Global warming - physicist's perspective - 05

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NAUKA O KLIMACIE
DLA SCEPTYCZNYCH

UNIVERSITY
OF WARSAW

CMIP Overview

On this Page

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 Researcher 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**.

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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.

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

CMIP6 Design: Scientific Focus

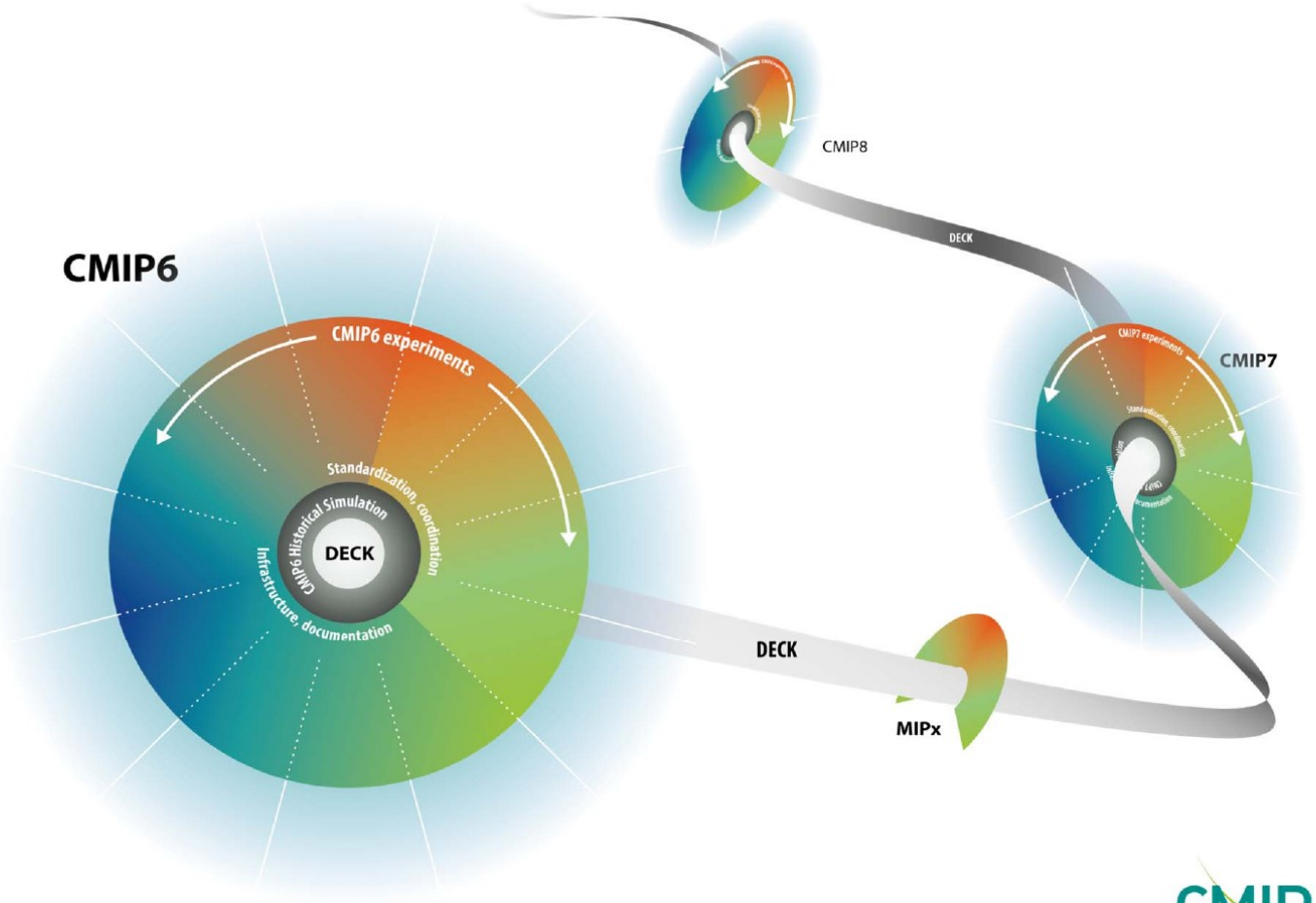
- The **scientific backdrop** for CMIP6 is the **WCRP Grand Science Challenges**:
  1. Clouds, Circulation and Climate Sensitivity
  2. Changes in Cryosphere
  3. Climate Extremes
  4. Regional Sea-level Rise
  5. Water Availability
  6. Near-Term Climate Prediction
  7. Biogeochemical Cycles and Climate 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?

Eyring et al., GMD, 2016

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

CMIP Continuity

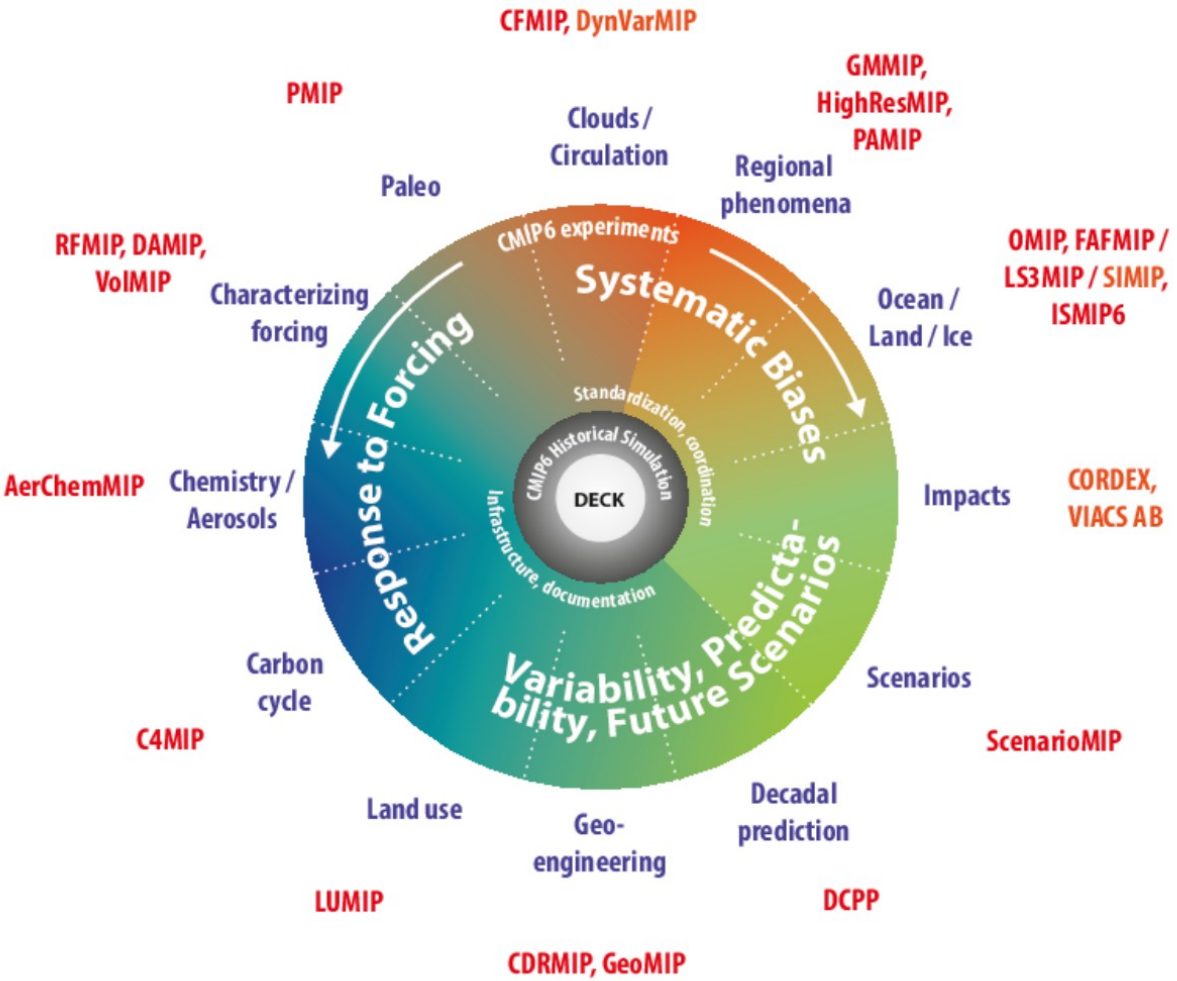
A common suite of experiments for each phase of CMIP provides an opportunity to construct a multi-model ensemble using model output from various phases of CMIP



Eyring et al., CMIP6 Experimental Design and Organization, GMD, 2016

CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

23 CMIP6-Endorsed MIPs



Diagnostic MIPs

Eyring et al., GMD, 2016

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**

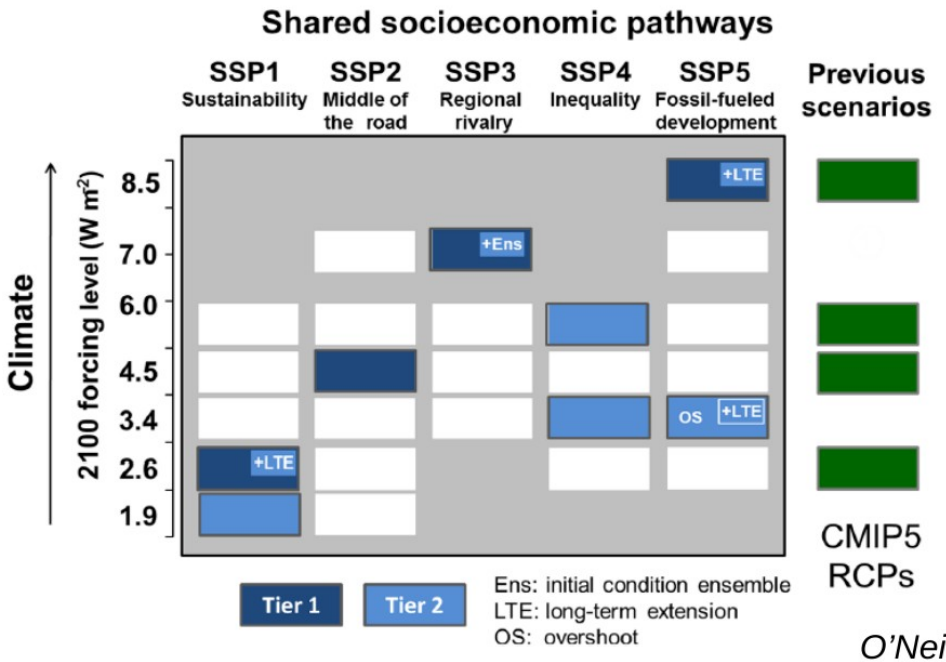
More models (>70)
New models
More complex models
Higher resolution models

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

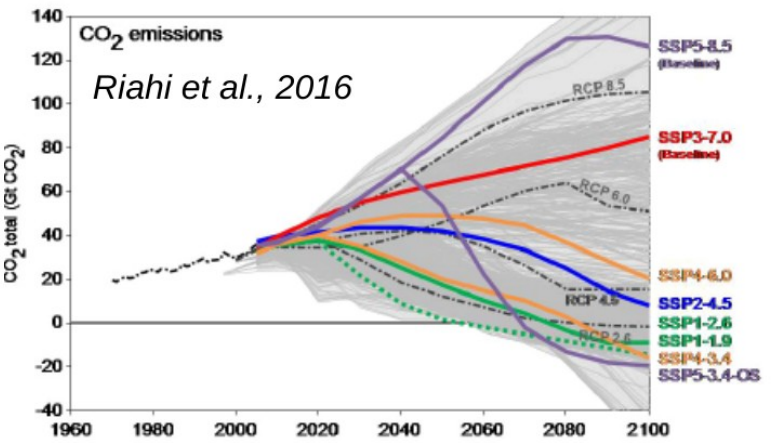
CMIP
The World Climate Research Programme's Coupled Model Intercomparison Project

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 Extentions 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

https://pcmdi.llnl.gov/CMIP6/

CMIP6 - Coupled Model Intercomparison Project Phase 6

Overview:

The WCRP Working Group on Coupled Modelling (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

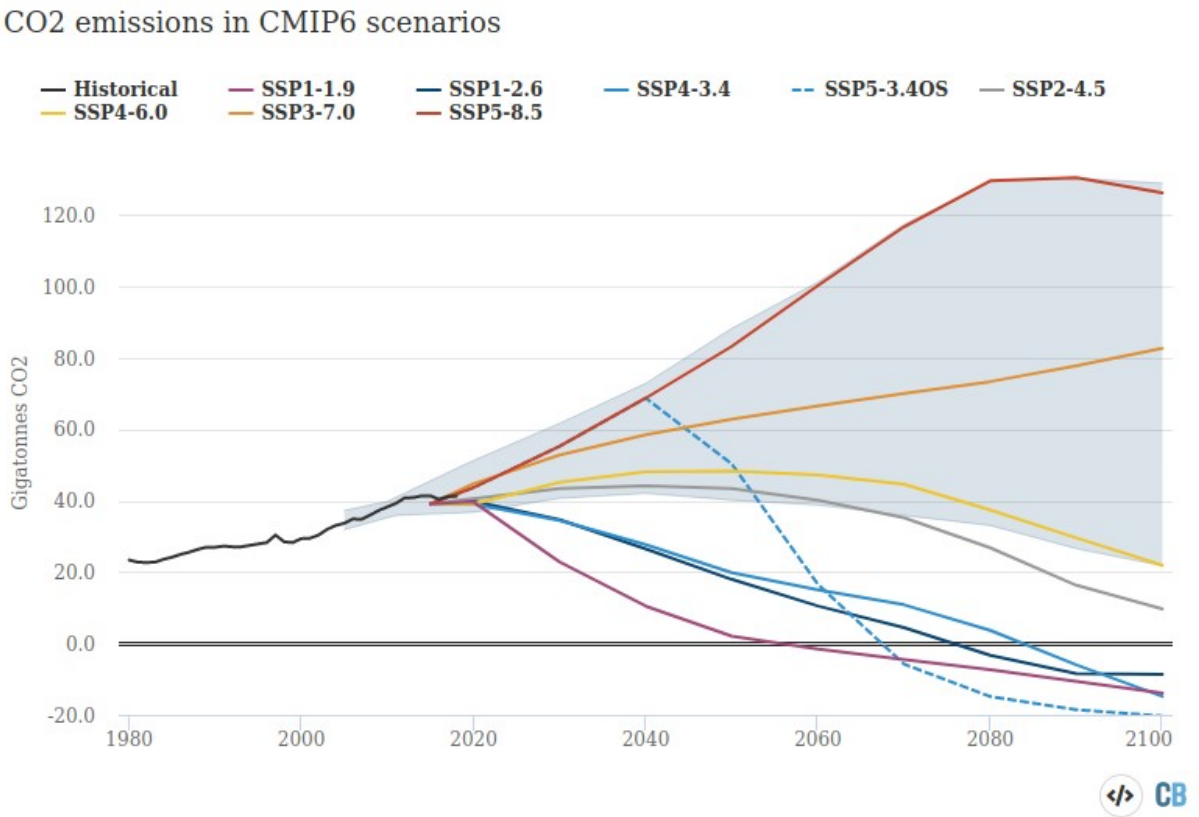
Additional information for CMIP6:

- CMIP6 license and terms of use

CMIP6 Modeling Groups (click on flags to reveal identity)

Document version: 13 February 2019

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).



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

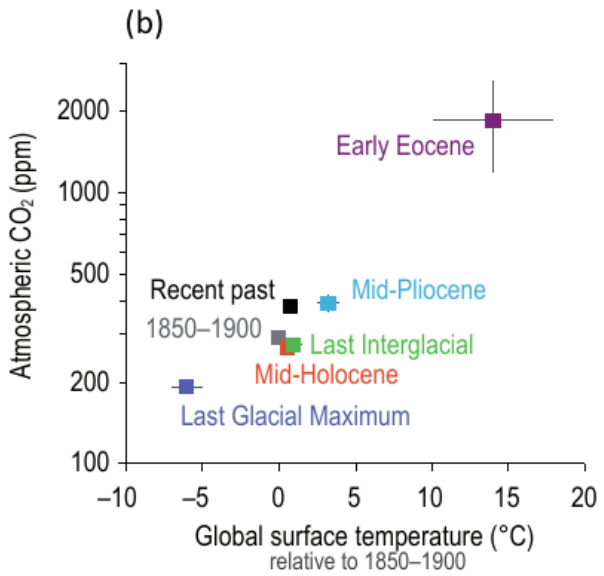
(a)

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

lower — 1850–1900 — higher

(b)



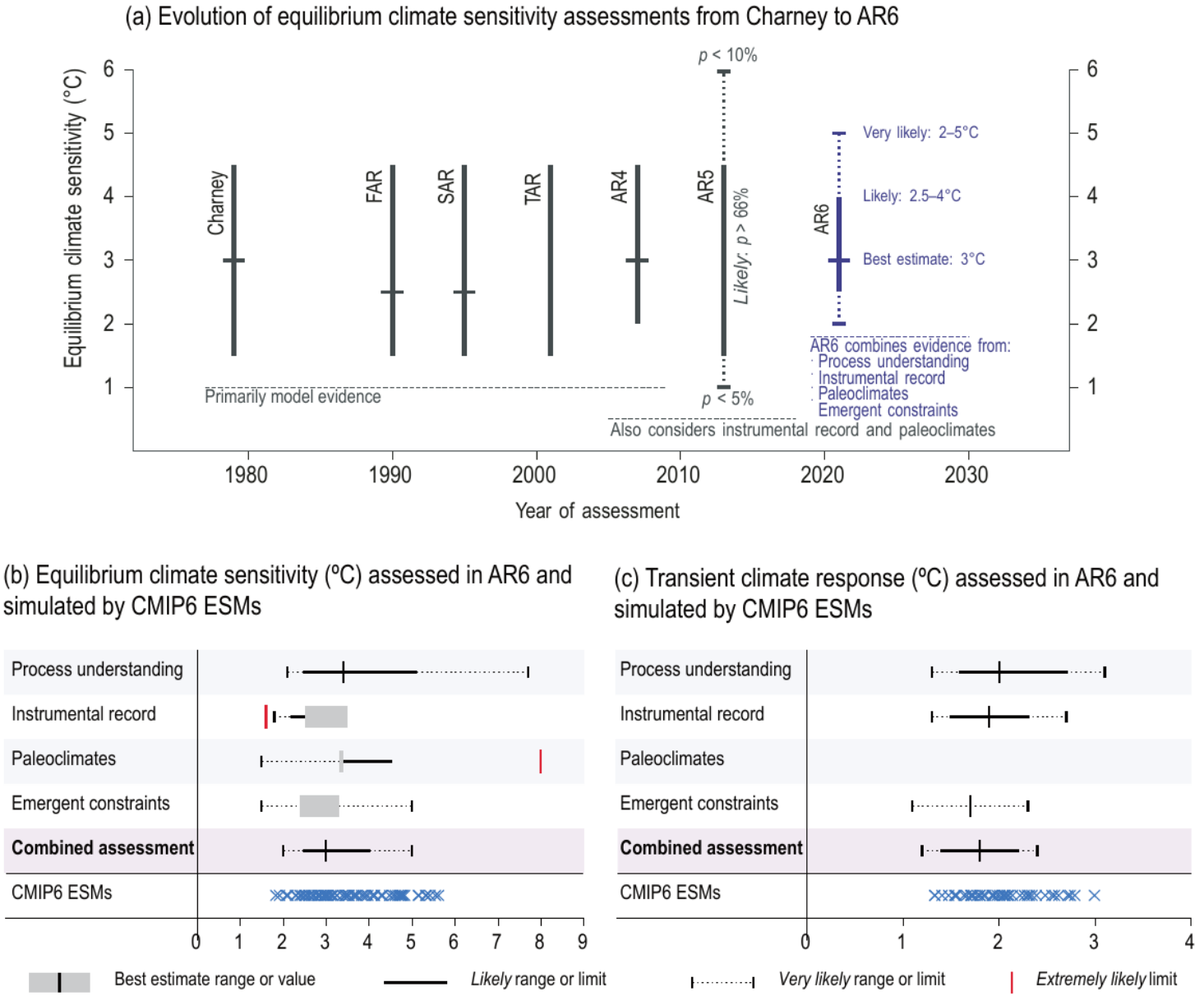
AR6
WG1
TS

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 CO_2 with global temperature over multiple periods.* **(a)** Three large-scale climate indicators (atmospheric CO_2, 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 CO_2 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

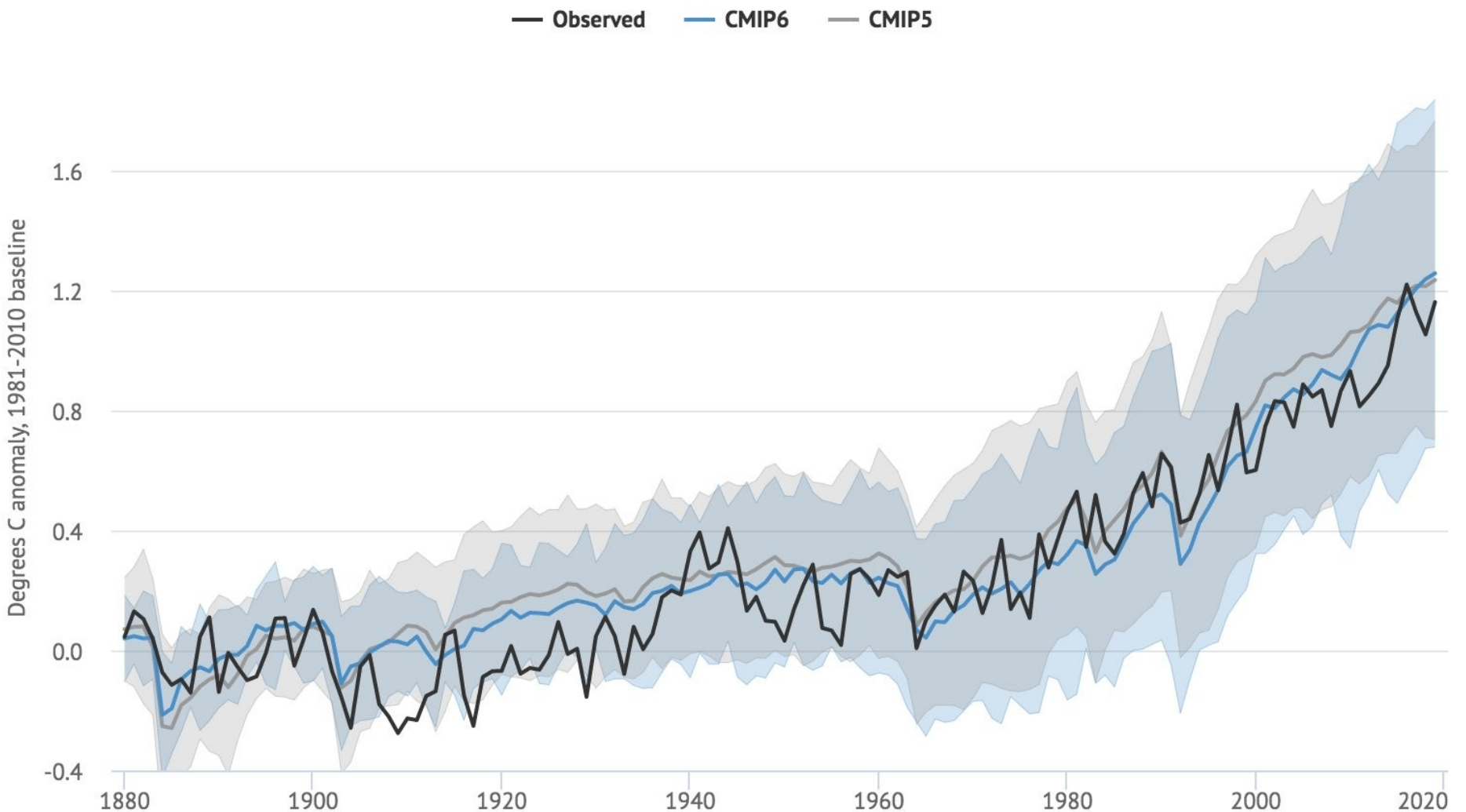
TS.3.2.1 Equilibrium Climate Sensitivity, Transient Climate Response, and Transient Climate Response to Cumulative Carbon-dioxide Emissions

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}

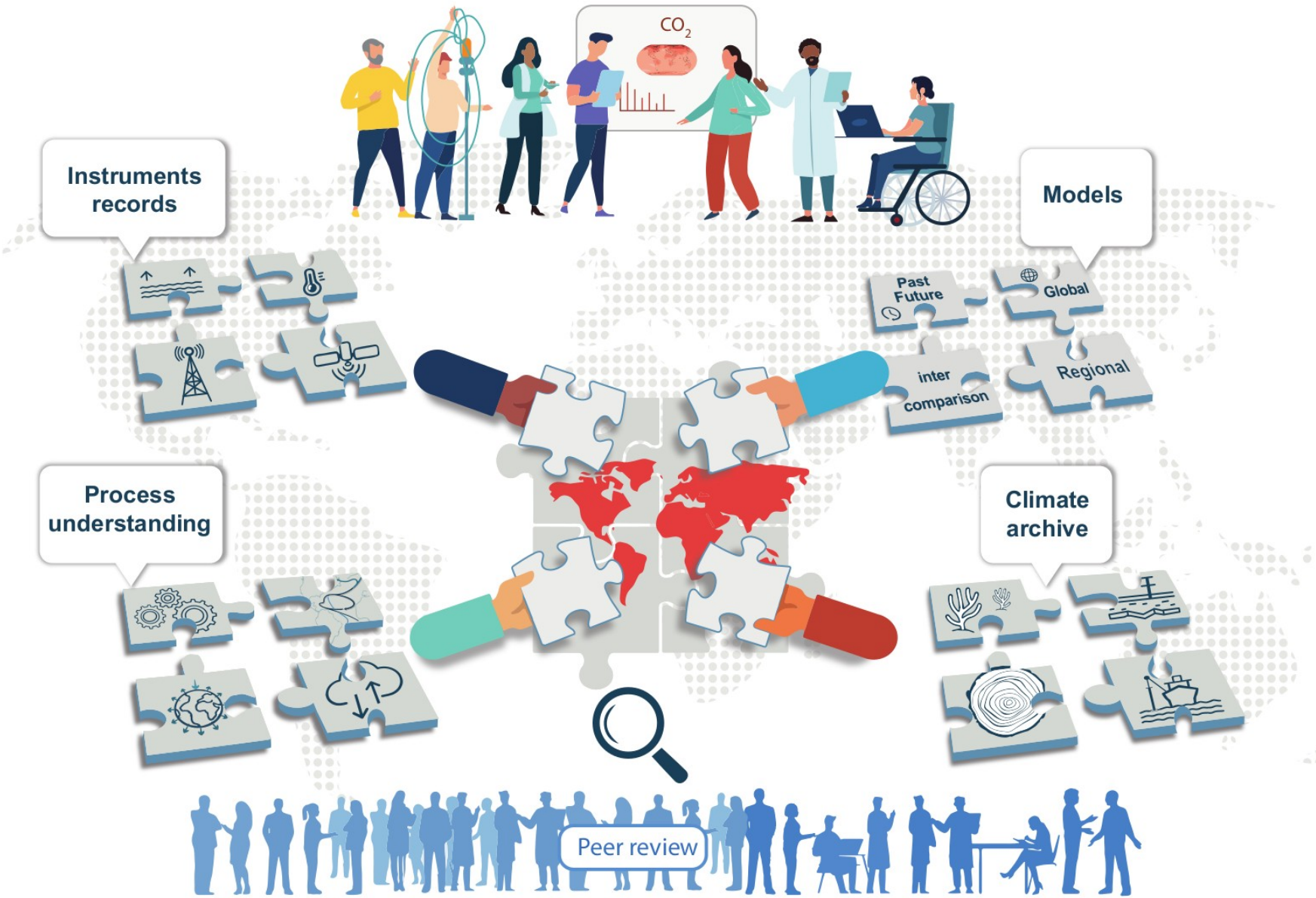


Global surface temperatures 1880-2019: CMIP5, CMIP6 and observations

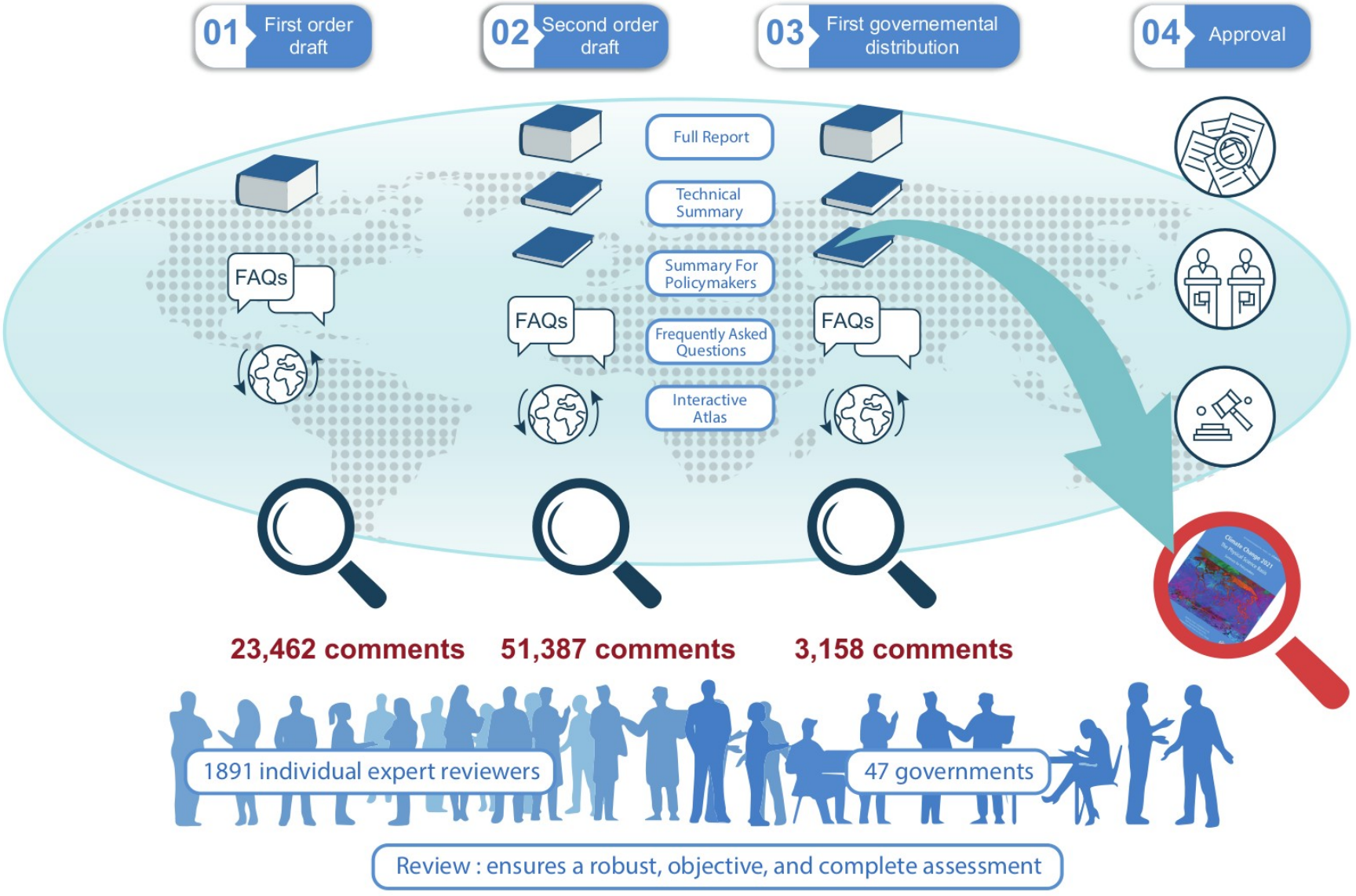
For currently available CMIP6 runs. Observational data from NASA GISTEMP.



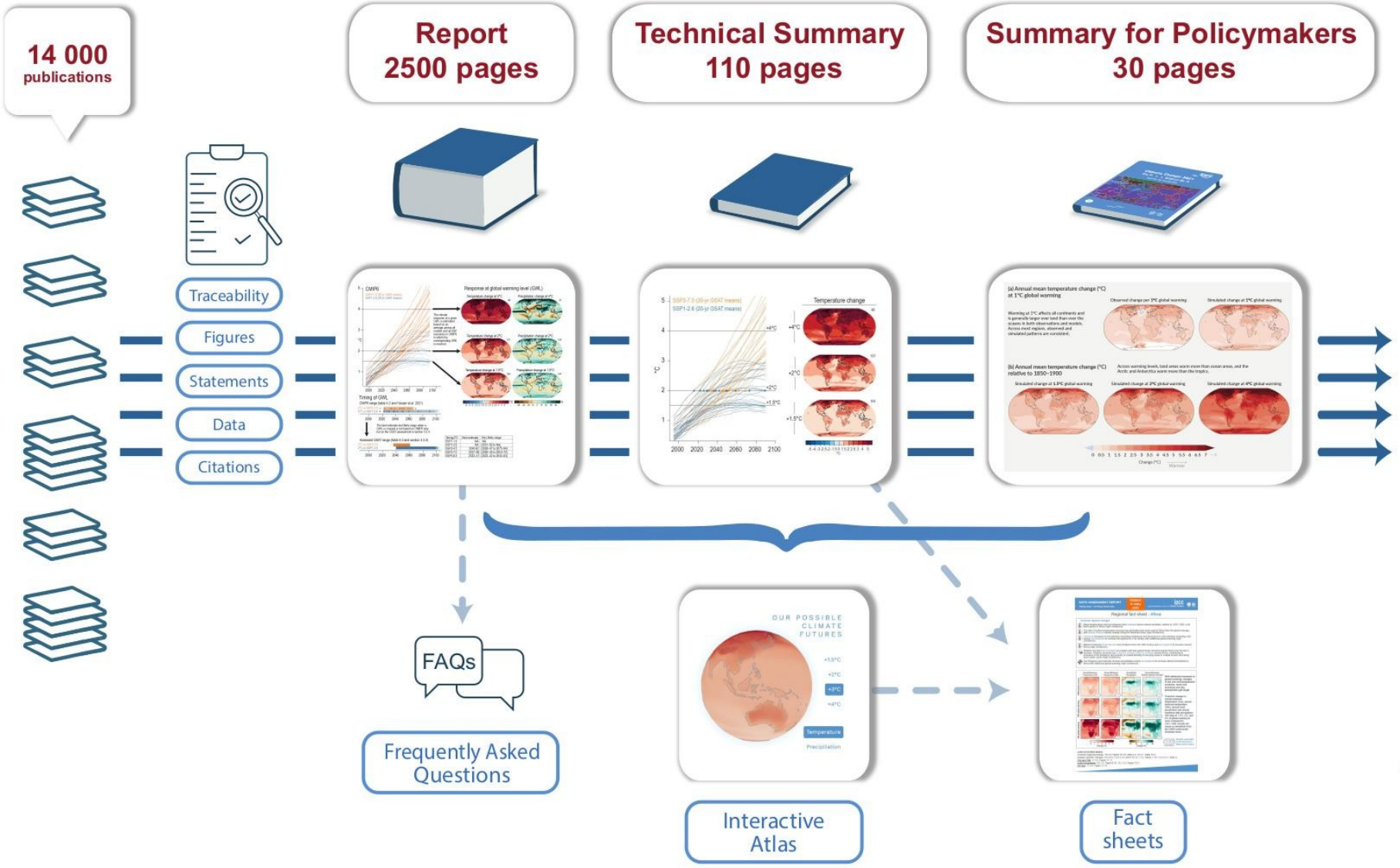
CLIMATE RESEARCH



IPCC REVIEW PROCESS



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

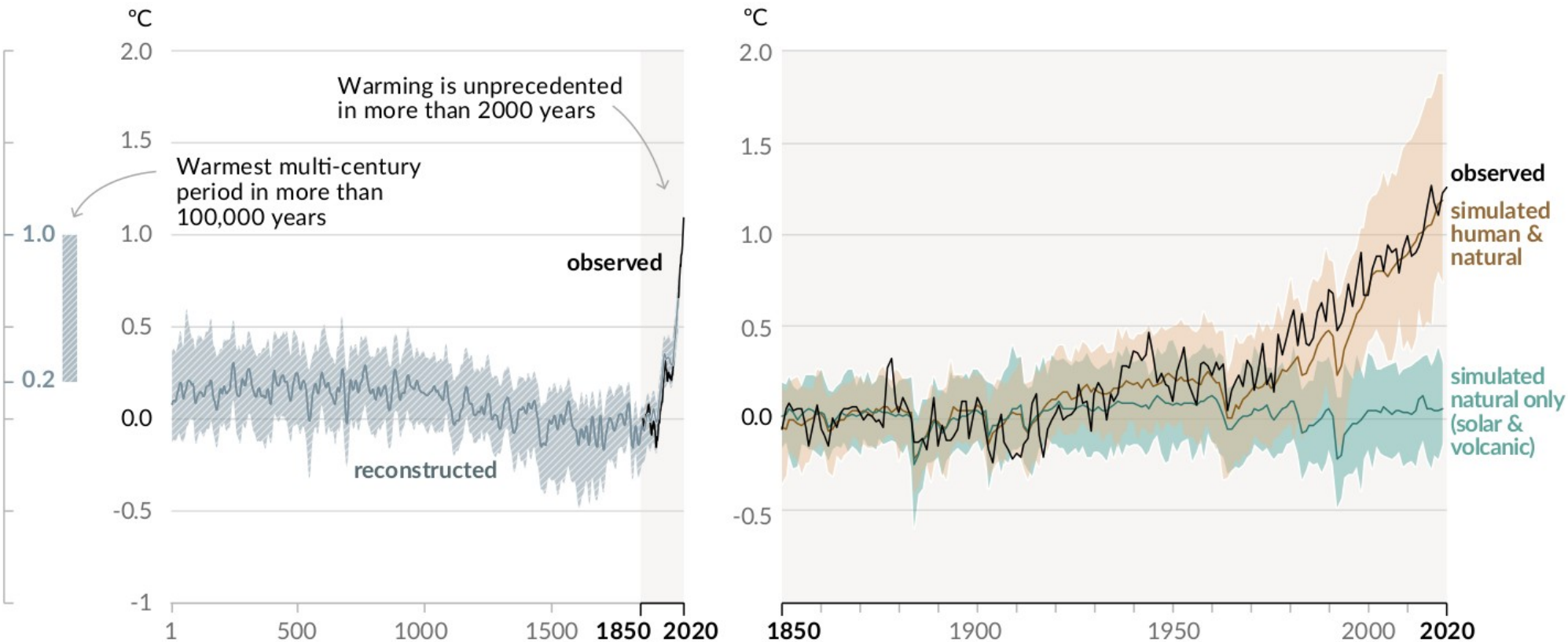
EXPLORE

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

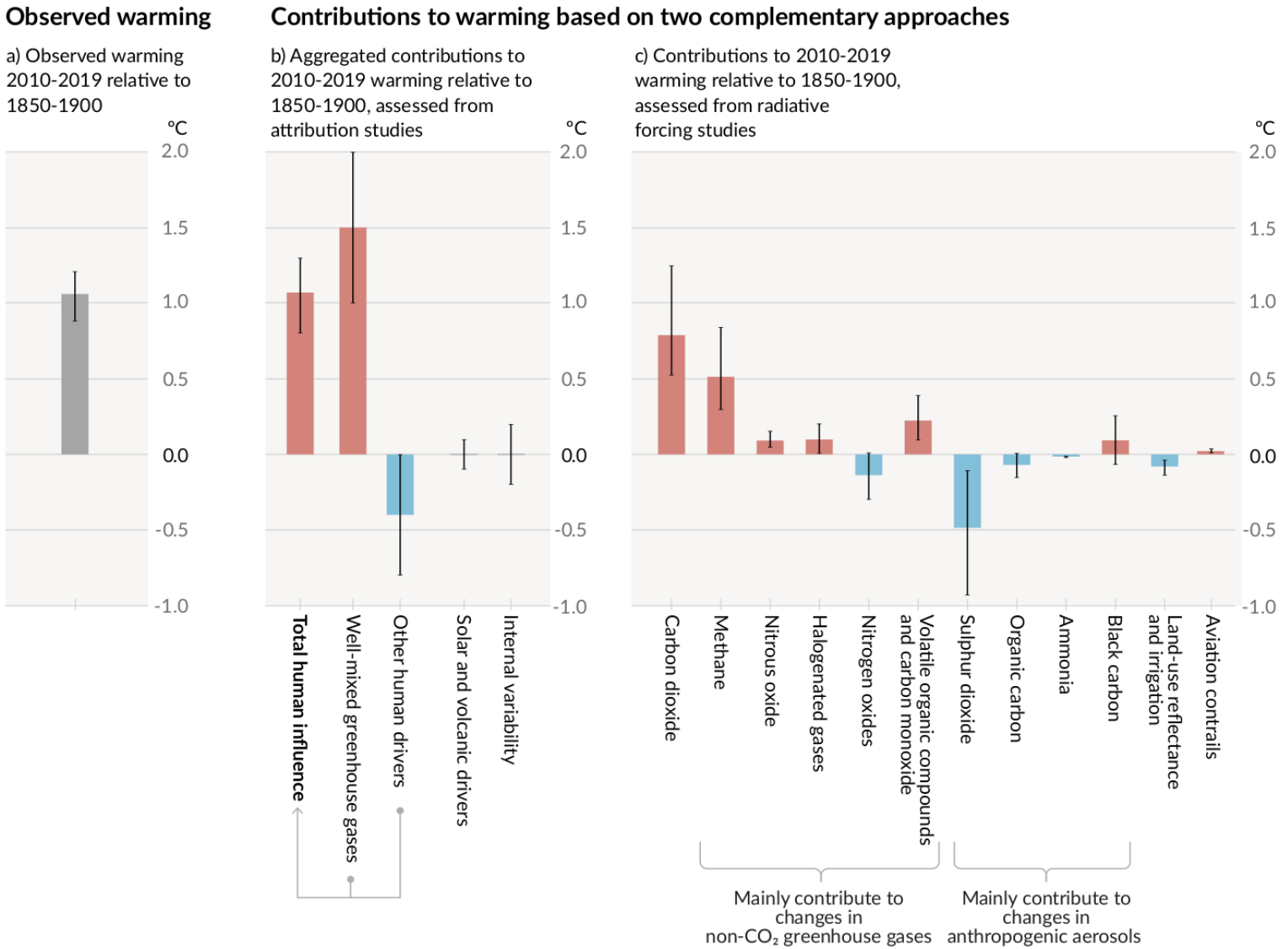
Changes in global surface temperature relative to 1850-1900

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)

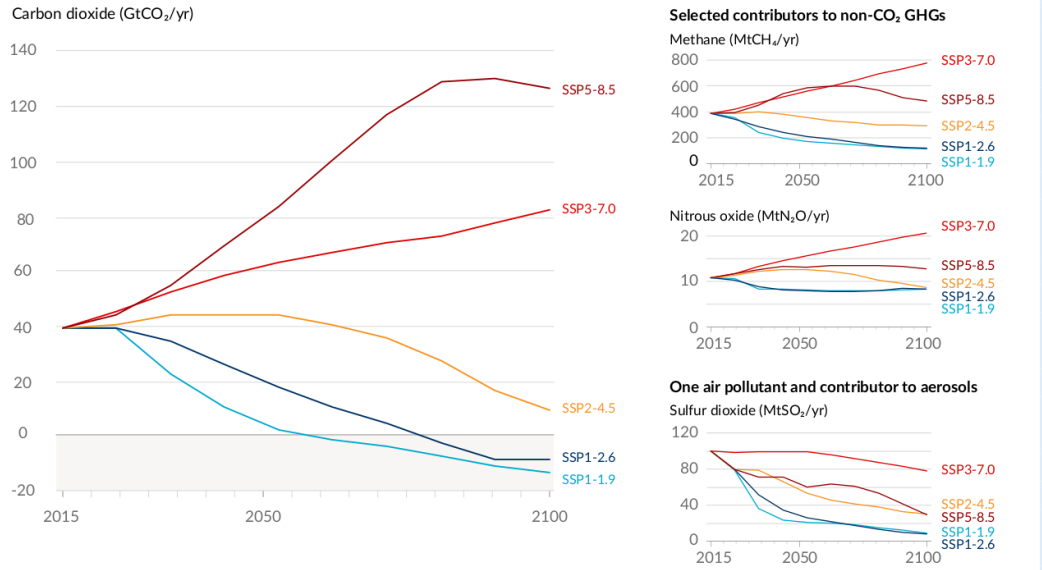


Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling



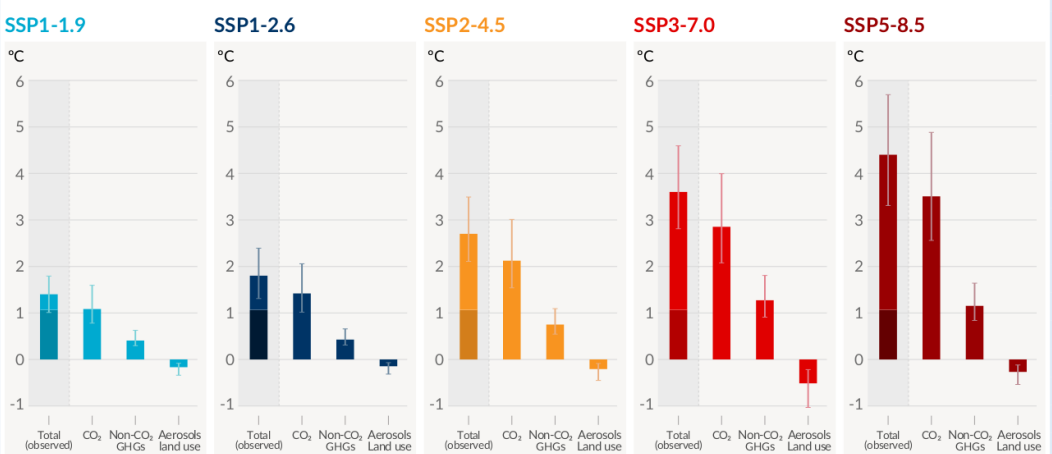
Future emissions cause future additional warming, with total warming dominated by past and future CO_2 emissions

a) Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five illustrative scenarios



b) Contribution to global surface temperature increase from different emissions, with a dominant role of CO_2 emissions

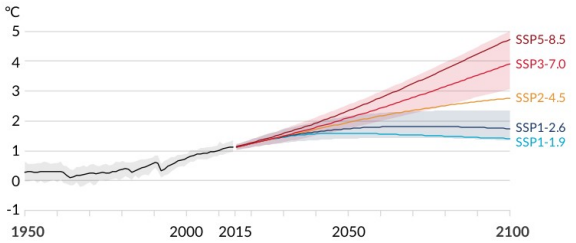
Change in global surface temperature in 2081-2100 relative to 1850-1900 (°C)



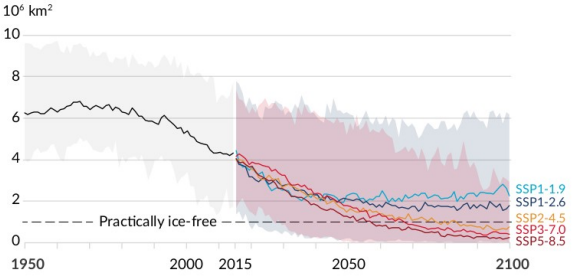
Total warming (observed warming to date in darker shade), warming from CO_2, warming from non-CO_2 GHGs and cooling from changes in aerosols and land use

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

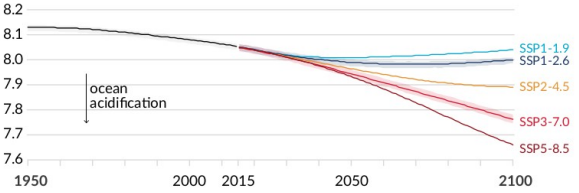
a) Global surface temperature change relative to 1850-1900



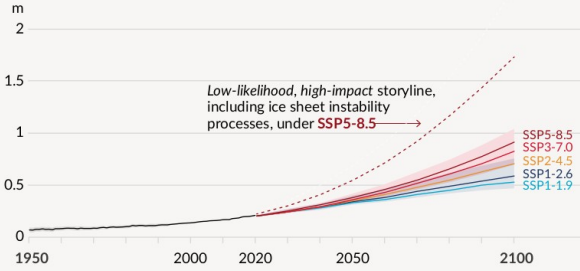
b) September Arctic sea ice area



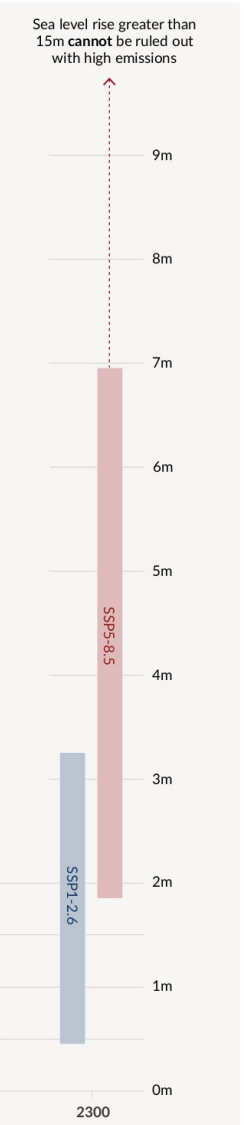
c) Global ocean surface pH (a measure of acidity)



d) Global mean sea level change relative to 1900

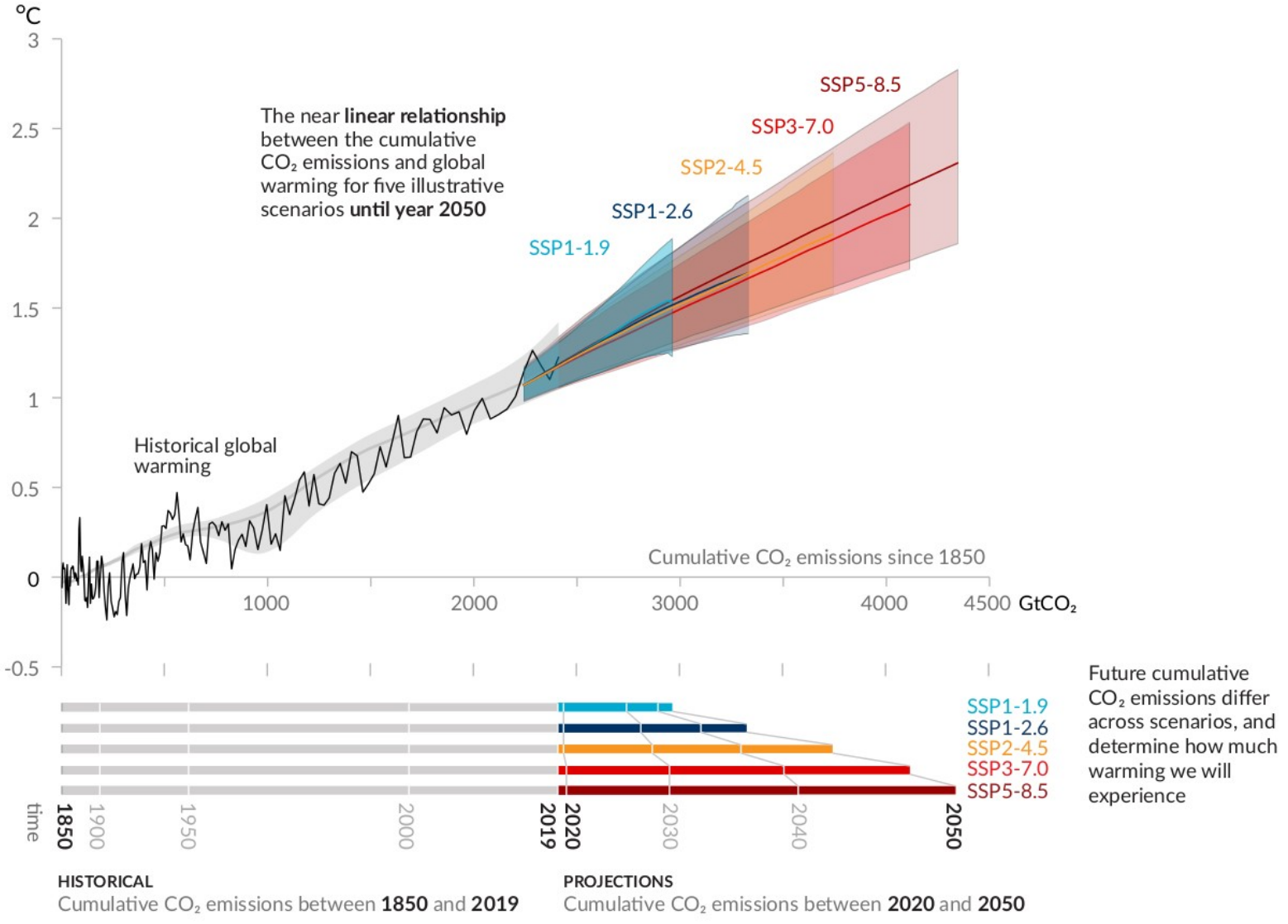


e) Global mean sea level change in 2300 relative to 1900



Every tonne of CO_2 emissions adds to global warming

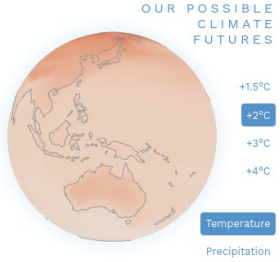
Global surface temperature increase since 1850-1900 (°C) as a function of cumulative CO_2 emissions ($GtCO_2$)

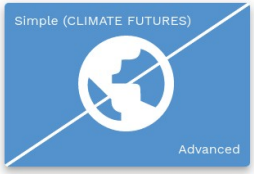


IPCC WGI Interactive Atlas

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



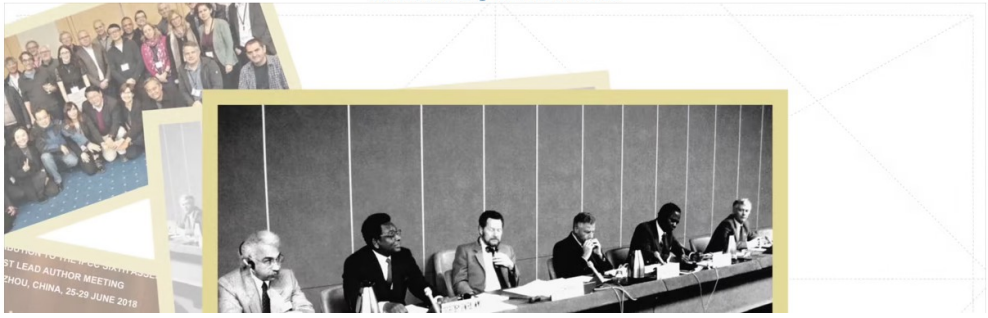


REGIONAL INFORMATION

REGIONAL SYNTHESIS

DOCUMENTATION

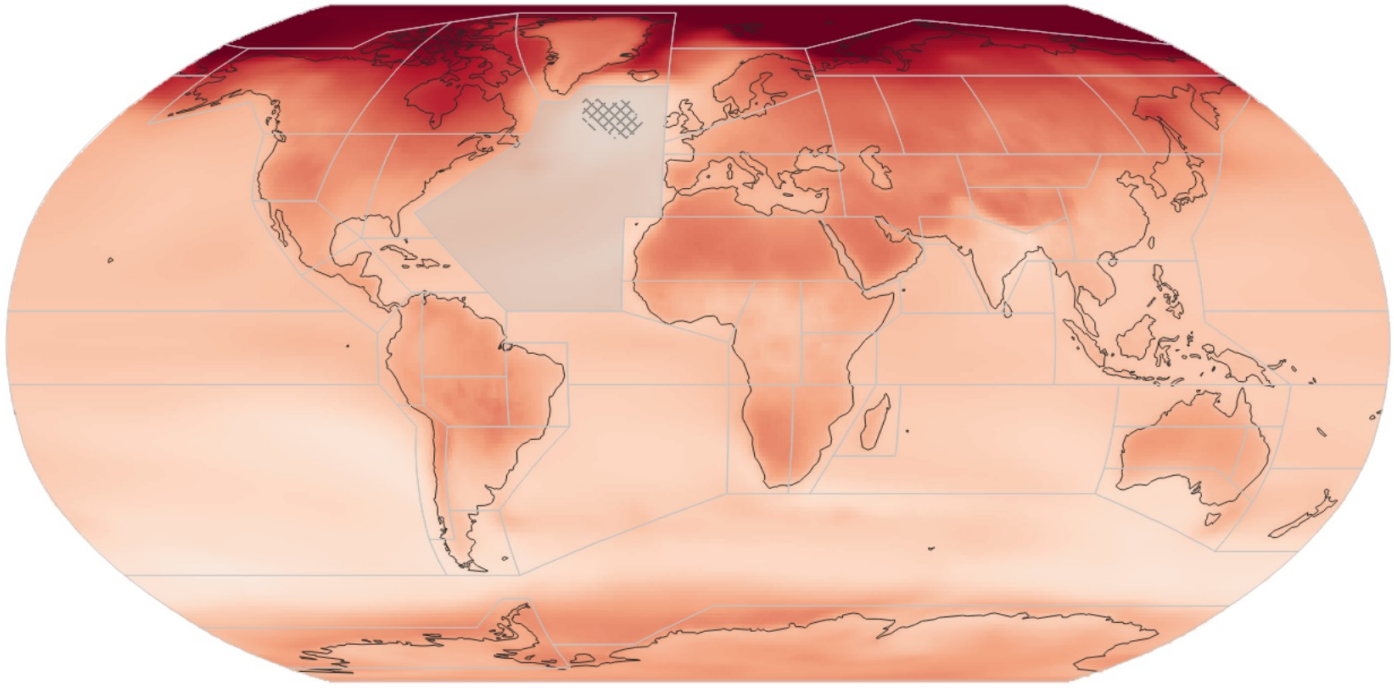
Video: Introducing the Interactive Atlas



VARIABLE | QUANTITY & SCENARIO | SEASON

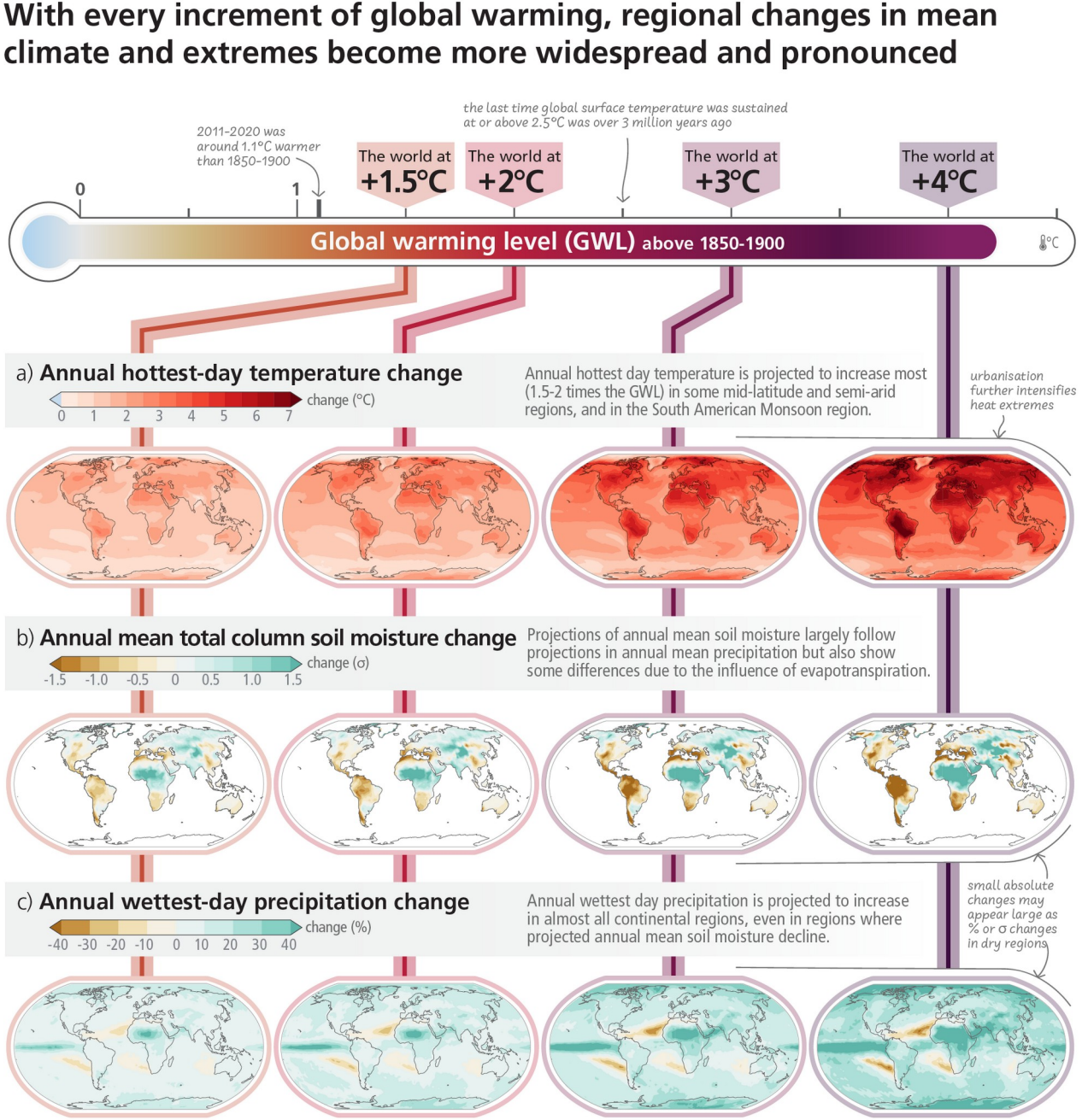
Region Set: WGI reference-re...

Uncertainty: Advanced



deg C
> 6
5
4
3
2
1
0
−1
−2
−3
−4
−5
< -6
C

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



IPCC AR6 synthesis