# SimCLIM Data Manual 4.x

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# Introduction

Climatic data management, analysis and visualization are the most elementary functions of the SimCLIM software system. Climatic data may come from miscellaneous sources and may have different characteristics: for example, spatial resolutions, data formations and time spans. According to specific cases, these data are post-processed, standardized, and then are maintained by CLIMsystems for inclusion in SimCLIM 4.x for Desktop.

SimCLIM 4.x for Desktop supports both *spatial* and *site* data. For the former, a region is used as the minimum data management unit, which ranges from global to a relatively small river basin, state or province or a city. Whatever the spatial scale climatic data can be divided into two periods – baseline and future climate change periods. A baseline period defines the observed climate with which climate change information is usually combined to create a climate scenario. When using climate model results for scenario construction, the baseline also serves as the reference period from which the modelled future change in climate is calculated. Since SimCLIM always follows the IPCC (currently the Fifth Assessment Report), SimCLIM 2013 mainly focuses on the *IPCC CMIP5 datasets* and the baseline period generally ranges from *1986 to 2005 (centred on 1995)*. In SimCLIM 4.x for Desktop, the most basic spatial dataset (baseline and future) is run at the global scale of 0.5°*0.5° resolution. Higher spatial resolution study areas for other regions are generally derived from this dataset through nonlinear/linear interpolation methods. As for the site data, they belong to the observational data set and are collected from global, publicly available observation networks or national Meteorological Departments. They are managed and visualized at the global scale without using particular regions as their spatial locations are defined by their own latitude and longitude.

This manual presents the details of the data sources and the corresponding standardization methods in two parts: Part 1 for spatial data, Part 2 for site data.

# Part 1 Spatial Data

## *Global Baseline Climatology*

The original data populating SimCLIM 2013 represented by global baseline climatology of different variables were obtained from various publicly accessible data sources. The data sources were selected based on our best knowledge, concerning the quality of the data. A ***bilinear interpolation*** method was applied to interpolate the data from their original resolution to 0.5°*0.5° degrees.

### Temperature

Mean, maximum and minimum temperatures for the land area are extracted from the CRU_ts3.20 (1981-2010) dataset with a spatial resolution of 0.5°. You can check the details on

http://badc.nerc.ac.uk/view/badc.nerc.ac.uk__ATOM__ACTIVITY_3ec0d1c6-4616-11e2-89a3-00163e251233

Mean temperature data for the ocean area were derived from NASA reanalysis data (http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl), and the diurnal temperature range were

calculated from multiple GCMs, then maximum and minimum temperatures were derived.

## Precipitation

Land precipitation: CRU_ts3.20 with a spatial resolution of 0.5°degrees (1981-2010). (CRU data was superseded because data inaccuracy)
Updated with Global Precipitation Climatology Centre (GPCC) 1981-2100 long-term climatology http://www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html
Ocean precipitation is from Xie Arkin (1981-2002), plus GPCP (2003-2010) (1.0°).

## Wind speed

In order to get a more accurate baseline and global coverage, SimCLIM global wind speed baseline is a monthly climatology combined with three different datasets, then interpolated to a 0.5°*0.5° latitude and longitude grid.

### *Wind speed for ocean*

The blended sea winds contain globally gridded, high resolution ocean surface vector winds and wind stresses on a global 0.25° grid, and multiple time resolutions of 6-hourly, daily, monthly, and 11-year (1995-2005) climatological monthlies (http://www.ncdc.noaa.gov/oa/rsad/air-sea/seawinds.html).

### *Wind speed for land area*

We describe the construction of a 10 minute latitude/longitude data set of mean monthly surface climate over global land areas, excluding Antarctica (New et al., 2002)

### *Wind speed for polar area*

Monthly and annual averaged values for a 10-year period (July 1983 - June 1993).
http://power.larc.nasa.gov/cgi-bin/cgiwrap/solar/global.cgi?email=global@larc.nasa.gov
Wind Speed At 50 m Above The Surface Of The Earth (m/s)

## Solar radiation

The data set contains monthly average global fields of eleven shortwave (SW) surface radiative parameters derived with the shortwave algorithm of the NASA World Climate Research Programme/Global Energy and Water-Cycle Experiment (WCRP/GEWEX) Surface Radiation Budget (SRB) Project.

The SimCLIM 2013 baseline uses all Sky Surface Downward Flux (RSDS in GCM variable name convention) monthly averages of 1984 to 2006.

Acknowledgments: These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center. For detailed data descriptions please refer to the readme file of the original dataset (http://eosweb.larc.nasa.gov/PRODOCS/srb/table_srb.html).

## Relative humidity

Relative data were derived from NASA reanalysis monthly assimilated state on pressure data 1981 to 2000, (http://disc.sci.gsfc.nasa.gov/daac-bin/FTPSubset.pl), with original resolution 0.8° .

## Other variables

Other variables such as Sea Surface Temperature (SST) can be transformed and inserted into SimCLIM 4.0 for Desktop data sets on demand.

# Global Climate Models and Climate Change

For SimCLIM 4.0 for Desktop CLIMsystems follows the IPCC Fifth Assessment Report. As the CMIP5 datasets under different emission scenarios (Table 1) for IPCC AR5 are publicly available. SimCLIM 4.0 for Desktop is supported by this data. In general, these data are produced and maintained by their respective research institutes. Moreover, these data have different spatial resolutions (Table 2). For convenience of analyses, all data were processed by a *pattern scaling* method, and then were regridded to a common 720*360 grid (0.5°*0.5°) using a *bilinear interpolation* method.

Emission Scenarios for IPCC AR5

The GCM data in SimCLIM is from CIMP5 which is also the data source for IPCC AR5 climate change projections. For more information on CMIP5 please visit: http://cmip-pcmdi.llnl.gov/cmip5/ guide_to_cmip5.html.
The Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its Fifth Assessment Report (AR5). The four RCPs, RCP2.6, RCP4.5, RCP6.0, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 (of 2.6, 4.5, 6.0, and 8.5 W/m2, respectively) (Table 1).

**Table 1. Overview of representative concentration pathways (RCPs) (van Vuuren *et al.* 2011; Moss *et al.* 2010; Rojeli *et al*. 2012)**

| Description[a] | | $CO_2$ Equivalent | SRES Equivalent | Publication – IA Model |
|---|---|---|---|---|
| **RCP8.5** | Rising radiative forcing pathway leading to 8.5 W/m2 in 2100. | **1370** | **A1FI** | **Raiahi *et al.* 2007 – MESSAGE** |
| **RCP6.0** | Stabilization without overshoot | **850** | **B2** | **Fujino *et al.*; Hijioka *et al.* 2008 – AIM** |

| | | | | |
|---|---|---|---|---|
| | pathway to 6 W/m2 at 2100 | | | |
| **RCP4.5** | Stabilization without overshoot pathway to 4.5 W/m2 2100 | **650** | **B1** | **Clark *et al.* 2006; Smith and Wigley 2006; Wise *et al.* 2009 – GCAM** |
| **RCP2.6** | Peak in radiative forcing at ~ 3 W/m2 before 2100 and decline | **490** | **None** | **van Vuuren *et al.*, 2007; van Vuuren *et al.* 2006 - IMAGE** |

[a] Approximate radiative forcing levels were defined as ±5% of the stated level in $W/m_2$ relative to pre-industrial levels. Radiative forcing values include the net effect of all anthropogenic GHGs and other forcing agents.

## GCM Description

GCM data were retrieved from the Earth System Grid (ESG) data portal for CMIP5 (Table 2). The main improvements in CMIP5 include (a) the addition of interactive ocean and land carbon cycles of varying degrees of complexity, (b) more comprehensive modelling of the indirect effect of aerosols, and (c) the use of time-evolving volcanic and solar forcing in most models (e.g., Taylor et al., 2012). The CMIP5 models generally have higher horizontal and vertical resolution (median resolution180*96L39) compared to the CMIP3 (median resolution 128*64L24).

Table 2. CMIP5 GCMs used in SimCLIM 4.0 for Desktop

| | Model | Country | Spatial resolution for atmospheric variable (longitude*latitude) | Spatial resolution for ocean variable (longitude*latitude) |
|---|---|---|---|---|
| 1 | ACCESS1.3 | Australia | 192*145 | 360*300 |
| 2 | ACCESS1.0 | Australia | 192*145 | 360*300 |
| 3 | BCC-CSM1-1 | China | 128*64 | 360*232 |
| 4 | BCC-CSM1-1-m | China | 320*160 | 360*232 |
| 5 | BNU-ESM | China | 128*64 | |
| 6 | CanESM2 | Canada | 128*64 | 256*192 |
| 7 | CCSM4 | USA | 288*192 | 320*384 |
| 8 | CESM1-BGC | USA | 288*192 | 320*384 |
| 9 | CESM1-CAM5 | USA | 288*192 | 320*384 |
| 10 | CMCC-CM | Italy | 480*240 | 182*149 |

| 11 | CMCC-CMS | Italy | 192*96 | 182*149 |
|----|----------|-------|--------|---------|
| 12 | CNRM-CM5 | France | 256*128 | 362*292 |
| 13 | CSIRO-Mk3-6-0 | Australia | 192*96 | 192*189 |
| 14 | EC-EARTH | Netherlands | 320*160 | 362*292 |
| 15 | FGOALS-g2 | China | 128*60 | 360*196 |
| 16 | FGOALS-s2 | China | 128*108 | 360*196 |
| 17 | GFDL-CM3 | USA | 144*90 | 360*200 |
| 18 | GFDL-ESM2G | USA | 144*90 | 360*210 |
| 19 | GFDL-ESM2M | USA | 144*90 | 360*200 |
| 20 | GISS-E2-H | USA | 144*90 | 144*90 |
| 21 | GISS-E2-H-CC | USA | 144*90 | 144*90 |
| 22 | GISS-E2-R | USA | 144*90 | 288*180 |
| 23 | GISS-E2-R-CC | USA | 144*90 | 288*180 |
| 24 | HADCM3 | UK | 96*73 | 96*73 |
| 25 | HadGEM2-AO | UK | 192*145 | 360*216 |
| 26 | HadGEM2-CC | UK | 192*145 | 360*216 |
| 27 | HadGEM2-ES | UK | 192*145 | 360*216 |
| 28 | INMCM4 | Russia | 180*120 | 360*340 |
| 29 | IPSL-CM5A-LR | France | 96*96 | 182*149 |
| 30 | IPSL-CM5A-MR | France | 144*142 | 182*149 |
| 31 | IPSL-CM5B-LR | France | 96*96 | 182*149 |
| 32 | MIROC4H | Japan | 640*320 | 1280*912 |
| 33 | MIROC5 | Japan | 256*128 | 256*224 |
| 34 | MIROC-ESM | Japan | 128*64 | 256*192 |
| 35 | MIROC-ESM-CHEM | Japan | 128*64 | 256*192 |
| 36 | MPI-ESM-LR | Germany | 192*96 | 256*220 |
| 37 | MPI-ESM-MR | Norway | 192*96 | 802*404 |
| 38 | MRI-CGCM3 | Japan | 320*160 | 360*368 |
| 39 | NorESM1-M | Norway | 144*96 | 320*384 |

| 40 | NorESM1-ME | Norway | 144*96 | 320*384 |
|---|---|---|---|---|

## Data Processing Methodology - Pattern Scaling

Pattern scaling is based on the theory that, firstly, a simple climate model can accurately represent the global responses of a GCM, even when the response is non-linear (Raper et al. 2001), and secondly, a wide range of climatic variables represented by a GCM are a linear function of the global annual mean temperature change represented by the same GCM at different spatial and/or temporal scales (Mitchell, 2003, Whetton et al. 2005). Pattern-scaling does not seem to be a very large source of error in constructing regional climate projections for extreme scenarios (Ruosteenoja, et al. 2007), however, in applying pattern-scaling, two fundamental sources of error related to its underlying theory need to be addressed: 1) Nonlinearity error: the local responses of climate variables, precipitation in particular, may not be inherently linear functions of the global mean temperature change; and 2) Noise due to the internal variability of the GCM. Based on the pattern scaling theory, for a given GCM, the linear response change pattern of a climate variable to global mean temperature change represented by the GCM, should be obtained from any one of its GHG emission simulation outputs. Pattern scaling may be described as follows: for a given climate variable $V$, its anomaly $\Delta V^{*}$ for a particular grid cell ($i$), month ($j$) and year or period ($y$) under an representative concentration pathway RCP 4.5:

$$\Delta V_{yij}^{*} = \Delta T_{y} \cdot \Delta V_{ij}^{'}$$

(1)

$\Delta T$ being the annual global mean temperature change.

The local change pattern value ($\Delta V_{ij}^{'}$) was calculated from the GCM simulation anomaly ($\Delta V_{yij}$) using linear least squares regression, that is, the slope of the fitted linear line.

$$\Delta V_{ij}^{'} = \frac{\sum_{y=1}^{m} \Delta T_{y} \cdot \Delta V_{yij}}{\sum_{y=1}^{m} (\Delta T_{y})^{2}}$$

(2)

where $m$ is the number of future sample periods used, from 2006-2100, 19 periods in total. The average of 5 years represents a period.

The RCP4.5 runs were used for generating the patterns for the SimCLIM 4.0 for Desktop default pattern dataset, regarding the compatibility with IPCC (2013), other patterns generated from other RCP runs are also available on request. The global patterns are in 0.5° latitude * longitude grids interpolated from GCM original resolution, using a bilinear interpolation method.

Global pattern for other variable, include wind, solar radiation, relative humidity, sea surface temperature, all use the same methodology. See table 2 for the list of GCMs used in SimCLIM 4.0 for Desktop monthly precipitation and temperature patterns.

## Mean Sea Level Rise Generator Methodology

Global-mean sea-level rise scenarios are readily available and are regularly updated by the IPCC. To date, most coastal impact and adaptation assessments have ignored regional variations in sea-level scenarios, largely due to a lack of technical guidance and access to the necessary data in a usable form. This has been rectified by the publishing of the IPCC Report in 2011 that includes sea level rise outputs generated using the SimCLIM modelling system (Nicholls et al., 2011). Nevertheless, regional and local assessments would benefit from considering the components of sea-level change on a more individual basis, since the uncertainty for sea-level change during the 21st century at any site is

very likely to be larger than the global-mean scenarios suggest.

The regional pattern of thermal expansion under RCP forcing can be approximated using a pattern-scaling method similar to that previously applied for other climate variables (e.g. Santer *et al.*, 1990; Carter *et al.*, 2001). In applying the pattern-scaling method to sea level, "standardised" (or "normalised") patterns of regional thermal expansion change, as produced by coupled AOGCMs, are derived by dividing the average spatial pattern of change for a future period (e.g. 2081-2100) by the corresponding global-mean value of thermal expansion for the same period. The resulting standardised sea-level pattern is thereby expressed per unit of global-mean thermal expansion. The pattern-scaling approach has been formalised within an integrated assessment modelling system called SimCLIM 4.0 for Desktop.

We employed the following equation to calculate the normalised sea surface elevation patterns, (or sea surface height above the geoid, ZOS), termed *DZOS (unit: cm/cm ΔGSLR)*:

$$DZOS_{ij} = \{(ZOS_{ij2090} - ZOS_{ij1995}) + \Delta GSLR \} / \Delta GSLR$$

Where,

$\Delta GSLR$ is the global mean annual sea level change due to thermal expansion
$\Delta GSLR$ being global annual mean sea level change :

$$\Delta GSLR = ZOSTOGA_{2090} - ZOSTOGA_{1995}$$

Where,

*ZOSTOGA* is the global mean thermosteric sea level change

$\Delta GSLR = ZOSTOGA_{2090} - ZOSTOGA_{1990}$ i, j denote the latitude and longitude position;

2090 is the average of 2080-2100; 1995 is the average of 1986-2005.

Twenty four GCM (RCP45) runs, which have both local *ZOS* and *ZOSTOGA* data, are used in SimCLIM 4.0 for Desktop.

For the local land movement component, we input a value for the local sea-level trend. If the trend in relative sea-level change from vertical land movement is known (i.e. from the SONEL database), we can simply enter the value (in mm/yr) which is added to the future projection. Often, however, only the total undifferentiated trend is known (as estimated, for example, from tide-gauge data). This total trend cannot simply be added onto the future projection because it would "double-count" the effect that global warming has already had on observed sea-level rise and would therefore inflate the future projected rise. A process for extracting a vertical land movement trend from tidal data can be applied to replace or supplement (cross check) SONEL data.

## Available GCM Variables

SimCLIM 4.0 for Desktop can display climate change information either for a single GCM or ensemble of multiple GCMs. However, each GCM might provide different data depending on the climate variable i.e. not every GCM possesses the same number or type of climate variables. For convenience, the availability of GCM variables is summarized in table 3. Please keep in mind that only the corresponding variables used for the baseline period are extracted from GCM archives. These variables includes Temp – Temperature (including mean, minimum and maximum), Precip – Precipitation, SolRad – Solar Radiation, RelHum – Relative Humidity, Wind – Wind Speed, and SLR – Sea Level Rise.

Table 3. Availability of GCM variables in the SimCLIM 4.0 for Desktop global data package

| | Model | Temp | Precip | SolRad | RelHum | Wind | SLR |
|---|---|---|---|---|---|---|---|
| 1 | ACCESS1.3 | Yes | Yes | Yes | Yes | Yes | |
| 2 | ACCESS1.0 | Yes | Yes | Yes | Yes | Yes | |
| 3 | BCC-CSM1-1 | Yes | Yes | | Yes | Yes | Yes |
| 4 | BCC-CSM1-1-m | Yes | Yes | | Yes | | Yes |
| 5 | BNU-ESM | Yes | Yes | | | | |
| 6 | CanESM2 | Yes | Yes | Yes | Yes | Yes | Yes |
| 7 | CCSM4 | Yes | Yes | Yes | Yes | | Yes |
| 8 | CESM1-BGC | Yes | Yes | Yes | Yes | | |
| 9 | CESM1-CAM5 | Yes | Yes | Yes | Yes | | |
| 10 | CMCC-CM | Yes | Yes | Yes | | Yes | Yes |
| 11 | CMCC-CMS | Yes | Yes | Yes | | Yes | Yes |
| 12 | CNRM-CM5 | Yes | Yes | Yes | | Yes | Yes |
| 13 | CSIRO-Mk3-6-0 | Yes | Yes | Yes | Yes | Yes | Yes |
| 14 | EC-EARTH | Yes | Yes | | | Yes | |
| 15 | FGOALS-g2 | Yes | Yes | | | | |
| 16 | FGOALS-s2 | Yes | Yes | | | | |
| 17 | GFDL-CM3 | Yes | Yes | Yes | Yes | Yes | Yes |
| 18 | GFDL-ESM2G | Yes | Yes | Yes | Yes | Yes | Yes |
| 19 | GFDL-ESM2M | Yes | Yes | Yes | Yes | Yes | Yes |
| 20 | GISS-E2-H | Yes | Yes | Yes | Yes | Yes | |
| 21 | GISS-E2-H-CC | Yes | Yes | Yes | Yes | Yes | |
| 22 | GISS-E2-R | Yes | Yes | Yes | Yes | Yes | |
| 23 | GISS-E2-R-CC | Yes | Yes | Yes | Yes | Yes | |
| 24 | HADCM3 | Yes | Yes | Yes | Yes | Yes | |
| 25 | HadGEM2-AO | Yes | Yes | Yes | | Yes | |
| 26 | HadGEM2-CC | Yes | Yes | Yes | Yes | Yes | Yes |
| 27 | HadGEM2-ES | Yes | Yes | Yes | Yes | Yes | Yes |

| 28 | INMCM4 | Yes | Yes | Yes | Yes | Yes | Yes |
| 29 | IPSL-CM5A-LR | Yes | Yes | Yes | Yes | Yes | |
| 30 | IPSL-CM5A-MR | Yes | Yes | Yes | Yes | Yes | |
| 31 | IPSL-CM5B-LR | Yes | Yes | Yes | Yes | Yes | |
| 32 | MIROC4H | Yes | Yes | Yes | Yes | | |
| 33 | MIROC5 | Yes | Yes | Yes | Yes | Yes | Yes |
| 34 | MIROC-ESM | Yes | Yes | Yes | Yes | Yes | Yes |
| 35 | MIROC-ESM-CHEM | Yes | Yes | Yes | Yes | Yes | Yes |
| 36 | MPI-ESM-LR | Yes | Yes | Yes | | Yes | Yes |
| 37 | MPI-ESM-MR | Yes | Yes | Yes | | Yes | Yes |
| 38 | MRI-CGCM3 | Yes | Yes | Yes | Yes | Yes | Yes |
| 39 | NorESM1-M | Yes | Yes | | | Yes | Yes |
| 40 | NorESM1-ME | Yes | Yes | | | | Yes |

## CORDEX RCM Data Available for SimCLIM

The COordinated Regional climate Downscaling Experiment (CORDEX) is a World Climate Research Program (WCRP) backed framework to produce ensembles of regional climate projections for all continents globally (Giorgi et al., 2009; http://wcrp.ipsl.jussieu.fr/SF_RCD_CORDEX.html). CORDEX will bring together regional scale climate projections produced using both statistical and dynamical techniques. It aims to provide a framework to evaluate and benchmark model performance as well as producing projections for use in impact and adaptation studies.

The climate projection framework within CORDEX is based on the set of GCM simulations currently underway in support of the IPCC fifth Assessment Report, referred to as CMIP5. CORDEX focused on the GCM experiments using emission scenarios known as RCP4.5 and RCP8.5 which represent a mid and a high-level emission scenario. Ideally CORDEX simulations will span 1951 to 2100 though given the computational demand of such long transient runs a series of 30 year time slices is also possible. Each RCM should perform these simulations for multiple GCMs.

The data availability please refers to tables which list details. For the domains which are not listed in the tables, there are raw RCM data available, but only one or two RCM simulations, or incomplete scenarios, also could be processed into SimCLIM, if the data is needed.
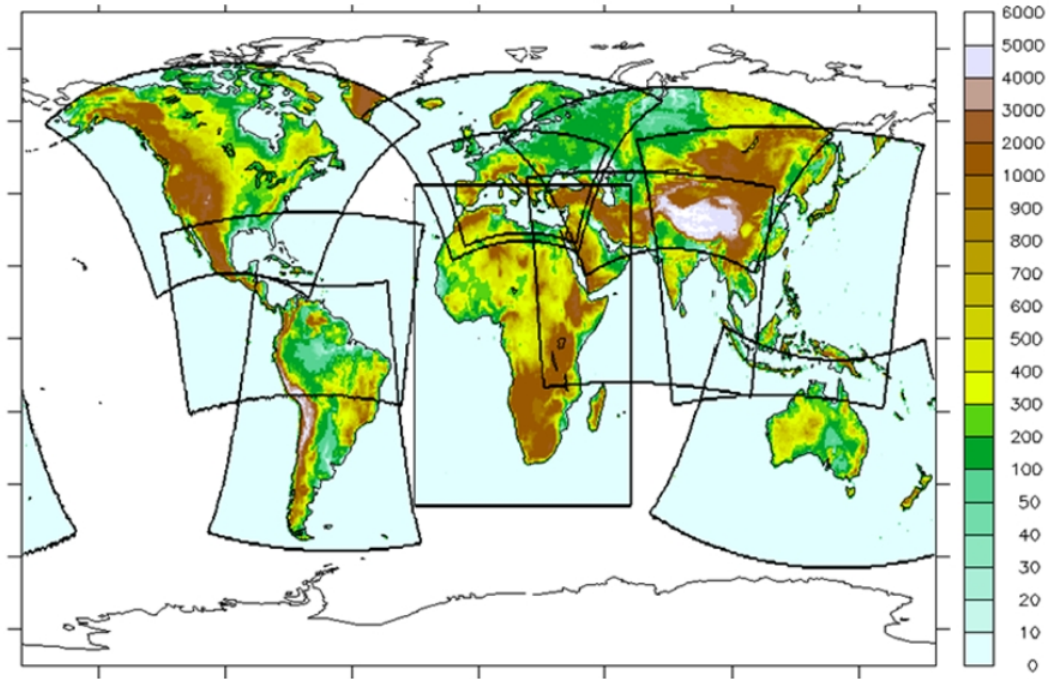
**Figure 1:** CORDEX domains and topography.

## Table 1: CORDEX data availability for Africa (AFR) domain

(Variables 6 include: precipitation, mean temperature, maximum temperature, minimum temperature, solar radiation, wind speed; Variables 7 indicates 6 variables plus relative humidity.

| ID | GCM RCM combination | Variables |
|----|---------------------|-----------|
| 1 | AFR-CanESM2-CRCM5 | 6 |
| 2 | AFR-CanESM2-RCA4 | 7 |
| 3 | AFR-CNRM-CM5-CCLM4-8-17 | 6 |
| 4 | AFR-CNRM-CM5-RCA4 | 7 |
| 5 | AFR-CSIRO-Mk3-6-0-RCA4 | 7 |
| 6 | AFR-EC-EARTH-CCLM4-8-17 | 6 |
| 7 | AFR-EC-EARTH-HIRHAM5 | 7 |
| 8 | AFR-EC-EARTH-RACMO22T | 7 |
| 9 | AFR-EC-EARTH-RCA4 | 7 |
| 10 | AFR-EC-EARTH-REMO2009 | 6 |
| 11 | AFR-GFDL-ESM2M-RCA4 | 7 |
| 12 | AFR-HADGEM2-ES-CCLM4-8-17 | 6 |
| 13 | AFR-HADGEM2-ES-RCA4 | 7 |
| 14 | AFR-IPSL-CM5A-LR-REMO2009 | 6 |
| 15 | AFR-IPSL-CM5A-MR-RCA4 | 7 |
| 16 | AFR-MIROC5-RCA4 | 7 |
| 17 | AFR-MPI_ESM-LR-CRCM5 | 6 |
| 18 | AFR-MPI-ESM-LR-CCLM4-8-17 | 6 |
| 19 | AFR-MPI-ESM-LR-RCA4 | 7 |
| 20 | AFR-MPI-ESM-LR-REMO2009 | 6 |
| 21 | AFR-NorESM1-M-HIRHAM5 | 7 |

| 22 | AFR-NORESM1-M-RCA4 | 7 |

**Table 2: CORDEX data availability for Middle East and North Africa (MNA) domain**

| ID | GCM RCM combination | Variables |
|---|---|---|
| 1 | MNA-22-EC-EARTH-RCA4 | 7 |
| 2 | MNA-22-GFDL-ESM2M-RCA4 | 7 |
| 3 | MNA-44-CNRM-CM5-RCA4 | 7 |
| 4 | MNA-44-EC-EARTH-RCA4 | 7 |
| 5 | MNA-44-GFDL-ESM2M-RCA4 | 7 |

**Table 3: CORDEX data availability for Central America (CAM) domain**

| ID | GCM RCM combination | Variables |
|---|---|---|
| 1 | CAM-44-EC-EARTH-RCA4 | 7 |
| 2 | CAM-44-HADGEM2-ES-RCA3 | 7 |
| 3 | CAM-44-MPI-ESM-LR-RCA4 | 7 |

**Table 4: CORDEX data availability for South Asia (WAS) domain**

| ID | GCM RCM combination | Variables |
|---|---|---|
| 1 | WAS-44-CNRM-CM5-RCA4 | 7 |
| 2 | WAS-44-EC-EARTH-RCA4 | 7 |
| 3 | WAS-44-GFDL-ESM2M-RCA4 | 7 |
| 4 | WAS-44-IPSL-CM5A-MR-RCA4 | 7 |
| 5 | WAS-44-MIROC5-RCA4 | 7 |
| 6 | WAS-44i-MPI-ESM-LR-RCA4 | 7 |
| 7 | WAS-44i-MPI-ESM-LR-REMO2009 | 6 |

**Table 5: CORDEX data availability for South America (SAM) domain**

| ID | GCM RCM combination | Variables |
|---|---|---|
| 1 | SAM-44i-EC-EARTH-RCA4 | 7 |
| 2 | SAM-44i-MPI-ESM-LR-RCA4 | 7 |

**Table 6: CORDEX data availability for Arctic (ARC) domain**

| ID | GCM RCM combination | Variables |
|---|---|---|
| 1 | ARC-44-CanESM2-RCA4 | 7 |
| 2 | ARC-44-EC-EARTH-HIRHAM5 | 7 |
| 3 | ARC-44-EC-EARTH-RCA4 | 7 |
| 4 | ARC-44-EC-EARTH-RCA4-SN | 7 |
| 5 | ARC-44-MPI-ESM-LR-RCA4 | 7 |
| 6 | ARC-44-MPI-ESM-LR-RCA4-SN | 7 |
| 7 | ARC-44-NorESM1-M-RCA4 | 7 |

**Table 7: CORDEX data availability for East Asia (EAS) domain**

| ID | GCM RCM combination | Variables |
|---|---|---|
| 1 | EAS-44-EC-EARTH-HIRRAM5 | 7 |
| 2 | EAS-44-HADGEM2-AO-HADGEM3-RA | 6 |
| 3 | EAS-44-HADGEM2-AO-RegCM_v4 | 6 |
| 4 | EAS-44-HADGEM2-AO-SNU-MM5_v3 | 6 |
| 5 | EAS-44-HADGEM2-AO-SNU-WRF_v3 | 6 |
| 6 | EAS-44-HADGEM2-AO-YSU-RSM_v3 | 6 |

## Regional Spatial Data Customisation

An area whose spatial scale is smaller than the global scale is defined as a region/study area in SimCLIM 4.0 for Desktop. The most commonly used region is the country. Sometimes, a region can be drilled down into for smaller areas such as the Upper Mekong River Basin versus the Lower Mekong River Basin. A regional data source and spatial resolution is typically derived through discussion between the SimCLIM 4.0 for Desktop end user and the development team at CLIMsystems. This consultation is conducted to provide the best data package to the end user. Generally, the smaller the region, the higher the spatial resolution.

For a specific region (country or area), producing regional climate dataset depends on the availability of baseline and future climate change projection data from local agencies. *The principle is that CLIMsystems will adopt local data as much as possible*, and then fill data gaps using publicly available data using the most appropriate interpolation method to generate an appropriate spatial resolution.

If there are datasets produced by national/local agencies, whenever possible or through the request of end users CLIMsystems will adopt local data for application in SimCLIM 4.0 for Desktop. For the USA, CLIMsystems has adopted PRISM data for the baseline and BCSD generated by BLM and then post-processed by CLIMsystems for climate change patterns which represent one source of publicly available data for the USA.

If there are datasets for baseline period for a region, but no climate change projection data, CLIMsystems uses the pattern scaling method to produce the change patterns, then interpolates the data to a pre-defined resolution.

## Extreme Precipitation Patterns

In SimCLIM 4.0 for Desktop, site data are mainly managed at the daily scale and mainly used to study the changes in the frequency and intensity of extreme events. Combined with GCM future climate change scenarios, the data can be extended to investigate extreme events under a changing climate. Due to the availability of daily data, only the 22 GCMs in the CMIP5 archive were analysed for extreme precipitation change patterns, using the average change patterns of RCP4.5 and RCP8.5 scenarios runs (Table 4). Detailed data processing methodology please refer to Li *et al.* (2011).

Table 4. GCM list for daily extreme precipitation change patterns

| ID | GCM name |
|---:|---|
| 1 | ACCESS1-0 |
| 2 | ACCESS1-3 |
| 3 | BCC-CSM1-1 |
| 4 | BNU-ESM |
| 5 | CANESM2 |
| 6 | CCSM4 |
| 7 | CESM1-BGC |
| 8 | CMCC-CM |
| 9 | CMCC-CMS |
| 10 | CNRM-CM5 |

| | |
|---|---|
| 11 | CSIRO-MK-3-6 |
| 12 | GDFL-CM3 |
| 13 | GFDL-ESM2G |
| 14 | GFDL-ESM2M |
| 15 | GISS-E2-H |
| 16 | GISS-E2-R |
| 17 | HADGEM2-AO |
| 18 | HADGEM2-CC |
| 19 | HADGEM2-ES |
| 20 | INMCM4 |
| 21 | IPSL-CM5A-LR |
| 22 | IPSL-CM5A-MR |
| 23 | IPSL-CM5B-LR |
| 24 | MIROC5 |
| 25 | MIROC-ESM |
| 26 | MIROC-ESM-CHEM |
| 27 | MPI-ESM-LR |
| 28 | MPI-ESM-MR |
| 29 | MRI-CGCM3 |
| 30 | NorESM1-M |

# Part 2: Site Data

Unlike spatial data, site data is not managed according to regions. All site data are visualized onto global domain according to their spatial coordinates (latitude and longitude).

## Public sources

SimCLIM 4.0 for Desktop site data are built upon the dataset of the Global Historical Climatology Network (GHCN)-Daily. The dataset is being maintained at the National Oceanic and Atmospheric Administration's National Climatic Data Centre (NCDC).

GHCN-Daily consists of more than 1 500 000 000 observations at over 40 000 land-based stations, some of which date back to the mid-1800s. The primary meteorological elements represented include daily maximum and minimum temperature (TMAX and TMIN), 24-h precipitation (PRCP) and snowfall (SNOW) totals, and the snow depth at a certain time of day (SNWD). The data originate from a variety of sources ranging from paper forms completed by volunteer observers to synoptic reports from automated weather stations (Durre et al., 2010).

It is worth noting that these site data are post-processed into SimCLIM 4.0 for Desktop's own data format, and then are identified and maintained by CLIMsystems.

## Customisation

Besides the publicly available (GHCN)-Daily dataset, site data sets provided by end-users for a specific region can be formatted and ingested in SimCLIM 4.0 for Desktop. However, they must be pre-processed to follow the SimCLIM 4.0 for Desktop data format. Contact CLIMsystems info@climsystems.com for instructions.

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# Glossary

The following glossary is mostly extracted from the WMO Book of *Climate knowledge for action: a global framework for climate services – Empowering the most vulnerable*.

*Adaptation*: The process or outcome of a process that leads to a reduction in harm or risk of harm, or a realisation of benefits associated with climate variability and climate change.

*Capacity building*: The process by which people, organisations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions. It involves learning and various types of training, but also continuous efforts to develop institutions, political awareness, financial resources, technology systems, and the wider social and cultural enabling environment.

*Climate*: Climate is typically defined as the average weather over a period of time. The quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense, is the state of the climate system, including its statistical description. For the purposes of this report, we have used the term climate to represent time periods of months or longer.

*Climate change*: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The Intergovernmental Panel on Climate

Change uses a relatively broad definition of climate change that is considered to mean an identifiable and statistical change in the state of the climate which persists for an extended period of time. This change may result from internal processes within the climate system or from external processes. These external processes (or forcing) could be natural, for example volcanoes, or caused by the activities of people, for example emissions of greenhouse gases or changes in land use.  Other bodies, notably the United Nations Framework Convention on Climate Change, define climate change slightly differently.  The United Nations Framework Convention on Climate Change makes a distinction between climate change that is directly attributable to human activities and climate variability that is attributable to natural causes. For the purposes of this report, either definition may be suitable, depending on the context.

***Climate change projection***: A projection of the response of the climate system to emission scenarios of greenhouse gases and aerosols, or radiative forcing scenarios based upon climate model simulations and past observations.  Climate change projections are expressed as departures from a baseline climatology, for example, that future average daily temperature in the summer will be 2°C warmer for a given location, time period and emissions scenario.

***Climate model***: A simplified mathematical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedbacks between them.

***Climate variability***: Climate variability refers to variations in the mean state and other statistics relating to the climate on all temporal and spatial scales beyond that of individual weather events. Climate can and does vary quite naturally, regardless of any human influence. Natural climate variability arises as a result of internal process with the climate system or because of variations in natural forcing such as solar activity.

***Downscaling***: The process of reducing coarse spatial scale model output to smaller (more detailed) scales.

***Ensemble***: A set of simulations (each one an ensemble member) made by either adjusting parameters within plausible limits in the model, or starting the model from different initial conditions. While many parameters are constrained by observations, some are subject to considerable  uncertainty. The best way to investigate this uncertainty is to run an ensemble experiment in which each relevant parameter combination is investigated. This is known as a perturbed physics ensemble.

***External climate forcing***: One component of the Earth's natural climatic variability, is that  due  to external variability factors, which arise from processes external to the climate system, chiefly, volcanic eruptions and variations in the amount of energy radiated by the sun.

***Extreme weather and climate events***: Extreme events refer to phenomena such as floods, droughts and storms that are at the extremes of, or beyond, the historical distribution of such events.

***Forecast***: Definite statement or statistical estimate of the likely occurrence of a future event or conditions for a specific area. Generally used in reference to weather forecasts, and hence to weather a week or so ahead.

***General Circulation Model (GCM)***: A General Circulation Model, or sometimes called a global climate model, is a mathematical model of the general circulation of the planet's atmosphere or oceans based on mathematic equations that represent physical processes. These equations are the basis for complex computer programs commonly used for simulating the atmosphere or oceans of the Earth. General Circulation Models are widely applied for weather forecasting, understanding the climate, and projecting climate change.

***Greenhouse gas***: A gas within the atmosphere which absorbs and emits energy radiated by the Earth. Carbon dioxide is the most important greenhouse gas being emitted by humans.

***Mitigation***: Action taken to reduce the impact of human activity on the climate system, primarily through reducing net greenhouse gas emissions.

***Observation***: Observation, or observed data, refers to any information which has been directly measured. In climatology, this means measurements of climate variables such as temperature and precipitation.

***Prediction***: The main term used for estimates of future climatic conditions over a range of about a month to a year ahead.

***Probability***: Probability is a way of expressing knowledge or belief that an event will occur, and is a concept most people are familiar with in everyday life. Probabilistic climate projections are projections of future absolute climate that assign a probability level to different climate outcomes.

***Projection***: A Projection is an estimate of future climate decades ahead consistent with a particular scenario. The scenario may include assumptions regarding elements such as: future economic development, population growth, technological innovation, future emissions of greenhouse gases and other pollutants into the atmosphere, and other factors.

***Regional Climate Model (RCM)***: A regional climate model is a climate model of higher resolution than a global climate model. It can be nested within a global model to provide more detailed simulations for a particular location.

***Risk***: Risk is conventionally defined as the combination of the likelihood of an occurrence of an event or exposure(s) and the severity of injury or cost that can be caused by the event or exposure(s). Understanding the risks and thresholds, including uncertainties, associated with climate is one principle of good adaptation.

***Risk management***: The systematic approach and practice of managing uncertainty to minimize potential harm and loss. Risk management comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks. It is widely practiced by organizations to minimise risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts and damage from fire and natural hazards. Risk management is a core issue for sectors such as water supply, energy and agriculture whose production is directly affected by extremes of weather and climate.

***Sea level rise***: Sea level rise can be described and projected in terms of absolute sea level rise or relative sea level rise. Increasing temperatures result in sea level rise by the thermal expansion of water and through the addition of water to the oceans from the melting of ice sheets. There is considerable uncertainty about the rate of future ice sheet melt and its contribution to sea level rise.

***Sustainable development***: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

***Uncertainty***: Uncertainty refers to a state of having limited knowledge. Uncertainty can result from lack of information or from disagreement over what is known or even knowable. Uncertainty may arise from many sources, such as quantifiable errors in data, or uncertain projections of human behaviour. Uncertainty can be represented by quantitative measures or by qualitative statements. Uncertainty in climate change projections is a major problem for those planning to adapt to a changing climate. Uncertainty in projections of future climate change arises from three principal causes: natural climate variability; modelling uncertainty, referring to an incomplete understanding of Earth system processes and their imperfect representation in climate models; and uncertainty in future emissions.

***Variable***: The name given to measurements such as temperature, precipitation, etc. (climate variables), sea level rise, salinity, etc. (marine variables) and cooling degree days, days of air frost, etc. (derived variables).

***Vulnerability***: Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. Vulnerability to climate change refers to the propensity of human and ecological systems to suffer harm and their ability to respond to stresses

imposed as a result of climate change effects. The vulnerability of a society is influenced by its development path, physical exposures, the distribution of resources, prior stresses and social and government institutions. All societies have inherent abilities to deal with certain variations in climate, yet adaptive capacities are unevenly distributed, both across countries and within societies. The poor and marginalised have historically been most at risk, and are most vulnerable to the impacts of climate change.

*Weather*: The state of the atmosphere at a given time and place, with respect to variables such as temperature, moisture, wind velocity and barometric pressure.

## New topic