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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud optical thickness and liquid water path. Does the *k* coefficient vary with droplet concentration?" *by* J.-L. Brenguier et al.

J.-L. Brenguier et al.

FREDERIC.BURNET@METEO.FR

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1) Why LWC or LWP instead of extinction or optical thickness ?

In fact, the constraint comes from the models. All meteorological models (forecast, climate) use conservative variables, starting with heat and total water mixing ratio. The combination of these two results in a LWC in each model grid. Radiative transfer is then calculated, most of the time using the independent pixel approximation, looking at each model column independently. The input variable in radiative transfer calculations is the vertically integrated LWC, hence the LWP. For radiative transfer calculations, it shall be translated into an optical thickness. That's where the k coefficient appears to translate a mean volume diameter (LWP) into a mean surface diameter (optical thickness). Therefore, we have no choice, because total droplet surface (extinction) is not a conservative variable, hence it shall be derived from LWC and droplet number concentration (another conservative variable).

2) Difference between the previous analyses and the current one:

We have not chosen this option because of the very large number of papers published on the subject and because, to our knowledge, all of them make reference to the seminal Martin et al, 94 paper. Moreover, the few parameterizations including a variation of the k coefficient with CDNC use the formula proposed by Martin et al. To publish a very concise paper we have therefore decided to limit our comparison to that formula shown in all the figures as a reference. For readers interested in more details, the Liu et al. 2008 paper provides a long list of references. To our knowledge all the papers on that subject used data from the FSSP-100 except those based on ACE2. We have added a reference to INDOEX (McFarquhar and Heymsfield, 2001) to emphasize this point.

3) Separating Cu and Sc:

We understand and fully agree with the recommendation. We have therefore separated Cu and Sc in Fig. 6a & b and 7a & b. The result is interesting because it shows no significant difference between Sc and Cu: 0.798 ± 0.063 and 0.812 ± 0.029 for $<k>$, and 0.737 ± 0.061 and 0.737 ± 0.047 for k*. This result is discussed in the manuscript at the end of Sec. 4.5 and 4.6.

4) Why using k* ?

Presently most of shallow clouds occupy only one layer in GCMs. This is why we limit our approach to the derivation of a cloud depth equivalent k value. We agree that for models with a finer vertical resolution, a more sophisticated approach shall be used, vertically integrating LWC and optical thickness on intermediate layers from

ACPD

11, C6819–C6821, 2011

Interactive Comment

base to top. It is not trivial, however, to derive a vertical stratification of the k coefficient that could easily be implemented in GCM depending on their vertical resolution and the assumed vertical overlap of the cloud layers. The issue, however, is not only for vertical stratification, but also for horizontal heterogeneity. The main source of biases (discussion section) is when averaging local k values instead of averaging the second and third moments of the size distribution to derive an unbiased k estimate. Showing that the actual k value to use in radiative transfer calculations is different from the one derived by averaging local k values is nevertheless an interesting step that deserve publication for raising awareness on the issue.

5) Martin et al methodology discussed in the introduction:

We appreciate this comment and have added a sentence in the introduction as recommended

6) Fig. 8 and inhomogeneous mixing:

This issue is discussed in lines 18 to 22, page 5192 of the manuscript

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C6819/2011/acpd-11-C6819-2011-supplement.pdf

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11, C6819–C6821, 2011

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