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ДИСТАНЦИОННОЕ ЗОНДИРОВАНИЕ АТМОСФЕРЫ, ГИДРОСФЕРЫ И ПОДСТИЛАЮЩЕЙ ПОВЕРХНОСТИ

Consistency between backscatter lidar products and visibility range

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We present a consistency of the following values: the aerosol backscatter coefficient (ABC) and top of Atmospheric Boundary Layer (ABL), derived from backscatter lidar measurements from one side, and the visually determined Visibility Range (VR) from the other. The VR is determined towards long-range reference topographic targets in horizontal or slant path, while the lidar measurement is performed in vertical. The mean extinction coefficient along line-of-sights to reference topographic objects is calculated from the lidar derived backscatter coefficient with model aerosol extinction-to-backscatter ratio (EBR), when necessary, taking into account the ABL top. The mean extinction coefficient along the line-of-sight to the reference target is also determined from the VR via Koschmieder equation. The correlation coefficient between the two data sets is $R^2 = 0.86$ for all data points and $R^2 = 0.91$ when selecting out the points with possible VR systematic error at the farthest reference target.

Keywords: backscatter lidar, aerosol backscatter, extinction coefficient, visibility range, Koschmieder equation.

Motivation and Objectives

A motivation for this study is the quality control of ABC derived with elastic backscatter lidars. In the lidar networks such control is carried by numerical exercises and lidar inter-comparisons campaigns [1, 2]. Although well established, such procedures suffer from limitations. The numerical tests address only the processing algorithm. The intercomparison campaigns are expensive since they require to move the tested lidars to a common site. I.e. there is no self-consistent method for ABC quality control during the backscatter lidar operation at the home site.

Another motivation is the importance of VR for air traffic at airports [3]. Although this problem is addressed by backscatter lidars since a long time [3], there are still open questions. As the measurements shall be at slant-path, eye-safety regulations apply. Eye-safe wavelength probing means that the VR value shall be re-evaluated for the visible wavelength range. One solution may be lidar measurements in direction in which the eye-safety requirements may be relaxed (e.g., vertical) or at some distance from the airports. In such case, it is necessary to demonstrate the consistency between the extinction in vertical direction and slant-path VR.

The above motivations determine the objective in this study: to demonstrate the consistency between the backscatter lidar determined extinction coefficients and ABL top altitude, with the VR to reference targets (objects) at horizontal and slant path direction.

Lidar and Site

The lidar measurements are performed in Neuchâtel, Switzerland, 47.002°N, 6.955°E, 487 m above sea level (asl). The backscatter lidar used in this study is based on an instrument, initially developed for airborne operation [4, 5]. Its adaptation for ground-based operation and respective results were already reported elsewhere [2, 6, 7]. The performances of the main lidar subsystems are summarized in Table 1.

Table 1

Specifications of the micro-pulse backscatter lidar

Laser/Wavelength	Micro-pulse/532 nm
Average power	18–20 mW
Polarization	Linear
Beam divergence	0.25 mrad (full angle)
Pulse repetition rate	5–6 kHz
Telescope type/aperture	Kepler type/50 mm
Field of view	0.5 mrad (full angle)
Interference filter: FWHM/Transmission	0.12 nm/38%
Range of full lidar overlap	400 m
Detection Type/Detectors	Photon counting/PMTs
Range resolution and single measurement duration	30 m/6 s

The ABC is derived with the classical Fernald's inversion procedure [8, 9]. The values for the molecular

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