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 2

Deliverable 2.2

Report on Data Rescue Missions

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1. Introduction

The Deliverable 2.2 (D2.2) "Report on Data Rescue Missions" is presented in this document, which has been conducted by the University Rovira i Virgili (URV) and Barcelona Supercomputing Center (BSC) in collaboration with the Royal Netherlands Meteorological Institute (KNMI). This work is part of Work Package 2 (WP2) named "Identification and Catalogue of Climate Datasets and Portal", one of the work packages that constitute the EU-co-funded project entitled "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)" project. INDECIS (www.indecis.eu) 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 (INDECIS: Grant agreement no.: 690462.

This document thoroughly describes all data rescue missions executed under the INDECIS project; from the identification of data gaps in the European Climate Assessment & Dataset (ECA&D) and the inspection of undigitized data sources to the digitizing process together with data and metadata collection for the main climate variables.

2. Digitization plan for Central Europe and the Balkans

The main aim of data rescue efforts was to improve spatial data coverage (new climate series recovery) and temporal coverage by filling data gaps from climate series already integrated in ECA&D (which is the core dataset of the INDECIS project). The variables of interest were maximum and minimum temperature (TX/TN), rainfall (RR), sunshine duration (SS) and snow depth (SD) at the daily scale.

An extensive examination of ECA&D dataset (http://www.ecad.eu/) was conducted first to find spatial and temporal data gaps across Europe. Regions located in eastern Europe showed the lowest spatial climate data coverage together with more presence of temporal data gaps, really variable along the 20th century. In particular, the Balkans region (Croatia, Republic of Serbia, Montenegro, Bosnia and Herzegovina and Republic of Macedonia) was identified as a key region for data rescue missions while other sub-regions from Central Europe (mainly Czech and Slovak Republics) or in the Mediterranean basin (Italy, Greece and Turkey) also showed a serious lack of climate data coverage.

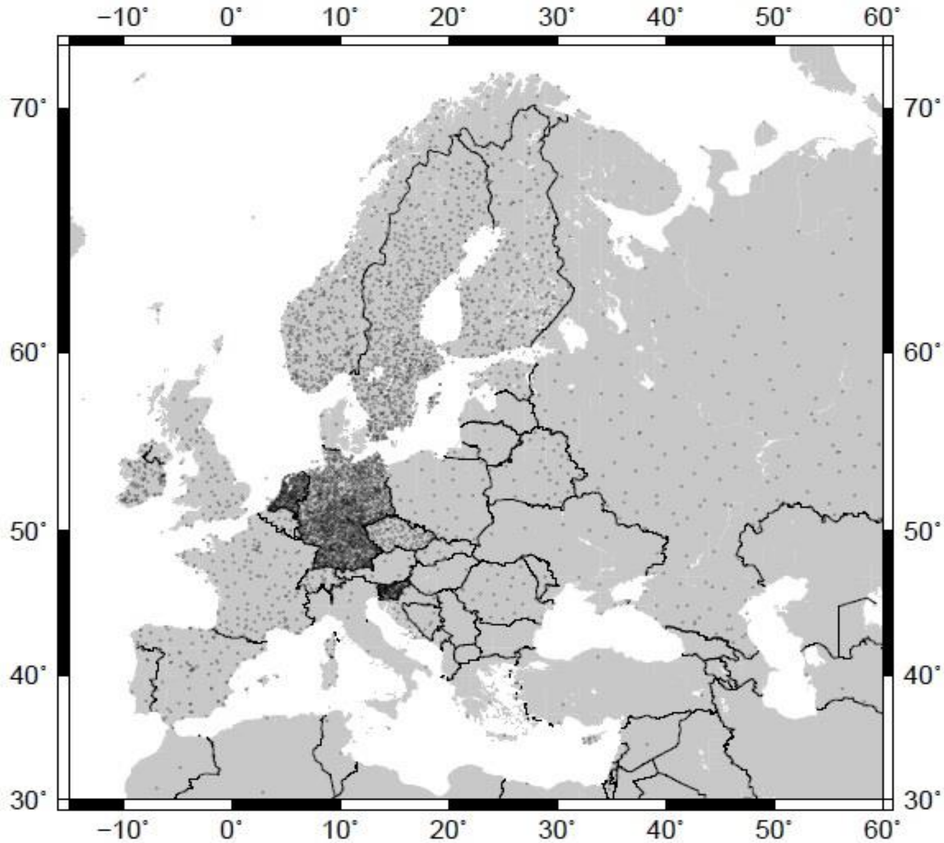


Figure 1: Spatial coverage of European climate series included in ECA&D dataset. Coverage shows stations for precipitation.

Once European sub-regions with lower availability of spatial and temporal climate data coverage were located, the data sources of undigitized records were identified for these particular sub-regions.

Some contacts were produced with National Meteorological and Hydrological Services (NMHSs) of some countries located in the Balkans region to obtain scanned images of available climate data not already digitized. Unfortunately, only the Croatian Meteorological Service (Croatia) responded positively to our request with the delivery of several pdf files containing meteorological records directly scanned from original log-books.

Other undigitized data sources were identified on-line thanks to the WMO MEDARE initiative and UERRA project through the United States of America's National Oceanic and Atmospheric Administration/National Climatic Data Center (NOAA/NCDC) Climate Data Modernization Project (CDMP: http://docs.lib.noaa.gov/rescue/data_rescue_home.html). This project included data for eastern European regions, the Balkans and the Mediterranean basin (Ashcroft et al., 2018, Brunet et al., 2014a, Brunet et al., 2014b).

Table 1 summarizes data sources obtained on-line through CDMP and also provided by the Croatian Meteorological Service depending on each European sub-region and for different periods along the 20th century and the first decade of the 21st century.

Table 1: Documental data sources used for data rescue purposes.

Region	Documental Source	Period
Central Europe	Rocenka povetrnostnich posoro vani site statniho ustavu meteorologickeho.	1916-1946
	Rocenka povetrnostnich pozorovani meteorologickeho stanie Republiky Ceskoslovenshe.	1948-1968
	Rocenka povetrnostnych pozorovani observtoria na Lomnickom Stite.	1940-1974
Balkans Region	Izvestaj meteoroloske opservatorije u Beogradu.	1920-1945
	Resultati osmatranija u Beogradu.	1946-1950
	Meteoroloski godisnjak. I.	1949-2012
	Scans from original log-books provided by the Croatian Meteorological Service	1930-1990

Once data sources were thoroughly inspected, the digitization plan was designed taking into account the spatial-temporal data gaps previously found in ECA&D dataset. Thus, an inventory of candidate climate series to be rescued was created prioritizing those stations not included in ECA&D first in order to increase climate spatial coverage across Europe. Those undigitized periods for the already existing stations at ECA&D were also digitized to fill temporal data gaps, but not as a priority task. A more detailed information about rescued climate series of the digitization plan can be found in table 2.

Once all scans of data sources were thoroughly inspected, the digitizing process was set up. The digitizing method used in this study consisted to apply a rigorous "key as you see" premise, meaning that each digitizer was in charge to transcribe meteorological observations as were handwritten/typed in data sources, without using any system code, following the recommendations given by WMO (2016).

Table 2: Rescued stations by country. Digitized variables are maximum (TX) and minimum (TN) temperature, rainfall (RR), snow depth (SD) and sunshine duration (SS).

Country	WMO code	Station Name	Lat. N	Lon. E	Alt. (m)	Variables	Digitizing period
Czech Republic	11542	Ceske Budejovice	48º58'00"	14º28'00"	389	TX/TN/RR/SD	1917-1938
	11748	Prerov	49º28'00"	17º27'00"	214	TX/TN/RR/SD	1917-1952
	11406	Eger/Cheb	50º05'00"	12º24'00"	483	TX/TN/RR/SD	1919-1936
	11763	Troppau/ Opava	49º56'00'	17º53'00"	268	TX/TN/RR/SD	1917-1937
	11461	Teplitz-Schnonau	50º39'00"	13º48'00"	229	TX/TN/RR/SD	1917-1936
	11446	Plzen	49º44'00"	13º80'00"	357	TX/TN/RR/SD	1948-1953
	Unknown	Turnov	50º36'00"	15º10'00"	280	TX/TN/RR/SD	1948-1951
	11721	Brno-Kvetna	49º12'00"	16º34'00"	233	TX/TN/RR/SD	1948-1968
	11735	Praded	50º05'00"	17º14'00"	1490	TX/TN/RR/SD	1948-1957
	11622	Caslav-Filipor	49º54'00"	15º24'00"	252	TX/TN/RR/SD	1946-1960
	Unknown	Frycovice	49º41'00"	18º13'00"	274	TX/TN/RR/SD	1946-1953
Slovak Republic	Unknown	O.-Gyalla/ Stara Dala	47º53'00"	18º12'00"	120	TX/TN/RR/SD	1919-1937
	Unknown	St. Smokovec	49º08'00"	20º13'00"	1018	TX/TN/RR/SD	1921-1937
	11814	Bratislava-Trnavaka	48º10'00"	17º08'00"	139	TX/TN/RR/SD	1946-1968
	Unknown	Skalnate Pleso	49º12'00"	20º55'00"	1778	TX/TN/RR/SD	1946-1960
	11968	Kosice	48º42'00"	21º16'00"	206	TX/TN/RR/SD	1946-1950
Republic of Serbia	13274	Belgrade	44º48'00"	20º28'00"	132	TX/TN/RR	1920-1935
	13363	Zlatibor	43º44'00"	19º43'00"	1028	TX/TN/RR/SD/SS	1992-2012
	Unknown	Vranje	42º33'00"	21º55'00"	432	TX/TN/RR/SD/SS	1999-2012
Bosnia & Herzegovina	14654	Sarajevo	43º52'00"	18º26'00"	630	TX/TN/RR/SD/SS	1949-1960
	14652	Bjelasnica	43º43'00"	18º16'00"	2067	TX/TN/RR/SD/SS	1953-1960
Montenegro	11374	Titograd/ Podgorica	42º26'00"	19º17'00"	52	TX/TN/RR/SD/SS	1949-1984
Republic of Macedonia	Unknown	Skopje	41º59'00"	21º28'00"	240	TX/TN/RR/SD/SS	1949-1972
	Unknown	Skopje (Petrovac)	41º58'00"	21º39'00"	238	TX/TN/RR/SD/SS	1974-1984
Croatia	5080	Brodanci	45,5425	18,4572	92	RR/SD	1930-1990

The best option was manual-keying data transcription to accomplish data rescue efforts. The digitizer was responsible to design a spreadsheet for data insertion by following the format; year, month, day and value for each variable. The digitizer also cross-checked the digitized values against data sources every 10th, 20th and 30th for each month to check accuracy (to avoid repeated or skipped values). Data gaps and potential unexpected variations in data sources were also recorded in a metadata spreadsheet following the recommendations outlined at Aguilar et al., (2003). The digitizer was also in charge to compute monthly totals and summaries from transcribed data for validation purposes once compared with monthly totals and summaries from data sources (when available). In those cases in which monthly totals and summaries were not available in data sources, a preliminary and effective quality control test was applied (data filtering) to detect out of range values for each transcribed variable in order to find aberrant values due to a digitizing error. Digitizing errors were reported in a specific template while data corrections were applied by using a copy of the raw series to preserve data traceability.

A total of 610K daily observations were rescued by URV in the INDECIS project for maximum and minimum temperature (in ºC), rainfall (in mm), sunshine duration (in hours) and snow depth (in cm) across Central Europe and the Balkans region along really variable periods along the 20th century. Figure 2 shows the spatial distribution of the 25 rescued climate series located in 7 European countries; 11 climate series in Czech Republic, 5 in Slovak Republic, 3 in Republic of Serbia, two in Bosnia and Herzegovina, two more climate series in Republic of Macedonia, one in Croatia and the last one in Montenegro. Table 3 shows a summary of number of rescued stations and total amount of digitised values for each country. Rescued variables and periods are also described. More details about particular periods for each station can be found recovering table 2.

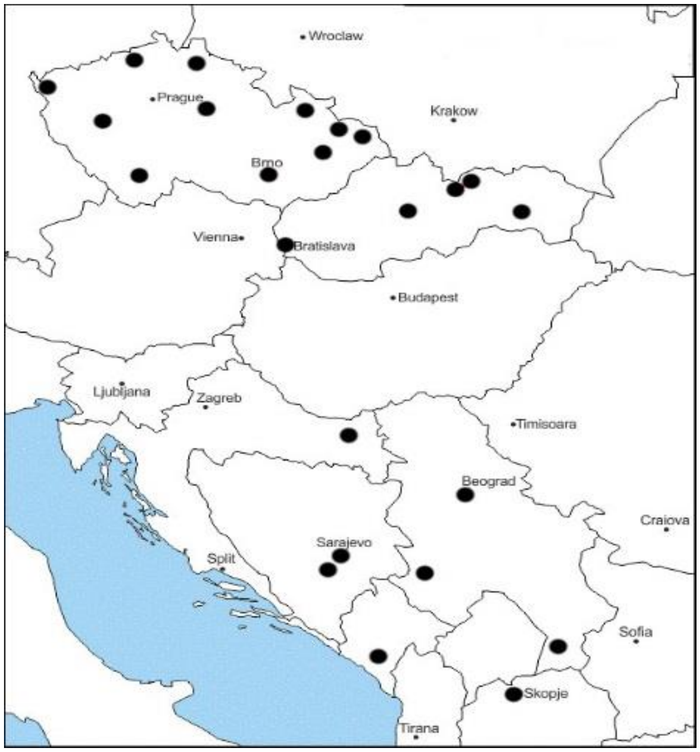


Figure 2: Spatial distribution of stations with rescued data.

Table 3: Summary of number of rescued stations and total amount of digitized values for each country and period. Variables are maximum (TX) and minimum (TN) temperature, rainfall (RR), snow depth (SD) and sunshine duration (SS).

Country	Nº stations	Variables	Period	Total digitized	%
Czech Republic	11	TX/TN/RR/SD	1917-1968	245935	40,3
Slovak Republic	5	TX/TN/RR/SD	1919-1968	110873	18,2
Republic of Serbia	4	TX/TN/RR/SD/SS	1920-2012	85343	14,0
Bosnia & Herzegovina	1	TX/TN/RR/SD/SS	1949-1960	8642	1,4
Montenegro	1	TX/TN/RR/SD/SS	1949-1984	64816	10,6
Republic of Macedonia	2	TX/TN/RR/SD/SS	1949-1984	51836	8,5
Croatia	1	RR/SD	1930-1990	42709	7,0

Figures 3 and 4 show the total amount of digitized values for each country and for each variable respectively. Total amount of digitized values was proportional to the number of rescued stations for each country and to the extension of digitizing periods too. There was no doubt that stations located in Czech and Slovak Republic cumulated the largest amount of digitized values, which represented around 40% and 18% of total amount respectively, due to the large number of rescued stations (see table 3). Total amount of digitized values representing the 14% and the 11% in Republic of Serbia and Montenegro respectively was significant due to the large rescued period rather than the number of digitized stations. Finally, the total amount of digitized observations was lower in Bosnia and Herzegovina due to the short length of digitizing periods and multiple data gaps.

Moreover, rescued variables with the highest rates of digitized values were rainfall (RR) and snow depth (SD) representing both together a 51% of total amount of digitized values (figure 9). Maximum (TX) and minimum (TN) temperature observations represented both the 43% of total amount of digitized values meanwhile sunshine duration (SS) represented only the 6%. The main differences among the amount of digitized values for each variable depended basically on the availability (or not) of such variables in the data sources.

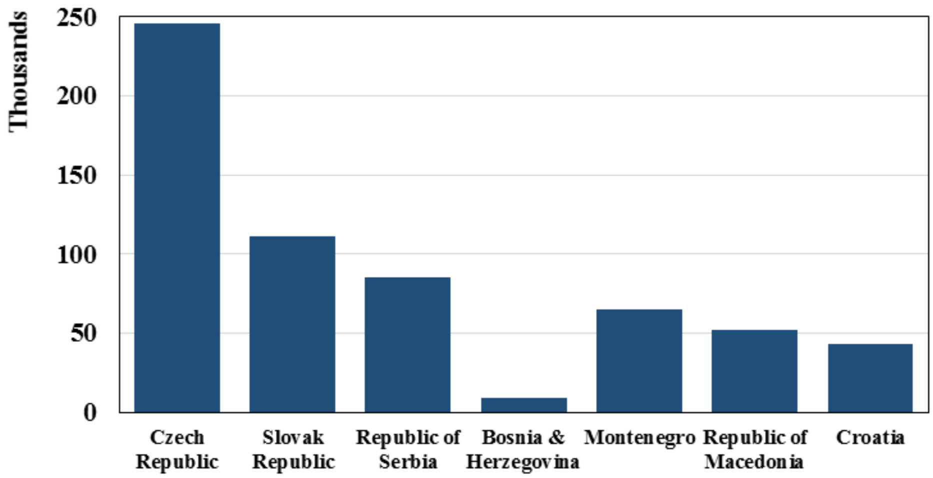


Figure 3: Total amount of digitized values (in thousands) by countries

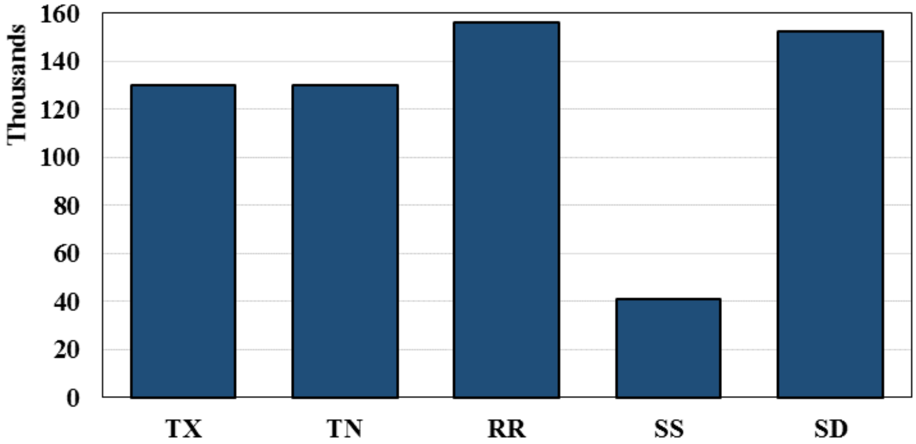


Figure 4: Total amount of digitized values (in thousands) by variables

A quality control of the digitizing process was applied to all climate series rescued in the INDECIS Project. Monthly totals and summaries provided by data sources (in most of the cases) were accurately cross-checked with monthly totals and summaries computed from transcribed data. Results demonstrated that the errors occurred during the digitizing process represented only the 0,6% of the total amount of digitized values. Most of errors were occurred due to hard to read records due to the low quality of particular sheets in the scanned data sources. All errors found in the preliminary quality control of the digitizing process were corrected successfully.

Once digitizing process and the preliminary quality control were finished, the 25 new climate series will be incorporated to the ECA&D Dataset.

3. Tall towers data rescue mission

Several institutions, research centers and national meteorological institutes host and maintain instrumented tall towers that record meteorological variables at heights of tenths of meters above ground. However this information is sparse, difficult to find and use. BSC has identified, compiled and processed climate data from existing tall towers around the world. Special efforts have been made to gather wind observations for the future usage within the energy sector. The Tall Tower Database is a unique archive containing meteorological observations from instrumented tall towers measuring winds at heights above 10 meters. A total of 311 potential sites have been identified (Figure 5). Almost 70% of these sites (214 tall towers) have been already processed and formatted so far. It is expected to enlarge this database by adding new observations, especially in the European continent. The heights of these structures is quite diverse. On the one hand, masts placed in historical observatories (i.e. often having more than 20 years of data) tend to be shorter. They usually range between 20 to 50 meters. On the other hand, modern towers often reach 100 to 200 meters of height and exceptionally, up to 400 meters. The record lengths of the 214 time series is also different (see Figure 5). Although it ranges from 1 to 37 years, most of the time series do not cover more than 20 years. Nevertheless, several of these masts have been recently installed and measurements are currently ongoing. Regarding the location of the towers, the 78% are found inland whilst the 22% of them are placed over oceanic regions. Finally, other meteorological variables have been included to complete wind speed and wind direction observations: temperature, relative humidity and barometric pressure have been added to the database when available (in most of the cases).

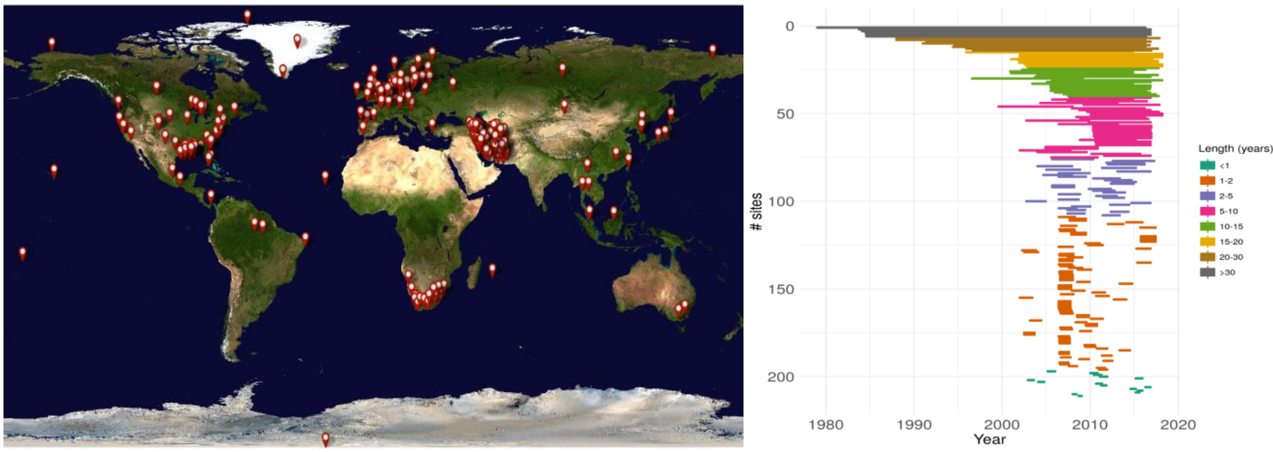


Figure 5: Global distribution of the 311 identified tall towers (left) and record lengths of the 214 processed masts (right).

Several difficulties have been faced during the data collection period. Some datasets were easily accessible through different data portals hosted by the data owners. However, other data were only available under request. More than 50 people from different institutions have been contacted in order to obtain tall tower data. Although most of them were keen to share their tall tower data, others were reluctant to provide their observations. In addition, several restrictions on the usage of the data have been encountered during this process. Therefore, a data policy has been specified for each site. Most of the data is freely accessible and can be distributed. However, the distribution of some datasets to third parties is strictly prohibited. Therefore, those observations will not be approachable through the INDECIS data portal. In all cases, the metadata for each of the 311 identified tall towers aims to be publicly accessible to facilitate the further access to these observations.

Other complications emerged from the original formats of the tall tower data and the lack of metadata in most cases. To overcome this, a common standard format has been defined for the Tall Tower Database. Table 4 shows the different original formats for the provided files, times and units, among others. The common final format is also indicated. In addition, all the available metadata for each site has been compiled and included in the NetCDF files as a global attributes (see Table 5).

Table 4: Original and final standard formats of the tall tower data

	Original	Final
File formats	ASCII (csv, tab, custom formats), NetCDF	NetCDF
Time resolution	From 1-minutely to 1-hourly	Preserve native resolution
Time stamps	Start/middle/end of average period time stamp	Middle of average period time stamp
Time zone	UTC, local time	UTC time
Units	Wind speed: km/h, kt, mph, cm/s, m/s Wind direction: degree Temperature: ºC, K Relative humidity: % Pressure: mbar, mmHg, Pa	Wind speed: m/s Wind direction: degree Temperature: K Relative humidity: % Pressure: Pa

Table 5: Metadata included in the NetCDF files

Attribute	Definition
tower_name	Name of the tall tower or observatory
institution	Owner organization of the tall tower
boom_direction	Orientation of the horizontal booms. Often missing, but usually provided for redundant sensors.
location	Country where the tower is placed. Using the Country Codes List ISO Alpha-2
offshore	Indicates whether the tall tower is placed over oceanic areas or continental regions
tower_type	Main usage of the tall tower (e.g.: meteorological mast, TV transmitter, etc.)
creation_time	UTC time indicating when the file was generated in format: YYYY-MM-DD-THH:MM:SSZ
Links	Main web pages containing information or data of the tall tower
History	Track of changes of the NetCDF file

Finally, a data summary sheet has been designed for each tall tower. An example is shown in Figure 6 for Lutjewad met mast in The Netherlands. Several plots have been included to compile the main local wind characteristics. After a short presentation of the tower and its location, a plot of the wind speed observations at the different measurement levels is displayed. On the right side, the monthly aggregated wind speeds at several heights are plotted. Then, total and monthly wind roses have been computed by averaging the winds in the vertical dimension. Heatmaps of daily and hourly averaged wind speeds at different heights have been plotted next. Lastly, histograms of wind speed values have been represented.

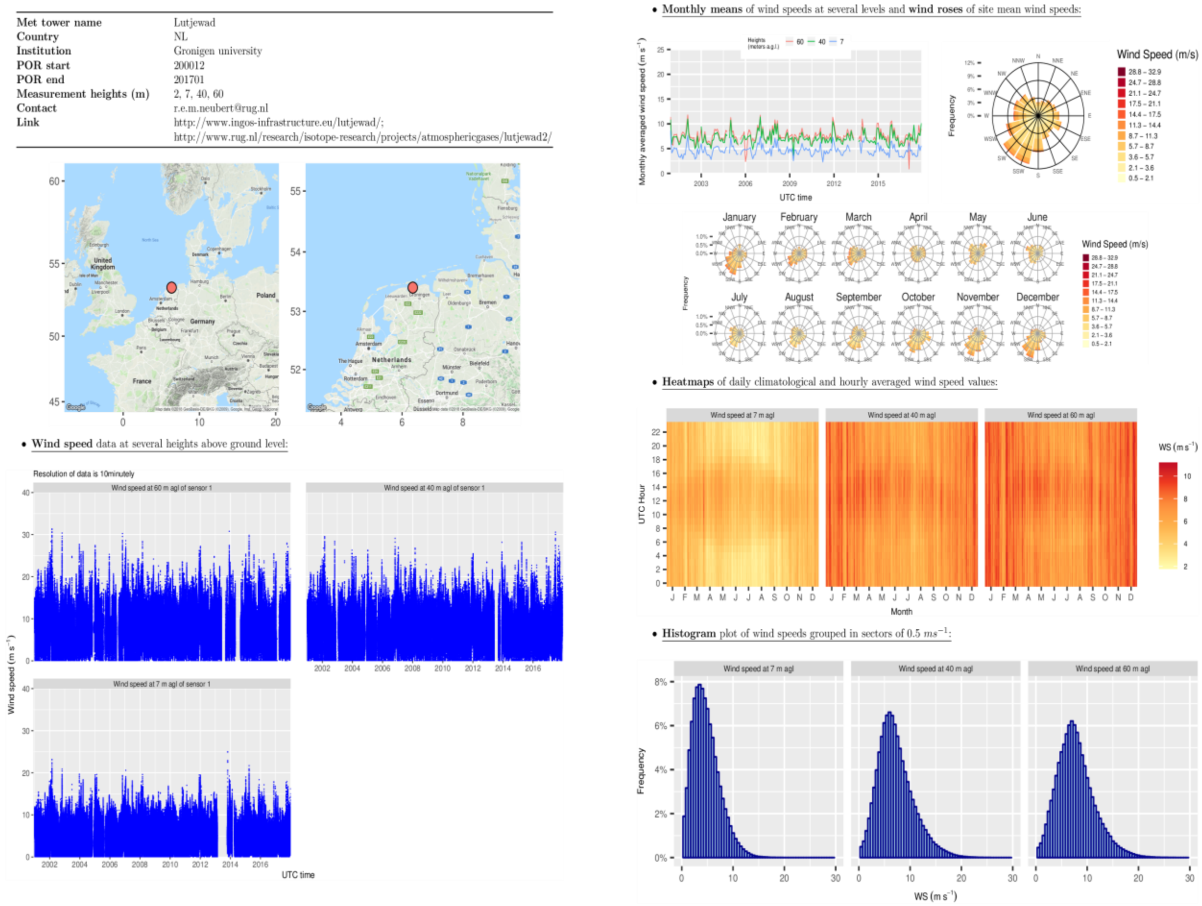


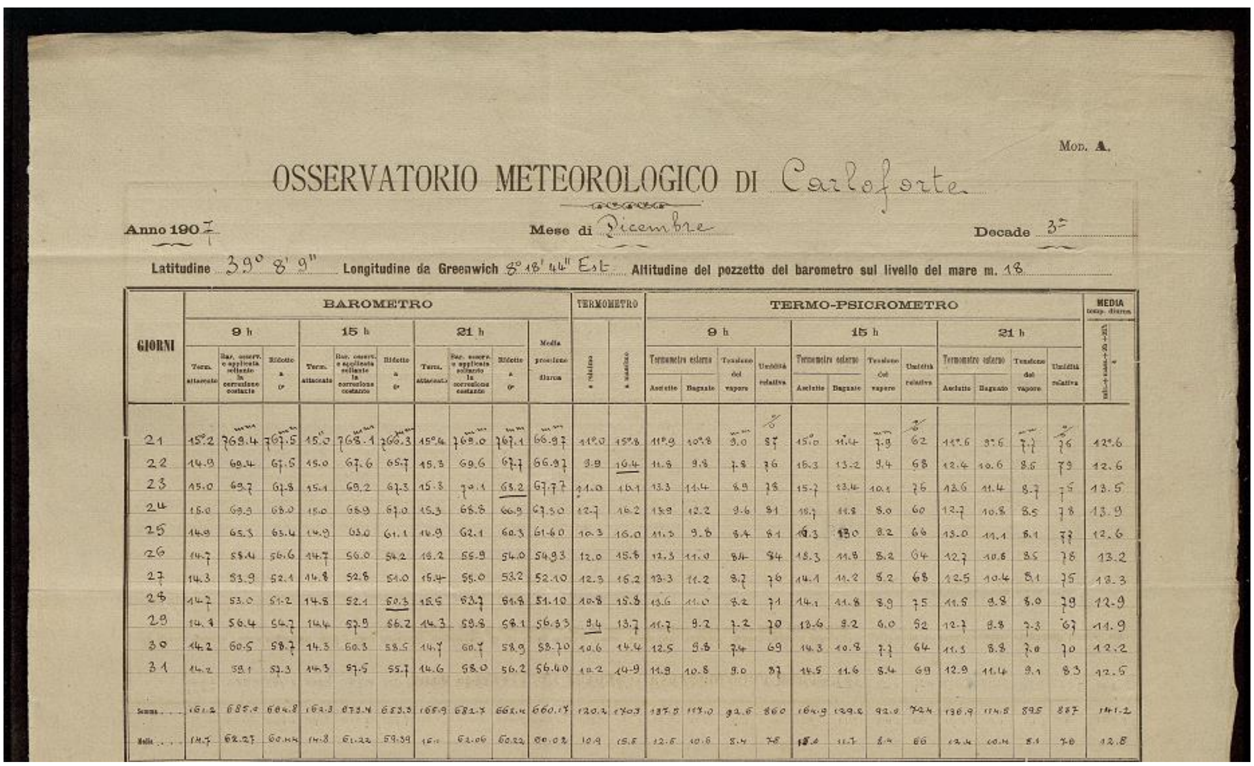
Figure 6: Summary sheet for the Lutjewad meteorological mast.

4. Carloforte (Sardinia) Data Rescue

The Data Rescue efforts of KNMI within WP2 of INDECIS are modest. Data from station Carloforte, Sardinia (figure 7) is digitized from 1901-1976. These data include temperature readings at 9, 15 and 21 h for air temperature and wet-bulb, daily maximum and minimum temperature, and readings at 9, 15 and 21h for air pressure, relative humidity, wind direction, wind speed and cloud cover. Precipitation sums are measured for the intervals 21-9, 9-15 and 15-21h. An example of the imaged hand-written records is shown in figure 8.

At the time of writing, the digitization is ongoing and no analyses on the data have been made yet.

Figure 7: Capo Sandalo Lighthouse in San Pietro island, Carloforte where the meteorological measurements are been made. Picture source: *http://www.italymagazine.com/carloforte*



Mod. A.

OSSERVATORIO METEOROLOGICO DI Carloforte

Anno 1907 Mese di Dicembre Decade 3a

Latitudine 39° 8' 9" Longitudine da Greenwich 8° 18' 44" Est Altitudine del pozzetto del barometro sul livello del mare m. 18

GIORNI	BAROMETRO 9 h Term. attaccato	Bar. osserv. e applicata soltanto la correzione costante	Ridotto a 0°	15 h Term. attaccato	Bar. osserv. e applicata soltanto la correzione costante	Ridotto a 0°	21 h Term. attaccato	Bar. osserv. e applicata soltanto la correzione costante	Ridotto a 0°	Media pressione diurna	TERMOMETRO [illegible]	[illegible]	TERMO-PSICROMETRO 9 h Termometro esterno Asciutto	Bagnato	Tensione del vapore	Umidità relativa	15 h Termometro esterno Asciutto	Bagnato	Tensione del vapore	Umidità relativa	21 h Termometro esterno Asciutto	Bagnato	Tensione del vapore	Umidità relativa	MEDIA temp. diurna
21	15°2	769.4	767.5	15.0	768.1	766.3	15°4	769.0	767.1	66.97	11°0	15°8	11°9	10°8	9.0	87	15°0	11.4	7.9	62	11°6	9°6	7.7	76	12°6
22	14.9	69.4	67.5	15.0	67.6	65.7	15.3	69.6	67.7	66.97	9.9	16.4	11.8	9.8	7.8	76	16.3	13.2	9.4	68	12.4	10.6	8.5	79	12.6
23	15.0	69.7	67.8	15.1	69.2	67.3	15.3	70.1	68.2	67.77	11.0	16.1	13.3	11.4	8.9	78	15.7	13.4	10.1	76	13.6	11.4	8.7	75	13.5
24	15.0	69.9	68.0	15.0	68.9	67.0	15.3	68.8	66.9	67.50	12.7	16.2	13.9	12.2	9.6	81	15.7	11.8	8.0	60	12.7	10.8	8.5	78	13.9
25	14.9	65.3	63.4	14.9	63.0	61.1	14.9	62.1	60.3	61.60	10.3	16.0	11.3	9.8	8.4	81	16.3	13.0	8.2	66	13.0	11.1	8.1	77	12.6
26	14.7	58.4	56.6	14.7	56.0	54.2	15.2	55.9	54.0	54.93	12.0	15.8	12.3	11.0	8.4	84	15.3	11.8	8.2	64	12.7	10.6	8.5	78	13.2
27	14.3	53.9	52.1	14.8	52.8	51.0	15.4	55.0	53.2	52.10	12.3	16.2	13.3	11.2	8.7	76	14.1	11.2	8.2	68	12.5	10.4	8.1	75	13.3
28	14.7	53.0	51.2	14.8	52.1	50.3	15.5	53.7	51.8	51.10	10.8	15.8	13.6	11.0	8.2	71	14.1	11.8	8.9	75	11.5	9.8	8.0	79	12.9
29	14.4	56.4	54.7	14.4	57.9	56.2	14.3	59.8	58.1	56.33	9.4	13.7	11.7	9.2	7.2	70	13.6	9.2	6.0	52	12.7	9.8	7.3	67	11.9
30	14.2	60.5	58.7	14.3	60.3	58.5	14.7	60.7	58.9	58.70	10.6	14.4	12.5	9.8	7.4	69	14.3	10.8	7.7	64	11.3	9.8	7.0	70	12.2
31	14.2	59.1	57.3	14.3	57.5	55.7	14.6	58.0	56.2	56.40	10.2	14.9	11.9	10.8	9.0	87	14.5	11.6	8.4	69	12.9	11.4	9.1	83	12.5
Somme	161.2	685.0	664.8	162.3	673.4	653.3	165.9	682.7	661.4	660.17	120.2	170.3	137.5	117.0	92.6	860	164.9	129.8	92.0	724	136.9	114.5	89.5	887	141.2
Medie	14.7	62.27	60.44	14.8	61.22	59.39	15.1	62.06	60.22	60.02	10.9	15.5	12.5	10.6	8.4	78	15.0	11.7	8.4	66	12.4	10.4	8.1	78	12.8

Figure 8: Example of the pdf with imaged data for station Carloforte.

5. Phoenix Park (Dublin) Data Rescue

Data rescue at Met Éireann was carried out on the Phoenix Park, Dublin, Ireland series for the period 1866 to 1959 inclusive. The imaging was carried out by a professional company and the data transcribed by a number of clerical officers and students of the CSO (Central Statistics Office). An example of an imaged hand-written record is shown (Figure 9). A number of different forms were used over the time period. All elements on each page were rescued onto excel templates which matched the original forms. Elements rescued included air pressure, dry bulb, maximum and minimum air temperature, dew point, humidity, wind direction and force, cloud amount and type, weather both as Beaufort letters and commentary, sunshine amount, visibility and rainfall. Some years also had phenology information. The data was keyed between April and December 2018 and it took approximately 6 hours to transcribe 1 station month. Each transcribed sheet was checked using SAS and visually. The data was extracted from the Excel worksheets into a single form using SAS. Metadata for the station was also rescued from inspector reports and station files.

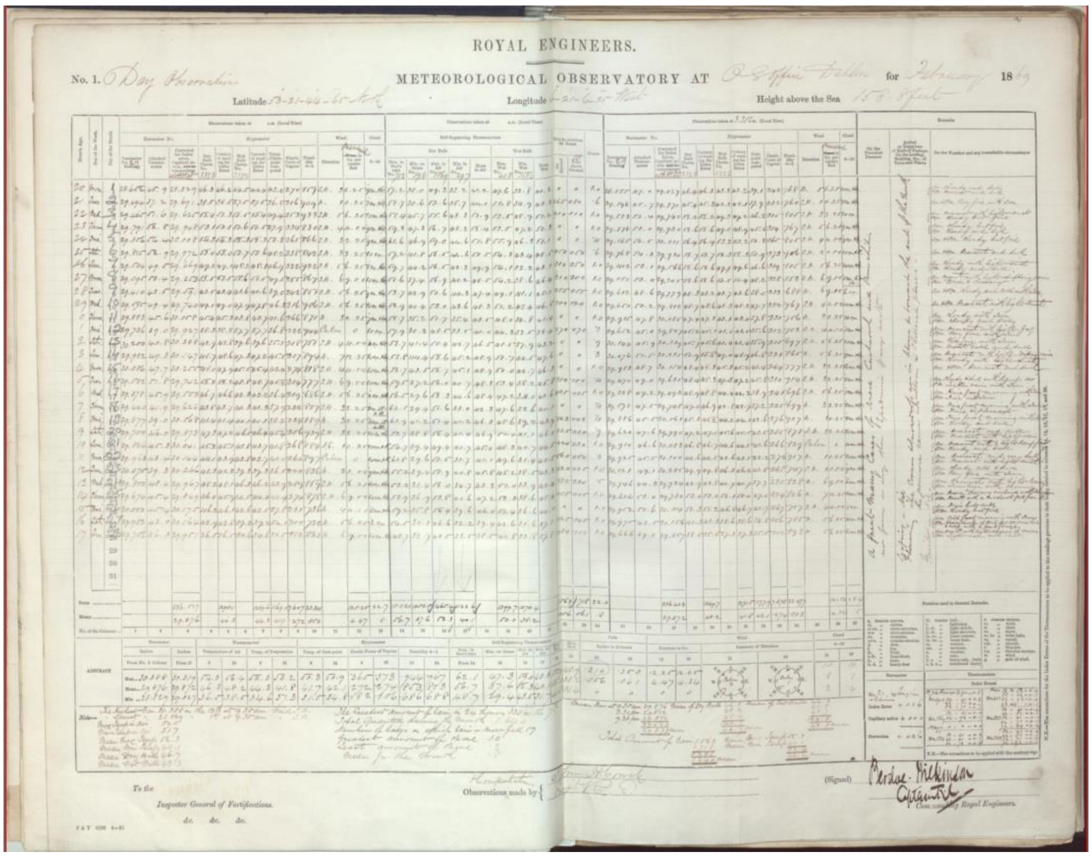


Figure 9: Example of the pdf with imaged data for station Phoenix Park.

REFERENCES

Aguilar, E., Auer, I., Brunet, M., Peterson, T. C. and Wieringa, J. (2003). Guidelines on Climate Metadata and Homogenization, World Meteorological Organisation, (1186), 55. https://www.wmo.int/datastat/documents/WCDMP-53_1.pdf

Ashcroft L., Coll J.R., Gilabert A., Domonkos P., Aguilar E., Sigró J., Castellà M., Unden P., Harris I., Jones P., Brunet M. (2018). A rescued dataset of sub-daily meteorological observations for Europe and the Mediterranean region, 1877–2012. Earth System Science Data (under revision). https://www.earth-syst-sci-data-discuss.net/essd-2018-39/

Brunet, M., Gilabert, A., Jones, P. and Efthymiadis, D. (2014a). A historical surface climate dataset from station observations in Mediterranean North Africa and Middle East areas. Geoscience Data Journal, 1(2), 121–128, doi:10.1002/gdj3.12. https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/gdj3.12

Brunet, M., Jones, P. D., Jourdain, S., Efthymiadis, D., Kerrouche, M. and Boroneant, C. (2014b). Data sources for rescuing the rich heritage of Mediterranean historical surface climate data, Geoscience Data Journal, 1(1), 61–73, doi:10.1002/gdj3.4. https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/gdj3.4

World Meteorological Organization (2016). Guidelines on Best Practices for Climate Data Rescue 2016. https://library.wmo.int/opac/doc_num.php?explnum_id=3318