WP2:NA2 – Remote sensing of vertical aerosol distribution

2.2: Quality assurance (LMU, CNR+all)

Lidar quality levels (LQL; per channel / wavelength)

Volker Freudenthaler Oct. 2011

Overview

Backscatter signals

Lidar quality 1B

Backscatter lidar signal without calibration (ceilometer)

Products:	Range corrected backscatter signal

Lidar quality 2B (LQLL 1B + calibration)

Lidar signal with calibration (e.g. Rayleigh fit) => inversion possible

Calibration:	Rayleigh fit to radiosonde data or equivalent.
Error calculation:	No
Products:	Attenuated backscatter coefficient; Fernald, Klett, etc.; $\beta_{attn}(r)$
	Backscatter coefficient assuming lidar ratios; Fernald, Klett, etc.; $\beta(r)$

Lidar quality 3B (LQL 2B + QA)

Backscatter lidar signal with calibration (e.g. Rayleigh fit) and quality checks

Calibration:	Rayleigh fit to radiosonde for each signal. Dark measurement for each signal if necessary.
Conditions:	Min. fit range 500 m with calibration error (stdev) let's say < 5% (relative).
Results:	Reference value for inversion $\beta_{0.}$
Quality checks:	1 Rayleigh fit for max. signal average time 1 h in certain time intervals => max. system range 2 Dark measurement 3 Telecover in certain time intervals (half year?). 4 Trigger delay once.
Conditions:	1 min. fit range 500 m with calibration error (stdev) let's say < 5% (relative). 2 sufficient averaging for analog nonlinearity determination 3 Telecover mean deviation < 5% (relative). 4 accuracy < 7.5 m for lower range limit < 500 m (or so; tbd)
Statistical error:	From the standard error of the mean (i.e. ref. value) => statistical uncertainty of the ref. value $\Delta^{stat}\beta_{0.}$
Systematic errors:	Signal offset at lidar range in % of Rayleigh reference value from dark meas.
Error calculation:	Determination of maximal error.
Products:	Backscatter coefficient from Fernald, Klett, etc.

Lidar quality 4B (LQL 3B + error calculation)

Backscatter lidar signal with calibration (e.g. Rayleigh fit) and quality checks and error calculation

Statistical errors:	Standard error of the mean of the reference value
Systematic errors:	Signal offset in the reference fit range in % of Rayleigh. Uncertainty of the range dependent, assumed lidar ratio. Signal uncertainty in overlap range from telecover. ...
Error calculation:	Full, range dependent error calculation; either analytical or Monte Carlo
Products:	Backscatter coefficient with statisitcal and systematic errors

Extinction from Raman, HSRL, etc.

Lidar quality 2E (LQL 1 + Raman etc. + calibration)

Two signals to get backscatter- and extinction coefficient (Raman, HSRL, etc.)

Calibration:	see level 2B
Error calculation:	No
Products:	Backscatter and extinction coefficient (lidar ratio) from Raman method etc.

Lidar quality 3E (LQL 2E + QA)

Two signals to get backscatter- and extinction coefficient (Raman, HSRL, etc.) and quality checks

Calibration:	Level 3B
Quality checks:	Trigger delay accuracy must be better for Raman than for backscatter.
Conditions:	Accuracy < 7.5 m (< 3.75 m) for lower range limit > (<) 500 m (or so; tbd).
Results:	Estimation of valid range and max. extinction error due to trigger delay uncertainty (see NA3 docu.).
Systematic errors:	Level 3B + ?
Error calculation:	
Products:	Backscatter coefficient and extinction coefficient from Raman method etc.

Lidar quality 4E (LQL 3E + error calculation)

Two signals to get backscatter- and extinction coefficient (Raman, HSRL, etc.) with QA and error calculation

Calibration:	See level 3B
Quality checks:	See level 3B
Systematic errors:	See llevel 4B
Error calculation:	Full range dependent including all input parameters/signal.
Products:	Backscatter coefficient and extinction coefficient from Raman method etc., lidar ratio

Depolarization

Lidar quality 1D

Parallel- and cross-polarized signals without calibration

These signals and their ratio give an indication of relative, range dependent changes of the depolarization ratio, but without absolute values. If e.g. the depolarization ratio of a certain range or aerosol layer is known, the depolarization ratio can be calibrated (=> level 2D). However, it is still not known, whether this calibration is a constant over range. With additional quality checks either the valid range of the calibration constant or the range dependency of the calibration values could be determined (=> level 3D). Finally, rigorous error calculation procedures – especially for the range dependent backscatter coefficient - are necessary to determine the accuracy of the particle depolarization ratios (=> level 4D). I would rather not accept a particle depolarization ratio without that.

Products:	Uncalibrated volume linear/circular depolarization ratio.

Lidar quality 2D (LQL 1D + calibration)

Parallel- and cross-polarized signals with depolarization calibration

Calibration:	45°, Δ90° (former +-45°), or equivalent techniques (tbd).
Results:	Inter-channel calibration constant.
Systematic errors:	- Accuracy of calibration device/procedure. - Uncertainty of depolarization splitter parameters.
Error calculation:	Direct error due to error of calibration constant.
Products:	Calibrated volume linear/circular depolarization ratio.

Lidar quality 3D (LQL 2D + QA)

Parallel- and cross-polarized signals with depolarization calibration and quality checks for each signal

Calibration constraints:	Depolarization calibration error less than (let's say) relative 5%.
Quality checks:	Level 3B + range dependency of the depolarization calibration.
Systematic errors:	See level 3B.
Error calculation:	Direct error due to error of calibration constant + due to signal uncertainty (range).
Products:	Calibrated volume linear/circular depolarization ratio (level 2D) + error less than tbd.

Lidar quality 4D (LQL 3D + error calculation)

Parallel- and cross-polarized signals with depolarization calibration and quality checks and error calculations

Prerequisites:	Particle backscatter coefficient of level 4B or 4E.
Systematic errors:	Signal offset at lidar range in % of Rayleigh.
Error calculation:	Range dependent error depending on the errors of all input parameters/signals.
Products:	Particle linear/circular depolarization ratio with error.