Atmos. Meas. Tech. Discuss., 6, C665–C669, 2013
www.atmos-meas-tech-discuss.net/6/C665/2013/

Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieving wind statistics from average spectrum of continuous-wave lidar" *by* E. Branlard et al.

Anonymous Referee #2

Received and published: 19 April 2013

Review for

Retrieving wind statistics from average spectrum of continuous-wave lidar

by

E. Branlard, A. T. Pedersen, J. Mann, N. Angelou, A. Fischer, T. Mikkelsen, M. Harris, C. Slinger, and B. F. Montes

AMTD-6-1943-2013

General comments

This manuscript presents a method for deriving wind statistics from a continuous-wave Doppler lidar together with evaluation/validation with in-situ measurements. Here, time-

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averaged Doppler spectra with appropriate scaling demonstrate better agreement experimentally with in-situ measurements than the pdf derived from the velocity time-series. Both field and wind-tunnel intercomparisons were performed, including investigating the influence of turbulence. Such intercomparisons are very useful for understanding how these Doppler lidars operate in practice, the uncertainties involved, and how they will perform in the field.

The manuscript is reasonably well written, introduced and logically presented. There are occasional phrases which are probably not appropriate for scientific use. Methodology is accurate and relevant, but a few instrument parameters should be included as they directly relate to the method. Figures are generally clear and precise, but the label names could be improved. However, the interpretation of the results requires some attention.

General comments:

What is the sampling rate of the Doppler lidar, and how many points are used to construct the FFTs from which the Doppler information is extracted? This information is important and should be included in the manuscript as this gives the precision of the initial velocity estimates, especially for the median method. I assume the sampling rate must be 200 MHz to achieve a Nyquist of 80 m s-1. Assuming a 512-point FFT, and 200 MHz, then the velocity resolution would be about 0.31 m s-1.

The velocity resolution of the Doppler spectra feeds directly into any discussion on the subsequent generation of velocity PDFs. For example, the expected sampling statistics for a measurement of even a known single velocity will broaden this across a number of bins in low SNR cases, especially when the beam broadening and the windowing method used in the creation of the FFT is taken into account. The FFT-windowing is mentioned on page 1961, but not explored as a potential contributor; and beam broadening at the high wind speeds used in the wind tunnel may be significant. This will show up most clearly in the PDF of velocities derived from the median method (or a

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maximum power method). In Figures 6-9, in each case the PDF denoted 'Lidar PDF' in red is not that different from the slight broadening expected just from beam broadening, Poisson statistics and the FFT-window effect, assuming 3 bins = 0.93 m s-1 (see above question about the velocity resolution). In the field experiment, this effect will be hidden since the wind is not constant, and the velocity resolution of the Doppler lidar is 0.15 m s-1.

This is a comment for the authors to consider, rather than a question for the manuscript. In Section 3.2, treatment of Doppler spectra, what is the effect of the quantization of the Doppler spectra into only 256 power bins, since, technically, you cannot retrieve the original spectra from the stored spectra by scaling? If the recorded resolution from the detector output is heavily quantized when storing, then this could also introduce artifacts when averaging the spectra later. I can however, understand the need to reduce the amount of data recorded!

Investigating turbulent statistics from velocity time series must take into account the length scales involved in the measurement. It is not surprising that the determination of velocity variance (or standard deviation) will vary from instrument to instrument if their spatial and temporal sampling characteristics are different. This does not mean that they cannot provide the same turbulent statistics, once the scale-dependence has been accounted for.

Specific comments:

Page 1951 (and preceding section). The scattering is from distributed targets (aerosol particles). These are almost always present in number concentrations certainly greater than 1e9 m-1 of which at least 1e7 m-1 are larger than 0.5 micron. Hence, even for the wind tunnel experiments, there will be plenty of backscattering targets per integration time.

Page 1955, line 19. Why not calculate the standard deviation directly from the data rather than attempt to fit a Gaussian distribution to a limited number of points?

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Page 1960. In Section 6.5, Laminar wind flow, some reasons are suggested for the slightly wider velocity distribution than predicted. The authors should also examine the beam-broadening effect, because the lidar beam is not a perfect 'pencil beam'. There will be slight contributions from the part of the beam that is not fully perpendicular before and after the waist point. Doviak and Zrnic (1993) give an excellent overview of the many potential contributions to Doppler spectral width.

Technical comments:

Page 1944, abstract, line 5. Remove 'precise' from this sentence.

Page 1944, line 13: This statement is rather subjective as it depends on what scales are of interest. It can be argued that sonic anemometers and cups do not precisely capture velocity fluctuations on the molecular scale, for example.

Page 1944, line 23. To be clear, use 'LOS' rather than 'los' as the shorthand for line-of-sight throughout the text.

Page 1945, line 9-15. It is not surprising that the variances are over or underestimated when compared to other instruments, as they are not covering the same spatial and temporal scales.

Page 1946, line 17. The fist sentence should start with 'Commercial Doppler lidar systems ..'. If you only refer to commercial CW Doppler lidar systems from this section onwards, then maybe this should also be stated here.

Page 1947, line 16. This sentence should explicitly state 'lidar frequency, lidar wavelength'

Page 1954, line 16 (and Page 1955, line 7). SI units may be more appropriate.

Figures 6-9. A more descriptive choice of labels would be appropriate for these figures. HW PDF is fine, but it is not obvious at a glance what the differences are between the two lidar PDFs, especially as they are not adequately explained in the figure captions.

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This also applies to Figure 4.

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