Logan Moderate $PM_{2.5}$ SIP NNSR Demonstration

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Introduction

Utah DAQ modeled two factious ammonia (NH_3) point sources near the FRM monitor in Logan, Utah. The ammonia was added to gauge how sensitive $PM_{2.5}$ concentrations in Cache Valley would be due to potentially large industrial sources that could begin future operations in the area. There are currently no planned or existing major sources in the Logan Non-Attainment Area that encompasses the Cache Valley.

The Cache Valley is highly ammonia rich due to the multitude of animal agricultural operations in the region[1]. It is worth noting that NO_x emissions are low in Cache County, Utah relative to a much more urbanized county such as Salt Lake County. During the wintertime persistent cold air pool conditions that often occur in the Cache Valley, $PM_{2.5}$ concentrations will likely be comprised of mostly ammonium nitrate (NH_4NO_3) on elevated pollution days.

Methodology

Utah DAQ determined, from the 2014 NEI inventory, what the largest existing source of NH_3 currently is in the three $PM_{2.5}$ non-attainment areas. Two hypothetical ammonia emissions point sources were set up, each, to emit the same annual average amount as the largest facility-wide point source for ammonia emissions. Hypothetical emissions were emitted at a constant rate (i.e., “flat”) over the course of a modeled eleven-day persistent cold air pool episode. The two hypothetical point sources were given coordinates such that the two point sources surrounded the Logan (L4) FRM monitor; one to the North (~ 15 km from L4) and one to the South (~ 10 km from L4). Please see Figure 1, below, for a map of point source placement.

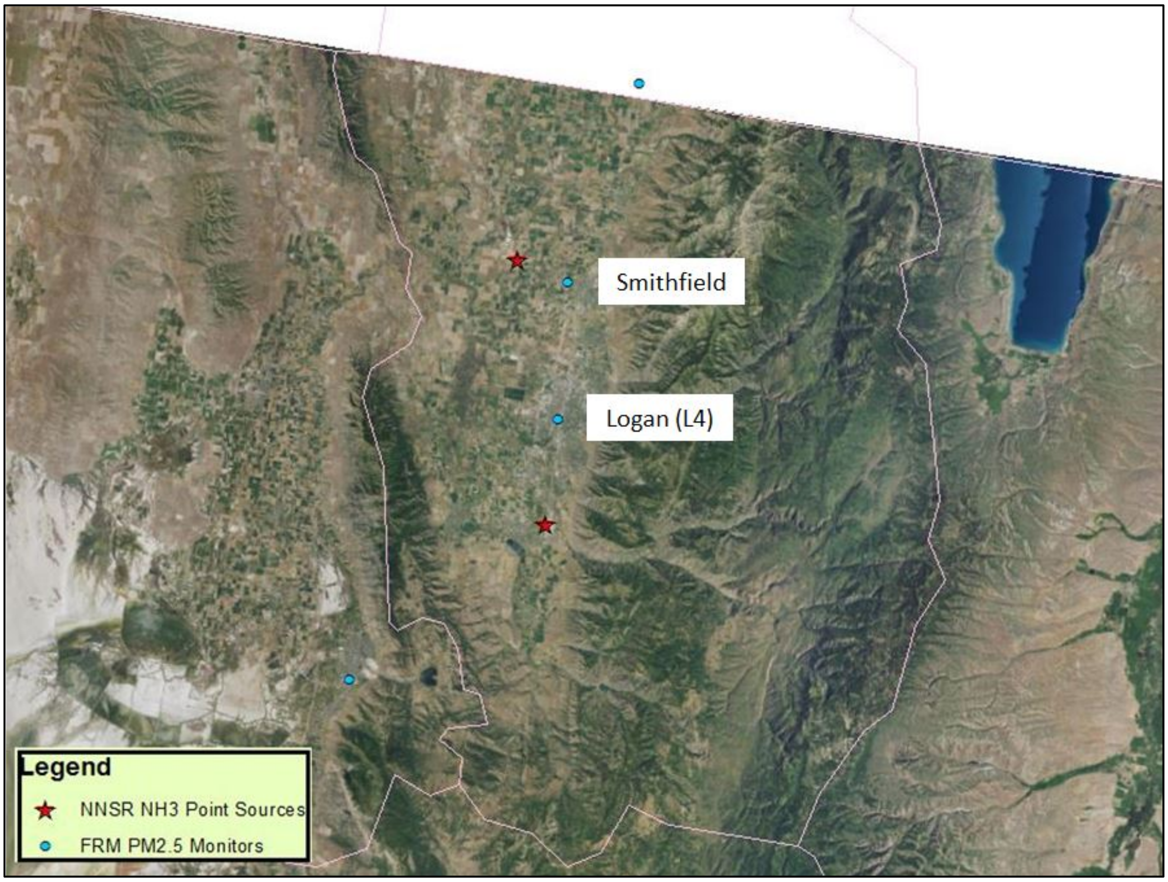

Figure 1: Map of Cache County, Utah that shows FRM monitors (blue circles) and hypothetical ammonia point sources (red stars). Hypothetical point sources are placed as to surround the Logan (L4) monitor; one upwind, one downwind.

Both hypothetical point sources emitted the exact same amount of NH_3 at the same "flat" rate. The two point sources did not emit any other compound or $PM_{2.5}$ precursor.

Two different modeling runs were performed. The first run used a "low" plume release configuration, whereby ammonia was emitted near ground level (3 feet, AGL). The second run employed a "low" plume release configuration with stack heights set to the height of the second tallest stack in Utah (254 feet, AGL). Other stack parameters (e.g., flow rate, temperature, and stack diameter) were modeled after the same existing point source. Table 1, below, shows the stack parameters of the hypothetical point sources as well as the ammonia emissions totals used in both model runs.

	"High" plume release	"Low" plume release
Stack height (ft)	254	3
Stack diameter (ft)	3	0.166
Exit temperature (F)	128	72
Exit velocity (ft/sec)	21.93	15.28
Flow rate (ft^3/sec)	155	0.331
Total Emissions (tons/year)	115.32	
January Emissions (tons/month)	9.61	
Inventory	Base year inventory (2014)	

Table 1: Hypothetical point source stack parameters and emissions rates used for two modeling runs. "High" plume release column notes parameters used for modeling with tall stacks. "Low" plume release column indicates parameters used for modeling run using near-ground level stacks.

Ammonia emissions were added (i.e., injected) uniformly in all low elevation (< 6,000 feet) areas in Cache County, Utah[2]. Ammonia was injected at a "flat" emissions rate in order to equate the ammonia gas from the model to measurements taken at Logan, Utah in February, 2016. Cache County 2014 NEI ammonia emissions totals, alone, were quite a bit lower than can be expected based on various measurements of Cache Valley ammonia[1]. The ammonia injection better facilitated a more realistic proportion of secondary aerosol to total $PM_{2.5}$ mass.

For this analysis, Utah DAQ used the CAMx 6.30 air quality model. Emissions were prepared for CAMx using the SMOKE 3.6.5 emissions processor. Temporal and spatial emission profiles used in SMOKE were appropriate for the wintertime season and region. The model domain resolution over the Cache Valley was 1.33 km. This domain was nested in a much larger 4 km domain for boundary/initial conditions. Modeling parameters to note are listed in the following table:

Number of Grids	2
Grid size(s)	4 km/1.33 km
Vertical layers	41
Grid interaction	Two-way nesting
Boundary conditions	MOZART
Emissions processor	SMOKE Version 3.6.5
Point Sources processing	Plume-in-grid model
Aerosol scheme	CF
Chemistry	cb6r2h
Chemistry solver	EBI
Advection scheme	PPM
Dry deposition	ZHANG03
Wet deposition	On

Table 2: List of important CAMx 6.30 parameters used in the analysis.

Results

Logan monitor

For the grid-cell collocated at the Logan (L4) monitor, the addition of the two hypothetical point sources showed no influence on simulated 24-hour $PM_{2.5}$ concentrations (Figure 2, below). The different stack heights used for the "low" and "high" plume rise runs made no significant impact as well.

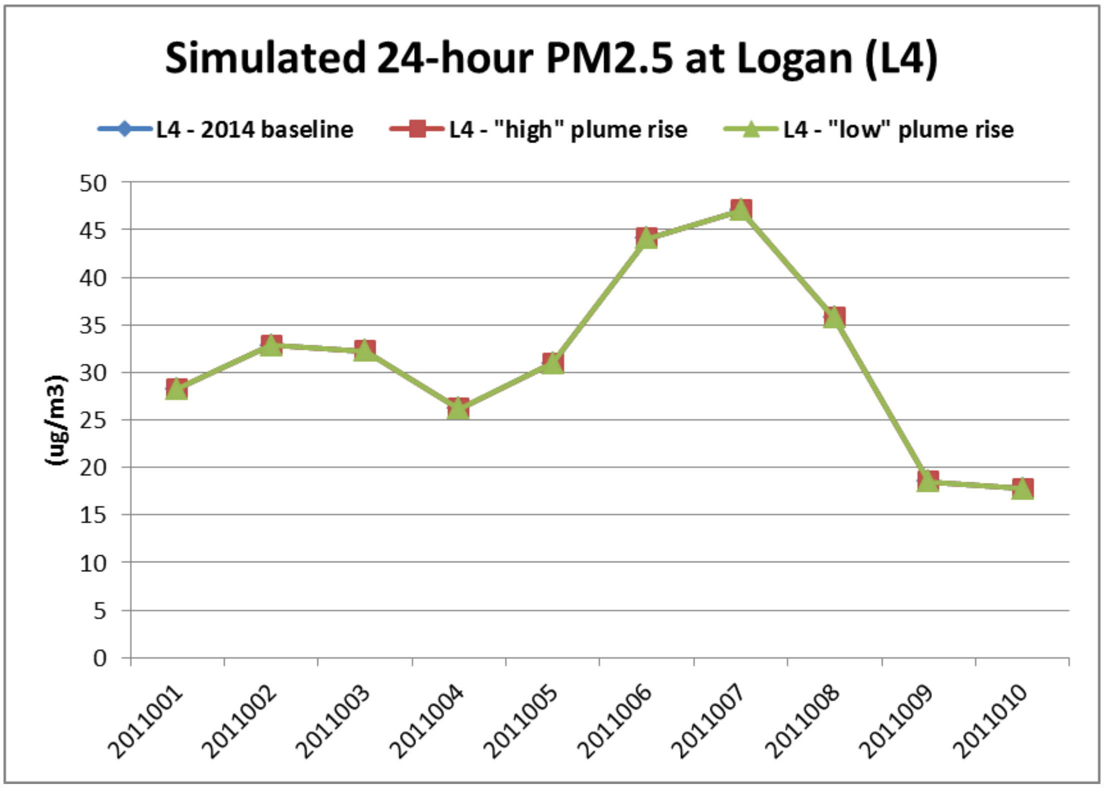

Figure 2: Modeled results for 24-hr $PM_{2.5}$ at grid-cell collocated with the Logan (L4) monitor for 2014 baseline (blue), "low" plume rise (green), and "high" plume rise (red). Note lines largely overlap suggesting no impact to 24-hour $PM_{2.5}$ from two hypothetical major ammonia point sources.

Cache County Spatial Fields

Examining spatial fields of simulated 24-hour $PM_{2.5}$ mass yielded no significant impact from the hypothetical ammonia point sources (Figures 3 and 4, below). Spatial fields were made by subtracting the plume rise results from the 2014 baseline results. A constant value of 1.3 μg m^{-3} (considered a threshold of significance) was then subtracted from the gridded difference between the plume rise runs and 2014 baseline. Spatial fields were examined for grid-cell values that exceeded 0 μg m^{-3} and none were found. Results were analyzed for the day with the largest $PM_{2.5}$ concentrations. Black lines depict county lines.

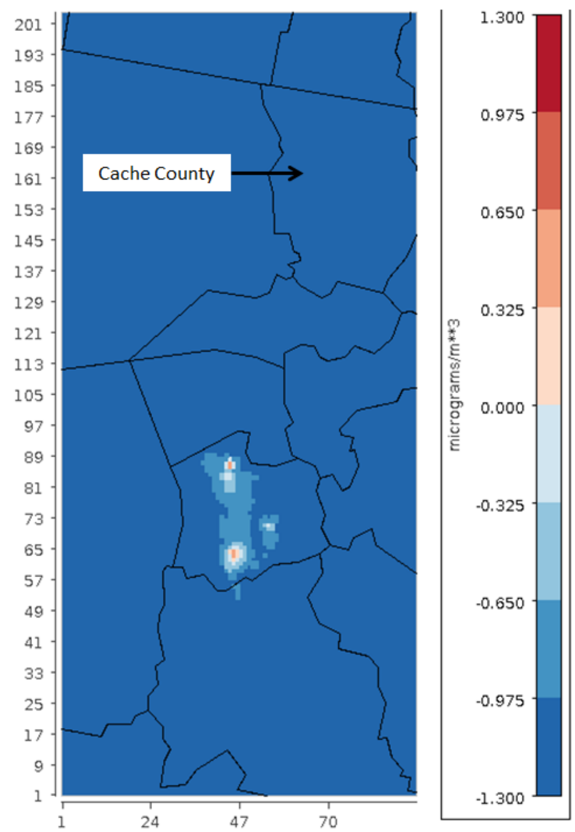

Figure 3: Spatial field shows difference in modeled 24-hour $PM_{2.5}$ concentrations between 2014 baseline and "low" plume rise as compared to the 1.3 μg m^{-3} threshold for significant change in $PM_{2.5}$: 2014 baseline – "low" plume rise – 1.3 (μg m^{-3}). Figure suggests there is no significant difference for 24-hour $PM_{2.5}$ between the 2014 baseline and "low" plume rise run for January 7, 2011 (MDT), the day with the largest $PM_{2.5}$ concentrations. Black lines depict county lines.

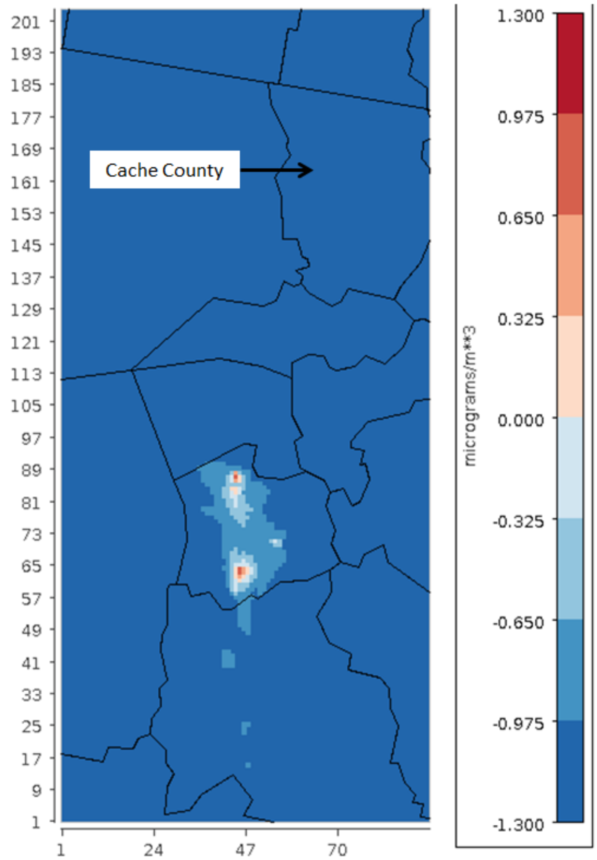

Figure 4: Similar to figure 3, but comparing modeled 2014 baseline 24-hour $PM_{2.5}$ concentrations to modeled concentrations from the "high" plume rise model run. As before, figure suggests no significant difference in the Cache Valley between 2014 baseline and "low" plume rise results for January 7, 2011 (MDT).

Conclusion

The modeling of two hypothetical ammonia major point sources near the Logan (L4) FRM monitor shows an insignificant increase in simulated $PM_{2.5}$ in Cache County. These results suggest that a major source of ammonia, becoming operational at a future date in Cache County, would unlikely contribute to elevated $PM_{2.5}$ concentrations in the Logan non-attainment area.

References

1. Brown S., Baasandorj M. (editors), 2017 Utah Winter Fine Particulate Study - Final Report (In Preparation)
2. Pennell C., Dahar N., 2017 Serious $PM_{2.5}$ SIP Modeling Protocol (submitted to EPA Region 8)