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Interactive comment on "An emulator approach to stratocumulus susceptibility" *by* F. Glassmeier et al.

Anonymous Referee #2

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Review of An Emulator Approach to Stratocumulus Susceptibility

By Glassmeier, Hoffman, Johnson, Yamaguchi, Carslaw, and Feingold

Summary

This paper describes experiments in which an ensemble of large eddy simulations is used to train a statistical emulator. The purpose is to explore the sensitivity of the cloud radiative effect, as represented by cloud fraction and cloud albedo, to changes in droplet number concentration and liquid water path. Since it is not feasible to realistically perturb the LWP and N space directly, the authors instead perturb the initial and boundary conditions, then resample the resulting ensemble so that it more evenly spans the range of LWP and N. The emulator is then trained to reproduce the response

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in Ac, CF, and rCRE as a function of changes in LWP and N.

The emulator appears to be able to effectively reproduce the behavior of Ac, CF, and rCRE over a range of LWP and N values. Perturbation of initial and boundary conditions is consistent with environmental controls on real Sc clouds, while the mapping to distribution of LWP and N allows for an effective exploration of the dependence of cloud radiative properties on cloud physical properties. The results indicate there are differences in response in drizzling and non-drizzling regimes, and that the emulator is more flexible in its representation of the cloud response than a linear regression methodology.

General Comments This paper presents an effective compromise between reductionist and emergent approaches, simplifying the former and adding more nuance and physical interpretation to the latter. The methodology is well described, and the sources of uncertainty are addressed. Overall, I find this to be a very interesting paper, and a nice contribution both scientifically and methodologically. The only issue I have is somewhat subtle and involves the partitioning of the LWP and N space into quadrants.

Specifically, I found the discussion of the four quadrants to be over-complicated - in particular, there does not appear to be much distinction between Q3 and Q4. The only plot that appears to show distinct behavior for Q3 vs Q4 is 5a, and the region of interest (the isolines of CF at lower left) is double-hatched, indicating much larger uncertainty in the emulator's ability to capture the behavior of the clouds in this region. Examination of Fig. 7 indicates there is perhaps only a single trajectory in this region of the state space, which makes me suspicious of the results. Instead of partitioning the drizzling portion of the state space into two distinct regions, I recommend first distinguishing between drizzling and non-drizzling (according to number) and then separating the non-drizzling cloud into those with large vs small LWP. This would result in three regions (Q1, Q2, and Q3+Q4), and I think the results based on the combined Q3+Q4 would be more robust. Certainly the key conclusion, that there is a strong dependence on N in the drizzling part of the state space, does not depend on dividing into Q3 vs Q4, right?

Specific Comments

1. p3, lines 30-31: Do the combinations of initial conditions make physical sense? E.g., do they correspond to physically realizable atmospheric states? LHS, as a space filling algorithm, does not necessarily respect the physical constraints known to be true of real environments, and often one must apply these constraints a posteriori to the LHS ensemble of initial conditions.

2. p12, line 4: Strictly speaking, the text here refers only to Fig. 4 not to Fig. 5, and I recommend removing the reference to Fig. 5 and instead making specific reference to it on line 7, which refers specifically to the cloud fraction results (shown in Fig. 5).

3. p12, line 10: I'm nit-picking here, but shouldn't the sampling uncertainty be Fig. 6 (not Fig. 7) and the combined uncertainty plot be Fig. 7 (not Fig. 6) so that they are in the proper order? In the current version, Fig. 7 is discussed before Fig. 6, which is a little strange.

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