

Availability, reliability and homogeneity of the historical series of meteorological data in Italy

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Various minor collaborations for recovering data and meta-data have been created.

We begin from an extremely important premise: our country boasts a role at the highest level in the development of meteorological observations. This role is well demonstrated from the inventions of some of the most important meteorological instruments and from the establishments of the first network of observatories. This strong Italian presence in the development of meteorological observations is also evidenced from six 17th century series.

- Bologna
- Milan
- Rome
- Padova
- Palermo
- Turin

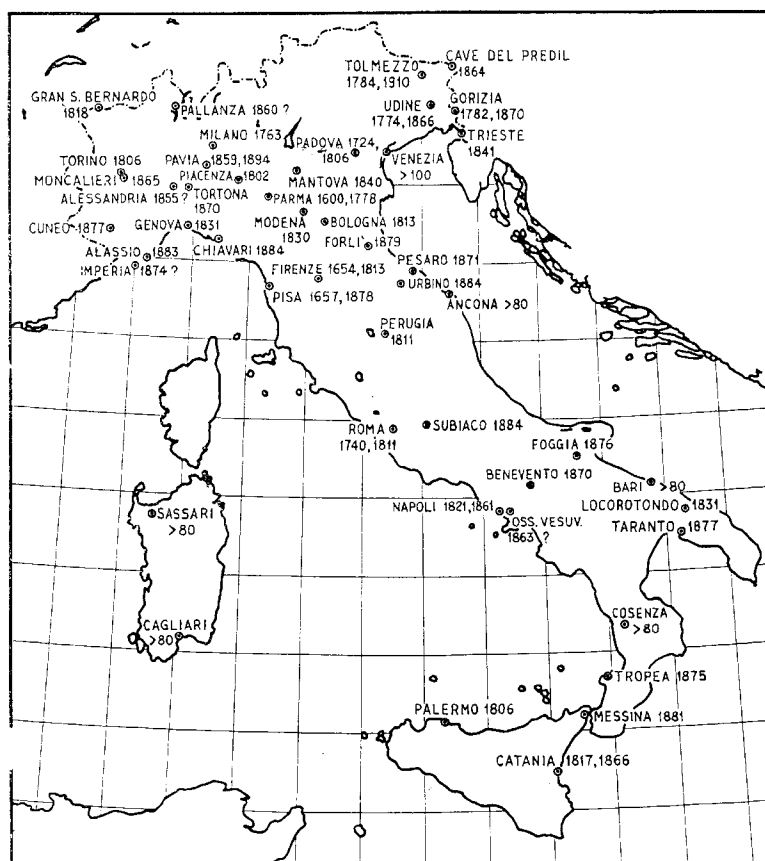
This strong “presence” has allowed Italy a heritage of observed data of enormous value has been accumulated within the last three centuries.

This heritage has been known for a long time. We have only to consider the important work of Cantù and Narducci (1967) "Lunghe serie di osservazioni meteorologiche", published in *Rivista di Meteorologia Aeronautica*, (Anno XXVII, n. 2, 71-79) from which the following figure that shows our series of centuries-old pluviometric and thermometric series is taken. Of notable interest also are other works that efficiently show how in our country there has been a deep understanding of the vastness of our meteorological archived data for a long time which concerns the following:

- Eredia F. (1908) *Le precipitazioni atmosferiche in Italia dal 1880 al 1905*. In: *Annali dell'Ufficio Centrale di Meteorologia*. Serie II, Vol. XXVII, anno 1905, Rome.
- Eredia, F. 1919. *Osservazioni pluviometriche raccolte a tutto l'anno 1915* from R. Ufficio Centrale di Meteorologia e Geodinamica. Ministero dei Lavori Pubblici, Rome.
- Eredia, F. 1925. *Osservazioni pluviometriche raccolte nel quinquennio 1916-1920* from R. Ufficio Centrale di Meteorologia e Geodinamica. Ministero dei Lavori Pubblici, Rome.
- Mennella, C. 1967. *Il Clima d'Italia*. Napoli: Fratelli Conti Editori.

- Millosevich. 1882. Sulla distribuzione della pioggia in Italia. In: Annali dell'Ufficio Centrale di Meteorologia. Serie II, Vol. III, 1881, Rome.
- Millosevich. 1885. Appendice alla memoria sulla pioggia in Italia. In: Annali dell'Ufficio Centrale di Meteorologia. Serie II, Vol. V, 1883, Rome.

A very complete framework of the richness of national publications emerges from the excellent bibliography, “Climatologica Italiana”, edited by Narducci and published in 1991 by the National Council of Geometricians (Rome). With this great resource, each researcher who has tried to recover the Italian historical series for use in his or her own work has surely encountered numerous problems.



In this context, the presentation proposes a guide for orientation in this complex “world” of the historical series of Italian meteorological data. The first step is to synthesize the situation of our historical series, which consists in identifying the homogeneous periods regarding availability, reliability and homogeneity of data. Normally, the periods can be identified as:

- (i) The “pioneer” period, that is, from the first observations at the beginning of 1800;
- (ii) The next period characterized by the progressive standardization of instruments and of observation methodologies;
- (iii) A period characterized by the creation of large national meteorological services;
- (iv) A final period characterized by the availability of data on magnetic support.

In reality, for a major categorization, in the presentation here, we are limited to three periods, considering the second as partially included in the first and in the third. Therefore, an initial phase is considered, which ended in 1865 with the establishment of a network of the Ministry of Agriculture, Industry and Commerce, a next phase ending at the beginning of 1950s and a final phase, now in progress.

The main problems relating to the first two phases are therefore considered. As far as the first phase is concerned, it is stressed that during the last years in Italy there has been a great deal of research activity conducted. This activity was directed above all towards the oldest series, that is, toward the 17th century series, as mentioned above. The common characteristics of the work carried out in the oldest series are that it concerns individual series of data and places great attention on the historical reconstruction of the ways in which the observations have been developed.

The most relevant consideration that comes from the group of these endeavours are: for the oldest series, the main problem resulting of reliability of data. Without detailed study of historical character that allows for the critical evaluation of the observed data, the oldest series is more like a group of numbers than a group of data!

For a more in-depth discussion of these problems, please refer to the literature. Here we would like to point out some relevant references to the European Union project, IMPROVE, within which the Milano and Padova series are studied:

- Camuffo, D. & Jones P. (eds): Improved Understanding of Past Climatic Variability from Early Daily European Instrumental Sources, Kluwer Academic Publishers, in press.
- Maugeri, M., Buffoni, L. & Chlistovsky, F. 2002: Daily Milan temperature and pressure series: history of the observations and data and metadata recovery, Climatic Change, (in press).
- Maugeri, M., Buffoni, L., Delmonte, B. & Fassina, A. 2002. Daily Milan temperature and pressure series: completing and homogenizing the data. Climatic Change, (in press).

The reliability of the data naturally improves slightly in the successive period due to a notable standardization of instruments and observation methods in the second half of the 1800s. However, some problems still remain.

One problem that is particularly pertinent to Italy could be constituted by the fact that, even after the creation of the Central Office of Meteorology, in many observatories, the observations are made in windows or meteorological balconies, and therefore could have given place to non-homogenic data with observations carried out in “Stevenson’s screens”. This problem provides an interesting example of the problems of data reliability that we have also had in relatively recent times.

In general, one can say that for the oldest data, the detailed knowledge of *the history of observation* is completely indispensable for transforming numbers extracted from the records of observations into data. For data of the following period, the reliability is surely greater, even if in this case the information of historical character often results in great interest for

evaluating the exact meaning of the data. However, this period was given great help in the comparison of data with other stations, as we will see detailed in the report of Teresa Nanni.

Year	1	2	3	4	5	6	7	8	9	10
1765										
1770										
1775										
1780										
1785										
1790										
1795										
1800										
1805										
1810										
1815										
1820										
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1980										
1985										
1990										
1995										

- 1 Carlini's Reform.
2. Other displacements of the instruments
- 3 Changes in the meteorological screen and its use
- 4 Improvements introduced by Cesaris.
- 5 Substitutions of the barometer and changes in instrumental corrections.
- 6 Effects of standardization due to the development of national and international meteorological networks.
- 7 Changes in observer(s); this is considered only until the end of 1880, because afterwards, standardization of measurements makes for less dependence on the observer.
- 8 Interruption of the Brera Observatory series.
- 9 Changes in the time of observations.
- 10 Effects of urban heat.

N.B. The vertical lines placed in the centre of the columns indicate that the change can occur in the 5-year interval preceding or following the year indicated. The dashes express uncertainty in determining the change.

The study approach in going from the oldest to the successive phases must necessarily be different for the same reliability of the data, which is still an important and problematic issue.

Here a fundamental problem is the availability of a high number of series. This availability is necessary also for a more efficacious application of homogenization methods. However, what are the data really available today? To answer this question, we will look at some fundamental events concerning the gathering and archiving of meteorological data after the Unification of Italy:

- 14 January 1865 – Circular of the Ministry of Agriculture, Industry and Commerce became the supervisor for the collection of Italian meteorological data. This led to the publication of data in the annals of "Meteorologia Italiana" (March 1865-1878);
- Congresses of Leipzig (1872), Wien (1873) and Rome (1879) and the foundation of the International Meteorological Organization;
- 26 November 1876 - decree with which the Government created a Board of Directors and a Central Meteorological Office [Ufficio Centrale di Meteorologia];
- 1879/1880 – Foundation of the Central Meteorological Office and the concentration of all activity in the sector at this structure. The publication of the Annals of the Royal Central Office of Meteorology and Geodynamics of the "Daily Meteorological Reports" then followed;
- 1917 – Institution of Hydrographic Service;
- 1925 – Allocation to the Forecasting Service under the responsibility of the Ministry of Air Force.

The Italian meteorological data after 1865 are therefore the most easily obtainable at:

- The ex-Central Office of Meteorology (today UCEA). This institute has continued to maintain its own network even after the foundation of the Hydrographic Service and the allocation of the Forecasting Service of the Air Force;
- Hydrographic Service;
- The Air Force

As far as the availability of computerized data is concerned, the first relevant attempt at reconstructing and computerizing centuries-old Italian meteorological series was made within a project in the 70s which computerized 26 daily series of T_{\min} , T_{\max} and rainfall data. This series (some updated) still constitute the data-set of the UCEA centuries-old series today (see Table).

For details, please refer to: Anzaldi C., Mirri, L. & Trevisan V. 1980. Archivio Storico delle osservazioni meteorologiche, Pubblicazione CNR AQ/5/27, Rome.

Cod.	Station	Rainfall		Temperature	
		<i>Length of series</i>	<i>Missing Data (%)</i>	<i>Length of series</i>	<i>Missing Data (%)</i>
45	Reggio Calabria	1878-1972	19.8	1878-1972	19.2
54	Palermo	1874-1973	0.7	1876-1973	0.1
55	Perugia	1874-1973	21.2	1876-1973	1.3

56	Torino	1866-1969	10.2	1870-1969	17.9
57	Padova	1877-1968	5.0	1877-1968	4.7
58	Alessandria	1875-1970	16.8	1878-1970	14.7
59	Arezzo	1879-1972	17.7	1879-1972	19.0
60	Belluno	1879-1986	7.7	1879-1966	6.9
61	Rovigo	1879-1976	12.4	1879-1966	13.0
62	L'Aquila	1879-1973	8.5	1879-1973	15.2
63	Reggio Emilia	1879-1970	10.8	1879-1970	23.8
64	Napoli	1865-1969	2.7	1870-1969	9.3
65	Cagliari	1879-1971	4.0	1879-1971	2.5
66	Mantova	1880-1973	11.5	1880-1973	11.4
67	Sassari	1876-1971	12.1	1876-1971	8.8
68	Siracusa	1874-1973	12.5	1878-1973	11.4
109	Roma	1862-1999	6.2	1870-1999	0.4
111	Pesaro	1876-1992	11.6	1876-1992	7.8
116	Bologna	1879-1988	10.3	1879-1988	14.8
118	Ferrara	1879-1974	17.9	1879-1974	16.6
121	Parma	1878-1994	6.3	1878-1994	2.5
122	Piacenza	1875-1999	6.0	1878-1999	9.4
139	Pavia	1883-1991	23.8	1870-1979	26.1
146	Cuneo	1879-1993	12.5	1879-1993	12.4
153	Messina	1881-1974	12.2	1881-1974	10.7
155	Livorno	1876-1994	10.3	1870-1994	11.8

A final important contribution was the CNR Special Project entitled, “Reconstruction of the climate in the past in the Mediterranean area”. This project did not operate at a daily scale, but only monthly. The UCEA data set in the project was:

- updated (1970-1998 period)- digitizing of published data on the annals of various sectors of the Hydrographic Service. Before digitizing, the observing stations were checked to see if they matched the ones that received the computerized data in the previous project in the 70s;
- extended in the past and completed in regard to missing data on the basis of bibliographic sources
- corrected on the basis of the above-cited sources;
- homogenized. This activity was principally carried out through Craddock’s homogeneity test;
- completed. The completion was accomplished by a statistical method, based on a series of references already used for homogenizing completed data.

The final databank then covers the period from 1865 to 1998 for temperatures, and from 1833 to 1998 for rainfall.

The contents of the database of the CNR Special Project “Reconstruction in the Mediterranean area in the past” are shown in the following table.

		Lat.	Lon	Alt.	Rainfall Length	<i>Missing Data (%)</i> <i>1833-1996</i>	Temperature Length	<i>Missing Data (%)</i> <i>1865-1996</i>
1	Alessandria	44° 41'	08° 45'	98	1857-1985	24.6		

2	Arezzo	43° 27'	11° 52'	274	1876-1992	26.6	1877-1992	15.3
3	Belluno	46° 07'	12° 13'	404	1875-1993	21.6	1873-1993	16.0
4	Benevento	41° 08'	14° 45'	135	1870-1996	22.6		
5	Bologna	44° 29'	11° 20'	60	1813-1988	5.5	1866-1996	0.0
6	Cagliari	39° 12'	09° 19'	55	1853-1996	21.4	1879-1996	13.7
7	Cuneo	44° 24'	07° 31'	536	1877-1992	29.7	1877-1993	13.7
8	Ferrara	44° 49'	11° 36'	15	1865-1983	20.7	1879-1996	15.3
9	Genova	44° 24'	09° 08'	53	1833-1980	4.9	1865-1981	12.2
10	L'Aquila	42° 21'	13° 24'	735	1874-1994	29.3	1874-1994	17.6
11	Livorno	43° 33'	10° 18'	3	1857-1994	23.9	1866-1994	7.6
12	Mantova	45° 09'	10° 45'	20	1840-1995	12.4	1866-1993	3.8
13	Messina	38° 12'	15° 30'	54	1866-1992	32.0	1881-1992	15.3
14	Milano	45° 28'	09° 11'	122	1764-1996	0.0	1763-1995	0.8
15	Napoli	40° 50'	14° 15'	149	1821-1969	2.4	1865-1989	10.7
16	Padova	45° 24'	11° 52'	14	1752-1987	8.6	1866-1979	13.0
17	Palermo	38° 06'	13° 21'	71	1806-1992	3.0	1866-1992	3.1
18	Parma	44° 48'	10° 18'	57	1833-1987	5.5	1866-1993	4.6
19	Pavia	45° 10'	09° 09'	75	1812-1979	18.1	1866-1980	13.7
20	Perugia	43° 06'	12° 23'	520	1811-1993	5.9	1866-1993	2.3
21	Pesaro	43° 52'	12° 52'	11	1866-1991	25.7	1871-1991	8.4
22	Piacenza	45° 01'	09° 43'	50	1872-1992	27.5	1872-1995	6.9
23	Reggio Calabria	38° 06'	15° 39'	15	1867-1996	38.0	1879-1996	23.7
24	Reggio Emilia	44° 42'	10° 37'	62	1867-1996	26.3	1876-1996	9.2
25	Roma	41° 54'	12° 28'	56	1782-1996	3.4	1831-1994	13.0
26	Rovigo	45° 03'	11° 46'	9	1878-1993	33.3	1879-1993	13.7
27	Sassari	40° 43'	08° 36'	224	1876-1996	30.5	1876-1997	12.6
28	Siracusa	37° 03'	15° 17'	23	1869-1989	34.2	1878-1988	26.0
29	Torino	45° 03'	07° 40'	275	1803-1996	2.3	1866-1995	37.0
30	Trieste	45° 39'	13° 45'	67	1841-1996	4.9		
31	Vallombrosa	43° 43'	11° 00'	955	1872-1989	29.9		
32	Venezia	45° 26'	12° 15'	1	1836-1980	11.6		

Identifying and correcting possible lack of homogeneity remains one of the main problems unresolved in the database created within the CNR Special Project, “Reconstruction in the Mediterranean area in the past”. Indeed, the scarce availability of metadata has severely limited the homogenization activity that allows for an almost exclusive application of indirect methodologies (for details relating to homogenizing of data, refer to the work of Teresa Nanni.).

The result was a rather cautious homogenization, with many “suspicious” periods for which, in absence of news of a historical nature, it is preferable to suspend judgment for now. Accordingly, it will be necessary to turn to this data and proceed to a more stringent homogenization.

This more accurate homogenization constitutes one of the objectives of our group within the CLIMAGRI project. I will conclude this commentary with a brief synthesis of what is being produced in my Research Team within the CLIMAGRI project.

The activities concern both data and historical information (metadata). Research in the sector of metadata was developed with the general goal of contributing to a deeper understanding of the history of observation. This was divided into various topics:

- The study of the historical and organizational context in which the network of observatories were born and developed, and the analysis of the evolution of the instruments used and the methodologies of observations undertaken.
- Reconstruction of the elements relating to history of each single station of the network.

The research was elaborated upon with the main objective of enlarging the available database. The results are summarized in the following table.

		Lat.	Lon.	Alt.	Monthly Data		Daily Data	
					Temperature	Rainfall	Temperature	Rainfall
1	Alessandria	44° 41'	08° 45'	98	1878-2000	1875-2000	1878-2000	1875-2000
2	Aosta	45° 44'	07° 18'	544	1841-2000			
3	Arezzo	43° 27'	11° 52'	274	1873-2000	1876-2000	1879-2000	1879-2000
4	Balme	45° 19'	07° 13'	1432		1914-2000		
5	Bardonecchia	45° 05'	06° 42'	1340		1914-2000		
6	Belluno	46° 07'	12° 13'	404	1873-2000	1875-2000	1879-2000	1879-2000
7	Benevento	41° 08'	14° 45'	135		1870-2000		
8	Bologna	44° 29'	11° 20'	60	1814-2000	1813-2000	1814-2000	1813-2000
9	Bolzano	46° 31'	11° 21'	272	1850-2000	1850-2000		1921-2000
10	Bra	44° 42'	07° 52'	308		1861-2000		1861-2000
11	Bressanone	46° 43'	11° 39'	569	1865-2000	1865-2000		1921-2000
12	Cagliari	39° 12'	09° 19'	55	1879-2000	1853-2000	1879-2000	1879-2000
13	Casale Monferrato	45° 08'	08° 30'	113		1870-2000		
14	Catania	37° 30'	15° 05'	75	1901-2000	1901-2000	1901-2000	1901-2000
15	Cuneo	44° 24'	07° 31'	536	1877-2000	1877-2000	1879-2000	1879-2000
16	Domodossola	46° 07'	08° 17'	300	1872-2000	1872-2000		1872-2000
17	Finestrelle	45° 02'	07° 04'	1200		1913-2000		
18	Ferrara	44° 49'	11° 36'	15	1879-2000	1865-2000	1879-2000	1879-2000
19	Firenze	43° 47'	11° 15'	51	1889-2000	1860-2000	1889-2000	1860-2000
20	Foggia	41° 28'	15° 32'	80	1901-2000	1901-2000	1901-2000	1901-2000
21	Formazza Ponte	46° 23'	08° 26'	1300	1933-2000	1913-2000		
22	Fossano				1874-2000	1865-2000		
23	Genova	44° 24'	09° 08'	53	1833-2000	1833-2000	1833-2000	1833-2000
24	Imperia				1875-2000	1876-2000		
25	Ivrea	45° 28'	07° 55'	267		1837-2000		
26	L'Aquila	42° 21'	13° 24'	735	1874-2000	1874-2000	1879-2000	1879-2000
27	Livorno	43° 33'	10° 18'	3	1866-2000	1857-2000	1870-2000	1876-2000
28	Locarno	46° 10'	08° 47'	379		1901-2000		1901-2000
29	Lombriasco	44° 50'	07° 39'	239		1913-2000		
30	Lugano	46° 00'	08° 54'	276	1864-2000	1901-2000		1901-2000
31	Mantova	45° 09'	10° 45'	20	1828-2000	1840-2000	1828-2000	1868-2000
32	Messina	38° 12'	15° 30'	54	1881-2000	1866-2000	1881-2000	1881-2000
33	Milano	45° 28'	09° 11'	122	1763-2000	1764-2000	1778-2000	1858-2000
34	Marienbergl	46° 44'	10° 29'	1323	1847-2000	1847-2000		1923-2000
35	Napoli	40° 50'	14° 15'	149	1865-2000	1821-2000	1870-2000	1866-2000
36	Ovada	44° 38'	08° 38'	187		1914-2000		
37	Padova	45° 24'	11° 52'	14	1866-2000	1752-2000	1877-2000	1877-2000
38	Palermo	38° 06'	13° 21'	71	1866-2000	1797-2000	1876-2000	1797-2000
39	Parma	44° 48'	10° 18'	57	1866-2000	1833-2000	1878-2000	1878-2000
40	Pavia	45° 10'	09° 09'	75	1866-2000	1812-2000	1870-2000	1883-2000
41	Perugia	43° 06'	12° 23'	520	1866-2000	1811-2000	1876-2000	1874-2000
42	Pesaro	43° 52'	12° 52'	11	1871-2000	1866-2000	1871-2000	1871-2000
43	Piacenza	45° 01'	09° 43'	50	1872-2000	1872-2000	1878-2000	1875-2000
44	Reggio Calabria	38° 06'	15° 39'	15	1878-2000	1867-2000	1878-2000	1878-2000
45	Reggio Emilia	44° 42'	10° 37'	62	1876-2000	1867-2000	1879-2000	1879-2000
46	Riva	45° 52'	10° 45'	73	1870-2000	1870-2000		1921-2000
47	Roma	41° 54'	12° 28'	56	1831-2000	1782-2000	1870-2000	1866-2000
48	Rovereto	45° 01'	11° 27'	206	1862-2000	1862-2000		1921-2000
49	Rovigo	45° 03'	11° 46'	9	1879-2000	1878-2000	1879-2000	1879-2000
50	San Bernardo	45° 52'	07° 11'	2472	1818-2000	1818-2000		
51	Sassari	40° 43'	08° 36'	224	1876-2000	1876-2000	1876-2000	1876-2000

52	Siracusa	37° 03'	15° 17'	23	1878-2000	1869-2000	1878-2000	1874-2000
53	Taranto	40° 27'	17° 18'	22	1901-2000	1901-2000	1901-2000	1901-2000
54	Torino	45° 03'	07° 40'	275	1753-2000	1802-2000	1753-2000	1802-2000
55	Torino moncalieri	45° 00'	07° 42'	267	1865-2000	1864-2000		
56	Tortona				1892-2000	1873-2000		
57	Trento	46° 04'	11° 07'	199	1816-2000	1816-2000		1921-2000
58	Trieste	45° 39'	13° 45'	67	1841-2000	1841-2000		
59	Udine	46° 00'	13° 12'	51		1803-2000		
60	Vallombrosa	43° 43'	11° 00'	955	1872-2000	1872-2000	1872-2000	1872-2000
61	Venezia	45° 26'	12° 15'	1	1900-2000	1836-2000	1900-2000	1900-2000

Note: some details within the table are still to be verified.