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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Droplet Clustering in Shallow Cumuli: The Effects of In–Cloud Location and Aerosol Number Concentration" *by* Dillon S. Dodson and Jennifer D. Small Griswold

Anonymous Referee #2

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The paper is on analysis of field experiment data pertaining to droplet clustering in clouds. This is an important subject considering that the experimental evidence for preferential concentration (inertial clustering) due to interaction with turbulence has been well established in the laboratory since at least a decade ago, yet it has never been satisfactorily documented from field data of atmospheric clouds (as far as I know). The main difficulty stems from statistical non-stationary commonly encountered in cloud data, as the author have discussed in the current manuscript.

In relation to my own criticism, I see it fitting to first clarify that I do not share Referee 1's disapproval (ref: RC1) of the "normalization" done by the authors in the analysis of PCF.

The methodology and the foundation of such practice, the authors failed to disclose, has evolved and, in my view, sufficiently matured in the course of time since Shaw et al. (2002). A mathematical foundation (or origin) of the multiplicative effect of larger scale inhomogeneity on small scale clustering signatures in the Radial Distribution Function (by definition = PCF+1) was exposed (if not proved in strict mathematical sense) in Saw et al. (2012); the same paper also includes a demonstration, using experimental data, of how large scale inhomogeneity resulting from incomplete turbulent mixing caused an apparent uniform upward "shift" of the inertial clustering signatures at small scales. In short, it was shown that the mathematics of how RDF is calculated dictates that: when two concurrent phenomena of inhomogeneities are uncorrelated and occurs with sufficient scale separation, the plainly calculated RDF equals the product of two RDFs, each results from the one of the two phenomena acting alone, i.e. g(r) =g_1(r) * g_2(r) .

The above discussion, while relieving the doubts on the normalizing practice, unfortunately triggers another conundrum. Referring to the results (e.g. Figure 4) in Saw et al. (2012), the RDF signature associated with mixing of large (above Kolmogorov) scale inhomogeneity is a curve monotonic increasing with decreasing scale at first, transitioning into a plateau as we approach dissipative scales (the height of the plateau gives a relative measure of the level of inhomogeneity observed). The shape of the corresponding PCF would be qualitatively similar (but somewhat stretched at the large scale end) and this is remarkably similar to all of the PCF seen in the current paper. While, on the other hand, the RDF signature associated with inertial clustering, as found in many previous studies (many direct numerical simulation studies, theories and some experiments e.g. Saw et al. (2012)), have shapes suggestive of power-laws. Thus, it is reasonable to ask if the resulting PCFs in this paper should be more appropriately associated with the inhomogeneity at cloud edges due to entrainment and thus mixing dry and cloudy air, rather than with inertial clustering? Such a view is not inconsistent with the authors own estimate of Stokes numbers of the observed droplets, which is on the order of 0.01 (although we don't really know how good is the 100cmËĘ2/sËĘ3 guess for the energy dissipation rate). Previous works suggests that St âĹij Order(0.01) should results in RDF with power-law exponent of order 0.01 or less, very likely indistinguishable from a plateau or flat horizontal line, given realistic signal-noise ratio of in-situ cloud measurements.

I think major addition/revision is needed to convincingly disentangle mixing signatures from inertial clustering signature, otherwise the paper might have to be rewritten with a different focus (see below).

In relation to points above, perhaps I would suggest, if I might be so bold, that the current data might be better used for careful study of the RDF signatures of the cloud edge entrainment-mixing, which is perhaps also of interest? A good understanding of this will certainly be informative for discovery of proper methods of disentangling entrainment-mixing from inertial clustering in cloud data.

minor comments: page 4, line 31: replace "by" with be page 8, line 1: time should have units in seconds not meter.

Ref: Saw, E. W., Shaw, R. A., Salazar, J. P., & Collins, L. R. (2012). Spatial clustering of polydisperse inertial particles in turbulence: II. Comparing simulation with experiment. New Journal of Physics, 14(10), 105031.

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