Indecis

Sectorial Climate Services

Integrated approach for the **d**evelopment across **E**urope of user oriented **c**limate **i**ndicators for GFCS high-priority **s**ectors: Agriculture, disaster risk reduction, energy, health, water and tourism

Work Package 4

Deliverable 4.2

Report on Indices of INDECIS-ISD, including definitions, and accompanying sectorial data

This report arises from the Project INDECIS which is part of ERA4CS, an ERA-NET initiated by JPI Climate, and funded by FORMAS (SE), DLR (DE), BMWFW (AT), IFD (DK), MINECO (ES), ANR (FR), with co-funding by the European Union's Horizon 2020 research and innovation programme

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1. An overview

In the framework of linking climatic indices with different sectorial data, we have collected non-climatic data that cover a wide array of sectorial data in Europe, mainly focusing on agriculture, human health, water resources, energy and tourism. These datasets include different statistics, spanning a broad range of specific sectorial information, such as forest fires, reservoir storages, landslides, mortality/morbidity, hydropower production, road accidents, crop yields, phenological indicators, economic and human losses, water availability, groundwater quality, tourism nights, etc. The overriding aim is to assess the response of these relevant sectors to different climate indices. Recalling the diversity of the sectorial data, combined with a comprehensive catalogue of climate extremes, this huge amount of information can be translated into "effective" climate services that can provide local and national European decision makers and stakeholders with information and tools required for better adaptation and planning to climate change, especially for agriculture, crop yield, power generation and health sectors.

The sectorial data were gathered from different local and regional governmental and non-governmental authorities in Europe, including –among others– the Ebro Basin Management Agency, the Finnish tourist board, Statistics Finland, the Finnish Ministry of economic affairs and employment, Visit Finland, Regional Agency for Enviroment in Calabria (Southern Italy) (A.R.P.A.CAL), Nnergix, Company for Water Resources in Calabria (SORICAL), Regional Agency for Agriculture in Calabria (ARSAC), , the Civil Protection Unit of the Calabria Region, Tourism Department of the Calabria Region, the Spanish insurance organisation, the Spanish Ministry of Agriculture, Natural resources institute in Finland, Swedish national association of farmers, Bajo Aragón County, Catalan Office of Climate Change, SEGITTUR. Other data were collected through direct contacts with a wide number of stakeholders and end-users in the different sectors through surveys, workshops and interviews (e.g. farmers, hydrologists, tourists, water consumers and managers, etc.). Based on data availability, the sectorial data were provided at different temporal scales (e.g. daily, monthly, and annual) and at various spatial scales (e.g. hydrological catchment, administrative divisions [e.g. counties, governments], and national level).

2. Available sectorial data

In the following section, we provide a detailed description of the spatial and temporal characteristics of the sectorial data provided by European agencies for the whole region, as well as the more detailed sectorial data provided by estates or regional agencies.

2.1 Sectorial data at the European scale

Eurostat provides non-commercial data for majority of the European countries, which can directly be linked to the wide range of climate indices available through INDECIS catalogue. Relevant sectorial data to the scope of INDECIS may include –for example:

2.1.1. Human health

Statistics are available for different human health indicators, such as the causes of death, crude death rate by NUTS 2 region of residence, and infant mortality by NUTS 2 region of residence. Other demographic statistics that can closely be related to climate indices include deaths by age group, sex and NUTS 3 region, deaths by age, sex and NUTS 2 region, as well as health care expenditure by function.

2.1.2. Agriculture

Through Eurostat, we have free access to different agronomic statistics, including –for example– crop statistics by NUTS 2 regions (from 2000 onwards), crop statistics by NUTS 2 regions (1974 - 1999), monthly data of cow's milk collection and products, production of cow's milk on farms by NUTS 2 regions; share of main land types in utilized agricultural area (UAA) by NUTS 2 regions, estimated soil erosion by water by NUTS 3 regions, irrigation information like the number of farms, areas and equipment by size of irrigated area and NUTS 2 regions, land use information like the number of farms and areas of different crops by agricultural size of farm (UAA) and NUTS 2 regions.

2.1.3. Disaster risk

Numerous risk indicators are also available that can be linked with climate extremes, including -among others- number of victims in road accidents by NUTS 2 regions, air transport of passengers by NUTS 2 regions, maritime transport of passengers by NUTS 2 regions, and national and international railway passengers transport by loading/unloading NUTS 2 region.

2.1.4. Tourism

We can consider various tourism-based statistics available through Eurostat, such as monthly nights spent at tourist accommodation establishments, annual nights spent at tourist accommodation establishments by NUTS 2 regions, annual nights spent at tourist accommodation establishments by coastal and non-coastal area and by NUTS 2 regions for the period from 2012 onwards, net occupancy rate of bed-places and bedrooms in hotels and similar accommodation by NUTS 2 regions from 2012 onwards, and the number of establishments, bedrooms and bed-places by NUTS 2 regions.

Nevertheless, albeit with the availability of huge and adverse amount of tourism-based indicators through Eurostat, this data still has certain limitations, mainly related to their temporal coverage and resolution, which may hinder achieving the overall objectives of INDECIS. In many instances, data at fine resolution (e.g. daily), even at local scale (e.g. destination or municipal level), are desired to meet the needs of managerial and decision-making levels. To handle these limitations, detailed spatial and temporal data can be acquired through direct contact with relevant stakeholders at local scale. These data may include -for example- arrivals by type of accommodation, nights spent by type of accommodation, % accommodation occupation, and number of visitors to different attractions. However, these attempts should be seen in the context of challenges in accessing more reliable data due to peculiarities corresponding to tourism sector.

2.1.4. Water

Hydrological data are already secured for different streams in a range of countries, mainly located in western and southwestern Europe (e.g. Potugal, Spain, France, Ireland, and the UK), spanning streamflow records for the period 1962-2016. Figure 1 illustrates all the series available and the selected streamflow series in these countries following a preprocessing procedure for data quality assurance and gap filling.

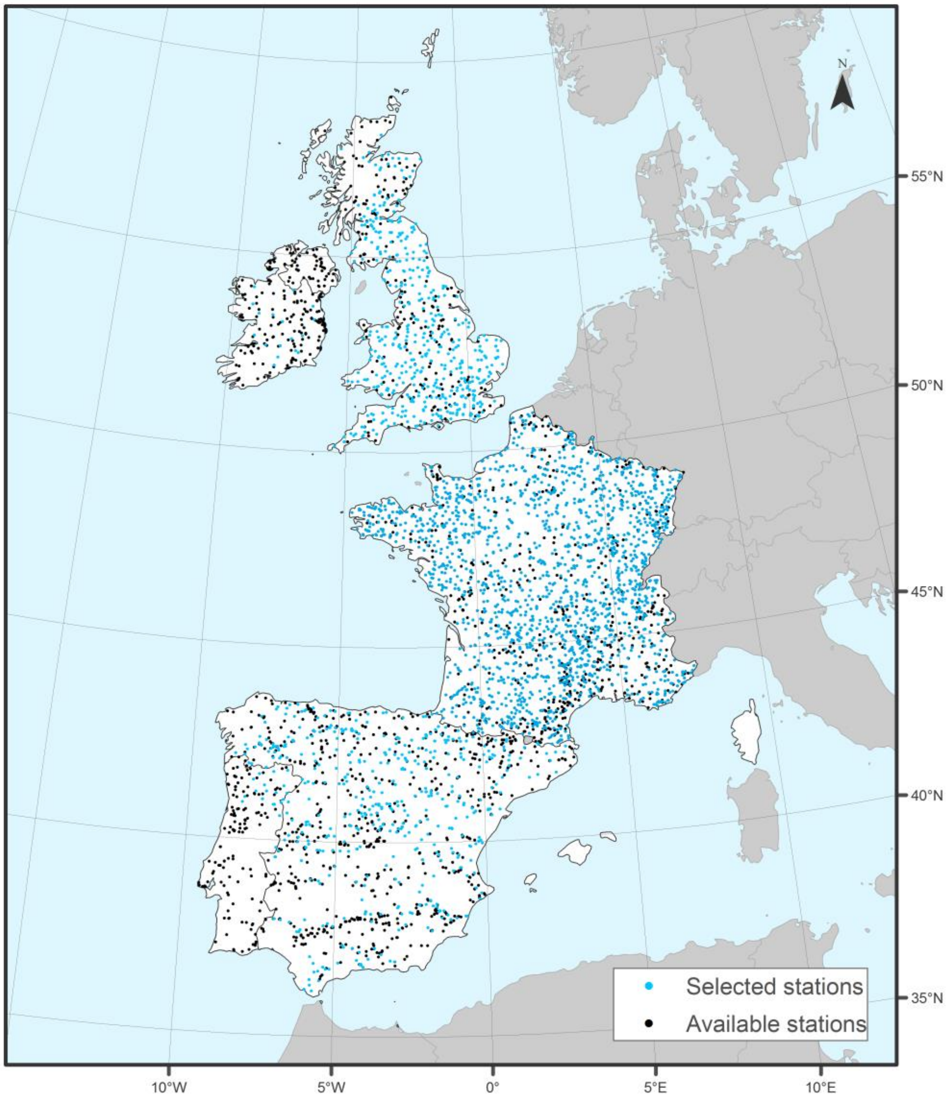


Figure 1. Spatial distribution of the available and selected streamflow series from 1962 to 2016.

2.2 Sectorial data at the country level

2.2.1. Spain

2.2.1.1. Water

Monthly storage reservoir records from 365 monitored dams, combined with records of monthly water levels, are available for the period 1962-2014 for the peninsular Spain (Figure 2).

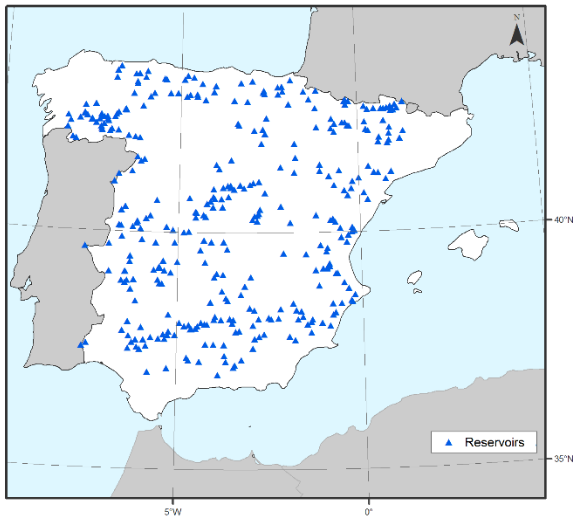


Figure 2: Spatial distribution of reservoirs with available hydrological data from 1962 to 2014.

In the same context, we secured monthly groundwater data using records from 2816 piezometers across Spain, spanning the period from the early 1990s to 2016. Albeit with the high spatial density of groundwater stations (Figure 3), it includes a high percentage of missing data for most of sites (Figure 3).

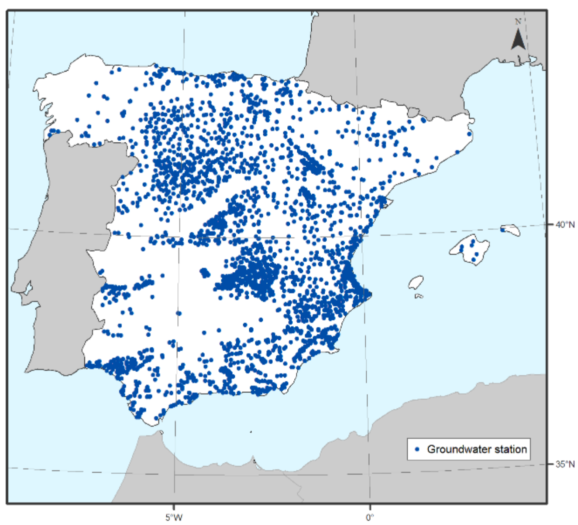


Figure 3: Spatial distributuon of groundwater stations in Spain.

2.2.1.2. Agriculture

Agricultural data are provided by the Spanish Ministry of Agriculture, Fishing, Food and Environment (MAPAMA) for two major non-irrigated crops in Spain: wheat and barley. Nonetheless, the data are available at different spatial scales and for various time periods. The data are available annually at province scale through the annual reports from 1962 to 2014. On the other hand, data are available at seasonal scale for agrarian regions only from 1993 to 2015.

These time series are aggregation of yield parcels records from the agrarian yield survey ESYRCE. Figure 4 depicts the spatial distribution of administrative divisions with wheat and barley yield records.

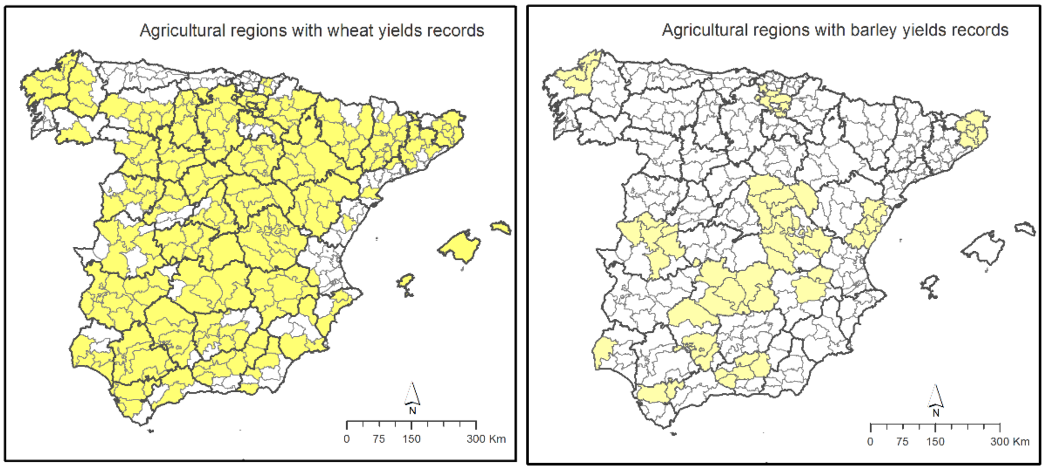


Figure 4: Spatial distribution of administrative divisions with wheat and barley yield records.

2.2.1.3. NDVI

A high-resolution spatial (1.1 km) normalized difference vegetation index (NDVI) dataset is available for Spain for the period from 1981 to 2015 at a bimonthly time scale. The original data were obtained from daily satellite images acquired from the Advanced Very High Resolution Radiometer (AVHRR) sensors operated by the National Oceanic and Atmospheric Administration (NOAA) polar orbiting satellites (Figure 5).

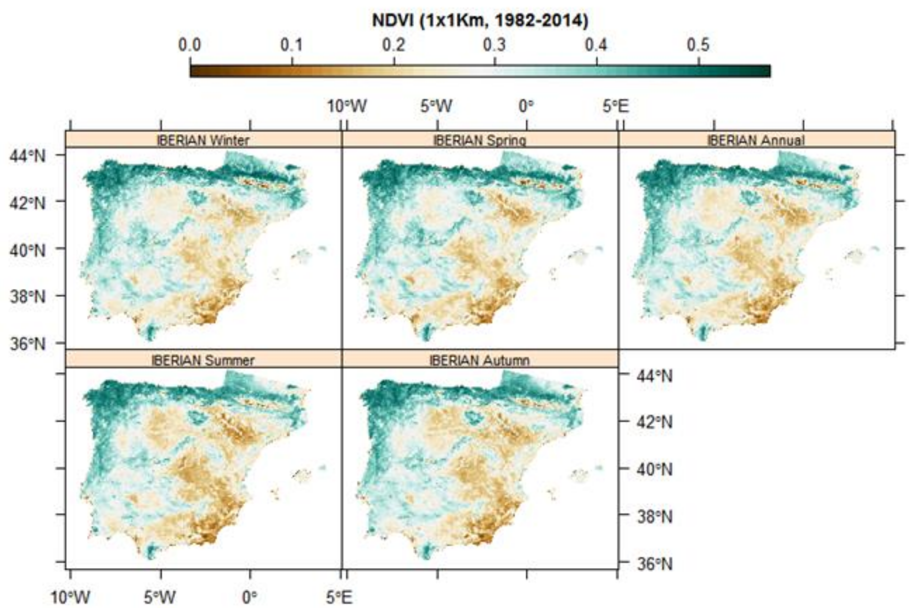


Figure 5. The magnitude of the seasonally-averaged NDVI over Spain for the period 1982-2014.

2.2.1.4. Forest

Annual tree-ring width chronologies from 568 forest stands (mainly conifers and harwood species), which cover the majority of forest areas across the Iberian Peninsula and the Balearic Islands, are available from 1980 to 2016 (Figure 6). Chronologies were obtained using the basic dendrochronological protocol. Tree-ring width was measured to at least the nearest 0.01 mm using binocular microscopes and measuring device systems.

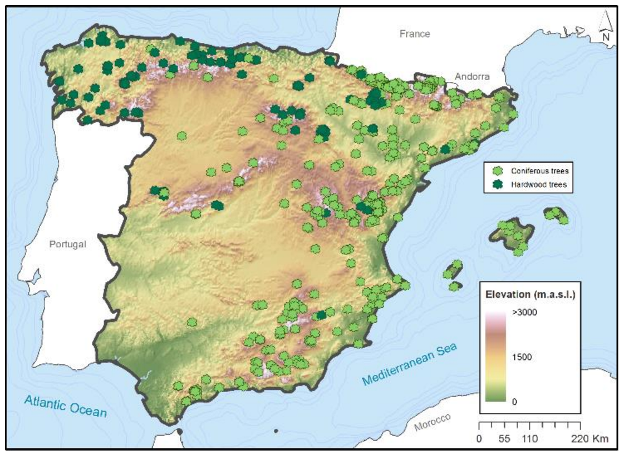


Figure 6. Spatial distribution of the 568 forest stands with annual tree-ring width chronologies

2.2.1.5. Wildfires

We considered Inventory of fires occurred in Spain from 1981 to 2013 at municipality scale (Figure 7) and the hectares burnt in each event. Fires are classified depending on their cause: arson, rays, negligence and accidents, and unknown origin.

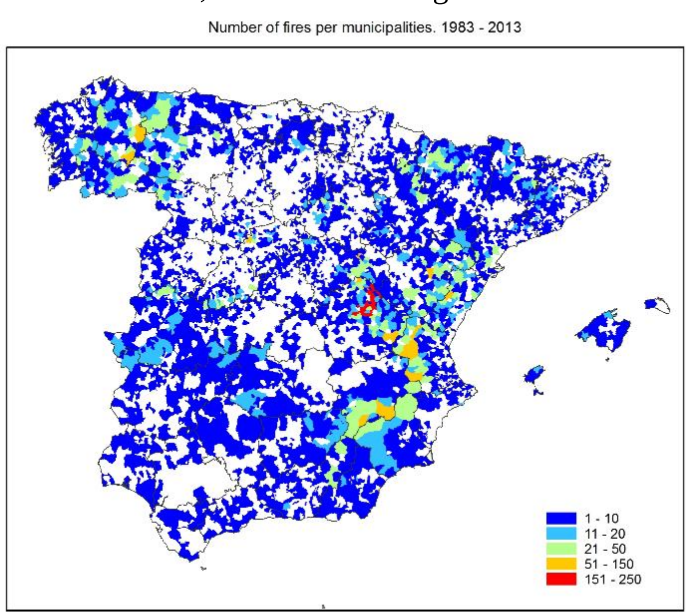


Figure 7. Classification of the Spanish teriorty according to the averaged number of fire events per municipalities from 1983 to 2013.

2.2.1.6. Human health

Daily non-accidental mortality statistics are avilable from 1975 to 2017 at the province scale over Spain (Figure 8).

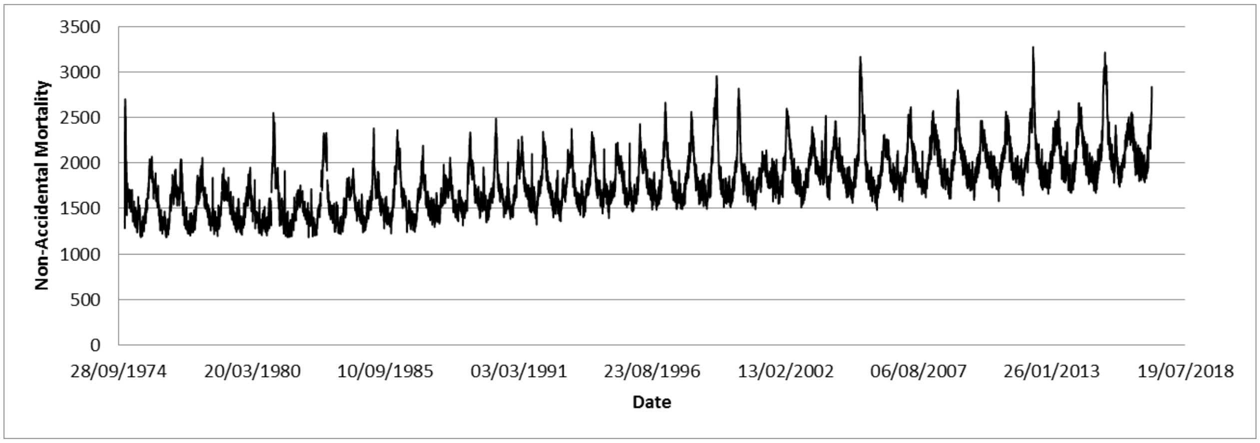


Figure 8. Temporal evolution of the total number of non-accidental mortality over Spain from 1974 to 2018.

2.2.2. France

2.2.2.1. Water

Discharges of the French rivers are monitored using more than 3200 hydrometric stations managed by the national environmental administration and public governmental and research institutions staff. The collected water height time series, which are managed by the French Hydrometeorological Central Service for Floods Prediction Support (SCHAPI), are freely available through HYDRO (http://www.hydro.eaufrance.fr/). Metadata (e.g. data precision, quality and availability) is provided for each monitored station. Through stream gauges and calibrating curves regularly updated, discharge time series can be viewed and downloaded for technical or scientific purposes (Figure 9). Numerous statistical indices are provided for the description of the interannual and intrannual variability and extreme events (e.g. floods and droughts).

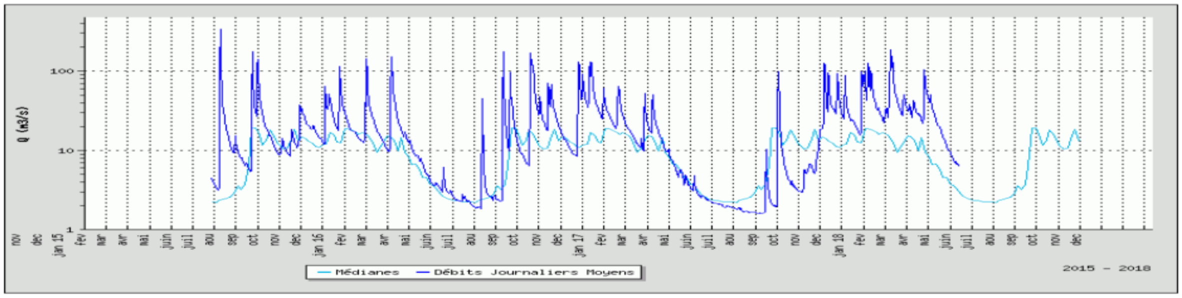


Figure 9: Daily discharge time series between 2015 and 2018 for the Herault River at Ganges, France.

In France, a wide range of public operators (e.g. water agencies, local and regional authorities, decentralized state administrative authorities, regional agencies of the French National Geological Survey (BRGM), etc.) manage stations for groundwater quantitative and qualitative state monitoring. More than 70,000 stations are distributed across the country, recording groundwater quality (qualitometers), or groundwater level (piezometers) or both. The ADES national public database (www.ades.eaufrance.fr) gives access to monitoring networks, providing descriptive data sheets for all the monitoring stations (e.g. geographical coordinates, location, station operator measurement frequency, etc.). The access to monitoring time series (e.g. piezométric levels, concentrations in waters of several chemical parameters) is also available (Figure 10). ADES is designed to facilitate data delivery and interconnecting with other data bases via Application Programming Interfaces (API - https://hubeau.eaufrance.fr/page/api-piezometrie and https://hubeau.eaufrance.fr/page/api-qualite-nappes).

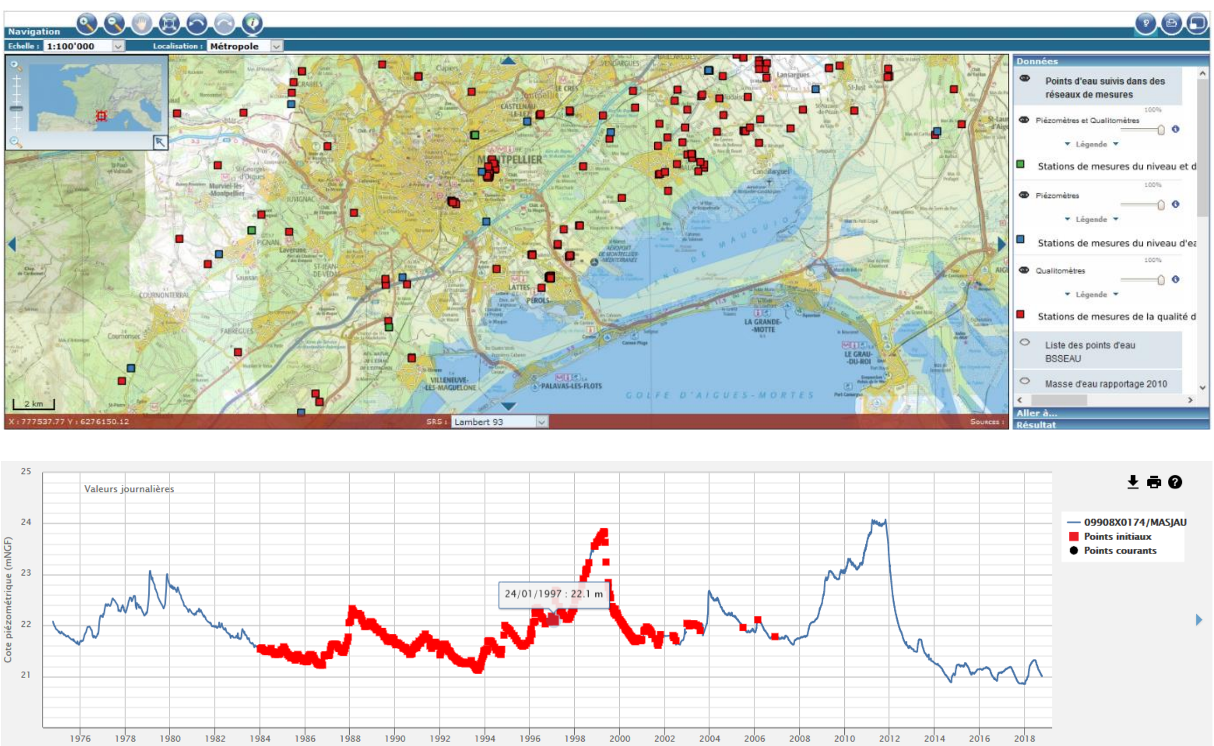


Figure 10: Screenshots of location maps and data series that can be obtained for a given piezometer (here close to Montpellier).

One of the outcomes of the ADES portal is the Standard Piezometric Level Index (IPS), which is used for monthly hydrological situation reports of groundwater bodies at the national and regional scale, published by the French national administration (http://www.eaufrance.fr/3/publications/bulletin-national-de-situation-233/). In order to provide a groundwater indicator comparable to the well-known Standardized Precipitation Index (SPI) or the Soil Wetness Indicator (SWI) generally provided by the meteorological community, the IPS is designed to reduce the impacts of non-stationarity, presence of trends, autocorrelation, and data inhomogeneity on the quantitative state description of a given groundwater resource. It allows qualifying groundwater quantitative state of any kind of aquifer, at the monthly (in association with the SPI and SWI) and annual scale (to describe increasing or decreasing trends) (Figure 11).

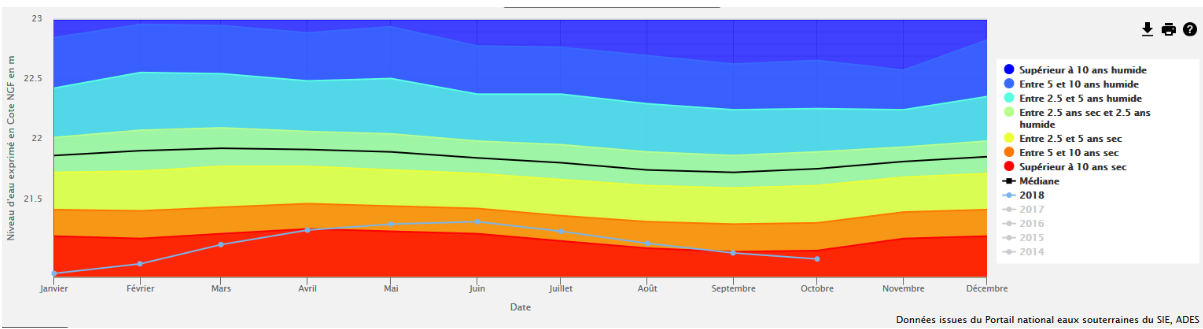


Figure 11: Example of October 2018 IPS computation for a piezometer close to Montpellier.

The qualitative state of groundwater bodies is also monitored through several networks at the regional and national scale. Groundwater chemical analyses can be collected and visualized by means of a comprehensive classification system that stores the data into the ADES database. Time series of one or more specific parameters can then be plotted for the assessment of the groundwater qualitative state on a given piezometer (Figure 12). Tools for trend or contamination assessments are also available with the downloaded data.

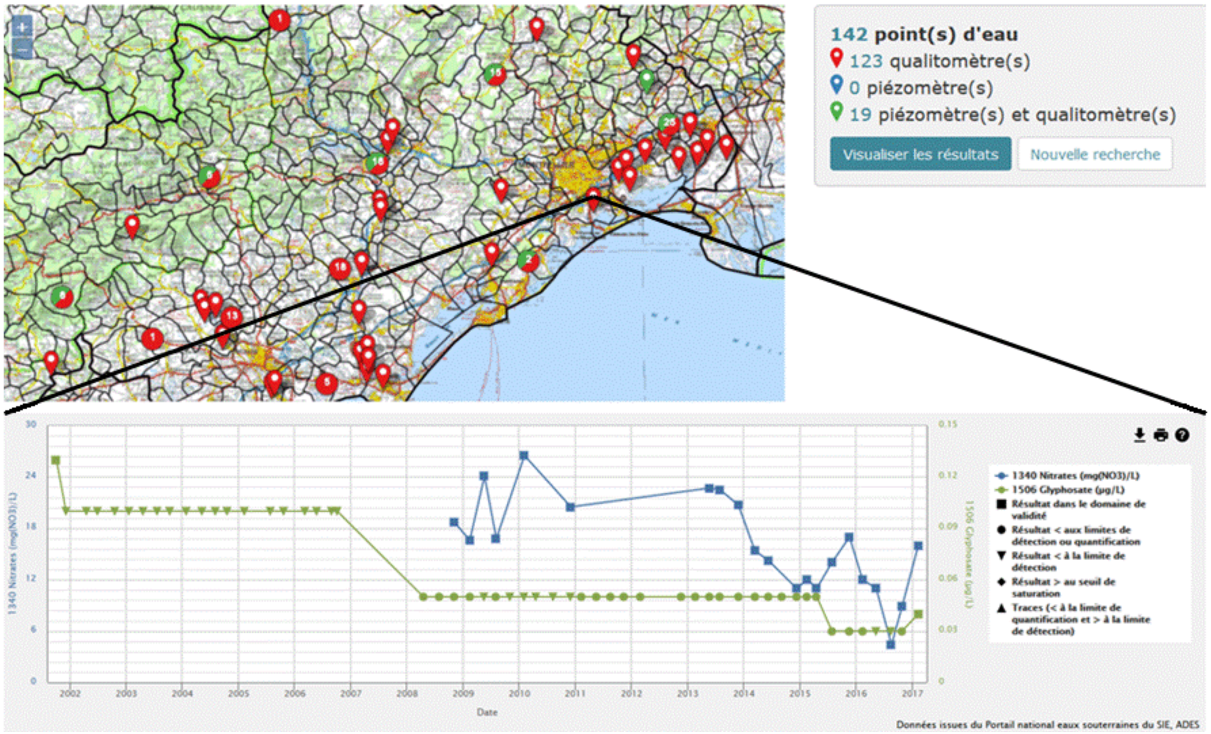
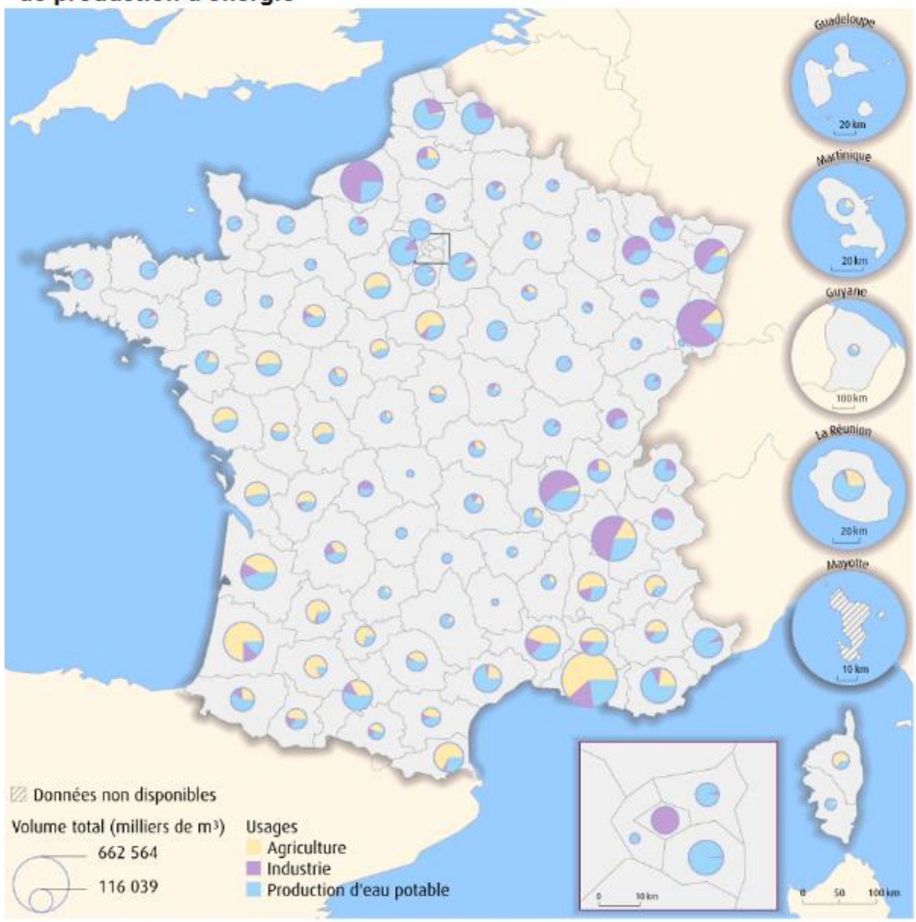


Figure 12: Example of a graph showing the Nitrates and Glyphosate concentration time series for an aquifer close to Montpellier.

In France, water resource uses data is provided to public through the National Database of Water Withdrawals (BNPE - http://www.bnpe.eaufrance.fr/presentation). Several different types of water uses (drinking, agricultural, and industrial) on different types of water resources (surface water, groundwater, and sea water) are monitored at the regional and national scale and updated yearly. From this database, reports are published on a yearly basis at the national scale (Figure *1*13). Similarly, locations of withdrawal and temporal evolution and data at all scales (from local to national) can be visualized and downloaded (Figure 14).

Prélèvements en eau par usage en 2010, hors refroidissement des usines de production d'énergie



Source : SOeS, d'après Agences de l'Eau et Offices de l'Eau, 2010

Figure 13: Water withdrawals by types of uses (agricultural, industrial, drinking water) for 2010.

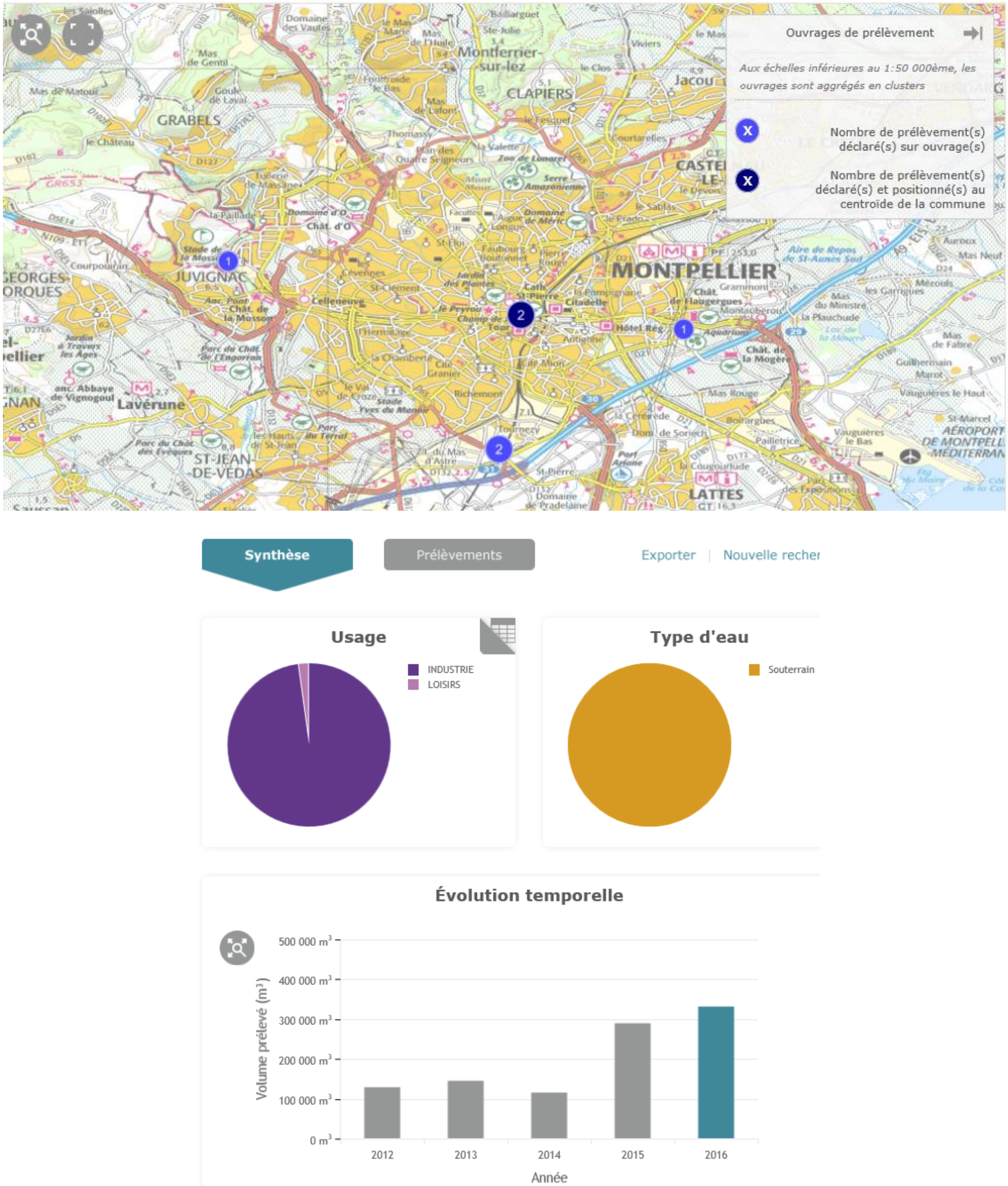


Figure14: location and synthesis of main withdrawals at the scale of the city of Montpellier.

2.2.3. Italy

In Italy the National Statistic Institute (ISTAT - www.istat.it) collects for the whole Nation the data regarding various aspects of society, population, economy, environment, etc. The Italian partner of the INDECIS project (CNR-IRPI) preferred to collect the sectorial data on a regional (NUTS2) or smaller scale (NUTS3), contacting and collecting the data directly by the regional Agencies/Authorities/Companies that could be considered also users of the project.

In the following, the data collected for the various sectorial indexes are shown and grouped for sectors. For each sector, at the beginning of the section the Agency/Authority/Company which has provided the data is indicated. The data collected refer to the whole territory of Calabria or/and for the 5 provinces of Calabria (Cosenza, Catanzaro, Crotone, Vibo Valentia, Reggio Calabria) – as indicated in Figure 2.2.3.1. For few sectors, the data are referred to specific areas (such as the territory of the Sila National Park) or sites (such as for the water springs).

Figure 2.2.3.1. Map of Calabria with the indication of the five provinces (Cosenza, Catanzaro, Crotone, Vibo Valentia, Reggio di Calabria).

2.2.3.1. Water

A data base of water availability for civil and agricultural demands is available from SORICAL, which is a semi-public Company that manages water resources in Calabria (Southern Italy). Water availability is estimated as water levels in some water bodies (e.g. reservoirs, artificial lakes, etc.) or as water discharge in selected springs.

The SORICAL Company has provided the water discharge data only for selected water springs, indicated in Figure 2.2.3.2. The datasets do not present a continuity over time, but for some of them it is possible to detect some trends or to highlight some periods with particularly high/low values.

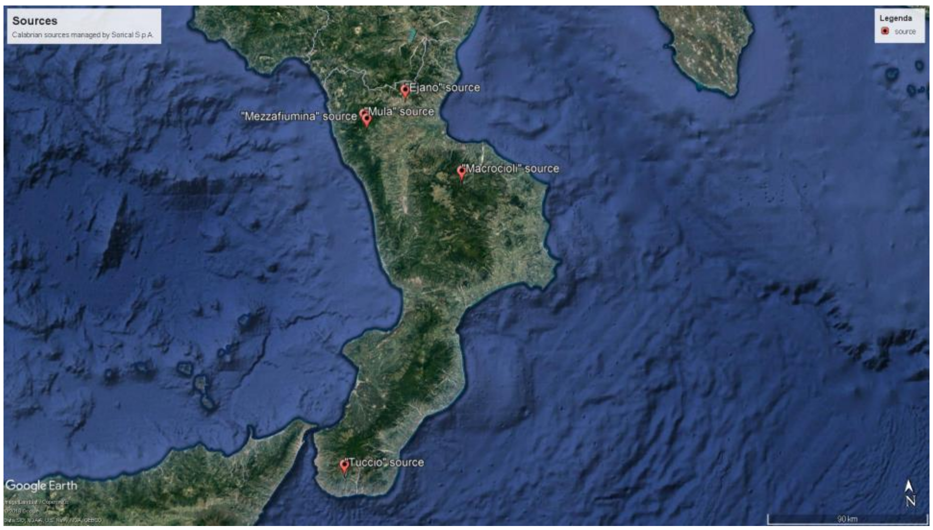


Figure 2.2.3.2. – Map of Calabria with indications of the water sources selected by SORICAL

The source with the longest registration period is the "Mezzafiumina" spring. In Figure 2.2.3.3 the discharge data of the "Mezzafiumina" spring are shown. The source presents the lowest yearly values in autumn and the highest in winter/early spring. In most recent years, the source presents also a lower variation during the year and from 2014 the highest yearly values seem to show a negative behaviour.

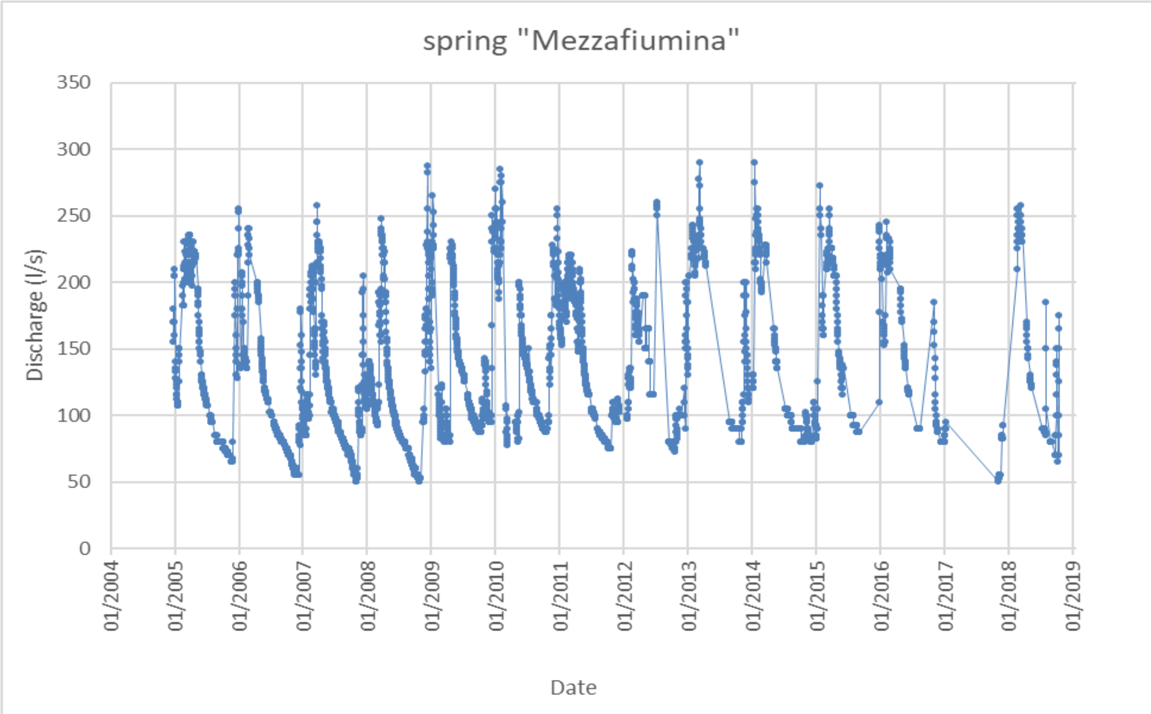


Figure 2.2.3.3 - Discharge data of the "Mezzafiumina" spring from December 2004 to October 2018

Figure 2.2.3.4 shows the discharge data of the "Tuccio" spring. The data series provided by SORICAL is from December 2009 to March 2019, more than 9 years but with several missing values. For this source the lowest yearly values were often registered in early autumn (September and October) and the highest ones in early summer (June and July). The figure shows a negative tendency of the highest values (from about 325 l/sec to 280 l/sec – a decreasing rate of about -14%). Based on the data available the lowest value was registered in October 2012 (about 100 l/sec).

The data sets of the other source provided by SORICAL were not upgraded to recent years or are very short. In particular, the data of "Macrocioli" source (Figure 2.2.3.5) are from June 1982 to November 1990 and those of the "Ejano" source (Figure 2.2.3.6) are from January 1976 to December 1990. For both the springs the figures show an averaged tendency to a decrease of the discharges registered even though this trend cannot be considered reliable owing to the several missing values. The discharge data set of the "Mula" spring (Figure 2.2.3.7) is from March 2009 to January 2011 (less than 2 years). For this period the "Mula" discharges present the highest values in early summer (June and July) – higher than 1 mc/sec – and the lowest ones in November and December (about 400 l/sec)

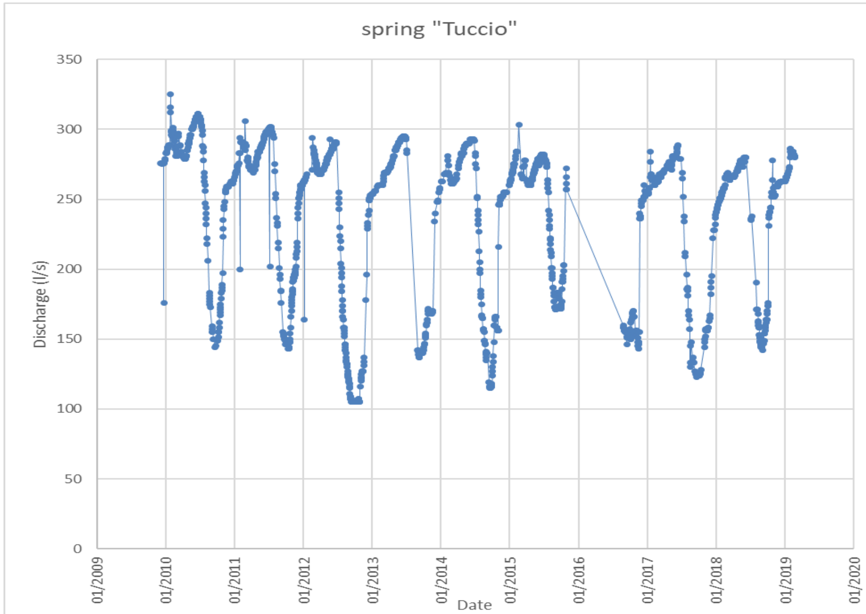


Figure 2.2.3.4 - Discharge data of the “Tuccio” spring from December 2009 to March 2019

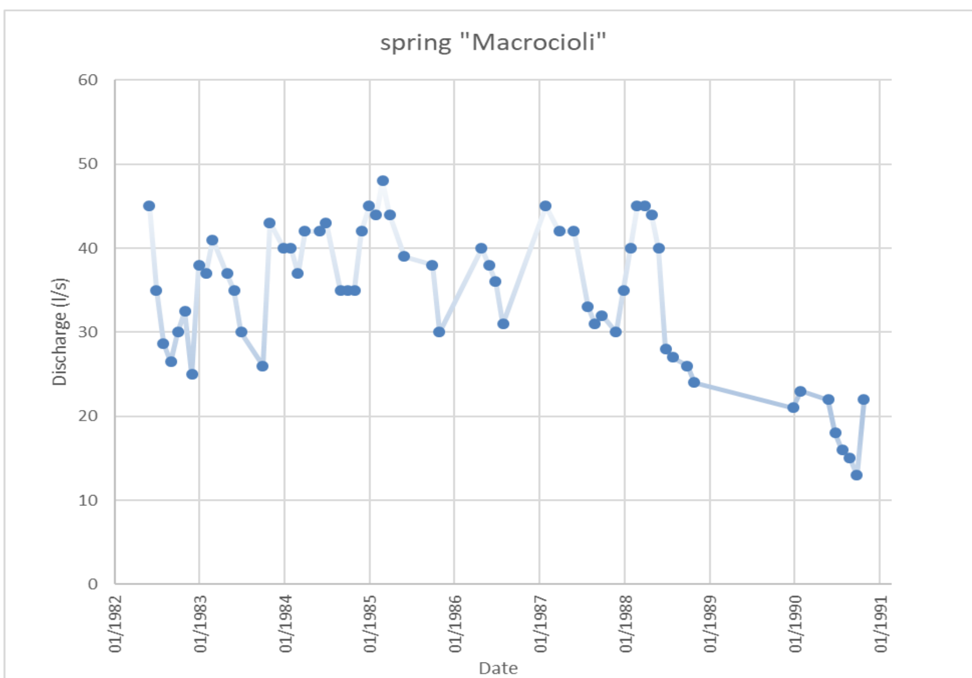


Figure 2.2.3.5 - Discharge data of the “Macrocioli” spring from June 1982 to November 1990

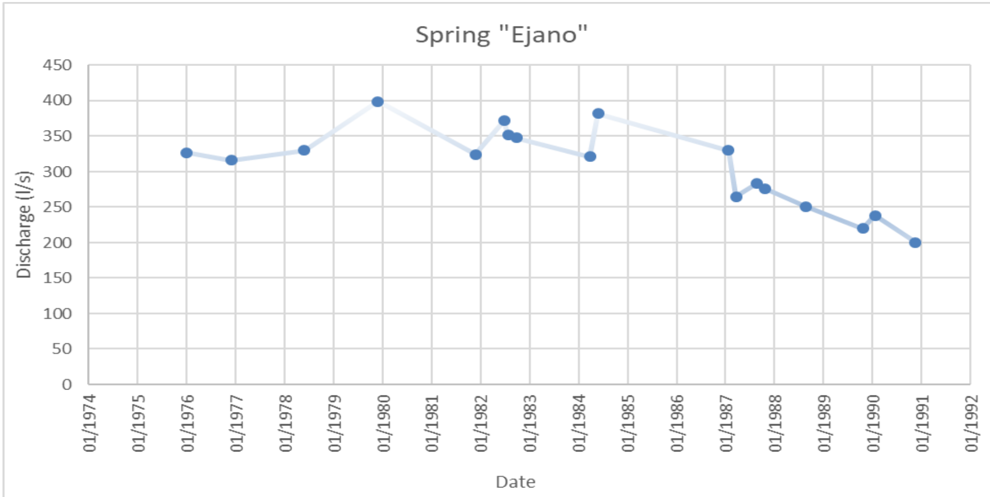


Figure 2.2.3.6 - Discharge data of the "Ejano" spring from January 1976 to December 1990

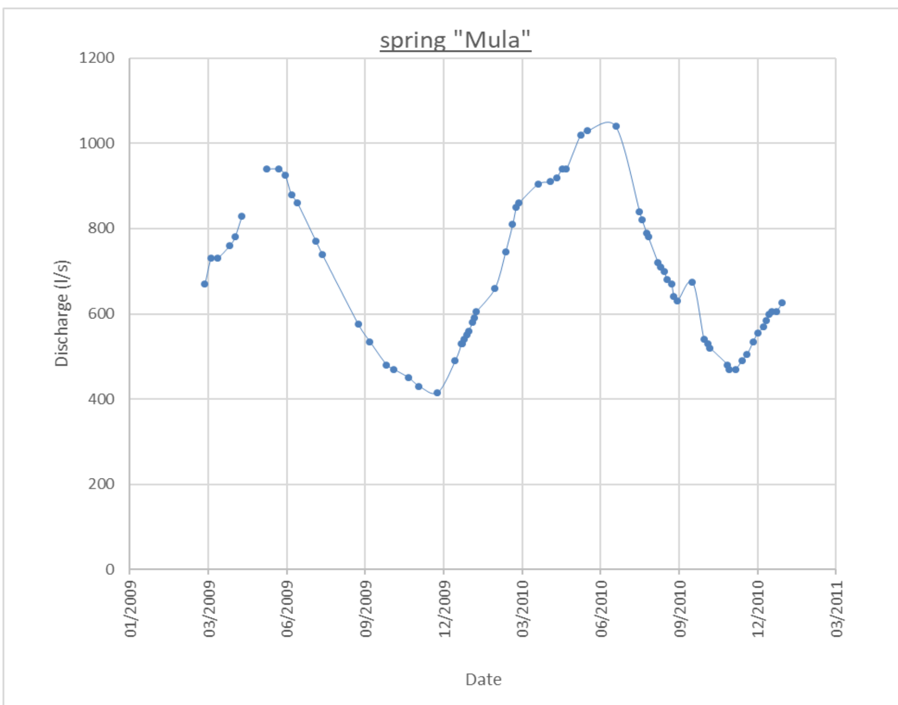


Figure 2.2.3.7 - Discharge data of the "Mula" spring from March 2009 to January 2011

Moreover, SORICAL has sent a letter of interest in which it communicates to the Italian Principal Investigator of INDECIS and to the Project Leader that the Company is always available to provide and update hydrological and management data of water resources, and interested in sharing Project results and products (Figure 2.2.3.8)

For collecting further discharge data, also ARPCAL (the Regional Agency for Environment in Calabria) was contacted. Few years ago this Agency carried out a project with a private Company regarding all the water resources in the regional territory. The project results were provided to the Italian PI of INDECIS project, but the data were not reported in the deliverable because all the series are very short (less than 2 years) and with few values for each year.

2.2.3.2. Agricultural

The data about water consumptions for irrigation were requested to the eleven "Consorzi di Bonifica" (Reclamation Consortia) that are present in Calabria (Figure 2.2.3.9). Several emails, calls and meetings were made with the Coordinators of these offices but only the "Consorzio Tirreno Catanzarese" (n. 7 in Figure 2.2.3.9) provided the data requested.

The provided data is relative only to 4 years (from 2015 to 2018) and contains the yearly data of the irrigated areas (ha), the total water consumptions (mc) and the unitary water consumptions (mc/ha), that is the ratio of the total water consumptions to the irrigated areas. These data are for each of the five districts that are included in the territory of the Consorzio Tirreno Catanzarese. Figure 2.2.3.10 shows the behaviour of the unitary water consumptions. For all the districts the consumptions show a decrease between 2015 and 2016. After this year, for almost all the districts, increases of the unitary water consumptions were registered up to 2018; only for districts no. 9212b and no. 9223 the lowest values were observed in 2017.

2.2.3.3. Forest

The data about the burned areas were provided by means of the module "Rapid Damage Assessment" (R.D.A.) of E.F.F.I.S. (European Forest Fire Information System), which has collected and mapped the burned areas that occurred in the European territory from 2003. The RDA module analyses the daily images of MODIS (on TERRA and AQUA satellites), with a spatial resolution of 250 m. The data refer to burned areas with extension greater than 30 hectares (in Europe these fires are about 75-80% of the total fires that occured) and are updated twice each day. In the obtained database there is no differences between natural fires and human induced fires. Moreover, small not-burned areas (lower than the spatial resolution of MODIS) could be grouped into the larger burned areas, increasing the extensions of the latter.

sorical

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Catanzaro, 26 giugno 2019 Prot. 1941

Dear Dr. Coscarelli,

So.Ri.Cal. is aware that the research Project "***INtegrated approach for the DEvelopment across Europe of user oriented Climate Indicators for GFCS high-priority Sectors: agriculture, disaster risk reduction, energy, health, water and tourism (INDECIS)***" (co-funded by the ERA4CS Joint Call on Researching and Advancing Climate Services Development, with a partnership of institutions from Spain, Czech Republic, Finland, France, Italy, Netherlands, Portugal, Romania, Republic of Ireland, Sweden and UK) is being carried out.

As a company involved in water resources management in Mediterranean area - namely in Calabria (South Italy) - So.Ri.Cal. is interested to make available hydrological and management data, as well as to share Project results and products that should be relevant for his own purposes in the field of water distribution.

With best regards

Ing. Sergio De Marco

Chief Operating Officer
So.Ri.Cal. S.p.A.

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Figure 2.2.3.8 - Letter of interest of SORICAL

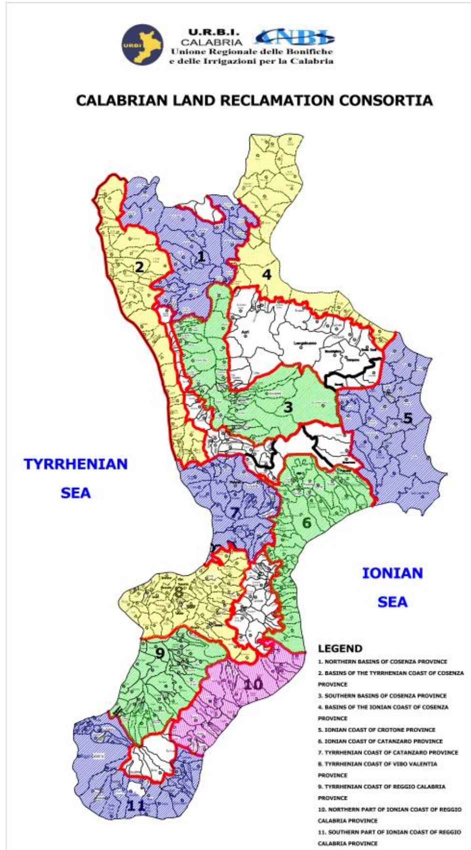

Figure 2.2.3.9 - Map of Calabria with indication of the eleven Reclamation Consortia of the region

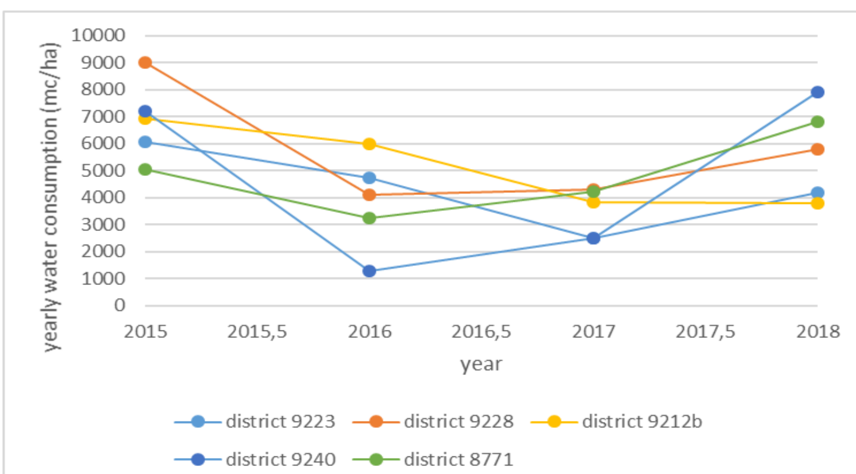

Figure 2.2.3.10 - Unitary water consumptions for irrigation in the years 2015, 2016, 2017, 2018 for the five districts of the Consortium no. 7 (“Tirreno Catanzarese”).

Figure 2.2.3.11 shows the yearly data from 2008 to 2018 of the extension (in hectares) and the number of fires that occurred over the whole territory of Italy. It is clearly shown that the highest values were registered in 2017 (about 800 fires and about 140 000 hectares of burned areas). In 2009, about 100 fires occurred in Italy but the burned areas were greater than 50 000 ha, which means that some fires with great extensions occurred in this year.

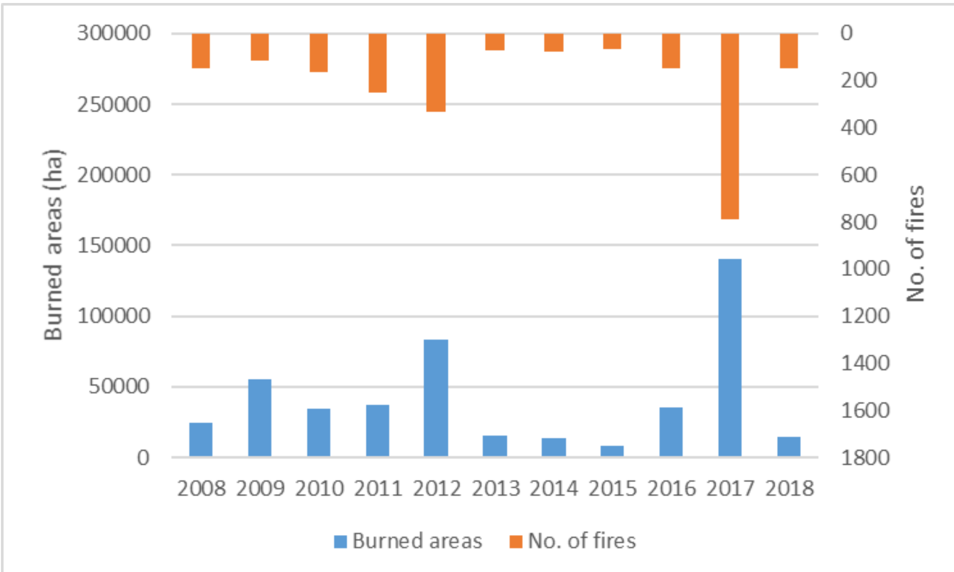

Figure 2.2.3.11 - Burned areas (in hectares) and number of fires that occurred in Italy from 2008 to 2018.

Table 2.2.3.1 and Figure 2.2.3.12 show the data for Calabria, evidencing that also in Calabria the highest values of burned areas and fires were registered in 2017 (232 fires and 33 522 hectares) and the lowest in 2014 (only 4 fires and 490 hectares). Analogous data have been collected for each of the 5 provinces of Calabria (not shown in this report).

Table 2.2.3.1 - Burned areas (in hectares) and number of fires that occurred in Calabria from 2008 to 2018

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Burned areas (ha)	5727	4374	2456	8201	15389	1146	490	1687	4038	33522	1874
No. of fires	42	19	14	64	100	13	4	14	30	232	34

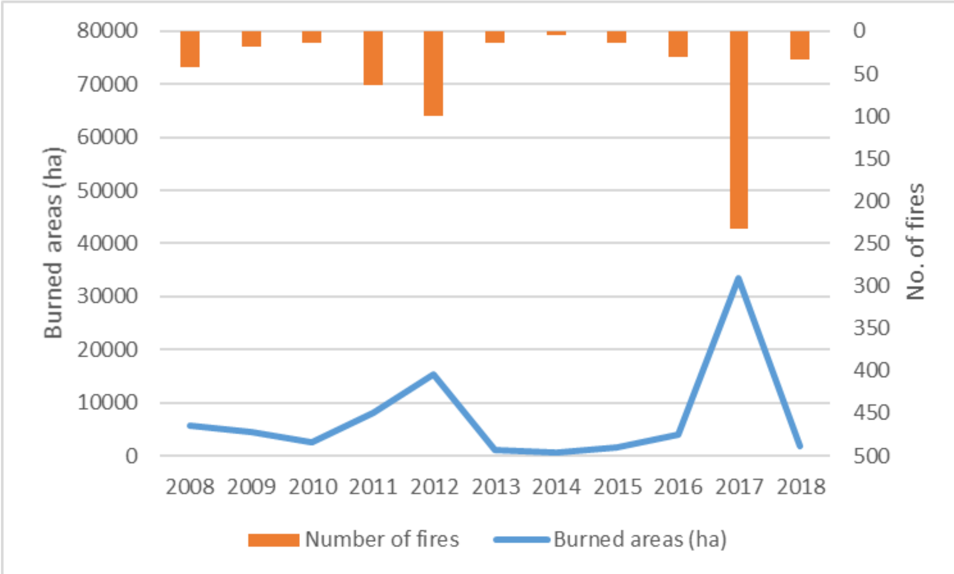

Figure 2.2.3.12 - Burned areas (in hectares) and number of fires that occurred in Calabria from 2008 to 2018

As indicated in the deliverables of WP7, the territory of the Sila National Park was chosen as study area especially for the organization of the focus groups in the tourism sector. For this reason, with the aim to have a complete description of this area the data of burned areas and number of fires, with indication of month and year in which these occurred in the territory of the Sila National Park, are shown in Table 2.2.3.2 and Figure 2.2.3.13.

Table 2.2.3.2 - Burned areas (in hectares), month and year, number of fires that occurred in the territory of the Sila National Park from 2008 to 2018

Month/year	Burned areas (ha)	No. of fires
08/2008	783	4
07/2009	79	1
08/2010	51	1
07/2011	108	1
09/2011	92	2
07/2012	113	1
08/2012	569	8
04/2013	56	1
07/2015	337	2
07/2016	332	2
07/2017	300	3
08/2017	3280	12
09/2018	83	1

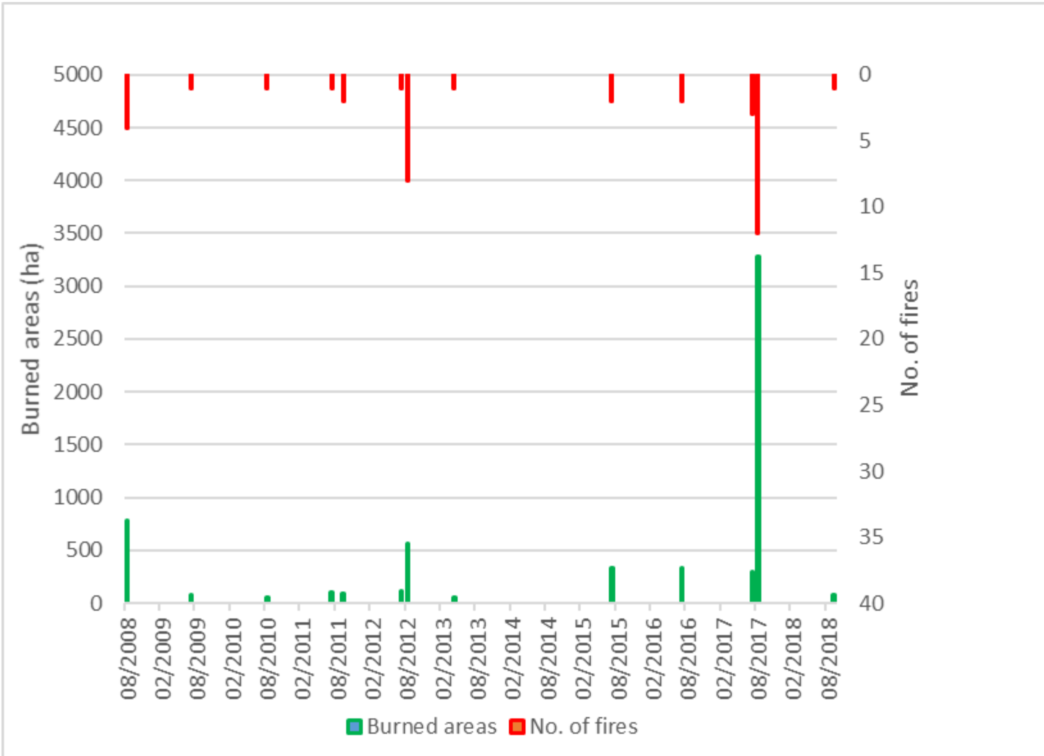

Figure 2.2.3.13 - Burned areas (in hectares) and number of fires that occurred in the Sila National Park territory from 2008 to 2018

2.2.3.4. Disaster Risk

The CNR-IRPI (Partner of the project), with the support of the Civil Protection Unit of the Calabria Region (which also wrote a letter of interest during the projecting phase) provided data, on a yearly basis, about landslides and floods, triggered by extreme or frequent rainfall events in the period 1990-2018, and the damage produced (damage on roads and buildings, victims, injuries - distinguished by causes). The data were collected from newspaper articles, technical reports, civil protection reports, etc. Table 2.2.3.3 shows the data for each year and for the whole territory of Calabria. As you can see, Table 2.2.3.3 shows years with very high values of events and damage, such as 1996, 2010, 2009, 2011, 2003. On the contrary, years, such as 2007, 2018, 1992, present very low values of events and damage.

Table 2.2.3.3 - Events and damage for the whole territory of Calabria from 1990 to 2017

	EVENTS		**DAMAGES**		**VICTIMS**		**INJURIES**	
Year	**Landslides**	**Floods**	**Roads**	**Buildings**	**Landslides**	**Floods**	**Landslides**	**Floods**
1990	107	38	81	64	0	0	0	0

1991	97	35	64	44	0	0	2	0
1992	46	9	28	33	0	0	3	0
1993	102	34	83	52	0	0	3	3
1994	87	35	69	51	0	0	0	0
1995	130	34	108	61	0	0	10	0
1996	693	56	531	276	0	6	1	52
1997	97	27	86	88	0	0	0	1
1998	130	19	101	61	0	0	1	0
1999	139	23	114	54	0	0	3	0
2000	171	86	151	97	0	13	5	52
2001	65	25	69	38	0	0	16	0
2002	109	24	105	61	0	0	5	0
2003	203	53	189	105	0	1	1	0
2004	135	52	132	90	0	1	3	0
2005	118	10	102	42	0	0	32	0
2006	94	25	84	32	0	3	2	77
2007	55	3	51	23	0	0	2	0
2008	211	83	223	96	0	2	2	3
2009	544	204	509	332	3	0	9	1
2010	553	198	505	248	0	1	3	0
2011	238	81	227	115	2	0	23	1
2012	185	84	198	146	1	0	3	0
2013	136	83	149	92	0	1	2	1
2014	111	48	104	33	0	0	3	0
2015	199	80	187	85	0	1	3	11

2016	103	53	85	41	0	0	0	0
2017	128	44	134	35	0	0	1	0
2018	36	38	51	29	0	13	3	11
TOTALS	**5022**	**1584**	**4520**	**2524**	**6**	**42**	**141**	**213**

Analogous data were obtained for the five provinces that are in Calabria (not shown). Globally, the data show that the provinces of Cosenza and Reggio Calabria registered the highest values of events and damages, but it is necessary to take into account that these 2 provinces are ones with the highest extensions.

By means of the provided data, the following diagrams were obtained. Figure 2.2.3.14 shows the behaviour of the events that occurred on the Calabria territory in the period 1990-2018, distinguishing landslides and floods. The histogram of Figure 2.2.3.15 shows the number of victims and injuries registered in Calabria for the same period.

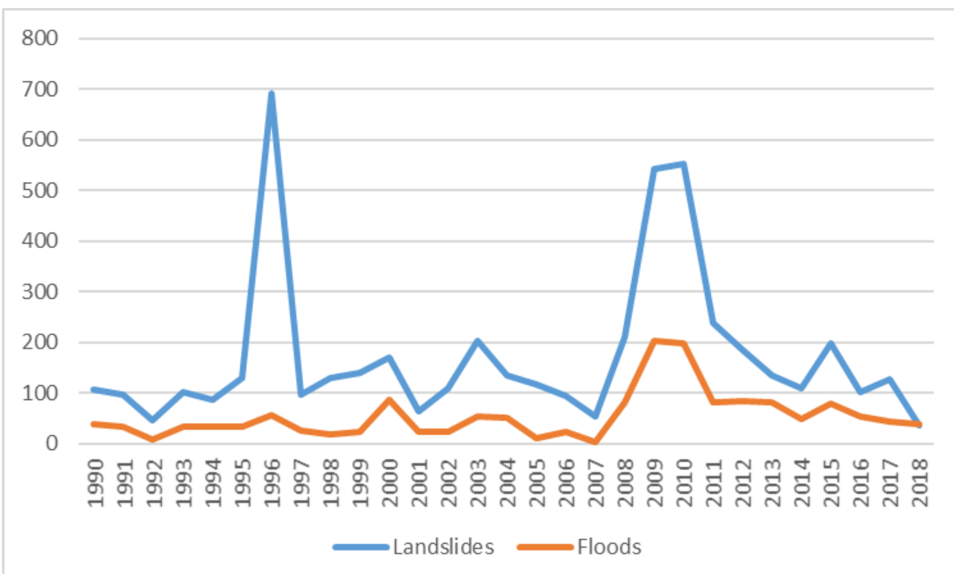

Figure 2.2.3.14 - Behaviours of number of landslides and floods that occurred in Calabria from 1990 to 2017

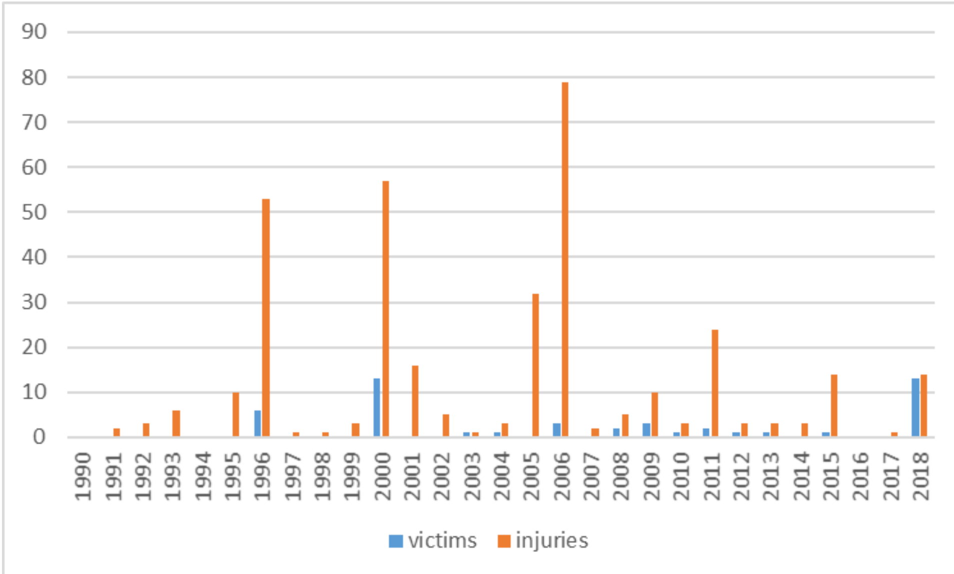

Figure 2.2.3.15 - Histogram of number of victims and injuries caused by landslides and floods in Calabria from 1990 to 2018.

2.2.3.5. Tourism

The Tourism Department of the Calabria Region provides different statistics related to tourism sector, such as the number of facilities, bedrooms and bed-places, the arrivals by Italian and foreign visitors to the various zones, the presences of Italian and foreign visitors, the average stays of Italian and foreign visitors. The data are provided on a yearly basis (from 2007) for the whole Calabria region (NUTS 2), the five provinces of Calabria (NUTS 3), the various zones of Calabria (i.e. coastal, mountainous, internal, etc.) and for selected famous tourist locations of Calabria. The data are also collected by means of tourism promotion associations, hotel networks and tourism agencies.

Tables 2.2.3.4, 2.2.3.5, 2.2.3.6 show the data of arrivals (number), presence (days) and average stays (days), respectively, for the whole territory of Calabria and for each year of the period 2007-2017. We distinguish the data for the Italian and foreign tourists and the 4 zones by which the territory can be divided: Tyrrhenian side, Ionian side, mountain areas, inland.

Table 2.2.3.4 - Arrivals of Italian and foreign tourists in the various zones of Calabria from 2007 to 2017.

	Tyrrhenian side		Ionian side		Mountain areas		Inland	
	italians	foreigners	italians	foreigners	italians	foreigners	italians	foreigners
2007	616.573	165.837	488.494	56.017	91.043	5.303	130.834	16.318
2008	600.851	155.099	482.121	50.627	96.080	5.376	137.380	17.914
2009	578.346	153.986	496.711	48.016	93.023	4.731	140.426	13.458
2010	556.311	151.373	475.132	37.760	92.029	4.905	152.321	18.000
2011	566.208	167.103	477.740	40.664	86.316	5.882	150.438	21.870
2012	564.163	172.528	453.646	43.914	96.905	7.113	150.122	20.946
2013	535.585	187.428	433.039	43.496	90.596	5.916	158.916	17.491

2014	517.073	175.118	418.757	42.335	79.099	5.853	146.176	17.962
2015	553.435	176.578	442.846	44.491	84.684	6.288	153.768	19.845
2016	574.301	192.267	473.934	59.759	90.911	7.350	179.254	25.236
2017	659.369	219.872	537.624	64.418	93.106	7.749	192.620	25.114

Table 2.2.3.5 - Presence (days) of Italian and foreign tourists in the various zones of Calabria from 2007 to 2017.

	Tyrrhenian side		Ionian side		Mountain areas		Inland	
	italians	foreigners	italians	foreigners	italians	foreigners	italians	foreigners
2007	3.373.881	1.107.387	3.225.396	370.693	241.913	14.280	353.525	52.106
2008	3.277.117	1.042.752	3.193.208	361.952	273.587	12.588	388.063	49.553
2009	2.989.315	1.068.675	3.338.552	345.723	248.066	14.460	406.688	43.313
2010	2.882.837	1.072.110	3.303.179	271.514	226.858	19.204	426.570	54.134
2011	2.972.839	1.242.395	3.291.869	286.898	222.100	20.230	422.173	90.500
2012	2.924.076	1.244.374	3.134.501	307.098	245.389	24.954	408.947	68.691
2013	2.734.259	1.275.971	3.000.724	316.122	217.801	21.851	386.638	49.430
2014	2.669.176	1.227.955	2.929.284	314.009	191.172	24.858	354.589	51.868
2015	2.851.756	1.217.979	3.059.491	331.262	204.814	31.676	375.093	63.807
2016	2.959.630	1.281.459	3.016.090	446.680	218.246	30.801	469.119	89.556
2017	3.214.846	1.444.200	3.134.090	458.135	213.149	28.746	441.872	89.542

Table 2.2.3.6 - Average stays (days) of Italian and foreign tourists in the various zones of Calabria from 2007 to 2017.

	Tyrrhenian side		Ionian side		Mountain areas		Inland	
	italians	foreigners	italians	foreigners	italians	foreigners	italians	foreigners
2007	5,47	6,68	6,60	6,62	2,66	2,69	2,70	3,19
2008	5,45	6,72	6,62	7,15	2,85	2,34	2,82	2,77
2009	5,17	6,94	6,72	7,20	2,67	3,06	2,90	3,22
2010	5,18	7,08	6,95	7,19	2,47	3,92	2,80	3,01
2011	5,25	7,43	6,89	7,06	2,57	3,44	2,81	4,14
2012	5,18	7,21	6,91	6,99	2,53	3,51	2,72	3,28
2013	5,11	6,81	6,93	7,27	2,40	3,69	2,43	2,83
2014	5,16	7,01	7,00	7,42	2,42	4,25	2,43	2,89
2015	5,15	6,90	6,91	7,45	2,42	5,04	2,44	3,22
2016	5,15	6,66	6,36	7,47	2,40	4,19	2,62	3,55
2017	4,88	6,57	5,83	7,11	2,29	3,71	2,29	3,57

Figure 2.2.3.16 shows the behaviour of the total arrivals and presence from 2007 to 2017. It is possible to distinguish 2010 and 2014 with the lowest values both for arrivals and presence.

Moreover, 2011 seems to have a relative maximum value. A constant increase in the last few years (from 2014) is evident for both arrivals and presence.

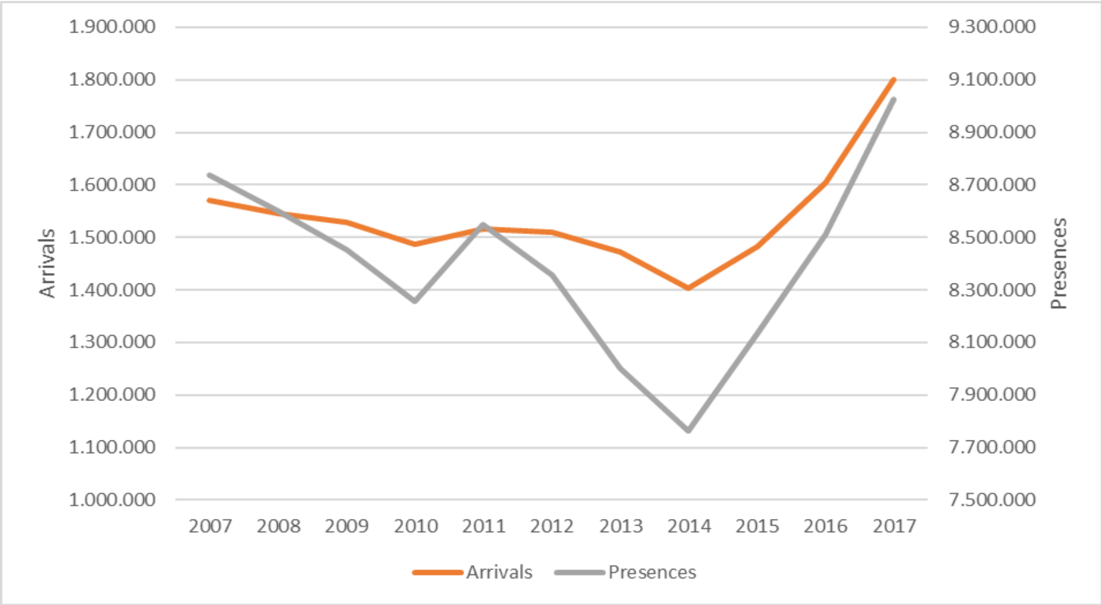

Figure 2.2.3.16 - Arrivals and presence of tourists from 2007 and 2017 in the Calabria territory.

Figures 2.2.3.17 and 2.2.3.18 show the different behaviours of the arrivals and presences, respectively, for the various zones of Calabria. Both the seaside zones present similar behaviours; on the contrary, the inland and mainly the mountain areas show flat behaviours.

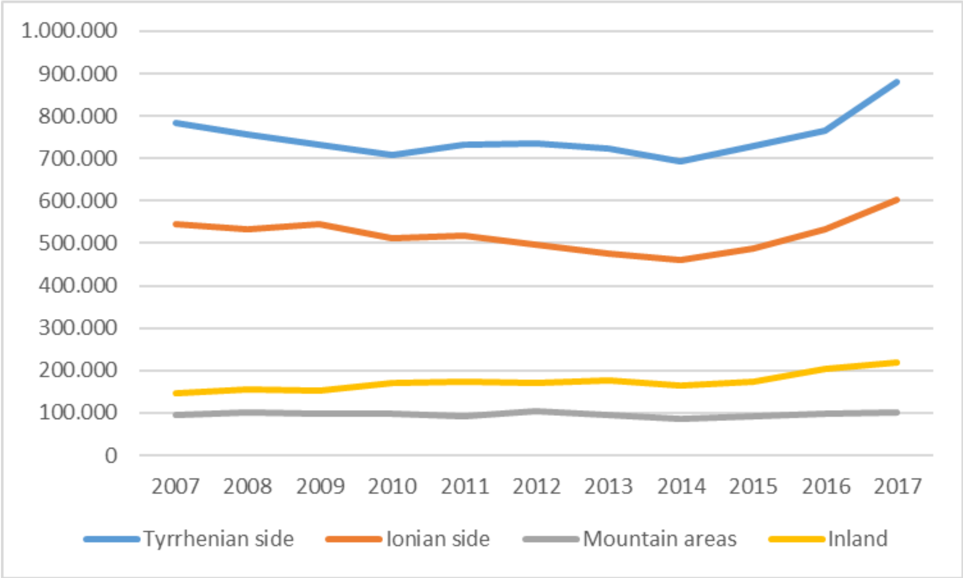

Figure 2.2.3.17 - Arrivals of tourists for the four zones of Calabria from 2007 and 2017.

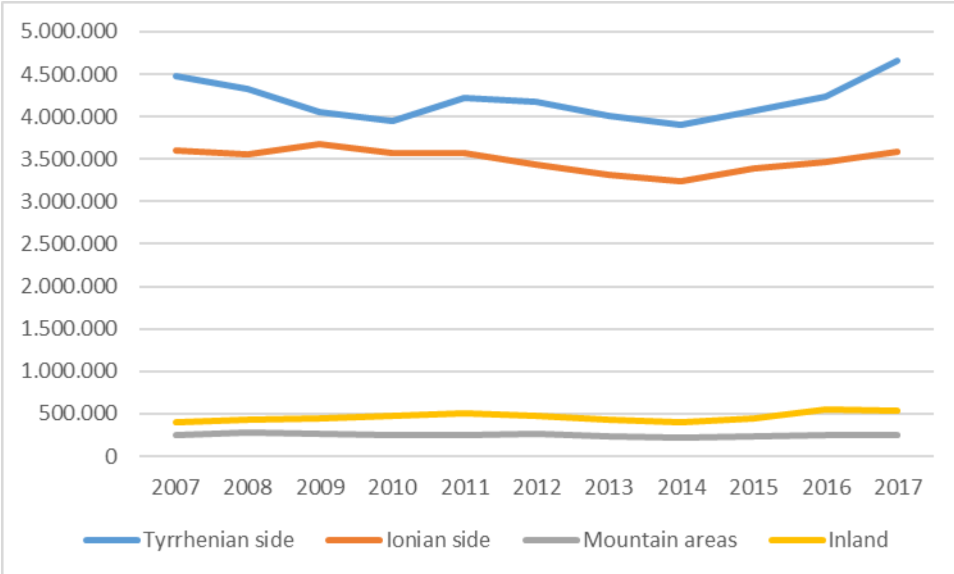

Figure 2.2.3.18 – Presence of tourists for the four zones of Calabria from 2007 and 2017.

Analogous data have been also collected for all the 5 provinces of Calabria (not shown in this report).

Since the area of the Sila National Park was chosen as a study area and in this area a workshop was organized in May 2019, with focus-groups relative to tourism stakeholders, the monthly data of arrivals and presence for this area were provided by the "Osservatorio per il Turismo" of the Calabria Region. Table 2.2.3.7 shows the data, distinguishing also the Italian and foreign tourists.

Table 2.2.3.7 - Monthly data of arrivals and presence of tourists in the territory of the Sila National Park, from 2011 to 2017

		Italians		Foreigners		Totals	
Year	**Month**	**Arrivals**	**Presences**	**Arrivals**	**Presences**	**Arrivals**	**Presences**
2011	1	6.046	16.691	48	183	6.094	16.874
	2	7.206	14.438	73	152	7.279	14.590
	3	2.543	5.889	46	140	2.589	6.029
	4	2.420	4.887	175	518	2.595	5.405
	5	1.782	3.656	268	385	2.050	4.041
	6	2.030	4.950	302	796	2.332	5.746
	7	4.051	13.392	323	1.115	4.374	14.507
	8	10.810	38.341	335	1.380	11.145	39.721
	9	3.403	7.766	348	1.072	3.751	8.838
	10	6.592	12.220	211	479	6.803	12.699
	11	1.687	2.968	31	117	1.718	3.085
	12	3.953	8.017	33	159	3.986	8.176

	Yearly total	**52.523**	**133.215**	**2.193**	**6.496**	**54.716**	**139.711**
2012	1	8.340	19.657	64	231	8.404	19.888
	2	8.554	16.666	131	280	8.685	16.946
	3	3.426	7.150	79	333	3.505	7.483
	4	4.016	9.323	231	684	4.247	10.007
	5	3.354	7.667	349	657	3.703	8.324
	6	2.578	7.477	356	821	2.934	8.298
	7	4.854	15.082	403	1.273	5.257	16.355
	8	12.441	43.901	452	1.857	12.893	45.758
	9	3.447	7.821	408	1.469	3.855	9.290
	10	5.590	10.270	221	593	5.811	10.863
	11	2.445	4.390	44	209	2.489	4.599
	12	4.520	8.704	76	213	4.596	8.917
	Yearly total	**63.565**	**158.108**	**2.814**	**8.620**	**66.379**	**166.728**
2013	1	5.820	14.097	33	107	5.853	14.204
	2	8.100	16.079	83	300	8.183	16.379
	3	3.829	7.049	58	192	3.887	7.241
	4	3.217	7.517	130	367	3.347	7.884
	5	3.442	6.828	299	535	3.741	7.363
	6	2.093	4.873	278	569	2.371	5.442
	7	3.791	10.986	357	1.246	4.148	12.232
	8	11.583	38.837	484	1.463	12.067	40.300
	9	3.099	7.078	330	666	3.429	7.744
	10	5.430	9.376	165	340	5.595	9.716
	11	3.191	5.624	35	48	3.226	5.672
	12	4.454	8.490	45	119	4.499	8.609
	Yearly total	**58.049**	**136.834**	**2.297**	**5.952**	**60.346**	**142.786**
2014	1	4.580	10.694	51	110	4.631	10.804
	2	5.832	11.500	54	85	5.886	11.585
	3	3.100	5.932	73	164	3.173	6.096
	4	3.004	5.791	99	274	3.103	6.065
	5	3.351	6.613	163	288	3.514	6.901
	6	1.527	3.421	165	332	1.692	3.753
	7	3.216	10.713	322	1.177	3.538	11.890
	8	10.197	36.741	523	2.358	10.720	39.099
	9	2.925	9.584	328	1.478	3.253	11.062
	10	5.558	9.194	215	1.581	5.773	10.775
	11	2.354	4.066	29	1.075	2.383	5.141
	12	4.343	8.196	22	933	4.365	9.129
	Yearly total	**49.987**	**122.445**	**2.044**	**9.855**	**52.031**	**132.300**
2015	1	4.669	10.449	80	1.103	4.749	11.552
	2	6.363	11.774	57	1.024	6.420	12.798
	3	3.142	5.703	81	1.199	3.223	6.902
	4	3.015	5.737	107	1.260	3.122	6.997
	5	3.544	6.885	181	1.227	3.725	8.112
	6	1.640	3.725	165	326	1.805	4.051
	7	3.835	12.721	336	1.229	4.171	13.950
	8	11.048	38.892	536	2.423	11.584	41.315
	9	3.139	10.526	311	1.487	3.450	12.013

	10	5.670	9.354	243	1.587	5.913	10.941
	11	2.411	4.169	31	1.079	2.442	5.248
	12	4.439	8.352	22	938	4.461	9.290
	Yearly total	**52.915**	**128.287**	**2.150**	**14.882**	**55.065**	**143.169**
2016	1	4.285	10.375	30	69	4.315	10.444
	2	6.215	11.228	43	70	6.258	11.298
	3	3.426	5.891	51	153	3.477	6.044
	4	2.992	6.496	96	238	3.088	6.734
	5	2.494	4.905	137	261	2.631	5.166
	6	2.626	5.640	208	379	2.834	6.019
	7	4.731	14.991	363	923	5.094	15.914
	8	11.797	39.364	375	1.298	12.172	40.662
	9	4.508	8.725	361	1.133	4.869	9.858
	10	7.611	12.895	173	1.426	7.784	14.321
	11	1.879	3.318	49	1.084	1.928	4.402
	12	5.012	9.890	35	941	5.047	10.831
	Yearly total	**57.576**	**133.718**	**1.921**	**7.975**	**59.497**	**141.693**
2017	1	7.399	15.211	51	125	7.450	15.336
	2	6.944	13.831	64	147	7.008	13.978
	3	2.854	5.436	73	179	2.927	5.615
	4	4.452	8.503	250	689	4.702	9.192
	5	2.294	4.835	248	517	2.542	5.352
	6	2.744	5.289	386	778	3.130	6.067
	7	4.815	13.715	432	1.140	5.247	14.855
	8	10.928	35.432	457	1.735	11.385	37.167
	9	4.877	9.681	440	1.258	5.317	10.939
	10	7.675	14.416	255	648	7.930	15.064
	11	2.674	4.844	71	151	2.745	4.995
	12	5.049	9.694	115	210	5.164	9.904
	Yearly total	**62.705**	**140.887**	**2.842**	**7.577**	**65.547**	**148.464**

Figure 2.2.3.19 shows the behaviour of presence and arrivals of tourists (Italians and foreigners) in the Sila National Park territory in the period for which data were provided. As you can see, the maximum values of both arrivals and presence were registered in 2012; the minimum values refer to 2014. Figure 2.2.3.20, which shows these data on a monthly scale, allows affirmation that the highest values were registered in August 2012 and that every year August is one with the highest presence and arrivals. On the contrary, every year November has the lowest values. In particular, November 2011 seems the month with the lowest value (3085) of presence in the observation period.

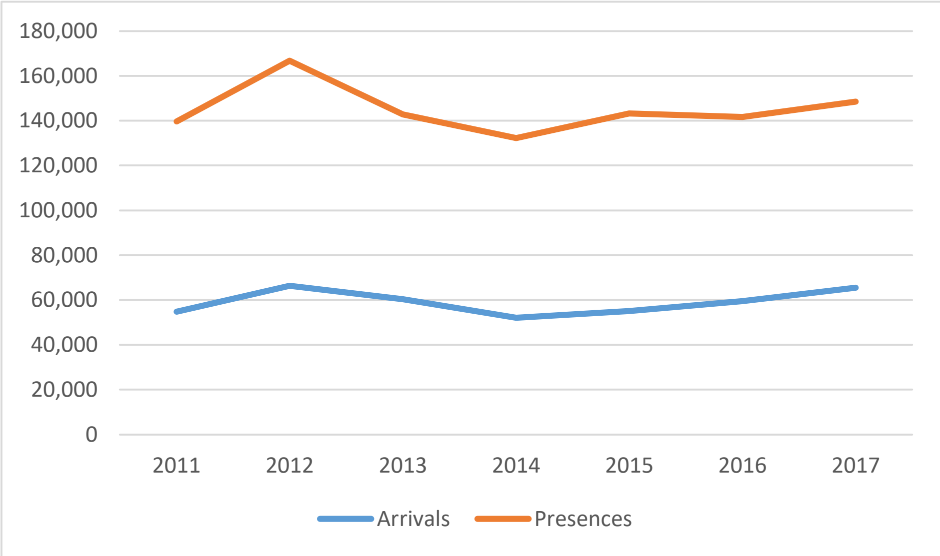

Figure 2.2.3.19 – Yearly number of arrivals and presence of tourists in the Sila National Park territory from 2011 to 2017

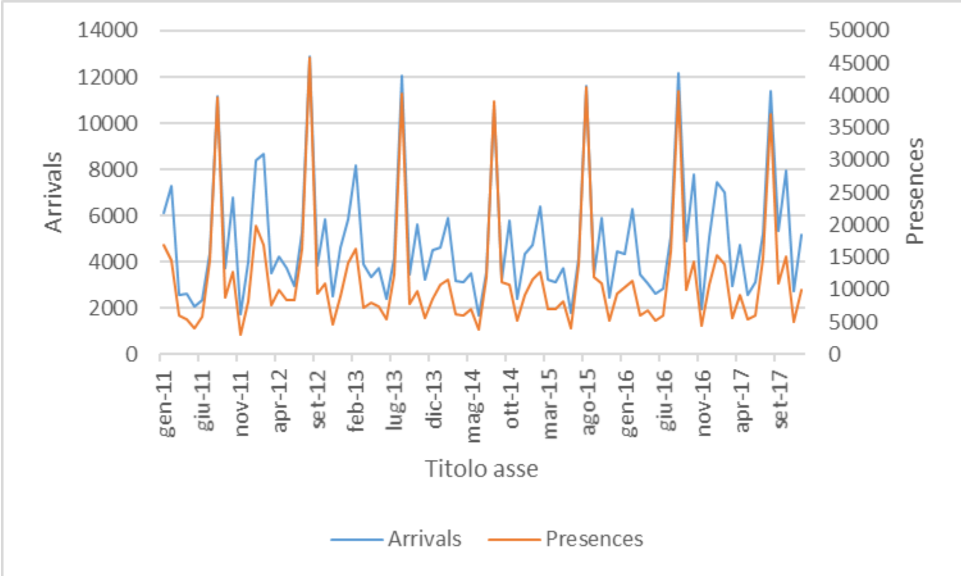

Figure 2.2.3.20 - Monthly data of arrivals and presence of tourists in the Sila National Park territory from 2011 to 2017

2.2.4. Finland

2.2.4.1. Tourism

Statistics related to tourism sector in Finland are available via the Statistical Service Rudolf (http://visitfinland.stat.fi/PXWeb/pxweb/en/VisitFinland/?rxid=494a85b1-a3f9-4a7c-9a54-b920410657aa), in collaboration with Visit Finland and Statistics Finland. The statistics are provided on a monthly basis from 1995 for 80 different countries, besides continents and EU-28. In Finland, the areas that can be classified as tourist destinations can be grouped into: Large areas (NUTS 2; 5 areas), Regions (NUTS 3; 19 areas), Sub-regions (LAU 1; 70 areas) and Municipalities (LAU2; 311 areas).

The common tourism statistics are mainly related to accommodation, tourism accounts, and travel related credits and debits. For accommodation, the key statistics include the monthly nights spent, arrivals by country of residence, duration of stay, yearly nights and arrivals by country of residence (see Figure 15). Other accomodation statistics also include the nights spent and arrivals by tourism season and country of residence, the nights spent by type of establishment (all, hotels, other) and the purpose of stay (leisure, business, other [share of nights, %]), the accommodation establishment monthly capacity and capacity utilization, the accommodation establishment average annual capacity and capacity utilization (e.g. number of establishments, bedrooms and bed-places, occupancy rates of bedrooms and bed-places, and accommodation revenue).

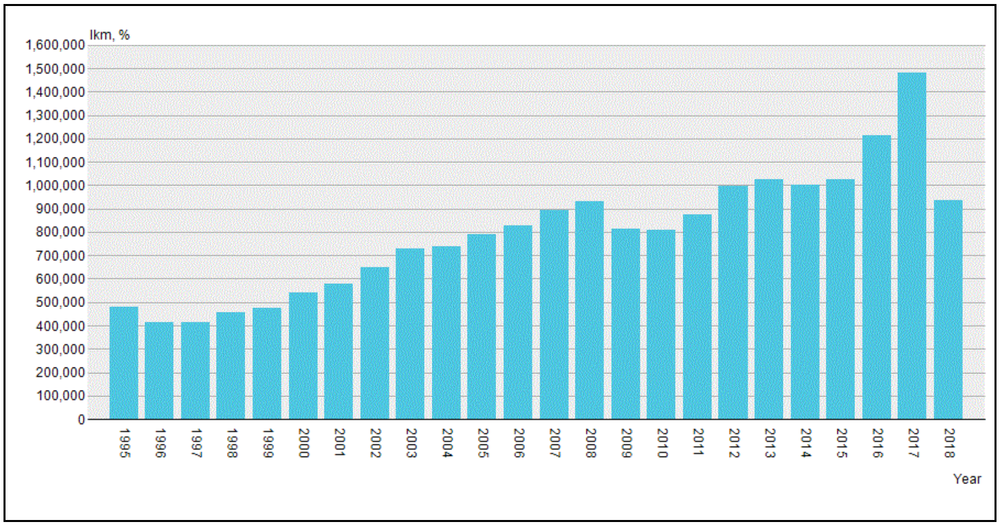

Figure 15: Total annual nights spent in Lapland by foreigners from 1995 to 2018.

On the other hand, statistics related to tourism accounts include key figures in tourism account, key figures in regional tourism account (e.g. tourism demand, employment in tourism industries, GDP, etc.), inbound tourism expenditure by consumption products (i.e. hotels, food, culture, sports) as well as category of visitors (i.e. day or overnight), domestic tourism expenditure, internal tourism consumption, domestic supply and internal tourism consumption, and employment in tourism industries (regional tourism accounts). Finally, the travel related credits and debits characterize travel related credits and debits by country.

Another relevant dataset to tourism sector in Finland is Aurora data, which are available through Auroras Now space weather service maintained by FMI (http://aurorasnow.fmi.fi/public_service/). These data include all-sky camera and magnetic measurements data. Their current activity and geomagnetic disturbances can be found in (https://en.ilmatieteenlaitos.fi/auroras-and-space-weather).

Statistics of Auroras are also available via (http://aurorasnow.fmi.fi/public_service/english/statistics.html) (see Figure 16). Operationally, it is common to normalize the number of nights with aurora by the number of nights when the camera has been in operation per year and per station.

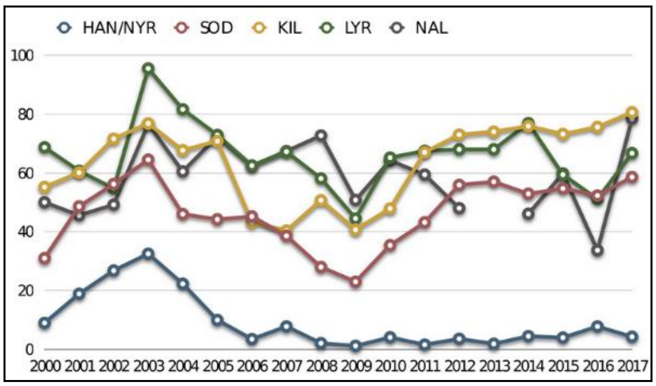

Figure 16: Annual frequency of auroral nights in different locations.

2.2.4.2. Snow data

The Finnish Meteorological Institute (FMI) and the Finnish Environment Institute (SYKE) provide snow data both in the form of in-situ and space-based products. For example, the SYKE satellite data of Snow Covered Area (SCA) are available for Finland for the period 2006-2013, for the Baltic Sea drainage basin area (2012 ->) and Snow Water Equivalent (SWE) for the period 2011-2013 (http://www.syke.fi/en-US/Open_information/Satellite_observations) (Figure 17). More satellite-based data related to snow can also be found in HSAF (http://hsaf.meteoam.it/) and GlobSnow projects (http://nsdc.fmi.fi/data/data_globsnow_se) (Figure 18).

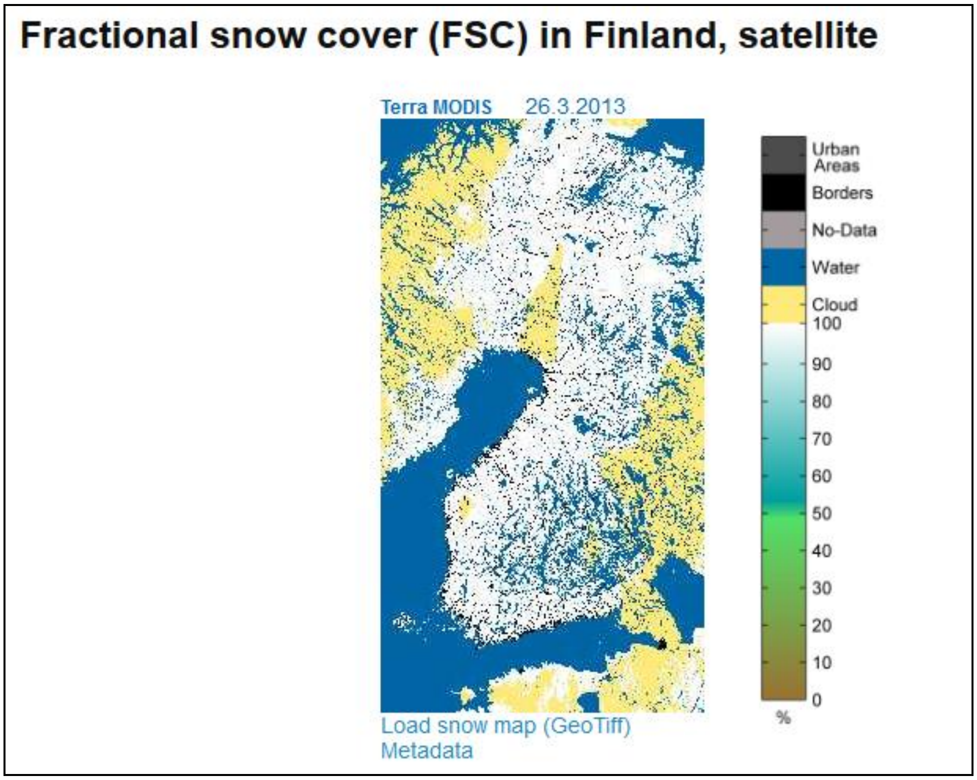

Figure 17: Spatial distribution of fractional snow cover, as derived from SYKE product.

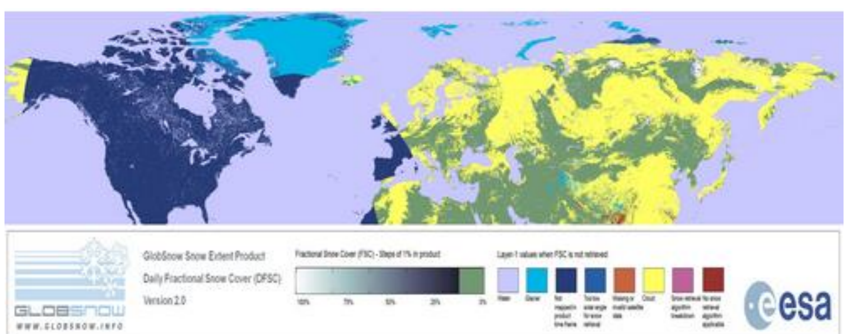

Figure 18. Spatial distribution of fractional Snow Cover, as derived from GlobSnow product.

Other indices related to snow course data (e.g. snow depth, snow patchiness, SWE, and snow density) can also be obtained from SYKE (http://monimet.fmi.fi/project/deliverables/Action_B3/1st%20summary%20report%20of%20snow%20data_30092014.pdf). In-situ based data from approximately 180 Automatic Weather Station(AWS) stations are also available from the FMI's Open data (https://en.ilmatieteenlaitos.fi/open-data) or from Download observations service (https://ilmatieteenlaitos.fi/havaintojen-lataus#!/). Other snow statistics, such as the number of days with snow cover, average snow depth 15th and 31th March, average date of first snow cover, average starting date of permanent snow cover, average ending date of permanent snow cover, are visualized in (https://en.ilmatieteenlaitos.fi/snow-statistics) (see for example Figure 19). Statistics about ice winters can be found from (https://ilmatieteenlaitos.fi/jaatalvet-1961-1990).

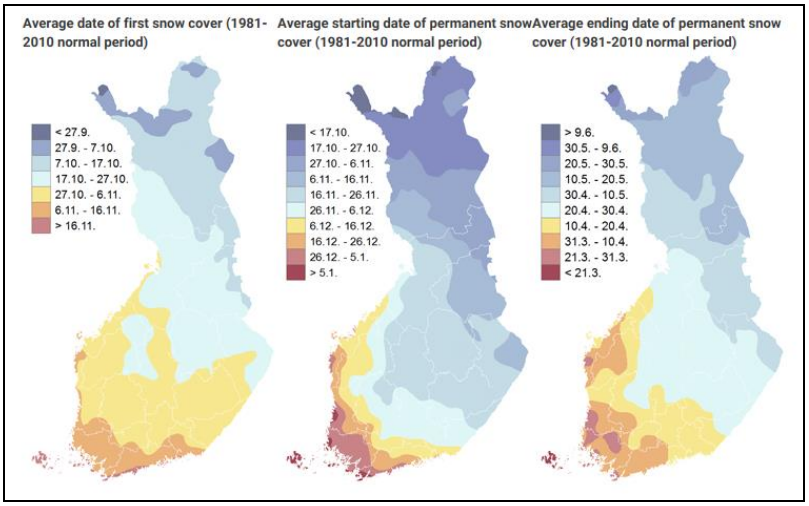

Figure 19. A visualized example of snow statistics,available via https://en.ilmatieteenlaitos.fi/snow-statistics.

2.2.4.3. Ice data

Ice data are also provided by the FMI and SYKE. While FMI data are closely related to sea ice, SYKE focuses more on lake ice. FMI produces ice charts for the Baltic Sea during winter (https://en.ilmatieteenlaitos.fi/ice-conditions), meanwhile data on thickness of lake ice are available via (http://wwwi3.ymparisto.fi/i3/tilanne/eng/IceThickness/IceThickness.htm) (see for example Figure 20). Moreover, data about lake ice extent in Finland (2017-) based on satellite observations are available through (http://www.syke.fi/en-US/Open_information/Satellite_observations).

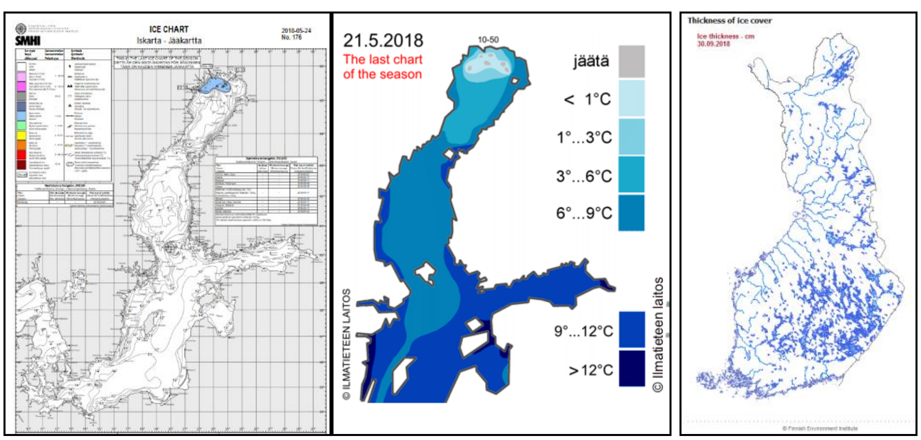

Figure 20. Left: Example of Baltic Sea Ice Chart (and simplified) from FMI, Right: thickness of Lake ice from SYKE.

2.2.4.4. Disaster risk

Statistics about accidents at work for the period 2005-2015 can be found from http://www.tvk.fi/tietopalvelu-ja-julkaisut/tilastot/tyotapaturmatilastot/. Other statistics related to killed and injured in road traffic accidents spanning the period 1931-2016 are found from http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__lii__ton/statfin_ton_pxt_009.px/?rxid=6ecc9db2-97e8-42c6-8e1b-fd53489a52ae.

2.2.4.5. Human health

Statistics of deaths by month, age, sex can be found from (http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/) (under population). Air quality data is available from FMI's Open data (https://en.ilmatieteenlaitos.fi/open-data) or from Download observations service (https://en.ilmatieteenlaitos.fi/download-observations#!/). Statistics related to air pollution gases on a yearly basis for 2016 and 2017 are available via (https://ilmatieteenlaitos.fi/ilmansaasteet#tilasto). There is also information about carbon monoxide, nitrogen dioxide, ozone, particles etc (Figure 21).

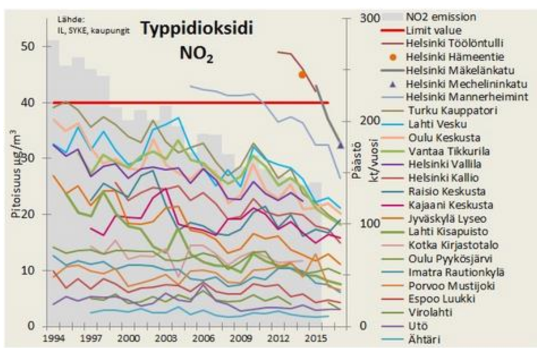

Figure 21. Temporal evolution of nitrogen dioxide statistics from 1994 to 2015 for different cities.

2.2.5. Romania

2.2.5.1. Tourism

Statistics related to tourism in Romania are freely available by the National Institute for Statistics (http://www.insse.ro). This includes monthly "tourists overnights" categorized according to accommodation type (e.g. hotel, hostel, camping) and the type of tourists (i.e. Romanian vs. foreigners) at both counties and locality levels (e.g. city) for the period from January 2010 to July 2018. Figure 21 gives an example on the monthly overnights in hotels (Romanian tourists) in Brasov city,

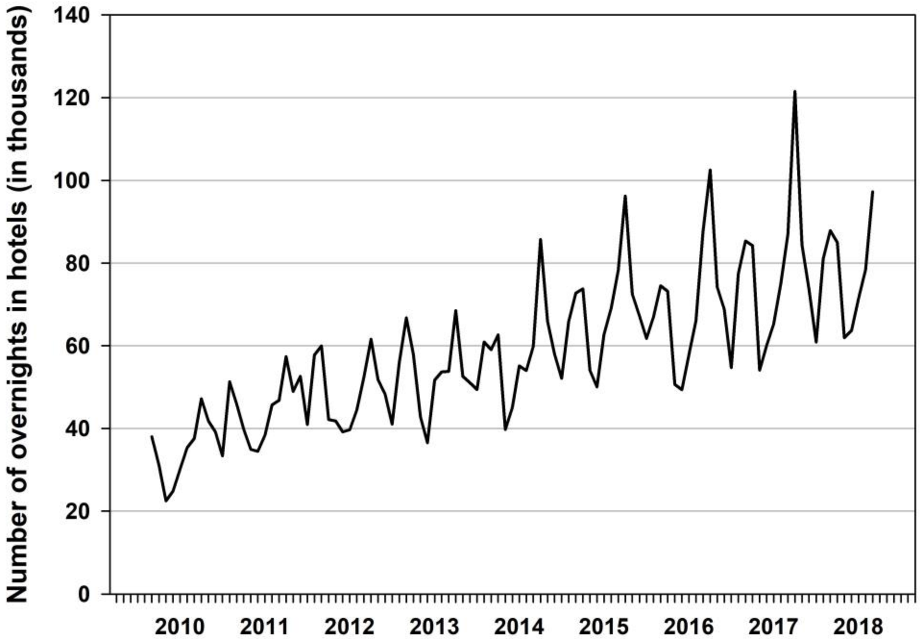

Figure 21: The temporal evolution of the total number of overnights in hotels in Brasov.

3. Clime Indices of INDECIS and their links to sectorial data

Taking into account the available sectoral data (i.e. agriculture, health, water, tourism, forest, and disaster risk) and the inventory of climatic indices (Deliverable 4.1), we have defined the Indices of INDECIS-ISD, highlighting their utility for the different sectoral data.

3.1 Temperature based indices

1.
ID: GTX
Name: Mean TX
Description: Average value of monthly maximum air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Average value of monthly maximum air temperature.
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

2.
ID: XTX
Name: Maximum TX
Description: Maximum value of monthly maximum air temperature
Importance of the index: Important application in agriculture, tourism, water, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum value of monthly maximum air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

3.
ID: NTX
Name: Minimum TX
Description: Minimum value of monthly maximum air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Minimum value of monthly maximum air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

4.ID: GTN
Name: Mean TN
Description: Average value of monthly minimum air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Average value of monthly minimum air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

5.
ID: XTN
Name: Maximum TN
Description: Maximum value of monthly minimum air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum value of monthly minimum air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

6.
ID: NTN
Name: Minimum TN
Description: Minimum value of monthly maximum air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Minimum value of monthly maximum air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

7.
ID: GTG
Name: Mean TG
Description: Average value of monthly mean air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe

Formula: Average value of monthly mean air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

8.
ID: XTG
Name: Maximum TG
Description: Maximum value of monthly mean air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum value of monthly mean air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

9.
ID: NTG
Name: Minimum TG
Description: Minimum value of monthly mean air temperature
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Minimum value of monthly mean air temperature
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

10.
ID: CD
Name: Cold days
Description: Total numbers of days with maximum air temperatures lower than the 10th percentile.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TX < 10p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

11.
ID: CN
Name: Cold nights
Description: Total numbers of days with minimum air temperatures lower than the 10th percentile.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TN < 10p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

12.
ID: CDDI
Name: Cold spell duration index
Description: Count of days with at least 6 consecutive days when TN < 10th percentile
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: 6 consecutive days TN < 10p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

13.
ID: DTR
Name: Diurnal air temperature range
Description: Mean difference between TX and TN.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: TX-TN
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

14.
ID: vDTR
Name: vDTR
Description: Mean absolute day-to-day difference in DTR
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual

Geographic limitation: valid for all Europe
Formula: Mean absolute day-to-day difference in DTR
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

15.
ID: FDs
Name: Annual number of frost days
Description: Total number of days with TN < 0°C
Importance of the index: Important application in agriculture.
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TN < 0°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

16.
ID: GSL
Name: Growing season length
Description: Annual count of days between the first span of at least 6 days with TG >5°C and first span after 1 July of 6 days with TG <5°C .
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: at least 6 days with TG >5°C and first span after 1 July of 6 days with TG <5 °C.
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

17.
ID: ID
Name: Ice days
Description: Number of days with TX <0°C
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TX< 0°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

18.
ID: CFD
Name: Maximum number of consecutive frost days (CFD)
Description: Maximum number of consecutive with days TN<0°C
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: n days with TN <0°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

19.
ID: ETR
Name: Extreme air temperature range
Description: Difference between the highest TX and the lowest TN.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $TX_{highest}-TN_{lowest}$

Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

20.
ID: SUD
Name: Summer days
Description: Number of days with TX >25°C.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TX < 25°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

21.
ID: CSD
Name: Maximum number of consecutive summer days (TX > 25°C)
Description: Maximum number of consecutive days with TX > 25°C

Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: n days with TX >25°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

22.
ID: TS
Name: Air temperature sums
Description: (days TX >17°C)–(days TX <17°C)
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: (days TX >17°C)–(days TX <17°C)
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

23.
ID: TN
Name: Tropical nights
Description: Number of days with TN >20°C.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TN >20°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

24.
ID: HD17
Name: Heating degree days
Description: (sum(17-TG)) only for days with TG<17°C
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: (sum(17-TG)) when daily TG<17°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing

climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

25.
ID: VCD
Name: Very cold days
Description: Number of days with TN <1st percentile.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TN < 1p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

26.
ID: VWD
Name: Very warm days
Description: Number of days with TX >99th percentile per year.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TX > 99p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

27.
ID: WD
Name: Warm days
Description: Total numbers of days with TX higher than the 90th percentile.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TX > 90p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

28.

ID: WN
Name: Warm nights
Description: Total numbers of days TN higher than the 90th percentile.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days TN > 90p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

29.
ID: WSD
Name: Warm spell duration index
Description: Count of days with at least 6 consecutive days when TX > 90th percentile.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: at least 6 days with TX >90p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

30.
ID: ZCD
Name: zero crossing days
Description: Number of days with TX > 0 ˚C and TN < 0 ˚C.
Importance of the index: Important application in agriculture, tourism, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: days with TX > 0 ˚C and TN < 0 ˚C.
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

31.
ID: OGS6
Name: Onset of growing season 6 days
Description: The start of the first span with at least 6 days with Tmean >5°C
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe

Formula: The start of the first span with at least 6 days with Tmean >5°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

32.
ID: OGS10
Name: Onset of growing season 10 days
Description: The start of the first span with at least 10 days with Tmean >5°C
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: The start of the first span with at least 10 days with Tmean >5°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

33.
ID: Ta_o
Name: Growing season air temperature 1
Description: growing season mean temperature (April-October in the Northern Hemisphere; and October-April in the Southern Hemisphere).
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: average of monthly mean temperatures in the growing season (April-October in the Northern Hemisphere; October-April in the Southern Hemisphere).
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

34.
ID: Tm_s
Name: Growing season air temperature 2
Description: Growing season (May to September) mean TG
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: mean TG averaged for the period from May to September
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72,

WMO-TD No 1500, p 5.

35.
ID: GD4
Name: Growing degree days
Description: Sum of degree days over 4°C
Importance of the index: Important application in agriculture
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Sum of degree days over 4°C
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

36.
ID: WKI
Name: Winkler index
Description: Sum of degree days over 10°C from April 1 until October 31
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: $\sum_{m=Oct}^{Abr} (T_m - 10) * n_m$; where n_m is the number of days, n, of the month, m. All the months with average temperatures < 10°C are not considered in the sum.
Reference: Winkler, A.J., J.A. Cook, W.M. Kliewer, and L.A. Lider. 1974. General Viticulture. 4th ed. University of California Press, Berkeley.

37.
ID: WSI
Name: Winter Severity index
Description: Mean TG of the coldest month of the year
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: Mean TG of the coldest month of the year
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

38.
ID: STX32
Name: Temperature sums above 32˚C (intensity)
Description: Is an agrometeorological parameter characterizing thermal impact on winter wheat and maize crops in Romania. The 32 °C limit is the critical biological threshold for the maximum air temperature from which the physiological optimal growth and development of wheat and maize plants is particularly affected during the critical period with maximum temperature requirements. This critical period corresponds to the June-August interval
Importance of the index: Important application in agriculture,water, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $\sum Tmax \geq 32^{\circ}C$ - on the interval June-August
Reference: Sandu I., Mateescu Elena, Vatamanu V. V, *Schimbari climatice in Romania si efectele asupra agriculturii*, Editura Sitech, Craiova, 2010

39.
ID: D32
Name: Temperature sums above 32˚C (duration)
Description: number of days whith $TX \geq 32^{\circ}C$
Importance of the index: Important application in agriculture,water, human health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: number of days whith $TX \geq 32^{\circ}C$
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

40.
ID: STN15
Name: Sums of minimum air temperatures ≤-15˚C recorded in December-February interval
Description: the amount of minimum air temperatures below -15˚C
Importance of the index: Important application in agriculture,energy, human health, tourism
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: $\sum Tmin \leq -15^{\circ}C$ recorded in December-February interval
Reference: Sandu I., Mateescu Elena, Vatamanu V. V, *Schimbari climatice in Romania si efectele asupra agriculturii*, Editura Sitech, Craiova, 2010

41.
ID: STN10
Name: Sums of minimum air temperatures ≤-10˚C recorded in December-February interval
Description: Sums of $TN \leq -10^{\circ}C$ recorded in December-February interval
Importance of the index: Important application in agriculture,energy, human health, tourism

Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: sum TN $\leq$-10˚C recorded in December-February interval
Reference: Sandu I., Mateescu Elena, Vatamanu V. V, *Schimbari climatice in Romania si efectele asupra agriculturii*, Editura Sitech, Craiova, 2010

42.
ID: PTG
Name: Spring index
Description: Sums of positive average temperatures calculated for the 1st of February to the 10th April interval
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: $\sum Tmed \geq 0^{\circ}C$ calculated from the 1^{st} of February to the 10^{th} of April
Reference: Sandu I., Mateescu Elena, Vatamanu V. V, *Schimbari climatice in Romania si efectele asupra agriculturii*, Editura Sitech, Craiova, 2010

3.2 Precipitation based indices

43.
ID: TP
Name: Total precipitation
Description: Total amounts of precipitation
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Total amounts of precipitation
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

44.
ID: XP
Name: Maximun precipitation
Description: The highest amount of precipitation
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: The highest amount of precipitation
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

45.
ID: R10mm
Name: R10mm
Description: Annual count of days when daily precipitation amount ≥ 10mm
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days ≥ 10mm
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

46.
ID: R20mm
Name: R20mm
Description: Annual count of days when daily precipitation amount ≥ 20mm
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days ≥ 20mm
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

47.
ID: Rx1day
Name: Rx1day
Description: Maximum 1-day precipitation
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum 1-day precipitation
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

48.
ID: Rx5day
Name: Rx5day
Description: Maximum consecutive 5-day precipitation
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum consecutive 5-day precipitation
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

49.
ID: SDII
Name: SDII
Description: Sum of precipitation in wet days (days with >1mm of precipitation), and dividing that by the number of wet days in the period.
Importance of the index: Important application in agriculture and water

Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Sum of precipitation in wet days (days with >1mm of precipitation), and dividing that by the number of wet days in the period.
Reference: Michele Brunetti, Maurizio Maugerib, Teresa Nanni, (2001) Changes in total precipitation, rainy days and extreme events in northeastern Italy, International Journal of Climatology

50.
ID: DD
Name: Dry days
Description: Number of days with less than 1 mm/day
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days < 1 mm/day
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

51.
ID: EP
Name: Effective precipitation
Description: Precipitation minus evapotranspiration
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: P- ET0
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

52.
ID: LDP
Name: Longest dry period
Description: Maximum length of consecutive dry days (RR<1)
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum number of consecutive dry days of a year
Reference: Gregory J. McCabe, David R. Legates, Harry F. Lins, Variability and trends in dry day frequency and dry event length in the southwestern United States, Journal of Geophysical Research, VOL. 115, D07108, doi:10.1029/2009JD012866, 2010

53.
ID: LWP
Name: Longest wet period
Description: Maximum length of consecutive wet days (RR>=1)
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days RR>=1
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

54.
ID: PVWD
Name: Precipitation fraction due to very wet days
Description: Precipitation at days exceeding the 95percentile divided by total precipitation
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: sum P when RR> 95p/ total precipitation
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

55.
ID: PEWD
Name: Precipitation fraction due to extremely wet days
Description: Precipitation at days exceeding the 99percentile divided by total precipitation
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: sum P when RR> 99p/ total precipitation
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

56.
ID: HPD
Name: Heavy precipitation days
Description: Number of days with precipitation above 50mm
Importance of the index: Important application in agriculture and water

Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days RR > 50mm
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

57.
ID: R95p
Name: R95p
Description: Days when precipitation > 95p
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days RR > 95p
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

58.
ID: PCI
Name: Precipitation Concentration Index
Description:
Importance of the index: Important application in agriculture and water
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula:

$$PCI = \frac{\sum_{i=1}^{12} P_i^2}{(P_t)^2} \times 100$$

Reference: J. Martin-Vide, "Spatial distribution of a daily precipitation concentration index in peninsular Spain," International Journal of Climatology, vol. 24, no. 8, pp. 959–971, 2004.

59.
ID: MFI
Name: ƒModified Fournier Index
Description: A precipitation concentration index
Importance of the index: Important application in agriculture and water
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula:

$$\mathrm{MFI} = \sum_{i=1}^{12} \frac{p_i^2}{P_t}$$

Reference: Gabriels, D. (2006). Assessing the Modified Fournier Index and the Precipitation Concentration Index for Some European Countries. In Soil Erosion in Europe (eds J. Boardman and J. Poesen). doi:10.1002/0470859202.ch48

60.
ID: GSP
Name: Growing season precipitation
Description: Growing season (April to October) total precipitation
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Total precipitation from April to October
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

61.
ID: NGSP
Name: Non-growing season precipitation
Description: October to April total precipitation, can inform on the resource available for low potential evaporation conditions
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Total precipitation from October to April
Reference: Klein Tank AMG, Zwiers FW, Zhang X. 2009. Guidelines on analysis of extremes in a changing climate in support of informed decisions for adaptation, climate data and monitoring WCDMP-No 72, WMO-TD No 1500, p 5.

62.
ID: TPWD
Name: Total precipitation in wet days
Description: Precipitation amount on days with RR ≥ 1 mm in a chosen period (e.g. year)
Importance of the index: Important application in agriculture, water management and tourism.
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $\mathrm{T}j = \sum_{i=1}^{I} RRij$

Let RR_{ij} be the daily precipitation amount on day *i* in period *j*. If *I* represents the number of days in *j*.

Reference: Karl, T.R., N. Nicholls, and A. Ghazi, 1999: CLIVAR/GCOS/WMO workshop on indices and indicators for climate extremes: Workshop summary. *Climatic Change*, **42**, 3-7.

63.
ID: RR1
Name: Wet days ≥ 1 mm
Description: Total number of wet days ≥ 1 mm; standard index computed by ECA&D
Importance of the index: Important application in agriculture, water management and tourism.
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $\mathrm{RRi}j \geq 1mm$

Let RR_{ij} be the daily precipitation amount on day *i* of period *j*. Count the number of days.
Reference: ECA&D website: https://www.ecad.eu//indicesextremes/indicesdictionary.php

64.
ID: RR3
Name: Wet days ≥ 3 mm
Description: Total number of wet days ≥ 3 mm; standard index computed by ECA&D
Importance of the index: Important application in agriculture, water management and tourism.
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days RR≥ 3mm
Reference: ECA&D website: https://www.ecad.eu//indicesextremes/indicesdictionary.php

65.
ID: BIO10
Name: BIO10
Description: TG of Warmest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TG of Warmest Quarter
Reference: http://www.worldclim.org/bioclim

66.
ID: BIO11
Name: BIO11
Description: TG of Coldest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TG of Coldest Quarter
Reference: http://www.worldclim.org/bioclim

67.
ID: BIO13
Name: BIO13
Description: Precipitation of Wettest Month
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Precipitation of Wettest Month
Reference: http://www.worldclim.org/bioclim

68.
ID: BIO14
Name: BIO14
Description: Precipitation of Driest Month
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Precipitation of Driest Month
Reference: http://www.worldclim.org/bioclim

69.
ID: BIO15
Name: BIO15
Description: This is a measure of the variation in monthly precipitation totals over the course of the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation (also known as the coefficient of variation) and is expressed as a percentage.
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: the coefficient of variation
Reference: http://www.worldclim.org/bioclim

70.
ID: BIO16
Name: BIO16
Description: Precipitation of Wettest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Precipitation of Wettest Quarter
Reference: http://www.worldclim.org/bioclim

71.
ID: BIO17
Name: BIO17
Description: Precipitation of Driest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Precipitation of Driest Quarter
Reference: http://www.worldclim.org/bioclim

72.
ID: BIO18
Name: BIO18
Description: Precipitation of Warmest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Precipitation of Warmest Quarter
Reference: http://www.worldclim.org/bioclim

73.
ID: BIO19
Name: BIO19
Description: Precipitation of Coldest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Precipitation of Coldest Quarter
Reference: http://www.worldclim.org/bioclim

74.
ID: BIO4
Name: BIO4
Description: Standard deviation *100
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: Standard deviation *100
Reference: http://www.worldclim.org/bioclim

75.
ID: BIO5
Name: BIO5
Description: TX of Warmest Month
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TX of Warmest Month
Reference: http://www.worldclim.org/bioclim

76.
ID: BIO6
Name: BIO6
Description: TN of Coldest Month
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TN of Coldest Month
Reference: http://www.worldclim.org/bioclim

77.
ID: BIO7
Name: BIO7
Description: TX of Warmest Month minus TN of Coldest Month
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TX of Warmest Month - TN of Coldest Month
Reference: http://www.worldclim.org/bioclim

78.
ID: BIO8
Name: BIO8
Description: TG of Wettest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TG of Wettest Quarter
Reference: http://www.worldclim.org/bioclim

79.
ID: BIO9
Name: BIO9
Description: TG of Driest Quarter
Importance of the index: Important application in agriculture
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: TG of Driest Quarter
Reference: http://www.worldclim.org/bioclim

80.
ID: BIO20
Name: BIO20
Description: Mean radiation (W m-2) following https://www.edenextdata.com/?q=content/climond-bioclimatic-variables-2030
Importance of the index: Important application in agriculture
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Mean radiation (W m-2)
Reference: http://www.worldclim.org/bioclim

81.
ID: UTCI
Name: Universal Thermal Climate Index
Description: Considers dry temperature, relative humidity, solar radiation, and wind speed into account and is regarded as the reference environmental temperature causing strain.
Importance of the index: Important application in tourism, energy and health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: UTCI is a complex function of several meteorological parameters (T2m [C],v10m [m/s],RH [%], cloudiness [%], soil temperature[C]) and additional parameters (latitude, Julian day, local solar time); a comprehensive description may be found at https://goo.gl/by4hH9 ; the coefficients of the polynomial approximation are available at http://www.utci.org/utci_doku.php (UTCI_a002.f90 file) and more info on the calculation of other parameters (e.g. Tmrt) may be found in the help files of the BioKlima2.6 software (https://www.igipz.pan.pl/Bioklima-zgik.html)
Reference: Bröde P et al. 2012: Deriving the operational procedure for the Universal Thermal Climate Index (UTCI). International journal of biometeorology 56:3, 481-494.
K.Y. Blazejczyk, G. Epstein, G. Jendritzky, H. Staiger, B. Tinz, Int J Biometeorol., 56:3, 515-535, doi: 10.1007/s00484-011-0453-2.

82.
ID: MI
Name: Mould index
Description: Number of days with a relative humidity over 90% in combination with air temperatures above 10°C.
Importance of the index: Important application in tourism, energy and health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days RH> 90% & TG> 10°C.
Reference: http://www.tut.fi/en/research/research-fields/civil-engineering/structural-engineering/building-physics/finnish-mould-growth-model/index.htm.

83.
ID: HI
Name: Heat Index
Description: Combines air temperature and relative humidity to determine the human-perceived equivalent temperature
Importance of the index: Important application in tourism, energy and health
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: HI= -42,379+(2,04901523)*T)+(10,14333127*rh)-(0,22475541*T*rh)

$-(6,83783*10^{-3}*T^2)-(5,481717*10^{-2}*rh^2)+(1,22874*10^{-3}*T^2*rh)+(8,5282*10^{-4}*T*rh^2)$

$-(1{,}99*10^{-6}*T^2*rh^2)$. Where T is air temperature in ºF and rh is relative humidity in %

Reference: http://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml

84.
ID: WCI
Name: Wind Chill Index: air temperature + wind
Description: is the lowering of body temperature due to the passing-flow of lower-temperature air. It combines air temperature and wind speed.
Importance of the index: Important application in energy and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $WCI=13{,}12+0{,}6215T-11{,}37v^{0{,}16}+0{,}3965Tv^{0{,}16}$

Where T is air temperature in ºC and v is wind speed in Km/h
Reference: : *Osczevski, Randall; Bluestein, Maurice (2005). "The new wind chill equivalent temperature chart". Bulletin of the American Meteorological Society. 86 (10): 1453–1458*

85.
ID: AT
Name: Apparent temperature
Description: AT = Ta + 0.33e -0.70v -4.00; Ta = air temperature in °C ; v = wind speed in m/s; e= water vapor pressure in hPa
Importance of the index: Important application in agriculture
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula:

$$e = \frac{\mathrm{RH}}{100} \cdot 6.105 \cdot \exp\left(\frac{17.27 \cdot T_\mathrm{a}}{237.7 + T_\mathrm{a}}\right)$$

here:
AT = Ta + 0.33e -0.70v -4.00; Ta = air temperature in °C ; v = wind speed in m/s; e= water vapor pressure in hPa
Reference: Steadman, R.G., 1984: A Universal Scale of Apparent Temperature. J. Climate Appl. Meteor., 23, 1674–1687, https://doi.org/10.1175/1520-0450(1984)023<1674:AUSOAT>2.0.CO;2

3.4 Wind-based indices

86.
ID: GusTX
Name: Days wind gusts above 21 m/s
Description: number of days with wind gusts above 21 m/s
Importance of the index: Important application in energy and agriculture
Time scale applicable: monthly, seasonal, annual

Geographic limitation: valid for all Europe
Formula: No. days with wind gusts > 21 m/s
Reference: Azad, Kalam & Alam, Muhammad. (2010). Determination of Wind Gust Factor at Windy areas of Bangladesh. 10.13140/2.1.2090.6884.

87.
ID: FXx
Name: Maximum value of daily maximum wind gust (m/s)
Description: Maximum value of daily maximum wind gust (m/s); standard index computed by ECA&D

Importance of the index: Important application in energy, agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $\mathrm{FXx}j = \max(\mathrm{FXi}j)$ Let FX_{ij} be the daily maximum wind gust for day *i* of period *j*.)
Reference: ECA&D website: https://www.ecad.eu//indicesextremes/indicesdictionary.php

88.
ID: FG
Name: FG
Description: Mean of daily mean wind strength (m/s); standard index computed by ECA&D
Importance of the index: Important application in energy, agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $FGj = \frac{\sum_{i=1}^{I} FGij}{I}$ Let FG_{ij} be the daily mean wind strength for day *i* of period *j*
Reference: https://www.ecad.eu//indicesextremes/indicesdictionary.php

89.
ID: FGcalm
Name: Calm days
Description: Number of calm days (FG ≤2 m/s); standard index computed by ECA&D
Importance of the index: Important application in energy and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $\mathrm{FGi}j \leq 2\, m/s^{-1}$ Let FG_{ij} be the daily averaged wind strength for day *i* of period *j*. Count the number of days with.
Reference: ECA&D website: https://www.ecad.eu//indicesextremes/indicesdictionary.php

90.
ID: FG6Bft

Name: FG6Bft
Description: Number of days with daily averaged wind ≥6 Bft (10.8 m/s) (days); standard index computed by ECA&D
Importance of the index: Important application in energy, agriculture and tourism.
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $FGij \geq 10{,}8\, m/s^{-1}$ Let FG_{ij} be the daily averaged wind strength for day *i* of period *j*. Count the number of days with.
Reference: ECA&D website: https://www.ecad.eu//indicesextremes/indicesdictionary.php

3.5 Aridity/continentality indices

91.
ID: Eto
Name: Reference Evapotranspiration
Description: If data available using Fao-56 Penman-Monteith, if not using the Hargreaves & Samani method.
Importance of the index: Important application in agriculture
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Fao-56 Penman-Monteith or the Hargreaves & Samani method.
Reference: Chiew, F.H.S., Kamaladasa, N.N., Malano, H.M., McMahon, T.A., 1995. Penman–Monteith FAO-24 reference crop evapotranspiration and class-A pan data in Australia. Agric. Water Manage. 28, 9–21

92.
ID: UAI
Name: ƒUNEP Aridity Index
Description: P/Eto
Importance of the index: Important application in agriculture
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: P/Eto
Reference: Huiping Huang, Yuping Han, Mingming Cao, Jinxi Song, and Heng Xiao, "Spatial-Temporal Variation of Aridity Index of China during 1960–2013," Advances in Meteorology, vol. 2016, Article ID 1536135, 10 pages, 2016. https://doi.org/10.1155/2016/1536135

93.
ID: CMD
Name: Climatic Moisture Deficit
Description: ETo - Effective Precipitation

Importance of the index: Important application in agriculture
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: ETo - Effective Precipitation
Reference: Parks, S. A., Parisien, M. , Miller, C. , Holsinger, L. M. and Baggett, L. S. (2018), Fine-scale spatial climate variation and drought mediate the likelihood of reburning. Ecol Appl, 28: 573-586. doi:10.1002/eap.1671

94.
ID: MAI
Name: De Martonne Aridity Index ƒ
Description: Annual rainfall/(Annual TG+10)
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: Annual rainfall/(Annual TG+10)
Reference: Baltas E (2007) Spatial distribution of climatic indices in northern Greece. Meteorol Appl 14: 69—78

95.
ID: EAI
Name: Emberger Aridity Index
Description: (100*annual rainfall)/(TGhottest month2-TG coldest month2)
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: (100*annual rainfall)/(TGhottest month2-TG coldest month2)
Reference: Wallén, C. (1967). Aridity Definitions and Their Applicability. Geografiska Annaler. Series A, Physical Geography, 49(2/4), 367-384. doi:10.2307/520903

96.
ID: JCI
Name: Johansson Continentality Index
Description: (1.7E/sinf)-20.4 where E (in8C) is the annual range of mean monthly air temperatures and f is the
geographical latitude of the station
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: (1.7E/sinf)-20.4 where E (in8C) is the annual range of mean monthly air temperatures and f is the
geographical latitude of the station

Reference: Gavilán RG (2005) The use of climatic parameters and indices in vegetation distribution. A case study in the Spanish Sistema Central. Int J Biometeorol 50: 111—120

97.
ID: KOI
Name: Kerner Oceanity Index
Description: (100*(To-Ta))/E where To and Ta are the October and April mean values of TG respectively and E is the annual range of monthly mean air temperatures, in °C.
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: (100*(To-Ta))/E where To and Ta are the October and April mean values of TG respectively and E is the annual range of monthly mean air temperatures, in °C.
Reference: Andrade, C. and Corte-Real, J. (2017), Assessment of the spatial distribution of continental-oceanic climate indices in the Iberian Peninsula. Int. J. Climatol., 37: 36-45. doi:10.1002/joc.4685

98.
ID: PiCI
Name: Pinna Combinative index
Description: 1/2((P/(T+10))+(12Pd/(Td+10))) where P and T are the annual mean values of precipitation and air temperature and P'd, T'd are the mean values of precipitation and air temperature of the driest month
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: 1/2((P/(T+10))+(12Pd/(Td+10))) where P and T are the annual mean values of precipitation and air temperature and P'd, T'd are the mean values of precipitation and air temperature of the driest month
Reference: Baltas, E. (2007), Spatial distribution of climatic indices in northern Greece. Met. Apps, 14: 69-78. doi:10.1002/met.7

99.
ID: BI
Name: Budyko Index
Description: (Rn/L*P)*100, where Rn is the mean annual net radiation (also known as the net radiation balance), P is the mean annual precipitation, and L is the latent heat of vaporization for water
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: (Rn/L*P)*100, where Rn is the mean annual net radiation, P is the mean annual precipitation, and L is the latent heat of vaporization for water

Reference: Creed, I. F., Spargo, A. T., Jones, J. A., Buttle, J. M., Adams, M. B., Beall, F. D., Booth, E. G., Campbell, J. L., Clow, D. , Elder, K. , Green, M. B., Grimm, N. B., Miniat, C. , Ramlal, P. , Saha, A. , Sebestyen, S. , Spittlehouse, D. , Sterling, S. , Williams, M. W., Winkler, R. and Yao, H. (2014), Changing forest water yields in response to climate warming: results from long-term experimental watershed sites across North America. Glob Change Biol, 20: 3191-3208. doi:10.1111/gcb.12615

100.
ID: MOI
Name: Marsz Oceanity Index
Description: (0.731ϕ+1.767)/Tamp where Tamp is the annual range of the monthly mean air temperatures (∘C) and ϕ (hereafter, degrees) is the geographical latitude of the grid point
Importance of the index: Important application in agriculture
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: (0.731+1.767)/Tamp where Tamp is the annual range of the monthly mean air temperatures (∘C) and (hereafter, degrees) is the geographical latitude of the grid point
Reference: Gavilán RG (2005) The use of climatic parameters and

3.6 Snow-based indices

101.
ID: SS
Name: Snowfall sum
Description: Sum of snowfall
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Sum of snowfall
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

102.
ID: SD0_10
Name: Snow depth n0to10
Description: The number of days with snow depth in the range 1-10 cm
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days snow depth in the range 1-10 cm

Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

103.
ID: SD10_20
Name: Snow depth n10to20
Description: The number of days with snow depth of 10-20 cm
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days snow depth of 10-20 cm
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

104.
ID: SD
Name: snow depth
Description: mean of daily snow depth
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: mean of daily snow depth
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

105.
ID: FSD
Name: Freq. of snow days
Description: number of snow days
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. snow days
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

106.
ID: MSD
Name: mild snowy days
Description: number of days with snow depth more than 5 cm.
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days snow depth> 5 cm.
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

107.
ID: HSD
Name: heavy snowy days
Description: number of days with snow depth more than 50 cm.
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days snow depth> 50 cm.
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

108.
ID: FSC
Name: The arrival date of first snow cover
Description: first day when there is measurable snow cover
Importance of the index: Important application in water and tourism
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: first day with measurable snow cover
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

109.
ID: FPSC
Name: The arrival date of first permanent snow cover
Description: First day of the longest period with consecutive snow cover day
Importance of the index: Important application in water and tourism
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: First day of the longest period with consecutive snow cover day
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

110.
ID: LPSC
Name: The departure date of last permanent snow cover
Description: Last day of the longest period with consecutive snow cover day
Importance of the index: Important application in water and tourism
Time scale applicable: Annual
Geographic limitation: valid for all Europe
Formula: Last day of the longest period with consecutive snow cover day
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

111.
ID: ASD
Name: Average snow depth
Description: Average snow depth
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Average snow depth
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

112.
ID: SCD
Name: Amount of snow covered days
Description: Amount of snow covered days
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Amount of snow covered days
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

113.
ID: MS
Name: Maximum snow depth
Description: Maximum snow depth
Importance of the index: Important application in water and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Maximum snow depth
Reference: https://www.ecad.eu/download/millennium/millennium.php#snow

3.7 Cloud/radiation based indices

114.
ID: SSD
Name: sum of sunshine duration
Description: Sunshine duration (hours); standard index computed by ECA&D
Importance of the index: Important application in agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: sum of sunshine duration
Reference: https://www.ecad.eu//indicesextremes/indicesdictionary.php

115.
ID: SND
Name: sunny days
Description: days with mean cloud cover less than 10%.
Importance of the index: Important application in agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days CC< 10%.
Reference: Rastogi, B., A.P. Williams, D.T. Fischer, S.F. Iacobellis, K. McEachern, L. Carvalho, C. Jones, S.A. Baguskas, and C.J. Still, 2016: Spatial and Temporal Patterns of Cloud Cover and Fog Inundation in Coastal California: Ecological Implications. Earth Interact., 20, 1–19, https://doi.org/10.1175/EI-D-15-0033.1

116.
ID: ClD
Name: cloudy days
Description: Number of days with cloud base below 100 meter.
Importance of the index: Important application in agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: No. days cloud base <100 m.
Reference: Rastogi, B., A.P. Williams, D.T. Fischer, S.F. Iacobellis, K. McEachern, L. Carvalho, C. Jones, S.A. Baguskas, and C.J. Still, 2016: Spatial and Temporal Patterns of Cloud Cover and Fog Inundation in Coastal California: Ecological Implications. Earth Interact., 20, 1–19, https://doi.org/10.1175/EI-D-15-0033.1

117.
ID: CC
Name: mean cloud cover

Description: Mean daily cloud cover (oktas)
Importance of the index: Important application in agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $CCj = \sum_{i=1}^{I} CCij/I$ Let $CCij$ be the daily cloud cover for day i of period j.
Reference: Huschke, Ralph E. (1970) [1959]. "Cloud cover". Glossary of Meteorology (2nd ed.). Boston: American Meteorological Society. Retrieved 2013-08-24.

118.
ID: SSp
Name: Sunshine duration fraction with respect to day length (%)
Description: Sunshine duration fraction with respect to day length (%); standard index computed by ECA&D.
Importance of the index: Important application in agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $SSj = \sum_{i=1}^{I} SSij \text{ and } SSj^{max} = \sum_{i=1}^{I} SSij^{max}$. This index is then given by:
$SSpj = 100 * \frac{SSj}{SSj^{max}}$. Let $SSij$ be the daily sunshine duration for day i of period j and SSj^{max} the maximum daylight hours for day I of period j.
Reference: https://www.ecad.eu//indicesextremes/indicesdictionary.php

119.
ID: ACI
Name: Atmospheric Clarity Index
Description: Ratio between solar radiation at surface and solar radiation at TOA (empirically obtained, see https://goo.gl/Wzs1Zk)
Importance of the index: Important application in agriculture and tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: Ratio between solar radiation at surface and solar radiation at TOA
Reference: HONTORIA, L.; AGUILERA, J.; ZUFIRIA, P. Generation of hourly irradiation synthetic series using the neural network multilayer perceptron. Solar Energy, v. 72, n. 5, p. 441-446, 2002.

3.8 Drought indices

120.
ID: SPI 1
Name: SPI 1
Description: Standardized precipitation index calculated at 1-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe

Formula: Standardized precipitation index calculated at 1-month time scale
Reference: McKee, T. B., Doesken, N. J. and Kleist, J.: The relationship of drought frequency and duration to time scales, Eighth Conf. Appl. Climatol., 179–184, 1993.

121.
ID: SPI 3
Name: SPI 3
Description: Standardized precipitation index calculated at 3-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe
Formula: Standardized precipitation index calculated at 3-month time scale
Reference: McKee, T. B., Doesken, N. J. and Kleist, J.: The relationship of drought frequency and duration to time scales, Eighth Conf. Appl. Climatol., 179–184, 1993.

122.
ID: SPI 6
Name: SPI 6
Description: Standardized precipitation index calculated at 6-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe
Formula: Standardized precipitation index calculated at 6-month time scale
Reference: McKee, T. B., Doesken, N. J. and Kleist, J.: The relationship of drought frequency and duration to time scales, Eighth Conf. Appl. Climatol., 179–184, 1993.

123.
ID: SPI 12
Name: SPI 12
Description: Standardized precipitation index calculated at 12-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe
Formula: Standardized precipitation index calculated at 12-month time scale
Reference: McKee, T. B., Doesken, N. J. and Kleist, J.: The relationship of drought frequency and duration to time scales, Eighth Conf. Appl. Climatol., 179–184, 1993.

124.

ID: SPEI 1
Name: SPEI 1
Description: Standardized precipitation-evapotranspiration index calculated at 1-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe
Formula: Standardized precipitation-evapotranspiration index calculated at 1-month time scale
Reference: Vicente-Serrano, S. M., Beguería, S. and López-Moreno, J. I.: A multiscalar drought index sensitive to global warming: The standardized precipitation evapotranspiration index, J. Clim., 23(7), doi:10.1175/2009JCLI2909.1, 2010.

125.
ID: SPEI 3
Name: SPEI 3
Description: Standardized precipitation-evapotranspiration index calculated at 3-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe
Formula: Standardized precipitation-evapotranspiration index calculated at 3-month time scale
Reference: Vicente-Serrano, S. M., Beguería, S. and López-Moreno, J. I.: A multiscalar drought index sensitive to global warming: The standardized precipitation evapotranspiration index, J. Clim., 23(7), doi:10.1175/2009JCLI2909.1, 2010.

126.
ID: SPEI 6
Name: SPEI 6
Description: Standardized precipitation-evapotranspiration index calculated at 6-month time scale
Importance of the index: Important application in agriculture and water
Time scale applicable: monthly
Geographic limitation: valid for all Europe
Formula: Standardized precipitation-evapotranspiration index calculated at 6-month time scale
Reference: Vicente-Serrano, S. M., Beguería, S. and López-Moreno, J. I.: A multiscalar drought index sensitive to global warming: The standardized precipitation evapotranspiration index, J. Clim., 23(7), doi:10.1175/2009JCLI2909.1, 2010.

127.
ID: SPEI 12
Name: SPEI 12
Description: Standardized precipitation-evapotranspiration index calculated at 12-month time scale
Importance of the index: Important application in agriculture
Time scale applicable: monthly
Geographic limitation: valid for all Europe

Formula: Standardized precipitation-evapotranspiration index calculated at 12-month time scale
Reference: Vicente-Serrano, S. M., Beguería, S. and López-Moreno, J. I.: A multiscalar drought index sensitive to global warming: The standardized precipitation evapotranspiration index, J. Clim., 23(7), doi:10.1175/2009JCLI2909.1, 2010.

3.9 Fire indices

128.
ID: FWI
Name: Canadian Fire Weather Index (FWI)
Description: The Canadian Forest Fire Weather Index (FWI) is an indicator of fire weather intensity and is used to represent potential fire danger. It is computed from daily values of precipitation, temperature, near-surface wind and relative humidity
Importance of the index: Important application for fire prevention
Time scale applicable: monthly, seasonal and annual
Geographic limitation: valid for all Europe
Formula: dimensionless, see Van Wagner (1987) for formula.
Reference: Van Wagner CE. 1987. Development and structure of the Canadian forest fire weather index system. Technical Report 35, Canadian Forestry Service: Ottawa, Ontario.

129.
ID: KBDI
Name: Keetch-Byram Drought Index
Description: The Keetch-Byram Drought Index (KBDI) is an indicator of drought conditions and is used to predict wildfire severity. It estimates soil water deficit, or the amount of net rainfall (in inches or cm) that is required to reduce the index to zero.
Importance of the index: Important application for fire prevention
Time scale applicable: monthly, seasonal and annual
Geographic limitation: valid for all Europe
Formula: R package fireDanger
Reference: Keetch, J.J. and Byram, G.M. (1968). A drought index for forest fire control. Tech. Rep., USDA Forest Service Research Paper SE-38, North Carolina, USA.

130.
ID: FFDI
Name: McArthur Forest Fire Danger Index (FFDI)
Description: : The McArthur Forest Fire Danger Index (FFDI) has been used in Australia for several decades, generally providing a good indication of the difficulty of fire suppression over a wide range of conditions. It estimates the amount of precipitation needed to bring the soil back to saturation and is

computed from the Keetch-Byram Drought Index (KBDI) and Drought Factor (DF).
Time scale applicable: monthly, seasonal and annual
Geographic limitation: valid for all Europe
Formula: inches or cm of precipitation Dimensionless, see Keetch and Byram (1968) for formula.
Reference: McArthur, A. G. (1967). Fire behaviour in eucalypt forests. Forestry and Timber Bureau Leaflet 107, 36 pp.

131.
ID: MNI
Name: Modified Nesterov Index (MNI)
Description: The Modified Nesterov Index (MNI) is based on the Nesterov Index (NI), which was developed in former Soviet Union as an empirical function reflecting the relationship between observed weather conditions and fire occurrence.
Importance of the index: Important application in fire prevention
Time scale applicable: monthly, seasonal and annual
Geographic limitation: valid for all Europe
Formula: Dimensionless, it is a cumulative index computed from daily temperature and dewpoint temperature, which is reset when a certain precipitation value is reached. See Groisman, P.Y., et al. (2007) for formula.
Reference: Groisman, P.Y., et al., 2007. Global and Planetary Change 56, 371–386.

132.
ID: FFFI
Name: Finnish Forest Fire Index (FFFI)
Description: Combination of air temperature, relative humidity, wind speed, radiation and precipitation
Importance of the index: Important application in tourism
Time scale applicable: annual
Geographic limitation: valid for all Europe
Formula: R package fireDanger
Reference: Giannakopoulos C, LeSager P, Moriondo M, Bindi M, Karali A, Hatzaki M, and Kostopoulou E. 2012. Comparison of fire danger indices in the Mediterranean for present day conditions. iForest - Biogeosciences and Forestry 5(4):197-203.

3.10 Tourism indices

133.
ID: HCI:U
Name: HCI:Urban
Description: Holliday Climate Index for Urban destinations (Scott et all, 2016) (TX, wind, cloudiness, RH, precipitation) Scott, D., Rutty, M., Amelung, B. and Tang, M. (2016): An inter-comparison of the Holiday

Climate Index (HCI) and the Tourism Climate Index (TCI), Atmosphere, 7, 80, doi:10.3390/atmos7060080
Importance of the index: Important application in tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: HCI : Urban= 4*TC +2*A+(3*precipitation+wind)

where TC=thermal comfort (as a function of Tmax [C] and RH [%]), A (aesthetic facet)=cloudiness (%), precipitation [mm],wind speed (at 10m)[km/h]. HCI scores may be in the range 0 (potentially dangerous for tourists) to 100 (ideal for tourism).

Reference: Scott, D., Rutty, M., Amelung, B. and Tang, M. (2016): An inter-comparison of the Holiday Climate Index (HCI) and the Tourism Climate Index (TCI), Atmosphere, 7, 80, doi:10.3390/atmos7060080

134.
ID: TCI
Name: Tourism Climatic Index
Description: Represents a quantitative evaluation of world climate for the purposes of tourism and is a composite measure of the climatic well-being of tourists.
Importance of the index: Important application in tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: TCI = 4cid + cia + 2R + 2S + W, where CId is a daytime comfort index, CIa a daily comfort index, R is cumulated rainfall, S the daily sunshine hours and W wind speed
Reference: Mieczkowski, Z. (1985). The tourism climatic index: a method of evaluating world climates for tourism. The Canadian Geographer/Le Géographe canadien, 29(3), 220-233.

135.
ID: TCI60
Name: Number of days TCI>60
Description: Number of days TCI>60 (see TCI)
Importance of the index: Important application in tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: TCI = 8·Cld + 2·Cla + 4·R + 4·S + 2·W. Let TCIij be the daily value of the Tourism Climatic Index at day i of period j. Then counted is the number of days where: TCIij≥60. Where C ld is a daytime comfort index, consisting of the mean maximum air temperature Ta, max (°C) and the mean minimum relative humidity RH (%), Cla is the daily comfort index, consisting of the mean air temperature (°C) and the mean relative humidity (%), R is the precipitation (mm), S is the daily sunshine duration (h), and W is the mean wind speed (m/s).
Reference: Mieczkowski, Z. (1985). The tourism climatic index: a method of evaluating world climates for tourism. The Canadian Geographer/Le Géographe canadien, 29(3), 220-233.

136.

ID: TCI80
Name: Excellent tourism days
Description: Number of days TCI>80 (see TCI)
Importance of the index: Important application in tourism
Time scale applicable: monthly, seasonal, annual
Geographic limitation: valid for all Europe
Formula: $TCI = 8 \cdot Cld + 2 \cdot Cla + 4 \cdot R + 4 \cdot S + 2 \cdot W$. Let TCI_{ij} be the daily value of the Tourism Climatic Index at day i of period j. Then counted is the number of days where: $TCI_{ij} \geq 80$. Where C ld is a daytime comfort index, consisting of the mean maximum air temperature Ta, max (°C) and the mean minimum relative humidity RH (%), Cla is the daily comfort index, consisting of the mean air temperature (°C) and the mean relative humidity (%), R is the precipitation (mm), S is the daily sunshine duration (h), and W is the mean wind speed (m/s).
Reference: Mieczkowski, Z. (1985). The tourism climatic index: a method of evaluating world climates for tourism. The Canadian Geographer/Le Géographe canadien, 29(3), 220-233.