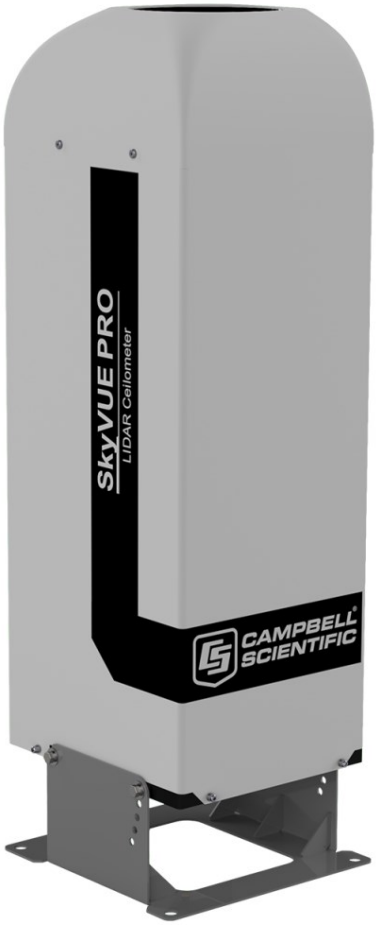
PRODUCT MANUAL

Sensor

SkyVUE™ PRO (CS135)

LIDAR Ceilometer



Revision: 06/2025

RELIABLE MONITORING SINCE 1974

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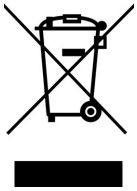
Please read first

About this manual

Please note that this manual was produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this. In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users. Differences include the U.S. standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. Please note, however, *that when a power supply adapter is ordered from Campbell Scientific it will be suitable for use in your country*.

Reference to some radio transmitters, digital cell phones and aerials (antennas) may also not be applicable according to your locality. Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered.

Recycling information for countries subject to WEEE regulations 2012/19/EU



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility, per The Waste Electrical and Electronic Equipment (WEEE) Regulations 2012/19/EU. Campbell Scientific can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories. For further support, please contact Campbell Scientific, or your local agent.

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1. General information

1.1 Packing list

The following table lists the products shipped with the SkyVue PRO.

Table 1-1: Packing list

Description	Quantity
Ceilometer	1
Power supply cable	1
Data cable	1
Bolt, sleeve anchor	4
Cable, USB type A plug to type B plug, 2 m	1
4 mm Allen key	1
Calibration plate	1

1.2 General safety

This manual provides important safety considerations for the installation, operation, and maintenance of the SkyVue™PRO. These safety considerations are classified into three levels:

WARNING:
Warnings alert the installer or user to serious hazards. Ignoring these warnings could result in injury or death and/or irrevocable damage to the sensor unit.

CAUTION:
Cautions warn of potential hazards. Ignoring these cautions could result in the sensor being damaged and data being lost.

NOTE:
Notes highlight useful information in the installation, use and maintenance of this product. These should be followed carefully in order to gain the maximum benefit from the use of this product.

1.3 Sensor unit safety

The SkyVue PRO sensor has been checked for safety before leaving the factory and contains no internally replaceable or modifiable parts.

WARNING:
Do not modify the SkyVue PRO because it can damage the unit and expose users to dangerous light levels and voltages.

WARNING:
Do not attempt to repair the SkyVue PRO unit without consulting Campbell Scientific.

CAUTION:
Ensure the correct voltage supply is provided to the sensor.

1.4 Laser safety

The SkyVue PRO sensor incorporates an InGaAs laser diode which is rated as a class 3B device. This is an embedded laser where the output from the sensor unit, through the optics, is minimized to class 1M. This classification means the naked eye can safely view the beam but looking directly into the beam with optical instruments, such as binoculars, can be dangerous.

The output from the laser head has the following characteristics:

Maximum average power: 15.0 mW (through 50 mm)

Maximum pulse energy: 1500 nJ (through 50 mm)

Pulse duration: 100 ns

Pulse frequency: 10 kHz

Wavelength: 912 nm ± 5 nm

Tested to: EN 60825-1:2014

Half angle divergence: 0.44 mrad

The sensor is marked with the following warning information:

INVISIBLE LASER RADIATION

DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS

CLASS 1M LASER PRODUCT

WARNING:
Removing the laser module with power applied to the SkyVue PRO may expose the user to hazardous class 3B laser radiation.

Do not operate the laser module while it is outside the housing.

WARNING:
Annually, check the laser warning label to ensure it is visible and can be clearly read.

When installing the sensor, avoid pointing the laser housing towards areas where binoculars are often used.

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

1.5 Electrical safety

Because of hazardous mains voltages, only qualified personnel should wire the power supply. Permanent outside installations usually require a certified electrician who is familiar with local electrical and safety legislation. Some general guidance is given in Connectors and wiring (p. 18), but the responsibility for the installation lies with the installer.

The unit is tested for electrical safety before dispatch but may need subsequent testing according to local practice.

NOTE:
The unit should only be serviced by trained personnel.

WARNING:
Removal of electronic module covers or connectors while the unit is powered will expose the operator to potentially hazardous voltages and may damage the sensor.

The SkyVue PRO has electrical and laser warning labels on the exterior and interior of the unit.

It is fitted with a hex-key access panel. It is recommended that the hood and access panel door are not opened in conditions of rain, hail or snow.

Isolate the sensor before removing internal components, including the cover to the avalanche photodiode (APD) module. Only trained personnel should disassemble the instrument.

Mains connectors are shrouded to prevent touching of the contacts. The mains supply should be isolated when connecting and disconnecting the cables to the sensor.

If an isolator switch is installed, it must be a two-pole type and located as close to the sensor as possible.

The SkyVue PRO must be properly grounded by a licensed and qualified electrician to protect against the risk of electric shock from voltage leakage. (Grounding [p. 16]).

Campbell Scientific recommends that a ground fault circuit interrupter (GFCI)[1] be used with all sensors. See Power connections (p. 21) for further information.

Mains powered heaters are enclosed to prevent contact.

> **CAUTION:**
> When powered, the heaters may operate automatically and without warning. They may remain hot when not powered. Follow the isolation precautions to avoid shock and burn hazards.

The sealed battery has cables and protected connectors to prevent shorts. Avoid shorting the battery to protect it from damage and to avoid burns to personnel through contact with hot surfaces.

2. Product overview

[1]The ground fault circuit interrupter (GFCI) is also known as the residual-current device (RCD) in the United Kingdom.

2.1 Introduction

The SkyVue PRO is a light detection and ranging (LIDAR) ceilometer that emits short pulses of near-infrared light into the atmosphere from a semiconductor laser. The pulses of infrared light are scattered back by aerosols, including cloud droplets. The time between transmission of the pulse and the return signal gives the range, and therefore height, of the scattering aerosols. The variation in the strength of the back-scattered light signal with height gives a profile of scatter coefficients and allows identification of cloud bases. If significant scattering is detected without a defined cloud base, then a vertical visibility can be calculated.

The control system of the SkyVue PRO is divided into three modules, DSP, TOP and PSU as follows:

DSP (Digital Signal Processor) is the main data processing and communications unit of the SkyVue PRO. It hosts two separate time keeping circuits that are cross checked. An alarm is triggered if the circuits disagree.

TOP (top of the unit) provides safety shutdown features such as over and under laser output level. It also contains the calibration circuitry and dirty windows system.

PSU (Power Supply Unit) controls the power supply including battery charging and deep discharge protection.

The SkyVue PRO has a rugged environmental enclosure that protects the instrument from the harshest conditions and will measure the atmosphere with high stability and repeatability.

2.1.1 Cloud height detection

A scatter profile is measured as described in Measurement of the attenuated backscatter profile (p. 113).

Cloud height detection is performed as described in Cloud height calculation (p. 115). Up to four cloud heights can be detected.

If clouds are not detected, the SkyVue PRO will give one of these reports. For the reports below, it will increase readability if you use a span, like span.emphasis, for the actual message. This will help separate the message from the description of the message.

- No significant backscatter.
- Full obscuration determined but no cloud base detected. This is reported if the criteria for detecting cloud base is not met but the integrated scattering coefficient reaches the limit of vertical visibility below a set height limit. The default value is 2000 m (6560 ft) but can be changed by the user. The height at which this occurs is given as vertical visibility.
- Some obscuration detected but determined to be transparent is reported if scattering is detected but no cloud is detected and the calculated vertical visibility exceeds a set height limit.

If no cloud is detected but significant scattering is detected below 50 m (160 ft), then vertical visibility is set to 0.

2.1.2 Sky condition

Sky condition is an assessment of cloud cover, measured in units of eighths, known as oktas. Each okta represents one-eighth of the sky covered by cloud in a given layer. The SkyVue PRO can

report up to five layers of cloud when reporting sky condition. The algorithm used in the SkyVue PRO follows guidance in the *ICAO 9837, Manual on Automatic Meteorological Observing Systems at Aerodromes*.

Sky condition is not an instantaneous measurement. It is based on cloud data for the previous 30 minutes, with cloud detection in the previous 10 minutes given an extra weighting. Therefore, sky condition is not available until sufficient data has been collected. See Sky condition algorithm description (p. 116) for more detail.

2.1.3 Backscatter profile reporting

Several data messages can contain the two-way attenuated backscatter profile. Each value in the profile consists of five ASCII characters—not raw binary. Each character is one of "0–9", "a–f", or "A–F", and represents 4 bits of data, even though it is stored as an 8-bit ASCII byte. Thus, 5 characters × 4 bits = a 20-bit value, which includes the sign. These values are encoded as signed two's complement integers. As a result, values greater than 2^{19}–1 represent negative integers. Each group therefore represents a signed 20-bit integer in the range of -2^{19} to $+(2^{19}-1)$, rather than the range of 0 to $(2^{20}-1)$, which would apply to an unsigned 20-bit integer.

To correct the decimal value, apply the following two-stage process: Convert the five-character hexadecimal string to a decimal number. If the result is greater than 1,048,575 ($2^{20} - 1$), subtract 1,048,576 (2^{20}) to account for two's complement representation of negative values. To convert the result into a backscatter coefficient (units of $sr^{-1} \cdot m^{-1}$), the sensor multiplies the corrected decimal value by a factor of 10^8. The values are scaled by the `Attenuated_SCALE` parameter, see Table 5-1 (p. 31).

> **NOTE:**
> The last two values of the profile will always be zero. They are beyond the 10 km (32,800 ft) range of the instrument.

> **NOTE:**
> The profile is not corrected for tilt angle even if cloud heights are corrected.

2.1.4 Mixing layer height

A **Mixing Layer Height** measurement option is available. This option retrieves the height of the mixed aerosol layer by applying the gradient method to the ceilometer backscatter signal. This

approach, based on the operational algorithm[1] used by KNMI[2], searches for the drop in backscatter associated with the transition from boundary layer aerosols to free troposphere. Since the signals measured depend on the type and amount of aerosol present as well as the background light level, the accuracy of the method varies, and therefore a quality factor is assigned that indicates the confidence in the reported layer height. The module can also detect the top of residual layers and elevated aerosol layers. To activate this option, please contact Campbell Scientific.

This quality factor provides a guide to how well the mixing layer height (MLH) is defined, using a scale from 1 to 3, with 3 indicating the highest confidence. It is determined by the magnitude of the difference between the average backscatter over a distance below the MLH and the average backscatter over a distance above it.

2.2 Optical arrangement

The SkyVue PRO uses a single split-lens design that increases optical signal-to-noise ratio, while maintaining Class 1M eye safety. This is achieved by integrating larger optics into a compact package (see Figure 2-1 [p. 9]). Half of the lens is used by the transmitter, and the other half is used by the receiver. This design provides an alternative to traditional two-lens or common-optics designs.It preserves the optical isolation characteristic of conventional biaxial systems—enhancing detector sensitivity—while also incorporating the low overlap onset height typical of common-optics systems, enabling accurate measurements at close ranges.

[1]Haij, M.J. de, H. Klein Baltink and W.M.F. Wauben: Continuous mixing layer height determination using the LD-40 ceilometer: a feasibility study, Scientific Report WR 2007-01, KNMI, De Bilt, 2007."

[2]KNMI, officially known as the Royal Netherlands Meteorological Institute, is a national research and information center for meteorology, climate, and seismology.

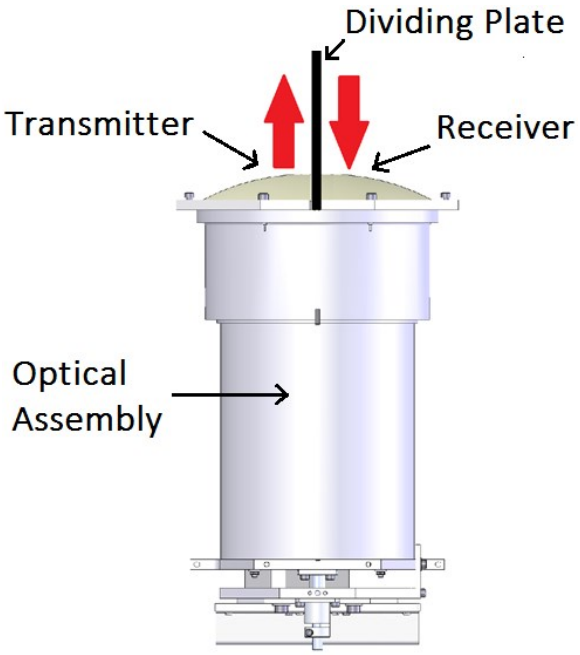


Figure 2-1. Principle of operation

2.3 Internal monitoring

The SkyVue PRO monitors window contamination, key voltages and currents, internal temperature and relative humidity, and other parameters relevant to its performance. Data messages (see Operation [p. 28]) include this information allowing remote diagnosis of the SkyVue PRO condition. In addition, a special status message can be polled.

2.4 Specifications

2.4.1 Measurement specifications

Maximum reporting range:	10 km (32800 ft)
Minimum reporting resolution:	5 m (16.4 ft)
Hard target range accuracy:	± 0.25% ± 4.6 m (15.1 ft)
Reporting cycle:	2 to 600 s
Cloud layers reported:	Up to four layers reported

2.4.2 Mechanical specifications

Height:	1000 mm (39.3 in)
Width:	327 mm (12.8 in)
Depth:	281 mm (11 in)
Total weight:	33 kg (72 lb), excluding cables
Shipping weight:	58 kg (128 lb)

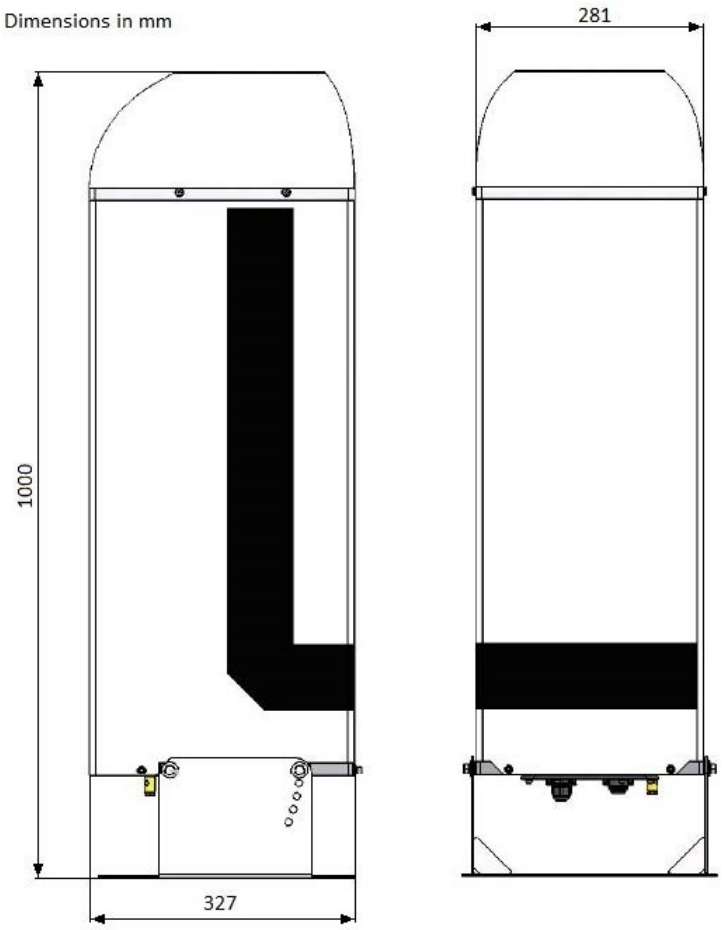


Figure 2-2. SkyVue PRO dimensions

2.4.3 Electrical specifications

Power required:	Nominal 115 VAC (106 to 137 VAC) or nominal 230 VAC (216 to 253 VAC) (automatic selection), 47 to 63 Hz, 470 W total maximum
Heater:	
Hood heater:	270 W, maximum
Internal heater:	120 W, maximum
Supply voltage:	Specified at time of order
Fuses:	Current models use HBC SA(T); older models used the following:
AUX fuse:	HBC 5A (T)
PSU fuse:	HBC 500 mA (T)
	All fuses are 5 x 20 mm slow blow (T) and are the same for both 115 VAC and 230 VAC.

CAUTION:
The fuse values used must match the design of power supply unit.

Battery: Internal 12 V, 7 Ah sealed lead-acid battery provides 2 hour measurement without the blower/heater. The power supply is equipped with a system to prevent deep discharge of the battery.

The SkyVue PRO uses positive temperature coefficient (PTC) heaters within its design. These heaters are self-regulating, simplifying the internal design of the sensor and improving safety. Due to the nature of these devices, the SkyVue PRO draws higher current during start up. The SkyVue PRO draws up to 1 KW for the first few seconds of operation, dropping off quickly to its normal operating power after a minute. In cold environments, the power consumption of the SkyVue PRO may be as high as 470 W. In warmer environments, it may be as low as 200 W.

The heaters are resistive, which is advantageous when connected to generators or when current consumption is important.

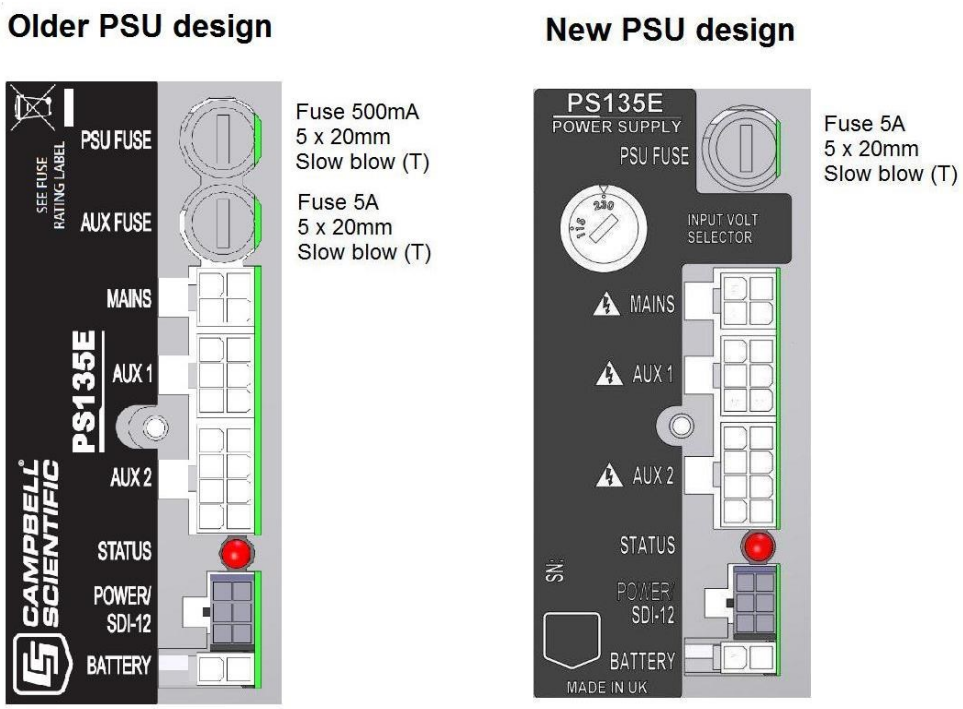


Figure 2-3. PSU types

2.4.4 Optical specifications

Pulse duration:	100 ns
Pulse frequency:	10 kHz
Wavelength:	912 ± 5 nm
Half-angle laser divergence:	0.35 mrad
Field of view:	1.5 mrad
Laser lifetime:	10 years typical
Eye safety class:	1M

2.4.5 Environmental specifications

Standard operating temperature range:	–40 to 60 °C (excluding battery)
Battery temperature range:	–20 to 50 °C (alternative battery types available)
Relative humidity range:	0 to 100%
IP rating:	IP 66
Maximum wind speed:	55 m/s

2.4.6 Communications specifications

Supported serial settings:
8 bits, no parity, 1 stop bit (default)
7 bits, even parity, 1 stop bit
7 bits, odd parity, 1 stop bit

Supported data rates:

300 baud	19200 baud
600 baud	38400 baud
1200 baud	57600 baud
2400 baud	76800 baud
4800 baud	115200 baud
9600 baud	(default)

Supported standards:
RS-232 (default)
RS-485 full duplex
RS-485 half duplex

Signal voltage levels:

	Minimum value	Nominal value	Maximum value
RS-232 communications			
RS-232 input threshold low	0.8 V	1.5 V	–
RS-232 input threshold high	–	2.0 V	2.4 V
RS-232 input absolute maximum	–15 V	–	+15 V
RS-232 input resistance	12 KΩ	–	–
RS-232 output voltage low	–	–	0.4 V
RS-232 output voltage high (into 3 KΩ)	4.4 V	–	–
RS-485/422 communications			
RS-485/422 input threshold voltage	–0.2 V	–	+0.2 V
RS-485/422 output (unloaded)	–	–	5V
RS-485/422 output (load 50 Ω)	2 V	–	–
Maximum voltage at any terminal	–7 V	–	+7 V

USB Service Port USB1.1 and 2.0 compatible, fixed 115200 baud.

3. Initial preparation and checks

The following steps will provide basic familiarization with the SkyVue PRO and allow for initial functionality checks. To do these, remove the cover and enclosure lid and connect the battery (see Connecting the back-up battery [p. 23]). Next, connect the hood heater plug (Figure 4-3 [p. 19]).

> **WARNING:**
> The laser begins operating as soon as the battery is connected. Do not point the laser where it can be viewed with magnifying optics.

The green LED, visible from above, should flash once every 10 seconds (see Figure 5-2 [p. 68]).

Connect the SkyVue PRO **USB** port (see Figure 4-5 [p. 23]) to a computer and use a terminal emulation program set to 115200 baud, 8N1 bits/parity.

The computer should identify the USB connection and allocate a port number. Enter the port setting in the terminal emulator program. Older computer operating systems may need upgrading or additional software.

The SkyVue PRO will output message type 004 (default) every 30 seconds (see CS messages [p. 70]).

Use the **open 0** command to open the terminal mode. You should now see the prompt **CS135>**. Type **Status** to see the sensor status information described in Status command (p. 50). If using date/time information, verify its accuracy since the date/time can drift up to ±14 seconds per day.

If the unit has been in storage or transit for more than a few months, the clock battery may be discharged. However, it will charge from the back-up battery or mains power.

Use the **Close** command to exit the terminal mode. It will close automatically after 10 minutes of inactivity.

If you are not installing the unit and connecting mains power, you should disconnect the battery to avoid it being discharged.

4. Installation

4.1 Location and orientation

The SkyVue PRO measures environmental variables and is designed to be located in harsh weather conditions. However, a few considerations must be taken into account to ensure the data collected from a site are accurate and representative.

To reduce how often the SkyVue PRO requires servicing, place the it away from sources of contamination. More frequent maintenance will be required when the instrument is placed in areas where contamination is unavoidable or where measurements are critical for safety.

Take care that the orientation allows tilting in whatever direction is desired.

> WARNING:
> If installing at an airport, follow local guidelines for the placement of non-frangible objects 1 m (3.2 ft) tall. Please contact Campbell Scientific if frangible fittings are required.

4.2 Grounding

The SkyVue PRO must be properly grounded using a ground wire with a minimum cross-sectional area of 16 mm^2 (0.62 in) and maximum length of 10 m (32.8 ft). Connect the wire from the brass grounding boss—shown in Figure 2-2 (p. 11) to a suitable grounding point.

4.3 Mounting the SkyVue PRO

Mount the SkyVue PRO by bolting to a firm, level foundation. When bolting down, ensure the SkyVue PRO can tilt in all desired directions. Figure 4-1 (p. 17) shows the mounting footprint. If a suitable surface does not already exist, construct a concrete foundation, at least 600 mm (23.6 in) square and 600 mm (23.6 in) deep, by using the following procedure:

1. Drill four 12 mm (0.47 in) diameter holes using the mount base as a template (see Figure 4-1 [p. 17]) to a depth of 77 mm (3.03 in).
2. Clean the holes of all debris.
3. Place washers and nuts on the ends of the wedge anchors supplied (to protect the threads during installation).
4. Hammer the wedge anchors into the holes until the start of the threads are below the surface.
5. Tighten the nuts until about 25 mm (0.98 in) of thread protrudes above the surface.
6. Remove the washers and nuts from the protruding mounting screw, then lower the SkyVue PRO into place.
7. Secure the SkyVue PRO with the washers and nuts.
8. If the surface is not level and flat, add washers under the base on one or more of the foundation screws.

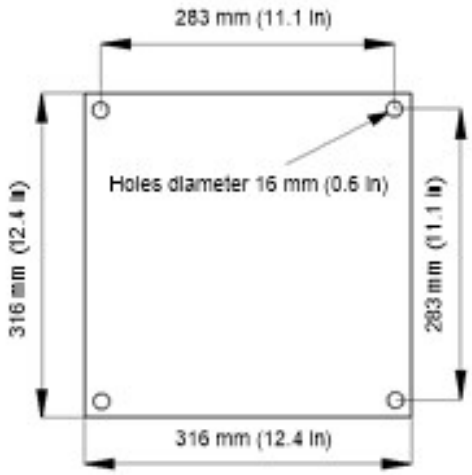


Figure 4-1. Mounting base footprint

4.4 Tilt angle

The SkyVue PRO can be tilted 6°, 12°, 18° or 24° from vertical. In tropical regions, tilting the sensor north in the northern hemisphere and south in the southern hemisphere can prevent the sun from shining directly into the sensor. The tilt angle also can reduce problems caused by direct specular reflections from ice crystals, and prevent rain or snow from falling onto the window. To adjust the tilt angle, remove the bolts shown in Figure 4-2 (p. 18), move the SkyVue PRO to the required tilt angle, and replace the bolts.

The SkyVue PRO has tilt sensors in both axes to compensate the cloud height when the base is not level. Set or disable cloud height compensation by using the `UNITS` command (Terminal mode command examples [p. 30]). This feature is useful for mobile or marine applications. Profile data is NOT compensated but tilt angles are included in data messages.

> **NOTE:**
> Increasing the tilt angle beyond 24° can cause significant errors in vertical visibility measurements if scatter coefficients vary significantly with height.

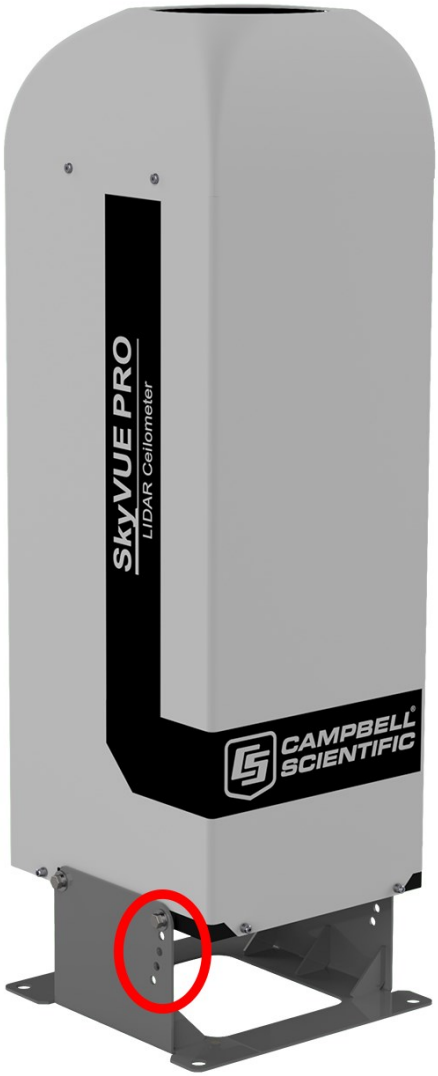


Figure 4-2. Setting the tilt angle

4.5 Connectors and wiring

4.5.1 Base connectors

The SkyVue PRO has three connectors on its base. One connector is for communications; another connector provides power to the unit, and the last connector takes power from the unit to the hood heater and blower.

> **NOTE:**
> Tilting the unit provides better access to these connectors.

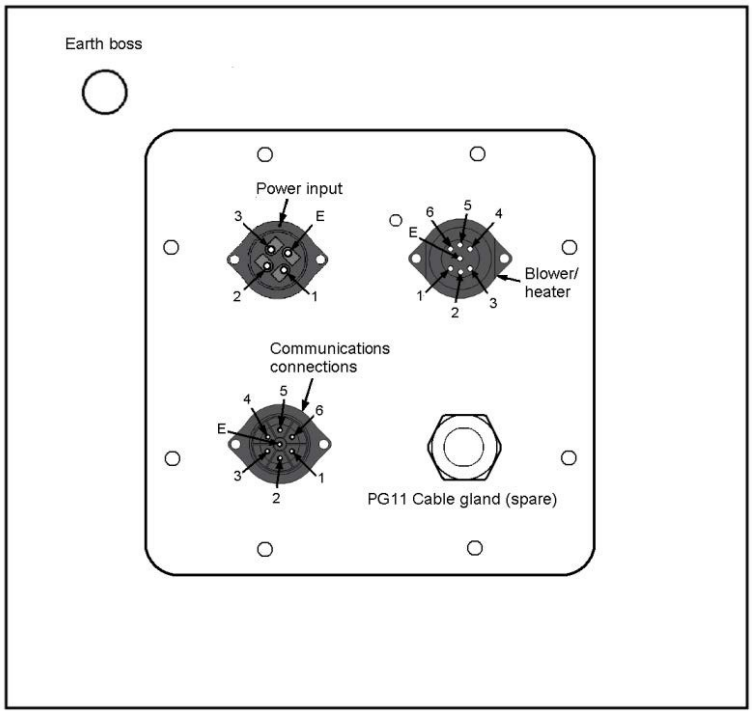


Figure 4-3. Connector layout

The function of the connector pins is shown in Table 4-1 (p. 19), Table 4-2 (p. 20), and Table 4-3 (p. 20).

Table 4-1: Function of the connector pins for the mains connector

Pin	Function	Color of supplied cable cores
1	Live	Brown
2	Not connected	NA
3	Neutral	Blue
4	Earth	Green/yellow

Table 4-2: Function of the connector pins for the blower/heater connector		
Pin	Function	Color of supplied cable cores
1	Neutral	Black (1)
2	Fan + 12 VDC	Black (2)
3	Thermistor	Black (3)
4	Thermistor (0 V)	Black (4)
5	Switched 230/115 VAC	Black (5)
6	Fan 0 V	Black (6)
E	Earth	Green/yellow

Table 4-3: Function of the connector pins for the communications connector					
Pin on connector on SkyVue PRO	Color of supplied cable cores	9-pin D connector	RS-232	RS-485 half duplex	RS-485 full duplex/ RS-422
1	Red	8	CTS (DCE) output	B/D+	Y/TXD non-inverting
2	Yellow	7	RTS (DCE) input		B/RXD non-inverting
3	Green	5	Gnd		
4	Black			Gnd	Gnd
5	White	2	RXD (DCE) output	A/D–	Z/TXD inverting
6	Blue	3	TXD (DCE) input		A/RXD inverting
E	Screen				

4.5.2 Wiring using supplied Campbell Scientific cables

Two cables are supplied, each 10 m (32.8 ft) long. One is for the mains power supply and the other is for communications.

WARNING:
Incorrectly wiring the power cable can cause irrevocable damage to the unit and can cause serious injury or death.

WARNING:
The power cable must not be carrying mains voltage when it is being connected or disconnected.

4.5.2.1 Power connections

The following is a guide for wiring and installing a permanent power supply.

As the sensor is used outside, a qualified electrician should install the power cables. Be sure to follow all applicable local safety regulations.

Ensure that the termination type, cable type, and cable run of the mains power source complies with local regulations and fits the installation requirements.

The power source needs to provide the correct voltage, frequency, and and provide sufficient current to meet or exceed the system's power requirements.

Voltage requirements: 106 to 137 VAC or 216 to 253 VAC (check power supply switch and fuses match the nominal 115/230V AC supply)

Current requirements: 5 A

Input frequency: 47 to 63 Hz

The power source needs fuses with ratings of 5 A or larger and a slow-blow design. Cable extensions or replacement cables should be capable of carrying current exceeding the fuse rating.

Include a two-pole isolator as close to the sensor as is possible.

The power cable needs three conductors (live, neutral, and a protective earth), normally with IEC wiring colors to match those used.

The equipment requires the connection of earth ground using the earth wire of the power connector/cable or via the earth stud on the sensor base. Ensure the earth connection at the power source is suitable for this purpose.

This equipment also requires correct connection of the live and neutral conductors — make sure these are identified and wired correctly at the power source.

Normally, fit the power source with its own or system-wide GFCI[1].

For short term testing of the sensor,a suitable plug can be attached to the power cable, allowing the sensor to be connected to a standard mains supply that provides 5 A at the rated voltage.

For DC operation, the SkyVue PRO requires a 10 to 40 VDC power supply capable of delivering 1 A at 12 VDC or 0.5 A at 24 VDC.

4.5.2.2 Communications connections

The communications cable terminates at one end with a removable 9-pin, D-connector (DB9). The D-connector connects directly to a computer or data logger such as the Campbell Scientific CR1000X using a suitable interconnecting cable such as the SC110. Figure 4-4 (p. 22). The connector can easily be removed for direct connection to screw terminals.

See www.campbellsci.com/downloads/skyvue-example-programs for CRBasic programs that connect the SkyVue PRO to a Campbell Scientific data logger.

> **CAUTION:**
> The supplied cable is not recommended for lengths greater than 10 m (32.8 ft). Longer RS-485 cables should incorporate twisted pairs. Contact Campbell Scientific if needing longer cable lengths.

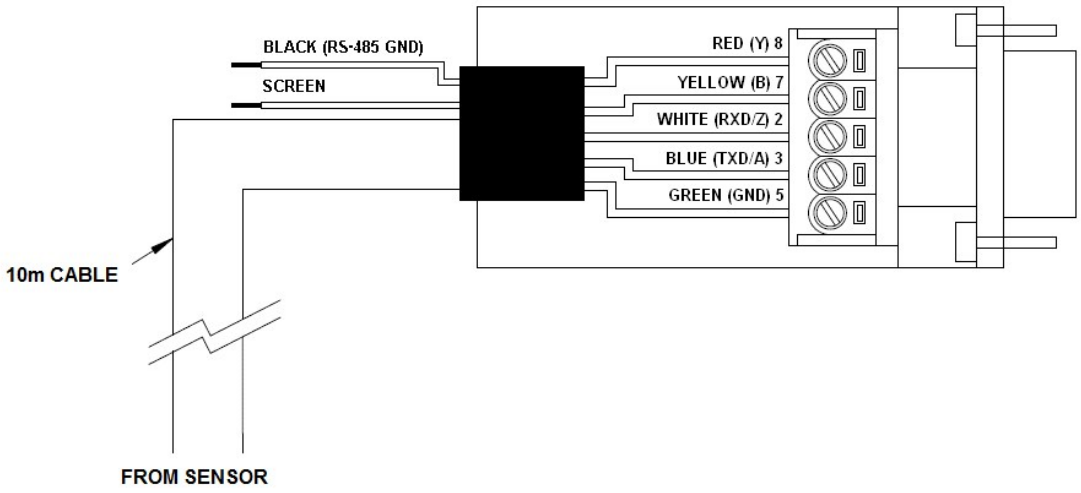


Figure 4-4. Cable connections

Tilting the unit (Figure 4-2 (p. 18)) will make wiring easier.

[1]The ground fault circuit interrupter (GFCI) is also known as the residual-current device (RCD) in the United Kingdom.

4.5.3 USB connection

The USB port provided inside the enclosure is for on-site maintenance. It supports communication of commands to the SkyVue PRO and responses in the same form as the main serial port, except the baud rate is fixed at 115200 (see Figure 4-5 [p. 23]).

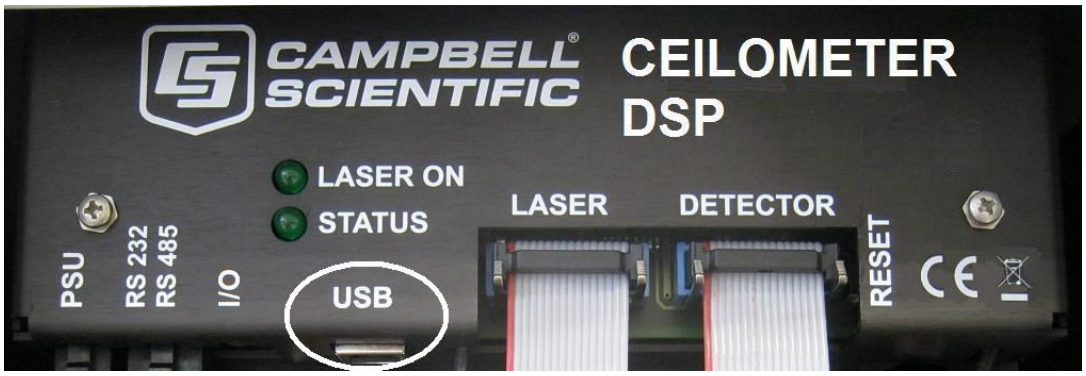


Figure 4-5. USB port

4.5.4 SDI-12 connection

An SDI-12 port is present but is only used for factory setting of the instrument.

4.6 Connecting the back-up battery

The SkyVue PRO is shipped with the back-up battery disconnected and includes desiccant used for transport. Before using the unit, remove the cover and enclosure lid, connect the internal battery (Figure 4-6 (p. 23), remove the desiccant, and replace the cover and enclosure lid.

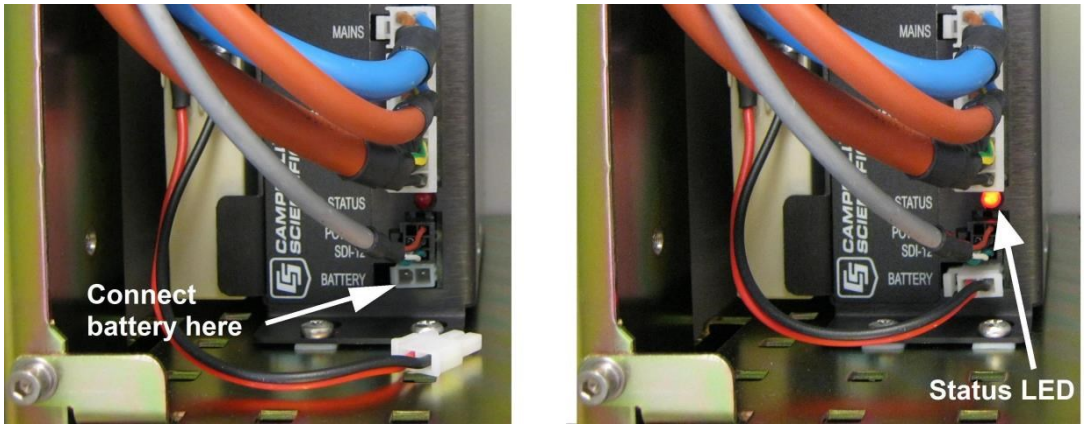


Figure 4-6. Connecting battery

4.6.1 Removing the cover

1. Remove four screws (Figure 4-7 (p. 24)).

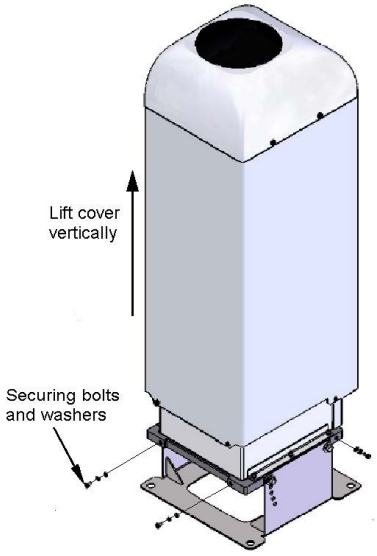


Figure 4-7. Removing the cover

2. Lift the cover off the base.

CAUTION:
The cover contains a flying lead that supplies power to the hood heater and blower. Be careful not to trap and damage the lead when lifting the cover off.

4.6.2 Removing the enclosure lid

1. Remove the four screws (Figure 4-8 [p. 25])
2. Pull the enclosure lid away from the electronic unit.

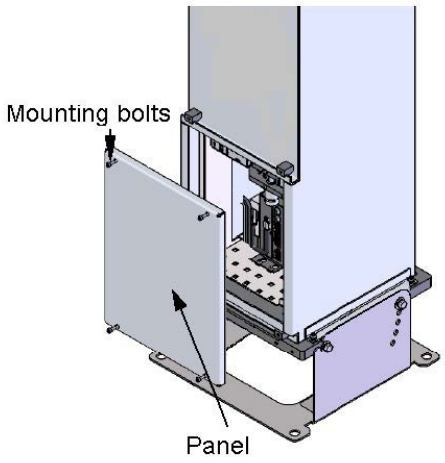


Figure 4-8. Removing the enclosure lid

WARNING:
Opening the access door MUST be performed by a competent person, with sufficient training, experience, and knowledge of electrical safety and the detail and the sensor's operation.

WARNING:
Removing the enclosure lid may expose hot surfaces.

4.7 Bird spike kit

The optional bird spike kit deters birds from sitting on the SkyVue PRO. It includes four stainless-steel spikes with rounded ends and a small reel of stainless-steel wire. The following figure shows installed bird spikes.

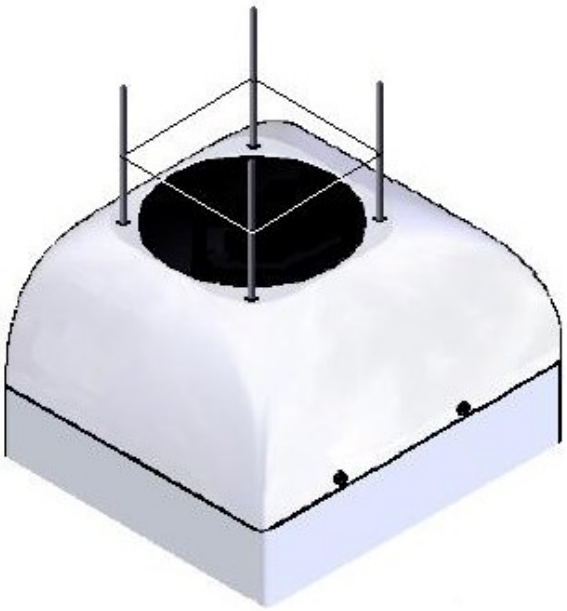


Figure 4-9. Ceilometer bird spike kit installed

To install the bird spikes, remove the cowl and blanking plugs from the cowl (Figure 4-10 [p. 26]). If the SkyVue PRO is an older unit without pre-existing holes, then drill four holes, each 4.5 mm (0.17 in) diameter, evenly spaced around the aperture and 10 mm (0.39 in) in from the edge. For each hole, place a nut and washer then thread the spike into the hole. Tighten the nuts and washers (see Figure 4-11 [p. 27]). Replace the cowl on the SkyVue PRO.

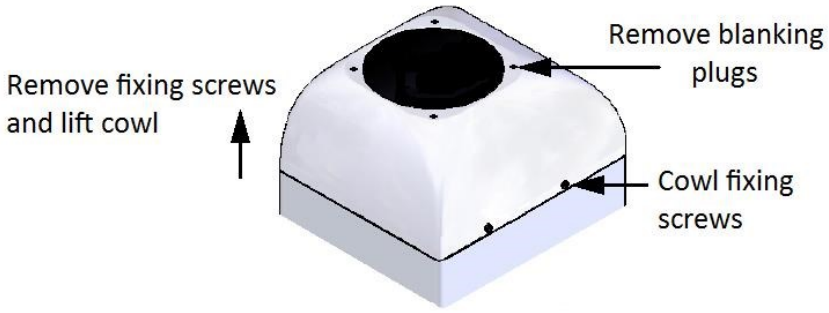


Figure 4-10. Preparing the SkyVue PRO for installing the bird spikes

Figure 4-11. Attaching bird spikes to the SkyVue PRO cowl

Wrap the stainless steel wire around each spike using the grooves in the spike then wrap it back on itself.

> **CAUTION:**
> Do not tighten the wire too much as it may pull the spikes inwards and obscure the field of view of the SkyVue PRO optics.

Only use one strand of wire to reduce the possibility of water drops being collected.

Check the wire during maintenance and replace if necessary.

4.8 Storage information

Store the SkyVue PRO in a dry place at –40 to 70 °C, preferably with the enclosures securely fastened. Protect the optics from possible accidental damage. Disconnect the back-up battery when storing the SkyVue PRO.

> **NOTE:**
> If the battery remains connected during storage, the unit will be powered until the battery voltage falls below a shut-down threshold.

> **NOTE:**
> Storing the SkyVue PRO below 0.0 °C will increase the start-up time by up to ten minutes. At –20 °C, the SkyVue PRO will not achieve full accuracy for an hour.

NOTE:
Remove the battery if the SkyVue PRO is to be stored outside the –20 to 50 °C temperature range.

5. Operation

5.1 Terminal mode

5.1.1 Entering/exiting the SkyVue PRO terminal mode

Use the `OPEN Sensor_ID Password` command to enter the menu system. The menu will time out and close automatically if not used for ten minutes.

`Sensor_ID` is the SkyVue PRO identification, which is a single character, 0-9, a-f, A-F and is case sensitive. Default is 0. Enter the password if using one. The following text should be displayed:

CS135>. The SkyVue PRO is now ready for terminal mode commands.

The SkyVue PRO commands are not case sensitive, but the parameters and password are case sensitive.

Example of the open command followed by the **0** parameter:

```
OPEN 0
```

Example of the open command with the password `Secret`:

```
OPEN 0 Secret
```

5.1.2 Terminal mode commands general

Table 5-1 (p. 31) provides a summary of the terminal mode commands.

To send commands that setup and control the SkyVue PRO, use the terminal interface, data logger, or terminal emulators built into many Campbell Scientific software products, such as the *Device Configuration Utility*.

> **NOTE:**
> To load an operating system (OS), you need a terminal emulator with XMODEM protocol, such as Tera Term.

Use the following settings:

Setting	RS-232/422/485 interface (default)	USB service port
	RS-232 handshaking	
Baud rate	115200	115200
Data bits	8	8
Parity	none	none
Stop bits	1	1
Flow control	none	none

The baud rate of the SkyVue PRO must match the port setting baud rate in the terminal emulator. The SkyVue PRO should now be ready to accept commands.

> NOTE:
> Commands always output all parameters on a new line after a CR LF (carriage return and line feed) followed by the SkyVue PRO prompt **CS135>**. If you only want to see parameter values without changing them, enter the command without parameters. If a particular parameter did not need changing, then the parameter can be replaced with a comma (,). Back space will abort the command.

5.1.3 Terminal mode command examples

How to enter a command

Example 1

The following text shows an example of setting up the SkyVue PRO serial port. This example sets the serial port to RS-232 hand shaking at 115200 bps, 8 data bits, no parity. If it was in RS-485 mode, then a 100 ms turn around delay would be applied.

```
serial 0 10 0 100
```

You could also type the following to obtain the same results because the RS-485 turn around delay is not needed:

```
serial 0 10 0
```

To change only the data baud rate, you can replace the mode parameter, with a comma (,) as shown below.

```
serial , 10
```

Alternatively if you just wished to change the parity to 8-bits no parity, type the following:

```
serial , , 0
```

You do not need to replace the remaining parameters with a comma (,); you only need to replace the ones up to the parameter you wish to edit.

> NOTE:
> Leave a space character between the command and the parameters as shown in the examples.

Example 2

Entering the **MCFG** command, as shown below, will set the sensor to send messages at 10 second intervals and to send one message only with the message number 112.

```
MCFG 10 112 0 0 0 0 (return)
```

The four zeros indicate that no other message outputs have been set. The **MCFG** command is described in Table 5-1 (p. 31).

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
ALARMS	Angle	Angle is the threshold tilt angle of the sensor beyond which an alarm will be flagged. The settable range is 0 to 90.0 degrees tilt and the default is 45.0 degrees.
APPLICATION	Application_n	**Application_n** selects pre-configured user settings optimized for a specific application. For the following values of n: 0 = Help 10 = Aviation 20 = Research 40 = Meteorology 225 = User defaults The default application for the SkyVue PRO is 40, Meteorology. Settings adjusted by the **APPLICATION** command include settings in **BS**, **MCFG**, and **UNITS**.
BS (see Measurement and message intervals (p. 48) for more information on compatibility of different parameters)	Attenuated_ SCALE, BS_Av_Time, Noise_Gate, Measurement_ Period, Rolling_Average, Message_Interval BS_Temporal_ Filter_Mode	Rules for **BS** command are: **BS_Av_Time <= Measurement_Period-1s**. **Message_Interval** must be a multiple of **Measurement_Period**. **Attenuated_SCALE** is the scalar for the attenuated backscatter percent. 0.001 to 100% (default 100%) **BS_Av_Time** is the backscatter average time in seconds. 1 to 30 (default 2). Note: Must not be greater than **Measurement_ Period** – 1.0 **Noise_Gate** controls the noise threshold applied to back-scatter. **Noise_Gate** = -1000, all backscatter range is

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		corrected. **Noise_Gate** = 0.0 to 1000.0, standard deviation (default 2) for noise threshold. Only backscatter above this is range corrected. **Measurement_Period** = 0 or 2 to 600 seconds (default 10). If set to 0 and the SkyVue PRO is polled, it will output the last measurement made. If between 2 and 600 seconds, the SkyVue PRO continually outputs messages. For sky condition output, Campbell Scientific recommends setting the **measurement_ Period** ≤ 30 seconds. If a **measurement_Period** is greater than 30 seconds, the sky condition algorithm will be less able to resolve coverage for higher layers. Note: Must be a sub multiple of **Message_ Interval** **Rolling_Average** = 1 to 29 (default 1). This is the number of **measurement_periods** to use in a rolling average of the backscatter. **Message_Interval** is the message interval in seconds. Range is 2 to 600 seconds (default 10 s); 0 gives polled messages. Note: Must be a multiple of **Measurement_ Period** **BS_Temporal_ Filter_Mode** allows the selection of backscatter filtering modes. 0 = Averaging 1 = Median signal processing Default setting is 1, the median mode for aviation.
CLOSE	No parameters	Closes the terminal interface to allow normal message output and saves new settings to flash non-volatile

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		storage.
CLOUDMODE	CloudMode_A	CloudMode_A turns on a filter that reports the highest cloud during precipitation to avoid precipitation from being reported as low cloud. 0 = Filter Off 1 = Filter On (default). Reports the highest cloud during precipitation
DEFAULTS	No parameters	Loads factory defaults
GETUSER		Reads all user settings as a string of text. Parameters are read in the following order: user = text user volVer = user volume version OS_VER = DSP OS version PsuOsVer = PSU OS version TopOsVer = TOP OS version Id = SkyVue PRO ID Pw = SkyVue PRO password terminalCrc = terminal crc mode terminalTimeout = terminal timeout unitsTiltMode = units and tilt mode hoodHBMode = hood heater / fan heater mode hoodHBTestInt = hood heater / blower test interval in hours battBoost_mV = boost voltage used for battery charging mV battCharge_mA = battery charge current mA psuPresent = PSU present switch hoodHBNormSpeed = fan voltage for normal speed

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		mV **hoodHBHighSpeed** = fan voltage for high speed mV **hoodHBLowSpeed** = fan voltage for low speed mV **intHMode** = internal heater mode **message[0]** = fields for message 0 **message[1]** = fields for message 1 **message[2]** = fields for message 2 **message[3]** = fields for message 3 **message[4]** = fields for message 4 **messagePeriod** = output message period in seconds **heightOffset**= height offset meters **bsAvTime**= backscatter average time in seconds **laserMode** = laser operation mode **laserPower** = laser power **laserHeater** = laser heater mode **attenuatedSCALE** = attenuated backscatter scaling factor **logInterval** = debug logging interval **measurementPeriod** = measurement interval in seconds **serMode** = serial port mode **baudSel** = serial port baud rate mode **dataParityStop** = serial port parity mode **rx2txTimeout** = serial port RX to TX turnaround time **snrMarginBoundary** = onset of backscatter detection threshold

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		`snrMarginDetector` = cloud detection threshold `alphaGuessEnd` = cloud alpha guess at boundary `alphaMin` = cloud detection alpha minimum `Vcld_D` = cloud detection `delta_Vcld_D` = cloud detection `vis_Av_T` = cloud detection `alphaGuess` = visibility initial alpha guess `ratioLevel` = visibility ratio `alphaMin` = visibility alpha minimum `cap` = visibility cap in meters `tiltLimit` = tilt limit in degrees used by alarms `noiseGate` = attenuated backscatter noise gate mode `vvLimit_percent` = sky condition report vertical visibility % `alphaGuessStart`= cloud detection alpha guess at lowest height bin `dt` = mixing layer height temporal filter in minutes `dr` = mixing layer height range filter in meters `q1threshold` = mixing layer height quality threshold 1 `q2threshold` = mixing layer height quality threshold 2 `q3threshold` = mixing layer height quality threshold 3 `stdWidth` = mixing layer height standard deviation width meters `cloudMode` = cloud detector mode parameter

Table 5-1: Summary of the terminal mode commands available		
Command	Parameter/ parameter block	Description
		(03072019a) **CRC** = 4-digit character. CRC calculated from the **u**up to but not including the CRC using the standard CRC-16. Note: Many parameters are not adjusted. This command allows a reliable technique for copying full settings from one SkyVue PRO to another with the **SETUSER** command. A typical response to the **GETUSER** command is: >>>>> COPY FROM START OF NEXT LINE >>>>> user 7 007638-6da 106 510 0 , 0 10 2 0 1 14520 400 1 1000 1000 2000 0 1 0 0 0 0 10 0.000E+00 2.000E+00 1 1.000E+00 0 1.000E+00 0 10 1 0 10 0 100 4.000E+00 6.000E+00 2.000E-03 2.500E-04 1.000E+03 2.200E+01 4.800E+03 1.000E-01 9.000E-01 2.500E-04 2.000E+03 4.500E+01 2.000E+00 50 2.00E-03 3.000E+01 1.500E+02 1.800E+00 5.000E+00 1.000E+01 150 98b2 <<<<< TO START OF THIS LINE <<<<<
HEATERS	Hood Internal Laser Test_interval	Sets or reads heater settings as follows: **Hood** = 0, Hood blower and heater OFF **Hood** = 1, Hood blower ON and heater OFF **Hood** = 2, Hood blower ON and heater ON **Hood** = 3, Hood blower and heater AUTO (default) – (see note (1) below). **Internal** = 0, Internal heater OFF **Internal** = 1, Internal heater ON **Internal** = 2, Internal heater AUTO (default) **Laser** = 0, laser heater off **Laser** = 1, laser heater on (default)

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		`Test_interval` = 1 to 168 hours (default 24 hours). Heater/Blower test interval
HELP	No parameters	Calls up a list of user commands with brief descriptions
HOFFSET	`Height_offset`	`Height_offset` is the offset to be added or subtracted in the range of ±1000 m (±3281 ft). Positive values are added to measured height and negative values are subtracted from measured height. The default is 0.
ID	`Sensor_ID`	Reads or sets the sensor ID, a single character, 0-9, a - z or A - Z, case sensitive. Default ID = 0. Note: Lower case letters are not allowed if using a CT25K message.
LASER	`Laser` `Laser_Power`	`Laser` = 0, laser off after power up (user must switch laser on) `Laser` = 1, laser on after power up (default) `Laser_Power` = 20% to 100%, default 100%
LASEROFF	No parameters	Instructs the SkyVue PRO to turn the laser off until either a power cycle or the sensor is instructed to turn the laser back on.
LASERON	No parameters	Instructs the SkyVue PRO to try and turn the laser on
LOADOS	`Module`	Loads new operating system into modules as follows: `Module` =1, DSP. Note: Operating systems earlier than 4 will need the boot loader updating. Refer to Loading a new operating system (OS) (p. 60) for more information. `Module` =2 `Module` =3, PSU `Module` =4, DSP, TOP, and PSU as one file. Only supported from operating system.

Table 5-1: Summary of the terminal mode commands available		
Command	Parameter/ parameter block	Description
MCFG	Message_Interval Message_ID_A Message_ID_B Message_ID_C Message_ID_D Message_ID_E	Set or read message configuration Message_Interval is the message interval in seconds. Range is 2 to 600 s (default 10); 0 gives polled messages. Note: This command may affect measurement parameters within the BS command. See Measurement and message intervals (p. 48). Message_ID is the message type to output between 0 and 999 (default 001). If Message_ID = 0, no message type is output. Up to five messages can be set (refer to MCFG command message types [p. 47]).
MLH (if available)	Temporal_Filter Range_Filter Std_Width Q1_Threshold Q2_Threshold Q3_Threshold	Sets or reads parameters used in identifying mixing layer heights Temporal_Filter = temporal filter half width used to filter data used by mixing layer height algorithm in minutes. Range is 1 to 40 minutes (default 30 minutes) Range_Filter = range filter half width used to smooth data used by mixing layer height algorithm in meters or feet. Range is 15 m to 600 m or 49 ft to 1969 ft (default 150 m or 492 ft). Std_Width = range half width used to calculate standard deviation of the slope in meters or feet. Range is 10 m to 400 m or 33 ft to 1312 ft (default 150 m or 492 ft). Q1_Threshold = SNR threshold for quality level 1 mixing layer height output. Range is 1.0 to 30.0 (default 1.8) Q2_Threshold = SNR threshold for quality level 2 mixing layer height output. Range is 1.0 to 30.0 (default 5.0). Q3_Threshold = SNR threshold for quality level 3

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		mixing layer height output. Range is 1.0 to 30.0 (default 10.0).
OPEN	ID Password	Opens the SkyVue PRO terminal mode ID = Sensor ID as per the terminal ID command. AnySkyVue PRO with OS OS2 or newer will respond to global ID = 99, regardless of its own ID number. Password = The sensors user password as per the terminal PASSWORD command. The default is no password.
PASSWORD	Password	Sets or clears a password from 1 to 10 characters in length. Valid characters, 0-9, a - z or A – Z, and letters are case sensitive. Typing the PASSWORD command without any parameters clears the password. The default is no password.
POLL	Sensor_ID Message_ID	Requests Message_ID from Sensor_ID. Refer to Message polling (p. 59) for more information on this command Note: If Message_ID is omitted, the SkyVue PRO outputs the message configured by MCFG.
POWEROFF	No parameters	Prepares the PSU to power down the SkyVue PRO even if the battery is connected. As soon as the mains supply is disconnected, the SkyVue PRO will power off and NOT run on battery back-up. The SkyVue PRO can be re-activated with battery back-up enabled by reconnecting the mains supply. You will be asked to confirm.
REBOOT	No parameters	Forces a system reboot. This will restore previously saved user settings. Any unsaved changes will be lost. (Settings are saved in the terminal mode when the CLOSE command is typed, which exits the terminal mode).

Table 5-1: Summary of the terminal mode commands available		
Command	Parameter/ parameter block	Description
SCCAL	No parameters but user interaction required	Stratocumulus backscatter calibration. This requires a human observer to confirm a stable Stratocumulus cloud layer between 250 m to 2500 m without holes, precipitation or reduced visibility and has been stable for at least 10 minutes prior to running this command. See Stratocumulus backscatter calibration (p. 63) for more information.
SERIAL	Mode Baud Bits_Parity Delay	Set or read the serial port. Mode = 0, RS-232, full duplex (default) Mode = 1, RS-232, half duplex Mode = 2, RS-485, full duplex Mode = 3, RS-485, half duplex Mode = 4, reserved Mode = 5, RS-422, full duplex Baud = 0, 300 baud Baud = 1, 600 baud Baud = 2, 1200 baud Baud = 3, 2400 baud Baud = 4, 4800 baud Baud = 5, 9600 baud Baud = 6, 19200 baud Baud = 7, 38400 baud Baud = 8, 57600 baud Baud = 9, 76800 baud Baud = 10, 115200 baud (default) Bits_Parity = 0, 8 bits, no parity, 1 stop bit (default) Bits_Parity = 1, 7 bits, even parity, 1 stop bit

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		`Bits_Parity` = 2, 7 bits, odd parity, 1 stop bit `Delay` = delay time, in milliseconds, before transmitting (RS-485 half-duplex mode only). Range: 0 to 100 ms (default 100 ms).
SERVICE	No parameters but user intervention required	Performs a service procedure
SETUSER	String	Load all user settings as a string of text. (not changed) = parameter will not be updated and the previously set value will persist. `String` = user (not changed) `volVer` = user volume version (not changed) `OS_VER` = `DSP OS` version (not changed) `PsuOsVer` = `PSU OS` version (not changed) `TopOsVer` = `TOP OS` version (not changed) `Id` = SkyVue PRO ID (not changed) `Pw` = SkyVue PRO password (not changed) `terminalCrc` = terminal crc mode `terminalTimeout` = terminal timeout `unitsTiltMode` = units and tilt mode `hoodHBMode` = hood heater / fan heater mode `hoodHBTestInt` = hood heater / blower test interval in hours `battBoost_mV` = boost voltage used for battery charging mV `battCharge_mA` = battery charge current mA `psuPresent` = PSU present switch `hoodHBNormSpeed` = Fan voltage for normal speed,

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		mV **hoodHBHighSpeed** = Fan voltage for high speed, mV **hoodHBLowSpeed** = Fan voltage for low speed, mV **intHMode** = internal heater mode **message[0]** = fields for message 0 **message[1]** = fields for message 1 **message[2]** = fields for message 2 **message[3]** = fields for message 3 **message[4]** = fields for message 4 **messagePeriod** = output message period in seconds **heightOffset** = height offset meters **bsAvTime** = backscatter average time in seconds **laserMode** = laser operation mode **laserPower** = laser power **laserHeater** = laser heater mode **attenuatedSCALE** = attenuated backscatter scaling factor **logInterval** = debug logging interval **measurementPeriod** = measurement interval in seconds **serMode** = serial port mode **baudSel** = serial port baud rate mode **dataParityStop** = serial port parity mode **rx2txTimeout** = serial port RX to TX turnaround time **snrMarginBoundary** = onset of back-scatter

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description

		detection threshold
		`snrMarginDetector` = cloud detection threshold
		`alphaGuessEnd` = cloud alpha guess at boundary
		`alphaMin` = cloud detection alpha minimum
		`Vcld_D` = cloud detection
		`delta_Vcld_D` = cloud detection
		`vis_Av_T` = cloud detection
		`alphaGuess` = visibility initial alpha guess
		`ratioLevel` = visibility ratio
		`alphaMin` = visibility alpha minimum
		`cap` = visibility cap in meters
		`tiltLimit` = tilt limit in degrees used by alarms
		`noiseGate` = attenuated backscatter noise gate mode
		`vvLimit_percent` = sky condition report vertical visibility %
		`alphaGuessStart` = cloud detection alpha guess at lowest height bin
		`dt`
		`dr`
		`q1threshold` = mixing layer height quality threshold 1
		`q2threshold` = mixing layer height quality threshold 2
		`q3threshold` = mixing layer height quality threshold 3
		`stdWidth` = mixing layer height standard deviation width in meters

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
		`cloudMode` = cloud detector mode parameter (03072019a) **CRC** = 4-digit character. CRC calculated from the **u** up to but not including the CRC using the standard CRC-16. Note: String is added as text and should be cut and pasted from a stored file.
STATUS	No parameters	Outputs SkyVue PRO, serial number, ID, DSP OS version, Time and Date, DSP version, TOP OS version, PSU OS version, watch dog counts, serial parameters, blower heater mode, internal heater mode, message parameters, tilt angle, units, temperature/humidity, temperatures, supply voltages, height offset, visibility cap, laser run days, window parameters, backscatter parameters, MLH parameters, features, alarms, warnings, and status. Note: Refer to Status command (p. 50) for more information on this command
TERMINAL	`Terminal Timeout`	Sets the user terminal time out. Timeout is the delay in minutes from 1 to 15 where the terminal will automatically close if no characters are sent to the SkyVue PRO. The default is 10 minutes.
TIME	Date_Time	Date is in the format yyyy/mm/dd Time is in the format hh:mm:ss yyyy=year, mm=month, dd=day hh=hours, mm=minutes, ss=seconds For example: time 2013/05/25 10:00:00, sets the date and time to May 25, 2013 at 10:00:00) Note: The set time could drift by up to ±14 seconds a day.

Table 5-1: Summary of the terminal mode commands available

Command	Parameter/ parameter block	Description
UNITS	Units	Sets measurement units and tilt correction Units = 0, meters corrected by tilt Units = 1, meters not corrected by tilt Units = 2, feet corrected by tilt (default) Units = 3, feet not corrected by tilt
UNLOCK	Key	Key = a 12 digit key purchased from Campbell Scientific. The key unlocks features such as Mixing Layer Height assessment. The key is specific to the individual SkyVue PRO and only has to be entered once.
VIS	Cap	Cap is the vertical visibility maximum range 100 to 10000 in meters or 328 to 32808 in feet (default 2000 m or 6561 ft).

NOTE:
If AUTO is set, the heater / blower will heat to 80 °C if (sky condition > 1 okta coverage) or (cloud height < 3 km (9842 ft) AND sky condition > 1 okta coverage) or window Tx < 80% or precipitation detected. When the event has passed, the blower/heater will remain active at 80 °C for a further 15 minutes before going into a fan-off state and the heater temperature drops to an average of approximately 40 °C, ready to be activated again.

5.1.4 Application command message types

The **Application_n** parameter for the APPLICATION command defines settings to optimize the ceilometer for a range of applications, Aviation, Research and Meteorology. The default application setting for the SkyVue PRO is Meteorology, but this can be changed, or returned to, using the **Application_n** command.

Users can adjust any element of these settings once an application has been applied through the following individual commands: **ALARMS**, **BS**, **CLOUDMODE**, **MCFG** and **UNITS**.

Table 5-2: Summary of applications and applied settings for SkyVue PRO					
	Application modes for SkyVue PRO using OS13 and newer				Defaults using OS12 and older
Settings	Aviation	Research	Air quality	Meteorology (default)	General application
ALARMS (tilt degs)	30	45	45	45	45
APPLICATION: Application n (sets user application settings)	Application 10	Application 20	Application 30	Application 40	N/A
BS: Attenuated scale (%)	100	100	100	100	100
BS: Backscatter averaging time (s)	2	7	7	7	7
BS: Noise Gate	2 (ON)	-1000 (OFF)	2 (ON)	-1000 (OFF)	-1000 (OFF)
BS: Measurement Period (s)	10	10	10	10	10
BS: Rolling Averages (sets the number of readings for averaging. Alternative description: Backscatter temperal filter rolling samples	3	6	6	3	3
BS: Message Interval (s)	30	30	30	30	30
BS: BS_Temporal_ Filter_ Mode (Sets Averaging or Median Mode.)	1 (Median)	0 (Average)	0 (Average)	0 (Average)	N/A (Average)
CLOUDMODE: CloudMode_A (Reports highest cloud only during precipitation)	ON	OFF	OFF	ON	N/A

Table 5-2: Summary of applications and applied settings for SkyVue PRO					
	Application modes for SkyVue PRO using OS13 and newer				Defaults using OS12 and older
Settings	Aviation	Research	Air quality	Meteorology (default)	General application
MCFG: Message ID	4 (CB,SC,BS)	6 (CB,SC, MLH,BS)	6 (CB,SC, MLH,BS)	4 (CB,SC,BS)	4 CB,SC,BS)
UNITS	2 (Feet, tilt corrected)	0 (Meters, tilt corrected)	0 (Meters, tilt corrected)	0 (Meters, tilt corrected)	0 (Meters, tilt corrected)

5.1.5 MCFG command message types

The `Message_ID_x` parameter for the `MCFG` commands defines the output types. Refer to Messages (p. 68) for further information on message output types.

Table 5-3: Summary of message ID and descriptions	
Message_ID_x type	Description
000	No message
001	Campbell Scientific Message 1, no sky condition, no profile data
002	Campbell Scientific Message 2, no sky condition, profile data, 2048 range bins, 5 m resolution
003	Campbell Scientific Message 3, sky condition, no profile data
004 (default)	Campbell Scientific Message 4, sky condition and profile data, 2048 range bins, 5 m resolution
005[1]	Campbell Scientific Message 5, sky condition, no profile data, mixing layer height
006[1]	Campbell Scientific Message 6, sky condition, profile data, 2048 range bins, 5 m resolution, mixing layer height
101	CL31 Message 1, 770 range bins, 10 m resolution
102	CL31 Message 1, 385 range bins, 20 m resolution

Table 5-3: Summary of message ID and descriptions	
Message_ID_x type	Description
103	CL31 Message 1, 1500 range bins, 5 m resolution
104	CL31 Message 1, 770 range bins, 5 m resolution
105	CL31 Message 1, No profile data
106	CL31 Message 1, Full SkyVue PRO output, 2048 range bins, 5 m resolution
107	CL31 Message 2, 770 range bins, 10 m resolution
108	CL31 Message 2, 385 range bins, 20 m resolution
109	CL31 Message 2, 1500 range bins, 5 m resolution
110	CL31 Message 2, 770 range bins, 5 m resolution
111	CL31 Message 2, No profile data
112	CL31 Message 2, Full SkyVue PRO output, 2048 range bins, 5 m resolution
113	CT25K Message 1
114	CT25K Message 6
[1]Only available if MLH option is active.	

5.1.6 Measurement and message intervals

The message interval is the time, in seconds, between the automatic message transmissions. It can be set between 2 to 600 s (**0** gives polled messages). The default is 10, meaning a message will be sent automatically every 10 seconds. The message interval must be a multiple of the measurement period.

The backscatter average time, **BS_Av_Time**, is the period over which the laser is firing and taking measurements.

The measurement period is the time interval between the start of backscatter average time (**BS_Av_Time**), during which the laser fires, and the start of the next measurement period. The measurement period must be long enough to include the backscatter average time and some processing time. The minimum measurement period is 2 seconds, which assumes the backscatter average time is 1 second. The measurement period can be set between 2 to 600 s (default is 10 s). If it is set to 0, then measurements must be polled.

The rolling average (1 to 29, default 1) is the number of periods used to calculate each scatter value that is either used in a profile message or in a calculation of cloud height.

The message interval chosen may affect measurement parameters allowed within the BS command, which can be used to set non-standard measurement parameters) as follows:

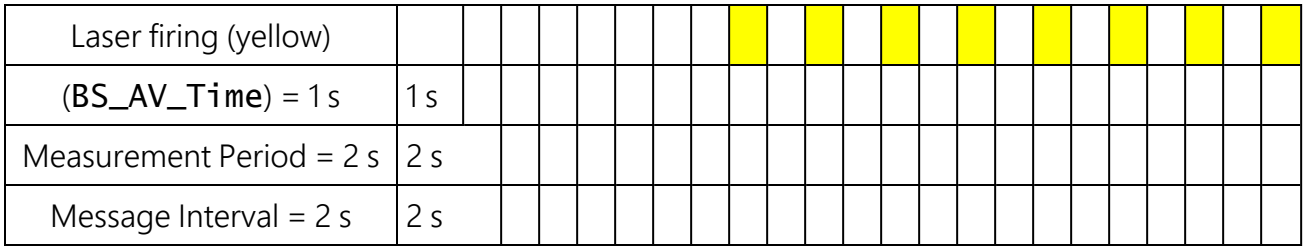
If message interval = measurement period = 2 (the lowest values allowed), then the backscatter average time (BS_Av_Time) must equal 1 and the rolling average must equal 1.

If the message interval is between 3 and 9 s, then the measurement period must be the same as the message interval.

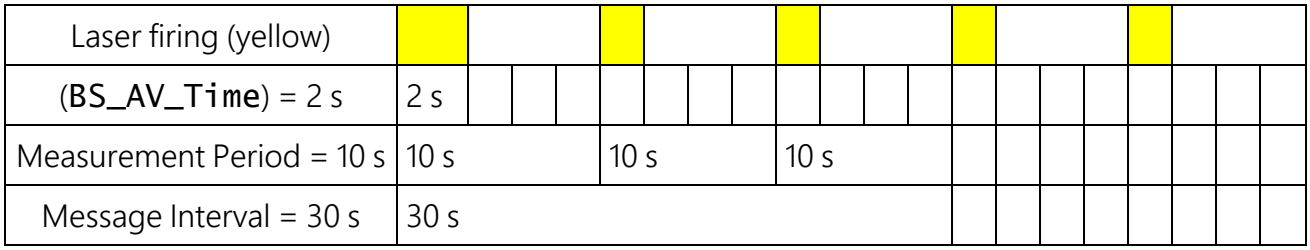
In the following examples, yellow means laser firing.

To comply with the requirements for Sky Condition the total measurement period for rolling averages should not exceed 30 seconds.

In the following case, the SkyVue PRO sends a message every 2 seconds based on one measurement averaged over 1 second. Therefore, each message is based on a single 1 second period of backscatter average data.



In following case, with the rolling average set to 1, the SkyVue PRO sends a message every 30 seconds. It takes three, 2 second, measurements at 10 second intervals. Only the last measurement is used in the output message but all three are used for calculating sky condition. Therefore, each message is based on a single 2 second period of backscatter average data.



In the following case, with the rolling average set to 3, the SkyVue PRO sends a message every 30 seconds that contains the average of the latest three measurements. Therefore, each message is based on three, 10 second measurement periods, with each containing 2 seconds of backscatter average data.

Laser firing (yellow)																							
(BS_AV_Time) = 2 s	2 s																						
Measurement Period = 10 s	10 s				10 s				10 s														
Message Interval = 30 s	30 s																						

In the following case, with the rolling average set to 3 (default), the SkyVue PRO sends a message every 10 seconds that contains the average of the latest three measurements. Therefore, each message is based on three, 10 second measurement periods, with each containing 2 seconds of backscatter average data.

Laser firing (yellow)																							
(BS_AV_Time) = 2 s	2 s																						
Measurement Period = 10 s	10 s				10 s				10 s														
Message Interval = 10 s	10 s				10 s				10 s														

In following case, the SkyVue PRO sends a message every 14 seconds based on one measurement taking 4 seconds over a 14 second interval. Therefore, each message is based on a single 4 second period of average data. This message cannot be set up using the MCFG command message types (p. 47) alone.

The BS command has to be used as follows:

BS_Av_Time (averaging period) has to be set to 4, not the default value.

Laser firing (yellow)																							
(BS_AV_Time) = 4 s																							
Measurement Period = 14 s	14 s				14 s				14 s				14 s										
Message Interval = 14 s	14 s				14 s				14 s				14 s										

5.1.7 Status command

The STATUS command returns the following information:

Line	Example line output
1	Identification CS135 SN1000 ID 0
Description of the line sections	
Section	Description
CS135	Product name
SN1000	Sensor serial number
ID 0	Sensor identification number

Line	Example line output
2	Date Time 2012/01/10 11:39:46
Description of the line sections	
Section	Description
2012/01/10	Date in the format yyyy/mm/dd
11:39:46	Time in the format hh:mm:ss

Line	Example line output
3	DSP_OS A
Description of the line sections	
Section	Description
A	DSP OS revision number

Line	Example line output
4	TOP_OS 1
Description of the line sections	
Section	Description
A	TOP board OS revision number

Line	Example line output
5	PSU_OS 1
Description of the line sections	
Section	Description
A	PSU board OS revision number

Line	Example line output
6	Watchdog A
Description of the line sections	
Section	Description
A	Watchdog counter for unscheduled system resets

Line	Example line output
7	Serial A B C D
Description of the line sections	
Section	Description
A	Serial mode (Note: Refer to the SERIAL command)
B	Serial baud rate (Note: Refer to the SERIAL command)
D	Receive to transmit delay time in RS-485 mode (Note: Refer to the SERIAL command)

Line	Example line output
8	Heaters A B C D
Description of the line sections	
Section	Description
A	Hood blower mode
B	Internal heater mode
D	Heater/blower test interval in hours

Line	Example line output
9	MCFG X A B C D E
Description of the line sections	
Section	Description
X	Message interval (Note: Refer to the MCFG command)
A	Message ID A (Note: Refer to the MCFG command)
E	Message ID E (Note: Refer to the MCFG command)

Line	Example line output
10	Angle A B C
Description of the line sections	
Section	Description
A	X axis tilt
B	Y axis tilt
C	Beam angle from vertical

Line	Example line output
11	Units A
Description of the line sections	
Section	Description
A	Measurement units and tilt correction. (Note: Refer to the UNITS command)

Line	Example line output
12	TRH A B C
Description of the line sections	
Section	Description
A	Sensor internal temperature reading in degrees Celsius
B	Sensor internal humidity reading as a percentage
C	Sensors internal dew point value in degrees Celsius

Line	Example line output
13	T A B C D E F
Description of the line sections	
Section	Description
A	External fan blower assembly temperature in degrees Celsius
B	PSU internal temperature in degrees Celsius

Line	Example line output
14	SupplyVoltage A B
Description of the line sections	
Section	Description
A	DSP board supply voltage
B	PS135E internal supply voltage

Line	Example line output
15	HOffset A
Description of the line sections	
Section	Description
A	Height offset reported in feet or meters dependent upon the UNITS command

Line	Example line output
16	Visibility Cap A
Description of the line sections	
Section	Description
A	Vertical visibility maximum range

Line	Example line output
17	LaserRunDays A
Description of the line sections	
Section	Description
A	Number of days that the laser module has been active for

Line	Example line output
18	WindowTX A
Description of the line sections	
Section	Description
A	Window transmittance %

Line	Example line output
19	BS A B C D E F (Note: refer to the BS command)
Description of the line sections	
Section	Description
A	Attenuated scale
B	Averaging time
F	Message interval

Line	Example line output
20	MLH A B C D E F (Note: refer to the MLH command)
Description of the line sections	
Section	Description
A	Temporal filter
B	Range filter
F	Q3 threshold

Line	Example line output
21	Features A
Description of the line sections	
Section	Description
A	List of features enabled

Line	Example line output
22	Flags 0000 0000 0000
Description of the most significant alarm word (left side, bits going left to right). Each alarm word is a hexadecimal sum of all the error bits.	
Bit	Description
8000 XXXX XXXX	Units. feet = 0, meters = 8
4000 XXXX XXXX	Reserved for future use
0001 XXXX XXXX	No communications between DSP and inclinometer board

Description of the middle alarm word (middle word, bits going left to right)	
Bit	Description
XXXX 8000 XXXX	The sensors internal humidity is high
XXXX 4000 XXXX	Communications to the DSP boards temperature and humidity chip have failed
XXXX 2000 XXXX	DSP input supply voltage is low
XXXX 1000 XXXX	Self-test active
XXXX 0001 XXXX	Photo diode background radiance is out of range

Description of the least significant alarm word (right side, bits going left to right)	
Bit	Description
XXXX XXXX 8000	Photo diode temperature is out of range
XXXX XXXX 4000	Photo diode is saturated
XXXX XXXX 2000	Photo diode calibrator temperature is out of range
XXXX XXXX 1000	Photo diode calibrator has failed
XXXX XXXX 0001	Laser is off

5.1.8 Message polling

The **POLL Sensor_ID Message_ID** command requests the **Message_ID** from the **Sensor_ID**. The**Message_ID** is a SkyVue PRO message type as defined in MCFG command message types (p. 47).

The following example uses the SkyVue PRO **POLL** command to request preconfigured message outputs.

First configure the SkyVue PRO to use polling mode from the terminal interface via the **MCFG** command as follows:

CS135> MCFG 0

0 1 0 0 0 0

This configures the SkyVue PRO into polling mode leaving your message output configurations unchanged. Exit the terminal by typing the **CLOSE** command. This will save the changes you just made.

CS135> CLOSE

COMMAND CLOSED

Automatic message outputs should continue. Type the **POLL** command as shown below to verify that the system is working as expected.

> **NOTE:**
> Once exited, the terminal characters will not be automatically echoed back to you.

POLL 0

This should return all messages you have set via the **MCFG** command. In this example, only default message output was set. Therefore, the **POLL** command returns text similar to the following.

> **NOTE:**
> If you have no message configured, the **MCFG** command returns **0 0 0 0 0**, then nothing will be returned from the command you just typed.

CS0100001

10 100 12345 ///// ///// ///// 000000000000

abcd

The following example shows how to use the **POLL** command to request a specific message output type.

To poll the SkyVue PRO for a particular message type, enter the following.

```
POLL 0 113
```

This command requests CT25K Message 1 and should look similar to the following.

```
CT00010
10 12345 ///// ///// 00000f80
```

5.1.9 Loading a new operating system (OS)

A new OS can be entered with the LOADOS module command. The three different modules have their own OS. The parameter module loads a new operating system into different modules as follows:

Module =1, DSP (file type *. ldr)

Module =2, TOP (file type *. hex)

Module =3, PSU (file type*. hex)

Module =4, DSP, TOP, and PSU as one file type *.ldr. This is the usual method.

> **NOTE:**
> The new OS must be sent using xmodem protocol using Tera Term. See Terminal mode commands general (p. 29).

To load a new operating system:

Enter terminal mode by typing **Open 0** (for a sensor with the default ID 0)

This will return the prompt: **CS135>**

Type the command: **LOADOS** 4

Or, type the command: **LOADOS**

The SkyVue PRO will respond:

Load OS into DSP

DO NOT REMOVE POWER DURING OS UPDATE!!!

Waiting for xmodem

At this point, use your terminal emulator to send the appropriate file. Loading the OS could take a few minutes.

When the process is complete the SkyVue PRO will return the message:

Wait 40 sec for OS to restart

Afterwards, the SkyVue PRO will resume operation according to the previously set operating parameters. It will no longer be in terminal mode.

To load a new operating system into a SkyVue PRO with an OS between 4 and 7:

Enter terminal mode by typing: **Open 0** (for a sensor with the default ID of 0)

This will return the prompt **CS135>**

Type the command **LOADOS 1**

The SkyVue PRO will respond:

Load OS into DSP

DO NOT REMOVE POWER DURING OS UPDATE!!!

Waiting for xmodem

At this point, use your terminal emulator to send the *.ldr file using xmodem protocol. Loading the OS could take a few minutes. When the process is complete the SkyVue PRO will return the message: Wait 40 sec for OS to restart. Afterwards, the SkyVue PRO will resume operation according to the previously set operating parameters. It will no longer be in terminal mode.

> **CAUTION:**
> Do not reboot the SkyVue PRO at this point.

Again enter terminal mode by typing Open 0 (for a sensor with the default ID 0)

This will return the prompt: **CS135>**

Type the command: **LOADOS 4**

The SkyVUETMPRO will respond:

Load OS into DSP

DO NOT REMOVE POWER DURING OS UPDATE!!!

Waiting for xmodem

At this point, use your terminal emulator to send the *.ldr file using xmodem protocol.

Loading the OS could take a few minutes.

When the process is complete the SkyVue PRO will return the message: Wait 40 sec for OS to restart. Afterwards, the SkyVue PRO will resume operation according to the previously set operating parameters. It will no longer be in terminal mode.

To load a new operating system into a SkyVue PRO with an OS between 1 and 3

For operating systems earlier than version 4, the boot loader must be updated using the **LOADOS 1** command, not **LOADOS 4**, before a new DSP OS can be uploaded. You will get the following verify error code the first time the OS is loaded:

Error writing word 32768

Verify OS

Error verifying word 327680 37020 4236

Reboot then load the OS using the terminal command **LOADOS 4** to correctly load the OS without errors.

The process is as follows:

Enter terminal mode by typing **Open 0** (for a sensor with the default ID 0)

This will return the prompt: **CS135>**

Type the command: **LOADOS 1**

The SkyVUETMPRO will respond:

Load OS into DSP

DO NOT REMOVE POWER DURING OS UPDATE!!!

Waiting for xmodem

At this point, use your terminal emulator to send the *.ldr file using xmodem protocol.

Loading the OS could take a few minutes.

When the process is complete the SkyVue PRO will return the message:

Error writing word 32768

Verify OS

Error verifying word 327680 37020 4236

Use the REBOOT command. Wait 40 sec for OS to restart after which it will resume operation according to the previously set operating parameters. It will no longer be in terminal mode.

Enter terminal mode by typing **Open 0** (for a sensor with the default ID 0).

This will return the prompt: **CS135>**

Type **LOADOS 4**

The SkyVue PRO will respond:

Load OS into DSP

DO NOT REMOVE POWER DURING OS UPDATE!!!

Waiting for xmodem

At this point, use your terminal emulator to send the *.ldr file again using xmodem protocol.

Loading the OS could take a few minutes.

When the process is complete the SkyVUETMPRO will return the message: Wait 40 sec for OS to restart.

The SkyVue PRO will resume operation according to the previously set operating parameters. It will no longer be in terminal mode.

It is good practice to reboot the sensor after loading a new OS.

5.1.10 Stratocumulus backscatter calibration

The **SCCAL** command allows a simple stratocumulus backscatter calibration of the scatter coefficient measurements. This requires a human observer to confirm a stable Stratocumulus cloud layer between 250 m (820 ft) to 2500 m (8202 ft) without holes, precipitation or reduced visibility, and that the layer has been stable for at least 10 minutes prior to running this command.

Set the **Measurement_Period** to 10 (see Table 5-1 [p. 31]).

A detailed description of this technique is given in: Ewan J. O'Connor, Anthony J. Illingworth, and Robin J. Hogan, 2004: A Technique for Autocalibration of Cloud Lidar. *Journal of Atmospheric and Ocean Technology*, **21**, pp 777 – 786.

Enter terminal mode by typing **Open 0** (for a sensor with an ID of 0)

This will return the prompt: **CS135>**

Type **SCCAL**

The SkyVue PRO will respond:

> **Stratocumulus calibration.**
>
> **Enter height above sea level (m)? Press enter to continue:**

Enter the sensor height above sea level, for example 70 m then type return.

The SkyVue PRO will respond: **70 m entered, is this correct? "Y", "N" or "Q"**

Type **Y** to confirm. If you have entered an incorrect number, type **N** and you will be able to replace it. Type **Q** to quit the calibration and return to the terminal command prompt.

The SkyVue PRO will respond:

> **For correct calibration a trained human observer must confirm that the layer is between 250 m (820 ft) to 2500 m (8200 ft) and has been stable for at least 10 minutes without drizzle. Has the Stratocumulus been stable for at least 10 minutes? "Y" or "N"**

To confirm, type **Y** and the SkyVue PRO will respond:

Old Stratocumulus calibration = 0.0282

New Stratocumulus calibration parameters = 0.0258 70 1328

Do you want to apply this calibration? "Y" or "N"

In this example, 70 is the height of the sensor above sea level previously entered and 1210 is the cloud base in meters above the sensor.

As a rough guide, if the calibration factor has changed by less than 20%, there is no need to change. If it has changed by a factor of 2, it is wise to run the service routine on the sensor (see Service command [p. 65]).

Type **Y** to confirm and the SkyVue PRO will respond:

Calibration saved.

The following error messages may appear during the process.

- **Error ... Time out**
- **Error ... Cloud not detected or height not within limits (250 m to 2500 m / 820 ft to 8200 ft)**
- **Try again when layer is stable**
- **Error ... Not enough data available try again in 10 minutes.**

5.1.11 CRC-16 codes on terminal commands

If **CRC-16** on mode is set using the `Terminal` command, all terminal commands need a CRC-16. A semi-colon is used to indicate start of the CRC-16 in 4-byte character, for example **`open 0;233A`**. The CRC-16 is calculated either from the start of a new line or after a [STX] up to but not including the semi-colon. ETX can follow the CRC-16 if required.

To find the valid CRC-16 for a command, type the command and then type: ;????. For example, typing **`open 0;????`** gives the response **[CRLF]CRC>233A<CRC[CRLF]** so **233A** is the CRC-16.

The CRC-16 is not case sensitive.

> **NOTE:**
> Make sure the terminal software sends [CR] and not [CRLF] for the command-line termination.

The table below gives some commonly used CRC-16 codes.

Terminal command	CRC-16
open 0	233A
close	D94E
status	7CE5
password	EB85
terminal 0 (this command will remove CRC-16 checking)	B576
defaults	7D8E
serial	7FCE

5.1.12 Service command

The service command triggers the SkyVue PRO to go through a series of tests, including tests that require the white test surface (ceilometer calibration plate supplied) to be placed on the SkyVue PRO windows.

The service command results in the following test procedures:

- System noise level including noise spike test
- Detector maximum gain test
- Simulates a clear night sky for calibration offset
- Window contamination functionality test
- Laser function and monitoring alarm check
- Thermistor fault alarm check
- Calibrator LED alarm check
- PSU supply alarm check
- Temperature RH% sensor alarm check
- Inclinometer alarm check
- Heater/blower alarm check
- Internal clocks alarm check
- Top board and PSU communications alarm check.

If any test or check fails, then full instrument status and debug information is output with a fault summary at the end.

The response is similar to the following:

Initially, the SkyVue PRO outputs a STATUS message, then goes through various self-test routines before requesting a white test surface to be placed over each of the windows in turn. This process is as follows:

self test, please wait

wait for new measurement.....

Place white test surface onto detector window (left side fan at the top)

Press Enter to continue

Cover the detector window and press **Enter** . The computer will respond:

wait for new measurement.....

Place white test surface onto laser window (right side fan at the top)

Press Enter to continue

Cover the laser window and press **Enter** . The computer will respond:

wait for new measurement.....

Remove white test surface from laser window. Press Enter to continue.

When this is complete, the SkyVue PRO will output a string of diagnostic data. This is useful for a Campbell Scientific engineer investigating problems with the SkyVue PRO.

Finally, the SkyVue PRO will list any faults found as shown below:

******** CS135 FAULT list ********

FAULT - external heater/blower thermistor

FAULT - detector dirty windows with white test surface

FAULT - max APD gain not achieved

Otherwise it will report the following message:

******** CS135 has PASSED all tests ********

5.1.13 Locked features

Optional features such as Mixing Layer Height assessment are protected by a key. They are enabled by typing UNLOCK followed by entering the key. This is specific to the individual SkyVue PRO and only has to be entered once.

5.2 Restoring factory defaults

Restore factory defaults by using the **DEFAULTS** command in the terminal mode.

Hard Reset

Alternatively, use the **RESET** push switch on the DSP to restore factory defaults (Figure 5-1 (p. 67)).

Remove the cover and enclosure lid. See Removing the cover (p. 109) and Removing the enclosure lid (p. 110).

WARNING:
Opening the access lid MUST be carried out by a competent person, who has sufficient training, experience and knowledge both in electrical safety and the detail and operation of the sensor.

WARNING:
Opening the access lid may expose hot surfaces.

Use a narrow tool such as a screw driver to reach the reset switch.

If the reset switch is pushed for four seconds, the SkyVue PRO will reboot in exactly the same way as the **REBOOT** terminal command. If the reset switch is held closed while the SkyVue PRO is powered off and on again, the SkyVue PRO will return to factory defaults. To power cycle the SkyVue PRO, disconnect the battery and switch the main power off and on.

Figure 5-1. Restoring factory defaults

5.3 LED indicator

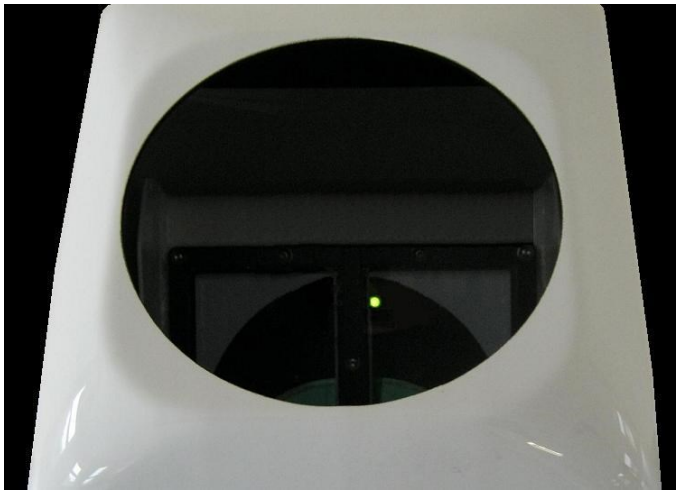


Figure 5-2. LED indicator

A green LED is visible through the window, see Figure 5-2 (p. 68). It will give 0.5 second flashes as follows:

One flash every 10 seconds = OK, no fault

Two flashes every 10 seconds = warning (possible degraded performance)

Three flashes every 10 seconds = alarm (measurements not possible)

6. Messages

6.1 Data messages general

The SkyVue PRO provides a variety of data message types to allow efficient output of data. Not all messages provide the full information available, but these messages may be more efficient in terms of data storage and transmission.

CL31 and CT25K messages use the same formats used by common existing CL31 and CT25K sensors, making it easier to replace existing units or expand an existing network.

6.2 Checksums used in SkyVue PRO messages

This is based on the CRC-16, with the output XOR'd with Hex 0xFFFF and outputs a two-byte CRC-16 character. The CRC-16 is calculated on all characters after the SOH character, up to and including the ETX character.

The following example uses the **C** code to calculate the SkyVue PRO checksum.

> **NOTE:**
> Shorts are 16 bits long and ints are 32 bits long.

```
// ----------------------------------------------------------------
// Calculate CRC-16
// buf is a pointer to the input string
// len is the length of the input string
// ----------------------------------------------------------------
unsigned short crc16(char *buffer, int length)
{
  unsigned short crc;
  unsigned short m;
  int i, j;

  crc = 0xFFFF;
  for (i=0; i < length; ++i)
  {
    crc ^= buffer[i] << 8;

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

6.3 CS messages

6.3.1 MESSAGE 001 (no profile, no sky condition)

Example message line outputs
CS0001001
10 087 00139 ///// ///// ///// 800000000000
942f

LINE 1

SOH CS ID OS N STX CR LF

where

SOH = Start-of-Heading character

CS = Always CS

ID (1 character) = A single character, 0 to 9, a to z or A to Z, case sensitive. Default ID = 0

OS (3 characters) = Operating system, 001 to 999

N (3 characters) = Message number

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣ tr␣h1␣h2␣h3␣h4␣flags CR LF

> NOTE:
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Four cloud bases detected
5 = Full obscuration determined but no cloud base detected
6 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

tr (3 characters) = Window transmission, %

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3, or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2, 3, or 4, h2 = Second cloud base reported
If detection status is 5, h2 = Highest signal received
If detection status is 0, 1, or 6, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3 or 4, h3 = Third cloud base reported
If detection status is 0, 1, 2, 5, or 6, h3 = /////

h4 (5 characters) = 4th Height

If detection status is 4, h4 = Fourth cloud base reported
If detection status is 0, 1, 2, 3, or 5, h4 = /////

flags (12 characters in 3 groups of 4) = Alarm or warning information

Table 6-1: Most significant alarm word for CS messages

Bit[1]	Description
8000 XXXX XXXX	Units. Feet = 0, meter = 1.
4000 XXXX XXXX	Reserved for future use
2000 XXXX XXXX	Reserved for future use
1000 XXXX XXXX	Reserved for future use
0800 XXXX XXXX	DSP clock out of specification
0400 XXXX XXXX	Laser shut down due to operating temperature out of range
0200 XXXX XXXX	The lead acid battery voltage is reading low
0100 XXXX XXXX	Mains supply has failed (requires a PSU to be present)
0080 XXXX XXXX	The external heater blower assembly temperature is out of bounds

Table 6-1: Most significant alarm word for CS messages	
Bit[1]	Description
0040 XXXX XXXX	External heater blower failure
0020 XXXX XXXX	The PSUs internal temperature is high
0010 XXXX XXXX	PSU OS has failed its signature check
0008 XXXX XXXX	No communications between DSP and PSU
0004 XXXX XXXX	Photo diode and Laser windows are dirty. This can only be set if the laser is on
0002 XXXX XXXX	Tilt beyond limit set by user, default 45 degrees
0001 XXXX XXXX	No communications between DSP and inclinometer board
[1] Alarm words are sum of error bits.	

Table 6-2: Middle alarm word for CS messages	
Bit[1]	Description
XXXX 8000 XXXX	The sensors internal humidity is high
XXXX 4000 XXXX	Communications to the DSP board temperature and humidity chip have failed
XXXX 2000 XXXX	DSP input supply voltage is low
XXXX 1000 XXXX	Self-test active
XXXX 0800 XXXX	Watch dog counter updated
XXXX 0400 XXXX	User setting stored in flash failed their signature checks
XXXX 0200 XXXX	DSP factory calibration stored in flash has failed its signature check
XXXX 0100 XXXX	DSP board OS signature test failed
XXXX 0080 XXXX	DSP board RAM test failed
XXXX 0040 XXXX	DSP boards on board PSUs are out of bounds
XXXX 0020 XXXX	TOP board non-volatile storage is corrupt
XXXX 0010 XXXX	TOP board OS signature test has failed
XXXX 0008 XXXX	TOP boards ADC and DAC are not within specifications

Table 6-2: Middle alarm word for CS messages	
Bit[1]	Description
XXXX 0004 XXXX	TOP boards on board PSUs are out of bounds
XXXX 0002 XXXX	Communications have failed between TOP board and the DSP
XXXX 0001 XXXX	Photo diode background radiance is out of range
[1] Alarm words are sum of error bits.	

Table 6-3: Least significant alarm word for CS messages	
Bit[1]	Description
XXXX XXXX 8000	Photo diode temperature is out of range
XXXX XXXX 4000	Photo diode is saturated
XXXX XXXX 2000	Photo diode calibrator temperature is out of range
XXXX XXXX 1000	Photo diode calibrator has failed
XXXX XXXX 0800	The sensor could not reach the desired gain levels
XXXX XXXX 0400	Laser run time or maximum laser drive current has been exceeded
XXXX XXXX 0200	Laser temperature out of range
XXXX XXXX 0100	Laser thermistor failure
XXXX XXXX 0080	Laser is obscured. This can only be set if the laser is on
XXXX XXXX 0040	Laser did not achieve significant output power
XXXX XXXX 0020	Laser max power exceeded
XXXX XXXX 0010	Laser max drive current exceeded
XXXX XXXX 0008	Laser power monitor temperature out of range
XXXX XXXX 0004	Laser power monitor test fail
XXXX XXXX 0002	Laser shutdown by top board
XXXX XXXX 0001	Laser is off
[1] Alarm words are sum of error bits.	

CR LF = Carriage Return and Line Feed

LINE 3

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT = End-of-Transmission character
CRLF = Carriage Return + Line Feed

6.3.2 MESSAGE 002 (Profile, no sky condition)

Example message line outputs
CS0001002
10 085 01123 ///// ///// ///// 800000000000
00100 05 2048 100 +40 02 0074 0070 30 000
0c5df047.....00000 (Line output cropped for clarity)
9f68

LINE 1

SOH CS ID OS N STX CR LF

where

SOH = Start-of-Heading character

CS = Always CS

ID (1 character) = A single character, 0 to 9, a to z or A to Z, case sensitive. Default ID = 0

OS (3 characters) = Operating system, 001 to 999

N (3 characters) = Message number

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣tr␣h1␣h2␣h3␣h4␣flags CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Four cloud bases detected
5 = Full obscuration determined but no cloud base detected
6 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

tr (3 characters) = Window transmission, %

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3, or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2, 3, or 4, h2 = Second cloud base reported
If detection status is 5, h2 = Highest signal received
If detection status is 0, 1, or 6, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3 or 4, h3 = Third cloud base reported
If detection status is 0, 1, 2, 5, or 6, h3 = /////

h4 (5 characters) = 4th Height

If detection status is 4, h4 = Fourth cloud base reported
If detection status is 0, 1, 2, 3, or 5, h4 = /////

flags (12 characters in 3 groups of 4) = Alarm or warning information.

Refer to Message 001 for a breakdown of the flags.

CR LF = Carriage Return and Line Feed

LINE 3

scale␣res␣n␣ energy␣lt␣ti_bl␣pulse␣rate␣sum CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

scale (5 characters) = Attenuated_SCALE parameter, %, 0 to 99999. 100% is default

res (2 characters) = Backscatter profile resolution in meters

n (4 characters) = Profile length

energy (3 characters) = Laser pulse energy, %.

lt (3 characters including leading +/-) = Laser temperature, degrees C

ti (2 characters) = Total tilt angle, degrees

bl (4 characters) = Background light, millivolts at internal ADC input (0 to 2500)

pulse (4 characters) = Pulse quantity x 1000 (0000 to 9999)

rate (2 characters) = Sample rate, MHz, (00 to 99)

sum (3 characters) = Sum of detected and normalized backscatter, 0 to 999. Multiplied by scaling factor times 10^4. At scaling factor 100 the SUM range 0 to 999 corresponds to integrated backscatter 0 to 0. $srad^{-1}$.

CR LF = Carriage Return + Line Feed

LINE 4

SSSSSSSSSSSSSSSSSSSSSSSSSSSS.....(2048 x 5 bytes) CR LF

The two-way attenuated normalized backscatter profile (Backscatter profile reporting (p. 7)

CR LF = Carriage Return + Line Feed

LINE 5

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT = End-of-Transmission character
CR LF = Carriage Return + Line Feed

6.3.3 MESSAGE 003 (no profile, sky condition)

Example message line outputs
CS0001003
10 091 00828 ///// ///// ///// 800000000000
99 //// 0 //// 0 //// 0 //// 0 ////
f62a

LINE 1

SOH CS ID OS N STX CR LF

where

SOH = Start-of-Heading character

CS = Always CS

ID (1 character) = A single character, 0 to 9, a to z, or A to Z, case sensitive. Default ID = 0

OS (3 characters) = Operating system, 001 to 999

N (3 characters) = Message number

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣tr␣h1␣h2␣h3␣h4␣flags CR LF

> NOTE:
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Four cloud bases detected
5 = Full obscuration determined but no cloud base detected
6 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

tr (3 characters) = Window transmission, %

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3, or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2, 3, or 4, h2 = Second cloud base reported
If detection status is 5, h2 = Highest signal received
If detection status is 0, 1, 5, or 6, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3 or 4, h3 = Third cloud base reported
If detection status is 0, 1, 2, 5, or 6, h3 = /////

h4 (5 characters) = 4th Height

If detection status is 4 h4 = Fourth cloud base reported
If detection status is 0, 1, 2, 3, or 5 h4 = /////

flags (12 characters in 3 groups of 4) = Alarm or warning information.

Refer to Message 001 for a breakdown of the flags.

CR LF = Carriage Return and Line Feed

LINE 3

␣d␣h1␣␣d2␣h2␣␣d3␣h3␣␣d4_h4␣␣d5_h5 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

d (1 or 2 characters) = Data available

0 to 8 Amount of lowest layer in oktas
9 Vertical visibility only available
–1 No sky condition data available
99 Insufficient data

> **NOTE:**
> Two spaces are at the beginning of the line if data is available. One space is at the beginning of the line if –1 (no sky condition data available) or 99 (insufficient data) are output.
>
> Examples:
>
> "␣–1_h1..." (single space) no sky condition data available
>
> "␣99_h1..." (single space) insufficient data available
>
> "␣␣9_h1..." (two spaces) vertical visibility only available
>
> "␣␣5_h1..." (two spaces) 5/8ths of sky covered in lowest layer

h1 (4 characters) = Height of the lowest cloud layer in 10 s of meters or 100 s of feet

d2 (1 character) = Cloud amount of the 2nd layer in oktas

h2 (4 characters) = Height of the 2nd cloud layer in 10 s of meters or 100 s of feet (if no 2nd layer is reported, h2 = ////).

d3 (1 character) = Cloud amount of the 3rd layer in oktas

h3 (4 characters) = Height of the 3rd cloud layer in 10 s of meters or 100 s of feet (if no 3rd layer is reported h3 = ////).

d4 (1 character) = Cloud amount of the 4th layer in oktas

h4 (4 characters) = Height of the 4th cloud layer in 10 s of meters or 100 s of feet, if no 4th layer is reported, h4 = ////).

d5 (1 character) = Cloud amount of the 5th layer in oktas

h5 (4 characters) = Height of the 5th cloud layer in 10 s of meters or 100 s of feet (if no 5th layer is reported, h5 = ////).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> Cloud amounts and heights cannot be reported until the SkyVue PRO has been in operation for 30 minutes.

LINE 4

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT = End-of-Transmission character
CR LF = Carriage Return + Line Feed

6.3.4 MESSAGE 004 (profile, sky condition) — default message

Example message line outputs
CS0001004
10 092 00698 ///// ///// ///// 800000000000
99 //// 0 //// 0 //// 0 //// 0 ////
00100 05 2048 100 +40 02 0074 0070 30 000
071fc024d.....000 (Line output cropped for clarity)
6212

LINE 1

SOH CS ID OS N STX CR LF

where

SOH = Start-of-Heading character

CS = Always CS

ID (1 character) = A single character, 0 to 9, a to z or A to Z, case sensitive. Default ID = 0

OS (3 characters) = Operating system, 001 to 999

N (3 characters) = Message number

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣tr␣h1␣h2␣h3␣h4␣flags CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Four cloud bases detected
5 = Full obscuration determined but no cloud base detected
6 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

Tr (3 characters) = Window transmission, %

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3, or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2, 3, or 4, h2 = Second cloud base reported
If detection status is 5, h2 = Highest signal received
If detection status is 0, 1, or 6, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3 or 4, h3 = Third cloud base reported
If detection status is 0, 1, 2, 5, or 6, h3 = /////

h4 (5 characters) = 4th Height

If detection status is 4, h4 = Fourth cloud base reported
If detection status is 0, 1, 2, 3, or 5, h4 = /////

flags (12 characters in 3 groups of 4) = Alarm or warning information. Refer to Message 001 for a breakdown of the flags.

CR LF = Carriage Return + Line Feed.

LINE 3

␣d␣h1h1h1␣␣d2␣h2h2h2␣␣d3␣h3h3h3␣␣d4␣h4h4h4␣␣d5_h5h5h5 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

d (2 characters) = Data available

0 to 8 Amount of lowest layer in oktas
9 Vertical visibility only available
–1 No sky condition data available
99 Insufficient data

> **NOTE:**
> Two spaces are at the beginning of the line if data is available. One space is at the beginning of the line if –1 (no sky condition data available) or 99 (insufficient data) are output.
>
> Examples:
>
> "␣–1_h1h1h1..." (single space) no sky condition data available
>
> "␣99_h1h1h1..." (single space) insufficient data available
>
> "␣␣9_h1h1h1..." (two spaces) vertical visibility only available
>
> "␣␣5_h1h1h1..." (two spaces) 5/8ths of sky covered in lowest layer

h1 (4 characters) = Height of the lowest cloud layer in 10 s of meters or 100 s of feet

d2 (1 character) = Cloud amount of the 2nd layer in oktas

h2 (4 characters) = Height of the 2nd cloud layer in 10s of meters or 100 s of feet (if no 2nd layer is reported, h2 = ////).

d3 (1 character) = Cloud amount of the 3rd layer in oktas

h3 (4 characters) = Height of the 3rd cloud layer in 10s of meters or 100s of feet (if no 3rd layer is reported, h3 = ////).

d4 (1 character) = Cloud amount of the 4th layer in oktas

h4 (4 characters) = Height of the 4th cloud layer in 10 s of meters or 100s of feet (if no 4th layer is reported, h4 = ////).

d5 (1 character) = Cloud amount of the 5th layer in oktas

h5 (4 characters) = Height of the 5th cloud layer in 10s of meters or 100s of feet (if no 5th layer is reported, h5 = ////).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> Cloud amounts and heights cannot be reported until the SkyVue PRO has been operating for 30 minutes.

LINE 4

scale␣res␣n␣energy␣lt␣ti_bl␣pulse␣rate␣sum CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

scale (5 characters) = Scale parameter,%, 0 to 99999. 100% is default

res (2 characters) = Backscatter profile resolution in meters

n (4 characters) = Profile length

energy (3 characters) = Laser pulse energy, %.

lt (3 characters including leading +/-) = Laser temperature, degrees C

ti (2 characters) = Total tilt angle, degrees

bl (4 characters) = Background light, millivolts at internal ADC input (0 to 2500)

pulse (4 characters) = Pulse quantity x 1000 (0000 to 9999)

rate (2 characters) = Sample rate, MHz, (00 to 99)

sum = (3 characters) Sum of detected and normalized backscatter, 0 to 999. Multiplied by scaling factor times 10^4. At scaling factor 100 the SUM range 0 to 999 corresponds to integrated backscatter 0 to 0. $srad^{-1}$.

CR LF = Carriage Return + Line Feed

LINE 5

SSSSSSSSSSSSSSSSSSSSSSSSSSS.....(2048 x 5 bytes) CR LF

The two-way attenuated normalized backscatter profile (Backscatter profile reporting (p. 7)

CR LF = Carriage Return + Line Feed

LINE 6

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT = End-of-Transmission character
CR LF = Carriage Return + Line Feed

6.3.5 MESSAGE 005 (no profile, sky condition, mixing layer heights)

Only available if an unlock key is entered (Locked features (p. 66))

Example message line outputs
CS0001005
10 092 00499 ///// ///// ///// 800000000000
99 //// 0 //// 0 //// 0 //// 0 ////
///// ///// ///// ///// ///// /////
b4b6

LINE 1

SOH CS ID OS N STX CR LF
where

SOH = Start-of-Heading character
CS = Always CS
ID (1 character) = A single character, 0 to 9, a to z, or A to Z, case sensitive. Default ID = 0
OS (3 characters) = Operating system, 001 to 999
N (3 characters) = Message number
STX = Start-of-Text Character

CR LF= Carriage Return + Line Feed

LINE 2

S WA␣tr␣h1␣h2␣h3␣h4␣flags CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Four cloud bases detected
5 = Full obscuration determined but no cloud base detected
6 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

tr (3 characters) = Window transmission, %

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3, or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2, 3, or 4, h2 = Second cloud base reported
If detection status is 5, h2 = Highest signal received
If detection status is 0, 1, 5, or 6, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3 or 4, h3 = Third cloud base reported
If detection status is 0, 1, 2, 5, or 6, h3 = /////

h4 (5 characters) = 4th Height

If detection status is 4 h4 = Fourth cloud base reported
If detection status is 0, 1, 2, 3, 5, or 6 h4 = /////

flags (12 characters in 3 groups of 4) = Alarm or warning information. Refer to Message 001 for a breakdown of the flags.

CR LF = Carriage Return and Line Feed

LINE 3

␣␣d␣h1␣␣d2␣h2␣␣d3␣h3␣␣d4␣h4␣␣d5␣h5 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

d (1 or 2 characters) = Data available

0 to 8 Amount of lowest layer in oktas
9 Vertical visibility only available
–1 No sky condition data available
99 Insufficient data

> **NOTE:**
> Two spaces are at the beginning of the line if data is available. One space is at the beginning of the line if –1 (no sky condition data available) or 99 (insufficient data) are output.
>
> Examples:
>
> "␣–1_h1..." (single space) no sky condition data available
>
> "␣99_h1..." (single space) insufficient data available
>
> "␣␣9_h1..." (two spaces) vertical visibility only available
>
> "␣␣5_h1..." (two spaces) 5/8ths of sky covered in lowest layer

h1 (4 characters) = Height of the lowest cloud layer in 10 s of meters or 100 s of feet

d2 (1 character) = Cloud amount of the 2nd layer in oktas

h2 (4 characters) = Height of the 2nd cloud layer in 10 s of meters or 100s of feet (if no 2nd layer is reported, h2 = ////).

d3 (1 character) = Cloud amount of the 3rd layer in oktas

h3 (4 characters) = Height of the 3rd cloud layer in 10 s of meters or 100 s of feet (if no 3rd layer is reported h3 = ////).

d4 (1 character) = Cloud amount of the 4th layer in oktas

h4 (4 characters) = Height of the 4th cloud layer in 10 s of meters or 100s of feet (if no 4th layer is reported h4 = ////).

d5 (1 character) = Cloud amount of the 5th layer in oktas

h5 (4 characters) = Height of the 5th cloud layer in 10,s of meters or 100 s of feet (if no 5th layer is reported h5h = ////).

CR LF= Carriage Return + Line Feed

NOTE:
The SkyVue PRO must be operating for 30 minutes before cloud amounts and heights are reported.

LINE 4

mh1_q1_mh2_q2_ mh3_q3 CR LF

where

mh1 (5 characters) = height of the 1st MLH in meters or feet
q1 (5 characters) = quality parameter of the 1st MLH
mh2 (5 characters) = height of the 2nd MLH in meters or feet
q2 (5 characters) = quality parameter of the 2nd MLH
mh3 (5 characters) = height of the 3rd MLH in meters or feet
q3 (5 characters) = quality parameter of the 3rd MLH

If there are no mixing layers detected, or less than 3, then missing data is shown as /////. If the MLH option is not activated then all fields in line 4 are /////.

LINE 5

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT= End-of-Transmission character
CR LF= Carriage Return + Line Feed

6.3.6 MESSAGE 006 (profile, sky condition, mixing layer heights)

Only available if a key is entered (see Locked features (p. 66))

Example message line outputs
CS0001006
10 095 01732 ///// ///// ///// 800000000000
99 //// 0 //// 0 //// 0 //// 0 ////
00100 05 2048 100 +40 02 0054 0070 30 000
///// ///// ///// ///// ///// /////
04ae3015fe.....0000 (Line output message cropped for clarity)
fe91

LINE 1

OH CS ID OS N STX CR LF

where

SOH = Start-of-Heading character
CS = Always CS
ID (1 character) = A single character, 0 to 9, a to z, or A to Z, case sensitive. Default ID = 0
OS (3 characters) = Operating system, 001 to 999
N (3 characters) = Message number
STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣tr␣h1␣h2␣h3␣h4␣flags CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Four cloud bases detected
5 = Full obscuration determined but no cloud base detected
6 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

tr (3 characters) = Window transmission, %

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3, or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2, 3, or 4, h2 = Second cloud base reported
If detection status is 5, h2 = Highest signal received
If detection status is 0, 1, 5, or 6, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3 or 4, h3 = Third cloud base reported
If detection status is 0, 1, 2, 5, or 6, h3 = /////

h4 (5 characters) = 4th Height

If detection status is 4, h4 = Fourth cloud base reported
If detection status is 0, 1, 2, 3, 5, or 6, h4 = /////

flags (12 characters in 3 groups of 4) = Alarm or warning information. Refer to Message 001 for a breakdown of the flags.

CR LF = Carriage Return and Line Feed

LINE 3

␣␣d␣h1␣␣d2␣h2␣␣d3␣h3␣␣d4␣h4␣␣d5␣h5 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

d (2 characters) = Data available

0 to 8 Amount of lowest layer in oktas
9 Vertical visibility only available
–1 No sky condition data available
99 Insufficient data

> **NOTE:**
> Two spaces are at the beginning of the line if data is available. One space is at the beginning of the line if –1 (no sky condition data available) or 99 (insufficient data) are output.
>
> Examples:
>
> "␣–1_h1..." (single space) no sky condition data available
>
> "␣99_h1..." (single space) insufficient data available
>
> "␣␣9_h1..." (two spaces) vertical visibility only available
>
> "␣␣5_h1..." (two spaces) 5/8ths of sky covered in lowest layer

h1 (4 characters) = Height of the lowest cloud layer in 10 s of meters or 100 s of feet

d2 (1 character) = Cloud amount of the 2nd layer in oktas

h2 (4 characters) = Height of the 2nd cloud layer in 10 s of meters or 100 s of feet (if no 2nd layer is reported, h2 = ////).

d3 (1 character) = Cloud amount of the 3rd layer in oktas
h3 (4 characters) = Height of the 3rd cloud layer in 10 s of meters or 100 s of feet (if no 3rd layer is reported, h3 = ////).

d4 (1 character) = Cloud amount of the 4th layer in oktas

h4 (4 characters) = Height of the 4th cloud layer in 10 s of meters or 100 s of feet (if no 4th layer is reported, h4 = ////).

d5 (1 character) = Cloud amount of the 5th layer in oktas

h5 (4 characters) = Height of the 5th cloud layer in 10 s of meters or 100 s of feet (if no 5th layer is reported, h5 = ////).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> The SkyVue PRO must be operating for 30 minutes before cloud amounts and heights are reported.

LINE 4

scale␣res␣n␣energy␣lt␣ti␣bl␣pulse␣rate␣sum CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

scale (5 characters) = Scale parameter,%, 0 to 99999. 100% is default res (2 characters) = Backscatter profile resolution in meters.

n (4 characters) = Profile length

energy (3 characters) = Laser pulse energy, %.

lt (3 characters including leading +/-) = Laser temperature, degrees C

ti (2 characters) = Total tilt angle, degrees

bl (4 characters) = Background light, millivolts at internal ADC input (0 to 2500)

pulse (4 characters) = Pulse quantity x 1000 (0000 to 9999)

rate (2 characters) = Sample rate, MHz, (00 to 99)

sum = (3 characters) Sum of detected and normalized backscatter, 0 to 999. Multiplied by scaling factor times 10^4. At scaling factor 100 the SUM range 0 to 999 corresponds to integrated backscatter 0 to 0. $srad^{-1}$

CR LF= Carriage Return + Line Feed

LINE 5

mh1␣q1␣mh2␣q2␣mh3␣q3 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

mh1 (5 characters) = height of the 1st MLH in meters or feet

q1 (5 characters) = quality parameter of the 1st MLH

mh2 (5 characters) = height of the 2nd MLH in meters or feet

q2 (5 characters) = quality parameter of the 2nd MLH

mh3 (5 characters) = height of the 3rd MLH in meters or feet

q3 (5 characters) = quality parameter of the 3rd MLH

If there are no mixing layers detected, or less than 3, then missing data is shown as /////. If the MLH option is not activated then all fields in Line 5 are /////.

LINE 6

SSSSSSSSSSSSSSSSSSSSSSSSSSSS.....(2048 x 5 bytes) CR LF

The two-way attenuated normalized backscatter profile (Backscatter profile reporting (p. 7))

CR LF= Carriage Return + Line Feed

LINE 7

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT = End-of-Transmission character
CR LF = Carriage Return + Line Feed

6.4 CL31 messages

6.4.1 MESSAGES 101 - 106, (CL31 MESSAGE 1)

Example message 101 line outputs

CL017011

10 01128 ///// ///// 00000000E080

00100 10 0770 100 +40 094 02 0032 L0112HN30 000

036B200CC1002.....EEFFB3F (Line output cropped for clarity)

e515

LINE 1

SOH CL ID OS 1 Samples STX CR LF

where

SOH = Start-of-Heading character

CL = Always CL

ID = A single character, 0 to 9, a to z or A to Z, case sensitive. Default ID = 0

OS = Operating system, 100 to 999

1 = Always 1

Samples = backscatter resolution and number of samples

1 = MESSAGE 101, 10 m x 770 samples, range 7700 m
2 = MESSAGE 102, 20 m x 385 samples, range 7700 m
3 = MESSAGE 103, 5 m x 1500 samples, range 7500 m
4 = MESSAGE 104, 5 m x 770 samples, range 3850 m
5 = MESSAGE 105, no backscatter profile
0 = MESSAGE 106, extended range, 5 m x 2048 samples, range 10,240 m

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣h1␣h2␣h3␣flags CR LF

6.4.2 MESSAGE 005 (no profile, sky condition, mixing layer heights)

Available only when a key is entered (see Locked features (p. 66))

LINE 1

SOH CS ID OS N STX CR LF

where

SOH = Start-of-Heading character

CS = Always C

ID (1 character) = A single character, 0 to 9, a to z or A to Z, case sensitive. Default ID = 0

OS (3 characters) = Operating system, 001 to 999

N (3 characters) = Message number

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣tr␣h1␣h2␣h3␣h4␣flags"

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Full obscuration determined but no cloud base detected
5 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

h1 (5 characters) = 1st Height

If detection status is 1, 2, 3 or 4, h1 = Lowest cloud base reported
If detection status is 5, h1 = Vertical visibility as calculated
If detection status is 0 or 6, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2 or 3, h2 = Second cloud base reported
If detection status is 4, h2 = Highest signal received
If detection status is 0, 1, or 5, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3, h3 = Third cloud base reported
If detection status is 0, 1, 2, 4, or 5, h3 = /////

flags (12 characters) = Alarm or warning information (refer to Table 6-4 (p. 94), Table 6-5 (p. 95), and Table 6-6 (p. 96) for a breakdown of flags)

Table 6-4: Most significant alarm word for CS31 messages

Bit[1]	Description
8000 XXXX XXXX	Transmitter shut-off
4000 XXXX XXXX	Transmitter failure
2000 XXXX XXXX	Receiver failure
1000 XXXX XXXX	Reserved for future use
0800 XXXX XXXX	Reserved for future use
0400 XXXX XXXX	Memory error
0200 XXXX XXXX	Light path obstruction
0100 XXXX XXXX	Receiver saturation
0080 XXXX XXXX	Reserved for future use
0040 XXXX XXXX	Reserved for future use
0020 XXXX XXXX	Reserved for future use
0010 XXXX XXXX	Reserved for future use

Table 6-4: Most significant alarm word for CS31 messages	
Bit[1]	Description
0008 XXXX XXXX	Reserved for future use
0004 XXXX XXXX	Reserved for future use
0002 XXXX XXXX	Reserved for future use
0001 XXXX XXXX	Ceilometer engine board failure
[1] Alarm words are sum of error bits.	

Table 6-5: Middle alarm word for CS31 messages	
Bit[1]	Description
XXXX 8000 XXXX	Window contamination
XXXX 4000 XXXX	Battery voltage low (not applicable to the SkyVue PRO)
XXXX 2000 XXXX	Transmitter expires
XXXX 1000 XXXX	High humidity
XXXX 0800 XXXX	Reserved for future use
XXXX 0400 XXXX	Blower failure
XXXX 0200 XXXX	Reserved for future use
XXXX 0100 XXXX	Humidity sensor failure
XXXX 0080 XXXX	Heater fault
XXXX 0040 XXXX	High background radiance
XXXX 0020 XXXX	Ceilometer engine board failure
XXXX 0010 XXXX	Reserved for future use
XXXX 0008 XXXX	Laser monitor failure
XXXX 0004 XXXX	Receiver warning
XXXX 0002 XXXX	Tilt beyond limit set by user, default 45 degrees
XXXX 0001 XXXX	Reserved for future use
[1] Alarm words are sum of error bits.	

Table 6-6: Least significant alarm word for CS31 messages	
Bit[1]	Description
XXXX XXXX 8000	Blower is on
XXXX XXXX 4000	Blower heater is on
XXXX XXXX 2000	Internal heater is on
XXXX XXXX 1000	Working from battery (not applicable to the SkyVue PRO)
XXXX XXXX 0800	Reserved for future use
XXXX XXXX 0400	Self test in progress
XXXX XXXX 0200	Reserved for future use
XXXX XXXX 0100	Reserved for future use
XXXX XXXX 0080	Units are meters if on, else feet
XXXX XXXX 0040	Reserved for future use
XXXX XXXX 0020	Polling mode is on
XXXX XXXX 0010	Reserved for future use
XXXX XXXX 0008	Reserved for future use
XXXX XXXX 0004	Reserved for future use
XXXX XXXX 0002	Reserved for future use
XXXX XXXX 0001	Reserved for future use
[1] Alarm words are sum of error bits.	

CR LF = Carriage Return + Line Feed

LINE 3

scale␣res␣n␣ energy␣lt␣tr␣ti_bl␣L0112HN15␣sum CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where,

scale (5 characters) = Scale parameter,%, 0 to 99999. 100% is typical

res (2 characters) = Backscatter profile resolution in meters

n (4 characters) = Profile length (385, 770, 1400, or 1500 samples)

energy (3 characters) = Laser pulse energy, %

lt (3 characters including leading +/-) = Laser temperature, degrees C

tr (3 characters) = Window transmission, %

ti (2 characters) = Total tilt angle, degrees

bl (4 characters) = Background light, millivolts at internal ADC input (0 to 2500)

"L0112HN15" (9 characters) = Reserved, defaults shown

sum = (3 characters) Sum of detected and normalized backscatter, 0 to 999.

CR LF = Carriage Return + Line Feed

> **NOTE:**
> This line is omitted from message 105.

LINE 4

SSSSSSSSSSSSSSSSSSSSSSSSSSSS.....(5 x 770 bytes) CR LF

The two-way attenuated normalize backscatter profile; see Backscatter profile reporting (p. 7).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> This line is omitted from message 105.

LINE 5

ETX CRC-16 EOT CR LF

where

ETX = End-of-Text character
CRC-16 (4 characters) = CRC-16 Checksum
EOT = End-of-Transmission character
CR LF = Carriage Return + Line Feed

6.4.3 MESSAGES 107 - 112, CL31 Message 2

Example message 107 line outputs
CL017021
10 01407 ///// ///// 00000000E080
99 /// 0 /// 0 /// 0 /// 0 ///
00100 10 0770 100 +40 095 02 0031 L0112HN30 000
03301009.....027F (Line output cropped for clarity)
e669

LINE 1

SOH CL ID OS 2 Samples STX CR LF

where

SOH = Start-of-Heading character

CL = Always CL

ID = A single character, 0 to 9, a to z or A to Z, case sensitive. Default ID = 0

OS = Operating system, 100 to 999

2 = Always 2

Samples = backscatter resolution and number of samples

1 = MESSAGE 107, 10 m x 770 samples, range 7700 m
2 = MESSAGE 108, 20 m x 385 samples, range 7700 m
3 = MESSAGE 109, 5 m x 1500 samples, range 7500 m
4 = MESSAGE 110, 5 m x 770 samples, range 3850 m
5 = MESSAGE 111, no backscatter profile
0 = MESSAGE 112, extended range, 5 m x 2048 samples, range 10240 m

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣h1␣h2␣h3␣flags CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Full obscuration determined but no cloud base detected
5 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

h1 (5 characters) = 1st Height

If detection status is 1, 2, or 3, h1 = Lowest cloud base reported
If detection status is 4, h1 = Vertical visibility as calculated
If detection status is 0 or 5, h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2 or 3, h2 = Second cloud base reported
If detection status is 4, h2 = Highest signal received
If detection status is 0, 1, or 5, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3, h3 = Third cloud base reported
If detection status is 0, 1, 2, 4, or 5, h3 = /////

flags (12 characters) = Alarm or warning information.

Same as for messages 101 to 106

CR LF = Carriage Return + Line Feed

LINE 3

␣␣d␣h1h1h1␣␣d2␣h2h2h2␣␣d3_h3h3h3␣␣d4␣h4h4h4␣␣d5␣h5h5h5 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

d (1 or characters) = Data available

0 to 8 Amount of lowest layer in oktas
9 Vertical visibility only available
-1 No sky condition data available
99 Insufficient data

> **NOTE:**
> Two spaces are at the beginning of the line if data is available. One space is at the beginning of the line if –1 (no sky condition data available) or 99 (insufficient data) are output.
>
> Examples:
>
> "␣–1_h1h1h1..." (single space) no sky condition data available
>
> "␣99_h1h1h1..." (single space) insufficient data available
>
> "␣␣9_h1h1h1..." (two spaces) vertical visibility only available
>
> "␣␣5_h1h1h1..." (two spaces) 5/8ths of sky covered in lowest layer

h1h1h1 (3 characters) = Height of the lowest cloud layer in 10 s of meters or 100 s of feet

d2 (1 character) = Cloud amount of the 2nd layer in oktas

h2h2h2 (3 characters) = Height of the 2nd cloud layer in 10 s of meters or 100 s of feet (if no 2nd layer is reported, h2h2h2 = ///).

d3 (1 character) = Cloud amount of the 3rd layer in oktas

h3h3h3 (3 characters) = Height of the 3rd cloud layer in 10 s of meters or 100 s of feet (if no 3rd layer is reported, h3h3h3 = ///).

d4 (1 character) = Cloud amount of the 4th layer in oktas

h4h4h4 (3 characters) = Height of the 4th cloud layer in 10 s of meters or 100 s of feet (if no 4th layer is reported, h4h4h4 = ///).

d5 (1 character) = Cloud amount of the 5th layer in oktas

h5h5h5 (3 characters) = Height of the 5th cloud layer in 10 s of meters or 100 s of feet (if no 5th layer is reported, h5h5h5 = ///).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> Cloud amount and height cannot be reported until the SkyVue PRO has been operating for 30 minutes.

LINE 4

scale␣res␣n␣ energy␣lt␣tr␣ti_bl␣L0112HN15␣sum CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

scale (5 characters) = Scale parameter,%, 0 to 99999. 100% is typical

res (2 characters) = Backscatter profile resolution in meters

n (4 characters) = Profile length 385, 770, 1400, or 1500 samples

energy (3 characters) = Laser pulse energy, %

lt (3 characters including leading +/-) = Laser temperature, degrees C

tr (3 characters) = Window transmission, %

ti (2 characters) = Total tilt angle, degrees

bl (4 characters) = Background light, millivolts at internal ADC input (0 to 2500)

L0112HN15 (9 characters) = Reserved, defaults shown

sum = (3 characters) Sum of detected and normalized backscatter, 0 to 999. Not used in Operating System 1.

CR LF = Carriage Return + Line Feed

> **NOTE:**
> This line is omitted from message 111.

LINE 5

SSSSSSSSSSSSSSSSSSSSSSSSSSSS.....(5 x 770 bytes) CR LF

The two-way attenuated normalized backscatter profile; see Backscatter profile reporting (p. 7).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> This line is omitted from message 111.

LINE 6

ETX CRC-16 EOT CR LF

ETX = End-of-Text Character

CRC-16 (4 characters) = CRC-16 Checksum

EOT = End-of-Transmission character

CR LF = Carriage Return + Line Feed

6.5 CT25K messages

6.5.1 MESSAGE 113, CT25K Data Message No. 1

Example message line outputs
CT02010
20 01333 01523 ///// 00000F00

LINE 1

SOH CT ID 20 10 STX CR LF

where

SOH = Start-of-Heading character

CT = Always CT

ID (1 character) = Unit number 0 to 9, A to Z (capitals only) Default ID = 0

20 = Always 20
10 = Always 10

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣h1␣h2␣h3␣flags CR LF

> NOTE:
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Full obscuration determined but no cloud base detected
5 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

h1 (5 characters) = 1st Height

If detection status is 1, 2, or 3 h1 = Lowest cloud base reported
If detection status is 4 h1 = Vertical visibility as calculated
If detection status is 0 or 5 h1 = /////

h2 (5 characters) = 2nd Height

If detection status is 2 or 3, h2 = Second cloud base reported
If detection status is 4, h2 = Height of highest signal detected
If detection status is 0, 1, or 5, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3, h3 = Third cloud base reported
If detection status is 0, 1, 2, 4, or 5, h3 = /////

flags (8 characters) = Alarm or warning information 4-byte hex coded

Table 6-7: Most significant alarm word for CT25K messages

Bit[1]	Description
8000 XXXX	Transmitter shut-off
4000 XXXX	Transmitter failure
2000 XXXX	Receiver failure
1000 XXXX	DSP, voltage or memory failure
0800 XXXX	Reserved for future use
0400 XXXX	Reserved for future use
0200 XXXX	Reserved for future use
0100 XXXX	Reserved for future use
0080 XXXX	Window contaminated
0040 XXXX	Battery low
0020 XXXX	Transmitter expire warning
0010 XXXX	Heater or humidity sensor failure

Table 6-7: Most significant alarm word for CT25K messages	
Bit[1]	Description
0008 XXXX	High radiance warning, also XXXX 0004
0004 XXXX	DSP, receiver, or laser monitor failure warning
0002 XXXX	Relative humidity > 85 %
0001 XXXX	Light path obstruction, receiver saturation or receiver failure
[1] Alarm words are sum of error bits.	

Table 6-8: Second alarm word for CT25K messages	
Bit[1]	Description
XXXX 8000	Blower failure
XXXX 4000	Reserved for future use
XXXX 2000	Reserved for future use
XXXX 1000	Reserved for future use
XXXX 0800	Blower on
XXXX 0400	Blower heater on
XXXX 0200	Internal heater on
XXXX 0100	Units meters if on, feet if off
XXXX 0080	Polling mode on
XXXX 0040	Working from battery
XXXX 0020	Always 0
XXXX 0010	Always 0
XXXX 0008	Tilt beyond limit set by user, default 45 degrees
XXXX 0004	High radiance warning, also 0008 XXXX
XXXX 0002	Reserved for future use
XXXX 0001	Reserved for future use
[1] Alarm words are sum of error bits.	

CR LF = Carriage Return + Line Feed

LINE 3

ETX CR LF

ETX = End-of-Text Character

CR LF = Carriage Return + Line Feed

6.5.2 MESSAGE 114, CT25K Data Message No. 6

Example message line outputs
CT02060
10 01767 ///// ///// 00000F00
99 /// 0 /// 0 /// 0 ///

LINE 1

SOH CT ID 20 60 STX CR LF

where

SOH = Start-of-Heading character

CT = Always CT

ID (1 character) = Unit number 0 to 9, A to Z (capitals only) Default ID = 0

20 = always 20

60 = always 60

STX = Start-of-Text Character

CR LF = Carriage Return + Line Feed

LINE 2

S WA␣h1␣h2␣h3␣flags CR LF

> NOTE:
> Notice the spaces which are indicated by '␣'.

where

S (1 character) = detection status:

0 = No significant backscatter
1 = One cloud base detected
2 = Two cloud bases detected
3 = Three cloud bases detected
4 = Full obscuration determined but no cloud base detected
5 = Some obscuration detected but determined to be transparent
/ = Raw data input to algorithm missing or suspect

WA (1 character) = Warning or alarm status:

0 = No alarm or warning
W = Warning
A = Alarm

h1 (5 characters) = 1st Height

If detection status is 1, 2, or 3, h1 = Lowest cloud base reported
If detection status is 4, h1 = Vertical visibility as calculated
If detection status is 0 or 5, h1 = /////

␣ = a space

h2 (5 characters) = 2nd Height

If detection status is 2 or 3, h2 = Second cloud base reported
If detection status is 4, h2 = Height of highest signal detected
If detection status is 0, 1, or 5, h2 = /////

h3 (5 characters) = 3rd Height

If detection status is 3, h3 = Third cloud base reported
If detection status is 0, 1, 2, 4, or 5, h3 = /////

flags (8 characters) = Alarm or warning information 4-byte hex coded

As for CT25K message 1.

CR LF = Carriage Return + Line Feed

LINE 3 (Sky CONDITION)

␣␣d_h1h1h1␣␣d2␣h2h2h2␣␣d3␣h3h3h3␣␣d4␣h4h4h4 CR LF

> **NOTE:**
> Notice the spaces which are indicated by '␣'.

where

d (1 or 2 characters) = Data available:

0 to 8 = Amount of lowest layer in oktas
9 = Vertical visibility only available
–1 = No sky condition data available
99 = Insufficient data

> **NOTE:**
> Two spaces are at the beginning of the line if data is available. One space is at the beginning of the line if –1 (no sky condition data available) or 99 (insufficient data) are output.
>
> Examples:
>
> "␣–1_h1h1h1..." (single space) no sky condition data available
>
> "␣99_h1h1h1..." (single space) insufficient data available
>
> "␣␣9_h1h1h1..." (two spaces) vertical visibility only available
>
> "␣␣5_h1h1h1..." (two spaces) 5/8ths of sky covered in lowest layer

h1h1h1 (3 characters) = Height of the lowest cloud layer in 10 s of meters or 100 s of feet

d2 (1 character) = Cloud amount of the 2nd layer in oktas

h2h2h2 (3 characters) = Height of the 2nd cloud layer in 10 s of meters or 100 s of feet (h2h2h2 = /// if no 2nd layer is reported).

d3 (1 character) = Cloud amount of the 3rd layer in oktas

h3h3h3 (3 characters) = Height of the 3rd cloud layer in 10 s of meters or 100 s of feet (h3h3h3 = /// if no 3rd layer is reported).

d4 (1 character) = Cloud amount of the 4th layer in oktas

h4h4h4 (3 characters) = Height of the 4th cloud layer in 10 s of meters or 100 s of feet (h4h4h4 = /// if no 4th layer is reported).

CR LF = Carriage Return + Line Feed

> **NOTE:**
> Cloud amount and height cannot be reported until the SkyVue PRO has been operating for 30 minutes.

LINE 4

ETX CR LF

ETX = End-of-Text Character

CR LF = Carriage Return + Line Feed

7. Maintenance

7.1 General

The SkyVue PRO is a robust weather resistant instrument and there is no need for routine maintenance other than cleaning. The instrument performance is monitored, and any potential problems are indicated by error messages.

7.2 Cleaning

The SkyVue PRO window will require cleaning from time to time. The frequency of required cleaning depends on the exposure of the instrument to contaminants such as salt and dust. This will vary depending on the site location. The SkyVue PRO is capable of self diagnosing dirty lenses and will indicate when the lenses are contaminated in its output.

In any case, we suggest six month intervals for locations not prone to contamination, and monthly intervals for environments that are (such as coastal areas, roadsides, or airports). In some cases, more frequent cleaning may be required where there are high levels of contaminants and high dependency on the instrument output.

CAUTION:
If the window requires cleaning, it is very important that only a proper lens cloth or lens tissue is used. The use of inappropriate materials to clean the windows can permanently damage or reduce their effectiveness, leading to reduced performance.

Start by using an air duster to blow any loose dust and dirt from the window as a first step. Then use a lint free lens cloth or lens tissue moistened with a non-aggressive standard, window cleaner. Gently drag the cloth across the surface, taking care not to apply excessive pressure.

Excessive pressure may lead to some types of contaminants scratching the window surface. Over time, such scratches can lead to reduced sensitivity.

When the cowl is removed, avoid spraying the heater/fan assembly with liquids.

7.3 Removing the cover

1. Remove four screws (Figure 7-1 (p. 109)).

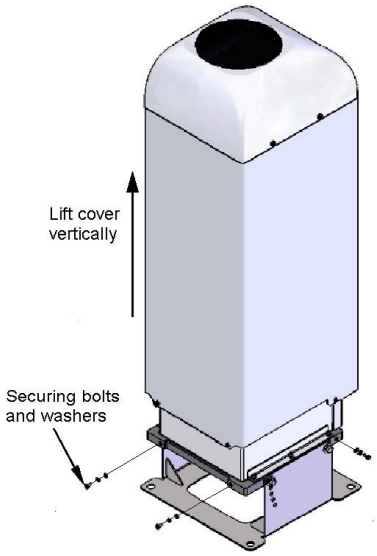


Figure 7-1. Removing the cover

2. Lift the cover off the base.

CAUTION:
The cover contains a flying lead that supplies power to the hood heater and blower. Be careful not to trap and damage the lead when lifting the cover off.

7.4 Removing the enclosure lid

1. Remove the four screws (Figure 7-2 [p. 110])
2. Pull the enclosure lid away from the electronic unit.

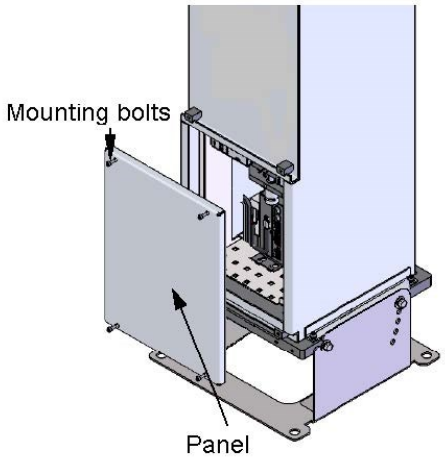


Figure 7-2. Removing the enclosure lid

WARNING:
Opening the access door MUST be performed by a competent person, with sufficient training, experience, and knowledge of electrical safety and the detail and the sensor's operation.

WARNING:
Removing the enclosure lid may expose hot surfaces.

7.5 Diagnostic LED indicators within the enclosure

The **LASER ON** and **STATUS** green LEDs are visible on the DSP (see Figure 7-3 [p. 111]). Their function is as follows:

LASER ON LED:

Off = laser off
Flashing = laser fault
On = laser on

STATUS LED:

1 flash every 10 seconds = OK
2 flashes every 10 seconds = warning (possible degraded performance)
3 flashes every 10 seconds = alarm (measurements not possible)

The DSP STATUS LED provides the same function as the LED visible through the top window.

The red LED on the PSU flashes for 0.5 seconds:

Permanently on = PSU OS fault
1 flash every 10 seconds = PSU OK
2 flashes every 10 seconds = running in battery mode
3 flashes every 10 seconds = no communications to the DSP. This takes 60 seconds to start after a communications failure.

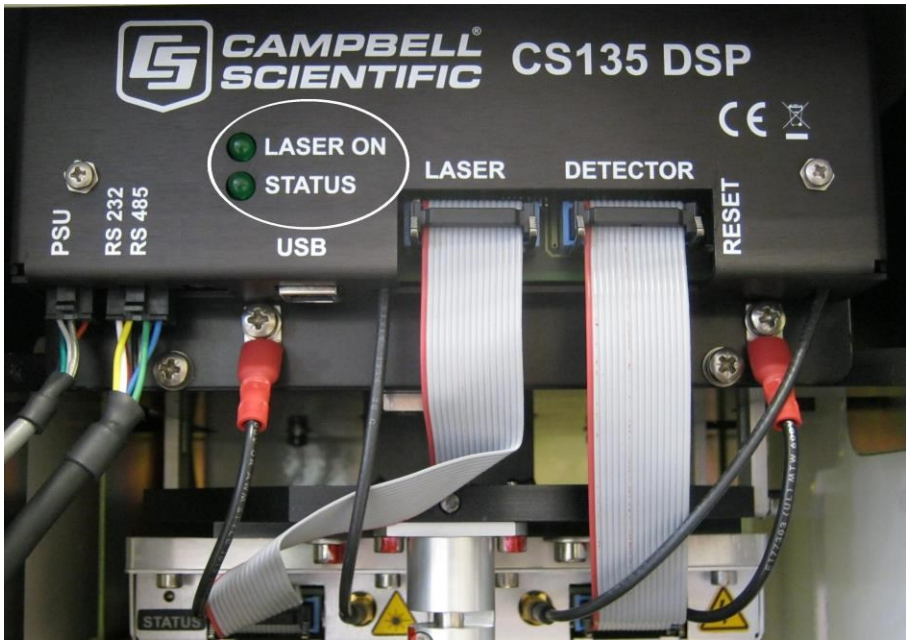


Figure 7-3. Diagnostic LED indicators

The red LED on the laser module indicates:

Off = Laser off
On = Laser on

7.6 Electrical safety testing

NOTE:
If carrying out insulation tests, do not use test voltages above 300 V RMS because the sensor is designed to clamp any mains input voltages above this level. Voltage clamping can result in a false failure being detected.

Appendix A. Measurement of the attenuated backscatter profile

A.1 Initial measurement

- Pulse the laser and measure the backscatter at optimal gains.
- Derive the impulse response and impulse correct the backscatter signal using the inverse filter derived.
- Remove the residual offset and slope from the impulse corrected backscatter.
- Apply an overlap correction based on the known generic overlap function of the SkyVue PRO.
- Apply the backscatter calibration constants.
- Remove the laser and electronic artefact signature. This is specific to the individual SkyVue PRO and determined during calibration.

A.2 Backscatter onset height detection

- Filter the backscatter with 20 m (65.6 ft) and 300 m (984 ft) width filters.
- Look for a 1500 m (4921 ft) block width where the standard deviation is at a minimum for both the 20 m (65.6 ft) and 300 m (984 ft) width filtered backscatters.
- Create a detection threshold by multiplying the 20 m (65.6 ft) and 300 m (984 ft) standard deviations by a constant.
- Find the onset of backscatter height by working from the highest height bin downwards until the backscatter is above one or both of the two detection thresholds.

A.3 Produce attenuated backscatter output message

- Range correct the backscatter to produce the attenuated backscatter.
- Attenuated backscatter (output), calibrated, range corrected but not tilt corrected.
- Smooth with a 20 m (65.6 ft) width running average.
- A noise gate can be applied based on a multiple of the 20 m (65.6 ft) detection threshold — this is customer configurable.
- The lower height range bins do not gate noise until the backscatter reaches zero. This allows the full extent of mixing layers to be viewed in gating mode.

Appendix B. Cloud height calculation

The scatter profile is inverted (using the Klett inversion technique) and an extinction profile is calculated.

Cloud base heights are identified using two criteria as follows (cloud is detected if either of them is met).

Criterion 1: likely cloud bases are estimated based on increasing slope of the extinction profile of at least 7 m (22.9 ft) per bin (bin width is 5 m (16.4 ft) and an extinction threshold. This threshold is based on an extinction coefficient (EXCO) of 3, equivalent to a horizontal visibility (MOR) of 1000 m (3280 ft). This results in a number of possible cloud bases at different heights.

Criterion 2: horizontal visibility falls below an average of 4800 m (15,748 ft) over 300 m (984 ft) starting at an altitude of 1000 m (3280 ft).

To report a cloud layer above a lower one the scatter coefficient first has to fall below the extinction threshold used for cloud definitions (less a small hysteresis offset). The scatter profile must then again meet the criteria above.

If rain is detected, the sensitivity of detection is increased by a factor of 3.

To avoid many very narrow close layers being reported when they have little significance a minimum separation based on WMO reporting intervals is applied. The separation is ± 30 m (98 ft) below 1500 m (4921 ft) and 300 m (984 ft) above 1500 m (4921 ft). The lowest cloud height is used. If a thin cloud identified by Criterion 2 above is within ±150 m (492 ft) of a cloud identified by criterion 1, then the thin cloud is ignored.

Appendix C. Sky condition algorithm description

The SkyVue PRO sky condition algorithm follows guidance from ICAO and WMO documents[1] and is based on 30 minutes of data. For this reason, sky condition is not available for 30 minutes after power cycling the sensor, a reboot, or changing measurement parameters. The sky condition algorithm is as follows:

Each measured hit comprising the lowest cloud height, (vertical visibility + onset of backscatter) / 2 and a weighting of 1 or 2 is stored in a running half hour buffer.

The weighting is 2 for hits in the last 10 minutes and 1 for hits in the previous 20 minutes.

If >50% of the hits in the latest 10 minutes are vertical visibility, then the vertical visibility averaged over the last 10 minutes is reported. Only hits below the vertical visibility height limit set are used.

The buffer is sorted in height order and hits combined into bins with the following widths:

Height	Bin width
0 – 5000 ft (0 – 1524 m)	100 ft (30.5 m)
5000 – 15,000 ft (1524 – 4572 m)	200 ft (61 m)
15,000 – 26,250 ft (4572 – 8000 m)	500 ft (152 m)

For each bin a mean height is calculated by the following:

$Hi = \sum(h_i w_i)/\sum(wi)$

Where w_i is the weight (1 or 2) of the hit with height h_i

Bins are then reduced. A distance (D) between adjacent bins is calculated by the following equation:

$D = N_i N_j (H_i - H_j)2/N_i + N_j$

[1]ICAO 9837 Manual on Automatic Meteorological Observing Systems at Aerodromes.
WMO – No. 306 Manual on Codes

Where N_i and N_j are the sum of hits of each bin and H_i and H_j the respective heights.

Find the pair with the minimum distance D and combine into one bin with the height of the lowest and number of hits of the combined total.

This process is repeated until 5 or less bins remain. These are now taken as cloud layers.

Finally, if cloud layers are closer than the distances below, then they are merged with the height of the lowest and combined total number of hits.

Height range	Distance (D)
Height ≤ 300 m (1000 ft)	≤ 90 m (300 ft)
300 m < Height ≤ 900 m (1000 ft < Height ≤ 3000 ft)	≤ 120 m (400 ft)
900 m < Height ≤ 1500 m (3000 ft < Height ≤ 5000 ft)	≤ 180 m (600 ft)
1500 m < Height ≤ 2400 m (5000 ft < Height ≤ 8000 ft)	≤ 300 m (1000 ft)
Height > 2400 m (8000 ft)	≤ 480 m (1600 ft)

Weights per layer are used to calculate number of oktas per layer.

If the total possible is W_{max}, then the cover is $(W_i/W_{max}) \times 8$.

Cloud amounts are rounded up to the next highest whole oktas.

For layers above the lowest this is based on the maximum possible weights. If the lower layers have W_1 hits and the next layer has W_2 hits, then the cover of the higher layer is given by:

$(W_2/(W_{max}-W_1)) \times 8$

For example, taking weighting into account, if lower layers of cloud only allow 4/8 of clear sky above and the cover is 2/8 out of those 4/8, then the layer above is taken as 4/8.

Finally, only layers meeting the following criteria are reported:

Layer 1 ≥ 1/33 oktas

Layer 2 ≥ 3 oktas

Layer 3 ≥ 5 oktas

Layer 4 ≥ 7 oktas

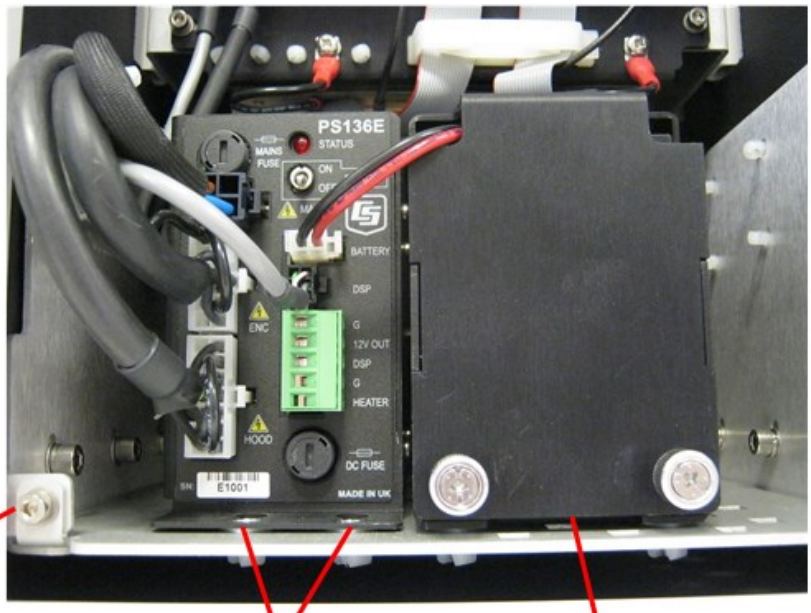
Layer 5 ≥ 7 oktas

Any layer > (8 – 1/33) oktas is reported as 8 oktas

Appendix D. Replacing the SkyVue PRO PSU

The Power Supply Unit (PSU) can be replaced in the SkyVue PRO as follows:

1. Disconnect the power to the SkyVue PRO and open the housing.
2. Disconnect all the plugs from the PSU including the battery.
3. Use a 3 mm ball-end hexagonal-key to remove the two M4 x 12 socket head screws on the chassis plate that are on the bent-up tabs on the left and right hand sides.
4. Pull the PSU forward removing the PSU and battery carrier.
5. Loosen the four screws holding the PSU in place and slide off the PSU.
6. Re-insert the new PSU and push back into position.
7. Replace the two screws on the chassis plate.
8. Re-attach the cable plugs into the correct sockets on the new PSU ensuring that each is connected properly.
9. Ensure that the battery (if used) is reconnected to the PSU.



Chassis plate M4 x 12 socket head screw (one of two shown)

PSU retaining screws. Two further screws are located at the rear of the PSU.

Battery carrier

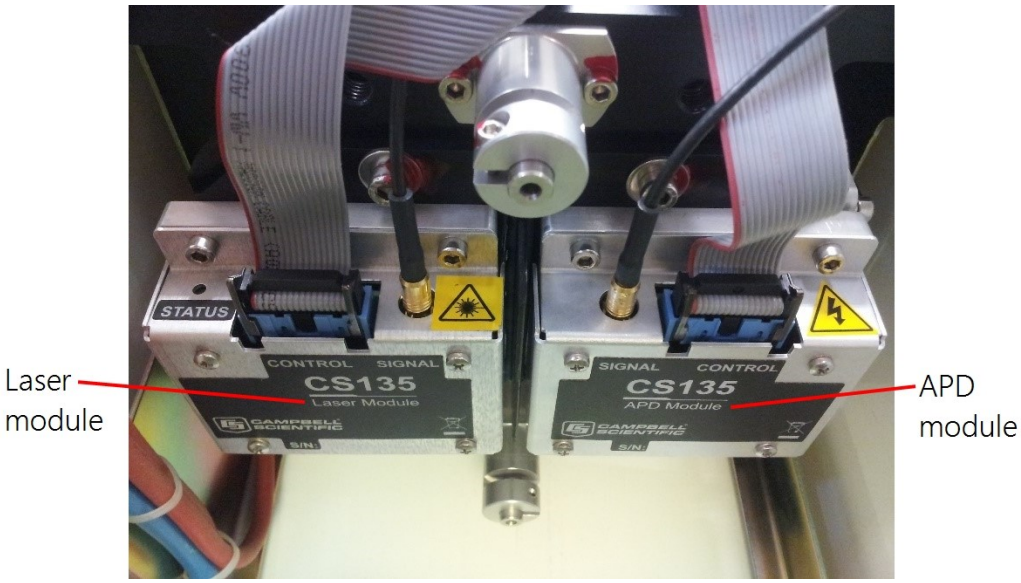
Appendix E. SkyVue PRO Laser/APD module replacement

Basic procedure:

1. Isolate the SkyVue PRO from AC mainspower.
2. Remove the outer enclosure.
3. Remove the access door using the supplied key.
4. Disconnect the cables from the Power Supply Unit (PSU) including the battery.

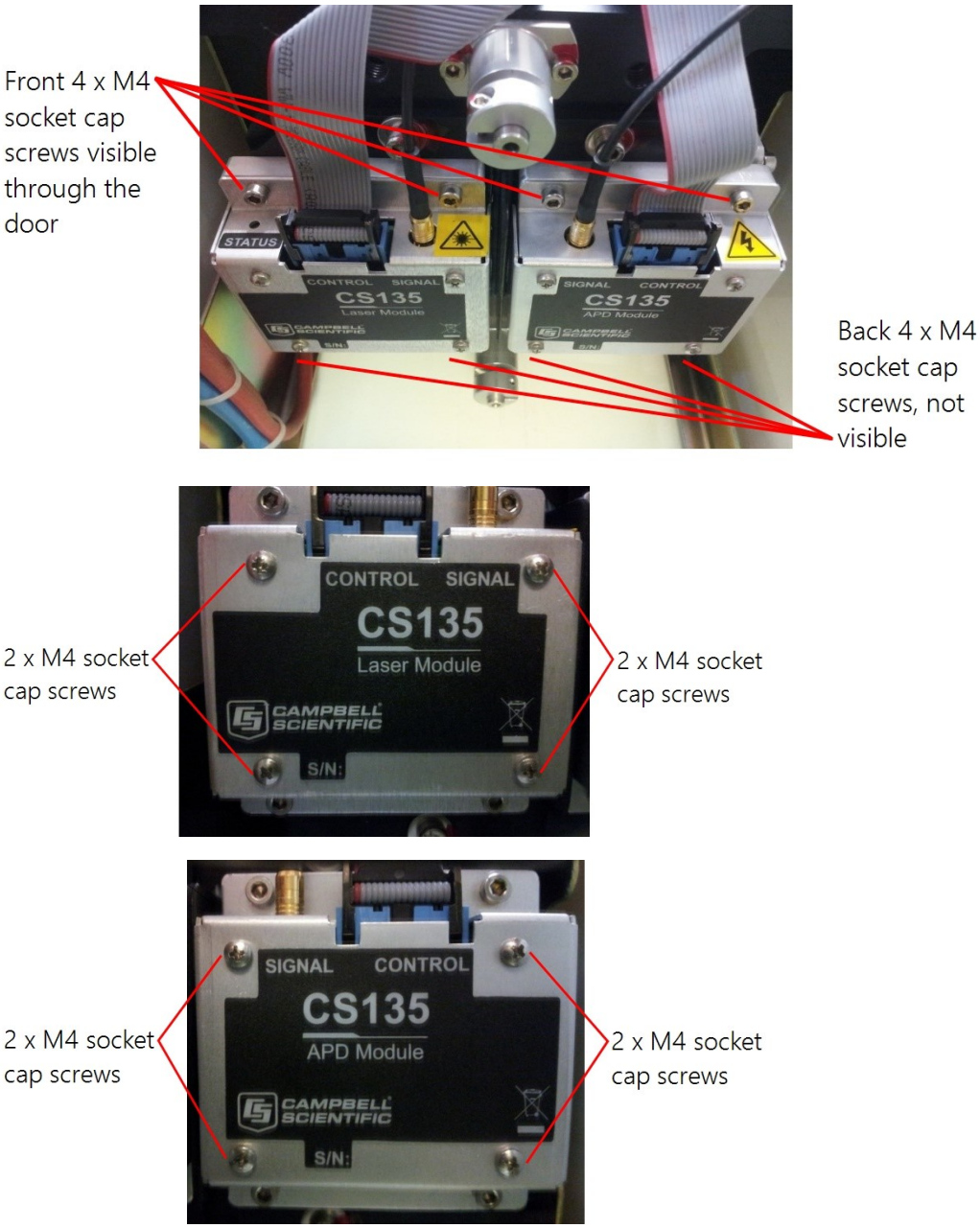
> **NOTE:**
> It is very important to disconnect the battery from the SkyVue PRO to ensure that the laser is not powered.

5. Unscrew the two securing screws from the PSU chassis plate so it can be pulled out to gain better access to the Laser and APD module.
6. Now the Laser module and avalanche photo diode (APD) module will be visible.



7. Disconnect the ribbon cable and SMB connector from the module that is being replaced. To avoid damage only pull the gold metal part of the SMB connector.

8. The laser module and APD module have four M4 x 14 mm long socket cap screws with a plain and spring washer securing them. Two of the screws are visible and the other two cannot be seen; they are at the back and directly across from the front screws. Feel for these screws or use a mirror to help locate and loosen them.



WARNING:
Do not loosen any other screws.

> **WARNING:**
> Do not replace screws with different length screws.

9. Remove any protective film from the filters of the new APD and laser modules before mounting them.
10. Once the screws have been removed pull the module off the locating pins. Fit the new module by pushing it onto the locating pins and then re-assembling, in reverse order, using the original screws, spring washers and plain washers.
11. Reconnect the ribbon cable and SMB connector to the module before closing and securing the access door.

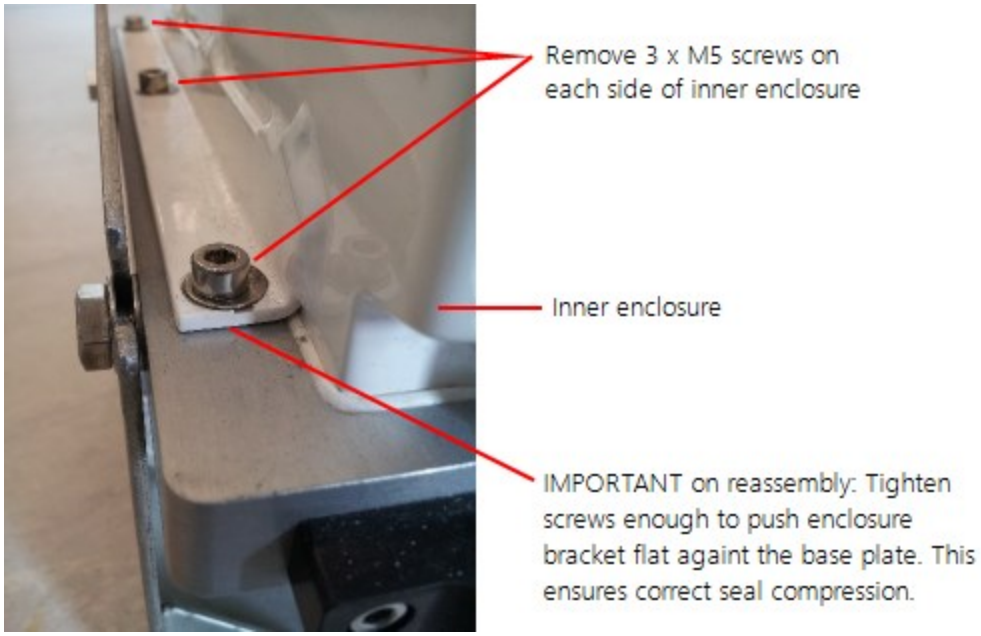
> **NOTE:**
> Make sure the module sits flat against the plate before tightening the four screws.

Appendix F. SkyVue PRO TOP board replacement

1. Isolate the SkyVue PRO from AC mainspower.
2. Remove the outer enclosure.
3. Remove the access door using the supplied key.
4. Disconnect the cables from the Power Supply Unit (PSU) including the battery.

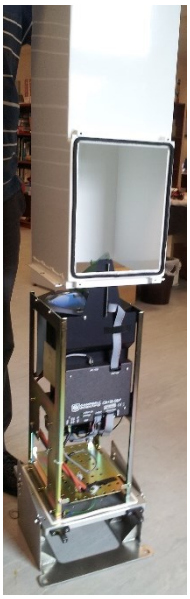
> NOTE:
> It is very important to disconnect the battery from the SkyVue PRO to ensure that the laser is not powered.

5. Use a 4 mm ball-end hexagon-key to remove 3 screws from each side of the inner enclosure as shown.

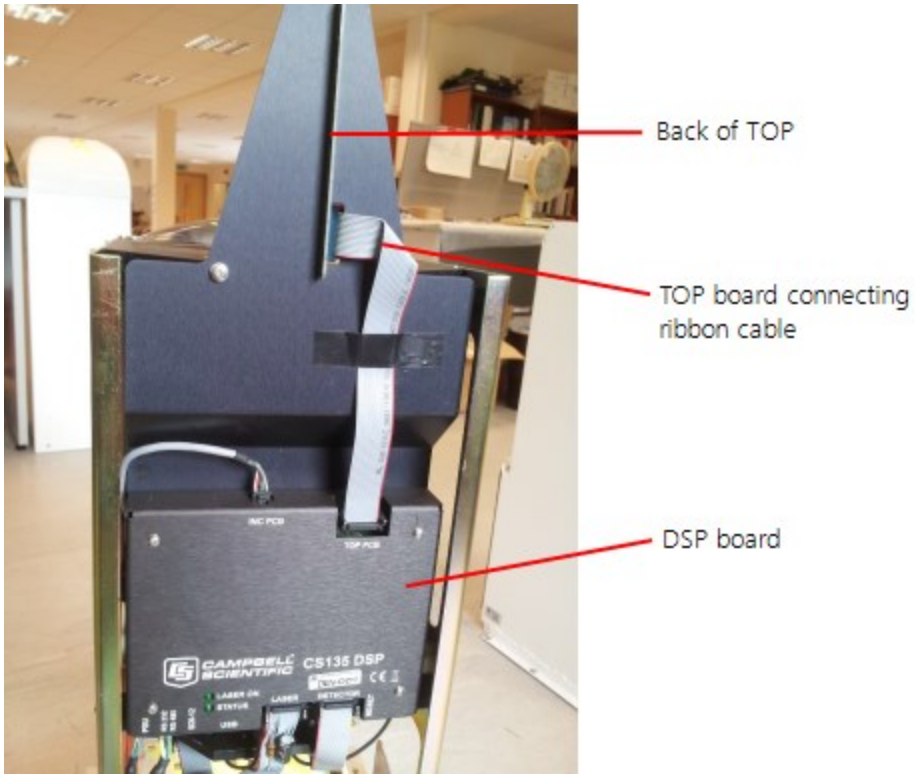


6. Use antistatic precautions. The electronics are sensitive to static discharge.

7. Carefully lift the inner enclosure upward until it is clear of the lens and TOP board assembly as shown.

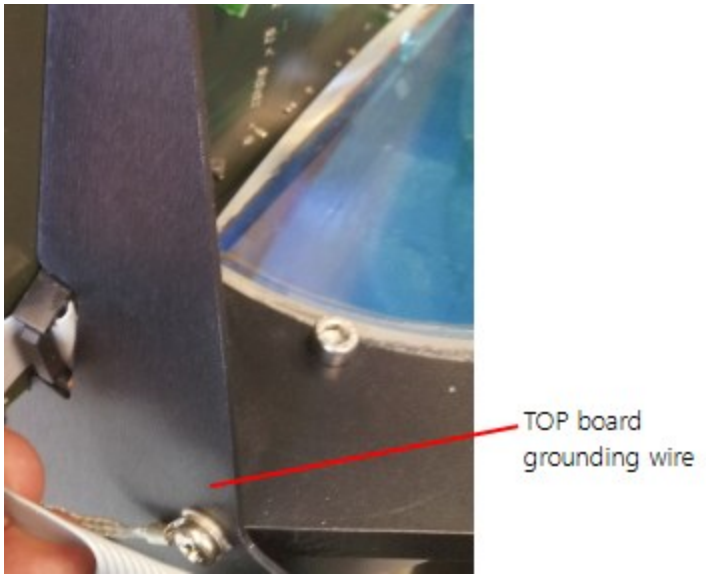


This will expose the lens and the TOP board. Do not touch the lens.

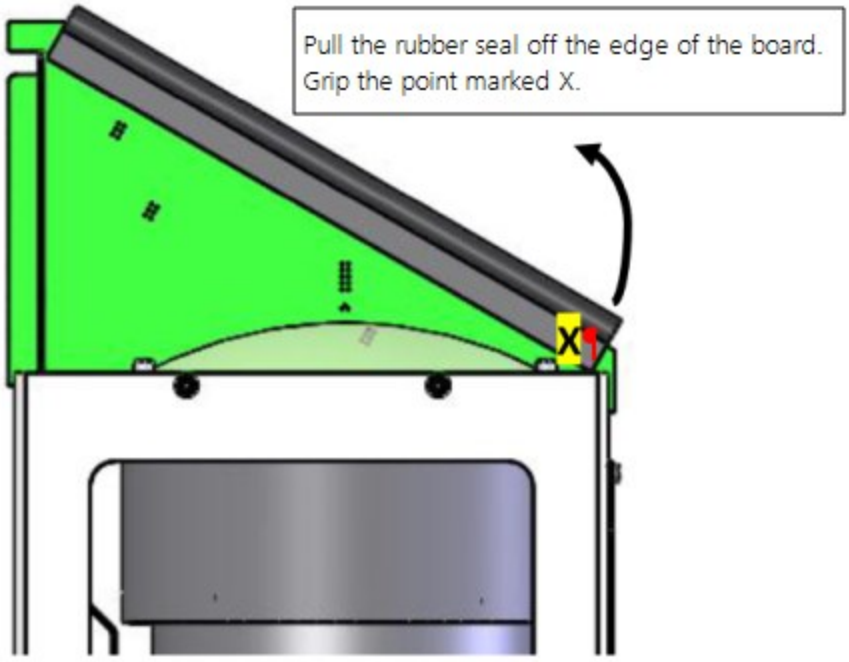


8. Disconnect the ribbon cable from the TOP board by pulling the two levers back towards the TOP board PCB as shown.

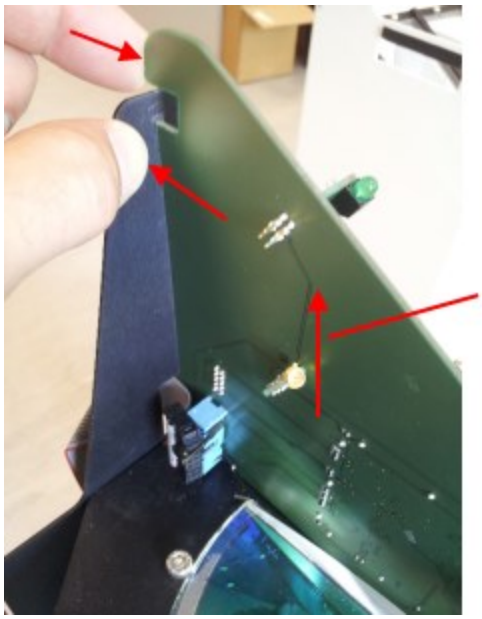
9. Remove TOP board grounding wire from under screw. Keep the screw in a secure place.



10. Observe and note the orientation and position of the rubber seal from the top edge of the board. There is a lip on the lower edge of the seal which, when reinstalled, should be on the same side of the board.
11. Remove the seal by gripping at the bottom of the lower flat sides and pulling it away from the board starting at one end. Do not pull the strip by gripping the top, soft part of the seal. The seal is not glued on, but grips the board using an internal spring. Put the strip in a secure place for reuse.

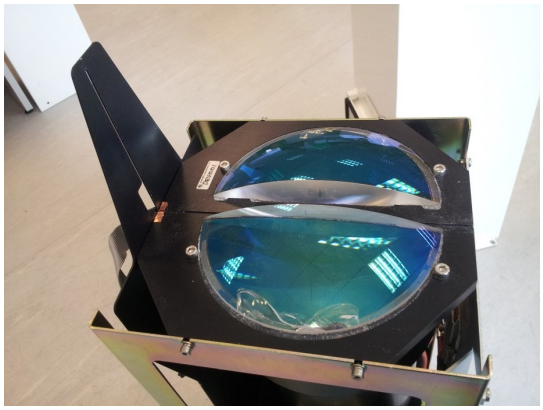


12. Remove the TOP board by pulling the black anodized aluminium plate away from the back of the board. Use your thumb to pull the plate, at the same time, push the top of the TOP board with you index finger. The TOP board should then move forward and up out of its slot. Do not lift until the top board has moved forward enough to unhook the front.



13. Carefully feed the TOP board ground cable through the ribbon cable slot.

14. Now the TOP board is completely removed.

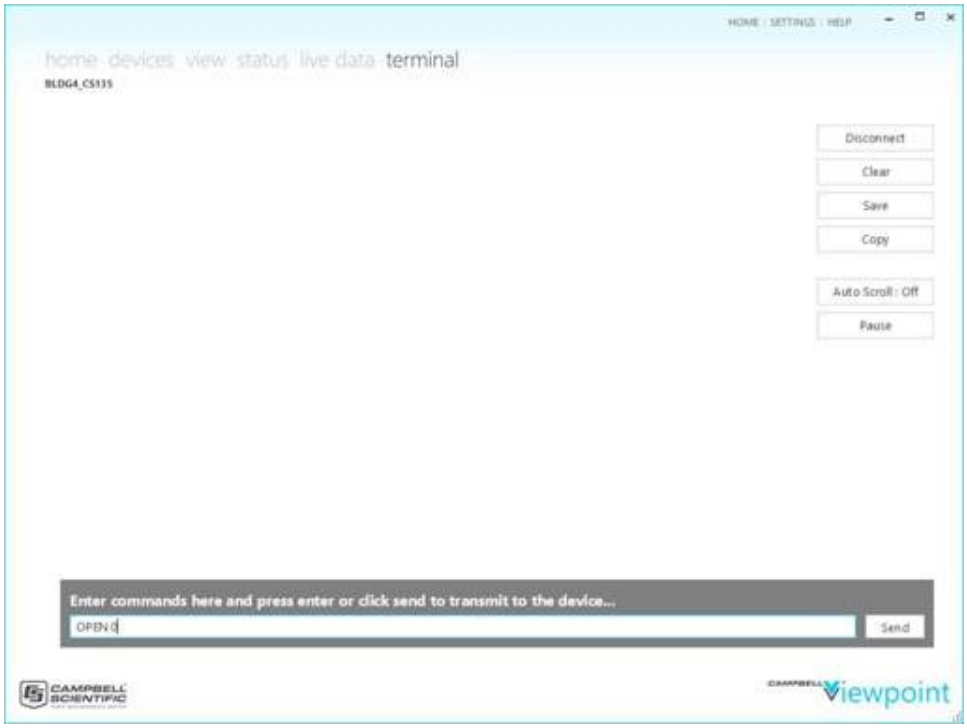


15. To fit the new TOP board reverse the procedure above. Clip the board in the vertical aluminium plate making sure to position the ribbon cable so the connector can plug into the socket on the new board. Attach the ground wire of the new board to the back of the unit using the screw as shown in step 9 above. Then refit the rubber seal to the top edge of the board by pushing it on, starting at one end and working along to the other end. Make sure the seal is in the same orientation and position as before so it does not overhang the end of the board and the lower lip of the seal do not obscure the lens closest to the board.
16. Check that there is no dirt or grit on the silicone rubber foam seal which sits around the edge of the base plate.
17. Check for and carefully remove any dust or marks on the top lenses.
18. Refit the internal enclosure.
19. Replace the screws which hold the enclosure down to the plate and make sure they are tight enough to push enclosure edges flat to the base plate. This ensures correct seal compression.
20. Look into the top window to make sure the rubber seal on the TOP board sits beneath the central bar of the metal window frame and, as far as is visible, has formed a light tight seal between the two sides of the top circuit board. If not, remove the inner enclosure and refit the seal.
21. Reconnect the battery.
22. Replace the outer enclosure.
23. Close and secure the access door.
24. Reconnect the sensor leads then connect to the sensor using a computer or data logger and power-on the sensor. Check the SkyVue PRO is operating correctly by observing the response to the status command or looking at the status flags in messages.

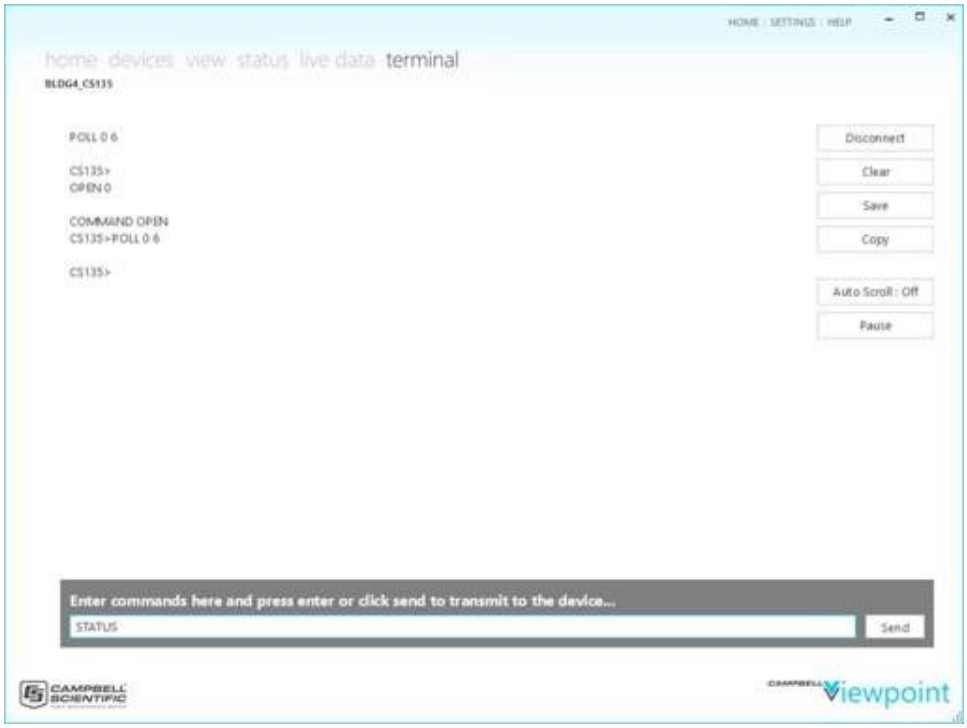
Appendix G. Self-diagnostic information

Use following procedure to get self-diagnostic information for troubleshooting the SkyVue PRO:

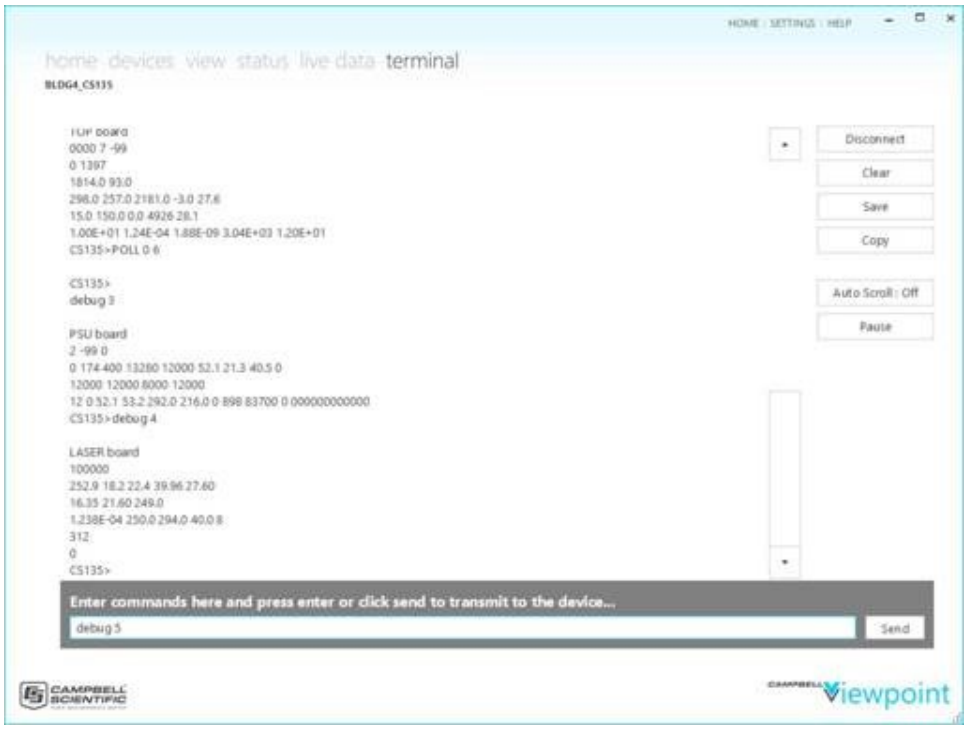
1. In the **ViewPoint** terminal screen, select **Connect** and type **OPEN 0** in the command section.



2. Type **STATUS**.



3. After the SkyVue PRO returns the status message, in the **Enter commands** box, type debug 1 <Enter>, debug 2 <Enter>, debug 3 <Enter>, debug 4 <Enter>, and debug 5 <Enter>.



The ViewPoint screen will be similar to the following. For help in debugging the SkyVue PRO, click the **Copy** button and paste the text in an email to a Campbell Scientific technical support engineer.

```
POLL 0 6

CS135>
Status

Identification CS135 SN E1048 ID 0
DateTime 2019/11/22 18:04:01
DSP_OS 007638-012 Jun 21 2018 07:28:22
TOP_OS 7
PSU_OS 2
WatchDog 0
Serial 0 10 0 100
Heaters 3 2 1 24
MCFG 0 6 0 0 0 0
Angle -0.2 0.3 0.4
Units 2
TRH 29.9 16.4 1.7
T 52.1 40.6 27.6 28.1 40.0 29.7
SupplyVoltages 12.4 21.4 13
HOffset 0.0
Visibility Cap 6562
LaserRunDays 312
WindowTX 97.3
bs 100.0 2.0 2.0 10 1 0
mlh 30 492 492 1.80 5.00 10.00
features MLH
Flags 0000 0000 0000
CS135>debug 1

DSP board
CS135 E1048 0
3 4
007638-012 7 2
0 10 0 100
0000 0000 0000
29.9 16.4 1.7
12.4 5.0 -5.0 3.3 13
CS135>debug 2
```

TOP board
0000 7 -99
0 1397
1814.0 93.0
298.0 257.0 2181.0 -3.0 27.6
15.0 150.0 0.0 4926 28.1
1.00E+01 1.24E-04 1.88E-09 3.04E+03 1.20E+01
CS135>POLL 0 6

CS135>
debug 3

PSU board
2 -99 0
0 174 400 13280 12000 52.1 21.3 40.5 0
12000 12000 8000 12000
12 0 52.1 53.2 292.0 216.0 0 898 83700 0 000000000000
CS135>debug 4

LASER board
100000
252.9 18.2 22.4 39.96 27.60
16.35 21.60 249.0
1.238E-04 250.0 294.0 40.0 8
312
0
CS135>POLL 0 6

CS135>
debug 5

APD board
0.0 121.8 107.4 171.8 0.07837 136.9
16.8 69.8 7.8
1.221E-04 4.150E-03 4.590E-02
0.613 335.0 1000.0 20.0 20.0 0.0257
25.0 21.4 73.0 5.17E-06
31.9 16.8 95.9 4.20E-06
40.6 13.1 117.5 3.33E-06
51.8 10.3 135.6 2.80E-06
66.1 8.1 150.2 2.43E-06
84.2 6.3 162.0 2.15E-06

107.4 5.0 171.8 2.08E-06
136.9 3.9 179.0 2.03E-06
174.6 3.1 185.0 2.26E-06
222.6 2.4 189.7 2.34E-06
283.8 1.9 193.4 2.47E-06
361.9 1.5 196.5 2.64E-06
461.4 1.2 198.9 3.01E-06
588.3 1.0 201.0 3.18E-06
750.0 1.0 202.7 3.50E-06
956.3 1.0 204.2 3.71E-06
CS135>

Limited warranty

Covered equipment is warranted/guaranteed against defects in materials and workmanship under normal use and service for the period listed on your sales invoice or the product order information web page. The covered period begins on the date of shipment unless otherwise specified. For a repair to be covered under warranty, the following criteria must be met:

1. There must be a defect in materials or workmanship that affects form, fit, or function of the device.

2. The defect cannot be the result of misuse.

3. The defect must have occurred within a specified period of time; and

4. The determination must be made by a qualified technician at a Campbell Scientific Service Center/ repair facility.

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2. Batteries; and

3. Any equipment which has been subjected to misuse, neglect, acts of God or damage in transit.

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Products may not be returned without prior authorization. Please inform us before returning equipment and obtain a **return material authorization (RMA) number** whether the repair is under warranty/guarantee or not. See Limited warranty for information on covered equipment.

Campbell Scientific regional offices handle repairs for customers within their territories. Please see the back page of the manual for a list of regional offices or visit www.campbellsci.com/contact to determine which Campbell Scientific office serves your country.

When returning equipment, a RMA number must be clearly marked on the outside of the package. Please state the faults as clearly as possible. Quotations for repairs can be given on request.

It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment. In support of this policy, when equipment is returned to Campbell Scientific, Logan, UT, USA, it is mandatory that a "Declaration of Hazardous Material and Decontamination" form be received before the return can be processed. If the form is not received within 5 working days of product receipt or is incomplete, the product will be returned to the customer at the customer's expense. For details on decontamination standards specific to your country, please reach out to your regional Campbell Scientific office.

> NOTE:
> All goods that cross trade boundaries may be subject to some form of fee (customs clearance, duties or import tax). Also, some regional offices require a purchase order upfront if a product is out of the warranty period. Please contact your regional Campbell Scientific office for details.

Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.com You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a hardhat and eye protection, and take other appropriate safety precautions while working on or around tripods and towers.
- Do not climb tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- You can be killed or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in contact with overhead or underground utility lines.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, whichever is greater, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.

- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

Use and disposal of batteries

- Where batteries need to be transported to the installation site, ensure they are packed to prevent the battery terminals shorting which could cause a fire or explosion. Especially in the case of lithium batteries, ensure they are packed and transported in a way that complies with local shipping regulations and the safety requirements of the carriers involved.
- When installing the batteries follow the installation instructions very carefully. This is to avoid risk of damage to the equipment caused by installing the wrong type of battery or reverse connections.
- When disposing of used batteries, it is still important to avoid the risk of shorting. Do not dispose of the batteries in a fire as there is risk of explosion and leakage of harmful chemicals into the environment. Batteries should be disposed of at registered recycling facilities.

Avoiding unnecessary exposure to radio transmitter radiation

- Where the equipment includes a radio transmitter, precautions should be taken to avoid unnecessary exposure to radiation from the antenna. The degree of caution required varies with the power of the transmitter, but as a rule it is best to avoid getting closer to the antenna than 20 cm (8 inches) when the antenna is active. In particular keep your head away from the antenna. For higher power radios (in excess of 1 W ERP) turn the radio off when servicing the system, unless the antenna is installed away from the station, e.g. it is mounted above the system on an arm or pole.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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