Assessing the Impacts of Hartsfield-Jackson Atlanta International Airport On $PM_{2.5}$ and O_3 in Atlanta Area

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INTRODUCTION

The goal of this study is to determine, through modeling, the impact of aircraft emissions on regional air quality, especially in regards to $PM_{2.5}$ as well as ozone and other pollutants. For this, we focus on Hartsfield-Jackson Atlanta International Airport which is the busiest airport in the world based on passenger traffic. Hartsfield-Jackson serves the metropolitan Atlanta area where air quality does not meet national standards. The objective of this study is to assess the impact of Hartsfield-Jackson Airport on air quality around Atlanta, Georgia, to compare it to the impacts of other emission sources in the area. To achieve this objective, this project is built upon other, related air quality studies involving both field and modeling components.

METHODOLOGY

Atlanta Hartsfield-Jackson International Airport is located south-eastern part of Atlanta and lies between Fulton and Clayton counties. In order to study the impact of Hartsfield-Jackson airport, first a detailed inventory is developed for aircraft and other emissions. Then, air quality simulations were performed to relate these emissions to regional air quality around Atlanta.

Episode Selection

August 11-20 2000 was selected as the episode to be modeled in this study. Prior modeling of this episode during the Fall Line Air Quality Study (FAQS) (Hu *et al.*, 2003 and 2004) and availability of additional $PM_{2.5}$ measurements for evaluation played a major role in this selection. Meteorological data for this episode as well as emission data for sources other than aircrafts were already available from FAQS.

Data Preparation

As part of Fall Line Air Quality Study (FAQS), we have prepared emissions inventory for each source category in Georgia, including airports (Unal, 2003). PM emissions factor for Commercial Aircraft were not provided by EPA. In FAQS study, PM emissions for Commercial Aircraft were estimated based upon the assumption that there is a relationship between emissions of Air Taxi and Commercial Aircraft for VOC and PM:PM emissions for Commercial Aircraft were estimated to be 345 tons/year for Hartsfield-Jackson Airport.

In this study we reviewed the literature to improve the estimate of fine PM emissions from commercial aircrafts. Recently FAA has developed a First-Order Approximation (FOA) method (Wayson and Fleming, 2001) for fine PM estimation from aircrafts. In their study, FAA developed a relationship between Smoke Number (SN) and PM emissions (Wayson and Fleming, 2001). In this study we decided to use characteristic value for smoke number and estimated that aircraft emissions are 43 tons/year.

Emissions Modeling

An air quality model like CMAQ needs hourly, gridded, and speciated emissions. In order to better resolve and distribute emissions from aircrafts, we developed a new emissions processing framework. This framework involves the following parts: temporal distribution; spatial distribution; and speciation.

Temporal Distribution: We obtained temporal profiles for Hartsfield-Jackson Airport from Dr. Tom Nissalke. Some of these temporal profiles differ significantly from default temporal profiles used in SMOKE. As an example, diurnal temporal profile of the aircraft activity (as a fraction of hourly activity to daily activity) is shown in Figure 1 both for SMOKE default profile and actual Hartsfield-Jackson Airport data. As seen in Figure 1, although there is not much actual activity, SMOKE default profile assumes more flight activity between midnight and 6:00 am than there usually is at Hartsfield-Jackson Airport. On the other hand, the actual evening flight activity increases until midnight while the SMOKE default profile assumes a decreasing trend in evening flight activity. These differences between a typical airport

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represented by SMOKE's default profile and the Hartsfield-Jackson Atlanta International Airport may cause significant errors not just in the aircraft emission estimates but their impact on air quality.

Spatial Distribution: Although by nature emissions from aircrafts are vertically distributed (especially in take off, approach, and climb out modes) for ease of estimation emissions are generally put into the first layer of the air quality model. In this study we distributed emissions vertically by utilizing location data obtained from Dr Tom Nissalke. As an example Figure 2 presents a path taken by DC-9 plane during take off. As seen in Figure 2, DC-9 elevates very fast and hence assigning all of its takeoff emissions to the first layer (i.e., first 19 meters from the ground) and in one horizontal cell (4 km×4 km) may lead to significant error. In this study we improve emissions by correcting this error. Also, depending on the relative position of runways with respect to the grid cells, placing emissions in a single cell may lead to additional errors. It should be noted that there is a different pathway for each aircraft and in this study all these data were used.

Speciation: In order to run the air quality model, it is necessary to provide speciated emissions rather than total PM. In order to speciate emissions we utilized speciation profiles provided by SMOKE.

MODELING RESULTS

In this study, the platform of choice for air quality modeling was Version 4.3 of CMAQ (Byun and Ching, 1999). The grid consisted of 102 columns by 78 rows of 4×4 km^2 grid cells, covering the State of Georgia. There were 13 layers in the vertical. Detailed information on modeling configuration can be found in Hu et al. (2004).

We conducted three different sets of air quality simulations for each of the different emissions inputs: 1) without aircraft emissions from Hartsfield-Jackson Airport, 2) with First-Layer aircraft emissions, 3) with FOA-PM emissions.

The area impacted by Hartsfield-Jackson's aircraft emissions and the level of impact changes every hour due to changes in meteorology, changes in flight paths, and changes in various other parameters that affect (O_3) and $PM_{2.5}$ levels.

Figure 3a and Figure 3b show the maximum ozone sensitivities to First-Layer and FOA-PM aircraft emissions, respectively. In Figure 3a, the maximum increase in ozone is 8 ppb in the grid cell directly to the west of Hartsfield-Jackson Airport. The effect of such high NO_x emissions into a single cell is a decrease in local ozone concentrations; that's why the maximum increase in ozone is zero in that cell. Within a 32-km radius, there are areas to the southwest over Fayette County and to the southeast over Henry County where ozone concentrations increase by as much as 4 ppb due to First-Layer aircraft emissions. Ozone levels increase by 1 ppb or more in Metro Atlanta except in North Fulton, DeKalb, Gwinnett, and Rockdale Counties.

The differences between the areas of impact shown in Figures 3a and 3b are due to distributing the FOA-PM emissions spatially over more than one horizontal cell and in several vertical layers. Otherwise the amounts of NO_X emissions (the primary reason for the increase in ozone concentrations) are the same in First-Layer and FOA-PM inventories. The distribution diluted NO_X emissions and resulted in a seemingly smaller area of impact. As a result, there is no northwesterly impact of FOA-PM aircraft emissions over Douglas and Cobb Counties and smaller impact (compared to First-Layer aircraft emissions) over Henry County. On the other hand the impact on ozone levels over South Fulton and Coweta Counties has increased. In Figure 3b, a maximum impact of 4 ppb is shown within an arc of 25-km radius to the southwest of the airport over Fulton and Fayette Counties. Also a location in DeKalb County approximately 50 km to the northeast of the airport is impacted at the 4 ppb level by aircraft emissions. Note that while there is a local airport in DeKalb, this impact is from the aircraft emissions from Hartsfield-Jackson Airport. Under different meteorological conditions this relatively distant impact could occur at a different location.

The impact of aircraft emissions from Hartsfield-Jackson Airport on $PM_{2.5}$ are presented in Figures 3c and 3d. Figure 3c shows the maximum (during the August 11-20, 2000 period) sensitivity of $PM_{2.5}$ to First-Layer aircraft emissions. Figure 3d shows the same sensitivity but to FOA-PM aircraft emissions. The differences are due to differences in the magnitude of aircraft $PM_{2.5}$ emissions in First-Layer and FOA-PM inventories as well as differences in spatial distribution of those emissions. Recall that $PM_{2.5}$ emissions were about 8 times larger in First-Layer inventories compared to FOA-PM inventories. Figure 3a shows a maximum impact of 87 $\mu g/m^3$ in the grid cell where all First-Layer aircraft emissions were injected. Within a radius of 20-km, especially over Clayton County and portions of Fulton and

Henry Counties, the impact is 4 µg/m^3 or more. Figure 3b shows a maximum impact of 12 µg/m^3 in the grid cell immediately to the west of the airport. The impact is larger than 1 µg/m^3 to the southeast over most of Clayton County but generally less than 1 µg/m^3 over the rest of the region.

DISCUSSIONS AND CONCLUSIONS

In this study our aim was to determine, through modeling, the impact of aircraft emissions on regional air quality, especially fine particulate matter and ozone. For this purpose we focused on Hartsfield-Jackson International Airport. We prepared the necessary input data to run air quality model simulations. An important contribution of this study is that we improved emissions estimates for aircrafts by using recently developed FOA method for $PM_{2.5}$. Furthermore, we improved spatial and temporal distribution of aircraft emissions by using activity data obtained from the Hartsfield-Jackson Atlanta International Airport Authority. It was observed that the temporal profile for Hartsfield-Jackson Airport is significantly different from the default temporal profile for aircrafts used in SMOKE. We compared our emissions as well as air quality results with runs conducted with First-Layer emissions where emissions were injected in the first layer only. Also injecting aircraft emissions in one cell and not distributing them spatially may have lead to overestimations of the impact of aircraft emissions. We provided revised estimates of the impact of Hartsfield-Jackson Airport on regional air quality in terms of ozone and particulate matter. Aircraft emissions from the Hartsfield-Jackson Atlanta International Airport may increase local ozone levels by as much as 4 ppb and $PM_{2.5}$ levels by as much as 12 µg/m^3. While the impact on $PM_{2.5}$ is generally local the impact on ozone may be 2-3 ppb over most counties of Metro Atlanta.

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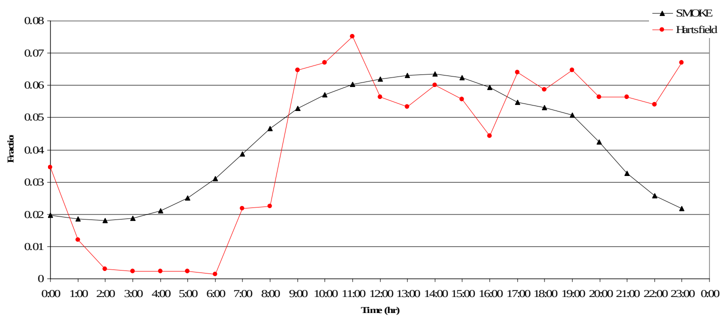

Figure 1. Diurnal Temporal Profile for Hartsfield-Jackson Airport

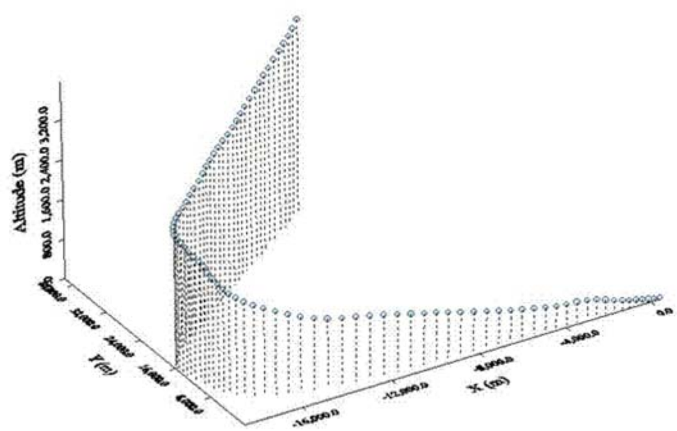

Figure 2. Typical three dimensional path for DC-9s that took off from Atlanta Hartsfield-Jackson Airport in August 2000

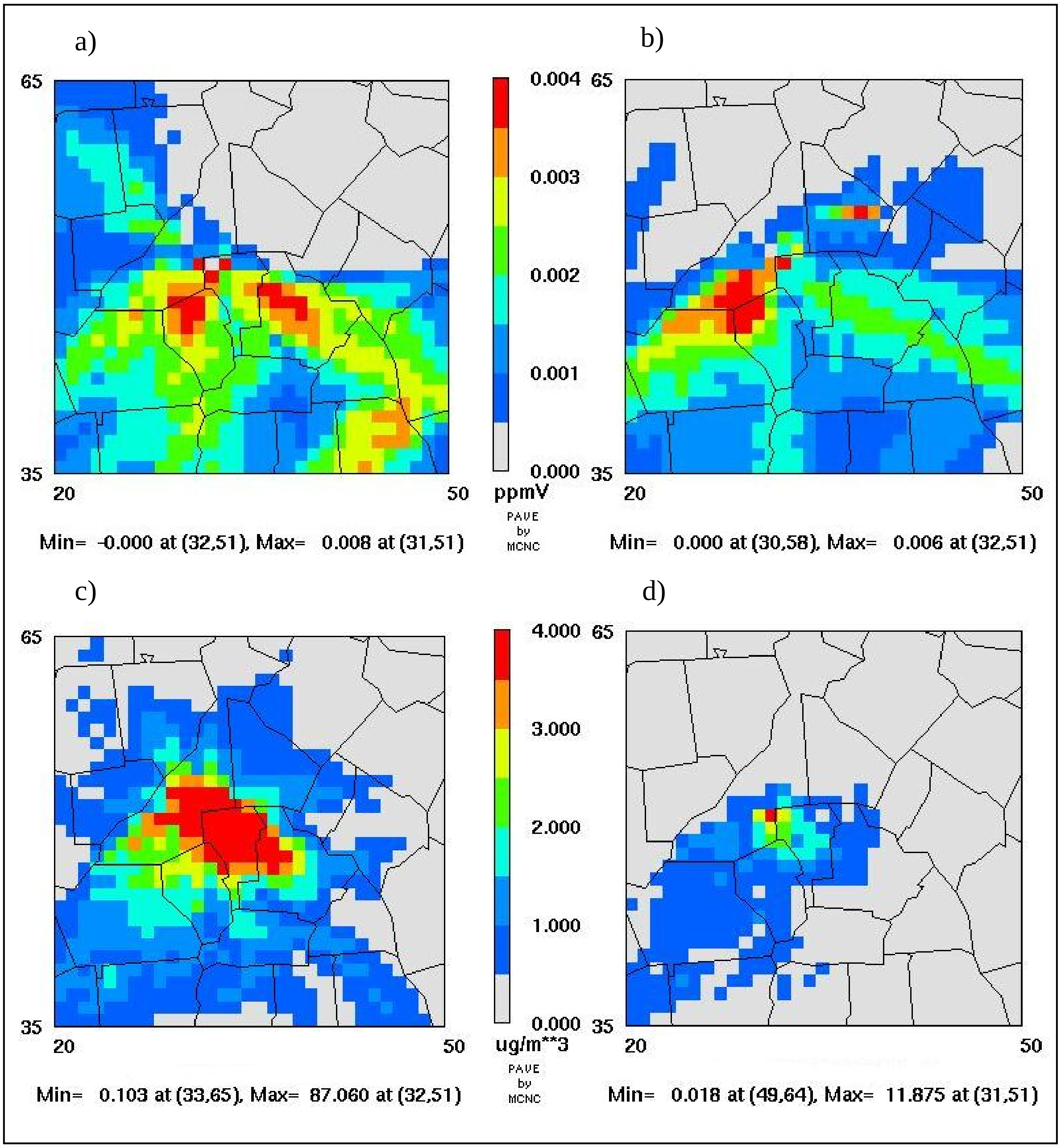

Figure 3. Maximum sensitivity of regional concentrations to aircraft emissions from Hartsfield-Jackson Atlanta International Airport during the August 11-20, 2000 period: a) O_3 to First-Layer emissions; b) O_3 to FOA-PM emissions; c)$PM_{2.5}$ to First-Layer emissions; and d)$PM_{2.5}$ to FOA-PM emissions.