Response to reviewer #2: We'd like to thank the reviewer for their critiques. Our responses to individual comments are below. In addition to the proposed changes to the manuscript, we have added a section (Section 3.6, Figures 11-13) in which the parameterizations for Dpm and sigma are tested against real smoke plumes observed at the Mount Bachelor Observatory (contribution by J.R. Laing and D.A. Jaffe).

This paper investigates the influence of coagulation on the particle number size distribution, notably on the mean diameter (Dm) and geometric standard deviation (Sigma) of a single particle mode, in biomass burning plumes. The work is based on a large number of sophisticated model simulations. The authors investigate how Dm and Sigma evolve with time in biomass burning plumes, and how their evolution is related to several parameters associated with primary particle emissions, fire conditions and atmospheric conditions. The authors compare briefly the influence of coagulation to that caused by organic aerosol formation/loss in a plume. The authors finally parameterize their results to a form that is applicable in large-scale modeling frameworks.

The is scientifically sound and original. The text is well organized and easy to read (with a couple of minor exceptions mentioned below). The authors are able to explain very well the numerous results obtained from model simulations. I have only a few minor suggestions for revisions.

Scientific comments:
I have a hard time of understanding Figure 3, even after reading the text on lines 210-213. I recommend that the authors work a bit more to make their message here clearer to readers.

In response to this comment and a comment by reviewer 1, we have simplified Figure 3 to show only two representative profiles of SAM-TOMAS simulations: one which shows the aerosol plume mixing through the boundary layer to the ground, and a second which shows the plume still suspended at the emission injection height at the end of the simulated run. These are the two “types” of mixing depths possible (to ground through the PBL and suspended).

The Figure 3 caption was updated to reflect the changed figure:

“Final vertical profiles for two representative SAM-TOMAS simulations after four hours, normalized to individual aerosol load and averaged horizontally across the domain. The black profile shows a simulation where the aerosol fully mixed through the boundary layer to the ground with some aerosol trapped in a stable layer above the boundary layer, while the red profile shows a simulation where the aerosol plume still stable at the emission injection layer.”

Lines 254-255. The authors state that the initial mode mean diameter have little effect on Dm. I do not get this point when looking at Figures 4a and c: if Dm is initially large, it seems to typically lead to higher values of Dm at later plume times compared to cases where Dm is initially small. Could the authors specify what they mean here?

We mean to emphasize that the variability in Dpm can mainly be attributed to factors outside of initial Dpm. While those simulations with higher initial diameters do climb to higher final diameters than others, the final Dpm variability is not principally driven by starting diameter. As the dominant Dpm variability factors form a discussion in Section 3.3, we have removed this line to alleviate confusion.

Line 390: Is this correct? Condensation of a non-volatile vapor into a single mode tend to narrow this mode, not widen it, as stated here.

Your are correct, we wrote the opposite of what we meant. Line 390 is now: "These assumptions are imperfect as irreversible condensation (evaporation) decreases (increases) σ…".

The authors analyze shortly the influence OA production/loss on their results (section 3.5), and discuss also the potential effects of cloud processing (lines 463-469). This is clearly sufficient for these two processes in this paper. However, the authors do not mention at all new particle formation (NPF) that has been estimated to be a frequent process in biomass burning plumes. NPF might have notable effects on aerosol size distribution, and thereby on both Dm and Sigma, in evolving biomass burning plume. The authors should spend at least a few lines on discussing the relevance of this process in biomass burning plumes and on the potential effects of NPF on their results.

We have changed the following discussion of SOA pathways in Section 1.1 (Lines 77-79):

"This SOA can condense onto existing particles causing growth of the aerosol size distribution. It can also spur new-particle formation in biomass-burning plumes as has been observed in lab studies (Hennigan et al., 2012) and field campaign analyses (Vakkari et al., 2014)."

We have added the following lines to our methods:

"We do not address new-particle formation in biomass-burning plumes in this work. In plumes where new-particle formation in biomass-burning plumes occurs, our parameterizations will underestimate the number of particles and overestimate the mean diameter of the plume particles."

Technical issues:

Line 265: Figures 5 shows Sigma versus Dm rather than Dm versus Sigma.

Line 382: "..OA has been. . ."

These have been corrected in text.