

Interactive comment on “How important is the vertical structure for the representation of aerosol impacts on the diurnal cycle of marine stratocumulus?” by I. Sandu et al.

I. Sandu et al.

irsandu@yahoo.com

Received and published: 24 April 2009

Before responding to the different comments, we would first like to thank the reviewer for pointing out some unclear aspects of the manuscript and for helping us thus to bring out more clearly our ideas.

General comment:

Indeed we know that the LES model has a number of weaknesses, and the resolution we integrate it at is quite coarse. However, we used the model to develop ideas that appear to stand on their own merit, and we would not like to be in a position where we have to "trust" the model. We acknowledge that it may exaggerate some effects, so

C327

certainly the ideas we develop warrant further evaluation.

Minor comments:

1. Aerosol only impact the cloud radiative properties by changing the droplet concentration, hence the extinction and the optical thickness when integrated over the cloudy column. The increase in optical thickness is proportional to $CDNC^{1/3}$, while it is proportional to LWP. Therefore the first aerosol indirect effect (Twomey) slightly contribute to differences between the two sets of simulations, but only at the second order since the first order is the response to changes in the LWP due to dynamics.

2. We will change this formulation in the revised version of the manuscript.

3. We will address this comment by introducing the following phrase in the revised version of the manuscript and by changing the title of sect. 2.3.1 to Polluted clouds

These two classes of simulations are hereafter referred to as PRIS and POL, respectively. The PRIS simulations always produce precipitation (Sec. 2.3.2), while the CDNC increase in the POL set of simulations is sufficient to inhibit drizzle formation within a few hours after the CCN concentration has been changed (Sec. 2.3.1).

4. The points at the bottom right of fig. 6 correspond to the end of the simulations (i.e. after 11 LT on the last day of simulation) where both the SST and the divergence vary in time. During this period both the pristine and the polluted boundary layers are deep and significantly decoupled (fig. 3), not only during daytime but also after sunset. The rightmost red star corresponds for instance to the last hour of simulation in this case. The corresponding profiles of θ_{sl} and q_{sl} are shown in fig. 2 (dotted grey lines) for the polluted case, and in the fig 1 attached here for the pristine case).

We will add this information at the end of the paragraph, as:

During the periods when the polluted STBL only (orange stars) or both STBLs (red stars) are decoupled, which mostly correspond to daytime conditions, the difference in LWP between the two clouds is underestimated, and in some cases it is even reversed.

C328

The largest discrepancies (lower-right corner in Fig.6) correspond to the last day of simulation with time-varying SST and divergence, for which Fig. 3 (lower panel) reveals that both the PRIS and POL simulations are significantly decoupled.

5. Yes. We'll change that in the text.

6. As explained in the paragraph beginning on line 25 p. 5479, for evaluation of the different parameterizations, we computed the entrainment rates using the horizontally averaged LES values of the surface fluxes (of θ_l and q_t), radiative divergence at cloud top, jumps in θ_l and q_t at cloud top and maximum cloud water content. The framework outlined in Stevens et al. 2002 expresses all the parameterizations tested here for the entrainment rate as a function of these parameters. So, the integrated buoyancy flux is not needed to compute the entrainment rate given by Turton and Nicholls 1987. Nevertheless, we agree that the phrase mentioned in the comment (We recall that. . .) confuses the reader and we will therefore remove it in the revised version.

7. No, we haven't tested the multiple mixed layer model, as our intent here was not to test different models, but rather to evaluate if a model which does not represent the vertical structure of the boundary layer is suited to investigate aerosol induced changes of the marine stratocumulus diurnal cycle. We will add the following sentences at the end of the conclusion (see response below to comment 8).

8. We agree that in principle one-dimensional TKE schemes could handle these features, as could K-Profile boundary layer schemes (such as used by the ECMWF) if the mixing profiles respond correctly to the boundary forcings. Indeed the point we wish to bring out here is that the deviations of the vertical structure from a well mixed layer is key to the response we observe, so how the parameterizations represent this will end up being key to their response. We will address this comment by rephrasing the last paragraph of the conclusions as follows:

This exercise therefore suggests that the deviations of the vertical structure from a well-

C329

mixed layer are key ingredients to the response of marine stratocumulus to changes in the aerosol loading. Such deviations should hence be properly represented by the parameterizations of cloudy boundary layers in order to correctly predict the aerosol impacts on clouds and thus to reduce the uncertainties of aerosol indirect effects in climate change predictions.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 5465, 2009.

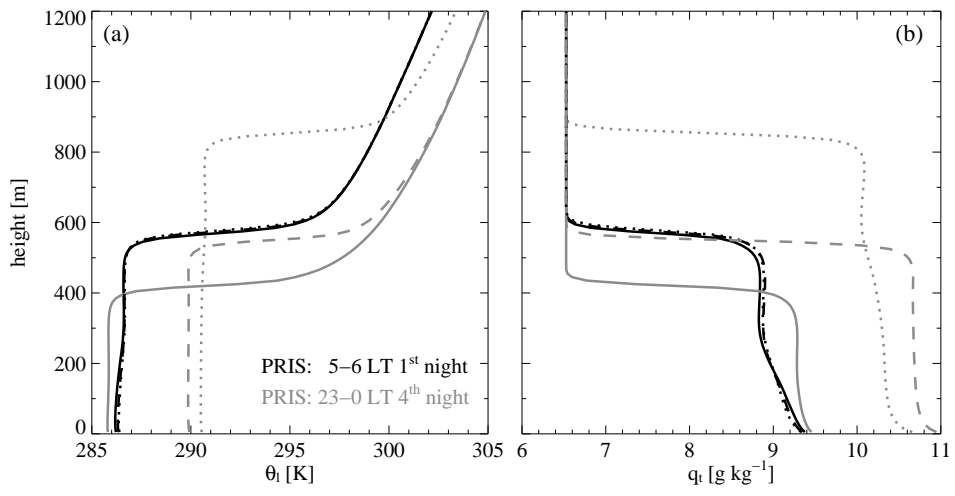


Fig. 1. As Fig. 2 from the manuscript but for pristine simulations.