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USER GUIDE

CL51

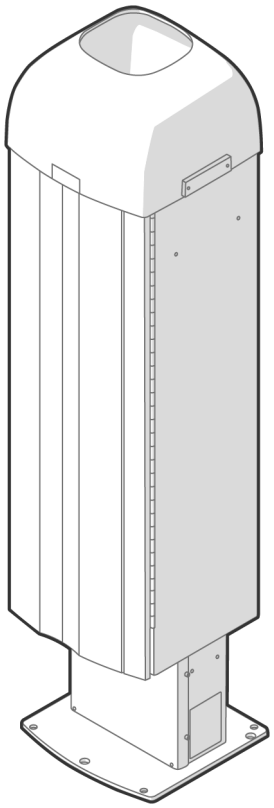
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M210801EN-K

User Guide

Vaisala Ceilometer
CL51



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1. About this document

1.1 Version information

Table 1 Document versions (English)

Document code	Date	Description
M210801EN-K	January 2025	Added DMU801 replacement instructions. Added information about netCDF data output. Added information about the PODS-MQTT interface. Added configuration instructions for measurement sensitivity, netCDF filename, and Ethernet, SFTP, and MQTT setup. Updated figures of type labels. Updated transmitter specifications. Updated item code of optical termination hood.
M210801EN-J	June 2024	Updated safety and laser safety information. Added a figure showing the warning labels and type label and their locations. Updated temperature specifications. Added a note about IP rating. Added instructions for replacing fuses. Added requirements for a disconnection device for the AC (mains) connection. Updated cable requirements. Updated laser transmitter instructions. Added a note instructing to use a flat head screwdriver to open ceilometer door. Moved chapter Functional description to a new document *CL51 Technical Description (M212735EN)*. Updated battery information with new figures.
M210801EN-H	December 2020	Updated safety information.

1.2 Related manuals

Table 2 Related manuals

Document code	Name
M210310EN	Vaisala Termination Box TERMBOX-9000, 1200, 1212, 1222 User Guide
M212735EN	Vaisala Ceilometer CL51 Technical Description
M211185EN	Vaisala Boundary Layer View Software BL-View User Guide

Document code	Name
M210717EN	*Vaisala Graphical User Interface for Ceilometers CL-View*

1.3 Documentation conventions



WARNING! Warning alerts you to a serious hazard. If you do not read and follow instructions carefully at this point, there is a risk of injury or even death.



CAUTION! Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.



Highlights important information on using the product.



Gives information for using the product more efficiently.



Lists tools needed to perform the task.



Indicates that you need to take some notes during the task.

1.4 Trademarks

Vaisala® is a registered trademark of Vaisala Oyj.

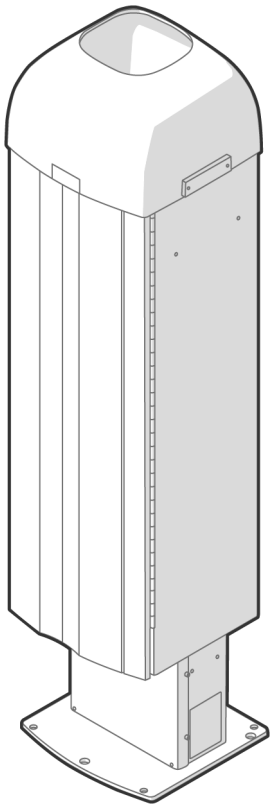
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2. Product overview

2.1 Vaisala ceilometer



Vaisala ceilometer measures cloud height and vertical visibility.

The ceilometer uses pulsed diode laser LIDAR technology (light detection and ranging, LIDAR), where short, powerful laser pulses are sent out in a vertical or near-vertical direction. The reflection of light, backscatter – caused by haze, fog, mist, virga, precipitation, and clouds – is measured as the laser pulses traverse the sky. The resulting backscatter profile, the signal strength versus the height, is stored and processed, and the cloud bases are detected. The time delay between the launch of the laser pulse and the detection of the backscatter signal indicates the cloud base height.

The ceilometer can detect 3 cloud layers simultaneously. If the cloud base is obscured due to precipitation or ground-based fog, the ceilometer reports vertical visibility. There is no need for adjustments in the field. The embedded software includes several service and maintenance functions and gives continuous status information from internal monitoring. The software is designed to give the full backscatter profile.

CL51 supports data messages used in CL31 and LD40. It is easy to transfer from older ceilometer versions to CL51.

You can order the ceilometer with an optional air quality plug-and-play package. The package contains:

- 2 Ethernet cables
- Ethernet switch
- Ethernet switch AC (mains) power cables with plugs for the USA, the EU, and the UK
- Ceilometer AC (mains) power cables with plugs for the USA, the EU, and the UK
- Laptop with BL-View software installed

The LAN module rules out the radio kit and Humitter options.

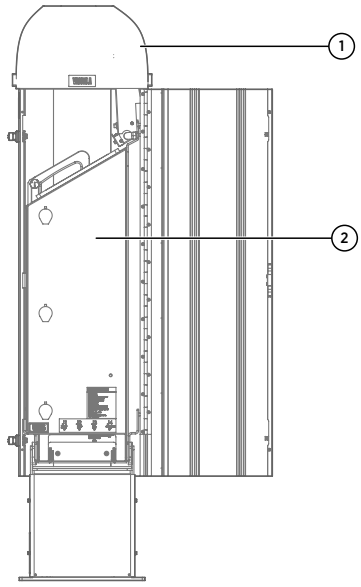


Figure 1 Vaisala Ceilometer CL51

1 Radiation shield
2 Measurement unit

2.2 Product and part names

Table 3 CL51 main parts

Item	Name
CLO521	Optics unit
CLW511	Window
CLT521	Transmitter
CLR321	Receiver
CLM311	Laser monitor board
CLE321	Engine board
CLP321	AC power unit

Item	Name
226116	Battery
CLH311-115	Internal heater (100–115 V AC)
CLH311-230	Internal heater (220–240 V AC)
CLB311-115	Window blower (100–115 V AC)
CLB311-230	Window blower (220–240 V AC)
CT3839	Power cable (230 V)
CT35324	Power cable (115 V)
CT3838	Data cable
226296	Coaxial cable

Table 4 CL51 optional parts

Item	Name	Description
CL51BIRDKIT	Bird deterrent	
DXL421	Modem module	
CL51RADIOKIT	Radio modem installation kit	Excluding radio modem and antenna
TERMBOX-1200	Termination box, mains and signal	For extended surge and overvoltage protection
CLTERMBOX	Termination boxes for mains and signal	Without surge and overvoltage protection
DMU801	Data management unit	
QMZ101	Maintenance cable	
CL51TERMHOODSP	Optical termination hood	
CT35022	Shock absorber	For ship installations
CL51HUMITTER	Internal humidity transmitter Humitter and assembly kit for CL51	
CL31USBCABLE	USB maintenance cable	
CLAQPACKAGE	Air quality plug-and-play package	Laptop, Ethernet switch, 2 Ethernet cables, Ethernet switch power source, 3 ceilometer AC (mains) power cables, BL-View software

The complete delivery also includes:

- Mating cables with connectors for power and communication
- Installation hardware
- User guide

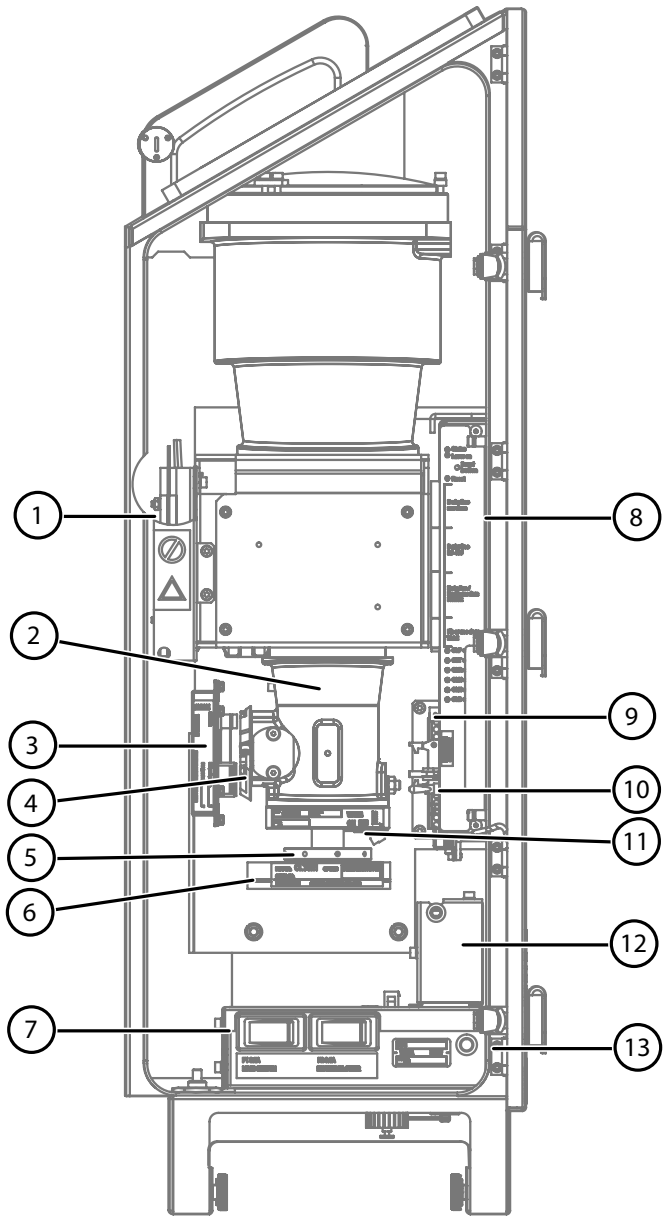


Figure 2 Measurement unit main parts

1 Internal heater CLH311
2 Optics unit CLO521
3 Receiver CLR321
4 Receiver ring
5 Transmitter ring
6 Transmitter CLT521
7 **F1** main circuit breaker, **F2** window blower and internal heater circuit breaker
8 Ceilometer engine board CLE321
9 Coaxial cable 226296
10 Battery switch
11 Laser monitor board CLM311
12 Battery cage
13 AC power CLP321

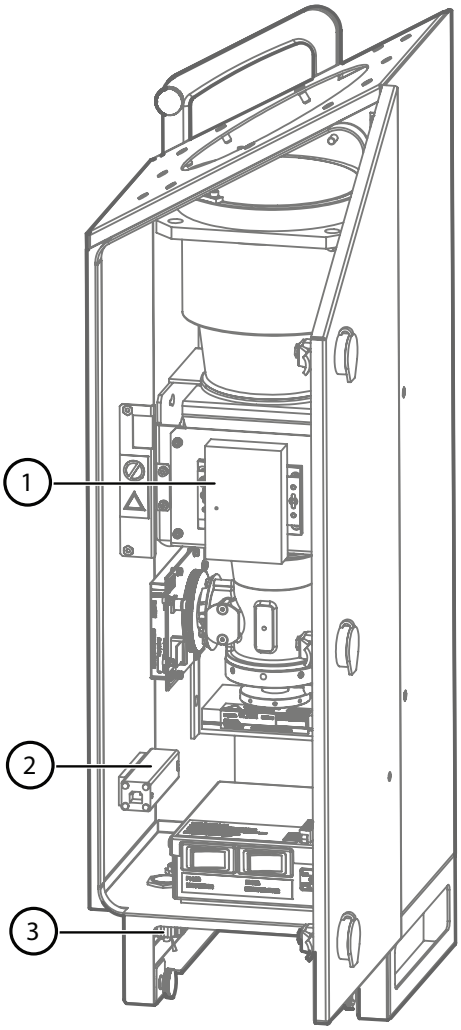


Figure 3 CL51 measurement unit with LAN (Ethernet) interface option

1 MOXA NPort 5232-T modem
2 Ethernet surge protector
3 RJ45 connector

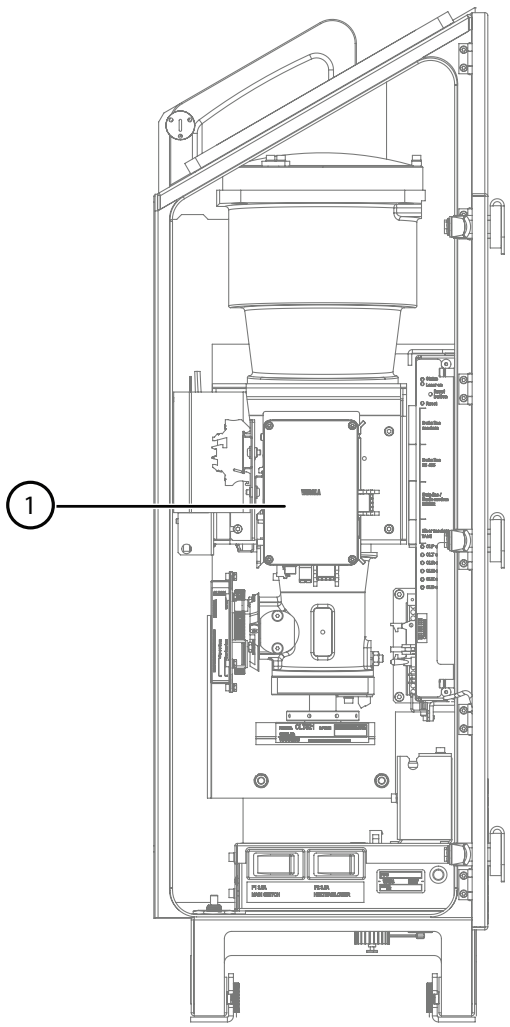


Figure 4 CL51 measurement unit with DMU801 option

2 DMU801

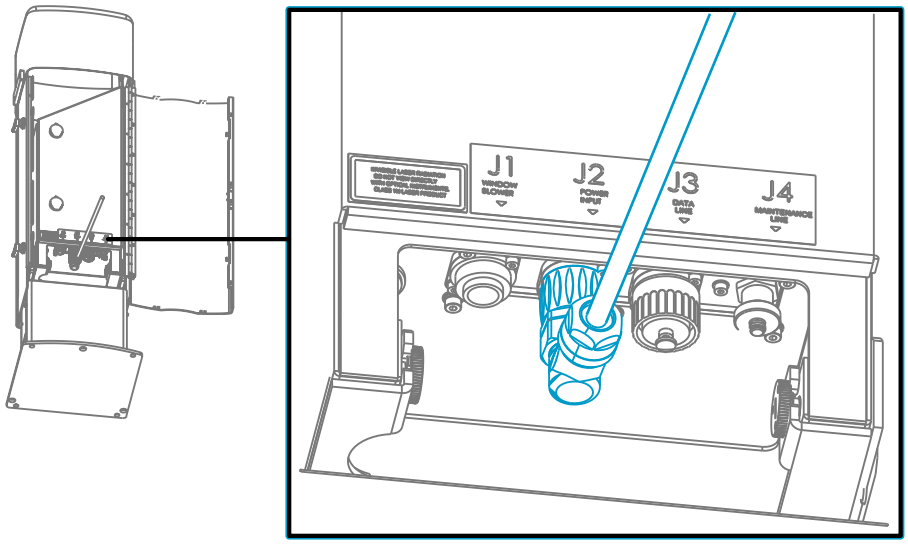
2.3 Safety

This product has been tested for safety. Note the following precautions:

WARNING! If you have Termbox, you need an external disconnection device (for example, a switch) for the AC (mains) power connection.

- The disconnection device must conform to local regulations.
- To prevent accidental switching on during installation and maintenance, the disconnection device must be visible from the enclosure, or lockable with a key.
- The installed enclosure must not block access to the disconnection device. The disconnection device must remain easy to operate.
- Mark the disconnection device as the disconnection device for the ceilometer.

WARNING! If you do not have Termbox, the power input connector is the disconnecting device. To disconnect the ceilometer from the electrical network without Termbox, disconnect the power cable from connector **J2**.



WARNING! Failure to comply with these precautions or with specific warnings elsewhere in these instructions violates safety standards of design, manufacture, and intended use of the product. Vaisala assumes no liability for the customer's failure to comply with these requirements.

WARNING! Do not substitute parts or modify the system, or install unsuitable parts in the system. Improper modification can damage the product or lead to malfunction.

WARNING! If the equipment is used in a manner not specified by Vaisala, the protection provided by the equipment may be impaired.

WARNING! Ground the product and verify outdoor installation grounding periodically. Failure to provide proper grounding can result in injury or death from electrical shock and can severely damage the equipment.



WARNING! To minimize shock hazard, the chassis and cabinet must be connected to a safety ground. The ceilometer is equipped with a 3-conductor AC power connector. The power cable must be plugged into an approved, grounded three-contact electrical outlet or the ceilometer must be carefully grounded to a low-resistance safety ground.



WARNING! Do not operate in an explosive atmosphere, for example, when flammable gases or fumes are present. Operation of electrical equipment in such an environment constitutes a safety hazard.



WARNING! Do not perform installation or maintenance procedures when there is a risk of thunderstorm or lightning activity in the area.



WARNING! Do not service the system alone. Do not reach into parts and assemblies that are AC (mains) powered and live except in the presence of someone who can provide first aid.



WARNING! Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized depot for service and repair to make sure that safety features are maintained.



WARNING! Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with the power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.



WARNING! High voltage is present when the laser transmitter CLT521 or receiver CLR321 covers are removed and they are connected to a powered unit. High voltage is present in the AC power unit CLP321, internal heater CLH311, engine board CLE321, and window blower CLB311 at the top of the radiation shield.



CAUTION! Improper modification can damage the product or lead to malfunction. Any modification voids your warranty.

The following warning is on the internal heater. The heater may be hot. Avoid touching it.



The following figure shows the locations of warning labels on the ceilometer.

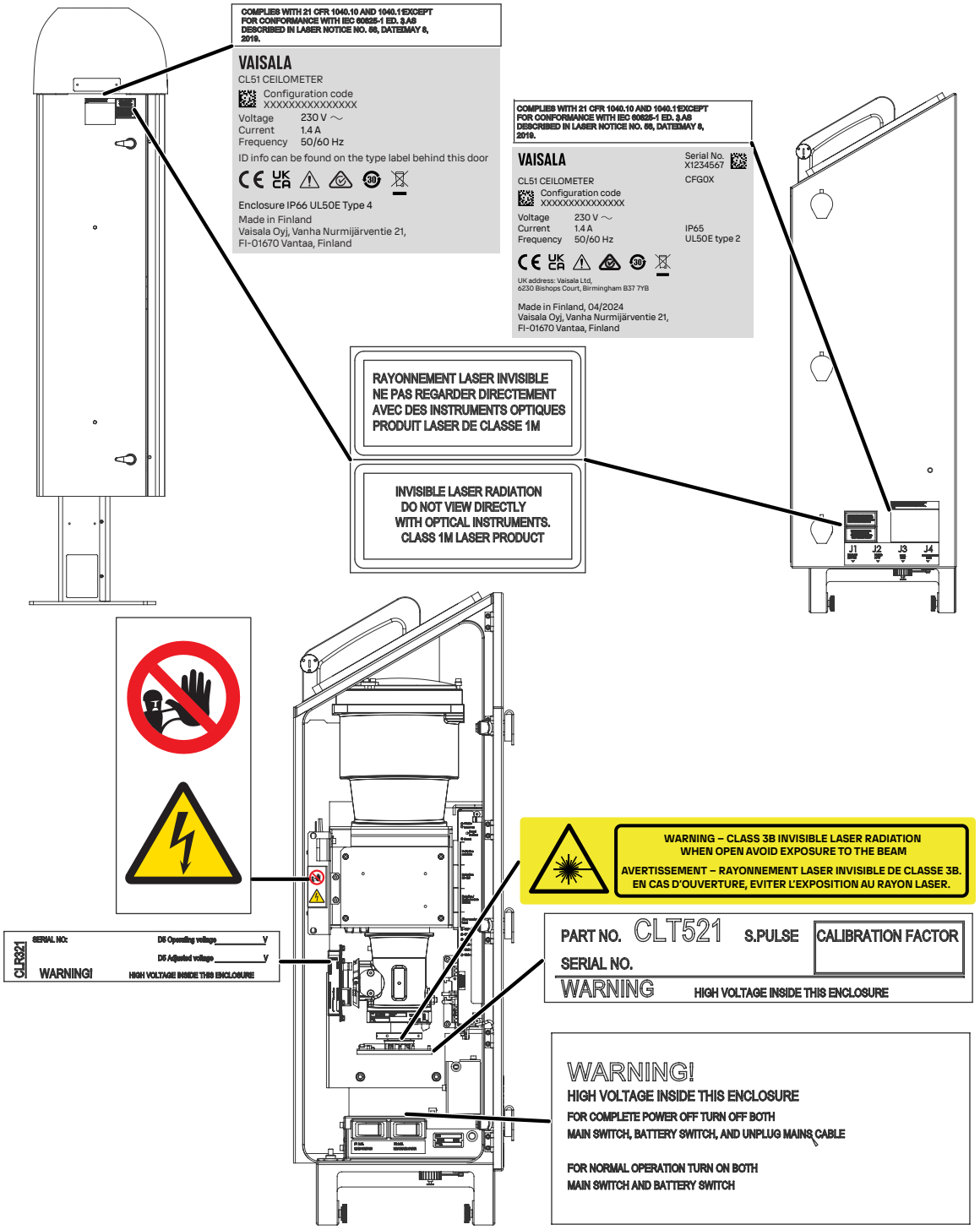


Figure 5 Locations of warning, type, and certification labels

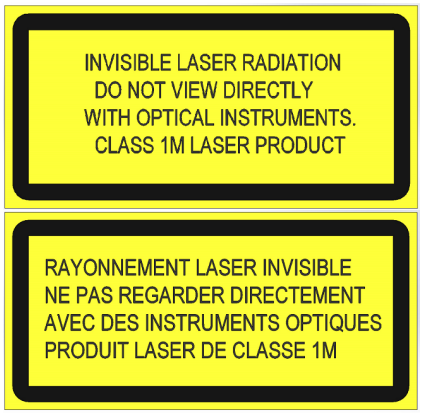
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2.3.1 Laser safety

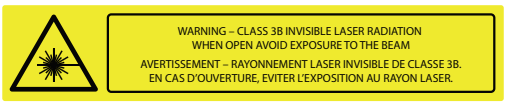
This Vaisala ceilometer is classified as a Class 1M laser device in accordance with International Standards IEC 60825-1:2014 and EN 60825-1:2014+A11:2021. It complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019. This means that when this ceilometer is installed in a field environment with instrument covers on and pointed vertically or near-vertically, it poses no established biological hazard to humans.

CAUTION! Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

The ceilometer has the following label on the measurement unit door and the radiation shield door:



The following warning is on the transmitter.



WARNING! This ceilometer must be operated in an area restricted from public access. It must be pointed vertically or near-vertically. Invisible laser radiation is emitted through the aperture on top of the ceilometer.

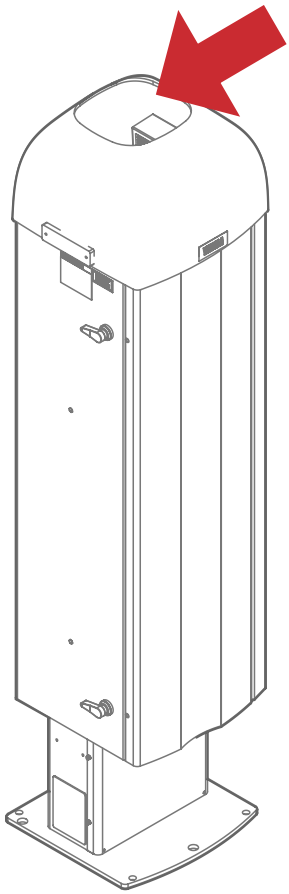


Figure 6 Location of CL51 laser aperture

Take the following precautions during service and maintenance:

WARNING! Do not look directly into the ceilometer transmitter or ceilometer optics with magnifying optics (such as glasses, binoculars, and telescopes). Do not direct the beam into an area where such instruments are used. Viewing the laser output may pose an eye hazard.

WARNING! Do not remove the ceilometer transmitter from its normal position without first switching off both the line and the battery power and detaching the transmitter ribbon cable from the ceilometer engine board.

WARNING! Only qualified maintenance personnel may perform maintenance procedures. Make sure unauthorized persons cannot access the work area during service operations.

2.3.2 Grounding terms

Table 5 Grounding terms

Term	Description
GND	Electronics common return, used only for signal and data circuits
SGND	Shield ground for signal cables shields
PE 	Protective earth, connects touchable metal structures to safe potential. Recognized by grounding symbol and green or yellow-green wire insulation.

2.3.3 Ceilometer ESD protection

The ESD handling instructions are for service persons who need to touch bare printed circuit boards and components inside the equipment.

2.3.3.1 ESD protection

Electrostatic discharge (ESD) can damage electronic circuits. Vaisala products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects in the equipment housing.

To avoid delivering high static voltages to the product:

- Handle ESD-sensitive components on a properly grounded and protected ESD workbench or by grounding yourself to the equipment chassis with a wrist strap and a resistive connection cord.
- If you are unable to take either precaution, touch a conductive part of the equipment chassis with your other hand before touching ESD-sensitive components.
- Hold component boards by the edges and avoid touching component contacts.

3. Installation

3.1 Unpacking

The ceilometer is shipped in a package that contains:

- Radiation shield
- Measurement unit inside the radiation shield
- Other equipment
- Accessories
- Documentation

CAUTION! When you open the package, place it on a flat surface with the indicated top side up. Open the container from the top side and carefully remove the ceilometer and other equipment.

CAUTION! Avoid touching the window or lens surfaces. Do not remove the protective sheet from the measurement unit window until the installation is ready.

CAUTION! Do not remove the integral protective caps from the unused external connectors (**J4** maintenance line).



Wear protective gloves and clothing against sharp edges.

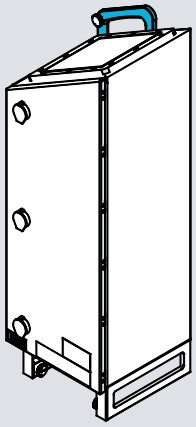


Store the original packaging for a possible later transportation need.



The unit is heavy. Vaisala recommends that unloading and unpacking is carried out by 2 people.

Use the measurement unit handle for lifting and carrying the measurement unit.



Use a flat head screwdriver to open the door.

3.2 Designing foundation

Place the ceilometer on a stable platform. Vaisala recommends installing the ceilometer so that the sensor points north, 3° off zenith. This minimizes solar background and helps avoiding specular reflection from ice clouds.

The standard foundation for the ground installation is a concrete foundation. For the recommended minimum dimensions, see the following figure. Mounting screws and bolts are included in the delivery.

If CL51 replaces another Vaisala ceilometer (CT25K, CT12K, LD40, LD25, or LD12), the existing foundation and foundation screws can be used.

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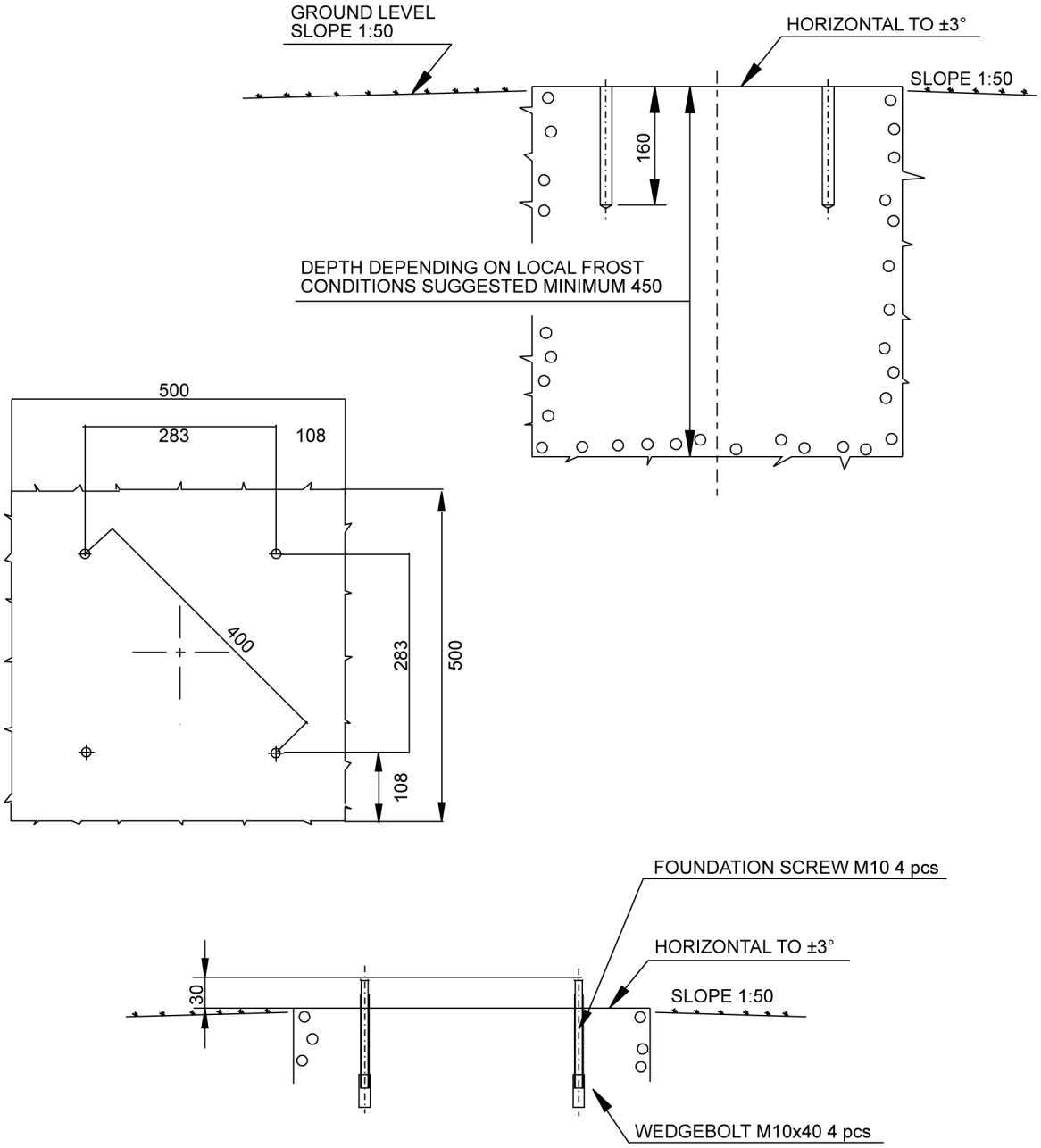


Figure 7 CL31 foundation construction

You can either use an existing concrete foundation or create a new one.

3.2.1 Creating new concrete foundation

1. Fasten the M10×40 wedge bolts to the lower ends of the foundation screws (4 each).
2. Fix a drilling template to the upper ends of the foundation screws with nuts.

3. Place the template with the attached foundation screws into the hole so that approximately 30 mm (1.25 in) of the foundation screw threads stand above the surface.
4. Pour in the concrete and finish the foundation.

3.2.2 Using existing concrete foundation

1. Drill 4 holes with a diameter of 12 mm (0.5 in) and a depth of 165 mm (6.5 in) into the concrete. Note the cardinal points indicated in Creating new concrete foundation (page 26).
2. Fasten the M10×40 wedge bolts to the lower ends of the foundation screws (4 each).
3. Place the wedge bolt and foundation screw combinations into the holes, with the wedge bolts down, and hammer the protruding threads down.
4. Tighten the foundation screws a few turns to attach the wedge bolts to the hole walls.

3.2.3 Grounding

Proper grounding protects the system and users from transients caused by lightning and ensures operation of the electrical safety systems in fault conditions.

WARNING! The ceilometer is equipped with a separate grounding rail for external grounding at the bottom of the radiation shield. It must be connected to a low resistance ground.

WARNING! At the installation site, a connection to a low resistance ground is mandatory for adequate lightning and transient protection.

WARNING! To minimize shock hazard, the chassis and cabinet must be connected to a safety ground. The ceilometer is equipped with a 3-conductor AC power connector. The power cable must be plugged into an approved, grounded three-contact electrical outlet or the ceilometer must be carefully grounded to a low-resistance safety ground.

3.2.3.1 Grounding in marine applications

If the application requires a "floating" AC mains power without a safety ground connected to either line, such as in marine IT power grid, do the following:

1. Use a 500 VA isolation transformer in the AC power input and bond the grounding rail at the bottom of the radiation shield ground to the installation platform (the metal hull/deck) and connect the grounding bolt at the bottom of the measurement unit to the grounding rail.

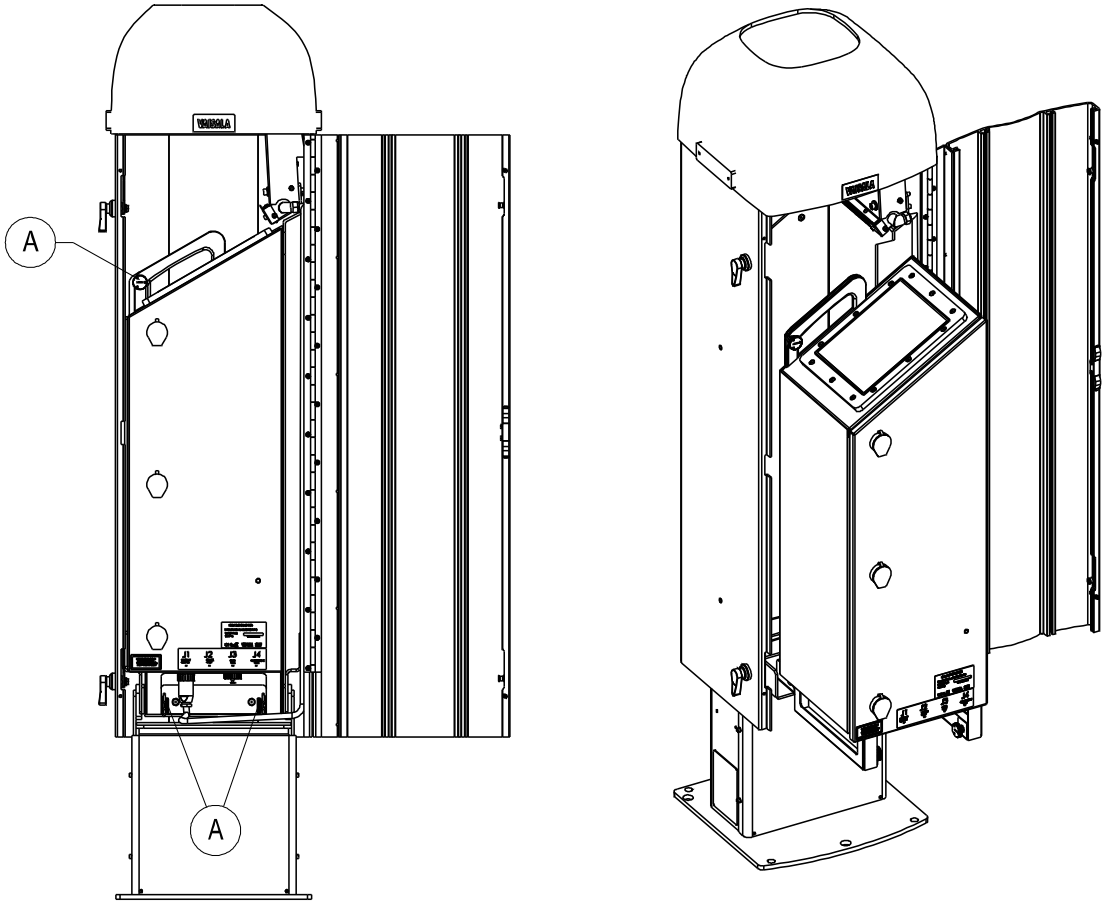
2. Connect the communication line to the data receiving system through a galvanic signal isolator or use fiber-optic communication.

3.3 Mounting ceilometer

The ceilometer is delivered with the measurement unit attached to the radiation shield.

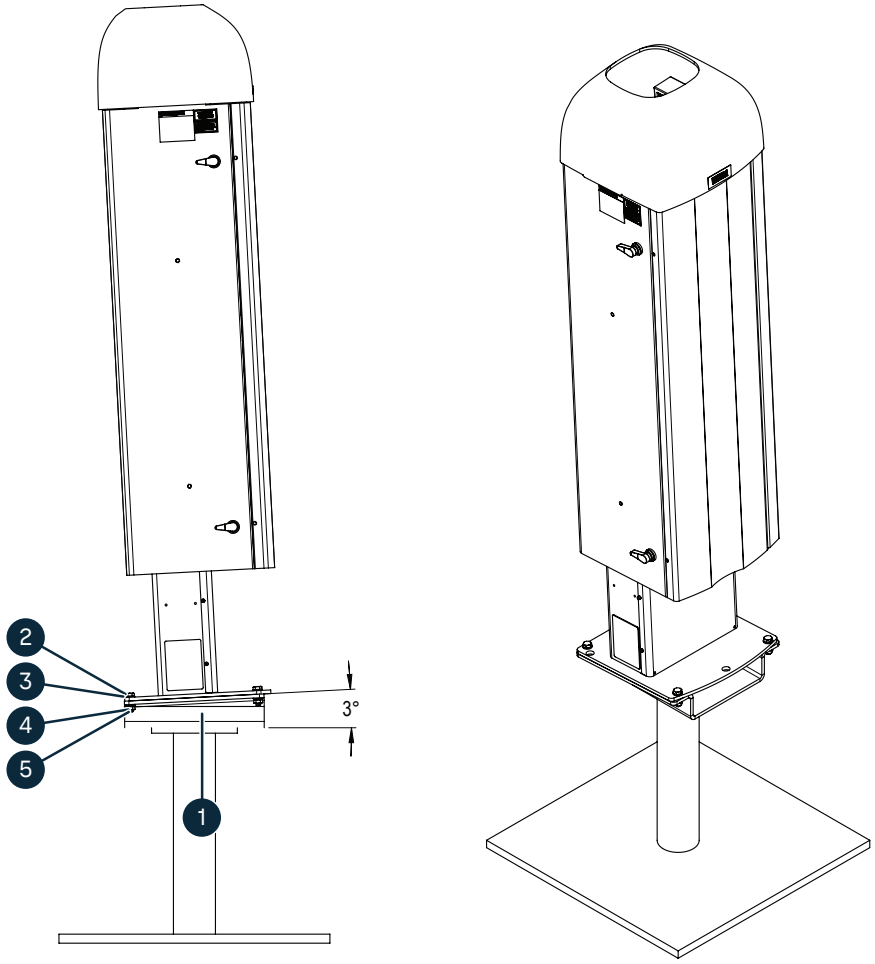
1. Remove the measurement unit from the radiation shield.

   Loosen the 3 attachment screws, disconnect the blower cable from connector **J1**, and pull out the unit.



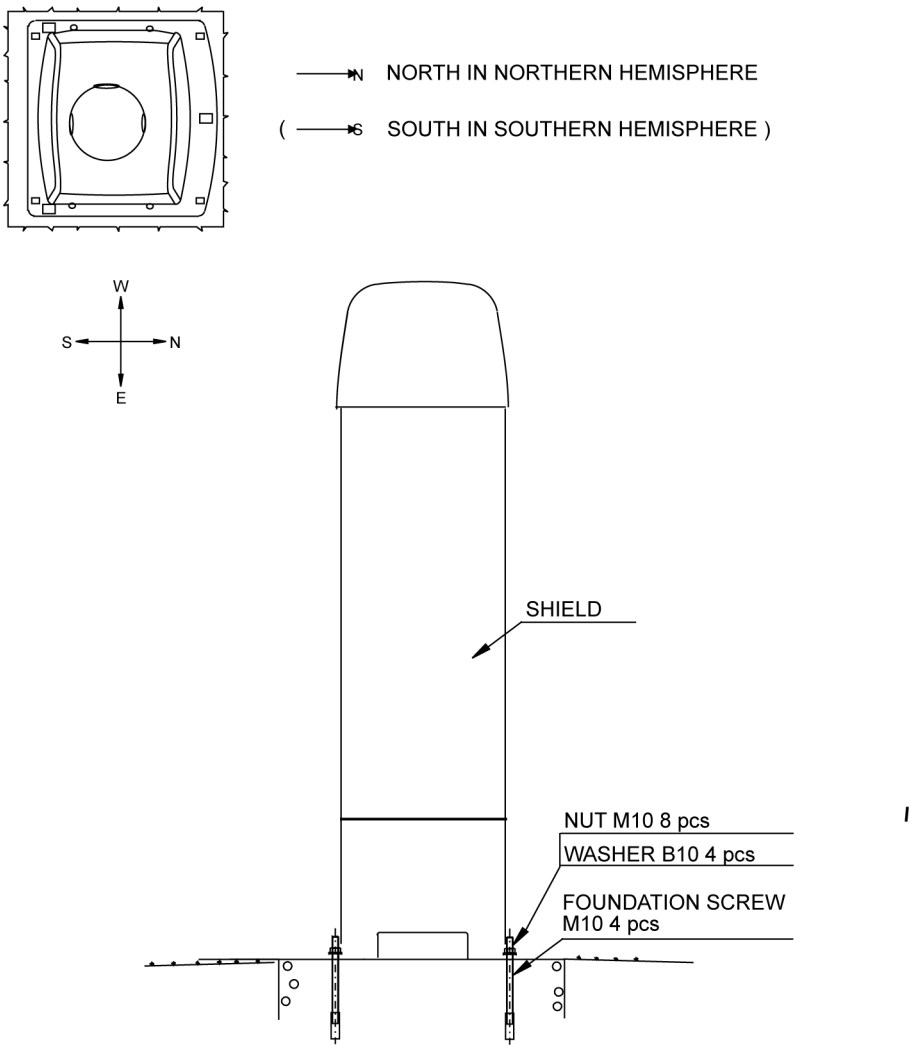
A Attachment screws

2. If you are using the ASOS pedestal adapter, attach it now as follows.
   The pedestal adapter provides a 3° tilt for the ceilometer.



1 Pedestal adapter
2 Screw (4 pcs)
3 Flat washer (8 pcs)
4 Spring washer (4 pcs)
5 Nut (4 pcs)

3. Place the radiation shield on the foundation so that the door faces North in the Northern hemisphere and South in the Southern hemisphere.



4. Place the washers on the foundation screws and tighten the nuts.

For installing an optional bird deterrent, see Mounting bird deterrent (page 32) .

5. Place the measurement unit inside the radiation shield, tighten the 3 attachment screws and connect the blower cable to connector **J1**.

3.4 Tilting ceilometer

The ceilometer can operate in a tilted position. The built-in sensor detects the tilt angle, the deviation from the vertical. The tilt feature allows 3 tilt angles:

- Vertical
- 12 degrees with the measurement unit door upwards
- 12 degrees with the measurement unit door downwards

The tilt angle is used for an automatic correction of the detected cloud base height, enabling accurate measurements in a tilted position.

The tilt feature provides the following advantages:

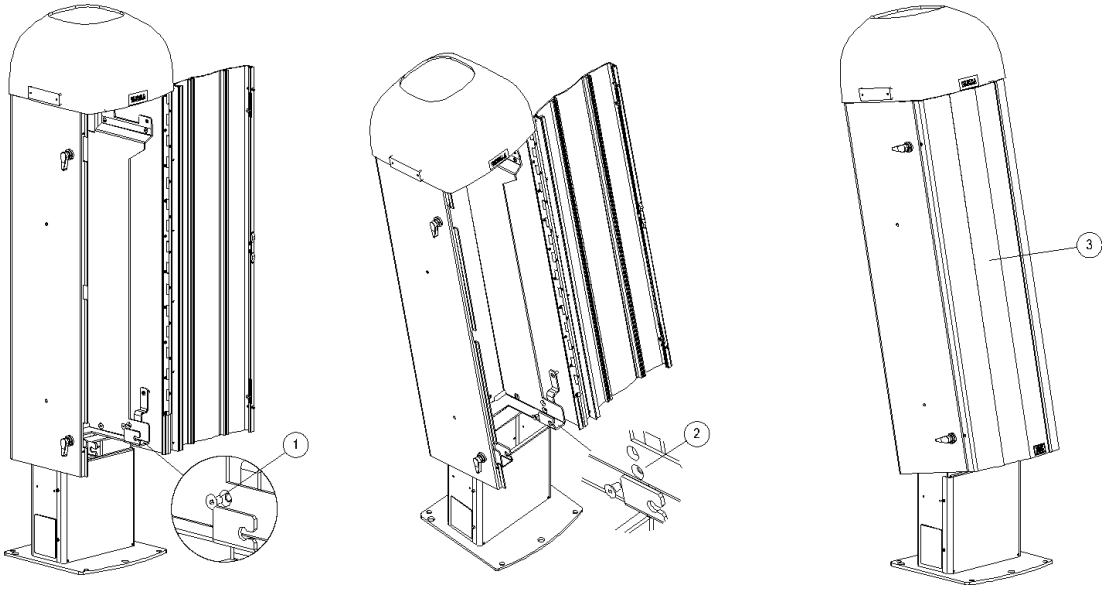
- Protection in heavy weather conditions: In heavy weather conditions, using a tilt angle of 12 degrees protects the measurement unit window from precipitation, thus enhancing performance.
- Precision in aircraft approach control: The beam can be pointed towards the approach direction of an aircraft. This is useful, for example, for helicopter approaches, and at sites where the ceilometer cannot be located exactly at the desired spot.



5-mm Allen key

1. Open the measurement unit door and switch off the power with all 3 switches (**F1**, **F2**, and battery).
2. Disconnect the cables from the measurement unit.

3. Remove the measurement unit as described in Mounting ceilometer (page 28).



1 Tilting screw
2 Frame
3 12-degree tilt

4. Loosen the tilting screws on both sides.
5. Tilt the ceilometer radiation shield 12 degrees with the measurement unit door facing up and lock it in place with the screws.

WARNING! When the unit is operating in a tilted position, make sure that it is not being viewed from the beam direction with magnifying optics.

To avoid direct sunlight, tilt the unit away from the sun. That is, tilt it north in the Northern hemisphere and south in the Southern hemisphere. Direct solar radiation exposure does not damage the unit but may cause alarms and temporarily invalidate the data.

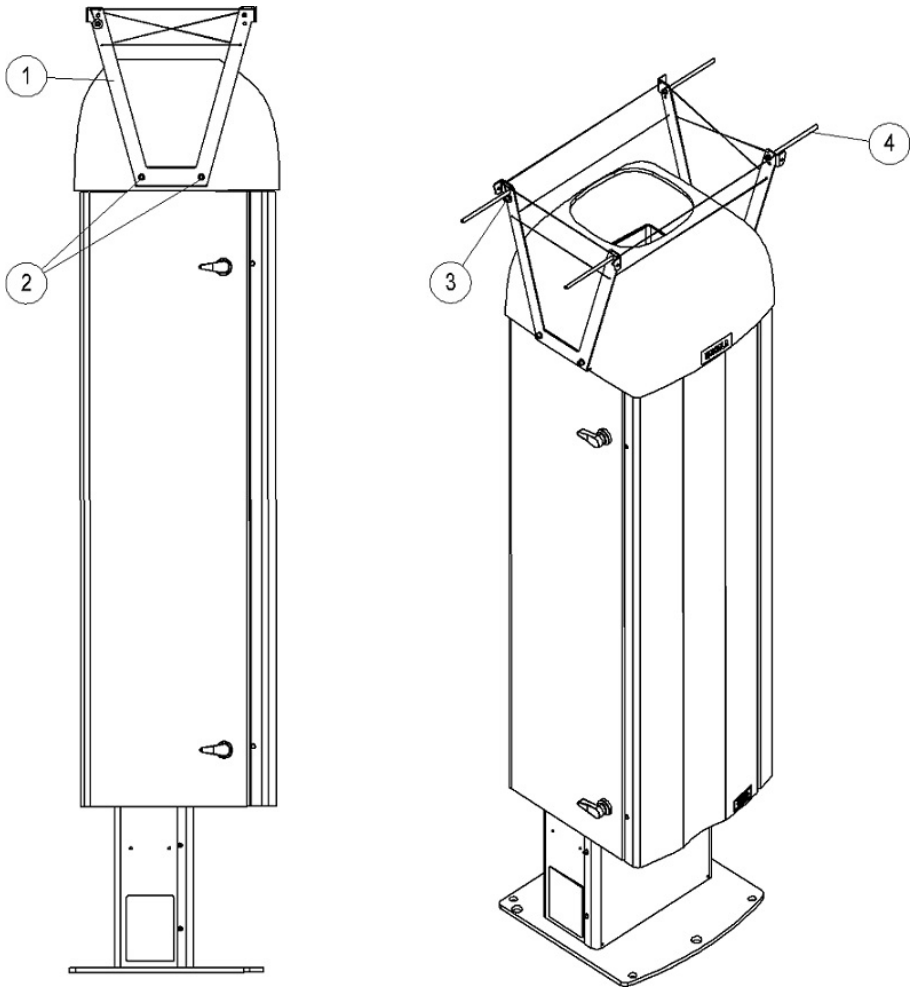
The benefits of different tilting directions may be contradictory and cannot be realized simultaneously. You must decide the direction of the final installation.

3.5 Mounting bird deterrent

The optional bird deterrent prevents birds from landing on the ceilometer which could interfere with the measurements. The bird deterrent consists of 2 side plates, a piece of fluorocarbon line, and 2 optional perches.

- 8 mm wrench
- 4 mm Allen key

1. Place the side plates on both sides of the ceilometer top cover and attach them with the washers and screws.

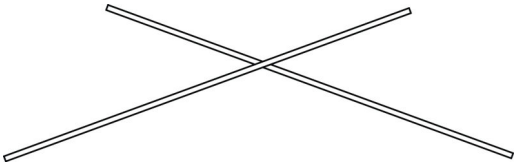


1 Side plate (2 pcs)
2 Screw and washer (2 pcs)
3 Fluorocarbon line
4 Bird perch (2 pcs)

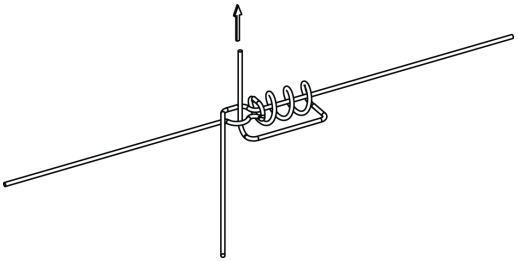
2. Slide a fluorocarbon line back and forth through the designated holes on the side plates, starting from the front of the ceilometer and continuing until the ends of the line meet on the back side of the ceilometer.
3. Adjust the line so that it is left slightly loose. Wrap both ends of the line around a screw, under the washer, and then tighten the screw.

4. Cut the remaining line ends short to avoid damage to the eyes when handling the ceilometer.

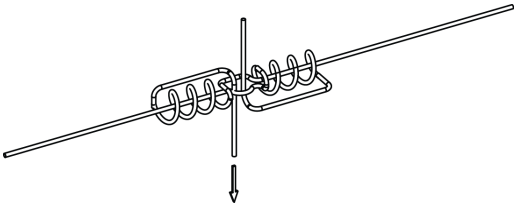
5. Tie the line ends together with a blood knot so that the line is left slightly loose.
   a. Cross both line ends.



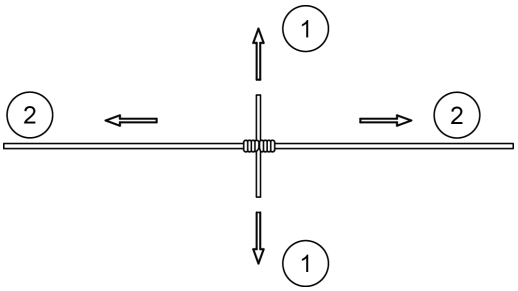
   b. Wind one wire end around the standing part of the other 3 times and pass the end on the other side.



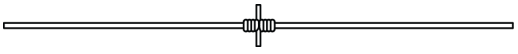
   c. Pinch the line and with the other hand wind the free end around the standing line in the opposite direction. Pass the end through the same loop but in the opposite direction.



   d. Hold in place the lines marked with (1) and pull those marked with (2), wet the knot and tighten.



   e. Trim tag ends.



6. Attach the optional bird perches to the side plates.

3.6 Connecting battery



WARNING! Do not replace the battery with a battery of an incorrect type. If you do, there is a risk of deflagration. Dispose of used batteries according to statutory regulations.



CAUTION! Make sure you do not short-circuit the battery.

The battery is delivered with the ceilometer, but it does not come attached to the measurement unit.



- Crosshead screwdriver
- 3-mm Allen key

1. Open the measurement unit door and loosen the 2 screws locking the battery cage lid.

> Do not remove the screws entirely.

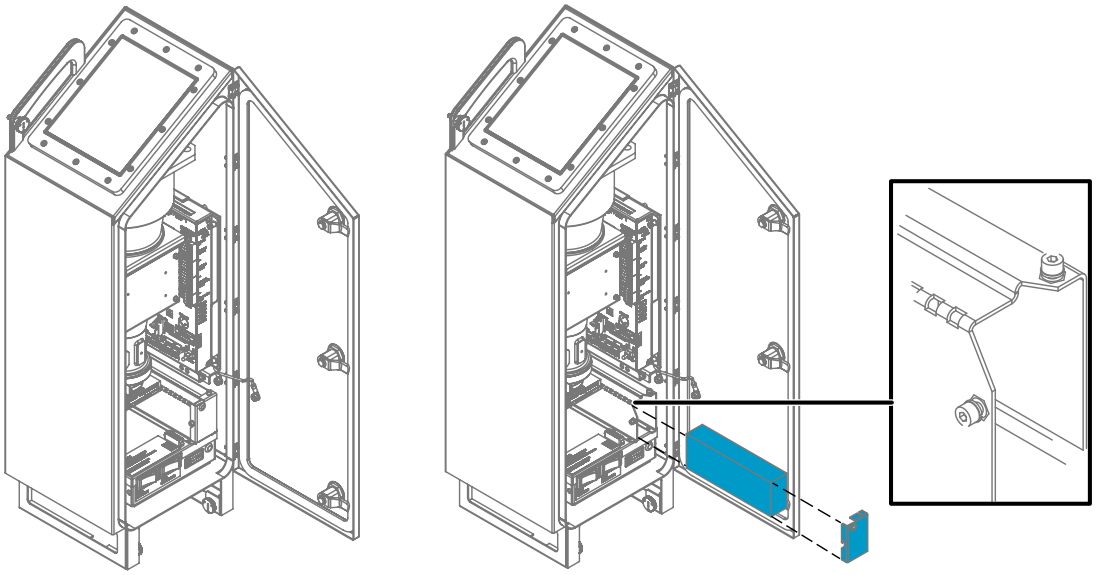
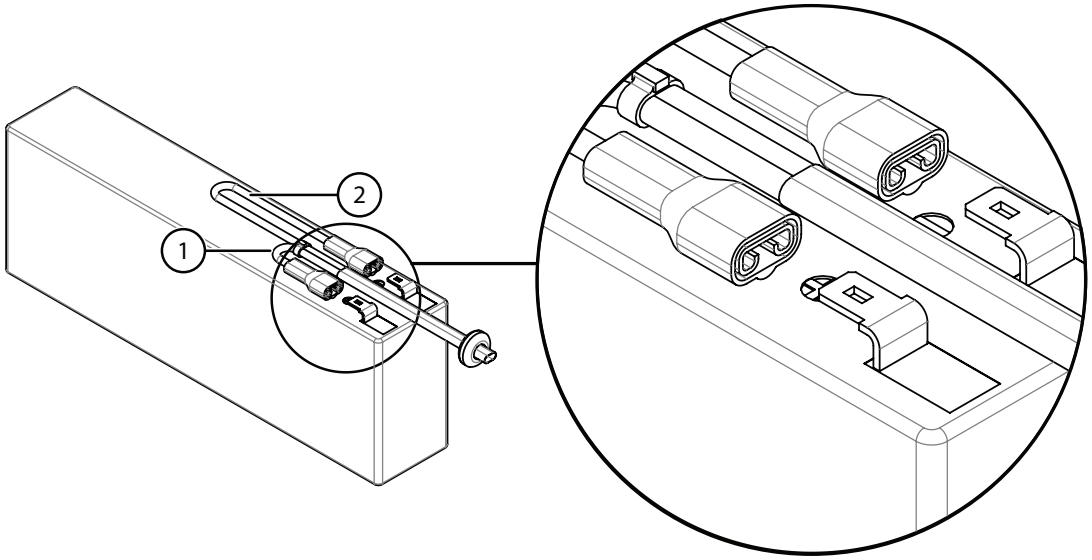


Figure 8 Connecting CL51 battery

2. Connect the battery cable to the new battery. Connect the red end to the positive (+) end terminal and the black end to the negative (-) end terminal.

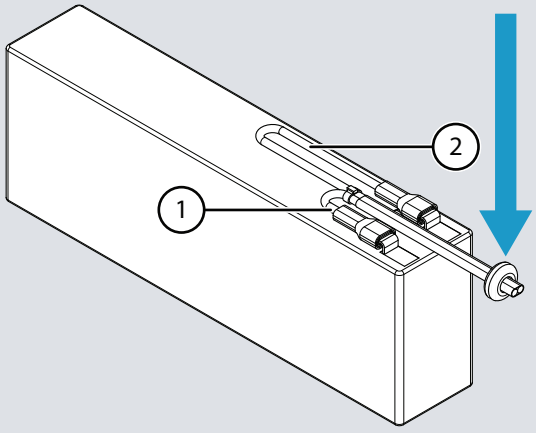
   Pay attention to the orientation of the wire connectors.



1 Red wire
2 Black wire

3. Open the battery cage lid and slide the battery into the battery cage.

Slide the grommet into the groove in the cover lid.



1 Red wire
2 Black wire

4. Close the battery cage lid and tighten the 2 screws to their places.

5. Make sure that the battery switch on the engine board is off.
6. Connect the battery cable to the engine board.

3.7 External connectors

All external connectors are located at the bottom of the measurement unit. The following figure shows the external connectors **J1**, **J2**, **J3**, and **J4**.

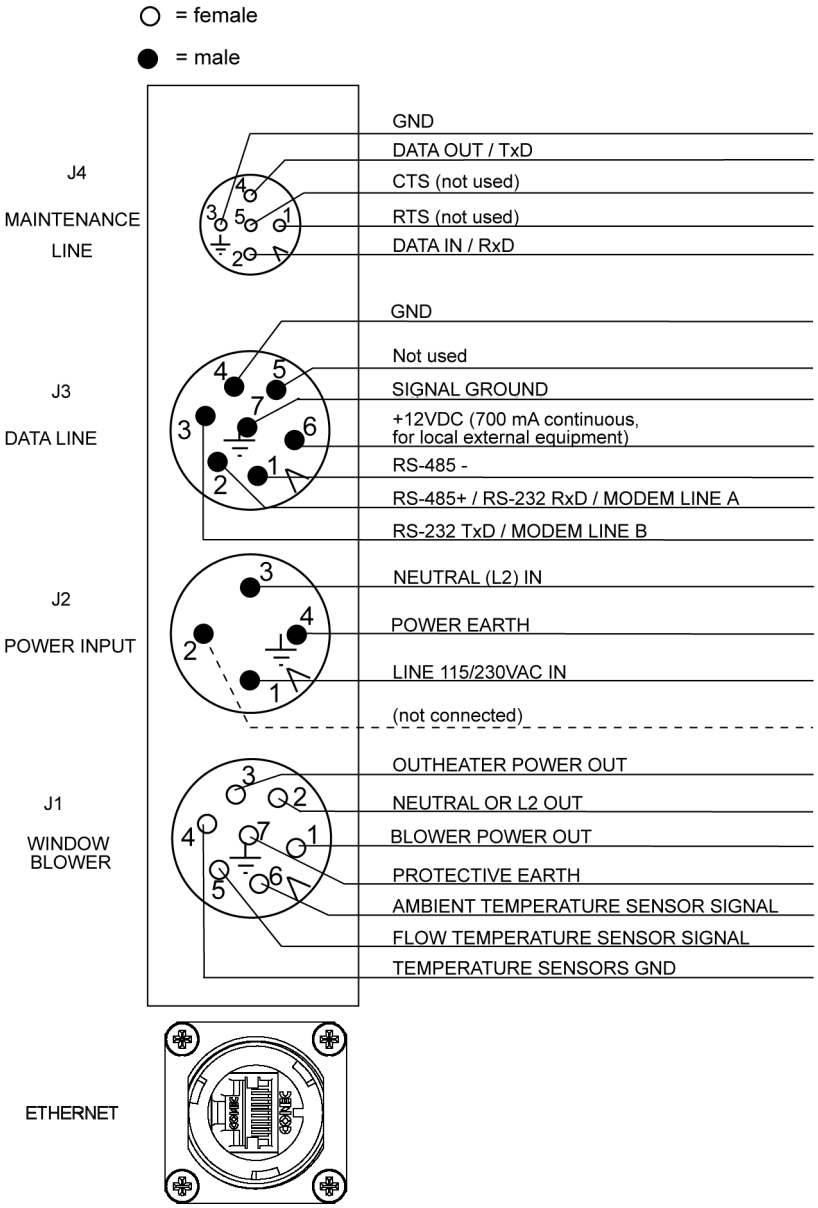


Figure 9 External connectors (bottom view)

You have the Ethernet connector only if you selected the LAN option when you placed the order.

Connector	Description
J1	The window blower mounted into the radiation shield is connected to **J1**.
J2	Line power is connected to **J2**. The power supply connector **J2** provides a standard protective ground for the instrument chassis.
J3	Remote communication is connected to **J3** in normal use.
J4	A local maintenance terminal, such as a laptop, can be connected to **J4**. Use the provided protective cap for covering **J4** when it is not in use.

3.7.1 Connecting power supply

WARNING! Only licensed experts may install electrical components. They must adhere to local and state legislation and regulations.

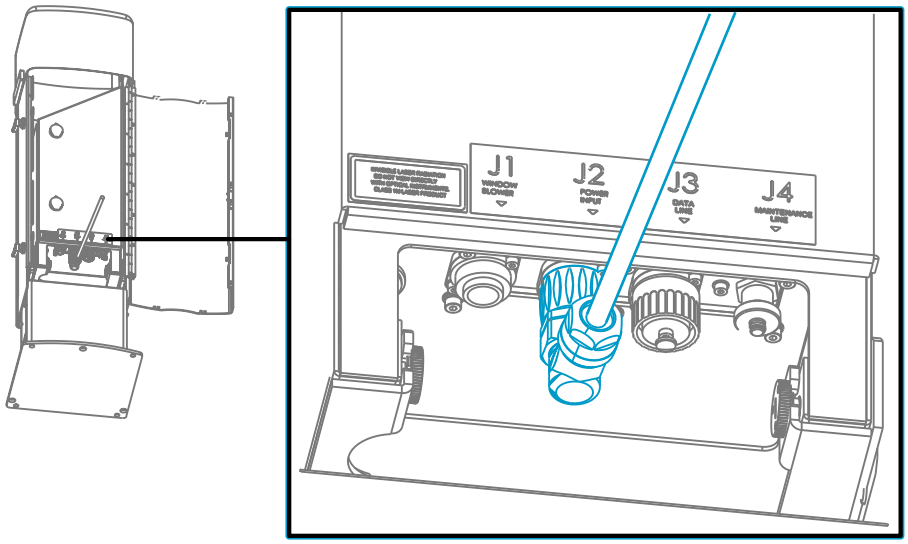
If you use the optional Termbox, make sure that the AC (mains) power cable material follows the UL/CSA C22.2 regulations. See UL/CSA C22.2 regulatory caution and warning statements (page 186).

WARNING! Use a copper (Cu) cable with a minimum cross-section of 3 x 1.5 mm^2 (15 AWG) that has the same operating temperature as the device.

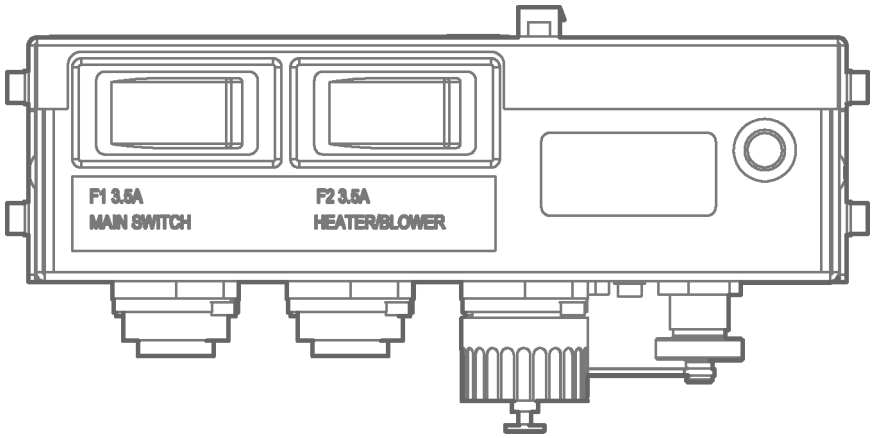
WARNING! The power supply must be protected with a fuse. The maximum sizes of the fuses protecting the power line:

- 10 A for 230 V power supply
- 15 A for 100 V / 115 V power supply

WARNING! If you do not have Termbox, the power input connector is the disconnecting device. To disconnect the ceilometer from the electrical network without Termbox, disconnect the power cable from connector **J2**.



1. Turn the **Main switch** and the **Heater/Blower** switches **OFF**.



2. Check the voltage of the power supply cable connector and plug in the AC (mains) power cable to connector **J2** at the bottom of the measurement unit.

J2 and **J3** include external mating connectors with a 2 m (7 ft) cable. You can remove the power plug from the **J2** cable when the unit is permanently installed at the site.

More information

‣ External connectors (page 39)

3.7.2 Data line connections

The ceilometer has the following data line options:

- RS-485 connection

- RS-232 connection
- LAN (Ethernet) connection (optional)
- DMU801 Ethernet connection (optional)

To change the connection type, see User commands (page 100).

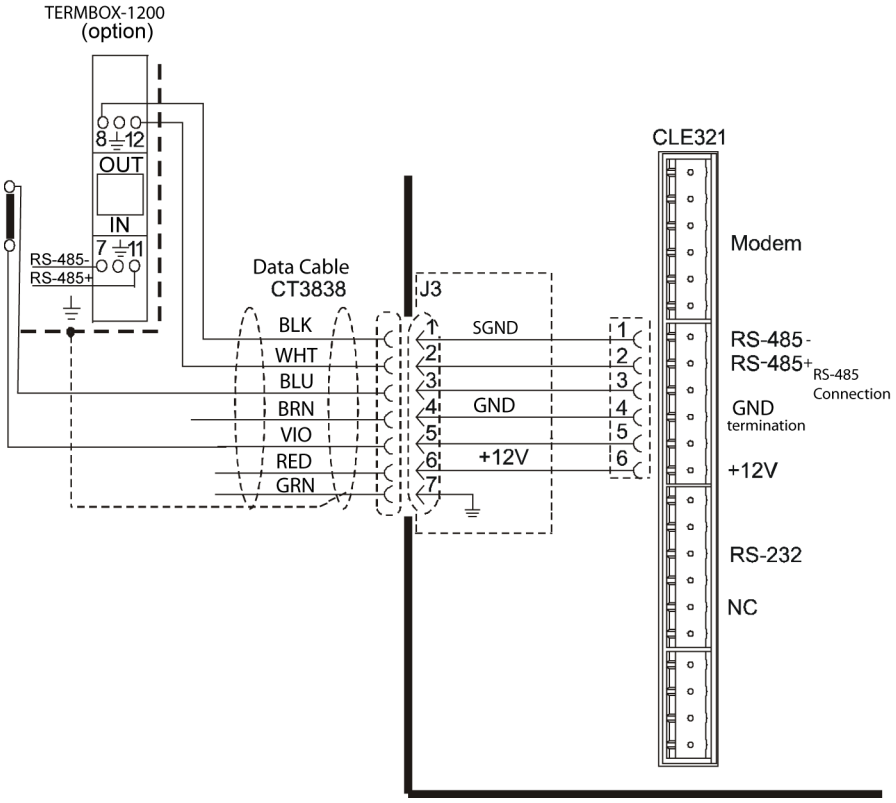


Figure 10 Data line RS-485 connection

The RS-485 connection is provided with a termination. If the ceilometer is connected to the end of a long line, consider connecting the 2 signals marked "termination" as shown in the previous figure. This can improve data transmission speed, quality, and reliability.

Table 6 Default settings for data line RS-485 connection

Setting	Value
Bit rate	19200
Data bits	8
Stop bits	1
Parity	None

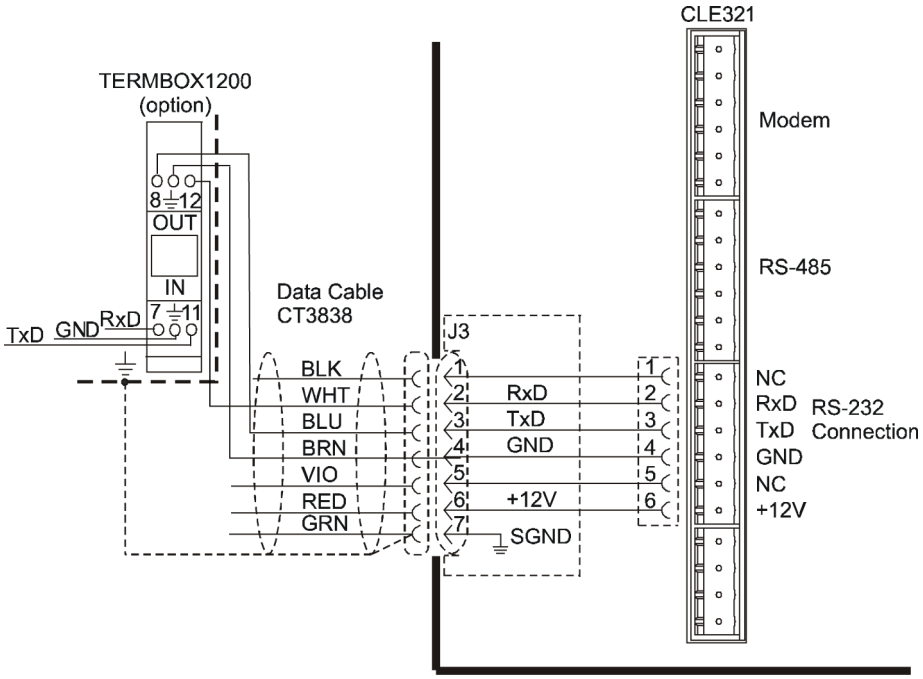


Figure 11 Data line RS-232 connection

Table 7 Default settings for data line RS-232 connection

Setting	Value
Bit rate	19200
Data bits	8
Stop bits	1
Parity	None
Handshake	None

3.7.3 Maintenance terminal connection

Use a flat head screwdriver to open the door.

You can use any terminal or laptop with a serial interface and a terminal emulation program for operating the ceilometer. The maintenance terminal connection is established with the QMZ101 maintenance cable, which connects the RS-232 port of the laptop to the maintenance port of the ceilometer.

3.7.3.1 Setting up maintenance terminal connection

1. Connect the RS cable to the ceilometer maintenance port (connector **J4**) and the terminal computer.
2. Configure the terminal:

Setting	Value
Bit rate	9600
Data bits	8
Stop bits	1
Parity	None
Handshake	None

3.7.3.2 Operating maintenance terminal connection

1. Turn on ceilometer power.
2. Open the maintenance line with the **open** command.

   The prompt `CEILO >` opens.

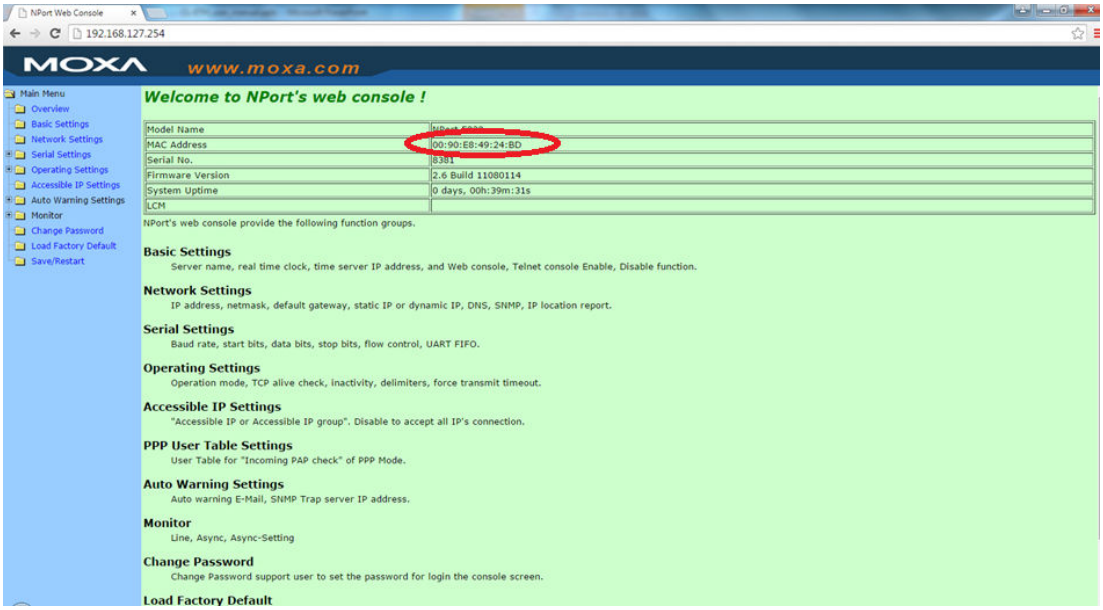
3.8 Setting up LAN connection

If you have the LAN output option or the air quality plug-and-play package, connect the laptop and the ceilometer to the Ethernet switch with Ethernet cables.

1. To open the LAN connection, connect the Ethernet cable to the laptop and to the ceilometer.

2. With the laptop Internet browser, go to *http://192.168.127.254/*.

   NPort Web console opens.



3. To change network settings, select **Network Settings**.

   If you use DHCP IP configuration, add the ceilometer MAC address to the allowed addresses on your DHCP server.

4. Select **Submit**.

More information

- External connectors (page 39)

3.9 Getting data from ceilometer

Ceilometer has the following modes for getting data from the ceilometer:

- Real COM mode
- TCP Client mode
- UDP mode

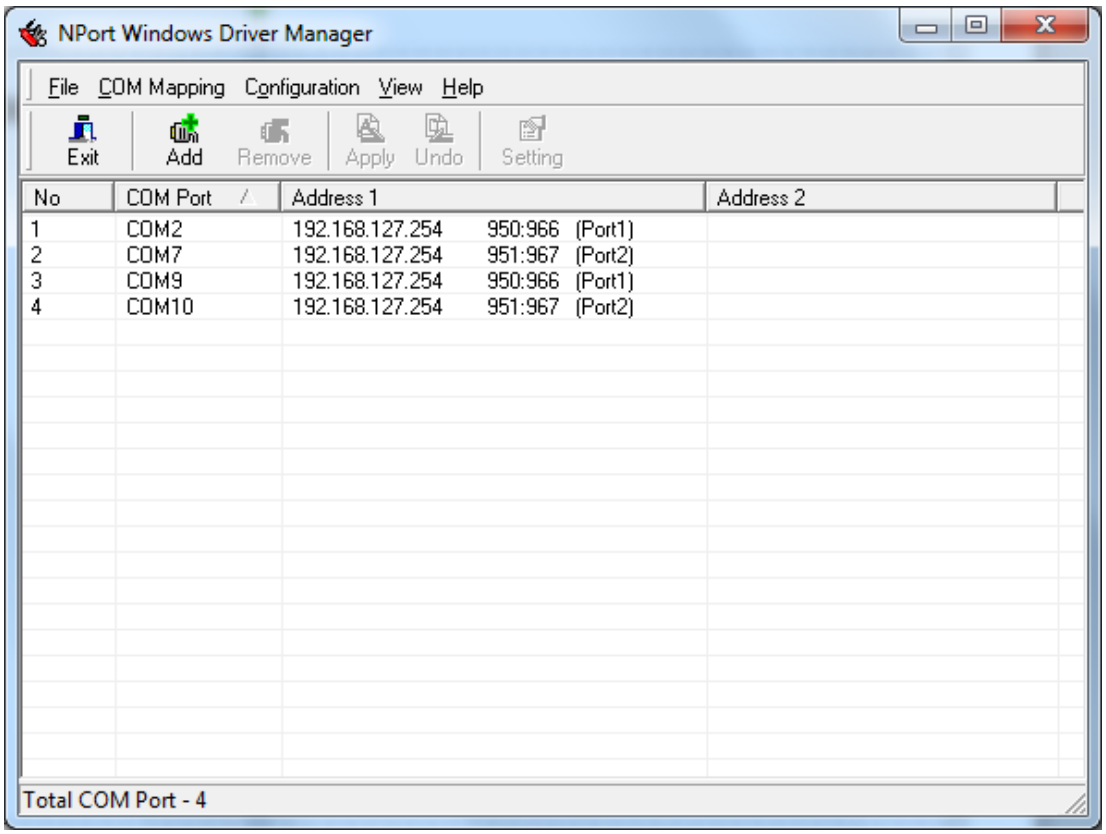
3.9.1 Entering real COM mode

1. Install and open NPort Windows Driver Manager:
   a. Download the NPort Windows Driver Manager file from

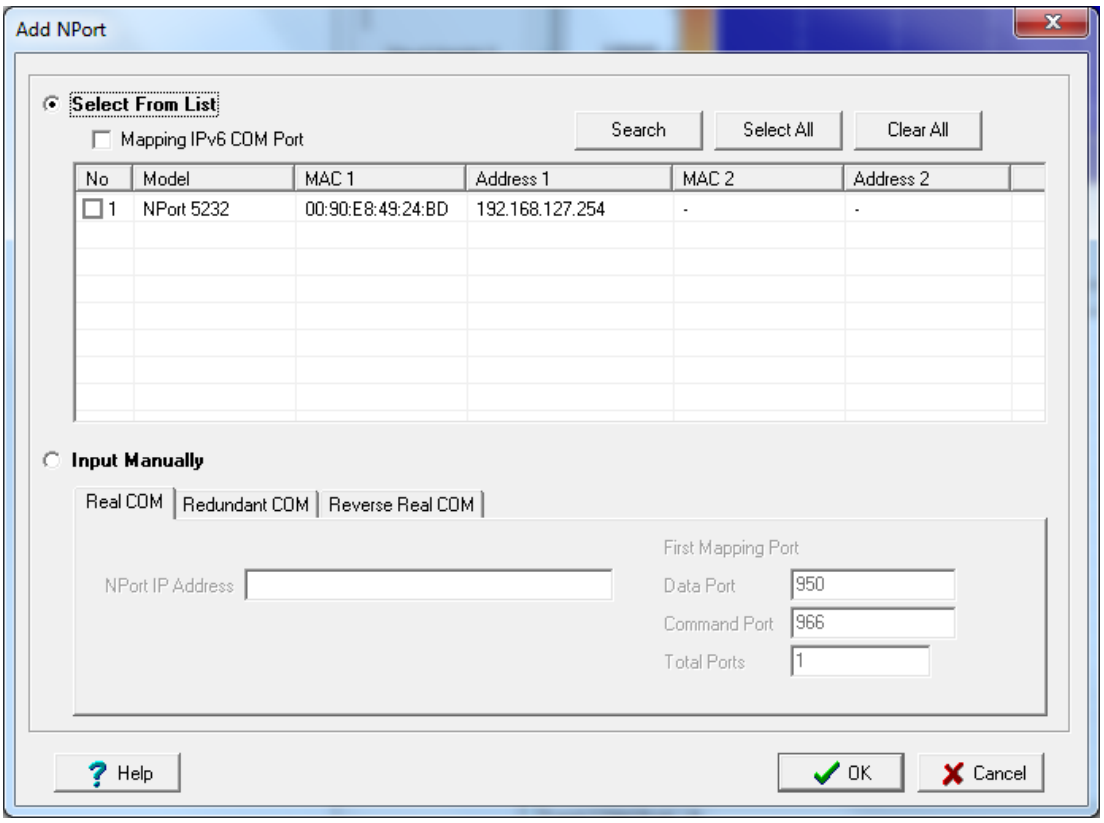
      http://www.moxa.com/support/download.aspx?d_id=1359

   b. Open the file and run installation.

2. Select **Add**.


NPort Windows Driver Manager
File COM Mapping Configuration View Help
Exit Add Remove Apply Undo Setting
No COM Port Address 1 Address 2
1 COM2 192.168.127.254 950:966 (Port1)
2 COM7 192.168.127.254 951:967 (Port2)
3 COM9 192.168.127.254 950:966 (Port1)
4 COM10 192.168.127.254 951:967 (Port2)
Total COM Port - 4

3. Select the correct NPort and **OK**.

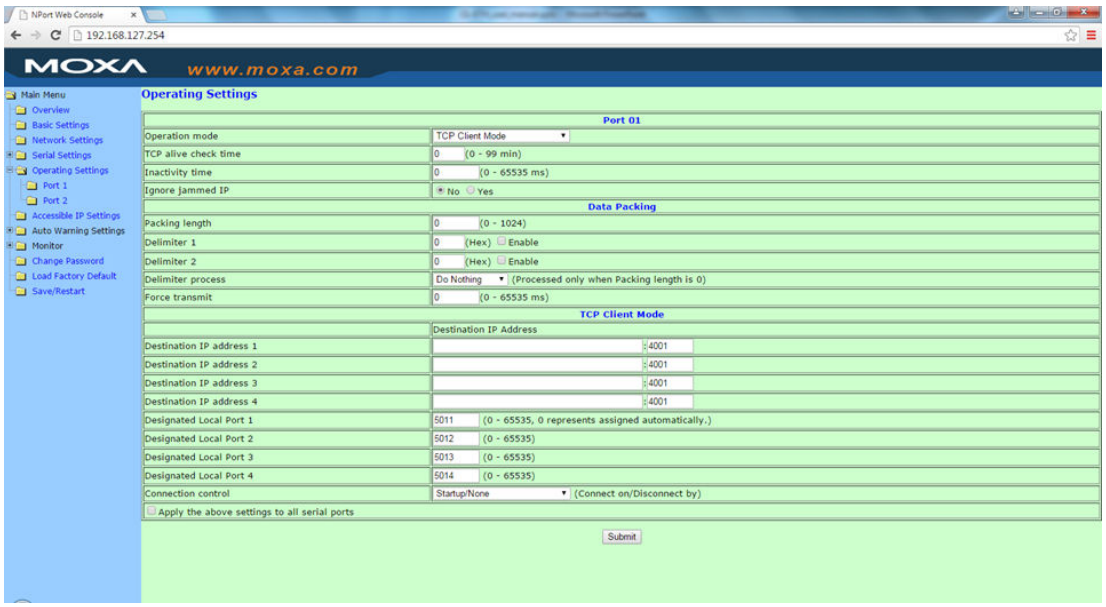


The created COM ports show in Windows Device Manager.

3.9.2 Entering TCP client mode

1. Select **Operating Settings**.
2. Select a port.

3. In **Operation Mode**, select **TCP Client Mode**.



4. In **Destination IP address 1**, type your destination address and port.

   You can add 4 destinations.

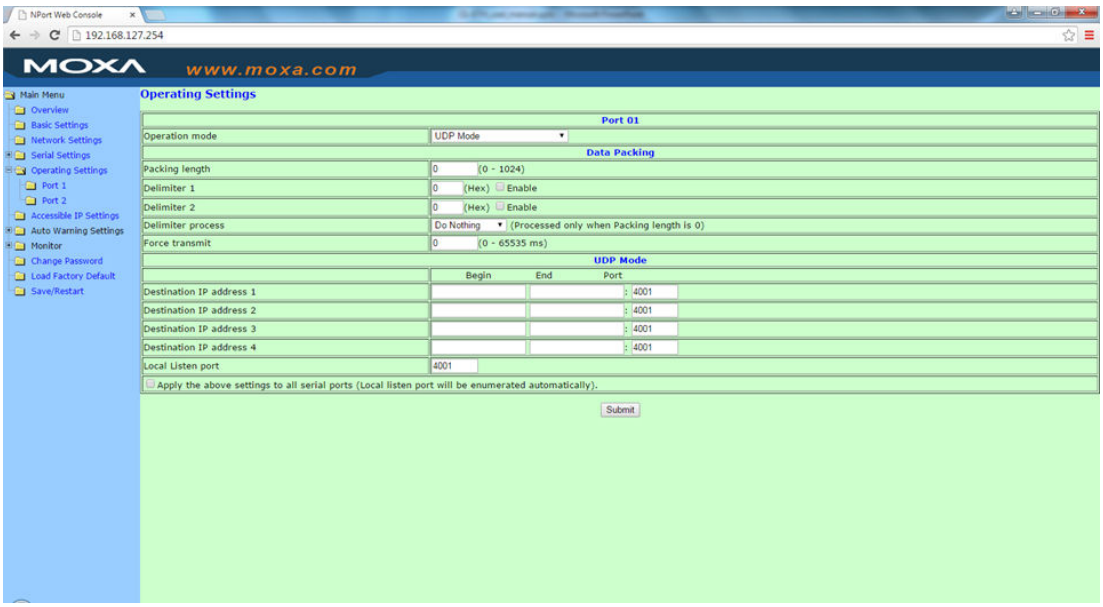
5. Select **Submit**.

3.9.3 Entering UDP mode

1. Select **Operating Settings**.
2. Select a port.

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3. In **Operation Mode**, select **UDP Mode**.



4. In **Destination IP address 1**, type your destination address and port.

   You can add 4 addresses.

5. Select **Submit**.

3.10 Setting up data collection for DMU801 option

3.10.1 Connecting data line

The ceilometer has the following data line options:

- Serial line RS-485
- Ethernet

In addition, there is a maintenance connection through DMU801.

Ceilometer outputs data in the following formats.

Table 8 Data output

Output	Data format	Logical interface	Physical interface
Cloud data	ASCII	–	RS-485
	JSON	PODS-MQTT	Ethernet
Profile data	netCDF	SFTP	Ethernet

1. For data connection over the serial line, see Connecting serial line (page 50).
2. For Ethernet use, activate the ceilometer and set up the SSH File Transfer Protocol (SFTP) and/or MQTT. See Ethernet setup (page 51).

3.10.2 Connecting serial line

Ceilometer uses the following default settings.

Table 9 RS-485 settings

Property	Value
Baud settings	38400, 8, N, 1
Message format	MES28 (`msg2_base`)
Message transmission	Poll
`unit_id`	0
Unit	Feet

1. Connect the serial cable to connector **J3** on the ceilometer.
2. Configure your system to match the ceilometer default settings.
3. Open a terminal program.
4. To open the connection to the ceilometer, type:

```
open
```

5. To check that device is operational, type:

```
get failure status
```

6. To activate the polling mode, type:

```
set message transmission request
```

For the message without sky condition data, type:

```
<enq> CL018
```

For the message with sky condition data, type:

```
<enq> CL028
```

Message format:

```
<ENQ> CL<ID><message identifier> <CR><LF>
```

Message field	Description
`ENQ`	Character ENQUIRE = ASCII, 05H = control-E
`CL`	Fixed ceilometer identifier for CL51 messages
`ID`	Ceilometer identification, 7-bit printable ASCII character
`message identifier`	Optional message identifier • `18` = `msg1_base` (does not contain sky condition data) • `28` = `msg2_base` (with sky condition data) • `S` = Status message
`CR`	Carriage return
`LF`	Line feed

7. To close the connection, type:

```
close
```

3.10.3 Ethernet setup

To connect the device to Ethernet, you must activate and configure the device.

- Activating device (page 52)
- Configuring Ethernet connection (page 55)
- Setting time (page 57)
- Configuring device location (page 58)

After the Ethernet setup, set up SFTP for profile data and/or MQTT for cloud data.

Cloud data is also available over the RS-485 line which requires no Ethernet setup.

More information

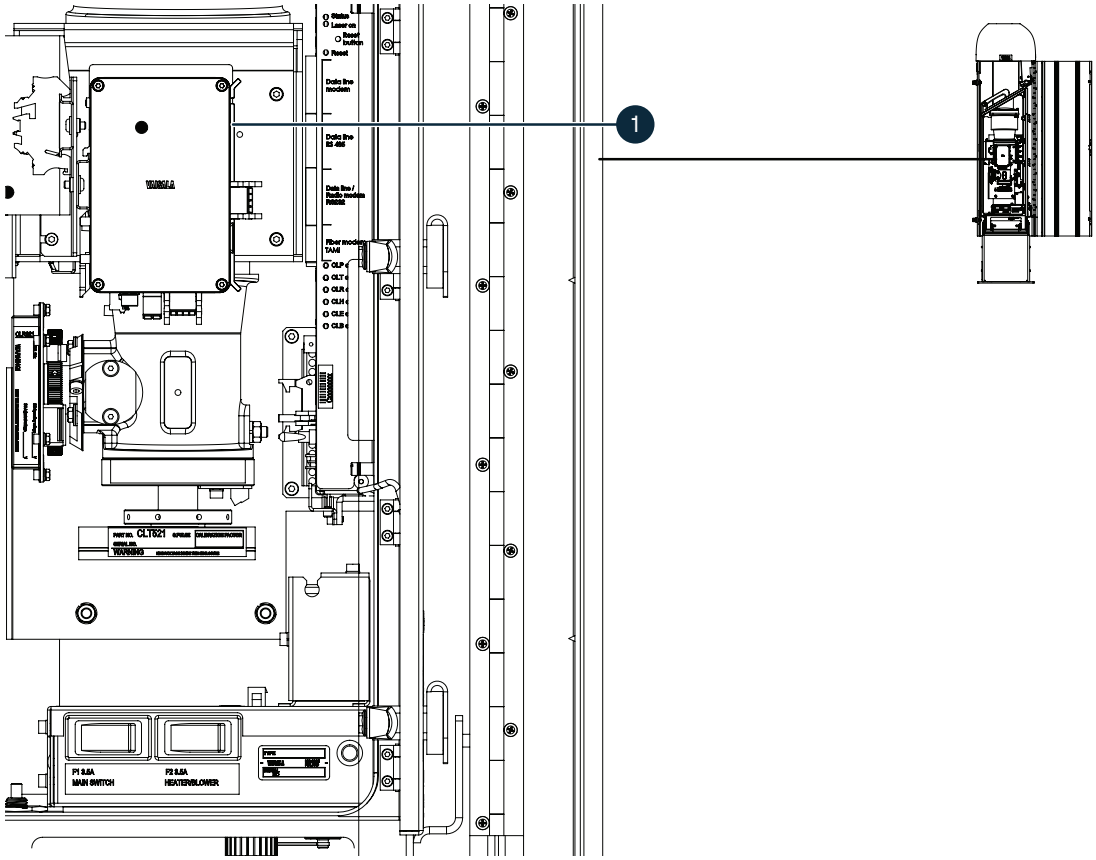
- NetCDF files (page 86)
- Replacing DMU801 (page 155)

3.10.3.1 Activating device

- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

If the laptop is not connecting to the ceilometer, the reason may be that the port of the laptop does not recognize the data connection. Try using a different laptop.

1. Connect DMU801 to your computer with a USB-C cable.



1 USB port on DMU801

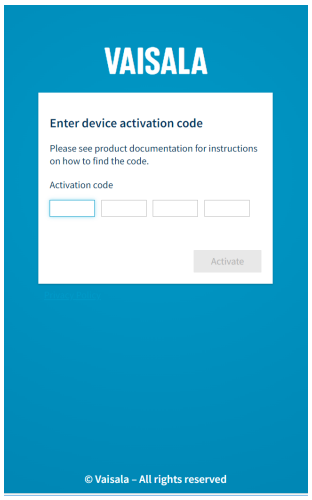
2. Open a web browser and go to the Web UI address:

   https://192.168.10.2.

3. Web browsers do not trust a self-signed certificate. If you are logging in for the first time, the browser indicates that the connection is untrusted or insecure. Ignore the warning and continue to the site.

4. Type the device activation code in the **Activation code** field.

   The code is unique for each DMU801. If you do not know the device activation code, contact Vaisala.

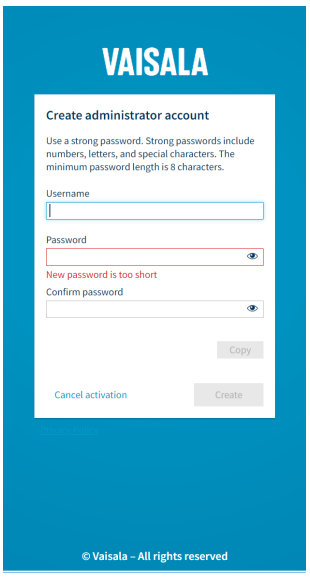


> Store the device activation code in a safe place. You have to re-enter the code after a factory reset. If you forget or do not know the device activation code, contact Vaisala.

5. Select **Activate**.

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6. After entering the correct device activation code, you are prompted to create an administrator user account. Create a username and password for the **Administrator** user, confirm the password, and select **Create**.



Store the username and password in a safe place. If you forget your username or password, you have to reset DMU801 to factory default settings.

The **Administrator** user account is created, and the Web UI main page opens.

3.10.3.2 Configuring Ethernet connection

- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

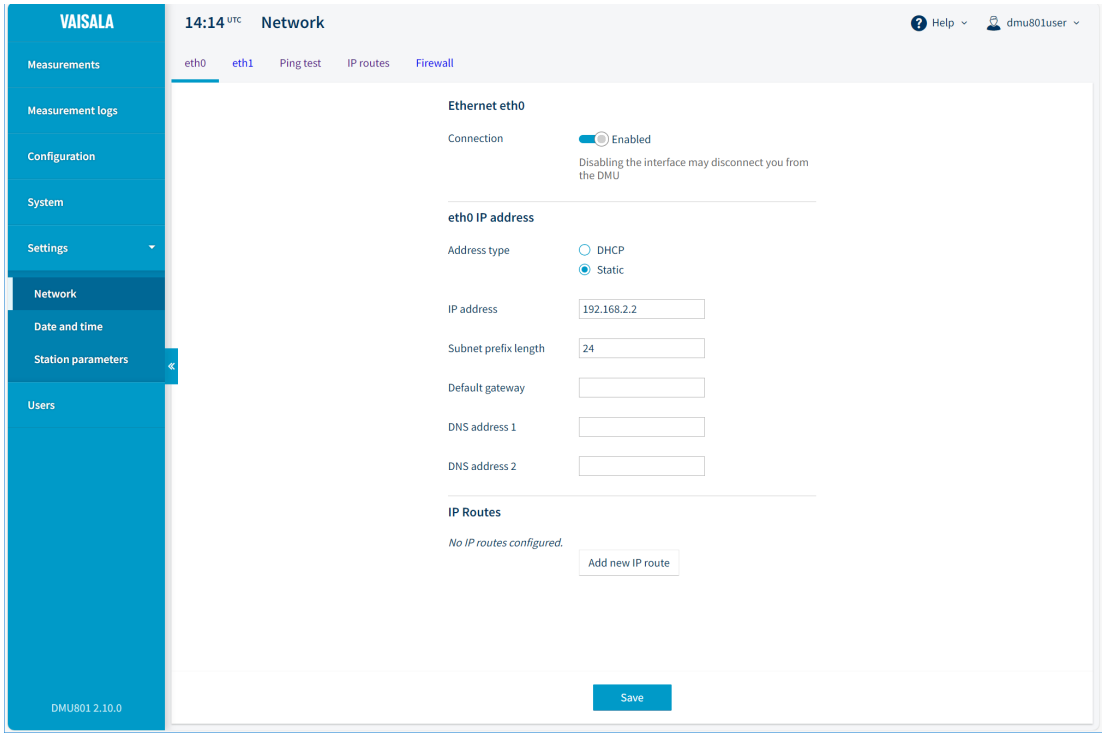
Configure the Ethernet connection to be able to connect to the device remotely over the Ethernet.

When configuring the eth0 connection, make sure that you are connected to DMU801 through the USB-C cable.

1. In a web browser, type the following Web UI address:

   https://192.168.10.2

2. In the Web UI, go to **Settings > Network**.



3. In **eth0**, set the following:

   Connection
   Select **Enabled**.

   Address type
   Select **Static**.

   IP address
   Set a suitable IP address according to the used network (default = **192.168.2.2**).

   Subnet prefix length
   Set the subnet length (default = **24**).

   Default gateway
   Leave empty.

   DNS address 1
   IP address of the primary DNS server.

   DNS address 2
   IP address of the secondary DNS server.

4. To save the changes, select **Save**.

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3.10.3.3 Setting time

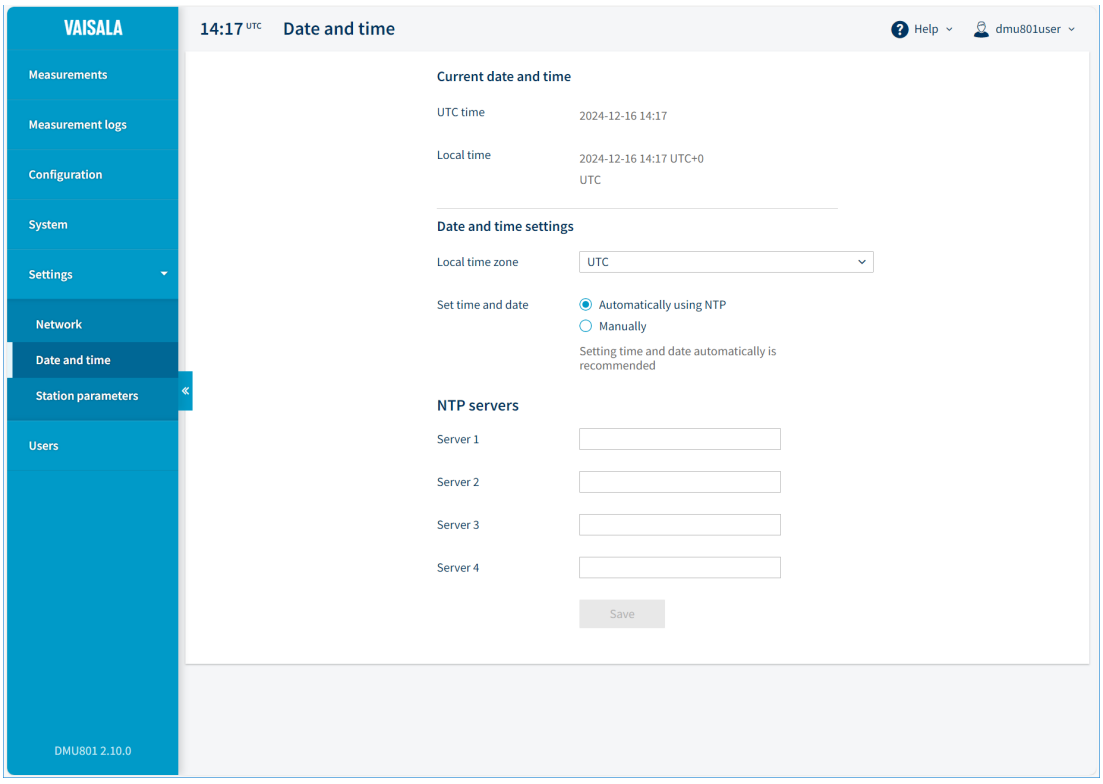
- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

The network time protocol NTP is used to set system clocks accurately to the current time. NTP makes sure that all observations have the correct timestamp.

Vaisala recommends that you use NTP if DMU801 is connected to the Internet. If Internet connectivity is not available, you can set the system time manually.

You need to configure the date and time settings if you want to use local time or other than the default NTP server.

1. Log in to the Web UI as an **Administrator**.
2. In the Web UI, select **Settings > Date and time**.



3. In **Local time zone**, select UTC time.
4. In **Set time and date**, select **Automatically using NTP**. Type the address of the NTP server or servers that you want to use.
5. To save the changes, select **Save**.

You are logged out of the Web UI. Logout does not happen if you select **Automatically using NTP** and the resulting time does not differ considerably from the current system time.

3.10.3.4 Configuring device location

- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

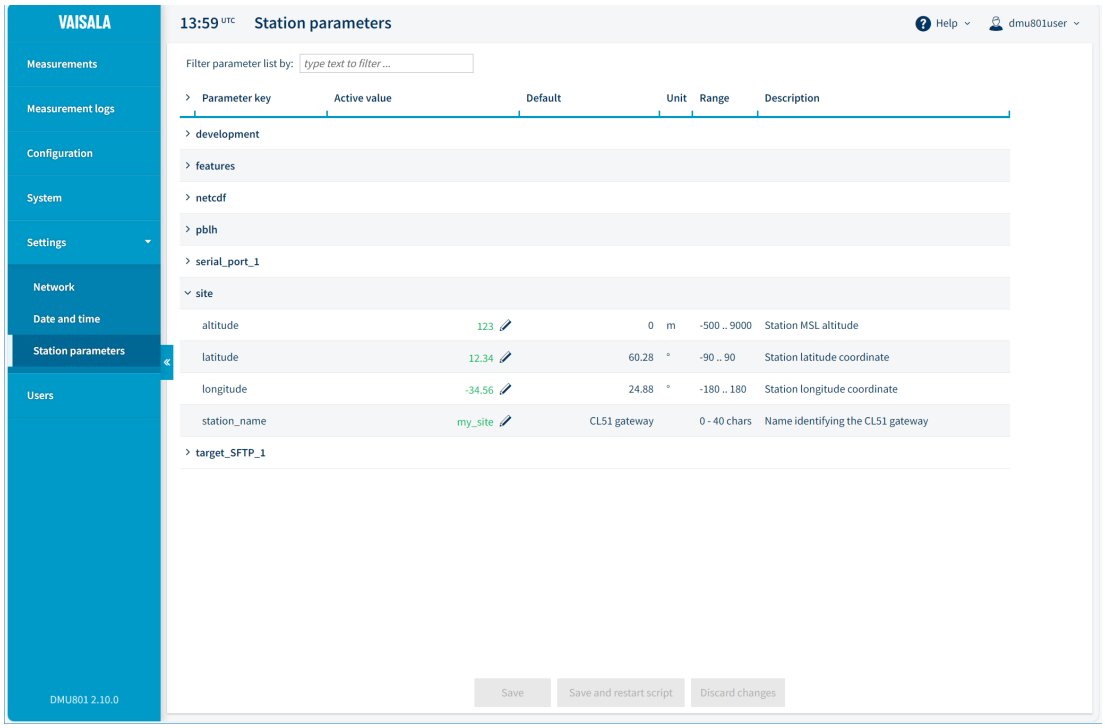
When starting to use the device or moving it to a new location, define the device location information in the Web UI. This information helps to distinguish several devices from each other.

1. In a web browser, type the following Web UI address:

   https://192.168.10.2

2. In the Web UI, go to **Settings > Station parameters**.
3. Select **site**, and type the altitude, height offset, latitude, and longitude information, and set a name for the device or site in **station_name**.
   - For altitude the range is −500 … 9000 meters.
   - For height offset, the range is −1000 … 1000 meters.
   - For latitude the range is −90.000000 … 90.000000.
   - For longitude the range is −180.000000 … 180.000000.

   For values below ground or sea level, use a negative value (−).
   For the station name, use the device serial number if possible.



4. Select **Save and restart script**.

3.10.4 SFTP setup for profile data

To enable data transfer of profile data in netCDF files, an SFTP server must be available to receive the files.

Setting up a local SFTP server requires admin rights on your Windows PC. Contact your IT department to perform the SFTP setup.

Windows OpenSSH server was tested at Vaisala and can be used. The installation of an SFTP server is not instructed in this document because the SFTP installation varies a lot depending on the used computer and IT environment. A simple alternative that we have instructed in this document is the mini-SFTP server installation.

- Installing mini-SFTP server (page 59)
- Configuring SFTP settings (page 60)
- Configuring netCDF data output (page 62)

More information

- NetCDF files (page 86)

3.10.4.1 Installing mini-SFTP server

- Windows PC

This instruction is based on the use of a mini-SFTP server setup. Vaisala is not responsible for the setup of third-party software.

1. Download the mini-SFTP server program from the following address:

   https://www.coreftp.com/server/
2. Allow port 22 through the Windows firewall.
   a. On your PC, open Windows Defender Firewall with Advanced Security.
   b. Select **Inbound Rules > New Rule**. In New Inbound Rule Wizard, select **TCP** and **Specific local ports**. To **Port** add port22. Select **Allow the connection**, allow **Domain**, **Private**, and **Public**. Type a name for the rule. Select **Finish**.
3. Double-click the downloaded EXE file.
4. If Windows Defender Firewall with Advanced Security prompts for security options, allow all.

5. Set the following in **Core FTP mini-sftp-server**:
   a. Fill in the user and password.
   b. Select port 22 (the same you opened in the firewall)
   c. Select the directory (**Root path)** for the files.
   d. Select **Options** and in **IP/Address** set the IP address of the host computer and select **OK**.
   e. Select **Start**.

3.10.4.2 Configuring SFTP settings

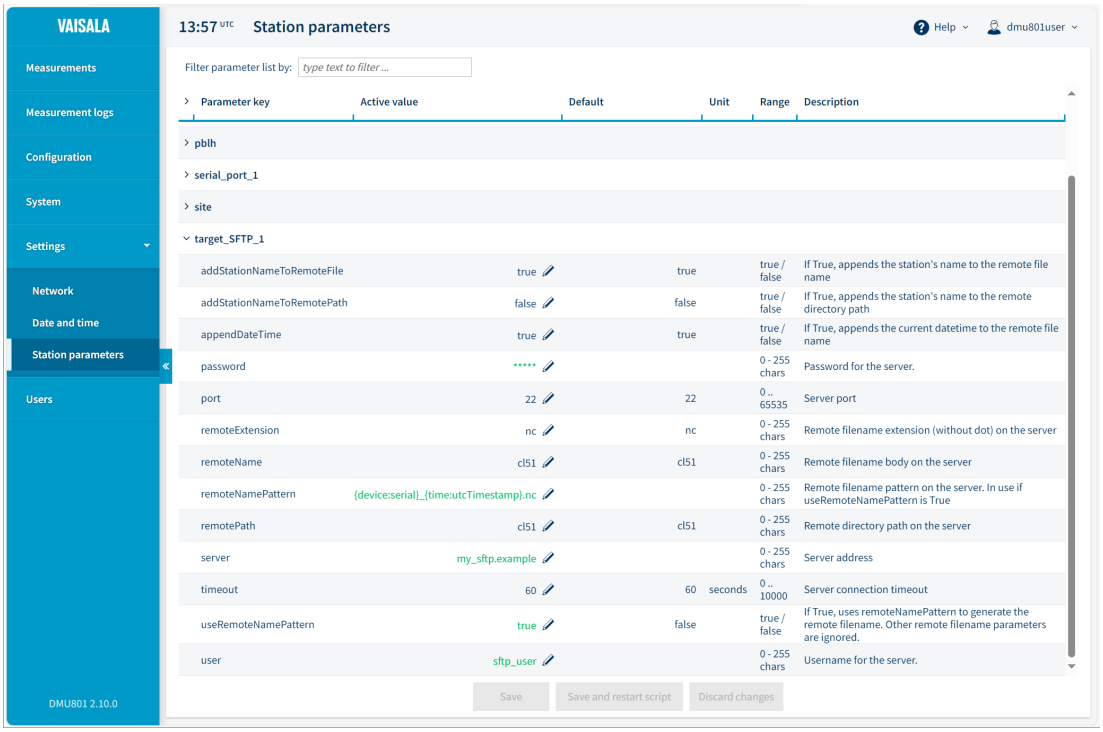


- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

The SFTP configuration is needed for the use of netCDF files over the Ethernet.

1. In the Web UI, select **Settings > Station parameters**.

2. Select **target_SFTP_1** and set the following:



addStationNameToRemoteFile
: Select **true**. This adds the station name set in **Settings > Station parameters > site > station_name**.

addStationNameToRemotePath
: Select **false**.

appendDateTime
: Select **true**.

password
: Password for the server.

port
: The same port that the server uses.

remoteExtension
: Use the default **nc**.

remoteName
: Set a text to add to the filename.

remoteNamePattern
: Leave empty. If you want to use this later on, see the instructions about configuring the netCDF filename.

remotePath
: Subfolder for the files on the server.

server
: IP address of the server.

timeout
Leave as is.

useRemoteNamePattern
Select **false**.

user
Username for the server.

3. Select **Save and restart script**.
4. To verify data output, select **Configuration > Debug console** and check the messages. Select **Measurements** and check **CL51** and **Algorithm.**

3.10.4.3 Configuring netCDF data output



- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

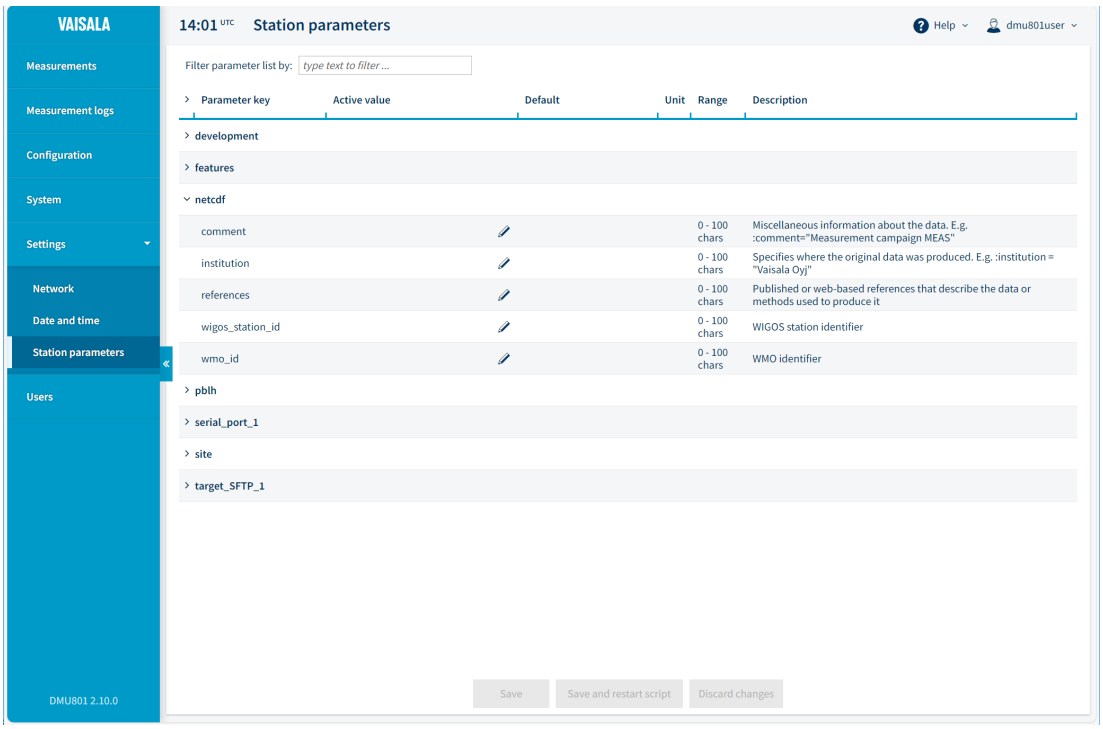
The data output configuration is needed for the netCDF files. The configured information is printed in the netCDF files.

1. In a web browser, type the following Web UI address:

   https://192.168.10.2

2. In the Web UI, select **Settings > Station parameters**.

3. Select **netcdf**, and set the following (all the fields are optional):



comment
: Miscellaneous information about the data.

institution
: Information about the producer of the data.

references
: Published or web-based references that describe the data or methods used to produce it.

wigos_station_id
: WIGOS station identifier.

wmo_id
: WMO identifier.

4. Select **Save and restart script**.

3.10.5 MQTT setup for cloud data

To receive cloud data in MQTT topics, set up the Mosquitto service.

The MQTT setup requires admin rights on your Windows PC.

- Configuring MQTT (page 64)

3.10.5.1 Configuring MQTT

- PC with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

The MQTT configuration is needed for ASCII data output over the PODS-MQTT interface.

1. Install and set up Mosquitto on your PC.
   a. Install Mosquitto from https://mosquitto.org/download/.
   b. Go to the folder where you installed Mosquitto.
   c. Browse to the configuration file ***mosquitto.conf*** and as an admin user, add the following lines to the end of the file:

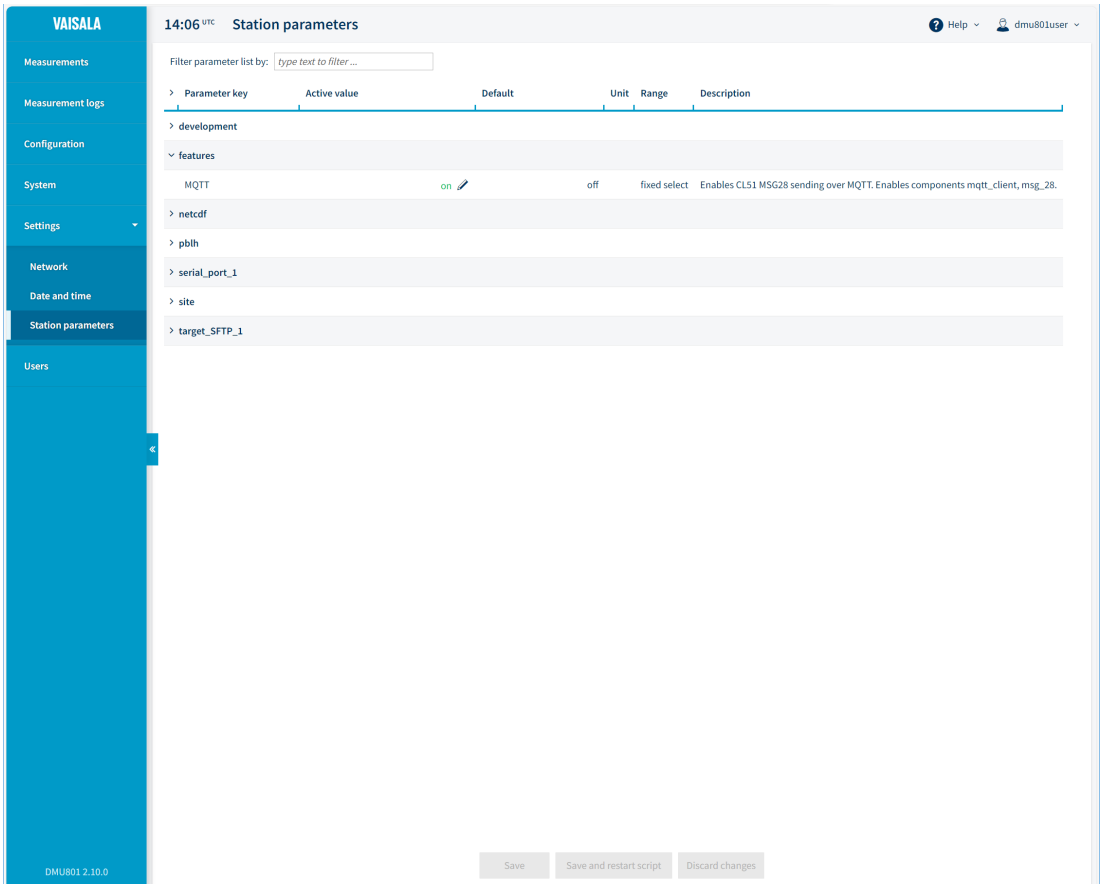
```
allow_anonymous true
listener 1883 0.0.0.0
```

   d. In Command Prompt, type the following:

```
sc stop mosquitto
sc start mosquitto
```

   Alternatively, on your PC, search for **Services** and locate Mosquitto Broker. Right-click and select **Stop** and right-click again and select **Start**.
2. Allow port 1883 through the Windows firewall.
   a. On your PC, open Windows Defender Firewall with Advanced Security.
   b. Select **Inbound Rules > New Rule**. In New Inbound Rule Wizard, select **Program** and browse to the file ***mosquitto.exe***. Follow the onscreen instructions, and select **Finish**.
3. In the Web UI, select **Settings > Station parameters**.

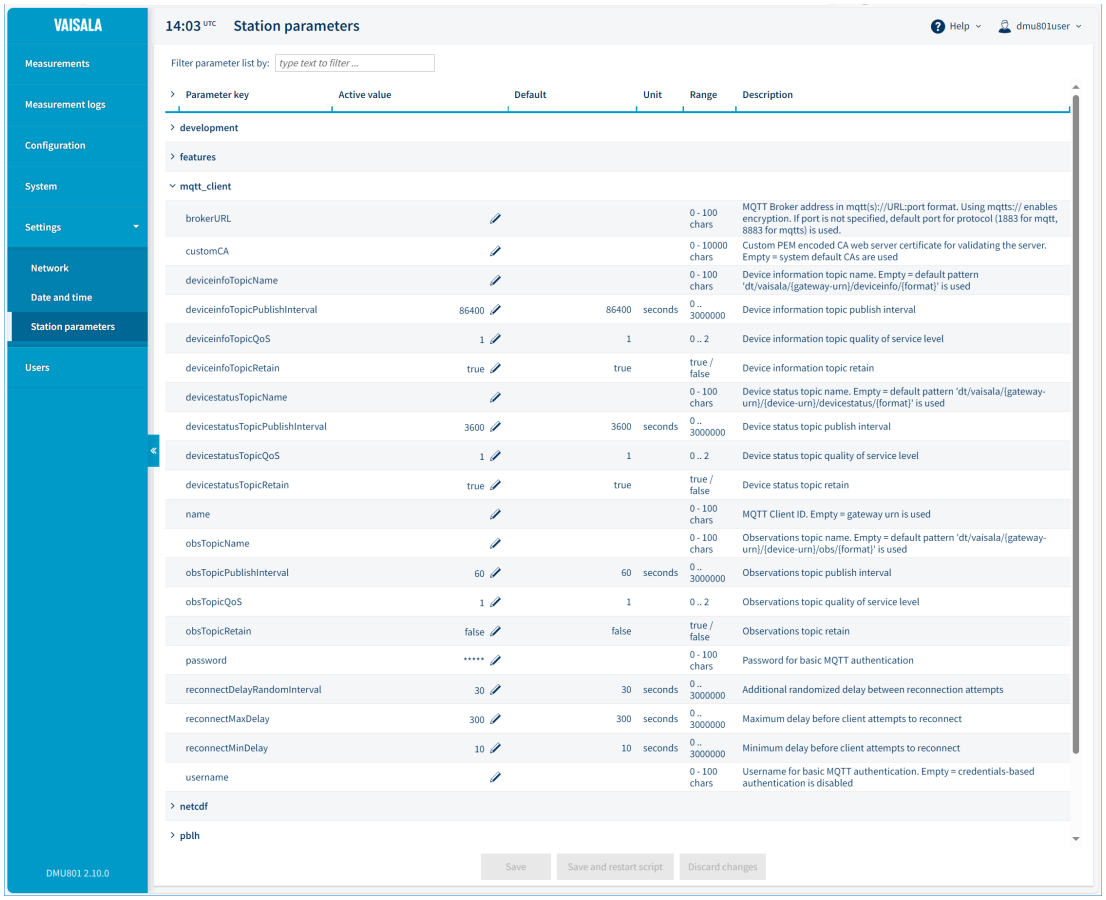
4. Select **features** and for **MQTT** select **on**.



5. Select **Save and restart script**.

6. Select **mqtt_client** and set **brokerURL** to match the IP address of the PC.

   Use the following format: **`mqtt://<IP address of the PC>`**.
   Leave the rest of the fields as they are.



7. Select **Save and restart script**.
8. To check that data is coming through, type the following in Command Prompt:

```
"C:\Program Files\mosquitto\mosquitto_sub.exe" -t "#"
```

9. To log the files on the PC, type the following:

```
C:\Program Files\mosquitto\mosquitto_sub.exe" -t "#" > messages.log
```

   The name of the log files is ***`messages.log`***. Use a file name of your choice.

3.10.5.2 Testing MQTT data transfer

1. Open Command Prompt.

2. To check that data is coming through, type the following:

```
C:\Program Files\mosquitto\mosquitto_sub.exe" -t "#"
```

   # retrieves all the topics.

3. To close the connection, type **Ctrl+C**.
4. To check the existing topics names, type the following:

```
C:\Program Files\mosquitto\mosquitto_sub.exe" -t "#" -F %t
```

   Wait 1 minute for the observation to be transferred.

5. To close the connection, type: **Ctrl+C**.
6. To fetch a specific observation topic, type the following:

```
C:\Program Files\mosquitto\mosquitto_sub.exe" -t "<topic name as URN>
```

   For example:

```
C:\Program Files\mosquitto\mosquitto_sub.exe" -t "dt/vaisala/
urn:dev:ops:16961-DMU801-W2010114/urn:dev:ops:16961-DMU801-W2010114/obs/
json-senml
```

   For device DMU801-W2010114, the following is displayed:

```
dt/vaisala/urn:dev:ops:16961-DMU801-W2010114/urn:dev:ops:16961-DMU801-
W2010114/obs/json-senml
```

4. Data reporting

4.1 Data messages

To ease the use of CL51 and to ease the transfer from old ceilometer versions to the new one, CL51 includes data messages used in CL31 and LD40. CL51 provides the following data messages:

- CL51 data messages 1 and 2
- CL51 status message
- CL31 data messages 1 and 2
- LD40 standard telegram

Each port can be set to transmit a specified message automatically. Alternatively, the port can be set to transmit the set message only when polled by a predetermined polling string, or the polling string can contain the message identification.

The messages may provide a different resolution and require a different measurement mode. A change of a message always switches into the correct measurement mode automatically.



All characters are 7-bit USASCII.
In this document:

- [CRLF] = Carriage return + line feed (2 characters)
- [SH] = Start of header
- [SX] = Start of text
- [EX] = End of text
- [ET] = End of transmission

In addition, ceilometers with DMU801 support the following:

- NetCDF files
- MQTT interface

4.1.1 Secondary message

Two different messages can be separately output on the two ports. This is enabled by configuring a secondary message using the command **`set message secondary`**. The secondary message is always output to the other port, meaning that the port is not configured for the primary message. Note that if both messages contain a backscatter profile, the message intervals must not be set to values lower than 12 seconds.

4.1.2 CL51 data messages No. 1 and 2

Data message No. 1 contains cloud height/vertical visibility measurement and elementary status information that enables a host system or operator to see that no warnings or alarms are present. This message also includes a range and sensitivity normalized backscatter profile that is suitable, for example, for a graphical data presentation or research purposes. In addition to the content of data message No. 1, data message No. 2 also includes sky condition data.

The backscatter profile includes data up to 15 km (50 000 ft), but clouds are reported only up to 13 km (43 000 ft).

The data resolution is 10 m (33 ft) in distance, and 20 bits (5 hex-ASCII characters) in signal magnitude.

An example of CL51 data message No. 1:

```
[SH]CLA10016[ST][CRLF]                                    1st line     12 char.
30 01230 12340 23450 FEDCBA987654[CRLF]                   2nd line     35 char.
00100 10 1540 098 +34 099 12 0621 L0112HN15 139[CRLF]     3rd line     49 char.
00000111112222233333 ... (5 x 1540 bytes)[CRLF]           4th line   7702 char.
[EX]1a3f[ET][CRLF]                                        5th line      8 char.
                                                          Total      7806 char.
```

An example of the CL51 data message No. 2:

```
[SH]CLA10026[SX][CRLF] 1st line 12 char.
30 01230 12340 23450 FEDCBA987654[CRLF]                   2nd line 35 char.
3 0055 5 0170 0 //// 0 //// 0 ////[CRLF]                  3rd line 42 char.
00100 10 1540 098 +34 099 12 0621 L0112HN15 139[CRLF]     4th line 49 char.
00000111112222233333 ... (5 x 1540 bytes)[CRLF]           5th line 7702 char.
[EX]1a3f[ET][CRLF] 6th line 8 char.
                                                          Total 7848 char.
```

For data lines with low bandwidth, there is also a base version of each message. In the short base version of message No. 1, lines 3 and 4 are left out. In the base version of message No. 2, lines 4 and 5 are left out. The following table summarizes the data message types with the minimum bit rates and storage capacity. The minimum reporting interval is 6 s.

Table 10 CL51 data messages No. 1 and 2

Message number and subclass	Message name	Length (bytes)	Min. bps (6 s)	Data/month (6 s)	Min. bps (30 s)	Data/month (30 s)
16	`msg1_10x1540`	7806	19.2 k	3220 MB	4800	644 MB
18	`msg1_base`	55	300	23 MB	300	5 MB
26	`msg2_10x1540`	7848	19.2 k	3240 MB	4800	647 MB

Message number and subclass	Message name	Length (bytes)	Min. bps (6 s)	Data/month (6 s)	Min. bps (30 s)	Data/month (30 s)
28	msg2_base	97	300	40 MB	300	8 MB

1ST LINE

```
[SH]CLA10016[SX][CRLF]
```

[SH]	Start of heading character
CL	Ceilometer identification sting. Always CL.
A	Unit identification character 0 ... 9, A ... Z
100	Software level ID 100 ... 999
1	Message number: 1 = message without sky condition data, 2 = with sky condition data.
6	Character for subclasses of message: 6 = 10 m x 1540 samples, range 15400 m (**msgl_10x1540**), 8 = without a backscatter profile (**msgl_base**)
[SX]	Start of text character
[CRLF]	Carriage return + line feed

2ND LINE

```
30 01230 12340 23450 FEDCBA987654[CRLF]
```

3	First digit of line: 0 = no significant backscatter
	1 = 1 cloud base detected
	2 = 2 cloud bases detected
	3 = 3 cloud bases detected
	4 = full obscuration determined but no cloud base detected
	5 = some obscuration detected but determined to be transparent
	/ = raw data input to algorithm missing or suspect
0	Second digit of line: 0 = Self-check OK
	W = At least one warning active, no alarms
	A = At least one Alarm active

01230	If detection status is 1, 2, or 3: lowest could base height
	If detection status is 4: vertical visibility as calculated
	If detection status is 0 or 5: /////
12340	If detection status is 2 or 3: second lowest cloud base height
	If detection status is 4: highest signal detected
	If detection status is 0 or 5: /////
23450	If detection status is 3: highest cloud base height
	If detection status is 0, 1, 2, 4, 5: /////

The message ends with FEDCBA987654.

It contains alarm (A), warning (W), and internal status (S) information. Each character is a hexadecimal representation of 4 bits, that is, values between 0 and 9 are presented with numbers and values 10, 11, 12, 13, 14, and 15 are presented with letters A, B, C, D, E, and F, respectively. As each of the 12 characters represent the sum of 4 individual bits, the total number of bits is 48 (b00-b47), with the following breakdown and interpretation.

Table 11 Diagnostics information on 2nd line

Hex number	Bit number	Binary number	Description
F	b47	(8000 0000 0000)	Transmitter shut-off (A)
	b46	(4000 0000 0000)	Transmitter failure (A)
	b45	(2000 0000 0000)	Receiver failure (A)
	b44	(1000 0000 0000)	Voltage failure (A)
E	b43	(0800 0000 0000)	(spare) (A)
	b42	(0400 0000 0000)	Memory error (A)
	b41	(0200 0000 0000)	Light path obstruction (A)
	b40	(0100 0000 0000)	Receiver saturation (A)
D	b39	(0080 0000 0000)	(spare) (A)
	b38	(0040 0000 0000)	(spare) (A)
	b37	(0020 0000 0000)	(spare) (A)
	b36	(0010 0000 0000)	(spare) (A)
C	b35	(0008 0000 0000)	(spare) (A)
	b34	(0004 0000 0000)	(spare) (A)
	b33	(0002 0000 0000)	Coaxial cable failure (A)
	b32	(0001 0000 0000)	Ceilometer engine board failure (A)

Hex number	Bit number	Binary number	Description
B	b31	(0000 8000 0000)	Window contamination (W)
	b30	(0000 4000 0000)	Battery voltage low (W)
	b29	(0000 2000 0000)	Transmitter expires (W)
	b28	(0000 1000 0000)	High humidity (W)
A	b27	(0000 0800 0000)	(spare) (W)
	b26	(0000 0400 0000)	Blower failure (W)
	b25	(0000 0200 0000)	(spare) (W)
	b24	(0000 0100 0000)	Humidity sensor failure (W)
9	b23	(0000 0080 0000)	Heater fault (W)
	b22	(0000 0040 0000)	High background radiance (W)
	b21	(0000 0020 0000)	Ceilometer engine board failure (W)
	b20	(0000 0010 0000)	Battery failure (W)
8	b19	(0000 0008 0000)	Laser monitor failure (W)
	b18	(0000 0004 0000)	Receiver warning (W)
	b17	(0000 0002 0000)	Tilt angle > 45 degrees warning (W)
	b16	(0000 0001 0000)	(spare) (W)
7	b15	(0000 0000 8000)	Blower is on (S)
	b14	(0000 0000 4000)	Blower heater is on (S)
	b13	(0000 0000 2000)	Internal heater is on (S)
	b12	(0000 0000 1000)	Working from battery (S)
6	b11	(0000 0000 0800)	Standby mode is on (S)
	b10	(0000 0000 0400)	Self-test in progress (S)
	b09	(0000 0000 0200)	Manual data acquisition settings are effective (S)
	b08	(0000 0000 0100)	(spare) (S)
5	b07	(0000 0000 0080)	Units are meters if on, else feet (S)
	b06	(0000 0000 0040)	Manual blower control (S)
	b05	(0000 0000 0020)	Polling mode is on (S)
	b04	(0000 0000 0010)	(spare) (S)
4	b03	(0000 0000 0008)	(spare) (S)
	b02	(0000 0000 0004)	(spare) (S)
	b01	(0000 0000 0002)	(spare) (S)
	b00	(0000 0000 0001)	(spare) (S)

For example, if no clouds are detected, if the window is contaminated, the battery voltage is too low, the internal heater is on and units are meters, a warning is given and the second line appears as follows:

```
0W ///// ///// ///// 0000C0002080
```

ADDITIONAL 3RD LINE IN MESSAGE NO. 2



The line starts with two space characters.

```
 3 0055 5 0170 0 //// 0 //// 0 ////[CRLF]
```

3	Detection status 0 ... 8 = cloud coverage of the first layer in octas 9 = vertical visibility 1 = data missing, sky condition option not active or ceilometer in standby mode. 99 = not enough data (after startup)
0055	Height of the 1st cloud layer (550 m or 5 500 ft depending on the units selection)
5	Cloud amount of the 2nd layer in octas
0170	Height of the 2nd cloud layer (1700 m or 17 000 ft depending on the selection)
0	Cloud amount of the 3rd layer in octas
////	Height of the 3rd cloud layer
0	Cloud amount of the 4th layer in octas
////	Height of the 4th cloud layer
0	Cloud amount of the 5th layer in octas
////	Height of the 5th cloud layer

The reporting resolution is 10 m or 100 ft depending on the unit selection. If the cloud amount is zero, the corresponding layer height is ////.

3RD LINE IN MESSAGE NO. 1 (4TH LINE IN MESSAGE NO. 2)

```
00100 10 1540 098 +34 099 12 621 L0032HN15 139[CRLF]
```

00100	Parameter SCALE, 100 (%) is normal (0 ... 99999 possible)
10	Backscatter profile resolution in meters

1540	Length of the profile in samples
098	Laser pulse energy, % of nominal factory setting (0 ... 999)
+34	Laser temperature degrees C (-50 ... +99)
099	Window transmission estimate % (0 ... 100)
12	Tilt angle, degrees from vertical (0 ... 90)
0621	Background light, millivolts at internal ADC input (0 ... 2500)
L0032HN15	Measurement parameters: • Pulse: L = long, S = short • Pulse quantity: 0032×1024 • Gain: H = high, L = low • Bandwidth: N = narrow, W = wide • Sampling: 15 or 30 MHz
139	Sum of detected and normalized backscatter, 0 ... 999. Multiplied by scaling factor times 104. At scaling factor 1.0 the sum range 0 ... 999 corresponds to integrated backscatter 0 ... 0.0999 srad-1.



This line is omitted if the message subclass is 5 or 8.

4TH LINE IN MESSAGE NO. 1 (5TH LINE IN MESSAGE NO. 2)

```
00000111112222233333........ [CRLF] (5 x 1540 + 2 bytes)
```

The 2-way attenuated backscatter profile with sensitivity normalized units $(100000 \cdot srad \cdot km)^{-1}$ unless otherwise scaled with the **SCALE** parameter. Each sample is coded with a 20-bit HEX ASCII character set; msb nibble and bit first, 2's complement. The length of this line is equal to 5 times the length of the profile + 2. Note that the profile is not corrected with the tilt angle.

Using the **SCALE** parameter a total dynamic range of 29 bits can be achieved for this message.

The line ends with carriage return and line feed characters.



This line is omitted if the message subclass is 5 or 8.

5TH LINE IN MESSAGE NO.1 (6TH LINE IN MESSAGE NO. 2)

```
[EX]1a3f[ET][CRLF]
```

[EX]	End of text character
1a3f	Checksum
[ET]	End of transmission character
[CRLF]	Carriage return + line feed

4.1.3 CL51 status message

The status message displays the internal monitoring of the entire unit. It is mainly meant for testing and maintenance purposes. The status message can be displayed by giving the **status** command.

The status message can also be used in the CL31 emulation mode, with 7700 m measurement range and 5 m or 10 m resolution. The CL31 emulation mode is activated using one of the commands **set data_acq meas_mode standard** (10 m resolution) or **set data_acq meas_mode high_res** (5 m resolution).

```
[SH]CL0100S0[SX][CRLF]
      ///// ///// 000000000080
Alarms[CRLF]
  Tmit Shutoff         OK    Transmitter  OK[CRLF]
  Receiver             OK    Voltages     OK[CRLF]
  Ext Memory           OK    Light Pth Obs OK[CRLF]
  Rec Saturat          OK    Coaxial Cable OK[CRLF]
  Engine               OK

Oper Mode:  normal          Autoadj:   on[CRLF]
Meas Mode:  high_end Interval:       6.0 s[CRLF]
Power Save: disabled Sleep Int:       60 s[CRLF]

Transmitter                 Receiver[CRLF]
  Pulse Len: long           Gain:      high[CRLF]
  Inlaser:   1745           Bandwidth: narrow[CRLF]
  Pulse Cnt: 32768          Smpl Rate: 15 MHz[CRLF]
  Pulse Frq: 6.5 kHz↵

Window Cnd: 100 %           Outlaser:      1064[CRLF]
Backg Rad:  2.4                           103 %[CRLF]

Tilt Angle: 0.4             Humidity: N/A[CRLF]

Temperatures[CRLF]
  Internal: 23.7            External:  8.7[CRLF]
  DC Power: 22.6            Inclinom:  28.9[CRLF]
  Laser:    25.6            Blower:    8.3[CRLF]

Internal heater: off (auto)
Blower:          on  (auto)
Blower heater:   on
Batt Use:        off

System Status:   OK[CRLF]
Suspect Module: none[CRLF]
[EX][CRLF]
```

Message interpretation:

1ST LINE

The first line of the CL51 status message is structurally identical to the first line of the CL51 data message No. 1, except that the second to last character that identifies the message number, is always `S0[SX][CRLF]`.

2ND LINE

The second line of the CL51 status message is structurally identical to the second line of the CL51 data message No. 1.

LINES 4 ... 9

Lines 4 ... 9 display the CL51 alarm status. If an alarm is present, CL51 invalidates the cloud data.

11TH LINE

Line 11 displays the operation mode and autoadjustment settings of CL51. In normal use, the operation mode should be set to **normal** and autoadjustment should be set to **on**.

12TH LINE

Line 12 displays the measurement mode and measurement interval settings of CL51. In normal use, the measurement mode should be set to **high_end**. By default the measurement interval is 6.0 s.

13TH LINE

Line 13 displays the power-save mode status and sleep interval settings of CL51. In normal use, the power-save mode is **disabled**. If the power-save mode is on, the sleep interval indicates the interval when CL51 does not measure.

LINES 15 ... 19

Lines 15 to 19 display the transmitter and receiver settings of the CL51.

Transmitter	`Pulse Len`	Pulse length, **long** in normal use (100 ns)
	`Inlaser`	Controls the peak laser power
	`Pulse Cnt`	Pulse count, the number of pulses during a single measurement cycle, 32768 by default
	`Pulse Frq`	Laser pulsing frequency (6.5 kHz)
Receiver	`Gain`	**High** by default, may be **low** in fog or heavy snow
	`Bandwidth`	**Narrow** by default
	`Smpl Rate`	Receiver signal sampling rate, defines the vertical resolution of the measurement. Default is 15 MHz which corresponds to a 10 m resolution.

21ST LINE

Line 21 displays the window contamination status and outlaser settings of CL51. The estimated transparency of 90 % to 100 % means that the window is clean. Vaisala recommends cleaning the window whenever there is a window contamination warning, that is, the transparency is estimated to be 70 % or lower.

Outlaser is the laser pulse energy measured with the CLM311 laser monitor board. The value underneath the outlaser value (on line 22) refers to the percentage of the laser power relative to the factory setting. The embedded software maintains this value at 95 ... 105 %.

22ND LINE

Line 22 displays the background radiance value of the CL51. The background radiance varies according to the background luminance condition and temperature. The following value, outlaser percentage, is described above.

24TH LINE

Line 24 displays the tilt angle in degrees from vertical. Humidity measurement is visible if the option is activated.

LINES 26 ... 29

Lines 26 to 29 display temperature values in Celsius degrees. These values are used for the automatic control of the internal heaters and the blower, and for status monitoring.

LINES 31 ... 34

Lines 31 to 34 display the status of the internal heater, the blower, the blower heater, and the battery.

36TH LINE

Line 36 displays a summary of the system status. It should be **OK**. Alternatively, it can display the texts **Warning** or **Alarm/Fail**, if there are warnings or alarms present.

37TH LINE

Line 37 displays the automatic diagnosis in case of a failure. The system suggests a module to be replaced. If there is a secondary option, it is stated in parentheses.

38TH LINE

```
[EX][CRLF]
```

[EX]	End of text character
[CRLF]	Carriage return + line feed

4.1.4 CL31 data messages No. 1 and 2

CL31 messages follow the same format as the CL51 messages. The data resolution is 5 m/ 10 m/20 m (16 ft/33 ft/66 ft). When a CL31 message is selected, CL51 automatically switches to CL31 emulation mode. The measurement range is then 7700 m and the resolution is either 5 m or 10 m depending on the message type.

Table 12 Messages with 10 m resolution (standard mode)

Message number and subclass	Message name	Length (bytes)	Min. bps (2 s)	Data/ month (2 s)	Min. bps (12 s)	Data/ month (12 s)
11	msg1_10x770	3956	28.8 k	4890 MB	4800	815 MB
12	msg1_20x385	2031	14.4 k	2510 MB	2400	418 MB
15	msg1_base	55	300	68 MB	300	11 MB
21	msg2_10x770	3993	28.8 k	4940 MB	4800	423 MB
22	msg2_20x385	2068	14.4 k	2560 MB	2400	425 MB

Message number and subclass	Message name	Length (bytes)	Min. bps (2 s)	Data/ month (2 s)	Min. bps (12 s)	Data/ month (12 s)
25	`msg2_base`	92	600	114 MB	300	19 MB

Table 13 Messages with 5 m resolution (high resolution)

Message number and subclass	Message name	Length (bytes)	Min. bps (3 s)	Data/ month (3 s)	Min. bps (15 s)	Data/ month (15 s)
13	`msg1_5x1500`	7606	28.8 k	6267 MB	9600	1253 MB
14	`msg1_5x770`	3956	14.4 k	3260 MB	4800	625 MB
15	`msg1_base`	55	300	45 MB	300	9 MB
23	`msg2_5x1500`	7643	28.8 k	6230 MB	9600	1260 MB
24	`msg2_5x770`	3993	14.4 k	3290 MB	4800	660 MB
25	`msg2_base`	92	600	76 MB	300	15 MB

CL31 data messages No. 1 and 2 of subclass 5 (without profile data) may be used in both 10 m and 5 m resolutions. A selection of these messages always activates the 10 m resolution (standard mode). If needed, users can change into the 5 m resolution (high resolution) by typing the following advanced level command: **`set data_acq meas_mode high_res`**. Thus, the above messages works in 5 m resolution.

4.1.5 CRC16 checksum

The CRC16 checksum can be calculated using the following algorithm written in the C programming language:

```
/* 16-bit type. */
typedef unsigned short Word16;

/* Calculate CRC-16 value as used in CL51. */

Word16 crc16(const unsigned char *buf, int len)
{
       Word16 crc;
       Word16 xmask;
       int    i, j;

       crc = 0xffff;

       for (i = 0; i < len; ++i)
       {
            crc ^= buf[i] << 8;

            for (j = 0; j < 8; ++j)
            {
                 xmask = (crc & 0x8000) ? 0x1021 : 0;
                 crc <<= 1;
                 crc ^= xmask;
             }
        }

        return crc ^ 0xffff;
}
```

The calculation of the checksum starts after the start of heading character [SH] and ends after the end of text character [EX], that is, the first character included is C and the last one included is end of text.

4.1.6 LD40 standard telegram

The ceilometer includes one Ceilometer LD40 data message. This is the standard telegram X1TA. This message is given in clear text and includes cloud heights and additional meteorological data, date, time, sensor address, and status information of the instrument.

An example of the X1TA telegram:

```
[SX]X1TA_8_015_00.00.00_00:00_00875_11150_NODET_0100_0325_NODT_11300_11600_
+025_ft_00_00000000_96 [CRLF][ET]
```

[SX]	Start of text character
X	Sensor type (X = LD40)
1	Sensor ID number (0 to 9..ABC..MN)
TA	Text telegram

8	Instrument type, always 8 = LD40
015	Telegram update time or message interval in seconds
00.00.00	Always (Date N/A)
00:00	Always (Time N/A)
00875	First cloud layer
11150	Second cloud layer
Second cloud layer NODET	Third cloud layer (in this case: not detected)
0100	Penetration depth of laser beam into second cloud layer
0325	Penetration depth of laser beam into second cloud layer
NODT	Penetration depth of laser beam into third cloud layer, not detected
11300	Vertical visibility
11600	Maximum range of detection
+025	Cloud height offset (in this case the ceilometer is situated 25 ft above the runway level)
ft	Dimensions of all values between byte 26 and byte 76 (ft or m_)
00	Not used
00000000	System status and messages
96	Checksum (this value is only an example; the correct value may be different from this one.)
[CRLF]	Carriage return + Line feed
[ET]	End of transmission character

The notation '_' stands for a space character.

4.1.6.1 Telegram structure remarks

- Spaces (20 hex) always appear with the following bytes: 5, 7, 11, 20, 26, 32, 38, 44, 49, 54, 59, 65, 71, 76, 79, 82, 91.
- The only other byte that may contain a <SPACE>, is byte 78, provided that the dimension is in meters.
- Numbers are always given with the leading zeros as in bytes 27 to 31 in the example.
- **NODET** (and **NODT**) indicates that the value in question has not been detected because, for example, there was only one cloud layer or no cloud layer at all.
- Like any measured value, **NODET** also contains information about the result of the measurement.
- **NODET** may appear instead of cloud layers, minimum vertical extensions of clouds, and vertical visibility.

- When bytes 83 to 90 signal a CL51 alarm, all cloud detection values within the telegram are replaced by minus signs (-, 2D Hex). For example: ----- is shown instead of bytes 27 to 31.
- All values given are height above the runway level. The ceilometer itself may be located above or below the runway level. Byte 72 must therefore contain a sign byte, either + or -.

4.1.6.2 Failure and warning messages

Bytes 83 to 89 of the LD40 standard telegram indicate warnings and errors. A `0` signifies that no error of that error group has happened.

An alarm causes data telegrams to contain invalid data. A warning status does not cause invalid data.

The following tables describe how the ceilometer is mapped to the LD40 error groups.

Table 14 Error group definition

Error group	Byte no.	Description
1	83	Engine board and voltages
2	84	Light path, receiver saturation and window condition
3	85	Receiver and coaxial cable
4	86	Transmitter
5	87	Memory failure and general warnings
6	88	Temperature regulation
7	89	Always 0. Not used.

The following tables describe the single error codes in different error groups.

Table 15 Error group 1 (byte 83)

Error code	Description
0	Status OK
1	Engine or voltage failure (A)
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used

Table 16 Error group 2 (byte 84)

Error code	Description
0	Status OK
1	• Light path obstruction (A) or • Window contamination warning (W)
2	Receiver saturation (A)

Table 17 Error group 3 (byte 85)

Error code	Description
0	Receiver OK
1	Not used
2	Not used
3	Not used
4	• Receiver failure (A) or • Coaxial cable failure (A) or • Receiver warning (W)
5	Not used
6	Not used

Table 18 Error group 4 (byte 86)

Error code	Description
0	Transmitter OK
1	Transmitter expires (laser power low) (W)
2	Transmitter failure
3	Not used
4	Not used
5	Not used
6	Transmitter shutoff (laser temperature too high) (A)

Table 19 Error group 5 (byte 87)

Error code	Description
0	Status OK

Error code	Description
1	• Laser monitor failure (W) or • Blower failure (W) or • High radiation warning (W) or • Engine warning (W) or • Tilt angle warning (angle is > 45 degrees) (W) or • Internal battery voltage low (W) or • Internal battery failure (W) or • Humidity high (option) (W) or • Humidity sensor failure (option) (W)
2	Not used
3	Memory failure (A)
4	Not used

Table 20 Error group 6 (byte 88)

Error code	Description
0	Temperature regulation OK
1	Heater failure (W)

Table 21 Error group 7 (byte 89)

Error code	Description
0	Always 0 (data transmission. N/A)
1	Not used
2	Not used
3	Not used
4	Not used
5	Not used
6	Not used
7	Not used
8	Not used

4.1.6.3 Calculating checksum

The checksum of a data or a command telegram is calculated by computing the sum of all signs (alphanumerical signs and control codes such as STX, EOT CR, LF, except the checksum bytes itself), building the two's complement and taking the lower byte of this result.

The higher half-byte and the lower half-byte converted to a visible ASCII character is the checksum.

An example with the **`polling`** command:

Telegram:

```
STX H0C!X1P----------83 EOT
```

1. Compute the sum:

   Sum = STX + 'H' + '0' + 'C' + !'' + 'X' + '1' + 'P'+ 10 x '-' + EOT
   Sum = 0x02 + 0x48 + 0x30 + 0x43 + 0x21 + 0x58+ 0x31 + 0x50 + 10 x 0x2D + 0x04
   Sum = 0x037D HEX = 893 DEZ

2. Build the complement:

   The complement is built by inverting the binary representation of the sum and adding 1:

   ```
   2Com = ¬ Sum + 1= ¬ 0x037D + 0x01 = 0x0C83 HEX = 3203 DEZ
   ```

3. Take the lower byte and build an ASCII-character:

   The lower byte of 2Com is 0x83 HEX, so the high byte of the checksum is 8 and the low byte is 3:
   Checksum = 83

4.1.7 Manual message

You can set the ceilometer to transmit user-defined cloud heights and status information. You can set a cloud message in the format of line 2 of any real cloud message (for example, Message No. 1 or CT25K data message). The message is a string and the maximum length is 33 characters. If the length is less than 33 characters, the remaining length is padded with spaces. (The CT25K messages use only 29 characters). The end of a string is determined by a new line and the leading spaces are omitted. This message is volatile. The manual message command is behind the password "advanced". Below is an example of a manual message:

```
CEILO >  advanced
Service password accepted.
CEILO >  set message manual_msg 30 00200 01000 05000
000000000000
OK
```

The **`get params message`** command displays the current manual message.

To return to the normal messages, type an empty string:

```
CEILO >   set message manual_msg
OK
```

The manual message is intended for testing purposes. After reset, the normal message takes effect.

4.2 NetCDF files



Ceilometers with DMU801 that have been configured to use the Ethernet and SFTP can output netCDF files.

CL51 creates data files based on the netCDF specification. The netCDF format used in CL51 is built on netCDF-4 which is built on Hadoop Distributed File System (HDFS).

You can open and read CL51 netCDF files with any HDFS or netCDF-4 reader, for example, Panoply.

For more information about netCDF, see https://www.unidata.ucar.edu/software/netcdf/.

CL51 netCDF files are sent over the secure file transfer protocol (SFTP) to a specified server. The files contain the following data:

- Attenuated backscatter profile
- Up to 3 cloud base and top heights or vertical visibility and highest detected signal
- Sky condition information (up to 5 cloud layer heights and their cloud cover in oktas)
- Planetary boundary layer height (PBLH) and quality index
- PBLH averaged over 1 hour and the related quality index
- In addition to the PBLH, up to 2 other aerosol gradient heights and quality indices
- Up to 5 separated aerosol layers and their base height, top height, vertical extent, and quality index
- Measurement metadata
- Status and monitoring information

More information

- Ethernet setup (page 51)
- SFTP setup for profile data (page 59)
- NetCDF example (page 179)

4.2.1 File naming

The netCDF filename format is:

`<file_prefix>_<YYYYMMDDTHHmmss>.nc`

For example:

W2010114_20250112T000500.nc

Table 22 Filename format

Name	Description	Value
`<file_prefix>`	By default, `CL51 gateway`. To use the serial number in the filename, configure it through the Web UI.	Freeform text
`<YYYYMMDDTHHmmss>`	Timestamp when the file was created.	UTC time

More information

- Configuring netCDF filename (page 113)

4.2.2 Global attributes

Table 23 Global, ungrouped attributes

Attribute	Description
`_NCProperties`	Information about the used netCDF libraries.
`title`	Device type, description. Displayed in the file title.
`instrument_firmware_version`	100–999 (software level ID in CL51 data messages No. 1 and 2).
`institution`	Information about the producer of the data. User configurable. Empty by default.
`source`	Information about the origin of the data. User configurable. Empty by default.
`Conventions`	NetCDF convention version of the file. Fixed to CF-1.8.
`schema_version`	Version of the netCDF schema. Distinguishes between schema versions to parse the version specific content.
`pblh_algorithm_version`	Version of the planetary boundary layer height algorithm.
`gateway_firmware_version`	Firmware version of the gateway.
`firmware_config_version`	Configuration version on top of gateway firmware version.
`history`	For use as an audit trail for modifications to the original data. User configurable with your preferred netCDF interface. Empty by default.
`comment`	Miscellaneous information about the data. User configurable. Empty by default.

Attribute	Description
`unit`	Reporting unit, always meters.
`file_temporal_span_in_minutes`	Time period that the file covers in minutes. Always 5 min.
`profile_interval_in_seconds`	Time between consecutive profiles in seconds. Always 30 seconds.
`overlap_is_corrected`	File overlap is corrected. • 1 = true; always true • 0 = false
`wigos_station_id`	User configurable WIGOS station identifier, for example `0-20000-0-07635`. Empty by default.
`wmo_id`	User configurable WMO identifier, for example `07635`. Empty by default.
`references`	User configurable published or web-based references that describes the data or methods used to produce it. Empty by default.

4.2.3 Missing data

The variables are assigned a numerical value under normal operation and fill value `-999` when the data is missing.

Applications that read the data file can use this to know how to represent these values. Most netCDF readers disregard fill values and do not visualize them.

String variables have custom fill values that are also strings and match the length that the variable would have under normal operation. The string fill values consist only of `/` (slash) characters.

4.2.4 Variables and dimensions in CL51 netCDF files

The following tables list the CL51 netCDF dimensions and variables. For the full list of attributes, types, and dimensions associated with each variable, see the example file in the appendix.



The dimensions and variables are listed in alphabetical order. The order in output files depends on the software used.

Table 24 Dimensions in netCDF files

Dimension	Description
`layer`	Vector that gives the running number of the observed aerosol or cloud layer, ordered from lowest to highest with length 5.

Dimension	Description
range	Range grid vector with a resolution of 10 m and a length of 1540.
time	Temporal grid of the measurements, length unlimited.

Table 25 Variables in netCDF files

Variable	Attribute	Value/Description
aerosol_gradient_heights	aerosol_gradient_heights:units	• m = meters
	aerosol_gradient_heights:long_name	Aerosol gradient heights
	aerosol_gradient_heights:comment	Height of the detected aerosol gradients
aerosol_gradient_quality_indices	aerosol_gradient_quality_indices:long_name	Aerosol gradient quality indices
	aerosol_gradient_quality_indices:comment	Quality indices for the detected aerosol gradients.
	aerosol_gradient_quality_indices:actual_range	0, 1, 2, or 3
aerosol_layer_base	aerosol_layer_base:units	• m = meters
	aerosol_layer_base:long_name	Aerosol layer base
	aerosol_layer_base:comment	Distance from the ground to the base of the aerosol layer.
aerosol_layer_count	aerosol_layer_count:long_name	Aerosol layer count
	aerosol_layer_count:comment	The number of detected aerosol layers.
	aerosol_layer_count:actual_range	0–5
aerosol_layer_quality_indices	aerosol_layer_quality_indices:long_name	Aerosol layer quality indices
	aerosol_layer_quality_indices:comment	Quality indices for the detected aerosol layers.
	aerosol_layer_quality_indices:actual_range	0, 1, 2, or 3
aerosol_layer_top	aerosol_layer_top:units	• m = meters
	aerosol_layer_top:long_name	Aerosol layer top
	aerosol_layer_top:comment	Distance from the ground to the top of the aerosol layer.

Variable	Attribute	Value/Description
aerosol_layer_vertical_extent	aerosol_layer_vertical_extent:units	• m = meters
	aerosol_layer_vertical_extent:long_name	Aerosol layer vertical extent
	aerosol_layer_vertical_extent:comment	The distance from the aerosol layer's base to its top.
background_radiance	background_radiance:long_name	Background radiance
	background_radiance:actual_range	0–2500
	background_radiance:comment	Millivolts at internal analog-to-digital converter (ADC) input.
beta_att	beta_att:units	1/(m*sr)
	beta_att:long_name	Attenuated volume backscatter coefficient
	beta_att:coordinates	Time range longitude latitude
	beta_att:comment	Profile data is not tilt-corrected.
	beta_att:averaging_time_in_seconds	30
beta_att_sum	beta_att_sum:units	1/(10^4*sr)
	beta_att_sum:long_name	Beta at sum
	beta_att_sum:actual_range	0–999
	beta_att_sum:comment	Scaled integral of the attenuated volume backscatter coefficient
boundary_layer_height	boundary_layer_height:units	• m = meters
	boundary_layer_height:long_name	Boundary layer height
	boundary_layer_height:comment	Height of the planetary boundary layer.
boundary_layer_quality_index	boundary_layer_quality_index:long_name	Boundary layer quality index
	boundary_layer_quality_index:comment	Quality index for the detected planetary boundary layer.
	boundary_layer_quality_index:actual_range	0, 1, 2, or 3

Variable	Attribute	Value/Description
cloud_base_heights	cloud_base_heights:units	• m = meters
	cloud_base_heights:long_name	Cloud base heights
	cloud_base_heights:coordinates	Time layer longitude latitude
	cloud_base_heights:comment	Reported in vertical, or in the instrument beam direction, depending on the angle_corr setting of the instrument. Up to 3 cloud bases are reported.
cloud_top_heights	cloud_top_heights:units	• m = meters
	cloud_top_heights:long_name	Top of the detected cloud bases
	cloud_top_heights:coordinates	Time layer longitude latitude
	cloud_top_heights:comment	Reported in the instrument beam direction. Up to 3 cloud tops are reported. Represents the cloud top or the penetration depth for optically thick clouds.
detection_status	detection_status:long_name	Detection status
	detection_status:actual_range	• 0 = No significant backscatter • 1 = 1 cloud base detected • 2 = 2 cloud bases detected • 3 = 3 cloud bases detected • 4 = Full obscuration determined, but no cloud base detected • 5 = Some obscuration detected, but determined to be transparent
	detection_status:comment	See previous row.

Variable	Attribute	Value/Description
elevation	elevation:units	• m = meters
	elevation:long_name	Elevation
	elevation:standard_name	ground_level_altitude
	elevation:comment	Measurement site height above or below a fixed reference point, most commonly a reference geoid
latitude	latitude:units	Degrees north
	latitude:long_name	Latitude
	latitude:standard_name	latitude
layer	layer:units	Layer
	layer:long_name	Layer
	layer:comment	Running number of the observed cloud layer or aerosol layer
	layer:actual_range	1–5
longitude	longitude:units	Degrees east
	longitude:long_name	Longitude
	longitude:standard_name	longitude
mean_boundary_layer_height	mean_boundary_layer_height:units	• m = meters
	mean_boundary_layer_height:long_name	Mean boundary layer height
	mean_boundary_layer_height:comment	Mean boundary layer height over the previous hour
mean_boundary_layer_quality	mean_boundary_layer_quality:long_name	Mean boundary layer quality
	mean_boundary_layer_quality:comment	Mean boundary layer quality index over the previous hour
	mean_boundary_layer_quality:actual_range	0, 1, 2, or 3

Variable	Attribute	Value/Description
measurement_parameters	measurement_parameters:long_name	Measurement parameters
	measurement_parameters:comment	9 characters: **L0032HN15** • Pulse: L = long, S = short • Pulse quantity: 0032×1024 • Gain: H = high, L = low • Bandwidth: N = narrow, W = wide • Sampling: 15 or 30 MHz
laser_power_percent	laser_power_percent:units	Percent
	laser_power_percent:long_name	Laser power percent
	laser_power_percent:comment	Percent of nominal factory setting / Laser output power relative to the laser power measured at factory.
	laser_power_percent:actual_range	0–999
laser_temperature	laser_temperature:units	Celsius
	laser_temperature:actual_range	−50 … +99
	laser_temperature:long_name	Laser temperature
overall_status	overall_status:long_name	Instrument overall status
	overall_status:actual_range	0–2
	overall_status:comment	• 0 = Self-check OK • 1 = At least 1 warning active, no alarms • 2 = At least 1 alarm active.

Variable	Attribute	Value/Description
pblh_algorithm_sensitivity	pblh_algorithm_sensitivity:long_name	Sensitivity of the planetary boundary layer height algorithm
	pblh_algorithm_sensitivity:comment	Smaller sensitivity results in fewer reported aerosol gradients. Default is 10.
	pblh_algorithm_sensitivity:actual_range	0–20 Smaller measurement sensitivity results in fewer reported aerosol gradients. To configure, see Configuring measurement sensitivity (page 115).
pblh_temporal_averaging	pblh_temporal_averaging:units	s
	pblh_temporal_averaging:long_name	Temporal averaging of the planetary boundary layer height
	pblh_temporal_averaging:comment	Amount of temporal averaging used to compute the planetary boundary layer height
range	range:units	• m = meters
	range:long_name	Measurement range
	range:axis	Z
	range:positive	Up
	range:comment	Measurement distance from the instrument in the direction of the transmitted laser beam
	range:actual_range	10–15 400
range_resolution	range_resolution:units	• m = meters
	range_resolution:long_name	Range resolution
	range_resolution:comment	Distance between consecutive profile elements

Variable	Attribute	Value/Description
self_diagnostics_info	self_diagnostics_info:long_name	Self-diagnostics information
	self_diagnostics_info:comment	12 characters For description, see Table 11 (page 71).
sky_condition_cloud_layer_covers	sky_condition_cloud_layer_covers:units	Oktas
	sky_condition_cloud_layer_covers:long_name	Cloud cover per cloud layer
	sky_condition_cloud_layer_covers:coordinates	Time layer longitude latitude
	sky_condition_cloud_layer_covers:averaging_time_in_seconds	1800
	sky_condition_cloud_layer_covers:comment	Amount of cloud cover for different cloud layers for up to 5 layers
sky_condition_cloud_layer_heights	sky_condition_cloud_layer_heights:units	• m = meters
	sky_condition_cloud_layer_heights:long_name	Cloud layer heights
	sky_condition_cloud_layer_heights:coordinates	Time layer longitude latitude
	sky_condition_cloud_layer_heights:averaging_time_in_seconds	1800
	sky_condition_cloud_layer_heights:comment	Heights for different cloud layers for up to 5 layers, reported in vertical, or in the instrument beam direction, depending on `angle_corr` setting of the instrument
sunrise_utc	sunrise_utc:long_name	Sunrise in UTC
	sunrise_utc:comment	UTC sunrise time in hours after midnight (decimal number).
sunset_utc	sunset_utc:long_name	Sunset in UTC
	sunset_utc:comment	UTC sunset time in hours after midnight (decimal number).

Variable	Attribute	Value/Description
tilt_angle	tilt_angle:units	Degrees
	tilt_angle:long_name	Tilt angle
	tilt_angle:standard_name	zenith_angle
	tilt_angle:actual_range	0–90
	tilt_angle:comment	Instrument tilt angle from the vertical
time	time:units	Seconds since 1970-01-01 00:00:00.000
	time:long_name	Time
	time:axis	T
	time:standard_name	time
	time:cf_role	profile_id
	time:comment	End of the averaging period
time_zone	time_zone:units	• h = Hours
	time_zone:long_name	Time zone
	time_zone:comment	Instrument time zone. Negative to the west and positive to the east of the Coordinated Universal Time.
vertical_visibility	vertical_visibility:units	• m = meters
	vertical_visibility:long_name	Vertical visibility
	vertical_visibility:coordinates	Time longitude latitude
	vertical_visibility:comment	Reported in the instrument beam direction
vv_highest_signal_detected	vv_highest_signal_detected:units	• m = meters
	vv_highest_signal_detected:long_name	Vertical visibility highest signal detected
	vv_highest_signal_detected:comment	Reported only together with vertical visibility (detection status 4). Represents the most distant range that gave a meaningful return.

Variable	Attribute	Value/Description
window_condition	window_condition:units	Percent
	window_condition:long_name	Window condition
	window_condition:comment	• 100 = Clean window • 0 = Dirty window
	window_condition:actual_range	0–100 %

4.3 PODS-MQTT interface

This section describes details of information provided by the PODS-MQTT providers implemented by the CL51 ASOS station.

4.3.1 MQTT topics

This interface uses the following MQTT topics to publish:

1. Device information
2. Observation data
3. Device status (health information, functional state, and uptime)

The observation data is available in the observations topic. The device information and device status topics contain metadata and are not described in this document.

Each MQTT topic name is configurable using pattern strings. The pattern string can contain fixed characters and variable identifiers enclosed in curly brackets ({}) that are substituted with dynamic content during station runtime.

If the default topic names are not suitable, you can change the names in the station parameters in the Web UI.

Table 26 Topic name variables

Topic level	Variable	Description	Example value
Station	gateway-urn	URN of the gateway device	dt/vaisala/urn:dev:ops:16961-DMU801-S1234567
	gateway-model	Model name of the sending gateway	DMU801
	gateway-serial	Serial number of the sending gateway	S1234567
All	format	Format of payload	json

4.3.2 Observations topic

Table 27 Observations topic

Property	Description
Topic level	Device
Payload	Observation data
Payload format	`senml-json`
Plurality	One publication per device having observations
Topic name	Configurable (default pattern: `dt/vaisala/{gateway-urn}/{device-urn}/obs/{format}`)
Update trigger	When MQTT connection is established. After that, periodically at configurable intervals (default: 1 minute).
MQTT properties	Configurable (default: QoS level 1 [1] (at least once), retain: false)

1) *Supported QoS levels: 0, 1, 2.*

4.3.3 Observations

This provider is implemented by **`mqtt_client`** configuration component. The provider is only enabled if **`MQTT`** feature is enabled in station parameters.

The topic name of observations topic:

`dt/vaisala/urn:dev:ops:16961-DMU801-W2010114/urn:dev:ops:16961-DMU801-W2010114/obs/json-senml`

The CL51 msg2_base message is included in the observation topic as a MSG28 SenML name identifier. A new message is sent every 60 seconds.

Example of observations topic payload:

```
[{"bver": 10, "bn": "urn:dev:ops:16961-DMU801-W2010114:", "bt": 1737386553,
"n": "MSG28", "vs": "\u0001CL021028\u0002\r\n20 02030 04780 /////
000000000080\r\n 3 0213 8 0433 0 //// 0 //// 0 ////\r\n\u00030fe4\u0004\r\n",
"qi": 8500}]
```

Topic payloads are expressed as JSON.

To support future extensions, parser components should be implemented so that any unknown JSON fields, measurements, units, values, and similar are ignored without an error.

More information

- CL51 data messages No. 1 and 2 (page 69)

5. Operation

5.1 Serial lines - open and closed port

The data line is used for measurement data communication and can be operated through a modem or a serial line (RS-232 or RS-485). It can also be used with a ceilometer maintenance terminal, PC, or other terminals. The maintenance line is for on-site maintenance access, and it is used only as an RS-232 serial line. It can be used with a ceilometer maintenance terminal, PC, or other terminal. Functionally the operation of the 2 lines is identical. The same commands, operations, and messages operate through both lines.

Ceilometer has the following line outputs:

- Data line (external connector **J3**)
- Maintenance line (external connector **J4**)

The factory default settings:

- 8 data bits
- No parity
- 1 stop bit and 9600 bps (for maintenance line)
- 19200 bps (for data line)

You can select the bit rate from the menu.

The lines use the 7-bit USASCII character format. Both the upper and lower case letters can be used.

The standard operation of the serial lines requires no handshake signals.

The communication port (the serial line), has the following internal states.

- CLOSED: This is the transmitting state of a measurement data message. Messages are transmitted as a response to a polling input string or automatically at predetermined intervals, depending on the settings (message transmission). User commands are not accepted, except for the **`open`** command, which turns the line into the OPEN state.
- OPEN: This is the user dialog state. The device responds to user commands and command input is echoed. A command prompt `CEILO >` indicates that the ceilometer is ready for command input from the user. Pressing **Enter** executes the command, for example, **`OPEN 1 <enter>`**. No automatic transmission of the measurement data message is executed in the open state. The port reverts to the closed state with the **`close`** command. An automatic, 2-minute timeout after the last character input is applied. A 2–30-minute timeout may be set with the **`set port_timeout`** command. Command input echoing can be turned on or off by giving the command **`set echo on/off`**. When turned off, typed characters are not echoed, but the command responses are given normally. By default echoing is on.



Only one of the ports can be open for commands at a time. Only one of the ports transmits measurement messages at a time. Additionally, in the RS-485 mode, you must give the unit ID with the **`open`** command.

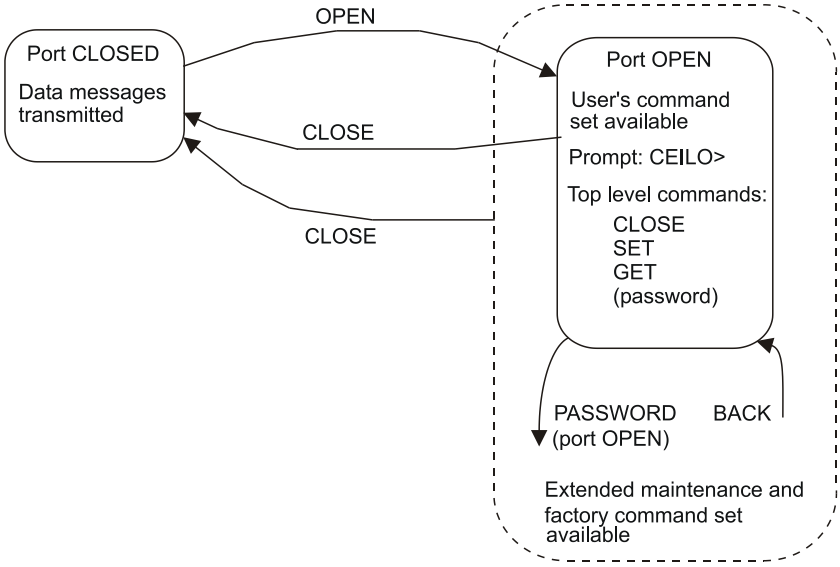


Figure 12 Open and closed port

5.2 Operation modes

There are 2 operation modes: normal and standby. The **`set oper_mode normal`** and **`set oper_mode standby`** commands are used to switch between the modes. In the normal mode, continuous measurement and message transmission occurs according to the chosen parameters. The standby mode, which involves turning off the wearing parts, can be used during periods when measurement is not needed.

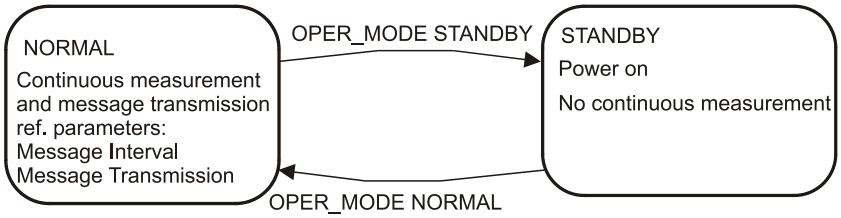


Figure 13 Operation modes

5.3 User commands

The following table describes the user commands. To access the user commands, open the line with the **open** command. You do not need a password.

The command line interpreter provides interactive support.

- At each menu level, pressing **Enter** provides an output of the available menu.
- Inserting a letter and **Enter** outputs all commands starting with that letter.
- Inserting 2 letters and **Enter** outputs all commands that start with the 2 letters, and so on, until only the desired command is left.
- You can execute the commands by pressing **Enter**.

In addition to the user menu and the user level command set, there is a second in-depth maintenance and service level menu and command set for more profound system changes and diagnostics.

Table 28 User level commands

Command	Description
close	Closes a user interface. Releases a port for message transmission.
get diag contamination	Prints diagnostic history of window contamination.
get diag angle	Prints diagnostic history of inclinometer angle.
get diag battery	Prints diagnostic history of internal battery voltage.
get diag int_temp	Prints diagnostic history of internal temperature.
get diag l_power	Prints diagnostic history of laser power.
get diag l_temp	Prints diagnostic history of laser temperature.
get failure history	Prints history of alarm and warning status.
get failure status	Shows active alarms and warnings.
get params data_acq	Prints data-acquisition related parameters.
get params factory	Prints factory calibration values.
get params message	Prints message related parameters.
get params port	Prints serial port and modem parameters.
get sensors	Prints data-acquisition values, tilt angles, and humidity, if available.
get temperatures	Displays temperatures.
get uptime	Displays uptime clock.
get voltages	Displays voltages.
name	Displays device type, name, and ID.
open	Opens a user interface.
reset	Resets the ceilometer using the watchdog reset.
set control blower on	Sets the window blower on.
set control blower off	Sets the window blower off.
set control blower manual	Sets manual control.
set control blower auto	Sets automatic control.
set control inheater on	Sets inheater on.
set control inheater off	Sets inheater off.
set control inheater manual	Sets manual control.
set control inheater auto	Sets automatic control.

Command	Description
set control outheater on	Sets outside heater on.
set control outheater off	Sets outside heater off.
set data_port baud 115.2 k	Data serial port speed
set data_port baud 57.6 k	Data serial port speed
set data_port baud 38.4 k	Data serial port speed
set data_port baud 19.2 k	Data serial port speed
set data_port baud 9600	Data serial port speed
set data_port baud 4800	Data serial port speed
set data_port baud 2400	Data serial port speed
set data_port baud 1200	Data serial port speed
set data_port baud 300	Data serial port speed
set data_port mode RS-232	Data serial port mode
set data_port mode RS-485	Data serial port mode
set data_port parity 7E1	Data serial port settings
set data_port parity 7O1	Data serial port settings
set data_port parity 7N2	Data serial port settings
set data_port parity 8N1	Data serial port settings
set defaults	Restores the following default settings: • Operation mode: **normal** • Measurement mode: **high_res** • Data acquisition autoadjustments: **on** • Blower control: **auto** • Inheater control: **auto** • Diagnostics intervals: **2 min** • Power-save mode: **disabled** • Power-save sleep interval: **60 s** • Message angle correction: **on** • Message transmission: **periodic** • Message secondary transmission: **none** • Message transmission delay: **100 ms** • Message height-offset: **0** • Message interval: **6 s** • Message secondary interval: **6 s** • Manual message: **disabled** • Message port: **data** • Message profile scale: **1.0** • Message profile noise-h2: **off** • Message type: **msg2_base** • Message secondary type: **none** • Message units: **feet** • Message VV limit ceiling: **6562 ft (2000 m)** • Port timeout: 2 min • Unit ID: **0** • Echo: **on**

Command	Description
set diag interval angle	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval battery	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval contam	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval int_temp	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval l_power	Sets diagnostic-data logging interval (min). 0 disables.
set diag interval l_temp	Sets diagnostic-data logging interval (min). 0 disables.
set diag clear	Clears all diagnostic-data history.
set echo on	Sets command input echoing on.
set echo off	Sets command input echoing off.
set failure history clear	Clears failure history.
set maint_port baud 115.2 k	Maintenance serial port speed.
set maint_port baud 57.6 k	Maintenance serial port speed
set maint_port baud 38.4 k	Maintenance serial port speed
set maint_port baud 19.2 k	Maintenance serial port speed
set maint_port baud 9600	Maintenance serial port speed
set maint_port baud 4800	Maintenance serial port speed
set maint_port baud 2400	Maintenance serial port speed
set maint_port baud 1200	Maintenance serial port speed
set maint_port baud 300	Maintenance serial port speed
set maint_port parity 7E1	Maintenance serial port settings
set maint_port parity 7O1	Maintenance serial port settings
set maint_port parity 7N2	Maintenance serial port settings
set maint_port parity 8N1	Maintenance serial port settings
set message transmission delay	Sets request-based delivery response delay (ms).
set message transmission request	Sets message request-based delivery.
set message interval [2 ... 120]	Sets message delivery interval in seconds.
set message port data	Delivers messages into data port.
set message port maintenance	Delivers messages into maintenance port.
set message secondary interval <interval>	Sets secondary message delivery interval in seconds.

Command	Description
set message secondary transmission none	Disables secondary message.
set message secondary transmission periodic	Sets periodic secondary message transmission.
set message secondary transmission request	Sets secondary message request-based delivery.
set message secondary type <message type>	Sets secondary message types, as in **set message type**.
set message type msg1_10x1540	Sets Msg1 with 10x1540 sample profile with 1540 samples and 10 m resolution.
set message type msg1_base	Sets Msg1 without a profile.
set message type msg2_10x1540	Sets Msg2 with 10x1540 sample profile with 1540 samples and 10 m resolution.
set message type msg2_base	Sets Msg2 without a profile.
set message type status	Sets status message.
set message type ld40_std_tg	Sets LD40 Standard Telegram.
set modem v21 answer	Sets modem to answer with v21.
set modem v21 originate	Sets modem to call with v21.
set modem v22 answer	Sets modem to answer with v22
set modem v22 originate	Sets modem to call with v22.
set modem v22bis answer	Sets modem to answer with v22bis.
set modem v22bis originate	Sets modem to call with v22bis.
set modem off	Disables the communication module and uses serial line communication.
set name <string>	Sets the unit name.
set oper_mode standby	Sets standby mode. Profile sampling is inactive.
set oper_mode normal	Sets normal operation.
set port_timeout 0 ... 30	Sets the command line time-out to 0 ... 30 minutes. 0 disables.
set unit_id <character>	Sets the unit ID.
status	Prints the status message.
system	Lists system information: type, ID, SW version, HW modules, serial number.
version	Displays the SW version.

Use the advanced level commands only as described in this manual.

The advanced level commands are described in the following table. The password for this level is `advanced`.

Table 29 Advanced level commands

Command	Description
back	Go back one security level. Go back to the user level commands.
dump	Outputs all settings and diagnostics data. Includes the responses of the following commands: **system**, **status**, **get failure status**, **get failure history**, **get params factory**, **get params message**, **get params port**, **get params algorithm**, and **get failure diag**.
get failure diag	Shows failure diagnostics data.
get params algorithm	Prints cloud algorithm related parameters.
service replace_instr battery	Prints service instructions for replacing an internal battery.
service replace_instr cle_engine_board	Prints service instructions for replacing CLE321 engine board.
service replace_instr clp_ac_power	Prints service instructions for replacing CLP321 power unit.
service replace_instr clr_receiver	Prints service instructions for replacing CLR321 receiver.
service replace_instr clt_transmitter	Prints service instructions for replacing CLT521 transmitter.
service self_check	Runs the self-check.
service spare_part cle_engine mark	Marks CLE spare part status.
service spare_part cle_engine clear	Clears CLE spare part status.
service spare_part clt_transmitter mark	Marks CLT spare part status.
service spare_part clt_transmitter clear	Clears CLT spare part status.
service spare_part show_state	Shows spare part status of CLE and CLT.
service sw_update	Updates the software.
set data_acq autoadj on	Sets SW control of data acquisition parameters.
set data_acq autoadj off	Disables SW control of data acquisition parameters.

Command	Description
set data_acq meas_mode standard	Activates CL31 emulation mode. Maximum range 7700 m, 10 m resolution, laser pulse rate 10 kHz.
set data_acq meas_mode high_res	Activates CL31 emulation mode. Maximum range 7550 m, 5 m resolution, laser pulse rate 7 kHz.
set data_acq meas_mode high_end	Activates standard CL51 mode. Maximum range 15 400 m, 10 m resolution, laser pulse rate 6.5 kHz.
set data_acq power_save disable	Disables power-save mode.
set data_acq power_save enable	Enables power-save mode.
set data_acq power_save interval 30 ... 30000	Power-save interval in seconds. Default is 60.
set data_acq receiver gain low	Sets receiver to low gain.
set data_acq receiver gain high	Sets receiver to high gain.
set data_acq transmit length_of_p short	Sets transmitter to short pulse.
set data_acq transmit length_of_p long	Sets transmitter to long pulse.
set data_acq transmit inlaser 0 ... 4095	Sets control value for laser pulse.
set factory calibr_outlaser	Starts automatic calibration of target outlaser.
set factory cross_talk	Calibrates factory cross talk.
set factory opt_sensit	Sets optics sensitivity.
set factory opt_type	Sets optics unit type to CLO511 or CLO521.
set factory outlaser 0 .. 2500	Sets target outlaser.
set factory win_clean	Sets window clean status for window condition calibration.
set message angle_corr on	Heights in messages are corrected for the tilt angle.
set message angle_corr off	Heights in messages are not corrected for the tilt angle.
set message height_offset <value>	Sets height offset in current units. (Range is -304 ... 304 m or -1000 ... 1000 ft.) Positive values are added to and negative values are subtracted from the measured height.
set message manual_msg <string>	Sets a manual message. Empty string disables.
set message profile scale	Scaling factor for range gate data (%)
set message profile noise_h2 on	Normalizes range gate data, even noise.
set message profile noise_h2 off	Normalizes range gates data, if backscatter is contained.

Command	Description
set message type cl31_msg1_10x770	Sets CL31 Msg1 with 10x770 profile.
set message type cl31_msg1_20x385	Sets CL31 Msg1 with 20x385 sample profile with 385 samples and 20 m resolution.
set message type cl31_msg1_5x1500	Sets CL31 Msg1 with 5x1500 profile.
set message type cl31_msg1_5x770	Sets CL31 Msg1 with 5x770 profile.
set message type cl31_msg1_base	Sets CL31 Msg1 without a profile.
set message type cl31_msg2_10x770	Sets CL31 Msg2 with 10x770 profile.
set message type cl31_msg2_20x385	Sets CL31 Msg2 with 20x385 profile.
set message type cl31_msg2_ 5x1500	Sets CL31 Msg2 with 5x1500 profile.
set message type cl31_msg2_ 5x770	Sets CL31 Msg2 with 5x770 profile.
set message type cl31_msg2_base	Sets CL31 Msg2 without a profile.
set message units feet	Reported height unit is feet.
set message units meters	Reported height unit is meters.
set message vv_limit ceiling	Sets vertical visibility ceiling limit (meters/feet). No vertical visibility will be reported above this limit. (Default: 2000 m).
set option humitter on	Enables the humitter option.
set option humitter off	Disables the humitter option.
set option sky_cond off	Disables the sky condition option.
set option sky_cond on 0 .. 99999	Enables the sky condition option with an option code.

5.4 Switch settings

The switch settings for normal operation:

Switch	Setting
Main circuit breaker **F1**	ON
Heater/Blower circuit breaker **F2**	ON
Battery switch	ON

The data message and interface configuration and the configuration of measuring interval and transmission speed are standard factory settings. You can change them by giving commands from the terminal.

Optical adjustments have been made at the factory or depot. There is no need to readjust them in the field.

To switch the ceilometer fully off, turn off the battery switch and **J2**. Having the unit on with the battery supply drains the battery.

5.5 Opening maintenance terminal connection

1. Switch on ceilometer power.
2. Open the maintenance terminal connection with the **open** command.

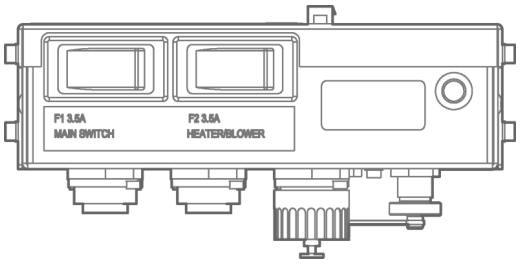
The `CEILO` > prompt opens.

5.6 Starting ceilometer

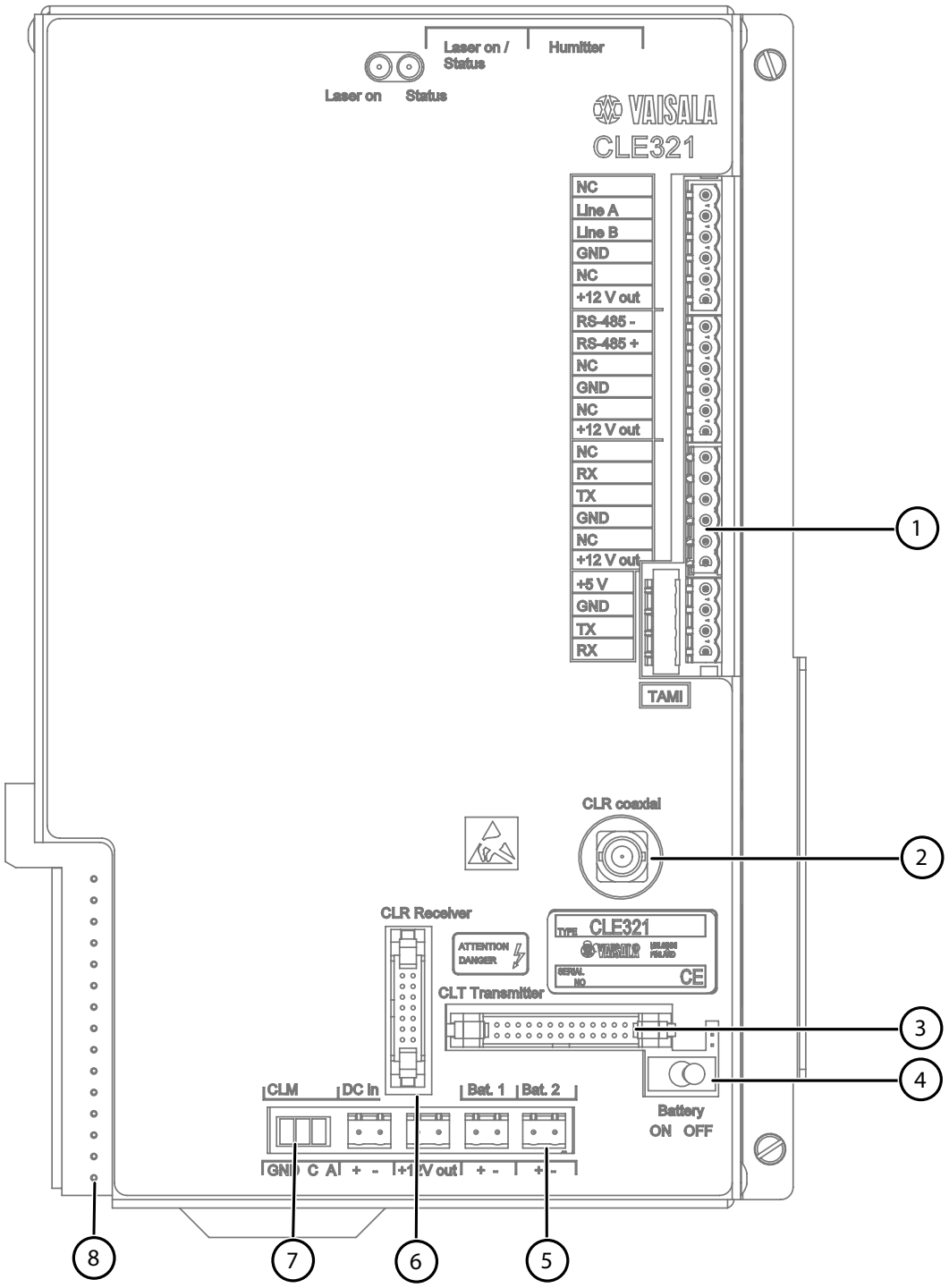
1. Open the unit door and make sure the internal connectors and subassemblies are intact.

   WARNING! Make sure that nobody is viewing the unit from the beam direction with magnifying optics.

2. Turn the **Main switch**, the **Heater/blower** switch, and the battery switch **ON**.



After initialization, the **Laser on** LED starts blinking at 2-second intervals. Also the 6 diagnostic LEDs light up.



1 Data line connection to AC power CLP321
2 Coaxial cable connection to receiver CLR321
3 Connection to transmitter CLT521
4 Battery switch
5 Connection to battery
6 Connection to receiver CLR321
7 Connection to laser monitor board CLM311
8 Connection to AC power CLP321

5.7 Polling mode

You can set a port to transmit a message only when polled by a predetermined polling string. The polling string can contain the message identification.

The ceilometer unit can be assigned an identification of one-character digit or letter. The factory setting is 0.

To activate the polling mode, type:

```
CEILO > set message transmission request
```

To return to the autosend mode, type:

```
CEILO > set message transmission periodic
```

The polling string format:

```
<Enq> CLIdNo [CRLF]
```

Enq	Character ENQUIRE = ASCII 05H = control-E
CL	Fixed ceilometer identifier; CL for CL51 messages, CT for CT25K and CT25KAM messages.
Id	Identification character, 7-bit printable ASCII character.
No	Optional message identifier; 1 or 6 for CT messages and 1, 2 or S for CL messages. The CL identifier 1 returns the default option for data message No. 1. To return a particular subclass message, use one of the following identifiers: 11, 12, 13, 14, or 15. Data message No. 2 is requested similarly: 21, 22, 23, 24, or 25. . The identifier S returns the Status message.
[CRLF]	Carriage return + line feed

Examples of the polling command:

<Enq> CL112<Enter>	Message 1, subclass 2 from ceilometer No.1
<Enq> CT11<Enter>	CT25K message 1 from ceilometer No.1

If the id character in a polling string is replaced with a blank space, all ceilometers on the line will respond. Accordingly, if No is a blank space, the ceilometer sends the default message. In RS-485 mode id is always needed, the blank space is ignored.

LD40 message is polled by sending an LD40 command telegram.

Table 30 Command telegram description 'polling request'

Byte	Example	Description
0	<STX>	02 HEX (Start of text)
1	H	Command telegram header
2	0	Command telegram header
3	C	Command telegram header
4	!	Command telegram header
5	X	Instrument type --> Ceilometer
6	1	Sensor ID number (0 to 9..ABC..MIN). In this case --> 1
7-17	P----------	Command indicator --> P (polling), byte 8-17 not used and filled with '-'
18-19	83	Checksum (Hex-coded two's complement of the sum of bytes from 0 to 20, excluding bytes 18 and 19.
20	<EOT>	04 Hex (End of transmission)

5.8 Activating sky condition

5.8.1 Option code

You can activate the sky condition algorithm by entering an option code to the ceilometer. The option code number is based on the ceilometer serial number. If you purchased the ceilometer with the sky condition activated, this has already been done at the factory. If you purchased the sky condition option, enter the following command to get the serial number:

```
CEILO >  system

Vaisala Ceilometer CL51

 Unit ID:    0
 Serial Nro: 421202
 SW Version: 1.010

 HW Options
  Modem:     N/A
  Humitter:  N/A
```



The ceilometer serial number is also in the label on the measurement unit door. Send it to Vaisala to get the option code. See Sky condition activation (page 112).

5.8.2 Sky condition activation

After you have received the option code, activate the sky condition algorithm as follows:

```
CEILO >  advanced
Service password accepted.

CEILO >  set option sky_cond on 63273
OK.
```

Select the sky condition message type (`msg2_base` or its subclass) to be reported:

```
CEILO >  set message type msg2_base
OK
CEILO>close
```

5.9 Storing ceilometer

Do not store the ceilometer in an unconditioned area.
If you store the ceilometer unpacked for a long time, store it in a conditioned area (temperature: −55 … + 60 °C (−67 … +140 °F), humidity below 95 %RH).

Save the container for future transport use. For transportation, the equipment must be placed and padded into the container in the same way as initially received.

5.10 Configuring ceilometer through Web UI

Ceilometers with DMU801 can be configured over the Web UI. In the Web UI you can:

- Configure the Ethernet, SFTP, and MQTT settings
- Configure the netCDF filename
- Configure the measurement sensitivity

More information

- Ethernet setup (page 51)
- SFTP setup for profile data (page 59)
- MQTT setup for cloud data (page 63)
- Configuring netCDF filename (page 113)
- Configuring measurement sensitivity (page 115)

5.10.1 Configuring netCDF filename

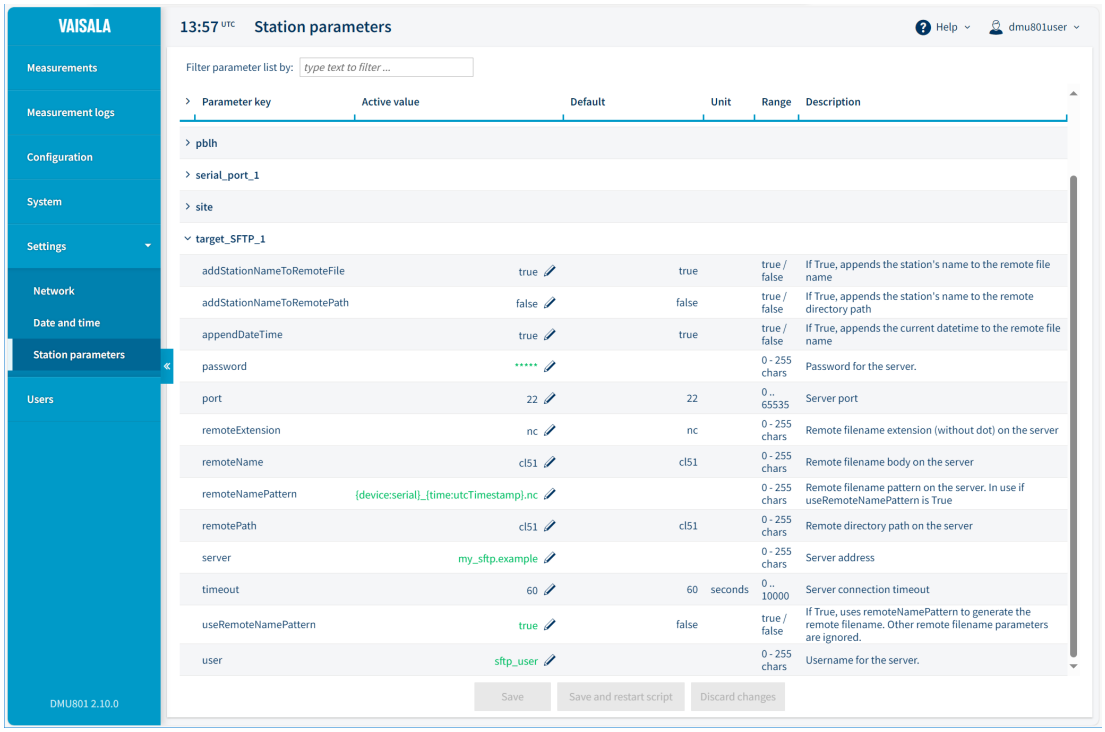


- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

You can define the netCDF filename with the Web UI.

1. In a web browser, type the following Web UI address:
   `https://192.168.10.2`
2. In the Web UI, select **Settings > Station parameters**.

3. Select **target_SFTP_1**, and set the following:



addStationNameToRemoteFile
: This adds the station name set in **Settings > Station parameters > site > station_name** to the netCDF files.

appendDateTime
: Select **true**. This adds the timestamp in format `YYYYMMDDTHHmmss` to the netCDF filename.

remoteExtension
: Use the default **nc**.

remoteName
: Set a text to add to the filename.

remoteNamePattern
: To use the pattern, type the following in the field: `{device:serial}_{time:utcTimestamp}.nc`. To use the **remoteNamePattern**, set **useRemoteNamePattern** to **true**.

useRemoteNamePattern
: Select **true** to use the defined **remoteNamePattern** in the netCDF filename. When **remoteNamePattern** is used, all other settings here are ignored.

4. Select **Save and restart script**.

More information

- File naming (page 86)

5.10.2 Configuring measurement sensitivity

- Laptop with browser and USB-C port
- USB-C to USB-C cable or Ethernet cable

You can adjust the sensitivity of the planetary boundary layer height measurement.

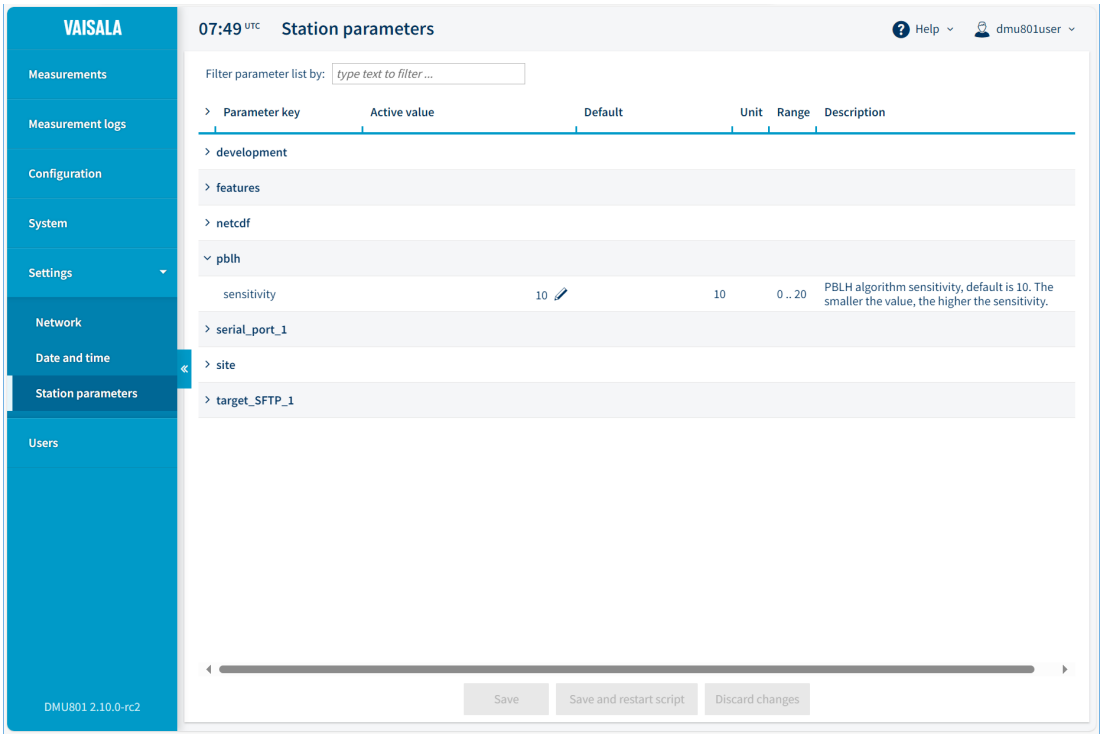
Smaller measurement sensitivity results in fewer reported aerosol gradients.

1. In a web browser, type the following Web UI address:

   https://192.168.10.2

2. In the Web UI, go to **Settings > Station parameters**.
3. Select **pblh** and set the following.

   sensitivity
   Planetary boundary layer height measurement sensitivity. The default is 10. Smaller sensitivity results in fewer reported aerosol gradients.



4. Select **Save and restart script**.

6. Maintenance

CAUTION! Only qualified service personnel may perform service procedures.

6.1 Periodic maintenance

Periodic maintenance is normally limited to window cleaning. In addition, check warnings and alarms regularly with the maintenance terminal, another terminal, or PC with a serial connection. The only mechanically moving part, the window blower, is automatically checked once an hour. Malfunction is reported in the data and status messages.

WARNING! Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized depot for service and repair to make sure that safety features are maintained.

WARNING! Verify outdoor installation grounding periodically to minimize shock hazard.

WARNING! Do not service the system alone. Do not reach into parts and assemblies that are AC (mains) powered and live except in the presence of someone who can provide first aid.

More information

- CL51 status message (page 75)

6.2 Alarms and warnings

Check the data message for alarms and warnings regularly. The second character in line 2 contains warning and alarm information indicating the present device status:

Character	Description
`0`	Self-check OK
`W`	At least one warning active, no alarms
`A`	At least one alarm active

If there is an active alarm or warning, more information is given at the end of the second line as a binary code indicating the cause. The status message gives detailed information about the failure.

More information

- Service overview (page 121)
- Warning and alarm messages (page 161)
- Data messages (page 68)

6.3 Cleaning window



WARNING! Do not look directly into the ceilometer transmitter or ceilometer optics with magnifying optics (such as glasses, binoculars, and telescopes). Do not direct the beam into an area where such instruments are used. Viewing the laser output may pose an eye hazard.



WARNING! Only qualified maintenance personnel may perform maintenance procedures. Make sure unauthorized persons cannot access the work area during service operations.

Data messages include a warning when the window is contaminated. After the system has detected contamination, it starts the blower, which removes light contaminants and dries off raindrops.

If the blower cannot remove the contamination, the ceilometer issues the `Window Contaminated` warning indicating that you must clean the window manually.

1. Make sure that the enclosure is closed. Rinse the window with clean water to remove coarse grains.



CAUTION! Do not use pressure cleaners.

2. Clean the window with a soft, lint-free cloth moistened with a mild detergent.



CAUTION! Be careful not to scratch the window surface.

You can also check the operation of the window blower. The blower starts when you block the laser beam with the cleaning cloth for approximately 5 seconds. This verifies that the blower is functional. If there are no low clouds, precipitation, or fog present, the blower stops after the window is cleaned. In case of malfunction, you must replace the window blower.

6.3.1 Calibrating window contamination measurement

After 5 years of operation, calibrate the window contamination measurement.

If the ceilometer system starts issuing `Window Contamination` warnings frequently without a real reason, this may indicate that the window is worn out or the window contamination measurement has drifted. You can calibrate the window contamination measurement to ensure proper functioning.

1. Check the sky condition.

   In case of fog, smoke, precipitation, or otherwise unclear sky, use the termination hood (CL51TERMHOODSP) in calibration.
2. Make sure that the window is clean.
3. Open the command line and enter the Advanced level with the **`advanced`** command.
4. Type the **`set factory win_clean`** command.

   The calibration is carried out automatically.

   If the window is visibly worn out, replace it.

6.4 Checking door gasket

The measurement unit door uses an electrically conductive gasket to suppress electromagnetic radiation.

1. When you open the door, check that the gasket and the opposite contact surfaces are clean.
2. If necessary, use a wet cloth for cleaning.

6.5 Checking battery

CAUTION! In freezing temperatures there is a danger of battery rupture if the battery is completely discharged. Do not store empty batteries in freezing temperatures. Replace the battery if signs of mechanical rupture are observed.

1. Check the battery condition annually.
2. If there are any signs of aging, such as a bulging battery case, white powder, or residue near the battery vent, leaking electrolyte, or corroded terminals, replace the battery.

   Lead acid batteries may age in 3 to 5 years and result in a rupture and loss of electrolyte.



When disposing of old batteries, follow local environmental regulations.

6.6 Cleaning and maintaining painted surfaces

Vaisala recommends that you wash all the painted surfaces at least once a year. Use only warm water or warm, mildly soapy water. Wipe with soft cloth or sponge and rinse with clean water.



CAUTION! Do not use solvents or abrasive sponges when cleaning painted surfaces.

6.6.1 Preparing for painting

1. Clean the surface and remove any loose coating with a scraper and a steel brush.
2. Use sandpaper on damaged areas and around the damaged area's edges.
3. Remove impurities, such as dirt and grease, with warm soapy water.
4. Rinse with warm water.

   The surface must be completely dry before starting maintenance painting. Protect the surfaces that will not be painted with tape or paper.



Make sure the air temperature, the paint, and the painted surface are at least +10 °C and the relative humidity below 80% during painting and drying. Do not paint in rain or in direct sunlight.

6.6.2 Painting

After preparing the surface, coat the surface as soon as possible. Follow your paint manufacturer's instructions carefully.

1. Use a primer, such as Teknos INERTA PRIMER 5 epoxy paint 60 ... 80 µm.
2. Paint the surface 2 to 3 times, so that the dry film layer thickness is 40 ... 60 µm. Use, for example, Teknos TEKNODUR 0190 polyurethane 40 µm, so that the total thickness is 100 ... 120 µm.

6.6.3 Commonly used Vaisala colors

- Solid White, Semi Gloss RAL 9003
- Shade Grey, Semi Gloss RAL 7035
- Construction Grey, Semi Gloss RAL 7024
- Signal Red, Semi Gloss RAL 3001

For more information on the paints, visit the paint manufacturer's website www.teknos.com.

If you use other paints, make sure the paint is compatible with the polyester powder coating.

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7. Service

CAUTION! Only qualified service personnel may perform service procedures.

CAUTION! Contact Vaisala or its authorized representative for repairs.

WARNING! Do not service the system alone. Do not reach into parts and assemblies that are AC (mains) powered and live except in the presence of someone who can provide first aid.

WARNING! Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Vaisala office or authorized depot for service and repair to make sure that safety features are maintained.

Do not perform service procedures in temperatures below −25 °C (−13 °F) .

7.1 Service overview

Perform a general check annually.

Table 31 Spare parts

Spare part code	Common name
226116	Battery
CLB311-115SP	Window blower 115 V AC
CLB311-230SP	Window blower 230 V AC
CLE321HRSP	Engine board

Spare part code	Common name
CLH311-115SP	Internal heater 115 V AC
CLH311-230SP	Internal heater 230 V AC
CLHUMITTERSP	Humitter
CLM311SP	Laser monitor board
CLP321SP	AC power
CLR321SP	Ceilometer receiver
CLT521SP	Ceilometer transmitter
CL51TERMHOODSP	Optical termination hood
CLW511SP	Window assembly
CT35022SP	Shock absorber kit
CT35324SP	Power cable (115 V)
CT3838SP	Data cable
CT3839SP	Power cable (230 V)
DXL421SP-CL51	Modem module
DMU801CL51ASOSSP	Data management unit DMU801
226296SP	Coaxial cable
TERMBOX-1200SP	Termination box with overvoltage protection
CLTERMBOXSP	Termination box
QMZ101SP	Terminal cable for MAWS
CL31USBCABLESP	CL31 USB cable
CL51RADIOKITSP	Radio modem kit
CL51BIRDKITSP	Bird deterrent
220570	Surge protector
242701	Moxa device server

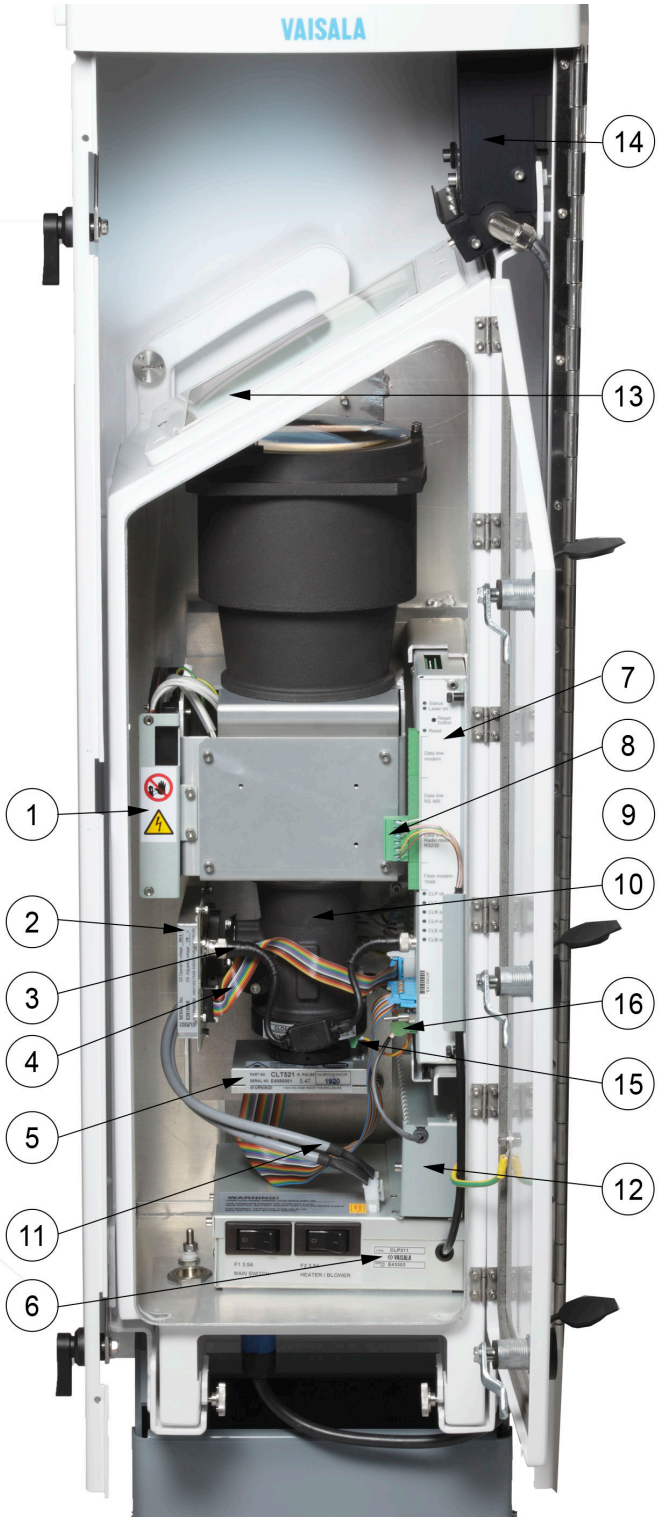


Figure 14 CL51 maintenance parts

1 Internal heater CLH311
2 Receiver CLR321
3 Coaxial cable
4 Receiver ribbon cable

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5 Transmitter CLT521
6 AC power CLP321
7 Engine board CLE321
8 Data line connector
9 Optics unit CLO521
10 Transmitter ribbon cable
11 AC power cables
12 Battery
13 Window CLW511
14 Window blower CLB311
15 Laser monitor board CLM311
16 Battery cable

More information

- Replacing window (page 124)
- Replacing engine board (page 128)
- Replacing laser transmitter (page 130)
- Replacing receiver (page 132)
- Replacing battery (page 134)
- Replacing AC power unit (page 137)
- Replacing fuse (page 145)
- Replacing window blower (page 147)
- Replacing internal heater (page 148)
- Replacing laser monitor board (page 150)
- Replacing modem module (page 152)
- Replacing DMU801 (page 155)

7.2 Replacing window

Vaisala recommends that you replace the ceilometer window CLW511SP indoors to prevent water and other contamination from getting into the measurement unit.

- 2.5-mm Allen key
- Screwdriver

1. Open the measurement unit door and switch the power off with all 3 switches (**F1**, **F2**, and battery).

> **WARNING!** Before you continue, disconnect the power cable from the **J2** connector.

2. Close the door and remove the measurement unit.

   Loosen the 3 attachment screws, disconnect the blower cable from the **J1** connector and pull out the unit.

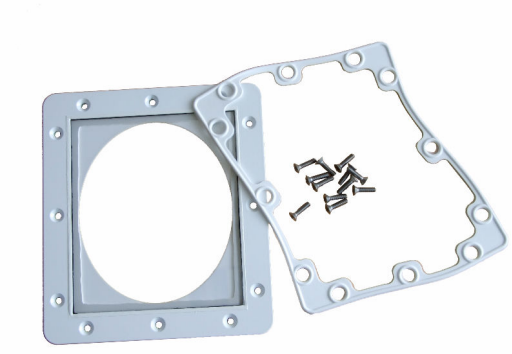
3. Loosen the 12 screws on the frame of the window and remove the window by lifting it out with the screws attached.

   Remove any pieces of the old gasket.

4. Use a solvent to clean the surface of the measurement unit before attaching the new window and make sure that the gasket on the window is undamaged and in place.

> **CAUTION!** Avoid touching the new window with your bare hands as it may get scratched.

> Avoid touching the clean window surface as it may get contaminated.



5. Place the window on the measurement unit and attach the 12 screws with your fingers to prevent the window from sliding off its place.

6. Tighten the screws in a crosswise order to allow the window gasket to tighten evenly.

   For example, tighten first the screw on top of the window frame, then the one on the bottom, then the one on the left, and the one on the right. Tighten the remaining 8 screws in a clockwise order so that you first tighten one screw and then the one opposite to this, then the one next to the first screw and so forth. Then retighten the first 4 screws.

   Remember to use thread-locking compound on the window screws before final tightening.

7. After attaching the window, clean it properly.
8. Place the measurement unit inside the radiation shield, reconnect the blower cable to connector **J1**, and tighten the 3 attachment screws.
9. Connect the power cable to connector **J2**.
10. Switch the power on with all 3 switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

More information

- Cleaning window (page 117)

7.3 Replacing engine board and laser transmitter

WARNING! Never replace both the engine board CLE321 and laser transmitter CLT521 at the same time. If you need to replace them both, see Replacing both units (page 127).

The item label on the ceilometer engine board is CLE321. The corresponding spare module is CLE321HRSP (HR stands for CL51 High Range firmware, SP stands for spare part.)

WARNING! Never replace an engine board or a transmitter from one ceilometer to another without consulting Vaisala.

The engine board and transmitter module are designed for plug-and-play replacements. To support plug-and-play replacement, they both contain all current system parameters in the internal memory.

Spare parts have an internal memory. By default, a new spare part component has the `spare_part mark` parameter on. For example, if you replace the engine board, the new engine board has the `spare_part mark` on. The ceilometer identifies that a new component is installed and fetches existing parameters from the transmitter board. No user settings are required. After installation, the `spare_part mark` is cleared from the engine board.

If you remove the engine board from one ceilometer and install it in another ceilometer without setting its `spare_part mark`, the replacing unit runs wrong parameters. This may severely affect ceilometer performance.
If you must change an engine board or a transmitter from one CL31 to another, change the `spare_part mark` setting:

```
service spare_part cle_engine mark
service spare_part clt_transmitter mark
```

After changing the setting, switch off CL31 and remove the module. The engine board is ready to be integrated into another CL31. The new parameters are applied automatically when the component is installed.

If you change both the engine board and the transmitter, the system returns to default settings.

7.3.1 Replacing both units

It is necessary to replace a unit if the unit has been generating warnings and alarms or when a malfunction has been detected.

Do not replace both the engine board and the laser transmitter at the same time. If you must replace both units, follow these instructions to avoid losing parameters.

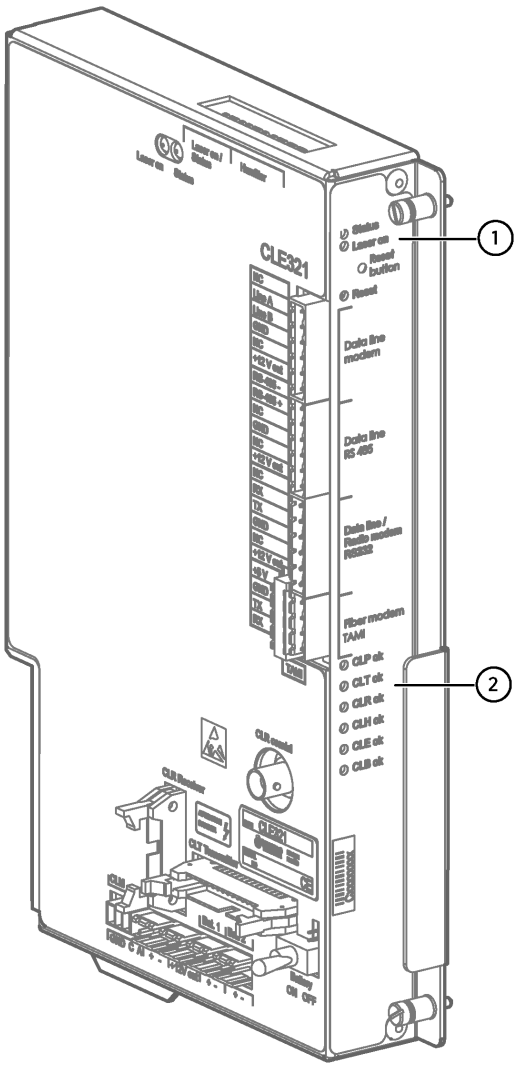
1. Perform either a or b.
   a. To replace the engine board first, perform Replacing engine board (page 128) and switch on the ceilometer and wait until the **Laser On** LED starts blinking at 2-second intervals.

      All parameters are restored and CLE321 spare bit is cleared. You can replace the laser transmitter.

   b. To replace the laser transmitter first, perform Replacing laser transmitter (page 130) and switch on the ceilometer and wait for at least 15 minutes.

      All parameters are restored and CLT521 spare bit is cleared. You can replace the engine board.

7.3.2 Replacing engine board



1 **Laser on** LED
2 Diagnostic LEDs

CAUTION! Only qualified service personnel may perform service procedures.

You must replace the ceilometer engine board CLE321 if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the CLE321 board has been detected.

If you must change both the laser transmitter and the engine board, see Replacing both units (page 127).

- Screwdriver

1. Open the measurement unit door and confirm that there is an active engine board CLE321 failure (**CLE ok** turns off).
2. Switch off power with all 3 switches (**F1**, **F2**, and battery)

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

3. Detach the transmitter ribbon cable, the receiver ribbon cable, and the coaxial cable from the engine board CLE321.
4. Memorize the position of the data line connector in front of the CLE321 board and detach it.
5. Loosen the hand screws to release the CLE321 board from the frame.

   Gently pull the engine board CLE321 board halfway out of the measurement unit and detach the battery cable and the laser monitor board CLM311 cable. Then remove the entire CLE321 board.
6. Place the new CLE321 board onto the frame and reconnect the battery cable and the CLM311 cable .
7. Reattach the receiver ribbon cable, the transmitter ribbon cable, and the coaxial cable when the board is pushed halfway in.
8. Push the CLE321 board so that it connects to the back plane connector and tighten the hand screws to lock the board position.
9. Connect the data line connector to the same position as it was connected to on the previous board.

10. Connect the AC power cable to connector **J2**.
11. Switch on power with all 3 switches.

    Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the set-test.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

More information

- Replacing laser transmitter (page 130)
- Starting ceilometer (page 108)

7.3.3 Replacing laser transmitter

If you must change both the transmitter and the engine board, see Replacing both units (page 127).

The ceilometer transmitter CLT521 emits invisible laser radiation, which is harmful to the eye if viewed at a short distance. Never remove the ceilometer transmitter from its normal position without first switching off both the AC (mains) power and the battery power and detaching the transmitter ribbon cable from the ceilometer engine board.
When the transmitter is contained in the enclosure, the laser class is 1M, the transmitter is safe to the eye if magnifying instruments are not used.
When the transmitter is removed from the optics unit, the laser class is 3B, the laser is hazardous to the eye.

WARNING! Do not look at the transmitter module CLT521 of the ceilometer from the beam direction when the transmitter is powered.

- 2.5-mm Allen key



Figure 15 Laser transmitter CLT521

Replace the transmitter if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the transmitter has been detected.

If you must replace both the transmitter and the engine board, see Replacing both units (page 127).

1. Open the measurement unit door and confirm that there is an active transmitter failure. In case of a transmitter failure, the **CLT ok** LED turns off.
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery). Disconnect the AC power cable from the **J2** connector and the data/DC cable from the **J1** connector.

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

3. Detach the transmitter ribbon cable from ceilometer engine board CLE321.
4. Detach the battery cable.
5. To detach the transmitter, loosen the transmitter ring by turning it to the right.

   If necessary, you can use a 2.5-mm Allen key as a lever.

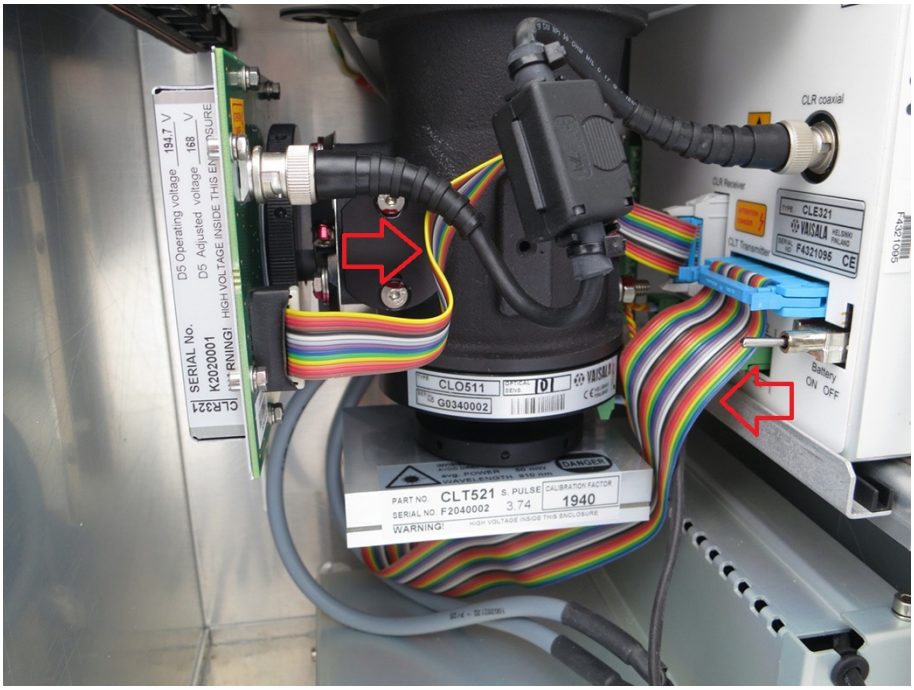
   Remove the transmitter from the unit.
6. Place the new transmitter to its place and tighten the transmitter ring so that the labels of the transmitter face the measurement unit door.
7. Connect the transmitter ribbon cable to the CLE321 board.
8. Connect the power cable to connector **J2**.
9. Switch on the power with all 3 switches.

   Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

If you must replace the engine board CLE321, wait for at least 15 minutes before proceeding.

To avoid interference, make sure that you keep the RX flat cable and the TX flat cable apart.



7.4 Replacing receiver

CAUTION! Only qualified service personnel may perform service procedures.

Replace the receiver if the ceilometer has been generating warnings and alarms, and you have detected a malfunction in the receiver operation.

- 2.5 mm Allen key

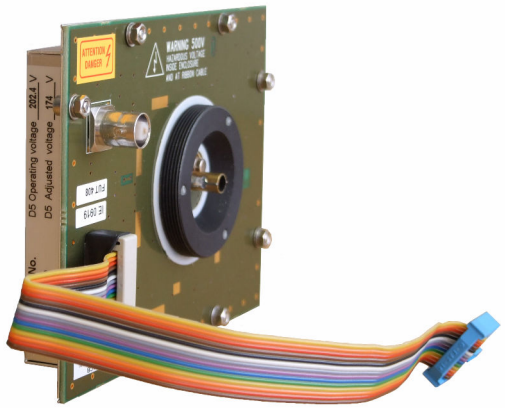


Figure 16 Receiver CLR321

1. Open the measurement unit door and confirm that there is an active receiver failure (the **CLR ok** LED turns off).
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

> **WARNING!** Before you continue, disconnect the power cable from the **J2** connector.

3. Detach the coaxial cable from the receiver and the receiver ribbon cable from the ceilometer engine board CLE321.
4. To detach the receiver, loosen the receiver ring by turning it downwards and remove the receiver from the unit.

> You can use a 2.5 mm Allen key as a lever.

5. Place the new receiver to its place and tighten the receiver ring so that the labels of the receiver face the left wall of the enclosure.

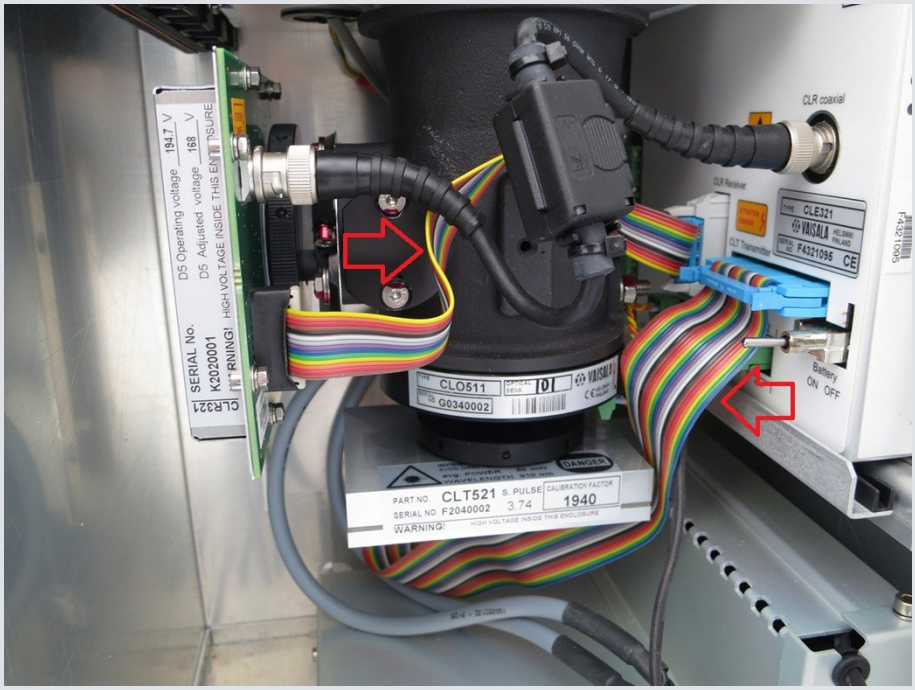
> **CAUTION!** When tightening the receiver, avoid applying force to the receiver enclosure. If the receiver starts rotating along when you tighten the ring, stop it from rotating by hand but do not apply force. If unnecessary force is used, the optical centering of the photo diode may be lost resulting in loss of cloud detection.

6. Connect the receiver ribbon cable to the CLE321 board and the coaxial cable to the receiver.
7. Connect the power cable to the connector **J2**.

8. Switch on the power with all 3 switches (**F1**, **F2**, and battery). Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

To avoid interference, make sure that you keep the RX flat cable and the TX flat cable apart.

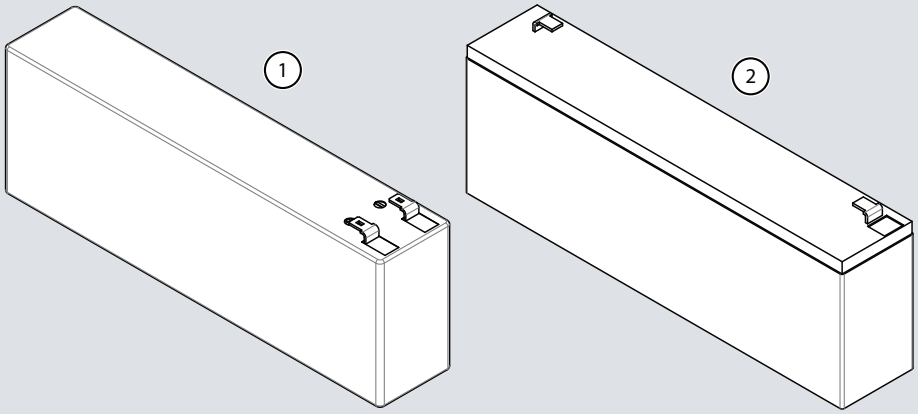


7.5 Replacing battery

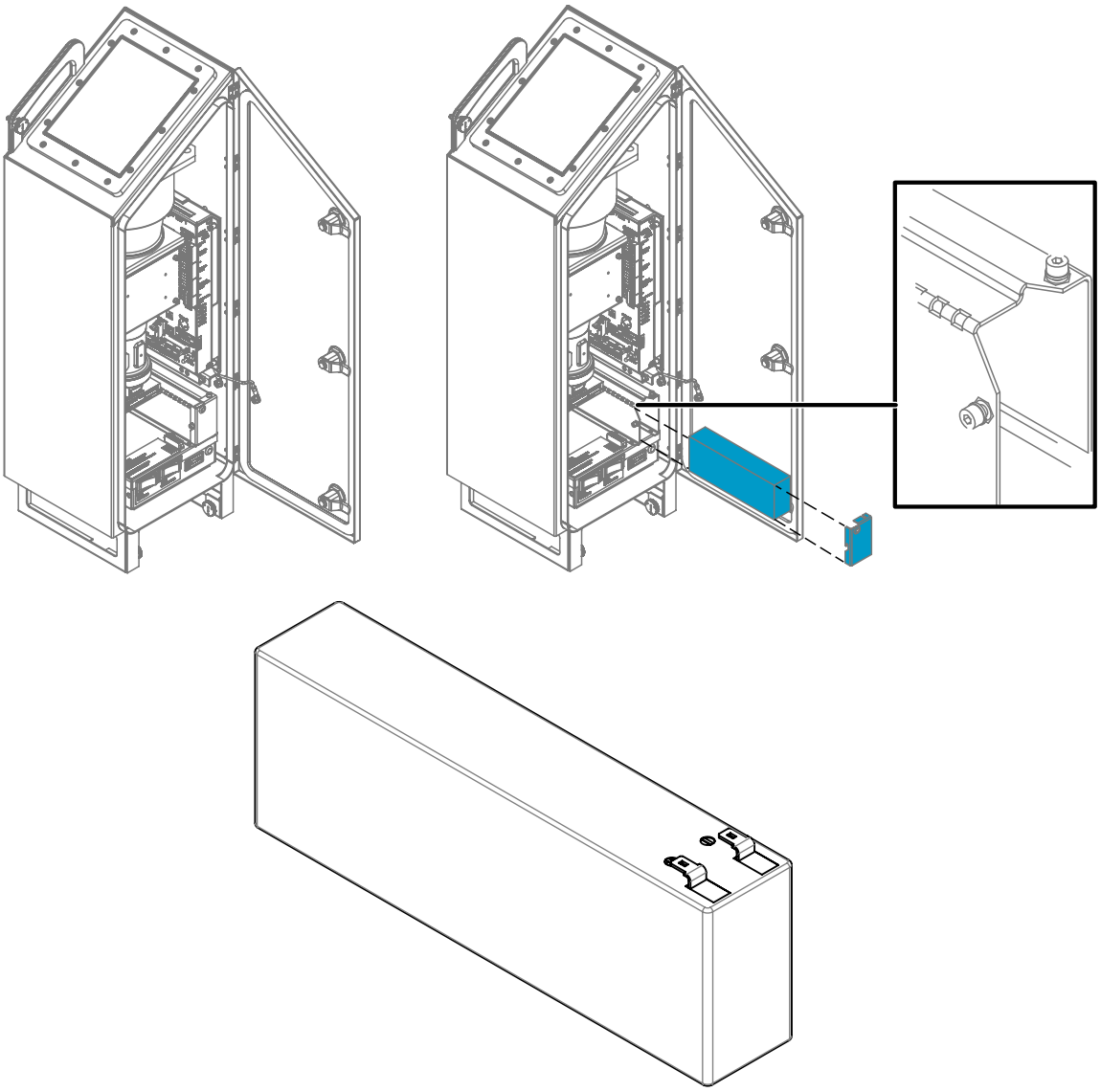
WARNING! Do not replace the battery with a battery of an incorrect type. If you do, there is a risk of deflagration. Dispose of used batteries according to statutory regulations.

CAUTION! Only qualified service personnel may perform service procedures.

Use a 12 V / 2.4 Ah valve-regulated-lead-acid battery with the maximum external dimensions of 178 mm x 34 mm x 64 mm.



1 Battery (available from June 2024)
2 Battery (available before June 2024)



You must replace the battery when it is damaged or you can no longer recharge it.

- 3-mm Allen key
- Crosshead screwdriver

The following instructions are applicable only to the 12 V / 2.4 Ah backup batteries supplied by Vaisala.

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1. Open the measurement unit door and switch off the power with all 3 switches (**F1**, **F2**, and battery).

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Disconnect the battery cable from the CLE321 board.
3. Remove the 2 screws locking the lid of the battery cage.

   One of the screws is located on top of the battery cage, the other is on the left side near the top of the cage.
4. Open the lid of the battery cage and slide out the battery and disconnect the battery cable.
5. Connect the battery cable to the new battery, connecting the red end to the positive (+) pin and the black end to the negative (-) pin.
6. Slide the new battery into the battery cage and close the lid and tighten the 2 screws back to their places.
7. Reconnect the battery cable to the CLE321 board.
8. Connect the power cable to the **J2** connector.
9. Switch on the power with all 3 switches.

   Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

Recycle the battery according to local rules and regulations.

7.6 Replacing AC power unit

WARNING! Do not replace the AC (mains) cable with an inadequately rated cable.

The figures in this procedure show CL31 but the instructions apply to both CL31 and CL51.

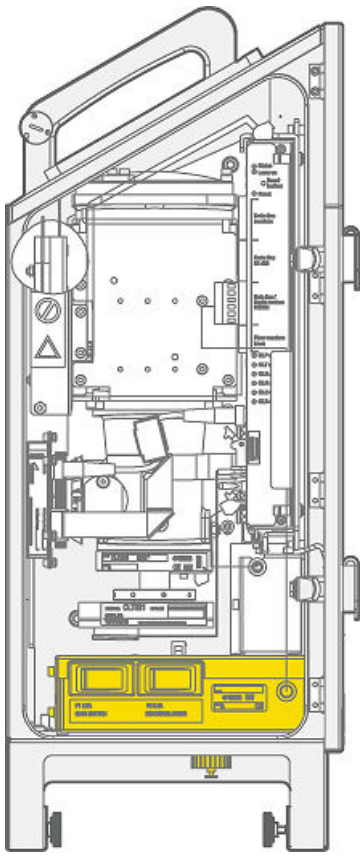


Figure 17 AC power unit

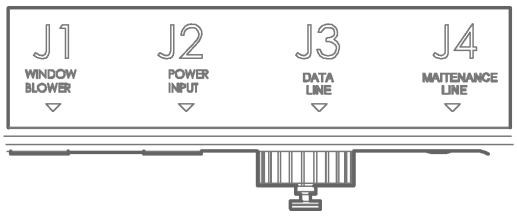
WARNING! High voltage is present in AC power unit CLP321, internal heater CLH311, ceilometer engine board CLE321, and window blower CLB311 at the top of the enclosure.

CAUTION! Only qualified service personnel may perform service procedures.

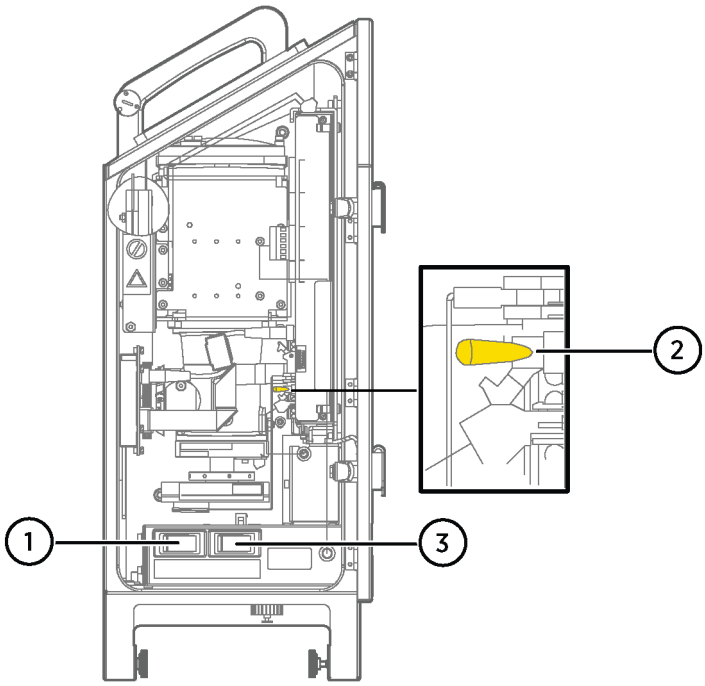
- 2-mm Allen key
- 2.5-mm Allen key
- 3-mm Allen key
- 3-mm flathead screwdriver

WARNING! Before you start, unplug the AC (mains) power cable from the external power source.

1. Open the ceilometer door.
2. Disconnect the cables from connectors **J1**, **J2**, **J3**, and **J4**.



3. Open the measurement unit door.
4. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

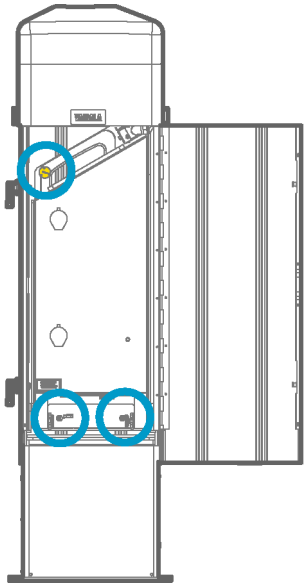


1 Power switch **F1**
2 Battery switch
3 Heater / blower switch **F2**

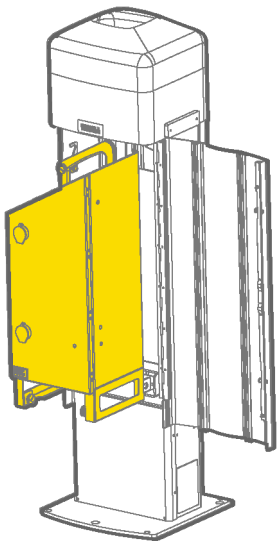
5. If you can replace the AC power indoors or in a service vehicle, remove the measurement unit from the ceilometer enclosure.

> You can try removing the AC power unit without removing the measurement unit from the enclosure, but the screws located on the bottom of the enclosure may be hard to reach.

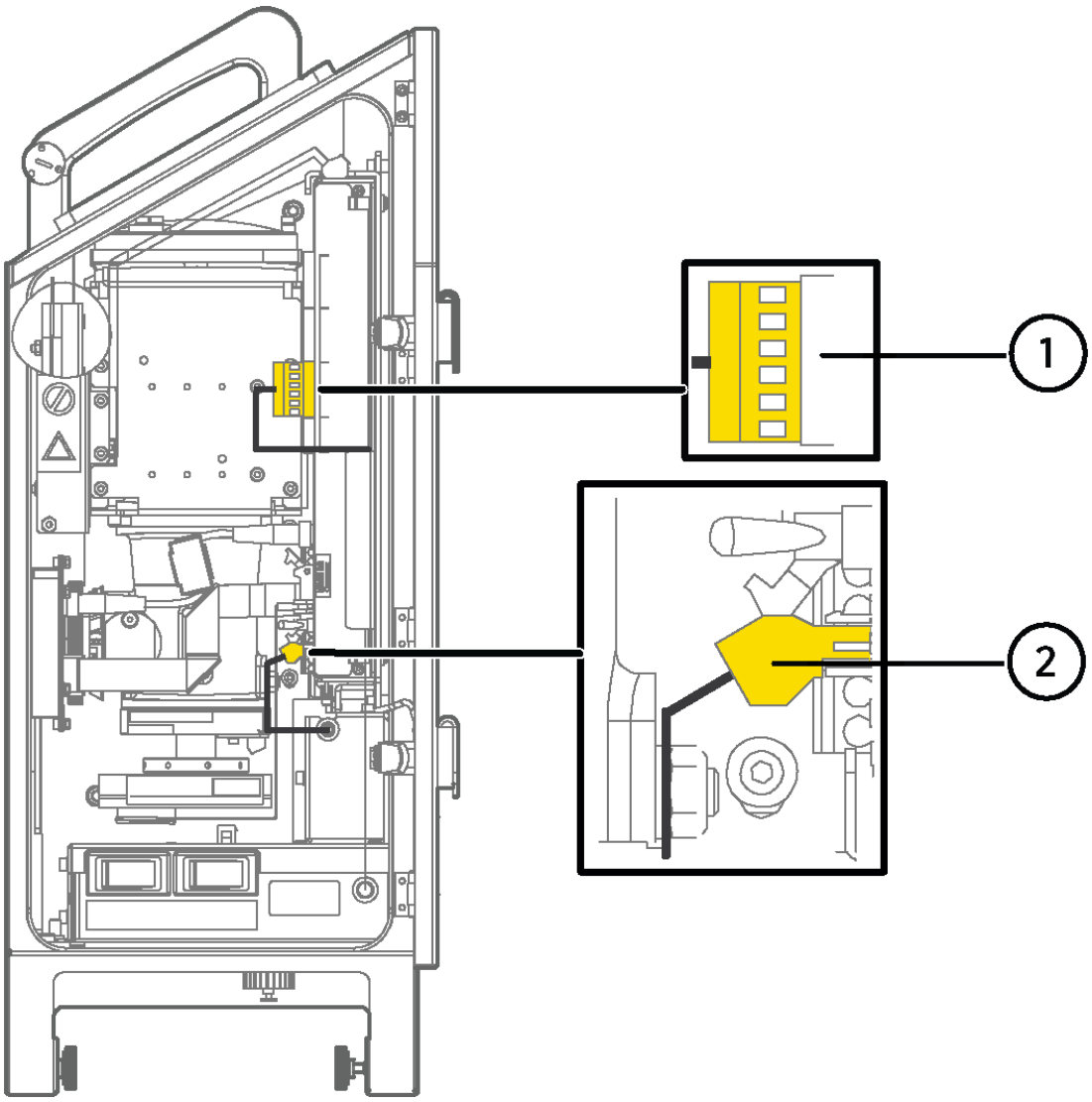
a. Open the 3 screws.



b. Pull out the measurement unit.



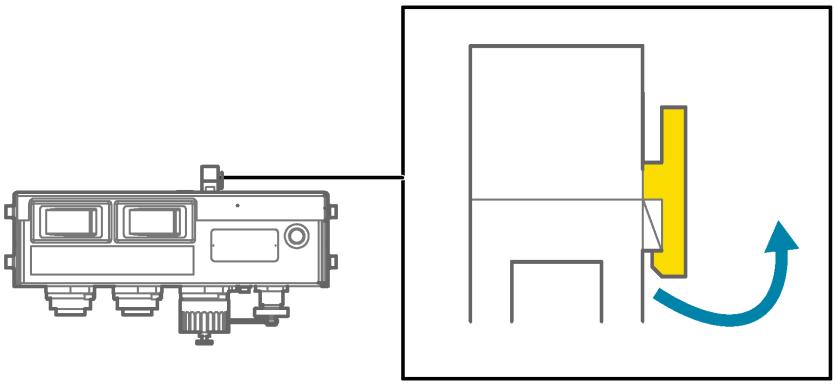
6. Disconnect the battery and data cables from the CLE321 board.



1 Data line connector
2 Battery cable

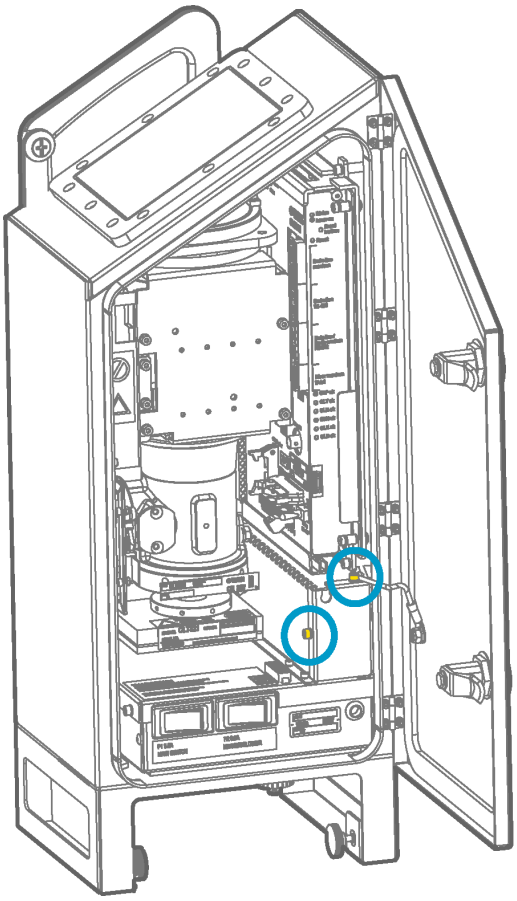
7. Squeeze the notch lock with your fingers to release the connector and disconnect the cable from the CLP321 connector.

Alternatively, you can release the notch lock with a 3-mm flathead screwdriver.



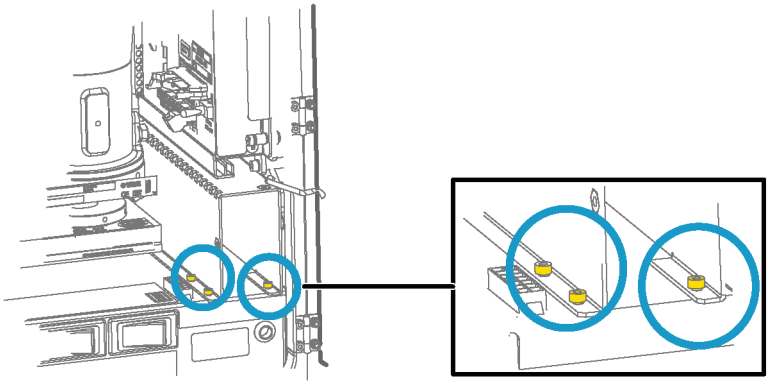
8. To remove the battery cage cover, open the 2 screws with a 3-mm Allen key.

   Press the Allen key firmly when you open the screw.

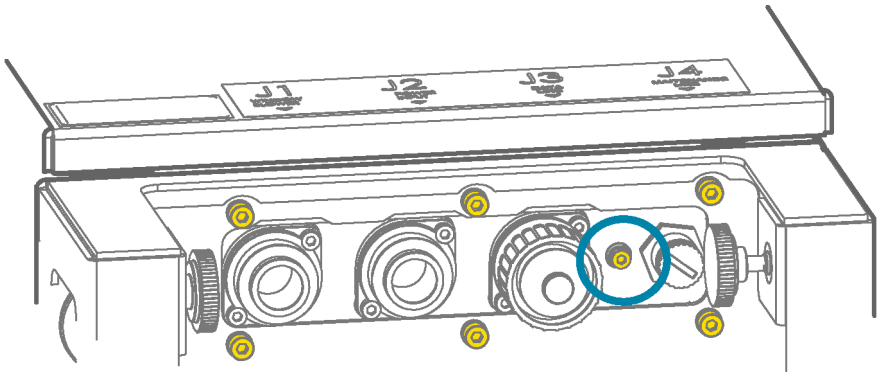


9. Remove the battery and the cable from the battery cage.
10. To remove the battery cage, open the 3 screws with a 2-mm Allen key.

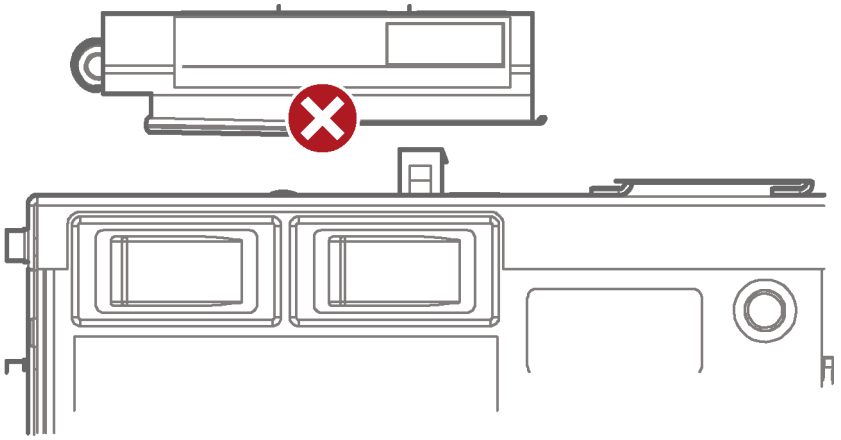
    One of the screws is located inside the battery cage, the other 2 are on the left side near the bottom of the cage.



11. If you removed the measurement unit from the enclosure, move the measurement unit in a horizontal position.
12. To remove the connector caps, open the screw between the data line connector and the maintenance line connector with a 2.5-mm Allen key. Removing them gives you more space to remove the AC power unit.



CAUTION! When lifting the AC power unit, be careful not to hit the transmitter above it. Hitting the transmitter may damage it or lead to incorrect measurements. If the transmitter is bent or twisted, the ceilometer may need a factory calibration.



13. Loosen the 6 CLP321 attachment screws with a 3-mm Allen key until you can carefully remove the AC power unit from the bottom of the measurement unit.

    Leave the screws and gasket in place to ease tightening. You do not need to remove them totally to remove the AC power unit.
14. To remove the connector caps from the new AC power unit, open the screw between the data line connector and the maintenance line connector.
15. Put the new AC power unit in place and perform the procedure in reverse order.
16. Put the connector caps back on and tighten the screw.

17. Tighten the 6 attachment screws on the bottom of the measurement unit. Hold the gasket to keep it in place.
18. Lift the measurement unit to a vertical position.
19. Put the battery cage back to its place and tighten the 3 screws with a 2-mm Allen key.
20. Insert and reconnect the battery and attach the battery cover with 2 screws with a 3-mm Allen key.
21. Connect the cable to the CLP321 connector.
22. Connect the battery and data cables to the CLE321 board.
23. Put the measurement unit back in the enclosure and attach the 3 screws.
24. Connect the blower cable to **J1**, power cable to connector **J2**, and data line cable to **J3**.
25. Switch on the power with all 3 switches (**F1**, **F2**, and battery).

    Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.

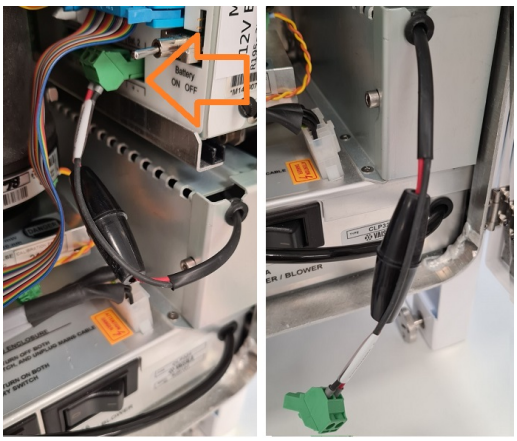
The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

7.7 Replacing fuse

1. Open the measurement unit door and switch off the power with all 3 switches (**F1**, **F2**, and battery).

   WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Disconnect the battery cable shown in the following figure.

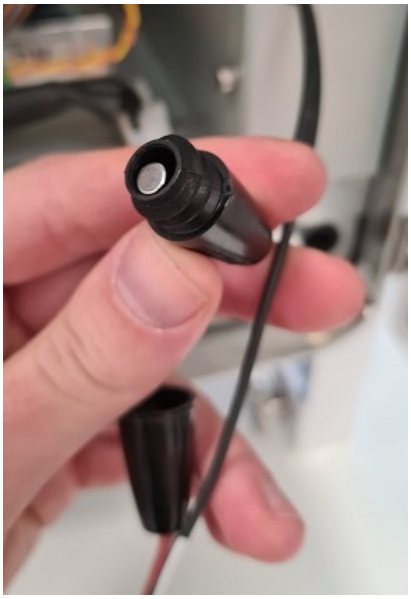


3. To open the fuse holder, rotate it by hand.



Make sure that the fuse does not fall when you open the fuse holder. The fuse is loose in the holder.

4. Remove the old fuse.
5. Place the new fuse in the fuse holder.



Make sure that the fuse does not fall when you open the fuse holder. The fuse is loose in the holder.

6. Close the fuse holder.
7. Connect the battery cable.
8. Connect the power cable to the **J2** connector and switch on power.

More information

- Service overview (page 121)

7.8 Replacing window blower

CAUTION! Only qualified service personnel may perform service procedures.

CAUTION! Make sure you do not to contaminate or scratch the window.

Replace the window blower if the ceilometer unit has been generating warnings and alarms, and a malfunction with the operation of the blower has been detected.



Figure 18 Window blower CLB311-115 / CLB311-230

- 5-mm Allen key

1. Open the measurement unit door and confirm that there is an active window blower failure. In case of a window blower failure, the **CLB ok** LED turns off.
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

WARNING! Before you continue, disconnect the power cable from the **J2** connector.

3. As the blower is attached to the radiation shield, you first have to remove the measurement unit from the radiation shield to get to the blower. To remove the measurement unit, loosen the 3 attachment screws, disconnect the blower cable from connector **J1** and pull out the unit.
4. Use an Allen key to loosen the 2 screws on the side of the window blower, then pull out the blower.
5. Use the same Allen screws to attach the new window blower.
6. Reattach the measurement unit by placing it inside the radiation shield, reconnecting the blower cable to connector **J1**, and tightening the 3 attachment screws.
7. Connect the power cable to connector **J2**.
8. Switch on the power with all 3 switches. Wait for 5 minutes after the start-up until self-check is completed. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

7.9 Replacing internal heater

You must remove the optics unit before replacing CLH311.

CAUTION! Only qualified service personnel may perform service procedures.

Vaisala recommends replacing the internal heater CLH311 indoors.

- 3-mm Allen key
- Screwdriver

Replace the internal heater if the ceilometer unit generates warnings and alarms, and a malfunction with the operation of the heater has been detected.

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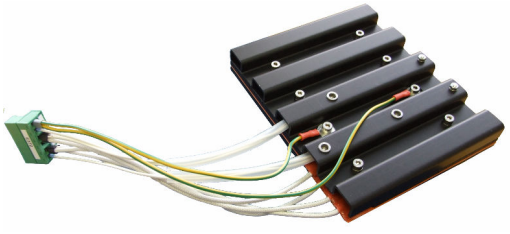


Figure 19 Internal heater CLH311-115 / CLH311-230

1. Open the measurement unit door and confirm that there is an active internal heater failure (the **CLH ok** LED is off).
2. Switch off the power with all 3 switches (**F1**, **F2**, and battery).

> **WARNING!** Before you continue, disconnect the power cable from the **J2** connector.

3. Close the enclosure door and remove the measurement unit. To do this, loosen the 3 attachment screws, disconnect the blower cable from connector **J1**, and pull out the unit.
4. Remove the metal plate protecting the heater by loosening its 2 screws.
5. Disconnect the battery, transmitter, receiver, and data cables from the CLE321 board.
6. To remove the optics unit, first remove the holder plate by loosening the 4 Allen screws on its front cover.
7. Detach the internal heater connector and holding the cable aside, carefully pull out the optics unit upper end first.

   Do not touch the lens of the optics unit.
8. Detach the CLM311 twisted pair cable from the CLE321 board.
9. To remove the internal heater, use an Allen key or a short screwdriver and loosen the 3 screws attaching the heater to the left wall of the measurement unit enclosure. Then slide out the internal heater.
10. Slide the new internal heater to its place and hold it there while tightening the 3 screws.
11. Attach the CLM311 twisted pair cable to the CLE321 board.
12. Slide the optics tube to its place with the bottom end first. Make sure no cables get stuck between the optics tube and other ceilometer components.
13. Snap the internal heater connector to its place.
14. Place all heater cables behind the holder and tighten the 4 holder screws.
15. Reconnect the battery, transmitter, receiver, and data cables to the CLE321 board.
16. Reattach the metal plate protecting the internal heater.

17. Insert the measurement unit inside the radiation shield, reconnect the blower cable to connector **J1**, and tighten the 3 attachment screws.
18. Connect the power cable to connector **J2**.
19. Switch on the power with all 3 switches. Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs are lit.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

7.10 Replacing laser monitor board

The optics unit and transmitter module must be removed before replacing CLM311.

CAUTION! Only qualified service personnel may perform service procedures.

- 2.5 mm Allen key
- Calculator
- Computer
- Service cable

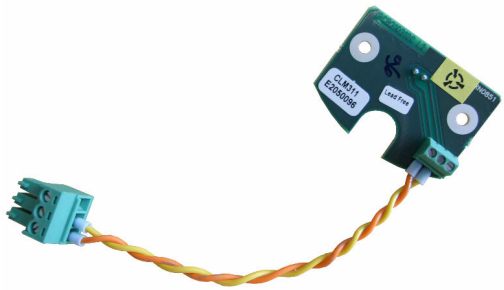


Figure 20 Laser monitor board CLM311

1. Open the measurement unit door and switch off the power with all three switches (**F1**, **F2**, and battery).

WARNING! Before you continue, disconnect the power cable from the **J2** connector.

2. Disconnect the battery, transmitter, receiver, and data cables from the CLE321 board.



For checking the maintenance parts locations, see Service overview (page 121)

3. To remove the optics unit, remove the holder plate by loosening the 4 Allen screws on its front cover.
4. Detach the internal heater connector and holding the cable aside, carefully pull out the optics unit upper end first.



Do not touch the lens of the optics unit.

5. Detach the CLM311 twisted pair cable from the CLE321 board.
6. To detach the transmitter, loosen the transmitter ring by turning it to the right. If necessary, you can use the Allen key as a lever. Remove the transmitter from the Optics unit.
7. Detach the laser monitor board CLM311 by loosening the two screws. You can access the screws through the hole in the transmitter ring.
8. Write down the sensitivity value of the old defective board, for example, 102 %. If no value is written on the CLM311, use the standard value 100 %.
9. Write down the sensitivity value of the new CLM311 board, for example, 98 %. If there is no value on the CLM311, use the standard value 100 %.
10. Attach the new CLM311 board into the optics unit and tighten the 2 screws.
11. Place the transmitter to its place and tighten the transmitter ring so that the labels of the transmitter face the measurement unit door.
12. Attach the CLM311 twisted pair cable to the CLE321 board.
13. Slide the optics unit to its place with the bottom end first.

    Make sure that no cables get stuck between the optics tube and other ceilometer components.
14. Snap the internal heater connector to its place.
15. Place all heater cables behind the holder and tighten the 4 holder screws.
16. Reconnect the battery, transmitter, receiver, and data cables to the CLE321 board.
17. Connect the power cable to the connector **J2** and the maintenance terminal to CL31.
18. Switch on the power with all 3 switches.

    Wait until the **Laser on** LED starts blinking at 2-second intervals. Ensure that all 6 diagnostic LEDs are lit.

19. Open the command line with the **open** command.

    The password is **advanced**.

20. Type the **get params factory** command and write down the **Target Outlaser** value.

21. The new calibration value is calculated as follows:

    ```
    NEW OUTLASER = (OLD OUTLASER x NEW CLM311 SENSITIVITY VALUE) / (OLD CLM311
    SENSITIVITY VALUE)
    ```

    For example: 880 x 98 % / 102 % = 837 (rounded to the nearest integer value)

22. Type the following command:

    ```
    SET FACTORY OUTLASER <value>
    ```

    where **<value>** is the new, calculated target outlaser value.

23. Type the **status** command and check from the status message that the measured outlaser is close (±5 %) to the new outlaser value. Make sure that the system status is OK and there are no suspect units.

The ceilometer unit returns to normal operation. Make sure that the unit is working properly and that there are no other failures with the system.

7.11 Replacing modem module



CAUTION! Only qualified service personnel may perform service procedures.



Always replace the modem module indoors.

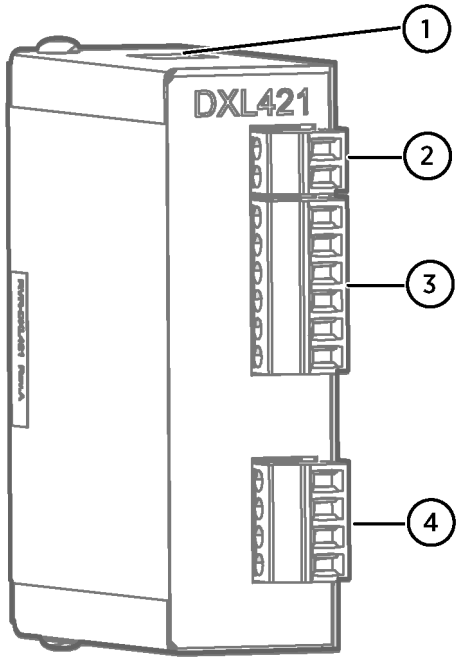


Figure 21 DXL421 leased line modem

1 DIL switch
2 Power input
3 RS-232 interface
4 Leased line interface

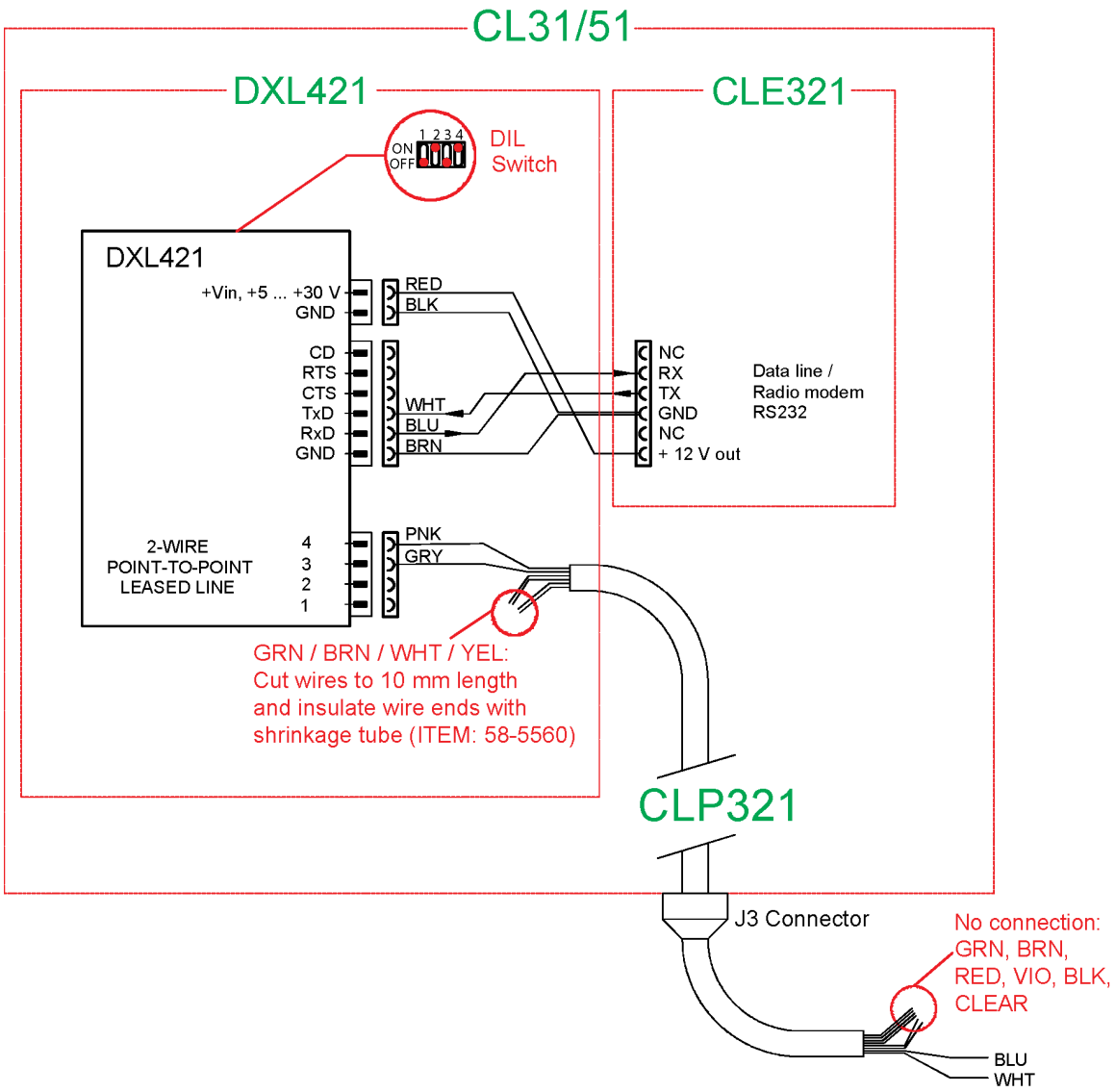


Figure 22 DXL421 modem connections

You can set the DXL421 operation mode by a DIL switch. The following figure shows the correct positions of the switches.

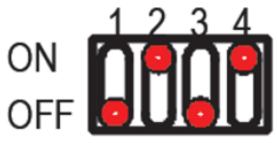


Figure 23 DXL421 DIL switch

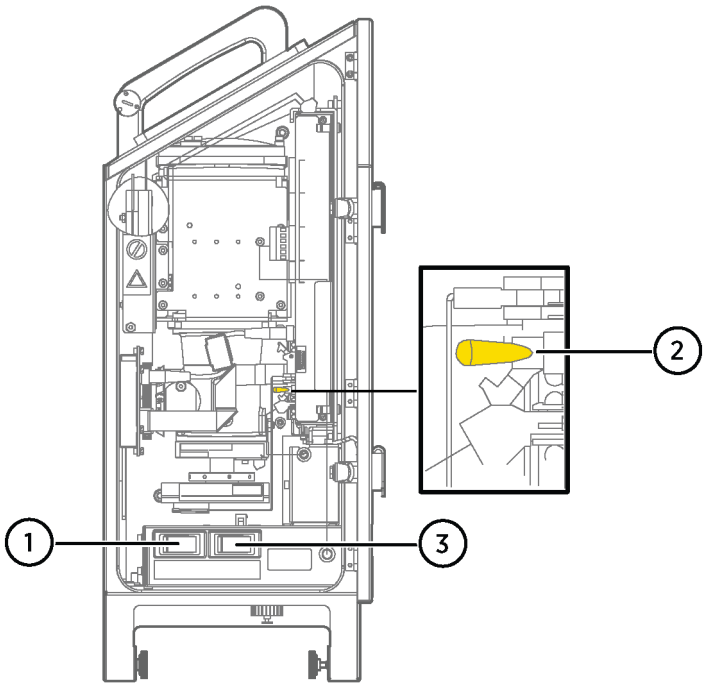
Table 32 Default settings for the DXL421 modem connection

Bit rate	19200
Data bits	8
Stop bits	1
Parity	None
Handshake	None

7.12 Replacing DMU801

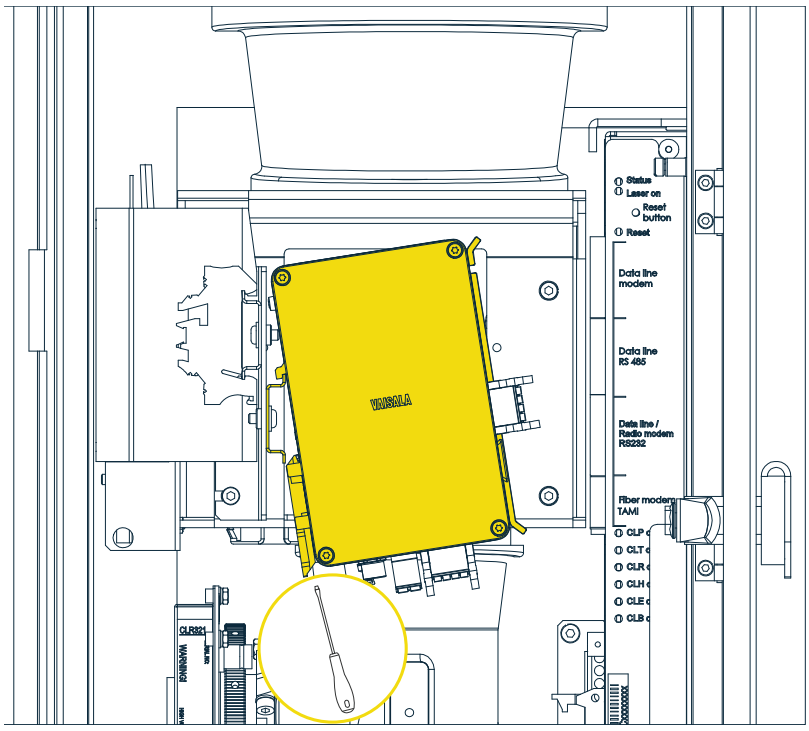
- Flat head screwdriver

1. In a web browser, type the following Web UI address:
   https://192.168.10.2
2. In the Web UI, select **System > Diagnostics package** and download the package.
   The file *station_params.txt* contains the settings of the current configuration.
3. Switch off the power with all 3 switches (**F1**, **F2**, and battery).



1 Power switch **F1**
2 Battery switch
3 Heater / blower switch **F2**

4. Remove all cabling from DMU801.
5. To remove DMU801 from the DIN rail, slide down the locking piece with a flat head screwdriver, and lift DMU801.



6. Insert the new DMU801 on the DIN rail and snap it into place.
7. Connect the cables to the new DMU801.
8. Switch on the power with all 3 switches (**F1**, **F2**, and battery).

   Wait until the **Laser on** LED starts blinking at 2-second intervals. Make sure that all 6 diagnostic LEDs light up after the self-test.
9. Activate the ceilometer and set up SFTP and/or MQTT. See the instructions about the Ethernet setup.

   Use the file *`station_params.txt`* that you downloaded to check the settings when configuring the new DMU801.

More information

- Ethernet setup (page 51)
- Service overview (page 121)

8. Troubleshooting

8.1 Troubleshooting overview

The goal of troubleshooting is to locate the cause for the potential problem. Failure situations are usually caused by dirt in optics or unclarity of the optical path. Also external conditions or the following replaceable subassemblies may be the source of problems:

- Ceilometer engine board CLE321
- Ceilometer transmitter CLT521
- Ceilometer receiver CLR321
- Coaxial cable 226296
- Laser monitor board CLM311
- AC power CLP321
- Blower CLB311-115/230
- Heater CLH311-115/230
- Battery

If damage is suspected in a subassembly or a board, replace it with a spare part and send the defective part to Vaisala for repair/replacement.



Replacements must only be performed by qualified maintenance personnel. As a principle, user repairs are restricted to the replacement of subassemblies.

8.2 Accessing diagnostic information

During normal operation, the ceilometer continuously monitors its internal status and regularly checks the blower and the heater. The ceilometer automatically analyzes the diagnostic test results and reports potential failures with every data message.

The ceilometer automatically identifies the potentially faulty subassemblies.

More information

‣ Warning and alarm messages (page 161)

8.3 Troubleshooting equipment

To establish a service connection to the ceilometer you must have a maintenance terminal which can be a laptop with an RS-232 interface or a PC with serial interface, maintenance cable QMZ101, and any terminal program. You can use the BL-View or CL-View software for this purpose. If you perform the operation check indoors, you must have an optical termination hood which absorbs the laser light that would otherwise reflect from the ceiling and possibly saturate the receiver.

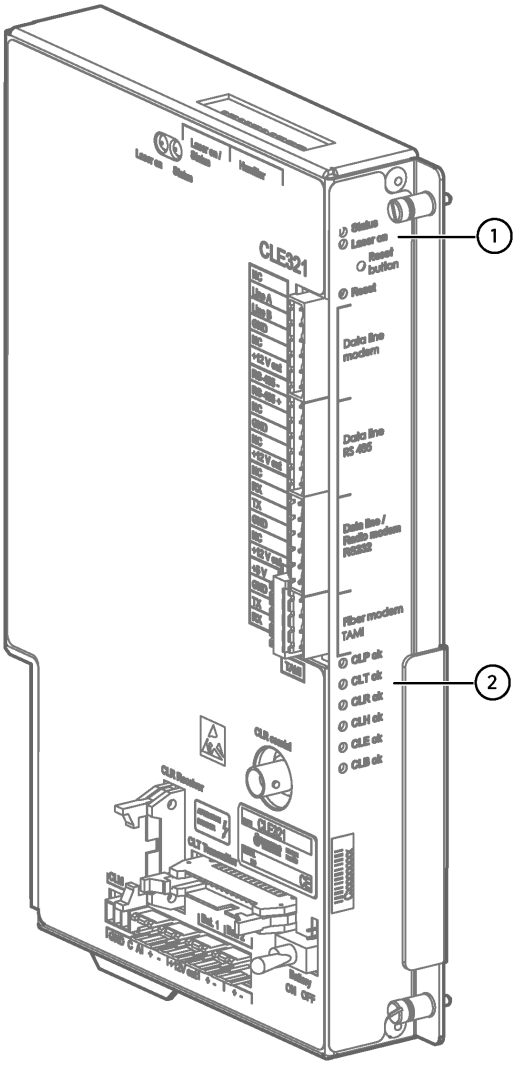
You can establish maintenance connection also through the data line if, for example, the ceilometer is out of use. This stops the data flow for as long as the command line is open.

8.4 Troubleshooting ceilometer

1. Clean the window carefully with a soft, lint-free cloth moistened with a mild detergent.

   Make sure you do not scratch the window surface.
2. If you are indoors, put the optical termination hood (CL51TERMHOODSP) on the ceilometer window. To the ceilometer this represents a clear, nighttime sky.
3. Connect the maintenance terminal to the maintenance port at the bottom of the ceilometer and turn on both the ceilometer and the maintenance terminal. .

4. Make sure that the ceilometer starts operating properly: the **Laser on** LED on the CLE321 board is blinking after initialization at 2 s intervals. If the key modules function properly, all 6 diagnostic LEDs light up.



1 **Laser on** LED
2 Diagnostic LEDs

During the first 5 minutes after startup an automatic blower check verifies that the blower heater functions properly. The result is available 5 minutes after starting the unit and it is indicated by the **CLB ok** LED. It is also displayed in the status message.

5. To get the failure status message, type **open** and press **Enter** on the maintenance terminal (computer) keyboard.

   `CEILO` > prompt appears. Type **`get failure status`** and press **Enter**.
   An example response:

```
Alarms
 Tmit Shutoff  OK    Transmitter  ALRM
 Receiver      OK    Voltages     OK
 Ext Memory    OK    Light Pth Obs OK
 Rec Saturat   OK    Coaxial Cable OK
 Engine        OK

Warnings
 Window Contam OK    Battery Low  OK
 Transm Expire OK    Humid High   OK
 Blower        OK    Humid Sensor OK
 Int Heater    OK    High Rad     OK
 Engine        OK    Battery      OK
 Laser Monitor OK    Receiver     OK
 Tilt Angle    OK

System Status:   FAIL
 Suspect Module: CLT
```

   The 2 last lines in the status message indicate if there are warnings or alarms present. The `Suspect module` line indicates the unit that is suspected to be faulty. In this example, it is transmitter CLT.

6. When the 5-minute blower check is over, check the result from the status message and place a piece of white paper on the ceilometer window. The blower starts within a minute. Remove the paper. The blower stops within 8 minutes.

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7. Do one of the following:
   - If there are clouds, compare the ceilometer measurement with a qualified weather observer's height approximation.
   - If there are no clouds and the site is suitable, perform a hard target test: turn the measurement unit 90 degrees and aim it on a fixed target such as a wall or a forest front.
     The minimum distance to a hard target must be 300 meters (1 000 ft). The backscatter signal from a hard target is very strong compared to the signal from a cloud. The receiver may saturate if the distance is too short.

     WARNING! When tilting the unit, make sure that nobody is watching the beam with binoculars or other magnifying optics.

   Disable the automatic angle correction with the following commands:

```
CEILO > SET MESSAGE ANGLE_COR OFF
CEILO > CLOSE
```

   Compare the distance reading of the ceilometer to a reference measurement.

More information

- Termhood (page 177)

8.5 Warning and alarm messages

Table 33 Ceilometer status, warnings

Status message	Reason	Instructions
`Battery failure`	Battery is dead.	Replace the battery.
`Battery voltage low`	The unit has been powered too long using the backup battery.	Connect the line voltage or replace the battery.
	Battery fails to recharge.	If the battery is old, replace it. If the battery is OK, check the operation of ceilometer engine board CLE321.

Status message	Reason	Instructions
`Blower failure`	Blower cable is not connected.	Check that the blower cable is connected.
	Window blower circuit breaker is not ON.	Check that the window blower circuit breaker is ON.
	Line voltage level is not correct.	Check that the line voltage is present and correct.
	Blower is stuck.	Check if visible obstacles disable blower operation.
	Blower is damaged.	Replace the blower.
	Blower is blowing, but only cool air. The blower heater is malfunctioning.	Replace the blower.
`Ceilometer engine board failure`	Non-critical fault in ceilometer engine board CLE321.	Replace ceilometer engine board CLE321.
`Heater fault`	Window blower circuit breaker is not ON.	Check that the window blower circuit breaker is ON.
	Line voltage level is not correct.	Check that the line voltage is present and correct.
	Heater is damaged.	Replace the heater.
`High background radiance`	Direct sunlight.	In case there are no alarms, the measurements are OK. If there is an alarm, the measurements are invalid.
`High humidity` (option)	Relative humidity > 85 %. Water has been condensed inside the ceilometer. Leakage in the enclosure or leakage in the door.	Take the ceilometer inside, open the maintenance door and let it dry in a warm air conditioned place. Condensed water on optical surface may disturb the measurement. There is a danger of short circuits.
`Humidity sensor failure` (option)	Humidity sensor is not connected.	Connect the humidity sensor or disable the option in the software.
	Humidity sensor is damaged.	Contact technical support and send the ceilometer to Service Center for the humidity sensor to be replaced.
`Laser monitoring failure`	Laser power monitor board CLM311 has failed.	Replace CLM311.
	Laser power measurement on ceilometer engine board CLE321 has failed.	Replace CLE321.
`Receiver warning`	A non-critical CLR321 receiver failure.	Replace CLR321.

Status message	Reason	Instructions
`Tilt angle > 45 degrees warning`	The unit is not correctly installed or the tilt angle is larger than 45°.	Check the installation. The height measurement accuracy is lost with tilt angles greater than 45°.
`Transmitter expires`	Laser diode is too old.	Replace transmitter. The measurement data is valid, but it is possible that some clouds are missed.
`Window contamination` (appears from time to time and lasts < 5 min)	Usually drizzle drops on the window.	The blower cleans the window. If clouds are detected, the height information is correct. If no clouds are detected, it is possible that high clouds are missed.
`Window contamination` (continuous)	For example, bird droppings, leaves, or dust have contaminated the window.	Clean the window.

Table 34 Ceilometer status, alarms

Status message	Reason	Instructions
`Ceilometer engine board failure`	Ceilometer engine board is damaged.	Replace ceilometer engine board CLE321.
`Coaxial cable failure`	Coaxial cable disconnected or broken.	Verify the connection or replace the coaxial cable.
`Light path obstruction`	Window is badly contaminated or severely scratched.	Clean the window or in case of damage, replace CLW311.
	Something blocks the laser beam.	Check the clarity of the optical path.
`Memory error`	A failure in the CLE321 memory.	Replace CLE321.
`Receiver failure`	Receiver CLR321 is damaged.	Replace CLR321.
	Loose cable connection.	Check that the cables from receiver CLR321 and ceilometer optics CLO521 are undamaged and correctly connected.
	Receiver test not operating.	Check that the optics unit CLO521 is not misplaced or damaged. If the unit is damaged or missing, contact Vaisala for repair and replacement, since the CLO521 unit is not field-replaceable.
`Receiver saturation`	Direct sunlight.	Wait for the sun to exit the field-of-view. The ceilometer returns to normal operation.
	Something is partially blocking the laser beam.	Check the clarity of the optical path.

Status message	Reason	Instructions
`Transmitter failure`	Laser is worn out or damaged.	Replace laser transmitter.
	Laser does not get electrical power.	Check from the status message that the line **Voltages** is marked **OK**.
`Transmitter shut-off` (Laser temperature > 85 °C)	Direct sunlight has heated the laser.	Wait for the sun to exit the field-of-view. The ceilometer returns to normal operation.
	Environment temperature is too high.	Check if there is a specific reason for the high temperature.
`Voltage failure`	Ceilometer engine board CLE321 is damaged.	Replace CLE321.

Table 35 Ceilometer status, miscellaneous problems

Problem	Reason	Instructions
The ceilometer does not start, no LEDs are lit	Power is not connected.	Check that both the main and the battery switches are in the ON position. Check the presence and correctness of the line voltage, and make sure that the battery is OK.
	Loose cable connection.	Check the cable connections.
Laser on LED is not blinking but the **Status** LED is lit.	Operation mode is standby.	Connect the maintenance terminal and check if the operation mode is normal.
	CLE321 is damaged.	Replace CLE321.
Data message is missing.	Dialogue is not operating.	Check the cable connections. Open the terminal.
	Wrong communication parameters.	Check the communication parameters (number of bits, parity, etc.).
	Wrong data port.	Open the terminal program and give **open** command and then **`get params message`** command. Check that the PORT is set to DATA.
	Operation mode is standby.	Open the terminal program and first give the **open** command and then the **status** command. Check that the OPERATION MODE is NORMAL.
Cloud detection is missing.	Equipment failure.	Open the terminal program and give **open** command and then **`get failure status`** command. Check the alarms and warnings. If there are no alarms or warnings in the data message, contact Vaisala.

Problem	Reason	Instructions
The capability to detect high clouds is reduced.	Low receiver gain (no fog or snow).	Check the automatic receiver gain setting in the status message. If it is low, check that the window is clean. Check that the optical path is clear. Visually check that the lens is clean.
	Extensive amount of dirt or water droplets on the window and a failure in the diagnostics.	Check the window clarity. Check the blower operation by giving the **`service self_check`** command and check that the blower works.

9. Technical data

9.1 CL51 specifications

Table 36 Mechanical specifications

Property	Value
Dimensions	
Measurement unit	834 × 266 × 264 mm (32.83 × 10.47 × 10.40 in)
Height with radiation shield	1531 mm (60.28 in)
Total	1531 × 335 × 324 mm (60.28 × 13.19 × 12.76 in)
Weight	
Measurement unit	18.6 kg (41.01 lb)
Radiation shield and blower	27.4 kg (60.41 lb)
Total	46.0 kg (101.41 lb)
Plywood transport container	
Container size	1650 × 540 × 480 mm (64.96 × 21.26 × 18.90 in)
Shipping weight	Typically 75 kg (165.3 lb)

Table 37 Measurement performance

Property	Value
Measurement range	0–13 km (0–43 000 ft)
Backscatter profiling range	0–15 km (0–49 200 ft)
Reporting resolution	10 m (30 ft), units selectable
Reporting cycle	6–120 s, or polling
Distance measurement accuracy against a hard target	±5 m (16 ft)

Table 38 Operating environment

Property	Value
Operating environment	Outdoor use
Use in wet location	Yes
Operating temperature	–50 … +60 °C (–58 … +140 °F)
Operating humidity	0–100 %RH
Wind tolerance	Up to 55 m/s (123 mph)

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Property	Value
Vibration	Lloyds Register / IEC 60068-2-6 5–13.2 Hz, ±1.0 mm 13.2–100 Hz, ±0.7 g 9.1–150 Hz, ±0.5 g
Pollution degree for inside electronics	2
Maximum operating altitude	3000 m (approx. 9800 ft)
IP rating [1)]	IP65 (measurement unit) Dust-tight. Protected from water jets from any direction. IPX6 (with radiation shield) : Protected against strong jets of water.
UL 50E rating	Type 4: Dust-tight. Protected from hose-directed water.

1) The IP rating is valid only when the ceilometer is installed according to Vaisala instructions.

Table 39 Inputs and outputs

Property	Description/Value
Operating voltage	115/230 V AC 100–127 V AC, 207–253 V AC
Current consumption	
Current consumption (typical) Total	2.7/1.4 A
Measurement unit	0.1/0.1 A
Internal heater	0.9/0.4 A
Window conditioner heater	1.5/0.8 A
Window blower	0.2/0.1 A
Frequency (min./max.)	50/60 Hz
Battery backup	12 V sealed lead-acid battery, 2.4 Ah
Overvoltage protection	Low-pass filter, VDR
Overvoltage category	II
Interfaces	
Data	• RS-232 • RS-485, multidrop, 2-wire • DXL421 modem module • LAN (Ethernet) interface option
Maintenance	RS-232
Baud rate	
RS-232/RS-485	300–115 200 bps

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Property	Description/Value
Modem V.21, V.22	300–1200 bps

Table 40 Compliance

Property	Value
EU directives and regulations	Low Voltage Directive (2014/35/EU) EMC Directive (2014/30/EU) RoHS Directive (2011/65/EU) as amended by 2015/863
EMC immunity	EN 61326-1:2013, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements.
EMC emissions	EN 55032:2015 + A11:2020 EN 61000-3-2 EN 61000-3-3
Electrical safety	EN 61010-1:2010 + A1:2019
Environmental	EN IEC 63000:2018
Eye safety	EN 60825-1:2014+A11:2021 Complies with 21 CFR 1040.10 and 1040.11 except for the deviations pursuant to the *Laser Notice No. 56*, date May 8, 2019.
Compliance marks	CE, RCM, China RoHS, UKCA

Table 41 Receiver specifications

Property	Value
Detector	Silicon avalanche photodiode (APD)
Surface diameter	0.5 mm (0.02 in)
Receiver bandwidth	3 MHz (–3 dB)
Interference filter	Center wavelength 915 nm typical
50 % pass band	36 nm
Transmissivity at 913 nm	80 % typical
Field-of-view divergence	±0.56 mrad

Table 42 Transmitter specifications

Property	Value
Laser source	Indium gallium arsenide (InGaAs) diode laser
Center wavelength	910 ±10 nm at 25 °C (77 °F)

Property	Value
Operating mode	Pulsed
Radiated pattern emitted from the protective housing (measurement unit window), standard CL51 mode	
Maximum average power through 7-mm aperture in the plane of the laser aperture	461.4 µW
Average pulse power	27 W typical
Peak power	44 W
Average power, nominal	19.5 mW
Beam divergence	±0.15 mrad × ±0.25 mrad
Pulse duration	110 ns
Repetition rate	6.5 kHz
Laser classification	Class 1M laser product, IEC 60825-1:2014 (Edition 3.0) and EN 60825-1:2014 + A11:2021
Radiated pattern emitted from the protective housing (measurement unit window), CL31 emulation mode	
Maximum average power through 7-mm aperture in the plane of the laser aperture	640 µW
Average pulse power	27 W
Peak power	44 W
Average power, nominal	30 mW
Beam divergence	±0.15 mrad × ±0.25 mrad
Pulse duration	110 ns
Repetition rate	10 kHz
Laser classification	Class 1M laser product, IEC 60825-1:2014 (Edition 3.0) and EN 60825-1:2014 + A11:2021
Incorporated laser source (CLT521 transmitter), standard CL51 mode	
Peak power	280 W
Maximum average power	167 mW
Typical beam divergence	±5 × ±12.5 degrees FWHM
Pulse duration	110 ns
Repetition rate	6.5 kHz
Laser class according to IEC/EN 60825:1:2014	3B
Incorporated laser source (CLT521 transmitter), CL31 emulation mode	
Peak power	280 W
Maximum average power	257 mW
Typical beam divergence	±5 × ±12.5 degrees FWHM

Property	Value
Pulse duration	110 ns
Repetition rate	10 kHz
Laser class according to IEC/EN 60825-1:2014	3B

Table 43 Optical system specifications

Property	Value
Optics system focal length	450 mm (17.72 in)
Effective lens diameter	148 mm (5.83 in)
Lens transmittance	98 % typical
Window transmittance	97 % typical, clean

Table 44 NPort 5232-T serial device server specifications

Property	Value
Speed	10/100 Mbps, auto MDI/MDIX
Network protocols	ICMP, IPv4, TCP, UDP, DHCP, BOOTP, Telnet, DNS, SNMP V1, HTTP, SMTP, SNTP
Supply voltage	+12 to 48 V DC
Current consumption	280 mA at 12 V 150 mA at 24 V
Maximum operating altitude	2000 m (6560 ft)
Max. operation distance	100 m (328 ft)

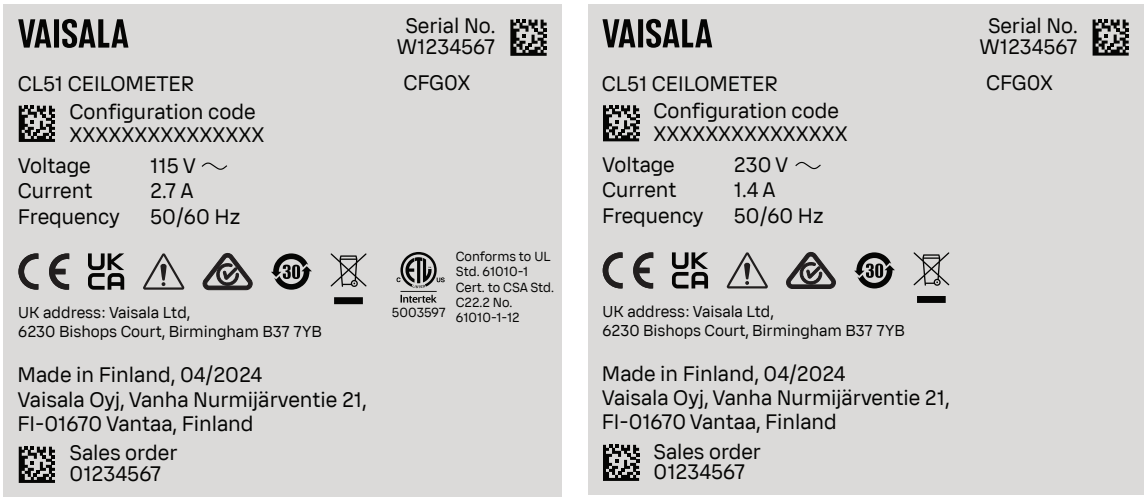


Figure 24 CL51 type labels (115 V and 230 V)

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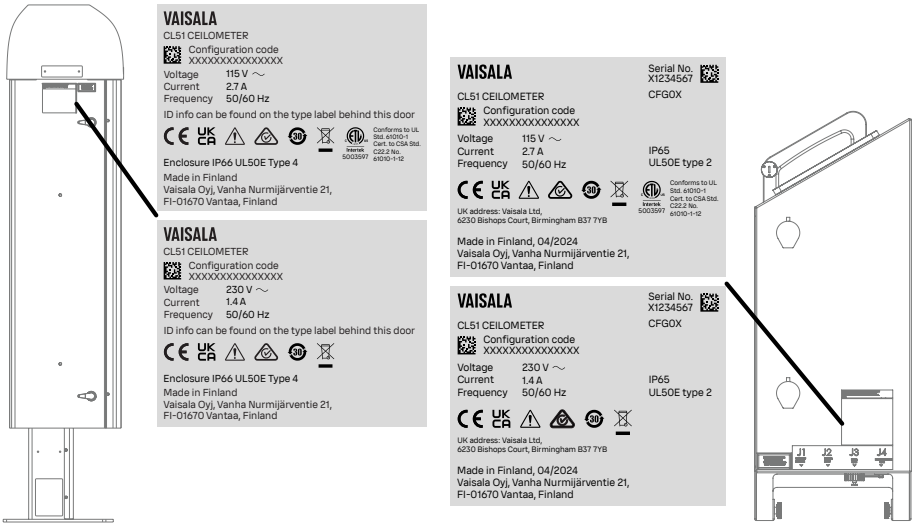


Figure 25 Location of type labels

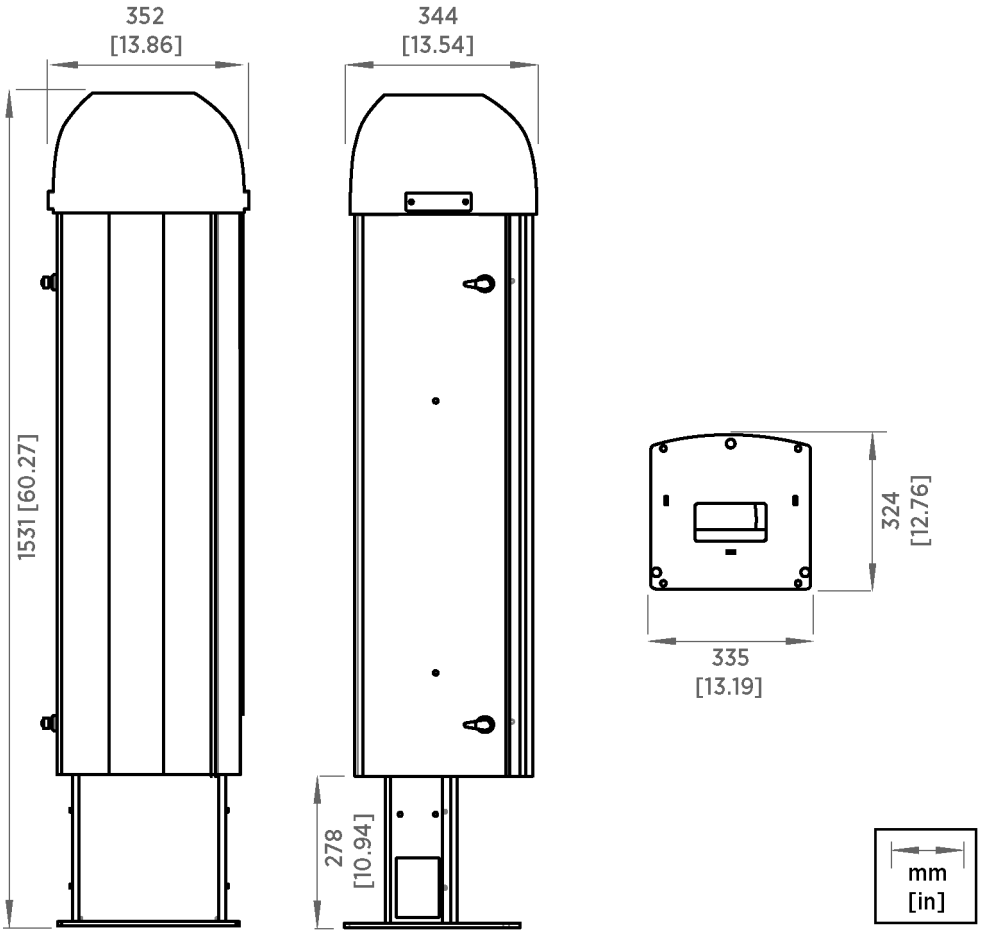


Figure 26 Ceilometer CL51 dimensions

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Table 45 External connector J1 - window blower specifications

Property	Value
Connector J1	Type Amphenol series 693, C016 30H006 110 10 (female)
Mating connector type	Type Amphenol series 693, C016 30H006 110 10 7-pin (male) elbow

Table 46 External connector J2 - power input specifications

Property	Value
Power connector J2	Type Amphenol series 693, C016 20C003 100 12 4-pin (male)
Mating connector type	Type Amphenol series 693, C016 20F003 100 10 (female) elbow
No-break power supply	12 V sealed lead-acid battery, 2.4 Ah
Overvoltage protection	Low-pass filter, VDR

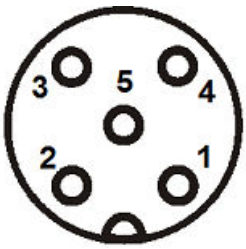
Table 47 External connector J3 - data line specifications

Property	Value
Connector J3	Type Amphenol series 693, C016 30C006 100 12 7-pin (male)
Mating connector type	Type Amphenol series 693, C016 30F006 100 10 (female) elbow
Baud rate	19200 bps standard with RS-232 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 bps available 300, 1200, or 2400 bps available with modem DXL421
Maximum distance to operate	300 m (1000 ft) with RS-232 1.2 km (4000 ft) with RS-485, all at 2400 bps with typical communication cables 10 km (6.2 mi.) with Modem
Standard character frame	1 start bit 8 data bits No parity 1 stop bit
Standard character code	USASCII

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Property	Value
Pin connections	1 RS-485 -/RTS# (no SW support) 2 RS-485+/RS-232 RxD/Modem Lead A 3 Modem Lead B/RS-232 TxD 4 Ground 5 CTS# (no SW support) 6 +12 V DC (700 mA continuous, for local external equipment) 7 Signal ground
Overvoltage protection in each circuit	Primary: noble gas surge arrester Secondary: VDRs, transient zener diodes or normal diodes.

Table 48 External connector J4 - maintenance line specifications

Property	Value
Connector J4	Female 5-pin M12 connector (for example, Lumberg RKF 5 / 0.5 M)
Mating connector type	Male 5-pin M12 connector (for example, Lumberg RST 5-644)
Baud rate	9600 default and standard 300, 2400, 4800, 9600, 19200, 38400, 57600, 115 200 bps available
Distance to operate	300 m (1000 ft) at 2400 baud with typical communication cables
Standard character frame	1 start bit 8 data bits No parity 1 stop bit
Standard character code	USASCII
Pin connections	 (RTS/CTS not used)
Overvoltage protection in each circuit	Primary: gas discharge tube Secondary: PCTs, thyristor overvoltage protector

9.2 DXL421 specifications

Table 49 DXL421 operating environment

Property	Description/Value
Operating temperature	−40 ... +55 °C (−40 ... +131 °F)
Storage temperature	−60 ... +75 °C (−76 ... +167 °F)
Operating humidity	0–100 %RH, non-condensing
IP rating	IP30: Protected against solid foreign objects of 2.5 mm Ø and greater.
UL 50E/NEMA rating	Type 1: Protected against solid foreign objects of 50 mm Ø and greater.

Table 50 DXL421 inputs

Property	Description/Value
Supply voltage	+5 ... +30 V DC
Power consumption	0.09 W
Fuse	0.5 A PTC
Transient protection	Yes, transil diode
Reverse connect protection	Yes
Connector	2-position screw terminal
Indicator	Green power LED

Table 51 DXL421 serial RS-232 interface

Property	Description/Value
Topology	EIA/TIA-232-F (RS-232C) interface
Serial port speed	300–57 600 bps
Connector	6-position screw terminal
Indicators	3 orange LEDs: **CD**, **TxD**, and **RxD**

Table 52 DXL421 PSTN interface

Property	Description/Value
Modem compatibility	• V.21 300/300 bps FSK • V.22 1200/1200 bps DPSK • V.23 1200/1200 bps FSK • 2-wire or 4-wire, point-to-point or multi-point
Transient protection	Yes, 350 V surge protector, PTC fuses, SIDACtor®

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Property	Description/Value
Isolation	1500 V
Connector	4-position screw terminal

Table 53 DXL421 mechanical specifications

Property	Description/Value
Housing material	EN AW-1050A aluminum, gray anodized
Dimensions (H × W × L)	80 × 76 × 25 mm (3.15 × 2.99 × 0.98 in)
Weight	94 g (3.31 oz)

Table 54 DXL421 compliance

Property	Description/Value
Vibration (random)	IEC 60068-2-64 Fh, 10–500 Hz, up to 2.0 g
Free fall	IEC 60068-2-32 Ed, fall height 1000 mm (39 in)
Cold	IEC 60068-2-1, −40 °C (−40 °F) 16 hours
Dry heat	IEC 60068-2-2, +55 °C (+131 °F) 16 hours
Slow change of temperature, 1 °C/min	IEC 60068-2-14, −40 … +55 °C (−40 … +131 °F), 2 cycles
EMC immunity	EN 61326-1, industrial environment
EMC emissions	CISPR 22 / EN 55022, Class B
ESD	EN 61000-4-2, contact dis. 4 kV, air dis. 8 kV
RF field	EN 61000-4-3
Fast transient bursts (EFT)	EN 61000-4-4
Transient surges	EN 61000-4-5
Conducted RF	EN 61000-4-6

Appendix A. Factory settings of user-programmable parameters

The following table lists the factory defaults of user-programmable parameters. For information on commands to read or change parameters, see User commands (page 100).

Table 55 Factory defaults of user-programmable parameters

Parameter	Factory default
Control blower	Auto
Control inheater	Auto
Data_acq power_save	Disabled
Data_port baud	19200
Data_port mode	RS-232
Data_port parity	8N1
Maint_port baud	9600
Maint_port parity	8N1
Message angle_corr	On
Message transmission	Periodic
Message secondary transmission	None
Message transmission delay	100 ms
Message height_offset	0
Message interval	6 s
Message secondary interval	6 s
Message port	Data
Message profile scale	1.0
Message profile noise h2	Off
Message type	msg2_base
Message secondary type	None
Message units	Feet
Message vv_limit ceiling	2000 m (6562 ft)
Oper_mode	Normal
Port_timeout	2 min
Unit_id	0 (zero)

Appendix B. Termhood

You can use the optical termination hood CL51TERMHOODSP for calibration:

- Outdoors if the sky is unclear
- Indoors to represent a clear, nighttime sky

Outdoor use

If you use Termhood outdoors, place the termination hood adapter over the ceilometer and Termhood over the adapter. The adapter keeps the hood in place.

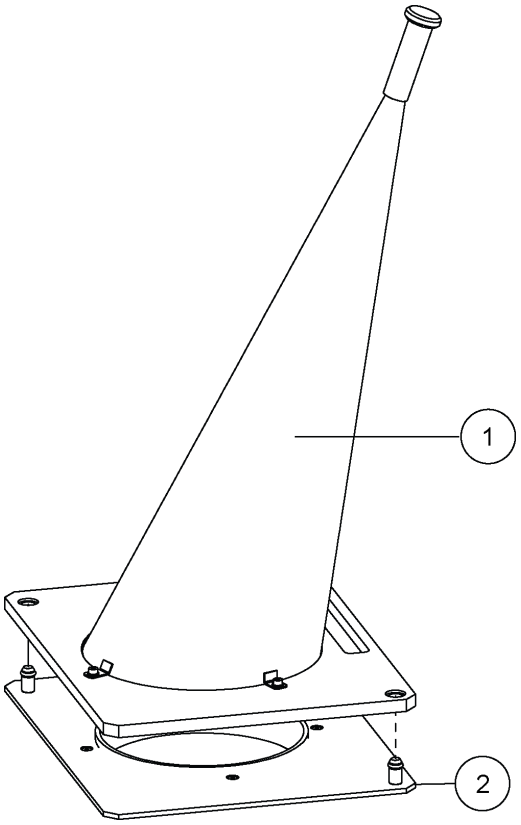


Figure 27 Termhood with adapter

1 Termhood
2 Termhood adapter

Indoor use

If you use Termhood indoors, place it on top of the ceilometer window so that the measurement unit handle goes in the slot to keep the hood in place.

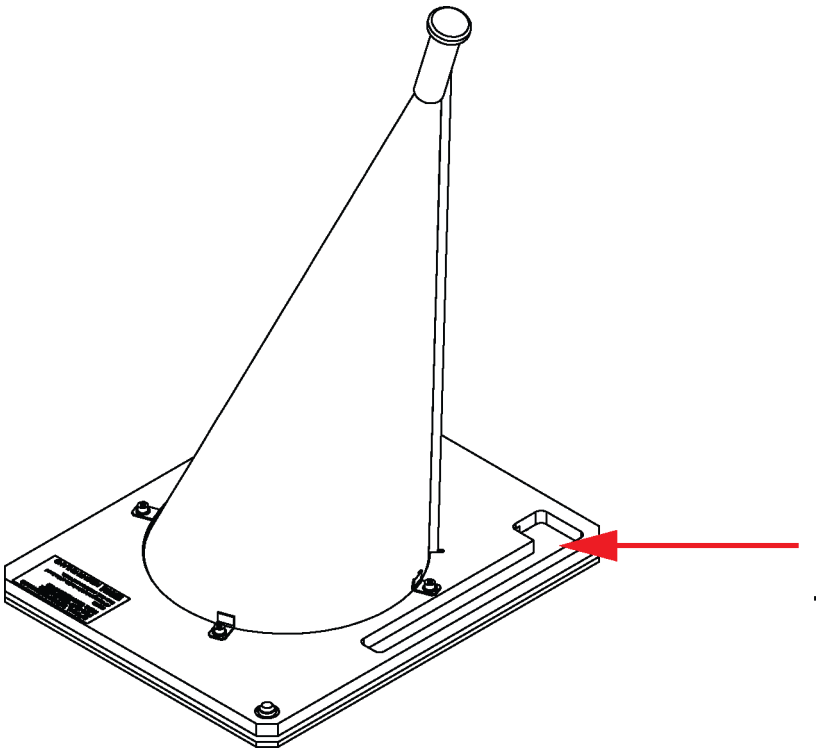


Figure 28 Termhood slot for measurement unit handle

More information

- Troubleshooting ceilometer (page 158)

Appendix C. NetCDF example

Here is an example of a netCDF file that Vaisala Ceilometer CL51 produces.

```
File "W2010114_20250112T000500.nc"
File type: Hierarchical Data Format, version 5

W2010114_20250112T000500.nc {
  dimensions:
    layer = 5;
    range = 1540;
    time = UNLIMITED;   // (10 currently)
  variables:
    int aerosol_gradient_heights(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "aerosol gradient heights";
      :comment = "Heights of the detected aerosol gradients.";
      :_ChunkSizes = 1U, 5U; // uint

    int aerosol_gradient_quality_indices(time=10, layer=5);
      :_FillValue = -999; // int
      :long_name = "aerosol gradient quality indices";
      :comment = "Quality indices for the detected aerosol gradients.";
      :actual_range = "0, 3";
      :_ChunkSizes = 1U, 5U; // uint

    int aerosol_layer_base(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "aerosol layer base";
      :comment = "Distance from the ground to the base of the aerosol layer.";
      :_ChunkSizes = 1U, 5U; // uint

    int aerosol_layer_count(time=10);
      :_FillValue = -999; // int
      :long_name = "aerosol layer count";
      :comment = "The number of detected aerosol layers.";
      :actual_range = "0, 5";
      :_ChunkSizes = 1024U; // uint

    int aerosol_layer_quality_indices(time=10, layer=5);
      :long_name = "aerosol layer quality indices";
      :comment = "Quality indices for the detected aerosol layers.";
      :_FillValue = -999; // int
      :actual_range = "1, 3";
      :_ChunkSizes = 1U, 5U; // uint
```

```
    int aerosol_layer_top(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "aerosol layer top";
      :comment = "Distance from the ground to the top of the aerosol layer.";
      :_ChunkSizes = 1U, 5U; // uint

    int aerosol_layer_vertical_extent(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "aerosol layer vertical extent";
      :comment = "The distance from the aerosol layer\'s base to its top.";
      :_ChunkSizes = 1U, 5U; // uint

    int background_radiance(time=10);
      :_FillValue = -999; // int
      :long_name = "background radiance";
      :actual_range = "0, 2500";
      :comment = "Millivolts at internal ADC input.";
      :_ChunkSizes = 1024U; // uint

    float beta_att(time=10, range=1540);
      :_FillValue = -999.0f; // float
      :units = "1/(m*sr)";
      :long_name = "attenuated volume backscatter coefficient";
      :coordinates = "time range longitude latitude";
      :comment = "Profile data is not tilt-corrected.";
      :averaging_time_in_seconds = 30; // int
      :_ChunkSizes = 1U, 1540U; // uint

    float beta_att_sum(time=10);
      :_FillValue = -999.0f; // float
      :units = "1/(10^4*sr)";
      :actual_range = "0, 999";
      :long_name = "beta att sum";
      :comment = "Scaled integral of the attenuated volume backscatter
coefficient.";
      :_ChunkSizes = 1024U; // uint

    int boundary_layer_height(time=10);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "boundary layer height";
      :comment = "Height of the planetary boundary layer.";
      :_ChunkSizes = 1024U; // uint

    int boundary_layer_quality_index(time=10);
      :_FillValue = -999; // int
      :long_name = "boundary layer quality index";
      :comment = "Quality index for the detected planetary boundary layer.";
      :actual_range = "0, 3";
      :_ChunkSizes = 1024U; // uint
```

```
    int cloud_base_heights(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "cloud base heights";
      :coordinates = "time layer longitude latitude";
      :comment = "Reported in the vertical or in the instrument beam
direction, depending on the angle_corr setting of the instrument. Up to 3
cloud bases are reported.";
      :_ChunkSizes = 1U, 5U; // uint

    int cloud_top_heights(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "cloud top heights";
      :coordinates = "time layer longitude latitude";
      :comment = "Reported in the instrument beam direction. Up to 3 cloud
tops are reported. Represents the cloud top or the penetration depth for
optically thick clouds.";
      :_ChunkSizes = 1U, 5U; // uint

    int detection_status(time=10);
      :_FillValue = -999; // int
      :actual_range = "0, 5";
      :long_name = "detection status";
      :comment = "See Vaisala CL51 User\'s Guide for interpretation.";
      :_ChunkSizes = 1024U; // uint

    int elevation;
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "elevation";
      :standard_name = "ground_level_altitude";
      :comment = "Measurement site height above or below a fixed reference
point, most commonly a reference geoid.";

    int laser_power_percent(time=10);
      :_FillValue = -999; // int
      :units = "percent";
      :long_name = "laser power percent";
      :comment = "Percent of nominal factory setting.";
      :actual_range = "0, 999";
      :_ChunkSizes = 1024U; // uint

    int laser_temperature(time=10);
      :_FillValue = -999; // int
      :units = "celsius";
      :long_name = "laser temperature";
      :actual_range = "-50, 99";
      :_ChunkSizes = 1024U; // uint

    float latitude;
      :_FillValue = -999.0f; // float
      :units = "degrees_north";
      :long_name = "latitude";
      :standard_name = "latitude";
```

```
    int layer(layer=5);
      :_FillValue = -999; // int
      :units = "layer";
      :long_name = "layer";
      :actual_range = "1, 5";
      :comment = "Running number of the observed layer (cloud or aerosol)";

    float longitude;
      :_FillValue = -999.0f; // float
      :units = "degrees_east";
      :long_name = "longitude";
      :standard_name = "longitude";

    int mean_boundary_layer_height(time=10);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "mean boundary layer height";
      :comment = "Mean boundary layer height for the period of one hour.";
      :_ChunkSizes = 1024U; // uint

    int mean_boundary_layer_quality(time=10);
      :_FillValue = -999; // int
      :long_name = "mean boundary layer quality";
      :comment = "Mean boundary layer quality index over the previous hour.";
      :actual_range = "0, 3";
      :_ChunkSizes = 1024U; // uint

    String measurement_parameters(time=10);
      :_FillValue = "/////////";
      :long_name = "measurement parameters";
      :comment = "9 chars, see Vaisala CL51 User\'s Guide for interpretation.";
      :_ChunkSizes = 1024U; // uint

    int overall_status(time=10);
      :_FillValue = -999; // int
      :long_name = "instrument overall status";
      :actual_range = "0, 2";
      :comment = "0 = Self-check OK, 1 = At least one warning active, no
alarms, 2 = At least one alarm active.";
      :_ChunkSizes = 1024U; // uint

    int pblh_algorithm_sensitivity;
      :_FillValue = -999; // int
      :long_name = "pblh algorithm sensitivity";
      :comment = "PBLH algorithm sensitivity, default is 10. The smaller the
value, the higher the sensitivity.";
      :actual_range = "0, 20";

    int pblh_temporal_averaging(time=10);
      :_FillValue = -999; // int
      :units = "s";
      :long_name = "pblh temporal averaging";
      :comment = "Amount of temporal averaging used to compute the boundary
layer height.";
```

```
      :_ChunkSizes = 1024U; // uint

    int range(range=1540);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "measurement range";
      :actual_range = "10, 15400";
      :axis = "Z";
      :positive = "up";
      :comment = "Measurement distance from the instrument in the direction of
the transmitted laser beam.";

    int range_resolution;
      :long_name = "range resolution";
      :comment = "Distance between consecutive profile elements.";
      :_FillValue = -999; // int
      :units = "m";

    String self_diagnostics_info(time=10);
      :_FillValue = "////////////";
      :long_name = "self diagnostics information";
      :comment = "12 chars, see Vaisala CL51 User\'s Guide for
interpretation.";
      :_ChunkSizes = 1024U; // uint

    int sky_condition_cloud_layer_covers(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "oktas";
      :long_name = "cloud cover per cloud layer";
      :comment = "Amount of cloud cover for different cloud layers for up to 5
layers.";
      :coordinates = "time layer longitude latitude";
      :averaging_time_in_seconds = 1800; // int
      :_ChunkSizes = 1U, 5U; // uint

    int sky_condition_cloud_layer_heights(time=10, layer=5);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "cloud layer heights";
      :comment = "Heights for different cloud layers for up to 5 layers.
Reported in the vertical or in the instrument beam direction, depending on the
angle_corr setting of the instrument.";
      :coordinates = "time layer longitude latitude";
      :averaging_time_in_seconds = 1800; // int
      :_ChunkSizes = 1U, 5U; // uint

    float sunrise_utc(time=10);
      :_FillValue = -999.0f; // float
      :long_name = "sunrise UTC";
      :comment = "UTC sunrise time in hours after midnight (decimal number).";
      :_ChunkSizes = 1024U; // uint

    float sunset_utc(time=10);
      :_FillValue = -999.0f; // float
      :long_name = "sunset UTC";
```

```
      :comment = "UTC sunset time in hours after midnight (decimal number).";
      :_ChunkSizes = 1024U; // uint

    int tilt_angle(time=10);
      :_FillValue = -999; // int
      :units = "degrees";
      :long_name = "tilt angle";
      :comment = "Instrument\'s tilt angle from the vertical.";
      :standard_name = "zenith_angle";
      :actual_range = "0, 90";
      :_ChunkSizes = 1024U; // uint

    double time(time=10);
      :_FillValue = -999.0; // double
      :units = "seconds since 1970-01-01 00:00:00.000";
      :long_name = "time";
      :axis = "T";
      :standard_name = "time";
      :cf_role = "profile_id";
      :comment = "Represents the end of the averaging period.";
      :_ChunkSizes = 512U; // uint

    float time_zone;
      :_FillValue = -999.0f; // float
      :units = "hours";
      :long_name = "time zone";
      :comment = "Instrument’s time zone. Negative to the west and positive to
the east of Coordinated Universal Time.";

    int vertical_visibility(time=10);
      :comment = "Reported in the instrument beam direction.";
      :coordinates = "time longitude latitude";
      :units = "m";
      :long_name = "vertical visibility";
      :_FillValue = -999; // int
      :_ChunkSizes = 1024U; // uint

    int vv_highest_signal_detected(time=10);
      :_FillValue = -999; // int
      :units = "m";
      :long_name = "vertical visibility highest signal detected";
      :comment = "Reported only together with vertical visibility (detection
status 4). Represents the most distant range that gave a meaningful return.";
      :_ChunkSizes = 1024U; // uint

    int window_condition(time=10);
      :_FillValue = -999; // int
      :units = "percent";
      :long_name = "window condition";
      :comment = "100 for a clean, 0 for a totally dirty window.";
      :actual_range = "0, 100";
      :_ChunkSizes = 1024U; // uint

  // global attributes:
  :title = "Vaisala Ceilometer CL51";
```

```
  :institution = "Vaisala";
  :source = "CL51 gateway";
  :conventions = "CF-1.8";
  :schema_version = "v1.0";
  :gateway_firmware_version = "2.10.0";
  :history = "";
  :comment = "example file content";
  :unit = "m";
  :file_temporal_span_in_minutes = 5; // int
  :profile_interval_in_seconds = 30; // int
  :overlap_is_corrected = 1; // int
  :wigos_station_id = "";
  :wmo_id = "";
  :references = "";
  :instrument_firmware_version = 210; // int
  :firmware_config_version = "1.0.3 2025-01-07T09:54:19Z
28a3809ed4dae439ee632351028e05973674650db973fdd29eebd20b623c19b1";
  :pblh_algorithm_version = "1.1.0";
}
```

More information

- NetCDF files (page 86)

Appendix D. UL/CSA C22.2 regulatory caution and warning statements

Note the following warning label on the product:

Notez l'étiquette d'avertissement suivante sur le produit:



WARNING! Use only copper cable for the AC (mains) connection. The cable must have the same operating temperature as the device.
AVERTISSEMENT ! Pour le raccordement au secteur, veuillez uniquement utiliser un câble en cuivre. Le câble doit avoir la même température de fonctionnement que l'appareil.

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Technical support



Contact Vaisala technical support at helpdesk@vaisala.com. Provide at least the following supporting information as applicable:

- Product name, model, and serial number
- Software/Firmware version
- Name and location of the installation site
- Name and contact information of a technical person who can provide further information on the problem

For more information, see vaisala.com/support.

Recycling



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