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Interactive comment on "The Importance of Considering Sub-grid Cloud Variability When Using Satellite Observations to Evaluate the Cloud and Precipitation Simulations in Climate Models" *by* Hua Song et al.

Anonymous Referee #2

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General Comments:

This is a well written paper that clearly demonstrates the importance of considering the sub-grid variability of cloud and precipitation when applying the COSP MODIS and CLOUDSAT satellite simulators. The authors demonstrate that the radar reflectivities derived from the sub-grid CRM cloud and precipitation properties, versus the grid mean properties, are vastly different and excluding sub-grid variations can lead to misinterpretation of model performance (leading to the conclusion that the drizzle or rain is triggered too frequently).

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I find this work to be important as its results will impact the analysis of CMIP6 model simulations, many of which will very likely be using the oversimplified COSP sub-column generator in version 1.4.

Specific Comments:

Line 83: What is the pixel resolution of MODIS?

Line 129: A more detailed description regarding clouds and micro-physics in SPCAM would be appreciated. How can microphysical processes be resolved at 4km? Does SPCAM use the Morrison and Gettelman (2008) microphysical scheme mentioned?

Fig 2 (& related Caption) - Add experiment name to plot and caption. In regards to Subplot e) Add title to columns (ie mixing ratio / eff. radius). (FYI - I like that the authors added the variable and routine 'frac_out from scops.f' to the caption. This will be very helpful for other modelers).

Line 218: Consider sharing the modification to COSP to the community.

Line 274-247: The obs. pdf needs to be further analyzed. Finding that CloudSat only detects 54% of collocated warm clouds MODIS detects is a significant problem that needs to understood/explained further. Are you saying that a large chunk of the 46% of undetected clouds are too thin and can explain the sharp decline in the pdf around -40 to -25dBZ? If so, how often are warm liquid clouds too thin to be detected by CloudSat (check with CALIPSO)? Ground clutter really only influences the lowest approx. 1$\sim$km. This would imply that nearly half (or some significant fraction) of the clouds MODIS detects are within the lowest 1$\sim$km (again, check with CALIPSO). Also, is there a way of checking for frequency of attenuation (for a given altitude) in the Observations? While I understand this will very likely not change the results of this plot, it is important to note which types of clouds are being eliminated in the observations.

Line 339 / Section 4: Can you state which other COSP simulators, and how a few selected variables, would be influenced by the sub-grid cloud variability (and in-cloud mi-

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crophysical properties)? Otherwise, I recommend changing broad statements of about the COSP simulator to more specific statements regarding the CloudSat simulator.

Section 4: It needs to be emphasized that the 'sub-grid variability of mass and microphysics within each hydrometeor type' is key.

Double check references.

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