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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "On transition-zone water clouds" *by* E. Hirsch et al.

Anonymous Referee #1

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Summary – this is the third paper in a three-part series (Hirsh12, Hirsh13) that uses a data from a new passive remote sensing retrieval of thin clouds to examine conditions governing the formation and character of very thin cumuli with lifetimes of a few minutes and depths of O(100 meters).

Recommendation: Accept with major revisions. Developing a new technique for measuring thin boundary layer clouds and using it to constrain models of the initiation of convection is definitely a worthwhile project. To make this work publishable however, the authors need to connect it to recent, similar work in cumulus convection. Specifically, they need to address horizontal as well as vertical variability in the thermodynamic variables that determine the their initial cloud properties, and incorporate (or explain why they don't have to incorporate) thermodynamic entrainment.

Specific comments:

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Interactive Discussion

Discussion Paper

1) use conserved thermodynamic variables

This paper focuses on the variation of effective radius, vertical velocity, cloud lifetime and supersaturation as calculated by a Lagrangian parcel model given a starting height and initial relative humidity and temperature. It's much more common for large eddy simulations and stochastic parcel models to start with thermodynamic variables that obey conservation laws, because this provides a much more natural reference state: the dry and moist adiabat, for which total water and entropy or static energy are conserved. A good example of this approach is Berg04, where they measure the joint probability density function of entropy (theta) and water vapor mixing ratio and use this to drive a series of parcel models. Given adiabatic ascent, the liquid water content is fairly well constrained as a function of height from the initial (theta,wv) perturbation. This approach would make the paragraph starting at line 22 on p. 1057 much more informative – as it stands the range of maximal reff and lwc listed there is arbitrary. Instead, start with a joint distribution of temperature and water vapor perturbations taken either from collocated observations or the boundary layer literature and use that to constrain the model and interpret the results.

2) entrainment and "nature vs. nurture"

A very active research question is the extent to which shallow cloud properties are determined by the characteristic of the updraft they form on, or entrainment events they undergo during their ascent. As far as I can tell from Hirsch13, the parcel model used in this paper accounts for entrainment of momentum (eq. 4) but not of entropy of water vapor. Romps10 is a good example of how entrainment can be accounted for in a (bulk) stochastic parcel model, and how important that potentially is for shallow convection. Looking at cloud properties using an ensemble generated from observed pdfs of conserved variables, undergoing entrainment in line with large eddy simulation estimates of small scale mixing, would connect this work to the current literature and provide a more tightly constrained and more physically consistent set of results.

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3) Haze vs. activated droplets

The beginning of the paper makes the distinction between aerosols which have passed through the peak of their Kohler curves and activated, and haze particles. That distinction is then dropped in the later part of the paper, for the arbitrary definition of a cloud as a collection of droplets with a distribution that has an reff larger than 0.5 um. Given that you are carrying 250 different size classes of aerosol in the model, it would be useful to provide more detail on, the role of haze vs. activated drops in forming the size distribution of clouds in the transition zone.

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Interactive comment on Atmos. Chem. Phys. Discuss., 14, 1051, 2014.