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UERRA Deliverable 1.3 (D1.3)

Infilling in temporal and spatial gaps for the post-1950 period in Europe and its borders

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1. Introduction

This report builds on Deliverables 1.1 and 1.2 from Work Package 1 (WP1) on Data Rescue and Development (Gridded and Observational Datasets) contributing to the EU-FP7-funded collaborative project entitled Uncertainties in Ensembles of Regional Reanalysis (UERRA: Grant agreement No. 607193, www.uerra.eu). The primary goal of WP1 is to increasing sub-daily data availability across the European regions, ultimately improving the quality of high-resolution European Regional Reanalysis. In the first 10 months of the UERRA project, areas of sparse sub-daily instrumental data coverage were identified in the Mediterranean Basin, Eastern Europe and Scandinavia, and sources of sub-daily instrumental data for these regions subsequently located (D1.1 and D1.2). Here we report on the temporal and spatial distribution of the sub-daily data that have been digitised so far (mid-June 2015), focussing on the post-1950 period.

2. Spatial gaps in current post-1950 data availability

As outlined in D1.2, a comprehensive examination was conducted into the data already available in digitised form within the Meteorological Archival and Retrieval System (MARS) from the European Centre for Medium-Range Weather Forecast (ECMWF). These data in turn mainly come from the International Surface Pressure Databank (ISPD) for station-based observations and the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) for marine data, both being the basic input of the MARS Archive to support reanalysis. For the latter part of the period also data transmitted through the Global Telecommunication System (GTS) form the input to the MARS archives.

The focus is on the availability of several Essential Climate Variables (ECVs) as defined by the World Meteorological Organization (WMO)/Global Climate Observing System (GCOS): air temperature (TT), atmospheric pressure (SLP), wind speed and direction (WS and WD), relative humidity (RH), dew point temperature (DP), precipitation (RR), snow depth (SD) and snowfall (FS). Originally we had considered addressing both the temporal and spatial availability of these ECVs to improve the basic input data for high-resolution European Regional Reanalysis. However, due to the dramatic low spatial density for the aforementioned European sub-regions, we decided to focus our recovery effort primarily on the spatial infilling.

Figure 1 shows the distribution of the stations with at least 60% ECV data availability in MARS from 1960–2010, and ISPD (Version 3, SLP only) from 1950 to 2010 separated into

three key subregions identified in D1.2: the Mediterranean, Eastern Europe and Scandinavia. The MARS data reveal generally sparse spatial coverage, particularly in northern Africa, across much of Spain, Turkey, Sweden, former Czechoslovakia, Romania and the Balkan area. Examining SLP observations only using the ISPD shows slightly greater coverage, although these regions are still poorly represented in the complete dataset, and are lacking other ECVs.

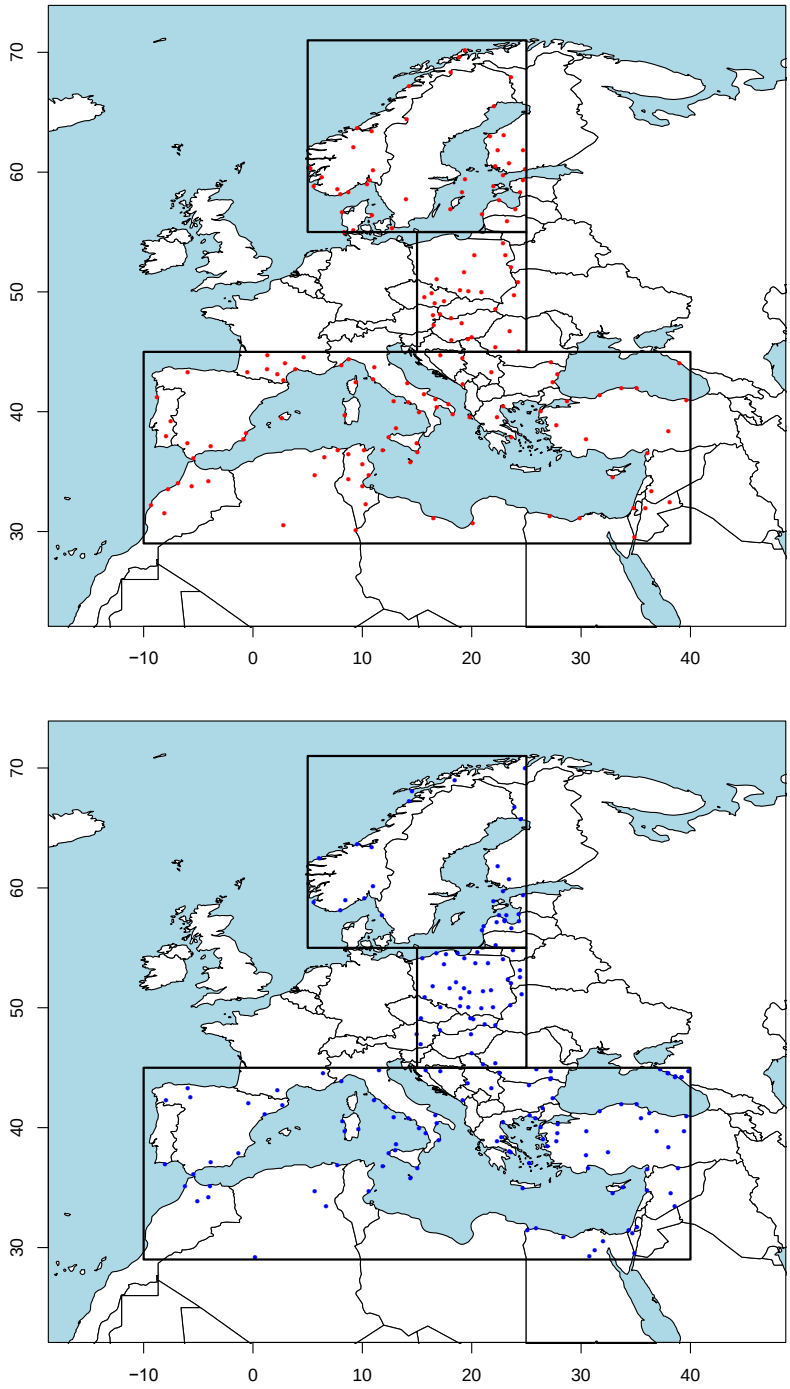

Figure 1. Coverage of stations with sub-daily data in MARS (top, 1960–2010) and ISPD (bottom, 1950–2010) in the three key subregions identified in D1.2: Scandinavia, Eastern Europe and the Mediterranean. Only stations with more than 60% of data available during

each period are shown.

3. Recovered station details and digitisation status

In this section, we give a summary of the digitisation effort on the first one and a half years of the project, while in Appendix A we provide a table listing the complete station details of our digitisation effort.

URV has so far located and digitised 107 stations with previously undigitised sub-daily data from the post-1950 period. The majority of the data sources were gathered from the US NOAA Climate Data Modernisation Program, with additional sources obtained from various NMSs. Germany airport and snowfall data were provided by the German Meteorological Service (Deutscher Wetterdienst), and the Catalonian Meteorological Service MeteoCat provided access to several Spanish scanned data sources given to them by the Spanish Meteorological Service (AEMET). Observations from Slovenia were provided by the Slovenian Environmental Agency and the Romanian National Meteorological Administration (NMA-RO) contributed digitising six-hourly precipitation data from Romania.

Table 1. Summary of the stations with recovered and digitised post-1950 data. In the variable column, TT = air temperature, RH=relative humidity, DP=dew point temperature, WD=wind direction, WS = wind speed, SLP = sea level pressure, RR=rainfall, FS = fresh snow and SD= total snow depth.

Country	**Number of Stations**	**Source**	**Variables**	**No. of obs per day**	**Main data period**
Algeria	2	NOAA-CDMP	SLP, TT, DP, WD, WS	3	1953–1968
Bosnia and Herzegovina	2	NOAA-CDMP	SLP, TT, RH, WD, WS	3	1951–1984
Croatia	2	NOAA-CDMP	SLP, TT, RH, WD, WS	3	1951–1984
Czech Republic	2	NOAA-CDMP	SLP, TT, RH, WD, WS	3–4	1951–1968
Egypt	18	NOAA-CDMP	TT, RH, DP, WD, WS, SLP	Up to 6	1951–1957
Germany	22	DWD	SD, FS, TT, SLP, RH, WD, WS	1 (snow stations), up to 24 (airport)	1958–1978
Morocco	8	NOAA-CDMP	SLP, TT, DP, WD, WS	2	1953–1968
Romania	6	National Meteorological Administration	RR	4	1979–2002
Serbia	3	NOAA-CDMP	SLP, TT, RH, WD, WS	3	1951–1970, 1992–2012
Slovakia	2	NOAA-CDMP	SLP, TT, RH, WD, WS	3	1951–1968
Slovenia	2	Slovenian Environmental	TT, SLP, RH, WD, WS, DP,	Up to 24	1950–1984

		Agency/NOAA-CDMP	RR, FS, SD		
Spain	2	AEMET through MeteoCat	SLP, TT, RH, DP, WD, WS	3–4	1954–1984
Turkey	24	NOAA-CDMP	SLP, TT, RH, WD, WS	3	1962–1971

The complete number of observations digitised by the URV partner under WP1 of the UERRA project for the post-1950 period at the moment of elaborating the report (mid-June 2015) is 4,993,413. An additional 300,000 precipitation values have been digitised by NMA-RO. Figure 2 shows the spatial distribution of the data, indicating the variables available at each station, the length (in decades) of the records and the number of observations per day at each station.

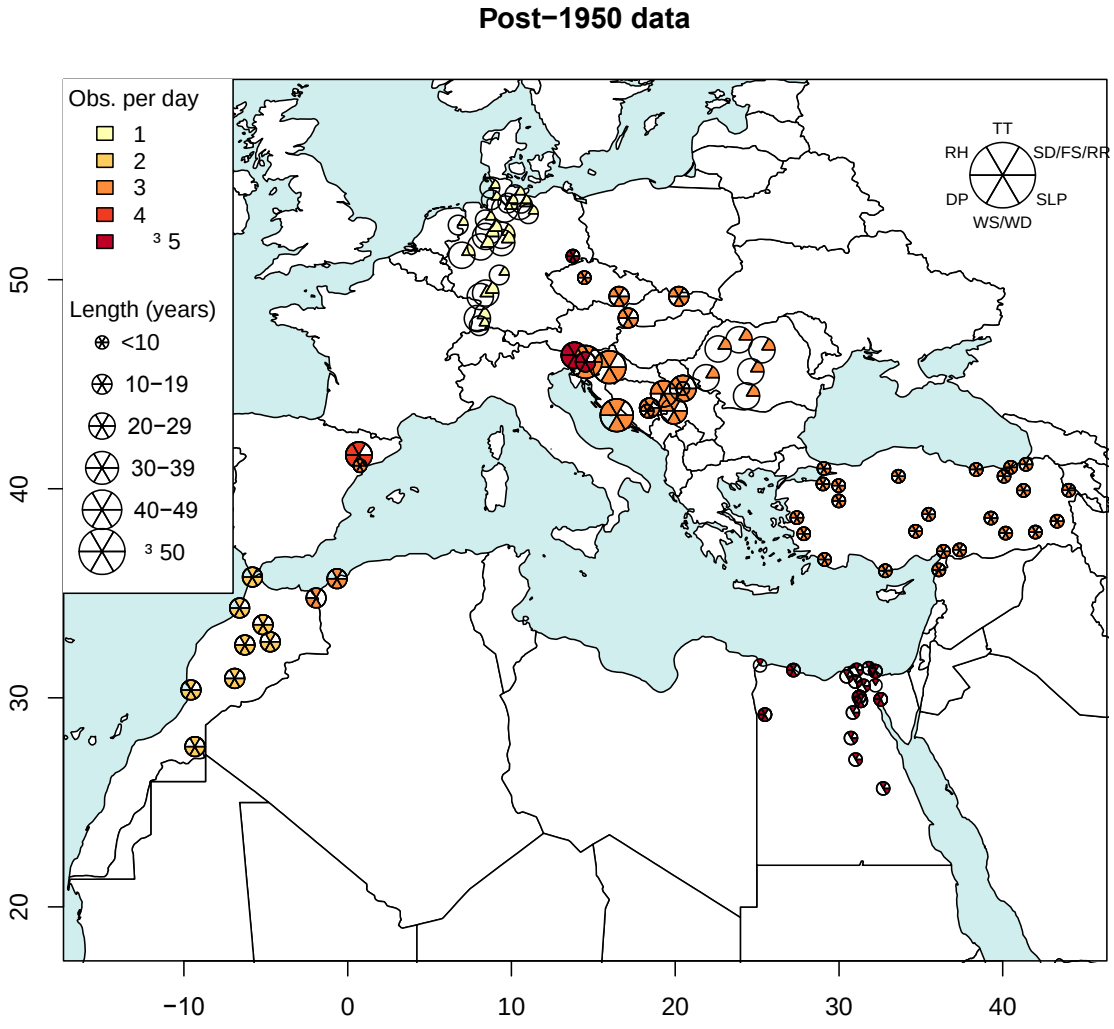

Figure 2. The geographical distribution of the post-1950 stations digitised through UERRA WP1. Shading represents the number of observations available per day at each station; the shaded section indicates the variables digitised; and the size of the symbol represents the length of the digitised record. Abbreviations are as in Table 1.

Breaking the digitised observations into variables (Figure 3), over 18% (977,592) are TT,

while nearly 16% (843,550) are SLP. WS and WD account for just over 32% of the data digitised (852,930 and 853,401 respectively), and over 15% of the observations are of RH (816,342). The difference in the total for wind speed and wind direction is due to several Egyptian stations, where WD was recorded with qualitative WS only for several periods during 1950–1957. There are also a number of observations where either WS or WD were illegible, and have not been digitised. DP, FS and SD data each make up less than 5% of the total amount of digitised observations, and the RR data contribute just over 8%, including the the NMA-RO contribution.

The bulk of the FS and SD data come from a network of stations in Germany (Figure 2), while precipitation data were mainly provided from the NMA-RO. Additional RR, FS and SD data have been gathered from Kredarica, a mountain station in Slovenia. Turkish data primarily consist of TT, RH, WD, WS and SLP, as do the longer datasets in the Balkan region. TT and SLP have been digitised for the Egyptian data network, although RH, DP, WS and WD were also digitised for several key stations.

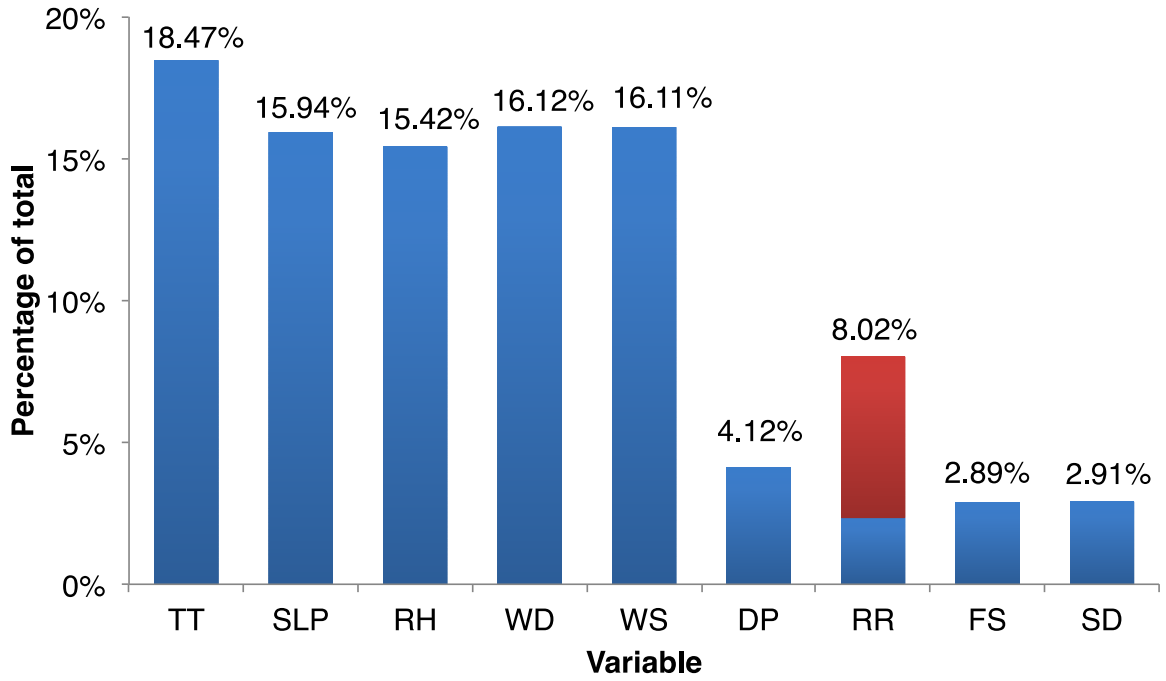

Figure 3. Percentage of total data digitised by URV (blue) and NMA-RO (red), separated into meteorological variables. Abbreviations as in Table 1.

Figure 4 shows the distribution of digitised data according to the time at which the observations were taken. The most frequent observing times are clearly 6–7am, 2pm, 6pm and 9pm. Data from the Balkans region and Turkey consist of observations at 7am, 2pm and 9pm. Data from Egypt provide observations at 6am, 8am, 12noon, 2pm, 6pm and 8pm, although these observations times change over the length of the dataset and generally only two or three are in use at once. The Romanian precipitation data are available for midnight, 6am, 12noon and 6pm.

The high percentage of daily observations is due to records of snowfall and snow depth from the network of 21 snowfall stations provided from Germany. The Slovenian snowfall observations from Kredarica are also daily, although occasional morning and afternoon

snowfall observations are provided. A small collection of stations from Slovenia and Germany with hourly records provides extremely high temporal resolution for these regions.

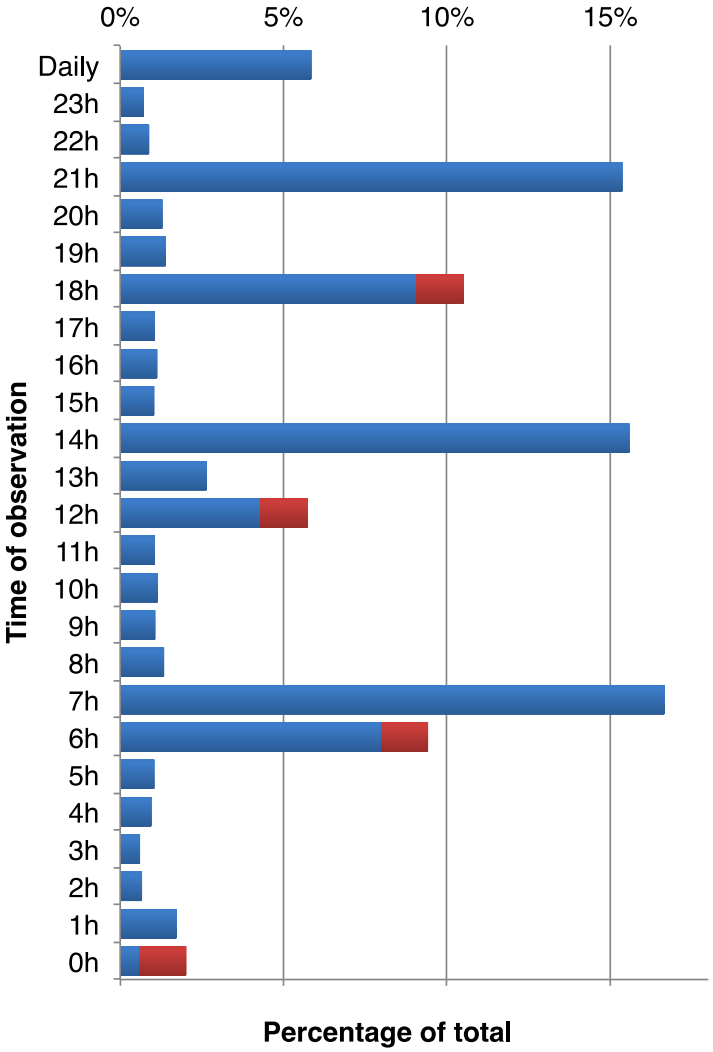

Figure 4. Distribution of post-1950 data digitised by URV (blue) and NMA-RO (red) under UERRA WP1 according to the time of observation.

3.1. Spatial and temporal distribution of digitised data

Comparing Figure 1 to Figure 2 reveals where spatial infilling has been achieved by the UERRA WP1 digitisation effort. A significant amount of data availability had been provided for the majority of the North African countries that border the Mediterranean, namely Morocco, Egypt and Algeria. The addition of 24 stations in Turkey also offers a valuable addition to the eastern Mediterranean area. Recovered data from Slovenia, Croatia, Serbia and the Czech Republic provide additional observations for the Eastern European sector. In the framework of UERRA, NMA-RO has also digitised 6-hourly precipitation data at six Romanian stations for the available time interval (generally starting in 1970s and ending in 2002).

Table 1 and Figure 2 indicate that most of the other newly digitised data cover the 1950s to 1970s, and the stations with the longest period of data availability are in the Balkans sector. Observations from northern Africa and Turkey are shorter (less than 20 years), although it

should be noted that many of these sources contain much longer series of observations in the pre-1950 period.

As already commented in D1.1, most of the accessible on-line data sources mainly provide information for the pre-1950 period, since the majority of the most recent period remains in original logbooks and scanned format at NMS archives. Therefore, the URV is also placing efforts to digitise pre-1950 data, since it will support an improved data input for historical reanalysis, such as the ERA-20C reanalysis of ECMWF.

3.2. Remaining post-1950 data to be gathered

No data have yet been made available for Scandinavia, one of the key sub-regions identified D1.2. This is largely due to the internal policies of the national data rescue (DARE) programs, which don't allow scanned data or original logbooks to be passed onto third parties. However, large amounts of digitised data are freely available from the respective NMSs, and these archives are currently being explored for sub-daily observations. Figure 5 shows examples of the online interfaces being used to identify and extract sub-daily data from the Swedish and Norwegian NMSs.

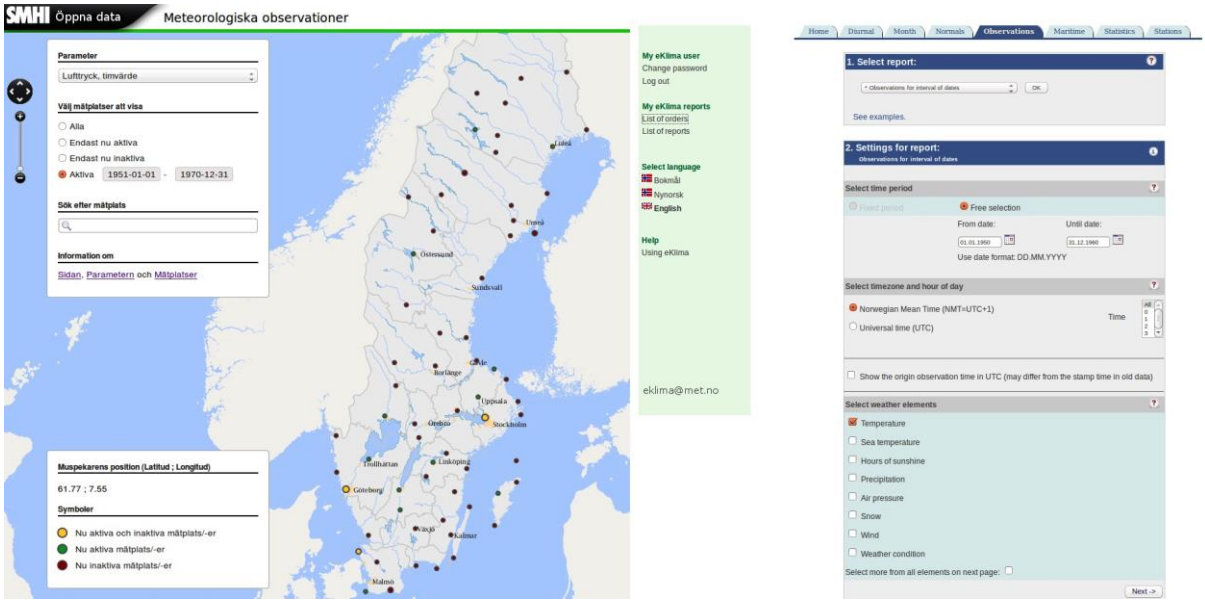

Figure 5. Examples of SMHI Öppna Data (http://opendata-catalog.smhi.se/explore/, left), the SMHI data portal, and Norwegian Meteorological Institute's eKlima (http://eklima.met.no, right), being used to extract digitised data for the Scandinavian region.

In addition, the URV partner is still attempting to gain access to further post-1950 scanned data from AEMET to continue adding observations and infilling spatial gaps of the targeted period in the last 6 months of UERRA digitisation effort (from month 19th to 24th). Requests for scanned data have also been sent to Libya, Jordan, Macedonia the FYR, Montenegro and Serbia (Romania). Every effort has been made to obtain data from these regions by contacting relevant NMSs and environmental organisations. However, political instability (e.g. Libya) and poorly-resourced services (e.g. Jordan, Montenegro, Macedonia, the FYR, Serbia) have so far prevented the successful delivery of scanned data for digitisation.

Appendix A. Complete list of stations with post-1950 sub-daily digitised data digitised under UERRA WP1.

Country	Station name	WMO code	Latitude	Longitude	Altitude (m)	Variables	Observing times	Period
Algeria	Oran	60461	35.7	-0.65	53	SLP, TT, DP, WD, WS	6h/7h/18h	1953-1968
	Tindouf	60656	27.67	-9.33	431	SLP, TT, DP, WD, WS	6h/18h	1953-1968
Bosnia & Herzegovina	Sarajevo-Butmir	14653	43.87	18.43	630	SLP,TT,RH,WD,WS	7h/14h/21h	1949-1960, 1970-1984
	Bjelasnica	14652	43.72	18.28	2067	SLP,TT,RH,WD,WS	7h/14h/21h	1953-1960
Croatia	Zagreb-Gric	14236	45.82	15.98	157	SLP,TT,RH,WD,WS	7h/14h/21h	1949-1984
	Split-Marjan	14445	43.52	16.43	122	SLP,TT,RH,WD,WS	7h/14h/21h	1949-1984
Czech Republic	Brno-Kvetna	11721	49.2	16.57	233	SLP,TT,RH,WD,WS	7h/14h/21h	1948-1968
	Praha-Luzyne	11518	50.1	14.45	381	SLP,TT,RH,WD,WS	7h/14h/21h	1965-1966
Egypt	Damietta	62330	31.42	31.82	5	TT, SLP	6h/8h/12h/14h/20h	1934-1957
	Damanhour	62339	31.03	30.47	2	TT, SLP	6h/8h/12h/14h/20h	1934-1957
	El Mansura	62342	31.34	31.08	10	TT, SLP	6h/8h/12h/14h/20h	1932-1957
	Tanta	62348	30.78	31	15	TT, SLP	6h/8h/12h/14h/20h	1927-1957
	Zagazig	62354	30.58	31.5	13	TT, SLP	6h/8h/12h/14h/20h	1913-1957
	Minya	62387	28.08	30.73	40	TT, SLP	6h/8h/12h/14h/20h	1907-1957
	Asyut-Heat airport	62393	27.05	31.02	226	TT, SLP	6h/8h/12h/14h/20h	1907-1957
	Luxor Airport	62405	25.67	32.7	93	TT, SLP	6h/8h/12h/14h/20h	1936-1957
	Fayoum	62381	29.3	30.85	23	TT, SLP	6h/8h/12h/14h/20h	1932-1957
	Salloum	62300	31.55	25.18	4	TT	6h/8h/12h/14h/20h	1919-1957
	Mersa Matruh	62306	31.33	27.22	25	TT, RH, DP, WD, WS	6h/8h/12h/14h/20h	1920-1957
	Port Said	62333	31.28	32.23	6	TT, RH, DP, WD, WS	6h/8h/12h/14h/20h	1907-1957
	Cairo Ezbekiya	62374	30.05	31.25	20	TT, RH, DP, WD, WS	6h/8h/12h/14h/20h	1909-1957
	Giza (Cairo)	62375	30.03	31.21	28	TT	6h/8h/12h/14h/20h	1907-1957
	Helwan (Cairo)	62378	29.86	31.34	116	TT, RH, DP, WD, WS	6h/8h/12h/14h/20h	1907-1957
	Siwa	62417	29.2	25.48	-15	TT, RH, DP, WD, WS	6h/8h/12h/14h/20h	1912-1957

	Ismailia	62441	30.6	32.23	10	TT	6h/8h/12h/14h/20h	1948-1957
	El Suez	62450	29.93	32.55	10	TT, RH, DP, WD, WS	6h/8h/12h/14h/20h	1907-1957
Germany	Nusse	27024	53.6572	10.585	35	SD,FS	Daily	1961-1978
	Bornhoved	27221	54.0667	10.2167	40	SD,FS	Daily	1960-1978
	Westerhever	30155	54.3808	8.6819	1	SD,FS	Daily	1960-1978
	Hademarschen	30301	52.1244	9.4069	46	SD,FS	Daily	1958-1978
	Cuxhaven	31115	53.8256	8.7719	2	SD,FS	Daily	1960-1978
	Laar	33055	52.6153	6.7442	11	SD,FS	Daily	1960-1978
	Hitzacker	48261	53.155	11.0358	28	SD,FS	Daily	1961-1978
	Schwarzerbek	48527	53.5047	10.4881	40	SD,FS	Daily	1958-1978
	Sauensiek	48605	53.3817	9.5975	39	SD,FS	Daily	1958-1979
	Pinneberg	48635	53.6642	9.7819	8	SD,FS	Daily	1958-1976
	Höxter	52336	51.7769	9.4006	93	SD,FS	Daily	1958-1978
	Werther	53024	52.07	8.4208	134	SD,FS	Daily	1958-1978
	Lubbecke	53131	52.3214	8.6189	55	SD,FS	Daily	1958-1978
	Wildeshausen	56402	52.8672	8.4047	48	SD,FS	Daily	1961-1978
	Bernau-kaiserhaus	70233	47.8	8.0333	920	SD,FS	Daily	1961-1976
	Freiamt-Keppenbach	70312	48.1447	7.9194	275	SD,FS	Daily	1958-1978
	Landau-Pfalz	70677	49.1958	8.0972	150	SD,FS	Daily	1958-1978
	Speyer	70755	49.3611	8.4225	99	SD,FS	Daily	1958-1978
	Biebergemund-Wirtheim	74151	50.2275	9.2519	135	SD,FS	Daily	1961-1978
	Hilden	78384	51.17	6.97	66	SD,FS	Daily	1958-1978
	Soest	79350	51.57	8.12	110	SD,FS	Daily	1958-1978
	Dresden	10488	51.13	13.75	230	SLP,TT,DP,RH,WS,WD	Hourly	1960-1966
Morocco	Tangier city	60100	35.78	-5.82	86	SLP, TT, DP, WD, WS	6h/18h	1953-1968
	Oujda	60115	34.78	-1.93	478	TT, DP, WD, WS	6h/7h/18h	1953-1964
	Agadir	60250	30.38	-9.57	19	SLP, TT, DP, WD, WS	6h/18h	1953-1968

	Ifrane	60160	33.50	-5.17	1664	SLP, TT, DP, WD, WS	6h/18h	1953-1968
	Kasba-Tadla	60190	32.53	-6.28	518	SLP, TT, DP, WD, WS	6h/18h	1953-1968
	Midelt	60195	32.68	-4.73	1515	SLP, TT, DP, WD, WS	6h/18h	1953-1968
	Ouarzazate	60265	30.93	-6.90	1136	SLP, TT, DP, WD, WS	6h/18h	1953-1968
	Kenitra (Port-L Yautey)	60120	34.30	-6.6	14	SLP, TT, DP, WD, WS	6h/18h	1953-1968
Romania	Bâlea Lac	15279	45.603	24.614	2070	RR	6h/12/18h/24h	1979 - 2002
	Bucin	15148	46.648	25.296	1282	RR	6h/12/18h/24h	1978 - 2002
	Dej	15083	47.128	23.898	232	RR	6h/12/18h/24h	1974 - 2002
	Reșita	15314	45.314	21.886	279	RR	6h/12/18h/24h	1979 - 2002
	Slatina	15434	44.442	24.354	172	RR	6h/12/18h/24h	1977 - 2002
	Stâna de Vale	15118	46.689	22.623	1108	RR	6h/12/18h/24h	1979 - 2002
Republic of Serbia	Zlatibor	13367	43.73	19.92	1029	SLP, TT, RH, WD, WS	7h/14h/21h	1992-2012
	Loznica	13262	44.55	19.3	121	SLP, TT, RH, WD, WS	7h/14h/21h	1992-2012
	Beograd-Surcin	13272	44.8	20.47	132	SLP,TT,RH,WD,WS	7h/14h/21h	1949-1970, 2011-2012
	Beograd-Surcin	13272	44.8	20.47	132	SLP,TT,RH,WD,WS	7h/14h/21h	2011-2012
Slovak Republic	Bratislava-Trnavaka	11814	48.17	17.13	139	SLP,TT,RH,WD,WS	7h/14h/21h	1948-1968
	Lomnicky Stit.	11930	49.2	20.22	2638	SLP,TT,RH,WD,WS	7h/14h/21h	1940-1966
Slovenia	Ljubljana-Bezigrad	14015	46.07	14.52	299	SLP,TT,RH,WD,WS, RR	7h/14h/21h	1951-1984
	Kredarica	14008	46.383	13.85	2515	SLP, TT, DP, RH, WD, WS, RR, FS,SD	Hourly	1958-1978
Spain	Tarragona	42	41.1	0.7517	58	SLP,TT,RH,DP,WD,WS	7h/13h/18h	1977-1984
	Lleida	9771	41.617	0.6855		SLP,TT,RH,DP,WD,WS	1h/7h/13h/18h	1954-1974
Turkey	Istambul-Goztepe	17062	40.97	29.08	40	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Bursa	17116	40.23	29.02	101	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1966
	Erzurum	17096	39.92	41.27	1756	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Van	17170	38.45	43.32	106	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971

	Diyarbakir	17280	37.88	40.18	686	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Rize	17040	41.03	40.49	29	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Manisa	17186	38.62	27.43	71	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Aydin	17234	37.85	27.85	57	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Kutahya	17155	39.42	29.99	969	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Kayseri	17195	38.78	35.48	1054	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1965
	Anamur	17320	36.08	32.83	4	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Antakya	17984	36.12	36.1	272	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Islahiye	17964	37.01	36.38	645	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Gaziantep	17260	37.08	37.37	855	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1966
	Siirt	17210	37.93	42	895	SLP,TT,RH,WD,WS	7h/14h/21h	1962-1971
	Artvin	17045	41.17	41.42	30	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971
	Bilecik	17120	40.15	29.98	539	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971
	Cankiri	Not found	40.6	33.63	245	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971
	Elazig	17202	38.6	39.28	903	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1966
	Fethiye	17296	36.62	29.12	3	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971
	Giresun	17034	40.92	38.38	37	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1966
	Igdir	17100	39.93	44.03	858	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971
	Kars	17098	40.6	40.08	1775	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971
	Nigde	17250	37.97	34.68	1208	SLP,TT,RH,WD,WS	7h/14h/21h	1963-1971