Use of CAMx in Establishing Statewide Default NO_2 Background Concentrations

Purpose

Modeled nitrogen dioxide (NO_2) concentrations produced by the Comprehensive Air Quality Model with Extensions (CAMx) model were used to identify an appropriate geographical delineation between background concentrations in urban and rural portions of the state. The modeled NO_2 concentrations were produced from an annual simulation covering the year 2007.

Model Inputs

CAMx is an Eulerian photochemical dispersion model that allows for integrated "one-atmosphere" assessments of gaseous and particulate air pollution over many scales ranging from sub-urban to continental. The CAMx modeling domain covered the Central and Eastern portions of the U.S., but emphasis was placed on grid cells over Iowa. The resolution of the domain was 12 km, which is much finer than the ambient air observation network. The annual simulation used the most recent model-ready emissions inventory available: the 2007 baseCv7 gridded emissions inventory produced by the Lake Michigan Air Directors Consortium (LADCO). Meteorological inputs were incorporated from the Weather Research and Forecasting (WRF) meteorological model and were generated by the Iowa DNR as part of a previous regional collaborative effort with Virginia DEQ, North Carolina DENR, Maryland DE, New York SDEC, and the University of Maryland.

Methodology

Background NO_2 values were established using the three-year design values from monitoring sites in both urban and rural areas. The urban and rural areas were then delineated using predicted NO_2 concentration gradients from CAMx.

Monitoring data in Iowa is limited to two sites located within urban areas: Davenport and Des Moines (see Table 1). Both are within the urban core of each city, but are located away from major industrial areas. This provides a good representation for an urban background value but does not supply the information necessary to determine an equivalent rural background value. In order to establish a rural NO_2 background value it was necessary to locate nearby monitoring data that is not influenced by urban areas. Four monitor locations were evaluated for this purpose: two in Kansas and two in South Dakota (see Table 2). All six monitors were chosen for the fact that they collected data during the 2009-2011 period, which is the same data period used to derive the current statewide default background levels for all other pollutants.

Both Iowa monitors had complete data records and were able to be used for the next stage of the analysis. The 20-107-0002 Kansas monitor and 46-127-0002 South Dakota monitor both had incomplete data records and so were excluded. Additionally, while located outside of the city, the 20-191-0002 Kansas monitor appears to be influenced by the nearby city of Wichita, KS. For this reason, this monitor was also excluded from the remainder of the analysis because the existing monitors in Iowa are more representative of the urban background value in the state. This left a single monitor in South Dakota, which was chosen to represent the rural background levels in the state.

The design values for both Iowa NO_2 monitors were averaged to obtain a 1-hour NO_2 default background value for the urban areas. The design value for the chosen rural monitor in South Dakota was used to represent the default background value for the rural areas. The 1-hour design values are the 3-year average of the 98th-percentile of the maximum daily concentrations at each location. The

design values were obtained from the Environmental Protection Agency's AirData website. The resulting 1-hour averages are 40 ppb (75 µg/m^3) for the urban portions of the state, and 18 ppb (34 µg/m^3) for the rural portions. In order to determine which areas of the state would be represented by the default urban and rural backgrounds, the concentration gradients predicted by the CAMx model were evaluated.

The concentrations generated from CAMx data were processed at each grid cell to produce total NO_2 concentrations in a form comparable to the metric used for the 1-hour NO_2 standard. The data represent the predicted 8th-high daily maximum 1-hour concentrations from CAMx. The 1-hour concentrations were chosen instead of annual averages because the aim of this analysis is to define the gradients between urban and rural areas of the state. The short-term concentrations provide a more appropriate metric for depicting these localized influences. Figure 1 shows the final analyzed NO_2 concentration field.

Using Golden Software's Surfer graphing program the model prediction at both urban monitor locations and the rural monitor location were determined. Comparison of the modeled NO_2 concentrations to monitored NO_2 values revealed a good correlation (see Table 3).

The average of the model predictions at the urban monitor locations was calculated (45.84 ppb) and was then assumed to represent the level of the urban NO_2 concentration in the model. Similarly the model prediction at the rural monitor location in South Dakota (18.87 ppb) was assumed to represent the level of the rural NO_2 concentration. The average of these predicted urban and rural NO_2 concentrations (32.35 ppb) was then used to divide the state into urban and rural NO_2 regions by plotting lines across a map of the state connecting all areas with a concentration equal to the average. The resulting urban/rural delineation is depicted in Figure 2 by the black lines surrounding major cities in and around Iowa.

Default NO_2 Background Values by County

County borders offer convenient permanent boundaries that are often used to divide areas of the state represented by different datasets. As can be seen in Figure 2, the dividing lines separating the urban and rural areas of the state cross County borders. In order to simplify the implementation of the default background concentrations it was decided to limit the extent of the areas represented by the urban background to the County in which the urban influence originates. The default urban background Counties are listed below:

- Clinton
- Linn
- Polk
- Pottawattamie
- Scott
- Woodbury

In most areas the urban influence does not extend into the entirety of the County in which it originated. In cases where a project occurs in an urban county, the Department will consider a rural background if the location can be shown to be outside the urban region in the data. A Google Earth KML file is provided on the website so that applicants can zoom in to a specific area to make this determination.

All other Counties will be considered to have a rural background (even if the black line partially crosses into the County).

The default 1-hour and annual urban background concentrations are 40 ppb (75 µg/m^3) and 8 ppb (15 µg/m^3) respectively. They were calculated based on the average of the design values for the two urban monitors. The default 1-hour and annual rural background concentrations are 18 ppb (34 µg/m^3) and 3 ppb (5 µg/m^3) respectively. They were based on the design values at the single rural monitor.

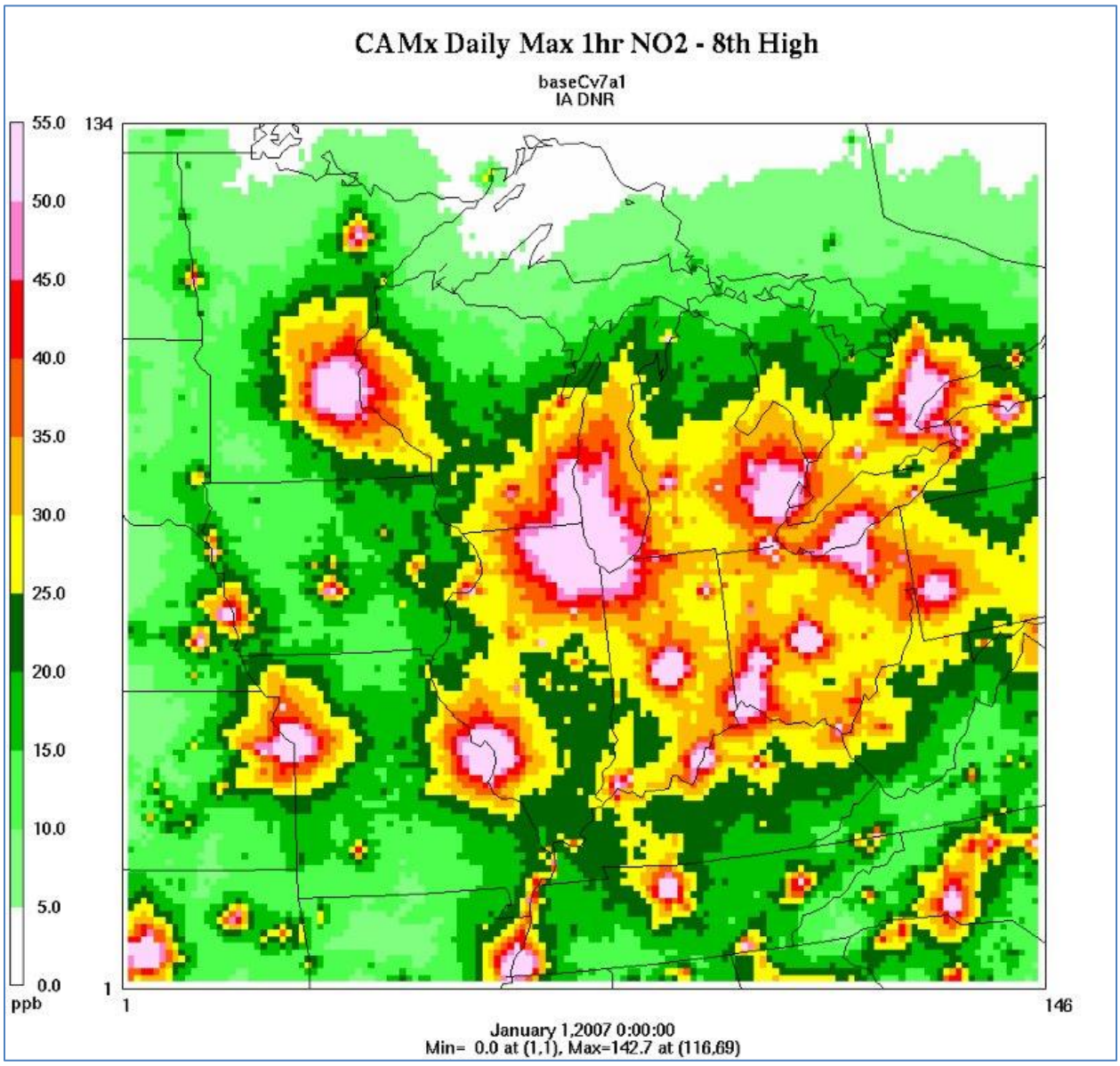

Figure 1. Modeled NO_2 design concentrations for 2007 over the Midwest.

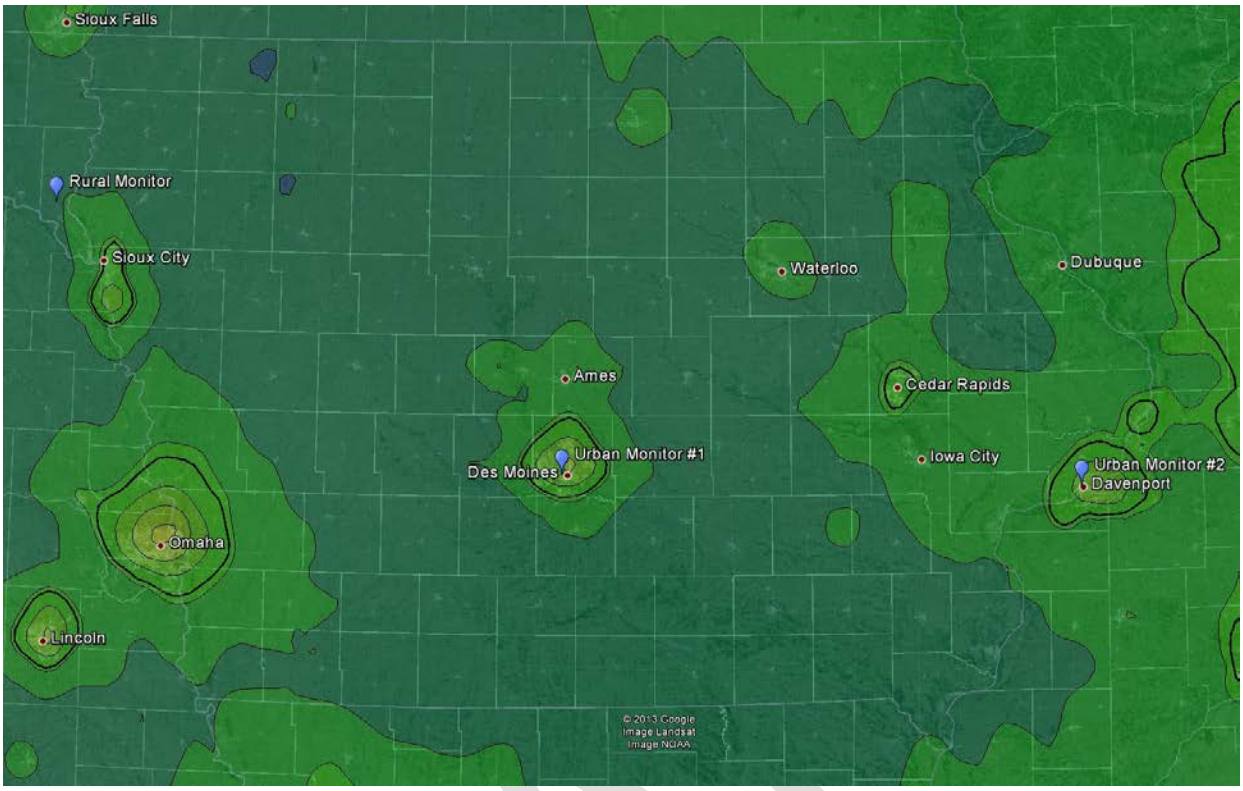

Figure 2. Modeled NO_2 design concentrations for 2007 over Iowa with urban/rural delineation.

Table 1. Urban Monitors (2009-2011 Data)

Site ID	**Location**	**Data Quality**	**1-hour Monitor Design Value** (ppb)	**Average Annual Monitor Design Value** (ppb)
19-153-0030	Des Moines, IA	Complete	44	8.6
19-163-0015	Davenport, IA	Complete	36	7.7
		Averages:	**40**	**8**

Table 2. Rural Monitors (2009-2011 Data)

Site ID	**Location**	**Data Quality**	**1-hour Monitor Design Value** (ppb)	**Average Annual Monitor Design Value** (ppb)
20-107-0002	Co. Road 1103, KS	Incomplete	11*	1.7*
20-191-0002	Wichita, KS	Complete	26**	4.3**
46-127-0001	31986 475th Ave, SD	Complete	18	2.5
46-127-0002	31307 473rd Ave, SD	Incomplete	17*	2.5*
		Averages:	**18**	**3**

* Data not used due to one or more incomplete quarters.

** Data not used due to urban influence.

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Table 3. Comparison of Monitored and Modeled 1-hour NO_2 Concentrations at Selected Locations

Site ID	**Location**	**Monitor Design Value** (ppb)	**Model Design Value** (ppb)
19-153-0030	Des Moines, IA	44	47.77
19-163-0015	Davenport, IA	36	43.90
46-127-0001	31986 475th Ave, SD	18	18.87

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