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Interactive comment on "Towards variational retrieval of warm rain from passive microwave observations" *by* David Ian Duncan et al.

Anonymous Referee #3

Received and published: 12 June 2018

This study examines the feasibility of using passive-only microwave satellite measurements to retrieve drizzle and rain in warm oceanic clouds. It's a topic that has been largely unexplored and the authors have made, in my opinion, a convincing case that it can be done but with caveats. Their results have confirmed my suspicions about the DPR missing a good portion of drizzle and light rain. Some argue that it doesn't matter since the amount of liquid mass associated with warm rain and drizzle is insignificant from a hydrological point of view. However, studies have shown that drizzle production in stratocumulus clouds has a significant impact on cloud albedo, which has implications for global climate.

The authors also have a firm understanding of the challenges involved and have thoroughly considered all sources of error and the method's limitations. Dynamical ad-

justment of the observation error covariance matrix in the context of rain drop size distributions is perhaps the most novel part of the study.

Specific comments:

Page 3, lines 1-9: As pointed the authors point out, there are important implications for this work in all-sky radiance data assimilation (DA). It is also important to note that aside from characterization of the observation and forward model errors, there are also limitations in the simulation of cloud fields in NWP models. Nearly all NWP models contain crude microphysics, not allowing the DA system to take full advantage of the information content provided by passive microwave measurements. Section 3.1: Partitioning the drizzle onset by other environmental parameters (TPW/SST) is a good way to deal with the fact that methods which use a single LWP threshold in all conditions (e.g., Wentz and Spencer 1998) do not work very well for warm clouds (Greenwald et al. 2018). Section 6.2: For me, the bottom line in the usefulness of a 1DVar retrieval is knowing whether it relies too much on the a priori information. One way to quantify how much the 1Dvar retrievals depend on this information is to compute the matrix Da = 1-A, where A = Dy K (K is the kernel matrix), and where Dy = Sa KˆT(K Sa KˆT + Sy) ˆ(-1), which uses the same notation as in eq (3). Da provides a measure of the contributions of the combined measurements relative to the a prior information. It varies between 0 and 1, where 0 means the retrieval is relying completely on the combined measurements and 1 means the retrieval relies completely on the a priori state.

A 1DVar retrieval also provides a means of computing the retrieval error, which may also be useful. Have the authors considered computing this error? Other comments and corrections:

Page 2, lines 16-17: It's not clear to me why only a 1DVar retrieval and not other retrieval techniques should be "sensitive to rainfall below the detectability of the DPR." Is there a past study that demonstrates this comparative sensitivity?

Interactive comment

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Discussion paper

Page 2, lines 20-27: I feel that the description of the Bayesian method is a bit over-simplified. A very good overview of the method is described in Evans et al. (1995; JAM).

Page 3, line 13: " For a rain retrieval . . ."

Page 4, lines 6-7: What spatial resolution are the brightness temperatures convolved to?

Page 5, line 1: I don't necessarily agree with the general statement that "passive radiances at typical frequencies contain almost no information on the vertical structure of hydrometeors." This is probably true for shallow warm clouds, but not for deep convective clouds. Studies have shown there is in fact some vertical information available (see, e.g., Smith et al. 1992; Evans et al. 1995).

Page 5, first paragraph of section 3.1: This paragraph contains well known information that could be removed.

Page 5, Figure 1: You might consider using color instead of grayscale.

Page 6, lines 1-2: I would mention somewhere that the retrieved LWP is actually the total LWP, that is, rain water path plus cloud liquid water path.

Page 6, line 4: I'm assuming the "observations" are the GMI observations?

Page 6, line 5: This part of the sentence is a bit confusing. What do you mean by "precipitation frequency?"

Page 15, line 19: "excepting" should be "except"

Page 16, lines 19-20: The sentence beginning with "The few pixels raining hardest . . ." sounds awkward. Consider rewriting as "The few pixels containing the largest rain rates . . ."

Page 18, last sentence: The meaning of the sentence beginning with "Here a threshold

of . . ." is unclear. Would it be possible to rewrite this sentence?

Page 24, line 1: What about radio interference at 10 GHz?

Page 25, line 15: Should "yet" be at the end of the sentence?

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