STATISTICAL ANALYSIS OF COLLECTED INFORMATION

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

DELIVERABLE INFORMATION	
WP:	WP3 Mapping and Harmonising Data & Downscaling
Activity:	3.2 Proposal for the cross-harmonized set of indicators and guidance documents for their calculation and potential use
WP Leader:	RHMSS
Activity leader:	RHMSS
Participating partners:	RHMSS, NIMH, OMSZ, NMA, DHMZ, RHMZ RS, HMSM, OSENU, BMLFUW, CMCC, PAT, Attica Region
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CONTENT

I Introduction

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

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

This document represents The Statistical Analysis of the relevant meteorological data collected from 12 WP3 and Pilot area partners. The information was collected by RHMSS through another document - *ORIENGATE questionnaire – Review of the currently used indicators of climate risks.* Hence, there is a correlation between different sections of The Statistical Analysis and the ORIENTGATE questionnaire. The Statistical Analysis maps different types of meteorological and hydrological stations, presents the current situation with regards to data quality control and the interpolation of data (*section II*), gives an overview of the currently used climate indices (*section III*), as well as the climate change modeling in the region (*section IV*).

Contributing partners:*WP3 partners* - Bulgaria, Croatia, Hungary, fYR of Macedonia, Republic of Srpska, Romania, Serbia, Ukraine and *pilot area partners* - Austria, Greece, Italy-CMCC and Italy-Trento. Pilot areas in Hungary and Romania are represented through their national meteorological services which are at the same time the WP3 partners.

II Information about stations and data

1. Basic information

Table 1 depicts both the institutions in charge of hydrometeorological stations network and the stations density on the basis of the information gathered by hydrometeorological services and pilot areas. Precipitation stations have the highest density. Croatia, fYR of Macedonia and Serbia possess the information on hydrological stations.

Pilot areas have network of meteorological stations corresponding to their needs and are under the jurisdiction of the national services as well as different institutions outside of it. The only exceptions to this are Hungary and Romania where meteorological services are included within the pilot areas.

2. Total number of stations

Information on the total number of the stations is based on the differently defined measurement programs at meteorological stations within national meteorological services.

The principle types of meteorological stations according to the measurement programs and locations are the following:
- Main meteorological stations refer to stations with hourly measurements and observations, measurements of minimum and maximum temperature as well as precipitation.
- Climatological stations are stations with climatological measurements at 7, 14 and 21h local time (e.g. extreme temperature and precipitation).
- Precipitation stations are the one with precipitation measurements including snow cover.
- Mountain station can be any type of previously defined stations, provided it is above 1000 m altitude (it is possible for station to be categorized at the same time as mountain station and some other type of station).

In addition to the information on meteorological stations network, information on the hydrological stations network from the national meteorological services with a hydrology within its structure are also gathered.

The following chapters present the number of stations according to the work duration. Additionally, it is given a number of stations in the 1971-2000 period which could be used for the verification of the numerical models.

Table 1 Basic information

	Country	**Operator of the network**	**Network density (n^o/10 000 km^2)**	
			Met.	**Hydro.**
1.	Austria	- Environment Agency Austria - Central Institute for Meteorology and Geodynamics Austria - Hydrographic Service - Kalkalpen National Park	12 / 625 km^2	-
2.	Bulgaria	National Institute of Meteorology and Hydrology	33 only conventional synoptic, climatological and precipitation stations	-
3.	Croatia	DHMZ	7 – main 21 – climatological 60 – precipitation 6 – automated	56 – hydrological recording stations 37 – hydrological non-recording stations 18 – automated hydrological stations
4.	Greece	- Hellenic National Meteorological Service - Ministry of Rural Development & Food - Ministry of Environment Energy & Climate Change	-	-
5.	Hungary	OMSZ	59 – precipitation 13 – automatic weather station with or without observer and climatological stations	-
6.	Italy – CMCC	- ARPA PUGLIA (*AP*) - UCEA-CRA (*UC*) - Areonautica Militare (*AM*) - Servizio Protezione Civile Ex-SIMN (*SPC*) - Rete Agrometeorologica Regionale (*RAR*)	- AP: 2.58 - UC: 1.55 - AM: 7.23 - RAR: 49.58	-
			SPC Ex-SIMN: 85.21	
7.	Italy – Trento	Autonomous Province of Trento Civil Protection Department	330	-
8.	fYR of Macedonia	HMS of Macedonia	8 - main 6 - climatological 46 - precipitation 4 – automated weather stations	44 hydrological 7 automated hydrological stations
9.	Republic of Srpska	National Hydrometeorological Service	10	-
10.	Romania	- Romanian National Meteorological Administration - National Company Romanian Waters	6,7	-
11.	Serbia	Republic Hydrometeorological Service of Serbia	3.5 - main 6.8 - climatological 54 - precipitation 3.4 - automated	21.5
12.	Ukraine	Hydrometeorological center Black and Azov sees	3	-

2.1 Total number of stations per partner

Figure 1 shows the number of meteorological and hydrological stations according to the station type and the project partner's areas.

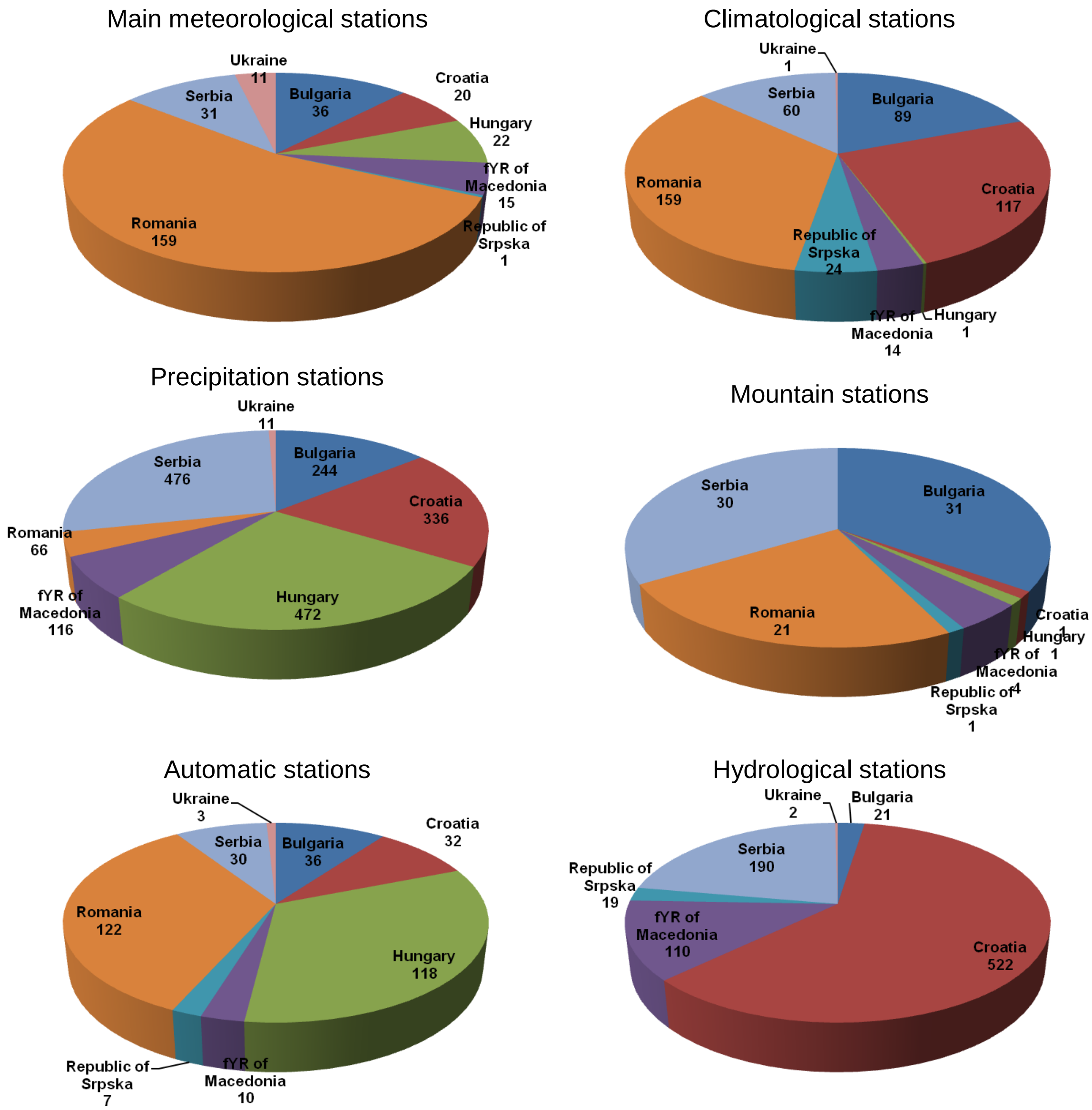


Figure 1. Total number of stations per project partner (excluding pilot areas)

In order to ensure easier overview of density of the meteorological and hydrological stations network, Figure 2 shows the number of stations per 10000km^2.

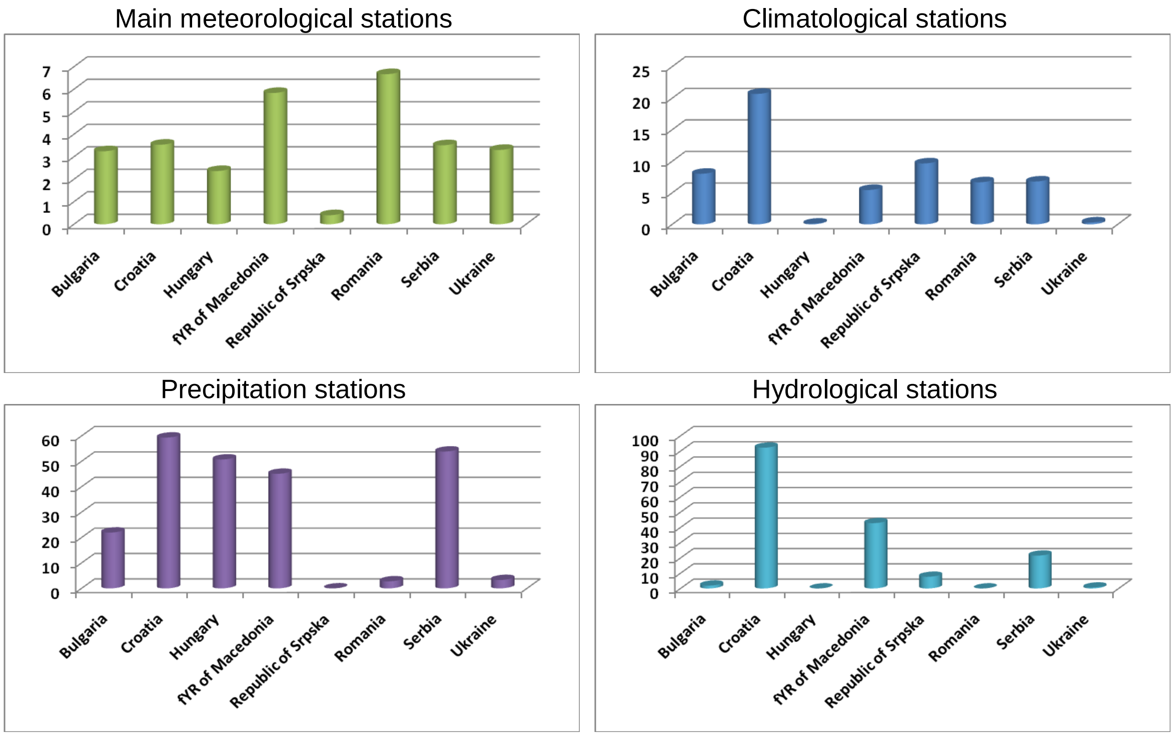


Figure 2. Density of the meteorological and hydrological stations network

In addition to above mentioned meteorological and hydrological stations, there are also stations characterized by specific measurements such as phenological, aerological, atmospheric background stations, wind stations, rime. Measurements at these stations can be also used for studying the climate indicators.

It is notable that meteorological services are shifting to automation.

2.2 Total number of stations per pilot area

Questionnaire is sent to the partners from the pilot area as well. The structure of their meteorological and hydrological stations is in accordance with their needs.

Table 2. Total number of stations per project partner (pilot area)

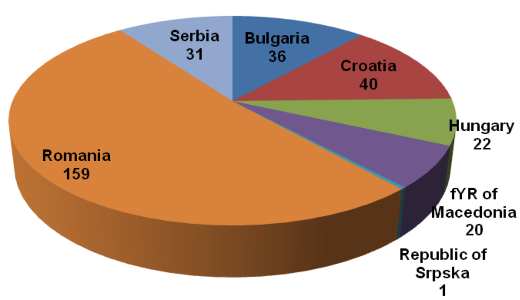
	Country		Main met. stations	Climatological stations	Precipitation stations	Mountain stations	Automatic met. stations	Hydrological stations
1.	Austria		7	2	5	6	9	7
2.	Greece		-	-	-	-	-	-
3.	Italy – CMCC	APUC AM SPC RAR	5 3 9+5 145 96	-	5 3 9+5 145 96	none none none 1 none	5 3 9+5 85 96	SPC - 22
4.	Italy - Trento		208	-	208	109	208	-

The network in Italy-Trento is automatized, and the measurements are taken according to the program of the main and the precipitation stations. For Italy-CMCC is given a number of the stations according to the institutions in charge of the network.

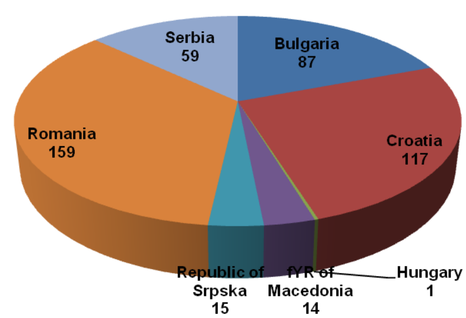
3. Number of stations for different time periods

Due to the user interest, there is a need for the current climate data, however because of the more detailed climatological analysis, longer time periods of meteorological data are necessary. The consequently conducted analysis of the data availability for the last 10, 20, 30, >30 years is shown on the following (Figures 3-6 and Tables 3-6).

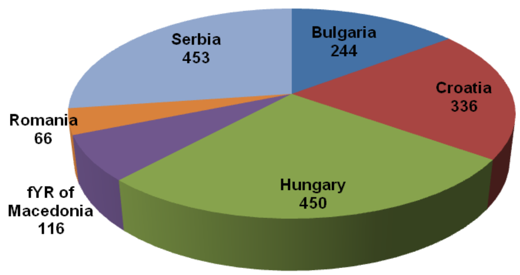
Main meteorological stations



Climatological stations



Precipitation stations



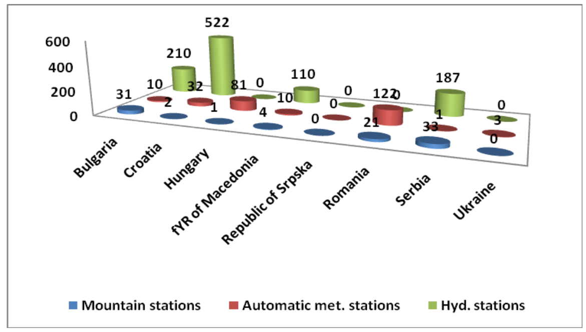
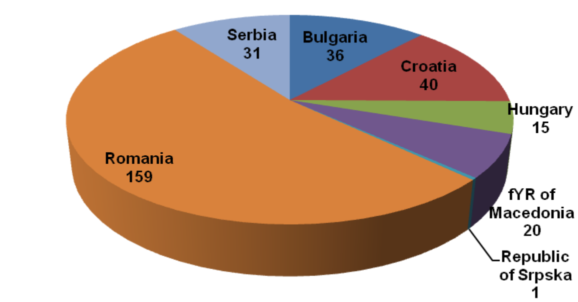


Figure 3. Number of stations with measurements in the last 10 years per project partner (excluding pilot areas)

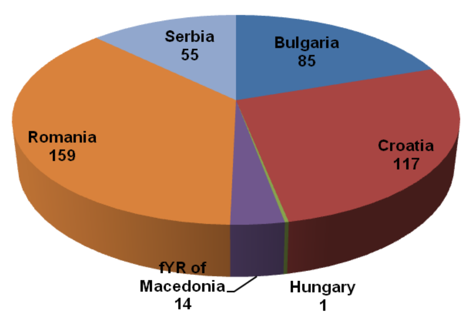
Table 3. Number of stations with measurements in the last 10 years per pilot area

	Country		Main met. stations	Climatological stations	Precipitation stations	Mountain stations	Automatic met. stations
1.	Austria		-	-	-	-	-
2.	Greece		-	-	-	-	-
3.	Italy – CMCC	AP UC RAR	5 1 70	-	5 1 70	none	5 1 70
4.	Italy - Trento		52	-	52	32	52

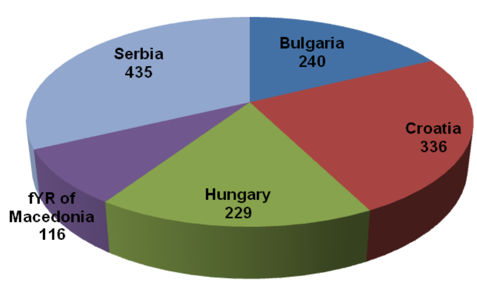
Main meteorological stations



Climatological stations



Precipitation stations



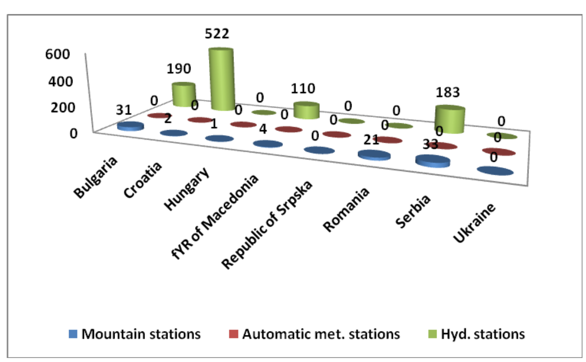


Figure 4. Number of stations with measurements in the last 20 years per project partner (excluding pilot areas)

Table 4. Number of stations with measurements in the last 20 years per pilot area

	Country		Main met. stations	Climatological stations	Precipitation stations	Mountain stations	Automatic met. stations	Hydrological stations
	Austria		6	-	2	6	6	1
	Greece		-	-	-	-	-	-
	Italy – CMCC	UCRAR	2 26	-	2 26	none	2 26	-
	Italy - Trento		16	-	16	12	16	-

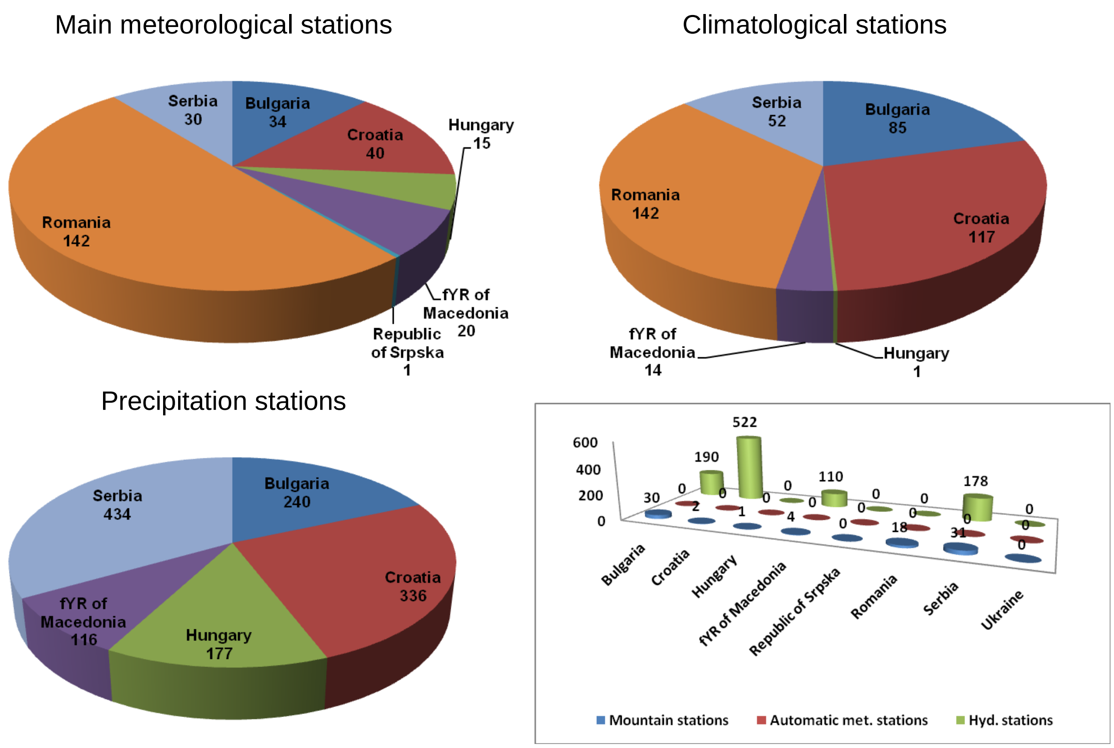


Figure 5. Number of stations with measurements in the last 30 years per project partner (excluding pilot areas)

Table 5. Number of stations with measurements in the last 30 years per pilot area

	Country	**Main met. stations**	**Climatological stations**	**Precipitation stations**	**Mountain stations**	**Automatic met. stations**
1.	Austria	-	-	-	-	-
2.	Greece	-	-	-	-	-
3.	Italy – CMCC	-	-	-	-	-
4.	Italy - Trento	7	-	7	6	7

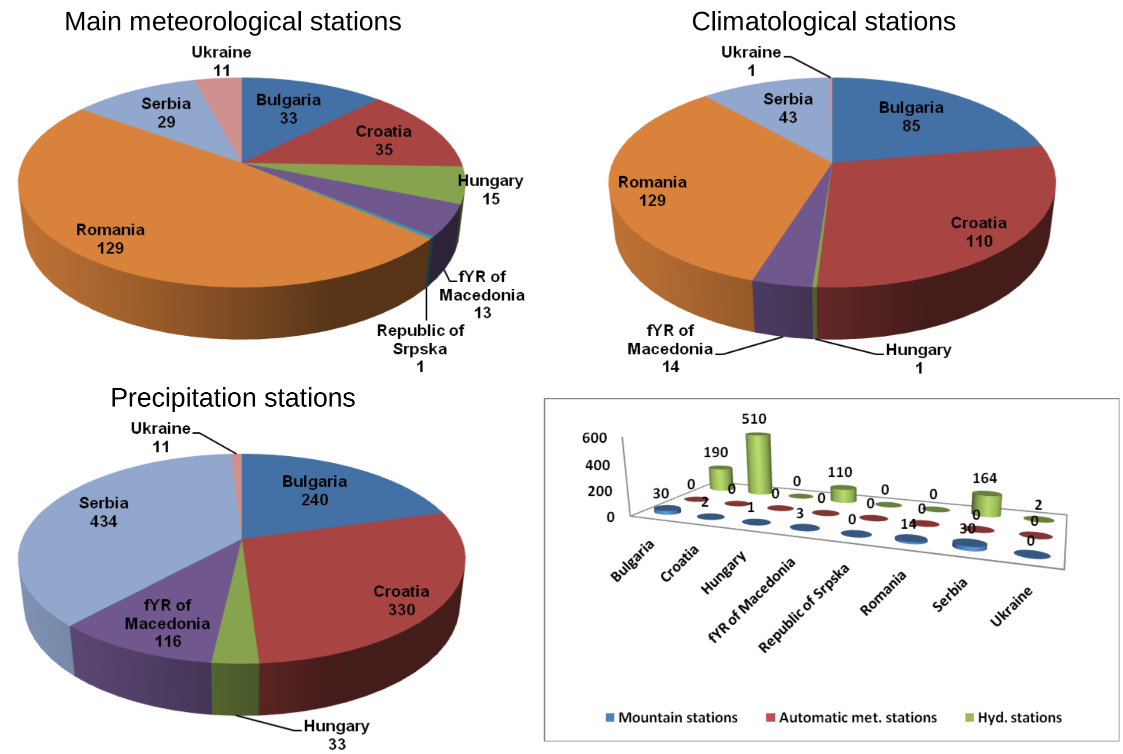


Figure 6. Number of stations with measurements in the last > 30 years per project partner (excluding pilot areas)

Table 6. Number of stations with measurements in the last > 30 years per pilot area

	Country	Main met. stations	Climatological stations	Precipitation stations	Mountain stations	Automatic met. stations	Hydrological stations
1.	Austria	1	2	3	-	3	2
2.	Greece	-	-	-	-	-	-
3.	Italy – CMCC AM	9+5	-	9+5	none	9+5	SPC – 22
4.	Italy - Trento	54	-	54	18	54	-

Specifically for the purpose of this project as well as for the verification of the climate models, the analysis of the data availability for the 1971-2000 period is done (Figure 7 and Table 7).

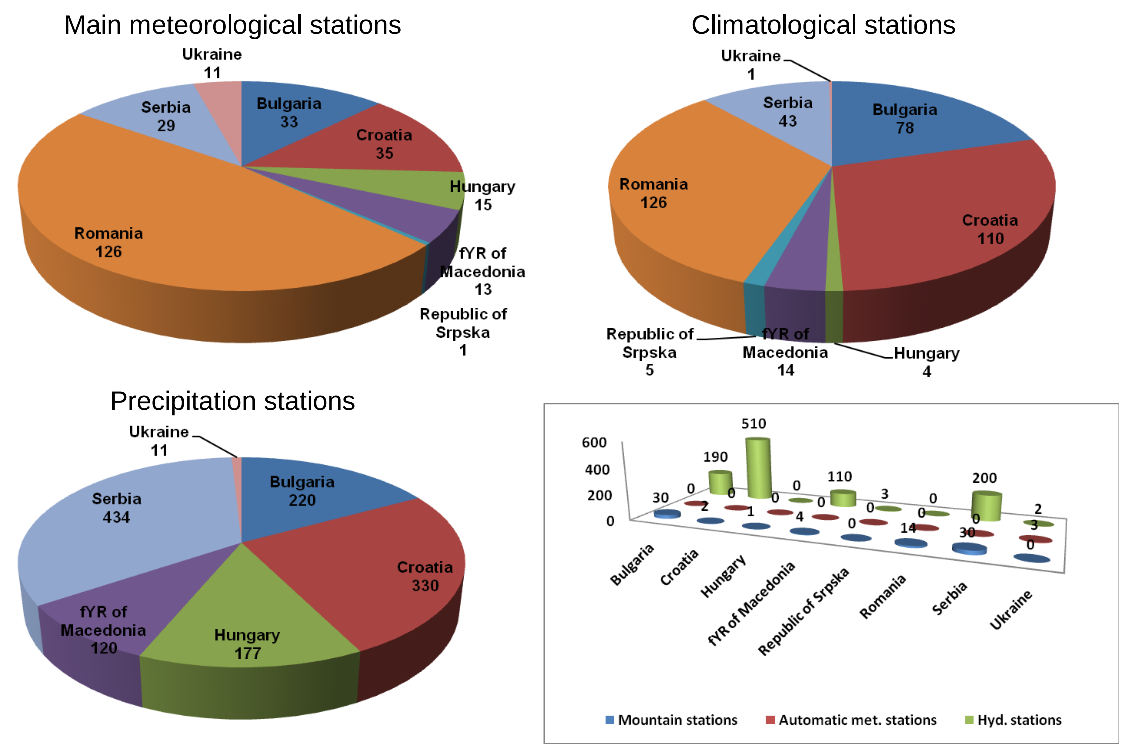


Figure 7. Number of stations with measurements since 1971 till 2000 with less then 10% of missing data per project partner (excluding pilot areas)

Table 7. Number of stations with measurements since 1971 till 2000 with less then 10% of missing data per pilot area

	Country	Main met. stations	Climato-logical stations	Precipita-tion stations	Mountain stations	Automatic met. stations	Hydrological stations
1.	Austria	1	2	3	-	3	2
2.	Greece	-	-	-	-	-	-
3.	Italy – CMCC	-	-	-	-	-	SPC – 22
4.	Italy - Trento	45/62 (now operating /active in 1971-2000)	-	45/62 (now operating/ active in 1971-2000)	14/22 (now operating/active in 1971-2000)	45/62 (now operating/active in 1971-2000)	-

4. Data measurements

4.1 Measurements of temperature and precipitation

Statistical analysis for the area defined by the project was performed based on the data availability of the temperature and precipitation.

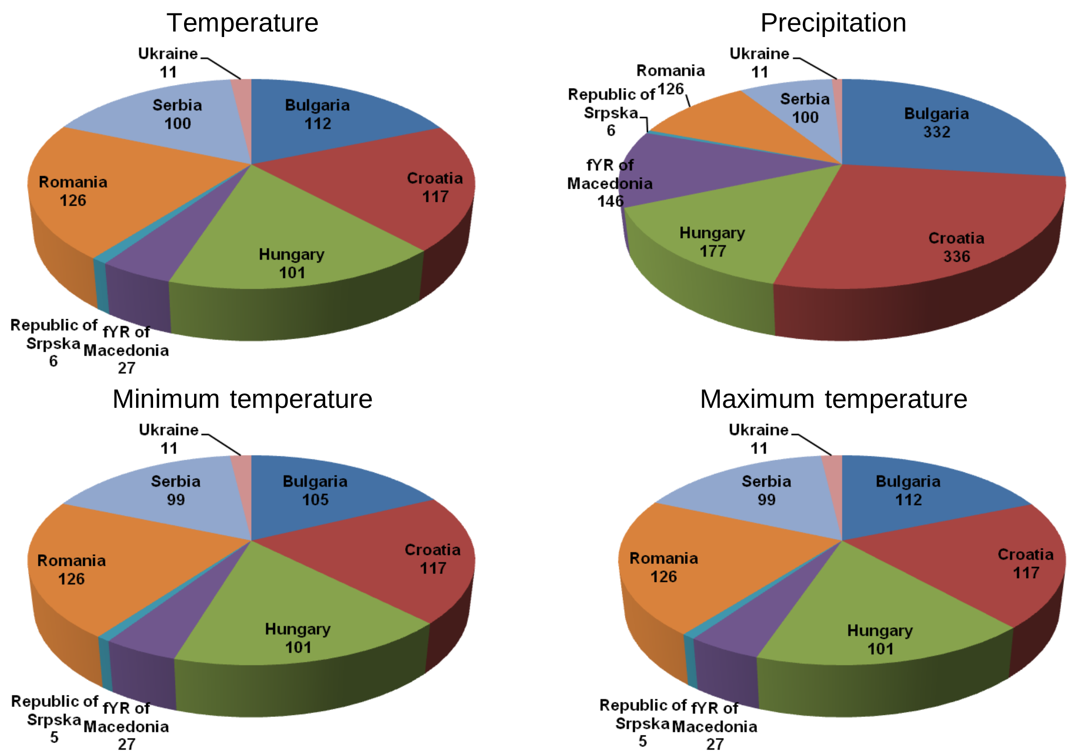


Figure 8. Total number of stations for temperature and precipitation per project partner (excluding pilot areas)

Table 8. Total number of stations for temperature and precipitation per pilot area

	Country		**Temperature**		**Precipitation**	
			n° of stations	**Beg.**	**n° of stations**	**Beg.**
1.	Austria		9	1900/ 1990	9	1900/ 1990
2.	Greece		-	-	-	-
3.	Italy – CMCC	AP	5	2010	5	2010
		UC	3	1991/ 2011	3	1991/ 2011
		AM	9+5	1950(1858)	9+5	1950(1858)
		SPC	85	???	99	???
		RAR	99	1994/2007	96	1994/2007
4.	Italy - Trento		87	1985	82	1921

Table 9. Total number of stations for minimum and maximum temperature per pilot area

	Country		Minimum temperature		Maximum temperature	
			n° of stations	Beg.	n° of stations	Beg.
1.	Austria		9	1900/ 1990	9	1900/ 1990
2.	Greece		-	-	-	-
3.	Italy – CMCC	UC AM SPC RAR	3 9+5 85 99	1991/ 2011 1950(1858) ??? 1994/2007	3 9+5 85 96	1991/ 2011 1950(1858) ??? 1994/2007
4.	Italy - Trento		71	1925	71	1925

For the pilot area Italy-Trento, the temperature data are available from 1991, whereas for the precipitation, minimum and maximum temperature mainly from 1975 or 1991.

4.2 Other measurements and observations

Besides the main meteorological elements for the calculation of certain climate indices, other meteorological parameters are also in use. Availability of those parameters is shown on the Figure 9 and Tables 10-13.

Additional data in pilot areas are in accordance with their work competence.

Table 10. Total number of stations for wind direction and speed and relative humidity per pilot area

	Country		Wind direction and speed		Relative humidity	
			n° of stations	Beg.	n° of stations	Beg.
1.	Austria		9	1900/ 1990	9	1960/ 1990
2.	Greece		-	-	-	-
3.	Italy – CMCC	AP UC AM SPC RAR	5 3 9+5 10 96	2010 1991/ 2011 1950(1858) ??? 1994/2007	5 3 9+5 13 96	2010 1991/ 2011 1950(1858) ??? 1994/2007
4.	Italy - Trento		25	2004	36	2004

Table 11. Total number of stations per pilot area for duration of sunshine and cloud cover

	Country	Duration of sunshine		Cloud cover	
		n° of stations	Beg.	n° of stations	Beg.
1.	Austria	1	1960	1	1960
2.	Greece	-	-	-	-
3.	Italy – CMCC	-	-	-	-
4.	Italy - Trento	-	-	-	-

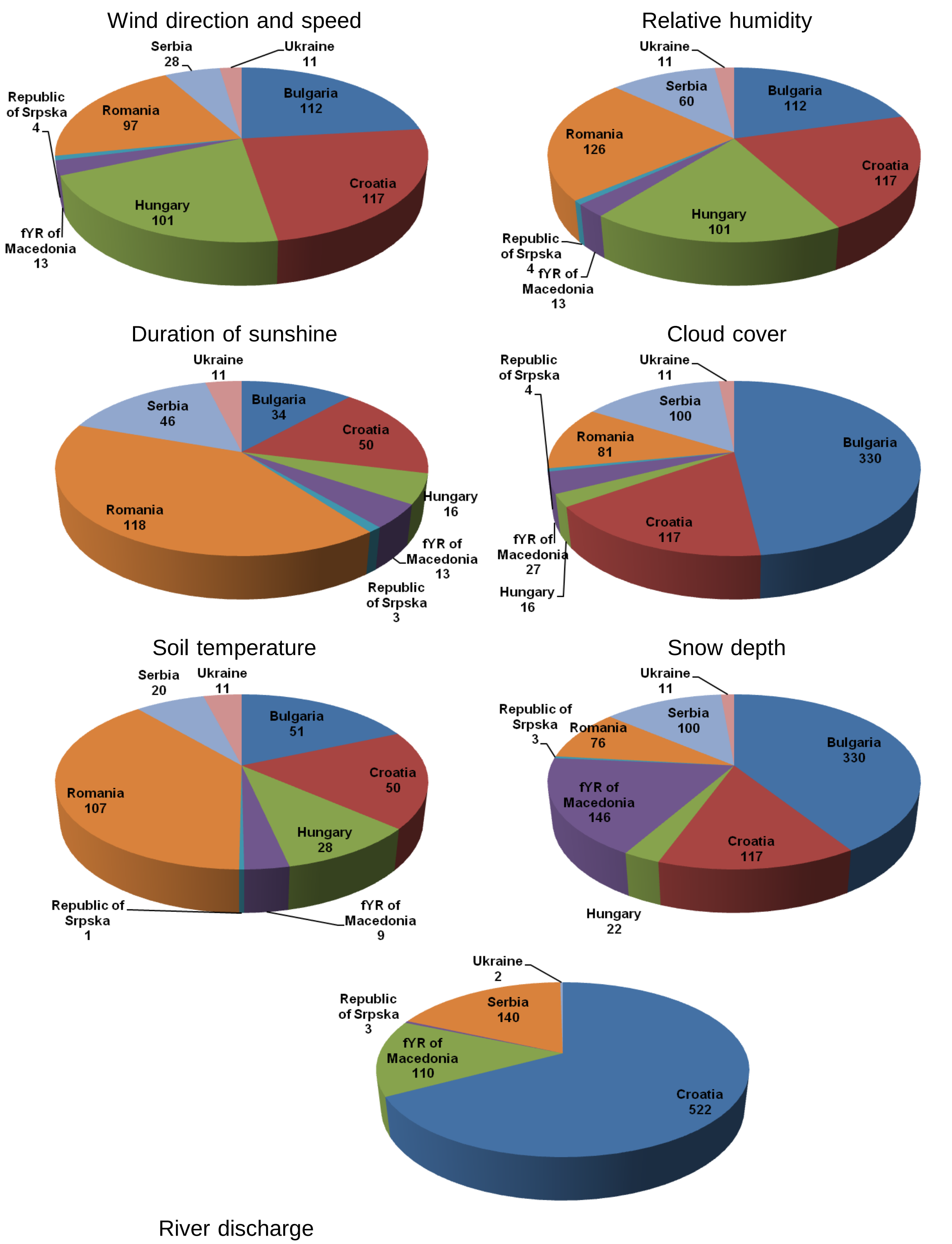


Figure 9. Total number of stations for other parameters per project partner (excluding pilot areas)

Table 12. Total number of stations for soil temperature and snow depth per pilot area

	Country	Soil temperature		Snow depth	
		n° of stations	Beg.	n° of stations	Beg.
1.	Austria	1	1993	7	1980/ 1990
2.	Greece	-	-	-	-
3.	Italy – CMCC	UC – 3 RAR - 61	UC - 2 from 1991, one from 2011 RAR - 1994	-	-
4.	Italy - Trento	-	-	-	-

Table 13. Total number of stations for river discharge and phenology per pilot area

	Country	River discharge		Phenology	
		n° of stations	Beg.	n° of stations	Beg.
1.	Austria	3	1957/ 1990	-	-
2.	Greece	-	-	-	-
3.	Italy – CMCC	-	-	-	-
4.	Italy - Trento	-	-	-	-

4.3 Data accessibility

All meteorological and hydrological data from the partners participating in WP3 are available. Some of them are published on the web pages, others are open for public, but they are mostly either accessible internally or possible to buy.

Table 14. Data accessibility

	Country	Online availability	Publicly available	Internally available	Restricted access	Available to buy	Not available
1.	Austria		x			x	
2.	Bulgaria				x	x	
3.	Croatia			x		x	
4.	Greece	-	-	-	-	-	-
5.	Hungary			x		x	
6.	Italy – CMCC	x	x			x	
7.	Italy - Trento	x					
8.	fYR of Macedonia			x		x	
9.	Republic of Srpska	x		x			
10.	Romania			x	x	x	
11.	Serbia		x	x			
12.	Ukraine		x	x			

5. Daily data

Following is the statistical analysis of the observation periods as well as calculation of the daily mean values of meteorological parameters.

5.1 Temperature

Temperature is measured both at main and climatological stations. Since the measurement times and programs vary, the calculation of the daily mean values is thus also different.

The following tables show measurement times and the methods of daily mean temperature calculations. Meteorological services and station networks in pilot areas were observed separately.

Table 15. Measurement times per project partner (excluding pilot areas)

	Country	7,14,21h local time	every 3 hours	Hourly	other
1.	Bulgaria	*	*		
2.	Croatia	*			*
3.	Hungary				*
4.	fYR of Macedonia	*		*	
5.	Republic of Srpska	*		*	
6.	Romania			*	*
7.	Serbia	*		*	
8.	Ukraine		*		

Croatia and Hungary take measurements every 10 minutes given the fact they have automatic stations. In addition to the above mentioned times (Table 15) Romania has stations, that take measurements more than 10 times per day according to the following schedule: 05 - 09, 11, 12, 17-19UTC.

Table 16. Measurement times per pilot area

	Country	7,14,21h local time	every 3 hours	Hourly	other
1.	Austria	*			
2.	Greece	-	-	-	-
3.	Italy – CMCC				*
4.	Italy - Trento				*

Italy-CMCC has different measurement times: every 10 minutes, every half an hour or daily depending on the network operator. Italy-Trento has automatized station network and therefore takes measurements every 15 minutes.

At climatological stations, measurements are usually taken three times a day at 7, 14, 21h local time. Daily mean temperature is calculated by using the following formula:

$$(T_{07}+T_{14}+2*T_{21})/4$$

This formula is advised by WMO in order to enable the comparison of the calculated daily mean temperatures.
In Hungary and Romania, the daily mean temperatures are calculated on the basis of four terms by using the formula:

$$(t_{00UTC}+t_{06UTC}+t_{12UTC}+t_{18UTC})/4 \quad (1)$$

Table 17. Daily average calculation per project partner (excluding pilot areas)

	Country	$(T_{07}+T_{14}+2*T_{21})/4$	$(t_{00UTC}+t_{06UTC}+t_{12UTC}+t_{18UTC})/4$	arithmetic mean
1.	Bulgaria	*		*
2.	Croatia	*		
3.	Hungary		*	
4.	fYR of Macedonia	*		
5.	Republic of Srpska	*		*
6.	Romania		*	
7.	Serbia	*		*
8.	Ukraine			*

Daily mean temperatures are not calculated in the pilot areas. The exception to this is Italy-Trento which uses automatic stations for temperature measurements and the daily mean temperature is calculated by using trapezoidal scheme:

$$\sum(i=1..n-1)\ 0.5*(D_{i+1}+D_i)*(T_{i+1}-T_i))\ /\ (T_n-T_1) \quad (2)$$

as well as Austria where calculation of the daily mean temperature is depending on the institution in charge of the meteorological station.

5.2 Precipitation

Table 18. Number of daily precipitation measurements per project partner (excluding pilot areas)

	Country	once per day	twice per day	four times per day	other
1.	Bulgaria	*		*	
2.	Croatia	*			*
3.	Hungary	*			*
4.	fYR of Macedonia	*			
5.	Republic of Srpska	*		*	
6.	Romania			*	
7.	Serbia	*			
8.	Ukraine		*		

Croatia and Hungary take measurements of the precipitation amount every 10 minutes because they use measurements from the automatic stations.

Table 19. Number of daily precipitation measurements per pilot area

	Country	once per day	twice per day	four times per day	other
1.	Austria				*
2.	Greece	-	-	-	-
3.	Italy – CMCC				*
4.	Italy - Trento				*

Italy-Trento take measurements every 5 minutes whereas Italy-CMCC have different times of measurement: every half an hour or hour depending on the network operator. Austria take hourly measurements.

Most of the countries take precipitation measurements for the period from 06 do 06 UTC reporting at the end date of the measurement. The only exceptions are Bulgaria and Romania. In Bulgaria the measurements are taken at 00, 06, 12, 18 UTC, whereas in Romania the precipitation amount is measured for the period from 18 do 18 UTC. Pilot area Italy-Trento calculates daily precipitation amounts by summing all 5-minute measurements in the period from 08 do 08 UTC.

5.3 Minimum temperature

Table 20. Measurement time of minimum temperature per project partner (excluding pilot areas)

	Country	6 UTC	20 UTC	18 UTC	other
1.	Bulgaria	*	*		
2.	Croatia		*		
3.	Hungary	*		*	
4.	fYR of Macedonia	*	*		
5.	Republic of Srpska	*	*		
6.	Romania			*	
7.	Serbia	*	*		
8.	Ukraine				*

Ukraine takes measurements of the minimum temperature every 3 hours. The validity period for minimum temperature is 24 hours in all countries.

However, there are certain minimum temperature measurements with the 12 hour validity period in Bulgaria, fYR of Macedonia and Serbia.

According to the provided data, among pilot areas only Italy-Trento measures minimum temperature at 08 UTC with the 24 hour validity. The measurements in Austria depend on the application.

5.4 Maximum temperature

Table 21. Measurement times of maximum temperature per project partner (excluding pilot areas)

	Country	6 UTC	20 UTC	18 UTC	other
1.	Bulgaria	*	*		
2.	Croatia		*		
3.	Hungary			*	
4.	fYR of Macedonia		*		
5.	Republic of Srpska		*		
6.	Romania			*	
7.	Serbia		*	*	
8.	Ukraine				*

Ukraine takes measurements of maximum temperature every 3 hours.

The validity period for the maximum temperature is 24 hours in all countries. However, there are maximum temperatures measurements with 12 hour validity period in Bulgaria and Serbia.

According to the provided data, among the pilot areas only Italy-Trento measures maximum temperature at 08 UTC with 24 hour validity. Measurements in Austria depend on the application.

5.5 Wind direction and speed

In most cases daily mean wind values are calculated as the arithmetic mean of all available data. Croatia and Hungary take measurements every 10 minutes and calculate mean values as the arithmetic mean of all measurements. In Romania, at certain number of stations measurements are taken 10 times a day (05-09, 11, 12, 17-19UTC), and daily mean value is calculated by using formula 1. In Romania, on the basis of this formula daily mean values are calculated at the stations with hourly measurements.

In Serbia, at the stations with 3 daily measurements, daily mean value is calculated using formula:

$$(X7+X14+X21)/3,$$

where measurement times are given according to the local time.

Table 22. Number of daily wind direction and speed measurements per project partner (excluding pilot areas)

	Country	3 times per day	8 times per day	24 times per day	other
1.	Bulgaria	*	*		
2.	Croatia				*
3.	Hungary				*
4.	fYR of Macedonia	*		*	
5.	Republic of Srpska	*		*	
6.	Romania			*	*
7.	Serbia	*		*	
8.	Ukraine		*		

Austria takes measurements on hourly basis, but calculation of the daily mean value depends on the purpose. Measurements of the wind direction and speed are taken every 10 minutes or half an hour in Italy-CMCC though without calculations of daily mean values. In Italy-Trento measurements are taken every 15 minutes. Daily mean value of the wind speed is calculated by using trapezoid scheme (formula 2), while for wind direction vector averaging is in use.

Table 23. Number of daily wind direction and speed measurements per pilot area

	Country	3 times per day	8 times per day	24 times per day	other
1.	Austria			*	*
2.	Greece	-	-	-	-
3.	Italy – CMCC				*
4.	Italy - Trento				*

5.6 Relative humidity

The number of relative humidity measurements per day is shown in the Table 24 for meteorological services and Table 25 for pilot areas. At the automatic stations in Hungary and Croatia, measurements are taken every 10 minutes, whereas in Romania that number goes up to 10 times per day at certain stations. Daily mean values are calculated as mean values of all available data. In Romania, regardless of the number of measurements per day, daily mean relative humidity is calculated by using the formula 1.

Table 24. Number of daily relative humidity measurements per project partner (excluding pilot areas)

	Country	3 times per day	8 times per day	24 times per day	other
1.	Bulgaria	*	*		
2.	Croatia	*			*
3.	Hungary	*		*	*
4.	fYR of Macedonia	*		*	
5.	Republic of Srpska	*		*	
6.	Romania			*	*
7.	Serbia	*		*	
8.	Ukraine		*		

Italy-Trento takes measurements every 15 minutes and for the calculation of the daily mean value use trapezoid scheme (formula 2). In the area of Italy-CMCC, depending on the operator, measurements are taken every 10 minutes, half an hour or hour, though daily mean values of relative humidity are not calculated. Three measurements during the day at 07, 14, 21UTC has Austria, while calculation of the daily mean value depends on the operator.

Table 25. Number of daily relative humidity measurements per pilot area

	Country	3 times per day	8 times per day	24 times per day	other
1.	Austria	*			
2.	Greece	-	-	-	-
3.	Italy – CMCC			*	*
4.	Italy - Trento				*

5.7 Duration of sunshine and cloud cover

Measurements of the duration of sunshine are carried out in all national meteorological services involved in the project. Austria is the only country among the pilot areas that measures the duration of sunshine.

Observation of the cloud cover is usually carried out 3 times a day or hourly depending on the station type. In Romania, at the majority of the stations, observations are done 10 (05-09, 11, 12, 17-19UTC) or 20 (05-19UTC) times per day. Mean value in all national services is calculated as an arithmetic mean of all available data.

Table 26. Number of cloud cover observations per project partner (excluding pilot areas)

	Country	3 times per day	8 times per day	24 times per day	other
1.	Bulgaria	*	*		
2.	Croatia			*	
3.	Hungary			*	
4.	fYR of Macedonia	*		*	
5.	Republic of Srpska	*		*	
6.	Romania			*	*
7.	Serbia	*		*	
8.	Ukraine		*		

Pilot areas don’t operationally observe the cloud cover.

5.8 Soil temperature

Meteorological services take measurements of the soil temperature mostly 3 times a day (07, 14, 21h local time). Romanian service has 4 times measurements per day (00, 06, 12, 18 UTC), and Hungarian every 10 minutes.

Daily mean values are calculated as arithmetic mean of available data.

Table 27. Number of soil temperature measurements per project partner (excluding pilot areas)

	Country	3 times per day	8 times per day	24 times per day	other
1.	Bulgaria	*			
2.	Croatia	*			
3.	Hungary				*
4.	fYR of Macedonia	*			
5.	Republic of Srpska	*			
6.	Romania				*
7.	Serbia	*			
8.	Ukraine	*			

Measurements of the soil temperature in the pilot areas are carried out in Austria and Italy-CMCC. In Austria measurements are taken every half an hour and calculation of the mean value depends on the purpose. 3-hour and hourly soil temperature measurements in Italy-CMCC are not given mean values on the daily basis.

5.9 Snow depth

Measurements of the snow depth are carried out once a day at 06 UTC except for Romania at 18 UTC. In Hungary and Republic of Srpska measurements are taken twice a day and in Bulgaria 8 times a day at the main meteorological stations. In Romania measurements are taken 4 times a day.

5.10 River discharge

Not all hydrological services nor pilot areas carry out hydrological measurements.

In Croatia, measurements are taken once a day (06 UTC) or hourly when the daily mean value is given as an arithmetic mean value. In Republic of Srpska, aside the daily measurements at 8am local time, there are continual measurements taken once a day as an arithmetic mean of all daily measurements. In fYR of Macedonia, hydrological measurements are taken once a month, while in Serbia measurements periodicity varies depending on the navigability of the rivers.

5.11 Phenology

Phenological measurements are carried out in Croatia, fYR of Macedonia, Romania, Serbia and Ukraine. Further information can be found in Appendix I.

6. Data quality control

All partners control the quality of data, apart from Greece and Italy-CMCC. Italy-CMCC uses gridded data. Hydrometeorlogical services control all meteorological as well as phenological and hydrological data. Depending on the data and the country, logical, statistical, spatial and graphic control is being carried out. Similarly, depending on the country and the data type there are different times when the control is being done (from hourly to annual). Pilot area from Austria controls 10 and 30 minutes data applying different methods after station data was sent to the server. Italy-Trento exerts monthly logical control of the temperature and precipitation amount.

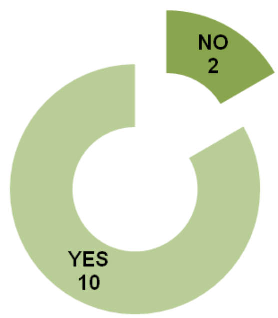


Figure 10. Number of partner performing data quality control

The more detailed overview of the methods and times of control is given in Appendix I.

7. Interpolation of meteorological data

Of all the partners that have meteorological data, Republic of Srpska, Greece and Austria don't apply the interpolation, while Italy-CMCC uses gridded data. The dominating parameters, which are being interpolated, are the mean temperature, precipitation amount as well as the air pressure, relative humidity, wind speed and duration of sunshine (Figure 11).

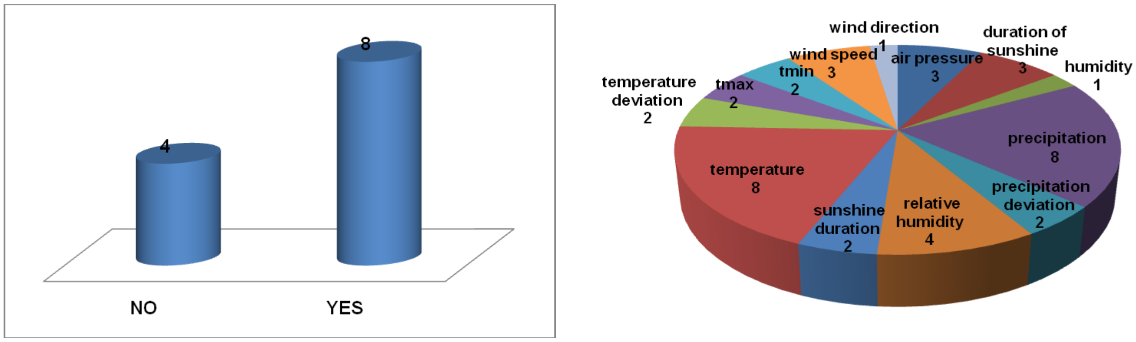
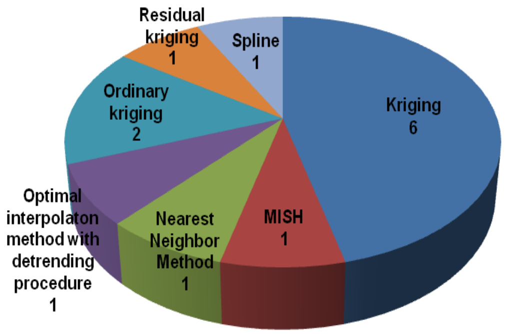


Figure 11. Number of countries which apply the interpolation of meteorological data (left). Elements that are being interpolated (right)

Meteorological data are interpolated by using kriging method within Surfer program or especially designed procedures in FORTRAN or other programming languages. Besides kriging, there are also other methods that are being used (spline, NNM, MISH, etc.). Additional data for interpolation are mainly DEM and other topographic values, land cover and land use.



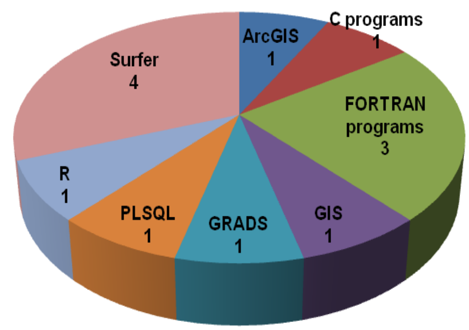


Figure 12. Interpolation methods (left). Software for interpolation (right)

Output is developed according to the end-user needs: pictures, maps, vector files, rasters, GeoTIFF in different resolutions on daily, weekly, monthly, seasonal and annual basis. The most commonly used softwares for the visualization are Surfer and GRADS, as well as different GIS applications (ArcGIS, ArcView, ArcMap, SAGA). Among the users of the final products are public and governmental organizations, as well as agriculture, civil engineering, energy sector, scientists from different sectors, water management sector (flood protection, drought monitoring, irrigation planning), traffic (land, maritime and air traffic), tourism, health, civil protection (e.g. forest fire protection service), risk assessment applications etc.

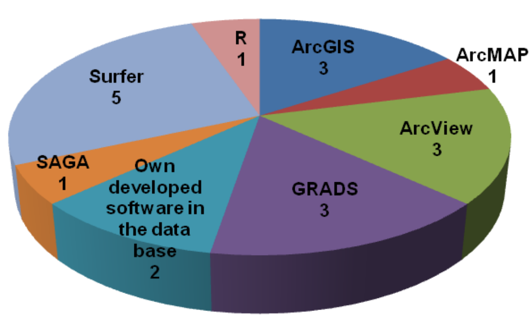


Figure 13. Software for visualization

III Climate indices

1. Climate indices based on temperature and precipitation

Out of 12 interviewed partners, Austria, Greece and Ukraine are among the three that thus far haven't had experience with the indices.

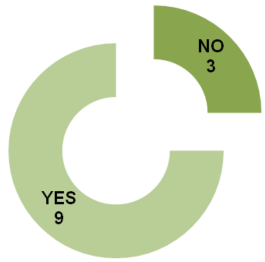


Figure 14. Number of partners that use climate indices

Almost all indices from the proposed list as well as the additional indices are being used (Figures 15 and 16). The calculation of the certain indices is being done on the request of the user. Customly developed programs in Excel and Fortran are being used for the calculation, as well as PLSQL, C++, CDO, ArcGIS, CLIDATA, R, RClimDex. Indices are estimated mainly for stations as well as in grid points. Only Hungary reported that the basic elements are interpolated first followed by the indices calculation. Many indices are used for different impact studies in the range of time periods. Croatia and Hungary applied some indices for the National Climate Change Strategy. More details can be found in Appendix I.

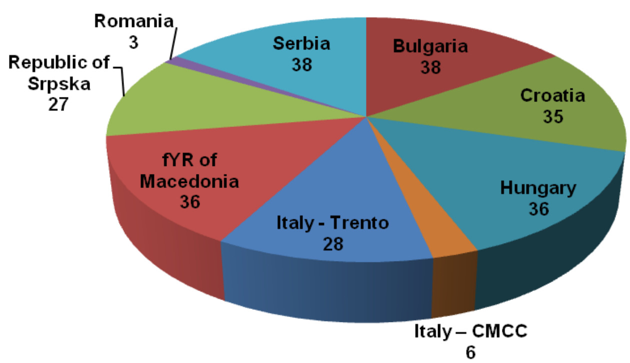


Figure 15. Number of indices used by different partners

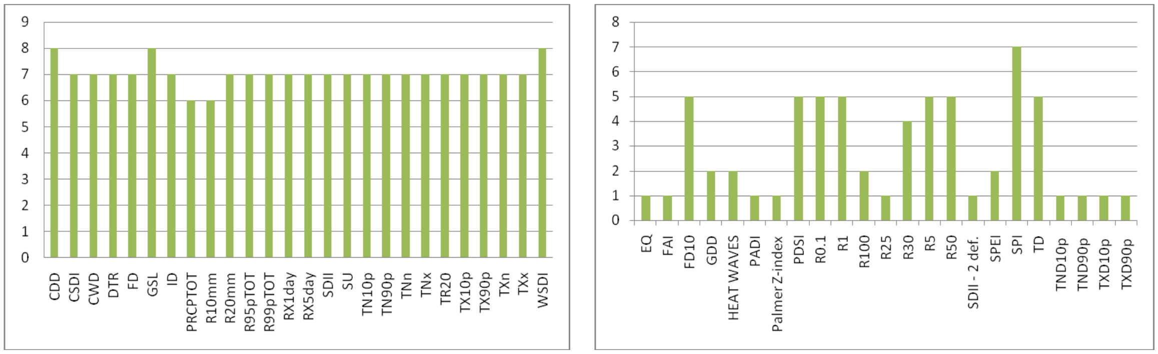


Figure 16. Indices - listed and non-listed in ETCCD index list.

2. Climate indices based on other parameters

In addition to the listed indices using temperature and precipitation amount for measurements, there are also other indices requiring additional parameters:

1. Human Comfort Index (HCI)
2. Forest Fire Weather Index (FFWI)
3. Physiologically Equivalent Temperature (PEqT)
4. Universal Thermal Climate Index (UTCI)
5. Temperature Humidity Index (THI)
6. Storage Yield Curve (SYC)
7. Potential EvapoTranspiration (PET)
8. Aridity Index (AI)
9. Potential Soil Moisture Deficit (PSMD)
10. Keetch-Byram Drought Index (KBDI)
11. Days with: fog, hail, lightning, strong wind.

For their calculation partners use customly developed programs in Excel and Fortran and some others (RayMan, CDO, ArcGIS, CLIDATA). Indices are estimated for stations and then interpolated except in case of Italy-CMCC which calculate indices in grid points. From the mentioned indices it is confirmed that HCI, FFWI and strong and stormy wind show the greatest change. Above mentioned indices are used for impact studies for different time periods based on the observations and projections (from mid-19th till the end of 21st century).

In addition to the temperature and precipitation amount, for the Index determination are also used observations of meteorological phenomena, evaporation, air pressure and vapor pressure.

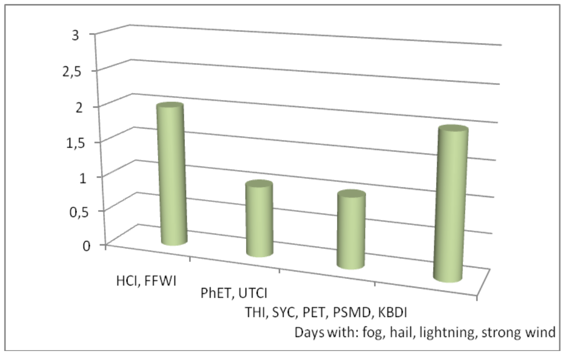


Figure 17. Other indices used by the WP3 partners and pilot areas

3. Interpolation of climate indices

Half of the interviewed partners are applying indices interpolation. In addition to Austria, Greece and Ukraine that don't use indices at all, Republic of Srpska and Italy-Trento don't apply the interpolation, whereas Italy-CMCC has no need for that since it uses gridded datasets.

With all partners that calculate indices by stations SPI index is the one being interpolated. Romania also interpolates PDSI index while Serbia interpolates anomalies of TD, TR, SU, FD and ID. Interpolation is being applied by using the kriging method, i.e. ordinary kriging as one form of kriging, with software Surfer, MISH or R in case of Romania. Certain partners use additional data in terms of soil type and vegetation cover index (Croatia and fYR of Macedonia), or elevation and land use (Bulgaria).

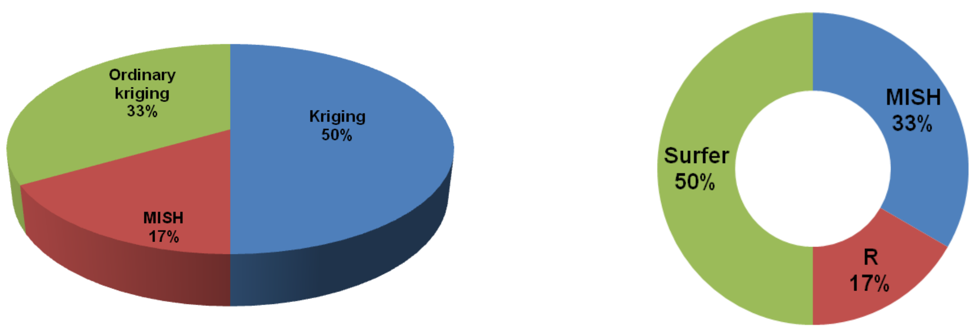


Figure 18. Interpolation methods. Software for interpolation.

There are different softwares for visualization of calculated indices that are currently in use. The most common ones are different GIS applications: ArcView, ArcGIS, SAGA, ILWIS. Besides them, Surfer, R and GRADS are also being used. Form of the output is largely in the form of the monthly maps with different resolutions, although it also depends on end-user needs. End users are: public ,government, agriculture, water management sector, forest fire protection sector, tourism, health, civil engineering, transportation etc.

Table 28. Software for visualization

Software for visualization	
ArcGIS	2
ArcView	2
GRADS	1
ILWIS	1
SAGA	2
Surfer	4
R	1

IV Climate models results

1. Climate change models output

Eight out of twelve partners confirmed that they have climate change outputs as well as the experience working with relevant data. Pilot areas Greece and Italy-Trento and meteorological services of fYR of Macedonia and Ukraine don't possess the climate model data. 6 out of 8 partners that have used the model results have independently run the model.

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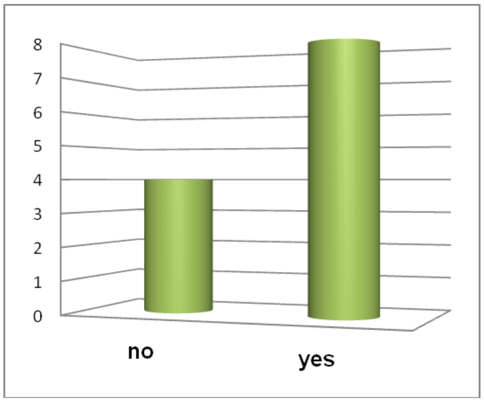


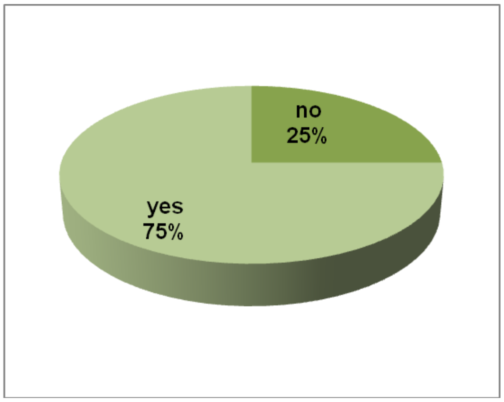


Figure 19. Number of partners with climate change model outputs

Table 29. Possession of climate model outputs and runs

Possession of cc output	
no	4
yes	8
Total	**12**

Run by the country	
no	2
yes	6
Total	**8**

Each of the institutions has used a different model. In SEE there are 6 models that are in use (Figure 20). Models ALADINE (Bulgaria and Hungary) and RegCM (Romania and Croatia) are being used by 2 partners, respectively.

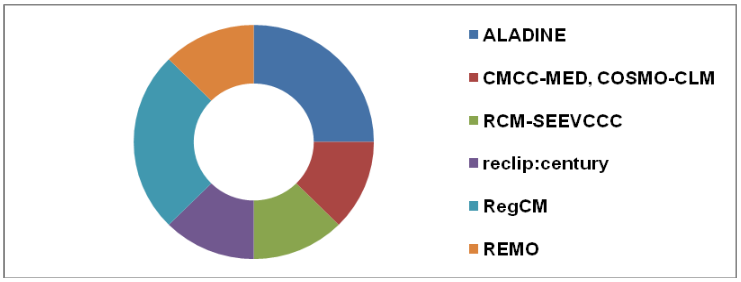
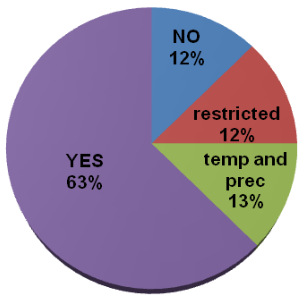


Figure 20. Climate models

Different institutions have different policies regarding accessibility of the climate model results. In most cases data are available for all the others, on a request. Only Romania (FTP) and Italy-CMCC (FTP and other) provide a service which allows data downloading.



Data policy	
Data available on the request	3
Depend on the data	1
Free download	1
Results are free, extraction and delivery costs	1
Total	**6**

Figure 21. Climate model results accessibility. Data policy

The most commonly used formats are Grib and NetCDF-CF convention. Formats as ASCII, GRADS and NetCDF-CF standard are being used as well. The file size depends on the country, simulation length, data aggregation and list of variables (from ~25GB to ~10TB). Metadata have only Romania in form of a proprietary schema and Italy-CMCC as NetCDF-CF.

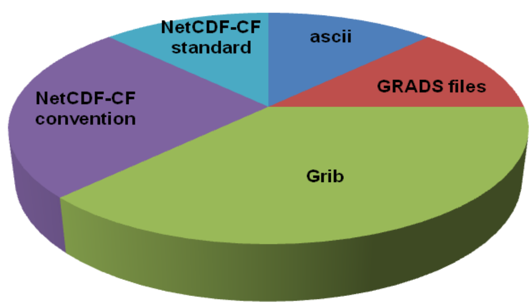


Figure 22. Data formats

Partners have stated that their first and foremost need is for the temperature and precipitation data in different time scales (hourly, daily, monthly values). Furthermore, Italy-CMCC requires solar radiation, wind speed, relative humidity and monthly fields on runoff. Romania needs all fields that will be used as lateral and initial conditions for their RegCM. Six countries have used climate outputs for indices calculations.

V Conclusion

- The area of the project contains sufficiently dense network of meteorological stations. The density of the hydrological stations network in the countries in which hydrological measurements are performed within national services is also sufficient. The stations have current meteorological data as well as long enough meteorological time series.
- Measurement methods and statistical procession of the meteorological data are comparable.
- The used data is either controlled and/or gridded.
- Interpolation of the meteorological values is applied in all countries (participating in WP3) except for one.
- The majority of the countries have experience with the use of climate indices. Almost all countries have the basic data set necessary for the calculation of climate indices based on the temperature and precipitation. Apart from the variation analysis and climate change, climate indices are being used in different fields, all depending on the demands and needs of the customers: public, government, energy, tourism etc.
- Interpolation of climate indices is applied in half of the countries participating in this WP. In some countries the values of the calculated climate indices are depicted in measurement stations, while in others, they are calculated in the grid points using gridded meteorological data. Certain countries don't have a practice of calculating indices.
- Most of the partners have deployed different climate models and results in their practices