Development of MOVES-Mexico

Stage I: Ciudad Juárez, Chihuahua and Uncertainty Quantification

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Abstract

MOVES inputs were collected and processed for Ciudad Juárez, Chihuahua, Mexico in 2008. The onroad mobile source emissions were estimated using MOVES2010b. The annual total VMT is estimated to be 2.9153E+09 miles. The 2008 NOx emission is estimated to be 13625 tons, and the CO emission is 57327.24 tons. However, several critical inputs are not available or incomplete, such as the road type distribution of vehicle miles traveled (VMT) for each vehicle type; and the information of fuel supply and fuel formulation.

Due to the lack of local data in Juárez, the county level emissions from 10 states in the Mid-Atlantic and Northeast region are analyzed to estimate the uncertainty range of emissions when only certain MOVES inputs are available, such as the annual VMT. There are 116 counties in the 10 states. They have been simulated in MOVES by 29 representative counties in term of emission factors, which has the same fuel, implementation and maintenance (I/M), fleet age distribution, and similar meteorology in each county group. Therefore these 116 counties make a good sample to generate statistically significant indices. The analysis shows that the annual NOx and CO emissions are generally within a factor of 1.5 of the fitted emissions as linear function of VMT. When the annual emissions are broken down by vehicle types, NOx emissions are narrowed down to within a factor of 1.2 of the fitted values, while the fitting of CO emissions stays roughly the same as when all vehicle types are lumped together.

It is expected the methodology of processing MOVES inputs for Juárez and the quantification of uncertainty to be useful for other regions in Mexico to develop MOVES emissions. Considering many countries do not have the complete input datasets required by MOVES, the conclusions could also provide good references to the application of MOVES in other countries.

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1. Introduction

Serious air pollution persists in Mexico like in other developing countries. Transportation is a major source of air pollution across regions. One important way to improve air quality is to regulate the transportation sector. It is critical to have a comprehensive regulatory tool to help make good transportation control strategies. MOtor Vehicle Emissions Simulator (MOVES), a computer program designed by the Office of Transportation and Air Quality (OTAQ) of the U.S. Environmental Protection Agency (EPA) to estimate air pollutant emissions from mobile sources, serves such a purpose in the U.S. The development of MOVES-Mexico will customize MOVES for Mexico to reflect local conditions and it will fulfill the same purpose in Mexico.

Ciudad Juárez, Chihuahua – El Paso Texas is the second largest binational urban communities along the international border between the U.S. and Mexico. It provides an opportunity to apply MOVES-Mexico to urban planning in the region, since it is important to model the air shed as "One Air Basin".

However, lacking of MOVES inputs prevents one to estimate the onroad mobile source emissions in a way as done in the U.S. And the emission uncertainties caused by many of these inputs haven't been quantified. It is recognized different applications of emissions require various levels of details. Air quality policy making requires the most detailed inputs, such as the State Implementation Plan (SIP) and transportation conformity analysis. This is because policy making works in a bottom-up manner, like the way emissions are estimated in MOVES. On the other hand, air quality modeling or climate modeling sometimes estimates emissions in a top-down manner, e.g. by collecting the total VMT or fuel consumption data for a region or a whole country. Bulk emission factors are used in these applications. The development of Emission Database for Global Atmospheric Research (EDGAR, http://edgar.jrc.ec.europa.eu/index.php) is one example. It is also noted that many countries do not have a system like the Highway Performance Monitoring System (HPMS) in the U.S. that provides major MOVES inputs. Therefore, it is important to quantify the uncertainty range of emissions when many ratio tables of MOVES inputs are not available, such as the VMT road type distribution.

2. The Current Status of Input Data in Ciudad Juárez, Chihuahua

2.1 Required MOVES Inputs

The required MOVES inputs to develop the base case emissions for the purpose of State Implementation Plans (SIPs) include 13 items on the county basis, which are Vehicle Population (VPOP), vehicle age distribution, annual Vehicle Miles Traveled (VMT), road type distribution, average speed distribution, fuel supply, fuel formulation, Inspection and Maintenance (I/M) coverage, month VMT fraction, day VMT fraction, hour VMT fraction, ramp fraction, and meteorology. Since Juárez is outside of U.S., the table of SCC Road Type Distribution is also required to be imported, assuming the emission factors in MOVES are applicable to Mexico. The issue of emission factors will be addressed in another report.

2.2 Available Input Data

Several items are available among the list of inputs required by MOVES, including (1) the average day VMT by road type; (2) the average speed distribution by road type; (3) the hour VMT distribution; (4) the ramp fraction; (5) the total VPOP; (6) the vehicle registration; (7) the distribution of VMT by vehicle type; (8) meteorology.

Items (1) to (4) are derived from the travel demand model built up by Salvador González-Ayala for Ciudad Juárez, Chihuahua; item (5) was collected by Gerardo Tarin; items (6) and (7) were retrieved from the TCEQ archive of MOBILE6-Mexico[1], which represent the average Mexican fleet. Item (8) was retrieved from the climate archive. It will be retrieved from the Weather Research and Forecasting (WRF) model simulation should it become available in the future.

2.3 Input Data not Available

It is noted that the total VPOP, which is listed as available input item (5) in the above section, still needs to be separated into 13 MOVES source types. And the road type VMT distribution is the same for different source types based on the available information.

The information of (9) fuel supply and (10) fuel formulation and (11) I/M is lacking. It appears MOBILE6-Mexico estimated emissions for different scenarios by assuming fuel RVP ranging from 8.4 to 9.5 psi, gasoline sulfur content of 30 ppm, and diesel sulfur content ranging from 15 to 500 ppm. Several different I/M scenarios are also accessed in MOBILE6-Mexico.

The input tables of VMT temporal distribution need to be set up, e.g. (12) the month VMT distribution and (13) day VMT distribution. And so is (14) the SCC road type distribution.

3. The Onroad Mobile Source Emissions in Ciudad Juárez, Chihuahua, 2008

3.1 Processing Available Input Data

Different methodologies are applied to transform the available input data listed in section 2.2 to MOVES format. For example, the vehicle registration data retrieved from MOBILE6-Mexico can be converted to MOVES vehicle age distribution by using converters provided by EPA. A procedure is set up to transform the road type VMT (Table 1) estimated by the Travel Demand Model (TDM) to MOVES format by 6 Highway Performance Monitoring System (HPMS) vehicle types (Table 2). The vehicle type VMT distribution retrieved from MOBILE6-Mexico can be used in the conversion, which however is given by 28 MOBILE6.2 vehicle types. The

EPA mapping table[2] needs to be invoked to transform the 28 vehicle type VMT distribution to 6 HPMS vehicle types.

Table 1. Average Day VMT in Ciudad Juárez, Chihuahua, 2008

TDM Road Type	VMT per day
0 Connector	487,245
2 Freeway	318,887
3 Expressway	3,000,642
4 Principal arterial divided	1,642,837
5 Principal arterial undivided	968,424
6 Minor arterial divided	160,543
7 Minor arterial undivided	694,402
8 Minor arterial unpaved	661,663
12 Ramp	32,975
Total	7,967,617

Table 2. Annual HPMS Vehicle Type VMT in Ciudad Juárez, Chihuahua, 2008

HPMS Vehicle Type	Annual VMT
10 Motorcycles	3.8202E+07
20 Passenger Cars	1.3928E+09
30 Other 2 axle-4 tire vehicles	1.1405E+09
40 Buses	1.7237E+07
50 Single Unit Trucks	7.7497E+07
60 Combination Trucks	2.4908E+08
Total	2.9153E+09

3.2 Onroad Mobile Source Emissions

The Juárez onroad mobile source emissions in 2008 were estimated using MOVES2010b. Figure 1a and 1b give the annual NOx and CO emissions by vehicle types. Table 3 lists the 7 digits SCC vehicle types and descriptions.

Table 3. Vehicle type codes by SCC and descriptions

SCC	Description
2201001	LDGV: Light Duty Gasoline Vehicles
2201020	LDGT1: Light Duty Gasoline Trucks 1
2201040	LDGT2: Light Duty Gasoline Trucks 2
2201070	HDGV: Heavy Duty Gasoline Trucks
2201080	MC: Motorcycles
2230001	LDDV: Light Duty Diesel Vehicles
2230060	LDDT: Light Duty Diesel Trucks
2230071	2BHDDV: Heavy Duty Diesel Vehicles 2B
2230072	LHDDV: Light Heavy Duty Diesel Vehicles 3, 4, 5
2230073	MHDDV: Medium Heavy Duty Diesel Vehicles 6, 7, 8A
2230074	HHDDV: Heavy Heavy Duty Diesel Vehicles 8B
2230075	BUSES: Diesel Transit, Urban and School Buses

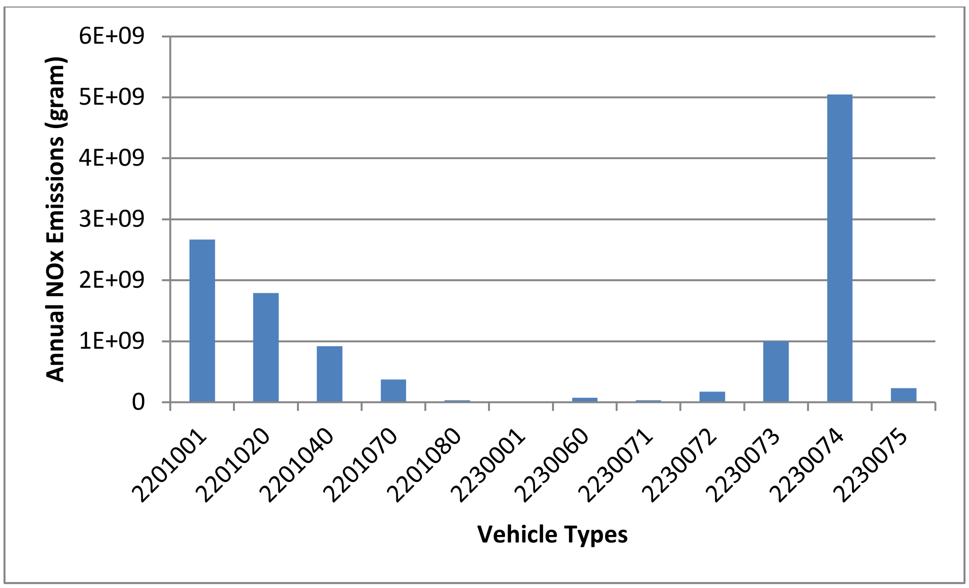

Figure 1a. The 2008 onroad mobile source NOx emissions in Ciudad Juárez, Chihuahua, Mexico

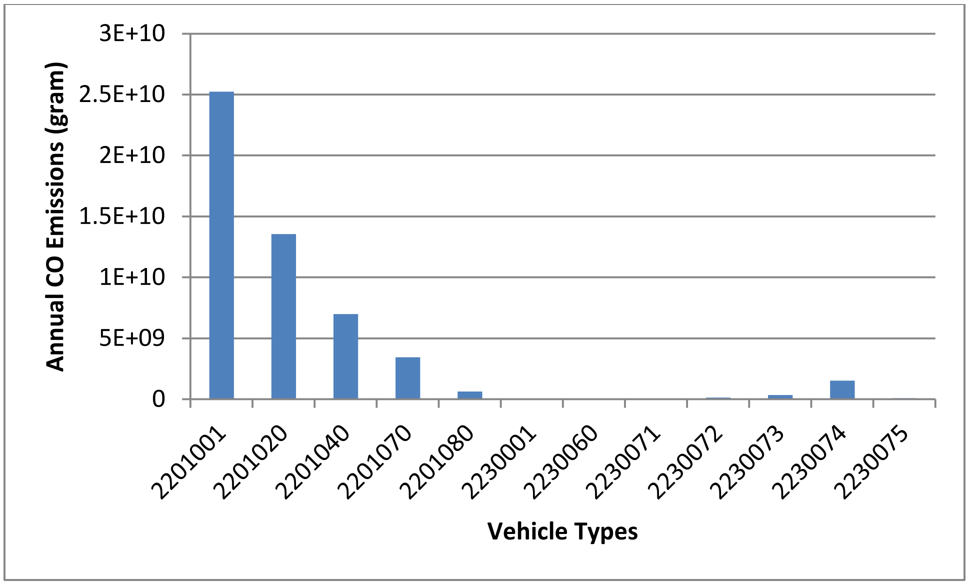

Figure 1b. The 2008 onroad mobile source CO emissions in Ciudad Juárez, Chihuahua, Mexico

4. The Quantification of Uncertainty

4.1 The Linear Regression of Emissions and VMT

The county level emissions of the 116 counties in the Mid-Atlantic and Northeast region are linearly regressed against VMT to estimate the uncertainty range of emissions of MOVES simulation when annual VMT is available while other inputs are either lacking or incomplete. The technical details of the MOVES simulation are provided in the report prepared by Yang for NESCAUM[3].

Figure 2 illustrates the 2007 annual NOx and CO emissions versus VMT. As expected, the correlation coefficients between emission and VMT are very high, which is 0.96 for NOx emissions and 0.99 for CO emissions.

Figure 3a and 3b gives the annual NOx and CO emissions versus VMT broken down by vehicle types. Table 3 lists the 7 digits SCC and descriptions for the vehicle types. It is interesting to observe that the correlation coefficients between vehicle type NOx emission and VMT increase compared to the lumped regression, while they stay roughly the same for CO emissions.

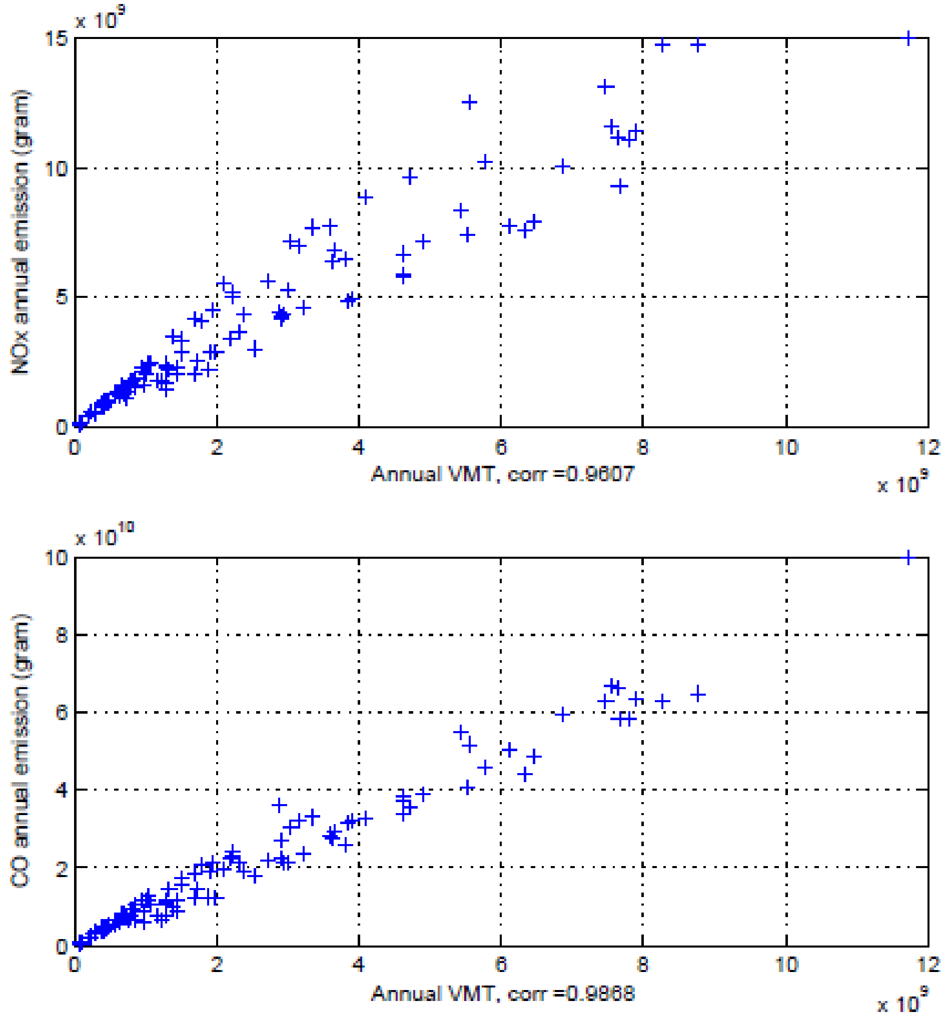

Figure 2. The Linear Regression of 2007 Emissions and VMT for the 116 counties in the Mid-Atlantic and Northeast region

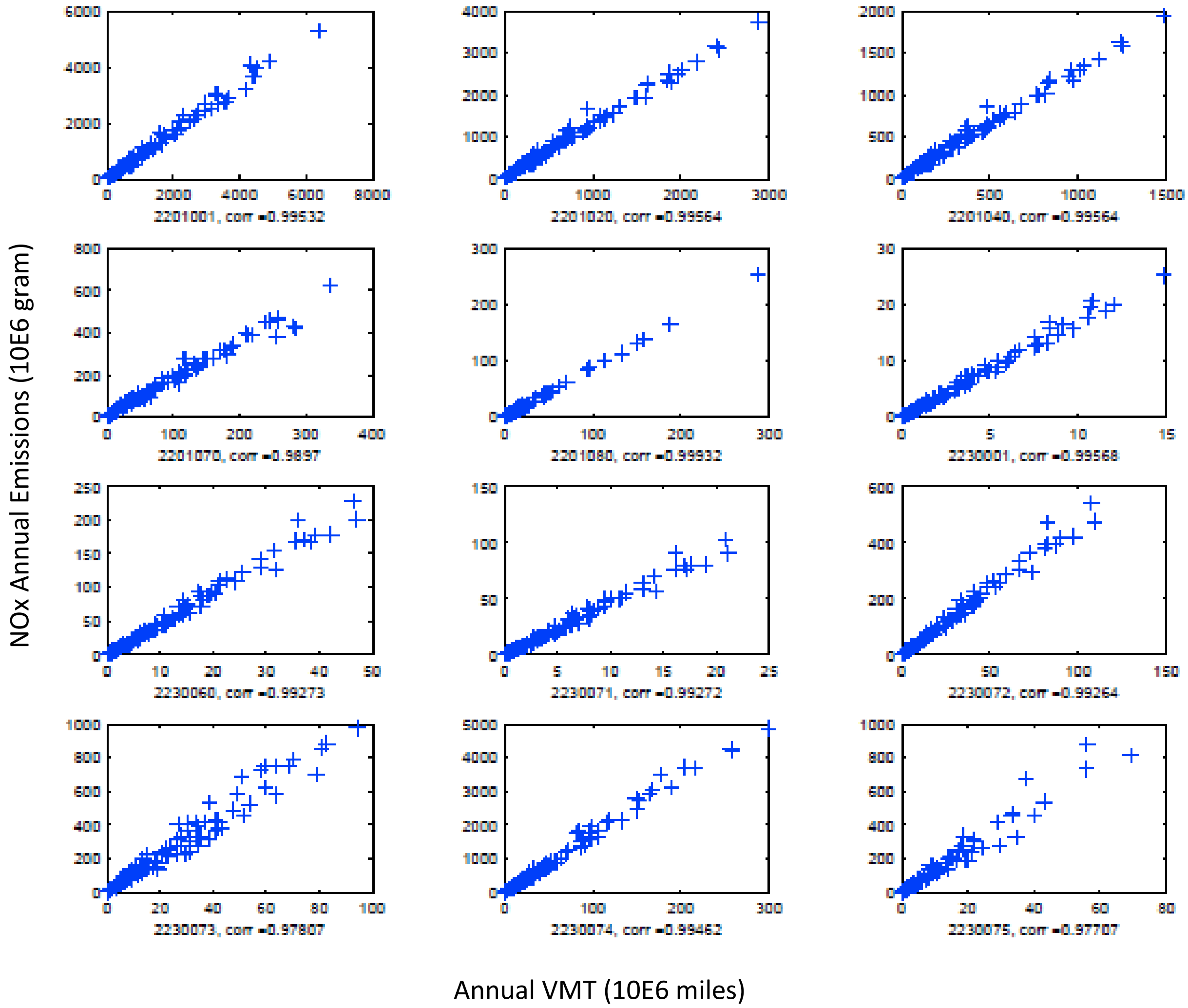

Figure 3a. The Linear Regression of 2007 NOx Emissions and VMT for the 116 counties in the Mid-Atlantic and Northeast region, broken down by vehicle types

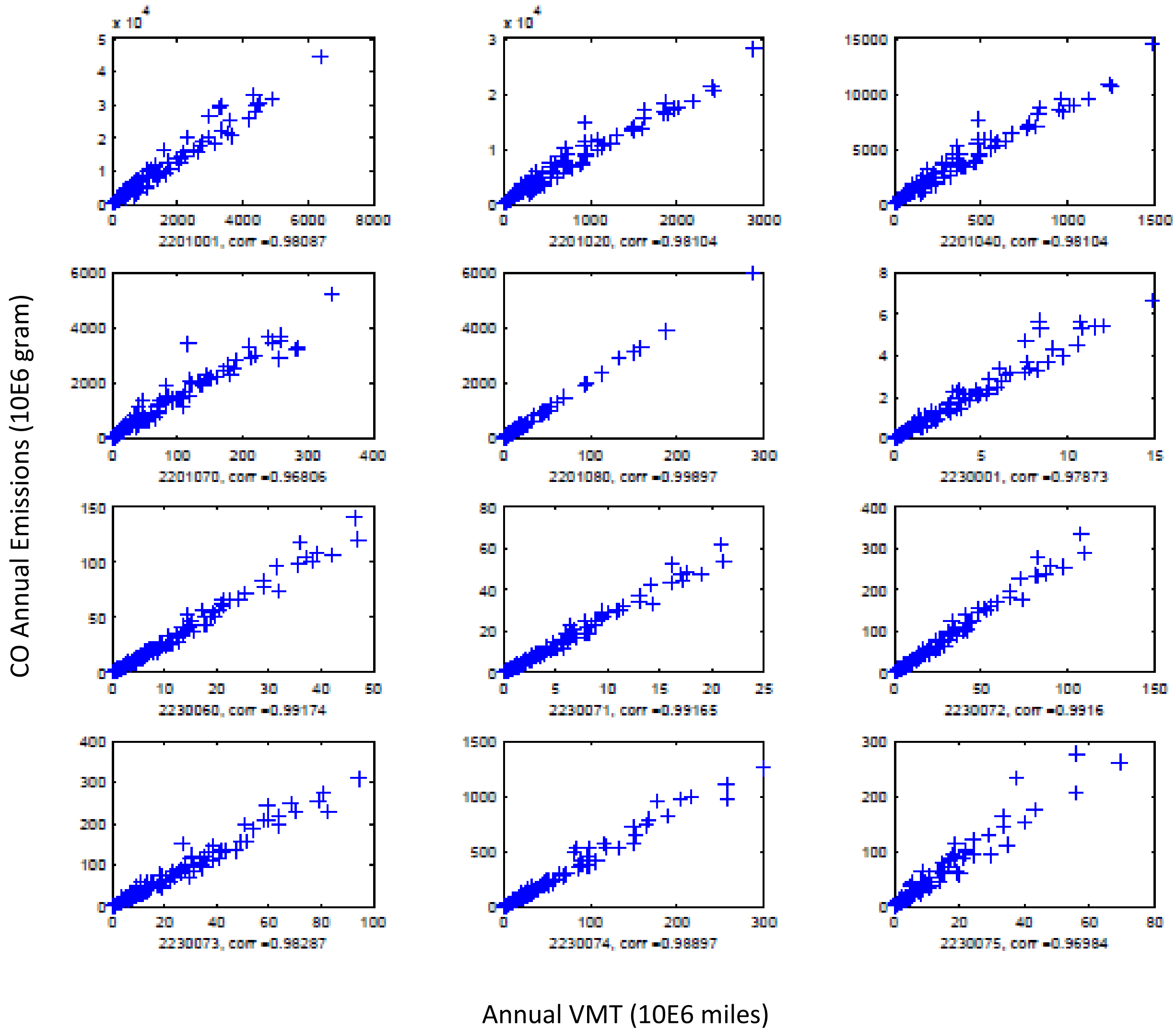

Figure 3b. The Linear Regression of 2007 CO Emissions and VMT for the 116 counties in the Mid-Atlantic and Northeast region, broken down by vehicle types

4.2 The Uncertainty of Emissions

The range of uncertainty is estimated by comparing the residues of MOVES emissions with the fitted values, as shown in Figure 4 for NOx and CO emissions.

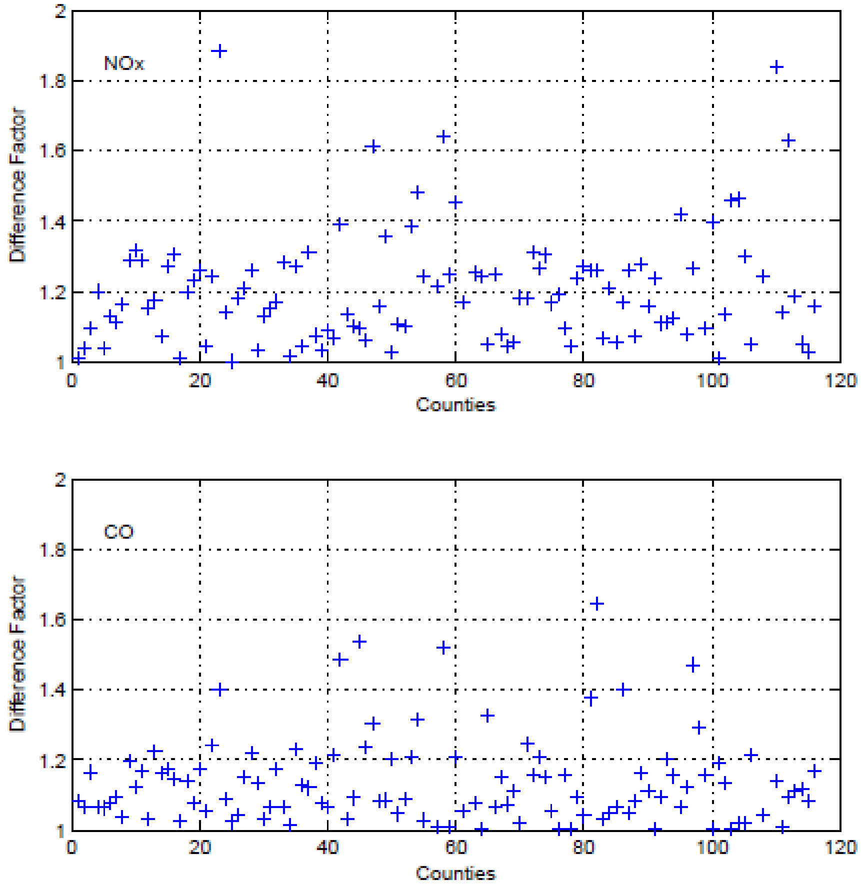

Figure 4. The Difference Factor of 2007 Emissions over the Fitted Values for the 116 counties in the Mid-Atlantic and Northeast region

5. Discussions

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References

[1]MOBILE6-Mexico, TCEQ, ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/MEX/m6mx/

[2]U.S. Environmental Protection Agency, Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity, Technical Guidance for MOVES2010, 2010a and 2010b, Table A.2. EPA-420-B-12-028, 2012.

[3]Yang, H., Development of MANE-VU Onroad Mobile Source Emissions for 2007 and 2020 using MOVES, Report to NESCAUM, 2012.