

Review of Makkonnen et al.

Overall a very nice paper, exploring an important topic. It is well written and clearly a lot of careful thought went into the paper. My points are mostly minor.

The most important point is for the authors to be more careful with statistical significance of their numbers. Sometimes they show 3 significant digits of % change! That seems unlikely to be statistically significant. Because they are running a climate model, interannual variability can be large: are the changes outside interannual variability? Please do not show or discuss changes that are not outside one standard deviation as a minimum (including on horizontal plots). I can't really find how many years were run: please describe that. Here are a few examples:

1. "where the change in cloud albedo from the year 1850 to the year 2000 was found to be +3.97% and +3.85% without and with boundary layer nucleation, respectively." This is a tiny difference? Is it really statistically significant? Are you really discussing this?

2. "Considering only the main experiments SULACT and ORGSULACT, the decrease in the cloud albedo from the year 2000 to the year 2100 is 4.1 %, 3.8 % and 3.4 %<sub>10</sub> with emission pathways RCP-2.6, RCP-4.5 and RCP-8.5, respectively. Averaged over all future pathways, MEGAN2 and LPJ-GUESS emissions lead to a similar change in cloud albedo (-3.8%)." Are any of these differences statistically significant? Are they statistically significant from each other?

3. "Averaged over all<sub>10</sub> future pathways, MEGAN2 and LPJ-GUESS emissions lead to a decrease in the low- cloud cover of -1.3% and -1.0%, respectively." Again, are these statistically significant?

4. "While binary nucleation simulations show a large change in cloud albedo since the pre-industrial period, 6.06–6.20%, the increase in low-cloud cover (ranging from +1.22 to +1.44%) is more modest than with boundary layer nucleation included (from +1.43 to +1.84%). All SULACT and ORGSULACT experiments show a similar change in cloud albedo, 4.45–4.49 %, and the highest (lowest) increase in low-cloud cover corresponds to the highest (lowest) change in shortwave cloud forcing." Do you really think you should show 3 significant digits in % in this case? Are these values statistically significant or just a result of interannual variability?

5. "The change in short-wave cloud forcing from pre-industrial to present-day, calculated with several boundary layer nucleation schemes and the two BVOC emission models, ranged from -1.54 to -1.75Wm<sup>-2</sup>. The reduction in cloud forcing from present-day until year 2100 varied from +0.99 to +1.53Wm<sup>-2</sup>, when boundary layer nucleation was included in the model." Given the uncertainties, should you really show 3 significant digits?

Other comments:

"We show that the change in shortwave cloud forcing from the year 2000 to 2100 ranges from 1.0 to 1.5Wm<sup>-2</sup>. Although increasing future BVOC emissions provide 3–5% additional CCN, the effect on the cloud albedo change is modest. Due to simulated decreases in future cloud cover, the increased CCN concentrations from BVOCs can not provide significant

additional cooling in the future.” 1 W/m<sup>2</sup> does not sound insignificant: it is offset somewhere else. Please be more clear about the relationship between short wave cloud forcing and climate RF.

“The anthropogenic influence on wildfire emissions is taken into account. Wildfire emissions are modeled according to AeroCom for pre-industrial and present-day (Den-  
tner et al., 2006), and according to each RCP pathway for the future.” Do the RCPs include fire emissions? I didn’t think so? Please be more explicit.

Section 2.3: “We will focus on experiments SULACT and ORGSULACT, which are simulated with each anthropogenic emission scenario and both BVOC emission datasets. The ORGSULHET and SULACT TER simulations are only done using MEGAN2 emissions,<sup>5</sup> to address the increase in future BVOCs. To further reduce the number of simulations, ORGSULHET and SULACT TER are only simulated with the RCP-2.6 emission sce- nario (lowest SO<sub>2</sub> emission in the year 2100).” I’m afraid I am confused. Please make a table which describes the experiments. The suffixes also don’t make much sense? Why HET and TER?

“This implies that although the BVOC-aerosol-climate feed- back would be negative with regard to CCN concentration (increased temperatures → increased BVOC emissions → increased CCN concentration), the indirect effects beyond the cloud albedo effect can have a large contribution on the resulting climate effect.” This sentence is important and confusing: negative feedbacks on climate or CCN number???? Should be only on climate, right as warming would lead to increase in BVOCs, which lead to a positive forcing on climate??? Please be clear.

Figure 1,3, 4 and 5: I found these hard to read. Another approach that might be easier to see differences, it to show the distribution for one model, but then show the differences between that model and the other models: otherwise we can’t really see anything but blobs.

Figure 9: which ones are megan2 and which are lpj-guess?