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# Atmospheric Scientists

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## Significant Points

- Almost 4 in 10 atmospheric scientists work for the Federal Government, which is the largest employer of such workers.
- A bachelor's degree in meteorology, or in a closely related field with courses in meteorology, is the minimum educational requirement; a master's degree is necessary for some positions, and a Ph.D. is required for most research positions.

## Nature of the Work

Atmospheric science is the study of the atmosphere—the blanket of air covering the Earth. *Atmospheric scientists*, commonly called *meteorologists*, study the atmosphere's physical characteristics, motions, and processes, and the way in which it affects the rest of our environment. The best known application of this knowledge is in forecasting the weather. Aside from predicting the weather, scientists also attempt to identify and interpret climate trends, understand past weather, and analyze today's weather. However, weather information and meteorological research also are applied in air-pollution control, agriculture, forestry, air and sea transportation, defense, and the study of possible trends in the Earth's climate, such as global warming, droughts, or ozone depletion.

Atmospheric scientists who forecast the weather, known professionally as *operational meteorologists*, are the largest group of specialists. They study information on air pressure, temperature, humidity, and wind velocity; and apply physical and mathematical relationships to make short-range and long-range weather forecasts. Their data come from weather satellites, weather radars, sensors, and weather stations in many parts of the world. Meteorologists use sophisticated computer models of the world's atmosphere to make long-term, short-term, and local-area forecasts. More accurate instruments for measuring and observing weather conditions, as well as high-speed computers to process and analyze weather data, have revolutionized weather forecasting. Using satellite data, climate theory, and sophisticated computer models of the world's atmosphere, meteorologists can more effectively interpret the results of these models to make local-area weather predictions. These forecasts inform not only the general public, but also those who need accurate weather information for both economic and safety reasons, such as the shipping, air transportation, agriculture, fishing, forestry, and utilities industries.

The use of weather balloons, launched a few times a day to measure wind, temperature, and humidity in the upper atmosphere, is currently supplemented by sophisticated atmospheric monitoring equipment that transmits data as frequently as every few minutes. Doppler radar, for example, can detect airflow patterns in violent storm systems—allowing forecasters to better predict tornadoes and other hazardous winds, and to monitor the storms' direction and intensity. Combined radar and satellite observations allow meteorologists to predict flash floods.

Some atmospheric scientists work in research. *Physical meteorologists*, for example, study the atmosphere's chemical and physical properties; the transmission of light, sound, and radio waves; and the transfer of energy in the atmosphere. They also study factors affecting the formation of clouds, rain, and snow;

the dispersal of air pollutants over urban areas; and other weather phenomena, such as the mechanics of severe storms. *Synoptic meteorologists* develop new tools for weather forecasting using computers and sophisticated mathematical models of atmospheric activity. *Climatologists* study climatic variations spanning hundreds or even millions of years. They also may collect, analyze, and interpret past records of wind, rainfall, sunshine, and temperature in specific areas or regions. Their studies are used to design buildings, plan heating and cooling systems, and aid in effective land use and agricultural production. Environmental problems, such as pollution and shortages of fresh water, have widened the scope of the meteorological profession. *Environmental meteorologists* study these problems and may evaluate and report on air quality for environmental impact statements. Other research meteorologists examine the most effective ways to control or diminish air pollution.

## Working Conditions

Most weather stations operate around the clock, 7 days a week. Jobs in such facilities usually involve night, weekend, and holiday work, often with rotating shifts. During weather emergencies, such as hurricanes, operational meteorologists may work overtime. Operational meteorologists also are often under pressure to meet forecast deadlines. Weather stations are found everywhere—at airports, in or near cities, and in isolated and remote areas. Some atmospheric scientists also spend time observing weather conditions and collecting data from aircraft. Weather forecasters who work for radio or television stations broadcast their reports from station studios, and may work evenings and weekends. Meteorologists in smaller weather offices often work alone; in larger ones, they work as part of a team. Meteorologists not involved in forecasting tasks work regular hours, usually in offices. Those who work for private consulting firms or for companies analyzing and monitoring emissions to improve air quality usually work with other scientists or engineers; fieldwork and travel may be common for these workers.

## Employment

Atmospheric scientists held about 7,700 jobs in 2002. The Federal Government was the largest single employer of civilian meteorologists, accounting for about 2,900. The National Oceanic and Atmospheric Administration (NOAA) employed most Federal meteorologists in National Weather Service stations



*Atmospheric scientists utilize sophisticated instruments and high-speed computers to predict weather and identify climate trends.*

throughout the Nation; the remainder of NOAA's meteorologists worked mainly in research and development or management. The U.S. Department of Defense employed several hundred civilian meteorologists. Others worked for professional, scientific, and technical services firms, including private weather consulting services; radio and television broadcasting; air carriers; and State government.

Although several hundred people teach atmospheric science and related courses in college and university departments of meteorology or atmospheric science, physics, earth science, or geophysics, these individuals are classified as college or university faculty, rather than atmospheric scientists. (See the statement on postsecondary teachers elsewhere in the *Handbook*.)

In addition to civilian meteorologists, hundreds of Armed Forces members are involved in forecasting and other meteorological work. (See the statement on job opportunities in the Armed Forces elsewhere in the *Handbook*.)

### **Training, Other Qualifications, and Advancement**

A bachelor's degree in meteorology or atmospheric science, or in a closely related field with courses in meteorology, usually is the minimum educational requirement for an entry-level position as an atmospheric scientist.

The preferred educational requirement for entry-level meteorologists in the Federal Government is a bachelor's degree—not necessarily in meteorology—with at least 24 semester hours of meteorology courses, including 6 hours in the analysis and prediction of weather systems, 6 hours of atmospheric dynamics and thermodynamics, 3 hours of physical meteorology, and 2 hours of remote sensing of the atmosphere or instrumentation. Other required courses include 3 semester hours of ordinary differential equations, 6 hours of college physics, and at least 9 hours of courses appropriate for a physical science major—such as statistics, chemistry, physical oceanography, physical climatology, physical hydrology, radiative transfer, aeronomy, advanced thermodynamics, advanced electricity and magnetism, light and optics, and computer science. Sometimes, a combination of education and appropriate experience may be substituted for a degree.

Although positions in operational meteorology are available for those with only a bachelor's degree, obtaining a second bachelor's degree or a master's degree enhances employment opportunities and advancement potential. A master's degree usually is necessary for conducting applied research and development, and a Ph.D. is required for most basic research positions. Students planning on a career in research and development need not necessarily major in atmospheric science or meteorology as an undergraduate. In fact, a bachelor's degree in mathematics, physics, or engineering provides excellent preparation for graduate study in atmospheric science.

Because atmospheric science is a small field, relatively few colleges and universities offer degrees in meteorology or atmospheric science, although many departments of physics, earth science, geography, and geophysics offer atmospheric science and related courses. Prospective students should make certain that courses required by the National Weather Service and other employers are offered at the college they are considering. Computer science courses, additional meteorology courses, a strong background in mathematics and physics, and good communication skills are important to prospective employers. Many programs combine the study of meteorology with another field, such as agriculture, oceanography, engineering, or physics. For example, hydrometeorology is the blending of hydrology (the

science of Earth's water) and meteorology, and is the field concerned with the effect of precipitation on the hydrologic cycle and the environment. Students who wish to become broadcast meteorologists for radio or television stations should develop excellent communication skills through courses in speech, journalism, and related fields. Those interested in air quality work should take courses in chemistry and supplement their technical training with coursework in policy or government affairs. Prospective meteorologists seeking opportunities at weather consulting firms should possess knowledge of business, statistics, and economics, as an increasing emphasis is being placed on long-range seasonal forecasting to assist businesses.

Beginning atmospheric scientists often do routine data collection, computation, or analysis, and some basic forecasting. Entry-level operational meteorologists in the Federal Government usually are placed in intern positions for training and experience. During this period, they learn about the Weather Service's forecasting equipment and procedures, and rotate to different offices to learn about various weather systems. After completing the training period, they are assigned a permanent duty station. Experienced meteorologists may advance to supervisory or administrative jobs, or may handle more complex forecasting jobs. After several years of experience, some meteorologists establish their own weather consulting services.

The American Meteorological Society offers professional certification of consulting meteorologists, administered by a Board of Certified Consulting Meteorologists. Applicants must meet formal education requirements (though not necessarily have a college degree), pass an examination to demonstrate thorough meteorological knowledge, have a minimum of 5 years of experience or a combination of experience plus an advanced degree, and provide character references from fellow professionals.

### **Job Outlook**

Employment of atmospheric scientists is projected to increase about as fast as the average for all occupations through 2012. The National Weather Service has completed an extensive modernization of its weather forecasting equipment and finished all hiring of meteorologists needed to staff the upgraded stations. The Service has no plans to increase the number of weather stations or the number of meteorologists in existing stations. Employment of meteorologists in other Federal agencies is expected to remain stable.

On the other hand, job opportunities for atmospheric scientists in private industry are expected to be better than for those in the Federal Government over the 2002-12 period. As research leads to continuing improvements in weather forecasting, demand should grow for private weather consulting firms to provide more detailed information than has formerly been available, especially to weather-sensitive industries. Farmers, commodity investors, radio and television stations, and utilities, transportation, and construction firms can greatly benefit from additional weather information more closely targeted to their needs than the general information provided by the National Weather Service. Additionally, research on seasonal and other long-range forecasting is yielding positive results, which should spur demand for more atmospheric scientists to interpret these forecasts and advise weather-sensitive industries. However, because many customers for private weather services are in industries sensitive to fluctuations in the economy, the sales and growth of private weather services depend on the health of the economy.

There will continue to be demand for atmospheric scientists to analyze and monitor the dispersion of pollutants into the air to ensure compliance with Federal environmental regulations outlined in the Clean Air Act of 1990, but related employment increases are expected to be small. Opportunities in broadcasting are rare and highly competitive, making for very few job openings.

### **Earnings**

Median annual earnings of atmospheric scientists in 2002 were \$60,200. The middle 50 percent earned between \$39,970 and \$76,880. The lowest 10 percent earned less than \$30,220, and the highest 10 percent earned more than \$92,430.

The average salary for meteorologists in nonsupervisory, supervisory, and managerial positions employed by the Federal Government was about \$74,528 in 2003. Meteorologists in the Federal Government with a bachelor's degree and no experience received a starting salary of \$23,442 or \$29,037, depending on their college grades. Those with a master's degree could start at \$35,519 or \$42,976; those with the Ph.D., at \$51,508. Beginning salaries for all degree levels are slightly higher in areas of the country where the prevailing local pay level is higher.

### **Related Occupations**

Workers in other occupations concerned with the physical environment include environmental scientists and geoscientists, physicists and astronomers, mathematicians, and civil, chemical, and environmental engineers.

### **Sources of Additional Information**

Information about careers in meteorology is available on the Internet from:

► American Meteorological Society. Internet: <http://www.ametsoc.org/AMS>. Phone: (617)-227-2425.

Information on obtaining a meteorologist position with the Federal Government is available from the U.S. Office of Personnel Management through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (703) 724-1850; Federal Relay Service: (800) 877-8339. The first number is not tollfree, and charges may result. Information also is available from the Internet site: <http://www.usajobs.opm.gov>.