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Interactive comment on "GTS v1.0: A Macrophysics Scheme for Climate Models Based on a Probability Density Function" *by* Chein-Jung Shiu et al.

Anonymous Referee #1

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The authors developed a new macrophysics scheme (so called, GTS) and showed that the global climate simulated by the GTS scheme has a good quality. This GTS scheme parameterizes both liquid and ice cloud fractions based on the sub-grid distribution of hydrometeor. The GTS uses two different shapes of PDF: one is a symmetric triangular PDF, which is identical to that of GTS's host scheme (the Park scheme), and the other is a uniform PDF. The authors analyzed the performance of the GTS scheme in many ways and showed that the GTS scheme using a uniform PDF (U_pdf) has a better performance than the triangular PDF in most cases. Before being published, I hope the authors address the below comments. My recommendation is to accept the draft with a major revision.

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Discussion paper

Major comments:

1. Lines 177-182 and others The authors said that "....with the uniform PDF: dC=qs(1-RHc). Therefore, RHc = 1-(dC/qs)." This sentence implies that a uniform PDF with dc corresponds to a symmetric triangular PDF with ãĂŰRHãĂŮ_c of 1-(dc/qs). Although these two distributions have the same dc and RHc as the authors mentioned, they have different variances. The variance of a uniform PDF is (1/3)dCˆ2 but that of a triangular PDF is (1/6)dCˆ2. Instead of using the same half width in two PDFs, isn't it more reasonable to use the same variance for fair comparison ? The authors may repeat the analysis with the same variance.

2. Lines 186-195 This paragraph suggested a formula for the fractional area of ice cloud (bi) as a function of grid-mean water vapor(qv), grid-mean ice condensate(qi), the half-width of PDF, and the saturation specific humidity over ice (qs,i) with a tunable parameter (sup). The authors should provide more detailed explanation on this formula. For example, can the ice cloud fraction be positive when temperature is above 0 degree ? What is 'sup' ? Is the 'qi' used in this formulation the input qi or the qi updated by the GTS scheme or the average of the two ?

3. Lines 219-221 Please provide more explanation on how the T_pdf computes the variable width after clouds are formed. Although the authors mentioned that this variable width is computed using the grid-mean mixing ratio of hydrometeors and the saturation ratio of the environment in Lines 648-654, more detailed explanation is necessary.

4. Lines 298-299 To assess the performance of the scheme, the authors used the ERA-Interim cloud fraction. However, ERA-Interim cloud fraction is not a direct observation but model result. As far as I know, researches do not use ERAI cloud fraction as an observation (in contrast to temperature etc.). The authors should use other data set as "observed" cloud fraction. Also, it may be good to provide some explanations on the sources of the biases in the cloud fraction. Is the bias due to the biases in the

environmental conditions (e.g., environmental relative humidity) or others (incomplete parameterization) under the same environmental conditions ?

5. Lines 290-292 The values of the tunable parameter (i.e., RHc) and the horizontal overlap assumption between liquid and ice cloud fraction, which are used to calculate offline CF in Figure 2, should be explained in detail.

6. Lines 331-334 The authors used the correlation coefficient between RH and CF to evaluate the performance of cloud parameterization. This is very weird: the correlation coefficient only shows the degree of the linear relation between two factors, not the performance of the scheme. In nature, non-linear relationship is likely to exist between RH and CF. Is it fair to say that a higher linear correlation indicates good performance ? I am not sure whether I can agree with the authors' argument.

7. Lines 381-383 and others The GTS scheme parameterizes the large-scale cloud (stratus) fraction in each grid layer. The cloud fraction and associated variables (e.g., cloud radiative forcings) in GCM are also influenced by the parameterizations of convective cloud and vertical cloud overlaps. The authors may want to discuss about this aspect.

8. Lines 648-650 As mentioned above, T_pdf and U_pdf have different variances although they have the same RHc. In other words, the U_pdf uses a wider distribution than the T_pdf. The larger differences between U_pdf and T_pdf compared to the differences between T_pdf and the Park scheme may be due to this difference in the variance.

9. Figure 1 Not all cloud macrophysics schemes assume uniform temperature over the grid. The authors should mention the uniform temperature assumption for the GTS scheme in the main text as well as in the caption of Figure 1.

Technical corrections: 1. Line 176 qt in Eq. 2 should be overlined as it denotes a grid-mean qt.

2. Line 182 use a subscript ‘c’ in δc

3. Line 209 The first line of Eq. 6 could be simplified to 1/6 ãĂŰ(1-s_s)ãĂŮˆ3.

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