

CMIP5 data provided at the IPCC Data Distribution Centre

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Executive Summary

This TGICA Fact Sheet introduces a multi-climate model dataset based on the fifth phase of the Coupled Model Intercomparison Project (CMIP5) archived at the Intergovernmental Panel on Climate Change (IPCC) Data Distribution Centre (DDC). Parts of the CMIP5 multi-model dataset were used in the Fifth Assessment Report (AR5) of the IPCC. The dataset has been analyzed by the scientific community worldwide and continues to be available for studying climate, its variability and change, and the societal and environmental implications of climate change in terms of impacts, adaptation and vulnerability. The document points to the different experiments for which data have been archived at the IPCC DDC as well as offering links to sources of more information and guidance on accessing the data. Its primary target audience is the climate change research community, especially those researchers engaged in accessing, interpreting and applying climate and related data and scenarios in studies of climate change vulnerability, impacts and adaptation.

Document history

This document, *CMIP5 data provided at the IPCC Data Distribution Centre*, constitutes "Supporting material" of the Intergovernmental Panel on Climate Change (as defined in the Procedures for the Preparation, Review, Acceptance, Adoption, Approval, and Publication of IPCC Reports). The Fact Sheet was prepared by the IPCC Task Group on Data and Scenario Support for Impacts and Climate Analysis (TGICA).

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CMIP5 data provided at the IPCC Data Distribution Centre

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1. What is the CMIP5 dataset?

The fifth phase of the Coupled Model Intercomparison Project (CMIP5) coordinated by the World Climate Research Program (WCRP) has produced a multi-model dataset designed to advance our knowledge of climate, its variability and change through the application of global models of the climate system (Taylor *et al.* 2012). CMIP5 notably provides a multi-model context for: 1) assessing the mechanisms responsible for model differences in poorly understood feedbacks associated with the carbon cycle and with clouds, 2) examining climate “predictability” and exploring the predictive capabilities of forecast systems on decadal time scales, 3) more generally, determining why similarly forced models produce a range of responses, and 4) supplying sample climate futures arising from a range of forcing scenarios that span uncertainties in future climate for application in impact, adaptation and vulnerability studies. The dataset has been analyzed by the scientific community worldwide to produce the results that underlay the IPCC Fifth Assessment Report (AR5; IPCC, 2013) and continues to be available for further analyses.

2. The CMIP5 experiments.

The CMIP5 strategy (Hibbard *et al.* 2007; Meehl and Hibbard 2007) includes two types of climate change modeling experiments: 1) long-term (century time scale) simulations and 2) near-term simulations (10–30 yr), also called decadal prediction experiments (Meehl *et al.* 2009). The long-term simulations are usually started from multi-century pre-industrial control (quasi equilibrium) simulations, whereas the decadal prediction experiments are initialized with observed recent ocean and sea ice conditions.

Both the long- and near-term experiments are conducted using atmosphere–ocean global climate models (AOGCMs), the “standard” models used in previous CMIP phases. The previous exercise was CMIP3 (Meehl *et al.*, 2007), which was analyzed extensively in the IPCC AR4 (IPCC, 2007) and from which data are available at the IPCC Data Distribution Centre (DDC). Note that there was no CMIP4; the choice to move to CMIP5 was designed to align the numbering with the IPCC AR5 (Figure 1). The AOGCMs respond to specified, time-varying concentrations of various atmospheric constituents (e.g., greenhouse gases) and include interactive representations of atmosphere, ocean, land, and sea ice. For the long-term simulations, some of the AOGCMs were, for the first time in CMIP, coupled to biogeochemical components that account for the important fluxes of carbon between the ocean, atmosphere, and terrestrial biosphere carbon reservoirs, thereby including a comprehensive representation of the carbon cycle in the model. These models are called Earth system models (ESMs), and have the capability of using time-evolving emissions of constituents from which concentrations can be computed interactively. The ESMs may in some cases also include interactive prognostic aerosol, chemistry, and dynamical vegetation components.

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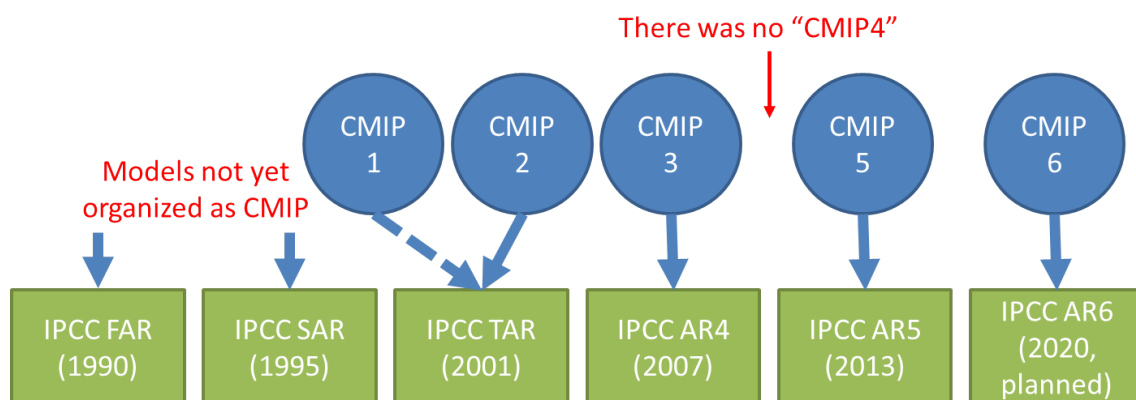


Figure 1. History of CMIPs and their contributions to IPCC Assessment Reports (ARs). Note that there was no CMIP4. As an initial attempt, CMIP1 only contains “control” (constant external conditions) simulations and contributed to the Third Assessment Report (TAR) through model evaluation together with CMIP2. The year given is the publication year of the Working Group I contribution to each Assessment Report.

Individual groups have chosen to perform either the long-term or the near-term experiments with either AOGCMs or ESMs, or they have done various combinations of each. Some groups have performed simulations with a higher resolution (20-50 km) than is typical for AOGCMs or ESMs (100-200 km). With these models, computer resources may be insufficient to allow fully coupled simulations, so CMIP5 includes an option to perform so-called time-slice simulations of both the present-day climate [essentially following the Atmospheric Model Intercomparison Project (AMIP) protocol first described by Gates (1992)] and the future climate (in particular, the decade 2026–35, which allows for direct comparison with the fully coupled experiments). In time-slice simulations of the future, projected changes in sea surface temperature (SST) and sea ice are obtained from a prior simulation of a fully coupled AOGCM.

CMIP5 experiments build on the CMIP3 experiments but include additional simulations to provide a more complete understanding of climate change and variability. In CMIP5 a new set of future greenhouse gas, aerosol and land use scenarios called Representative Concentration Pathways (RCPs; van Vuuren *et al.*, 2011)⁷ are used while in CMIP3, SRES scenarios (IPCC, 2000) were used⁸.

The CMIP5 decadal prediction experiments are a new addition to CMIP and are considered more exploratory in nature. In the decadal prediction simulations the models will not only respond to RCP forcings⁹ but can also potentially track the natural variability of the real-world climate system to some degree. Decadal predictions require sophisticated post processing, such as complex bias correction (Taylor *et al.*, 2012), and should not be used for impact assessments without expert guidance.

For detailed specifications of all the experiments, the reader is referred to the experiment design document (Taylor *et al.* 2009), which can be obtained from the CMIP5 website (<http://cmip-pcmdi.llnl.gov/cmip5>).

7 http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html

8 <http://sedac.ipcc-data.org/ddc/sres/>

9 “Forcings” in this context generally means external factors that affect the Earth’s climate. More specifically, it often means imposed perturbations of Earth’s energy balance.

3. CMIP5 data at the DDC

The full CMIP5 archive, available through the portals supported by the Earth System Grid Federation (ESGF; <https://pcmdi.llnl.gov/projects/cmip5/>), has evolved through and beyond the IPCC Fifth Assessment process, with modeling groups eager to contribute their best available data to the research community. The IPCC DDC provides access to two snapshots of the CMIP5 archive in the World Data Center for Climate (WDCC):

- (i) the IPCC Working Group I snapshot (http://www.ipcc-data.org/sim/gcm_monthly/AR5/WG1-Archive.html), and
- (ii) the DDC Reference snapshot (http://www.ipcc-data.org/sim/gcm_monthly/AR5/Reference-Archive.html).

The IPCC WGI snapshot was collected at ETH Zurich to support the IPCC WGI AR5 assessment process, including the production of CMIP5-based figures in the WGI AR5. This dataset is a subset of the data in the full CMIP5 archive on 15 March 2013 (the cutoff date for literature to be included in the WGI AR5), selected according to the requirements of WGI authors. Since that time, some data in the full archive have been corrected or withdrawn, and additional data have been contributed, while the data archived at the IPCC DDC remain unchanged. The latest data are available through the ESGF website.

In total 952 simulations provided by 58 models from 24 institutes are archived in the IPCC WGI snapshot. Only selected variables are provided at different frequencies: annual, monthly and daily. Detailed information about the simulations done for each experiment can be found at the ESGF website.

The DDC Reference snapshot was collected by the World Data Center for Climate (WDCC) at the German Climate Computing Center (DKRZ), the Centre for Environmental Data Analysis (CEDA) in the UK and the Program for Climate Model Diagnosis and Intercomparison (PCMDI) at the University of California in the USA. The DDC Reference snapshot is more extensive than the IPCC WGI snapshot: It contains additional data that, while not directly referred to in the IPCC assessment, were analyzed and discussed in the scientific literature that forms the basis of the assessment and thus indirectly contributed to the IPCC AR5. The reference snapshot is also based on the status of the full CMIP5 data archive as of 15 March 2013.

In total 1145 simulations provided by 60 models from 28 institutes are archived in the DDC Reference snapshot. The frequencies of provided data depend on variables: annual, monthly, daily, 6-hourly, 3-hourly and sub-hourly. Atmospheric fields at 6-hourly frequency, which can drive regional climate models as initial and boundary conditions to produce downscaled climate information, are also available¹⁰.

The experiments included in the two IPCC DDC archives are summarized in Figure 2. From a user perspective, in contrast to the full CMIP5 dataset at the ESGF portals, the two DDC snapshots provide a long-term data archive containing more detailed documentation, error mapping, contact and citation information as well as quality assurance following best practices in data management.

¹⁰ Note that the DDC currently does not host data downscaled from the CMIP5 simulations. The website of the WCRP Co-ordinated Downscaling Experiment (CORDEX) provides links to such data at: <http://www.cordex.org/>

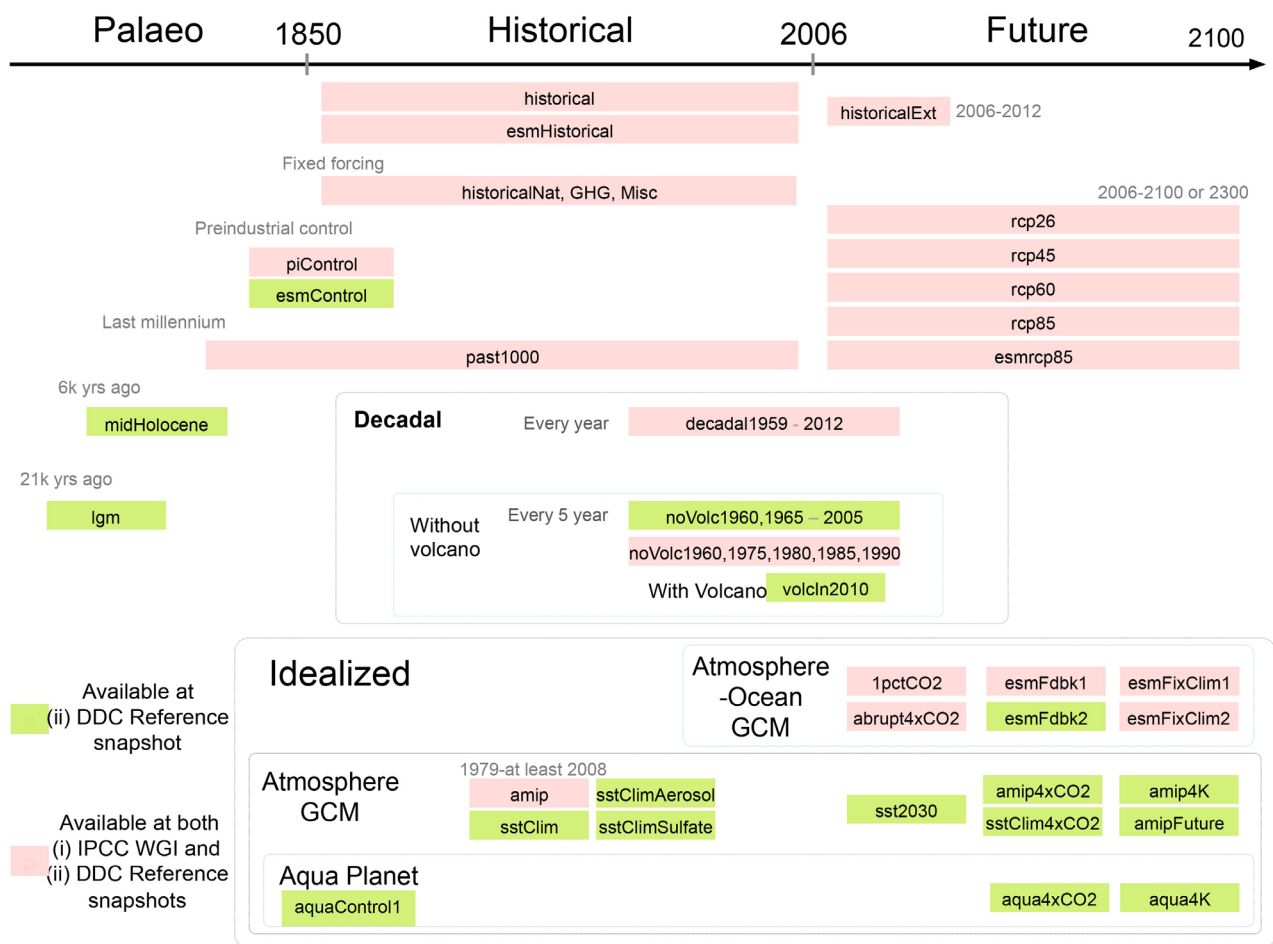


Figure 2. Summary of CMIP5 experiments included in the two archives in the IPCC DDC. Experiments available only at the DDC Reference snapshot and those available at both the IPCC WGI and DDC Reference snapshots are indicated by green and pink colors, respectively. Paleo- climate, historical and future projection experiments are arranged along an approximate timeline on the horizontal axis.

4. Description of the CMIP5 experiments

Brief descriptions of the CMIP5 experiments that are available at the IPCC DDC are provided below. Experiments available only at the DDC Reference archive and those available at both the IPCC WGI and DDC Reference snapshots are indicated by green and pink colors, respectively (Figure 2).

Coupled Model Long-Term Simulations

- **piControl** (Pre-industrial Control): Impose non-evolving, pre-industrial conditions, which may include prescribed atmospheric concentrations or non-evolving emissions of gases, aerosols or their precursors, as well as unperturbed land use.
- **historical**: Impose changing conditions (consistent with observations from 1850-2005), which may include: atmospheric composition due to both anthropogenic and volcanic influences, solar forcing, emissions or concentrations of short-lived species and natural and anthropogenic aerosols or their precursors, as well as land use.

- **historicalNat, GHG, Misc**: Historical simulations but with **Nat**: natural forcing only; **GHG**: greenhouse gas forcing only; **Misc**: other individual forcing agents or combinations of forcings.
- **historicalExt** (historical extension): Extension of the historical simulation to the year 2102.
- **rcp26, rcp45, rcp60, rcp85**: Future projections (2006-2100) forced by RCP2.6, 4.5, 6.0, and 8.5. RCPs (representative concentration pathways) approximately result in radiative forcings of 2.6, 4.5, 6.0 and 8.5 W m⁻² at year 2100 respectively, relative to pre-industrial conditions.
- **esmControl** (ESM pre-industrial control): Impose non-evolving pre-industrial conditions as in '**piControl**' but emissions-forced (with atmospheric CO₂ determined by the model itself).
- **esmHistorical**: Historical simulation as in '**historical**' but emissions-forced (with atmospheric CO₂ determined by the model itself).
- **esmrcp85**: Future projection (2006-2100) forced by RCP8.5. As in '**rcp85**' but emissions-forced (with atmospheric CO₂ determined by the model itself).
- **past1000** (Last millennium): Impose evolving conditions including solar variations and volcanic aerosols [consistent with Paleoclimate Modeling Intercomparison Project (PMIP) requirements].
- **midHolocene**: Impose Mid-Holocene (6 kyrs ago) conditions including relevant changes in the Earth's orbital parameters and atmospheric concentrations of well-mixed greenhouse gases (consistent with PMIP requirements).
- **lgm** (Last Glacial Maximum): Impose Last Glacial Maximum (21 kyrs ago) conditions including ice sheets and atmospheric concentrations of well-mixed greenhouse gases (consistent with PMIP requirements).

Coupled Model Long-Term Idealized Simulations

- **1pctCO2** (1 percent per year CO₂): Initialized from the '**piControl**' and CO₂ concentration is prescribed to increase at 1%/yr.
- **abrupt4xCO2**: Impose an instantaneous quadrupling of atmospheric CO₂ concentration (relative to pre-industrial) and then hold it fixed.
- **esmFdbk1** (ESM Feedback 1): Impose conditions identical to '**piControl**' but CO₂ concentration increase of 1%/yr is imposed for radiation code.
- **esmFdbk2** (ESM Feedback 2): Impose conditions identical to '**piControl**' but historical followed by RCP4.5 rise in CO₂ is imposed for radiation code.
- **esmFixClim1** (ESM fixed climate 1): Impose conditions identical to '**piControl**' but CO₂ concentration increase of 1%/yr is imposed for carbon cycle.
- **esmFixClim2** (ESM fixed climate 2): Impose conditions identical to '**piControl**', but historical followed by RCP4.5 rise in CO₂ is imposed for carbon cycle.

Atmosphere-Only Simulations

- **amip**: As in the Atmospheric Model Intercomparison Project (AMIP), impose sea surface temperatures (SSTs) & sea ice (from observations over 1979-at least 2008), but with other conditions (including CO₂ concentrations and aerosols) as in '**historical**'.
- **sstClim** (control SST climatology): AMIP-style experiment with climatological SSTs and sea ice from '**piControl**'.
- **sstClimAerosol** (all aerosol forcing): AMIP-style experiment with climatological SSTs and sea ice from '**piControl**' (as in '**sstClim**') but with aerosols consistent with conditions in year 2000 of the historical run.

- **sstClimSulfate** (sulfate aerosol forcing): AMIP-style experiment with climatological SSTs and sea ice from 'piControl' (as in 'sstClim') but with sulfate aerosols consistent with conditions in year 2000 of the historical simulation.
- **sst2030** (2030 time-slice): Simulation of a future decade covering the years 2026-2035, with prescribed SSTs and sea ice concentration anomalies relative to 'amip'.
- **sstClim4xCO2**: AMIP-style experiment with climatological SSTs and sea ice from 'piControl' (as in 'sstClim') but with quadrupled CO₂ imposed.
- **amip4xCO2**: Identical to 'sstClim4xCO2', but with AMIP SSTs prescribed as in 'amip'.
- **amip4K** (AMIP plus 4K anomaly): Identical to 'amip', but with a uniform 4 K increase in SST (consistent with Cloud Feedback Model Intercomparison Project (CFMIP) requirements).
- **amipFuture** (AMIP plus patterned anomaly): Add a patterned SST perturbation (provided by CFMIP based on '1pctCO2') to the AMIP SSTs of 'amip' (consistent with CFMIP requirements).
- **aquaControl** (aqua planet control): Impose zonally uniform SSTs on a planet without continents (consistent with CFMIP requirements).
- **aqua4xCO2**: Impose quadrupled CO₂ on zonally uniform SSTs of 'aquaControl' (consistent with CFMIP requirements).
- **aqua4K** (aqua planet plus 4K anomaly): Identical to 'aquaControl', but with a uniform 4 K increase in SST. (consistent with CFMIP requirements)

Coupled Model "Decadal" Prediction Experiments

- **decadalXXXX** (10-year simulation initialized in year XXXX, where XXXX denotes individual years from 1959 to 2012): Decadal hindcast/prediction. Comparison of initialization strategies using an alternate initialization strategy or alternate initial data.
- **noVolcXXXX** (volcano-free hindcasts): Hindcast without volcanoes. 10-year simulation from year XXXX, where XXXX is 5-yearly from 1960 to 2005, without including the Agung, El Chichon and Pinatubo eruptions.
- **volcIn2010** (prediction with 2010 volcano): Pinatubo-like eruption imposed. Repeat of the 'decadal2005' forecast with an imposed 'Pinatubo' eruption in 2010.

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