Driving Mechanisms for Subsiding Shells in Simulations of Deep Moist Convection

The manuscript studies the mechanisms driving downdrafts at the edges of deep convective clouds. It specifically looks into the role of the environment in which these clouds are developing, mainly the effect of relative humidity in the free troposphere. Though such studies have been done before for shallow cumulus clouds, studies for deep convective clouds have been less common. The authors use LES along with a lagrangian parcel trajectory analysis to study the effect of buoyancy and vertical pressure gradients in driving the subsiding shell. The manuscript is well written, and the analysis seems sound for the most part, though I do have some concerns with some more fundamental choices made for the study. My comments and concerns are listed below:

1. Choice of spatial resolution.

   The resolution of 100m is surprisingly low and I believe you are not close to resolving the shell. How do you justify such a low resolution, and have you done any kind of sensitivity studies to check the effect of spatial resolution? Could you possibly do some kind of grid stretching in one direction to increase your resolution and reduce costs? Was there a reason to choose an isotropic grid?

   I also do not see any mention of the actual physical width of the shell?

2. Novelty of the study and new findings

   Though you mention that studies on the driving mechanisms of deep convective shells are less common, there have been a few studies. Could you make very clear what exactly the new findings are? Maybe in the conclusions? Savre 2021 seems to make some similar findings (though using an idealised CRM?), and maybe it is worth comparing the results to existing studies to confirm which ambiguities you address and solve? You do make a couple of hypothesis in the introduction motivated by observations. Can you sharpen the conclusion to make it more explicit which hypothesis you are confirming?

Detailed comments:

L34: Maybe remove ‘recently’? Your first reference itself is from 1990!

L37: at ‘the’ cloud edge

L37: protect cumulus clouds from ‘dilution’ ?

L52: Rodts et al 2003 showed evaporative cooling as the dominant mechanism before Heus and Jonker 2008? Maybe re-order this or rephrase/ remove ‘corroborate’ here?

L105: The resolution of 100m is surprisingly low and you are getting nowhere close to resolving the shell I believe. How do you justify such a low resolution?

L110: Have you tried this for a different background temperature profile? And also, do you expect changes to your results if you started with different temperature profiles? Additionally, have you tried a case with a different magnitude of RH difference between wet and dry?

L114: This slightly stronger vertical wind shear should affect your results? Can you not have the same shear?

L124: Please define qv. Maybe in L120 where you talk about water vapor mixing ratios?

L135-137: If I understand your description correctly, the shell is defined as regions with $ql<0.01$g/kg and $w<0$? How about the regions with $ql>0.01$g/kg and $w<0$? Have you checked how significant these regions are? I guess I am referring to the validity of the assumption that all cloudy points have a positive vertical velocity. Nair et al 2021 talk about different interfaces (though thresholds are set on buoyancy and vertical velocity) and it might be worth checking if there are cloudy parcels with negative velocities that should be assigned as the ‘downdraft’ and if that affects your results.

L134: Is qc calculated with a saturation adjustment scheme? The same with ice nucleation. With a resolution of a 100m this could be important? Is there any way in which you can show/plot qc and qi means across the width of the cloud and shell?

Is qc or qi more important in setting the shell boundaries? How big a role do you expect the microphysics scheme and the relatively simple droplet activation/ice nucleation parameterization to play in the identification of the cloud and shell boundaries and ultimately your results?

L140: Are the parcels uniformly distributed across x and y?

L150: Is this a commonly applied adjustment in LES or is this the first time this is being done?

L226: How are you calculating the diluted and undiluted profiles? Are these from the parcels in the LES?

L284: How much would adding wind shear affect the results?

L328: Maybe remove the word ‘both’ and include ‘(a) and (b) respectively’ at the end of the sentence. ‘parcels passing through both deep and congestus shells’ is a bit confusing/misleading.

L330 and throughout the manuscript: Could you remove the space between m and s^{-1} to make it ms^{-1}.