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Reply on RC1

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Author comment on "Interaction between cloud–radiation, atmospheric dynamics and thermodynamics based on observational data from GoAmazon 2014/15 and a cloud-resolving model" by Layrson J. M. Gonçalves et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-1014-AC1, 2022

RC1: This study examines observations of cloud cover, radiation, precipitation and atmospheric thermodynamic variables from the ARM site located in central Amazonian during GoAmazon and compares them with output from a CRM. The investigation looks for relationships between these variables in the observations and model outputs to see what can be learnt about the interaction of the clouds with their environment and their impact on radiation. The Amazon region provides an excellent environment in which to study the evolution of moist convection and how it relates to the large-scale environment. The use of CRMs is also well established to simulate deep convection and provide additional insight into convective cloud evolution. The authors evaluate various aspects of the CRM's performance including a thorough investigation of the sensitivity of CRM results to the horizontal resolution and show that the standard 2km set does a good job of simulating the temporal variability of clouds, precipitation and radiation although higher resolution better captures the distribution of cloud fraction. The study finds strong co-variations in cloud fraction and surface radiative fluxes at the surface and some correlations between cloud fraction, vertical motion, and column anomalies in temperature and relative humidity. Such relationships are to be expected given the nature of clouds, convection and radiation. In a general sense understanding these relationships better could aid the development and evaluation of cloud parameterizations in large-scale models.

AC: We thank the reviewer for carefully reading our manuscript and providing very thoughtful comments and suggestions. We are glad that the reviewer highlighted the main results aspects of this study. Please find below a detailed response to each of the comments.

RC1: The analysis looks mostly at correlations between the fractional cover of different cloud types and the min/max anomalies of T and RH in the column based on day-to-day variations. This is interesting from an observational point of view in explaining the daily variations in cloud cover and precipitation but the limitation here is that there is only a loose physical connection between these anomalies and what determines the development of these convective clouds.

AC: In this article, one of the objectives is to understand how the variation of large-scale variables (such as omega, T and RH), in relation to the average of the previous 24 hours, impacts the diagnosis of cloud fraction and radiation fields. These anomalies are produced by the physical processes (entrainment, dentrainment, updraft, downdraft, static energy, etc.) related to convective clouds, shallow, stratus, cirrus, etc. However, in numerical models, cloud fraction parameterizations are based on macrophysics variables (such as temperature, omega, relative humidity), and cloud microphysics variables (as liquid water and ice concentration) [Slingo, 1987; Sundqvist et al., 1989; Roeckner, et al. 1996; Tompkins, 2002; Gettelman et al., 2010; Bogenschutz et al., 2012; Machulskaya 2015; Dietlicher et al., 2019; Muench and Lohmann 2020]. Therefore, using information related to the convective cloud's development only helps define the cloud´s top and bottom of the cloud in the cloud fraction parameterization. The information from the convective clouds development of convective clouds may not contribute to improving the cloud fraction parameterizations currently used in numerical models. It is important to mention that cloud fraction and deep convection parameterization are independent algorithms. We are glad about this comment, we can better clarify these aspects associated with correlation analyses in the manuscript, and make the reader note that the analysed variables are based on those used in numerical model parameterizations, mainly in the cloud fraction parameterization.

RC1: The vertical profile of temperature and moisture and the resulting stability or instability (CAPE, CIN etc) is also a crucial factor that is missing from the analysis, along with broader constraints such as the large-scale convergence of moisture. This may be why the cloud fractions display a lot of scatter in their relationships to the column anomalies of T, RH and omega and relatively low correlation coefficients.

AC: CAPE and CINE are used to analyze the life-cycle of deep convection and these variables are considered in the deep convection parameterizations. Notice that this study is focused on cloud cover parameterization, and not deep convection parameterization. Because of this, the article has a more specific interest in analyzing the relationships between the diurnal variability of large-scale variables (temperature, omega, relative humidity) and the cloud fraction. Due to the use of point data from the GoAmazon experiment, the hypothesis adopted is that the information on the development of deep convection is already associated with diurnal variability of large-scale variables, as well as large-scale moisture convergence. Regarding the low correlation coefficient values found between the cloud fractions and the column anomalies of T, RH and omega, it is necessary to mention that the data of cloud fractions, liquid water and ice from the GoAmazon experiment are a restricted data and with availability limited. Therefore, the informations used as cloud fractions, liquid water and ice are obtained in this work through simulations with CRMs.

RC1: Moreover, the relationships observed during these IOPs are unlikely to be generalizable as they assume a certain degree of convective instability and hence sensitivity to the T and RH anomalies.

AC: The IOP1 and IOP2 experiments are used to analyze the dry and wet periods in the Amazon region. In the IOP1 (wet) condition, the large-scale systems that act on the region of the GoAmazon experiment are active in this period, contributing to the convective developments, while in the IOP2 (dry) period, the performance of large-scale systems is very reduced in this period, not favoring the development of convection. We also agree that the results obtained cannot be generalized, however, the analysis of these two periods (IOP1 and IOP2) statistically represents well the convective activity of the region of the GoAmazon experiment.

RC1: Perhaps there is more that could be gained from this general perspective but it is not obvious from the conclusions how the analysis presented so far could be taken forward to aid the evaluation and development of parameterizations in large-scale models.

AC: The results of this article are part of the Brazilian Atmospheric Model (BAM) development project (Coelho, et al, 2021a, 2021b, 2021c, Guimarães, et al. 2021, Figueroa, et al. 2016). All information obtained through this work is being used to develop and improve the cloud fraction parameterization used in the BAM model. A second article is being prepared focused on describing the new cloud fraction parameterization and its validation. We also glad for this comment, we could include this perspective in the manuscript.

RC1: For these reasons I find it difficult to recommend this study for publication in ACP.

AC: We hope that our answers for the reviewer may have clarified their doubts and some points that were probably not clear in the article. We intend to take the above discussion into account in the final version. The suggestions and comments from the reviewer significantly can contribute to improving the publication quality.

RC1: The study would need to show an increased understanding of the physical interactions involved or a clearer path towards improving the physics in models.

AC: We can clarify and direct the conclusions to show how to use these results to improve the cloud fraction parameterization in the models.

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