Referee Report to the article titled “Observationally constrained analysis of sulfur cycle in the marine atmosphere with NASA ATom measurements and AeroCom model simulations”

Summary and Scope

The authors aim to understand sulfur cycle at remote regions in the troposphere. They use measurement data from ATom campaign and compare it with the simulated sulfur species in AeroCom chemical transport models. They discuss the possible reasons for inconsistency among models in simulating the concentrations of various sulfur species over wide ranges of conditions, and further point to possible sources of discrepancies that are avenues for further investigation. The structure of the manuscript is very logical, enabling the reader to arrive at clear inferences.

I have a few comments on the tagging method discussed in this study.

Explicit recommendation

I recommend **minor revisions** to certain parts of the text before accepting.

Detailed comments

Main comments

Confusion between sensitivity analysis and tagging method.

Comment 1:
In section 2.2, the authors say that they perform source attribution using sensitivity analysis method. By sensitivity analysis I would assume a perturbation approach where two simulations are performed: one with the baseline emissions and another where emissions from a given source are changed. The difference between the simulated variables in the two simulations would communicate the sensitivity of the simulated concentrations to changes in precursor emissions from a particular source.

Comment 2:
However, section 5 mentions tagging method being used for source attribution within GEOS-Chem model. Tagging involves changing the chemical mechanism within the model to write out the concentration variables along with the label of the source which they originate from.

Comment 3:
I would also like to point to Line 45 (abstract) where the authors write: “sensitivity studies by applying tagged tracers”. I recommend the authors to reframe this sentence by clarifying the exact source attribution approach and model (GEOS-Chem), to avoid possible confusion among readers.

Comment 4:
Since you discuss the results from GEOS-Chem tagged simulation, please specify the tagging method in section 2.2. Cite the relevant documentation of GEOS-Chem version and other previous papers where this tagging method has been used previously if any, for attributing sulfur species to its source origins.

Comment 5:
Could you also say something about the contribution from shipping in the Pacific and Atlantic? Have you considered ship-based emissions also as anthropogenic emissions in your models? Would ship emissions which are also anthropogenic emissions be misread as anthropogenic emissions that are generally thought of as land-based emissions? Please make the necessary adjustments in their manuscripts at the locations wherever applicable (mostly sections 2.2 and section 5) and specify those changes in response to this comment.

Minor Comments

Comment 6:
Since you have used this tagged approach, I would also recommend that you specify the list of tags that you use. This could be either as a list in the text in section 2.2, or as a special mention in table 2.

Comment 7:
You could also add some future recommendations related to the scope of tagged simulations. With this approach we could also understand the contribution characteristics of emissions from various regions: both oceanic regions (Pacific, Atlantic, Sulfur Emission Control Areas etc.) and continental regions' (Asia, North America, South America, etc) sulfur emissions. These recommendations could be added either in section 5, where the tagged model's results are being discussed, or in the concluding section (section 6)