Observation of rainfall velocity and raindrop size using power spectrum of coherent Doppler lidar

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[09- Atmospheric temperature, water vapor, wind, turbulence, and waves]

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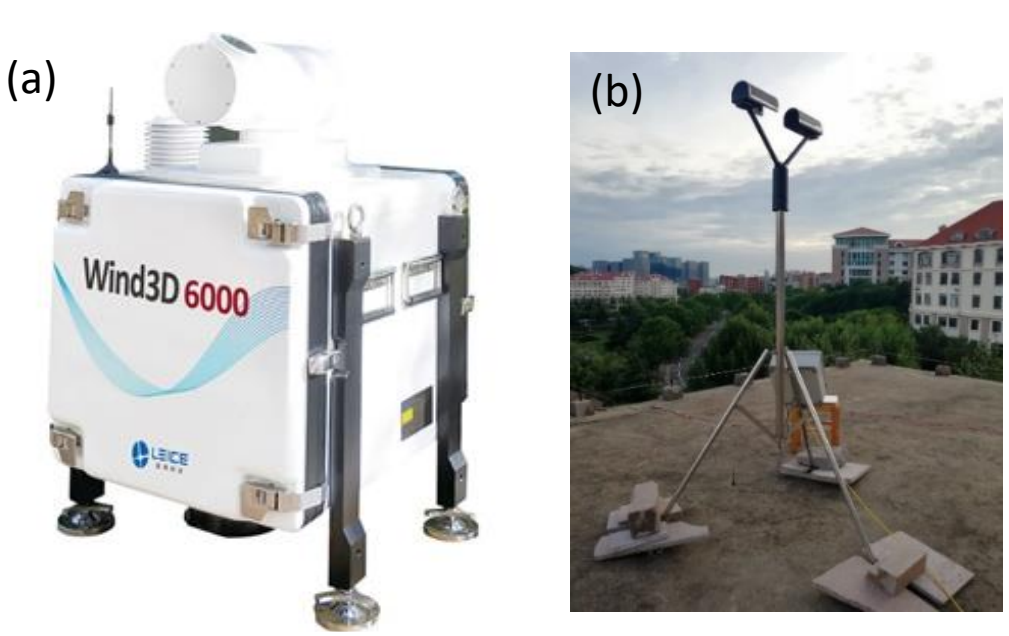
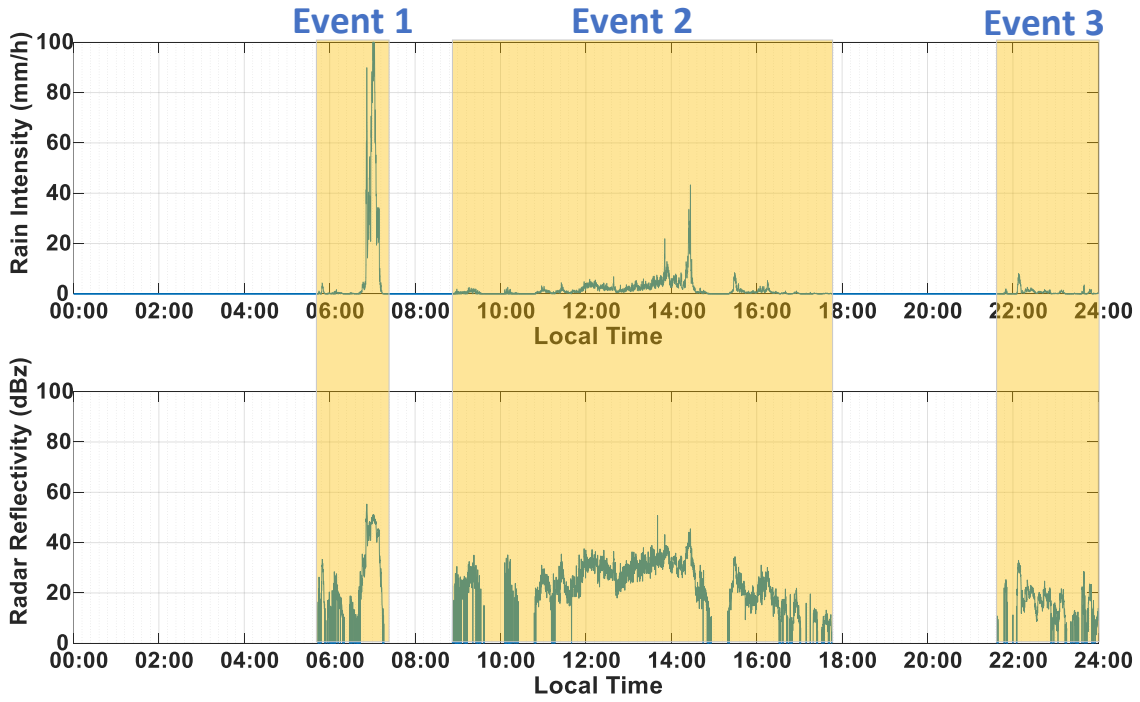
1. Experiments and Instruments

- The rain measurement campaign was conducted at the Laoshan campus of Ocean University of China.
- A ground-based coherent Doppler lidar, Wind3D 6000, is applied to observe rain in this study.
- A Parsivel2 disdrometer was deployed on the top of the building with a height of 12 m.



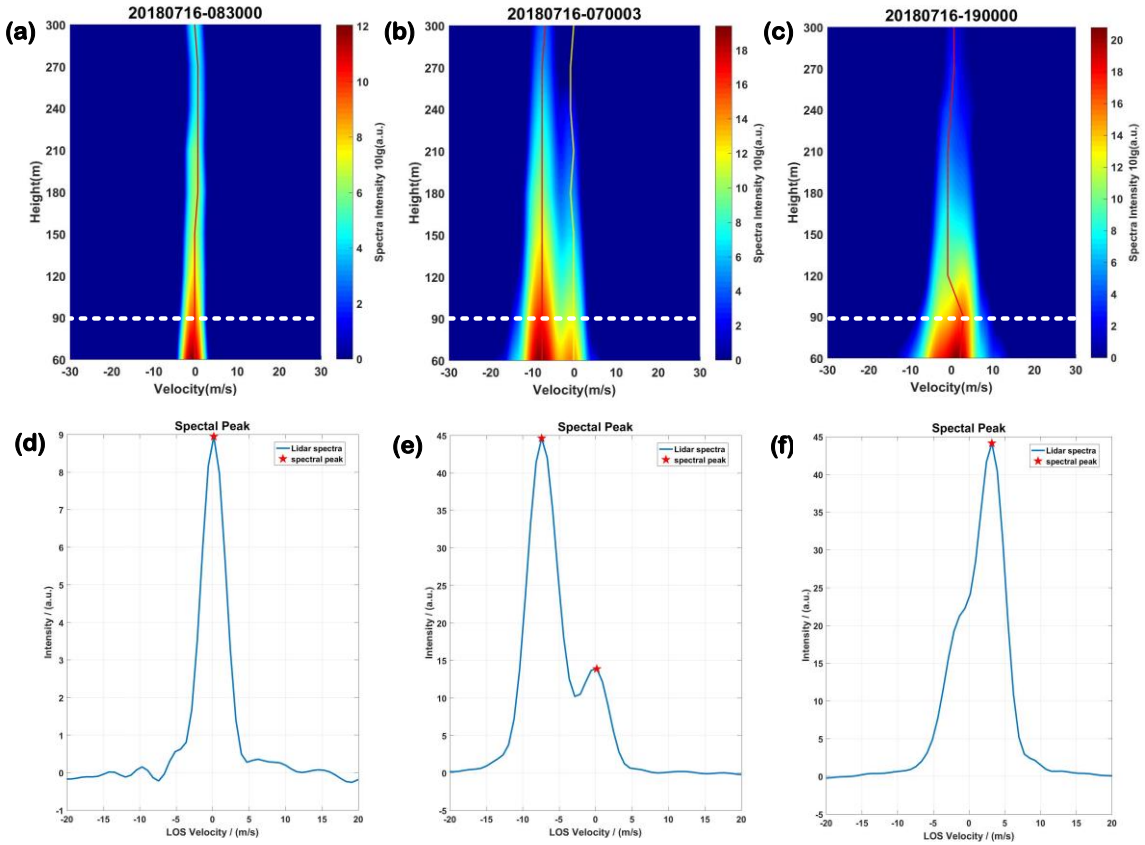
The measurement instruments. (a) Wind3D 6000 lidar system. (b) Parsivel2 disdrometer



Rain events measured by disdrometer on 23 August 2021.

2. Lidar power spectra during rain events

- During rain events, falling raindrops also introduce the Doppler shift to the power spectrum with the broadening band.
- Fig. 1e shows the lidar power spectrum with obvious double peaks at the height of 90 m. In this case, the spectrum is the superposition of the backscattering signal from aerosol particles and raindrops at various velocities.
- Different from the cases in Fig. 1a and 1b, the spectrum with a broadening band has only a single peak, as illustrated in Fig. 1c and 1f. It is called the hidden double-peak spectrum.

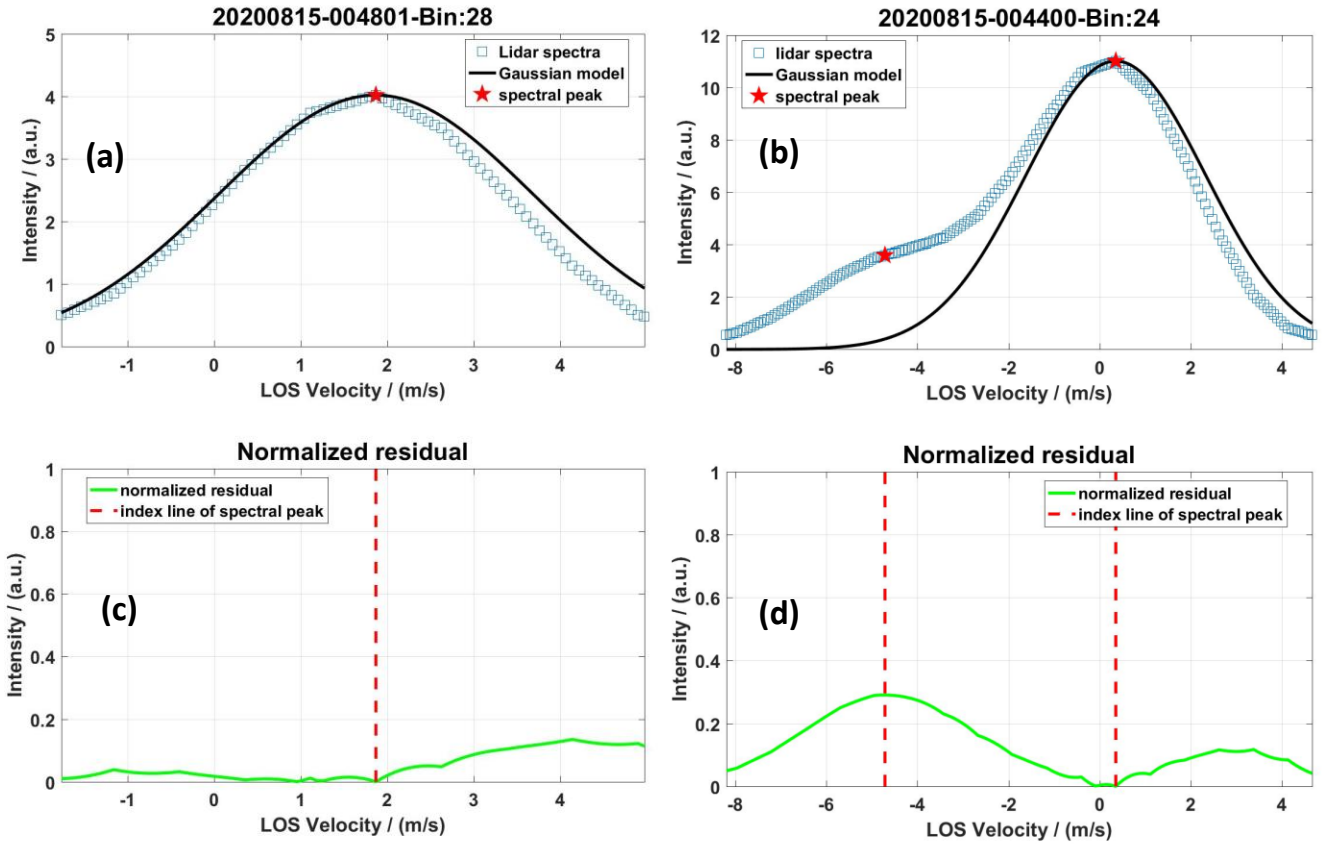


- Figure 1: Lidar power spectra under different weather conditions.

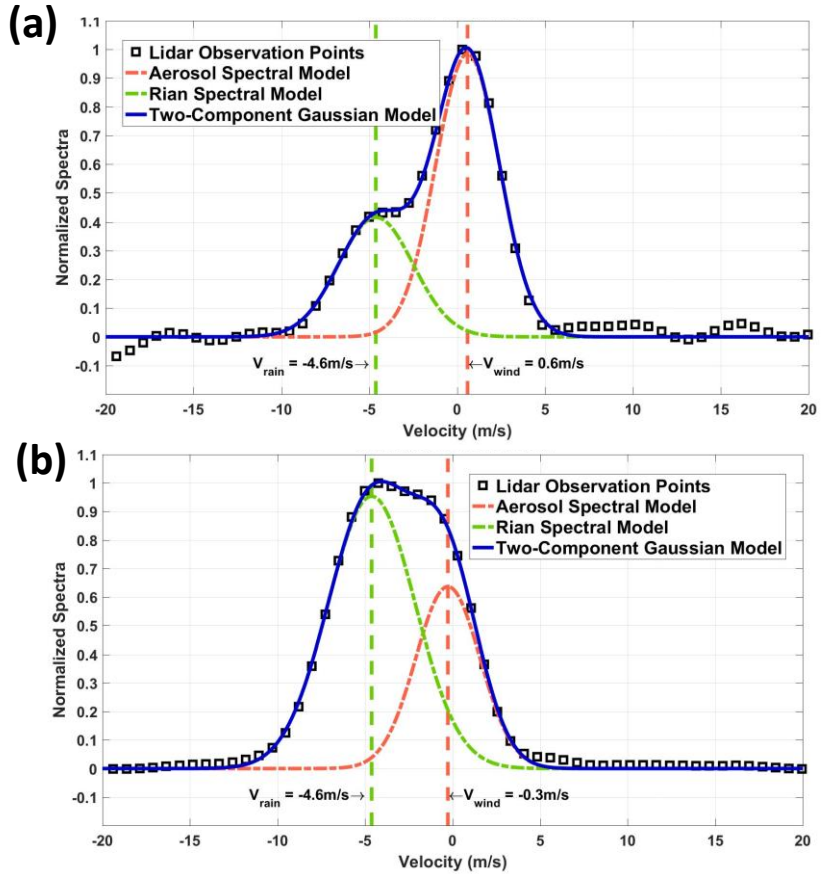
- (a) Single narrow spectral band on a clear day at different heights;
- (b) Two spectral bands on a rainy day at different heights;
- (c) Single broadening spectral band on a rainy day at different heights;
- (d) Single peak of the spectrum on a clear day at 90 m;
- (e) Obvious double peaks of the spectrum on a rainy day at 90 m;
- (f) Hidden double peaks of the spectrum on a rainy day at 90 m;

3. Rain identification

- Hidden double peaks identification of power spectrum using normalized residual.
- Spectrum-weighted rainfall velocity and vertical wind velocity can be obtained using two-component Gaussian model.



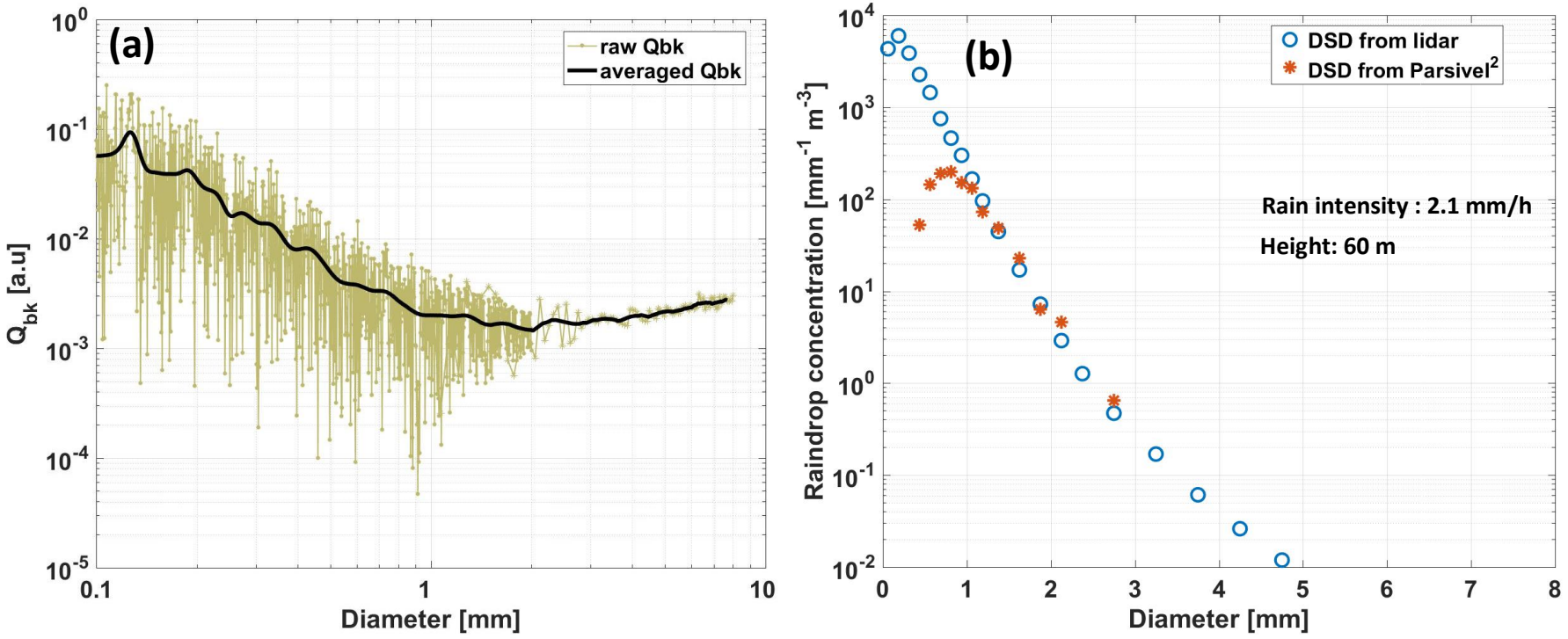
Rain spectrum identification for the power spectrum with hidden double peaks. (a) (c) single peak in clear day. (b)(d) hidden double peaks during rain event.



Rainfall velocity and vertical wind speed retrieval. (a) Obvious double peaks; (b) Hidden double peaks.

4. Estimation of raindrop size distribution (DSD)

- For the spherical raindrops with diameters ranging from 0.1 mm to 1 mm, the MiePlot model is used to simulate the backscattering efficiency (Q_{bk}). Differently, the backscattering efficiency of non-spherical rain particles is estimated by the vectorial complex ray model (VCRM) at the diameter range from 1 mm to 8 mm.
- DSD estimated by lidar have a good agreement with that measured by Parsivel2 at the diameter range of 1 ~ 3 mm.



Estimation of raindrop size distribution. (a) Backscattering efficiency of raindrops; (b) Raindrop size distribution observed from lidar and disdrometer at 12:10 on 23 August 2021.

Thank you for your attention!

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