The manuscript "A comprehensive numerical study of aerosol-cloud-precipitation interactions in marine stratocumulus" starts with a valuable synthesis of the Large Eddy Simulation studies that have so far focused on the tight coupling between aerosol, large-scale conditions, cloud and precipitation within stratocumulus capped marine boundary layers. The authors go one step further and attempt to do a more systematic evaluation of the impact of aerosol, precipitation and large-scale conditions on the evolution of marine stratocumulus, by performing an extensive set of LES which basically gather the sensitivities (to aerosol or large-scale conditions) explored by the similar LES studies lead up to now. Although the idea is valuable and this paper would constitute a comprehensive review of our current understanding of marine stratocumulus-aerosol interactions, a few flaws of the manuscript should be addressed before the paper is suitable for publication in ACP.

General comments

- The authors should better emphasize in the introduction why is important to perform another set of LES, which could be in fact be seen as a repeat of previous sensitivity tests of marine stratocumulus to aerosol and large-scale conditions published in the literature. The design of the set of simulations the authors perform here could also allow to compare the relative importance of changes in aerosol to that of changes in meteorology for the evolution of marine stratocumulus. Such a discussion would be very valuable, given the difficulty in making such a comparison based on observations. And therefore would worth to be included in the manuscript.

- The discussion of the results should be revised, because it often is too long, not clear and sometimes leaves the impression the authors misunderstood some of the basic mechanisms driving the stratocumulus clouds (see specific comments below).

- The differentiation of the two regimes non/light drizzling and heavy drizzling leeds often to confusion, as sometimes the clean case becomes non-precipitating and then it is not clear if when the authors talk about the impact of aerosol in heavy drizzling conditions they still/always reffer to the clean case or not.

- Drizzle evaporation in the sub-cloud layer does not always lead to a rise of the cloud base, hence a diminution of the LWP, by stabilizing the under-cloud layer and decoupling the cloud layer from the surface. Sometimes, when the cloud is only slightly drizzling the cooling of the cloud base region, via evaporation of rain drops just under the cloud base, may maintain a lower condensation level, hence a lower cloud base (Lu and Seinfeld, 2005). During daytime it can moreover partially compensate the warming of the cloud base region due to absorption of solar radiation and also prevent, or diminish the raise of the cloud base (Sandu et al. 2008). This feedback should be mentioned along with the others pathways of aerosol-drizzle-cloud interactions summarized in the introduction, and considered in the analysis of the results.

Specific comments

Abstract

The switching between night-day-night when the contribution of the different effects to cloud susceptibility is summarized is confusing.

Introduction

- pp 15501 L 13-19: this paragraph should be revised according to point 4 in the general comments above.

- pp 15501 L 20- this paragraph is just a repeat of pathways d and e, isn't it?

- pp 15502 - this part of the introduction would become clearer if the authors were better introducing the discussion of the sensitivity to large-scale conditions, by mentioning that the previous studies did not only explore how these clouds are affected by aerosol in certain conditions, but also how the clouds behave and respond to aerosol perturbations under different large-scale conditions. It should appear clearly for the reader that MSc depend strongly on large-scale conditions such as divergence, sst, etc, and therefore their reponse to aerosol perturbations may depend on the conditions governing the boundary layer.

- pp 15502 L 15-16: higher/lower divergence corresponds to shallower/deeper boundary layer and not the other way around.
- pp 15503 first paragraph: The authors should explain here clearly what drives the diurnal cycle: during nighttime, due to the LW cooling that takes place in a thin layer at cloud top, the cloudy air from this region becomes heavier than the surrounding air, so it sinks, initiating downdrafts which are often strong enough to get to the surface. Otherwise said the LW cooling creates positive buoyancy in the cloud top region, so it enhances in-cloud TKE, hence the mixing in the boundary layer. As the boundary layer is often well mixed the cloud is supplied with moisture from the surface and it thickens despite mixing with the warmer and drier air entrained at cloud top. During daytime the absorption of solar radiation in the cloud layer partially outweighs the LW radiative cooling, but also slightly warms the cloud layer throughout its depth. Under the effect of mixing with warm air from the inversion and absorption of solar radiation, the cloud becomes slightly warmer than the undercloud layer and a thin stable layer may appear at its base. This slightly stable layer decouples the cloud from the subcloud layer. So the supply of moisture from the surface is weakened and the cloud gradually thins.
- pp 15503 L11-12 and 21-22: the phrases: "Also, distinct..." and "The sign ..." should be rephrased.

Section 2

- pp 15504 L2: ",providing a consistent..." not well phrased.
- pp 15506 L13-15: remind why the dispersion effect would lead to a warming effect.
- pp 15506 L18: The explanation of the mechanism described by Lu and Seinfeld is not clear.
- pp 15507 L18- : The summary of Wood(2006) findings is not clear: how can more evaporation limit the moistening/cooling of the sub-cloud layer.

Section 4

- pp 15511 L4-5: Why would the cloud dissipate in summer conditions? FIRE was performed in July and all the simulations of this case with other LES show a nice diurnal cycle (Duynkerke et al. 2004, Sandu et al. 2008).
- pp 15511 L7 : recent intercomparison studies lead by the GCSS modeling groups showed that 20m vertical resolution is too coarse for reproducing well the cloud top entrainment in STBLs. Models had a hard time converging even for resolutions inferior to 5m. The authors mention that differences are small when using 10m on the vertical, what about 5m? I would expect the cloud to thin and brake up much less during daytime with finer vertical resolution.
- pp 15511 L10 : the authors are stating that the bulk properties of the cloud are similar for their big and small domain. Is this true as well about precipitation rates? Precipitation rate is generally very sensitive to the size of the domain in LES.

Section 5

- pp 15512 first paragraph : The second statement is false! the TKE is enhanced by the positive buoyancy production in the cloud layer driven by the LW cooling, and not by the negative buoyancy above the cloud layer. Same for the next phrase: the surface fluxes are not increased by the enhanced TKE. The surface fluxes depend only on horizontal wind speed and the difference in temperature and resp. humidity between the surface and the air above. One of the possible explanations could be the following: given that the level of mixing is increased, the water vapor evaporated at the surface is transported more efficiently towards upper levels, so the difference in qsat between the surface and the air above increases...In the following phrase: the cloud thickens during nighttime primary because the increased turbulent mixing favours the transport of moisture towards the cloud layer. The rest of this paragraph should be revised cf to the comment about the mechanisms driving the diurnal cycle made above (for the introduction).

- pp 15512 second paragraph: Large scale divergence plays a big role in defining the cloud top height, so it is not true that the cloud top is primarily defined by the LW cooling. What do you mean by the last 2 phrases on this page?
- pp 15513 L 2 - Why is Nd decreasing so much along the hours? Isn't that the reason why the cloud disappears (low nd implies high precipitation)?
- pp 15513 L6-8: not well phrased.
- pp 15513 L10-12 the reason why precipitation decreases the turbulent mixing should be better explained. See Stevens et al. 1998. Besides it should be mentioned that this is the case for nightime, during daytime, precipitation may maintained a less decoupled BL acc. to Sandu et al. 2008.
- pp 15513 L16-19. The size of the droplets is not the only reason why there is more evaporation in the cloud base region. At cloud top absorption of SW radiation is outweighed by the much stronger LW cooling, and the cloud water content is higher.
- pp 15513 L23: sedimentation-entrainment and evaporation-entrainment feedbacks.
- pp 15514 L3-4: the authors should perhaps note that this finding shouldn't be generalized, as it's mainly due to the fact that the clean cloud disappears. Which might be just an artifact of the model used in this study (and a result of a strong diminution of Nd in time).
- pp 15514 last paragraph: this is a typical example of the confusing discussion related to the clasification in non-drizzling/heavy drizzling regimes mentioned in the third general comment.
- pp 15515 L4-5: the authors should better explain the chain of phenomena which lead to a rise of the cloud top, filling the gaps which might not be obvious for the reader. The affirmation in the next phrase ("Also, the cloud base...) is not that trivial to make: the evolution of the LCL depends on how much the BL warms compared to how much it moistens.
- pp 15515 L13: is not the cloud who becomes stable but the thin layer at its base.
- pp 15515 L24: the other way around. Besides, here it might have been useful to have a look at the vertical profiles to understand in which case the BL is warmer/drier, etc.
- pp 15515 last paragraph: the analysis of the profiles and the entrainment rates would have perhaps allowed to better understand why the cloud is disappearing in the polluted case when the SST is increased. Otherwise the affirmation in point (2) seems unsustained.
- pp 15516 L5: Again the surface fluxes don't increase directly because of the TKE increase (see comment concerning pp 15512 first paragraph). What probably happens is that by mixing with drier air at cloud top the BL becomes gradually drier and the difference in qsat at the surface, so the latent heat fluxes, increase.
- pp 15516 L6: "as well as stronger drying" and warming.
- pp 15516 L10: also, no precipitation implies more mixing in the BL so the vapour from the surface is more efficiently transported towards the cloud layer.
- pp 15516 L12: there is no supplementary moistening at the beginning of the simulation, i.e. the latent heat fluxes are equal. What are you referring to?
- pp 15517 L3: here and throughout the text when you are taking about a precipitation rate you are talikng about the precipitation at the surface, right? perhaps this should be mentioned somewhere.
- pp 15517 L11: This statement is confusing. The entrainment rate does primarily depends on the mixing in the BL, or more precisely on the cloud top radiative cooling, so on the LWP. While, the cloud top evolution depends on the balance between entrainment and subsidence.
- pp 15517 L15-20: Sometimes light precipitation which evaporates at cloud base may maintain a lower cloud base (Lu and Seinfeld, 2005).

- pp 15517 L24: (1) this is true in the precipitating case only.
- pp 15518 L16: LWP is higher than in what case?
- pp 15518 L21: This phrase should be reformulated as is not clear. Also, when you are saying "under these moister conditions", what are you referring to? moister than in what cases?
- pp 15519 L4: The last statement would deserve more explanation. Also you might want to discuss here how the difference in LWP between the polluted and the clean clouds depends on the time of the day. Are you finding opposite behaviour during night/day like in the study of Sandu et al. 2008?
- pp 15519 L14: Why only certain cases are used for deriving these relationships?
- pp 15519 L21: "a result of a drier atmosphere and lower supersaturation". Why is the atmosphere drier in the SST290 case?
- pp 15522 L2-4: The phrase "Overall, though..." is not clear.
- pp 15522 L13-14: It would worth mentioning that this is explained by the fact that the cloud changes the most when the change in Nd leads to a suppression of precipitation (the passage from a precipitating to a non-precipitating cloud).
- pp 15524 L1-3: The phrase : "the cloud base height ..." is not clear.

Conclusions

- pp 15525 L9: SW heating partially offsets the LW cooling. Mention that in his paragraph you are referring to the control case you have considered.
- pp 15525 L21: "Also, the entrainment dries the air". The entrainment does not dry the air, the mixing of dry air entrained at cloud top with the cloudy air leads to a drying of the BL. In this paragraph you are referring to the impact of the large-scale conditions on the cloud in the clean case, or in both clean and polluted cases? It would worth mentioning.
- pp 15526 L12: The phrase: "The drier the environment, ..." is not clear.
- pp 15526 L15: Sometimes when you are talking about "cloud susceptibility" it's not clear if you mean the total cloud susceptibility, or the LWP, the optical thickness, etc susceptibility to aerosol perturbations. It would worth being more careful when using this formulation throughout the manuscript.
- I think it would be very valuable to add at the end of the conclusions a few lines reminding what have we learned from all these sensitivity experiments, what is the take home message of this study, or in general of all the LES studies performed so far that focused on MSc-aerosol interactions.

Figures

For all figures where dashed lines are used: these lines are hardly distinguishable from full lines. Perhaphs using dotts instead of dashes is a better option.

Fig. 3: how come the boundary layer stabilizes so much during daytime despite of the very weak rain? is the SW heating realistic, isn't it overestimated?
Fig. 4: the title is misleading, these are not all cloud properties. For all the figures of this type it would be worth adding the cloud cover.