**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "A multi-decadal history of biomass burning plume heights identified using aerosol index measurements" *by* H. Guan et al.

Anonymous Referee #1

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This is a useful study, in which the authors have applied a technique based on the TOMS/OMI aerosol index (AI) to determine the heights of smoke plumes. They calibrate the method using coincident CALIPSO data. They then analyze 31 years of AI data to identify smoke plumes more than 5 km above the surface, and estimate their heights. The results extend the CALIPSO smoke plume height climatology in both space and time, and can be used to help validate the vertical placement of smoke plumes in chemical transport models.

In my opinion, several points should be addressed before the paper is accepted.

1. Abstract, and Introduction Paragraphs 3, 4, and 6. The term "injection height" is used here to refer to the heights of plumes up to several days old. Subsequent to initial injection, plume height can change significantly due to advection, turbulent

mixing, self-lofting, and other processes. Many references cited in the introduction, both modeling studies and observations, use "injection height" to mean only the initial injection of smoke associated with the fire-generated buoyancy. As such, the definition of "injection height" might be clarified, and the characterization of these references might be revised to reflect this distinction.

2. Section 3, page 7 line 23. Why do you select the highest CALIPSO height in the plume area? Most of the smoke will reside below this level, and in addition, the highest pixels could be outliers that can occur for a variety of reasons. Statistics obtained this way are likely to be biased high relative to the effective heights of the plumes themselves.

3. Section 3, page 8, line13. How did you determine the height uncertainty? More specifically, what is the actual height uncertainty of the AI technique?

4. Section 4, page 9, lines 5 - 14. ". . . suggests that for all plumes. . ." There are not really very many plumes in the climatology. Over 31 years, 181 plumes averages to about 6 plumes per year over the entire globe. What are the statistical uncertainties in Equation 2?

Also, what factors contribute to the uncertainty in the retrieved height itself? The histogram in Figure 7 seems to suggest confidence in the height determination of about 2 km. An uncertainty analysis is needed, and the degree of applicability of the results needs to be assessed based on the result. In my view, this is important.

5. Section 4, page 9, lines 20-23. How much does the asymptote depend on particle single-scattering albedo? What contribution does this make to the overall uncertainty of the method?

6. Section 4, page 10, lines 3-4. Might dissipation and particle aging both contribute to changing the AI value as plumes evolve?

7. Section 4, page 10, line 12. Why would you assume that plume heights do not

change with aging? Any forward trajectory model will illustrate how much change can be expected.

8. Section 5, page 11, Figure 5. There is not one plume over Africa in the entire climatology. Could this be a sampling issue associated with the AI technique, e.g., due to particle property or optical thickness requirements for plumes to be detected with this method? What properties must a plume have be to be detected by the AI method?

9. Conclusions, page 12, lines 14-15. The authors mention that detecting low-elevation plumes would not be expected with the AI method. In addition, the sampling is very limited, and there are likely other systematic biases inherent in the data (e.g., Point 8 above). As such, the percents reported here might not be all that meaningful.

In summary – I think the key result is that there are 181 smoke plumes, in various stages of their evolution, that could be used to test the vertical distribution of smoke calculated in CTMs. An uncertainty estimate on the heights is needed, and generalizations about global plume behavior need to be tempered by the sampling limitations of this data set, and biases inherent in the technique.

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