Cloud Height Meter CHM 15k

User Manual

Dear User

You are advised to read this Manual carefully before you start using the CHM 15k Cloud Height Meter.

This is necessary to ensure that you will be able to utilize all the capabilities which have been designed into the equipment.

This technology is subject to further development.

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Date	Revision	Comment
May 2009	04	all chapters

CE

Note

1 Basic Information

This User Manual provides the information that is required to operate the CHM 15k Cloud Height Meter.

1.1 Manual Structuring & Layout Note

The Manual consists of eleven chapters, each page indicating the chapter title in its headline.

The bottom line of each page contains the details of the revision state, date of issue and page number. In the appendix a content list of the service manual, a list of software releases for this manual revision and a configuration example is applied.

1.2 Intended Use

Operating safety can only be guaranteed when the CHM 15k Cloud Height Meter is operated as intended and in accordance with the information contained in this Manual.

The CHM 15k is only intended for single-phase operation powered by a public low-voltage distribution system as stipulated in IEC38, 6th revision of 1983.

The Cloud Height Meter may be used with a maximum tilt angle setting of 20 degrees. Any angle setting in excess of this limit will be regarded as non-conforming use! The owner (operator) will be solely responsible in the event of damage due to non-compliance of this kind.

You are strictly prohibited from using the CHM 15k in a horizontal position.

For proper operation, scheduled cleaning and maintenance cycles must be observed (refer to chapter 10 of this Manual or to the Service Manual).

2 Safety

2.1 Standards & Directives

To guarantee the safe operation of laser devices, all binding standards, directives and instructions regarding laser safety and laser radiation protection must be observed by manufacturers and users (refer to Declaration of Conformity).

The CHM 15k Cloud Height Meter is built and tested for compliance with the following standards and directives:

1. Council Directive 89/336/EEC
   of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC), conforming to EN 61326 and EN 55011 standard requirements
2. Council Directive 72/23/EEC
   of 19 February 1973 relating to electrical equipment designed for use within certain voltage limits (73/23/EEC), OJ of EC no. L 77 of 26 March 1973,
   page 204, amended by Directive (93/68/EEC), OJ of EC no. L 220 of 30 August 1993, page 1, conforming to the following standards:
   - EN 60825-1; Safety of laser products
   - EN 61010-1; Safety requirements for electrical equipment for measurement, control and laboratory use

In accordance with DIN EN 60825-1:2003 and its inherent risk potential, the CHM 15k qualifies as a class 1M laser device.

2.2 General Safety Measures

- All safety notes in this User Manual, including any other applicable documents, must be duly observed and followed.
- This User Manual must be kept within easy reach of personnel at all times.
- The CHM 15k may only be operated with the inner door closed.
- The CHM 15k Cloud Height Meter may not be powered by nominal voltages other than 230 V AC.

2.3 Safety Notes Regarding the Laser System

There is invisible 1064-nm laser radiation emerging from the CHM 15k. It emits a laser beam of very small divergence (< 0.5 mrad) and 90 mm beam diameter.

- Do not directly look into the beam.
- Avoid unnecessary exposure to invisible laser radiation.
- It is strictly forbidden to use optical instruments, notably, field glasses, for viewing the laser beam.
- **Class 1M laser radiation, if viewed over an extended period of time, may cause damage to the eyes such as glare or irritation or even full loss of eyesight.**

- Make sure the laser beam path is free from material with reflecting surfaces.
- Follow all instructions especially those on emergence of laser radiation (also refer to chapter 2.6 Safety Labelling).

2.4 Requirements on Personnel

- The CHM 15k may only be installed and commissioned by properly trained personnel who have received instructions on operating safety.
- Maintenance or adjustment work on the CHM 15k may only be carried by JENOPTIK Laser, Optik, Systeme GmbH service personnel or specially trained and authorized technicians of the Customer.
- Anyone who is entrusted with work to install and commission the CHMk15 must have completely read and understood this Manual.
- Personnel working with the CHM 15k must not be in a state of fatigue or under the influence of alcohol or medication or have physical impairments of any kind that might temporarily or lastingly restrict their attention or judgement.

2.5 Safety Notes Regarding Transportation, Installation, Commissioning & Cleaning

- For handling, shipment or transportation, the CHMk15 must be duly packaged and placed in the transporting position (refer to Fig. 5). Adequate hoisting equipment and an appropriate means of transportation must be used in all cases.
- Once packaged, the CHM 15k must be secured and protected against accidental shifting, mechanical shock or other similar impacts that may occur inside the selected means of transportation, for example, by using tension belts.
- A packaged CHM 15k must not be stacked.
- The CHM 15k requires a footprint area of 50 x 50 cm. It must be installed and assembled in a stable and fixed position on a suitably sized concrete foundation. The maximum permitted inclination angle of the mounting base is 5 mm/m.
- If the CHM 15k is not intended to be assembled immediately, it must be protected from external influences and securely stored.
- For installation, the following minimum prescribed clearances must be kept betweenthe CHM 15k and:

- mobile phones 2,5 m
- stationary emitters, ground stations (≥ 100 W of output power) 25 m
- and a second cloud height meter (to prevent optical interferences) 10 m

- Prevent irradiation from strong light sources.
- The angle of insolation must be less or equal 10 degrees against the vertical line.

- The assembly site must be at a great enough distance from tree plantations or shrubbery to prevent leaves or needles restricting the cloud meter's light outlet openings.
- At least two persons are required for installation of the CHM 15k.
- On completion of installation work, ensure that no safety-relevant changes have impacted the CHM 15k during installation.

2.6 Safety Labelling

2.6.1 User Manual

Throughout this Manual the following pictograms and signal words are used:

DANGER
Warns of laser radiation

CAUTION
Warns of potential damage

NOTE
Important general note

NOTE
Important note on environmental protection

2.6.2 CHM 15k

Product labelling is as follows (see Fig. 1):

- 4 warning labels with safety notes
- 1 plate with performance data
- 1 "Beware of Laser Radiation" warning label
- 1 type plate (rear side)

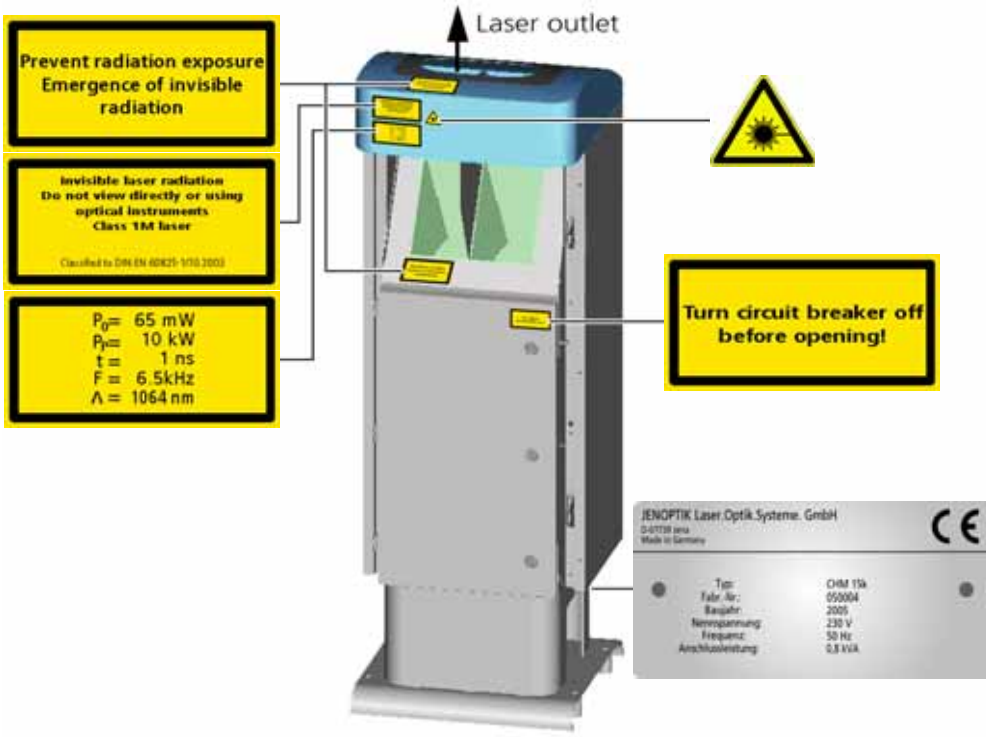

Fig. 1: Labelling

3 Technical Data

Measurement parameter	
Measuring range	30 – 15,000 m
Resolution	15 m
Measuring time (programmable)	5 s to 60 min typically 30 s
Targets	Aerosols, clouds
Measurands	Raw data Cloud height up to 3 layers, penetration depth/cloud thickness Visibility
Measuring principle	Optical (Lidar)
Light source	Laser, Laser protection class 1M under DIN EN 60825-1
Laser parameters	
Wavelength	1,064 nm
Bandwidth	< 0.1 nm
Pulse duration	About 1 ns
Pulse repetition rate	5 – 7 kHz
Beam diameter (1/e²)	Expanded to: 90 mm
Laser divergence	0,3 mrad
Energy per pulse	8 µJ
Long-time stability over 12 months (pulse repetition rate)	< 10 % variance
Pulse-to-pulse variance of laser energy	< 3 %
Data interfaces	
Standard interface	RS485
Electrical parameters	
Nominal voltage	230 V, ±10 %
Line frequency	50 Hz
Max. power consumption	0.8 kW

Table 1: Technical data

Operating safety	
Environmental compliance	ISO 10109-11
Protection class	1
Internal protection standard	IP 65
EMC	EN 61326 class B
Light source	Laser protection class 1M under DIN EN 60825-1
Certification	CE
Operating conditions	
Temperature range	-40 °C to +50 °C
Rel. air humidity	0 % to 100 %
Physical dimensions	
Dimensions of casing	W x H x L = 0.5 m x 0.5 m x 1.55 m
Packed dimensions	W x H x L = 0.65 m x 0.8 m x 1.67 m
Weight	
Weight	70 kg
Installation requirements	
Suitable low-voltage distribution systems	TN-S-system: grounded supply network, CHMk15 casing grounded, neutral and protective conductor as separate wires TN-C-system: CHMk15 casing grounded, neutral and protective conductor in one single wire
Type of connection	Non-detachable connection
Requirements to be met by Owner/Operator	
Lightning protection	External lightning protection to DIN V VDE 0185-3
Grounding	Grounding system to DIN V VDE 0185-3
Requirements for outdoor installation	- Circuit breaker to cut low-voltage power supply, installed near the CHM 15k - Within easy reach - Clearly marked as a part of CHM 15k - Back-up fuse matched to wire cross-section ≥ 6 A, B or C

Table 1: Technical data

4 Technical Description

4.1 General

The CHM 15k Cloud Height Meter is intended to measure clouds at a maximum height of fifteen kilometers, to determine cloud layer thickness and vertical visibility.

The measured data is transmitted by remote data transfer via digital standard interfaces.

The CHM 15k uses the Lidar technique (Lidar: **Li**ght **d**etection **a**nd **r**anging, refer to chapter 9.1) to emit short light pulses into the atmosphere. These are scattered back by aerosols and air molecules.

The pulse-flight time and intensity of a backscattered light signal are then analyzed. Using this data as input, aerosol or cloud layers can be assigned in terms of height and visibility levels can be determined.

Engineering design features of the CHM 15k

The CHM 15k Cloud Height Meter is:

- of compact design
- operational in climatic conditions as specified in Table 1
- of modular setup

4.2 Setup of CHM 15k

The CHM 15k is enclosed by a double-shell casing of corrosion-resistant aluminium. The purpose of the outer shell is to reduce and prevent potential external influences such as:

- solar radiation
- wind
- rain
- snow

from effecting the inner casing shell that carries the measuring unit. There is a chimney effect between the outer shell and the inner shell to support this process.

The top cover protects the inner casing shell from dirt and precipitation.

An opening for laser beam outlet and inlet is machined into this cover. A partition panel inside the top cover separates the emitter module from the receiver module and an air deflector in the interior cover space directs the air stream from the two fans onto the glass panels in the inner casing shell.

The inner casing shell contains all equipment parts for CHM 15k operation. The cable ports for data line, current supply, grounding and power supply of the external fans are designed as compression glands. For pressure equalization, the inner casing shell includes a pressure-balancing component with a Goretex membrane.

Integrated into the top wall of the inner casing shell is a split-area vision panel of neutral-color float glass. Both vision panels are somewhat inclined in keeping

with the Brewster angle. This ensures that laser light will suffer only minimal loss as it passes through and the vision panels remain in an optimal condition due to a self-cleaning effect. This effect is supported by the fans which are located on the back panel of the equipment. The fans cut in at hourly intervals or when there is rain or snow. The two fans are also intended to remove the heat from the inner casing space.

For maintenance of the fans, the back wall panel of the CHM 15k has to be removed.

The outer door provides access to the inner casing shell and the glass panels, for example, for necessary cleaning. To access the inner space of the inner casing shell, an inner door must be opened. The outer and the inner door work on different locking mechanisms in order to prevent cleaning of inner space components by personnel who have not undergone any safety briefing.

Functional units in inner casing space:

- Emitter module and receiver module
- Computer and related components
- Sensor controller module
- Laser controller module
- RS485 communication module
- Power supply
- Blower and temperature sensors
- Lightning protection system

Each functional unit is of modular setup, separately fixed to the inner casing shell and can be individually retrieved for replacement or necessary service work.

4.3 Functional Chart

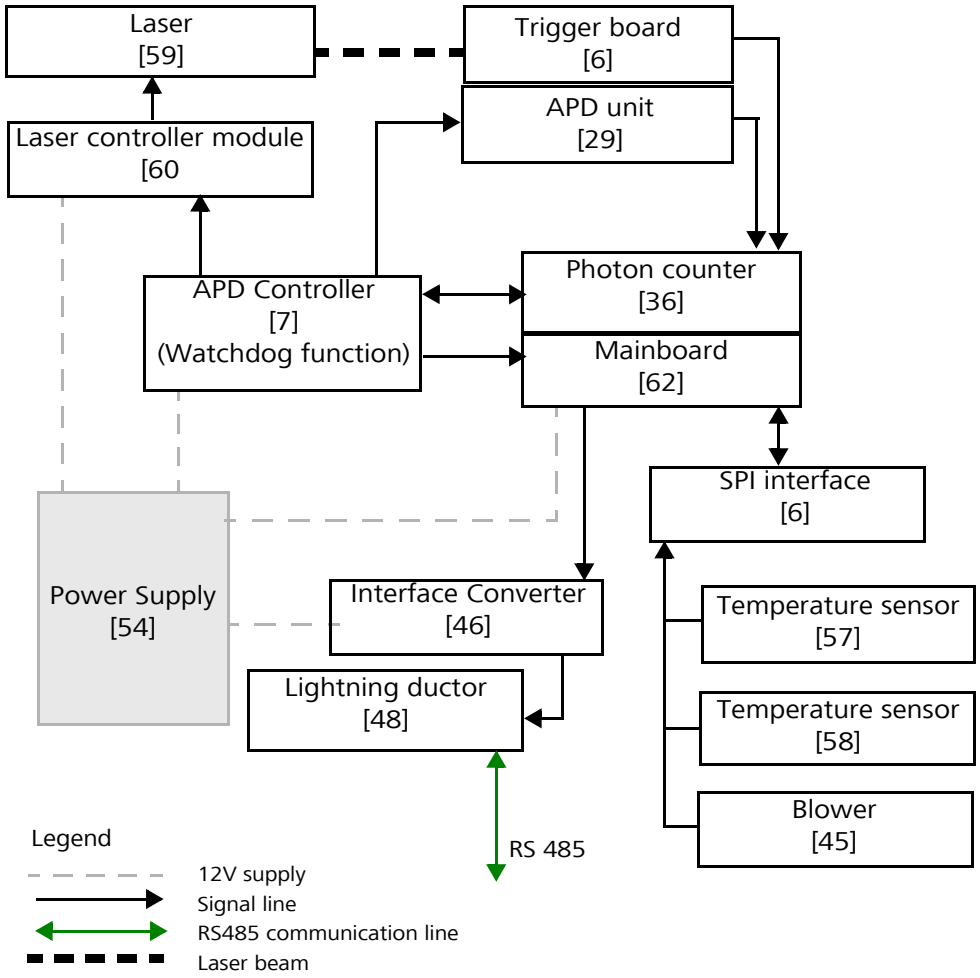

Fig. 2: Functional chart, the numbers in brackets are corresponding to spare parts (refer to service manual)

The two central modules "Mainboard with photon counter" and "APD controller" are monitoring each other during operation. They drive all operating functions shown in the chart above and output corresponding status values.

4.3.1 Signal Acquisition

The CHM 15k works based on a photon counting method. Compared to analog measurement techniques, the benefits of this method are very high detection accuracy and sensitiveness which makes it particularly suited for applications with a small count rate. This equally refers to the useful signal and to potential "noise signals", for example, background light.

4.3.2 Monitoring Operation & Operating State

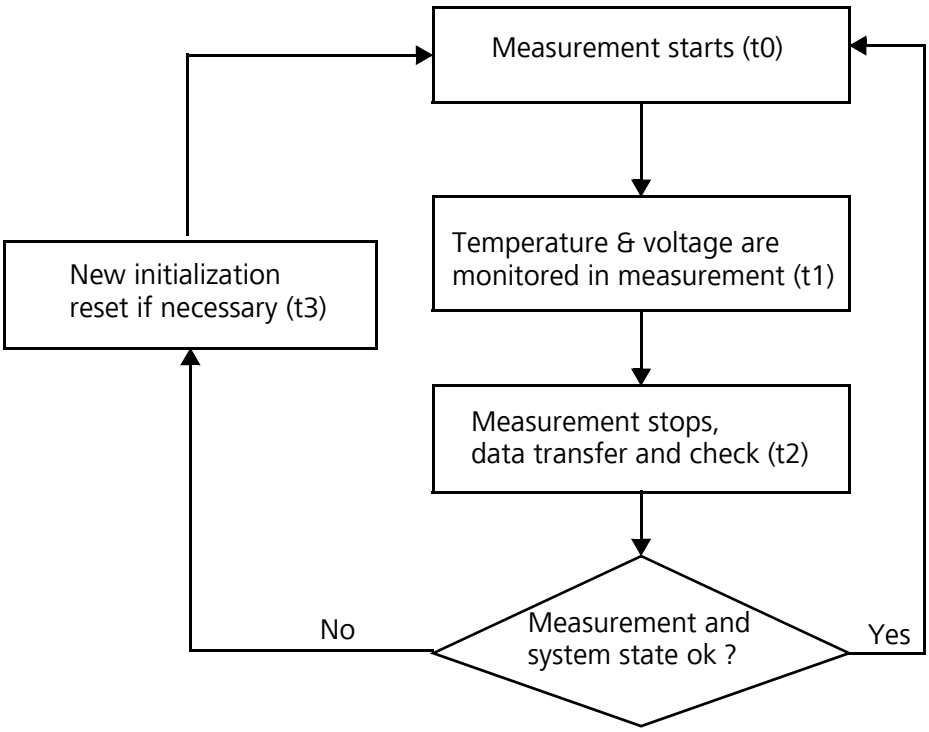

Fig. 3: Flowchart of standard measurement cycle

Figure 3 shows a standard measurement cycle. On completion of each measurement cycle (time t2), the measured data is checked and status parameters are evaluated. If a value is found to be out of tolerance or if there is a hardware error, the standard measurement cycle will be re-initialized.

Cyclic standard measurement is monitored by the external APD controller. On detection of a malfunction or failure to establish communication, the controller's watchdog will induce the PC to trigger a new measurement cycle.

The state of the receiver depends on the results of monitoring for noise level and supply voltage. Due to its internal setup, the light source is essentially characterized by the pulse repetition rate which may decrease because of light source aging. The pulse rate is subject to monitoring. For pulse rates below 4.5 kHz, an error message is output. The reflex at the window panel is analyzed to monitor for window contamination.

All obtained values are output in an extended data telegram. The standard data telegram contains approximate information about the service code (refer to chapter 8.2, and 8.5).

5 Transportation & Scope of Delivery

CAUTION
Danger of damage!
The CHM 15k may only be transported and moved with the help of suitable lifting gear and an appropriate means of transportation.
The CHM 15k may only be loaded and transported in packaged condition and in the transporting position (see Fig. 5).
Inside its shipping container, the CHM 15k must be adequately protected against slipping, shock, stroke or other mechanical impacts.

The **scope of delivery** includes:

- CHM 15k Cloud Height Meter
- Drilling template
- Fastener components
  4 S12 dowels (from Fischer)
  4 DIN 571-10 x 140-ZN screws
  4 ISO 7093-10.5-KST/PA washers
  4 ISO 7093-10.5-A2 washers
- User manual and device software

If requested by the customer, an adopter frame will be delivered together with the equipment to allow the CHM 15k to be screwed onto prepared fastening bolts. Please contact JENOPTIK Laser, Optik, Systeme GmbH for further technical details.

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Operating state at the time of CHM 15k product delivery:

Transfer mode 1	Automatic output of standard data telegram
Device code (device)	16
Baud rate	9,600
Duration of measurement	30 seconds

For further details on operating states, consult chapter 8.

6 Installation

CAUTION

There is danger of mechanical damage!
The owner/operator of the CHM 15k will be responsible for dimensioning and manufacturing a concrete base. This mounting base must be properly sized to withstand the lasting strain that is caused by the equipment's own weight and by external influences.

CAUTION

There is danger of mechanical damage!
The device must not be opened during work for setting up or starting up, in order to prevent the penetration of dirt or humidity. If opening becomes necessary, e.g. following a malfunction, work of this kind may only be performed by duly instructed personnel.

The CHM 15k Cloud Height Meter is assembled and fixed on a suitably sized concrete foundation.

Levelling screws are integrated with the bottom of the support legs to allow for vertical adjustment and, hence, vertical adjustment of the measuring unit.

6.1 Installing the CHM 15k

6.1.1 Preparatory Work

Before CHM 15k installation may begin, diameter 12 holes and dowels (4 dowels included in delivery) have to be made and inserted in accordance with the drilling template (Fig. 4).

Make sure that the outer door is properly oriented for power connections to the power box of the operator.

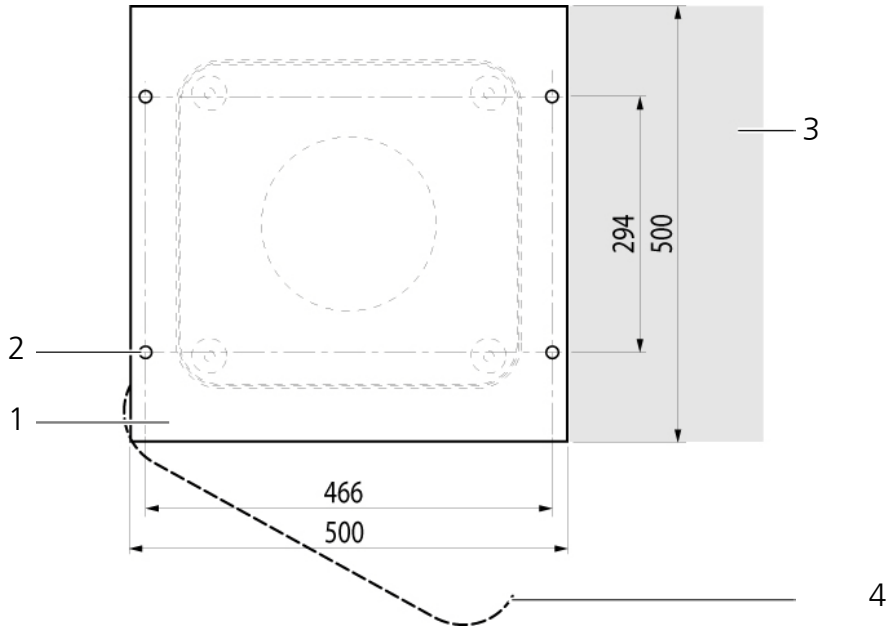

Fig. 4: Drilling template

1 Drilling template
2 Holes (15 mm in diameter) for mech. attachment
3 Power supply port (for connection box)
4 Opening direction of outer door

6.1.2 Installation on the Mounting Base

CAUTION

There is danger of accidents during installation work!
The weight of the CHM 15k amounts to 70 kg. For this reason, at least two persons are required to assemble the Cloud Height Meter.

To install the CHMK 15k Cloud Height Meter, proceed as follows:

1. Unload the CHM 15k from its means of transportation, using appropriate lifting gear and place it down as near as possible to the designated installation.

Fig. 5: The CHM 15k packaged and in transporting position

1 Packaging of wooden
2 Pallet

2. Remove packaging
   – Screw the side walls
   – Remove the sidewalls seperate

Fig. 6: The CHM 15k with styrofoam packing pads

1 Styrofoam packing pads
2 CHM 15k
3 Pallet

3. Cautiously lift the CHM 15k out of the styrofoam packing pads by hand. Comply with all safety regulations as you do this (Position for raising: Fig. 8).

Relocation/further transportation options:

– By sack barrow: with bigger distances to concrete base (Fig. 7)
– Manual transportation: put your hands into the openings which marked with arrows (Fig. 8) for this purpose

CAUTION

There is danger of damage to the Cloud Height Meter!
Make sure that the CHM 15k is transported with the outer door facing down (Fig. 7) when loaded onto a sack barrow.

Fig. 7: Transporting by sack barrow

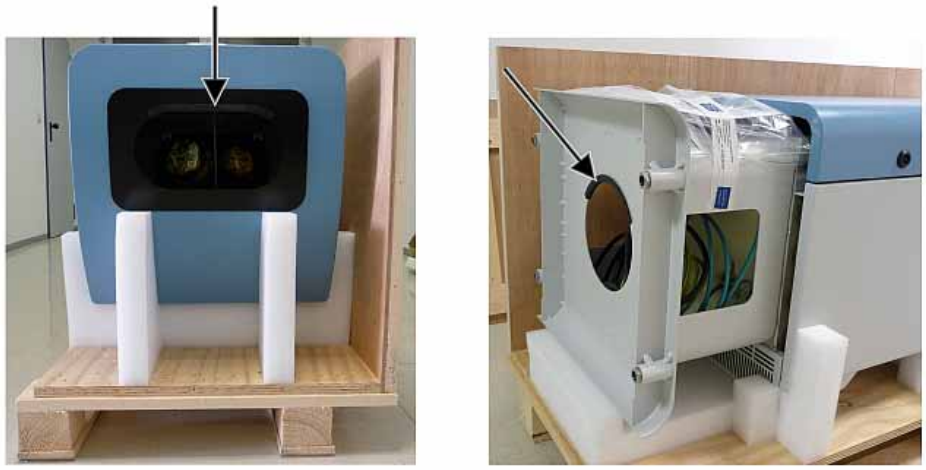

Fig. 8: Position for raising

4. Place the CHM 15k in the mounting position (vertical) onto its concrete base. As you do this, pay attention to the outer door position in relation to the local power connection box (see Fig. 4).

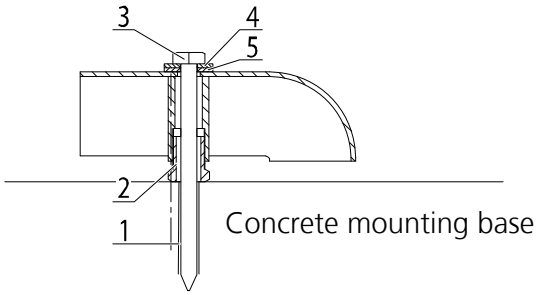

Fig. 9: Fasteners

1 S12 dowel
2 ±5 mm levelling screw (integrated into the device foot)
3 DIN 571-10 x 140-ZN screw
4 ISO 7093-10,5-A2 washer
5 ISO 7093-10,5-KST/PA washer

5. Use the washers and screws (supplied) to pre-assemble the CHM 15k (see Fig. 9) so it is preliminarily fixed on its concrete base.
6. Turn the levelling screws (integrated with the support legs) until the CHM 15k is properly aligned in a vertical direction (using a water-level placed onto a side wall or the front face).
7. Tighten fastening screws (nuts).

6.2 Electrical Installation

CAUTION

There is risk of damaging the Cloud Height Meter!
Work for connection of the CHM 15k to electric power supply may only be carried out by an electrician of JENOPTIK Laser, Optik, Systeme GmbH or another specialist electrician. Failure to comply will void any claims of guarantee or warranty.

NOTE

It is the operator's responsibility to create all preconditions that are required for CHM 15k Cloud Height Meter connections according to EN 61016-1, e. g. he must install a connection box.

Installed connections must be in accordance with the valid national regulations.

A connection box may be installed directly beside the CHM 15k or at a distance < 3 meters.

Electrical connection of the CHM 15k requires non-detachable cabling as follows:

1. 10 mm² grounding cable (1-pole, green-yellow), 3 meters.
2. Data cable (RS 485); A (+) conductor: green, B (-) conductor: red, earth-ground: cable shield, 3 meters.
3. 230 V supply (power supply: neutral conductor: blue; conductor: brown; grounding conductor: green-yellow), 3 meters.

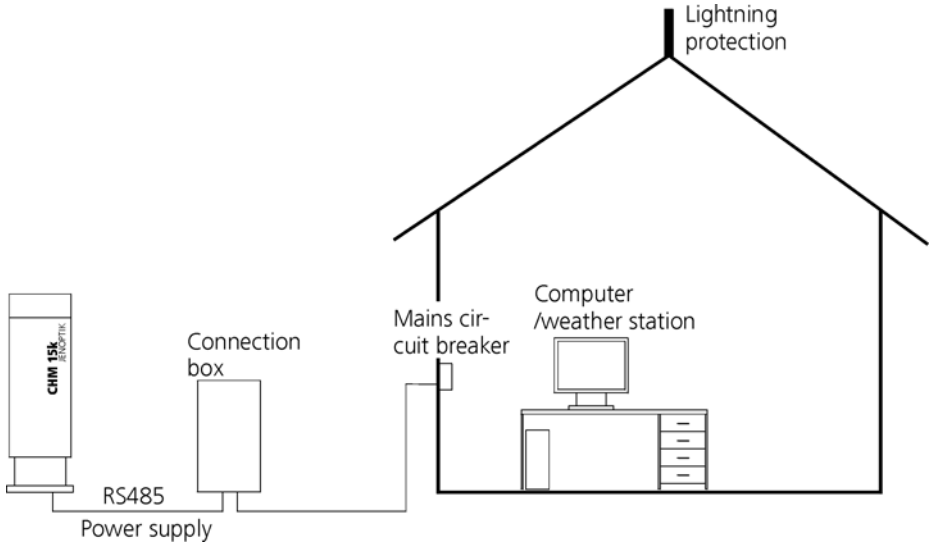

Fig. 10: Principal diagram

7 Starting Up & Shutting Down

7.1 Starting Up

Preconditions

- The CHM 15k Cloud Height Meter has been installed in a conforming manner.
- The control cable (RS485), ground cable and power cable (230 V) are connected.
- For communication checks, a terminal program, e.g. a hyper terminal working under Windows is available. It has been configured for communication as follows:
  - Baud rate: 9,600
  - Data bits: 8
  - Parity: none
  - Stop bits: 1
  - Flow control: none

DANGER

Laser radiation! There is danger of eye injury!
Once power is on, the CHM 15k emits invisible laser radiation. Don't directly look into the laser beam. Under no circumstances may the laser beam be observed using optical instruments (field glasses).

Starting conditions

After the on-site mains circuit breaker has been turned into power-on position, the CHM 15k will start up by itself. It will be fully operational after a temperature adjustment phase of varying length. Depending on outdoor temperatures, this phase may last from a few minutes to one hour (at 40 °C below zero).

NOTE

Following a short-time power failure (for a few seconds), no warming-up phase is required. The CHM 15k will be fit for use again after two minutes.

Communication with the CHM 15k will be possible if a minimum temperature of 0 °C is reached in its inner space.

System state query via RS485

Operating state of the CHM 15k at the time of delivery:

- Automatic output of standard data telegram
- Device identification (device) 16
- Baud rate 9,600
- Measuring time: 30 seconds

For further detailed information about operating states, refer to chapter 8.

For testing of communication, use a

set<SPACE><Device>:Transfermodus=0<CR><LF>

command. It will switch to polling mode.

Working in this mode, you are able to test the following three types of telegram:

- Standard data telegram
- Extended data telegram
- Raw data telegram

and make device settings as may be required. Chapter 8 describes available commands and their effects in detail.

Table 2 shows the most important commands that are necessary to perform simple function tests in routine mode.

Command	Description	Reply (shortened)
get<SPACE>16:L<CR><LF>	Outputs extended data telegram	refer to chapter 8.2.4
get<SPACE>16:Device=14<CR><LF>	Sets device number to 14	set 16:Device=14
set<SPACE>16:Baud=4<CR><LF>	Sets baud rate to 19,200	set 16:Baud=4
set<SPACE>16:dt(s)=15<CR><LF>	Sets measuring time to 15 seconds	set 16:dt(s)=15
get<SPACE>16:Lifetime(h)<CR><LF>	Reads laser operating time counter	get 16:Lifetime(h)

Table 2: Essential commands for function testing (examples)
On completion of simple function testing: of the CHM 15k:

- continue to operate the CHM 15k in polling mode or
- set it back to automatic transfer mode

set<SPACE><Device>:Transfermodus=1<CR><LF>

Note: This command refers to automatic transfer mode.

NOTE

A reasonable optional online communication software “JO-DataClient” for windows operational systems may be purchased. A free of charge version “JO-DataClient_light” is part of the ceilometer delivery.
A visualization program illustrating raw data, system status and cloud paramete is also available.The data carrier will contain a free of charge JO-DataClient_light version in this case.

NOTE

Pay special attention to the baud rate setting for RS485 bus operation. To work in raw data transfer mode, you should set at least 19,200 bauds. This is necessary to be able to query all devices even with measuring intervals <1 minute in a controlled manner.

NOTE

In case of malfunction/faults, disconnect the CHM 15k from power supply (using the mains circuit breaker). Turn on power again after a short pause. If the problem persists, you should contact a qualified on-site service technician. If case of urgent problems, you should directly contact the JENOPTIK Laser, Optik, Systeme GmbH Service.

Phone: +49 3641 65-3041
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7.2 Shutting Down

Turn CHM 15k power supply off, using the local mains circuit breaker.
To disassemble the CMH15k Cloud Height Meter and install it in another location, perform the sequence of working steps described in chapter 6.1.2 in reverse order.

7.3 Disposal

NOTE

Disposal of the CHM 15k Cloud Height Meter must be in accordance with national regulations.

8 Communication via RS485

The values measured by the CHM 15k are transferred to the user's data processing system via the RS485 interface. For data evaluation, query software (terminal program) is required. Optionally, the "JO-DataClient" can be supplied together with the equipment.

CAUTION

Loss of data!
If you use query software other than "JO-DataClient", make sure that it provides an internal function for automatic switching between emitting mode and receiving mode. Otherwise, malfunctions may occur at the RS485 interface and cause loss of data.

NOTE

The RS 485 interface does not allow sending and receiving mode to be on at the same time. Accordingly, the interface has its own automatic switching mechanism. This explains why you cannot send other commands (refer to chapter 8.1) while receiving a data telegram that was sent automatically (described in chapter 8.2.3 to 8.2.5).
Incoming initial <STX> and end <EOT> character codes are indication of a running receive transmission session.

8.1 Device Configuration

The device is configured to allow the user to make settings via the RS485 interface for:

- control of the measuring process
- configuration of the communication
- data evaluation.

Table 3 contains the most important setting options. They will be explained in the following sections. For safety reasons and because they have a considerable influence on the way the CHM 15k functions, some options are only available if the ceilometer is set into a service mode.

Table 16 in chapter 9 provides a list of additional parameters, including specific device settings. They have an impact on data collection, data evaluation and basic system settings. The tables contain the permissible value range for each parameter together with the default value that is set at the time of product shipment and an idicator if service mode is required or not.

Parameter	Standard value	Service Mode required	Range
Altitude(m)	0		0 – 9999
Baud	3		0 – 7 (1.200 – 115.200 Baud)
BaudAfterError	3	X	0 – 7 (1.200 – 115.200 Baud)
DateTime			DD.MM.YYYY;hh:mm:ss (8.1.6)
DeviceName	16		0-99
dt(s)	30		5 – 3.600
FabName	CHMyyxxxx		–
IgnoreChars	06	X	8Bit-ASCII-Codes
Institution	JO-LOS		Any character (text) string
LaserPower	50	X	0 – 100
Latitude	52,40050		-90 – 90
Lifetime (h)	xxxxxxx		For query only
Location	Jena		Any character (text) string
Longitude	13,23905		0 – 360
MaxCrossTalk-Chars	5	X	0 – 1024
Offset(m)	15		0 – 99999
Parameters			For query only
ResetPC	0		0 – 3
ServiceMode	0		0; 1
SetPeltier	True	X	False, true
SoftwareUpdate			Refer to Service Manual
SystemLifetime(h)	xxxxxxx		For query only
TimeOutRS485(s)	30	X	5 – 3600
TransferMode	0		0 – 3
Unit(m/ft)	m		m, ft
UpdateBlockSize	2048	X	512 – 32768
UseAltitude	False		False, true

Table 3: Summary table of essential parameter settings, Parameter checked with a “x” can be changed only in service mode.

Explanatory notes relating to Table 3

Altitude(m): Indicates altitude of working site above sea level (in meters).

Baud: For changes in baud rate (refer to chapter 8.1.3).

BaudAfterError: Standard baud rate after communication error (refer to chapter 8.1.3)

DataTime: Set date and time (refer to chapter 8.1.6)

DeviceName: Designates the identification number in a bus system, which is required to address a given device via a data port.

dt(s): Sets and reads time-related measuring range.
A decrease in time resolution (corresponding to an increase in dt) will cause more photon pulses (shots) to be averaged over time and yields an improvement in signal-to-noise performance. An increase by a factor of n results in an improvement by a factor of the root of n. All raw data which is found to be within a given time window dt(s) will be involved in evaluation. There is no single data selection option available.

FabName: The product designation (CHM) combined with serial number of a given device, e.g. CHM060001.

IgnoreChars: Variable contains 8Bit-ASCII-codes will be ignored by the CHM 15k. The ASCII-codes have to coded as 2 character HEX-code, eg. "06" corresponds to <ack>. Only HEX-codes will be evaluated!

Institution: The name of the institution or company

LaserPower: Laser Power in mW

Latitude: The latitude of a given location, in decimal numbers.

Sample value for Berlin: 52.51833 (corresponds 52° 31' 6'' N)

Lifetime(h): For querying of operating counter state of the laser lifetime.

Location: Refer to Service Manual.

Longitude: The longitude of a given location, in decimal numbers, where easterly is defined as positive orientation.

Sample value for Berlin: 13.40833 (corresponds to 13° 24' 30'' E)

MaxCrossTalkChars: Sets a Number of charcters the CHM 15k will ignore within "TimeOutRS485(s)" if they are receives in a fragmentary string, which may be a query not ended with <EOT> (04 HEX), <CR> (0D HEX), <LF> (0A HEX). The parameter is included to prevent the ceilometer to fall back in its standard baud rate caused by noise on unstable communication lines.

Parameters: For querying of a complete parameter list (see Annex B for details)

ResetPC: Resets PC to/restores factory settings (refer to chapter 8.1.4)

ServiceMode: Switch from normal operation to Servicemode, Refer to Service Manual.

SetPeltier: Switch on /off detector temperature control

SoftwareUpdate: Refer to Service Manual.

SystemLifetime (h): For querying the operating state of system lifetime.

TimeOutRS485(s): Set time intervall within MaxCrossTalkChars and BaudAfterError is reacting (standard 30s).

TransferMode: Refer to chapter 8.2.1 to 8.2.5.

Unit(m/ft): Indicates target dimensions in meters (m) or feet (ft).

UpdateBlockSize: Size (in Bytes) of a single update block during Software Update (refer to service manual, JO-DataClient manual)

UseAltitude: Adds Altitude(m) to data output string.
If a value of e.g. 60 m is specified for Altitude, the output value for a given cloud base will increase by 60 m.

8.1.1 Reading a parameter

To read a parameter, you must trigger a

get<SPACE><Device>:<ParameterName><CR><LF>

command. If <ParameterName> is found to contain a valid designation according to Table 3, its value will be output as part of

<STX>get<SPACE><Device>:<ParameterName>=<Wert>;<ASCII-Two's complement><CR><LF><EOT>

Example:

If DeviceName corresponds to a presetting of 16, you may query the device name, using the command

get 16: FabName<CR><LF>

The response to this query may look like this (example):

<STX>get 16: FabName=CHM060003;3F<CR><LF><EOT>.

where each of <STX>, <CR>, <LF> and <EOT> stand for one byte with hexadecimal codes 02, 0D, 0A and 04 in this same order. The value 3F represents the checksum of the two's complement formed over the whole response line, excluding the two characters (3F) themselves, in accordance with the established protocol response format (refer to chapter 8.2.3 to 8.2.5).

8.1.2 Setting a parameter

With the help of a

set<SPACE><Device>:<ParameterName>=<Wert><CR><LF>

command you can change a desired configuration parameter. The successful completion of a change in parameter setting is reported via:

<STX>set<SPACE><Device>:<ParameterName>=<NeuerWert>;<ASCII-Two's complement><CR><LF><EOT>

If <Value> is found to be within permissible limits, the newly set value <NeWalue> meets this requirement. If an entry is found to be above the upper limit or below the lower limit, the permitted maximum or minimum value will be applied instead. With alphanumerical entries the default value will be applied as <Value>.

Example:

Following a

set 16:Unit(m/ft)=ft<CR><LF>

command, all height data in a protocol response will be indicated in feet (ft) instead of the standard meter unit of measure (m). Since **Unit(m/ft)** provides a switching option,

<STX>set 16:Unit(m/ft)=ft;2A<CR><LF><EOT>

is output for confirmation. 2A is the checksum value of the response line.

8.1.3 Change in Baud Rate

Changes in the baud rate are a special setting option. To make a change, proceed as described in chapter 8.1.2. For example, by triggering a

set<SPACE>16:Baud=4<CR><LF>

command, you will set baud rate "4", i.e. 19,200 bits per second, for device 16. Table 4 shows all baud rate numbers and their assigned baud rate values.

Baud rate no.	Baud rate [bits/s]
(0)	(1,200)
(1)	(2,400)
2	4,800
3	9,600
4	19,200
5	38,400
6	57,600
7	115,200

Table 4: Baud-rate-number-to-baud-rate assignments

NOTE

With an ICM5 interface converter the two lowest baud rates will not be available. Currently, the lowest selectable transfer speed is 4,800 bits per second.
By agreement with JENOPTIK Laser, Optik, Systeme GmbH the CHM 15k may be equipped with another interface converter capable of handling all baud rates.

Immediately on triggering a set command of this type, the interface will be set to the new baud rate. In the event of a false baud rate setting with consequential communication errors, it is not possible to reverse this setting as usual because of failure to establish normal communication. It will be reset to the default baud rate specified by parameter **BaudAfterError** after 30 seconds, standard value: TimeOutRS485(s). The standard value of **BaudAfterError** is 3 (refer to chapter Table 3:) which means 9,600 bits per second. If this baud rate still proves too high, a different desired baud rate can be preset as the default rate before product shipment or by service personnel.

8.1.4 Restart of Internal PC/Factory Settings

By triggering a

set<SPACE>16:ResetPC=1<CR><LF>

command, the internal PC can be instructed to immediately perform a restart. A restart procedure takes about two minutes. Before or unless it has finished, communication with the CHM 15k is not possible. The same applies to continuously ongoing telegram outputs.

With a

set<SPACE>16:ResetPC=2<CR><LF>

command you can restore all parameters to their factory settings.
Both entries can also be additively combined, i.e. after a ResetPC=3, factory settings will be restored, which is immediately followed by a restart of the PC.

8.1.5 Changing Measurement Time

set<SPACE><Device>:dt(s)=30<CR><LF>

8.1.6 Changing Ceilometer Date & Time

With the help of

set<SPACE>16:DateTime=DD.MM.YYYY;hh:mm:ss<CR><LF>

you can switch the date and time settings of the internal PC, where DD means day, MM month, YYYY year, hh hours, mm minutes and ss seconds, referenced to GMT zone (Greenwich Mean Time).

Example:

set 16:DateTime=13.04.2006;17:22:46<CR><LF>

will set 13th April 2006 as the date and 17:22:46 GMT as the exact time.

8.2 Data Queries

At any time during operation, the CHM 15k is in one of the following four transfer modes as shown in Table 5.

Transfer mode	Meaning
0	Data telegrams are output on special request
1	Automatic output of standard data telegram
2	Automatic output of extended data telegram
3	Automatic output of raw data telegram

Table 5: Summary table of transfer modes

Changes in transfer mode can be made with the help of set commands as described in chapter 8.1.2.

For example:

set<SPACE>16:TransferMode=1<CR><LF>

will activate the standard transfer mode (automatic output of standard data telegram) that had been factory-set before shipment of device 16.

8.2.1 Polling Mode

The command

set<SPACE><Device>:TransferMode=0<CR><LF>

will turn on polling mode, while turning off automatic telegram output mode which may have been active until that moment. The following three commands

get<SPACE><Device>:S<CR><LF>

get<SPACE><Device>:L<CR><LF>

get<SPACE><Device>:A<CR><LF>

can now be used for a single standard telegram (**S**), a single extended data telegram (**L**) or a single raw data telegram (**A**) polling action. Refer to data telegram description parts in refer to chapter 8.2.3 to 8.2.5 (Table 6, 7, 9) for format information.

8.2.2 Automatic Output Mode

The command

set<SPACE><Device>:TransferMode=1<CR><LF>

will turn on automatic mode with the standard telegram output. Its repetition rate depends on the content of variable dt(s) which is set to 30 seconds by default.

Table 6 contains the format of standard data telegrams

For extended data telegram output use the command:

set<SPACE><Device>:TransferMode=2<CR><LF>

Table 7 contains the format of extended data telegrams.

The output of the raw data plus extended data telegram will received using the command:

set<SPACE><Device>:TransferMode=3<CR><LF>

Table 9 contains the additional format structure of raw data telegrams.

8.2.3 Standard Data Telegram

The standard data telegram consist of 96 Bytes. Data are separated with spaces (20 HEX). Table 6 shows details of the format structure.

Byte	Value[1]	Description
0	<STX>	02 HEX
1	X	
2	1	
3, 4	TA	
5	<SPACE>	20 HEX

Table 6: Standard data telegram format

Byte	Value[1]	Description
6	8	
7	<SPACE>	20 HEX
8-10	***	Output interval [s]
11	<SPACE>	20 HEX
12-19	**.**.**	Date (dd.mm.yy)
20	<SPACE>	20 HEX
21-25	**.**	Time (hh:mm)
26	<SPACE>	20 HEX
27-31	*****	1st cloud layer
32	<SPACE>	20 HEX
33-37	*****	2nd cloud layer
38	<SPACE>	20 HEX
39-43	*****	3rd cloud layer
44	<SPACE>	20 HEX
45-48	****	Laser beam penetration depth into 1st cloud layer
49	<SPACE>	20 HEX
50-53	****	Laser beam penetration depth into 2nd cloud layer
54	<SPACE>	20 HEX
55-58	****	Laser beam penetration depth into 3rd cloud layer
59	<SPACE>	20 HEX
60-64	*****	Vertical visibility
65	<SPACE>	20 HEX
66-70	*****	Maximum detection range
71	<SPACE>	20 HEX
72-75	****	Cloud height offset
76	<SPACE>	20 HEX
77, 78	Ft/m<SPACE>	Unit of measure (Ft/m)
79	<SPACE>	20 HEX
80, 81	**	Precipitation index
82	<SPACE>	20 HEX
83-90	********	System status and messages (flags may take on "0" or "1" state)
91	<SPACE>	20 HEX
92, 93	**	Checksum (two's complement of the sum of bytes 0 to 96, excluding bytes 92 and 93,expressed in hex code)
94	<CR>	0D HEX
95	<LF>	0A HEX
96	<EOT>	04 HEX

Table 6: Standard data telegram format

1 *=any character

A maximum of three cloud heights can be indicated. If less than three could heights were detected, a "NODET" message will appear in the remaining field(s). Failure to determine a cloud penetration depth will be reported through a "NODET" message in the corresponding display field.

The fields:

- Cloud height
- Cloud penetration depth/Cloud thickness
- Visibility
- Maximum detection range

will show a "NaN" value (filled with space characters) on failure to receive enough backscatter power for determining these values. The same fields will carry a "-" sign if their values cannot be established because of a device error. For detailed information on device error types, you should refer to the service codes table (refer to chapter 8.5).

8.2.4 Extended Data Telegram

The extended data telegram consists of 240 Bytes. Semicolon (3B HEX) replaces space (20 HEX) as delimiter for extended data telegrams. Table 7 shows details about the telegram structure.

Byte	Value[1]	Description
0-91		Same as standard data telegram (refer to Table 6)
92, 93	16	CHM 15k device identification number
94	;	3B HEX
95-103	CHMjjnnnn	FabName (jj for year, nnnn for consecutive number)
104	;	3B HEX
105-109	*****	Standard deviation for 1st cloud layer
110	;	3B HEX
111-115	*****	Standard deviation for 2nd cloud layer
116	;	3B HEX
117-121	*****	Standard deviation for 3rd cloud layer
122	;	3B HEX
123-126	****	Standard deviation for laser beam penetration depth into 1st cloud layer
127	;	3B HEX
128-131	****	Standard deviation for laser beam penetration depth into 2nd cloud layer
132	;	3B HEX

Table 7: Format of extended data telegrams (also refer to Table 8)

Byte	Value[1]	Description
133-136	****	Standard deviation for laser beam penetration depth into 3rd cloud layer
137	;	3B HEX
138-142	*****	Standard deviation for vertical visibility
143	;	3B HEX
144-147	****	Software version for signal acquisition
148	;	3B HEX
149-152	****	Software version for signal processing
153	;	3B HEX
154-155	**	System status: "OK" or "ER"
156	;	3B HEX
157-164	********	32 bits of service code in hex code (see chapter 8.5)
165	;	3B HEX
166-169	****	Outer temperature (Kelvin x 10)
170	;	3B HEX
171-174	****	Inner temperature (Kelvin x 10)
175	;	3B HEX
176-179	****	Detector temperature (Kelvin x 10)
180	;	3B HEX
181-184	****	NN1
185	;	3B HEX
186-189	****	NN2
190	;	3B HEX
191-196	*******	Laser running time (h)
197	;	3B HEX
198-201	****	Optics status
202	;	3B HEX
203-209	*******	Laser shot number (7 digits)
210	;	3B HEX
211-214	****	Receiver status
215	;	3B HEX
216-219	****	Light source status
220	;	3B HEX
221-225	*****	PBL height (PBL: **P**lanetary **B**uodary **L**ayer)
226		3B HEX
227-231	*****	Standard deviation for PBL height (PBL)
232		3B HEX
233-234	**	Time, only in seconds (ss)
235		3B HEX

Table 7: Format of extended data telegrams (also refer to Table 8)

Byte	Value[1]	Description
236-237	**	Checksum (two's complement of the sum of bytes 0 to 240, excluding bytes 236 and 237,expressed in hex code)
238	<CR>	0D HEX
239	<LF>	0A HEX
240	<EOT>	04 HEX

Table 7: Format of extended data telegrams (also refer to Table 8)

1 *=any character

For standard deviations quoted above, the same exceptional "NODET/NODT/ NaN/---" values are valid as for the corresponding reference parameters (refer to chapter 8.2.3).

NOTE

For explanations regarding system parameters involved in data evaluation, such as penetration depth, refer to chapter 9

Term	Explanatory note
Outer temperature	The outer temperature measured at the CHM's bottom face. For precise measurement of outer temperature, an error of ±5 °C is permissible. Readings are displayed in Kelvin x 10.
Inner temperature	Temperature measured at the sensor: displayed in Kelvin x 10; ±2 K
Detector temperature	Temperature measured at the sensor: displayed in Kelvin x 10; ±2 K
NN1	Unass.
NN2	Unass.
Laser operating time (h)	Laser lifetime hours of operation
Optics status	Degree of contamination of glass panel 255=transparent, 0=opaque
Laser pulse number	Number of laser pulses in a measuring interval (7-digit)
Receiver status	For tracking of optical beampath and reciever status. 255 = maximal sensivity 0 = sensivity down to zero (for example, caused be detector or filter defect)
Light source status	Evaluates light source Less laser power results in a decrease of the pulse repetition rate; 255=starting value, 0=laser off

Table 8: Terms in extended data telegram

8.2.5 Raw Data Telegram

Raw data are output in NetCDF-format (refer to chapter 8.4 for structure). This binary format is converted into 7-bit ASCII code (21 to 60 HEX range) using UUencode before transmission to be able to handle <EOT> Bytes.

The NetCDF-file of a raw data set is about 6 Kbytes long. UUencode transformation turns these into 8 Kbyte of ASCII data that need to be transmitted. With a baud rate setting of 9,600 bits per second, transmission takes about 9 seconds, which results in the following additional restrictions on automatic raw data telegram outputs as shown in Table 9.

Baud rate no.	Baud rate [bits/s]	dt
0	1,200	Not available
1	2,400	Not available
2	4,800	≥ 36 s
3	9,600	≥ 20 s
4	19,200	≥ 12 s
5	38,400	≥ 7 s
6	57,600	No further restrictions
7	115,200	No further restrictions

Table 9: Additional restrictions

Table 10 describes the structure of additional data in a raw data telegram.

Byte	Value[1]	Description
0-235		Same as in extended data telegram
236	<CR>	0D HEX
237	<LF>	0A HEX
238-(eeee-5)		Raw data in ASCII format (UUencode)
eeee-4 eeee-3	**	Checksum (two's complement of the sum of bytes 0 to eeee, excluding bytes eeee-4 and eeee-3,expressed in hex code)
eeee-2	<CR>	0D HEX
eeee-1	<LF>	0A HEX
eeee	<EOT>	04 HEX

Table 10: Raw data telegram format

1 *=any character

According to the UUencode standard, lines containing raw data are organized as follows:

1st line:
begin 644 YYYYMMDDhhmmss_[Site]_[Device].nc<CR><LF>

2nd line:
M***<CR><LF>

3rd line:
M**********<CR><LF>

...

(n-2)th line:
M**********<CR><LF>

(n-1)th line:
E********** ***<CR><LF>

nth Zeile:
end<CR><LF>

* stands for any UUencode character that falls within the hex range HEX 21 to 60.
"M" (HEX 4D) at the beginning of a data line designates the number of data bytes in this line, equally UUencoded:

- 4D, when decoded, corresponds to the number HEX 2D = 45 decimal.

By 4/3-UUencode conversion, these 45 bytes are encoded in 60 (60=45/3 x 4) ASCII characters following "M", except for the last line where only the last bytes, typically less than 45, are encoded.

The example above contains "E" (HEX 45, HEX 25=37 decimal, decoded) which means that 37 bytes of raw data are following. As a consequence of 4/3-encoding (rounded up to a multiple of four), however, they require 52 (52=(37/3 rounded) x 4) ASCII characters.

The last line with "end" marks the termination of UUencode data.

An example of a file name in line 1

YYYYMMDDhhmmss_ [Site]_[Device].nc

is 20060331123730_Jena_CHM06003.nc (also refer to chapter 8.4.3).

which means:

- CHM060003 fabrication number in Jena, data of 31st March 2006, at 12:37:30.

8.3 Alternative telegram request

The CHM 15k is accepting an alternative data request in polling mode for the standard telegram (8.2.3) to be compatible with existing infrastructure on measurement sites. Table 11 shows the structure of the request. It is necessary that the encoded ID number in Byte 06 corresponds with the device number of the CHM 15k.

Byte	Value[1]	Description
00	<STX>	02 HEX
01	H	Telegram Header
02	0	Telegram Header
03	C	Telegram Header
04	!	Telegram Header
05	X	device type -> Ceilometer
06	G	Sensor-ID-Number (01...9AB..MN) In this example the character „G“ match the decimal number 16.
07	P	Command indicator – only „P“ for polling is accepted
08-17	----------	Not used, filled up with „-“
18-19	**	Checksum (two's complement) – ignored
20	<EOT>	04 HEX

Table 11: Structure alternative telegram request

1 *=any character

8.4 NetCDF Format Structure

8.4.1 General

The Cloud Height Meter saves all measured backscatter profiles in a day file of NetCDF format (**Net**work **C**ommon **D**ata **F**ile). Its storage capacity allows the files to be kept on record for approximately one month. In a "Communication interrupted" service case, affected data can be inspected and traced back. The raw data of a single measurement can be called up as a raw data telegram via the RS485 interface. Standard operation does not include the transmission of a day file, since this would negatively influence the time sequencing in this mode. Because the transmission rate depends on the time resolution of the measured data and the RS485 interface settings, this transmission would take too long. An one day NetCDF file with dt(s)=30s measurment time intervals will be approximately 11 MB in size. Switching to 15s time resolution 22 MB file sizes are generated. In service cases, a transmission of the NetCDF file is possible (direct connection to Cloud Height Meter via RS485 or LAN) (refer to Service Manual).

8.4.2 Fundamentals

NetCDF provides a computer-platform-independent interface for the saving and reading of scientific data. It was developed under Unidata, a project funded by the National Science Foundation (http://www.unidata.ucar.edu). Each data set contains an explanation of its storage content.

The Cloud Height Meter saves all data from a single day in a file, using UTC as the time base. The CHM 15k transmits a raw data telegram with a single backscatter profile and any related descriptive variables and attributes in NetCDF format. The raw data daily telegrams may, in turn, be summarised in a day file.The full version of Jenoptik "JO-DataClient" software will generate the day files automatically.

8.4.3 File Names

Day file:	**YYYYMMDD_[location]_[Device].nc**
Raw data telegram:	**YYYYMMDDhhmmss_[Site]_[Device].nc**

NOTE

For failsafe transmission of files, ISO standard requirements must be observed in their extended version, i.e. the length of a file name must not exceed 31 characters. In terms of the setup of a day file with [Date]_[location]_[Device ID].nc (8_9_9.2=31 characters)
this implies that the site name must not be longer than 9 characters.

8.4.4 Format Structure

Value saved in NetCDF format can be dimensions, variables and attributes.
Table 12 to 14 describe the various terms.

Dimensions

Dimension	Description
time	The number of backscatter profiles inside the NetCDF file
range	The number of points measured in a backscatter profile

Table 12: Dimensions in NetCDF

Variables

Variable	Description
float latitude units = "degrees_north" long_name = "latitude of site"	The latitude of the installation site, decimal Example: Jena = 50.93333 corresponding to: 50°56'0'' N
float longitude units = "degrees_east" long_name = "longitude of site"	The longitude of the installation site, decimal Example: Jena = 11.58333 corresponding to: 11°35'0'' E
float time (time) units = "seconds since YYYY-MM-DD 00:00:00 00:00" long_name = "time UTC" axis = "t"	End time of measurement Allows for accuracy of 0.007 seconds
float range units = "m" long_name = "range from lidar to the bottom of each range gate" axis = "range"	The distance from the CHM 15k in meter, independently of altitude of the installation site.
float altitude units = "m" long_name = "altitude of ceilometer above mean sea level"	The altitude of the installation site above sea level
float wavelength units = "nm" long_name = "laser wavelength"	The laser wavelength in nm here: 1064
int laser_pulses (time) long_name = "number of laser pulses averaged per record" units = "unitless"	The number of laser pulses averaged in one measurement.
float range_gate long_name = "length of range gate, binwidth" units = "m"	The spatial resolution of measurement

int average_time(time) long_name = "average time per record" units = "ms"	The time over which averaging is performed.
float beta_raw(time, range) units = "counts" long_name = "lidar backscatter raw data 1064 nm, photons per time & range"	The offset corrected backscatter profile data.
int error_ext (time) long_name = 31 Bit ServiceCode" units = "unitless"	Standard status bit sequence Service codes described n chapter 8.5
short state_optics (time) long_name = "transmission of optics" units = "unitless"	The status of optical components Transmission indicated in values from 0 to 255, example: 255 (optics perfectly clean)
short temp_int (time) long_name = "internal temperature in K*10" units = "K" scale_factor = 10	Inner casing temperature [Kelvin x 10]
short temp_ext (time) long_name = "external temperature in K*10" units = "K" scale_factor = 10	Outer casing temperature [Kelvin x 10]
short temp_det (time) long_name = "detector temperature in K*10" units = "K" scale_factor = 10	Detector temperature [Kelvin x 10]
int life_time (time) long_name = "laser life time" units = "h"	Laser operating time in hours
short state_laser (time) long_name = "laser qualitiy index – 255 max" units = "unitless"	Laser status in values from 0 to 255
short state_detector (time) long_name = "qualitiy of dedector signal – 255 max" units = "unitless"	Status of signal detector in values from 0 to 255
float base (time) long_name = " Daylight correction factor, photons per shot " units = "counts"	Daylight correction factor, photons per shot

float stddev (time) long_name = " Standard Deviation raw signal, photons/ shot " units = "counts"	Standard Deviation raw signal, photons/ shot

Table 13: Variables in NetCDF

Global Attributes

Attribut	Description
short day	The day of a month, on which the data was recorded
short month	The month, in which the data was recorded, for example, January = 1
short year	The year, in which the data was recorded
text location	Site of measurement
text title	Heading for graphical representation, e.g. "Lindenberg 1064 nm Cloud Height Meter, Jenoptik CHM 15k"
text source	Serial number
byte device	Device number or device ID
text institution	Institution or company
text software_version	Program version of "JO-main" data recording software
text comment	Descriptive comment

Table 14: Global attributes in NetCDF

8.5 Service Codes

Table 15 explains the meaning of each bit in a 31-bit service code string. Bits 8 to 1 (i.e. reverse order) are quoted in characters 83 to 90 of a standard data telegram (as ASCII "0" or "1" signals, Table 6). A 31-bit service code string is contained in characters 157 to 164 of the extended data telegram or the raw data telegram as an eight-digit hexadecimal number (Table 7 and 10). A bit in unset state means that the corresponding part works properly. A bit in set state suggests an error or indicates that initialization is still underway, e.g. shortly after turning power on.

Bit	HEX	Programm part	Error description
1	00000001	JO-Main	Controller communication and software test
2	00000002	JO-Main	Setting and reading of controller commands functions properly, initialization completed
3	00000004	JO-Main	Measurement qualified, APD voltage OK
4	00000008	JO-Main	Main software "JO-main" running
5	00000010	JO-Main	Measured data written
6	00000020	JO-Main	Temperature sensors OK
7	00000040	JO-CloVis	Data evaluation OK, data available

Table 15: Service codes

Bit	HEX	Programm part	Error description
8	00000080	JO-Main	Laser photon count communication OK
9	00000100	JO-Main	Measured signal within working range
10	00000200	JO-Main	Registration entry written
11	00000400	JO-Main	NetCDF file written
12	00000800	JO-CloVis	Data evaluation: signal and reach OK
13	00001000	JO-CloVis	Data evaluation: no error during evaluation process
14	00002000	JO-Main	Laser test OK
15	00004000	JO-Main	APD cooling on
16	00008000	JO-Main	Watchdog off
17	00010000	JO-Main	Fan OK
18	00020000	JO-Main	Laser status - long-time tendency
19	00040000	JO-Main	Glass panel status OK
20	00080000	JO-Main	Heating status OK
21	00100000	JO-Main	Receiver status OK
22	00200000	JO-Main	Cooling elements detector faultless
23	00400000	NN	NN
24	00800000	NN	NN
25	01000000	NN	NN
26	02000000	NN	NN
27	04000000	NN	NN
28	08000000	NN	NN
29	10000000	NN	NN
30	20000000	JO-DataServer	Software Layer comparison OK
31	40000000	JO-DataServer	Software CPU-Last OK

Table 15: Service codes

Bits 23 to 29 are unassigned and set to "0" by default. Accordingly, a hexadecimal service code "0" indicates that the CHM 15k is fully operational.

8.6 Software Update

The CHM 15k system software can be updated via RS485 connection. Because of the complex machanism we recommend to use the “JO-DataClient” software for necessary updates. Refer to the JO-DataClient manual.

For advanced users a detailed description of the update process is part of the service manual.

9 Data Evaluation

The ceilometer CHM 15k is a laser remote sensing instrument for precise cloud ceiling, cloud thickness and vertical visibility measurements. Moreover it detects the mixed layer height, haze and precipitation type.

9.1 Laser remote sensing

One near infrared laser probes the sky vertically from ground to 15000 m. Targets like aerosol layers and clouds show up as echoes with certain backscatter intensity and signal extinction. Molecular absorption of as well as Rayleigh scattering by air molecules is negligible at a laser wavelength of 1064 nm. The distance from ground is calculated from the travelling time of the laser pulses.

9.2 Cloud ceilings

Cloud echoes show up as bumps in the backscatter signal. The algorithm detects a cloud, as soon as a bump exceeds a certain threshold value. When this happens, it starts searching downward for the ceiling and upward for the extension of the cloud. The metering precision is calculated from the distance between the height where the threshold is exceeded and the ceiling and the distance where the threshold is undercut and the end of the bump respectively. The threshold is a function of height from ground. Signal to noise values are used to homogenize measurements (Figure 11).

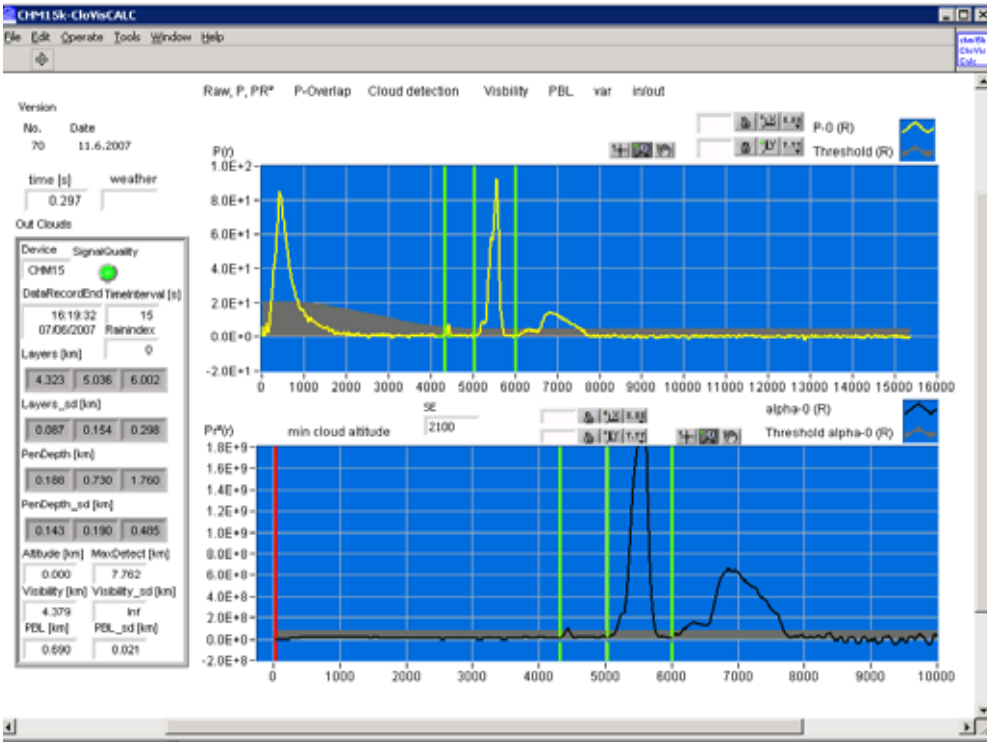

Fig. 11: Cloud detection algorithm. Simultaneous identification of 3 cloud layer.

9.3 Cloud Penetration Depth

A cloud penetration depth is established by identifying a cloud lower and upper level using the threshold level" ThAlphaStart(m-1E7)" (9.2). The subtraction of these values result in the cloud penetration depth. The "ThAlphaFactor(%)" is used to check the surrounding area of the calculated values. Both values combined deliver the standard deviation for the penetration depth of a cloud layer. Figure 12 show how the evaluation process for the cloud parameters are done.

9.4 Determination of Maximum Detection Range

The maximum detection range corresponds to the maximum distance at which significant signals can still be measured. It follows from averaged signal/noise ratios versus the distance range. At heights which are beyond the planetary boundary layer,significant signals are only generated by clouds. In presents of clouds the maximum detection range determined by means of the penetration depth of the highest detectable cloud layer.

9.5 Vertical optical range

The method for calculating VOR (vertical optical range) is described in the standard VDI 3786, sheet 15. First an extinction profile a is calculated from the backscatter signal. The VOR is where the integral of extinctions equals 3.

$$\int_0^{VOR} \alpha(r)dr = 3$$

9.6 Precipitation and haze

Haze and precipitation types are detected by multiple scattering. Usually only single scattering is considered as a signal source. Strong atmospheric turbidity and high particle density respectively produce a stronger signal than usual close to the instrument. An integral over the signal in certain ranges is used to evaluate haze and precipitation.

9.7 Mixed layer height

Pollution from sources at ground level is spreading to a height depending on atmospheric conditions. The resulting aerosol layer has a typical signature in the backscatter signal. The mixed layer height is determined by finding this signature.

9.8 Parameters for data evaluation

A set of parameters controls the data evaluation routine Jo-CloVisCHM. The parameters can be changed after entering the CHM 15k service mode.

Parameter	Default value	Range	Description
Calibration-factor1	100	0 to 200	Instrument performance dependent scaling for cloud detection threshold (high clouds)
Calibration-factor2	100	0 to 200	Instrument performance dependent scaling for cloud detection threshold (low clouds)
Calibration-factor3	100	10 to 2000	Calibration factor for VOR detection
Calibration-factor4	10	> 0	Parameter for PBL detection
EndOfP0(m)	2 100	2 000 – 4 000	End of strong signal range
EndOfP1(m)	5 000	5 000 – 15 000	Beginning of high cloud range
IntegralLimit-forFog	70 000	> IntegralLimit-forRain	Detection threshold for haze
IntegralLimit-forRain	2 000	> 0	Detection threshold for precip-itation
MinCloud(m)	30	0 – 15 000	Lower clouds are neglected
MinCloud-Width(m)	45	> 0	Thinner clouds are neglected
MinDistbet-wClouds(m)	105		Closer clouds are considered as one
S/N(P0)	20	> S/N(P2)	Signal to noise cloud detection threshold for P0
S/N(P2)	4	> 0	Signal to noise cloud detection threshold for P2
ThAlphaFac-tor(%)	80	1 to 100	Cloud detection parameter
ThAl-phaStart(m-1E7)	70 000 000	> 0	Cloud detection threshold for range corrected signals

Table 16: Data evaluation parameters

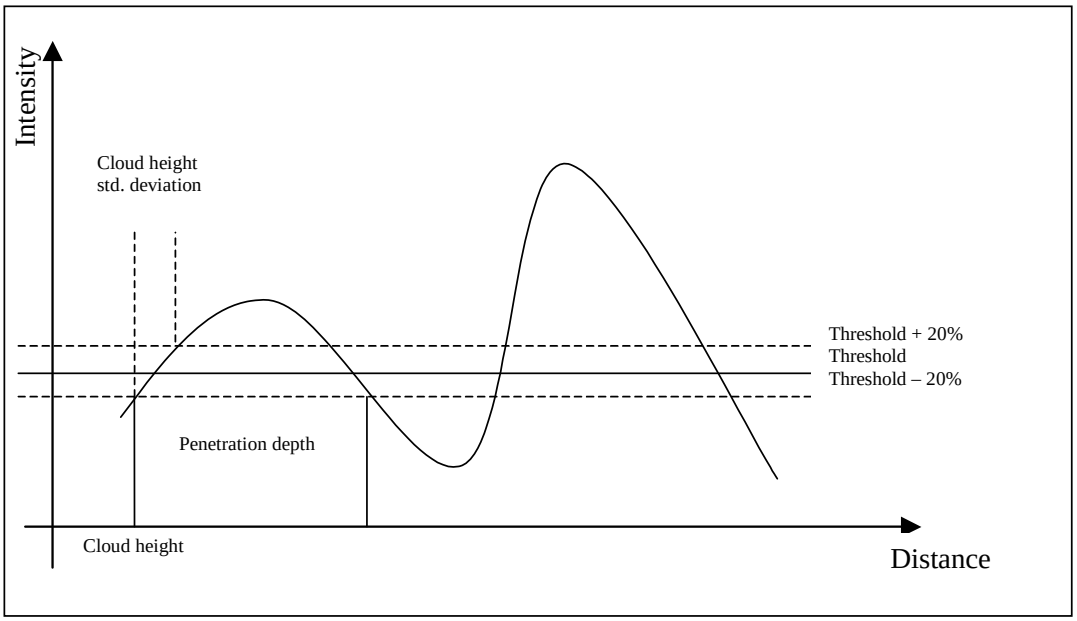

Fig. 12: Evaluation of cloud parameters

10 Cleaning

DANGER

Laser radiation! There is danger of eye injury!
Class 1M laser radiation, if viewed over an extended period of time, may cause damage to the eyes such as glare or irritation or even full loss of eyesight. Do not directly look into the laser beam. Under no circumstances should the laser beam be directly inspected with the help of optical instruments (e.g. field glasses). Make also sure that no items with a reflecting surface (e.g. watches) are placed in the beam path.

Interval	Cleaning	Comment/Aids
Quaterly[1]	Clean glass panels (as shown in Fig. 13)	Liquid commercial glass cleaner, soft non-shedding cloth
As required	Remove sedimentation from space below casing top	Neutral cleaning agents, micro-fibre wipes
As required	Remove potential plant pockets in front of fan inlet grids (rear side)	Keep fan intake area unobstructed, see Fig. 14
As required	Remove snow[2]	Keep fan intake area unobstructed, see Fig. 14

Table 17: Cleaning schedule and cleaning action

1 for average dust load level of 25 µg/m³ in the air

2 as soon as snow reaches the air inlet plane of the fans

Fig. 13: Glass panels

1 Laser outlet
2 Casing top
3 Glass panels

Fig. 14: Fans

11 Maintenance & Service Instructions

NOTE

The CHM 15k Cloud Height Meter requires regular maintenance (at two-year intervals). Maintenance work may not be performed by anyone other than service personnel of JENOPTIK Laser, Optik, Systeme GmbH or specially trained Customer technicians. For detailed instructions on maintenance, you should consult the Service Manual.

If you have questions or if a recommended User Manual procedure fails to fix a particular problem, you are advised to contact your on-site service technician or JENOPTIK Laser, Optik, Systeme GmbH. We shall be glad to assist you in every respect.

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NOTE

For other detailed information which is in excess of this User Manual (maintenance, replacement and system assembly particulars), you should refer to the Service Manual. The Service Manual is only available to JENOPTIK Laser, Optik, Systeme GmbH personnel or specially trained technicians who have a documented proof of qualification (valid certificate) to handle respective maintenance and service work responsibilities.

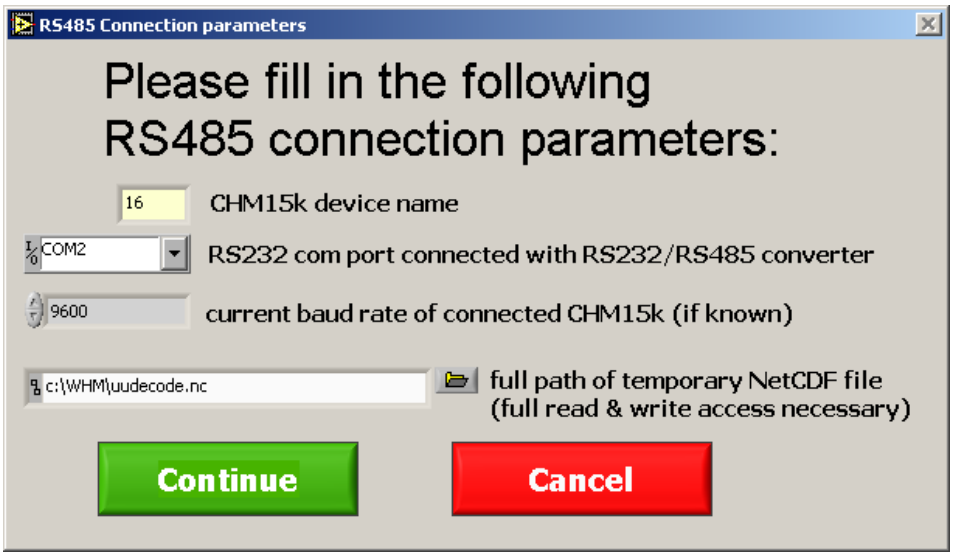
12 JO-DataClient - Terminal software for CHM15k

12.1 Introduction

The main purpose of the Terminal program JO-DataClient is receiving data telegrams from CHM15k via RS485 connection line and displaying these data. Moreover, it can also be used for remote maintenance and diagnosis of connected CHM15k devices. Especially for these tasks there are basic commands for reading CHM15k system parameters, and with some restrictions also writing these parameters. This is based on the CHM15k command structure, described in chapter 8 of the User Manual. Finally, JO-DataClient provides an update procedure for CHM15k software components “JO-Main.exe” and “JO-CloVisCHM.exe” without interruption of normal measurement operation mode.

12.1.1 Menus and Commands

Immediately after start the following dialog appears.

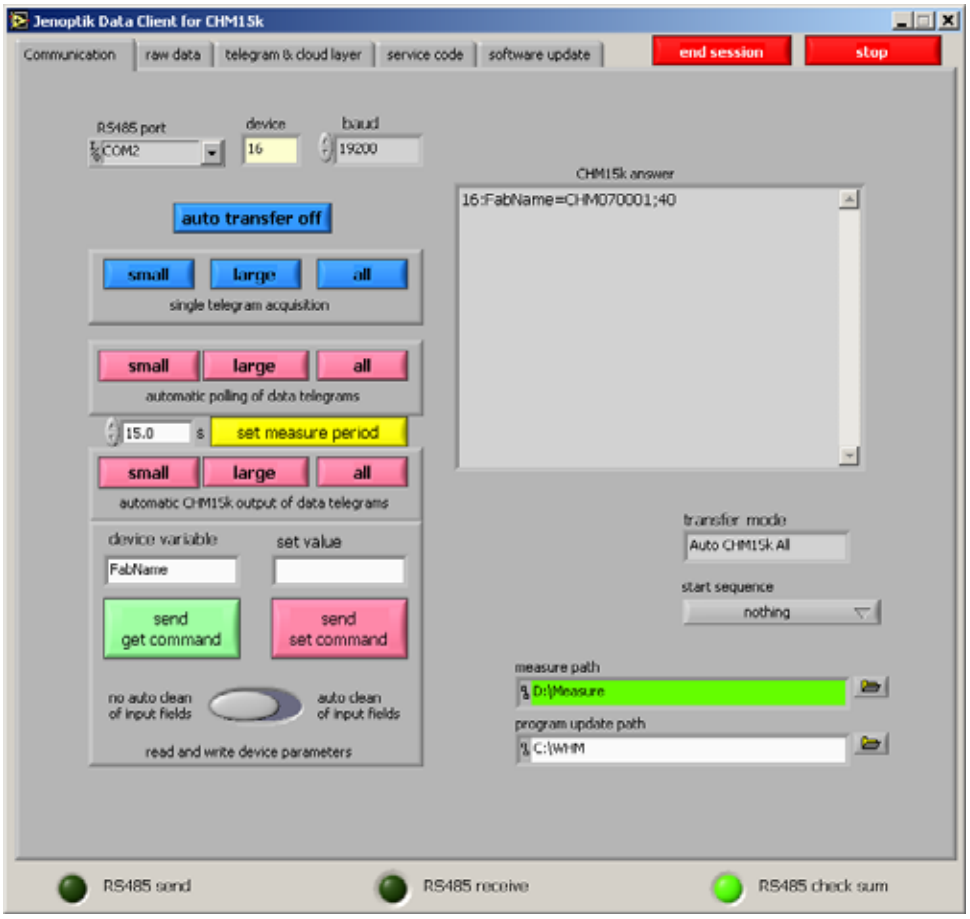


The four input fields on the left side should be filled with appropriate values. If the current baud rate of the connected CHM15k is unknown, then use the value “9600”, in case of false connection speed the CHM15k will automatically set speed 9600 for itself after 30 seconds.

With “Cancel” the program terminates.

With “Continue” the program will enter normal operation mode with five pages, which are explained in the following sections.

12.1.2 Communication



This is the main page where all actions (except Software update) are carried out. Remaining four pages serve merely the monitoring of the measuring data as well as service information.

All control elements are placed on the left side of the page. Responses of the CHM15k can be read unfiltered in the display box "CHM15k answer". The raw data part of raw data telegrams is not displayed here, because these data would be too much for this box.

Details of control elements. The top row encloses the interface parameters:

- RS485 port:: Here the RS232 port which is connected to the RS232-485 adaptor is displayed. It can only be changed by the initial dialog (see above).
- device:
- The name of the connected CHM15k device.
- baud: With this electoral switch the baud rates 1200, 2400, 4800, 9600, 19600 or 38400 bauds can be selected. Note, that the factory default value is 9600 baud.

Below there is a button named “auto transfer off”. Pressing this button means, that all previous automatic transfer modes will be cancelled.

The next block contains three buttons for single telegram acquisitions:

- small: The standard data telegram is requested, see user guide, section 8.2.2.
- large: The advanced data telegram is requested, see user guide, section 8.2.3.
- all: The raw data telegram is requested, see user guide, section 8.2.4.

The next block contains three buttons for automatic polling of data telegrams.

Below there is an input field for the internal measure period (in seconds) of the CHM15k. The associated button must be pressed, if this value should go into effect for the CHM15k device. Nevertheless, this value is also used as the time between automatic polling mode acquisitions described in the previous paragraph, and changes of the value in this sense are applied **without** pressing the button “set measure period”!

The next block contains three buttons for automatic telegram output, initiated by the CHM15k itself, i.e., not by polling.

Remark: All six automatic telegram modes will be cancelled by pressing the button “auto transfer off”, or also by acquisition of one of the three single telegrams.

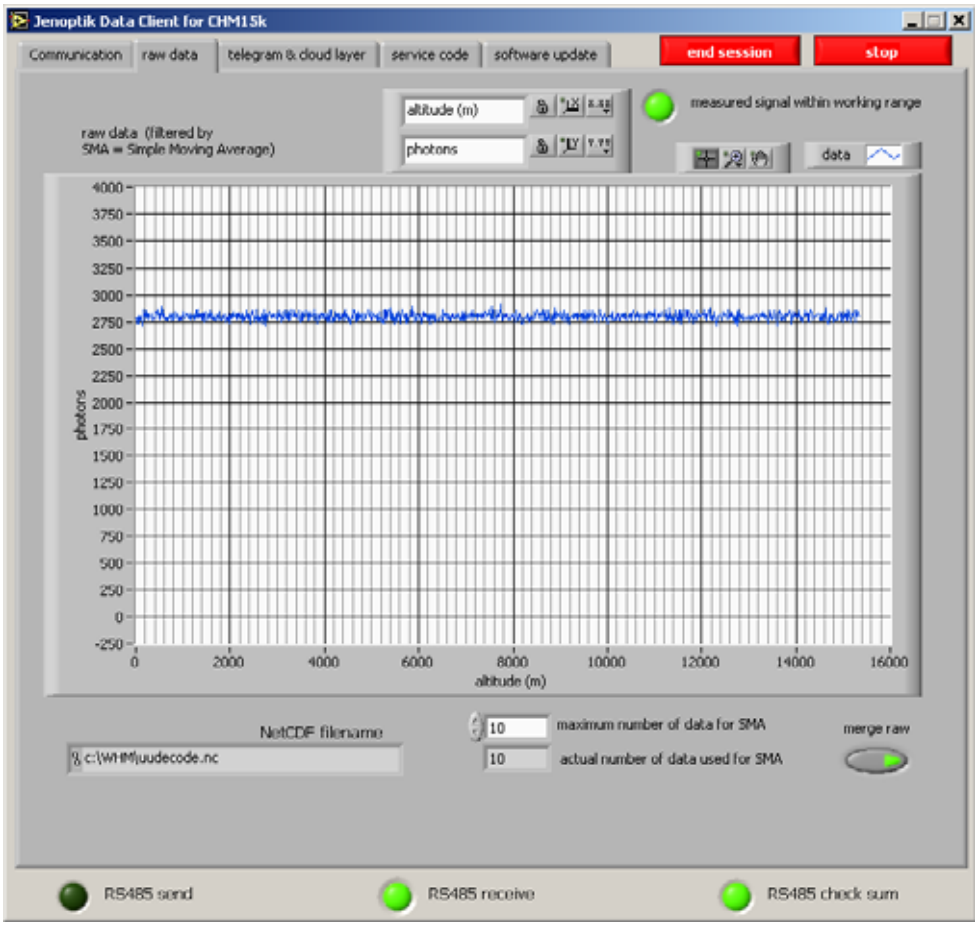
Now a block follows for reading and writing internal CHM15k parameters:

- device variable: Here the name of the concerning CHM15 parameter has to be specified. A summary of these parameters can be find in the user guide, tables 4 and 16.
- set value: Value for the “send set command”.
- send get command: The current value of the parameter is displayed in the box “CHM15k answer” on the right side.
- send set command: Value "set value" is transmitted to the CHM15k. Provided that the suitable parameter is really alterable and is in the permissible range, the successful parameter update will be acknowledged in the box “CHM15k answer”. If one of these restrictions is violated, there is no acknowledgement and the parameter is not changed. For safety reasons some of the parameters are alterable only in the service mode, see user guide, section 8.6.
- switch “auto clean of input fields”: If activated, the two input fields “device variable” and “set value” will be erased after each set or get command

Finally another two paths are adjustable which concern local paths of the computer, where JO-DataClient runs:

- measure path: In this directory the telegram messages of CHM15k will be saved in subdirectory structure, which depends on device name and date, for later evaluations.
- program update path: If a software update has to be carried out (see last page) this path must contain the new program files to be transmitted. This path is to be set here only in the case, if during a running update process JO-DataClient is terminated and is newly started later again. In the latter case the update directory has to be customized immediately after the restart.

12.1.3 Raw Data

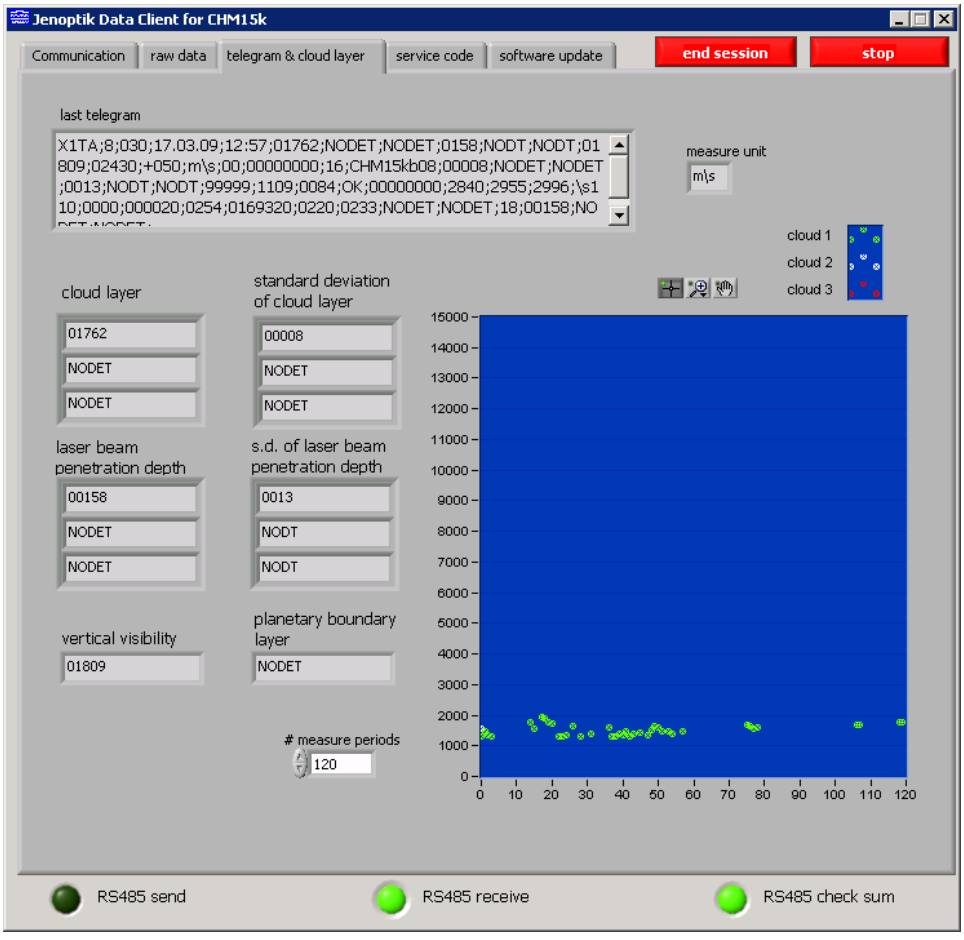


In the graph shown here the raw data of the last transmitted raw data telegrams are grasped. In fact, a simple moving average (SMA) filter is applied on the last 10 raw data telegrams, this number 10 is changeable in the input field “maximum number of data for SMA ”. If the value 1 is set in this field, the raw data of the last received raw data telegram are displayed in the graph. The field “actual number of data used for SMA” contains the number of raw data records used for SMA calculation - without change of parameter “maximum number of data for SMA” this value should grow with succeeding telegrams up to 10.

The signal light “measured signal within working range“ shows whether the data are suitable for cloud height calculation. During the start phase of the CHM15k this light is possibly still red, nevertheless, after a run time of about four minutes it should change to green, which indicates correct operation mode of the detector.

“NetCDF filename” specifies the entire local path of the last transmitted raw data telegram, this file is overwritten every time a raw data telegram is received. A sequential acquisition of these NetCDF raw data is possible by setting on the switch "Merge Raw".

12.1.4 Telegram & Cloud layer

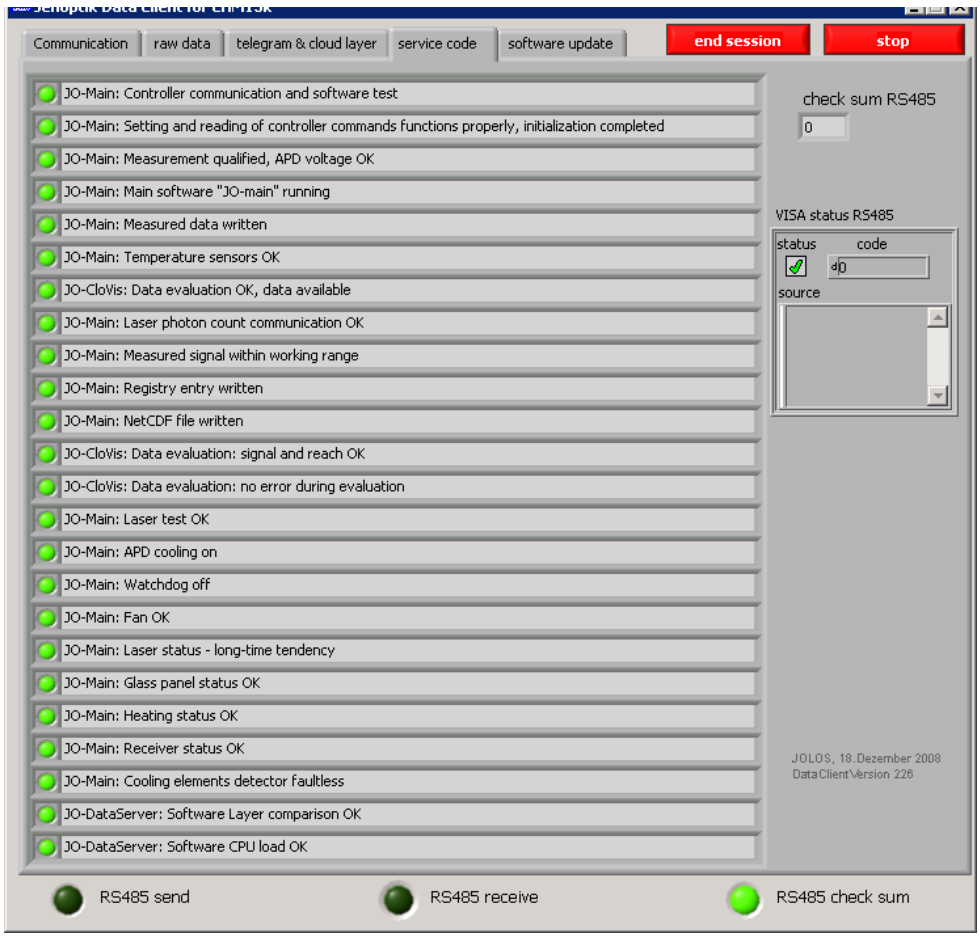


All types of telegrams contain up to three cloud layer an associated laser beam penetration depths; in the advanced and raw data telegrams also the standard deviations of these values. All these values are displayed on the left side of this page, together with the last received telegram message. At the bottom there is also a line displaying the vertical visibility and the planetary boundary layer.

The right side shows the course of cloud heights over the last 120 telegrams.

In the above example we see two recognized cloud layer, hence the field for the third cloud layer is marked with NODET or NODT, short form for "not detected". The first cloud layer is at a height of 765 meters with a penetration depth of 105 meters, the second layer at a height of 4,980 meters and a penetration depth of 285 meters. The vertical visibility is 1,880 meters and the planetary boundary layer is located at 8760 meter

12.1.5 Service Code



Each telegram message contains a service code field: In the standard telegram it consists of 8 bit, in all other telegrams of 32 bit. On this page these service code bits are listed clearly by their meaning. Moreover, a green signal light shows the proper operation of the suitable function. During the start phase of CHM15k some of these signals lights maybe still dark. However, after some minutes the CHM15k should enter normal operation mode with all lights on. Disabled lights can be hints for trouble-shooting.

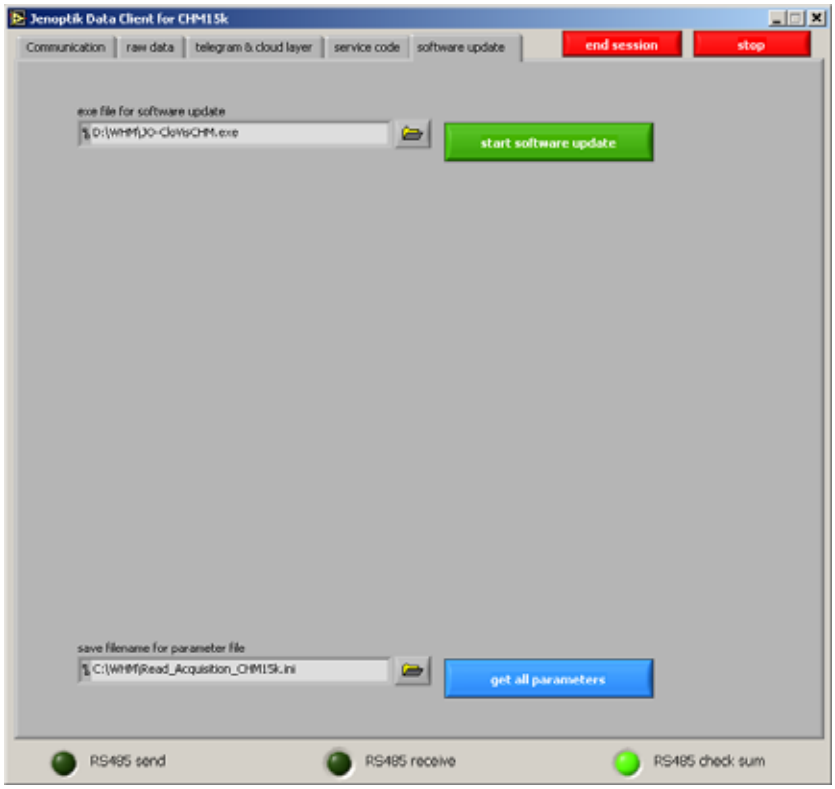
Every received message from CHM15k (telegrams & set/get command answers) contains a gibberish total in terms of two's complement. Transmission is checked by this gibberish total, proper transmission is indicated by value zero in the field "check sum RS485". Non-zero values indicates transmission problems, cables and transformers must be checked carefully (proper grounding, termination and pull up/pull down resistors etc.) and/or the transmission speed should be lowered (see field "baud" in section 2.1).

12.1.6 Software Update

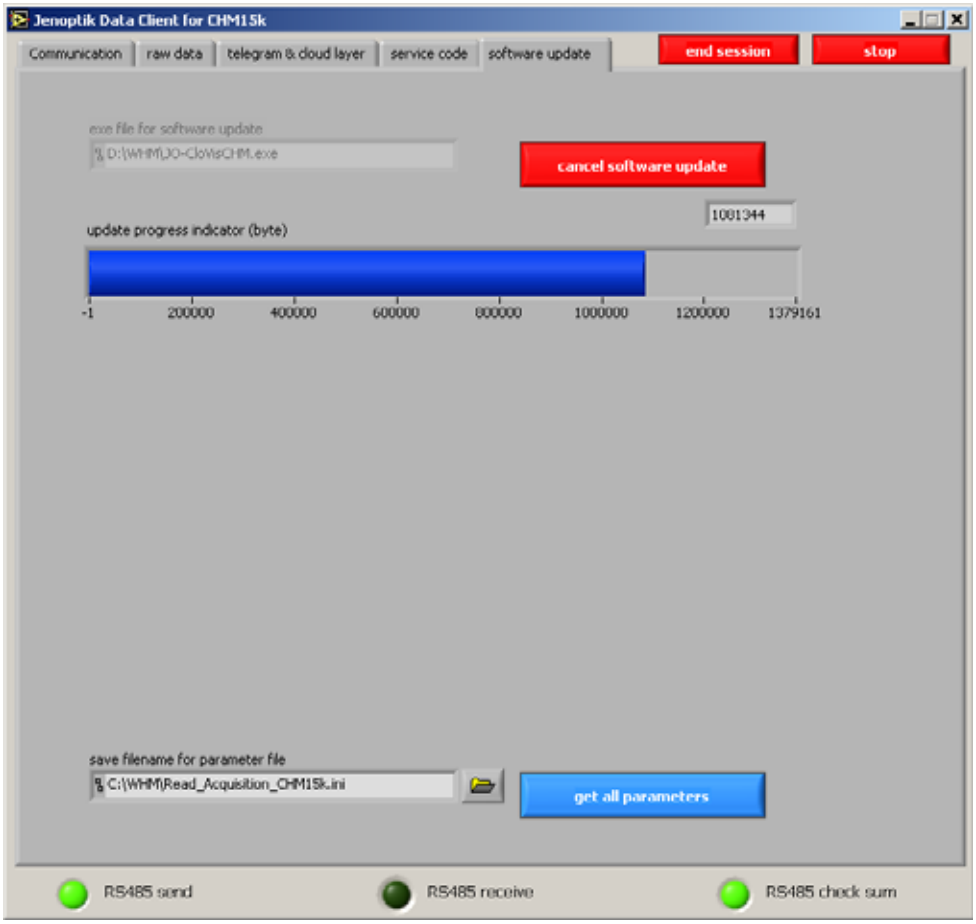
JO-DataClient contains an update function for two main components of the internal CHM15k software:

- JO-Main.exe: software for controlling the hardware & saving raw data
- JO-CloVisCHM.exe:
- calculation of cloud layer, laser beam penetration depths, vertical visibility and planetary boundary layer

Update transmissions to the CHM15k take place interlocked with automatic telegram transmissions. More precisely, an update transmission consists of a data block which is sent to CHM15k immediately after receiving a telegram from CHM15k. Of course, this procedure seems more useful in the automatic telegram modes than in polling mode.



First, a file must be chosen in the field "exe file for software update". After pressing the (green) button "start software update" the update transmission to the CHM15k starts.



This image shows a snapshot of the update process for JO-CloVisCHM.exe. 1,081,344 of a total of 1,379,161 bytes were already transmitted.

During the whole time of the update process (which may last for hours) the regular operation of the CHM15k is not impaired. Moreover, a temporary shutdown of the CHM15k as well as of JO-DataClient does not interrupt a running update – when both components run again, a discontinued update process will be resumed. Finally, a running update can be cancelled only by pressing the (red) button “cancel software update”.

Only if all data blocks of the update were transmitted successfully, the old program file “JO-CloVisCHM.exe” is replaced by the new one. Normally this replacement should take no longer as one minute, so that only for this time interval no current data telegram are calculated. The successful end of the update process can be noticed within JO-DataClient by disappearing of the red cancel button and reappearing of the green start button.

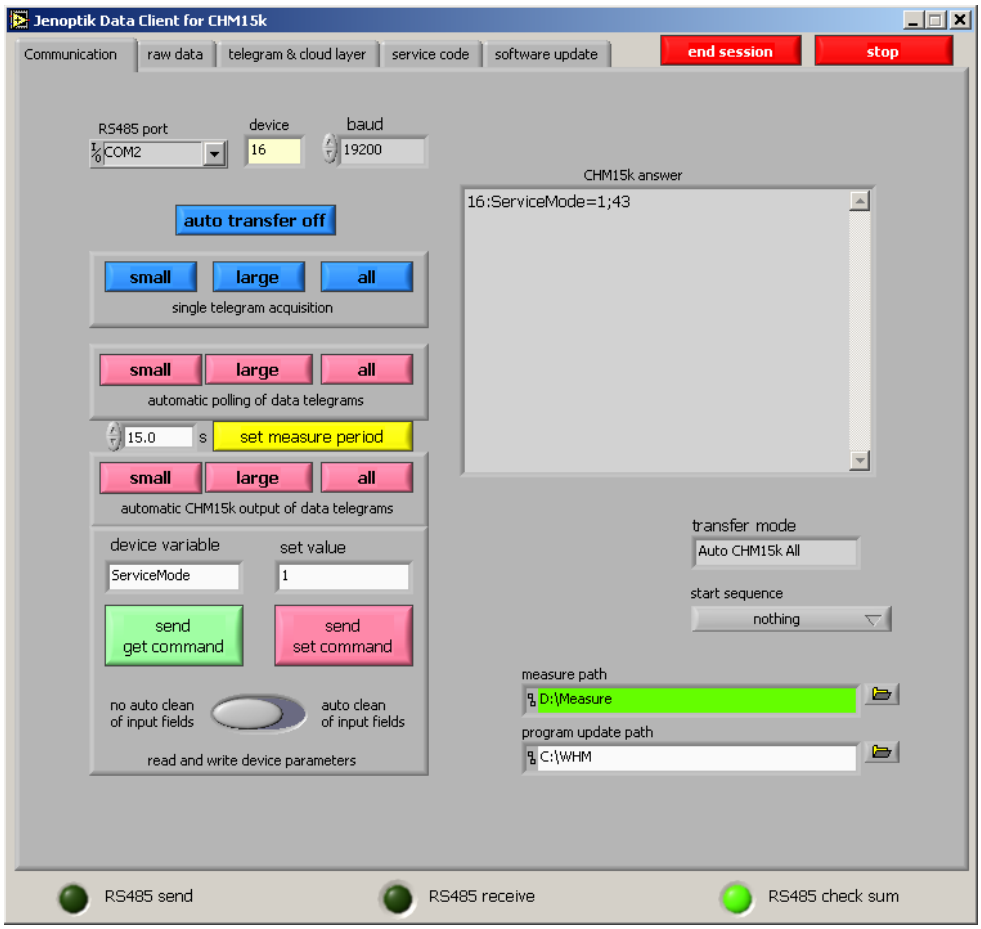
Acceleration of the update:

Default setting for the update block size is 2,048 byte, this amount of update data will be transmitted following every received telegram. With 30 seconds of

measure period and approx. 2 MByte program file a whole update process consist of approx. 1000 blocks and therefore lasts more than 8 hours! However, the update block size can be raised with the variable **UpdateBlockSize** up to and including a value of 32,768 byte, this parameter can be changed by the set command from section 2.1. However, it must be clearly warned that a single block transmission of 32,768 byte lasts about 12 seconds at transmission speed 38400 baud. So one has to think (and calculate) carefully about possible combinations of measure period, raw telegram mode and update block size before changing this parameter – at current time there is no lock in JO-DataClient to prevent users from choosing dangerous parameter combinations!

Important Remark:

Update operation is only permitted in ServiceMode. Therefore this service mode must be initiated before starting the update:



There is an additional button “get all parameters” on this page (not related to software update) for this purpose:

All parameters of the CHM15k will be saved into the local text “file save filename for parameter file”.

12.1.7 General available controls or indicators

At the bottom line of the window there are three light indicators:

- RS485 send: Normally this light should only blink for a short moment, while sending commands. An exception is a running software update, where large blocks of data will be sent to the CHM15k, in this case this light shines for some seconds.
- RS485 receive: This light shines while receiving data from CHM15k. During this period send actions (like set/get variables) must not be done because there is only a half-duplex RS485 connection to the CHM15, so simultaneous sending and receiving is not possible.
- RS485 check sum: Each answer of CHM15k (telegram or set/get command confirmation) is closed by two checksum bytes (complement of two). The result of check is indicated by this light: green - ok / red - failure.

There are two buttons in the upper right corner of the program window:

"end session": The current session is finished, and the very first start dialog (with RS 485 connection parameters) appears again. Now possibly changed connection values should be filled in and another session can start.

"stop": The program terminates.

12.2 Command line parameters

JO-DataClient can be invoked with one ore more of the following command line parameters:

- **–baud <index>**:
  Possible values of <index> can be 0 (1200 baud), 1 (2400 baud), 2 (4800 baud) , 3 (9600 baud, default) , 4 (19200 baud) , 5 (38400 baud) , 6 (57600 baud) or 7 (115200 baud).
- **–com <port>**:
  Usually <port> is one of the serial ports ASRL1::INSTR (default), ASRL2::INSTR, and so on. Depending on the Labview environment on the host PC, the alternative names COM1, COM2 may be available too.
- **–device <number>**:
  The default <number> is 16, suitable for the factory default device number of a CHM15k.
- **–measurepath <path>**:
  <path> specifies the main directory of locally saved raw data telegrams (NetCDF). Default <path> is D:\Measure
- **–ncpath <filename>**:
  <filename> specifies the full qualified filename (i.e. including path) of a required temporary NetCDF file for the decoding of raw data telegrams.

Therefore the user must have read and write access to this path. Default <filename> is C:\WHM\uudecode.nc

- **–utcupdaterate <hours>**:
  Any positive value means that the internal CHM PC clock is synchronized with the client PC clock (converted to UTC) every <hour> hours. Default value for <hour> is 0, i.e., no synchronization is done.

Changing these parameters via command line affects the input fields of the start dialog (see Chapter 2). Moreover, by setting appropriate values for these parameters the start dialog can be skipped by the additional command line parameter **-nostartdialog**.

Example:

JO-DataClient –com ASRL2::INSTR –baud 5 –ncpath D:\uudecode.nc –utcupdaterate 24 –nostartdialog

(without linebreak!)

It is important that the current internal baud rate of the CHM15k (set in previous sessions) must coincide with the baud rate in this command line, in this example value 5 means 38400 baud. Otherwise connection failures can occur, see Chapter 2 (start dialog). In this example the CHM PC clock is synchronized once a day.

A Annex - Service Manual Contents

B Annex - Example for querying a complete parameter list

To get a complete list of parameters you must type:

get <Device>:Parameters<CR><LF>

The format structure is as following:

<STX><get <Device>:Parameters=<ParameterName1>:<TABS><ParameterValue1>
<ParameterName2>:<TABS><ParameterValue2> …
<ParameterNameN>:<TABS><ParameterValueN><CR><LF><EOT>

<RS> is the ASCII character "Record Separator" (HEX 1E), and <TABS> stands for one or more tab characters (HEX 09). Changing the characters after receiving <LF> or <CR><LF> a clearly arranged list of all system parameters are generated. The number of tabs are chosen in a way that with a standard tabulator grid of 8 characters the names of variables and its values are well aligned in two columns.

Example:

<STX>get 16	Parameters=
Altitude(m):	50
APD:	ASRL2::INSTR
APDBreakdown:	400
Baud:	5
BaudAfterError:	3
Calibrationfactor1:	100
Calibrationfactor2:	100
Calibrationfactor3:	100
Calibrationfactor4:	10
CloudsTimeOut(s):	300
CorrectBaseline:	1
DataServerVersion:	202
DatFile:	1
DeviceName:	16
dR(m):	15
dt(s):	15
EndOffset(m):	15300
EndOfP0(m):	2100
EndOfP1(m):	5000
FabName:	CHM15kb05
HVGAP:	139

Example parameter list

IgnoreChars:	06<CR><LF><EOT>
Institution:	JOLOS
IntegralLimitforFog:	70000
IntegralLimitforRain:	2000
Laser:	0
LASERPORT:	ASRL3::INSTR
LaserPower:	50
Latitude:	12000000
Lifetime(h):	4712
Location:	Teltow
LogbookPath:	d:\Logbook
LogFile:	0
Longitude:	51000000
MaxCrossTalkChars:	5
MeasurePath:	d:\Measure
MinCloud(m):	30
MinCloudWidth(m):	45
MinDistbetwClouds(m):	105
MultiplierP0(s):	1
Offset(m):	15
ProgramPath:	c:\WHM
Range(bins):	1024
RangeSmoothP0(m):	45
RangeSmoothP2(m):	60
RLS:	ASRL4::INSTR
RS485:	ASRL1::INSTR
S/N(P0):	20
S/N(P2):	4
S/N(PBL):	8
ServiceMode:	1
SetHV:	1
SetPeltier:	1
SignalCheck:	1
StartOffset(m):	14500
SystemLifetime(h):	8399
TempCo:	220
Tempoffset:	0
TempPath:	c:\Temp
ThAlphaFactor(%):	80
ThAlphaStart(m-1E7):	70000000
TimeOutRS485:	48
TimeSmoothP2(s):	300

Example parameter list

TimeSmoothPBL(s):	600
TimeSmoothVIS(s):	600
TransferMode:	0
TransferModeAfterError:	1
Unit(m/ft):	m
UpdateBlockSize:	32768
UseAltitude:	0
VerAlg:	0870
VerCont:	2337
VerMain:	139
WaveLength(nm):	1064

Example parameter list

C Annex - Software Version

This manual corresponds to the following software versions:

Software	Release	Published
JO-Main	1.39	6th June 2007
JO-DataServer	2.02	27th March 2007
JO- CloVisCHM	8.70	8th June 2007

Notes on pre versions (history):

Following essential modifications in obverse of pre versions has been carried out:

JO-Main (all previous versions):

- Measuring data (variable beta_raw) are saved as float (single) instead of integer. For better presentation the measuring data are saved as S/N values. The "Noise" values are saved with the new variable "stddev" to allow a back-calculating
- a couple of minor error correction

JO-CloVisCHM (version 8.68)

- detection algorithm of boundary layer height is optimized

JO-CloVisCHM (previous versions to 8.68)

- changes in the evaluation algorithm, for reducing cloud dection errors on lower altitude ranges
- adjustment of readin routine for measuring data

JENOPTIK Laser, Optik, Systeme GmbH · 07739 Jena · Germany

EG-Konformitätserklärung
EC Declaration of Conformity

Hiermit erklären wir, vertreten durch die Unterzeichner, dass das nachfolgend bezeichnete Produkt
We herewith declare, represented by the signatories, that the following designated product

Wolkenhöhenmessgerät
Cloud Height Meter

CHM 15k

der Niederspannungsrichtlinie 2006/95/EG und der EMV - Richtlinie 2004/108/EG entspricht.
agree with the Low Voltage Directive 2006/95/EC and the Directive of Electromagnetic Compatibility 2004/108/EC.

Folgende harmonisierte Normen wurden berücksichtigt:
The following harmonized standards were considered:

EN 61010-1:2001	Sicherheitsbestimmungen für elektrische Mess-, Steuer-, Regel- und Laborgeräte – Teil 1: Allgemeine Anforderungen / *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 1: General requirements*
EN 61326-1:2006	Elektrische Mess-, Steuer-, Regel- und Laborgeräte - EMV-Anforderungen - Teil 1: Allgemeine Anforderungen / *Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements*
EN 60825-1:+A1+A2:2002	Sicherheit von Laser-Einrichtungen - Teil 1: Klassifizierung von Anlagen, Anforderungen und Benutzer-Richtlinien / *Safety of laser products - Part 1: Equipment classification, requirements and user's guide*

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