Impact of Point Sources Emissions on Ozone Formation for Houston Galveston Brazoria (HGB) Area

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***Abstract*—** NOx and VOC released from point sources are the major precursors for secondary pollutant ozone (O_3). South East Texas, particularly Houston-Galveston-Brazoria (HGB) area is a non-attainment area for Ozone pollutant. The point source emissions are the focus of this study due to their significance compared to other emission sources. CAMx 5.40 model was used to simulate ozone concentrations for three different cases: WOP (Without point source), ALL, HGB. After EPS3 processing, emissions data show that June 2nd concentration of NOx is highest for Case 'ALL' and highest VOC is observed on June 4th for Case 'ALL'. CAMx simulation results demonstrated maximum 8 hour average ozone concentration of 113 ppb for June 3, 2006 for Case 'ALL'. The point source emissions in HGB increase the ozone formation by 16%. A 0.16% point source emission difference impacts the ozone formation significantly with a 3% ozone concentration difference.

***Keywords*—** Point Source, Ozone, EPS3, CAMx, Air Quality.

I. Introduction

HOUSTON Galveston Brazoria (HGB) is in the southeast region of Texas. This region consists of eight counties: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller. Due to great anthropogenic emission activities from Houston metropolitan area and the energy industry corridor in this region, the secondary ozone pollution is a significant problem for HGB area. In 2008, EPA declared HGB area as a non-attainment area for Ozone pollutant according to National Ambient Air Quality Standard (NAAQS) for eight hour Ozone of 75ppb [1]. The various emission sources including point source, area source, mobile source, non-road source and biogenic source are the main sources for emissions in HGB area. These sources produce major Ozone(O3) precursors, like- Nitrogen Oxides (NOx) and Volatile Organic Compound (VOC)[2]. All emission sources contribute to ozone pollution, however, contribution of point sources emissions in energy industry to ozone formation is relatively easy to be regulated and controlled. For this reason, the point sources emissions have been evaluated for their impact on ozone formation by using Emission Processing System, version 3 (EPS3) model and point sources emissions input files have been produced for ozone simulation with CAMx model. In this study, Texas-4km domain (Figure1) has been used to analyze the air pollutant, Ozone in HGB area. For this purpose, three different case scenarios: ALL, HGB, WOP (Without Point sources) have been observed. For this study summer 2006, from May 28 to June 4th have been simulated, where June 1 and June 2 are the representation of weekdays and June 3 and June 4 are the weekend representation for summer 2006.

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II. Methodology

A. Model Selection

The Emissions Processing System (EPS3) model was selected in this study to process the raw emission data from the point sources. The raw emission data can be converted into the domain-fitted, time resolved, and chemically speciated emissions input files for the proposed air quality model simulation. In this study, Comprehensive Air Quality Model with extensions, CAMx, a three dimensional photochemical grid model has been used to simulate the air pollutants concentration. CAMx model version 5.40 use chemical mechanism 7 (CB6)[4]. This mechanism uses 218 chemical reactions and up to 114 species. Visualization Environment Rich Data Interpretation (VERDI) tool has been used to view CAMx simulation output files.

B. Modeling Domain

The CAMx modeling domains used in this study consist of three different nested grid size, which from the most outer 36 km x 36 km grid (black box) nesting a 12 km x 12 km grid covering the whole parts of Texas, Oklahoma, Arkansas, Louisiana, and Mississippi states (blue box) and then nesting a 4 km x 4 km grid encompassing the HGB nonattainment counties and Dallas-Fort Worth ozone nonattainment area (green box). Table I shows the detailed information of the modeling domain used in this study. Tx_4km domain covers Houston-Galveston-Brazoria(HGB) area and portion of surrounding states. It could have been more accurate if we could have the TCEQ Rider8 base-case data files for HGB sub-domain. Unfortunately, due to lack of input data file for sub-domain, tx_4km data were used for all cases of simulation.

TABLE I
MODELING DOMAIN FOR CAMX AND EPS3[3]

Domain	Easting (E)	Northing (N)	Number of cells	
			(E)	(N)
rpo_36km	-2735, 2592	-2088, 1944	148	112
tx_12km	-984, 804	-1632, -312	149	110
tx_4km	-328, 436	-1536, -644	191	218

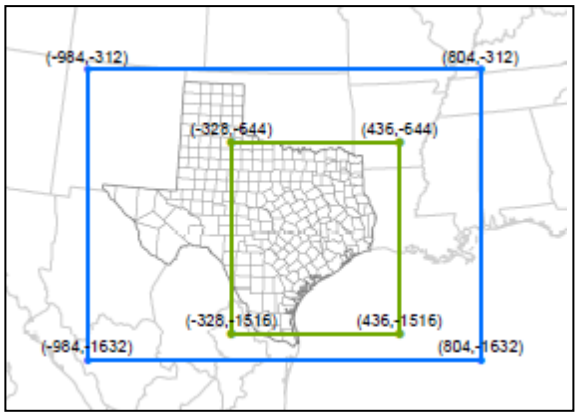

Fig. 1 CAMx domain with co-ordinates for tx_12km grid (blue rectangle) and tx_4km grid (green rectangle)[3]

C. Data collection

All EPS3 processes ASCII formatted AFS data files. The AFS files contain emissions data in various forms including ozone season day (OSD) emissions as well as annual emissions. If the raw data files did not contain OSD emissions the best estimate of the OSD emission based on information in the extract of raw data was produced in the AFS files. For Case 'HGB', EPS3 input AFS data file have been collected from TCEQ Houston-Galveston-Brazoria 8-Hour Ozone state implementation plan (SIP) Modeling (2005/2006 Episodes). Input AFS file included emissions for OSD summer 2006. The files for other cases inputs have been collected from TCEQ's Rider 8 State and Local Air Quality Planning Program [5].

D. Modeling Procedure

There are three emission cases: Case 'ALL', 'HGB' and 'WOP' have been studied to analyze the impact of point source emission in troposphere Ozone production. For Case 'ALL', emission from - point source, area source, mobile source, non-road source and biogenic source have been considered. Here, point sources present in entire tx_4km area have been considered. For Case 'HGB', point sources present only within the HGB eight counties have been considered. Preparation of point source emission input file for Case 'HGB' is done using Emission Processing System (EPS3). Processing the point source emission data file in EPS3 source code involves seven modules: PREPNT, SPECEMS, TMPRL, PSTPNT, PIGEMS, GRDEM and MRGUAM. Each of the module is essential to process and produce the CAMx compatible emission input data files [6].

Other emission files like- mobile source, biogenic source, area source, on-road source and non-road source data were generated by various other models by Texas Commission on Environmental Quality (TCEQ), such as mobile source emission data by MOVES model, off-road source emission by NON-ROAD and biogenic source emission by GloBEIS model. The other data such as meteorological data and boundary condition data files were collected from TCEQ air quality modeling data ftp site. For generating meteorological data TCEQ used Weather Research and Forecasting (WRF) model and for Boundary condition data TCEQ used GOES-Chem model. After having all the emission files, are merged together. For case 'ALL' and case 'WOP', MRGUAM module has been also used.

III. RESULTS AND DISCUSSION

A. Emission Processing System (EPS3)

Successful completion of each EPS3 module results in a message file and this message file displays total estimated emissions. The message files show the total emissions of NOx, VOC and CO. We skipped the estimation for SO_2, PM10 and PM2.5 as they are not significant for the formation of ozone. All modules of EPS3 were completed successfully for each of the representative day before MRGUAM module is used to compile point source, mobile source, non-road source, area source and biogenic source files. Table II summarizes the final emission estimation from EPS3 MRGUAM module.

TABLE II
TOTAL ESTIMATED EMISSION FOR CASES 'ALL','HGB', 'WOP' FROM JUNE 1ST TO JUNE 4TH, 2006 FOR TX_4KM DOMAIN

Case	**ALL (unit: English tons/day)**		
Date	NOx	VOC	CO
6/1/2006	3041	32200	14500
6/2/2006	3221	41600	15600
6/3/2006	2628	45800	16000
6/4/2006	2372	50400	15000
Case	**HGB (unit: English tons/day)**		
Date	NOx	VOC	CO
6/1/2006	2958	32900	14400
6/2/2006	3138	41300	15500
6/3/2006	2545	45400	15900
6/4/2006	2289	50000	14900
Case	**WOP (unit: English tons/day)**		
Date	NOx	VOC	CO
6/1/2006	2955	32900	14400
6/2/2006	3135	41300	15500
6/3/2006	2541	45400	15900
6/4/2006	2286	50000	14900

From these results, it is clear that total NOx emission is much higher on Weekdays than Weekends for all three cases

and NOx is higher on June 2 than June 1. On the other hand, VOC concentration was found to be higher for Weekends. For total VOC species maximum VOC concentration has been found for June 4 for Case 'ALL'. Additionally, point source emission message files showed that VOC emission is prominent over NOx and CO emissions.

B. CAMx Results

After CAMx model simulation, outputs of all the days and for three cases were visualized using VERDI graphic tool. Tile Plot of CAMx output files gives maximum average concentration of each criteria air pollutant species including ozone. For this study, maximum ozone concentration was determined to be on June 3 for all simulated days and cases. From hour 11:00:00 to 15:00:00 of day June 3 the maximum ozone concentration was 0.113 ppm.

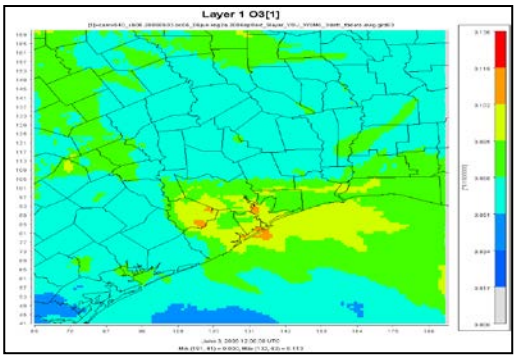

Fig. 2 CAMx simulation to observe Ozone Concentration for Case ALL on June3, 2006 for TX_ 4km

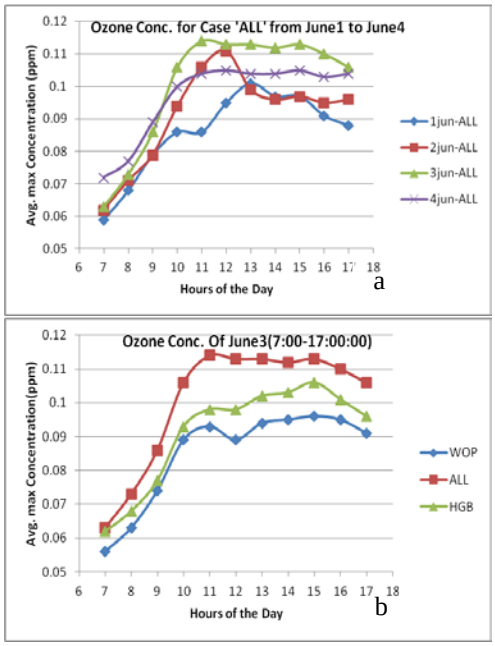

Fig. 3 (a) Average 8hour Ozone Concentration during hour (7:00:00-17:00:00) from June 1 to June 4 (b) Ozone concentration on June 3 for all three cases

Figure 3(a) shows Ozone concentration for Case 'ALL' from June 1 to June 4, 2006. From Figure 3(a) the ozone concentration profile of Saturday (June 3) demonstrated higher ozone concentrations than Sunday (June 4). The weekend (June 3 and June 4) average ozone concentrations are higher than weekday (June 1 and June 2) ozone concentrations. In Figure 3(b) Ozone concentration trends for day of June 3 for all three cases from hour (7:00:00-17:00:00) are shown. For each of the days the same graphs are produced and always maximum ozone is found for case 'ALL'. On June 3, maximum ozone concentration is found to be 113 ppb for Case ALL. On same day for Case 'HGB' ozone concentration is found to be 96 ppb and for Case 'WOP' Ozone concentration is found to be 93 ppb. This indicates point source from HGB increases ozone concentration by 3% for June 3. From this comparison, it is suggested that only total NOx emission difference of 4 English tons NOx/day (0.16%) between HGB case and WOP case on June 3 cause 3% ozone concentration difference. This indicated that NOx emissions acted as the major limited precursor species for ozone formation in HGB area.

In Figure 4, the difference in ozone concentrations for three cases have been analyzed from comparison between Case 'HGB' and Case 'ALL' also between Case 'WOP' and Case 'ALL'. This plot shows Ozone percentage difference for all the days. It is clear that that Ozone concentration greatly varies for Case 'WOP', like- 10%, 14%, 17%, 24% for June 1,2,3 and 4 respectively from Case 'ALL'. Whereas, ozone concentrations of Case 'HGB' varies like- 7%, 9%, 10%, 10% for June 1,2,3 and 4 respectively. These two comparisons reflect the impact of point sources emissions on ozone formation is significant.

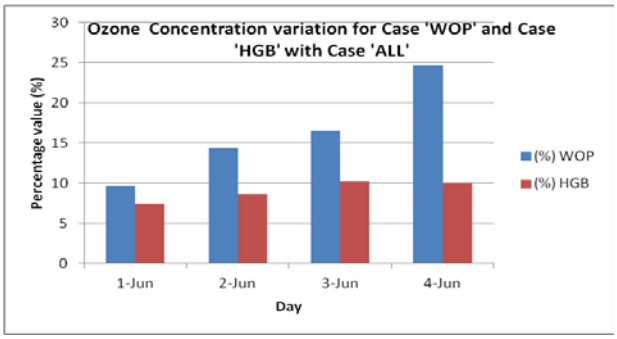

Fig. 4 Percentage difference in average of average 8 hour Ozone Concentration for Case 'WOP' and Case 'HGB' with Case 'ALL' for hours (7:00:00 to 15:00:00) from June 1 to June 4, 2006

IV. Conclusions

HGB area is a non-attainment area for ozone pollutant. From this study it is found that in summer 2006, ozone pollutant exceeds the National Ambient Air Quality Standard almost every day in afternoon. On June 3, Ozone concentration (0.113 ppm) was maximum for Case 'ALL', additionally Case 'HGB' also showed highest Ozone concentration (0.096 ppm) on June 3. On the other hand, on June 3, Case 'WOP' showed Ozone concentration (0.093 ppm). From analysis of three cases it can be concluded that, point sources emission in Houston-Galveston-Brazoria (HGB) increases the ozone formation by 16%. It is found that, even small number of point sources emission greatly impact the ozone concentration. A 0.16% point source emission

difference produced a 3% ozone concentration difference. Specially, point source emission control and regulations are very important for areas like HGB, where secondary ozone pollution is of great concern.

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