heavier carbon isotopes. Wildfire methane has a fingerprint somewhere between the other two types.

However, there are limitations to using isotopic techniques to estimate sources of atmospheric methane. Isotopic fingerprints overlap, making it difficult to distinguish between biologic and thermogenic methane, for example.

29 AMAP, 2021. AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health, page 37.

30 European Commission, CORDIS – EU research results, n.d. "The sleeping giants of the global carbon cycle".

31 IPCC Sixth Assessment Report, 2021. Climate Change 2021: The Physical Science Basis, Box 5.1, page 728.

32 Ibid page 41.

33 Parmentier, F-J. W. et al., 2024. Vulnerability of Arctic-Boreal methane emissions to climate change.

34 AMAP, 2021. AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality, and Human Health, page 38.

35 Ibid page 41.

36 Schädel, C., et al., 2026. Permafrost and wildfire carbon emissions indicate need for additional action to keep Paris Agreement temperature goals within reach.

37 Ibid.

INVERSE MODELLING TO UNDERSTAND EMISSION SOURCES IN THE ARCTIC

It is challenging for researchers to quantify future Arctic methane emissions, due to observational gaps in some regions, limited data on methane isotopes that can indicate emissions sources (see box on previous page), and the challenges in distinguishing between natural and anthropogenic emissions. These difficulties are exacerbated by the potential for abrupt increases in emissions, due to permafrost thaw, for example.

Researchers can use inverse modelling systems to estimate the distribution and extent of methane emissions. They use observations of concentrations, simulations of atmospheric transport, and data assimilation techniques to estimate emissions. The *Reduch4e* project, which studied the implications for the Arctic of the GMP, used NOAA's CarbonTracker-CH_4 atmospheric inversion system to estimate the sources of methane emissions in the Arctic. It confirms that the methane budget in the Arctic is dominated by fossil fuels and that those emissions are underestimated in the inventories.[37]



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METHANE OBSERVATIONS: TRENDS



Because methane is mixed in the atmosphere, it is more straightforward to measure atmospheric concentrations of the gas than it is to measure emissions from its sources. Concentrations of methane in the atmosphere are now more than two-and-a-half times pre-industrial levels.[38] Concentrations in the Arctic have risen from 1850 parts per billion (ppb) in 1994 to 2040 ppb in 2025.

Atmospheric methane concentrations are measured at monitoring stations around the world. These include the Mauna Loa Observatory in Hawaii, operated by the US National Oceanic and Atmospheric Administration, and the Dr. Neil Trivett Observatory at Alert, Nunavut, Canada, operated by Environment and Climate Change Canada. The ICOS network, which provides uniform calibrated measurements of atmospheric methane concentrations at high time resolution (less than 1 hour), includes a number of Arctic sites, such as the Zeppelin station (ICOS-ZEP) on Svalbard and the Villum Research Station / Nord (ICOS-SNO) in Greenland.[39]

Ground-based observations are complemented by high-resolution satellite monitoring, such as that provided by the European Space Agency's Sentinel-5P satellite and the Japanese Aerospace Exploration Agency's GOSAT-GW satellite. These can spot plumes from methane leaks, such as from oil and gas infrastructure and some landfill sites, but are less able to measure dispersed methane emissions at the low concentrations produced in wetlands or by thawing permafrost.

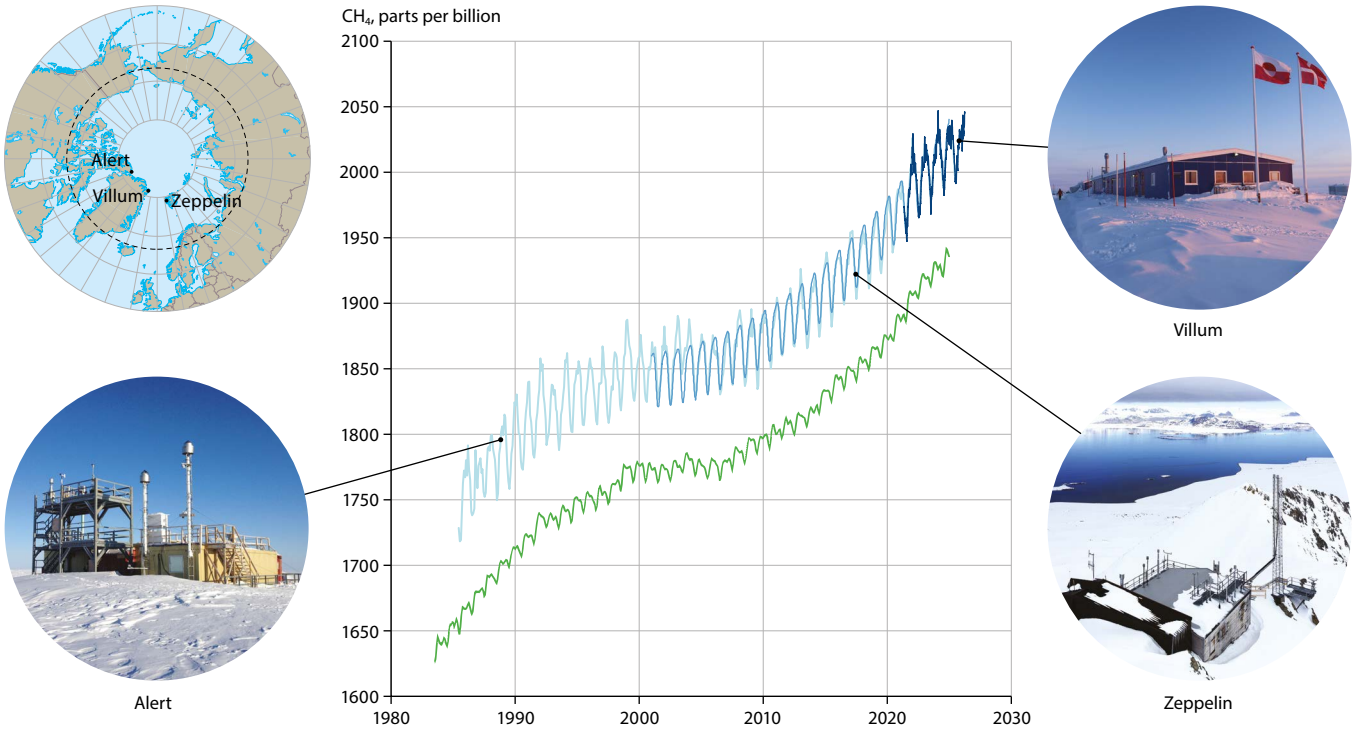
Methane concentrations demonstrate high variability between seasons. There is some seasonal variability in anthropogenic emissions in high latitudes, believed to be related to gas production and biomass burning, while natural emissions show much stronger changes between seasons. This is driven by changes to wetland conditions from temperatures, soil moisture and water table level, snow cover, and soil frost.[40]

Bottom-up monitoring of methane emissions in the Arctic is extremely challenging, given the size of the region, its sparse population and inaccessibility for much of the year. Methane emissions processes vary significantly depending on ecosystem type, which are difficult to track given ongoing changes to the Arctic environment, while the seasonality of these processes adds to the complexity in estimating methane emissions fluxes across the region.

38 UNEP, 2025. Global Methane Status Report 2025, page 15.

39 See www.icos-cp.eu

40 Kivimäki, E., et al., 2025. Environmental drivers constraining the seasonal variability in satellite-observed and modelled methane at northern high latitudes.



Atmospheric methane concentrations at selected Arctic sites, and from a global network of air sampling sites *(Source: NOAA).* Elevated levels at Arctic sites are associated with the generally higher methane emissions from both natural and anthropogenic sources that take place in the northern hemisphere; however, the observed annual methane trends are similar.

TRENDS IN GLOBAL METHANE CONCENTRATIONS

Methane emissions mix through the troposphere on timescales shorter than their globally averaged atmospheric lifetime, so the average trends in atmospheric concentration are similar everywhere on Earth. From approximately 2000 to about 2005, growth in global methane concentrations stalled. The underlying causes remain uncertain, although recent research points to increased atmospheric oxidation due to rising emissions of nitrogen oxides (NO_x). These emissions were the result of economic growth in developing countries and increased shipping during this period.[41]

Oxidation by atmospheric hydroxyl (OH) radicals is the primary sink for methane and, after being relatively stable over the 20th century, OH concentrations rose from the 1980s due to climate change, stratospheric ozone depletion, and rising NO_X emissions.[42]

Since around 2007, growth in methane concentrations resumed, and accelerated from 2015. In 2020-2021, the growth rate rose sharply and reached 16.2 ppb in 2020, the highest level on record[43] before declining to 8.6 ppb by 2023. Some scientists have attributed this surge to reductions in OH concentrations, due to reduced human activities during the COVID pandemic leading to decreased emissions of NO_X, which is an indirect source of OH.[44]

Other explanations for changes in the rate of growth of methane concentrations include changes in tropical wetlands, livestock, fossil fuels, and biomass burning. Contradictions in these hypotheses arise because our current observational network cannot clearly link recent methane variations to specific sources.[45]

TRENDS IN METHANE CONCENTRATIONS IN THE ARCTIC

Despite the success of Arctic Council states in reducing their anthropogenic methane emissions since 2013, atmospheric concentrations of methane in the Arctic have continued to rise. This is largely due to increased global emissions of methane and their transport to the Arctic,[46] although hotspots of Arctic emissions may make a contribution.[47]

41 Zhu, Y. et al., 2026. Atmospheric CH_4 plateau sustained by NO_X emission rise and southward shift.

42 Schaeffer, H., et al., 2026. A 21st-century shift from fossil-fuel to biogenic methane emissions indicated by $^{13}CH_4$, and references therein.

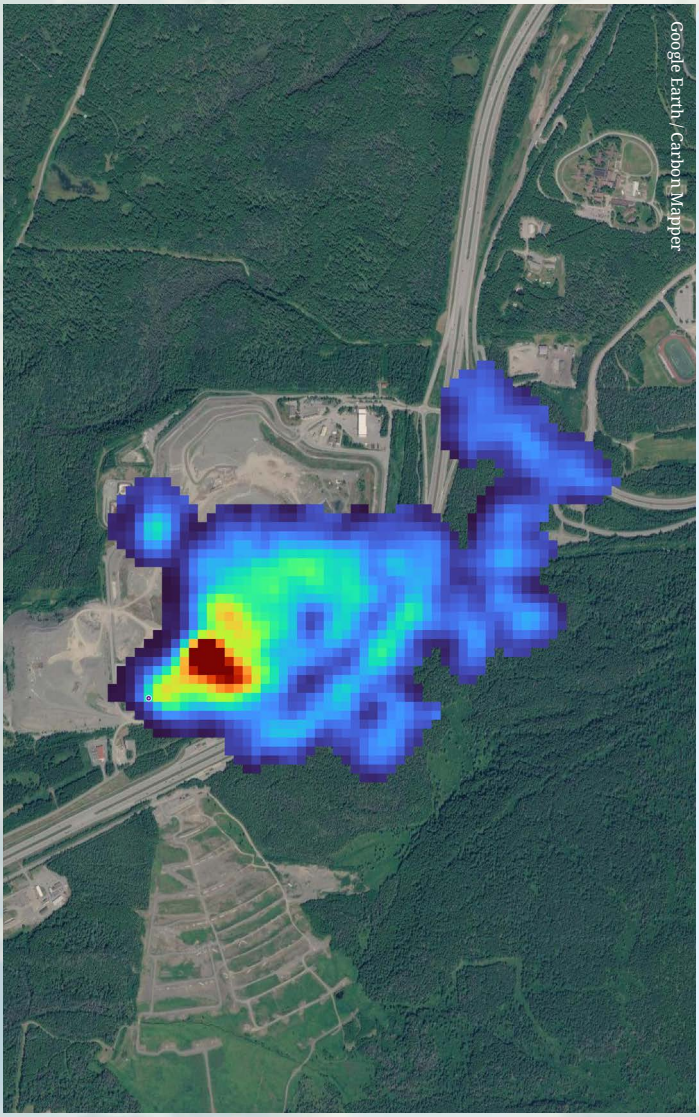
43 Nisbet, E.G., et al., 2023. Atmospheric Methane: Comparison Between Methane's Record in 2006–2022 and During Glacial Terminations.

44 Ciais, P. et al., 2026. Why methane surged in the atmosphere during the early 2020s.

45 Nisbet, E.G. et al., 2019. Very Strong Atmospheric Methane Growth in the 4 Years 2014–2017: Implications for the Paris Agreement, and references therein.

46 Lawrence, C. et al., 2019. Anthropogenic and Natural Factors Affecting Trends in Atmospheric Methane in Barrow, Alaska.

47 Platt, S.,et al., 2018. Methane at Svalbard and over the European Arctic Ocean.


Google Earth / Carbon Mapper

APPROACHES TO MODELLING METHANE CONCENTRATIONS AND IMPACTS

To better understand the likely evolution and effects of methane concentrations, researchers use a variety of modelling techniques.

In **modelling using prescribed concentrations,** global methane levels are fixed rather than allowed to respond dynamically to other components of the climate system as the scenario evolves. These models allow easier interpretation of cause-and-effect dynamics and are less computationally intensive to run. However, they do not capture feedbacks and are therefore less realistic.[48] For example, in modelling methane, a prescribed model might not capture the effects of warming temperatures on permafrost thawing and the resulting increased production of microbial methane.

Interactive or dynamic modelling allows levels of emissions to respond to biological and meteorological changes, integrating the effects of feedbacks. This was the approach taken by the *Reduch4e* project in its modelling of the impact of GMP reductions on methane concentrations and avoided warming.

48 Im U., et al., 2025. Future CH_4 as modelled by a fully coupled Earth system model: prescribed GHG concentrations vs. interactive CH_4 sources and sinks.


Katie Rodriguez / Unsplash

POLICY MEASURES TO REDUCE EMISSIONS AND THEIR LIKELY IMPACTS

Arctic States are involved in national, regional and international policy initiatives to reduce methane emissions. All Arctic Council member states have national climate policy frameworks or other regulations in place that address methane emissions. In 2015, the Arctic Council adopted a framework for action on black carbon and methane, that committed members to take "enhanced, ambitious, national and collective action … to significantly reduce our overall methane emissions".[49] While the Arctic Council set a quantified target for reductions in emissions of black carbon, it did not for methane.

That framework led to the establishment of the Arctic Council's Expert Group on Black Carbon and Methane, which tracks progress by member states in reducing emissions of the two pollutants and issues recommendations. Its most recent report was published in 2025.[50]

Globally, the most significant policy initiative since the preparation of the last AMAP assessment was the signing, in 2021, of the Global Methane Pledge (GMP). As of late 2025, 159 countries had agreed to take voluntary action to contribute to the goal of reducing global methane emissions to at least 30% below 2020 levels by 2030.[51] Doing so would avoid an estimated warming of at least 0.2°C by 2050.[52]



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THE POTENTIAL ROLE OF THE GOTHENBURG PROTOCOL

The Gothenburg Protocol is an international agreement that, among other things, seeks to control ground-level ozone. Signed in 1999 under the UNECE Air Convention, the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone sets targets for ratifying countries to reduce NO_x and non-methane volatile organic compounds, which are precursors of ground-level ozone.

Given the role of methane emissions in ozone formation, in May 2025 the Protocol's Working Group on Strategies and Review recommended the Executive Body consider whether to include methane in the next revision of the Protocol.[53] As of June 2026, that process was ongoing.

49 Arctic Council, 2015. IQALUIT 2015 SAO Report to Ministers: Enhanced Black Carbon and Methane Emissions Reductions - An Arctic Council Framework for Action.

50 EGBCM, 2025. 4th Summary of Progress and Recommendations.

51 UNEP, 2025. Ministers urge decisive methane action as global report shows progress, warns of gaps, press release, 17th November 2025.

52 UNEP, 2025. Global Methane Status Report 2025.

53 UNECE, "UNECE Air Convention advances Gothenburg Protocol revision", press release, 29th May 2025.

PROGRESS TOWARDS THE GOALS OF THE GMP

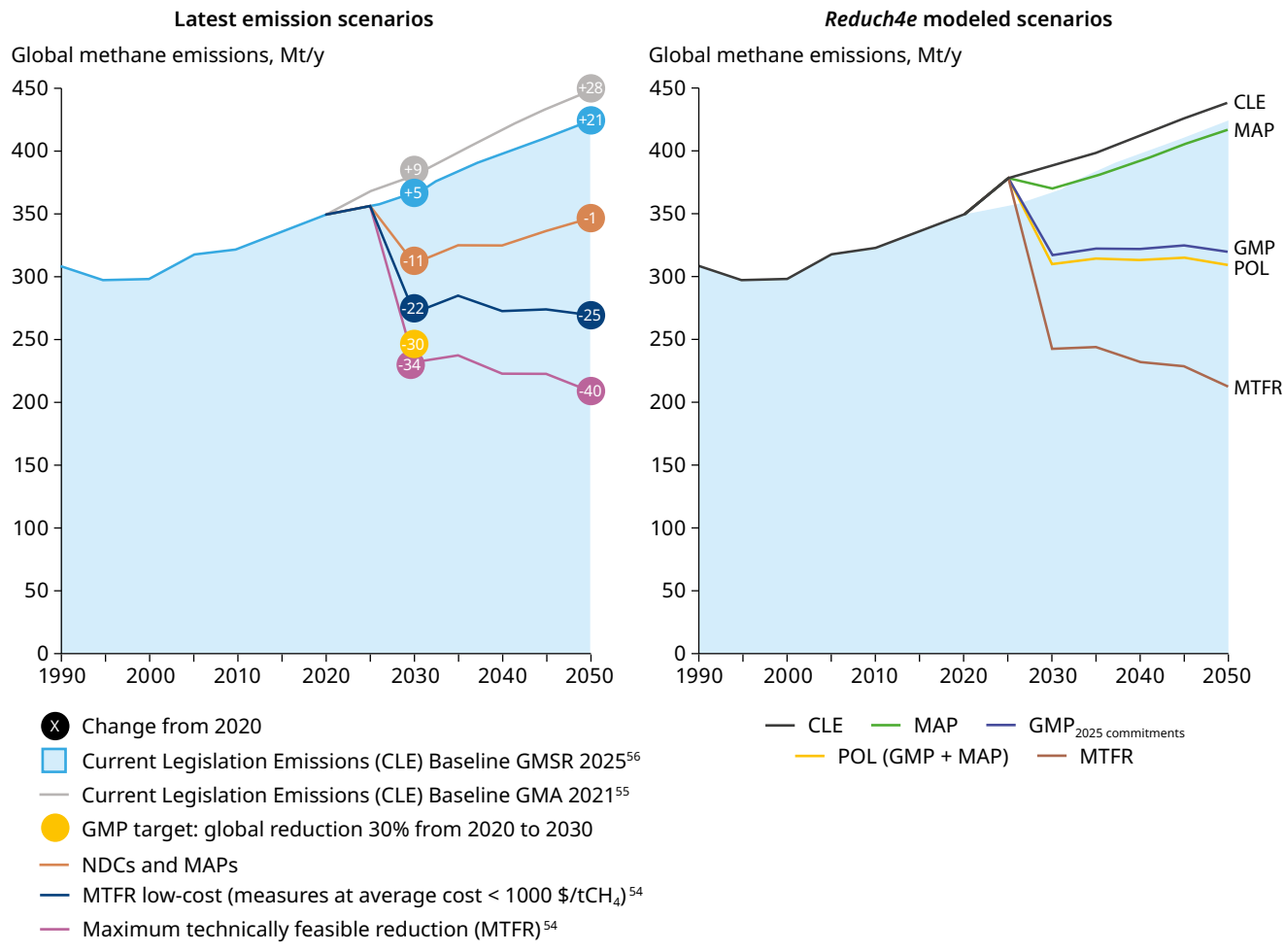
Currently, the world is not on track to meet the GMP's target. Under legislation in place globally as of January 2026, anthropogenic methane emissions are projected to fall by 11% below 2020 levels by 2030.[54] Those from the eight Arctic Council States were projected to fall by 12% over the same period. These measures include those explicitly and implicitly targeting methane set out in countries' Nationally Determined Contributions to the Paris Agreement and in Methane Action Plans published by those that are not GMP signatories.

While this projected reduction remains some way off the GMP goal, it anticipates significantly lower emissions than projections of a 9% rise by 2030 made before the pledge was launched (GMA 2021).[55]

MODELLING DEEPER REDUCTIONS

Researchers also have considered the potential reductions that could be achieved under alternative scenarios to that described above. These include a scenario where countries implement the maximum technically feasible reductions (MTFR), which are those achievable with the best available technologies and practices, regardless of cost. They also include one where countries implement those reductions achievable at a cost below US$1,000 per tonne of methane, in 2030, or the equivalent of around US$36 per tonne of CO_2.

If every country were to implement MTFR, a global reduction in methane emissions of between 32% and 34% would be possible by 2030, according to recent studies including UNEP's latest Global Methane Status report. These studies found that pursuing low-cost mitigation options would cut global anthropogenic methane emissions by 22–26% below 2020 levels by 2030.[54, 56]



(Left panel) Anthropogenic methane emissions, 1990-2050, under various scenarios,[54] compared with emission scenarios applied in the *Reduch4e* project to model implications of the GMP (right panel) (see maps on page 16).

54 Höglund-Isaksson, L., et al. 2026. IIASA-GAINS model: Global database on anthropogenic methane emissions, future mitigation potentials and costs.

55 UNEP, 2021. Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions.

56 UNEP, 2025. Global Methane Status Report 2025, page 38.

Pre-print

THE LIKELY IMPACT OF POLICY MEASURES ON FUTURE ARCTIC EMISSIONS, CONCENTRATIONS AND CLIMATE

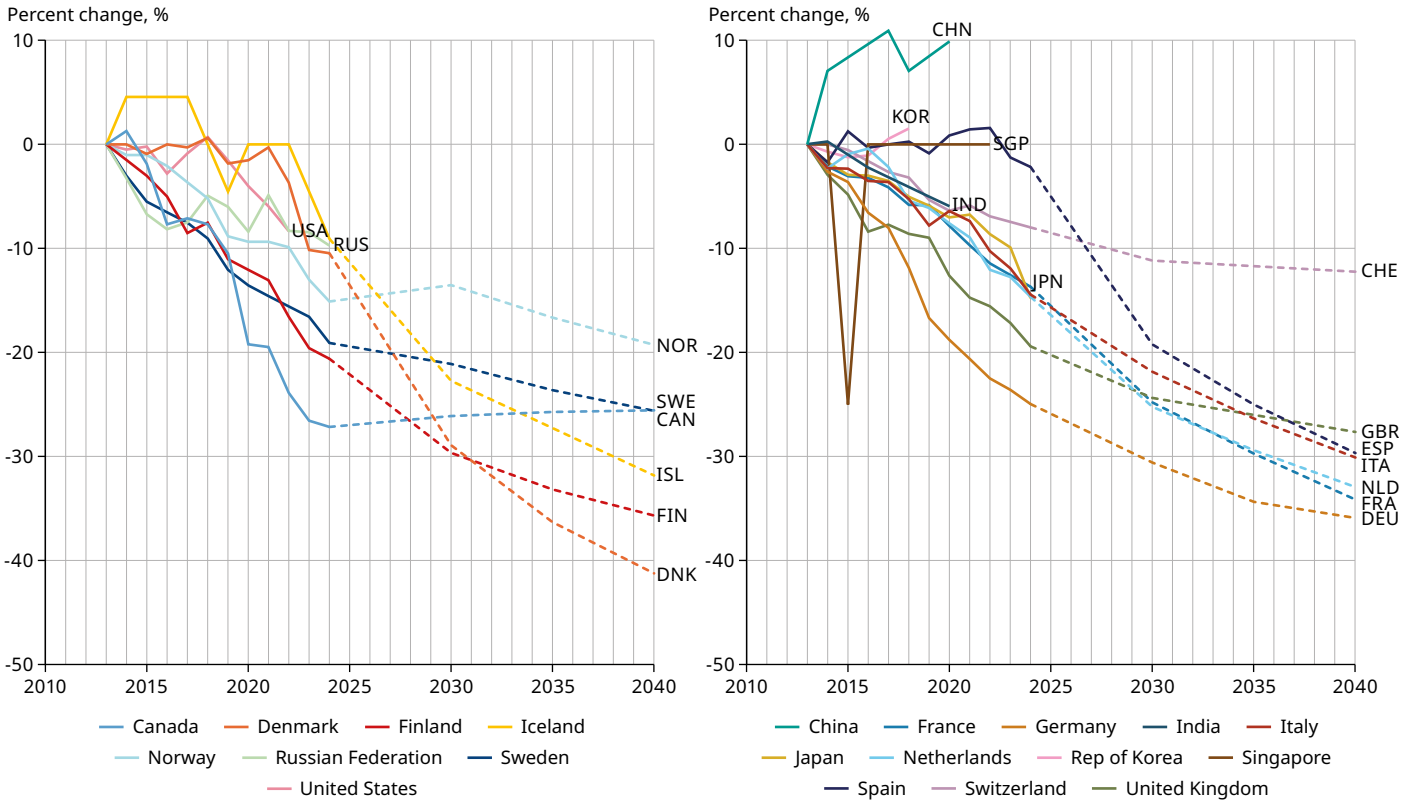


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A number of studies and reports have set out to model future anthropogenic methane emissions, concentrations, and climate impacts in the Arctic. These cover varying timelines and use different scenarios and techniques.

PROJECTIONS FOR ARCTIC COUNCIL MEMBER STATE & OBSERVER METHANE EMISSIONS

The Arctic Council's Expert Group on Black Carbon and Methane (EGBCM) has compiled projections of anthropogenic methane emissions from Arctic states to 2035, based on emissions reported to it and the UNFCCC by those states in 2024. Those projections indicate a collective reduction of 18% by 2035 from 2013 levels.[57]



Percent change in historical 2013–2024 (solid lines) and projections 2030, 2035 and 2040 (dashed lines) for methane emissions in Arctic Council member states and observer countries relative to emissions in 2013.[58]

57 EGBCM, 2025. 4th Summary of Progress and Recommendations, p28;

58 UNFCCC National Inventory Submissions 2026.

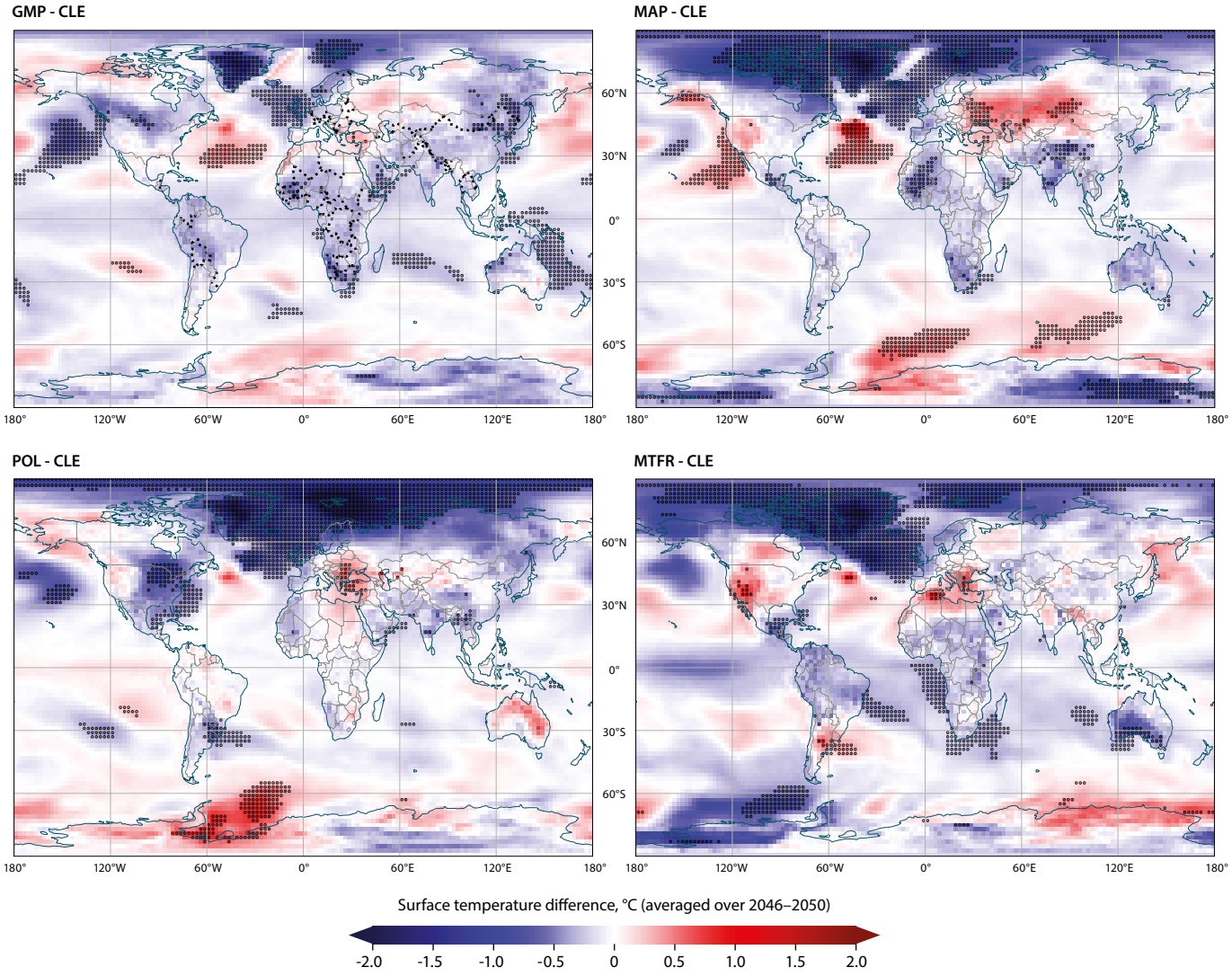
PROJECTIONS OF CLIMATE IMPACTS FROM METHANE REDUCTIONS

The *Reduch4e* project considered the impact of reducing methane emissions over the period 2025–30 on atmospheric concentrations out to 2100, modelling three scenarios against a baseline 'Current Legislation' (CLE) scenario. Some of the scenarios specifically focused on the Global Methane Pledge and Methane Action Plans (MAP) (see figure on page 14).

It is possible to model the potential climate impacts of the various reduction scenarios, looking at impacts on radiative forcing (RF) at the top of the atmosphere.

RF measures changes in the energy balance at the top of the atmosphere caused by changes in climate forcers – for example, the amounts of GHGs such as methane in the atmosphere. Of the five scenarios considered in Im et al (2026), the largest effect on RF is under the Maximum Technical Feasible Reduction (MTFR) scenario, which reduces RF from methane by 2050 back to 2010 levels.[59]

This research also considered how global surface temperatures might respond under the various scenarios. Compared with the baseline scenario (CLE), the MTFR scenario avoids 0.13±0.12ºC of global warming by 2050 averaged over the globe; the avoided warming is strongest over the Arctic (see Figure below).



Simulated surface temperature differences between the Current Legislation (CLE) scenario and the Global Methane Pledge (GMP), Methane Action Plans (MAP), Full Policy (POL, combination of GMP and MAP), and Maximum Technical Feasible Reduction (MTFR) scenarios, respectively, averaged over 2046–2050. The dotted areas show responses within a 95% confidence interval.[59]

59 Im, U. et al. 2026. Evolution of near-term atmospheric methane emissions, concentrations, and associated forcing and temperature response under the Global Methane Pledge: insights from an Earth system model.

Researchers have simulated the effects of reduced methane emissions on surface temperatures in the Arctic, specifically. Previous assessments have estimated that around a quarter of the total projected Arctic warming of around 2°C could be avoided by 2050 if all technically feasible reductions of SLCF emissions globally were implemented.[60]

Modelling conducted for the *Reduch4e* project investigated avoided warming under different mitigation scenarios, including a GMP (2025 commitments) scenario (see figure on page 14). Arctic surface temperature responses varied over time but, by the period 2046–2050, lower surface temperatures were acheived under all mitigation scenarios relative to the CLE scenario. Models considering interactions between multiple emitted species still exhibit large uncertainties and therefore need to be improved.[61]

These findings underscore the importance to the region of rapid reductions in methane emissions, alongside continuing longer-term efforts to reduce other greenhouse gases, particularly carbon dioxide.



Bo Elberling





METHANE AND HUMAN AND PLANT HEALTH

Methane contributes to the formation of ground-level ozone, an air pollutant which is harmful to human health, ecosystems and agriculture, and which is a major component of photochemical smog.

One study estimated that a 45% reduction in methane emissions would prevent 255,000 premature deaths and 26 million tonnes of crop losses a year globally.[62]

There is some evidence of elevated ozone concentrations in parts of the Arctic, for example due to emissions from shipping.[63] Although low population density in the Arctic means that smog does not have significant impacts on mortality in the region, it can nonetheless have serious implications for communities where local pollution is an issue.

There is evidence of adverse impacts from ground-level ozone on crops and natural vegetation, including reduced growth and seed production and reduced ability to over-winter and withstand stresses. Global yield losses from ozone are estimated at 2-16% for wheat, rice, maize and soybean. While these crops are not currently of major importance in the Arctic, rising temperatures are likely to lead to greater agricultural production in the region.[64]

60 AMAP, 2015. AMAP Assessment 2015: Methane as an Arctic climate forcer.

61 Im, U. et al. 2026. Evolution of near-term atmospheric methane emissions, concentrations, and associated forcing and temperature response under the Global Methane Pledge: insights from an Earth system model. Additional model run.

62 CCAC, UNEP, 2021. Global Methane Assessment, page 8.

63 Schmale, J. et al., 2018. Local Arctic Air Pollution: A Neglected but Serious Problem.

64 AMAP, 2021. AMAP Assessment 2021: Impacts of Short-lived Climate Forcers on Arctic Climate, Air Quality and Human Health, page 294.

CONCLUSIONS AND RECOMMENDATIONS

Key findings and recommendations concerning methane from AMAP's 2021 SLCF assessment continue to apply. Reducing emissions of methane and other SLCFs will affect the Arctic climate, both in the short-term and on longer timescales due to feedback mechanisms. Global anthropogenic emissions of methane are considerably above pre-industrial levels and are continuing to increase, compounding their negative impacts. This underscores the need to effectively implement current legislation and deploy the best available technologies to reduce those emissions. The faster that action is taken, the more effective it will be, given feedbacks that further accelerate warming.



Igor Barilo / Adobe Stock

SUBSTANTIAL REDUCTIONS IN METHANE EMISSIONS ARE REQUIRED TO SIGNIFICANTLY SLOW GLOBAL WARMING IN THE NEAR TERM AND AVOID CROSSING POTENTIALLY IRREVERSIBLE CLIMATE TIPPING POINTS.

Reducing methane emissions could have a significant near-term effect on slowing warming, globally and, in particular, in the Arctic. Reducing Arctic warming is particularly important to reduce the risk of passing tipping points and accelerating natural emissions of carbon dioxide and methane from the region.



Katie Rodriguez / Unsplash

ACTIONS TO REDUCE METHANE EMISSIONS UNDER THE GMP AND OTHER PARALLEL INTERNATIONAL AGREEMENTS NEED TO ACCELERATE IF THE GMP TARGET IS TO BE MET.

To do so, policy-makers should ensure country-specific legislation is effectively implemented and additional technically feasible reduction options explored. Ongoing revisions to the Gothenburg Protocol, an international agreement to address acidification, eutrophication, and ground-level ozone, could support this aim, as would ratification of the Protocol by countries that are yet to do so.



COLLECTIVELY, ARCTIC NATIONS HAVE THE POTENTIAL TO FURTHER REDUCE THEIR ANTHROPOGENIC METHANE EMISSIONS BY IMPLEMENTING EXISTING TECHNOLOGICALLY FEASIBLE MEASURES.

Methane emissions from the oil and gas sector, including from leakages and inefficient flaring, are currently likely underestimated. They have high potential for technological mitigation and are therefore a priority in this respect. The Arctic Council's Expert Working Group on Black Carbon and Methane identified emissions from waste, energy, and agricultural sectors as targets for emission reduction in Arctic countries.



URGENT ACTION ON CLIMATE WARMING IS REQUIRED TO REDUCE THE RATE OF ENHANCED NATURAL METHANE EMISSIONS FROM THE ARCTIC THAT WILL HAVE SIGNIFICANT IMPACTS ON THE GLOBAL CARBON BUDGET.

Thawing permafrost and warming Arctic sea temperatures have the potential to cause abrupt increases in methane emissions from the region and need to be better understood.



EFFORTS TO BETTER UNDERSTAND FUTURE ARCTIC METHANE EMISSIONS AND DETECT SUDDEN CHANGES IN NATURAL EMISSIONS REQUIRE IMPROVED MODELLING AND ENHANCED MONITORING.

Policy-makers might consider supporting the strategic placement of observation sites, more sensitive remote-sensing methods, and the integration of multi-source data into advanced process-based models.



AS FUTURE POLICY IS INCREASINGLY FOCUSING ON THE BENEFITS OF CONNECTING CLIMATE AND CLEAN AIR, ARCTIC COUNCIL MEMBERS ARE ENCOURAGED TO SUPPORT THE ESTABLISHMENT OF A REGIONAL TARGET TO REDUCE METHANE EMISSIONS.

This could be implemented under the Arctic Council's Framework for Action on Black Carbon and Methane, or under the auspices of the UNECE Air Convention.

Pre-print

AMAP, established in 1991 under the eight-country Arctic Environmental Protection Strategy, monitors and assesses the status of the Arctic region with respect to pollution and climate change. AMAP produces evidence-based policy-relevant assessments and public outreach products to inform policy and decision-making processes. Since 1996, AMAP has served as one of the Arctic Council's six working groups.

AMAP Policy Briefs address specific policy-relevant questions relating to Arctic pollution and climate change issues in an Arctic Council or broader policy setting. They provide context, information, and technical analysis specific to the policy questions under consideration, along with the key take-away messages and policy-relevant recommendations. AMAP Policy Briefs build on the results of previous AMAP assessments and/or technical work. They take into consideration additional peer-reviewed materials as referenced in their *Supplementary Technical Explanations* (full citations are available via the QR code below), as well as knowledge synthesized by experts affiliated with AMAP Expert Groups.

AMAP Policy Briefs are produced according to AMAP's *Guiding Principles.* Contributing experts are acknowledged in the document. Key findings and Recommendations presented at the start of the document can be extracted as stand-alone messages for use by policy-makers.

This document was prepared by the Arctic Monitoring and Assessment Programme (AMAP) and does not necessarily represent the views of the Arctic Council, its members or its observers.

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Cover image: Bo Elberling (icefreegreenland.com), soil-contaminated ice core.

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