Response to Reviewer 2

General comment:

This paper provides a nice overview of how to obtain process information from snapshot measurements of cloud systems through reviewing the literature of previous observational and modeling studies. The previous relevant works are reviewed in the well-organized manner that classifies the past approaches according to relative magnitudes of time scales of phenomena and observations. I think that this review is enlightening and encouraging to further explore key fundamental processes of cloud systems through deliberate use of measurement data to obtain observation-based process understanding that is highly required these days to essentially advance numerical modeling of clouds. I only have a couple of minor comments listed below that I hope can be addressed easily by the authors. After the authors address those points, I recommend this manuscript to be published.

We thank the reviewer for their positive comments!

Specific points:

Line 74-75: It is a bit unclear to me what the "observation timescale" means. At first, I interpreted it to be a "temporal resolution" of observation, but later I realized that this means what is more like a "duration of observation". Is this interpretation correct? I would appreciate the authors to clarify this point to avoid possible confusion for interpreting the meaning of the Deborah number and the classification into Type 1 and 2.

The reviewer is correct: the observation timescale is the duration of observation. We now make this clear in the revised manuscript on first usage on line 74.

Section 2: Given a remarkable progress in satellite observations with active sensors in this couple of decades, I'm just curious how various types of statistical analysis with vertical profiling data from radar/lidar are classified into the two types the authors defined. In particular, I'm wondering how three statistical methods of compositing the vertical cloud profiles, namely, Contoured Frequency by Altitude Diagram (CFAD), Contoured Frequency by Temperature Diagram (CFED), and Contoured Frequency by Optical Depth Diagram (CFODD), are classified into the two types or any other type. A-Train satellite data is touched on in Section 4, but more detailed discussion of active sensor-based analysis would be appreciated.

Statistical compositing methods can be applied to single storms or to large composites. Based on the ideas laid out here, the former is likely to yield better physical constraints than the latter because of the increasing likelihood of changing conditions with multi-day composites. We expect that changing conditions would generate more variance in e.g., CFODD plots.

Note that one of the first examples we introduced in the original was for surface radar tracking a storm system over its lifetime (lines 77-80 in the revised manuscript) but we now add more text on statistical compositing as in work by e.g., Suzuki et al. (2010, DOI: 10.1175/2010JAS3463.1). In keeping with our discussion of the Stephens and Haynes example, we now add the following text on lines 262-266:

A related topic is the use of space-based radar and spectrometer retrievals of Z and COD, respectively, to interpret the relative importance of condensation growth (higher COD but almost no change in Z) and collision-coalescence growth (higher Z but little to no change in COD) (Suzuki et al., 2010). Based on the arguments above, when applied to single storm systems one expects such data to be of Type 1, but when compositing over many storms with different dynamics the analysis is expected to be of Type 2.

Section 2.3: As a quick note on Stephens and Haynes (2007), I like to point out that the left-hand side and right-hand side of equation (2) are not obtained from independent measurement information. The left-hand side quantity (P times h) is derived from r_e, COD and Z, according to the expression on the right-hand side. By carefully looking at the right-hand side, the timescale of auto-conversion, represented by the slope in Figure 3, is solely determined by Z. This correspondence of Z to the timescale comes from the assumption of Long's collection kernel proportional to sixth power of particle radius that happens to coincide with the dependence of Z on particle radius (which is also sixth power). Constrained by this assumption, the variability range of the timescale (or slope in Figure 3) simply reflects the variability range of Z bracketed between -15dBZ and 0dBZ. This understanding of Stephens and Haynes (2007) should be more clearly described in the authors' argument of Line 224-230 to interpret "why the process rates are relatively poorly constrained". Again, the diversity of the timescale is just a simple translation from the diversity of Z, according to equation (2).

The reviewer is correct. We have modified the text to clarify the Stephens and Haynes methodology and the origin of Z on the RHS of the equation. We still keep this brief in order to focus on the conceptual aspects of the paper. See changes on lines

230-231: *Of note is that the appearance of $\bar Z$ in Eq. (2) derives from Long's collection kernel for small drops, which has an r^6 dependency*.

238-239: *Because the kernel function is a function of r^6, the range of time-scales simply reflects the variability in $\bar Z$ bracketed between -15 dBZ and 0 dBZ.*