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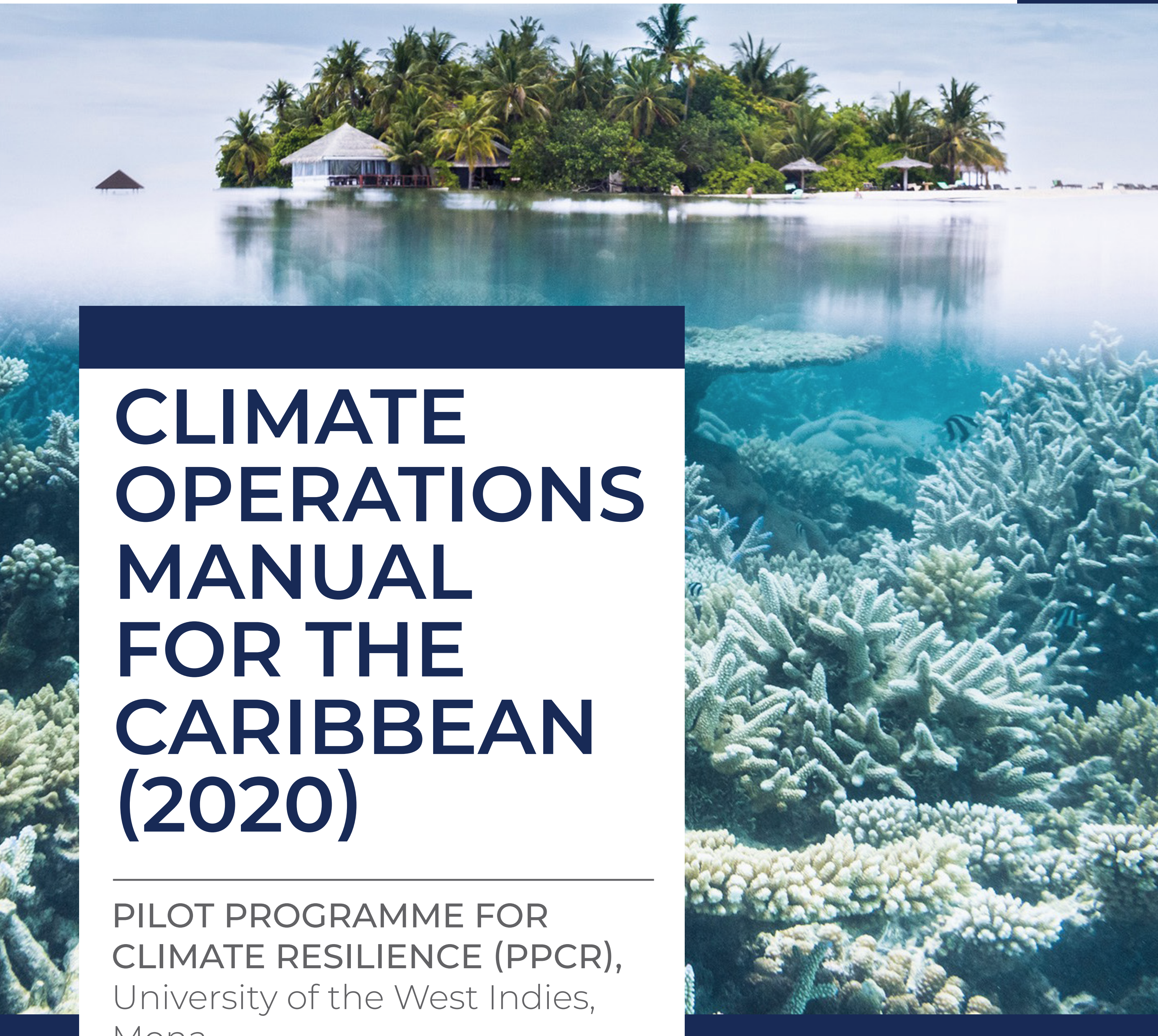
Caribbean Institute for Meteorology and Hydrology
CIMH

CIF CLIMATE INVESTMENT FUNDS

IDB Inter-American Development Bank



CLIMATE OPERATIONS MANUAL FOR THE CARIBBEAN (2020)

PILOT PROGRAMME FOR CLIMATE RESILIENCE (PPCR),
University of the West Indies, Mona

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CARIBBEAN REGIONAL TRACK OF THE PILOT PROGRAMME FOR CLIMATE RESILIENCE (PPCR), UNIVERSITY OF THE WEST INDIES MONA

ACRONYMS

AMCS	Applied Meteorology and Climatology Section
CAMI	Caribbean Agrometeorological Initiative
CariCOF	Caribbean Climate Outlook Forum
CAROGEN	CariCOF Outlook Generator
CDPMN	Caribbean Drought and Precipitation Monitoring Network
CIMH	Caribbean Institute for Meteorology and Hydrology
ET-SCI	Expert Team on Sector-specific Climate Indices
CMO	Caribbean Meteorology Organization
NCOF	National Caribbean Outlook Forum
NOAA	National Oceanic and Atmospheric Administration
PDSI	Palmer Drought Severity Index
RCC	Regional Climate Centre
RCOF	Regional Caribbean Outlook Forum
SPEI	Standardized Precipitation - Evaporation Index
SPI	Standardized Precipitation Index
WMO	World Meteorological Organization

GLOSSARY

CLIMATE	The mean state and other statistics (such as the occurrence of extremes) of conditions in the atmosphere, ocean and other parts of the environment as observed over many years or decades.
CLIMATOLOGY	A location's climatology refers to the summary statistics (i.e. averages, extreme values, frequency of events, etc.) of weather variables (e.g. temperatures, precipitation, sunshine, etc.) or events (e.g. dry spells, wet spells, heatwaves, etc.) as computed from a historical record of observations taken over a given time span of typically 30 years or longer.
CLIMATE CHANGE	Variations in the mean state and/or the variability within the Earth climate system, typically over decades or longer, as driven by natural factors (such as volcanic activity or solar activity) or man-made factors (such as greenhouse gas emissions, changes in land use)
CLIMATE VARIABILITY	Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events that occur naturally and typically last from a month to several years
PALMER DROUGHT SEVERITY INDEX	A measurement of dryness based on recent precipitation and temperature.
POTENTIAL EVAPOTRANSPIRATION	The amount of evaporation that would occur if a sufficient water source were available.
WEATHER	Conditions of the atmosphere such as temperature, winds, cloudiness, air pressure, etc. as they vary on time scales from seconds to about two weeks.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 PURPOSE

The purpose of this manual in general is to serve as training material for users of climate services and information within the Caribbean region, primary within Caribbean Climate Outlook Forum (CariCOF) countries. In addition, the manual promotes consistency of procedures and the reduction of variations within the procedures employed by users.

"The purpose of this manual in general is to serve as training material for users of climate services and information within the Caribbean region"

1.2 BACKGROUND

1.2.1 THE EARTH'S CLIMATE SYSTEM

The climate of a region is influenced by terrain, altitude, latitude, as well as nearby water bodies and their currents and is an overall product of the 5 interacting spheres of the Earth's climate system. These spheres include:

ATMOSPHERE - the gaseous envelope surrounding the Earth.

BIOSPHERE - the collection of ecosystems across the Earth, including both living organisms and dead and/or decaying organic matter; such as litter, soil organic matter and oceanic detritus.

CRYOSPHERE - all regions on and beneath the surface of the Earth and ocean, where water is in solid form. This includes sea ice, lake ice, river ice, snow cover, glaciers and ice sheets, and frozen ground (including permafrost).

HYDROSPHERE - the collection of liquid surface and subterranean water, such as oceans, seas, rivers, lakes, underground water, etc.

LITHOSPHERE - the upper layer of the solid Earth, both continental and oceanic, which comprises all crustal rocks and the cold, mainly elastic, part of the uppermost mantle.

1.2.2 THE EARTH'S CLIMATE SYSTEM

Weather and climate are both quantitative descriptions of the state of the Earth's atmosphere at a particular place and period of time. However, while both are generally assessed and predicted over similar spatial scales (i.e. ranging from local to global), their temporal scales are mutually exclusive. The temporal scale for deterministic weather prediction is limited to a two week period, beyond this exists the climatic temporal scales.

One commonly employed climatic temporal scale is the 30-year standard averaging period used to establish climate normals. Climate normals are used for two principal purposes. They serve as a benchmark against which recent or current observations can be compared, including providing a basis for many anomaly-based climate datasets (for example, global mean temperatures). They are also widely used, implicitly or explicitly, as a prediction of the conditions most likely to be experienced in a given location. Historical practices regarding climate normals date from the first half of the twentieth century. The 30-year period of reference was set as a standard mainly because only 30 years of data were available for summarization at the time. Contrarily, a number of studies have found that 30 years is not generally the optimal averaging period for a predictive use of normals. The optimal length of record varies with element, geography and secular trend. For example, the optimal period for temperatures is often substantially shorter than 30 years, but the optimal period for precipitation is often substantially greater than 30 years. In that sense the 30 year averaging period represents a compromise for the sake of consistency. For these reasons, shorter period averages (also known as provisional normals) may be calculated at any time, especially for stations not having 30 years of available data. Period averages are averages computed for any period of at least ten years starting on 1 January of a year ending with the digit 1 (for example, 1 January 1991 to 31 December 2004). Although not required by WMO, some countries calculate period averages every decade. However, it is strongly recommended not to use provisional normals as the basis for climate change and variability assessment.

Furthermore, the mean is an incomplete description of the climate, and many applications require information about other aspects of that element's frequency distribution and statistical behaviour, such as the frequency of extended periods when a value is above a threshold. Extreme values of an element over a specified period, and other statistical descriptors of the frequency distribution of an element (such as the standard deviation of daily or monthly values), are useful descriptors of the climate at a location and should be included with datasets of normals.

1.2.3 CLIMATE CLASSIFICATION SYSTEMS

A climate classification system is a means of categorizing the different regional climate regimes across the globe, and is often closely correlated with different biomes. Common climate classification systems include:

ARIDITY INDEX - a calculated statistic indicating the degree of dryness of the climate at a given location that seeks to separate the globe into climate regions varying from hyper-arid to hyper-humid.

ALISOV CLIMATE CLASSIFICATION SYSTEM - a genetic scheme, based on physical causes (i.e. circulation types, air mass types, fronts, etc.) for classifying climates.

KÖPPEN CLIMATE CLASSIFICATION SYSTEM - a vegetation-based, applied classification system aimed at defining climate boundaries in such a way as to correspond to the different vegetation biomes across the globe. In contemporary times, modifications to the Köppen system; such as the Köppen – Geiger (1954) and Köppen – Thewartha (1980) systems are among the most highly utilized climate classification system.

HOLDRIDGE LIFE ZONE CLASSIFICATION SYSTEM - a global bio-climatic scheme for classifying land areas by soil and climax vegetation using barycentric subdivisions based on precipitation (annual, logarithmic), bio-temperature (mean annual, logarithmic) and potential evapotranspiration ratio to mean total annual precipitation.

1.2.4 CARIBBEAN REGIONAL CLIMATE CENTRE

The World Meteorological Organization (WMO) Caribbean Regional Climate Centre (RCC) builds upon the rich history of the Applied Meteorology and Climatology Section (AMCS) at CIMH in the development and delivery of critical climate services and products to the Caribbean region. Within the Caribbean, the AMCS has developed a strong research and development programme in the area of climate variability which, although it has a significant impact on the sustainable development of many islands of the Caribbean, is under-appreciated relative to long-term climate change.

Since its inception in 2007, the AMCS has been the lead in the development and delivery of:

- Drought and precipitation monitoring and forecast products to the region.
- The development of climate data products and services.
- The development of agro-meteorological products and services.
- Applied meteorology and climate training services.

In 2012, the AMCS along with the National Oceanic and Atmospheric Administration (NOAA) established a crucial partnership that lead to the re-establishment of CariCOF. The AMCS also played a critical role in the development of the Caribbean Science Plan and Implementation Strategy (GECAFS) programme – another under-appreciated regional output. Other noteworthy activities completed by the AMCS in recent years include:

- The Caribbean Agrometeorological Initiative (CAMI)
- The Caribbean Water Initiative (CARIWIN)
- The Caribbean Agro-Meteorological Network
- The CMO Climate and Hydrological Data Rescue Initiative

The WMO Caribbean RCC expands and extends the excellent work started by the AMCS by taking advantage of the many opportunities expected under the implementation of the Global Framework for Climate Service (GFCS). In particular, the WMO Caribbean RCC:

- Currently manages, archives and disseminates the climate data of Member States of the CMO. This service is being expanded to all Member States of the WMO Caribbean RCC.
- Coordinates the development and operational delivery of climate monitoring and prediction products and services and publishes many of these on behalf of the Caribbean Drought and Precipitation Monitoring Network (CDPMN) and the Caribbean Outlook Forum (CariCOF).
- Liaises with national and regional stakeholders in the development and delivery of critical climate services and products in the fields of Health, Disaster Risk Reduction, Agriculture and Food Security, Water Resource, Tourism and Energy.
- Facilitates real-time data sharing and acquisition between participating states and regional and international organizations.
- Conducts research and development necessary to sustain the actions of critical climate sectors in participating states. In addition, the WMO Caribbean RCC conducts and supports fundamental research in tropical climatology.
- Supports human capacity development in climate science and its applications in applications in participating states through the development of long-term and short-term training programmes and international and regional attachments.

2 CLIMATE MONITORING

2.1 ESSENTIAL CLIMATE VARIABLES

The climate of a region is described, monitored and predicted using a set of variables describing the physical state of the Earth's climate system, known as Essential Climate Variables (ECVs). An ECV is one of a set of physical, chemical or biological parameter, or a group of linked parameters, that critically contributes to climate. The procured set of ECVs (refer to Appendix A) are continually sustained, coordinated and improved in the WMO Global Climate Observing System (GCOS) and are identified based on the following criteria:

- **RELEVANCE** - the variable is critical for characterizing the climate system and its changes
- **FEASIBILITY** - observing or deriving the variable on a global scale is technically feasible using proven, scientifically understood methods.
- **COST EFFECTIVENESS** - generating and archiving data on the variable is affordable, mainly relying on coordinated observing systems using proven technology, taking advantage where possible of historical datasets.

Furthermore, the GCOS set requirements for observing the different essential characteristics for each ECV. These characteristics, known as products, provide the empirical evidence required to:

- Understand and predict the evolution of climate
- Guide mitigation and adaptation measures
- Assess risks and enable attribution of climate events to underlying causes
- Underpin climate

2.2 MONITORING CLIMATE VARIABILITY AND CLIMATE CHANGE

Climate monitoring is commonly done by tracking variability and trends in climate indicators and indices derived from ECVs.

2.2.1 CLIMATE INDICATORS

A climate indicator is a calculation, made using a single ECV, which summarizes the observed spatiotemporal distribution of the particular variable. These indicators allow for a quantification of the state of the climate. Commonly used indicators include:

- **MEAN** - mainly applied using climate normals, provisional normals and period averages (refer to Subsubsection 1.1.2).
- **MEDIAN** - a common descriptor used to express a central tendency (middle value) of a dataset. Median is determined by ranking the data from largest to smallest, and then identifying the middle so that there are an equal number of data values larger and smaller than it is. While the mean and median can be the same or nearly the same, they are different if more of the data values are highly skewed (i.e. clustered toward one end of their range) and/or if there are a few extreme values. This can result in an unrepresentative mean that is significantly influence by only a few values. In this case, the median gives a better representation of central tendency than the mean (*https://www.wcc.nrcs.usda.gov/normals/median_average.htm*).
- **ANOMALIES** - These are simple temporal differences between the observed and reference normal values for a single ECV product, over a specific location or region. A positive anomaly indicates the observed state of the ECV product was above average, while a negative anomaly indicates the observed state of the ECV product was below average.
- **PERCENTILES** - a convenient term for denoting thresholds or boundary values in frequency distributions. Hence, the 5th percentile is that value which marks off the lowest 5 per cent of the observations from the rest, the 50th percentile is the same as the median, and the 95th percentile exceeds all but 5 per cent of the values. When percentiles are estimated by ranking the items of a finite sample, the percentile generally falls between two of the observed values, and the midway value is often taken. The terms tercile, quartile, quintile and decile should refer to the percentiles which divide the distribution into 3, 4, 5, or 10 equal parts, respectively (http://www.bom.gov.au/climate/glossary/percent.shtml). Changes in the (very high or very low) percentiles with climate change tell you how the tails of the distributions are moving. We are often less concerned with mean or median changes than with changes in the tails because extreme events have more serious consequences for society.

2.2.2 CLIMATE INDICES

A climate index is a statistical value calculated by applying defining equations to one or multiple ECVs, primarily (i) air temperature, (ii) precipitation, (iii) air pressure and (iv) sea surface temperature (refer to the table below). These indices are indicative of specific climatic conditions that impact the environment or society and act as a basis for the objective measurement and characterization of climate variability and change.

The Expert Team (ET) on Sector Specific Climate Indices (ET-SCI) has developed a number of climate indices for use in sector applications, based on dialogue and cooperation with experts from health, agriculture, and water sectors, in close collaboration with the (now disbanded) Commission for Climatology (CCl) Expert Team on Climate Change Detection and Indices (ET-CCDI), which developed RClimDex software for the calculation of a number of climate indices based on daily maximum and minimum temperatures and precipitation. The ET-SCI has since added a number of indices recommended by sector experts to the set of indices in RClimDex and produced a new software package ClimPACT. The current version of the software (ClimPACTv2) produces indices primarily on heat waves, droughts, and extreme rainfall, and is in the process of being expanded to cover other relevant indices. A primary mission of the ET-SCI is to promote the use of consistent, sector-specific climate data and indices in tandem with sector-relevant data, through outreach and workshops at the regional and local level.

TABLE SHOWING THE COMMON INDICES EMPLOYED IN CLIMATE MONITORING

AIR TEMPERATURE	PRECIPITATION	AIR PRESSURE	SEA SURFACE TEMPERATURE
Extreme values during a specific period	Maximum 1- and 5-day precipitation per year	Arctic Oscillation (AO)	El Niño/La Niña
Exceeding specific limits (Percentile)	Simple Precipitation Intensity Index	North Atlantic Oscillation (NAO)	Atlantic Multidecadal Oscillation (AMO)
Daily Temperature Range	Annual count of days when the precipitation is greater than a defined limit	Pacific North-American pattern (PNA)	Pacific Decadal Oscillation (PDO)
Cooling Degree Day	Maximum length of dry spell	Southern Oscillation (SO)	Trends of sea surface temperature
Warm and cold spell duration	Maximum length of wet spell	Blocking index	
	Annual total precipitation when rain rate is above a defined limit (percentile)		
	Annual total precipitation in wet days		
	Standardized Precipitation Index (SPI)		
	Standardized Precipitation Evapotranspiration Index (SPEI)		

2.2 DATA PREPARATION AND QUALITY CONTROL USING ClimPACT2

Source: *https://github.com/ARCCSS-extremes/climpact2*

ClimPACT2 is an R software package that calculates the ET-SCI indices as well as additional climate extremes indices from data stored in text or netCDF files. It directly incorporates the R packages climdex.pcic and climdex.pcic.ncdf developed by the Pacific Climate Impacts Consortium (PCIC). Three methods of using the software allow the user to calculate indices on a station text file via a Graphical User Interface, to batch process multiple station text files in parallel and to calculate the indices on netCDF data in parallel.

In terms data preparation, the input data file used by ClimPACT2 to perform quality control, and further to calculate the required indices, is a simple .txt file containing 6 columns of data representing the (1) year (2) month (3) day (4) precipitation amount (5) maximum temperature (6) minimum temperature. Each row represents the corresponding values for a single day. ClimPACT2 does not permit missing days within the input file. However, missing precipitation and/or temperature values should be represented by -99.9.

EXAMPLE OF ClimPACT2 INPUT FILE

File Edit View Text Document Navigation Help

1931	2	8	-99.9	6	-0.8
1931	2	9	-99.9	3.2	1.3
1931	2	10	-99.9	2.8	1.2
1931	2	11	-99.9	2.9	-3.4
1931	2	12	-99.9	3.5	-5.4
1931	2	13	-99.9	-2.3	-8.4
1931	2	13	-99.9	-3.9	-11.3
1931	2	15	-99.9	-2.1	-13.1
1931	2	16	-99.9	4.5	-2.1
1931	2	17	-99.9	1.5	-5
1931	2	17	-99.9	0.6	-6.5
1931	2	19	-99.9	-0.1	-6

Data quality control is the identification of errors and outliers, whether the outliers represent true extremes or artefacts within a dataset, and the removal or correction of these errors and likely erroneous outliers. Each scientific measurement is subject to an inherent degree of uncertainty due to the limits of instruments and the people using them. Datasets compiled scientific measurements are further subject to data entry errors; such as incorrect dates or repeated values. Within the field of data science, unreliable or even misleading results produced by running good models on dirty data is quite common. Indeed, any model's output can only be as good as its input data and the level of detail of the processes represented in them.

Additionally, error propagation during the data analysis process can produce even greater discrepancies within model results. Hence, even though obtaining a clean dataset of measurements that perfectly represents the environmental conditions is impossible, it is imperative to apply controls (procedures) to improve data quality.

ClimPACT2 facilitates the quality control of input data by producing 7 .pdf files with graphical information and 9 .csv files with numerical information in the format displayed below.

GRAPHICAL INFORMATION FILES

- <Station_Name>_tminPLOT.pdf
- <Station_Name>_tmaxPLOT.pdf
- <Station_Name>_dtrPLOT.pdf
- <Station_Name>_prcpPLOT.pdf
- <Station_Name>_boxes.pdf
- <Station_Name>_boxseries.pdf
- <Station_Name>_rounding.pdf

NUMERICAL INFORMATION FILES

- <Station_Name>_duplicates.csv
- <Station_Name>_outliers.csv
- <Station_Name>_tmaxmin.csv
- <Station_Name>_tx_flatline.csv
- <Station_Name>_tn_flatline.csv
- <Station_Name>_toolarge.csv
- <Station_Name>_tx_jumps.csv
- <Station_Name>_tn_jumps.csv
- <Station_Name>_nastatistics.csv

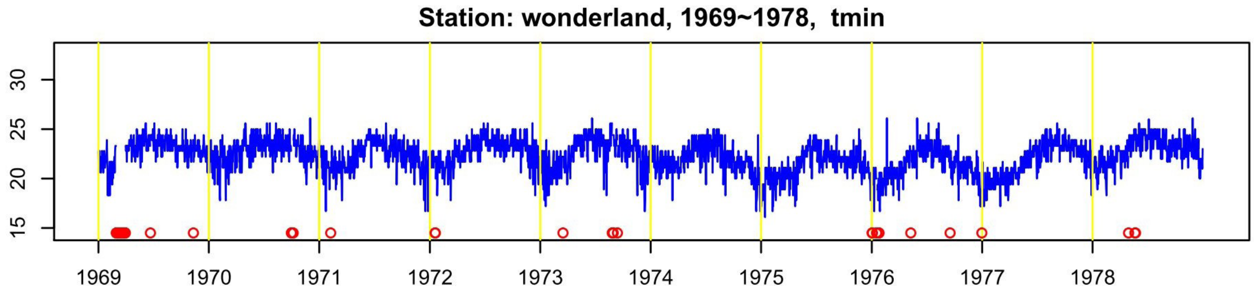
These files help users to identify potential issues relating to:

- Rounding biases
- Unphysical values
- Unusually large values
- Runs of the same value
- Duplicated dates
- Unusually large jumps between time-steps
- Missing Values

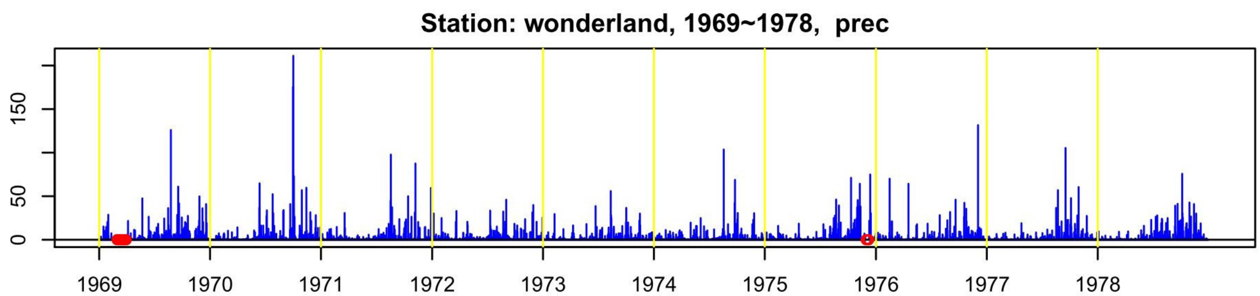
TIME SERIES PLOTS

Time series plots are good for showing how the data changes over time. Climpact2 plots 4 time series charts for the maximum air temperature (<Station_Name>_tmaxPLOT.pdf), minimum air temperature (<Station_Name>_tminPLOT.pdf), diurnal air temperature range (<Station_Name>_dtrPLOT.pdf) and precipitation (<Station_Name>_prcpPLOT.pdf).

EXAMPLE OF TIME SERIES PLOT FOR THE MINIMUM AIR TEMPERATURE RECORD:
wonderland_tminPLOT.pdf



EXAMPLE: TIME SERIES PLOT FOR THE PRECIPITATION RECORD: *wonderland_prcpPLOT.pdf*



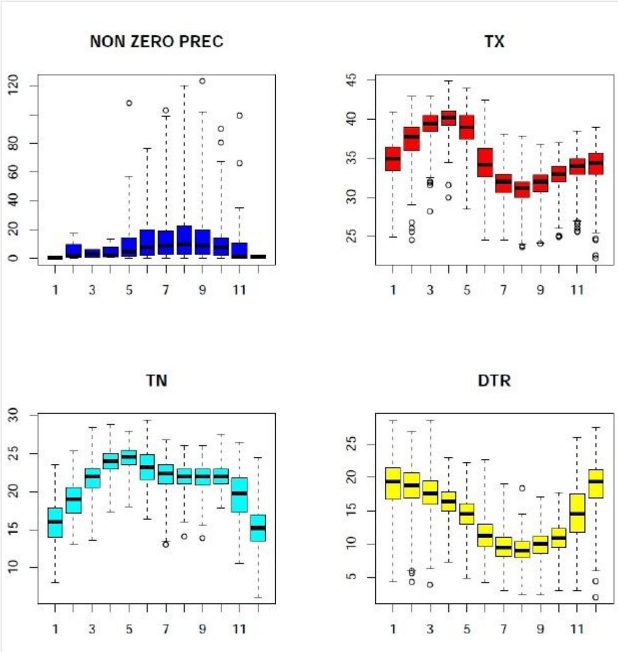
OUTLIERS

ClimPACT2 detects outliers using the Inter-Quartile Range (IQR) by the following process:

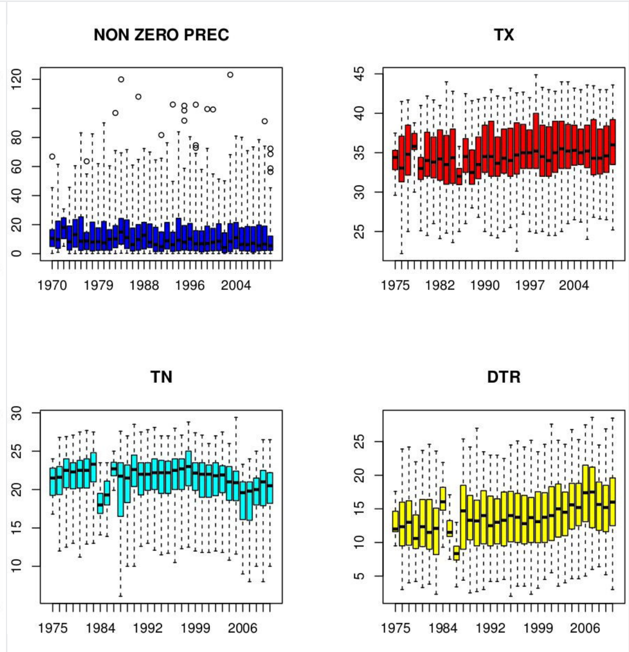
1. Calculate the 1st (Q1) and 3rd (Q3) quartiles of the dataset.
2. Calculate the IQR as the difference between the 3rd and 1st quartile (i.e. Q3 – Q1).
3. Calculate the range within which inliers fall by the calculation (Q1 – 1.5 x IQR, Q3 + 1.5 x IQR).
4. Any values outside the inlier range is suspected to be an outlier

A list of suggested outliers is directly output to the <Station_Name>_outliers.csv. These outliers are further visualized in the <Station_Name>_boxes.pdf and <Station_Name>_boxseries.pdf files.

The <Station_Name>__boxes.pdf file contains boxplots flagging as outliers (round circles) all those values falling outside the range (the lower bound and upper bound). The <Station_Name>_boxseries.pdf file contains a plot annual boxplots. It is useful to have a panoramic view of the series and be alerted of parts of the series which can be problematic.



BOX PLOTS: wonderland_boxes.pdf

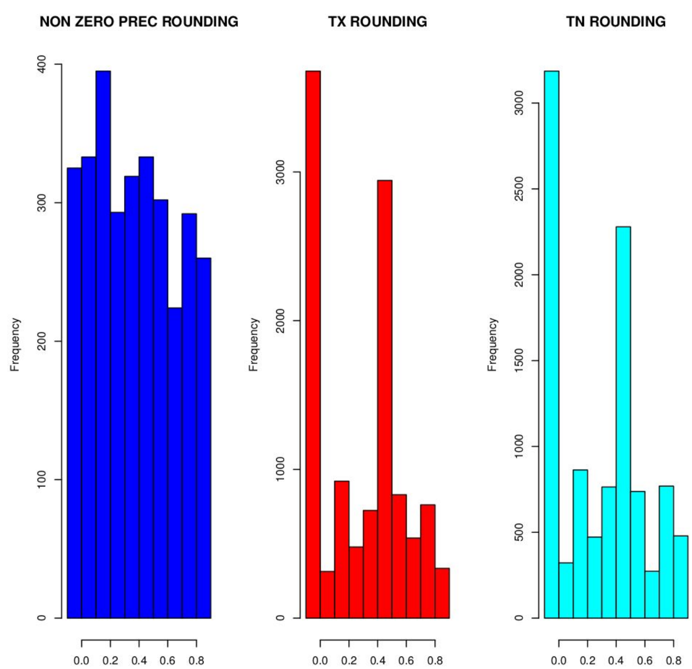


BOX SERIES PLOTS: wonderland_boxseries.pdf

ROUNDING BIASES

ClimPACT2 produces frequency tables for the floating points of the input data as the file <Station_Name>_rounding.pdf. This graphic shows the rounding bias within the dataset and can help users to identify possible rounding errors.

ROUNDING FREQUENCY FILE SHOWING A ROUNDING BIAS OF .0 AND .5 FOR TEMPERATURE VALUES: ***wonderland_rounding.pdf***



DUPLICATED DATES

Duplicated dates is one of many forms of input errors. ClimPACT2 produces a .csv metadata file entitles <Station_ Name>_duplicateds.csv that contains duplicated dates within the dataset.

File Edit View Text Document Navigation Help

39	1931	2	8	-99.9	6	-0.8
40	1931	2	9	-99.9	3.2	1.3
41	1931	2	10	-99.9	2.8	1.2
42	1931	2	11	-99.9	2.9	-3.4
43	1931	2	12	-99.9	3.5	-5.4
44	1931	2	13	-99.9	-2.3	-8.4
45	1931	2	13	-99.9	-3.9	-11.3
46	1931	2	15	-99.9	-2.1	-13.1
47	1931	2	16	-99.9	4.5	-2.1
48	1931	2	17	-99.9	1.5	-5
49	1931	2	17	-99.9	0.6	-6.5
50	1931	2	19	-99.9	-0.1	-6
51	1931	2	20	-99.9	-2.4	-10.5

Section of the wonderland input data file showing duplicated dates

	A	B
1	Station:	wonderland
2	Latitude:	-30
3	Longitude:	10
4	ClimPACT2_version:	1.1.2
5	Date_of_calculation:	2016-02-09
6	Dates_duplicated	
7	1931-2-13	
8	1931-2-17	
9		

Climpact2 produced metadata file identifying the duplicated dates seen in the input data file: wonderland_duplicates.csv

UNPHYSICAL VALUES

Unphysical values are physically unlikely. They can result in a dataset from various sources, commonly equipment malfunction and user error.

The occurrence of extreme values where the maximum is lower than the minimum is impossible by definition. Climpact 2 produces a metadata file entitled <Station_Name>_tmaxmin.csv that displays instances where the recorded maximum temperature is less than the recorded minimum temperature within the dataset.

File Edit View Text Document Navigation Help

1	1931	1	1	-99.9	-3.1	0
2	1931	1	2	-99.9	-1.3	0
3	1931	1	3	-99.9	-0.5	0
4	1931	1	4	-99.9	-1	0
5	1931	1	5	-99.9	-1.8	-8.4
6	1931	1	6	-99.9	-7.8	-11.5
7	1931	1	7	-99.9	-6.6	-12.2
8	1931	1	8	-99.9	-0.6	-9.4
9	1931	1	9	-99.9	4.2	-2.7
10	1931	1	10	-99.9	5.9	-1.4
11	1931	1	11	-99.9	4.9	-7.8

Section of input file containing instances where the maximum temperature is less than the minimum

	A	B	C	D
1	Station:	wonderland		
2	Latitude:	-30		
3	Longitude:	10		
4	ClimPACT2_version:	1.1.2		
5	Date_of_calculation:	2016-02-09		
6	Date	Prec	TX	TN
7	1931-1-1	NA	-3.1	0
8	1931-1-2	NA	-1.3	0
9	1931-1-3	NA	-0.5	0
10	1931-1-4	NA	-1	0
11				

Example of the metadata file showing the instances where temperature maximum is less than minimum: wonderland_tmaxmin.csv

RUNS OF THE SAME VALUE

Climpact2 also spots instances of 4 or more runs of the same temperature value as there is a high possibility that the run is an error. The period for the run is contained within the metadata files entitled <Station_Name>_tx_flatline.csv for maximum temperature and <Station_Name>_tn_flatline.csv for minimum temperature.

File Edit View Text Document Navigation Help

1	1931	1	1	-99.9	-3.1	0
2	1931	1	2	-99.9	-1.3	0
3	1931	1	3	-99.9	-0.5	0
4	1931	1	4	-99.9	-1	0
5	1931	1	5	-99.9	-1.8	-8.4
6	1931	1	6	-99.9	-7.8	-11.5
7	1931	1	7	-99.9	-6.6	-12.2
8	1931	1	8	-99.9	-0.6	-9.4
9	1931	1	9	-99.9	4.2	-2.7
10	1931	1	10	-99.9	5.9	-1.4
11	1931	1	11	-99.9	4.9	-7.8

Section of input file where there is a run of 4 days with a 00°C minimum temperature.

	A	B	C
1	Station:	wonderland	
2	Latitude:	-30	
3	Longitude:	10	
4	ClimPACT2_version:	1.1.2	
5	Date_of_calculation:	2016-02-09	
6	Date	TN	Number of duplicates
7	1931-1-3	0	3
8			

Example of the metadata file showing the period, variable and number of repeats within the minimum temperature: wonderland_tn_flatline.csv

UNUSUALLY LARGE VALUES

Climpact2 produces a metadata file identifying instances of unusually large values within the dataset entitled <Station_Name>_toolarge.csv. Unusually large values are identified as instances where (1) temperature values exceed 500°C and (2) precipitation values exceed 200mm.

File Edit View Text Document Navigation Help

35	1931	2	4	-99.9	-1.6	-8.6
36	1931	2	5	-99.9	1.8	-3.6
37	1931	2	6	-99.9	0.3	-4.4
38	1931	2	7	-99.9	2.8	60
39	1931	2	8	-99.9	6	-0.8
40	1931	2	9	-99.9	3.2	1.3
41	1931	2	10	-99.9	2.8	1.2
42	1931	2	11	-99.9	2.9	-3.4
43	1931	2	12	-99.9	55	-5.4
44	1931	2	13	-99.9	-2.3	-8.4
45	1931	2	14	-99.9	-3.9	-11.3
46	1931	2	15	-99.9	-2.1	-13.1
47	1931	2	16	250	4.5	-2.1
48	1931	2	17	-99.9	1.5	-5

Section of the wonderland input data file showing instances of unusually large values

	A	B	C	D
1	Station:	wonderland		
2	Latitude:	-30		
3	Longitude:	10		
4	ClimPACT2_version:	1.1.2		
5	Date_of_calculation:	2016-02-09		
6	Date	Prec	TX	TN
7	1931-2-7	NA	2.8	60
8	1931-2-12	NA	55	-5.4
9	1931-2-16	250	4.5	-2.1
10				

Climpact2 produced metadata file identifying the instances of unusually large values: wonderland_toolarge.csv

UNUSUALLY LARGE JUMPS BETWEEN TIME STEPS

Climpact2 produces a metadata files identifying instances of unusually large jumps between time steps within the dataset entitled <Station_Name>_txjumps.csv and <Station_Name>_tnjumps.csv. Unusually large jumps between time steps are identified by an hour where the recorded temperature in the successive hours differs to that temperature by an absolute value of 200°C or more.

File Edit View Text Document Navigation Help

15278	1972	10	29	11.7	-5.1	-12.6
15279	1972	10	30	2.5	-11.2	-23.4
15280	1972	10	31	4.3	-4.8	-24.8
15281	1972	11	1	3.6	4.3	-4.8
15282	1972	11	2	3.2	2.1	-3.9
15283	1972	11	3	3.1	0.1	-4.1
15284	1972	11	4	6.4	-1.5	-4.9
15285	1972	11	5	0	-3.2	-6.3
15286	1972	11	6	0	-5.6	-15.9
15287	1972	11	7	11.3	-3.9	-17.6
15288	1972	11	8	5.3	-3.5	-5.8
15289	1972	11	9	0.4	-2.9	-6

Section of the wonderland input data file showing instances of unusually large jumps between time steps

	A	B
1	Station:	wonderland
2	Latitude:	-30
3	Longitude:	10
4	ClimPACT2_version:	1.1.2
5	Date_of_calculation:	2016-02-09
6	Date	TN
7	1972-10-31	-24.8
8		
9		

Climpact2 produced metadata file identifying the instances of unusually large jumps between time steps: wonderland_tnjumps.csv

MISSING VALUES

Missing values is another data input error accounted for by Climpact2. Climpact2 generates a metadata file entitled <Station_Name>_nastatistics.csv that contains a record of all missing dates within the dataset.

EXAMPLE OF THE METADATA FILE OF MISSING DATES VALUES WITHIN THE DATASET: *wonderland_nastatistics*

	A	B	C	D	E
1	Station:	wonderland			
2	Latitude:	-30			
3	Longitude:	10			
4	ClimPACT2_version:	1.1.2			
5	Date_of_calculation:	2016-02-09			
6	Year	Prec	TX	TN	
7	1931	364	9	9	
8	1932	366	7	7	
9	1933	365	7	7	
10	1934	365	6	6	
11	1935	365	6	6	
12	1936	40	7	7	
13	1937	7	7	7	
14	1938	6	6	6	
15	1939	7	7	7	
16	1940	7	7	7	
17	1941	7	7	7	
18	1942	6	6	6	
19	1943	7	7	7	
20	1944	6	6	6	
21	1945	7	7	7	
22	1946	6	6	6	
23	1947	7	7	7	
24	1948	7	7	7	
25	1949	8	7	7	
26	1950	6	6	6	
27	1951	7	7	7	
28	1952	7	7	7	
29	1953	7	7	7	
30	1954	6	6	6	
31	1955	7	7	7	
32	1956	7	7	7	
33	1957	7	7	7	
34	1958	5	5	5	
35	1959	7	7	7	
36	1960	7	7	7	
37	1961	7	7	7	
38	1962	6	6	6	

2.4 CLIMATE MONITORING PRODUCTS AND SERVICES PROVIDED BY THE CARIBBEAN REGIONAL CLIMATE CENTRE

2.4.1 CARIBBEAN CLIMATOLOGY

Webpage: *http://rcc.cimh.edu.bb/caribbean-climatology/*

The Caribbean RCC offers a technical description of the climate in the Caribbean, followed by maps of average monthly rainfall sums and average monthly temperatures at eye height, as registered by land-based weather stations across the region. Also, you will find more detailed rainfall and temperature statistics per territory and per station.

2.4.2 DROUGHT AND PRECIPITATION INFORMATION AS GUIDED BY THE CARIBBEAN DROUGHT AND PRECIPITATION MONITORING NETWORK

Webpage: *http://rcc.cimh.edu.bb/climate-monitoring/caribbean-drought-and-precipitation-monitoring-network/*

The Caribbean Drought and Precipitation Monitoring Network (CDPMN) was launched in January 2009 under the Caribbean Water Initiative (CARIWIN). The goal of CARIWIN is to increase the capacity of Caribbean countries to deliver equitable and sustainable Integrated Water Resources Management (IWRM). It sets out to achieve this by improving the capacity of Caribbean Institute for Meteorology and Hydrology (CIMH) to meet water management needs of their member states in a multi-stakeholder environment, in collaboration with regional and national networks, selected national governments and community water users.

The CDPMN monitors drought and the general precipitation status on two scales: (i) regional, encompassing the entire Caribbean basin and (ii) national using a number of indices and indicators. Indices such as the Standardized Precipitation Index (see Subsubsection 2.4.2.1) and Deciles (see Subsubsection 2.4.2.2), accessible from the CDPMN webpage, would be indicators of normal or abnormal rainfall. Other indices can provide information on normal or abnormal soil moisture (Palmer Drought Severity index, PDSI, developed by Palmer 1965; and Crop Moisture Index, CMI, developed by Palmer 1968) or status of vegetation (Normalized Difference Vegetation Index, NDVI). Other indicators can provide information on stream and river flow, lake and reservoir levels and ground water quantities.

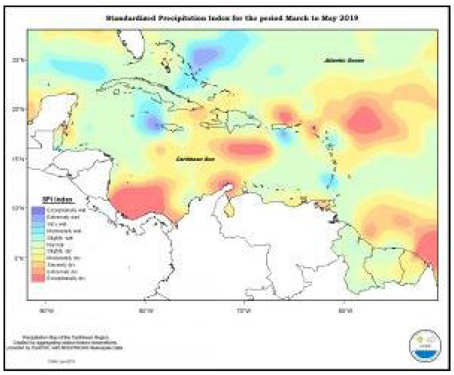
As an addition to these final drought and precipitation status products, short term and seasonal precipitation forecasts will be used to provide a projection of future drought and excessive precipitation in the short and medium terms (see Subsection 4.3.3).

2.4.2.1 STANDARDIZED PRECIPITATION INDEX MONITOR

Webpage: *http://rcc.cimh.edu.bb/spi-monitor/*

The Standardized Precipitation Index (SPI), developed by T.B. Mckee, N.J. Doesken and J. Kleist (McKee et al. 1993) of Colorado State University is an index that, if used carefully, can provide early warning of an extended drought period and aid in assessing drought severity and expected impact level by the end of the period. It can also provide similar information at the other end of the spectrum- extremely high precipitation.

March to May 2019



Mixed conditions were observed in the eastern Caribbean islands over the three month period. Trinidad was normal to severely dry, from northeast to southwest; Tobago normal; Grenada and St. Vincent slight to moderately wet; Barbados and St. Lucia normal to moderately dry; Martinique and Dominica slight to moderately dry; Guadeloupe normal to slightly wet; Antigua slightly wet, St. Kitts moderate to severely dry; and. St. Maarten extremely dry. In the Guianas, conditions ranged from slightly wet in northern Guyana to exceptionally dry in northern French Guiana, with Guyana being predominantly normal, and Suriname and French Guiana predominantly below normal. Curacao was normal. .Puerto Rico was predominantly normal, with the extreme southeastern area ranging from slight to moderately wet, whereas, the extreme north ranged from slightly dry in the west, to severely dry in the northeast. Hispaniola was predominantly normal, particularly over the Dominican Republic with the exception of the northwestern and southern tip that were slightly dry, and in the west, north and south that were slight to moderately dry. Jamaica ranged from slightly dry to normal from central to eastern areas, with western areas ranging from normal to extremely wet; but Grand Cayman was normal to slightly wet, from west to east. Cuba was predominantly normal, with slightly wet areas in the northeast, south and west, however slight to severely dry in the east, whilst Northern Bahamas ranged from slightly wet to slightly dry. Conditions in Belize ranged from slight to extremely dry in the north, slight to moderately dry in the west, with predominantly normal conditions elsewhere, except for a small area in the center which was slightly wet, and the south which ranged from slightly wet to very wet.

SPI is basically a representation of rainfall in units of standard deviation. Positive values indicate greater than median rainfall; negative values indicate less than median rainfall. Prior to 2011, CIMH used the category system for SPI values and precipitation intensities adopted by the US Drought Monitor; proposed by McKee et al 1993. However, impacts experienced (particularly in agriculture) during the Caribbean drought of 2009-2010, prompted a re-thinking of the categories for SPI values and precipitation intensities. Both the newly adopted and previous category systems are shown in the table below.

SPI VALUES AND PRECIPITATION INTENSITIES (CIMH 2011)			SPI VALUES AND PRECIPITATION INTENSITIES (MCKEE ET AL 1993)		
SPI	Category	Probability (%)	SPI	Category	Probability (%)
2.01 and more	Exceptionally wet	2.22	2.0 and more	Extremely wet	2.3
1.61 to 2.0	Extremely wet	3.20	1.5 to 1.99	Very wet	4.4
1.31 to 1.6	Very wet	4.20	1.0 to 1.49	Moderately wet	9.2
0.81 to 1.3	Moderately wet	11.51	-0.99 to 0.99	Near Normal	68.2
0.51 to 0.8	Slightly wet	9.67	-1.49 to -1.0	Moderately dry	9.2
-0.5 to 0.5	Normal	38.30	-1.99 to -1.5	Very dry	4.4
-0.8 to -0.51	Slightly dry	9.67	-2.0 and less	Extremely dry	2.3
-1.3 to -0.81	Moderately dry	11.51			
-1.6 to -1.31	Very dry	4.20			
-2.0 to -1.61	Extremely dry	3.20			
-2.01 and less	Exceptionally dry	2.22			

The SPI is flexible and can be calculated for different time scales. A time scale analysis reflects the impact of drought on the availability of the different water resources. A one-month SPI analysis reflects short term soil moisture and crop stress especially during the growing season. A three-month SPI analysis reflects short to medium term moisture and can give an indication of available moisture conditions at the beginning of the growing season. A six-month SPI analysis reflects medium term trends in rainfall and is effective in showing rainfall distribution over distinct seasons as well as being associated with anomalous stream flows and reservoir levels, which takes longer to manifest itself than does agricultural drought. A twelve-month SPI can indicate potential periods of shortfall in groundwater amounts.

Using NCEP/NCAR reanalysis data in combination with data from land-based stations, SPIs are calculated in 1, 3, 6 and 12 month time intervals for the Caribbean basin as part of the Caribbean Drought and Precipitation monitoring Network. CIMH hopes to add more land stations in due course.

When used in combination with forecast products, such as seasonal precipitation forecasts, projections can be made on the future status of drought (or extreme high rainfall) for the region. CIMH is currently investigating the use of other indices to monitor drought and precipitation.

KEY STRENGTHS:

- Uses precipitation only; can characterize drought or abnormal wetness at different time scales which correspond with the time availability of different water resources (e.g. soil moisture, snowpack, groundwater, river discharge and reservoir storage)
- More comparable across regions with different climates than the Palmer Severity Drought Index (PDSI)
- Less complex to calculate than the PDSI

KEY LIMITATIONS:

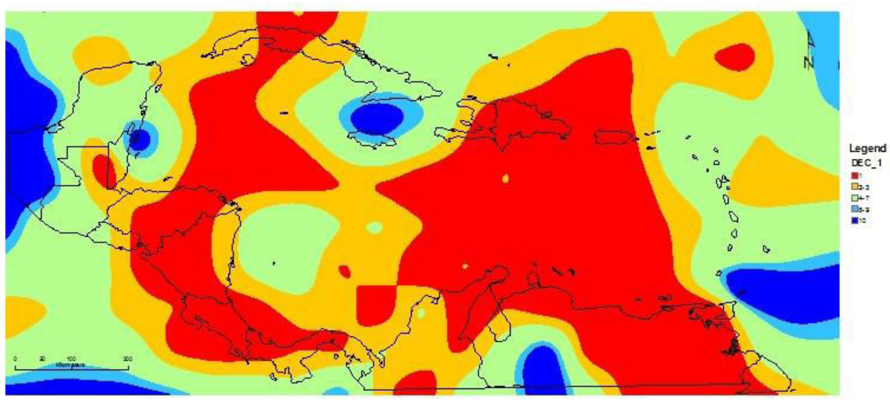
- As a measure of water supply only, the SPI does not account for evapotranspiration, and this limits its ability to capture the effect of increased temperatures (associated with climate change) on moisture demand and availability
- Sensitive to the quantity and reliability of the data used to fit the distribution; 30-50 years recommended
- Does not consider the intensity of precipitation and its potential impacts on runoff, streamflow, and water availability within the system of interest

Archive for Monthly SPI maps: *http://rcc.cimh.edu.bb/spi-archive/*

2.4.2.2 DECILE MONITOR

Webpage: *http://rcc.cimh.edu.bb/decile-monitor/*

Deciles October 2015



A number of drought/precipitation indices have previously been utilized, are currently being utilized or are in the experimental stage with the view to them being used together to monitor drought and periods with extremely high precipitation. Deciles is one such index.

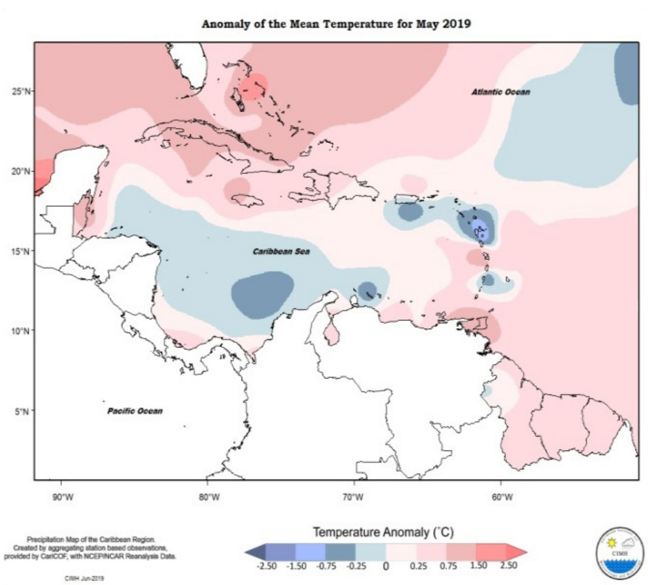
Deciles were developed by W. J. Gibbs, and J.V. Maher in 1967. It is a very simple index. Indices are acquired by ranking the rainfall data into deciles (percentiles of ten) so that the lowest 10% of the values are in the first decile and the highest 10% are in the 10th decile. Half of the data is above the median (the 50th percentile) and half below. The deciles are classified as follows:

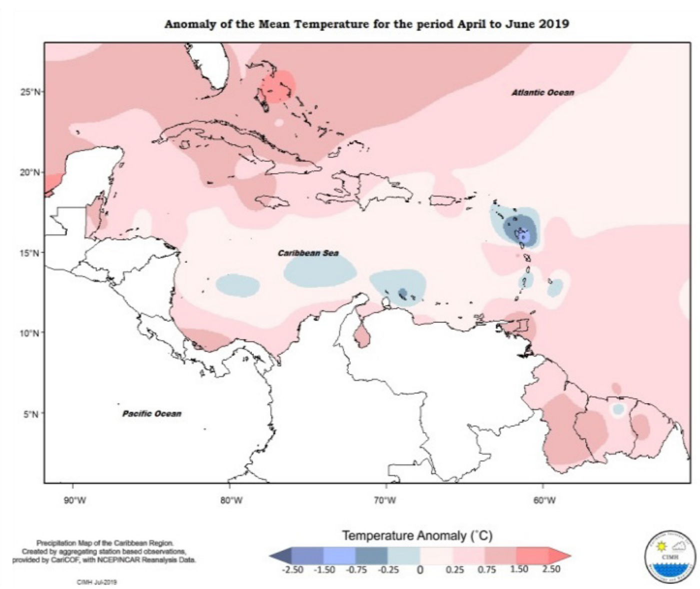
	Decile 10 (Highest 10%)	Very much above normal
	Deciles 8-9 (Next highest 20%)	Above normal
	Deciles 4-7 (Middle 40%)	Normal
	Deciles 2-3 (Next lowest 20%)	Below normal
	Decile 1 (Lowest 10%)	Very much above normal

Note: Deciles are being phased out as an operational index by CIMH.

2.4.3 MONTHLY AND SEASONAL MEAN TEMPERATURE ANOMALIES ACROSS THE CARIBBEAN REGION

Webpage: http://rcc.cimh.edu.bb/mean-temperature-anomalies/

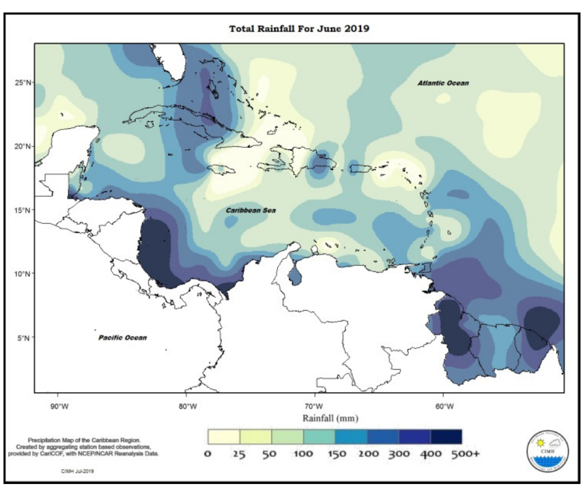




The Caribbean RCC provides maps of the anomaly of the mean temperature for each specific month and the 3-month period from the reference climate normal (1981-2010) representing that period. Positive or Negative anomalies indicate that the mean temperature, over the period, is above or below normal. These maps can provide a first estimate of the level of heat exposure throughout a month compared to the usual situation.

Archive for Monthly Anomaly of the Mean temperature: http://rcc.cimh.edu.bb/mean-temperature-anomalies-archive/

2.4.4 ANALYSIS OF MONTHLY RAINFALL ACROSS THE CARIBBEAN REGION



Webpage:
http://rcc.cimh.edu.bb/caribbean-monthly-rainfall/

The Caribbean RCC provides monthly maps of the regional accumulated total precipitation (rainfall) across the Caribbean region.

Archive for monthly rainfall totals:
http://rcc.cimh.edu.bb/monthly-rainfall-archive/

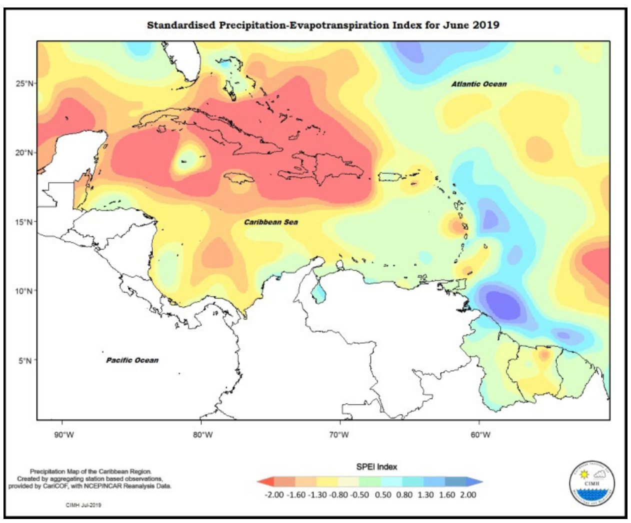
2.4.5 CURRENTLY DEVELOPING (EXPERIMENTAL) PRODUCTS

The Caribbean RCC continues to advance the climate services it provides to the region. Currently, the following products are still experimental and being developed.

- SPEI Monitor
- SPI difference maps
- SPEI difference maps

2.4.5.1 STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX MONITOR

Source: *https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-evapotranspiration-index-spei*



The Standardized Precipitation Evapotranspiration Index (SPEI) is an extension of the widely used SPI. The SPEI is designed to take into account both precipitation and potential evapotranspiration (PET) in determining drought. Thus, unlike the SPI, the SPEI captures the main impact of increased temperatures on water demand. Like the SPI, the SPEI can be calculated on a range of timescales from 1-48 months. At longer timescales (18 months or more), the SPEI has been shown to correlate with the self-calibrating PDSI. If only limited data are available, say temperature and precipitation, PET can be estimated with the simple Thornthwaite method. In this simplified approach, variables that can affect PET such as wind speed, surface humidity and solar radiation are not accounted for. In cases where more data are available, a more sophisticated method to calculate PET is often preferred in order to make a more complete accounting of drought variability. However, these additional variables can have large uncertainties.

KEY STRENGTHS:

- Combines multi-timescales aspects of the SPI with information about evapotranspiration, making it more useful for climate change studies and for assessment of soil moisture availability.
- Statistically based index that requires only climatological information without assumptions about the characteristics of the underlying system.

KEY LIMITATIONS:

- More data requirements than the precipitation SPI
- Sensitive to the method to calculate PET
- As with other drought indices, a long base period (30-50+ years) that samples the natural variability should be used

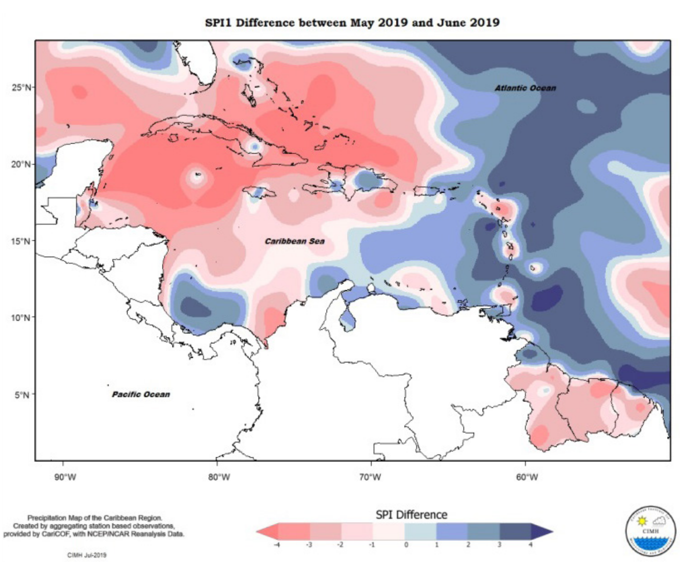
Similarly, to the SPI Monitor, SPEI maps calculated for 1, 3, 6, 12 and 24 month time intervals for the Caribbean basin using NCEP/NCAR reanalysis data in combination with data from land-based stations.

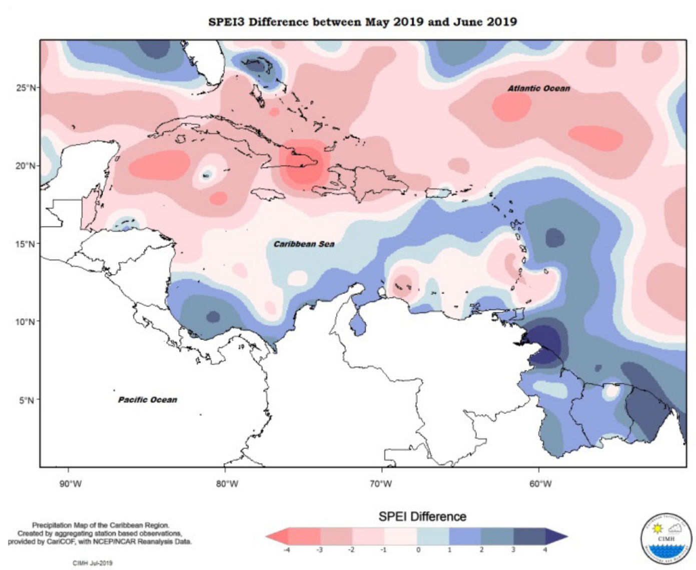
Archive for Monthly SPEI maps: *http://rcc.cimh.edu.bb/spei-archive/*

2.4.5.2 DIFFERENCE MAPS FOR THE STANDARDIZED PRECIPITATION INDEX AND THE STANDARDIZED PRECIPITATION EVAPOTRANSPIRATION INDEX

Webpage for SPI Difference Maps: *https://rcc.cimh.edu.bb/spi-change-experimental/*

Webpage for SPEI Difference Maps: *http://rcc.cimh.edu.bb/spei-difference-experimental/*





The Caribbean RCC is currently developing SPI and SPEI difference maps over the 1, 3, 6, 12 and 24 month period leading up to the current month.

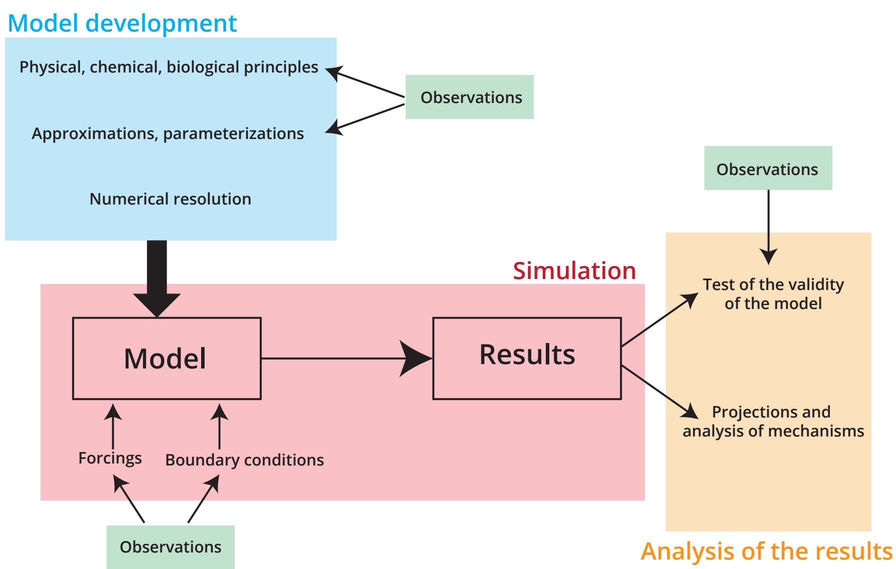
Archive for SPI change maps totals: *https://rcc.cimh.edu.bb/spi-change-archive/*

Archive for SPI change maps totals: *http://rcc.cimh.edu.bb/spei-difference-archive/*

3 CLIMATE PREDICTION

3.1 GENERAL CIRCULATION MODELS & DOWNSCALING

In general terms, a climate model could be defined as a mathematical representation of the climate system based on physical, biological and chemical principles. The equations derived from these laws are so complex that they must be solved numerically. As a consequence, climate models provide a solution which is discrete in space and time, meaning that the results obtained represent averages over regions, whose size depends on model resolution, and for specific times.



General Circulation Models (GCMs), representing physical processes in the atmosphere, ocean, cryosphere and land surface, are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations . While simpler models have also been used to provide globally- or regionally-averaged estimates of the climate response, only GCMs, possibly in conjunction with nested regional models, have the potential to provide geographically and physically consistent estimates of regional climate change which are required in impact analysis.

GCMs continue to yield important scientific insights into the dynamics and evolution of the climate system on time scales ranging from months to centuries. Outputs from GCMs have also played a key role in informing diverse assessments of the impact of large-scale climate variation and change on natural resources, human health, infrastructure and commerce. Raw GCM output, however, is not always adequate to address the inter-disciplinary questions of interest to stakeholders. Two primary impediments to impacts studies are the spatial scales represented by the GCM may not be as fine as the end-use application requires, and the GCM raw output is deemed to contain biases relative to observational data, which preclude its direct use in downstream applications.

Over time, high-resolution GCMs and advances in model formulation will reduce these impediments, but the myriad of climate impacts questions makes it unlikely that even these improved models will be able to effectively address all scales and applications of interest. A variety of downscaling methods may be used to process and refine GCM output with the aim of producing output more suitable for impacts studies. The refined output aims to address the limitations of coarse resolution and/or regional biases in the GCM output.

Downscaling techniques can be divided into two broad categories: dynamical and statistical. Dynamical downscaling refers to the use of high-resolution regional simulations to dynamically extrapolate the effects of large-scale climate processes to regional or local scales of interest. Statistical downscaling encompasses the use of various statistics-based techniques to determine relationships between large-scale climate patterns resolved by global climate models and observed local climate responses. These relationships are applied to GCM results to transform climate model outputs into statistically refined products, often considered to be more appropriate for use as input to regional or local climate impacts studies.

3.1.1 STATISTICAL DOWNSCALING USING THE CLIMATE PREDICTABILITY TOOL

The Climate Predictability Tool (CPT) provides a Windows package for constructing a seasonal climate forecast model, performing model validation, and producing forecasts given updated data. Its design has been tailored for producing seasonal climate forecasts using Model Output Statistic (MOS) corrections to climate predictions from GCMs, or for producing forecasts using fields of sea-surface temperatures. Although the software is specifically tailored for these applications, it can be used in more general settings to perform Canonical Correlation Analysis (CCA) or Principal Components Regression (PCR) on any data, and for any application. Principle Component Regression (PCR) techniques form part of the above family of spatial pattern regression-based statistical downscaling tools (Fowler et al., 2007). PCR can be used in a variety of contexts for the downscaling of seasonal climate forecasts.

As common to regression models, CPT requires two datasets for its operations. The first data set is the "X variables", also known as predictors or independent variables. In the context of MOS applications, the X variables will normally be a GCM output field, such as precipitation or geopotential heights, while in a more traditional model the X variables typically will be something like a set of sea-surface temperature data, or an ENSO index. The X variables are used to predict the variables in the second dataset, which should contain the "Y variables", also known as the predictands or dependent variables. Most frequently the Y dataset contains a set of station seasonal rainfall totals or temperature averages.

The complete user guide for CPT can be found at:
https://iri.columbia.edu/~awr/wiki/Downscaling/HydroOutlooks/Documents/cpttutorial_june08.pdf

3.2 CARIBBEAN CLIMATE OUTLOOK FORUM

The combination of climate variability and change pose significant risks for the Caribbean region. Pressures on regional resources are anticipated to increase along with demands due to population growth and the expansion of tourism. Coupled with these risks are:

- The threats already posed to society from today's climate extremes and variations
- The potentially high-impact but uncertain additional risks presented by climate change

Regional Climate Outlook Forums (RCOFs), sponsored by the World Meteorological Organization (WMO) are active in several parts of the world. These RCOFs are critical for the development and delivery of effective early warning systems, in that they provide real-time seasonal climate forecasts and interpretation across relevant time and spatial scales. The Caribbean Climate Outlook Forum (CariCOF) is one such RCOFs that seeks to develop appropriate climate services, tailored to the Caribbean region to support the goals of climate variability and change adaptation and disaster risk reduction.

Failure to maintain a Caribbean RCOF after initial activity in the late 1990s meant that such early warning systems were in jeopardy. However, in June 2010, a workshop was convened to re-establish the CariCOF in order to develop a sustained collaborative process that provides credible and authoritative real-time regional climate products. This did not include the delivery of outlooks, but rather sought direction and regional support for future CariCOF activity. The first CariCOF since re-establishment that included the delivery of a rainfall forecast occurred in March 2012. There, a rainfall forecast for the period March to May 2012 was discussed by the many stakeholders present that represented some key climate sensitive sectors such as agriculture, health, water resources management, along with those from disaster management. This successful stakeholder forum that succeeded a training workshop on seasonal rainfall forecasting for meteorologist, was deemed a success. It was agreed that such forums were extremely important, and should be held twice per year just prior to the beginning of the wet and dry seasons in the Caribbean.

Ever since 2013, CariCOF has been held at the end of May/beginning to June to deliver forecasts for the wet/hurricane season, while the first dry season CariCOF was hosted by Antigua and Barbuda in November/December 2014. Between CariCOFs, the region's meteorologists/climatologists now numbering some 20 or more, update the forecasts monthly and deliver them to a wide range of regional and national stakeholders. The suite of forecasts currently includes products for rainfall and temperature, for up to 3 to 6 months, and for drought that itself include an alerting system supported by response actions that were developed with the stakeholders. It is anticipated that other products and applications will be added as training continues for meteorologists/climatologists from across the region.

3.3 CARICOF OUTLOOK GENERATOR (CAROGEN) USER GUIDE

The CariCOF Outlook Generator (CAROGEN) is the data archiving, retrieving, processing and visualizing platform developed and maintained by the Caribbean RCC to be:

- An on-line portal that allows meteorological services from CariCOF member countries (users) to submit and access historical daily and monthly temperature and precipitation data.

- A portal that offers access to the general public (guests) to view climatological norms, summaries of climate statistics and basic monitoring tools for daily and monthly temperature and precipitation disaggregated by country and weather station, dating back to 1971.
- A platform for meteorological services to generate and deliver national and regional wide forecasts that drive seasonal climate outlooks using the Climate Predictability Tool (CPT).

CAROGEN supports the development of national and regional climate forecasts by meteorological services within the Caribbean region. Outlooks based on these forecasts provide climate-sensitive sectors with key information to support their decision-making and build climate resilience. The CAROGEN platform helps users to:

- Adopt a high standard of production for climate outlooks that are uniform across the region
- Produce climate outlooks and related climate information in both a user-friendly and time efficient manner
- Track the evolution of temperature and rainfall conditions across the region in real-time.

Data Center and CPT Tool are the main services provided by the CAROGEN platform. While the Data Center provides the user with accessibility to the unprocessed historical climate data archived in CAROGEN, the CPT Tool constructs seasonal climate forecast models data (Currently CPT Version 15.3.5). The processes provided by these tools allow users to:

DATA CENTER

- Request Add a Station
- Update Monthly Data
- Update Daily Data
- Query Database
- Country Daily Statistics
- Country Monthly Statistics
- Download Data Template
- Update Data Template System
- Check Data Upload Status

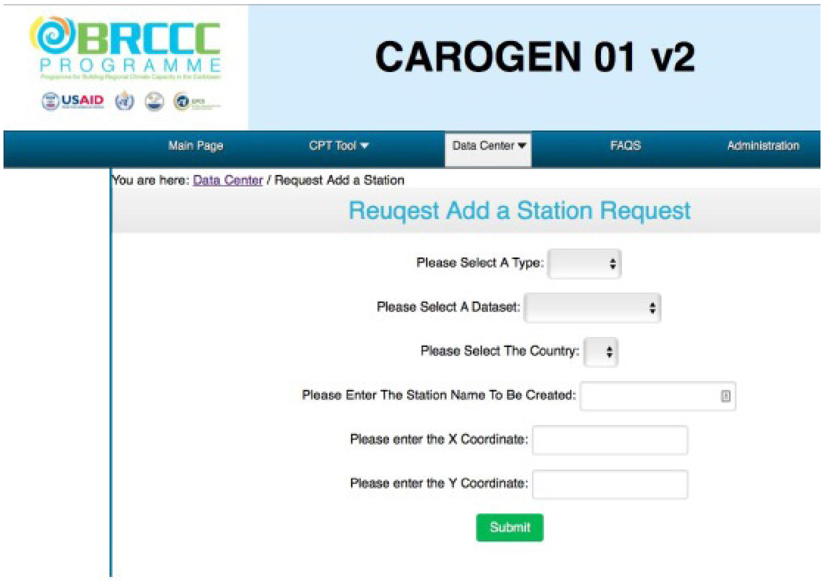
CPT TOOL

- Download CPT Data Files
- Pre-set National Outlook
- View Submitted Request
- Accept/Reject Results
- Generate Outlook Maps
- View Your Outlook Maps
- View Submitted Outlooks
- Archived Outlook Maps
- Archived Submitted Outlooks
- CPT Experimental Setup

3.3.1 DATA CENTER

3.3.1.1 REQUEST ADD A STATION

Request Add a Station provides a form for users to request the addition a new station, strictly within their respective country, to **Data Center**. Each submitted request specifies the (i) name (2) country (3) X-coordinate (longitude) and Y-coordinate (latitude) (4) type (daily or monthly) and (5) dataset (average, minimum or maximum temperature, as well as rainfall) for the station being requested. As a result, stations with multiple type and/or datasets require separate requests for each combination of type and dataset, with a total maximum of 8 submissions.

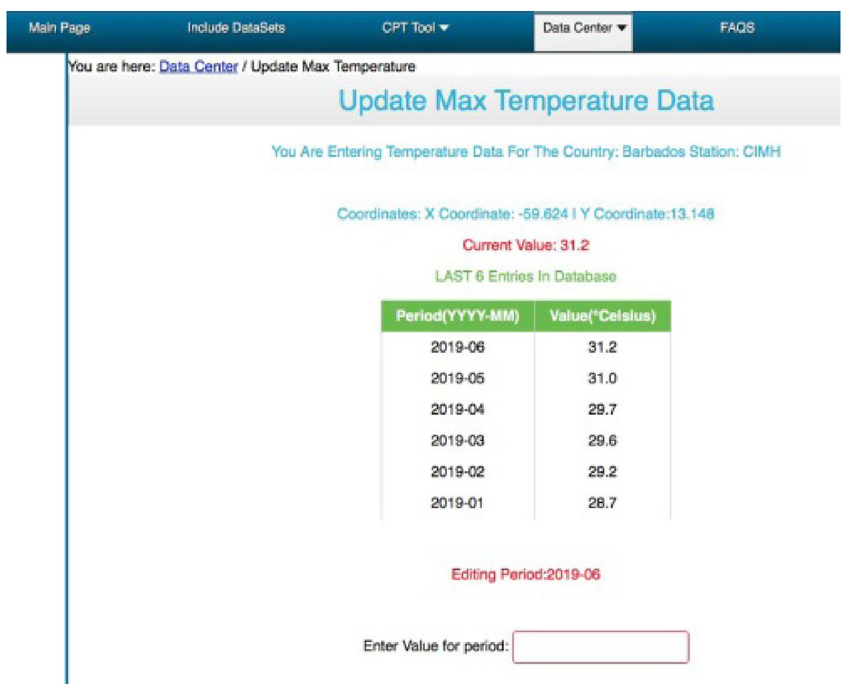


3.3.1.2 UPDATE MONTHLY DATA AND UPDATE DAILY DATA

Update Daily Data/Update Monthly Data allows users to update CAROGEN's archived daily/monthly climate datasets archived by adding or changing the value for a single day/month.

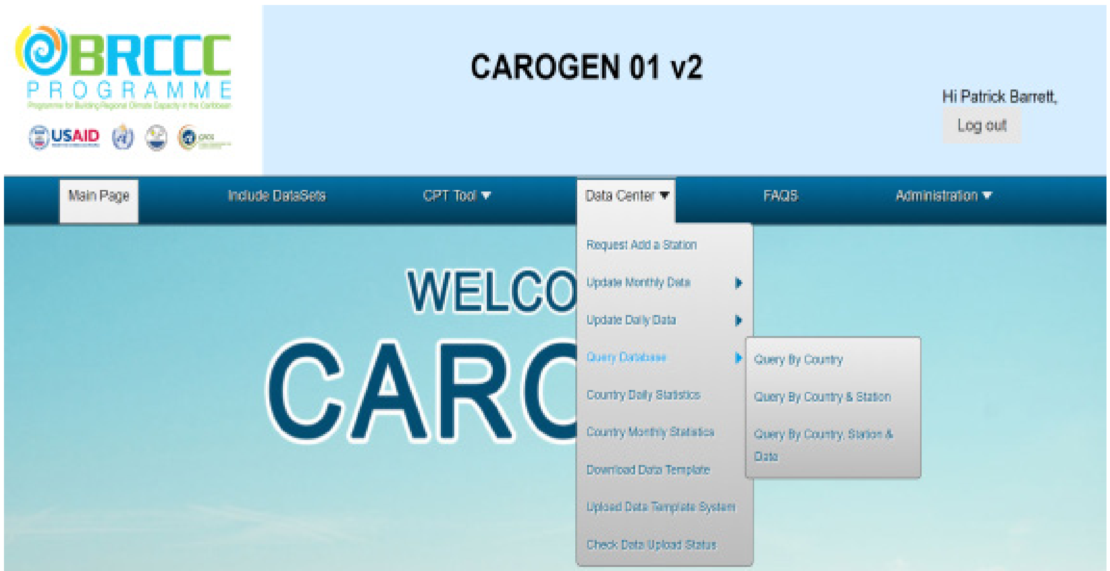
Pointing the cursor at **Update Daily Data/Update Monthly Data** releases a cascading menu of the monthly climate datasets (top picture). After clicking the dataset to be updated, the user is prompted to **Select Your Country**, then **Select A Station** and finally **Select Period** for the data to be entered. Having specified the exact data point to be updated, the user is then prompted to click **Enter Data**. Clicking **Enter Data** sends the user to a page that displays the entire history of that specific dataset for that specific station and presents a box for the user to **Enter Value for period** (shown in the image to the right).

The procedure to Update Daily Data is the same as the procedure to Update Monthly Data.



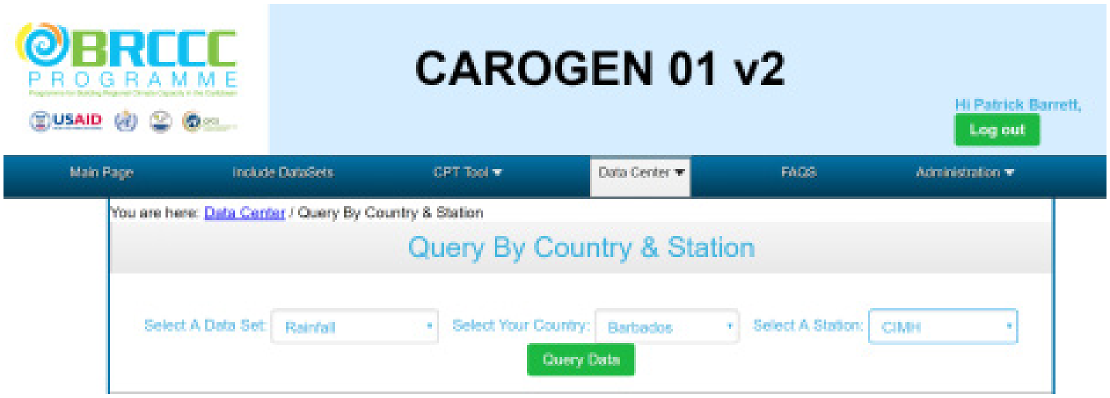
Note: Update Daily Data does not allow updating of daily data for an ongoing month, but can only be utilized to update the daily record up until the end of the previous month.

3.3.1.3 QUERY DATABASE



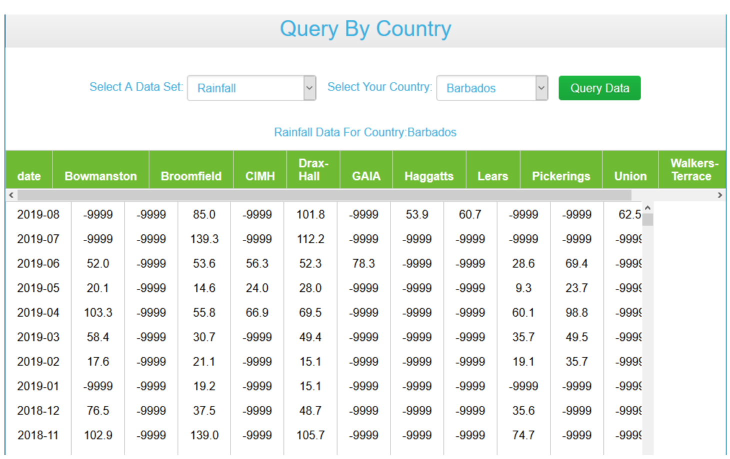
Query Database allows users to view entire or portions of selected monthly datasets from CAROGEN's data archive. Query Database provides users with the options of either (i) **Query By Country** (ii) **Query By Country & Station** or (iii) **Query by Country, Station and Date** (shown in the images below correspondingly). After selecting the type of query required, the user is prompted to entire the dataset of the query. Finally the user is prompted to enter the appropriate specificities of the query.

AN EXAMPLE OF QUERY BY COUNTRY: QUERY RAINFALL DATA FOR BARBADOS *(shown in the above image)*



AN EXAMPLE OF QUERY BY COUNTRY & STATION: QUERY RAINFALL FOR CIMH CLIMATE STATION, BARBADOS *(shown in the above image)*

EXAMPLE OF QUERY BY COUNTRY, STATION AND DATE: QUERY RAINFALL FOR CIMH, BARBADOS FOR THE MONTH OF JULY, 2007 *(shown in the image above)*



Query By Country

Select A Data Set: Rainfall Select Your Country: Barbados Query Data

Rainfall Data For Country:Barbados

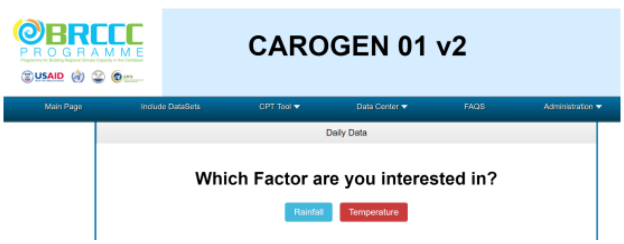
date	Bowmanston	Broomfield	CIMH	Drax-Hall	GAIA	Haggatts	Lears	Pickerings	Union	Walkers-Terrace	
2019-08	-9999	-9999	85.0	-9999	101.8	-9999	53.9	60.7	-9999	-9999	62.5
2019-07	-9999	-9999	139.3	-9999	112.2	-9999	-9999	-9999	-9999	-9999	-999
2019-06	52.0	-9999	53.6	56.3	52.3	78.3	-9999	-9999	28.6	69.4	-999
2019-05	20.1	-9999	14.6	24.0	28.0	-9999	-9999	-9999	9.3	23.7	-999
2019-04	103.3	-9999	55.8	66.9	69.5	-9999	-9999	-9999	60.1	98.8	-999
2019-03	58.4	-9999	30.7	-9999	49.4	-9999	-9999	-9999	35.7	49.5	-999
2019-02	17.6	-9999	21.1	-9999	15.1	-9999	-9999	-9999	19.1	35.7	-999
2019-01	-9999	-9999	19.2	-9999	15.1	-9999	-9999	-9999	-9999	-9999	-999
2018-12	76.5	-9999	37.5	-9999	48.7	-9999	-9999	-9999	35.6	-9999	-999
2018-11	102.9	-9999	139.0	-9999	105.7	-9999	-9999	-9999	74.7	-9999	-999

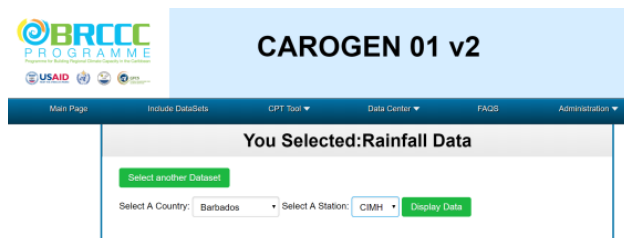
RESULT OF THE AFOREMENTIONED QUERY RAINFALL FOR BARBADOS
(shown in the image above)

3.3.1.4 COUNTRY DAILY STATISTICS AND COUNTRY MONTHLY STATISTICS

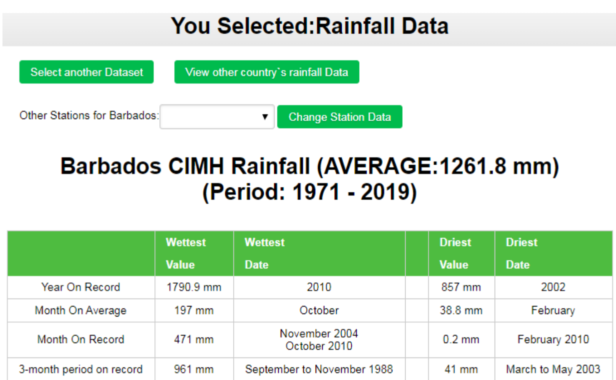
Country Daily Statistics and **Country Monthly Statistics** are the only 2 CAROGEN services that are accessible to unauthenticated (not logged on) users. Both services provide on-the-fly updated values whenever new data is entered or existing data is amended in the database. However, the daily statistics functionality here is currently not as useful as can be. This will be remediated in an ensuing version of CAROGEN. By contrast, the country monthly statistics elaborated on below form a much more mature tool with a variety of useful climate information at each station in the database.

Country Monthly Statistics first prompts the user to select the dataset (shown in the below image on the left) for the required statistics, and then presents a form for the user to enter the country and station (shown in the below image on the right).

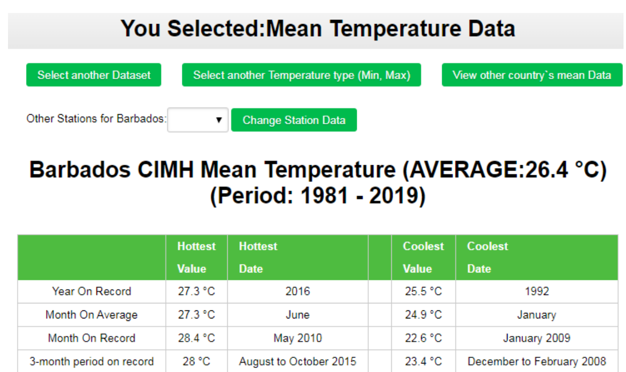




Clicking display data takes the user to a page displaying statistical data for the selected dataset and station. The following images represent the Country Monthly Statistics for CIMH, Barbados for the data types rainfall and mean temperature.

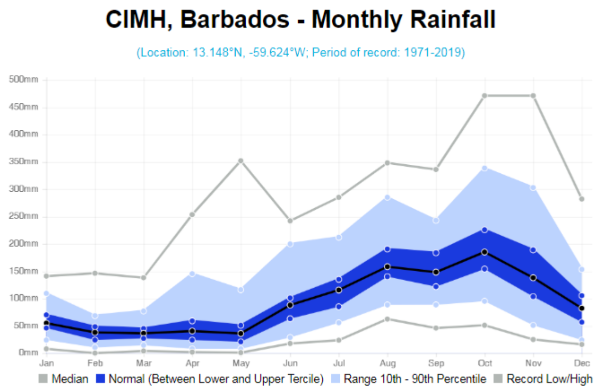


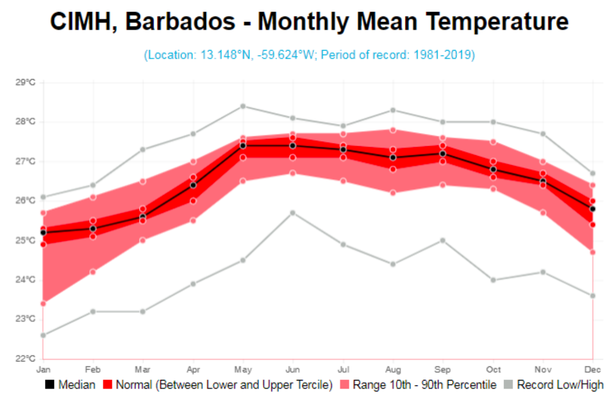
	Wettest Value	Wettest Date	Driest Value	Driest Date
Year On Record	1790.9 mm	2010	857 mm	2002
Month On Average	197 mm	October	38.8 mm	February
Month On Record	471 mm	November 2004 October 2010	0.2 mm	February 2010
3-month period on record	961 mm	September to November 1988	41 mm	March to May 2003



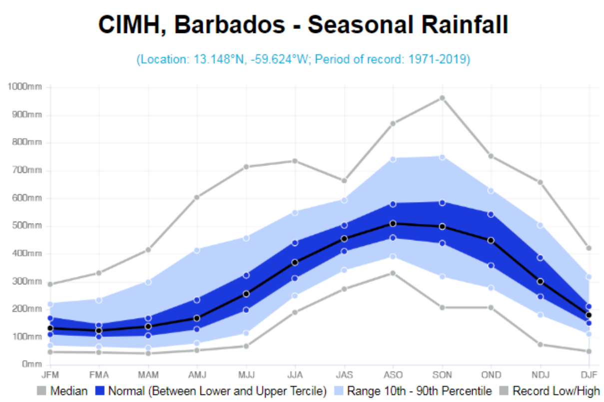
	Hottest Value	Hottest Date	Coolest Value	Coolest Date
Year On Record	27.3 °C	2016	25.5 °C	1992
Month On Average	27.3 °C	June	24.9 °C	January
Month On Record	28.4 °C	May 2010	22.6 °C	January 2009
3-month period on record	28 °C	August to October 2015	23.4 °C	December to February 2008

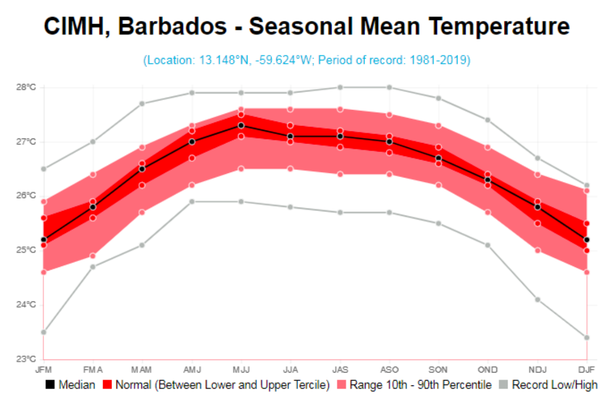
- The instance of the wettest and driest (hottest and coolest) singular year, singular month and average month within the record for rainfall (temperature) (shown in the images below).





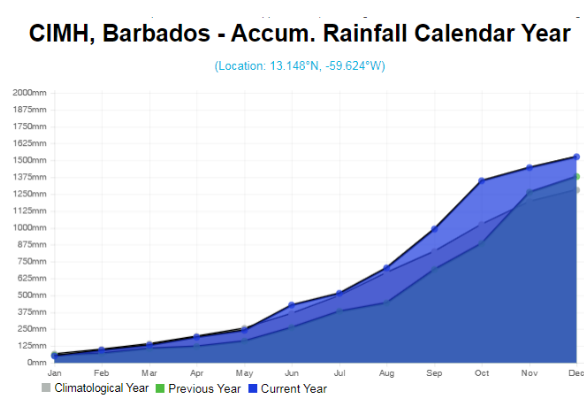
- The monthly median, normal between the lower and upper tercile, 10th and 90th percentile range and the record low and high for the selected data type (shown in the images below).





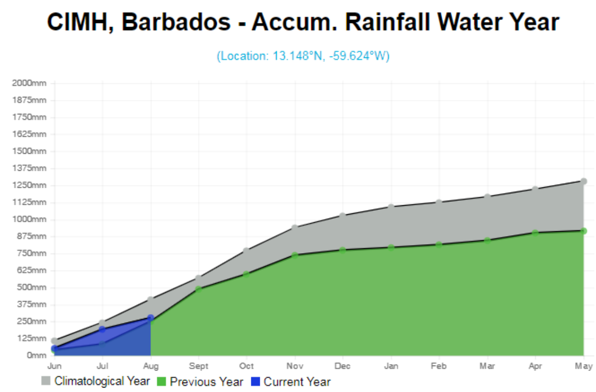
- The seasonal median, normal between the lower and upper tercile, 10th and 90th percentile range and the record low and high for the selected data type (shown in the images below).

ACCUMULATES RAINFALL OVER THE CALENDAR YEAR (JAN-DEC) FOR CIMH, BARBADOS ▶

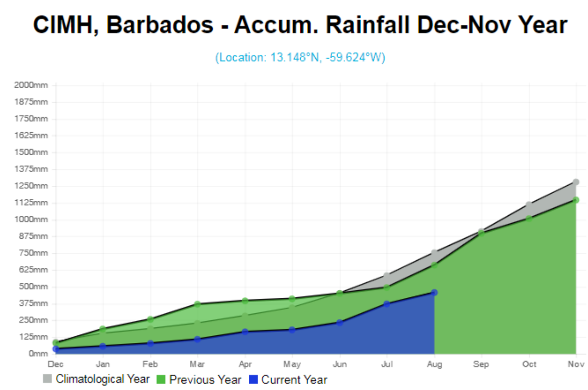


- The current, previous and climatological year accumulated rainfall for the year defined by periods (1) January to December (calendar year) (2) June to May (water year) (3) December to November (shown in the images below).

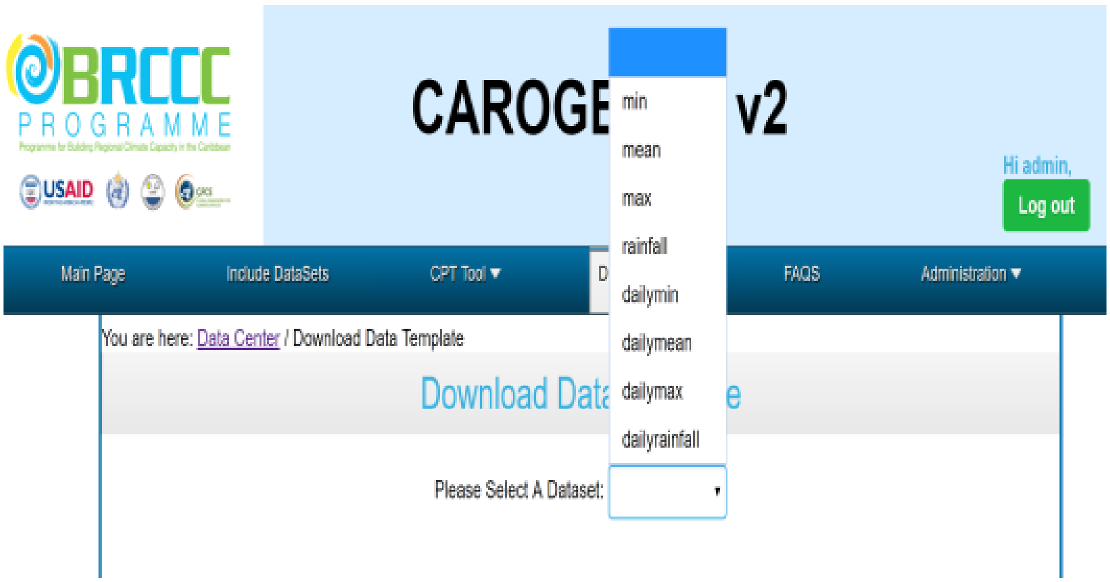
ACCUMULATES RAINFALL OVER THE WATER YEAR (JUN-MAY) FOR CIMH, BARBADOS ▶



ACCUMULATES RAINFALL OVER THE PERIOD FROM DEC-NOV FOR CIMH, BARBADOS ▶



3.3.1.5 DOWNLOAD DATA TEMPLATE



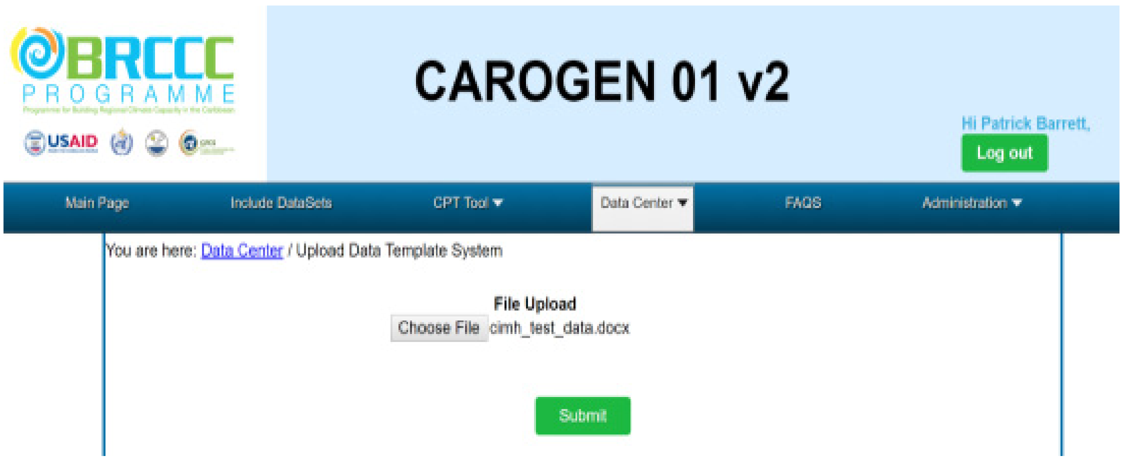
Download Data Template provides users a more efficient method to update a dataset for a specific station with multiple data points as opposed to **Update Daily Data** and **Upload Monthly Data**. Firstly, the user is provided a dropdown box to **Please Select A Dataset**. Following this, the user is provided a dropdown box to **Please Select A Country**. After selecting a country, the user is provided a series of dropdown boxes allowing them to add/drop the required station (s) for their specific CariCOF territory, then **Confirm Selection**.

Following **Confirm Selection**, the user is provided an icon to **Generate Template** which provides a downloadable .txt file is the form "country name"_"dataset" _CPT_File (shown in the below image). In this data template, the user is required to fill in missing fields, indicated by *, with the data points for the selected dataset and upload the data template using **Upload Data Template System**.

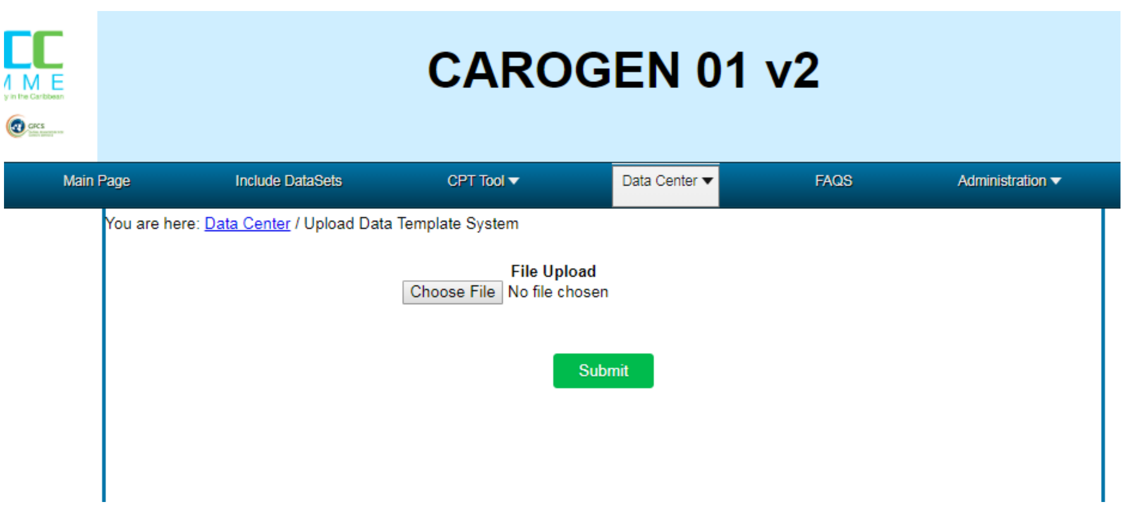
1	CAROGEN-Template-File-V1	
2	xmlns:cpt=http://iri.columbia.edu/CPT/v10/	
3	cpt:nfields=1	
4	cpt:field=tmax, cpt:nrow=584, cpt:ncol=1, cpt:row=T, cpt:col=station, cpt:units=C, cpt:missing=-9999	
5		Barbados_CIMH
6	cpt:X	-59.624
7	cpt:Y	13.148
8	1971-01	*
9	1971-02	*
10	1971-03	*
11	1971-04	*
12	1971-05	*
13	1971-06	*
14	1971-07	*
15	1971-08	*
16	1971-09	*
17	1971-10	*
18	1971-11	*

DATA TEMPLATE FOR BARBADOS WITH DATA POINTS TO BE FILLED IN INDICATED BY * *(shown in image above)*

3.3.1.6 UPLOAD DATA TEMPLATE SYSTEM



Upload Data Template System allows users to upload a completed data template from their device into CAROGEN's data archive.

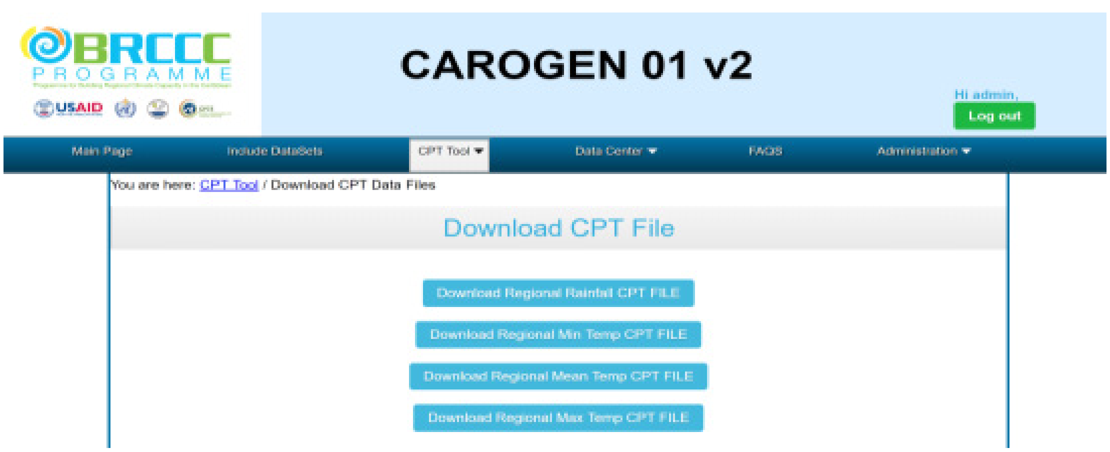


3.2.1.7 CHECK DATA UPLOAD STATUS

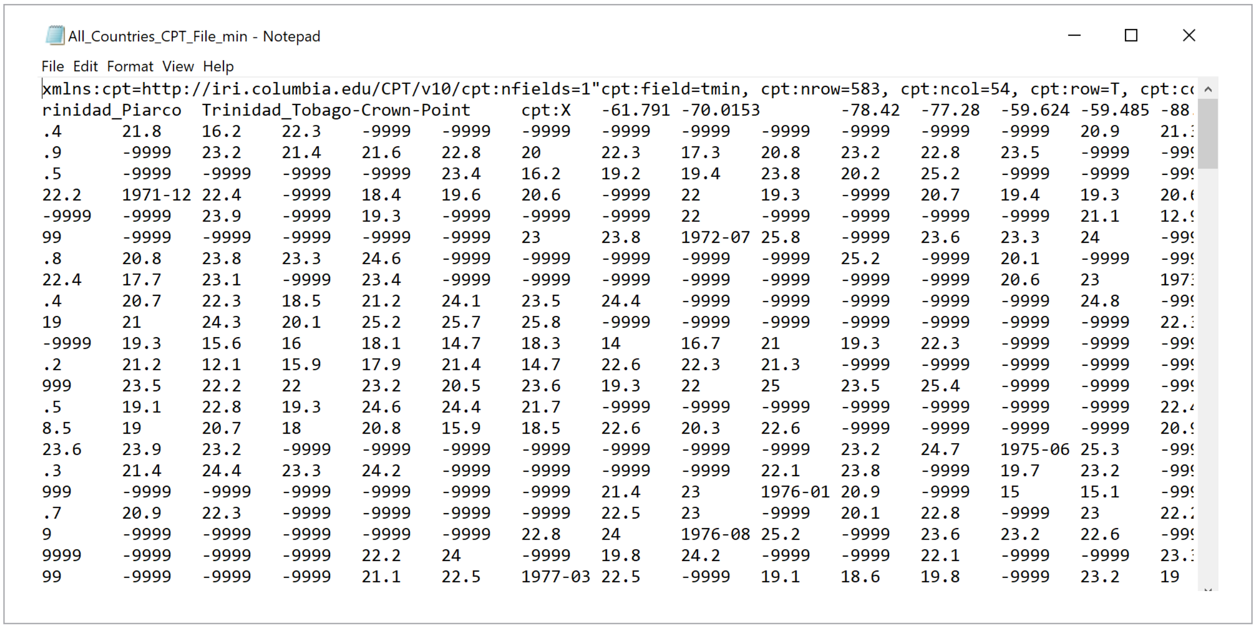
Check Data Upload Status allows users to see the status of a data template uploaded using **Upload Data Template System**.

3.3.2 CPT TOOL

3.3.2.1 DOWNLOAD CPT DATA



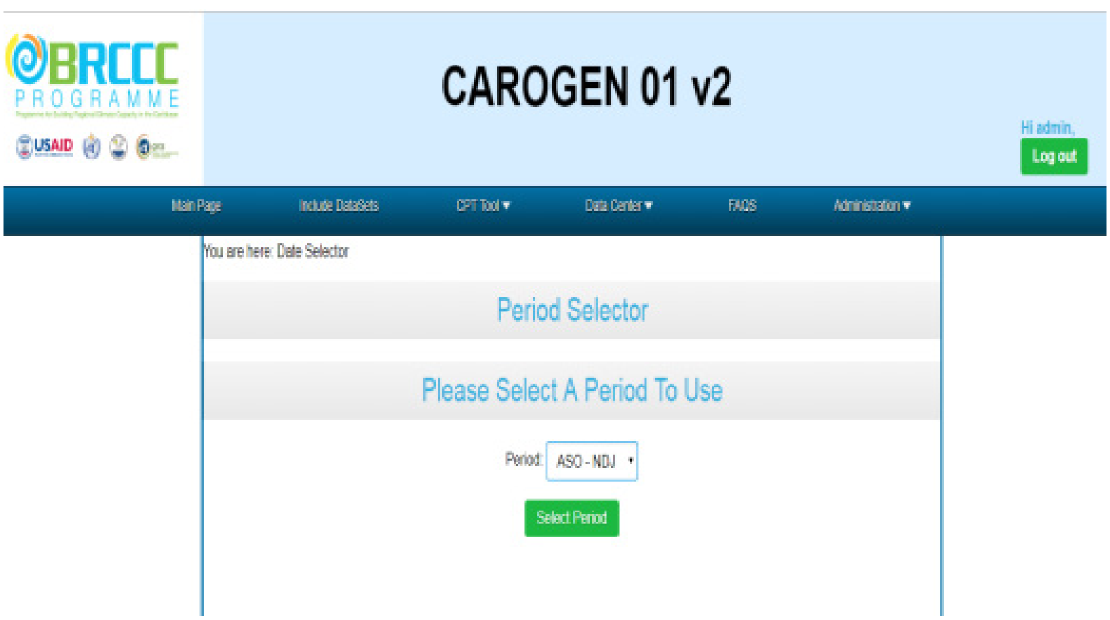
Download CPT Data allows users to download the entire datasets for all countries and stations within CAROGEN's data archive (shown in the image below), serving as the predictands variables for CPT.



```
All_Countries_CPT_File_min - Notepad
File  Edit  Format  View  Help
xmlns:cpt=http://iri.columbia.edu/CPT/v10/cpt:nfields=1"cpt:field=tmin, cpt:nrow=583, cpt:ncol=54, cpt:row=T, cpt:c
rinidad_Piarco  Trinidad_Tobago-Crown-Point     cpt:X   -61.791 -70.0153        -78.42  -77.28  -59.624 -59.485 -88
.4      21.8    16.2    22.3    -9999   -9999   -9999   -9999   -9999   -9999   -9999   -9999   -9999   20.9    21.
.9      -9999   23.2    21.4    21.6    22.8    20      22.3    17.3    20.8    23.2    22.8    23.5    -9999   -99
.5      -9999   -9999   -9999   -9999   23.4    16.2    19.2    19.4    23.8    20.2    25.2    -9999   -9999   -99
22.2    1971-12 22.4    -9999   18.4    19.6    20.6    -9999   22      19.3    -9999   20.7    19.4    19.3    20.
-9999   -9999   23.9    -9999   19.3    -9999   -9999   -9999   22      -9999   -9999   -9999   -9999   21.1    12.
99      -9999   -9999   -9999   -9999   -9999   23      23.8    1972-07 25.8    -9999   23.6    23.3    24      -99
.8      20.8    23.8    23.3    24.6    -9999   -9999   -9999   -9999   -9999   25.2    -9999   20.1    -9999   -99
22.4    17.7    23.1    -9999   23.4    -9999   -9999   -9999   -9999   -9999   -9999   -9999   20.6    23      197
.4      20.7    22.3    18.5    21.2    24.1    23.5    24.4    -9999   -9999   -9999   -9999   -9999   24.8    -99
19      21      24.3    20.1    25.2    25.7    25.8    -9999   -9999   -9999   -9999   -9999   -9999   -9999   22.
-9999   19.3    15.6    16      18.1    14.7    18.3    14      16.7    21      19.3    22.3    -9999   -9999   -99
.2      21.2    12.1    15.9    17.9    21.4    14.7    22.6    22.3    21.3    -9999   -9999   -9999   -9999   -99
999     23.5    22.2    22      23.2    20.5    23.6    19.3    22      25      23.5    25.4    -9999   -9999   -99
.5      19.1    22.8    19.3    24.6    24.4    21.7    -9999   -9999   -9999   -9999   -9999   -9999   -9999   22.
8.5     19      20.7    18      20.8    15.9    18.5    22.6    20.3    22.6    -9999   -9999   -9999   -9999   20.
23.6    23.9    23.2    -9999   -9999   -9999   -9999   -9999   -9999   -9999   23.2    24.7    1975-06 25.3    -99
.3      21.4    24.4    23.3    24.2    -9999   -9999   -9999   -9999   22.1    23.8    -9999   19.7    23.2    -99
999     -9999   -9999   -9999   -9999   -9999   -9999   21.4    23      1976-01 20.9    -9999   15      15.1    -99
.7      20.9    22.3    -9999   -9999   -9999   -9999   22.5    23      -9999   20.1    22.8    -9999   23      22.
9       -9999   -9999   -9999   -9999   -9999   22.8    24      1976-08 25.2    -9999   23.6    23.2    22.6    -99
9999    -9999   -9999   -9999   22.2    24      -9999   19.8    24.2    -9999   -9999   22.1    -9999   -9999   23.
99      -9999   -9999   -9999   21.1    22.5    1977-03 22.5    -9999   19.1    18.6    19.8    -9999   23.2    19
```

MINIMUM TEMPERATURE DATASET DOWNLOADED FROM CAROGEN'S DATA ARCHIVE

3.3.2.2 PRE-SET NATIONAL OUTLOOK

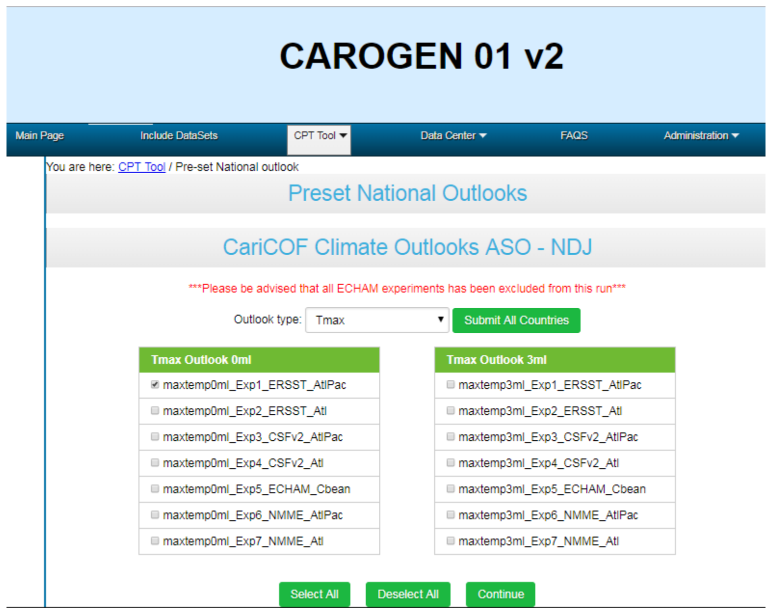


Pre-set National Outlook allows users to set the conditions required by CPT Tool to Generate Outlook Maps for the user's specific CariCOF Territory. The conditions required are predictor, predictand and period for the model prediction. To accomplish all this Pre-set National Outlook must be clicked twice, first to select the period for the model run (shown in above image) then secondly to select the predictand followed by the predictor for the model run.

Each execution of Pre-set National Outlook allows CPT to generate up to 7 models, each m model predicting the selected predictand by 1 of 7 pre-set GCM model variables (shown in below image).

NB: At this time Experiments 2,3 and 7 are disabled due to issues of data availability.

EXAMPLE OF A PRE-SET FOR A MODEL RUN PREDICTING THE MAXIMUM TEMPERATURE AS A FUNCTION OF THE SEAS SURFACE TEMPERATURES WITHIN THE ATLANTIC AND PACIFIC OCEANS ▶



3.3.2.3 VIEW SUBMITTED REQUESTS

View Submitted Requests allow users to view the status for their selected CPT model run based on the input conditions selected in Pre-set National Outlook.

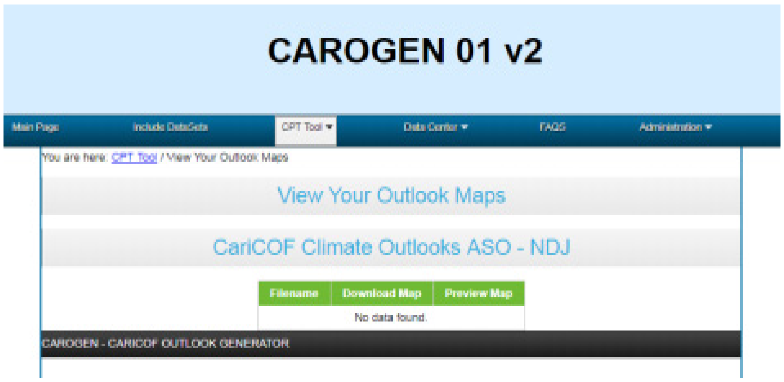
3.3.2.4 ACCEPT/REJECT RESULTS

Accept/Reject Results allows users to accept or reject the output results of the completed requested CPT model runs. Once accepted, CAROGEN allows users to from Generate Outlook Maps successful CPT model runs.

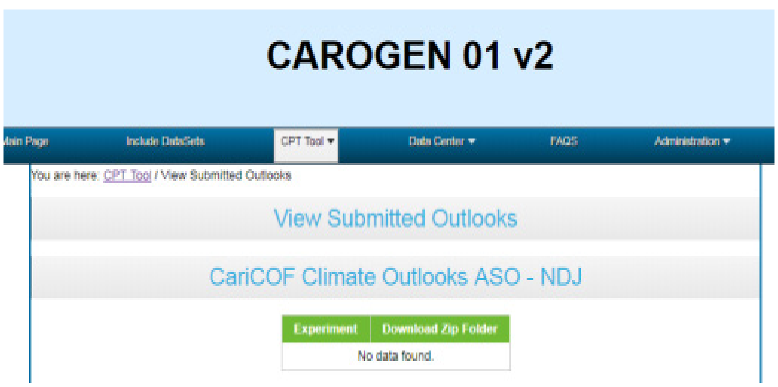
3.3.2.5 GENERATE OUTLOOK MAPS

Generate Outlook Maps allows users to generate outlook maps for their respective CariCOF territory using accepted successful CPT model runs.

3.3.2.6 VIEW YOUR OUTLOOK MAPS



View Your Outlook Maps allows users to download the generated outlook maps, from the most previous CPT model run, to their device.



View Submitted Outlooks allows users to view all outlooks for the time period selected in Pre-set National Outlook that have been generated by all CariCOF territories.

3.3.2.8 CPT EXPERIMENTAL SETUP

CariCOF regional and national outlook experiments in CPT - Experimental Setup

1. Rainfall and Temperature Outlook Experiments

1.1. *Zero (0) Month Lead*

Forecast Period (0 month Lead)	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	DJF
Forecast done in	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**
Observed SST (NOAA ERSST v4)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Simulated SST (NOAA CFSv2 and NMME ensemble mean) initial conditions	Decic JFM	Janic FMA	Febic MAM	Maric AMJ	Apric MJJ	Mayic JJA	Junic JAS	Julic ASO	Augic SON	Sepic OND	Octic NDJ	Novic DJF
Simulated rainfall totals (ECHAM4.5)	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	DJF
1st month of season to forecast	1	2	3	4	5	6	7	8	9	10	11	12
Length of season	3	3	3	3	3	3	3	3	3	3	3	3
Add persistence	No	No	No	No	No	No	No	No	No	No	No	No

CPT Experimental Setup is an information page, displaying the set up of predictand (s), predictor (s) and time periods used by CAROGEN to run the CPT model.

4 ADDITIONAL SERVICES PROVIDED BY THE CARIBBEAN REGIONAL CLIMATE CENTRE

4.1 TEMPLATE: PRESENTING REGIONAL OR NATIONAL CLIMATE OUTLOOKS AT A REGIONAL CLIMATE OUTLOOK FORUM OR NATIONAL CLIMATE OUTLOOK FORUMS

The following template serves as a tutorial for presenting regional or national climate outlooks at a Regional Climate Outlook Forum (RCOF) or National Climate Outlook Forum (NCOF). It has evolved from continuous improvements in the delivery of climate outlook presentations during the years 2012 through 2017 at the CariCOF. As such, the examples given for the segments of this template are taken from different CariCOF sessions throughout the stated period.

Contextualizing the presented topic from the audience's perspective is essential to any delivery. Climate outlook presentations are not usually meant primarily for scientists but for organizations and shareholders. By employing the style of a news report, the story line that unfolds from the presentation modelled within this template:

- Hooks the audience onto the climate and climate impacts information to be presented using key messages.
- Highlights and discusses the state of the climate system, its drivers and resulting climate events prior to the forecast period.
- Highlights the climate conditions that generally prevail over the forecast period and discuss whether the current state of drivers indicates any deviations.
- Provides information on the climate conditions, likely climate events and possible impacts of these events predicted to occur over the forecast period.
- Accounts for deviations in the predicted climate conditions by discussing changes in the state of the climate drivers that would result in the forecast.
- Provides information on source material for these forecasts, i.e. climate outlooks.

The following effective outline (further detailed in Table 4.1.1) forms the main topics and sub-topics for presenting regional or national climate outlooks at RCOFs or NCOFs:

- Key Messages
- Looking Back
  - Recently in the news
  - Climatic drivers
  - Recent climate events
  - Current state of the climate system
- What's Next
  - What usually happens
  - What about the drivers at this time
  - The forecast
  - Expected Impact
- Summary of outlooks

TABLE OF THE MAIN AND SUB TOPICS OF THE TEMPLATE FOR PRESENTING REGIONAL OR NATIONAL CLIMATE OUTLOOKS AT RCOFS AND NCOFS

SECTION	SUBSECTION	QUESTION ADDRESSED	PURPOSE
Key Messages		What should we be concerned with in the coming months?	Provide the main points of information that clarify meaning. Provide the takeaway headlines you want from the information provided.
Looking Back	Recently in the news	What have we really been concerned with?	Highlight some recent news topics surrounding recent climate impacts within the region or country being discussed.
	Climatic Drivers	Why did it happen now?	Explain the known climatic drivers and their state of activity during the recent period.
	Recent Climate Events	What about the recent climate conditions make those events unfold?	Visualize how the news worthy climate impacts came about. Present an effective way of increasing climate literacy within the audience with authority and credibility.
	Current State of the Climate	Where are we now?	Visualize the starting point of the evolution of the climate over the period being addressed by the presentation.
What's Next	What Usually Happens	What do we usually expect in the coming season?	Provide the audience with the information and understanding of the predicted climate events and their impacts. Ensure that these conditions are framed from the reference point of the prevailing climate conditions over the period of time covered by the forecast.
	What about the Drivers at the this time	Can we expect something different than usual in the coming season?	Point the audience to trends in the current and future states of the climatic drivers responsible for the predicted climate conditions.
	The Forecast	How long will the coming season play out different than usual?	Present the climatic events, and their generally associated impacts, predicted to unfold over the related period
Summary of Outlooks			Display Climate outlooks covering the forecast period Provide key points on the implications of as well the feedback on the outlooks

4.2 NATIONAL CLIMATE BULLETIN TEMPLATE

The following serves as a template for the creation of national climate bulletins.

1 | Wakanda Monthly Bulletin

WAKANDA MONTHLY CLIMATE BULLETIN

Vol 1 | Issue 0 November 2018

The Wakanda national climate bulletin provides a broad overview of current climate conditions, as well as, an outlook of climate conditions up to 3 months in advance. The information is developed and disseminated by the Wakanda National Met Service and is intended to help [insert range of users here] manage climate risk and help build resilience to climate related hazards in Wakanda.

Highlights or Key Messages

November 30th marks the official end of the North Atlantic hurricane season.

Fewer chances of drought events in the upcoming season except for northern Wakanda where long-term drought may be of concern.

Conditions in Wakanda ranged from normal in extreme western areas to exceptionally dry in the east

The last month saw cooler temperatures than was forecasted in the eastern sections of the island.

Flooding in northern sections of the island on displaced hundreds.

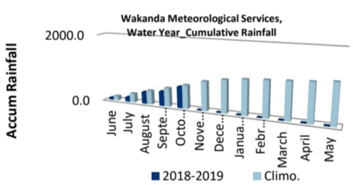
Figure 3: Flooding in Wakanda (October 2018)

Temperature Review

Temp (°C)	Climatological Mean (1981-2010)	October Highest	October Lowest
Monthly Max	31.0	32.8	29.5
Monthly Min	25.2	27.5	22.5
Monthly Mean	27.9	29.1	25.7

The average daytime maximum temperature (30.6 °C) at Diamond Point was below the long-term average (1985 – 2017) which stands at 31.0 °C.

Looking Back or What Happened? (October 2018) Rainfall review:



Above the usual amount of rainfall was accumulated for the season. The month of October brought two significant wet spells (7th – 9th and 16th – 22nd) to Wakanda and the wider southeast Caribbean. After consecutive days of rain, minor flooding and landslide were reported in northern Wakanda while during the same wet spells, neighboring islands Pearl and Ruby experienced devastating flooding.

Troughs dominated the daily weather for most days in October. There was a report of violent winds lifting the roofs from three buildings, in communities in St. Diamond on the afternoon of October 9, as a Tropical Wave moved across the island.

www.wakandametservice.com 800-858-4795 climsection@wakanda.com

2 | Wakanda Monthly Bulletin

Looking Forward or Outlook or What Should We Expect? (November-December-January 2018)

Precipitation: The usual rainfall range for November to January at Diamond Point is 292.0 – 375.8 mm. November 2018 to January 2019 below the usual rainfall is anticipated.

Frequency of wet days: Historically, out of the 92 days in Nov – Dec – Jan, there are about 35 to 50 wet days. The forecast indicates slightly fewer wet days for Wakanda.

Frequency of 7 – day wet spells: Between 2 and 5 wet spells occur from November to January. The forecast indicates slightly fewer wet spells for Wakanda.

Frequency of extreme (top 1%) 3 – day wet spells: The forecast indicates the number of extreme wet spells might be slightly close to the usual 1 or 2.

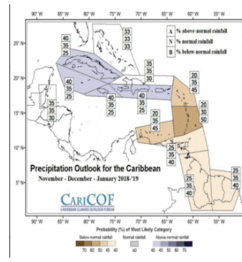


Figure 4: CariCOF Precipitation Outlook

Precipitation: The usual rainfall range for November to January at Diamond Point is 292.0 – 375.8 mm. November 2018 to January 2019 below the usual rainfall is anticipated.

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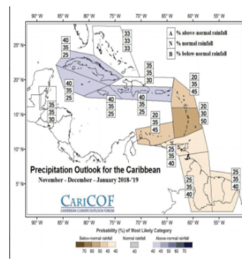


Figure 4: CariCOF Precipitation Outlook

Drought: The south of the island could experience possible short term drought during the first half of the dry season. There is no concern for long term drought.

El Niño Southern Oscillation (ENSO) Update

Recent observations: In recent months, sea-surface temperatures (SSTs) in the equatorial eastern Pacific (NINO3.4) have increased to around 0.4°C above average, meaning warm neutral ENSO conditions. Model forecast and guidance: Most models suggest ENSO conditions to evolve into a weak or moderate El Niño (with 70-90% and 65-90% confidence for NDJ and FMA, respectively). Expected impacts on rainfall and temperatures: An El Niño state will tend to tilt the odds to drier conditions with less shower activity.

Find out more about climate conditions in the Caribbean region by reading the CariCOF Outlook Newsletter http://rcc.cimh.edu.bb/caribbean-climate-outlook-newsletter/

Disclaimer: The Wakanda National Climate Bulletin is meant to provide a general summary of current climate conditions and an outlook of future seasonal climate conditions for Wakanda as well as some implications for the agriculture, health and tourism sectors. The information contained herein is provided with the understanding that the Wakanda Met Services makes no warranties, either expressed or implied, concerning the accuracy, completeness, reliability or suitability of said information and takes no responsibility for improper use or interpretation of the Bulletin.

Bulletin content, structure and design conceptualised by the Caribbean Institute for Meteorology and Hydrology with further design support from the Investment Plan for the Caribbean Regional Track of the Pilot Programme for Climate Resilience

Forecast Implication and Guidance/Advice for Tourism

Although drought is not expected to be a major concern there is still the possibility of drier than usual conditions. Tourism facilities should continue to engage in precautionary water conservation practices (e.g. rainwater harvesting and repairs to leaky pipes) and advise guests of these measures on an ongoing basis.

The UV index will initially be very high on sunny days, but will decrease towards December. There is a high risk of skin damage on sunny days due to intense UV radiation. Tourists should be encouraged to apply high SPF sunscreen lotion regularly (preferably reef safe), and seek shaded areas between the hours of 10 AM and 3 PM. Staff should also be mindful to minimise skin exposure during these times, and to wear sunscreen if they frequently work outdoors.

Thanks to slightly cooler ocean temperatures than in recent years, coral bleaching is not presently expected to be a widespread issue.

Find out more about the implications for the Tourism sector regionally by reading the Caribbean Health-Climatic Bulletin http://rcc.cimh.edu.bb/caribbean-tourism-climatic-bulletin/

Forecast Implication and Guidance/Advice for

The island may experience heatwave days of up to 14 days duration. This can give rise to heat stress in crops, livestock and even for the farmer.

With the favourable chance of increased day and night-time temperatures, heat stress is a likely factor to consider from heat waves. Guard against heat stress for livestock, crops and yourselves by:

- Ensuring livestock are kept cool by providing cool and clean drinking water; establishing/locating shading for livestock such as: cows, sheep, goat
- Ensuring cooling systems such as fans are in place and good ventilation available for poultry houses
- Keeping irrigation equipment ready to apply water as necessary to cropping systems
- Keeping hydrated, taking frequent breaks, and resting in the shade

Find out more about the implications for the agriculture sector regionally by reading the Caribbean Agro-Climatic Bulletin http://rcc.cimh.edu.bb/carisam-bulletin/

Forecast Implication and Guidance/Advice for Health

Non-communicable Diseases
During the period, excessive exposure due to dangerous UV radiation can cause skin damage across the population on sunny day

Vector-Borne Illness
There may be accelerated mosquito proliferation in communities where water is stored in containers without protective mesh, or accumulating in any unattended, open containers.

Respiratory Illness
Where episodes of flooding may occur, there is increased risk of Leptospirosis and ENT infections from contact with contaminated water

Gastrointestinal Illness
Where episodes of flooding may occur, cases of gastroenteritis may increase resting in the shade

Well-Being and Mental Health
Health systems and infrastructure in countries affected by Hurricanes during the 2017 season may still be undergoing recovery and may be unable to fully support the health related needs of their populations.

Find out more about the implications for the Health sector regionally by reading the Caribbean Health-Climatic Bulletin http://rcc.cimh.edu.bb/caribbean-health-climatic-bulletin/

Bulletin content, structure and design conceptualised by the Caribbean Institute for Meteorology and Hydrology with further design support from the Investment Plan for the Caribbean Regional Track of the Pilot Programme for Climate Resilience

4.3 CLIMATE BULLETINS

The following climate bulletins are provided by the Caribbean RCC:

- Caribbean Agro-climatic Bulletin of CariSAM
- Coral Reef Watch
- Caribbean Drought Bulletin
- Caribbean Health Climatic Bulletin
- Caribbean Tourism Climatic Bulletin

4.3.1 CARIBBEAN AGRO-CLIMATIC BULLETIN OF CARISAM

Webpage for the bulletin of the Caribbean RCC Caribbean Society for Agricultural Meteorology (CariSAM): *http://rcc.cimh.edu.bb/carisam-bulletin/*

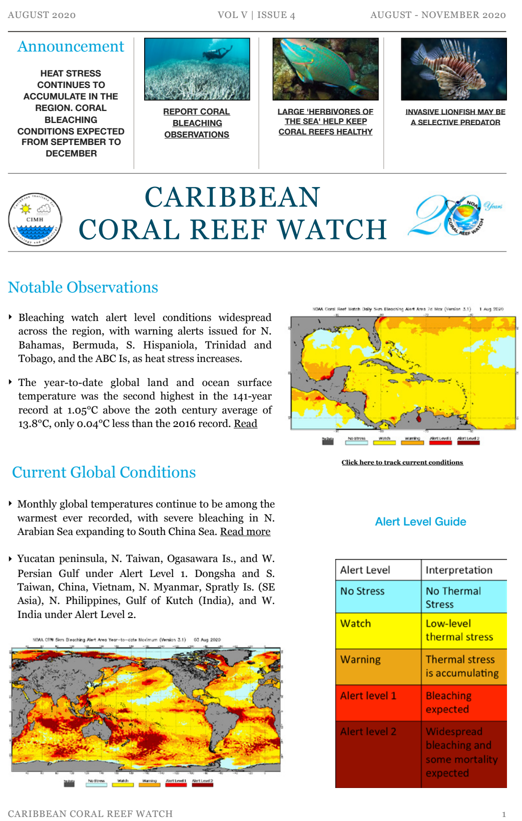
The bulletin of the Caribbean Society for Agricultural Meteorology (CariSAM) replaces the bulletin of the Caribbean Agro-Meteorological Initiative (CAMI). This bulletin is prepared by CIMH in collaboration with the Caribbean Agricultural Research and Development Institute (CARDI). The previous Agro-climatological Bulletin reported on significant pass and present weather and climatic conditions that are essential to agriculture at National, Regional and local levels.

Each issue of the CariSAM bulletin takes a look at the climate of the previous month, highlighting any agricultural impacts as well as provides climate smart information to the stakeholders. Climate products produced through CIMH's Regional Climate Centre such as its drought monitoring products as well as forecasting products (rainfall, temperature, and drought) are embedded within the bulletin for useful information to guide decision making and planning.

The National bulletins illustrate average extreme values of meteorological, agro-meteorological and hydro-meteorological elements, with information presented as graphs, tables, drawings, maps, satellite imagery and text. Some bulletins also give an overview of the state and phases of agricultural crops, forest plantation and farm animal development. They may also feature forecasted agro-climatological conditions with descriptions of their possible effects on developments and yield.

4.3.2 CORAL REEF WATCH

Webpage for the Caribbean RCC Coral Reef Watch: http://rcc.cimh.edu.bb/caribbean-coral-reef-watch/



AUGUST 2020 VOL V | ISSUE 4 AUGUST - NOVEMBER 2020

Announcement

HEAT STRESS CONTINUES TO ACCUMULATE IN THE REGION. CORAL BLEACHING CONDITIONS EXPECTED FROM SEPTEMBER TO DECEMBER

REPORT CORAL BLEACHING OBSERVATIONS

LARGE 'HERBIVORES OF THE SEA' HELP KEEP CORAL REEFS HEALTHY

INVASIVE LIONFISH MAY BE A SELECTIVE PREDATOR

CARIBBEAN CORAL REEF WATCH

Notable Observations

- Bleaching watch alert level conditions widespread across the region, with warning alerts issued for N. Bahamas, Bermuda, S. Hispaniola, Trinidad and Tobago, and the ABC Is, as heat stress increases.
- The year-to-date global land and ocean surface temperature was the second highest in the 141-year record at 1.05°C above the 20th century average of 13.8°C, only 0.04°C less than the 2016 record. Read

Click here to track current conditions

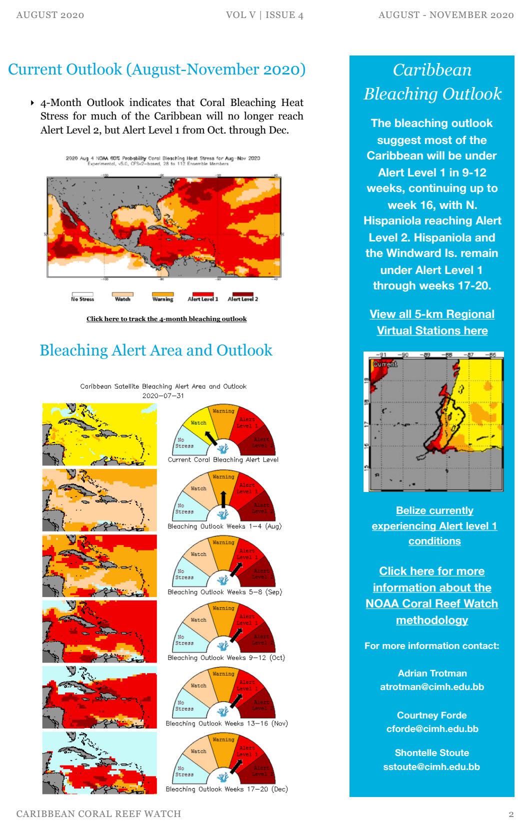
Current Global Conditions

- Monthly global temperatures continue to be among the warmest ever recorded, with severe bleaching in N. Arabian Sea expanding to South China Sea. Read more
- Yucatan peninsula, N. Taiwan, Ogasawara Is., and W. Persian Gulf under Alert Level 1. Dongsha and S. Taiwan, China, Vietnam, N. Myanmar, Spratly Is. (SE Asia), N. Philippines, Gulf of Kutch (India), and W. India under Alert Level 2.

Alert Level Guide

Alert Level	Interpretation
No Stress	No Thermal Stress
Watch	Low-level thermal stress
Warning	Thermal stress is accumulating
Alert level 1	Bleaching expected
Alert level 2	Widespread bleaching and some mortality expected

CARIBBEAN CORAL REEF WATCH 1



AUGUST 2020 VOL V | ISSUE 4 AUGUST - NOVEMBER 2020

Current Outlook (August-November 2020)

- 4-Month Outlook indicates that Coral Bleaching Heat Stress for much of the Caribbean will no longer reach Alert Level 2, but Alert Level 1 from Oct. through Dec.

Click here to track the 4-month bleaching outlook

Bleaching Alert Area and Outlook

Caribbean Satellite Bleaching Alert Area and Outlook 2020–07–31

Current Coral Bleaching Alert Level

Bleaching Outlook Weeks 1–4 (Aug)

Bleaching Outlook Weeks 5–8 (Sep)

Bleaching Outlook Weeks 9–12 (Oct)

Bleaching Outlook Weeks 13–16 (Nov)

Bleaching Outlook Weeks 17–20 (Dec)

Caribbean Bleaching Outlook

The bleaching outlook suggest most of the Caribbean will be under Alert Level 1 in 9-12 weeks, continuing up to week 16, with N. Hispaniola reaching Alert Level 2. Hispaniola and the Windward Is. remain under Alert Level 1 through weeks 17-20.

View all 5-km Regional Virtual Stations here

Belize currently experiencing Alert level 1 conditions

Click here for more information about the NOAA Coral Reef Watch methodology

For more information contact:

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Shontelle Stoute sstoute@cimh.edu.bb

CARIBBEAN CORAL REEF WATCH 2

Developed in collaboration with the NOAA's Coral Reef Watch, the Caribbean Coral Reef Watch tracks the current sea surface temperatures and the related coral reef health, globally and regionally. It maps regional thermal stress levels and coral bleaching potential with a lead time of 20 weeks.

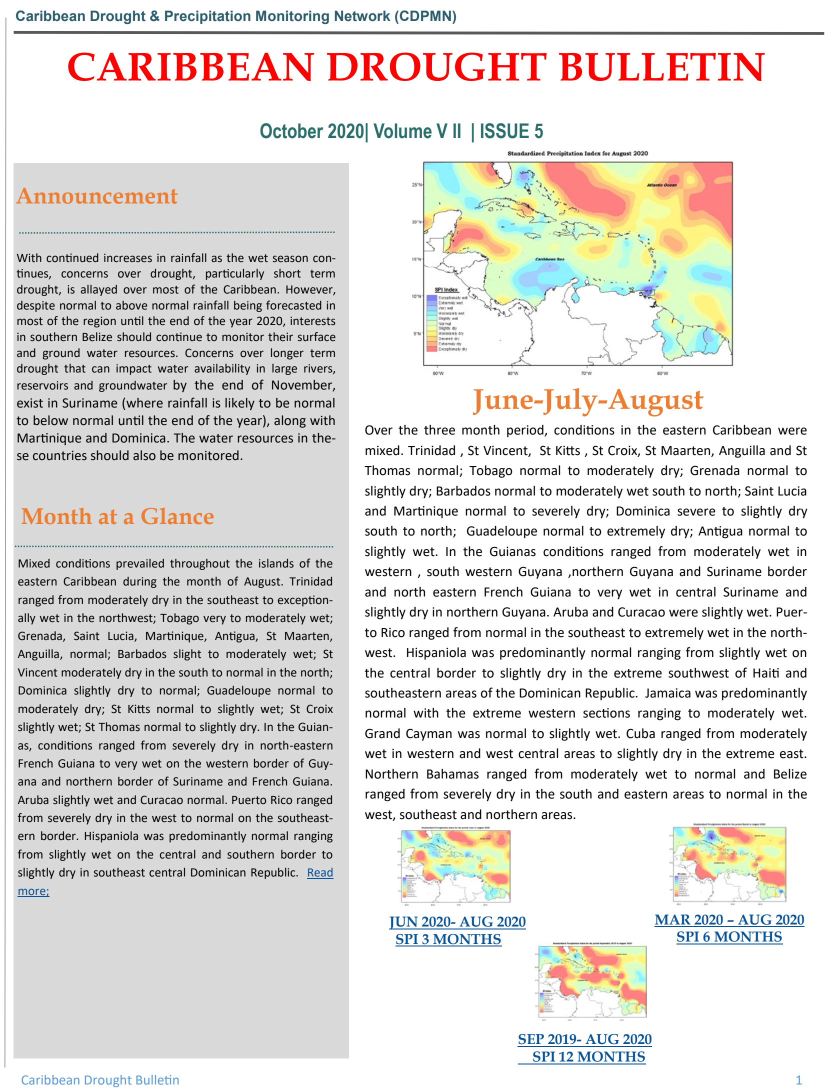
Also included in this early warning tool is a detailed outlook for countries most at risk of coral bleaching.

It is published between May and December to correspond with the season in which bleaching can occur.

Archive for Coral Reef Watch Bulletins: http://rcc.cimh.edu.bb/coral-reef-watch-archive/

4.3.3 CARIBBEAN DROUGHT BULLETIN

Webpage for the Caribbean RCC Caribbean Drought Bulletin: *http://rcc.cimh.edu.bb/drought-bulletin-caribbean/*



Caribbean Drought & Precipitation Monitoring Network (CDPMN)

CARIBBEAN DROUGHT BULLETIN

October 2020| Volume V II | ISSUE 5

Announcement

With continued increases in rainfall as the wet season continues, concerns over drought, particularly short term drought, is allayed over most of the Caribbean. However, despite normal to above normal rainfall being forecasted in most of the region until the end of the year 2020, interests in southern Belize should continue to monitor their surface and ground water resources. Concerns over longer term drought that can impact water availability in large rivers, reservoirs and groundwater by the end of November, exist in Suriname (where rainfall is likely to be normal to below normal until the end of the year), along with Martinique and Dominica. The water resources in these countries should also be monitored.

Month at a Glance

Mixed conditions prevailed throughout the islands of the eastern Caribbean during the month of August. Trinidad ranged from moderately dry in the southeast to exceptionally wet in the northwest; Tobago very to moderately wet; Grenada, Saint Lucia, Martinique, Antigua, St Maarten, Anguilla, normal; Barbados slight to moderately wet; St Vincent moderately dry in the south to normal in the north; Dominica slightly dry to normal; Guadeloupe normal to moderately dry; St Kitts normal to slightly wet; St Croix slightly wet; St Thomas normal to slightly dry. In the Guianas, conditions ranged from severely dry in north-eastern French Guiana to very wet on the western border of Guyana and northern border of Suriname and French Guiana. Aruba slightly wet and Curacao normal. Puerto Rico ranged from severely dry in the west to normal on the southeastern border. Hispaniola was predominantly normal ranging from slightly wet on the central and southern border to slightly dry in southeast central Dominican Republic. Read more;

Standardized Precipitation Index for August 2020

June-July-August

Over the three month period, conditions in the eastern Caribbean were mixed. Trinidad , St Vincent, St Kitts , St Croix, St Maarten, Anguilla and St Thomas normal; Tobago normal to moderately dry; Grenada normal to slightly dry; Barbados normal to moderately wet south to north; Saint Lucia and Martinique normal to severely dry; Dominica severe to slightly dry south to north; Guadeloupe normal to extremely dry; Antigua normal to slightly wet. In the Guianas conditions ranged from moderately wet in western , south western Guyana ,northern Guyana and Suriname border and north eastern French Guiana to very wet in central Suriname and slightly dry in northern Guyana. Aruba and Curacao were slightly wet. Puerto Rico ranged from normal in the southeast to extremely wet in the northwest. Hispaniola was predominantly normal ranging from slightly wet on the central border to slightly dry in the extreme southwest of Haiti and southeastern areas of the Dominican Republic. Jamaica was predominantly normal with the extreme western sections ranging to moderately wet. Grand Cayman was normal to slightly wet. Cuba ranged from moderately wet in western and west central areas to slightly dry in the extreme east. Northern Bahamas ranged from moderately wet to normal and Belize ranged from severely dry in the south and eastern areas to normal in the west, southeast and northern areas.

JUN 2020- AUG 2020
SPI 3 MONTHS

MAR 2020 – AUG 2020
SPI 6 MONTHS

SEP 2019- AUG 2020
SPI 12 MONTHS

Caribbean Drought Bulletin 1

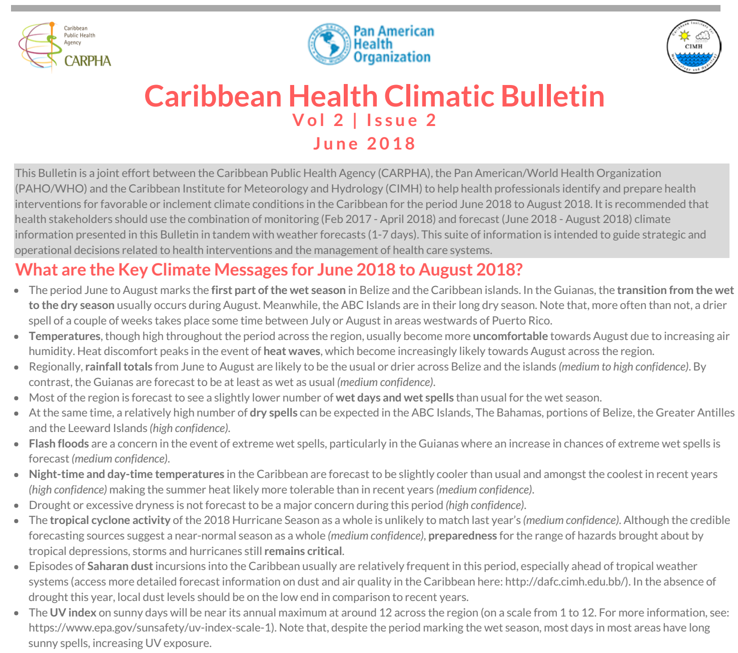
The Caribbean Drought Bulletin tracks how dry spells or droughts, and to a lesser extent excessive rainfall, have developed in the past few months and up to a year.

The Bulletin details drought situations at regional and national levels and for one-, three-, six- and 12-month time periods through short- and long-term drought outlooks and drought alert maps. Also included are headlines on drought impacts affecting the region’s climate-sensitive sectors.

Archive for Caribbean Drought Bulletins: *http://rcc.cimh.edu.bb/drought-bulletin-archive/*

4.3.4 CARIBBEAN HEALTH CLIMATIC BULLETIN

Webpage for the Caribbean Health Climatic Bulletin: *http://rcc.cimh.edu.bb/caribbean-health-climatic-bulletin/*



Caribbean Public Health Agency CARPHA

Pan American Health Organization

CIMH

Caribbean Health Climatic Bulletin

Vol 2 | Issue 2

June 2018

This Bulletin is a joint effort between the Caribbean Public Health Agency (CARPHA), the Pan American/World Health Organization (PAHO/WHO) and the Caribbean Institute for Meteorology and Hydrology (CIMH) to help health professionals identify and prepare health interventions for favorable or inclement climate conditions in the Caribbean for the period June 2018 to August 2018. It is recommended that health stakeholders should use the combination of monitoring (Feb 2017 - April 2018) and forecast (June 2018 - August 2018) climate information presented in this Bulletin in tandem with weather forecasts (1-7 days). This suite of information is intended to guide strategic and operational decisions related to health interventions and the management of health care systems.

What are the Key Climate Messages for June 2018 to August 2018?

- The period June to August marks the **first part of the wet season** in Belize and the Caribbean islands. In the Guianas, the **transition from the wet to the dry season** usually occurs during August. Meanwhile, the ABC Islands are in their long dry season. Note that, more often than not, a drier spell of a couple of weeks takes place some time between July or August in areas westwards of Puerto Rico.
- **Temperatures**, though high throughout the period across the region, usually become more **uncomfortable** towards August due to increasing air humidity. Heat discomfort peaks in the event of **heat waves**, which become increasingly likely towards August across the region.
- Regionally, **rainfall totals** from June to August are likely to be the usual or drier across Belize and the islands *(medium to high confidence)*. By contrast, the Guianas are forecast to be at least as wet as usual *(medium confidence)*.
- Most of the region is forecast to see a slightly lower number of **wet days and wet spells** than usual for the wet season.
- At the same time, a relatively high number of **dry spells** can be expected in the ABC Islands, The Bahamas, portions of Belize, the Greater Antilles and the Leeward Islands *(high confidence)*.
- **Flash floods** are a concern in the event of extreme wet spells, particularly in the Guianas where an increase in chances of extreme wet spells is forecast *(medium confidence)*.
- **Night-time and day-time temperatures** in the Caribbean are forecast to be slightly cooler than usual and amongst the coolest in recent years *(high confidence)* making the summer heat likely more tolerable than in recent years *(medium confidence)*.
- Drought or excessive dryness is not forecast to be a major concern during this period *(high confidence)*.
- The **tropical cyclone activity** of the 2018 Hurricane Season as a whole is unlikely to match last year's *(medium confidence)*. Although the credible forecasting sources suggest a near-normal season as a whole *(medium confidence)*, **preparedness** for the range of hazards brought about by tropical depressions, storms and hurricanes still **remains critical**.
- Episodes of **Saharan dust** incursions into the Caribbean usually are relatively frequent in this period, especially ahead of tropical weather systems (access more detailed forecast information on dust and air quality in the Caribbean here: http://dafc.cimh.edu.bb/). In the absence of drought this year, local dust levels should be on the low end in comparison to recent years.
- The **UV index** on sunny days will be near its annual maximum at around 12 across the region (on a scale from 1 to 12. For more information, see: https://www.epa.gov/sunsafety/uv-index-scale-1). Note that, despite the period marking the wet season, most days in most areas have long sunny spells, increasing UV exposure.

The Health-Climatic Bulletin is a climate-smart tool developed and disseminated by the Caribbean Public Health Agency (CARPHA), the Pan American Health Organization (PAHO) and the Caribbean Institute for Meteorology and Hydrology (CIMH) to help the health sector to manage climate risk.

The Health-Climatic Bulletin:

- Offers insights on the typical climate conditions of the upcoming season or forecast period.
- Provides an outlook (how wet, how dry, how hot etc.) for the upcoming quarter in the Caribbean, and offers key climate messages for that period.
- Advises on the health implications arising from this seasonal climate information.

The HCB guides health professionals that manage health systems to identify and prepare for upcoming favourable or inclement climate conditions in the Caribbean in the very near future. It does this by suggesting several implications of forecasted climate in a number of key areas including respiratory illness, non-communicable diseases, vector borne illness, gastrointestinal illness, physical injury or death, and well-being and mental health. Use of this information can help to inform strategic and operational decisions.

Archive for Caribbean Health Climatic Bulletins: *http://rcc.cimh.edu.bb/health-bulletin-archive/*

4.3.5 CARIBBEAN TOURISM CLIMATIC BULLETIN

Webpage for the Caribbean Health Climatic Bulletin: *http://rcc.cimh.edu.bb/caribbean-tourism-climatic-bulletin/*

The Tourism-Climatic Bulletin (TCB) is a new operational tool jointly developed and disseminated by the Caribbean Tourism Organization (CTO), the Caribbean Hotel and Tourism Association (CHTA) and the Caribbean Institute for Meteorology and Hydrology (CIMH) to help the tourism sector manage climate risk and take advantage of climate opportunities in an interactive and compact online document.

The TCB provides a broad overview of climate conditions (how wet, how dry, how hot etc.) in the Caribbean and source markets (in North America and Europe) and communicates implications for the tourism sector 3 months in advance. It offers tailored advice using climate information for the Caribbean and source markets that can help tourism businesses and policymakers identify and prepare for favourable or inclement climate conditions in the Caribbean and source markets, before they occur. This tailored climate early warning information can be used to inform strategic and operational decisions related to the use of environmental resources, marketing, and enhancement of the visitor experience.

Archive for Caribbean Health Climatic Bulletins: *http://rcc.cimh.edu.bb/health-bulletin-archive/*

NOTES

NOTES

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