

In focus

The heat is on: How investors are underestimating physical risks of climate change

February 2024

More severe and frequent physical risks are expected to hit sooner than expected. It appears unlikely that the global system will limit global warming to 1.5 °C

As we stand in the early weeks of 2024, it is increasingly clear that the climate crisis is not only a looming threat but a rapidly unfolding reality. Climate scientists have long warned that we must limit global warming to 1.5 °C to avoid triggering climate tipping points and stave off the worst impacts of climate change. Yet, the data from 2023 paints a chilling picture: it was the warmest year on record, and by a considerable margin.



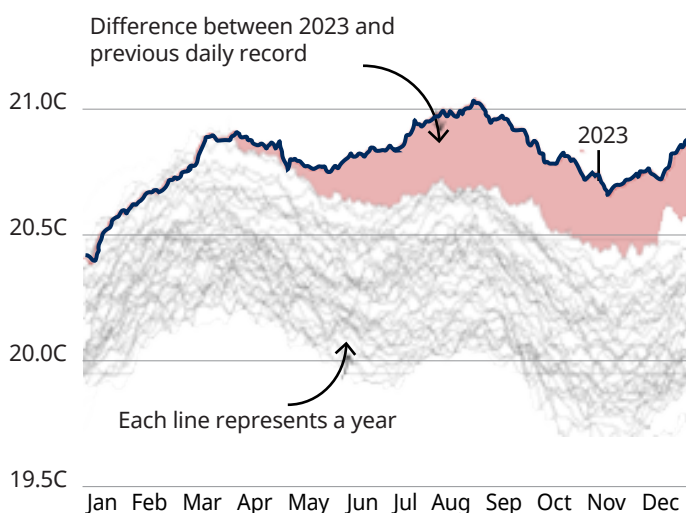
Samar Khanna
Environmental Economist

Average global temperatures in 2023 were 1.48°C above pre-industrial levels (Figure 1) – perilously close to the 1.5°C threshold, beyond which humanity's ability to influence climate change will significantly reduce as climate systems enter self-reinforcing patterns. Global warming continues its record-breaking streak in 2024. The world experienced the warmest January on Record ([Copernicus](#)).

Figure 1: The extraordinary data from 2023 bolsters our belief that the pace of global warming is indeed intensifying

Ocean temperatures highest on record

Daily average sea surface temperature, 1979–2023

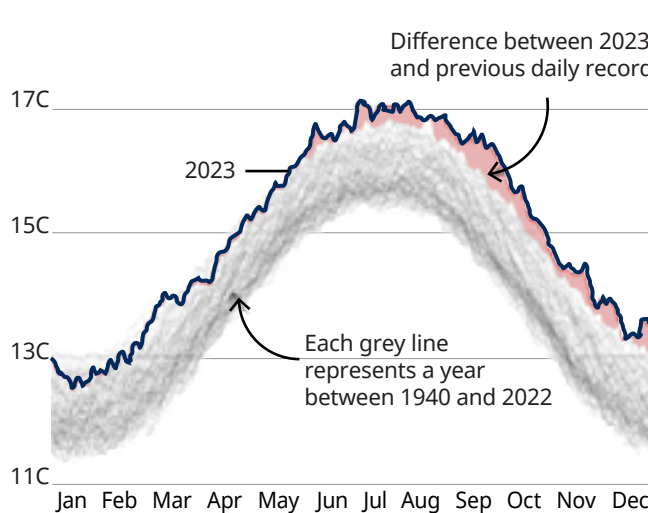


Source: BBC, ERAS, C3S/ECMWF.

As capital market strategists and economists, we are perpetually fine-tuning our assessment of risk in response to emerging data. The *off-the-charts* climate data stemming from a faster rate of global warming necessitate a critical re-assessment of our understanding of 'true' risk in financial markets. The urgency to reduce emissions by around 43% by 2030 to limit global warming to 1.5 °C is becoming increasingly obvious, but are we, as a global community, on track to meet this goal?

Global temperatures at record levels in 2023

Daily global average air temperature, 1940–2023



In this article, I discuss why limiting global warming to 1.5 °C is not just a goal for environmental sustainability but a crucial factor for maintaining stability in financial markets, how it's appearing increasingly likely that this threshold will be breached within this decade and why more severe and frequent physical risks are expected to hit sooner than anticipated.

It is important to note the growing disconnect between climate science and climate-scenario modelling undertaken by financial firms. This chasm is leading to a severe underestimation of the risks posed by climate change, a miscalculation that could have significant implications for global financial markets. The intersection of climate science and financial analysis has never been more relevant, and understanding these risks is not just important, it's essential for the resilience and sustainability of global financial markets.

“
Risk is what's left over after you think you've thought of everything.
 ”

Carl Richards

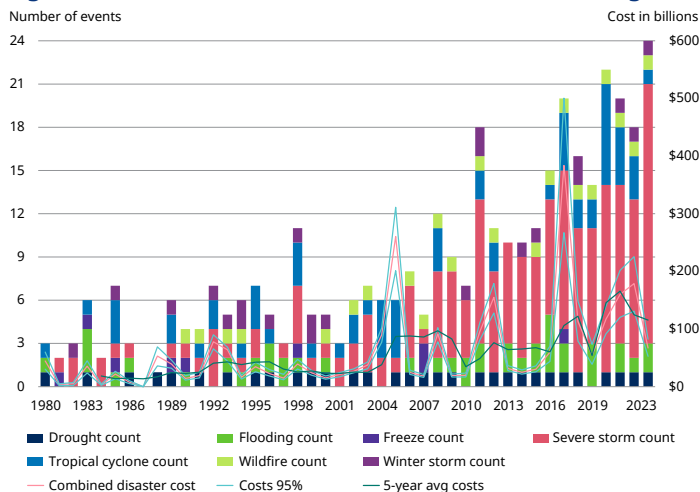
To help put the climate crisis into perspective and showcase why investors should care about these growing risks, we begin our discussion by highlighting escalating physical risks due to worsening climate change and how investors are being impacted worldwide.

What physical risks are we experiencing which might impact investors?

1. Billion-dollar climate disasters on the rise

In 2023, the US experienced 28 weather and climate disasters costing at least \$1 billion, according to the [National Oceanic and Atmospheric Administration](#). This was the highest number of disasters on record with a total cost of \$93 billion, and a far cry from the three disasters witnessed in 1980 (Figure 2).

Figure 2: Billion-dollar disaster events in the US are rising



Source: [National Centers for Environmental Information](#).

2. The insurance sector is coming under pressure from rising natural catastrophes

United States: The growing frequency and severity of climate-related disasters in the US has led to ballooning losses, and private homeowner insurers have felt this pain acutely. Over the past couple of years, insurance companies have had to restrict their coverage, increase premiums considerably or pull out of markets in states like California and Florida:

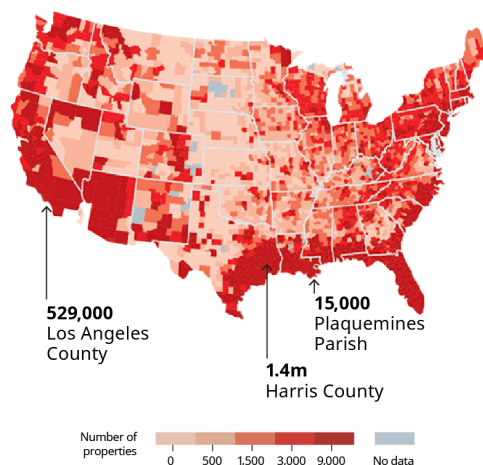
- In Florida, average home insurance rose 42% year-on-year (y/y) with at least 15 firms limiting their business ([Parts of America are becoming uninsurable – The Economist](#)).

- In California, seven of the twelve insurance firms halted or pulled back coverage claiming that homeowners' premiums do not match the climate risk they face ([Washington Post](#)), leading to wide-ranging reforms in the state.
- Taxpayer-backed insurance coverage programmes – which stepped in to replace private insurers – have also faced significant losses, with Congress having to forgive debts in some instances. These programmes are now setting premiums to accurately reflect climate impacts – insurance premiums are expected to rise sharply ([Climate shocks are making parts of America uninsurable – NYT](#)).
- According to a paper released by [First Street Foundation](#) – 25% of all US real estate face increasing insurance prices and reduced coverage due to growing climate risks (Figure 3).

Figure 3: Home insurance premiums are being appraised to reflect growing climate risks

Noah's premium

US, risk of an insurance correction due to fire, flood or wind¹, by country, 2023 estimate.



Source: [Parts of America are becoming uninsurable – The Economist](#).
¹Premium increase or coverage reduction.

Swiss Re:

- Insured losses for natural catastrophes in H1 2023 were 54% higher than the 10-year average (Figure 4).
- Severe thunderstorms in the US were the main driver of global insured losses from natural catastrophes.

Figure 4: Total economic and insured losses

Total economic and insured losses in H1 2023 and H1 2022 (USD billion in 2023 prices)

	H1 2023	H1 2022	H1 previous 10-y avg	% change vs. 10-y avg
Economic losses	125	129	89	41%
Natural catastrophes	120	123	82	46%
Man-made catastrophes	5	6	7	-23%
Insured losses	54	52	38	42%
Natural catastrophes	50	48	32	54%
Man-made catastrophes	4	5	6	-28%

Source: [Swiss Re](#) and [ET](#).

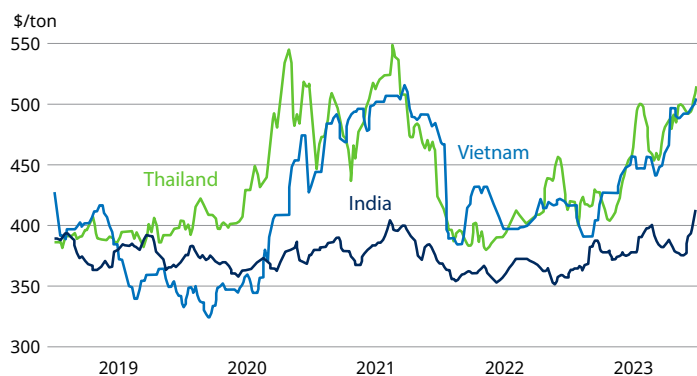
Australia:

- Climate change is creating an insurability crisis in Australia due to worsening extreme weather and sky-rocketing insurance premiums. One in every 25 properties in Australia will be high risk and uninsurable this decade ([Climate Council](#)).

3. Declining food production:

- **India:** the largest rice exporter in the world, accounting for 40% of total rice exports, banned the exports of certain categories of rice in July 2023 causing prices to rise to the highest in over a decade. The cause was severe drought conditions made worse by global warming and El Niño (Figure 5).

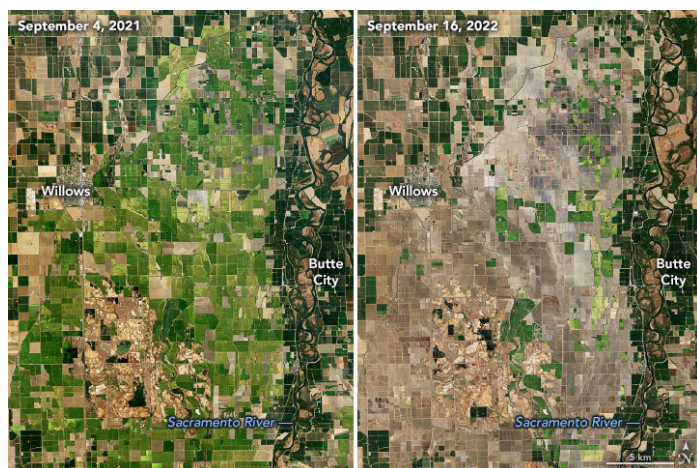
Figure 5: Rice exports prices jump as El Niño develops



Source: [US Department of Agriculture, Foreign Agricultural Service](#).

- **California:** the US state planted half as much rice as usual in 2022 due to severe droughts, causing \$703 million in losses. It has been experiencing the worst megadrought in over [1200 years](#) (Figure 6). The recent flooding is unlikely to break this dry spell. As authorities [noted](#) - “We are in the middle of a flood emergency and also in the middle of a drought emergency”. According to the [World Economic Forum](#), the impacts of the droughts are being felt through the supply chain including millers, dryers, storage and trucking.

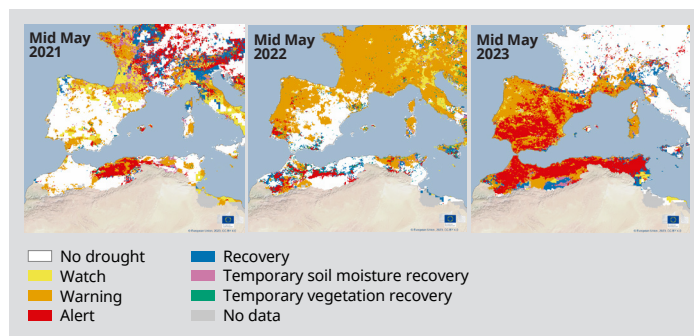
Figure 6: Image of droughts in California impacting crops



Source: [World Economic Forum](#).

- **Europe:** severe drought in the Western Mediterranean has led to lower yields than average, particularly in olive oil and rice production (Figure 7). In certain parts of Spain, water reservoirs are down to around 25% of capacity ([World Economic Forum](#)).

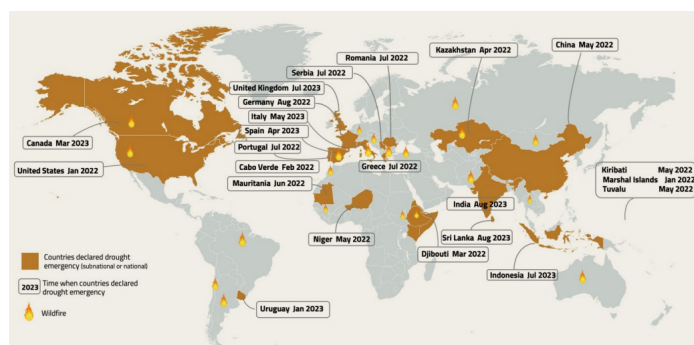
Figure 7: Intensity of droughts in the Mediterranean rising



Source: [European Commission](#). Note: The Combined Drought Indicator (CDI), based on a combination of indicators of precipitation, soil moisture and vegetation conditions, Mid May 2021, 2022, 2023.

- **United Nations:** according to UN’s recent publication, [Global Drought Snapshot 2023](#), a quarter of the global population experienced drought conditions over 2022/23 (Figure 8). They expect global crop markets to continue to be impacted by heat stress over 2024 as the El Niño phenomenon continues. The last time El Niño was at its peak in 2015/16, rice production fell sharply in South East Asia and maize yields declined significantly in Central America and Southern Africa.

Figure 8: List of countries declaring drought emergency (2022–2023)



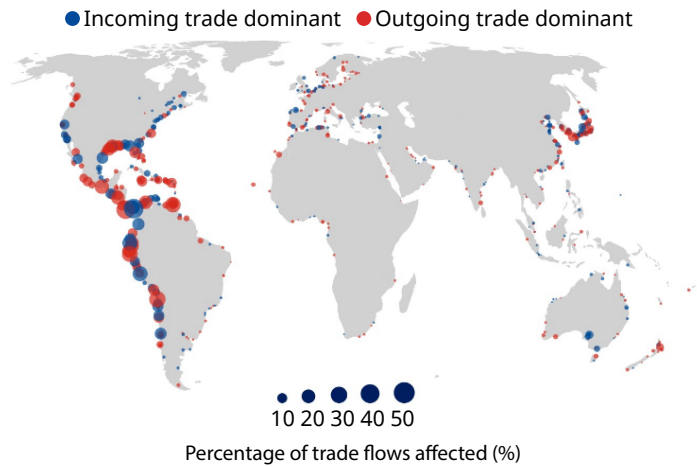
Source: [UN Global Drought Snapshot](#).

4. More severe droughts are disrupting crucial trade routes:

- Panama Canal:** the canal is facing the worst drought in its 140 year period, hindering operations in the waterway responsible for 5% of global maritime trade by volume. Rainfall in Panama has been 30% below average in 2023 leading to record low levels of water in the canal (Figure 10). Longer waiting times, fewer ships crossing and reduced cargo on ships is leading to increased freight costs. Economies such as Panama, Nicaragua, Ecuador, Peru, El Salvador and Jamaica are the most impacted, with 10-25% of their total maritime trade flows affected. But supply chain disruptions will be felt across the globe, highlighting the vulnerability of complex global supply chains to climate change (Figure 9). The disruption is expected to last at least 10 months, according to Panama Canal officials.

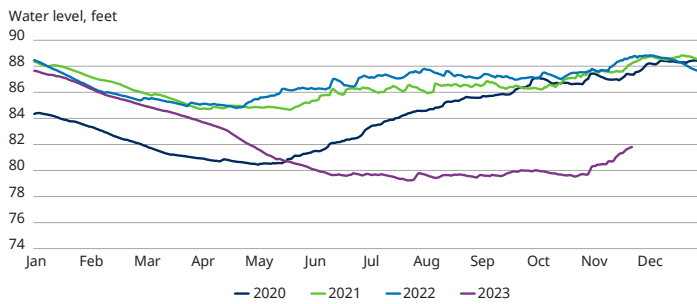
Figure 9: Drought has reduced Panama Canal flows by 5% so far in 2023, slowing the global trade of goods

Port-level trade flows affected by Panama drought since March 2023



Source: [International Monetary Fund](#).

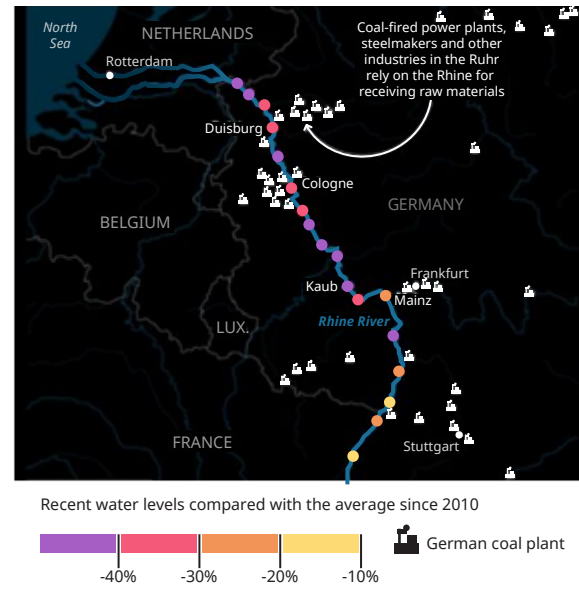
Figure 10: Gatun Lake in Panama Canal is at its lowest level in a decade



Source: [Panama Canal Authority](#).

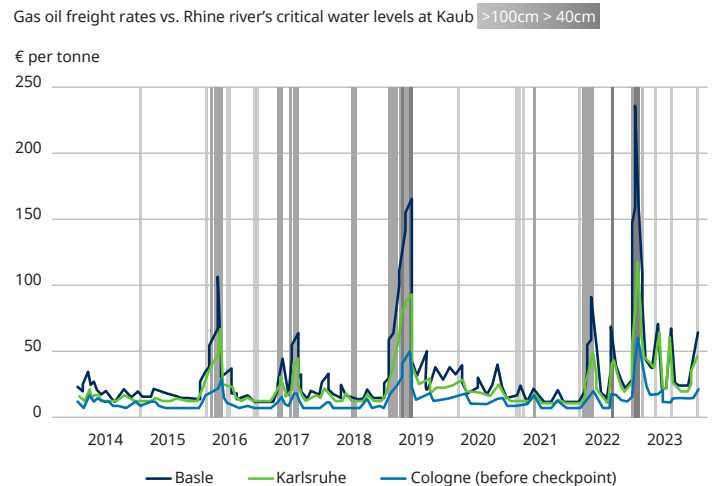
b. **The Rhine, Germany:** the Rhine’s importance in European and global trade cannot be overstated. Not only is the river responsible for 6% of total goods volumes transported in Germany, including 30% of coal, crude oil and natural gas and 20% of coking plant and petroleum products ([Kiel Institute for the World Economy](#)) – it’s also a key regional transport artery. The waterway delivers crucial raw materials to Europe’s heavy industry – around 20% of the world’s chemical industries have manufacturing facilities along the river. Growing drought conditions and lower water levels have led to a notable reduction in cargo transported (Figures 11 and 12). The risk initially appeared in 2018, when drought conditions caused German industrial production to fall by 1.5% and GDP to decline by 0.4% (IfW). The severity of droughts has grown ever since – 2022 was the worst drought Europe experienced in 500 years and caused a 50% reduction in cargo transported. The German government has planned to spend €180 million and transporters are redesigning barges to adapt to shallower waters – at a notable cost to the economy.

Figure 11: Water levels in some sections of the Rhine are currently over 40% lower than historical average



Source: [German Federal Institute of Hydrology](#).

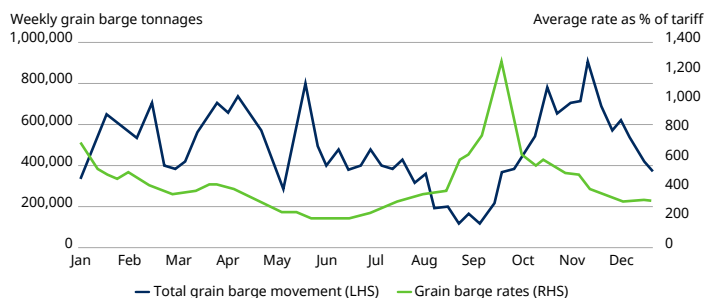
Figure 12: Droughts cause Rhine shipping rates to spike



Source: [Refinitiv Datastream](#).

c. **Mississippi, United States:** The river forms an important trade channel to transport grains from the Midwest to the Gulf Coast ports. Two-thirds of US wheat shipments are transported via this route. However, record droughts for two years running have reduced barge movements by 55% compared to last year. Low levels of water in 2022 led to loading capacity being slashed by a third, **causing \$20 billion losses in economic activity**. Figure 13 shows how reduced levels of grain barge movements leads to an immediate spike in average barge rates. Low water levels over a longer period have also led to saltwater from the Gulf of Mexico making its way upriver and threatening the water supply for over 50 cities.

Figure 13: Barge movements and the corresponding barge rates on the Mississippi river system



Source: [US States Department of Agriculture](#).

What are the implications for investors?

Elevated volatility: It is more likely than not that financial markets will experience elevated volatility sooner than expected. This can materialise due to:

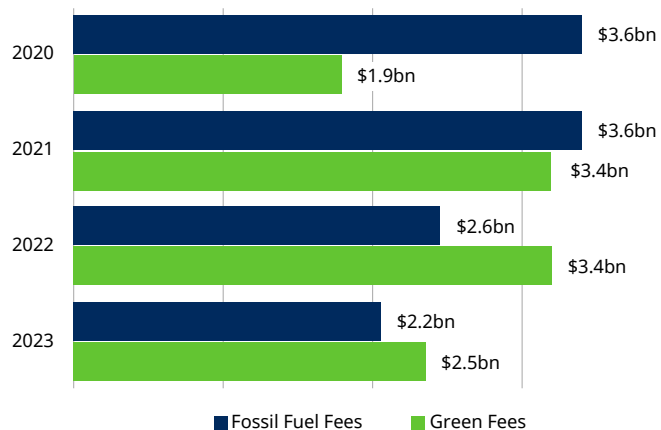
- **A disorderly transition:** delayed action on climate change means that the global system needs transformational change in order to reduce emissions by 43% by 2030 (Stoddard). The scale and pace of the transition required to limit warming to 1.5 °C will be disruptive, costly and messy (UNFCCC).
- **More severe and frequent physical risks, which precipitate abrupt policy change:** given the slow progress in our decarbonisation journey, accelerating pace of climate change, and inadequate carbon budgets to limit warming to 1.5 °C – there is a higher probability that the global system (and its financial institutions) will experience higher physical risks sooner. According to the Intergovernmental Panel on Climate Change, or IPCC’s [sixth assessment report](#), physical risks are more severe than anticipated at current levels of warming.

Preparing for a hotter world: adaptation becomes as important as mitigation

- This has implications for risk-return considerations for investors. According to the [World Resources Institute](#), mitigation activities like investing in solar PV, electric vehicles, bring more immediate and certain financial return than adaptation activities. The focus of mitigation measures around greenhouse gas (GHG) emissions not only makes them easier to define, but also easier to invest in. Adaptation activities, on the other hand, focus on building long-term resilience and creating social benefits but may not result in clear financial returns for private investors.
- Adaptation is most pressing for countries which are more vulnerable to climate change – and which are also located in areas perceived as too risky for private investment.
- There are no risk-return considerations in loss and damages resulting from a hotter world, These costs sit outside the purview of financial institutions.

Banks are taking advantage of new revenue streams from the green transition: banks have earned revenues of \$2.5 billion from climate-related projects, compared to \$2.2 billion from fossil fuel companies. (Figure 14). This represents a notable change from 2020 when revenues from fossil fuel companies were nearly double those related to green projects.

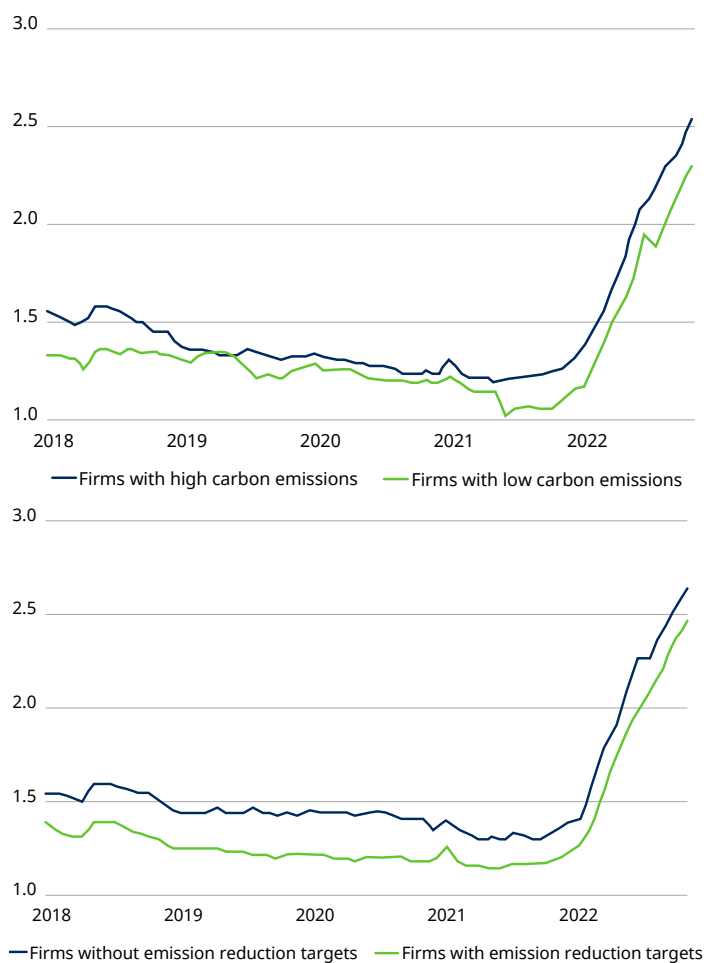
Figure 14: Banks are earning more from providing green financing



Source: [Bloomberg](#).

Euro area banks are pricing climate risk in their lending policies: a report by [CEPR](#) notes that monthly mean interest rate charged to firms in the top quartile of carbon emissions exceeds that charged to firms in the bottom quartile, with a difference of 15 basis points (bps) (Figure 15, left chart). In addition, the difference in rates charged by banks to those who have committed to reducing future emissions versus those which haven’t is around 20 bps (Figure 15, bottom chart).

Figure 15: Interest rates charged to green and brown firms



Source: [Centre for Economic Policy Research](#).

Physical risks - why we expect them to materialise sooner than expected

There are three reasons why physical risks are more imminent than many currently anticipate:

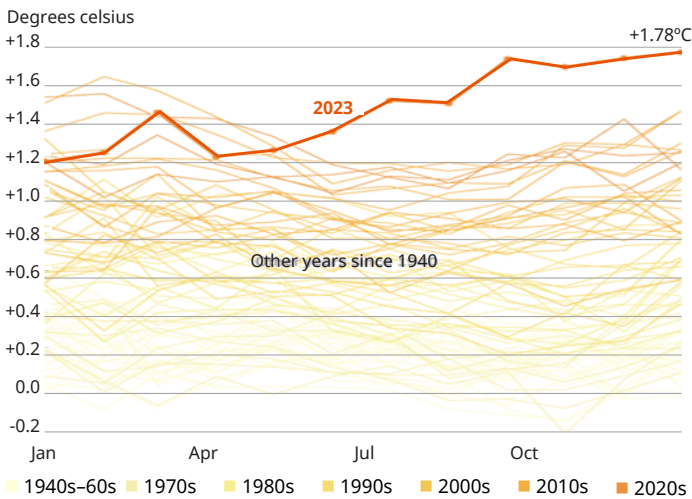
- 1 The pace of global warming is accelerating
- 2 Carbon budget is half of what it should be
- 3 Financial models severely underestimate the risks

1. Pace of global warming is accelerating:

September 2023 was the warmest September on record globally, with average global temperatures 1.75 °C warmer than pre-industrial levels (Copernicus Climate Change Service) (Figure 16). This was after July and August 2023 were estimated to be around 1.5 °C warmer than the pre-industrial average. 2023 is estimated to be the warmest year on record at 1.43 °C above preindustrial averages (Copernicus Climate Change Service).

Figure 16: Global temperature conditions since 1850

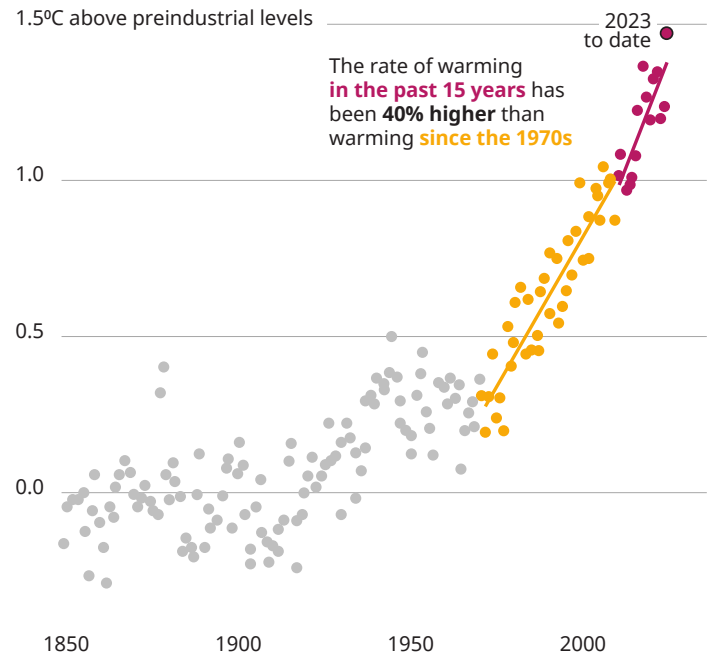
Monthly global temperature compared with preindustrial levels



Source: Copernicus Climate Change Service and Berkley Earth.

Recent reports from climate scientists show that the world is warming more quickly than before due to record levels of annual GHG emissions (Figure 17).

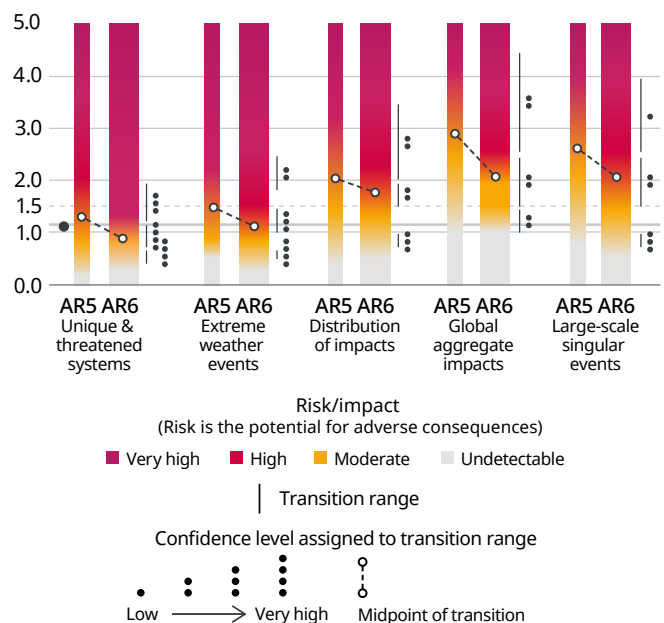
Figure 17: Global warming may have accelerated in the past 15 years



Source: Berkley Earth.

More severe impacts are being felt at lower temperatures than anticipated. When climate scientists at the IPCC released their 5th assessment report in 2014, they noted that climate tipping points would be triggered around the 2°C mark. They revised this threshold down to 1.5°C in their 6th assessment report as harsher physical impacts were being experienced at lower temperatures. Figure 18 below shows how extreme weather events are occurring at lower levels of warming than scientists initially anticipated.

Figure 18: More severe impacts are being felt at lower temperatures than anticipated



Source: The Emperor's New Climate Scenarios. Note: AR5 and AR6 are IPCC's assessment reports released every 7 years.

2. Carbon budget is half of what it should be:

A carbon budget is the total amount of carbon dioxide that can be emitted by humans whilst limiting temperature increases to a certain level – in this case 1.5°C by 2030. The 1.5°C threshold is critical as irreversible climate tipping points are triggered once it is breached. A recent study shows how the carbon budget is estimated to be half of what it was in 2020 and is expected to be used up before the end of the decade (Lamboll et.al. Oct 2023). There is a real possibility that we are close to running out of the carbon budget to limit warming to 1.5°C (Climate Crisis Advisory Group).

3. Financial models severely underestimate the risks

According to climate scientists and the Institute and Faculty of Actuaries (The Emperor's New Climate Scenarios), a majority of climate-scenario models in financial services are significantly underestimating climate risk. There is a stark disconnect between climate-economy models and climate science. This is because:

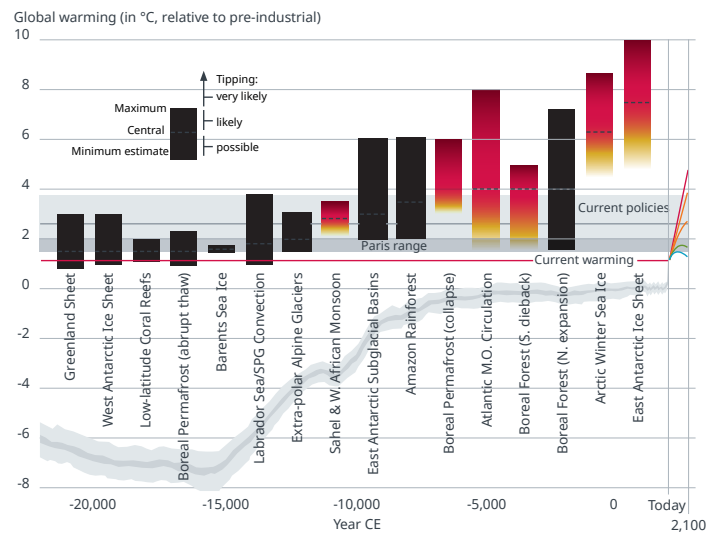
- Climate-scenario modelling has struggled to incorporate non-linear and exponential impacts of climate risk (such as tipping points and cascades) and second-order impacts (such as involuntary mass migration) in their damage functions.
- There is limited relevant past data for climate modelling.
- Economies have never been subject to a transition of this speed and scale, alongside the increasing physical risks.
- Modelling climate-economy models is a complex undertaking involving an integration of different models, leading to compounding errors.

Interestingly, financial institutions have primarily focused on transition risk over physical climate risk, probably because transition costs are a more immediate concern than physical costs – which are expected to materialise over the long-run. Less than half of financial institutions surveyed have reported on physical risk in their climate disclosures (World Resources Institute), creating potential physical risk 'blind spots.'

Why is limiting warming to 1.5°C our climate target?

The risk of triggering **climate tipping points** is significantly higher if the earth warms to a long-term temperature average of 1.5°C compared to pre-industrial levels (Figure 19). Climate tipping points are critical planetary thresholds that, once crossed, create self-reinforcing feedback loops which are irreversible, and which 'could prevent stabilisation of climate at intermediate temperature rises and cause continued warming even as human emissions are reduced' (Steffen, Rockstrom; 2018). In other words, the earth will move from self-regulating to self-heating, and human endeavours to limit temperature increases beyond this point might be limited.

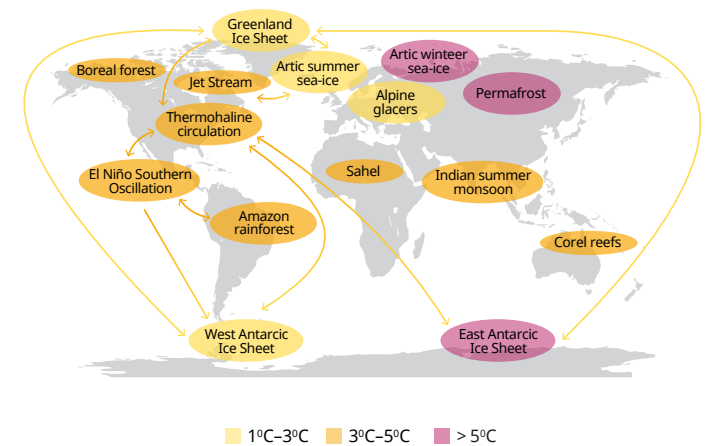
Figure 19: Likelihood of tipping points being triggered for different global warming temperatures



Source: [Armstrong, McKay et al. Science, 2022](#) and Institute and [Faculty of Actuaries, 2023](#). Note: There is a higher likelihood of Greenland and West Antarctic icesheet collapse at around 1.5C of global warming.

Given the interdependence between different climate systems, the crossing of a tipping point in one climate system can catalyse feedbacks that increase the likelihood of crossing other climate system tipping points. This leads to a **cascading impact** that would push the earth's system into a significantly hotter state (OECD) (Figure 20).

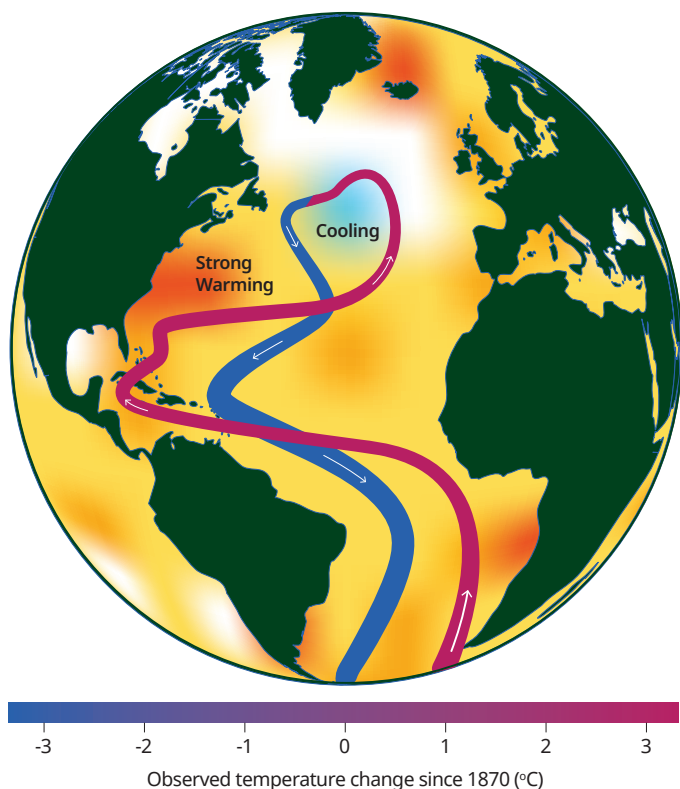
Figure 20: Global map of potential tipping cascades



Source: [Trajectories of the Earth System in the Anthropocene](#). Note: The diagram shows the interdependence of different climate systems and how triggering a tipping point in one system can lead to a cascade of tipping points emerging.

Climate scientists have noted growing cascading risks at current average long-term global temperatures of 1.2°C. The [West Antarctic](#) and Greenland icesheet is experiencing significant destabilisation. According to the [British Antarctic Survey](#), the disappearing bright white ice sheets reduce the ability of the earth to reflect the sun's energy back into space (known as the Albedo effect). The more ice sheets melt, the more heat the darker water bodies absorb. These rapidly melting ice sheets are, in turn, slowing down ocean circulation. Also known as the Atlantic Meridional Overturning Circulation (AMOC) or the Gulf Stream – it is a system which circulates water within the Atlantic Ocean, bringing warm water up north and cold water south. AMOC is the weakest it has been in 1600 years, causing declines in food production ([OECD](#)) and destabilising the Amazon forest (Figure 21).

Figure 21: AMOC running amok: AMOC is the weakest it's been in 1,600 years



Source: [Postdam Institute for Climate Impact Research](#).

Reducing carbon emissions by 43% by 2030 is a crucial interim milestone in our journey to net-zero by 2050 as it ensures that we limit temperature increases to 1.5°C, avoid triggering tipping points, and stave off the worst impacts of climate change.

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