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GLOBAL TIPPING POINTS



GLOBAL TIPPING POINTS REPORT: CRYOSPHERE BRIEFING



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TIPPING POINT

The point in time at which a system starts to undergo self-propelling change that continues even if the original pressure driving it is reduced. This can lead to major changes that spread, are difficult to stop and may be impossible to reverse on human timescales.

WHY THE CRYOSPHERE?

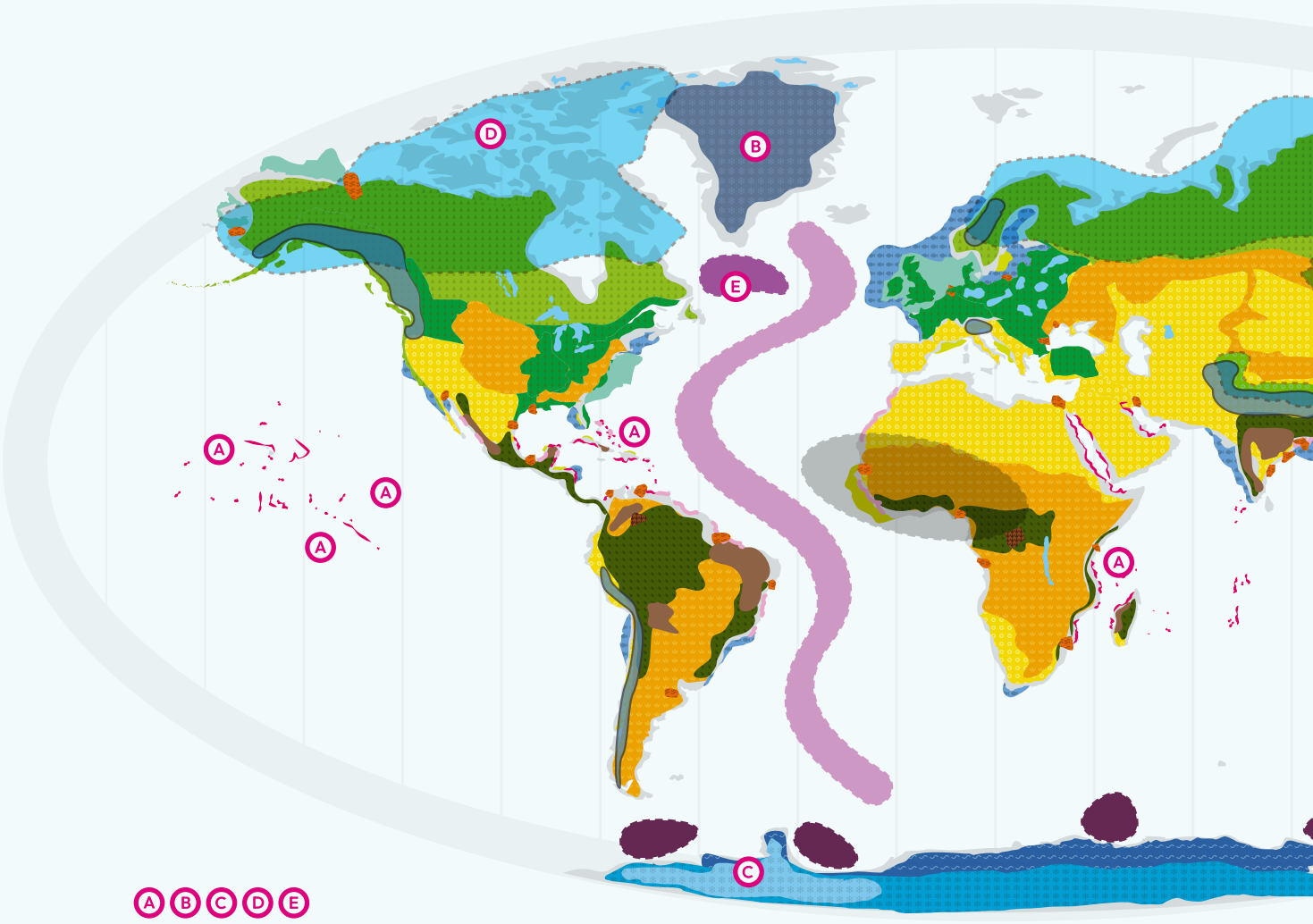
The Global Tipping Points Report 2025[1] found that up to five tipping points could be crossed at today's level of warming. Three of the five are cryosphere systems: West Antarctic Ice Sheet, Greenland Ice Sheet, and permafrost. One can be driven by changes in the cryosphere: the subpolar gyre. The fifth being coral reefs. Their effects reach well beyond the polar regions, through rising sea levels, the release of carbon from permafrost, and changes to Atlantic Ocean circulation. The threshold ranges for these systems all begin at or near 1°C of warming.

Warming is now around 1.4°C[2], and current policies point to 2.2 to 3.4°C by the end of the century. The World Meteorological Organization's decadal update of May 2026 projects annual global temperatures of 1.3 to 1.9°C above the 1850 to 1900 average for 2026 to 2030[3]. It gives a 91 per cent chance that at least one year in that period exceeds 1.5°C, and a 75 per cent chance that the five-year mean does.

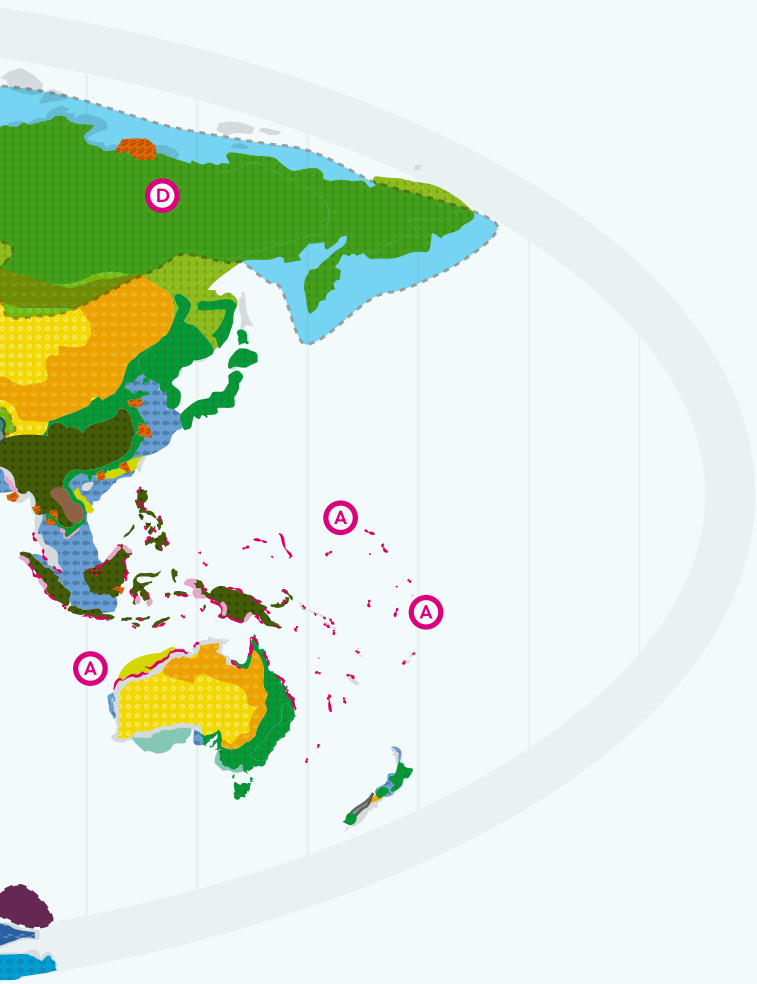
1 Lenton et al.(2025) The Global Tipping Points Report 2025.
2 WMO (2026a
3 WMO (2026b)

Key points:

- **Parts of the cryosphere are already close to, or past, their tipping points.** The Global Tipping Points Report 2025 found that up to five tipping points could be crossed at today's level of warming. Three are in the frozen parts of the planet, namely the West Antarctic Ice Sheet, the Greenland Ice Sheet and permafrost. A fourth, the Subpolar Gyre ocean current south of Greenland, is driven in part by ice melt. The fifth is warm-water coral reefs.
- **Crossing a threshold starts a process that runs for centuries.** It does not cause an overnight collapse. Once a tipping point is passed, change continues even if warming stops. The speed of that change depends on how much further the world warms, and for how long.
- **Every fraction of a degree changes how fast and how far the losses go.** Limiting peak warming, and keeping the time spent above 1.5°C short, can slow the loss of ice and permafrost, buy time for adaptation and reduce the risk of triggering further instabilities.
- **Harm in one system raises the risk in the others.** Permafrost carbon adds to warming. Ice melt and sea ice loss freshen polar waters and weaken ocean currents. Weaker currents may in turn speed up melting.
- **The costs reach well beyond the polar regions.** They fall on coastlines, food and energy supply chains, infrastructure and security, and most heavily on small island states and Arctic communities that did the least to cause them.



System	Threshold range	Where we stand
West Antarctic Ice Sheet	**1 to 3°C**, with a precautionary limit of **0.5°C**	May already be crossed
East Antarctic Ice Sheet (marine basins)	**2 to 6°C**, central estimate **3°C**	Not yet crossed
Greenland Ice Sheet	**0.8 to 3.4°C**, central estimate **1.5°C**	May already be crossed
Subpolar Gyre	**1.1 to 3.8°C**, central estimate **1.8°C**	May already be crossed
Permafrost	No single global threshold	Localised tipping already underway



BIOSPHERE

- Tropical dry forest
- Tropical rainforest
- Tundra/Boreal forest
- Temperate forest
- Savannas & grasslands
- Drylands
- Peat bogs
- Lakes
- Coral reefs (A)
- Mangroves
- Fisheries
- Seagrass
- Kelp forest
- Delta

CRYOSPHERE

- Greenland Ice Sheet (B)
- West Antarctic Ice Sheet (C)
- Non-marine East Antarctica
- Marine basins East Antarctica
- Permafrost (D)
- Mountain glaciers

OCEAN & ATMOSPHERE CIRCULATIONS

- Atlantic Meridional Overturning Circulation (AMOC)
- Subpolar Gyre (SPG) (E)
- Southern Ocean Overturning
- West African monsoon

WEST ANTARCTIC ICE SHEET

The West Antarctic Ice Sheet (WAIS) is the mostly marine-based part of the Antarctic Ice Sheet, separated from the East Antarctic Ice Sheet by the Transantarctic Mountains. Most of its bed sits below sea level, so it is far more exposed to ocean warming than much of East Antarctica.

Full loss would raise sea level by roughly 5 metres. The WAIS tipping threshold is at 1 to 3°C global warming, with a precautionary limit of 0.5°C because the lower bound of 1°C may be too high to be safe. In other words, its tipping point could already be crossed.

Marine-based basins in East Antarctica, including Wilkes, Aurora and Recovery, are vulnerable to the same instabilities but are assessed as having higher thresholds of 2 to 6°C global warming. Although these thresholds have not yet been crossed, current policies set us on this track. If these basins are lost, Antarctica as a whole could yield sea level increases of around 19 metres.

Tipping mechanisms:

- **Marine Ice Sheet Instability:** Where the bed slopes downward towards the interior, retreat of the grounding line exposes thicker ice, increases flow to the ocean and drives further retreat.
- **Marine Ice Cliff Instability:** Collapse of ice shelves leaves tall ice cliffs that fail under their own weight. This mechanism is less well established than Marine Ice Sheet Instability, with only limited empirical data for calving of tall ice cliffs[4] .



4 Needell et al. (2026) Science

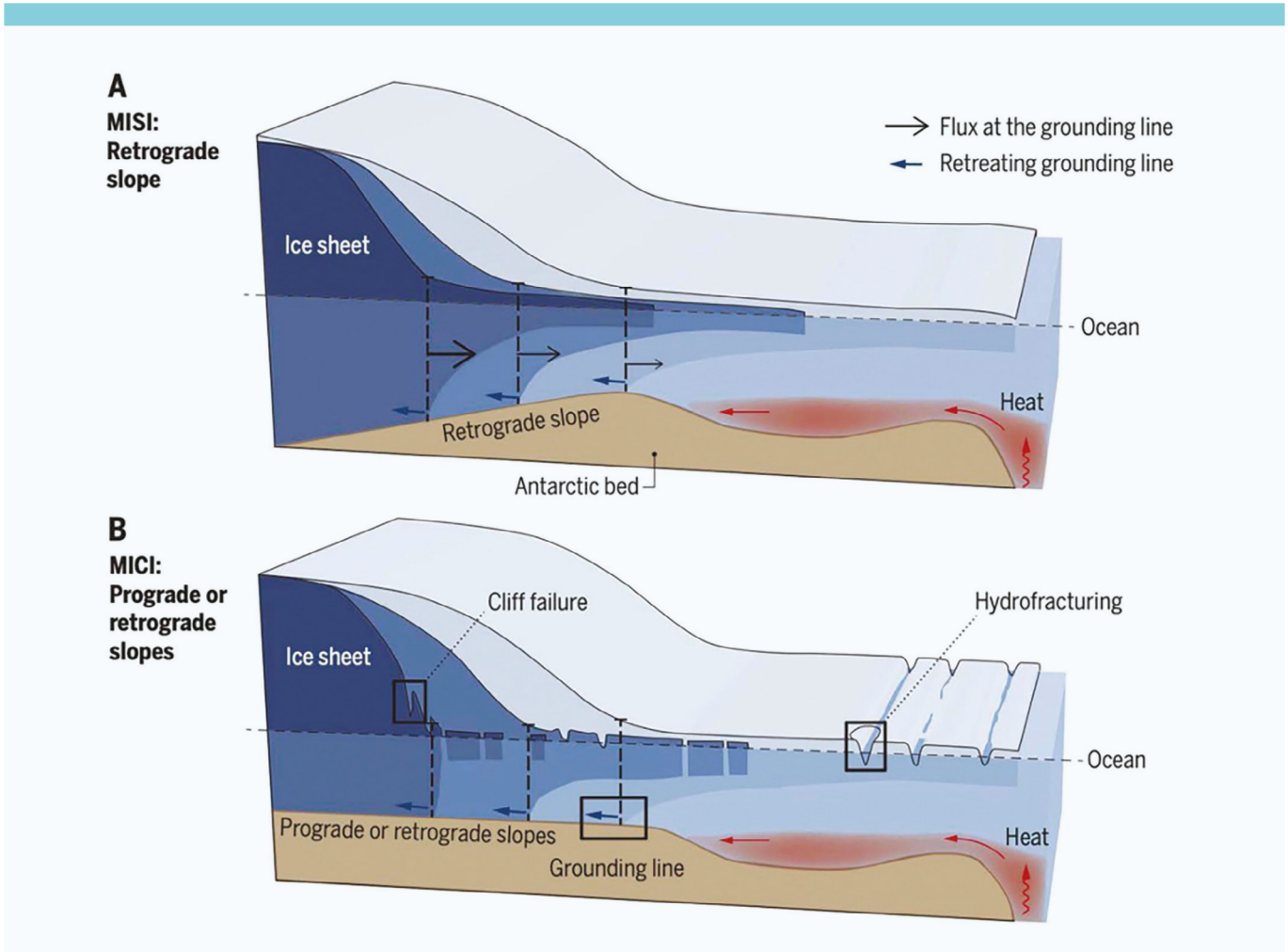


Figure 1 : Schematic illustration of marine ice sheet instability (MISI; top) and marine ice cliff instability (MICI; bottom). From Pattyn and Morlighem (2020) .

What's new since the 2025 report:

- A 2026 study assessed the tipping risk of 18 Antarctic basins[5] and found that some basins lose ice gradually with warming while others have tipping points. The Amundsen Sea basin, which includes Thwaites and Pine Island glaciers, and the Ronne basin have the lowest thresholds and may already be past them at about 1.3°C global warming. The authors stress that large-scale loss unfolds over centuries.
- Ice sheet simulations constrained by present-day observed mass change find that Thwaites and Pine Island glaciers collapse without further warming, over centuries to around a thousand years[6] .
- Satellite observations show near-total loss of buttressing stress on the Pine Island Ice Shelf[7] . Calving events, including one in 2017, sped up the glacier by about 20 per cent.

Impacts:

- Ice sheet model ensembles reach up to 4.4 metres of sea level equivalent from Antarctica by 2300 under high emissions, with a rapid increase after 2100[8] .
- Ice sheet loss from West Antarctica and Greenland together puts coastal populations of more than 2 billion people at long-term risk, with Small Island Developing States facing the prospect of national-scale displacement.
- Freshwater discharge from ice loss can weaken ocean currents.

5 Winkelmann et al. (2026) Nature Climate Change
6 Van den Akker (2025) The Cryosphere
7 Wells-Moran et al. (2026) PNAS
8 Seroussi et al. (2024) Earth's Future

GREENLAND ICE SHEET

The Greenland Ice Sheet holds about 7 metres of sea level equivalent. It partly collapsed in past warm periods, including the last interglacial about 130,000 to 115,000 years ago, when global temperatures were only marginally above pre-industrial levels. It lost on average 78 million Olympic swimming pools worth of ice per year between 2010 and 2022. The tipping threshold range is 0.8 to 3.4°C global warming.

Tipping mechanisms:

- **Melt-elevation feedback:** As the surface lowers it sits in warmer air, which accelerates melt. Below a critical elevation, loss continues even if warming stops or reverses.
- **Marine Ice Sheet Instability:** Where the bed slopes downward towards the interior, retreat of the grounding line exposes thicker ice, increases flow to the ocean and drives further retreat. Unlike the WAIS, this mechanism is limited to certain regions of the ice sheet.

What's new since the 2025 report:

- Coupled ice sheet simulations show amplifying feedbacks driving near-complete loss by the year 3000 under a high emissions scenario, a contribution of more than 7 metres[9].
- Chaotic variability in ice streams limits how precisely tipping can be predicted[10].

Impacts:

- About 30 centimetres of sea level rise from Greenland may already be 'locked in' [11].
- Approximately 7 metres of sea level rise over millennia, with the rate rising as warming increases [12].
- Once the southern ice sheet has lost more than about 0.4 metres of sea level equivalent, modelling indicates regrowth would take tens of thousands of years [13].
- Greenland meltwater freshens the North Atlantic, weakening the Subpolar Gyre [14].

9 Paice et al. (2026) The Cryosphere
10 Kypke et al. (2026) Earth System Dynamics
11 Box et al, (2022) Nature Climate Change
12 Fox-Kemper et al. (2021) IPCC WG1 Report
13 Höning et al. (2024) Environmental Research Letters
14 Bakker et al. (2016) Geophysical Research Letters



Image credit: Adam Sébire / Climate Visuals

SUBPOLAR GYRE

The Subpolar Gyre (SPG) is the anticlockwise system of currents south of Greenland, spanning the Labrador, Irminger and Iceland basins. In its centre, winter cooling triggers deep convection of surface waters to great depth. With the Nordic Seas, this is one of the two main sources of the deep water feeding the Atlantic meridional overturning circulation (AMOC). Though closely coupled to the AMOC, SPG convection can collapse on its own and much faster (a few years or a small number of decades, against several decades or longer for the AMOC), and may be a precursor to broader AMOC collapse.

SPG collapse is estimated to become possible between 1.1 and 3.8 °C of global warming, with a central estimate of 1.8 °C[15] ; the lower bound is already behind us. In 2012-2016 the eastern subpolar North Atlantic saw its largest freshening in 120 years of measurements, a reminder of how quickly the region can freshen[16].

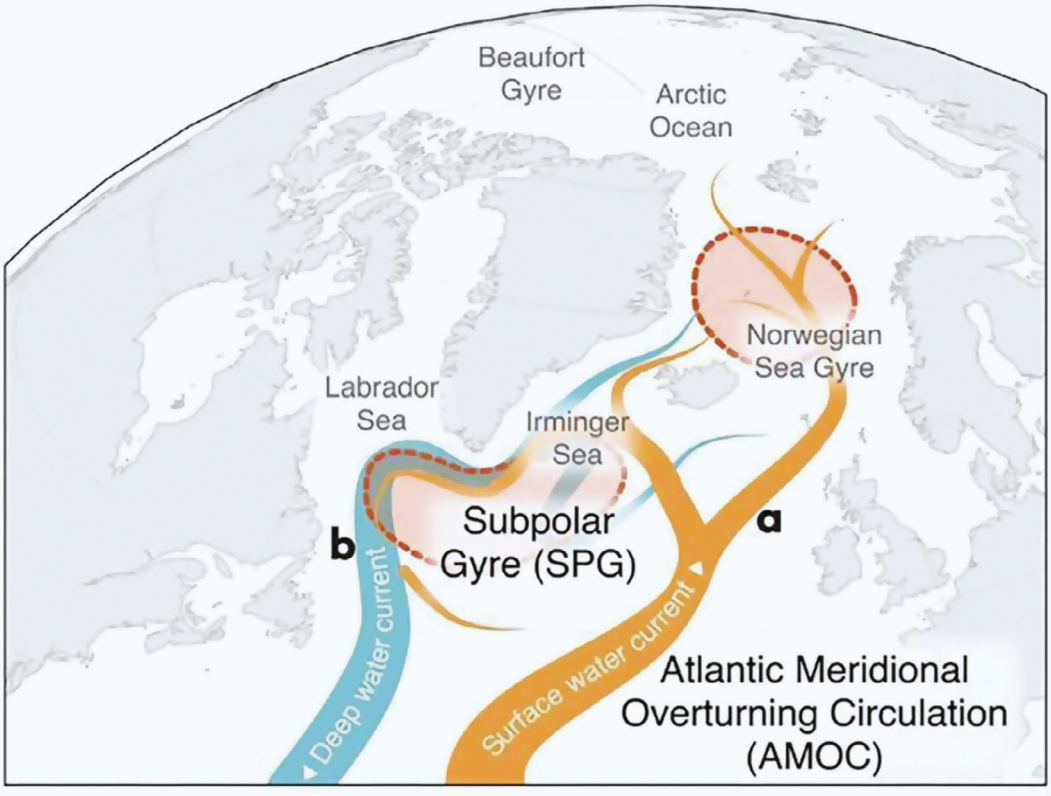


Figure 2: Sketch of the AMOC-SPG current systems in the North Atlantic, depicting (orange) lighter surface currents, (blue) dense deep currents and (shading) regions of pronounced water mass transformation. Source: Lenton et al. (2023), Credit: Sina Loriani.

15 Armstrong McKay et al. (2022) Science
16 Holliday et al. (2020) Nature Communications



Image credit: Alastair Johnstone-Hack / Climate Visuals

Tipping mechanism:

- **Warming and freshening of the surface ocean,** driven by Arctic sea ice export, Greenland melt and Beaufort Gyre release, reduces surface density and shuts down convection. Weakened convection is self-reinforcing through stratification.

What's new since the 2025 report?

- SPG weakening may accelerate Greenland melt: in model experiments, freshening weakens SPG convection and warms the 100-400 m layer around Greenland significantly, implying a melt-driven feedback[17].
- The "cold blob" is an ambiguous SPG signal: local freshening can produce the North Atlantic cold blob without any change in large-scale circulation, which adds complexity to its use as an indicator of SPG or AMOC weakening[18].
- SPG convection decline is now raising sea level locally. Warming, freshening and decreased deep convection pushed Labrador Sea sea level to a record high, rising about 1.4 cm/year since 2017, four times the global rate[19] .

Impacts:

- Colder, stormier winters in northwest Europe, and displaced rainfall[20].
- SPG collapse may be a warning of potential AMOC collapse.

17 Menviel et al. (2026) Nature Communications
18 Ayres & Oltmanns (2026) Geophysical Research Letters
19 Yashayaev & Zhang (2025) Nature Communications
20 Meccia et al. (2024) Environmental Research Letters

PERMAFROST

Permafrost is ground frozen for at least two consecutive years. It underlies about 14 million square kilometres, around 15 per cent of the Northern Hemisphere land surface, and Arctic terrestrial permafrost holds around 1,500 gigatonnes of carbon[21]. This is almost double the amount of carbon currently in the Earth's atmosphere.

Rather than having one temperature threshold, permafrost can be viewed as a mosaic of locally conditioned behaviours[22] with the global effect coming from the aggregate of many local transitions. Localised abrupt permafrost thaw is already underway.

Localised tipping mechanisms:

- **Ice-wedge and polygonal ground deformation:** Thaw of ground ice causes collapse that exposes more frozen material, so change continues without further warming.
- **Thermokarst lake, wetland and talik formation:** Subsidence lets water pool, and standing water carries heat downward, driving further thaw and creating year-round unfrozen ground beneath. Lakes and wetlands rarely recover to the original state, and their waterlogged conditions favour methane release, which is a more potent greenhouse gas.
- **Retrogressive thaw slumps:** Under some conditions, retreat of a headwall exposes ice-rich ground, which thaws and sustains further retreat for years to decades without a new trigger.
- **Peat plateau and palsa collapse:** Loss of the frozen core leads to collapse and effectively irreversible loss of permafrost, with recovery to stable peatland only after several hundred years.



Image credit: Rakesh Rao / Climate Visuals Countdown

21 Schuur et al. (2015) Nature
22 Nitzbon et al. (2024) Nature Climate Change

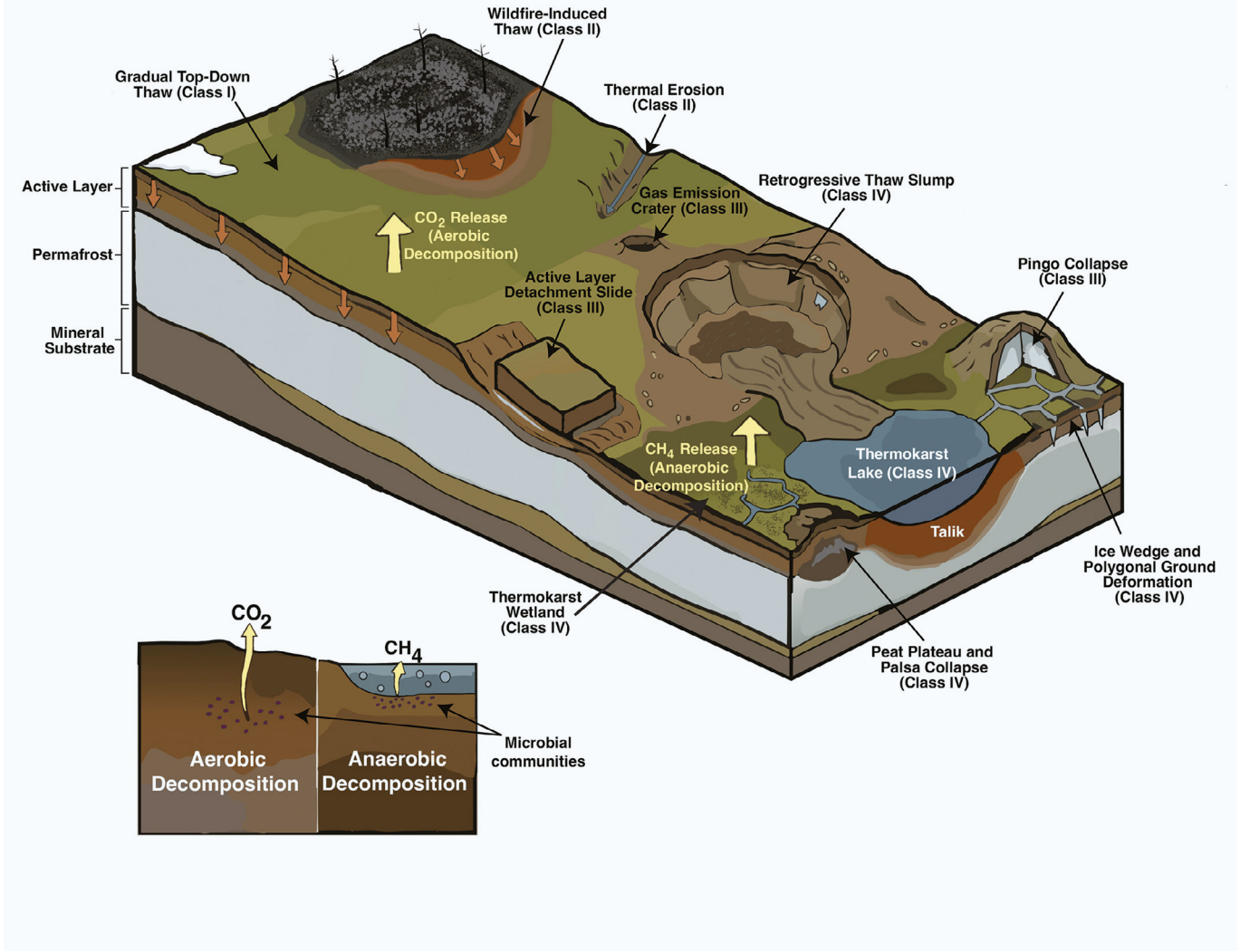


Figure 3 : Schematic showing permafrost degradation processes. Class IV = tipping mechanisms, Class III = threshold system, Class II = Non-linear but reversible, Class I = Gradual, linear change. Credit: Millman et al. (in review).

What's new since the 2025 report?

- Including abrupt permafrost thaw and wildfire emissions cuts the remaining carbon budget from 2025 by 25 per cent ± 12 for 1.5°C and by 17 per cent ± 7 for 2°C[23].
- Warming-induced emissions from permafrost, wetlands, freshwaters and wildfire together could amplify post-2020 warming by 20 to 30 per cent[24].

Impacts:

- Permafrost carbon release shrinks the remaining carbon budget, so emissions elsewhere must fall further to hold the same temperature limit.
- Around 70 per cent of infrastructure in permafrost regions may face high thaw potential by 2050. Some communities may need to relocate.

23 Schädel et al. (2026) Communications Earth & Environment
24 Abernethy et al. (2026) Environmental Research Letters

RECOMMENDATIONS

Mitigation

1 **Align NDCs with Paris Agreement.** Global greenhouse gas emissions need to halve by 2030 against 2010 levels and reach net zero by 2050, followed by net removal. Current policies lead to 2.2 to 3.4°C.

2 **Treat peak warming and overshoot duration as explicit policy targets.** For the ice sheets, warming should return below 1.5°C before 2100 and stabilise near or below 1.0°C in the long term.

3 **Cut methane** and other short-lived climate pollutants quickly, and scale sustainable carbon removal.

4 **Harness positive tipping points.** Solar power, batteries and electric vehicles have reached self-reinforcing growth, and policy mandates and lower cost of capital for the Global South can accelerate this.

5 **Avoid risky geoengineering approaches.** These carry severe risks including unintended side effects. No international governance framework exists to regulate them, and they may distract from emissions cuts.

Adaptation & resilience

6 **Plan for locked-in sea level rise.** Multi-metre rise over centuries should be built into coastal planning, with horizons beyond 2100.

7 **Sustain and extend monitoring of the Subpolar Gyre and AMOC.** European governments should update adaptation plans to account for possible Subpolar Gyre convection collapse.

8 **Strengthen global supply chains** for food and energy against compound shocks from sea level rise, extreme weather and permafrost damage to infrastructure.

9 **Fund loss and damage,** including relocation of Arctic communities and support for Small Island Developing States, within a human rights framework.

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