

Overshoot: from implicit assumption to political plan for going net-negative?

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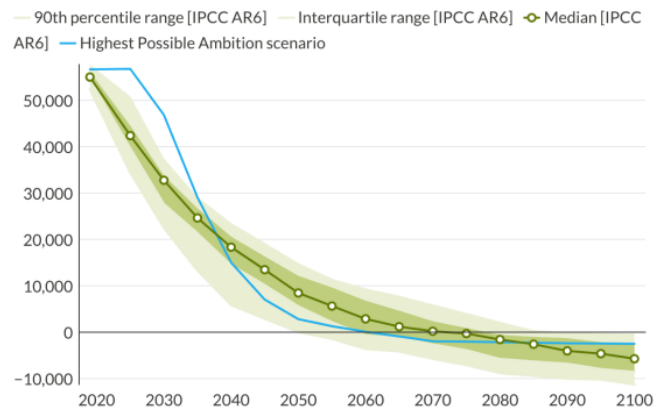
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Delayed mitigation results in higher peak temperature



This peak is 0.1°C higher than in the median of the IPCC AR6 scenarios.

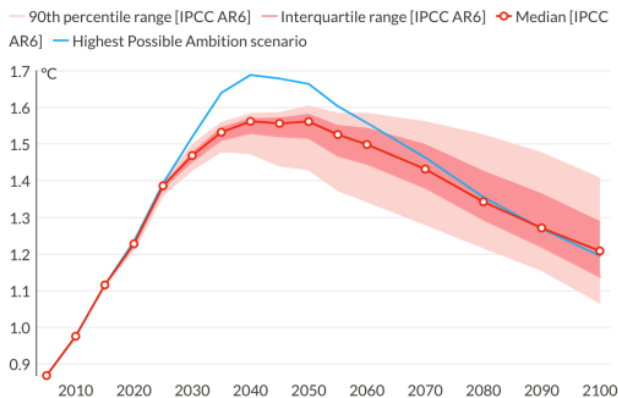


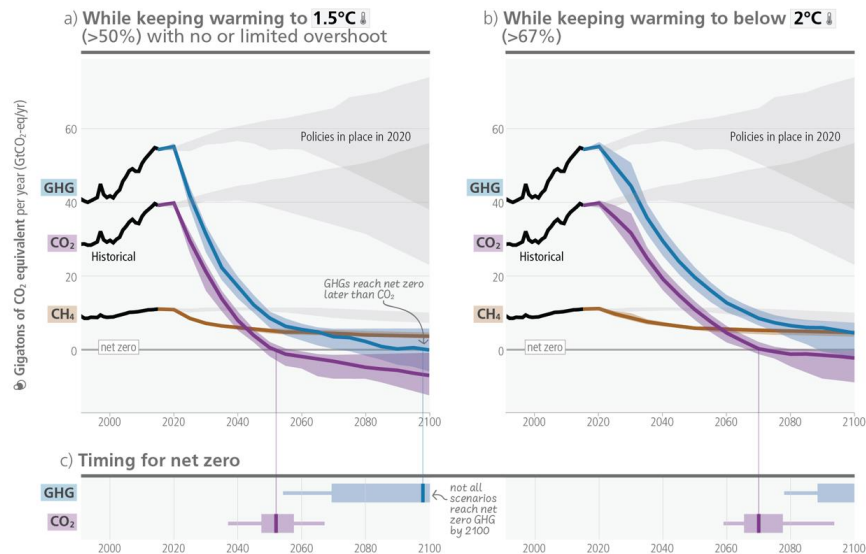
Figure 3 compares the global average temperatures out to 2100 in the Highest Possible Ambition scenario with the IPCC AR6 scenarios.

- Emissions have not been falling since 2019 (IPCC AR6 base year for mitigation benchmarks)
- Together with methodological changes in calculating remaining carbon budgets since AR6, this leaves only 3-4 years for 1.5°C carbon budget
- **Exceedance** of 1.5°C, **peak** at 1.7°C (and **return** to 1.5° before 2100) increasingly seen as “Highest Possible Ambition”
- But “1.5°C overshoot” is not a new design feature, it was already part of IPCC Special Report on 1.5°C and IPCC AR6

IPCC AR6 1.5°C pathways already about overshoot

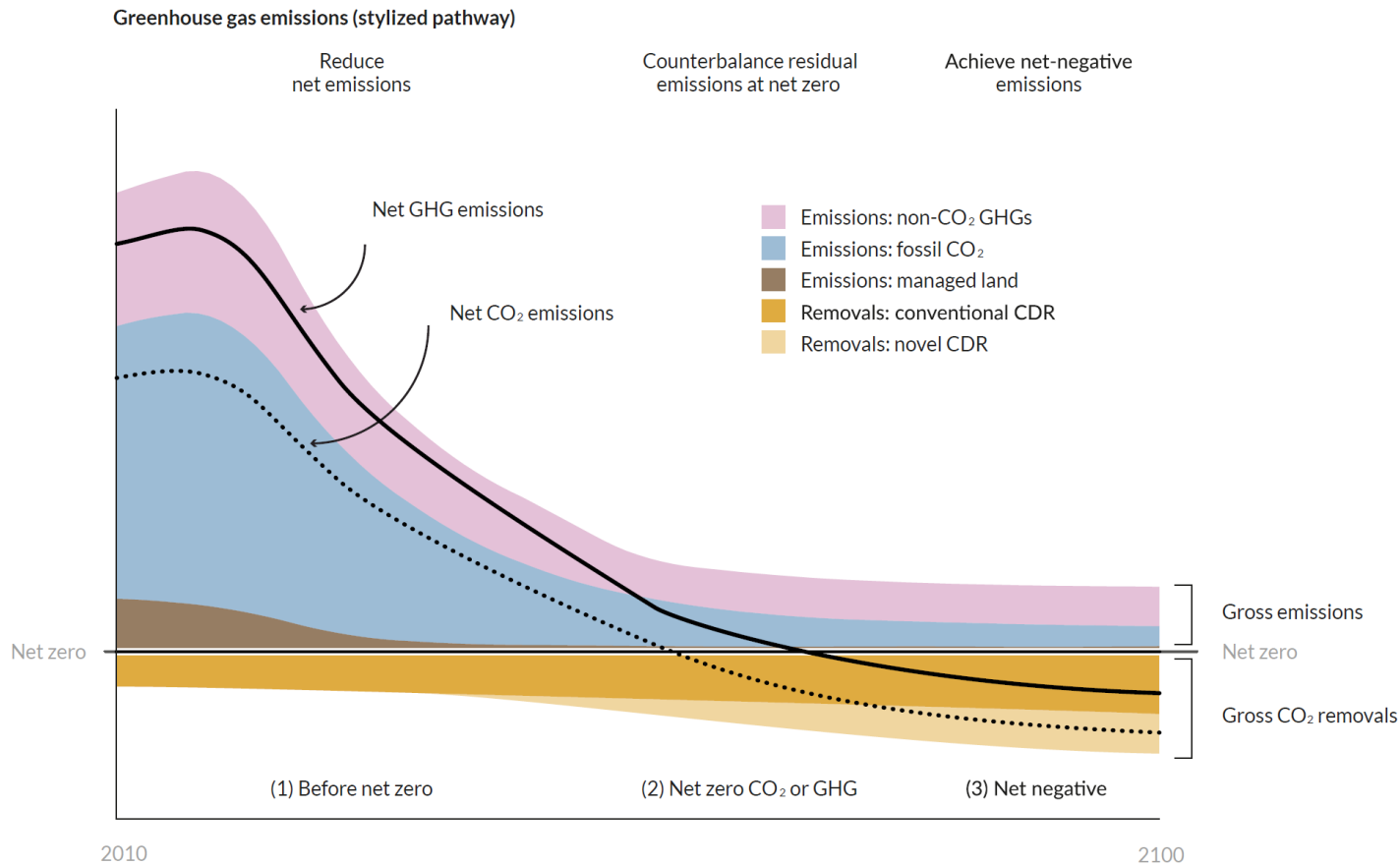
Global modelled pathways that limit warming to 1.5°C (>50%) with no or limited overshoot reach **net zero CO₂ emissions** around 2050

Total **greenhouse gases (GHG)** reach net zero later

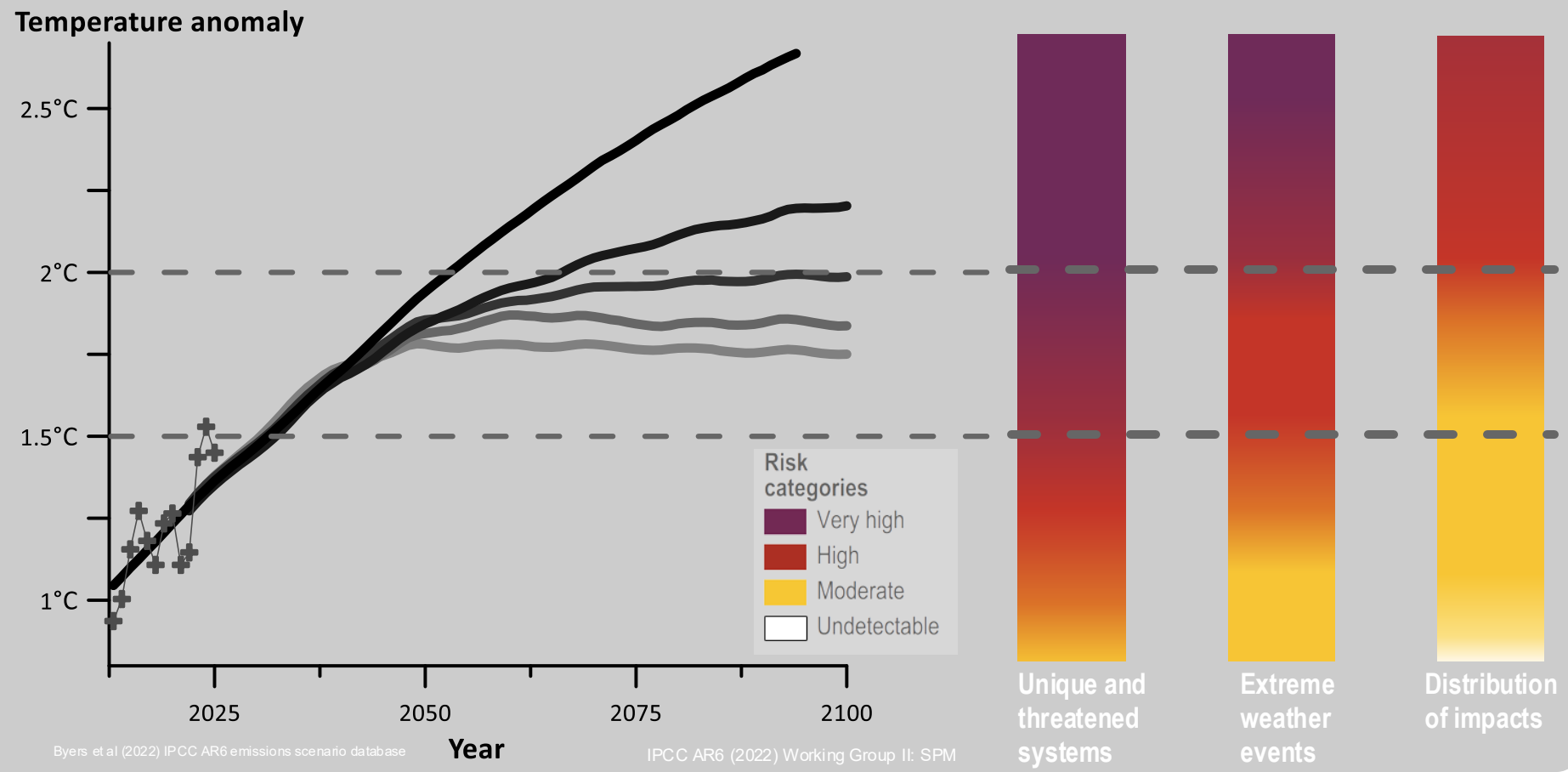


- **Overshoot** in IPCC AR6 1.5°C mitigation scenarios (C1 – 1.5°C with no or **limited overshoot**: 97 scenarios, 6 no vs. **91 limited overshoot**)
- 1.5 limited overshoot (+ 0.1°C) implicit in UNFCCC decisions referring to 2030/2035 benchmarks in AR6 pathways: -48/-65% CO₂ vs. 2019 for 1.5°C
- 1.5°C reached by 2030-35 (AR6 SYR) = net-zero (-100%) CO₂ by 2030-35 to avoid exceedance
- Net-zero CO₂ in 2050 (for 1.5°C by 2100) = **exceedance** of 1.5°C before 2050 & **return** to 1.5°C after 2050, via net-negative CO₂ emissions
- Reducing global warming by 0.1°C = cumulative net-negative CO₂ emissions of **~220 Gigatons** (residual CO₂ emissions minus CO₂ removal)

CO₂ removal unavoidable to reach *net-zero* and *net-negative*

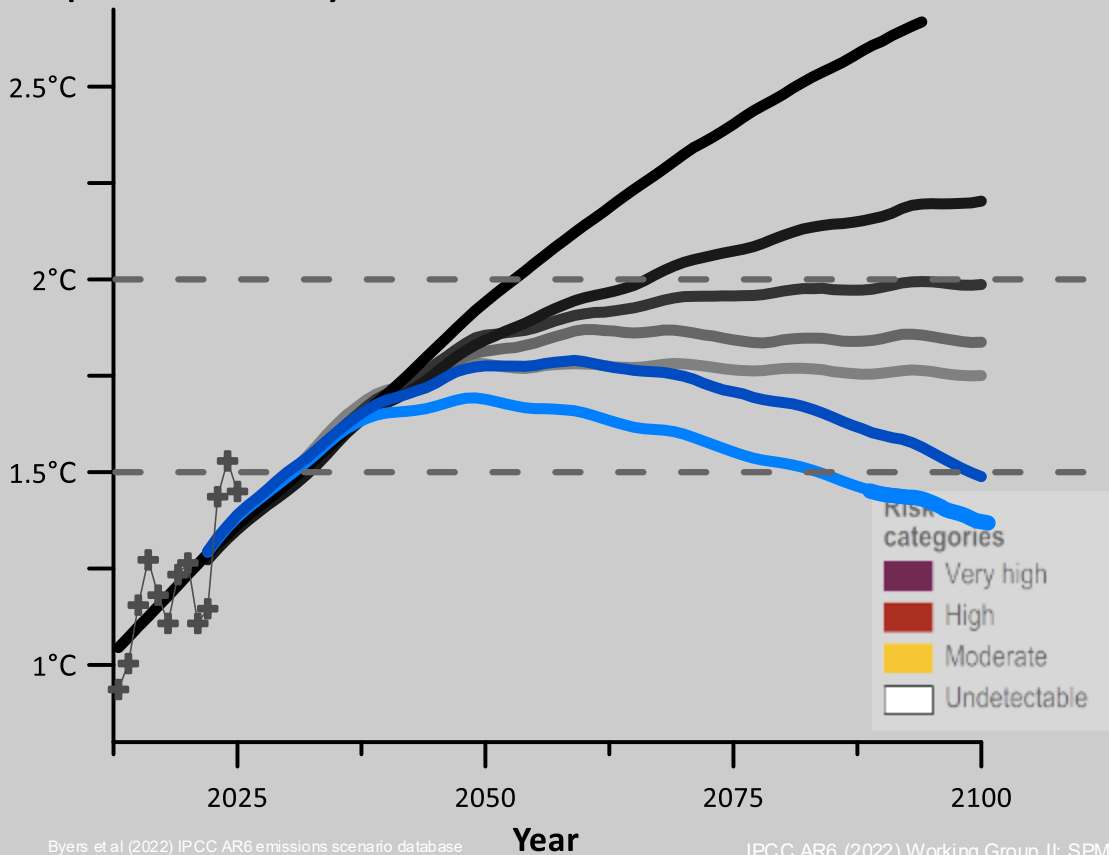


The next exit above 1.5C°: Every year, every tonne matters



The long way home to 1.5°C

Temperature anomaly



Unique and threatened systems



Extreme weather events



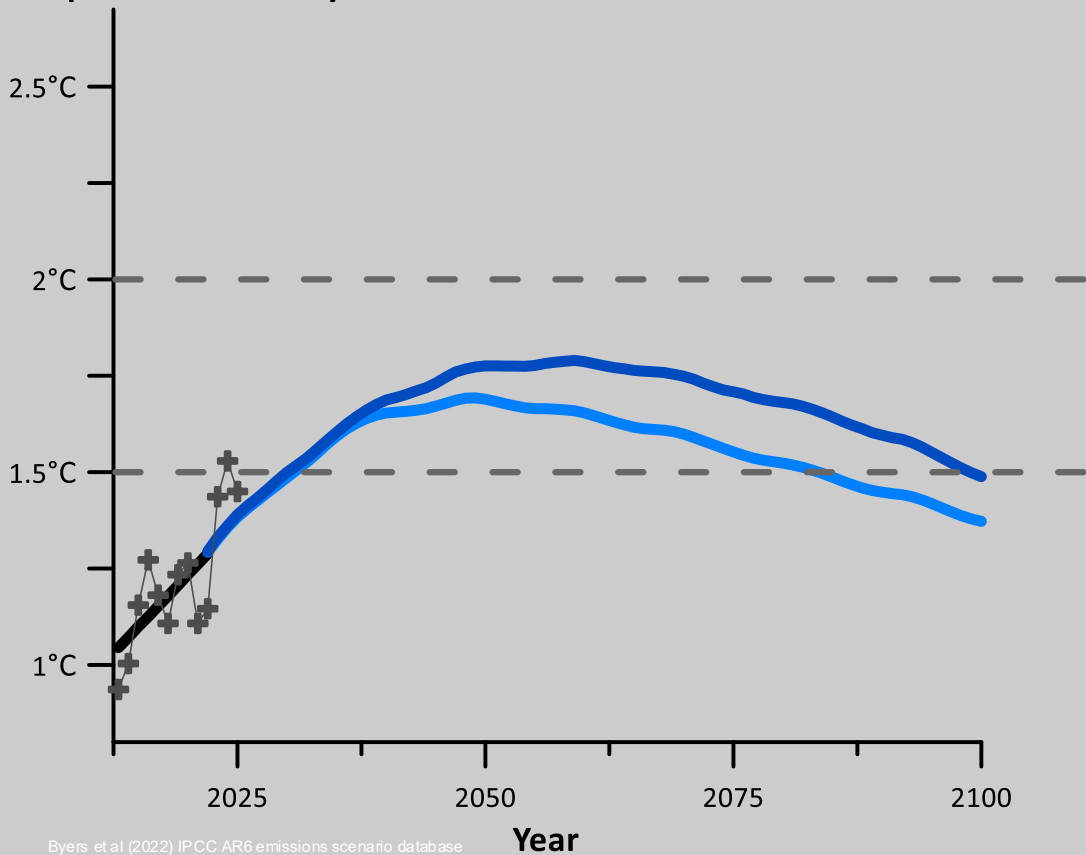
Distribution of impacts

Byers et al (2022) IPCC AR6 emissions scenario database

IPCC AR6 (2022) Working Group II: SPM

The long way home to 1.5°C

Temperature anomaly



“Overshoot”

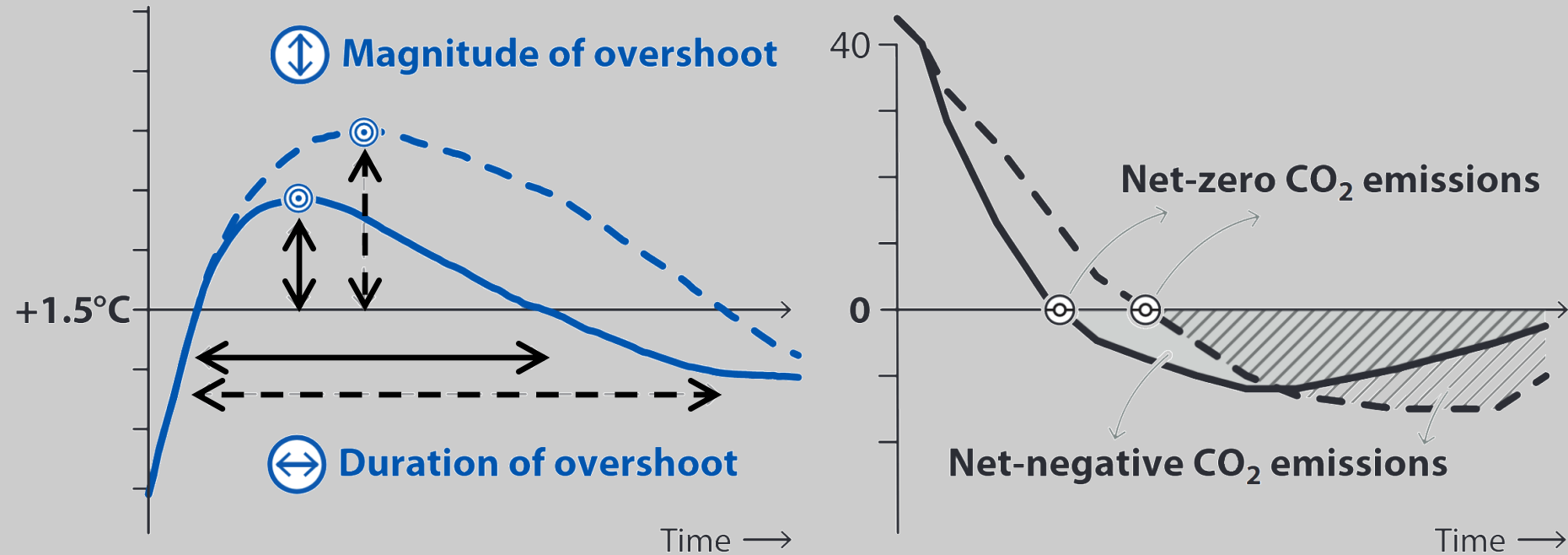
=

exceed and
return

(to a specified warming level)
(within a specified time frame)

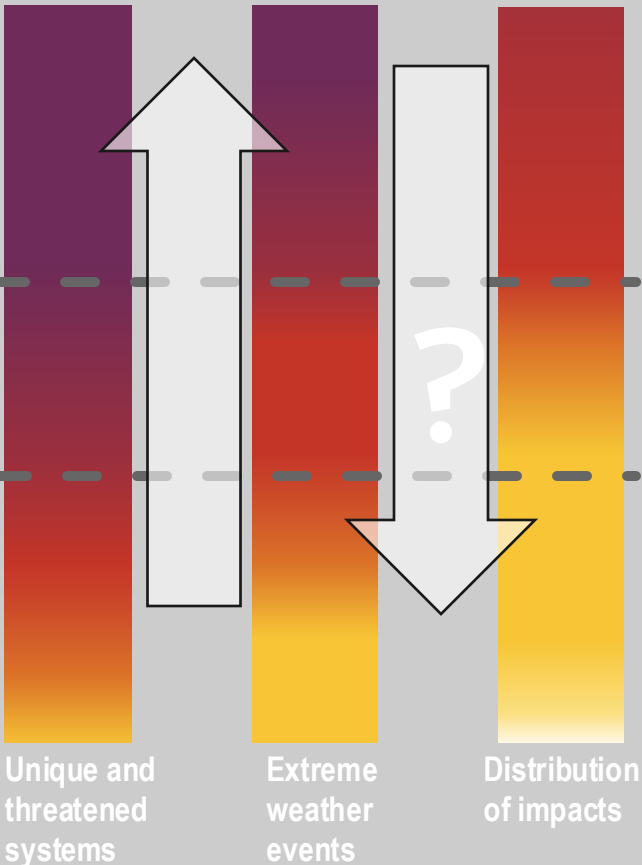
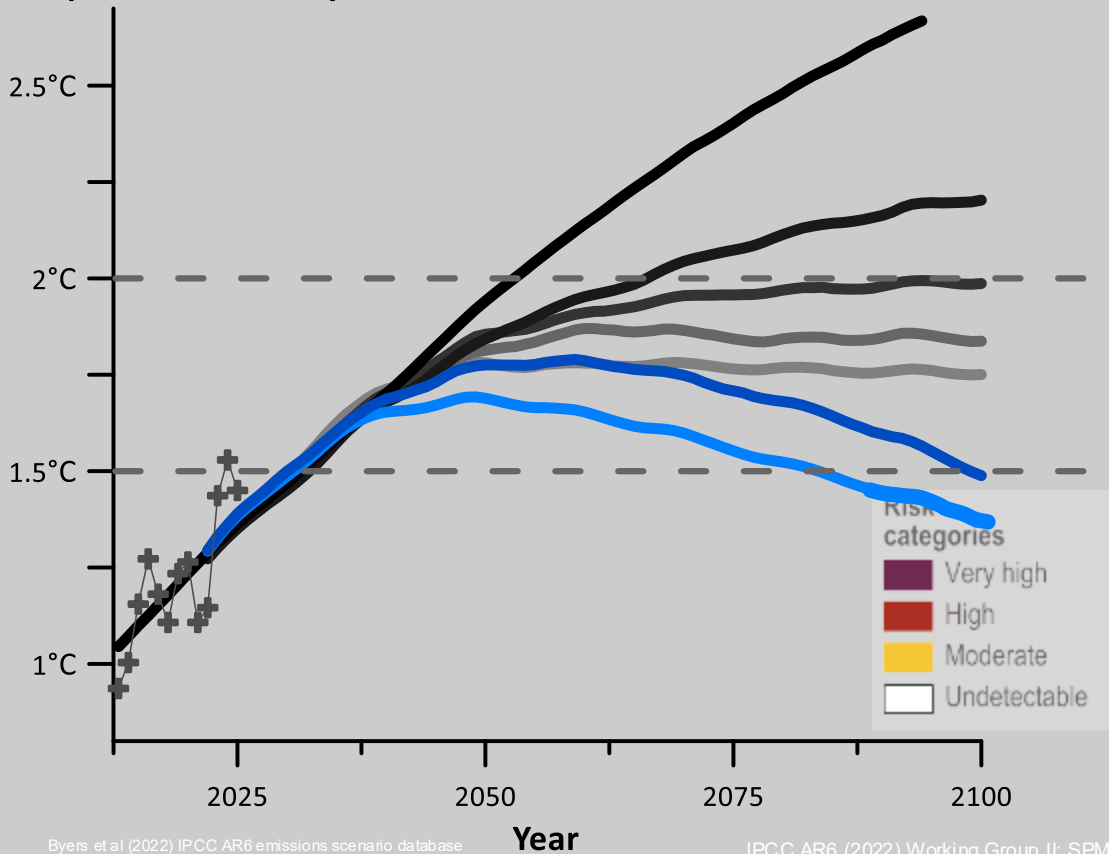
COP30 on overshoot: stating the *what*, leaving out the *how*

„reiterates its resolve [...] to limit both the magnitude and the duration of any temperature overshoot”



return ≠ recovery

Temperature anomaly

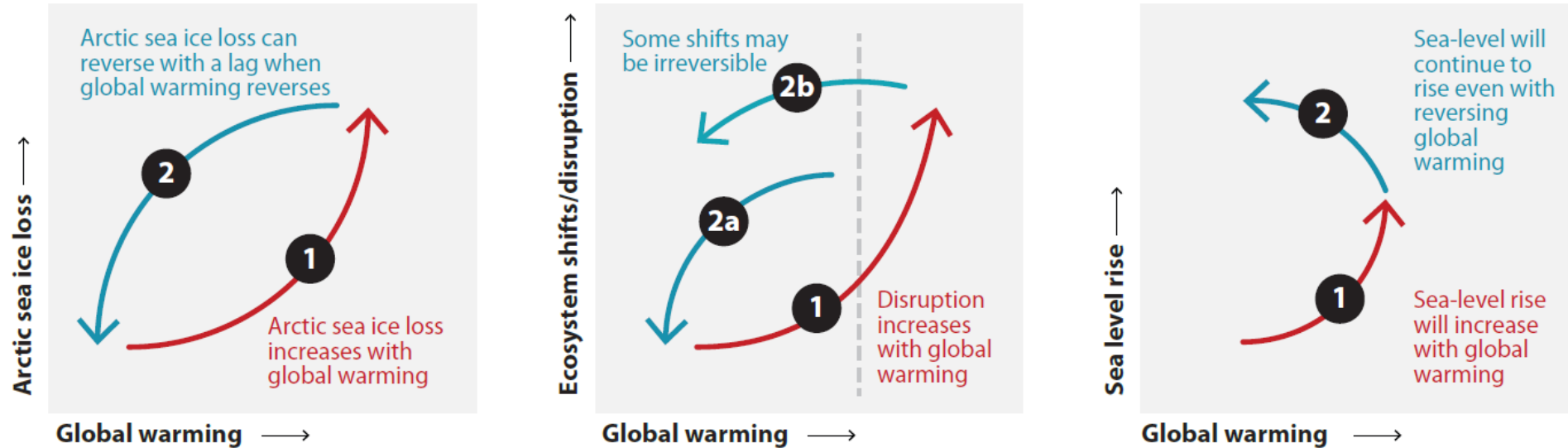


Byers et al (2022) IPCC AR6 emissions scenario database

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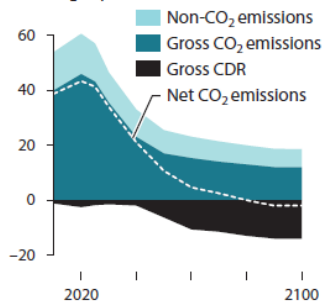
return $\neq$ recovery

A reversal of global temperature would not reverse all bio-geo-physical Earth system changes



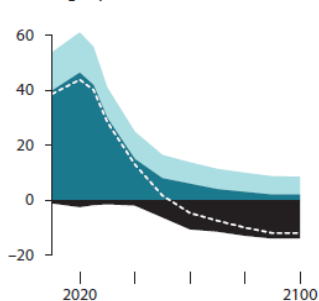
**a) Reference scenario:
exceed 1.5°C and stabilise
at ~1.7°C**

Global annual GHG emissions
(GtCO₂-eq)



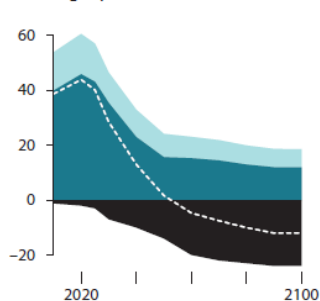
**b) Overshoot scenario:
emphasis on gross
CO₂ reductions**

Global annual GHG emissions
(GtCO₂-eq)



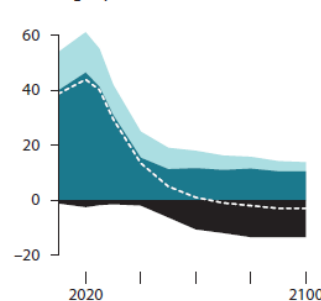
**c) Overshoot scenario:
emphasis on CDR**

Global annual GHG emissions
(GtCO₂-eq)



**d) Overshoot scenario:
emphasis on further
CH₄ reductions**

Global annual GHG emissions
(GtCO₂-eq)

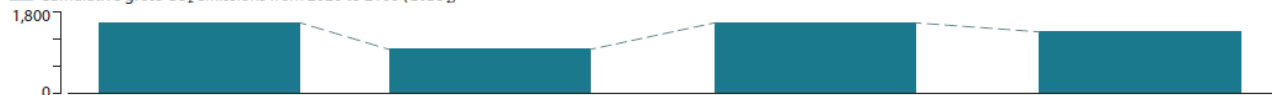


**Return is not
only about CO₂
removal, it's also
about residual
CO₂ & non-CO₂
emissions**

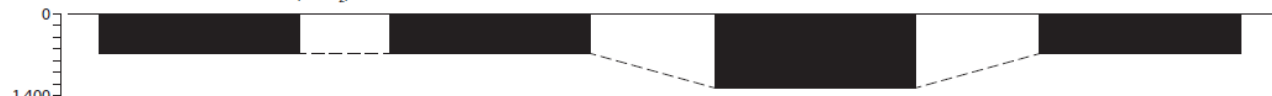
▨ Methane (CH₄) in 2100 (Mt, million tonnes)



■ Cumulative gross CO₂ emissions from 2020 to 2100 (GtCO₂)



■ Cumulative CDR from 2020 to 2100 (GtCO₂)



■ Cumulative net CO₂ emissions from the point of net-zero to 2100 (GtCO₂)



Enabling conditions for (credible) overshoot pathways

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SWP Comment

NO. 47 NOVEMBER 2025

Overshoot: Returning to 1.5°C Requires Net-negative Emissions Targets

Oliver Geden and Andy Reisinger

Global warming is set to rise above 1.5°C by the early 2030s. Returning to 1.5°C before the end of the 21st century would not prevent all harms resulting from a period of excess temperatures, but it would reduce risks when compared to permanent warming above 1.5°C. Limiting the magnitude and duration of this period of “overshoot” to manage climate risks requires enhanced near-term mitigation efforts to ensure that warming peaks well below 2°C, followed by sustained net-negative carbon dioxide (CO₂) and potentially net-negative greenhouse gas (GHG) emissions globally. This presents new challenges to international climate policy in efforts “to keep 1.5°C alive”. For frontrunners such as the European Union (EU), this will require reframing “net-zero” as a transitional stage towards net-negative GHG emissions rather than an endpoint, and developing policy instruments that are able to deliver this.

In 2015, the United Nations Framework Convention on Climate Change (UNFCCC) created a long-term temperature goal with the adoption of its Paris Agreement, namely “holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C”.

Ten years later, global emissions of CO₂ and other GHGs are at their highest levels ever. It has now become virtually impossible to avoid exceeding 1.5°C, even when considering that global temperature goals do not refer to individual years, but 20-year running averages. Reaching and then exceeding 1.5°C is expected to happen by the early 2030s, regardless of the emissions

reductions that may be achieved in the coming years. This was already indicated in the *Synthesis Report of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)* in 2023, and recently confirmed in the *Emissions Gap Report* issued by the United Nations Environment Programme (UNEP).

This growing realisation – catalysed by a marked shift in UN officials’ communications in late 2023 – confronts Parties to the UNFCCC with a choice either to aim for stabilising warming between 1.5°C and well below 2°C, or to try to achieve a reversal of global warming back to 1.5°C, after a period of overshoot that may last multiple decades (see Figure 1).

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... that aim to achieve cumulative net-negative CO₂ emissions of ~220 Gt per 0.1°C exceedance, paying back accumulated carbon debt

- Strong link between 1.5° OS & global/national net-negative pledges/plans (incl. in global scenarios), i.e. developed countries need to set net-negative (GHG) emissions targets
- No prolongation of the end of the overshoot period beyond 2100
- Political demand from developing countries & NGOs for quantified net-negative (CO₂ or GHG) targets in OECD countries soon after net-zero (via LT-LEDS and NDCs), and by extension to sectors or cities
- Viable macroeconomic & political concepts for successfully running net-negative countries, beyond simple *polluter pays* principle & win/win narratives, e.g., what’s is a *just transition* into net-negative?
- Shift CO₂ removal from (being seen as) barrier to ambition to an enabler of even higher ambition, but not by betting on ever more CDR

Annual Review of Environment and Resources
Overshoot: A Conceptual
Review of Exceeding and
Returning to Global
Warming of 1.5°C

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Abstract. This review examines the concept of overshoot, a state in which global warming exceeds 1.5°C, and the potential for returning to 1.5°C. It discusses the scientific basis for overshoot, the risks of exceeding 1.5°C, and the potential for returning to 1.5°C. It also discusses the political and social challenges of returning to 1.5°C.



the concept of
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Dioxide
Removal

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One Earth

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INTERGOVERNATIONAL PANEL ON CLIMATE CHANGE

CLIMATE CHANGE 2023
Synthesis Report

A Report of the Intergovernmental Panel on Climate Change

Summary

The world has made significant progress in understanding the science of climate change. The Intergovernmental Panel on Climate Change (IPCC) has produced a series of reports that have provided the scientific basis for the Paris Agreement. This synthesis report brings together the findings of the IPCC's Working Group I contribution to the Sixth Assessment Report (AR6), which was published in 2021. It provides a comprehensive overview of the current state of climate science, including the latest findings on the physical science of climate change, the impacts of climate change, and the options for limiting climate change and adapting to its effects. The report also highlights the urgent need for action to address climate change and the potential for a just and equitable transition to a sustainable future.

Thanks
for
your
attention

Article
Operationalizing the net-negative carbon economy

Michael O'Riordan¹, Michael O'Riordan², Armin Balleisen³, Marcus Thomas⁴,
John Weyant⁵, Oliver Geden⁶, Wilco Albers⁷, and Alex M. Smith⁸

The remaining carbon budget for limiting global warming to 1.5°C depends critically on the carbon removal technologies that are deployed. This article discusses the challenges of operationalizing a net-negative carbon economy, which would require the deployment of large-scale carbon removal technologies. It examines the scientific, technological, and economic challenges of achieving net-negative emissions and the potential for a just and equitable transition to a sustainable future.

Delivering on the many natural and corporate net-zero emissions pledges and targets requires the use of carbon removal technologies. This article discusses the challenges of operationalizing a net-negative carbon economy, which would require the deployment of large-scale carbon removal technologies. It examines the scientific, technological, and economic challenges of achieving net-negative emissions and the potential for a just and equitable transition to a sustainable future.

Setting the agenda in research
Comment



Three ways to improve
net-zero emissions targets

Joeri Rogier, Oliver Geden, Kenneth Coen, and Andy Reisinger

Net-zero emissions targets are a key tool for limiting global warming. However, there are several challenges to achieving net-zero emissions, including the need for large-scale carbon removal technologies. This article discusses three ways to improve net-zero emissions targets: (1) by requiring the deployment of large-scale carbon removal technologies, (2) by requiring the deployment of large-scale carbon removal technologies, and (3) by requiring the deployment of large-scale carbon removal technologies.

Define limits for temperature overshoot targets

Temperature overshoot scenarios that make the 1.5°C climate target feasible could turn into sources of political friction. Climate scientists must provide clear constraints on overshoot magnitude, duration and timing.

Oliver Geden and Armin Balleisen

The concept of temperature overshoot is a key tool for limiting global warming. However, there are several challenges to achieving net-zero emissions, including the need for large-scale carbon removal technologies. This article discusses three ways to improve net-zero emissions targets: (1) by requiring the deployment of large-scale carbon removal technologies, (2) by requiring the deployment of large-scale carbon removal technologies, and (3) by requiring the deployment of large-scale carbon removal technologies.

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The Paris Agreement and the
inherent inconsistency of
climate policymaking

Edited by Mike Hulme

Edited by Mike Hulme, Domain Editor and Editor-in-Chief

The Paris Agreement is a key tool for limiting global warming. However, there are several challenges to achieving net-zero emissions, including the need for large-scale carbon removal technologies. This article discusses three ways to improve net-zero emissions targets: (1) by requiring the deployment of large-scale carbon removal technologies, (2) by requiring the deployment of large-scale carbon removal technologies, and (3) by requiring the deployment of large-scale carbon removal technologies.