The CMIP6 multi-model ensembles technical documentation

This is the technical documentation for the Coupled Model Intercomparison Project Phase 6 (CMIP6) global climate models (GCMs) provided on the Canadian Centre for Climate Services (CCCS) website. The documentation provides a description of the CMIP6 multi-model ensemble datasets, ensemble methodology, and a list of models included.

On this page

Overview

Climate scenarios based on an ensemble of global climate model projections from CMIP6 are provided. Projections among climate models can vary because of differences in their underlying representation of earth system processes. Thus, the use of a multi-model ensemble approach has been demonstrated in recent scientific literature to likely provide better projected climate change information.

Multi-model ensembles of modelled output and projected change are available for historical simulations and four Shared Socioeconomic Pathways (SSPs), SSP1-26, SSP2-45, SSP3-70 and SSP5-85, at a 1x1 degree grid resolution. Projected changes are expressed as anomalies according to a historical reference period of 1995-2014. Please see Table 1 for a description of the main characteristics of each product.

Table 1. The characteristics of products produced with the CMIP6 multi-model ensemble.

Variables and units	Mean temperature (°C) Projected change in mean temperature (°C) Mean precipitation (mm/day) Projected relative change in mean precipitation (%) Wind speed (m/s) Projected change in wind speed (%) Snow depth (m) Projected change in snow depth (%) Sea ice thickness (m) Projected change in sea ice thickness (%) Sea ice concentration (Percentage, %, of grid cell area) Projected change in sea ice concentration (%)
Geographic area	Canada
Spatial resolution	1x1 degree grid resolution
Temporal resolution	Monthly, seasonal, and annual Seasons are defined using standard meteorological seasons: • Spring: March to May (MAM) • Summer: June to August (JJA) • Autumn: September to November (SON) • Winter: December to February (DJF)
Time period	Historical period: 1900-2014 Historical reference period used for projected change calculations: 1995-2014

	Future projections: 2015-2100 20-year averages of projected change for four future time periods: • near term (2021-2040) • mid term (2041-2060 and 2061-2080) • end of century (2081-2100)
Percentiles	5th, 25th, 50th (median), 75th, and 95th
Emissions scenarios	SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5

Data and processing

Data download and interpolation

Monthly CMIP6 GCM datasets were downloaded from the Earth System Grid Federation (ESGF) online database in NetCDF format. Each model simulation was interpolated to a common 1x1 degree global grid. See Tables 2-6 for a list of included models.

Only one realization member from each model was included in the multi-model ensembles, giving each model equal weight.

Calculation of anomalies

Projected changes in climate are provided as anomalies according to a historical reference period of 1995-2014 for all anomaly datasets and products.

Projected anomalies for a future time period are calculated by subtracting the mean over the historical reference period from the mean of the projected values of the future time period for each model.

Ensemble statistics, specifically the 5th, 25th, 50th (median), 75th, and 95th percentiles, are provided to demonstrate some of the range of uncertainty across model projections.

List of models

Table 2. The list of the models included in the CMIP6 multi-model ensembles of temperature and precipitation for each SSP. The number of models used to compute the multi-model ensembles may differ for each SSP.

#	CMIP6 Model Name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
1	AWI-CM-1-1-MR	✓	✓	✓	✓	✓
2	BCC-CSM2-MR	✓	✓	✓	✓	✓
3	CAMS-CSM1-0	✓	✓	✓	✓	✓
4	CanESM5	✓	✓	✓	✓	✓
5	CESM2-WACCM	✓	✓	✓	✓	✓
6	CESM2	✓	✓	✓	✓	✓
7	CIESM	✓	✓	✓		✓
8	CMCC-CM2-SR5	✓	✓	✓	✓	✓
9	EC-Earth3-Veg	✓	✓	✓	✓	✓
10	EC-Earth3	✓	✓	✓	✓	✓
11	FGOALS-f3-L	✓	✓	✓	✓	✓
12	FGOALS-g3	✓	✓	✓	✓	✓
13	FIO-ESM-2-0	✓	✓	✓		✓
14	GFDL-CM4	✓	✓	✓		✓

#	CMIP6 Model Name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
15	GFDL-ESM4	✓		✓		✓
16	INM-CM4-8	✓	✓	✓	✓	✓
17	INM-CM5-0	✓	✓	✓	✓	✓
18	IPSL-CM6A-LR	✓	✓	✓	✓	✓
19	KACE-1-0-G	✓	✓	✓	✓	✓
20	KIOST-ESM	✓	✓	✓		✓
21	MIROC6	✓	✓	✓	✓	✓
22	MPI-ESM1-2-HR	✓	✓	✓	✓	✓
23	MPI-ESM1-2-LR	✓	✓	✓	✓	✓
24	MRI-ESM2-0	✓	✓	✓	✓	✓
25	NESM3	✓	✓	✓		✓
26	NorESM2-LM	✓	✓	✓	✓	✓
27	NorESM2-MM	✓	✓	✓	✓	✓
	Number of models	**27**	**26**	**27**	**22**	**27**

Table 3: The list of the models included in the CMIP6 multi-model ensembles of wind speed for each SSP. The number of models used to compute the multi-model ensembles may differ for each SSP.

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
1	BCC-CSM2-MR	✓	✓	✓		✓
2	CAMS-CSM1-0	✓	✓	✓		✓
3	CanESM5	✓	✓	✓	✓	✓
4	CESM2	✓	✓	✓		✓
5	CESM2-WACCM	✓	✓	✓		✓
6	EC-Earth3	✓	✓	✓		✓
7	EC-Earth3-Veg	✓	✓	✓		✓
8	FGOALS-f3-L	✓	✓	✓		✓
9	FGOALS-g3	✓	✓	✓	✓	✓
10	GFDL-CM4	✓		✓		✓
11	GFDL-ESM4	✓	✓	✓		✓
12	INM-CM4-8	✓	✓	✓		✓
13	INM-CM5-0	✓	✓	✓		✓
14	IPSL-CM6A-LR	✓	✓	✓	✓	✓
15	KACE-1-0-G	✓	✓	✓		✓
16	MIROC6	✓	✓	✓	✓	✓
17	MPI-ESM1-2-HR	✓	✓	✓		✓
18	MPI-ESM1-2-LR	✓	✓	✓		✓
19	MRI-ESM2-0	✓	✓	✓	✓	✓
20	NorESM2-LM	✓	✓	✓		✓

21	NorESM2-MM	✓	✓	✓		✓
	Number of models	**21**	**20**	**21**	**5**	**21**

Table 4: The list of the models included in the CMIP6 multi-model ensembles of sea ice thickness for each SSP. The number of models used to compute the multi-model ensembles may differ for each SSP.

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
1	AWI-CM-1-1-MR	✓	✓	✓	✓	✓
2	CanESM5	✓	✓	✓	✓	✓
3	CESM2-WACCM	✓	✓	✓	✓	✓
4	CIESM	✓	✓	✓		✓
5	CMCC-CM2-SR5	✓	✓	✓	✓	✓
6	CMCC-ESM2	✓	✓	✓	✓	✓
7	E3SM-1-1	✓				✓
8	E3SM-1-1-ECA	✓				✓
9	EC-Earth3	✓	✓	✓	✓	✓
10	EC-Earth3-AerChem	✓		✓		✓
11	EC-Earth3-CC					
12	EC-Earth3-Veg	✓	✓	✓	✓	✓
13	EC-Earth3-Veg-LR	✓	✓	✓	✓	✓
14	GFDL-CM4	✓		✓		✓
15	GFDL-ESM4	✓	✓	✓	✓	✓
16	IPSL-CM5A2-INCA	✓	✓		✓	

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
17	IPSL-CM6A-LR	✓	✓	✓	✓	✓
18	KACE-1-0-G	✓	✓	✓	✓	✓
19	MIROC6	✓	✓	✓	✓	✓
20	MPI-ESM1-2-HR	✓	✓	✓		✓
21	MPI-ESM1-2-LR	✓	✓	✓		✓
22	MRI-ESM2-0	✓	✓	✓	✓	✓
23	NESM3	✓	✓	✓	✓	✓
24	NorESM2-LM	✓	✓	✓	✓	✓
25	NorESM2-MM	✓	✓	✓	✓	✓
	Number of models	**25**	**20**	**21**	**19**	**21**

Table 5: The list of the models included in the CMIP6 multi-model ensembles of sea ice concentration for each SSP. The number of models used to compute the multi-model ensembles may differ for each SSP.

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
1	BCC-CSM2-MR	✓	✓	✓	✓	✓
2	CAMS-CSM1-0	✓	✓	✓	✓	✓
3	CanESM5	✓	✓	✓	✓	✓
4	CAS-ESM2-0	✓	✓	✓	✓	✓
5	CESM2	✓	✓	✓	✓	✓
6	CESM2-WACCM	✓	✓	✓	✓	✓
7	CMCC-CM2-SR5	✓	✓	✓	✓	✓
8	CMCC-ESM2	✓	✓	✓	✓	✓

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
9	E3SM-1-1	✓				✓
10	E3SM-1-1-ECA	✓				✓
11	EC-Earth3	✓	✓	✓	✓	✓
12	EC-Earth3-AerChem	✓			✓	
13	EC-Earth3-CC	✓		✓		
14	EC-Earth3-Veg	✓	✓	✓	✓	✓
15	EC-Earth3-Veg-LR	✓	✓	✓	✓	✓
16	FGOALS-f3-L	✓	✓	✓	✓	✓
17	FGOALS-g3	✓	✓	✓	✓	✓
18	FIO-ESM-2-0	✓	✓	✓		
19	GFDL-CM4	✓		✓		✓
20	GFDL-ESM4	✓	✓	✓	✓	✓
21	INM-CM4-8	✓	✓	✓	✓	✓
22	INM-CM5-0	✓	✓	✓	✓	✓
23	IPSL-CM5A2-INCA	✓		✓	✓	
24	IPSL-CM6A-LR	✓	✓	✓	✓	✓
25	MIROC6	✓	✓	✓	✓	✓
26	MPI-ESM1-2-HR	✓	✓	✓	✓	✓
27	MPI-ESM1-2-LR	✓	✓	✓	✓	✓
28	MRI-ESM2-0	✓	✓	✓	✓	✓
29	NESM3	✓	✓	✓		

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
30	NorESM2-LM	✓	✓	✓	✓	✓
31	NorESM2-MM	✓	✓	✓	✓	✓
32	TaiESM1	✓	✓	✓	✓	✓
	Number of models	**32**	**27**	**28**	**26**	**30**

Table 6: The list of the models included in the CMIP6 multi-model ensembles of snow depth for each SSP. The number of models used to compute the multi-model ensembles may differ for each SSP.

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
1	CanESM5	✓	✓	✓	✓	✓
2	CAS-ESM2-0	✓	✓	✓	✓	✓
3	CESM2-WACCM	✓	✓	✓	✓	✓
4	CMCC-CM2-SR5	✓	✓	✓	✓	✓
5	CMCC-ESM2	✓	✓	✓	✓	✓
6	EC-Earth3	✓	✓	✓	✓	✓
7	EC-Earth3-AerChem	✓			✓	
8	EC-Earth3-CC	✓		✓		✓
9	EC-Earth3-Veg	✓	✓	✓	✓	✓
10	EC-Earth3-Veg-LR	✓	✓	✓	✓	✓
11	FGOALS-f3-L	✓	✓	✓	✓	✓
12	FGOALS-g3	✓	✓	✓	✓	✓
13	GFDL-CM4	✓		✓		✓

#	CMIP6 model name	Historical	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
14	GFDL-ESM4	✓	✓	✓	✓	✓
15	IPSL-CM6A-LR	✓	✓	✓	✓	✓
17	MIROC6	✓	✓	✓	✓	✓
18	MRI-ESM2-0	✓	✓	✓	✓	✓
19	NorESM2-LM	✓	✓	✓	✓	✓
20	NorESM2-MM	✓	✓	✓	✓	✓
	Number of models	**19**	**16**	**18**	**17**	**18**

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