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# *Interactive comment on* "An uncertainty-based protocol for the setup and measurement of soot/black carbon emissions from gas flares using sky-LOSA" *by* Bradley M. Conrad and Matthew R. Johnson

**Anonymous Referee #1**

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The manuscript amt-2020-255 by Conrad and Johnson describes a software heuristic for assisting a remote optical technique (skylight line-of-sight attenuation; skyLOSA) for measuring soot/black carbon emissions in large industrial flames. The technique allows a user to select the most reasonable position to set up the skyLOSA camera for a given set of flare and sky conditions. The computations behind this technique are intensive, so the manuscript spends some time describing a useful pre-computation approach. The pre-computed values are later used as inputs to a Monte Carlo uncertainty calculation.



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Discussion paper

From the skyLOSA perspective, the manuscript does not present new concepts or results. The main novel concept of this work is to apply the same theory used during detailed analysis to measurement, so that the measurement can be carefully configured to provide optimal results. This is a generally interesting concept, but could be considered as a technical note rather than a manuscript.

I recommend substantially shortening the manuscript's description of skyLOSA in order to reflect the subsequent conclusions. I also have reservations about the assumptions made in the MC analysis, especially the assumption that the flame emits only soot and no volatiles. These and other comments are detailed below.

**Length.** The manuscript often reads like a hybrid between a doctoral thesis and an instrument manual, especially in Sections 2, 3, 4.1.2, and 4.2. The text is well written, but inappropriately long. The audience here is not reading to reproduce skyLOSA calculations, but to understand the general concepts used. Please either cite other work or move this text to a supplement. This text can be replaced by short descriptions focussed on key concepts.

Similarly, too many acronyms are used in these sections and are not used frequently enough to be necessary (including ET, SPF, CM-LHS, ...) and not all symbols are defined next to their equations (e.g. L(b) in Equation 9 and $a_k$ next to Equation 18).

**Monte Carlo clarification.** A Monte Carlo calculation randomly samples prior distribution(s) and repeats a calculation in order to obtain a posterior distribution of results. The key question here is what priors were assumed, and how accurate are they? The manuscript glosses over this point and takes the MC output as correct without any top-down validation.

Please revise Section 3 and Table 2 to emphasize the prior distributions used. The authors have already done this in their earlier work (Johnson et al., 2013, Table 2) by tabulating "Distributions used in MC". I believe the authors did intend to include this information but I do not find it clear enough. In Table 2 of this work, the last column "MC

Implementation" is specified as "MC-randomized" multiple times – this is a meaningless statement. Of course the MC calculation performs random sampling.

**Validation of assumptions.**

The manuscript assumes throughout that a perfect skyLOSA measurement gives a perfect result. This has not been justified in the manuscript nor in earlier skyLOSA work, to my knowledge. These calculations are not constrained by any direct measurements. The skyLOSA approach is comparable to a satellite retrieval algorithm and requires direct validation. Until directly validated, this limitation must always be repeated. The concentrations reported by the current approach are a type of "equivalent black carbon" defined by the authors' assumptions.

My main concern here is with respect to the aerosol optical properties, which have not been discussed at all. Instead, Johnson et al. 2013 is cited. The authors have assumed that the flame emits only soot. What about organics, which may condense when the plume cools? The photograph in Johnson et al. 2013 clearly suggests that the plume may have cooled before measurement. What about inorganics such as sulfates? How pure are the fuels burnt in these flares? Any impurities are likely to influence the aerosol optical properties.

Please add calculations where black carbon is assumed to be mixed with organics or other impurities, using reasonable and literature-based assumptions, and show how the conclusions of this work change in response.

A lesser concern is the assumption (Section 3.1.3) of an ideal clean atmosphere. What about background aerosol? Surely the air around an oil field is not perfectly clean.

**Other minor comments.**

The justification of a quantile-based coefficient of variation in Section 3.2.1 can be shortened.

The word compiled in Section 3.1.5 should probably be changed to grouped. And I am not sure I understand what concept the authors are trying to convey here. Was the grouping done based on skyLOSA results?

I found the discussion of the total order L(b) in Section 3.1.4 unclear. Is this discussion significant, considering the uncertainties in the assumption of a black-carbon-only aerosol and aerosol-free sky?

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