Rescue of Ukrainian early historical climatological data

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1 Introduction

- Detection and quantitative assessment of the recent climate change on global and regional scales is mainly performed based on data of instrumental measurements conducted on meteorological/climatological stations all over the world. Modern climate applications and climate services are seeing the need for more data and information (including its historical part) on climate variability at high temporal and spatial resolution.
- It is obvious that the longer and detailed records are the more valuable information can be extracted from the data regarding past, present and, definitely, future of the atmosphere, the climate and its variability. Their significant historical part still exists only in a hard copy form and has not been digitized yet in order to be introduced into scientific analysis.
- The main objective of our work is to present information on results of data rescue (DARE) activity conducted recently in the Ukrainian Hydrometeorological Institute (UHMI, Kyiv, Ukraine) in close collaboration with several national and international partners.

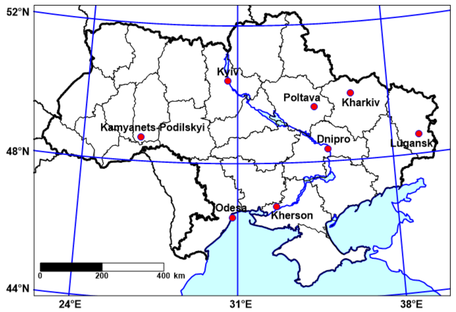
2 Data

- Our focus was concentrated on original sub-daily pre-1850 meteorological observations conducted at 8 meteorological stations located on the territory of the modern Ukraine. These 8 meteorological stations are only ones whose pre-1850 data have been found in a specialized archive of the Central Geophysical Observatory (an observation institution of the Ukrainian Weather Service).
- Meteorological stations: Kyiv, Kharkiv (Kharkiv, university), Poltava, Kamyanets-Podilsky, Lugansk, Dnipro, Kherson and Odesa.

Station	Geographical coordinates		Altitude ASL, m	Number of books with records	Beginning of observations in the rescued books
	latitude	longitude			
Kyiv	50º23'32''	30º32'11''	166	2	1812
Kharkiv	49º55'36''	36º16'44''	154	6	1840
Poltava	49º36'34''	34º32'41''	160	6	1824
Kamyanets-Podilskyi	48º41'36''	26º36'31''	217	1	1844
Lugansk	48º33'56''	39º13'39''	59	9	1827
Dnipro	48º21'36''	35º05'06''	142	6	1833
Kherson	46º44'18''	32º42'30''	47	2	1808
Odesa	46º26'27''	30º46'13''	42	6	1839

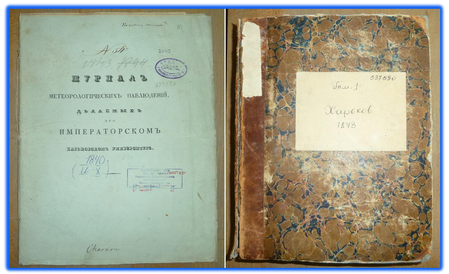
Remark. The geographical coordinates and altitudes are given for modern meteorological stations. These metadata are slightly different for the rescued stations because all of them were relocated to new places in every town/city.

Details on the rescued meteorological stations

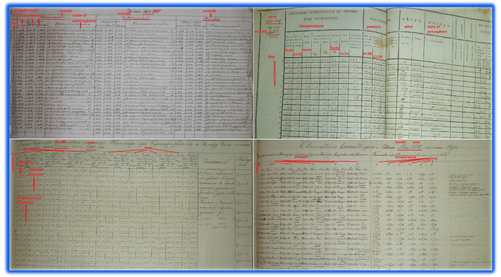


Location of the rescued stations on the territory of Ukraine

- The data from all stations were stored in paper (hard copy) format in special tables/books where meteorological records were made by hands (manually). Their total number is 38.
- They are written in different languages (old Russian, German or French). There is no unique format of the data records in the tables. They differ from each other by a number of observed/measured meteorological variables, time of observations, their frequency during a day etc.
- Several historical events such as WWII, had, probably, an influence on a state of the climatological archive of the Ukrainian Weather Service and a volume of the information preserved.



Examples of hard copy books with meteorological observations. To the left is Kharkiv (Kharkiv, University), 1840; to the right is Kharkiv (Kharkiv, University), 1843.



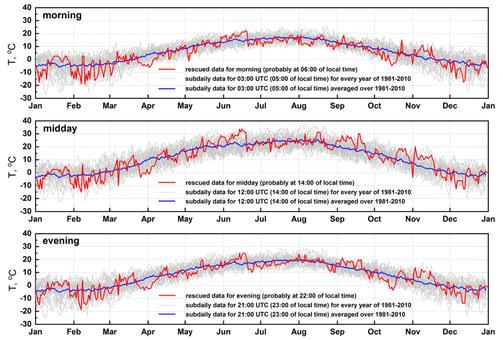
Examples of the original paper tables with meteorological observations (some explanations on the photos are shown in red). Top left panel: Kyiv, 1825; top right panel: Kherson 1827; bottom left panel: Lugansk 1850; bottom right panel: Odesa, 1840.

3 Methods

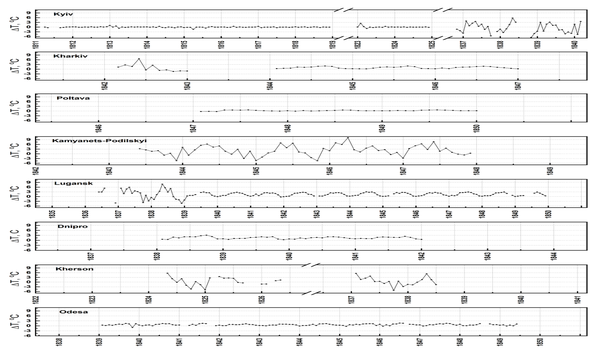
- DARE was performed according to the recommendations of WMO (2016)
- All pages of the tables/books were photocopied.
- After creation of the database of the images, data were digitized manually by the authors
- Values of only three variables were digitized: air temperature, atmospheric pressure (station level) and amount of atmospheric precipitations (rainfall).
- Several quality assurance procedures were performed in order to check the quality of data and the digitization process, including comparison with data previously digitized from other paper sources (URHMI, 1953) and intercomparison between stations by means of HOMER software (both on the monthly scale)

4 Results

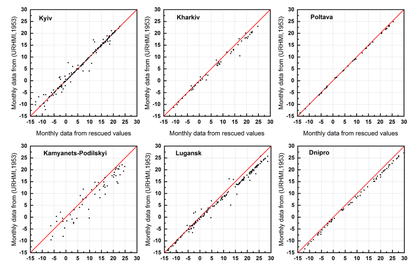
- In total 291 103 values were digitized.
- These include 165 980 air temperature records (~57% of the total), 124 376 atmospheric pressure measurements (~42.7%) and 747 precipitation totals (~0.3%).



Time series of sub-daily air temperature measurements at Kyiv in 1816 ('year without summer'). Temperature data were converted to the Celsius scale . The present climate sub-daily data (1981-2010) measured at the times closest to the supposed historical observations are also shown for comparison.

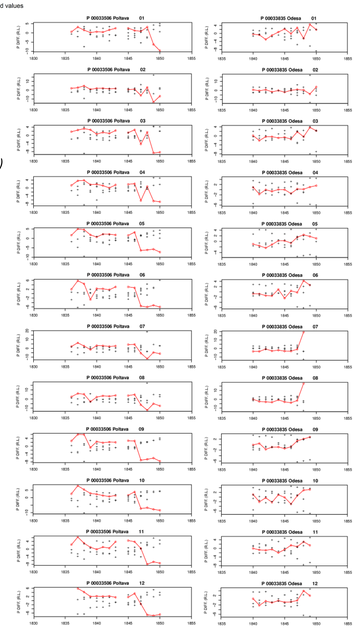


Time series of differences between monthly data calculated from the rescued records and from URHMI (1953). The figures for all stations were adjusted for the same temperature range for convenient mutual comparison



Scatter diagrams of monthly data digitized from URHMI (1953) against similar values calculated from the rescued data

- Based on QA part of the HOMER software a mutual evaluation of monthly time series was performed and potential outliers were localized.
- However, due to the large number of missing values along with the small number of stations analyzed, the results of such evaluation have limited validity.



Graphical output of HOMER's QA procedure for atmospheric pressure at Poltava and Odesa

5 Conclusion

- The quality control procedures revealed a fairly good agreement among the rescued time series on the monthly time scale as well as a good accordance with the monthly data from other sources
- However, several periods at some stations should be used with caution, due to relatively large discrepancies revealed
- The rescued digital dataset can be used for different meteorological and climatological purposes, including the analysis of extreme events for the pre-1850, regional climatological studies, etc.
- The dataset is an important supplement to existing digitized archives of meteorological measurements for the first half of the 19th century.
- Apart from Kyiv, Kamyanets-Podilskyi and Kherson, anomalies between the two kinds of monthly data increase with temperature magnitude, which leads to the significant seasonal/periodic course of the anomalies

References

WMO (World Meteorological Organization). 2016. Guidelines on best practices for climate data rescue. WMO-No. 1182, pp. 30. Geneva, Switzerland: WMO.

URHMI (Ukrainian Research Hydrometeorological Institute). 1953. Meteorological Data for Separate Years. Issue 10a. Ukrainian SSR and Moldavian SSR. Part 1. Air Temperature. Kiev: Publishing of Academy of Science of USSR, 577 pp. (in Russian)