The importance of weather monitoring

Sensing the winds and weather has been important to man over the centuries. Athenians built the eight-sided Tower of the Winds in the first century B.C. in honour of the eight gods of the winds. The Tower of the Winds stands to this day in the ancient *agora*, or market, in Athens.

Many significant weather events have affected mankind over the years. We know of these because their effects have become part of history. Since much of history is a recollection of a series of wars and battles, it is interesting to note that a well known early reference to the importance of the weather is from the Chinese philosopher Sun Tsu, who said, "Know yourself and know your enemy, and victory is guaranteed. Know the terrain and know the weather, and you will have total victory."

Much later in history, we know that Napoleon's invasion of Russia in 1812 was stymied when snow and cold weather came earlier in the season than he and his generals had planned. This, combined with Russian militia attacks, helped defeat the French, who invaded with 50,000 troops, and left with only 20,000 survivors. One hundred thirty years later, this was repeated when Hitler's invasion of the Soviet Union was again foiled in part by brutally cold winter weather.

In the 20th century, large population migrations were brought about by adverse weather conditions, including those of the Dust Bowl in the United States during the 1930s, multiple Asian droughts throughout the century, and three significant periods of drought in the *sahel* region of Africa. Individual events that killed and affected many people include the great smog event in London in 1952, which killed 4,000 people in five days in December, hurricane impacts on the coasts of the United States, from Galveston in 1900 to Katrina, Rita and Wilma last year, and several notable blizzards. Man's affect upon the environment has also been seen in the weather, in more recent events, when the release of radioactive particles from the reactor accident at Chernobyl, Ukraine, was detected by sensors outside of the Soviet Union, and traced back to Chernobyl using sophisticated weather sensors and meteorological models. In a similar fashion, local weather instruments were used to help estimate the impact of smoke and soot from oil well fires set during the 1991 Gulf War.

Present day monitoring techniques

Today, the winds and other weather variables are of equal concern and can have an even greater impact on our modern, high-tech life style. Weather affects a wide range of man's activities, including agriculture, transportation and leisure time. Often the affects involve the movement of gases and particulates through the atmosphere.

Modern weather monitoring systems and networks are designed to make the measurements necessary to track these movements in a cost effective manner. This requires that the total life-cycle cost of a monitoring system is minimized, and one way to do this is to minimize or eliminate the maintenance of the weather monitoring system. Using a solid-state system to measure the weather, including the wind speed and direction, is paramount to minimize equipment servicing and costs.

The conventional weather monitoring system consisted of individual sensors to measure one meteorological variable, each connected to a data collection device or recorder. Modern technology has allowed the combination of several sensors into one integrated weather station that can be permanently located at one site, or transported to a site where localized weather is needed.

The TACMET II weather station is easily carried in two cases. One case houses the radio, battery and charger, and the other holds the weather station, tripod, mount to attach the sensor to the tripod, and all of the system's cables.

Scientists have worked to develop solid-state meteorological sensors since the 1950s. The first of these were sonic anemometers, which measure the time required for a sound wave to travel from point A to point B. This time is affected by the speed of the wind in a predictable and repeatable way. The earliest sonic anemometers were used to measure the small scale fluctuations of the winds caused by atmospheric turbulence. The earliest sensors were not very stable and needed a great deal of maintenance to keep them operating. Thus, since the turbulence is measured by subtracting a running mean value from the data to determine the fluctuations, and since the means were unreliable, this was a perfect use of this instrument. It is only in the past 10 to 15 years that the electronics have become suitable for use in an instrument that is used for long term measurements of the winds.

There have been other types of instruments developed to measure the winds without moving parts. One of these is a thermal anemometer – an instrument that measures the temperature of a small element in the sensor, and calculates the wind by measuring the amount of energy carried away from the anemometer. These are often called hot wire or hot film anemometers. Significant drawbacks of these sensors are that they are very prone to contamination by dirt, and it is difficult to distinguish energy carried away by the wind from cooling caused by the impact of raindrops and snowflakes.

Another technique used to measure the winds is to measure the vortices caused by a fixed shape that is projected into the wind. These vortex shedding anemometers operate on the principle that when a fluid flows around an obstruction in the flow stream, vortices are shed from alternating sides of the obstruction in a repeating and continuous fashion. The frequency at which the shedding alternates is proportional to the velocity of the flowing fluid. Sensors downstream of the obstruction sense the presence of the vortices and derive the wind speed from them. These work well in pipes and ducts, but have not been successfully implemented in the ambient environment.

Solid state anemometers

There are many manufacturers of solid state anemometers today, but few have integrated the anemometer into a single-piece solid-state weather station. Of the three that appear to be available today, one is a lightweight plastic unit that might not stand up to rough handling, and the other is very expensive. Only the robust TACMET II weather station provides a rugged yet accurate and reliable solid-state solution for fixed or mobile weather monitoring requirements at a modest price.

One current example of this precept is a military user who has the responsibility of responding to emergencies when chemical or biological agents are released into the environment. These brave soldiers bring with them the equipment they need for their response activities, including three weather stations, all of which have solid-state weather systems to measure the winds, temperature, relative humidity and pressure. These sensors also have built-in systems to protect them against the effects of radio frequency and electromagnetic interference, and they automatically orient the wind direction data to North using an internal flux-gate compass. These systems communicate with the base station data collection system either via cables connected to the base station or with spread spectrum radios. The ability to switch between the two communication media was one of the principal features requested by the users of these systems.

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In the case of a second user, a time difference of just under a year has allowed an improvement in the ability to package several of the system components inside the weather station. Recently, a state government's toxic air pollutant monitoring group, in the division of air quality in the department of natural resources, procured a group of three such portable weather stations, all of which report their data to a base station via spread spectrum radio telemetry. The solid-state, one-piece TACMET II weather station mounts on top of the lightweight tripod. The improvement in this system is that inside the weather station is a small data radio modem module, which transmits the data from the weather station when the base station requests it, over a distance of up to twenty miles. Each weather station measures the winds with a solid-state anemometer that has no moving parts. The temperature and relative humidity sensors are included in a set of shield plates which protect them from the solar heating and precipitation. An internal flux-gate compass is included in the system which is used to automatically orient the wind direction to North. This allows the operator to set up the system quickly in this portable application without the possibility of mis-orienting the sensor.

Power for the system is provided by a flexible solar panel and rechargeable battery. The case also has a port to interface a laptop computer or a PDA to view the data locally.

The state organization uses the weather stations when they respond to an accidental toxic or other hazardous material spill. The weather stations are used to provide data to input into air quality dispersion models that predict where the released material will travel on the wind. The responders then use the results of the model to help warn residents in the affected area.

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The third example of the usefulness of a solid-state weather station for tracking hazardous materials released into the air is the Biological Identification and Detection System (BIDS). The BIDS consists of a shelter mounted on a vehicle and equipped with a biological detection suite employing complementary technologies to detect large area biological attacks. The BIDS Biological Detection Suite links aerodynamic particle sizing, bioluminescence/fluorescence, flow cytometry, mass spectrometry and immunoassay technologies in a complementary, layered manner to increase detection confidence. The TACMET II weather station is deployed on a mast above the shelter. The weather data are used to determine where the detected material came from, and to predict where it is travelling. This information is used to warn personnel downwind to take protective action, and to take action against the enemy forces who released the biological agents into the environment.

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