

Interactive comment on “SimCloud version 1.0: a simple diagnostic cloud scheme for idealized climate models” by Qun Liu et al.

Anonymous Referee #1

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1. General Comments

This study proposes a simple diagnostic cloud scheme that could readily be adapted to multiple GCMs. The authors demonstrate that the cloud scheme can capture many of the basic features of observed cloud fraction and cloud radiative effects using an idealized GCM, Isca. Skill scores of the simulated results are comparable to many of the CMIP5 models, which is impressive. The proposal of the simple cloud scheme is useful, because the cloud scheme potentially helps to understand the inter-model difference in climate simulated by multiple GCMs, which has been a serious issue in climate science. The manuscript is well written. The description of the cloud scheme is sufficiently complete to allow reproduction by fellow scientists, although there is room for improvement. I recommend accepting the manuscript for publication after minor

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revisions.

2. Specific comments

P1L20 "(e.g., Zelinka et al. 2017;...)" Maybe you could cite a study by Wild et al. (2019) who recently assessed cloud radiative effects. Wild et al. (2019), *Climate Dynamics*, 52, 4787-4812.

P2L27 "our best estimates are between..." Maybe you could mention the results of CMIP6, which is described by Zelinka et al. (2020). Zelinka et al. (2020), *GRL*, 47, e2019GL085782.

P5L122 "grid-mean relative humidity" Readers may be interested in the details of the relative humidity definition. Is it defined with respect to the liquid saturation only, or is it defined with respect to the ice saturation at temperatures below the freezing point? In addition, I suggest that the authors briefly describe how precipitation is calculated in the Isca GCM, because it may be relevant to the relative humidity distribution. I assume that the precipitation is diagnosed to remove super-saturation. Is the super-saturation with respect to liquid or ice?

P7L150 "0.95 at the surface, 0.85 at 700 hPa, and 0.99 at 200 hPa" Readers may be interested in how these values are determined.

P7L154 "a and b are determined from the least squares fitting" Are the parameters a and b dependent on pressure, as shown in Fig 2(a), or are they assumed constant globally?

P7L164 "biases in the cloud fraction and cloud radiative effect" Maybe you could also state that the biases are positive, namely overestimation, because you discuss reasons for the overestimation and how to reduce clouds in the following sentences.

P7L166 "there is little subgrid-scale heterogeneity of relative humidity" How does the subgrid-scale heterogeneity cause the overestimation of cloud fraction in the model simulation? It would be helpful to readers if you could describe the mechanism in more

detail.

P7L167 "The small quantity of condensation nuclei" How does the quantity of condensation nuclei cause the overestimation of cloud fraction in the model simulation? It would be helpful to readers if you could describe the mechanism in more detail.

P7L174 "only polar regions will be affected" It appears to me that the freeze-dry adjustment affects clouds in low latitudes as well, because cloud fraction is smaller in Fig 6(e) than in Fig 6(d) between 30S and 30N, at around 100 hPa level.

P9 Figure 4 caption "The thick solid and dashed black lines are specific humidity profiles" Maybe you could add that the profiles are from the Isca simulation, and whether they are annual averages or seasonal averages.

P12L245 "the liquid cloud fraction varies with temperature" Maybe you could reword the term "liquid cloud fraction", because "cloud fraction" has been used in the manuscript with a different meaning, namely, the areal fraction of a grid box that is covered with cloud.

P12L245 "which only has an influence on the effective radius" Readers may be interested in whether the "liquid cloud fraction" affects precipitation efficiency.

P13L266 " $3 \times 10^{-4} \text{ g kg}^{-1}$ at 220 K and $w_{i0} = 0.18 \text{ g kg}^{-1}$ " Readers may be interested in how these values are determined.

P14L283 "The sea ice data ... is averaged over all years and months" Readers may be interested in why you specified annual mean, not the monthly mean, of the sea ice distribution.

P21L403 "over the maritime continent regions" It appears to me that the positive bias of the LW CRE is pronounced over the subtropical oceans located east of the maritime continent, as shown in Fig.12g.

P31L525 "all the parameters associated with the critical relative humidity (a_s or a_t)"

It would be helpful to readers if you could suggest plausible range of the parameters (a_s and a_t), within which we are allowed to perturb the values.

3. Technical corrections

P1L4 "inversion strength" inversion height?

P1L4 "a simple function of relative humidity" specific humidity?

P6L148 " $C_s=1-\text{sqrt}()$ " The definition of the C_s could be written as $\max(0, 1-\text{sqrt}())$.

P19 Figure9, units shown near the color scales g m^{-2} ?

P20L376 "Fig.9e" Fig.9ef?

P20L384 "Fig.10c" Fig.10d?

P20L393 "LD" FD?

P22L418 "Isca simulations have more weakly ascending regions and fewer weakly descending regions" Fewer weakly ascending regions and more weakly descending regions?

P35L619 "Bony, S." Bony, S. and J.-L. Dufresne?

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