UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards (OAQPS)
Research Triangle Park, North Carolina 27711

MEMORANDUM

TO: Ozone NAAQS Review Docket (EPA–HQ–OAR–2008–0699)

FROM: John Langstaff

SUBJECT: Lung function risk sensitivity analyses

DATE: September 17, 2015

This technical memorandum describes analyses of (1) a comparison of risk estimates based on the McDonnell *et al*. (2012) FEV_1 model[1] with and without the body mass index (BMI) term and (2) simulation noise in the APEX model results. These analyses support EPA's responses to comments in Section A.1.c.ii (Risk of O_3-Induced FEV_1 Decrements) in the Response To Comments document.

[1] McDonnell, W.F.; P.W. Stewart; M.V. Smith; C.S. Kim and E.S. Schelegle. 2012. Prediction of lung function response for populations exposed to a wide range of ozone conditions. *Inhalation Toxicology*. 24:619-633.

Comparison of Risk Estimates based on the McDonnell *et al*. (2012) FEV_1 Model[1] With and Without the BMI Term

Refer to the *Health Risk and Exposure Assessment for Ozone*[2] (HREA) for background on and discussion of this issue.

In the HREA EPA presents a rationale supporting the use of the MSS model without the BMI term for modeling risks (FEV_1 decrements) of children. There are no studies of how BMI would enter into the prediction of lung function response for children, and no evidence that the BMI term in the MSS model is appropriate for children.

If the BMI model were used, it would predict lower projected numbers of FEV_1 decrements in children; <u>however, the differences in these numbers between alternative standards analyzed would be very small, as shown in Table 2</u>. E.g., 3.2% vs. 3.4% for the percent of children with $\Delta FEV_1 > 10\%$ for 1 or more days. The APEX simulations summarized in Tables 1 and 2 modeled 200,000 profiles for all ages, 44,698 of which were children. Four simulations (using the same seed) were conducted: the 75 and 70 ppb air quality scenarios, with and without the BMI term in the MSS model. Table 1 has the results of these runs and Table 2 has the differences between the 75 and 70 ppb air quality scenarios with and without the BMI term.

Table 1. Risk results for simulations with and without the BMI term in the MSS model. Atlanta, CSA 122, 2006, Children aged 5-18. 75 and 70 ppb air quality scenarios.

Scenario level (ppb)	Run	pct pop with ΔFEV1 > 10% 1 or more days	pct pop with ΔFEV1 > 15% 1 or more days	pct pop with ΔFEV1 > 10% 6 or more days	pct pop with ΔFEV1 > 15% 6 or more days
70	with BMI	13.95%	3.27%	2.68%	0.47%
75	with BMI	17.11%	4.63%	3.63%	0.80%
70	without BMI	15.85%	3.80%	3.19%	0.57%
75	without BMI	19.21%	5.29%	4.34%	0.93%

Table 2. Differential risk results for simulations with and without the BMI term in the MSS model. Atlanta, CSA 122, 2006, Children aged 5-18. Differences between the 75 and 70 ppb air quality scenarios.

Run	pct pop with dFEV1 > 10% 1 or more days	pct pop with dFEV1 > 15% 1 or more days	pct pop with dFEV1 > 10% 6 or more days	pct pop with dFEV1 > 15% 6 or more days
with BMI	3.2%	1.4%	0.9%	0.3%
without BMI	3.4%	1.5%	1.1%	0.4%

[1] McDonnell, , W.F.; P.W. Stewart; M.V. Smith; C.S. Kim and E.S. Schelegle. 2012. Prediction of lung function response for populations exposed to a wide range of ozone conditions. *Inhalation Toxicology*. 24:619-633.

[2] U.S. EPA (2014a). Health Risk and Exposure Assessment for Ozone (Final). U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 27711. EPA-452/R-14-004a. http://www.epa.gov/ttn/naaqs/standards/ozone/data/20140829healthrea.pdf

Simulation Noise (Convergence)

Simulation noise adds slightly to the uncertainties of the risk results. When comparing differences in risks from different air quality scenarios, the uncertainty due to simulation noise mostly cancels out, as we demonstrate below.

This is Section 6.5.2 from the REA:

6.5.2 Convergence of APEX Results

APEX accounts for several sources of variability by drawing random variables from specified distributions. Some variables are drawn once for each simulated individual (e.g., age, location of residence), some are drawn every day or every hour for each simulated individual, and others are drawn more frequently, at the event level (e.g., activity). Increasing the number of individuals simulated in an APEX run increases the accuracy of the modeled variability and the results of the APEX runs are more reproducible. In order to assess the number of individuals to simulate to achieve convergence of APEX results, we perform multiple APEX runs with identical inputs except for the random number seed, and look at the variability of the results of these model runs. Table 6-17 summarizes the results of 40 APEX simulations of the Atlanta 2006 base case with 200,000 simulated individuals. For each of these measures, the range of results over the 40 APEX runs is less than one percent. This analysis of the convergence of APEX results shows that modeling 200,000 simulated individuals is adequate for reasonable convergence of the FEV_1 risk measures.

Table 6-17. Convergence results for the Atlanta 2006 base case with 200,000 simulated individuals. Percents of the population by age group with one or more days (and six or more days) during the O_3 season with lung function (FEV_1) decrements more than 10, 15, and 20%. Minimum and maximum values and ranges over 40 APEX runs.

	$\Delta FEV_1 \geq 10\%$			$\Delta FEV_1 \geq 15\%$			$\Delta FEV_1 \geq 20\%$		
Age group	**min**	**max**	**range**	**min**	**max**	**range**	**min**	**max**	**range**
1 or more days in the season									
5 to 18	31.3%	32.1%	0.88%	12.4%	12.9%	0.49%	6.21%	6.71%	0.50%
19 to 35	11.1%	11.5%	0.39%	3.00%	3.26%	0.26%	1.11%	1.32%	0.22%
36 to 55	3.54%	3.79%	0.25%	0.55%	0.68%	0.13%	0.13%	0.20%	0.07%
6 or more days in the season									
5 to 18	9.28%	9.73%	0.45%	2.80%	3.18%	0.38%	1.11%	1.37%	0.27%
19 to 35	1.09%	1.25%	0.16%	0.15%	0.21%	0.06%	0.03%	0.06%	0.03%
36 to 55	0.22%	0.30%	0.08%	0.01%	0.03%	0.02%	0.00%	0.01%	0.01%

The difference in risk estimates between levels of alternative standards is an important measure and the simulation convergence uncertainty is much less for the differences than for the absolute risks for each scenario. This results from the cancellation of the simulation noise when subtracting the risk estimates. We demonstrate this as follows.

100 pairs of APEX simulations were conducted for Atlanta, 2006, where one simulation had air quality adjusted to just meet the current standard level of 75 ppb, and the other with air quality adjusted to just meet an alternative standard level of 70 ppb. These simulations used the same inputs as those used for the HREA, except for the random number seeds. Each pair of simulations used the same random number seed, so 100 different seeds were used in all. For each of the 100 pairs of simulations, the percent of children (ages 5 to 18) who experienced 1 or more and 6 or more FEV_1 decrements greater than 10% and 15% were calculated. The minimum and maximum values of these percentages across these simulations are given in Table 3, along with the range (= max – min). For example, the 100 simulations of the current standard had percents of children with 1 or more FEV_1 decrements ≥ 10% ranging from 18.8% to 19.5%. This range represents the simulation convergence uncertainty described by the commenter.

However, when we look at the difference of this measure for each pair of simulations, we find that these differences are much smaller. Table 4 gives the differences between the 75 and 70 ppb scenario pairs of the percent of children (ages 5 to 18) who experienced 1 or more and 6 or more FEV_1 decrements greater than 10% and 15%. The differences of percents of children with 1 or more FEV_1 decrements ≥ 10% range from 3.2% to 3.6%.

Table 3. The percents of children (ages 5 to 18) who experienced 1 or more and 6 or more FEV_1 decrements greater than 10% and 15%, for the current standard level of 75 ppb, and an alternative standard level of 70 ppb. Statistics across 100 APEX simulations of Atlanta, 2006.

		FEV_1 decrements ≥ 10%			**FEV_1 decrements ≥ 15%**		
	scenario	**min**	**max**	**range**	**min**	**max**	**range**
≥ 1 days	70 ppb	15.5%	16.1%	0.67%	3.68%	4.07%	0.38%
≥ 1 days	75 ppb	18.8%	19.5%	0.75%	5.19%	5.67%	0.48%
≥ 6 days	70 ppb	3.08%	3.46%	0.38%	0.49%	0.66%	0.16%
≥ 6 days	75 ppb	4.22%	4.69%	0.47%	0.79%	1.05%	0.26%

Table 4. The percents of children (ages 5 to 18) who experienced 1 or more and 6 or more FEV_1 decrements greater than 10% and 15%, for the current standard level of 75 ppb, and an alternative standard level of 70 ppb. Statistics for the difference of this measure for each pair of simulations (75 ppb – 70 ppb), across 100 pairs of APEX simulations of Atlanta, 2006.

		FEV_1 decrements ≥ 10%			**FEV_1 decrements ≥ 15%**		
	scenario	**min**	**max**	**range**	**min**	**max**	**range**
≥ 1 days	difference	3.2%	3.6%	0.46%	1.4%	1.7%	0.33%
≥ 6 days	difference	1.0%	1.3%	0.27%	0.30%	0.42%	0.12%