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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The breakup of levitating water drops observed with a high speed camera" *by* C. Emersic and P. J. Connolly

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Review of "The breakup of levitating water drops observed with a high speed camera" by Emersic and Connolly

Recommendation: Requires major revision before the paper can be published.

This paper presents experimental results from a wind tunnel regarding the fragment size distribution of drops that is generated by the collisions of pairs of raindrops. The paper is noteworthy because it attempts to fill in the phase space of colliding raindrops beyond that investigated by Low and List (1982) by examining the products that are generated from collisions of raindrop pairs that are closer in size to each other than the pairs of raindrops that were used by Low and List (1982). In this regards, the paper

could offer some significant insight into the nature of raindrop collisions and should be published provided that an extremely important limitation of the study be clarified. In addition, there are a couple of other major comments that should be addressed and some additional relatively minor corrections.

The major problem with this study is the manner in which the collisions of the levitating raindrops occurred. In nature, a raindrop collision occurs when a large raindrop overtakes a smaller raindrop because larger drops have faster terminal fall speeds. This is the manner in which the original Low and List study was conductedâĂŤlarger drops overtook smaller drops and the resulting fragment distributions were examined. However, in this study drops were levitated in an air stream and the drop impacting from above was always smaller than the levitated drop. The authors state that "this approach was appropriate to address the aims of this study." However, they need to do a better job to explain why this is the case. The physics behind raindrop collisions is a 3-body problem, where one must consider the interactions of both the two drops and the air molecules in between them. A small drop overtaking a large drop will have different physical processes at work than a large drop overtaking a small one, and I believe that the energetics of the collision will be different. In order for this paper to be publishable, the authors have to explain why the results from their experimental setup are expected to apply to raindrop collisions in nature, and why their experiments would be expected to provide the same fragment size distributions as the original Low and List experiments. Indeed, some of the differences that the authors are reporting from the parameterization of Low and List may be caused by the fact that they are observing a different physical process.

I am also recommending some other major revisions to the manuscript that should be easier to address than the point above. The authors compare their experimental results to the parameterization of Low and List. I do not think this is the best way to assess the output of their study for a couple of reasons. First, there are problems with the Low and List parameterization that the authors acknowledge. Most of these shortcomings of the Low and List parameterization were overcome by the McFarquhar (2004) parameterization. It ensures mass conservation, provides more of a physical basis for extending the results of the original 10 colliding pairs to arbitrary drop pairs, and has a complete uncertainty analysis. Thus, provided that this current study is representing the same physical phenomena as the original Low and List collisions, I would expect to see a closer match to the McFarquhar (2004) parameterization than the Low and List (1982b) parameterization. However, the best way to do a comparison would be to compare the original experimental results of Low and List against the experimental results of this study (i.e., is it possible to examine the fragment size distributions generated by one of the original 10 colliding pairs of Low and List). Such a comparison also might alleviate some of the concerns noted in the first major comment above.

My third major suggested revision relates to the use of the Low and List parameterization in the numerical modeling study. As stated above, I would not recommend the use of the Low and List parameterization because of its inherent problems. I would recommend the authors use the McFarquhar parameterization because it gives a better representation and more of a physical basis to the products generated by the collisions of arbitrary sized raindrops. It is important to note that with the use of the McFarquhar parameterization, a three-peak steady-state distribution of raindrops is no longer realized in the numerical outputâĂŤrather a two-peak distribution is realized, with the two peaks representing the drops generated by coalescence and by the breakup fragments respectively. It should also be noted that much of the original observational evidence of the three-peak raindrop distribution is now in question. McFarquhar and List (1993) showed that the effects of irregularities in the diameter classification of the Joss-Waldvogel disdrometer produced artificial peaks at the locations where peaks had been reported in observational studies, and further, that the magnitudes of the instrument-related peaks were similar to the magnitudes of the observed peaks, negating some of the previous evidence of three-peak distributions. Thus, I recommend that the authors use the McFarquhar parameterization in their modeling studies and rewrite their sections concerning the observed three-peak distributions of raindrops. I refer them to

my review paper (McFarquhar, 2010, Raindrop size distribution and evolution, Rainfall: State of the Science, Ed. F. Testik and M. Gebremichael, Geophysical Monograph 191, American Geophys. Union, 49-60) for more details on this topic.

Minor comments:

To me the use of “drop spectra” should be replaced by “drop size distribution”. I think the term “spectra” should be reserved for electromagnetic radiation. However, I leave this as a suggestion that the authors can either accept or ignore.

Check the first sentence of the abstract. It reads awkwardly.

Page 11744, line 14, coalescence and drop should be separated by a space.

Page 11746, line 24. What is the definition of a significant change? Is a statistical test applied?

Page 11747, line 2. What does slight mean?

Page 11750, line 29. 25 breakup events is very few. By contrast, Low and List observed approximately 1,000 breakup events.

Page 11751, Can Section 4.2 and 3.2 be combined? That might help with the flow of the paper.

Page 11753, lines 20-22. There is a lot of difficulty in extending the Low and List parameterization outside the range of observations where data were collected (see McFarquhar 2004). Suggest comparing against McFarquhar (2004) parameterization results instead, or preferably comparing against the original Low and List data.

Page 11754, Lines 17-18. This lack of drops interacting at their true terminal velocity could be a major reason why the results of this study differs from that of Low and List. The terminal velocity affects the collisional kinetic energy, which is one parameter that the generated fragment distributions depend on.

I hope that the authors find these comments helpful.

Greg McFarquhar

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