Weather Primer

Temperature

Temperature is a measure of hotness or coldness, expressed on an arbitrary scale. In relation to weather, temperature usually refers to the air temperature when shielded from sunlight and wind.

Galileo develeoped the first version of a thermometer in 1607. His invention consisted of an inverted glass vessel, partially filled with water. Changes in air temperature caused the air within the vessel to expand and contract. The level of the water then gave a rough measure of the temperature.

A more refined and accurate thermometer was invented by Daniel Gabriel Fahrenheit in 1709. His design relied on the expansion of alcohol in much the same manner as modern thermometers. A version using mercury was also developed in 1714. It was not widely used, however, until 1866, when Sir Thomas Clifford Allbutt invented a pocket-sized version.

The Fahrenheit temperature scale was originally based upon 30 for an ice water solution and 90 for normal body temperature. The numbers were later revised to 32 and 98.6, respectively, after more more precise measurements were made. The Fahrenheit scale was used in English-speaking countries until the 1970s, when the Celsius scale was adopted. Currently, the United States is about the only place where the Fahrenheit scale is still used.

The Celsius scale was developed by Anders Celsius in 1742 and was originally known as the Centigrade scale because of its 100 divisions between the freezing and boiling points of water. The scale was officially renamed in 1948 to honor the work of Anders Celsius. It is now in general use throughout the world.

The highest air temperature ever recorded was 58 °C (136 °F) in Al' Aziyah, Libya on September 13, 1922. The lowest recorded air temperature was -88 °C (-127 °F) in Vostok, Antarctica on August 24, 1960. The lowest recorded air semperature at a permanently inhabited site was -71 °C (-96 °F) in Oymakon, Siberia in 1964.

Thermometers can use any substance that changes properties with temperature. There are four major type of thermometers: liquid-in-glass, electrical resistance, thermocouples, and bimetallic strips. Electrical resistance thermometers typically use a platinum wire that changes resistance with temperature. Thermocouples consist of two wires of different metals bonded together at one end. A common type is ISA Type K, which is made from Chromel® (nickel/chromium alloy) and Alumel® (nickel/aluminum/manganese/silicon alloy). Changes in temperature create a voltage difference across the wires. Thermocouples are widely used in industry due to their rugged nature.

Bimetallic strips are most commonly used in home thermostats. They consist of two strips of different metals, bonded together and held at one end. A common type of bimetallic strip is made from brass and Invar®, an alloy composed of nickel and iron. The different expansion rates of the two metals cause the strip to bend when the temperature changes.

Two numbers related to air temperature are windchill and heat index. Windchill gives a measure of the cooling power of air on bare skin in relation to air temperature and wind speed. It is generally reported as windchill equivalent temperature, which is the air temperature that would provide the same rate of cooling at a walking speed of 4 miles per hour (1.8 m/s). Heat index is a measure of the apparent rise of temperature under conditions of high relative humidity. The increased humidity reduces the effectiveness of evaporative cooling through perspiration.

Barometric Pressure

Barometric pressure, also known as atmospheric pressure, is the pressure caused by the weight of the atmosphere above a given point. Changes in barometric pressure can be used to forecast changes in weather conditions. Stormy weather is usually characterized by low pressure, while high pressure yields fair conditions.

The most common tool to measure barometric pressure is the mercury barometer, invented in 1643-1644 by Evangelista Torricelli. It consists of a glass tube, sealed at the top and inverted in a dish of mercury. Barometric pressure on the mercury in the dish causes it to be pushed up into the tube. The pressure is directly related to the height of the mercury column.

Since there is a direct relationship between pressure and height of the mercury column, pressure is often reported as the height of mercury in inches, centimeters, or millimeters. The torr, named for Torricelli, is eqivalent to millimeters of mercury. More recently, the SI-derived unit of kilopascal has begun to be used. On weather maps, pressure is usually denoted in millibars, where 1 millibar equals 0.1 kilopascal.

The average barometric pressure at sea level is 101.3 kPa (29.92 inches Hg or 760 mm Hg). The highest atmospheric pressure ever recorded was 108.4 kPa (32.00 inches Hg or 812 mm Hg) in Agata, Siberia on December 31, 1968. The lowest pressure ever recorded was 85.6 kPa (25.28 inches Hg or 642 mm Hg) aboard the U.S.S. Repose in the eye of a typhoon off of Okinawa on September 16, 1945.

By its very nature, the mercury barometer is not a portable instrument. When small size, portability, or ruggedness are needed, an aneroid barometer is often used. It consists of an evacuated chamber with a flexible wall. Changes in barometric pressure cause the degree of deflection in the wall. This deflection can be measured electronically, or linked mechanically to an indicator needle. The readout scale is calibrated using a mercury barometer.

Wind Speed

Winds play a major role in global climate by mixing the atmoshpere and transporting water vapor and pollutants great distances. Wind is caused by changes in temperature and pressure, as well as the Coriolis force resulting from rotation of the Earth.

The simplest way to measure wind speed is with a rotating cup anemometer. The speed of rotation is directly proportional to the wind speed. The rotating cups can also be used to drive a generator, with the voltage produced being used as a measure of the wind speed.

Wind speed over land is reported in typical units of velocity such as miles per hour, kilometers per hour, or meters per second. Over water, wind speed is often reported in knots, where 1 knot is 1 nautical mile per hour or about 1.15 statute miles per hour (1.85 kilometers per hour). The term "knot" comes from the method ships would use to measure their speed. A log would be tossed overboard, with a rope tied to it with knots about every 47 feet (14.3 meters). After 28 seconds, the number of knots that had passed as the rope deployed was equal to the ship's speed in knots.

Freezing weather conditions often make the use of a rotating cup anemometer impractical. In these cases, a pitot tube is used to measure wind speed. The pitot tube consists of a tube, closed at one end, and the other end open to the wind. Air striking the open face of the tube causes an increase in pressure inside the tube. The difference in pressure inside and outside the tube is then related to the wind speed. For very accurate measurements of low air speeds, a hot wire anemometer is used. It relies on the moving air to cool a fine wire. The additional power needed to maintain the wire at a constant temperature is related to the wind speed.

Humidity

Relative humidity is the percent of water vapor in the air, relative to the maximum amount of water vapor that the air can hold. It is often expressed in terms of the dewpoint, which is the temperature at which the vapor in the air becomes saturated.

The measurement of humidity was first made in 1783 by Horace Benedict de Sassure, who related changes in the length of a strand of human hair to changing humidity. John Frederic Daniell later invented the dewpoint hygrometer in 1820. This instrument passes air over a polished surface, which is then cooled until water vapor begins to condense on the surface.

Other means of measuring humidity include the electrical hygrometer and the psychometer. An electrical hygrometer measures the change in electrical resistance of a thin layer of lithium chloride or semiconductor. Psychometers have two thermometers, one of which is wetted, which give "wet bulb" and "dry bulb" temperatures. Evaporation of water from the wet bulb causes a decrease in temerature. The rate of evaporation, and therefore the amount of temperature depression, is inversely related to the relative humidity.