

Interactive comment on “Comparison of a global-climate model simulation to a cloud-system resolving model simulation for long-term thin stratocumulus clouds” by S. S. Lee et al.

Anonymous Referee #1

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General Comments:

This is a detailed analysis of a case study involving a stratocumulus-to-cumulus transition. The case is modeled using a general circulation model (GCM) and a large-eddy model (LEM). The GCM fails to produce a transition to Cu, as observed, whereas the LEM does. The reasons for failure are related to the facts that 1) the GCM's parameterized turbulent fluxes do not properly represent the deepening-warming decoupling; and 2) the GCM's microphysics produces precipitation that reaches the ocean surface, thereby stabilizing the below-cloud layer.

This problem is of great scientific importance. The manuscript is clear and thorough.

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However, it might have gone further in the two areas mentioned in the Specific Comments below.

Specific Comments:

1... Section 2: I like the authors' approach of running both the CSRМ and GCM with the same initial conditions, large-scale forcings, and surface fluxes. However, the CSRМ and the GCM used different physical parameterizations. The CSRМ contains the microphysics parameterization of Saleeby and Cotton (2004); and the radiation parameterizations of Chou and Suarez (1999), Chou and Kouvaris (1991), Chou et al. (1999), and Kratz et al. (1998). The GCM contains the microphysics parameterizations of Boucher et al. (1995), Tripoli and Cotton (1980), and Beheng (1994); and the radiation parameterizations of Collins et al. (2006). Because the CSRМ and GCM use different physical parameterizations, it is difficult to disentangle the effects of different resolutions from the effects of different microphysics parameterizations. In section 6.1, the authors compare the parameterizations for clear-sky and cloudy cases. This is a start, but it does not demonstrate that the microphysics schemes behave the same in both models when clouds are present. Therefore, it is non-trivial to attribute differences to either the change in resolution or the change in physics schemes. This may matter because (p. 12312) "The presence of the surface precipitation in the GCM run throughout the entire simulation period stabilizes the whole sub-cloud layer" whereas (p. 12307) "The surface precipitation is absent in the CSRМ run when stratocumulus is a dominant cloud type before the development of cumulus clouds . . . As indicated by Jiang et al. (2002), when precipitating particles evaporate completely before reaching the surface, even the slightly increased evaporation of precipitation around the cloud base can cause the increased instability concentrated around the cloud base (leading to increased updrafts and condensation) in stratiform clouds."

Ideally, one would perform the CSRМ and GCM runs using identical physical parameterizations. If this is impracticable, it might be of interest to simulate an idealized case that does not produce precipitation, or to shut off precipitation processes in both the

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CSRM and the relevant region of the GCM. Even running a single column of the GCM with precipitation shut off might be illuminating.

2... Section 6.3. The authors nicely demonstrate that the transition from Sc to Cu is related to increased latent heat flux (Section 6.3), but the GCM presumably contains this increased latent heat flux, and the authors do not show why the GCM does not respond to the increased latent heat flux. The authors only provide only a few general comments. For instance, the abstract states that "However, in the simulation by the GCM, these interactions are not resolved and thus the transition to cumulus clouds is not simulated." On p. 12311, the manuscript writes "the GCM used here is not able to resolve cloud-scale turbulent motions, which in turn makes it impossible to simulate interactions among latent heat fluxes, buoyancy fluxes, and entrainments in the GCM run." On p. 12314, the manuscript writes "In the GCM run where the interactions between the latent heat fluxes and buoyancy fluxes were not represented explicitly, the deepening-warming decoupling was not simulated."

It is useful to know that in one case, at least, the GCM was unable to simulate the transition between Sc and Cu. However, it would be useful to have more guidance on how to fix the GCM's parameterizations. Presumably the GCM contains a shallow cumulus scheme, such as the scheme of Hack (1994). Under what conditions is this scheme triggered? Is the scheme triggered at all in the GCM simulation in the region of interest? If the scheme is triggered, how does it alter subgrid fluxes or turbulence?

Technical Corrections.

p. 12284, line 12: The article refers often to "cloud mass". Does this mean cloud cover? Cloud fraction? Liquid water content? I am not familiar with the term "cloud mass".

p. 12284, line 25: Change "cilimate sensitivity" to "climate sensitivity".

p. 12294: The CSRM uses a horizontal grid spacing of 50 m. Such grid spacings are

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typical of large-eddy simulations (LES). The authors might want to note early (e.g. in the abstract) that the "CSRM" will be run at fine resolutions typical of LES.

p. 12294, line 27: Change "masoscale" to "mesoscale".

p. 12296, line 18-20: The manuscript writes "In other words, aerosol impacts on cloud-particle properties after its activation are only taken into account for both the GCM run and the CSRM run." Is it more accurate to say "In other words, only aerosol impacts on cloud-particle properties after its activation are taken into account for both the GCM run and the CSRM run."?

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 12283, 2009.

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