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PRESENTS

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WHAT ARCTIC BREAKDOWN MEANS FOR WEF 2022

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SUMMARY:

- **Leaders see climate change as a top global risk:** the WEF Global Risks Report Survey 2022 found leaders rank failure of climate action as the number one long-term threat to the world. The report cautions against the risk of a disorderly climate transition.
- **The Arctic is a disproportionately important region driving this risk:** the Arctic is warming at least three times faster than the rest of the world. Its role as a regulator of the world's climate and weather regimes means the consequences of this warming go far beyond its borders.
- **Arctic breakdown is central to WEF's 2022 agenda:** elevated global risks due to Arctic breakdown add urgency to implementing near-term mitigation to prevent global temperature rises beyond 1.5°C, as well as local adaptation and disaster risk reduction efforts to reduce the magnitude and impacts of rapid Arctic change. The WEF meeting in Davos is a critical opportunity to align government policies and business strategies to collectively act to address climate change mitigation and adaptation.
- **The Arctic is a climate-change early-warning system, and its alarms are flashing red:** the latest analyses paint a picture of rapidly unfolding environmental breakdown as a direct result of increases in atmospheric greenhouse gas concentrations. Winter 2022 in the Arctic was characterized by extreme warming events resulting in rapid sea ice loss. Anomalously low Arctic sea ice conditions during fall were followed in winter by cold spells in Europe and North America, and later by severe heat waves in India, Europe, Greenland, and the western U.S..

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SUMMARY (continued):

- **Arctic warming unleashes socio-economic risks across the world:** it contributes to rising sea levels, higher global temperatures and increasingly extreme weather. These physical changes translate into global socio-economic and ecological impacts by exacerbating food and water insecurity, supply chain disruption, disease, and damage to infrastructure and ecosystems. Recent estimates of global socio-economic and ecological impacts linked with Arctic warming put a price tag of tens of billions USD per year in the years and decades leading to the 2050 net zero emissions target.
  This estimate is likely to rise to hundreds of billions USD per year in the latter part of the century as long-term effects of Arctic warming – such as permafrost degradation and Greenland ice sheet decline – accelerate. The costs could be several times higher if impacts on economic growth are larger than assumed in most assessments to date. Limiting climate change to 1.5°C in line with the Paris Agreement is projected to reduce Arctic-driven losses considerably relative to the current warming trajectory of around 3°C by the end of the century.

- **Business and government must lead the way:** Comprehensive solutions exist to address climate change by cutting emissions and adapting to a changing climate. They require deep transformation, not miraculous technological progress: there are no silver bullets or shortcuts in the fight against climate change. We are taking huge risks with our shared future if we allow our focus to shift away from rapid and deep emissions reductions and instead rely on technology not yet developed, or any single silver bullet solution. Business and government must move away from past practices because changes in citizen and consumer behaviour cannot happen on a sufficiently large scale without leadership by the world's most powerful state and economic actors.

RAPID CHANGES IN THE ARCTIC AFFECT US ALL

Life and business as we know it are both in trouble. As human-made CO_2 keeps rising and the world warms, signs of the climate crisis are intensifying across the world.

> "Respondents rank 'climate action failure' as the **number one long-term threat to the world** and the risk with potentially the most severe impacts over the next decade" – *World Economic Forum Global Risks Report 2022*

The Arctic is central to these risks because it has a disproportionately strong effect on climate and weather in the rest of the world. The Arctic helps regulate the world's climate, influencing the Earth's atmospheric and oceanographic circulation systems. In other words, what happens in the Arctic doesn't stay there: it has direct and indirect impacts on extreme heat and cold, storm surges, sea level rise, and precipitation patterns far beyond its borders.

Scientific evidence shows that the Arctic is in crisis as it warms at least three times faster than the rest of the planet. Arctic warming has rapid and profound consequences: snow and ice cover, which blanket much of the Arctic land and ocean, help to keep our planet cooler than it would be otherwise by reflecting much of the sun's energy back to space. However, as the snow and ice melt, bare ground and ocean are exposed, which absorb more of the sun's energy and warm up, helping to further melt more snow and ice, with both immediate and indirect impacts. This positive feedback loop, once initiated, is difficult to slow down. Meanwhile, higher Arctic temperatures thaw permafrost, unlocking the huge amounts of frozen carbon it contains. Rapid Arctic warming also accelerates melting of the Greenland ice sheet – which contains the equivalent of 7.4m of sea level rise and is now the single largest contributor to rising sea levels.

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> “The 1.5°C figure is not some random statistic... For as long as we continue to emit greenhouse gases, temperatures will continue to rise. And alongside that, our oceans will continue to become warmer and more acidic, sea ice and glaciers will continue to melt, sea level will continue to rise and our weather will become more extreme. Arctic warming is disproportionately high and what happens in the Arctic affects all of us” – *Professor Petteri Taalas, head of the World Meteorological Organization*

The Arctic’s abrupt transition is unleashing a cascade of risks across the world (Figure 1):

- extreme weather
- sea level rise
- supply chain disruption
- food and water insecurity
- heat stress
- wider spread of vector-borne disease

Later parts of this briefing summarise these risks and their link to Arctic breakdown.

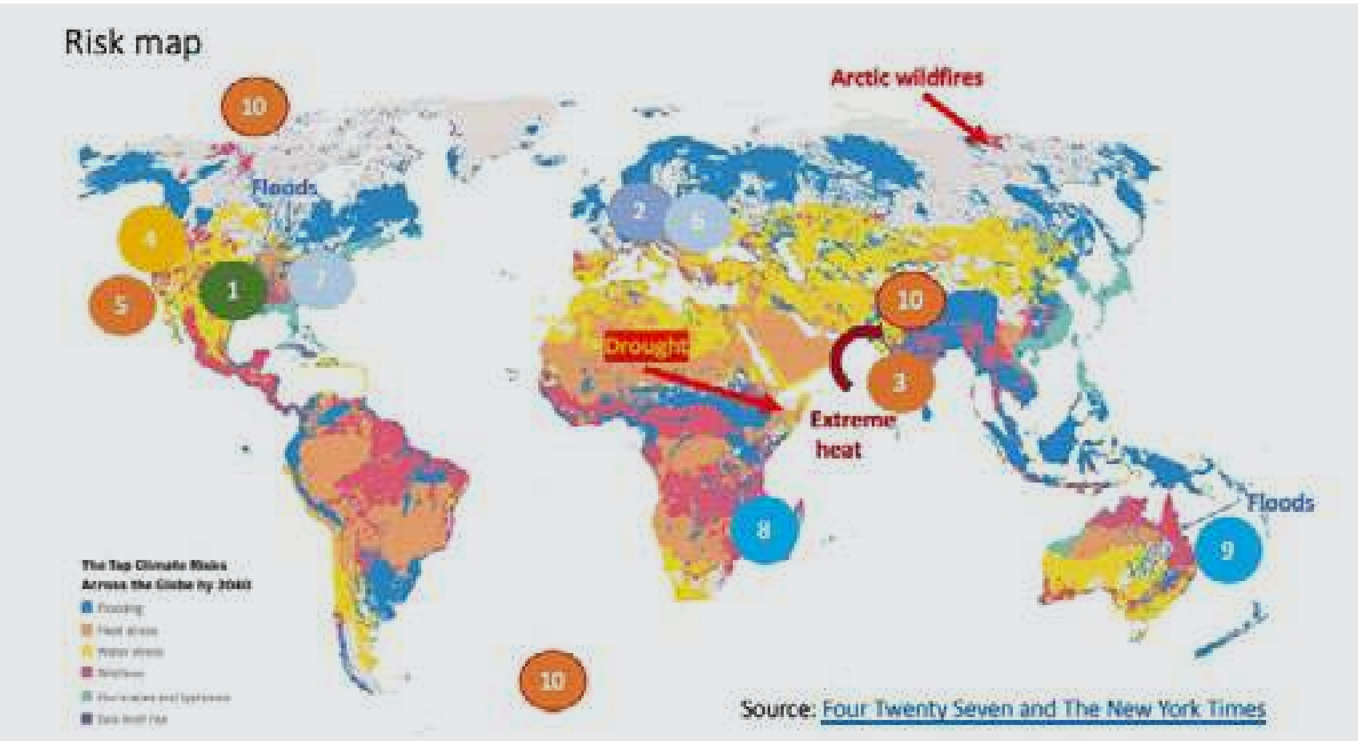

Figure 1. Recent (2022) climate-related hazards (drought, extreme heat, wildfires, floods) superimposed on a map of anticipated global risks by 2040 (Source: New York Times). Numbered events are described in the text.

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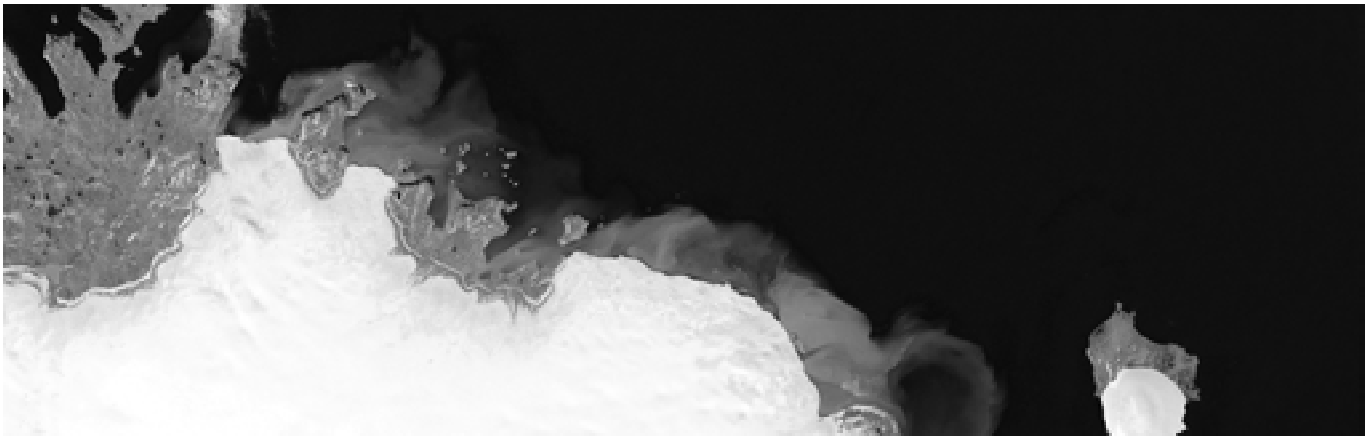
Global risks resulting from human-induced global warming associated with greenhouse gas emissions and unsustainable practices include food and water insecurity due to altered ice and landscapes,, increased coastal and in-land flooding, degradation and collapse of vital ecosystems, and adverse impacts of extreme heat on human health and productivity. These risks present shared challenges and opportunities to collectively act to find local solutions in a global context. Permafrost thaw, sea ice loss, changes in seasonality in surface water availability (White et al., 2007; Sohns et al., 2019) and resource development and extraction in the Arctic limit access to clean drinking water and sufficient, safe, and nutritious food (Inuit Circumpolar Council, 2012), evident most recently in the Iqaluit, Nunavut water crisis where 8,000 residents were denied access to clean drinking water for two months. Unprecedented drought in Africa and Afghanistan have resulted in acute malnutrition and food shortage and humanitarian crises. Melting snow and glaciers in the Himalayas have similarly resulted in changes in the seasonality of the hydrological cycle, with implications for agriculture and hydroelectric power distribution in urban and rural centres that rely on both.

These risks are being driven and amplified by climate change in the Arctic. Understanding the early warning signs from the Arctic is essential to mitigating and managing these global risks.

What’s at stake in the Arctic is the future of humanity itself.



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RISK UPDATE: THE STATE OF THE ARCTIC IN 2022

Unusual heat at both poles in Winter 2022

(Professor Julienne Stroeve, Senior Canada 150 Research Chair, University of Manitoba, UCL, and NSIDC)

Arctic sea ice in winter, 2022, experienced the second earliest sea ice maximum due in part to heat waves in March. In the Antarctic, the sea ice extent reached an all-time summer low in February. Extreme events known as atmospheric rivers transported warm and moist air from lower latitudes to the Arctic and Antarctica. In the Arctic, this resulted in significant deterioration in sea ice concentrations to the east of Greenland (Spreen et al., 2022; NSIDC Arctic sea ice news and analysis). A corresponding reduction in sea ice thickness was also observed in the central and Eastern Arctic (PIOMAS), while fractures and areas of open water (flaw leads) characteristic of a weakened sea ice cover existed in the Beaufort and Chukchi Seas, resulting in thinner sea ice regimes in these regions. Down south, a pulse of warm air from an atmospheric river reached the coast of Antarctica in mid-March. While this event was not responsible for the record low sea ice extent reached in February, the atmospheric river caused temperatures at Casey and Dumont D'Urville Stations to go above freezing at 6°C and 4°C, respectively. High up on the ice sheet, temperatures at Vostok Station and Dome Concordia were more than 35°C above average.

Damage incurred by atmospheric rivers goes well beyond the Arctic; flooding and landslides experienced in British Columbia in November, 2021 were similarly a result of intense atmospheric rivers which contributed to successive storms of extreme precipitation that destabilized the landscape. All hazards, namely heat waves at the poles, flooding and landslides at lower latitudes, demonstrate that projected increases in the length, width, intensity and duration of atmospheric rivers in a changing climate and warming planet (Espinoza et al., 2018) are already occurring.

Extreme greenland ice sheet melt in winter 2022

(Professor Alun Hubbard, UiT – The Arctic University of Norway & University of Oulu)

In 2021/22 on the Greenland ice sheet, an extreme rainfall and widespread melt event was witnessed – the first since records began in 1978. Mean August temperatures at Summit Camp are -16°C , and frequently fall to -40°C, so the 2021 record warmth and sustained rainfall stands out as a "watershed moment" and ominous precursor for the entire ice sheet's trajectory, and not just its margins. From February to April, 2022, severe storms have prevailed across western and southwestern Greenland, bringing enhanced snowfall that has positively charged the ice sheet. They have resulted in severe disruption to transport and logistics for weeks on end. In April, an early spring event kicked in with sustained high temperatures across southern Greenland. Even though the first surface melt has been observed across lower elevations of the ice sheet, it is too early to tell if this is a forewarning of a big melt season ahead.

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Extreme weather in the Arctic and beyond in Spring 2022

Spring 2022, saw extreme weather events in the Arctic and beyond. These included the aforementioned Arctic wildfires in Siberia and drought in the Horn of Africa in April and May (Figure 1), a record number of tornadoes that pummelled the United States (1; Figure 1) in March resulting in loss of life and significant infrastructure damage; false springs and extreme cold spells in Europe (2) and the United States that resulted in agricultural and crop damage due to frost; record snowfall in Spain (6) and snowstorms in New York (7); heat waves in India (3) and Pakistan with the warmest temperatures in 121 years, and in California (5) with implications for water security; moderate to exceptional drought (4) evident in wildfires in the western US; floods in eastern Australia (8), South Africa (9), and central Canada, due to persistent rainfall, heat waves at all three poles (10) (Arctic, Antarctica and a number of Himalayan states).

In the northern hemisphere, such events in the context of Arctic change are related to i) a meandering in the tropospheric jet stream resulting in the transport of cold Arctic air to midlatitudes, ii) an atmospheric river or plume of warm and moist air associated with migration of an extreme (lowest recorded pressure over Greenland) mid-latitude cyclone into the Arctic via eastern Greenland, and iii) significant disruptions in mid-March to the stratospheric (upper atmospheric) polar vortex characteristic of subsequent mid-latitude cold spells (Cohen et al., 2020). In the southern hemisphere, the atmospheric river of warm and moist air originating in southeast Australia and extending to East Antarctica contributed to unusually warm temperatures and heavy snowfall in this region.

RISK UPDATE: GLOBAL IMPLICATIONS

Arctic permafrost is thawing at record rates, releasing greenhouse gases and worsening climate change

(Dr. Jennifer Watts, Assistant Scientist, with contributions from Dr. Sue Natali, Natalie Baillargeon, Dr. Brendan Rogers, Anneka Williams, and Dr. Rachaael Treharne, Woodwell Climate Research Center)

Permafrost – continuously frozen ground – is present throughout the Arctic-boreal region. Permafrost soils are immensely important because they store over 1.4 trillion tonnes of highly organic carbon, a considerable part of which could be gradually released in the atmosphere in the coming decades and centuries as permafrost thaws. Rapidly warming Arctic air temperatures, now exceeding rates over three times the global average, are threatening our planet's freezer. As the freezer shuts down, carbon from thawing permafrost is released into the atmosphere as potent greenhouse gases, further amplifying global climate change, and impacting all regions on Earth.

Image showing themokarst activity from the North Slope of Alaska. Pictures by Mary Farina/Woodwell Climate.

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A recent review study found that local conditions, including vegetation cover, are extremely important for protecting permafrost. In boreal forests, dense tree canopies intercept insulating (ground-warming) snow in winter and, in summer, shield the forest floor from down welling solar radiation. While directly protecting permafrost, boreal forests also serve as climate change mitigators by providing a considerable amount of the globe's net carbon dioxide sink. Ensuring the future of permafrost and our planet will require the immediate safeguarding of intact boreal forests from logging and fire disturbance, while also curtailing anthropogenic carbon emissions to prevent further acceleration of atmospheric warming.

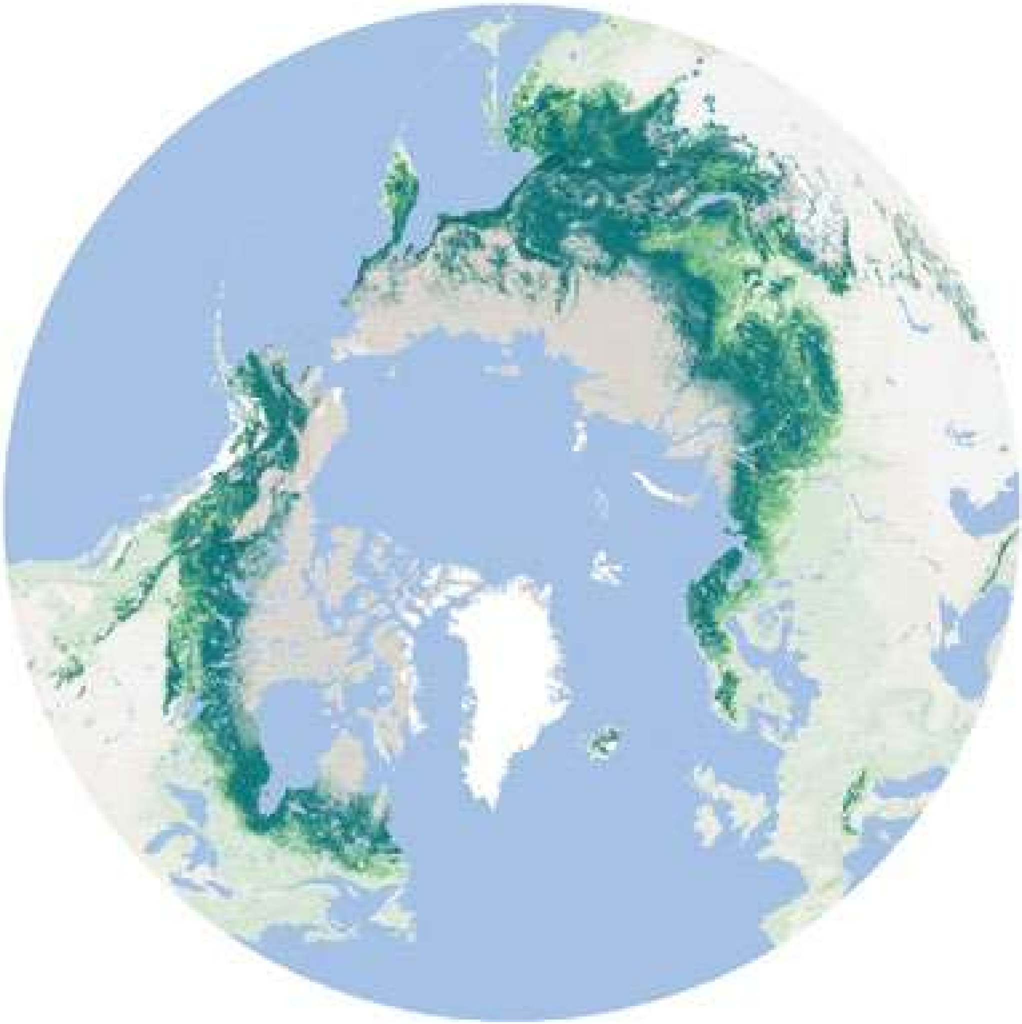


Figure 2: Approximately 3.1 million square km of permafrost are covered by relatively dense forest cover (indicated by the regions of darker green). These forests provide an important barrier that protects subsurface frozen ground (aka the permafrost) against rapidly increasing Arctic air temperatures. These permafrost soils hold vast stores of organic carbon. If thawed, this organic carbon can be readily released into the atmosphere as potent greenhouse gases. Keeping these forests intact is an important strategy in the fight against global climate change

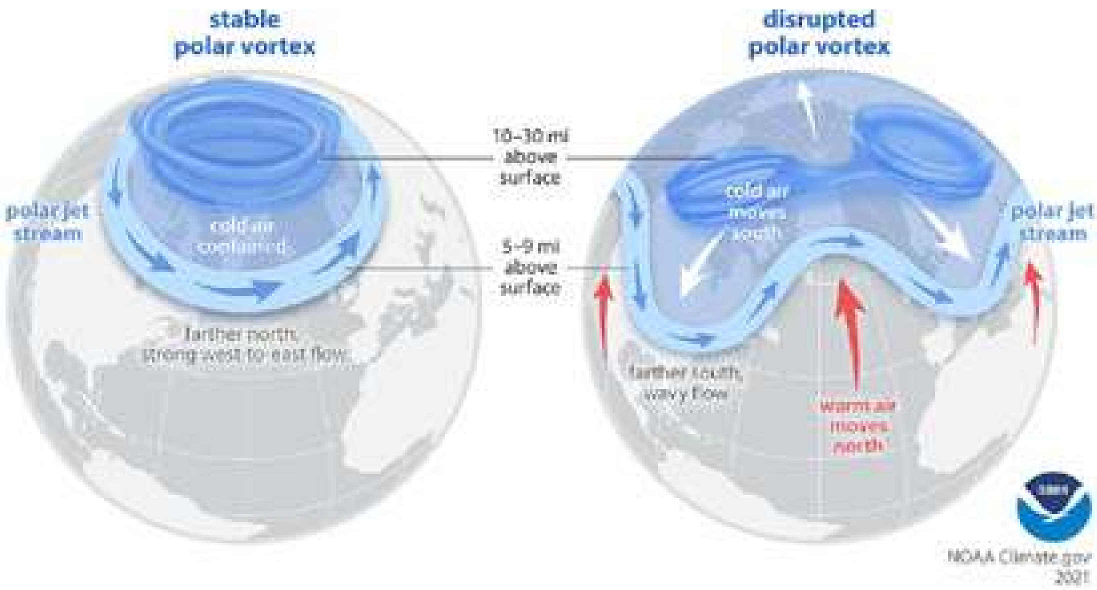
Recent studies highlight the importance of incorporating permafrost-related carbon release into carbon budgets for limiting global temperature increase to 1.5°C or 2.0°C. Carbon budgets are critical tools for climate action, guiding the ambition and urgency of action to cut emissions, but still neglect the 30-150 billion tonnes of carbon expected to be released from permafrost this century – without accounting for abrupt permafrost thaw, and interactions with wildfire. These emissions alone could account for as much as 40% of the carbon budgets currently being used to guide progress towards our global temperature targets. As is described further below, solutions including an international collaborative permafrost monitoring network, and boreal forest and peatland conservation and restoration, provide an opportunity to limit permafrost-related disruptions to the global carbon budget and local infrastructure.

The warming Arctic can disrupt the stratospheric polar vortex, causing winter weather extremes

(Dr. Jennifer Francis, Acting Deputy Director and Senior Scientist, Woodwell Climate Research Centre)

A clear and straightforward symptom of a warming Earth is that fewer cold records will be broken and many more high temperature records will be set. This is already happening. Less straightforward, however, are the complicated ways that climate change will affect the jet stream – the river of strong west-to-east winds that encircle the northern hemisphere at altitudes where jets fly. The north/south meanders in the jet stream create the weather we experience, and anything that affects the size and/or location of those waves will change our weather. Cold spells occur when the jet stream takes a large southward dip, allowing cold Arctic air to spill into southern regions ill-equipped to cope with it.

During winter months only, another ring of strong west winds encircles a pool of extremely cold air that sits over the north pole at much higher altitudes – this is the stratospheric polar vortex (see figure). Occasionally the vortex can become disrupted – i.e., elongated or broken into smaller swirls. When this happens, we often see impacts on the behavior of the jet stream, such as unusually large southward dips, bringing severe cold events to North America or Eurasia. Recent research suggests these disruptions to the vortex are happening more often in connection with a rapidly warming, melting Arctic, which we know is a clear symptom of climate change. This means that cold spells may occur more frequently, particularly long-lived events that affect regions unaccustomed to disruptive cold (e.g., the devastating Texas freeze in February 2021) unless we can curtail our emissions of heat-trapping gases dramatically and quickly. As is described further below, extreme winter weather events linked to stratospheric polar vortex disruptions via Arctic change in sea ice and snow cover in fall highlight the need for (innovations in) forecasting and early warning systems in local and regional disaster risk reduction efforts.



Arctic warming puts food security at risk by disrupting the tropospheric jet stream in summer

The world is already bracing for a food crisis following the war in Ukraine – one of the bread baskets of the world. Arctic warming adds another layer on top of these threats to food security.

It's already established that Arctic warming disrupts the jet stream. Now, research suggests that changes to the jet stream heighten the risk of simultaneous crop failures in multiple grain-producing parts of the world:

"The probability of simultaneous heat extremes in these regions increases by a factor of up to 20 for the most severe heat events when either of these two waves dominate the circulation. Two or more weeks per summer spent in the wave-5 or wave-7 regime are associated with 4% reductions in crop production when averaged across the affected regions, with regional decreases of up to 11%."

Extreme summer weather events linked to tropospheric jet stream disruptions further highlight the need for coordinated monitoring and early warning systems in local and regional disaster risk reduction efforts, sustainable/non-industrial local agricultural practices, and effective water management in ensuring food and water security, as is described in the Solutions section.

> "Normally, low harvests in one region are expected to be balanced out by good harvests elsewhere. These waves can cause reduced harvests in several important breadbaskets simultaneously, creating risks for global food production." – *Dim Coumou, Institute for Environmental Studies at VU University Amsterdam*

Arctic warming increases the economic cost of climate change

(Dr. Dmitry Yumashev, Principal Sustainability Consultant (Land Use), Small World Consulting Associate Consultant, UN)

Arctic warming contributes to physical changes in the Earth's climate in response to human greenhouse gas emissions and land use. The physical changes in the climate cause extra pressures on societies, economies and ecosystems around the world. The resulting impacts of climate change are complex and their quantification remains challenging, but the uncertainties are gradually being narrowed down as more data from around the world emerges. Global data on correlations between year-on-year climatic variations and economic outputs has provided a window into the scale of recent and projected future damages from climate change, totalling hundreds of billions of USD per year already and projected to grow further. As a large subset of these losses, recent extreme events such as widespread wildfires in Australia (2019-20) and the US (2020) or floods in Germany (2021) and the UK (2015-16) have caused billions of USD worth of economic damage each, not to mention both human and wildlife suffering and ecosystem damages.

Attributing isolated extreme events to man-made climate change, let alone to Arctic warming, is challenging. However, recent developments in climate science summarised in the latest IPCC report proved a causal physical link between climate change and growing extreme weather events. Simultaneously, there has been a persistent year-on-year growth in insured economic losses from extreme weather globally, which reflect the same trend, albeit with a caveat that this is partly attributed to an expansion of the insurance sectors and the underlying economic growth. Introduction of government-backed reinsurance schemes also points to increasing uninsurable risks due to more extreme weather.

Arctic warming alone is estimated to be responsible for around 5% of all costs of climate change, once monetised damages to ecosystems and human health and wellbeing are factored in alongside economic losses. A smaller but a very critical part of these losses are incurred in the Arctic region itself, affecting indigenous communities who have adapted to living in harsh Arctic conditions over thousands of years. These communities are finding it increasingly difficult to keep pace with the rapid changes in the Arctic climate and weather. Some of the pressures facing Arctic communities include damages to infrastructure from thawing permafrost and growing wildfires, and challenging reindeer herding conditions in winter due to extreme weather. The losses may in part be offset by economic opportunities in the Arctic brought about by climate change. These include growing fishing stocks, expanding tourism and better access to mineral deposits, although most of these opportunities come with their own challenges, not least detrimental environmental impacts to fragile Arctic ecosystems from industrial activities and from climate change itself. Instead, an emphasis may be placed on scaling up nature-based climate solutions and conservation initiatives, alongside promoting sustainable business practices and lifestyles.

SOLUTIONS

The Arctic's early warning system is telling us we need to act now.

Roadmap to 1.5°C

Global risks related to climate change keep climbing: extreme weather, sea level rise, supply chain disruption, food and water insecurity, heat stress in urban areas, disease.

The World Meteorological Organization and the UK Met Office have announced that if we stay on current trends, there is a 48% chance that the Earth's annual-average temperature exceeds +1.5°C of warming, compared with pre-industrial levels, sometime between now and 2026.

Science clearly shows that the +1.5°C target is not a random number — it's the point beyond which these kinds of impacts cause risk of irreversible damage. The loss of Arctic ice, unstoppable glacier melt, and abrupt permafrost thaw are all examples of the kind of tipping points we need to avoid to ensure a safe space for humanity and Earth's ecosystems.

To remain within the +1.5°C trajectory, global emissions need to get to net zero by 2050 – meaning that the emissions we add to the atmosphere is no more than the amount we remove. Emissions need to halve by 2030. Limiting warming involves rapid, deep and immediate greenhouse gas emission reductions in all sectors.

In addition, we highlight these specific solutions:

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SOLUTION:

No new investments in fossil fuels and stop subsidies for fossil-fuel-related industries

Government should ensure no new investments in fossil fuel development anywhere in the world in line with the recommendations from the International Energy Agency.

Banks should not finance oil, gas or mining projects in the Arctic or anywhere else.

Every major US bank has already joined the list of nearly 30 major banks worldwide that have committed to not fund oil and gas development in the Arctic. In the US, this includes Bank of America, Goldman Sachs, JPMorgan Chase, Wells Fargo, Citi, and Morgan Stanley. We most hold these banks to these pledges.

Pressure on the oil industry is likely to increase thanks to growing regulation and shareholder pressure – like the Bank of America shareholder resolution asking for answers on financing Arctic exploration.

SOLUTION:

Phase out coal power

Coal is the most polluting way of producing energy. Governments should ensure a full phase out of coal-power by 2030 in advanced economies, and globally by 2040.

SOLUTION:

Strengthen energy security and climate neutrality

The European Union should introduce measures to accelerate energy efficiency, the green energy transition, sustainable investment through incentives, training and employment opportunities.

SOLUTION:

Define a business roadmap for climate action

All companies should develop a roadmap for climate action through such initiatives as SOS 1.5, a collaboration between WMB and WBCSD focused on providing pathways for companies to decarbonize.

The roadmap will require coordinated action to push forward the emission mitigation options highlighted by the IPCC: demand management, energy and materials efficiency, circular material flows, as well as abatement technologies and transformational changes in production processes.

The emerging technology of carbon capture and storage can help hard-to-abate sectors achieve net zero, but should be used with caution. Its ability to capture significant quantities of carbon is still unproven and faces significant technological and practical barriers – for example, it is often land intensive. It should not be used as a replacement for mitigation and businesses should not over-rely on it as a mechanism to achieve net zero.

SOLUTION:

Change shipping practices in the Arctic to reduce black carbon emissions

Business and government should work together to reduce the damage done by commercial shipping in the Arctic, in support of the Arctic Black Carbon impacting on Climate and Air Pollution (ABC-iCAP) initiative.

Black carbon – black soot particles produced in ship engine exhaust – settles on polar ice and snow, reducing the ability of ice and snow to reflect light, leading to it melting faster.

Businesses who run, or benefit from, commercial shipping routes through the Arctic should immediately stop heavy fuel use.

The International Maritime Organisation should pursue stricter regulation to ban heavy fuel use in the Arctic. Exemptions and allowances in its current proposals for a ban are estimated to reduce black carbon by just 5%, where a full ban on heavy fuel oil could reduce black carbon emissions by 30% in the Arctic according to the International Council on Clean Transportation.

SOLUTION:

Protect nature to enhance carbon sinks

Agriculture, deforestation and other land uses account for 23% of net global greenhouse gas emissions. Nature – soil, oceans, forests and vegetation – can either capture carbon or emit it, meaning that how we manage the natural world can have a major impact on our progress toward net zero. Analysis published by the Organisation for Economic Co-operation and Development modelled the impact of policies on greenhouse gas emissions. It found that a comprehensive policy strategy including taxes on emissions from agriculture and land use, disincentivising deforestation, and subsidies to encourage carbon sequestration could reduce net emissions from this sector by between 89% and 129% depending on the carbon price used.

> "Agriculture, forestry and other land use mitigation options, when sustainably implemented, can deliver large-scale GHG emission reductions and enhanced removals, but cannot fully compensate for delayed action in other sectors." – *IPCC*

SOLUTION:
Aligning financial flows with net zero

> "Given the global nature of climate change, we need an effective coordinated global response to help developed and developing countries reach net zero faster. Critically, all of society — public and private enterprises in all regions — must move forward together and the global financial architecture must ensure this. The current architecture was born in the age of fossil fuels to meet the challenges of the post-war era. We need to reset it in order to address the challenges of the green transition." – *Glasgow Financial Alliance for Net Zero*

Climate disclosures: Governments, investors and businesses should implement the recommendations of the Task Force on Climate-related Financial Disclosures. G20 governments should recognise the disproportionate financial power of their countries and follow recommendations from the Glasgow Financial Alliance for Net Zero (GFANZ) to set a target for net-zero transition plans by 2024 for public and private enterprises, including financial institutions.

Carbon pricing: Businesses and governments should work towards putting a price on carbon, which allows companies to incorporate the externalities of their emissions accurately. Businesses can begin by using an internal carbon price to support their transition plans. Governments should follow GFANZ's recommendation and introduce policies, regulatory approaches and incentives that price the externalities of carbon emissions in line with the science.

Invest in developing countries: Companies, investors and financial institutions should invest in key technologies, especially in developing countries. Many countries have high potential for a rapid transition which could see them leapfrog others in deployment of modern, low emission technologies which are falling rapidly in price. These countries require private investment to stay aligned with the Paris Agreement.

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Adaptation, loss and damage

Climate change impacts are already here, and climate change in the Arctic is unleashing a domino effect of risks on the rest of the world. Adapting to these changes must occur in parallel with efforts to accelerate the pace of emissions reduction to mitigate climate change.

Many developing countries already know what adaptation measures they need to put in place – but they lack the finances to do it. This is a critical piece of the solution needed to ensure that the world can cope with the cascade of risks unleashed by climate change generally and a warming Arctic specifically.

> "Bold efforts to accelerate adaptation drawing on the template of major initiatives such as the Africa Adaptation Acceleration Program are urgently needed in every region, including to support locally-led community action and to empower the most vulnerable communities." – *Dhaka-Glasgow Declaration of the Climate Vulnerable Forum, CVF*

SOLUTION:

Early warning systems to increase resilience to extreme weather and sea-level rise

The extreme weather associated with a warming Arctic, in addition to sea-level rise and landslides resulting from glacier melt, causes death, injury, and severe economic disruption. Addressing this risk requires national and regional plans and early warning systems to help vulnerable communities protect themselves, along with the policy-making and finance to realise them.

- The Hondsbossche Dunes in the Netherlands are nature-based infrastructure comprised of an artificial beach and dune landscape across 7 kilometres of the Dutch North Sea coast. It's an essential part of Dutch flood protection measures. They can withstand severe storm surges and can be upgraded by adding more sand when sea levels rise.

- The Coastal Inundation Forecasting Demonstration Project provides an early warning system and alerts for coastal flooding in Pacific Island countries. In The Netherlands, a flood early warning system for the rivers Rhine and Meuse is informed by hydrological and meteorological forecasts monitored by the Ministry of Infrastructure and water management. The existing early warning system for the Thames River consists of stream gauges and weather stations in a system also controlled by regulation that discourages development in the floodplain.

- The recently-released New Zealand draft climate adaptation plan documents strategies to address SLR and extreme events such as droughts and flooding through the three focus areas of i) climate change-related institutional reform, ii) data and tool accessibility, and iii) resilience-oriented government strategies and policies. The plan further underscores the importance of disaster risk reduction and climate adaptation initiatives combined in building resilience (preparedness, resilience and disaster risk reduction) for coastal communities, and presents nature-based solutions that can be adapted to regional needs and priorities globally.

- As advocated by the WMO, early warning systems are essential to human security, as are frameworks such as the Global Heat Health Information Network designed to facilitate adaptation to the health risks associated with heat waves in a changing climate.

CASE STUDY:
Adapting to glacier-related disaster risks in the Hindu Kush Himalayas

The Hindu Kush Hiamalaya (HKH) extends over 3,500km, from Afghanistan in the west to Myanmar in the east and crossing Pakistan, India, China, Nepal, Bhutan, and Bangladesh. Its waters irrigate the food baskets of Asia. The HKH and the Tian Shan mountains together form the largest area of permanent ice cover outside of the north and south poles and are also referred to as the Third Pole.

Global warming at 2°C, and beyond, will result in the loss of half the volume of the HKH's glaciers and destabilize Asia's river systems, with enormous downstream consequences for billions of people. It will cause severe and irreversible losses of ecosystem services and biodiversity while leading to food and water insecurity. Even a 11.5°C rise will increase the risks of extreme weather events, triggering flash floods, altering agriculture, and causing multiple long-term instabilities.

More than one billion people in the HKH are at risk from increasing natural hazards, many cascading in nature. Regional transboundary collaboration through sharing of data, climate services, tools for interpretation, and training, is amongst a top priority. Innovative earth observation and geospatial solutions and gender-sensitive and socially-inclusive services need to be developed and implemented, in alignment with the national needs and priorities. Climate services for local decision making need to be strengthened through enabling user-provider interface. Institutional, community and individual capacities need to be strengthened.

Dr. Chi Huyen Truong, International Centre for Integrated Mountain Development

SOLUTION:
Improve food and water security

The risk multiplier effect of the Arctic means that climate change is already causing food and water insecurity. Adapting food systems to this reality is essential. The IPCC recommends several solutions:

> "Supply-side options include increased soil organic matter and erosion control, improved cropland, livestock, grazing land management, and genetic improvements for tolerance to heat and drought. Diversification in the food system (e.g., implementation of integrated production systems, broad-based genetic resources, and heterogeneous diets) is a key strategy to reduce risks.
>
> Demand-side adaptation, such as adoption of healthy and sustainable diets, in conjunction with reduction in food loss and waste, can contribute to adaptation through reduction in additional land area needed for food production and associated food system vulnerabilities."

SOLUTION:
Loss and damage payments

The world's richest nations should follow through on their climate finance promise, originally made in 2009, to pay US$100bn a year to developing countries. This should also be accompanied by support like technology transfer and in-country capacity building.

A UK House of Commons briefing highlights this target has been missed every year since 2013.

SOLUTION:

Building on indigenous intelligence and traditional knowledge

The Inuit community of Mittimatalik in Canada used their traditional knowledge, earth observations and Canadian Ice Service sea ice charts to produce the Sea Ice Climate Atlas. It builds on the fact that Inuit maintain the longest unrecorded climate history of sea ice in Canada, and allows the community to share locations of changing sea ice conditions. The atlas also helps search and rescue partners, and was used in environmental assessments of a proposal to extend the shipping seasons for a nearby river.
– *Research report*

Indigenous knowledge is integral to effective wildfire management. Organizations such as Indigenous Guardians and Wildfire Management provide models for environmental management, fire stewardship, and increasing biodiversity on our planet.

SOLUTION:

More investment in the Arctic to help communities adapt to climate change

People living in the Arctic are hit first and worst by climate change. Supporting their adaptation helps develop adaptation models we can apply elsewhere; if we can get it right here, we can get it right elsewhere. Despite this, analysis by the Arctic Resilience Action Framework found "investment from the private sector in resilience building appears to be a weak link."

Social enterprise serves as a model for resilience in the Arctic and globally.

SmartICE is a social enterprise initiative that helps northern communities adapt to the reality that sea ice is becoming less predictable as the Arctic warms, increasing the risk of vital ice travel. SmartICE combines Indigenous knowledge, sensor technology and satellite imagery to generate up-to-date information about areas where travelling across the ice is too hazardous. That information is shared via mobile apps, maps in public places and local radio to help northern communities navigate sea ice and preserve traditional travel and hunting.

"SmartICE partners with Arctic Indigenous communities to empower them to monitor the ice that not only acts as their harvesting platform and travel highway but is central to their culture and identity. By helping to document and share their indigenous knowledge of ice travel safety, while also putting into their hands the sensors that monitors the ice, SmartICE is demonstrating to Davos that traditional knowledge and novel technology can work hand-in-hand for a climate change solution." – *Dr. Trevor Bell, SmartICE Co-Founder*

SOLUTION:

Environmental management in the Arctic

Research in northeastern Russia found that areas with herds of large Arctic herbivores like reindeer, horses and bison have a soil temperature about 2 degrees colder compared to herd-free areas. It's thought that herds thin snow cover and increase its density, allowing heat to escape from the soil and preserving vita thermafrost. This means that strategically resettling herds like these could help preserve the Arctic's permafrost.

Protecting forests and peatland can also limit permafrost disruption. Peat insulates permafrost by trapping air pockets above it, while vegetation shades the ground from direct sun, slowing down thaw. A modelling study found that the areas most likely to suffer from permafrost degradation are those with mineral-based soil and no vegetation.

Permafrost Pathways is an initiative designed to explore the scientific, social, economic implications of permafrost thaw, including unaccounted for carbon and methane release due to permafrost degradation. Central to understanding the implications of permafrost thaw in a warming climate are international permafrost thaw monitoring programs. Specifically, the permafrost thaw action group of the Terrestrial Multidisciplinary distributed Observatories for the Study of the Arctic Connections (T-MOSAiC) has developed a standardized approach to monitoring permafrost thaw by monitoring surface and subsurface conditions (Boika et al., 2022). Also of interest is Russia's advanced permafrost monitoring program, and the Aurora College permafrost monitoring program in the Inuvik region, launched in 2012.

SOLUTION:

Improve monitoring of the effects of climate change in the Arctic

Improved monitoring helps direct efforts to adapt the Arctic to meet the realities of climate change.

Monitoring changes in vegetation and permafrost thaw in the Arctic combined with distributed monitoring systems can highlight regions for preservation and conservation. Emissions tracking can give rise to improved understanding of pollutant transport into and out of the Arctic from extractive industries, shipping, and mining operations

Right now, we can only observe the vast Arctic with a very limited amount of sensors and observation systems that are deployed and maintained on the ice (sea ice, glaciers), on land, and in the sea (buoys, moorings) by various research teams every year.

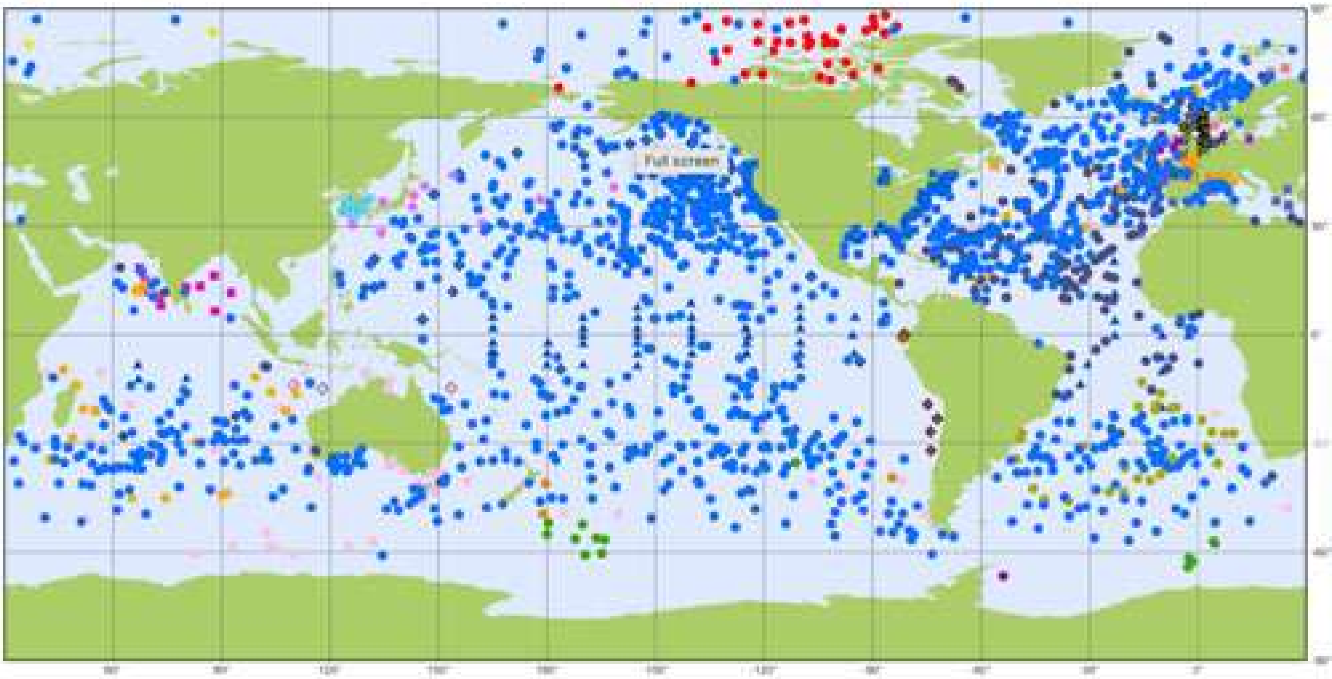

Figure 3: Observation systems sending data to WMO GTS service in September 2021. Explore more @ https://www.ocean-ops.org/board/wa/Archives?t=dbcp

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Sensors in the Arctic play a critical role in monitoring the atmosphere, land, sea ice and ocean by collecting and broadcasting their observations.

More sensors could be deployed from various research missions and observatories if there was adequate and continuous funding for a selection of key indicators/values. The nature of research funding for observation systems in the Arctic is mostly based on short-term grants from various national programs (e.g. EU projects, USA NSF projects, etc.) and individual institutes/universities. This often gives us amazing breakthroughs in sensing technology, followed by the abrupt stop to deployments and data observations as the funding runs out.

With collaborators, Arctic Basecamp is aiming to develop a global trust fund for sensors to address this funding shortage and significantly increase our observations for several key metrics such as air and sea surface temperature, atmospheric pressure, sea surface salinity, etc. We would focus on sourcing or developing sensors and observation systems which are easy to deploy by the general public (e.g. cruise/tourist ships, researchers from other fields with limited relevant fieldwork experience) and aim to open this trust fund to international Arctic research community, citizen scientists and local Arctic communities in a combined effort to provide a stable source of continuous observations for key metrics. Such an observing network of marine-and land-based sensors strategically located within communities, and uniformly distributed throughout the Arctic would, with local knowledge be the key to monitoring, recording, and preparing for Arctic hazards and their global impacts.

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About Arctic Basecamp

Arctic Basecamp is a registered not-for-profit organization headquartered in the Netherlands. Our mission is to “speak science to power” and communicate how the Arctic is a critical barometer for, and a driver of, global risk. We support urgent low carbon action based on insightful analysis that is supported by robust, rigorous and cutting-edge science.

By sharing knowledge and science, Arctic Basecamp works with partners to call for urgent action from global leaders to mitigate, adapt and build resilience to global risks from climate change.

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