Development and Application of PM2.5 Interpollutant Trading Ratios to Account for PM2.5 Secondary Formation in Georgia

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Introduction

- Facilities applying for PSD air permits are required to model the impact of direct PM2.5 emissions ($\geq$10 TPY) using AERMOD.
  - In addition, these facilities must account for the impact of secondary PM2.5 formation from precursor emissions (NOx and/or SO2 $\geq$ 40 TPY).
- AERMOD does not contain chemistry or aerosol formation modules
  - The secondary formation of PM2.5 cannot be modeled directly in AERMOD.

Interpollutant Trading Ratios

- Sources applying for permits in areas designated nonattainment for PM2.5 can offset emissions increases of direct PM2.5 emissions with reductions of PM2.5 precursors in accordance with interpollutant trading ratios (also called "PM2.5 offset ratios") contained in the approved SIP for the applicable nonattainment area.
  - For example, an existing source can increases PM2.5 emissions by <u>X</u> tons in exchange for reducing SO2 emissions by <u>Y</u> tons.

Secondary Formation in AERMOD

- PM2.5 offset trading ratios can be used to account for secondary formation of PM2.5 in AERMOD.
- Convert SO2 and NOx emissions into “equivalent” direct PM2.5 emissions and model them in AERMOD
  - Option 1: Add SO2 and NOx “equivalent” direct PM2.5 emissions to the actual direct PM2.5 emissions and run AERMOD
    - Allows for ratios that vary temporally
  - Option 2: Calculate a percent increase in direct PM2.5 emissions due to the addition of SO2 and NOx “equivalent” direct PM2.5 emissions and scale the AERMOD output for actual direct PM2.5 emissions
    - Allows for ratios that vary spatially

EPA Memo – July 21, 2011

The general framework for developing PM2.5 offset ratios would include the following steps:

1) Define the geographic area(s).
2) Conduct a series of sensitivity runs with appropriate air quality models to develop a database of modeled PM2.5 concentration changes associated with reductions of direct PM2.5 emissions and PM2.5 precursor emissions.
3) Calculate the interpollutant offset ratios for PM2.5.
4) Conduct quality assurance of the resulting ratios.

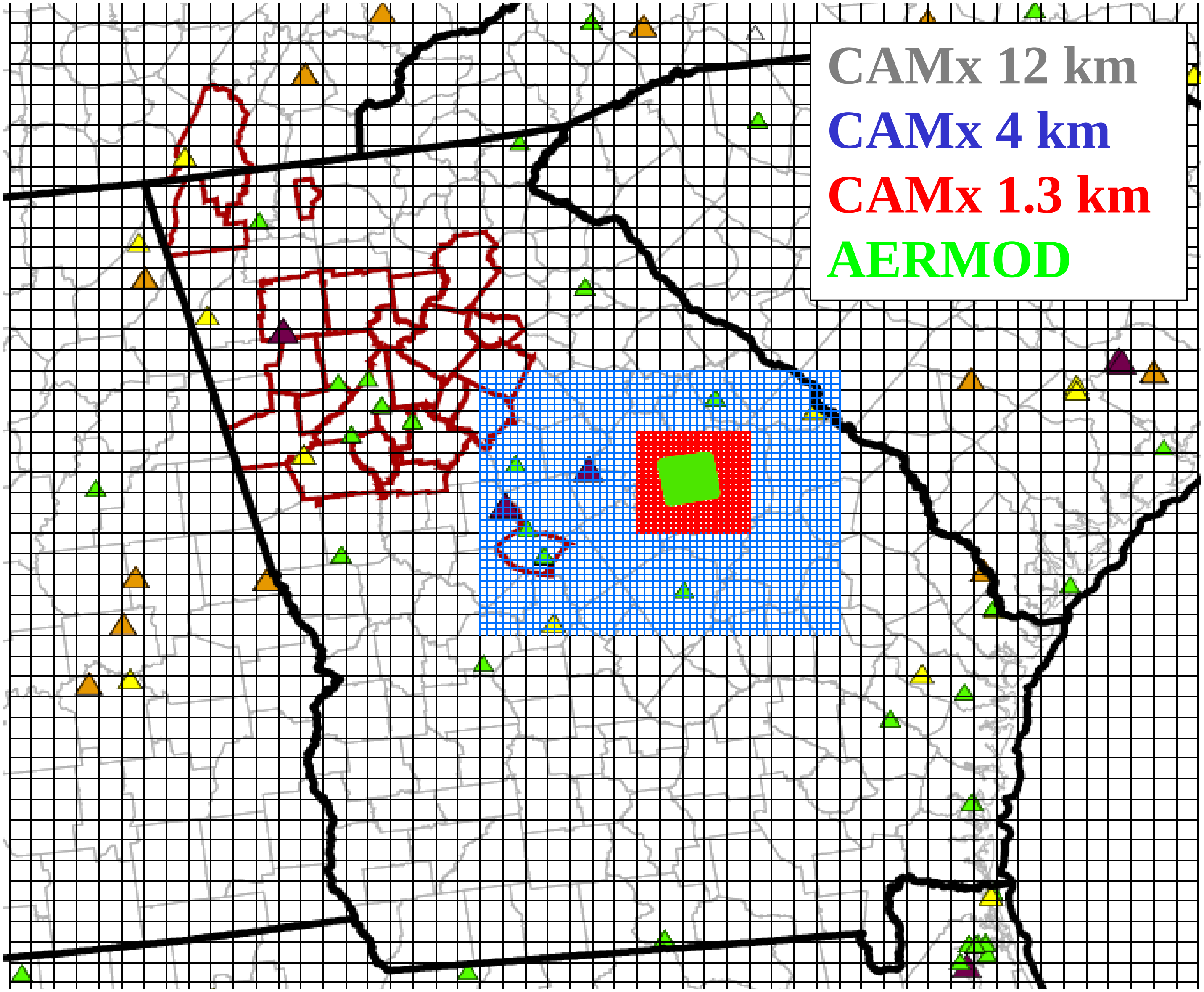
Case Study: Georgia

- Plant Washington
  – 850 MW Coal Fired Power Plant located in Washington County, GA
- Final permit issued on April 8, 2010
- GA EPD used CAMx modeling to account for secondary PM2.5 impacts and ozone impacts from the proposed facility.

Model Setup

- MM5 for Meteorology
  - VISTAS 2002
- SMOKE for Emissions
  - VISTAS 2009 used in Georgia PM2.5 SIP
  - Added power plant emissions
    - 4200 TPY SO2, 1817 TPY NOx, 6 TPY EC
    - Stack height = 137.16 meters
- CAMx with Flexi-nesting
  - 12-km/4-km/1.333-km
- Three sensitivity runs to calculate baseline PM2.5 offset ratios
  - Zero-out stack emissions: (1) SO2, (2) NOx, (3) EC

CAMx Modeling Domains



Modeled PM2.5 Offset Ratios

- Normalized Sensitivity (S)
  - $S_{SO2} = (\Delta PM2.5_{SO2}/\Delta TPY_{SO2})$
  - $S_{NOx} = (\Delta PM2.5_{NOx}/\Delta TPY_{NOx})$
  - $S_{PM2.5} = (\Delta PM2.5_{PM2.5}/\Delta TPY_{PM2.5})$
- PM2.5 Offset Ratios (R)
  - $R_{SO2} = S_{PM2.5}/S_{SO2}$
  - $R_{NOx} = S_{PM2.5}/S_{NOx}$

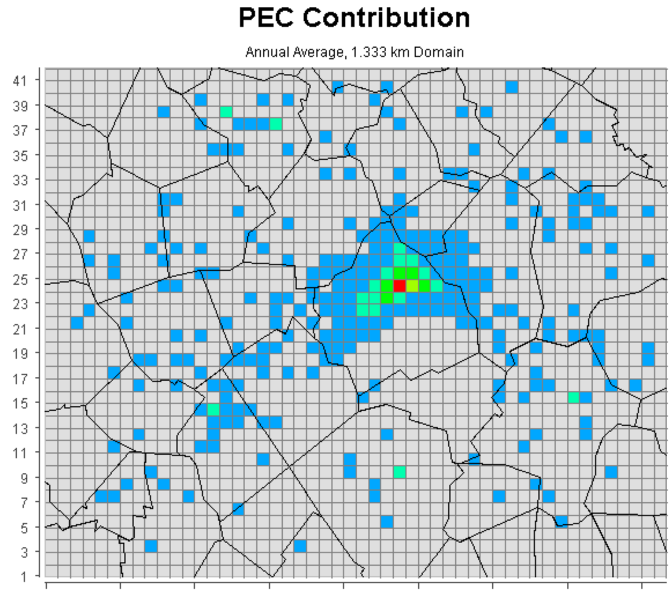
Sensitivity Runs

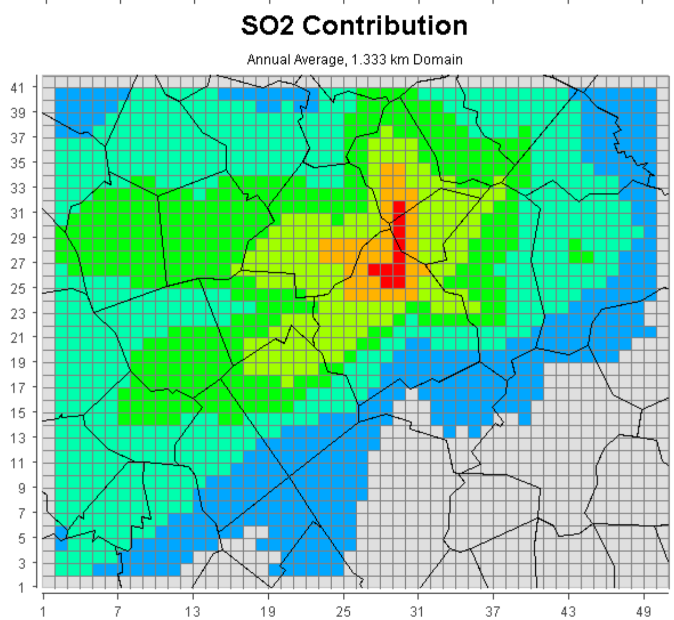
- Sensitivity runs were performed to evaluate how PM2.5 offset ratios varied by:
  - Distance from the source
  - Grid resolution
  - Season of the year
  - Stack height
  - Location in the state

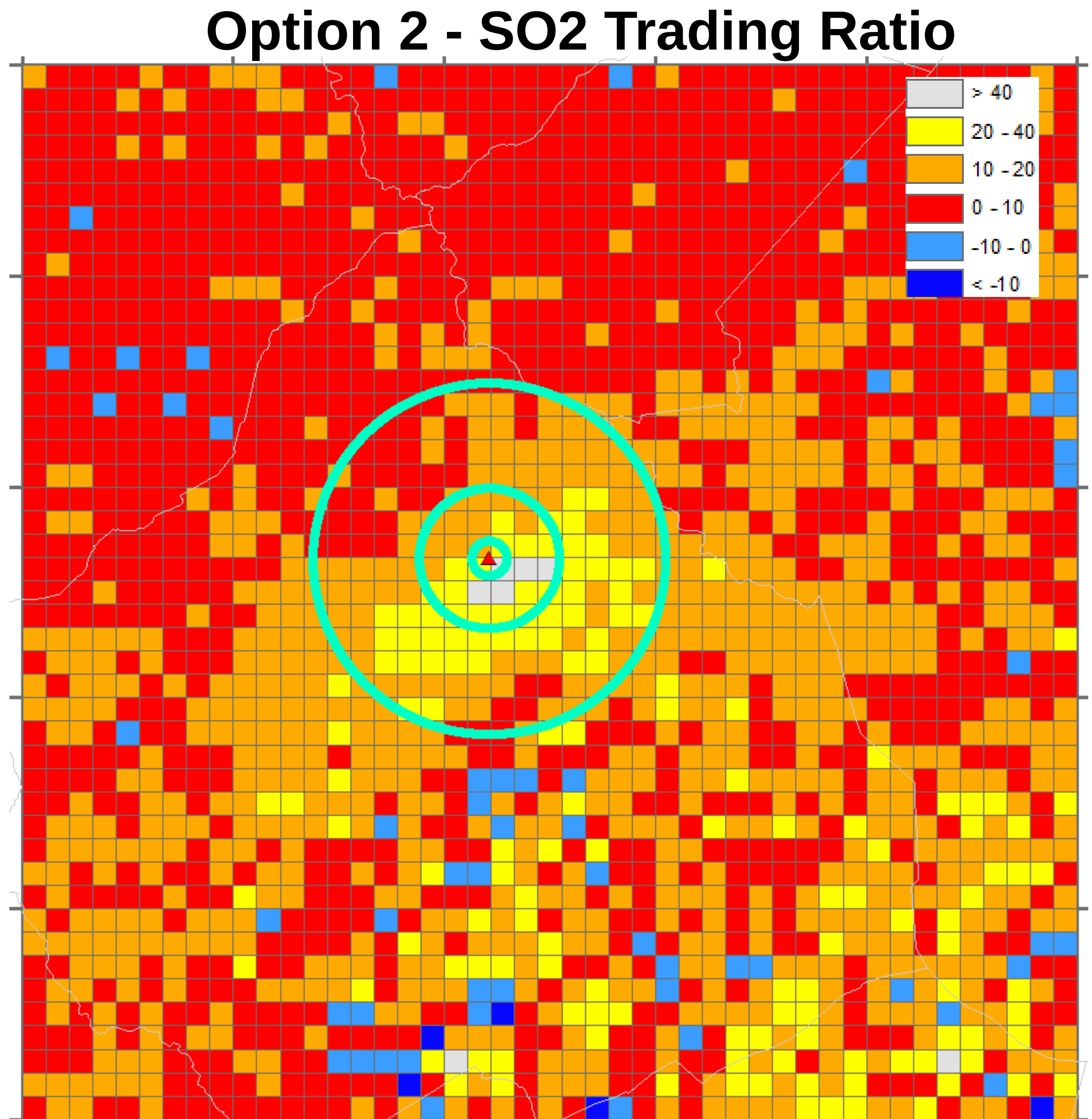
Trading Ratio vs. Distance

- **OPTION 1:** Average S_{SO2}, S_{NOx}, and $S_{PM2.5}$ for all grid cells at a given distance, then calculate the average trading ratios (R_{SO2} and R_{NOx})
- **OPTION 2:** Calculate trading ratios (R_{SO2} and R_{NOx}) for each individual grid cell, then average for all grid cells at a given distance
  - A single cell with small $\Delta PM2.5_{SO2}$ or small $\Delta PM2.5_{NOx}$ can skew the results
- **GA EPD picked OPTION 1.**

Δ PM2.5 – Annual EC and SO2



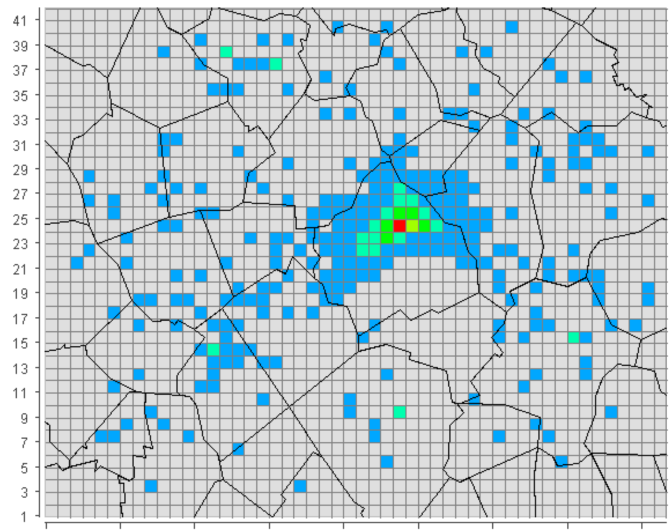




Δ PM2.5 – Annual EC and NOx

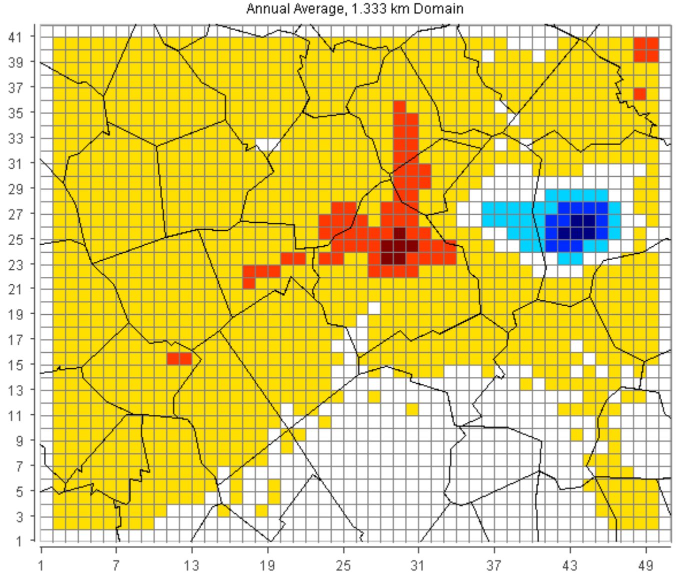
PEC Contribution

Annual Average, 1.333 km Domain

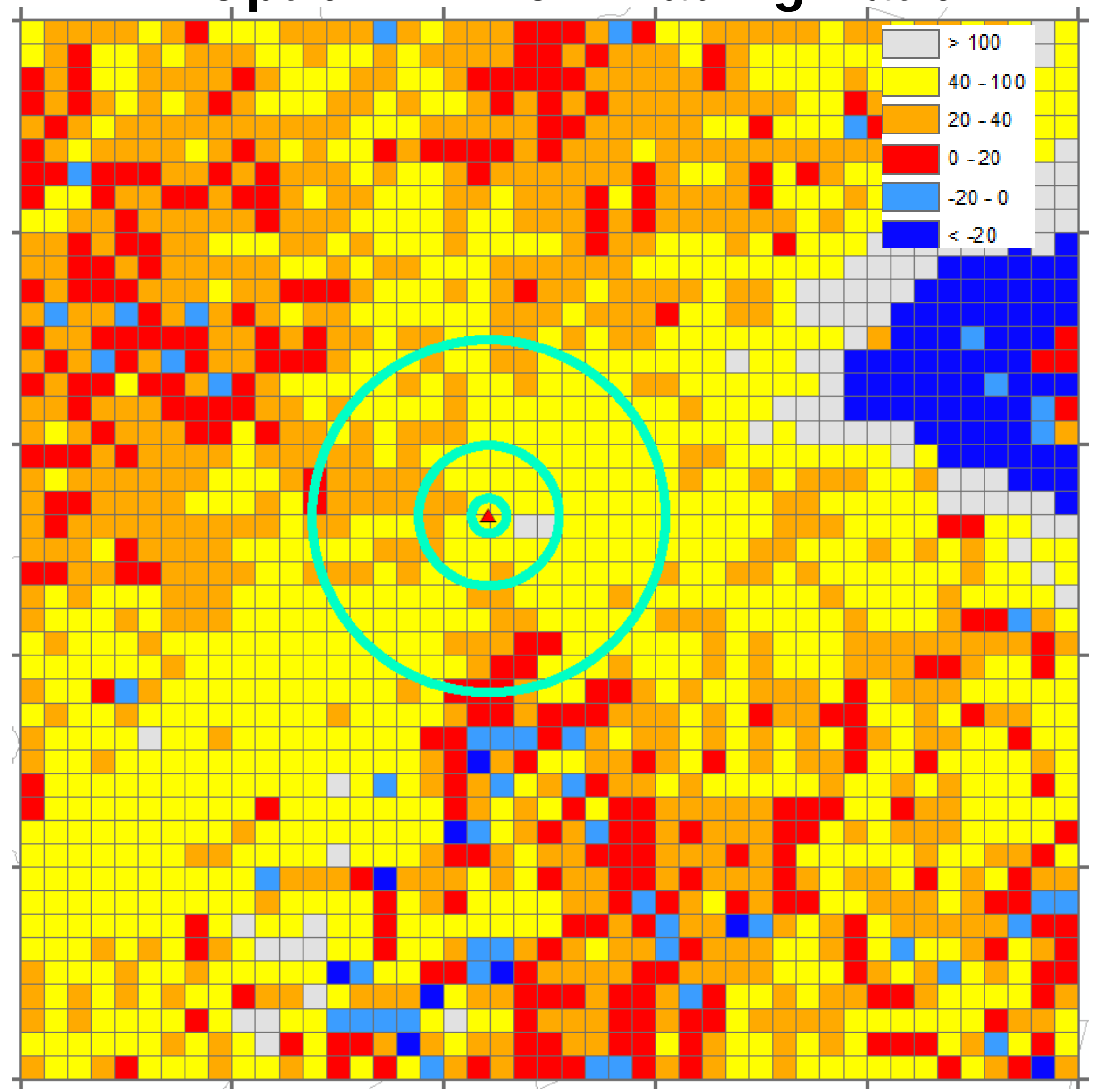


NOx Contribution

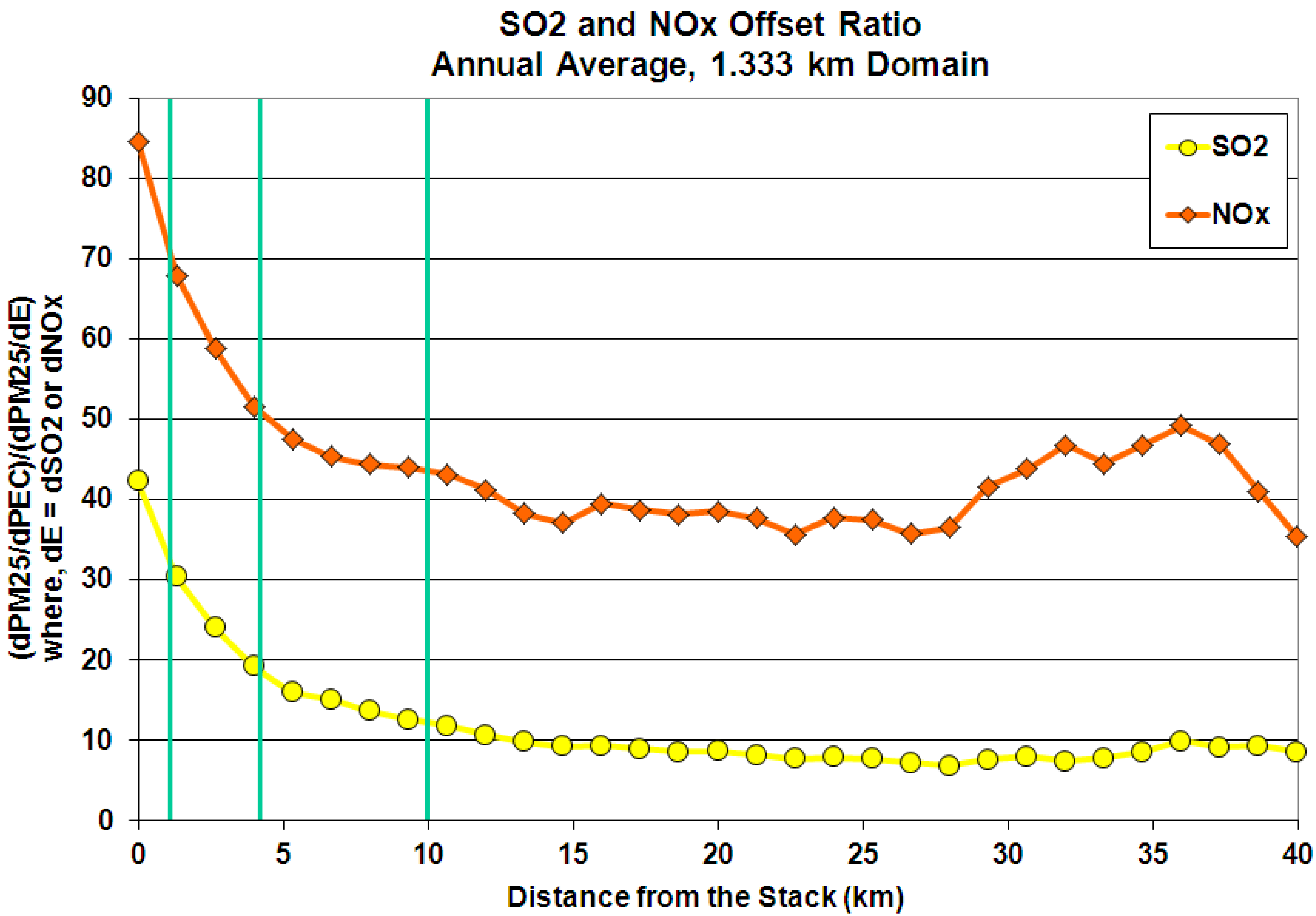
Annual Average, 1.333 km Domain



Option 2 - NOx Trading Ratio



Annual PM2.5 Offset Ratios

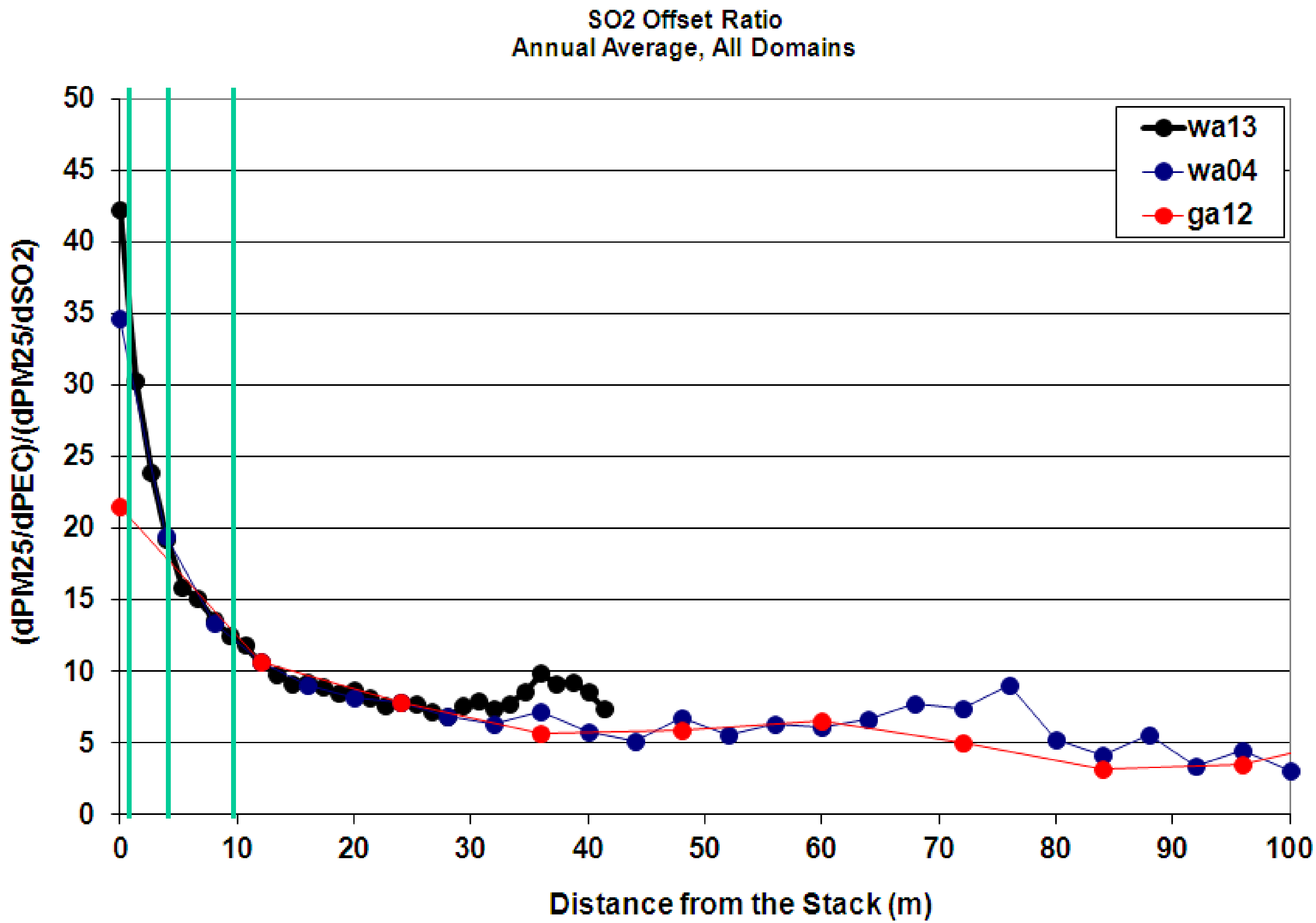


Distance from Source

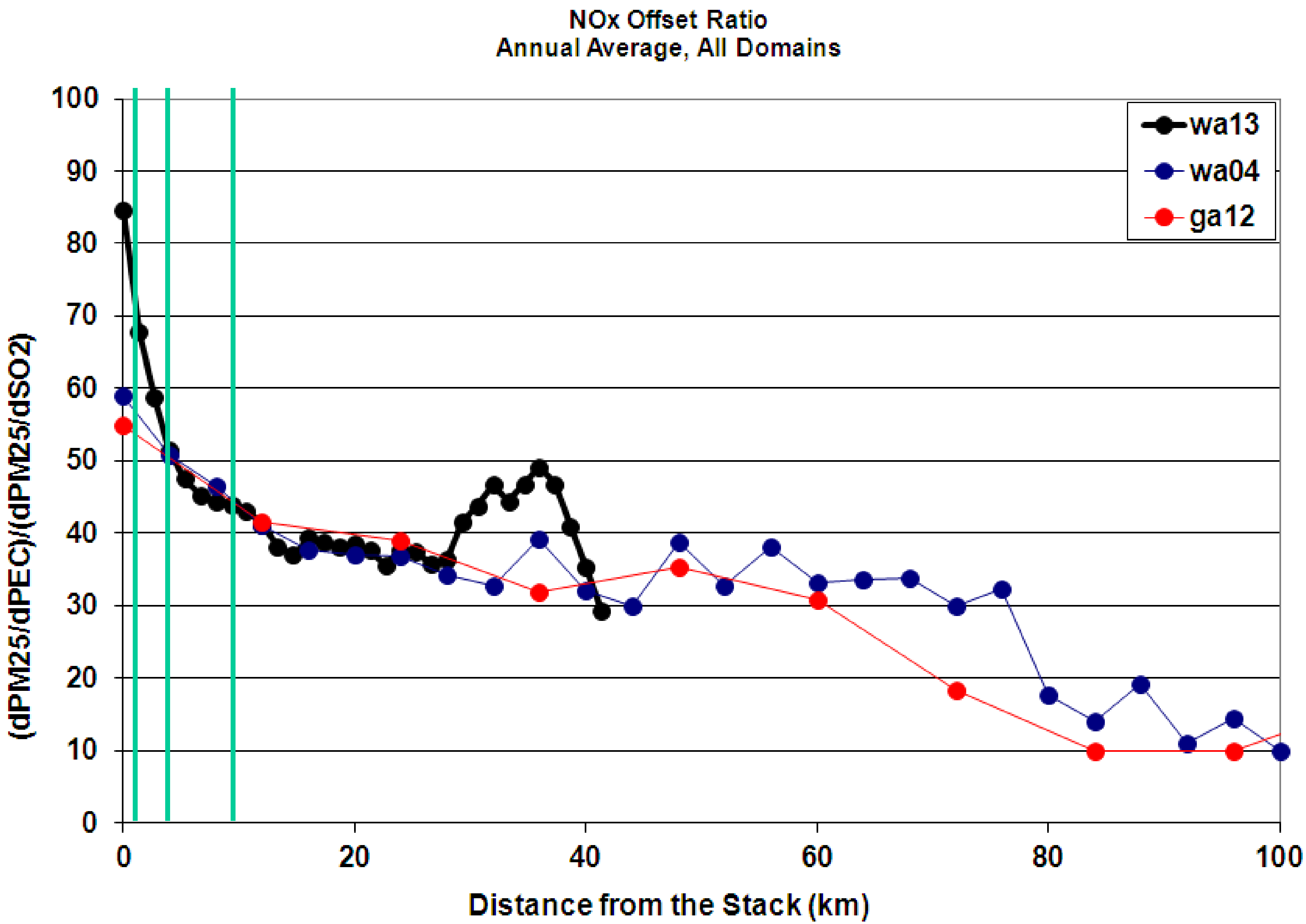
- Lower PM2.5 offset ratio values are more conservative (i.e., each ton of SO_2 and NO_x will produce more secondary PM2.5).
- Select lowest ratio in each distance bin:

Distance	SO_2 Ratio	NO_x Ratio
< 1 km	30:1	70:1
1 – 4 km	20:1	50:1
4 – 10 km	10:1	40:1
> 10 km	7:1	35:1

R_{SO2} vs. Grid Resolution



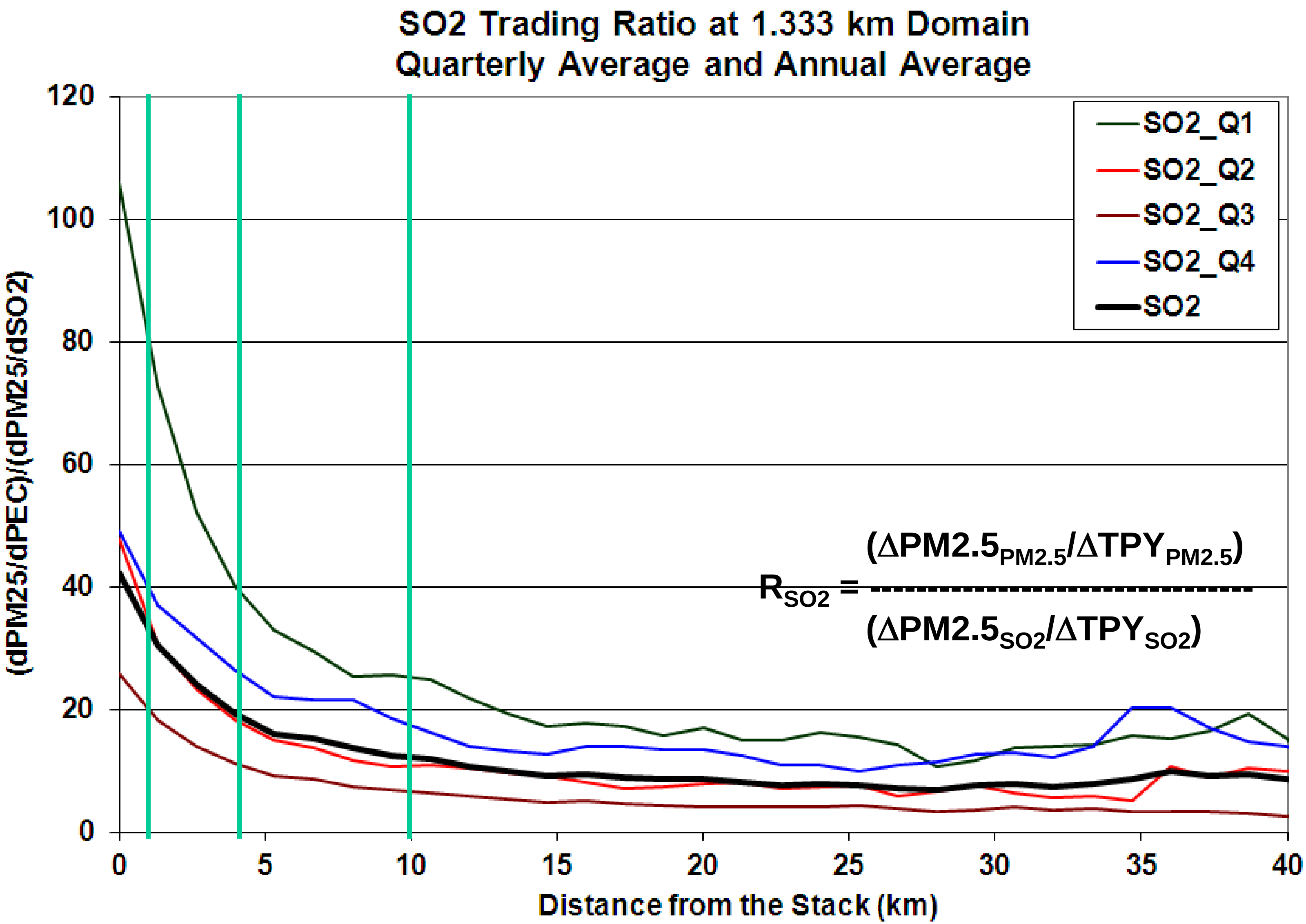
R_{NOx} vs. Grid Resolution



Impacts of Grid Resolution

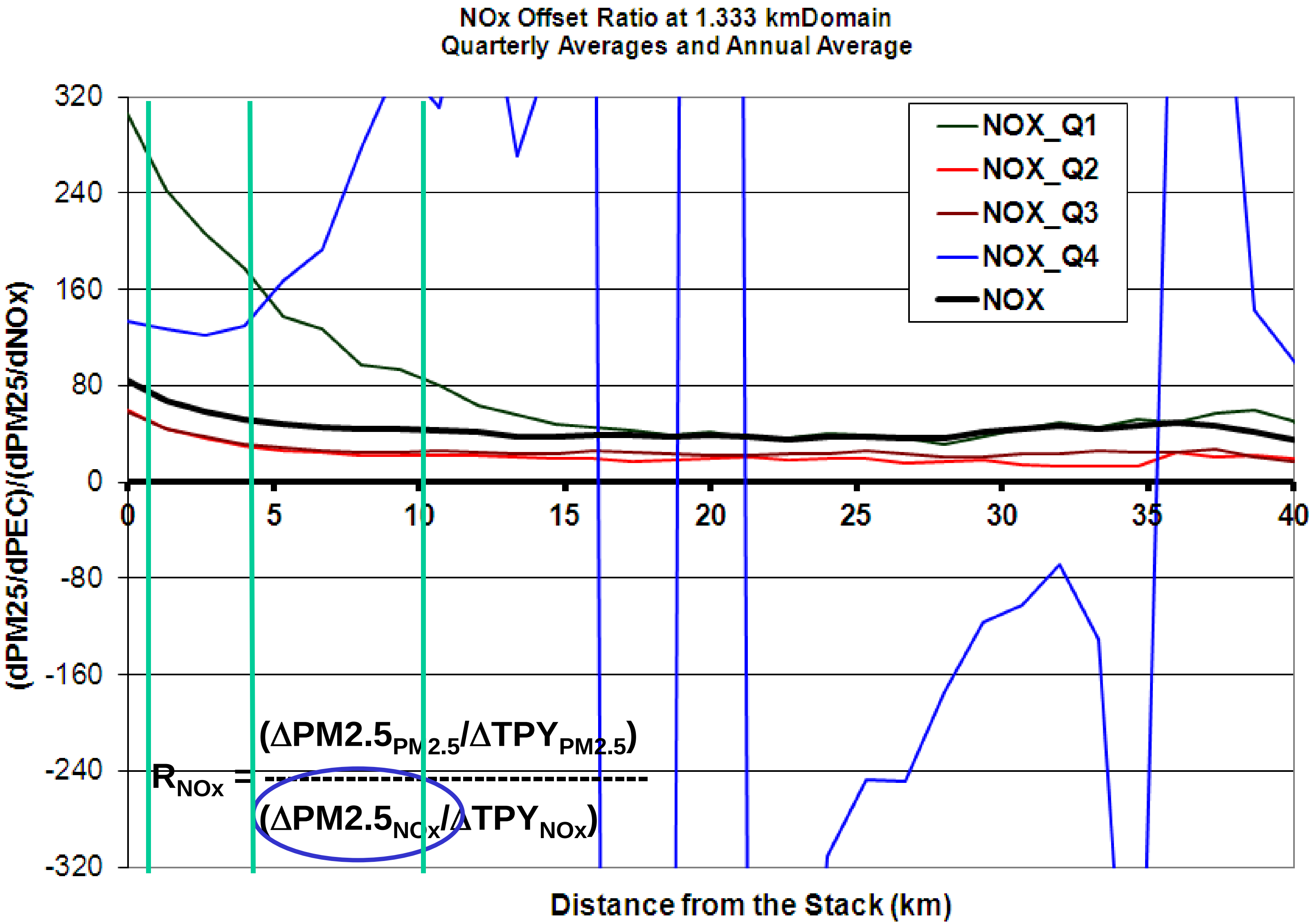
- Larger grid resolutions (e.g., 12 km) produce more conservative SO_2 and NO_x offset ratios (lower ratios) compared to smaller grid resolutions (e.g., 1.3 km) near the source.
- Larger grid resolutions produce similar SO_2 and NO_x offset ratios compared to smaller grid resolutions far from the source.
- Creating SO_2 and NO_x offset ratios using larger grid cells is a conservative approach.

Quarterly SO_2 Offset Ratios



$$R_{SO2} = \frac{(\Delta PM2.5_{PM2.5}/\Delta TPY_{PM2.5})}{(\Delta PM2.5_{SO2}/\Delta TPY_{SO2})}$$

Quarterly NOx Offset Ratios



$$R_{NOx} = \frac{(\Delta PM2.5_{PM2.5}/\Delta TPY_{PM2.5})}{(\Delta PM2.5_{NOx}/\Delta TPY_{NOx})}$$

Impacts of Season of Year

- SO2 and NOx offset ratios vary by season of the year and distance from the source:

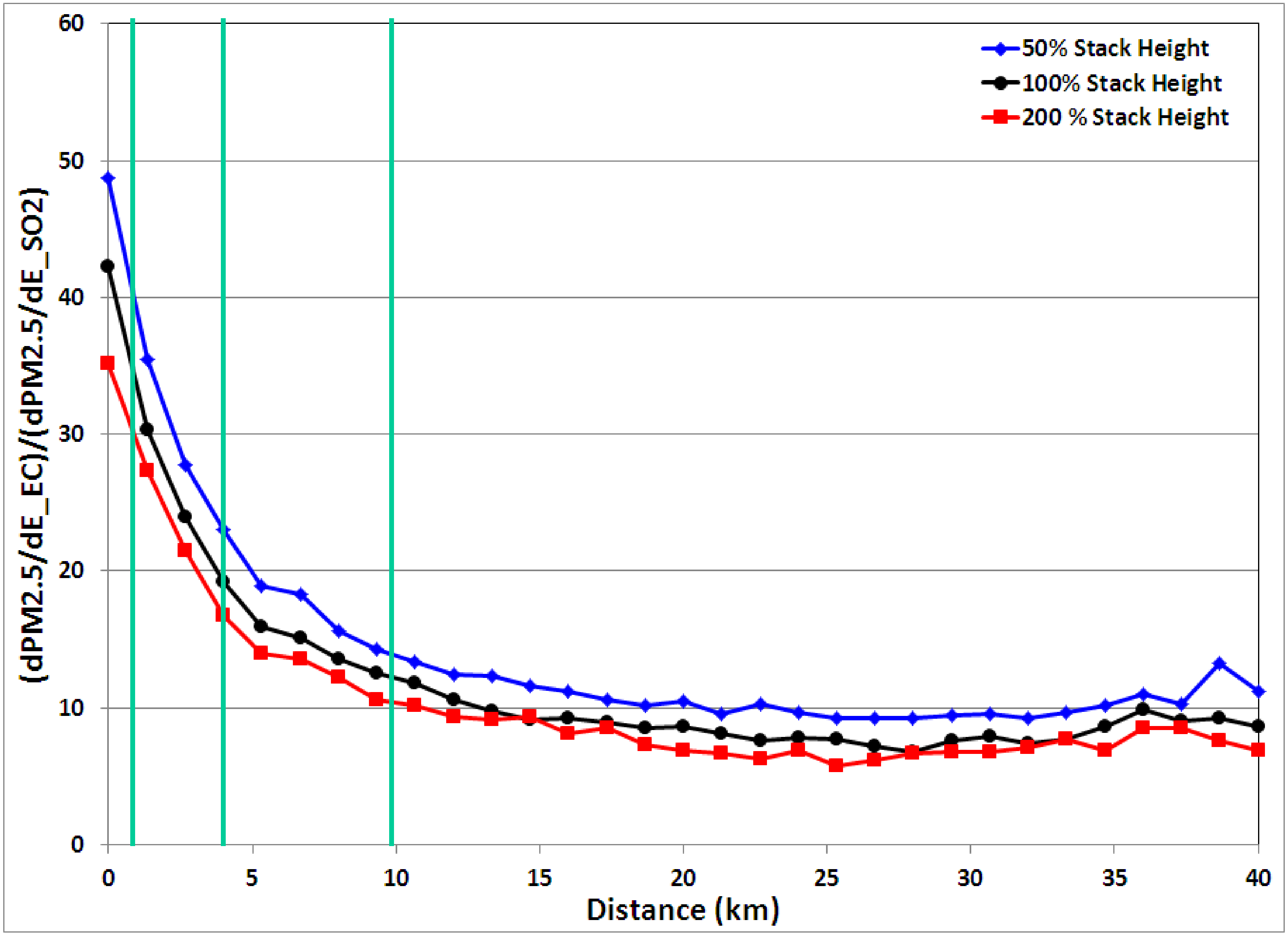
SO2 Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	80:1	35:1	20:1	40:1
1 – 4 km	40:1	20:1	10:1	25:1
4 – 10 km	25:1	10:1	7:1	18:1
> 10 km	15:1	7:1	5:1	10:1

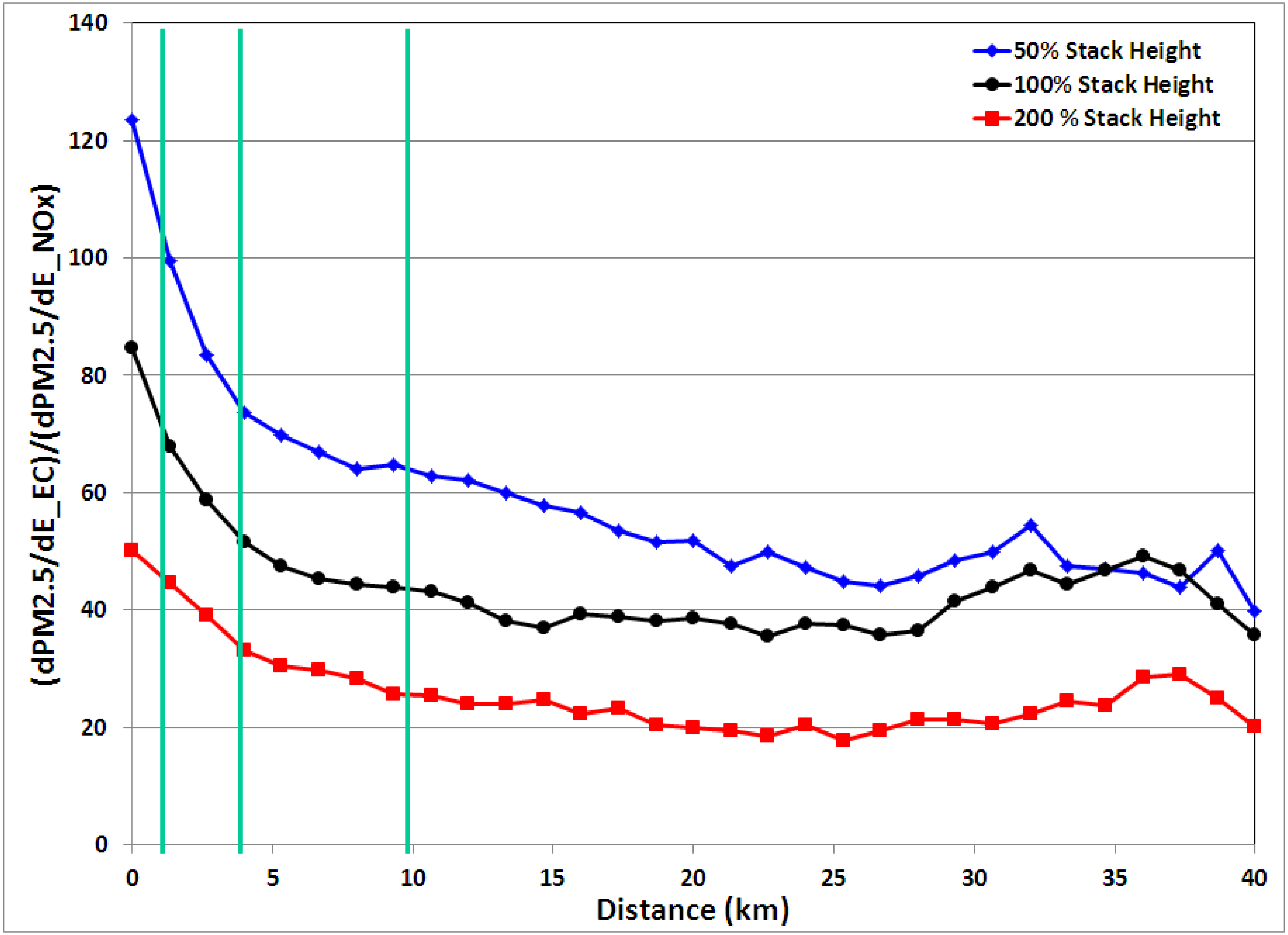
NOx Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	250:1	50:1	50:1	120:1
1 – 4 km	160:1	35:1	35:1	120:1
4 – 10 km	80:1	20:1	20:1	N/A
> 10 km	40:1	20:1	20:1	N/A

R_{SO2} vs. Stack Height



R_{NOx} vs. Stack Height



Impact of Stack Height

- Stack height has a small impact on the SO2 offset ratios.
- Stack height has a bigger impact on NOx offset ratios.
- Shorter stacks have higher offset ratios, so using the lower offset ratios are conservative.
- Taller stacks will be limited by GEP Stack Height Regulations, so we will not need to adjust the ratios.

Impact of Location

- Downtown Atlanta and west Georgia are currently being analyzed.
- Will perform sensitivity runs for five additional locations in Georgia
- Will either pick the most conservative trading ratios by looking at variations across the state <u>or</u> provide trading ratios that vary by region of the state.

Tiered Approach

- Use tiered approach starting with the most conservative offset ratios and easiest to apply:
  - Tier 1
    - SO_2 and NO_x ratios from Q3 at d > 10 km
  - Tier 2
    - SO_2 and NO_x ratios from Q3, vary with distance
  - Tier 3
    - SO_2 and NO_x ratios by quarter at d > 10 km
  - Tier 4
    - SO_2 and NO_x ratios by quarter, vary with distance

Tier 1

SO2 Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	80:1	35:1	20:1	40:1
1 – 4 km	40:1	20:1	10:1	25:1
4 – 10 km	25:1	10:1	7:1	18:1
> 10 km	15:1	7:1	**5:1**	10:1

NOx Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	250:1	50:1	50:1	120:1
1 – 4 km	160:1	35:1	35:1	120:1
4 – 10 km	80:1	20:1	20:1	N/A
> 10 km	40:1	20:1	**20:1**	N/A

Tier 1 "equivalent" direct PM2.5 emissions from SO2 and NOx can be accounted for by scaling the standard AERMOD output files.

Tier 2

SO2 Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	80:1	35:1	**20:1**	40:1
1 – 4 km	40:1	20:1	**10:1**	25:1
4 – 10 km	25:1	10:1	**7:1**	18:1
> 10 km	15:1	7:1	**5:1**	10:1

NOx Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	250:1	50:1	**50:1**	120:1
1 – 4 km	160:1	35:1	**35:1**	120:1
4 – 10 km	80:1	20:1	**20:1**	N/A
> 10 km	40:1	20:1	**20:1**	N/A

Tier 2 "equivalent" direct PM2.5 emissions from SO2 and NOx can be accounted for by scaling the standard AERMOD output files.

Tier 3

SO2 Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	80:1	35:1	20:1	40:1
1 – 4 km	40:1	20:1	10:1	25:1
4 – 10 km	25:1	10:1	7:1	18:1
> 10 km	**15:1**	**7:1**	**5:1**	**10:1**

NOx Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	250:1	50:1	50:1	120:1
1 – 4 km	160:1	35:1	35:1	**120:1**
4 – 10 km	80:1	20:1	20:1	N/A
> 10 km	**40:1**	**20:1**	**20:1**	N/A

Tier 3 "equivalent" direct PM2.5 emissions from SO2 and NOx should be added to the actual direct PM2.5 emissions prior to running AERMOD.

Tier 4

SO2 Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	80:1	35:1	20:1	40:1
1 – 4 km	40:1	20:1	10:1	25:1
4 – 10 km	25:1	10:1	7:1	18:1
> 10 km	15:1	7:1	5:1	10:1

NOx Ratios

Distance	Q1	Q2	Q3	Q4
< 1 km	250:1	50:1	50:1	120:1
1 – 4 km	160:1	35:1	35:1	120:1
4 – 10 km	80:1	20:1	20:1	N/A
> 10 km	40:1	20:1	20:1	N/A

Tier 4 "equivalent" direct PM2.5 emissions from SO2 and NOx will require scaling quarterly AERMOD outputs followed by recalculation of annual and daily PM2.5 impacts.

Example PSD Application

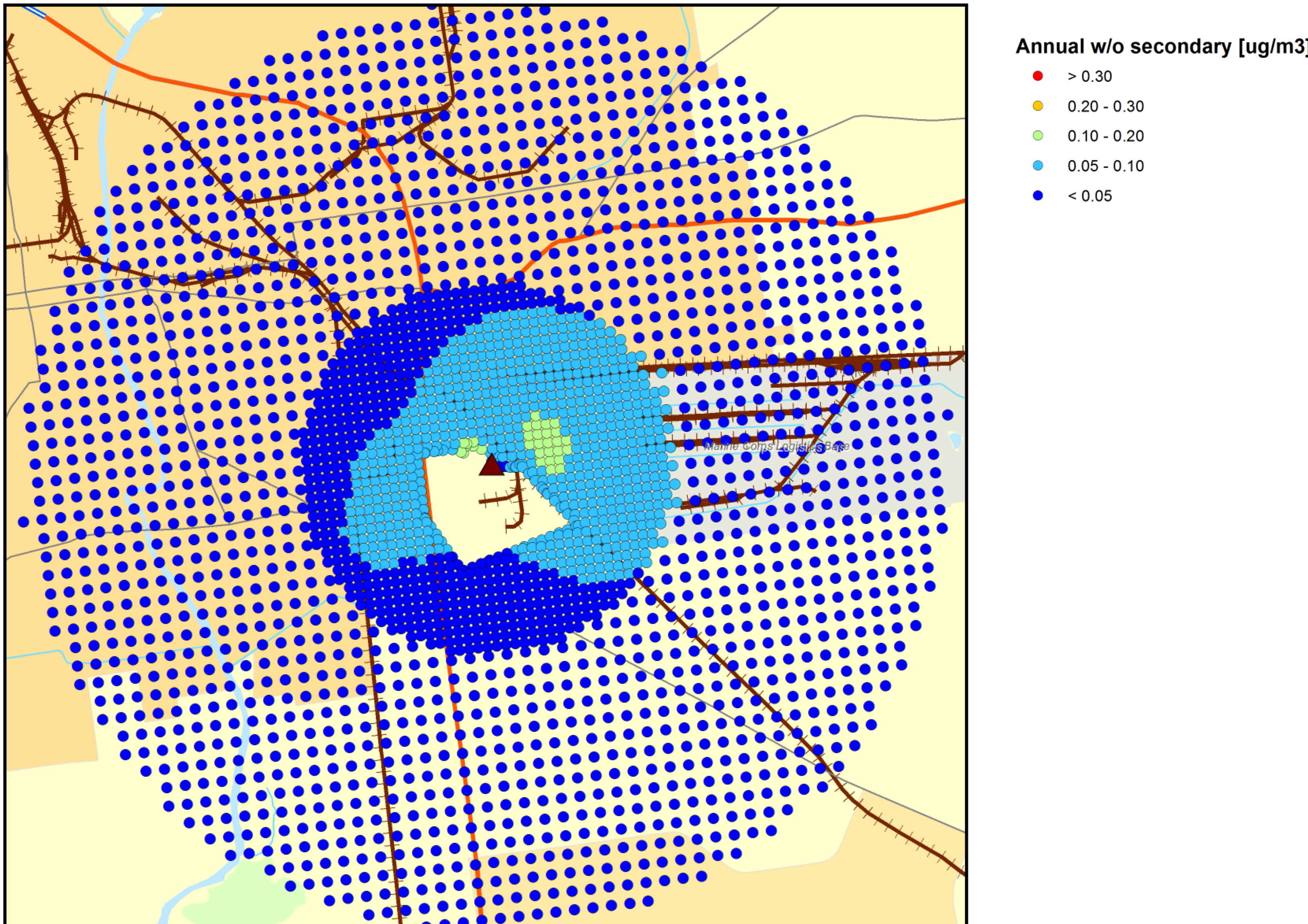
- Direct PM2.5 emissions = 118.30 TYP
- SO2 emissions = 190.93 TPY
- NOx emissions = 340.65 TPY

- PM2.5 Scaling Factor =

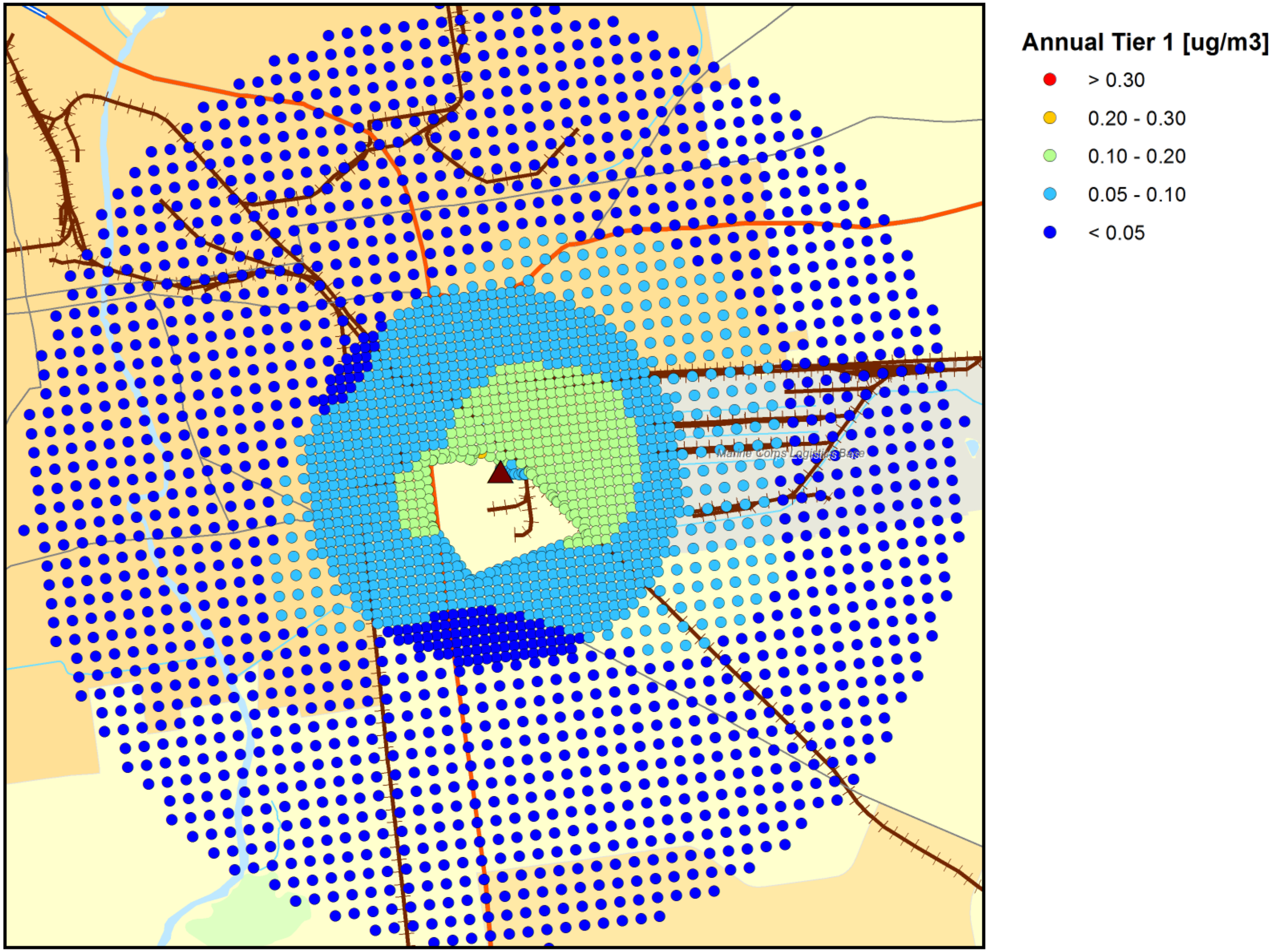
$$\frac{(\text{SO2 TPY/SO2 Ratio}) + (\text{NOx TPY/NOx Ratio}) + \text{PM2.5 TPY}}{\text{PM2.5 TPY}}$$

Distance	Q3 SO2 Ratio	Q3 NOx Ratio	Scaling Factor
< 1 km	20	50	1.138
1 - 4 km	10	35	1.244
4 - 10 km	7	20	1.375
> 10 km	5	20	1.467

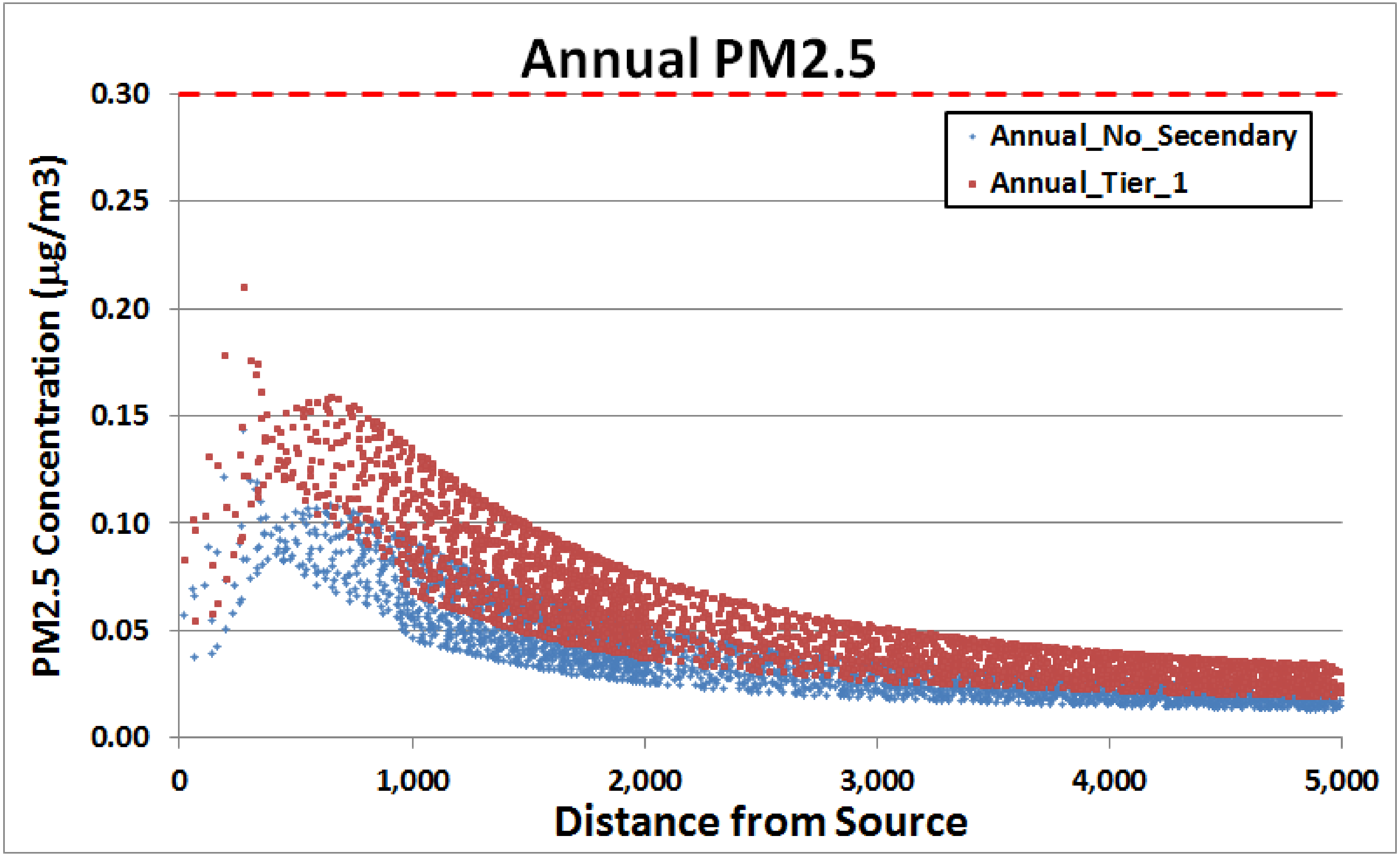
Annual PM2.5 – No Secondary



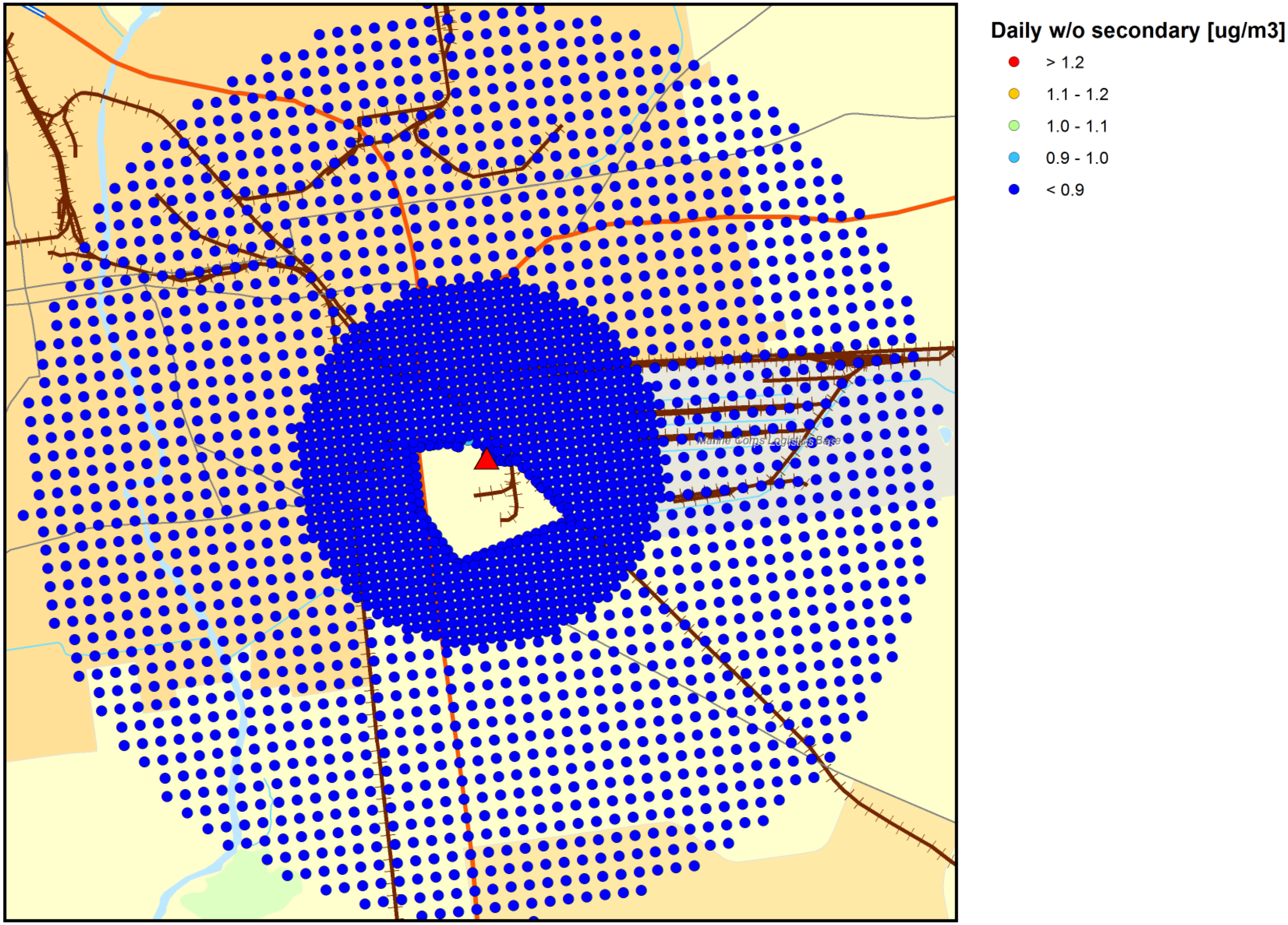
Annual PM2.5 – Tier 1



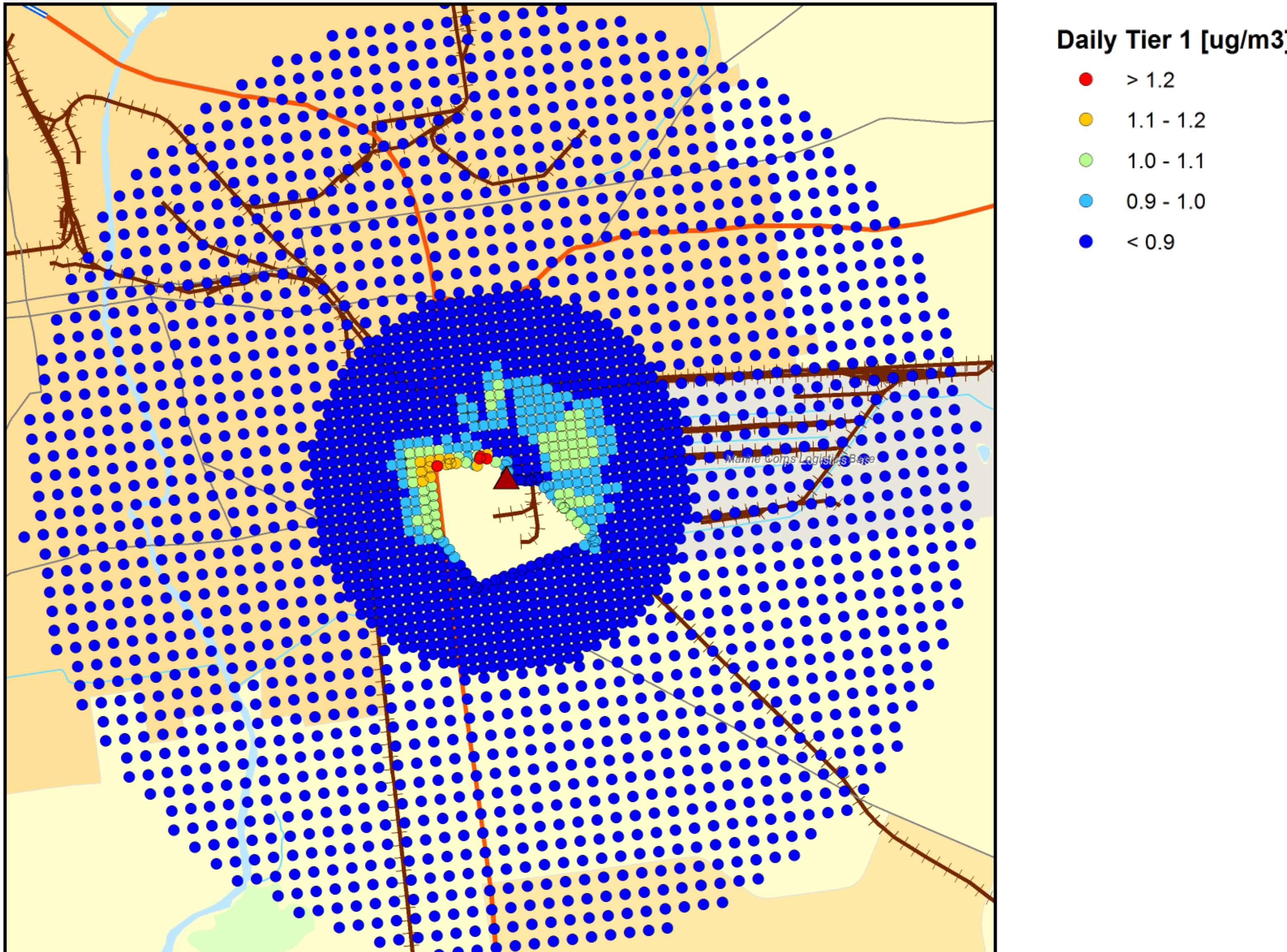
Annual PM2.5 vs. SIL



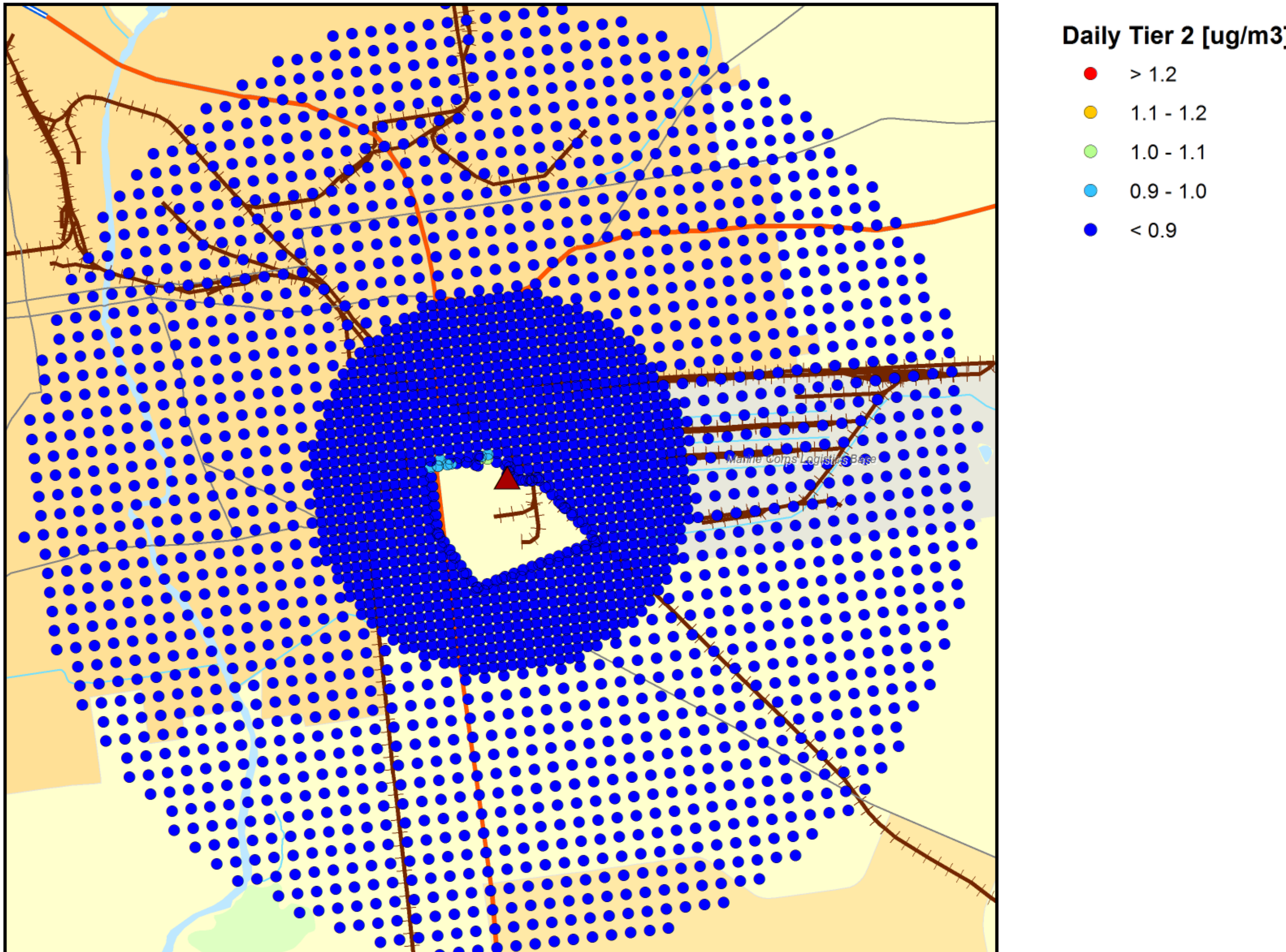
Daily PM2.5 – No Secondary



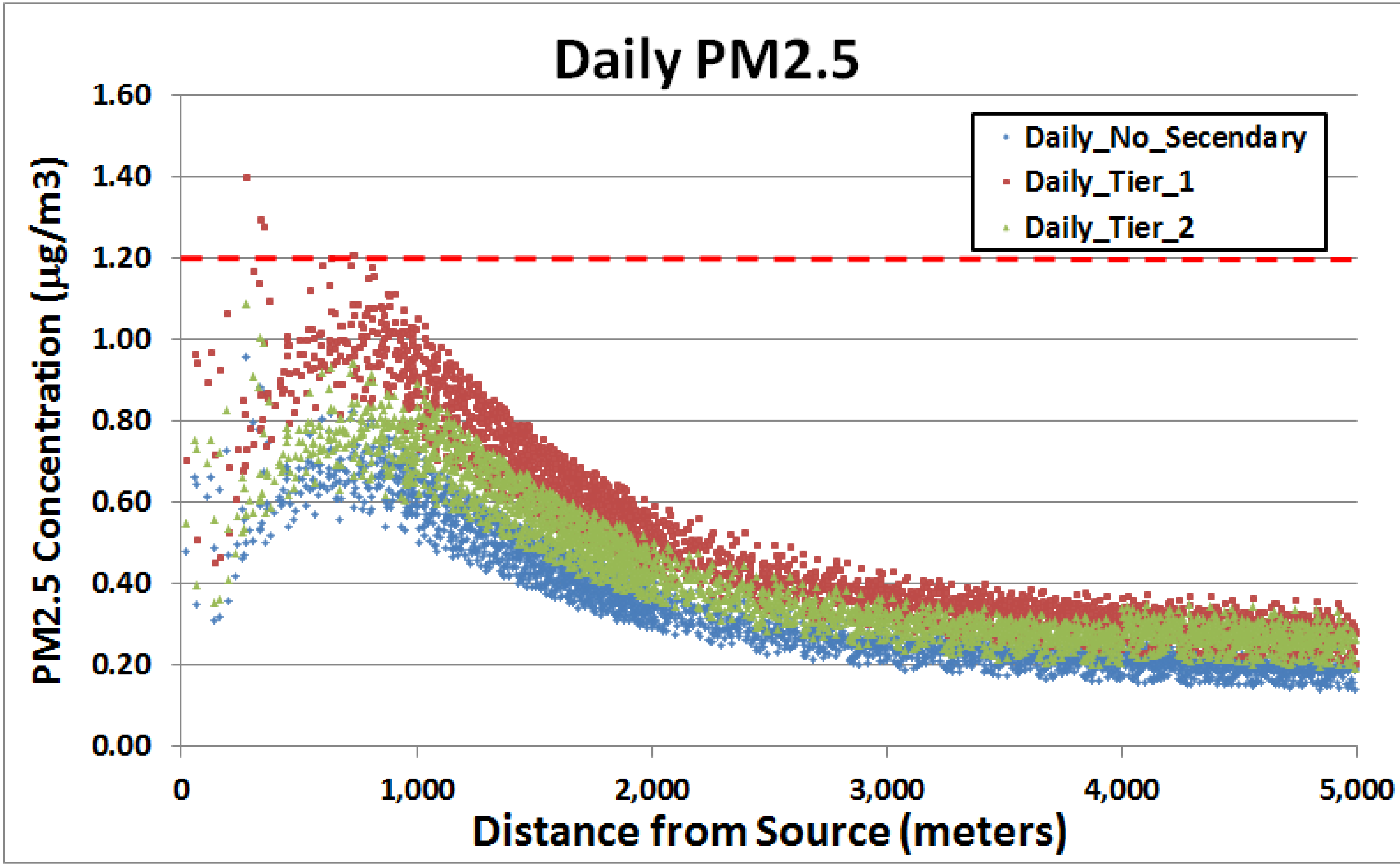
Daily PM2.5 – Tier 1



Daily PM2.5 – Tier 2



Daily PM2.5 vs. SIL



Summary

- PM2.5 offset ratios can be used to account for secondary PM2.5 formation in AERMOD.
- Tier 1 and Tier 2 approaches involve directly scaling the standard AERMOD output files.
- Tier 3 approach involves scaling actual direct PM2.5 emissions <u>prior</u> to running AERMOD.
- Tier 4 approach will require scaling quarterly AERMOD outputs followed by <u>recalculation</u> of annual and daily PM2.5 impacts.

Contact Information

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