V 1.0   2009-02-27

CL31 MLH User's Guide 3.0

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1. Program structure

The CL31 MLH PC software consists of the following software modules:

CL31 MH control.exe

cl31_mh.exe

MCRInstaller.exe

CL31 MH control.exe

This Vaisala Visual C++ program is the user interface for handling mixing layer height (MHL) calculation and data management. It creates text message files telling the Matlab routine cl31_mh.exe what data files (generated by CL-VIEW) to examine with what parameters.

During startup it reads the parameters that were saved at last program termination.

It also starts cl31_mh.exe automatically (must be in same folder!).

cl31_mh.exe

This compiled Vaisala MATLAB program processes the text message files created by CL31 MH control.exe.

cl31_mh.exe is delivered with the file cl31_mh.ctf. Both cl31_mh.exe and cl31_mh.ctf have to be in the same folder as CL31 MH control.exe.

cl31_mh.exe can only run if the MATLAB component runtime (MCR) has been installed on the computer using MCRInstaller.exe.

MCRInstaller.exe

MATLAB component runtime (MCR) has to be installed prior to running cl31_mh.exe.

The file MCR_documentation.pdf explains the installation process.

2. Installation

MCRInstaller

Run the utility program MCRInstaller.exe that is delivered with the software package.

Follow the instructions given on the screen or consult the manual MCR_documentation.pdf delivered with the software package.

NOTE:

Vaisala does not provide any troubleshooting for this MATLAB utility.

CL31 MH control.exe and cl31_mh.exe

Create a new folder, for example C:\MLH_Software.

Copy the files
CL31 MH control.exe
cl31_mh.exe
cl31_mh.ctf
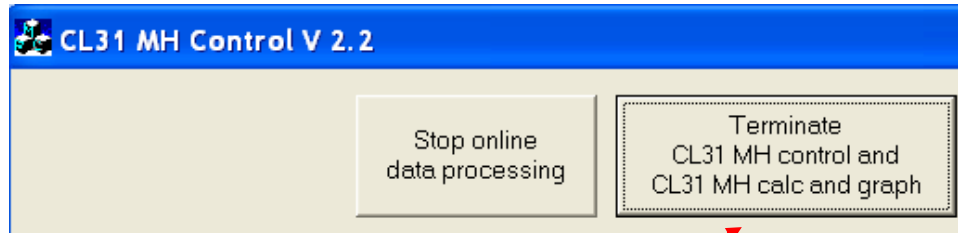delivered with the software package to the new folder.

3. Starting and exiting the CL31 MLH software

Start

Double-click CL31 MH control.exe.

Exit

Click the Pushbutton "Terminate CL31 MH control...".

A "Quit CL31 MH control?" message box appears.
Click the Pushbutton "Yes".
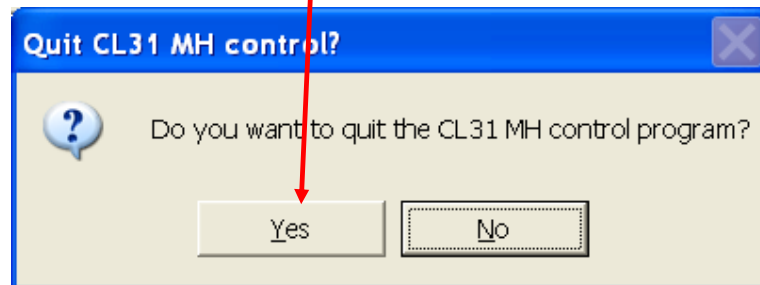
The current program settings are automatically saved to the file
"CL31 MH control.cnf" and the program execution is terminated.

4. Operating the CL31 MLH software

Online mode

After program start CL31 MH Control operates in online data processing mode.

At the first program start when no settings file "CL31 MH control.cnf" exists, the software uses its default settings. A message box is created informing about the missing setting file.
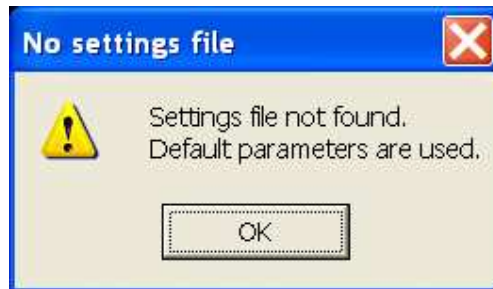
Click the OK pushbutton to confirm default parameter choice.

The following screen gives the default settings.

Possible changes to these recommended settings are explained later in this section.

CL31 MH control automatically starts cl31_mh.exe.

If MATLAB component runtime had been installed correctly, a black DOS screen like the one below appears. Otherwise cl31_mh.exe exits immediately.

If the DAT files directory (C:\Example_Data in the default settings) contains valid CL31 profile data collected by CL-VIEW, online processing produces the requested MATLAB figures and files described below.

The contents of the DAT files directory should look like this:

The first letter of each DAT file name is the CL-VIEW log letter that has to be entered in the appropriate field of CL31 MH control.
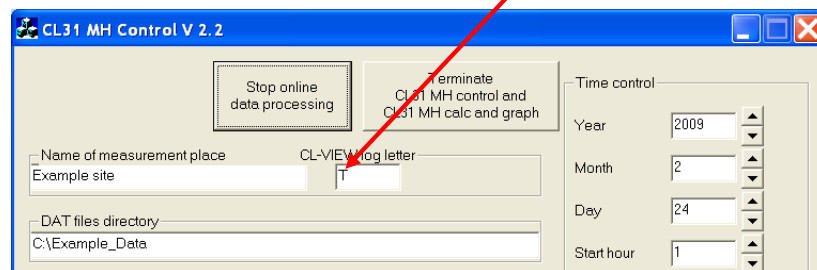
A DAT file looks like this (cp. CL-VIEW user's guide):

```
-Ceilometer Logfile
-File created: 24.02.2009 12:00:00
-2009-02-24 12:00:08
⌐CL017121⌐
0W ///// ///// ///// 000004002080
  0 ///  0 ///  0 ///  0 ///  0 ///
00100 10 0770 101 +27 100 11 0005 L0016HN15 007
00043000430004200040000440003f000400003d0004000042
└a53a┘

-2009-02-24 12:00:24
⌐CL017121⌐
0W ///// ///// ///// 000004002080
  0 ///  0 ///  0 ///  0 ///  0 ///
00100 10 0770 101 +27 100 11 0004 L0016HN15 007
0004b00044000420004000044000400004000003e0004100043
└7da1┘

-2009-02-24 12:00:40
⌐CL017121⌐
0W ///// ///// ///// 000004002080
  0 ///  0 ///  0 ///  0 ///  0 ///
00100 10 0770 100 +27 100 11 0004 L0016HN15 006
00046000410004000040000460004200042000003f0004200044
└d4cf┘
```

In online mode cl31_mh produces MATLAB figures containing text and density graphs, as well as text files containing mixing layer and cloud base heights, and PNG-graphic files. Some examples:
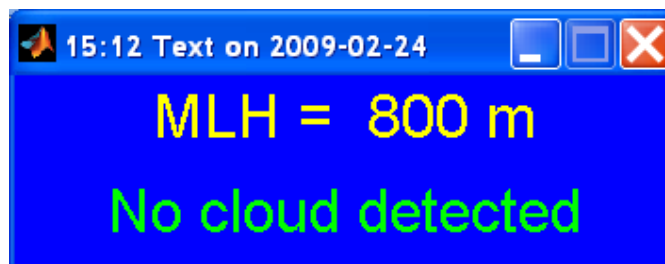
Text figure on screen

```
24/02/2009 09:15  130    0
24/02/2009 09:30  140    0
24/02/2009 09:45  170  280
24/02/2009 10:00  170  270
24/02/2009 10:15  340    0
24/02/2009 10:30  290    0
24/02/2009 10:45  540  440
24/02/2009 11:00  540    0
```

A part of the MLH and cloud base text file 200902240909.txt
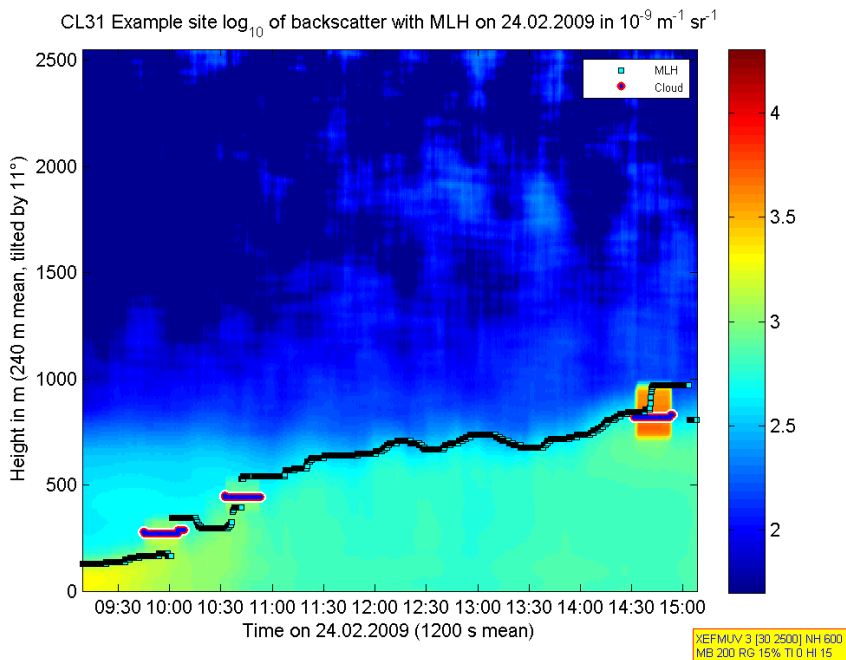
Backscatter density plot d200902240909.PNG
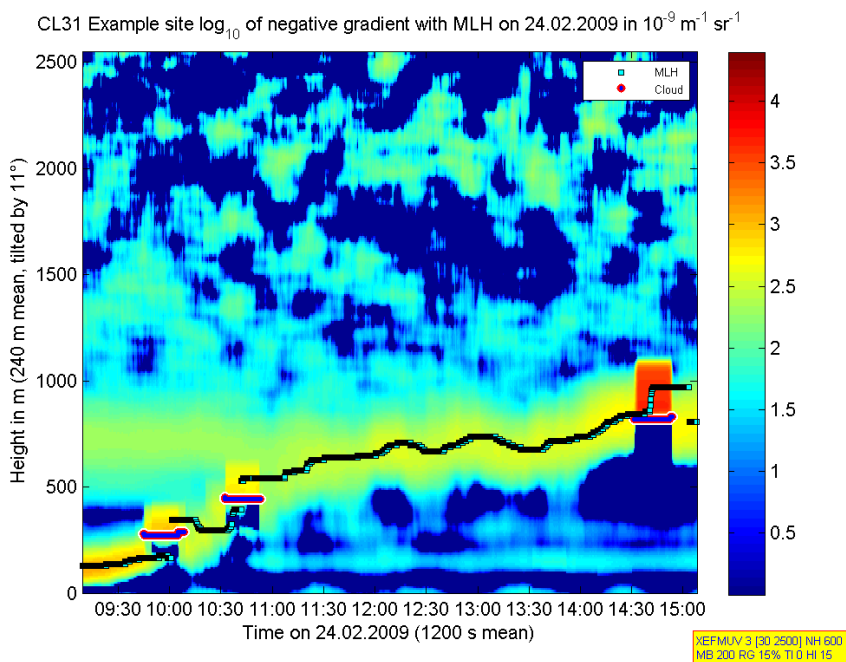
Negative gradient plot g200902240909.PNG

Offline mode

A click on the "Stop online data processing" pushbutton switches CL31 MH control mode to offline. This enables processing of historical data.
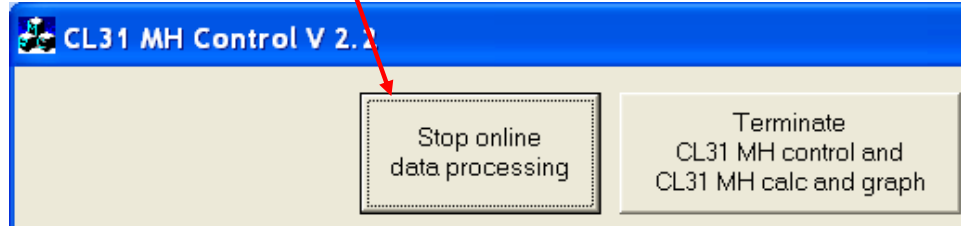
In offline mode a click on the "Offline data processing..." pushbutton starts data processing using the current parameters.

"Start online data processing" switches back to online mode.
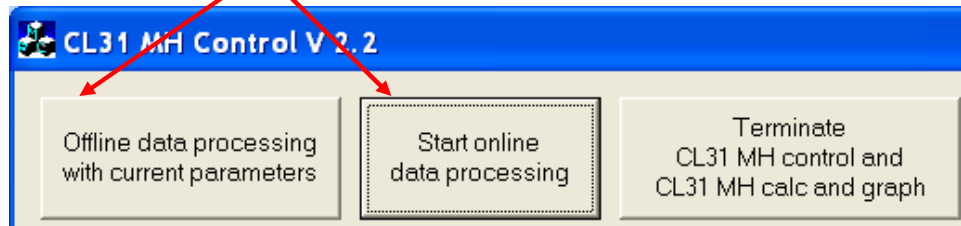
Settings

This section describes possible settings of CL31 MH control and their effect on MLH calculation.

Name of measurement place

The text entered here is displayed on all density graphs.

CL-VIEW log letter

First letter of the DAT files to be processed. CL-VIEW settings determine this letter.
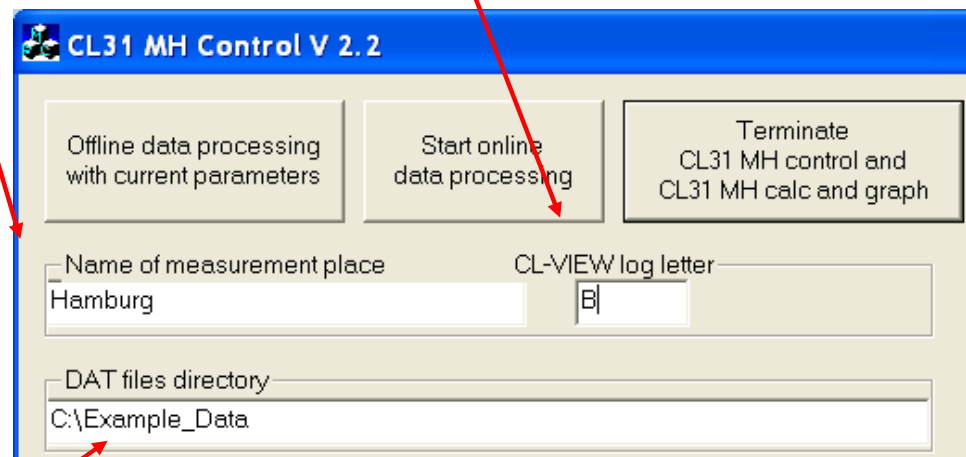
DAT files directory

Path to the folder containing the DAT files to be processed. CL-VIEW settings determine this path.

Paths may contain blanks and may lead to another computer on the network, for example \\ham-cm_2006\network test data.

MH text directory

Path to the folder containing the mixing layer and cloud base height text files generated by cl31_mh.exe.

The format of these text files is discussed below in the 'Extras' section.

```
┌─DAT files directory────────────────────────────────┐
│ \\ham-cm_2006\network test data                     │
└─────────────────────────────────────────────────────┘
┌─MH text directory──────────────────────────────────┐
│ \\ham-cm_2006\network test data\mixing layer height test data │
└─────────────────────────────────────────────────────┘
┌─Plots directory────────────────────────────────────┐
│ H:\Hamburg\New Plots                                 │
└─────────────────────────────────────────────────────┘
```

Plots directory

Path to the folder containing all directories with PNG graphic hardcopy files of the MATLAB graphic figures shown on the screen.

Directory structure and graphics layout is discussed below in the 'Extras' section.

Radiosonde data directory

Path to the folder containing radiosonde text data retrieved from the web site of the University of Wyoming http://weather.uwyo.edu/upperair/sounding.html.

Use Text: List and name the data files RYYYYMM.txt (e.g. R200810 for October 2008).

```
┌─Plots directory────────────────────────────────────┐
│ H:\Helsinki\New Plots                                │
└─────────────────────────────────────────────────────┘
┌─Radiosonde data directory──────────────────────────┐
│ C:\Helsinki\Soundings              Ahead of UTC [2 ▲▼] h │
└─────────────────────────────────────────────────────┘
```

Radiosonde data plot activation is described in the 'Extras' section.

Ahead of UTC

For correct radiosonde data plotting enter here the difference between the time zone of the computer running the CL-VIEW program that is logging the DAT files and UTC.

Example: Helsinki, Finland in winter time is 2 h ahead of UTC, so 2 should be entered here for this case.

Time control

Enter here start and end time of the time interval that shall be processed with cl31_mh in offline mode.

The largest time interval possible to process is 24 h.

Processing time with a standard desktop PC (2 GHz) is typically around 10 s for the example time interval if 16 s report interval is configured in the CL31.

Evaluation of a whole day takes about 1 minute.

The recommended minimum time interval to be processed is 2 h.

Averaging options

Averaging options can be adjusted in the middle right part of the CL31 MH control screen. Time and height averaging reduces MLH detection errors caused by signal noise.

Time(s)

Regardless of the CL31 report interval sliding profile time averaging is done using the value entered here.

Limits are from 15 s to 3600 s; a recommended value is 1200 s.

Height (m)

CL31 profile height resolution standard value is 10 m.

Values for height averaging that can be entered in this field range from 30 m to 600 m; a recommended value is 240 m.

If 30 m is used as height averaging value, the value plotted for height h is the average of the signal in h - 10 m, h, h + 10 m.

If the height averaging parameter chosen increases 80 m, smaller averaging parameters are used in the near range:

> 0 ... 200 m take 80 m average
>
> 210 ... 300 m take 100 m average
>
> 310 ... 400 m take 120 m average
>
> 410 ... 500 m take 140 m average
>
> 510 ... 600 m take 160 m average

and so on until the height averaging parameter is reached.

Example: height averaging parameter is 150 m
→ finer averaging is performed up to 500 m height

Norm height

Above this value (in m), increased time and/or height averaging can be initiated.

The recommended value in this field is 600.

Time Inc. (%)

Above norm height, the time averaging value entered in the top field of averaging options is continuously raised by this percentage every 600 m.

Example: 15 %, norm height = 1000 m → time averaging interval is 15 % higher in 1600 m height and 30 % higher in 2200 m height.

The recommended value in this field is 0.

HI

Above norm height, height averaging for gradient determination is increased by this percentage in the same way as described in the previous section.

The recommended value in this field is 15.

NOTE:

HI is only used for gradient determination; there is no effect on the density plots.

Density plot limits

When density plot scale is not logarithmic (see section Extras), the values entered in the middle left part of the CL31 MLH control screen determine the lower (blue) and upper (red) limit of the color scale in the density plots.

Height options

This section defines the lower and upper limit for mixing layer height determination and the upper height limit of the density plot in m.

Recommended values are given in the above figure.

Min MH can be chosen between 30 m and 500 m.
Max MH can be chosen between 400 m and 5000 m.
Max display height range is from 100 m to 5000 m.

Local minima parameters

Parameters affecting the calculation of local gradient minima and mixing layer height are entered here.

Min backscatter

gives the minimum backscatter that is accepted at a local gradient minimum to make it a candidate for MLH.

$200*10^{-9}$ m^{-1} sr^{-1} is the recommended value in this field.

Relative gradient

This percentage determines the threshold for a local gradient minimum to be reported as MLH. The backscatter amount change in the vicinity of the possible MLH has to exceed this percentage of the mean backscatter value between 0 m and 1000 m. This procedure accounts for the fact that in a clear atmosphere gradient minima marking the top of the mixed layer are usually much less extinct than those in a hazy condition.

15% is a recommended value.

Extras (center bottom part of the screen)

Option Box

The capital letters entered here change performance of the MLH algorithm and layout of the graphics produced (see below).

Mat files generation

If this box is checked, a mat file containing time stamps, backscatter profiles, gradient profiles, and gradient minima is produced. MATLAB is required for processing this file that is copied to the Matlab mat files directory

Offline data processing of several days

If this box is checked, several days can be evaluated with one click on the "Offline data processing..." checkbox. The end of the month is the last day that is processed.

Detailed explanation of the letters that can be entered in the Option Box

A

Automatic calculation of the upper limit for density plots from the maximum backscatter value in the lowest 100 m of the profile. No effect on logarithmic scaling (E).

B

Additional creation of color EPS postscript backscatter graphics in the Plots directory.

C (NOT RECOMMENDED)

Produces cloud only plots with a less sensitive backscatter density scale. No gradient plots.

E (RECOMMENDED)

Logarithmic density plot scaling. Scaling is fixed from $50*10^{-9}$ m^{-1} sr^{-1} to $40000*10^{-9}$ m^{-1} sr^{-1}.

F (RECOMMENDED)

Backscatter in the very near range up to 40 m is slightly influenced by the crosstalk from lens and window of the ceilometer. If F is placed in the Option Box, these values are reduced by a small amount to account for this effect.

L (ONLY RECOMMENDED FOR DEBUGGING)

The log file that is produced when the 'U' option is not set is extended by the time stamp of every data set read by cl31_mh.exe.

M

The PNG file names contain also the minute of the first profile plotted.

O (NOT RECOMMENDED)

Offline day file mixing height text creation.

Q

Only to be used when CL31 report interval is less than 15 s.

R

Radiosounding data are available (see Radiosonde data directory above).

T (NOT RECOMMENDED)

Radiosounding plot temperature scaling is taken from sounding.

U (RECOMMENDED)

No log file creation.

V (RECOMMENDED in ONLINE MODE)

PNG graphic files are only produced at minutes between 0 and 10 of a full hour. Graphic update time should be chosen 10 minutes or smaller when this option is active.

W

Angle correction was on when data were recorded by CL-VIEW.

Online options (left bottom part of the screen)

Online options give graphic and text window update times and time interval contained in each graphic in minutes.

The update time numbers can only be edited in offline mode.

Offline data processing of several days uses also these numbers.

After online activation this part of the screen looks like this:

The numbers given are recommended values.

MH text options (lower right part of the screen)

The interval in minutes entered here is the time between two consecutive lines in the text file containing mixing layer height and cloud base.

Example:

```
26/02/2009 08:00   670    400
26/02/2009 08:15   680    440
26/02/2009 08:30     0    430
26/02/2009 08:45     0    430
```

At 08:30 and 08:45 no MLH had been detected.

Plot options (bottom right part of the screen)

Every time cl31_mh.exe processes a message file generated by CL31 MH control.exe, color gradient and backscatter plots are shown on the screen.

The plot options rule additional hardcopy file production in color, hot or gray density colormaps. In the example on the right side (recommended setting) only color hardcopy files are produced.

If Close old figures is checked (recommended in online mode), all open MATLAB figures are closed before new plots are generated.

Text window gives current mixing layer and cloud base height whenever an update is scheduled in online mode.

When the Plot gradient local minima box is checked, up to 5 local gradient minima are plotted instead of MLH (not recommended).

5. Directory structure and file naming conventions

Plots

All folders are created automatically if they do not yet exist.

If C:\Example_Plots is the Plots directory, logarithmic scaled (extra letter 'E') color backscatter density plots can be found in

> C:\Example_Plots\log\color\density

The gradient plots are in

> C:\Example_Plots\log\color\gradient

Replace color by hot or gray in this path if you have also used other colormaps.

Standard scaled plots are in

> C:\Example_Plots\color\density

and in

> C:\Example_Plots\color\gradient

A density plot name has the format

> dYYYYMMDDHHMM.png (example: d200902261350.png)

A gradient plot name has the format
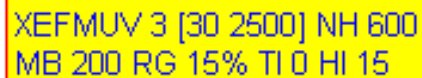
> gYYYYMMDDHHMM.png (example: g200902261350.png)

If the 'M' extra letter is not set, the minute is not contained in the file name.

The time determining the file name is the time stamp of the first profile shown in the plot.

Each plot contains a yellow info box at its bottom right corner. It gives the parameters used for its creation.

Example:

Explanation:

EFMUV is the contents of the Extras letter box.
Up to 3 gradient local minima are plotted (if chosen).
[30 2500]: Min MH and Max MH
Norm height is 600 m.
Min backsc. is $200*10^{-9}$ m^{-1} sr^{-1}.
Relative gradient is 15%.
Time Inc. is 0 %.
HI is 15 %.

Mixing height text files

The MH text directory contains files named

YYYYMMDDHHMM.txt (example: 200902260802.txt)

that contain time stamps, MLH and cloud base data.

The time determining the file name is the time stamp of the first profile shown in the plot produced at the same time, the first time stamp in the text file is usually later like in this example (with 15 minute interval):

```
26/02/2009 08:15  680   440
26/02/2009 08:30    0   430
26/02/2009 08:45    0   430
26/02/2009 09:00  540    0
```

At 08:30 and 08:45 no MLH had been detected.

At 09:00 MLH was 540 m and no cloud base was reported.

Log files

When the 'U' option is not active, cl31_mh.exe produces and updates a log file named LOG_YYYY_MM_DD_HH_MM.txt in the program directory that contains the exe-files (example: LOG_2009_02_18_12_16.txt).

This file contains information regarding program start, message files received and processed (see next section), and CL-VIEW data files read and processed.

The idea behind this concept is to find reasons for possible program failures.

The safety concept described in the next section makes log files obsolete. Therefore it is recommended to use the 'U' option in the Extras Option Box.

6. Interface CL31 MH control.exe → cl31_mh.exe

Message file concept

The MATLAB program cl31_mh.exe is idle until the control program writes a message file to the directory both programs have been started from, either automatically in online mode or triggered by the user in offline mode.

Message file naming convention is

MH_CALC_MSG_nnnnnn.txt

with nnnnnn ranging from 000001 to 000100.

The first message file sent is

MH_CALC_MSG_000001.txt

The second message file sent is

MH_CALC_MSG_000002.txt

and so on.

Having processed message file 1, cl31_mh.exe deletes that file and waits for message file 2. It will not process any other message files before message file 2 is created.

Example:

```
.\CL31_mh.exe                                                    _ □ ×
Extracting CTF archive. This may take a few seconds, depending on the
 size of your application. Please wait...
...CTF archive extraction complete.
Start of CL31_MH Calc and Graph V 3.0 at 24-Feb-2009 15:08:16
Waiting for MH_CALC_MSG_000001.txt...
Processing MH_CALC_MSG_000001.txt at 24-Feb-2009 15:09:15
Averaging done at 24-Feb-2009 15:09:30
Elapsed time is 23.237666 seconds.
Waiting for MH_CALC_MSG_000002.txt...
Processing MH_CALC_MSG_000002.txt at 24-Feb-2009 15:12:15
Averaging done at 24-Feb-2009 15:12:19
Elapsed time is 5.170284 seconds.
Waiting for MH_CALC_MSG_000003.txt...
Processing MH_CALC_MSG_000003.txt at 24-Feb-2009 15:16:15
Averaging done at 24-Feb-2009 15:16:19
Elapsed time is 5.020393 seconds.
Waiting for MH_CALC_MSG_000004.txt...
Processing MH_CALC_MSG_000004.txt at 24-Feb-2009 15:19:15
Averaging done at 24-Feb-2009 15:19:29
Elapsed time is 20.564320 seconds.
Waiting for MH_CALC_MSG_000005.txt...
```

Message file contents

A message file contains all parameters entered in the CL31 MH control screen as readable ASCII text. It should not be edited.

Safety concept

Before creating message file i, CL31 MH control deletes message file i+1 if that exists. This makes sure that cl31_mh does not process any out-of-date message files.

When the message file counter is 99, before creating the next message file, CL31 MH control performs the following actions:

- A special message file named
    WAIT_MSG.TXT
  is written.
  It contains just the line
    wait.

- MH_CALC_MSG_000100.txt containing just the line
    end
  is written.

- The message counter is resetted to 1 and
  MH_CALC_MSG_000001.txt is created as next message file.

- CL31 MH control pauses for 10 s.

- cl31_mh.exe is started from CL31 MH control.

The active cl31_mh.exe that waits for MH_CALC_MSG_000100.txt receives the message 'end' telling it to terminate. Before termination it deletes the files WAIT_MSG.TXT and MH_CALC_MSG_000100.txt.

Before processing MH_CALC_MSG_000001.txt, the freshly started cl31_mh.exe waits up to 200 s for WAIT_MSG.TXT to be deleted.

All folders are created automatically if they do not yet exist.

10 minutes after the creation of WAIT_MSG.TXT, the program CL31 MH control deletes it when it still exists.

Advantages of safety concept

- Number of message files created is not higher than 100.

- In case of a MATLAB error caused by corrupted CL31 data files cl31_mh.exe may stop its operation. The safety concept makes sure that in such a case online operation is only interrupted for a limited time.

- Having processed a few thousand message files, the PC memory used by cl31_mh.exe needs some re-organization. The best way to do this is to terminate and restart this program as it is done automatically in the concept described above.

7. Mixing layer height algorithm
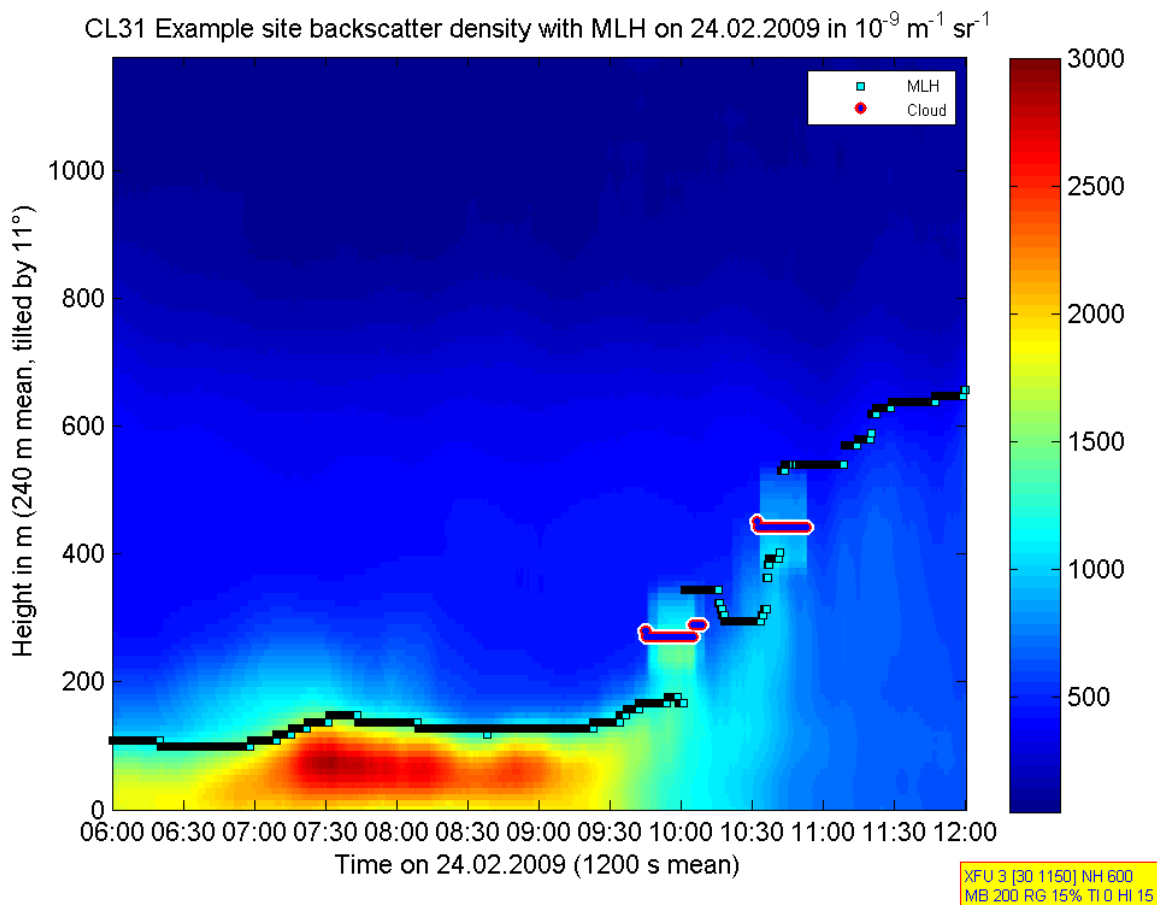
Basic concept

The mixing layer height algorithm used by cl31_mh.exe is based on the gradient method.
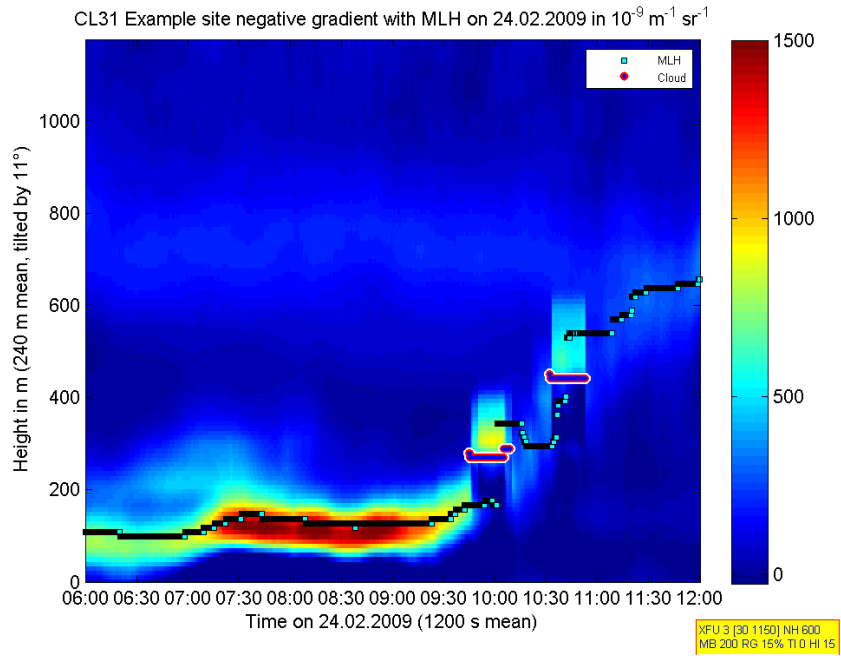
Within the range to be investigated, all local gradient minima within the backscatter profile are identified. The lowest of these that fulfills the threshold conditions given in the message text file is reported as mixing layer height (MLH).

Time averaging interval

To avoid unnecessary jumps in rapidly changing conditions, the MLH value reported is the prevailing value detected during the past time averaging interval.

Example with stable nocturnal layer, residual layer and convection

CL31 Example site backscatter density with MLH on 24.02.2009 in 10^{-9} m^{-1} sr^{-1}

CL31 Example site negative gradient with MLH on 24.02.2009 in 10^{-9} m^{-1} sr^{-1}

The gradient plot reveals a second local gradient minimum layer around 750 m. It can be visualized with the gradient local minima plot option:

CL31 Example site negative gradient on 24.02.2009 in 10^{-9} m^{-1} sr^{-1}
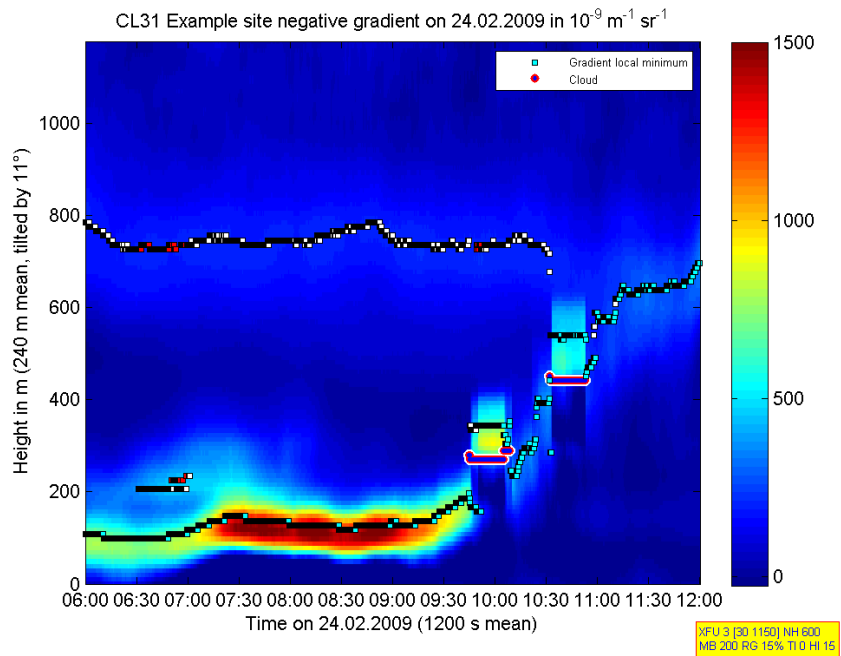
Clouds and precipitation

If no significant local gradient minimum is found below a not precipitating cloud, the cloud itself defines a local gradient minimum reported as MLH.

In case of precipitation no MLH should be reported. Precipitation yes/no discrimination is done based on the minimum backscatter value between the ground and the cloud.

CL31 Example site $\log_{10}$ of backscatter with MLH on 26.02.2009 in 10^{-9} m^{-1} sr^{-1}
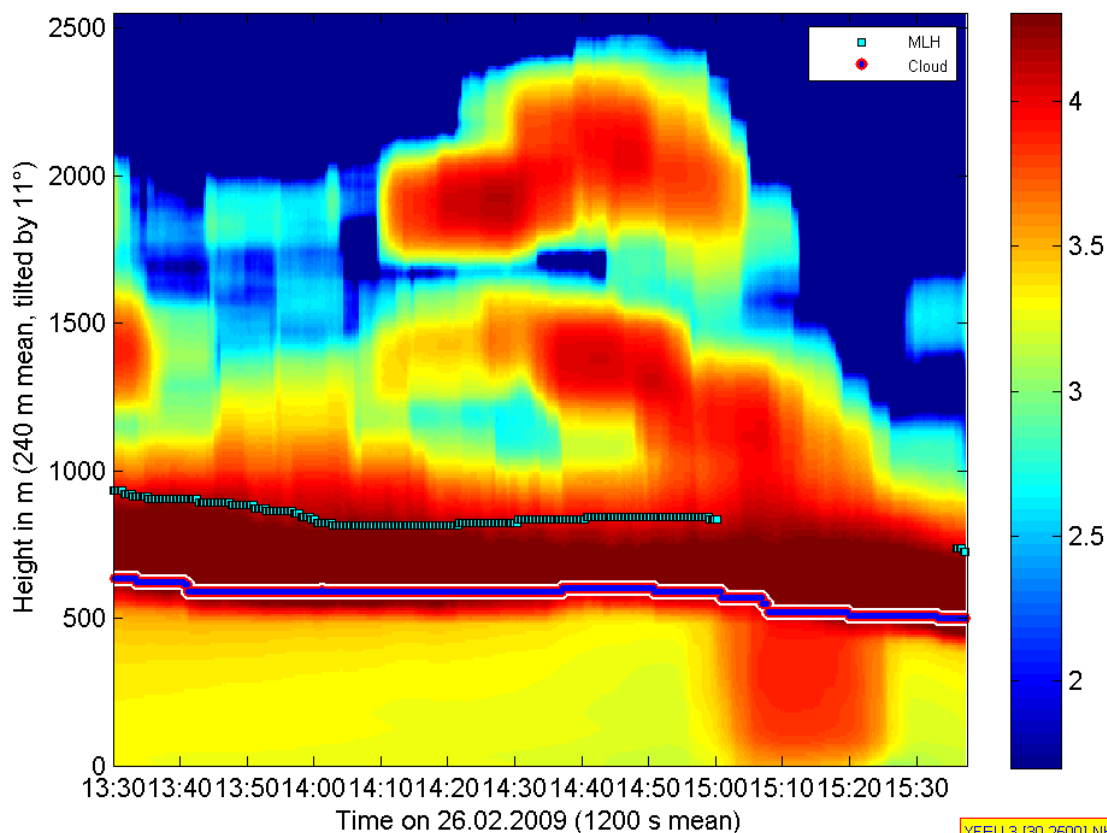
This example shows a not precipitating cloud until 15:00 and a rain shower with no MLH detection from 15:00 and 15:30.

The graph gives only the lowest cloud layer.