NETLAKE Guidelines for automated monitoring system development

008 Weather stations

Objective

In this factsheet, we give an overview of whether you should add a weather station to your platform, which types of weather instruments and stations are available on the market and how to position the weather station on your platform.

Some reasons to add weather measurements to your lake buoy:

1. You don't have a weather station in the locality
2. Your lake is surrounded by obstacles (trees, buildings), meaning that your local land based station does not describe the weather situation on the lake surface adequately.
3. The lake significantly modifies meteorological conditions, such that an on-lake weather station is the only way of capturing meteorological conditions.
4. You want to calculate common metrics for lake physical states. Some of these metrics (Lake Number, Wedderburn number or gas Piston velocity) require lake specific weather data such as wind speed.
5. You want to calculate common metrics for lake biological states, but some metrics require weather data. For example, lake production calculations need global irradiance or PAR measurements.
6. You want to calculate more complex metrics for your lake, requiring weather data other than basic meteorological variables. For example, lake metabolism calculations need wind and irradiance data, while estimates of heat fluxes and evaporation additionally require measurements of air temperature and humidity.
7. You want to study your lake water movements and waves. For this, you need wind speed and direction measurements.

Commonly used weather measurement sensors on lake buoys

When considering the addition of meteorological sensors on your station, there are two main options: either an off the shelf multi-parameter station or a collection of individually specified sensors.

Multi-weather sensors – Are able to measure up to seven of the most essential weather parameters: barometric pressure, humidity, precipitation, temperature, wind speed, wind direction and solar irradiance. Some of them are available with an integrated electronic compass. Most multi-weather sensors are compact, light in weight, require low power for consumption and are compatible with many commonly-used data logging systems.

Individual sensors - some options

Cup anemometer – Cup anemometers are widely used. They are generally well suited to measuring wind speed, tend to be cost attractive in comparison to other types of instruments and are very robust. Cup anemometers are ostensibly adirectional i.e. they should respond identically to winds coming from different directions within the horizontal plane. The cup anemometer is primarily designed to measure the horizontal wind speed, not the magnitude of the horizontal vector.

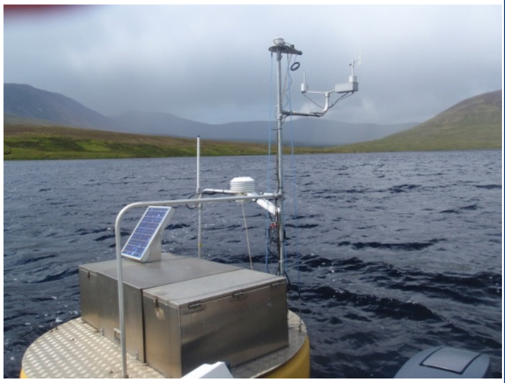
Vane or windmill anemometer – Contrary to the cup anemometer, the axis on the vane anemometer must be parallel to the direction of the wind and therefore horizontal. A vane anemometer combines a propeller and a tail on the same axis to obtain accurate and precise wind speed and direction measurements from the same instrument. In some cases, the speed of the propeller is measured by a counting device and converted to a wind speed output by internal electronic processing. In other cases the propeller shaft turns a magnet which induces a signal in a coil. The frequency of this signal is measured by the data logger and then converted to a wind speed. Wind direction is commonly measured as changes in the resistance of a potentiometer coupled to the wind vane shaft.

Sonic anemometer – Contrary to cup and vane anemometers sonic anemometers use ultrasonic sound waves to measure wind velocity. They measure wind speed based on the time of travel of sonic pulses between pairs of transducers. Sonic anemometers can take measurements with very fine temporal resolution, 20 Hz or better. The lack of moving parts makes them appropriate for long-term use in exposed automated weather stations where the accuracy and reliability of traditional cup-and-vane anemometers are adversely affected by salty air or large amounts of dust. Their main disadvantage is the distortion of the flow itself by the structure supporting the transducers. Since the speed of sound varies with temperature, and is virtually stable with pressure change, sonic anemometers are also used as thermometers.

Solar irradiance sensor - There are two main irradiance sensors which are used in buoy systems: pyranometers and quantum sensors. Pyranometers are designed to measure total solar radiation – the combination of direct and diffuse solar radiation – in the 400 to 2800 nm range. Quantum or PAR sensors measure photosynthetically active radiation. PAR sensors measure light in the wavelength range of about 400 to 700 nm which plants use to drive photosynthesis. PAR sensors measure light as a photon flux density i.e. (moles photons m^{-2} s^{-1}) since photosynthesis is a quantum process, while pyranometers measure the energy of the solar radiation (w m^{-2}). They are not completely comparable as the energy of a photon is wavelength dependent. However, there are a number of simple conversion factors that are based on the average spectral composition of incoming solar radiation.

In addition to wind and light, other possible additions include sensors for barometric pressure, air temperature, precipitation and humidity. As with all AMS, cost will be your main determinant.

Position of weather sensors on your platform



Weather sensors should never be sheltered by other parts of your monitoring system, and are best placed above any other infrastructure (right). Even small PAR sensors shouldn't be close to your wind sensors, because it could cause distortion in the wind speed and direction measurements. At the same time, your irradiance sensor cannot be sheltered by other devices. Many lake mathematical models presume wind speed measurements are taken at 10 meters above the land or water surface. It is possible to correct wind speed measured at one height to wind speed at 10 m with given formulae, but be sure that you know at which height you measure your wind speed!

Considerations

The weather sensor types and configuration to be selected depend mainly on the needs of your research, the monitoring objectives, the required data quality and the available budget. Some sensors are better in accuracy, some need more power, some more frequent calibration while others need to be calibrated less frequently and are therefore better for longer deployment in buoy systems.

Keep in mind that if your platform anchoring lets your system move or rotate you should have your wind direction sensor corrected with an integrated compass.

More information

http://www.act-us.info/sensor_list.php?cat=Meteorological&type=Physical

http://www.skyeinstruments.com/

http://www.windspeed.co.uk/ws/index.html

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