Dear Dr. Davide Ori,

We appreciate the time and effort you have dedicated to providing detailed feedback on our manuscript. Your comments are valuable to improve the physical framework of our Doppler spectrum simulator. The detailed responses are shown below.

Response to the dynamical system comments:

In the original manuscript we adapted a simple and idealized assumption to simulate the droplets movement in the air: we assumed that all the droplets are moving horizontally, and the only force being exerted is the horizontal wind. To simulate the Doppler spectrum observed from a vertical pointing radar, we further assume that the droplets falling with their terminal velocity (V) is equivalent to exerting an additional horizontal wind (with speed as V) to the particle. In the revised manuscript, we adapt the reviewer's suggestions and include the particle gravity in Eq1. for the Doppler spectrum simulation. We also included a sign function to accounting for the wind force exerted from different direction detailed in Eq.2. The equation describing the motion of particle in a fluid is now consistent with previous study, e.g., Equation 3 in Businger (1965) and Equation 9.1 in Lamb and Verlinde (2011). A detailed description of the modified model can be seen in section 2.1 in the revised manuscript. The results shown in Figure 5 and Figure 6 are reproduced using the modified framework.

Response to the inconsistent terminal fall velocity comments:

The relationship between the drage coefficient (C_d) and Reynolds number (R_e) in the original manuscript is based on Schlichting and Kestin (1961), in which the relationship is fitted from experiment results where a rigid sphere falls in the fluid. This relationship is not applicable to non-spherical or distorted particles such as for raindrops with diameter larger than 2 mm. The terminal fall velocity used in the original manuscript (Eq.8) is one of the fitting function based on Gunn and Kinzer (1949) in which a carefully experiment is conducted to measure terminal fall velocity of liquid droplets terminal in atmosphere. In the reviewer's comments, we can notice a consistent terminal fall velocity between the experimental-based (i.e., Gunn and Kinzer, 1949) and the theoretical-derived (i.e., Schlichting and Kestin, 1961) method until rain drops are larger than 2 mm. To mitigate this discrepancy for larger rain drop, we utilized a new fitting function in the revised manuscript to describe the relationship between C_d and R_e based on the same experiment data to derive the terminal fall velocity(Gunn and Kinzer, 1949). This newly fitted C_d - R_e function can generate a consistent terminal fall velocity compared with the experimental results (Figure R1). We have modified the manuscript accordingly.

Line122: "…The only unknown factor is the drag coefficient C_d, which should be derived from experiment. Numerous studies have been conducted to measure the sphere terminal fall velocity in fluid and estimate C_d as a function of Reynolds number (Re) (Schlichting and Kestin, 1961;Lapple and Shepherd, 1940;Haider and Levenspiel, 1989). However, the derived C_d - Re relationships in the previous studies are applied for rigid spherical particles. For the rain droplets with large diameter, the droplet is distorted and the exerted drag coefficient for a given Re deviates from the rigid sphere. To this end, the drag term of the rain droplet is obtained from the measurement of the terminal velocity of liquid droplets. Here, we adapt the experiment data from Gunn and Kinzer (1949), in which study C_d and Re are estimated for liquid droplets with diameter ranging from 100 μm to 5.8 mm. The experiment-derived C_d and Re are shown in Fig. 1, we further fit the data with a fifth-degree polynomial (red line) to estimate C_d for a given Re:…"

$$logC_d = 1.4277 - 0.8598 \times logRe + 0.0699 \times (logRe)^2 - 0.0023 \times (logRe)^3 - 0.0003 \times (logRe)^4 + 0.0013 \times (logRe)^5 \quad (1)$$

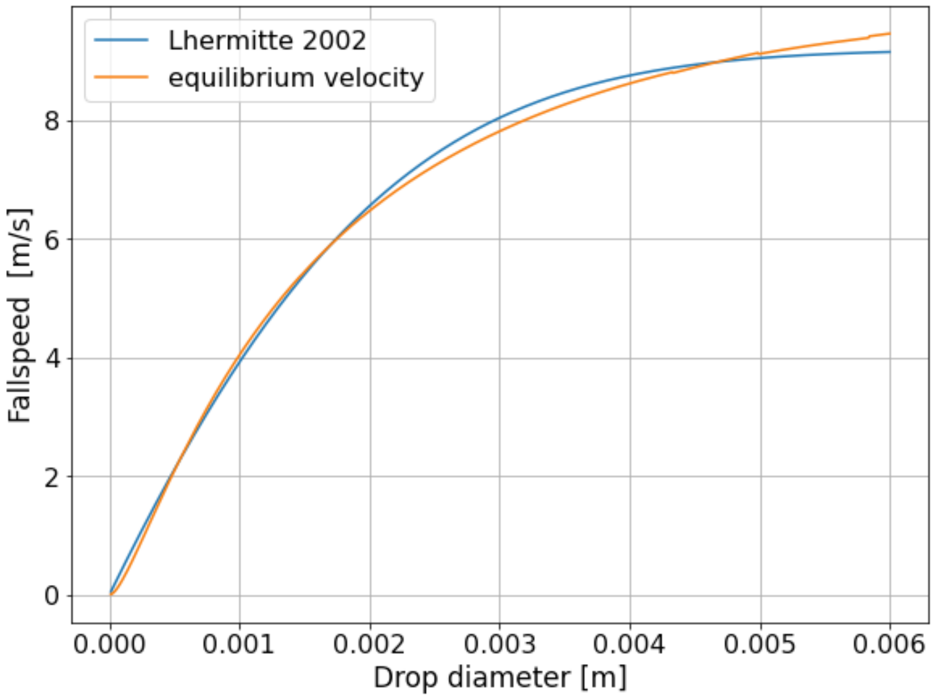

Figure R1: Droplet terminal fall velocity as a function of diameter from the experiment fitting (Lhermitte 2002) and from the theoretical estimation of the terminal fall speed. We adapted the reviewer's python code to generate Figure R1, except a newly fitted C_d - R_e function is utilized. This newly fitted C_d - R_e function (Eq. 5) can generate a consistent terminal fall velocity compared with the experimental results.

Minor Points:

Title and Line 13 - the generic term" particle" suggest that the model is applicable to any hydrometeor. However, it seems clear to me that the proposed methodology is applicable only to liquid drops. Perhaps it is better to specifically address only liquid precipitation.

Response: We have clarified that the proposed simulator is applicable to liquid phase particles in the revised text.

Line 13: "…Here, we investigate the inertia effects of liquid phase particles on the forward modelled radar Doppler spectra…"

Line 454: "… Here, the impact of the liquid droplet's inertia on the shape of the radar Doppler spectrum was investigated…"

Line 53-56: I believe that there are some additional contributors to the spectral broadening. For example, the finite beamwidth allows for some of the horizontal wind component as well as the vertical shear of the horizontal wind to cause some spectral broadening.

Response: We have rephrased the sentence as follows:

Line 53:"…the Doppler spectrum width is mainly contributed by the spread of the hydrometers terminal velocity, the horizontal and vertical wind shear within the radar observation volume, and small-scale turbulence.."

Line 89 - The data section seems a little misplaced here, it makes a sudden interruption to the introductory argument which focuses on the methodology and the methodology itself which is presented in Sec 3. Sec. 2 is very short and the data are used only in section 5 which is again quite short. Since the method is the central focus of the paper I suggest to make Section 2 a subsection of the current Section 5.

Response: We have merged the previous data section and the Doppler spectrum comparison section in the revised manuscript as the reviewer suggested.

Line 102 -" turbulence" - turbulent

Response: Changes have been made in the revised manuscript.

Line 109 - The title of this subsection explicitly mention turbulence. However there is no effect of turbulence explicitly taken into account. The subsection merely list the equations used to define the dynamics of spherical objects in a fluid regardless of its laminar or turbulent status.

Response: The subsection title has been modified as:

Line 102: "Motion of droplets in the air"

Figure 3 - y-label velcoity - velocity

Response: Changes have been made in the revised manuscript.

Sec 4.2 (and partially also Fig 1) it is not clear to me how the equation of motion is resolved. Is a numerical method for the solution of ordinary differential equations used? What is the time resolution of the method? Is the power spectrum of turbulent air motion truncated at a certain frequency? what is the expected uncertainty in the determination of the drop speed?

Response: The ordinary differential equations described in section 2.1 are solved numerically, in this project we applied the Matlab function *ode45*. For the Doppler spectrum simulation, the utilized time resolution is 0.05s which is consistent with the frequency of the generated velocity field (20 Hz). The full spectrum of the generated turbulent air velocity is applied with no truncation in frequency. We have rephrased the description of the Doppler spectrum simulator in Section 3.2 in the revised manuscript.

Line 370 - I am not sure how the DSD shape might shift the location of the scattering notch. To me the notch occurs at a specific size and provided that there is a well-defined velocity-size relation it would occur at a specific velocity regardless of the DSD. DSD discrepancies might only move the notch up or down in the spectral power. At lines 229-230 it is stated that Mie scattering theory is used for the scattering computation which would imply perfectly spherical raindrops, However, I think that such big raindrops are not spherical but rather slightly oblate. This means that their length along the vertical (which is the one relevant for the Mie resonances considering the vertical propagation direction) is smaller. Thus, a larger oblate raindrop is needed to produce a Mie resonance effect along the vertical direction than a spherical one. I suggest the authors to try using a spheroidal approximation of raindrops for scattering.

Response: We thank the reviewer's suggestions. We have considered the oblate shape of the droplets for Mie scattering in the Doppler spectrum comparison section (Section 4) in the revised manuscript.

Line 400: "…With the observed DSD and the estimated σ_t, the radar Doppler spectrum can be simulated. It is noted that large rain droplets falling in the air are nonspherical, backscattered power from an oblate droplet may be different from the one from rigid liquid sphere. To this end, for the Mie scattering calculation, axis ratio ($\frac{a}{b}$) of the droplet with diameter larger than 2mm is considered as a function of diameter (D) with unit of mm (Pruppacher and Beard, 1970):…"

$$\frac{a}{b} = 1.03 - 0.062D$$

Code/Data availability - the authors include reference to a github repository owned by a person which is not listed among the co-authors. It is fine but I would suggest to include not the github repository, which is subject to modifications, but a more permanent link. Luckily, the repository offers also a packaged version that got a DOI on zenodo. It is ok to keep the reference in the data availability section, but zenodo offers the option to properly give author attribution, have it in the list of references, and to pin the citation to a permanent link of a specific version of the software.

I take the opportunity to also invite the authors to publish their code openly which would be of great benefit for the radar community and for the repeatability of their results. The AMT journal invites all authors to publish their data and codes, and in this particular case it would have greatly helped in the understanding of what has been done in the study

Response: We thank the reviewer's suggestions. We have cited the codes used in the manuscript in the way provided by the author. The cited reference is linked to a zenodo page.

Line 177: "…the codes being applied to generate the wind can be accessed from Cheynet (2020)…"

We would like to publish our radar Doppler spectrum simulator codes once the revised manuscript addresses all the reviewer's concerns and no more changes will be made to the simulator.

Reference

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Gunn, R., and Kinzer, G. D.: The terminal velocity of fall for water droplets in stagnant air, Journal of Atmospheric Sciences, 6, 243-248, 1949.
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