17. Wind Measurements

How is wind measured?

Since wind has a mass, it can move objects, which some of the measuring instruments for wind measurements (anemometer) take advantage of. The wind speed can thus be determined by the speed of a propeller. Alternatively, different measuring devices measure the wind speed by the reflection or speed of waves (sound, light) (see measuring methods).

The hourly values of speed are averages from 6 to 10 minute intervals. These 10 minute intervals consist of 4 measurements per second, which are aggregated to 10 minutes. Maximum and minimum speeds are derived from 3-second intervals consisting of 12 individual measurements.

The direction can be determined for example by a wind vane, which outputs a measured value every second. These are also averaged over 10 minutes and then aggregated to hourly values.

Figure 1: Weather station in La Brévine, Switzerland

How should an anemometer be set up?

An anemometer must be placed on a level surface (optimally cut grass) and ten meters above the ground according to WMO standards. No major obstacles (trees, buildings) affecting the circulation of air are allowed be nearby. The distance from a larger obstacle to the meter has to be at least 4 times the height of the object.

Wind speed and wind direction change with increasing altitude over ground. Therefore meteorological masts usually have wind sensors attached in different altitudes (2m, 10m, 80m, etc.).

Which measuring instruments are used?

Figure 2: Cup anemometer with wind vane

National meteorological services usually use one of the following two devices to measure wind speed and direction:

- A cup anemometer with wind vane (see Figure 2)
- An ultrasonic anemometer that measures both wind speed and direction (see Figure 3)

Which other measuring methods are available?

A cup or propeller anemometer measures the wind speed using the circular speed of the unit. This includes a wind vane, which measures the direction of the wind. These devices are the most common and often seen on private buildings. Their measurements are relatively accurate, but they have the disadvantage that they can be blocked by dust or at sea by salt.

Figure 3: Ultrasonic anemometer

Other anemometers (SODAR / LIDAR) do their measurements using the Doppler frequency shift. This so-called Doppler effect works as follows: If the sound / light waves hit a particle in the air that moves towards the meter, the reflected wave will have a higher frequency than the output signal. With the help of this frequency shift both wind direction and speed can be calculated and thus measured. These measuring instruments have the advantage that they can create a 3D image of the air currents up to 200m in height. This is especially helpful when assessing wind farm locations. However, the instruments only work with limited accuracy when precipitation (rain, snow, etc.) is present, as the waves are reflected by water as well.

The ultrasonic anemometer measures the time that elapses between transmission and reception of the signal between two receptors. If the signal has tailwind, it will arrive faster than the speed of sound, if it has headwind, it will be slower. Since a measuring cycle of this device only takes about 5ms, up to 200 measuring cycles per second can be performed. This makes it possible to measure microcirculations. But this instrument is not reliable to use in precipitation.

For very high wind speeds, there are also pitot pressure anemometers (Pitot tubes). These measure the pressure difference between incoming air and normal pressure.

Difficulties of wind measurement

The biggest problem with wind is that every little object causes turbulence. Even a power line is enough to swirl the wind for a certain distance. Since wind sensors usually need a regular and constant wind to provide accurate measurements, turbulence is not desirable. It is therefore all the more important that the wind measurement is placed in a place where there are no obstacles.

In the case of propeller or shell anemometers, there is also the problem of contamination or blocking by dust or near the sea by salt. Therefore, they must be serviced at regular intervals. In addition, these devices have a certain delay in heavy gusts of wind, since the shells must first accelerate and the speed of the propeller does not change immediately. The bigger problem is the overspeed after a gust of wind, because of the fact that the devices are created with as little friction as possible (for a fast acceleration), the reduction of the propeller speed is delayed even more with decreasing wind speed.