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The potential for rain rate estimation from spectral moments of vertically pointing doppler radar

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Most retrieval algorithms for estimating rainfall rate from vertically pointing doppler radar observations operate on a spectrum-by-spectrum basis. In other words, these algorithms estimate the parameters of the raindrop size distribution, the magnitude of the vertical wind, and the magnitude of the turbulence-induced spectral broadening (i.e. 4 to 5 parameters in total) for each doppler spectrum separately. Hence, they generally do not take into account the spatial and temporal correlation structure that is characteristic for these parameters in rainfall. We propose a rainfall retrieval algorithm which bypasses the need for estimating drop size distribution parameters on a spectrum-by-spectrum basis. It is based on statistical relationships between rain rate and the low-order moments of the doppler spectrum, i.e. the radar reflectivity factor (0th order moment), the mean doppler velocity (1st order moment), and the doppler spectral width (2nd order moment). These relationships are in fact generalizations of the widely used power law radar reflectivity - rain rate relations. We derive theoretical relations between rain rate and the doppler spectral moments for several widely used parametric forms of the raindrop size distribution (gamma, lognormal), taking into account diameter truncation effects. We demonstrate that by taking into account additional information provided by higher order spectral moments, the parameters of the derived statistical relations should become less dependent on the raindrop size distribution and its variability. Using measured raindrop size spectra, we demonstrate the validity of the derived theoretical relations in different types of rainfall (convective, stratiform) in different climatic settings (The Netherlands, south of France). We discuss the implications of our approach for the scaling (normalization) of raindrop size distributions and doppler spectra. Finally, we assess the potential of the proposed methodology for practical purposes by investigating its sensitivity to the magnitudes

of vertical wind and turbulence-induced spectral broadening.