We would like to thank the referee for the thoughtful and insightful comments. We have addressed all of the comments. Our responses are itemized below.

This study uses the GEOSH-CHEM adjoint model and BC observations from the IMPROVE network to invert summertime anthropogenic and biomass burning BC emissions over the western U.S. The authors' best estimate for BC emissions are approximately twice the magnitude of the a priori inventories, which is very similar to the results previously obtained by the same group (Mao et al., 2014). In my opinion, the real value of this paper lies in the various sets of sensitivity and pseudo observation experiments, designed to test the adjoint's ability. These methods are novel and of great interest to the community. The paper is generally well written. As a reviewer, I try in general to avoid recommending new experiments. However, in the present case, I do think that two sets of experiments (fortunately, relatively easy to do) would add to the comprehensiveness of the study. The first would be an inversion of the total BC emission, since the adjoint cannot distinguish individual source sectors. The other would a pseudo observation inversion to determine if observations placed at strategic locations would improve the inversion of total emissions or sources.

Point well taken. We have conducted the two experiments as suggested and discussed the corresponding results in Sects. 4.1.3 and 4.2.

Page 21870, Line 27-page 21871, line 2: It is reassuring that the derivative of the cost function (J) calculated by the forward model is perfectly correlated with that calculated by the adjoint model. But why is the slope in Fig 2 not 1 (it is close to unity, but there is a 5% bias). For a perfectly linear species such as BC, one would image in the slope to be unity.

Agree. We have recalculated the sensitivities and found a perfectly linear relationship between the forward model and the adjoint model, as shown in Fig. S1.

Page 21872, lines 15-16; page 21873, line 20-25: I appreciate that characterizing the error structures of a priori emission inventories is difficult. But one would imagine that the errors of the a priori emission inventory would be spatially correlated, perhaps strongly so, particularly for biomass burning emissions (e.g., underestimation of agriculture fires over extensive farming regions). I see that this is hinted at in page 21873, line 20-25. However, the use of gamma does not completely resolve this issue. A few words about how the spatial correlation of error may impact your inversion would be helpful.

Point well taken. Added discussions, 'The spatial correlations between the *a priori* errors have been proved to improve the inversion, particularly in regions adjacent to strong sources and less directly constrained (Stavrakou and Müller, 2006). For example, the assumption of no spatial correlation between *a priori* errors would underestimate the biomass burning emissions in regions close to the extensive agriculture fires.'

Page 21873, line 14-28: What is this "hybrid" form? Please write out the mathematical form.

Added as Eq. (4).

Page 21878, lines 3-8: The authors used an indirect method to evaluate the adjoint's ability to distinguish between anthropogenic and biomass burning sources. To me, this is the most interesting experiment in the paper, but the texts here are not very clear. Please re-write.

Revised to 'We conduct another inversion (Case 8) to examine how much the inversion can distinguish the collocated emissions. In each grid box, we add 2.5 Mg (~10% of the maximum emissions among the grid boxes) as a diagnosis to the (*a priori*) biomass burning emissions of BC and examine the degree to which the inversion results change the partitioning of biomass burning versus anthropogenic emissions by comparing the inversion results with those from Case 1 (or Case 7). The differences in the *a posteriori* emissions of BC between Cases 8 and 1 are shown in Fig. 6. '(Sect. 4.1.3)

Page 21878, lines 3-8: Also, if the inversion is unable to distinguish between anthropogenic and biomass burning sources, would it not make sense to do an inversion on the total emission? What are the results?

One experiment Case 7 added in Table 1 and Sect.4.1.3. We find that 'the resulting total *a posteriori* emissions increase by a factor of 2.2 relative to the *a priori* and are within 2% of those from Case 1. '.

Page 21881, lines 13-24: Again, this set of sensitivity tests are very interesting. Would it be possible to find out, using pseudo observations, at which locations would observations be most useful in constraining BC emission totals and sources? For example, I would imagine observations on the eastern slope of the Rockies (leeward of biomass burning emissions and less affected by precipitation) would be most effective.

Point well taken. We have added one experiment Pseudo 9 and used pseudo observations at the grid boxes with more than 5 fire counts in August (covering 50% of surface grid boxes). We find that ' With pseudo observations located at biomass burning source regions (Pseudo 9), the resulting *a posteriori* biomass burning emissions are 5% higher than those from the inversion with similar amount of pseudo observations (covering 50% of surface grid boxes, Pseudo 7), whereas the total *a posteriori* emissions are almost unchanged between Pseudos 7 and 9. Thus, pseudo observations located at source regions would be more effective to constrain sources.'.

Minor comments:
p21866, Line 13: What does 'both' refer to? Please specify. Also 'two-fold'. p21866, Line 14: '... their respective a priori emission inventories, ...'

Revised to ' both anthropogenic and biomass burning emissions in the adjoint inversions increase twofold relative to the respective *a priori* emissions '.

p21866, Line 16 and line 20: What does the 'inversion system' refer to? Are you talking about the adjoint or the analytical inversion system?

Revised to 'adjoint inversion system'.

p21867, Line 7: '... and cause global warming (...)': the global warming effect of BC was already mentioned in the previous sentence.

Removed.

p21867, Line 24: "increase in fires": are you referring to an increase in fire frequency, burnt area, emissions, or a combination thereof?

Revised to ' an increase in fires in terms of both fire frequency and burned area '

p21868, Lines 17-28: Here and throughout: When you say "inverse modeling" or "inverse system", it is not clear whether you are referring to the analytical inversion method, the adjoint method, or the general inversion problem. Please use consistent nomenclature.

Revised to 'Inverse modeling in general'.