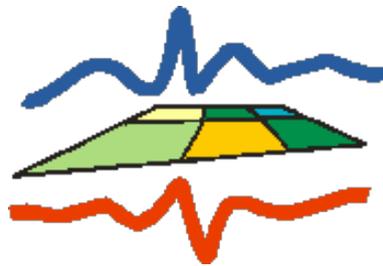


Transregio SFB 32
Subproject D2
Cloudbase heights and
aerosol backscatter profiles



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Figure 1: Setup for the instrument at the measuring site Selhausen.

1 Instrument

Data described here come from a ceilometer that has been installed at the measuring site Selhausen. A ceilometer is a low cost LIDAR (from light detecting and ranging) designed to measure the cloud base height (*ceiling* in aviation). The instrument is a Vaisala CT25K purchased in 2006 by our group. Resolution is in the vertical 30 m, temporal 15 sec and vertical range is 7.5 km. Field of view divergence is 0.6 mrad and wavelength of the laser is 905 nm.

A laser-pulse is sent and the backscattered signal is recorded. Height is calculated from travel time of the light pulse. The instrument sends some ten-thousand light pulses, averages them every 15 seconds and calculates a profile of the backscatter coefficient via the Klett algorithm [Klett:1981]. As clouds are strong backscatterers they can be detected by finding respective strong peaks in the backscatter. If clouds are transparent it is possible to detect up to three cloud bases where the first cloud layer is always the lowest one.

The instrument is connected to a standard windows PC. A software re-

Table 1: Time table of the ceilometer installations.

from	to	remarks
24.5.2007	25.9.2007	first installation CT25K from Köln
16.4.2008	8.8.2008	second installation CT25K from Köln
21.4.2009	30.4.2009	installation of the CT25K from Bonn
30.4.2009	5.6.2009	installation of the CL31 from Vaisala
5.6.2009	now	CT25K from Köln

ceives the data via RS232 and stores it in day files with a complex ASCII structure. All data presented here are standard output of the instrument converted to netcdf format (see below).

2 location

The instrument was set up at the measuring site Selhausen at 50°52'9.48" N, 6°27'3.60" E, 100 m ASL . To protect it from wind and weather it was placed between the two containers at the site (Fig.1).

Until May 2009 the instrument was visited every 3-4 weeks and data was copied manually from the PC and brought to cologne. From May 8, 2009 a WLAN data link to the research center Jülich was established and data is copied in two steps via a linux machine in the research center to our institute in cologne every 10 minutes. Actual data can be seen at <http://www.uni-koeln.de/~jschween/tr32/ceilo/>.

3 time table

Times of installation are summarized in table 1 The instrument was brought in April 2007 for the first time to the site. In the winters of 2007/2008 and 2008/2009 it was brought to the Umwelt Forschungs Station Zugspitze (UFS) for another project (TOSCA) of our group. Beginning 2008 it was buried under an avalanche on the platform of the UFS. Its outer enclosure was not damaged and seemed to work properly. To ensure its data quality we brought the instrument to Meteorological Institute Bonn to compare it with their ceilometer. Both instruments showed no significant difference in backscatter values nor in detected cloud heights.

During the stay at Zugspitze in the winter 2008/2009 the instrument showed repeatedly problems with data transfer to the PC. It was send to Vaisala for repair, the main board was replaced and the instrument came back

to Selhausen on June 5. During this time we could borrow the similar CT25K from the Meteorological institute in Bonn (21.4.2009-30.4.2009). Afterwards the manufacturer Vaisala borrowed us a successor model CL31 (30.4.2009-5.6.2009). The CL31 showed compared to the other ceilometers a rather high noise level in the upper levels.

4 additional DWD instrument

In summer 2009 the Met.Inst. Bonn could organize a Jenoptic CHM15K from DWD. The instrument was installed in the research center Jülich at 50°54'41.95"N, 6°24'27.49"E, 93 mASL. The site is about 2 km north of the site Selhausen and the the instrument was present from 23.4.2009-2.10.2009. Due to problems with the very basic raw data acquisition system we used, data between 28.5.2009-18.8.2009 were lost. The CHM15K has higher power and thus has a larger range (15 km). Resolution is 15 m vertical and 30 sec temporal. The instrument does not perform the Klett inversion algorithm and delivers signal to noise ratios instead of physical backscatter.

5 data files

Original data files are ASCII containing control codes below 32 and backscatter data as Hex numbers. We convert them to netcdf because this data format is binary, compact, faster read and because it becomes a standard in meteorology. Each netcdf file contains a descriptive header explaining its content. An example can for a header be found in the appendix at the end of this document. We also deliver quicklooks to give a first impression for every day (Fig. 2).

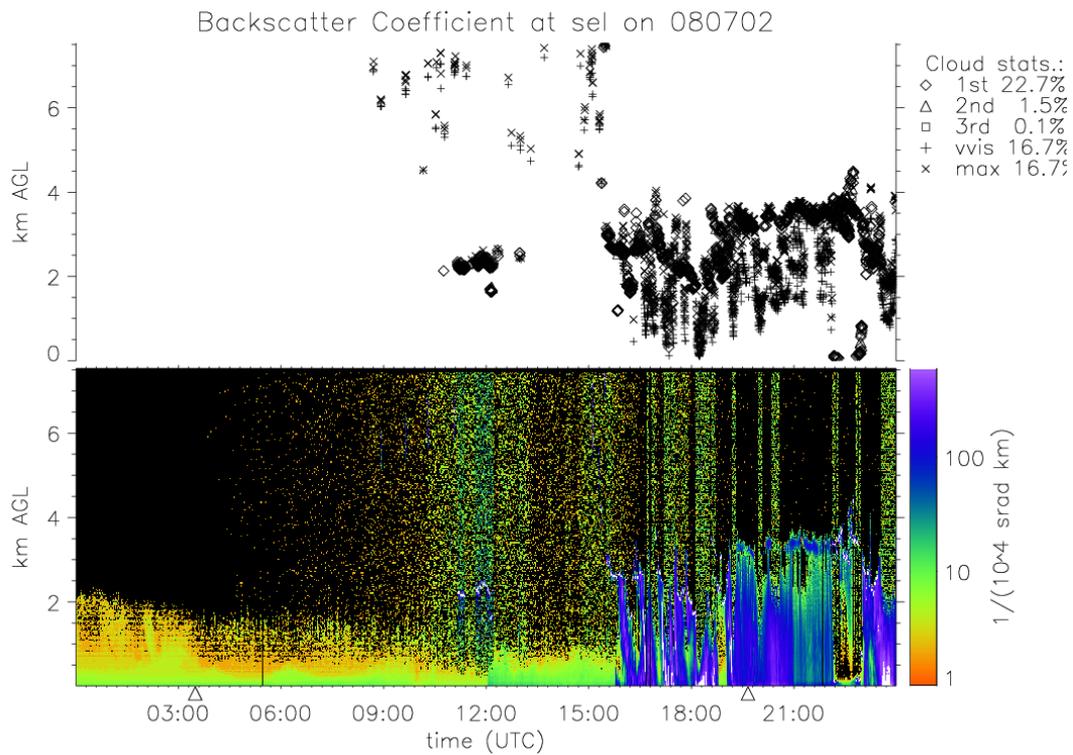


Figure 2: Exemplary quicklook from 2.7.2008. Upper part of the plot: cloud base heights as a function of time, with different symbols for the first (1st), second (2nd) and third (3rd) cloud base, vertical visibility (vvis) and level of maximum backscatter (max). The numbers in the legend to the right give the relative frequency for the whole day. Lower part of the plot: Time height sections of the observed backscatter coefficients. The Color scale is chosen such that rain appears in most cases in blue.

Table 2: Basic structure of the zip files in the database: every zip file contains one month of data. with <YYMM> the year and month of the file. Data files for every day are named *.nc. A subdirectory plots/ contains quicklook plots of the data as .png files. Images with names *_10b.png are basic data plots, *_10b_v3.png contain additionally nearly complete internal status information of the instrument, and *_10b_blh.png show derived boundary layer heights.

```
ceilo_sel_<YYMM>.zip
  <YYMM>/
    <YYMMDD>_ct25k_sel_10b.nc
    ...
    plots/
      <YYMMDD>_ct25k_sel_10b.png
      <YYMMDD>_ct25k_sel_10b_v3.png
      <YYMMDD>_ct25k_sel_10b_blh.png
      ...
```

6 appendix

netcdf header

```
netcdf 100608_ct25k_sel_10b {
dimensions:
  time = 5686 ;
  range = 252 ;
  string_len = 8 ;
variables:
  int base_time ;
    base_time:string = "08-06-2010,0:00:13 UTC" ;
    base_time:long_name = "Base time in Epoch" ;
    base_time:units = "seconds since 1970-1-1 0:00:00 0:00" ;
  float time(time) ;
    time:units = "hours since 2010-06-08 00:00:00" ;
    time:long_name = "Time UTC" ;
    time:comment = "time at the end of each individual measurement" ;
  float range(range) ;
    range:long_name = "Distance to the center of the corresponding range bin"
```

```

range:units = "m" ;
range:missing_value = "-9999.f" ;
range:accuracy = "30 m" ;
byte detection_status(time) ;
detection_status:long_name = "Detection status" ;
detection_status:units = "unitless" ;
detection_status:missing_value = "99" ;
detection_status:values =
    "0=No sig backscatter,
    1=One cloud base (cb) det.,
    2=Two cb det.,
    3=Three cb det.,
    4=Full obscuration determined but no cloud base detected,
    5=Some obscuration det. but determined to be transparent." ;
char status_flag(time) ;
status_flag:long_name = "Ceilometer status indicator" ;
status_flag:units = "1" ;
status_flag:values = "Warning and alarm information as follows,
    0 = Self-check OK,
    W = At least one Warning active, no Alarms,
    A = At least one Alarm active" ;
float first_cbh(time) ;
first_cbh:long_name = "Lowest cloud base height detected" ;
first_cbh:units = "m" ;
first_cbh:valid_min = "0.f" ;
first_cbh:valid_max = "7620.f" ;
first_cbh:missing_values = "-9999.f" ;
float second_cbh(time) ;
second_cbh:long_name = "Second lowest cloud base height detected" ;
second_cbh:units = "m" ;
second_cbh:valid_min = "0.f" ;
second_cbh:valid_max = "7620.f" ;
second_cbh:missing_values = "-9999.f" ;
float third_cbh(time) ;
third_cbh:long_name = "Third cloud base height detected" ;
third_cbh:units = "m" ;
third_cbh:valid_min = "0.f" ;
third_cbh:valid_max = "7620.f" ;
third_cbh:missing_values = "-9999.f" ;
float vertical_visibility(time) ;
vertical_visibility:long_name = "Vertical visibility" ;

```

```

vertical_visibility:units = "m" ;
vertical_visibility:valid_min = "0.f" ;
vertical_visibility:valid_max = "7620.f" ;
vertical_visibility:missing_values = "-9999.f" ;
vertical_visibility:values =
    "This field will only be stored if detection_status
    is = 4. In all other cases, a value of -9999 will
    be recorded." ;
vertical_visibility:comment =
    " This is calculated using a proprietary contrast threshold
    which has been found to give vertical visibilities in
    closer agreement to those reported by ground-based human
    observers than the 5 % MOR contrast threshold used for
    horizontal visibility." ;
float alt_highest_signal(time) ;
    alt_highest_signal:long_name = "Altitude of highest signal" ;
    alt_highest_signal:units = "m" ;
    alt_highest_signal:valid_min = "0.f" ;
    alt_highest_signal:valid_max = "7620.f" ;
    alt_highest_signal:missing_values = "-9999.f" ;
    alt_highest_signal:values =
        " If detection_status = 4, this value is the
        distance from the ground to the highest signal
        detected.
        If detection_status = 0, 1, 2, 3 or 5, -9999
        will be recorded." ;
float laser_pulse_energy(time) ;
    laser_pulse_energy:long_name = "Laser pulse energy" ;
    laser_pulse_energy:units = "%" ;
    laser_pulse_energy:values = "0 to 999" ;
    laser_pulse_energy:valid_min = "10.f" ;
    laser_pulse_energy:valid_max = "110.f" ;
    laser_pulse_energy:missing_values = "-9999.f" ;
    laser_pulse_energy:comment = "Percentage of nominal factory setting" ;
float laser_temperature(time) ;
    laser_temperature:long_name = "Laser temperature" ;
    laser_temperature:units = "C" ;
    laser_temperature:valid_min = "-10.f" ;
    laser_temperature:valid_max = "60.f" ;
    laser_temperature:missing_values = "-9999.f" ;
    laser_temperature:values = "\"-50 to +99" ;

```

```

float receiver_sensitivity(time) ;
    receiver_sensitivity:long_name = "Receiver sensitivity" ;
    receiver_sensitivity:units = "%" ;
    receiver_sensitivity:missing_values = "-9999.f" ;
    receiver_sensitivity:values = "\"0 to 999 %" ;
    receiver_sensitivity:comment = "Percentage of nominal factory setting" ;
float window_contamination(time) ;
    window_contamination:long_name = "Window contamination" ;
    window_contamination:units = "mV" ;
    window_contamination:missing_values = "-9999.f" ;
    window_contamination:values = "\"0 to 2500 mV" ;
    window_contamination:comment = "Millivolts measured at the internal ADC i
float tilt_angle(time) ;
    tilt_angle:long_name = "Tilt angle" ;
    tilt_angle:units = "deg" ;
    tilt_angle:valid_min = "0.f" ;
    tilt_angle:valid_max = "90.f" ;
    tilt_angle:missing_values = "-9999.f" ;
    tilt_angle:values = "-15 to +90 degrees from vertical" ;
float background_light(time) ;
    background_light:long_name = "Background light" ;
    background_light:units = "mV" ;
    background_light:missing_values = "-9999.f" ;
    background_light:values = "0 to 2500 mV" ;
    background_light:comment = "Millivolts measured at the internal ADC input
float sum_backscatter(time) ;
    sum_backscatter:long_name = "SUM of detected and normalized backscatter" ;
    sum_backscatter:units = "1/srad" ;
    sum_backscatter:missing_values = "-9999.f" ;
    sum_backscatter:values =
        "Multiplied by scaling factor
        times 10^4. At scaling factor 100 the sum range,
        which is 0 to 999, this corresponds to integrated,
        backscatter, which ranges from 0 to 0.0999 srad^-1" ;
float backscatter(time, range) ;
    backscatter:long_name = "Backscatter" ;
    backscatter:units = "1/(srad*km*10000.0)" ;
    backscatter:missing_values = "-9999.f" ;
    backscatter:comment = "Data is range and sensitivity normalized backscatter
char measurement_parameters(time, string_len) ;
    measurement_parameters:long_name =

```

```

    "6 character string describing instrument measurement parameters";
measurement_parameters:units = "unitless" ;
measurement_parameters:values =
    "(L)ong/(S)hort - (F)req - pulse qty r ^(7) + 1,
    - gain (H)igh/(L)ow - bandwidth (N)arrow/(W)ide - sampling (5) / (1)0
char status_string(time, string_len) ;
status_string:long_name = "Warning and alarm status bits" ;
status_string:units = "unitless" ;
status_string:missing_values = "-9999" ;
status_string:comment1 = "Has Form FEDCBA98.
    Each character is a hexadecimal representation of
    four bits, altogether 32 bits. See additional comments for interpretation
status_string:commentF =
    "(8000 0000)= Laser temperature shut-off(A),
    (4000 0000)= Laser failure(A),
    (2000 0000)= Receiver failure(A),
    (1000 0000)= Voltage failure(A)" ;
status_string:commentE =
    "(0800 0000)= Profile error(A)" ;
status_string:commentD =
    "(0080 0000)= Window contaminated(W),
    (0040 0000)= Battery low(W),
    (0020 0000)= Laser power low(W),
    (0010 0000)= Laser temperature high or low(W)" ;
status_string:commentC =
    "(0008 0000)= Internal temperature high or low(W),
    (0004 0000)= Voltage high or low(W),
    (0002 0000)= Relative humidity is > 85 % (W),
    (0001 0000)= Receiver optical cross-talk compensation poor(W)" ;
status_string:commentB =
    "(0000 8000)= Fan suspect(W),
    (0000 4000)= Profile warning(W)" ;
status_string:commentA =
    "(0000 0800)= Blower is ON,
    (0000 0400)= Blower heater is ON,
    (0000 0200)= Internal heater is ON,
    (0000 0100)= Units are METERS if ON, else FEET." ;
status_string:comment9 =
    "(0000 0080)= Polling mode is ON,
    (0000 0040)= Working from battery,
    (0000 0020)= Single sequence mode is ON,

```

```

        (0000 0010)= Manual Settings are effective." ;
    status_string:comment8 =
        "(0000 0008) = Tilt angle is > 45 degrees." ;
float lat ;
    lat:long_name = "north latitude" ;
    lat:units = "degrees" ;
float lon ;
    lon:long_name = "east longitude" ;
    lon:units = "degrees" ;
float alt ;
    alt:long_name = "altitudes" ;
    alt:units = "meters above Mean Sea Level" ;

// global attributes:
    :Date_of_file_generation = "Wed Jun  9 00:13:07 2010" ;
    :Conventions = "CT25K LMU-1.0" ;
    :location = "Selhausen          " ;
    :system = "Vaisala CT25K lidar ceilometer CT02023 of University of Cologne" ;
    :day = "08" ;
    :month = "06" ;
    :year = "2010" ;
    :institution = "Data processed by University of Cologne;
        contact: jschween@meteo.uni-koeln.de" ;
    :sample_int = "15 seconds" ;
    :averaging_int = "11.5 seconds" ;
    :input_source = "data/201006:A0060800.DAT" ;
}

```

References

- [Klett:1981] J. D. Klett, "Stable Analytical Inversion Solution for Processing Lidar Returns," Appl. Opt. 20, 211 (1981)