Phase 1 Quality control and homogenisation of the hourly air temperature data

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1 Introduction

Air temperature is an essential climate variable that characterizes the heating or cooling state of the atmosphere measured in the immediate vicinity of the ground. It is the direct result of the interaction between solar radiation, atmospheric circulation and terrestrial surface (Jarraud 2008).

Air temperature plays an important role in socio-economic activities, therefore for the spatio-temporal analysis of the thermal regime all existing data sources have to be considered. For climatic studies, it is always preferable to use data provided by a dense network of meteorological stations. However, the quality of data sets is directly influenced by different standards of data measurements and types of instruments. The main objectives of the current project phase were (1) to do an inventory of all available data sources useful for project purposes, and (2) to perform the quality control and homogenization of the selected set.

2 Select and pre-process the input data

Hourly air temperature data sources available between 2009-2017 on the territory and in the immediate vicinity of Romania have been selected from four data sources: Romanian National Meteorological Administration Network (ANM), Romanian National Air Quality Monitoring Network (RNMCA), Regional Basic Synoptic Networks (RBSN) and Meteorological Aerodrome Report Network (METAR). To achieve the objectives of this stage, all available hourly air temperature measurements have been used.

TThe ANM network consists of 161 weather stations measuring the most essential weather parameters. Observations are carried out within ANM according to methodologies established by the World Meteorological Organization (WMO) and adapted to national needs with comparable instruments and methodologies.

The National Network for Monitoring Air Quality (RNMCA) comprises 142 stations equipped with automatic instruments to measure concentrations of the main atmospheric pollutants: sulphur dioxide (SO2), nitrogen oxides (NO2 / NOX), carbon monoxide (CO), ozone O3), suspension powders (PM10 and PM2.5), benzene (C6H6) metals (http://www.anpm.ro/reteaua-nationala-de-monitorizare-a-calitatii-aerului). In addition to the monitoring of atmospheric pollutants, there are stations (117) in the RNMCA that also perform air temperature, relative humidity and wind speed and direction measurements at hourly frequency. Both atmospheric pollutant data and meteorological measurements can be accessed in real time on the Air Quality website (http://www.calitateaer.ro), managed by the Ministry of Environment.

Weather stations located at airports, military bases, and other sites perform measurements of meteorological parameters (air and dew point temperature, wind direction and speed, precipitation, cloud cover and heights, visibility, and barometric pressure), with an hourly and sub-hourly frequency, to ensure the safety of the air traffic. Meteorological information is available in real time through the Global Telecommunications System (GTS), using the METAR standardized format (WMO 2008).

More than 4900 stations comprise the Regional Basic Synoptic Networks, which is a component of a of the Global Observing System (http://www.wmo.int/pages/prog/www/OSY/Gos-components.html). Data measured from these stations at are exchanged globally in real time using GTS (transmission completed 30 minutes after each synoptic observation hour). Meteorological data are freely available and unrestricted according to the WMO data policy agreed in Resolution 40 (http://www.wmo.int/pages/prog/hwrp/documents/wmo_827_enCG-XII-Res40.pdf). 2

Using four data sources (ANM, RNMCA, METAR and RBSN), metadata and air temperature data from 354 meteorological stations (ANM 161 stations, RNMCA 117 stations, METAR 5 stations and RBSN 71 stations) were extracted (Appendix 1). The spatial distribution of the selected stations is approximately homogeneous, air temperature records being available for both Romania and neighbouring regions (figure 1).

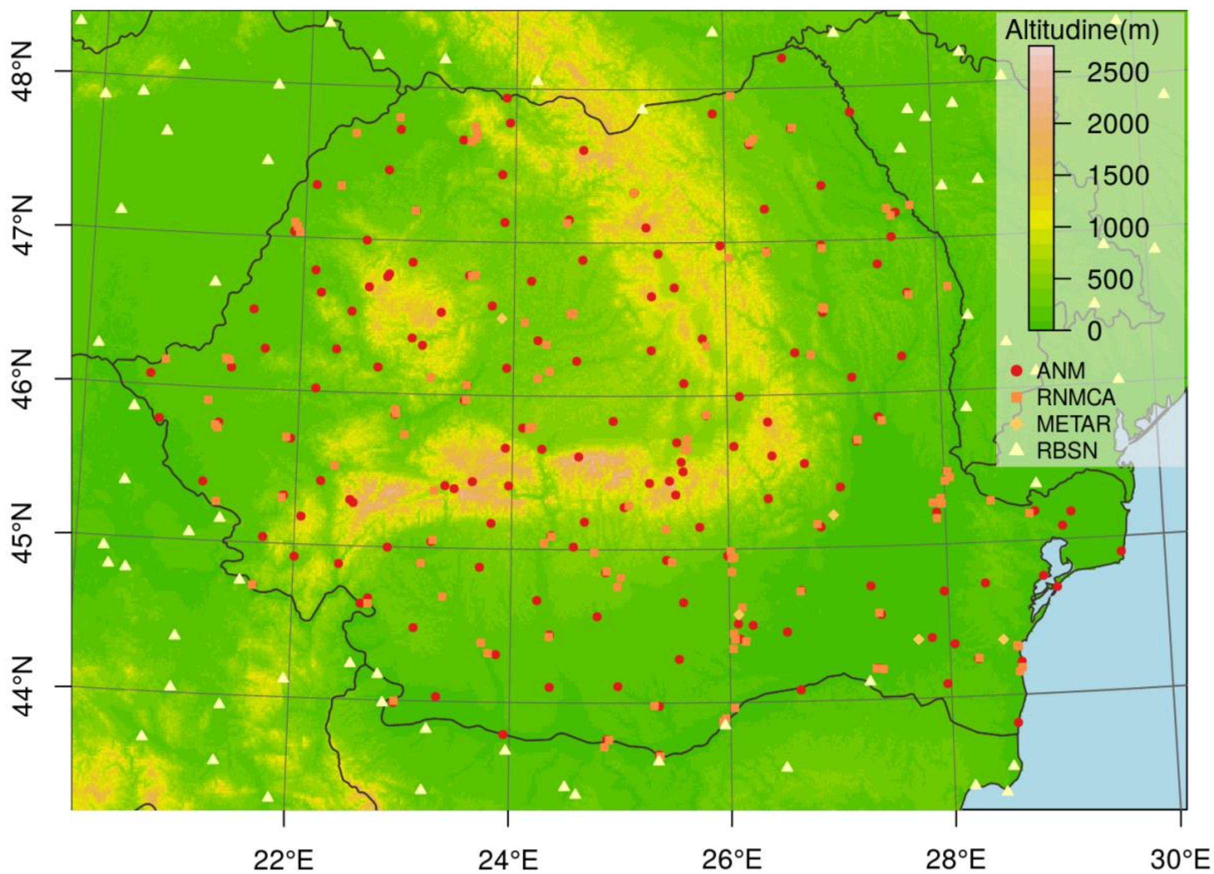

Figure 1: Spatial distribution of the selected weather stations (ANM, RBSN, METAR and RBSN)

Analysing the availability of hourly measurements, one can remark that from the total of 27,926,352 values (354 stations * 78888 hours), 7,067,118 hourly air temperature values are unavailable due to various causes (e.g. sensors fault, transmission errors, etc). A summary of the completeness of data, based on data source categories, is presented in the table 1. Compared to the total number of values, the fewest missing values were found in the ANM database (7.9%), and the most in the RBSN database (63.0%).

Table 1: Availability of the hourly air temperature data

Missing data	ANM	RNMCA	METAR	RBSN	Total
NO	11694123	6785612	308202	2071297	20859234
YES	1006845	2444284	86238	3529751	7067118

3 Quality control of air temperature data

In Romania, meteorological measurements are currently almost entirely realised by using automatic instruments. The information provided by automatic instruments, at a hourly and sub-hourly intervals, is archived in near-real time. Validation of meteorological data implies identifying outliers, from the point of view of the statistical consistency with the time series analysed, for a period of at least five years of data. Automated data quality control (QC) is required to determine whether meteorological information has been properly obtained and implicitly whether if maintenance and/or calibration of the sensors must be performed (Estévez et al. 2011).

The different types of instruments and standards used in performing the meteorological measurements determine the quality of weather observations (figure 2).

Four tests were used to assess the quality of hourly air temperature measurements, obtained between 2009-2017 on the territory and in the immediate vicinity of Romania: climatic limits consistency, persistence, step and spatial consistency.

3.1 Climatic limit test (T1)

Test if the hourly observed value is lower or higher than the specific climatological limits for the area analysed (Cheng et al. 2016; Steinacker et al. 2011). Monthly multi-annual maximum and minimum air temperature obtained from the National Meteorological Administration Network computed between 1981-2017 were used as climatological limits (figure 3).

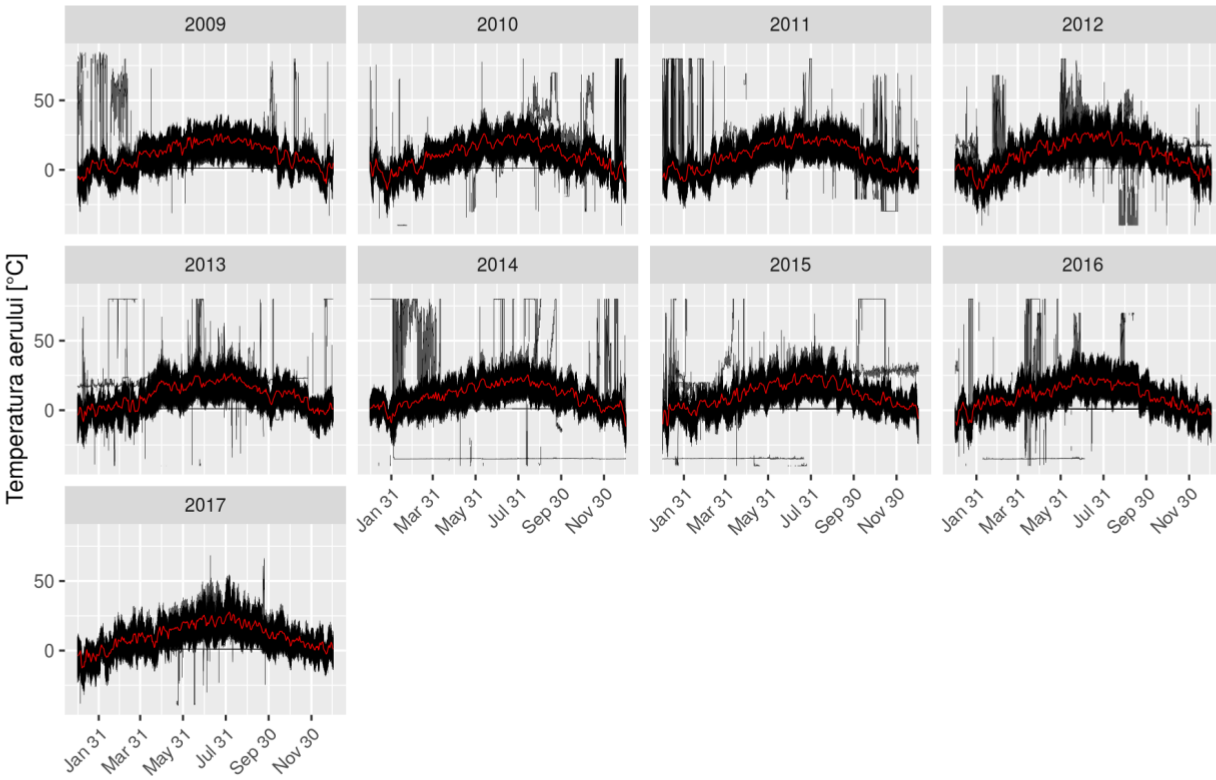

Figure 2: Yearly time series plots of the hourly air temperature data from four data sources (raw data). The spatial median across all stations is shown in red.

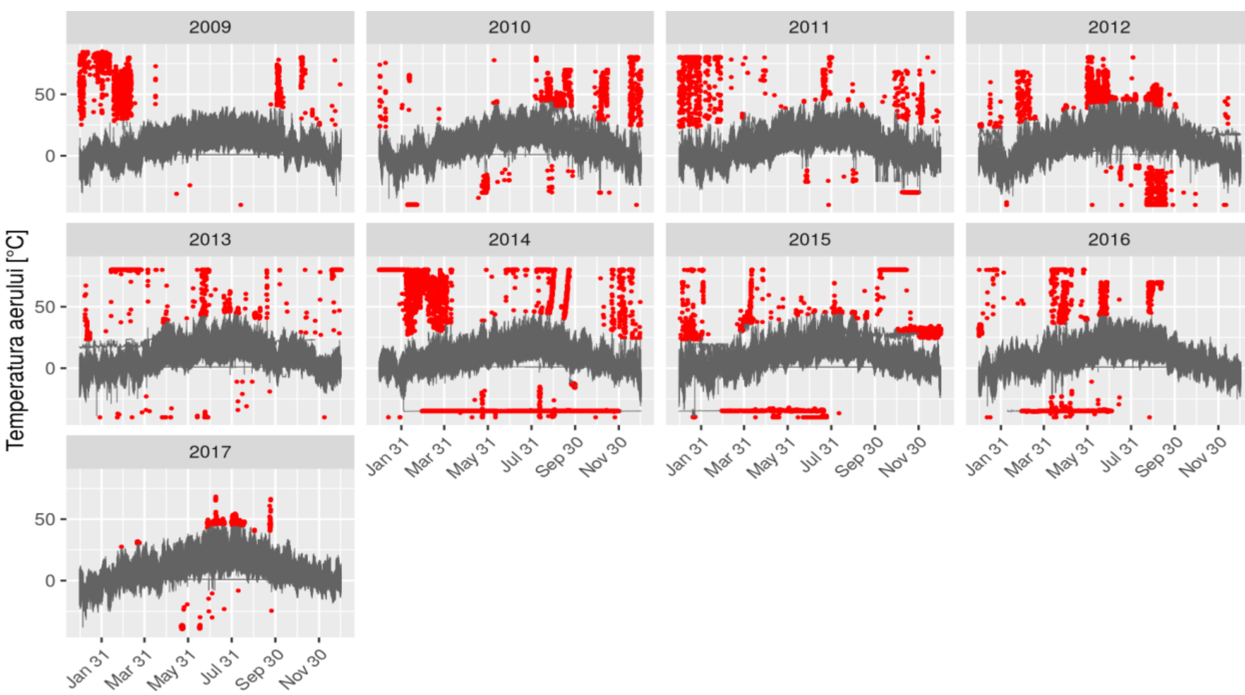

Figure 3: Yearly time series of the hourly air temperature data. The red dots represent the suspicious values detected by T1.

3.2 Persistence test (T2)

Check the largest difference between observations within a moving time range (24 h) (Schroeder et al. 2005; Zahumensky 2004). If the difference is less than a maximum acceptable change (0.1°C), all the values of that parameter for the station under consideration are flagged as questionable (figure 4).

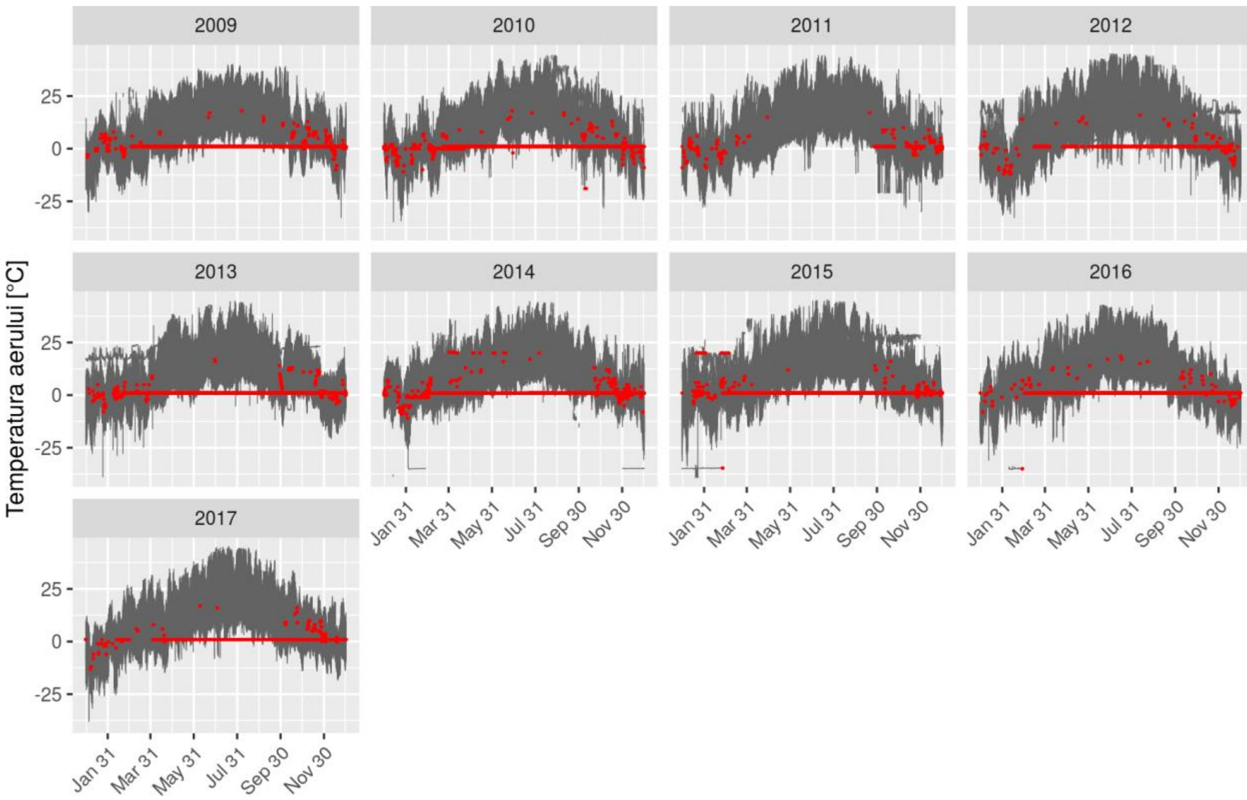

Figure 4: Yearly time series of the hourly air temperature data. The red dots represent the suspicious values detected by T2

3.3 Step test (T3)

Check the differences between the current value (T_i) and the previous one ($T_i - 1$) and between the current value and the following one ($T_i + 1$) (figure 4). If the computed values met the following criteria, the air temperature values were excluded from further analysis (Lott 2004):

$(T_i - T_{i-1}) > 8°C$

and

$(T_i - T_{i+1}) > 8°C$

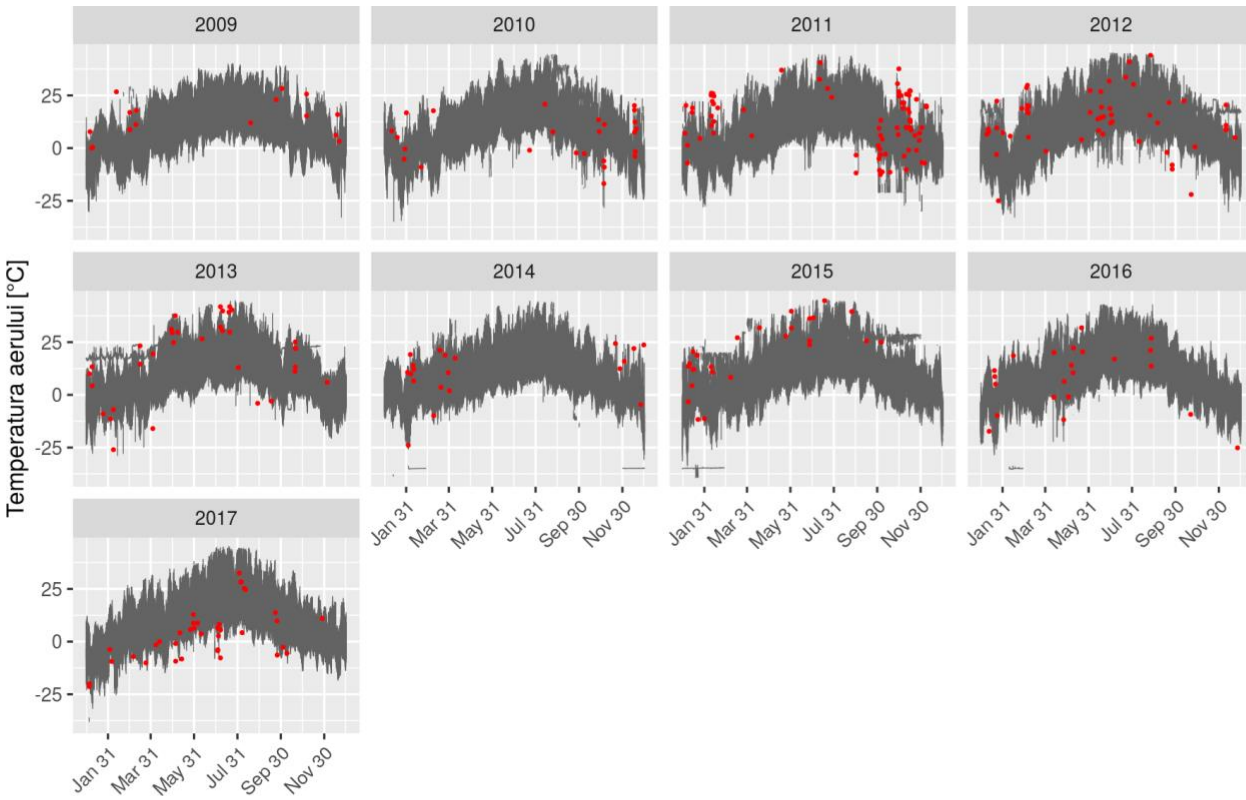

Figure 5: Yearly time series of the hourly air temperature data. The red dots represent the suspicious values detected by T3.

3.4 Spatial consistency check (T4)

Checks are performed on the hourly air temperature data by using Regression Kriging (RK) spatial interpolation method. The true values (T_i) and expected values (Z_i) of the hourly air temperature are compared by using the following criteria (Shafer et al. 2000):

$$\frac{T_i - Z_i}{\sigma_i} > p$$

If the differences between the two values exceed certain threshold (p) , the observed values are removed from the analysis (figure 4). The threshold was determined by computing the standard deviation (σ_i) from all the stations used to estimate the hourly temperature values for a given station:

$$p = \begin{cases} 1.0, & \text{if } \sigma_i \leq 0.5 \\ 2.0, & \text{if } \sigma_i > 0.5 \;\&\; \sigma_i \leq 1.0 \\ 3.0, & \text{if } \sigma_i > 1.0 \;\&\; \sigma_i \leq 2.0 \\ 4.0, & \text{if } \sigma_i > 2.0 \;\&\; \sigma_i \leq 3.0 \\ 6.0, & \text{if } \sigma_i > 3.0 \;\&\; \sigma_i \leq 4.0 \\ 8.0, & \text{if } \sigma_i > 4.0 \;\&\; \sigma_i \leq 5.0 \\ 10.0, & \text{if } \sigma_i > 5.0 \end{cases}$$

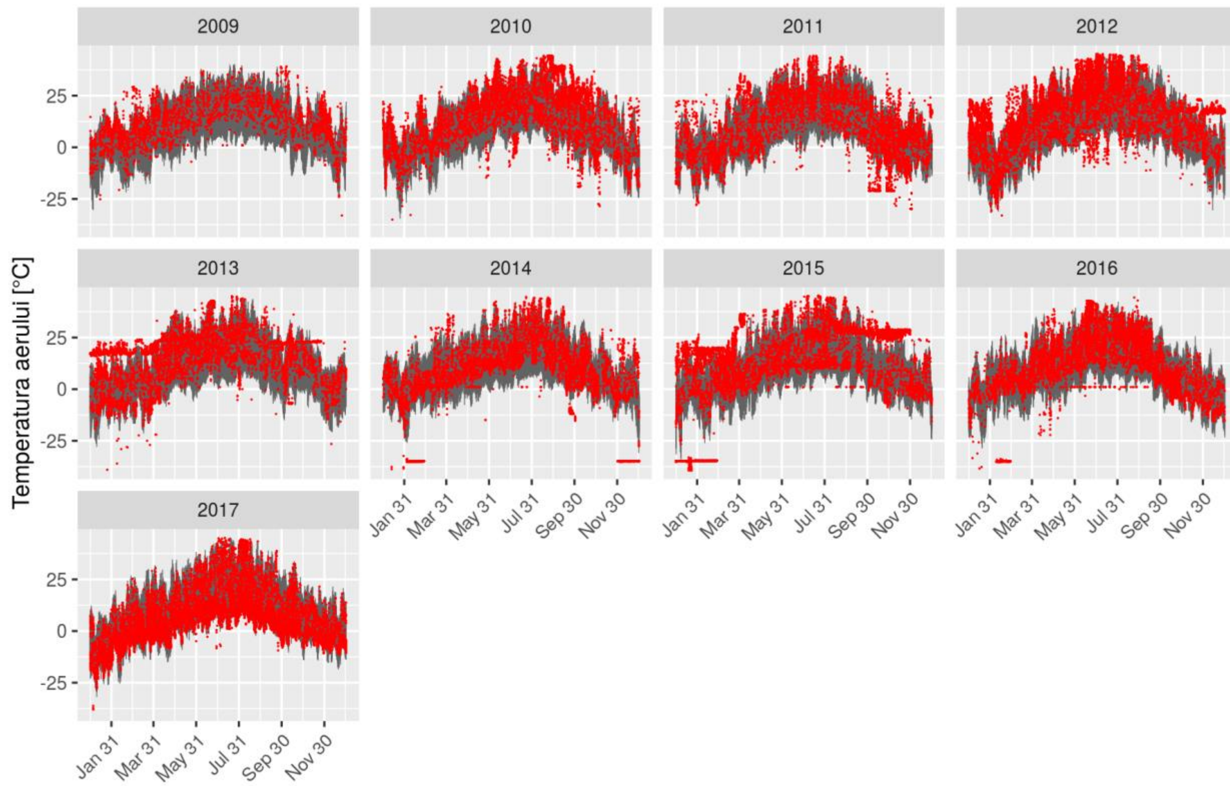

Figure 6: Yearly time series of the hourly air temperature data. The red dots represent the suspicious values detected by T4.

3.5 Hourly air temperature quality-controlled data set

Following the quality control procedures (T1, T2, T3 and T4), a unified set of hourly air temperature data was obtained (figure 7), provided by a network of stations covering homogeneously the country's surface, as well as its surrounding. Gross errors have been identified, mostly due to the malfunctioning of the temperature sensors, which have transmitted the same value for a long time, as well as errors in which variations in measurements have been high for at least two consecutive hours. Also, analysing the values from the neighbouring stations, the possible errors were also reported in cases when the measurements at the analysed station do not fall within the general limits of the spatial variation of the temperature, according to the measurements of the closest 30 meteorological stations (neighbour stations).

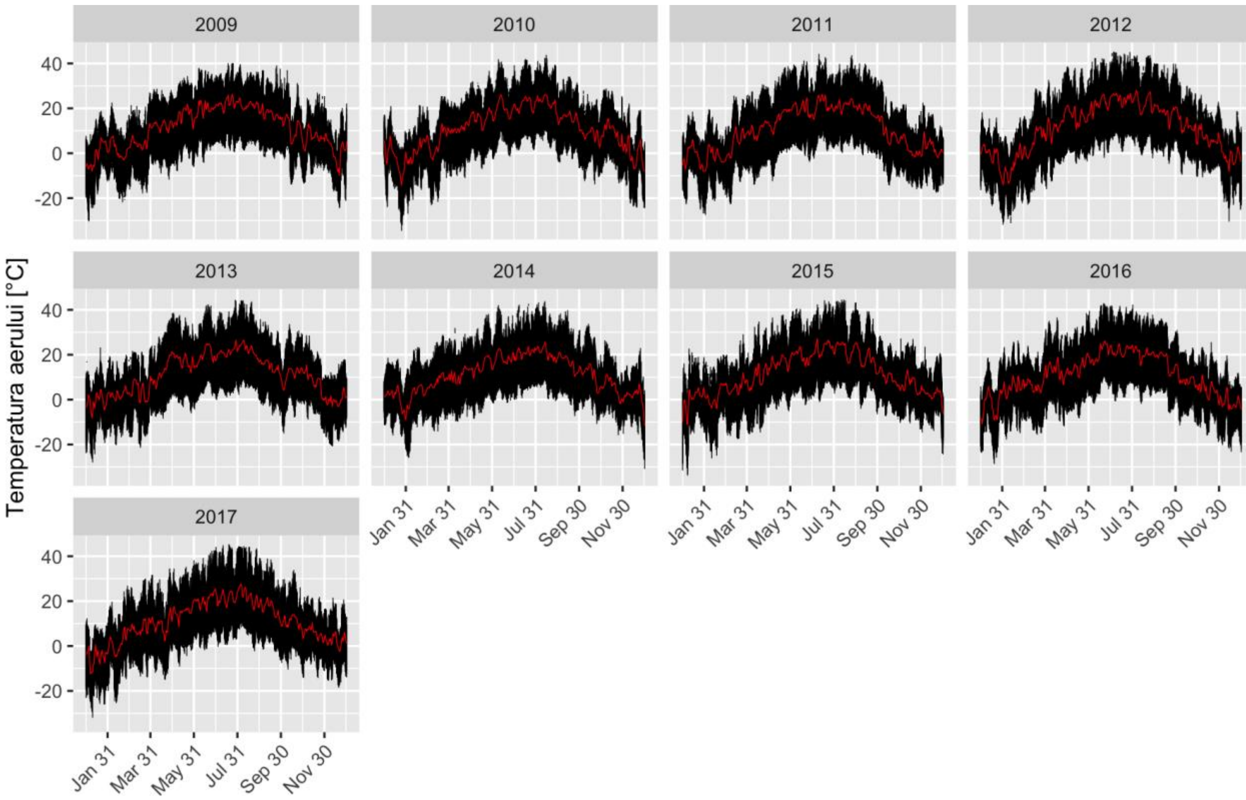

Figure 7: Yearly time series of the hourly air temperature data. The red dots represent the suspicious values detected by T1, T2, T3 and T4.

4 Homogenisation

Meteorological observations may be affected by events unrelated to spatio-temporal variability specific to weather phenomena (errors in transmitting or measuring). Independent of true weather and climate variability and change, changes in the measuring instruments, and the changes in the location or the surroundings of the stations represent another category of factors that can influence meteorological measurements (Aguilar et al. 2003).

Findings of meteorological and climatic studies may be altered when they are based on data sets that contain inhomogeneities. Therefore, in order to reduce or eliminate the false signals from the climatic data series, several methods of homogenisation were developed (Venema et al. 2013).

4.1 Climatol

The homogenisation and data filling of the unified hourly air temperature data set were performed using the R package climatol: Climate Tools (Series Homogenization and Derived Products). Beside meteorological records, Climatol uses as additional data information about meteorological stations (metadata) as longitude, latitude and altitude (Guijarro 2018).

The *climatol* method was successfully used to homogenize air temperature data in Spain, Greece, Chile (Guijarro 2017), obtaining similar results like other homogenization methods tested under COST ES0601 (Mamara et al. 2013; Venema et al. 2013).

4.2 Exploratory data analysis

Prior to homogenise the data, it must be checked if for each time step temperature data from at least five weather stations are available. Considering the large number of selected stations, this criteria is met, the unified set of data containing the necessary number of data required to carry out the homogenization procedure (figure 8).

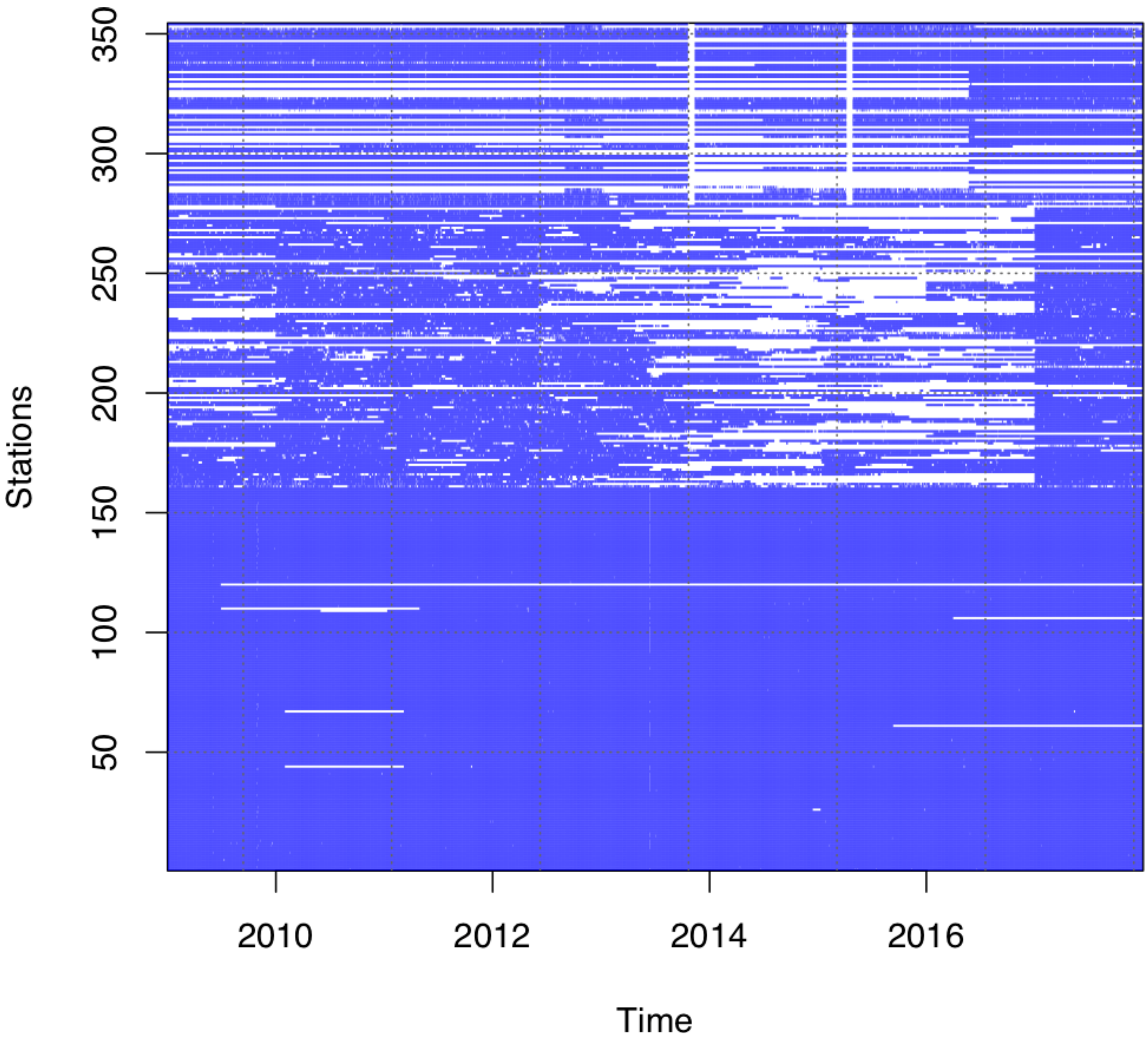

Figure 8: Data availability from unified data set (00:00 UTC). Stations from the graph (Y axis) are indexed according to Appendix 1. The white areas represent missing data.

It is also necessary to verify whether the outliers that have not been eliminated in the pre-homogenization stage (data quality control) are present in the database. The seasonal histogram constructed from all the hourly data confirms that the values have a normal distribution. (figure 9).

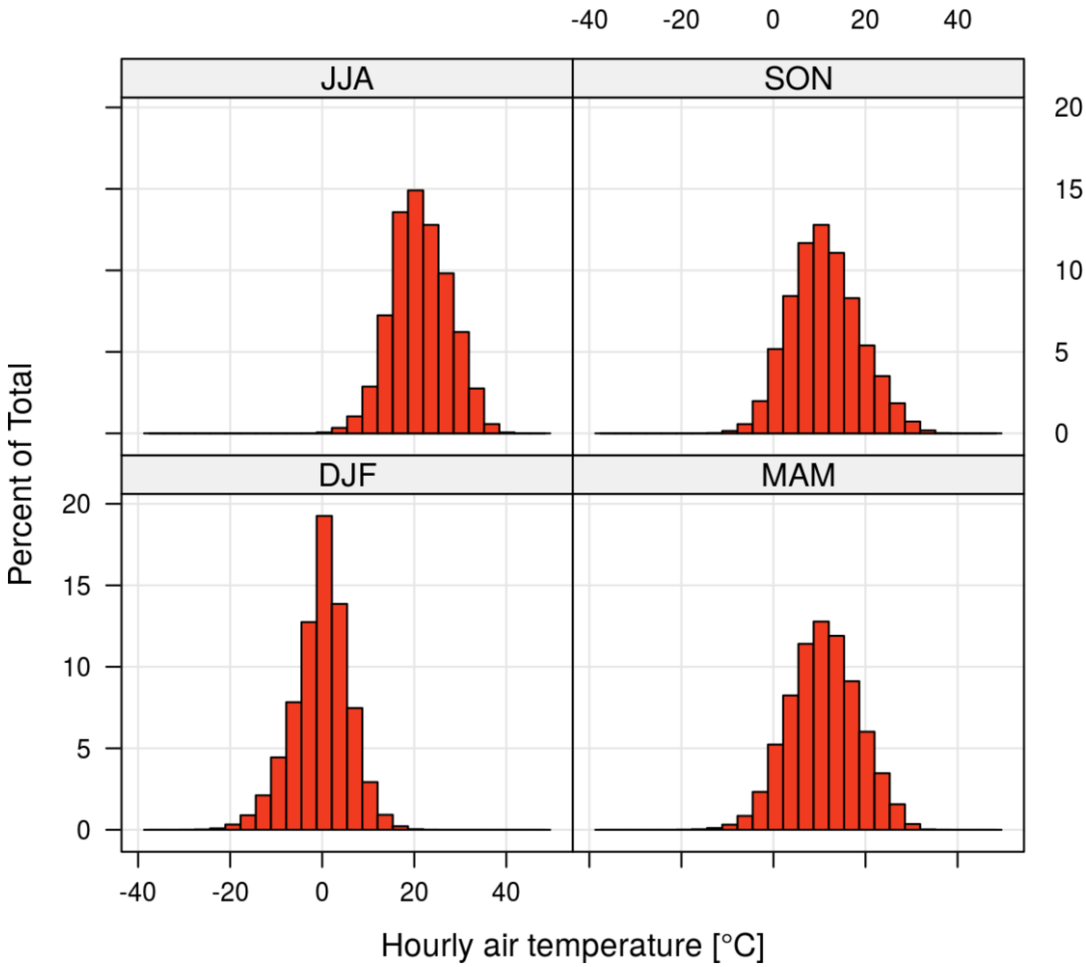

Figure 9: Histogram of all hourly air temperature data.

In the unified data set, climatol identified 63 breakpoints, most of them in the RNMCA database (58), 4 in the ANM and 1 in the RBSN, respectively. No breakpoints were detected in the data obtained from METAR network. Given the short series of times (a few years), break points in data series can be attributed to the existence of anomalies in the operation of measuring instruments. No major changes in station metadata have been identified that may explain the occurrence of change points in data series (location change or major changes in surface characteristics in the proximity of stations).

4.3 Results

After inspecting the exploratory analysis plots dedicated to check the data, the standardized anomalies plots are used to identify the inhomogeneities in the time series (break points). They are realised iteratively, for each station, using the differences between the data from analysed station and its corresponding reference series. Figure (10) displays one of these plots, which also contains at the bottom information about the minimum distance of neighbour data (in green) and the number of used reference data (in orange), both using the logarithmic scale on the Y axis.

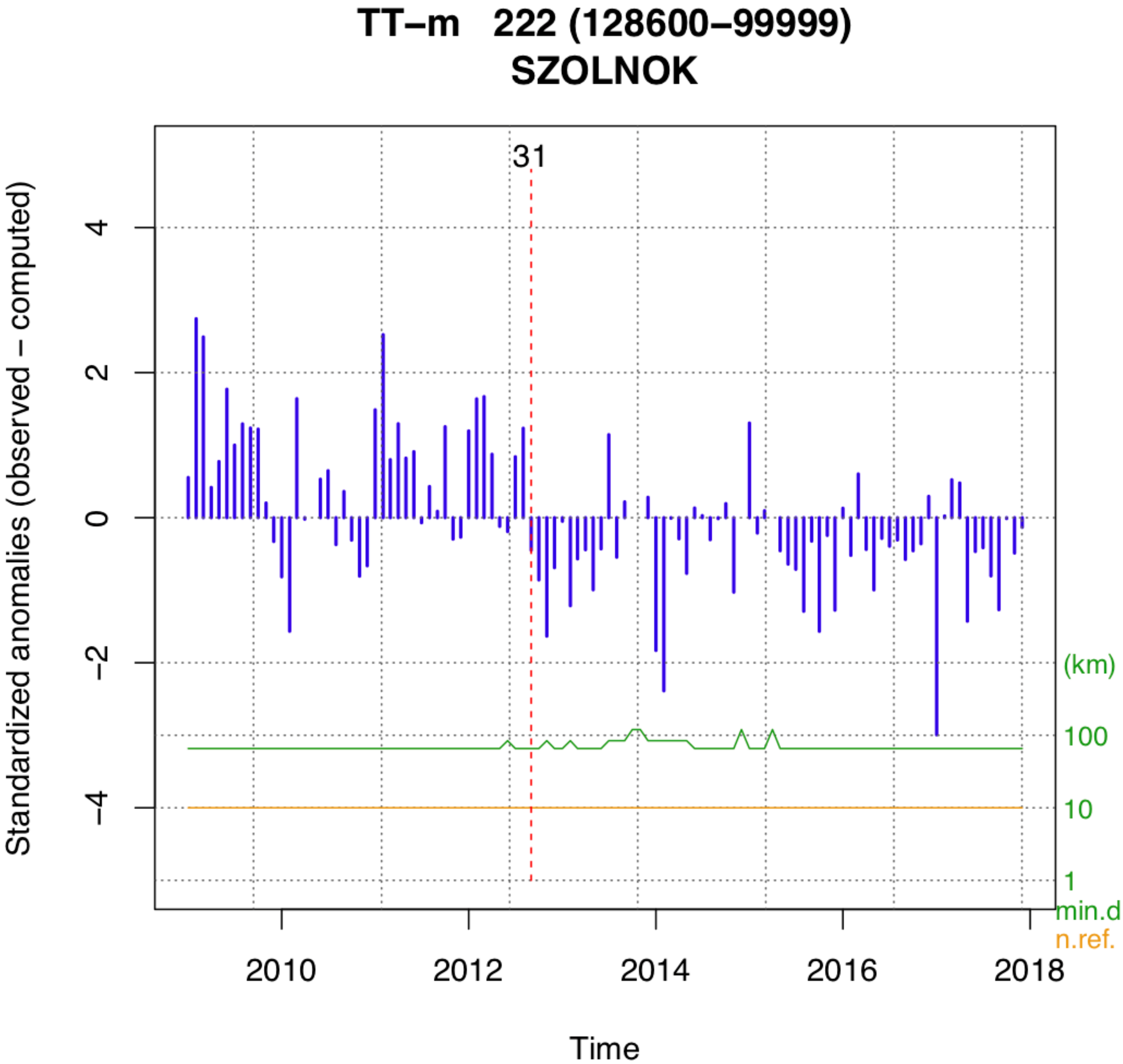

Figure 10: Anomalies of inhomogeneous series.

After identifying the break-points, complete series for each homogenous sub-period are rebuilt. Figure 11 shows a time series that was split into two sub-periods. The top of the graphs are the moving averages (365 running means) of the rebuilt series, the original data being represented by the black line and the series homogenized in different colours. At the bottom are displayed the corrections applied to the series, which have seasonal variations specific to the air temperature. Finally, the homogenized data set was obtained for each station, selecting the reconstructed series containing the highest percentage of raw data.

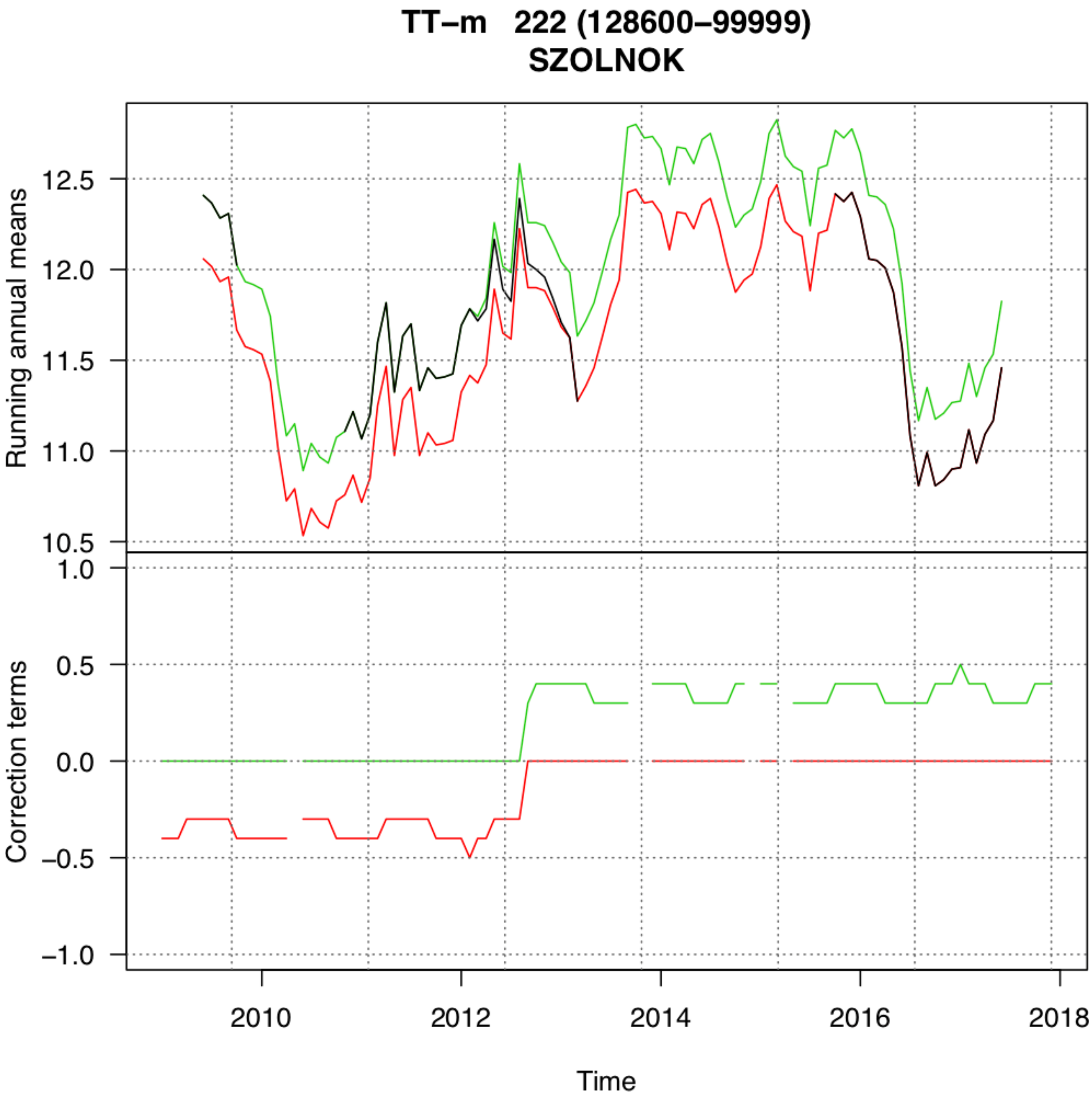

Figure 11: The reconstruction of complete series from two homogeneous sub-period

The results and potential improvements in the quality of time series due to homogenization are analysed by comparing the statistical properties between original and homogenised data. The comparison of the standard deviation values, computed for each day and station in the two sets of data, was done by the box-plot diagram. The ranges of standard deviations obtained from the homogenized data are lower for all years as a result of removing the breakpoints and adjusting the data series (figure 12). However, the annual averages (the horizontal black line inside the rectangles) have not changed significantly, being almost identical for all years (small differences can be noticed in 2016 and 2017).

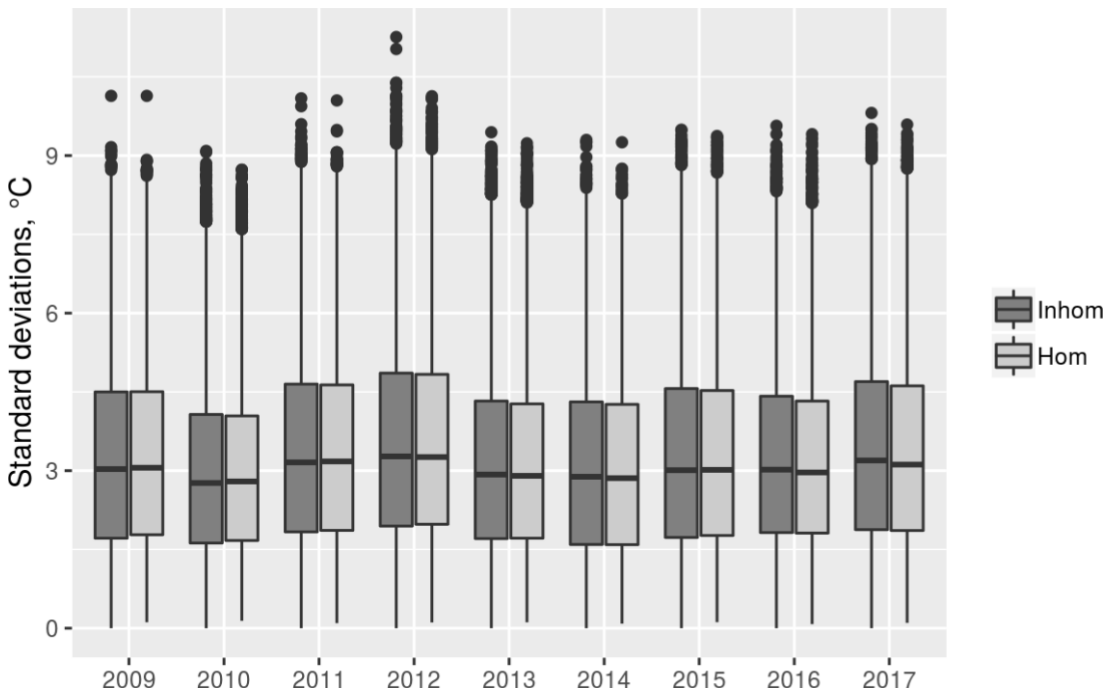

Figure 12: Standard deviations boxplots of the time series before and after homogenization

Using the same type of diagrams, the daily extreme values values of hourly temperature were also analysed: the percentiles of 10% and 90%. Some extreme values were also eliminated during the homogenization process, but the rest of the statistical properties of the percentiles obtained from the two data sets (non-homogenized, homogenized) remained unchanged (figure 13).

The statistical analysis of homogenization results reveals that the hourly air temperature data contain some inhomogeneities, therefore, even for a dataset available for a relatively short period of time, it is mandatory to homogenise the time series before using it for climate studies.

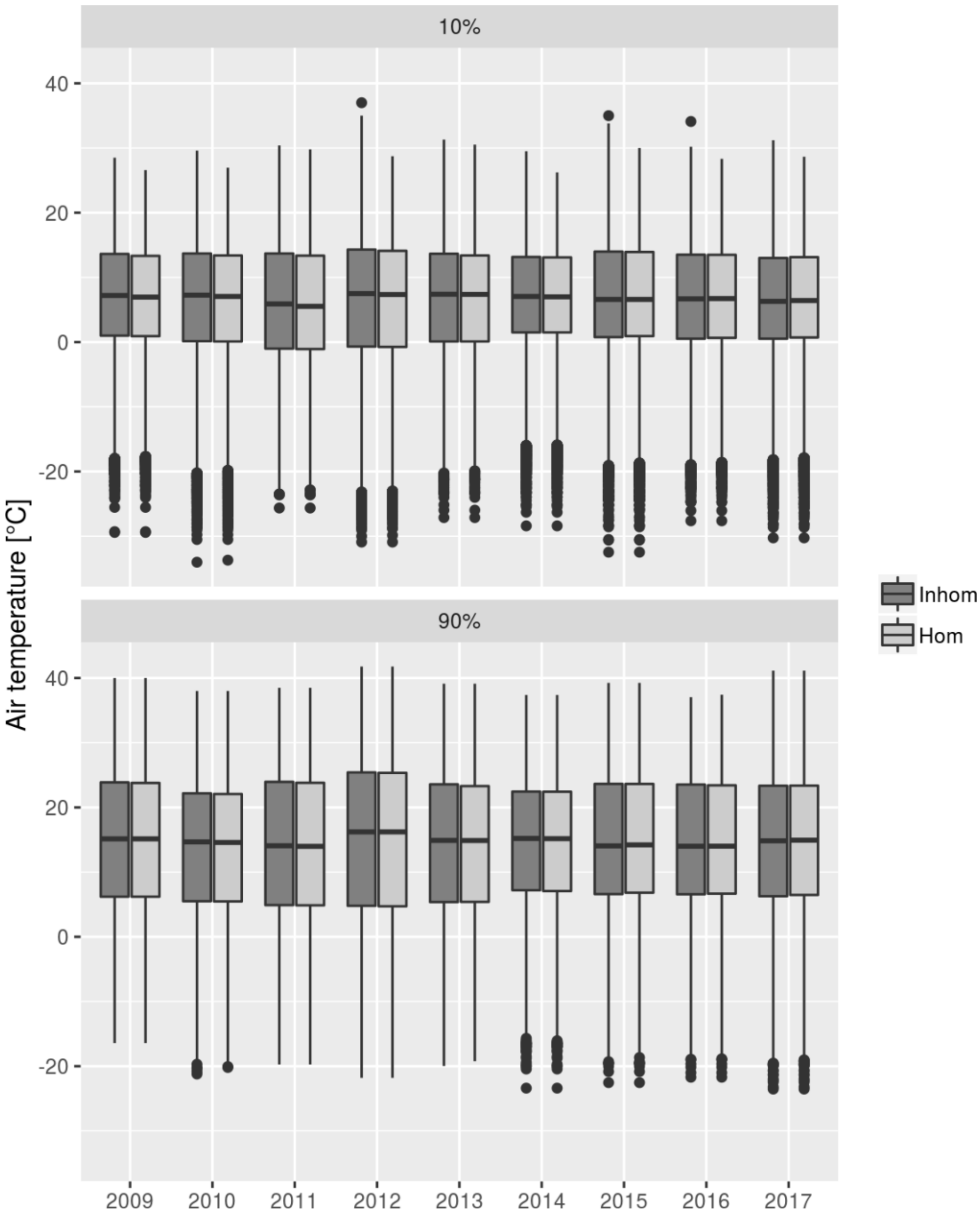

Figure 13: 10% and 90% percentiles boxplots of the hourly temperature series before and after homogenization

5 Conclusions

The hourly air temperature data were selected and analysed for both the Romanian territory and for its immediate vicinity. Air temperature records were obtained from four data sources: National Meteorological Administration (ANM), National Network for Monitoring Air Quality (RNMCA), Regional Basic Synoptic Network (RBSN), Meteorological Terminal Aviation Routine Weather Report network (METAR). Data and metadata were extracted from 354 weather stations, covering almost homogeneously the study area.

Hourly temperature measurements were checked by applying four automated data quality control procedures: (1) climatological limits, (2) persistence, (3) temporal variation (step test), and (4) spatial consistency. After application of the tests, the raw errors due to malfunctioning of the temperature sensors, or coding and transmission errors were eliminated. By removing the errors using the four quality control procedures, a new dataset was obtained, with values which not significantly deviate from the spatio-temporal variability of the air temperature specific to the latitudes of the analysed area.

By using the *climatol* homogenization method, values unrelated to real changes in the natural meteorological and climatic system were identified and corrected. Also, missing data were filled at this stage by considering the similarities of data from each station with the reference series (records from the stations that correlate with the values of the analyzed station). Comparing the homogenization results with the original (non-homogenized) data revealed that by removing the breakpoints and correcting the analyzed series, the statistical properties of the new data set (homogenized) do not differ significantly from those computed from raw data.

The main result of this phase consists of a complete set of the homogeneous hourly air temperature from 349 meteorological stations. The data set can serve as a basis for conducting studies of the spatial-temporal variability of the air temperature diurnal cycle, as well as for the development of the hourly gridded dataset at high spatial resolution.

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Appendix

Table A1: Metadata of the selected weather stations

No.	ID	Name	Longitude	Latitude	Altitude	Source
1	408800	ADAMCLISI	27.96709	44.08854	156	ANM
2	606705	ADJUD	27.17193	46.10497	101	ANM
3	604335	ALBA IULIA	23.56497	46.06421	252	ANM
4	359521	ALEXANDRIA	25.35434	43.97823	85	ANM
5	608121	ARAD	21.35522	46.13385	117	ANM
6	635658	BACAU	26.91407	46.53215	183	ANM
7	428307	BACLES	23.11460	44.47652	313	ANM
8	740330	BAIA MARE	23.49324	47.66113	224	ANM
9	452230	BAILE HERCULANE	22.41799	44.88137	190	ANM
10	401321	BAILESTI	23.33274	44.02961	59	ANM
11	634322	BAISOARA	23.31182	46.53577	1357	ANM
12	536437	BALEA LAC	24.61630	45.60422	2037	ANM
13	523108	BANLOC	21.13797	45.38305	83	ANM
14	605537	BARAOLT	25.59740	46.08104	508	ANM
15	614740	BARLAD	27.64598	46.23329	168	ANM
16	700733	BARNOVA (RADAR)	27.58416	47.01262	395	ANM
17	654438	BATOS	24.64696	46.88644	450	ANM
18	347357	BECHET	23.94569	43.79006	39	ANM
19	533642	BISOCA	26.71186	45.54916	851	ANM
20	708430	BISTRITA	24.51555	47.14937	374	ANM
21	611355	BLAJ	23.93675	46.17873	342	ANM
22	538416	BOITA	24.27311	45.65326	523	ANM
23	659236	BOROD	22.59184	46.99395	333	ANM
24	741640	BOTOSANI	26.64714	47.73588	160	ANM
25	455200	BOZOVICI	22.00774	44.91865	256	ANM
26	512755	BRAILA	27.92120	45.20685	17	ANM
27	542532	BRASOV	25.52772	45.69613	535	ANM
28	639518	BUCIN	25.29808	46.64927	1290	ANM
29	430613	BUCURESTI AFUMATI	26.21429	44.50039	90	ANM
30	430608	BUCURESTI BANEASA	26.07969	44.51072	90	ANM
31	425606	BUCURESTI FILARET	26.09532	44.41236	82	ANM
32	509649	BUZAU	26.85324	45.13293	89	ANM
33	359257	CALAFAT	22.94757	43.98525	61	ANM
34	412721	CALARASI	27.33978	44.20602	22	ANM
35	706515	CALIMANI (RETITIS)	25.24777	47.09818	2022	ANM

No.	ID	Name	Longitude	Latitude	Altitude	Source
36	622303	CAMPENI (BISTRA)	23.04195	46.36410	621	ANM
37	517545	CAMPINA	25.73494	45.14399	461	ANM
38	517507	CAMPULUNG MUSCEL	25.03813	45.27505	690	ANM
39	406421	CARACAL	24.35881	44.10044	105	ANM
40	525215	CARANSEBES	22.22785	45.41744	241	ANM
41	656555	CEAHLAU TOACA	25.95151	46.97776	1897	ANM
42	421803	CERNAVODA	28.04518	44.34590	90	ANM
43	632130	CHISINEU CRIS	21.54327	46.51885	96	ANM
44	647334	CLUJ-NAPOCA	23.57290	46.77806	417	ANM
45	413838	CONSTANTA	28.64702	44.21407	13	ANM
46	444820	CORUGEA	28.34352	44.73459	221	ANM
47	722657	COTNARI	26.92721	47.35855	289	ANM
48	414352	CRAIOVA	23.86850	44.31047	192	ANM
49	518231	CUNTU	22.50305	45.30081	1456	ANM
50	509441	CURTEA DE ARGES	24.67127	45.17909	449	ANM
51	812637	DARABANI	26.57508	48.19512	259	ANM
52	500432	DEDULESTI-MORARESTI	24.57168	45.01661	550	ANM
53	709352	DEJ	23.90046	47.12827	240	ANM
54	553254	DEVA	22.90038	45.86524	230	ANM
55	444417	DRAGASANI	24.23871	44.66575	275	ANM
56	438238	DROBETA TURNU SEVERIN	22.62761	44.62680	77	ANM
57	614436	DUMBRAVENI	24.59318	46.22815	323	ANM
58	639210	DUMBRAVITA DE CODRU	22.17281	46.64494	586	ANM
59	551459	FAGARAS	24.93680	45.83654	435	ANM
60	422751	FETESTI	27.84048	44.39178	58	ANM
61	541712	FOCSANI	27.20131	45.68778	47	ANM
62	528518	FUNDATA	25.27307	45.43176	1376	ANM
63	428632	FUNDULEA	26.52505	44.45323	67	ANM
64	530801	GALATI	28.03380	45.47316	71	ANM
65	352557	GIURGIU	25.93422	43.87547	24	ANM
66	511912	GORGOVA	29.15827	45.17711	3	ANM
67	445718	GRIVITA	27.29609	44.74106	51	ANM
68	617220	GURAHONT	22.33490	46.27951	177	ANM
69	441900	GURA PORTITEI	29.00045	44.69008	4	ANM
70	440242	HALANGA	22.69331	44.66295	74	ANM
71	441757	HARSOVA	27.96501	44.69196	41	ANM
72	646207	HOLOD	22.11387	46.78889	163	ANM
73	651305	HUEDIN	23.03415	46.85761	566	ANM
74	710736	IASI	27.62987	47.17119	103	ANM
75	737439	IEZER	24.65063	47.60284	1792	ANM
76	541601	INTORSURA BUZAULUI	26.05830	45.66855	707	ANM

No.	ID	Name	Longitude	Latitude	Altitude	Source
77	547042	JIMBOLIA	20.70395	45.78120	79	ANM
78	642540	JOSENI	25.51414	46.70600	747	ANM
79	446853	JURILOVCA	28.87789	44.76632	36	ANM
80	551621	LACAUTI	26.37709	45.82418	1778	ANM
81	541154	LUGOJ	21.93486	45.68687	168	ANM
82	505904	MAHMUDIA	29.07487	45.08742	175	ANM
83	349835	MANGALIA	28.58890	43.81639	1	ANM
84	415816	MEDGIDIA	28.25286	44.24346	67	ANM
85	622544	MIERCUREA CIUC	25.77417	46.37158	667	ANM
86	444127	MOLDOVA VECHE	21.63481	44.72280	82	ANM
87	650727	NEGRESTI (VASLUI)	27.44369	46.83833	134	ANM
88	526338	OBARSIA LOTRULUI	23.63240	45.43577	1348	ANM
89	747356	OCNA SUGATAG	23.94208	47.77733	508	ANM
90	618518	ODORHEIUL SECUIESC	25.29332	46.29704	532	ANM
91	404638	OLTENITA	26.63861	44.07498	14	ANM
92	703156	ORADEA	21.89755	47.03602	136	ANM
93	502141	ORAVITA	21.71204	45.03906	309	ANM
94	501252	PADES (APA NEAGRA)	22.86105	44.99714	260	ANM
95	539357	PALTINIS	23.93400	45.65743	1462	ANM
96	523328	PARANG	23.46462	45.38769	1559	ANM
97	519622	PATARLAGELE	26.37102	45.32492	293	ANM
98	536625	PENTELEU	26.41136	45.60293	1633	ANM
99	525323	PETROSANI	23.37825	45.40661	607	ANM
100	656621	PIATRA NEAMT	26.39108	46.93392	360	ANM
101	452452	PITESTI	24.86751	44.84923	332	ANM
102	457600	PLOIESTI	25.98893	44.95604	172	ANM
103	719507	POIANA STAMPEI	25.13604	47.32492	931	ANM
104	511349	POLOVRAGI	23.81015	45.16576	525	ANM
105	534533	POSTAVARU	25.56755	45.56855	1778	ANM
106	530535	PREDEAL	25.58504	45.50657	1096	ANM
107	751555	RADAUTI	25.89205	47.83810	387	ANM
108	523703	RAMNICU SARAT	27.04004	45.39090	155	ANM
109	506422	RAMNICU VALCEA	24.36435	45.08913	242	ANM
110	518155	RESITA	21.88856	45.31471	279	ANM
111	655650	ROMAN	26.91339	46.96934	218	ANM
112	619308	ROSIA MONTANA	23.14063	46.31790	1198	ANM
113	407500	ROSIORII DE VEDE	24.98024	44.10753	111	ANM
114	722205	SACUIENI	22.09614	47.34446	124	ANM
115	604037	SANNICOLAU MARE	20.60316	46.07163	85	ANM
116	645410	SARMASU	24.16139	46.74783	397	ANM
117	748253	SATU MARE	22.88878	47.72177	128	ANM

No.	ID	Name	Longitude	Latitude	Altitude	Source
118	557334	SEBES (ALBA)	23.54305	45.96444	267	ANM
119	507158	SEMENIC	22.05737	45.18173	1432	ANM
120	454936	SFANTU GHEORGHE (DELTA)	29.60057	44.89788	1	ANM
121	552548	SFANTU GHEORGHE (MUNTE)	25.80366	45.87183	525	ANM
122	548409	SIBIU	24.09298	45.78960	453	ANM
123	758355	SIGHETUL MARMATIEI	23.90597	47.93957	283	ANM
124	523530	SINAIA 1500	25.51571	45.35526	1510	ANM
125	616140	SIRIA	21.66438	46.26518	473	ANM
126	426421	SLATINA	24.35604	44.44249	172	ANM
127	433724	SLOBOZIA	27.38504	44.55303	53	ANM
128	641237	STANA DE VALE	22.62498	46.69013	1108	ANM
129	749713	STEFANESTI STANCA	27.22131	47.83247	110	ANM
130	632229	STEI (PETRU GROZA)	22.46809	46.52832	278	ANM
131	436447	STOLNICI	24.79132	44.56303	225	ANM
132	739615	SUCEAVA	26.24214	47.63313	366	ANM
133	728247	SUPURU DE JOS	22.78521	47.45538	166	ANM
134	515231	TARCU	22.53428	45.28134	2180	ANM
135	456526	TARGOVISTE	25.42720	44.92984	285	ANM
136	502317	TARGU JIU	23.26088	45.04096	204	ANM
137	726352	TARGU LAPUS	23.87383	47.43990	375	ANM
138	453344	TARGU LOGRESTI	23.71024	44.87842	271	ANM
139	632432	TARGU MURES	24.53536	46.53358	317	ANM
140	714623	TARGU NEAMT	26.38077	47.21238	385	ANM
141	617637	TARGU OCNA	26.64259	46.27296	245	ANM
142	600608	TARGU SECUIESC	26.11662	45.99317	571	ANM
143	622414	TARNAVENI (BOBOHALMA)	24.22755	46.36036	525	ANM
144	610244	TEBEA	22.72777	46.16979	273	ANM
145	551716	TECUCI	27.41053	45.84182	57	ANM
146	546115	TIMISOARA	21.25966	45.77140	86	ANM
147	439534	TITU	25.58071	44.65315	174	ANM
148	655522	TOPLITA	25.36148	46.92665	690	ANM
149	511849	TULCEA	28.82564	45.19075	5	ANM
150	635347	TURDA	23.79283	46.58334	431	ANM
151	346452	TURNU MAGURELE	24.87996	43.76047	25	ANM
152	443639	URZICENI	26.65870	44.72201	65	ANM
153	602213	VARADIA DE MURES	22.15254	46.01953	156	ANM
154	527527	VARFUL OMU	25.45822	45.44608	2506	ANM
155	639744	VASLUI	27.71599	46.64635	121	ANM
156	417530	VIDELE	25.53850	44.28317	118	ANM
157	647248	VLADEASA 1400	22.81330	46.77840	1404	ANM
158	646247	VLADEASA 1800	22.79579	46.75956	1840	ANM

No.	ID	Name	Longitude	Latitude	Altitude	Source
159	525358	VOINEASA	23.96855	45.41150	573	ANM
160	711305	ZALAU	23.04835	47.19517	303	ANM
161	340521	ZIMNICEA	25.35510	43.66183	39	ANM
162	150001-99999	BOBOC AIR BASE	26.97000	45.21000	103	METAR
163	150002-99999	BORCEA FETESTI AIR BASE	27.71700	44.38300	54	METAR
164	154215-99999	CAMPIA TURZII	23.88600	46.50200	330	METAR
165	154210-99999	HENRI COANDA	26.08500	44.57100	96	METAR
166	154810-99999	MIHAIL KOGALNICEANU	28.48800	44.36200	108	METAR
167	155257-99999	BALCHICK AB	28.18300	43.41700	183	RBSN
168	337450-99999	BALTI	27.95000	47.78300	112	RBSN
169	338388-99999	BALTI INTL	27.78100	47.83800	217	RBSN
170	131800-99999	BANATSKI KARLOVAC	21.03300	45.05000	90	RBSN
171	129920-99999	BEKESCSABA	21.16700	46.68300	82	RBSN
172	132740-99999	BEOGRAD	20.46700	44.80000	128	RBSN
173	132720-99999	BEOGRAD	20.30900	44.81800	95	RBSN
174	132725-99999	BEOGRAD/BATAJNICA	20.25800	44.93500	79	RBSN
175	336340-99999	BEREHOVE	22.65000	48.20000	114	RBSN
176	337490-99999	BRAVICEA	28.43300	47.36700	111	RBSN
177	336640-99999	BRICENI	27.08300	48.35000	218	RBSN
178	338850-99999	CAHUL	28.23300	45.88300	107	RBSN
179	336790-99999	CAMENCA	28.70000	48.03300	42	RBSN
180	338860-99999	CEADIR-LUNGA	28.90000	46.10000	121	RBSN
181	336580-99999	CHERNIVTSI	25.90000	48.36700	176	RBSN
182	338150-99999	CHISINAU	28.98300	47.01700	97	RBSN
183	338387-99999	CHISINAU INTL	28.93100	46.92800	101	RBSN
184	337480-99999	CORNESTI	28.08300	47.33300	175	RBSN
185	132890-99999	CRNI VRH	21.95000	44.11700	841	RBSN
186	133840-99999	CUPRIJA	21.38300	43.93300	125	RBSN
187	128820-99999	DEBRECEN	21.61500	47.48900	104	RBSN
188	155254-99999	DOLNA MITROPOLIA AB	24.50000	43.45000	92	RBSN
189	338210-99999	DUBASARI	29.13300	47.28300	53	RBSN
190	128700-99999	EGER	20.38300	47.90000	165	RBSN
191	337440-99999	FALESTI	27.70000	47.58300	106	RBSN
192	336860-99999	HAIVORON	29.85000	48.35000	160	RBSN
193	338890-99999	IZMAIL	28.85000	45.36700	26	RBSN
194	155620-99999	KALIAKPA	28.46700	43.36700	27	RBSN
195	128510-99999	KEKESTETO	20.01700	47.86700	965	RBSN
196	336380-99999	KHUST	23.30000	48.18300	167	RBSN
197	131740-99999	KIKINDA	20.46700	45.85000	75	RBSN
198	338830-99999	KOMRAT	28.63300	46.30000	121	RBSN
199	132780-99999	KRAGUJEVAC	20.93300	44.03300	161	RBSN

No.	ID	Name	Longitude	Latitude	Altitude	Source
200	133760-99999	KRALJEVO	20.70000	43.70000	221	RBSN
201	133830-99999	KRUSEVAC	21.35000	43.56700	153	RBSN
202	338810-99999	LEOVA	28.28300	46.48300	136	RBSN
203	337610-99999	LIUBASHIVKA	30.26700	47.85000	181	RBSN
204	155110-99999	LOM	23.25000	43.81700	44	RBSN
205	119270-99999	LUCENEC	19.73300	48.33300	208	RBSN
206	337175-99999	MARCULESTI INTL	28.21700	47.86700	98	RBSN
207	127720-99999	MISKOLC	20.76700	48.08300	148	RBSN
208	336630-99999	MOHYLIV-PODIL'S'KYI	27.78300	48.45000	68	RBSN
209	155070-99999	MONTANA	23.21700	43.41700	164	RBSN
210	132950-99999	NEGOTIN	22.55000	44.23300	39	RBSN
211	133880-99999	NIS	21.85400	43.33700	194	RBSN
212	155010-99999	NOVO SELO	22.80000	44.16700	36	RBSN
213	128920-99999	NYIREGYHAZA	21.69200	47.98400	100	RBSN
214	155140-99999	ORYAHOVO	23.96700	43.68300	172	RBSN
215	155280-99999	PLEVEN	24.60000	43.40000	164	RBSN
216	128660-99999	POROSZLO	20.63300	47.65000	88	RBSN
217	336470-99999	RAKHIV	24.20000	48.05000	436	RBSN
218	155490-99999	RAZGRAD	26.50000	43.56700	314	RBSN
219	337540-99999	RIBNITA	29.01700	47.76700	96	RBSN
220	155350-99999	ROUSSE/RUSE	25.95000	43.85000	32	RBSN
221	338340-99999	ROZDIL'NA	30.08300	46.85000	142	RBSN
222	338960-99999	SARATA	29.66700	46.01700	14	RBSN
223	336570-99999	SELIATYN	25.21700	47.86700	799	RBSN
224	155610-99999	SHABLA	28.53300	43.53300	20	RBSN
225	155500-99999	SILISTRA	27.26700	44.11700	25	RBSN
226	132790-99999	SMEDEREVSKA PALANKA	20.95000	44.36700	105	RBSN
227	336780-99999	SOROCA	28.30000	48.20000	175	RBSN
228	338920-99999	STEFAN-VODA	29.48300	46.51700	174	RBSN
229	155330-99999	SVICHTOV	25.35000	43.61700	91	RBSN
230	129820-99999	SZEGED (AUT)	20.10000	46.25000	78	RBSN
231	128600-99999	SZOLNOK	20.23600	47.12300	85	RBSN
232	338290-99999	TIRASPOL	29.60000	46.90000	54	RBSN
233	132850-99999	VELIKO GRADISTE	21.51700	44.75000	86	RBSN
234	155020-99999	VIDIN	22.85000	43.98300	33	RBSN
235	131830-99999	VRSAC	21.31000	45.14700	82	RBSN
236	127860-99999	ZAHONY	22.16700	48.40000	100	RBSN
237	131730-99999	ZRENJANIN	20.41700	45.36700	78	RBSN
238	RO0092A	AB-1	23.56348	46.06422	246	RNMCA
239	RO0093A	AB-2	23.56140	45.96690	256	RNMCA
240	RO0094A	AB-3	23.22560	46.10830	450	RNMCA

No.	ID	Name	Longitude	Latitude	Altitude	Source
241	RO0099A	AG-2	24.87715	44.85817	278	RNMCA
242	RO0100A	AG-3	25.00740	44.81664	296	RNMCA
243	RO0101A	AG-4	24.76262	44.98061	322	RNMCA
244	RO0102A	AG-5	24.97548	44.75563	268	RNMCA
245	RO0103A	AG-6	25.08058	45.28619	580	RNMCA
246	RO0095A	AR-1	21.33472	46.18139	107	RNMCA
247	RO0096A	AR-2	21.30248	46.19055	107	RNMCA
248	RO0097A	AR-3	20.73685	46.16682	100	RNMCA
249	RO0065A	B-1	26.03683	44.44707	30	RNMCA
250	RO0068A	B-4	26.14835	44.39583	30	RNMCA
251	RO0069A	B-5	26.05224	44.41167	30	RNMCA
252	RO0071A	B-7	26.03361	44.34889	30	RNMCA
253	RO0072A	B-8	26.11667	44.61666	30	RNMCA
254	RO0104A	BC-1	26.91067	46.56459	161	RNMCA
255	RO0105A	BC-2	26.92703	46.55593	160	RNMCA
256	RO0106A	BC-3	26.79309	46.25693	201	RNMCA
257	RO0107A	BH-1	21.92724	47.06861	139	RNMCA
258	RO0108A	BH-2	21.90140	47.09750	145	RNMCA
259	RO0109A	BH-3	21.95056	47.03251	128	RNMCA
260	RO0110A	BH-4	22.33167	47.34361	213	RNMCA
261	RO0111A	BN-1	24.49543	47.12738	365	RNMCA
262	RO0114A	BR-2	27.96966	45.26297	16	RNMCA
263	RO0115A	BR-3	27.88944	45.27085	28	RNMCA
264	RO0116A	BR-4	27.96139	45.29774	22	RNMCA
265	RO0117A	BR-5	27.92255	45.16853	28	RNMCA
266	RO0112A	BT-1	26.65858	47.73989	169	RNMCA
267	RO0119A	BV-2	25.60359	45.64975	569	RNMCA
268	RO0120A	BV-3	25.61622	45.65937	566	RNMCA
269	RO0121A	BV-4	25.62414	45.71814	516	RNMCA
270	RO0122A	BV-5	25.62556	45.65161	579	RNMCA
271	RO0123A	BZ-1	26.81914	45.15360	98	RNMCA
272	RO0074A	CJ-2	23.59668	46.77500	333	RNMCA
273	RO0076A	CJ-4	23.63057	46.78222	343	RNMCA
274	RO0126A	CL-2	27.32796	44.20176	12	RNMCA
275	RO0213A	CL-3	27.39133	44.19681	11	RNMCA
276	RO0127A	CS-1	21.87214	45.29933	259	RNMCA
277	RO0128A	CS-2	22.35275	45.51861	283	RNMCA
278	RO0129A	CS-3	21.63337	44.72331	25	RNMCA
279	RO0132A	CT-2	28.64944	44.17639	36	RNMCA
280	RO0133A	CT-3	28.62313	44.31235	20	RNMCA
281	RO0135A	CT-5	28.62380	44.14941	20	RNMCA

No.	ID	Name	Longitude	Latitude	Altitude	Source
282	RO0136A	CT-6	28.61026	44.31963	20	RNMCA
283	RO0137A	CT-7	28.26123	44.24833	60	RNMCA
284	RO0138A	CV-1	25.80445	45.87512	523	RNMCA
285	RO0139A	DB-1	25.47807	44.91622	261	RNMCA
286	RO0140A	DB-2	25.42174	45.13138	464	RNMCA
287	RO0079A	DJ-2	23.79668	44.31916	120	RNMCA
288	RO0081A	DJ-4	23.73361	44.38667	98	RNMCA
289	RO0214A	DJ-6	22.95358	43.99711	35	RNMCA
290	RO0008R	EM-3	25.13466	47.32479	908	RNMCA
291	RO0150A	GJ-1	23.27527	45.05163	203	RNMCA
292	RO0151A	GJ-2	23.17109	44.89909	167	RNMCA
293	RO0152A	GJ-3	23.37516	44.68211	123	RNMCA
294	RO0142A	GL-2	28.05474	45.43154	10	RNMCA
295	RO0143A	GL-3	28.03394	45.47295	67	RNMCA
296	RO0144A	GL-4	28.00639	45.41119	86	RNMCA
297	RO0145A	GL-5	27.44015	45.81849	50	RNMCA
298	RO0208A	GR-2	25.95650	43.89552	12	RNMCA
299	RO0209A	GR-3	25.93178	43.87544	23	RNMCA
300	RO0210A	GR-4	26.03874	43.96381	20	RNMCA
301	RO0154A	HD-1	22.90875	45.87138	187	RNMCA
302	RO0155A	HD-2	22.89935	45.89550	187	RNMCA
303	RO0156A	HD-3	22.89935	45.89550	187	RNMCA
304	RO0157A	HD-4	22.99182	45.73457	230	RNMCA
305	RO0158A	HD-5	23.27860	45.37313	618	RNMCA
306	RO0153A	HR-1	25.81136	46.32662	710	RNMCA
307	RO0159A	IL-1	27.36592	44.56491	22	RNMCA
308	RO0160A	IL-2	26.65267	44.71697	60	RNMCA
309	RO0084A	IS-2	27.58361	47.15111	44	RNMCA
310	RO0086A	IS-4	27.54528	47.19889	165	RNMCA
311	RO0211A	IS-6	27.76866	47.21561	25	RNMCA
312	RO0166A	MH-1	22.69417	44.62749	69	RNMCA
313	RO0162A	MM-2	23.57049	47.65199	223	RNMCA
314	RO0163A	MM-3	23.60529	47.75131	354	RNMCA
315	RO0164A	MM-4	23.61418	47.67099	259	RNMCA
316	RO0165A	MM-5	23.62831	47.70441	290	RNMCA
317	RO0167A	MS-1	24.55966	46.54105	328	RNMCA
318	RO0168A	MS-2	24.53361	46.53336	308	RNMCA
319	RO0169A	MS-3	24.10140	46.47751	279	RNMCA
320	RO0170A	MS-4	24.30841	46.33409	300	RNMCA
321	RO0171A	NT-1	26.39001	46.93000	360	RNMCA
322	RO0172A	NT-2	26.92000	46.95028	206	RNMCA

No.	ID	Name	Longitude	Latitude	Altitude	Source
323	RO0173A	NT-3	26.03407	46.89874	400	RNMCA
324	RO0174A	OT-1	24.35111	44.42945	169	RNMCA
325	RO0176A	PH-2	26.02590	44.93920	160	RNMCA
326	RO0177A	PH-3	26.01802	44.98465	150	RNMCA
327	RO0178A	PH-4	26.02592	44.85023	140	RNMCA
328	RO0180A	PH-6	26.04861	44.94361	160	RNMCA
329	RO0184A	SB-1	24.15347	45.78511	445	RNMCA
330	RO0185A	SB-2	24.18444	45.79750	415	RNMCA
331	RO0186A	SB-3	24.22944	46.11305	285	RNMCA
332	RO0187A	SB-4	24.34000	46.15889	320	RNMCA
333	RO0181A	SJ-1	23.04691	47.19506	275	RNMCA
334	RO0182A	SM-1	22.87702	47.79968	123	RNMCA
335	RO0183A	SM-2	22.45907	47.68976	160	RNMCA
336	RO0188A	SV-1	26.24905	47.64919	385	RNMCA
337	RO0189A	SV-2	26.28333	47.66967	350	RNMCA
338	RO0190A	SV-3	26.06812	47.95318	500	RNMCA
339	RO0201A	TL-2	28.77473	45.17609	30	RNMCA
340	RO0202A	TL-3	28.42440	45.27108	27	RNMCA
341	RO0194A	TM-2	21.22745	45.75549	89	RNMCA
342	RO0195A	TM-3	21.15178	45.91349	119	RNMCA
343	RO0196A	TM-4	21.25094	45.73670	89	RNMCA
344	RO0198A	TM-6	21.26697	45.25794	80	RNMCA
345	RO0199A	TM-7	21.89341	45.69472	124	RNMCA
346	RO0191A	TR-1	25.31240	43.98033	41	RNMCA
347	RO0192A	TR-2	24.90180	43.75798	31	RNMCA
348	RO0216A	TR-4	24.85986	43.71194	31	RNMCA
349	RO0217A	TR-5	25.36358	43.65072	48	RNMCA
350	RO0203A	VL-1	24.36979	45.08273	300	RNMCA
351	RO0204A	VL-2	24.29862	45.03883	300	RNMCA
352	RO0206A	VN-1	27.21159	45.69662	52	RNMCA
353	RO0205A	VS-1	27.73089	46.63214	110	RNMCA
354	RO0212A	VS-2	28.10110	46.67739	85	RNMCA