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Data Article

Historical fog climate dataset for Carpathian Basin from 1886 to 1919

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ABSTRACT

This paper presents the historical fog climate dataset from 1886 to 1919 for Hungary and its neighbouring countries in the Carpathian Basin. The dataset was obtained from the yearbooks of the Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM) established in 1870 to investigate the climatic features of Hungary during the time of the Austro-Hungarian Monarchy. Monthly observations were recorded from 1871 and daily observations were recorded from 1886. The yearbooks contain daily meteorological records of temperature, relative humidity, rainfall, pressure, wind speed and direction, cloudiness and surface weather conditions along with monthly summaries for 24 meteorological stations. The daily weather observations were recorded three times a day, namely at 07:00, 14:00 and 21:00 local time. Station information (location, environment, instrumentation, observations etc.) can also be found in the yearbooks as metadata. For example, the definition of fog in the case of historical observations is the same as that of today, i.e., fog is detected if the maximum horizontal visibility is less than 1 km. In this way fog observations are easily comparable to today's observations without requiring further data correction and homogenisation. The longest 13 continu-

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ously recorded fog observation datasets have the length between 15 and 34 years. The stations are located in 5 countries of the Carpathian Basin at present. These datastests are suitable for conducting historical climatic investigations and can also serve as reference datasets. The historical dataset can be used to study the annual and seasonal changes in frequency and duration of fog events in the Carpathian Basin as a reference, thus facilitating research in the field of fog climatology and forecast.

Specifications Table

Subject	Earth and planetary sciences
Specific subject area	Meteorology, climatology, fog
Type of data	Table Figure
How the data were acquired	Fog climate data was obtained from the yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM). The daily dataset covers a period of 34 years starting from 1886 to 1919. The dataset consists of daily weather observations for 24 synoptic weather stations recorded 3 times during the day at 07:00, 14:00 and 21:00 local time. The stations were located in the present-day Hungary and its neighbouring four countries in the Carpathian Basin (except Fiume/Rijeka which is located on the south western Croatian coastline). The data was transformed into Microsoft (MS) excel spreadsheets and separate MS excel files have been made for each year, containing data for the corresponding weather stations.
Data format	Raw data for fog occurrence is provided starting from 1886 to 1919 in separate MS excel files for each year.
Description of data collection	The daily dataset from 1886 to 1919 recorded in the yearbooks was transformed into MS excel spreadsheets. The occurrence of fog is denoted by 1 and rest of the data (where no fog was detected) is denoted by 0. The recorded data were visually checked and compared with the records in the yearbooks. The definition of fog has remained unchanged since the first international conference of International Meteorological Organisation (IMO) in Vienna in 1873. Maximum visibility is less than 1 km in case of the foggy situations.
Data source location	Institution: Eötvös Loránd University, Faculty of Sciences, Institute of Geography and Earth Sciences, Department of Meteorology, Library City/Town/Region: Budapest Country: Hungary Primary data sources: Yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM) from 1886 to 1919. Pdf files of the yearbooks photographed page by page are available upon request from the authors.
Data accessibility	Repository name: Mendeley Data Data identification number: 10.17632/tfwkmjr49c.1 Direct URL to data: https://data.mendeley.com/datasets/tfwkmjr49c/1 Instructions for accessing these data: The data is publicly available via Mendeley Data and can be downloaded from the above mentioned URL Python code repository name: Zenodo.org Data identification number: 10.5281/zenodo.6670891 Direct URL for python code: https://zenodo.org/record/6670891#.YrB9PpBBwQM
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Value of the Data

- Historical fog climate data for Hungary and its neighbouring countries provides an opportunity to perform comprehensive long term data analysis of fog climatology in order to determine the annual and seasonal changes in frequency and duration of fog events. The complete quality-controlled dataset from the end of the 19th and beginning of 20th century provides a reference data for investigating the impact of urbanisation in cities like Budapest where the population has grown by more than 3 times from 355,000 in 1880 to 1.1 million in 1910. Population of Budapest is 1.7 million in 2022.
- The dataset could be used by researchers in the field of climatology and meteorology from the countries in Carpathian Basin, thus supporting the research in the field of fog climatology and weather forecast. It is recommended to use the dataset for historical climatological investigations too.
- The historical dataset can be combined with the latest available weather observation data set from the Carpathian Basin. Thus, it can be used for constructing a long term (over 100 years) fog climate time series which could facilitate performing a fog climatological intercomparison among countries in the region.
- The yearbooks of Hungarian Meteorological Services until 1990 and the digital data archive from 1961 combined with our dataset gives opportunity to analyse fog dataset from 1886-2021 for Budapest and from 1890 for Pécs in order to investigate urban effects and human activities on fog climatology.
- The historical database offers opportunities for a deeper analysis of regional climate model results connected with the foggy situations.
- Improved dataset with historical meteorological measurements (temperature, humidity cloudiness etc.) offers a possibility for synoptic climatological investigations in the Carpathian Basin.

1. Data Description

Central and Southern Europe holds a large documentary-based historical climatological datasets information about the flood and drought and index-based local-regional temperature and precipitation reconstructions [1]. Carpathian Basin, is situated in the southeastern Central Europe and is one of the world's largest enclosed Basins with special meteorological, hydrological and air pollution situations [2–4]. Carpathian basin is centred around Hungary which lies entirely in the basin and also encompasses the territories of Slovakia, southwest Ukraine, western Romania, northern Serbia, northeast Croatia, northeast Slovenia and eastern part of Austria. Characteristic phenomenon in the central part of Carpathian Basin (located in Hungary) during the winter half year are the mist (500-1000 hours/year), fog (150-300 hours/year) and the cold air pool with high air pollution [5]. There are affects that contribute to pollutant enrichment in a similar way in other basin areas, for example the Uintah Basin in Utah [6].

In the Carpathian Basin, we already know weather records from the 11th century coming from contemporary diplomas and archive sources. Using the index-based historical climate data (more than 15,000 digitalized information) a climate reconstruction was processed between 1650 and 1900 by Bartholy et al. [7]. The first recorded instrumental measurement in the Carpathian Basin was carried out in 1718 in Sopron (western part of Hungary near the Austrian border). However, the longest continuous measurement data series comes from Buda (Budapest from 1873), where the measurements began in 1777. This station was a member of the Societas Meteorologica Palatina between 1781 and 1792, which was the first international meteorological network [8]. Historical weather observation data exists also in case of Temesvár/Timişoara covering the period of 1780 to 1803 describing several weather extremes such as severe winter and unusually large number of foggy days in the summer of 1784 [9]. Historical meteorological information was extracted for the last two decades of 19th century from Romania, and

Austro-Hungarian Monarchy using archives of three newspapers published during that time in the region as a part of a data recovery and climate reconstruction project [10]

Our study aims at extracting and digitalizing the historical data on fog occurrence from the end of 19th century till the beginning of the First World War for Hungary and surrounding countries in the Carpathian Basin. The daily weather observation dataset with respect to fog occurrence recorded in the yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM) from 1886 to 1919 is presented in this study. The data for fog occurrence from all the stations which are described in the yearbooks of RHCIMEM has been digitalized in MS excel files. Every station described in the yearbooks of the RHCIMEM and presented in this study fall in the Carpathian Basin except Fiume/ Rijeka which is located on southwestern Croatian coastline. However, we have included it in this study because along with all the other stations, Fiume/ Rijeka was under the control of the Austro-Hungarian Monarchy and had a synoptic station after RHCIMEM was established. Fig. 1 (a) shows the map of Europe and Fig. 1 (b) shows Carpathian Basin and surrounding areas along with the locations of the meteorological stations for which data is available in the yearbooks of the institute. The stations located in Hungary and its neighbouring four Carpathian Basin countries namely Croatia, Romania, Slovakia and Ukraine, are presented with different colours. The time period of available historical fog climate data for each station is also depicted.

Fig. 2 presents a picture taken from the yearbook of 1912, showing the daily meteorological data recorded in the month of January for Budapest and Dobogókő. The yearbooks (1886 to 1919) contain datasets on quantitative variables like temperature (°Celsius), pressure (mmHg), vapour pressure (mmHg), relative humidity (%), cloudiness (tenth), wind direction (cardinal and intercardinal directions), wind speed (Beaufort number) and precipitation (mm). Qualitative information about the weather situations occurring at the stations for example: weather condition near to the surface like haze, fog, dew etc. and the sky overhead situation (cloudiness) is described using pictorial and abstract symbols. Fig. 2 is reproduced in the Tables 2 and 3 including the quantitative and qualitative meteorological variables with all the letters, numbers and symbols. Column names are given in English, Hungarian and German languages. The explanations of weather symbols used in the Tables 2 and 3 are described in Table 4. The definition of fog has remained unchanged since the first international conference of International Meteorological Organisation (IMO) in Vienna in 1873, namely in case of the foggy situations the maximum visibility is less than 1 km [12]. Tables 2 and 3 are presented to show the way in which the meteorological data was registered in the yearbooks.

The dataset consists of daily weather observations for 24 stations recorded 3 times a day at 07:00, 14:00 and 21:00 local time. In this study only the data of fog occurrence has been transformed into MS excel files for each year and station (digitization of the complete synoptic database has also begun). Every MS excel file has been named after the year for which it contains the data. In the MS excel files, the data has been organized stationwise. Occurrence of a fog event has been denoted as ‘1’ while ‘0’ has been used to denote non-occurrence of foggy event. The total number of foggy events occurring at 3 time periods (07:00, 14:00, 21:00) have been summed up across all days in order to get the total number of foggy events occurring during a particular month for every station. No weather station is found to have the data recorded for the whole period of 34 years except Budapest, where the data exists from 1886 – 1919. Table 1 shows the stations with time periods of data availability. Budapest, Pécs and Nagyszeben/Sibiu related data series exceed 30 years. Majority of the stations have data recorded for more than 15 years. Only 7 stations, mostly in Slovakia (expect Ógyalla/Hurbanovo and Árvaváralja/ Oravský) were found to have data available for 3 – 5 years. Most parallel fog measurements were performed in the period of 1900 – 1915.

Fig. 3(a) shows consecutive fog events per year, averaged over the time period from 1886 to 1919 for Budapest, Pécs, Nagyszeben/Sibiu, Ungvár/Uzshorod, Herény and Zágráb/Zagreb (based on continuous time series from 28 to 34-year). These stations were chosen as they were found to have the longest and overlapping time periods of fog data availability. Fig. 3(a) shows that fog events falling in the category of 3 or more consecutive cases occur only once or twice every year (3 consecutive cases means practically a whole foggy day). Fig. 3(b) shows the monthly dis-

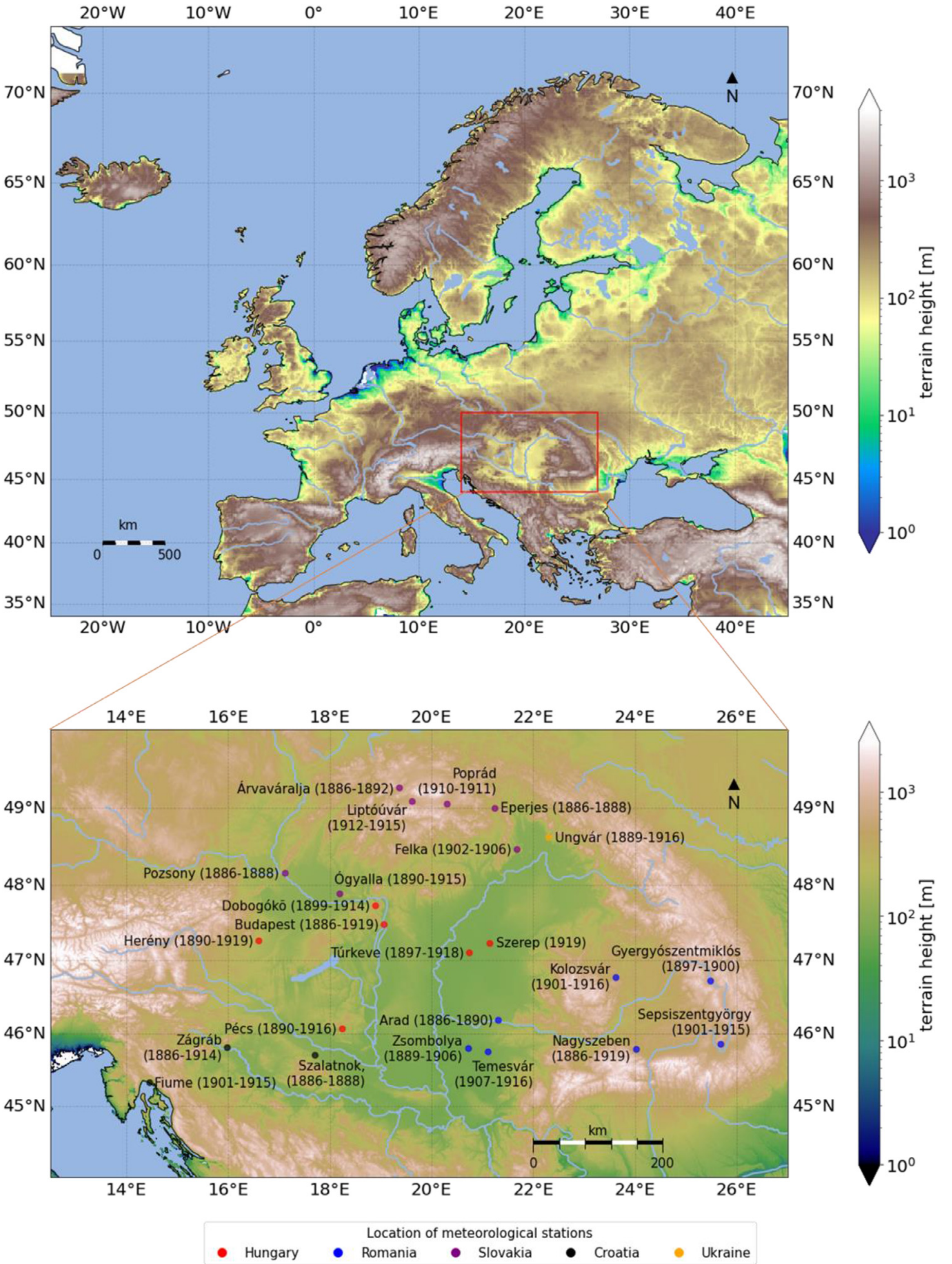
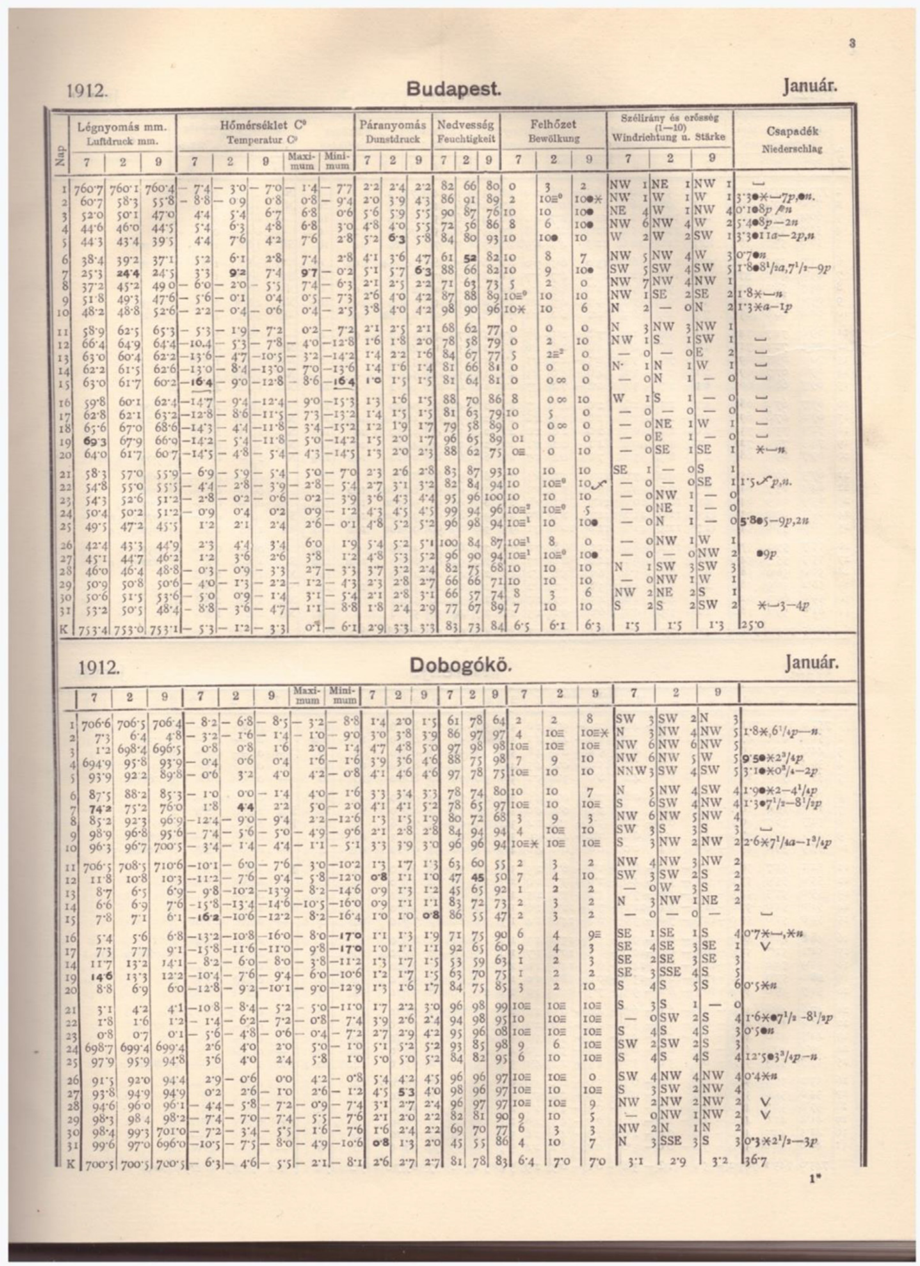


Fig. 1. Map of a) Europe (top panel) with the study area demarcated in a red box and map of b) Carpathian Basin and surrounding areas (lower panel). The locations of historical meteorological stations where historical fog data is available for the given period in the yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM) are presented with different colors as per their present locations; Croatia (black), Hungary (red), Romania (blue), Slovakia (purple) and Ukraine (orange). Present names of the stations/cities and the countries where they are situated at present are provided in the Table 1. Fiume/Rijeka on the southwestern Croatian coastline is out of the geographical context of Carpathian Basin, but important meteorological station with long term time series. Maps have been produced using python jupyter notebooks [11]



3

1912. **Budapest.** Január.

Nap	Légnyomás mm. Luftdruck mm. 7	2	9	Hőmérséklet C° Temperatur C° 7	2	9	Maximum	Minimum	Páranyomás Dunstdruck 7	2	9	Nedvesség Feuchtigkeit 7	2	9	Felhőzet Bewölkung 7	2	9	Szélirány és erősség (1—10) Windrichtung u. Stärke 7	2	9	Csapadék Niederschlag
1	760·7	760·1	760·4	−7·4	−3·0	−7·0	−1·4	−7·7	2·2	2·4	2·2	82	66	80	0	3	2	NW 1	NE 1	NW 1	⌴
2	60·7	58·3	55·8	−8·8	−0·9	0·8	0·8	−9·4	2·0	3·9	4·3	86	91	89	2	10≡⁰	10●✳	NW 1	W 1	W 1	3·3●✳—7p,●n.
3	52·0	50·1	47·0	4·4	5·4	6·7	6·8	0·6	5·6	5·9	5·5	90	87	76	10	10	10●	NE 4	W 1	NW 4	0·1●8p ↗n
4	44·6	46·0	44·5	5·4	6·3	4·8	6·8	3·0	4·8	4·0	5·5	72	56	86	8	6	10●	NW 6	NW 4	W 2	5·4●8p—2n
5	44·3	43·4	39·5	4·4	7·6	4·2	7·6	2·8	5·2	**6·3**	5·8	84	80	93	10	10●	10	W 2	W 2	SW 1	3·3●11a—2p,n
6	38·4	39·2	37·1	5·2	6·1	2·8	7·4	2·8	4·1	3·6	4·7	61	**52**	82	10	8	7	NW 5	NW 4	W 3	0·7●n
7	25·3	**24·4**	24·5	3·3	**9·2**	7·4	**9·7**	−0·2	5·1	5·7	**6·3**	88	66	82	10	9	10●	SW 5	SW 4	SW 5	1·8●8½a,7½—9p
8	37·2	45·2	49·0	−6·0	−2·0	−5·5	7·4	−6·3	2·1	2·5	2·2	71	63	73	5	2	0	NW 7	NW 4	NW 1	
9	51·8	49·3	47·6	−5·6	−0·1	0·4	0·5	−7·3	2·6	4·0	4·2	87	88	89	10≡⁰	10	10	NW 1	SE 2	SE 2	1·8✳—n
10	48·2	48·8	52·6	−2·2	−0·4	−0·6	0·4	−2·5	3·8	4·0	4·2	98	90	96	10✳	10	6	N 2	— 0	N 2	1·3✳a—1p
11	58·9	62·5	65·3	−5·3	−1·9	−7·2	0·2	−7·2	2·1	2·5	2·1	68	62	77	0	0	0	N 3	NW 3	NW 1	
12	66·4	64·9	64·4	−10.4	−5·3	−7·8	−4·0	−12·8	1·6	1·8	2·0	78	58	79	0	2	10	NW 1	S 1	SW 1	⌴
13	63·0	60·4	62·2	−13·6	−4·7	−10·5	−3·2	−14·2	1·4	2·2	1·6	84	67	77	5	2≡²	0	— 0	— 0	E 2	⌴
14	62·2	61·5	62·6	−13·0	−8·4	−13·0	−7·0	−13·6	1·4	1·6	1·4	81	66	81	0	0	0	N· 1	N 1	W 1	⌴
15	63·0	61·7	60·2	**−16·4**	−9·0	−12·8	−8·6	**−16·4**	**1·0**	1·5	1·5	81	64	81	0	0 ∞	0	— 0	N 1	— 0	⌴
16	59·8	60·1	62·4	−14·7	−9·4	−12·4	−9·0	−15·3	1·3	1·6	1·5	88	70	86	8	0 ∞	10	W 1	S 1	— 0	⌴
17	62·8	62·1	63·2	−12·8	−8·6	−11·5	−7·3	−13·2	1·4	1·5	1·5	81	63	79	10	5	0	— 0	— 0	— 0	⌴
18	65·6	67·0	68·6	−14·3	−4·4	−11·8	−3·4	−15·2	1·2	1·9	1·7	79	58	89	0	0 ∞	0	— 0	NE 1	W 1	⌴
19	**69·3**	67·9	66·0	−14·2	−5·4	−11·8	−5·0	−14·2	1·5	2·0	1·7	96	65	89	01	0	0	— 0	E 1	— 0	⌴
20	64·0	61·7	60·7	−14·5	−4·8	−5·4	−4·3	−14·5	1·3	2·0	2·3	88	62	75	0≡	0	10	— 0	SE 1	SE 1	✳—n
21	58·3	57·0	55·9	−6·9	−5·9	−5·4	−5·0	−7·0	2·3	2·6	2·8	83	87	93	10	10	10	SE 1	— 0	S 1	
22	54·8	55·0	55·5	−4·4	−2·8	−3·9	−2·8	−5·4	2·7	3·1	3·2	82	84	94	10	10≡⁰	10,↗	— 0	— 0	SE 1	1·5↗p,n.
23	54·3	52·6	51·2	−2·8	−0·2	−0·6	−0·2	−3·9	3·6	4·3	4·4	95	96	100	10	10	10	— 0	NW 1	— 0	
24	50·4	50·2	51·2	−0·9	0·4	0·2	0·9	−1·2	4·3	4·5	4·5	99	94	96	10≡²	10≡⁰	5	— 0	NE 1	— 0	
25	49·5	47·2	45·5	1·2	2·1	2·4	2·6	−0·1	4·8	5·2	5·2	96	98	94	10≡¹	10	10●	— 0	N 1	— 0	5·8●5—9p,2n
26	42·4	43·3	44·9	2·3	4·4	3·4	6·0	1·9	5·4	5·2	5·1	100	84	87	10≡¹	8	0	— 0	NW 1	W 1	
27	45·1	44·7	46·2	1·2	3·6	2·6	3·8	1·2	4·8	5·3	5·2	96	90	94	10≡¹	10≡⁰	10●	— 0	— 0	NW 2	●9p
28	46·0	46·4	48·8	−0·3	−0·9	−3·3	2·7	−3·3	3·7	3·2	2·4	82	75	68	10	10	10	N 1	SW 3	SW 3	
29	50·9	50·8	50·6	−4·0	−1·3	−2·2	−1·2	−4·3	2·3	2·8	2·7	66	66	71	10	10	10	— 0	NW 1	W 1	
30	50·6	51·5	53·6	−5·0	0·9	−1·4	3·1	−5·4	2·1	2·8	3·1	66	57	74	8	3	6	NW 2	NE 2	S 1	
31	53·2	50·5	48·4	−8·8	−3·6	−4·7	−1·1	−8·8	1·8	2·4	2·9	77	67	89	7	10	10	S 2	S 2	SW 2	✳—3—4p
K	753·4	753·0	753·1	−5·3	−1·2	−3·3	0·1	−6·1	2·9	3·3	3·3	83	73	84	6·5	6·1	6·3	1·5	1·5	1·3	25·0

1912. **Dobogókő.** Január.

	7	2	9	7	2	9	Maximum	Minimum	7	2	9	7	2	9	7	2	9	7	2	9	
1	706·6	706·5	706·4	−8·2	−6·8	−8·5	−3·2	−8·8	1·4	2·0	1·5	61	78	64	2	2	8	SW 3	SW 2	N 3	
2	7·3	6·4	4·8	−3·2	−1·6	−1·4	−1·0	−9·0	3·0	3·8	3·9	86	97	97	4	10≡	10≡✳	N 3	NW 4	NW 5	1·8✳,6¼p—n.
3	1·2	698·4	696·5	0·8	0·8	1·6	2·0	−1·4	4·7	4·8	5·0	97	98	98	10≡	10≡	10≡	NW 6	NW 6	NW 5	
4	694·9	95·8	93·9	−0·4	0·6	0·4	1·6	−1·6	3·9	3·6	4·6	88	75	98	7	9	10	NW 6	NW 5	W 5	**9·5**●✳2¾p
5	93·9	92·2	89·8	−0·6	3·2	4·0	4·2	−0·8	4·1	4·6	4·6	97	78	75	10≡	10	10	NNW 3	SW 4	SW 5	3·1●✳0¾—2p
6	87·5	88·2	85·3	−1·0	0·0	−1·4	4·0	−1·6	3·3	3·4	3·3	78	74	80	10	10	7	N 5	NW 4	SW 4	1·9●✳2—4¼p
7	**74·2**	75·2	76·0	1·8	**4·4**	2·2	5·0	−2·0	4·1	4·1	5·2	78	65	97	10≡	10	10≡	S 6	SW 4	NW 4	1·3●7½—8½p
8	85·2	92·3	96·9	−12·4	−9·0	−9·4	2·2	−12·6	1·3	1·5	1·9	80	72	68	3	9	3	NW 6	NW 5	NW 4	
9	98·9	96·8	95·6	−7·4	−5·6	−5·0	−4·9	−9·6	2·1	2·8	2·8	84	94	94	4	10≡	10	SW 3	S 3	S 3	⌴
10	96·3	96·7	700·5	−3·4	−1·4	−4·4	−1·1	−5·1	3·3	3·9	3·0	96	96	94	10≡✳	10≡	10≡	S 3	NW 2	NW 2	2·6✳7¼a—1¾p
11	706·5	708·5	710·6	−10·1	−6·0	−7·6	−3·0	−10·2	1·3	1·7	1·3	63	60	55	2	3	2	NW 4	NW 3	NW 2	
12	11·8	10·8	10·3	−11·2	−7·6	−9·4	−5·8	−12·0	**0·8**	1·1	1·0	47	**45**	50	7	4	10	SW 3	SW 2	S 2	
13	8·7	6·5	6·9	−9·8	−10·2	−13·9	−8·2	−14·6	0·9	1·3	1·2	45	65	92	1	2	2	— 0	W 3	S 2	
14	6·6	6·9	7·6	−15·8	−13·4	−14·6	−10·5	−16·0	0·9	1·1	1·1	83	72	73	2	3	2	N 3	NW 1	NE 2	
15	7·8	7·1	6·1	**−16·2**	−10·6	−12·2	−8·2	−16·4	1·0	1·0	**0·8**	86	55	47	2	3	2	— 0	— 0	—	⌴
16	5·4	5·6	6·8	−13·2	−10·8	−16·0	−8·0	**−17·0**	1·1	1·3	1·9	71	75	90	6	4	9≡	SE 1	SE 1	S 4	0·7✳—,✳n
17	7·3	7·7	9·1	−15·8	−11·6	−11·0	−9·8	**−17·0**	1·0	1·1	1·1	92	65	60	9	4	3	SE 4	SE 3	SE 1	V
14	11·7	13·2	14·1	−8·2	−6·0	−8·0	−3·8	−11·2	1·3	1·7	1·5	53	59	63	1	2	3	SE 2	SE 3	SE 3	
19	**14·6**	13·3	12·2	−10·4	−7·6	−9·4	−6·0	−10·6	1·2	1·7	1·5	63	70	75	1	2	2	SE 3	SSE 4	S 5	
20	8·8	6·9	6·0	−12·8	−9·2	−10·1	−9·0	−12·9	1·3	1·6	1·7	84	75	85	3	2	10	S 4	S 5	S 6	0·5✳n
21	3·1	4·2	4·1	−10·8	−8·4	−5·2	−5·0	−11·0	1·7	2·2	3·0	96	98	99	10≡	10≡	10≡	S 3	S 1	— 0	
22	1·8	1·6	1·2	−1·4	−6·2	−7·2	−0·8	−7·4	3·9	2·6	2·4	94	98	95	10	10≡	10≡	— 0	SW 2	S 4	1·6✳●7½—8½p
23	0·8	0·7	0·1	−5·6	−4·8	−0·6	−0·4	−7·2	2·7	2·9	4·2	95	96	08	10≡	10≡	10≡	S 4	S 4	S 3	0·5●n
24	698·7	699·4	699·4	2·6	4·0	2·0	5·0	−1·0	5·1	5·2	5·2	93	85	98	9	6	10≡	SW 2	SW 2	S 3	
25	97·9	95·9	94·8	3·6	4·0	2·4	5·8	1·0	5·0	5·0	5·2	84	82	95	6	10	10≡	S 4	S 4	S 4	12·5●3¾p—n
26	91·5	92·0	94·4	2·9	−0·6	0·0	4·2	−0·8	5·4	4·2	4·5	96	96	97	10≡	10≡	0	SW 4	NW 4	NW 4	0·4✳n
27	93·8	94·9	94·9	0·2	2·6	−1·0	2·6	−1·2	4·5	**5·3**	4·0	98	96	97	10≡	10	10≡	S 3	SW 2	NW 4	
28	94·6	96·0	96·1	−4·4	−5·8	−7·2	−0·9	−7·4	3·1	2·7	2·4	96	97	97	10≡	10≡	9	NW 2	NW 2	NW 2	V
29	98·3	98·4	98·2	−7·4	−7·0	−7·4	−5·5	−7·6	2·1	2·0	2·2	82	81	90	9	10	5	— 0	NW 1	NW 2	V
30	98·4	99·3	701·0	−7·2	−3·4	−5·5	−1·6	−7·6	1·6	2·4	2·2	69	70	77	6	3	3	NW 2	N 1	N 2	
31	99·6	97·0	696·0	−10·5	−7·5	−8·0	−4·9	−10·6	**0·8**	1·3	2·0	45	55	86	4	10	7	N 3	SSE 3	S 3	0·3✳2½—3p
K	700·5	700·5	700·5	−6·3	−4·6	−5·5	−2·1	−8·1	2·6	2·7	2·7	81	78	83	6·4	7·0	7·0	3·1	2·9	3·2	36·7

1*

Fig. 2. Daily meteorological data recorded three times a day at 7:00, 14:00 and 21:00 local time [13] in the yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM) are presented for Budapest (upper) and Dobogókő (bottom) for January 1912. The meteorological variables included are pressure – "Légnyomás" / "Luftdruck" (mmHg), temperature – "Hőmérséklet" / "Temperatur" (°Celsius), water vapour pressure – "Páranyomás" / "Dunstdruck" (mmHg), relative humidity –"Nedvesség" / "Feuchtigkeit" (%), cloudiness – "Felhőzet" / "Bewölkung" (tenth), wind direction – "Szélirány" / "Windrichtung" (cardinal and intercardinal directions), wind speed – "szél erősség" / "Windstärke" (Beaufort number), and precipitation – "Csapadék" / "Niederschlag" (mm). Sky and ground weather description including the fog is given qualitatively using symbols developed at International Meteorological Congress in Vienna in 1873 [13].

Table 1
Weather stations in Hungary and neighboring Carpathian Basin countries with the time periods for which the historical fog observational data is available from 1886 – 1919.

S.No.	Station name (historical/present), Country	Historical fog data (time period)
1	Budapest, Hungary	1886 – 1919
2	Pécs, Hungary	1890 – 1916
3	Nagyszeben/Sibiu, Romania	1886 – 1916
4	Ungvár/ Uzshorod, Ukraine	1889 – 1916
5	Herény/Hungary	1890 – 1919
6	Zágráb/Zagreb, Croatia	1886 – 1914
7	Túrkeve/Hungary	1897 – 1918
8	Kolozsvár/Cluj Napoca, Romania	1901 – 1916
9	Sepsiszentgyörgy/ Sfântu Gheorghe, Romania	1901 – 1915
10	Dobogókő, Hungary	1899 – 1914
11	Fiume/Rijeka, Croatia	1901 – 1915
12	Ógyalla/Hurbanovo, Slovakia	1890 – 1915
13	Felka/Veľká, part of Poprád/Poprad, Slovakia	1902 – 1906
14	Zsombolya/Jimbolia, Romania	1889 – 1906
15	Temesvár/Timișoara, Romania	1907 – 1916
16	Arad/Arad, Romania	1886 – 1890
17	Árvaváralja/ Oravský Podzámok, Slovakia	1886 – 1892
18	Gyergyószentmiklós/Gheorgheni, Romania	1897 – 1900
20	Eperjes/Prešov, Slovakia	1886 – 1888
21	Pozsony/Bratislava, Slovakia	1886 – 1888
21	Szlatanok/Slatina, Croatia	1886 – 1888
22	Poprád/Poprad, Slovakia	1910 – 1911
23	Liptóújvár/Liptovský Hrádok, Slovakia	1912 – 1915
24	Szerep/Hungary	1919

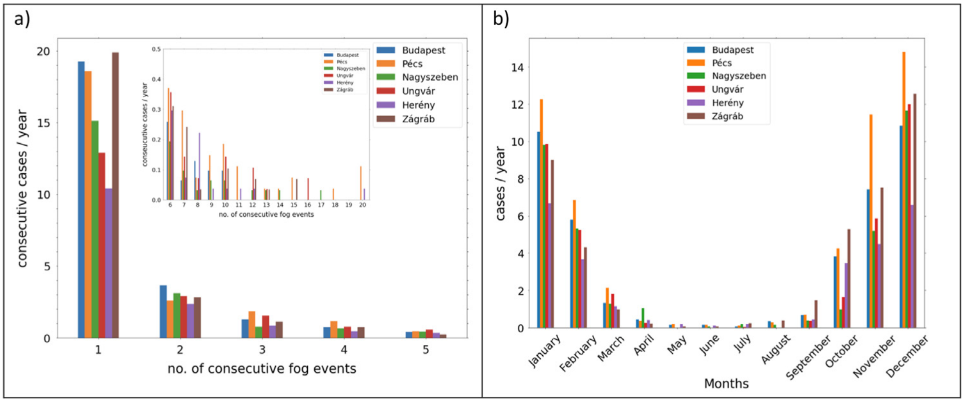


Fig. 3. Number of consecutive fog events per year in Budapest, Pécs, Nagyszeben/Sibiu, Ungvár/Uzshorod, Herény and Zágráb/Zagreb between 1886 – 1919 (left, a), Monthly distribution of fog events for the stations (same as in Fig. 3a) averaged over the time period from 1886 to 1919 (right, b).

tribution of fog events per year for the similar 6 stations and for similar time period from 1886 to 1919. It shows that there was no month without fog occurrence and the highest numbers of fog events were observed in December and January for all stations as expected [5].

2. Experimental Design, Materials and Methods

2.1. Dataset collection

Data was collected from the yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM), starting from the year of 1886 to 1919 [13]. The yearbooks provide daily meteorological data, recorded 3 times a day at 07:00, 14:00 and 21:00 local time. The yearbooks have recorded dataset on quantitative variables like temperature (°Celsius), pressure (mmHg), vapour pressure (mmHg), relative humidity (%), cloudiness (tenth), wind direction (cardinal and intercardinal directions), wind speed (Beaufort number) and precipitation (mm) (see Fig. 2, Tables 2 and 3). The qualitative information about the weather occurring at a station, weather condition near to the surface like haze, fog, dew etc. and the sky overhead situation (cloudiness) are also described using pictorial and abstract symbols. These symbols were developed at the International Meteorological Congress in Vienna in 1873 to standardize the weather mapping across different European and non-European countries [12]. These symbols were adopted as a standard for producing weather maps and were published in the report of the congress. The yearbooks included these symbols to represent a variety of weather phenomenon like black dot for representing rain, asterisk for snow, a dynamic angled line for displaying thunderstorm, a solid black triangle, open triangle for representing hail/freezing rain/graupel, three horizontal lines for fog, horizontal bracket for rime and drop over a horizontal surface for showing dew etc. (see Table 4). Thunderstorm and lightning bolts have been represented using stylized letter R [12].

2.2. Processing

In the dataset development we focussed on finding the occurrence of fog in the yearbook's dataset from 1886 to 1919 [11,13]. Wherever the symbol of 'three horizontal bars' has been depicted in the yearbooks, that has been represented as '1' in the MS excel files [11]. '1' in the MS excel files denote a foggy event which simply indicates that at that time fog was reported for that meteorological station. Non-occurrence of fog has been simply represented as '0' in the MS excel files.

Foggy events were added to obtain the total number of fog events for every station and later normalized to obtain their monthly distribution. The monthly distribution of foggy events for six meteorological stations namely Budapest, Pécs, Nagyszeben/Sibiu, Ungvár/Uzshorod, Herény and Zágráb/Zagreb has been shown in the Fig. 3(b). A day with a fog is a day where fog was recorded at least once, and the fog duration has been disregarded. Similarly, the occurrence of consecutive fog events for the above mentioned six meteorological stations is shown in the Fig. 3(a). Fig. 3(a) and (b) were visualized using the Python jupyter notebooks [11].

Table 2
Daily weather observations in the month of January, 1912 for Budapest recorded three times a day at 07:00, 14:00, 21:00 local time. This table has been produced from the Fig. 2.

	Pressure / légnyomás /Luftdruck (mmHg)			Temperature / Hőmerséklet / Temperatur (°C)					Vapor Pressure / Páranyomás / Dunstdruck (mmHg)			Humidity / Nedvesség / Feuchtigkeit (%)			Clouds/ Felhőzet/ Bewölkung (tenth)			Wind direction and Strength / Szélirány és erősség / Windrichtung u. stärke (Beaufort no. [1–10])			Precipitation/ Csapadék/ Niederschlag (mm)
Day	7	2	9	7	2	9	Maximum	Minimum	7	2	9	7	2	9	7	2	9	7	2	9	
1	760.7	760	760.4	−7.4	−3	−7	−1.4	−7.7	2.2	2.4	2.2	82	66	80	0	3	2	NW 1	NE 1	NW 1	⎵
2	60.7	58.3	55.8	−8.8	−0.9	0.8	0.8	−9.4	2	3.9	4.3	86	91	89	2	10≡	10●*	NW 1	W 1	W 1	3.3●*⎵7p,●n
3	52. 0	50.1	47	4.4	5.4	6.7	6.8	0.6	5.6	5.9	5.5	90	87	76	10	10	10●	NE 4	W 1	NW 4	0.1●8pn
4	44.6	46	44.5	5.4	6.3	4.8	6.8	3	4.8	4	5.5	72	56	86	8	6	10●	NW 6	NW 4	W 2	5.4●8p-2n
5	44.3	43.4	39.5	4.4	7.6	4.2	7.6	2.8	5.2	6.3	5.8	84	80	93	10	10●	10	W 2	W 2	SW I	3.3●11a-2p,n
6	38.4	39.2	37.1	5.2	6.1	2-8	7.4	2.8	4.1	3.6	4.7	61	52	82	10	8	7	NW 5	NW 4	W 3	*0.7●n*
7	25.3	24.4	24.5	3.3	9.2	7.4	9.7	−0.2	5.1	5.7	6.3	88	66	82	10	9	10●	SW 3	SW 4	SW 5	1.8●
8	37.2	45.2	49	−6	−2	−5.5	7.4	−6.3	2.1	2.5	2.2	71	63	73	5	2	0	NW 7	NW 4	NW 1	
9	51. 8	49.3	47.6	−3.6	−0.1	0.4	0.5	−7.3	2.6	4	4.2	87	88	89	10≡	10	10	NW 1	SE 2	SE 2	1.8*⎵n
10	48.2	48.8	32.6	−2.2	−0.4	−0.6	0.4	−2.3	3.8	4	4.2	98	90	96	10*	10	6	N 2	− 0	N 2	1.3* a-1p
11	58.9	62.5	65.3	−5.3	−1.9	−7.2	0.2	−7.2	2.1	2.5	2.1	68	62	77	0	0	0	N 3	NW 3	NW 1	
12	66.4	64.9	64.4	−10.4	−5.3	−7.8	−4	−12.8	1.6	1.8	2	78	58	79	0	2	10	NW 1	S 1	SW 1	⎵
13	63. 0	60.4	62.2	−13.6	−4.7	−10.3	−3.2	−14.2	1.4	2. 2	1.6	84	67	77	5	2≡	0	− 0	− 0	E 2	⎵
14	62.2	61.5	62.6	−13	−8.4	−13	−7	−13.6	1.4	1.6	1.4	81	66	81	0	0	0	N 1	N 1	W 1	⎵
15	63 .0	61.7	60.2	−16.4	−9	−12.8	−8.6	−16.4	1	1.5	1.5	81	64	81	0	0 ∞	0	− 0	N 1	− 0	⎵
l6	59.8	60.1	62.4	−14.7	−9.4	−12.4	−9	−15.3	1.3	1.6	1.5	88	70	86	8	0 ∞	10	W I	S 1	− 0	
17	62.8	62.1	63.2	−12.8	−8.6	−11.5	−7.3	−13.2	1.4	1.5	1.5	81	63	79	10	5	0	− 0	− 0	− 0	⎵
18	65.6	67	68.6	−14.3	−4.4	−11.8	−3.4	−15.2	1.2	1.9	1.7	79	58	89	0	0 ∞	0	− 0	NE 1	WI	⎵
19	69.3	67.9	66.9	−14.2	−5.4	−11.8	−5	−14.2	1.5	2	1.7	96	65	89	1	0	0	− 0	E 1	− 0	⎵
20	64	61.7	60.7	−14.5	−4.8	−5.4	−4.3	−14.5	1.3	2	2.3	88	62	75	0≡	0	0	− 0	SE 1	SE 1	⎵
21	58.3	57	55.9	−6.9	−5.9	−5.4	−5	−7	2.3	2.6	2.8	83	87	93	10	10	10	SE 1	− 0	S 1	*⎵n
22	34.8	55	55.5	−4.4	−2.8	−3.9	−2.8	−5.4	2.7	3.1	3.2	82	84	94	10	10≡	10	− 0	− 0	SE 1	1.5p,n
23	54.3	32.6	51.2	−2.8	−0.2	−0.6	−0.2	−3.9	3.6	4.3	4.4	95	96	100	10	10	10	− 0	NW 1	− 0	
24	50.4	50.2	51.2	− 0.9	0.4	0.2	0.9	−1.2	4.3	4.5	4.5	99	94	96	10≡	10≡	5	− 0	NE 1	− 0	
25	49.5	47.2	45.5	1.2	2.1	2.4	2.6	−0.1	4.8	5.2	5.2	96	98	94	10≡	10	10	− 0	N 1	− 0	5.8●5-9p,2n
26	42.4	43.3	44.9	2.3	4.4	3.4	6	1.9	5.4	5.2	5	100	84	87	10≡	8	0	− 0	NW 1	W I	
27	45.1	44.7	46.2	1.2	3.6	2.6	3.8	1.2	4.8	5.3	5.2	96	90	94	10≡	10≡	10●	− 0	− 0	NW 2	•9p
28	46	46.4	48.8	−0.3	−0.9	−3.3	2.7	−3.3	3.7	3.2	2.4	82	75	68	10	10	10	N 1	SW 3	SW 3	
29	50.9	30.8	30.6	−4	−1.3	−2.2	−1.2	−4.3	2.3	2.8	2.7	66	66	71	10	10	10	− 0	NW 1	W 1	
30	50.6	51.5	53.6	−5	0.9	-1.4	3.1	−5.4	2.1	2.8	3.1	66	57	74	8	3	6	NW 2	NE 2	S 1	
31	53.2	50.5	48.4	−8.8	−3.6	−4.7	−1.1	-8.8	1.8	2.4	2.9	77	67	89	7	10	10	S 2	S 2	SW 2	*⎵3-4p
K(mean/ közep/ bedeuten)	753.4	753	753.l	−5.3	−1.2	−3.3	0.1	−6.1	2.9	3.3	3.3	83	73	84	6.5	6.1	6.3	1.5	1.5	1.3	25

Table 3

Daily weather observations in the month of January, 1912 for Dobogókő recorded three times a day at 07:00, 14:00, 21:00 local time. This table has been produced from the Fig. 2

	Air Pressure / légnyomás /Luftdruck (mmHg)			Temperature / Hőmerséklet / Temperatur (°C)					Vapor Pressure / Páranyomás / Dunstdruck (mmHg)			Humidity / Nedvesség / Feuchtigkeit (%)			Clouds/ Felhőzet/ Bewölkung (tenth)			Wind direction and Strength / Szélirány és erősség / Windrichtung u. stärke (Beaufort no [1–10])			Precipitation/ Csapadék/ Niederschlag (mm)
Day	7	2	9	7	2	9	Maximum	Minimum	7	2	9	7	2	9	7	2	9	7	2	9	
1	706.6	707	706.4	−8.2	−6.8	−8.5	−3.2	−8.8	1.4	2	1.5	61	78	64	2	2	8	SW 3	SW 2	N 3	
2	7.3	6.4	4.8	−3.2	−1.6	−1.4	−1	−9	3	3.8	3.9	86	97	97	4	10≡	10≡*	N 3	NW 4	NW 5	1.8*,6¼p-n
3	1.2	698	696.5	0.8	0.8	1.6	2	−1.4	4.7	4.8	5	97	98	98	10≡	10≡	10≡	NW 6	NW 6	NW 5	
4	694.9	95.8	93.9	−0.4	0.6	0.4	1.6	−1.6	3.9	3.6	4.6	88	75	98	7	9	10	NW 6	NW 5	W 5	9.5●*2¾p
5	93.9	92 .2	89.8	−0.6	3.2	4	4.2	−0.8	4.1	4.6	4.6	97	78	75	10≡	10	10	NNW 3	SW 4	SW 5	3.1●*0¾-2p
6	87.5	88.2	85.3	−1	0	−1.4	4	−1.6	3.3	3.4	3.3	78	74	80	10	10	7	N 3	NW 4	SW 4	1.9●*2-4¼p
7	74.2	75.2	76	1.8	4.4	2.2	5	−2	4.1	4.1	5.2	78	65	97	10≡	10	10≡	S 6	SW 4	NW 4	1.3●7½-8½p
8	85.2	92.3	96.9	−12.4	−9	−9.4	2.2	−12.6	1.3	1.5	1.9	80	72	68	3	9	3	NW 6	NW 5	NW 4	
9	98.9	96.8	95.6	−7.4	−5.6	−5	−4.9	−9.6	2.1	2.8	2.8	84	94	94	4	10≡	10	SW 3	S 3	S 3	⎵
10	96.3	96.5	700.5	−3.4	−1.4	−4.4	−1.1	−5.1	3.3	3.9	3	96	96	94	10≡*	10≡	10≡	S 3	NW 2	NW 2	2.6*7¼a-1¾p
11	706.3	708	710.6	−10.1	−6	−7.6	−3	−10.2	1.3	1.7	1.3	63	60	55	2	3	2	NW 4	NW 3	NW 2	
12	11.8	10.8	10.3	−11.2	−7.6	−9.4	−5.8	−2	0.8	1.1	1	47	45	50	7	4	10	SW 3	SW 2	S 2	
13	8.7	6.5	6.9	−9.8	−10	−13.9	−8.2	−14.6	0.9	1.3	1.2	45	65	92	I	2	2	− 0	W 3	S 2	
14	6.6	6.9	7.6	−15.8	−13	−14.6	−10.5	−16	0.9	1.1	1.1	83	72	73	2	3	2	N 3	NW 1	NE 2	
15	7.8	7.1	6.1	−16.2	−11	−12.2	−8.2	−16.4	1	1	0.8	86	55	47	2	3	2	− 0	− 0	−	
l6	5.4	5.6	6.8	−13.2	−11	−16	−8	−17	1.1	1.3	1.9	71	75	90	6	4	9≡	SE 1	SE 1	S4	0.7*⎵,*n
17	7.3	7.7	9.1	−15.8	−12	−11	−9.8	−17	1	1.1	1.1	92	65	60	9	4	3	SE 4	SE 3	SE 1	**V**
18	11.7	13.2	14.1	−8.2	−6	−8	−3.8	−11.2	1.3	1.7	1.5	53	59	63	I	2	3	SE 2	SE 3	SE 3	
19	14.6	13.3	12.2	−10.4	−7.6	−9.4	−6	−10.6	1.2	1.7	1.5	63	70	75	I	2	2	SE 3	SSE 4	S 5	
20	8.8	6.9	6	−12.8	−9.2	−10.1	−9	−12.9	1.3	1.6	1.7	84	75	85	3	2	10	S 4	S 5	S 6	0.5*n
21	3.1	4.2	4.1	−10.8	−8.4	−5.2	−5	−11	1.7	2.2	3	96	98	99	10≡	10≡	10≡	S 3	S 1	− 0	
22	1.8	1.6	1.2	−1.4	−6.2	−7.2	−0.8	−7.4	3.9	2.6	2.4	94	98	95	10	10≡	10≡	− 0	SW 2	S4	1.6* ●7½-8½p
23	0.8	0.7	0.1	−5.6	−4.8	−0.6	−0.4	−7.2	2.7	2.9	4.2	95	96	8	10≡	10≡	10≡	S 4	S 4	S 3	0.5●n
24	698.7	699	699.4	2.6	4	2	5	−1	5.1	5.2	5.2	93	85	98	9	6	10≡	SW 2	SW 2	S 3	
25	97.9	95.9	94.8	3.6	4	2.4	5.8	1	5	5	5.2	84	82	95	6	10	10≡	S 4	S 4	S 4	12.5●3¾p-n
26	91.5	92	94.4	2.9	−0.6	0	4.2	−0.8	5.4	4.2	4.5	96	96	97	10≡	10≡	0	SW 4	NW 4	NW 4	0.4*n
27	93.8	94.9	94.9	0.2	2.6	−1	2.6	−1.2	4.5	5.3	4	98	96	97	10≡	10	10≡	S 3	SW 2	NW 4	
28	94.6	96	96.1	−4.4	−5.8	−7.2	−0.9	−7.4	3.1	2.7	2.4	96	97	97	10≡	10≡	9	NW 2	NW 2	NW 2	**V**
29	98.3	98.4	98.2	−7.4	−7	−7.4	−5.5	−7.6	2.1	2	2.2	82	81	90	9	10	5	− 0	NW 1	NW 2	**V**
30	98.4	99.3	701	−7.2	−3.4	−5.5	−1.6	−7.6	1.6	2.4	2.2	69	70	77	6	3	3	NW 2	N 1	N 2	
31	99.6	97	696	−10.5	−7.5	−8	−4.9	−10.6	0.8	1.3	2	45	55	86	4	10	7	N 3	SSE 3	S 3	0.3*2½-3p
K(Mean/ Közep/ bedeuten)	700.5	701	700.3	−6.3	−4.6	−5.5	-2.1	−8.1	2.6	2.7	2.7	81	78	83	6.4	7	7	3.1	2.9	3.2	36.7

Table 4
Weather symbols used in the yearbooks of Royal Hungarian Central Institute of Meteorology and Earth Magnetism (RHCIMEM). Symbols from 1 to 8 were suggested by the 1873 Vienna Congress [12].

S. No.	Symbol	Meaning
1	•	Rain
2	*	Snow
3	☈	Thunderstorm
4	▲	Hail
5	**Δ**	Graupel
6	≡	Fog
7	⎵	Rime
8	⌓	Dew
9	∞	Haze
10	**V**	Frost
11	**a**	Am
12	**p**	Pm
13	**n**	Night

Ethics Statement

CRediT Author Statement

Arun Gandhi: Writing – original draft preparation, Software, Database creation, Validation, Visualization, Investigation; **Blanka Bartok** and **Judit Ilona:** Database creation, Validation, Writing – reviewing the text; **Peter K. Musyimi:** Dataset checking and validation; **Tamás Weidinger:** Conceptualization, Methodology, Writing – review & editing, Dataset checking, Validation, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

Data Availability

Historical fog climate dataset for carpathian basin countries (Original data) (Mendeley Data).

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