CLIPC Milestone M26: Toolkit for calculation of CCII-T1

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Overview

This milestone presents work on extending an existing toolkit, `icclim`, for calculating Tier-1 Climate Change Impact Indicators (CCII T1, aka “climate indices”). The CLIPC WP6 work, which draws on previous code development within the European projects IS-ENES and IS-ENES2, has resulted in a new major version of the `icclim` software that has been released to the public domain. The new version includes upgrades related to the following four main areas:

1. implementation of the bootstrapping procedure for correct calculation percentiles used in several indices,
2. validation of indices calculated by `icclim` by comparison with indices calculated by a reference software,
3. implementation of new functionalities to enable the calculation of a larger set of climate indices, as well as certain types of user-defined indices based on one or several variables,
4. implementation of user-defined seasons.

In addition the development of new and upgraded functionalities of the software, we have initiated an international collaboration for developing metadata standards for climate indices. This is an ongoing work that will facilitate consistent and federated deployment of climate indices datasets though existing and future data infrastructures, such as the Earth System Grid Federation.

Tier-1 Climate Change Impact indicators – Climate Indices

Tier-1 Climate Change Impact Indicators are defined as those indicators that can be calculated from climate data only (i.e. commonly available data about the physical climate system), without including other types of data, such as information related to biology, ecology, agriculture, forestry, tourism, health, infrastructure, population, socio-economy, etc.

Such CCII T-1’s have a long history within the climate community and are, within the community, commonly known as “climate indices”. There is almost an infinite possibility to define specific indices, but the overall aim is to summarise climate data in a way that focusses on some specific sector, application or impact, rather than presenting general information about the average climate, or similar. Over the time there has been some convergence to define “core sets of indices”. In particular two international expert teams have worked to standardise the set of climate indices. One is the joint CCl/WCRP/JCOMM Expert Team on Climate Change Detection and Indices, ETCCDI (http://www.wcrp-climate.org/unifying-themes/unifying-themes-observations/data-etccdi), the other one is the WMO/CCl Expert Team on Sector-specific Climate Indices, ET-SCI (http://www.wmo.int/pages/prog/wcp/ccl/opace/opace4/ET-SCI-4-1.php). Both expert teams have published dictionaries of core climate indices, which partly overlap and complement each other.

The `icclim` software

The initial version of `icclim` has been developed within the IS-ENES2 European project. The main objective of this development was to provide online (on-the-fly) calculations for the climate4impact http://climate4impact.eu/ IS-ENES portal, through the OGC standard Web Processing Services (WPS) interface. The focus of this initial version has been to implement all the ECA-D climate indices (core climate indices set very similar to ETCCDI) along with standard statistical functions, such as temporal and spatial averages. Users of the climate4impact portal could then apply processing to selected datasets.

The new version of `icclim` substantially increases the number of indices that can be computed from these lists, and updates the algorithm for calculating percentiles, which improves the accuracy of all indices based on percentiles. Furthermore, the new version enables users to define their own indices using a set of fundamental operations, as well as define their own seasons that go beyond the usual division into annual, the four standard seasons and monthly indices.

Detailed documentation of the work done is available in Appendix A, and Appendix B gives a Table of the indices defined by the two expert teams. This Table also shows which of these indices are implemented in the new `icclim` version.

Documentation of the new `icclim` Python code version is available through the following link:

http://icclim.readthedocs.org/en/latest/index.html

And the code base is available in the public domain through github:

https://github.com/cerfacs-globc/icclim/releases/tag/v4.1.0

Metadata standards for climate indices

In order to enable publication and efficient processing of data files containing climate indices the relevant metadata have to be standardised. Within CLIPC the strategic decision was taken to use the NetCDF file format and the Climate and Forecasting (CF-) convention when relevant and as far as possible. In this way CLIPC is able to build on earlier work in various EU projects, in particular IS-ENES and IS-ENES2. Some earlier attempts have been within the CF-convention to accommodate climate indices. However, this work has not been generally adopted by actors working on producing climate indices. The main reason for this is that there has not been any effort to coordinate data dissemination across communities. However, with ESGF this need has now surfaced.

In order to facilitate the coordination of metadata for climate indices the WCRP International Project Office for CORDEX (IPOC) organised a telephone conference bringing together representatives from CORDEX, ETCCDI, ET-SCI, and CLIPC to discuss this matter and initiate technical collaboration. An ad hoc working group was formed involving representatives from these groups. Work is ongoing.

Appendix A CLIPC Milestone M26: Toolkit for calculation of CCII-T1

`ICCLIM` code extension Final report

Natalia Tatarinova July-October 2015

Accomplished work:

1. Implementation of the bootstrapping procedure described in (http://etccdi.pacificclimate.org/docs/Zhangetal05JumpPaper.pdf).

2. Validation of `icclim` indices by comparison with climdex.pcic indices (https://github.com/pacificclimate/climdex.pcic). For more details see the Annex AA.

3. User defined indices based on one or several variables ("user_indice" parameter) and user defined seasons ("slice_mode" parameter). All details in the `icclim` documentation in the section "Custom indices" + examples (http://icclim.readthedocs.org/en/latest/).

4. The document "ConsolidatedIndicesList" with indices and their status is in attachment to the current report.

   Notes for "ConsolidatedIndicesList":

   - I set the status "OK" to all indices which could be computed by `icclim`. However, metadata of indices must be redefined for standard indices and developed for custom indices.

   - I corrected the definitions and units for R95pTOT and R99pTOT indices.

   - nTXnTN and nTXbnTNb: status "OK (?)" - `icclim` computes just **max nb** of consecutive events satisfying to the both conditions.

Remaining tasks to do:

1. Meta data for standard and custom indices!

2. Eventually, remove the "threshold" parameter from the main function icclim.indice which is not necessary anymore, thanks to the new possibility to create custom indices.
   However, the variable "thresh" in "user_indice" currently could be set only to a single value *for each variable* contrary to the "threshold" which can be a list of values.

3. Add full support for the calendar "360_days".

Annex AA

Comparison: `icclim` vs climdex.pcic

indice	status	comment
SU	OK	
ID	OK	
FD	OK	
TR	OK	
TXx	OK	
TXn	OK	
TNx	OK	
TNn	OK	
DTR	OK	
RX1day	OK	
RX5day	+/-	See below about the difference in computing in `icclim` and climdex.pcic
SDII	OK	
R10mm	OK	
R20mm	OK	
CDD	OK	In climdex.cdd, option “spells.can.span.years” must be FALSE
CWD	OK	In climdex.cwd, option “spells.can.span.years” must be FALSE
PRCPTOT	OK	
TX10p	OK	
TX90p	OK	
TN10p	OK	
TN90p	OK	
WSDI	-	https://github.com/pacificclimate/climdex.pcic/issues/8
CSDI	-	https://github.com/pacificclimate/climdex.pcic/issues/8
R95pTOT	OK	
R99pTOT	OK	

Difference in computing of RX5day

In *climdex.rx5day* there is the option “center.mean.on.last.day” which is True/False.

```
RX5day annual frequency, years: 1850-2005

(climdex.rx5day: center.mean.on.last.day = FALSE)

year    climdex         icclim                  abs(diff)

1858    58.4053         58.4052                 0.000129559326169
1905    70.67743        70.6775                 0.000113640136718
1906    70.1884         65.3346                 4.85381290283
1907    55.283467       31.2416                 24.0418574266
1908    66.75086        66.751          0.000101303710935
1913    58.93162        58.9315                 0.000105260009768
1922    79.426  79.4259                 0.000104309082033
1928    48.89282        42.3817                 6.51115190918
1951    67.8925         67.8924                 0.000104980468748
1957    47.643142       47.6433                 0.000115141113284
```

```
RX5day annual frequency, years: 1850-2005

(climdex.rx5day: center.mean.on.last.day = TRUE)

year    climdex         icclim                  abs(diff)

1858    58.4053         58.4052                 0.000129559326169
1905    70.67743        70.6775                 0.000113640136718
1907    70.1884         31.2416                 38.9467904266
1908    66.75086        66.751          0.000101303710935
1913    58.93162        58.9315                 0.000105260009768
1922    79.426  79.4259                 0.000104309082033
1951    67.8925         67.8924                 0.000104980468748
1957    47.643142       47.6433                 0.000115141113284
```

Explanation of the difference in computing for year 1907:

climdex: center.mean.on.last.day=FALSE	climdex: center.mean.on.last.day=TRUE	icclim
7.70727 + 32.039 + 10.8575 + 0.255137 +4.42456 = **55.283467**	13.71 + 5.87463 + 7.70727 + 32.039 + 10.8575 = **70.1884**	10.8575 + 0.255137 + 4.42456 + 6.69094 + 9.01346 = **31.241597**

climdex: center.mean.on.last.day=FALSE

	A	B	C	D	E
20813	1906	12	25	0.213495	
20814	1906	12	26	1.16397	
20815	1906	12	27	6.00368	
20816	1906	12	28	13.71	
20817	1906	12	29	5.87463	
20818	1906	12	30	7.70727	
20819	1906	12	31	32.039	
20820	1907	1	1	10.8575	
20821	1907	1	2	0.255137	
20822	1907	1	3	4.42456	
20823	1907	1	4	6.69094	
20824	1907	1	5	9.01346	
20825	1907	1	6	5.68429	
20826	1907	1	7	3.02932	
20827	1907	1	8	0.0063445	
20828	1907	1	9	0.00179311	
20829	1907	1	10	9.87526E-009	

climdex: center.mean.on.last.day=TRUE

	A	B	C	D	E
20813	1906	12	25	0.213495	
20814	1906	12	26	1.16397	
20815	1906	12	27	6.00368	
20816	1906	12	28	13.71	
20817	1906	12	29	5.87463	
20818	1906	12	30	7.70727	
20819	1906	12	31	32.039	
20820	1907	1	1	10.8575	
20821	1907	1	2	0.255137	
20822	1907	1	3	4.42456	
20823	1907	1	4	6.69094	
20824	1907	1	5	9.01346	
20825	1907	1	6	5.68429	
20826	1907	1	7	3.02932	
20827	1907	1	8	0.0063445	
20828	1907	1	9	0.00179311	
20829	1907	1	10	9.87526E-009	

icclim

	A	B	C	D	E
20813	1906	12	25	0.213495	
20814	1906	12	26	1.16397	
20815	1906	12	27	6.00368	
20816	1906	12	28	13.71	
20817	1906	12	29	5.87463	
20818	1906	12	30	7.70727	
20819	1906	12	31	32.039	
20820	1907	1	1	10.8575	
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20823	1907	1	4	6.69094	
20824	1907	1	5	9.01346	
20825	1907	1	6	5.68429	
20826	1907	1	7	3.02932	
20827	1907	1	8	0.0063445	
20828	1907	1	9	0.00179311	
20829	1907	1	10	9.87526E-009	

Appendix B CLIPC Milestone M26: Toolkit for calculation of CCII-T1

Colour coding

green	ETCCDI and ET-SCI
blue	ETCCDI
yellow	ET-SCI core indices
light yellow	ET-SCI additional sector-specific indices

ETCCDI	ET-SCI	ID	Indicator name	Definitions	Units	Status
1	1	**FD** = FD0	Frost days 0	Annual count when TN < 0°C	days	OK
--	2	FD2	Frost days 2	Annual count when TN < 2°C	days	OK
--	3	FDm2	Hard freeze	Annual count when TN < -2°C	days	OK
--	4	FDm20	Very Hard freeze	Annual count when TN < -20°C	days	OK
3	5	**ID** = ID0	Ice days	Annual count when TX < 0°C	days	OK
2	6	**SU** = SU25	Summer days	Annual count when TX > 25°C	days	OK
4	7	**TR** = TR20	Tropical nights	Annual count when TN > 20°C	days	OK
5	8	GSL	Growing season Length	Annual (1st Jan to 31st Dec in NH, 1st July to 30st June in SH) count between first span of at least 6 days with TM>5°C and first span after July 1 (January 1 in SH) of 6 days with TM<5°C	days	
6	9	TXx	Max TX	Monthly maximum value of daily TX	°C	OK
7	--	TNx	Max TN	Monthly maximum value of daily TN	°C	OK
8	--	TXn	Min TX	Monthly minimum value of daily TX	°C	OK
9	10	TNn	Min TN	Monthly minimum value of daily TN	°C	OK
14	11	WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX>90th percentile	days	OK
--	12	WSDIn	User-defined WSDI	Annual count of days with at least *n* consecutive days when TX>90th percentile ~~where n>= 2 (and max 10)~~	days	
15	13	CSDI	Cold spell duration indicator	Annual count of days with at least 6 consecutive days when TN<10th percentile	days	OK
--	14	CSDIn	User-defined CSDI	Annual count of days with at least *n* consecutive days when TN<10th percentile ~~where n>= 2 (and max 10)~~	days	
--	15	TX50p	Above average Days	Percentage of days where TX>50th percentile	%	OK
10	--	TN10p		Percentage of days when TN < 10th percentile	%	OK
11	--	TX10p		Percentage of days when TX < 10th percentile	%	OK
12	--	TN90p		Percentage of days when TN > 90th percentile	%	OK
13	--	TX90p		Percentage of days when TX > 90th percentile	%	OK
16	--	DTR	Daily temperature range	Monthly mean difference between TX and TN	°C	OK
--	16	TX95t	Very warm day threshold	Value of 95th percentile of TX	°C	
--	17	TM5a	TM above 5°C	Annual count when TM >= 5°C	days	OK
--	18	TM5b	TM below 5°C	Annual count when TM < 5°C	days	OK
--	19	TM10a	TM above 10°C	Annual count when TM >= 10°C	days	OK

--	20	TM10b	TM below 10°C	Annual count when TM < 10°C	days	OK
--	21	SU30	Hot days	Annual count when TX >= 30°C	days	OK
--	22	SU35	Very hot days	Annual count when TX > = 35°C	days	OK
--	23	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	OK (?) **max nb** consec. days
--	24	HDDheat	Heating degree Days	Annual sum of Tb- TM (where Tb is a user-defined location-specific base temperature and TM < Tb)	°C	
--	25	CDDcold	Cooling degree Days	Annual sum of TM - Tb (where Tb is a user-defined location-specific base temperature and TM > Tb)	°C	
--	26	GDDgrow	Growing degree Days	Annual sum of TM - Tb (where Tb is a user-defined location-specific base temperature and TM >Tb)	°C	
20	--	R10mm	Number of heavy precipitation days	Annual count of days when P>=10mm	days	OK
21	27	R20mm	Number of very heavy precipitation days	Annual count of days when P>=20mm	days	OK
22	--	**Rnnmm** = Rnn	Number of days above a user-defined threshold		days	OK
23	28	CDD	Consecutive dry Days	Maximum number of consecutive days with P<1mm	days	OK
24	--	CWD	Consecutive wet Days	Maximum number of consecutive days with P>=1mm	days	OK
27	29	PRCPTOT	Annual total wet- day precipitation	PRCP from wet days (P>=1mm)	mm	OK
19	--	SDII	Simple precipitation intensity index	PRCPTOT / Nwetdays	mm	OK
25	30	R95pTOT	Contribution from very wet days	~~Annual percentage of RR>95th percentile / PRCPTOT~~ Annual total precipitation amount when RR > 95th pctl on wet days	~~%~~ mm	OK
26	31	R99pTOT	Contribution from extremely wet days	~~Annual percentage of P>99th percentile / PRCPTOT~~ Annual total precipitation amount when RR > 99th pctl on wet days	~~%~~ mm	OK
17	--	Rx1day	Monthly maximum 1-day precipitation	Monthly maximum one-day precipitation	mm	OK
18	--	Rx5day	Monthly maximum 5-day precipitation	Monthly maximum consecutive five-day precipitation	mm	OK
--	32	RXnday	User-defined consecutive days precipitation amount	Monthly maximum consecutive *n*-day precipitation ~~(up to a maximum of 10)~~	mm	OK
--	33	SPIflex	Standardised Precipitation Index	Measure of “drought” using the Standardised Precipitation Index ~~on time scales of 3, 6 and 12~~ months. No missing data are allowed to calculate SPIflex.	Dimension less index	
--	34	SPEIflex	Standardised Precipitation Evapotranspiration Index	Measure of “drought” using the Standardised Precipitation Evapotranspiration Index on time scales of 3, 6 and 12 months. No missing data are allowed to calculate SPEIflex.	Dimension less index	
--	35	HWN (EHF/ CTN90pct/ CTX90pct)	Heat wave number	The annual number of summer (Nov-Mar in SH and May-Sep in NH) heat waves where conditions persist for at least 3 consecutive days per the definitions of EHF/CTN90pct/CTX90pct in Appendix B	Number of events	
--	36	HWD (EHF/ CTN90pct/ CTX90pct)	Heat wave duration	The length of the longest summer (Nov-Mar in SH and May-Sep in NH) heat wave where conditions persist for at least 3 consecutive days per definitions per the definitions of EHF/CTN90pct/CTX90pct in Appendix B	days	

--	37	HWF (EHF/ CTN90pct/ CTX90pct)	Heat wave day frequency	The total number of days each summer (Nov-Mar in SH and May-Sep in NH) that contribute to all heat waves where conditions persist for at least 3 consecutive days per definitions per the definitions of EHF/CTN90pct/CTX90pct in Appendix B	days	
--	38	HWA (EHF/ CTN90pct/ CTX90pct)	Heat wave amplitude	The hottest day of the hottest summer (Nov- Mar in SH and May-Sep in NH) heat wave where conditions persist for at least 3 consecutive days per definitions per the definitions of EHF/CTN90pct/CTX90pct in Appendix B	°C (°C^2 EHF)	
--	39	HWM (EHF/ CTN90pct/ CTX90pct)	Heat wave mean	Average magnitude of all heat wave days (Nov-Mar in SH and May-Sep in NH) heat wave where conditions persist for at least 3 consecutive days per definitions per the definitions of EHF/CTN90pct/CTX90pct in Appendix B	°C (°C^2 EHF)	
--	40	nTXbnTNb	User-defined consecutive number of cold days and nights	Annual count of *n* consecutive days where both TX < 5th percentile and TN < 5th percentile where n >=2 and n <=10?	Number of events	1 (?) **max nb** consec. days