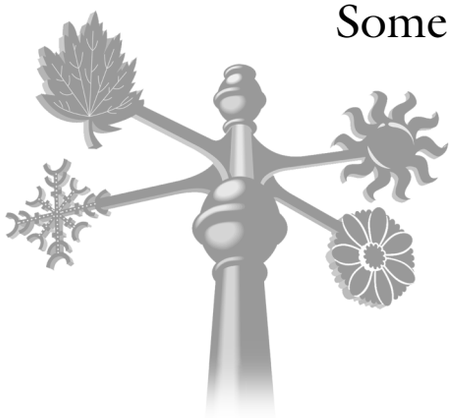
CHAPTER 1

History of Weather Science and Observing in the Philadelphia Area



Some are weatherwise, some are otherwise.
—*Benjamin Franklin*

Imagine not knowing what this afternoon's weather will be like, let alone tomorrow's. Imagine planning a trip to New York City in March and unexpectedly running into a late-season blizzard. Or planting crops vital to your family's survival, unsure whether the current drought will break in time. Imagine being on a ship crossing the ocean and not knowing that a hurricane with 120-mph winds was stalled in your path. Or as you set out to sea, that a minor nor'easter is about to explode in strength to become the Colonial American equivalent of the "Perfect Storm."

The early European settlers of this part of the world sometimes found themselves in precisely these situations. They quickly observed that the weather in the new land was more varied and often more extreme than what they were used to in the Old World. These early settlers came from places where hurricanes did not occur and where temperatures below 0°F and wind chills of −20°F rarely, if ever, happened. Extended heat waves with high humidity and many days above 90°F? Also unheard of back home. The variety of weather in the New World both fascinated and threatened the colonists, and they soon began to take detailed notice of it.

This chapter traces the evolution of our understanding of weather and the process of weather observation in this country, emphasizing the Philadelphia area's role in the advancement of the science of meteorology. This story of progress combines individual passion with institutional commitment and scientific innovation. Technological advances have profoundly influenced weather observations, which are truly at the heart of weather forecasting. These observations may be as simple as looking at the sky, as common as measuring the temperature with a thermometer, or as sophisticated as electronically scanning the atmosphere with weather radar.

From before Benjamin Franklin's time to the dawn of television weathercasting in the mid-twentieth century, the Philadelphia area has produced many weather "firsts." Some are listed in Table 1.1. We begin our story a century before Franklin, in the mid-seventeenth century when some of the earliest weather observations made by settlers in the New World were recorded near Philadelphia. Franklin himself was at the center of eighteenth-century progress in weather science, while another local meteorologist, Dr. James Espy, and the organization he worked for, The Franklin Institute, kept Philadelphia at the forefront of meteorological advances in the nineteenth century. Starting in the middle of the twentieth century, technological innovations such as weather satellites and radar rapidly advanced the science of meteorology, and the new medium of television weathercasting emerged. Once again, Philadelphia produced several pioneers in this area, including television legends Dr. Francis Davis and Wally Kinnan, "The Weatherman." The "Story from the Trenches" in this chapter features recent

TABLE 1.1 Some Philadelphia-area Weather "Firsts"

1644–45	The first continuous weather observations in Colonial America are recorded by Reverend John Campanius near present-day Wilmington, Delaware.
1717–18	Cadwallader Colden of Philadelphia makes some of the first known weather observations in the Colonies with a thermometer and a barometer.
1731–32	Mr. De. S. takes thermometer measurements twice a day in Germantown—the earliest known surviving daily temperature observations.
1743	Benjamin Franklin was the first to suggest that big storms in the Northeast come from the southwest.
1836	Franklin Institute meteorologist James Espy publishes the first weather map in the United States that uses widespread weather observations to study a specific storm.
1837	One of the first government-funded weather observing networks is established in Pennsylvania as a joint venture of The Franklin Institute and the American Philosophical Society.
1882	Franklin Institute member W. N. Jennings takes the first photographs of lightning.
1946	The University of Pennsylvania unveils ENIAC, the world's first electronic, general-purpose, large-scale computer, which helps to pave the way for the era of numerical weather prediction.
1947	Dr. David Ludlum of Philadelphia, who later became America's foremost weather historian, is one of the earliest television meteorologists in the United States, and starts *Weatherwise* magazine while working at The Franklin Institute.
1959	Philadelphia television weathercasters Dr. Francis Davis and Wally Kinnan are two of the first three television meteorologists in the country to earn the Seal of Approval of the American Meteorological Society.

interviews with Davis, Kinnan, and Herb Clarke, another legendary Philadelphia weathercaster. They discuss the groundbreaking role that Philadelphia played in the 1950s and 1960s as a national leader in the early days of television weather.

We also chronicle the government's crucial role in the evolution of weather observation and weather forecasting in this country. From the U.S. Army Signal Corps observers in the 1870s to the present-day National Weather Service (NWS), the federal government has been the primary institution charged with taking and organizing weather observations and creating and disseminating forecasts and warnings. The federal government has also led the development and implementation of the satellite and radar technology that is vital to meteorologists today. Because information from these two weather observing systems is commonly shown on television and available to everyone via the World Wide Web, we describe satellite and radar imagery in detail.

Observations: It All Starts Here

Weatherwise, Benjamin Franklin most certainly was. Although he is probably known best as an inventor, author, statesman, and postmaster, Franklin was also a shrewd weather observer. Throughout his life, he observed and studied the weather, offering theories as to the hows and whys of various atmospheric phenomena. Although his kite-flying encounter with lightning in 1752 gets the most attention, Franklin also pondered cold waves, changes in air pressure, tornadoes and waterspouts (see Illustration 1.1), and even climate change. Like modern weather forecasters, he was also interested in comparing weather observations from different parts of the country (although he could not do it while the weather was happening—the telegraph was invented half a century after he died). Franklin recognized the importance of observations for making deductions about how the weather

works and how weather systems move. In fact, Franklin led one of the first attempts at organizing a network of weather observers in Colonial America, using the only countrywide organization in place in the eighteenth century: the post office. His wide-ranging interest in weather and skill as an observer made Franklin the leader in meteorology in this country in the eighteenth century, and his speculations became the starting points for weather theories of the next century.

In at least one fundamental way, weather science has not changed much since Franklin's time. As simple as it sounds, good observations are essential for good forecasts. We meteorologists often are asked how we predict the weather, and we sometimes answer with a grin, "First we look out the window." As simple as it sounds, good forecasts start with good observations. Experienced forecasters know that the first step in preparing a weather forecast is to look at observations; the next step is to look at more observations. By "observations," we mean not only what is happening outside your window, but also what is happening outside windows all over the country and beyond. We also mean measurements of the atmosphere above the earth's surface, cloud images obtained from satellites, and radar images of precipitation. There is so much data for modern meteorologists to consider that Franklin would be very envious. These observations are evaluated by forecasters as well as fed to weather computer models, huge software programs that turn weather prediction into a complicated math problem. Clearly, weather observations are still at the heart of understanding how the atmosphere works, though the modern-day process of using these observations occurs at a level of sophistication that even Franklin could not have imagined.

Though Franklin was one of the first in this country to attempt to scientifically study and explain the weather, the earliest daily records of weather observations by settlers of the New World preceded him by about a century. Some of those observations were taken in the Philadelphia area.

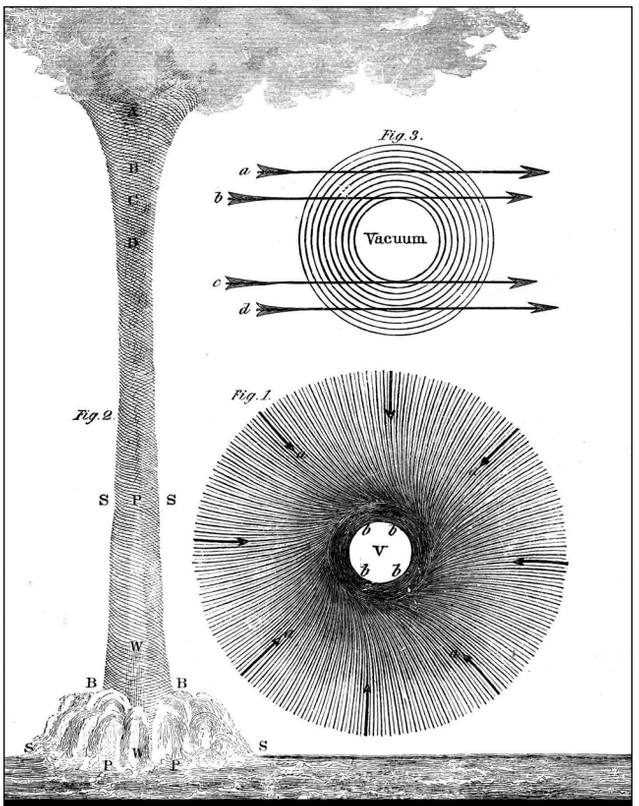


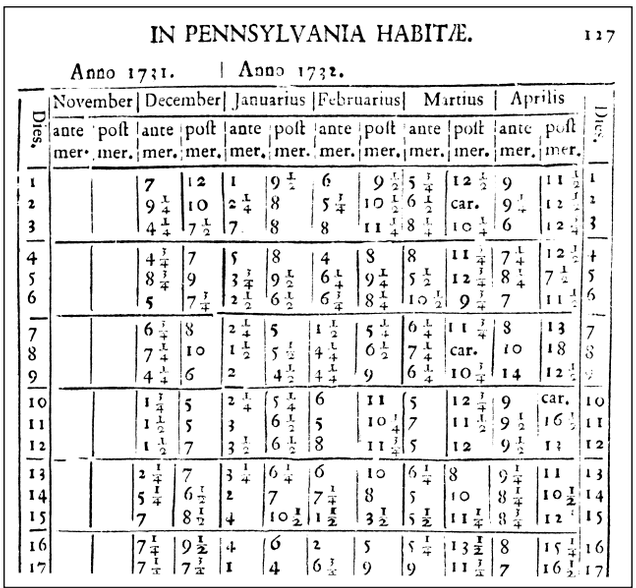
ILLUSTRATION 1.1 **Benjamin Franklin's model of a waterspout/tornado, drawn in the 1750s (from *The Works of Benjamin Franklin*, vol. 2, 391–95).**

Early Colonial Weather Watchers

Instruments are not necessary for observing the weather. For example, the speed and direction of the wind; the sky cover; and sensations of warmth, chill, dryness, and humidity can be described qualitatively, without using numbers. Relative descriptions such as "Yesterday was cloudier than today" or "It turned warmer and more humid in the afternoon" are also useful weather observations. Some people can even sense changes in air pressure in their "bones." And so it was with the earliest weather observers. Most of them had no instruments—they just recorded qualitative accounts of what they saw and felt.

Reverend John Campanius's daily weather observations during 1644–45 at Swedes Fort, a Swedish settlement near present-day Wilmington, Delaware, may have been the first continuous weather observations in Colonial America. Campanius had no instruments—he simply kept a descriptive journal of weather events. Although his original observations are lost, Campanius's grandson summarized them in an article published in 1702. An example translated from that summary shows that Campanius's observations could easily describe a recent Delaware Valley winter as well as one more than 350 years ago:

> January 1644—The winter began about the 21st, with severe cold, and then much snow. Afterwards came rain and a thick fog, with occasional sunshine, until the end of the month. During this time the winds were NW. ESE. SE. S.



IN PENNSYLVANIA HABITÆ. 127

Anno 1731. | Anno 1732.

Dies.	November ante mer.	November post mer.	December ante mer.	December post mer.	Januarius ante mer.	Januarius post mer.	Februarius ante mer.	Februarius post mer.	Martius ante mer.	Martius post mer.	Aprilis ante mer.	Aprilis post mer.	Dies.
1			7	12	1	9 1/2	6	9 1/2	5 3/4	12 1/2	9	11 1/2	1
2			9 1/4	10	2 1/4	8	5 3/4	10 1/2	6 1/2	car.	9 1/4	12 1/2	2
3			4 1/4	7 1/2	7	8	8	11 1/4	8 1/4	10 1/4	6	12 1/4	3
4			4 3/4	7	5	8	4	8	8	11 3/4	7 1/4	12 1/2	4
5			8 3/4	9	3 3/4	9 1/2	6 1/4	9 1/4	5 1/2	12 3/4	8 1/4	7 1/2	5
6			5	7 3/4	2 1/2	6 1/2	6 3/4	8 1/4	10 1/2	9 3/4	7	11 1/2	6
7			6 3/4	8	2 1/4	5	1 1/2	5 1/4	6 1/4	11 3/4	8	13	7
8			7 1/4	10	1 1/2	5 1/2	4 1/4	6 1/2	7 1/4	car.	10	18	8
9			4 1/4	6	2	4 1/2	4 1/4	9	6 1/4	10 3/4	14	12 1/2	9
10			1 3/4	5	2 1/4	5 1/4	6	11	5	12 3/4	9	car.	10
11			1 1/2	5	3	6 1/2	5	10 1/4	7	11 1/2	9 1/2	16 1/2	11
12			1 1/2	7	3 1/2	6 1/2	8	11 3/4	5	12	9 1/2	13	12
13			2 1/4	7	3 1/4	6 1/4	6	10	6 1/4	8	9 1/4	11	13
14			5 1/4	6 1/2	2	7	7 1/4	8	5	10	8 1/4	10 1/2	14
15			7	8 1/2	4	10 1/2	1 1/2	3 1/2	5 1/2	11 1/4	8 3/4	12 1/2	15
16			7 1/4	9 1/2	4	6	2	5	5 1/4	13 1/2	8	15 1/4	16
17			7 1/4	7 3/4	1	4	6 3/4	9	9	11 3/4	7	16 1/2	17

ILLUSTRATION 1.2 **The earliest known surviving continuous temperature observations, taken twice a day in the Germantown section of Philadelphia in 1731–32 by a man known only as "Mr. De S." He took readings to the nearest one-quarter degree Celsius (Columbia University Library).**

With all due respect to Benjamin Franklin, Campanius is sometimes referred to as "America's First Weatherman." Campanius's contribution to weather observing in this country is considered so significant that the National Weather Service gives annual awards in his name to recognize outstanding volunteer weather observers.

Though purely descriptive weather observations have great value, weather instruments enable measurement and provide the quantitative standard that is necessary for comparing observations. Meteorology's emergence as a true scientific endeavor really began with the development of reliable instruments for measuring important atmospheric elements such as temperature and pressure. Though the thermometer and barometer (for measuring air pressure) were perfected in the seventeenth century in Europe, they were not really used much for taking weather observations for another century or so.

Some of the earliest instrumented weather observations in Colonial America date from the Delaware Valley in the early eighteenth century. Dr. Cadwallader Colden of Philadelphia took measurements of temperature and pressure during the winter of 1717–18. We know of his observations through a letter written to Colden by William Douglass of Boston. "I thank you for your account of the state of the Barometer and Thermometer at Philadelphia part 1717 and part 1718," Douglass wrote in 1721, acknowledging the measurements. Continuing the Philadelphia connection, the earliest known surviving temperature data taken in the Colonies came from the Germantown section of the city. The observer is known only as Mr. De S., and he took two thermometer readings each day from December 1731 to October 1732. His observations, taken in Celsius to the nearest quarter degree, were published in 1737 in a European journal (see Illustration 1.2).

The activities of Campanius, Colden, and Mr. De S. accurately portray the state of weather data collecting in early Colonial America. Weather observers were isolated individuals who were not part of any organized network. Many of these weather enthusiasts were physicians, ministers, and educators. They kept records in diaries and journals and not on standardized forms. The few who had instruments rarely had instructions to guide them. The most common instruments were a thermometer and a rain gauge, and they were not always reliable. And the observers did not always follow what are today considered standard rules of observation—for example, taking measurements on a daily basis and at the same time each day.

In the mid-eighteenth century, famous Philadelphian John Bartram was a diligent weather observer for a time. Bartram, who cofounded the American Philosophical Society (APS) with Benjamin Franklin in 1743, recorded temperature, wind, and weather conditions twice each day from August 1748 to January 1750. The APS, which is still headquartered in Philadelphia, was the premier learned society of the time, America's counterpart to the Royal Society of London. Members were enlightened men who believed that nature was knowable and behaved in consistent ways. In many ways, APS members were the earliest "natural philosophers."

Also around this time, Franklin's observations of wind and sky, combined with similar data from other colonial cities, helped establish that storms in the Northeast often approach from the southwest. Franklin's most celebrated observation involved a lunar eclipse that he planned to view from Philadelphia in the fall of 1743. In Franklin's words:

> There was an eclipse of the moon at nine o'clock in the evening, which I intended to observe; but before night a storm blew up . . . and continued violent all night . . . so that neither moon nor stars could be seen. . . . But what surprised me was, to find in the Boston newspapers an account of the observation of

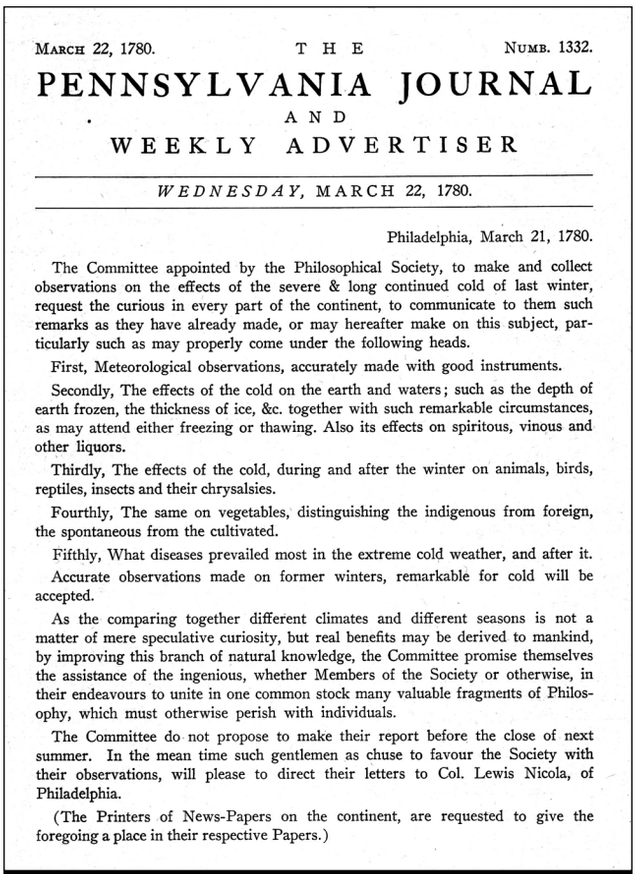
> that eclipse made there. . . . I wrote to my brother about it, and he informed me that the eclipse was over an hour before the storm began.

Piecing together the scanty information available, Franklin reasoned that the same storm that hit Philadelphia moved to the northeast and arrived in Boston several hours later. From this observation and others that he had made, Franklin proposed that many strong storms along the East Coast take this same track, approaching from the southwest. This was a bold leap at the time, because surface winds preceding such storms blew from the northeast, and the prevailing notion was that storms moved with the surface wind. More generally, Franklin's observations led to the realization that weather tends to move in a west-to-east fashion across the country.

Many other individuals were taking weather observations in the Philadelphia area during Franklin's time. These included William Bartram, son of John Bartram, and noted astronomer David Rittenhouse. Other observations survive from less well-known individuals such as Peter Legaux, a French lawyer and farmer living in Spring Mills, just northwest of Philadelphia; Reverend Henry Muhlenberg in Trappe, near Valley Forge; and prominent Philadelphians such as Phineas Pemberton, Thomas Coombe, and Dr. John Redman Coxe.

Thomas Jefferson, also a dedicated observer, recorded weather data from 1776 to 1818, usually several times a day. He even purchased a thermometer in Philadelphia on the morning of July 4, 1776, when he recorded temperatures of 68°F at 6 A.M., 76°F at 1 P.M., and 73.5°F at 9 P.M. in his weather journal. Like Franklin, Jefferson recognized that comparing weather observations from different locations was necessary for understanding how the weather worked, and Jefferson had access to Philadelphia weather data taken by Rittenhouse, Bartram, Legaux, and others. In recognition of Jefferson's weatherwise nature, the National Weather Service's highest award for outstanding volunteer weather observers is called the Jefferson Award.

By the late eighteenth and early nineteenth centuries, the potential value of organized networks of weather observers was becoming evident. Following an extraordinarily harsh winter in 1779–80 in the midst of the War of Independence, the American Philosophical Society publicly requested observations from "every part of the continent" (see Illustration 1.3). One item of interest was "what diseases prevailed most in the extreme cold." Indeed, physicians were one group that supported more systematic and regular observations, since the general health of patients and the occurrence of outbreaks of disease were thought to be related to the weather. In 1787, the prestigious College of Physicians in Philadelphia included a statement in its charter concerning the link between taking weather observations and investigating disease and epidemics. Dr. Benjamin Rush, a renowned professor at the University of Pennsylvania (and a founder of the College of Physicians), investigated the role of weather in the devastating yellow fever epidemic that was responsible for approximately 5,000 deaths in Philadelphia in 1793. In 1807, Dr. B. S. Barton of the University of Pennsylvania even suggested in an article in a Philadelphia medical journal that a national network of



MARCH 22, 1780. THE NUMB. 1332.

PENNSYLVANIA JOURNAL
AND
WEEKLY ADVERTISER

WEDNESDAY, MARCH 22, 1780.

Philadelphia, March 21, 1780.

The Committee appointed by the Philosophical Society, to make and collect observations on the effects of the severe & long continued cold of last winter, request the curious in every part of the continent, to communicate to them such remarks as they have already made, or may hereafter make on this subject, particularly such as may properly come under the following heads.

First, Meteorological observations, accurately made with good instruments.

Secondly, The effects of the cold on the earth and waters; such as the depth of earth frozen, the thickness of ice, &c. together with such remarkable circumstances, as may attend either freezing or thawing. Also its effects on spiritous, vinous and other liquors.

Thirdly, The effects of the cold, during and after the winter on animals, birds, reptiles, insects and their chrysalsies.

Fourthly, The same on vegetables, distinguishing the indigenous from foreign, the spontaneous from the cultivated.

Fifthly, What diseases prevailed most in the extreme cold weather, and after it.

Accurate observations made on former winters, remarkable for cold will be accepted.

As the comparing together different climates and different seasons is not a matter of mere speculative curiosity, but real benefits may be derived to mankind, by improving this branch of natural knowledge, the Committee promise themselves the assistance of the ingenious, whether Members of the Society or otherwise, in their endeavours to unite in one common stock many valuable fragments of Philosophy, which must otherwise perish with individuals.

The Committee do not propose to make their report before the close of next summer. In the mean time such gentlemen as chuse to favour the Society with their observations, will please to direct their letters to Col. Lewis Nicola, of Philadelphia.

(The Printers of News-Papers on the continent, are requested to give the foregoing a place in their respective Papers.)

ILLUSTRATION 1.3 **The American Philosophical Society circulated this request for weather observations following the brutal winter of 1779–80 for the purpose of "improving this branch of natural knowledge" (American Philosophical Society, in the *Pennsylvania Journal and Weekly Advertiser,* no. 1332, March 22, 1780).**

thermometers, barometers, and rain gauges be operated by one of the learned societies in Philadelphia.

During the War of 1812, Dr. James Tilton, Surgeon General of the Army (and a graduate of the College of Physicians), ordered his hospital surgeons to record weather data. This system of weather observers is generally considered the first in the country organized by the government. Starting with about twenty army posts with thermometers and rain gauges, the network grew to nearly 100 camps by the 1850s. In the Philadelphia area, observers at Fort Mifflin, the Frankford Arsenal in Bridesburg, and the U.S. General Hospital in Chester, among others, participated in this network at one time or another.

In the early nineteenth century, several extreme weather events helped to increase interest in creating new systems of weather observing. In September 1815, "The Great September Gale," the worst storm to hit New England in almost 200 years, devastated parts of Connecticut, Rhode Island, and Massachusetts. The next year, 1816, was the infamous "Year without a Summer" when snow fell in June in parts of the northeastern United States and killing frosts struck in July and August. (See Chapter 5 for more about that summer in the Philadelphia area.) These events demonstrated to the citizens and the government of the still relatively new nation just how critical the weather was to their livelihood and survival.

Several new weather observing networks sprang up in the decades to follow. In 1825, the New York State Legislature authorized funds to take temperature and rainfall observations at each state academy. Starting with about ten sites, the network grew to approximately forty-five stations by 1835, and functioned into the 1860s. A key figure in the history of American meteorology emerged from the New York network. Joseph Henry, a friend of many Philadelphia-area scientists, started his meteorological career compiling reports for the New York system. He later became the first secretary of the Smithsonian Institution and a driving force behind the creation of the first national "weather bureau." But before the Smithsonian would take its place in American weather history, the bright light of weather observation, research, and theory would first shine from Philadelphia.

James Espy and The Franklin Institute

What Benjamin Franklin was to Philadelphia's place in weather history in the eighteenth century, James Pollard Espy (Illustration 1.4) and The Franklin Institute (TFI) were in the nineteenth.

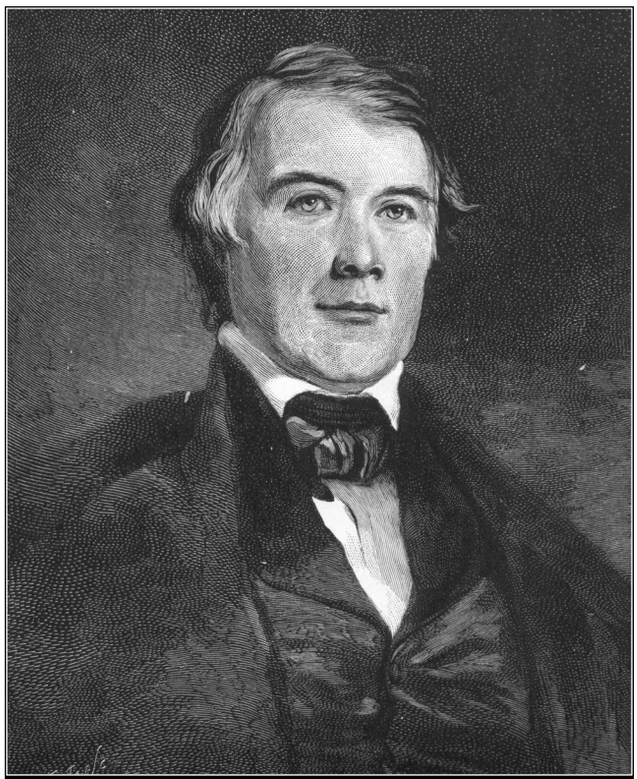


ILLUSTRATION 1.4 James Pollard Espy, first meteorologist at The Franklin Institute (in *Popular Science Monthly* 34[1889]: 834–40).

In view of Franklin's interest in weather, meteorology had a special status in TFI's early years. Chartered in 1824 to honor Franklin and advance the usefulness of his inventions, the institute hosted Espy's volunteer lectures on meteorology in its first year of operation. By the early 1830s, Espy had formally joined TFI and devoted himself entirely to studying the weather. Over the next decade, he was the driving force who would turn Philadelphia into the hub of meteorological activity in the United States. Espy's weather interests were nearly as diverse as Franklin's; he lectured and published on a variety of topics, including the importance of humidity in weather forecasting, the formation of clouds in mountainous regions, the mechanisms for tornado formation, and weather modification. Espy even enlisted the help of the Franklin Kite Club to verify his calculations of the heights of clouds.

But Espy's greatest meteorological passion was studying storms. For the rest of his life, he focused his research on understanding the causes and characteristics of all types of storms, from the routine rains that came every

few days to hurricanes and tornadoes. This desire to understand storms led Espy to push for new and expanded weather observing systems, and also earned him the title "The Storm King."

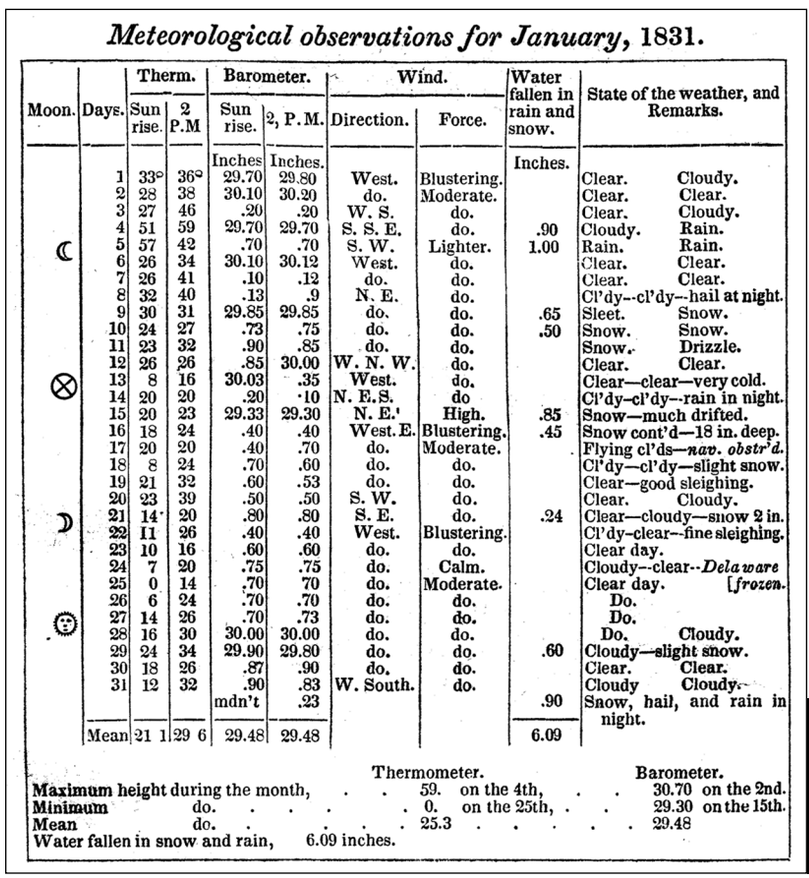
Though Franklin had proposed almost a century earlier that storms in the Northeast approached from the southwest, there had been little (if any) formal study of how storms formed and moved, mainly due to the lack of organized weather data. Espy firmly believed that meteorology in general had been a neglected science:

> Why is it that this highly interesting and useful branch of human knowledge makes such slow advances? . . . Do philosophers think that . . . the weather never can be predicted?

With the study of storms in mind, Espy helped organize a committee of meteorology at TFI in 1831. One of its tasks was to keep a "meteorological register" of weather in Philadelphia. The data—twice-daily temperature, pressure, and wind measurements, plus daily precipitation observations and remarks on the day's weather—were published in the *Journal of The Franklin Institute*. The first set of monthly data, collected in January 1831, is shown in Illustration 1.5. Espy knew, just as Franklin did, that observations like these were needed from many observers in distant locations in order to gain insight into the structure of storms and the paths that they took across the country. In Espy's words, such knowledge could be gained only "by simultaneous observations over a wide extent of territory."

Over the next few years, Espy urged The Franklin Institute to petition the federal government for funding to establish a national network of weather observers. Meanwhile, Espy organized his own group of volunteers to record weather conditions and send them to him for compilation.

Espy's volunteer network found a home in September 1834 when TFI teamed with the American Philosophical Society to establish a Joint Committee on Meteorology to compile weather observations from around the country. Espy chaired the committee, which also included Alexander D. Bache, great-grandson of Benjamin Franklin



***Meteorological observations for January*, 1831.**

Moon.	Days.	Therm. Sun rise.	Therm. 2 P.M	Barometer. Sun rise.	Barometer. 2, P. M.	Wind. Direction.	Wind. Force.	Water fallen in rain and snow.	State of the weather, and Remarks.
				Inches	Inches.			Inches.	
	1	33°	36°	29.70	29.80	West.	Blustering.		Clear. Cloudy.
	2	28	38	30.10	30.20	do.	Moderate.		Clear. Clear.
	3	27	46	.20	.20	W. S.	do.		Clear. Cloudy.
	4	51	59	29.70	29.70	S. S. E.	do.	.90	Cloudy. Rain.
☾	5	57	42	.70	.70	S. W.	Lighter.	1.00	Rain. Rain.
	6	26	34	30.10	30.12	West.	do.		Clear. Clear.
	7	26	41	.10	.12	do.	do.		Clear. Clear.
	8	32	40	.13	.9	N. E.	do.		Cl'dy--cl'dy--hail at night.
	9	30	31	29.85	29.85	do.	do.	.65	Sleet. Snow.
	10	24	27	.73	.75	do.	do.	.50	Snow. Snow.
	11	23	32	.90	.85	do.	do.		Snow. Drizzle.
	12	26	26	.85	30.00	W. N. W.	do.		Clear. Clear.
⊗	13	8	16	30.03	.35	West.	do.		Clear—clear—very cold.
	14	20	20	.20	.10	N. E. S.	do		Cl'dy–cl'dy--rain in night.
	15	20	23	29.33	29.30	N. E.'	High.	.85	Snow—much drifted.
	16	18	24	.40	.40	West. E.	Blustering.	.45	Snow cont'd—18 in. deep.
	17	20	20	.40	.70	do.	Moderate.		Flying cl'ds—*nav. obstr'd.*
	18	8	24	.70	.60	do.	do.		Cl'dy—cl'dy—slight snow.
	19	21	32	.60	.53	do.	do.		Clear—good sleighing.
	20	23	39	.50	.50	S. W.	do.		Clear. Cloudy.
☽	21	14	20	.80	.80	S. E.	do.	.24	Clear—cloudy—snow 2 in.
	22	11	26	.40	.40	West.	Blustering.		Cl'dy–clear--fine sleighing.
	23	10	16	.60	.60	do.	do.		Clear day.
	24	7	20	.75	.75	do.	Calm.		Cloudy--clear--*Delaware*
	25	0	14	.70	70	do.	Moderate.		Clear day. [*frozen.*
	26	6	24	.70	.70	do.	do.		Do.
⊜	27	14	26	.70	.73	do.	do.		Do.
	28	16	30	30.00	30.00	do.	do.		Do. Cloudy.
	29	24	34	29.90	29.80	do.	do.	.60	Cloudy—slight snow.
	30	18	26	.87	.90	do.	do.		Clear. Clear.
	31	12	32	.90	.83	W. South.	do.		Cloudy Cloudy.
				mdn't	.23			.90	Snow, hail, and rain in night.
	Mean	21 1	29 6	29.48	29.48			6.09	

	Thermometer.		Barometer.	
Maximum height during the month,	59.	on the 4th,	30.70	on the 2nd.
Minimum do.	0.	on the 25th,	29.30	on the 15th.
Mean do.	25.3		29.48	

Water fallen in snow and rain, 6.09 inches.

ILLUSTRATION 1.5 The first Philadelphia weather data published in the *Journal of The Franklin Institute*, from January 1831 (*Journal of The Franklin Institute*, n.s., 7 [1831]: 144).

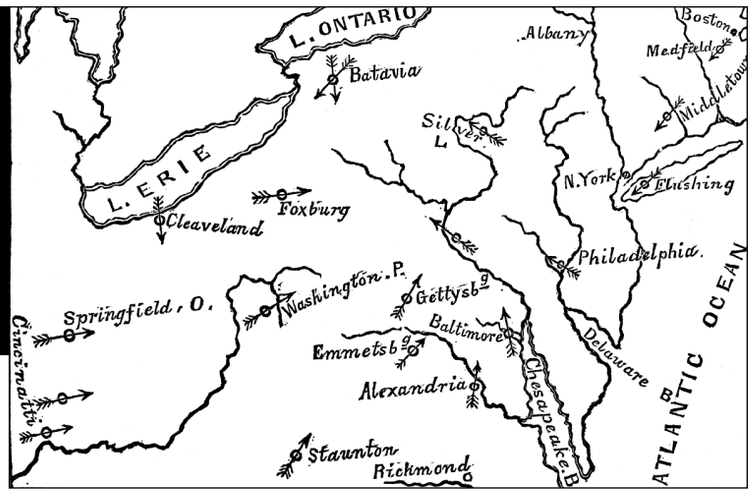


ILLUSTRATION 1.6 **This chart depicting a June 1836 storm in Pennsylvania and surrounding states shows wind directions using arrows and may be the first weather map published in the United States that focuses on a specific storm. In compiling such maps, Espy noted that the winds converged toward a central point where the heaviest rain tended to fall (in this case, somewhere between Foxburg, Batavia, and Silver Lake, New York) (from the *Journal of The Franklin Institute*, n.s., 19 [1837]: 19).**

and a prominent member of TFI. Bache would later become the first president of the prestigious National Academy of Sciences. Within a month, the Joint Committee circulated a request for observers:

> The prime object of this circular is to obtain a complete knowledge of all the phenomena accompanying one or more storms of rain or hail . . . For this purpose, you are requested, immediately on receiving this circular, to commence a journal of the weather, noting the direction of the wind at the surface of the earth . . . the appearance of the heavens as to clear or cloudy, and the character of the clouds, according to your own mode of description, be noted at least three times a day, as near the following hours as convenient—7 A.M., 2 A.M., and sunset. . . . Please to forward your observations, monthly, to the Joint Committee of the American Philosophical Society and Franklin Institute.

In response to this request, volunteers from points as close as Bucks County Academy and Gettysburg, Pennsylvania, and as distant as Baton Rouge, Louisiana, and Portland, Maine, sent observations. Led by Espy, the Joint Committee analyzed and published detailed reports about the most significant storms, the first time this had been done in the United States. A map of the storm of June 19–20, 1836, covering an area from the Mississippi River to New England, is shown in Illustration 1.6. This chart is probably the first weather map published in the United States showing widely collected data focusing on a single storm. For the first time, fundamental characteristics such as the tendency for winds to converge toward the center of a storm were confirmed using observations. In Espy's words, "By casting an eye on the woodcut, it will be seen at a glance that the wind blew on all sides toward the point of greatest rain."

In its reports, the Joint Committee also lobbied for government funding of a countrywide weather network. In 1837, The Franklin Institute took the bolder step of authorizing the committee to "memorialize Congress for the purpose of obtaining national aid in furtherance of this interesting object." The letter from the Joint Committee, which appears in the records of the House of Representatives on April 20, 1838, was the first official request to Congress for a government-funded national weather service. More than thirty years would pass, though, before the federal government would create one.

But progress was made at the state level. On April 1, 1837 the Pennsylvania Legislature appropriated $4,000 (in 1837 dollars) to TFI to organize and run a statewide meteorological research program. With these funds, TFI planned to equip one observer in each Pennsylvania county with a barometer, several thermometers, and a rain gauge. Instrument maker L. C. Francis made more than fifty sets of instruments for $16 per set in his workshop on Fetter Lane in Philadelphia. The standard barometer, which was used to calibrate the other sets, was designated "No.1" and presented to the city of Philadelphia. This original is on public display today at The Franklin Institute (Illustration 1.7).

Making the instruments turned out to be the simplest part of the project. Finding competent, dependable observers and delivering and maintaining the instruments in working order was the biggest challenge. By October 1839, all but four counties had received instruments, but twenty counties with instruments had never sent in any observations. In fact, only about thirty counties ever

reported during any single month. Espy took charge of compiling and summarizing the data. Starting with January 1839, statewide monthly summaries were published in the *Journal of The Franklin Institute*. A portion of the "Meteorological Report for the State of Pennsylvania" for August 1840 is shown in Illustration 1.8. Other Philadelphia-area observers listed in the report included L. H. Parsons of Newtown, Bucks County; William Jefferies of West Chester, Chester County; and an unidentified observer at the Haverford School in Delaware County. William Hough, a schoolmaster in Hatboro, Montgomery County, was also an observer; the barometer he used, one of the few remaining from the original network, is today in possession of the Historical Society of Montgomery County.

In addition to the observers participating in TFI's statewide system, several other weather observing sites were active in the Philadelphia area around this time. At the Frankford Arsenal in Bridesburg, Captain Albert Mordecai of the U.S. Army was a faithful observer of temperature and precipitation from 1836 to 1843. His observations were also published in the *Journal of The Franklin Institute*. Alexander Bache established a privately funded weather observatory at Girard College in 1840, where meteorological observations were taken until 1845. Charles Peirce was a faithful observer of the weather in Morrisville, Pennsylvania, across the Delaware River from Trenton, from 1790 to 1846. He summarized each month of observations in *A Meteorological Account of the Weather in Philadelphia,* which he wrote in 1847. To our knowledge, Peirce's book is the last written specifically about the weather of the Philadelphia area, and as such it is a valuable resource for reconstructing that era of local weather.

By 1840, Espy's reputation as "The Storm King" had grown (by some accounts, so had his ego), and he was lecturing around the country to promote his theories about storms and build support for expanding weather observing systems. Espy also traveled abroad—in France, he was so highly regarded that he was compared to Isaac Newton when introduced to the prestigious French Academy of Sciences. When Espy published *The Philosophy of Storms* in 1841, a popular book describing his theories about storms, he reinforced his standing as the premier American meteorologist of his time.

It was this success, and his still-unfulfilled goal of establishing a truly "national" weather service, that soon led Espy to Washington, D.C.

ILLUSTRATION 1.7 Barometer "No. 1," made in 1837 and used by James Espy and other observers at The Franklin Institute (courtesy of the Historical and Interpretive Collections of The Franklin Institute, Philadelphia, Pa.).

The Smithsonian Institution and a National Weather Service

During the 1840s, meteorology's center of gravity in the United States began to shift to Washington, D.C. This transition occurred partly because Espy headed there to lobby for a federally financed, countrywide weather observing service. Once in Washington, he served as a professor for the Navy Department and also oversaw improvements in the Army Surgeon General's weather network. In essence, these roles made him America's first "national meteorologist" and allowed him to continue compiling weather observations from across the country to pursue his studies of storms. He also expanded observing to some navy posts, including the U.S. Navy Yard in Philadelphia.

Washington's growing prominence in weather science was also related to the opening of the Smithsonian Institution in 1846 and the appointment of Joseph Henry as its first secretary. Henry was a veteran of the New York weather-observing network and familiar with Espy's in Pennsylvania. For Henry, establishing "systems of extending meteorological observations for solving the problem of American storms" was a primary research objective for

ILLUSTRATION 1.8 A portion of a monthly "Meteorological Report for Pennsylvania" compiled from data collected on the weather observing network established in 1837 by The Franklin Institute and the American Philosophical Society. Counties, towns and observers are listed, as well as temperature data for August 1840 (from the *Journal of The Franklin Institute*, 3d ser., 1 [1841]: 144).

METEOROLOGICAL REPORT

FOR THE STATE OF PENNSYLVANIA,

Collated from returns made to the Committee on Meteorology of the Franklin Institute of the State of Pennsylvania, for

AUGUST, 1840.

	County.	Town.	Observer.	Thermometer. 7, A. M.	2, P. M.	9, P. M.	Maximum.	Minimum.	Mean.	Days omitted.
1	Philadelphia,	Philadelphia,	J. M. Hamilton,	74.47	78.85	70.96	86.00	66.00	74.76	3
2	Montgomery,									
3	Bucks,	Newtown,	L. H. Parsons,	71.63	80.67	66.30	88.00	47.00	72.87	.
4	Lehigh,									
5	Northampton,	Easton,	Charles Elliot,	65.74	70.00	67.57	83.00	57.00	67.77	1
6	Monroe	Stroudsburg,	A. M. Stokes,	66.65	81.05	70.20	88.00	50.00	72.63	11⅛
7	Pike,	Milford,	Ralph Bull,	60.80	78.90	62.50	87.00	51.00	67.40	.
8	Wayne,	Honesdale,	W. Richardson,							
9	Susquehanna,	Silver Lake,	E. Rose,							
10	Luzerne,	Wilkesbarre,	W. F. Dennis,							
11	Schuylkill,	Port Carbon	John G. Hewes,	64.27	80.81	66.25	90.00	54.00	70.44	1
12	Berks,	Reading,	C. F. Egelmann,	69.10	78.06	68.35	84.00	60.00	71.84	.
13	Chester,	West Chester,	Wm. W. Jefferies,	72.46	80.38	76.92	87.25	65.00	76.59	.
14	Delaware,	Haverford,	Haverford School,	69.87	79.68	68.06	86.00	60.00	72.54	
15	Lancaster,	Lancaster,	Conservatory of Arts,	69.15	81.57	70.61	89.00	59.50	73.78	
16	York,									
17	Lebanon,									
18	Dauphin,	Harrisburg,	J. Heisely,	71.65	79.90	75.94	86.00	64.00	75.83	.
19	Northumberland,	Northumberland,	Andrew C. Huston,	68.68	77.44	70.77	85.00	60.00	72.30	.
20	Columbia,	Danville,	C. H. Frick.							
21	Bradford,									
22	Tioga,									
23	Lycoming,									
24	Union,									
25	Mifflin,									
26	Juniata,	Mifflintown,	J. A. Rinkead,	61.94	81.63	66.94	92.00	53.50	70.17	5⅛
27	Perry,									
28	Cumberland,	Carlisle,	Prof. W. H. Allen,							
29	Adams,	Gettysburg,	Prof. M. Jacobs,	67.39	80.58	70.35	86.50	59.00	72.77	.
30	Franklin,									
31	Huntingdon,	Huntingdon,	Jacob Miller,	67.87	83.03	69.45	91.00	55.00	73.45	.
32	Centre,	Bellefonte,	John Harris,	63.83	78.97	66.96	86.50	52.50	69.92	7
33	Potter,									
34	M'Kean,	Smithport,	Richard Chadwick,	61.23	75.55	56.87	86.00	48.00	64.55	.
35	Clearfield,									
36	Cambria,	Ebensburgh,	Richard Lewis,	63.13	76.72	62.87	86.00	49.00	67.57	2⅜
37	Bedford,	Bedford,	Samuel Brown,	70.87	78.68	74.15	87.20	60.50	74.57	.
38	Somerset,	Somerset,	George Mowry,	63.65	73.52	63.64	82.00	52.00	66.94	.
39	Indiana,	Indiana,	Richard White,	72.94	77.74	66.00	85.00	58.00	72.23	.
40	Jefferson,	Rose Cottage,	C. C. Gaskell,							
41	Warren,	Warren,	C. S. Brown,	65.82	73.62	71.38	82.00	55.00	70.27	6⅜
42	Venango,	Franklin,	Wm. Connely,	59.97	82.81	68.26	94.00	48.00	70.35	.
43	Armstrong,									
44	Westmoreland,									
45	Fayette,	Uniontown,	J. P. Weithers,	68.87	83.58	69.34	94.00	54.00	73.93	.
46	Green,									
47	Washington,	Cannonsburg,	A. H. Campbell,	66.29	78.78	70.13	86.00	52.00	71.73	.
48	Alleghany,	Pittsburgh,								
49	Beaver,	Beaver,	Wm. Allison,							
50	Butler,	Butler,	Jacob Mechling,	66.26	77.48	71.32	86.00	52.00	71.69	.
51	Mercer,	West Greenfield,	S. Campbell,							
52	Crawford,	Meadville,	J. Limber,	68.97	77.21	68.48	92.00	60.00	71.55	1⅞
53	Erie,	Erie,	Park & Reid,							

the new institution. With a $1,000 appropriation in 1848, the Smithsonian Meteorological Project came to life. Henry consulted closely with Espy on the new project, using some aspects of the Pennsylvania weather observing system as a model. For example, the first Smithsonian observers used the same reporting forms as Espy used in Pennsylvania a decade earlier.

Henry, as secretary of the Smithsonian, and Espy, as national meteorologist, co-signed an announcement for volunteer observers. The request was sent to more than 400 people in thirty states. About 150 observers volunteered to keep weather journals and submit monthly reports by mail. They were to take observations at sunrise, 9 A.M., 3 P.M., and 9 P.M. local time. The first monthly reports arrived in March 1849, and Espy used the data to construct weather maps to aid in his storm studies. Professor James Coffin, a prominent meteorologist and mathematician at Lafayette College in Easton, Pennsylvania, summarized the data by computing daily, monthly, seasonal, and annual averages—essentially producing some of the earliest climate data for the United States.

Henry was also a hearty supporter of the use of the telegraph for relaying weather information. The telegraph would finally allow weather information to move faster than the weather itself, giving the possibility of

advance warning of approaching storms. Telegraph lines had linked Washington with Baltimore in 1844 and expanded to Philadelphia by 1845. David Brooks, a telegraph operator in Philadelphia around that time, described the practical benefit of sharing weather information by telegraph:

> About the year 1849, I became manager in Philadelphia, and was in the habit of getting information about the condition of the lines westward every morning. If I learned from Cincinnati that the wires to St. Louis were interrupted by rain, I was tolerably sure a "northeast" storm was approaching (from the west or southwest). For cold waves we looked in Chicago.

Many observers from the Philadelphia area participated in the Smithsonian Meteorological Project at one time or another, including volunteers at West Chester, Valley Forge, Haverford, Norristown, Germantown, the Pennsylvania Hospital, Burlington, and Trenton. One dedicated Philadelphia observer was Professor J. A. Kirkpatrick, who taught civil engineering at both Philadelphia and Central High Schools. With a thermometer, barometer, rain gauge, and psychrometer (for measuring humidity), Kirkpatrick observed the weather on Vine Street for more than three decades. From 1857 to 1869, summaries of his observations were published in the *Journal of The Franklin Institute,* and for a few years he even wrote a monthly column titled "The Meteorology of Philadelphia."

While the Smithsonian network was growing in importance and stature, Espy retired from his posts in 1857. He died three years later without seeing his dream of a national weather service realized. But after the disruption of the Civil War, Henry and other prominent meteorologists of the time resumed the lobbying campaign Espy had started. Probably the most vocal supporter was Professor Increase Lapham of Milwaukee, a former observer for Espy. Lapham proposed a storm warning service for the Great Lakes, and he sent frequent clippings about casualties and property damage on the lakes to General Halbert Paine, Congressman for Milwaukee. Lapham pointed out that in 1868 alone, 209 lives were lost in storms on the lakes, with property damage valued at $4.1 million (in 1868 dollars). In one letter Lapham asked if it were not "the duty of the government to see whether anything can be done to prevent, at least, some portion of this sad loss in the future?" Congressman Paine recognized the importance of Lapham's cause, and on February 2, 1870 he introduced a Joint Congressional Resolution

> . . . to provide for taking meteorological observations at the military stations in the interior of the continent and at other points in the States and Territories of the United States . . . and for giving notice on the northern Lakes and on the sea coast by magnetic telegraph and marine signals, of the approach and force of storms.

The resolution was passed by Congress and signed into law on February 9, 1870 by President Ulysses S. Grant, with little notice from the news media. But an agency had been born that would affect the daily lives of most of the citizens of the United States through its forecasts and warnings. The new service was placed under the direction of the Secretary of War, because "military discipline would probably secure the greatest promptness, regularity, and accuracy in the required observations." Because the entire operation depended on a reliable communication system, it was assigned to the Army Signal Service Corps under General Albert J. Myer, who named the new agency the Division of Telegrams and Reports for the Benefit of Commerce.

On November 1, 1870, observer-sergeants at about twenty-five locations took the first meteorological reports of the new weather service. (Philadelphia was added two months later.) Each observer had a thermometer, barometer (for pressure), hygrometer (for humidity), anemometer (for wind speed), wind vane (for wind direction), and a rain gauge. Three times a day, around 8 A.M., 6 P.M., and midnight (Washington, D.C. time), each station telegraphed an observation to Washington. There, meteorologists interpreted the data, prepared forecasts, and sent them back to the observers, to railroad stations, and to interested news media.

Although the military took most of the weather observations for the new weather service, Myer also hired civilians. The first, Professor Lapham, took responsibility for the Great Lakes region. On his first day on the job, November 8, 1870, Lapham issued the first storm warning in the history of United States weather services, sending this message to observers on the Great Lakes:

> High wind all day yesterday at Cheyenne and Omaha; a very high wind this morning at Omaha; barometer falling with high winds at Chicago and Milwaukee today; barometer falling and thermometer rising at Chicago, Detroit, Toledo, Cleveland, Buffalo, and Rochester; high winds probable along the Lakes.

Some eighteen months later, on June 10, 1872, Congress extended the warning service beyond the Great Lakes and the coasts to all of the United States, making it truly a "national" weather system.

The Army Signal Corps and U.S. Weather Bureau in Philadelphia

The Army Signal Corps arrived in Philadelphia with little fanfare. With Sergeant A. W. Eastlake in charge, observations began on January 1, 1871 on the fourth floor of the Board of Trade Building at 505 Chestnut Street. A year later, after a move to the Chamber of Commerce Building on South Second Street, the Corps was still learning how to arrange a practical setup for the instruments, as illustrated by these comments of the observer on December 31, 1871:

> Shelter for hygrometer and thermometers rather too open. When it snows the room is filled with snow. When it rains the instruments become thoroughly wet, so that the drying of the bulbs must be done before each observation.

From 1871 to 1873, only three temperature readings were taken each day, not frequently enough to give reliable daily maximum and minimum temperatures. So from the standpoint of "official" record-keeping purposes, reliable high and low temperature records for Philadelphia did not start until January 1, 1874. Official precipitation measurements begin a little earlier, on April 1, 1872. "Precipitation" means rain plus melted snow and ice.

While the Army Signal Corps was settling into Philadelphia, The Franklin Institute continued to be a national leader in meteorology, with several institute members engaged in innovative weather observations. In the 1870s, Professor John Wise made more than 450 ascensions in a hot-air balloon and took measurements of atmospheric conditions above the ground. W. N. Jennings's photographs of lightning (see Illustration 1.9) in the early 1880s showed for the first time that a lightning bolt occurred as more of a wavy line than a zigzag, as was commonly depicted at that time. (His photographs were even published in *Scientific American* in 1885.) And The Franklin Institute organized the Pennsylvania State Weather Service in 1887 to assist the Army Signal Corps Weather Service in providing additional weather information at the local level, particularly for agricultural needs.

The growing recognition that weather conditions were critical to agriculture, and therefore to the nation's food supply, led to a reorganization of the government's weather system in 1891. All weather services were combined into a single agency, renamed the United States Weather Bureau (USWB), which was housed in the Department of Agriculture. With the USWB established,

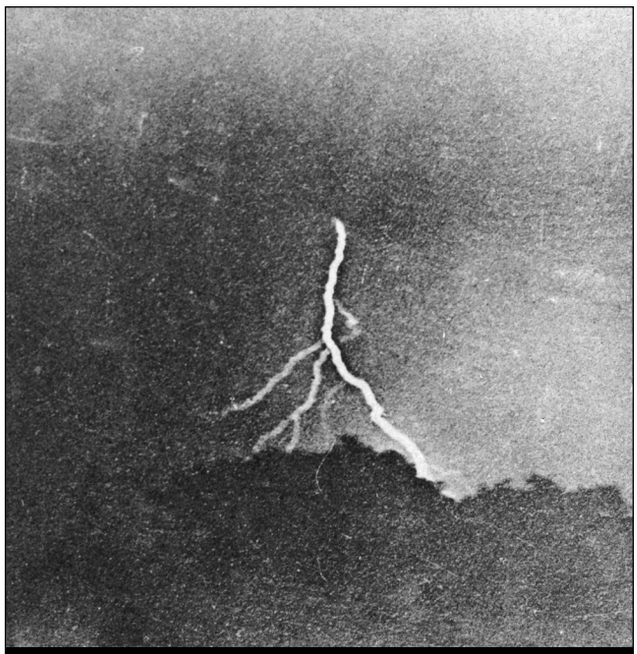


ILLUSTRATION 1.9 **First photograph of lightning, taken September 2, 1882 by W. N. Jennings (courtesy of the Historical and Interpretive Collections of The Franklin Institute, Philadelphia, Pa.).**

The Franklin Institute gave up ownership of the Pennsylvania State Weather Service. For the next forty years or so, Philadelphia's presence on the national weather scene consisted primarily of the USWB office, which by that time had moved to the Post Office Building at Ninth and Chestnut Streets. There, in the heart of downtown Philadelphia, the official record warmest day (106°F, August 8, 1918) and coldest day (−11°F, February 9, 1934) in Philadelphia history were measured. The original records of the USWB during this period are on public display today at The Franklin Institute.

Nearly fifty years after the United States Weather Bureau was established, and nearly a century after Espy put Philadelphia in the meteorological spotlight, The Franklin Institute once again revitalized Philadelphia's national role in meteorology. In 1934, TFI moved to its present location on the Benjamin Franklin Parkway and opened as one of the first two public science museums in the country. (Chicago's Museum of Science and Industry was the other.) At first, there was no exhibit devoted entirely to meteorology, but public interest and the recognition of TFI's place in weather history spurred a plan for such an exhibit. With contributions of funds, equipment,

and time from the USWB, private and corporate donors, and the American Meteorological Society (the nation's premier professional organization of meteorologists), the *Hall of Weather* opened in June 1942. The exhibit featured sections on the history of weather science, the preparation of weather maps, and the application of weather knowledge to industry and daily life, as well as the largest (at that time) collection of weather instruments in the country.

Two other events of the 1940s enhanced Philadelphia's role in U.S. weather science. In 1946, just after World War II had ended, the University of Pennsylvania formally dedicated the world's first electronic, general purpose, large-scale computer, dubbed ENIAC (for Electronic Numerical Integrator And Computer). Although ENIAC was an army project and used primarily for plotting ballistic trajectories, some primitive weather calculations were also run on the new computer. The military certainly recognized the potential benefits of better weather forecasting for their operations because critical plans during the war, such as the invasion of Normandy, depended on weather conditions. In 1950, the first successful computer weather forecast was made using ENIAC, ushering in the era of numerical weather prediction. (For more on ENIAC, see Chapter 2.)

While the work on weather modeling was underway, a man who would later become America's foremost weather historian, Dr. David Ludlum, joined The Franklin Institute in 1947 as its Director of Meteorology. Ludlum had been a battlefield weather forecaster in World War II and, as such, was responsible for predicting the weather for the 1944 assault on German forces at Cassino, Italy. This complicated land and air operation succeeded, in part, because of Ludlum's weather forecasts and came to be known as "Operation Ludlum," the only World War II action named for its weatherman. Like Espy a century before, Ludlum had a passion for weather and worked in an institution that supported that enthusiasm. At The Franklin Institute, Ludlum founded the Amateur Weathermen of America, a club for weather enthusiasts, and headquartered it at TFI. Soon, branches of the new organization appeared all over the country. He started *Weatherwise,* a popular nontechnical weather magazine that is still published today. And, in 1947, Ludlum worked briefly as Philadelphia's first (and one of the nation's first) television meteorologists.

Ludlum's short stint on local television just preceded the era when three personalities would make Philadelphia *the* place in early television weather: Dr. Francis Davis, Wally Kinnan, and Herb Clarke. Francis Davis had started weather forecasting on the radio in Philadelphia in 1946 and added television to his duties in 1948. He remained on Philadelphia's Channel 6 until 1971, when he left to become a full-time dean at Drexel University. In the 1950s, another legend-to-be—Wally Kinnan, "The Weatherman"—joined Channel 3, where he would remain for a decade. Kinnan also opened a weather forecasting service at The Franklin Institute and, with Davis, helped to start a national accreditation program for meteorologists. The third television weather pioneer arrived in 1958, when Herb Clarke joined WCAU-TV. Clarke had the longest tenure of the three, remaining on-air for nearly forty years. Meteorologists and viewers alike recall the period from 1958 to 1965, when the three were on-air at the same time, as the heyday of Philadelphia television meteorology (see Illustration 1.10). During that period, three innovations in meteorology—computer models, satellites, and radar—were just coming into use, so it was a time when technology met personality to make Philadelphia a national leader in television weathercasting. (For more on these Philadelphia television legends, see the "Story from the Trenches" in this chapter.)

ILLUSTRATION 1.10 **Philadelphia's three legendary television weather personalities in the early 1960s: *(l–r)* Wally Kinnan, Herb Clarke, and Dr. Francis Davis (courtesy of Herb Clarke).**

STORY FROM THE TRENCHES

Philadelphia's Early Television Weather Legends

Research studies throughout the country confirm that the number-one reason that people watch local television newscasts is for the weather report. Weather combines mass appeal (we all want to know what will happen tomorrow) with compelling pictures of local, national, and international interest.

Television weathercasts began in the United States around 1940. Some used fashion models or mascots to present the forecast. Weather, and other segments, were sponsored in ways not seen today: the weathercaster (or a cartoon character) would actually do the commercials. In New York City, for example, the weather on the station that is now WNBC was sponsored by Botany wrinkle-proof ties. An animated creature named Wooly Lamb started the weather segment by looking through a telescope, then singing: "It's hot, it's cold. It's rain, it's fair. It's all mixed up together. But I, as Botany's Wooly Lamb, predict tomorrow's weather." Then a slide would appear showing the latest forecast. Wooly Lamb presented the weather for seven years.

In Philadelphia, the commercial connection drove one of the great meteorologists right off the small screen. Dr. David Ludlum, after a very brief stay on local television in 1947, was fired because he refused to do the commercials required by management. "I couldn't croon the weather ditty they wanted to use to introduce the program, so they hired a crooner and made him the weatherman. I was just as glad," he later said.

About the time that Ludlum left the air, the first Philadelphia legend in television weather reporting arrived. As was the case with many other meteorologists of that era, Dr. Francis Davis had studied other sciences before becoming involved in weather. He was recruited to be a meteorologist during World War II. (See the story of his involvement in the D-Day forecast in Chapter 2.) With degrees in physics and math, he taught physics at Drexel University after the war and gave no thought to further work in weather.

Enter Walter Annenberg. The owner of newspapers and television and radio stations around the Philadelphia area, Annenberg saw the need to improve weather coverage and contacted the American Meteorological Society. He asked Ken Spengler, the Executive Director of the AMS, if he knew anyone in the Philadelphia area who could help. Spengler, who had been Davis's boss at the Pentagon during the war, recommended Davis for the job. This was the first step in Philadelphia's rise to national prominence in television weather over the next two decades.

Davis auditioned and was offered a job on radio in 1946. His salary was $10,000 a year to forecast at 7 A.M., 7 P.M., and 10 P.M. By 1948, he added television (Channel 6) to his weather duties, and his salary was doubled. Forecasting at that time was complicated by the limited amount of available weather information and a certain amount of guardedness about sharing it. Weather data at that time was distributed by teletype, essentially a typewriter that received and printed messages carried by telegraph or telephone. As Davis remembers, "I didn't have anything to work with. The U.S. Weather Bureau was jealous of private meteorologists taking over their terrain. They [the national office of the USWB] refused to allow us to get teletype data. They said it was dangerous to put teletype data in a television station because anyone could look at it." However, the local Philadelphia office of the USWB did allow Davis to visit their office each morning, look at the maps, and make some copies. And he did the same in the afternoon. He also got an evening phone update from the Weather Bureau.

In those days, the thirty-minute Channel 6 newscast was divided into three segments: fifteen minutes of news, ten minutes of sports, and finally five minutes of weather. Commercials took up about a minute and a half of that five minutes, leaving three and a half minutes for the weather. Davis was told that weather was last because it was "the most important thing people want, so we want to keep the viewers to the end." He did the weather by rear projection, using acetate overlays, so he could draw all the weather features individually. The forecast extended to three days in the future. Davis's philosophy of weather forecasting sounds similar to some used today: "I talked about all the different possibilities. I always found that even if the forecast wasn't right, there would be people the next day who would say: 'You got it right—you said it might rain.'" Davis's style was authoritative and somewhat professorial, and indeed he still taught physics full time at Drexel while he was

working in television. Davis continued to forecast the weather on Channel 6 until 1971, when he left to become a dean at Drexel.

In 1957, another meteorologist, Wally Kinnan, joined Davis on the Philadelphia television weather scene. Kinnan's early training was in engineering, and, like Davis, he became involved in weather forecasting while in the military during World War II. After the war, Kinnan stayed in the Air Force and was stationed in Oklahoma City, where in 1950 he started doing local television weather. But within six months, he was sent overseas to serve in the Korean War. According to Kinnan, he was "in charge of forecasting the upper air for the entire Pacific Ocean." When his tour of duty ended, he returned to Oklahoma City and did weather at the NBC station there from 1953 to 1957. When his boss left to become manager of NBC stations in Philadelphia and New York City, Wally was asked to audition for weather jobs at both stations. "I didn't like the atmosphere in New York, but I did like Philly," he recalls (referring to his feelings about the stations, not the weather in either city).

At Channel 3 in Philadelphia (which at the time was WRCV, an NBC station), Wally replaced a fashion model who, in his words, "swished down the stairs à la Loretta Young, with a new dress each night." With Wally Kinnan, "The Weatherman," things changed immediately. "I believed in explaining what was going on, and why," says Kinnan. The team of Kinnan and Vince Leonard "in a span of two years became the number one news team in the city." Part of the reason for Wally's success was his personable, humble, self-deprecating style on air. He looked and talked like a regular guy.

While establishing his reputation on Philadelphia television, Kinnan also put his mark on local and national meteorology in several other ways: he started a weather forecasting center at The Franklin Institute; he was one of the first (if not the first) meteorologist to issue a five-day forecast; and he helped create the Seal of Approval program of the American Meteorological Society. The Franklin Institute Weather Service opened in May 1963. Kinnan designed the weather center and staffed it full time with six other meteorologists. Kinnan's assistant director was Colonel Robert C. Miller, who fifteen years earlier had issued the first successful tornado forecast while an Air Force meteorologist in Oklahoma. The weather center was an observation room behind windows (see Illustration 1.11); people could watch the meteorologists work and ask questions. Kinnan would prepare his television program at the institute and then go to the station for the early newscast.

ILLUSTRATION 1.11 **Meteorologists Maximillian Kozak, Charles Umpenhour, and Wally Kinnan study maps in the newly opened Franklin Institute Weather Center in May 1963 (Urban Archives, Temple University, Philadelphia, Pennsylvania).**

A few years earlier, around 1960, Kinnan had introduced the five-day forecast on Channel 3. "I believe it was the first effort in that regard in the country," he recalls. To make the five-day, he used his experience from forecasting upper-air patterns during the Korean War. "It was my belief that you could take that upper-level flow and predict surface conditions out to five days with a certain degree of success," he says. Kinnan would compare the current upper-air weather map with charts from the past that were similar and use those past comparable situations to guide his forecasting, a technique known as the "analog method." (This method is still used today for seasonal forecasting—see Chapter 7.)

Many of his colleagues instantly condemned his innovation. At the time, the American Meteorological

Society's guidelines for meteorologists recommended against forecasting beyond three days. According to Kinnan, other meteorologists "fought me at every turn because no one wanted to try to do it, or even knew how to do it . . . the Weather Bureau opposed it, although never publicly." And so did Dr. Francis Davis, though he too never made his protest public. The conflict over the five-day strained the relationship between the Philadelphia weather pioneers. Kinnan recalls, "Francis and I were good friends. We did have that disagreement over the five-day forecast for awhile, and I don't know if he ever really forgave me." The irony is that some of the "analog" maps that Kinnan used for his five-day forecasts may have been the ones drawn up years before by Davis when he was part of one of the D-Day forecast teams.

The two did work together on the Seal of Approval program of the American Meteorological Society. In the mid-1950s, the AMS convened a committee to find ways to promote and accredit professional meteorologists on radio and television. Davis chaired the committee, and in an article in *TV Guide* in 1955, he summarized the AMS rationale for doing this:

> If TV weathermen are going to pose as experts, we feel they *should* be experts. We think the weather should be discussed with dignity. . . . We think many TV "weathermen" make a caricature of what is essentially a serious and scientific occupation, helping foster the notion that forecasters merely grab forecasts out of a fish bowl.

Davis's committee recommended a procedure and a set of standards for certifying television meteorologists. An applicant would send a film clip of a weather program that would be reviewed by members of the Board of Broadcast Meteorology. Davis, Kinnan, and three others served on the initial board. The men on the committee applied for the seal first, and to avoid a controversy about who would receive the first seal, AMS Director Ken Spengler decided they would be given in alphabetical order. That's how Francis Davis received AMS Seal Number One and Wally Kinnan AMS Seal Number Three. To date, the AMS seal has been awarded to more than 1,200 people, and it is required of television weathercasters by many stations throughout the country.

Kinnan inspired many other Philadelphians to become meteorologists, including Glenn Schwartz. Another young Kinnan disciple from Philadelphia, Joel Myers, went on to found AccuWeather, currently the world's largest commercial weather service. AccuWeather's forecasts were combined with the talents of the late Jim O'Brien in the 1970s on Channel 6, leading to more success for both in the Philadelphia television market.

In the mid-1960s when the ownership of the station changed, Wally relocated with NBC to Cleveland. He is still remembered as a key contributor to Philadelphia's reputation for television meteorology. Kinnan and Francis Davis were two of the three personalities that made the period from the late 1950s to the early 1960s the heyday of Philadelphia televi-

The Modern National Weather Service

It was true when Francis Davis and Wally Kinnan were doing the weather on Philadelphia television, and it is true today. Most of the raw weather information that meteorologists use—including surface and upper-air weather observations, computer model guidance, and satellite and radar images—comes from, in some way, an observation or prediction system maintained by the federal government. In 1970, the U.S. Weather Bureau was renamed the National Weather Service, and today the NWS is part of the Department of Commerce as an agency of the National Oceanic and Atmospheric Administration (NOAA). The mission of the modern National Weather Service is "to provide weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy."

Today, the National Weather Service maintains about 120 forecast offices across the United States. Every year, these offices issue more than 700,000 weather forecasts, 800,000 river and flood forecasts, and nearly 50,000 potentially life-saving severe weather warnings. NWS meteorologists issue forecasts twice each day, around 4 A.M. and 4 P.M. (local time) for individual counties or groups of counties, and the forecasts are updated at other times as needed. (The "local forecasts" shown on the Weather Channel are NWS forecasts.) NWS offices also issue a variety of other products, including aviation and marine forecasts and river and drought statements. The

sion weather. But the Philadelphia legend with the longest tenure is Herb Clarke, whose on-air weather career spanned some forty years.

Herb had been news director at a television station in Richmond, Virginia, but his on-air warmth and communication skills led to a career as one of more than forty "Atlantic weathermen" on television stations along the East Coast. The program was sponsored by the Atlantic Oil Company, which was headquartered in Philadelphia. In October 1958, Herb auditioned for the job in the company's home city. He was hired at $200 per week on WCAU, where he did a three-minute-and-twenty-second weathercast, a little longer than today's shows, using four sliding boards that showed various maps (see Illustration 1.12). His anchorman on the news was the legendary John Fascenda (known later as the voice of NFL films).

Since Herb was not a meteorologist, he used forecasts from the U.S. Weather Bureau, giving credit to the government forecasters and calling it the "official forecast." This acknowledgement earned him the enduring respect of his competitors and other meteorologists in the area. His style could be described as folksy and reassuring. Viewers would not be frightened of impending stormy weather after hearing a calm, collected Herb deliver the forecast. After Wally Kinnan's departure, Herb and Channel 10 relied on Franklin Institute meteorologists for forecasts, giving them full credit.

Herb's television career in Philadelphia spanned five decades; he started with drawing on maps and

ILLUSTRATION 1.12 **Herb Clarke as an Atlantic weatherman in 1959 (courtesy of Herb Clarke).**

closed using three-dimensional computer graphics. But according to Herb, the main change is: "Compared to what we're getting now, there was time for a bit more togetherness with the audience. The viewer gets closer to the person doing the weather than anyone else on the news . . . we both care for the same reason." As evidence of this connection with viewers, Herb received between forty and sixty letters a day. "I tried to answer them all," he says. Herb retired from Philadelphia television weather forecasting on New Year's Eve, 1997. ❖

local NWS office was located in Center City Philadelphia until 1993 when it moved to Mount Holly, New Jersey. Illustration 1.13 is a view inside that office, which is a typical NWS office. The Mount Holly office is responsible for ten counties in eastern Pennsylvania, sixteen counties in New Jersey, five counties on the upper eastern shore of Maryland, and all of Delaware (see Illustration 1.14). This area of responsibility includes the cities of Philadelphia, Allentown, Reading, Atlantic City, Trenton, Wilmington, and Dover.

The National Weather Service performs other essential activities as well. The NWS oversees several networks of weather observation—on land, at sea, and above the ground. They maintain a national system of radars for detecting precipitation and potentially severe weather. And the NWS runs the computer weather models used by every forecaster—not just NWS meteorologists. All this information is made available to other government agencies, the private sector, the media, and the public. The cost for these services amounts to about $2.50 for each American citizen every year.

Today, the primary nationwide weather observing system consists of about 1,000 "first-order" observing locations, most at airports or military installations. The official Philadelphia first-order observing site has moved several times since the Army Signal Corps observers arrived in 1871. (See Table 1.2 for a complete list of these sites.) Since 1940, the official Philadelphia observation has been taken at the airport a few miles southwest of Center City. Other local first-order observing sites include the Northeast Philadelphia Airport, Dover Air Force Base, and the Mercer County Airport in Trenton,

ILLUSTRATION 1.13 **Inside the National Weather Service office in Mount Holly, New Jersey (courtesy of National Weather Service).**

New Jersey. Illustration 1.15 shows the locations of the first-order observing stations within the forecast area of the NWS Mount Holly office and some adjacent counties. Meteorologists identify each site with a unique three-character code—the same city codes used by the airlines to route luggage. Often, the code is easy to decipher—for example, PHL is the Philadelphia International Airport. Note the lack of observing stations in some areas, including Chester, Delaware, and Schuylkill counties in Pennsylvania and Cecil County in Maryland. These gaps in the data-observing network are problematic for local forecasters, because the weather in the Philadelphia area typically approaches from a westerly direction.

First-order observing sites routinely report weather conditions on the hour, but can report more frequently if weather conditions are changing rapidly. Typically, the following are observed: temperature, humidity, air pressure, wind speed and direction, cloud cover and cloud height, horizontal and vertical visibility, and weather (such as rain, snow, or fog). The National Weather Service, in partnership with the Federal Aviation Administration and the Department of Defense, has nearly completed automating the first-order observing network. Human observers have been replaced with a suite of electronic monitoring devices known as ASOS (for Automated Surface Observing System). Illustration 1.16 is a picture of an ASOS. The change to ASOS allows more frequent and more remote weather observations, and the new automated system has performed well for measuring basic weather elements such as temperature, humidity, and wind. But ASOS cannot measure snowfall depth (among other things), so a human observer still augments the reports at some ASOS sites. (In fact, many meteorologists still long for the days when humans took all the observations.) The observation site at the Philadelphia International Airport was automated on December 1, 1995.

In addition to these first-order observing stations, the National Weather Service supports other countrywide observing systems, including a network of thousands of automated rain gauges. Another nationwide observing system, called the "cooperative observing network," is staffed by citizen volunteers at over 10,000 sites. Data at these locations is collected only once per day—typically, an observer might take readings at 8 A.M. local time, noting the high and low temperature and any precipitation over the previous twenty-four hours. Because of this observing schedule, data from this network is primarily used for climatological purposes and not for short-term forecasting. The Franklin Institute has been the cooperative observing site for Center City Philadelphia since

ILLUSTRATION 1.14 **The thirty-four counties that are shaded and labeled are in the service area of the Mount Holly office of the National Weather Service (courtesy of National Weather Service).**

TABLE 1.2 Location of the Official Philadelphia Weather Observing Site, 1871 to the Present

Location	Period
Philadelphia Board of Trade 505 Chestnut	Jan. 1, 1871 to Sept. 20, 1871
Chamber of Commerce Building 133 South Second	Sept. 21, 1871 to Jan. 31, 1882
Mutual Life Insurance Building Tenth and Chestnut	Feb. 1, 1882 to March 31, 1884
Post Office Building Ninth and Chestnut	April 1, 1884 to Dec. 17, 1934
U.S. Custom House Second and Chestnut	Dec. 18, 1934 to June 19, 1940*
Southwest (International**) Airport Administration Building	June 20, 1940 to Dec. 22, 1954***
International Airport New Terminal Building	Dec. 23, 1954 to Nov. 30, 1995
International Airport Automated Surface Observing System	Dec. 1, 1995 to present

*When the official observation site for Philadelphia moved to the airport in 1940, the U.S. Custom House (home of the U.S. Weather Bureau) continued its observations as the official reporting site for downtown Philadelphia. That downtown site moved to the Philadelphia Electric Building at Tenth and Chestnut on May 16, 1959 and then to the Federal Office Building at 600 Arch Street on Dec. 3, 1973, where it resided until 1993 when the National Weather Service moved to Mount Holly, N.J.

**Name changed to International Airport on April 1, 1948.

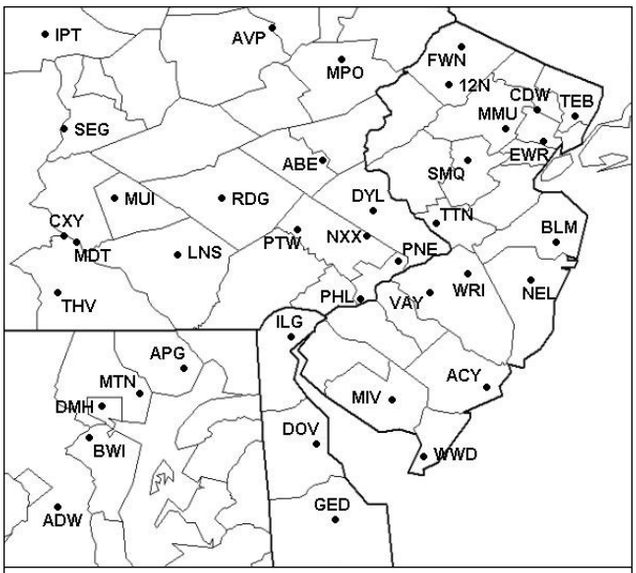
***From June 23 to November 30, 1945 the airport office was closed, and official observations were taken at the U.S. Custom House.

1993. Other local cooperative observing stations include Valley Forge and Washington Crossing in Pennsylvania, Moorestown and Glassboro in New Jersey, and Newark and Lewes in Delaware.

There are other weather observing networks that are not administered by the National Weather Service. For example, the Department of Environmental Protection in Pennsylvania maintains a statewide system of several dozen weather and pollution monitoring stations. The New Jersey Department of Transportation operates a similar network of over thirty roadside weather information systems. And some television stations install weather equipment in local schools and businesses, and then show the live observations during their weathercasts. These weather observing systems often provide very useful data, especially in areas where there are few first-order stations, but the observations usually are not quality controlled, so the data varies in reliability.

Weather observations at the earth's surface are a small part of the observational puzzle that meteorologists must build to understand the current weather pattern and predict future ones. Weather data from above the ground comes primarily from instrument packages called **radiosondes** that are carried aloft by weather balloons. During their ascent, they transmit back observations of temperature, pressure, and humidity to a ground-based receiving station until the balloon bursts at around fifteen to twenty miles altitude. (The radiosonde then parachutes back to earth—some are returned to the NWS and recycled.) Tracking the position of the radiosonde as it ascends also enables meteorologists to infer the wind speed and direction at various levels. Presently, radiosondes are launched twice a day from about seventy-five sites in North America and hundreds more worldwide.

First used by the U.S. Weather Bureau in 1936, radiosondes (many made by VIZ Corporation, based in



PENNSYLVANIA

ABE	Allentown (Lehigh Valley Intl. Airport)
AVP	Wilkes–Barre/Scranton Intl. Airport
CXY	Harrisburg (Capital City Airport)
DYL	Doylestown Airport
IPT	Williamsport (Lycoming County Airport)
LNS	Lancaster Airport
MDT	Harrisburg Intl. Airport
MPO	Mount Pocono (Pocono Mountains Municipal Airport)
MUI	Muir Army Air Field/Indiantown
NXX	Willow Grove Naval Air Station
PHL	Philadelphia Intl. Airport
PNE	Northeast Philadelphia Airport
PTW	Pottstown-Limerick Airport
RDG	Reading Regional Airport
SEG	Selinsgrove (Penn Valley Airport)
THV	York Airport

MARYLAND

ADW	Camp Springs/Andrews Air Force Base
APG	Phillips Army Air Field/Aberdeen
BWI	Baltimore–Washington Intl. Airport
DMH	Baltimore, Inner Harbor
MTN	Baltimore, Martin

DELAWARE

DOV	Dover Air Force Base
GED	Georgetown (Sussex County Airport)
ILG	Wilmington (New Castle County Airport)

NEW JERSEY

12N	Andover (Aeroflex–Andover Airport)
ACY	Atlantic City Intl. Airport
BLM	Belmar–Farmdale
CDW	Caldwell (Essex County Airport)
EWR	Newark Intl. Airport
FWN	Sussex Airport
MIV	Millville Municipal Airport
MMU	Morristown Municipal Airport
NEL	Lakehurst Naval Air Station
SMQ	Somerville (Somerset Airport)
TEB	Teterboro Airport
TTN	Trenton (Mercer County Airport)
VAY	Mount Holly (South Jersey Regional Airport)
WRI	Mcguire Air Force Base
WWD	Wildwood

ILLUSTRATION 1.15 **First-order weather observing sites, with official three-character identifiers.**

Philadelphia) are relatively low-tech devices. Probably the most technologically advanced weather observations come from an armada of orbiting satellites and ground-based radars (two more NWS/NOAA services) that are continuously monitoring the skies for clouds, precipitation, and much more. Because they revolutionized the science of meteorology and the way weather information is presented to the public, weather satellites and weather radar deserve a closer look.

Weather Satellites

Satellites, man-made objects put into orbit around the earth, are used for communications, military monitoring, scientific research, and weather observing. U.S. weather satellites are maintained and operated by NOAA. Along with radar and computer models, weather satellites are one of the three great technological advances in meteorology of the latter half of the twentieth century.

The first weather satellite was TIROS-1, launched on April 1, 1960. (TIROS stands for Television InfraRed Observation Satellite). Early satellite images were black and white and rather grainy (see Illustration 1.17), but at the time such images were a monumental advance. Previously, cloud patterns could be visualized only in theory; with satellite imagery, meteorologists could finally see the sharp line of thunderstorms along a cold front, the spiral bands around a hurricane, and the comma shape of a mature low-pressure system. TIROS-1 and other early weather satellites orbited too low to see much of the earth at once. To get a wider view, meteorologists had to piece together the individual images taken as the satellite circled the earth. The result was a collage of pictures taken at different times, with some of the images hours old.

To solve the problem, scientists put a satellite higher up, where it had a wider view. And if the satellite was placed over the equator at an altitude of about 22,500 miles, it could orbit at the same rate as the earth rotated. In this way, the satellite would essentially remain fixed above the same point on earth and thus always have a view of the same area. Then, images of that area could be played one after another to create loops, or animations, to show the movement of weather systems. The first such "geostationary" weather satellite, GOES-1, was launched in October 1975. (GOES stands for Geostationary Operational Environmental Satellite.) Today, several generations later, GOES-8 monitors the eastern United States and the Atlantic Ocean, while GOES-10 tracks the weather in the eastern Pacific and western U.S. GOES-11