MAPS OF CURRENTLY USED INDICATORS

A structured network for integration of climate knowledge into policy and territorial planning

DELIVERABLE INFORMATION	
WP:	WP3 Mapping and Harmonising Data & Downscaling
Activity:	3.1 Review of the currently used indicators of climate risks
WP Leader:	RHMSS
Activity leader:	RHMSS
Participating partners:	RHMSS, NIMH, OMSZ, NMA, DHMZ, RHMZ RS, HMSM, OSENU, BMLFUW, CMCC, PAT, Attica Region
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CONTENT

I Introduction

The ORIENTGATE project aims to implement concerted and coordinated climate adaptation actions across South Eastern Europe (SEE). The partnership comprises 22 financing partners, nine associates and three observers, covering 13 countries, that together will explore climate risks faced by coastal, rural and urban communities, contributing to a better understanding of the impacts of climate variability and climate change on water regimes, forests and agroecosystems. The main objective of the project is to communicate up-to-date climate knowledge for the benefit of policy makers, including urban planners, nature protection authorities, regional and local development agencies, and territorial and public works authorities. *Retrieved from http://orientgate.rec.org/.*

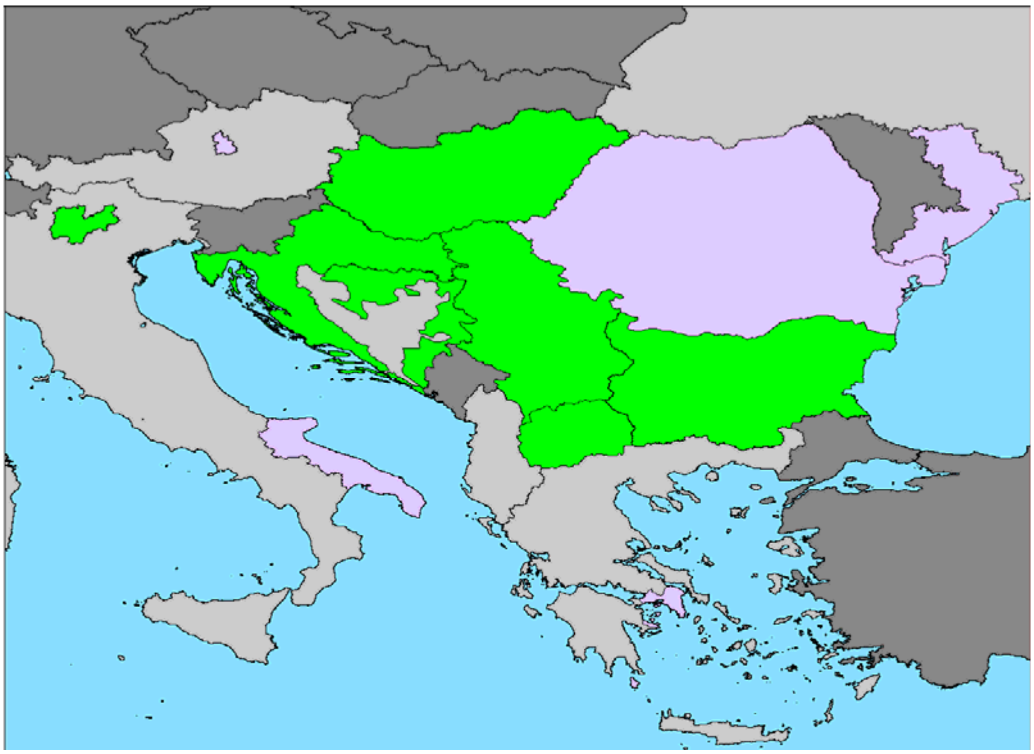
Republic Hydrometeorological Service of Serbia (RHMSS) is the leader of the Work Package 3 (WP3)-*Mapping and Harmonizing data and Downscaling*. WP3 maps the variety of the methodologies, tools and indicators used by the Hydrometeorological offices across the SEE countries. All information is collected from different Meteorological services based on a custom made template by WP leader. Collected data will serve as a starting point to create a proposal for a new cross-harmonized set of indicators.

This document shows the currently used indices by the meteorological services and pilot partners in the project area. In order to obtain a uniform perspective on perceived changes in weather and climate extremes, the core set of 27 extremes indices proposed by the Expert Team on Climate Change Detection and Indices (ETCCDI) was used. In addition, maps are showing other relevant indices used by the project partners that have proved to be very useful for climate monitoring. Maps are designed in the Geographic Coordinate System: GCS_WGS_1984 projection.

II Maps of indices based on temperature and precipitation amount

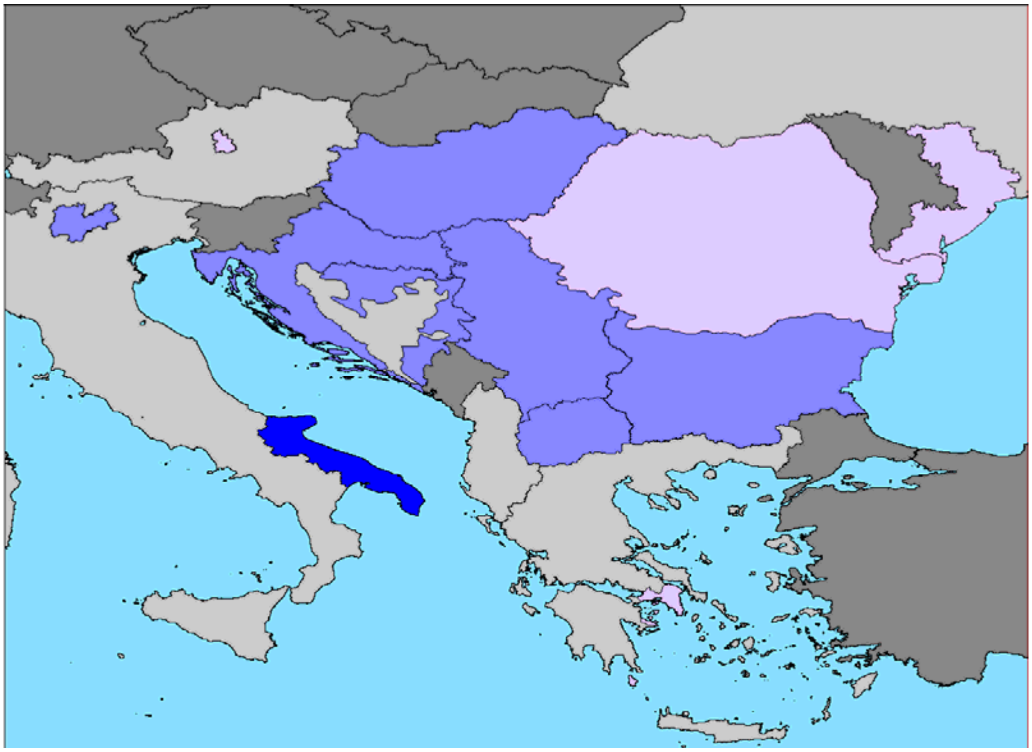
1. Maps of indices that are proposed by ETCCDI

The maps 1-3 depict the spatial coverage of the index usage calculated on the basis of the daily mean, minimum and maximum temperatures and precipitation amount. All the index abbreviations are listed in the map's legend highlighting project partner's areas in different colors while their definitions are given in the Appendix I.



(green)	Project partners (PPs) that calculate: FD, SU, ID, TR20, TXx, TNx, TXn, TNn, TN10p, TX10p, TN90p, TX90p, CSDI, DTR, RX1day, RX5day, R20mm, CWD, R95pTOT, R99pTOT	(light grey)	PPs that participate with pilot areas / Observing PPs
(lilac)	PPs that do not calculate stated indices	(dark grey)	Not participating in the project

Figure 1 – Spatial coverage of indices FD, SU, ID, TR20, TXx, TNx, TXn, TNn, TN10p, TX10p, TN90p, TX90p, CSDI, DTR, RX1day, RX5day, R20mm, CWD, R95pTOT, R99pTOT



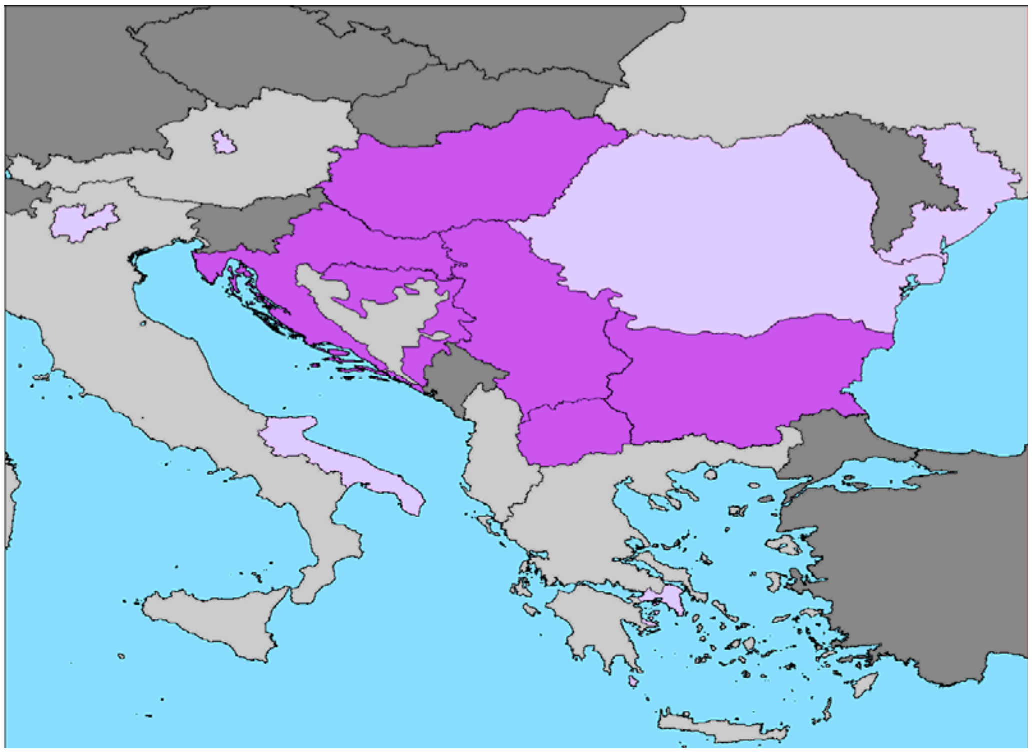
	Project partners that calculate: GSL, WSDI, CDD, SDII		Participating PPs with pilot areas / Observing PPs
	Project partners that calculate: GSL, WSDI, CDD, SDII – different definition		Not participating in the project
	PPs that do not calculate stated indices		

Figure 2 – Spatial coverage of indices GSL, WSDI, CDD, SDII

SDII, simple daily intensity index: mean precipitation amount on a wet day

Let RRij be the daily precipitation amount on wet day w (RR ≥ 1 mm) in period j. If W represents the number of wet days in j then the simple precipitation intensity index SDIIj = sum (RRwj) / W.

SDII – different definition - simple daily intensity index: anomaly of mean daily precipitation intensity from climate normal values

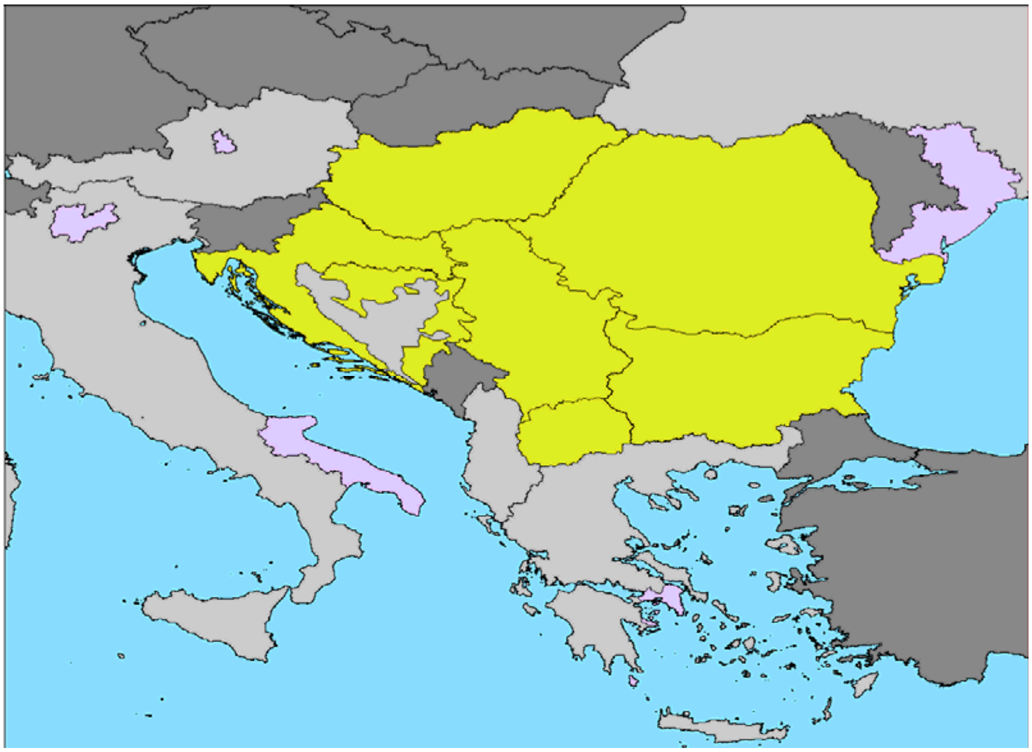


	PPs that calculate: R10mm, PRCPTOT		Participating PPs with pilot areas / Observing PPs
	PPs that do not calculate stated indices		Not participating in the project

Figure 3 – Spatial coverage of R10mm, PRCPTOT

2. Maps of indices that are not proposed by ETCCDI

One of the most commonly used indices, though non-listed on ETCCDI is Standardized Precipitation Index (SPI). Mutual for all project participants is that all meteorological services either use or have used this index. Ukraine, Austria and Italy-Trento have the possibility to calculate SPI for certain stations. Definition and method of calculation can be found in e.g. McKee (1993) and Loukas (2004).



	PPs that calculate: SPI		Participating PPs with pilot areas / Observing PPs
	PPs that do not calculate stated indices		Not participating in the project

Figure 4 - Spatial coverage of SPI index

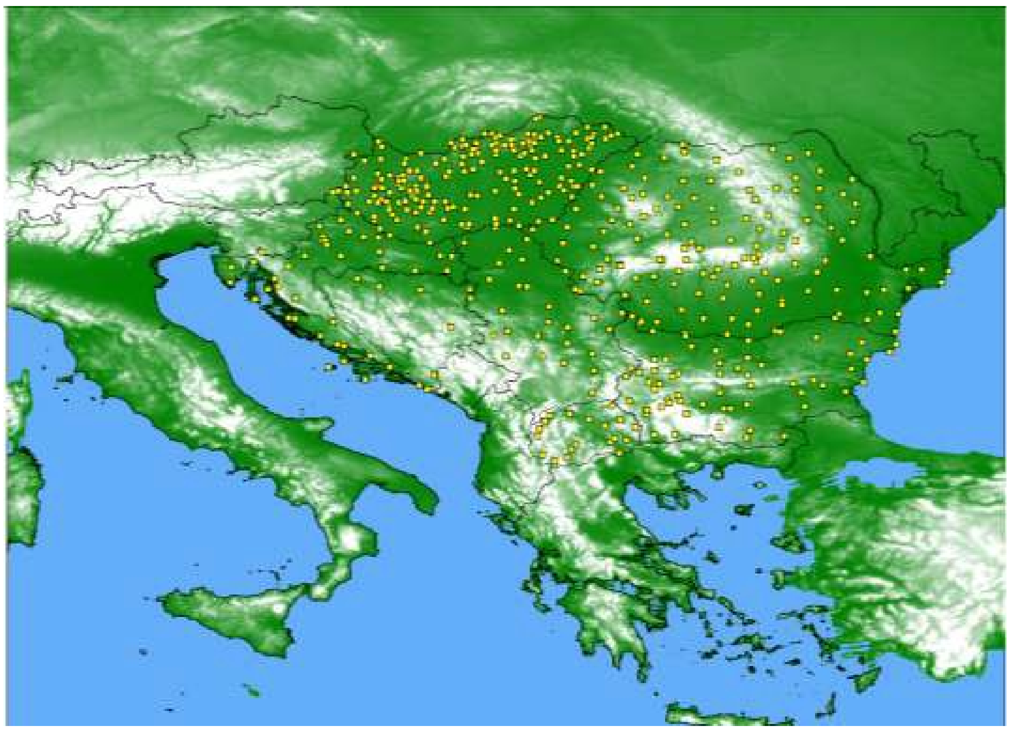
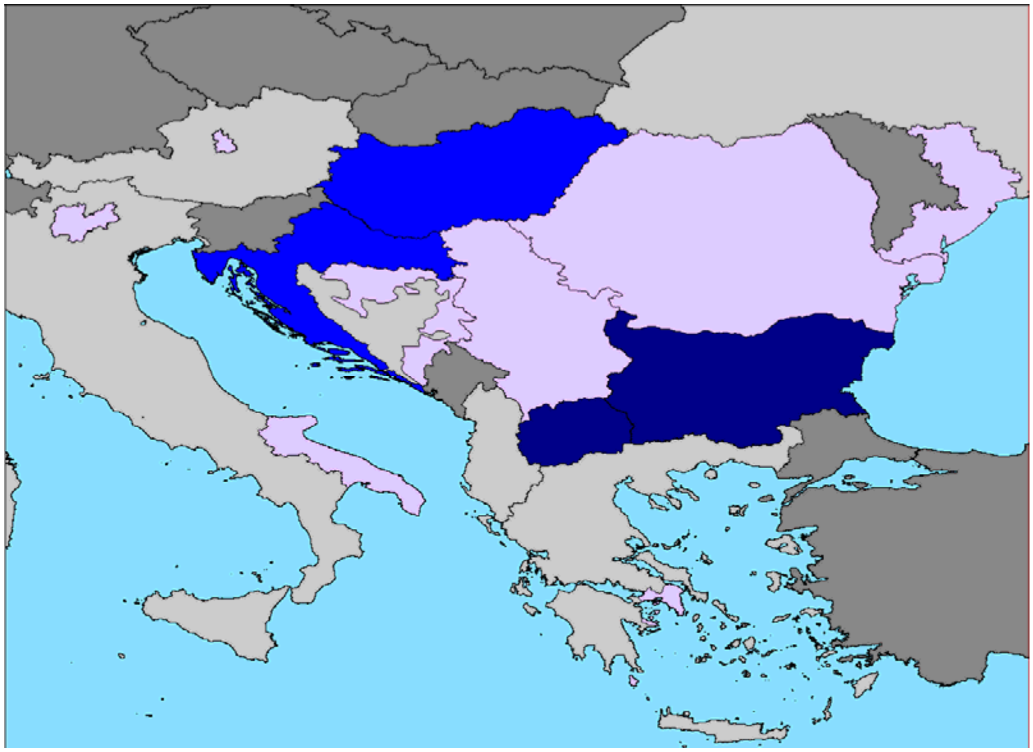


Figure 5 – Spatial distribution of meteorological stations in which SPI index is calculated

Both R30mm and R100mm are indices based on the precipitation amount, regarded as the concretization of the Rnnmm index for the threshold interesting to the users (user-defined threshold in mm). Moreover, R100mm can be applied in the analysis of the extreme precipitation days, as well as for the flood risk assessment.



	PPs that calculate: R30mm		Participating PPs with pilot areas / Observing PPs
	PPs that calculate: R30mm, R100mm		Not participating in the project
	PPs that do not calculate stated indices		

Figure 6 – Spatial coverage of indices R30mm, R100mm

The definitions of the indices maped on the Figure 7 are the following:

- FD10 – heavy frost days: count of days where TN (daily minimum temperature) < -10°C

- TD - tropical days: count of days where TX (daily maximum temperature) > 30°C

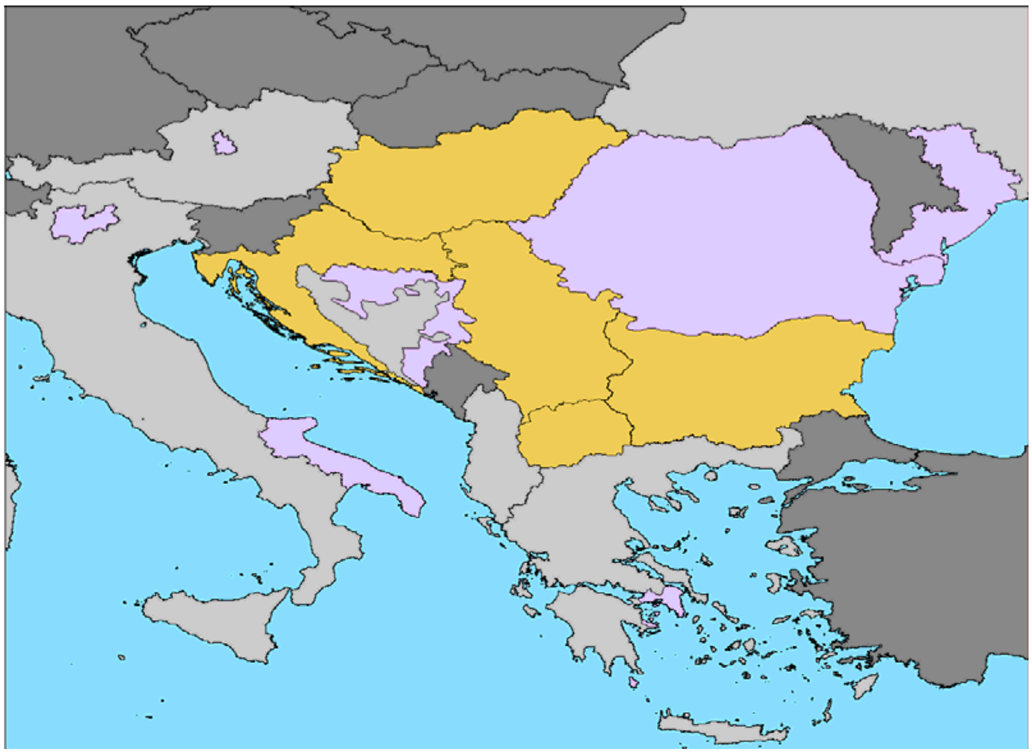
- R0.1mm – count of days where RR ≥ 0.1 mm

- R1mm - count of days where RR ≥ 1 mm

- R5mm - count of days where RR ≥ 5 mm

- R50mm - count of days where RR ≥ 50 mm

These indices modification of the ETCCDI indices according to the climate characteristics of certain areas.

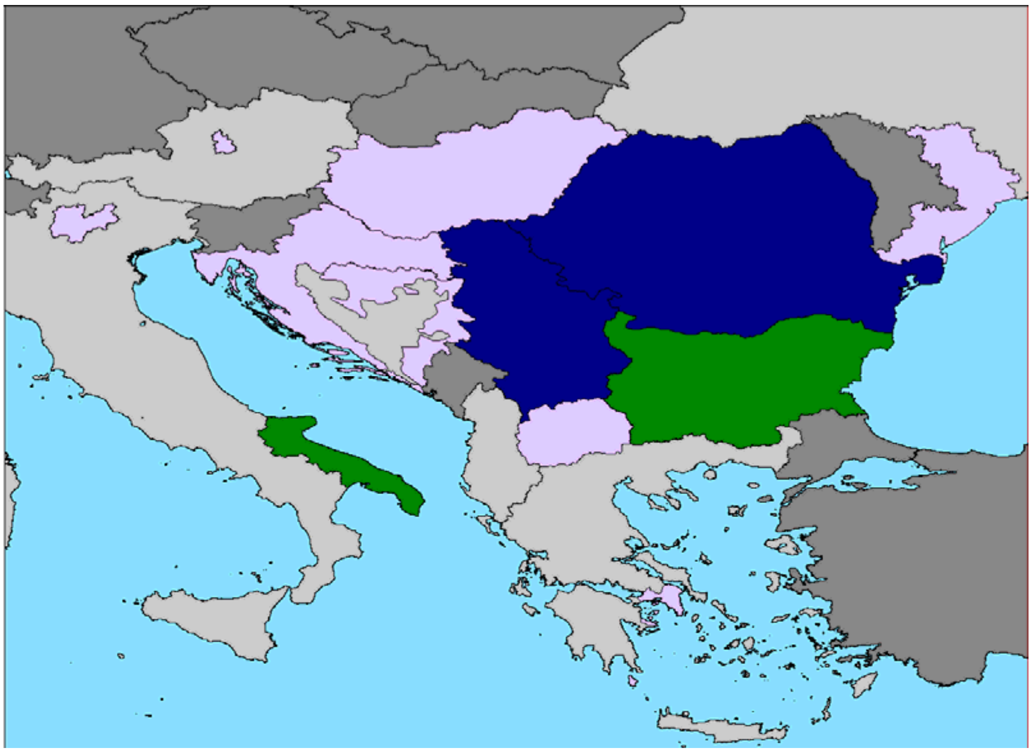


	PPs that calculate: FD10, TD, R0.1mm, R1mm, R5mm, R50mm		Participating PPs with pilot areas / Observing PPs
	PPs that do not calculate stated indices		Not participating in the project

Figure 7 – Spatial coverage of the indices FD10, TD, R0.1mm, R1mm, R5mm, R50mm

Figure 8 shows the index GDD defined as: Growing Degree Days: subtraction the plant's lowers base temperature of 5 °C from the average daily air temperature.

In addition to GDD, Standardized Precipitation Evaporation Index (SPEI) is also depicted. Definition and method of calculation for SPEI can be found in Vicente-Serrano (2009).



	PPs that calculate: GDD		Participating PPs with pilot areas / Observing PPs
	PPs that calculate: SPEI		Not participating in the project
	PPs that do not calculate stated indices		

Figure 8 – Spatial coverage of indices GDD and SPEI

The definitions of the indices used on the Figure 9 are the following:

- R25mm - count of days where RR ≥ 25 mm

- TND90p – number of warm nights: count of days where TN> 90th percentile

- TXD90p – number of warm day-times: count of days where TX> 90th percentile

- TND10p – number of cold nights: count of days where TN< 10th percentile

- TXD10p – number of cold day-times: count of days where TX< 10th percentile

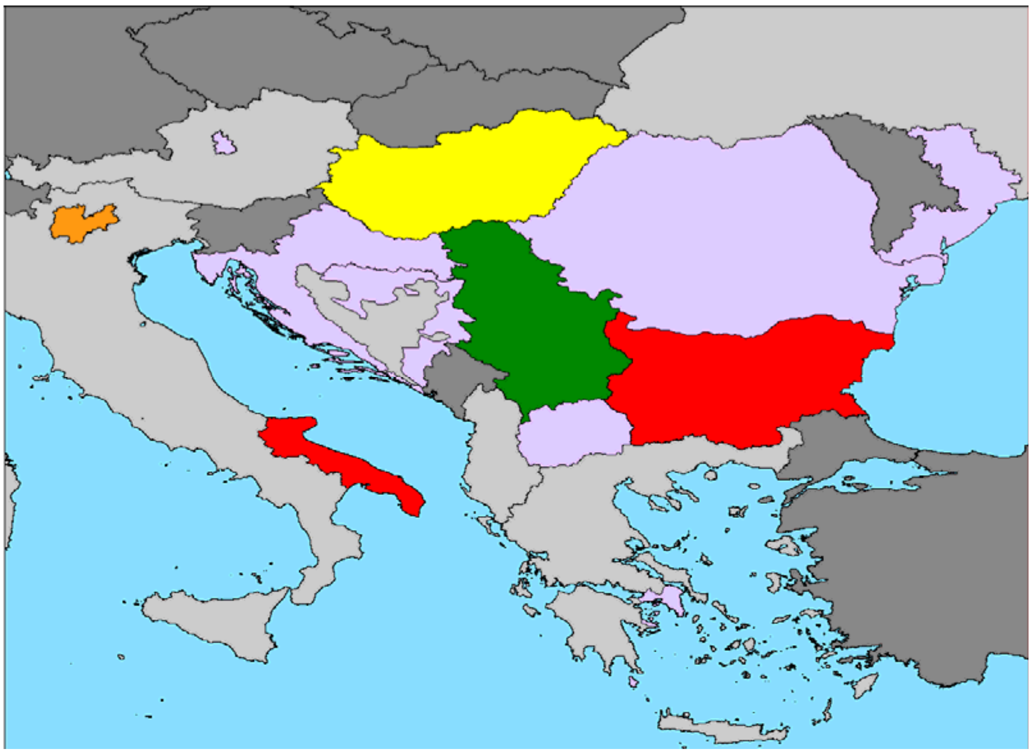
- PADI -
http://www.atikovizig.hu/projektx/dmcsee/ThePalfaiDroughtIndex_PaDI_Summary.pdf

- EQ – Ellenberg's climate quotient - EQ = (Tvii / Pannual) * 1000

- FAI - forest aridity index – FAI = 100 * Tvii-viii / (Pv-vii + Pvii-viii)

- Heat waves according to Italy-CMCC define more than 3 days with daylight average temperature above 32°C and deviating from 30-year mean of at least 5°C

The first five indices are modified ETCCDI indices. PADI is used both in agriculture and water management, while EQ i FAI are used in forestry.

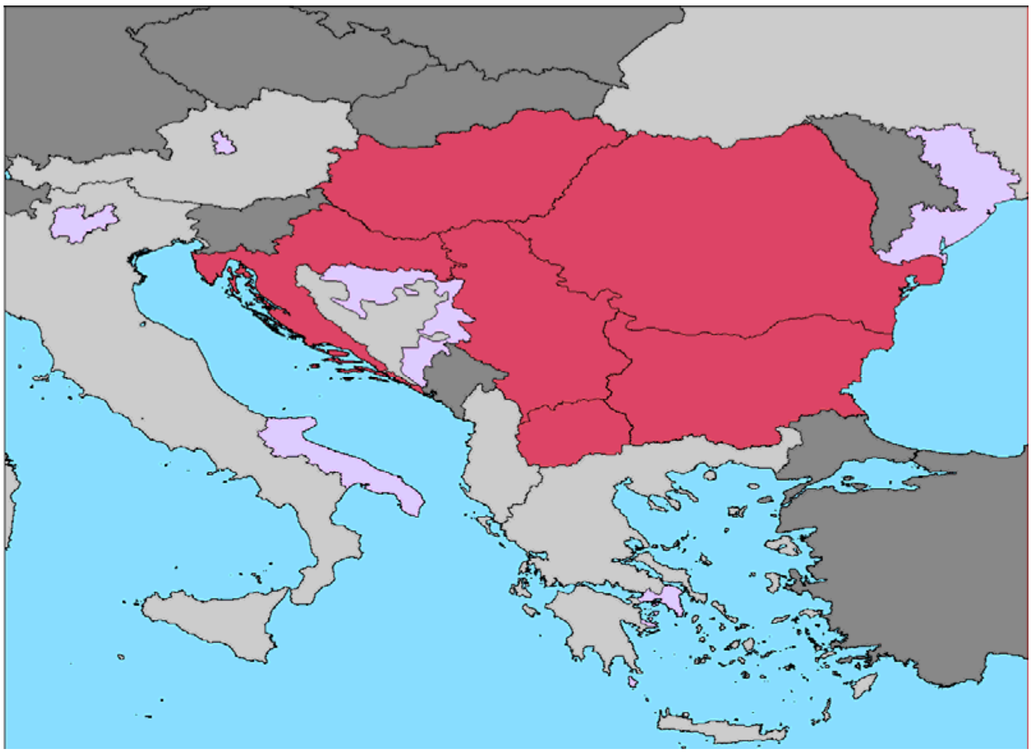


(yellow)	PPs that calculate: PADI	(light purple)	PPs that do not calculate stated indices
(orange)	PPs that calculate: TND90p, TXD90p, TND10p, TXD10p	(light grey)	Participating PPs with pilot areas / Observing PPs
(red)	PPs that calculate: HEAT WAVES	(dark grey)	Not participating in the project
(green)	PPs that calculate: R25mm, EQ, FAI		

Figure 9 – Spatial coverage of indices PADI, TND90p, TXD90p, TND10p, TXD10p, heat waves, R25mm, EQ, FAI

III Maps of indices based on other parameters in addition to temperature and precipitation amount

Besides SPI, the second, most frequently used index, not listed on ETCCDI is Palmer Drought Severity Index (PDSI). Index is originally described in the paper of Palmer and can be found on http://www.ncdc.noaa.gov/temp-and-precip/drought/docs/palmer.pdf.



	PPs that calculate: PDSI		Participating PPs with pilot areas / Observing PPs
	PPs that do not calculate stated indices		Not participating in the project

Figure 10 – Spatial coverage of the indices PDSI

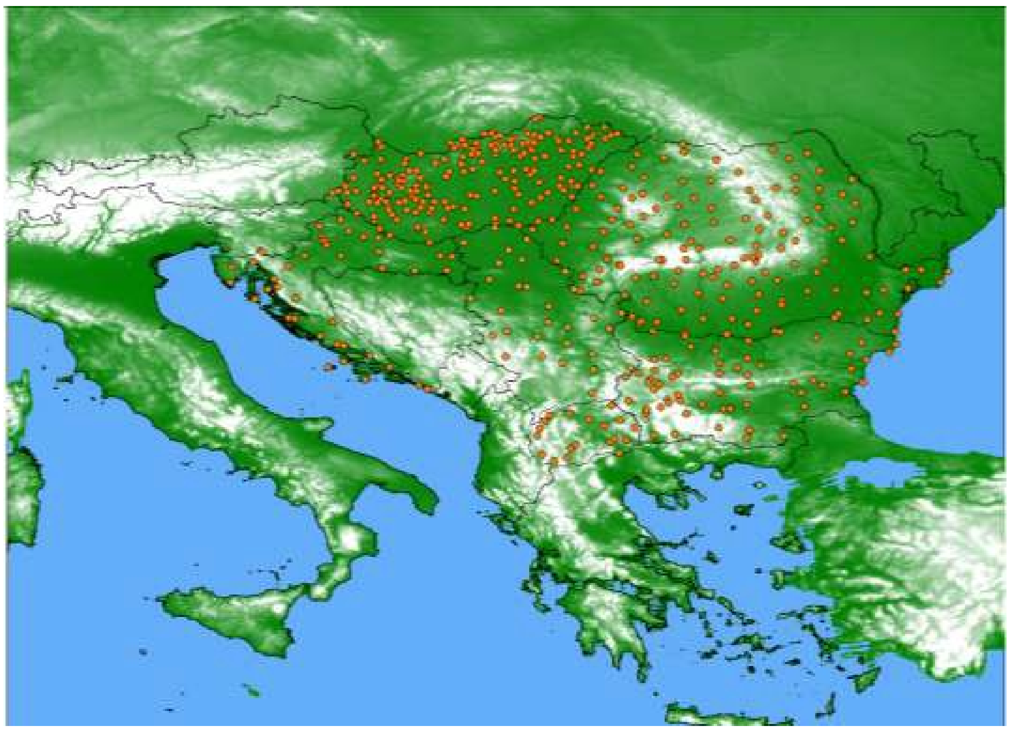
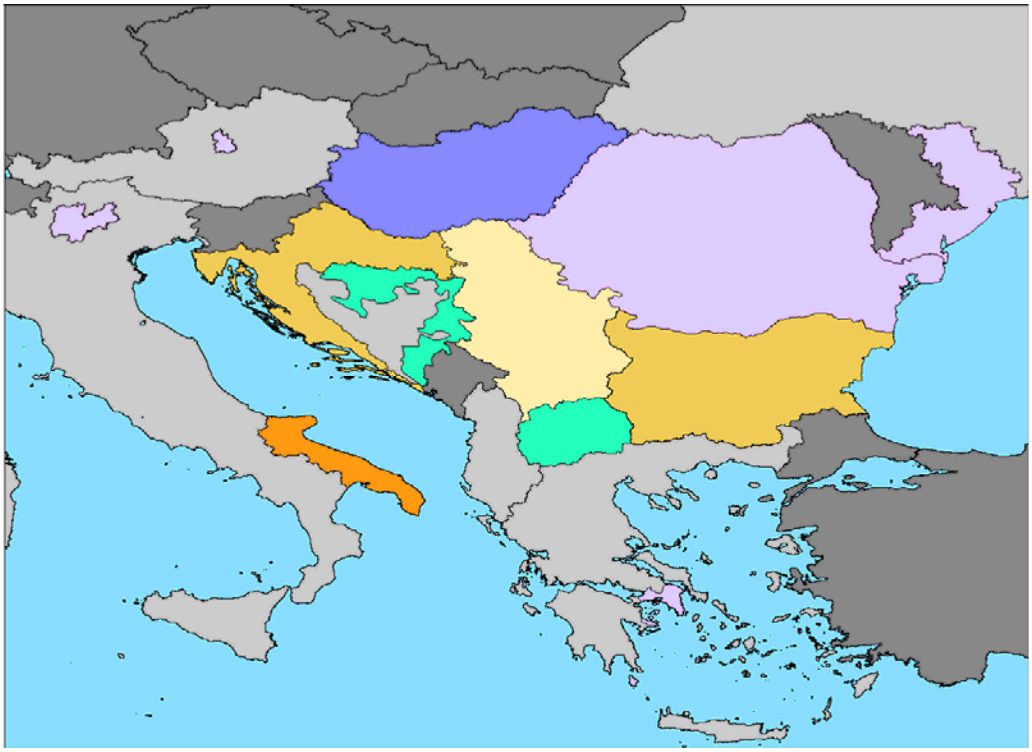


Figure 11 – Spatial distribution of meteorological stations in which PDSI index is calculated

The indices based on other parameters in addition to temperature and precipitation amount are shown on the Figure 12.



	PPs that calculate: HCI, FFWI		PPs that calculate: FFWI
	PPs that calculate: THI, SYC, PET, PSMD, KBDI		PPs that do not calculate stated indices
	PPs that calculate: Days with: fog, hail, lightning, strong wind		Participating PPs with pilot areas / Observing PPs
	PPs that calculate: PhET, UTCI		Not participating in the project

Figure 12 – Spatial coverage of the indices HCI, FFWI, THI, SYC, PET, PSMD, KBDI, PhET, UTCI, days with: fog, hail, lightning, strong wind

Definitions of the index acronyms are the following:

- HCI - Human comfort Index,

- FFWI - Forest Fire Weather Index

- PhET - Physiologically Equivalent Temperature

- UTCI - Universal Thermal Climate Index

- THI - Temperature Humidity Index: combination of temperature and humidity that is a measure of the degree of discomfort experienced by grazing animal species.

- SYC - Area under the curve of Storage Yield Curve: it is a hydrological index, based on monthly river discharge series (at least 30 year) and representing the basin water yield produced from a given level of storage or, alternatively, storage capacity needed to provide a given basin yield. Useful for irrigation planning purposes

- PET - Potential EvapoTranspiration based on the Penman Monteith method.

- AI - Aridity Index: the ratio of annual precipitation over annual PET.

- PSMD - Potential Soil Moisture Deficit: the cumulated (daily or monthly basis) deficit of precipitation to satisfy PET during the growing season.

- KBDI - Keetch-Byram Drought Index: representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers.

IV CONCLUSION

Among the most frequently used indices, particularly within hydrometeorological services, are the ones which are proposed by ETCCDI (Expert Team on Climate Change Detection and Indices). The deployment of indices presenting modification of the indices proposed by the ETCCDI in terms of differently defined boundaries for temperature and precipitation amount is being used in a high degree as well. In common use are also other indices based on the temperature and precipitation amount as well as indices whose calculation is dependent on other parameters.

The sectors in which indices are most frequently used are agriculture, forestry, waterpower engineering and human health. Furthermore, they are highly useful for the examination of the climate variability and the related changes as well as for the assessment of the climate change impacts on different economy sectors and human health.

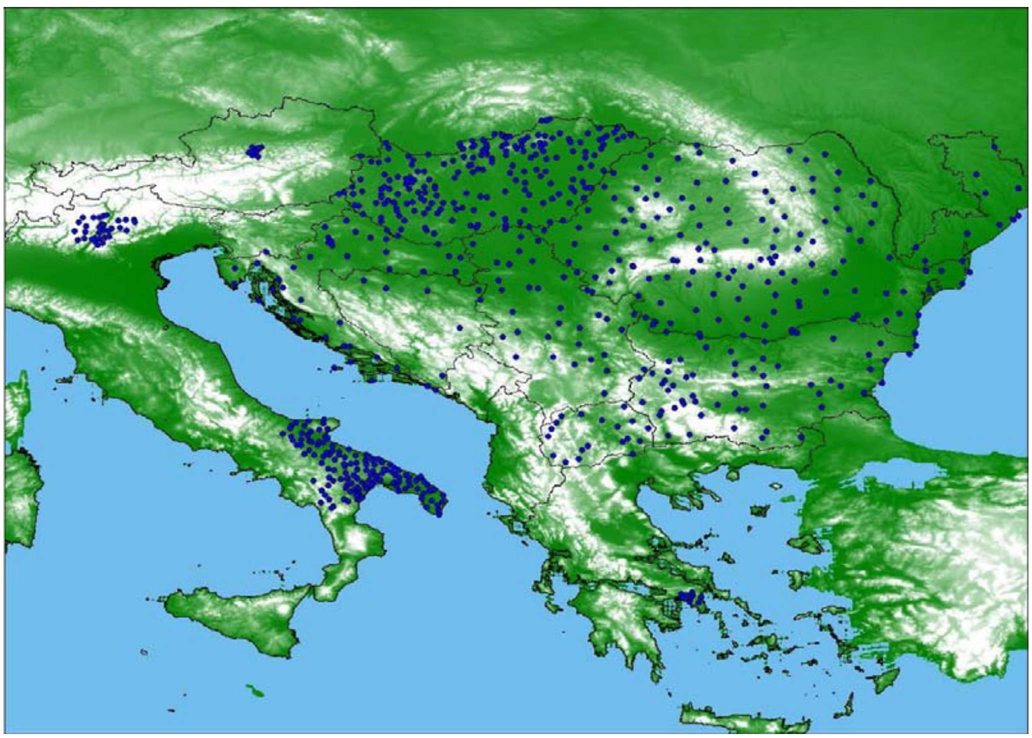


Figure 13 – Spatial distribution of all the meteorological stations from the PPs involved in WP3 activities

V Reference

Loukas A., Vasiliades L., 2004: Probabilistic analysis of drought spatiotemporal characteristics in Thessaly region, Greece. Natural Hazards and Earth System Sciences, 4, 719-73

McKee T.B., Doesken N.J., Kleist J., 1993: The relationship of drought frequency and duration to time scales. Eighth Conference on Applied Climatology, Anaheim, California

Vicente-Serrano S. M., Begueria S., Lopez-Moreno J. I., 2009: A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. Journal of Climate, doi: 10.1175/2009JCLI2909.1

VI Appendix I - ETCCDI indices

The definitions for a core set of 27 descriptive indices of extremes defined by the Joint CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI, see http://www.clivar.org/organization/etccdi/etccdi.php) are provided below.

Temperature indices:

1. **FD**, frost days: count of days where TN (daily minimum temperature) < 0°C

   Let TNij be the daily minimum temperature on day i in period j. Count the number of days where TNij < 0°C.

2. **SU**, summer days: count of days where TX (daily maximum temperature) > 25°C

   Let TXij be the daily maximum temperature on day i in period j. Count the number of days where TXij > 25°C.

3. **ID**, icing days: count of days where TX < 0°C

   Let TXij be the daily maximum temperature on day i in period j. Count the number of days where TXij < 0°C.

4. **TR**, tropical nights: count of days where TN > 20°C

   Let TNij be the daily minimum temperature on day i in period j. Count the number of days where TNij > 20°C.

5. **GSL**, growing season length: annual count of days between first span of at least six days where TG (daily mean temperature) > 5°C and first span in second half of the year of at least six days where TG < 5°C.

   Let TGij be the daily mean temperature on day i in period j. Count the annual (1 Jan to 31 Dec in Northern Hemisphere, 1 July to 30 June in Southern Hemisphere) number of days between the first occurrence of at least six consecutive days where TGij > 5°C and the first occurrence after 1 July (1 Jan in Southern Hemisphere) of at least six consecutive days where TGij < 5°C.

6. **TXx**: monthly maximum value of daily maximum temperature:

   Let TXik be the daily maximum temperature on day i in month k. The maximum daily maximum temperature is then TXx = max (TXik).

7. **TNx**: monthly maximum value of daily minimum temperature:

   Let TNik be the daily minium temperature on day i in month k. The maximum daily minimum temperature is then TNx = max (TNik).

8. **TXn**: monthly minimum value of daily maximum temperature:

   Let TXik be the daily maximum temperature on day i in month k. The minimum daily maximum temperature is then TXn = min (TXik).

9. **TNn**: monthly minimum value of daily minimum temperature:

> Let TNik be the daily minimum temperature on day i in month k. The minimum daily minimum temperature is then TNn = min (TNik).

10. **TN10p**, cold nights: count of days where TN < 10th percentile

> Let TNij be the daily minimum temperature on day i in period j and let TNin10 be the calendar day 10th percentile of daily minimum temperature calculated for a five-day window centred on each calendar day in the base period n (1961-1990). Count the number of days where TNij < TNin10.

11. **TX10p**, cold day-times: count of days where TX < 10th percentile

> Let TXij be the daily maximum temperature on day i in period j and let TXin10 be the calendar day 10th percentile of daily maximum temperature calculated for a five-day window centred on each calendar day in the base period n (1961-1990). Count the number of days where TXij < TXin10.

12. **TN90p**, warm nights: count of days where TN > 90th percentile

> Let TNij be the daily minimum temperature on day i in period j and let TNin90 be the calendar day 90th percentile of daily minimum temperature calculated for a five-day window centred on each calendar day in the base period n (1961-1990). Count the number of days where TNij > TNin90.

13. **TX90p**, warm day-times: count of days where TX > 90th percentile

> Let TXij be the daily maximum temperature on day i in period j and let TXin90 be the calendar day 90th percentile of daily maximum temperature calculated for a five-day window centred on each calendar day in the base period n (1961-1990). Count the number of days where TXij > TXin90.

14. **WSDI**, warm spell duration index: count of days in a span of at least six days where TX > 90th percentile

> Let TXij be the daily maximum temperature on day i in period j and let TXin90 be the calendar day 90th percentile of daily maximum temperature calculated for a five-day window centred on each calendar day in the base period n (1961-1990). Count the number of days where, in intervals of at least six consecutive days TXij > TXin90.

15. **CSDI**, cold spell duration index: count of days in a span of at least six days where TN > 10th percentile

> Let TNij be the daily minimum temperature on day i in period j and let TNin10 be the calendar day 10th percentile of daily minimum temperature calculated for a five-day window centred on each calendar day in the base period n (1961-1990). Count the number of days where, in intervals of at least six consecutive days TNij < TNin10.

16. **DTR**, diurnal temperature range: mean difference between TX and TN (°C)

Let TXij and TNij be the daily maximum and minium temperature on day i in period j. If I represents the total number of days in j then the mean diurnal temperature range in period j DTRj = sum (TXij - TNij) / I.

Precipitation indices:

17. **RX1day**, maximum one-day precipitation: highest precipitation amount in one-day period

Let RRij be the daily precipitation amount on day i in period j. The maximum one-day value for period j is RX1dayj = max (RRij).

18. **RX5day**, maximum five-day precipitation: highest precipitation amount in five-day period

Let RRkj be the precipitation amount for the five-day interval k in period j, where k is defined by the last day. The maximum five-day values for period j are RX5dayj = max (RRkj).

19. **SDII**, simple daily intensity index: mean precipitation amount on a wet day

Let RRij be the daily precipitation amount on wet day w (RR ≥ 1 mm) in period j. If W represents the number of wet days in j then the simple precipitation intensity index SDIIj = sum (RRwj) / W.

20. **R10mm**, heavy precipitation days: count of days where RR (daily precipitation amount) ≥ 10 mm

Let RRij be the daily precipitation amount on day i in period j. Count the number of days where RRij ≥ 10mm.

21. **R20mm**, very heavy precipitation days: count of days where RR ≥ 20 mm

Let RRij be the daily precipitation amount on day i in period j. Count the number of days where RRij ≥ 20 mm.

22. **Rnnmm**: count of days where RR ≥ user-defined threshold in mm

Let RRij be the daily precipitation amount on day i in period j. Count the number of days where RRij ≥ nnmm.

23. **CDD**, consecutive dry days: maximum length of dry spell (RR < 1 mm)

Let RRij be the daily precipitation amount on day i in period j. Count the largest number of consecutive days where RRij < 1 mm.

24. **CWD**, consecutive wet days: maximum length of wet spell (RR ≥ 1 mm)

Let RRij be the daily precipitation amount on day i in period j. Count the largest number of consecutive days where RRij ≥ 1 mm.

25. **R95pTOT**: precipitation due to very wet days (> 95th percentile)

Let RRwj be the daily precipitation amount on a wet day w (RR ≥ 1 mm) in period j and let RRwn95 be the 95th percentile of precipitation on wet days in the base period n (1961-1990). Then R95pTOTj = sum (RRwj), where RRwj > RRwn95.

26. **R99pTOT**: precipitation due to extremely wet days (> 99th percentile)

    Let RRwj be the daily precipitation amount on a wet day w (RR ≥ 1 mm) in period j and let RRwn99 be the 99th percentile of precipitation on wet days in the base period n (1961-1990). Then R99pTOTj =sum (RRwj), where RRwj > RRwn99.

27. **PRCPTOT**: total precipitation in wet days (> 1 mm)

    Let RRwj be the daily precipitation amount on a wet day w (RR ≥ 1 mm) in period j. Then PRCPTOTj = sum (RRwj).