Comment

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Governing cryospheric risk beyond political timeframes

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Cryospheric risks unfold over decades to millennia, while climate governance remains tied to short political cycles. We argue that cryosphere science must be embedded in governance mechanisms that connect near-term decisions with long-term accountability for irreversible change.

The cryosphere—Earth's coupled system of glaciers, ice sheets, sea ice, snow, and permafrost—is destabilising rapidly as greenhouse gas concentrations rise. In 2024, global annual mean temperature reach ~1.5 °C above pre-industrial levels[1], a range at which several cryospheric tipping elements may be activated[2]. Even small overshoots could commit future generations to centuries of glacier loss, sea level rise, and permafrost carbon release[3,4]. These changes affect coastal security, water availability, infrastructure, Indigenous livelihoods, and global climate feedbacks[5]. Decisions taken this decade could influence cryospheric trajectories for centuries to millennia[3,5,6], placing cryospheric risk within long-horizon climate governance while current policy mechanisms remain tied to much shorter financial and political cycles.

Since the release of the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) ahead of COP25[6], and with the UN-designated Decade of Action for Cryospheric Sciences (2025–2034)[7], cryosphere science has become increasingly visible through assessments, pavilions, observer engagement, ministerial efforts, and community-led mobilisation[8]. Yet formal mechanisms for translating long-term cryospheric commitments into near-term emission reductions, finance, and adaptation decisions remain limited. COP30—the 30th Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC), convened in Belém, Brazil, on 10–21 November 2025 under the banner of implementation and justice—offers a recent lens for examining this gap. Here, we use COP30 as an entry point into the broader challenge of aligning climate governance with cryospheric timescales. From our perspective, this Comment focuses specifically on how cryosphere science can be better connected to climate governance processes across timescales, while recognising that this is only one dimension of the broader political, economic, and geopolitical challenges surrounding the cryosphere.

This governance gap is deepening at a moment of heightened geopolitical turbulence: institutional support for climate science is weakening in several major economies, disinformation is undermining public understanding of cryospheric risk, and access to polar observation infrastructure is increasingly shaped by geopolitical competition rather than scientific need. These pressures make the case for durable, institutionalised governance mechanisms, ones capable of persisting across political cycles, more urgent, not less.

From cryosphere visibility to integration

Observations show accelerating mass loss from the Greenland and West Antarctic ice sheets[9], continued retreat of mountain glaciers worldwide[10], declining snow meltwater[11], the possibility of the first nearly ice-free day in the Arctic Ocean before 2030[12], and a sharp decline in Antarctic sea ice since 2016[13]. Across recent COPs, including COP30, cryosphere science has gained visibility but remains only partly integrated into formal negotiation and assessment processes[8]. References to polar and high-mountain regions have appeared mainly in adaptation, observation, and loss and damage contexts, while the links between near-term mitigation, long-term sea-level commitment, permafrost carbon feedbacks, and glacier-fed water security remain weakly institutionalised. Recognition of cryospheric impacts has increased, but regular mechanisms for translating cryosphere risk into mitigation, finance, adaptation, and accountability processes remain limited.

The implications extend far beyond frozen regions. Cryospheric change threatens water security for people living in, or downstream of, mountain areas, with knock-on effects for food and energy systems. It also exposes coastal infrastructure to sea level rise and affects Indigenous Peoples' livelihoods, regional economies, and security[5,6]. Together, these impacts make cryosphere loss a global climate stability issue, not a geographically confined environmental concern.

Scientists have increasingly sought to make this connection visible in climate fora. The Open Letter to world leaders issued ahead of COP30[14], the COP28 2 °C is Too High statement endorsed by more than 1000 cryosphere scientists[15], and successive Cryosphere Pavilions at COP26 through COP30[8] together formed part of a sustained mobilisation of the cryosphere community since SROCC[6], including ministerial events, observer engagement, and coordination through the Ambition on Melting Ice (AMI) group[16]. Such engagement demonstrates growing scientific consensus and public visibility, but visibility alone has not yet created regular pathways for cryosphere science to shape formal assessment, mitigation, finance, and policy processes.

Where current frameworks fall short

Recent COPs have brought greater visibility to mountain and polar risks through scientific initiatives, adaptation discussions, observation-focused events, and emerging finance partnerships[8]. However, this attention remains fragmented and has not yet produced durable mechanisms for incorporating cryospheric risk into mitigation, adaptation, and finance frameworks at the pace and scale required by cryosphere change.

Carbon-budget assumptions need regular cryosphere updates. While some permafrost processes are represented in major assessments, evolving estimates of abrupt thaw, wildfire-related thaw, and other non-linear feedbacks are not yet consistently reflected in carbon budgets used for policy planning[17]. Committed sea level rise and changes in glacier- and snow-fed water systems could instead be treated as long-term impact and commitment indicators: they do not belong inside carbon budgets, but are essential for assessing the consequences of near-term emissions pathways[3,5,6].

Long-term observations remain vulnerable. Polar and alpine measurement networks depend heavily on sustained support, despite their importance for detecting rapid change and supporting adaptation[18]. Sustained observations are not only a scientific requirement, but also a public good for long-term risk management.

Finance is not yet sufficiently aligned with systemic risk. Adaptation finance does not yet adequately account for the long-term and cross-regional consequences of cryosphere loss. These risks affect polar and high-mountain regions, glacier-fed basins, low-lying coastal zones, permafrost-affected infrastructure, and communities dependent on seasonal snow and ice[5,6]. Finance mechanisms therefore need to better connect cryosphere-driven hazards with long-term adaptation planning, infrastructure resilience, and loss and damage considerations.

Cryospheric risks are amplified by global inequities in exposure and vulnerability

Like greenhouse gas emissions, declining cryospheric stability has global consequences, but these consequences are not evenly distributed. Small Island Developing States, Least Developed Countries, and Indigenous and low-income communities in polar, mountain, and coastal areas face disproportionate risks despite contributing least to the emissions driving cryosphere loss[5,6]. Political and economic power shape which risks receive attention, resources, and protection. The political economy of cryosphere governance also creates trade-offs between near-term economic interests and long-term risk reduction: mitigation, adaptation, infrastructure protection, and ecosystem conservation can impose immediate costs on governments, firms, and communities, while many of the benefits accrue over longer timescales and across borders. These trade-offs are further complicated by uneven capacities to absorb transition costs and by the uneven distribution of economic benefits from carbon-intensive activities relative to exposure to cryosphere-related harms. Recognising these uneven direct and indirect consequences is essential if cryosphere governance is to support both long-term Earth system stability and climate justice.

Until these gaps are addressed, climate policy is likely to continue to underestimate irreversible cryospheric risk and the long-term consequences of delayed mitigation.

Aligning governance with cryospheric timescales

The physical evidence indicates that current policy mechanisms remain substantially mismatched with cryospheric timescales[5,6]: cryospheric impacts unfold over decades to millennia, while the mitigation decisions that can still slow, limit, or avert the most severe outcomes need to occur in the near term, particularly this decade. Addressing this gap requires mechanisms that connect near-term decisions with long-term physical commitments.

Commit dedicated resources for sustained cryospheric science. Stable multilateral and national funding for polar and high-mountain monitoring, modelling, and data stewardship is essential for detecting rapid change and informing both adaptation and mitigation[18]. Without sustained observations, governments cannot reliably assess whether thresholds are approaching, risks are accelerating, or policy responses are reducing exposure and vulnerability.

Create regular routes for cryosphere science into climate negotiations. Existing structures, including the Global Cryosphere Watch of the World Meteorological Organization[18], already coordinate important observations. A missing element is a regular, cryosphere-specific route into UNFCCC processes. An annual Cryosphere Dialogue, analogous to the Ocean and Climate Change Dialogue[19], could synthesise evidence on ice sheets, glaciers, sea ice, snow, and permafrost for mitigation, adaptation, finance, and loss and damage discussions.

Use appropriate assessment processes for long-term cryospheric risk. Future Global Stocktake technical dialogues could draw on cryosphere-relevant indicators when assessing collective progress towards Paris Agreement goals. However, the Periodic Review of the long-term temperature goal[20] is the more direct venue for assessing whether current temperature limits are adequate to limit dangerous cryospheric impacts. Cryosphere-commitment indicators, such as committed sea level rise, projected permafrost carbon feedbacks, glacier mass loss, and changes in snow-dependent water availability, could support these assessments and provide signals of emerging risk to guide mitigation and adaptation priorities.

Embed long-term scenarios into national and regional decision-making. Long-term cryosphere scenarios could inform land-use and marine spatial planning, ecosystem conservation and restoration, and the design of urban, rural, mountain, coastal, and Arctic infrastructure. Assessments need to extend to the centennial to multi-centennial timescales at which cryospheric change becomes most consequential[5,6]. This includes long-term coastal hazard mapping, permafrost-related infrastructure liability assessments, and water-resource planning for snow- and glacier-fed basins. Indigenous Peoples' governance systems, grounded in multigenerational stewardship in Arctic and high-mountain regions, offer additional models for long-horizon decision-making and could be engaged through equitable partnerships.

Recognise the implications for international law. Cryospheric change is increasingly relevant to human rights obligations, duties to prevent transboundary harm, maritime entitlements affected by sea level rise, and responsibilities towards present and future generations. The 2025 International Court of Justice Advisory Opinion[21] shows how long-term climate impacts, including sea level rise, are being connected to state duties.

Improve transparency and accountability of cryosphere-focused investments. Development banks, climate funds, and national adaptation plans could more clearly track investments linked to cryospheric risk, including glacier-dependent water systems, Arctic infrastructure, polar observation networks, and low-lying coastal adaptation. Initiatives such as Glaciers to Farms[22] illustrate how

finance can connect glacier retreat with downstream water security and adaptation planning.

Together, these entry points would not resolve the politics of climate action, but they could make cryospheric commitments more visible within climate governance processes. They could also help shift the focus from reacting to cryospheric impacts after they occur to acting while the most damaging thresholds can still be limited or avoided.

Creating incentives and momentum

For the cryosphere, timing matters. Emission reductions achieved before 2030 have greater potential to slow, limit, or avert irreversible cryospheric change than equivalent reductions delayed by decades[2,3,5,6]. Climate cooperation mechanisms could recognise this time sensitivity by rewarding early mitigation, supporting countries that bring forward national mitigation milestones, and directing finance toward actions that reduce long-term cryosphere-related liabilities. If national milestones are delayed, incentives for early and rapid decarbonisation weaken precisely when benefits for cryosphere stability are greatest. Incentives could also make the avoided costs of cryosphere loss more visible. National risk assessments could incorporate cryosphere-driven hazards such as committed sea level rise, coastal flooding, declining snow and glacier water resources, and permafrost-related infrastructure loss[5,6]. These assessments could help governments recognise how early mitigation and adaptation reduce future fiscal, social, and security risks. Strengthening partnerships with Arctic, alpine, mountain, and coastal communities can also align mitigation and adaptation by coupling local resilience with global stability.

Cryosphere governance, however, operates in an increasingly contested political environment. Observation access, scientific cooperation, and long-term funding can be weakened by geopolitical conflict, disinformation, and shifting national priorities. These pressures vary across geopolitical contexts, and effective cryosphere governance cannot be assumed to follow a single institutional or regional model. Cryosphere loss may also intensify debates around resource competition, displacement, or technological interventions. Where universal consensus is difficult, coalitions organised around shared cryospheric risks — such as mountain water security, low-lying coastal exposure, polar observation, or Arctic infrastructure resilience — may provide practical routes for cooperation while broader multilateral processes continue.

The cryosphere as a barometer of political will

The accelerating decline of the cryosphere is a measurable indicator of whether climate action is aligned with the timescales that matter[5,6,9–13]. COP30 should therefore be read less as a single missed opportunity than as evidence of a wider institutional gap. Without institutions capable of connecting cryosphere science to decisions across timescales, societies risk governing for a climate that effectively no longer exists. Safeguarding the cryosphere is therefore not a specialised concern, but a foundation of long-term societal stability. The task now is to make today's climate decisions accountable to the multi-century trajectories already unfolding in ice, snow, and permafrost.

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