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Interactive comment on "Turbulence Induced Cloud Voids: Observation and Interpretation" *by* Katarzyna Karpińska et al.

Anonymous Referee #2

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Review report on "Turbulence Induced Cloud Voids: Observation and Interpretation" by K. Karpinska et al.

Authors report about an experimental investigation of the behaviour of water droplets measured in cloudy air at a mountain-top station. In particular, they focus on cloud voids, that is spatial regions which are devoid of droplets. To explain the observed phenomenon, they perform a numerical study of a model of inertial particles moving in a Burgers vortex (Marcu et al 1995), under the action of drag and gravity forces. On the basis of these results, with model parameters matched to those of the experiments, authors draw the conclusion that cloud voids observed under the experimental conditions were very likely a result of the presence of relatively thin yet long vortex tubes.

The most interesting part of this work is the observation of the phenomenon: cloud

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voids at the centimetre scale tell us that cloud droplets do not distribute homogeneously in space and that inhomogeneities take place also at scales much larger than the estimated Kolmogorov scale of the flow.

As for the analysis and interpretation of results, I find it weak for the following reasons. To me, the application of a simplified model like the Burgers vortex one is meaningful if we can learn something new about the dynamics of inertial particles in turbulent flows. However this does not seem the case. Indeed a detailed theoretical analysis for the motion of inertial particles in these vortical structures had already been done by Marcu et al.; the present paper reproduces one of possible scenarios of the model with suitable parameters, without adding new knowledge.

Moreover, since the work of Marcu et al., there has been a considerable amount of research about statistical characterisation of inertial particle spatial distribution in turbulent flows. Many different analysis in terms of deviations from Poisson distribution, Radial Distribution Function or Voronoi diagrams, have been applied to the case of polydisperse solutions also (see e.g. 2012 New J. Phys. vol. 14, 095013). Let me stress that voids appear at scales which are about 20-40 Kolmogorov scales, so distances at the edge between the dissipative and the inertial ranges of turbulence, where the strongest intermittent fluctuations take place.

To summarise: turbulence at small scales is very different from a superposition of Burgers vortices, the use of simplified models can be accepted at a qualitative level to make things clearer but can not replace statistical analysis. Since the observations are interesting and worth of publication, I suggest the authors to perform additional work and to make a considerable revision of the manuscript.

Detailed comments 1) Starting from the Abstract and then few times in the paper, authors speak about sorting effect. What is it? Can they state clearly what is the sorting effect and how it is different/similar to the preferential concentration effect?

2) In Section 2, the authors should detail what are the Mie scattering visual effects.

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These are often called as possible co-responsible for the creation of voids, but there are not data or analysis related to them. Have these effects been observed in laboratory experiment? Can we reproduce similar conditions? Either the authors better detail what they have in mind, or it is better to simply mention the problem once.

Also in Section 2, they mention that the "velocity structure functions were calculated using Taylor's frozen-flow hypothesis, and the energy dissipation rates were determined using inertial range scaling". Can they show these data to see the extent of the inertial range both for the temporal and the spatial scales?

3) At the end of page 4, the authors mention that they selected 27 voids for further analysis. Are these statistically equivalent? Can the authors perform a statistical analysis of the way droplets distribute in space? See comments above.

4) Table I should be enriched with turbulent flow parameters such as the value of the Taylor scale Reynolds number Re_{λ}, the value of the Kolmogorov scale τ, estimate for large-scale eddy-turn-over-time T_L and correlation length L, the expression used for St and Sv.

5) Pages 8 and beyond: I would suggest that values such as $A_{cr} = 0.02176$ or $r_i=2.1866$ to be put in a table, they have no special physical meaning (only within the Burgers vortex model).

6) Section 4 is not clear and moreover as the authors specify: "Different scenarios of particle motion determined by above stability conditions were shown in Fig.4 in Marcu et al. (1995). Fig. 4 here presents a simplified illustration of one of the scenarios: three equilibrium points, unstable point near the axis, stable point far from the axis, and droplets rotating around the vortex center." How are the other scenarios excluded? What is special in the one chosen?

Here the whole analysis can also be made much shorter, and summarised in terms of the very natural rough conclusions mentioned at the end of page 11. Details can be

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moved in an appendix.

7) Authors want to reproduce observations of August 27: from figure 1 it is the day with a very broad radii distribution. Have they used this shape to initialise the numerical simulations? Or can they superpose the shape they used to the experimental one? This is not clear from the text and the sentence "A semi-Gaussian distribution of droplet radii cut off at R = 1.5μm was chosen for simulations to match the experimental values from the 27th of August (see Table 1)" without further details does not clarify the point.

8)The work reports about void/clustering effects of inertial particles in turbulent flows but many relevant papers for the topic are not cited. To mention just a few: Collins and Keswani, 2004 New Journal of Physics 6 (1), 119; Bec et al. 2007 Phys. Rev. Lett. 98, 084502; Monchaux, Bourgoin, and Cartellier, 2010 Phys. Fluids 22, 103304.

9) A number of typos are present.

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