Regional Climate Change Data Portal
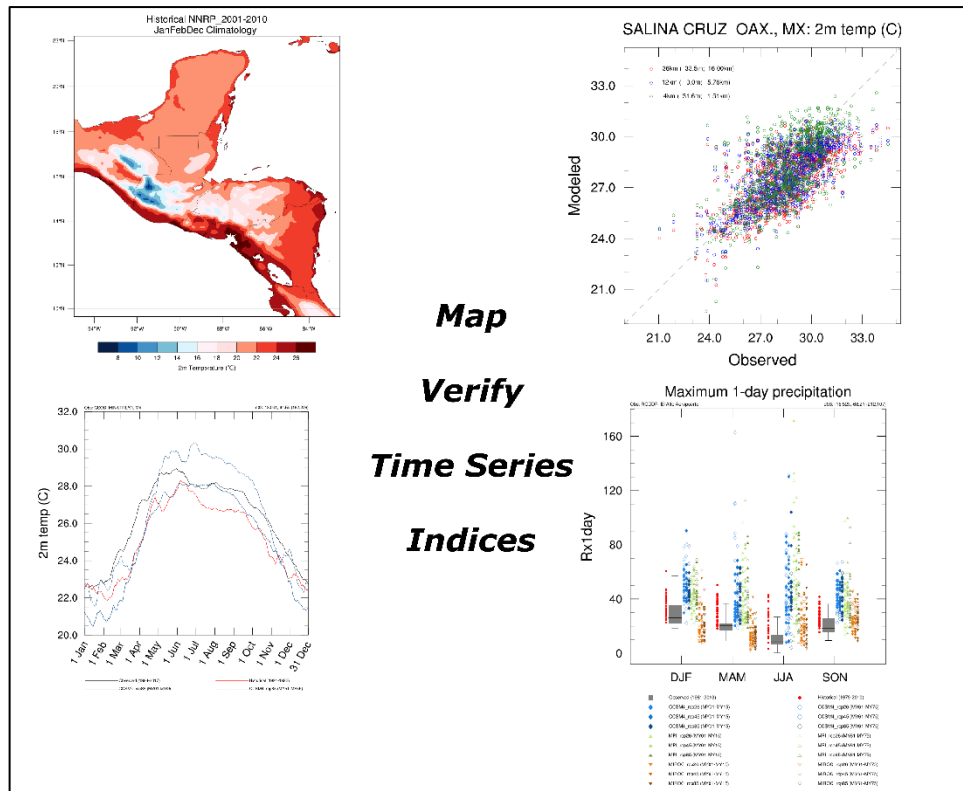
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PROLOGUE

The Regional Climate Change Data Portal (RCCDP, hereafter, the Climate Portal) was developed at the University of Nebraska-Lincoln by the Regional Climate Modeling Task Force under the auspices of the Sustainable Energy and Climate Change Initiative at the Interamerican Development Bank.

The Climate Portal provides access to already completed, proof-of-concept, dynamical downscaling scenarios for the Mesoamerican-Caribbean region, as well as more complete (longer or more comprehensive) scenarios for individual countries in Latin America (at this time, Bolivia, Guatemala, and Honduras). Applications to display, verify, analyze, and download these scenarios comprise the Climate Portal. These scenarios can be used as one source of climate change information for planning and policymaking in the region. The Climate Portal is configured to allow additional climate change scenarios to be easily added as new downscaling simulations become available.

While the Climate Portal provides high-resolution scenarios of possible climate change that can be a part of any decision-making process when climate change has potential impacts, those planning or policy decisions must still be made by responsible individuals or agencies in each country or region. Even though the Climate Portal does not

directly integrate directly with other tools often used by decision-makers (*e.g.*, GIS), data from the Climate Portal can easily be downloaded for that purpose.

OVERVIEW

The Climate Portal is an outgrowth of an effort to provide an easy-to-use, online application to allow workshop participants to visualize and analyze high-resolution, downscaled climate mode output. These workshops were organized by the University of Nebraska-Lincoln's Regional Climate Modeling Task Force under the auspices of the Sustainable Energy and Climate Change Initiative at the Interamerican Development Bank.

EARLY DEVELOPMENTS

Development of the initial application, *MapMaker*, started in late 2012 after it became apparent that a one-week training workshop format did not allow sufficient time for participants to learn the programming skills needed to access, visualize, and analyze the large datasets that were the outcome of the high-resolution climate change downscaling efforts that were underway. In addition, carrying data to workshops on portable hard drives only allowed participants access to small subsets of the data during the workshop and to limited (or no) access after the workshop.

Initially, *MapMaker* provided a means for participants to choose a single model output parameter for a single run from the first downscaling project for Mesoamerica and the Caribbean and display a

contour map of the selected parameter over the selected project domain. Over time, additional options were added and, as more downscaling projects were undertaken, access to more, often larger, datasets was desired. Unfortunately, due to early software design choices that favored expediency over flexibility, different versions of *MapMaker* were implemented for each project.

A second application, *Verify*, which provided a means of comparing historical downscaled runs to station observations, suffered from the same inflexibility, as each project required a separate version. In addition, observational data and model output needed significant preprocessing before any verification could be conducted.

Finally, participants wanting to download the output data had web access only to monthly data and only to complete datasets (all variables, all times, over an entire domain) often outstripping their networking and local storage capacities.

RESTRUCTURING

In 2016, an effort was undertaken to redesign the software for these applications so that a single version could access all of the available project datasets. As this would greatly simplify software maintenance, resources could then be devoted to adding more capabilities to the original applications and to developing new applications. Unifying the different versions of *MapMaker* and *Verify* was completed quickly and a new web interface to subset datasets for *Download* was developed soon after. All three applications were tested at workshops during that year.

Based on participant feedback at workshops, modifications and additional options were added to the initial applications and three new applications were developed: *TimeSeries*, *Indices* and *ChangeFactor*. The first of these, *TimeSeries*, allows users to plot climatological time series for selected parameters across one or more downscaling runs and observed data. The second new application,

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Indices, allows the computation and display of a number of standard climate indices for observations and downscaled runs. The third added application, *ChangeFactor*, scale climate change to intermediate periods between the downscaling simulations. All applications are now accessible through the Climate Portal (Figure 1).
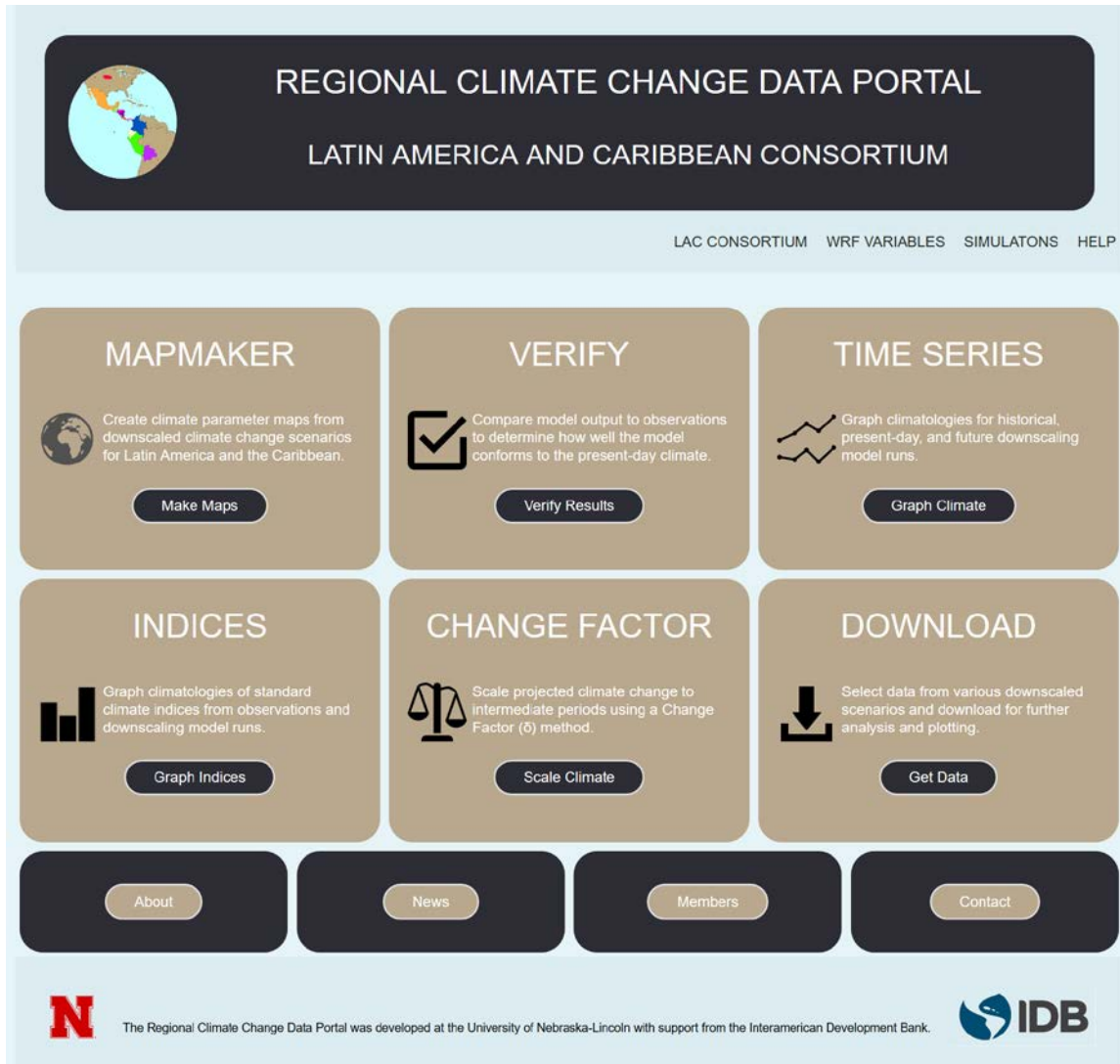

Figure 1: Climate Portal provides access to each of the six application programs as well as additional information.

THIS GUIDE

The remaining sections of this guide provide detailed instructions on the use of, and available options for, each of the applications available in the Climate Portal.

Downscaled Climate Data

Primary data for each of these applications come from various climate change dynamical downscaling **projects** for Mesoamerica, the Caribbean and Latin America. Each of these projects defines three or more nested model **domains** at spatial resolutions of 36, 12, and 4 km (Figure 2). Every project includes at least one historical **scenario**, forced by a reanalysis dataset over a period for which climatic observations are available. These historical scenario **runs** allow comparison of the dynamically downscaled output with climatic observations at stations throughout the project domains to determine how well the downscaling performs.

In addition, one or more climate change scenarios have been dynamically downscaled. Each of these scenarios includes two runs; the first is for a period near the beginning of the CMIP5 climate change projections (*i.e.*, "present-day" or a *baseline*), and the second for a period of the same length at least 50 years later (*i.e.*, "mid-century"). Each scenario is comprised of a pairing between a CMIP5 GCM and one of the four IPCC RCPs (Table 1). Because any GCM simulation is just one realization of a possible climate in the future, starting from given initial conditions and specified boundary conditions, they cannot be expected to simulate the climate of any specific year. Rather, their output must be interpreted as a *representative* year at a certain time in the future. For this reason, GCM output is labeled in the climate portal applications as the "model year (MY)", starting from MY01 (the first IPCC-designated projection year).

In addition to model output from each year of the historical, baseline, and future runs, a monthly climatology (*i.e.*, monthly averages over a

period of years, as noted in Table 1) from each run is available. From these climatologies, "Offset" and "Change" datasets are produced and made available. The Offset dataset is the difference between the baseline climate change run (forced by a GCM) and the historical run (forced by a reanalysis). If the period of the historical run and that of the baseline run are not too separated in time, the Offset should be small. Significant differences between these runs could be due to a large temporal separation between them (which could be indicative of actual climate change during the intervening period) or some mismatch between the large-scale forcing (reanalysis or GCM) and the actual climate forcing for the respective time period.

The Change dataset is the difference between the mid-century climate change run and the present-day, or baseline, run (forced by the same GCM scenario). Differences between these runs are indicative of the projected climate change under the given scenario, based upon the selected forcing model.

All dynamical downscaling was performed using the Weather Research and Forecasting (WRF) model. Details about each downscaling project are provided in Table 2 and information about each WRF output or derived variable is given in Table 3.

Observed Climate Data

Several Climate Portal applications (*i.e.*, **Verify**, **TimeSeries**, and **Indices**) make use of observations collected by National Meteorological and Hydrological Centers (NMHCs) and other agencies throughout the world. Two different global observation datasets are made available through the U.S. National Center for Environmental Information (NCEI, formerly NCDC): Global Summary of Day (GSOD) and Global Historical Climate Network-Daily (GHCN). Additionally, data contributed by LAC country participants specifically for this project (Country data) provide a third observational dataset for some regions.

GSOD is a dataset derived from operational synoptic reports made by NMHCs and shared internationally. Hourly, three-hourly, and 6-hourly observations are summarized into daily observations for over 9,000 stations worldwide and are regularly updated. For more information, see https://data.noaa.gov/dataset/dataset/global-surface-summary-of-the-day-gsod.

GHCN-D is an integrated database of daily climate summaries from over 100,000 stations across the globe that have been subjected to a common suite of quality assurance reviews. GHCN-D includes GSOD stations as well as many stations not included in GSOD. Some stations report most standard climate parameters, others include only a small subset of parameters (some only temperature or precipitation). Many non-GSOD stations are not currently providing new data and only historical data are included for those stations. For more information, see https://www.ncdc.noaa.gov/ghcn-daily-description.

Country data is a collection of climate observations contributed by participating countries. The data included varies by country, but most countries have included minimum, maximum and average temperature as well as precipitation data for most of their stations. Some stations have considerably more data than others, both in terms of parameters included and missing data.

So, which dataset to use? There are no hard and fast guidelines to be able to tell you which dataset to use. If the station you want is in one of the datasets and does not have too much missing data, then that is the dataset to use. The most practical advice is to check each of the datasets to determine which gives you the most data for the station(s) you want to use.
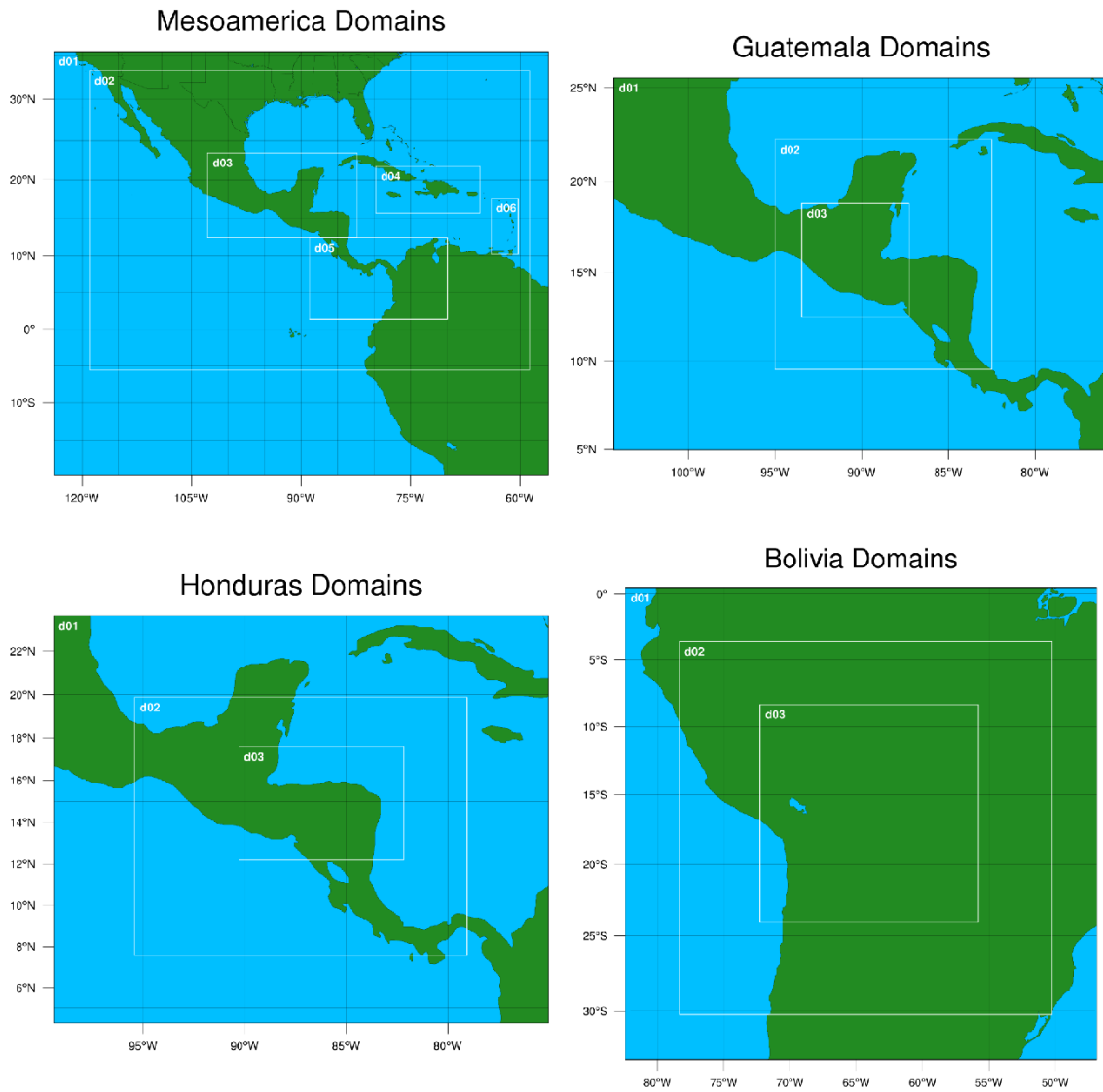
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Figure 2: Domains for the four downscaling simulations currently available through the Climate Portal. The entire map represents domain 1 (d01), which is at 36 km resolution. Domain 2 (d02) is at 12 km resolution and the remaining domains (d03 and, for Mesoamerica, d04, d05, and d06) are at 4 km resolution.

Table 1: Latin American and Caribbean (LAC) Consortium Downscaling Simulations

Project	Domains	Scenarios	Runs	Years	Climatology		Change	Offset
Mesoamerica	d01 d04 d02 d05 d03 d06	Historical	NNRP	1991-1993	1991-1993	(HS)		
		CCSM4_rcp8.5	Baseline	2006-2010	2006-2010	(BL)	FT - BL	BL - HS
			Future	2056-2060	2056-2060	(FT)		
Guatemala	d01 d02 d03	Historical	NNRP_1971-1980	1971-1980	1971-1980			
			NNRP_2001-2010	2001-2010	2001-2010	(HS)		
		CCSM4_rcp8.5	Baseline	2011-2020	2011-2020	(BL)	FT - BL	BL - HS
			Future	2061-2070	2061-2070	(FT)		
Honduras	d02 d03	Historical	ERA-I	1986-1993	1986-1993	(HS)		
		CCSM4_rpc8.5	Baseline	2011-2020	2011-2020	(BL)	FT - BL	BL - HS
			Future	2061-2070	2061-2070	(FT)		
		ECHAM_rcp8.5	Baseline	2011-2020	2011-2020	(BL)	FT - BL	BL - HS
			Future	2061-2070	2061-2070	(FT)		
Bolivia	d01 d02 d03	Historical	NNRP	1979-2012	1996-2010	(HS)		
		CCSM4_rcp2.6	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2066-2080	2066-2080	(FT)		
		CCSM4_rcp4.5	Baseline	2006-2040	2006-2020	(BL)	FT - BL	BL - HS
			Future	2066-2080	2066-2080	(FT)		
		CCSM4_rcp8.5	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2056-2080	2066-2080	(FT)		
		MPI_rcp2.6	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2066-2080	2066-2080	(FT)		
		MPI_rcp4.5	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2066-2080	2066-2080	(FT)		
		MPI_rcp8.5	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2056-2080	2066-2080	(FT)		
		MIROC_rcp2.6	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2066-2080	2066-2080	(FT)		
		MIROC_rcp4.5	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2066-2080	2066-2080	(FT)		
		MIROC_rcp8.5	Baseline	2006-2020	2006-2020	(BL)	FT - BL	BL - HS
			Future	2056-2060 2066-2080	2066-2080	(FT)		

Table 2: WRF version, discretization, parameterizations, grid sizes

	Mesoamerica			Bolivia			Guatemala			Honduras		
WRF version	3.3			3.3			3.5			3.6.1		
Levels	27			29			29			29		
Time step	adaptive			adaptive			adaptive			adaptive		
SW radiation	Dudhia			Dudhia			Dudhia			Dudhia		
LW radiation	RRTM			RRTM			RRTM			RRTM		
Cumulus	Kain-Fritsch			Kain-Fritsch			Kain-Fritsch			Kain-Fritsch		
Microphysics	WSM5			WSM5			WSM5			WSM5		
Boundary layer	YSU			YSU			YSU			YSU		
Surface layer	MM5 similarity			MM5 similarity			MM5 similarity			MM5 similarity (revised)		
Land-surface	Noah LSM			Noah LSM			Noah LSM			Noah LSM		
SST update	true			true			true			true		
Domains		delta	SN×WE		delta	SN×WE		delta	SN×WE		delta	SN×WE
	d01	36km	207×177	d01	36km	105×105	d01	36km	60×80	d01	36km	60×73[a]
	d02	12km	552×375	d02	12km	249×249	d02	12km	111×105	d02	12km	114×147
	d03	4km	564×321	d03	4km	435×438	d03	4km	165×156	d03	4km	150×219
	d04	4km	393×177									
	d05	4km	519×306									
	d06	4km	210×102									

[a] d01 results for Honduras were not retained due to storage constraints

PRELIMINARIES

Browser Settings

The Climate Portal applications make use of pop-ups to display the maps and graphs you create, as well as to open Help menus and ancillary maps. Before you start using these applications, you will need to set your browser to allow pop-ups from http://rccdp.unl.edu/. Instructions for the two most popular browsers are given below, along with the version number tested; actual steps may vary slightly depending on the version used.

Allowing pop-ups in Chrome
[Windows Version 62.0.3202.94 (Official Build) (64-bit)]

1. On your computer, open Chrome.
2. At the top right, click ⋮
3. Click **Settings**.
4. At the bottom, click **Advanced**.
5. Under "**Privacy and security**", click **Content settings**.
6. Click **Popups**.

7. In the "**Allow**" section, click **Add**.

8. Enter the site name, http://rccdp.unl.edu/ and click "**Add**".

9. Close the **Settings** tab.

Allowing pop-ups in Firefox
[Windows Version 57.0 (64-bit)]

1. Click the menu button ☰ and choose **Options**.

2. Select **Privacy & Security** in the left-side panel.

3. Under the **Permission** section, if **Block pop-up windows** is checked, click on **Exceptions**.

4. In the dialog box, enter the site name, http://rccdp.unl.edu/ and click "**Allow**".

5. Click "**Save Changes**".

6. Close the **Options** tab.

Browser Issues

Some browser-specific issues have been noted that remain unresolved at this time. Specific issues (and work-arounds, when available) for the two most popular browsers are given below, along with the version number tested; actual steps may vary slightly depending on the version used.

Chrome
[Windows Version 62.0.3202.94 (Official Build) (64-bit)]

Save image as ...

right-clicking on images brings up the menu which includes "Save image as ...". In some versions of Chrome, this option does not work. If this occurs, use the "Open image in new tab" option, then right-click on the image and select

"Save image as …", which will allow the image to be saved to disk.

Firefox
[Windows Version 57.0 (64-bit)]

Calendar support

by default, dates cannot be selected from a popup calendar. Firefox must be updated to version 56 (or later) and configured by the user to allow calendar input. To do this, enter "about:config" in the browser's URL box, accept the "risk" and scroll through (or search) the Preference Names to find "dom.forms.datetime". Double-click on that entry so it shows "modified boolean true" in bold. Reload the Climate Portal page.

Image loading

the indicator on the browser tab that the web page is still loading never stops, even after loading is complete. Clicking on the "x" to the right of the URL will stop the indicator and load the Climate Portal icon.

Table 3: WRF variables – daily and monthly RCCDP files

dimensions	Name	Dimensions
	time	t
	south_north	s_n
	west_east	w_e
	pres_lev	p
	soil_layers	s

This table identifies and describes the variables contained in the daily files processed from the raw WRF three-hourly output. The same variables are in the monthly files processed from the daily files, with two additions (**bold-italic**).

Variables in **bold** are not stored in the daily or monthly files but are computed, as needed, in software.

	Variable	Description	Units	Dimensions	MapMaker (MM)	Verify (V)	Download (D)	TimeSeries (TS)
time, location	TIME	YYYYMMDD or YYYYMM	day or month	(t)				
	PRES_LEV	Pressure level	hPa	(p)				
	DZS	Thicknesses of soil layers	m	(s)				
	XLAT	Latitude, south is negative	degree_north	(t, s_n, w_e)				
	XLONG	Longitude, west is negative	degree_east	(t, s_n, w_e)				
surface parameters	**Variable**	**Description**	**Units**	**Dimensions**				
	PSFC	Surface pressure	hPa	(t, s_n, w_e)	✓	✓	✓	
	PMSL	Pressure at mean sea level	hPa	(t, s_n, w_e)	✓	✓	✓	
	T2	Temperature at 2m	K	(t, s_n, w_e)	✓	✓	✓	
	T2_MIN	Daily minimum temperature at 2m	K	(t, s_n, w_e)	✓		✓	
	T2_MAX	Daily maximum temperature at 2m	K	(t, s_n, w_e)	✓		✓	
	Q2	Water vapor mixing ratio at 2m	kg kg^{-1}	(t, s_n, w_e)	✓		✓	
	U10	X-wind at 10m	m s^{-1}	(t, s_n, w_e)	✓		✓	
	V10	Y-wind at 10m	m s^{-1}	(t, s_n, w_e)	✓		✓	
	PRCP	Daily total precipitation	mm	(t, s_n, w_e)	✓	✓	✓	
	SNOW	Snow water equivalent	kg m^{-2}	(t, s_n, w_e)	✓		✓	
	RAINC	Daily total convective precipitation	mm	(t, s_n, w_e)				
	RAINNC	Daily total non-convective precipitation	mm	(t, s_n, w_e)				
	RAINSH	Daily total shallow convective precipitation	mm	(t, s_n, w_e)				
	SNOWNC	Daily total snow and ice	mm	(t, s_n, w_e)				
	GRAUPELNC	Daily total graupel	mm	(t, s_n, w_e)				
	HAILNC	Daily total hail	mm	(t, s_n, w_e)				
	SNOWH	Physical snow depth	m	(t, s_n, w_e)				
	CANWAT	Canopy water	kg m^{-2}	(t, s_n, w_e)				
	SFROFF	Daily total surface runoff	mm	(t, s_n, w_e)				
	UDROFF	Daily total underground runoff	mm	(t, s_n, w_e)				
	SST	Sea surface temperature	K	(t, s_n, w_e)				
	TSK	Surface skin temperature	K	(t, s_n, w_e)	✓		✓	
	RH2	Relative humidity at 2m	%	(t, s_n, w_e)	✓		✓	
	WSPD10	Wind speed at 10m	m s^{-1}	(t, s_n, w_e)	✓	✓	✓	
	WDIR10	Wind direction at 10m	degree	(t, s_n, w_e)			✓	
	SNOW15	Mid-month snow water equivalent	kg m^{-2}	(t, s_n, w_e)	✓			

	Variable	Description	Units	Dimensions	MM	V	D	TS
atmospheric parameters	T	Temperature	K	(t, p, s_n, w_e)	✓		✓	
	Z	Geopotential height	m	(t, p, s_n, w_e)	✓		✓	
	Q	Water vapor mixing ratio	kg kg^{-1}	(t, p, s_n, w_e)	✓		✓	
	U	X-wind component	m s^{-1}	(t, p, s_n, w_e)	✓		✓	
	V	Y-wind component	m s^{-1}	(t, p, s_n, w_e)	✓		✓	
	W	Z-wind component	m s^{-1}	(t, p, s_n, w_e)	✓		✓	
	QC	Cloud water mixing ratio	kg kg^{-1}	(t, p, s_n, w_e)				
	QR	Rain water mixing ratio	kg kg^{-1}	(t, p, s_n, w_e)				
	QI	Ice mixing ratio	kg kg^{-1}	(t, p, s_n, w_e)				
	QS	Snow mixing ratio	kg kg^{-1}	(t, p, s_n, w_e)				
	CLD	Cloud fraction		(t, p, s_n, w_e)				
	RH	Relative humidity	%	(t, p, s_n, w_e)	✓		✓	
	WSPD	Wind speed	m s^{-1}	(t, p, s_n, w_e)	✓		✓	
	WDIR	Wind direction	degree	(t, p, s_n, w_e)			✓	
land-surface parameters	Variable	Description	Units	Dimensions				
	LU_INDEX	Land use category		(t, s_n, w_e)	✓			
	LANDMASK	Land mask (1 for land, 0 for water)		(t, s_n, w_e)				
	IVGTYP	Dominant vegetation category		(t, s_n, w_e)	✓			
	ISLTYP	Dominant soil category		(t, s_n, w_e)	✓			
	VEGFRA	Vegetation fraction		(t, s_n, w_e)	✓		✓	
	LAI	Leaf area index	m^2 m^{-2}	(t, s_n, w_e)	✓			
	HGT	Terrain height	m	(t, s_n, w_e)	✓		✓	
	ALBEDO	Albedo		(t, s_n, w_e)	✓		✓	
	ALBBCK	Background albedo		(t, s_n, w_e)	✓		✓	
	EMISS	Surface emissivity		(t, s_n, w_e)	✓		✓	
	XLAND	Land mask (1 for land, 2 for water)		(t, s_n, w_e)				
flux parameters	Variable	Description	Units	Dimensions				
	SWDOWN	Downward shortwave flux at ground surface	W m^{-2}	(t, s_n, w_e)	✓		✓	
	GLW	Downward longwave flux at ground surface	W m^{-2}	(t, s_n, w_e)	✓		✓	
	OLR	TOA outgoing longwave	W m^{-2}	(t, s_n, w_e)	✓		✓	
	GRDFLX	Ground heat flux	W m^{-2}	(t, s_n, w_e)	✓		✓	
	HFX	Upward heat flux at the surface	W m^{-2}	(t, s_n, w_e)	✓		✓	
	QFX	Upward moisture flux at the surface	kg m^{-2} s^{-1}	(t, s_n, w_e)	✓		✓	
	LH	Latent heat flux at the surface	W m^{-2}	(t, s_n, w_e)	✓		✓	
	SNOPCX	Snow phase change heat flux	W m^{-2}	(t, s_n, w_e)				
soil parameters	Variable	Description	Units	Dimensions				
	TSLB	Soil temperature	K	(t, s, s_n, w_e)	✓		✓	
	SMOIS	Soil moisture	m^3 m^{-3}	(t, s, s_n, w_e)	✓		✓	
	SH2O	Soil liquid water	m^3 m^{-3}	(t, s, s_n, w_e)				
	SMCREL	Relative soil moisture		(t, s, s_n, w_e)				
	SMOIS15	Mid-month soil moisture	m^3 m^{-3}	(t, s, s_n, w_e)	✓			

DEFINITIONS

TERM	DEFINITION	EXAMPLE
Project	Focal region of the downscaling, often the sponsoring country	Bolivia
Domain	nested WRF domain	d02 – Regional (12km)
Scenario	forcing used to drive the dynamical downscaling, formed as a combination of the CMIP5 model and the RCP (without the decimal point)	MPI_rcp85
Run	for historical scenarios, the forcing used for climate change scenarios, period covered by the run	Mid-century

ACKNOWLEDGEMENTS

MAPMAKER

The *MapMaker* user interface (Figure 3) is separated into three distinct areas. At the top, the User selects the project, domain, scenario, run, and time period for which they desire to produce a map. The middle section allows selection of the desired parameter or parameters and the general method to be used to display the parameter on the map. The lower section provides the User with options to modify the appearance of the map and output format. Each of these interface sections is described in more detail below, using the user input (shown in **bold green**, inside square brackets) needed to produce the sample output at the end of this chapter as an example.

GEOGRAPHY AND TIME SECTION

This section (Figure 4) provides the User with a selection of drop-down menus from which they can select the Project, Domain, Scenario, Run, and Year they wish to use. These menus are created dynamically so that selections must be made from left to right. That is, selection of a Project [**Guatemala**] determines the Domains available [**d02: Regional (12km)**], selection of a Domain determines the Scenarios [**Historical**] available, selection of a Scenario determines the Runs available [**NNRP_2001-2010**], and selection of the Run determines the Years available [**Climatology**]. If, after initial

*Figure 3: **MapMaker** menu, with sections outlined in red, (top) geography and time section, (middle) parameter section, and (bottom) plot modifications section.*

selection, the User changes a selection from one of these drop-down menus, all menus to the right must be re-selected, as well.

In addition to model output from each year of the historical, baseline, and future runs, a climatology from each run is available. From these

*Figure 4: Geography and Time section of the **MapMaker** user interface. Selections shown here are those used to produce the Sample Output at the end of this chapter.*

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climatologies, "Offset" and "Change" datasets are produced and made available (Table 1). The Offset dataset is the difference between the baseline climate change run (forced by a GCM) and the historical run (forced by a reanalysis). The Change dataset is the difference between the future climate change run and the baseline run (forced by the same GCM scenario). Land-surface fields that do not change between runs are not differenced, but represent the actual value for the runs. These include terrain height, background albedo, vegetation fraction, leaf area index, land use category, dominant vegetation category, and dominant soil category. This allows, for example, the User to plot a climate change (*e.g.*, change in temperature) over a static field (*e.g.*, terrain height).

Below the drop-downs, the User can choose one or more months of data for their map [**Jan, Feb, Dec**]. An "Annual" checkbox simplifies the selection of all months. Ordinarily, all months selected for averaging come from the same calendar year. The "Wrap calendar" checkbox allows the User to create a map of a true winter season (summer in the Southern Hemisphere), consisting of one or months from the end of one calendar year averaged with one or more months from the beginning of the following calendar year. For example, selecting Year 2001 from the drop-down and months January, February, and December would average January and February from 2001 with December of 2001. If the User checks "Wrap calendar", December 2000 is averaged with January and February of 2001 (a "true season"). For obvious reasons, this cannot be done for the first year of a model run as all runs begin in January and the preceding December is not available.

PARAMETER SECTION

In this section, the User can choose up to four parameters to include on their map: one plotted as a color-filled contour map, one plotted as line contours, one surface (10-meter) wind vector, and one upper-air wind vector. In general, trying to include all four on a single map will

result in a cluttered map, so most maps will include a smaller subset of parameters. The available model parameters are grouped into five subsections: *surface* **parameters**, *atmospheric* **parameters**, *flux* **parameters**, *land-surface* **parameters**, and *soil* **parameters**. These are the same groups delineated, by color, in Table 3.

A single parameter can be selected from any one of the five subsections as the parameter to be plotted as a color-filled field by selecting the appropriate radio button under the "Fill" heading for that subsection [**Temperature (°C)**, for the upper-left sample output]. If no selection under "Fill" is made, no color-filled contour plot will be produced.

A single parameter can be selected from any one of the five subsections as the parameter to be plotted as line contours by selecting the appropriate radio button under the "Line" heading for that subsection [**Temperature (°C)**, for the upper-right sample output]. If no selection under "Line" is made, no contour lines will be plotted. If the same parameter is selected for color-fill and contours, the User can create a map with contour interval highlighting, if desired.

To plot surface or upper-air winds, the User can select either meteorological wind barbs ("barb") or vectors ("arrow") from the appropriate drop-down menu in that subsection [**barb**, for the lower-left sample output; **arrow**, for the lower-right sample output]. For arrows, the length of the arrow corresponds to the wind speed. For barbs, the barbs indicate the wind speed; an unadorned line indicates less than 2 m s^{-1}, a half- barb indicates 5 m s^{-1}, a whole barb indicates 10 m s^{-1}, and a flag (triangle) indicates 50 m s^{-1}. The half-barb, barbs, and flags are summed to obtain the actual wind speed. Calm conditions are indicated by a circle. In both cases, the symbol plotted indicates the direction of the wind; with barbs at the tail or the arrowhead at the head of the wind vector.

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Surface Pressure (hPa)
Skin temperature (°C)
Snow Water Equivalent [SWE] (kg m⁻²)
Mid-month SWE (kg m⁻²)
U-component (m s⁻¹)
V-component (m s⁻¹)
Wind Speed (m s⁻¹)
Wind Vector (m s⁻¹)

1000
925
850
700
500
400
300
250
200
150
100

Atmospheric Parameter	Fill	Line	Le...a)
Temperature (°C)	○	○	
Geopotential Height (m)	○	○	
Mixing Ratio (g kg⁻¹)	○	○	
Relative humidity (%)	○	○	
U-component (m s⁻¹)	○	○	
V-component (m s⁻¹)	○	○	
Horizontal Wind Speed (m s⁻¹)	○	○	
Vertical Velocity (m s⁻¹)	○	○	
Wind Vector (m s⁻¹)	arrow ▾		

Soil Parameter	Fill	Line	Layer
Soil Temperature (°C)	○	○	
Soil Moisture (m³ m⁻³)	○	○	
Mid-month Soil Moisture (m³ m⁻³)	○	○	

0-10 cm
10-40 cm
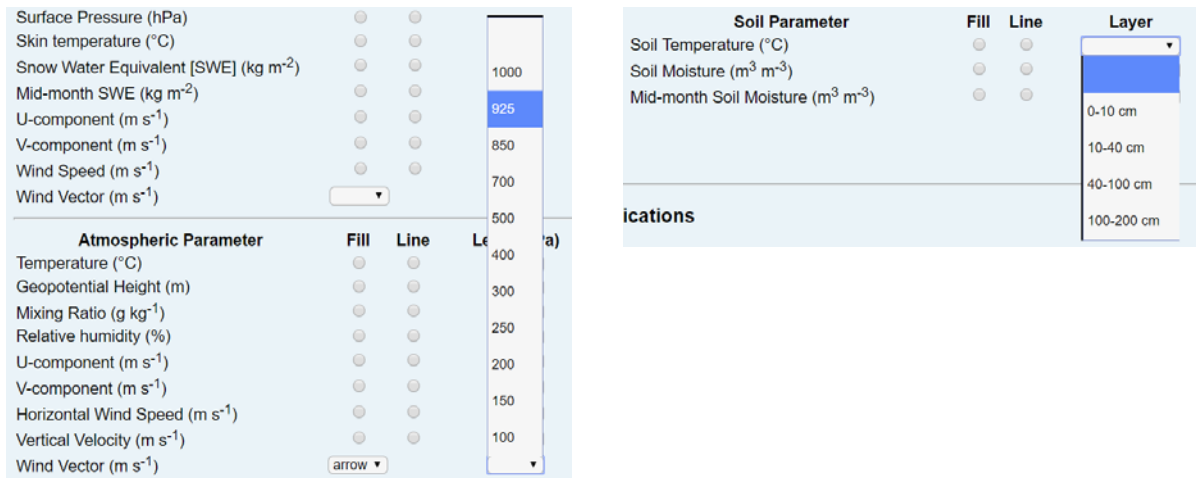40-100 cm
100-200 cm

ications

*Figure 5: Drop-down selection menus for atmospheric parameter levels (left) and soil parameter layers (right). The atmospheric parameter menu shows the selections [**Wind Vector (m s⁻¹), arrow, 925 hPa**] for the lower-right sample output.*

Regardless of the plotting method selected, for atmospheric parameters, a pressure level [**925**, for the lower-right sample output] must be chosen and, for soil parameters, a soil layer must be selected from the corresponding drop-down menu (Figure 5).

Several land-surface parameters (*i.e.*, land use category, dominant vegetation category, and dominant soil category) can only be mapped using color fill, as they do not represent a continuous variable but rather a nominal category. As such a value of 17 adjacent to a value of 2 does not imply that there are values of 3, 4 … 16 between them, as line contours would imply. A link to a table of index values is provided for each of these parameters.

Should your map become too cluttered by choosing multiple parameters to plot, fill or contour selections may be cleared by holding down the Control key and clicking (*i.e.*, ctrl-click) the appropriate radio button. To clear a wind selection (either surface or atmospheric), select the blank entry from the appropriate drop-down menu.

PLOT MODIFICATION SECTION

While the default mapping options will suffice for many users, at least for an initial map, the User can make adjustments to the final product, if desired. For example, when making a series of maps of the same parameter for different time periods, it may be desirable to hold the contours constant for all maps. Another example might be to ensure that the contour interval spans equally to the positive and negative side of zero, if plotting climatological differences.

Left side

The left two-thirds of this section (Figure 6) allows the User to specify contour intervals and ranges for color-filled or line contours, to scale wind vectors, or to modify the colors used for the map. The right side of this section provides the User with a means to zoom in on a portion

*Figure 6: Left side of plot modification menu, showing selections for contour interval [**2**] and range [minimum **8,** maximum **26**], and color table [**temp_19lev**, the default for temperature] used for the upper-left sample output.*

of the selected domain and to mask plotting of the selected parameter over water (the default), over land, or neither.

To specify contour intervals and range, for either color-filled or line contours, the User may enter values into the appropriate boxes. If either a specific minimum or a specific maximum is desired, a valid number must be entered in each box (that is, the range must be fully specified). It is not necessary to enter both the interval [**2**] and the range [minimum **8**, maximum **26**].

For color-filled contours, the number of colors used will be 2 more than the number of intervals specified, to allow for filling areas with values less than the minimum or greater than the maximum. Color-filled contours make use of a pre-defined color table, with a default defined for each parameter. A drop-down menu (with color swatches shown) allows selection from a small subset (23) of the currently available (240) color tables; the User may specify any valid color table by entering its name in the drop-down box. A link to all pre-defined color tables is provided to the right of the drop-down.

For line contours, the color of the contour lines can be selected from a drop-down menu of 8 basic colors (default is black); alternatively, the User may specify any valid named color by entering its name in the drop-down box. A link to all named colors is provided to the right of the drop-down.

Scaling of wind vectors is accomplished by changing the length of the reference vector or its magnitude. The length of the reference vector or barb is multiplied by the value entered in the "Ref. Len." box; values less than 1.0 will shorten the reference vector, values greater than 1.0 will lengthen the reference vector. The wind speed assigned to the reference vector is changed by entering a value in the "Magnitude" box; the default is 10 m s^{-1}. By default, all wind vectors will be plotted, which can result in the individual vectors becoming impossible to discern, due to crowding. A thinning parameter can be

specified to reduce the crowding. This parameter varies from 0.0 (no thinning, the default) to 1.0 (maximum thinning).

The color of wind vector(s) can be changed by selecting from a drop-down menu of 8 basic colors (default is black); alternatively, the User may specify any valid named color by entering its name in the drop-down box. If both surface and atmospheric wind vectors are plotted, the selected color will be used for the surface vector and the atmospheric vector will be plotted in its complimentary color, if one of the 8 basic colors is chosen. Otherwise, the surface vector will be plotted as the user-specified color and the atmospheric vector will be plotted in black.

Right side

On the right side of this section (Figure 7, left), the User can choose a subregion of the selected Domain as the map area to be plotted. The User may specify a rectangular region by specifying the latitude and longitude of opposite corners in the respective boxes. North latitudes
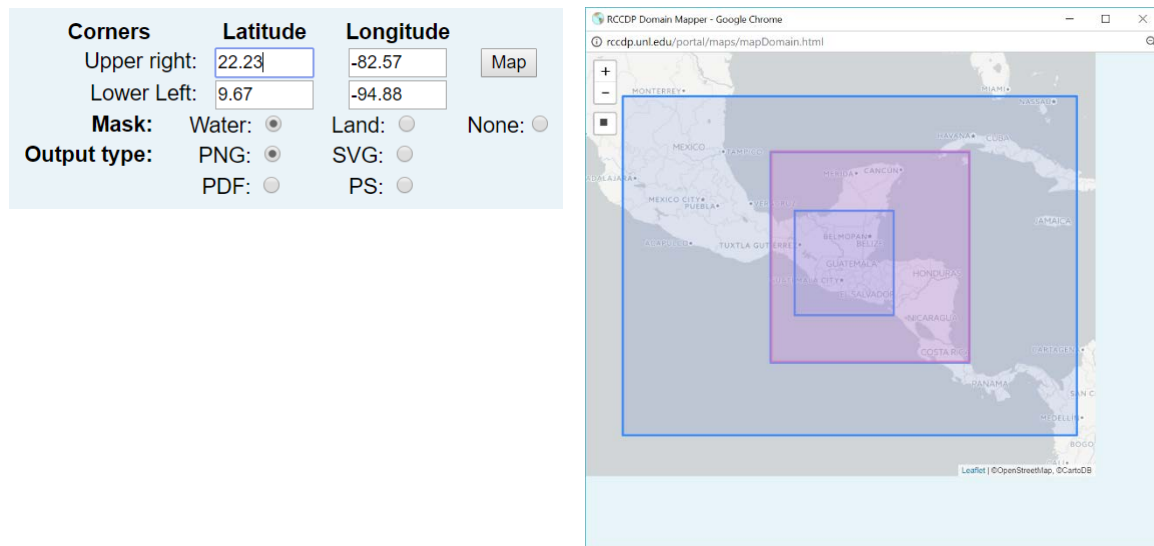

Figure 7: Map controls section (left) of the Plot Modifications menu. Here the user has selected the entire 12km domain (pink shading) using the "Map" pop-up (right). As the entire domain is the default, this is for illustration only. Selection of an area on the map automatically populates the latitude and longitude boxes for the map corners.

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and east longitudes are positive; south latitudes and west longitudes are negative. Alternatively, the User can click the "Map" button to open a new window with the Domains for the selected Project mapped (Figure 7, right). The User can zoom and scroll this map to the desired area and use the box select tool (■) to draw the desired subregion (which must be completely contained in the selected domain). The latitude and longitude of the subregion are automatically transferred to the *MapMaker* menu page.

By default, *MapMaker* draws the selected parameters only over land areas by masking out water bodies (Figure 8). The User may choose to mask out land areas so that the selected parameters are drawn only over water or they may choose to apply no masking. In the latter case, parameters are drawn over the entire map area.

Four types of output files are available: portable network graphic (PNG), scalable vector graphic (SVG), portable document format (PDF), or PostScript (PS). Depending on the configuration of the User's browser, the resulting map will be displayed automatically on the screen or will be downloaded to the local hard drive.
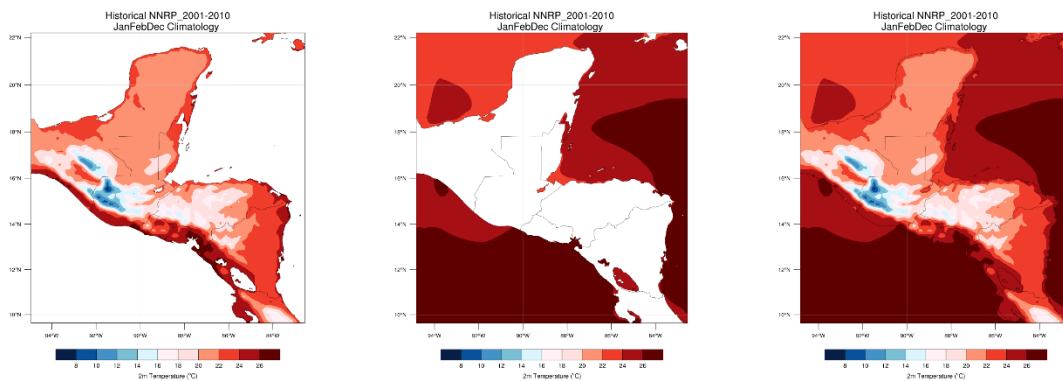
Figure 8: Examples of the three masking options: water masked (left), land masked (center) and no mask (right). Water masking is the default.

SAMPLE OUTPUT

Examples of each of the 4 map types are given in Figure 9.

PNG or SVG maps will be displayed in a new browser window (see Preliminaries in the Overview chapter for required browser setup) with a "Get Data" button at the bottom of the page. Depending on your browser configuration, PDF or PS maps will be displayed, automatically downloaded, or a link provided for manual download. For these outout types, the "Get Data" button may or may not be displayed in the browser window. Clicking on the "Get Data" button will download to your local disk a netCDF file containing the data displayed on the map.

*Figure 9: Sample **MapMaker** output from the Guatemala project at 12 km resolution for a winter climatology. (top left) color-filled contour of 2-m temperature, (top right) line contour of 200 hPa Wind speed, (bottom left) 10-m wind barbs, and (bottom right) 925 hPa wind vectors. Blank areas at 925 hPa are where the land surface is above that pressure level.*

VERIFY

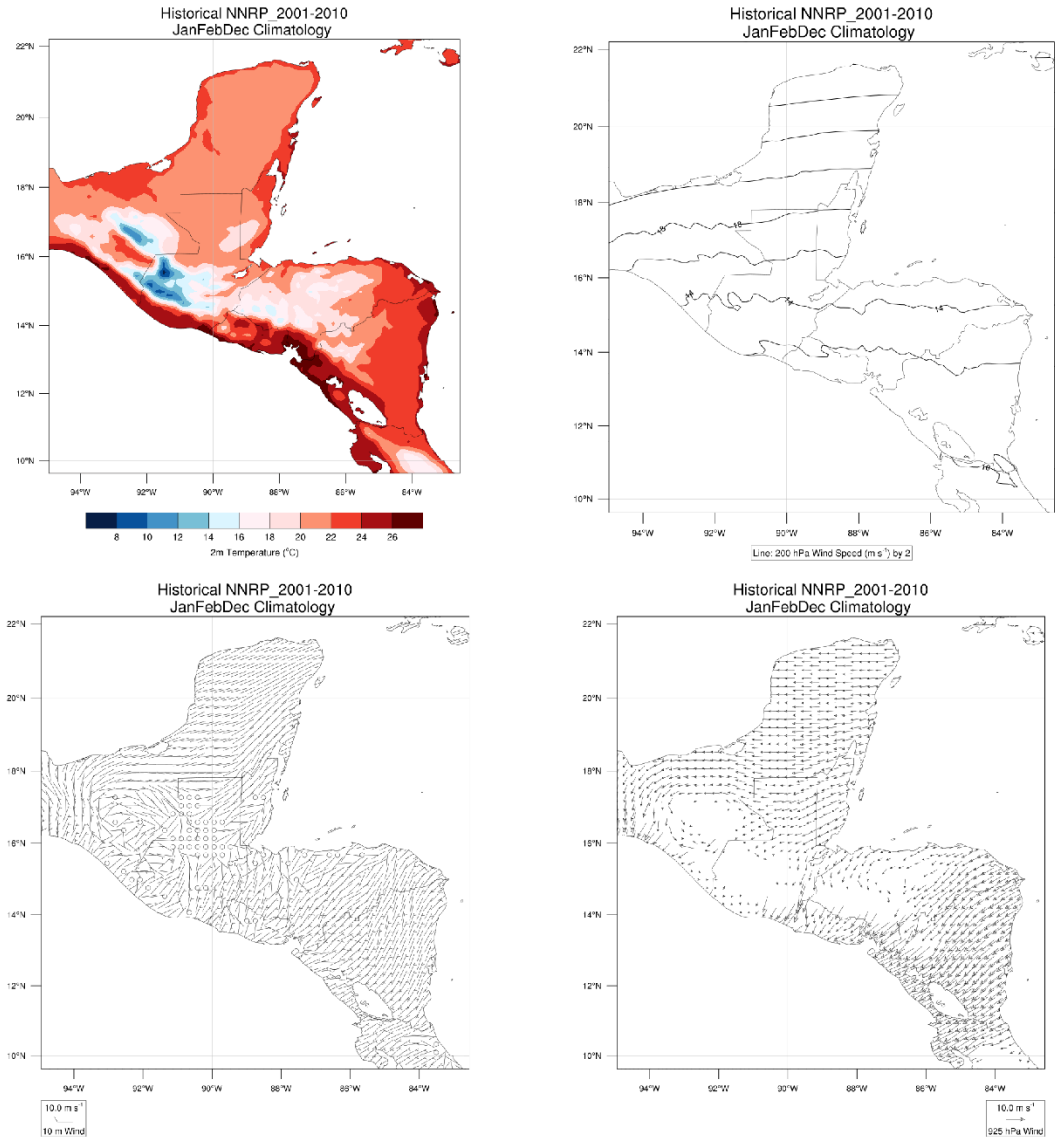The *Verify* user interface (Figure 10) is divided into three distinct sections. At the top, the User selects the project and run for which to compare historical scenario model results to station observations. The right-hand section allows selection of the observation dataset, desired parameter, and the type of plot to be produced. The left-hand map section provides the User with a means of selecting the climatic station for which model results and observations will be compared. Each of these interface sections is described in more detail below, using the user input (shown in **bold green**, inside square brackets) needed to produce the sample output at the end of this chapter as an example.

PROJECT AND RUN SECTION

This section (Figure 11) provides the User with drop-down menus from which they can select the Project and Run they wish to use. These menus are created dynamically so that selections must be made from left to right. That is, selection of a Project [**Mesoamerica**] determines the Runs available [**NNRP**]. As verification compares model output to actual station observations, only Historical runs are available.

If, after initial selection, the User changes the selected Project, the Run must be re-selected, as well. When the Project is selected, the
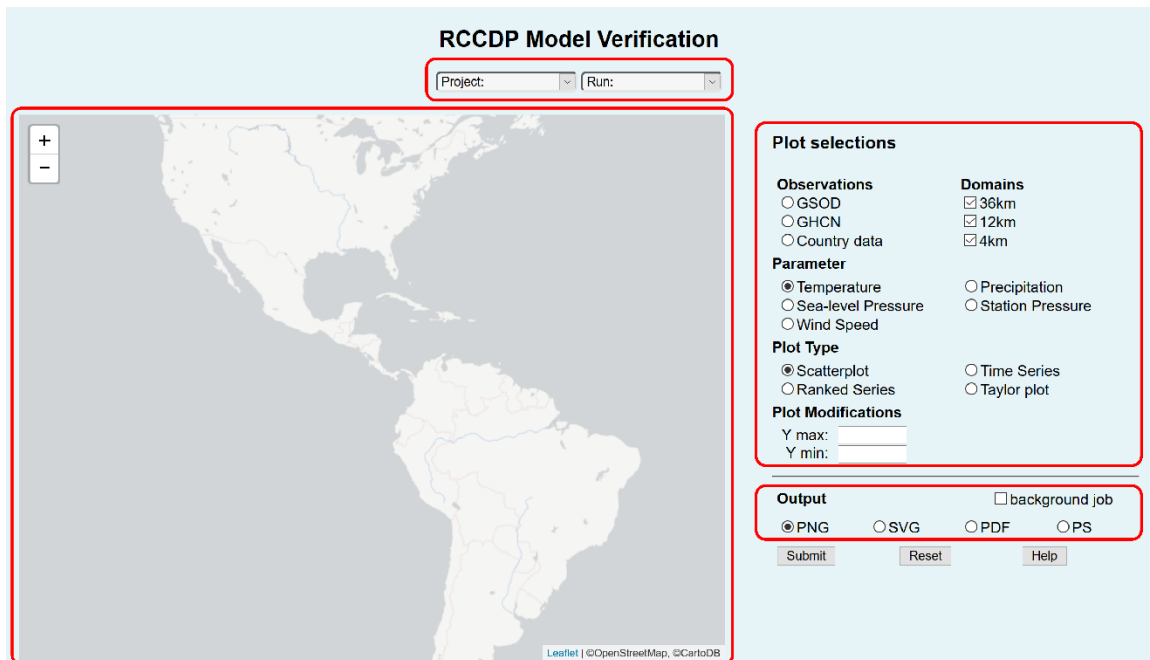
*Figure 10: **Verify** menu, with sections outlined in red, (top) project and run section, (bottom left) station selection section, and (bottom right) plot and parameter section.*

available Domains will be plotted on the map below and the map will be re-centered over those Domains (Figure 12, left).
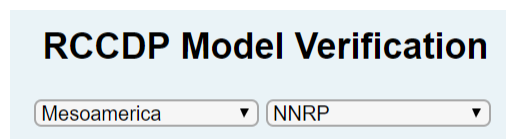
*Figure 11: Project and Run section of the **Verify** user interface. Selections shown here are those used to produce the Sample Output at the end of this chapter.*

PLOT AND PARAMETER SECTION

At the top of this section (Figure 13), the User selects the observational dataset to use as the basis of the verification, as well as which model domains will be verified. Two different global observation datasets are available: Global Summary of Day (GSOD) and Global Historical Climate Network-Daily (GHCN). Additionally, contributed data from LAC country participants (Country data) provide a third observational dataset for some regions. Additional information about these datasets is given in the Observed Climate Data section of the
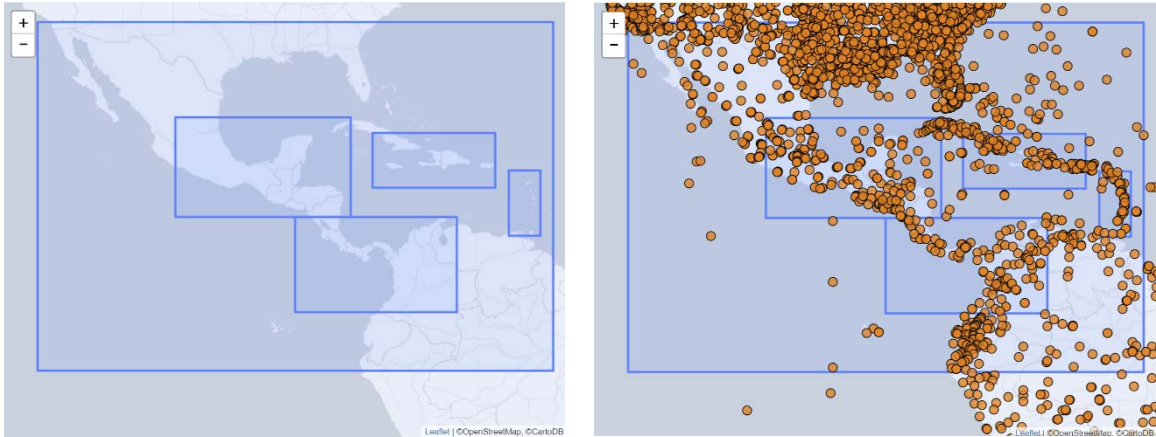
*Figure 12: Map section after selection of a Project (left) and after selection of an Observation dataset (right). Project [**Mesoamerica**] and Observations [**GSOD**] are for the sample output and the end of this chapter.*

Overview chapter in this guide. When a dataset is selected, the available stations will appear on the map (Figure 12, right). The user must select a station from those available on the map. Statistics and verification plots can include one or more of the available nested domains that include the selected observing station; by default, all available domain resolutions are included.

*Figure 13: Plot and Parameter section of the **Verify** user interface. Selections [**GSOD, all domains, Temperature, Scatterplot**] shown here are those used to produce the upper-left sample output.*

The next subsection allows the User to select the parameter on which verification statistics and plots will be computed. Five parameters are included at present, as the observation datasets do not include as many parameters as the model output.

Four type of plots are available for selection in the next subsection, scatterplot, time series, ranked series, and Taylor plot:

- *Scatterplots allow a rapid assessment of how well the model is able to reproduce the climate at the chosen station. The dashed line is a y=x plot that would represent a "perfect model" if all the points fell on that line. Deviations in slope and intercept of the point cloud represent systematic model biases while scatter represents random model (or data) errors.*

- *Time series offer another visual assessment of model efficacy. Systematic biases, trends, and other inconsistencies between model output and observations can easily be detected.*

- *Rank series are often useful for comparing statistical distributions of non-continuous time series, such as precipitation. Similarly shaped distributions imply that the relative number and magnitude of events are similar.*

- *Taylor plots are a "concise statistical summary of how well patterns match each other in terms of their correlation, their root-mean-square difference, and the ratio of their variance" (Taylor 2001). Originally designed to compare model fields, here we use them to compare time series.*

For scatterplots and series, the User can set the range of the y-axis to facilitate comparisons between stations, for example. The x-axis for scatterplots will be scaled to match the y-axis. For all plots, data may be smoothed before plotting, using a running average of a specified width, *N* (*i.e.*, an odd number of days), centered on each day of the time series. The smoothing procedure will result in a reduction of the number of days displayed in the plot, as *N/2* days will be lost at the

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beginning and end of the time series, as well as around any days for which observations are missing. For stations with significant missing data, this can result in a considerable reduction in available verification days.

OUTPUT SECTION

At the bottom right, the User can select from four types of output files: portable network graphic (PNG), scalable vector graphic (SVG), portable document format (PDF), or PostScript (PS). Depending on the configuration of the User's browser, the resulting graph will be displayed automatically of the screen or will be downloaded to the local hard drive.
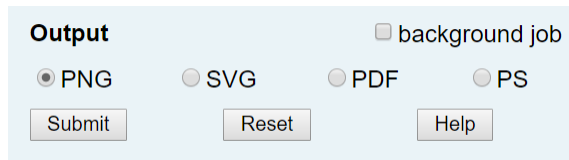
Figure 14: Output menu for the ***Verify*** *user interface.*

Because the computation of the verification statistics may take considerable time, depending on the length of the selected Run, a "background job" checkbox allows the User to do the calculations behind the scenes and receive an email when they are completed so they can retrieve the graph, table of statistics and, if desired, the data used.

STATION SELECTION SECTION (MAP)

As noted above, when the User selects a Project, the available Domains are plotted on the map in this section and the map will be re-centered over those Domains. Upon selection of an observational dataset, all available stations from that dataset will be added to the map. The User can zoom and pan as needed to display stations in the desired domain or region.

Clicking on a station circle selects that station location for verification, using the observations from that station and model output from the nearest grid point at each of the selected model resolutions. Clicking

on a station will display a pop-up balloon with the station name and additional information about the station (Figure 15). If the chosen station is not within a higher-resolution domain, you should unselect the checkbox(es) for those resolutions, to avoid unnecessary labeling on the output graph.

768330 99999 SALINA CRUZ OAX., MX 19730102 20170730
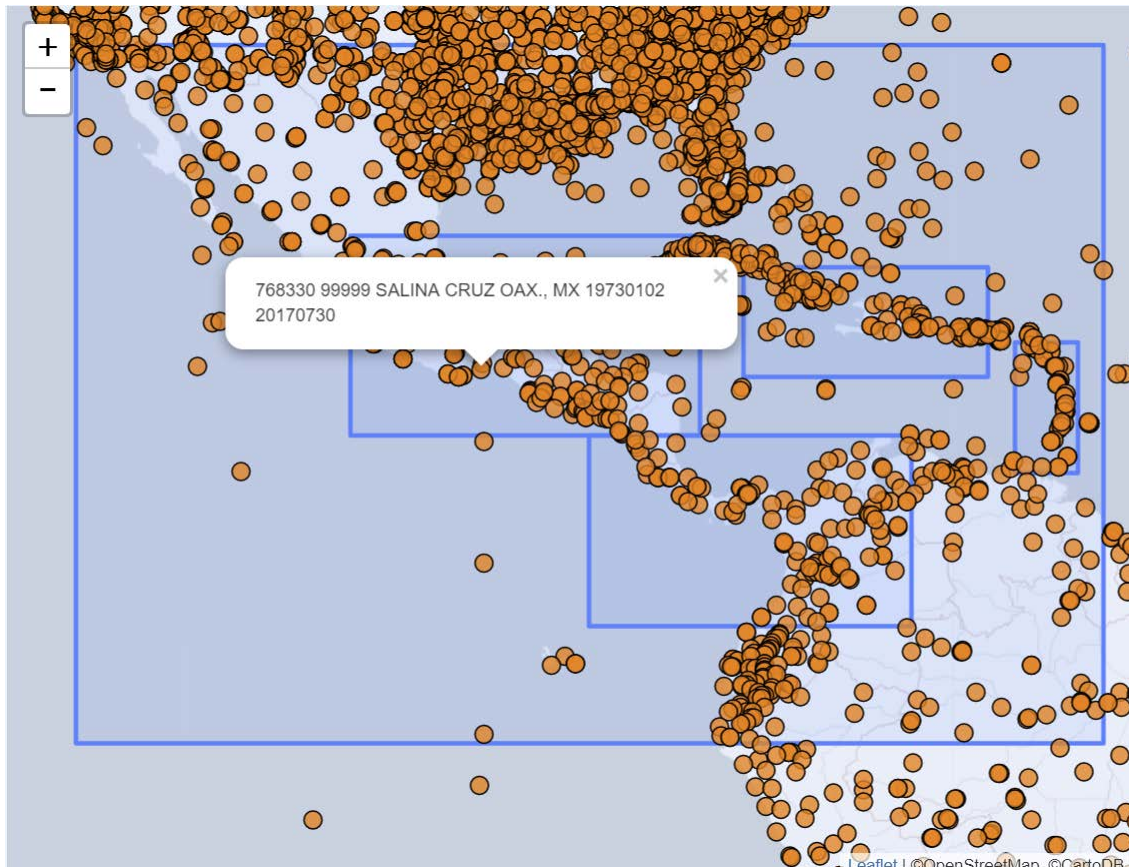
*Figure 15: Map section after selection of a station [**Salina Cruz, MX**] for the sample output at the end of this chapter. Additional information shown in the pop-up include the station number (768330 99999) for this dataset and the period with available data (19730102 to 20170730, in YearMonthDay format). Information displayed for GHCN stations is similar; information for Country Data is variable, but will include a station number and name.*

SAMPLE OUTPUT

Examples of the four type of plots are shown in Figure 16 and an example table of summary statistics and performance metrics is shown in Figure 17.
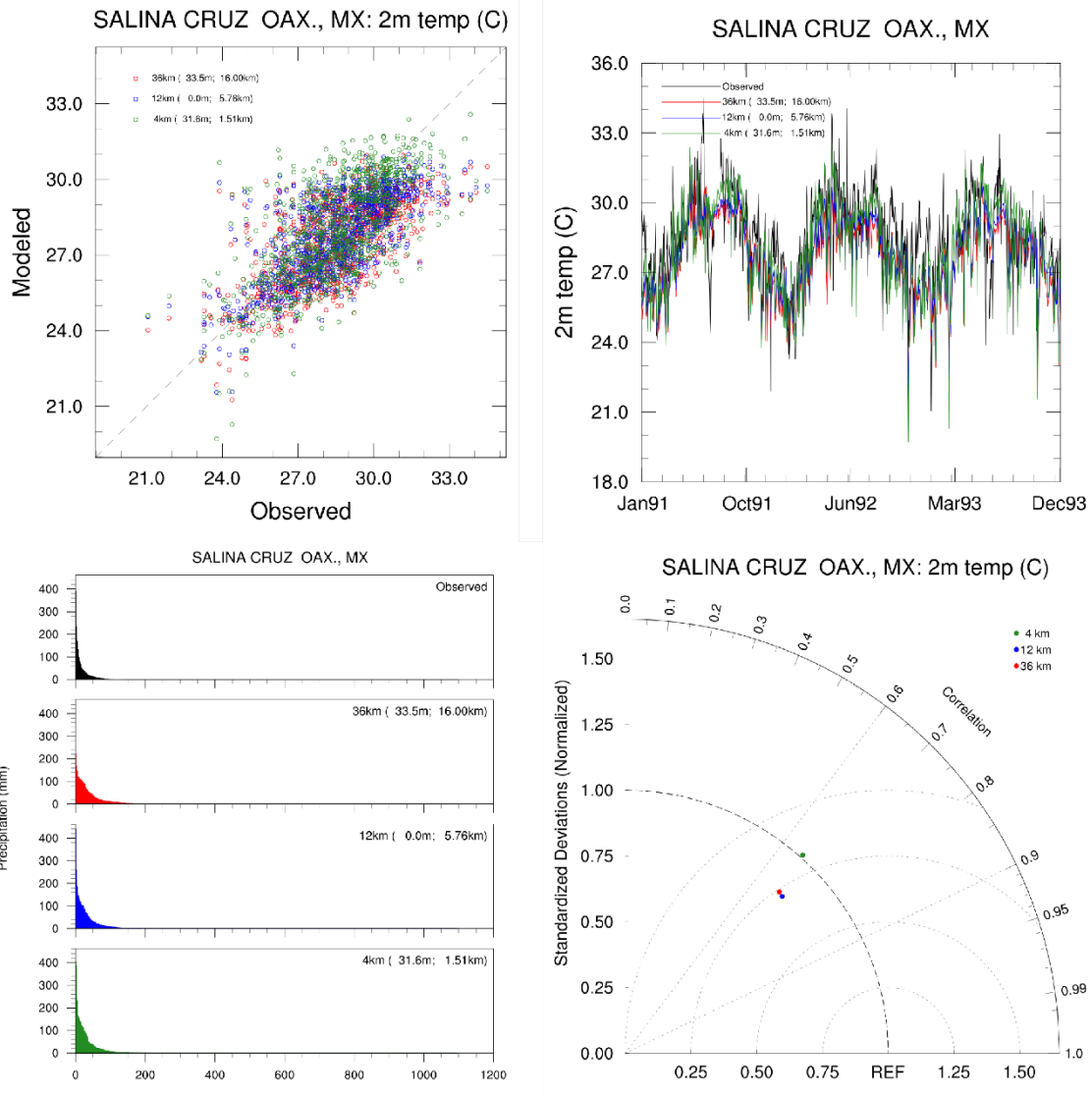
*Figure 16: Sample **Verify** output graphs for Salina Cruz, MX based on the GSOD observations and the Mesoamerican Project historical run. (top left) scatterplot for temperature, (top right) time series for temperature, (bottom left) ranked series for precipitation, and (bottom right) Taylor plot for temperature.*

For foreground jobs, PNG or SVG plots will be displayed in a new browser window (see Preliminaries in the Overview chapter for required browser setup) with a "Get Data" button at the bottom of the page. Depending on your browser configuration, PDF or PS plots will be displayed, automatically downloaded, or a link provided for manual download. For these outout types, the "Get Data" button may or may not be displayed in the browser window.

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Clicking on the "Get Data" button will download to your local disk a comma-separated variable (CSV) file containing the data displayed on the plot.

For background jobs, the User will receive an email containing links to the plot, the statistics table, and the data used.

SALINA CRUZ OAX., MX: 2m temp (C)

N= 1016 / 1096	Obs	36km	12km	4km
Mean	28.55	27.59	27.79	28.03
Std. Dev.	1.9	1.61	1.6	1.92
Bias		-0.98	-0.78	-0.55
MAE		1.41	1.28	1.29
RMSE		1.71	1.58	1.66
Correlation		0.691	0.707	0.667
Elev (m)	11.0	34.0	0.0	32.0
Dist (km)		16.0	5.8	1.5
LU/LC		16	16	14

*Figure 17: Example output table of summary statistics and performance metrics from **Verify** for temperature at Salina Cruz, MX based on the GSOD observations and the Mesoamerican Project historical run. The columns represent the statistics for the observations (**Obs**) and the nearest grid point at each of the model resolutions (**36km**, **12km**, and **4km**). **N** represents the number of observations and the number of model days, so the number of missing observations can be determined, as the model has no missing data. **Dist** is the distance between the station and the nearest model grid point and **LU/LC** represents the model land use/land cover code at that grid point.*

TIME SERIES

The *TimeSeries* user interface (Figure 19) has three distinct sections on the left-hand side and a graphical location selection on the right-hand side. At the top left, the User selects the project and scenario(s) for which to compare daily climatologies for observations (if an observation dataset is selected) and model results. The middle-left section allows selection of the desired parameter and any desired smoothing. The lower-left section allowed the User to choose the output format. The right-hand map section provides the User with a means of selecting the location or area for which time series will be constructed. Each of these interface sections is described in more detail below, using the user input (shown in **bold green**, inside square brackets) needed to produce the sample output at the end of this chapter as an example.

PROJECT AND SCENARIO SECTION

This section (Figure 18) provides the User with drop-down menus from which they can select the Project and one or more Scenarios they wish to use. These menus are created dynamically so that selections must be made from left to right. That is, selection of a Project [**Mesoamerica**] determines the Scenarios [**Historical, CCSM4_rcp85**] available. If, after initial selection, the User changes

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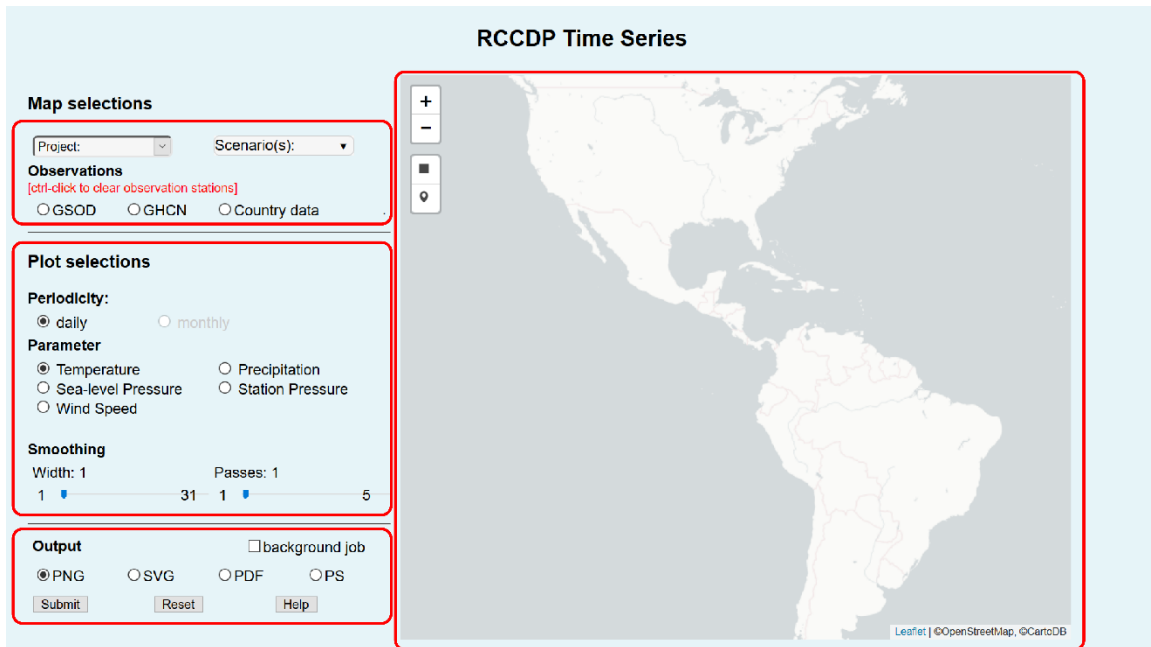
*Figure 19: **TimeSeries** menu, with sections outlined in red, (top left) project and scenario section, (middle left) plot selection section, (bottom left) output section, and (right) locations selection section.*

the selected Project, the Scenario(s) must be re-selected, as well. When the Project is selected, the available Domains will be plotted on the map and the map will be re-centered over those Domains (Figure 20, left).

*Figure 18: Project and Scenario section of the **TimeSeries** user interface, showing the drop-down menu for Scenario selection. Selections shown here are those used to produce the Sample Output at the end of this chapter.*

If the User wishes to include an observational time series, a dataset can be chosen. Two different global observation datasets are available: Global Summary of Day (GSOD) and Global Historical Climate Network-Daily (GHCN). Additionally, contributed data from LAC country participants (Country data) provide a third observational dataset for some regions. Additional information about these datasets is given in the Observed
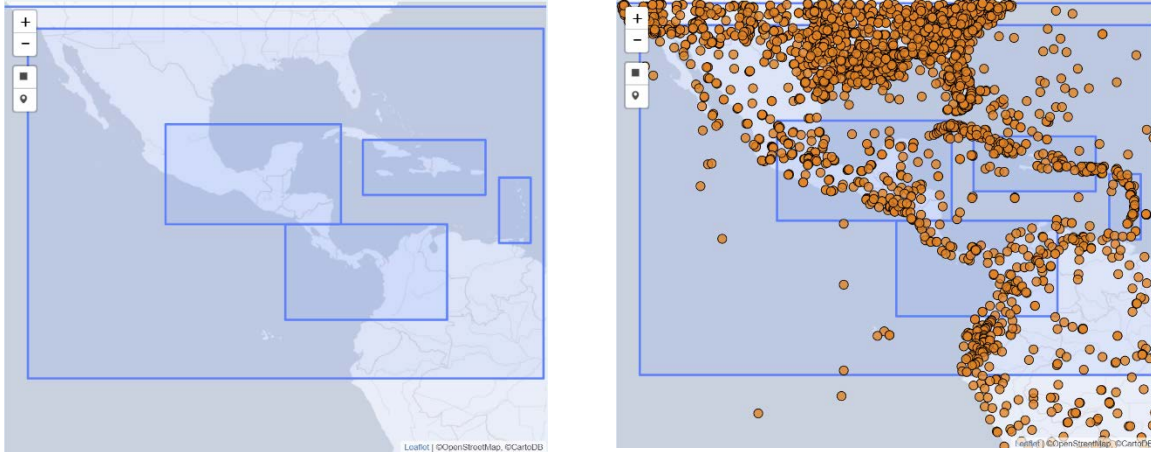
*Figure 20: Map section after selection of a Project (left) and after selection of an Observation dataset (right). Project [**Mesoamerica**] and Observations [**GSOD**] are for the sample output at the end of this chapter.*

Climate Data section of the Overview chapter in this guide. If a dataset is selected, the available stations will appear on the map (Figure 20, right).

PLOT SELECTION SECTION

This section (Figure 21) allows the User to select the parameter for which climatological time series plots will be constructed. Five parameters are included at present, as the observation datasets do not include as many parameters as the model output.

*Figure 21: Plot and Parameter section of the **TimeSeries** user interface. Selections [**GSOD, Temperature, Smoothing=15, Passes=1**] shown here are those used to produce the sample output. Monthly plots are not yet available, but are planned for future versions.*

The climatologies may be smoothed before plotting, using a running average of a specified width, *N* (*i.e.*, an odd number of days), centered on each day of the year. As the time series are climatologies, the running average process is circular, meaning that the last *N*/2 days of

December are appended to the beginning and the last *N/2* days of January are appended to the end of the time series before smoothing. If stronger smoothing is desired, multiple smoothing passes (up to 5) can be specified. The smoothing procedure can result in a reduction of the number of days displayed in the observed time series, as *N/2* days will be lost around any days for which observations are missing. For stations with significant missing data, this can result in gaps in the observed time series.
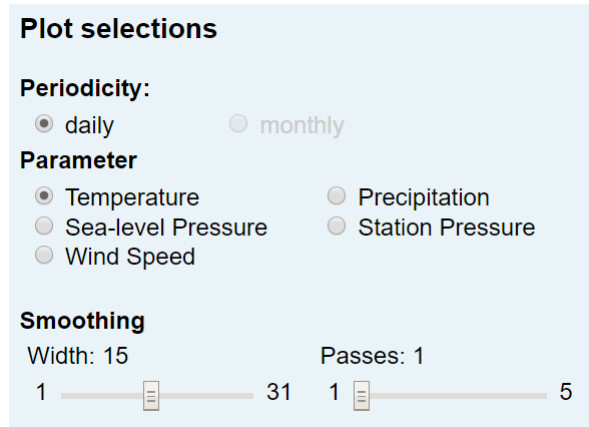
OUTPUT SECTION

In this section (Figure 22), the User can select from four types of output files that are available: portable network graphic (PNG), scalable vector graphic (SVG), portable document format (PDF),
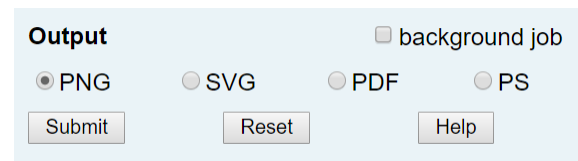
Figure 22: Output menu for the TimeSeries user interface.

or PostScript (PS). Depending on the configuration of the User's browser, the resulting graph will be displayed automatically of the screen or will be downloaded to the local hard drive.

Because the computation of the climatologies may take considerable time, depending on the length of the selected Run, a "background job" checkbox allows the User to do the calculations behind the scenes and receive an email when they are completed so they can retrieve the graph and, if desired, the computed climatologies.

LOCATION SELECTION SECTION (MAP)

As noted above, when the User selects a Project, the available Domains are plotted on the map in this section and the map will be re-centered over those Domains. The User can zoom and pan as needed to display the desired domain or region. If an observational dataset is selected, all available stations from that dataset will be displayed on the map (ctrl-click Observation radio button to remove stations from map).

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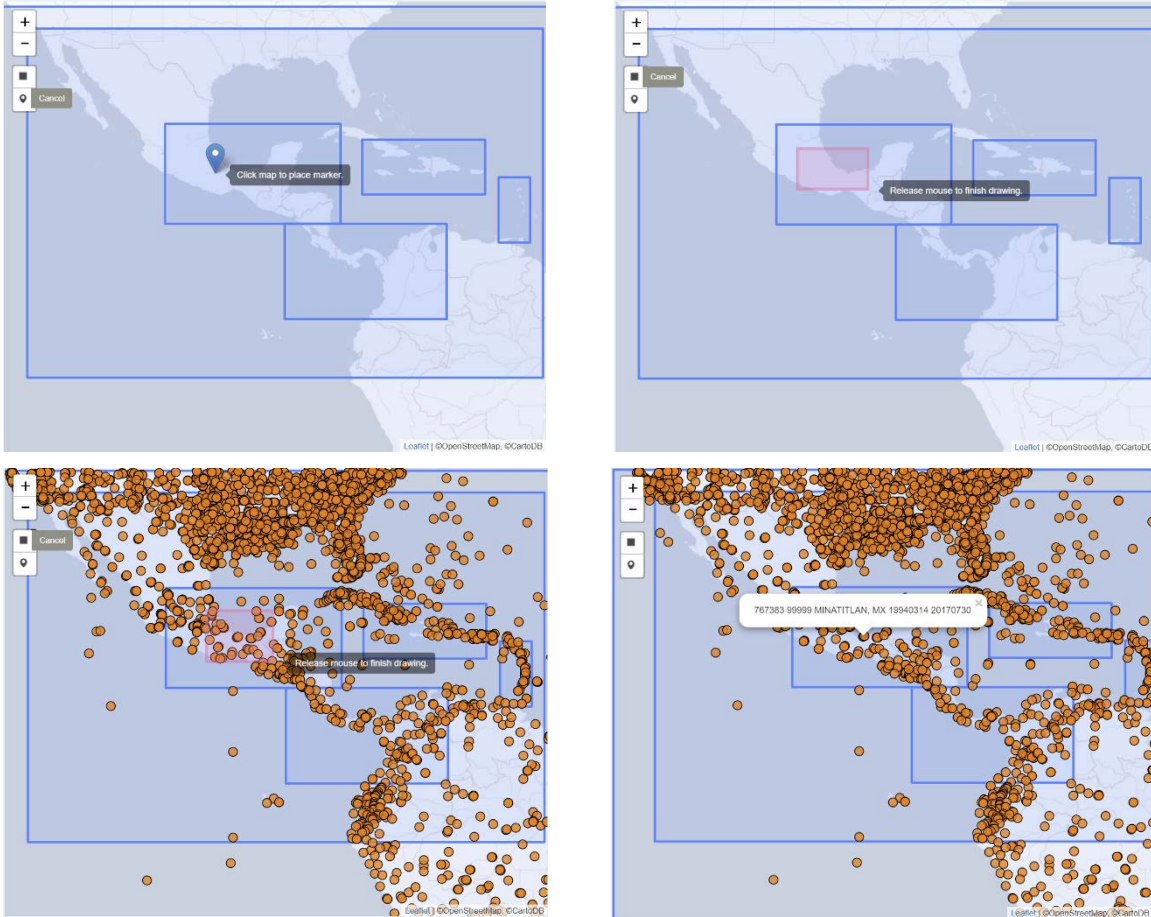
*Figure 23: Map section after selection of a Project [**Mesoamerica**], showing*
- *selection of a point using the map pin tool (top-left),*
- *selection of an area using the box tool (in pink, top-right)*

*and, after selection of an Observation [**GSOD**] dataset,*
- *selection of an area using the box tool (in pink, bottom-left),*
- *selection of a station (bottom-right).*

*Project [**Mesoamerica**], Observations [**GSOD**] and Station [**Minatitlan, MX**] are for the sample output at the end of this chapter.*

There are three ways for a user to select the data used to create the time series: selecting a point, selecting a region, or clicking on a station. Each of the methods is described in detail as follows:

- *map pin tool: when the User selects the map pin tool (⚲) from the map toolbox (below the zoom controls) they can click anywhere on the Domain to select a single point for analysis (Figure 23, top-left).*

In this case, only model data are used and the nearest grid point in the highest resolution domain is chosen.

- *box tool: when the User selects the box tool (■) from the map toolbox (below the zoom controls) they can draw a box on the Domain to select a region. All grid points from the highest resolution domain contained completely within the selection box will be averaged (Figure 23, top-right). If an observational dataset has been selected, any stations within the box will be averaged to create an observed time series (Figure 23, bottom-left).*

- *station: if an observational dataset has been selected, clicking on a station circle selects that station location for producing climatologies, using the observations from that station and model output from the nearest grid point in the highest resolution domain. A popup balloon displays the station number, station name and period of record for GSOD and GHCN datasets, and station number and name for Country Data (Figure 23, bottom-right).*

SAMPLE OUTPUT

An example plot is shown in Figure 24.

For foreground jobs, PNG or SVG plots will be displayed in a new browser window (see Preliminaries in the Overview chapter for required browser setup) with a "Get Data" button at the bottom of the page. Depending on your browser configuration, PDF or PS plots will be displayed, automatically downloaded, or a link provided for manual download. For these outout types, the "Get Data" button may or may not be displayed in the browser window.

Clicking on the "Get Data" button will download to your local disk a comma-separated variable (CSV) file containing the data displayed on the plot.

For background jobs, the User will receive an email containing links to the plot, the statistics table, and the data used.

Figure 24: Sample output from Time Series for Minatitlan, MX temperature. Observations from GSOD and model output from Mesoamerican Project. Time series were smoothed using a 15-point running average before plotting.

INDICES

The *Indices* user interface (Figure 26) is divided into three distinct sections at the left and a station selection map on the right. At the top left, the User selects the project and one or more scenarios for which to compute standard climate indices. In the middle left, the User can select from a set of standard indices. The right-hand map section provides the User with a means of selecting the climatic station at which the selected index will be computed. Each of these interface sections is described in more detail below, using the user input (shown in **bold green**, inside square brackets) needed to produce the sample output at the end of this chapter as an example.

PROJECT AND SCENARIO SECTION

This section (Figure 25) provides the User with drop-down menus from which they can select the Project and one or more Scenarios they wish to use. If a climate change scenario is selected, the index is computed and plotted for both the present-day and the mid-century Runs. These menus are created dynamically so that selections must be made from left to right. That is, selection of a Project [**Bolivia**] determines the Scenarios [**Historical and all GCM runs**] available. If, after initial selection, the User changes the selected Project, the Scenario(s) must
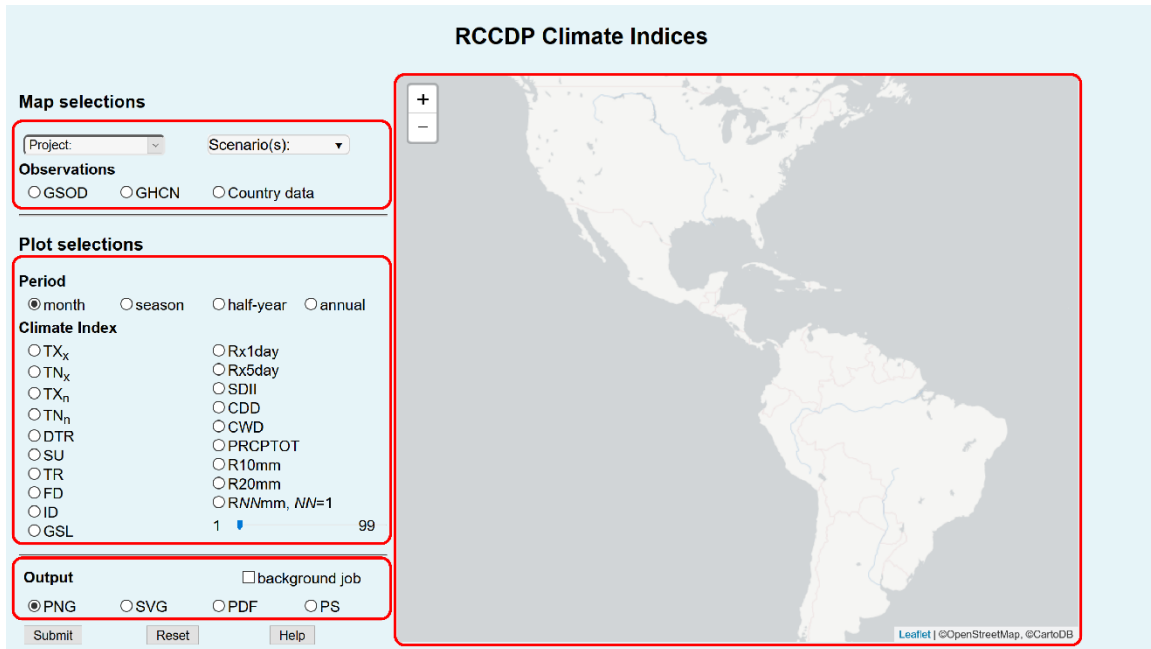
*Figure 26: **Indices** menu, with sections outlined in red, (top left) project and run section, (bottom left) parameter section, and (right) station selection section.*

be re-selected, as well. When the Project is selected, the available Domains will be plotted on the map at right and the map will be re-centered over those Domains.

*Figure 25: Project and Scenario section of the **Indices** user interface. Selections shown here are those used to produce the Sample Output at the end of this chapter.*

A dataset can be chosen for an observational time series, if desired. Two different global observation datasets are available: Global Summary of Day (GSOD) and Global Historical Climate Network-Daily (GHCN). Additionally, contributed data from LAC country participants (Country data) provide a third observational dataset for some regions. Additional information about these datasets is given in the Observed Climate Data section of the Overview chapter in this guide. When the dataset [**Bolivia**] is selected, the available stations will appear on the map at right (Figure 27, left).

Figure 27: Map section after selection of a Project and an Observation dataset (left) an after zooming in and selecting a station (right). Project [**Bolivia**]*, Observations* [**Country Data**] *and Station* [**El Alto Aeropuerto, Bolivia**] *are for the sample output at the end of this chapter.*

Climate indices are computed from observations based on the most recent 30-year period for climate normals (*i.e.*, 1981-2010), while climate indices for model output are computed for all available model years.

PLOT SELECTION SECTION

The statistical distribution of standard climate indices (Table 4) computed from station observations can be compared to index values [**Rx1day**] from each year of selected downscaling runs. Computations can be done on monthly, seasonal, half-year and annual periods [**season**].

Important: not all indices can be computed from all observational databases. For example, some datasets do not include minimum or maximum temperatures, so any indices that require either of these values cannot be computed and are disabled when that data source is selected.

Table 4: Standard climate indices

Index	Description	Data needed
TX$_x$	maximum of daily maximum temperature	T$_x$
TN$_x$	maximum of daily minimum temperature	T$_n$
TX$_n$	minimum of daily maximum temperature	T$_x$
TN$_n$	minimum of daily minimum temperature	T$_n$
DTR	average diurnal temperature range	T$_n$, T$_x$
SU	number of summer days	T$_x$
TR	number of tropical nights	T$_n$
FD	number of frost days	T$_n$
ID	number of icing days	T$_x$
GSL	growing season length (annual period only)	T$_g$
Rx1day	maximum 1-day precipitation	RR
Rx5day	maximum 5-day precipitation	RR
SDII	simple daily intensity index	RR
CDD	number of consecutive dry days	RR
CWD	number of consecutive wet days	RR
PRCPTOT	total precipitation	RR
R10mm	number of days with precipitation ≥ 10mm	RR
R20mm	number of days with precipitation ≥ 20mm	RR
RNNmm	number of days with precipitation ≥ NN mm	RR

T$_x$ daily maximum temperature
T$_n$ daily minimum temperature
T$_g$ daily average temperature
RR   daily precipitation rate

OUTPUT SECTION

In this section (Figure 28), the User can select from four types of output files that are available: portable network graphic (PNG), scalable vector graphic (SVG), portable document format (PDF), or PostScript (PS). Depending on the configuration of the User's
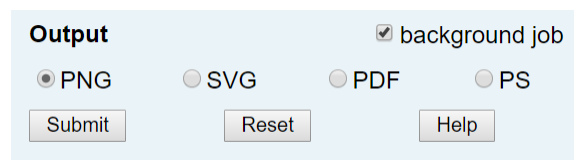

*Figure 28: Output menu for the **Indices** user interface. Here, a background job has been selected to allow the computations to be completed.*

browser, the resulting graph will be displayed automatically of the screen or will be downloaded to the local hard drive.

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Because the computation of the climatologies may take considerable time, depending on the length of the selected Run, a "background job" checkbox allows the User to do the calculations behind the scenes and receive an email when they are completed so they can retrieve the graph and, if desired, the computed climatologies.

STATION SELECTION SECTION (MAP)

As noted above, when the User selects a Project, the available Domains are plotted on the map in this section and the map will be re-centered over those Domains. Upon selection of an observational dataset, all available stations from that dataset will be added to the map. The User can zoom and pan as needed to display stations in the desired domain or region (Figure 27, right).

Clicking on a station circle selects that station [**El Alto Aeropuerto, Bolivia**] for computation of the selected climate index, using the observations from that station and model output from the nearest grid point at the highest model resolution, for all selected scenarios. A popup balloon displays the station number, station name and period of record (Figure 27, right).

SAMPLE OUTPUT

An example plot is shown in Figure 29. The index values computed from observed data are plotted as a box plot (lower quartile and upper quartile denoted by the box extents, the median as a line across the box, and the minimum and maximum values as the "whiskers"). Index values from the Historical run are plotted as red circles to the left of the box plot, and index values from each climate change scenario are plotted as colored symbols to the right of the box plot, with each symbol representing each year of the run. Each model is plotted as a unique symbol and color, with darker shades representing higher RCPs. The filled symbols are for present-day (baseline) runs and the open symbols are for mid-century (future) runs.

For foreground jobs, PNG or SVG plots will be displayed in a new browser window (see Preliminaries in the Overview chapter for required browser setup) with a "Get Data" button at the bottom of the page. Depending on your browser configuration, PDF or PS plots will be displayed, automatically downloaded, or a link provided for manual download. For these outout types, the "Get Data" button may or may not be displayed in the browser window.

Clicking on the "Get Data" button will download to your local disk a netCDF file containing the data displayed on the plot.

For background jobs, the User will receive an email containing links to the plot, the statistics table, and the data used.

*Figure 29: Sample output from **Indices** for El Alto Airport, BL. Observations are from country-supplied data and model output from 4 km downscaling from Bolivia project. The index values computed from observed data are plotted as a box plot (lower quartile and upper quartile denoted by the box extents, the median as a line across the box, and the minimum and maximum values as the "whiskers"). Index values from the Historical run are plotted as red circles to the left of the box plot, and index values from each climate change scenario are plotted as colored symbols to the right of the box plot, with each symbol representing each year of the run. Each model is plotted as a unique symbol and color, with darker shades representing higher RCPs. The filled symbols are for present-day (baseline) runs and the open symbols are for mid-century (future) runs.*

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CHANGE FACTOR

The ***ChangeFactor*** application scales projected climate change to times intermediate to the Present-day (baseline) and Mid-century (future) simulations. It accomplished this by computing a change factor at each model grid point based on the difference between the climatologies for the baseline and future simulations and scaling it by the fraction of the time between simulations. That is, if a User wishes to estimate the climate of a time halfway between the baseline and future simulations, the change would be scaled by half. After the scaled change is computed, it is applied to the Historical run to produce a projected climatology of the selected parameter(s) for the selected month(s).

Two different change factor methods are used: an additive method for all parameters except precipitation and a multiplicative method for precipitation.

In the additive method, the change factor is simply the difference between the baseline and future climatological values of the parameter(s), scaled by the number of years needed to reach the desired time. This absolute change then is added to the historical climatological value to give the desired result for the intermediate year. That is,

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$$C_{int} = C_{hs} + (C_{ft} - C_{bl}) \times \left(\frac{yr_{int} - yr_{bl}}{yr_{ft} - yr_{bl}}\right)$$

where C is the selected climate parameter, yr is the year and the subscripts hs, bl, ft, and int represent the historical, baseline, future and desired intermediate climatologies, respectively. For the historical, baseline and future climatologies, the year is the midpoint of the respective downscaling simulation; for the intermediate climatology, the year is selected by the User.

For the multiplicative method, the change factor is the difference between baseline and future climatological values of the parameter(s) divided by the baseline value to give a proportional change, which is then scaled by the number of years needed to reach the desired time. The historical climatological value is then multiplied by this scaled, proportional change to give the desired result for the intermediate year. That is,

$$C_{int} = C_{hs} \times (1 + \left(\frac{C_{ft} - C_{bl}}{C_{bl}}\right) \times \left(\frac{yr_{int} - yr_{bl}}{yr_{ft} - yr_{bl}}\right)$$

with variables defined as above.

The **_ChangeFactor_** user interface (Figure 30) is separated into three distinct areas. At the top, the User selects the project, domain, scenario, and time period for which they desire to produce a map. The middle section allows selection of the desired parameter or parameters and the general method to be used to display the parameter on the map. The lower section provides the User with options to modify the appearance of the map and output format. Each of these interface sections is described in more detail below, using the user input (shown in **bold green**, inside square brackets) needed to produce the sample output at the end of this chapter as an example.

*Figure 30: **ChangeFactor** menu, with sections outlined in red, (top) geography and time section, (middle) parameter section, and (bottom) plot modifications section.*

GEOGRAPHY AND TIME SECTION

This section (Figure 31) provides the User with a selection of drop-down menus from which they can select the Project, Domain, Scenario, and Year they wish to use. These menus are created dynamically so that selections must be made from left to right. That is, selection of a Project [**Guatemala**] determines the Domains available [**d01: Guatemala (4km)**], selection of a Domain determines the Scenarios [**CCSM4_rcp85**] available, and selection of

*Figure 31: Geography and Time section of the **ChangeFactor** user interface. Selections shown here are those used to produce the Sample Output at the end of this chapter.*

a Scenario determines the Years available [**2040**] for change factor scaling. If, after initial selection, the User changes a selection from one of these drop-down menus, all menus to the right must be re-selected, as well.

Land-surface fields that do not change between runs are not scaled, but represent the actual value for the runs. These include terrain height, background albedo, vegetation fraction, leaf area index, land use category, dominant vegetation category, and dominant soil category. This allows, for example, the User to plot a climate change (*e.g.*, change in temperature) over a static field (*e.g.*, terrain height).

Below the drop-downs, the User can choose one or more months of data for their map [**Jun, Jul, Aug**]. An "Annual" checkbox simplifies the selection of all months.

PARAMETER SECTION

In this section, which is the same as for the *MapMaker* application, the User can choose up to four parameters to include on their map: one plotted as a color-filled contour map, one plotted as line contours, one surface (10-meter) wind vector, and one upper-air wind vector. In general, trying to include all four on a single map will result in a cluttered map, so most maps will include a smaller subset of parameters. The available model parameters are grouped into five subsections: *surface* **parameters**, *atmospheric* **parameters**, *flux* **parameters**, *land-surface* **parameters**, and *soil* **parameters**. These are the same groups delineated, by color, in Table 3.

A single parameter can be selected from any one of the five subsections as the parameter to be plotted as a color-filled field by selecting the appropriate radio button under the "Fill" heading for that subsection [**Temperature (°C**] (Figure 32). If no selection under "Fill" is made, no color-filled contour plot will be produced.

Surface Parameter	Fill	Line
Temperature (°C)	◉	○
Precipitation (mm)	○	○
Mean Sea-Level Pressure (hPa)	○	○
Minimum Temperature (°C)	○	○
Maximum Temperature (°C)	○	○
Mixing Ratio (g kg^{-1})	○	○
Relative Humidity (%)	○	○
Surface Pressure (hPa)	○	○
Skin temperature (°C)	○	○
Snow Water Equivalent [SWE] (kg m^{-2})	○	○
Mid-month SWE (kg m^{-2})	○	○
U-component (m s^{-1})	○	○
V-component (m s^{-1})	○	○
Wind Speed (m s^{-1})	○	○
Wind Vector (m s^{-1})	▾	○

*Figure 32: Surface parameter section of the **ChangeFactor** user interface. Selections [**Temperature, fill**] shown here are those used to produce the sample output.*

A single parameter can be selected from any one of the five subsections as the parameter to be plotted as line contours by selecting the appropriate radio button under the "Line" heading for that subsection. If no selection under "Line" is made, no contour lines will be plotted. If the same parameter is selected for color-fill and contours, the User can create a map with contour interval highlighting, if desired.

To plot surface or upper-air winds, the User can select either meteorological wind barbs ("barb") or vectors ("arrow") from the appropriate drop-down menu in that subsection. For arrows, the length of the arrow corresponds to the wind speed. For barbs, the barbs indicate the wind speed; an unadorned line indicates less than 2 m s^{-1}, a half- barb indicates 5 m s^{-1}, a whole barb indicates 10 m s^{-1}, and a flag (triangle) indicates 50 m s^{-1}. The half-barb, barbs, and flags are summed to obtain the actual wind speed. Calm conditions are indicated by a circle. In both cases, the symbol plotted indicates the direction of the wind; with barbs at the tail or the arrowhead at the head of the wind vector.

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Regardless of the plotting method selected, for atmospheric parameters, a pressure level must be chosen and, for soil parameters, a soil layer must be selected from the corresponding drop-down menu (Figure 5).

Several land-surface parameters (*i.e.*, land use category, dominant vegetation category, and dominant soil category) can only be mapped using color fill, as they do not represent a continuous variable but rather a nominal category. As such a value of 17 adjacent to a value of 2 does not imply that there are values of 3, 4 … 16 between them, as line contours would imply. A link to a table of index values is provided for each of these parameters.

Should your map become too cluttered by choosing multiple parameters to plot, fill or contour selections may be cleared by holding down the Control key and clicking (*i.e.*, ctrl-click) the appropriate radio button. To clear a wind selection (either surface or atmospheric), select the blank entry from the appropriate drop-down menu.

PLOT MODIFICATION SECTION

While the default mapping options will suffice for many users, at least for an initial map, the User can make adjustments to the final product, if desired. For example, when making a series of maps of the same parameter for different time periods, it may be desirable to hold the contours constant for all maps. Another example might be to ensure that the contour interval spans equally to the positive and negative side of zero, if plotting climatological differences. This section is the same as for the *MapMaker* application.

Left side

The left two-thirds of this section (Figure 6) allows the User to specify contour intervals and ranges for color-filled or line contours, to scale wind vectors, or to modify the colors used for the map. The right side

of this section provides the User with a means to zoom in on a portion of the selected domain and to mask plotting of the selected parameter over water (the default), over land, or neither.

To specify contour intervals and range, for either color-filled or line contours, the User may enter values into the appropriate boxes. If either a specific minimum or a specific maximum is desired, a valid number must be entered in each box (that is, the range must be fully specified). It is not necessary to enter both the interval [2] and the range [minimum 8, maximum 32].

For color-filled contours, the number of colors used will be 2 more than the number of intervals specified, to allow for filling areas with values less than the minimum or greater than the maximum. Color-filled contours make use of a pre-defined color table, with a default defined for each parameter. A drop-down menu (with color swatches shown) allows selection from a small subset (23) of the currently available (240) color tables; the User may specify any valid color table by entering its name in the drop-down box. A link to all pre-defined color tables is provided to the right of the drop-down.

For line contours, the color of the contour lines can be selected from a drop-down menu of 8 basic colors (default is black); alternatively, the User may specify any valid named color by entering its name in the drop-down box. A link to all named colors is provided to the right of the drop-down.

Scaling of wind vectors is accomplished by changing the length of the reference vector or its magnitude. The length of the reference vector or barb is multiplied by the value entered in the "Ref. Len." box; values less than 1.0 will shorten the reference vector, values greater than 1.0 will lengthen the reference vector. The wind speed assigned to the reference vector is changed by entering a value in the "Magnitude" box; the default is 10 m s^{-1}. By default, all wind vectors will be plotted, which can result in the individual vectors becoming

impossible to discern, due to crowding. A thinning parameter can be specified to reduce the crowding. This parameter varies from 0.0 (no thinning, the default) to 1.0 (maximum thinning).

The color of wind vector(s) can be changed by selecting from a drop-down menu of 8 basic colors (default is black); alternatively, the User may specify any valid named color by entering its name in the drop-down box. If both surface and atmospheric wind vectors are plotted, the selected color will be used for the surface vector and the atmospheric vector will be plotted in its complimentary color, if one of the 8 basic colors is chosen. Otherwise, the surface vector will be plotted as the user-specified color and the atmospheric vector will be plotted in black.

Right side

On the right side of this section (Figure 7, left), the User can choose a subregion of the selected Domain as the map area to be plotted. The User may specify a rectangular region by specifying the latitude and longitude of opposite corners in the respective boxes. North latitudes and east longitudes are positive; south latitudes and west longitudes are negative. Alternatively, the User can click the "Map" button to open a new window with the Domains for the selected Project mapped (Figure 7, right). The User can zoom and scroll this map to the desired area and use the box select tool (∎) to draw the desired subregion (which must be completely contained in the selected domain). The latitude and longitude of the subregion are automatically transferred to the *ChangeFactor* menu page.

By default, *ChangeFactor* draws the selected parameters only over land areas by masking out water bodies (Figure 8). The User may choose to mask out land areas so that the selected parameters are

drawn only over water or they may choose to apply no masking. In the latter case, parameters are drawn over the entire map area.

Four types of output files are available: portable network graphic (PNG), scalable vector graphic (SVG), portable document format (PDF), or PostScript (PS). Depending on the configuration of the User's browser, the resulting map will be displayed automatically on the screen or will be downloaded to the local hard drive.

SAMPLE OUTPUT

Examples of the climate factor scaling method are given in Figure 33. To illustrate the change factor scaling method, baseline (left) and future (right) summer temperatures for Guatemala under the RCP 8.5 scenario are shown in the top row. The baseline climatology is representative of 2015, while the future is representative of 2065, the middle year of the respective downscaling simulations. Thus, the difference (middle) between these represents the projected change over the intervening 50 years. This difference is scaled by half (*i.e.*, 25 years instead of the full 50 years) and added to the climatological temperature from the historical downscaling run (bottom right) to approximate the climatological temperatures for a period centered on 2040 (bottom middle). This method eliminates any offset caused by differences between the reanalysis forcing used for the historical run and the GCM forcing used for the baseline and future runs. Applying this methodology to the full time difference between the GCN-forced runs effectively removes this offset, as well.

PNG or SVG maps will be displayed in a new browser window (see Preliminaries in the Overview chapter for required browser setup) with a "Get Data" button at the bottom of the page. Depending on your browser configuration, PDF or PS maps will be displayed, automatically downloaded, or a link provided for manual download. For these outout types, the "Get Data" button may or may not be displayed in the browser window. Clicking on the "Get Data" button will download to your local disk a netCDF file containing the data displayed on the map.
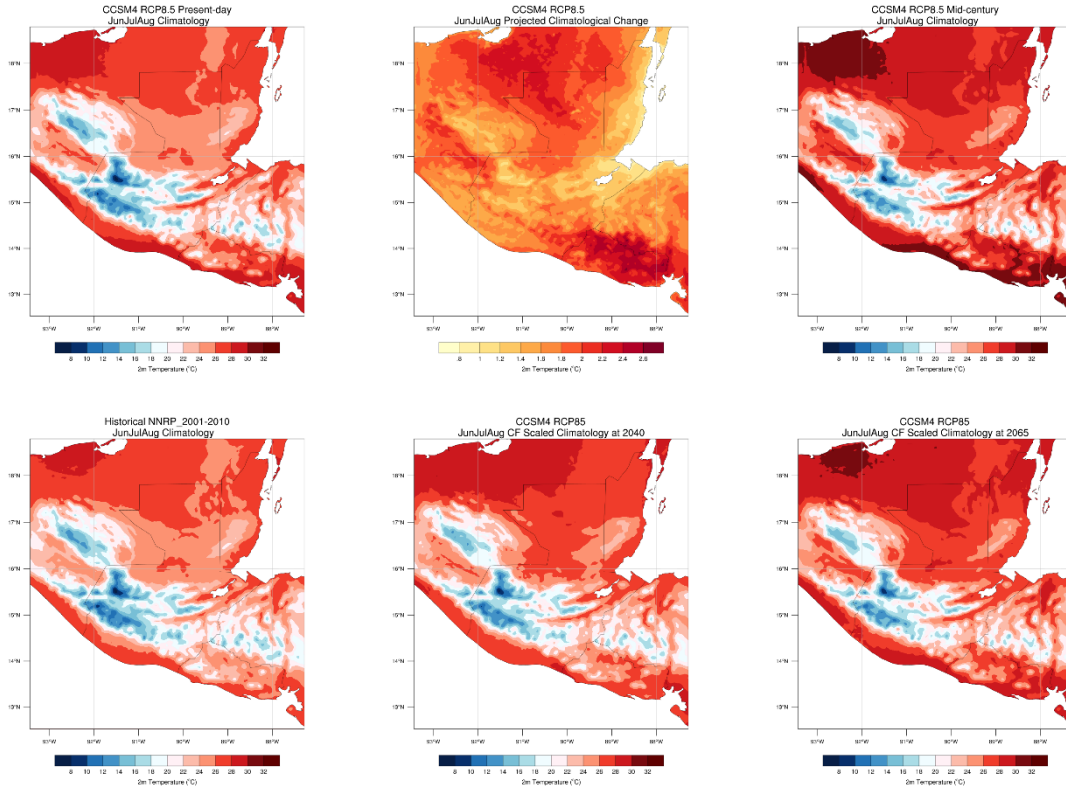
Figure 33: Sample output from **MapMaker** and **ChangeFactor**, illustrating the change factor scaling methodology for generating climate parameters for times intermediate to the baseline and future downscaling simulations for summer temperature over Guatemala. Top row (left to right): baseline, change, and future climatologies; bottom row (left to right): historical, 2040, and 2065 climatologies. Only the last two maps are generated by **ChangeFactor**; the others are from **MapMaker**, to illustrate the method.

DOWNLOAD

The *Download* user interface (Figure 34) is divided into three distinct sections. At the top, the User selects the Project, Domain, Scenario and Run from which to extract model output. The User can select a temporal subset of the selected Run or a subset of the selected Domain, if data for the entire Run or Domain are not desired. The right-hand map section provides the User with a graphical means of selecting a subarea of the domain. Each of these interface sections is described in more detail below, using the user input (shown in **bold green**, inside square brackets) needed to produce the sample output at the end of this chapter as an example.

PROJECT, TIME, AND REGION SECTION

The first subsection of this section provides the User with radio buttons to select either daily or monthly data for download, and set of drop-down menus from which they can select the Project [**Guatemala**], Domain [**d03: Guatemala (4km)**], Scenario [**CCSM4_rcp85**], and Run [**Mid-century**] they wish to use. These menus are created dynamically so that selections must be made from left to right, top to bottom (Project → Domain → Scenario → Run). That is, selection of a Project determines the Domains available, selection of a Domain determines the Scenarios available, and so on. If, after initial

Figure 34: **Download** *menu, with sections outlined in red (top left) project and run section, (bottom left) parameter section, and (right) station selection section.*

selection, the User changes a selection from one of these drop-down menus, all following menus must be re-selected, as well. If a climate change Scenario is selected and the selected Run is either "Change" or "Offset", only monthly data are available for download and the selection for daily data is disabled.

The middle subsection allows the User to restrict the date range for the downloaded data, rather than using the default of the entire Run. Start and end dates for the selected Run will be displayed in the appropriate boxes.

By default, data for the entire Domain chosen will be downloaded. At the bottom of this section, the User can choose a subregion of the selected Domain, if desired. The User may specify a rectangular region by specifying the latitude and longitude of opposite corners in the respective boxes. North latitudes and east longitudes are positive; south latitudes and west longitudes are negative. Alternatively, the

*Figure 35: Project, Domain, Scenario and Run section of the **Download** user interface. Selections shown here are those used to produce the Sample Output at the end of this chapter. Start and End dates are populated with the full period for the selected Run and latitude(s) and longitude(s) are populated from the map selection.*

User can graphically select a subregion using the map (described below) the subregion to be downloaded.

PARAMETER SECTION

In the top part of this section, the User can choose one or more parameters to include in their download file. The available model parameters are grouped into 5 subsections, each with its own drop-down menu: *surface* parameters, *atmospheric* parameter, *flux* parameters, *land-surface* parameters, and *soil* parameters. These are the same groups delineated, by color, in Table 3.

For atmospheric parameters, one or more pressure level

*Figure 36: Parameter selection menus for **Download**.*

can be chosen and, for soil parameters, one or more soil layer can be selected, to reduce the amount of data downloaded. By default, all levels or all layers are included.

SUBREGION SELECTION SECTION (MAP)

The User can zoom and scroll this map to the desired area and use the box select tool (■) to draw the desired subregion, or use the map pin tool (📍) to select the model gridpoint closest to the pin (Figure 37).

The latitude(s) and longitude(s) of the point or subregion are automatically transferred to the appropriate boxes in the Project section. The selected subregion must be completely contained within the selected Domain.
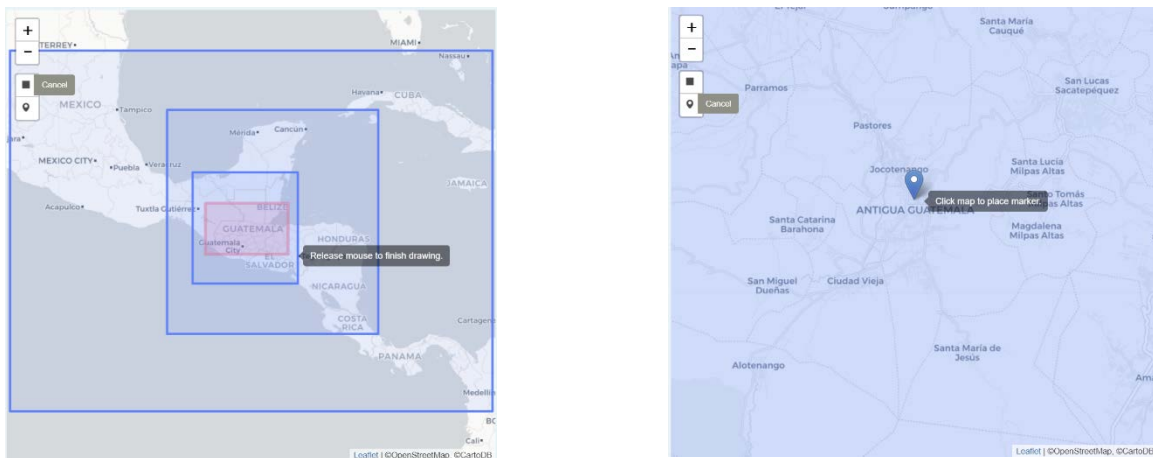

*Figure 37: Selecting an subarea of domain 3 for download (left) or a point [**Antigua, Guatemala**] on a zoomed in region of domain 3 (right)*

SAMPLE OUTPUT

If a single point is selected, the output is available in both comma-separated variable (CSV) format and netCDF. If a region is chosen or if the entire domain is selected, data will be available in netCDF only. "Get CSV Data" and "Get netCDF Data" buttons will be displayed, as appropriate, in a new browser window.

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For background jobs, the User will receive an email containing links to the data requested in CSV or netCDF format, as appropriate to the selection.

An example of downloaded model output, in CSV format, is in Figure 38.

Figure 38: Example of downloaded data from Guatemala project for the mid-century (i.e., future) run for the model point nearest to Antigua. Only point data are available in CSV format; data for points and regions are available in netCDF format (not shown).

GLOSSARY

background job An analysis run "behind the scenes" because of the extra processing time needed to avoid a time-out between the server and the user's browser.

ChangeFactor one of the applications of the Climate Portal. *ChangeFactor* allows the User to scale climate change projections to intermediate periods.

Climate Portal Alternative name for the Regional Climate Change Data Portal (RCCDP).

CMIP5 Coupled Model Intercomparison Project phase 5
A project of the World Climate Research Programme (WCP) to understand better any past, present and future climate changes arising from natural, unforced variability or in response to changes in radiative forcing in a multi-model context. This understanding includes assessments of model performance during the historical period and quantifications of the causes of the spread in future projections. An important goal of CMIP is to make the multi-model output publically available in a standardized format. For more information, see https://www.wcrp-climate.org/wgcm-cmip/wgcm-cmip5.

Country data Data supplied by a participant country for analysis and visualization in the Climate Portal.

CSV Comma Separated Variables
A simple format for storing tabular data in ASCII. Each line represents one record (row) of data and variables are separated by commas to create columns.

Download one of the applications of the Climate Portal. *Download* allows the User to download daily or monthly downscaled climate variables for any of the project runs. Data can be subset by time, geographic area, or climate variable.

foreground job An analysis run "up front" because it is short enough to avoid a time-out between the server and the user's browser. [default]

GCM Global Climate Model
Numerical models representing physical processes in the atmosphere, ocean, cryosphere and land surface. These are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations. GCMs depict the climate using a three dimensional grid over the entire globe, typically having a horizontal resolution of between 250 and 600 km, 10 to 20 vertical layers in the atmosphere, and sometimes as many as 30 layers in the oceans. Their resolution is thus quite coarse relative to the scale of exposure units in most impact assessments.

GHCN-D Global Historical Climate Network-Daily
An integrated database of daily climate summaries from land surface stations across the globe that have been subjected to a common suite of quality assurance reviews. The data are obtained from more than 20 sources. Some data are more than 175 years old while others are less than an hour old. GHCN-D is the official archived dataset, and it serves as a replacement product for older international datasets. For more information, see https://www.ncdc.noaa.gov/ghcn-daily-description.

GSOD Global Summary of the Day
A dataset derived from the Integrated Surface Hourly (ISH) dataset. The ISH dataset includes global data obtained from the USAF Climatology Center, located in the Federal Climate Complex with NCEI. The latest daily summary data are normally available 1-2 days after the date-time of the observations used in the daily summaries. The online data files begin with 1929 and data from over 9000 stations are typically available. For more information, see https://data.noaa.gov/dataset/dataset/global-surface-summary-of-the-day-gsod.

Indices one of the applications of the Climate Portal. *Indices* provides the User with the capability to compute and plot selected standard climate indices from observations and downscaled climate variables for any of the project runs.

IPCC Intergovernmental Panel on Climate Change
The international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. For more information, see http://www.ipcc.ch/.

MapMaker   one of the applications of the Climate Portal. *MapMaker* provides the User with the capability to create maps of downscaled climate variables for any of the project runs.

netCDF   Network Common Data Format

The Network Common Data Format (netCDF) is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. The netCDF software was developed by Unidata in Boulder, Colorado. For more information on netCDF, including documentation and links to compatible software, go to https://www.unidata.ucar.edu/software/netcdf/.

PDF   Portable Document Format

A file format used to present and exchange documents reliably, independent of software, hardware, or operating system. Invented by Adobe, PDF is now an open standard maintained by the International Organization for Standardization (ISO).

PNG   Portable Network Graphic

An open, extensible image format with lossless compression.

PS   PostScript

The first device-independent Page Description Language (PDL) and a programming language. Developed by Adobe.

RCCDP   Regional Climate Change Data Portal

The primary website for accessing the tools described in this manual, http://rccdp.unl.edu/portal/. Also referred to as The Climate Portal.

RCP   Representative Concentration Pathway

Scenarios that include time series of emissons and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover. Each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. Four different RCPs were used in the Fifth IPCC Assessment as a basis for climate predictions and projections. For more information, see http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html.

SVG   Scalable Vector Graphic

A text-based graphics language developed by the World Wide Web Consortium (W3C) that describes images with vector shapes, text, and embedded raster graphics. SVG files provide resolution independent, high-resolution dots per inch (HiDPI) graphics in a compact format.

TimeSeries   one of the applications of the Climate Portal. *TimeSeries* provides the User with the capability to compute and plot climatologies from observations and downscaled climate variables for any of the project runs.

Verify one of the applications of the Climate Portal. Verify provides the User with the capability to compare statistically and graphically daily downscaled climate variables to daily observations from stations available from several data archives for any of the project runs.

WRF Weather Research and Forecasting model
A mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. The model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometers. WRF can produce simulations based on actual atmospheric conditions (i.e., from observations and analyses), climate model projections, or idealized conditions. For more information, see https://www.mmm.ucar.edu/weather-research-and-forecasting-model.