"Unique Approach to Measuring Mixing Layer Structures Using a Common Lidar Ceilometer"

Frank DeFina                  Vaisala Boston
Christoph Münkel             Vaisala GmbH
### Vaisala Ceilometers

<table>
<thead>
<tr>
<th>Name</th>
<th>CT12K</th>
<th>CT25K</th>
<th>CL31</th>
<th>CL51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud reporting range</td>
<td>12600 ft</td>
<td>25000 ft</td>
<td>25000 ft</td>
<td>43000 ft</td>
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<tr>
<td>Manufactured</td>
<td>1987 - 1996</td>
<td>1995 - 2006</td>
<td>2005 -</td>
<td>2010 -</td>
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<td>Installed base</td>
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<td>2600</td>
<td>2000</td>
<td></td>
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<td>NWS installations</td>
<td>1000</td>
<td>&lt; 10</td>
<td>500 now</td>
<td>&gt;500 to be delivered</td>
</tr>
</tbody>
</table>
LIDAR ceilometer operating principle

LIDAR = Light Detection And Ranging

• Short pulse of light is transmitted into air
• Receiver monitors the light backscattered by aerosols
• Altitude of backscatterer is given by time (speed of light is 30 cm/ns ~ 1 ft/ns)
• Several profiles are summed to increase signal to noise ratio
Enhanced single lens system – Vaisala Ceilometers CL31 and CL51

- Mirror with a hole in the center divides lens into transmitting and receiving area.
- The single lens technology provides excellent data at low altitudes (below 200m).
- Simple and reliable instrument design fit for 24/7 operation in harsh environments.
Clear day mixing layer evolution
Mixing layer height retrieval – motivation

- The mixing layer height is a
  - key parameter for the characterization of air pollution impacts e.g. wind, long-range transport and deposition.
  - necessary parameter for the verification of numerical simulations of air pollution.
  - necessary parameter for the calculation of near-surface pollutant concentrations from optical thickness data derived from satellite images.
Mixing layer height retrieval with ceilometer
Mixing layer height retrieval with ceilometer – gradient method

- The mixing layer is expected to have a somewhat constant aerosol concentration that is higher than in the layers above.
- Consequently, the difference between the mixing layer and the air above is assumed to be seen as a shift from a relatively strong backscatter inside the boundary layer to a lower backscatter level above it.
- The gradient method takes focuses on the gradient minimum usually seen at the top of the boundary layer.
Mixing layer height retrieval with ceilometer – radiosonde verification

- High resolution sounding data are available at the Vaisala test field in Helsinki, Finland.
- Sharp increases within the potential temperature profile mark inversion layers and are a reliable tool for ceilometer mixing layer height verification.
Some CL31 installation sites for mixing layer investigation

- Puget Sound Clean Air Agency, Seattle, WA
  - Comparison campaign involving wind profiler and RASS, summer 2007
- National Weather Service test site Sterling, VA
  - Testing of up to six CL31 units, comparison to regular Sterling soundings, 01-2008 till 11-2009
- Karlsruhe Institute of Technology (KIT) air quality measuring campaign in Augsburg, Germany
  - Two CL31 units, one co-located to a RASS, ongoing since 2007
- Department of Environment, Perth, Western Australia
  - Comparison to AMDAR temperature profiles, ongoing since 2007
- Installations in harsh environments
  - Neumayer Station III, Antarctica, since 2009
  - Princess Elisabeth Station, Antarctica, since 2009
  - Research vessel Planet (German Navy), Mediterranean Sea and North Atlantic, 06-2007
Some CL31 installation sites for mixing layer investigation

Augsburg

Princess Elisabeth Station, Antarctica
René Robert - © International Polar Foundation

Mediterranean Sea
Source: Dr. Lothar Ginzkey
Convective boundary layer evolution in Helsinki, Finland – CL31

- Gradient local minima mark
  - 300 m layer till 10:00
  - Convective layer rising up to 1200 m in the afternoon.

- Potential temperature profiles from soundings launched at 09:23 and 12:03 local time confirm these results.
Convective boundary layer evolution in Helsinki, Finland – CL51

- Result is very similar to that of CL31.
- Better signal-to-noise ratio reveals more structures above the boundary layer.
- Backscatter amplitudes are correlated to relative humidity values.
Stable winter boundary layer in Sterling, VA

- Gradient local minima mark a layer reaching up to about 1000 m.
- Potential temperature profile from the 07:00 sounding confirms this layer.
- Wind direction changes from NW to N at mixing layer height.
Low winter inversion layer in Sterling, VA – unit D

- Nearly full overlap in the first range gates enables reliable detection of very low winter inversion layers.
Precipitation filter – no profile averaging and mixing layer reports during rain showers

- Stable nocturnal layer is detected before and after the rain showers.
- Enhanced gradient method detects precipitation and suppresses profile averaging to avoid false hits after the rain shower.
Vaisala BL-VIEW
Mixing layer Reporting and Analysis Tool

- BL-VIEW - Supportive PC-software package for Vaisala Ceilometers
  - Ceilometer CL31 or CL51 reports profile data
  - BL-View calculates PBL/Mixing layer structure parameters and generates graphics and text output

- Main features
  - Automatic reporting of Mixing Layer structure with cost effective Vaisala Ceilometers CL31 and CL51
  - Reporting of evolution of Mixing Layer
  - Quality index of reported Mixing Layer data

- Available spring 2010
- For more information: [www.vaisala.com/airquality](http://www.vaisala.com/airquality)
- [frank.defina@vaisala.com](mailto:frank.defina@vaisala.com)