FlowCapt FC4

Instrument for measuring
the aeolian flux of solid particles and wind speed

Full documentation and User manual

Version 5.03

FlowCapt™ FC4 is a Swiss made product of ISAW line of meteorological sensing instruments by IAV Technologies SARL, a Swiss based company and original manufacturer of the product since 1997. The ISAW instruments are ultra robust, high performance, very low-power consumption and near zero-maintenance instruments, ideal for a wide range of gravity or aeolian transported liquid or solid precipitations applications. This manual provides the technical characteristics and all the information required to procure, configure and operate the FlowCapt FC4 instrument and its accessories. The configuration of the instrument can be done through various direct or remote serial connection methods, as well as by means of the ISAW Toolbox software utility, which is available anytime on our website www.isaw-products.com, this without functional restrictions on use or duration. The articles, dimensions and other technical or informational details described in this document may be subject to minor changes, but any change that could impact the operation of the instrument will lead to a new version of the documentation.

Note about the firmware: This document applies to all instruments with firmware 3.55 onwards. If your instrument operates with an earlier firmware version, we advise you to update it with the latest firmware. However, even if you keep the older firmware, almost all of the information in this manual remains valid.

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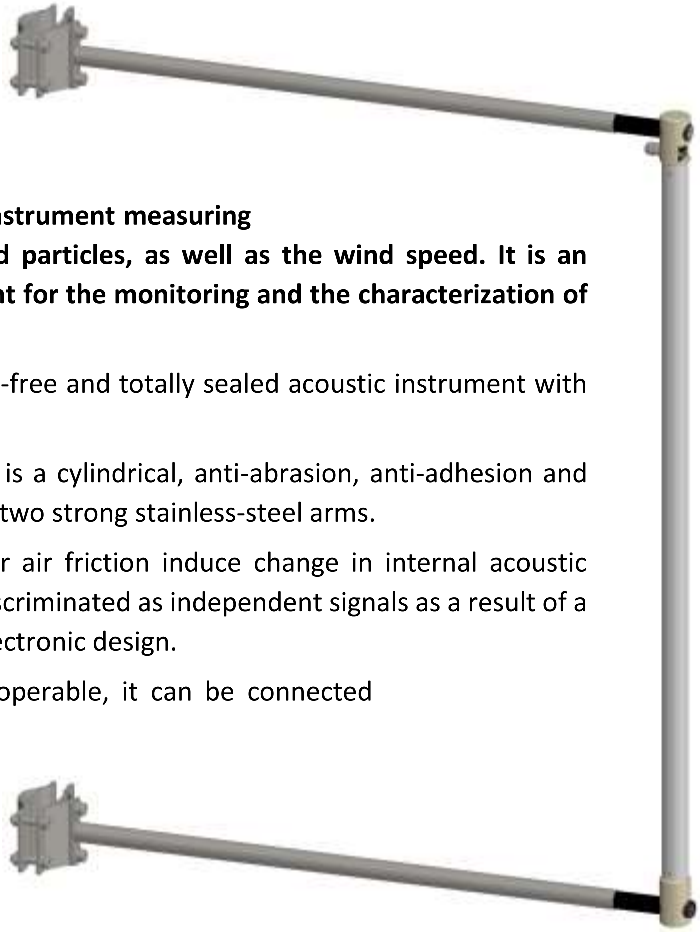
Contents

1. THE ESSENTIAL IN BRIEF

1.1. Introduction

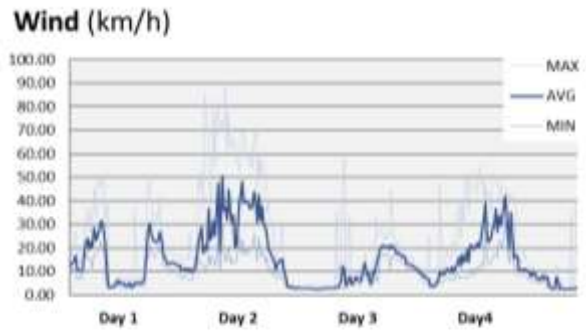


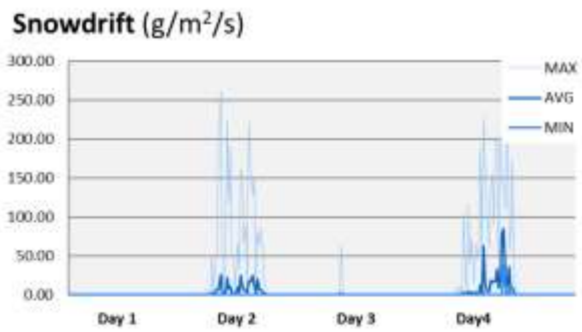
FlowCapt™ FC4 is an acoustic sensing instrument measuring the intensity of an aeolian flux of solid particles, as well as the wind speed. It is an extremely robust and reliable instrument for the monitoring and the characterization of snowdrift.

- It is a very low-power, maintenance-free and totally sealed acoustic instrument with no mobile parts.
- The sensing part of the instrument is a cylindrical, anti-abrasion, anti-adhesion and anti-rime coated tube supported by two strong stainless-steel arms.
- Snow flux impact and wind laminar air friction induce change in internal acoustic pressure. The two excitations are discriminated as independent signals as a result of a specific acoustic, mechanical and electronic design.
- The instrument is universally interoperable, it can be connected conveniently to almost any external electrical or computerized interface (data logger, industrial module interface, instrumentation DAQ, USB port, etc.).

Typical applications:

- Monitoring of snowdrift and snow-blowing
- Solid particles mass flux and wind-speed measurements
- Meteorological and scientific applications
- Road security and avalanche danger
- Industrial surveillance applications





1.2. Operating principle and measurement range

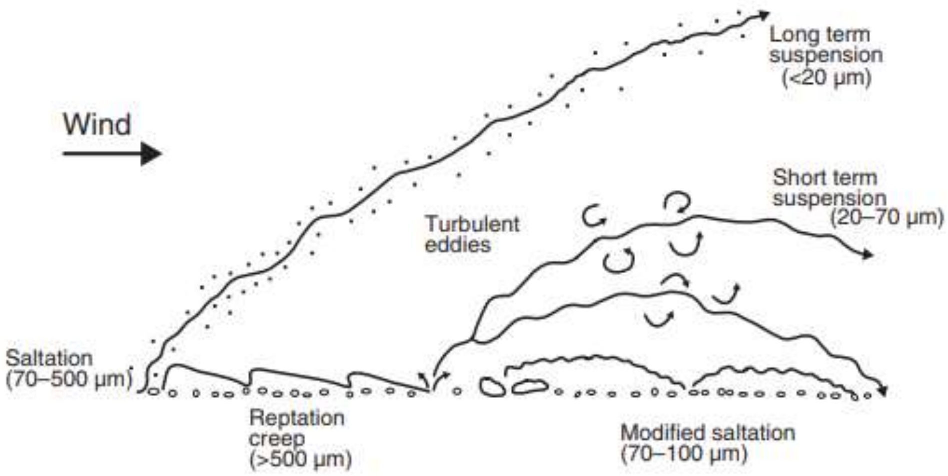
Tip: For a quick start with the instrument, go directly to section 1.11.

Acoustic sensing technology for monitoring aeolian and snow-driven particle transport has evolved significantly since its first introduction in the 1990s. The FlowCapt instrument, originally developed for snowdrift monitoring in alpine environments, has since become a family of rugged, autonomous environmental instruments capable of detecting and quantifying particle impacts and wind velocity, and —more recently— aeolian blowing sand, and precipitations.

The FlowCapt FC4 instrument measures the impacts of the solid particles and the air friction on an omnidirectional aluminum tube, using an ultra-dedicated acoustic transducer, signal processing and calculation. The acoustic-mechanical sensing supports long-term environmental monitoring and the performance constraints and calibration considerations that influence quantitative flux measurements.

1.3. Aeolian sediment transport

Aeolian sediment transport is the transport of sediment by wind. There are multiple ways of transport that can be seen as aeolian sediment transport. In the figure below these ways of transport can be found.



Aeolian sediment transport [Nickling and Neuman, 1994]

The way sediment moves in the air is decided by the size of the sediment particles. The three main transport methods are: suspension, creep and saltation. Particles that are light and small (up to 70 µm) can be suspended. Because these particles are so light they are easily transported by the wind for a longer period. The lightest particles can be suspended for even a couple of days. The medium sized particles (70-500 µm) are transported by the process that is called saltation. They bounce across the surface because they are too heavy to be transported through the air for a longer time. Creep occurs when particles are too heavy to be transported through the air (> 500 µm). These particles are transported by rolling over the surface [Nickling and Neuman, 1984]. For the experiment sediments are used that have a diameter in the range of sediments that are transported by saltation or creep.

1.4. Origins and physical principle

Chritin and colleagues presented in 1999 an acoustic method for measuring snow transport for avalanche forecasting. Their prototype consisted of a cylindrical tube coated with a specialized surface and equipped with electroacoustic transducers inside a sealed cavity. Snow grains impacting the tube generated vibrational acoustic pressure waves that were transformed into electrical signals proportional to momentum transfer. The mechanical simplicity—no moving parts, sealed electronics, and anti-abrasion coatings—enabled robust operation under extreme winter conditions.

The instrument measured vertically (or sometimes, for scientific purposes horizontally) integrated snow flux along its full length, unlike point traps requiring extrapolation. Field tests validated its reliability in identifying snow-drift episodes and provided flux estimates comparable to traditional traps, establishing FlowCapt as a very reliable tool for long-term operational monitoring.

Now 4th generation of the instrument, the FlowCapt FC4, retains the original acoustic impact principle but include two decades of improvements in electronics, signal processing, and communication interfaces.

The instrument features a hardened, coated tube containing a sealed acoustic chamber, piezoelectric transducers, and embedded microcontroller-based electronics. Standard length is 1 meter, with custom variants such as FC4-short (33 cm) and bicephalic dual-head configurations for some special scientific needs. The coating ensures anti-abrasion and anti-icing performance, enabling very long-term use across all solid particles aeolian environments.

1.5. Summary of the measurement capability

FlowCapt FC4 instruments provide particle flux (snowdrift and blowing snow ice particles) and wind velocity as **continuous or pulse analog voltage** (0–2.5 V or 0–5 V), or 4-20 mA current, or all **standards digital outputs** (SDI-12, RS-422/485 ASCII, optional Modbus RTU).

The typical sensitivity is 20 mV per g/m^2/s for flux and 10–20 mV per km/h for wind.

Using the ISAW-Toolbox software suite, or through serial communication, users can configure acquisition duration (A), cycle duration (C), measurement period (M), output mapping, voltage range, datalogging, and communication parameters. The A–C–M scheme enables both high-resolution measurements and ultra-low-power modes (see § 1.8).

Key advantages include omnidirectional sensing, vertical integration of the full transport layer, low maintenance, dual wind-and-flux measurement, universal compatibility with all dataloggers or any kind of other external peripheral or electrical unit.

1.6. Adequation to the characterization of aeolian sediments transport

The combined insights from the foundational research, modern documentation, and independent evaluation highlight several themes. Several dozens of authors conducted long-term field tests during extremely diverse wind-erosion events in almost every latitude and altitude, alongside with many very specialized laboratory tests and comparisons with MWAC traps and other mechanical, acoustical or optical sensors. In a most general manner, for the snowdrift ice particles range of size and velocities, the FlowCapt FC4 reliably identified transport events with more than 90 % agreement compared to all other characterizing methods, confirming its strong detection capability.

Quantitatively, it is well known that the flux values have a particle-size dependence, i.e. a declining efficiency with the decreasing of the size of the particles. At a 15 m/s mid-range velocity of a flux of ice particles, the efficiency of the instrument is respectively typically about:

- 100 % for particles > 200 µm
- 30 % for 150–200 µm
- 10 % for 100–150 µm
- < 2% for < 100 µm

On the other hand, for highest fluxes, the FlowCapt FC4 instruments saturates at 435 $g/m^2/s$, so extreme transport events may partially exceed its dynamic range, though detection of occurrence remains accurate with this very high saturation limit.

For wind, the low limit of the dynamic range is around 5 m/s (which is the physical limit to induce a sufficient air friction vibroacoustic excitation of the sensing tube body of the instrument), and, theoretically, the upper limit is about 400 km/h, but a measurement which could never be reported to our knowledge.

In summary, the FlowCapt FC4 technology is exceptionally suited for long-term, autonomous deployments in remote or energy-limited environments, withstanding abrasion, icing, humidity, and extreme winds, and with the following strengths and limitations:

- Robust, continuous monitoring.
- Excellent detection of event timing.
- Good correspondence with reference sensors in temporal dynamics.
- Flux accuracy dependent on grain size (underestimation of the fluxes of finest ice particles).

Detection vs. Quantification: FlowCapt FC4 excels at detecting the presence and timing of particle transport. For accurate quantification, sensitivity to particle size must be accounted for. The instrument performs best in coarse-grained environments where acoustic impact energies exceed detection thresholds.

Wind–Flux Coupling: A major advantage of the FlowCapt FC4 instrument is simultaneous wind-speed measurement, enabling tighter analysis of the relationship between transport intensity and atmospheric forcing.

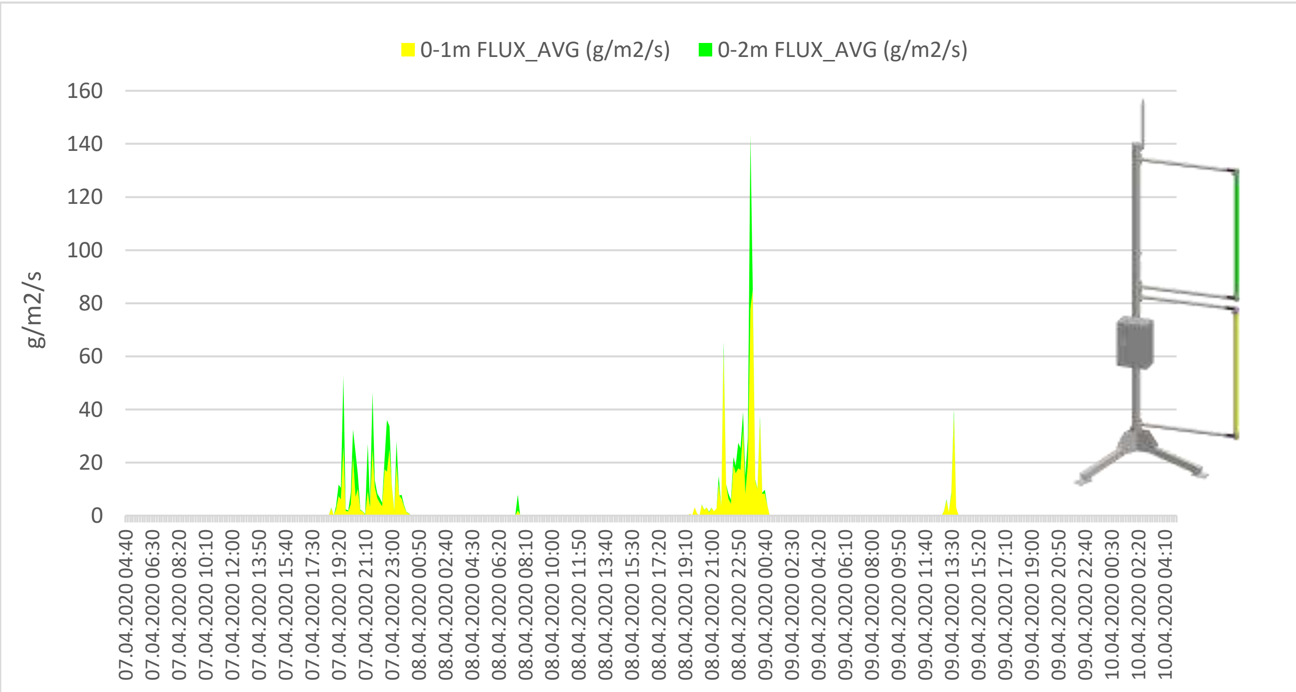
Interoperability: Compatibility with SDI-12, analog, serial, pulse, and Modbus outputs ensures integration with all meteorological networks, industrial systems, and research platforms.

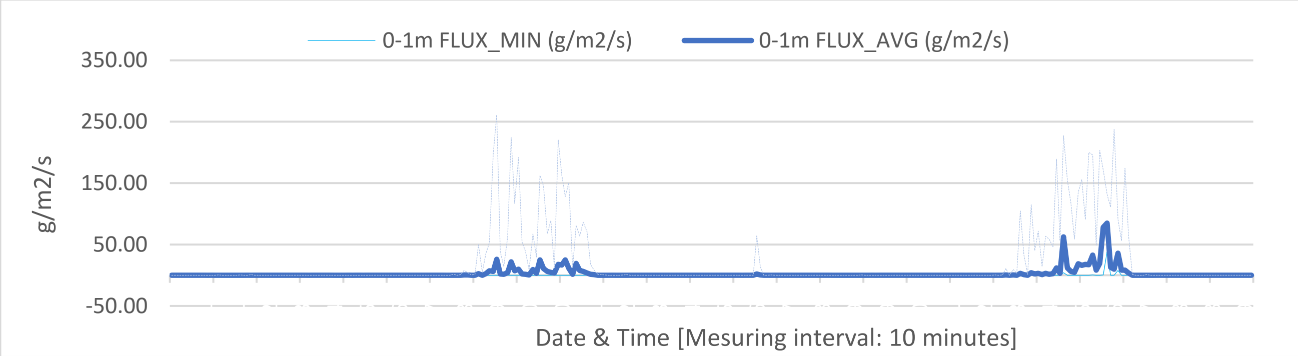
Note: For more information about snowdrift physics, please refer to Appendix E

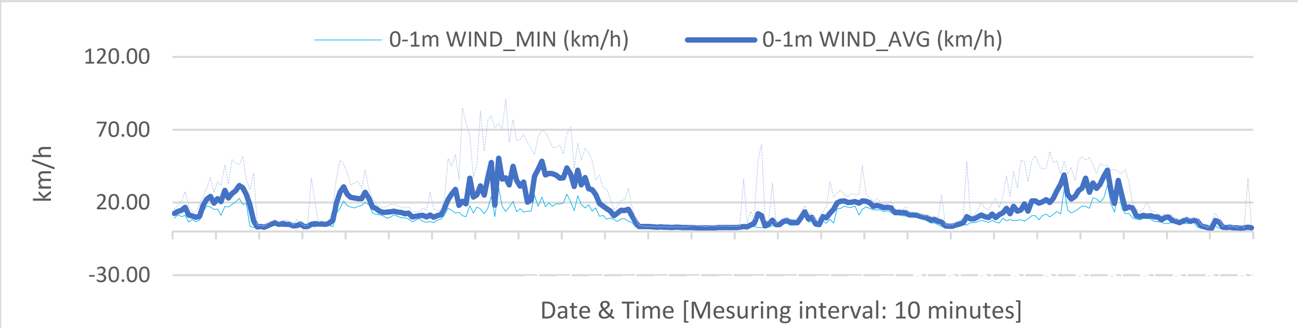
1.7. Data example

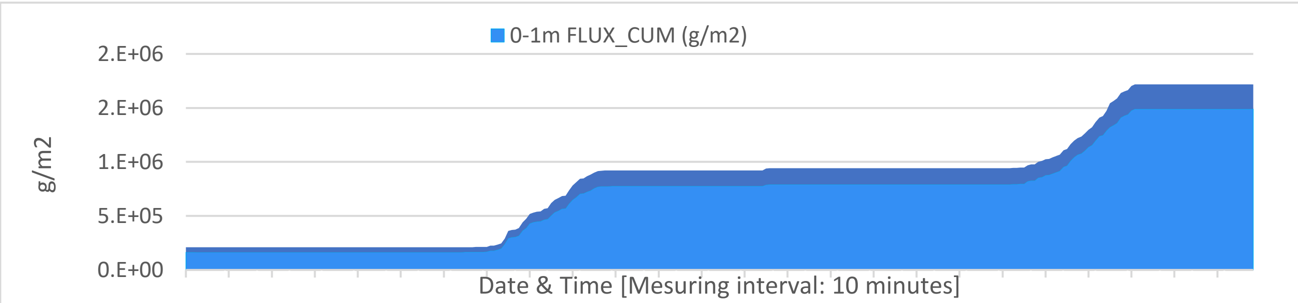
The following example is a raw data file produced with a pair of two FlowCapt FC4 instruments that recorded a 3-days snowdrift episode with a 10 minutes averaging and writing resolution (i.e. the instrument recorded continuously the full episode and produced a data frame every 10 minutes).

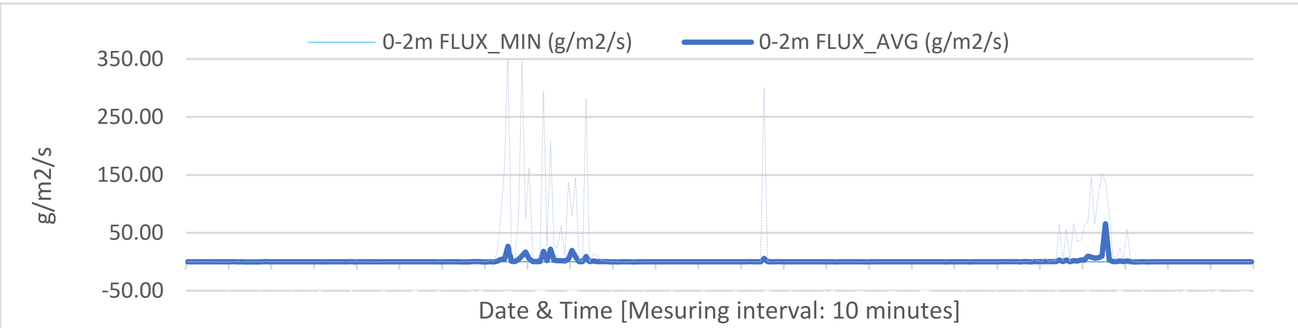
#	TIMESTAMP (s)	DATE & TIME	0-1m FLUX_MIN (g/m2/s)	0-1m FLUX_AVG (g/m2/s)	0-1m FLUX_MAX (g/m2/s)	0-1m FLUX_STD (g/m2/s)	0-1m FLUX_CUM (g/m2)	0-1m WIND_MIN (km/h)	0-1m WIND_AVG (km/h)	0-1m WIND_MAX (km/h)	0-2m FLUX_MIN (g/m2/s)	0-2m FLUX_AVG (g/m2/s)	0-2m FLUX_MAX (g/m2/s)	0-2m FLUX_STD (g/m2/s)	0-2m FLUX_CUM (g/m2)	0-2m WIND_MIN (km/h)	0-2m WIND_AVG (km/h)	0-2m WIND_MAX (km/h)
71	42600	07.04.2020 16:20	0.00	0.00	0.00	0.00	163758.27	6.21	10.08	14.58	0.00	0.00	0.00	0.00	45737.92	7.66	11.15	15.75
72	43200	07.04.2020 16:30	0.00	0.00	0.00	0.00	163758.48	6.98	11.31	27.02	0.00	0.00	0.03	0.01	45738.52	5.61	10.14	41.54
73	43800	07.04.2020 16:40	0.00	0.00	0.00	0.00	163758.48	6.16	9.74	15.62	0.00	0.00	0.00	0.00	45738.52	7.10	10.68	17.77
74	44400	07.04.2020 16:50	0.00	0.00	0.00	0.00	163758.48	7.78	11.00	14.58	0.00	0.00	0.00	0.00	45738.52	7.41	13.70	20.10
75	45000	07.04.2020 17:00	0.00	0.00	0.00	0.00	163758.48	8.55	11.57	14.48	0.00	0.00	0.00	0.00	45738.52	9.15	12.02	16.86
76	45600	07.04.2020 17:10	0.00	0.00	0.00	0.00	163758.70	11.43	16.23	23.16	0.00	0.00	0.00	0.00	45738.52	10.44	15.91	29.56
77	46200	07.04.2020 17:20	0.00	0.00	0.04	0.01	163767.37	16.04	21.92	50.11	0.00	0.00	0.00	0.00	45738.52	15.73	25.33	43.72
78	46800	07.04.2020 17:30	0.00	0.01	0.06	0.02	163779.33	14.76	25.74	44.98	0.00	0.00	0.02	0.01	45739.12	18.69	28.30	50.95
79	47400	07.04.2020 17:40	0.00	0.05	1.29	0.46	164053.28	12.71	29.01	53.08	0.00	0.00	0.03	0.01	45740.32	16.41	38.54	57.69
80	48000	07.04.2020 17:50	0.00	0.00	0.03	0.01	164059.79	13.29	17.86	35.86	0.00	0.00	0.05	0.02	45740.92	13.30	23.47	43.78
81	48600	07.04.2020 18:00	0.00	0.05	1.09	0.39	164291.31	10.99	20.89	85.00	0.00	0.01	0.18	0.06	45746.32	12.37	18.87	60.06
82	49200	07.04.2020 18:10	0.00	0.23	7.73	2.75	165939.94	10.22	19.05	74.64	0.00	0.02	0.74	0.27	45755.92	12.70	19.57	63.10
83	49800	07.04.2020 18:20	0.00	0.23	3.96	1.39	166774.66	17.80	36.72	65.60	0.00	0.02	0.29	0.10	45766.12	23.17	36.75	66.25
84	50400	07.04.2020 18:30	0.00	0.02	0.39	0.14	166856.24	12.58	23.59	37.21	0.00	0.00	0.02	0.01	45767.32	12.13	27.22	37.45
85	51000	07.04.2020 18:40	0.00	0.07	1.56	0.55	167185.61	16.81	25.26	45.82	0.00	0.01	0.03	0.01	45770.32	17.81	27.55	50.08
86	51600	07.04.2020 18:50	0.00	2.73	49.45	17.37	177609.09	15.61	31.47	82.90	0.00	0.28	4.36	1.54	45940.72	15.55	32.90	77.41
87	52200	07.04.2020 19:00	0.00	0.15	4.95	1.76	178664.19	12.19	25.07	55.25	0.00	0.01	0.07	0.03	45943.72	12.52	34.62	67.20
88	52800	07.04.2020 19:10	0.00	2.46	34.97	12.20	185983.76	16.07	36.98	76.49	0.00	1.09	17.41	6.17	46599.52	19.58	48.42	66.12
89	53400	07.04.2020 19:20	0.00	7.40	53.29	18.04	196809.71	24.11	47.38	79.74	0.00	4.26	79.08	28.15	49153.72	23.17	55.93	71.84
90	54000	07.04.2020 19:30	0.00	6.13	197.70	70.26	238964.89	10.18	18.18	71.23	0.00	4.34	163.80	59.08	51755.32	12.16	20.86	80.80
91	54600	07.04.2020 19:40	0.03	26.18	261.20	89.90	292902.48	30.08	50.43	74.41	0.00	26.61	360.10	127.00	67721.32	37.60	56.16	93.20
92	55200	07.04.2020 19:50	0.00	1.85	38.51	13.57	301047.06	17.34	35.96	70.20	0.00	0.56	15.09	5.41	68056.72	20.53	28.04	67.97
93	55800	07.04.2020 20:00	0.00	1.61	14.23	4.87	303969.11	13.84	36.97	91.00	0.00	0.33	5.99	2.13	68255.92	15.17	38.81	71.58
94	56400	07.04.2020 20:10	0.00	4.18	62.20	21.73	317007.27	16.95	32.06	61.15	0.00	4.40	78.51	27.92	70894.72	17.02	23.08	70.92
95	57000	07.04.2020 20:20	0.00	22.00	223.80	77.09	363263.99	20.72	44.73	76.96	0.00	10.40	345.70	124.47	77134.72	16.00	32.24	121.20
96	57600	07.04.2020 20:30	0.00	7.03	117.40	41.15	387956.52	13.56	35.23	62.66	0.08	16.57	74.66	24.80	87076.72	34.28	49.76	57.48
97	58200	07.04.2020 20:40	0.00	10.00	191.50	67.37	428378.46	15.79	31.07	63.31	0.00	5.48	162.50	58.40	90361.72	19.04	34.03	66.71
98	58800	07.04.2020 20:50	0.00	2.05	54.40	19.27	439940.57	13.34	34.02	66.93	0.00	0.28	5.75	2.05	90526.72	12.85	34.20	56.25
99	59400	07.04.2020 21:00	0.00	1.56	38.33	13.56	448076.15	13.90	20.11	61.21	0.00	0.17	5.24	1.89	90630.52	15.24	23.28	55.23
100	60000	07.04.2020 21:10	0.00	0.42	8.68	3.06	449912.05	13.89	21.71	57.14	0.00	0.22	8.92	3.22	90764.92	17.14	27.73	59.36

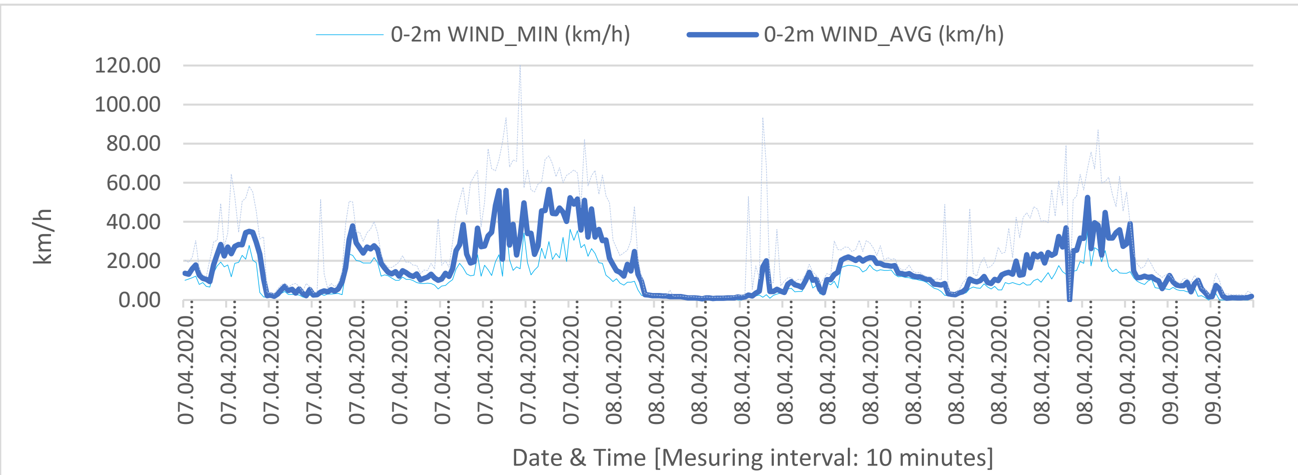



0-1m FLUX_MIN (g/m2/s)
0-1m FLUX_AVG (g/m2/s)
350.00
250.00
150.00
50.00
-50.00
g/m2/s
Date & Time [Mesuring interval: 10 minutes]


0-1m WIND_MIN (km/h)
0-1m WIND_AVG (km/h)
120.00
70.00
20.00
-30.00
km/h
Date & Time [Mesuring interval: 10 minutes]


0-1m FLUX_CUM (g/m2)
2.E+06
2.E+06
1.E+06
5.E+05
0.E+00
g/m2
Date & Time [Mesuring interval: 10 minutes]


0-2m FLUX_MIN (g/m2/s)
0-2m FLUX_AVG (g/m2/s)
350.00
250.00
150.00
50.00
-50.00
g/m2/s
Date & Time [Mesuring interval: 10 minutes]

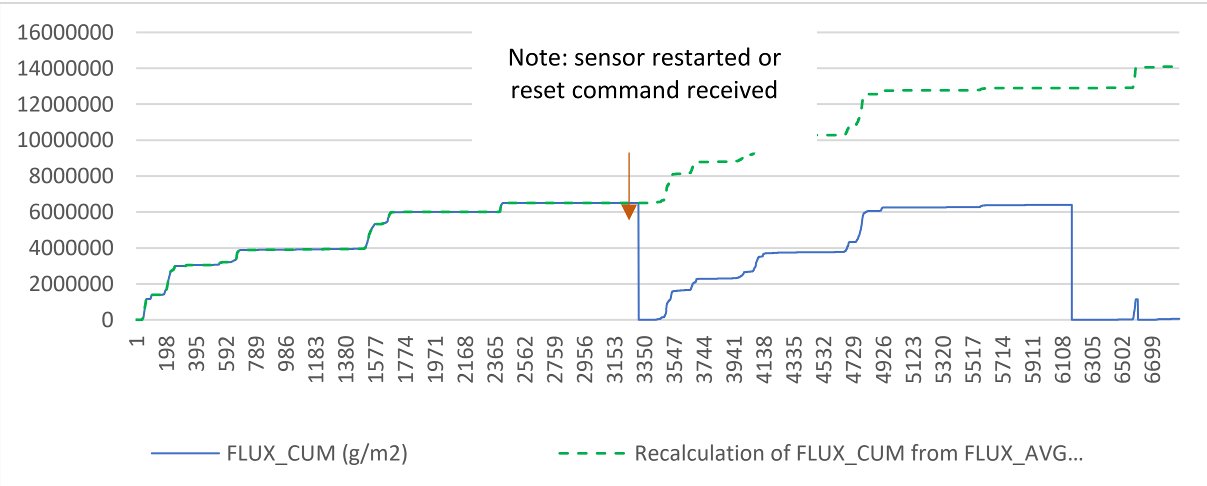

0-2m WIND_MIN (km/h)
0-2m WIND_AVG (km/h)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
km/h
07.04.2020…
08.04.2020…
09.04.2020…
Date & Time [Mesuring interval: 10 minutes]

The graphs above show respectively the reading of the episode in terms of flux intensity (g/m²/s) and wind speed (km/h) recorded on each of the two instruments, the first one positioned at 0-1 m above the ground and the second one at 1-2 m above the ground. The graph in the center (third graph) allows to compare the cumulative flux (g/m²) on each of the two instruments.

The cumulative flux (g/m²) is a value that represents the sum of the mass flux, i.e. a current value is calculated as the sum of the preceding cumulative value with the product of the current intensity (g/m²/s) × the measurement interval M. For example, as per the table below, at line 16, we get M=9600-9000=600 sec with a flux average intensity of 0.17 g/m²/s, which gives a cumulative flux increase of 600 × 0.17 = 102 g/m², which added to 760.82 g/m² gives the current updated value of 760.82 + 102 = 860.82 which is 99.833% of the displayed value 864.26 g/m². The 0.0017% (1/600) difference between the logged value and our calculated value comes from rounding's and the fact that in the internal calculation of the instrument, the last percentile outlier values and the self-noise values are removed from the cumulative calculation, so that the cumulative counter is more accurate and does not slightly increase because of long-term integration of non-significant values when the instrument detects only self and background noise.

#	TIMESTAMP (s)	FLUX_MIN (g/m²/s)	FLUX_AVG (g/ m²/s)	FLUX_MAX (g/ m²/s)	FLUX_STD (g/ m²/s)	FLUX_CUM (g/ m²)	WIND_MIN (km/h)	WIND_AVG (km/h)	WIND_MAX (km/h)
13	7800	0.06	0.08	0.09	0.01	624.41	161.43	173.18	181.51
14	8400	0.06	0.1	0.13	0.03	684.37	161.83	193.32	252.63
15	9000	0.07	0.13	0.19	0.04	760.82	167.06	218.69	258.09
16	9600	0.1	0.17	0.29	0.06	864.26	190.29	233.58	262.77
17	10200	0.12	0.23	0.56	0.14	999.92	200.66	232.47	251.38
18	10800	0.13	0.22	0.47	0.11	1131.67	219.78	238.89	258.31

The following graph shows an overlay of the cumulative flow value recalculated according to the formula explained earlier, and the native cumulative flow value produced by the instrument, over a total period of 47 days (6748 timestamps × 600 sec / 24 hr / 60 min /60 sec = 46.86 days).



1.8. Communication protocols

The following serial and bus communication protocols can be used with all ISAW instruments:

Protocol	Notes
MODBUS-RTU over RS-485 (with Modbus adapter)	Modbus RTU is recommended for network installations. The device can operate on a Modbus RTU network, or in a point-to-point configuration with the Modbus RTU protocol.
Continuous ASCII (native)	The device can be configured to output serial data every “M” seconds. Necessarily, in this mode the device must be in a point-to-point arrangement. The output format is configurable by the user.
SDI-12	The device is certified SDI-12 v1.3 compliant, a multi-drop serial data bus interface, compatible with long-distance cabling (typically up to 150 m) and with possibility to connect several instruments.

The instrument can also be used in **analog mode**, i.e. through the reading of DC voltage outputs (+0 to +2.5 V or +0 to +5 V analog voltage; continuous or pulse), or, when using the AD420 accessory, adapting to a **4-20 mA current loop mode**.

1.9. Main operating modes

1.9.1. Smart adjustability for all uses

While the instrument is capable of producing very high-resolution data down to a 1-second integration time, in meteorology applications the data services often process and display the data averaged on relatively longer periods of time, like typically intervals of 1 minute, 5 minutes, 10 minutes, 30 minutes, 1 hour, 4 hours. When using and manipulating time series of meteorological data, there is thus always some risk of making averaging miscalculations when displaying a data with a certain time interval granularity, while the data was recorded with another production interval (i.e. the output measurement or writing interval).

There are indeed most often different temporizations at play in a measure, because when we observe a physical phenomenon with a system, several durations come into consideration:

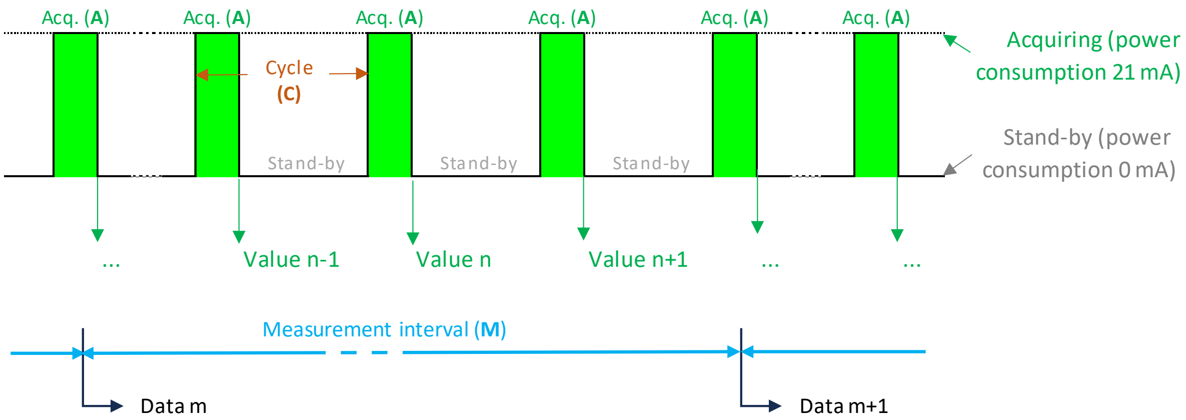
- The actual observation time of the phenomenon: **Acquisition "A"**.
- The Stand-by time which allows to optimize the energy consumption when necessary.
- The observation **Cycle "C"** includes one acquisition period and one stand-by period.
- The **Measurement "M"** time is the interval between two consecutive data writings. It usually covers several cycles.

This is why it is necessary to make averages and it is over these periods that the statistical data must be calculated. For example, as per the scenario figure above, supposing we have an instrument operating as follows:

- With a duty-cycle of 50%, to cope with some power consumption limitations, and with a writing interval set to five minutes (so we will get a data frame every five minutes, which has to give the flux of the last five minutes, whereas the instrument was acquiring and measuring only 50% of that duration).
- Or at the extreme, the same scenario still with a writing interval set to five minutes but measured with a duty-cycle of only 10% (so a data frame every five minutes that has to give the prognosis (supposedly the phenomenon was stationary over the period) of the flux of these last five minute, while the instrument was acquiring and measuring only 10% of that duration, i.e. the phenomenon observed during one second every 10 seconds):
- As per the averaging calculation process described in the above example figure, and, again, with the assumption that the observed event (snowdrift) was stationary over the total period of a cycle (resp. 50% of 1 minute or 10% of 1 minute), the instrument will automatically process the averaging and the statistics accordingly.

The choice of the internal averaging and output writing and logging data rate of the instrument then depends on several contingencies, among them the memory capacity and/or the transmission baud rate of the receiving, storing and displaying infrastructures. Furthermore, in some cases, the total power consumption of the instrument can be an important concern, especially when operating in isolated remote locations.

To be able to cope very easily and smartly to every situation, the instrument can be adapted very largely to almost any desired averaging, data rate and total power consumption through **a very simple and immediate principle of operation that entirely relies on only three parameters of operation, and is called "the A,C,M setting" of the instrument**:



Measurement settings	Description	Default value
Measurement duration [M]	The measurement duration M is the period you would like to read a new measurement result, in other words, a data statistics of the period M. In other words, it is the time between the production by the instrument of two consecutive output data records. Depending on your need, it can vary from one second to several minutes, hours or even more. Whatever duration M you set, the instrument will internally aggregate and process all intermediate acquisitions and produce exactly the desired data.	10 minutes
Acquisition duration [A]	During the measurement period, the instrument will make some acquisitions and process them to produce the result. Acquisition can be continuous, or, in order to lower power consumption, it can also alternate with a certain percentage of stand-by periods where the instrument does not consume any current.	10 seconds
Cycle duration [C]	Sum of one acquisition duration A and one stand-by duration. If the instrument is set to operate continuously (i.e. no stand-by), we simply get A=C. When the stand-by duration A equals the measurement duration M, the instrument is continuously acquiring and there is no need for averaging (1 acquisition = 1 measurement). When the measurement duration M is greater than the acquisition duration A, the measurement result is produced as the MIN, AVG, MAX, and STD statistics of all the acquisitions produced during M.	10 seconds
Duty cycle	Ratio between acquisition duration A and cycle duration C, i.e. fraction of time in which the instrument is effectively active to the fraction of time it is in stand-by mode and drains no current. The greater the duty cycle, the more precise and accurate the data will be to the phenomenon being measured. For example, a duty-cycle of 10% means that over a period M (for example M=10 minutes) the instrument is 90% of the time in stand-by mode (54 seconds per minute) and the acquisition happens 6 seconds per minute.	100%

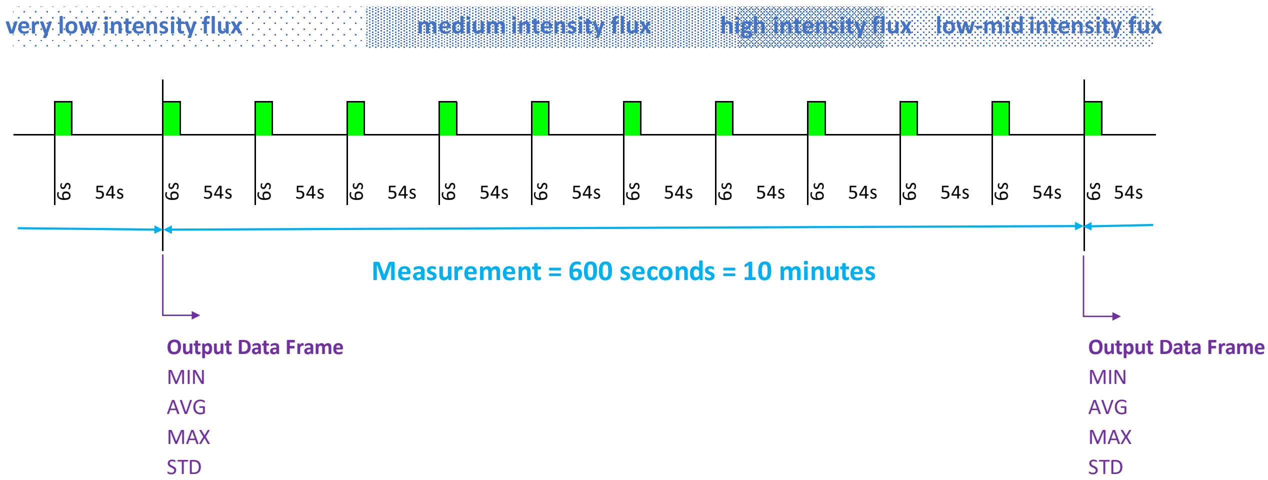
Note: This particularity is extremely useful to avoid any miscalculation in the time averaging of the output data, and it allows the instrument to be used even under severe power consumption constraints, with an accuracy that depends on how much the phenomenon is stationary over the measurement cycle.

The higher the duty-cycle, the higher the accuracy of the instrument (i.e. maximal accuracy reached for the duty-cycle set to 100%), so that, unless some power limitations reasons, the duty-cycle of the instrument shall be left to 100%.

For situations with power limitations and where the episodes of snowdrift are well established, the duty-cycle can be lowered to 10% with only a minor loss of accuracy.

1.9.2. Standard continuous operation mode

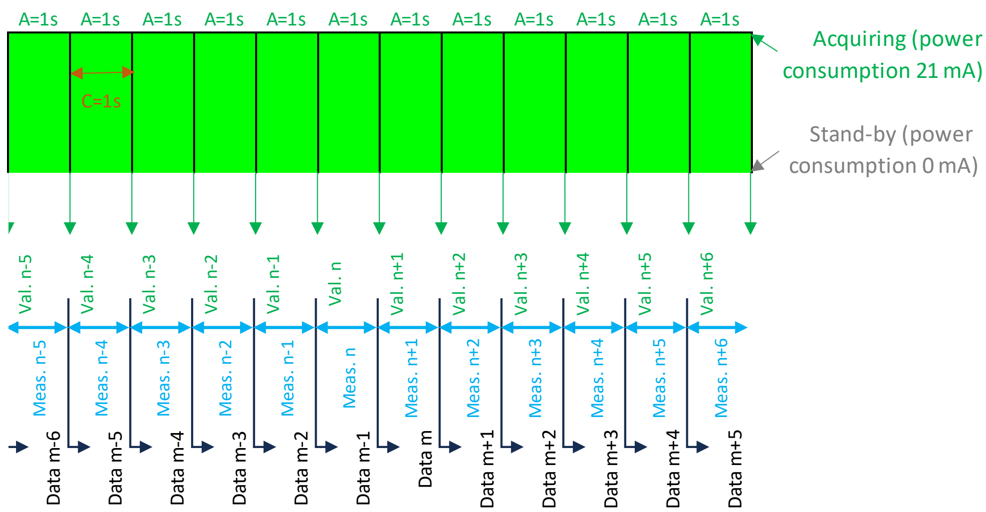
The most standard – and also default factory – configuration of the FlowCapt FC4 instrument is a setting of A,C,M = 6,60,600 s, i.e. the instrument continuously acquires sequences of A=6 seconds and the data statistics is produced every 10 minutes on 10 consecutive samples:



"The sensor is acquiring 6 seconds every minute (stand-by period of 54 second). It produces a data frame every 10 minutes that is a MIN, AVG, MAX and STD statistics on 10 consecutive acquisitions"

1.9.3. Maximum accuracy mode

To analyze the snowdrift with the maximum time resolution of the instrument (1 second), set the instrument with the values A=C=M=1 second, which corresponds to the following processing:



"The sensor is continuously acquiring (no stand-by periods). It produces a data frame every second, which is a statistic with MIN=AVG=MAX=Value n, and STD=0."

According to this diagram:

- The instrument will be continuously powered and acquiring, i.e. a duty-cycle of A/C = 1 = 100%.
- There is no need for any averaging nor statistics, as each acquisition of A=1 second is directly written in a data frame.

In summary, this configuration allows to be in continuous acquisition with a data logging every 1 second.

Note: With a setting of A=C=M=10 seconds, we would also have a continuous measurement, but with a data logging every 10 seconds, and still with AVG=MIN-MAX and STD=0. In this configuration, the data granularity is less precise, but it **saves space on the datalogger**.

1.9.4. Ultra-low power mode

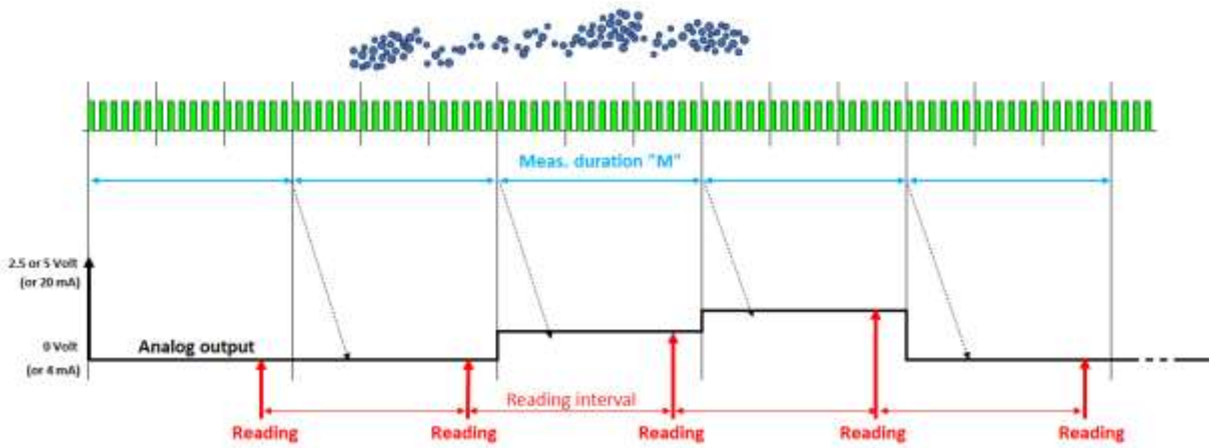
At the cost of a greater probability of reducing the good coverage of the observed phenomenon, the consumption of the instrument can be reduced as much as desired by reducing the duty-cycle. In plain terms, with a small duty-cycle, the longer and more stationary the flux, the better the precision remains, because stationarity and duration mean that even if the phenomenon is observed only partially, the acquisition periods are faithful to the average intensity of the phenomenon.

Compared to the maximum accuracy mode of the preceding section, to reduce the consumption of the instrument say to a factor of 10, the duty cycle must be set to 10%. In this case, it seems wiser to establish this setting with the highest possible periodicity, i.e. better choose A = 1 second and C = 10 seconds than A = 1 minute and C = 10 minutes, because we have a better chance to catch possibly short duration bursts

1.9.5. Analog output mode

In analog output mode, just possibly set the Measurement interval “M” according to your reading device: if your reading device is programmed to periodically read a voltage or current from the instrument, set the Measurement interval to the same period. Then you will always get the expected data, whatever the synchronization between the reading device and the instrument, because the analog outputs of the instrument are persistent on the wire until refreshed by the next measurement.

For example, if you have configured your instrument with a 1-minute Measurement duration, and your reading instrument is configured to take one reading of the voltage or the current every minute, then, except for the residual internal clock drifts of both instruments (which may rarely cause a loss of data), you will always get the live current value of the last minute on the reading side.



Also, in analog mode, note that the instrument is able to operate in **pulse mode**, i.e. a mode in which each time a certain accumulation of the physical phenomenon (snowdrift) happens, a standardized pre-configured pulse is produced.

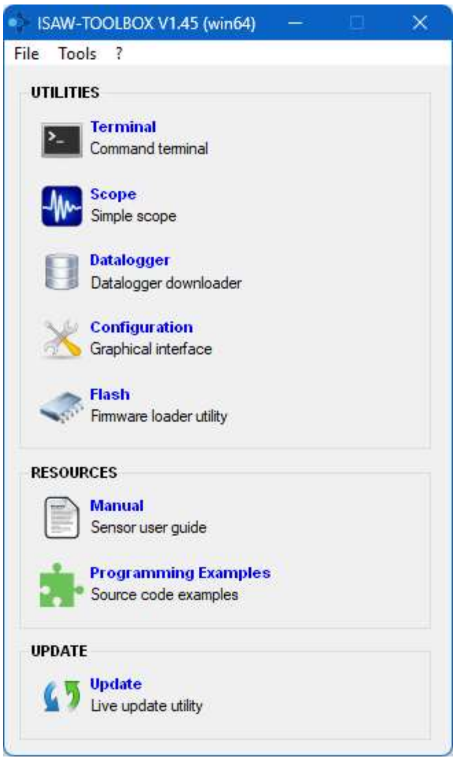
1.10. The ISAW toolbox software suite

Download and install the free ISAW-Toolbox software suite from www.isaw-products.com. Add an ISAW icon on your Desktop to ensure a direct access to the ISAW-Toolbox utilities.

Plug the instrument to your computer using the USB Link accessory (UDONG). Wait for the device driver to be automatically installed and completed.

Note: If the driver is not properly installed, download it from https://ftdichip.com/drivers/vcp-drivers/ and install it manually: in the "Configuration panel" of your computer, open the "Device manager", and in the "Ports (COM & LPT)" section, you will find a new serial communication port (e.g. COM7).

The ISAW-Toolbox software suite includes a range of utilities and resources that you may need to configure, operate or maintain your ISAW instrument:



UTLITIES:

Terminal: Serial terminal emulator used for example to display the data produced by the instrument or to send a command to the instrument.

Scope: Simple scope tool allowing to check the live response of an instrument.

Datalogger: Download the data stored in the instrument's internal datalogger.

Configuration: Change the instrument's configuration parameters.

Flash: Update the instrument's firmware.

RESOURCES:

Manual: ISAW documentation (PDF files)

Programming Examples: Source code examples that you can use to interface your instrument with your acquisition equipment.

UPDATE: Check for new upgrades of the utilities or resources.

When opening one of the ISAW-Toolbox Utilities, select the **Serial port** the instrument is connected to, then press the **[Connect]** button. The connection procedure is completed when the [Connect] button is disabled and the [Disconnect] button is enabled.

Notes: If the instrument is plugged in after the start of the application and you can't find the serial port in the list, click on the reload button to update the list, then select the right port.

When switching from one utility to another, first **[Disconnect]** the instrument from the first utility before connecting it to the other one.

IAV Technologies constantly improves its products and provides upgrades of the ISAW instruments firmware as well as for the ISAW Toolbox utilities. Each time you open the ISAW Toolbox, it automatically checks for new upgrades of tools and resources.

1.11. Getting acquainted with your instrument

In this section we propose two ways to get acquainted with the instrument in a few minutes: either with a computer, or with a smartphone (or tablet).

1.11.1. Quick start using a computer

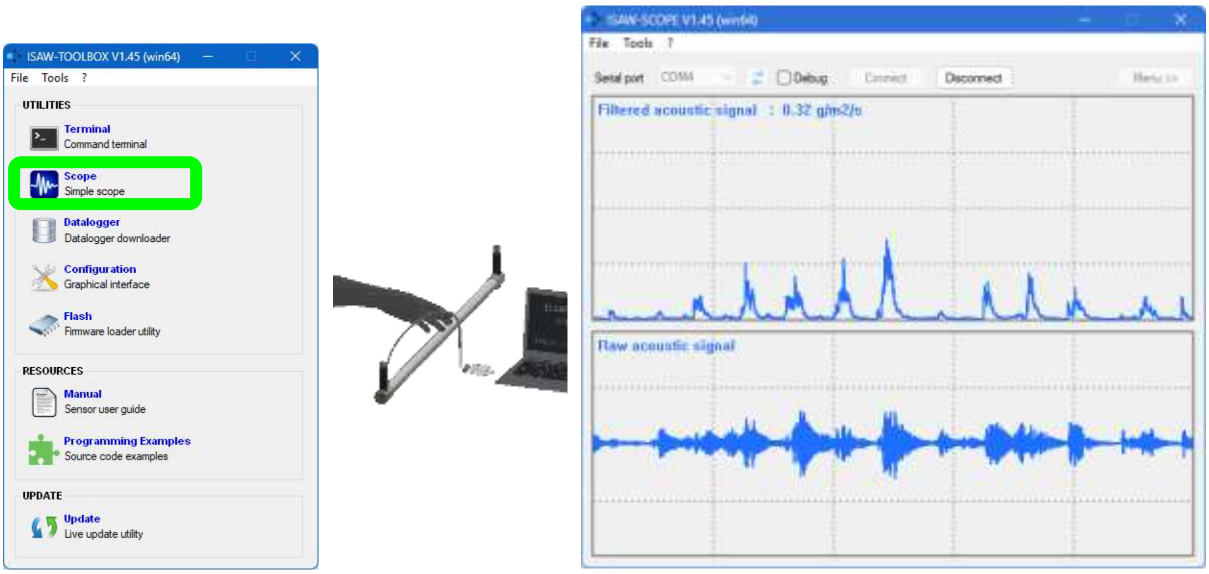
You will need:

- your FlowCapt FC4 instrument,
- the USB link accessory (UDONG) provided with the instrument,
- the ISAW-Toolbox software suite installed on your computer (PC or Mac with USB port).

Tip: To download and install the ISAW-Toolbox software suite and plug your instrument to your computer using the USB link accessory, see § 1.8.

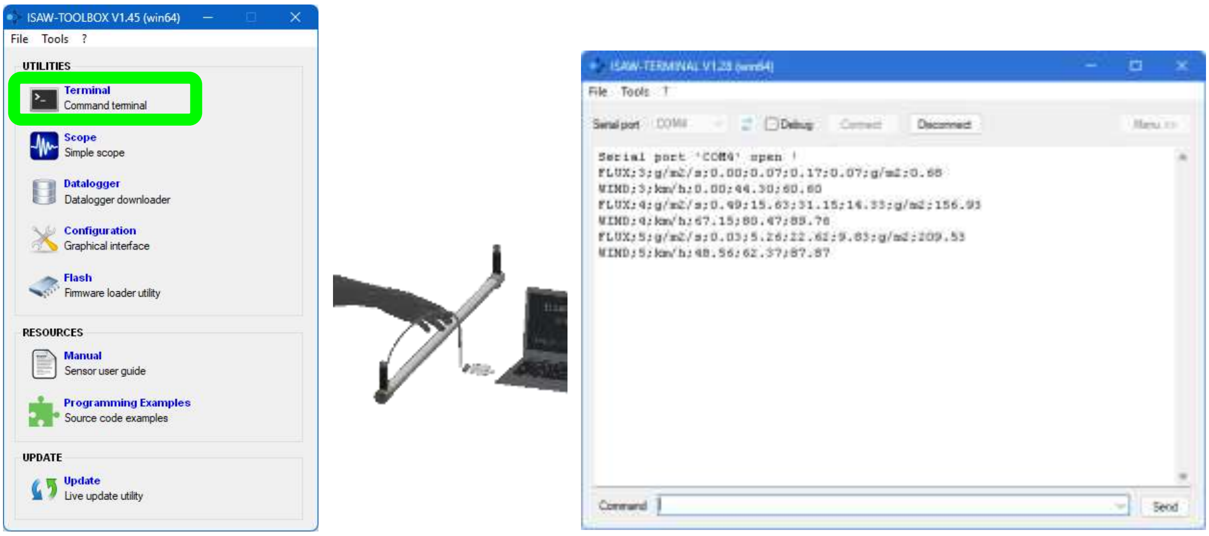
Open the Scope utility and connect your instrument.

TO CHECK THE LIVE RESPONSE of your instrument, open the **Scope utility** of the ISAW Toolbox and connect your instrument. Scratch gently the surface of the tube with your fingernail, a pen or a screwdriver. A live signal appears on the scope window (see example hereafter).



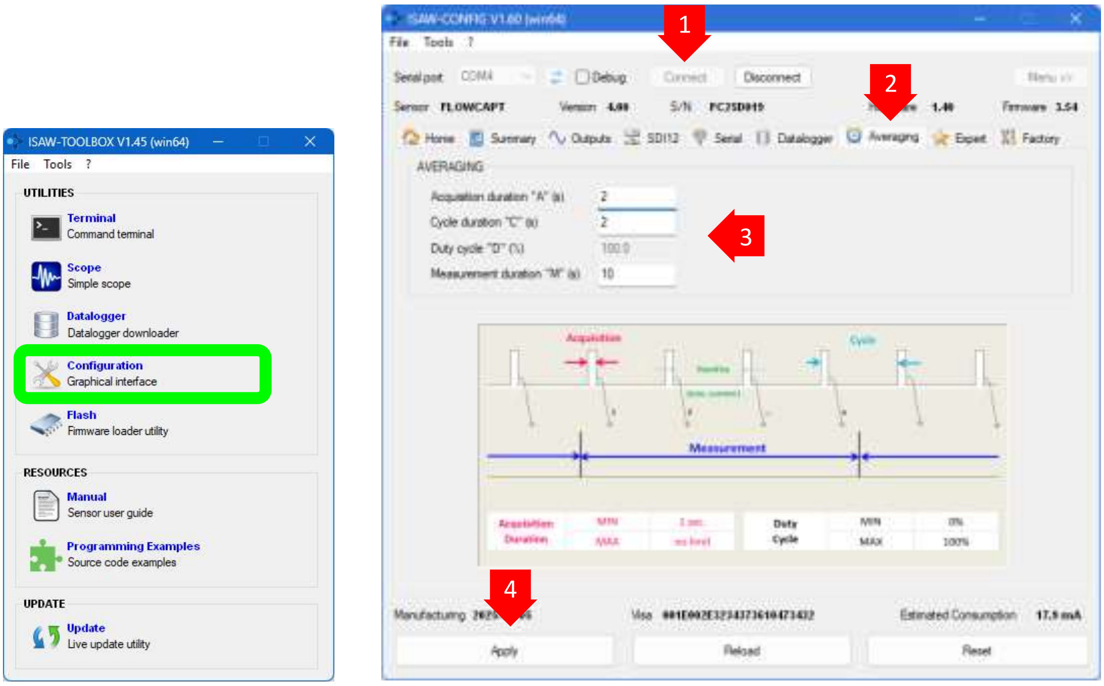
[Disconnect] your instrument when the test is over.

TO SEE THE DATA FRAMES produced by the instrument, open the **Terminal utility** of the ISAW Toolbox and connect your instrument. Scratch gently the surface of the tube with your fingernail, a pen or a screwdriver. The values in the displayed frames should increase according to the speed and force of the scratch.

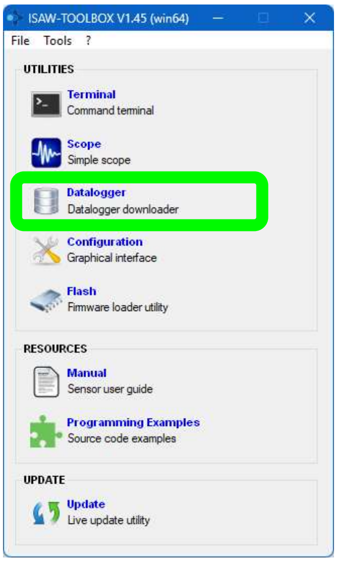


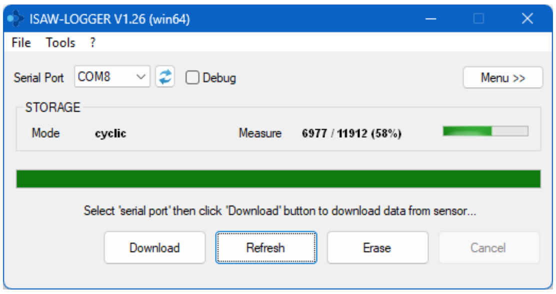
[Disconnect] your instrument when the test is over.

Note: In its default factory configuration, the instrument provides data **every 10 minutes**. To increase the data rate, adjust the averaging parameters of the instrument: in the **Configuration utility** of the ISAW Toolbox (see screenshots below), [Connect] your instrument [1], go to the Averaging panel [2] and set the values of parameters Acquisition (A), Cycle (C) and Measurement (M) respectively to 2 seconds, 2 seconds and 10 seconds [3], then press [Apply], [Disconnect], and go back to the Terminal utility. With this new configuration, the instrument measures continuously and produces a data frame every 10 seconds, and the MIN, AVG and MAX values are statistics on the 5 consecutives acquisitions of 2 seconds each (more explanation about data and averaging rate in section 1.8).



TO RECORD AND DOWNLOAD THE DATA: By default, the instrument's internal datalogger is set to **Cyclic** so the instrument has already recorded your test data and you can retrieve it by using the **Datalogger utility**:





1.11.2. Quick start using a mobile device (smartphone, tablet)

You will need:

- Your FlowCapt FC4 instrument.
- the USB link accessory (UDONG) provided with the instrument, with USB-to-USB-C adapter,
- a generic terminal / console app such as "Serial USB Terminal" installed on your mobile device (smartphone or tablet with USB-C interface).

Note: The instrument is directly powered by the USB-C connection.

Terminal app settings: Make sure to choose a baud rate of 115200. The FlowCapt FC4 instrument is then immediately recognized and the data frames displayed in text mode. Frame example:

```
FLUX;4;g/m2/s;0.49;15.63;31.15;14.33;g/m2;156.93
WIND;4;km/h;67.15;80.47;89.76
```

The frame contains all the data for characterizing the flux and the wind speed. Its definition is provided in the § B.4.

Note: In its default factory configuration, the instrument provides data **every 10 minutes**. To increase the data rate, set the Acquisition, Cycle and Measurement parameters of the instrument to a shorter duration, for example every 10 seconds by typing the following commands:

```
set avg-a=2
set avg-c=2
set avg-m=10
```

With this new configuration, the instrument measures continuously and produces a data frame every 10 seconds, and the MIN, AVG and MAX values are a statistic on the 5 consecutives acquisitions of 2 seconds each (more explanation about data and averaging rate in section 1.8).

TO CHECK THE LIVE RESPONSE of your instrument, scratch gently the surface of the tube with your fingernail, a pen or a screwdriver. The values in the next displayed frame will increase according to the number and intensity of the hits.

TO RECORD AND DOWNLOAD THE DATA: By default, the instrument's internal datalogger is set to **Cyclic** so the instrument has already recorded your test data and you can retrieve it by typing the following command:

```
datalogger download
```

A .CSV text file is produced, containing all recorded data frames.

1.11.3. Stand-alone use without any peripheral

In the simplest way of use, just power the instrument with a standard USB charger using the USB link accessory, and let the instrument operate in **standalone** mode on its internal datalogger.

Tip: Make sure that the datalogger is enabled, which is the case in the default factory configuration.

No software installation is required, and when you need to collect the recorded data, just connect your instrument to a laptop or mobile device and retrieve the data file from the internal datalogger. Note that the device is not equipped with an RTC, thus the appended data is not timestamped with absolute date and time. In case of temporary power shutdown of the instrument, when the instrument is powered again, the data continues to be appended after the last record.

You can also indefinitely log the data of the instrument on a computer by the means of the *livelogger utility* which is a programming executable example available with the ISAW-Toolbox software suite. In this case, instead of connecting the USB link accessory to a USB charger, connect it to your computer and execute the *livelogger* program. This way the data will be timestamped and headed using with the computer clock.

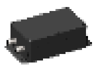
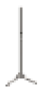
Note: Of course, in more integrated ways of use, the instrument can as well be connected to most of the existing datalogging, peripheral, network or all other kind of external units to get remote unlimited monitoring. All these ways of use are explained in details later in this document.

1.11.4. Direct USB serial connection without UDONG

To connect the instrument to your computer without using the USB link accessory, you can do a custom connection as follows:

- Do not directly connect RX and TX wires to a serial RS232 connector (like a DB9).
- But use an **FTDI 3.3V serial USB converter/adapter** such as model https://ftdichip.com/products/ttl-232r-3v3-we/ (USB-to-TTL Serial Adapter Cable w/ Embedded Controller, 3.3V, Wire Ended), or equivalent (several other cable termination variants are available). Such an adapter is required to adapt the TTL 5V of the RS-232 to the 3.3V of the device.

2. FLOWCAPT FC4 ACCESSORIES

Ref.		Description
C2BRA		Complete **mounting kit** for fastening the instrument anywhere. This item is included in the FCBRA reference.
UDONG		**USB Link accessory** for connecting the instrument to a computer or a mobile device with USB-A or USB-C port. Provided with each FlowCapt FC4 instrument.
EXT10		**Cable extension, 10 meters**, including junction box (Note: you can chain several items, or ask for a specific cable length, on request).
MOBUS		**Modbus RTU-485 adapter** for connecting the instrument to a Modbus RTU-485 environment.
AD420		**4-20 mA adapter** for converting the analog voltage output of the instrument in 4-20 mA current loop.
TMAST		Supporting structure: Tripod mast

C2BRA – Fastening arms (mounting kit)

The FlowCapt FC4 standard mounting kit is composed of 2 cylindrical arms fastened to V brackets adaptable to a mast of outer diameter between 16 and 86 mm. They can also be screwed directly onto a flat surface. See mounting examples on page 55.

UDONG – USB Link accessory

The UDONG is a **universal USB-to-serial TTL3V3 interface** for direct connection of any ISAW instrument to a PC, Mac, Linux, etc. It enables the instrument's power supply and the immediate use of all the software features of the ISAW-TOOLBOX freeware. The USB dongle is generic and can thus be used or interchanged with all ISAW instruments.

Main features:

- Immediate and standard consistent 8-pin connector and pinout
- Direct 12V (84 mA) power supply (from USB 5V 150 mA) of every ISAW instrument
- Genuine FTDI USB-Serial converter (FT232R). Reliable connection, drivers often already installed on Windows/Mac.
- USB port offering a solid and robust design. "Flex" micro-USB cables can be used. Reduces the risk of the USB connector breaking off the board.
- Bright LEDs for Power, RX, and TX.
  The **power LED** is on when the dongle is plugged into the computer's USB-port and switched on. The **TX LED** turns on when data is **T**ransmitted (sent out) through the USB port, while the **RX LED** turns on when data is **R**eceived from the USB port.

ISAW instrument cable

USB COM port

EXT10 – Cable extension, 10 meters

Each instrument is delivered with a 5-meter cable (see description and reference in § 4.1). Use one or several EXT10 cable extensions to extend this default length up to typically 200 m.

EXT10 is a **10 meters extension of the ISAW instrument cable**, equipped at one end with an IP68 aluminum enclosure **junction box**, which contains an 8-pin screw connector to connect any ISAW instrument or chaining several EXT10 extension cables.

Instrument cable

JUBOX (Junction box)

Plugging the cable extension:

Open the junction box (4 screws), disconnect the instrument wires from the terminal block plug, thread the instrument cable into the junction box through the cable gland, connect the instrument wires back into the terminal block plug, plug it into the junction box, tighten back the cable gland, tightly screw the lid back on the junction box.

MOBUS – Modbus adapter

The ISAW **Modbus RTU RS485 Adapter** (MOBUS) enables the power supply and connection of any ISAW instrument to a Modbus network.

MOBUS is the recommended accessory to interconnect the instrument through the open serial Modbus RTU (RS485) protocol based on a master/slave or client/server architecture. The fieldbus environment is the base level group of digital networks in the hierarchy of plant networks.

Complete description and instructions for use are given in Appendix D.

AD420 – 4-20 mA adapter

The ISAW **4-20 mA Adapter (AD420)** converts analog outputs voltages OUT1 and OUT2 of the FlowCapt FC4 to a 4-20 mA current loop.

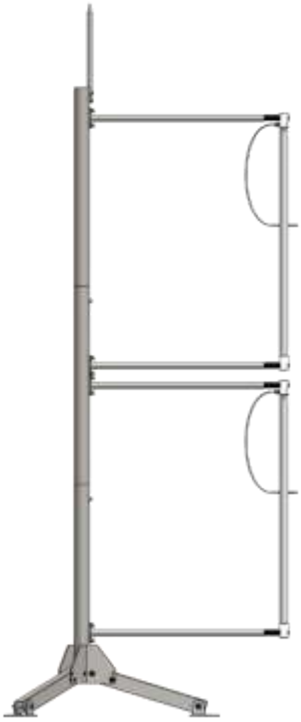
The enclosure is an IP68 aluminum box, with two cable glands, on one side with an 8-pin screw connector to connect your ISAW instrument, and on the other side a 4-pin screw connector to connect your power supply and your 4-20 mA current loop terminal.

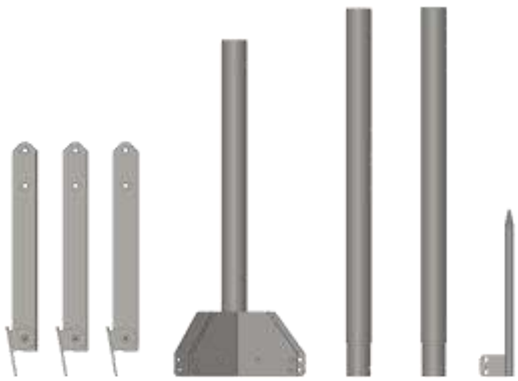
<table>
<tr><th colspan="2">FlowCapt FC4</th><th rowspan="2">AD420 adapter</th><th colspan="2">Your instrument</th></tr>
<tr><th>Wire</th><th>Signal</th><th>Pin</th><th>Signal</th></tr>
<tr><td>White</td><td>Power</td><td rowspan="8"></td><td rowspan="2">PWR+</td><td rowspan="2">Positive power supply</td></tr>
<tr><td>Brown</td><td>Signals GND</td></tr>
<tr><td>Green</td><td>OUT1</td><td rowspan="2">PWR-</td><td rowspan="2">Negative/ground power supply</td></tr>
<tr><td>Yellow</td><td>OUT2</td></tr>
<tr><td>Blue</td><td>SDI-12</td><td rowspan="2">LOOP-</td><td rowspan="2">4-20 mA output current loop -</td></tr>
<tr><td>Grey</td><td>RX</td></tr>
<tr><td>Pink</td><td>TX</td><td rowspan="2">LOOP+</td><td rowspan="2">4-20 mA output current loop +</td></tr>
<tr><td>Black</td><td>Power GND (0V)</td></tr>
</table>

TMAST – Tripod mast

TMAST is a heavy-duty, modular, cost-effective stainless steel tripod mast, lightweight and easy to transport. It allows all the usual ISAW instrument mountings, as well as supporting additional instruments and other accessories or auxiliary equipment. The H=2.89m (from ground to top of lightning rod) mast is dismountable (3 parts) and equipped with 3 tiltable legs and a lightning rod.

The tripod mast is used in particular in the FC2MA configuration (Pair of FlowCapt FC4 instruments fastened on a mast), with two instruments directly screwed one above the other on the mast.





3. CONFIGURE THE FLOWCAPT FC4

3.1. Introduction

Your FlowCapt FC4 instrument is delivered **completely pre-configured** to **operate in continuous mode**. It is ready to be plugged into a power supply and into your reading peripheral (I/O module, data datalogger, automation server, controller, computer, etc.). See next page for an example of the full factory default configuration.

Configuration settings include:

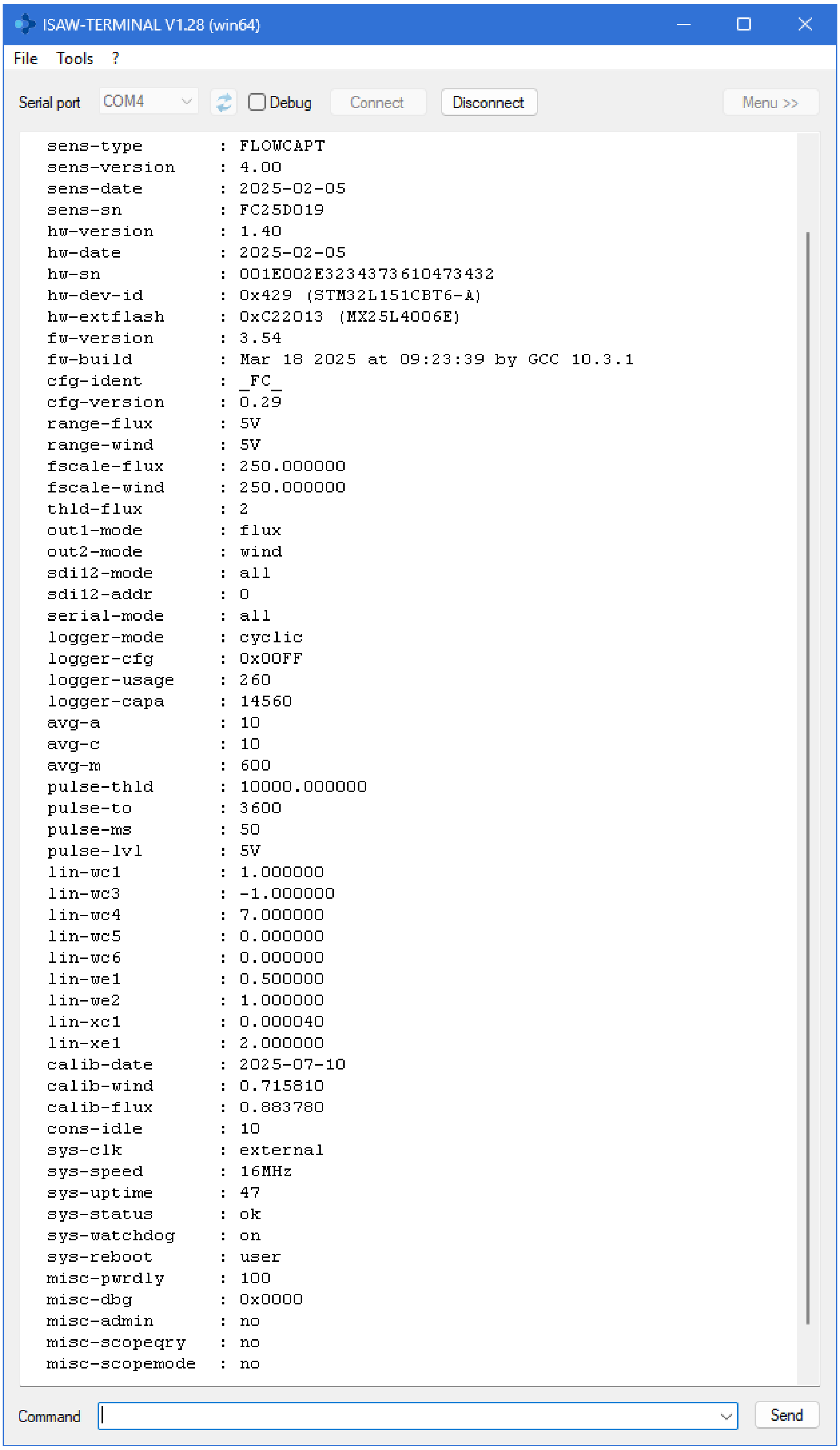
- Measuring settings (e.g., acquisition and averaging / logging /writing durations)
- Power settings (e.g. automated duty-cycle of the instrument, in case of implementation with critical electrical consumption concerns)
- Communication and mapping settings (e.g., analog and/or digital outputs, voltage scales, duty-cycle, bus address, etc.).

Note: The default configuration, as well as any other customized configuration, is **non-volatile**, i.e. your instrument **remains in the desired operating configuration whatever the powering scenario**. Thus, even in case of repeated power failures, **the instrument will always restart automatically in the desired configuration mode**. When adding or replacing an ISAW instrument, it is possible to pre-configure it in order to achieve Plug and Play functionality without any on-site configuration.

You can change and adjust anytime the configuration settings, either by using the ISAW Toolbox Configuration utility (see § 3.3) or directly in terminal mode (see § 3.4),), or even using an extended SDI-12 command (see Appendix C.2).

3.2. Operating parameters

The complete configuration of a FlowCapt F4 instrument consists in the following parameters:



```
sens-type        : FLOWCAPT
sens-version     : 4.00
sens-date        : 2025-02-05
sens-sn          : FC25D019
hw-version       : 1.40
hw-date          : 2025-02-05
hw-sn            : 001E002E3234373610473432
hw-dev-id        : 0x429 (STM32L151CBT6-A)
hw-extflash      : 0xC22013 (MX25L4006E)
fw-version       : 3.54
fw-build         : Mar 18 2025 at 09:23:39 by GCC 10.3.1
cfg-ident        : _FC_
cfg-version      : 0.29
range-flux       : 5V
range-wind       : 5V
fscale-flux      : 250.000000
fscale-wind      : 250.000000
thld-flux        : 2
out1-mode        : flux
out2-mode        : wind
sdi12-mode       : all
sdi12-addr       : 0
serial-mode      : all
logger-mode      : cyclic
logger-cfg       : 0x00FF
logger-usage     : 260
logger-capa      : 14560
avg-a            : 10
avg-c            : 10
avg-m            : 600
pulse-thld       : 10000.000000
pulse-to         : 3600
pulse-ms         : 50
pulse-lvl        : 5V
lin-wc1          : 1.000000
lin-wc3          : -1.000000
lin-wc4          : 7.000000
lin-wc5          : 0.000000
lin-wc6          : 0.000000
lin-we1          : 0.500000
lin-we2          : 1.000000
lin-xc1          : 0.000040
lin-xe1          : 2.000000
calib-date       : 2025-07-10
calib-wind       : 0.715810
calib-flux       : 0.883780
cons-idle        : 10
sys-clk          : external
sys-speed        : 16MHz
sys-uptime       : 47
sys-status       : ok
sys-watchdog     : on
sys-reboot       : user
misc-pwrdly      : 100
misc-dbg         : 0x0000
misc-admin       : no
misc-scopeqry    : no
misc-scopemode   : no
```

Default configuration of a FlowCapt FC4 sensor

Parameter	Description	Type	Access[1]	Values / Format	Default value / *Example*
sens-type	Instrument type	string	ro	FLOWCAPT	FLOWCAPT
sens-version	Model version of the sensor	version	rw*	<major>.<minor> where major and minor cannot exceed 255	4.00
sens-date	Date of manufacturing/assembly of the full sensor	date	rw*	YYYY-MM-DD YYYY: Year, MM: Month, DD: Day	*2025-02-05*
sens-sn	Instrument serial number (matches instrument body engraving)	string	rw*	FCxxxxxxx	*FC25D019*
hw-version	Version of electronic hardware	version	rw*	<major>.<minor> where major and minor cannot exceed 255	*1.40*
hw-date	Date of electronic hardware manufacturing/assembly	date	rw*	YYYY-MM-DD YYYY: Year, MM: Month, DD: Day	*2025-02-05*
hw-sn	Electronic hardware's serial number	string	ro	xxxxxxxxxxxxxxxxxxxxxxxx	*001E002E3234373610473432*
fw-version	Version of current firmware	version	ro	<major>.<minor> where major and minor cannot exceed 99	*3.54*
hw-extflash	Internal Flash memory identifier	string	ro	0xxxxxxx(<model>) (0x000000 if no Flash memory is soldered to the instrument electronic board)	*0xC22013 (MX25L4006E)*
fw-build	Compilation information of current firmware	string	ro	Not specified	*Mar 18 2025 at 09:23:39 by GCC 10.3.1*
cfg-ident	Eeprom configuration map identifier	string	ro	_FC_ eeprom identifier	_FC_
cfg-version	Eeprom configuration map version	version	ro	<major>.<minor> where major and minor cannot exceed 255	*0.29*
range-wind	OUT1 and/or OUT2 range for full-scale wind speed	string	rw	2V5 2.5 volts for 250 km/h full-scale 5V 5 volts for 250 km/h full-scale	5V
range-flux	OUT1 and/or OUT2 range for full-scale particle flux	string	rw	2V5 2.5 volts for 250 $g/m^2/s$ full-scale 5V 5 volts for 250 $g/m^2/s$ full-scale	5V
fscale-wind	OUT1 and/or OUT2 full scale wind, km/h	string	ro	250	250.000000
fscale-flux	OUT1 and/or OUT2 full scale particle flux, $g/m^2/s$	string	ro	250	250.000000
thld-flux	Flux noise threshold [mV]	integer	rw	0 to 3300	2
out1-mode	OUT1 mode (green wire)	string	rw	off Disabled wind Wind speed (Persistent, 0 to full-scale) flux Particle flux (Persistent, 0 to full-scale) pulse Particle flux (Pulse, 0 or full-scale)	flux

[1] ro: read-only – rw: read/write – rw*: read/admin-write

Parameter	Description	Type	Access[1]	Values / Format	Default value / *Example*
out2-mode	OUT2 mode (yellow wire)	string	rw	off Disabled wind Wind speed (Persistent, 0 to full-scale) flux Particle flux (Persistent, 0 to full-scale) pulse Particle flux (Pulse, 0 or full-scale) raw Raw analog AC signal	wind
sdi12-mode	SDI-12 mode (blue wire)	string	rw	off Disabled wind Wind speed only flux Particle flux only all Wind speed and particle flux	all
sdi12-addr	SDI-12 address	string	rw	ASCII character (standard SDI-12 characters are 0 to 9)	0
serial-mode	Serial mode (pink wire)	string	rw	off Disabled wind Wind speed only flux Particle flux only all Wind speed and particle flux	all
logger-mode	Datalogger mode	string	rw	off No recording on Data are recorded until memory is full. cyclic Data are recorded and the oldest data are constantly overwritten when memory is full.	cyclic
logger-cfg	Datalogger field configuration	integer	rw	The value is expressed in hexadecimal. Each bit matches a field. If the bit value is 1, the field is logged. Bit 15: reserved Bit 7: min. flux Bit 14: reserved Bit 6: avg flux Bit 13: reserved Bit 5: max. flux Bit 12: N.A. Bit 4: std flux Bit 11: N.A. Bit 3: cum. flux Bit 10: N.A. Bit 2: min. wind Bit 9: N.A. Bit 1: avg wind Bit 8: N.A. Bit 0: max. wind	0x00FF
logger-usage	Datalogger record count usage	integer	ro	Number of recorded measurements.	0
logger-capa	Datalogger record count capacity	integer	ro	Maximum number of recordable measurements. Depends on the number of fields selected in logger-cfg.	0
avg-a	Acquisition duration (s)	integer	rw	Must be > 0 (see Averaging duration rules below)	6
avg-c	Cycle duration (s)	integer	rw	Must be >= avg-a and avg-m/avg-c is integer (see Averaging duration rules below)	60
avg-m	Measurement duration (s)	integer	rw	Must be >= avg-c and avg-c must be modulo avg-m (see Averaging duration rules below)	600
pulse-thld	OUT1/OUT2 flux pulse threshold (g/m^2)	float	rw	No limit	10000.0

Parameter	Description	Type	Access[1]	Values / Format	Default value / *Example*
pulse-to	OUT1/OUT2 flux pulse reset timeout (s)	integer	rw	Must be > avg-m	3600
pulse-ms	OUT1/OUT2 flux pulse duration (ms)	integer	rw	1 < pulse-ms < 500	50
pulse-lvl	OUT1/OUT2 flux pulse level	string	rw	2V5 Pulse level is 2.5 volts 5V Pulse level is 5 volts	5V
lin-wc1	Wind linearization coefficient WC1	float	rw	Default factory setting	1.000000
lin-wc3	Wind linearization coefficient WC3	float	rw	Default factory setting	-1.000000
lin-wc4	Wind linearization coefficient WC4	float	rw	Default factory setting	7.000000
lin-wc5	Wind linearization coefficient WC5	float	rw	Default factory setting	0.000000
lin-wc6	Wind linearization coefficient WC6	float	rw	Default factory setting	0.000000
lin-we1	Wind linearization exponent WE1	float	rw	Default factory setting	0.500000
lin-we2	Wind linearization exponent WE2	float	rw	Default factory setting	1.000000
lin-xc1	Particle flux intensity linearization coefficient XC1	float	rw	Default factory setting	0.000040
lin-xe1	Particle flux intensity linearization exponent XE1	float	rw	Default factory setting	2.000000
calib-date	Date of sensor calibration	date	rw*	YYYY-MM-DD YYYY: Year, MM: Month, DD: Day	*2025-07-10*
calib-wind	Wind calibration factor	float	rw*	Must be > 0	1.000000
calib-flux	Particle flux calibration factor	float	rw*	Must be > 0	1.000000
cons-idle[2]	Timeout of console to return in idle mode	integer	rw	Seconds	10
sys-clk	System clock (It's not recommended to change this parameter)	string	rw	internal Use internal clock external Use external clock	external
sys-speed	System speed (It's not recommended to change this parameter)	string	rw	4MHz Run at 4 MHz 8MHz Run at 8 MHz 16MHz Run at 16 MHz 32MHz Run at 32 MHz	16MHz
sys-uptime	Time elapsed since power on	integer	ro	Seconds	*3426*
sys-status	System status	string	ro	OK No error ADC-OVERRUN ADC Error	ok
sys-watchdog[3]	Hardware watchdog timer status	string	rw	on Watchdog is enabled off Watchdog is disabled	on

[2] When you enter this command, the console temporarily hides the measurement message (to clear the display), and then returns, after the selected timeout, to idle mode (stop hiding message).

[3] The **watchdog timer** is and independent hardware system which detects and recovers from sensor malfunctions due to software failure: if the sensor fails to reset the watchdog regularly (every 10 to 20 s) the timer will elapse, and the sensor will be restarted automatically.

Parameter	Description	Type	Access[1]	Values / Format	Default value / *Example*
sys-reboot	Last system reboot type	string	ro	user Sensor has been rebooted manually by the user (power or software) watchdog Sensor has been rebooted by the watchdog	user
misc-pwrdly	Analog stage power delay: time to wait after power on amplifier and start acquisition	integer	rw	Milliseconds. Must be < 500	100
misc-debug	Debug bit-field status	integer	ro	See "debug" command.	0x0000
misc-admin[4]	Current admin rights status	string	ro	yes User is admin, special parameters can be changed. no User is not admin, special parameters cannot be changed.	no
misc_scopeqry	Enable scope mode at next reboot, (automatically reset after startup)	integer	ro	yes or no, set by scopemode command (see appendix B.2)	no
misc_scopemode	Scope mode currently enabled	integer	ro	yes or no, set by scopemode command (see appendix B.2)	no

[4] You can change the admin status using the “admin” command. Admin status is automatically reset to default ("no") after reboot.

3.3. Configuration using the ISAW Toolbox software suite

The configuration of the FlowCapt FC4 instrument can be done either with the ISAW Toolbox software suite (see section 1.8.), and/or by direct or remote connection methods. This section describes how to configure your FlowCapt FC4 instrument using the ISAW Toolbox Configuration Utility.

1. Open the ISAW-Toolbox by double-clicking on the ISAW icon on your desktop.
2. Start the Configuration utility by clicking on the corresponding item.
3. Select the Serial port the instrument is connected to and press the [Connect] button. Once the instrument is connected, the Configuration tabs appear and the control buttons are enabled.

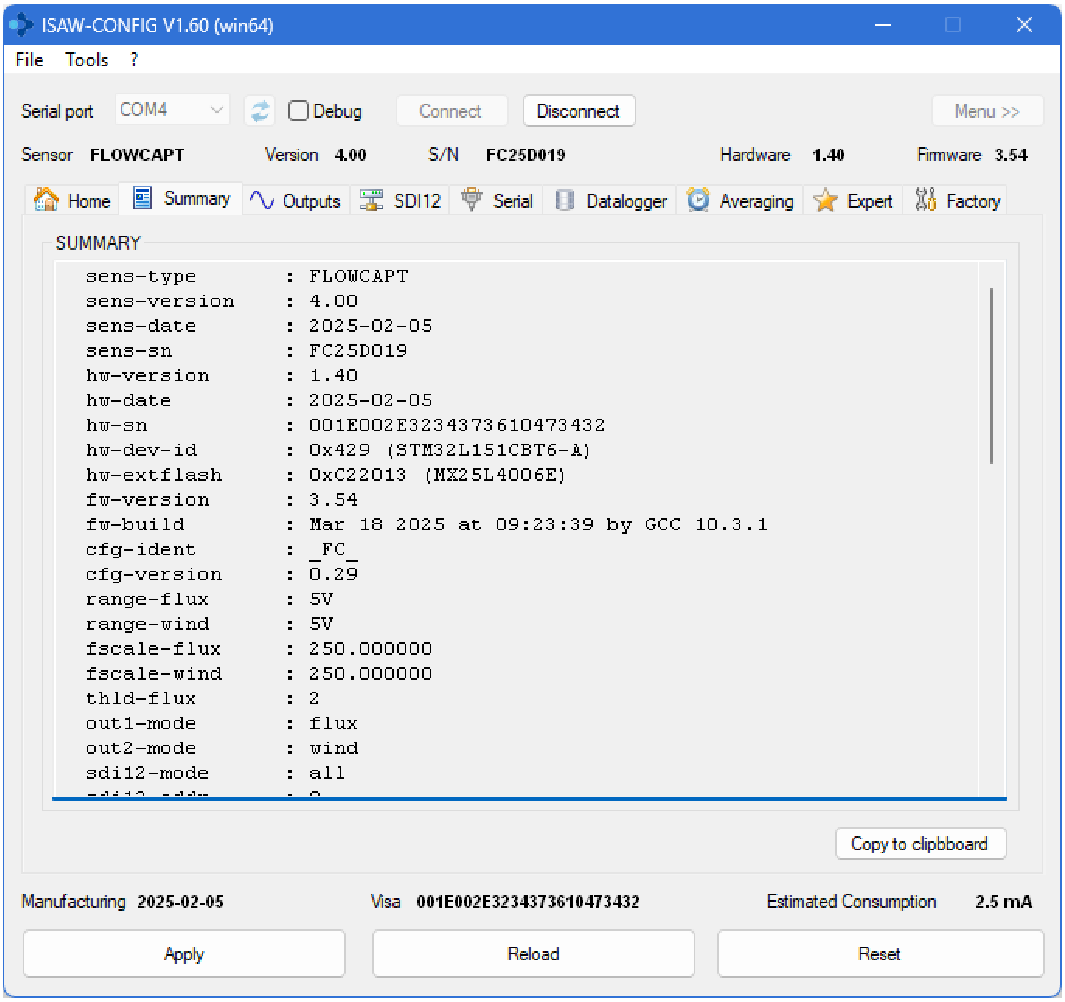
Configuration panels	
Summary	Current configuration.
Outputs	Setting analog outputs, voltage ranges, and pulse settings.
Sdi12	Setting SDI-12 settings.
Serial	Serial settings.
Datalogger	Internal data recorder.
Averaging	Setting acquisition duration, cycle duration, duty cycle and measurement duration.
Expert	Setting coefficients of the polynomial linearization functions, internal clock and timeout parameter.
Factory	Reading the instrument's factory information.

Control buttons	
[Apply]	Sends the complete configuration displayed in all tabs to the instrument. After receiving the configuration, the instrument restarts.
[Reload]	Reloads the instrument's configuration.
[Reset]	Resets the instrument with the default factory configuration. To confirm that the configuration has been properly installed, the application then reloads the configuration and displays it again. See the "reset confirm" command in appendix B.2 for more information.

3.3.1. Summary panel

To quickly check the full configuration of your instrument, the summary panel lists all the settings and instrument information.

See § 3.2 for more details on the parameters.

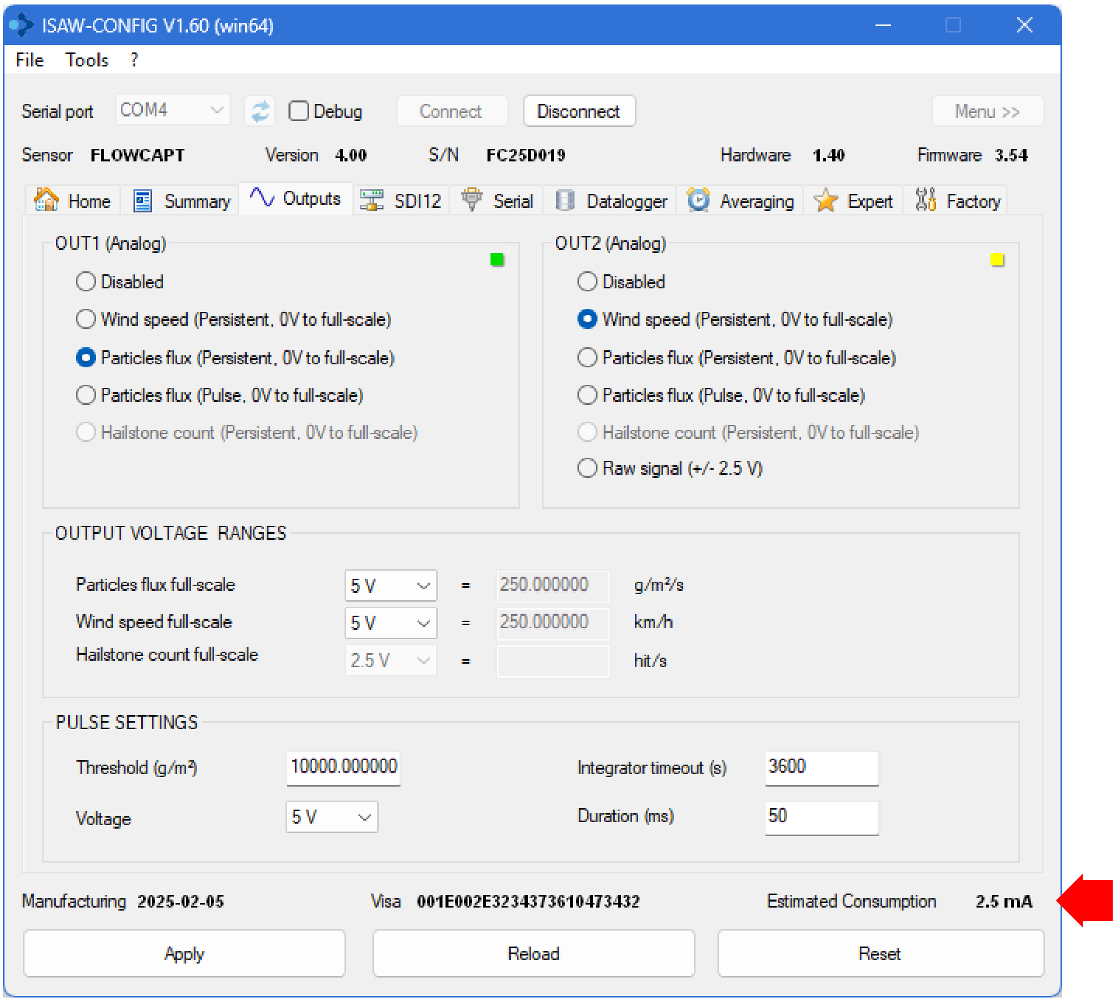


The [Copy to clipboard] button allows you to copy the whole configuration and paste it in another destination for example in case of concurrently testing different settings, or for diagnostic, reporting or backup purposes.

The [Copy to clipboard] button allows you to copy the whole configuration and paste it in another destination for example in case of concurrently testing different settings, or for diagnostic, reporting or backup purposes.

3.3.2. Outputs panel

The outputs panel allows you to set the so-called OUT1 and OUT2 analog outputs, which mapping is user-selectable as explained in the next paragraph.



When choosing to connect your instrument to the analog input(s) of a reading device (so the reading device reads positive continuous voltage or counts pulses from either the green or the yellow wire of the instrument), you can decide which output signal you want to be physically present on each of the wires.

This functionality, called the *output mapping*, is a facility that allows the instrument to be adapted to almost any reading device.

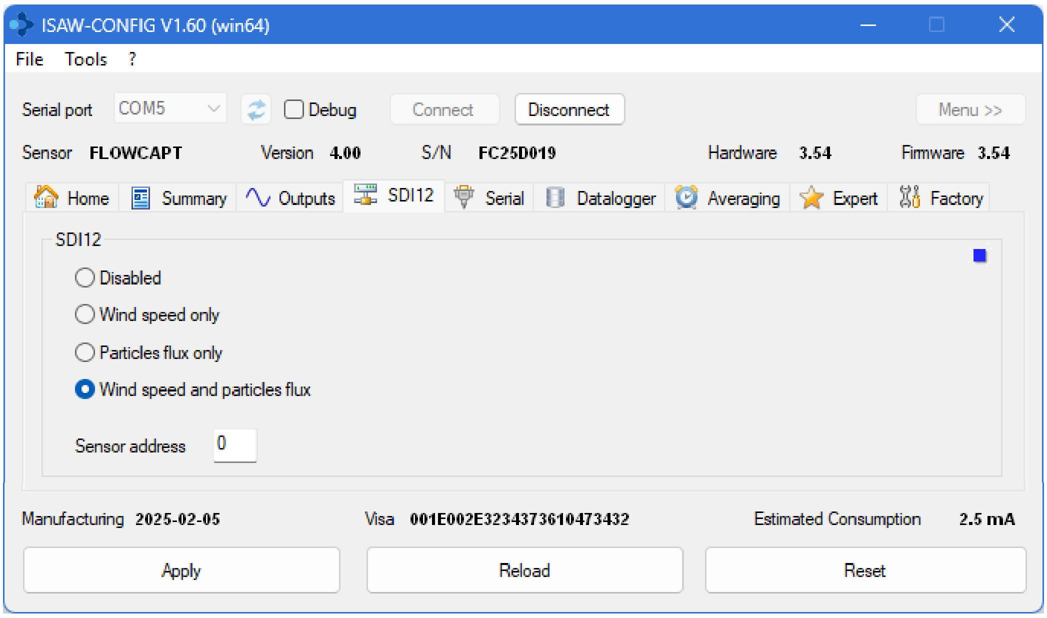
To understand the output mapping, the only thing to consider is that the instruments have two generic analog outputs, called OUT1 and OUT2. OUT1 is always carried by the green wire, OUT2 is always carried by the yellow wire. You decide which signal is attributed to OUT1 and OUT2 by selecting one of the options in this panel.

Further settings available in the output panel are the voltage ranges and the pulse settings, so that you can also adapt these to the characteristics of your reading device.

Tip: The **average power consumption** corresponding to your selected settings is displayed at the bottom right of the panel.

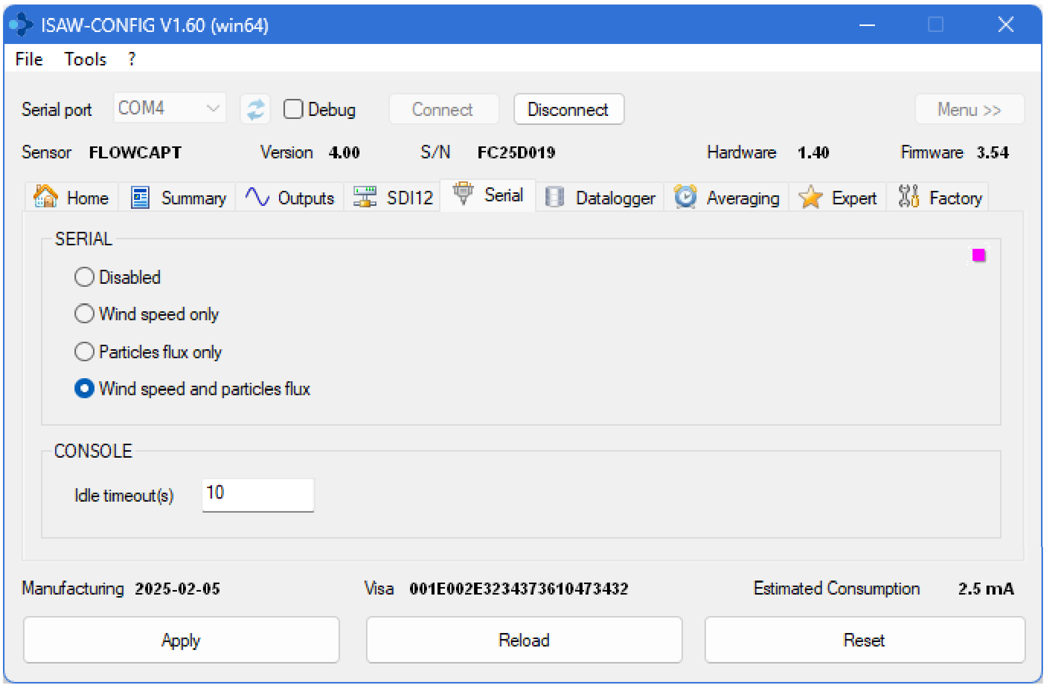
3.3.3. SDI-12 panel

When choosing an SDI-12 interface for your instrument, its positive voltage is always physically carried by the blue wire. You can select in the SDI-12 panel the data frame content you need and set the instrument address of your choice. For more instructions about the use of the SDI-12 interface, please refer to Appendix C.



3.3.4. Serial panel

Serial communication is always available and, unless disabled by the user, physically carried by the pink (TX) and grey (RX) wires in all ISAW instruments. You can select the data frame content you need in the Serial panel and set the idle timeout of your console.



For more instructions on the use of the serial communication, please refer to Appendix B.

3.3.5. Datalogger panel

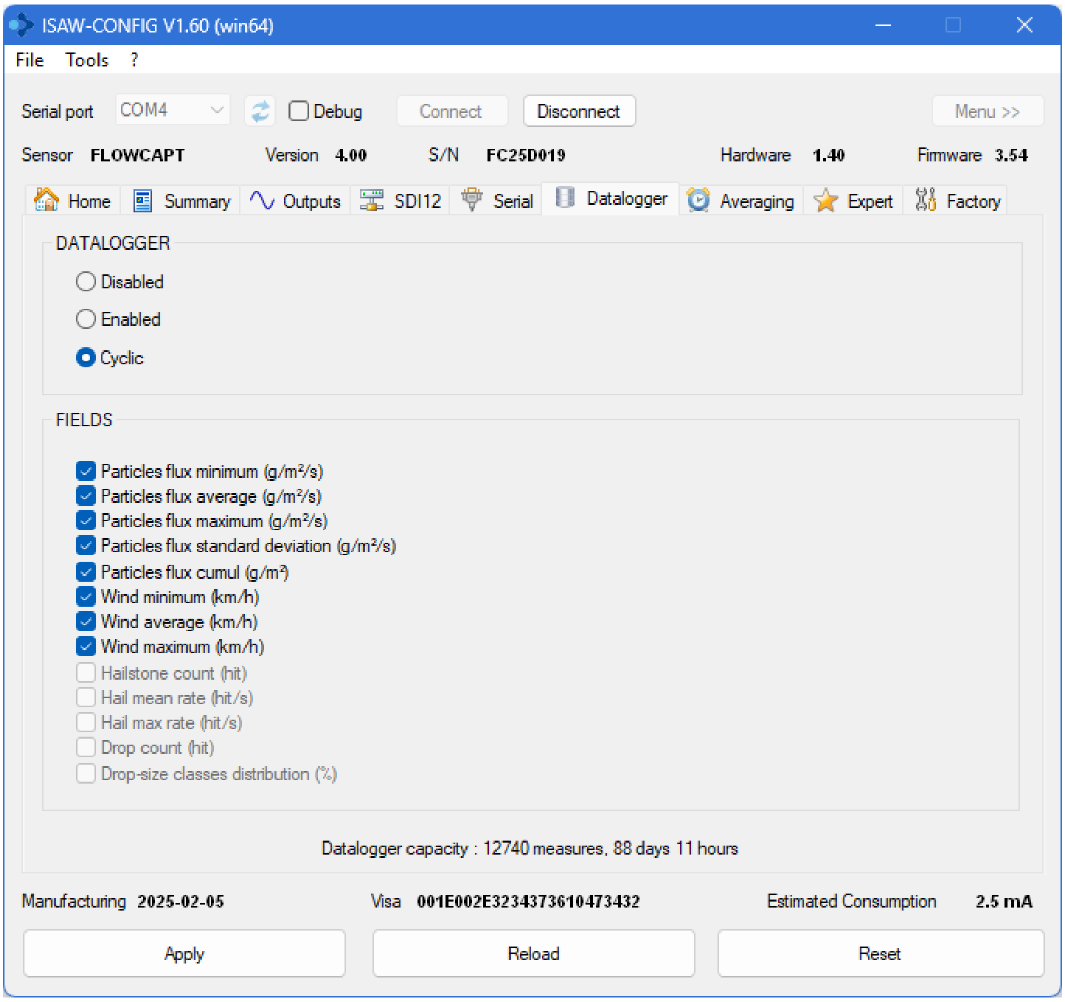
The internal datalogger can be configured as follows:

Disabled: No data is recorded.

Enabled: Data are recorded until the memory is full.

Cyclic: Data are recorded and the oldest data are constantly overwritten when the memory is full.

The logging frequency matches the measurement duration (see next section).



You can individually select the fields you want to record.

Note: The more fields you select, the fewer measurements you can record.

The datalogger capacity indicates the estimated number of measurements and the duration of the measurement session based on the measurement duration.

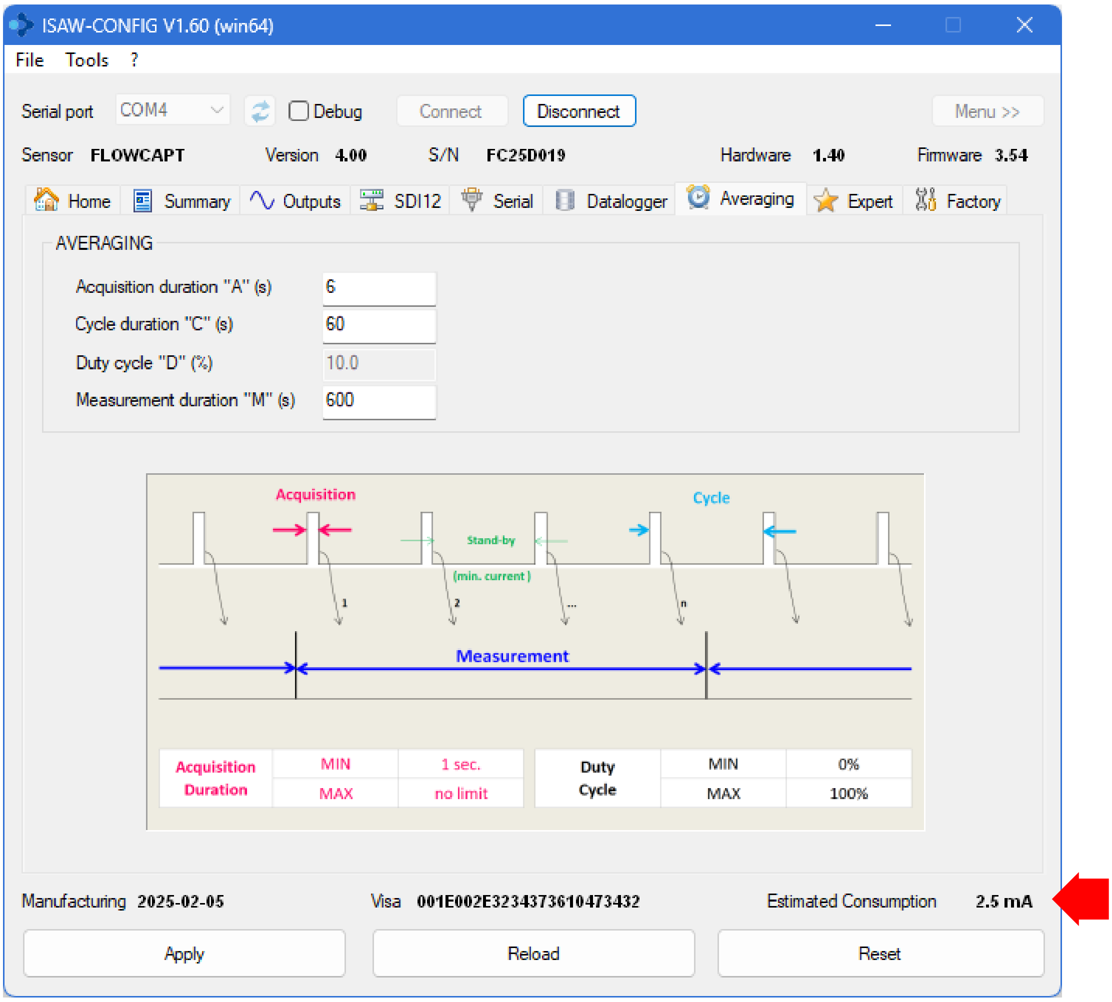
WARNING: The datalogger must be erased after changing the configuration fields (see § 5.1).

3.3.6. Averaging panel

The averaging panel allows you to set all the measurement settings, i.e.

- Acquisition duration (true observation time of the physical phenomena, also called *time integration window*),
- Cycle duration (the sum of the acquisition duration and a stand-by duration),
- Duty cycle (ratio between acquisition duration and cycle duration, the fraction of time in which the instrument is effectively active),
- Measurement duration or also called the *averaging duration* (the reading or writing data interval you want).

These parameters are explained in details in section 1.8.



Tip: The **average power consumption** corresponding to your selected settings is displayed at the bottom right of the panel.

Averaging duration rules:

The parameters "avg-a", "avg-c" and "avg-m" are interdependent and must satisfy the following rules:

`avg-a`, `avg-c` and `avg-m` are integers

0 < `avg-a` ≤ `avg-c` ≤ `avg-m`

`avg-m` / `avg-c` is an integer

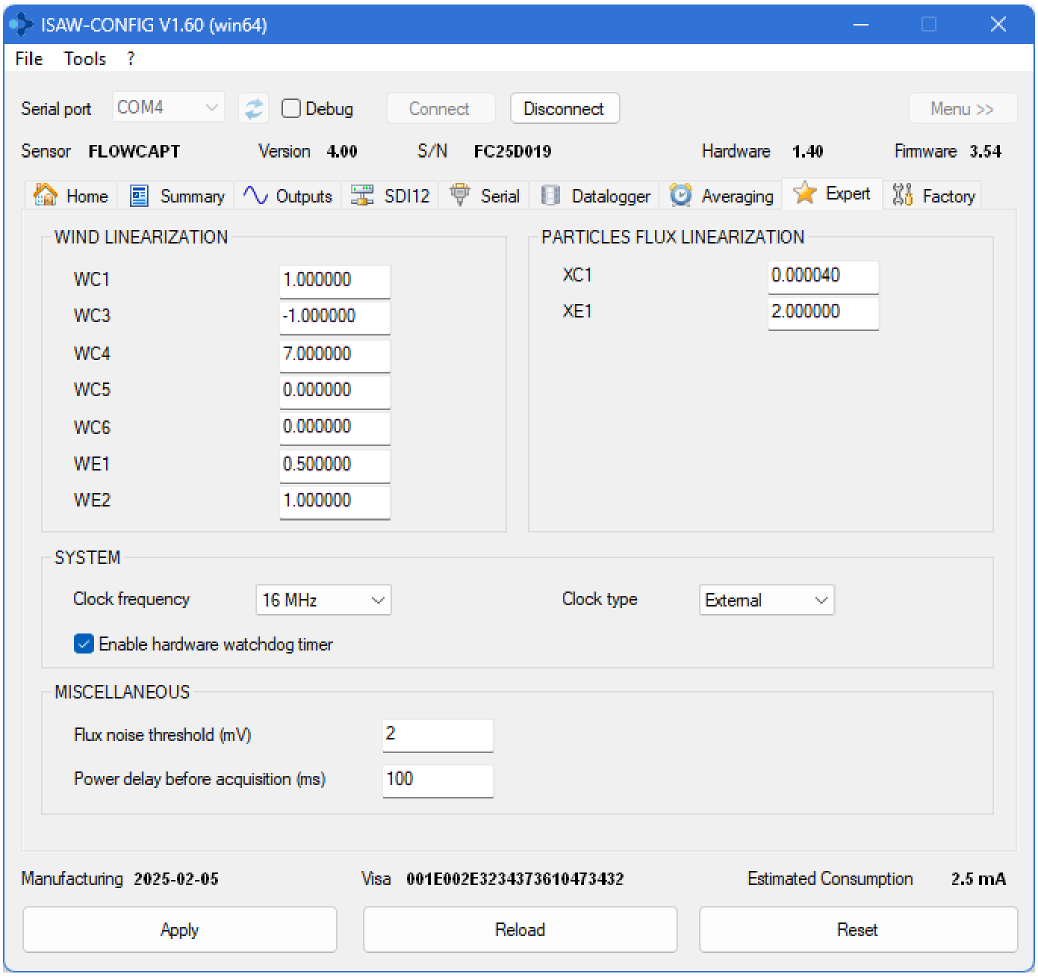
The rules are checked each time a parameter is changed. Therefore, in some cases, the user is unable to set the requested value.

In this case, set the requested averaging parameters in the following order:

1. Set the `avg-a` parameter to 1.
2. Set the `avg-c` parameter to 1.
3. Set the `avg-m` parameter to the requested value.
4. Set the `avg-c` parameter to the requested value.
5. Set the `avg-a` parameter to the requested value.

3.3.7. Expert panel

The Expert panel, reserved for scientific users or customized use of the instruments, allows you to set advanced linearization parameters, i.e. changing the internal calculation mode of the instrument.



For example, you can turn the instrument into pass-through mode, change the internal noise threshold or implement different coefficients to the internal calculation functions of the instrument.

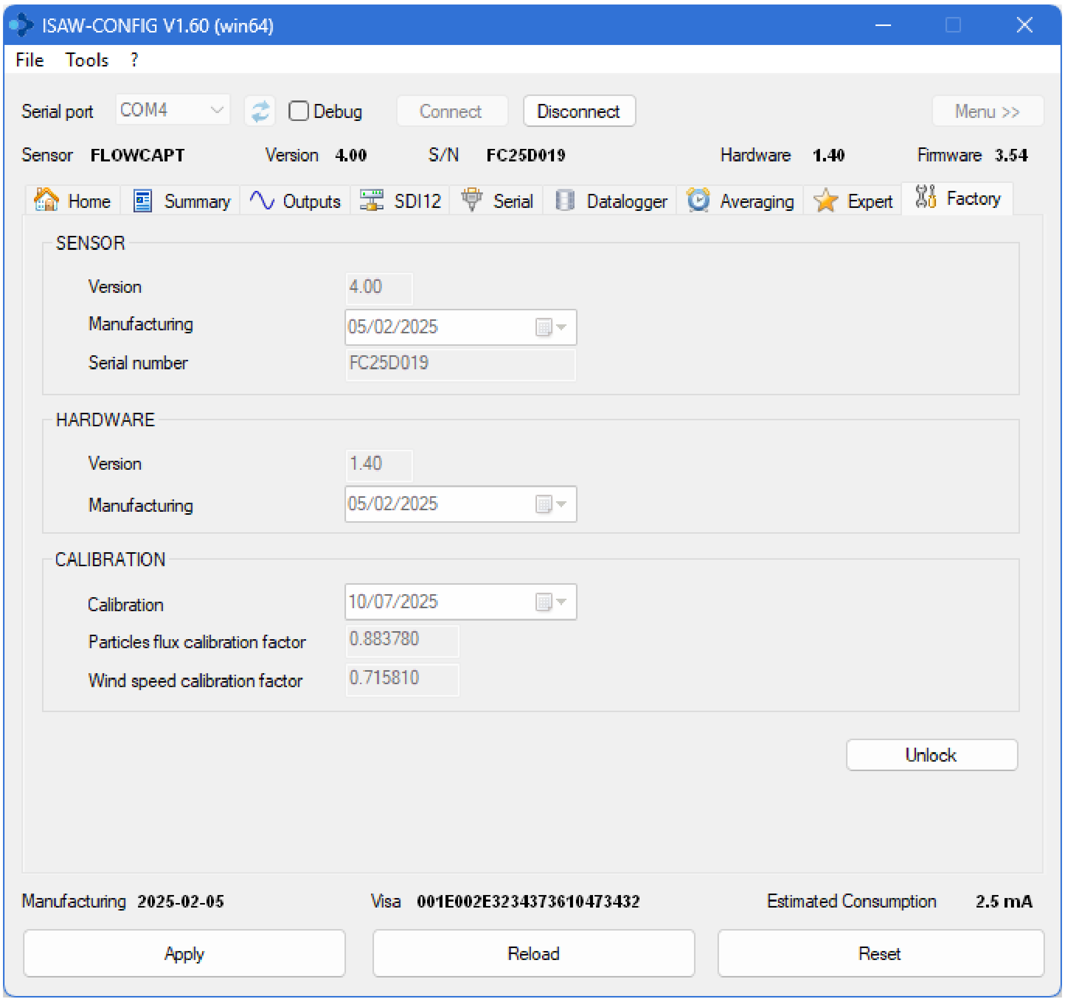
WARNING: Changing these parameters is not recommended.

The [Reset] button allows you to always return to the default factory settings.

3.3.8. Factory panel

The factory panel displays, in a read-only mode, the factory identifiers and calibration settings of your instrument.

Note: Only the manufacturer or the integrator can modify these parameters.



In case of failure of your instrument or when contacting the support, it is recommended to keep a copy of this information at hand to facilitate the identification of your instrument.

3.4. Configuration in Terminal mode (serial communication)

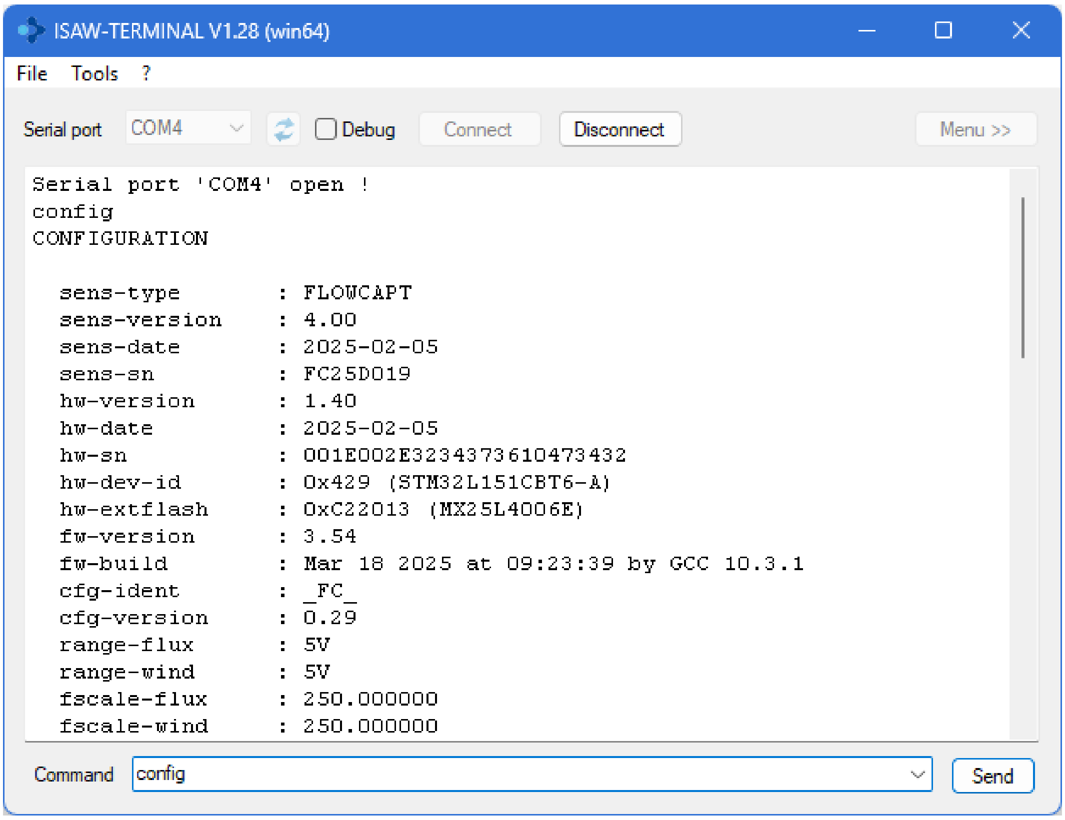
This section describes how to change a parameter of your FlowCapt FC4 sensor using a serial terminal utility.

To use the ISAW Toolbox Configuration Utility, refer to section 3.3.

In the following explanations we use the terminal emulator provided with the free ISAW Toolbox software suite (available at www.isaw-products.com), but you can also use any serial terminal like Putty, TeraTerm, HyperTerminal, or other.

1. Open the ISAW-Toolbox by double-clicking on the ISAW icon on your desktop.
2. Start the Terminal utility by clicking on the corresponding item.
3. Select the Serial port the instrument is connected to and press the [Connect] button.
4. Optional: To check the current configuration, enter the `Config` command in the Command entry field and press the [Send] button.

The values of all parameters are displayed[5].



5. To change the required parameter, enter the command `set <parameter> <value>` in the Command entry field, then press the [Send] button.

Note: More serial commands are available in Appendix B

[5] All parameters are detailed in section 3.1.

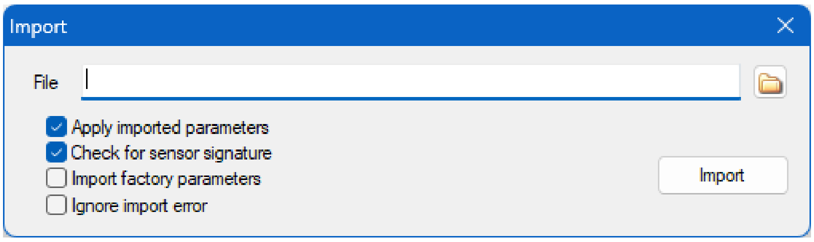
3.5. Import/export configuration

3.5.1. Import configuration

This function allows you to reload the previously exported configuration of an instrument.

Open the ISAW Toolbox Configuration Utility.

Open the Import window: select the "File > Import Configuration" menu. The Import window is displayed.



Select the file to import (*.isawcfg file): either enter the file name in the field, or click on the selection button, or drag and drop the file directly on the entry field.

Choose the import options. The default settings cover most of the situations, but you can change any of the following options:

Option	Description
Apply imported parameters	Send the imported configuration directly to the instrument when the import is completed.
Check for instrument signature	Check if the imported file has been exported from the same instrument (check the instrument's physical address).
Import factory parameters	Include the factory parameters in the import. This operation requires a password to unlock the factory parameters.
Ignore import error	Continue the import even if an import error occurs. If this option is not activated, the import stops at the first error.

Start importing by clicking on the [Import] button.

Note: If the option "Apply imported parameters" is unchecked, you will need to click on the [Apply] button once the import is completed to send the imported configuration to the instrument.

3.5.2. Export configuration

The export function operates the same way. It allows saving the instrument current configuration into a file.

Open the ISAW Toolbox Configuration Utility.

Open the Export window: select the "File > Export Configuration" menu. The Export window is displayed.

Enter the name of the export file. The default file name is the instrument's serial number with a .isawcfg extension.

Start the export by clicking on the [Save] button.

4. INSTALL THE FlowCapt FC4

4.1. Conditions of use

Always remember that the FlowCapt FC4 instrument is an acoustic instrument and could thus potentially be affected by structure-borne vibrations issuing from the supporting structure (for example, a steel cable impacting repetitively on a metal mast when subjected to wind); or to a lesser extent by parasitic low-frequency noise from the immediate environment (for example, excessive proximity to heavy traffic or machinery could lead to parasitic signals). It is recommended that you pay attention to avoiding possible parasitic noise when mounting the project.

4.2. Wiring & I/O Mapping

4.2.1. Instrument cable

Each instrument is delivered with a **5 m cable** prepared with bootlace ferrules at each of its 8 conducting wires, ready to be plugged into the 8-pin screw terminals of the ISAW accessories or any other terminal of your choice.

Cable reference:

LÜTZE SUPERFLEX ® TRONIC (C) PUR 7×0.25, ref. 117103with 7 conductors AWS 24 / 0.25 mm^2

The 8th conductor (color: BLACK) is a 10 cm length termination welded on the shield.

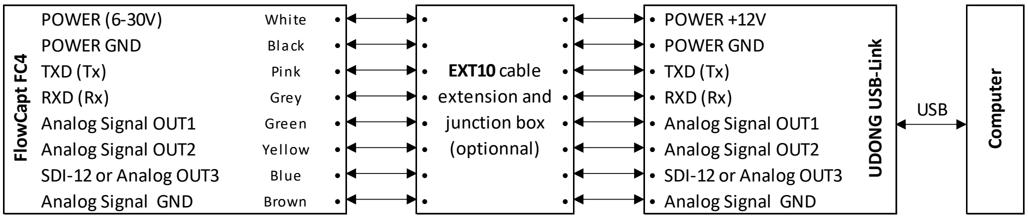
WARNING: It is strongly advised **not to shorten the factory cable**. Should you be obliged to, you must absolutely treat the shield as the BLACK (POWER GND) conductor, that is, protect the nude shield with a black thermo sleeve, crimp a terminal, and make sure to connect it to the GND of your connected device.

Wire	Signal	User selectable	Plug and play Default factory settings
White	Power +	No	Positive power supply (6 to 30) VDC
Black	Power GND (0V)	No	Power GND (0V)
Pink	TX	▪ Disabled ▪ Wind speed only ▪ Particle flux only ▪ Wind speed and particle flux	RS-232 active, Wind speed and particle flux
Grey	RX		
Green	OUT1	▪ Disabled ▪ Wind speed (Persistent, +0V to full-scale +2.5V or +5V) ▪ Particle flux (Persistent, +0V to full-scale +2.5V or +5V) ▪ Particle flux (Pulse, +0V to full-scale +2.5V or +5V)	Particle flux, persistent, +0V to +5V
Yellow	OUT2	▪ Disabled ▪ Wind speed (Persistent, +0V to full-scale +2.5V or +5V) ▪ Particle flux (Persistent, +0V to full-scale +2.5V or +5V) ▪ Particle flux (Pulse, +0V to full-scale +2.5V or +5V) ▪ aw signal (±2.5V) (Note: direct, unfiltered AC output of the instrument)	Wind speed, persistent, +0V to +5V
Blue	SDI-12	▪ Disabled ▪ Wind speed only ▪ Particle flux only ▪ Wind speed and particle flux	SDI 12 bus active, address: 0, Wind speed and particle flux
Brown	Signals GND	No	OUT1 GND, OUT2 GND and SDI-12 GND

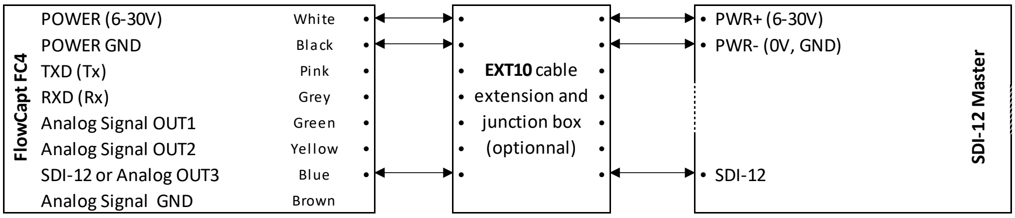
The instrument can simply be used by reading DC outputs (+0 to +2.5V or +0 to +5V continuous or pulse analog voltages available). Note that the continuous DC analog voltages are persistent on the outputs so that output voltages can be read at any time (the reading interval from your peripheral is independent from the duration of the time integration of the instrument).

4.2.2. Wiring diagrams

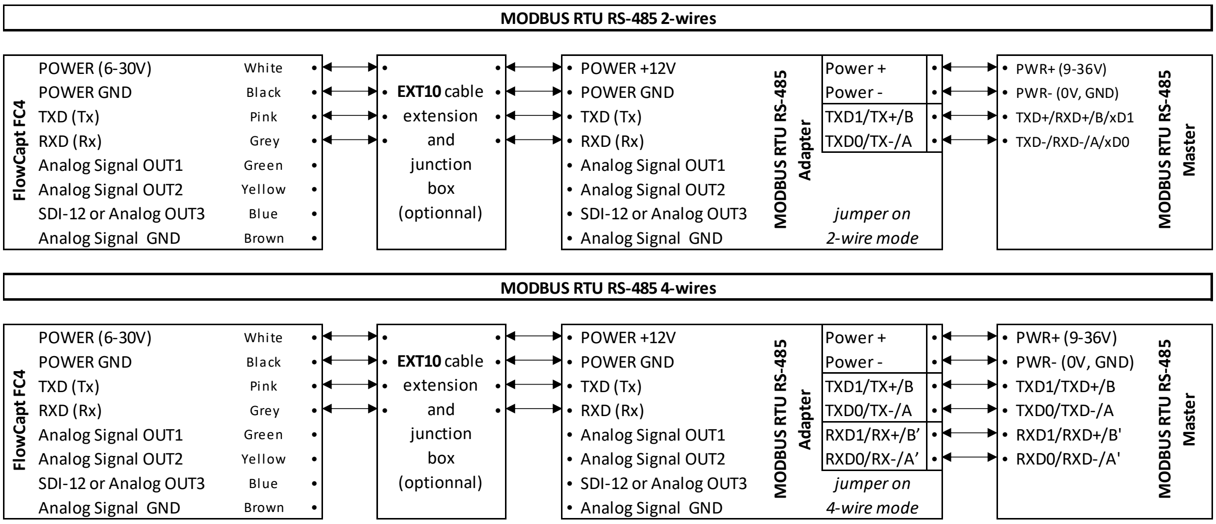
Direct USB-Link serial connection to computer COM port



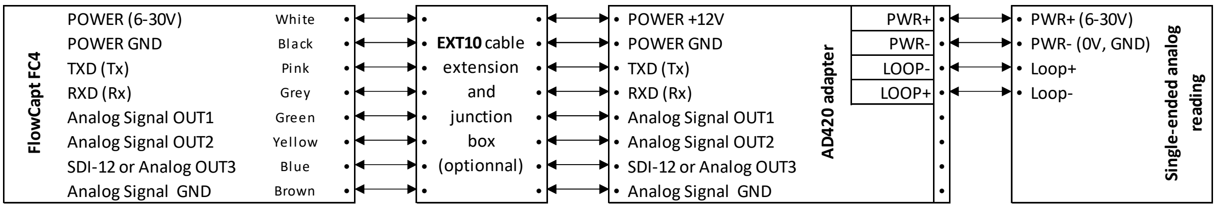
SDI-12 Data logger (or other SDI-12 interface)



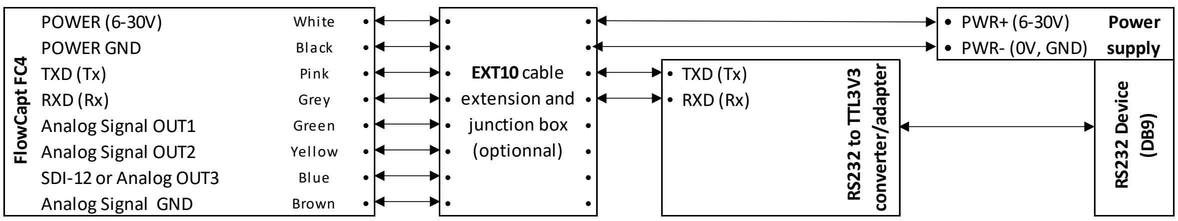
Modbus RTU RS-485



4-20 mA Current Loop



RS232 Serial (ex. DB9 on computer)



4.3. Mounting instructions

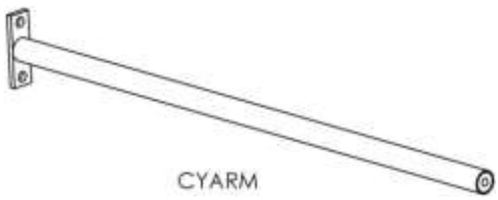
FlowCapt FC4 package content

Item ref.	Description	Quantity	
		FCBRA	FC2MA
FC4	FC4 FlowCapt instrument	1	2
UDONG	USB dongle	1	1
CYARM	Cylindrical arm	2	4
BRARF	Front bracket	2	
BRARB	Back bracket	2	
BRASH	Reduction shim	4	
SLEEVE	Plastic sleeve	2	4
BN 611 M10x110	M10 × 110 mm screw	2	4
BN 611 M10X70	M10 × 70 mm screw	4	
BN 610 M10X40	M10 × 40 mm screw	4	
BN 610 M10x25	M10 × 25 mm screw		8
BN 675 M10	M10 serrated lock washer		8
BN 13289 M10x25x4	M10 washer 4 mm thick	8	
BN 33010 M10	M10 securing nut	8	
TMAST	Tripod mast (see TMAST Package content)		1

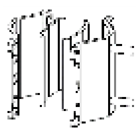
Instrument

FC4

Mounting kit



Bracket kit

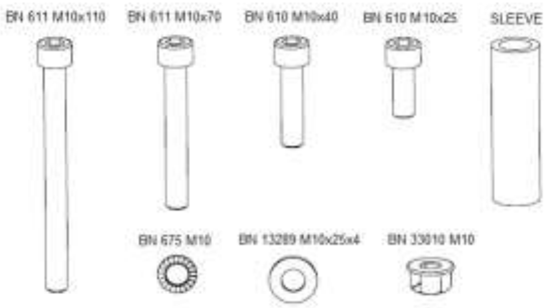


BRARB + 2xBRASH + BRARF

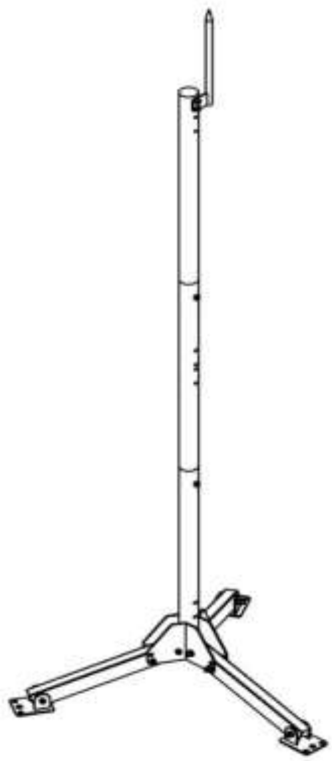
USB dongle

UDONG

Screw kit

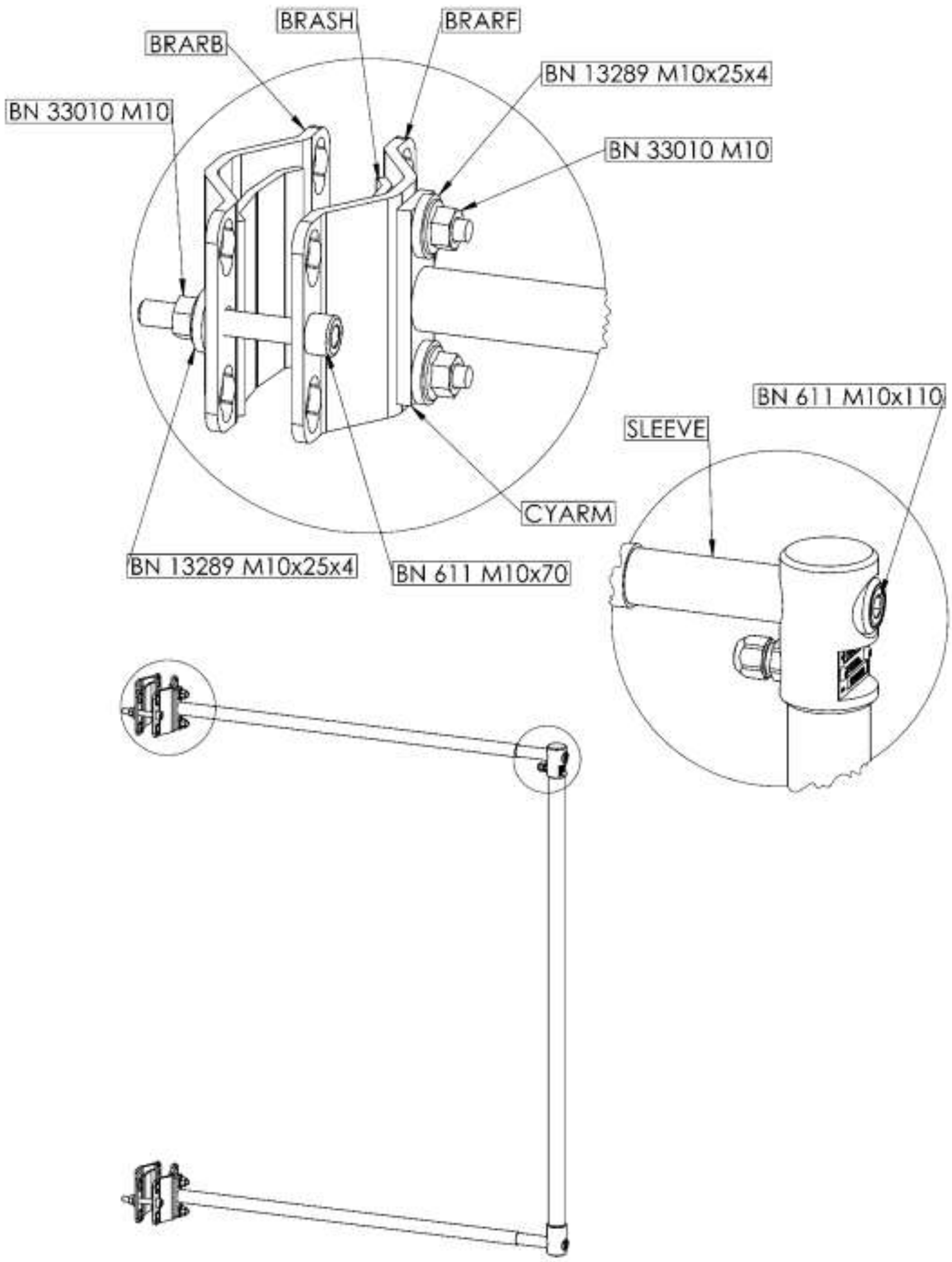


Tripod mast



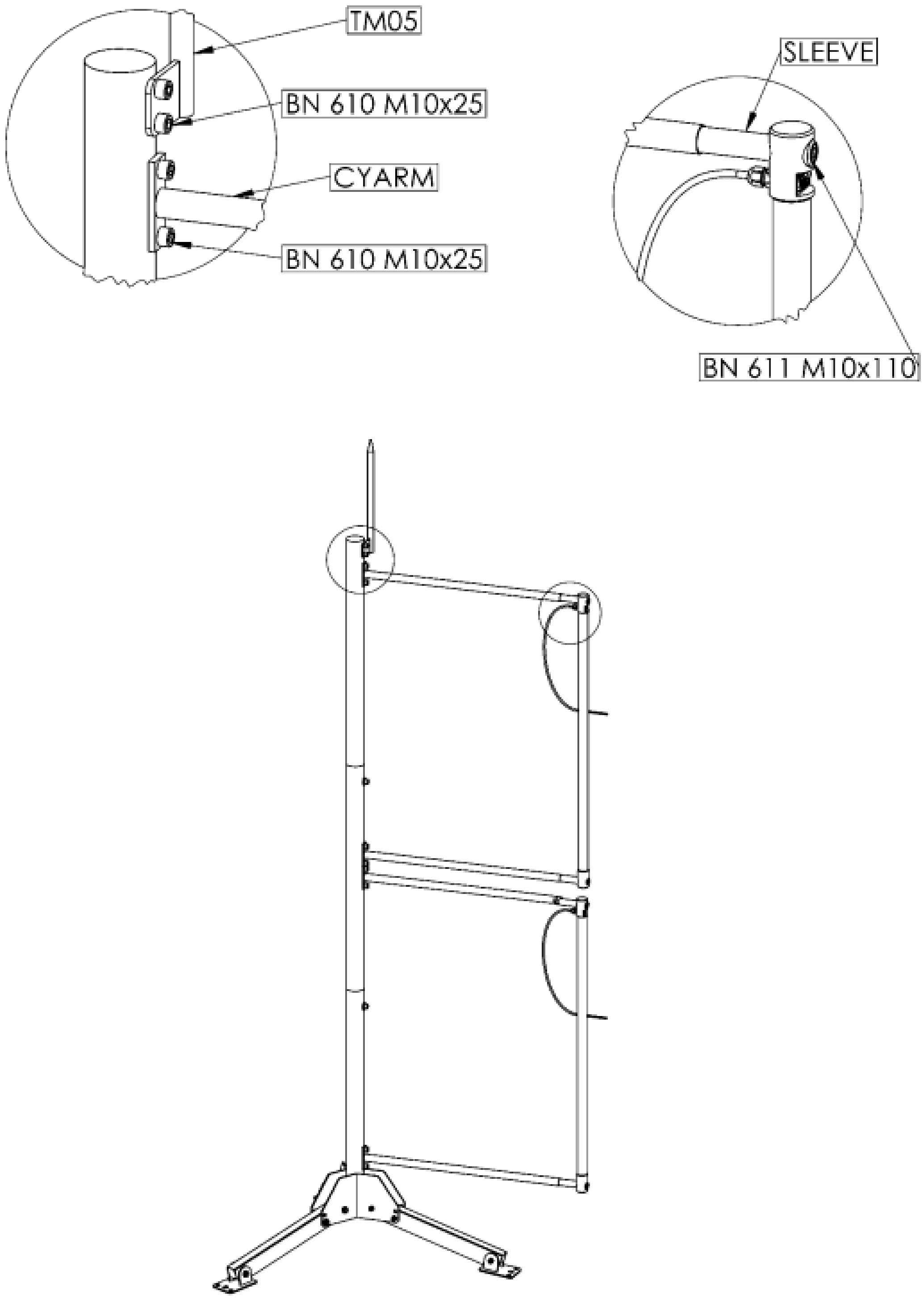
TMAST

FCBRA Mounting instructions



- Always mount the **INSTRUMENT HEAD** (end with cable) **ON TOP**.
- For a **MAST OF OUTER DIAMETER ≥ 60 mm**, replace the screws BN 610 M10X40 with BN 611 M10X70.
- For a **MAST OF OUTER DIAMETER ≥ 65 mm**, remove the reduction shims (BRASH).
- To fasten the sensor on a **FLAT SURFACE**, screw the front brackets (BRACF) directly onto the surface.
- The instrument's cable must be **tightly secured** to the arm and mast using tie wraps.

FC2MA Mounting instructions

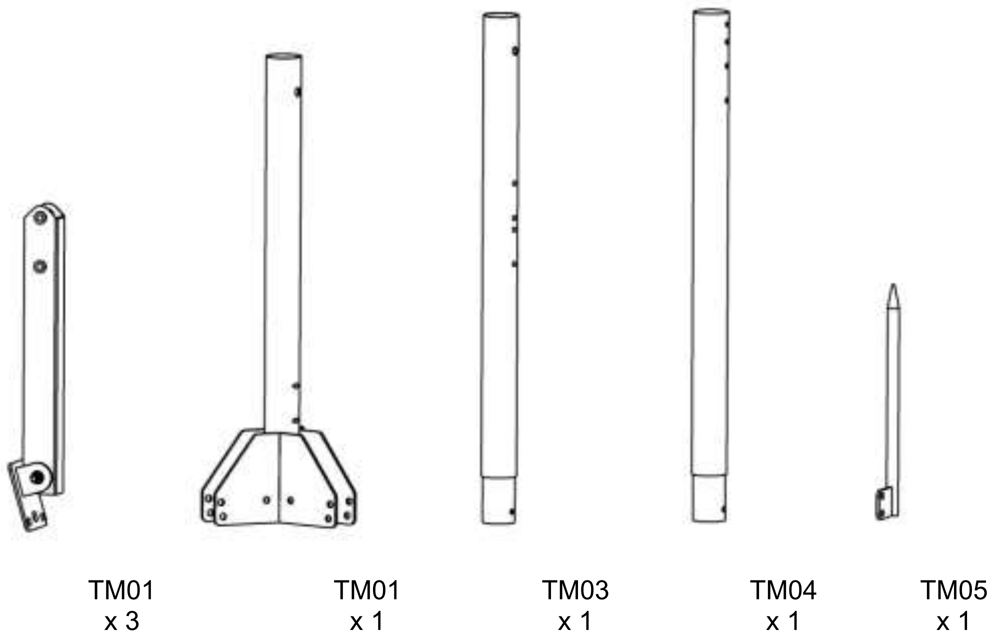


- See **TMAST Mounting Instructions** to assemble the tripod mast (TMAST).
- Always mount the **INSTRUMENT HEAD** (end with cable) **ON TOP**.
- The instrument’s cable must be **tightly secured** to the arm and mast using tie wraps.

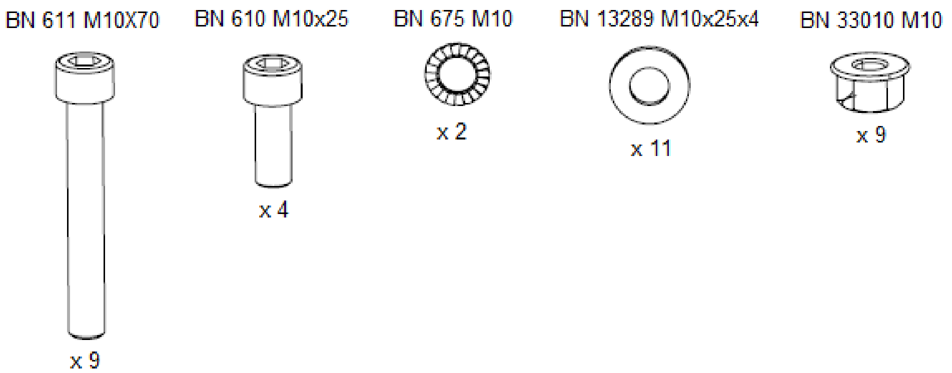
TMAST Package content

Ref.	Description	Quantity
TM01	Leg with inclinable foot	3
TM02	Base tube	1
TM03	Mid tube	1
TM04	Top tube	1
TM05	Lightning rod	1
BN 610 M10x25	M10 × 25 mm screw	4
BN 611 M10x70	M10 × 70 mm screw	9
BN 675 M10	M10 serrated lock washer	2
BN 13289 M10x25x4	M10 washer 4 mm thick	11
BN 33010 M10	M10 securing nut	9

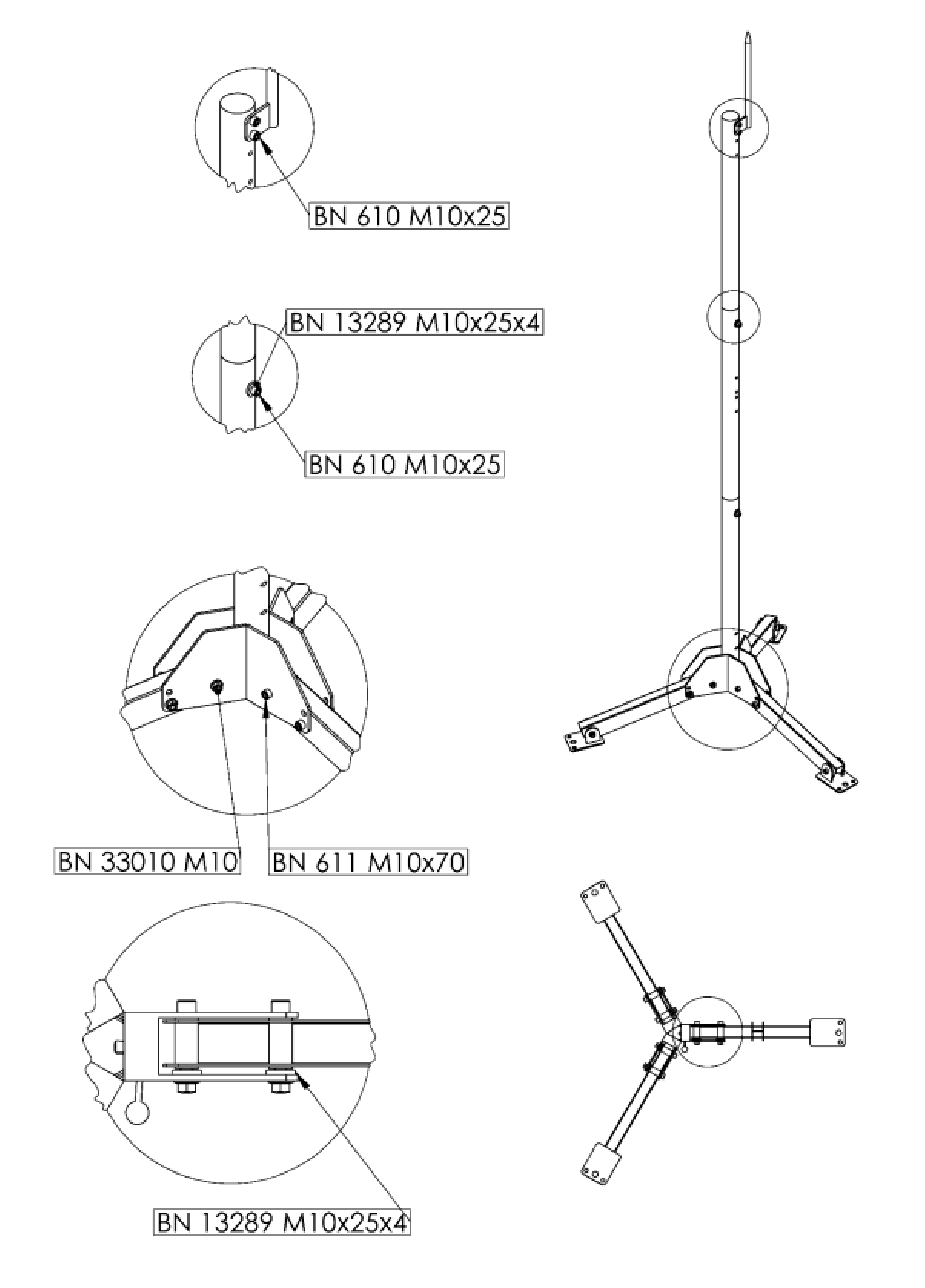
Mast kit



Screw kit



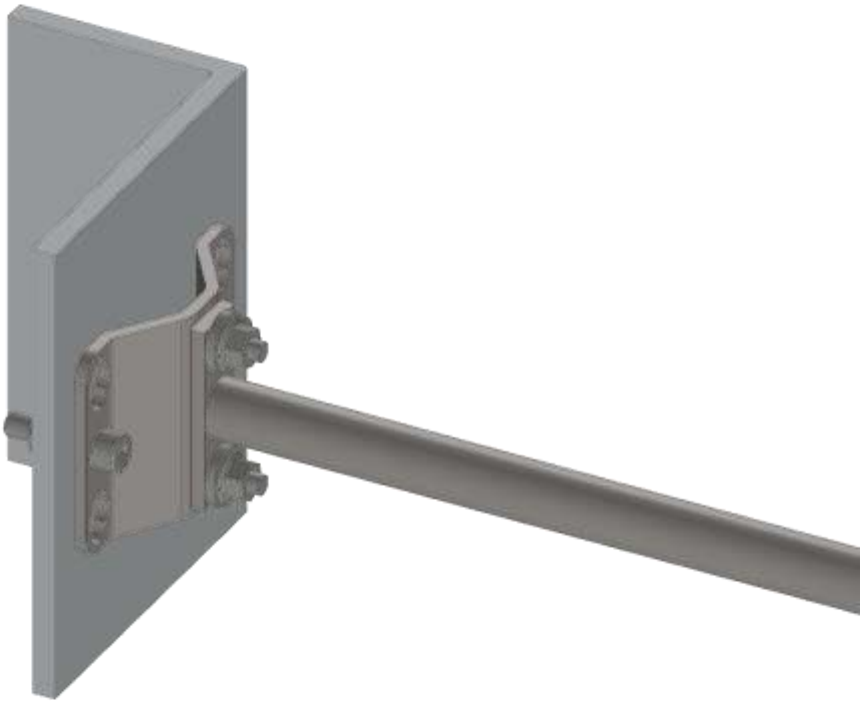
TMAST Mounting instructions



4.4. Mounting examples

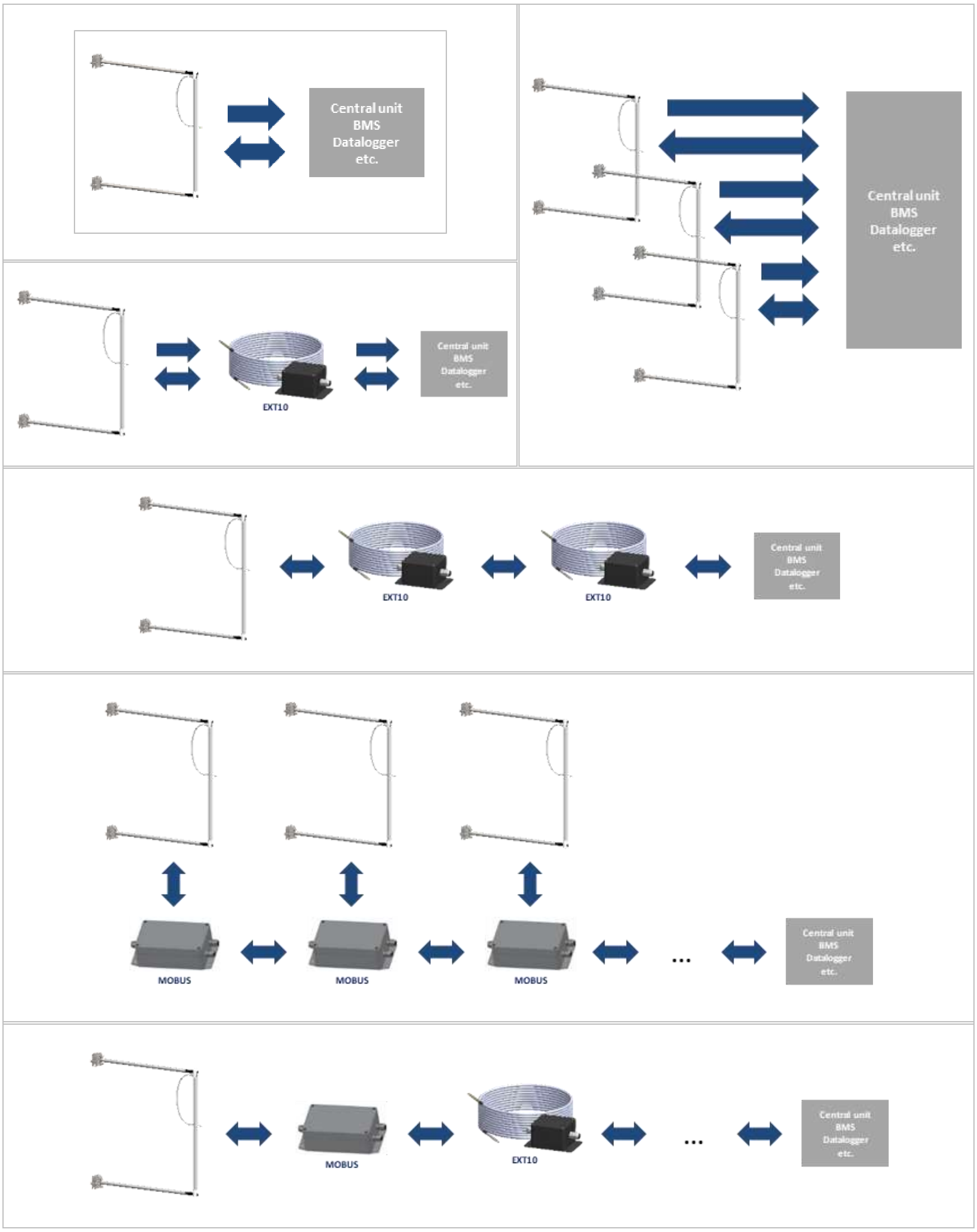
On a vertical, horizontal (or oblique) **cylindrical mast** with an outer diameter of **40 mm**, use the provided V brackets.

On a vertical, horizontal (or oblique) **cylindrical mast** with an outer diameter of **25 mm**, use the provided V brackets and reduction shims.



On a **flat surface**, screw the V brackets (or the arms directly) onto the surface.

4.5. Chaining examples



5. OPERATE THE FlowCapt FC4

5.1. Disclaimer

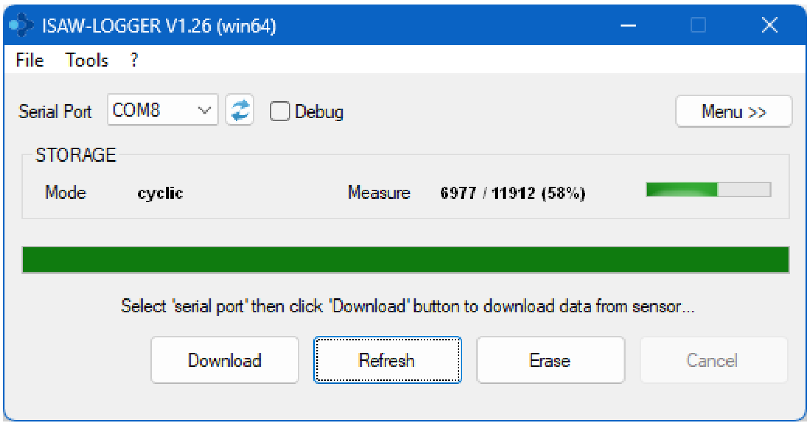
When using the FlowCapt FC4, IAV Technologies SARL is not responsible for the choice, selection, relevance and usage appropriateness of the instrument installation site; nor for the usage, interpretation, and extrapolation of the information made available to the users. Any known system issues that may induce dysfunction or skew the measurements are reported to the users through documentation updates. To continually improve the system, the ISAW Products division of IAV Technologies SARL reserves the option to upgrade the instrument hardware, software, and user recommendations anytime.

5.2. Recording data using the internal datalogger

By default, the internal datalogger is activated in cyclic mode, i.e. the newest data constantly overwrites the oldest ones when the memory is full.

To change the recording mode or the content of the data frames, please refer to section 3.3.5.

To check the status of the datalogger, open the Datalogger utility of the ISAW-Toolbox (see § 1.9.4).



The mode can be: **Disabled** (no data is recorded), **Enabled** (data are recorded until the memory is full) or **Cyclic** (data are recorded and the oldest data are constantly overwritten when the memory is full).

Measure is the number of recorded measurements / Total number of recordable measurements.

The **gauge** shows the datalogger's memory status.

Press the [Refresh] button to update this information.

To download data from the datalogger, press the [Download] button. The content of the datalogger is saved into a .CSV file. This operation does not clear the datalogger.

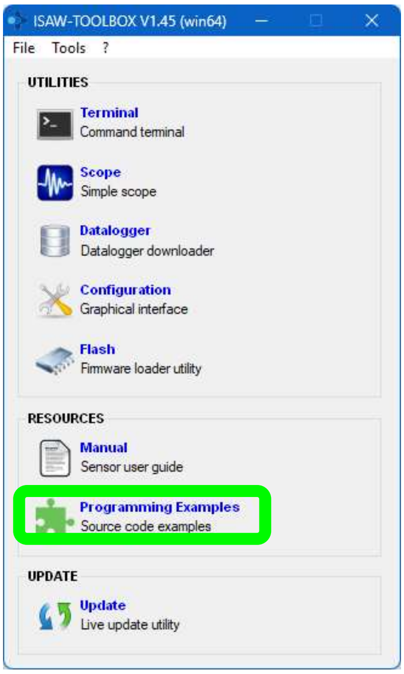
To clear the datalogger (i.e. delete all logged data), use the [Erase] button.

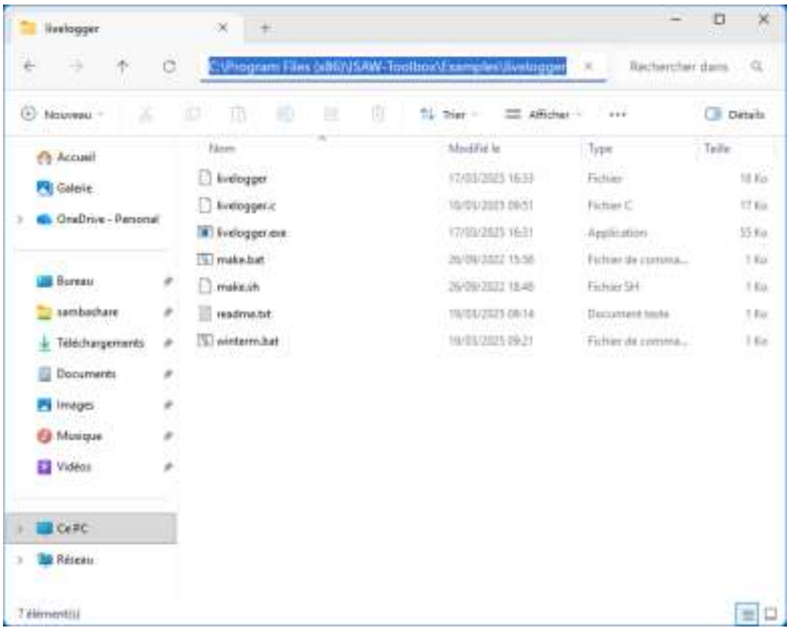
WARNING: This operation is irreversible: deleted data are definitely lost.

5.3. Recording data on a computer

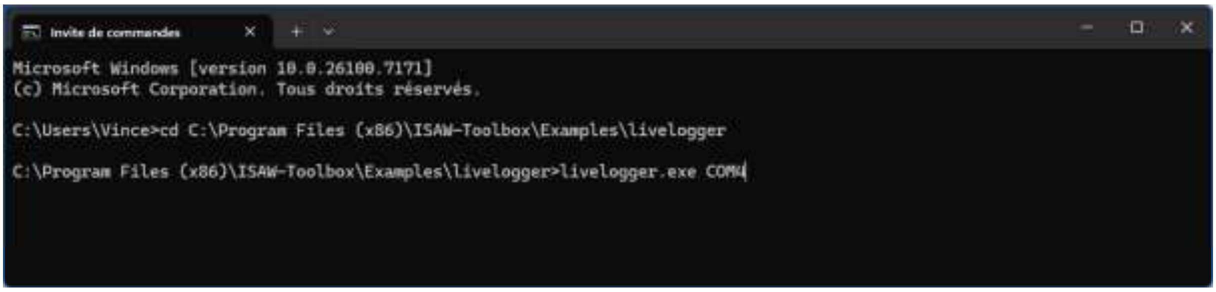
If connected to a computer with the USB link accessory, you can also log indefinitely the data produced by the instrument and without installing any software by means of the **livelogger utility** which is an executable program example available with the ISAW-Toolbox software suite.

Open the **Programming Examples** folder from the ISAW Toolbox to get the full pathname of the livelogger executable.





Open a command prompt, go to the right directory and execute livelogger.exe on the COM port the instrument is connected to.



The data is displayed according to the specified A,C,M setting of the instrument (cf. § 0), and a .CSV file is also produced in the same directory. The data is timestamped according to the clock of your computer.

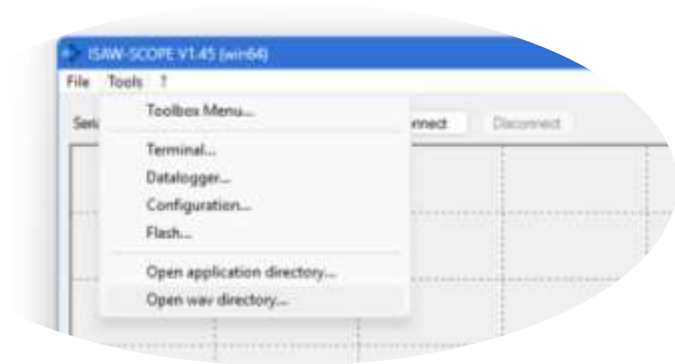
```
Microsoft Windows [version 10.0.26100.7171]
(c) Microsoft Corporation. Tous droits réservés.

C:\Users\Vince>cd C:\Program Files (x86)\ISAW-Toolbox\Examples\livelogger

C:\Program Files (x86)\ISAW-Toolbox\Examples\livelogger>livelogger COM4
LIVELOGGER SAMPLE V1.01 (WIN64)
Waking up sensor...
Getting sensor type...
Getting sensor serial number...
Logging data from FLOWCAPT FC25D019 to 'ISAW_FLOWCAPT_FC25D019_20251119_180624.csv'...
(Use CTRL+C to abort)
2025-11-19 18:06:43;FLUX;10;g/m2/s;0.76;1.48;2.52;0.68;g/m2;22.42
2025-11-19 18:06:43;WIND;10;km/h;59.96;64.49;72.71
2025-11-19 18:06:53;FLUX;11;g/m2/s;0.03;0.12;0.36;0.13;g/m2;23.66
2025-11-19 18:06:53;WIND;11;km/h;48.90;52.40;58.42
2025-11-19 18:07:03;FLUX;12;g/m2/s;0.05;0.17;0.60;0.24;g/m2;25.33
2025-11-19 18:07:03;WIND;12;km/h;36.13;44.10;51.78
```

Note: If the internal datalogger of the instrument is activated, in case of unwanted interruption of the livelogger communication you will still be able to retrieve a backup of the data.

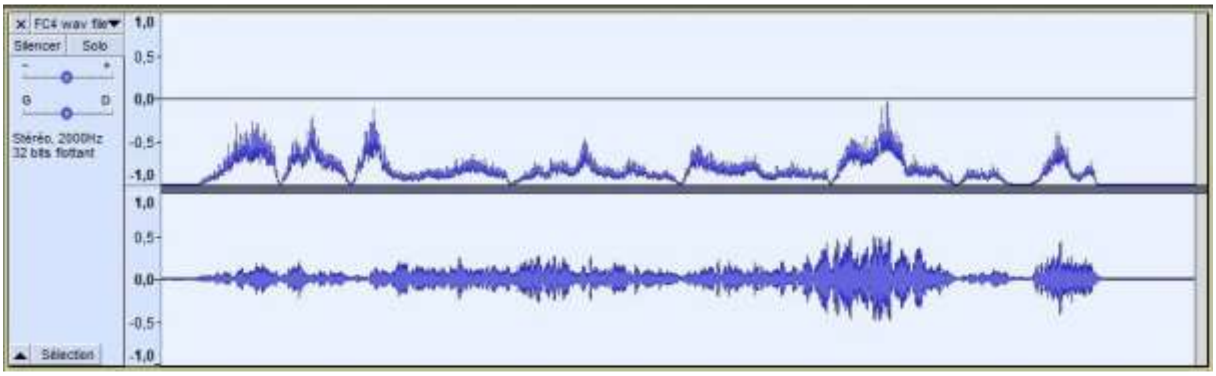
5.4. Getting a .WAV signal from the instrument

The instrument has a function that allows the direct recording of the raw measurement signal in the format of a .WAV sound file. To activate this function, open the **Scope utility** of the ISAW-Toolbox (see § 1.10) and check the "Record to wav" item in the "File" menu.

To open the .WAV file, use the "Tools > Open wav directory…" menu of the Scope utility.



The .WAV file is 16 bits, PCM, 2000 Hz sampling rate stereo file, which contains in the left channel the RMS, unfiltered envelop of the raw AC signal, and in the right channel the unfiltered raw AC signal. The following example shows a reading of such .WAV file in the Audacity® freeware, the capture showing a 18 seconds time history recording obtained while grabbing the tube with the fingers.



5.5. Update the instrument firmware

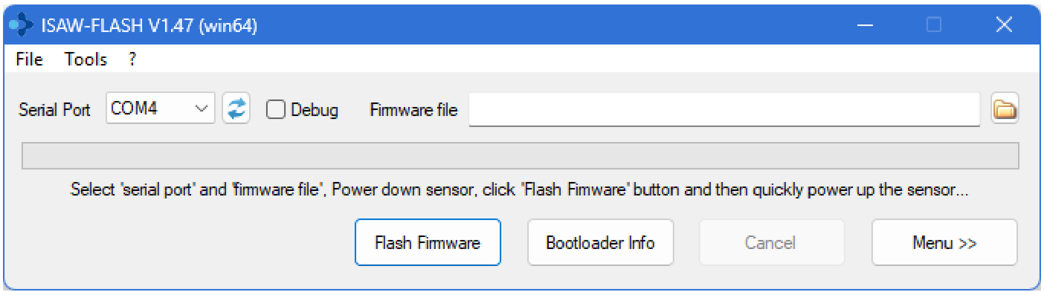
IAV Technologies constantly improves its products and provides upgrades of the ISAW firmware for all instruments. This section describes the procedure for upgrading the ISAW firmware.

Note: The instrument's configuration is not affected by the firmware update: existing parameters keep their value and new parameters, introduced with the new firmware's version, are set to their default value (see section 3.1).

Prerequisites:

- The ISAW-Toolbox is installed (see § 1.9.4).
- The last versions of the instrument firmware are installed (use the Update utility to check).
- The instrument is plugged to your computer using the USB Link accessory.

Open the ISAW Toolbox **Flash** Utility



Select the Serial Port the USB link is connected on.

Note: If you don't see the USB link serial port, it may be that another application is using it, so close all applications and restart ISAW-Flash.

Select the firmware file: Select the last version of the firmware corresponding to your instrument:

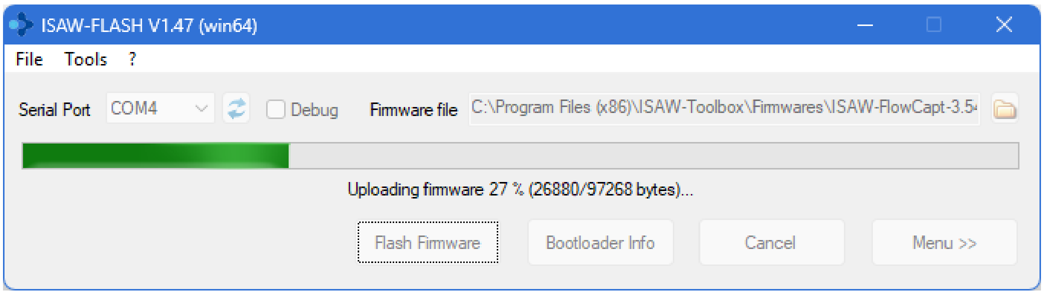
ISAW-FlowCapt-x.xx.bin (where x.xx is the version number)

WARNING: The firmware folder contains all instruments firmware files. Make sure you select the one dedicated to your instrument!

Shut down the instrument power supply: set the USB Link power switch to OFF.

Press the [Flash Firmware] button. At this stage, ISAW-Flash will automatically search for a powered instrument during ten seconds.

Power-on the instrument: Switch the USB link power back to ON. As soon as ISAW-Flash has found the powered instrument, the firmware upload starts automatically.



Wait during the firmware upload. This may take a few minutes.

WARNING: Do not disconnect the power supply during firmware upload.

When the firmware upload is successfully completed, a confirmation message is displayed.

The instrument is now ready to use.

Note: The [Bootloader Info] command button retrieves the information of the bootloader installed on the instrument.

5.6. Troubleshooting

5.6.1. USB connection problem

Not or no longer recognizing the COM port when the UDONG is plugged to the computer. The port is not auto-selected, nor available in the pull-down menu.

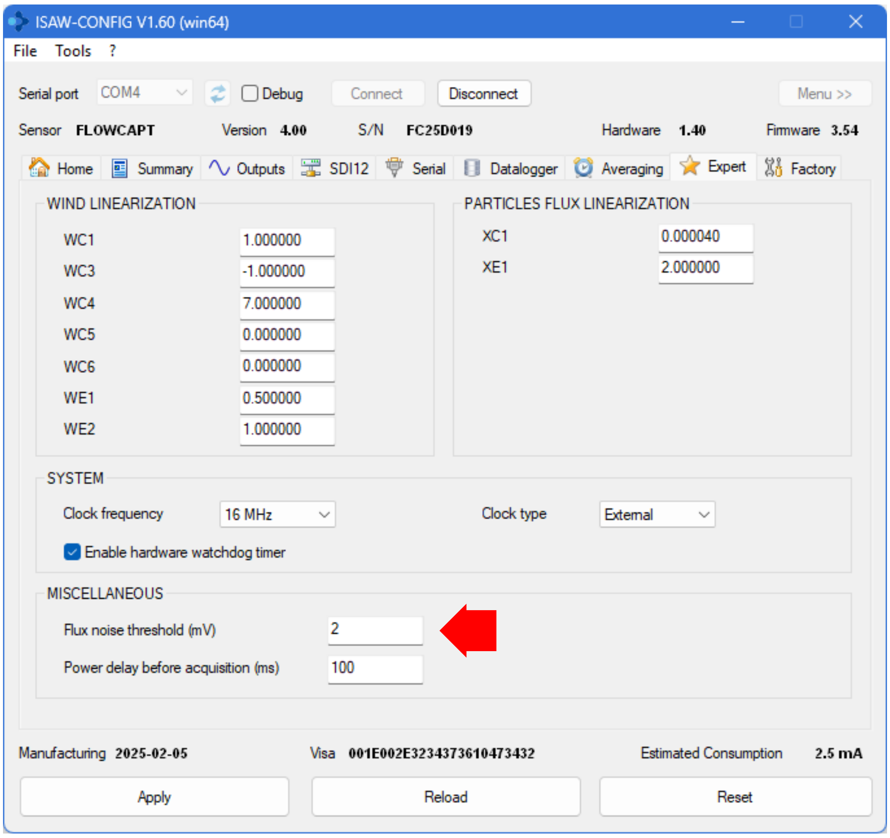
- Power off the UDONG. Unplug the UDONG from the computer and unplug the instrument from the UDONG.
- Plug the UDONG alone back to the computer. The TX and RX (red and orange) LEDs on the UDONG should blink for a few milliseconds. Then, when powering "ON" the UDONG, the green led on the UDONG should switch on. If not, either the UDONG or the USB port is defective.
- If you have a multimeter, connect the instrument (or just the terminal block alone) to the UDONG and check on the terminal block screws if you really get 12 V between "POWER +12V (white)" and "POWER GND (black)". If not, this means that the USB port of your computer is not providing the standard 12V, 500 mA USB powering.
- Double-check the wiring of the instrument to the terminal block pins (cut cable, untightened screw, cable(s) on the wrong terminal pin(s)).
- If the LEDs are working properly and the wiring is correct, it may happen that the COM port is preempted by another application, for example if another USB-to-serial device has been installed, which can cause driver conflict. In this case, try to choose an alternate driver in the "Device Manager", or fully uninstall and reinstall the driver. In both cases, unplug and re-plug the device after to re-enumerate USB and/or reinstall the driver.

As another simple test of the full chain (UDONG and instrument), try to connect the instrument to another computer or smartphone (see introduction chapter). If the instrument is recognized, this means that the issue is most probably on the USB side of your computer.

Tip: While testing the USB connection, seize the opportunity to upgrade the ISAW-Toolbox software suite (just open it) as well as the instrument firmware (see § 5.5). This is not a requirement, but may help to solve the issue.

5.6.2. Avoid parasitic noise

In the case of an instrument placed in a particularly noisy environment or for example rigidly attached to a structure subject to high vibrations, it is possible to set a threshold below which the signals will be automatically converted to zero by the instrument in the internal calculations of wind flux and speed.



6. ORDERING, MAINTENANCE & SUPPORT

Ordering references

The FlowCapt FC4 instrument is available with its fastening arm, and a set of complementary accessories allows you to select the equipment that perfectly matches your operating situation:

Ref.	Description
FCBRA	FlowCapt FC4 instrument with mounting kit
FC2MA	Pair of FlowCapt FC4 instruments fastened on a mast
UDONG	USB Link accessory (provided with FCBRA)
EXT10	Cable extension, 10 meters, including JUBOX junction box. (Note: You can chain several items, or ask for a specific cable length.)
MOBUS	Modbus RTU-485 adapter
AD420	4-20 mA adapter
TMAST	Supporting structure: tripod mast

Shipping

Eco-friendly packaging, worldwide shipping within 1-5 days a.r.o., URGENT BUSINESS shipping mode.

Safety and care

The full instrument and fastening elements is a heavy and plain device, it must always be fastened very cautiously and all the nuts tightened to avoid any possible looseness. The nuts are all with an integrated anti-unscrewing washer flange so apart from an improper assembly they cannot loosen themselves.

Cleaning and handling

There is no specific recommendation for cleaning or handling the instrument. The only soft material of the instrument are the cable and the elastomer damper of the mounting kit. They only require the standard state-of-art of protecting cables and connections, and visual check of the integrity of the material.

Product repair

In the event of an instrument breakdown or damage, IAV Technologies SARL provides all the support and spare parts necessary for a repair, either remotely or by returning the instrument to the factory, if the repair requires a recalibration of the instrument.

Warranty

The FlowCapt FC4 instrument is a repairable products and benefits of a two-year warranty. The instrument, the USB dongle accessory and the mounting accessories are designed and produced with the highest standards. In case of failure, DO NOT TRY to open the instrument. Opening is destructive unless it is done at the factory for repair. None of the moving or user-serviceable parts requires routine maintenance. Opening the unit will void the warranty.

In the event of failure, before returning the unit, we recommend that you:

1. Check all cables and connectors for continuity, bad contacts, corrosion, etc.
2. Conduct a bench test e.g. using the Scope utility.
3. Contact us directly for advice.

Disposal

The instrument and mounting accessories are made of detachable and separable plain metals parts (stainless steel and aluminum), plastic or elastomer elements, a PUR cable and one electronic PCB circuit.

To recycle the instrument and its entire assembly kit, all screws must be disassembled, all the unit elements listed above must be recognized and separated, and placed in the appropriate recycling bins or circuits.

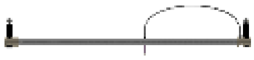
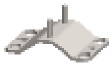
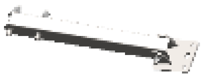
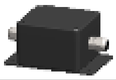
CE

Factory return address:
IAV TECHNOLOGIES SARL
ISAW Products Division
Chemin des Couleuvres 4A
1295 TANNAY
SWITZERLAND

Assistance:
isaw@iav.ch
+41 (0)22 960 11 04

www.isaw-products.com

Spare parts

	Item ref.	Short name		Full description	Quantity			
					FCBRA	FC2MA	EXT10	TMAST
Instrument	FC4	FlowCapt instrument		FlowCapt FC4 instrument	1	2		
Mounting parts	CYARM	Cylindrical arm		ISAW - Cylindrical arm	2	4		
	SLEEVE	Cylinder sleeve		ISAW - Plastic sleeve for instrument	2	4		
	BRARF	Front bracket		Front bracket for fastening arm	1			
	BRARB	Back bracket		Back bracket for fastening arm	1			
	BRASH	Reduction shim		Reduction shim	2			
Mast	TM01	Leg with inclinable foot		Leg with inclinable foot for supporting structure TMAST		3		3
	TM02	Base		Base for supporting structure TMAST		1		1
	TM03	Mid tube		Mid tube for supporting structure TMAST		1		1
	TM04	Top tube		Top tube for supporting structure TMAST		1		1
	TM05	Lightning rod		Lightning rod for supporting structure TMAST		1		1
Acc.	JUBOX	Junction box		Junction box for cable extension EXT10			1	
Standard	BN 610 M10x25	M10 × 25 mm screw		Hex socket head cap screws fully threaded (DIN 912, ISO 4762), stainless steel A2, M10x25 (e.g., Bossard BN 610 Art. No. 1233505)		8		4
	BN 610 M10X40	M10 × 40 mm screw		Hex socket head cap screws fully threaded (DIN 912, ISO 4762), stainless steel A2, M10x40 (e.g., Bossard BN 610 Art. No. 1032860)	4			
	BN 611 M10X70	M10 × 70 mm screw		Hex socket head cap screws partially threaded (DIN 912, ISO 4762), stainless steel A2, M10x70 (e.g., Bossard BN 611 Art. No. 1113356)	4			9
	BN 611 M10x110	M10 × 110 mm screw		Hex socket head cap screws partially threaded (DIN 912, ISO 4762), stainless steel A2, M10x110 (e.g., Bossard BN 611 Art. No. 1488759)				

Item ref.	Short name		Full description	Quantity			
				FCBRA	FC2MA	EXT10	TMAST
BN 13289 M10x25x4	M10 washer 4 mm thick		Flat washers without chamfer, for bolts with heavy duty type spring pins (DIN 7349), A2, M10/10.5/25/4 (e.g., Bossard BN 13289 Art. No. 3062099)	8			9
BN 33010 M10	M10 securing nut		Hex flange nuts (DIN 6923; EN 1661), stainless steel A2, M10 (e.g., Bossard BN 14476 Art. No. 1329359)	8			9
TERM BLOCK PLUG 8POS STR 5.08MM	Terminal block plug		8 Position Terminal Block Plug, Male Pins 0.200" (5.08mm) 180° Free Hanging (In-Line)	1	2	2	

Appendix A: TECHNICAL DATA

Specifications

Measuring characteristics	
Measuring surface	Ø32 × 920 mm cylindrical tube
Physical phenomena detected by the instrument	**Flux** of solid particles transported by the wind (snowdrift, blowing snow, and more generally all kind of solid particle fluxes of the same range of kinetic energy generating **impacts** on the measuring surface). **Wind** speed (more generally, an estimation of the average speed of the laminar aeolian flux generating **friction** on measuring surface).
Measurement accuracy	**Flux:** For a given controlled flux homogeneously distributed along the measuring surface of the instrument (such as particles of a given shape profile, density, Young modulus, falling speed and incidence angle), the response of the instrument varies of ± 5% and the variability between two instruments is below ± 10%. **Wind:** In laminar established conditions and without external parasitic turbulences or low-frequency noise, the wind speed accuracy is ± 15%.
Particle velocity	Not measured. Can only be an interpretation of the wind speed measurement.

Voltage ranges and measuring scales	
Voltage outputs	Continuous analog voltage or pulse analog voltage, user selectable +0 to +2.5V or +0 to +5V are available. Pulse threshold, integrator timeout and duration are also user selectable. The continuous analog voltage persists on the outputs so that output voltages can be read at any time.
Wind speed scaling	Sensitivity @voltage range +2.5V: [10 mV/(km/h)] i.e. +2.5V corresponds to 250 km/h
	Sensitivity @voltage range +5V: [20 mV/(km/h)] i.e. +5V corresponds to 250 km/h
Particles flux scaling	Sensitivity @voltage range +2.5V: [10 mV/(g/m^2/s)] i.e. +2.5V corresponds to 250 g/m^2/s
	Sensitivity @voltage range +5V: [20 mV/(g/m^2/s)] i.e. +5V corresponds to 250 g/m^2/s

Mechanical data	
Material	Plastic and aluminum
Installation	Universal mounting kit provided (ordering reference: FCBRA)
Weight	1 kg without mounting kit 5 kg with mounting kit
Dimensions (H×W×D)	Sensor alone: 1040 mm × ∅32 mm With mounting kit: 1040 mm × 874 mm × 40 mm

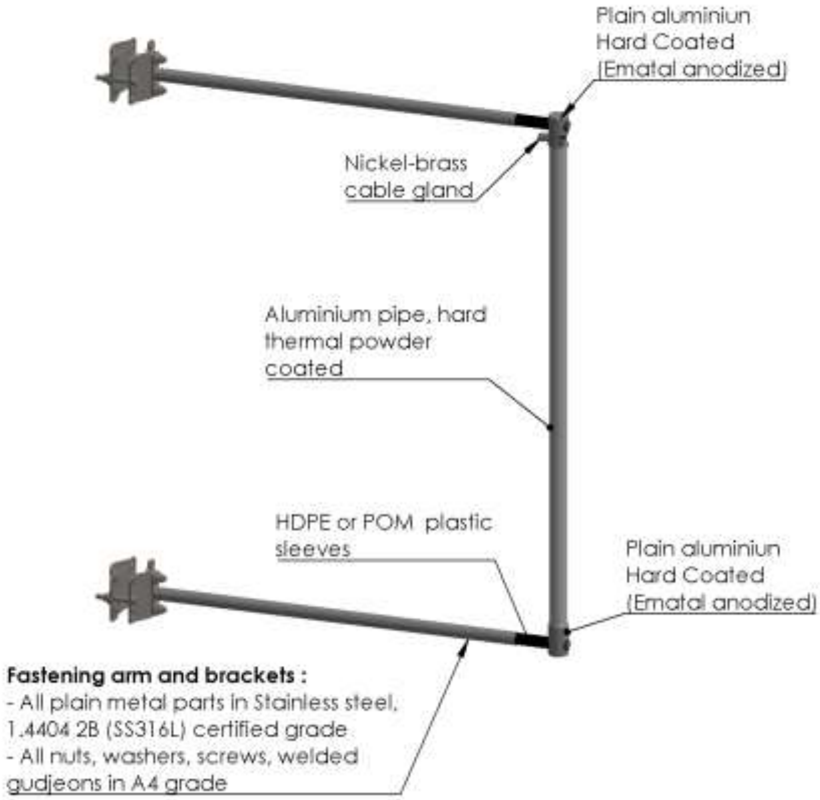
Supply	Ratings
Voltage	6 V to 30 V DC (9.6 V and 16 V DC in case of powering through the SDI-12 terminals)
Current	< 1 mA in stand-by mode and 20 mA max in acquisition mode. For a typical nominal duty-cycle of 10%: 2.1 mA (20 mA for duty-cycle of 100%).

Interfaces	
Analog	Pulse and continuous (and persistent) voltages, 0-2.5V or 0-5V
SDI-12	Yes, 1.3 certified (fully complies with the NR Systems SDI-12 Verifier)
Serial 3V3 TTL	Yes
Modbus RTU (RS485)	Yes, with the Modbus adapter accessory

Environmental conditions	
Temperature range	-40°C to +80°C. Can even operate over this range.
Relative humidity	0 to 100%
Protection	IP67
Standards	EN 61326-1: 2013, CE compliant 2014/30/EU, CE compliant

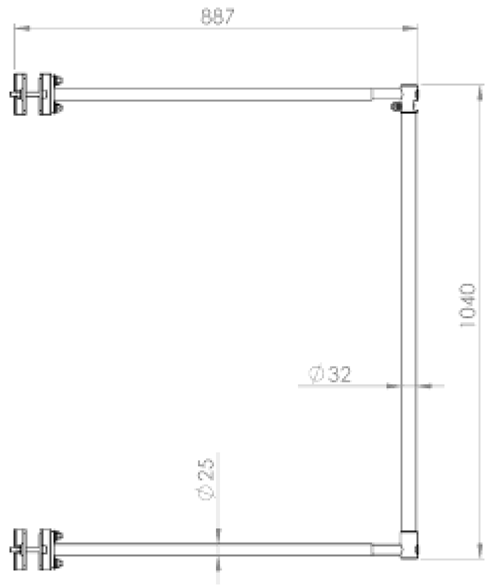
Materials

The sensing of the instrument is a 32 mm outer diameter hard coated aluminum pipe terminated by two plain aluminum hard coated body ends, the sensing head containing the embedded electronics of the device. Both ends are mounted through an elastomer damper and plastic sleeves on a rigid cylindrical high grade stainless-steel fastening arm.

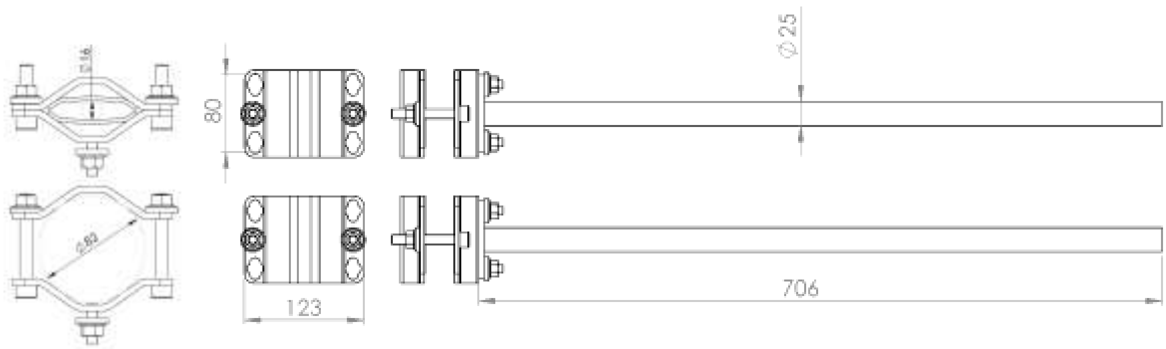


Dimensions

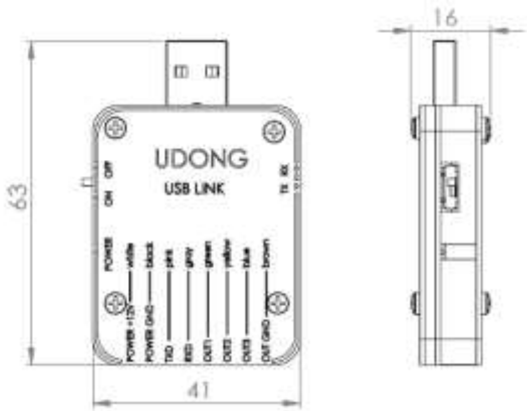
FCBRA



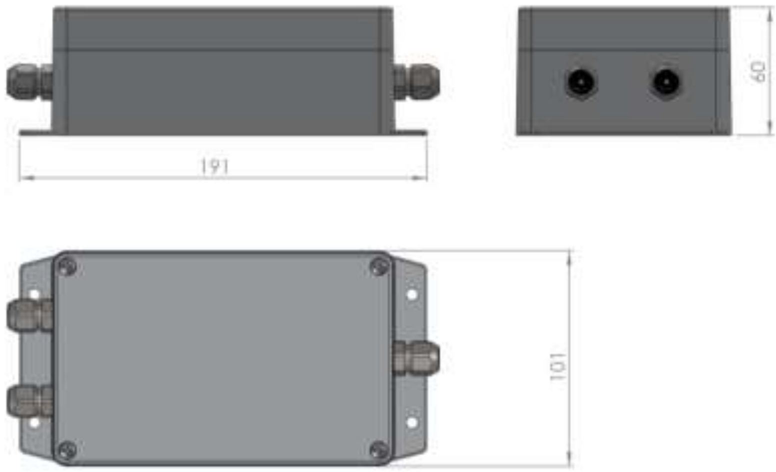
C2BRA



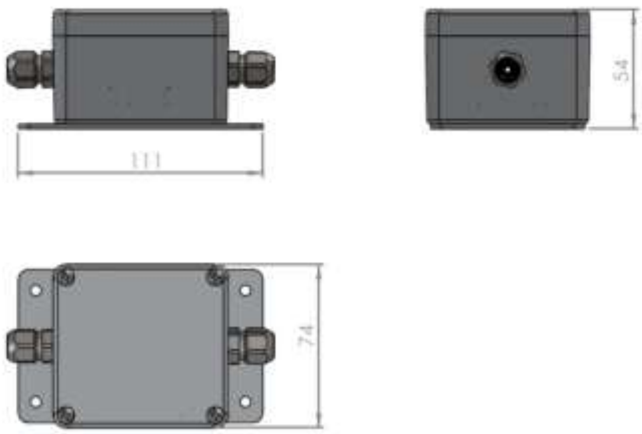
UDONG

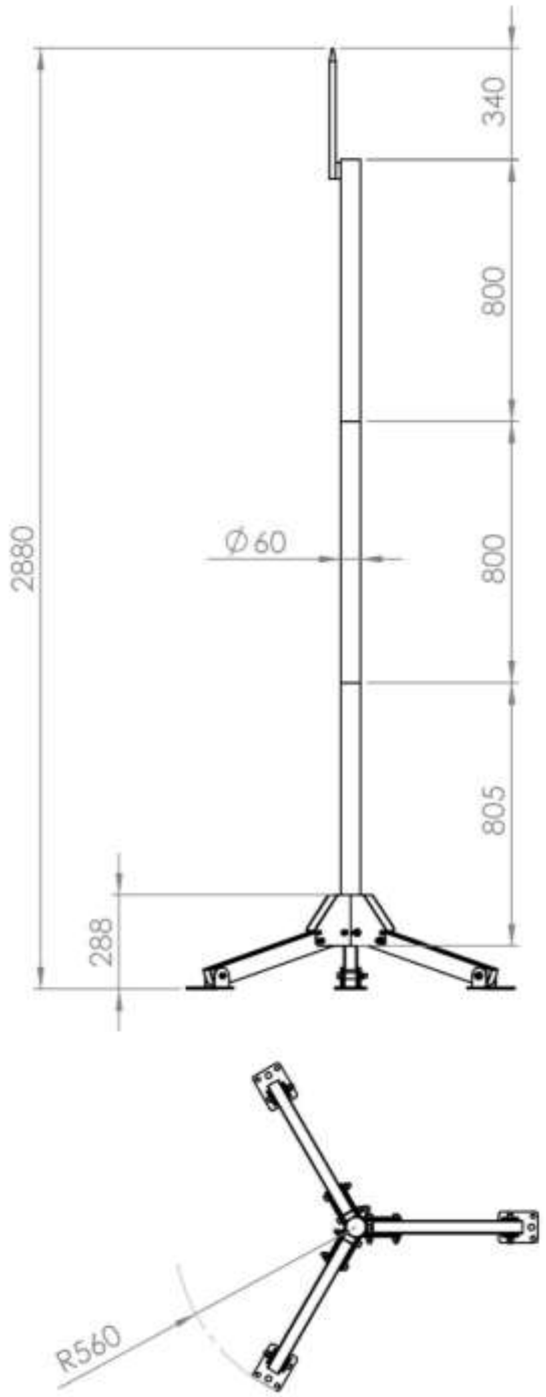
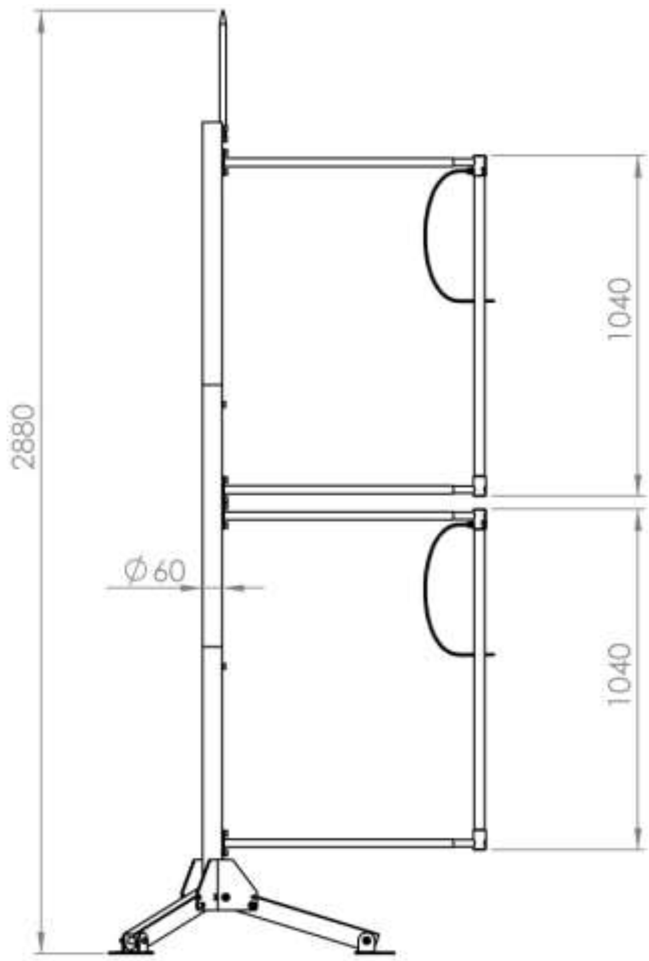


MOBUS



EXT10 / AD420



TMAST	FC2MA
	

Appendix B: SERIAL COMMUNICATION

ISAW provides a serial communication with the instrument with any serial terminal utility like Putty, TeraTerm, HyperTerminal, or other.

B.1. Connect in terminal or console mode

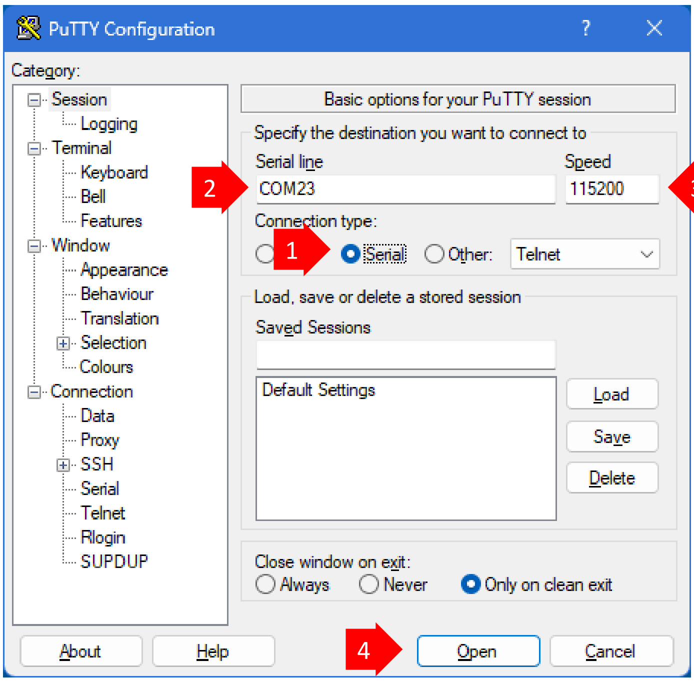
First you need to connect the instrument to a computer with the USB dongle accessory (or using a FTDI 3.3V serial USB converter/adapter).

WARNING: Do not connect the instrument directly to a non-TTL serial port like standard RS232 (DB9 connector). You must use a 3.3V serial adapter; otherwise, you may cause permanent damage to the instrument!

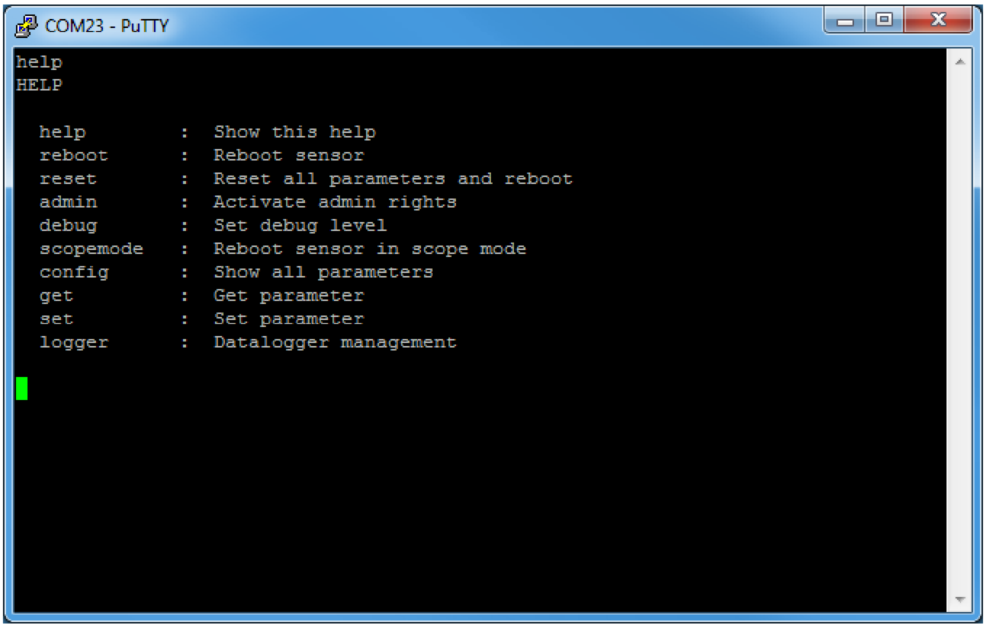
Connect your Terminal software

Open your favorite serial terminal on the serial port (*e.g.: COM23*) at 115200 bauds, 8 bits, 1 stop, no parity. Input terminator is <CR>, Output terminator is <CRLF>.

Example: You can use the lightweight and non-intrusive "putty.exe" freeware available at http://www.putty.org:



Type "help" and press [Enter] to display all available commands:



Execute an ISAW command

Once connected, you can enter any one of the following commands.

B.2. Console commands

All command results share the same format:

`OK` : Successful command.

`OK=<value>` : Successful command with return value.

`ER=<message>` : Command error with error message.

Command	Result / Description
`help`	Displays the list of all available commands.
`reboot`	After changing the instrument configuration, you need to reboot the instrument by using the "reboot" command.
`reset confirm`	Recovers the default factory configuration and reboots the instrument. All parameters are reinitialized, except the following ones (internal factory parameters): sens-type, sens-version, sens-date, sens-sn hw-version, hw-date, hw-sn, fw-version, fw-build cfg-ident, cfg-version, calib-date, calib-wind, calib-flux sys-uptime, sys-status, misc-dbg
`config`	Displays the instrument current configuration (list of all parameters and corresponding values).
`admin <password>`	Activates the admin rights and allows changing special parameters. This command is reserved for factory parameters initialization and requires a password.

<table>
<tr><th>Command</th><th>Result / Description</th></tr>
<tr><td>debug <module> <on|off></td><td>Activates / deactivates the debug mode for a given module. Debug messages are available on the serial console.
Note: It is not recommended to activate the debug mode in production as it may result in ADC overrun.
<module> can be:
all Enable/disable all debug messages (very verbose).
console Enable/disable console debug messages.
acq Enable/disable acquisition buffer output.
measure Enable/disable measurement calculation debug messages.
power Enable/disable power status.
board Enable/disable board debug messages.
sdi12 Enable/disable SDI-12 debug messages.
Example: debug sdi12 on
OK</td></tr>
<tr><td>get <parameter></td><td>Allows getting a parameter value from the configuration.
Example: get sens-date
OK=2016-01-28</td></tr>
<tr><td>set <parameter> <value></td><td>Allows changing a parameter value of the configuration.
The list of all parameters and corresponding values is given in § 3.2.
Note: Remember you need to reboot the instrument after changing the instrument configuration.
Example: set sdi12-addr 7
OK</td></tr>
<tr><td>datalogger <command></td><td>Control the datalogger:
<command> can be:
download Download the data.
clear Delete all logged data.</td></tr>
<tr><td>datalogger <field> <on|off></td><td>Activates/deactivates the logging of a value: <field> can be:
flux_min Minimum flux ($g/m^2/s$)
flux_avg Average flux ($g/m^2/s$)
flux_max Maximum flux ($g/m^2/s$)
flux_std Standard flux deviation ($g/m^2/s$)
flux_cum Cumulative flux (g/m^2)
wind_min Minimum wind (km/h)
wind_avg Average wind (km/h)
wind_max Maximum wind (km/h)
Note: The datalogger must be cleared after changing the configuration fields (see p. 57).
Example: datalogger wind_min off</td></tr>
<tr><td>scopemode</td><td>Reboots the instrument in scope mode.
This command is used by the Scope Utility. It toggles the "misc_scopeqry" flag and reboots the instrument, which then restarts with the streams activated via the serial port.
Note: Streams are transmitted in binary. If you execute this command in a text console, it may display strange characters or behave oddly.</td></tr>
</table>

B.3. Error messages

Error message	Description
Parameter is read-only	You cannot change this parameter.
Need admin permission	You need to use the "admin" command before executing the present command.
Busy	Command currently executed. Retry later.
Invalid unsigned integer value/argument	Value or argument is not a valid integer (only digits and <+> (plus) character are allowed).
Invalid integer value/argument	Value or argument is not a valid integer (only digits, <+> (plus) and <-> (minus) character are allowed).
Invalid float value/argument	Value or argument is not a float (only digits, <+> (plus), <-> (minus) and <.> (dot) characters are allowed).
Invalid value/argument size	Value or argument size is too long or empty.
Invalid value/argument	Value or argument is not valid.
Invalid dependent value/argument	Value or argument is not valid and depends on another parameter.
Value/argument out of range	Value or argument is out of range.
Invalid internal function	Internal error.
Invalid internal parameter type	Internal error.
Invalid internal limit type	Internal error.
Unknown command	Command is unknown.
Unknown parameter	Parameter is unknown.
Forbidden	Operation is forbidden with these parameters.
Invalid password	Password is not valid.

B.4. Serial measurement frame

Get a measurement result in a CSV formatted parameter after each "avg-m" on the serial port (TX: pink wire).

The serial result is computed and reset every [Measurement duration] interval.

FLUX

FLUX;<counter>;<unit>;<min>;<avg>;<max>;<std>;<unit>;<sum>

<counter> is a frame counter incremented at each result
<unit> is the unit of the following values in the frame: “g/m^2/s”
<min> is the minimum of the flux measurement [g/m^2/s]
<avg> is the average of the flux measurement [g/m^2/s]
<max> is the maximum of the flux measurement [g/m^2/s]
<std> is the standard deviation of the flux measurement [g/m^2/s]
<unit> is the unit of the following value in the frame: “g/m^2”
<sum> is the cumulative flux [g/m^2]

Example: FLUX;987;g/m2/s;247.24;262.41;288.12;4.80;g/m2;98652.94

WIND

WIND;<counter>;<unit>;<min>;<avg>;<max>

<counter> is a frame counter incremented at each result
<unit> is the unit of the following values in the frame:” km/h”
<min> is the minimum of the wind measurement [km/h]
<avg> is the average of the wind measurement [km/h]
<max> is the maximum of the wind measurement [km/h]

Example: WIND;987;km/h;57.63;68.74;89.32

Appendix C: SDI-12 – SERIAL DIGITAL INTERFACE

The ISAW firmware supports Serial Digital Interface (SDI-12) standard V1.3 (the SDI-12 V1.3 standard specification can be found at http://www.sdi-12.org).

SDI-12 stands for "serial data interface at 1200 baud" [Source: www.sdi-12.org]. It is recommended for applications of the ISAW instruments that you intend to interface with battery powered data recorders with minimal current drain and/or long-distance cabling (typically up to 150 m).

It is possible to connect more than one ISAW instrument (as well as other SDI instruments) to a single data recorder thanks to the fact that SDI-12 is a multi-drop interface that can communicate with multiple and multi-parameter instruments. The SDI-12 bus supports having ten or more connected instruments. “Multi-parameter” means that a single instrument may return more than one measurement.

This serial-digital interface is thus a logical choice for interfacing your ISAW instrument with a distant data recorder.

This has advantages for instruments and data recorders:

- Unique and complex self-calibration algorithms are executed in the microprocessor-based ISAW instrument.
- The instruments can be interchanged without reprogramming the data recorder with calibration or other information.
- Power is supplied to instruments through the interface.
- The use of a standard serial interface eliminates significant complexity in the design of data recorders.
- SDI-12 data recorders interface with a variety of instruments.
- SDI-12 instruments interface with a variety of data recorders.
- Personnel trained for SDI-12 will have skills to work with a variety of SDI-12 data recorders and SDI-12 instruments.

C.1. SDI-12 standard commands

Name	Command	Description/Response		
Acknowledge Active	`a!`			
Instrument Identification	`aI!`	`13IAV-TECFLOWCAP354`		
Change Address	`aAb!`	*No need to reboot instrument*		
Address query	`?!`	`a`		
Start Measurement	`aM!`	*Always reset measure*		
		sdi12-mode=wind	`a0003`	
		sdi12-mode=flux	`a0005`	
		sdi12-mode=all	`a0008`	
Start Measurement and request CRC	`aMC!`	*Always reset measure*		
		sdi12-mode=wind	`a0003`	
		sdi12-mode=flux	`a0005`	
		sdi12-mode=all	`a0008`	
Send Data	`aD0!` … `aD9!`	sdi12-mode=wind	`aD0!`	Min. wind (km/h)
			`aD1!`	Avg wind (km/h)
			`aD2!`	Max. wind (km/h)
		sdi12-mode=flux	`aD0!`	Min. particle flux (g/m²/s)
			`aD1!`	Avg particle flux (g/m²/s)
			`aD2!`	Max. particle flux (g/m²/s)
			`aD3!`	Std particle flux (g/m²/s)
			`aD4!`	Cumulative flux (g/m²)
		sdi12-mode=all	`aD0!`	Min. particle flux (g/m²/s)
			`aD1!`	Avg particle flux (g/m²/s)
			`aD2!`	Max. particle flux (g/m²/s)
			`aD3!`	Std particle flux (g/m²/s)
			`aD4!`	Cumulative flux (g/m²)
			`aD5!`	Wind min (km/h)
			`aD6!`	Wind avg (km/h)
			`aD7!`	Wind max (km/h)
Additional Measurements	`aM1!` … `aM9!`	***No additional measurement*** `a0000`		
Additional Measurements and request CRC	`aMC1!` … `aMC9!`	***No additional measurement*** `a0000`		
Start Verification	`aV!`	No verification `a0000`		
Start Concurrent Measurement	`aC!`	*Always reset measure*		
		sdi12-mode=wind	`a0003`	
		sdi12-mode=flux	`a0005`	
		sdi12-mode=all	`a0008`	
Start Concurrent Measurement and request CRC	`aCC!`	*Always reset measure*		
		sdi12-mode=wind	`a0003`	
		sdi12-mode=flux	`a0005`	
		sdi12-mode=all	`a0008`	
Additional Concurrent Measurements	`aC1!` … `aC9!`	*No additional measurement* `a00000`		
Additional Concurrent Measurements and request CRC	`aCC1!` … `aCC9!`	*No additional measurement* `a00000`		

Name	Command	Description/Response		
Continuous Measurements	`aR0!` … `aR9!` `aRC0!` … `aRC9!`	sdi12-mode=wind	`aR0!`	Min. wind (km/h)
			`aR1!`	Avg wind (km/h)
			`aR2!`	Max. wind (km/h)
		sdi12-mode=flux	`aR0!`	Min. particle flux (g/m^2/s)
			`aR1!`	Avg particle flux (g/m^2/s)
			`aR2!`	Max. particle flux (g/m^2/s)
			`aR3!`	Std particle flux (g/m^2/s)
			`aR4!`	Cumulative flux (g/m^2)
		sdi12-mode=all	`aR0!`	Min. particle flux (g/m^2/s)
			`aR1!`	Avg particle flux (g/m^2/s)
			`aR2!`	Max. particle flux (g/m^2/s)
			`aR3!`	Std particle flux (g/m^2/s)
			`aR4!`	Cumulative flux (g/m^2)
			`aR5!`	Min. wind (km/h)
			`aR6!`	Avg wind (km/h)
			`aR7!`	Max. wind (km/h)

Notes: Wildcard character "?" is supported.

Start Measurement (`aM!`) and Send Data (`aD0!...aD9!`) always send measurement since last request. So in this mode, measurement is reinitialized after each request.

Continuous Measurement (`aR0!...aR9!`) sends the current measurement. So in this mode, measurement is reinitialized after M duration.

The interval used for the calculation of the min, max and average statistical values starts either with each SDI-12 command, or after the avg-m parameter's duration, depending on which of these two conditions occurs first.

The behavior of the SDI depends on the sdi12-mode setting.

C.2. SDI-12 extended commands

ISAW firmware can handle an extended SDI-12 command that allows instrument configuration from SDI-12 bus.

All SDI-12 extended commands derivate from console commands.

All SDI-12 extended commands, in compliance with SDI-12 standard V1.3, have a generic format like:

```
aXcooo…!

a     : Instrument address
c     : Extended command identifier
ooo…  : Optional argument
!     : Command terminator
```

For each SDI-12 extended command, the instrument answers with a response formatted in the same way:

aOK	: Command success
aOK:vvvv…<CR><LF>	: Command success with value
aER:mmmm…<CR><LF>	: Command error with error message

a	: Instrument address
vvvv…	: Value
mmmm…	: Error message (see p. 76)
<CR><LF>	: Response terminator

Notes: Writing to eeprom to store a new parameter can take some time, which is why the "aXS!" command is delayed.

When the "aXS!" command is received, the instrument checks if the parameter and the value are correct and then sends the "aOK" response before the value is written on eeprom. Sending another "aXS!" while the instrument is currently writing a previous parameter value may result in a "Busy" error. Waiting at least 20 ms between two "aXS!" commands is recommended.

To be assured of the integrity of the parameter's writing in the memory read the parameter value (aXG!) after each "aXS!" command.

Remember that you need to reboot the instrument after changing instrument configuration.

Name	Description	Command	Response
reboot (aXR!)	After changing the instrument configuration, you need to reboot the instrument by using this command.	aXR! a : Instrument address ! : Command terminator	aOK<CR><LF> aER=mmmm…<CR><LF> a : Instrument address mmmm… : Error message (see p. 76) <CR><LF> : Response terminator
reset (aXZ…!)	Use this command if you want to recover the default factory configuration and reboot the instrument. All parameters are reinitialized, except internal factory parameters.	aXZccccccc! a : Instrument address ccccccc : Reset confirmation "confirm" ! : Command terminator	aOK<CR><LF> aER=mmmm…<CR><LF> a : Instrument address mmmm… : Error message (see p. 76) <CR><LF> : Response terminator
admin (aXA…!)	This command activates the admin rights and allows changing special parameters. This command is reserved for the initialization of factory parameters.	aXAwwwwwwww! a : Instrument address wwwwwwww : Admin password ! : Command terminator	aOK<CR><LF> aER=mmmm…<CR><LF> a : Instrument address mmmm… : Error message (see p. 76) <CR><LF> : Response terminator
get (aXG…!)	The get command allows getting a parameter value from configuration.	aXGpppppp…! a : Instrument address pppppp… : Parameter name (see § 3.1) ! : Command terminator	aOK=vvvv…<CR><LF> aER=mmmm…<CR><LF> a : Instrument address vvvv… : Parameter value (see § 3.1) <CR><LF> : Response terminator
set (aXS…!)	This command allows changing parameter values of the configuration.	aXSpppp…=vvvv…! a : Instrument address pppppp… : Parameter name (see § 3.1) vvvv… : Parameter value (see § 3.1) ! : Command terminator	aOK<CR><LF> aER=mmmm…<CR><LF> a : Instrument address mmmm… : Error message (see p. 76) <CR><LF> : Response terminator
disdrometer (aXD!)	This command allows getting disdrometry results	aXD! a : Instrument address ! : Command terminator	aOK=vvvv…<CR><LF> aER=mmmm…<CR><LF> a : Instrument address vvvv… : Disdrometry value mmmm… : Error message (see p. 76) <CR><LF> : Response terminator

C.3. SDI-12 Synchronous vs. Asynchronous mode

Reminder about the instrument configuration:

[A] Acquisition duration
[C] Cycle duration
[M] Measurement refresh interval

Typical values: [A] = 6 s, [C] = 60 s, [M] = 600 s

The instrument acquires data for 6 seconds, then sleeps for 54 seconds, then wakes up for 6 seconds, etc. The **duty cycle** is 10% (= 6 / 60 seconds).

After 600 seconds, the measurement (min, max, avg, std, cum, etc.) is refreshed; the statistics are therefore calculated over 10 acquisitions of 6 seconds.

Note: Turning off the power of the instrument resets all measurements: cumulative values and counters are reset to zero.

Datalogger – SDI-12 Interrogation:

SDI-12 commands always wake up the instrument immediately and generate a response according to SDI-12 specification v.1.4, within 15 milliseconds.

The instrument can be interrogated in two ways: **asynchronous** mode or **synchronous** mode.

Asynchronous mode: "aM!/aDx!"

The data datalogger retrieves data at a customized, possibly variable frequency, which can be different from the one the instrument measures with (DATALOGGER is master).

Command:

aM! // Stores instrument measurements (min, max, avg, std, cum, etc.) for being retrieved by aDx! command, and resets measurements.

aDx! // Retrieves last measurements being stored by previous aM! Command.

Notes:

In this mode, the instrument parameter [M] is not taken into account.

In this mode, the instrument measurements are updated after each acquisition (at [C] interval rate).

Datalogger retrieve rate scenario (e.g., [C] = 60):

If the data datalogger retrieves data every 5 seconds, it receives 12 times the same value of the last cycle C (OVERSAMPLING).

If the data datalogger retrieves data every 60 seconds, it receives measurements integrated over the last 60 seconds, i.e., one cycle and one acquisition. So, all the values (min, max, avg, std, cum, etc.) are identical.

If the data datalogger retrieves data once a day, it receives measurements integrated over 86400 / 60 = 1440 cycles. All the statistical values (min, max, avg, std) are estimated over 1440 values; the cumulative result is integrated over the last 24 hours.

Synchronous mode: "aRx!"

The data datalogger should be programmed to send a "retrieve" command every [M] interval to acquire all instrument data.

Measurements (min, max, avg, std, cum, etc.) are automatically updated after [M] interval.

Command:

```
aRx! // Retrieves the last measurements available (min, max, avg, cum,
       etc.)
```

Datalogger retrieve rate scenario (e.g., [M] = 600):

- If the data datalogger retrieves data more frequently than every [M] seconds, for example every 60 seconds, the instrument will respond with 10 successive identical values (OVERSAMPLING).
- If the data datalogger retrieves data less frequently than every [M] seconds, for example every 6000 seconds, it will only receive 1 value in 10 (UNDERSAMPLING).

Notes:

- If the data datalogger command frequency is set to [M], the measurement retrieved in asynchronous mode "aM!/aDx!" will correspond to the measurement retrieved in synchronous mode "aRx!".
- The asynchronous mode is generally preferred when the user wants to update the sampling interval according to the previous measurement. For example, if the last average instrument intensity exceeds a certain threshold, the command frequency is increased.

C.4. SDI-12 Campbell datalogger program example

Read wind and snowdrift values for a FlowCapt FC4 with SDI-12 address 4 connected to a Campbell CR800 / CR1000 port C1:

```
'***   variable definition
Public FC(8)
Alias FC(1) = FluxMin
Alias FC(2) = FluxMean
Alias FC(3) = FluxMax
Alias FC(4) = FluxStd
Alias FC(5) = FluxSum
Alias FC(6) = WindMin
Alias FC(7) = WindMean
Alias FC(8) = WindMax

'***   reading instrument
SDI12Recorder (FC(),1,4,"M!",1.0,0)
```

In this example, the second parameter is the port (C1) and the third one is the SDI-12 address (4).

How often you call the SDI-12 measurement command depends on the configuration of your instrument (power cycling, measurement interval, storage interval).

Measure the analog voltage output on your datalogger's ports SE1 (flux) and SE2 (wind):

```
VoltSe(FC_Flux,1,mV5000,1,False,0,_50Hz,0.05,0)
VoltSe(FC_Wind,1,mV5000,2,False,0,_50Hz,0.05,0)
```

The values of the multiplier (second last parameter) and the offset (last parameter) depend on your analog output settings.

In this example the settings are:	out1-mode = flux	out2-mode = wind
	range-flux = 5V	range-wind = 5V
	fscale-flux = 250	fscale-wind = 250

so `VoltSe` multiplier (second last parameter) is 250/5000 = 0.05. If you set OUT range to 2V5, multiplier must be 250/2500 = 0.1.

Appendix D: MODBUS RTU 485 – INSTRUCTIONS FOR USE

D.1. Introduction to using Modbus

Modbus is one of the most widely adopted industrial communication protocols for interfacing field instruments with supervisory control and data acquisition (**SCADA**) systems. Designed for simplicity, robustness, and interoperability, it provides a standardized method for exchanging real-time measurements, status information, and configuration data between instruments, controllers, and central monitoring platforms. When integrated into **SCADA** infrastructures, Modbus ensures deterministic polling, structured register mapping, and straightforward compatibility with **PLCs, RTUs, and industrial data loggers**.

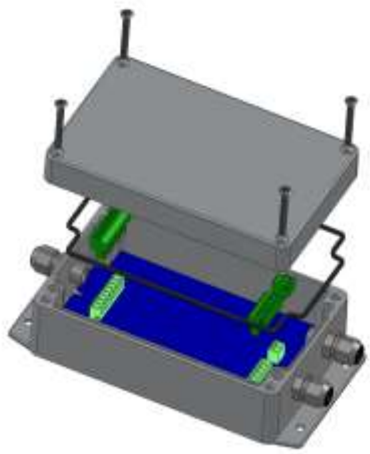
In its **Modbus RTU** implementation – operating over **RS-485 twisted-pair cabling** – the protocol supports long-distance, multi-drop networks of up to 247 addressable devices, making it well suited for distributed environmental and industrial monitoring architectures.

Modbus RTU is also widely used in **Building Management Systems (BMS)**. The ISAW Modbus adapter therefore enables direct integration of all ISAW instruments into auxiliary such as HVAC controllers, facility automation units, and centralized building monitoring infrastructures. This allows **ISAW instruments data and risk indicators** to be natively incorporated into building protection strategies, automated procedures, and alert systems.

D.2. The ISAW Modbus adapter

Because of its low overhead, minimal hardware requirements, and universal support in **SCADA software suites**, the **ISAW Modbus adapter** is often a preferred interface for transmitting instrument data into supervisory dashboards, alarm systems, and automated decision sequences. It provides access to measurement frames, configuration registers, and diagnostic functions through standardized Modbus function codes, ensuring consistent and reliable data acquisition.

The **ISAW Modbus adapter** is housed in a cast-aluminum enclosure, offering excellent mechanical robustness, strong electromagnetic shielding, and high resistance to outdoor exposure and sealing constraints. Its internal electronics are designed and assembled to demanding industrial standards, with reinforced isolation, comprehensive electrical protections, and high-quality components that ensure long-term reliability in harsh and mission-critical field deployments.

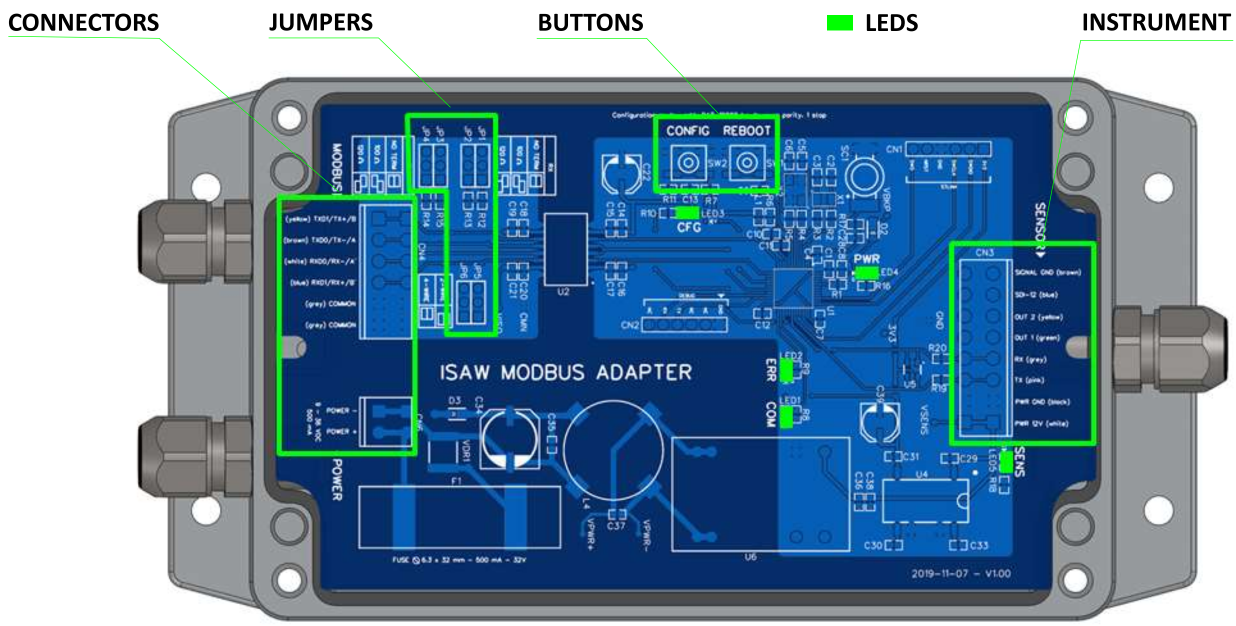


CHARACTERISTICS	
Protocol	MODBUS RTU (V1.1b3)
Physical Layer	EIA/TIA-485 (RS485) 2-wire and 4-wire
Galvanic isolation	Power 3kV RMS, Bus 5kV RMS
Unit load	1/8-unit load, up to 256 nodes on the bus
Startup time	1 s
Power supply	9 to 36 VDC (Typ. 100 mA, Max. 500 mA)
Implemented function codes	0x04 Read Input Registers 0x03 Read Holding Registers 0x06 Write Single Register 0x10 Write Multiple Registers 0x64 Pass-through 0x08 Diagnostic 0x17 Report Server ID
Configurable Baud rate	9600, 19200, 38400, 57600, 115200, 128000, 256000
Configurable Parity	No, Odd, Even
Configurable Stop Bit	1 or 2
Configurable Address	1 to 247

DEFAULT COMMUNICATION PARAMETERS	
Address	247
Baudrate	19200 bauds
Parity	Even
Stop bits	1 bit
Response timeout	1000 ms

MECHANICAL DATA	
Material	Aluminum box Nickel-plated brass cable glands
Protection	IP 68 (up to 10 bar) IP 69 for the cable glands
Dimensions (L×W×H)	160 mm × 100 mm × 60 mm Box thickness: 2.5 mm
Operating temperature	-40°C / +85°C (most sensitive electronic component)
Manufacturer references	Box: Bud Industries, product number AN-2866-AB Cable glands: AGRO, product number 1160.12.065

D.3. Description



BUTTONS

BUTTONS	
REBOOT	Restarts the Modbus adapter with the Holding register's parameters. **Note:** Switching the power OFF/ON also restarts the Modbus adapter.
CONFIG	Holding the CONFIG button pressed while starting (or restarting) the Modbus adapter starts (or restarts) the adapter with the default communication parameters (cf. previous page). **Note:** This operation does not change the parameters stored in the Holding register.

LEDS

LEDS	
COM	Flashing during a Modbus communication.
ERR	Flashing when a Modbus communication error occurs. Steady when a critical error occurs requiring a restart.
CFG	Flashing when the instrument is in CONFIG mode (started with the CONFIG button pressed).
PWR	Steady when input power OK.
SENS	Steady when output 12 V instrument power OK.

CONNECTORS

INSTRUMENT			
#	Name	Color	Description
1	PWR 12V	White	Power output 12VDC – 300 mA
2	PWR GND	Black	Power ground
3	TX	Pink	Serial input 3V3
4	RX	Grey	Serial output 3V3
5	OUT 1	Green	Not connected
6	OUT 2	Yellow	Not connected
7	SDI-12	Blue	Not connected
8	Signal GND	Brown	Not connected

POWER			
#	Name	Color	Description
1	PWR -	Black	Power ground
2	PWR +	Red	Power input 9…36VDC (500 mA)

MODBUS 4-WIRE			
#	Name	Color	Description
1	TXD1/TX+/B	Yellow	Output terminal 1, Vb voltage (Vb > Va for binary 1)
2	TXD0/TX-/A	Brown	Output terminal 0, Va voltage (Va > Vb for binary 0)
3	RXD0/RX-/A'	White	Input terminal 0, Va' voltage (Va' > Vb' for binary 0)
4	RXD1/RX+/B'	Blue	Input terminal 1, Vb' voltage (Vb' > Va' for binary 1)
5	COMMON	Grey	Signal ground
6	COMMON	Grey	Signal ground

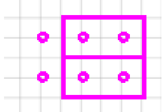
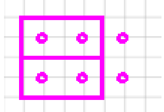
MODBUS 2-WIRE			
#	Name	Color	Description
1	TXD1/TX+/B	Yellow	Transceiver terminal 1, Vb voltage (Vb > Va for binary 1)
2	TXD0/TX-/A	Brown	Transceiver terminal 0, Va voltage (Va > Vb for binary 0)
3	RXD0/RX-/A'	White	Not connected
4	RXD1/RX+/B'	Blue	Not connected
5	COMMON	Grey	Signal ground
6	COMMON	Grey	Signal ground

Note: TXD0-RXD0 and TXD1-RXD1 are connected.

The polarity of the "A" and "B" wires can be reversed. Please check in the datasheet of your RS485/RS422 converter the polarity "+" or "-" ("1" or "0") affected to the "A" and "B" labels.

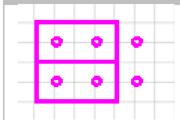
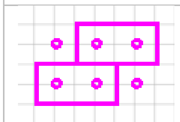
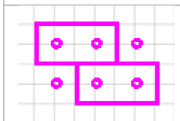
If you don't find this information in your converter documentation, try to plug "A" and "B" wires and if you get no communication, just invert the wiring.

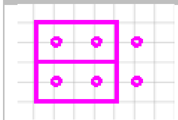
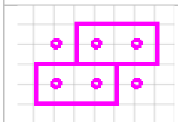
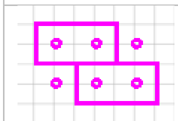
JUMPERS

MODE	
Jumper position	Description
	**2-WIRE MODE** [default] (TXD0-RXD0 et TXD1-RXD1 are connected)
	**4-WIRE MODE**

Notes:

1. If the ISAW Modbus adapter node is the last one of the bus, the jumper RX must be set to "100 Ω" or "120 Ω".
2. In 4 wire mode only, if the ISAW Modbus adapter node is the last one of the bus, the jumper TX must be set to "100 Ω" or "120 Ω".

TX TERMINATION	
Jumper position	Description
	**NO TERM.** *[default]* No termination resistor on TX pair
	120 **Ω** Standard 120 Ω termination resistor wired on TX pair
	100 **Ω** 100 Ω termination resistor wired on TX pair

RX TERMINATION	
Jumper position	Description
	**NO TERM.** *[default]* No termination resistor on RX pair
	**120 Ω** Standard 120 Ω termination resistor wired on RX pair
	**100 Ω** 100 Ω termination resistor wired on RX pair

D.4. Modbus function / Register definition

D.4.1. INPUT Registers

The Input registers contain measurements. The content of these registers is updated each time the instrument sends new measurements to the Modbus adapter.

Modbus function: READ INPUT REGISTER (0x04)

Address	Type*	Bytes	Offset	Alias	Comment
0x0000	UINT32	4	0	Counter	Flux measurement frame counter
0x0002	STRING8	8	2	Unit	Flux measurement unit: “g/m^2/s”
0x0006	FLOAT	4	6	Min	Flux measurement minimum
0x0008	FLOAT	4	8	Avg	Flux measurement average
0x000A	FLOAT	4	10	Max	Flux measurement maximum
0x000C	FLOAT	4	12	Std	Flux measurement standard deviation
0x000E	STRING8	8	14	Unit	Cumulative flux measurement unit: “g/m^2”
0x0012	FLOAT	4	18	Sum	Cumulative flux measurement
0x0014	UINT32	4	20	Counter	Wind measurement frame counter
0x0016	STRING8	8	22	Unit	Wind measurement unit: “km/h”
0x001A	FLOAT	4	26	Min	Wind measurement minimum
0x001C	FLOAT	4	28	Avg	Wind measurement average
0x001E	FLOAT	4	30	Max	Wind measurement maximum
0x0057	UINT16	2	87	UINT16 Test	Fixed value: 54321 (0xD431)
0x0058	UINT32	4	88	UNIT32 Test	Fixed value: 1234567890 (0x499602D2)
0x005A	FLOAT	4	90	FLOAT Test	Fixed value: 3,14159265 (0x40490FDB)
0x005C	UINT16	2	92	VERmaj	Major version of Modbus adapter firmware (since V1.19)**
0x005D	UINT16	2	93	VERmin	Minor version of Modbus adapter firmware (since V1.19)**

* Note: String are zero-padded.
** If not present, Modbus adapter firmware is V1.18

D.4.2. HOLDING Registers

Holding resisters are mainly used to configure the Modbus adapter communication.

Note: Restart the Modbus adapter after changing the configuration.

Modbus functions: READ HOLDING REGISTERS (0x03)
WRITE SINGLE REGISTER (0x06)
WRITE MULTIPLE REGISTERS (0x10)

Address	Type	Bytes	Offset	Name	Values
0x0000	UINT32	4	0	Serial speed	9600, 19200 [default], 38400, 57600, 115200, 128000, 256000
0x0002	UINT16	2	2	Parity	0: No parity, 1: Even [default], 2: Odd
0x0003	UINT16	2	3	Stop Bit	1 [default] or 2 (if no parity)
0x0004	UINT16	2	4	Device address	1 to 247 [default]
0x0005	UINT16	2	5	Response timeout (ms)	Default: 1000
	Total bytes:	12			
	Nb. REG:	6			

D.4.3. DATA TYPE Format

UINT16 (Big Endian)		High Byte	Low Byte	
UINT32 (Big Endian)	High Byte			Low Byte
FLOAT (IEEEE-754)	SEEEEEEE	EMMMMMMM	MMMMMMMM	MMMMMMMM
	(S: Sign, E: Exponent, M: Mantissa)			
RAW	Char 1	Char 2	Char 3	…

EXAMPLES:	**Decimal**	**Hexadecimal**	**Register N**	**Register N+1**
UINT16 (Big Endian)	54321	0xD431	0xD431	
UINT32 (Big Endian)	1234567890	0x499602D2	0x02D2	0x4996
FLOAT (IEEEE-754)	3.14159265	0x40490FDB	0x0FDB	0x4049
RAW	"hit"	0x68697400	0x6869	0x7400

D.5. Modbus function PASS-THROUGH (0x64)

This user-defined Modbus function, available for Modbus firmware version V1.19 and higher, allows to send an ISAW command through the Modbus (see Appendix B for more information about the ISAW console commands). For example, use this function with the “set” or “get” ISAW command to access the instrument’s configuration.

Note: The use of this function is limited by the request and answer lengths.

Request:

Address	Function	ISAW console command	CRC

Modbus PDU

Field	Size (bytes)	Description
Address	1	Device address (target)
Function	1	0x64
ISAW Command	N	ISAW command as ASCII string
CRC	2	CRC16

Response:

Address	Function	ISAW command result	CRC

Modbus PDU

Field	Size (bytes)	Description
Address	1	Device address (same as request)
Function	1	0x64
Result	N	ISAW command result as ASCII string
CRC	2	CRC16

Note: The response timeout of this command must be > 2 seconds to allow instrument wake-up.

D.6. Modbus frame examples

Raw examples of Modbus communication.

READ HOLDING REGISTER (all registers)

TX > 0xF7 0x03 0x00 0x00 0x00 0x06 0xD1 0x5E
RX > 0xF7 0x03 0x0C 0x4B 0x00 0x00 0x00 0x00 0x01 0x00 0x01 0x00 0xF7 0x03 0xE8 0x9D
RX > 0x9E

READ INPUT REGISTERS (All registers)

TX > 0xF7 0x04 0x00 0x00 0x00 0x5E 0x65 0x64
RX > 0xF7 0x04 0xBC 0x00 0x01 0x00 0x00 0x68 0x69 0x74 0x2F 0x73 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x68
RX > 0x69 0x74 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x01 0x00 0x00 0x68 0x69 0x74 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x25 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00 0x00
RX > 0x00 0xD4 0x31 0x02 0xD2 0x49 0x96 0x0F 0xDB 0x40 0x49 0x00 0x01 0x00 0x13 0x14
RX > 0xC6

READ INPUT REGISTERS (read adapter version only)

Available on firmware version V1.19 or higher. If you receive a Modbus exception, firmware version is V1.18.

TX > 0xF7 0x04 0x00 0x5C 0x00 0x02 0xA5 0x4F
RX > 0xF7 0x04 0x04 0x00 0x01 0x00 0x13 0x7D 0x86

PASSTHROUGH (get avg-a)

TX > 0xF7 0x64 0x67 0x65 0x74 0x20 0x61 0x76 0x67 0x2D 0x61 0xEC 0x5D
RX > 0xF7 0x64 0x4F 0x4B 0x3D 0x31 0xD3 0x12

PASSTHROUGH (get avg-c)

TX > 0xF7 0x64 0x67 0x65 0x74 0x20 0x61 0x76 0x67 0x2D 0x63 0x6D 0x9C
RX > 0xF7 0x64 0x4F 0x4B 0x3D 0x32 0x93 0x13

PASSTHROUGH (get avg-m)

TX > 0xF7 0x64 0x67 0x65 0x74 0x20 0x61 0x76 0x67 0x2D 0x6D 0xEC 0x58
RX > 0xF7 0x64 0x4F 0x4B 0x3D 0x38 0x13 0x14

PASSTHROUGH (get hw-sn)

TX > 0xF7 0x64 0x67 0x65 0x74 0x20 0x68 0x77 0x2D 0x73 0x6E 0x68 0x12
RX > 0xF7 0x64 0x4F 0x4B 0x3D 0x30 0x30 0x32 0x45 0x30 0x30 0x34 0x30 0x33 0x36 0x33
RX > 0x32 0x33 0x30 0x33 0x36 0x30 0x43 0x34 0x37 0x33 0x34 0x33 0x31 0x1E 0xDF

PASSTHROUGH (get fw-build)

TX > 0xF7 0x64 0x67 0x65 0x74 0x20 0x66 0x77 0x2D 0x62 0x75 0x69 0x6C 0x64 0x0A 0xE0
RX > 0xF7 0x64 0x4F 0x4B 0x3D 0x4A 0x75 0x6C 0x20 0x32 0x32 0x20 0x32 0x30 0x32 0x30
RX > 0x20 0x61 0x74 0x20 0x31 0x36 0x3A 0x31 0x37 0x3A 0x30 0x36 0x20 0x62 0x79 0x20
RX > 0x47 0x43 0x43 0x20 0x37 0x2E 0x32 0x2E 0x31 0xF8 0x2C

PASSTHROUGH (set avg-m 8)

TX > 0xF7 0x64 0x73 0x65 0x74 0x20 0x61 0x76 0x67 0x2D 0x6D 0x20 0x38 0x14 0xD8
RX > 0xF7 0x64 0x4F 0x4B 0x07 0x88

PASSTHROUGH (reboot)

TX > 0xF7 0x64 0x72 0x65 0x62 0x6F 0x6F 0x74 0x6F 0xC7
RX > 0xF7 0x64 0x4F 0x4B 0x07 0x88

NOTES: Some useful tools to manually forge and decode your Modbus frames:

Compute CRC16 for Modbus online: https://crccalc.com/?method=CRC-16/MODBUS

Convert ASCII to HEX online: https://www.rapidtables.com/convert/number/ascii-to-hex.html

Convert HEX to ASCII online: https://www.rapidtables.com/convert/number/hex-to-ascii.html

Parse and decode MODBUS frame online (remove 0x prefix on the previous examples): https://rapidscada.net/modbus/

D.7. Test procedure

Communication example between an ISAW instrument and a PC using the Modbus Adapter.

D.7.1. Hardware setup

Picture 1: Hardware setup

The **instrument** is connected directly to the "INSTRUMENT" connector of the Modbus adapter as per Picture 2.

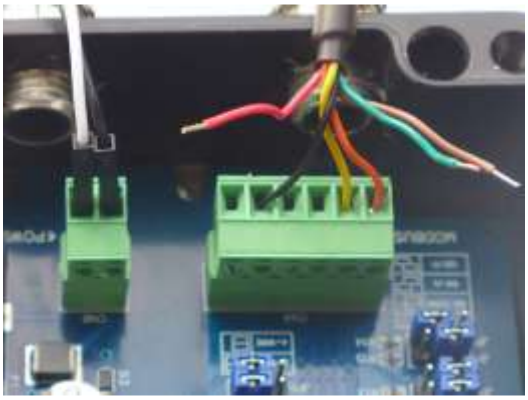
To **power** both the Modbus adapter and the instrument we simply use the white and black wires of the UDONG accessory, connected to the "POWER" connector of the Modbus adapter. The UDONG is plugged to the PC either directly or via a USB Hub (see Picture 2 and Picture 3).

To **communicate** between the MODBUS ADAPTER and the PC we use an RS485/422 adapter (e.g. FTDI USB-RS485-WE-1800-BT) connected to the "MODBUS" connector of the MODBUS adapter on one side, and to the USB hub (or directly to the PC) on the other side.

USB-to-RS485 Serial Converter Cable

Picture 2: Modbus adapter connectors. Left: MODBUS and POWER connectors. Right: INSTRUMENT connector.

Picture 3: USB hub with UDONG on the left and RS485/422 adapter on the right

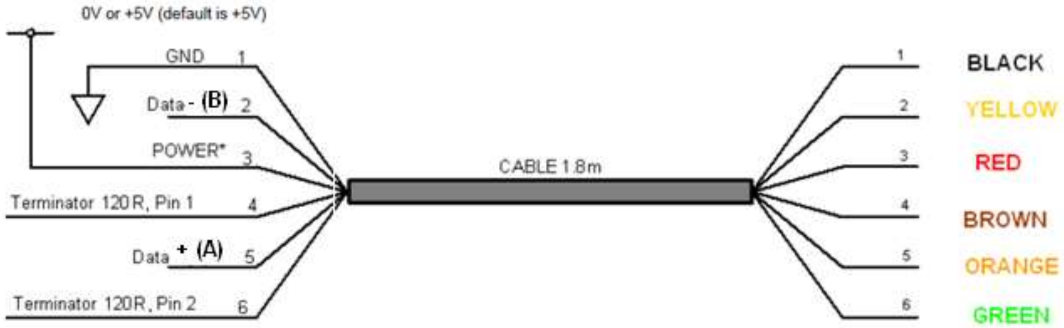


Picture 4: POWER connector (on the left), MODBUS connector (on the right)

Picture 5: Jumpers

Picture 6: Modbus adapter LEDs

Cable signals and wire colors are detailed on the following figure:



(Source: https://www.ftdichip.com/Support/Documents/DataSheets/Cables/DS_USB_RS485_CABLES.pdf)

If needed, download the driver according to your operating system: https://ftdichip.com/drivers/vcp-drivers.

Then, on the Modbus adapter side, connect the USB-RS485 FTDI as per Picture 4, i.e. only black, yellow and orange wires (thus leaving the red, green and brown wires unused).

Set the jumpers of the Modbus adapter as per Picture 5.

Set the UDONG power switch to ON which activates the UDONG green led (see Picture 3) and also two green LEDs on the Modbus adapter (see Picture 6).

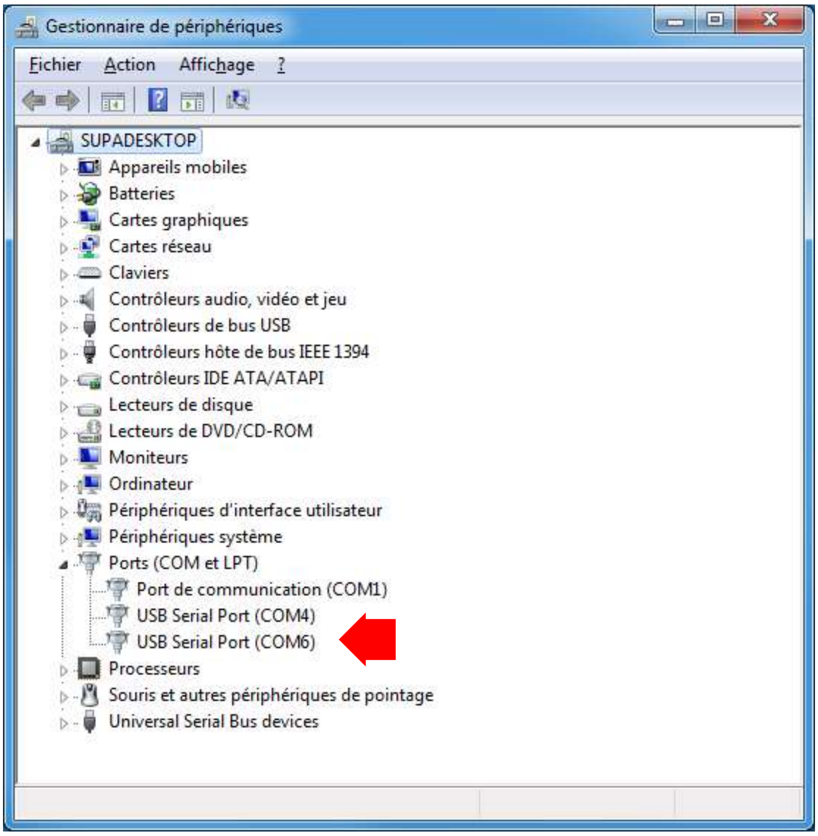
The hardware setup is complete. We can now communicate.

D.7.2. Communicating with the FlowCapt FC4 instrument

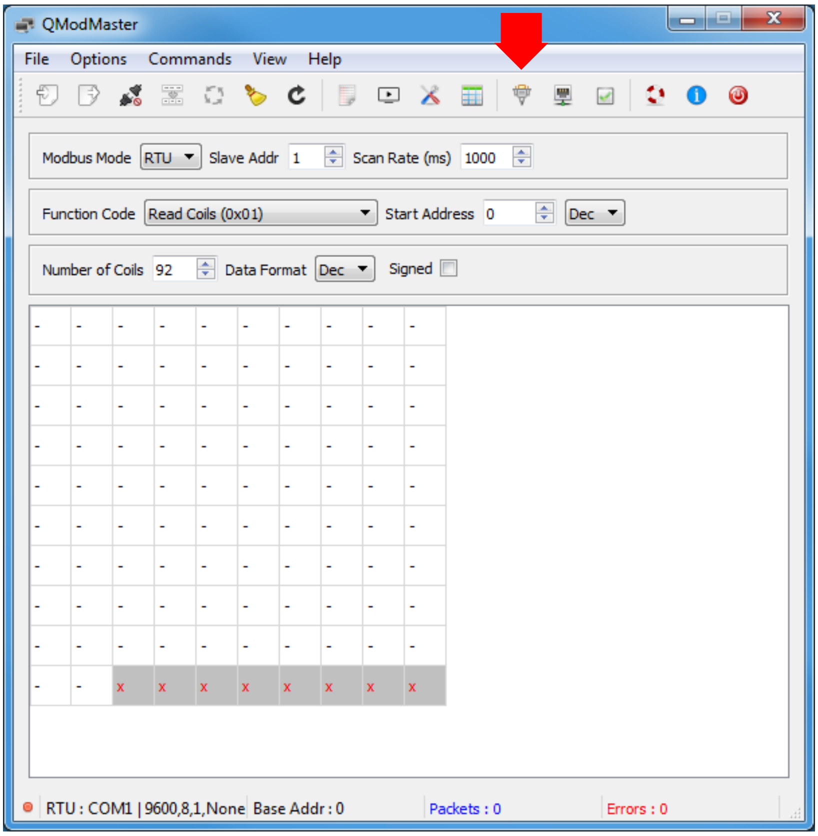
Download a communication software, for example QModMaster. QModMaster is a free Qt-based implementation of a Modbus master application. A graphical user interface allows easy communication with Modbus RTU and TCP slaves. QModMaster also includes a bus monitor for examining all traffic on the bus. See https://sourceforge.net/projects/qmodmaster/.

Open the « Device Manager » on your computer.

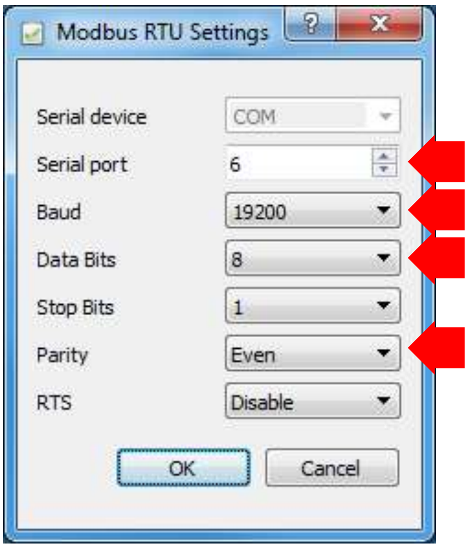
Plug the RS485/422 adapter USB connector to the USB hub or PC and install the required drivers. When the drivers are successfully installed, a new serial port appears (here: COM6).



Start QModMaster and open the Configuration Panel.

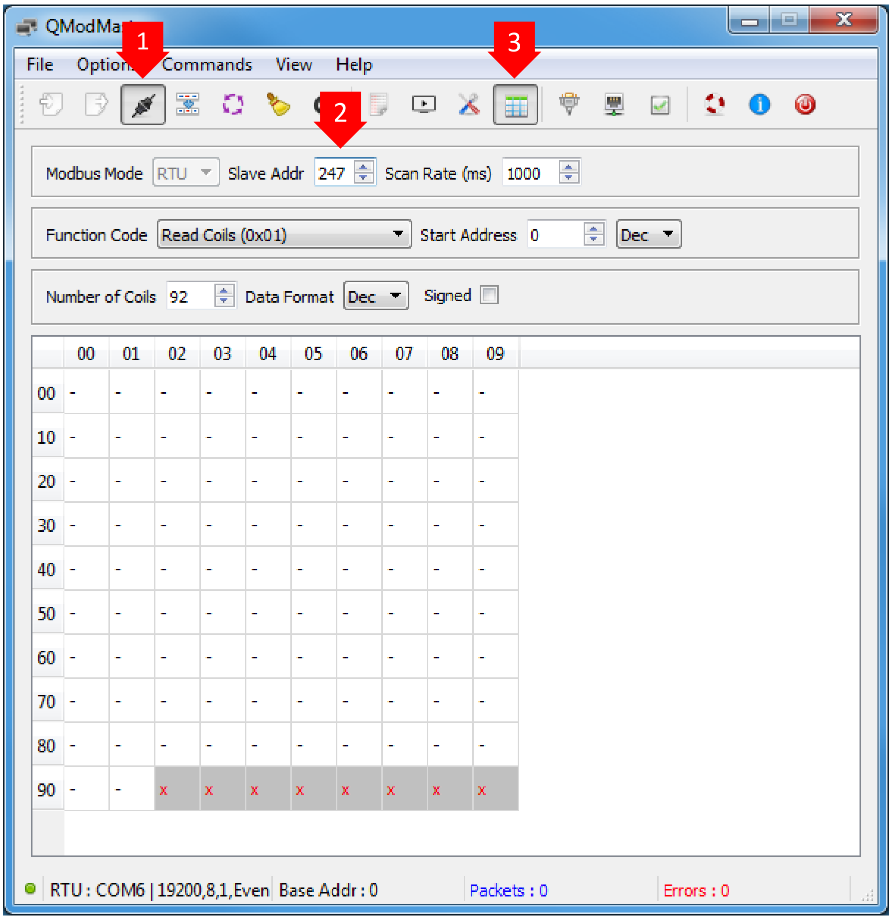


Set the serial communication parameters. Use the relevant serial port number (here: 6).



Connect the MODBUS adapter:

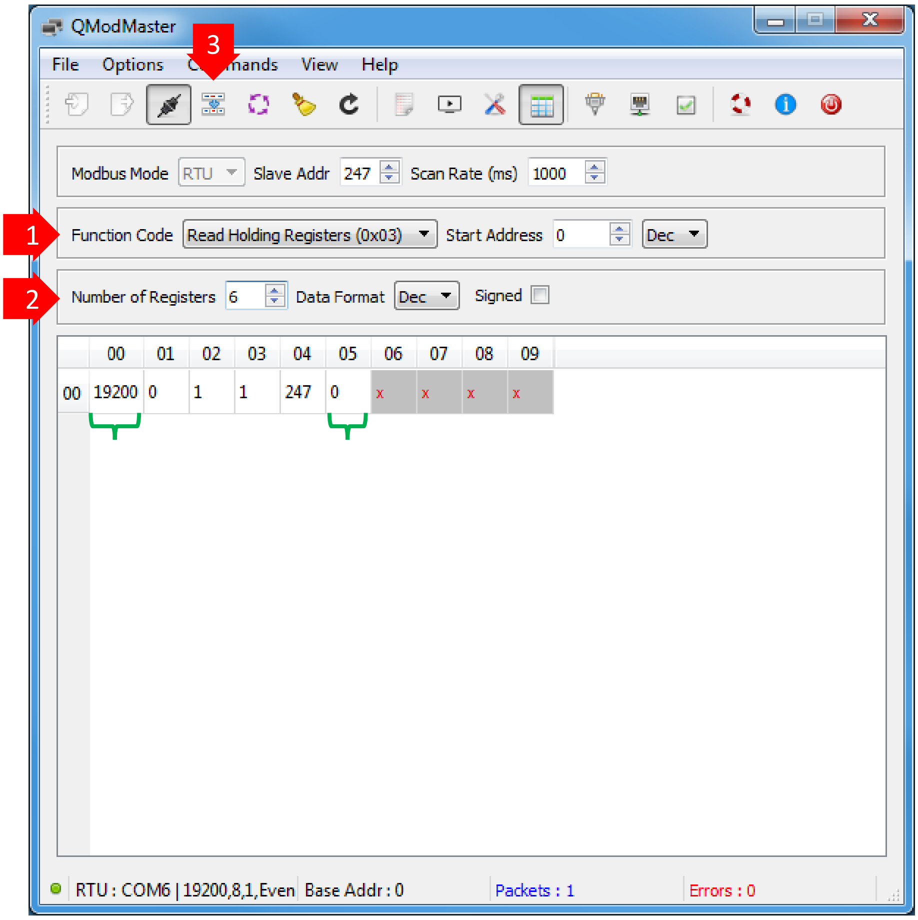
[1] Open the QModMaster serial port.
[2] Set the Modbus address (e.g. 247).
[3] Display grid header if needed.



Tip : If you receive the « Connection failed » message below, your serial port is probably already opened by another application. Stop the other application and retry.

To read the configuration:

[1] Select the function code « Read Holding Registers ».
[2] Set the number of registers (e.g., 6 for the whole configuration).
[3] Click on the [Read/Write] button.

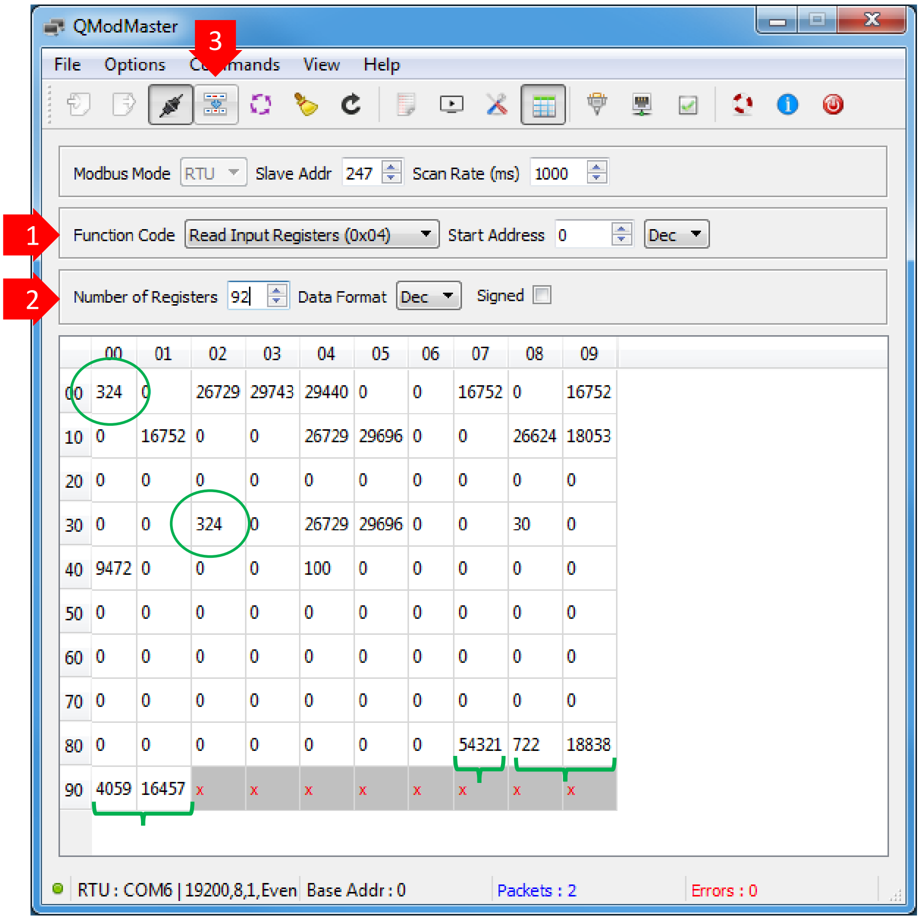


You can see for example the « Baudrate » (Register 0) and « Address » (Register 4). To understand the registers definitions, values and formats please refer to § D.4.

Tip : If you receive « Read data failed » message below (Timeout or CRC), please check your hardware wiring (especially data wire swapping), jumper position and QModMaster serial configuration (especially baud rate and parity).

To read the measurements:

[1] Select the function code « Read Input Registers ».
[2] Set the number of registers (e.g. 92 for the whole measurement).
[3] Click on the [Read/Write] button.



	00	01	02	03	04	05	06	07	08	09
00	324	0	26729	29743	29440	0	0	16752	0	16752
10	0	16752	0	0	26729	29696	0	0	26624	18053
20	0	0	0	0	0	0	0	0	0	0
30	0	0	324	0	26729	29696	0	0	30	0
40	9472	0	0	0	100	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	54321	722	18838
90	4059	16457	x	x	x	x	x	x	x	x

You can see for example « Frame counters » (Registers 0 & 32) and « Test fixed values » (Registers 87, 88 & 90).

To understand the registers definitions, values and formats please refer to § D.4.3.

Tip: The interval between two measurements of the instrument depends on the instrument's "Averaging" setting: by default, the instrument sends one measurement every 600 seconds, i.e. a refresh of the displayed data every 10 minutes. To get more frequent refresh of the displayed data, you can change the "Averaging" parameters "Acquisition (A)", "Cycle (C)" and "Measure (M)" of the instrument. To do so, connect the instrument to a PC using the UDONG accessory and refer to the "Averaging panel" section of the User Guide. Example for quick test: set A=1s, C=2s and M=4s. In this case, do not forget to re-set the "Averaging" configuration of your instrument according to your needs after this test.

D.8. Update the Modbus adapter firmware

IAV Technologies constantly improves its products and provides upgrades of the ISAW firmware for all instruments. This section describes the procedure for upgrading the ISAW firmware.

This chapter describes the procedure for upgrading the Modbus adapter's firmware.

D.8.1. Hardware setup

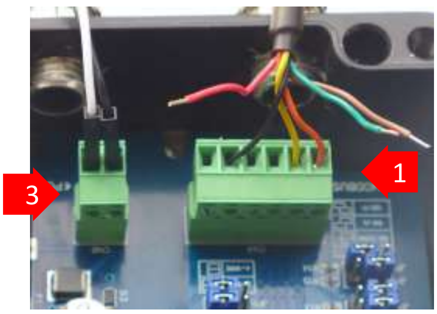
You will need

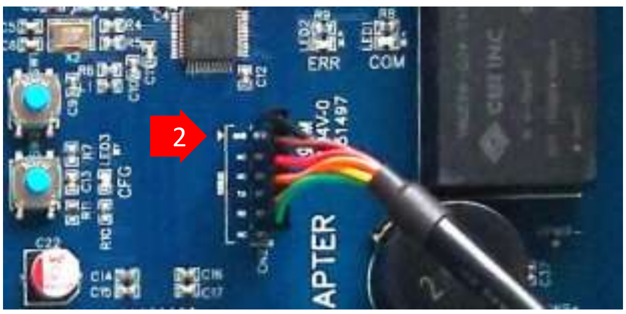
- a USB-to-RS485 Serial Converter Cable,
- the USB link accessory, which will be used as a 12V power supply,
- optional: an FTDI TTL-232 cable (if you want to know the Modbus adapter version before V1.19).

USB-to-RS485 Serial Converter Cable

FTDI TTL-232 Cable (optional)

1. **To communicate between the Modbus adapter and the PC**, use any RS485/422 adapter (e.g. FTDI USB-RS485-WE-1800-BT) connected to the "MODBUS" connector of the MODBUS ADAPTER.
2. **Optional:** Connect the Modbus adapter to the PC using the FTDI 232 cable with the black wire (ground) facing the GND mark ▶.
3. **To power the Modbus adapter**, use the white and black wires of the UDONG accessory connected to the "POWER" connector.





Hardware setup with USB hub and Modbus adapter

D.8.2. Update procedure

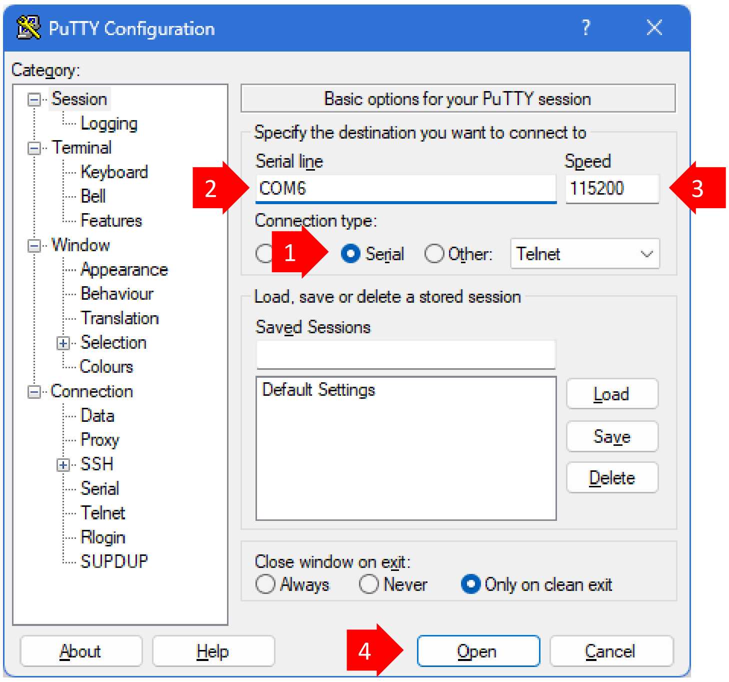
Prerequisites:

- The hardware setup is complete.
- The ISAW-Toolbox is installed (see § 1.8).
- The last versions of the firmwares are installed (use the Update utility to check).

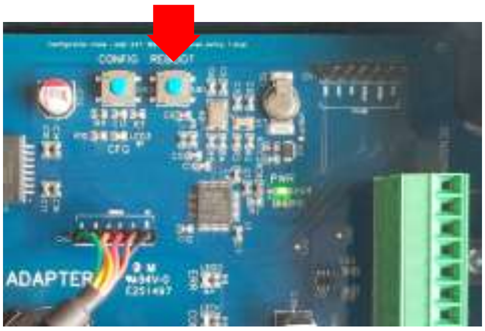
To display the current Modbus adapter configuration (optional), open your favorite serial terminal (e.g., Putty[6], TeraTerm, HyperTerminal) on the right serial port (here COM6) at 115200 bauds, 8 bits, 1 stop, no parity.

Tip: To identify the serial port the FTDI 232 cable is connected to, open the Control Panel > Device Manager > Ports interface. Unplug then plug the FTDI USB end and check the activated USB serial port.

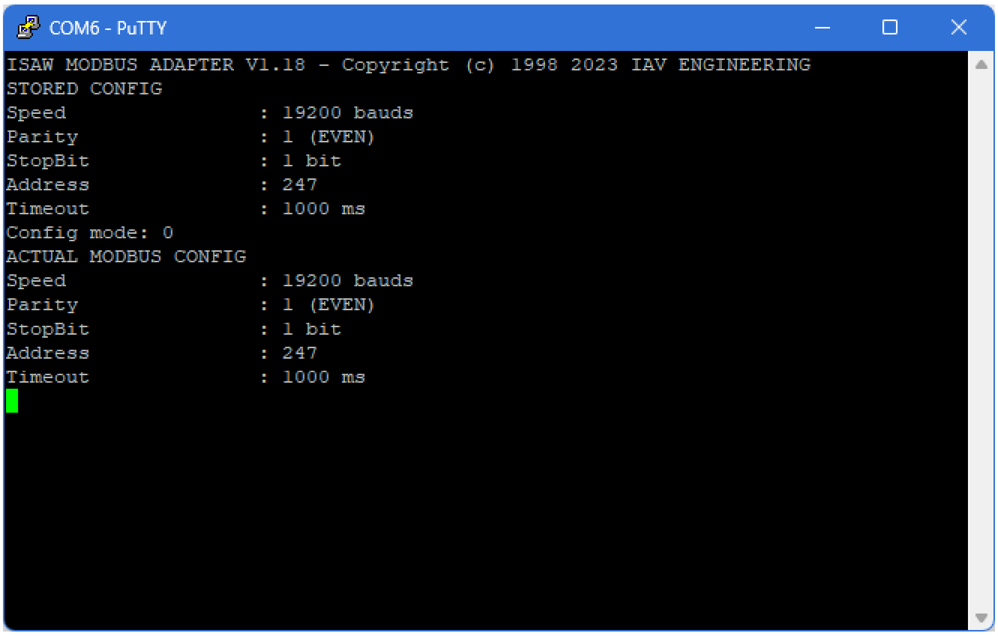
[6] Lightweight and non-intrusive "putty.exe" freeware available at http://www.putty.org.



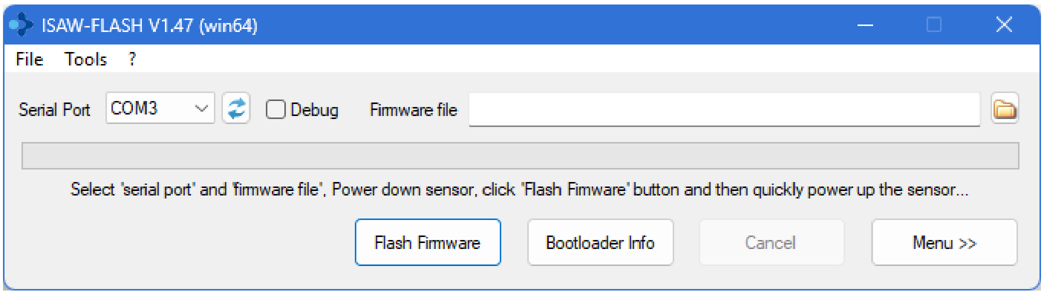
Press the REBOOT button on the Modbus adapter.



The current configuration of the Modbus adapter is displayed, starting with the firmware version:



Open the ISAW Toolbox **Flash** Utility.



Serial Port: Select the FTDI 485 serial port.

Tip: To identify the serial port the FTDI 485 cable is connected to, open the Control Panel > Device Manager > Ports interface. Unplug then plug the FTDI USB end and check the activated USB serial port.

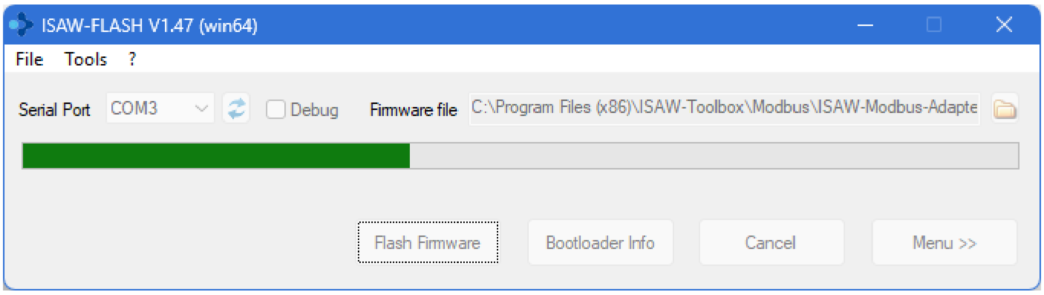
Select the firmware file: Select the last version of the Modbus firmware in the "ISAW-Toolbox\Modbus" directory:

ISAW-Modbus-Adapter-x.xx.bin (where x.xx is the version number)

Shut down the Modbus adapter power supply: set the USB link power switch to OFF.

Press the [Flash Firmware] button. At this stage, ISAW-Flash will automatically search for a powered device during ten seconds.

Power-on the Modbus adapter: Switch the USB link power back to ON. As soon as ISAW-Flash has found the powered Modbus adapter, the firmware upload starts automatically.



Wait during the firmware upload. This may take a few minutes.

WARNING: Do not disconnect the power supply during the firmware upload.

When the firmware upload is successfully completed, a confirmation message is displayed.

The Modbus adapter is now ready to use.

Optional: Use your serial terminal to check if the firmware version is properly updated (see first step).

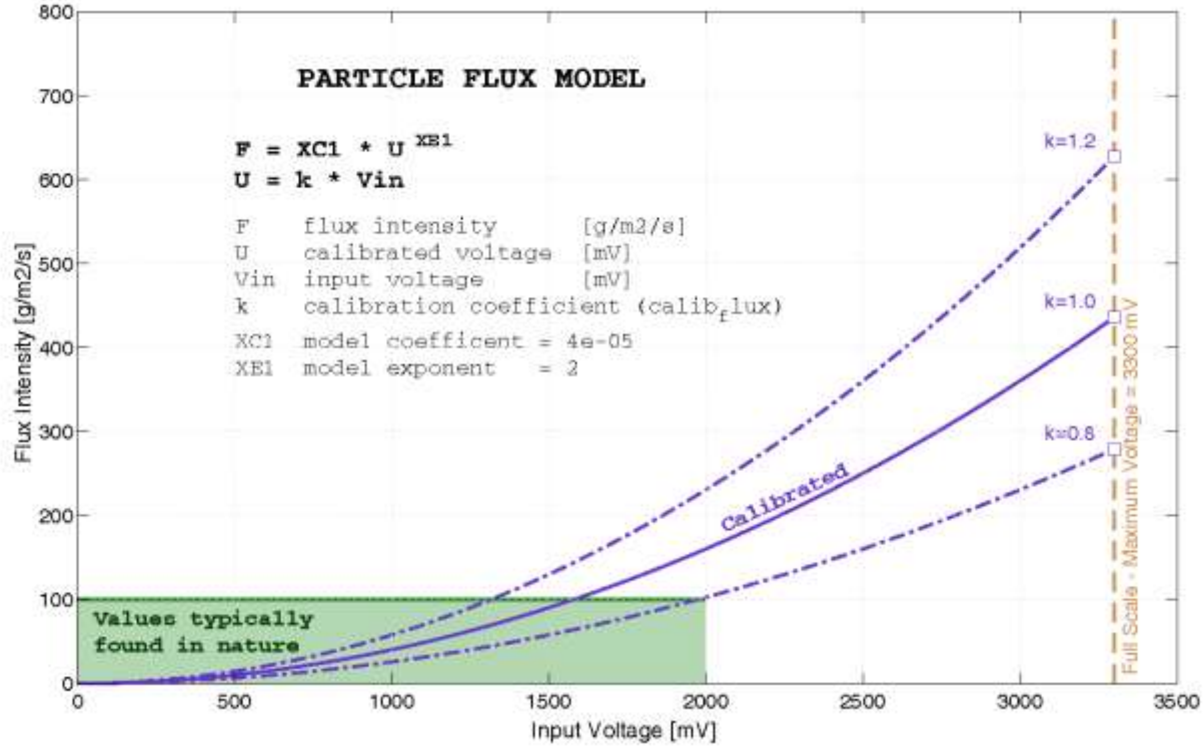
Appendix E: More about aeolian solid particles physics and principle of detection

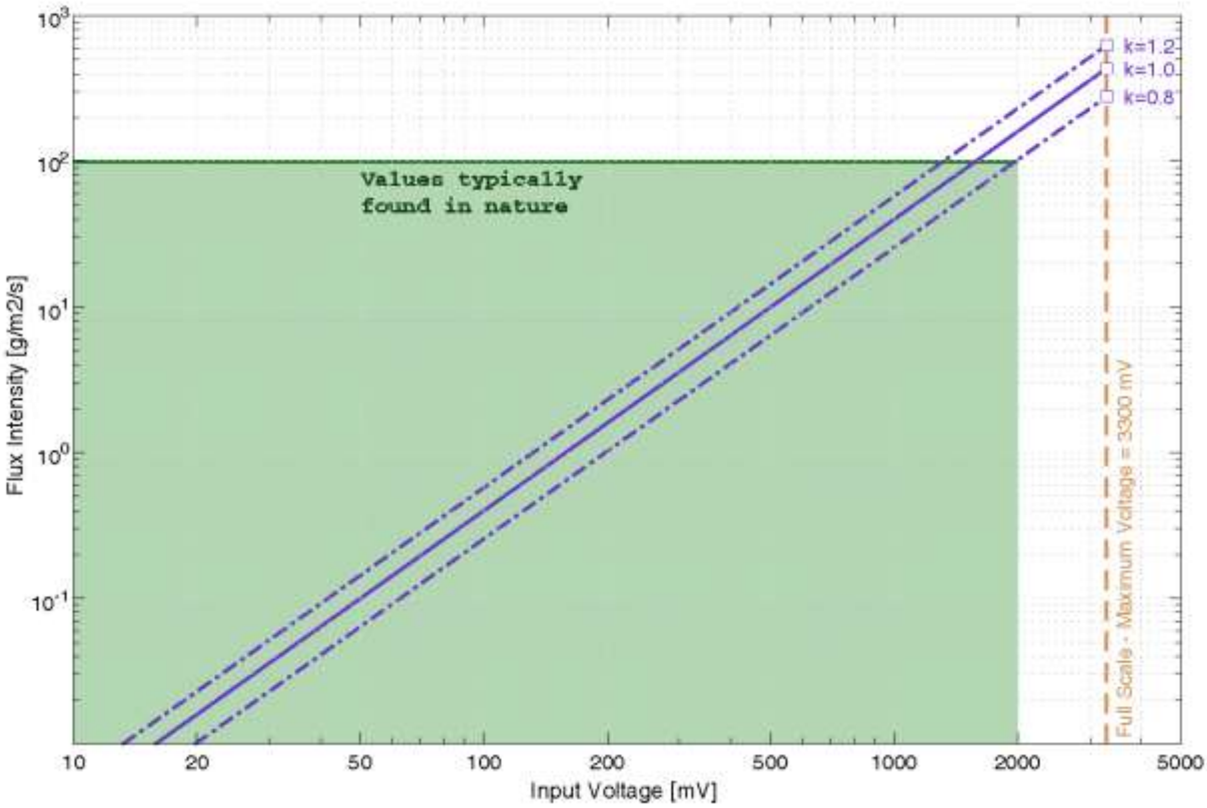
E.1. Linearization function

The next table and figures show the linearization formula with the factory default values (Note: for custom applications, the value of the coefficients can be modified in the Expert mode panel of the instrument's configuration utility).

FLUX Channel Input Voltage [U mV]	Flux [g/m²/s]
0	0
100	0.40
200	1.60
300	3.60
400	6.40
500	10.00
600	14.40
700	19.60
800	25.60
900	32.40
1000	40.00
1100	48.40
1200	57.60
1300	67.60
1400	78.40
1500	90.00
1600	102.40
1700	115.60
1800	129.60
1900	144.40
2000	160.00
2100	176.40
2200	193.60
2300	211.60
2400	230.40
2500	250.00
2600	270.40
2700	291.60
2800	313.60
2900	336.40
3000	360.00
3100	384.40
3200	409.60
3300	435.60

WIND channel Input Voltage [U mV]	Wind [km/h]
0	0
100	69.65
200	98.75
300	121.04
400	139.82
500	156.37
600	171.32
700	185.07
800	197.87
900	209.88
1000	221.25
1100	232.06
1200	242.39
1300	252.29
1400	261.82
1500	271.02
1600	279.91
1700	288.53
1800	296.90
1900	305.04
2000	312.97
2100	320.70
2200	328.25
2300	335.64
2400	342.86
2500	349.93
2600	356.86
2700	363.66
2800	370.34
2900	376.90
3000	383.34
3100	389.68
3200	395.92
3300	402.06



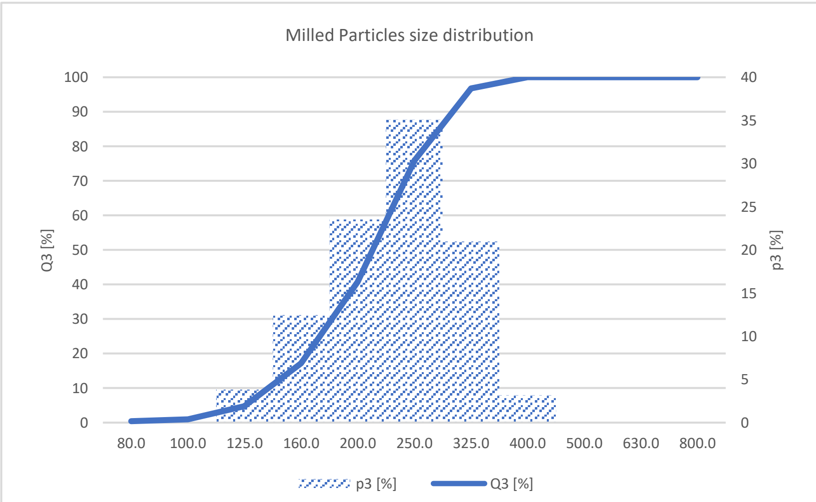


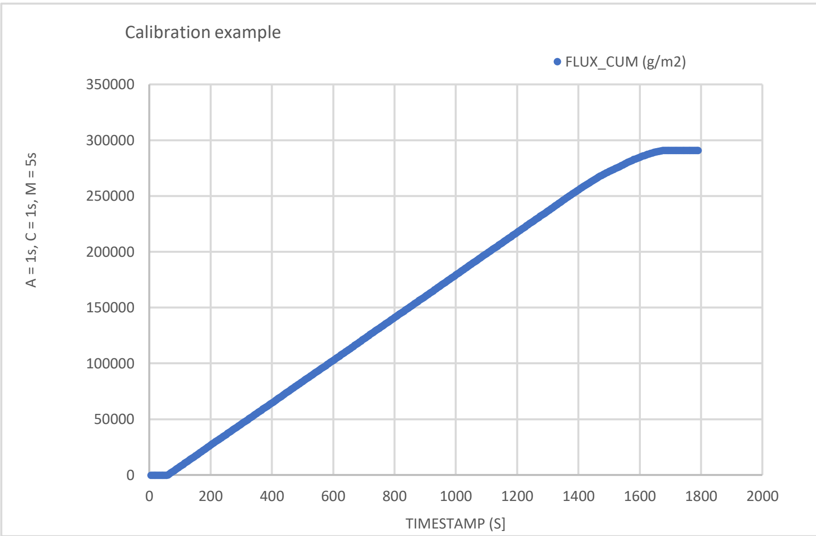
Considering the realty of the aeolian solid particles transport dynamic ranges which are widely discussed in the literature, this linearization function must always be interpreted only as a simplified and practically-oriented model.

E.2. Calibration method of the instrument

The electronic and the mechanical response instrument is factory-calibrated individually and this for a lifetime duration so without requiring periodic recalibration.

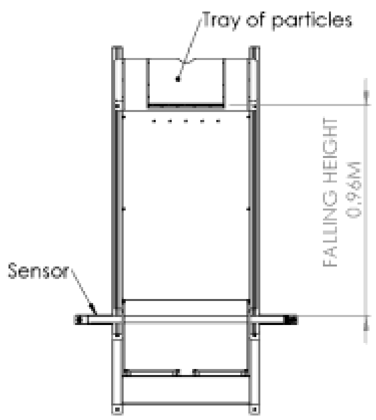
This is performed trough a controlled vibroacoustic coupler and some artificial particles flux excitation of each instrument. The method produces the needed reference acoustics and vibration signals and the needed momentum impacts excitations so that the whole sensitivity of the instrument can be set to the desired nominal reference sensitivity, with a precision and an accuracy of ±5 %.





CALIBRATION - GRAVITARY CONTROLLED FLUX OF SOLID PARTICLES

TEST BENCH



THEORY	
EC	**EP**
1/2 × M × V2	M × G × H
0.5 × KG × M2 × S-2	KG × (M × S-2) × M
J=KG × M2 × S-2	J=KG × M2 × S-2
TERMINAL VELOCITY IN VACCUM = (2 × G × H) ^0.5 [M × S-1]	
Note (1): KE/FLUX prop. to M4 × S-1	

INDIVIDUAL PARTICLE (CALIBRATED TEST PARTICLES, PLASTIC MATERIAL)

PART. DENSITY	1.2	[GR × CM-3]
PART. DENSITY	1200	[KG × M-3]
PART. SIZE	5.00E-04	[M]
PART. SHAPE	QUASI CUBIC	[1]
PART. VOL.	1.25E-10	[M3]
PART. MASS	1.50E-07	[KG]
PART. MASS	1.50E-04	[GR]

FALLING TRAY OF PARTICLES & FALLING APERTURE

EFFECTIVE FALLING HEIGHT	0.960	[M]
EFFECTIVE WIDTH	0.060	[M]
EFFECTIVE LENGHT	0.345	[M]
HEIGHT	0.224	[M]
EFFECTIVE HEIGHT	0.215	[M]
TOT. EFF. VOL.	4.45E-03	[M3]
NUMBER OF PART.	1.84E+07	[1]
TOT. EFF. MASS	2.760	[KG]
APERTURE: NUMBER OF HOLES	5	[1]
DIA.OF HOLES	3.60E-03	[M]
TOT. EFF. HOLES APERTURE	5.09E-05	[M2]
EST. INTERCEPTION RATE	9.80E-01	[%]
MEASURED FALLING DURATION	1.62E+03	[S]
HITS/SEC FOR THE FALLING DURATION	1.12E+02	[HITS × S-1]

PHYSICS OF THE FALL

EST. TERM. VEL. (THEOR. VACCUM)	4.34	[M × S-1]
EST. KE (J) TOT as M × G × H	2.60E+01	[J=KG × M2 × S-2]
EST. KE (J) TOT as 1/2 × M × V2	2.60E+01	[J=KG × M2 × S-2]
EST. KE/T FOR THE FALLING DURATION	1.61E-02	[POWER, W=J × S-1]

READING ON CALIBRATED SENSOR

mV RMS	1605.20	[10E-3V]
LINEARIZATION COEFFICIENT XC1	4.00E-05	[1]
LINEARIZATION COEFFICIENT XE1	2	[1]
FLUX_AVG READING=XC1 × mV ^XE1	103.1	[G × M-2 × S-1]
FLUX_AVG READING	0.103	[KG × M-2 × S-1]
FLUX_CUM READING	1.66E+05	[G × M-2]
FLUX_CUM READING	166.45	[KG × M-2]
Note (2) : Mass of 2760 grams of particles in the tray falls in 1620 seconds from 0.960m height on the 32mm*983mm= 0.031 m2 horizontal section of the sensor, while the reading gives 2.760/166.45=0.0166m2 : the ratio between 0.031 m2 and 0.0166 m2 is because of the cylindricity of the sensor i.e. the particles hitting the edges transmit less energy than those in the axis of the tube (the effective *apparent* interception section of the sensor is approx. half the geometrical projection).		

SENSITIVITY OF THE SENSOR

MILLIVOLTS PER MILLIJOULE/SEC	99.7	10E-3V × 10E-3J × S-1
VOLTS PER JOULE/SEC		V × J × S-1
VOLTS PER WATT OF FLUX		V × W-1

Appendix F: Application case: Monitoring drifting-snow transport & accumulation for avalanche forecasting and land management

From its origins in avalanche research to modern environmental sensing applications, the FlowCapt technology – and now its 4th generation instrument the FlowCapt FC4 – has always evolved into a more and more robust and versatile system for monitoring wind-driven particle movement. The instrument is highly reliable for detecting transport events and providing long-term observational capability.

F.1. Introduction

Wind-driven snow transport is one of the most critical and least visible processes influencing avalanche hazard in mountainous terrain. In the Alps, where topographic complexity and intense winter storms combine to create highly variable loading patterns, **wind is often the dominant factor controlling the spatial distribution of snow**, the formation of unstable wind slabs, and the timing of avalanche cycles.

Operational avalanche forecasters and road-safety managers have long recognized that **precipitation measurements alone are insufficient**: many destructive avalanches occur **without new snowfall**, triggered instead by wind redistribution of existing snow. Continuous, field-based measurements of drifting snow are therefore essential for understanding when, where, and how rapidly potentially unstable slabs form on leeward slopes. However, direct measurement of snow transport is notoriously difficult under Alpine conditions, where icing, visibility, and access constraints can make conventional instruments unreliable.

The **FlowCapt FC4 acoustic instrument** offers a uniquely robust and low-maintenance solution to this problem. As demonstrated in almost all mountain ranges, this instrument enables continuous, real-time monitoring of drifting-snow episodes, erosion-accumulation dynamics, and wind-induced loading prognosis — for the small to the most severe winter storms.

Drawing on key references from the literature (see bibliography), this appendix explains how the FlowCapt FC4 instrument contributes operationally to **avalanche forecasting**, **road protection**, and **drifting-snow accumulation assessment**.

F.2. Wind loading drives slab formation

Wind acts as both a **redistributor of snow** and a **mechanical modifier** of the snow surface:

• It erodes windward slopes and transports snow into leeward zones, where drifts and slabs accumulate.

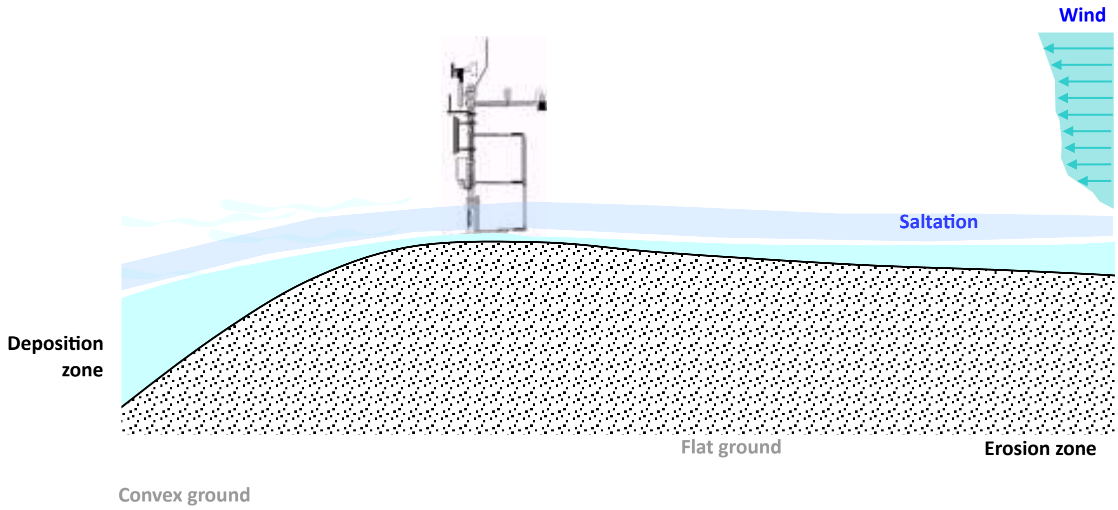
• It hardens snow through compaction and fragmenting of grains, creating dense layers that can act as structural weaknesses or stiff slabs.

• It can rapidly load slopes far from snowfall measurement sites, making local snowfall totals a poor predictor of actual loading.

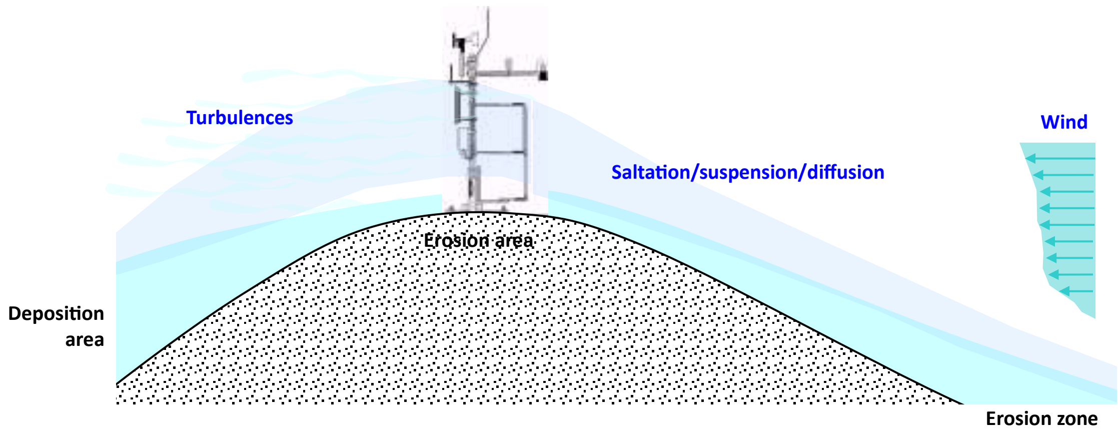
As noted in operational studies, **avalanches are frequently triggered during or immediately after intense drifting-snow events**, regardless of whether new snow has fallen. This makes the ability to *measure the intensity and timing of snow transport* indispensable for day-to-day hazard assessment.

Schematically, the three following basic measurement situations are distinguished.

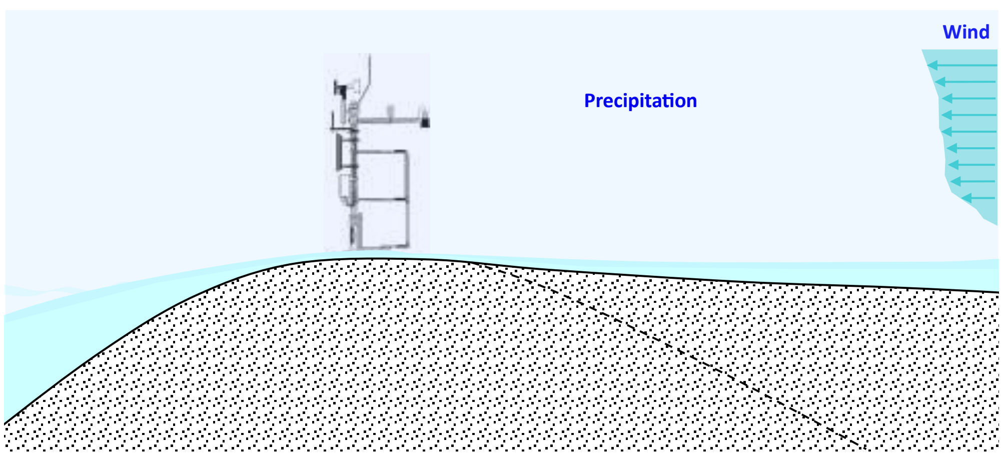
Case 1: Saltation snowdrift on an implantation satisfying the reference criteria



Case 2: Saltation/suspension/diffusion snowdrift on an implantation on convex ground



Case 3: Blowing snow



To anticipate slab development and respond proactively, avalanche forecasters require c**ontinuous measurements,** including at remote starting zones, r**eliable sensors** unaffected by icing, possibly complementary **wind information** and rapid detection of both **erosion and accumulation**.

Except for the measurement of the wind direction, the FlowCapt FC4 instrument meets these requirements and is robust enough to withstand severe wind, low temperatures, and long unattended deployments.

F.2.1. Multi-height measurements for vertical transport profiles

In a most common mode of use, the snowdrift stations deployed operationally uses two staggered FlowCapt FC4 sensors: the lower tube measures the transport rate in the first meter above the snow surface, and the upper tube records transport at higher elevations.

This allows operators to infer:

- the development of a **saltation layer**,
- the height and severity of transport,
- whether drifting snow is primarily **surface-based** or **deep/fully turbulent**.

This vertical information is sometime crucial for understanding slab formation potential.

F.2.2. Reliability during extreme storm events

Unlike instruments which may fail due to extreme conditions, or need more energy consumption to operate in such conditions, the FlowCapt FC4 instrument continues to function even when visibility is zero, riming is high and temperatures are deeply sub-freezing. Several authors emphasize that the FlowCapt FC4 instrument maintained operational data during severe weather episodes where other instruments — particularly propelled anemometers or optical devices — failed due to icing, yet FlowCapt still detected drifting snow and snowpack changes.

The resistance of operation even under extreme riming is because for the measurement of the flux, the excitation is not only acoustic but also a so-called "structure-borne conduction" (vibroacoustic coupling), and therefore as long as the frost gangue is really 'solid' ice (with little air in it), the conduction of the vibrational energy of the impacts of the particles remains good. Moreover, if the conduction is a little attenuated, one can imagine that it is somehow compensated by the increase in the size of the obstacle (the size of the sensor with the ice is larger than the size of the sensor by itself). So, in this sense, we can assume that in the end, the ice does not change the sensitivity of the sensor too much.

Note: This stated less optimistic effects, that may contradict the previous analysis, are that there is an additional interface in the conduction link (ice-metal interface). The conduction will therefore firstly depend on the condition of this interface (for example, if the metal heats up a bit and there is water between the ice gangue and the body of the sensor, the conduction will drop sharply). And secondly, if the ice is not very solid, the loss in the conduction will increase and thus decrease the global sensitivity.

But in general, based on field measurements, we almost never observe curves where the flow or the wind signals of the FlowCapt FC4 fall to flat "zero" curves: it seems that the signals never drop sharply, or really change their dynamics, for that matter. This can be an indication that the instrument behavior remains quite stable even when it is very icy

F.3. Operational use case: Road safety management in Savoie (France)

The Savoie Department manages **1000 km of high-altitude roads** and over **100 avalanche-exposed sections**. A dozen of snowdrift stations each equipped with two FlowCapt FC4 instruments were installed to provide real-time guidance for closure decisions, preventive artificial releases, and post-storm assessments.

Dual snow-height sensors combined with FlowCapt FC4

Duclos et al. (2013) describe an innovative setup:

- One snow-height sensor is placed at the FlowCapt station, typically in a wind-erosion zone.
- A second snow-height sensor is placed 50–80 m away, in an accumulation zone.

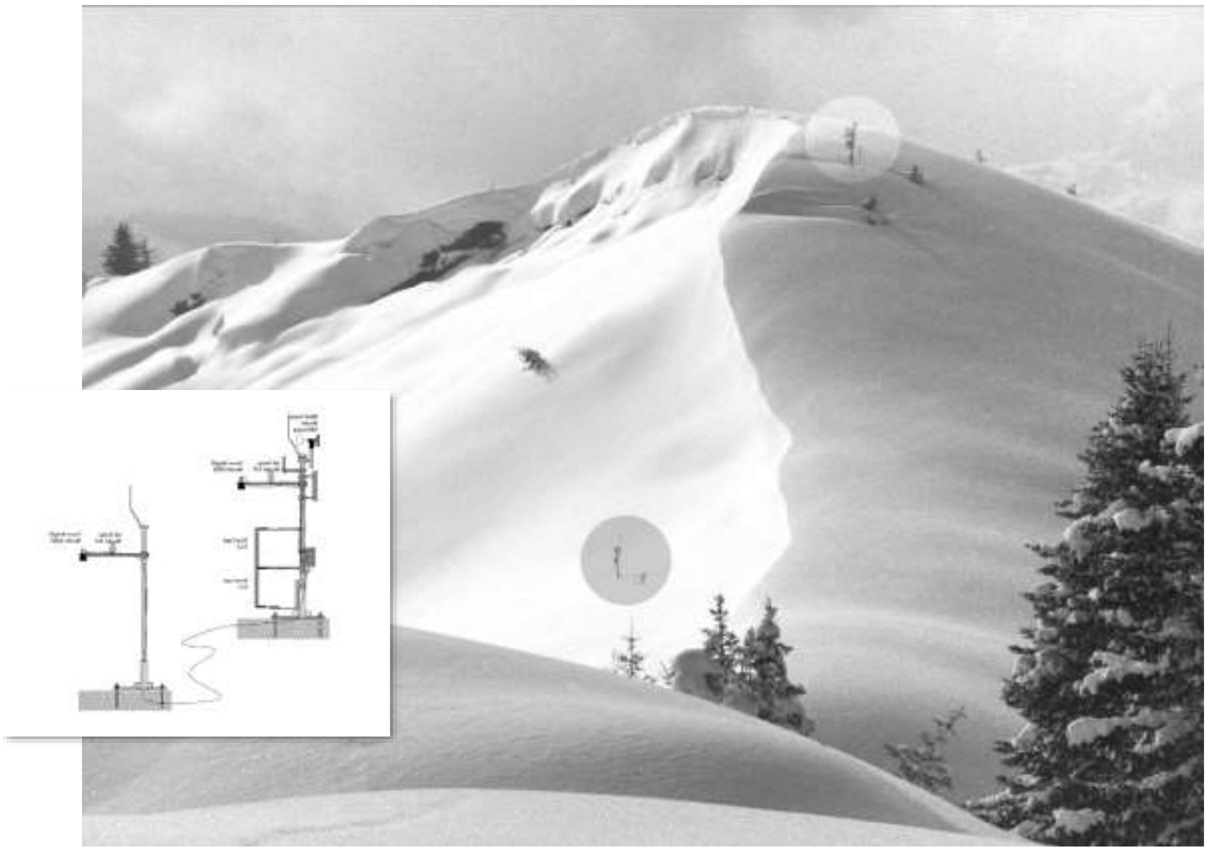
This configuration reveals:

- whether wind is eroding or loading the slope,
- where accumulations are forming,
- whether an avalanche has occurred (sudden snow-depth drop).

This dual-measurement concept gives some crucial advantages for interpreting FlowCapt FC4 readings operationally. A key advantage demonstrated at one of the sites (Celliers):

- A snow-depth sensor located near a Gaz-Ex exploder shows an abrupt drop in snow height when a slab release is triggered.
- The FlowCapt FC4 data confirms that the slab release occurred during a period of strong transport.

Figures in Duclos et al. show that FlowCapt sensors captured significant drifting-snow episodes, including the one preceding the 8 December 2011 slab release.



Measurements from 3 to 9 December 2011, at the station in Celliers (Savoie, France). In period 1, we can see a first episode of wind transport: the FlowCapt instruments record transport, the anemometer, frosted, does not give any indication, the main snow depth decreases while the other increases. On period 2: we see a snowfall without much transport: The FlowCapt instruments don't register much, the snow depths both increases. On Period 3: we see a well-marked transport episode, with strong erosion, the anemometer has finally unlocked. The effectiveness of the artificial release that followed this period is clearly visible.

In a general manner, the snowdrift stations help revealing dangerous loading events at high elevation that cannot be seen from valley roads, providing early warning when slabs are forming above critical road corridors, and reducing uncertainty when other instruments fail (e.g., when anemometers freeze); operators can therefore take preventive actions *before* spontaneous avalanches threaten infrastructure.

F.4. FlowCapt for operational avalanche forecasting models (Météo-France)

Guyomarc'h et al. (2016) describe how FlowCapt data are used to validate and calibrate French operational avalanche forecast s2M model chain: SAFRAN (meteorological downscaling), Crocus (snowpack stratigraphy), Sytron (drifting snow redistribution module). FlowCapt sensors are instrumental in validating the drifting-snow occurrences predicted by Sytron, which computes erosion/accumulation around idealized crests based on wind thresholds and snow-surface conditions. The study compares model predictions to nine FlowCapt FC4 stations across the French Alps and the experimental site at Col du Lac Blanc.

- Results show a mean probability of detection (POD) of ~0.65 across stations, a low false alarm rate (FAR ~0.18), and that at high-quality sites like *Col du Lac Blanc*, POD reaches 0.89. These metrics confirm that the FlowCapt FC4 instrument provides reliable ground truth for evaluating model performance.
- When model predictions and FlowCapt observations align, the confidence in forecasted drifting-snow hazard increases, forecasters can justify raising risk levels based on strengthened evidence and avalanche bulletins become more accurate and defensible. When they diverge, forecasters can identify biases (often wind-speed underestimation in SAFRAN), they can re-evaluate local hazard ratings more critically, long-term model improvements become possible.
- Real-time monitoring of drifting-snow accumulation (detection of erosion vs accumulation patterns): the FlowCapt FC4 data combined with snow-depth sensors allows Identifying strong erosion episodes (snow-depth drop at windward station), pinpointing rapid accumulation (snow-depth rise at leeward station), and interpreting the differential growth of slabs across nearby slopes. This insight cannot be obtained from simple meteorological data.

F.5. Summary of the limitations and proper use in operational settings

While FlowCapt FC4 is excellent for detecting drifting snow, absolute flux values are not always accurate due to the influence of particle size, particle velocity, temperature and the vibroacoustic coupling condition between the sensitive body of the sensor and the fluxes of particles (in particular, in presence of heavy riming). FlowCapt FC4 should then not be used as an absolute measurement of true mass flux without complementary calibrations.

Apart from these limitations, relative measurements are robust and operationally sufficient as operational forecasting does not require absolute fluxes, what matters being the onset of transport, duration, relative intensity, temporal peaks and vertical distribution, FlowCapt FC4 excelling at all of these.

At very high transport intensities (> 435 g m^{-2} s^{-1}), the signal will saturate, but even in these cases, the occurrence of transport is still recorded and the signal plateau itself indicates "extreme loading conditions", forecasters can then interpret the plateau as very high drifting-snow hazard.

Across Alpine deployments, FlowCapt has proven to be:

✔ A robust, all-weather drift detector

Working during storms, freezing rain, icing, and low visibility.

✔ A real-time indicator of slab formation

Detecting critical loading on leeward slopes.

✔ **A complementary tool to snow-height sensors**

Revealing erosion vs accumulation dynamics within the same basin.

✔ **A ground-truth instrument for avalanche forecasting models**

Validating drifting-snow algorithms in the operational S2M chain.

✔ **A decision tool for road safety operations**

Supporting preventive artificial triggering, road closures, and hazard warnings.

✔ **An essential component of modern avalanche-warning infrastructure**

Providing continuous, high-frequency measurements in locations inaccessible to human observers.

By making hidden wind-driven loading processes visible, FlowCapt FC4 significantly improves the accuracy, reliability, and safety of avalanche hazard management across mountainous regions.

Appendix G: Application case: Measuring snowdrift in Antarctic cryosphere regions and its importance for climate studies

G.1. Introduction

Blowing and drifting snow (collectively referred to here as snowdrift) plays a central role in shaping the surface mass balance (SMB) of the polar ice sheets, influencing the hydrological cycle, atmospheric boundary-layer structure, and long-term sea-level projections. In Antarctica particularly, strong katabatic winds remobilize vast quantities of previously deposited snow, redistributing it over long distances, promoting sublimation, and in extreme cases exporting mass irreversibly to the ocean. This process is both ubiquitous and poorly constrained observationally. Large sectors of the Antarctic coast experience snow transport **60-90% of the time**, with transport rates exceeding fresh snowfall fluxes by several orders of magnitude in the windiest regions, such as Terra Nova Bay and Adélie Land.

The lack of long-term, reliable, and spatially distributed **in situ measurements** has long hindered accurate quantification of this component of SMB. Traditional measurement systems—snow traps, SPC devices, optical counters—are either power-intensive, prone to icing, mechanically fragile, or insufficiently autonomous for multi-month deployments in polar environments. As a result, blowing-snow parameterizations in global and regional climate models remain insufficiently validated. This limitation is specifically acknowledged by models used in IPCC assessments, which typically include snowfall processes but **do not include explicit blowing-snow physics**, resulting in major uncertainties in projections of Antarctic SMB changes and therefore global sea level.

To address this gap, the **FlowCapt acoustic sensor**, developed during the 1990s and continuously improved since, has become a cornerstone instrument for monitoring drifting snow in both polar and alpine environments. The FlowCapt FC4 version combines rugged design, very low power consumption, and the ability to measure acoustic vibrations produced by particle impacts on a tubular resonator, which serves as a surrogate for snow particle flux.

G.2. Physical and climatic importance of snowdrift

Antarctica's SMB is influenced by the balance between precipitation and various ablation processes, including sublimation, melt (limited to warm coastal zones), and wind-driven erosion and export. The **erosion and wind transport of snow constitute a major and often unmeasured ablation term**, potentially reducing local accumulation by **5–10% on average** and up to nearly 100% in blue-ice areas. Blue-ice regions near Cap Prud'homme, for example, exhibit strongly negative surface balances almost entirely driven by wind erosion.

Climate models predict increased Antarctic precipitation under warming due to enhanced moisture content in the atmosphere. Yet, this increase may be partly or wholly offset by enhanced blowing-snow sublimation or export. The magnitude of this offset is currently one of the largest uncertainties in projections of sea-level rise. The lack of high-quality observations of blowing snow is a primary reason for the uncertainty surrounding the SMB's sensitivity to climate change.

Snowdrift's contribution is not limited to mass loss. It also influences the **spatial variability** of SMB, creating heterogeneous accumulation patterns that strongly affect ice-flow dynamics and firn-air content, important for ice-core interpretations.

G.3. Impact on boundary-layer structure and atmospheric processes

Blowing snow modifies the near-surface atmosphere in several ways:

- **Moistening of the boundary layer** due to sublimation of suspended particles. This effect reduces humidity biases in models that do not include blowing snow, as shown in Appendix A and in the MAR model comparisons.
- **Cooling of the near-surface air** via sublimation, enhancing density-driven katabatic flows.
- **Reduction of temperature and humidity gradients**, complicating turbulence estimation.
- **Formation of deep suspension layers**, sometimes extending tens of meters above ground, as observed in the multi-level FlowCapt configurations and in Adélie Land (Trouvilliez et al. 2014).

In atmospheric models lacking these processes, simulated humidity remains too low during drift events, leading to errors in cloud formation, precipitation recycling, and radiative fluxes.

G.4. Influence on remote sensing and plume interpretation

Satellite imagery frequently detects snow-plume structures. Without ground truth, however, these detections cannot distinguish between snowfall, surface erosion, and sublimation plumes. FlowCapt time series provide essential validation signals, linking plume occurrence with particle transport intensity.

G.5. FlowCapt FC4 multi-level deployment and insights into vertical transport

A knowledge of the vertical flux gradients is essential for evaluating snowdrift parameterizations in regional climate models. Trouvilliez et al. (2014) used such configurations to compare observed vertical flux profiles with model simulations, highlighting model underestimations when blowing-snow physics is disabled.

FlowCapt sensors consist of a cylindrical tube instrumented with acoustic transducers. Snow particles impacting the tube generate vibrations whose amplitude and frequency spectrum correlate with the momentum flux of drifting particles. Vertically stacked FlowCapt tubes beside a meteorological mast conveniently allow the determination of such full vertical profile up to a several meters elevation, and such multi-level FlowCapt arrangements have demonstrated:

- Snow transport occurs through the entire measured column (typically >3 m), not just in the saltation layer.
- Particle concentrations may **increase with height** in extreme conditions, indicating the development of deep suspension layers.

G.6. Operational robustness and long-term autonomy

Several authors emphasize the difficulty of maintaining instruments in the "kingdom of the blizzard," where storms make winter access impossible. For example, Genthon et al. (2011) reported the successful year-long autonomy of FlowCapt at D3, D17, and D47 that confirms its suitability for permanent observation networks in Antarctica. Even when other instruments failed—e.g., anemometers destroyed by icing or violently shaken by storms—FlowCapt often remained operational. For example, the multi-level tower at D17 provides vertical wind profiles and snow fluxes that are essential for estimating friction velocity, a key driver of erosion threshold.

The evaluation against Snow Particle Counters (SPC) provided a strong validation of FlowCapt scientific utility (Trouvilliez et al. 2015). The February 6, 2012 case study showed a correlation coefficient of **0.91** between SPC-measured fluxes and FlowCapt, demonstrating strong quantitative agreement despite differences in sampling geometry.

An addition to blowing-snow theory comes from **He & Ohara (2017)**, who developed a physically based formulation for the threshold wind speed required to initiate snow movement. Using a long-term FlowCapt dataset, they calibrated the model and found strong agreement with observed thresholds. The threshold-formulation highlights several points directly relevant to Antarctic blowing snow:

1. **Recently deposited snow is extremely mobile** even at low wind speeds (4–6 m s^{-1} at 10 m height).
2. **Threshold wind speed increases logarithmically with time**, especially during the first hours to days after snowfall.
3. **Temperature modulates bonding**, with very slow sintering at –30 °C, typical of the Antarctic interior.

G.7. Contributions of FlowCapt to climate modeling and observational networks

FlowCapt data have been central to validating simulations of:

- surface wind fields,
- blowing-snow mass flux profiles,
- near-surface humidity evolution.

Genthon et al. (2011) show good agreement between MAR-simulated vent and observed events at D3, supporting the robustness of MAR when blowing-snow parameterizations are active.

About the quantification of SMB processes, FlowCapt-derived data also allowed:

- estimation of erosion fluxes,
- identification of redistribution pathways,
- correction of accumulation datasets for drift-related losses.

This is crucial for studies showing that SMB variability is dominated by wind redistribution rather than precipitation variability.

For a long-term monitoring, FlowCapt reliability makes it ideal for networks represent prototypes for a continent-wide system:

- Antarctic Observing Network (AntON) sites,
- validation of future satellite missions,
- continuous monitoring of blizzard frequency.

G.8. Instrument limitations and mitigation

Although FlowCapt is exceptionally useful, users must be aware of certain limitations:

- **Quantification accuracy** is sensitive to snow type, particle size, density and aerodynamic properties.
- The sensor may **underestimate flux** in very cold, low-density snow conditions.
- Extremely high transport events (>10^{-2} kg m^{-2} s^{-1}) may reach or exceed the nominal range of the sensor.
- **Dependence on vertical installation stability** (structure-borne conduction of loose parts from the supporting structure exposed to high winds can introduce parasitic noise).
- **Inability to distinguish blowing precipitation vs snow drift without ancillary meteorological data**.

However, the studies document practical strategies to mitigate these through careful mounting of the supporting structures, thresholding, cross-checks with wind data, and multi-sensor deployments. For

climatological and detection purposes, these limitations are manageable, and FlowCapt FC4 still produces an extremely reliable continuous Antarctic snow-transport instrument.

G.9. Conclusion

This integrated synthesis demonstrates that the FlowCapt FC4 sensor is a **fundamental tool for modern cryosphere climate science**, uniquely capable of delivering long-term, reliable, and physically meaningful observations of blowing snow in extreme environments. Its contributions can be summarized as follows:

1. **Operational reliability** in polar blizzard conditions unmatched by other instruments.
2. **Validated ability** to detect snow transport events and quantify relative flux variations.
3. **Critical support** for climate-model development, especially in representing blowing-snow physics.
4. **Insight into vertical structure** of drift fluxes, essential for understanding deep suspension layers.
5. **Improvement of SMB estimates** through quantification of erosion, sublimation, and redistribution.
6. **Foundation for theoretical advances**, including threshold wind-speed formulations grounded in real-world observations.
7. **Enabling continent-wide observatories** that address long-standing observational gaps.

In cryosphere regions such as Antarctica—where blowing snow is ubiquitous, intense, and climatically influential—FlowCapt FC4 is not just useful; it is indispensable. Its unique combination of durability, sensitivity, and ability to operate autonomously for years makes it one of the few instruments capable of capturing the processes that govern the Antarctic surface mass balance and its climate interactions.

In sum, FlowCapt has enabled a qualitative leap in our understanding of polar blowing-snow processes, and its integration with modern modeling frameworks positions it as a central component of present and future Antarctic climate research.

As climate models and satellite systems continue to improve, ground-truth data from FlowCapt FC4 networks will remain essential for understanding, predicting, and monitoring the evolving Antarctic climate system.

Note: This appendix is a synthesis and integration of evidence from scientific papers among the list of the following bibliography.

Seasonal Variations in Drag Coefficient over a Sastrugi-Covered Snowfield in Coastal East Antarctica
Charles Amory, Hubert Gallée, Florence Naaim-Bouvet, Vincent Favier, Etienne Vignon, Ghislain Picard, Alexandre Trouvilliez, Luc Piard, Christophe Genthon and Hervé Bellot
Boundary-Layer Meteorology, 21 February 2017, 27 pages
Mots-clés : Antarctica, Drag coefficient, Drifting snow, Sastrugi, Snow surface roughness

Brief communication: Two well-marked cases of aerodynamic adjustment of sastrugi
C. Amory, F. Naaim-Bouvet, H. Gallée and E. Vignon
The Cryosphere, 10, 743–750, 2016, 1 April 2016, 8 pages

Comparison between observed and simulated aeolian snow mass fluxes in Adélie Land, East Antarctica
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Appendix H: : DECLARATIONS

- EU DECLARATION OF CONFORMITY
- TREACABILITY AND CALIBRATION DECLARATION
- WMO APPLICABILITY

DECLARATION DE CONFORMITE UE
EU DECLARATION OF CONFORMITY

Nous | *We* **IAV Technologies SARL**
Chemin des Couleuvres 4A
CH-1295 TANNAY

ID: CHE-197.530.466

déclarons que les produits | *declare that the products*

Désignation *Name*	**Fabriqués depuis** *Manufactured since*	**Numéro de série S/N*** *Serial number S/N**
FlowCapt FC4	Jan. 2016	FC*YYBxxx*
SandFlow SF4	Jan. 2016	SF*YYBxxx*
RainFlow RF4	Jan. 2016	RF*YYBxxx*
HailFlow RF4	Jan. 2020	HF*YYBxxx*
WindFlow WF4	Jan. 2016	WF*YYBxxx*
USB Link Accessory (UDONG)	Jan. 2016	U*YYxxx*
Modbus Adapter (MOBUS)	Jan. 2020	MB*Bxxx*
4-20 mA Adapter (AD420)	Mar. 2024	A*YYxxx*
Extension Cable (EXT10)	Nov.2019	E*YYxxx*

* YY = Année de fabrication (2 chiffres) – *Year of manufacturing (2 digits)*
B = Numéro de batch (de A à Z) – *Batch number (from A to Z)*
xxx = Numéro de production dans le batch – *Production number in the batch*

auxquels se réfèrent cette déclaration, sont conformes aux prescriptions de la directive et des normes qualité suivantes | *to which this declaration relates, are in conformity with the requirements of the following directive and quality standards:*

2004/108/EU « Compatibilité électromagnétique », selon les standards suivants |***« Electromagnetic compatibility »****, using the following standards:*

EN 61326-1:2013 Matériels électriques de mesure, de commande et de laboratoire | *Electrical equipment for measurement, control and laboratory use.*

EN 55022:2010 Appareils de traitement de l'information - Caractéristiques des perturbations radioélectriques - Limites et méthodes de mesure |*Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement.*

2011/65/EU « Limitation de l'utilisation de certaines substances dangereuses dans les équipements électriques et électroniques », selon les standards suivants |***« Restriction of the use of certain hazardous substances in electrical and electronic equipment »****, using the following standards:*

EN 50581:2012 Documentation technique pour l'évaluation des produits électriques et électroniques par rapport à la restriction des substances dangereuses | *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances.*

2006/42/CE « Machines », avec les qualités de composants électroniques et mécaniques suivantes **|** *« Machinery », with the following additional electrical/electronic and mechanical qualities:*

Parties électriques/électroniques : | *Electrical/electronic parts:*

- Production certifiée ISO9001 et ISO13485 (EN46001) |*ISO9001 and ISO13485 (EN46001) certified production*
- Assemblage conforme à RoHS |*RoHS compliant assembly*
- Contrôle final par échantillonnage AQL 0.65 pour les défauts majeurs et 1.00 pour les défauts mineurs |*Final control per sampling AQL 0.65 for major defects and 1.00 for minor defects*
- Référentiel qualité par défaut IPC-A-610, produits de classe II |*Default quality referential IPC-A-610, class II products.*

Parties mécaniques métal/plastiques | *Metal/plastic parts:*

- Production certifiée IQNet et SQS | *IQNet and SQS certified production*
- Acier certifié INOX 1.4301 2B / 316L 1.4404 1.4401 2B, soudures selon la norme ISO5817 Qualité D | *Certified stainless steel INOX 1.4301 2B / 316L 1.4404 1.4401 2B, welded process ISO5817 Quality D*
- Conformité plastique PET-C | *PET-C plastic conformity*: FDA 21 CFR 177.1630 2011/65/EU (RoHS2); 2015/863/EU (RoHS3); 1907/2006/EU (REACH)

Nous déclarons également que la personne autorisée à constituer le dossier technique est le chargé de projet de la société, basé au siège social de la société IAV Technologies SARL | *We also declare that the person authorized to produce the technical documentation is the project manager located at the IAV Technologies SARL Company.*

Mis à jour à Tannay, le 1er avril 2024
Updated in Tannay on the 1st of April 2024

Signatures autorisées et timbre :
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Directeur / *Director*
Associé-gérant

Dr. Vincent CHRITIN
Fondateur / *Founder*
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ISAW PRODUCT
TRACEABILITY AND CALIBRATION DECLARATION

We,

IAV Technologies SARL
Chemin des Couleuvres 4A
CH-1295 TANNAY

ID: CHE-197.530.466

hereby certify that all ISAW instruments: HailFlow HF4, RainFlow RF4, FlowCapt FC4, SandFlow SF4 and WindFlow WF4

are delivered **factory calibrated** and accompanied by their individual calibration certificate.

The factory calibration is valid **for the entire lifetime of the instrument**. It consists of a calibration coefficient written in the internal memory of the instrument in a non-volatile and non-modifiable way. This calibration value is accessible anytime in the sensor parameters list.

This calibration is stored and remains valid even after a firmware update.

Should you wish to **check the instrument calibration**, IAV Technologies SARL has the exclusive right to perform this check. This operation requires the instrument to be returned to the factory, where it will be recalibrated and issued a new calibration value and a new individual calibration certificate.

Tannay, **May 16th, 2023**,

Vincent Chritin

V. Chritin

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WMO Applicability

The FlowCapt FC4 snowdrift and wind-transport sensor (measures blowing and drifting snow flux, snow transport detection, and near-surface wind speed) operates in accordance with the main recommendations of the World Meteorological Organization (WMO) for the monitoring of solid precipitation, blowing snow and near-surface wind. In particular,

- Its acoustic impact measurement principle, detection capabilities, and multi-height drift profiling align with WMO-No. 8 – Guide to Meteorological Instruments and Methods of Observation, particularly the sections addressing drifting snow, blowing snow events, and wind measurement in high-exposure environments.
- The instrument's robustness, resistance to icing, and long-term stability fulfil the operational expectations derived from WMO SPICE/CIMO intercomparison practices for solid precipitation instrumentation.
- Additionally, the FC4 follows the traceability, documentation and calibration requirements specified in WMO-No. 49 Technical Regulations, supported by its lifetime factory calibration stored in non-volatile memory.
- The data formats generated by the FC4 are compatible with WMO-No. 306 (BUFR) descriptors for snowdrift and wind, ensuring interoperability with national and international observation networks.

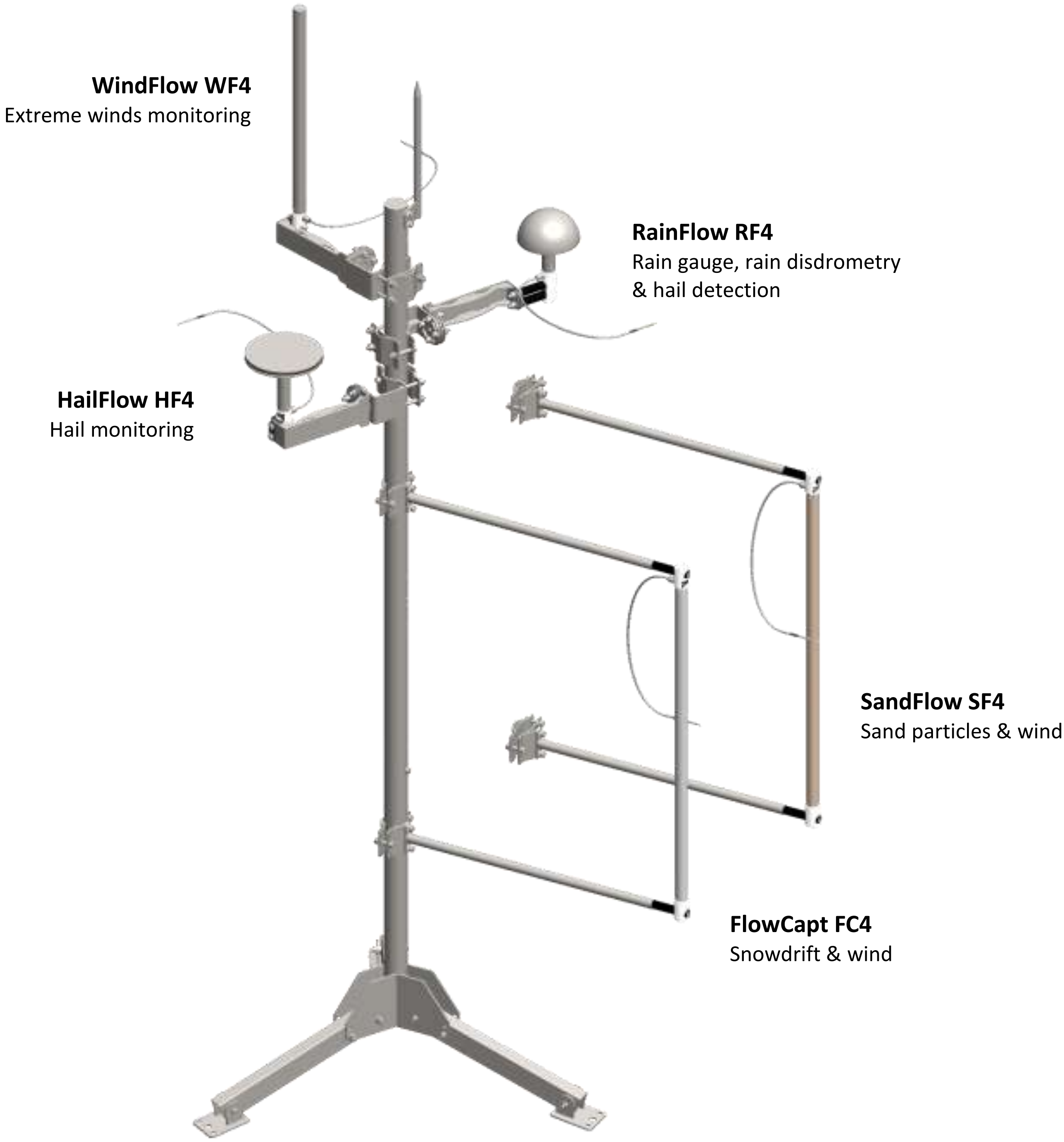
WMO Standard or Document	Applicability	Relevance to FlowCapt FC4
WMO-No. 8 (Solid Precipitation & Wind Sections)	Primary	Requirements for blowing snow measurement, drifting snow detection, wind measurement, siting
WMO SPICE / CIMO Recommendations	High	Methods for evaluating drifting-snow sensors, validation protocols
WMO-No. 485	Applicable	Hydrometeorological applications (hazard monitoring, avalanche risk, road safety)
WMO-No. 49	Applicable	Traceability, calibration, reliability — FC4 meets lifetime calibration requirements

WMO Standards Relevant to FlowCapt FC4

As such, the FlowCapt FC4 satisfies WMO guidance for high-quality, reliable, and all-weather drifting snow monitoring.

Appendix I: ISAW INSTRUMENTS OVERVIEW

A total of five instruments is available as ISAW ultra-specialized sensors for the monitoring of solid and liquid precipitation, as well as aeolian blowing particles.



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