Relative Response Factor (RRF) and "Modeled Attainment Test"

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EPA guidance (EPA 2005) and the subsequent document (EPA 2006) require the use of a *modeled attainment test* which is described as a procedure in which an air quality model is used to simulate current and future air quality. If future estimates of ozone concentrations are <= 84 ppb, then this element of the attainment test is satisfied. A *modeled attainment demonstration* that consists of (a) analyses which estimate whether selected emissions reductions will result in ambient concentrations that meet the NAAQS or progress goals and (b) an identified set of control measures which will result in the required emissions reductions is provided elsewhere.

For this modeled attainment test, model estimates are used in a "relative" rather than "absolute" sense. That is, one calculates the ratio of the model's future to current (baseline) predictions at ozone monitors. These ratios are called *relative response factors (RRF)*. Future ozone concentrations are estimated at existing monitoring sites by multiplying modeled RRF at locations "near" each monitor by the observation-based monitor-specific "baseline" ozone design value. Therefore, the following equation describes approach as applied to a monitoring site i:

$$(DVF)_i = (RRF)_i \ x \ (DVC)_i \qquad\qquad \text{(Equation 1)}$$

Where $(DVC)_i$ is the baseline concentration monitored at site i; $(RRF)_i$ is the relative response factor, calculated for site i, and $(DVF)_i$ is the estimated future design value for site i. The RRF is the ratio of the future 8-hour daily maximum concentration predicted at a monitor to the baseline 8-hour daily maximum concentration predicted at the monitor location averaged over multiple days determined from the base case.

The following sections describe the calculation of each of the elements in Equation 1 as implemented by NYSDEC through an in-house computer program (fortran). Note, the subscript "i" from equation is dropped in the following description. However, all calculations are still performed on a monitor-by-monitor basis.

1. Calculation of DVC

Design values (DV) at each monitoring site are calculated in accordance with 40 CFR Part 50.10, Appendix I. The DV is calculated as the 3 year average of the fourth highest monitored daily 8-hour maximum value at each monitoring site. For example, the design value for the 2000-2002 is the average of the fourth highest monitored daily 8-hour maximum values in 2000, 2001 and 2002. Design values are labeled with the *last* year of the design value period, i.e. the design value for the 2000 – 2002 is labeled as "2002 design value".

For the "modeled attainment test", the guidance defines the DVC in Equation 1 as the average of the design values, which straddle the baseline inventory year. In our case, the baseline inventory year is 2002. Therefore, DVC is the average of the "2002 design value" (determined from 2000-2002 observations), the "2003 design value" (determined

from 2001-2003 observations), and the "2004 design value" (determined from 2002-2004 observations). Consequently, DVC is derived from observations covering a five year period and is a weighted average with 2002 observations "weighted" three times, 2001 and 2003 observations weighted twice, and 2000 and 2004 observations weighted once.

The following criteria concerning missing DV were implemented in the fortran code calculating DVC:

- For monitors with only four years of consecutive data, the guidance allows DVC to be computed as the average of two DV within that period.
- For monitors with only three years of consecutive data, the DVC is equal to the DV calculated for that three year period
- For monitors with less than three years of consecutive data, no DVC can be estimated

2. **Calculation of RRF**

The guidance requires the calculation of RRF with CMAQ output from grids that are "near" a monitor. Because of the 12km grid spacing used in the CMAQ simulations, model predictions in a 3*3 grid array centered on the monitoring location are considered "near" that monitor. For each day, the maximum base case and control case concentration within that array is selected for RRF calculation as set forth in the guidance document.

Because photochemical models were found to be less responsive to emission reductions on days of lower simulated ozone concentrations, the guidance recommends applying screening criteria to the daily model predictions at individual monitors to determine whether that day's predictions are to be used to calculate the RRF or not. Only "high ozone days" are to be selected:

RRF = (average control case over high ozone days selected based on base case concentrations) / (average base case over selected high ozone days)

In addition, the guidance recommends that preferably ten or more "high ozone days", as identified below, be selected for RRF calculation. In no case can the RRF be calculated with fewer than five "high ozone days".

The following describes the logic with which NYSDEC implemented these screening criteria into its Fortran code for RRF calculation:

a. Selecting concentrations from grid cells surrounding the monitor

  i. Determine the grid cell in which the monitor is located and include the surrounding 8 grid cells to form a 3*3 grid cell array

  ii. Determine daily maximum 8-hr ozone concentrations for each day for each of the 9 grid cells for both the base case and control case

iii. For each day, pick the highest daily maximum 8-hr ozone value out of all 9 grid cells. This is the daily maximum 8-hr ozone concentration for that monitor for that day to be used in RRF calculations (following the screening criteria below).

iv. This is done for both the base case and the control case. Note that the grid cell selected on any given day for the base case need not be the same as the grid cell selected for the same day in the control case.

b. <u>Selecting modeling days to be used in the RRF computation (again, this is done on a monitor-by-monitor basis)</u>

i. Starting with a ozone threshold (TO_3) of 85 ppb and a minimum required number of days (Dmin) of 10, determine all days for which the simulated base case concentration (as determined in step (a) is at or above the threshold TO_3.

ii. If the number of such days is greater to or equal Dmin, identify these days and proceed to step (c). Otherwise, continue to b(iii), below.

iii. Lower the threshold (TO_3) by 1ppb interval and go back to b(i) to identify the days. If the minimum number of days is not reached then reduce that requirement by 1 but no lower than 5 days and with $TO_3 >= 70$ ppb and go back to b(i). Otherwise proceed to b(iv) below.

iv. Stop. No RRF can be calculated for this monitor because there were less than 5 days with base case daily maximum concentration $>= 70$ ppb.

c. <u>RRF computation:</u> Compute the RRF by averaging the daily maximum 8-hr ozone concentrations for base case and control case determined in step (a) over all of the days determined in step (b). The RRF is the ratio of average control case concentrations over average base case concentrations.

3. **Computation of DVF**

Compute DVF as the product of DVC from step (1) and RRF from step (2). Note, the following conventions on numerical precision (truncation, rounding) were applied:

a. DV are truncated in accordance with 40 CFR Part 50.10, Appendix I. This applies to the "2002 DV", the "2003 DV", and the "2004 DV"

b. DVC (averages of DV over multiple years) are calculated in ppb and carried to 1 significant digit

c. RRF are calculated and carried to three significant digits

d. DVF is calculated by multiplying DVC with RRF, followed by truncation

References

EPA (2005) Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS. EPA-454/R-05-002.

EPA (2006) Guidance on the use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze. Draft 3.2-September 2006.