Atmos. Chem. Phys. Discuss., 15, C8013–C8018, 2015
www.atmos-chem-phys-discuss.net/15/C8013/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Drizzle formation in stratocumulus clouds: effects of turbulent mixing" *by* L. Magaritz-Ronen et al.

Anonymous Referee #2

Received and published: 14 October 2015

In this manuscript, the author analyse the effect of turbulent mixing on drizzle formation in stratocumulus using a Lagrangian-Eulerian model. They find that mixing has two opposing effects: first mixing delays the initial formation of drizzle drops by diluting high LWC parcels, but later mixing is essential to create an environment in which drizzle drops are able to develop further and therefor reach the sub-cloud layer.

The Lagrangian-Eulerian model is a great tool to analyse drizzle formation and I think that the manuscript can contribute to better understand the puzzling role of mixing in drizzle formation in Sc. However, I have two general comments which should be taken into account before publication.

General comments

I understand that the LEM, which is used for this study, has been developed and described in earlier papers and that turbulent mixing has been included as a process in the LEM by the same group of authors (Magaritz-Ronen et al. 2014). In that 2014 study, the authors simulate and analyse a different research flight (RF01 instead of RF07) from the same field campaign (DYCOMS-II). Although RF01 is a non-precipitating case and RF07 develops more pronounced precipitation, in their 2014 paper the authors already conclude that "turbulent mixing leads to an increase in the effective radius and facilitates and accelerates drizzle formation" (this is from the 2014 abstract). I think that the current analysis shows some new results compared to the 2014 paper, especially concerning the opposing effects of mixing. However, some of the analysis overlaps, e.g., Fig.6 in the 2014 paper and Fig.3 in this manuscript. Please point out more clearly, where the currents study builds on (or reproduces) results from the earlier study and where it contributes new insights. Please skip overlapping analysis if necessary.

In the manuscript, a collision parameter is defined as $N^2 r_e^5$. In the stochastic collection equation, the collision rate depends on the droplet concentration, the size of the droplets and on the velocity difference of pairs of droplets. Assuming that drops fall with terminal fall velocity, the velocity difference can be related to a size difference. Therefore, I would expect that a collision parameter should be highly sensitive to the DSD width, which characterises droplet size differences. However, in Fig.11 there is only a small dependence of the collision parameter on the spectrum width. Please discuss, how and why you define the collision parameter as you did. Which assumptions are in the formulation? Why does it not depend on the DSD width? How does the formulation effect the interpretation of the results?

Specific comments

1. Throughout the text, e.g., p.24132, l.20: If several references are listed to support one statement, they are usually sorted by year, not alphabetically.

2. p.24133: The first paragraph is hard to read because it jumps between different topics, please restructure. Maybe have two paragraphs: one about the processes that foster drizzle, and one about the difficulties of LES to simulate drizzle.

3. p.24135, l.3: Is the model version used in this study exactly the same as described in Magaritz-Ronen et al. (2014)? Or are there differences to that version?

4. p.24135, l.5: 2D turbulence is known to have a quite different structure from 3D turbulence. (See, e.g., Stevens, B., Feingold, G., Cotton, W. R., and Walko, R. L. (1996). Elements of the microphysical structure of numerically simulated nonprecipitating stratocumulus. Journal of the atmospheric sciences, 53, 980-1006.) What are the limitations of using a 2D model? What might be the effect on the results?

5. p.24136, l.6: Does the formulation of Pinsky et al. 2001 include turbulent enhancement in the collision efficiency? If so, I think it would be worth to state that here. If not, what is the effect of neglecting turbulent enhancement?

6. p.24136, l.21: In that formula, why is K a function of l? Is ϵ a function of l? Later, in section 3 it is said that ϵ is set constant (in the BL).

7. p.24136, last paragraph: Do inconsistencies arise from those "two kinds" of diffusional growth?

8. p.24137, l.3: Is SST fixed? At what value?

9. p.24137, l.11: Please add references here or skip that sentence.

10. How long is the simulation? What is the timestep?

11. It might be my personal taste of style so please ignore this comment if you feel strongly about it: I think figure caption should not be repeated in the text, e.g., Fig.3. on p. 24140, l.9-13 or Fig.11 on p.24146, l.8-11. Skipping them would shorten especially section 4, which is sometimes a bit lengthy to read.

12. p.24140: This paragraph is hard to follow. At several points I am not sure how the sentences are relating to each other: l.7 what kind of changes in the variable field? l.17 How does homogenisation making the processes (which?) adiabatic? l.17 Which two limits? Cloudy and inversion layer from two sentences ago? l.20 What do you mean by magnitude of q_t and θ_l?

13. p.24144, l.14-15: I think the statement of the second half of the sentence is too strong. Looking at the last panel of Fig.7a, it is not the parcels with the highest initial humidity that have the highest LWC, but the parcels with the highest LWC that preferable start from the highest initial humidity.

14. p.24144, l.24: What is "the maximum value of the DSD"? Maximum r_e?

15. p.24145, l.3: It would be interesting to see how much LWC a parcel loses through sedimentation. Looking at Fig.8b the contribution might be small.

16. p.24146, l.22-23: This sentence does not makes sense to me. Why would drizzle drop formation continue because something has happened before?

17. p.24150, l.25-27: This paragraph/sentence appears somehow unrelated. Please skip or relate to the following text.

18. p.24151, l.2-17: The recirculation of aerosols and the importance of large aerosols for the drizzle drops seems somewhat speculative to me. Please back this up with analysis or skip it.

19. p.24151ff: Section 5 is rather a summary of section 4 than a discussion. Although I like the conclusion section 6 in its current (concise) form, please think about combining section 5 and 6 (or section 4 and 5).
20. p.24152, l.10-18: The comparison of Sc and Cu appears here out of the blue. I would recommend to skip it because Cu are not the topic of the manuscript. If you want to keep it, a thorough discussion of literature on lucky parcels in shallow cumulus is needed (e.g. studies by Lasher-Trapp, Cooper, etc.).
21. p.24153, l.29f: Larger compared to what? Fig. 13 does not show spectrum width.
22. Fig.1: Please use the same colour scale to make the figs comparable.
23. Fig.2: Labels of the x-axis are wrong. Is concentration the concentration of cloud droplets?
24. Fig.3: Why do you show data for different height layers from the model and the observation?
25. Several figure (e.g., 2, 3, 5, ...) show model data from different point or periods in simulation time. For what reason did you chose those (different) time frames? It seems a bit arbitrary to me.
26. Throughout the text and e.g. in Fig.6 and Fig.7: Is humidity and q_t the same in manuscript? Please clarify.
27. Fig.8b: Please explain the y-axis. M is never mentioned.
28. Fig.11: How do you calculate the spectrum width?

Technical corrections

1. p.24132 l.25: comparatively to what?
2. p.24134, l.12: of the droplet size distribution
3. p.24137, l.3: Lagrangian-Eulerian Model (LEM).
4. p.24137, third paragraph: Stay in present tense for the model description.
5. p.24139, l.29: model by using
6. p.24140, l.13: Concentration of cloud droplets?
7. p.24142, l.11: Insert a paragraph break here.
8. p.24143, l.5: layers
9. p.24143, l.16: $t = 150$ min?
10. p.24144, l.27: g m^{-3}
11. p.24145, l.14: to investigate
12. p.24146, l.4: substantially, leading
13. p.24152, l.20-22: This sentence is grammatically not correct, please rephrase.
14. p.24153, l.23: as a result of
15. Fig.16: Add "in cloudy parcels" to the caption.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 24131, 2015.