SimCLIM for ArcGIS Climate

Manual 1.4

Sep 2017

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1. Introduction

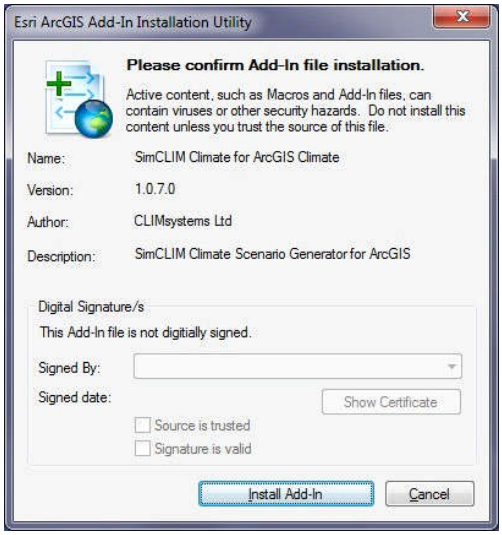
This document introduces and explains the SimCLIM for ArcGIS add-in. The add-in enables ArcGIS users to produce spatial images of climate change in a very easy, quick, straight---forward process. The add-in is based on 20 years of development of the standalone SimCLIM tool, marketed by CLIMsystems, and uses outputs from global climate models, produced for the IPCC (Intergovernmental Panel for Climate Change) 5th Assessment Report. The add-in allows for evaluating uncertainties stemming from different emission scenarios, different climate sensitivities and different climate change models. Projections of future climate, and changes compared with a baseline climate can be produced.

The target audience includes persons that already know how to work with ArcGIS and like to add climate change effects to their toolbox. Some prior knowledge on climate change (which can be found in the IPCC AR reports) is assumed.

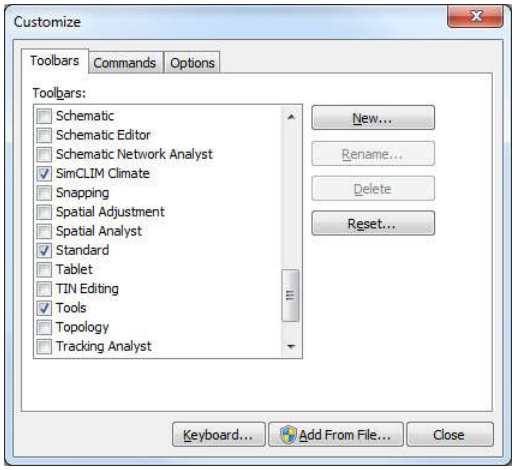
The functionality of the toolbar allows for more climate variables than are part of the basic distribution (precipitation, mean---min---max temperatures and sea surface temperature). It is possible to purchase other variables (wind speed, relative humidity and solar radiation) from CLIMsystems as well as down---scaled patterns for regional and national areas with (much) more detail than the global patterns.

2. Installation

The add--in consists of a single .esriAddIn file (CLIMsystems.SimCLIM.Climate.ArcGISAddIn.esriAddin) that can be placed in any directory. If ArcGIS is installed on your computer, the .esriAddIn file will have an ArcGIS icon, and can be added to ArcGIS by double clicking it. It is best to do this while ArcGIS is not running.



After starting ArcGIS, if the toolbar is not already shown, it can be added to the ArcGIS toolbar through "Customize", "Customize", "Toolbars" and ticking the SimCLIM Climate toolbar.



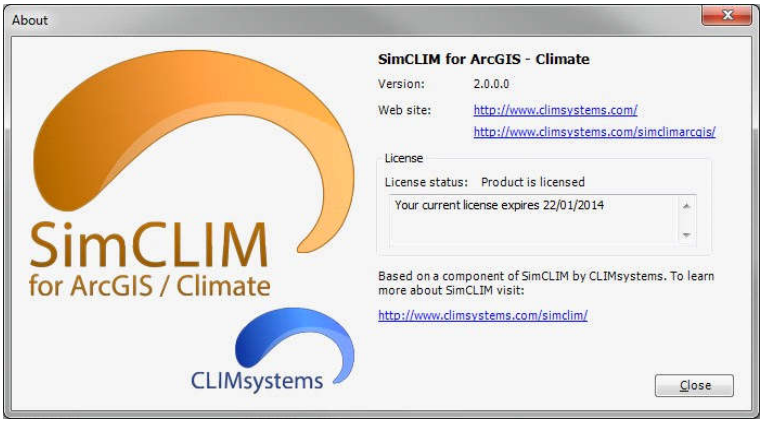
If the toolbar does not show up, you might need to change the setting for allowing Add---Ins under the Add-In Manager / Options to "Load all Add---Ins without restrictions".
SimCLIM for ArcGIS uses sets of patterns of climate and climate change for the various areas. In the basic distribution the Global area is included. The files for this area can be in any directory (maintaining the sub---directory structure), as the path can be specified through the settings option in the toolbar.

3. Usage

The SimCLIM for ArcGIS toolbar has six buttons. From right to left they offer the following functionality:

	Shows the about box, with version number of the toolbar (relevant for communicating issue the toolbar), a link with CLIMsystems website, as well as a link to the SimCLIM full stand-alone software web page
	Checks for update. An internet connection to CLIMsystems software update.
	Manage your product licensing.
	Here you manage the images that you create with the toolbar. A record is kept on the details of how images created.
	Opens the options dialog-box in which defaults (data-directory, color ramps) can be set
	Opens the dialog box for defining and producing outputs for climate change scenarios (the core of the toolbar)

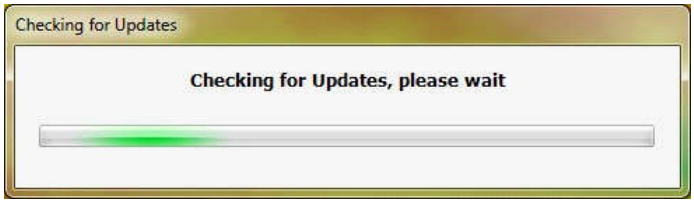
 About



Lists the version of the toolbar and contact details and also shows your license status.

 Update

This button checks if there is an update of the toolbar available. You need an internet connection for this.



If an update is found, you are prompted for the next step, otherwise (most of the time) you will get:

Licensing

The toolbar is licensed and needs a product key in order to function. The dialogue is self-explanatory.

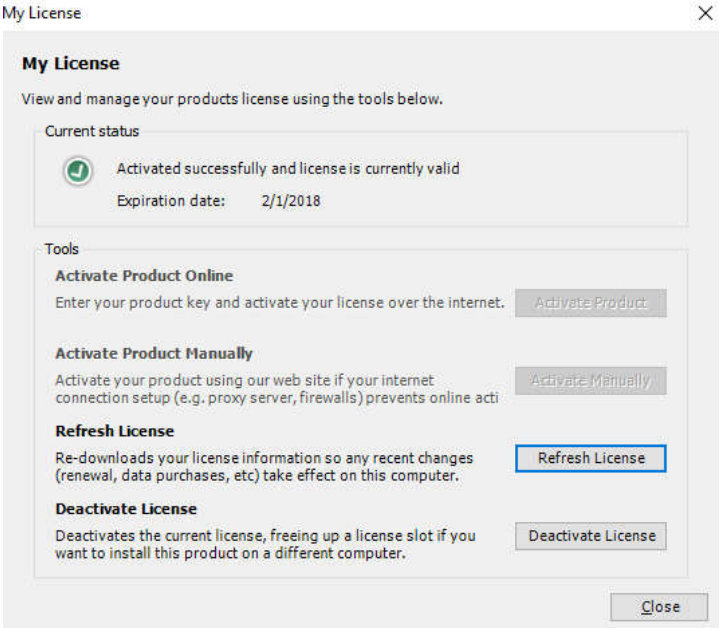
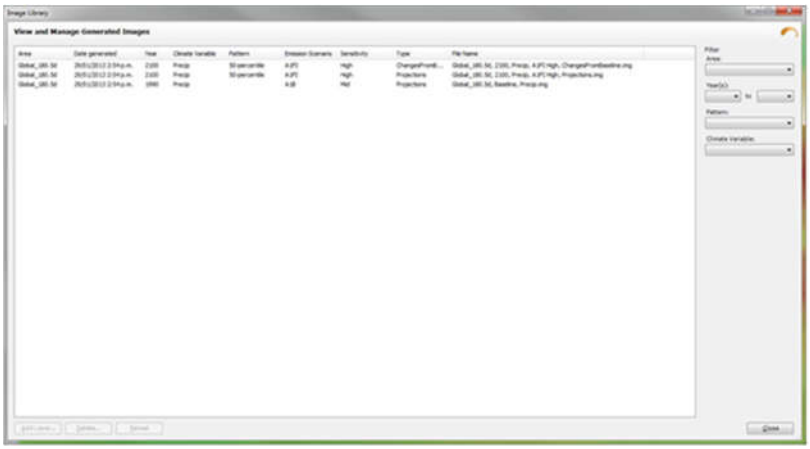


Image Library

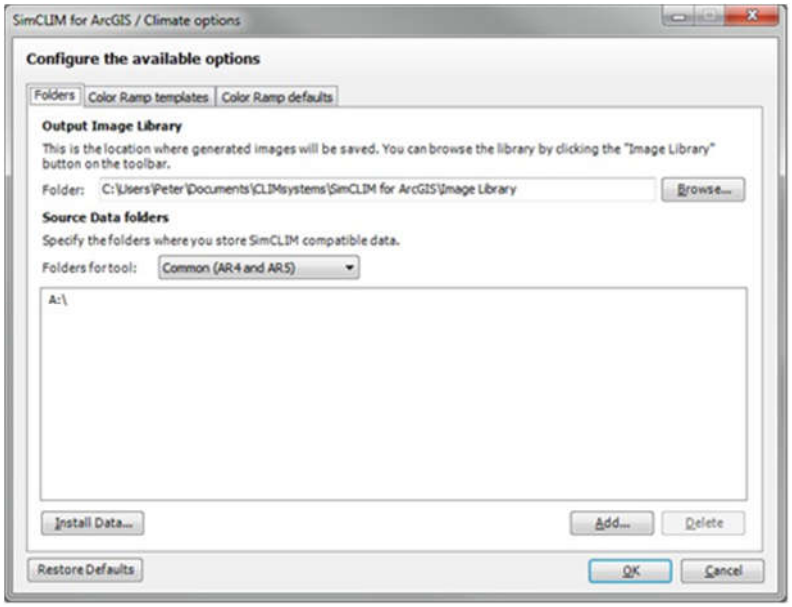


The toolbar keeps track of the images that are created with it. The images are stored in the director that is specified under "Settings" (see below). If maps need to be exported, this is

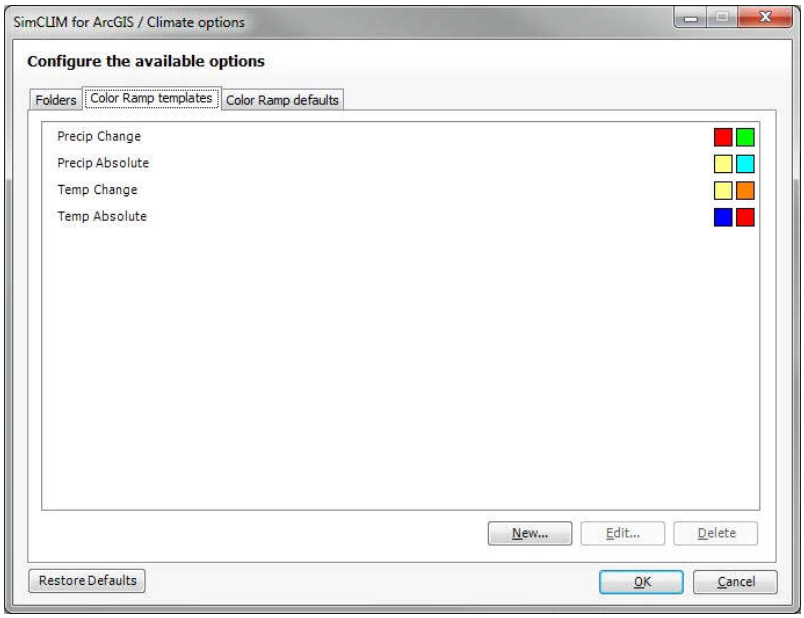
where the original images can be found. Over time, the number of images will build up. The maintenance is left to the user.
If the images are no longer needed, they can be selected (using the standard Windows point---and click, shift/ctrl functionality) and deleted.


Options

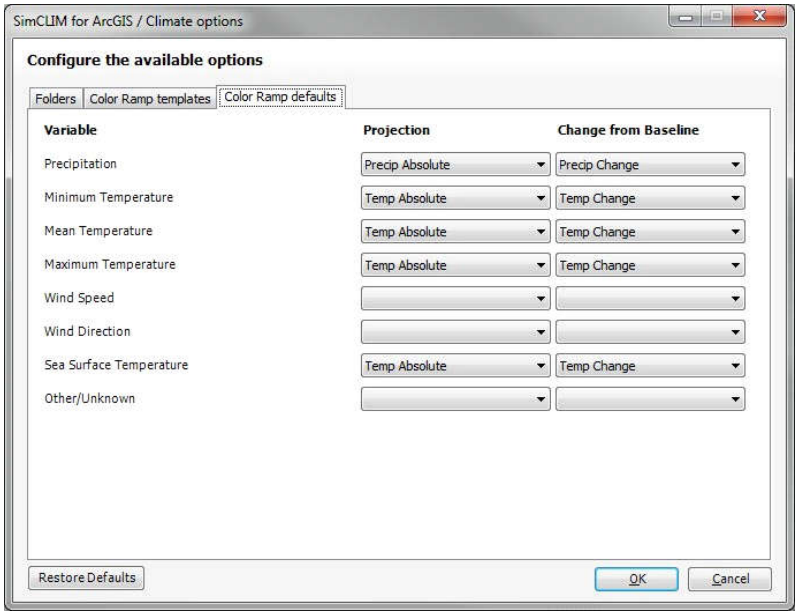
The settings dialogue has 3 tabs: Folders, Color Ramp templates and Color Ramp defaults.



The Folders tab allows to specify the folder where the toolbar stores created images and to list the directories in which the Climate Change data files (“patterns”) are kept that will be available in the Climate Change Scenario dialog. The directories for AR5 patterns (see Climate Change Scenario below) can be specified separately. “Install data” allows for adding new patterns that were purchased from CLIMsystems.



The Color Ramp templates allow defining the “low” and “high” colors for a color ramp that can be used in the mapping of outputs from Climate Change scenarios.



The Color Ramp defaults allow for setting a default color ramp for the climate variables that the SimCLIM for ArcGIS Climate recognise.

Climate change scenario

The toolbar allows for generating climate change scenarios according to either the AR5 results. The methodology for generating the results is the same, but the data used and some of the terminology is different.

IPCC	AR5
Baseline year	1995
Baseline period	1981---2010
Emission scenarios	RCPs: 2.6, 4.5, 6.0, 8.5

The dialog forAR5 are mostly the same (baseline year and selectable emission scenarios depend on chosen AR):

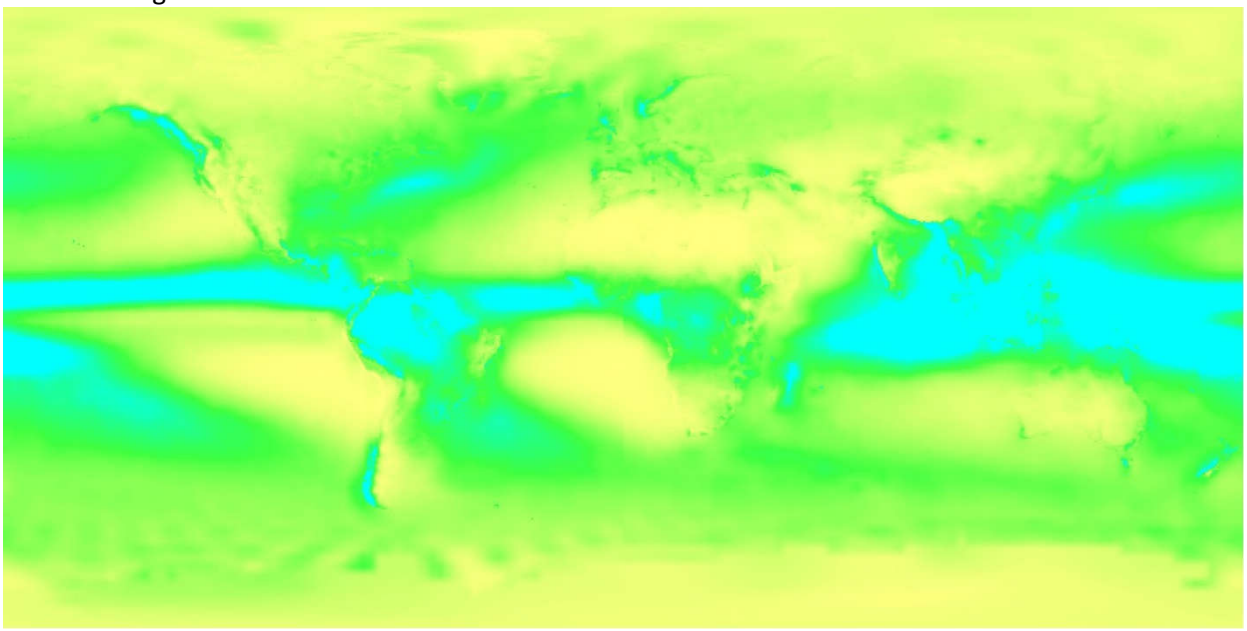
There are three types of usage of the scenario generator:

1) Generate an image for the baseline climate
2) Generate a projection for the future climate
3) Generate an image with the change from baseline these require different choices.

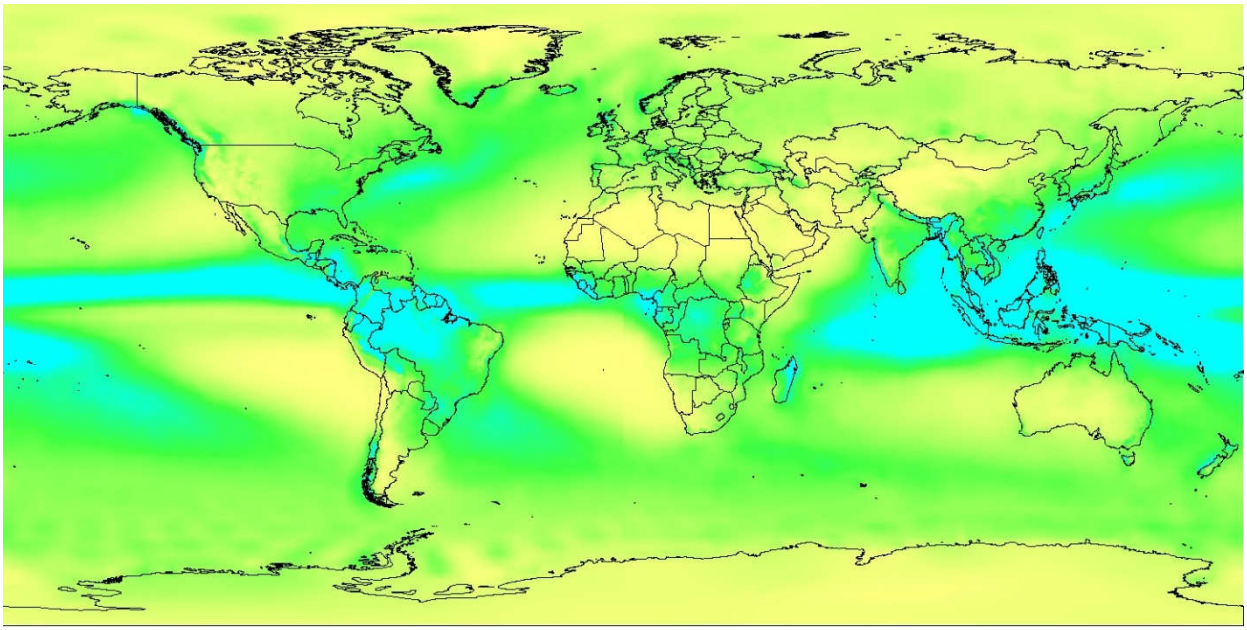
Baseline climate:

- Select Area (Global)
- Select Baseline
- Select months (all)
- Select climate variable (precipitation)
- Accept or change predefined Color Ramp, or specify From: and To: colors
- Click OK

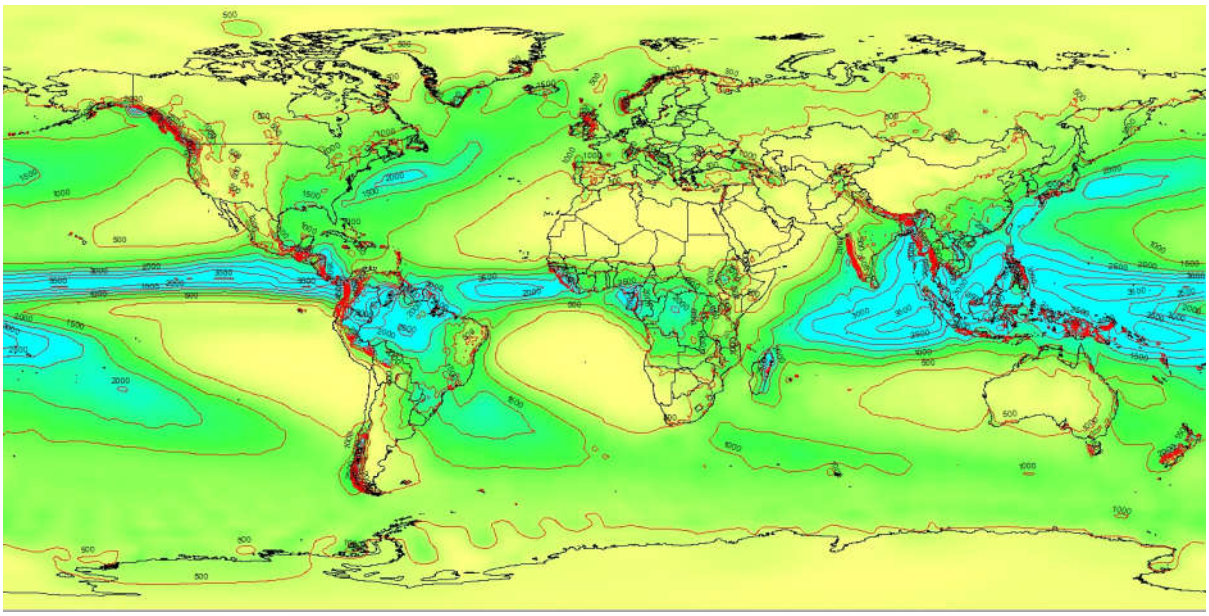
The first image will be shown as below



ArcGIS functionality can be used to add features: Country boundaries:



Contour lines (ArcToolbox, Spatial AnalystTools, Surface, Contour)

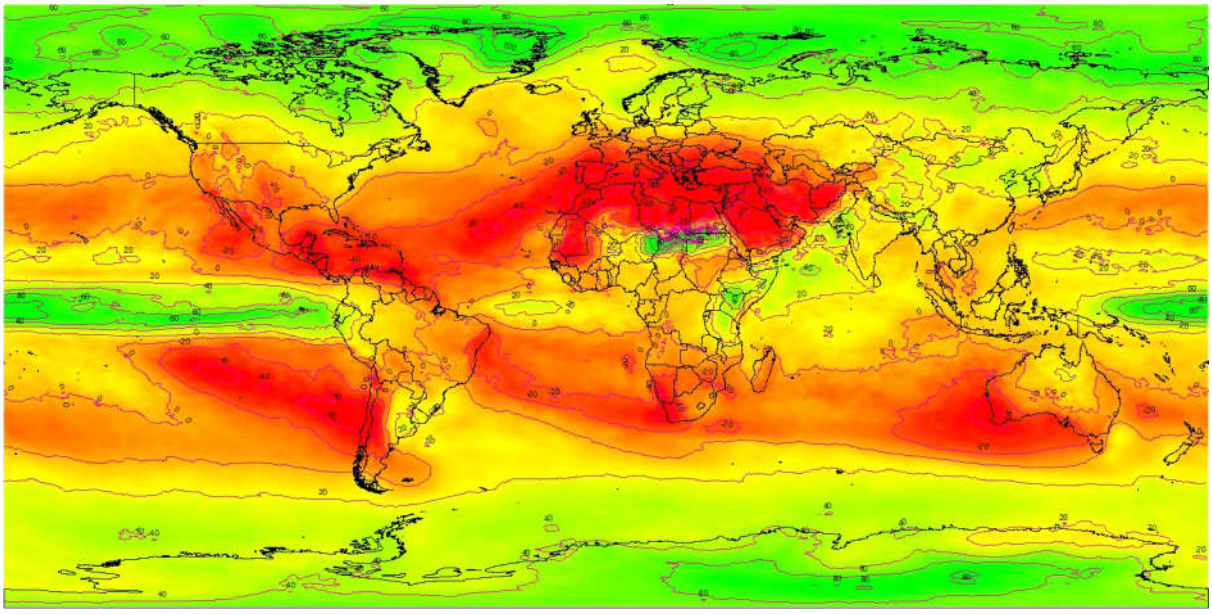


Generate future climate maps:

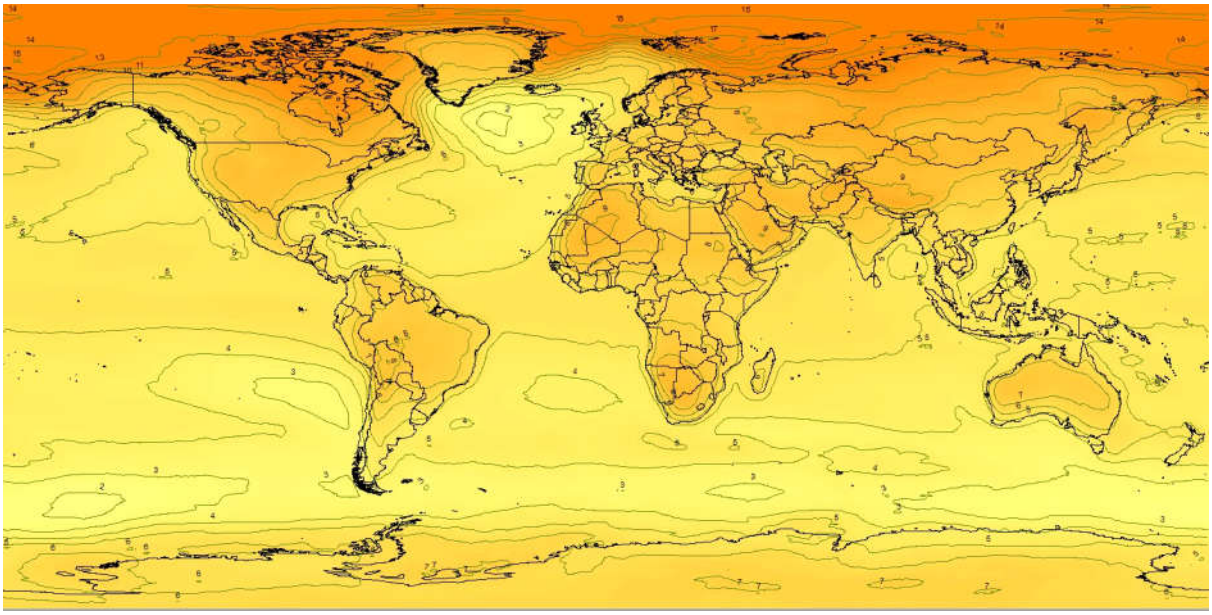
- Select Work Area (*Global*)
- Select Year and specify (*2100*)
- Select **Projection**
- Select Pattern (*50-percentile*)

The Patterns correspond to the various GCM (Global Climate Models) that produced climate change outputs for IPCC (see Annex for a list of models and their characteristics). Three special patterns were created to facilitate analysis; they are based on the results of an ensemble of all 21 models: 1) the 50---percentile pattern represents the median values from the 21 models, 2) the 25---percentile the values for which 75% of the models indicate a change bigger than that, while 3) the 75---percentile the values for which 75% of the models indicate a smaller change. If you wish to select your own ensemble (less models) and/or percentiles, use the "Ensemble" tab.

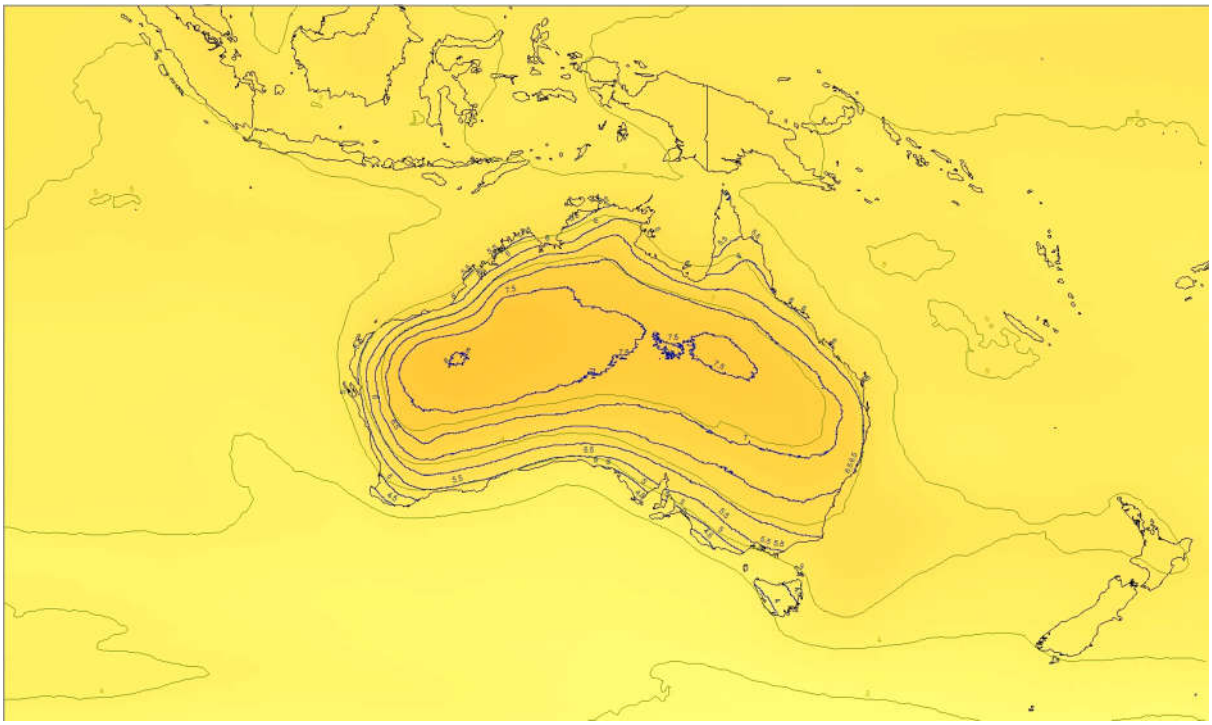
- Select Months (*all*)
- Select Emission Scenario (RCP8.5) Emission Scenarios are from the IPCC (see Annex for an explanation). RCP8.5 is the high emission scenario
- Select Sensitivity (*High*): Climate sensitivity expresses how 'strongly' the climate systems responses to a change in atmospheric greenhouse gases changes.
- Select Climate Variable (*Precipitation*)
- Accept or change predefined Color Ramps or specify From and To: colors
- Click 'OK'



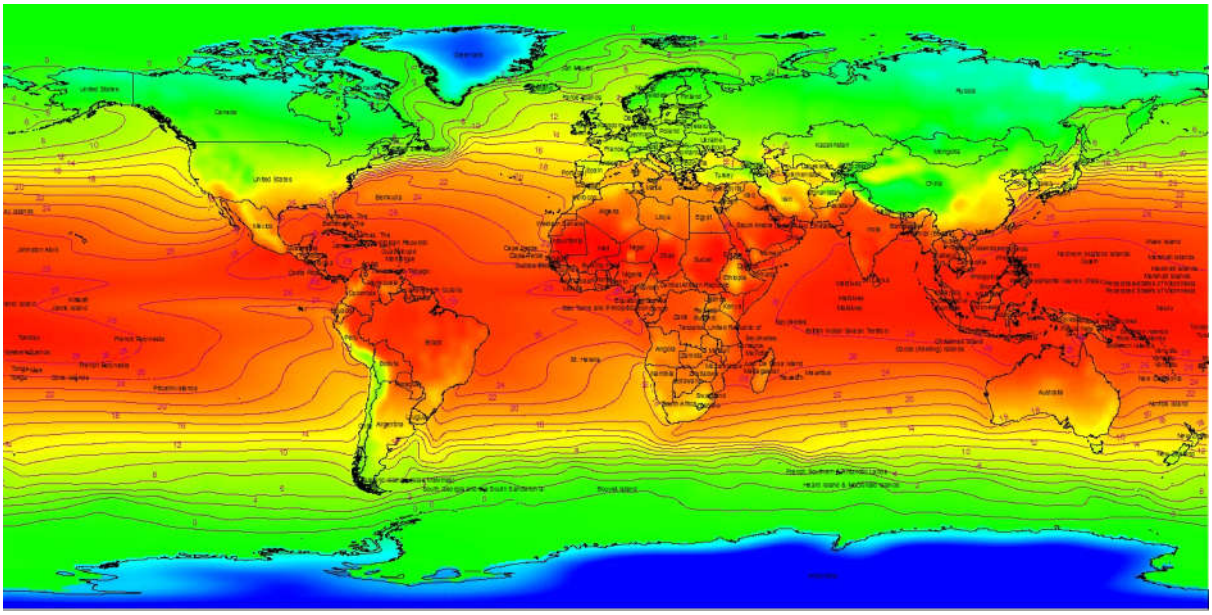
Below is the output (change from baseline) for the TMean variable (*2100, 50-percentile, all months, RCP8.5-high*):



This figure below shows a combination of Global (50x50 km resolution) and Australian (2.5x2.5 km resolution, not included in the basic distribution) results:



The following example shows the baseline sea surface temperatures, overlaid with the TMean land temperatures, together with country labeling and contour lines:



Annex 1. Representative Concentration Pathways (RCPs)

The Representative Concentration Pathways (RCPs) are a set of four new pathways developed for the climate modeling community as a basis for long---term and near---term climate modeling experiments. The four RCPs together span the range of radiative forcing values (cumulative measure of human emissions of GHGs from all sources expressed in Watts per square meter) found in the open literature, from 2.6 to 8.5 W/m2 for the year 2100. The RCPs are the product of an innovative collaboration between integrated assessment modelers, climate modelers, terrestrial ecosystem modelers and emission inventory experts. The resulting product forms a comprehensive data set with high spatial and sectoral resolutions for the period extending to 2100. Land use and emissions of air pollutants and greenhouse gases are reported mostly at a 0.5*0.5 degree spatial resolution, with air pollutants also provided per sector (for well---mixed gases, a coarser resolution is used). The underlying integrated assessment model outputs for land use, atmospheric emissions and concentration data are harmonized across models and scenarios to ensure consistency with historical observations while preserving individual scenario trends. For most variables, the RCPs cover a wide range of the existing literature. The RCPs are supplemented with extensions (Extended Concentration Pathways, ECPs), which allow climate modeling experiments through the year 2300. The RCPs are an important development in climate research and provide a potential foundation for further research and assessment, including emissions mitigation and impact analysis.

The words “concentration pathway” are meant to emphasize that these RCPs are not the final new, fully integrated scenarios (i.e. they are not a complete package of socio---economic, emission and climate projections), but instead are internally consistent sets of projections of the components of radiative forcing that are used in subsequent phases. The use of the word “concentration” instead of “emissions” emphasizes that concentrations are used as the primary product of the RCPs, designed as input to climate models. Coupled carbon---cycle climate models can calculate associated emission levels (which can be compared to the original emissions of the Integrated Assessment Models --- IAMs). In total, a set of four pathways are produced that lead to radiative forcing levels of 8.5, 6, 4.5 and 2.6 W/m2, by 2100. Each of the RCPs covers the 1850---2100 period, and extensions have been formulated for the period thereafter (up to 2300).

The RCPs were chosen to represent a broad range of climate outcomes, based on a literature review, and are neither forecasts nor policy recommendations and while each single RCP is based on an internally consistent set of socioeconomic assumptions, the four RCPs together cannot be treated as a set with consistent internal socioeconomic logic. For example, RCP8.5 cannot be used as a no---climate---policy socioeconomic reference scenario for the other RCPs because RCP8.5’s socioeconomic, technology, and biophysical assumptions differ from those of the other RCPs.

Each RCP could result from different combinations of economic, technological, demographic, policy, and institutional futures. For example, RCP4.5 could be considered as a moderate mitigation scenario. However, it is also consistent with a baseline scenario that assumes a global development that focuses on technological improvements and a shift to service industries but does not aim to reduce greenhouse gas emissions as a goal in itself (similar to the B1 scenario of the SRES scenarios).

Choosing a Representative Concentration Pathway (RCP) for examination in this project should be based on a consultative process. This part of the manual outlines some of the current thinking we have had on defining RCPs for various clients in project work and given the latest Conference of Party (COP) discussions we have tried to make it as up-to-date as possible and bring to the discussion consideration of Intended Nationally Determined Contributions (INDCs) and potential limitations in societal capacity for achieving not only a reduction in greenhouse gas emissions but a decarbonisation of the world economy. We have taken a pragmatic approach that explores the big picture issues rather than diving deeply into individual and nuanced aspects of each and every possibility that could impact change.

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		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 pathway to 6 W/m2 at 2100	850	B2	Fujino *et al.*; Hijioka *et al*. 2008 – AIM
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

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 for ArcGIS Climate

	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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