Climpact Indices.

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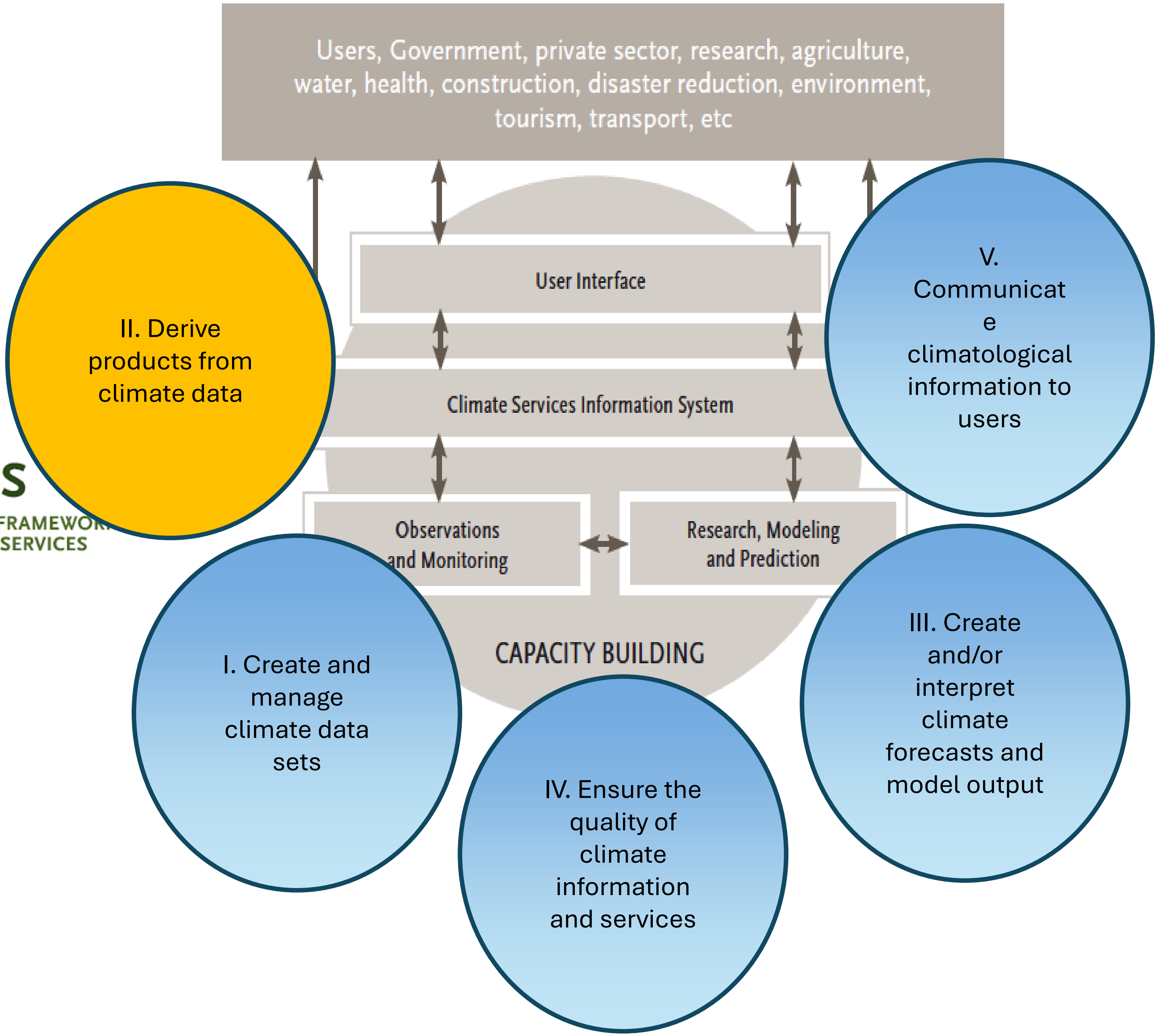
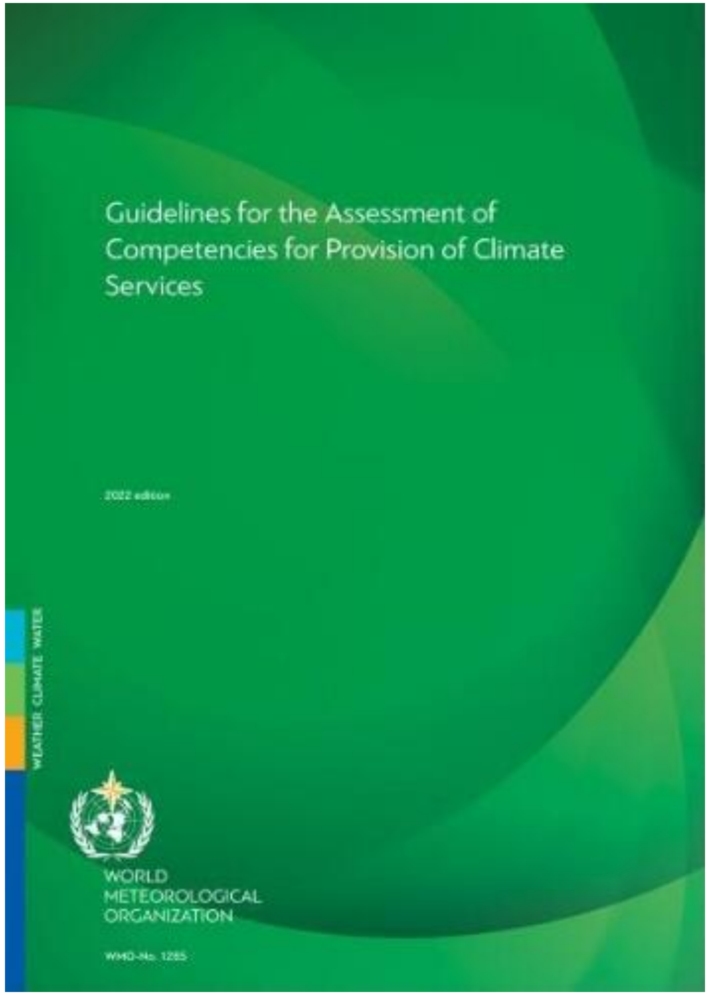
Centre for Climate Change

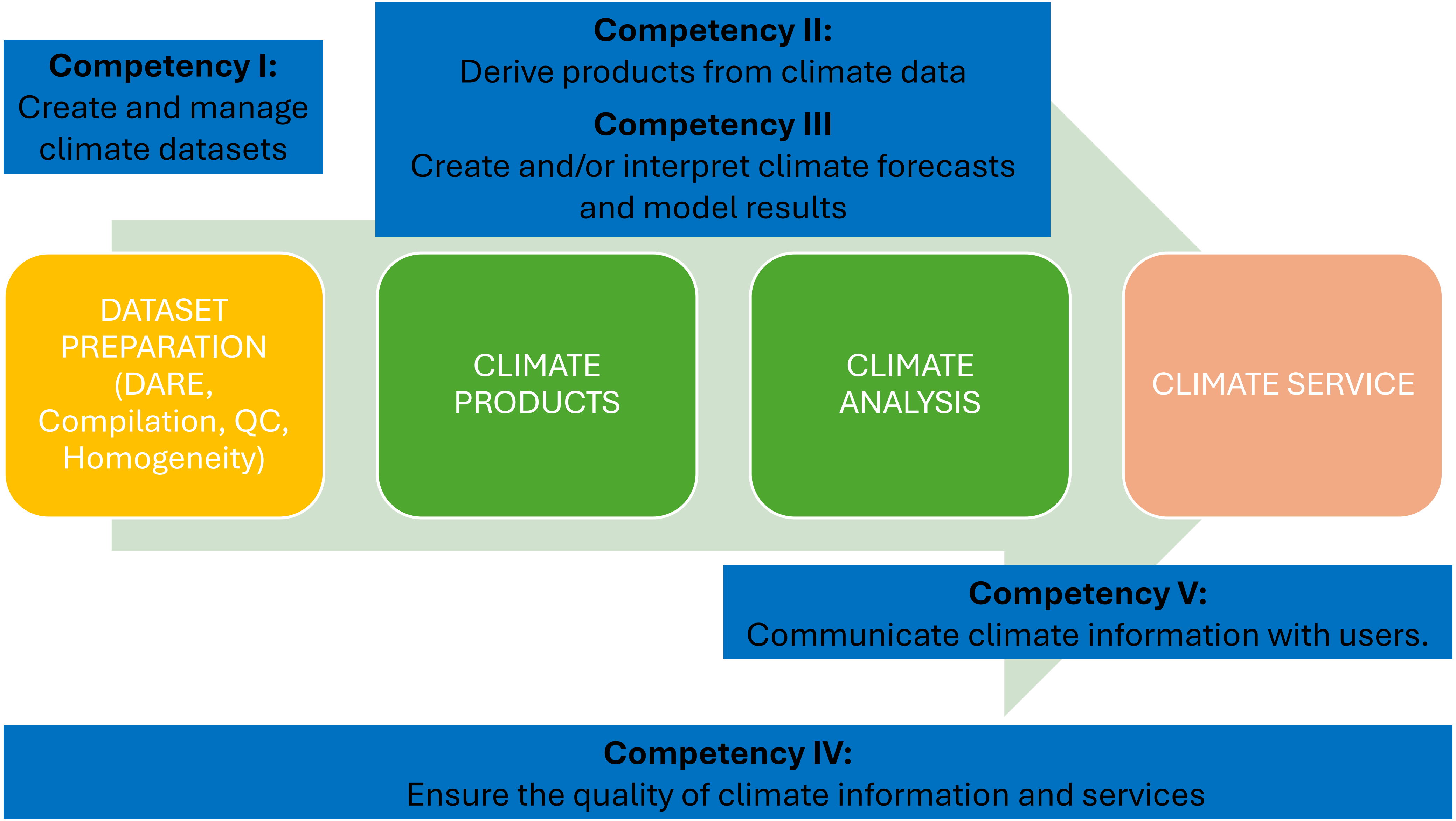
IU RESCAT

UNIVERSITAT ROVIRA i VIRGILI
Institut Universitari de Recerca en Sostenibilitat, Canvi Climàtic i Transició Energètica (IU-RESCAT)

ClimEd Workshop, Vila-seca, Tarragona, Spain.
April, 2025


Users, Government, private sector, research, agriculture, water, health, construction, disaster reduction, environment, tourism, transport, etc
User Interface
Climate Services Information System
Observations and Monitoring
Research, Modeling and Prediction
CAPACITY BUILDING
II. Derive products from climate data
V. Communicate climatological information to users
I. Create and manage climate data sets
IV. Ensure the quality of climate information and services
III. Create and/or interpret climate forecasts and model output


Guidelines for the Assessment of Competencies for Provision of Climate Services
WORLD METEOROLOGICAL ORGANIZATION



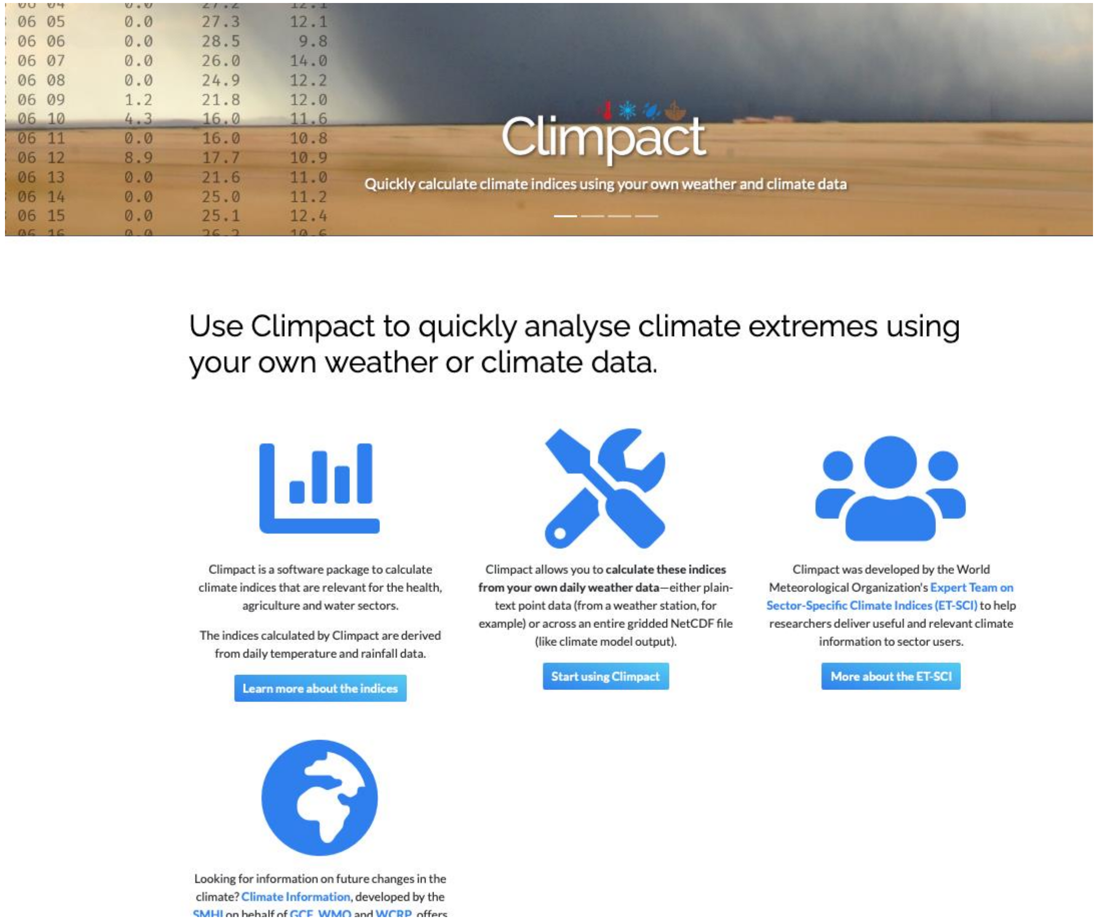
Competency I:
Create and manage climate datasets
Competency II:
Derive products from climate data
Competency III
Create and/or interpret climate forecasts and model results
DATASET PREPARATION (DARE, Compilation, QC, Homogeneity)
CLIMATE PRODUCTS
CLIMATE ANALYSIS
CLIMATE SERVICE
Competency V:
Communicate climate information with users.
Competency IV:
Ensure the quality of climate information and services

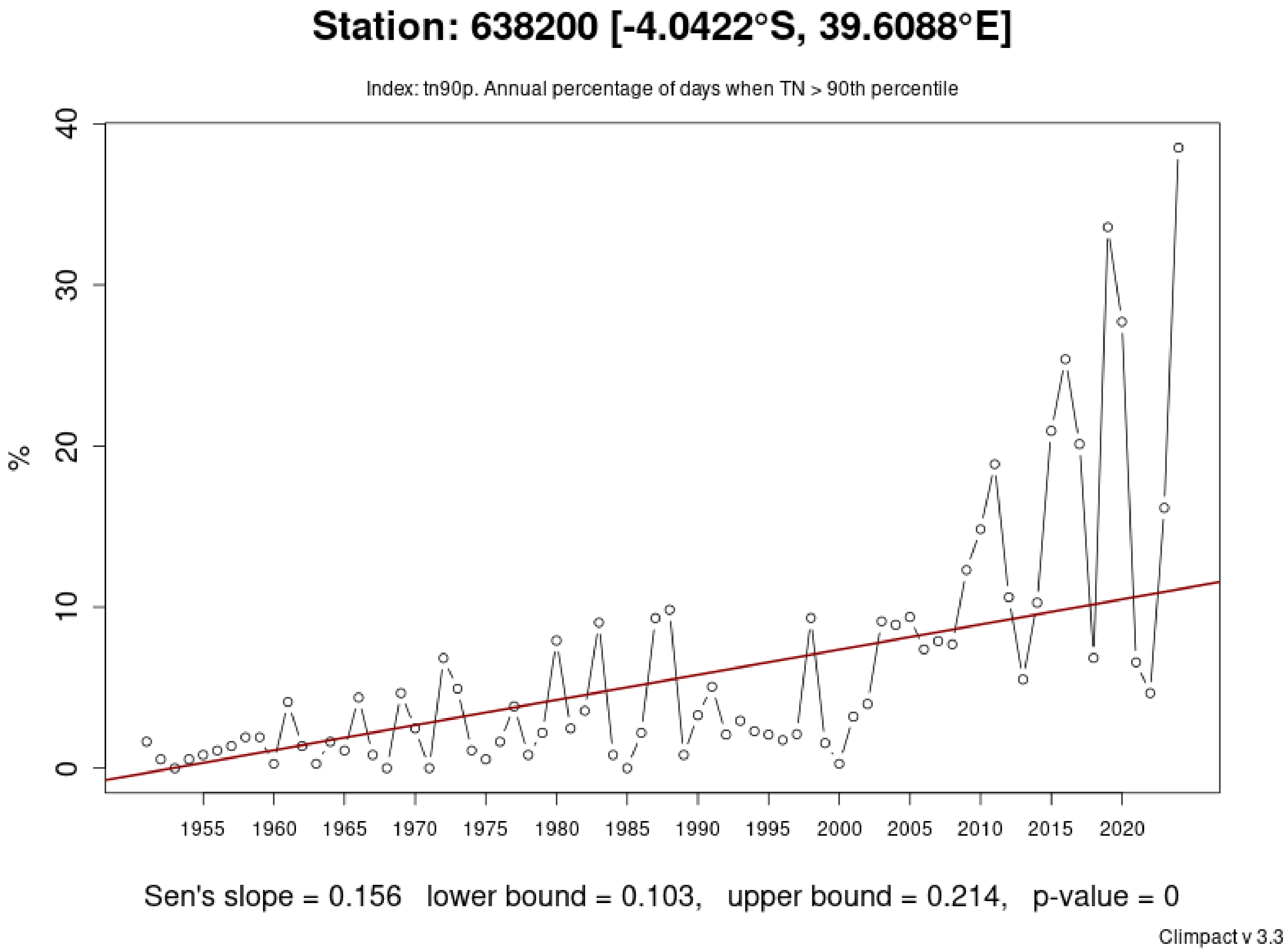
ORIGEN

- Expert Team on Climate Change Detection and Indices, ETCCDI
- 27 carefully selected indicators to cover many aspects of climate change beyond changes in the mean
- Useful for monitoring climate change at local, regional and global scales
- Rclimdex Software, Fclimdex, CRAN Package pcic.climdex
- Expanded to Climpact (Climate Impact), first pilot workshop in Guayaquil, Ecuador, 2012

Accessing Climpact

- https://climpact-sci.org





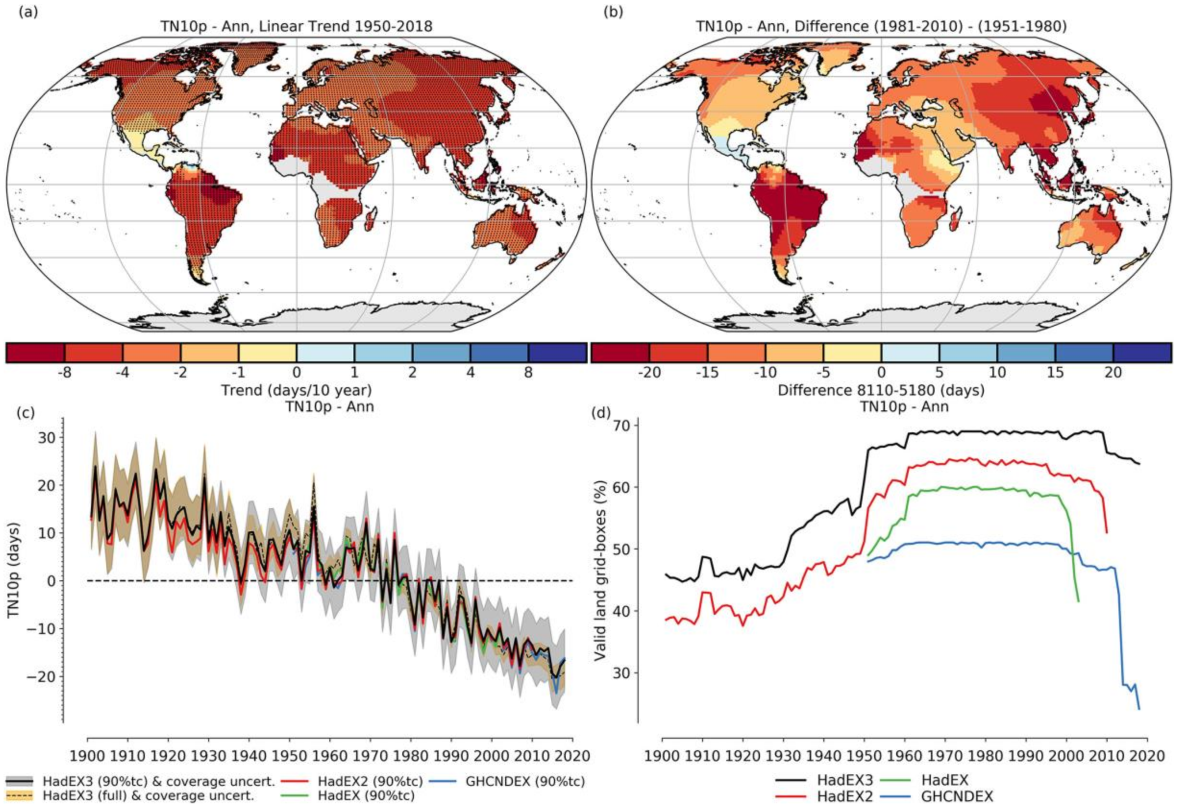
Sen slope:

$$Q = \text{Median}\left(\frac{x_j - x_i}{j - i}\right)$$

for $i < j$

Development of an Updated Global Land In Situ-Based Data Set of Temperature and Precipitation Extremes: HadEX3

Global Analisys



JGR Atmospheres

Research Article | Open Access

Development of an Updated Global Land In Situ-Based Data Set of Temperature and Precipitation Extremes: HadEX3

Robert J. H. Dunn, Lisa V. Alexander, Markus G. Donat, Xuebin Zhang, Margot Bador, Nicholas Herold, Tanya Lippmann, Rob Allan, Enric Aguilar, Abdoul Aziz Barry, Manola Brunet, John Caesar, Guillaume Chagnaud, Vincent Cheng, Thelma Cinco, Imke Durre, Rosaline de Guzman, Tin Mar Htay, Wan Maisarah Wan Ibadullah, Muhammad Khairul Izzat Bin Ibrahim, Mahbobeh Khoshkam, Andries Kruger, Hisayuki Kubota, Tan Wee Leng, Gerald Lim, Lim Li-Sha, Jose Marengo, Sifiso Mbatha, Simon McGree, Matthew Menne, Maria de los Milagros Skansi, Sandile Ngwenya, Francis Nkrumah, Chalump Oonariya, Jose Daniel Pabon-Caicedo, Gérémy Panthou, Cham Pham, Fatemeh Rahimzadeh, Andrea Ramos, Ernesto Salgado, Jim Salinger, Youssouph Sané, Ardhasena Sopaheluwakan, Arvind Srivastava, Ying Sun, Bertrand Timbal, Nichanun Trachow, Blair Trewin, Gerard van der Schrier, Jorge Vazquez-Aguirre, Ricardo Vasquez, Claudia Villarroel, Lucie Vincent, Theo Vischel, Russ Vose, Mohd Noor'Arifin Bin Hj Yussof

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Indices looking at number of days referred to an absolute threshold TN

Short name	Long name	Definition	Plain language description	Units	Time scale	Sector(s)
FD	Frost Days	Number of days when TN < 0 °C	Days when minimum temperature is below 0°C	days	Mon/ Ann	H, AFS
TNlt2	TN below 2°C	Number of days when TN < 2 °C	Days when minimum temperature is below 2°C	days	Mon/ Ann	AFS
TNltm2	TN below -2°C	Number of days when TN < -2 °C	Days when minimum temperature is below -2°C	days	Mon/ Ann	AFS
TNltm20	TN below -20°C	Number of days when TN < -20 °C	Days when minimum temperature is below -20°C	days	Mon/ Ann	H, AFS
TR	Tropical nights	Number of days when TN > 20 °C	Days when minimum temperature exceeds 20°C	days	Mon/ Ann	H,AFS

Indices looking at number of days referred to an absolute temperature threshold TX

ID	Ice Days	Number of days when TX < 0 °C	Days when maximum temperature is below 0°C	days	Mon/ Ann	H, AFS
SU	Summer days	Number of days when TX > 25 °C	Days when maximum temperature exceeds 25°C	days	Mon/ Ann	H
TXge30	TX of at least 30°C	Number of days when TX >= 30 °C	Days when maximum temperature is at least 30°C	days	Mon/ Ann	H, AFS
TXge35	TX of at least 35°C	Number of days when TX >= 35 °C	Days when maximum temperature is at least 35°C	days	Mon/ Ann	H, AFS

Indices looking at number of days referred to an absolute mean temperature threshold

TMge5	TM of at least 5°C	Number of days when TM >= 5 °C	Days when average temperature is at least 5°C	days	Mon/ Ann	AFS
TMlt5	TM below 5°C	Number of days when TM < 5 °C	Days when average temperature is below 5°C	days	Mon/ Ann	AFS
TMge10	TM of at least 10°C	Number of days when TM >= 10 °C	Days when average temperature is at least 10°C	days	Mon/ Ann	AFS
TMlt10	TM below 10°C	Number of days when TM < 10 °C	Days when average temperature is below 10°C	days	Mon/ Ann	AFS

Indices looking at the length of the growing season unsing TG

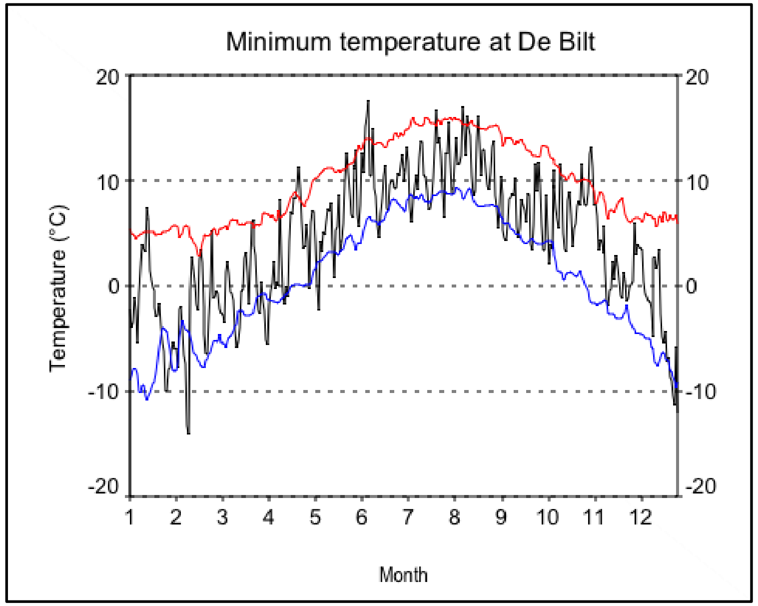
GSL	Growing Season Length	Annual number of days between the first occurrence of 6 consecutive days with TM > 5 °C and the first occurrence of 6 consecutive days with TM < 5 °C	Length of time in which plants can grow	days	Ann	AFS

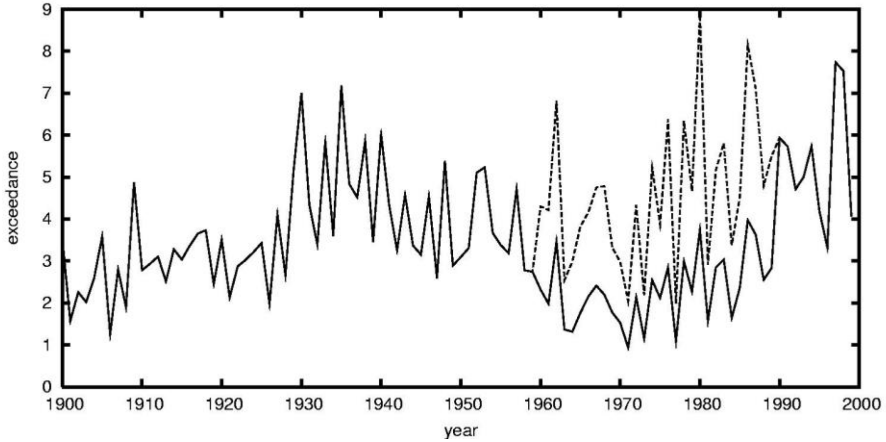
Indices looking at temperaures in ºC

DTR	Daily Temperature Range	Mean difference between daily TX and daily TN	Average range of maximum and minimum temperature	°C	Mon/ Ann	
TNx	Max TN	Warmest daily TN	Hottest night	°C	Mon/ Ann	
TXn	Min TX	Coldest daily TX	Coldest day	°C	Mon/ Ann	
TMm	Mean TM	Mean daily mean temperature	Average daily temperature	°C	Mon/ Ann	
TXm	Mean TX	Mean daily maximum temperature	Average daily maximum temperature	°C	Mon/ Ann	
TNm	Mean TN	Mean daily minimum temperature	Average daily minimum temperature	°C	Mon/ Ann	

Classic temperature percentile indices

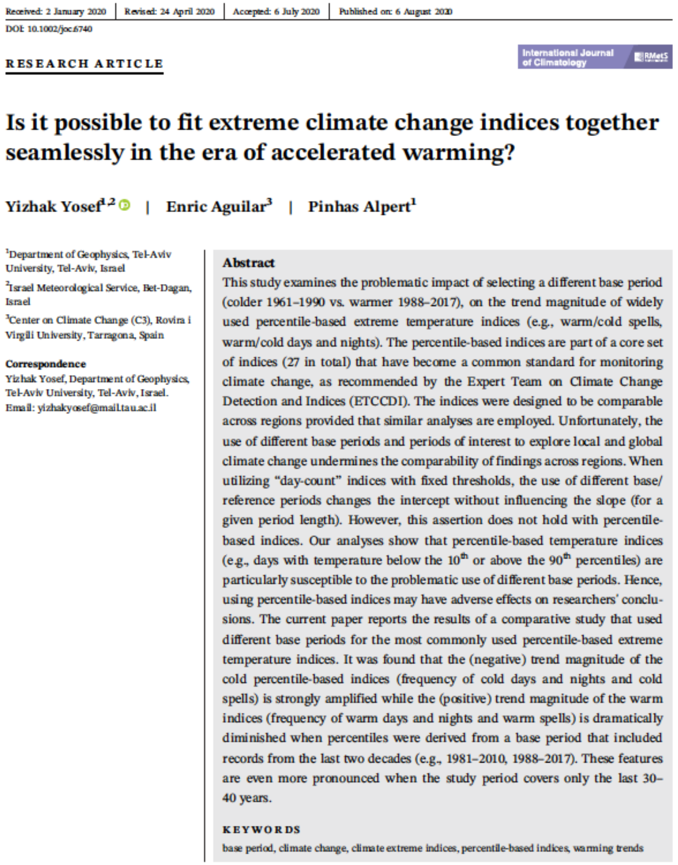
TX10p	Amount of cool days	Percentage of days when TX < 10th percentile	Fraction of days with cool day time temperatures	%	Ann	
TX90p	Amount of hot days	Percentage of days when TX > 90th percentile	Fraction of days with hot day time temperatures	%	Ann	
TN10p	Amount of cold nights	Percentage of days when TN < 10th percentile	Fraction of days with cold night time temperatures	%	Ann	
TN90p	Amount of warm nights	Percentage of days when TN > 90th percentile	Fraction of days with warm night time temperatures	%	Ann	





CLIMATE CHANGE INDICATORS:
exceedances of percentiles (temperature)

- Selecting the reference period alters the slope in percentile-based indices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RESEARCH ARTICLE

International Journal of Climatology RMetS

Is it possible to fit extreme climate change indices together seamlessly in the era of accelerated warming?

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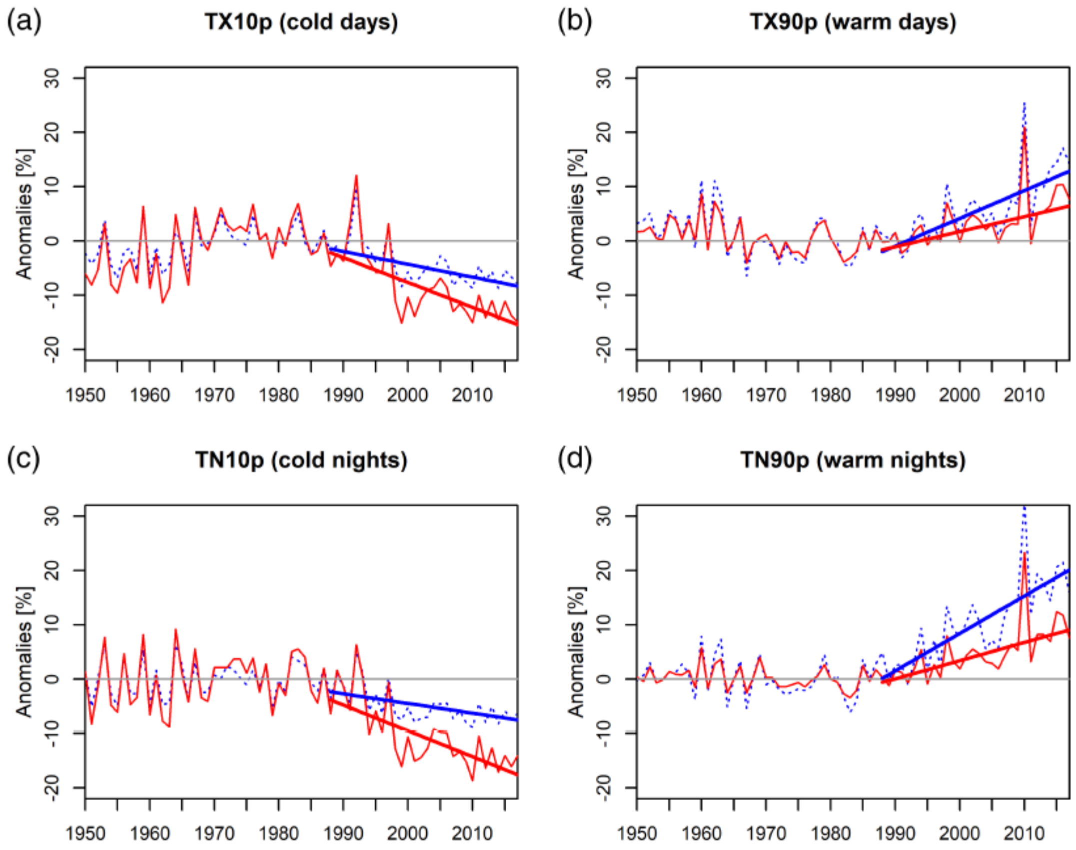
Abstract

This study examines the problematic impact of selecting a different base period (colder 1961–1990 vs. warmer 1988–2017), on the trend magnitude of widely used percentile-based extreme temperature indices (e.g., warm/cold spells, warm/cold days and nights). The percentile-based indices are part of a core set of indices (27 in total) that have become a common standard for monitoring climate change, as recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI). The indices were designed to be comparable across regions provided that similar analyses are employed. Unfortunately, the use of different base periods and periods of interest to explore local and global climate change undermines the comparability of findings across regions. When utilizing "day-count" indices with fixed thresholds, the use of different base/reference periods changes the intercept without influencing the slope (for a given period length). However, this assertion does not hold with percentile-based indices. Our analyses show that percentile-based temperature indices (e.g., days with temperature below the 10th or above the 90th percentiles) are particularly susceptible to the problematic use of different base periods. Hence, using percentile-based indices may have adverse effects on researchers' conclusions. The current paper reports the results of a comparative study that used different base periods for the most commonly used percentile-based extreme temperature indices. It was found that the (negative) trend magnitude of the cold percentile-based indices (frequency of cold days and nights and cold spells) is strongly amplified while the (positive) trend magnitude of the warm indices (frequency of warm days and nights and warm spells) is dramatically diminished when percentiles were derived from a base period that included records from the last two decades (e.g., 1981–2010, 1988–2017). These features are even more pronounced when the study period covers only the last 30–40 years.

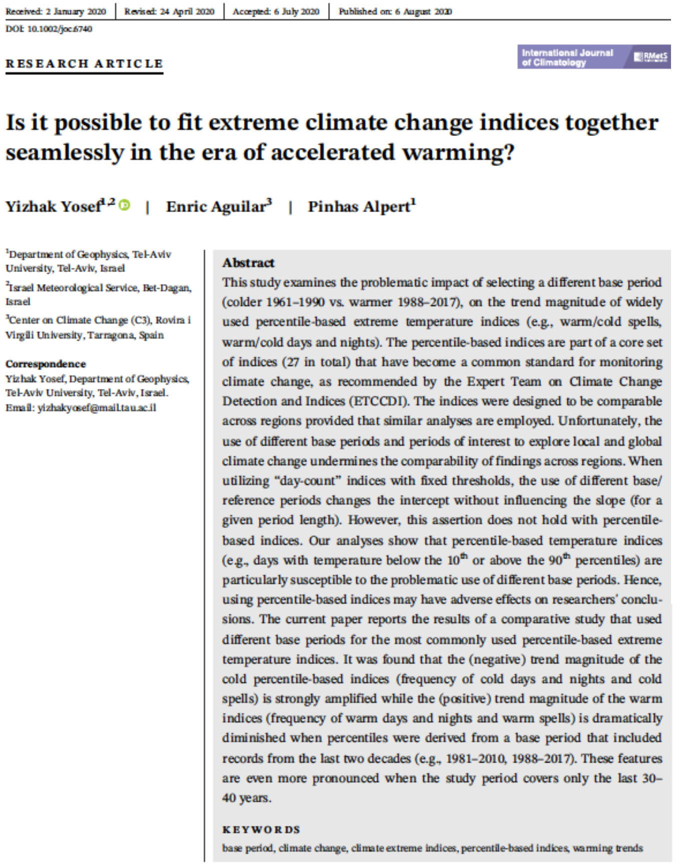
KEYWORDS
base period, climate change, climate extreme indices, percentile-based indices, warming trends

FIGURE 4 Regional averaged anomaly series (1950–2017) relative to 1961–1990 mean values of four percentile-based indices: TX10p, TX90p, TN10p, and TN90p. Solid (red) and dashed (blue) lines represent the two base periods from which the percentiles were derived, 1988–2017 (warmer) and 1961–1990 (colder) respectively. Solid blue and red lines denote the linear trends of the period 1988–2017 for both base periods



CLIMATE CHANGE INDICATORS: exceedances of percentiles (temperature)

- Selecting the reference period alters the slope in percentile-based indices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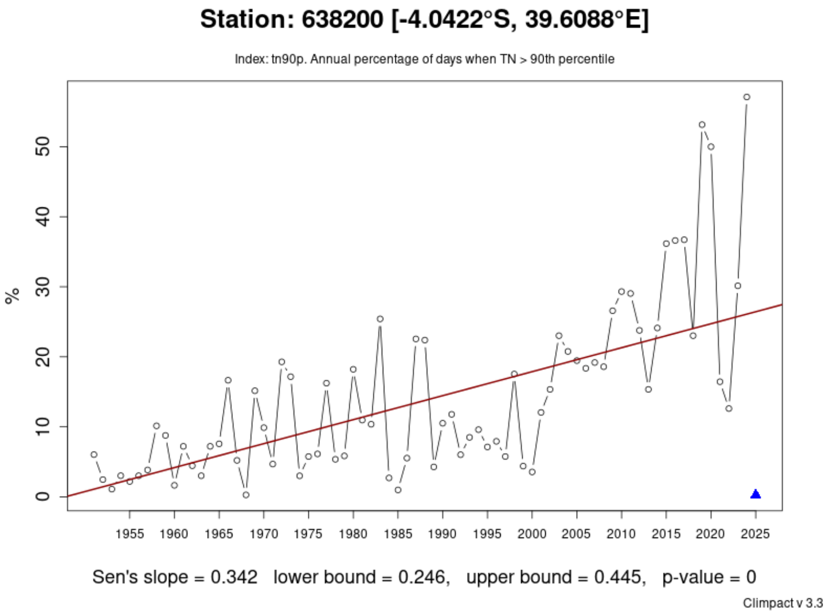
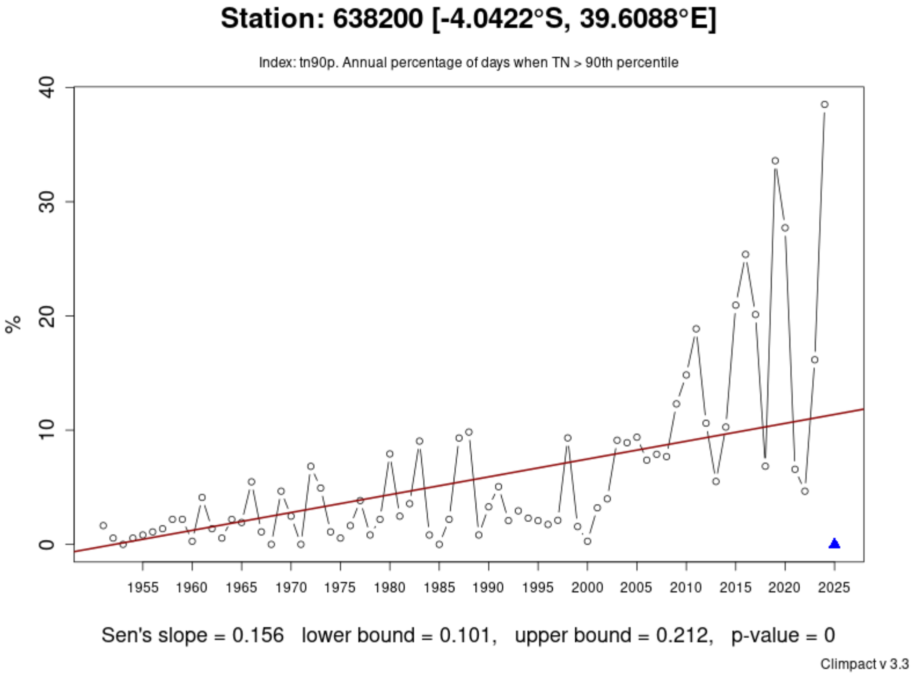


Mombasa ref. 1961-1990

Mombasa ref. 1991-2020



Other percentile temperature indices

TXgt50p	Fraction of days with temperatures above the median	Percentage of days where TX > 50th percentile	Fraction of days with above-median temperature	%	Mon/ Ann	H, AFS, WRH

TX95t	Very warm day threshold	Value of 95th percentile of TX	A threshold where days above this temperature would be classified as very warm	°C	Daily	H, AFS

Indices expressing Warm (Cold) spells based on the persistence of days above (below) the 90^{th} (10^{th}) percentile

WSDI	Warm spell duration indicator	Annual number of days contributing to events where 6 or more consecutive days experience TX > 90th percentile	Number of days contributing to a warm period (where the period has to be at least 6 days long)	days	Ann	H, AFS, WRH
WSDId	User-defined WSDI	Annual number of days contributing to events where d or more consecutive days experience TX > 90th percentile	Number of days contributing to a warm period (where the minimum length is user-specified)	days	Ann	H, AFS, WRH
CSDI	Cold spell duration indicator	Annual number of days contributing to events where 6 or more consecutive days experience TN < 10th percentile	Number of days contributing to a cold period (where the period has to be at least 6 days long)	days	Ann	H, AFS
CSDId	User-defined CSDI	Annual number of days contributing to events where d or more consecutive days experience TN < 10th percentile	Number of days contributing to a cold period (where the minimum length is user-specified)	days	Ann	H, AFS, WRH

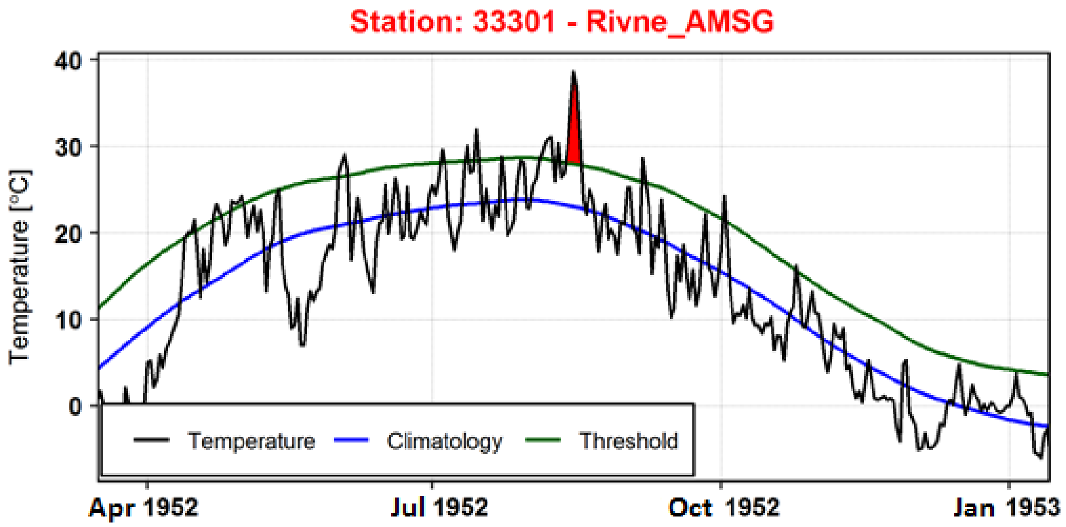
Consectutive hot days and nights

TXdTNd	User-defined consecutive number of hot days and nights	Annual count of d consecutive days where both TX > 95th percentile and TN > 95th percentile, where 10 >= d >= 2	Total consecutive hot days and hot nights (where consecutive periods are user-specified)	events	Ann	H, AFS, WRH

Indices based on the “degree days concept”

HDDheatn	Heating Degree Days	Annual sum of n - TM (where n is a user-defined location-specific base temperature and TM < n)	A measure of the energy demand needed to heat a building	degree-days	Ann	H
CDDcoldn	Cooling Degree Days	Annual sum of TM - n (where n is a user-defined location-specific base temperature and TM > n)	A measure of the energy demand needed to cool a building	degree-days	Ann	H
GDDgrown	Growing Degree Days	Annual sum of TM - n (where n is a user-defined location-specific base temperature and TM > n)	A measure of heat accumulation to predict plant and animal developmental rates	degree-days	Ann	H, AFS

Heat waves: definitions, metrics



- Several HW definitions are usually used depending on purposes/target sector (economy, public health, etc.).
- We use the generalized and unified approach by Perkins and Alexander (2013)*, which is the most suitable for climatology
- **HW is an event when TX above 90-th percentile, calculated based on the WMO standard 1961-1990 reference period, persist at least three consecutive days, with permission of a 1-day time gap**

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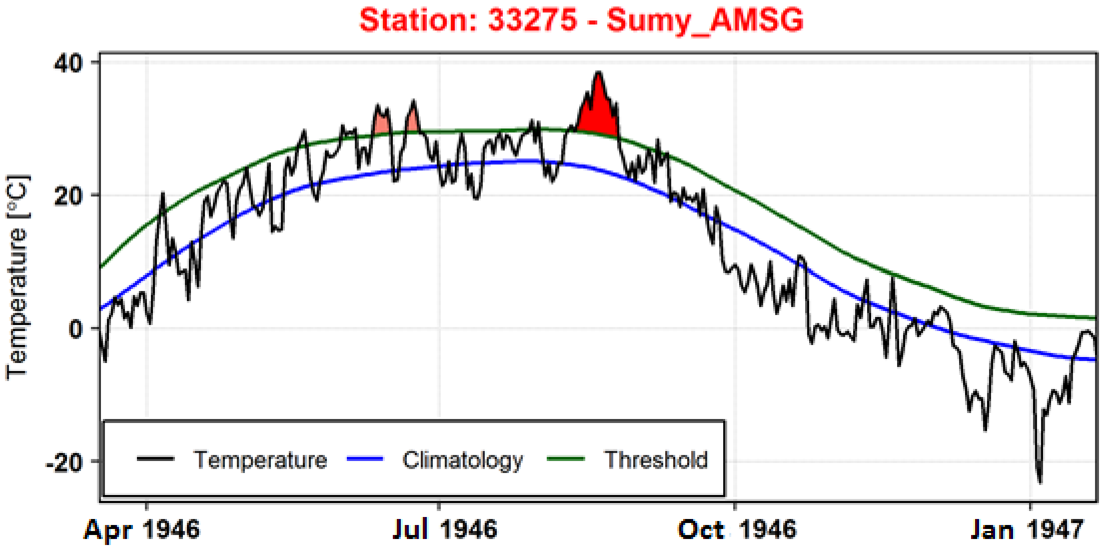
*Perkins S.E., Alexander L.V. (2013) On the Measurement of Heat Waves. *J. Climate*, 26, 4500–4517

Heat waves: definitions, metrics, uncertainty

- HW metrics (all calculated on the yearly basis):
  - *heat wave number* (**HWN**) is the yearly number of heat wave events, [events]
  - *heat wave duration* (**HWD**) is the length of the longest yearly event, [days]
  - *heat wave frequency* (**HWF**) is the sum of participating heat wave days per year, [days]
  - *heat wave amplitude* (**HWA**) is the maximum intensity of the hottest yearly event, [^{o}C] (the HW intensity is defined as a difference between TX and a corresponding value of the climatological seasonal cycle)



HWN(1946) = 3 [events]

HWD(1946) = 12 [days]

HWF(1946) = 23 (6+5+12) [days]

HWA(1946) = 17 [^{o}C]

All HW metric calculations were performed with R package ***heatwaveR***

HW Indices (Days and Events)

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.	See Appendix D and Perkins and Alexander (2013) for more details.	Number of individual heatwaves events	Ann	H, AFS, WRH
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 D and Perkins and Alexander (2013) for more details.	days	Ann	H, AFS, WRH

HW Indices (ºC)

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 D and Perkins and Alexander (2013) for more details.	°C (°C^2 for EHF)	Ann	H, AFS, WRH
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 D and Perkins and Alexander (2013) for more details.	°C (°C^2 for EHF)	Ann	H, AFS, WRH

CW Indices (Days)

CWN_ECF	Coldwave number (CWN) as defined by the Excess Cold Factor (ECF).	The number of individual 'coldwaves' that occur each year.	See Appendix D and Nairn and Fawcett (2013) for more information.	events	Ann	H, AFS, WRH
CWF_ECF	Coldwave frequency (CWF) as defined by the Excess Cold Factor (ECF).	The number of days that contribute to 'coldwaves' as identified by ECF_HWN.	See Appendix D and Nairn and Fawcett (2013) for more information.	days	Ann	H, AFS, WRH
CWD_ECF	Coldwave duration (CWD) as defined by the Excess Cold Factor (ECF).	The length of the longest 'coldwave' identified by ECF_HWN.	See Appendix D and Nairn and Fawcett (2013) for more information.	days	Ann	H, AFS, WRH

CW Indices (ºC)

CWM_ECF	Coldwave magnitude (CWM) as defined by the Excess Cold Factor (ECF).	The mean temperature of all 'coldwaves' identified by ECF_HWN.	See Appendix D and Nairn and Fawcett (2013) for more information.	°C^2	Ann	H, AFS, WRH
CWA_ECF	Coldwave amplitude (CWA) 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 Appendix D and Nairn and Fawcett (2013) for more information.	°C^2	Ann	H, AFS, WRH

Drought Indices (adimensional)

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 details. Calculated using the SPEI R package.	A drought measure specified as a precipitation deficit	unitless	Custom	H, AFS, WRH
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 details. Calculated using the SPEI R package.	A drought measure specified using precipitation and evaporation	unitless	Custom	H, AFS, WRH

Consecutive Wet/Dry Days

CWD	Consecutive Wet Days	Maximum annual number of consecutive wet days (when PR >= 1.0 mm)	The longest wet spell	days	Ann	
CDD	Consecutive Dry Days	Maximum number of consecutive dry days (when PR < 1.0 mm)	Longest dry spell	days	Ann	H, AFS, WRH

Rainfall indices in days or mm/day

R10mm	Number of heavy rain days	Number of days when PR >= 10 mm	Days when rainfall is at least 10mm	days	Mon/ Ann	
Rnnmm	Number of customised rain days	Number of days when PR >= nn	Days when rainfall is at least a user-specified number of mm	days	Mon/ Ann	
SDII	Daily PR intensity	Annual total PR divided by the number of wet days (when total PR >= 1.0 mm)	Average daily wet-day rainfall intensity	mm/day	Ann	

Rainfall indices based on percentiles

R95p	Total annual PR from heavy rain days	Annual sum of daily PR > 95th percentile	Amount of rainfall from very wet days	mm	Ann	
R99p	Total annual PR from very heavy rain days	Annual sum of daily PR > 99th percentile	Amount of rainfall from extremely wet days	mm	Ann	
R95pTOT	Contribution from very wet days	100*r95p / PRCPTOT	Fraction of total wet-day rainfall that comes from very wet days	%	Ann	AFS, WRH
R99pTOT	Contribution from extremely wet days	100*r99p / PRCPTOT	Fraction of total wet-day rainfall that comes from extremely wet days	%	Ann	AFS, WRH

Rainfall indices based mm

Rx1day	Max 1-day PR	Maximum 1-day PR total	Maximum amount of rain that falls in one day	mm	Mon/ Ann	
Rx5day	Max 5-day PR	Maximum 5-day PR total	Maximum amount of rain that falls in five consecutive days	mm	Mon/ Ann	
RXdday	User-defined consecutive days PR amount	Maximum d-day PR total	Maximum amount of rain that falls in a user-specified period	mm	Mon/ Ann	H, AFS, WRH
PRCPTOT	Annual total wet-day PR	Sum of daily PR >= 1.0 mm	Total wet-day rainfall	mm	Mon/ Ann	AFS, WRH

Thanks for your attention!

Any questions?