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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Clear-air lidar dark band" *by* Paolo Di Girolamo et al.

Anonymous Referee #1

Received and published: 21 December 2017

Summary:

The paper reports on an aerosol event that was observed with lidars in southwest Germany during the HOPE campaign in 2013. Over the presented period of 1 hour, the multi-parameter BASIL lidar, the key instrument in this study, measured a slowly descending, geometrically thin and stable filament of boundary-layer aerosols that exhibited diminished elastic light backscattering. This feature, which the authors dub a clear-air lidar dark band, contrasts with the prevalent dynamic conditions. With the help of wind data from a near-by wind lidar and radiosonde data it is argued that the optical phenomenon was produced by lignite particles transported from an open-pit mine about 3 km away, and that it occurred in updrafts rather than downdrafts at a background relative humidity of about 62 percent. After a short literature survey on lignite particle emissions, the authors then employ Mie theory to model the backscattering efficiency of lignite particle spectra with relatively narrow size distributions and

conclude that the observed lidar dark band may be the result of the particles growing by water uptake during updrafts, with the backscattering efficiency passing through a local minimum. No satisfactory explanation is given why the reversal process likely to occur in downdrafts does not produce a similar effect.

The subject material falls within the scope of Atmos. Chem. Phys., and is of interest to the aerosol lidar and modeling communities. The presented experimental data are interesting, and the explanation is plausible, however, more effort should be made to better support the conclusions, especially, profiles of other parameters as measured wit BASIL should be included in the study, and the origin of the observed air masses should be accessed more carefully.

In summary, the manuscript is suited for publication in Atmos. Chem. Phys., however, revisions are deemed necessary.

General comments:

1. BASIL is, according to Section 2, a high-performance multi-parameter instrument, capable of measuring water vapor, temperature, and several aerosol optical properties at up to three wavelengths, including depolarization ratio and extinction ratios. How come then that only its range-corrected backscatter signal at 1064 nm (RCS1064) and the 532-nm depolarization ratio (DR532) are used to visualize the lidar dark band? Neither the water vapor and temperature measurements are utilized to determine relative humidity directly nor the set of particle optical properties is exploited to obtain some microphysical parameters of the aerosol as constraints for the model runs. And why is only RCS1064 given and not the particle backscatter coefficient (PBC1064), the physically meaningful quantity? The reviewer understands that the measurement conditions were certainly difficult around noon, so probably water vapor and temperature may not be readily available. But some sort of microphysical analysis and certainly calculation of PBC1064 should be possible and should be part of this investigation.

2. Because DR532 is significant, application of Mie theory is questionable. Please,

discuss.

3. Discussion on Figs. 7 and 8, page 6: Why is backscattering efficiency in arbitrary units, and why is backscattering efficiency presented at all? Assuming a constant particle number density n, particle backscatter coefficient is proportional to the product of backscattering efficiency Q and the square of the particle radius, r^2. So, Qr^2 should be modeled to explain the lidar dark band, and ideally it should be compared to the BASIL measurements of PBC1064. Note that a decrease in Q of 10% (top panel) and 40% (bottom panel) as modeled maximally for small and large initial lignite particles (Fig. 7) would be compensated for by an increase in r by a factor of 1.05 and 1.19, respectively.

4. According to Figs. 3 and 4, westerly winds (> 240 degrees wind direction) prevailed throughout the boundary layer which did not pass over the open-pit mine (Fig. 1). The only exception is the dark-band layer characterized by slightly more southerly winds blowing from the edge of the pit. So isn't it possible that BASIL simply observed air masses of different origin (and therefore different aerosols) at different heights? Or asked differently, how certain can one be that really aerosol growth was observed? Please, discuss.

5. Page 7, lines 29ff., page 8, lines 27ff.: In their discussion of the differing aerosol behavior in up- and downdrafts the authors mention the possibility that different particles were measured. The reviewer agrees, see 4. (above). To investigate this important issue, the authors should not only show vertical wind speed for up- and downdraft periods in Fig. 5 but also wind direction.

Specific comments:

1. Page 3, lines 29, 30: Please, discard RCS1064 in Fig. 3 and show the full profile of PBC1064 instead for a better understanding of the measurement situation.

2. Page 4, line 25: This is no true. Depolarization ratio also depends on size and

refractive index of the aerosol particles. Please, be more accurate.

3. Page 5, line 1: The authors probably mean 'Figure 6'. The observation made is not at all obvious. Please, show some example profile pairs (PBC1064, DR532).

4. Page 6, line 4: How do the authors arrive at the conclusion of 15-30% size growth? And is it volume, mass, diameter growth?

Figures:

All figures: Use the same style, make sure axis labels and titles are easy to read.

Figure 2, upper panel: Show PBC1064. Dotted line hard to see. Color bar?

Figure 2, lower panel: Up-/down drafts hardly visible, use different color table.

Figure 3: Show PBC1064, full profile.

Figure 4: Use colored curves instead of symbols, explain curves in caption. Choose narrower direction range so that relevant values can be better judged, for instance 180-320 degrees.

Figure 5: Good start. Please, show PBC1064 instead of RCS1064. Also include DR532 and wind direction for a better characterization of the particles and the measurement conditions, respectively.

Figure 6: As previously noted, it is hard to discern (anti)correlations comparing Figs. 2 and 6 by eye. Example profile pairs (PBC1064, DR532) would help.

Technical corrections:

1. Throughout text: Subscripts that are not variables must not be italic

2. Abstract, 1st line: Remove ')'at line end

3. Page 1, line 17: '200 m'

4. Page 2, line 8: 'for a selected'

5. Page 3, line 25: ‘on other days’
6. Page 4, line 8: ‘wind to the’
7. Reference Civis. . .: Remove ‘Jan’
8. Reference Krawczy. . .: Include ‘and’ between authors.
9. Reference Yau. . .: Include ‘and’ between authors, move to end of list

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