Helena Wingert, content specialist, Lufft

LASER PRECISION

For long-term observations, optical snow-depth sensors provide greater stability than their ultrasound counterparts

The heated window on the SHM31 prevents disruption in even the most extreme weather events

Test field for the Wiener Wasser project in the Austrian Alps

Last year saw measurement technology provider Lufft launch the SHM31 snow-depth sensor as a successor to the innovative SHM30. Manufactured by ESW, a subsidiary of integrated photonics developer Jenoptik, the original SHM30 was supplied by Lufft from 2011 until 2014, at which point it was permanently incorporated into the company's product range, along with ESW's CHM15k ceilometer. In February 2018, Lufft released the CHM8k ceilometer, further expanding its range of optical meteorology sensors.

THE 8KM (5-MILE) CEILOMETER

The CHM8k is suitable for applications in which low-lying tropospheric measurement ranges are required, such as safety-related monitoring tasks at airports or offshore sites. Furthermore, it can be used for particle observations within the atmospheric boundary layer (fine dust measurements) or the determination of the mixing layer height. Another interesting market is renewable energy since cloud-cover data is relevant for solar plant efficiency and cloud-base information is useful for wind turbines.

Through backscatter profiles calculated from the light detection and ranging (lidar) measurements, the instrument determines cloud bases, cloud penetration depths, aerosol layers, cloud-cover height, vertical visibility and a sky condition index (precipitation and fog). The measurements are averaged and logged every five to 60 seconds – depending on the setting. "For mixing layer observations, average intervals of 10 minutes are sufficient, whereas very short measurement frequencies are required for rapidly forming fog," explains Holger Wille, optical sensor manager at Lufft.

For the data transfer, the CHM8k is equipped with a RS485 interface issuing the data in ASCII formats as well as a LAN interface through which protocols can be generated and configurations handled. The sensor is also available with a digital subscriber line (DSL) interface. Behind the measurements is an optical distance meter which uses the lidar principle to scan the sky for obstacles. The centerpiece is formed by an eye-safe, 1M-classified laser diode emitting light in the near-infrared wavelength range. It enables extraordinarily sensitive measurements of small air particles (fine dust) and droplets of several hundred nanometers or larger in size.

The device's bi-axial optical construction is tolerant against strong diffusion events such as fog, precipitation or low-lying stratus clouds. Both Lufft ceilometers are accurate to 5m (16.4ft) and their double-walled and heated IP65 casing prevents the window from fogging up. It is therefore suitable for every climate zone and for ambient temperatures between -40°C and +55°C (-40°F to +131°F).

By monitoring ambient and device temperature, window contamination, and laser and receiver status, the ceilometers monitor themselves, enabling them to be controlled remotely and easily integrated into networks. In case of a power cut, an internal backup battery steps in to ensure continued operation. Further accessories include a tilt adapter and a cloud simulator.

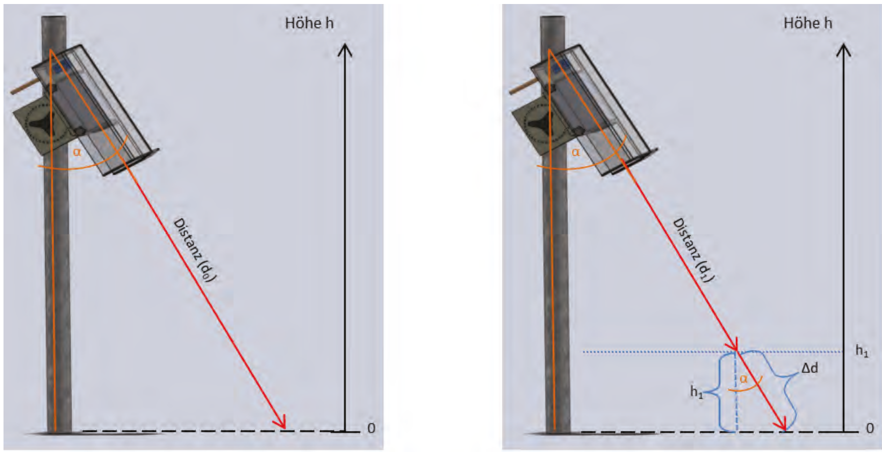
But why did Lufft decide to provide a ceilometer for smaller ranges? Simply because of the changing application requirements in terms of measuring distances and sensitivities since the market introduction of the first Lufft (Jenoptik) ceilometer.

"Helipads require measurements in the one-mile range, while for the aviation market, a range up to 25,000ft altitude plays a role, as the focus lies on the cloud bases and the vertical visual range," explains Wille.

"Weather services, on the other hand, use devices that measure in heights of up to 15km (9.miles) to capture many details of the atmosphere.

"For environmental protection agencies, fine dust and aerosol observations measurements up to 3km (2 miles) in height are fine, but to catch the important information, the sensitivity must be as high as with the 15km ceilometer, to get all details.

"Volcanic ash observations need high sensitivity through the whole troposphere and are hard to measure in detail for all instruments in the 'ceilometer class' of lidar systems, whereas saturated water clouds and fog merely need low sensitivity. Another

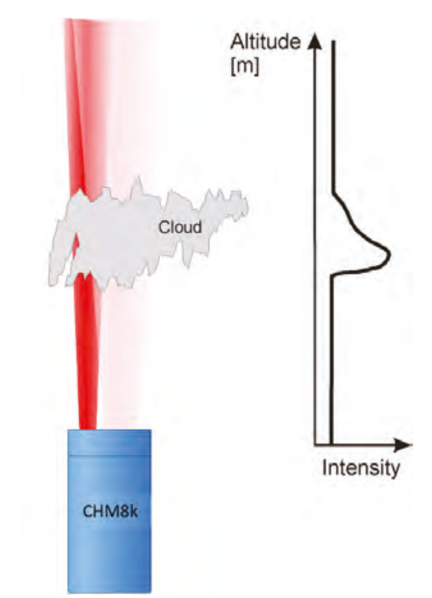


$$\Delta d = d_0 - d_1$$

$$h_1 = (d_0 - d_1)\cos\alpha$$

Mounting instructions for the Lufft SHM31 snow-depth sensor

Measurement principle of the Lufft CHM8k



important factor is the product price. Lower equipment prices enable you to form a denser network and airports are obliged to use redundancy devices, meaning they need even more sensors in their network. To address these needs, Lufft decided to offer a second version of the ceilometer."

THE LUFFT SHM31

The SHM31 optical snow-depth sensor measures snow depths of up to 15m (49ft) from mast height within seconds and with millimeter-accuracy. It's suitable for meteorological services, airports, road maintenance depots and ski resorts, as well as for the renewable energy market. The distance measuring technique is based on an amplitude modulated series of short laser light pulses scattered by the surface. This is analyzed by the sensor to calculate the distance and the signal strength of the target.

Among the new features of the Lufft SHM31 snow-depth sensor are different communication interfaces, which make the sensor fully compatible with Lufft's universal measurement bus (UMB) standards. In addition, the sensor is equipped with a window heater for the laser beam and an integrated goniometer for easy deployment. The sensor is fitted with the RS232, RD485 and SDI-12 communication interfaces, two of which can be used simultaneously. Despite the expanded, two-stage heating function, the energy consumption has been reduced. Thanks to its heating system, the snow depth measurements are not affected by even the most extreme weather events, such as snowstorms or cold snaps.

The snow-depth sensor is based on the laser distance measurement and works with a visible, easy-to-configure beam. It determines snow layers on natural, diffusely reflective surfaces. Furthermore, the integrated evaluation of signal intensity enables reflectivity to be assessed, and other surfaces to be differentiated from snow. The optical measurement principle copes well with wind gusts, temperature changes, rain or extreme humidity events.

Thanks to the IP68-certified casing and the stable operating principle, no maintenance is required in terms of replacement of drying agents or regular calibrations. Combined with its low false alarm rate, the measurement instrument has a low total cost of ownership.

VIENNA'S WATER PROVIDER IN THE ALPS

Most of Vienna's fresh water stems from the Lower Austrian-Styrian Alps and is transported via high-source pipelines. For this, reliable snow-depth observations are essential, since snowmelt events can result in large amounts of water, triggering floods. To forecast the consequences of snowmelt, the so-called water equivalent, meaning the water content in the total snowpack of a certain area, needs to be recorded.

During a trial, Vienna's water provider, Wiener Wasser, compared the two most common automatic measurement methods: an ultrasonic sensor and the laser sensor SHM31.

Ultrasound snow-depth sensors are relatively affordable and have a low power consumption. The technology is based on a sound wave emitted at a specific frequency and the receipt of the echo. The interval between transmission and receipt provides the distance to the next obstacle. This is possible since the speed of sound is 343m/s (767mph). With a beam angle of 10° to 30°, ultrasound systems have a larger measurement spot than laser beams, which can be marked as a positive attribute whenever an averaged value over the larger probe area is preferred.

An accuracy of 1-2cm (0.4-0.8in) was observed in the field in good conditions in terms of stable temperature and no precipitation. Unfortunately, the accuracy of ultrasonic sensors can be influenced by temperature fluctuations, wind and humidity. Due to the wide-beam angle, the performance can also be affected by precipitation within the measuring cone. From a maintenance point of view, the desiccant and transducer need to be checked or exchanged regularly. The laser-based systems have a higher stability, but also require the optical path to be cleaned occasionally, depending on the location. A check is recommended at least once a year, before the winter season begins. Finally, the total costs of ownership should be compared carefully. After comprehensive testing, Wiener Wasser opted for the laser measuring technology. ∎