# Global climate model scenarios

## 1. Overview

Climate scenarios based on an ensemble of global climate model projections from the Coupled Model Intercomparison Project Phase 5 (CMIP5) are provided. Multi-model ensembles of modelled output and projected change are available for historical simulations and three emission scenarios, RCP2.6, RCP4.5 and RCP8.5, at a 1x1 degree grid resolution. Projected changes are expressed as anomalies with respect to the reference period of 1986-2005.

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.

Table 1. Main Characteristics

| | |
|---|---|
| Variables and units | Mean temperature (°C)<br>Projected change in mean temperature (°C)<br>Mean precipitation (mm/day)<br>Projected relative change in mean precipitation (%)<br>Wind speed (m/s)<br>Projected change in wind speed (%)<br>Snow depth (m)<br>Projected change in snow depth (%)<br>Sea ice thickness (m)<br>Projected change in sea ice thickness (%)<br>Sea ice concentration (Percentage, %, of grid cell area)<br>Projected change in sea ice concentration (%) |
| Geographic Area | Canada |
| Spatial Resolution | 1 x 1 degree grid resolution |
| Time Period | 1900 to 2100 for sea ice thickness, sea ice concentration, snow depth and wind speed<br><br>1901 to 2100 for mean temperature and precipitation<br><br>*20-year averages of projected change are available for four future time periods:*<br>2021-2040; 2041-2060; 2061-2080; 2081-2100 |
| Temporal Resolution | Monthly, seasonal, and annual<br><br>*Seasons:* The standard meteorological seasons are used: March to May (spring), June to August (summer), September to November (autumn/fall), and December to February (winter). |
| Emission Scenario | RCP2.6<br>RCP4.5<br>RCP8.5 |

## 2. Data and processing

Multi-model ensembles have been constructed using the Coupled Model Intercomparison Project Phase 5 (CMIP5) projections model output available at the Program For Climate Model Diagnosis and Intercomparison (PCMDI) site (downloaded 15 April 2014). Multi-model ensemble datasets of temperature, precipitation, and wind speed comprise 29/29/29 scenario experiments for RCP2.6/4.5/8.5 from 29 climate models (Table 2). Multi-model ensembles of snow depth and sea ice concentration comprise of 28[1] of the climate models listed in Table 2, while 26[2] of the climate models listed in Table 2 were used for multi-model ensembles of sea ice thickness.

Only concentration-driven experiments are used (i.e., those in which concentrations rather than emissions of greenhouse gases are prescribed) and only one ensemble member from each model is selected, even if multiple realizations exist with different initial conditions and different realizations of natural variability. Hence each model is given equal weight.

## 3. Reference period for anomaly results (projected change)

Projected changes are expressed as anomalies with respect to the reference period of 1986-2005 for both anomaly time series and spatial maps (i.e., differences between the future period and the reference period). Therefore, twenty-year averages of projected change (in the climate variable) for the four future time periods (2021-2040; 2041-2060; 2061-2080; 2081-2100) are with respect to the reference period of 1986-2005.

## 4. Equal model weighting

The different CMIP5 models used for the projections are all considered to give equally likely projections in the sense of 'one model, one vote'. Models with variations in physical parameterization schemes are treated as distinct models.

## 5. Model range through the use of ensemble percentiles

As local projections of climate change are uncertain, a measure of the range of model projections is provided (i.e., $5^{th}$, $25^{th}$, $75^{th}$, $95^{th}$ percentiles) in addition to the median response ($50^{th}$ percentile) of the model ensemble interpolated to a common 1x1 degree grid. It should again be emphasized that this range does not represent the full uncertainty in the projection. The distribution combines the effects of natural variability and model spread.

## 6. Best practice

Given the range of natural climate variability and uncertainties regarding future greenhouse gas emission pathways and climate response, changes projected by one climate model should not be used in isolation. Rather, it is good practice to consider a range of projections from multiple climate models (ensembles) and emission scenarios.

While likelihoods are not associated with particular climate change scenarios, the use of a range of scenarios may help convey to users the potential spread across a range of possible emission pathways.

## 7. Use Limitation



[1] The climate model (earth system model), BNU-ESM, was excluded from the snow depth ensembles and sea ice concentration ensembles due to a data issue.

[2] The climate models (earth system models), BNUESM, GISS-E2-H, GISS-E2-R, were excluded from the sea ice thickness ensembles due to data issues.

## 8. Contact Information

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Table 2. List of climate models used in the multi-model ensembles.

| | CMIP5 model name | Historical | RCP2.6 | RCP4.5 | RCP8.5 |
|---|---|---|---|---|---|
| #1 | BNU-ESM | 1 | 1 | 1 | 1 |
| #2 | CCSM4 | 1 | 1 | 1 | 1 |
| #3 | CESM1-CAM5 | 1 | 1 | 1 | 1 |
| #4 | CESM1-WACCM | 1 | 1 | 1 | 1 |
| #5 | CNRM-CM5 | 1 | 1 | 1 | 1 |
| #6 | CSIRO-Mk3-6-0 | 1 | 1 | 1 | 1 |
| #7 | CanESM2 | 1 | 1 | 1 | 1 |
| #8 | EC-EARTH | 1 | 1 | 1 | 1 |
| #9 | FGOALS-g2 | 1 | 1 | 1 | 1 |
| #10 | FIO-ESM | 1 | 1 | 1 | 1 |
| #11 | GFDL-CM3 | 1 | 1 | 1 | 1 |
| #12 | GFDL-ESM2G | 1 | 1 | 1 | 1 |
| #13 | GFDL-ESM2M | 1 | 1 | 1 | 1 |
| #14 | GISS-E2-H | 1 | 1 | 1 | 1 |
| #15 | GISS-E2-R | 1 | 1 | 1 | 1 |
| #16 | HadGEM2-AO | 1 | 1 | 1 | 1 |
| #17 | HadGEM2-ES | 1 | 1 | 1 | 1 |
| #18 | IPSL-CM5A-LR | 1 | 1 | 1 | 1 |
| #19 | IPSL-CM5A-MR | 1 | 1 | 1 | 1 |
| #20 | MIROC-ESM | 1 | 1 | 1 | 1 |
| #21 | MIROC-ESM-CHEM | 1 | 1 | 1 | 1 |
| #22 | MIROC5 | 1 | 1 | 1 | 1 |
| #23 | MPI-ESM-LR | 1 | 1 | 1 | 1 |
| #24 | MPI-ESM-MR | 1 | 1 | 1 | 1 |
| #25 | MRI-CGCM3 | 1 | 1 | 1 | 1 |
| #26 | NorESM1-M | 1 | 1 | 1 | 1 |
| #27 | NorESM1-ME | 1 | 1 | 1 | 1 |
| #28 | bcc-csm1-1 | 1 | 1 | 1 | 1 |
| #29 | bcc-csm1-1-m | 1 | 1 | 1 | 1 |

Note: The earth system model, BNU-ESM, was excluded from the snow depth ensembles and sea ice concentration ensembles due to a data issue. The earth system models, BNUESM, GISS-E2-H, GISS-E2-R, were excluded from the sea ice thickness ensembles due to data issues.