Investigation of Aerosol Layer Height Algorithms to Identify the Transition Layers Using Synergy of Lidar, Ceilometer and Radiometer Measurements

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Motivation

- Investigation of layer-height algorithms capability to identify the aerosol-cloud transition layers using synergy of ground-based remote sensing measurements.
- Improvement of the "lidar constant" using an algorithm based on dynamic time warping method.

Instruments

- **Ceilometer** type CHM15k having one elastic channel at 1064 nm; photon counting mode of operation.
- **RALI** Raman multispectral lidar system having 7 channels; analog and photon counting modes of operation.
- **Microwave radiometer** that provides:
  - Relative humidity
  - Temperature

Methods and data processing

The "lidar constant" is computed by inter-calibrating the ceilometer profiles with lidar profiles in two steps:

A. the backscatter time series from ceilometer are scaled to the lidar backscatter profiles;

B. the calibration constant value is computed as the distance between the two simultaneous scaled time series of lidar and ceilometer measurements using the dynamic time warping algorithm [1]

then **the attenuated backscatter profiles** is computed by correcting the ceilometer backscatter profiles with the "lidar constant" [2].

The aerosol and cloud layers are computed using two methods :

A. **Gradient method**: aerosol and cloud layers are identified using local minima and maxima of the attenuated backscatter profiles from ceilometer [3];

B. **Ceilometer-Luft method**: aerosol and cloud layers are identified using a typical signature (based on threshold value) in the attenuated backscatter profiles.

Data analysis

- The study was performed for events from August 2018 measured at the Romanian Atmospheric 3D Observatory – RADO, Magurele, Romania.
- Eight days with different atmospheric conditions were analyzed, having simultaneous ceilometer, lidar and radiometer measurements.

	Aug.02	Aug.06	Aug.09	Aug.13	Aug.16	Aug.23	Aug.27	Aug.30
Lc	4.9E10	1.2E11	3.8E10	6.9E10	3.4E10	4.6E10	1.0E10	3.5E10
Stdev	3.7E09	3.6E09	3.2E09	1.5E09	3.4E09	2.9E09	2.9E09	2.9E09

Table 1: Lidar constant (Lc) and its standard deviation.

- The aerosol-cloud transition layer: the layer where the distance between dew point temperature and air temperature was smaller than 5°C.

	Aug.02	Aug.09	Aug.23	Aug.27
Radiometer	3.1–3.2 km	1.3–2.0 km	1.3–2.0 km	3.1–3.5 km
Ceilometer-Gradient	3.1–3.3 km	1.2–2.1 km	1.5–2.3 km	3.3–3.5 km
Ceilometer-Luft	–	1.8–2.4 km	1.6–2.3 km	2.2–2.5 km

Table 2: Aerosol-cloud transition layer height.

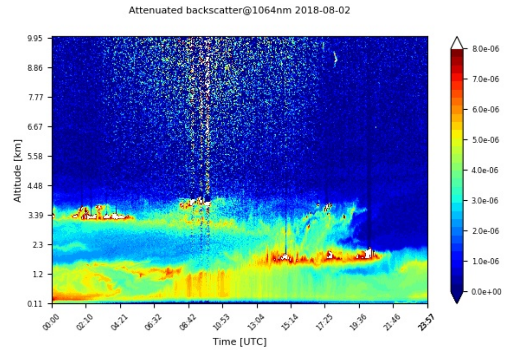
Discussion and conclusions

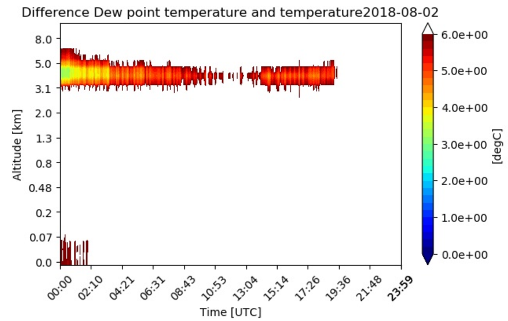
- The results from Table 1 show that the "lidar constant" varies among the cases, therefore it is important to compute it case by case. The method presented in this study allows its computation case by case, if simultaneous measurements from collocated ceilometer and lidar are available.
- The Ceilometer-Luft method does not identify all the aerosol-cloud transition layers, and in some cases gives inconsistent layering with respect to radiometer.
- The aerosol-cloud transition layers from the ceilometer attenuated backscatter profiles computed with the gradient method showed transition layers in agreement with the layers from radiometer measurements.

In conclusion, the layer detection algorithm based on the gradient method applied to the attenuated backscatter from a ceilometer can identify not only the cloud base height, but can also identify aerosol and aerosol-cloud transition layers, if simultaneous measurements from a collocated lidar are available.

Results

The transition layers obtained from radiometer and the attenuated backscatter profiles with the layer identified for one case (Aug. 02, 2018)





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