

Responses to the Reviewer's Comments

We would like to thank the reviewers for their comments and believe that it has improved the manuscript. The reviewers' comments are in grey italics and our response is given in black.

Line 3 to 14 has been updated to reflect the recent changes in the author's affiliation changes.

Referee Comments:

Line 645-646: In your comments, you mention that it was not appropriate to talk about ozone control. However I still see this statement here. Please remove

Thanks for this comment. **Line 645 to 646** has been removed.

Lines 259-274: I disagree with the statement in the author's response which states:

"These ASD by road type does not represent a proper cycle of average speed distribution from a road link, because they are simply a collection of average speed values from road links."

The average speed distribution in MOVES is intended to be a collection of average speed values from different roadway links.

You could mention that the average speeds from SK, don't include the lower average speeds that are anticipated to occur across time due to congestion. However, I can see that the authors wanted to evaluate the sensitivity to having average speeds with more lower speed driving, and I don't think it is defensible for you to say that the adjustments from the State of Georgia is better, or that the current values are underestimated. I think you can say that you obtain different values, by adjusting the SK ASD values based on the State of Georgia ASD. And you state your assumptions about why you made the adjustments.

I would be ok with the adjustments to the SK ASD, if you clarified that . I have suggested edits below.

However, the ASD based on the SK GIS road shapefiles ~~wasn't able to~~ did not capture ~~the low-~~ speed range (<16 km h-1) driving ~~that occurs while it operates~~ (Fig. 4a). ~~It This causes d the a~~ significantly ~~under~~ lower estimation of NOx and VOC emissions compared to the CAPSS (Appendix G). We believe the SK average speed distribution is missing low speed driving that can occur on links on different days due to congestion. To address this absence of low-speed driving in the SK ASD issue, we incorporated data from the ASD (Figure 4b) from the state of Georgia developed by U.S. EPA to ~~improve the representation~~ adjust the low-speed ranges (speed bin #1 and #2 for road type 1 to 7).

In response to comment 4. You mention "But the link level speed data in SK are average speed only, there is no variance speed by link and by road type."

I don't understand this statement. This makes me think that you have a different definition of average speed distribution than MOVES. Looking at Figure 4a, you clearly have calculated an

average speed distributions for each average speed from each road type and link from the SK data. To calculate the Figure 41, you clearly have average speed by link that varies within each roadtype.

These average speed distributions from each link are appropriate for use in MOVES. But then you mention that it is not sufficient. Are you thinking that you need speed distributions based on sec/sec data? Rather than based on average link-level speeds?

I am ok with your changes. But want to make sure you're giving the correct rationale for making the changes. To me it seems that you want to calculate average speed distributions across links, road types AND time. You have links and road types. It seems that the missing dimension you would like to have in your current average speed distribution is time. You want to calculate an average speed distribution based on link-level average speed that vary across time due to days with congestions.

We really appreciate your accurate comments and suggestions. You are correct. We did not properly state in our responses on ASD development based on the SK road shapefiles. While the average speed values from reach road type and link from SK road data can be used for ASD development for use in MOVES, it did not represent actual low-speed driving patterns occurring during traffic congestions.

Following your suggestion. **Line 264-272** has been modified. Now it reads:

“We first developed the ASD (Fig. 4a) for eight different road types (No. 101-108) in South Korea based on the latest road link-specific average speed and the length of link from the SK GIS road network shapefiles (NIER, 2018). However, the ASD based on the SK GIS road shapefiles did not capture low-speed range ($<16 \text{ km h}^{-1}$) driving (Fig. 4a). This causes a significantly lower estimation of NO_x and VOC emissions compared to the CAPSS (Appendix G). We believe the SK average speed distribution is missing low-speed driving that can occur on links on different days due to traffic congestion. To address this absence of low-speed driving in the SK ASD, we incorporated data from the ASD (Figure 4b) from the state of Georgia developed by U.S. EPA to the low-speed ranges (speed bin #1 and #2 for road type 1 to 7).”

Lines 695-701: I'm good with the description here between average speed distributions and single speeds—and your assertion that the average speed distribution is better

Thanks for your response to our updates.

Line 95-96 “MOVES has a high degree of specificity”

Thanks for this comment. **Line 101-102** has been modified. Now it reads:

“Disadvantage of this model is it difficult to update and apply to countries outside of the U.S. because MOVES model has a high degree of specificity.”

Line 179-186: Each vehicle is categorized with Korea's NIER which defines the vehicle types (Ryu et al., 2003; Ryu et al., 2004; Ryu et al., 2005; Lee et al., 2011a) ~~that~~ based on a combination of...

Thanks for this comment. **Line 187-191** has been modified. Now it reads:

“Each vehicle is categorized with Korea's NIER which defines the vehicle types (Ryu et al., 2003; Ryu et al., 2004; Ryu et al., 2005; Lee et al., 2011a) based on a combination of....”

Line 189-190: Recommend clarifying that you have both on and off-network sources. The current text implies that off-network is part of on-network??

Automobile emission sources include motorized engine sources ~~both~~ on the paved road network including ~~off-network~~ and off the road network (e.g., drive way and parking lots).

Thanks for this comment. **Line 194-195** has been modified. Now it reads:

“Automobile emission sources include motorized engine sources on the paved road network and off the road network (e.g., drive way and parking lots).”

Line 216 to 217: Recommend changing this to the engine—fuel rich engine conditions don't produce high amount of NOx. But NOx is produce in lean-burn conditions

“Nitrogen oxides (NO_x) are produced due to the ~~abundant~~ abundance of nitrogen (N₂) and oxygen (O₂) ~~in~~ during the combustion process ~~due to atmosphere~~. “

Thanks for this comment. **Line 221 to 222** has been modified. Now it reads:

“Nitrogen oxides (NO_x) are produced due to the abundance of nitrogen (N₂) and oxygen (O₂) during the combustion process.