Network for Greening the Financial System

Physical risks in the updated Climate Impact Explorer

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Executive Summary

Physical risks from climate change are projected to be severe, also for lower levels of global warming. Scientific evidence shows that human-induced climate change is already driving widespread shifts in weather and climate extremes. The 6th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) finds that even small increases in global mean temperature produce statistically significant changes in extremes, including temperature spikes (very likely), intensified heavy rainfall (high confidence), and worsening droughts in many regions (high confidence). Projections confirm that extreme events with intensities and frequencies beyond anything in historical records will occur even at 1.5 °C of warming, underlining the importance of ambitious climate action in line with the Paris Agreement. Recent insights moreover suggests that our climate system may respond more strongly to emissions than previously thought, indicating that we cannot rule out the possibility of high warming outcomes as a result of a global climate sensitivity[1] well above our current best estimate.

Climate Impact Explorer update

The **Climate Impact Explorer (CIE) is an open-access web tool** that has been developed in cooperation with the NGFS **to inform about physical risks from climate change and make scientific information accessible for non-climate-scientists.** Built on consistent global data sets, which have also been key inputs to the latest IPCC Assessment Report, the tool allows users to explore projected climate impacts across climate scenarios – including the NGFS climate scenarios – at provincial, national, and continental scale with global coverage. The CIE features 43 physical risks indicators across the categories basic climate, heat, drought, extreme precipitation, fire weather, freshwater, labour productivity and agriculture with projections until 2100.

In 2025, the CIE underwent a major update. Key changes in the Climate Impact Explorer and related implications for users:

- **Updated and improved input datasets:** The CIE is now based on the latest generation of climate and impact models from CMIP6[2]/ISIMIP3, allowing CIE users to benefit from the methodological improvements among other things an improved underlying modelling resolution and representation of physical processes, including tail risks. Yet the underlying models remain *global* models which may exhibit weaknesses in representing local patterns accurately compared to higher resolution, regional climate datasets, which we recommend using complementarily.
- **Improved methodology:** CIE users benefit from a more robust handling of uncertainty ranges and non-linear impact relationships. Moreover, as the underlying newly developed Python package will be made available open-source, advanced users can apply it to their own local data sources to produce their projects along the NGFS scenarios. In 2026, an example of such an application will be provided.
- **Enhanced usability:** A new framework is introduced, categorising indicators based on the underlying level of complexity to better communicate about differences and implications for the confidence in the estimates, differentiating between three levels of modelling complexity. Absolute values for selected indicators are provided. Socio-economic data used for e.g. spatial aggregation based on GDP have been updated. Socioeconomic assumptions continue to be kept fixed for the projections to focus on the climate impact. An improved tool design and the above mentioned open-source Python package allows for wider application of the new CIE methodology.
- **Revised indicators:** Improved heat stress and drought indicators (feeding into next year's NiGEM acute risk update) as well as a variety of indicators that had not been covered in the previous CIE version are provided in the new CIE. For data consistency reasons, the indicators for

1 *Climate sensitivity* refers generally to the response of global mean temperature to increases in greenhouse gases, and is typically measured as the temperature response until equilibrium to a doubling in atmospheric carbon dioxide levels. The IPCCs AR6 best estimate of equilibrium climate sensitivity is 3 °C, with a likely range of 2.5 °C to 4 °C (high confidence) (https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/). The larger range at the upper end of sensitivity emphasises the importance of exploring high warming scenarios.

2 The **Coupled Model Intercomparison Project (CMIP)** is a collaboration between global climate modelling teams from around the world coordinated by the World Climate Research Programme (WCRP).

river flood and tropical cyclone direct damage estimates are no longer featured on the updated CIE. This means that currently no indicator in the updated CIE is in economic units (e.g. direct (socio-) economic damages as GDP losses).

- **"High climate response" world for the NGFS Current Policies Scenario:** CIE users can now explore the implications if the climate proves more sensitive to emissions than current best estimates, i.e. responding with a higher global warming trajectory.

Key findings for physical risks

Building on this update, the report focuses on three priority indicators for acute physical risks – extremes of precipitation, heat and drought – to highlight the acute physical risks from climate change and inform about the costs of inaction.

Best estimate

- Under the ***NGFS NetZero 2050 scenario***, which aligns with the Paris Agreement's 1.5 °C goal, physical risks are projected to increase notably. This is due to the inherent inertia of the climate system, committing impacts such as intensifying extreme weather for decades. Since CO_2 remains in the atmosphere for centuries, only sustained use of negative emission technology going far beyond unavoidable emissions could lead to a reduction of warming levels and associated impacts within multiple decades. Overall, even in this optimistic scenario, risks from climate impacts will be elevated compared to present-day conditions for multiple decades, but remain considerably lower than under less ambitious pathways.
- By contrast, the ***NGFS Current Policies scenario*** shows much higher levels of climate impacts, illustrating the severe consequences of delayed or insufficient mitigation. For example, high heat risk days over Western Europe may be three times more frequent by the end of the century than in the NetZero 2050 scenario.

"High Climate Response" world

- To enhance the applicability of the CIE for physical stress testing, we provide data for a physically plausible high-risk future in which the **same emissions pathway (NGFS Current Policies) results in *additional* 0.9 °C of warming by the end of the century when assuming a "high climate response" world.**
- Physical risks **increase substantially for many countries under this high-response case compared with the best-estimate projection**, underscoring the importance of preparing for worst-case outcomes given the plausibility of such a "high climate response" world.

1. Introduction

Purpose of this report

***This report** i) informs about the changes and improvements in the updated Climate Impact Explorer, ii) illustrates the overarching main messages for physical risks from the updated Climate Impact Explorer and the cost of inaction with a focus on precipitation extremes, extreme heat and extreme drought and iii) provides insights on the projected physical risks of a "high climate response world" as a plausible future based on the upper uncertainty range of how emissions from the NGFS Current Policies Scenario translate into global warming levels.*

This report highlights key messages on physical risks based on the major update of the Climate Impact Explorer (CIE) web tool and its underlying climate risk indicators. The updated CIE tool allows users to explore the data across countries or regions and climate indicators of specific interest, while this accompanying narrative report aims to summarise the overarching messages from the climate impact perspective. It highlights areas of high physical risks and illustrates key risks through examples of selected indicators and countries or regions.

Although the CIE web tool features a wide range of different climate indicators with a global coverage, this report focuses on a subset of priority indicators, with particular emphasis on extremes of precipitation, heat and drought for a subset of two NGFS climate scenarios (NGFS Current Policies and Net Zero 2050).

To make implications of underlying uncertainties more tangible in terms of risks, this report not only discusses the main messages on estimated climate impacts based on median estimates ("best estimates"), but also includes a dedicated section on the implications for physical risks under high sensitivity of the climate system, i.e., a scenario-version based on the 20% of climate model simulations that result in the strongest plausible warming response to emissions.

While the Climate Impact Explorer already covers a wide range of indicators, this report also provides a brief discussion of the types of physical risks and associated damages that remain outside the scope of the current Climate Impact Explorer.

About the Climate Impact Explorer web tool

The Climate Impact Explorer (CIE) is an open-access web tool developed in cooperation with the NGFS to make scientific data and knowledge accessible to the finance sector and policymakers, as well as the broader public.

Building on globally consistent data sets, the CIE enables users to explore projected climate impacts through interactive graphs and gridded maps showing impacts at the continental, national and even provincial level. Users can also directly compare scenarios using a pairwise format. The CIE features a wide range of physical risk indicators, covering 43 indicators across the categories basic climate, heat, drought, extreme precipitation, fire, freshwater, labour productivity and agriculture with projections until 2100 (see Table 1 at the end of chapter 2).

The tool includes 9 climate scenarios, among them:

- All NGFS climate scenarios (vintage V).
- The Climate Action Tracker's Current Policy Scenario.

All displayed graphs, maps, and their underlying data can be downloaded.

Key features and updates of the CIE 2025

Users appreciate the Climate Impact Explorer for the following reasons[3]:

- The tool is **very easy to use**, as it works in a browser and does not require any software to download nor any log-in. It is intuitive to navigate, offering users to select directly in the drop-down menus, which country or region, which physical risk indicator and which scenario they want to choose to see the data.
- Users from the finance sector appreciate that the CIE offers physical risk projections for **all NGFS climate scenarios**, which can be easily compared with each other in the tool. This is complemented by the Climate Action Tracker's (CAT) Current Policy Scenario.
- The **information is presented transparently**, providing a short description for each indicator directly in the drop-down menu. More information, including an explanation of the definition of the indicator and the limitations of the analysis is readily accessible below the maps.
- The **interactive line plots** provide information on the underlying values and Global Warming Levels in 5-year steps.
- It makes **complex scientific data tangible** and easily accessible by visualizing it in graphs and maps and also offering easy **data download**. This way, complex climate data, which typically requires certain programming skills for processing, is made accessible also to non-climate-scientists.
- The **broad range of indicators** offers users a certain flexibility to choose the indicator that is most suitable for their interest.
- The **map** view offers flexibility allowing the user to choose whether to compare two scenarios, two warming levels or compare between years.

With the 2025 Update of the CIE, tool users can moreover benefit from (more details in Chapter 2 and 3):

- **The latest generation of climate and impact model inputs:** Using climate model and impact data from CMIP6 and ISIMIP3 provides data bias corrected to match observations, and ensures consistency of climate and impact variables.
- **Additional indicators:** New heat indicators (Heat Index combining heat and humidity) and new drought indicators have been developed over the course of 2024 and 2025, allowing users to explore different levels of heat stress and drought intensity. Additionally, the updated CIE features many other new indicators that had not yet been in the previous CIE allowing for a more comprehensive analysis of regional extreme event trends.
- **Improved methodology to estimate uncertainties:** Combining climate and impact models requires combining uncertainties of the different model chain components. The updated CIE allows for a more accurate uncertainty quantification by relaxing linearity assumptions.
- **A "high climate response" world as a new unique feature:** The updated CIE features a version of the NGFS Current Policy Scenario examining the risk that the same emissions scenario could lead to a significantly higher global warming trajectory due to a stronger climate response within plausible ranges. Such a plausible outcome may be a valuable input to consider for physical stress testing purposes, as accounting of these risks is essential for the financial sector and the economy at large.
- **Improved visualization:** structuring, clarity of units and colour scales.

3 According to CIE user feedback or e.g. the Climate-ADAPT Tools database on the strengths of the CIE.

Access

- **Phase V Updated CIE:**
- **Phase IV CIE (archived version):** The previous version will remain accessible at a separate link but will no longer receive updates (neither new data nor NGFS scenario vintages) This previous version includes the CLIMADA-based direct damage estimates for tropical cyclones and river floods which were not part of the methodological update and have been removed from the 2025 CIE to avoid inconsistencies of the featured indicators.

What the Climate Impact Explorer can be used for: The Climate Impact Explorer provides a globally comprehensive and consistent dataset of physical risk projections across climate scenarios. With a wide range of indicators, established downscaling and bias correction[4], a consistent comparison across countries and regions is enabled. This allows an exploration of the different hazards for example for regional and sector specific analysis of climate impacts (e.g. comparison of exposure of different regions). Depending on the use case and regions, the data provided may be appropriate, whilst in other cases, higher resolution products, e.g., from regional climate models, may be available. Therefore, whilst the CIE may serve as a useful entry point or screening tool for climate risk, it is not a substitute for detailed national or subnational risk assessments.

Illustrative use cases

Examples of how the CIE has been used:

- The Central Bank of Chile's climate risk assessment involved a bottom-up hazard, regionally disaggregated analysis of climate impacts using physical risks from the CIE, alongside Chilean Climatic Risk Atlas (ARCLIM), to obtain the exposure to heat waves, fires, floods, drought and coastal deterioration with the purpose of assessing Chilean real estate physical risk exposure, to inform financial stability analysis.
- The Central Bank of Italy used the Climate Impact Explorer subnational level data as a starting point for vulnerability assessments of regional manufacturing industry with regard to climate extremes.

Potential applications of the CIE for illustration:

Getting an overview of regional changes in drought risks between best estimate *vs.* "high climate response" world

1. Visualisation of changes in maps enables identification of potential high-risk regions offering different drought severity thresholds.
2. Statistical crop models might give first indication of agricultural impacts.
3. Follow-up with regional data and models to assess detailed risks (depending on use case).

A potential application of results from such a drought risk assessment could, for example, be to contribute to assessments of potential price effects relevant to central banks.

Assessing heat risks

1. Identify heat-risk regions based on the new Heat Index indicator also offering different severity thresholds for comparison.
2. Scenario comparison enables best case *vs.* worst case comparison, e.g. NGFS 'high climate response' scenarios.
3. Combined with appropriate exposure data (e.g. regional GDP combined with share of outdoor economic activity) to evaluate risks in a use-case specific model.

Heat risks can impact economic activity through multiple impact channels, including mortality, morbidity, labour productivity, agricultural production and infrastructure. Results from such heat risk assessments could be used for in-house economic modelling if available.

4 Bias correction (also called bias-adjustment), uses observational data to correct any systematic errors (i.e. biases) that modeled data may be subject to (see this short explainer from the Copernicus Climate Change Services on what bias correction is and why it is needed).

Relation of the CIE and this report to other NGFS Long-term Scenario outputs

The **NGFS climate scenarios (transition risks, vintage V) and the 'Scenario Narratives and key findings' Reports (2025)** are key references for this work. The emissions pathways from the various transition scenarios are translated into Global Mean Temperature trajectories using the MAGICC model. For the CIE, emissions from the REMIND Model are used as the primary input. These are then translated into local climate responses for the different indicators shown in the CIE.

As explained in more detail in section 3, the CIE "best estimate" shows the median response of an indicator to the emissions levels resulting from the transition risk scenarios, considering uncertainty in how the emissions translate into global mean temperatures and how global mean temperatures manifest into regional impacts. To illustrate uncertainty, the CIE also presents a new "What-if" case, in which the same emission trajectory for the NGFS Current Policies Scenario result in stronger climate responses, consistent with the upper uncertainty ranges of climate sensitivity as assessed by the IPCC AR6 (2023), and reproduced by the MAGICC model.

All NGFS transition risk scenarios are featured in the CIE dropdown menu, enabling users to compare between NGFS scenarios and also with other non-NGFS scenarios which are commonly used in the literature. The 2025 *Narrative and Deep Dive Reports* bring together the insights from transition risks and physical risks.

NiGEM acute physical risks

The most recent NiGEM estimate of acute physical risk – economic impacts of river floods, tropical cyclones, extreme drought and extreme heat – date from 2023. These were partly derived based on indicators included in the (now outdated) 2024 CIE. This included the two CLIMADA-based indicators of direct damages from river floods and tropical cyclones. Updating these with ISIMIP3/CMIP6 data, along with improvements to underlying modelling, has not yet been feasible. To avoid inconsistencies in the CIE data, the indicators for direct damages from river floods and tropical cyclones are not represented in the 2025 CIE. As a result, there is no direct link between the 2025 CIE update and the 2023 NiGEM acute risk estimates. However, the 2025 CIE includes improved drought and heat indicators (see Chapter 2). These will form the basis for new NiGEM economic impact estimates for acute drought and heat risks, to be conducted in 2026.

Indicators for aggregate damage functions

Recent developments in aggregate damage functions use a range of indicators beyond annual mean temperature. We provide a range of those indicators covered in the literature that allows NGFS users to derive aggregate damage functions based on the data provided.

Tipping Points Note

Although many processes relevant to tipping points (e.g., weakening of the AMOC) are represented within the modelling underlying CIE indicators, explicit tipping dynamics are not modelled and are therefore not included in the CIE. The NGFS note on tipping points (2025) explores this topic in greater detail and suggest ways forward to enhance the representation of tipping points in the context of the NGFS.

The scientific context of physical risks and the CIE

The Intergovernmental Panel on Climate Change (IPCC) brings together climate experts from around the world to assess and synthesise the state of scientific knowledge on climate change, through its multi-year Assessment Reports, produced roughly every seven years. The IPCC's most recent 6th Assessment Report (AR6) Synthesis Report concludes with high confidence that human-induced climate change is already affecting every region of the world, driving widespread changes in weather and climate extremes which are already tangible today. Vulnerable communities, those least responsible for historical emissions, are disproportionately affected.

AR6 highlights that even relatively small increases in global mean temperature cause statistically significant changes in extremes:

- **Temperature extremes** are very likely to increase (high confidence).
- **Heavy precipitation** is projected to intensify (high confidence).
- **Droughts** are expected to worsen in some regions (high confidence).

Critically, AR6 finds that **rare, high-impact events** will become disproportionately more frequent, even at 1.5 °C of warming. It further emphasizes that risks at any given warming level are now assessed as significantly higher than in the Fifth Assessment Report (AR5). The damages, economic costs, and societal risks will escalate with every fraction of additional warming (very high confidence). Many of the underlying models and data sources for the NGFS long-term climate scenario work including the Climate Impact Explorer input data sources, derive from CMIP and ISIMIP, which are key inputs to IPCC's Assessment Reports.

The IPCC's Interactive Atlas of the Working Group I in the 6th Assessment report provides a high-level view of the historically observed and projected trends across a wide range of climate variables. The Climate Impact Explorer is based on projected trends and focuses primarily on climate hazards, allowing users to go deeper into the climate data (for selected indicators) by exploring projected changes on the country and provincial levels. Users can compare physical risks across the various NGFS scenarios, as well as the Climate Action Tracker Current Policies scenario. While the CIE includes a broad range of physical risk indicators, it does not yet cover important impacts such as sea-level rise, coastal flooding, marine heatwaves, or tipping points. These gaps are discussed in Chapter 7. In this report, we focus on insights from the Climate Impact Explorer for three key types of acute risks: **heavy precipitation, extreme heat, and extreme drought.**

The modelling of climate impacts is usually conducted for a given level of global warming. However, there is considerable **uncertainty around the climate sensitivity** of our planet, i.e. how much global warming the emitted greenhouse gases cause. We are already at atmospheric greenhouse gas concentration levels that are *unprecedented* in human history and even several hundred thousand years before humankind emerged[5]. The response of the climate system to greenhouse gas emissions and other anthropogenic forcings is subject to considerable uncertainty. Specifically, this implies that there is a **wide range of physically possible global warming outcomes** (determined by the spread in climate response) **for a given emission pathway**.

The 2023-2024 global warming anomaly has highlighted once again that we cannot rule out the possibility of high warming outcomes as a result of a global climate sensitivity well above our current best estimate (Goessling *et al.* 2024)[6]. Recent scientific research has shown that the climate system may be more sensitive than previously thought (e.g. Myhre *et al.* 2025)[7]. Historically, the world's ocean has had a tremendous buffering capacity, absorbing over 90% of the warming from the coupled atmosphere-ocean system (Venegas *et al.* 2023)[8]. As so much heat has already been absorbed by the upper ocean, there are some signs that the heat absorption capacity of the ocean is starting to weaken (Lee *et al.* 2025)[9].

This uncertainty around the planet's climate sensitivity is the motivation for **highlighting the risks of a highly climate sensitive world** by introducing a plausible alternative version of the NGFS Current Policies Scenario which can be compared with the "best estimate" climate response.

Physical risk assessments relevant to a global climate policy context

Recognizing the existential threat of climate change, the Paris Agreement, adopted at COP21 in 2015 and entering into force in 2016, set a legally-binding global framework for action (UNFCCC). Its long-term temperature goal is to hold warming to well below 2 °C and to pursue efforts to limit it to 1.5 °C. The Agreement was grounded in IPCC science showing that crossing 1.5 °C would lead to increasingly severe and irreversible impacts.

5 See e.g. the World Metereological Organisation https://wmo.int/news/media-centre/greenhouse-gas-concentrations-surge-again-new-record-2023 or the Royal Society https://royalsociety.org/news-resources/projects/climate-change-evidence-causes/question-7/.

6 https://www.science.org/doi/10.1126/science.adq7280.

7 https://www.science.org/doi/10.1126/science.adt0647.

8 https://www.sciencedirect.com/science/article/pii/S0967064523000681.

9 https://www.nature.com/articles/s41558-025-02245-w.

Ten years on, the 1.5 °C threshold continues to represent the ethical boundary established to avoid the most dangerous impacts of climate change. Since 2015, the science underpinning the necessity of this limit has grown more conclusive. Yet global mitigation efforts remain far off track, as reflected in the NGFS *Current Policies* scenario, which shows the emission trajectory under today's implemented measures, which projects a warming level of 2.9 °C for the best estimate for 2100 and even 3.8 °C for the "high climate response" world.

In July 2025, the International Court of Justice (ICJ) issued a landmark advisory opinion affirming that nations have a legal obligation under international law to prevent significant harm to the climate, and can be held accountable for failing to reduce greenhouse gas emissions. While this opinion is non-binding, it strengthens the case for holding polluters accountable and for compensating those harmed by climate change.

The CIE situates these political commitments in practical terms by enabling users to **compare projected risks at different warming levels (1.5 °C, 2 °C, 2.5 °C, 3 °C, 3.5 °C)**. By overlaying pathways from NGFS scenarios (or other scenarios), the tool shows how policy choices translate into physical risks over time.

This report compares two NGFS scenarios to illustrate the costs of action versus inaction:

- **NGFS Current policies scenario**: a pathway consistent with present climate policies (as of vintage V, 2024), leading to higher warming and risks.
- **NGFS Net Zero 2050 scenario**: aligned with the Paris Agreement, limiting end-of-century warming to 1.5 °C through stringent climate action, with global net zero CO_2 reached around 2050.

To reflect the possibility of a **highly climate sensitive world**, we also present a "what if" storyline for the NGFS Current Policies Scenario comparing outcomes under a median climate response (best estimate) with outcomes assuming a strong warming response to greenhouse gas emissions.

2. Climate Impact Explorer update: Key improvements

In NGFS Phase V a fundamental update of the Climate Impact Explorer (CIE) webtool has been carried out which includes several key improvements:

- Updating to a newer generation of climate data and underlying models (from ISIMIP2/CMIP5 to ISIMIP3/CMIP6).
- Improving the CIE methodology.
- Revising the list of indicators shown in the CIE, including newly developed indicators for heat and drought, providing absolute values for selected indicators and informing about differences in the underlying complexity of the indicators.
- Introducing a "high climate response" world for the NGFS Current Policies Scenario.

This chapter explains the improvements in detail, providing an overview on what has changed compared to the previous CIE version. Chapter 3 is dedicated to explaining the different types of underlying uncertainty and the approach for the new "high climate response" world. Chapter 4 and 5 discuss the resulting physical risk estimates from the updated CIE for selected examples.

Updating the data and underlying models from ISIMIP2/CMIP5 to ISIMIP3/CMIP6

A new generation of physical risk indicators based on CMIP6 and ISIMIP3 has become increasingly available, some of which are used in the latest round of reports from the Intergovernmental Panel on Climate Change (IPCC) (6th Assessment Report).

Until the Phase V Climate Impact Explorer Update described here, the physical risk indicators in the CIE have been based on the CMIP5/ISIMIP2b generation of climate model and impact simulations. We have conducted a comprehensive update of the CIE physical risk indicators to this latest generation of modelling results, which is CMIP6 and ISIMIP3.

The latest ensemble of model simulations **CMIP6** was a key input to the IPCC's 6th Assessment Report. CMIP6 exhibits improvements compared to CMIP5 by incorporating increased modelling complexity and a higher spatial resolution allowing for a more detailed representation of underlying physical processes happening in e.g. oceans, clouds, and for aerosols. This leads to potentially more accurate climate projections, especially in geographically complex regions such as coasts and mountainous areas. Comparing the skill of CMIP5 and CMIP6 model output has shown evidence for substantial improvements in dynamical features of the Earth System such as rainfall and wind patterns (Donat *et al.* 2023, Chemke & Coumou 2024), and their response to climate change, important for accurately modelling extreme weather events.

The **Inter-Sectoral Impact Model Intercomparison Project (ISIMIP)** is a climate-impacts modelling initiative that is a collective effort by the climate impact modelling community. It aims to contribute to a cross-sectoral synthesis and quantification of a wide range of environmental and societal impacts of climate change, as well as the related uncertainties (IAMC 2021). A wide range of sectors are represented in ISIMIP, such as hydrology, agriculture, forestry, energy, fire, and fisheries, amongst others. The newest simulation round, ISIMIP3, introduces several key improvements compared to ISIMIP2. Importantly, it features refined bias adjustment methods, providing access to bias-adjusted climate data both for historical periods and future projections under various climate scenarios. ISIMIP3 makes use of the newest CMIP6 simulations as inputs for the impact modelling, making use of higher spatial resolution Earth System Models (ESMs) leading to more confidence in some extreme weather event projections.

Updating the CIE to this latest generation of modelling results for CMIP and ISIMIP is a critical step towards the exploration of tail risks from unprecedented extremes and compound risks in future work, as the representation of these risks is significantly improved in the latest generation of modelling results. The shift to ISIMIP3/CMIP6 has required reprocessing all the data inputs for the CIE, which has presented an opportunity to enhance our overall data-processing methodology in the CIE and revise the list of CIE indicators as described below.

Improvements in the methodology of the Climate Impact Explorer

The CIE translates the insights from existing state-of-the-art climate model outputs and climate impact model outputs into projected physical risks for specific climate scenarios. In 2025, the underlying methodology for this process has been substantially improved. It is shortly described below followed by a comparison to the previous CIE methodology.

Methodology for the NGFS physical risks impact chain

The CIE uses established approaches to convert datasets of regional climate impacts at global warming levels (e.g. 1.5 °C, 2 °C), into trajectories of climate impacts through time, consistent with the global warming profile of an emissions scenario.

To determine the probabilistic global warming outcomes of greenhouse gas emissions scenarios, such as the NGFS transition risk scenarios, reduced complexity climate models are used. They produce an ensemble of Global Mean Temperature (GMT) projections covering a range of possible outcomes. Following the established methodology and model setup used in the IPCC AR6 cycle, the MAGICC model is used to produce probabilistic projections of GMT for the NGFS scenarios and the CAT current policy scenario for comparison in the CIE.

Complementary, global bias corrected Earth System Model and Sectorial Impact Model simulations from the Inter-Sectoral Impact Model Intercomparison Project are used to calculate regional impact indicators (e.g. heavy precipitation days, drought indicators) at different global warming levels, ranging from present day (~1.2 °C) up to 6.5 °C. Following established approaches in the scientific literature (see 'time sampling' as described in James *et al.* 2017, as implemented in Schleussner *et al.* 2016), it is assumed that for a given GMT level, the change in an indicator (or its distribution) will on average be the same, regardless of when it is reached or the emissions pathway to get there.

Pooling impact indicator data by global warming levels, enables estimation of how impacts change with global mean temperature. These estimates are combined with GMT distributions extracted from the MAGICC ensemble for each scenario and year to generate time series that project impacts through time for each scenario.

A more detailed description of the new CIE methodology can be found here.
In the Annex, Table A1 explains the methodological differences between the previous CIE and the new version of the CIE in more detail.

The new methodology has several advantages:

1. It can calculate any response quantile using all available MAGICC and ISIMIP data, not just the median response and is therefore likely smoother and more robust.
2. The new quantiles come from a consistently defined probability distribution, which does not assume that the uncertainty bands have a linear relationship with the warming level as previously.
3. It is universally applicable to indicators with stationary distributions at constant warming levels and will be made available as an open source python package applicable to ISIMIP data.

Revising the indicators featured on the CAT current policy scenario

The methodology and data update provided an opportunity to revise the list of indicators featured in the CIE as well as improving communication around the underlying modelling complexity. The update also included substantial scientific work on developing new indicators for heat stress and drought. This chapter explains the changes and improvements. Table 1 at the end of this subchapter provides an overview of the indicators featured in the CIE 2025.

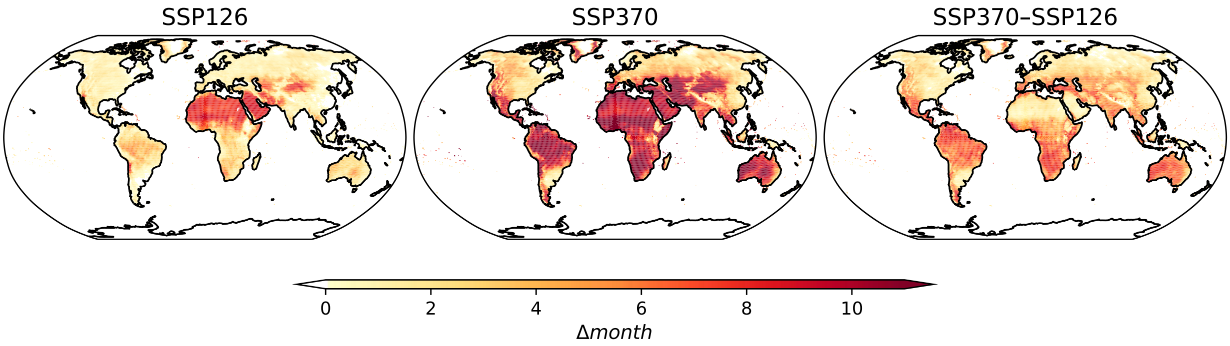
Improvements to the heat and drought indicators

As part of the Phase V, a new heat stress indicator as well as a new drought risk indicator have been developed. These are described in more detail below. Both indicators will serve as a basis to a planned updating of the NiGEM acute risk estimates on economic impacts in phase VI (2026).

Drought severity indicator

Globally changing drought frequency and severity constitute a major risk to agricultural production and food security with implications for national and worldwide economies. The drought severity indicator is based on the 12-month Standardized Precipitation Evaporation

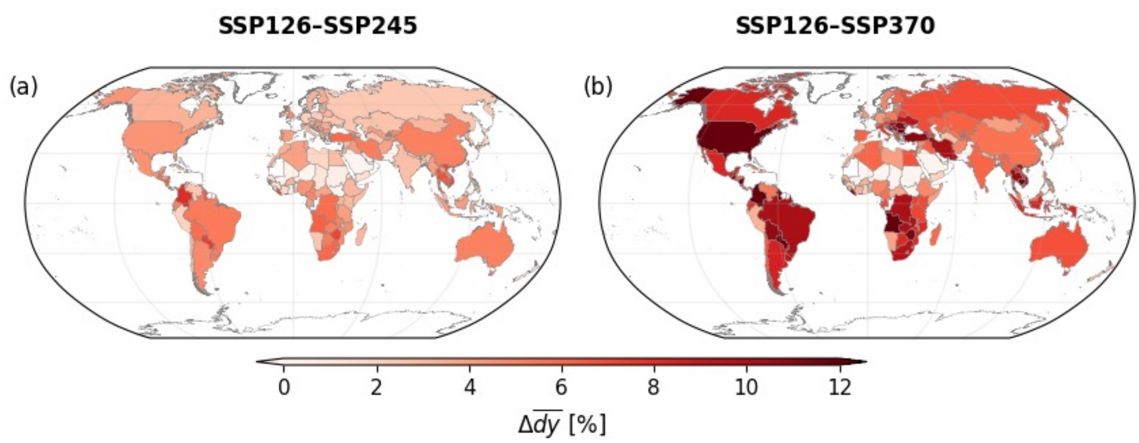
Figure 1 **Change in number of extreme drought months per year (SPEI-12 < –2) projected for 2080-2100 under SSP1-2.6, SSP3-7.0 and their difference (SSP1.2-6–SSP-37.0), relative to the historical reference period (1995-2015)**



Index (SPEI-12), a widely employed measure for persistent drought conditions (Araujo *et al.*, 2025; Vicente-Serrano *et al.*, 2010). We use variables from the novel ISIMIP3 (Frieler *et al.* 2024) simulations which allow for estimating global drought risks on the grid-point level at improved spatial resolution (0.5° x 0.5°). SPEI-12 serves as a proxy for deep-layer soil moisture dynamics (Wang *et al.*, 2015; Xu *et al.*, 2021) and is therefore particularly suitable for assessing impacts on agricultural production. It is calculated by accumulating the water balance (D = P – PET) over the preceding 12 months, where precipitation (P) represents water supply and potential evapotranspiration (PET) represents atmospheric moisture demand. Figure 1 shows global change in drought risks under different scenarios compared to a historical baseline, highlighting the benefits of climate mitigation to avoid widespread drought risk by the end of the century.

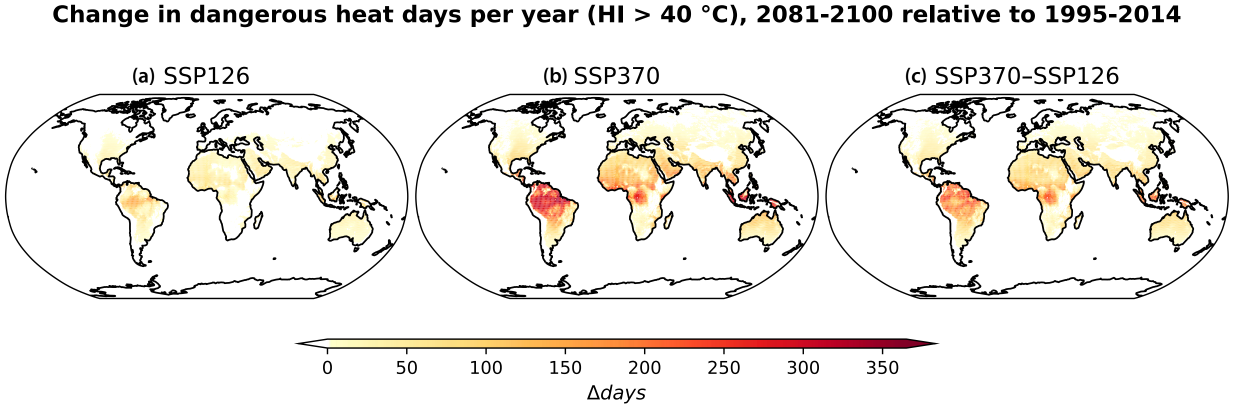
In a substantial advancement, we developed a statistical crop impact model, which uses the drought severity indicator (SPEI-12) and extreme heat as inputs. Trained with data[10] from the UN Food and Agriculture Organization (FAO) for a range of crop types on a national level, this model allows us to estimate agricultural yield and production loss inflicted by drought changes under different climatic conditions (Fig. 2).

Figure 2 **Projected heat- and drought-induced mean yield (*dy*) differences under panel a and panel b, relative to SSP1-2.6, for three crops (maize, wheat, soybean) combined. Figure adapted from Hwong *et al.* (in preparation)**



10 FAO (2020). FAOSTAT Crops and Livestock Products. Retrieved June 2024. Available at: https://www.fao.org/faostat.

Figure 3 **Projected changes in dangerous heat stress days based on the Heat Index by the end of the century (2081-2100) under a) SSP2-4.5 and b) SSP3-7.0 scenarios relative to present day climate (1995-2014) and c) differences between both scenarios. Figures are based on a multimodel mean (five models) using the ISIMIP3 simulations**



Heat stress indicator

For estimating impacts from extreme heat we employ the Heat Index (HI)[11] a widely used and well studied metric for quantifying human heat stress from the combined effects of air temperature and relative humidity (Gosling *et al.* 2014, Anderson *et al.* 2013). Compared to indicators based on the commonly used Wet-bulb Globe Temperature (e.g. Clark & Konrad 2025) we find that the HI exhibits a higher sensitivity to heat stress in moderate to dry climates (Langer & Kornhuber 2024), which can have considerable health implications (see 66,000 estimated deaths during the 2022 European heatwave (Ballester *et al.* 2023) and is therefore more universally applicable. In addition, the new index features a higher temporal accuracy by estimating the most severe heat stress levels during the hottest hour of the day, which can be considerably higher compared to daily average values. This increased accuracy is achieved by applying a physical approximation to the daily average humidity values provided in ISIMIP3 (Bolton 1980). Existing peer reviewed damage functions allow for a conversion of heat stress levels to labor productivity losses (Foster *et al.* 2021) for more reliable projections of future economic damages from heat stress changes.

Estimating the change in dangerous heat days per year (HI > 40) by the end of the century (2081-2100) under two different scenarios SSP1-2.6 and SPP-3.7.0 we find a considerable increase primarily in tropical regions compared to a present day climate (1995-2014) (Fig. 3 a, b). Further, moderate climatic regions in the mid to high latitudes will be exposed to unprecedented periods of heat stress under SPP3-7.0 which could be avoided under SS1-2.6 (Figure 3c).

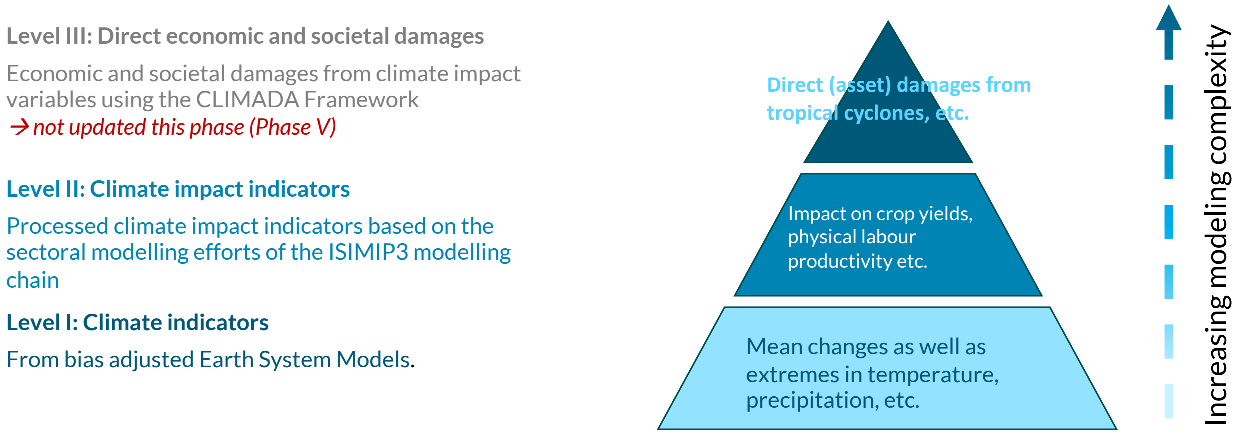
Improved communication on underlying modelling complexity levels

The indicators included in the CIE are subject to different levels of uncertainty, validation and input assumptions. This is due to the diversity of acute and physical risk indicators, and the aim of providing comprehensive coverage of the climate risk landscape. Some indicators are locally validated, while for others global validation data does not exist and assumptions about future adaptation and socio-economic development can strongly influence the results. Given the broad use of CIE indicators for different applications, a three level categorisation is used, in which variables and indicators[12] are categorised on the basis of their modeling complexity. The approach is illustrated in Fig. 4 below.

11 Originally developed by the U.S. National Weather Service (NWS) as a heat-stress warning tool, the HI is based on Steadman's model of human thermoregulation (Steadman 1979, Steadman 1984), which describes heat exchange between the human body and the environment in a single quantitative value that can be classified into heat-stress categories defined by the NWS ranging from 'caution' to 'extreme danger' (Anderson *et al.* 2013).

12 We use the term 'variable' for raw model data on e.g. mean surface air temperature (tas) which is the basis to calculate several temperature-related 'indicators' such as temperature variability or annual mean temperature.

Figure 4 **A hierarchical categorisation of physical risk indicators and variables with complexity from top to bottom: Level I. Climate indicators from bias adjusted earth system models (e.g. number of hot days); Level II. Climate impact indicators based on ISIMIP modeling efforts (e.g. crop yields); Level III. Economic and societal damages based on the CLIMADA framework (e.g. asset damages from tropical cyclones)**



As these indicators and variables represent the output from different steps of an evolving modeling chain, they form a natural hierarchy (Fig. 4), in which uncertainties and assumptions increase with each step.

Level I – Climate indicators from bias adjusted earth system models (CMIP) Level I climate indicators are directly based on Earth System Models (ESMs) and are in part in direct correspondence to the physical variables which are bias adjusted[13] and consistently downscaled within the ISIMIP3 project. The confidence in the level I indicators can be considered highest as uncertainties and required assumptions are typically lower. The lower overall underlying model complexity as well as the bias correction allows higher confidence in directly applying level I data for own analyses of CIE users. Table 1 provides information on which CIE indicators are categorized as Level I.

Level II – Climate impact indicators based on sectoral impact modeling efforts (e.g. ISIMIP)

Level II Climate impact indicators are the outcome of the ISIMIP3 modelling chain. Unlike Level I indicators, which are derived from ESMs, these indicators are modelled using impact models, such as agricultural or hydrological models for yield and flood estimates, respectively. For level II indicators, the additional layer of complexity and uncertainties coming from the impact modeling (typically multiple impact models) is additional to the modeling complexity and uncertainty related to the level I climate indicators used as inputs. Even when some of the input climate variables have been bias corrected, the outcome of the impact modeling is typically not bias-corrected and not validated, or potentially only for selected regions. When working with level II indicators, users should make themselves familiar with the limitations as outlined in the technical documents and disclaimers on applicability when applying the data and interpreting the results. Table 1 provides information on which CIE indicators are categorized as Level II.

Level III – Direct economic and societal damages

Level III indicators, i.e. those related to economic damages, are subject to a range of additional modeling complexity and socio-economic assumptions which adds to the above described complexity and modeling uncertainty ranges. Especially the underlying socio-economic assumptions typically have a normative dimension. Therefore, the level III *economic damage* indicators are of a more indicative nature, which the CIE user should be aware of when using or interpreting the data. Please note that the level III indicators (i.e. economic

13 Bias adjustment (also called bias-correction), uses observational data to correct any systematic errors (i.e. biases) that modeled data may be subject to (see this short explainer from the Copernicus Climate Change Services on what bias correction is and why it is needed).

and societal damages) have not been updated due to resource constraints.[14]

Providing absolute values for selected indicators

As in the previous version of the CIE, absolute values are shown for bias-corrected climate indicators (level 1). In the updated version of the CIE, additional indicators were calculated using bias-corrected climate data. These serve as proxy indicators for estimating risks from extreme weather events and related economic damages. Examples include the SPEI index; the fire weather index for wildfire risk; and several heat risk indicators, such as the frequency of heat index threshold exceedances and the maximum number of consecutive tropical nights per year. Because these indicators are based on the bias-corrected climate indicators, we have confidence in their absolute values and display them accordingly.

Due to potential biases, the CIE does not provide absolute values for certain indicators. These include impact model-based results such as agricultural yields for different crops, freshwater indicators, as well as heavy precipitation indicators like 5-day extreme precipitation, where we consider relative values more robust and easier to interpret.

Overview of indicators featured on the new CIE

Table 1 provides an overview of the physical risk indicators featured in the updated 2025 CIE, including information on i) the categorisation with regard to the underlying modeling complexity, and ii) whether the same indicator had already been featured on the previous versions of the CIE. Table A3 in the Annex moreover includes additional information on the indicators, including whether they represent a chronic or an acute physical risk. Annex A.1.2 provides more information on underlying climate data inputs for estimating aggregate damage functions which are also covered by the CIE.

Table 1 **Overview of physical risk indicators featured in the updated CIE**

Indicator name	Level	In 2024 CIE
Climate		
Relative Humidity	I	Yes
Specific Humidity	I	Yes
Precipitation (Rainfall + Snowfall)	I	Yes
Snowfall	I	Yes
Atmospheric Pressure (Surface)	I	Yes
Downwelling Longwave Radiation	I	Yes
Wind Speed	I	Yes
Mean Air Temperature	I	Yes
Daily Maximum Air Temperature	I	Yes
Daily Minimum Air Temperature	I	Yes
Temperature Variability	I	No
Precipitation Days	I	No
Total Annual Precipitation	I	No

14 We aim to add updated or new Level III indicators to the CIE in the future. The previous indicators on direct damages of Tropical Cyclones and river floods (from CLIMADA) remain available in the previous (archived) CIE but remain as of ISIMIP2b/CMIP5 and NGFS scenario vintage V and will no longer receive updates (neither new data nor NGFS scenario vintages).

Heat		
Consecutive Tropical Nights	I	No
Cooling Degree Days	I	No
Annual Maximum Daily Temperature	I	No
Daily Maximum Wet Bulb Temperature	I	No
Days Per Year With Emerging Heat Risk	II	No
Days Per Year With High Heat Risk	II	No
Days Per Year With Dangerous Heat Risk	II	No
Days Per Year With Extremely Dangerous Heat Risk	II	No
Extreme Precipitation		
Annual Maximum 5-day Precipitation	I	No
Total Precipitation From Extreme Precipitation Events	I	No
Heavy Precipitation Days	I	No
Annual Maximum Daily Precipitation	I	No
Freshwater		
Surface Runoff	II	Yes
River Discharge	II	Yes
Drought		
Annual Drought Intensity	II	No
Consecutive Dry Days	I	No
SPEI	I	No
Annual Minimum SPEI	I	No
Water Stress Index	I	No
Area Under Moderate Drought (SPEI < -1)	I	No
Area Under Severe Drought (SPEI < -1.5)	I	No
Area Under Extreme Drought (SPEI < -2)	I	No
Area Under Very Extreme Drought (SPEI < -2.5)	I	No
Fire		
Fire Weather Index – length of fire season	I	No
Fire Weather Index – days with extreme fire weather	I	No
Agriculture		
Maize Yield Change	II	Yes
Rice Yield Change	II	Yes
Soy Yield Change	II	Yes
Wheat Yield Change	II	Yes
Labour Productivity		
Labour Productivity Loss due to Heat Stress	II	Yes

3. Understanding physical risks and related uncertainties

Types of uncertainty featured in the CIE

When considering climate impacts and projections, uncertainties are unavoidable. Understanding these uncertainties, individually and in combination, is crucial for planning and decision-making. Regional impacts of climate change are typically assessed by analysing climate simulations and their consequences for natural and human systems under assumed greenhouse gas emission scenarios. This process follows a chain of models:

- emissions scenarios are first produced by integrated assessment models (IAMs),
- emissions scenarios are run by Earth system models (ESMs) to simulate the response of the climate system,
- the climate responses are translated into sectoral impacts (e.g., on hydrology or the economy) using impact models (Jones *et al.* 2024).

Each step in this chain introduces a separate source of uncertainty that will be described in the following.

Scenario uncertainty

Scenario uncertainty arises from different possible future emissions trajectories. In the CIE this is addressed by enabling users to compare climate impacts under a broad set of different scenarios developed under the NGFS, in addition to the Current Policies scenario of the Climate Action Tracker.

Global climate response uncertainty

This refers to how much the planet warms for a given amount of GHG emissions. For example, for a certain amount of CO_2, will global average temperatures (GMT) rise by 2 °C or closer to 3 °C? This depends on the climate system's sensitivity to emissions that depends on factors such as climate model physics, differences in ocean and land carbon uptake, and uncertainties in climate system responses to different climate forcers such as greenhouse gases or aerosols.

Natural variability

Natural variability arises from the inherently chaotic nature of the climate system: small differences in initial conditions can amplify over time, producing diverging climate outcomes even within the same model and scenario. Furthermore, multi-annual or multi-decadal modes of the climate system, such as the El Niño Southern Oscillation, the Pacific Decadal Oscillation or the Atlantic Multidecadal Oscillation will affect regional climates on longer time scales. To account for the internal variability of the climate system, impact assessments such as by the IPCC typically use multi-decadal (20 or 30 year) averages. In the context of CIE, we rely on 21 year time slices to calculate warming level dependent regional impacts averaging out internal variability of the climate system.

Global to Regional Model uncertainty

Even with a given global warming level, there is still uncertainty about how that warming translates into local impacts. Model uncertainty refers to differences in how various ESMs or impact models simulate responses under the same scenario – such as impacts on crop yields, water availability, or flood risk. Different models simulate these impacts differently, leading to a range of possible outcomes.

How are the uncertainties quantified?

Assessing the combined effect of these uncertainties is essential for understanding the full range of possible future climate outcomes, their impacts, and associated risks.
To represent these uncertainties, the CIE relies on two established tools from the scientific community – simple climate models (SCMs) and Model Intercomparison Projects (MIPs).

SCMs simulate key global indicators such as global mean temperature (GMT). Their simplicity makes it feasible to run large probabilistic ensembles based on parameter sets constrained by historical observations and known parameter ranges, thus systematically exploring global climate response uncertainty (e.g. Sandstad *et al.* 2024,

Leach *et al.* 2021, Dornheim *et al.* 2024, Smith *at al.* 2018, Meinshausen *et al.* 2011). To represent the uncertainty in how emissions translate into global temperature change, we use the IPCC AR6 Working Group I–calibrated version of the MAGICC simple climate model. This calibration is designed to reflect the best estimate and uncertainty range of climate sensitivity assessed in AR6. In particular, it aligns with the AR6 assessed *"very likely"* range for the transient climate response (TCR) of 1.2 °C-2.4 °C.
In the CIE, the SCM MAGICC is used to generate an ensemble of 600 equally plausible GMT trajectories for each scenario, capturing global climate response uncertainty. By using this calibrated setup, the uncertainty in global mean temperature projections is consistent with the latest IPCC assessment and provides a robust representation of the range of possible climate responses to emissions scenarios.

To comprehensively address model uncertainty, we rely on ISIMIP3b, which provides simulations of climate and climate impact indicators from up to 14 ESMs and various sectoral impact models for the SSP scenarios. This ensemble is used to estimate model uncertainty in the local response of climate indicators to global temperature change. The bias-corrected ESM outputs are used to drive a range of sectoral impact models, including those for hydrology, labour productivity under heat stress, and crop yields. This approach reflects structural differences between models and their assumptions about processes such as water availability and plant growth. By combining multiple ESMs with multiple impact models, we represent a broad and scientifically credible range of possible outcomes, consistent with the latest intercomparison exercises.

How are impact indicators calculated and combined?

For each simulation from the MIP ensemble, we calculate impact indicators through time with their associated global warming levels (21-year temporal average), then pool local indicator values across models at specific warming levels. From this pooled set we derive warming-level – dependent distributions of local indicator values using linear interpolation.

How is the CIE uncertainty range estimated?

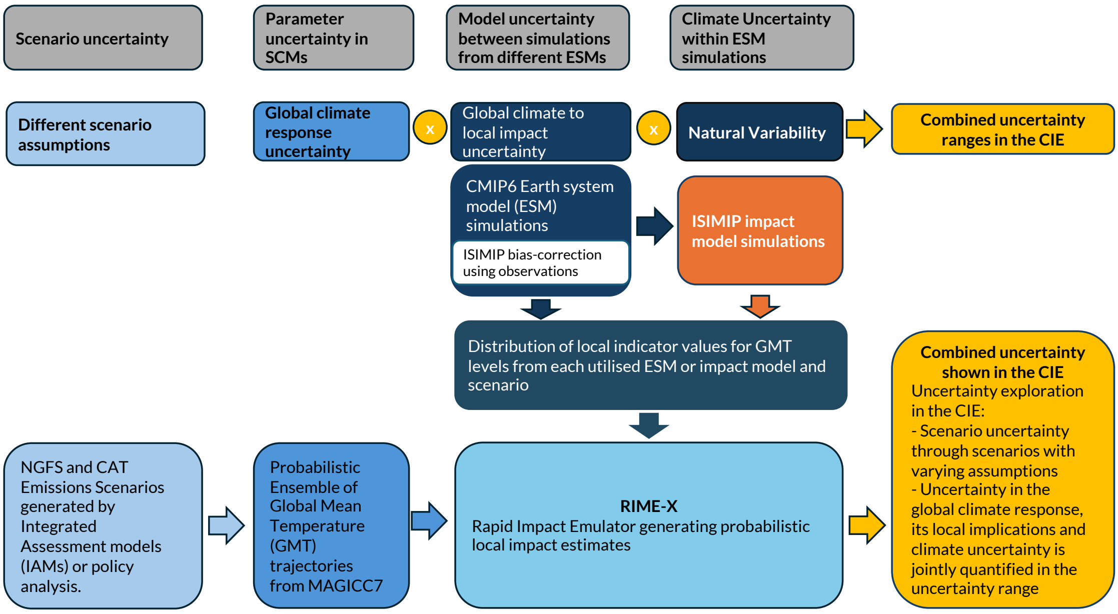
The CIE allows for a consistent treatment of different sources of uncertainty. To construct the CIE time series, we generate 5,000 samples of possible local indicator values per year. Each sample is created by first drawing a GMT trajectory from the MAGICC ensemble, then drawing local indicator values for the GMT trajectory from the warming-level – dependent distribution.
The resulting time series in the CIE shows the 5th, 50th, and 95th percentiles of these samples, thus a range that covers 90% of possible outcomes. Our sampling strategy ensures that the underlying distribution of these percentiles jointly quantifies global climate response uncertainty and model uncertainty in the implications of the global response for the local indicator.
In the CIE, natural variability was removed from the data as much as possible by applying a 21-year temporal average to the ISIMIP3b simulations before we calculate the local indicators. This is done to show the trend in the indicator values without natural variability.

For the given level of emissions from the selected scenario, the methodology incorporates the full uncertainties that result from the global climate sensitivity to emissions and the uncertainties of the regional impacts from different climate and impact models, thus showing the full plausible range from the modelling of the respective physical risks. Figure 5 highlights the sources of sources including:

- The **uncertainty in global temperature projections** (from the MAGICC model) for a given GHG emissions pathway is combined with
- **the uncertainty of the regional impact indicator resulting from the different climate and impact models,** for a given global temperature projection.

The **shading shown in the CIE line plots (see CIE tool or chapter 4) represent the combined uncertainty range of both distributions**. For the given level of emissions from the selected scenario, it incorporates the full uncertainties that result from the global climate sensitivity to emissions and the uncertainties of the regional impacts from different climate and impact models, thus showing the full plausible range from the modelling of the respective physical risks.

Figure 5 **Illustration of the combined types of uncertainties stemming from the global mean temperature and the local impact response**



This approach comes with several key assumptions:

1. Local climate changes or impact responses are independent of the rate of warming. While this is generally a justifiable assumption, there might be specific regions and impacts for which global sensitivities and regional changes in impact indicators are more tightly coupled.
2. Changes in climate impacts and climate impact drivers are primarily dependent on global mean temperature. This assumption has shown to be robust for a range of climate impact drivers including in the last IPCC AR6 report. However, some impacts, particularly those on the biosphere and agriculture, are more strongly influenced by other drivers linked to human activities. For example, elevated CO_2 concentrations result in a 'CO_2 fertilisation effect' on plant growth (Schleussner *et al.*, 2018), and high aerosol loadings affect local climates, particularly over East and South Asia. These effects are considered in the assessment of uncertainty in the CIE, which leads to elevated uncertainty bands for specific indicators.

Risks in a highly climate sensitive world: What if emissions lead to stronger climate responses?

There is a wide range of physically possible global warming outcomes (determined by the spread in climate response, see Chapter 1) for a given emission pathway.

A higher global climate sensitivity[15] would lead to faster and stronger global warming for the same emission trajectory and thus also much stronger climate impacts and damages already in the near-term. We suggest that such an outcome would need to be considered by regulators for physical stress testing purposes, as accounting of these risks is essential for the financial sector and the economy at large.

We therefore also show projected climate impacts for a "***high climate response world***" as a plausible future (Chapter 5), giving the global warming outcome for the NGFS Current Policies emissions scenario assuming

15 *Climate sensitivity* refers generally to the response of global mean temperature to increases in greenhouse gases, and is typically measured as the temperature response until equilibrium to a doubling in atmospheric carbon dioxide levels. The IPCCs AR6 best estimate of equilibrium climate sensitivity is 3 °C, with a likely range of 2.5 °C to 4 °C (high confidence) (https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/). The larger range at the upper end of sensitivity emphasises the importance of exploring high warming scenarios.

a high climate response world. To obtain this we only consider the upper 20 percent of the MAGICC model's output ensemble for the construction of the scenarios' GMT response – thus considering a 1-in-5 chance of these higher warming outcomes occurring. In total, this means we focus on 120 ensemble members[16] showing the highest end of century global mean temperature increase from the 600 member ensemble of the MAGICC model.

Note that this approach does not consider global to regional climate uncertainties (compare Fig 5). The reason for this is that regional climate uncertainties are variable and model dependent (i.e. over a certain region, one Earth System Model might project a particularly pronounced drying trend vs. another projects stronger increases in extreme precipitation). By focusing on a higher climate response world, however, we modulate the key driver variable of our ensemble thereby providing an internally consistent set of CIE climate impact indicators, but for a high physical risk world outcome.

Chapter 5 shows a comparison of projected global warming levels comparing the "high climate response" world and the "best estimate" NGFS Current Policies Scenario.

The CIE Update allows exploring the differences between the "best estimate" and a "high climate response world"

What is our "best estimate" for physical risks from climate change?

To provide a "best estimate" and uncertainty band for the projected climate impacts, the Climate Impact Explorer takes into account i) all possible global climate responses (i.e. translating emissions into GMT projections) and ii) all values modelled for the projected climate impact by simulations participating in ISIMIP3b at global climate states possible in the scenario. These results are shown in Chapter 4.

Where to find this "What-if high climate response world" in the CIE?

The high climate response options serve to illustrate climate impacts in cases where the climate response to emissions is at the upper ends of the very likely equilibrium climate sensitivity range as determined by the IPCC AR6 report. They are obtained by only taking into account the 20 percent upper possible climate responses from the MAGICC ensemble. We include this additional "what-if"-scenario-version for the NGFS Current Policies Scenario (Chapter 5).

The updated Climate Impact Explorer allows users to explore the implications from this "what-if" plausible future for the NGFS current policies scenario. CIE users can select this "what-if" plausible future from the Scenario drop down menu in the CIE. It can be identified by the bracket "high climate response" behind the scenario name. The drop down selection without the bracket refers to the "standard" assumption of a median climate response.

The CIE also allows comparing the results for two different scenarios by selection one scenario e.g. *NGFS Current Policies Scenario* and then pressing the button "compare to alternative scenario" that can be found above the line graph and selecting the *NGFS Current Policies Scenario (high climate response)* for comparison.

The line plot will then show the differences between these over time and the maps can be used to explore the (spatial) differences between these for selected years. Chapter 5 discusses selected results from the Climate Impact Explorer comparing the "best estimate" results with the "high climate response" world.

16 *Ensemble member* refers to a single simulation within an ensemble of simulations from a climate model (here MAGICC). Each member represents a possible future pathway based on a different parametrisation of MAGICC.

4. Key insights for physical risks from the CIE 2025

This chapter highlights the insights from the Climate Impact Explorer Update with a focus on three priority indicators for acute physical risks – extremes of precipitation, heat and drought – to highlight the acute physical risks from climate change and inform about the costs of inaction and showcase the CIE functionalities.

Projected trends for temperature and precipitation from the literature

Global temperature trends: The World Meteorological Organisation states that 2024 was the hottest year in the 175-year observational record (WMO 2025). The 10 hottest years in recorded history have been since 2010 (NOAA).

Regional temperature trends: The IPCC's Interactive Atlas of the Working Group I in the 6th Assessment report shows that for all regions across the globe, mean temperature is projected to increase with high confidence. Climate change is expected to increase temperatures more rapidly in continental interiors than over the ocean and is also expected to increase average temperatures more rapidly in high latitudes than in low latitudes.

Precipitation trends: Climate change intensifies the hydrological cycle (IPCC AR6 WG1 Chapter 8, 2021): warmer air holds more moisture, leading to heavier rainfall when saturation occurs, while stronger convection drives more intense storms. At the same time, other regions experience suppressed rainfall and prolonged dry periods. As a result, both wet and dry extremes are expected to increase, though regional patterns and confidence levels vary. The IPCC's Interactive Atlas illustrates the heterogenous key precipitation trends for different regions, showing strong regional differences in terms of direction of the projected changes and in terms of scientific confidence in the projected trends.

Next to the acute physical risks described in detail below, we want to highlight that the **Climate Impact Explorer also includes a range of *"chronic physical risk"* indicators** based on temperature and precipitation as well as other climate indicators which allow exploring the regional or country-specific trends in more detail for the different scenarios.

Projected changes for extreme events

The Summary for Policymakers of the AR6 WGI report concludes that that even for relatively small increases in global mean temperature statistically significant changes in extremes can be detected, both globally as well as for large regions, highlighting particularly temperature extremes (very likely), heavy precipitation extremes (high confidence) and droughts worsening in some regions (high confidence) (IPCC AR6 WGI Summary for Policymakers). Even at 1.5 °C of global warming, the world is projected to be exposed to extreme events which are more extreme than what we have historically observed.

This section exemplifies the functionalities of the CIE by showcasing timeseries and geo-spatially resolved information based on two scenarios: NGFS Net Zero 2050 and the NGFS Current Policies scenario (best estimate). Screenshots from the online tool will focus on statistics from selected hot-spot countries. A discussion of CIE results for more countries can be found in the Annex (A3) and further information can also be found online in the CIE tool. Note that in this chapter we show the results of the "best estimate" assuming a median climate response (see Chapter 3 for an explanation). In Chapter 5, we look into a "high climate response" what-if storyline, contrasting the projected impacts for the "best estimate" (median) with projections for a high climate response for the NGFS Current Policies scenario.

Extreme precipitation

Extreme precipitation (primarily rainfall[17]), is the main driver of non-coastal, pluvial and fluvial flooding. To account for the complexity of the processes that cause rainfall (e.g. small scale thunderstorms vs. slow moving fronts) and associated changes in rainfall events (e.g. shifts in long-term averages vs. changes in intense short duration events), the Climate Impact Explorer covers a set of different indicators related to extreme precipitation (see Table 2 in Chapter 2, highlighting two of these here:

- 'Annual Maximum Daily Precipitation' provides information on projected changes for the annual maximum amount of rainfall within one day.
- "Annual Maximum 5-Day Precipitation" is the sum of precipitation accumulated over a period of 5 consecutive days accounting for longer periods of rainfall. Projected changes for heavy precipitation can be an indication for pluvial flooding risks, i.e., local flooding caused by heavy rainfall, including flash flooding risks and urban flooding (see e.g. Fofana *et al.* 2022, Tan *et al.* 2024).

While heavy precipitation in one location can also contribute to rising water levels in rivers contributing to down-stream river flooding elsewhere, projections on river flooding require complex hydrological models and will thus not be the focus of this section. The updated CIE will also include indicators related to river run-off and river discharge[18], however, these cannot be directly translated to river flooding risks without further modelling.

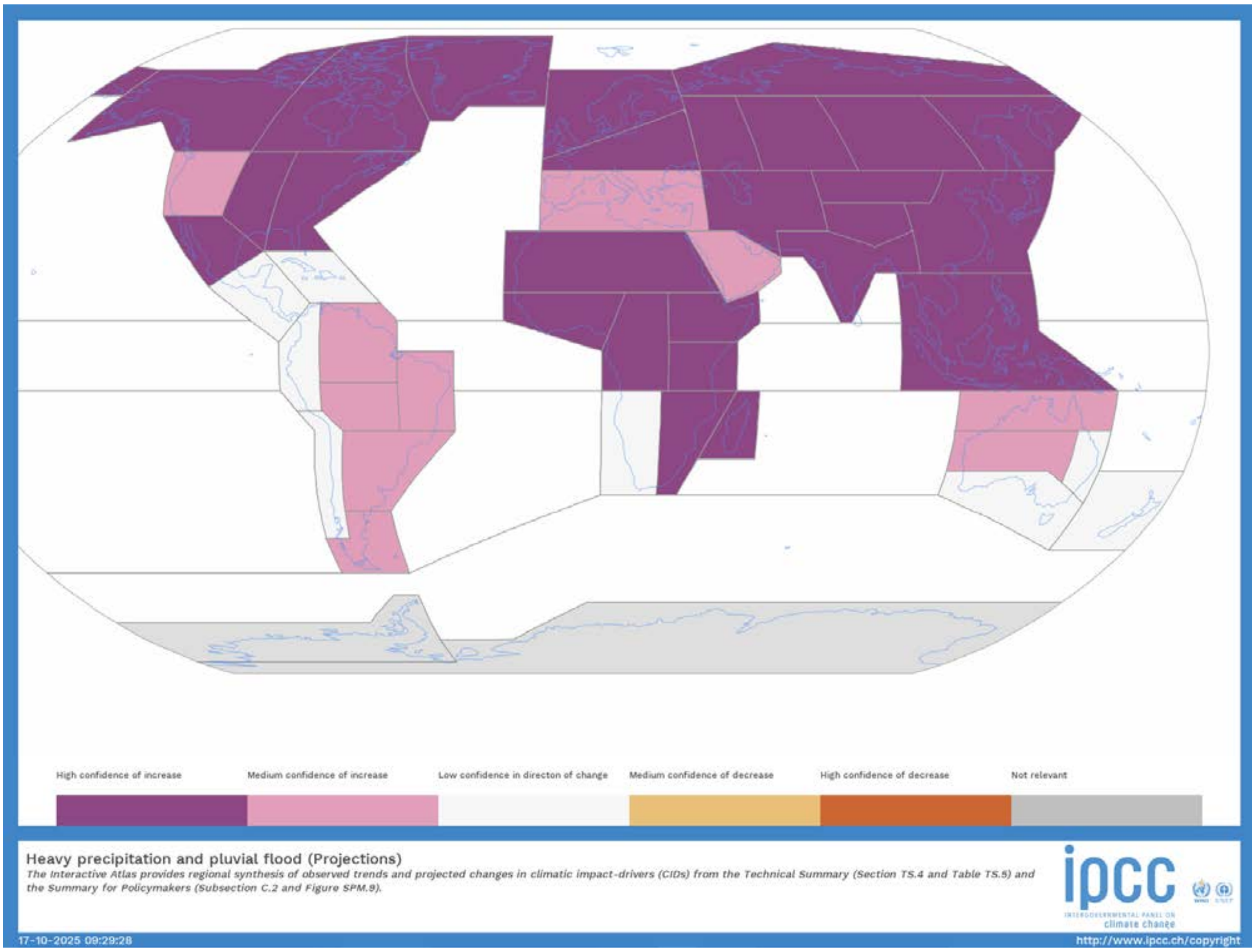
17 The climate model variable used is precipitation, which covers both rainfall and snowfall.

18 Note that at the time of writing, the ISIMIP3 flood data was still unpublished and being finalized CIE will be updated once the data is released.

Insights from the IPCC on pluvial flood-related trends

The IPCCs Interactive Atlas shows that the projected high level trends for heavy precipitation and pluvial floods for most regions around the world are projected to increase with high to medium confidence (see Figure 6 below).

Figure 6 **Projected trends for heavy precipitation and pluvial floods from the IPCC**[19]



19 Source: Gutiérrez, J.M., R.G. Jones, G.T. Narisma, L.M. Alves, M. Amjad, I.V. Gorodetskaya, M. Grose, N.A.B. Klutse, S. Krakovska, J. Li, D. Martínez-Castro, L.O. Mearns, S.H. Mernild, T. Ngo-Duc, B. van den Hurk, and J.-H. Yoon, 2021: Atlas. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, *et al.* (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1927–2058, doi:10.1017/9781009157896.021. Interactive Atlas available from http://interactive-atlas.ipcc.ch/Iturbide, M., Fernández, J., Gutiérrez, J.M. *et al*. Implementation of FAIR principles in the IPCC: the WGI AR6 Atlas repository. Sci Data 9, 629 (2022). https://doi.org/10.1038/s41597-022-01739-y; Global Commons License: https://interactiveatlas.ipcc.ch/license.

Below, we show selected results from the CIE on projections on relative change for different CIE indicators related to extreme precipitation, comparing end of century projections for the NGFS Current Policies Scenario with the Paris-Agreement aligned NGFS Net Zero 2050 scenario.

The maps shown below compare the projected change in the respective extreme precipitation indicator (in %) since the reference period 1996-2014, for the year 2100 for selected countries. The first two maps show the projected changes under a NGFS Current Policies (left) and a NGFS Net-Zero 2050 scenario (middle), while the third map (right) shows how much more (or less) precipitation is projected for the Current Policies Scenario compared to the Net Zero 2050 scenario (percentage point difference between the respective projected changes). The line graphs show the spatially aggregated projected changes for the respective country using area weighting, comparing the projections for the two scenarios over time.

Note that reported projected changes in impacts are compared to the reference period 1996-2014 and not compared to pre-industrial times without climate change. So these changes are additional to the changes already experienced compared to pre-climate change times.

For **China**, the projected changes by 2100 for the Current Policies Scenario amount to 13.7% increase in Annual Maximum 5-day Precipitation compared to the reference period (1996-2014), while in the Net Zero scenario these would be only about 4% (see Figure 7). Regional differences for the projected changes in China are substantial, with certain regions having over 37% increases in Annual Maximum 5-day Precipitation compared to the reference period, and almost 25%-points higher projected increase than the Net Zero Scenario.

Also the "Global North" is affected. In **Japan**, annual maximum 5-day precipitation is projected to increase by almost 13% by 2100 compared to the reference period (1996-2014) in the NGFS Current Policy Scenario (2.9% in the Net Zero Scenario by 2100 and close to 6% by midcentury) (see Figure 8). Certain regions within Japan are projected to experience up to 30% increases in annual maximum 5-day precipitation compared to the reference period in the Current Policies Scenario, 15 percentage points higher than in the Net Zero Scenario (see Figure 9).

Figure 7 **Projected changes in annual maximum 5-day precipitation for China comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**

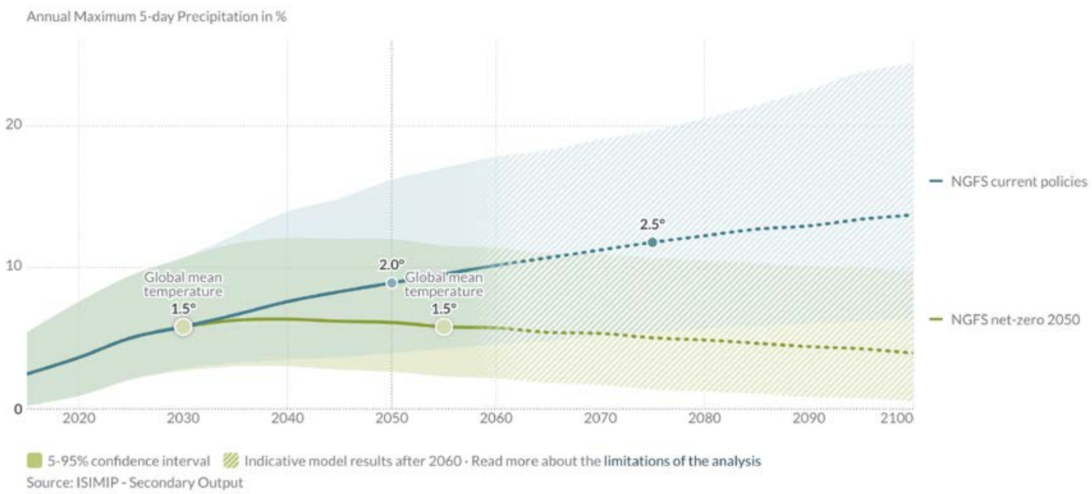


Figure 8 **Projected changes in annual maximum 5-day precipitation for Japan comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**

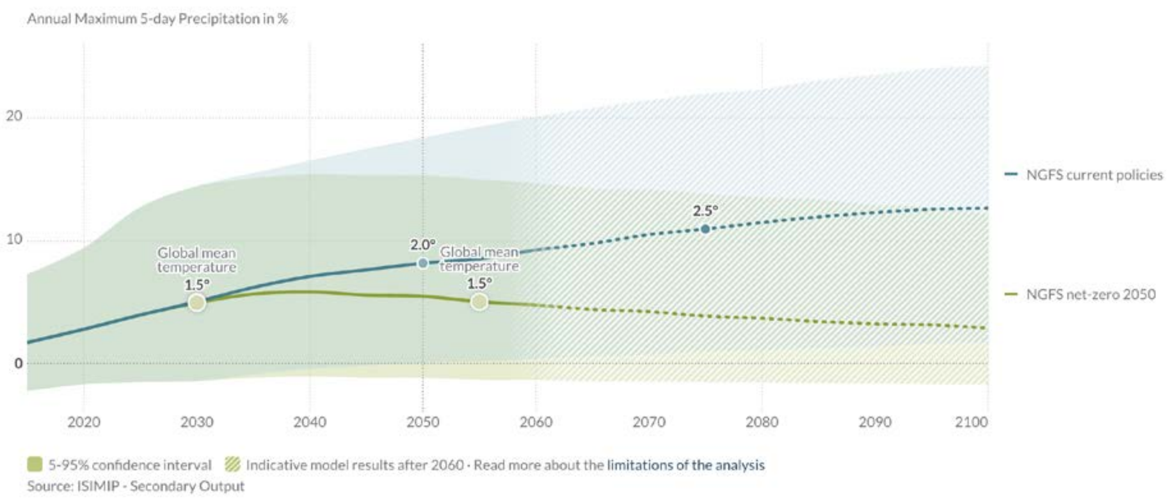
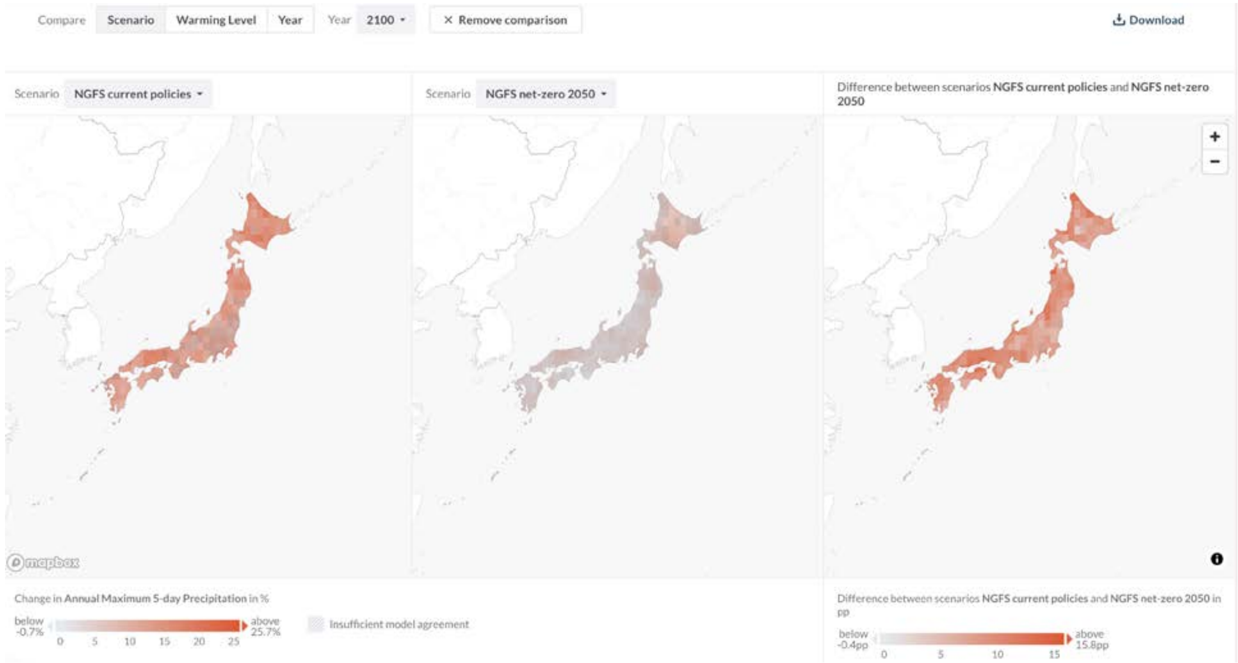


Figure 9 **Map with projected changes in annual maximum 5-day precipitation relative to a 1996-2014 reference period for Japan, comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**



Extreme Heat

Insights from the literature on extreme heat

Extreme heat is projected to increase with high confidence in all inhabited regions according to the high level trends of the IPCC's Interactive Atlas of the Working Group I (AR6).

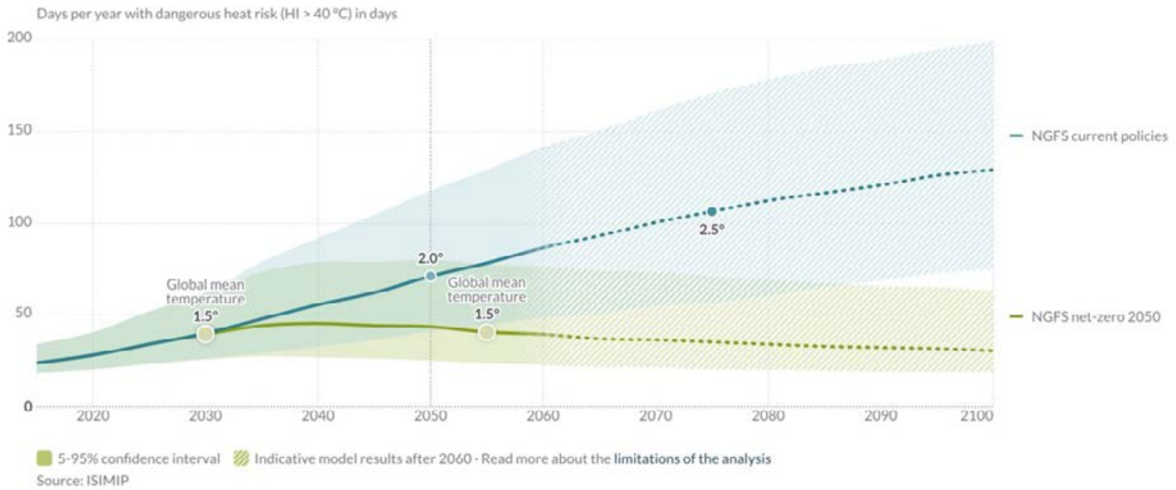
Increases in frequency and intensity of extreme heat events can be attributed to anthropogenic activities with high confidence. A recently released report by Climate Central and the Red Cross Climate Centre (Giguere, Otto, Tannenbaum, Vahlberg *et al.* 2025) found that all of the 67 extreme heat events around the world in the last year, were found to be influenced by climate change. With some events made more than 10-20 times more likely because of human-induced warming. Another related concern with heat waves is the increased likelihood of dangerous heat stress that can have severe consequences to human health. In 195 countries or territories, climate change at least doubled the number of days with extreme heat stress compared to a world without climate change.

The CIE offers a range of indicators that account for different types of heat associated impacts (see Table1 in Chapter 2). This chapter highlights results based on the newly developed heat risk indicator, which incorporates daily maximum temperature and relative humidity to estimate an apparent temperature value (further described in chapter 2.3). Here we focus on days per year with dangerous heat risk (i.e. a Heat Index above 40 deg. C)[20] for selected hotspot countries, comparing the number of days with dangerous heat risk levels in the NGFS Current Policies Scenario and the more ambitious Net Zero 2050 scenario.

Extreme heat is projected to increase substantially in many places around the world. For example, in **Brazil**, the projected number of days subject to dangerous heat risk levels increases from 24 days in 2015 to 71 days by 2050 and 129 days by 2100 under the Current Policies Scenario – a 5-fold increase (see Figure 10). Regional differences in Brazil are substantial (see Figure 11), with certain regions in the South of Brazil projected to be exposed to up to 135 days more in the Current Policy scenario compared to the Net Zero scenario by 2100.

Also countries in more temperate latitudes will be affected. For example, in the **United States of America (USA)**, the projected number of days subject to dangerous heat risk levels increases from 4 days (in 2015) to 9 days by 2050 and 16 days by 2100 under the Current Policies Scenario, a four-fold increase. In the Net Zero Scenario, in contrast, the USA is projected to be exposed to 6 days by 2050 and 5 days by 2100 (see CIE). Not only the South of the USA but also the central regions of the USA are projected to be most strongly affected by heat risks (see Figure 12).

Figure 10 **Projected (absolute) number of days per year with dangerous heat risk levels for Brazil, comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**



20 Number of days per year at which the daily maximum Heat Index exceeds the 'danger' threshold of 40 °C.

Figure 11 **Map with projected changes in days per year with dangerous heat risk levels compared to their projected amount in 2015 for Brazil, comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**

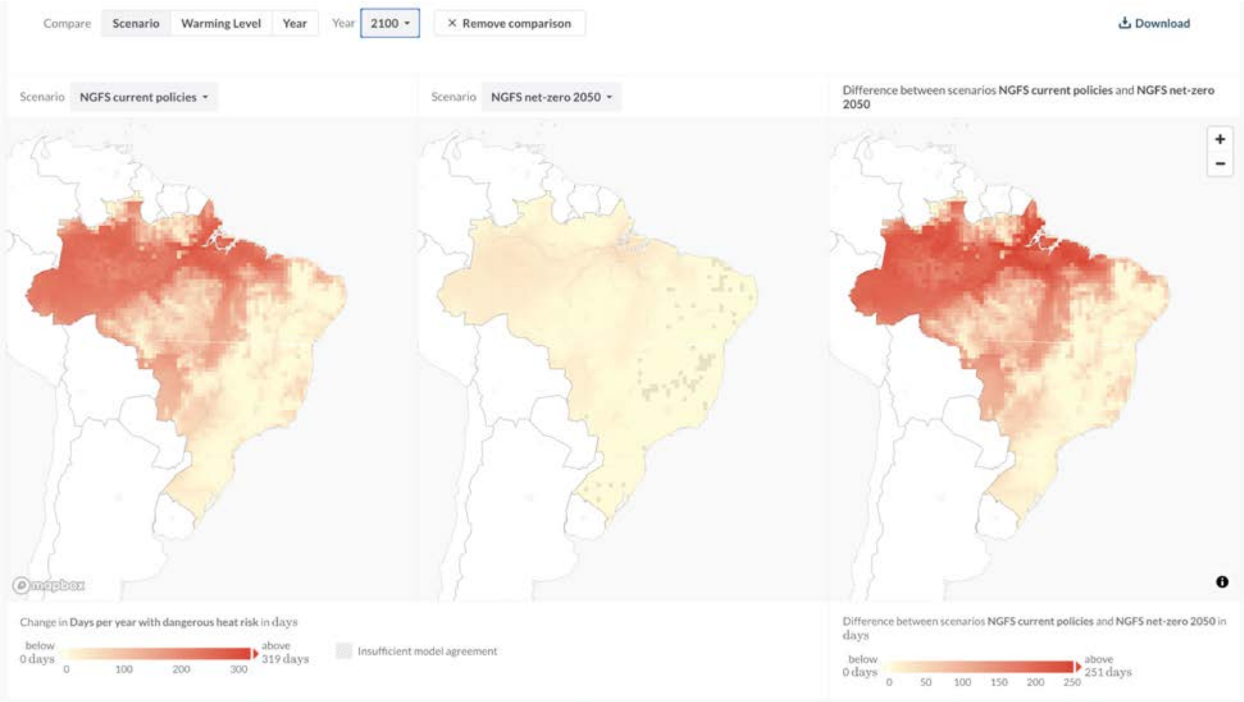
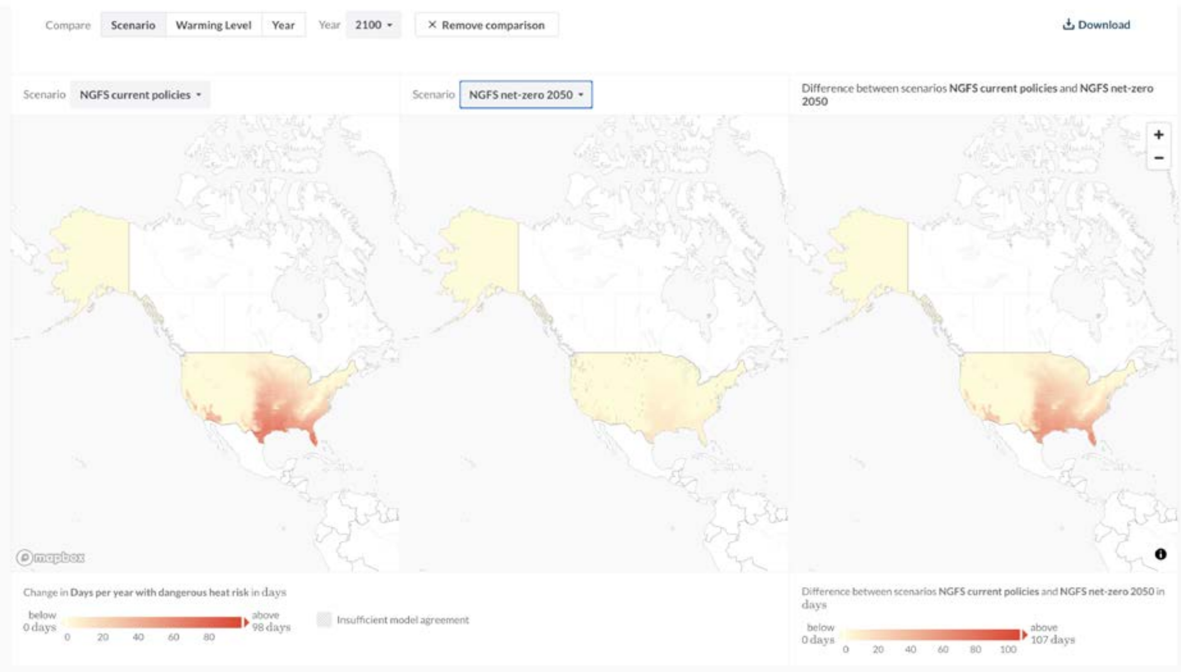


Figure 12 **Map with projected changes in days per year with dangerous heat risk levels compared to their projected amount in 2015 for the USA, comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**



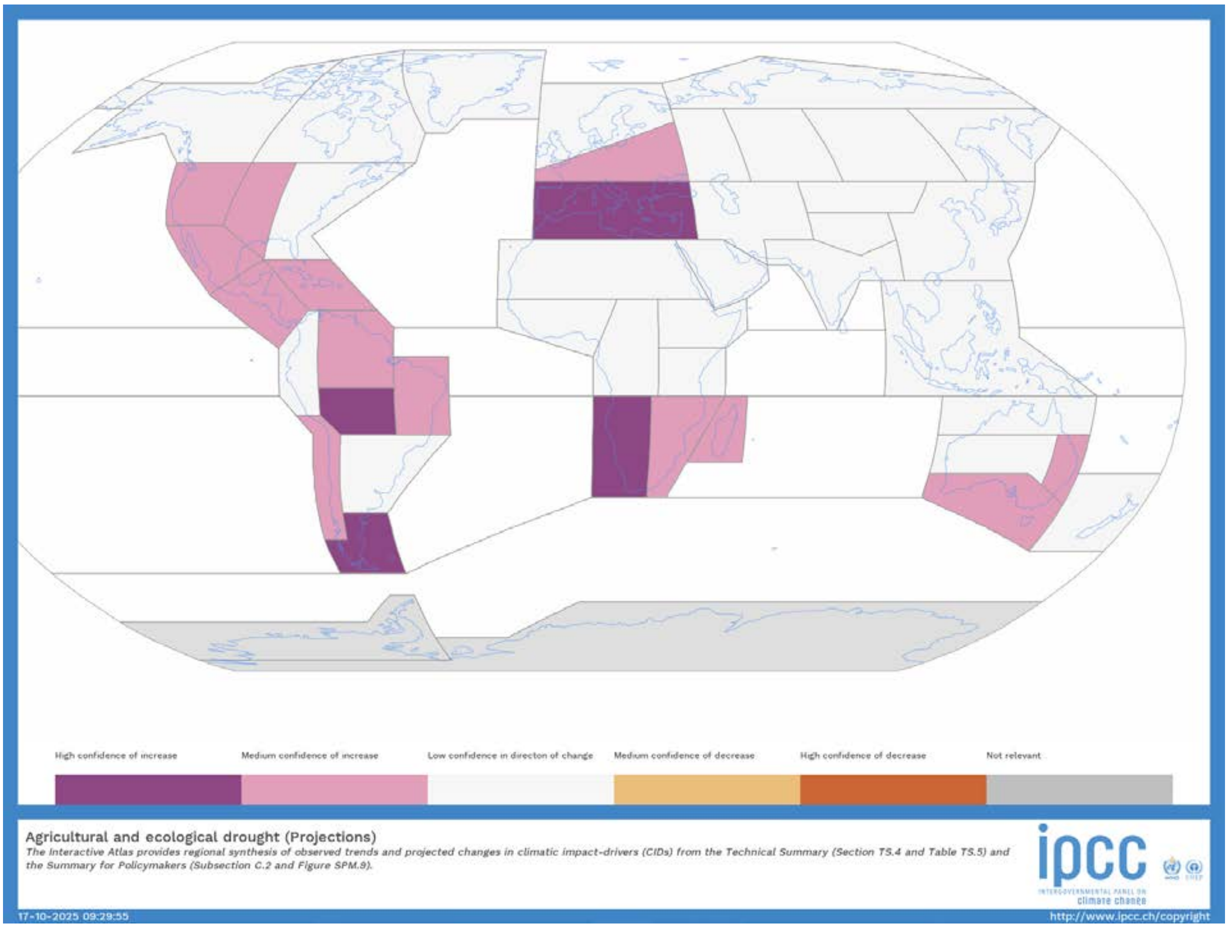
Extreme drought

Insights on drought risks from the literature

Already today, many areas around the world suffer from severe drought conditions, as illustrated e.g. by the World Bank drought and desertification hotspot map.

The IPCC's Interactive Atlas illustrates high level trends for droughts (here showing agricultural and ecological droughts), showing the regions in which the literature projects increases in drought with medium to high confidence.

Figure 13 **Projected high level trends for agricultural and ecological drought from the IPCC[21]**



21 Source: Gutiérrez, J.M., R.G. Jones, G.T. Narisma, L.M. Alves, M. Amjad, I.V. Gorodetskaya, M. Grose, N.A.B. Klutse, S. Krakovska, J. Li, D. Martínez-Castro, L.O. Mearns, S.H. Mernild, T. Ngo-Duc, B. van den Hurk, and J.-H. Yoon, 2021: Atlas. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, *et al.* (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1927–2058, doi:10.1017/9781009157896.021. Interactive Atlas available from http://interactive-atlas.ipcc.ch/Iturbide, M., Fernández, J., Gutiérrez, J.M. *et al*. Implementation of FAIR principles in the IPCC: the WGI AR6 Atlas repository. Sci Data 9, 629 (2022). https://doi.org/10.1038/s41597-022-01739-y; Global Commons License: https://interactive-atlas.ipcc.ch/license.

The CIE provides information on projected drought trends and changes compared to current drought exposure. The CIE features a number of drought-related indicators (see Table 1 in Chapter 2), including information on different drought severity levels based on the Standardised Precipitation Evapotranspiration Index (SPEI). Here, we focus on the SPEI drought indicator (see section 2), selecting the indicator '*Area under extreme drought (SPEI < -2)*', showing the projected absolute change in exposed area, in percentage points (pp), compared to the exposed area for the same region in the reference period 2005-2025.

Figure 14 shows the projections from the CIE for **South Africa**, comparing the NGFS Current Policies Scenario with the NGFS Net Zero 2050 Scenario. While in the reference period (2005-2025) already over 18% of the area of South Africa are subject to extreme drought conditions, this is projected to change by an additional 57 percentage points by the end of the century under the current level of climate ambitions (NGFS Current Policies Scenario, with almost 76% of South Africa's land area projected to be subject to drought) while under the Paris-Agreement aligned scenario (NGFS Net Zero 2050) the additional area affected by extreme drought is projected to be less than 10% percentage points (a total of almost 25% of its land area).

The CIE visualization in the maps allows exploring the within-region differences. The maps in Fig. 15 compare the projected change in the area under extreme drought (SPEI < -2) (in pp) in **South Africa** since the reference period 2005-2025, for the year 2100 and under two different scenarios, showing the projected changes under a NGFS current policies scenario (left) and a NGFS net zero 2050 scenario (middle) with the third map (right) showing the difference between the two scenarios, illustrating the cost of inaction. It can be seen that in South Africa, the area affected by extreme drought in certain grid cells within South Africa in the current policies scenario is up to 70%-points higher, in the median case, compared to the projected impacts for 2100 in the Paris-aligned scenario.

The Mediterranean is identified as a small hotspot region for severe drought events as shown in the IPCC AR6. The CIE allows for a mapping of country and region specific drought risks, in which these signals become evident.

For **Italy**, projected changes in area exposed to extreme drought increase with global warming, with a pronounced divergence by the 2050s between the NGFS Current Policies and Net Zero 2050 scenarios. By 2050, the Current Policies scenario median case has approximately doubled the exposed area to over 40% and by end-of-century to 66% of Italy being exposed to extreme drought (Figure 16).

Figure 14 **Projected area under extreme drought per year (as percentage of the region area) for South Africa, comparing the NGFS Current Policies Scenario (blue) and the Net Zero 2050 scenario (green)**

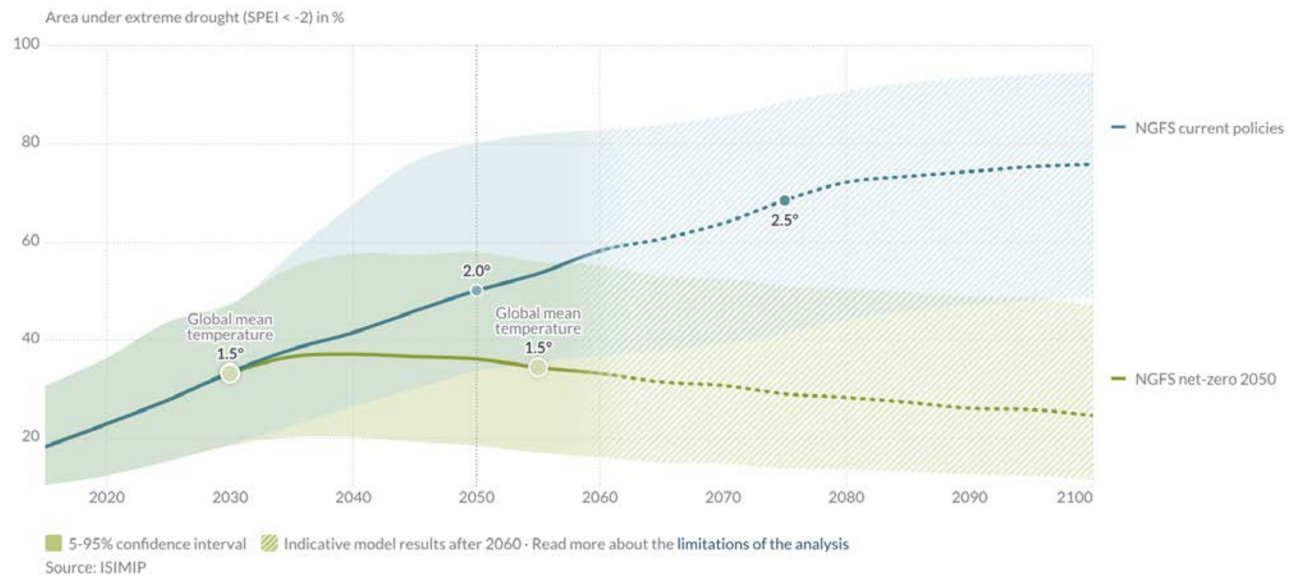


Figure 15 **Map with projected absolute changes in area under extreme drought per year (in percentage points) for South Africa, comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**

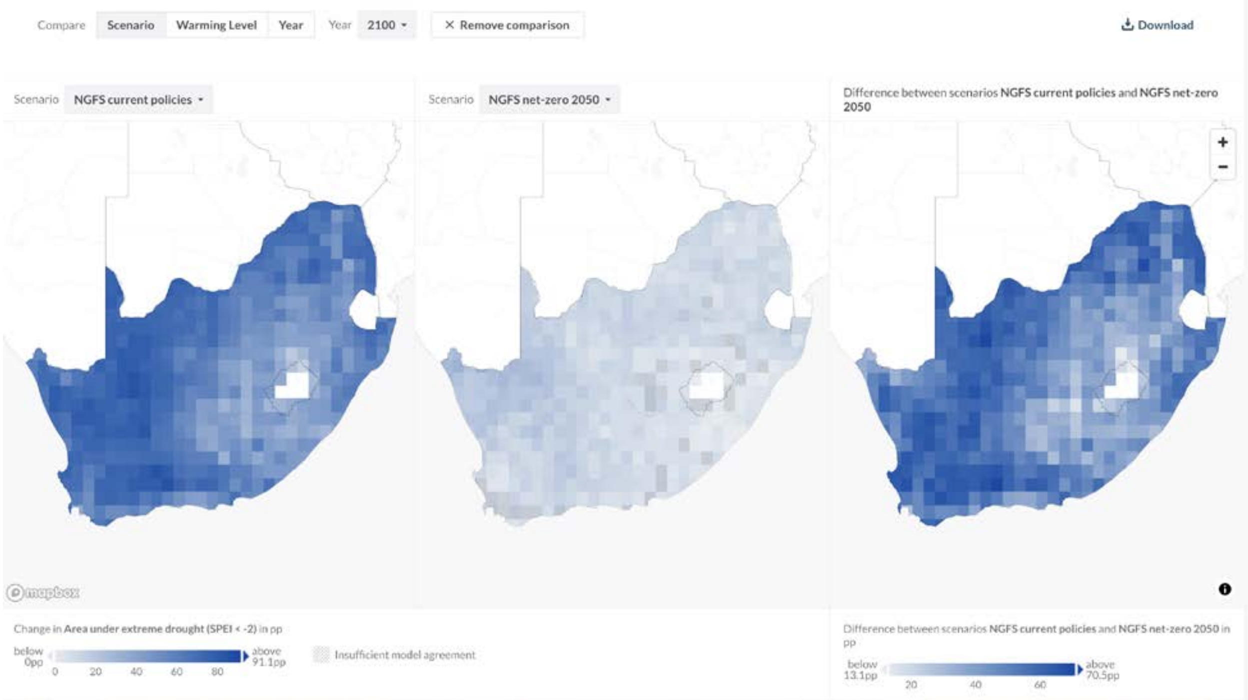
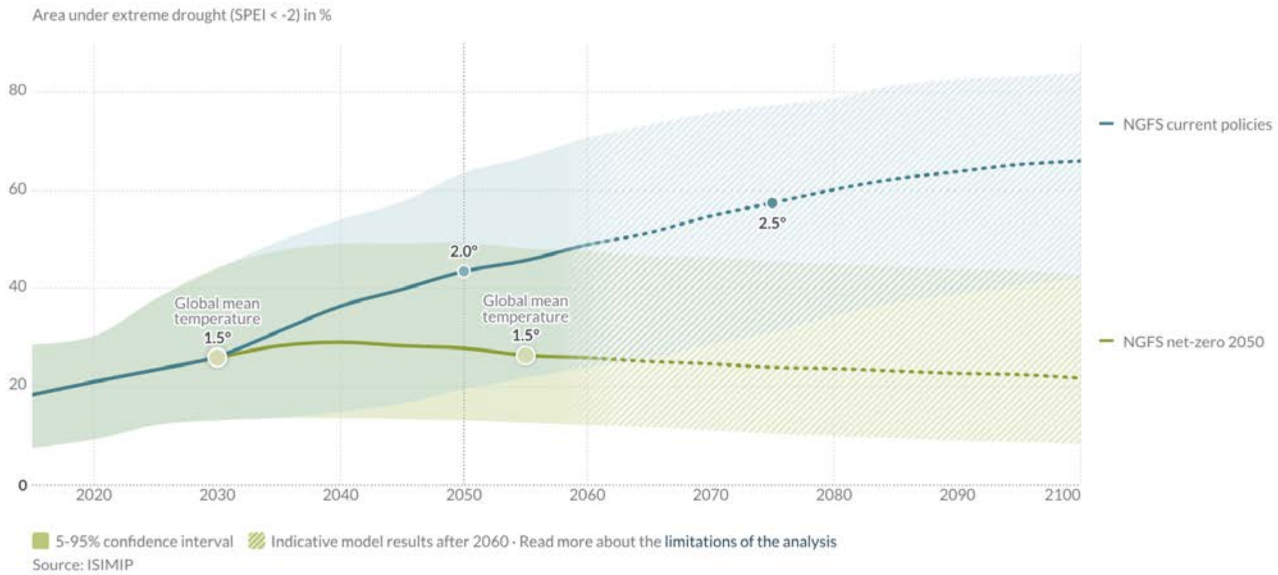
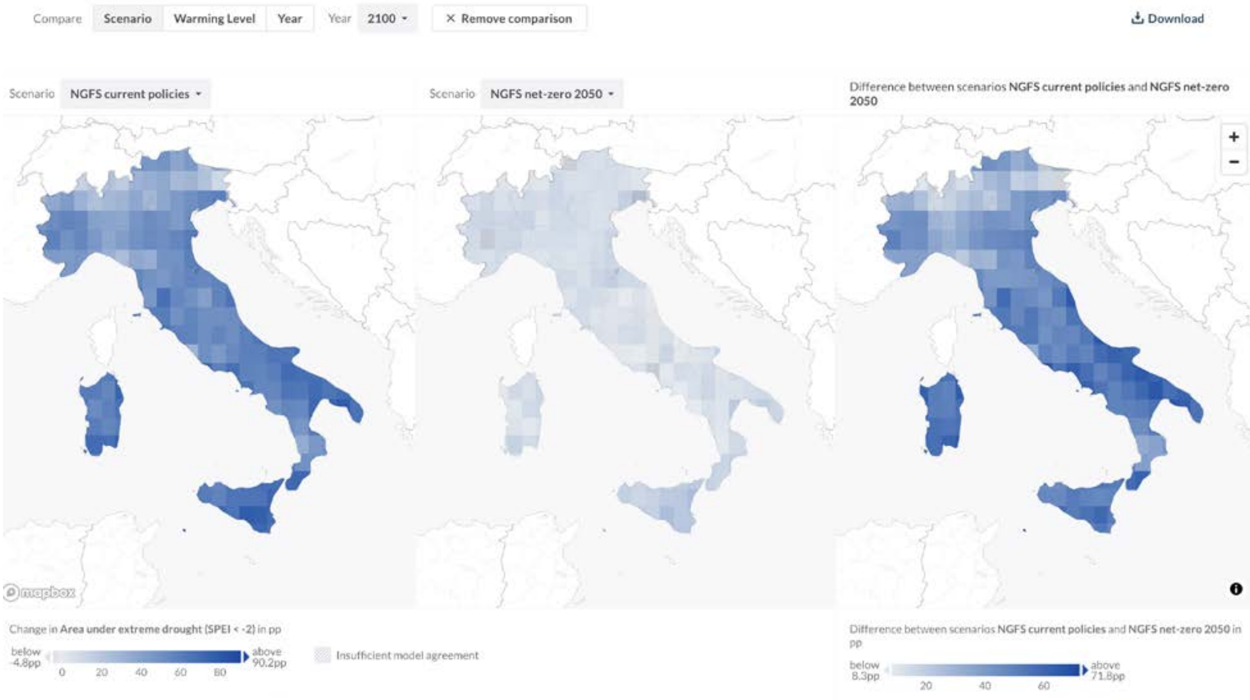


Figure 16 **Projected absolute changes in area under extreme drought per year (as percentage of the region area for Italy, comparing the NGFS Current Policies Scenario (blue) and the Net-Zero 2050 scenario (green)**



Considering the uncertainty ranges of the two scenarios, the results indicate that the best case exposed area under Current Policies is approximately equal to the worst case in the Net Zero 2050 scenario. The within-country distribution of impacts can be viewed on the maps, illustrated in Figure 17 for the same scenarios in 2100. Both scenarios indicate slightly more severe impacts in absolute terms in the southern and eastern regions of Italy, whilst similarly the difference between the two scenarios is also larger in these regions.

Figure 17 **Map with projected absolute changes in area under extreme drought per year (in percentage points) for Italy, comparing the NGFS Current Policies Scenario and the Net-Zero 2050 scenario**



5. Risks in a world of high climate sensitivity

Implications for physical risks if the Current Policies emissions trajectory results in higher warming

There is a wide range of physically possible global warming outcomes (determined by the spread in climate response) for a given emission pathway. A higher global climate sensitivity would lead to *faster and stronger* global warming for the *same* emission trajectory. This would result in stronger climate impacts and damages already in the near-term.

This section explores the consequences of a "high climate response" from Chapter 3, where the climate system responds more strongly to the same emissions pathway used in the *NGFS Current Policies Scenario*. While Chapter 4 assumed a "best estimate" climate response, here we examine the plausible risk that the same emission scenario could lead to a significantly higher global warming trajectory due to a stronger climate response, resulting in a projected end-of-century warming level of almost 1 degree more (see table 2).

We suggest that such an outcome would need to be considered by regulators for physical stress testing purposes, as accounting for plausible 'highest-possible impacts is essential for the financial sector and the economy at large.

Table 2 **Projected Global Mean temperature increase (relative to pre-industrial average) comparing the NGFS Current Policies "best estimate" with the "high climate response" world**

Year	Central estimate of global warming in the Current Policies Scenario "best estimate"	Central estimate of global warming in the Current Policies Scenario "high climate response"
2030	1.5 °C	1.7 °C
2050	2.0 °C	2.5 °C
2080	2.6 °C	3.4 °C
2100	2.9 °C	3.8 °C

Projected changes for extreme events (acute risks) comparing the best estimate with a "high climate response" world

Below, we show results from the CIE for selected countries and indicators comparing the projected physical risks between the "best estimate" assumption versus the "high climate response" world focusing on the NGFS Current Policies scenario. The examples used here do not necessarily represent the most extreme cases, they are only a selection of examples from different regions around the world. Detailed descriptions and trends can be found for other countries and regions in the Annex (A3) and further information can also be found online in the CIE tool.

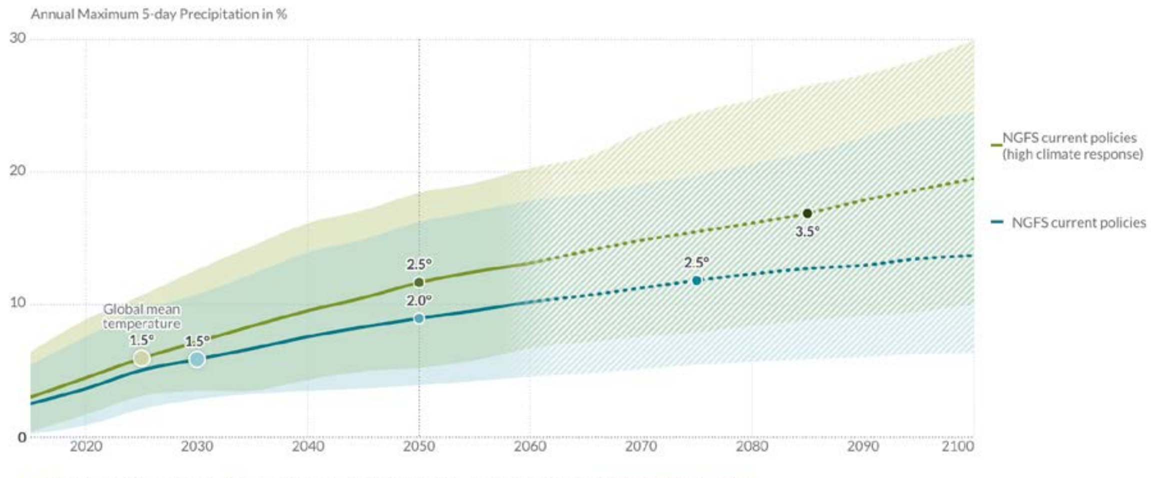
Extreme precipitation

For **China**, extreme precipitation (5 days) is projected to increase by over 19% (relative to 1996-2014) under the "high climate response" world by 2100 versus 13% in the "best estimate" for the NGFS Current Policies scenario (see Figure 18) for the same underlying emission trajectory. In some regions in China, the increase in annual maximum 5-day precipitation is even 28 percentage points higher in the "high climate response" world compared to the best estimate projections.

For **Japan**, the end-of-century increase for the best estimate of the NGFS Current Policy Scenario would be a 12.7% increase in annual maximum 5-day precipitation (relative to 1996-2014) compared to over 16% increase in the "high climate response" world despite the same underlying emission trajectory (see CIE).

Similar trends can be found for other countries and regions globally.

Figure 18 **Projected changes in annual maximum 5-day precipitation relative to a 1996-2014 reference period for China, comparing the NGFS Current Policies Scenario "best estimate" (see chapter 4) with the projected risks in a "high climate response" world**



Source: ISIMIP - Secondary Output

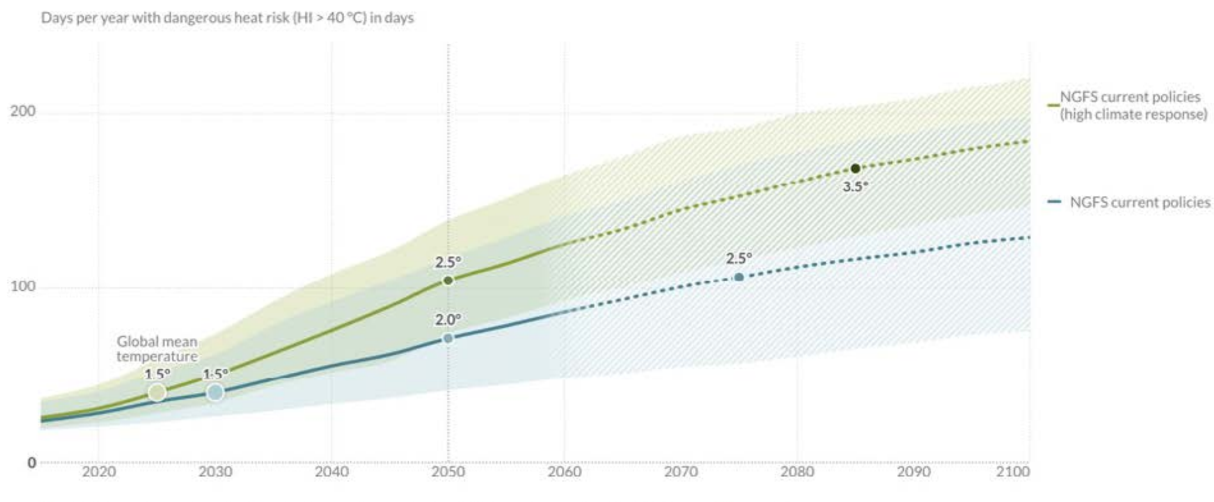
Extreme heat

In the "high climate response" world, the projections for extreme heat would increase dramatically.

For **Brazil**, the projected number of days per year with dangerous heat risk levels by 2100 would be as high as 184 days in the "high climate response" world compared to 129 days from the "best estimate" for same emission trajectory from the NGFS Current Policy scenario. This means that in a "high climate response world" Brazil would suffer from days with dangerous heat risk levels for almost half of the entire year by 2100 (see Figure 19). In Brazil, regional differences are particularly pronounced, with certain areas projected to suffer from up to 135 more days in the "high climate response" world compared to the best estimate projection for 2100 (see Figure 20).

For the **United States**, the projected number of days subject to dangerous heat risk levels increases from 4 days (in 2015) to 13 days by 2050 (instead of 9 for median climate response) and 25 days by 2100 (instead of 16) under a strong climate response in the Current Policies Scenario, a five-fold increase of heat days instead of a four-fold increase.

Figure 19 **Projected (absolute) number of days with dangerous heat levels for Brazil comparing the NGFS Current Policies Scenario "best estimate" with the projected risks in a "high climate response" world**



Source: ISIMIP

Figure 20 **Map with projected changes in days per year with dangerous heat risk levels compared to their projected amount in 2015 for Brazil, between the NGFS Current Policies (high climate response) scenario (left panel) and the best estimate NGFS Current Policies scenario (central panel). Differences are shown in the right panel**

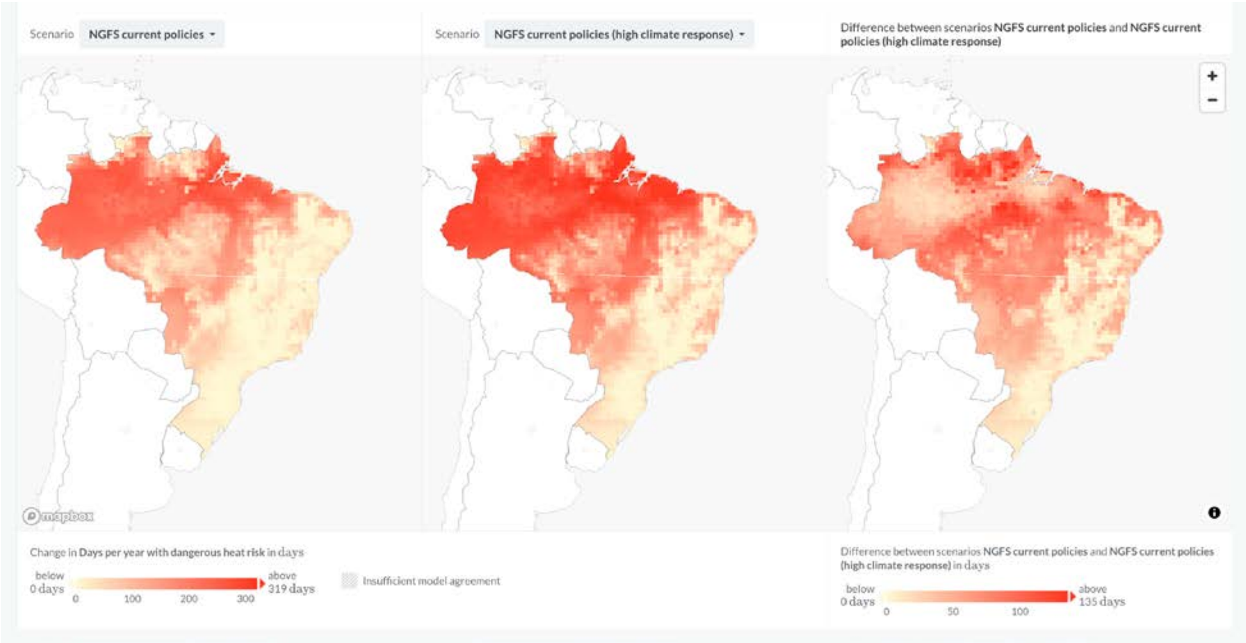
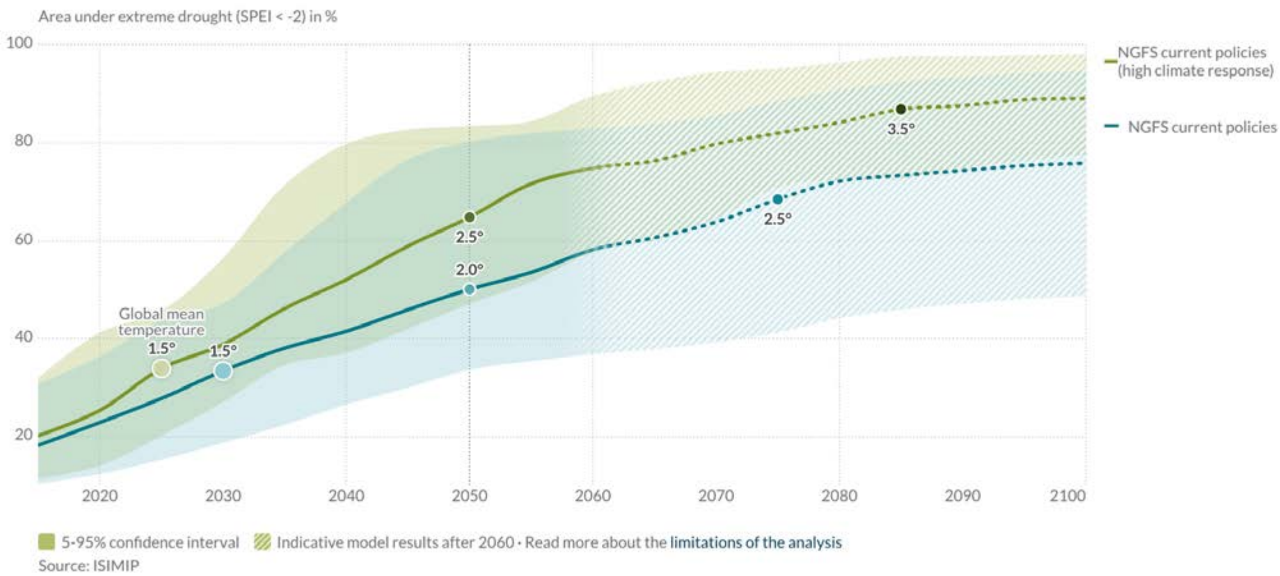


Figure 21 **Projected change in land area exposed to extreme drought for South Africa, comparing the NGFS Current Policies Scenario "best estimate" (blue) with the projected impacts under the same emissions of the Current Policies scenario but where there is a "high climate response" (green) of warming and subsequently different impacts**



Extreme drought

Considering the exposed area to extreme drought conditions, the projections under a "high climate response" world are expected to be more severe compared to the best estimate (median) for the same NGFS Current Policies scenario.

For example, the absolute change for **South Africa** in area under extreme drought (SPEI < -2) would increase by almost 76% compared to the reference period of 2005-2025 in the "best estimate", while in the "high climate response" world it would increase to over 89% by 2100 (see Figure 21).

Figure 22 **Projected changes in the regional distribution of area exposed to extreme drought (SPEI <-2) for South Africa, between the NGFS Current Policies (high climate response) scenario (left panel) and the best estimate NGFS Current Policies scenario (central panel). Differences are shown in the right panel**

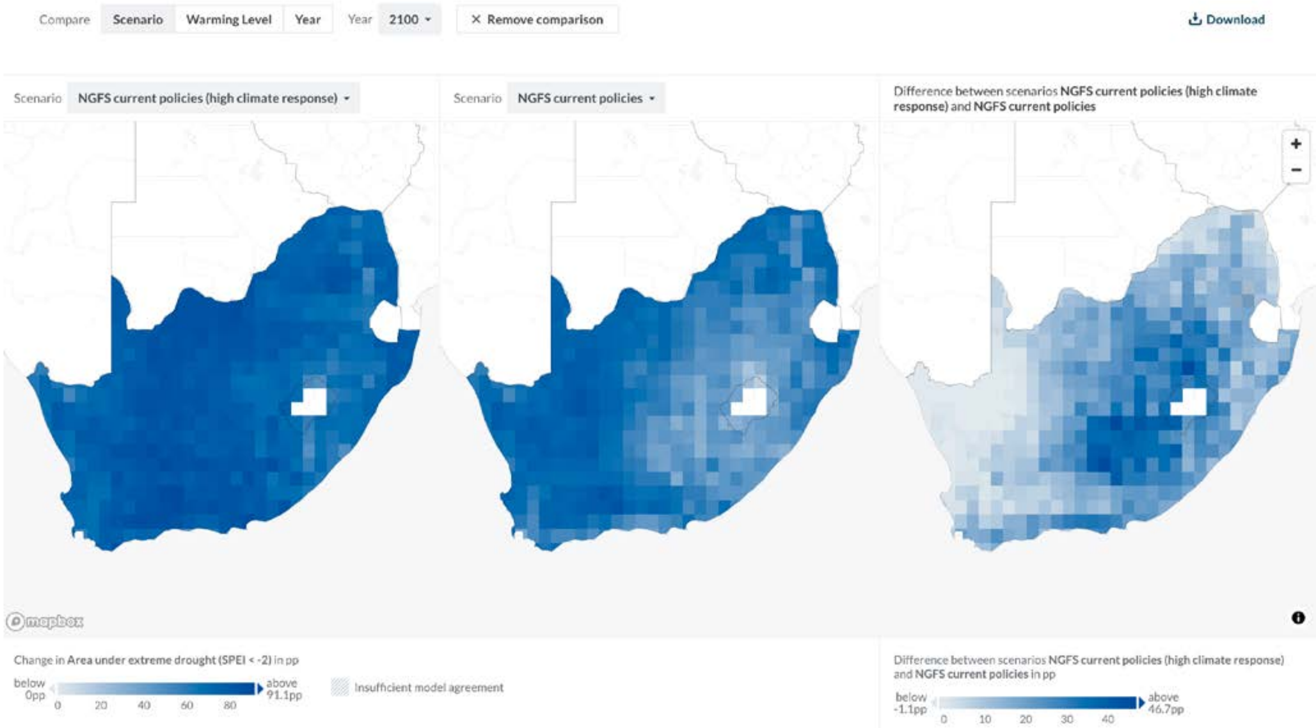


Figure 22 shows the within-country regional response. Impacts are slightly less pronounced in the central south-east of the country in the best-estimate case. Thus, the largest differences between the two scenarios are found here, as shown in the right panel.

For **Italy** the projected area under extreme drought increases steeply from about 20% currently, in the best estimate approaching 45% in the NGFS Current Policies Scenario in the 2050s and at around 55% under the assumption of high climate response. By end of the century these shares are expected to be 66% and 78%, respectively (see CIE). The uncertainty ranges do overlap, as is expected, with the lower limit of the high climate response scenario being similar to the best estimate of the Current Policies scenario, in the second half of the century. Comparing the within-country regional response, impacts are slightly more pronounced in the south and south east of the country in the best estimate case. The largest differences here between the two scenarios are in the central and north west regions (see CIE).

6. While the CIE is a comprehensive tool, it does not cover all risks related to climate change

While the CIE features a broad variety of different physical risks indicators, there are certain gaps in terms of physical risks which are currently not covered. These include risks such as those related to **sea level rise, coastal flooding and storm surges, winter storms / hailstorms, permafrost melting, landslide risk, marine heatwaves, ocean acidification, biodiversity impacts or other sectoral impacts.** The IPCC's Interactive Atlas provides high-level projected changes for most of these. Annex A4 provides insights on the literature on sea level rise and related coastal flooding and storm surges.

Direct damages from tropical cyclones and river floods have been featured in the previous version of the CIE which is now archived and is no longer receiving updates (neither data updates nor scenario vintage updates). For consistency reasons, however, these indicators can no longer be featured in the updated 2025 CIE until the required more work-intense updating processes for these Level III indicators have been carried out.

There is also a discussion in the literature on the potential existence of certain **"Tipping Points"** for the climate system. Although many processes relevant to tipping points (e.g., weakening of the AMOC) are represented within the modelling underlying the CIE indicators, explicit tipping dynamics are not modelled and are therefore not included in the CIE. A forthcoming NGFS note on tipping points (2025) will provide background, rationale, and suggested ways forward.

The IPCC's AR6 also warns that climatic and non-climatic risks will increasingly interact, creating **compound and cascading risks** that are more complex and difficult to manage (high confidence). While some CIE indicators already consider compounding of certain risk factors, e.g. heat and humidity are inputs into the new heat stress and drought indicators, the CIE does not feature specific "storylines" on compounding of acute risks as e.g. is done for the NGFS Short term scenarios. The CIE does not feature any level III indicators at the moment which project economic impacts.[22] However, the CIE shows that it can be the same countries that are projected to face both more intense precipitation extremes as well as more drought extremes (e.g. India), making some form of compounding extremes (e.g. in the same year or consecutive years) more likely.

There is also growing evidence for **physical climate risks to the economy and society**. In the past decade (2015-2025), climate change fueled hazards have cost more than half a million lives and over a trillion dollars of economic damage globally (NOAA NCEI Billion dollar disasters, Climate Risk Index, Neal *et al.* 2025, Trust *et al.* 2025, Actuaries Report). The World Meteorological Organization (WMO) State of the Global Climate Report 2024 features a page-long record of the different extreme events that happened in 2024 only, including information on the related lives lost and economic impacts. The related interactive tool of the WMO provides an overview of 617 reported extreme events of different types that happened in 2024 around the world, classifying 152 of these as "unprecedented" [numbers at the time of writing this report]. Newman and Noy (2023) estimate the costs of extreme events that are attributable to human-driven climate change to be as high as 143 billion USD every year, with 63% of these costs related to losses of human life.

22 Different compound hazards exist that may emerge from complex event relationships over space and time (e.g. concurrent heat extremes over important crop producing regions Kornhuber *et al.* 2020) or the sequential occurrence of several tropical cyclones within a short period of time). While these types of hazards would deserve a rigorous analysis and should be explicitly investigated in the context of climate impacts on the financial system (see. Dolk *et al.* 2023), we are referring to multivariate event types in this context, thus the joint occurrence of extreme heat and humidity for heat stress or the joint occurrence of dry and hot conditions as a risk indicator for crop yields.

7. Summarised implications for CIE users and outlook

CIE users have previously valued the CIE for being a free web tool providing easy access to visualization and download of complex globally consistent climate data for a range of physical risks and a range of scenarios including the NGFS scenarios.

The 2025 update has added more useful features to the CIE that users can now benefit from (see Chapter 2 for more details):

- **Updated and improved input datasets:** The CIE is now based on the latest generation of climate and impact models from CMIP6/ISIMIP3, allowing CIE users to benefit from the methodological improvements including an improved underlying modelling resolution and representation of physical processes, including tail risks. Yet the underlying models remain *global* models which may exhibit weaknesses in representing local patterns accurately compared to higher resolution, regional climate datasets.[23]
- **Improved methodology:** CIE users benefit from a more robust handling of uncertainty ranges and non-linear impact relationships. Moreover, as the underlying newly developed Python package will be made available open-source, advanced users can apply it to their own local data sources to produce their own projections along the NGFS scenarios. In 2026, an example of such an application will be provided (see outlook).
- **Revised indicators:** Improved heat stress and drought indicators (feeding into next year's NiGEM acute risk update) as well as a variety of indicators that had not been covered in the previous CIE version are provided in the new CIE (as shown in Table 1). For data consistency reasons, the indicators for river flood and tropical cyclone direct damage estimates are no longer featured on the updated CIE until a profound update of these can be conducted. To allow users which have been built on the CIE Phase IV, the archived 2024 CIE will remain accessible but will no longer be updated, nor in terms of data nor in terms of new NGFS scenario vintages.
- **Enhanced usability:** A new framework is introduced, categorising indicators based on the underlying level of complexity to better communicate about underlying differences and implications for the confidence in the estimates. We also provide absolute values for selected indicators. Socio-economic data used for e.g. aggregating based on GDP has been updated. However, socioeconomic assumptions are still kept fixed for the projections. An improved tool design and the above mentioned open-source Python package allows for wider application of the new CIE methodology.
- **"High climate response" world for the NGFS Current Policies Scenario:** CIE users can now explore the implications if the climate proves more (or less) sensitive to emissions than currently assumed within plausible ranges. As shown in Chapter 5, for the same emissions scenario, the projected physical risks can be substantially higher if our planet responds more strongly to emissions than currently assumed, i.e. responding with a higher global warming trajectory.

Outlook for 2026:

- The application of the new CIE Methodology to a regional climate model dataset will be tested with the intention of demonstrating its use in more local and high resolution applications, along with a guidance note.
- The new heat and drought indicators will serve as a basis to a planned updating of the NiGEM acute risk estimates on economic impacts in phase VI (2026).

23 The CIE provides a globally comprehensive and consistent dataset of physical risk projections across climate scenarios. With a wide range of indicators, established downscaling and bias correction, a consistent comparison across countries and regions is enabled. Depending on the use case and regions, the data provided may be appropriate, whilst in other cases, higher resolution products, e.g., from regional climate models, may be available. Therefore, whilst the CIE may serve as a useful entry point or screening tool for climate risk, it is not a substitute for detailed national or subnational risk assessments.

Annex
A1 Additional information on the CIE Update

A1.1 Comparison of the previous and the new CIE methodology

Table A1 **What has changed compared to the previous CIE methodology?**

	Previous methodology underlying the 2024 CIE version	New methodology for 2025 CIE
ISIMIP3 preprocessing	(1) Calculate all indicator values from all ISIMIP simulations, mapped to the global warming levels at which they occur (0.1 °C precision), and apply MAGICC to the scenario to obtain an ensemble of probabilistic GMT trajectories.	
Additional ISIMIP preprocessing	(2) For every warming level in the ISIMIP data: Calculate the median indicator value from all indicator values simulated at that warming level in ISIMIP. (3) Calculate the differences between every simulated indicator value and the median indicator value at the warming level it occurred at. Then apply quantile regression to predict the 95th percentile and the 5th percentile of the difference values per warming level.	(2) Retrieve a "quantile map" of indicator values by calculating 11 equidistant quantiles (0–100) describing the distribution of indicator values at each warming level.
MAGICC ensemble preprocessing	(4) Calculate the 5th, median and 95th percentile GMT response for the scenario in five year differences from the probabilistic GMT ensemble.	/
Obtaining the median response for the scenario	(5) For every considered year: Map median GMT response to the median indicator value at that GMT level.	(3) For each year: draw 5,000 samples of indicator values by first randomly selecting one of the 600 MAGICC ensemble members and retrieving its GMT value for that year. Then, create an indicator value distribution by linear interpolation between the 11 quantiles for the selected GMT value and sample one indicator value. Compute the median of the 5,000 samples.
Obtaining the uncertainty band	(6) For every considered year: Predict difference between median response and 5th (95th) percentile using the 5th (95th) percentile of the GMT and the result of the quantile regression in (3). Add that to the median response calculated in (5).	(4) From the same 5,000 samples, calculate the 5th and 95th percentiles (or other chosen percentiles).
	(2) Calculate the 5th and 95th percentile of the differences between the median indicator value and the rest of the indicator values by applying a quantile regression. It uses the global warming level as the predictor and the differences of every indicator value to the median indicator value at the same warming level as the target.	(2) Using the MAGICC output data, calculate the probability that a warming level is reached in a scenario and year.
	(3) Create a time-series by mapping the median global warming level reached in the scenario to the median response of the indicator according to step (1). Then add the 5th and 95th percentile of the differences between indicator values and median responses according to (2), predicted for the 5th and 95th percentile of the GMT in the scenario according to MAGICC.	(3) Calculate the median response, as well as the uncertainty bands as the 5th, 50th and 95th weighted percentile from all ISIMIP3 simulation values, weighted by the probability of the warming levels where they appear at happening at the given point of time in the scenario.
Quantiles available	Limited to 5th, 50th and 95th percentiles (determined *ex-ante*).	Full range, can be chosen ex-post.
Uncertainties	Assumes linear response to GWL.	Response to GWL can be non-linear.

A1.2 Adding the indicators that are the underlying climate data inputs for estimating aggregate damage functions

In the recent literature on climate related damages, a number of climate indicators exhibit meaningful and independent correlations with climate related damages. These have been used in the literature to create regression-based relationships between GDP growth and with climate damage. In addition to standard indicators such as "mean annual surface temperature", a number of studies also consider physical risks indicators such as those described below and in Table A2. The five indicators are described below:

Temperature Variability: The standard deviation of daily mean temperature around monthly mean (°C).

Total Annual Precipitation: This is the sum of all rainfall within a year (in mm/year).

Monthly precipitation deviation: within-year standardized anomalies of monthly rainfall from the long-term mean.

Precipitation Days: The number of precipitation days is simply the count (within a year) of the number of days with at least 1 mm of precipitation. Also often referred to as "wet days".

Extreme Daily Precipitation: The extreme daily precipitation is defined as the rainfall exceeding the 99.9th percentile. This threshold is inferred from the empirical local distribution of daily rainfall amounts. The value shown in the CIE is the percentage change in the extreme daily precipitation over time, relative to the reference periods of 2005-2025.

The 2025 Climate Impact Explorer update includes these typical damage function input indicators in the set of CIE indicators that users can choose from, allowing the exploration of the respective damage function climate input data for their country of interest and also comparing it to alternative climate indicators. These indicators have been calculated using the same CIE datasets, which may differ from the original datasets used in the development of the damage functions. For example, older studies would have been based on CMIP5 not CMIP6 datasets. Note that in NGFS Phase VI (2026) a further exploration of the damage function landscape and ranges is planned.

Table A2 **Overview of damage functions and associated climate variables available through the CIE**

	Annual mean air temperature	Temperature variability	Total annual precipitation	Monthly precipitation deviation	Precipitation days	Extreme daily precipitation
Burke, Hsiang & Miguel (2015)	✔					
Dell, Jones & Olken (2012)	✔		✔			
Kalkuhl & Wenz (2020)	✔		✔			
Kotz *et al.* (2021)	✔	✔				
Kotz, Levermann & Wenz (2022)			✔	✔	✔	✔
Nath, Ramey & Klenow (2024)	✔					
Waidelich *et al.* (2024)	✔	✔	✔	✔	✔	✔

A1.3 Detailed overview of the indicators featured on the updated CIE

To provide more guidance on the underlying nature of the CIE indicators, we provide a categorization into "acute" and "chronic" in Table A3, which we define in the following. Note that these terms are not clear cut.

Acute climate risks are event-driven impacts of climate change, such as storms, floods, heatwaves, and wildfires, resulting from the increasing frequency and severity of extreme weather events. Indicators related to such events, to shorter-term climate conditions, or measuring annual maxima/minima, are considered acute.

Chronic climate risks stem from longer-term shifts in climate patterns, including sustained rising average temperatures, sea level rise, and changes in precipitation patterns, which lead to gradual environmental shifts.

Table A3 **Overview of physical risk indicators featured in the updated CIE including additional description of the indicators**

Indicator name	Indicator description	Unit	Level	Temporal average	Aggregation method	In 2024 CIE	Changes	Acute/ chronic
				Climate				
Relative Humidity	Ratio of water vapour in the air to the total amount that could be held at its current temperature (saturation level, at 2 m above ground)	%	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Specific Humidity	Mass of water vapour contained in each kg of air (at 2 m above ground)	kg kg^{-1}	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Precipitation (Rainfall + Snowfall)	Mass of water (both rainfall and snowfall) falling on the Earth's surface, per unit area and time	mm/day	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Snowfall	Mass of water falling on the Earth's surface in the form of snow, per unit area and time	mm/day	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Atmospheric Pressure (surface)	Force exerted by the weight of the column of air situated at 2 m above a given location, per unit area and time	hPa	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Downwelling Longwave Radiation	Downward energy flux in the form of infrared light that reaches the Earth's surface	W m^{-2}	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Wind Speed	Velocity of an air mass 10 m above ground	m s^{-1}	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Mean Air Temperature	Average temperature of air masses near the Earth's surface (2 m above ground)	°C	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Chronic
Daily Maximum Air Temperature	Peak air temperature reached in a day (2 m above ground)	°C	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Acute
Daily Minimum Air Temperature	Lowest air temperature reached in a day (2 m above ground)	°C	I	Annual, seasonal	Area, population, GDP	Yes	Absolute	Acute
Temperature Variability	Average variability between maximum and minimum daily temperature	°C	I	Annual	Area, population, GDP	No	Absolute	Chronic

Precipitation Days	Count of the number of days within a year with at least 1 mm of rainfall	days	I	Annual	Area, population, GDP	No	Absolute	Chronic
Total Annual Precipitation	Sum of all rainfall within a year	mm $year^{-1}$	I	Annual	Area, population, GDP	No	Absolute	Chronic
				Heat				
Consecutive Tropical Nights	Maximum number of consecutive days where the daily minimum air temperature does not fall below 20 °C	nights	I	Annual	Area, population, GDP	No	Absolute	Acute
Cooling Degree Days	Annual sum of the number of degrees that the daily mean air temperature is above a 26 °C set-point temperature	degree days	I	Annual	Area, population, GDP	No	Absolute	Acute
Annual Maximum Daily Temperature	Annual maximum of the average temperature of air masses near the Earth's surface (2 m above ground)	°C	I	Annual	Area, population, GDP	No	Absolute	Acute
Daily Maximum Wet Bulb Temperature	Annual maximum of the wet-bulb temperature, calculated using the Stull equation based on maximum daily temperature of air masses near the Earth's surface (2 m above ground) and relative humidity	°C	I	Annual, seasonal	Area, population, GDP	No	Absolute	Acute
Days Per Year With Emerging Heat Risk	Number of days per year at which the daily maximum Heat Index exceeds the 'caution' threshold of 26.7 °C. The Heat Index is based on a definition by NOAA and relies on daily maximum temperature (tasmax) and relative humidity (hurs), and is widely used for heat risk warnings	days	I	Annual	Area, population, GDP	No	Absolute	Acute
Days Per Year With High Heat Risk	Number of days per year at which the daily maximum Heat Index exceeds the 'extreme caution' threshold of 32.2 °C. The Heat Index is based on a definition by NOAA and relies on daily maximum temperature (tasmax) and relative humidity (hurs), and is widely used for heat risk warnings	days	I	Annual	Area, population, GDP	No	Absolute	Acute
Days Per Year With Dangerous Heat Risk	Number of days per year at which the daily maximum Heat Index exceeds the 'danger' threshold of 40 °C. The Heat Index is based on a definition by NOAA and relies on daily maximum temperature (tasmax) and relative humidity (hurs), and is widely used for heat risk warnings	days	I	Annual	Area, population, GDP	No	Absolute	Acute
Days Per Year With Extremely Dangerous Heat Risk	Number of days per year at which the daily maximum Heat Index exceeds 'extreme danger' threshold of 51.7 °C. The Heat Index is based on a definition by NOAA and relies on daily maximum temperature (tasmax) and relative humidity (hurs), and is widely used for heat risk warnings	days	I	Annual	Area, population, GDP	No	Absolute	Acute

Extreme Precipitation								
Annual Maximum 5-day Precipitation	Maximum accumulated mass of water (both rainfall and snowfall) falling on the Earth's surface over a period of five days	%	I	Annual	Area, population, GDP	No	Relative	Acute
Total Precipitation From Extreme Precipitation Events	Rainfall exceeding the 99.9th percentile (derived from the empirical distribution of daily rainfall amounts)	%	I	Annual	Area, population, GDP	No	Relative	Acute
Heavy Precipitation Days	Annual number of days with daily precipitation exceeding 10 mm	days	I	Annual	Area, population, GDP	No	Absolute	Acute
Annual Maximum Daily Precipitation	Maximum daily precipitation	%	I	Annual	Area, population, GDP	No	Relative	Acute
Freshwater								
Surface Runoff	Flow of water occurring on the Earth's surface when excess water, e.g. rainwater, can no longer be absorbed by the soil	%	II	Annual, seasonal	Area, population, GDP	Yes	Relative	Chronic
River Discharge	Volume of water flowing through a river or stream channel	%	II	Annual, seasonal	Area, population, GDP	Yes	Relative	Chronic
Drought								
Annual Drought Intensity	Fraction between daily river discharge deficit volume below the 10th percentile daily discharge (Q90) of the reference period (1974-2004) and drought event duration	$m^3\ s^{-1}\ day^{-1}$	II	Annual	Area, population, GDP	No	Absolute	Chronic
Consecutive Dry Days	Maximum number of consecutive dry days with a daily precipitation amount < 1 mm	days	I	Annual	Area, population, GDP	No	Absolute	Acute
SPEI	Balance between precipitation (water supply) and potential evapotranspiration (water demand) over the past 12 months (SPEI-12), expressed in standard deviations from a historical reference period (1974-2004); values below -1.0 are considered drought conditions	Unitless	I	Annual, seasonal	Area, population, GDP	No	Absolute	Chronic
Annual Minimum SPEI	Lowest monthly SPEI-12 value within a given year, representing the maximum drought severity experienced during that year	Unitless	I	Annual, seasonal	Area, population, GDP	No	Absolute	Acute
Water Stress Index	Fraction between net human demands (domestic, industrial, irrigation) and renewable surface water availability, also known as the withdrawal to availability ratio	Unitless	II	Annual	Area, population, GDP	No	Absolute	Chronic
Area Under Moderate drought (SPEI < -1)	Fraction of area where the SPEI-12 index falls below -1, indicating regions experiencing moderate drought (or worse) relative to the historical reference period (1974-2004)	%	I	Annual	Area, population, GDP, harvest area	No	Absolute	Acute

Area Under Severe Drought (SPEI < -1.5)	Fraction of area where the SPEI-12 index falls below -1.5, indicating regions experiencing severe drought (or worse) relative to the historical reference period (1974-2004)	%	I	Annual	Area, population, GDP, harvest area	No	Absolute	Acute
Area Under Extreme Drought (SPEI < -2)	Fraction of area where the SPEI-12 index falls below -2.0, indicating regions experiencing extreme drought (or worse) relative to the historical reference period (1974-2004)	%	I	Annual	Area, population, GDP, harvest area	No	Absolute	Acute
Area Under Very Extreme Drought (SPEI < -2.5)	Fraction of area where the SPEI-12 index falls below -2.5, indicating regions experiencing very extreme drought (or worse) relative to the historical reference period (1974-2004)	%	I	Annual	Area, population, GDP, harvest area	No	Absolute	Acute
Fire								
Fire Weather Index – length of fire season	Number of days above the local threshold defined as the mid range of the extrema in the FWI over the reference period (1974-2004)	days	II	Annual	Area, population, GDP	No	Absolute	Chronic
Fire Weather Index – days with extreme fire weather	Local annual number of days above the local threshold (the local thresholds are defined as the 95th percentile of the FWI over the 1974-2004 historical period)	days	II	Annual	Area, population, GDP	No	Absolute	Acute
Agriculture								
Maize Yield Changes	Annual mean yields are derived from the ISIMIP3b crop model ensemble (Jägermeyr *et al.*, 2021) and represent the simulated yield per hectare in each grid cell relative to the 1983-2013 reference period	%	II	Annual	Area, observed yield	Yes	Relative	Chronic
Rice Yield Changes	Annual mean yields are derived from the ISIMIP3b crop model ensemble (Jägermeyr *et al.*, 2021) and represent the simulated yield per hectare in each grid cell relative to the 1983-2013 reference period	%	II	Annual	Area, observed yield	Yes	Relative	Chronic
Soy Yield Changes	Annual mean yields are derived from the ISIMIP3b crop model ensemble (Jägermeyr *et al.*, 2021) and represent the simulated yield per hectare in each grid cell relative to the 1983-2013 reference period	%	II	Annual	Area, observed yield	Yes	Relative	Chronic
Wheat Yield Changes	Annual mean yields are derived from the ISIMIP3b crop model ensemble (Jägermeyr *et al.*, 2021) and represent the simulated yield per hectare in each grid cell relative to the 1983-2013 reference period	%	II	Annual	Area, observed yield	Yes	Relative	Chronic
Labour Productivity								
Labour Productivity Loss due to Heat Stress	Percentage decrease in efficiency during regular working hours under hot and humid climate conditions, due to the reduced capacity of the human body to perform physical labour, in a given area and year	%	II	Annual, Seasonal	Area, population, GDP	Yes		Acute

A2 Technical information on deriving the uncertainty ranges related to the climate response

The 5-95% uncertainty ranges jointly quantify response uncertainty and model uncertainty. We start by quantifying response uncertainty in the GMT changes by applying the simple climate model MAGICC to the assumed greenhouse gas emission of each scenario. MAGICC translates those greenhouse gas emissions into pathways for globally defined atmospheric variables such as the GMT using a simple carbon cycle model and a set of energy balance equations. However, as some key climate system properties of the Earth cannot be unambiguously determined, MAGICC runs 600 times making differing plausible assumptions about their values. As a result, MAGICC generates a set of 600 plausible trajectories of GMT, which we use to quantify response uncertainty. To quantify model uncertainty in the climate impact projections at given GMT levels, we collect all values for the impact simulated in ISIMIP3 along with the GMT level at the time the value is simulated. Then we group all impact values according to their corresponding GMT levels. This gives us a large sample of possible impact outcomes at every considered GMT level from which we estimate an impact value distribution conditioned on the GMT value. We generate 5,000 impact value samples by randomly selecting a GMT value from the MAGICC ensemble distribution and then randomly selecting an impact value from the impact value distribution corresponding to the GMT value. We calculate the 5th and 95th quantile from those samples.

The 5-95% uncertainty ranges characterizing each source of uncertainty are then combined to provide the full uncertainty range. An illustration is provided in Figure 5 in Chapter 3 with the 5-95% MAGICC uncertainty for GMT projections highlighted in green and the 5-95% uncertainty for impact projections in orange. The combined full uncertainty range is given by the blue markers. More information on the methodology and underlying assumptions can be found on the methodology page of the CIE.

A3 Discussion of CIE insights for additional countries

A3.1 Extreme precipitation

India

For **India**, by 2100 the Current Policies scenario projects an almost 12% increase in Annual Maximum 5-day Precipitation compared to the reference period, while the projected increase for the more ambitious Net Zero scenario would be less than 4% by the end of the century, illustrating the extent to which climate impacts that could be mitigated by ambitious climate action (see CIE). Regional differences within India are strong with projected increases in certain regions by up to 39% compared to the reference period in the Current Policies Scenario, up to 25 percentage points higher than in the Net Zero Scenario (for visual depiction of these estimates we refer to the CIE webtool).

Accounting for uncertainty in the climate responding to emissions, the picture looks even more severe for India. Annual maximum 5-day precipitation is projected to increase by 18% in the "high climate response" world (relative to reference period 1996-2014) compared to less than 12% in the "best estimate" projection for 2100.

Paraguay

On the other side of the planet, for **Paraguay**, the projected changes by 2100 for the Current Policies Scenario amount to over 10% increase in Annual Maximum 5-day Precipitation compared to the reference period (1996-2014), while in the Net Zero scenario these would be only about 2.5% (see CIE). In the South of Paraguay, the projected changes amount to over 18% increases in Annual Maximum 5-day Precipitation compared to the reference period, and more than 12%-points higher projected increase than the Net Zero Scenario (see CIE).

In the "high climate response" world, the picture worsens. Annual maximum 5-day precipitation is projected to increase by 16.8% in the "high climate response" world (relative to reference period 1996-2014) compared to 10.5% in the "best estimate" projection for 2100, with certain regions within Paraguay projected to be exposed to almost 13 percentage points higher increases in the "high climate response" world compared to the best estimate.

USA

Annual maximum 5-day precipitation in the **USA** is projected to increase by almost 10% in the Current Policies scenario compared to the reference period (1996-2014) by the end of the century, while in the Net Zero Scenario, it is projected to increase by 3.1% by 2100 (close to 5% by 2050) (see CIE).

Accounting for uncertainty in the climate responding to emissions, the difference would be between less than 10% (best estimate projection for 2100) compared to over 13% increase by 2100 relative to the reference period in the "high climate response" world.

A3.2 Extreme heat

Mali

In Africa, **Mali** as well as Niger are among the countries to be most strongly affected by increases in dangerous heat risk levels. For Mali, the projected number of days would grow in the Net Zero scenario to 80 days by 2050 returning to 68 days by 2100 compared to roughly 61 days in 2015, and more than double to 136 days in the Current Policies scenario (see CIE).

Colombia

For **Colombia**, the projected number of days subject to dangerous heat risk levels increases from 14 days in 2015 to 47 days by 2050 and 107 days by 2100 under the Current Policies Scenario – a more than 7-fold increase. In the Net Zero Scenario, in contrast, the number of dangerous heat days in Colombia is projected to increase to 26 days by 2050 and be about 18 days in 2100 (see CIE).

Greece

For **Greece**, the projected number of days subject to dangerous heat risk levels increases from only 1 day in 2015 to 3 days by 2050 and 9 days by 2100 under the Current Policies Scenario. In the Net Zero Scenario, in contrast, the number of dangerous heat days in Greece is projected to not change. In the "high climate response" scenario the projected number of days with dangerous heat levels by 2100 would be 22 days compared to 9 days in the "best estimate", thus a high climate sensitivity would lead to more than a doubling for the same emission trajectory (see CIE).

Indonesia

Indonesia is among the countries to be strongly affected by rising numbers of days per year with dangerous heat risk. Starting from 18 days with dangerous heat risk levels in 2015, the number of days is projected to more than triple to 62 days by 2050 and to increase by almost a factor of seven to 125 days by 2100 in the Current Policies scenario, while it would be projected to increase to 37 by 2050 and decrease to 23 days by 2100 in the Paris-aligned Net Zero scenario. In a "high climate response world", the projected number of days with dangerous heat risk levels for the end of the century would be 125 days in the "best estimate" compared to 187 days in a "high climate response world", with a high climate sensitivity adding over 60 additional days for the same Current Policy emission trajectory (see CIE).

A4 Additional insights from the literature on selected physical risks not covered in the CIE

Sea level rise

As the global climate changes, the impact of those changes will be a function of changes in vulnerability, exposure and adaptive capacity as well. Of the world's 8 billion people, a little over 2 billion (or almost 30%) live within 50 km of the coastline (Cosby *et al.* 2024). This exposure of people and assets to coastal hazards amplifies the risk from storm surge and sea level rise.

According to the IPCC, the projected range of sea level rise by 2100 is between 0.3 and 1 meter (IPCC AR6 WG1 Chapter 9) (noting that since 1900, there has already been about 0.2-0.25 m of sea level rise). However, there are significant uncertainties associated with these projections and there is a non-zero risk that the actual sea level rise from glacier and ice sheet melt might be much much larger – potentially on the order of several meters (Horton *et al.*, 2020). The West Antarctic ice sheet constitutes about 4-5 meters of global sea level rise and the Greenland ice sheet constitutes about 7 meters, whereas the vast ice sheet in eastern Antarctica constitutes about 60 meters of sea level rise (antarcticglaciers.org).

Thus far, the main manifestation of sea level rise related losses have been through the amplification of storm surges (Buchanan *et al.* 2017, Wang and Yang 2019). But chronic, creeping sea level rise has already had significant impacts, particularly on low-lying island nations including small island developing states (Martyr *et al.* 2021, Vousdoukas *et al.* 2023).

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