Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-831-RC2, 2016

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The source of discrepancies in aerosol–cloud–precipitation interactions between GCM and A-Train retrievals" *by* Takuro Michibata et al.

Anonymous Referee #2

Received and published: 11 October 2016

This paper investigates the strength of aerosol cloud interactions in both models and observations, seeking to examine the sources of the strong lifetime effect in the MIROC5 GCM. The authors show that the precipitation susceptibility for the model shows some similarities to satellite observations, but displays some different characteristics at low and high LWP, which they attribute to the autoconversion scheme in the model. They go on to show how the relationship between liquid water path (LWP) and cloud droplet number concentration (Nd) in the model and observations is very different, changing sign depending on the meteorological environment in the observations but not in the model. They suggest that this means that the precipitation scheme in the model is not capturing some important aspects of the precipitation process.

The paper is well written and the plots are appropriate. I think that this is a nice way of investigating the model and observational differences. There are a couple of points that I think need clarification, involving the possibility of correlated errors in the retrievals and the validity of the assumptions used in the satellite retrievals along with a few other small points. If these points are addressed, I feel this paper would be suitable for publication in Atmospheric Chemistry and Physics.

Specific comments

Sec 2.2: I am slightly concerned about the use of LWP and Nd from the same instrument and retrieval. Both of these are derived from the MODIS optical depth and effective radius retrievals, which themselves are retrieved together. This means that any errors in the retrieval of the effective radius or the optical depth will propagate through to the LWP and Nd, such that the errors in these derived properties are not independent. If the errors in the effective radius and optical are large enough, this can result in biases in the LWP-Nd relationship (the same thing also applies for the re-Nd relationship). Even random errors in the MODIS optical depth and effective radius retrievals would thus be able to generate a LWP-Nd or re-Nd sensitivity. These retrieval issues would not be replicated in the model output and could be part of the reason for the model-satellite discrepancy, especially in broken cloud regions.

P4 L14: It may also be important that the MODIS derived Nd and LWP depend on the adiabatic assumption, which is not valid in precipitating cases. Is it possible that the relationship in precipitating or broken cloud cases might be influenced by variations in the adiabaticity of the cloud? Again, this assumption would not affect the model results.

P5 L21: 'Pconv can be estimated' - it would make the paper a little more self contained if there was a brief description as to how. It looks like it is also connected to retrievals of the droplet number and cloud water content? Could this also be affected by correlated errors in the retrievals or are these CloudSat number and water content retrievals?

P5 L30: perhaps 'at a higher frequency ... compared to observations'

P5 L33: 'alternatively ... related to unrealistically light rain.' Just to check, the biases in condensation lead to lower LWP, which in turn leads to more light rain as the autoconversion rate is lower at low LWP?

P6 L22: Why is it more likely to find a change in the response of the relationship with precipitation in a high aerosol region? I would have thought that the LWP-Nd relationship is a property of the clouds rather than of the aerosols, which would make it relatively independent of the aerosol level as long as the LWP-Nd relationship is linear.

P7 L31: How difficult would it be to show the causes of the positive relationship at high stability in precipitating environments? It would help to demonstrate the dominant role of precipitation. At the moment, stability has almost as large an effect as precipitation but this does not fit so neatly into the explanation given (that precipitation is the driving factor in determining the strength of the LWP-Nd relationship).

Fig. 4: I understand that the model version of this figure will be positive almost everywhere, but is there still a pattern in the strength of the relationship that depends on stability or precipitation?

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-831, 2016.