

Interactive comment on “Large-eddy simulation of mesoscale dynamics and entrainment around a pocket of open cells observed in VOCALS RF06” by A. H. Berner et al.

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Review of “Large-Eddy Simulation of Mesoscale Dynamics and Entrainment around a Pocket of Open Cells observed in VOCALS RF06”, Berner, A. H. et al.

General comments

This paper presents a well planned, competently executed and useful case study analysis between tailored large eddy cloud simulations and observations recorded during a specific aircraft mission of the VOCALS-Rex field campaign. Figures and Tables are of a good quality. The paper builds on a body of work currently being reported in an ACPD Special Issue on this campaign and adds new insight into the processes and controls

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on the development and sustainability of open cellular cloud structures in stratocumulus cloud decks – an important yet incompletely understood phenomena, which not only act as modulators in overall radiative energy budget but also potentially serve as a useful natural laboratory to advance understanding in aerosol-cloud-dynamic feedbacks. Specifically, this paper adds an interesting new contrasted sensitivity study between fixed and free cloud droplet number, the latter advected with turbulent flow. Comparison of the two shows that turbulent advection of N_c is non-critical in determining LWP structure and magnitude over the length scale of POCs. Furthermore, the discussion of resulting mesoscale circulation and the dynamic role in POC sustainability is useful and clearly presented. It is this reviewer’s recommendation that the paper is well suited to publication in ACP and in this Special Issue and should be published subject to minor revisions and satisfactory responses to the few general comments below.

Specific comments:

1/ The simulations ultimately presented in this case study are for a fixed N_c cross-section across the horizontal domain (the NCADVECT analysis is quickly removed from further analysis after small differences in LWP structure etc were observed). As far as I can tell, this is the only (and fixed) initial difference (microphysical or otherwise) between the POC and overcast regions in the domain. Assuming proportionally the same droplet size distribution in all regions, then I would have expected LWP to be greatly different between regions at the spin up of the run but the difference doesn’t manifest until 2 hrs in if I read correctly? Can the authors clarify that even active precipitation is not allowed to reduce N_c in the run?

2/ Subsidence is assumed to be constant (see next comment) and prognostic aerosol is not employed. Given these constraints, it is not surprising that the cloud cover in the POC does not reduce to observed near clear sky and the authors correctly note that the fixed N_c is the cause of this. However, I am concerned that gradients between the POC and overcast region gradually reduce and converge throughout the simulation, which extend into the daytime. This is the opposite of satellite observations, which show that

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the POCs “open up” in the daytime and “fill in” in the night time. The discussion on the role of cold pools undercutting and limiting LHF is valid but can the authors comment on why all properties converge between regions throughout the simulation whilst N_c remains fixed (but different) in each region. One would expect that whatever control is leading to the initial dynamical perturbation observed in the simulation should remain active throughout; and if not, why not? Understanding the causes of this convergence in the model may add insight into the true observed multi-day sustainability of POCs that this simulation is unable to capture.

3/ Subsidence: I am concerned that the model runs performed here go from local night time into day (i.e. cover the full range of the diurnal cycle) whilst a constant divergence is assumed. Subsidence is correctly noted by the authors to undergo a strong diurnal modulation, yet a constant is assumed for simplicity with the rationale that it is difficult to ascertain from observations. Since the strengths of this paper are its insights into POC mesoscale dynamics, this issue is potentially important to the central conclusions of the study. A good attempt has been made to obtain average divergence profiles from ECMWF and Quikscat data yet it would have been equally possible to take a more useful diurnal peak-to-trough amplitude in subsidence from e.g. GFS/ECMWF reanalyses. Was this not considered for reasons of numerical instability? Could the authors comment on the potential implications of their assumption? The POCs are known to undergo a dramatic diurnal cycle of their own and the relaxation/strengthening of subsidence is likely to have a highly significant role. Too often, and to detriment, free tropospheric dynamics are ignored or over-simplified in boundary layer simulations. I would be happy with the assumption used if the authors could flag the potential errors that may occur, to at least alert readers. I'd be even more interested to see what model runs with diurnally modulated subsidence looked like.

4/ In essence, this study simply captures the evolution and interaction between regions with different, but fixed local N_c . This is indeed a useful result and helps to pin down some of the resulting dynamical controls but perhaps a clearer summary of what the

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simulation does and doesn't do, and what it aims and doesn't aim to achieve, stated earlier on in the paper (it is clearly stated only in the final para of the conclusions) would aid the reader. The strengths of this paper are the analysis of the mesoscale structure, entrainment and dynamics of POCs in general and those should be strongly pitched (section 4.3 and 4.4 are especially interesting).

Technical notes:

Abstract, line 2: Consider adding “NSF-C130. . .” before “Research Flight 06” so as to distinguish this flight from other VOCALS aircraft. The simple designation of Research Flight 06 could be confused by casual readers not familiar with VOCALS.

Abstract, line 17: Revise sentence: “A secondary circulation sets up. . .” to “A secondary circulation is initiated in the model. . .” so as to distinguish between modelling and true observation and also potential ambiguity surrounding how the circulation is “set up”.

P. 13318, line 22. Consider revising use of word “emblematic” to something more appropriate and descriptive such as “symptomatic” perhaps.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 13317, 2011.

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