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Interactive comment on "Turbulent enhancement of radar reflectivity factor for polydisperse cloud droplets" *by* Keigo Matsuda and Ryo Onishi

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This paper extends the prior work carried out by Matsuda, Onishi and colleagues on radar Bragg scattering resulting from spatial correlations in hydrometeors in turbulent flow. Here the work is extended to polydisperse particle size distributions, which is of importance for atmospheric clouds in which size distributions are almost always broad. Specifically, it is known that polydispersity in particle Stokes number directly influences the distribution-averaged radial distribution function, and indeed, here it is shown that the Bragg scattering is also modified. The problem is of relevance to fully quantifying radar returns from clouds, and possibly in the future can lead to methods for remotely determining additional cloud properties, such as turbulence intensity or perhaps even size distribution width.

The work is sound, and would be publishable except for one critical factor that has been neglected. The authors have used direct numerical simulations of turbulence with Lagrangian particles having finite inertia (Stokes number), but have neglected the gravitational sedimentation term. This is justified by referring to a 2017 paper in which the authors showed that the gravitational sedimentation effect is small (< 1 dB for the size and turbulence ranges of interest). The 2017 paper, however, deals only with monodisperse droplet populations, and it is reasonably well established that a key signature of gravitational settling for low-Stokes-number particle clustering is reduction of the bi-disperse radial distribution function. The effect is similar to the bi-disperse clustering effect described in the theoretical treatment of Chun et al. (2005, see their section 2.3). It leads to saturation of the power-law dependence of the bi-disperse radial distribution function. This cross-over scale is discussed by the authors in section 4.1, but the role of gravity in modifying that is not discussed. The radial distribution function is directly and quantitatively connected to the Bragg signature, so it is very likely that the sedimentation-induced saturation effect will be a first-order effect. The saturation effect resulting from particle settling has been confirmed in subsequent DNS and experimental studies (e.g., Ireland et al. “The effect of Reynolds number on inertial particle dynamics in isotropic turbulence. Part 2. Simulations with gravitational effects” J. Fluid Mechanics 2016, see their section 4.2; Lu et al. “Clustering of settling charged particles in turbulence: theory and experiments” New J. Physics 2010, see their section 4).

The current neglect of sedimentation requires, at least, major revision of the manuscript. Simulations that include gravitational sedimentation should be used, and perhaps compared to those without sedimentation. If the results are as strongly influenced by the gravitational settling effect as I suspect they will be, then it will be necessary to rewrite the results and conclusions sections of the paper.

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