Atmos. Chem. Phys. Discuss., 10, C2321–C2325, 2010
www.atmos-chem-phys-discuss.net/10/C2321/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Precipitation and cloud cellular structures in marine stratocumulus over the southeast pacific: model simulations" *by* H. Wang et al.

B. Stevens (Referee)

bjorn.stevens@zmaw.de

Received and published: 2 May 2010

This is an interesting manuscript that addresses itself to many open questions pertaining to the development, longevity and growth of pockets of open cells. Experiments motivated by state of the art field data from the recent VOCALS campaign are used to explore the role of meteorological factors versus the aerosol. The ideas are clearly presented both through the writing and the figures. The experiments are novel and touch on a number of factors thought to be related to the issues mentioned above. For these reasons the manuscript is in general suitable for publication in Atmospheric Chemistry and Physics.

I believe the quality of the ideas could and should be strengthened. The major weakness of the paper in its current form is that it consists mostly of show and tell and does not attempt to develop a clear message. The authors have interesting things to show, and the narrative is informative, but ideas are poorly developed. My major reservation is that no framework is developed for motivating and comparing the different experiments.

The experiments, while qualitatively well chosen, are quantitatively poorly motivated. From a broader perspective the two key parameters are buoyancy and lifting condensation level. Increasing the moisture enhances the buoyancy and lowers the LCL. Increasing temperature enhances the buoyancy but raises the LCL. This is the theoretical backdrop for many of the experiments they conduct, but it seems as if wasn't really thought about. A 0.45 g kg^{-1} moisture perturbation has an influence on the buoyancy that is equivalent to a 0.08 K temperature perturbation. Similarly one can calculate the depression of the LCL that would occur from a temperature and moisture perturbation. Why compare a 0.5 K temperature change to a 0.45 g kg^{-1} moisture perturbation? If one wants to explore the relative role of cloud deepening (LCL changes) versus secondary circulation changes, why not pick experiments that minimize the change in the buoyancy but maximize the changes in the LCL (this is hard to do perfectly because of the difference between how temperature/moisture perturbations project onto buoyancy in saturated versus unsaturated air.) Likewise a 10 W m^{-2} change in sensible heat fluxes is, in terms of buoyancy, equivalent to a 140 W m^{-2} change in latent heat flux, so why is the response so different for a sensible heat flux as compared to a latent heat flux. Simply from the point of view of energetics the PLFX experiment should be similar to the PSFX experiment, but it is not. Why?

Because no framework has been established for evaluating what a change in moisture means, relative to a change in CCN, or a change in temperature, one has really no basis for comparing the different responses. Hence the paper looses its focus.

Some more minor issues are as follows:

- RE the title: The only thing that makes the discussions here germane to the southeast Pacific is the depth of the boundary layer. A more descriptive title might be worth considering.
- 8344.14 The Peters et al. study here is quite relevant and probably merits discussion.
- 8347.22 What do you do about cloud optics. Generally clouds are very nearly conservative scatterers, hence the absorption may disproportionately be due to aerosol. However solar radiation models that have a poorly resolved solar spectrum often over-estimate the cloud absorption. Given the introduction of the cloud microphysics and aerosol model it would be good to know in detail how this is coupled to the radiation.
- 8348.22 The grid spacing is an issue. Particularly the wide body of work that shows that coarse vertical resolution and monotonic schemes greatly exaggerate the decoupling of the layer and the dissipation of the cloud. You may be forming POCS to easily here.
- 8349.01 One outstanding puzzle in an attempts to model precipitating boundary layers is the vertical velocity variance profile. Generally models show much more damped circulations than what we could infer from measurements. Including $\overline{w'w'}$ as one of your observables would help the reader determine if this remains an issue in your simulations. I suppose it does.
- 8349.23 There is the long-standing appreciation that precipitation reduces entrainment deepening (e.g., Stevens et al., 1998), how did you determine here that this was purely a radiative effect.
- 8350.01 Isn't this an idea you have the data to test. As it reads now it seems like you are speculating about something that is easy to check in the simulations.

- 8351.24 Of course the simulations with clouds and water vapor have water vapor and cloud absorption. It is not like the water vapor is being exchanged from the cloud. It would be helpful if you understood the sources of SW absorption in your model (see comment above).
- 8352.25 The figures are nice and concise, but would be better if the x-y plot array were rotated to correspond with the flow visualization.
- 8353.08 I gather that I was not supposed to see this from the plots, is that correct? If so it might help to indicate parenthetically that the evidence for this point is not shown.
- 8353.19 But the CCN change is relatively bigger. See my major point above, what is the metric for comparing a change in one quantity to a change in another?
- 8354.19 What is the point of drawing the analogy with thermally direct frontal circulations?
- 8356.13 Isn't the Atkinson and Zhang work referring to cold-air outbreaks, which is somewhat different than what you are talking about, or where were you supposing the 1200 Wm $^{-2}$ is coming from?
- 8356.21 Why does "upsidence" (I am not sure that the community benefits from the wider use of this phrase) lead to more entrainment. I think of this being an adiabatic contribution to the evolution of the layer. Please explain.
- 8358.14 Please provide a reference or justification for the estimated aerosol source strength. It might be good to compare to a sea-spray production mechanism.
- 8359.17 The figure is missing.

- 8360.19 Of course there will be pre-existing variability in the water vapor field during the process of stratocumulus formation, hence deeper more precipitating clouds may exist from the outset, i.e., POCS may often be there from the very beginning.
- 8361.11 What does this discussion add beyond what was shown by Savic-Jovic and Stevens.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 8341, 2010.