EARTH The Science Behind the Headlines

Earliest instrumental temperature record recovered in Italy

The Little Florentine Thermometer, the first modern thermometer, consisted of a glass tube with a bulb at one end with glass beads welded onto the tube to create a fixed, calibrated reference scale. Previous thermometers had separate scales and were unsealed and thus were affected by air pressure.

Credit:
Courtesy of the Photographic Laboratory and Archive of Museo Galileo

The Mediterranean cyclone that struck northern Italy Nov. 4, 1966, took 118 lives, caused a catastrophic flood in Florence and produced the highest storm surge ever recorded in Venice on the Adriatic coast. Here, the floodwaters that damaged the national library collection are seen filling the square near the Ponte Vecchio.

Credit:
Courtesy of Julia Bolton Holloway, http://florin.ms/1966flood.html

The Medici Network measured temperatures during the Little Ice Age

A few hours before dawn on the morning of Nov. 4, 1966, engineers at the Valdarno Dam on the Arno River in Italy were faced with an exigent decision. After days of intense precipitation from a Mediterranean cyclone, the swollen Arno was surging over the dam at a rate of 2,000 cubic meters per second. In an attempt to prevent the dam from bursting, engineers decided to release a surge of water downstream toward Florence. Immediately in the torrent's path was one of the most important libraries in Italy, the Biblioteca Nazionale Centrale Firenze, founded in the late 1600s.

The water was moving up to 60 kilometers per hour when it reached the outskirts of Florence where the narrow streets channeled the water, which reached a maximum depth of 6.7 meters in town. The library's main entrance faced the river and took the full force of the barrage, which left more than a third of the library's collection — 1.3 million books — submerged. When the water receded, the lower levels held two meters of mud. Some of the most historic and important of the damaged works were those collected by the famed Florentine Medici family, including records from the first international meteorological network, which operated from 1654 to 1670.

Within days, hundreds of volunteers from around the world, called "mud angels," descended on Florence to begin the cleanup of not just the library's collection, but thousands of other cultural and historical treasures damaged in the flood. In the aftermath of the flood, the earliest weather data logs were scattered about Italy. Now, after decades of hunting them down in museums, libraries and ecclesiastical archives, the earliest set of instrumental temperature records in the world have been analyzed and published for the first time.

The Medici Network comprised 11 stations, seven in Italy, including the two main stations in Florence and Vallombrosa, and four outside Italy, in Innsbruck, Warsaw, Osnabruck and Paris. The network was founded by Ferdinando II de' Medici, the Grand Duke of Tuscany, and his brother Prince Leopold, both students of Galileo. The brothers wanted to know if temperature varied between countries, between cities and rural areas, between the mountains and the plains. They also wanted to answer fundamental physical science questions such as whether geographic location affects the density of liquids and the melting point of ice. To do so, they needed well-coordinated observations performed with identical instruments, exposure, schedule and protocols.

Starting in 1639, with the invention of the rain gauge and evaporimeter, and several years later, the barometer and condensation hygrometer, new instruments made it possible to standardize the recording of meteorological data from place to place. In 1654, the newly invented "spirit-in-glass" thermometer, called the Little Florentine Thermometer, solved the problem of previous thermometers that were open to the air and thus were affected by atmospheric pressure. The new instruments, along with a protocol of where and when to take readings, were disseminated to monks and Jesuit priests who operated the stations. The thermometers were hung on both north- and south-facing walls, and temperature

readings were recorded every three to four hours between 1654 and 1670, resulting in roughly 40,000 readings.

Significantly, the readings occurred during the climatic cooling event known as the Little Ice Age, which lasted from the end of the Middle Ages to about 1850.

“Good-quality instrumental data are fundamental to know our past climate,” says Dario Camuffo, a meteorologist at the Institute of Atmospheric Sciences and Climate at the National Research Council in Padua, Italy, who found the records and analyzed them with colleague Chiara Bertolin, also at the Institute. “Now we have precise information from 1654 to 1670.”

Camuffo and Bertolin compared those data to modern temperature records taken in Italy, sometimes at the same location, through 2009. The Medici readings, Camuffo notes, had to be laboriously adjusted in order to standardize the data; for example, the team had to adjust the time (which was then measured from twilight rather than midnight) and the temperature scale, which was measured on the Galileo scale (Anders Celsius did not propose his temperature scale until 1742). They also researched the development of the Little Florentine Thermometer and examined the few historical examples of the instrument that have survived in order to calibrate it against modern instruments.

The authors compared the climate in 17th-century Italy to modern climate using data recorded from 1961 to 1990 at the Ximenian Observatory in Florence, which is located 400 meters from the Medici Network’s weather station at the Convent of Angels, and from the same period at the mountain station at Vallombrosa, which still exists today, although it was rebuilt at a slightly different location after being destroyed near the end of World War II.

At Vallombrosa (literally “valley in the shade”), Camuffo and Bertolin discovered a rise of 1.41 degrees Celsius in the average annual temperature. In Florence, however, the change was smaller, only 0.18 degrees Celsius warmer, the authors reported this year in the journal Climatic Change. However, they note that in Florence the modern observations were taken at roof level, whereas the historic readings were taken at ground level, which may underestimate the amount of warming that has occurred.

Although the yearly average temperature in Florence shows little change since the middle of the 17th century, the authors report, the seasonal departures have become greater over time with warmer summers, colder winters, and unstable mid-seasons. However, the authors note that changes in vegetation or sun exposure since the 17th century — for example, deforestation around the weather stations or the construction of buildings and asphalt roads — might have affected the comparison.

“I’m fascinated by papers such as this and love to think about climate change that occurred during recorded history,” says Lloyd Keigwin, a paleoclimatologist at Woods Hole Oceanographic Institution in Woods Hole, Mass. “This particular paper is cool because the Medici Network had multiple stations, so regional trends might be apparent.”

Keigwin says an interesting next step would be to compare the Medici data to isotope-derived temperatures from contemporary cave deposits in the Alps and also to North Atlantic Oscillation data.

The Medici Network was officially closed by the Catholic Church in 1667 because of its relationship with Galileo and the idea that instrumental readings, rather than the Bible, could be used to interpret nature. However, two of the stations continued to take readings until 1670, when the Grand Duke died and the readings ceased.

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