WMO WORKSHOP ON ENHANCING CLIMATE INDICES FOR SECTOR-SPECIFIC APPLICATIONS IN THE CARIBBEAN REGION

15th -19th February, 2016

Barbados

Vision: To enhance the use of sector specific climate information in various sectors (e.g. agriculture, water, health) for Climate Risk Management and adaptation, through interdisciplinary analysis and interpretation of sector-specific climate indices.

WORKSHOP REPORT

WORLD METEOROLOGICAL ORGANIZATION

The Caribbean Institute for Meteorology and Hydrology (CIMH)

An activity under the Programme of Implementing the Global Framework for Climate Services on Regional and National Scales, funded by Environment Canada

Table of Contents

1. Background

Substantial progress has been made in developing globally standardized indices for assessing climate extremes under the leadership of WMO Commission for Climatology (CCl) through its joint Expert Team on Climate Change Detection and Indices (ETCCDI) along with other partners. The work of ETCCDI made major contributions to the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC). However, little work to date has focused on the development of such indices that can be directly used in sectoral applications. With the advent of the Global Framework for Climate Services (GFCS), with an overarching goal to provide climate information and services to meet user requirements, CCl has taken up a new initiative to develop climate indices with targeted sectoral applications, building on the indices and associated software developed by ETCCDI.

CCl has established an Expert Team on Sector-Specific Climate Indices (ET_SCI), which, in cooperation with sectoral experts in agricultural meteorology, water resources and health, is working to identify and evaluate additional sector-specific indices, both single- and multi-variable types, to define both simple and complex climate risks of interest to user groups. Relying on the principles of ETCCDI, this work focuses on systematic and globally-consistent approaches using high quality data and appropriate statistical methods to help characterize the susceptibility of various sectors to climate variability and change in an authoritative manner. ET-SCI has developed a new software package called ***"ClimPACT2"***for this purpose, and has successfully organized a proof of concept workshop in 2013 for six countries in western South America (http://www.wmo.int/pages/prog/wcp/ccl/opace/opace4/meetings/WorkshopEnhancingClimIndices.php) and a follow up for 10 countries workshop in the Pacific Island region http://www.wmo.int/pages/prog/wcp/ccl/opace/opace4/meetings/ET-SCI-fiji2015.php

As a part of the Programme of Implementing Global Framework for Climate Services (GFCS) on Regional and National Scales, funded by the Department of Environment Canada, the ET-SCI has undertaken this workshop on Sector-specific Climate Indices to bring together the experts from National meteorological and Hydrological Services (NMHSs) along with representatives from one of the GFCS priority sectors (agriculture and food security, water, health, disaster risk reduction and energy) in each of the Caribbean Countries and Territories. The Caribbean's focus on climate services for sectors has embraced the five afore-mentioned sectors along with tourism, as a climate sensitive sector of importance to the region.

The vision of the workshop is:

> *"To enhance the use of sector specific climate information in various sectors (e.g. agriculture, water, health) for Climate Risk Management and adaptation, through interdisciplinary analysis and interpretation of sector-specific climate indices."*

1.1 Workshop Structure

The workshop comprised of key note lectures, plenary discussions and hands-on training on the application of a new and improved version of the ***ClimPACT2*** software. It must be noted that training commenced for meteorologists, who focused on enhancing data quality through quality checks and homogenization. With this training completed, sector participants joined the meteorologists from Day 3, with the focus on the indices. Also joining on Day3 for the first half of the day were regional journalists for a special one-day session on media and climate, facilitated by Mr. David Eades new anchor from the British Broadcasting Corporation (BBC), and media consultant on the project, Mr. Steve Menzies of New Zealand.

See Appendix I for the workshop agenda and Appendix II for the participant list.

1.2 Opening of the Workshop

There was an informal opening for meteorologists on Day 1, with the formal opening on Day 3.

Both formal and informal opening ceremonies were led by Mr Adrian Trotman, Chief of Applied Meteorology and Climatology, CIMH. He began both workshops by inviting key representatives to make brief remarks.

At the informal ceremony, Ms Lisa-Anne Jepsen brought greetings on behalf of WMO, and stated that the workshop was sponsored by the Department of Environment, Canada, in support of the GFCS. Dr Toshiyuka Nakaegawa of the Japanese Meteorological Agency (JMA) greeted the meteorologists on behalf of the Expert Team on Sector-Specific Climate Indices (ET-SCI).

Both Ms. Jepsen and Dr Nakaegawa gave remarks at the formal meeting on behalf of the WMO and ET-SCI, after participants were welcomed by the Deputy Director of the Barbados Meteorological Services, Ms. Sonia Nurse. Mr Eades also provided remarks, highlighting the importance of the engagement of the media in climate workshops such as this and importance of the media in understanding the climate messages and supporting the dissemination of the messages to the general public.

2. Summary of Presentations to Meteorological Services

Dr Toshiyuka Nakaegawa of the Japanese Meteorological Agency, took participants through an overview of the management team of the WMO, ET-SCI. He stated that the first official meeting was held in 2011 in Spain and the main topics discussed were the specific needs for climate information in the sectors like health, water and agriculture. It was stressed however that there was a great need to promote the use of globally consistent, sector specific climate indices, and therefore a need for the further development of ***ClimPACT*** and the necessary training materials, as well as the coordination and leadership of regional workshops. Dr. Nakaegawa also spoke about the role of the GFCS and how its main objective is to enable society to better manage the risks of climate variability. He therefore concluded that the aim of the workshop is to build the necessary partnerships to support and enhance interdisciplinary knowledge.

Dr Cèdric Van Meerbeeck and Ms Wazita Scott of CIMH presented on regional climate variability and change. In their presentation they stated that their mode of focus with respect to climate variability was with the El Niño Southern Oscillation (ENSO) (which gives the most predictability for the region), the Madden-Julian Oscillation (MJO) and The North Atlantic Oscillation (NAO). Such drivers influence conditions such as the region is experiencing related to drought. In monitoring drought in the Caribbean, the SPI (Standardized Precipitation Index) is used, along with reported impacts that informs of what is actually being witnessed on the ground. The presenters also reported that thus far, analysis indicate statistically significant increases in maximum and minimum temperatures; the number of warm nights and days; as well as extreme rainfall. However, there is no statistically significant change in annual precipitation totals or dry spells. It was suggested that longer records are needed to distinguish between climate variability and change for precipitation.

In his presentation, Enric Angular[1] discussed the drivers behind the establishment of the climate indices. After the IPCC's second assessment, the available data for any analysis was inadequate for assessments to be made regarding the nature of global changes in extreme climate records. Therefore the ETCCDI was organised, which then produced RClimdex. This allowed for (i) information sharing (as some countries do not like to share data); and (ii) trend analysis of events that would have occurred only a few times a year. The approach to the calculation of indices was based on having both a fixed and variable threshold value.

3. Quality Control and Homogenisation of Climate Data

On the first day of the workshop participants were introduced to the ***ClimPact2*** software, where it was emphasised that climate analysis is preceded by quality control and homogenization[2] of the data. When your input data is not of a high quality and homogenous then the analyses would not be of a good quality. The process of homogenization involves identifying and adjusting non-climatic variations caused by changes in observing practices/time, site relocation etc. One method of homogenization demonstrated was the RH-test. This test compares data with other stations that are correlated to the one in question.

4. Summary of Presentations to the Meteorologists and Sectors

Ms Jepsen, reiterated that the five climate sensitive sectors of the GFCS depend on climate services through (i) engagement between providers and users of information; (ii) targeted climate information products that respond to the user's needs; and effective/efficient application of information. Climate products have been developed based on science and various levels of users can be positively affected by effective use of climate services. The vision of the GFCS is:

> *"To enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale."*

Some success stories of GFCS include: (i) Regional Climate Centres (RCCs), of which CIMH is currently in demonstration phase; (ii) Regional Climate Outlook Forums (RCOFs), which bring together representatives of the National Meteorological and Hydrological Services (NHMSs) to develop a consensus outlook; and (iii) National stakeholder consultations with the NHMS with respect to the needs of the stakeholders and how the NMHS can be of help.

In expressing the value of climate services, Dr Nakaegawa stated that the climate indices produced are useful, since monthly averages can at times make important information on extremes. Climate indices also describe important climate aspects, thus they help to mitigate, adapt, reduce risk and

---

[1] Senior Researcher, Center for Climate Change, C3 Geography Department Universitat Rocira i Virgili, Tarragona, Spain

[2] A homogenous climate time series is defined as one where variations are caused only by variations in climate.

drive policy planning. The ETCCDI has developed an international coordinated set of climate indices, with the focus on number of days crossing a certain threshold. However, the challenge with ETCCDI is that the needs of the sectors are not readily addressed. Drought indices are not included and real-time updating/monitoring is problematic. Ideal climate indices would be those that can be applied across a wide number of sectors and regions; be flexible to the needs of sectors in specific regions; and able to understand historical changes as well as make useful predictions for the future.

4.1 Applications of ClimPACT

In looking at climate indices and indicators for agriculture, Mr Adrian Trotman, defined an index as a method of deriving "value added" information by comparing current conditions to historical information based on statistical calculations. In developing indices/indicators for agriculture it is important to bear in mind that different crops have different phenological requirements. Indices can also be developed for insurance purposes (more in particular Weather Index Insurance). During Mr Trotman's presentation Dr Tannecia Stephenson of the University of the West Indies, the lead author of a peer-reviewed paper[3] on historical trends in the Caribbean using the ETCCDI indices, was invited to report briefly on the research paper and the indices involved.

A heat wave was defined by Dr Adam Kalkstein[4] as a prolonged period of excessive heat, usually defined with respect to thresholds. Some aspects of a good heat wave index are (i) a relative threshold; (ii) consecutive days; (ii) based on (at least) temperature; and (iii) considers all aspects of heat waves (i.e. intensity, frequency, duration, etc.).

With respect to water resources, the relative indices would include the number of days where rainfall exceeded a particular threshold as well as consecutive dry days.

5. Sectors' Introduction to ClimPACT2/Analysing Sector Data

Sector participants were introduced to the ***ClimPACT2*** software where they worked along with meteorological services to produce indices relevant to their sectors.

Some participants were impressed by the meaningful information that could be obtained from the software. The challenge observed however, was the lack in availability of some data sets for analysis.

Participants then were given the opportunity to present the analysis of their data. Some participants, for example in the health sector, found correlations between rainfall and some diseases.

Generally, the preferred timescales for sector/events were expressed to be:

Agriculture – monthly to seasonal

Flash floods – daily to 5 days

Seasonal floods – monthly to annual

---

[3] Stephenson et al Changes in extreme temperature and precipitation in the Caribbean region, 1961–2010 *Int. J. Climatol.* **34**: 2957–2971 (2014)

[4] Department of Geography and Environmental Engineering, United States Military Academy

Water resources – monthly to annual

Health – daily to 7 days

Tourism – monthly to seasonal

Energy – monthly to seasonal

6. Suggested Improvements to the Workshop Structure, Indices and *Clim*PACT2 software

Suggested improvements to the indices were to have the sector specific indices available for the timescales listed in section 5. Participants also suggested to have other data sets included for indices such as wind and relative humidity. A combination of indices (temperature and relative humidity) would be of great use in dealing with heat stress.

7. Conclusions and Next Steps

Proposals and suggestions for the region going forward:

- A series of pilot projects for countries have been proposed under the Department of Environment Canada project that seeks to support enhancing climate information for sectors, including indices. Discussions on these will continue with the Department of Environment Canada
- Continued capacity building for the region on the sector specific indices is necessary. This exercise was a good introduction, but it needs to be continued.
- More work with the media should be pursued as they support message delivery and reach of climate information, including that for sectors
- It was suggested that a manuscript on the findings from the workshop, including the results from individuals and groups be prepared. This would support continued development of and assessment of sector specific indices.

Appendix I: Workshop Agenda

MONDAY, 15 February 2016

09:00 – 09:15 Welcome Addresses

- **Adrian Trotman**, CIMH
- **Lisa-Anne Jepsen**, WMO
- **Toshiyuki Nakaegawa, co-lead, ET-SCI**

09:15 – 09:30 *Tour de table*: Self-introductions of participants

09:30 – 09:50 **Introduction to the CCI ET-SCI**

Includes where ET-SCI sits within the WMO structure, the history of the Expert Team and previous meetings; the terms of reference and expected deliverables of the Expert Team; the importance of this workshop as a milestone within the Global Framework on Climate Services.

- **Toshiyuki Nakaegawa,** co-lead, ET-SCI

9:50 – 10:10 Expected Outcomes of first two days -

Introduction to previous ET-SCI workshops held in Ecuador and Fiji and outcomes. What outcomes can we expect from this workshop.

- **Nicholas Herold**

10:10 – 10:40 Regional Climate Variability and Change

Includes climate observations and projections for the SIDS region and the importance of regional climate drivers (e.g. ENSO etc) in understanding variability and change.

- Van Meerbeeck and Scott

10:40 – 10:55 Coffee Break

10:55 –11:25 The ETCCDI indices as a starting point for ET-SCI

A brief history of the ETCCDI and workshops, what indices were calculated and why ET-SCI has used this model.

- **Enric Aguilar**

11:25 – 12:10 Introduction to ***ClimPACT2***

*Includes an overview of the **ClimPACT2** software developed for the ET workshops and available from: https://github.com/ARCCSS-extremes/climpact2. This software uses a statistical system known as "R". The R statistical software are available free of charge from http://www.r-project.org.*

- **Nicholas Herold Participants watching only!**

12:10 – 12:30 Checking software and data formats

More time will be added later if necessary.

12:30 – 13:30 **Lunch**

13:30 – 14:20 Quality control of climate data and data issues

Includes aspects such as ensuring correct station location, correct units and assessment of outliers. The latter is particularly problematic as the indices we will be calculating mostly focus on extremes, yet it is the extremes that are most likely to be flagged as bad data by quality control (QC) software. Throwing out valid extreme values can cause errors as easily as keeping erroneous extreme values. The basic concepts and purposes of climate data quality control will be refreshed and we will introduce you to improved quality control features in ClimPACT2

- **Nicholas Herold and Enric Aguilar**

14:20 – 15:30 QC checks of updated station data

Base data used is Stephenson et al. 2014, but if you bring updates or new series we will be happy

- **C. Van Meerbeeck**

15:30 – 15:45 Coffee Break

15:45 – 17:00 **QC checks of updated station data**

TUESDAY, 16 FEB 2016

09:00 – 09:45 **Introduction to homogeneity**

An overview of RHTest software

- **Enric Aguilar**

09:45 – 10:30 Homogeneity checks

10:30 – 10:45 Coffee Break

10:45 – 12:30 Homogeneity checks (continued)

12:30 – 13:30 **Lunch**

13:30 – 15:15 Homogeneity checks (continued)

15:15 – 15:30 Coffee Break

15:30 – 17:00 Homogeneity checks (continued)

WEDNESDAY, 17 FEB 2016

09:00 – 09:15 Welcome Addresses

- **David Farrell, Principal CIMH.**
- **Hampden Lovell, Director of Barbados Met Service and Permanent Representative of Barbados with WMO**
- **Lisa-Anne Jepsen, WMO**
- **Toshiyuki Nakaegawa, ET-SCI co-lead**

09:15 – 09:25 *Keynote Address*

09:25 – 09:45 The Global Framework for Climate Services (GFCS)

- **Lisa-Anne Jepsen, WMO**

9:45 – 10:00 Climate information and the media

- **David Eades, BBC**

10:00 – 10:20 Introduction to the value of Climate Indices for Sector applications

Includes discussion of: History of the development of Climate Indices as a proxy for data; the work of the ETCCDI (briefly) following the need for indices; problems with indices (e.g., non-reproducible by other scientist who lack access to the data); Data exchange problems; ET-SCI concept and purpose; Examples of some indices and usefulness to sectors; Identification of indices of relevance for this region and sector

- **Toshiyuki Nakaegawa**

10:20 – 10:45 Climate information for Agriculture and Food Security

- **Adrian Trotman, CIMH**

10:45 – 11:00 Coffee Break and group photo

11:00 – 11:30 Climate information for Water Resources

- **Toshiyuki Nakaegawa**

11:30 – 12:00 Climate information for Health

- **Adam Kalkstein, ET-SCI**

12:00 – 12:30 Climate information and Health – Case Study from Dominica

- **Eric St. Ville, MoH, Dominica.**

12:30 – 13:30 **Lunch**

13:30 – 14:00 Introduction to the ET-SCI indices – new and old

Includes types of indices that are calculated and showing which sectors are relevant for which indices

- **Adam Kalkstein**

14:00 – 14:30 Introduction to drought indices

Brief drought concepts and widely used drought indices. Includes more detailed description of the Standardized Precipitation Index (SPI) and Standardized Precipitation Evapotranspiration Index (SPEI) included in ClimPACT2.

- **Acacia Pepler**

14:30 – 15:00 Introduction to heatwave indices

Includes discussion of global framework for defining heatwaves and warm spells – brief overview of the three different definitions used and the various characteristics measured for each definition. Participants will be able to decide which definitions and characteristics are best suited for their sector.

- **Adam Kalkstein**

15:00 – 15:15 Coffee Break

15:15 – 15:35 Introduction to ***ClimPACT2*** software

- **Nicholas Herold**

15:35 – 17:00 Interactive ***ClimPACT2*** software session

Includes examples using sample data.

- Met Service share country quality checked Met Data with Sector participant from their countries. Also show them up to Step 1, including installation.

THURSDAY, 18 FEB 2016

09:00 – 09:05 Activity thus far and day's objectives

09:05 – 10:30 **Interactive *ClimPACT2* software session**

Up to Practice Step 2

- **All**

10:30 – 10:45 Coffee Break

10:45 – 12:30 Calculate indices and analyse results

Quality-controlled data assessed at this and other workshops in the region will be used to calculate new ET-SCI indices

- **All**

12:30 – 13:30 Lunch

13:30 – 15:15 Continue calculating indices and analysing results

- **All**

15:15 – 15:30 Coffee Break

15:30 – 16:00 Regional modelling and climate indices

- **David Hein, UK Met Office**

16:00 -17:00 Continue calculating indices and analysing results, commence preparation of country presentations

FRIDAY, 19 FEB 2016

09:00 – 09:05 Activity thus far and day's objectives

09:05 – 10:30 Preparation of country presentations

10:30 – 10:45 Coffee Break

10:45 – 12:30 Country Presentations

12:30 – 13:30 Lunch

13:30 – 15:15 Country Presentations

15:15 – 15:30 Coffee Break

15:30 – 16:30 Discussion

Includes the future of the indices for sector applications, where to next, publications (sector applications and peer reviewed)

16:30 – 16:45 Summary of the Discussion and the main conclusions and decisions

- **Toshiyuki Nakaegawa and Adrian Trotman**

16:45 – 17:00 Workshop closure

Appendix II: Attendee List

	Meteorologists Participants		
		Name	
		Last	First
1	Antigua	Destin	Dale
2	Antigua	Ford	Tammie
3	Bahamas	King	Arnold
4	Belize	Cumberbatch	Catherine
5	Cuba	Laguardia	Ingrid
6	Dominica	Carrette-Joseph	Annie
7	Dominican Republic	Salado	Juan
8	Grenada	Tamar	Gerard
9	Guyana	Dhiram	Komlachand
10	Haiti	Etienne	Emmanuel
11	Jamaica	Brown	Glenroy
12	Jamaica	Shaw	Adrian
13	St. Kitts	Burke	Elmo
14	St. Lucia	Willie	Shem
15	St. Marteen	Etienne-LeBlanc	Sheryl
16	St. Vincent	Neverson-Jack	Desiree
17	Suriname	Mitro	Sukarni
18	Trinidad	Kerr	Kenneth
19	Trinidad	Gangadeen	Savitri
20	UWI	Stephenson	Tannecia
21	Bureau of Meteorology, Australia	Herold	Nicholas
22	Bureau of Meteorology, Australia	Pepler	Acacia
23	WMO	Aguilar	Enric
24	Department of Geography and Env. Engineering	Kalkstein	Adam
25	Japan	Nakaegawa	Toshiyuka
26	WMO	Hein-Griggs	David
27	WMO	Jepsen	Lisa-Anne
28	Barbados	Blenman	Rosalind
29	CIMH	Trotman	Adrian
30	CIMH	van Meerbeeck	Cedric
31	CIMH	Stoute	Shontelle
32	CIMH	Kirton-Reed	Lisa
33	CIMH	Mahon	Roche
34	CIMH	Cox	Shelly-anne
35	CIMH	Cuthbert	Shireen
36	CIMH	Scott	Wazita
37	CIMH	Applewhaite	Andrea

Sector Participants			
		Name	
		Last	First
1	APUA, Antigua & Barbuda	Yearwood	Veronica
2	Bahamas Water	Bowleg	John
3	Belize MOA	Harrison	Andrew
4	CaFaN	Abraham	Norville
5	CARDI	Richards	Kerrn
6	CARPHA	Clauzel	Shermaine
7	Cuba Health	Borrotto-Gutierrez	Susanna
8	CWSA, St Vincent & The Grenadines	Richards	Vialey
9	GWP-C	Boodram	Natalie
10	Dominica MOH	St. Ville	Sylvester
11	Haiti Water	Thomas	Ernso
12	St Kitts WATER	Greenaway	Shawn
13	St Lucia MOA	Constantin	Thaddeus
14	Suriname MOA	Samoender	Iwan
15	WASA, Trinidad & Tobago	Bachu	Nerisha
16	WRA, Jamaica	Sutherland	Anika
17	Barbados MOH	Daniel	Steve
18	Barbados MOH	Russell	Wayne
19	BWA, Barbados	Paul	Jaime
20	CDEMA	Riley	Liz
21	CDEMA	Pierre	Donna
22	PAHO	Edwards	Sally

Media Participants			
		Name	
		Last	First
1	The Daily Observer	George	Elesha
2	The Sun	Jno Baptiste	Carlisle
3	Grenada Broadcasting Network	Campbell	Curlan
4	Stabroek News	Sutherland	Gaulbert
5	The Gleaner	Gilpin	Jodi-Ann
6	The Montserrat Reporter	Roach	Bennette
7	ZIZ Television	Bristol	Marlon
8	i-Witness News	Chance	Kenton
9	Caribbean New Media Group	Wallace	Ean
10	BBC News	Menzies	Steve
11	BBC News	Eades	David
12	Starcom Network		
13	CBC	Farrell	Sean
14	CMC	Seon	Renee
15	The Nation News	King	Lisa
16	Barbados Today	Bennett	Randy

Appendix III: *ClimPACT2* Indices

Table of indices calculated by ClimPACT2

To calculate all of the following indices time-series of daily minimum temperature (TN), maximum temperature (TX) and daily precipitation (PR) are required. Daily mean temperature (TM) is calculated from TM = (TX + TN)/2 and diurnal temperature range from DTR = TX - TN.

Short name	Long name	Definition	Units
FD0	Frost days 0	Annual number of days when TN < 0 °C	days
FD2	Frost days 2	Annual number of days when TN < 2 °C	days
FDm2	Hard freeze	Annual number of days when TN < -2 °C	days
FDm20	Very Hard freeze	Annual number of days when TN < -20 °C	days
ID	Ice days	Annual number of days when TX < 0 °C	days
SU25	Summer days	Annual number of days when TX > 25 °C	days
TR	Tropical nights	Annual number of days when TN > 20 °C	days
GSL	Growing season Length	Annual number of days between the first occurrence of 6 consecutive days with TM > 5 °C and the first occurrence of 6 consecutive days with TM < 5 °C	days
TXx	Max TX	Warmest daily TX	°C
TNn	Min TN	Coldest daily TN	°C
WSDI	Warm spell duration indicator	Annual number of days with at least 6 consecutive days when TX > 90th percentile	days
WSDIn	User-defined WSDI	Annual number of days with at least n consecutive days when TX > 90th percentile	days
CSDI	Cold spell duration indicator	Annual number of days with at least 6 consecutive days when TN < 10th percentile	days
CSDIn	User-defined CSDI	Annual number of days with at least n consecutive days when TN < 10th percentile	days
TX50p	Above average Days	Percentage of days of days where TX > 50th percentile	%
TX95t	Very warm day threshold	Value of 95th percentile of TX	°C
TM5a	TM above 5°C	Annual number of days when TM >= 5 °C	days
TM5b	TM below 5°C	Annual number of days when TM < 5 °C	days
TM10a	TM above 10°C	Annual number of days when TM >= 10 °C	days
TM10b	TM below 10°C	Annual number of days when TM < 10 °C	days
SU30	Hot days	Annual number of days when TX >= 30 °C	days
SU35	Very hot days	Annual number of days when TX >= 35 °C	days
nTXnTN	User-defined consecutive number of hot days and nights	Annual count of n consecutive days where both TX > 95th percentile and TN > 95th percentile, where n >= 2 (and max of 10)	Number of events

HDDheat	Heating degree Days	Annual sum of Tb - TM (where Tb is a user-defined location-specific base temperature and TM < Tb)	°C
CDDcold	Cooling degree Days	Annual sum of TM - Tb (where Tb is a user-defined location-specific base temperature and TM > Tb)	°C
GDDgrow	Growing degree Days	Annual sum of TM - Tb (where Tb is a user-defined location-specific base temperature and TM > Tb)	°C
CDD	Consecutive dry days	Maximum annual number of consecutive dry days (when PR < 1.0 mm)	days
R20mm	Number of very heavy rain days	Annual number of days when PR >= 20 mm	days
PRCPTOT	Annual total wet-day PR	Annual sum of daily PR >= 1.0 mm	mm
R95pTOT	Contribution from very wet days	100*r95p / PRCPTOT	%
R99pTOT	Contribution from extremely wet days	100*r99p / PRCPTOT	%
RXnday	User-defined consecutive days PR amount	Maximum n-day PR total	mm
SPI	Standardised Precipitation Index	Measure of "drought" using the Standardised Precipitation Index on time scales of 3, 6 and 12 months. See McKee et al. (1993) and the WMO SPI User guide (World Meteorological Organization, 2012) for more details.	unitless
SPEI	Standardised Precipitation Evapotranspiration Index	Measure of "drought" using the Standardised Precipitation Evapotranspiration Index on time scales of 3, 6 and 12 months. See Vicente-Serrano et al. (2010) for more details.	unitless
nTXbnTNb	User-defined consecutive number of cold days and nights	Annual number of n consecutive days where both TX < 5th percentile and TN < 5th percentile where 10 >= n >=2	Number of events
TNx	Max TN	Warmest daily TN	°C
TXn	Min TX	Coldest daily TX	°C
DTR	Diurnal temperature range	Mean difference between daily TX and daily TN	°C
TMm	Mean TM	Mean daily mean temperature	°C
TXm	Mean TX	Mean daily maximum temperature	°C
TNm	Mean TN	Mean daily minimum temperature	°C
TX10p	Amount of cool days	Percentage of days when TX < 10th percentile	%
TX90p	Amount of hot days	Percentage of days when TX > 90th percentile	%
TN10p	Amount of cold nights	Percentage of days when TN < 10th percentile	%
TN90p	Amount of hot nights	Percentage of days when TN > 90th percentile	%

CWD	Consecutive wet days	Maximum annual number of consecutive wet days (when PR >= 1.0 mm)	days
R10mm	Number of heavy rain days	Annual number of days when PR >= 10 mm	days
Rnnmm	Number of customised rain days	Annual number of days when PR >= n	days
SDII	Daily PR intensity	Annual total PR divided by the number of wet days (when total PR >= 1.0 mm)	mm/day
R95p	Total annual PR from heavy rain days	Annual sum of daily PR > 95th percentile	mm
R99p	Total annual PR from very heavy rain days	Annual sum of daily PR > 99th percentile	mm
Rx1day	Max 1-day PR	Maximum 1-day PR total	mm
Rx5day	Max 5-day PR	Maximum 5-day PR total	mm
HWN (EHF/Tx90/ Tn90)	Heatwave number (HWN) as defined by either the Excess Heat Factor (EHF), 90th percentile of TX or the 90th percentile of TN	The number of individual heatwaves that occur each summer (Nov – Mar in southern hemisphere and May – Sep in northern hemisphere). A heatwave is defined as 3 or more days where either the EHF is positive, TX > 90th percentile of TX or where TN > 90th percentile of TN. Where percentiles are calculated from base period specified by user in section 3.4. See Appendix C and Perkins and Alexander (2013) for more details.	events
HWF (EHF/Tx90/ Tn90)	Heatwave frequency (HWF) as defined by either the Excess Heat Factor (EHF), 90th percentile of TX or the 90th percentile of TN	The number of days that contribute to heatwaves as identified by HWN. See Appendix C and Perkins and Alexander (2013) for more details.	days
HWD (EHF/Tx90/ Tn90)	Heatwave duration (HWD) as defined by either the Excess Heat Factor (EHF), 90th percentile of TX or the 90th percentile of TN	The length of the longest heatwave identified by HWN. See Appendix C and Perkins and Alexander (2013) for more details.	days
HWM (EHF/Tx90/ Tn90)	Heatwave magnitude (HWM) as defined by either the Excess Heat Factor (EHF), 90th percentile of TX or the 90th percentile of TN	The mean temperature of all heatwaves identified by HWN. See Appendix C and Perkins and Alexander (2013) for more details.	°C(°C2 for ECF/EHF)

HWA (EHF/Tx90/ Tn90)	Heatwave amplitude (HWA) as defined by either the Excess Heat Factor (EHF), 90th percentile of TX or the 90th percentile of TN	The peak daily value in the hottest heatwave (defined as the heatwave with highest HWM). See Appendix C and Perkins and Alexander (2013) for more details.	°C(°C2 for ECF/EHF)
ECF_HWN	Heatwave number (HWN) as defined by the Excess Cold Factor (ECF).	The number of individual 'coldwaves' that occur each year. See Naim and Fawcett (2013) for more information.	events
ECF_HWF	Heatwave frequency (HWF) as defined by the Excess Cold Factor (ECF).	The number of days that contribute to 'coldwaves' as identified by ECF_HWN. See Naim and Fawcett (2013) for more information.	days
ECF_HWD	Heatwave duration (HWD) as defined by the Excess Cold Factor (ECF).	The length of the longest 'coldwave' identified by ECF_HWN. See Naim and Fawcett (2013) for more information.	days
ECF_HWM	Heatwave magnitude (HWM) as defined by the Excess Cold Factor (ECF).	The mean temperature of all 'coldwaves' identified by ECF_HWN. See Naim and Fawcett (2013) for more information.	°C2
ECF_HWA	Heatwave amplitude (HWA) as defined by the Excess Cold Factor (ECF).	The minimum daily value in the coldest 'coldwave' (defined as the 'coldwave' with lowest ECF_HWM). See Naim and Fawcett (2013) for more information.	°C2