

Global warming - physicist's perspective - 05

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NAUKA O KLIMACIE
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CMIP Overview

On this Page

[What is CMIP?](#)[History](#)[CMIP Data](#)

CMIP is a project of the World Climate Research Programme (WCRP). Members of the [CMIP Core Panel](#) are currently working on developing the design of CMIP phase 7 (CMIP7). [Task teams](#) have been created to bring in expertise from across the climate science community, each tackling a different aspect of the design. [Click here](#) for updates on CMIP7 and for the pages on the [CMIP7 task teams](#). The data output for CMIP phase 6 (CMIP6) is available on the Earth System Grid Federation (ESGF). For more information on CMIP6, [click here](#).

What is CMIP?

The Coupled Model Intercomparison Project (CMIP) is an international climate modelling project, designed to better understand past, present and future changes in the climate. A climate model is a complex computer code that creates a digital analogue to Earth. This model digitises the processes and interactions between parts of Earth's climate system: the atmosphere, ocean, land surface, cryosphere and biosphere. We use models to experiment how future changes in human activities will impact the Earth's future climate, how much it warms, how floods, droughts and other extremes will change. However, many processes in our climate occur on such small scales, that models are not able to exactly represent them in models, and therefore some simplifications are required. How we simplify the climate system is unique to each model. Therefore comparing simulations from different models is useful for understanding which results are consistent across models, and which results are less agreed upon. Since 1995, CMIP has been coordinating this model intercomparison across the climate science community. This multi-model approach helps to evaluate climate models, leads to improvements in the model simulations and provides a better understanding of past, present and future climates. One additional strength of CMIP lies in its global infrastructure which has gathered the data and gives open access for a growing global research community. CMIP has grown from a modest scientific research initiative in the early nineties to become a global enterprise: more than 50 modelling centres around the world are participating in the sixth phase of CMIP, CMIP6. Many hundreds of scientific papers have already been published and the results are taken into account for policy decisions. CMIP has been organised in different phases, each with new and improved climate model experiment protocols, standards, and data distribution mechanisms. [CMIP6](#) is the most recent phase to release its modelling output data for general use, whilst the latest phase, [CMIP7](#) is in its earliest organisational stages. CMIP is a project of the World Climate Research Programme (WCRP), providing climate projections to understand past, present, and future climate changes. It is part of the WCRP Earth System Modelling and Observations (ESMO) Core Project, which was formed to coordinate all modelling, data, and observation activities across WCRP and its key partners. Under the guidance and at the direction of the [Working Group on Coupled Modelling \(WGCM\)](#), CMIP activities are overseen by a coordinated pair of subcommittees: the [CMIP Panel](#) and the [WGCM Infrastructure Panel \(WIP\)](#). This continued collaboration of climate scientists has resulted in CMIP knowledge being extended across the world. As such, this website brings this together to provide a one-stop shop for key resources, events, news, and information for the CMIP community. If there is any information you cannot find on these webpages, please see our [FAQs](#) and [community-led Q&A forum](#).



Coupled Model Intercomparison Project (CMIP)

- Understanding past, present and future climate -

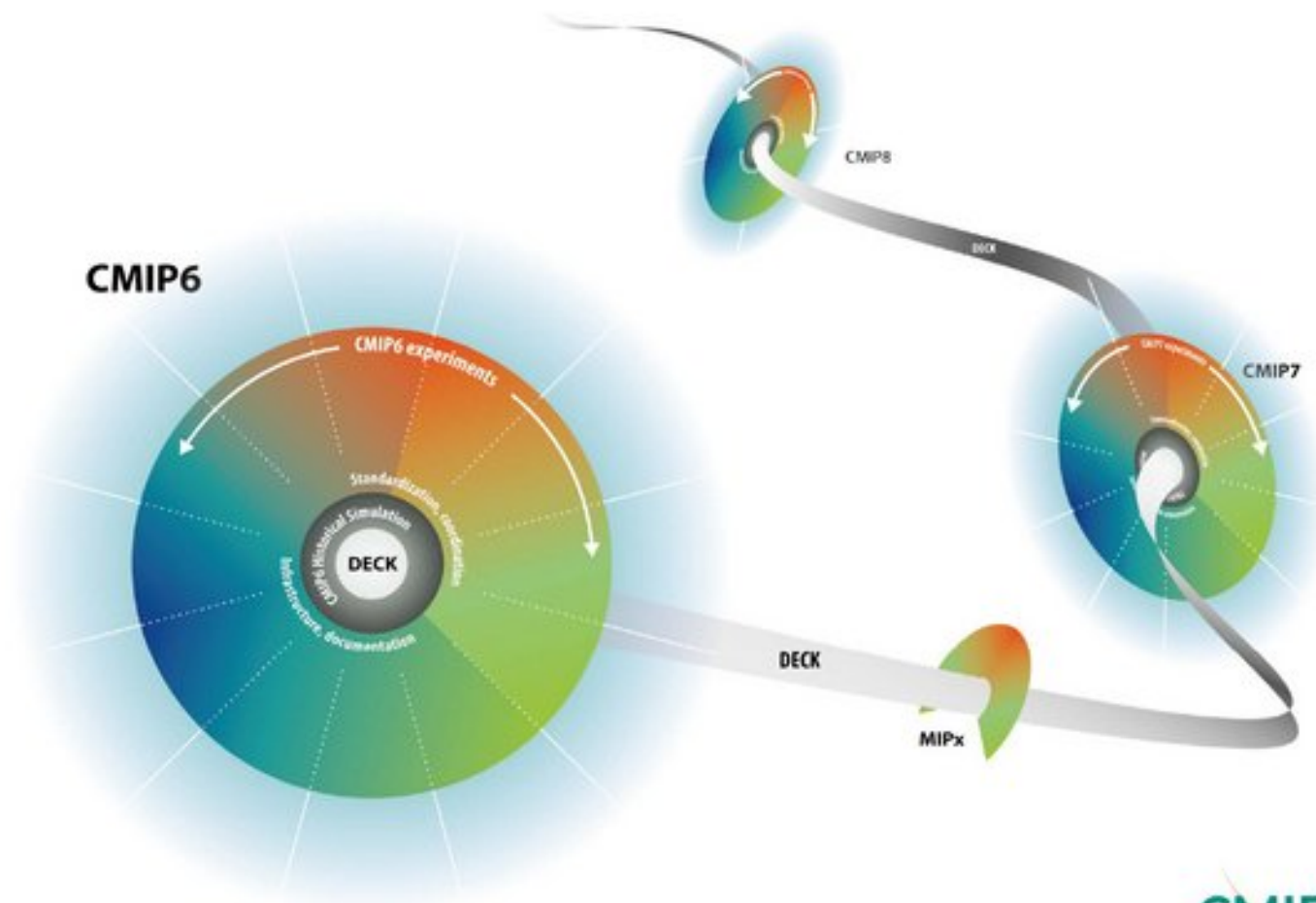
- CMIP is a project of the World Climate Research Programme (**WCRP**)'s Working Group of Coupled Modelling (**WGCM**).
- Since 1995, **CMIP** has coordinated climate model experiments involving multiple international modeling teams worldwide.
- CMIP has led to a better understanding of past, present and future climate change and variability in a **multi-model framework**.
- CMIP defines **common experiment protocols, forcings and output**.
- CMIP has developed in phases, with the simulations of the fifth phase, CMIP5, now completed, and the planning of the sixth phase, i.e. CMIP6, well underway.
- CMIP's central goal is to advance scientific understanding of the Earth system.
- CMIP model simulations have also been regularly assessed as part of the IPCC Climate Assessments Reports and various national assessments.

CMIP6 Design: Scientific Focus

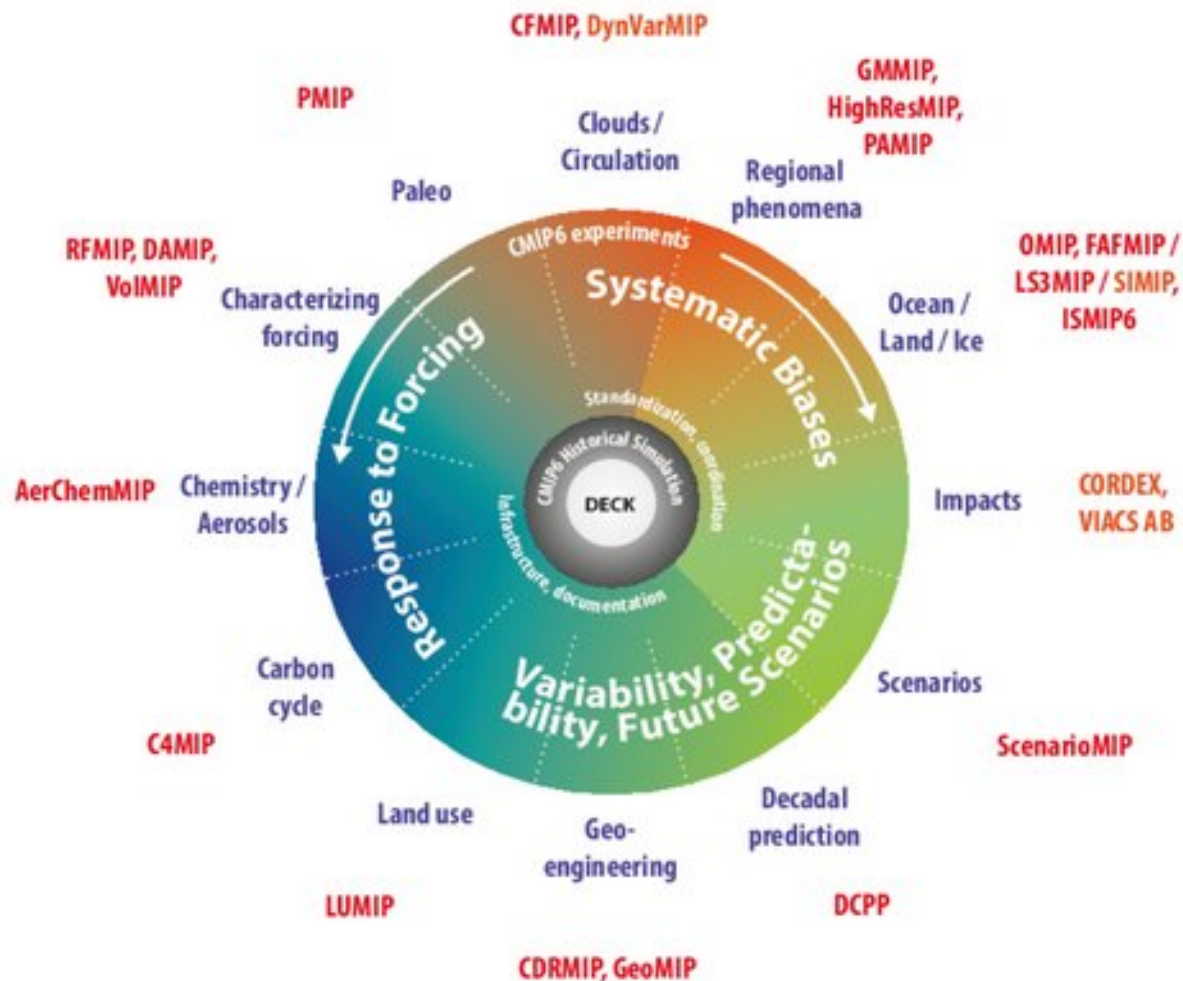
- The **scientific backdrop** for CMIP6 is the **WCRP Grand Science Challenges**:
 1. Clouds, Circulation and Climate Sensitivity
 2. Changes in Cryosphere
 3. Climate Extremes
 4. Regional Sea-level Rise
 5. Water Availability
 6. Near-Term Climate Prediction
 7. Biogeochemical Cycles and Climate Change
- The specific experimental design is focused on **three broad scientific questions**:
 1. How does the Earth System respond to forcing?
 2. What are the origins and consequences of systematic model biases?
 3. How can we assess future climate changes given climate variability, predictability and uncertainties in scenarios?

CMIP Continuity

A common suite of experiments for each phase of CMIP provides an opportunity to construct a multi-model ensemble using model output from various phases of CMIP



23 CMIP6-Endorsed MIPs



CMIP6: Participating Model Groups

	Institution	Country		Institution	Country		Institution	Country
1	AWI	Germany	12	DOE	USA	23	MRI	Japan
2	BCC	China	13	EC-Earth-Cons	Europe	24	NASA-GISS	USA
3	BNU	China	14	FGOALS	China	25	NCAR	USA
4	CAMS	China	15	FIO-RONM	China	26	NCC	Norway
5	CasESM	China	16	INM	Russia	27	NERC	UK
6	CCCma	Canada	17	INPE	Brazil	28	NIMS-KMA	Republic of Korea
7	CCCR-IITM	India	18	IPSL	France	29	NOAA-GFDL	USA
8	CMCC	Italy	19	MESSY-Cons	Germany	30	NUIST	China
9	CNRM	France	20	MIROC	Japan	31	TaiESM	Taiwan, China
10	CSIR-CSIRO	South Africa	21	MOHC	UK	32	THU	China
11	CSIRO-BOM	Australia	22	MPI-M	Germany	33	Seoul Nat.Uni	Republic of Korea

New in CMIP:

- 2 new model groups from Germany (AWI, MESSY-Consortium)
- 4 new model groups from China (CAMS, CasESM, NUIST, THU)
- 1 new model group from Brazil (INPE)
- 1 new model group from India (CCCR-IITM)
- 1 new model group from Taiwan, China (TaiESM)
- 1 new model group from USA (DOE)
- 2 new model group from Republic of Korea (NIMS-KMA, SAM0-UNICON)
- 1 new model group from South Africa / Australia (CSIR-CSIRO)

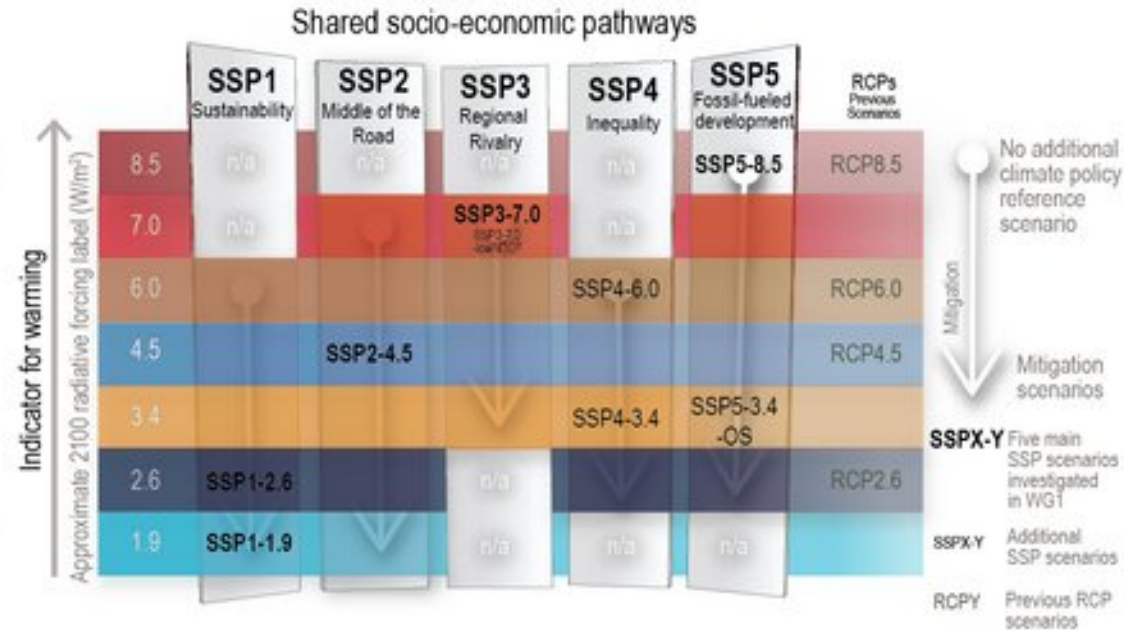
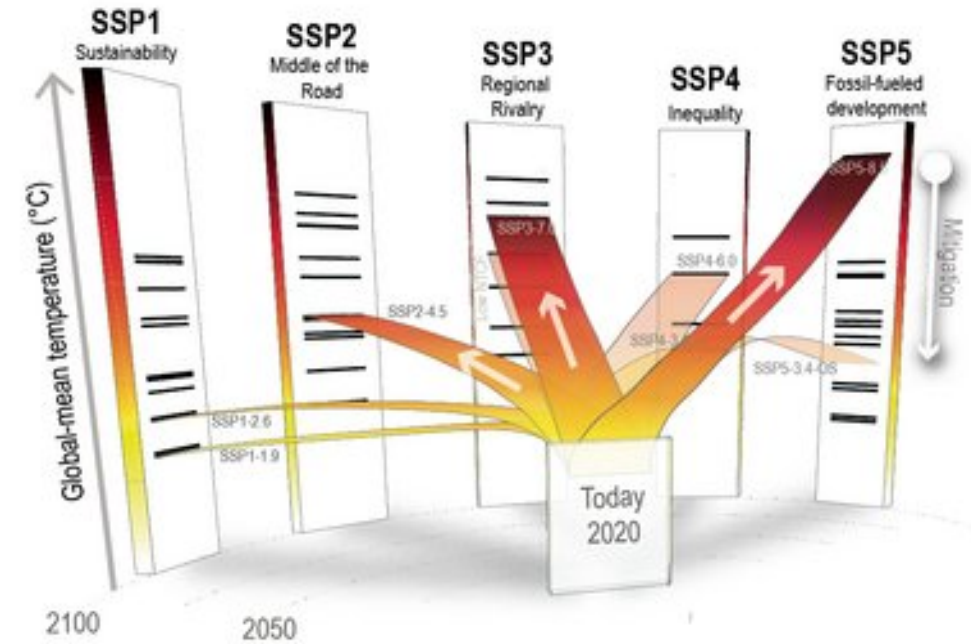
=====

⇒ **13 new model groups so far**

* Other models can join providing DECK and historical simulations are submitted

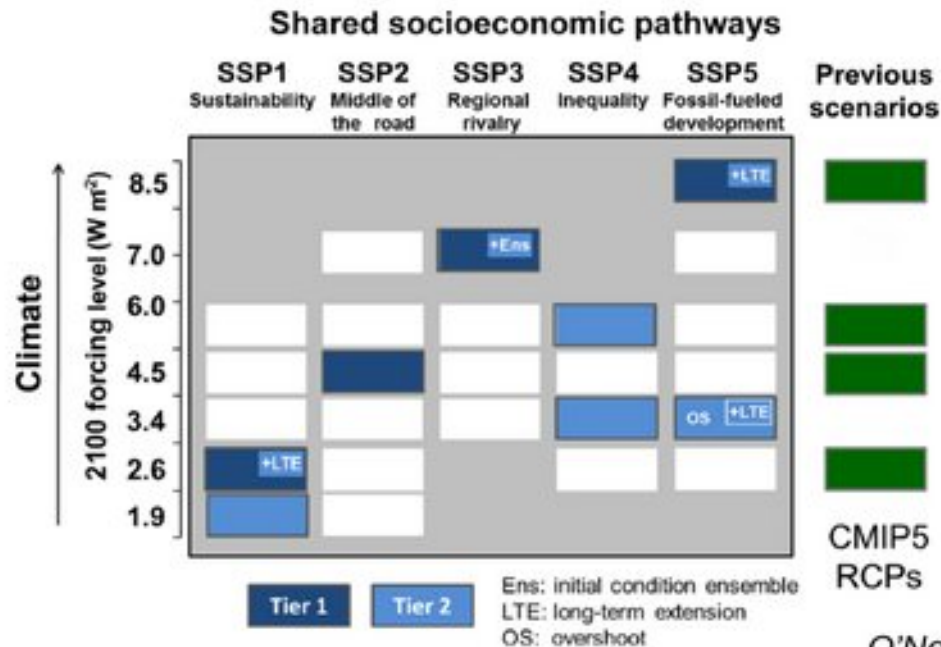
More models (>70)
New models
More complex models
Higher resolution models

Future is hardly predictable.
But we may do something. We have power and knowledge.

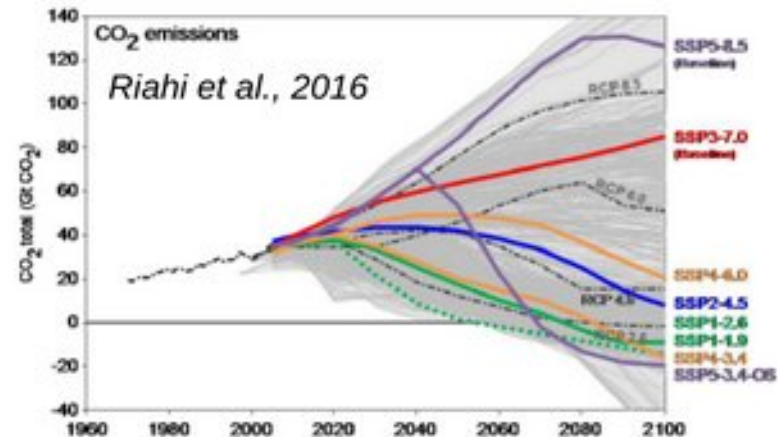


Key Messages: Model Projections / Predictions (2)

SSPs: set of baselines, with future developments in absence of new climate policies beyond those in place today



Future in CMIP6: 2015-2100 plus Extensions to 2300



O'Neill et al., ScenarioMIP for CMIP6, GMD, 2016

ScenarioMIP: New scenarios span a similar range as the RCPs, but fill critical gaps, including

- Role of specific forcings such as land use and short-lived species (air quality)
- The effect of a peak and decline in forcing,
- The consequences of scenarios that limit warming to below 2 °C,

DCPP: Improvements in models, reanalysis, methods of initialization and ensemble generation, and data analysis will provide extended comprehensive decadal predictions

CMIP6 - Coupled Model Intercomparison Project Phase 6

Overview:

The WCRP Working Group on Coupled Modeling (WGCM) oversees the Coupled Model Intercomparison Project, which is now in its 6th phase. Background information about CMIP and its phases can be found on WGCM website as well as on the PCMDI hosted pages. An introductory overview of CMIP6 is also provided by the WGCM.

Practical information for those interested in participating in CMIP6 is provided in [three guides](#), tailored to different groups:

1. Modelers carrying out CMIP6 simulations,
2. Data managers responsible for data node operations, and
3. Data users analyzing and making use of CMIP6 model output

Model output Access:

- First see the [Data Users Guide](#)
- [Summary table](#) of currently available data
- The complete archive of CMIP6 output is accessible from any one of the following portals:
 - USA, PCMDI/LLNL (California) - <https://esgf-node.llnl.gov/projects/cmip6/>
 - France, IPSL - <https://esgf-node.ipsl.upmc.fr/projects/cmip6-ipsl/>
 - Germany, DKRZ - <https://esgf-data.dkrz.de/projects/cmip6-dkrz/>
 - UK, CEDA - <https://esgf-index1.ceda.ac.uk/projects/cmip6-ceda/>

CMIP6 Endorsed MIPs:

- WCRP Endorsed (Model Intercomparison Project) MIPs overview page
- CMIP6 Ocean Model Intercomparison Project (OMIP) overview page

Additional information for CMIP6:

- [CMIP6 license and terms of use](#)

CMIP6 Modeling Groups (click on flags to reveal identity)



Document version: 15 February 2018



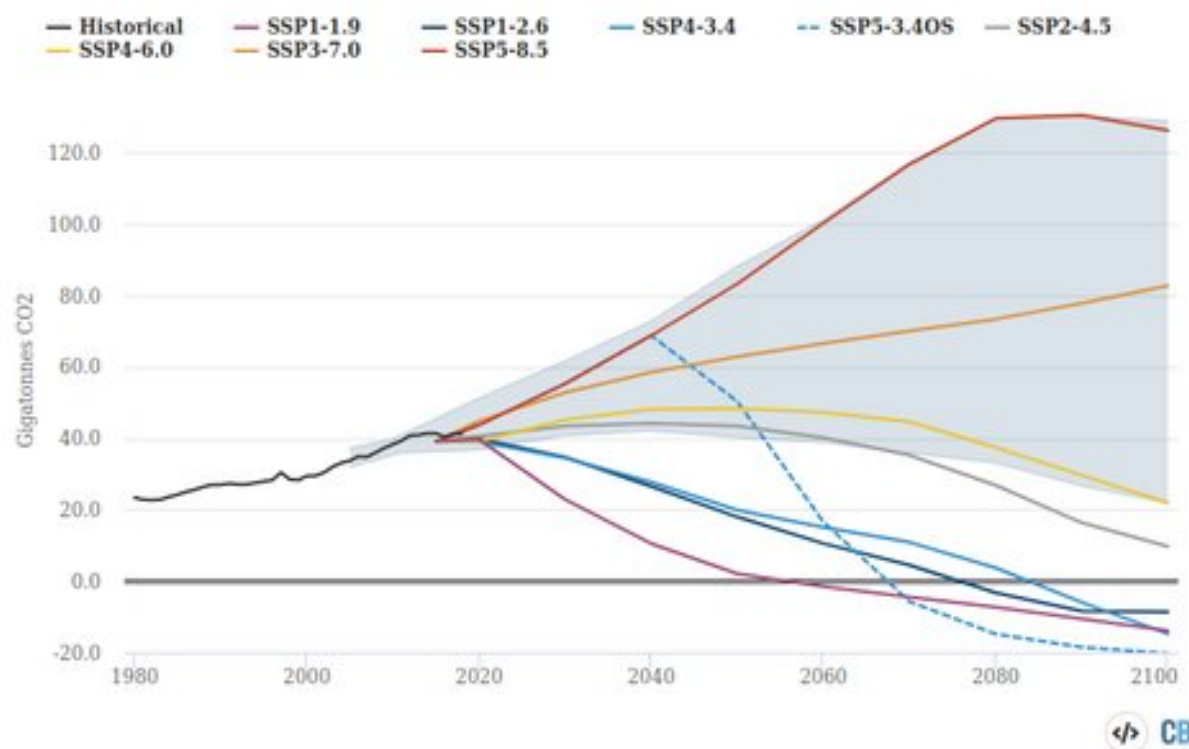
Lawrence Livermore National Laboratory
7000 East Avenue - Livermore, CA 94550

Operated by Lawrence Livermore National Security, LLC, for the
Department of Energy's National Nuclear Security Administration



A number of new scenarios are also being used for CMIP6 in order to give a wider selection of futures for scientists to simulate. These scenarios are included in the chart below, which shows the annual CO₂ emissions assumed under each scenario out to 2100. The new scenarios include SSP1-1.9 (purple line), SSP4-3.4 (blue solid), SSP5-3.4OS (blue dashed) and SSP3-7.0 (orange).

CO₂ emissions in CMIP6 scenarios



Future CO₂ emissions scenarios featured in CMIP6, as well as historical CO₂ emissions (in black). The shaded area represents the range of no-policy baseline scenarios. Data from the [SSP database](#); chart by Carbon Brief using [Highcharts](#).

Paleoclimate reference periods. Over the long evolution of Earth's climate, several periods have received extensive research attention as examples of distinct climate states and rapid climate transitions (Box TS.2, Figure 1). These paleoclimate reference periods represent the present geological era (Cenozoic; past 65 million years) and are used across chapters to help structure the assessment of climate changes prior to industrialization. Cross-Chapter Box 2.1 describes the reference periods, along with a brief account of their climate forcings, and lists where each is discussed in other chapters. Cross-Chapter Box 2.4 summarizes information on one of the reference periods, the mid-Pliocene Warm Period. The Interactive Atlas includes model output from the World Climate Research Programme Coupled Model Intercomparison Project Phase 6 (CMIP6) for four of the paleoclimate reference periods.

Three selected global climate indicators covary across multiple paleoclimate reference periods

(a)

Reference period (*See Interactive Atlas for climate model output)	Age	CO ₂ (ppm)	Temperature (°C)	Sea level (m)
Recent past	1995–2014 CE	360 → 397	0.66 to 1.00	0.15 to 0.25
Approximate pre-industrial	1850–1900 CE	286 → 296	–0.15 to +0.11	–0.03 to 0.00
Last Millennium	850–1850 CE	278 to 285	–0.14 ~ 0.24	–0.05 to 0.03
Mid-Holocene*	6.5–5.5 ka	260 to 268	0.2 to 1.0	–3.5 to +0.5
Last Deglacial Transition	18–11 ka	193 → 271	not assessed	–120 → –50
Last Glacial Maximum*	23–19 ka	188 to 194	–5 to –7	–134 to –125
Last Interglacial*	129–116 ka	266 to 282	0.5 to 1.5	5 to 10
Mid-Pliocene Warm Period*	3.3–3.0 ka	360 to 420	2.5 to 4.0	5 to 25
Early Eocene	53–49 Ma	1150 to 2500	10 to 18	70 to 76
Paleocene-Eocene Thermal Maximum	55.9–55.7 Ma	900 → 2000	10 to 25	not assessed

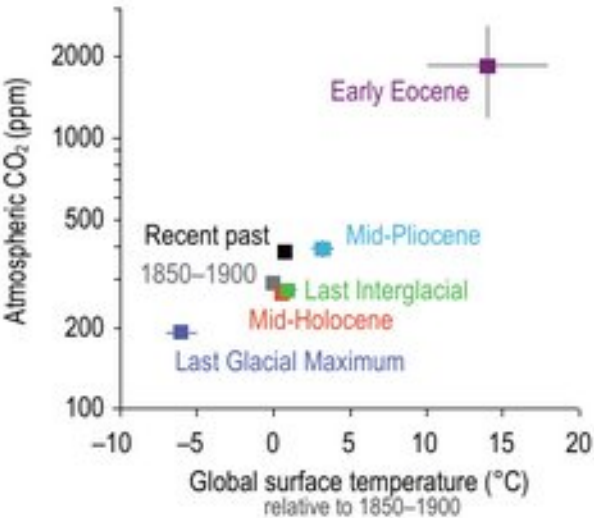
X to Y: very likely range (caveats in Figure 2.34)

X → Y: start to end of period, with no stated uncertainty

X ~ Y: lowest and highest values, with not stated uncertainty



(b)



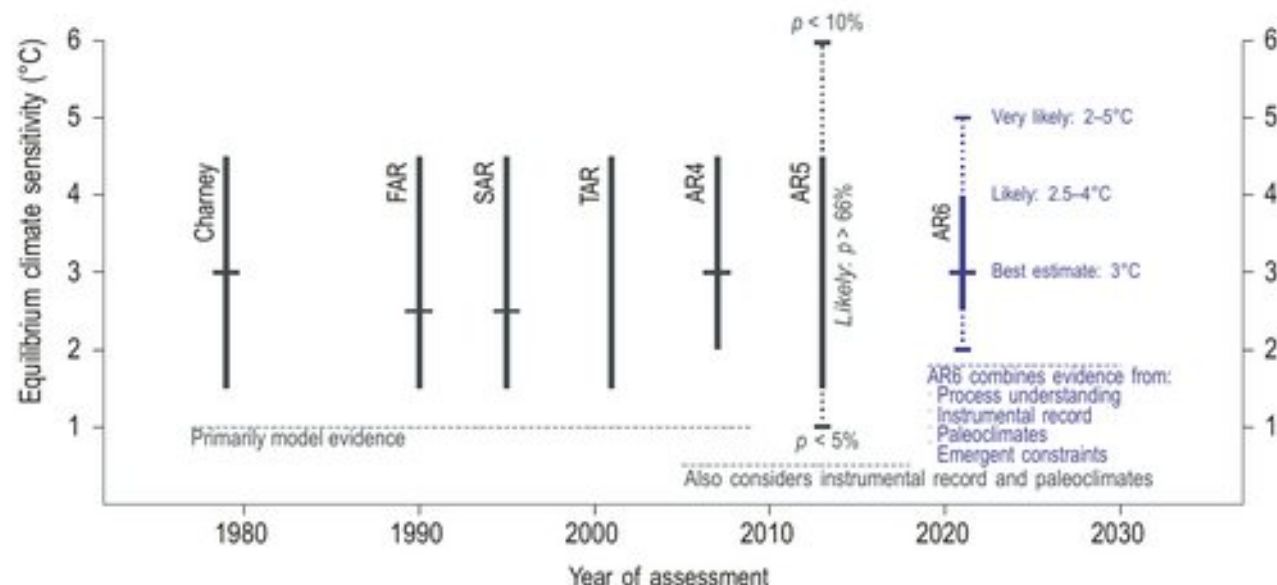
Box TS.2, Figure 1 | Paleoclimate and recent reference periods, with selected key indicators. The intent of this figure is to list the paleoclimate reference periods used in this Report, to summarize three key global climate indicators, and compare CO₂ with global temperature over multiple periods. (a) Three large-scale climate indicators (atmospheric CO₂, global surface temperature relative to 1850–1900, and global mean sea level relative to 1900), based on assessments in Chapter 2, with confidence levels ranging from low to very high. (b) Comparison between global surface temperature (relative to 1850–1900) and atmospheric CO₂ concentration (shown on a log scale) for multiple reference periods (mid-points with 5–95% ranges). {2.2.3, 2.3.1.1, 2.3.3.3, Figure 2.34}

TS.3.2 Climate Sensitivity and Earth System Feedbacks

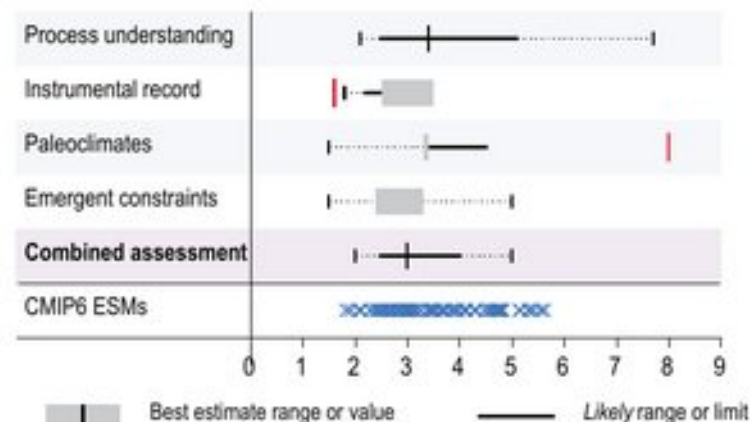
TS.3.2.1 Equilibrium Climate Sensitivity, Transient Climate Response, and Transient Climate Response to Cumulative Carbon-dioxide Emissions

Since AR5, substantial quantitative progress has been made in combining new evidence of Earth's climate sensitivity with improvements in the understanding and quantification of Earth's energy imbalance, the instrumental record of global surface temperature change, paleoclimate change from proxy records, climate feedbacks and their dependence on time scale and climate state. A key advance is the broad agreement across these multiple lines of evidence, supporting a best estimate of equilibrium climate sensitivity of 3°C, with a very likely range of 2°C to 5°C. The likely range of 2.5°C to 4°C is narrower than the AR5 likely range of 1.5°C to 4.5°C. (7.4, 7.5)

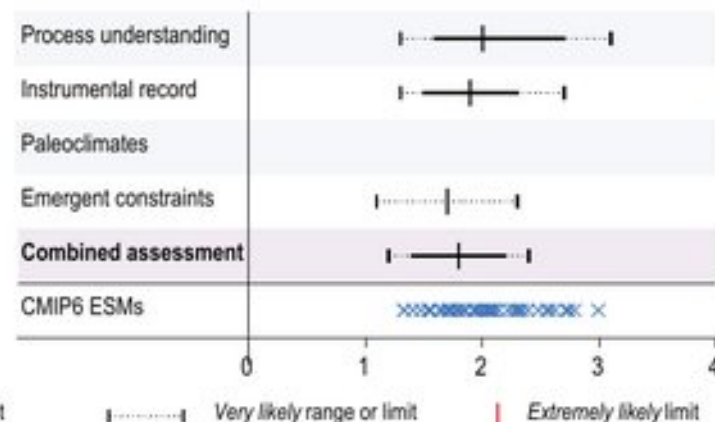
(a) Evolution of equilibrium climate sensitivity assessments from Charney to AR6



(b) Equilibrium climate sensitivity (°C) assessed in AR6 and simulated by CMIP6 ESMs

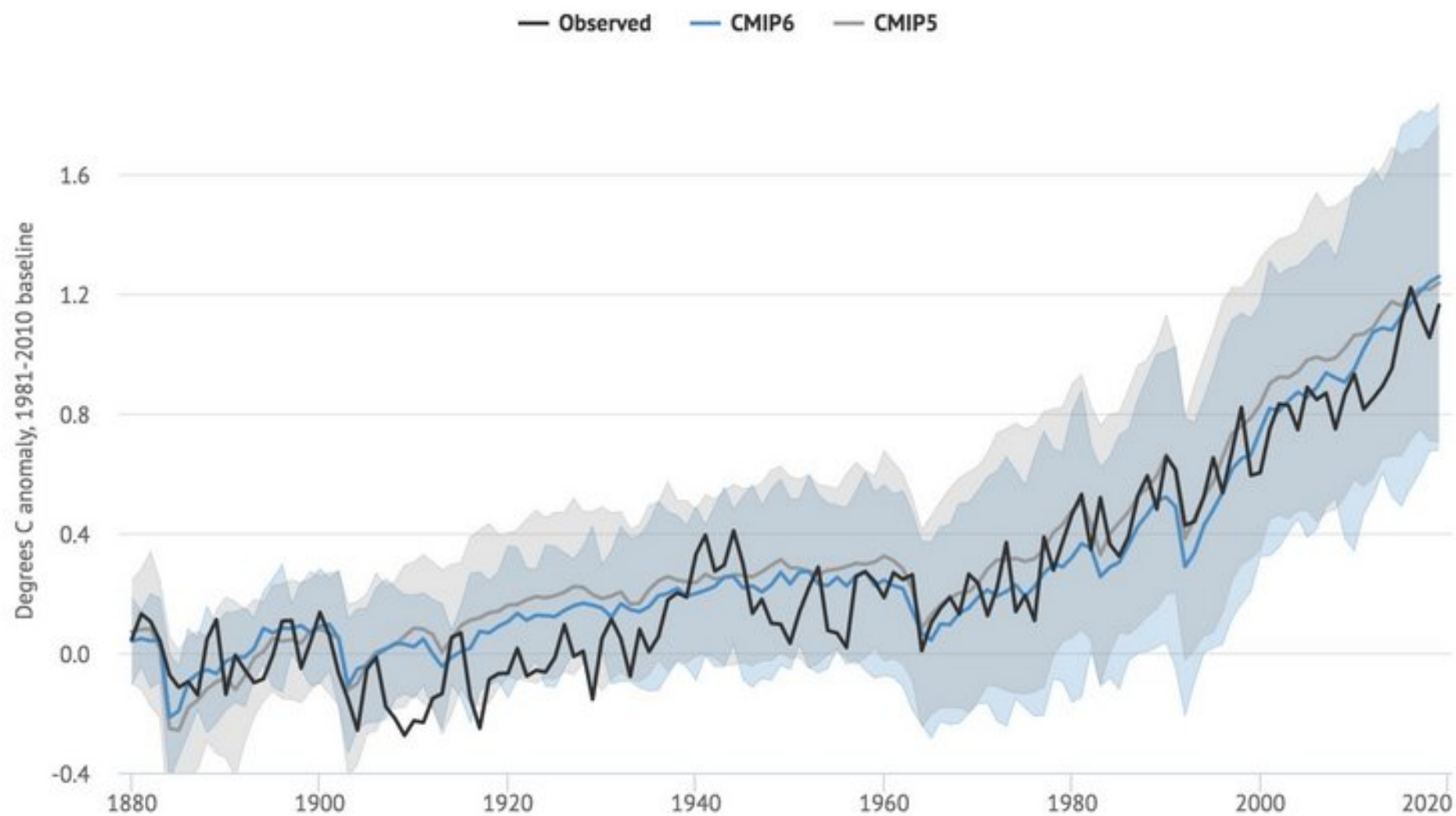


(c) Transient climate response (°C) assessed in AR6 and simulated by CMIP6 ESMs



Global surface temperatures 1880-2019: CMIP5, CMIP6 and observations

For currently available CMIP6 runs. Observational data from NASA GISTEMP.

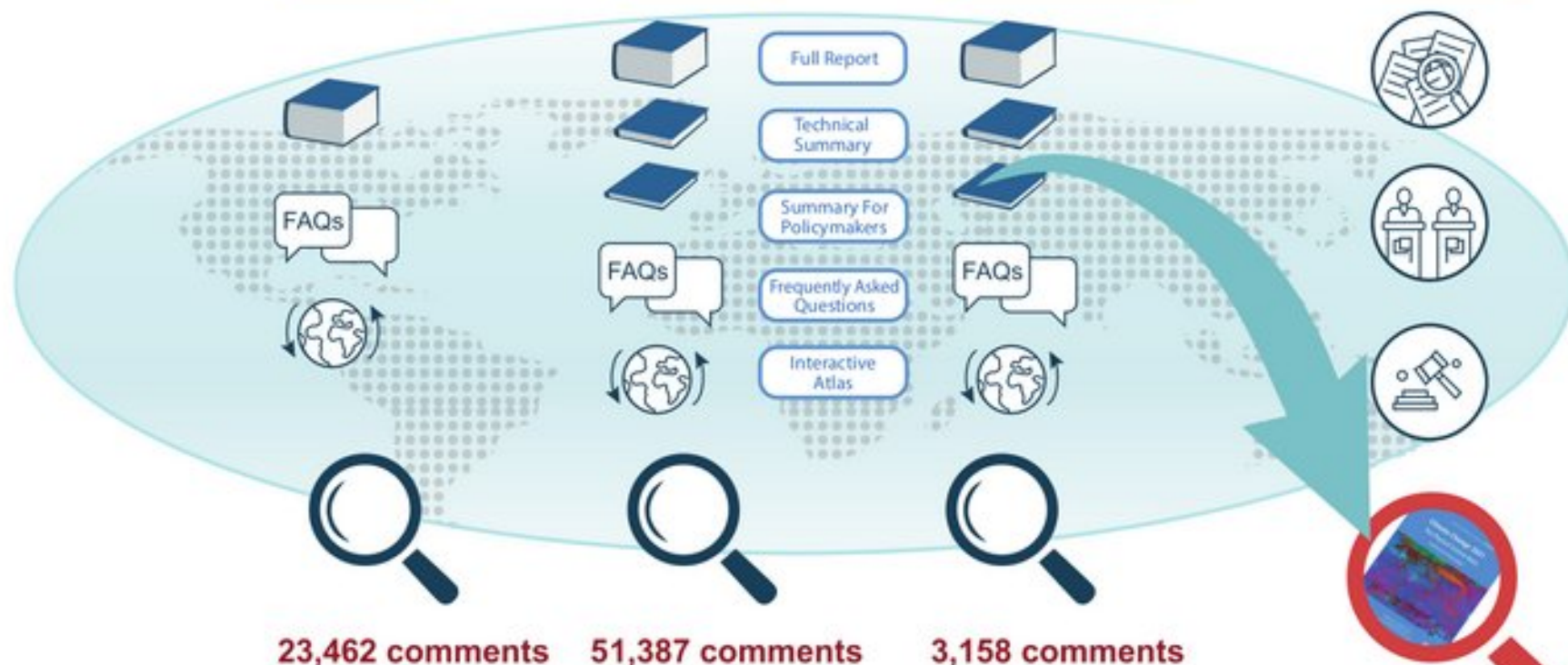


CLIMATE RESEARCH



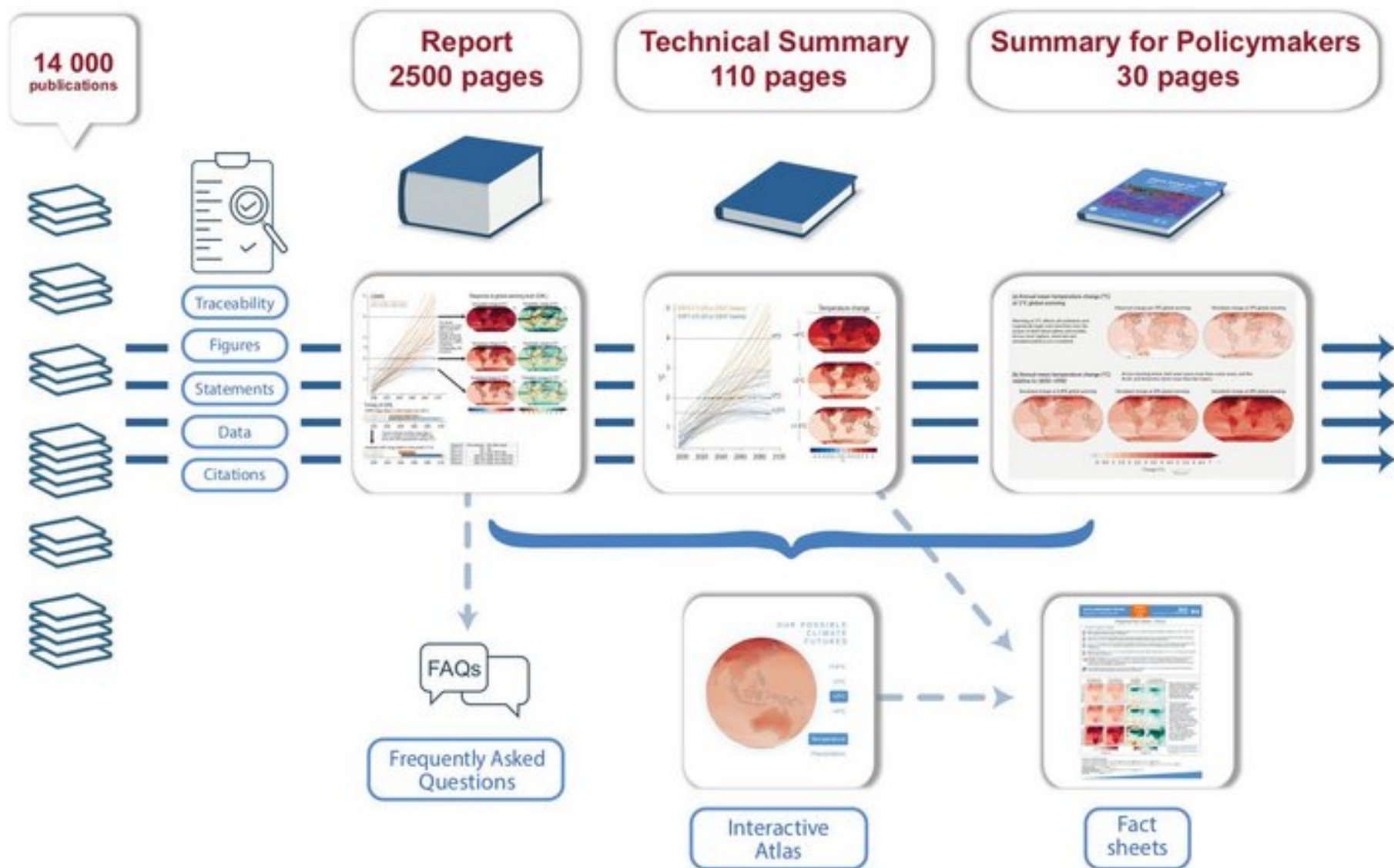
IPCC REVIEW PROCESS

- 01 First order draft
- 02 Second order draft
- 03 First governmental distribution
- 04 Approval



Review : ensures a robust, objective, and complete assessment

IPCC PRODUCTS AND TRACEABILITY





SYNTHESIS REPORT

AR6 Synthesis Report: Climate Change 2023

March 2023

EXPLORE



REPORT

AR6 Climate Change 2022: Mitigation of Climate Change

April 2022

EXPLORE



WORKING GROUP REPORT

AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability

February 2022

EXPLORE



REPORT

AR6 Climate Change 2021: The Physical Science Basis

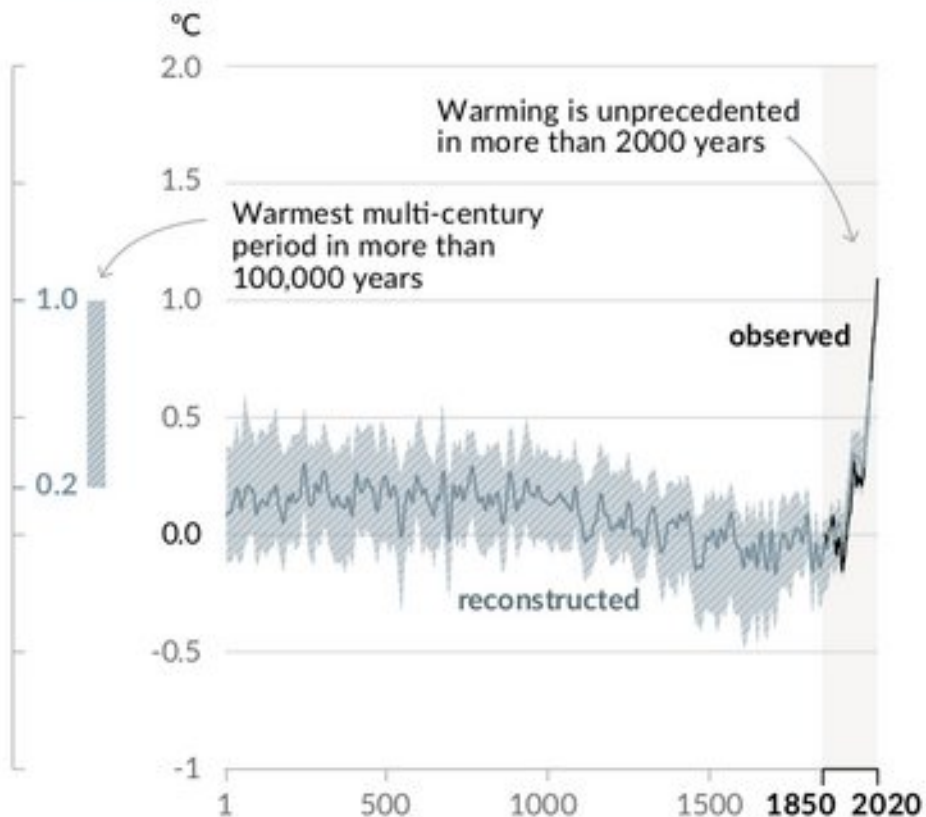
August 2021

EXPLORE

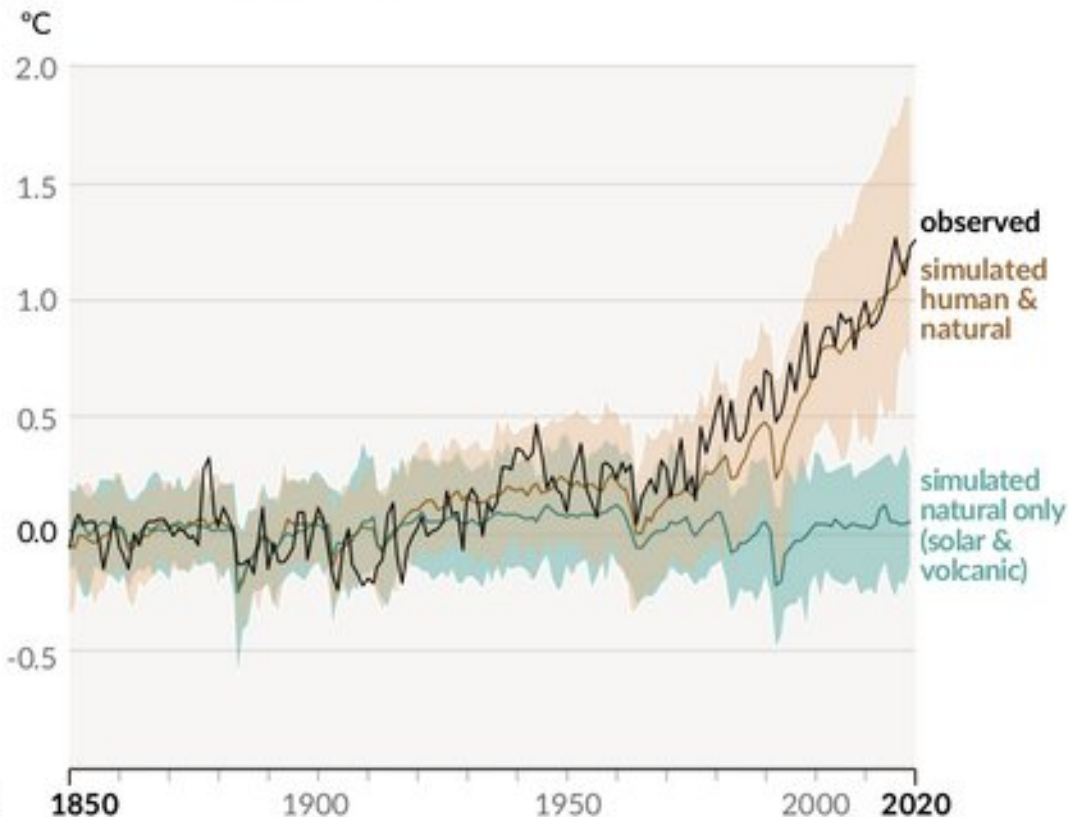
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Changes in global surface temperature relative to 1850-1900

a) Change in global surface temperature (decadal average) as **reconstructed** (1-2000) and **observed** (1850-2020)



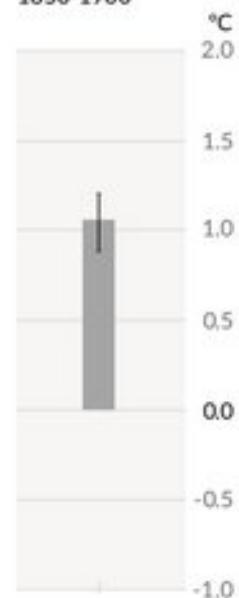
b) Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850-2020)



Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling

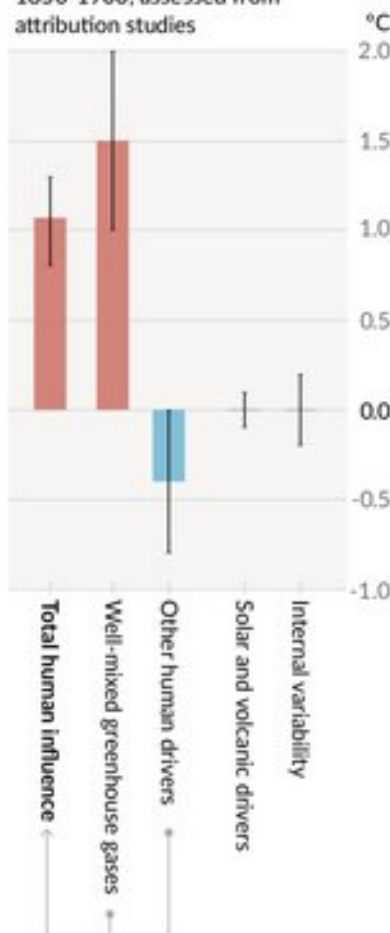
Observed warming

a) Observed warming 2010-2019 relative to 1850-1900

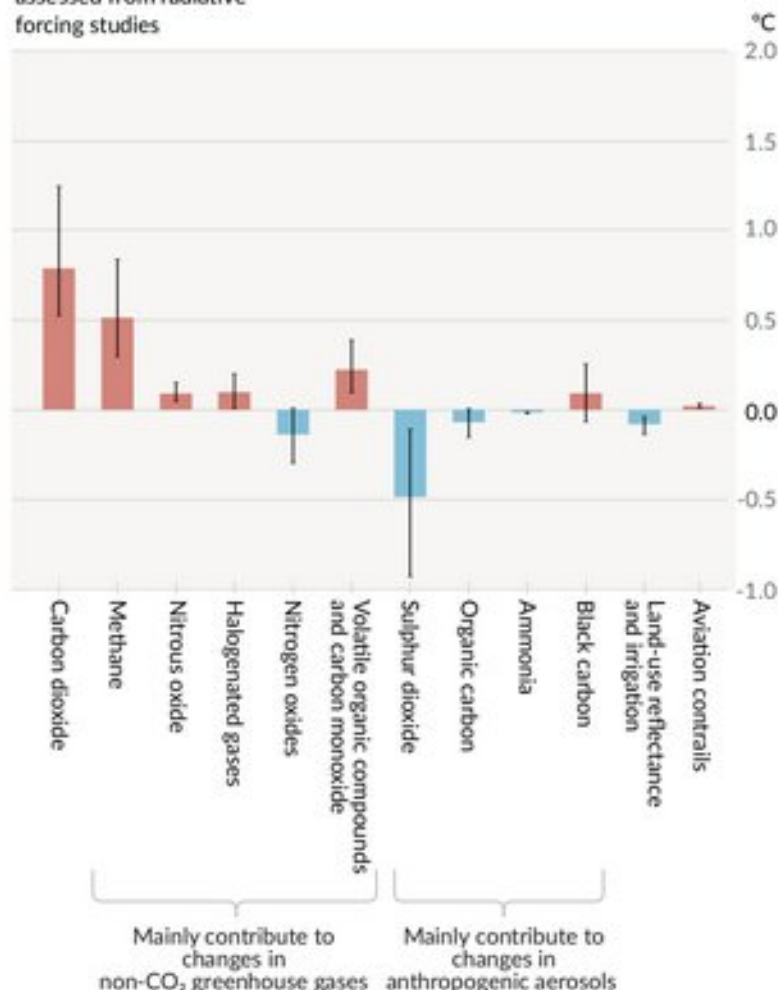


Contributions to warming based on two complementary approaches

b) Aggregated contributions to 2010-2019 warming relative to 1850-1900, assessed from attribution studies

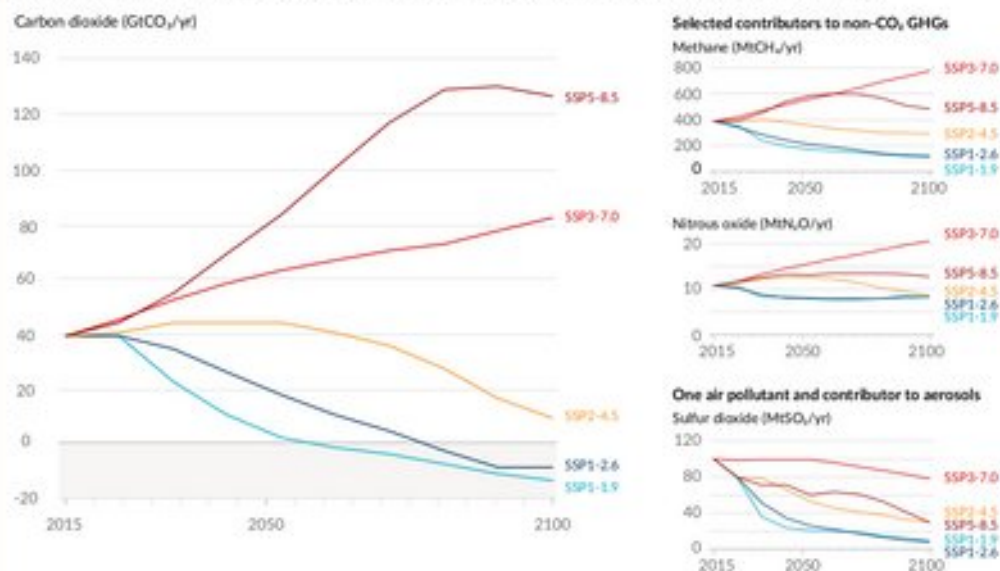


c) Contributions to 2010-2019 warming relative to 1850-1900, assessed from radiative forcing studies



Future emissions cause future additional warming, with total warming dominated by past and future CO₂ emissions

a) Future annual emissions of CO₂ (left) and of a subset of key non-CO₂ drivers (right), across five illustrative scenarios



b) Contribution to global surface temperature increase from different emissions, with a dominant role of CO₂ emissions

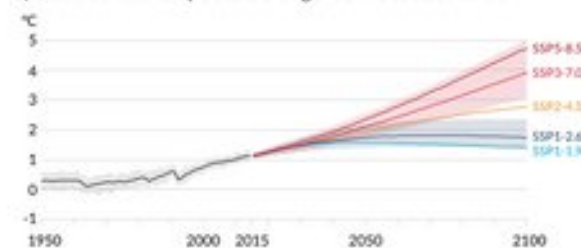
Change in global surface temperature in 2081-2100 relative to 1850-1900 (°C)



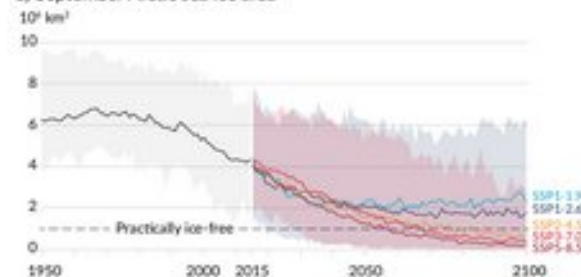
Total warming (observed warming to date in darker shade), warming from CO₂, warming from non-CO₂ GHGs and cooling from changes in aerosols and land use

Human activities affect all the major climate system components, with some responding over decades and others over centuries

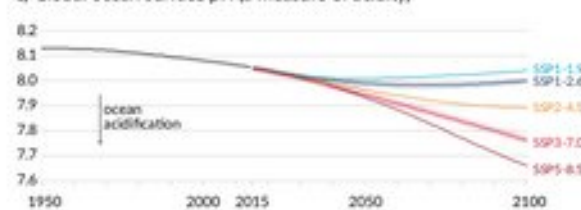
a) Global surface temperature change relative to 1850-1900



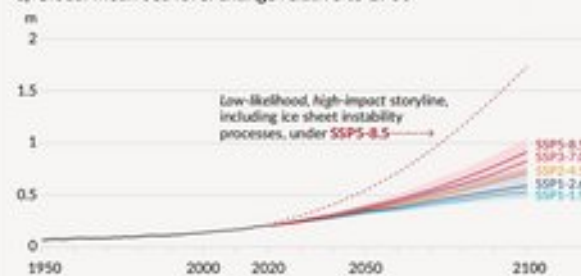
b) September Arctic sea ice area



c) Global ocean surface pH (a measure of acidity)

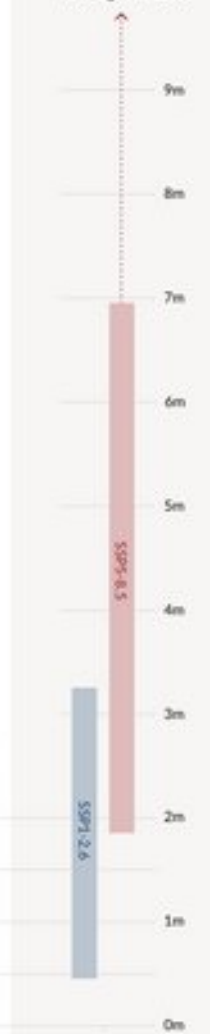


d) Global mean sea level change relative to 1900



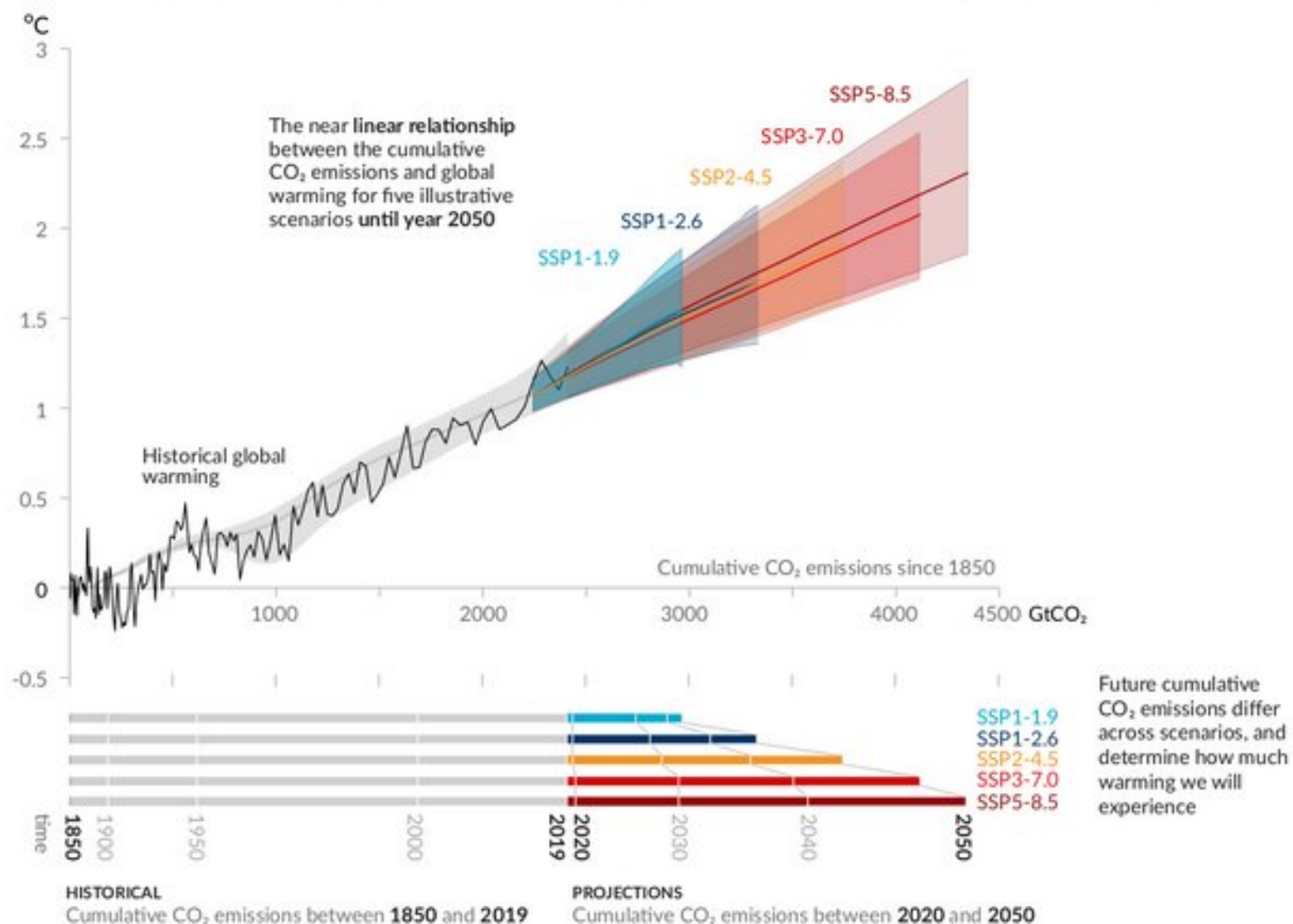
e) Global mean sea level change in 2300 relative to 1900

Sea level rise greater than 15m cannot be ruled out with high emissions



Every tonne of CO₂ emissions adds to global warming

Global surface temperature increase since 1850-1900 (°C) as a function of cumulative CO₂ emissions (GtCO₂)





IPCC Working Group I (WGI): Sixth Assessment Report

IPCC WGI Interactive Atlas

A novel tool for flexible spatial and temporal analyses of much of the observed and projected climate change information underpinning the Working Group I contribution to the Sixth Assessment Report, including regional synthesis for Climatic Impact-Drivers (CIDs).

[Participate in the user testing survey](#)[Errata and problem reporting](#)

REGIONAL INFORMATION



REGIONAL SYNTHESIS



DOCUMENTATION

Video: Introducing the Interactive Atlas



VARIABLE

QUANTITY & SCENARIO

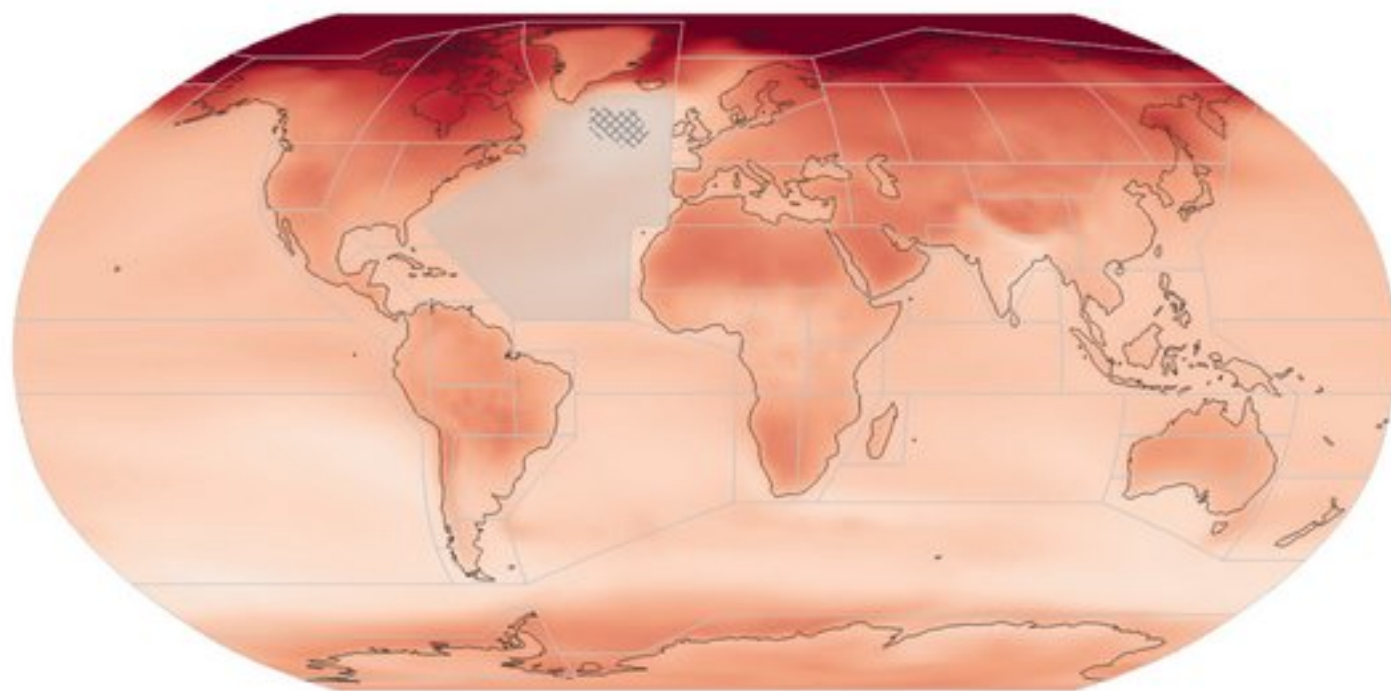
SEASON

Region Set1

WGI reference-re...

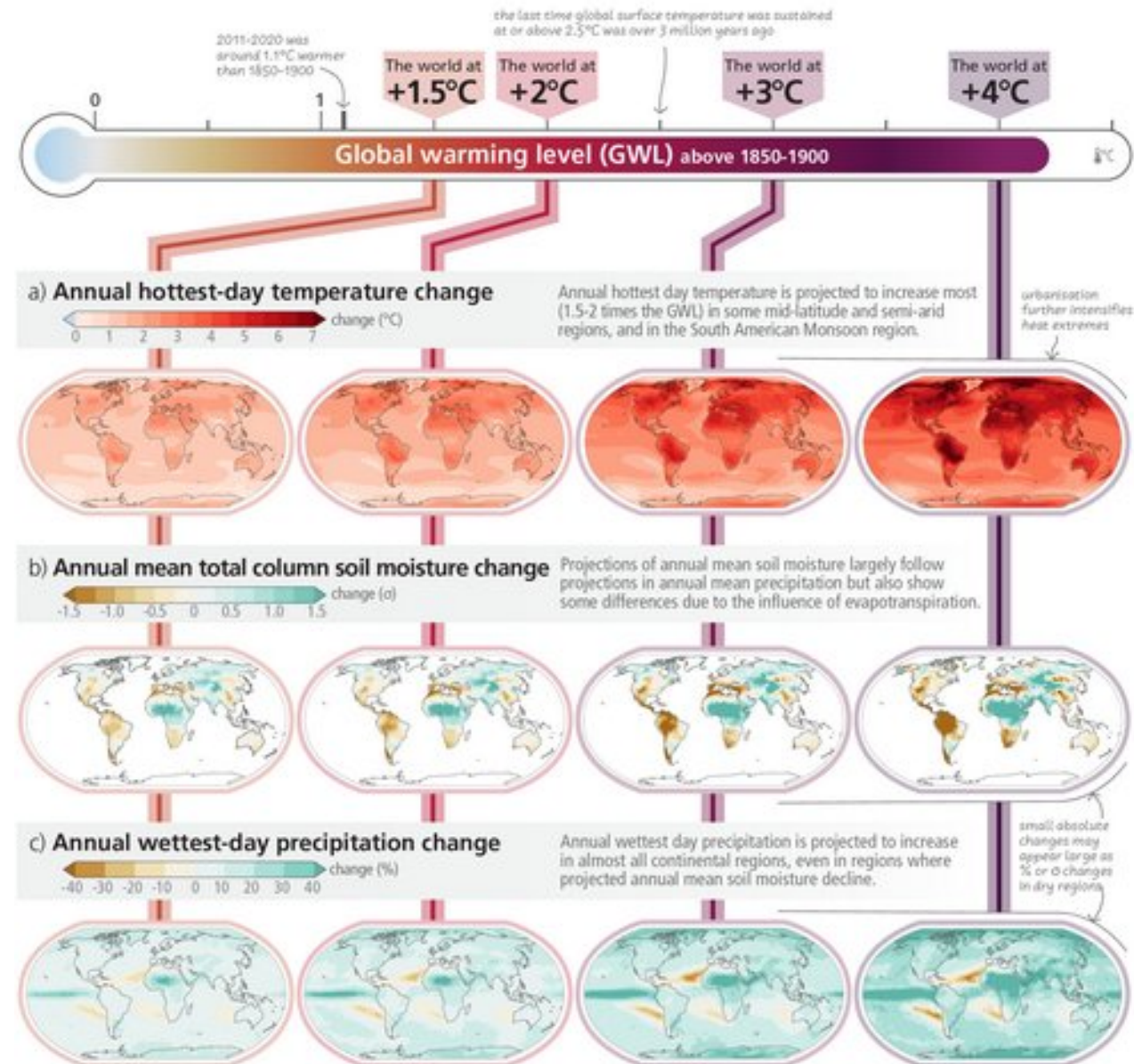
Uncertainty

Advanced



CMIP6 - Mean temperature (T) Change deg C - Warming 2°C SSP5-8.5 (rel. to 1850-1900) - Annual (34 models)

With every increment of global warming, regional changes in mean climate and extremes become more widespread and pronounced



IPCC AR6
synthesis

Beyond IPCC

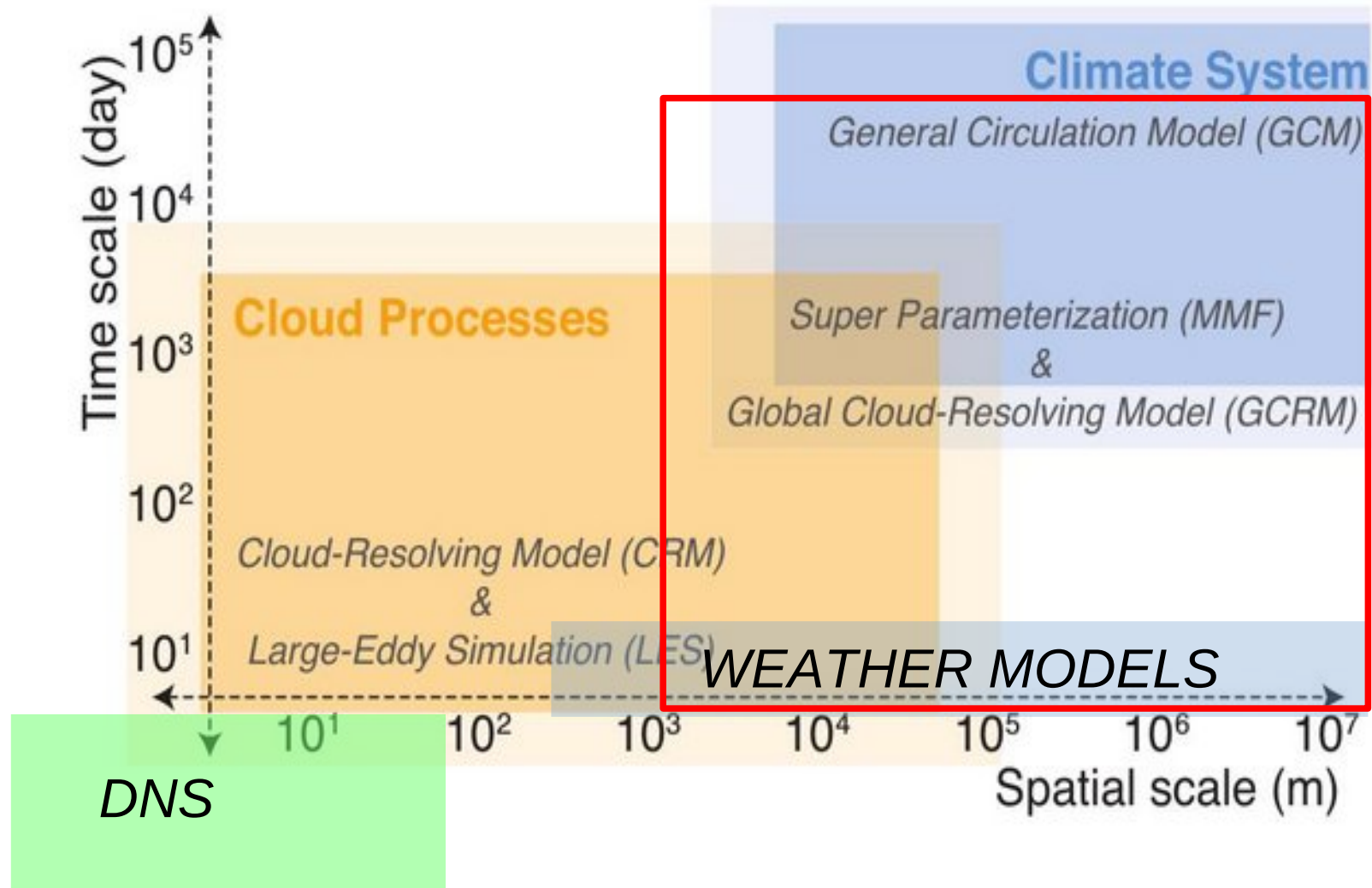


NextGEMS is a project funded by the EU's Horizon 2020 program.

It brings together teams from 14 European countries to create the next generation of climate models with the resolution to represent convective ensembles and storm clouds.

The nextGEMS models will allow realistic modeling of the climate system for the next 30 years, making it possible to estimate extreme meteorological events or details of such important processes as the carbon cycle, aerosol emissions and transformations, and changes in cloud properties.

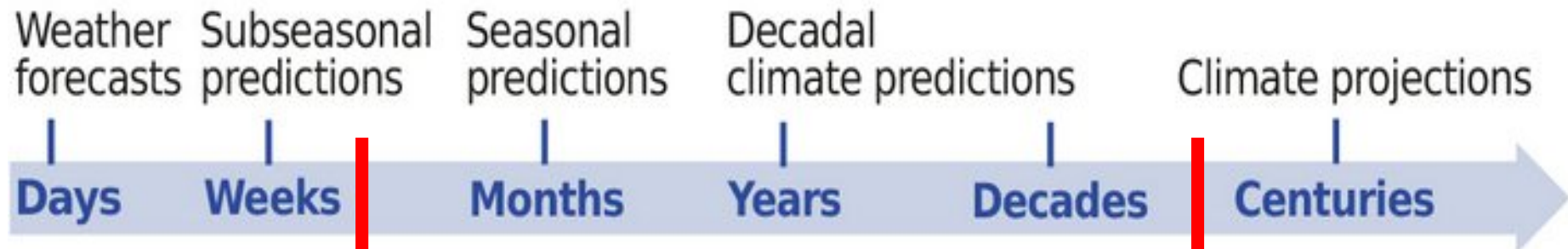




Contemporary climate and weather models

**Boundary
value problem**

Initial value problem



**next
GEMS**

Who we are

nextGEMS is a Horizon 2020 project funded by the European Commission. It is coordinated by Björn Stevens at the Max Planck Institute for Meteorology and Irina Sandu at the ECMWF. The nextGEMS consortium is made up of 26 institutes:

Max Planck Institute for Meteorology (MPI-M), Germany

European Centre for Medium-Range Weather Forecasts (ECMWF)

Alfred-Wegener-Institut (AWI), Germany

University of Bergen (UiB), Norway

University of Copenhagen (UCPH), Denmark

French National Centre for Scientific Research (CNRS), France

Stockholm University (SU), Sweden

University of Warsaw (UW), Poland

University of Oxford (UOXF), UK

Helmholtz Centre for Ocean Research Kiel (GEOMAR), Germany

Barcelona Supercomputing Center (BSC), Spain

University of Reading (UREAD), UK

Wageningen University (WU), The Netherlands

Eidgenössische Technische Hochschule Zürich (ETHZ), Switzerland

Universität Bern (UBER), Switzerland

Instituto Português do Mar e da Atmosfera IP (IPMA), Portugal

University of Helsinki (UH), Finland

University of Trento (UNITN), Italy

Deutsches Klimarechenzentrum GmbH (DKRZ), Germany

Universidad Complutense de Madrid (UCM), Spain

French National Institute for Sustainable Development (IRD), France

Iberdrola Renovables Energía S.A.U. (IBE), Spain

Institut Sénégalais de Recherches Agricoles (ISRA), Senegal

Latest Thinking GmbH (LT), Germany

Karlsruhe Institute of Technology (KIT), Germany

University of Hamburg (UHH), Germany



nextGEMS is funded through the European Union's Horizon 2020 research and innovation program under the grant agreement number 101003470.

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MTG-I1 FCI

ECMWF IFS 2.8-km forecast



The first visible-light image from the MTG-FCI satellite from EUMETSAT (left) and a 12-hour simulation using ECMWF's Integrated Forecasting System (IFS) at 2.8km resolution (right), valid for March 18, 2023 at 12:00 UTC. Source: EUMETSAT/ECMWF

Selected spectacular simulations:

<https://www.youtube.com/watch?v=N0qY-ShqKOY>

<https://www.youtube.com/watch?v=EzqjAFJYmgY>

https://www.youtube.com/watch?v=-l_N8nT9Bnc

https://www.youtube.com/watch?v=PNkD0YmEp_Y

Project

<https://nextgems-h2020.eu/>

