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Earliest meteorological observations in Naples in the 18th century

Salvatore Esposito[1] and Adele Naddeo[2]

[1]University of Naples Federico II - Department of Physics & INFN - Sezione di Napoli, Naples, salvatore.ssposito@na.infn.it.
[2]University of Naples Federico II - Department of Physics & INFN - Sezione di Napoli, Naples, anaddeo@na.infn.it.

Abstract: The 18th century marked the beginning of a widespread diffusion of thermometers and other meteorological instruments, fostering the birth of the first correspondence networks in Europe (including Italy), aimed at collecting and comparing meteorological observations from different sites. An active role was played starting from 1723 by the secretary of the Royal Society, James Jurin, who built one of these networks. Participants were requested to record daily observations concerning temperature, barometric pressure, direction and strength of winds, description of clouds and amount of rain or snow. The Neapolitan Niccolò Cirillo was among Jurin's correspondents; he carried out a variety of observations, ranging from weather conditions and wind directions to rainfalls and the activity of Mount Vesuvius, also including an account on the eruption during March 1730. Original documents from the Royal Society historical archives testifies the activity carried out by Cirillo within Jurin's network, including excerpts of his meteorological diary. The emerging feature is a unifying vision of meteorology, as a comprehensive science including any Earth phenomenon, which was widespread among scientists and naturalists in 18th and 19th century, leading to a common belief of a deep relationship between earthquakes, eruptions and atmospheric phenomena.

Keywords: Meteorological Networks, Earthquakes, Vesuvius

1. Introduction: the birth of the first correspondence networks in Europe

The XVI and XVII centuries were characterized by the rejection of old Aristotelian meteorological theories and, mainly in Germany, England, France and Italy, by the birth of the modern approach to weather science, prompted by the invention of three basic instruments: the hygrometer, the thermometer and the barometer (Jacobson, 2005). The first instruments for the measurement of the amount of water vapour in the atmosphere were described by Nicholas de Cusa (1401-1464) and Leonardo da Vinci (1452-1519), while a thermometer based on the expansion and contraction of air was built by Galileo Galilei (1564-1642) by the end of XVI century. Galilei compared the temperatures of different places and investigated diurnal and seasonal variations of temperature. Finally, the mercurial barometer was invented by Evangelista Torricelli (1608-1647) who, in 1643, carried out his celebrated experiment on the pressure of the atmosphere.

These efforts paved the way for a widespread diffusion of observations of various meteorological quantities, such as temperature, pressure, humidity, wind strength and direction, and of the corresponding data analysis aimed at weather forecasting. The consequence was the birth and spreading of the first correspondence networks in Europe, whose primary purpose was to collect and compare meteorological observations from different sites.

The first international network of meteorological stations (the Medici network) was set up in 1654 by the Grand Duke Ferdinand II de' Medici and his brother Prince Leopold (Middleton, 1971). It was led by the Jesuit Luigi Antinori and involved stations at Florence, Vallombrosa, Pisa, Cutigliano, Bologna, Parma, Milan, Warsaw, Innsbruck, Osnabruck and Paris (Camuffo & Bertolin, 2012). Observations had to be carried out with identical instruments and had to follow the same schedule and protocols, finally data had to be collected in special tables. The network's activity developed in close connection with the Accademia del Cimento of Florence and its aim was to provide an answer to several questions, dealing with the main weather issues of the chosen localities, as for instance:

1. What is the difference in temperature in various places, ranging from middle to higher latitudes?
2. What about the melting temperature of ice and its possible dependence on the height or other geographical features?
3. How does the density of liquids depend on temperature?

The main result of the activity of the Cimento scholars within meteorology was to point out the relevance of setting up a network for the simultaneous collection and rapid communication of data (Middleton, 1966). Indeed, the Medici network became a model, soon followed by other European countries. In England, between 1666 and 1692, John Locke (1632-1704) carried out weather observations and collected data from stations in Oxford, London and Oates. A prominent role in the development of meteorology was played by the Royal Society since its foundation in 1660, and two members gave fundamental contributions, that is Robert Boyle (1627-1691) and his assistant Robert Hooke (1635-1703). They developed barometers, thermometers and thermometric scales (Patterson, 1953) and introduced the use of barometer in weather forecasting. The Royal Society strongly contributed to the spreading of the best practice in meteorology, i.e. to make weather observations regularly and systematically. This activity was pioneered by Hooke (Purrington, 2009) and triggered the birth of networks of meteorological stations in different European countries, as France and Germany. In Germany Gottfried Wilhelm Leibniz (1646-1716) and Samuel Reyher (1635-1714) started meteorological observations in Hannover and in Kiel, respectively, while in France, since 1699, Philippe De La Hire (1640-1718) carried out daily weather observations as a member of the Paris Académie des Science; these observations continued until 1754 and were regularly published in the Académie Memoirs since 1710 (Frisinger, 1983). In Italy as well, after the Medici network's experience, some scholars began to carry out regularly meteorological observations; among them there were Paris M. Salvago (1643-1724) and Giovanni Poleni (1683-1761) (Iafrate, 2000).

As the above examples show, the beginning of the 18th century in Europe was characterized by the development of meteorological instruments, while the Royal Society continued to play a prominent role in pursuing meteorological activity. There was an impressive increase of scholars making regular weather observations as well as of knowledge of weather systems. Thus, meteorology became more and more organized and attempts to build up international networks of weather observers increased at a rapid pace. Starting from 1723, huge efforts were performed in this direction by the Secretary of the Royal Society, James Jurin (1684-1750), who developed an international correspondence network including stations located in Europe and in American colonies. Among Jurin's correspondents there was the Neapolitan physician and botanist Niccolò Cirillo (1671-1735), who became fellow of the Royal Society in 1718 and soon began to collect meteorological data on the climate of Naples.

The aim of this contribution is to reconstruct the activity of Niccolò Cirillo within Jurin's network. This task will be pursued by relying on the close analysis of original documents from the Royal Society historical archives, which include also excerpts of Cirillo's meteorological diary. This study is reported in Section 3, after a brief account of the main features of Jurin's meteorological project (Section 2). Finally, conclusions and perspectives of this work are outlined in Section 4.

2. James Jurin's network

The strength of the Royal Society activity in the XVIII century mainly relied upon its extensive correspondence (Rusnock, 1999). Communications from observers outside London soon became part of the Society's practice. Several fellows started projects aimed at gathering observations and reports on specific topics, ranging from natural history to philosophy. In this respect a key role was played by Jurin, who served as Secretary from 1721 to 1727 and deeply rebuilt the Society's correspondence practice. His huge efforts clearly showed how correspondence increased cooperation among natural philosophers and contributed to build scientific knowledge. As such, with Jurin's main project, devoted to collect meteorological observations, correspondence became a scientific method.

In his speech entitled "A Proposal for Joint Observations on the Weather", delivered at the Royal Society meeting of 12 December 1723, Jurin put forward his ambitious program whose qualifying point was the organization of a network of correspondents from various places, located not only in England but also abroad: "a true Theory of the Weather is not to be attained by a knowledge of the Successive Alterations in any one certain place... it must needs require the joint Assistance of many Observers" (Rusnock, 1999, p. 164). He further explained his idea in a letter to Niccolò Cirillo, dated 26 March 1725: "My intention and desire [is] by collecting accurate observations made successively over wide areas, to be able eventually to learn for what reasons such great changes in the atmosphere are effected so suddenly. If it is ever granted to the race of Mortals to know this, it is by this kind of method, I think, that it will be revealed" (Rusnock, 1999, p. 164).

The speech followed the publication of his proposal, "Invitatio ad observationes meteorologicas communi consilio instituendas" (Jurin, 1723), on the Society's Philosophical Transactions, which was written in Latin in order to emphasize the international target of the project. Interestingly, it contained the template that correspondents should have followed to write their meteorological reports. In fact, Jurin's main idea was to standardize observations, that is to make uniform measurements, instruments and methods (Walker, 2012). As such, participants were requested to record observations twice daily, focusing on temperature, barometric pressure, amount of rain or snow, direction and strength of winds, and on issues such as a description of clouds (Rusnock, 1996). Correspondents had to provide conversion tables between local measures and London measures. While this task was easily pursued for length measurements, the real challenge was indeed how to compare different thermometric and barometric scales due to the recent introduction of thermometers and barometers and the little standardization level even within a single country. Between 1725 and 1726 Jurin tried to cope with these difficulties by persuading the Royal Society council to fund eighteen Hauksbee's thermometers to be sent to foreign observers, especially to those operating in the farthest stations. Despite these efforts, he didn't succeed in obtaining uniform measures from all the correspondents, the main problems residing in the use of thermometers, as stated for instance in Cirillo's letters and manuscripts (see Section 3).

Jurin's network involved observers in Uppsala, St Petersburg, Berlin, Leiden, Naples, Luneville, Boston and many towns in Great Britain, who regularly compiled weather diaries (Rusnock, 1999). His project gave a significant contribution to the production of scientific knowledge in the 18th century. Indeed, despite some drawbacks, it showed a high degree of international cooperation, the effective use of correspondence and the need of standardized instruments and measurements.

3. Niccolò Cirillo's activity within Jurin's network

Neapolitan correspondent Niccolò Cirillo worked at Incurabili hospital as a physician, then he held the chair of Natural Philosophy in 1705 and that of Medicine in 1706. In 1718 he became a fellow of the

Royal Society of London and soon began to collect meteorological data on the climate of Naples, as requested by Jurin who gave him detailed instructions:

> please be so good as to write the time, along with the date, of each observation. Please enter the actual numbers everywhere; short transverse lines, which occur in various entries, leave me in doubt whether an observation has been omitted or the numbers written by the previous observation are to be understood. (Rusnock, 1999, p. 167)

In many circumstances, Jurin publicly acknowledged and appreciated Cirillo's contributions, as shown for instance in a letter dated 26 March 1725. There he wrote:

> Most Learned Sir, Your letter written on the first of January gave much pleasure to me personally, and filled the whole of the Royal Society also, at whose meeting I read it out a few days ago, with a rare and special delight. And rightly so: for in it you showed so many examples of keen intellect and of subtle and refined judgement and at the same time such kindness and such ardour for the advancement of Natural History, that it could not fail to be most welcome and give the greater satisfaction that you Sir, a man of such eminence, have done the Society the honour of reporting to it so promptly your work for the development of that aspect of Natural Science. And so by the unanimous votes of all I have been instructed to inform you of the Society's warm feelings of goodwill towards you, and in its name to return our special thanks for your observations, both those which you have already given us and those you have promised. (Rusnock, 1996, p. 290)

The activity carried out by Cirillo within Jurin's network is testified by a handful of original documents from the Royal Society historical archives, dated from January 1725 to April 1733, which include also excerpts of his meteorological diary. In general, these documents are letters addressed to Jurin and, after 1727, to the subsequent Secretaries of the Royal Society, William Rutty until 1730 and finally Cromwell Mortimer (until 1735, when Cirillo passed away). The letters are mainly written in Latin, although in a few cases there are also English translations. Some of them contain manuscripts which he submitted for publication in the Philosophical Transactions of the Society.

A first interesting document is a letter to Jurin, dated 1 January 1725 (Cirillo, 1725), followed by an excerpt of his meteorological diary, reporting observations from August to December 1724, These observations are collected in a table, according to Jurin's prescriptions, which records the date, the hour, the overall weather conditions, the wind direction, the rainfall and, interestingly, information about Mount Vesuvius. The status of Mount Vesuvius would have been always under close scrutiny by Cirillo, who later gave an account of the eruption, which took place in March 1730, within a letter addressed to William Rutty (Cirillo, 1731). The same account, extracted from his 1730 Meteorological Diary, was the subject of a communication in the Philosophical Transactions (Cirillo, 1732a). Preliminary considerations on the Hauksbee thermometer and related critical issues were given in both documents, followed by a possible interpretation of the observed phenomenon:

> The Thermometer used in this Diary, was made by Mr. Hauksbee, in which the Freezing Point is marked at 65 Degrees under the Point extreme Hoy; but the Doctor observes, that at Naples Water will freeze when this Thermometer stands at 55 Degrees only: Which, he is of Opinion, seems to argue, that there is something else besides an intense Degree of Cold required for freezing Water; that the Air of Naples abounds in it, more than the Air of London; and that this may probably be of a saline Nature; because when we turn Water into Ice by the Help of Snow, it is necessary to mix Salt with it. (Cirillo, 1732a, p. 336)

Then, a detailed description of eruption was provided, starting from the very beginning and including the weather conditions. A wide range of phenomena was registered, ranging from the emission of smoak and stream of fire to strong thunders and a little trembling of windows, and culminating in the formation of the eruptive column and the subsequent pyroclastic flow:

> In the Evening after Eight o'Clock the Fire arose to a vast Height, and threw huge Stones to almost half the perpendicular Height of the Mountain. Pumice Stones red hot of two or more Ounces Weight, were driven several Miles like a Shower of Hail, and frightened away the Birds. In about an Hour's time the Height of the Flame was somewhat lessened; and through the middle of the thick Smoak Flashes of Lightning were often seen... Thick Smoak scattered the Ashes many Miles over the Sea. (Cirillo, 1732a, p. 337)

Finally, "The City was sprinkled over with small Ashes... Vesuvius became entirely quiet" (Cirillo, 1732a, p. 338).

Among the remaining documents, two manuscripts are of particular importance. They are both accompanied by a letter addressed to Cromwell Mortimer, dated back to 1732 (Cirillo, 1732b) and 1733 (Cirillo, 1733c), respectively, which were later published in the Philosophical Transactions of the Royal Society (Cirillo, 1733a; 1733b).

The first one contains a detailed description of the violent earthquake which, in March 1731, shook the Apulia region and was felt in almost the whole Kingdom of Naples (Cirillo, 1732b). The seismic event developed according to the following phenomenology:

> While it lasted, there were observed in it all its different Species taken notice of by the Ancients. First, the Tremor; next the Shake, called σφυγμος by Aristotle, or Succussatio by Posidonius in Seneca; and last the Inclination or tottering of the Earth, like that of a ship. These different motions followed one another by turns and successively, during the Space of three Minutes and some Seconds. (Cirillo, 1732b, p. 2)

It was followed by a number of shorter and weaker aftershocks, ranging from the next day to November, and caused severe damage to houses and people. Interestingly, according to Cirillo observations, the shocks were centered about the town of Foggia and the corresponding strength diminished upon the distance from it. He conjectured a progressive motion diminishing successively in a quadratic proportion of the distances and checked this hypothesis by recording the oscillations of a couple of pendula, with a length of a palm, applied to a semicircle divided into degrees and located in Ascoli Satriano and Giovinazzo. He concluded that:

> For the Number of those Degrees being greater at Ascoli, which is nearer, than at Iuvenazzo, which is farther off, almost answered the duplicate Proportion of the Distances of those Places from the Center of the Earthquake. And it was for this Reason, that when the Earth was very slightly shaken at Foggia, the Pendulum was a little moved at Ascoli, but was observed not to move at all at Iuvenazzo. (Cirillo, 1732b, p. 4)

As an interesting feature of this report, the author focused at length on the natural phenomena observed before, during and after the seismic event under investigation and put forward hypotheses on the possible relationship between these and the event itself.

The second manuscript consists of a detailed account of meteorological observations carried out in Naples during the whole year 1732, concerning the following phenomena: rain, snow, winds (including an interesting discussion of viable experimental apparatuses and methods for the measurement of their strength), atmospheric pressure, temperature, the volcanic activity of Mounts Vesuvius, Etna and Stromboli, respectively (Cirillo, 1733c). Also, here Cirillo raised critical issues related to the use of Hauksbee's thermometer and stated clearly his intention to carry out further clarifying experiments:

> In the Month of December, when there appeared some Ice the Thermometer was fallen to 55 and 56. In this place I think worth observing, that on the Table which is fixed to the Hauksbeian Thermometer the 65 Degree is marked with the word Frost. However I have found by many years observation that it froze Ice, when the Liquor in the same Thermometer, that had been sent to me from England, was fallen down no farther than 55 Degrees. Hence it cannot be denied, but that a less Degree of Cold will produce Ice here at Naples than at London. This Phenomenon affords a subject for a Dissertation on purpose, which I intend, if God permit, to draw up, after having first gathered some Materials serving to this end and made more accurate Experiments. (Cirillo, 1733c, p. 7)

Then he focused on the strong explosive activity of Vesuvius, which took place in December 1732, accompanied by lava flows and a huge dispersion of ashes.

In the final paragraph the author only mentioned the earthquake, which in November 1732 hit Irpinia and Sannio (the so called Province of Principato Ultra), because a complete information was still lacking.

4. Conclusions

The development of weather science in XVII and XVIII centuries was accompanied by the rising of the first meteorological networks, characterized by the massive use of correspondence as a scientific method. A prominent role in this respect was played by the Royal Society since its foundation, and especially by its secretary James Jurin, who set up one of these networks in 1723.

The Neapolitan Niccolò Cirillo, who was among Jurin's correspondent, carried out observations, ranging from weather conditions and wind directions to rainfalls and volcanic activity. In particular, he gave an account of the eruption of Mount Vesuvius during March 1730 and of the earthquake that in 1731 affected Apulia and almost the whole Kingdom of Naples. Other seismic and volcanic events were reported as well, as testified by archival documents from Royal Society.

The emerging overall picture is a unifying vision of meteorology, as a comprehensive science including any Earth phenomenon, which was widespread among scientists and naturalists in XVIII and XIX centuries, leading to a common belief of a deep relationship between earthquakes, eruptions and atmospheric phenomena.

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