Detection of Planetary Boundary Layer Height with ARM Ceilometers

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Introduction

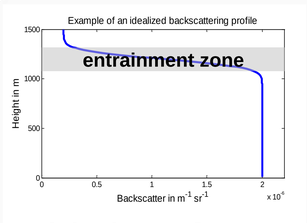
The height of the planetary boundary layer (PBL) is an important parameter for characterizing many atmospheric processes including the dispersion of air pollutants and the formation of clouds. PBL depth is usually inferred from radiosonde measurements. However, at the ARM Climate Research Facilities balloon soundings occur only a few times per day and sometimes coincide with times that the PBL is rapidly developing. To improve the modeling of low-level clouds, an accurate measure of PBL height with higher temporal resolution is desired.

Background

As part of the American Recovery and Reinvestment Act (ARRA), an integrated Boundary Layer Cloud System was deployed in 2010 at each of the ARM Facilities that comprise a suite of instruments that include a laser ceilometer. The new Vaisala ceilometers have the capability of continuous monitoring of the aerosol structure within the PBL. Vaisala has developed an algorithm that uses an enhanced gradient method for robust, all-weather retrieval of PBL depth. A brief test of new software that applies the algorithm was conducted at the Southern Great Plains (SGP) site in June 2011.

Vaisala PBL Algorithm

- Standard gradient method
  - searches for steepest decrease within aerosol backscatter profile
  - works well for cloudless days
- Enhanced gradient method
  - applies cloud and precipitation filter
  - performs variable height and time averaging
  - suppresses false layer hits
  - identifies situations where precipitation or fog prevents detection of PBL height

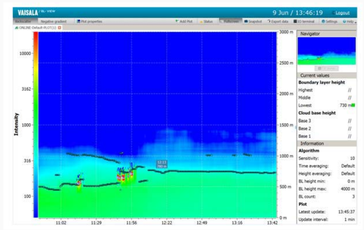


ARM Ceilometer

- Vaisala CL31 Laser Ceilometer
- Purchased with ARRA funds
- Deployed in April 2010
- Enhanced single lens optics
- Fast digital signal processor electronics
- Range: 0 – 7500 m
- Vertical resolution: 10 m
- Temporal resolution: 16 s
- Detection of very low (< 200 m) nocturnal stable layers
- Configured to optimize measurements for aerosol and PBL detection

Vaisala Boundary Layer View Software

- Data collection, storage, analysis, and reporting tool
- Automatic detection and logging of PBL structure, cloud heights, and aerosol backscatter profile
- Test of BL-View conducted at SGP Central Facility from June 6 to June 10, 2011
- Evaluated affect on operational data acquisition, format of output file, and algorithm parameters
- Compared derived PBL heights with those from Balloon-Borne Sounding System (BBSS)



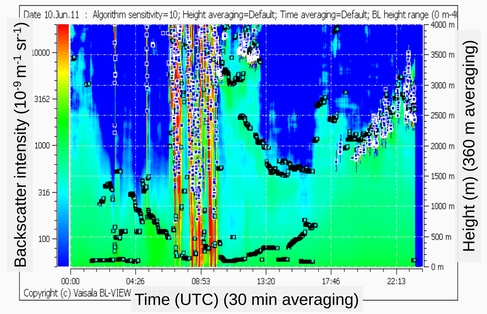
Example of BL-View Display

Summary

- Vaisala algorithm implemented in BL-View software
- Algorithm detects PBL height from CL31 Ceilometer backscatter measurements
- Derived heights compare favorably with radiosonde profiles
- Collection of PBL height data will be implemented on ceilometers at all ARM sites
- Data will be ingested and included in new value added product

Comparison of PBL Height

SGP, 10 June 2011



BL-View plot of backscatter profile with PBL heights

BBSS temperature profile with PBL heights

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