review of egusphere-2024-1519

In this manuscript, the authors couple a 3D ray-tracing radiative transfer scheme to large eddy simulations of cumulus clouds in order to investigate the effect of 3D radiative transfer, including feedbacks on cloud properties due to instantaneous changes in radiative fluxes during cloud development. This kind of study is important, because as the authors demonstrate, the coupled effect in global radiation is largely due to the changes in clouds ("the cloud effect"). They found that coupled 3D radiation increases cloud liquid water path and cloud size, which causes a decrease in global radiation, and to a certain extent, this counterbalances the increase in global radiation due to uncoupled 3D radiative transfer. Even though the authors found a net difference in global radiation of only 1 W m−2 on account of this counterbalancing effect, they revealed the importance of the changes in the clouds themselves due to the coupling, and the assessment of the magnitude of the effect is important in and of itself. The manuscript is well written, and the results are interesting and important. As such, in my opinion, this manuscript is appropriate for publication in Atmospheric Chemistry and Physics pending some clarifications and small corrections, as I list below.

We want to thank the reviewer for the kind words about our manuscript and for taking the time to review our manuscript. We address the suggested clarifications and corrections below (in green text).

1. lines 15-16: There are a few other works that could be cited here: Marshak, A. and A. Davis, Eds., 3D Radiative Transfer in Cloudy Atmospheres, Springer, 2005, and references therein; additional research by R. Pincus not already cited.
   We will add the suggested references.
2. lines 44-51: In previous studies, which specific changes in cloud development were found to be caused by shortwave 3D radiative transfer, such as cloud shadows, and which specific effects on cloud development were found to be caused by longwave 3D radiative transfer? If the authors do not want to explain that here, then perhaps refer the reader here to section 2.2.2.
   We will elaborate the indicated paragraph such that it names the changes in cloud development that were found before.
3. lines 56-58: "To validate the inclusion of aerosols, we performed simulations for a set of days with clear skies over Cabauw, the Netherlands, which we compared with observations." – I suggest adding "see section 3" here.
   We will add this.
4. lines 58-59: "Next, we used the setup with aerosols to simulate a set of 12 days during which shallow cumulus clouds developed. After comparing the results with observations to ensure that the simulations resemble reality…" – Are these sentences referring to simulations with or without coupled 3D radiative transfer, or both?
   We will add here that these were simulations with 1D radiative transfer. However, as the cloud cover with coupled 3D radiative transfer is very similar to the cloud cover with 1D radiative transfer, we would have come to the same selection if we had used simulations with coupled 3D radiation or both.

5. line 133: “The impact of coupled 3D radiation, hereafter referred to as the coupled effect, is the difference between the two, so 3D – 1D,” – This is a little confusing at first, because it sounds like the impact of the dimensionality, not an isolation of the coupling, but the distinction becomes clearer in the sentences that follow.
   We thank the reviewer for pointing out that this is not immediately clear. We will rephrase the sentence such that it is immediately clear that we are referring to the schematic and the experiments as we labelled them for the schematic.
6. lines 142-143: “The uncoupled effect using uncoupled 3D radiation was studied before, e.g. by Gristey et al. (2020a).” – Similar comment to my comment 1 above.
   We explicitly meant to refer to the paper by gristey et al here, as they have exactly the same effect in a way that is directly comparable to ours. We will formulate this more explicitly.
7. line 158: “based on a give location” – “based on a given location”
   We will change this as suggested.
8. line 185: “However, we miss part of the variability in cloud cover, which is likely because of the limited domain size and double-periodic boundaries of our simulations, which prohibit the formation of meso-scale structures…” – The authors refer to this fact again when they discuss future studies in section 5, but they should also mention whether this fact could have influenced the magnitude and direction of their results.
   We will mention in section 5 that this fact might have an influence on the results. Unfortunately, with the current setup it is impossible to tell if it impacts the results and if so what the magnitude and direction would be. It is not straightforward to reason what would happen, as cloud enhancements and the position of the cloud shadows relative to the cloud depends on much more than just the cloud size. One would need open boundary conditions to test this, which we have recently implemented in our model. We will start using this feature in future research to further investigate this.
9. lines 194-195: “Simulation with 3D radiation have deeper clouds” – “Simulations with 3D radiation have deeper clouds”
   We will change this as suggested.
10. lines 309-10, 310-311, and 318-319: Do these statements conflict one another? “When the difference in liquid water path (and cloud cover) is close to zero, the global radiation is higher in simulations with coupled 3D radiation.” And “… when the clouds are the same, 3D radiation gives less global radiation, which is also what we find as the uncoupled effect…” and “… uncoupled 3D radiation causes a decrease in direct radiation by side illumination and an increase in diffuse radiation by side escape and entrapment, resulting in a net increase in global radiation…”
    We thank the reviewer for pointing this out and we apologise for these conflicting statements. We made a mistake in the second phrase mentioned. This should be more global radiation instead of less global radiation.