We would like to thank the referee for the thoughtful and constructive comments.

1. The paragraph describing constraints on model analysis on p. 13947 is much too brief to be convincing and really deserves to be discussed in a separate methods section. First, mixed-phased clouds are ubiquitous below 700 hPa, even outside polar regions. I agree that constraining to liquid clouds is important, but why not do this using the operational MODIS cloud phase product or the MODIS/POLDER product by Riedi et al., 2007? (Incidentally on p. 13946 the satellite is PARASOL: POLDER is the instrument). With regards to co-locating aerosol and cloud fields, this is an important point, and has been highlighted in articles by Avey et al. (2007, JGR) and Brioude et al. (2009, ACP).

We have reorganized and improved the description of satellite data sets and methods in the manuscript according to the suggestions of the reviewer.

We looked at the fraction of liquid water in low clouds relative to liquid + ice in the same clouds, using the ISCCP-like CERES satellite product (http://eosweb.larc.nasa.gov/PRODOCS/ceres/level3_isccp-d2like_table.html). Results shown in Figure below indicate that the fraction, computed using the monthly mean liquid and ice cloud fractions, is very close to 1 for most regions, especially in the Northern Hemisphere. At high latitudes in the Southern Hemisphere, the fraction is on the order of 0.8 - 0.9.

This seems to confirm that the assumption of liquid clouds, at the monthly mean and longer, is rather reasonable in the study.

We were not aware of the data set by Reidi et al. (2007). The data set described in the paper seems to be for a level 1 data set (pixel level) combining information MODIS and POLDER to improve the phase determination. We have been using level 3 data (monthly averaged and gridded data). We currently do not have any capacity to work with level 1 or 2 data given our lack of expertise and amount of work that would be required.

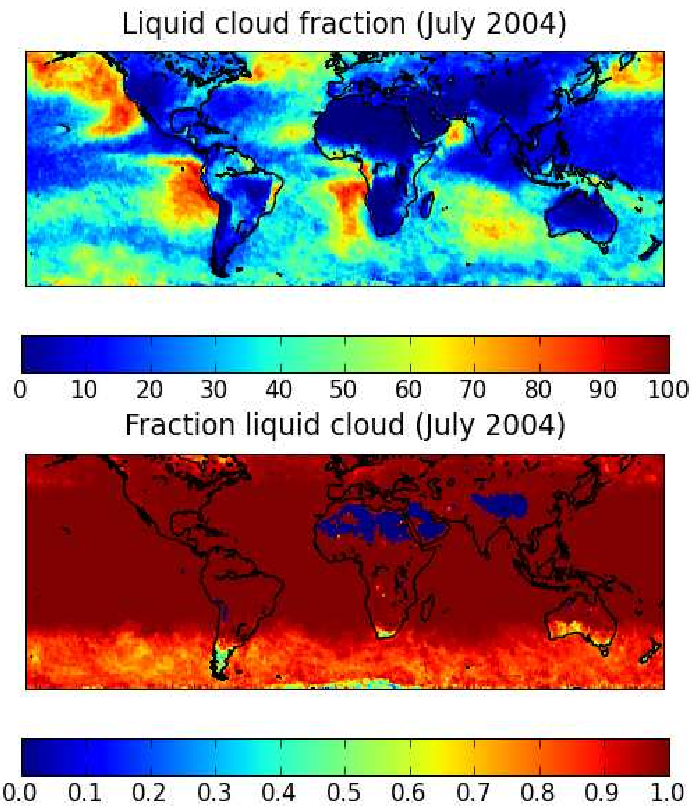

Figure. The monthly mean low cloud fraction (top) and monthly mean fraction of liquid water in low clouds relative to liquid + ice in the same clouds. The data is for July in 2004 and from CERES ISCCP-like cloud product. The dark blue over Africa and Asia indicate there is no data available in these regions.

To a degree we have used the MODIS cloud product as requested to generate the lowest row of plots in Fig. 6. These effective radii were computed from the Level 3 joint histogram of cloud top pressure and effective radius for liquid clouds (MODIS separates ice and liquid clouds).

Thanks for bringing the studies by Avey et al. (2007) and Brioude et al. (2009) to our attention, which are relevant to this study. We also agree that co-location of cloud and aerosol results is important. This is precisely why we used joint horizontal distributions of aerosol concentrations and cloud droplet effective radius results. In the vertical, results are limited to a layer from the surface to 700 hPa, which appears to be major improvement over many other studies of global-scale relationships between aerosols and clouds. Only cloudy grid cells are considered in the analysis.

Unfortunately, our approach does not allow an exact co-location of results given the limited vertical and horizontal resolutions of the satellite and GCM data. It appears that suitable global data sets with higher resolution are not available yet.

2. There is no discussion in the article about how the GCM parameterizes the removal of aerosol by clouds. Perhaps the GCM is underestimating the indirect effect, not because it is insensitive to the effects of aerosols on clouds, but rather that it is overly efficient at removing aerosols from the cloudy column through wet scavenging. Aerosols have sources and sinks, and both of these points can influence aerosol-cloud interactions. Currently the manuscript presents a very one-sided picture on this point.

A brief description on dry and wet scavenging is included in the model description section. We also added a table (table 1) to show the aerosol burdens and dry and wet deposition fluxes in CanAM4 and other GCMs. According to these and other (yet unpublished) studies, results of CanAM4 for aerosols are quite reasonable.

The model slightly underestimates the first indirect effect mainly because the parameterization in Eq. 1 uses a relatively small exponent. We determined the sensitivity of simulated radiative fluxes to various parameterizations in the GCM based on a number of sensitivity tests (unpublished). From these we concluded that the uncertainty range for the exponent in Eq. 1 is much more important for the representation of the first aerosol indirect effect in our model than the uncertainty range for parameters in the scavenging scheme.

3. At the top of p. 13950, it is unclear what exactly is being said, however, it seems to state that it is reasonable to compare climatological averages of aerosol and cloud properties over a large region. This is not necessarily so. Imagine as an extreme hypothetical case a partly cloud region where aerosol concentrations are only high where there is no cloud. These partly cloudy regions move around (say with frontal passages) such that averaged over time and space, the cloudy regions look polluted. In reality, though, the opposite is true: it is only ever polluted where the sky is clear. The impression would be a very weak effect of aerosols on clouds, just as is simulated in the GCM.

This is a very important topic in our mind and we tried to improve the text accordingly.

The objective for this study was to obtain broad relationships between aerosol and clouds using mean, all-sky aerosol amounts from the GCM. Given the limited resolution of the satellite and GCM data sets, it does not appear to be practical nor appropriate to use below-cloud aerosol concentrations, as is common practice in more detailed studies on interactions of aerosols and clouds that are based on observations from aircraft, for example. This choice may indeed bias the results in the sense that you describe. However, it would probably be very difficult to estimate the magnitude, or even the sign of a potential bias owing to various non-linear interactions between aerosols and clouds (e.g. Stevens and Feingold, 2009).

While potential biases from omission of small-scale distributions (in space and time) of clouds and aerosols cannot be ruled out, this does not necessarily limit the usefulness of comparisons between relationships between cloud droplet size and aerosol amounts from satellite and GCMs. For each case, the relationships are based on mean results for clouds and aerosols and so one may expect the relationships all to be affected by similar biases.

4. Top of 13951: This figure doesn't look at all similar to the observations, as stated in the text.

From Figs. 2 and 7, it can be concluded that the simulated cloud effective radius captures basic features in the observations, i.e. relatively small values over land and larger values over the ocean and in the Southern Hemisphere. We agree that there are still substantial differences on regional scales and we modified the text to emphasize this point. We expect that a combination of more sophisticated aerosol microphysics scheme with a cloud microphysics scheme in the GCM will lead to improved results on regional scales in the future.