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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Interpreting the cloud cover – aerosol optical depth relationship found in satellite data using a general circulation model" *by* J. Quaas et al.

Anonymous Referee #2

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General Comments:

This work investigates the feasibility of several hypotheses used to explain observed increases in aerosol optical depth (AOD) around cloudy regions to better understand the legitimacy of satellite measurements of this relationship. This is done utilizing a General Circulation Model (ECHAM5). Generally speaking, the authors are attempting to address very relevant and important questions about the measurement of interactions between aerosols and clouds. Although utilizing a GCM to answer these questions allows for for the completion of global simulations, allowing analysis of the relationships in question across a similar scale of conditions represented by the satellite data set,

I'm not convinced that the GCM is actually able to capture the hypotheses investigated. More specifically, I have concerns about using a GCM to look at processes occurring at scales that are not well represented within the model grid box. I suppose that there is some information on these types of processes that can be accessed via statistical analysis, but I would require that the authors provide significantly more detail into some of their methods, and further explanation on how they are interpreting GCM results at a relatively coarse resolution at the cloud scale. As indicated by the comments below, I fear that the authors are not using appropriate tools in this evaluation, and without significant additional work, their conclusions are not justified or useful.

Specific Comments:

Regarding evaluation of each of the listed hypotheses:

Hypothesis 1: How confident are you in the model's representation of the first aerosol indirect effect? Can you provide error estimates? If not, can you justify your use of this model to evaluate the relative contribution of the AIE to the AOD-TCC relationship? Since climate models are not necessarily known for their ability to accurately represent the transition from cloud to precipitation, and since this transition would largely impact cloud lifetime, can you provide an error analysis of the model's ability to do so?

Hypothesis 2: I think that the convergence of aerosol could be captured in the model, but the accurate placement of clouds along meteorological features (frontal zones, gust fronts, etc.) may be a stretch. How confident are you in the model's ability to put clouds in the right place for meso and synoptic scale events? If not confident, can you explain your use of the model in evaluating this scenario?

Hypothesis 3: Although the model can likely predict aerosol swelling in grid boxes with increased vapor via simple humidity curves, I don't believe that it can accurately represent the fine scale gradient that occurs between clear and cloudy air, and it is this gradient that would result in dramatic increases in AOD near cloud edges. I've included a real observation of this type of swelling at the edge of a cloud as seen by a

high spectral resolution lidar. Note how small the difference is until right at cloud edge!

Hypothesis 4: I'd find it very difficult to believe that model errors are better understood/quantified than satellite retrieval errors at this point in time. If so, these error comparisons need to be presented here to make any statement about the satellite retrieval errors based solely on the difference in observed and simulated TCC-AOD relationships. Also, since the errors in estimating the other hypotheses using the model are very difficult (if not impossible) to present, it is not possible to make a statement such as that provided on line 1 of page 26021: that the difference between the simulated and observed relationships infers the amount of retrieval error. There is VERY LITTLE basis for that statement (even when it is qualified with a preliminary statement indicating that model processes are unlikely to be perfect!!).

Hypotheses 5&6: - Evaluation of these processes can not be justified without a thorough error analysis of the cloud microphysical processes in the model.

additional comments/questions:

how/where is MODIS data used to calculate AOD (clear air vs. cloudy air)

To what extend does ice nucleation over polar and mid-latitude regions play into this comparison (i.e. presence of cirrus on satellite retrievals, and ice nucleation leading to glaciation of mixed-phase clouds)?

How does MODIS calculate TCC?

How does the model calculate AOD?

How does the model calculate aerosol swelling?

Nucleation in the GCM? How is RH affected when droplets nucleate? How does this, in turn influence aerosol swelling?

page 26019, line 19: this is pure speculation, and can not be supported without a thorough comparison of the differences between the two microphysical schemes!

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 26013, 2009.

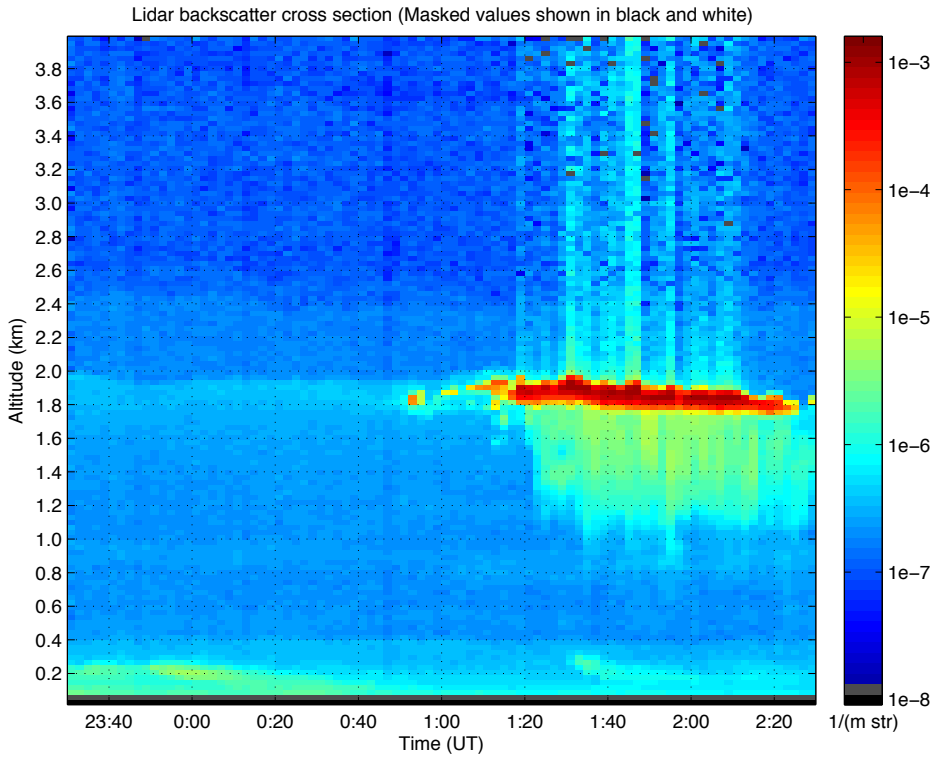

Fig. 1. Aerosol backscatter cross-section as captured by a high-spectral resolution lidar. Note the scale of the aerosol swelling near cloud.