Review of the manuscript "Inverse modeling of cloud-aerosol interactions – Part 2: Sensitivity tests on liquid phase clouds using a Markov Chain Monte Carlo based simulation approach" by Partridge et al.

General comments

The work presented in the manuscript continues and expands the author's previous work presented in Partridge et al.: Inverse modeling of cloud-aerosol interactions – Part 1: Detailed response surface analysis, Atmos. Chem. Phys., 11, 7269-7287, 2011. Here, the connection between certain aerosol properties and resulting cloud droplet distributions is investigated through using a Multiple Chain Monte Carlo Method (MCMC). The underlying assumption here is that the clouds are formed in an adiabatically rising homogeneous air parcel. This allows for an application of a well-established, although simplified cloud model to simulate the cloud formation process. The cloud model is coupled with the applied MCMC algorithm, which produces posterior estimate distributions for the values of the considered aerosol properties. Through making a clever use of the modeling setup, the authors provide new insight on the relative importance of the various aerosol properties to the cloud droplet formation.

Even though sensitivity the of the cloud droplet formation to the aerosol properties has been investigated in several previous studies (as the authors acknowledge), the approach taken in this study, is to my best knowledge, quite unique. The authors first describe their methodology, then verify its usefulness after which several kind of sensitivity studies are carried out. Finally, conclusions and suggestions for further research are presented. The manuscript is well written, and the results as well as method are novel enough to warrant publication in Atmospheric Chemistry and Physics. However, I have several minor points which should be addressed before publication.

Major comments

1. The sensitivity studies of the work are based on perturbing the parameter values through equations 4-6. As seen from the equation, all parameters are perturbed by sampling from a normal distribution in a uniform manner so that the relative "spread" stays constant among the perturbed parameters. In the author's words, this represents a "synthetic measurement error". How sensitive are the results to the choice of the way how the parameters are perturbed? For example, how sensitive the results are to the choice of the coefficient in equation 4 (0.10 is the current value)? Also, would be possible to incorporate physical knowledge on the uncertainties to the perturbation scheme? For example, particle size distribution can be relatively easily determined compared to the soluble mass fraction. I do not propose that authors include a comprehensive qualitative study to address the issue, but it would be good to discuss about the point.

2. As can be seen from tables 1 and 2, several important parameters are fixed in the sensitivity studies. Would it be possible to repeat the sensitivity study while perturbing e.g. mass accommodation coefficient and/or updraft velocity. Although the authors touch

this topic briefly in the text, I believe that a more extended discussion would strengthen the manuscript. In particular, are the conclusions of the study sensitive to the choice of the perturbed parameters?

Minor and technical comments

1. Please update the reference for your previous article (Partridge, D et al.: Inverse modeling of cloud-aerosol interactions – Part 1: Detailed response surface analysis, Atmos. Chem. Phys., 11, 7269-7287, 2011).

2. Section 3.5. Even though "marginal distribution" is an established concept in statistics, I'd propose that the authors describe or define the concept in a compact fashion. This would make the section easier to understand for those who do not have a clear grasp of the concept.

3. The exact meaning of the lower and upper limits given in Tables 1 and 2 remains a bit unclear to me. In text it's mentioned that "The only difference to P11 is that we constrain the prior limits for each environment so that they are more physically realistic". Does this imply that when generating the "perturbed" calibrated data sets (eqs. 4-6) those combinations which are out of the boundaries are discarded? Or do the limits apply to the posterior distributions so that those samples which fall outside the limits are discarded in the sensitivity analysis? Please clarify the issue.

4. Caption for the Figure 3. Even though this is mentioned in the text, please indicate the meaning of blue circles.

5. Caption for the Figure 5. As in previous comment, please indicate what does the color of the contour surface stand for.