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ACCURATE measurements

MPS System is helping to reduce negative influences, such as wind, temperature and inlet losses, to improve the quality of data from weighing precipitation gauges

The advantages of using weighing gauges for precipitation measurement are well known. They include no limits on rainfall intensity, inlets aren't blocked with particles or leaves, and they offer high accuracy. However, there are some disadvantages, including the requirement to manually empty the bucket, and the effect that negative temperatures and wind have on data accuracy. MPS System has been developing its TRwS family of weighing precipitation gauges for 15 years. Currently there are seven types of TRwS gauges in production. Two of them are stainless steel, and three are self-emptying, using unique weighing and self-emptying technology. The latter combine the advantages of the weighing and tipping principle.

Reducing negative influences

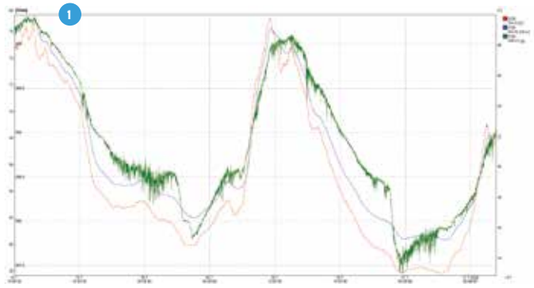
The TRwS gauges include load cells, which are analog sensors that change according to weight and temperature. The most difficult situation occurs when temperature changes rapidly, such as at sunrise and sunset, as this can generate false precipitation. Temperature compensation for the load cell is carried out, but this is often not enough for these rapid temperature changes, and false precipitation can be generated.

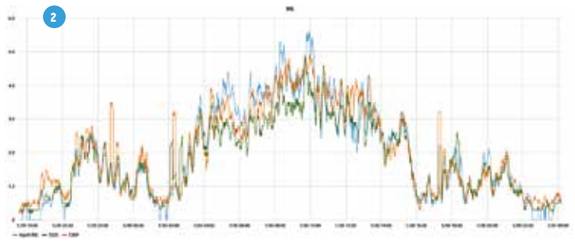
One approach to combat this is to put the load cell in an extra thermal box. However, this solution is complicated and often does not solve the problem. MPS System has developed an algorithm that can help overcome this challenge. It calculates the load cell value and temperature so that changes in temperature are taken into consideration when determining weight and, as a result, data is accurate. Years of development have resulted in stable firmware in this area.

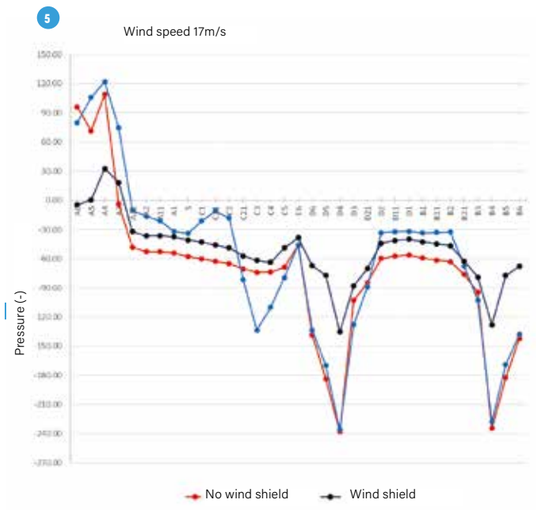
Wind is another important factor that can affect the weighing precipitation gauge measurement. The signal from the load cell is modulated by wind in Figure 1. It is processed in a statistics module to eliminate 'wind noise' from the weight value. This separated 'wind noise' corresponds well with wind speed. The module can then provide a direct comparison with the wind sensor and wind noise from the rain gauges.

FIGURE 1
The influence of wind and temperature on weight measurement. Green = weight, red = temperature, and blue = wind speed

FIGURE 2
Correlations between wind speed measurement by wind sensor and extracted signals as a wind noise from weight measurements. Blue = wind speed, green = wind noise from 400cm², red = wind noise from 200cm²







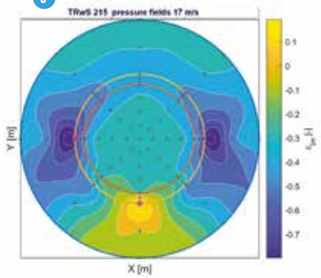


FIGURE 3
The wind tunnel at the Slovak University of Technology

FIGURE 4
The rain gauge with wind shield installed in wind tunnel

FIGURE 5
Measured pressure from 31 points during wind speed of 17m/s

FIGURE 6
Pressure fields

FIGURE 7
Installation of TRwS 4E25 and with two MPS TB IOT modules with GPRS and Sigfox modems

The correlation of this data can be seen in Figure 2. The value of the 'wind force' is available on the sensor output. It is well known that wind can have a negative influence on the data output of gauges, especially during light precipitation events.[1] However, thanks to the 'wind force' extracted from the measurement of weight, MPS implemented an algorithm that provides a direct measurement of precipitation and corrected data calculated with the adapted formula.

Weighing precipitation gauge measurements can also be improved by reducing the losses caused by drops coming from the orifice and inlet sleeve. The inlet surface keeps drops during a rain event and such losses are also defined by WMO and published in CIMO guides for manual and automatic observation.

MPS System carried out many tests with different types of surfaces, colors and nanolayers using the 'lotus' effect. Thanks to special treatment of the inlet surface, MPS reduced the amount of water by 80% without the need to use special layers that would need to be activated every two years. As a result, rainfall losses correspond to just 0.08mm. This value gauge adds to the several minute precipitations and such value is available as a corrected precipitation.

Wind shields

MPS System has evaluated years of measurements from two gauges that have different orifice diameters: 200cm² and 400cm². The results show differences in the measured precipitation. During conditions with no wind and high rain intensity, these two gauges show the same value. The total capture content of water was 1-2mm. However, during wind conditions, the 200cm² gauge measured less water than the 400cm² one.

To test whether wind shields would help provide more accurate data, MPS System undertook laboratory testing in wind tunnels at the Slovak University of Technology in Bratislava. The dimensions of the tunnel were 2.6 x 1.6 x 26.4m. The discharge of air was 52m³/s (Figure 3).

The two rain gauges were tested (200cm² and 400cm²) and they were adapted with 31 measurement points across the inlet and outside the cover. The same conditions were provided for both types, and tests were carried out both with and without wind shields. Figure 4 shows the position of the gauge with the wind shield in the tunnel. Tests were carried out with wind speeds of 5, 10, 15 and 17m/s. Figure 5 shows the measured pressure in each measurement point; Figure 6 shows pressure fields across the cover. The final data is available in *Experimental measurement of pressure distribution on models of weight gauges*[2] and further studies will be carried out.

MPS's new IoT module

MPS System's Tipping Bucket (TB) IoT module was developed primarily for precipitation sensors with pulse output, such as tipping bucket gauges. The most important advantages of the TB module include zero power consumption, a self-emptying system and competitive price.

The module features information on total precipitation, rain intensity, ambient temperature, calculation of mean, maximum and minimum values, and battery power. GPRS, Sigfox and LoRa networks are supported with corresponding modems to the plug-in module.

The module is powered by one primary battery and its lifetime is up to 15 years. Dimensions are such that the module can be installed in most of the tipping buckets on the market. Figure 7 illustrates the installation of MPS's self-emptying TRwS 4E25, with two modules for Sigfox and GPRS networks. ▮

References

1) Boris Sevruk, Niederschlag als Wasserkreislaufelement, 2004, Zurich-Nitra, page 119
2) *Experimental measurement of pressure distribution on models of weight gauges*, Slovak University of Technology, Bratislava, 2020