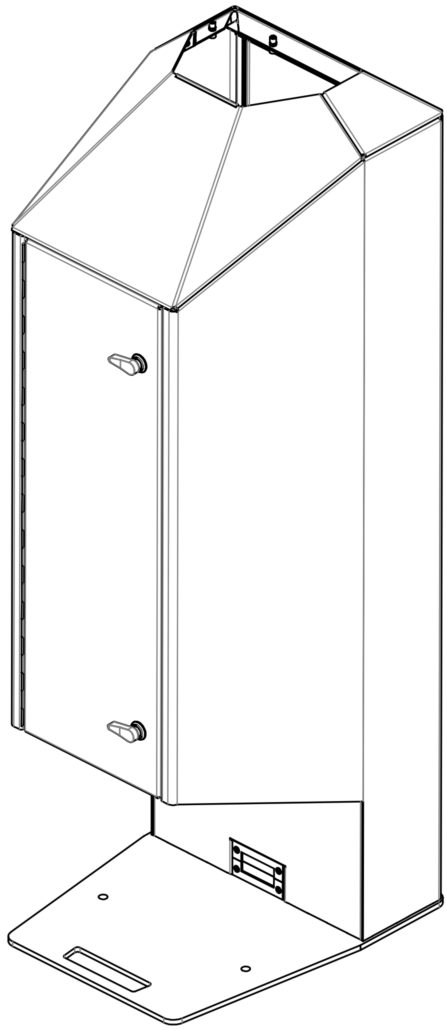
M212475EN-D

User Guide

Vaisala Lidar Ceilometer

CL61



VAISALA

PUBLISHED BY

Vaisala Oyj
Vanha Nurmijärventie 21, FI-01670 Vantaa, Finland
P.O. Box 26, FI-00421 Helsinki, Finland
+358 9 8949 1

Visit our Internet pages at www.vaisala.com.

Table of contents

1. About this document

1.1 Version information

This document provides a description of Vaisala Lidar Ceilometer CL61 and instructions for configuring and maintaining CL61.

Table 1 Document versions (English)

Document code	Date	Description
M212475EN-D	February 2022	For release 1.1 • Command list updated with new commands **`configure sender`** and **`elog`** • NetCDF message format updated • Sky condition reporting added • Status information updated • Tilt angle reporting added • Window condition monitoring added Other changes: • Document name changed from *Vaisala Lidar Ceilometer CL61 Configuration and Maintenance Guide* to *Vaisala Lidar Ceilometer CL61 User Guide* • Maintenance checklist added • SW update instruction using CLI removed
M212475EN-C	October 2021	This document combines previously published documents *Vaisala Lidar Ceilometer CL61 Technical Description* (M212473EN) and *Vaisala Lidar Ceilometer CL61 User Guide* (M212475EN). In addition, the following changes have been made: • Safety information updated
M212475EN-B	March 2021	First version for production.

1.2 Related manuals

Table 2 CL61 manuals

Document code	Name
M212499EN	*Vaisala Lidar Ceilometer CL61 Product and Package Description*
M212474EN	*Vaisala Lidar Ceilometer CL61 Installation Guide*
M212475EN	*Vaisala Lidar Ceilometer CL61 User Guide*

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.

Note highlights important information on using the product.

Tip 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.

Microsoft® and Windows® are either registered trademarks or trademarks of Microsoft Corporation in the United States and other countries.

All other product or company names that may be mentioned in this publication are trade names, trademarks, or registered trademarks of their respective owners.

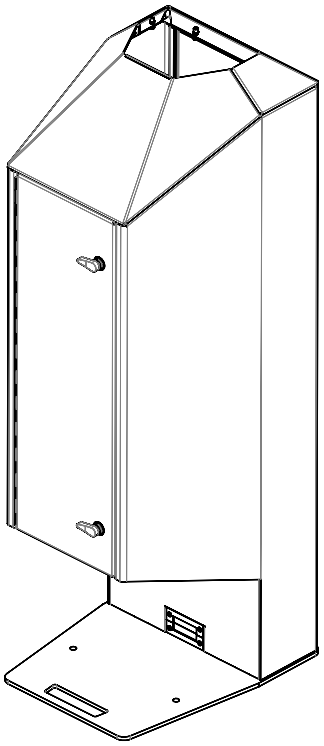
1.5 Patent notice

This product is protected by the following patents and patent applications and their corresponding national rights:

- International Publication Number WO 2011/135183 A1

2. Product overview

2.1 Vaisala Lidar Ceilometer CL61



Vaisala Lidar Ceilometer CL61 is a high-performance light detection and ranging (LiDAR) instrument with depolarization measurement capable of unattended operation 24/7 in all weather conditions. The depolarization measurement capability enables clear liquid/solid differentiation for particles and clouds, providing ready-to-use information for atmospheric characterization.

The ceilometer uses pulsed diode laser LiDAR technology where short, powerful laser pulses are sent out in a vertical or near-vertical direction. The reflection of light, backscatter – caused by clouds, precipitation, virga, haze, fog, and aerosols – is measured as the laser pulses traverse the sky. The ceilometer processes these returns and reports the resulting profiles of attenuated backscatter, linear depolarization ratio and cloud base heights.

The ceilometer detects up to 5 cloud layers simultaneously. If the cloud base is obscured due to heavy precipitation or 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.

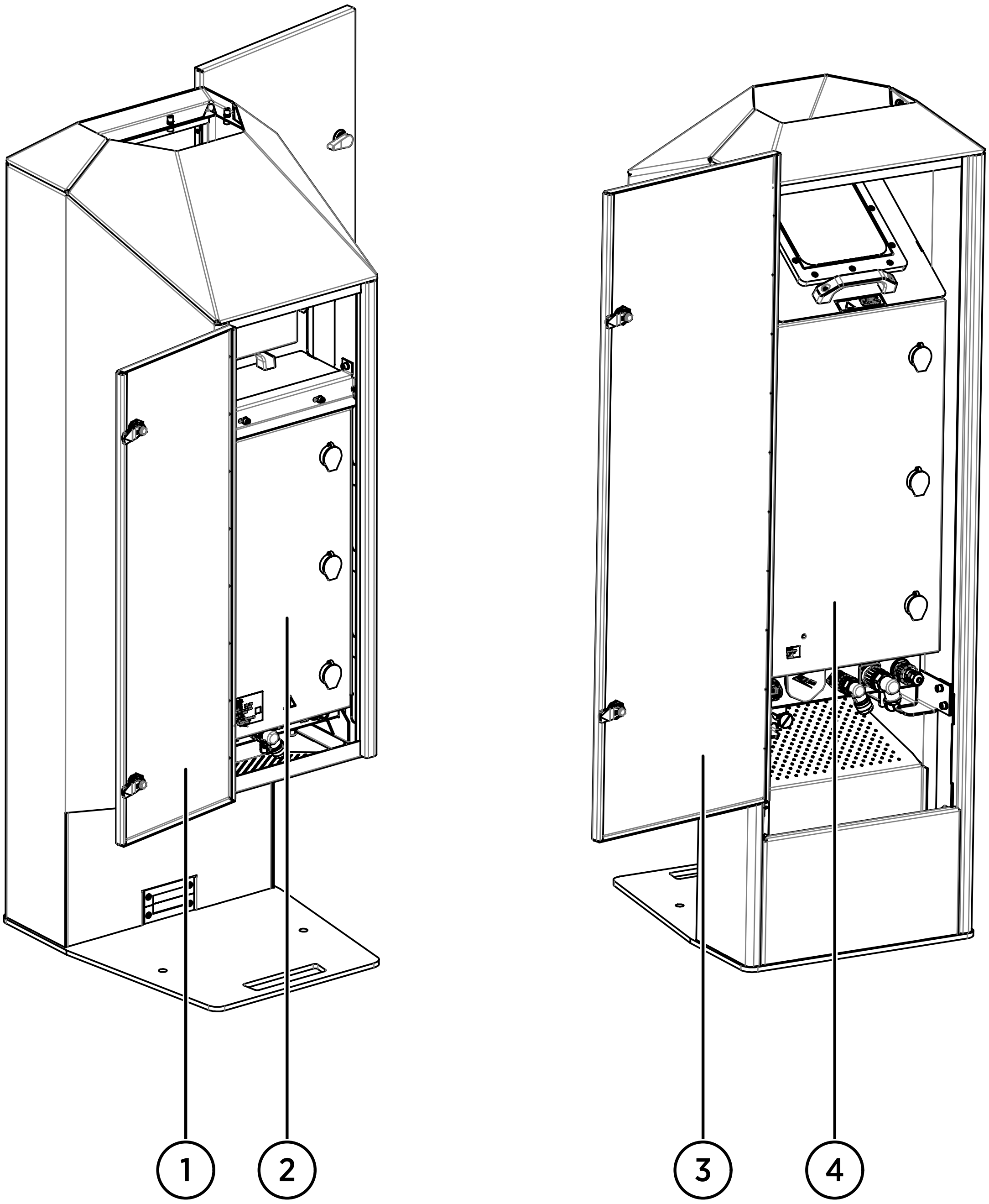


Figure 1 CL61 structure

1 Unit front door
2 Interface unit
3 Unit back door
4 Measurement unit

2.2 Product nomenclature

Table 3 Vaisala Lidar Ceilometer CL61 main parts

Code	Common name
CLO611	Optics unit
CLW611	Window
CLT611	Transmitter module
CLR611	Receiver module
CLC611	Device control module
CLP611	Polarization unit
CLS611	Servo drive module
CLL611	Laser power monitor
CLO611CB	Environmental sensor
CLH611	Internal heater module
One of the following: • CLB611-230 • CLB611-115	One of the following: • Window blower module 230 V • Window blower module 120 V
One of the following: • CBL210996 • CBL211048	One of the following: • AC power cable 230 V AC 5 m • AC power cable 120 V AC 5 m
CBL210983-11M	Data cable 10 m
CBL210983-2M	Maintenance cable 2 m
CBL210915	Receiver coaxial cable

Table 4 Vaisala Lidar Ceilometer CL61 optional parts

Code	Common name
ASM214227	Bird deterrent kit
CL61TERMHOOD	Optical termination hood
CL61SHOCKABSORBER	Shock absorber

The complete delivery also includes:

- *Vaisala Lidar Ceilometer CL61 Product and Package Description*
- Installation accessories
- *Vaisala Lidar Ceilometer CL61 Installation Guide*

2.3 Mechanical structure

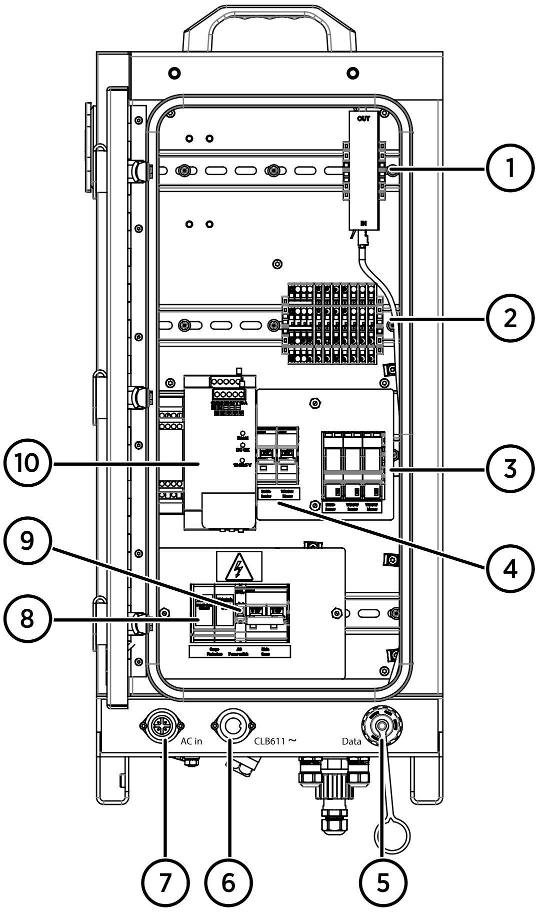


Figure 2 Interface unit

1 Data line or Ethernet surge protector
2 Terminal strip
3 Window blower, window heater and internal heater control
4 Window blower and internal heater switch
5 Data port
6 Window blower port
7 AC in
8 Surge protectors and fuses
9 AC (mains) power switch
10 AC/DC power supply

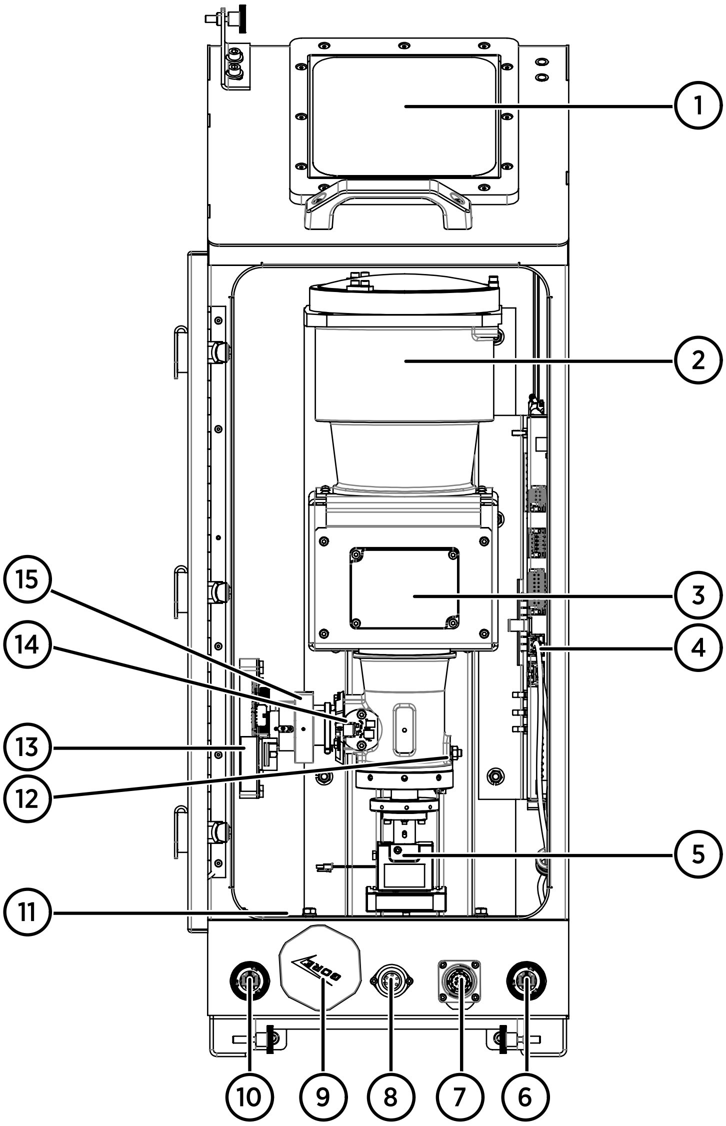


Figure 3 Measurement unit

1	Window CLW611
2	Optics unit CLO611
3	Servo drive module CLS611
4	Device control module CLC611
5	Transmitter module (including optics) CLT611
6	Interface unit (data)
7	Interface unit (control)
8	AC/DC in
9	Ventilation plug
10	Maintenance port
11	Internal heater module CLH611
12	Laser power monitor CLL611
13	Receiver module CLR611
14	Environmental sensor CLO611CB
15	Polarization unit CLP611

2.4 Safety

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

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

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.

2.4.1 Eye safety

This Vaisala Lidar Ceilometer CL61 is classified as a Class 1M optical device in accordance with International Standard IEC / EN 60825-1:2014. It complies with 21 CFR 1040.10 and 1040.11 except for the deviations pursuant to the Laser Notice No. 56.

Table 5 Incorporated laser (CLT611 transmitter)

Property	Value
Laser wavelength	910.55 nm
Maximum pulse power	50 W
Maximum average power	70 mW
Typical beam divergence	±7 degrees
Pulse frequency	9.5 kHz
Pulse length	160 ns

Table 6 Radiated pattern emitted from protective housing, from CL61 window

Property	Value
Laser wavelength	910.55 nm typical
Maximum pulse power	40 W
Maximum average power	50 mW

Property	Value
Typical beam divergence	±0.2 mrad × ±0.35 mrad
Pulse frequency	9.5 kHz
Pulse length	160 ns

The device is equipped with the following labels:

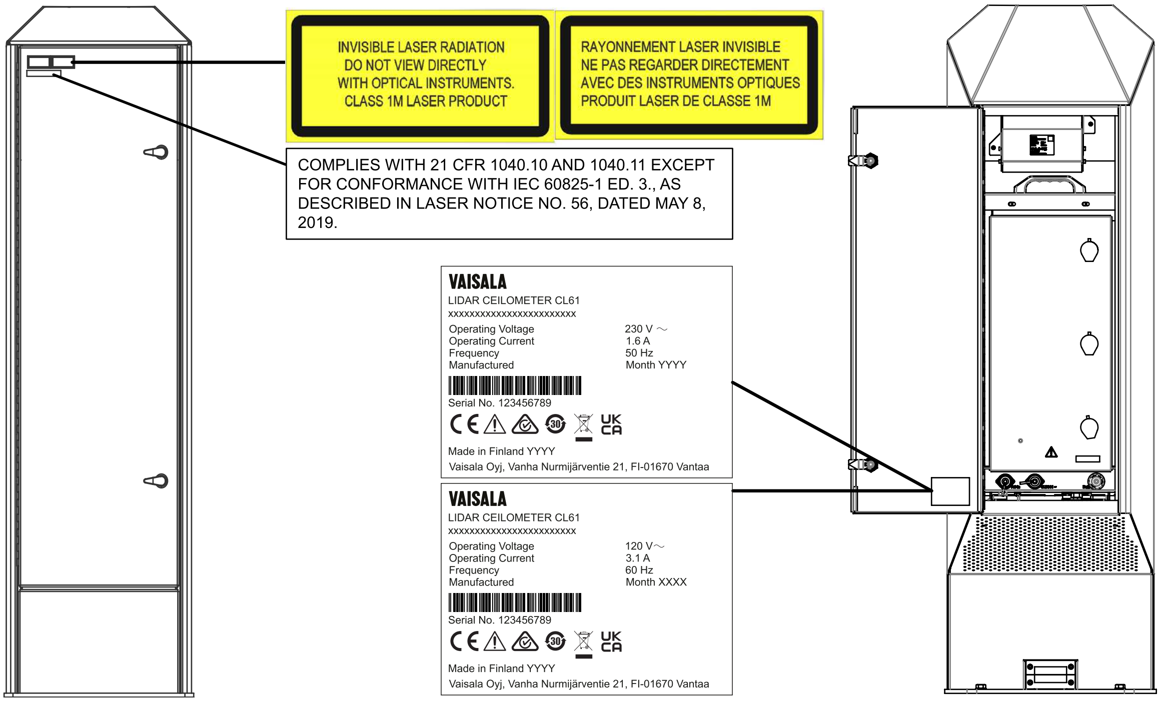


Figure 4 Location of explanatory and certification labels on CL61

Take the following precautions during installation, operation, and maintenance:

WARNING! Viewing the laser output with telescopic optical instruments (for example, telescopes or binoculars) may pose an eye hazard. Do not direct the beam into an area where such instruments are likely to be used.

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

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

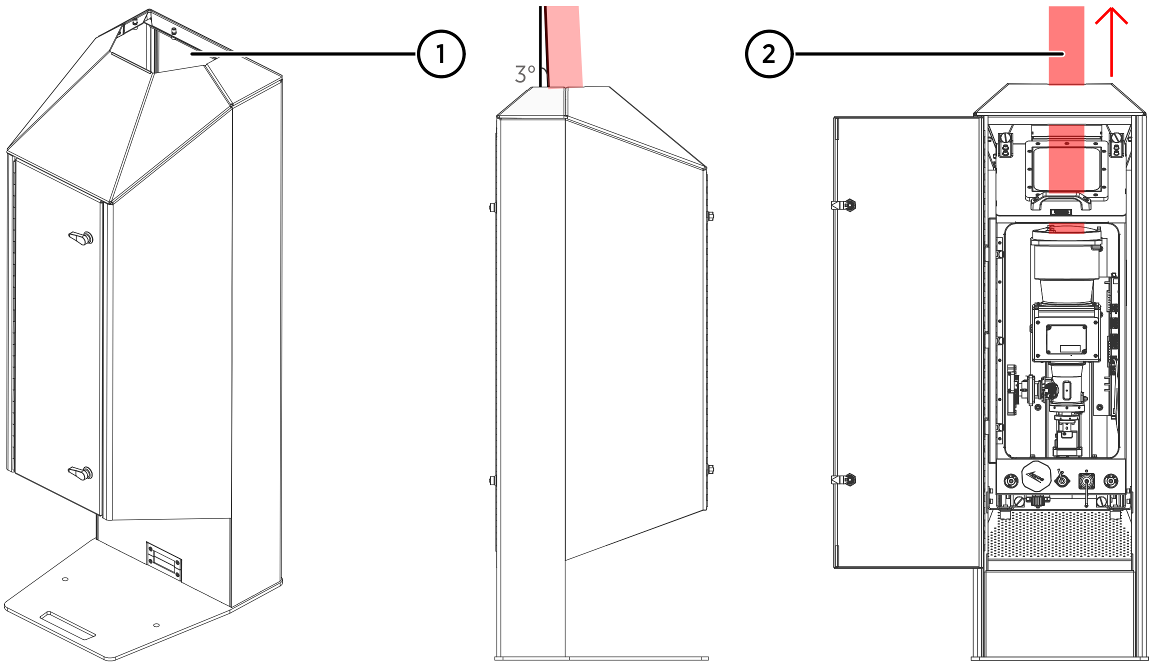


Figure 5 Location of CL61 laser aperture

1 Laser aperture
2 Laser class 1M, direction of transmitted light

Laser class of the incorporated laser (transmitter module CLT611) is 3B.

The transmitter module has a laser aperture and label as shown in the following figure. Avoid exposure to the beam from the aperture.

WARNING! Do not remove the transmitter module CLT611 from its normal position without first switching off both the AC (mains) line and the battery power.

WARNING! Do not look at the transmitter module CLT611 of the ceilometer from the beam direction when the transmitter is powered.

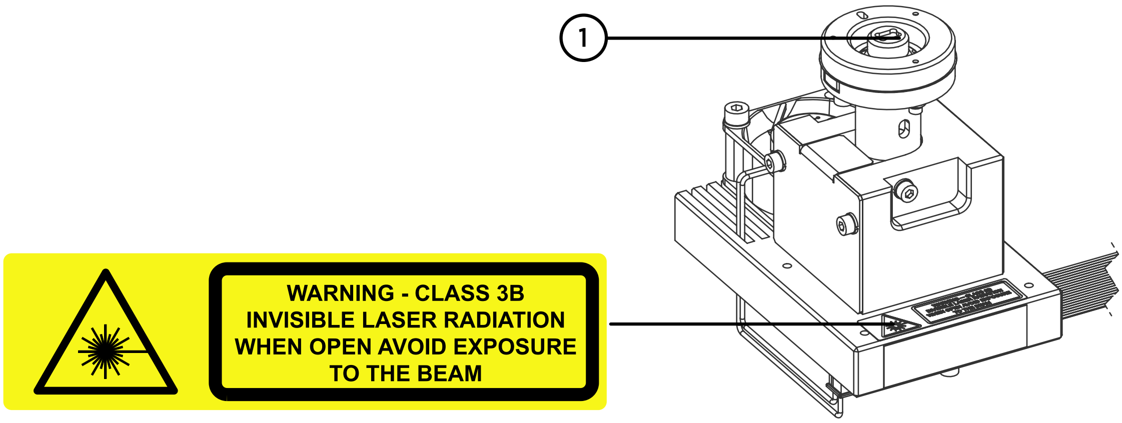


Figure 6 Location of warning and explanatory labels on transmitter module CLT611

1 Laser aperture

2.4.2 Hot surface safety

The internal heater module CLH611 gets hot when the heater is activated.

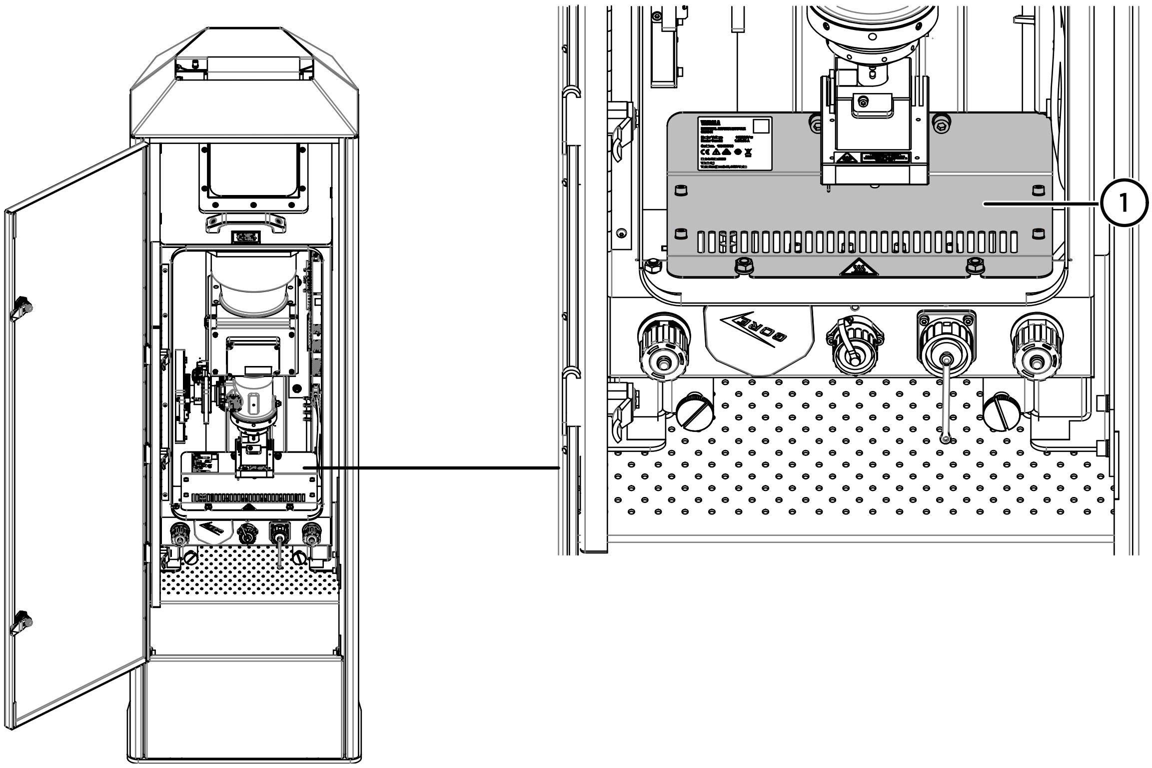


Figure 7 Location of hot surface and label

1 Potentially hot surface and warning label

2.4.3 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. Configuration

CL61 data is reported in netCDF file format and the file output can be configured.

When you have installed and activated ceilometer and it is sending data, there are still some settings to configure. You can, for example, set the location information of the ceilometer and define the measurement profile and netCDF reporting parameters, including filenames.

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

More information

- Configuring location information (page 19)
- Configuring netCDF reporting (page 20)

3.1 Establishing maintenance connection

- Laptop with terminal software that supports SSH (for example, freeware TeraTerm or latest version of PuTTY)
- Ethernet maintenance cable

Use of the maintenance connection is allowed only when maintenance operations are performed at qualified locations. CL61 does not comply with EMC standards when the door is open. The door has a conductive gasket to suppress electromagnetic radiation. When CL61 is used for normal operation, the door must always be closed.

The maintenance connection is established with the Ethernet maintenance cable included in the delivery, connecting the PC or laptop to the maintenance port of the ceilometer. The Ethernet maintenance port is located at the bottom of the measurement unit.

Push the plug into the port and turn 90º to lock in place.

The following steps use the PuTTY terminal software as an example.

1. Connect your laptop to the maintenance port of CL61 with the Ethernet maintenance cable.

   > Maintenance port: eth0
   > Data port: eth1

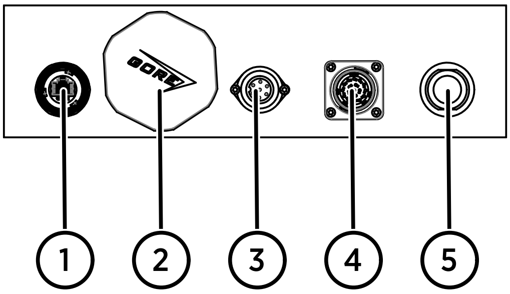


Figure 8 Measurement unit connectors, back of ceilometer

1 Ethernet maintenance port (eth0)
2 Ventilation plug
3 AC/DC in
4 Interface unit (control)
5 Interface unit (data)

> **CAUTION!** Remove the Ethernet maintenance cable after setup. It is not intended for permanent installation.

2. Configure your computer settings to match the CL61 network settings.

   a. From your computer **Control Panel**, open **Network and Internet** / **Network and Sharing Center**.

   b. Select **Change adapter settings**.

   c. Right-click **Ethernet** and select **Properties**.

   d. Double-click **Internet Protocol Version 4 (TCP/IPv4)**.

   e. Fill in **IP address**, **Subnet mask**, and **Default gateway** using the following computer settings.
   The following instructions use the default IP of `172.17.0.2`. Make sure that you know the IP address of the device you are establishing connection with.

Property	Value
IP address	172.17.0.5
Subnet mask	255.255.255.0
Default gateway	172.17.0.1

   f. After configuring your computer settings, select **OK** on both pop-up windows to close them. The settings save and apply when the windows are closed.

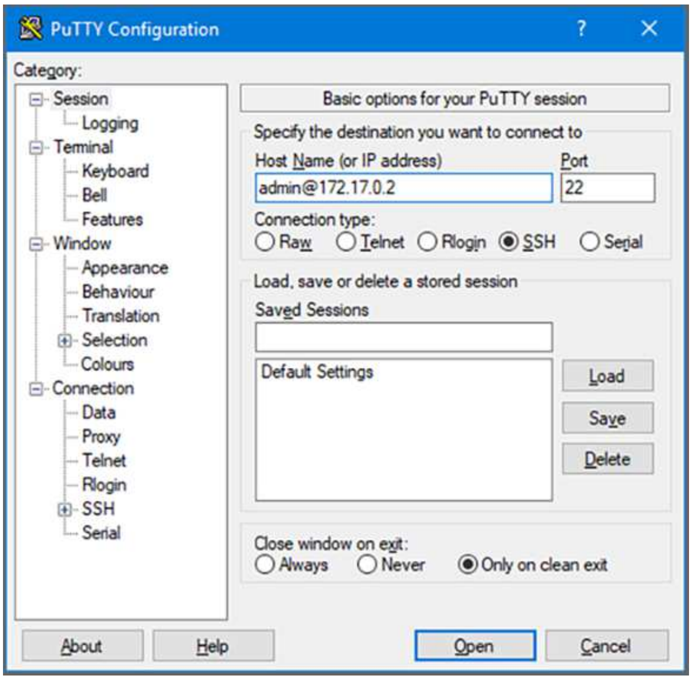
3. Open the command prompt app on your laptop.

4. Test if you can connect to CL61 by typing the following in command prompt:

```
ping 172.17.0.2
```

5. Open the terminal software.
6. In the **PuTTY Configuration** window, type in **Host Name** the following:

```
admin@172.17.0.2
```



Do not modify the other settings.
Select **Open**.

7. In the **Security Alert** window, accept the key.
8. When prompted, type the admin password.

For security reasons the password does not display in the interface window as you type it, but the keystrokes register. Type the password as normal.

CAUTION! If you forget the admin password, you cannot retrieve it without factory resetting the device (requires device activation code).

3.2 Configuring location information

- Laptop
- Maintenance cable

When starting to use CL61, define the device identifier and device location information.

This information helps to distinguish several devices from each other and provides metadata for the measurements.

The configurable unit metadata settings are listed in the following table. Use the settings that are suitable for you.

Table 7 Unit metadata

Parameter	Description	Value / range	GET	SET
`cl.unit.alias1`	Alias name 1	Freeform text	0	1
`cl.unit.latitude`	Latitude Unit: degrees	−90.000000 ... 90.000000	0	1
`cl.unit.longitude`	Longitude Unit: degrees	−180.000000 ... 180.000000	0	1
`cl.unit.altitude`	Altitude Unit: Meters Resolution: full meters Use negative value (-) for values below sea level	−999 ... 9999	0	1

1. Establish a connection to CL61.
2. Change the user level:

```
level 1
```

3. Configure the device identifier:

```
set cl.unit.alias1 <alias>
```

4. To set the device location, type the latitude, longitude, and altitude information:

```
set cl.unit.latitude <latitude>
```

```
set cl.unit.longitude <longitude>
```

- For latitude the range is -90.0000 ... 90.0000.
- For longitude the range is -180.0000 ... 180.0000.

```
set cl.unit.altitude <altitude>
```

For altitude, the resolution is full meters. Use negative value (-) for values below sea level.

More information

- CL61 configuration parameters (page 24)

3.3 Configuring netCDF reporting

- Laptop
- Maintenance cable

When you have set up the data collection in CL61, CL61 starts generating netCDF files. To customize the data output, you can define an averaging scheme for the measurements, and set netCDF attributes and netCDF file naming.

1. Change the user level.

```
level 1
```

2. Define the averaging settings.

```
set algo.1averaging.interval <averaging interval>
set algo.1averaging.depolinterval <averaging interval>
set reporting.profile.interval <profile interval>
set reporting.livefile.profilesperfile <number of profiles>
```

The maximum averaging is 2 minutes inside CL61. If you want additional averaging, do this outside CL61, for example, in Matlab.
The backscatter profiles and the depolarization ratio profile have separate averaging schemes.
The interval parameters are a multiple of 5-second profiles (n × 5).
The following table shows examples of measurement averaging schemes.

Parameter	Value
DEFAULT	
5 profiles with 1-minute averaging, 5-minute file	
`algo.l1averaging.interval`	12
`algo.l1averaging.depolinterval`	12
`reporting.profile.interval`	12
`reporting.livefile.profilesperfile`	5
MAXIMUM RESOLUTION	
12 profiles with 5-second averaging, 1-minute file	
`algo.l1averaging.interval`	1
`algo.l1averaging.depolinterval`	2
`reporting.profile.interval`	1
`reporting.livefile.profilesperfile`	12
24 ABS profiles with 5-second averaging, 24 DEPOL profiles with 1-minute rolling averaging, 2-minute file	
`algo.l1averaging.interval`	1
`algo.l1averaging.depolinterval`	12
`reporting.profile.interval`	1
`reporting.livefile.profilesperfile`	24
30 profiles with 2-minute averaging, 60-minute file	
`algo.l1averaging.interval`	24
`algo.l1averaging.depolinterval`	24
`reporting.profile.interval`	24
`reporting.livefile.profilesperfile`	30

The following table explains the parameters.

Parameter	Description	Value / range	Default
`algo.l1averaging.interval`	Averaging interval for ABS, XPOL, and PPOL in L1 / Number of 5 s profiles averaged in each x-polarization (XPOL), p-polarization (PPOL), and attenuated backscatter profile (ABS) Averaging refers to the running average, so for every 5 s profile, this parameter averages the number of previous profiles. The algorithm produces profiles in 5 second intervals. You can specify that profiles recorded in netCDF files are averaged by n × 5 s, where n = 1 ... 24. NOTE: Vaisala recommends setting n = 1 to enable the reprocessing of archived data sets with new algorithms in the future. While it may be useful to have n > 1 for compact file sizes, this limits reprocessing.	1 ... 24	12
`algo.l1averaging.depolinterval`	Averaging interval for depol in L1 / Number of 5 s profiles averaged in each depolarization profile For every 5-second profile, this parameter averages the number of previous profiles. The algorithm produces profiles in 5-second intervals.	1 ... 24	12
`reporting.profile.interval`	Interval for reporting to write out profiles Only every *n*th profile is written to the netCDF file where the *n* is this parameter. This parameter can be used to avoid overlapping averaging. For example, if `algo.l1averaging.interval` is set to **6** corresponding to a 30 s time span, this parameter can be set to **6** as well to get the profiles every 30 s.	1 ... no maximum	12
`reporting.livefile.profilesperfile`	Number of profiles that are written in each .nc file If `reporting.profile.interval` is set to **6** and this parameter is set to **4**, one netCDF file will cover 2 min of data (6 × 4 × 5 s).	1 ... 1440	5

3. Define the reporting unit (meters or feet).
   The measurements are always done in meters and the conversion to feet is done before writing the netCDF file.

```
set reporting.netcdf.unit <m|f>
```

4. Define what metadata to include in the netCDF files if needed.

```
set reporting.netcdf.institution
set reporting.netcdf.comment
```

5. Define how the netCDF files are named using prefixes if needed.

```
set reporting.livefile.nameprefix <prefix>
set cl.sender.fileprefix <prefix>
```

Parameter	Description
`reporting.livefile.nameprefix`	Adds user-selected prefix to the netCDF file when transferring the file to the customer server. Used to distinguish between live and archive files.
`cl.sender.fileprefix`	Adds user-selected prefix to netCDF file when transferring the file to the customer server. Used to distinguish files coming from different CL61 devices.

   The filename format is the following:
   <cl.sender.fileprefix><reporting.livefile.nameprefix>_YYYYMMDD_HHmmss.nc

6. Use the **get** command to check the changed configuration.

```
get algo
get reporting
```

The changes are visible in the netCDF files immediately.

More information

- CL61 configuration parameters (page 24)
- NetCDF files (page 31)
- NetCDF example file (page 70)

3.4 List of commands

The user commands are divided into the following groups:

- Configuration commands include commands such as **getset**, **level**, **set**, and **swupdate**, as well as the configuration parameters.
- Troubleshooting commands include **elog**, **reset**, **status**, and **system**.

To access the user commands, establish a maintenance terminal connection and provide the password. The command prompt opens.

Table 8 CL61 user commands

Command	Description
configure sender	Stores STFP server settings to ceilometer
elog	Displays event log
get <parameter>	Displays parameter value or parameter list values
getset <parameter> [<value>]	Displays parameter value or parameter list values with SET command included
help	Provides help on the commands and use
level [0|1|2]	Changes the user level (0, 1 or 2) Levels are: • 0 = Read access (default) • 1 = Write access to basic parameters • 2 = Write access to advanced parameters
reset	Resets the device
set <parameter> [<value>]	Sets parameter value or parameter list values
status	Displays the functional status on the device
swupdate	Updates the software version
system	Displays information on the device

3.5 CL61 configuration parameters

The following parameters are used with the **GET**, **GETSET**, and **SET** commands.

The following levels are in use:

- Level 0: read access
- Level 1: write access to basic parameters
- Level 2: write access to advanced parameters

To change the user level, use the **level** command.

Columns GET and SET indicate the required user level to view or change the setting.

Table 9 Product metadata

Parameter	Description	Value / range	GET	SET
`cl.product.model`	Product model	CL61D	0	-
`cl.product.modelname`	Product model name	CL61 with Depolarization	0	-
`cl.product.revision`	Product revision	A - Z	0	-

Table 10 Unit metadata

Parameter	Description	Value / range	GET	SET
`cl.unit.alias1`	Alias name 1	Freeform text	0	1
`cl.unit.latitude`	Latitude Unit: degrees	−90.000000 ... 90.000000	0	1
`cl.unit.longitude`	Longitude Unit: degrees	−180.000000 ... 180.000000	0	1
`cl.unit.altitude`	Altitude Unit: Meters Resolution: full meters Use negative value (-) for values below sea level	−999 ... 9999	0	1

Table 11 User parameters

Parameter	Description	Value / range	GET	SET
`cl.password.admin`	Admin user password	String	-	1

Table 12 Ethernet parameters

Parameter	Description	Value / range	Default	GET	SET
`eth0.address.mac`	MAC address	–	Set at factory, different for each device	0	-
`eth0.address.dhcp`	DHCP	• ON • OFF	–	0	-
`eth0.address.ip1`	IP address	172.17.0.2	–	0	-
`eth0.address.nm1`	Netmask	255.255.255.0	–	0	-
`eth0.address.gw1`	Gateway	172.17.0.1	–	0	-
`eth0.address.dns1`	DNS server1	172.17.0.1	–	0	-
`eth0.address.dns2`	DNS server 2	OFF	–	0	-
`eth1.address.mac`	MAC address	–	–	0	-

Parameter	Description	Value / range	Default	GET	SET
`eth1.address.dhcp`	DHCP	• ON • OFF	OFF	0	1
`eth1.address.ip1`	IP address	–	192.168.2.102	0	1
`eth1.address.nm1`	Netmask	–	255.255.255.0	0	1
`eth1.address.gw1`	Gateway	–	192.168.2.1	0	1
`eth1.address.dns1`	DNS server1	–	192.168.2.1	0	1
`eth1.address.dns2`	DNS server2	• ON • OFF	OFF	0	1

Restart the device after changing DNS settings.

Table 13 Time parameters

Parameter	Description	Value / range	Default	GET	SET
`time.sync.ntp1`	Network time protocol server address 1	• Address of NTP server • OFF	2.openembedded.pool.ntp.org (default)	0	1
`time.sync.ntp2`	Network time protocol server address 2	• Address of NTP sever • OFF	OFF	0	1
`time.unit.optime`	Unit operation since factory reset Unit: hours	0 ... 1000000	–	0	-
`time.unit.now`	Unit date and time, UTC	Format: YYYY-MM-DD HH:MM:SS	–	0	1

Table 14 Measurement parameters

Parameter	Description	Value / range	Default	GET	SET
`algo.l1averaging.interval`	Averaging interval for ABS, XPOL, and PPOL in L1 / Number of 5 s profiles averaged in each x-polarization (XPOL), p-polarization (PPOL), and attenuated backscatter profile (ABS) Averaging refers to the running average, so for every 5 s profile, this parameter averages the number of previous profiles. The algorithm produces profiles in 5 second intervals. You can specify that profiles recorded in netCDF files are averaged by n × 5 s, where n = 1 ... 24. NOTE: Vaisala recommends setting n = 1 to enable the reprocessing of archived data sets with new algorithms in the future. While it may be useful to have n > 1 for compact file sizes, this limits reprocessing.	1 ... 24	12	0	1
`algo.l1averaging.depolinterval`	Averaging interval for depol in L1 / Number of 5 s profiles averaged in each depolarization profile For every 5-second profile, this parameter averages the number of previous profiles. The algorithm produces profiles in 5-second intervals.	1 ... 24	12	0	1
`algo.tiltanglecorrection.enabled`	Correction of cloud height by tilt angle	• ON • OFF	OFF	0	1
`algo.cloudlayers.offsetinmeters`	Corrected cloud height by offset value Can be used when device is installed above or below reference height.	−999 ... 9999	0.0	0	1

Parameter	Description	Value / range	Default	GET	SET
`algo.airplanefilter.enabled`	Filtering outliers caused by low-altitude airplanes from cloud data Can be used when device is installed at an airport.	• ON • OFF	OFF	0	1

Table 15 Reporting parameters

Parameter	Description	Value / range	Default	GET	SET
`reporting.destination.address`	Destination	Valid URL	–	0	1
`reporting.netcdf.institution`	Institution attribute in the .nc file	Freeform text	–	0	1
`reporting.netcdf.conventions`	NetCDF convention attribute in the .nc filehttps://cfconventions.org/Data/cf-conventions/cf-conventions-1.8/cf-conventions.html	Acc. to CF-1.8	–	0	-
`reporting.netcdf.comment`	Comment attribute in the .nc file	Freeform text	–	0	1
`reporting.netcdf.unit`	Unit used for reporting vertical visibility, cloud base heights, and range	• m • ft	m	0	1
`reporting.profile.interval`	Interval for reporting to write out profiles Only every *n*th profile is written to the netCDF file where the *n* is this parameter. This parameter can be used to avoid overlapping averaging. For example, if `algo.l1averaging.interval` is set to **6** corresponding to a 30 s time span, this parameter can be set to **6** as well to get the profiles every 30 s.	1 ... no maximum	12	0	1
`reporting.livefile.profilesperfile`	Number of profiles that are written in each .nc file If `reporting.profile.interval` is set to **6** and this parameter is set to **4**, one netCDF file will cover 2 min of data (6 × 4 × 5 s).	1 ... 1440	5	0	1

Parameter	Description	Value / range	Default	GET	SET
reporting.livefile.nameprefix	Prefix in netCDF file name Used to distinguish between live and archive files See also cl.sender.fileprefix NetCDF filename format: <cl.sender.fileprefix><reporting.livefile.nameprefix>_YYYYMMDD_HHmmss.nc	Freeform text	–	0	1
reporting.archivefile.profilesperfile [1)]	Number of profiles written in each .nc file If the reporting.profile.interval is set to **6** and this parameter is set to **4**, one netCDF file covers 2 min of data (6 × 4 × 5 s).	0 = Archive file not written	–		
reporting.archivefile.nameprefix [1)]	Prefix in netCDF file name Used to distinguish between live and archive files See also cl.sender.fileprefix NetCDF filename format: <cl.sender.fileprefix><reporting.archivefile.nameprefix>_YYYYMMDD_HHmmss.nc	Freeform text	–		

1) *Available later*

Table 16 Sender configuration parameters

Parameter	Description	Value / range	GET	SET
cl.sender.fileprefix	Prefix in netCDF file name Used to distinguish files coming from different CL61 devices See also reporting.livefile.nameprefix and reporting.arhivefile.nameprefix NetCDF filename format: <cl.sender.fileprefix><reporting.livefile.nameprefix>_YYYYMMDD_HHmmss.nc	Freeform text	0	1
cl.sender.hostpubmd5	MD5 hash of the SSH server host key	String	1	1
cl.sender.publickey	Public key	String	1	-

Table 17 Alert parameters

Parameter	Description	Value / range	Default	GET	SET
`alerts.cl.recentlystarted`	After reset, time period for keeping recently restarted indication alert on Unit: seconds	0 ... 3600	180	2	-
`alerts.clo.tiltanglew`	Angle of ceilometer in degrees from vertical that triggers tilt angle warning		45	2	-
`alerts.clr.windowconditioni`	Limit for triggering `window condition` indication		80	2	-
`alerts.clr.windowconditionw`	Limit for triggering `window condition` warning		50	2	-
`alerts.clr.windowconditiona`	Limit for triggering `window condition` alarm		20	2	-
`alerts.clr.windowblockingratio`	Limit for triggering `window blocking` warning		0.2	2	-
`alerts.clt.lightsourcepowerw`	Limit for triggering TX `light source power` warning		80	2	-
`alerts.clt.lightsourcepowera`	Limit for triggering TX `light source power` alarm		60	2	-
`alerts.clt.lightsourcefailure`	Limit for triggering transmitter laser power failure		10	2	-

4. Data reporting

4.1 NetCDF files

Network Common Data Form (netCDF) is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array oriented scientific data.

The netCDF file name format is *<cl.sender.fileprefix><reporting.livefile.nameprefix>_YYYYMMDD_HHmmss.nc*, where:

- You can define 2 different types of prefixes to write in the netCDF filename.
- The last part is the timestamp when the file was created.

NetCDF is a set of interfaces for array-oriented data access and a freely distributed collection of data access libraries for C, Fortran, C++, Java, and other languages.

The netCDF format used in CL61 is built on netCDF-4 which is built on Hadoop Distributed File System (HDFS). You can open and read CL61 netCDF files with any HDFS or netCDF-4 reader, for example, Panoply.

NetCDF file format allows the grouping of data types into a single file. A netCDF file is made of one or several variables. Each variable consists of:

- Data: a multidimensional table or value
- Metadata: data that characterizes the data

CL61 netCDF files are sent using SFTP protocol to a customer server. The ceilometer is defined as a secure client using a key-based scheme. The files contain the following data:

- Time series of atmospheric backscatter and polarization profiles
- Time series of cloud heights and vertical visibility
- Time series of total cloud cover (sky condition)
- Time series of cloud layer specific covers and heights (sky condition)
- Metadata, including:
    - Interface version
    - Device identity and location
    - Device status and monitoring data

Table 18 NetCDF global attributes

Attribute	Description
Title	Type of the device
Institution	User configurable with CL61 configuration parameters
Source	Blank
Conventions	NetCDF convention version

Attribute	Description
History	Device firmware version, the version of the netCDF schema This attribute needs to be checked when parsing older files for backward compatibility. Instructions to be added when there are changes in the netCDF schema.
Comment	User configurable with CL61 configuration parameters
Unit	m
Temporal span of this file in minutes	Default 1 min
Time between consecutive profiles in seconds	Default 5 s

Table 19 Variables in output netCDF file

Variable name	Type	Dimension	Description	Unit
cloud_base_heights	int	time, layer	Heights (range) of the detected cloud bases	meters
vertical_visibility	int	time	Visibility in the direction of the instrument beam	meters
p_pol	float	time, range	Parallel-polarized component of the backscattered light (PPOL)	$m^{-1}sr^{-1}$
x_pol	float	time, range	Cross-polarized component of the backscattered light (XPOL)	$m^{-1}sr^{-1}$
beta_att	float	time, range	Attenuated volume backscatter coefficient (ABS)	$m^{-1}sr^{-1}$
linear_depol_ratio	float	time, range	Linear depolarization ratio of the backscatter volume (LDR)	-
time	double	time	Seconds since 1970-01-01 00:00:00.000	seconds
range	double	range	Distance in the direction of the instrument beam	meters
layer	int	layer	Number of the observed cloud layer (1, 2, 3, 4, 5)	-
longitude	double	time	Longitude	degrees east
latitude	double	time	Latitude	degrees north

Variable name	Type	Dimension	Description	Unit
elevation	int	time	Measurement site height above or below a fixed reference point, most commonly a reference geoid	meters
beta_att_sum	double	time	Scaled integral of the attenuated volume backscatter coefficient	$10^{-4}sr^{-1}$
beta_att_noise_level	double	time	A unitless number describing the noise level of the attenuated volume backscatter coefficient	-
tilt_correction	short	time	Use of tilt correction	
tilt_angle	float	time	Instrument tilt angle from the vertical	
height_offset	short	time	Instrument height offset to reference level Positive if the instrument is placed, for example, on the roof of a building. Negative if the instrument is placed below the ground level altitude, for example, in a pit. This value will be added to the cloud base height results.	meters
sky_condition_total_cloud_cover	short	time	Total amount of cloud cover	oktas
sky_condition_cloud_layer_covers	short	time, layer	Amount of cloud cover in different cloud layers	oktas
sky_condition_cloud_layer_heights	int	time, layer	Height of different cloud layers	meters

Table 20 NetCDF dimensions

Dimension	Description	Value
Time	Number of profiles in file	Depends on file length
Range	Length of single profile	3276
Layer	Number of reported cloud base heights	5

More information

- NetCDF example file (page 70)

4.2 NetCDF parameters

CL61 reports measurements in netCDF format.

CL61 provides 2 file feeds which can be configured separately:

- Archive feed (coming soon)
- Live feed

Functionally the feeds work in the same way, but the live feed is designed to be used with BL-View and the archive feed is designed to be used for archiving purposes.

To configure the feeds in the command line interface (CLI), see the instructions about configuring netCDF reporting and the list of parameters.

More information

- Configuring netCDF reporting (page 20)
- CL61 configuration parameters (page 24)

5. Maintenance

The ceilometer's self diagnostic system runs in the background and generates warnings and alarms according to issues discovered. The window blower and the polarization unit are automatically checked once an hour. Malfunctions are reported in data and status messages.

CL61 requires the following periodic maintenance.

Table 21 CL61 maintenance

Task	Frequency
Clean the window	As needed
Check the door gaskets	As needed
Perform a general check	Annually
Clean and maintain painted surfaces	Annually

Check warnings and alarms regularly using a PC with Ethernet connection.

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 perform periodic maintenance on 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

- Cleaning window (page 36)
- Checking door gasket (page 37)
- Cleaning and maintaining painted surfaces (page 37)

5.1 Cleaning window

WARNING! Viewing the laser output with telescopic optical instruments (for example, telescopes or binoculars) may pose an eye hazard. Do not direct the beam into an area where such instruments are likely to be used.

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

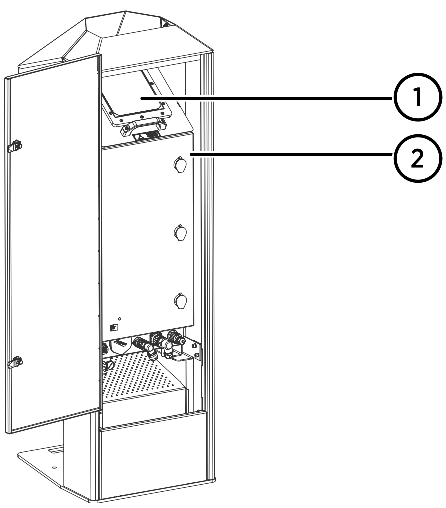
The status message and netCDF files include a warning when the window is contaminated. After the system has detected contamination, it starts the blower, which removes light contaminants and dries off raindrops.

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

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

   CAUTION! Do not use pressure cleaners.

   CAUTION! Avoid spraying water into the window blower.



1 Window
2 Measurement unit door

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

CAUTION! Be careful not to scratch the window surface.

5.2 Checking door gasket

The interface unit and measurement unit doors have 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.

5.3 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.

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

5.3.1 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.

5.3.2 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.

5.3.3 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.

6. Service instructions

WARNING! Do not remove the transmitter module CLT611 from its normal position without first switching off both the AC (mains) line and the battery power.

WARNING! Do not look at the transmitter module CLT611 of the ceilometer from the beam direction when the transmitter is powered.

WARNING! The transmitter replacement procedure is a service procedure and not maintenance. Contact Vaisala to replace the part.

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.

6.1 CL61 spare parts

Table 22 CL61 spare parts

Part name	Spare part code
Radiation shield	CL61SHIELDSP
Radiation shield top cover kit	CL61TOPCOVERSP
Window blower module	CLB611-230SP/CLB611-115SP
Termination hood	CL61TERMHOOD
Measurement unit	CLM611SP
Window kit	CLW611SP
Door seal for measurement unit	– [1]
Device control module	CLC611SP
Transmitter module	CLT611SP
Receiver module	CLR611SP

Part name	Spare part code
Servo drive module	CLS611SP
Internal heater module	CLH611SP
Interface unit	CLI611SP
Door seal for interface unit	– [1]
AC/DC power supply	CL61POWERSP
Laser monitoring module	CLL611SP
Surge protection unit for AC	CL61SURGESP
Surge protection unit for Ethernet	– [1]
Relay unit for module control: • Window blower control • Window blower heater control • Internal heater control	– [1]
AC power cable 230 V AC 5 m	CBL210996
AC power cable 120 V AC 5 m	CBL211048
Data cable 10 m	CBL210983-11M
Maintenance cable 2 m	CBL210983-2M
Receiver coaxial cable	CBL210915
Plastic part kit: • Gore valves • Cable passthrough	CL61PLASTICSP

1) *Available later.*

7. Software update

A backup is not needed before the software update.

The software update interrupts measurements.

7.1 Preparing software update

- Laptop with Vaisala Field Application software installed

Check that Vaisala Field Application opens on your computer.

The following instruction applies to Windows PCs.

1. Unzip the full software package into a folder on your computer. The package contains the firmware file and server program necessary for the software update.

   Before proceeding, delete any existing update folders and packages, or create a new folder to unzip the new update package into.

7.2 Updating software using field app

- Ethernet maintenance cable
- Laptop with Vaisala Field Application software installed

The laptop must support an Ethernet connection.

Before you start, make sure that:

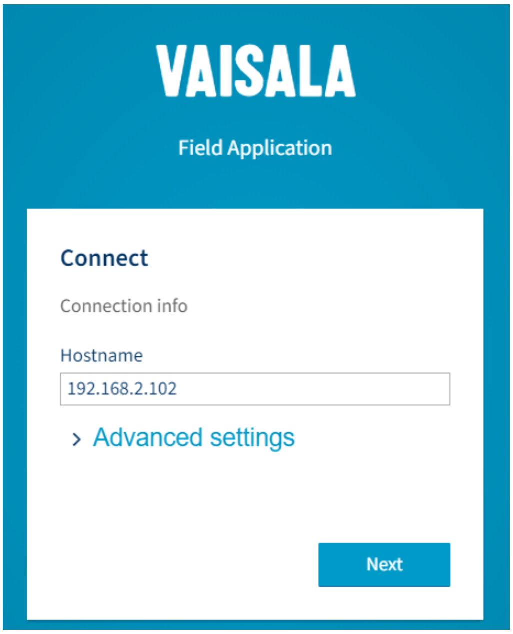
- You know the IP address of the device you are updating. The following instructions use the default IP of **192.168.2.102**.
- You know the admin password for the device. (Set the admin password during device activation, see *Vaisala Lidar Ceilometer CL61 Installation Guide*.)

The software update interrupts measurements.

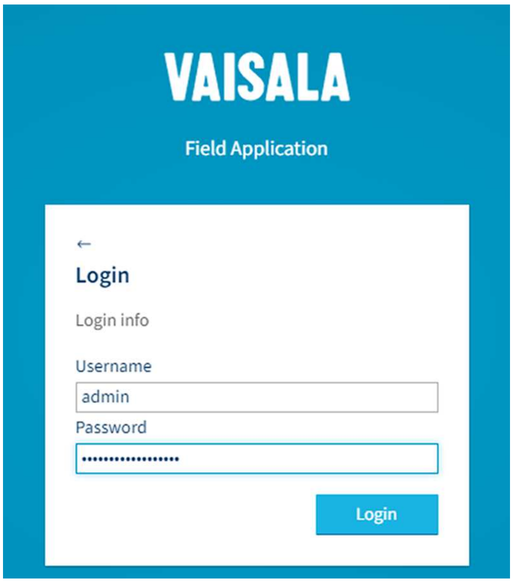
1. Connect your computer to the same network as the ceilometer.
   Use the Ethernet maintenance cable.

   CAUTION! Remove the Ethernet maintenance cable after setup. It is not intended for permanent installation.

2. Configure your computer settings to match the device (ceilometer) network settings.
3. Browse to the folder where you unzipped the software package on your computer.
4. Open Vaisala Field Application.
5. Type the device IP address.



6. Log in with username and password.



7. Select **Maintain > Update Firmware**.
8. Select **Browse** and browse to the software package you unzipped.
   Select **Open**.
9. Select **Update Firmware**.

Field app confirms the overall device status.

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 modules may be the source of problems:

- Polarization unit
- Window blower module
- Device control module
- Transmitter module
- Receiver module
- Servo drive module
- Internal heater module
- AC/DC power supply
- Laser monitoring module
- Surge protection units
- Relay unit for module control
- AC power cable 5 m
- Data cable 10 m
- Maintenance cable 2 m
- Receiver coaxial cable

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, and they must be performed according to the instructions. As a principle, user repairs are restricted to the replacement of modules.

More information

‣ CL61 spare parts (page 39)

8.2 Accessing diagnostic information

During normal operation, the ceilometer continuously monitors its internal status and reports the results in each netCDF file.

This information includes:

- Communications status monitoring
- Hardware monitoring such as heater, blower, and tilt angle monitoring
- Maintenance monitoring, such as window blocking and window condition monitoring

The ceilometer automatically identifies the potentially faulty subassemblies.

To establish a service connection to the ceilometer you must have a maintenance terminal, an Ethernet maintenance cable, and a laptop with TeraTerm or PuTTY terminal software. If you perform the operation check indoors, you must have an optical termination hood (CL61TERMHOOD), which absorbs the laser light that would otherwise reflect from the ceiling and possibly saturate the receiver.

CAUTION! Use of maintenance connection is allowed only when maintenance operations are performed at qualified locations. CL61 does not comply with EMC standards when the door is open. The door has a conductive gasket to suppress electromagnetic radiation. When CL61 is used for normal operation, the door must always be closed.

You can establish a 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.

More information

- Establishing maintenance connection (page 16)

8.3 Troubleshooting ceilometer

Troubleshoot the ceilometer using the **`status`** command.

The **`get`** command shows all parameters and values.

The following steps provide instructions on general troubleshooting.

1. Clean the window carefully with a soft, lint-free cloth moistened with a mild detergent. Make sure that you do not scratch the window surface.
2. Connect the maintenance terminal to the maintenance port at the bottom of the ceilometer and turn on both the ceilometer and the maintenance terminal.
3. Make sure that the ceilometer starts operating properly (DC power light is green). The command prompt opens automatically.
4. Type the **`status`** command and press **ENTER**.
5. 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 (1000 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.

8.4 Status information

To check status information:

- Use the command **`status`** in the CLI.
- See the status information in the netCDF file.

CL61 alerts can have up to 4 statuses.

The alert limits are based on alert configuration parameters. See CL61 configuration parameters (page 24).

Table 23 Alert status values

Value	Description
`O`	OK
`I`	Indication
`W`	At least one warning active, no alarms
`A`	At least one alarm active

The following tables list the possible status values in the order that they appear in the CLI status information response. The order and naming of items in the CLI status information response and in the netCDF file differ slightly.

Table 24 Device configuration (block 1 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Recent re-start occurred	Recently_started	0	Normal operation
		1	Device recently restarted

Table 25 Data communication (block 2 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Reporting destination URL	Measurement_data_destination_not_set	0	Reporting destination URL for output data set
		I	Reporting destination URL for output data not set
-	Measurement_status	0	OK
		W	Measurement failure, contact Vaisala Technical Support
-	Datacom_overall	0	OK

Table 26 Maintenance (block 3 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Maintenance overall	Maintenance_overall	0	OK
		I	Prepare for maintenance
		W	Maintenance recommended
		A	Immediate maintenance needed
Window condition	Window_condition	0	OK
		I	Window slightly contaminated Prepare for window cleaning in near future. Measurement data is valid.
		W	Window moderately contaminated Cleaning is recommended. Measurement data is valid.
		A	Window dirty Immediate window cleaning needed. Measurement data is NOT valid.
Window blocking	Window_blocking	0	OK
		W	Window intermittently blocked
		A	Window blocked

Table 27 Hardware (block 4 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Hardware overall	Device_overall	0	OK
		W	At least one warning
		A	At least one alarm
Transmitter	Transmitter_overall	0	OK
		W	At least one warning Check transmitter warnings
		A	At least one alarm Check transmitter warnings and alarms

Alert (CLI)	netCDF	Value	Description
Receiver	Receiver_overall	0	OK
		W	At least one warning Check receiver warnings
		A	At least one alarm Check receiver warnings and alarms
Servo drive module	Servo_drive_overall	0	OK
		W	At least one warning Check servo drive module warnings
		A	At least one alarm Check servo drive module warnings and alarms
Optics	Optics_unit_overall	0	OK
		W	At least one warning Check optics warnings
		A	At least one alarm Check optics warnings and alarms
Device control module	Device_controller_overall	0	OK
		W	At least one warning Check device control module warnings
		A	At least one alarm Check device control module warnings and alarms

Table 28 Transmitter (block 5 of CLI status information)

Alert (CLI)	netCDF	Value	Description
-	Transmitter_light_source	0	OK
		W	Warning
		A	Transmitter laser power failure, contact Vaisala Technical Support

Alert (CLI)	netCDF	Value	Description
TX light source power	Transmitter_light_source_power	0	OK
		W	Transmitter laser power low, contact Vaisala Technical Support
		A	Transmitter laser power very low, contact Vaisala Technical Support
TX module electronics	Transmitter_electronics	0	OK
		A	Laser power failure and memory failure Restart device and if issue persists, replace transmitter
-	Transmitter_memory	0	OK
		A	Memory failure Restart device and if issue persists, replace transmitter

Table 29 Receiver (block 6 of CLI status information)

Alert (CLI)	netCDF	Value	Description
RX module electronics	Receiver_electronics	0	OK
		A	Memory failure Restart device and if issue persists, replace receiver
-	Receiver_memory	0	OK
		A	Memory failure Restart device and if issue persists, replace receiver

Table 30 Servo drive module (block 7 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Polarizator electronics	Servo_drive_electronics	0	OK
		I	Polarizator not ready
		A	Polarizator initialization failure
		A	Polarizator failure Restart device and if issue persists, replace device control module

Alert (CLI)	netCDF	Value	Description
Polarizator electronics	Servo_drive_memory	0	OK
		A	Memory failure Restart device and if issue persists, replace device control module
-	Servo_drive_control	0	OK
		A	Polarizator servo control failure Restart device and if issue persists, replace device control module
-	Servo_drive_ready	0	OK
		W	Recent restart, waiting servo to be ready
		A	Polarizator servo is not ready, contact Vaisala Technical Support

Table 31 Optics (block 8 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Tilt angle	Optics_unit_tilt_angle	0	OK
		W	Tilt angle too steep
Optics electronics	Optics_unit_electronics	0	OK
		A	Memory failure Restart device and if issue persists, replace device control module
Optics electronics	Optics_unit_accelerometer	0	OK
		A	Tilt angle sensor failure Restart device
Optics electronics	Optics_unit_memory	0	OK
		A	Memory failure Restart device and if issue persists, replace device control module

Table 32 Device control module (block 9 of CLI status information)

Alert (CLI)	netCDF	Value	Description
Internal temperature sensor	Device_controller_temperature	0	OK
		A	Temperature sensor failure Restart device and if issue persists, replace device control module
Module electronics	Device_controller_electronics	0	OK
		A	Temperature sensor failure Restart device and if issue persists, replace device control module

Status information example (CLI)

```
Device configuration
  Recent re-start occurred        0 Normal operation

Data communication
  Reporting destination URL       0 Reporting destination URL for output
                                      data set

Maintenance
  Maintenance overall             0 OK
  Window condition                0 OK 99 %
  Window blocking                 0 OK

Hardware
  Hardware overall                0 OK
  Transmitter                     0 OK
  Receiver                        0 OK
  Servo drive module              0 OK
  Optics                          0 OK
  Device control module           0 OK

Transmitter
  TX Light source power           0 OK
  TX module electronics           0 OK

Receiver
  RX module electronics           0 OK

Servo drive module
  Polarizator electronics         0 OK

Optics
  Tilt Angle                      0 OK 3.9 °
  Optics electronics              0 OK

Device control module
  Internal temperature sensor     0 OK
  Module electronics              0 OK
```

Status information example in netCDF file

```
group: status {
    // group attributes:
    :Timestamp = "1640186884.550009";
    :Device_controller_temperature = "OK: 0";
    :Device_controller_electronics = "OK: 0";
    :Device_controller_overall = "OK: 0";
    :Optics_unit_accelerometer = "OK: 0";
    :Optics_unit_electronics = "OK: 0";
    :Optics_unit_overall = "OK: 0";
    :Optics_unit_memory = "OK: 0";
    :Optics_unit_tilt_angle = "OK: 0";
    :Receiver_electronics = "OK: 0";
    :Receiver_overall = "OK: 0";
    :Receiver_memory = "OK: 0";
    :Window_blocking = "OK: 0";
    :Window_condition = "OK: 0";
    :Servo_drive_electronics = "OK: 0";
    :Servo_drive_overall = "OK: 0";
    :Servo_drive_memory = "OK: 0";
    :Servo_drive_control = "OK: 0";
    :Servo_drive_ready = "OK: 0";
    :Transmitter_electronics = "OK: 0";
    :Transmitter_light_source = "OK: 0";
    :Transmitter_light_source_power = "OK: 0";
    :Transmitter_overall = "OK: 0";
    :Transmitter_memory = "OK: 0";
    :Maintenance_overall = "OK: 0";
    :Device_overall = "OK: 0";
    :Recently_started = "OK: 0";
    :Measurement_status = "OK: 0";
    :Datacom_overall = "OK: 0";
    :Measurement_data_destination_not_set = "Reporting destination URL for
output data set: 0";
```

8.5 Factory resetting ceilometer

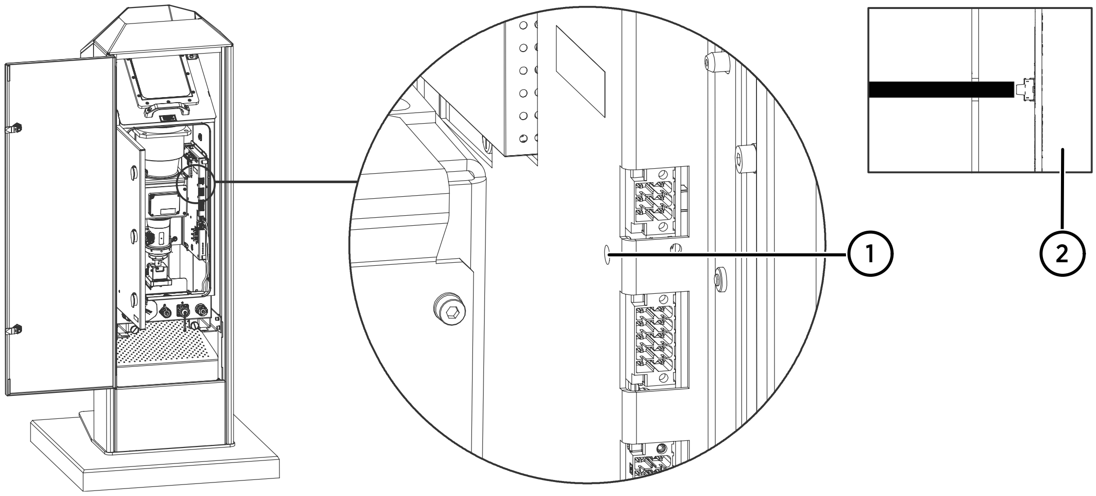
- Blunt instrument with an approximately 5-mm tip, for example Allen key

To reset the device, you need the device activation code, which is 16 characters long. The original delivery included 2 stickers that contain the device activation code.

Resetting the device (hard reset) restores factory settings. Reset the device if you have lost or forgotten the admin password or the configuration must be reset back to the original.

CAUTION! Using the device activation code restores factory settings in the device and clears all user and measurement data from the device.

1. Open the door of the measurement unit.
2. Locate the reset button on the device control module CLC611, inside the measurement unit.



1 Reset button
2 Pressing reset button with blunt instrument, side view

3. Press the button for 15 seconds.
   You can hear the device shutting down and starting after approximately 10 seconds, but keep the button pressed for approximately 15 seconds to complete the restart.
4. Close the measurement unit door.
5. Activate the ceilometer and copy the updated public key of the ceilometer to the SFTP server.
6. If the reset does not help, contact Vaisala.

9. Functional description

9.1 Operating principle

The ceilometer operating principle is based on LIDAR technology where short, powerful laser pulses are sent out in a vertical or near-vertical direction. The height measurement is based on the time-of-flight measurement. Time-of-flight is the time needed for a short pulse of light to traverse the atmosphere from the transmitter of the ceilometer to a backscattering particle and back to the receiver of the ceilometer.

The time delay between the launch of the laser pulse and the detection of the backscatter signal indicates the cloud base height.

The general expression connecting time delay and backscattering height is:

```
h = ct/2
```

Table 33 Operating principle formula

Variable	Description
h	Backscattering height
c	Speed of light ($c = 3.00 \times 10^8$ m/s)
t	Time delay

The receiver sees a reflection from 15 000 m (49 212 ft) after `t = 100 µs`.

9.2 Practical measurement signal

The emitted laser pulse is scattered by each particle it encounters on its path through the atmosphere. A portion of this light is scattered back towards the instrument and is registered. The rest of the light is either absorbed or scattered in directions not seen by the ceilometer. The portion of backscattered light registered by the ceilometer is called **attenuated backscatter**.

Each particle also interacts with the laser pulse by either maintaining or altering the polarization of the emitted light. The ceilometer registers changes in polarization and reports them as profiles called the **linear depolarization ratio**. The information in these profiles can be used to differentiate between liquid and solid particles.

The following figures show attenuated backscatter and depolarization ratio data covering a period of 1.5 days. The detected data shows liquid cloud layers, ice clouds and snow, as well as precipitation including the melting layer. The data also shows the aerosol signal in the boundary layer.

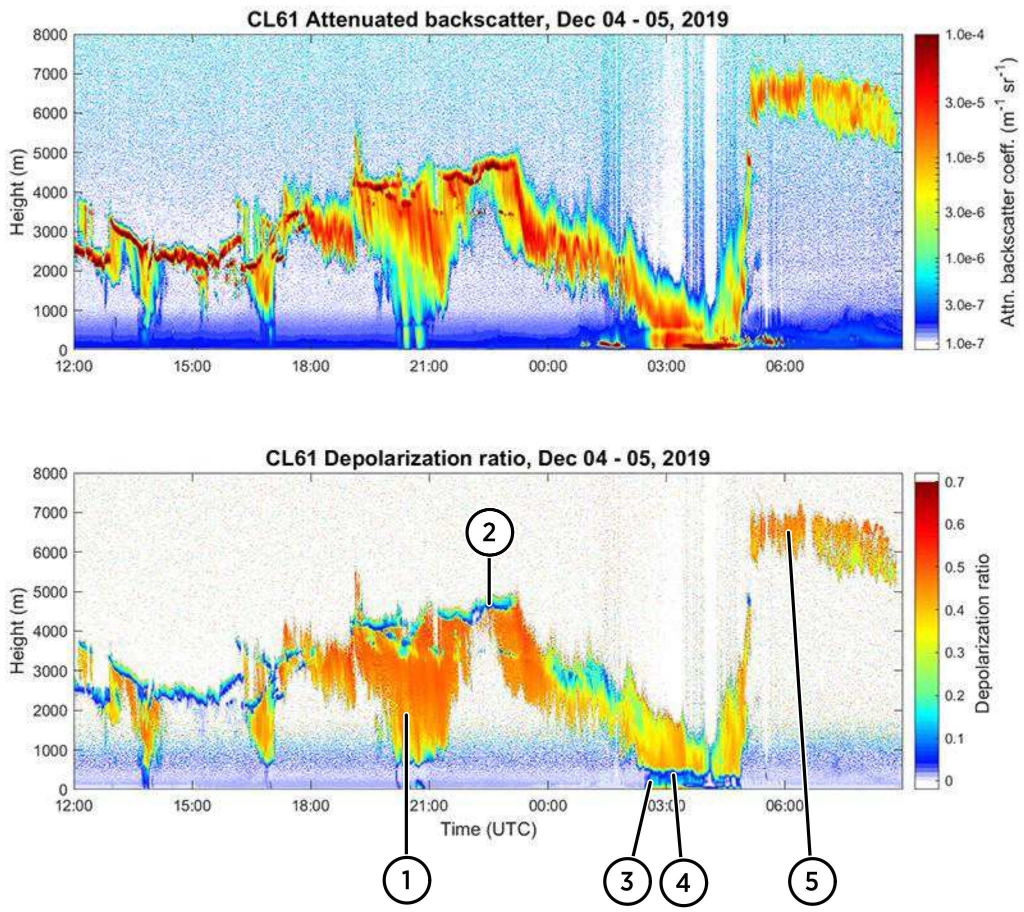


Figure 9 Example signal data

1 Solid precipitation
2 Supercooled liquid cloud
3 Rain
4 Melting layer
5 Ice crystals

9.3 Noise cancellation

The transmitted laser power is set so that the noise of the ambient light exceeds the backscattered signal. To overcome this, a large number of laser pulses are sent, and the returns are summed. During this process the noise, being random, partially cancels itself. The degree of cancellation for white (Gaussian) noise equals the square root of the number of samples; thus, the resulting signal-to-noise ratio improvement is equal to the square root of the number of samples. However, this processing gain cannot be extended endlessly since the environment changes and, for example, clouds move.

9.4 Return signal strength

In general form, the instantaneous return signal power can be derived from the lidar equation:

$$\mathrm{Pr}(z) = E_0 \times \frac{c}{2} \times \frac{A}{z^2} \times \beta(z) \times e^{-2\int_0^z \sigma(z')dz'}$$

Table 34 Signal power formula

Variable	Description
$P_r(z)$	Instantaneous power received from distance z
E_O	Effective pulse energy (taking all optics attenuation into account) [Ws]
c	Speed of light [m/s]
A	Receiver aperture [m^2]
z	Distance [m]
ß(z)	Volume backscatter coefficient at distance z [$m^{-1}srad^{-1}$, srad = steradian]
$e^{-2\int_0^z \sigma(z')dz'}$	Two-way atmospheric transmittance, accounts for the attenuation of transmitted and backscattered power. The transmittance equals 1 in clear atmosphere, that is, with no attenuation.

9.5 Height normalization

Assuming a clear atmosphere, the power of the return signal (P_r) is inversely proportional to the square of the distance. It means that the signal strength from 304.8 m (1000 ft) is generally hundred times stronger than from 3048 m (l0 000 ft).

The height dependence is eliminated by multiplying the measured signal value with the square of height (height normalization). Noise, however, being height-independent from a measurement point of view, is then correspondingly accentuated with increasing height.

9.6 Measurement profiles

CL61 is able to report the following vertical profiles:

- Parallel-polarized attenuated backscatter profile (PPOL)
- Cross-polarized attenuated backscatter profile (XPOL)
- Total attenuated backscatter profile (ABS = PPOL + XPOL)
- Depolarization ratio profile (LDR = XPOL / PPOL)

Profiles are reported at 4.8 m (15.75 ft) height intervals.

LDR varies between 0 and 1.

Averaging time can be adjusted. For more information, see *Vaisala Lidar Ceilometer CL61 User Guide*.

9.6.1 Measurement with polarization lidar

Lidar ceilometers emit linearly polarized laser pulses. When a portion of this light scatters back towards the instrument, the polarization direction may change. This depolarization depends strongly on scatterer shape, orientation, and laser wavelength. CL61 can detect the level of depolarization in the received signal.

Spherical scatterers

The laser pulses that fall back to the receiver have interacted at a 180° backscatter angle with spherical, homogeneous scatterers, such as liquid cloud droplets or small raindrops. Due to the symmetry of the scattering event, the detected return signal is not depolarized.

Multiple scattering in optically thick media, such as liquid clouds, can cause depolarization even when the scatterers are spherical. A portion of the detected light may have experienced forward and backward scattering in angles that deviate from 180°, still reaching the receiver.

Non-spherical scatterers

Non-spherical solid particles cause significant depolarization due to multiple internal reflections at solid-air interfaces. Larger raindrops with flattened bottom shapes also produce some depolarization.

Depolarization ratio

The level of depolarization for lidars can be described by the linear depolarization ratio (LDR). LDR is the ratio of the perpendicular or cross-polarized (XPOL) components and the parallel (PPOL) signal components and is equal to or greater than zero. The maximum LDR value is less than one because PPOL is the dominant backscattered signal component from atmospheric particles. Both particles and air molecules affect the degree of depolarization.

Their mixed contribution is known as the volume depolarization ratio (VDR). Accurate depolarization measurement requires relatively high backscatter, for example, from dust, smoke, ash, or boundary layer aerosols. CL61 measures VDR.

CL61 alternates acquisition of XPOL and PPOL signals with a measurement time of 0.2 s for each. Vertical profiles from ground level to a measurement range of 15.4 km (9.6 mi) are time averaged for 5 s before analysis.

CL61 measures depolarization with two filters in front of a single avalanche photodiode detector on the coaxial optical path. As the same receiver module is used for XPOL and PPOL signals, there is no need for receiver sensitivity calibration.

9.6.2 Attenuated backscatter profile

CL61 measurement is based on PPOL and XPOL attenuated backscatter profiles. The total attenuated backscatter profile (ABS) is calculated as a sum of PPOL and XPOL profiles.

The unit for attenuated backscatter profile intensity is one per meter per steradian ($m^{-1}\ sr^{-1}$).

The following figures show examples of ABS, PPOL, and XPOL profiles from the same time window. All four 1-dimensional profiles are moments in time contained in the 2-dimensional data displayed in Figure 9 (page 56). Specifically, the following profiles are taken from within a 1-minute period.

The following figure shows the ABS profile. The signal between 3000 m and 4000 m (9843 ... 13 123 ft) is caused by the falling precipitation. High signal returns between 4000 m and 4200 m (13 123 ... 13 779 ft) originate from a cloud.

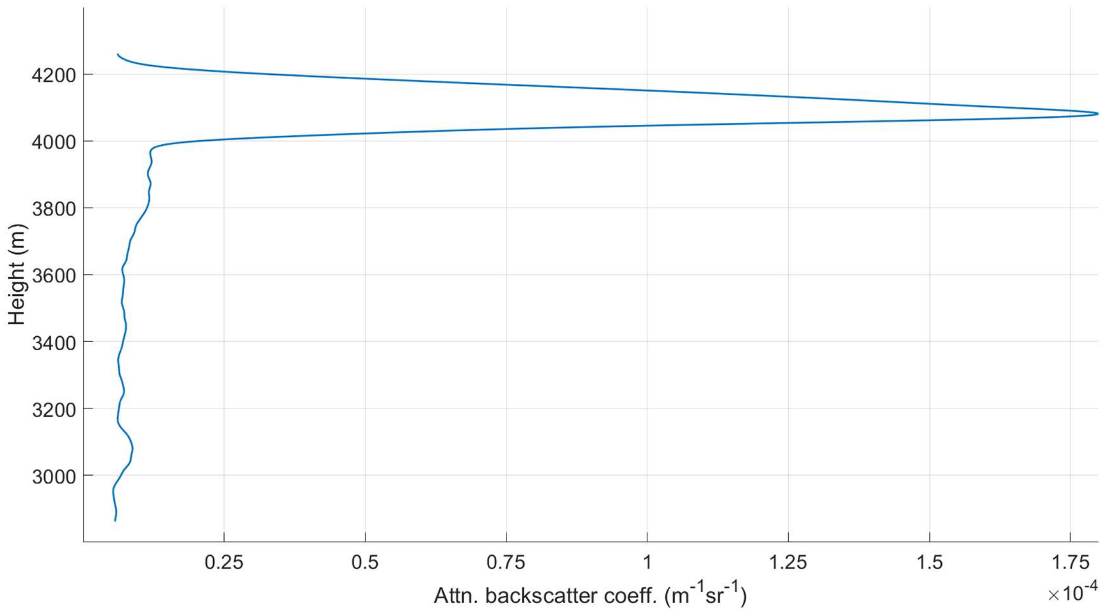


Figure 10 Attenuated backscatter profile

The same features can be seen in the PPOL return. The following figure shows the PPOL profile.

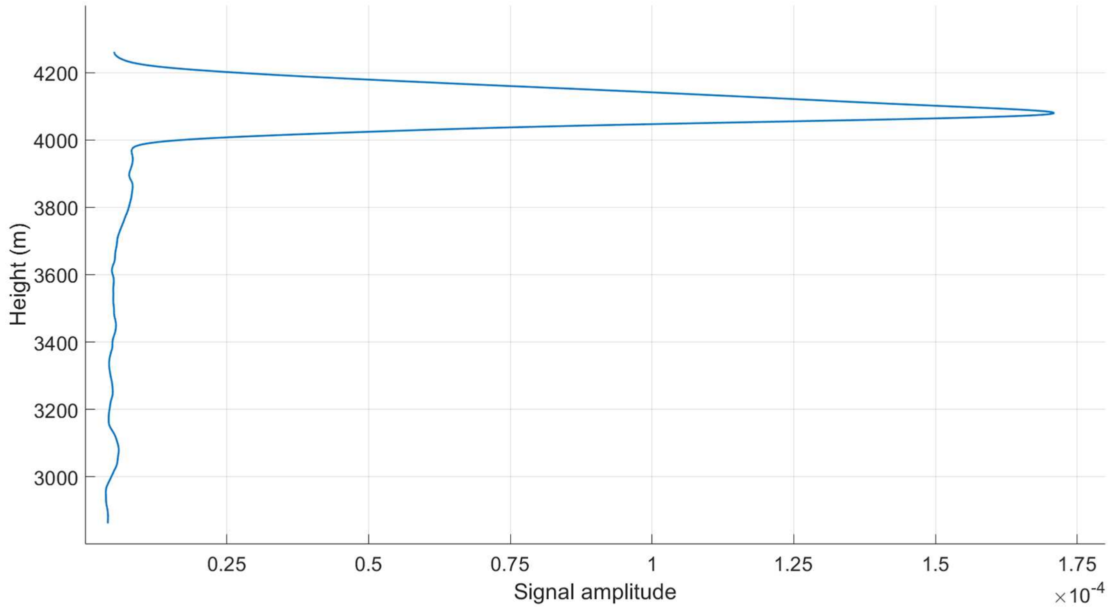


Figure 11 Parallel-polarized attenuated backscatter profile

The orthogonally polarized return shows increased signal levels in the precipitation between 3000 m and 4000 m. The returns increase inside the cloud, but not nearly as much as for the parallel-polarized channel. The following figure shows the XPOL profile.

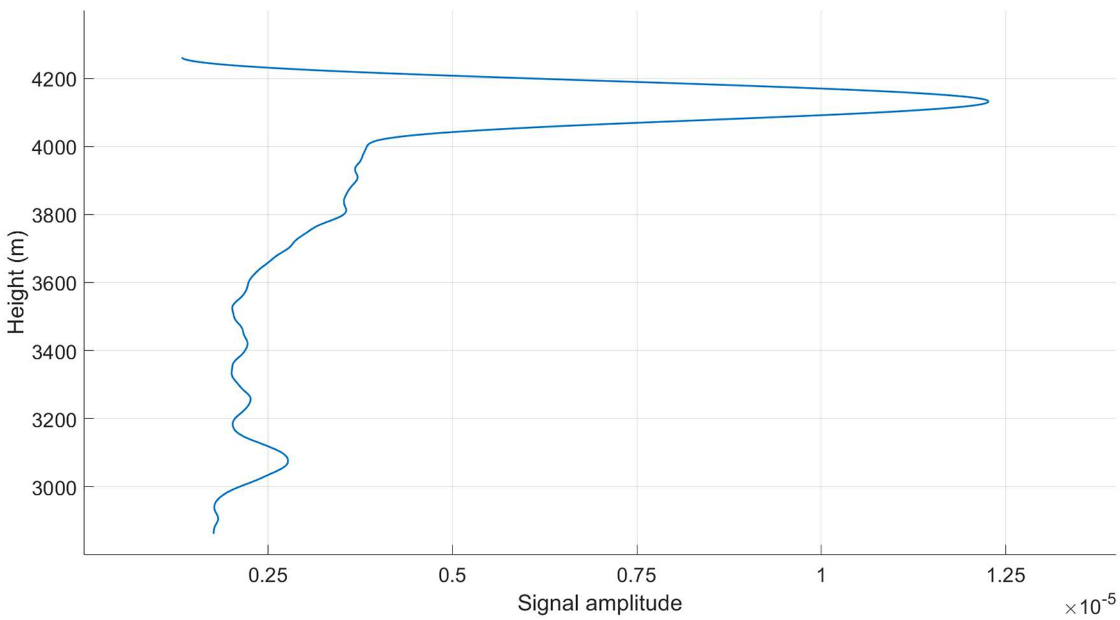


Figure 12 Cross-polarized attenuated backscatter profile

9.6.3 Depolarization ratio profile

Depolarization ratio (LDR) is the ratio of the perpendicular or cross-polarized (XPOL) components and parallel (PPOL) signal components.

The following figure presents the same time period as Figure 10 (page 59), Figure 11 (page 60) and Figure 12 (page 60).

The linear depolarization ratio reveals the precipitation between 3 000 m and 4 000 m to consist of non-symmetrical solid particles. The ratio falls near zero at the beginning of the cloud signal, signifying a liquid cloud. The ratio increases inside the liquid cloud due to the presence of multiple scatterers.

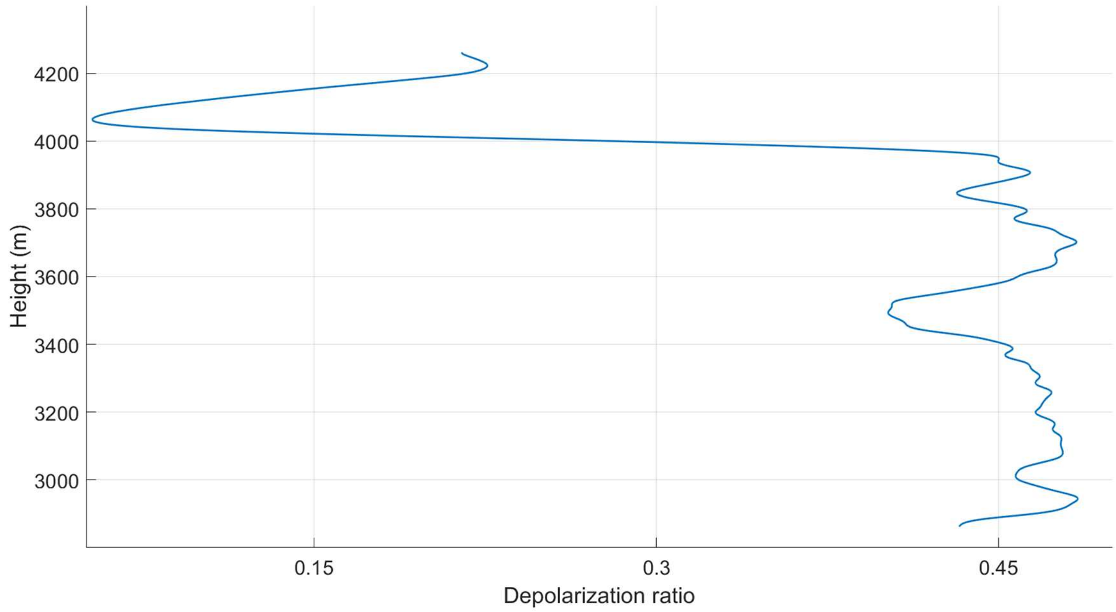


Figure 13 Depolarization ratio profile

The following figure shows another example case of attenuated backscatter (ABS) and LDR results over a set time period.

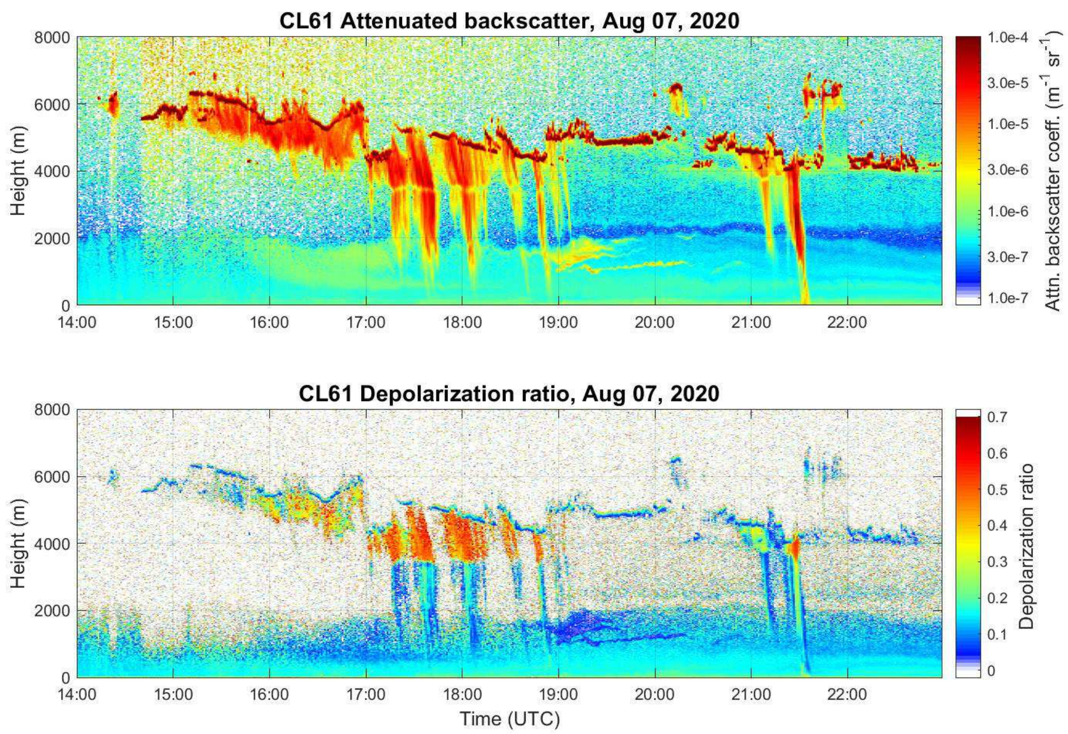


Figure 14 Example attenuated backscatter (ABS) and depolarization ratio (LDR) values

Interpreting depolarization

Vertical depolarization ratio profiles allow straightforward identification of several weather phenomena, such as liquid vs. solid precipitation, cloud phase, and melting layer. Near-zero values from liquid scatterers are clearly distinguished from larger values from complex ice crystal shapes.

In most cases it is better to do a side-by-side visual inspection of the time-height figures of ABS and LDR.

Characteristic behavior of local weather events, seen in signal strength, variance, and shape of patterns, are clearly recognizable with some practice.

For example, by looking only at LDR values, it may be difficult to distinguish some aerosols from liquid clouds without the ABS information. Aerosol characterization is also possible, especially when additional information is available, such as in model forecasts and backward trajectories, or complimentary lidar measurements.

Polarization lidars operating in one wavelength cannot provide independent, unambiguous aerosol type identification. Aerosols can also exist in mixtures and go through hygroscopic growth, which complicates identification. However, they can help quickly and confidently identify several weather conditions, such as snowfall, supercooled liquid clouds, and freezing rain, and support research lidars in aerosol studies.

The following figure shows some approximate LDR value ranges for various scatterers, indicated by the widths of the gray boxes. The ranges of values shown above the color bar have been observed in Vaisala studies with 910 nm depolarization lidar.

The ranges of values shown below the color bar may not accurately represent observations at 910 nm.

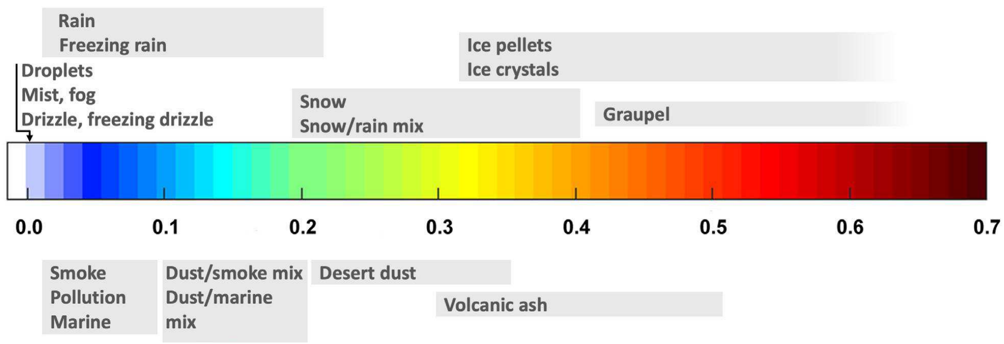


Figure 15 Depolarization ratio (LDR) value ranges

9.7 Backscatter coefficient

The volume backscatter coefficient represents the portion of light reflected back towards the ceilometer from a distance (for example, from water droplets). A dense cloud gives a stronger reflection. This can be expressed as follows:

```
ß(z) = k·σ (z)
```

ß(z)	Backscatter coefficient
z	Distance
k	Proportionality constant [1/srad]
σ (z)	Extinction coefficient (the attenuation factor in forward direction) [1/m]

The extinction coefficient relates to visibility in a straightforward manner. If visibility is defined according to a 5 % contrast threshold (World Meteorological Organization definition for Meteorological Optical Range, MOR, equals daylight horizontal visibility), the extinction coefficient is:

```
σ = 3 / V
```

V	MOR visibility (5 % contrast) [m]

The proportionality constant, k, also called the lidar ratio, has been subjected to a lot of research. Although the lidar equation can be solved without knowing the ratio, it must remain constant with the height if accurate estimates of the extinction (or visibility) profile are to be made.

It has been discovered that in many cases, κ can be assumed to equal 0.03, tending to be lower (down to 0.02) in high humidity, and higher (up to 0.05) in low humidity conditions. However, in precipitation conditions, κ can have a wider range of values.

Assuming k value of 0.03 sr^{-1}, visibility in clouds in the range of 15 to 150 m (50 to 500 ft), gives the following range for β:

$$\beta = 0.0006 \ldots 0.006\ m^{-1}sr^{-1} = 0.6 \ldots 6\ km^{-1}sr^{-1}$$

9.8 Cloud height

The basic function of the lidar ceilometer is to report cloud base height. Clouds have a large signal in the attenuated backscatter profile. The cloud algorithm searches the profiles for cloud signals. The cloud signal is based on the signal strength and strength of the change in order to report the cloud. The lidar ceilometer reports the base height of the cloud as that is the most important value for the user.

9.9 Vertical visibility

If there is obscuration in the atmosphere and the cloud signal is not identified in the attenuated backscatter profile, the lidar ceilometer reports vertical visibility instead. This typically occurs in the event of heavy precipitation where the transmitted signal is attenuated by precipitation droplets, or in the event of other ground-based visibility obscuration like fog or haze. Vertical visibility is used for aviation purposes to report to the pilot at which height they will be able to see the ground.

Any fog, precipitation, or similar obstruction to vision between the ground and the cloud base may attenuate the cloud base signal and produce backscatter peaks that far exceed that from the cloud. Virtually any backscatter height profile is possible, up to some physical limits. To distinguish a significant cloud return signal, the attenuation of, for example, fog or precipitation, has to be taken into account by normalizing with regard to extinction. The profile thus obtained is proportional to the extinction coefficient at various heights, and enables the use of fairly straightforward threshold criteria to determine what cloud is and what it is not.

By assuming a linear relationship between backscatter and extinction coefficient according to the previous formula and by assuming that the ratio, k, is constant over the observation range, it is possible to obtain an extinction coefficient profile through a mathematical computation. This is also called inverting the backscatter profile, and it basically answers the question of what kind of an extinction coefficient profile would produce the measured backscatter profile.

No assumption as to the absolute value of the ratio, k, needs to be made if k is constant in terms of height. The assumptions that have to be made are fairly truthful, and accurate enough for cloud detection purposes.

The backscatter profile inversion is also independent of several instrumental uncertainties including transmitted power and receiver sensitivity.

An estimate of vertical visibility can easily be calculated from the extinction coefficient profile because of the straightforward extinction coefficient-to-visibility relationship, assuming a constant contrast threshold. Visibility is simply the height where the integral of the extinction coefficient profile, starting from the ground, equals the natural logarithm of the contrast threshold, sign disregarded.

Tests and research have, however, shown that the 5 % contrast threshold widely used for horizontal measurement is unsuitable for vertical measurement if values close to those estimated by a ground-based observer are to be obtained.

Vaisala ceilometers use a contrast threshold value which, through many tests, has been found to give vertical visibility values closest to those reported by ground-based human observers. A safety margin is obtained with regard to pilots looking down in the same conditions since the contrast between objects, especially runway lights, is much more distinct on the ground.

9.10 Sky condition algorithm

The sky condition algorithm is calculated every 5 seconds based on data collected during the last 30 minutes. The last 10 minutes are double-weighted to make the algorithm more responsive to variations in cloudiness.

Operation of the sky condition algorithm is shown in the following figure. Instead of forming a histogram of hit heights, the algorithm uses both height and timing information to find hits close to each other. These hits are combined into clusters and a height value is calculated for each cluster. This height gives the base height of a cloud or cloud layer represented by the cluster. The algorithm reports layers by combining clusters whose heights are close to each other and then selecting clusters that cover the greatest amount of sky.

The sky condition algorithm reports the total sky cover in octas with values between 0 and 9. (One octa equals one eighth.) Value 9 is reported only in a vertical visibility condition. In addition, the sky cover can attain the value -99. The value -99 is reported after the start-up of the ceilometer indicating there is not enough data for algorithm processing.

Table 35 Sky cover values from sky condition algorithm

Volume	Sky cover
0–8	Cloudiness in octas
9	Vertical visibility (VV)
-99	Not enough data

10. Technical data

10.1 Specifications

Table 36 Measurement performance

Property	Description/Value
Measurement range, cloud and backscatter	0 ... 15 400 m (0 ... 50 500 ft)
Reporting resolution	4.8 m (15.7 ft)
Measurement interval	5 s
Measurement accuracy against hard target	±5 m (16.4 ft)
Laser	InGaAs diode
Laser wavelength	910.55 nm

Table 37 Data reporting

Property	Description/Value
Atmospheric parameters	Cloud base heights (up to 5 layers) Cloud depth and penetration [1)] Precipitation/fog detection [1)] Sky condition
Atmospheric profiles	Attenuated backscatter profile Parallel and cross-polarized profiles Depolarization ratio profile
Status information	Internal monitoring data

1) *Available later.*

Table 38 Inputs and outputs

Property	Description/Value
Nominal voltage	120 / 230 V AC 3.1 / 1.6 A
Operating voltage	90 – 130 / 200 – 250 V AC
Overvoltage category	CAT III
Operating frequency	50 ... 60 Hz
Data interface	Ethernet (> 10 Mbit/s)
Maintenance interface	Ethernet

Property	Description/Value
Message format	NetCDF
Power consumption	
With heating	Max. 370 W
Without heating	Max. 100 W

Table 39 Operating environment

Property	Description/Value
IP rating (when inside radiation shield, excluding window blower)	IP66
Operating temperature	−55 ... +55 °C (−67 ... +131 °F)
Storage temperature	−55 ... +60 °C (−67 ... +140 °F)
Operating humidity	0 ... 100 %RH
Maximum operating altitude	3000 m (9800 ft)
Wind	Up to 60 m/s (134 mph)
Pollution degree for inside electronics	2

Table 40 Mechanical specifications

Property	Description/Value
Dimensions (H × W × L)	1400 × 420 × 512 mm (55.12 × 16.54 × 20.16 in)
Weight, total	55 kg (121 lb)
Weight, radiation shield	23 kg (51 lb)
Weight, interface unit	12 kg (26 lb)
Weight, measurement unit	20 kg (44 lb)
Material	Aluminum
Color	White (RAL9003)
Coating	Multi-layer coating to prevent environmental corrosion
Tilt angle	Default: 3°

Table 41 Transmitter specifications

Property	Value
Laser source	Indium gallium arsenide (InGaAs) diode laser
Center wavelength	910.55 nm typical

Property	Value
Operating mode	Pulsed
Nominal pulse properties at full range measurement	
Pulse energy	4.2 µJ ±20 % (factory adjustment)
Peak power	26 W typical
Pulse duration	160 ns FWHM
Repetition rate	9.5 kHz
Average power	40 mW
Laser classification	Classified as Class 1M laser device in accordance with IEC/EN 60825-1 Complies with 21 CFR 1040.10 and 1040.11 except for the deviations pursuant to the *Laser Notice No. 56*, dated July 26, 2001.
Beam divergence	±0.2 mrad × ±0.35 mrad

Table 42 Receiver specifications

Property	Value
Detector	Silicon avalanche photodiode (APD)
Detector surface diameter	0.5 mm (0.02 in)
Receiver bandwidth	8 MHz (−3 dB)
Interference filter bandwidth	2.4 nm nominal
Transmissivity at 910.5 nm	90 % typical
Field-of-view divergence	±0.56 mrad
Polarization measurement	Single receiver method 2 orthogonal linear polarizers - parallel and cross polarizations

Table 43 Compliance

Property	Description/Value
EMC immunity	EN 61326-1, industrial environment
EMC emissions	CISPR 32 / EN 55032, Class B
Electrical safety	IEC / EN 61010-1 [1)]
Eye safety	Class 1M IEC / EN 60825-1:2014
Compliance marks	CE, China RoHS, RCM, UKCA
Complies with ICAO frangibility requirements.	

1) *IEC / EN / UL / CSA 61010-1 available later.*

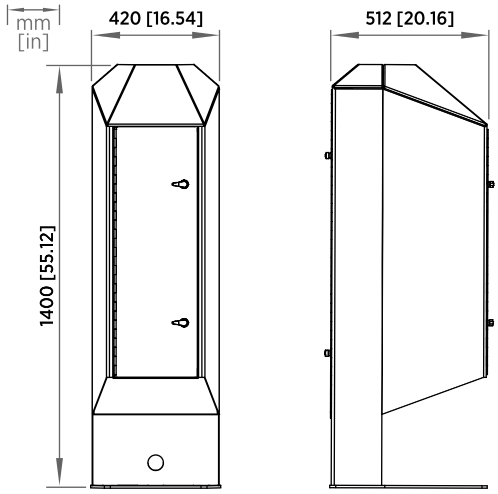


Figure 16 CL61 dimensions

Appendix A. NetCDF example file

Here is an example of a netCDF file that Vaisala Lidar Ceilometer CL61 produces.

```
netcdf file: {
  dimensions:
    time = UNLIMITED;   // (12 currently)
    range = 3276;
    layer = 5;
  variables:
    int cloud_base_heights(time=12, layer=5);
      :long_name = "heights (range) of the detected cloud bases";
      :coordinates = "time layer longitude latitude";
      :_FillValue = -99; // int
      :units = "m";
      :_ChunkSizes = 1U, 5U; // uint

    int vertical_visibility(time=12);
      :_FillValue = -99; // int
      :units = "m";
      :long_name = "visibility in the direction of the instrument beam";
      :coordinates = "time longitude latitude";
      :_ChunkSizes = 1024U; // uint

    float p_pol(time=12, range=3276);
      :_FillValue = -999.0f; // float
      :units = "1/(m?sr)";
      :long_name = "parallel-polarized component of the backscattered light";
      :coordinates = "time range longitude latitude";
      :averaging_time_in_seconds = 5; // int
      :_ChunkSizes = 1U, 3276U; // uint

    float x_pol(time=12, range=3276);
      :units = "1/(m?sr)";
      :long_name = "cross-polarized component of the backscattered light";
      :coordinates = "time range longitude latitude";
      :averaging_time_in_seconds = 5; // int
      :_FillValue = -999.0f; // float
      :_ChunkSizes = 1U, 3276U; // uint

    float beta_att(time=12, range=3276);
      :_FillValue = -999.0f; // float
      :units = "1/(m?sr)";
      :long_name = "attenuated volume backscatter coefficient";
      :coordinates = "time range longitude latitude";
      :averaging_time_in_seconds = 5; // int
      :_ChunkSizes = 1U, 3276U; // uint
```

```
    float linear_depol_ratio(time=12, range=3276);
      :long_name = "linear depolarisation ratio of the backscatter volume";
      :coordinates = "time range longitude latitude";
      :averaging_time_in_seconds = 10; // int
      :_FillValue = -999.0f; // float
      :_ChunkSizes = 1U, 3276U; // uint

    double time(time=12);
      :_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";
      :_ChunkSizes = 512U; // uint

    double range(range=3276);
      :_FillValue = -999.0; // double
      :units = "m";
      :long_name = "measurement distance from the instrument in the direction of
the transmitted laser beam";
      :axis = "Z";
      :positive = "up";

    int layer(layer=5);
      :_FillValue = -999; // int
      :units = "layer";
      :long_name = "number of the observed cloud layer (1,2,...,5)";

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

    double latitude;
      :_FillValue = -999.0; // double
      :units = "degrees_north";
      :long_name = "latitude";
      :standard_name = "latitude";

    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";

    double beta_att_sum(time=12);
      :_FillValue = -999.0; // double
      :units = "1/(10^4?sr)";
      :long_name = "scaled integral of the attenuated volume backscatter
```

```
coefficient";
      :_ChunkSizes = 512U; // uint

    double beta_att_noise_level(time=12);
      :_FillValue = -999.0; // double
      :long_name = "a unitless number describing the noise level of the attenuated
volume backscatter coefficient";
      :_ChunkSizes = 512U; // uint

    short tilt_correction(time=12);
      :_FillValue = -999S; // short
      :long_name = "tilt correction";
      :comment = "on/off (1/0)";
      :_ChunkSizes = 2048U; // uint

    float tilt_angle(time=12);
      :_FillValue = -999.0f; // float
      :units = "°";
      :standard_name = "zenith_angle";
      :long_name = "instrument tilt angle from the vertical";
      :_ChunkSizes = 1024U; // uint

    short height_offset(time=12);
      :_FillValue = -999S; // short
      :long_name = "instrument height offset to reference level";
      :comment = "positive, if the instrument is placed e.g. on the roof of a
building. Negative, if the instrument is placed below the ground level altitude
e.g. in a pit. This value will be added to the cloud base height results.";
      :units = "m";
      :_ChunkSizes = 2048U; // uint

    short sky_condition_total_cloud_cover(time=12);
      :_FillValue = -99S; // short
      :units = "oktas";
      :long_name = "total amount of cloud cover";
      :comment = "aggregated across layers";
      :coordinates = "time longitude latitude";
      :_ChunkSizes = 2048U; // uint

    short sky_condition_cloud_layer_covers(time=12, layer=5);
      :_FillValue = -99S; // short
      :units = "oktas";
      :long_name = "amount of cloud cover in different cloud layers";
      :comment = "for up to 3 layers";
      :coordinates = "time layer longitude latitude";
      :_ChunkSizes = 1U, 5U; // uint

    int sky_condition_cloud_layer_heights(time=12, layer=5);
      :_FillValue = -99; // int
      :units = "m";
      :long_name = "height of different cloud layers";
      :comment = "for up to 3 layers";
      :coordinates = "time layer longitude latitude";
      :_ChunkSizes = 1U, 5U; // uint
```

```
  group: status {
    // group attributes:
    :Timestamp = "1640186884.550009";
    :Device_controller_temperature = "OK: 0";
    :Device_controller_electronics = "OK: 0";
    :Device_controller_overall = "OK: 0";
    :Optics_unit_accelerometer = "OK: 0";
    :Optics_unit_electronics = "OK: 0";
    :Optics_unit_overall = "OK: 0";
    :Optics_unit_memory = "OK: 0";
    :Optics_unit_tilt_angle = "OK: 0";
    :Receiver_electronics = "OK: 0";
    :Receiver_overall = "OK: 0";
    :Receiver_memory = "OK: 0";
    :Window_blocking = "OK: 0";
    :Window_condition = "OK: 0";
    :Servo_drive_electronics = "OK: 0";
    :Servo_drive_overall = "OK: 0";
    :Servo_drive_memory = "OK: 0";
    :Servo_drive_control = "OK: 0";
    :Servo_drive_ready = "OK: 0";
    :Transmitter_electronics = "OK: 0";
    :Transmitter_light_source = "OK: 0";
    :Transmitter_light_source_power = "OK: 0";
    :Transmitter_overall = "OK: 0";
    :Transmitter_memory = "OK: 0";
    :Maintenance_overall = "OK: 0";
    :Device_overall = "OK: 0";
    :Recently_started = "OK: 0";
    :Measurement_status = "OK: 0";
    :Datacom_overall = "OK: 0";
    :Measurement_data_destination_not_set = "Reporting destination URL for output
data set: 0";
  }

  group: monitoring {
    // group attributes:
    :internal_pressure = 1017.99896f; // float
    :internal_temperature = 6.75f; // float
    :laser_temperature = 21.29001f; // float
    :laser_power_percent = 101.81151f; // float
    :window_condition = 96.429214f; // float
    :background_radiance = 0.0f; // float
    :Timestamp = "1640186884.550009";
    :internal_humidity = 17.362f; // float
  }

  // global attributes:
  :title = "CL61, Ceilometer CL61, A";
  :institution = ;
  :source = ;
  :conventions = "CF-1.8";
  :history = "1.1.0";
  :comment = ;
  :unit = "m";
```

```
    :temporal_span_of_this_file_in_minutes = 1.0; // double
    :time_between_consecutive_profiles_in_seconds = 5; // int

    data:
      cloud_base_heights =
        {
          {86, -99, -99, -99, -99},
          {-99, -99, -99, -99, -99},
          {-99, -99, -99, -99, -99},
          {-99, -99, -99, -99, -99},
          {81, -99, -99, -99, -99},
          {81, -99, -99, -99, -99},
          {81, -99, -99, -99, -99},
          {86, -99, -99, -99, -99},
          {86, -99, -99, -99, -99},
          {81, -99, -99, -99, -99},
          {81, -99, -99, -99, -99},
          {81, -99, -99, -99, -99}
        }
      vertical_visibility =
        {-99, -99, -99, -99, -99, -99, -99, -99, -99, -99, -99, -99}
      p_pol =
        {
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6},
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6},
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6}
        }
      x_pol =
        {
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6},
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6},
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6}
        }
      beta_att =
        {
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
```

```
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6},
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6},
          {8.1808787E-7, 7.196612E-7, 7.6596643E-7, ... 1.9492056E-6, 3.3532885E-6},
          {8.6130206E-7, 7.419825E-7, 7.705374E-7, ... 1.2308351E-5, 1.2614914E-5},
          {9.196278E-7, 7.776576E-7, 7.893953E-7, ... 3.2520134E-6, 2.9151818E-6},
          {9.572715E-7, 8.0411735E-7, 8.094215E-7, ... -1.7989412E-6, -2.6651007E-6}
        }
      linear_depol_ratio =
        {
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
          {0.21420485, 0.17058994, 0.12048329, ... 1.021156, 0.952593},
        }
      time =
        {1.640186886033E9, 1.640186890919E9, 1.640186896032E9, 1.640186901047E9,
  1.640186905973E9, 1.640186911053E9, 1.640186916055E9, 1.640186920758E9,
  1.640186925974E9, 1.640186930877E9, 1.640186936075E9, 1.640186941011E9}
      range =
        {0.0, 4.8, 9.6, ... 15715.2, 15720.0}
      layer =
        {1, 2, 3, 4, 5}
      longitude = 64.2
      latitude = 24.6
      elevation = 0
      beta_att_sum =
        {12.676630493901454, 11.963449728784887, 11.758387273891177,
  13.38413042211819, 15.025900580184715, 14.927933812508114, 17.323201550107125,
  15.68775262897133, 15.414092167236513, 16.80869399145431, 18.79932434840589,
  17.38548745227421}
      beta_att_noise_level =
        {41.28067396748121, 54.77361843069384, 52.75878232463023, 49.07445047015669,
  48.80510728010196, 57.04194084693743, 47.93769764434323, 49.35536192047626,
  53.582720995137045, 57.49766685100461, 46.805902240568955, 51.07191906017475}
      tilt_correction =
        {1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1}
      tilt_angle =
        {4.0, 3.9, 4.0, 3.9, 3.9, 3.9, 4.0, 4.0, 3.9, 4.0, 3.9, 3.9}
      height_offset =
        {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}
      sky_condition_total_cloud_cover =
        {4, 4, 4, 3, 3, 3, 3, 3, 3, 3, 3, 3}
      sky_condition_cloud_layer_covers =
```

```
        {
          {1, 4, -99, -99, -99},
          {1, 4, -99, -99, -99},
          {1, 4, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99},
          {1, 3, -99, -99, -99}
        }
      sky_condition_cloud_layer_heights =
        {
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {70, 170, -99, -99, -99},
          {80, 170, -99, -99, -99}
        }
  }
```

More information

- Configuring netCDF reporting (page 20)
- NetCDF files (page 31)

Appendix B. Maintenance checklist

Fill in the checklist and save it to record completed tasks.
Make copies of the list as needed.

Table 44 CL61 maintenance checklist

Maintenance details	
Customer name:	
Site name:	
CL61 serial number:	
Maintenance person:	
Date (day/month/year):	

#	Task	Reference	OK / Not OK	Remarks
Maintenance preparations				
1	Check the software version			
2	Check warnings and alarms			
As needed				
3	Clean the window	Cleaning window (page 36)		
4	Check the door gaskets	Checking door gasket (page 37)		
Annual maintenance				
5	Perform a general check	-		
6	Clean the painted surfaces	Cleaning and maintaining painted surfaces (page 37)		
Notes for next maintenance check				

Appendix C. Recycling instructions

These recycling instructions guide you on the end-of-life treatment of this Vaisala product. As waste regulations and infrastructure vary in each country, these instructions only indicate the different components to be separated and common ways to handle them. Always follow local requirements when disposing of the product. Vaisala encourages to use the best available recycling practices to minimize related environmental impacts.

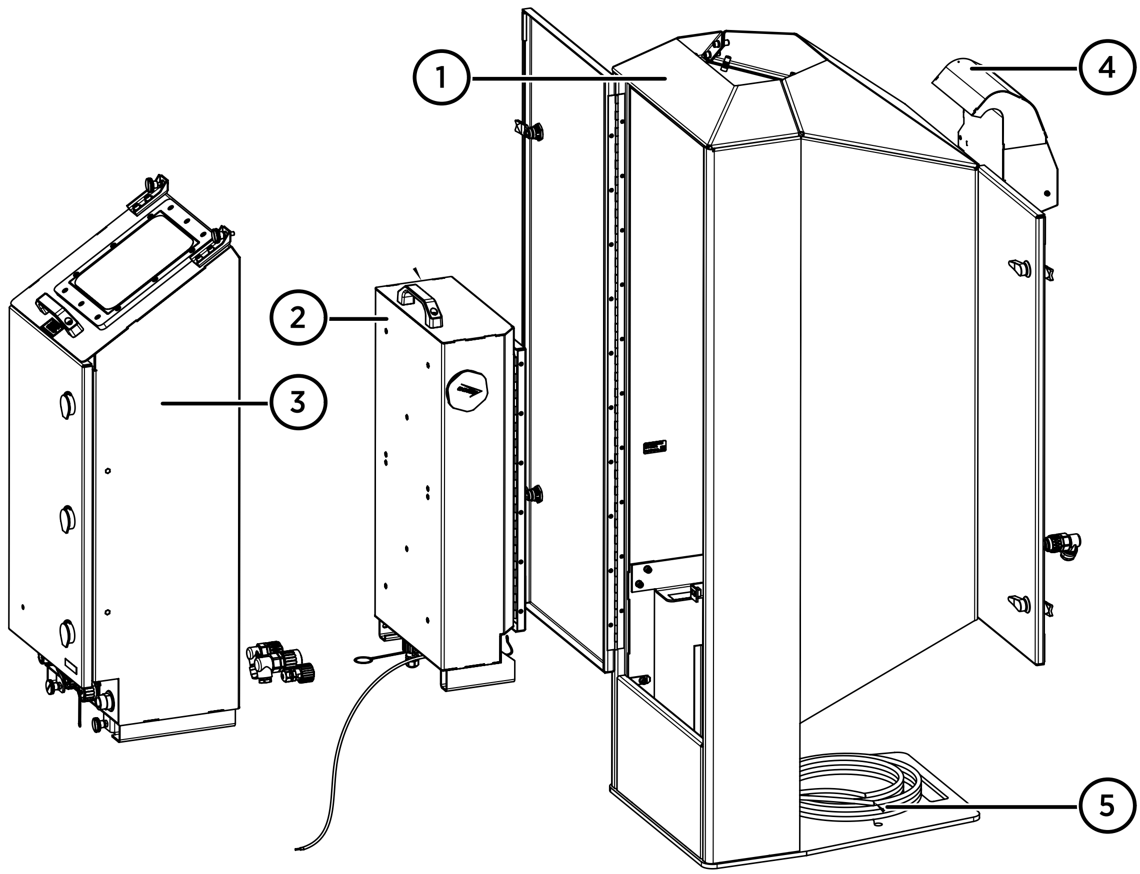
Vaisala is committed to meeting the requirements of the EU Waste Electrical and Electronic Equipment (WEEE) Directive. This directive aims to minimize the impact of electrical and electronic goods on the environment, by increasing reuse and recycling, and reducing the amount of WEEE going to landfill. This symbol indicates that the product should be collected separately from other waste streams and treated appropriately.

Recycle all applicable material.

Follow the statutory regulations for disposing of the product and packaging.

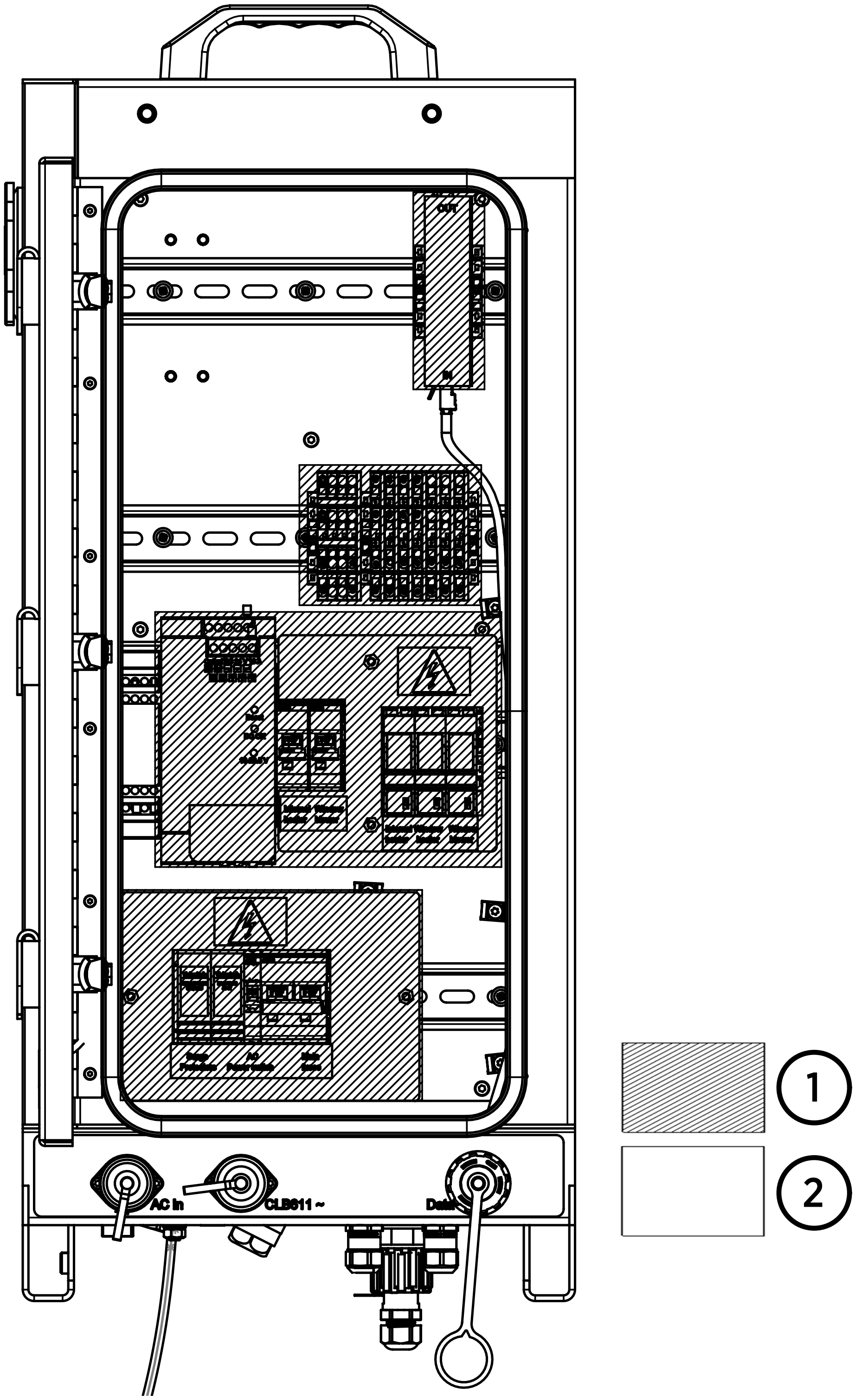
If applicable, Vaisala recommends removing the battery unit before recycling the rest of the device as typical electronic waste. The battery unit can be recycled separately in accordance with local waste management practices and regulations. Integrated small sized batteries are typically left in place and removed by professionals at the recycling facilities.

The following figures show the components of CL61 and their recyclable materials.



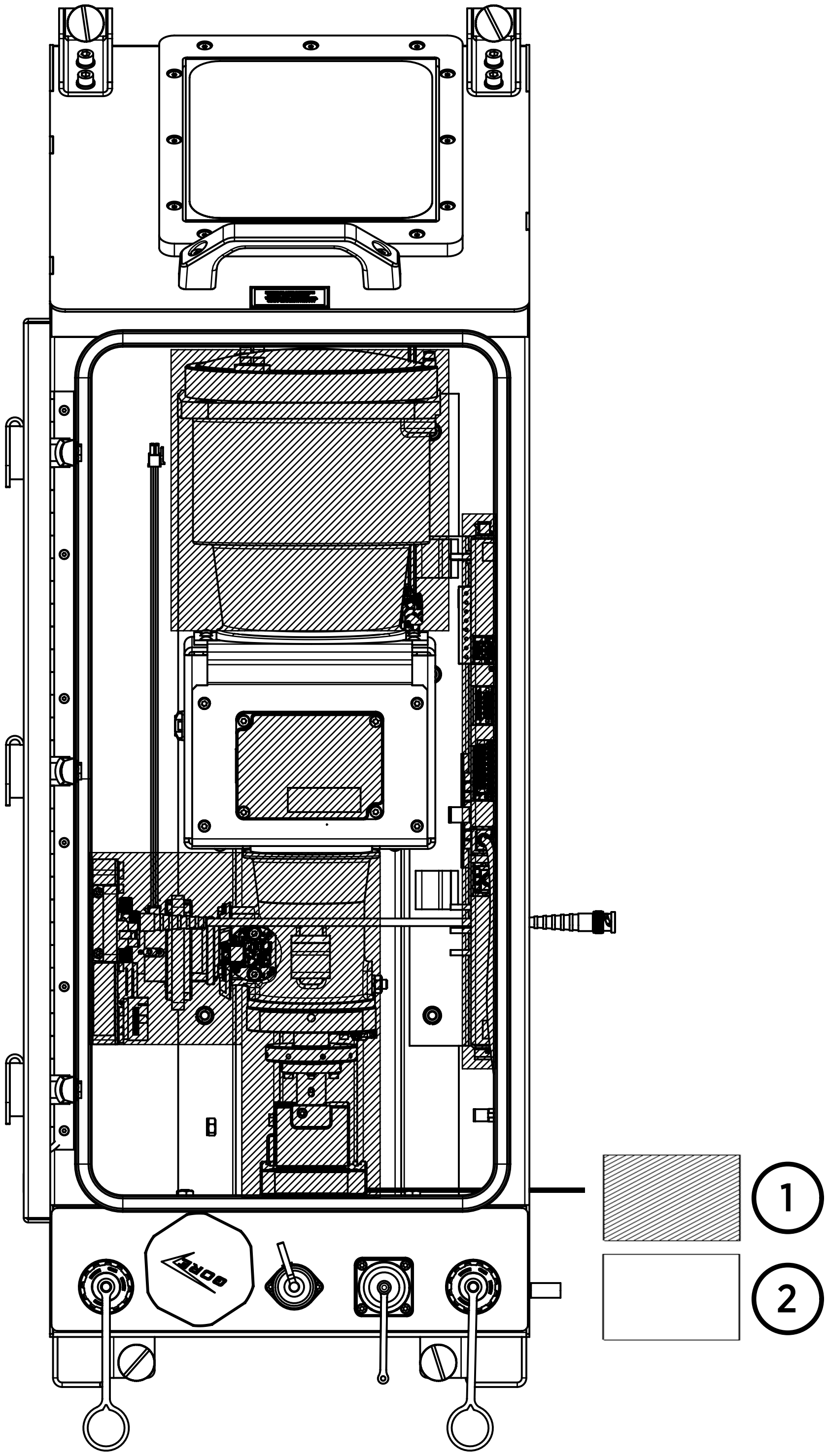
1 Radiation shield (metal waste)
2 Interface unit (see below)
3 Measurement unit (see below)
4 Window blower (electrical waste)
5 Cables (electrical waste)

Interface unit recycling materials



1 Electrical and electronic waste (internal components, cables)
2 Metal waste (enclosure backplate)

Measurement unit recycling materials



1 Electrical and electronic waste (inside heater, optics unit, device control unit, window, cables and connectors)
2 Metal waste (enclosure backplate, optic unit holder)

Warranty

For standard warranty terms and conditions, see www.vaisala.com/warranty.

Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or Conditions of Sale for details of the warranty for each product.

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 www.vaisala.com/support.

VAISALA