2.6 Data logger

When flux measurements are made with the eddy covariance method, multiple observational values need to be simultaneously logged at a sampling rate of approximately 10 Hz. When turbulence statistics are sought, the data storage capacity needs to be sufficiently high so that the values of the fluctuating component of *w*, *w*', and of the fluctuating component of a scalar quantity can be stored for several days. The data recorded on the data logger can be transferred to a PC with the use of a communication cable or by swapping the media on which the data are recorded. The use of a versatile digital data format such as the comma separated value (CSV) format allows easy storage and backup of data.

Logger types

Data loggers can be classified roughly into two types: those which first digitalize analog voltage data and record the digitalized data; and those which directly record digital output data. Some data loggers are able to accommodate both logging modes. Storage capacity varies among data loggers. Some of them are equipped with internal memories, and others record data on compact flash storage cards or MO discs (Table 2.6-1). Data logging for turbulence measurements requires a high-speed logging function and a large memory size. For data loggers that are used for other micrometeorological measurements, refer to Section 3.9 "Data logger". Because turbulence and micrometeorological measurements require different sampling intervals, it is recommended to log the data using two separate data loggers in order to avoid problems. In this case, the clocks of the two data loggers need to be synchronized so that the two data sets are synchronized in time. Incidentally, recent models can be networked for time synchronization.

When values of a physical variable are logged as analog output, it is necessary to be aware of the conversion relationship between the voltage and the value of the physical variable. With this relationship, the ranges of measurements and data logging need to be optimized in advance so that accurate measurements can be made. Because most instruments for measuring turbulence produce output data at 0 ~ 5 V, it is desirable to use a data logger capable of data logging in the range between 0 and 5 V.

Table 2.6-1 Data loggers used for turbulence measurements.

Model (manufacturer)	A/D resolution	Maximum Logging rate	Memory medium
CR3000 (Campbell)	83.33 µV (±5 V)	40 Hz	CF (optional), USB flash drive (optional)
CR1000 (Campbell)	667 µV (±5 V)	10 Hz	CF (optional), USB flash drive (optional)
es8 (TEAC, discontinued model)	16 bit (±5 V)	5 kHz	CF, USB flash drive
NR-1000 (KEYENCE)	16 bit (±5 V)	10 Hz	CF, USB flash drive
MEMORY HiLOGGER LR8430-20 (HIOKI)	500 µV (±10 V)	10 Hz	CF, USB flash drive
ZR-RX20/40A (OMRON)	16 bit (±5 V)	10 Hz	USB flash drive

Tips!

The resolutions of the sensor and the data logger also need to be taken into account in data logging. "Resolution" is the minimum signal variation that can be recognized by the sensor or the minimum signal variation that is allowed in the digital data after an AD conversion by the data logger. As an example, consider a sonic anemometer with a resolution of 0.005 ms^{-1}. If the measurement range is set to ±30 ms^{-1} and the analogue output range of the anemometer is ±1 V, the size of the minimum output signal is approximately 166.7 µV. The minimum output from this case can be recorded only with a data logger with a resolution of at least 166.7 µV.

Tips 2.6-2

The CR1000 and CR3000 data loggers (Campbell Scientific, Inc., US) are highly flexible and are compatible with various measuring instruments. The CR1000 and CR3000 data loggers allow the user to program the voltage measurement range, the logging interval, and the applied voltage. These data loggers are also capable of numerical computations, thus can also record turbulence statistical data.

While many of the sensors which allow digital output use the RS-232C format, some use RS-422 or SDI-12 (Serial Data Interface at 1200 baud rate). Because of the RS-232C standard, the cable length is limited to 10 m or less. If the separation distance between the sensor and the data logger is more than 10m, an optical cable can be used together with a transducer for extending the connection length between the sensor and the data logger. RS-422 signals can be transferred at a maximum speed of 10 Mbps up to a distance of 1.2 km. An RS-422 signal can be converted to an RS-232C signal with a commercially available signal converter. The CR1000 and CR3000 data loggers are equipped with both SDI and RS-232C communication ports, and thus are useful when the sensor and the data logger need to be deployed far apart.

A PC can also be used as a data logger. When a sensor capable of analog output is used with a PC, an analog-to-digital (AD) conversion board is required. Many of the sensors which output digital signals are equipped with an RS-232C interface. However, because RS-232C ports are now obsolete interfaces on PCs (as of 2008), most PCs (as of 2008) are not equipped with these ports. Thus, a USB-RS232C conversion cable or an RS-232C extension board is needed to use a PC as a data logger. Because many types of data loggers support data input to PCs, data can be automatically uploaded to a PC on a regular schedule in order to make up for the insufficient memory size of a data logger.

Most data loggers record data in a binary format in order to maximize memory usage. Furthermore, most of the software which comes with data loggers transfers data to PCs and converts the data on the PCs to the CSV format or other versatile formats. HTTP server and FTP server functions are also available on some data loggers.

Measuring procedures

When an AC power supply is used to operate a data logger, an earth connection is necessary to avoid noise in the data. (The internal switching power supply in a data logger generates noise.) It is also effective to filter out the noise according to the frequency of the power supply. Noise is caused mainly by electromagnetic induction. Effective countermeasures against noise include the following: 1) the signal and power cables should be separated as much as possible; 2) shielded cables should be used; 3) twisted pair cables should be used; 4) the cables should be shortened as much as possible; 5) the cables should not be looped; and 6) the cables should be firmly fixed.