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Air Quality Exposure Assessment: Modeling the Impact of DeKalb-Peachtree Airport (PDK) on Surrounding Residential Neighborhoods.

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By

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Bachelor of Science

University of Notre Dame

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P. Barry Ryan, PhD

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Public Health
in Environmental Health

2012

Abstract

Air Quality Exposure Assessment: Modeling the Impact of DeKalb-Peachtree Airport (PDK) on Surrounding Residential Neighborhoods.

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Background: In 2011, DeKalb-Peachtree Airport Director, Mike Wie, and a citizens' group, Open DeKalb, Inc., met to discuss concerns about the impact of the airport on the health and welfare of the surrounding community. This meeting resulted in the proposal of a study at Emory University led by Dr. P Barry Ryan to assess the noise and air contaminant exposures experienced by residential neighborhoods around PDK airport.

Purpose: This study will (1) model and analyze the impact of air contaminant exposure experienced by residential neighborhoods around PDK Airport, (2) project the impact of the airport and surrounding highways on the local community using already existing data on temperature, air pressure, wind speed, wind direction and other meteorological parameters, and (3) aid in the data collection, monitoring and evaluation of air pollutants and the impact of these exposures on the surrounding community.

Methods: We use AERMOD, a U.S. Environmental Protection Agency regulatory guideline model, to model the average concentration of NO_2 from various area sources: PDK airport, I-85 and I-285. A series of analysis was conducted on a 15 km x 15 km receptor network grid modeled with each area source using meteorological data from 2006- 2011. Seasonal averages of hypothetical NO_2 emission rates based on emission source input calculations were computed and the percent of NO_2 concentration attributable to PDK Airport.

Results: The model showed high concentrations of NO_2 at several receptors located near I-85 and I-285. The south and southwestern areas of the receptor network grid had the highest PDK-attributable percent of NO_2 concentrations. However, the concentrations at the receptors with the highest PDK-attributable percent of NO_2 concentrations were not high enough for concern about potential health effects due to poor air quality.

Conclusion: Monitors should be set up in the areas where the model indicates the highest concentrations of NO_2. The evidence based on the data collected from monitors could help support whether there is a need for health concerns due to poor air quality from nearby area emission sources.

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I. Introduction

Airports are known to be major sources of noise and air pollution in the community (Holzman 1997). Airports are the largest source of non-road greenhouse gas (GHG) emissions and airport-related emissions are only increasing as emissions from other major source sectors, such as highways and roads, are decreasing (NESCAUM 2003). The impact of airports on the air quality of surrounding communities will increase as air traffic continues to increase (NESCAUM 2003). The Federal Aviation Administration (FAA) expects that the aviation industry will continue to experience steady and moderate growth over the long term. Despite the fact that the air carrier industry has suffered several setbacks since the turn of the century, including the terror attacks of September 11th, rising fuel prices, debt restructuring in Europe and United States (U.S.) and a global recession, the demand for air travel continues to increase (FAA 2012). It is projected that the domestic capacity for air travel will increase by about 2 to 3 percent each year over the next 20 years. This will allow for the accommodation of 1.2 billion passengers in 2032 compared to the 731 million passengers that flew in 2011. Air traffic growth grew by 3.5% in 2011 and it is expected to rise by more than 90% in the next 20 years (FAA 2012).

In a study of Logan International Airport (Boston, MA), Bradley International Airport (Windsor Locks, CT), and Manchester Airport (Manchester, NH), approximately 85% of nitrogen oxides (NO_x) are from aircrafts and 15% are from auxiliary power units and ground service equipment (NESCAUM 2003). Ground level emissions from an aircraft mainly occur during the landing and takeoff cycle (LTO). LTO cycles are comprised of five steps: Approach (AP), Taxi/ Idle-In, Taxi/ Idle-Out, Takeoff (TK), and Climbout

(CB). The LTO cycle begins as the aircraft descends from cruising altitude. From the moment the aircraft enters the pollutant mixing zone[1] until it lands at the airport, it is in the approach step. The second step in the landing portion of the cycle is to taxi to the gate and any subsequent idling.

Aircraft taxiing can significantly contribute to the release of emissions at airports. Deonandan and Balakrishnan reported in 2007 that the people in the United States spent more than 63 million minutes taxiing to their gates and over 150 million minutes taxiing out from their gates (Deonandan 2010). This can be a substantial contribution to air pollutants released each year by taxing and idling alone. The next three steps of the LTO cycles are the three operating modes in the takeoff portion of the LTO cycle: taxi-out/idle, takeoff and climbout. The takeoff is characterized primarily by a full-throttle operation that lasts until the aircraft reaches 500 to 1,000 feet. The climbout is the period following takeoff until the plane passes out of the mixing zone. In 1993, 350 million pounds of VOCs and NOx were emitted during landing and takeoff cycles, which is more than double the levels seen in 1970, according to a National Resources Defense Council (NRDC) report (Holzman 1997). In 2002, the Royal Commission on Environmental Pollution reported that, if unchecked, air travel will soon be the major factor driving climate change with disproportionate effects from short-haul passenger flights. (Banatvala 2004).

The growth of air traffic will further exacerbate existing environmental issues in air quality. Burning jet fuel releases several major air pollutants including: carbon dioxide (CO_2), nitrogen oxides (NO_x),, particulate matter (PM), and volatile organic compounds

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[1] The mixing zone is the layer of the earth's atmosphere where chemical reactions of pollutants can ultimately affect ground level pollutant concentrations (EPA 1999).

(VOCs) (US EPA 2011). At different points in the LTO cycle, the ratio of air pollutants emitted also differs. VOCs emission rates are highest when engines are operating at low power, such as when idling or taxiing. Conversely, NOx emissions are highest when engines are operating at high power and combustion temperatures during TK and CB. PM emissions result from the incomplete combustion of fuel, with high power operations producing the highest PM emission rates due to the high fuel consumption under those conditions.

CO_2, and methane (CH_4), which is considered a VOC, are major greenhouse gases (GHGs). GHGs are important because they absorb long-wave energy that is reradiated from the Earth's surface into the atmosphere. Absorbing this energy allows less heat to escape back to space and traps it in the lower atmosphere, disrupting the balance between energy received from the sun and energy emitted back to space from the Earth and its atmosphere (Spiro 2003). Without greenhouse gases to absorb the sun's natural heat, the Earth's average surface temperature would be about 33 degrees Celsius cooler than present conditions.

PM with a diameter of 2.5 µm or less are defined as fine particles ($PM_{2.5}$) and particles with a diameter greater than 2.5 µm but less than 10 µm are coarse particles (PM_{10}). Epidemiological evidence associate PM more directly with morbidity and mortality than any gaseous pollutant (Spiro 2003). A study of six U.S. cities that monitored 8,111 adult subjects for 14-16 years found that increased particles were correlated with increased mortality from all causes, but especially from cardiopulmonary disease (Dockery et al. 1993). Nawrot et al. found that a difference of 30 $\mu g/m^3$ in PM_{10} is associated with a 4.8% change (Odds Ratio of 2.6-7.1) in incidence of myocardial infarction through a review of 36 epidemiological studies (Nawrot, et al. 2011).

VOCs and $NO_{x,}$ are also precursors to ground-level ozone. Ozone can produce cracks in rubber, destroy plants and cause respiratory illness and eye irritation in humans (Spiro 2003). Data were analyzed from the American Cancer Society Cancer Prevention Study cohort of 448,850 subjects with an 18-year follow up period for associations between ozone concentrations and mortality risks. The study found that in single-pollutant models, ozone was significantly associated with an increased mortality risk from cardiopulmonary diseases. However, the authors were not able to detect an effect of ozone on the risk of death from cardiovascular causes in a two-pollutant model including $PM_{2.5}$. The study was, however, able to demonstrate a significant increase in mortality risk from respiratory causes in association with an increase in ozone concentration (Jerret M, et al. 2009) Ehrlich et al. found that the ability to clear inhaled *Staphylococcus aureus* from lungs was diminished in mice exposed to NO_2 and O_3 mixtures. NO_2 ranged from 1.5 to 5.0 ppm and O_3 ranged from 0.05 to 0.5 ppm. Ehrlich et al's results indicate the impairment of the basic defense mechanisms in the lung and can reflect the overall toxic response of the respiratory system, such as edema, inflammation, cellular necrosis, reduced macrophage function and ciliostasis to NO_2 and O_3 exposure. The study also indicated that the mixture of NO_2 and O_3 show additive synergistic effects (Ehrlich 1997).

There are few studies looking at the health effect of airports on the surrounding community. However, a cross sectional study conducted in New York State assessed whether residents living near commercial airports (less than five miles) increased rates of hospital admissions due to respiratory diseases compared to those living greater than five miles away from the airport (Lin 2008). Lin found that those residents living closest to Rochester and LaGuardia Airports had an increased relative risk of hospital admissions for respiratory conditions compared to residents that live further away. However, the study did not find an increased risk of respiratory hospital admissions and wind-flow patterns Therefore, Lin suggests that residential proximity to some airports may increase hospital admissions for respiratory disorders, but acknowledges that other existing factors could also be contributing to this association that differ by airport (Lin 2008).

In 2011, DeKalb-Peachtree Airport Director, Mike Wie, and a citizens' group, Open DeKalb, Inc., met to discuss concerns about the impact of the airport on the health and welfare of the surrounding community. DeKalb-Peachtree airport (PDK) in DeKalb and Chamblee Counties is the second busiest airport in the state of Georgia with over 200,000 airport operations each year (PDK Airport 2011). PDK is classified as a general aviation reliever airport for the Atlanta metropolitan area. A reliever airport reduces airport congestion by providing service for smaller general aviation aircrafts including corporate and business jets, training aircrafts and helicopters.

The outcome of the meeting was a set of goals to analyze the air and noise pollution of PDK Airport:

1. Analyze the air and noise pollution impacts of three categories of aircraft.
    a. Those with certified maximum takeoff weights of 66,000 pounds or less.
    b. Those with certified maximum takeoff weights in excess of 66,000 pounds but less than 75,000 pounds.
    c. Those with certified maximum takeoff weights of 75,000 pounds or more.

2. Not include air and noise pollution impacts from major vehicular highways near PDK.
3. Not include air and noise pollution impacts from air traffic in and out of Hartsfield-Jackson Airport.
4. Provide analysis of PDK's relative impact on air quality in the area, so that PDK emissions can be understood as one contributor to the area's air and noise pollution, rather than with static figures for PDK's emissions without any qualifying context for the figures.
5. Provide comparative analysis of similar airport's(s') emissions.

Both groups agreed that they are fundamentally interested in the potential health impacts on the surrounding community and potential strategies that could help mitigate these impacts.

This study is part of a larger study at Emory University led by Dr. Barry Ryan to address the needs of the community and PDK Airport by assessing both noise and air contaminant exposures experienced by the residential neighborhoods around PDK airport. The larger study at Emory University will be completed in three phases. Phase I will develop a series of modeling exercises that will afford assessment of current and expected noise levels and projected impact of the airport and the surrounding highways on the local community. Phase II focuses on data collection and analysis of the impact of these exposures on the surrounding community. Phase III is the data analytic component of the investigation. While the work proposed by Emory focuses on air contaminant data collection, it will also make use of noise data already being collected in developing time increments over which air pollution data will receive closer scrutiny in Phase III. Phase

III focuses on data analysis and report generation. This phase will commence as soon as significant data are generated to afford analysis and will continue through to the end of the project.

My study focuses on Phase I of the larger study and prepares it for the next step, Phase II. Version 11353 AERMOD (US EPA 2004) and meteorological data taken at the airport was used to model and analyze the impact of PDK Airport, I-85 and I-285 on the air quality in the surrounding residential community. AERMOD is a steady-state plume model that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, including treatment of both surface and elevated sources, and both simple and complex terrain. It is used as a regulatory modeling program by the United States Environmental Protection Agency (EPA). AERMOD requires two types of meteorological data file, one file consisting of surface scalar parameters and the other file consisting of vertical profiles of meteorological data, using a format provided by Version 06341 AERMET (US EPA 2004), a meteorological preprocessor program. The model for PDK and the highways requires input for source location and rates, receptor networks and meteorology. Using these input factors, AERMOD can produce several different types of output files, the most basic being high values by receptors, overall maximum values and tables of concurrent values summarized by receptor for each averaging period and source group combination.

A series of analyses will be conducted from 2006 to 2011 computing seasonal averages of hypothetical air contaminant constituents. The analysis will also take into account major vehicular highways, Interstate 85 (I-85) and Interstate 285 (I-285) that are in close proximity to PDK. The results of the study will then aid in developing appropriate placement strategies for data acquisition.

The aims of this study are to:

- Model and analyze the impact of air contaminant exposure experienced by residential neighborhoods around PDK Airport.
- Project the impact of the airport and surrounding highways on the local community using already existing data on temperature, air pressure, wind speed, wind direction and other meteorological parameters.
- Aid in the data collection, monitoring and evaluation of air pollutants and the impact of these exposures on the surrounding community.

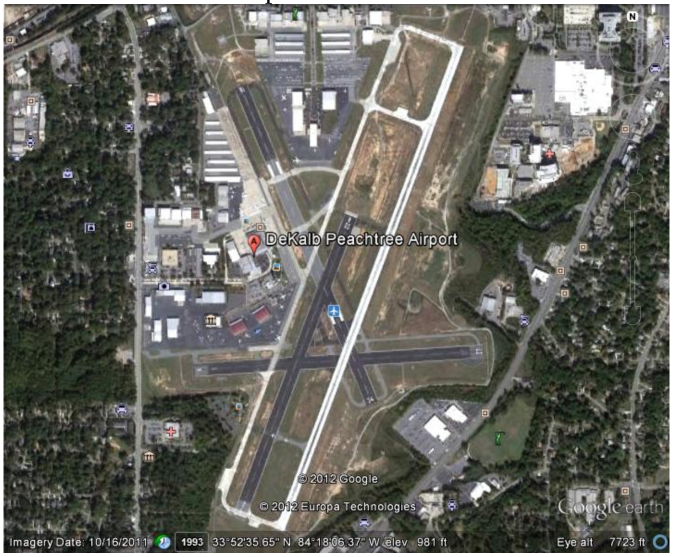
II. Methods

Study Site:

PDK Airport lies on over 700 acres mainly in the northeastern part of DeKalb County. The coordinates are N33°52.52’, W84°18.12’ with a field elevation of 1002’MSL (PDK Airport 2011). There are four runways at PDK. The principal runway, Runway 2R- 20L, is 6,001 ft long, runs essentially North/South (N/S) and is concrete/ grooved. Runway 2L-20R is 3,744 ft long, runs N/S and is asphalt. Runway 16-34 is 3,966 ft long, runs N/S and is asphalt. Runway 9-27 is 3,378 ft long, runs East/West (E/W) and is asphalt. On average, PDK has 214,151 operations per year (DeKalb Peachtree Airport). The annual prevailing wind direction in Atlanta is NW and the annual mean wind speed is 9 miles per hour (mph). Monthly prevailing wind patterns for Atlanta, GA are provided in Table A-1 (NCDC 1999).

Figure 1: Satellite Google Imagery of PDK Airport

Approximate scale is 2 km E/W and N/S.
North is up.

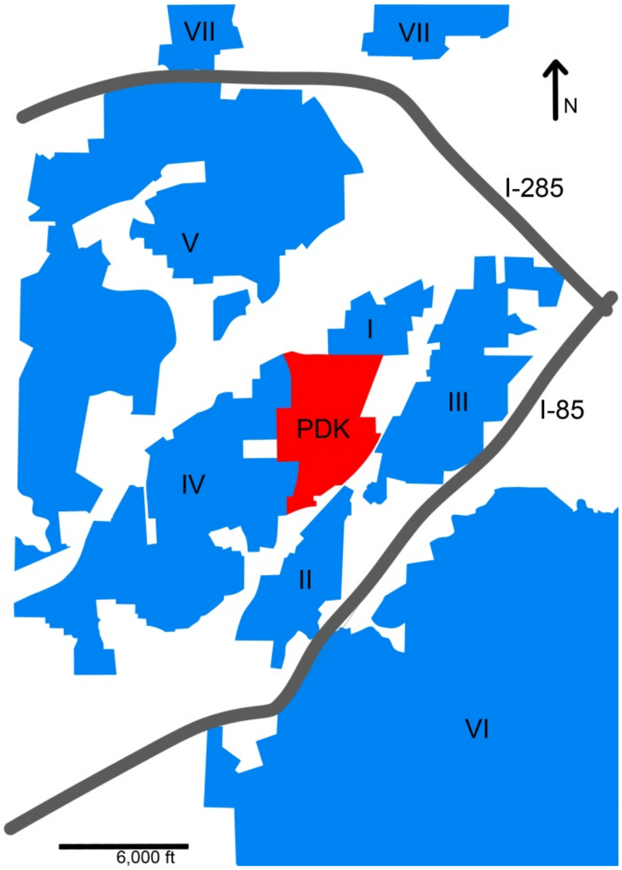


Google Earth

I-85 and I-285 are two major vehicular highways surrounding PDK Airport. I-85 is located approximately 2,000 m due E of the southwestern (SW) corner of PDK Airport in a 40° NE/SW heading from the N. I-285 surrounds metro Atlanta. From the SW corner of PDK, I-285 is located approximately 6,000 m N and circles around to approximately 5,000 m due E of PDK's SW corner.

There are seven residential areas in close proximity to PDK. These residential areas are largely identified as Suburban zones in DeKalb County. Zone I and II lie directly north and south, respectively, of PDK Airport. Both areas are currently undergoing residential acquisitions and re-zoning plans. Zone III is east of PDK between Buford Highway and I-85. Zone IV lays west of the airport starting in the south from Buford Highway and extending all the way north to Peachtree Road. Zone V is in Chamblee with Peachtree Industrial Blvd as its southern border and I-285 as its northern border. Zone VI is in Decatur, the entire area southeast of I-85. The last zone, Zone VII is north of I-285 in Dunwoody.

Figure 2. Graphical Representations of Residential Zones, PDK Airport, I-85 and I- 285.



Study Design:

The model was designed with a 15 km x 15 km receptor grid network design. NO_2 was chosen as the hypothetical air pollutant in the model because it is emitted by both vehicular and aviation sources. North was designated as the 0° direction. The SW corner of PDK Airport was anchored to the origin of the grid. PDK Airport was modeled as a 1,947.7 m x 1,080.9 m (X= 1,080.9 m, Y= 1,947.7 m) area source. The aviation source was modeled to be emitted 3 m off the ground to simulate the location of a jet engine on the runway.

I-85 was modeled as two long area sources (X= 44 m, Y= 9,000 m), identified as I85V1 and I85V2 in the model. Both I85V1 and I85V2 were anchored at (2208 m, 0 m) on the receptor network grid. I85V1 was angled 40° from N and I85V2 was angled 220° from N. I-285 was modeled as three separate area sources; I285V1, I285V2 and I285V3. I285V1 (X= 64 m, Y= 6,000m) was modeled as 6 km and I285V2 and I285V3 were both modeled as 7km (X=7,000 m, Y=64 m). This was necessary in order to model the northeastern perimeter of I-285 correctly. I285V1 and I285V2 were both anchored at (0 m, 5715.35 m). I285V1 was angled 132° from N and I285V2 was angled at 270° from N. I285V3 was anchored at (5000 m, 1500 m) and 180° from N.

Seasonal average concentration values for NO_2 were then calculated for each receptor point on the 15 km x 15 km receptor network grid. The seasons were categorized as Winter, Spring, Summer or Fall according to the date of their corresponding equinox or solstice. A file of (X,Y) coordinates and the period’s average concentration values of NO_2 were generated for each seasonal period.

Source area emissions for both PDK and the highways were calculated based on variable annual emission factors discussed in the methods analysis section. The model was also run with three different emissions source scenarios for the seasonal average concentration values of NO_2. The first scenario was with just the PDK area source, then only the highway sources and the final scenario was with both PDK and the highways. Then the percent air pollutant contribution of PDK was calculated at each receptor point for each season and year.

Data Collection:

Meteorological data are collected at PDK Airport by an Automated Surface Observing System (ASOS). ASOS systems serve as the nation’s primary surface weather observing network (NOAA 2011). They provide minute-by-minute observations 24 hours a day and generate the basic Aviation Routine Weather Report (METAR) and Aviation Selected Special Weather (SPECI) report.

Surface data files are made available by The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Centers (NCDC). We obtained monthly quality controlled local climatological data (12 files for each year) from the DeKalb-Peachtree Airport (53863) meteorological station from 2006- 2011. The matching upper-air data was retrieved from the NOAA/ Earth System Research Laboratory Radiosonde Database (NOA 2011).

Airport operations were retrieved from the 2011 Annual Noise Report generated by PDK and given to the Airport Advisory Board in January of each year. The aircraft emission rate for the model was calculated based on an Aircraft/Engine Emission Factor Database created by the Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft from the EPA (US EPA 1999). All roadway mileage and characteristic data pertaining to I-85 and I-285 were obtained from the annual Interstate Mileage Reports (IMR) released by the Georgia Department of Transportation Office of Transportation Data.

Analytical Methods:

AERMET

The raw data consists of surface and upper-air data files taken at an hourly basis at PDK from 2006-2011. AERMET is designed to be run as a three-stage process. The first stage process retrieves data and assesses data quality. The second stage merges the available data for 24-hour periods and writes these data to an intermediate file. The third and final stage reads the merged data file and develops the necessary boundary layer parameters for dispersion calculations by AERMOD (US EPA 2004).

Upper air and surface data are available from the NCDC in a compact format. Quality assessment (QA) and quality checks (QC) were performed on all data types to identify occurrences of missing data, values that are outside a range of values and inconsistencies between selected variables within an observation period. After QA/QC, the data was converted into .FSL and .SAM (SAMSON) files for upper air and surface data, respectively. The .FSL files were generated by copying and pasting the contents of the file from NOAA/ESRL Radiosonde Database into a text file with a .FSL extension. The file was then formatted by deleting the very first line containing the words “Hourly Obs.” .SAM files for surface data require a DOS based program called NCDC_CNV (Lee 2008) that can convert the abbreviated hourly surface meteorological data in comma-separated ASCII format into the SAMSON format. The monthly files from NCDC along with NCDC_CNV.EXE file and a Filelist.INP file need to be located in the same directory. The NCDC raw monthly files were formatted by deleting the first line containing the words “Hourly Obs” and the following blank line. Once these two lines were deleted in all twelve monthly files, the file names were listed on the Filelist.INP before running the NCDC_CNV executable file to create the .SAM file. Once the .SAM and .FSL files were created, they were moved to the same directory with the AERMET.exe and AERMET.INP files. Then each stage's command input will need to be copied in chronological order into the AERMET.INP file and ran to produce the correct set of output files.

Stage 2 of the AERMET process combines the files from Stage 1 into a single ASCII file. The file is organized so that the period begins with hour 1 and ends with hour 24. Stage 3 is the final stage for processing. The merged file is read and, in conjunction with site-specific that characterize the underlying surface, produces two input files for AERMOD: .SFC for surface data and .PFL for upper-air profile data. The .SFC file contains boundary layer scaling parameters; such as surface friction velocity, mixing height and Monin-Obukhov length; reference-height winds and temperature (US EPA 2004). The .PFL file contains one or more levels, or profile) of winds, temperature and the standard deviation of the fluctuating components of the wind.

AERMOD Input Calculations

In order to calculate the emission rate from PDK Airport, it was assumed that all PDK operations were from a Beech B99A Airliner. Time-in-mode (TIM) estimates are the time period (mins) that the aircraft engines actually spend at an identified power setting, typically pertaining to one of the LTO operating modes of the operational flight cycles. The TIM estimates used in the data analysis were reference values taken from the International Civil Aviation Organization (ICAO). The TIM estimates were multiplied by the emission rate for AP, CB and TK to calculate the mass of NO_2 (g) emitted (g) by an aircraft in a single LTO cycle. A single LTO cycle consists of two operations because an operation is defined as either a takeoff or landing (PDK Airport). Only the total number of operations at PDK was released in the PDK Annual Noise Reports not the number of takeoff versus landing operations. Therefore, it was assumed that there were an equal number of takeoff operations as there were landing operations each year at PDK. In order to calculate the total grams of NO_2 emitted from PDK each year the grams emitted during AP, CB and TK were multiplied by half the number of annual operations at PDK. Each step of the LTO cycle was then summed for the total grams of NO_2 released at PDK per year. This was converted into the total grams of NO_2 released at PDK per second and then divided by the area of PDK for the annual area source emission rate of PDK airport.

The emission rates for I-85 and I-285 were calculated using a 1.39 g of NO_2/mi emission rate for passenger cars (US EPA 2000). The passenger vehicle emission rate was then multiplied by the daily vehicle miles traveled (VMT) (mi/day) for the g of NO_2 produced each day on either I-85 or I-285. Daily VMT is calculated by multiplying the annual average daily traffic for a section of the highway by the section length and summing for all the section lengths (TABLE). Therefore, in order to scale the production of NO_2 for our model, we divided the length of the line source by the total mileage of its highway. Then we converted the rate from g/day to g/s and divided by the area of the line source for the line area source emission rate ($g/(s \cdot m^2)$).

AERMOD

The input file for AERMOD (aertest.INP) is divided into five functional pathways: control (CO) for specifying overall job control options, source (SO) information, receptor (RE) information, meteorology (ME) information, event (EV) processing and output (OU) options. These functional pathways can be thought of as a command language that allows the user to communicate with the model. The beginning of each pathway must is identified with a “STARTING” keyword and ends with “FINISHED.”

The mandatory keywords for the CO pathway are listed in Table 1.

Table 1. Mandatory Command Pathway Keywords (US EPA 2004, User guide for AERMOD)

TITLEONE	A user-specified title line (up to 68 characters) that will appear on each page of the printed output file
MODELOPT	Controls the modeling options selected for a particular run through a series of secondary keywords.
AVERTIME	Identifies the averaging periods to be calculated for a particular run.
POLLUTID	Identified the type of pollutant being modeled. This option has no influence on the results.
RUNORNOT	A special keyword that tells the model whether to run the full model or not.

The title of the model is “PDK Air Pollution Modeling.” We specified for the model to output concentration values on flat terrain by inserting “CONC” and “FLAT” keywords in the CO MODELOPT. The AVERTIME was set to average over a period and our POLLUTID was “NO2.”

The mandatory SO pathway keywords are in Table 2:

Table 2. Mandatory Source Pathway Keywords (US EPA 2004, User guide for AERMOD)

LOCATION	Identified a particular source ID and specifies the source type and location of that source.
SRCPARAM	Specifies the source parameters for a particular source ID identified by a previous LOCATION card.
SRCGROUP	Specifies how sources will be grouped for calculation purposes.

The PDK model contained three different source scenarios. The first source scenario modeled only PDK Airport as the area source. The source ID for PDK Airport was "AIRPORT." The airport LOCATION was at (0,0,0). The SRCPARAM contains the following source parameters; area emission, relative height, X length, Y length and Angle. The angle refers to the orientation of the area source from N (0°). The X length for the area source is identified in AERMOD by the first side encountered when moving counterclockwise from N. PDK Airport was an area source (X= 1080.9 m, Y= 1947.7 m) with a height of 3 m off the ground. The SW corner of the rectangular PDK area source was anchored to the origin. The area emission differed depending on the number of yearly operations out of PDK. The second source scenario modeled only the highways. As mentioned previously, I-85 was modeled as two area sources and I-285 as three with source IDs I85V1, I85V2, I285V1, I285V2 and I285V3. The LOCATION of both I85V1 and I85V2 was (2208 m, 0 m, 0 m). The LOCATION of I285V1 and I285V2 was (0 m,5715.35 m, 0 m) and I285V3 was (5000 m, 1500 m, 0 m). The SRCPARAM was 0 for all area sources with the X length, Y length and angles mentioned in the study design. The final source scenario combined all three area sources; PDK Airport, I-85 and I-285; into one model.

A Cartesian grid receptor network was identified for the RE pathway. The grid network is a 15 km x 15 km grid. The grid receptor network shares the same origin as the PDK area source and extends 7 km in each cardinal direction.

The ME pathway requires four mandatory keywords (aside from STARTING and FINISHED) outlined in Table 3.

Table 3. Mandatory Meteorology Pathway Keywords
(US EPA 2004, User guide for AERMOD)

SURFFILE	Specified the filename and format for the input surface meteorological data file.
PROFFILE	Specified the filename and format for the input profile meteorological data file.
SURFDATA	Specifies information about the surface meteorological data which will be used in the modeling. Requires the Weather-Bureau-Army-Navy (WBAN) number for NWS stations, year and a station name
UAIRDATA	Specifies information about the upper air meteorological data which will be used in modeling. Requires the WBAN number for NWS stations, year and a station name.
PROFBASE	Specifies the base elevation above mean sea level (MSL) for the potential temperature profile.

The .SFC and .PFL files names were inserted for the SURFFILE and PROFFILE keywords. The SURFDATA was 53863 YEAR(e.g. 2006) DeKalb, GA. The UAIRDATA was 53819 YEAR PeachtreeCity, GA. The PROFBASE was set at 0.0. Seasonality was analyzed for the model using the DAYRANGE keyword. DAYRANGE ranges from 1-365 (2008 was coded as 1-366 because it was a leap year) indicating the days of the year that should be included in the analysis. The days of each season were calculated for the year and inserted into the model (Table A-2).

All OU pathway keywords are optional. There are three printed table keywords: RECTABLE provides the highest, second-highest and third-highest values by receptor and MAXTABLE provides the overall 50 maximum values. The output was coded to generate an X-Y coordinate graph of the receptor grid network with the period average concentration values. The 10 highest average concentrations for the period were also generated.

The output was then created into tables on MS Excel (Redmond, WA). First, output was generated for the first source scenario of PDK only. Tables were constructed for each year starting from 2006- 2011. Each year were then further categorized into the 5 season categories (Winter, Spring, Summer, Fall, Winter2) creating 30 output tables. The second source scenario (only I-85 and I-285) was run with the same protocol. Finally all three sources were inserted into the model and ran. Once output was obtained for each scenario (a total of 90 output tables), several analyses were conducted. First, annual tables were constructed by averaging the NO_2 concentration values of Winter, Summer, Spring and Fall. Winter2 was excluded because the time period was only about 8 days compared to the other seasons which were about 80 days. The receptors with the top ten highest NO_2 concentration values were then identified for each year. A summary table of averaging the NO_2 concentration values from 2006- 2011 was also constructed. Lastly, an attributable percent of NO_2 concentrations to PDK Airport was calculated. This value was calculated by taking the average concentration value for a receptor in the PDK only model and dividing it by the average concentration value for the same receptor with all three sources present for a percent contribution of PDK to the total NO_2 concentration measured in the model.

III. Results

The NO_2 emission factors for a Beech B99A aircraft were found to be 50 g/min for TK, 42 g/min for CB and 27 g/min for AP (US EPA 1999). The TIM for AP is 4.0 min, TK is .7 min and CB is 2.2 min (ICAO 1999). The grams of NO_2 released by a single plane at each step of the LTO cycle is 108.9 g for AP, 35.1 g for TK and 93.1 g for CB. For takeoff phase of the LTO cycle 128.2 g of NO_2 are emitted. For the landing phase, only 108.9 g of NO_2 are emitted by a single plane. With the assumption that there are equal numbers of landings as they are takeoffs at PDK, it was calculated that about 21,408,802.4 g of NO_2 are released each year or 0.58 g of NO_2 per second. The annual operations for PDK Airport from 2006- 2011 are reported in Table A-3. The emission source rate was divided by the area of PDK Airport (2,105,268.9 m^2) in our model to calculate the area source emission rate (Table 4).

Table 4. Annual PDK Area Source Emission Rates ($g/(s \cdot m^2)$)

	2011	2010	2009	2008	2007	2006
PDK	2.77E-07	2.87E-07	2.71E-07	3.33E-07	3.94E-07	3.71E-07

The NO_2 emission factor for passenger cars is 1.39 g of NO_2/mi (US EPA 2000). The 2011 IMR was not yet released at the time of data analysis. Therefore, the calculations for 2010 were also used for 2011. The daily VMT used to calculate the area sources are listed in Table A-4. I-85 releases about 834,201,600 g of NO_2 each year or about 26.5 g NO_2 each second. I-285 releases on average 1,054,468,168 g of NO_2 each year or about 33.4 g NO_2 per second. The area of each modeled segment of I-85 was 396,000 m^2. I-285 was modeled as 384,000 m^2 for the first segment and 448,000 m^2 for the second and third segment. The total area of I-85 in the model is 792,000 m^2 and the total area of I-285 is 1,280,000 m^2. The annual NO_2 area emission source rates were calculated for each segment of the modeled highways (Table 5).

Table 5. Annual Highway Area Source Emission Rates ($g/(s \cdot m^2)$)

	2011	2010	2009	2008	2007	2006
I-85V1	3.23E-05	3.23E-05	3.28E-05	3.33E-05	3.47E-05	3.39E-05
I-85V2	3.23E-05	3.23E-05	3.28E-05	3.33E-05	3.47E-05	3.39E-05
I-285V1	2.52E-05	2.52E-05	2.59E-05	2.61E-05	2.67E-05	2.68E-05
I-285V2	2.52E-05	2.52E-05	2.59E-05	2.61E-05	2.67E-05	2.68E-05
I-285V3	2.52E-05	2.52E-05	2.59E-05	2.61E-05	2.67E-05	2.68E-05

The calculated area sources for PDK, I-85 and I-285 were inserted into the model. PDK and the highways were individually modeled and then combined into a single model. Average NO_2 concentration values ($\mu g/m^3$) were calculated for at each receptor for Winter, Summer, Spring, Fall and Winter2 for the 2006- 2011 years. Annual tables were constructed by averaging the NO_2 concentration values of Winter, Summer, Spring and Fall. Winter2 was excluded because the time period was only about 8 days compared to the other seasons which were about 80 days. The receptors with the top ten highest NO_2 concentration values were then identified for each year (Table 4).

Table 6. 2006- 2011 Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border. Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	2	3	5	5	6	7	10	294	13	9	7	6	6	6	8
6	3	4	7	10	8	8	11	297	15	11	9	8	8	10	25
5	3	4	7	33	17	11	11	18	45	16	12	10	11	20	19
4	3	4	5	9	22	23	14	14	18	70	19	15	19	25	11
3	3	4	5	6	10	19	32	18	17	21	430	27	39	15	9
2	3	4	5	6	8	15	25	59	29	26	32	167	25	13	9
1	3	3	4	6	8	12	20	29	525	33	84	30	21	12	8
0	2	3	3	4	5	6	8	11	17	45	20	14	11	8	7
-1	2	2	2	3	3	4	4	5	6	8	9	8	7	6	5
-2	1	2	2	2	2	2	3	4	4	5	5	5	5	4	4
-3	1	1	1	1	2	2	2	3	3	4	4	4	3	3	3
-4	1	1	1	1	1	2	2	2	2	3	3	3	3	3	2
-5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
-7	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1

With the exception of Year 2006, all years exhibited the same distribution of top ten highest NO_2 concentration values as Table 4. Year 2006 had the top ten highest NO_2

concentration values at (0 km, 7 km); (0 km, 6 km); (1 km, 1 km); (1 km, 5 km); (2 km, 0 km); (3 km, 3 km); (2 km, 4 km) (3 km, 1 km); (4 km, 2 km); and (5 km, 3 km). The only difference between Year 2006 and Years 2007- 2011 was that NO_2 concentration was slightly higher at the (5 km, 3 km) receptor pushing (0 km, 2 km) receptor out of the top ten. Examining seasonality differences of NO_2 concentrations within each year, the receptors with the top 10 highest NO_2 concentration values were often in the same location each year with an occasional difference of one receptor between seasons (Tables A-5 to A-29). All of the ten highest NO_2 concentration values are in the North-East quadrant of the receptor grid network, except in the Fall of 2009 and 2011. Fall 2009 and Fall 2011 both have a top ten recording of 39.8 µg/m^3 at the (-4 km, 5 km) receptor.

The annual average NO_2 concentration values from modeling only PDK as an area source was divided by the annual average NO_2 concentration values from the model with PDK and Highways. The resulting percent was the percent of NO_2 emissions attributed to PDK Airport. The receptors with the highest 10% NO_2 concentration values were identified in each model from 2006- 2011 (Tables 7 to 12).

Table 7. 2006 Attributable Percent Contribution of PDK to NO_2 Concentrations

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10% highest attributable percentage values.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	1%	1%	1%	1%	1%	1%	1%	0%	0%	1%	1%	1%	0%	0%	0%
6	1%	1%	1%	0%	1%	1%	1%	0%	0%	1%	1%	1%	0%	0%	0%
5	1%	1%	1%	0%	0%	1%	1%	1%	0%	1%	1%	1%	0%	0%	0%
4	1%	1%	1%	1%	0%	1%	1%	1%	1%	0%	1%	1%	0%	0%	0%
3	1%	1%	1%	1%	1%	1%	1%	2%	2%	1%	0%	1%	0%	1%	1%
2	2%	2%	2%	2%	2%	1%	2%	3%	6%	2%	1%	0%	0%	1%	1%
1	2%	2%	2%	2%	2%	2%	2%	11%	1%	2%	0%	1%	1%	1%	1%
0	2%	2%	2%	2%	2%	3%	3%	12%	18%	1%	1%	1%	1%	1%	1%
-1	2%	2%	2%	2%	2%	2%	3%	5%	5%	3%	2%	2%	2%	2%	1%
-2	2%	2%	2%	1%	2%	2%	4%	3%	3%	3%	2%	2%	2%	2%	2%
-3	2%	1%	1%	1%	2%	3%	3%	3%	3%	2%	2%	2%	2%	2%	2%
-4	1%	1%	1%	2%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%
-5	1%	1%	2%	2%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%
-6	1%	2%	2%	2%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%
-7	2%	2%	2%	3%	2%	1%	2%	2%	2%	2%	2%	2%	2%	2%	1%

Table 8. 2007 Attributable Percent Contribution of PDK to NO_2 Concentrations

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10% highest attributable percentage values.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	1%	1%	1%	1%	2%	1%	1%	0%	0%	1%	1%	1%	1%	1%	0%
6	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%	1%	0%	0%
5	1%	1%	0%	0%	0%	1%	1%	1%	0%	1%	1%	1%	1%	0%	0%
4	1%	1%	1%	0%	0%	1%	2%	2%	1%	0%	1%	1%	0%	0%	1%
3	1%	1%	1%	1%	1%	1%	1%	3%	2%	1%	0%	1%	0%	1%	1%
2	2%	2%	2%	2%	2%	1%	2%	4%	7%	2%	1%	0%	1%	1%	1%
1	2%	2%	2%	2%	3%	3%	3%	12%	1%	2%	0%	1%	1%	1%	1%
0	2%	2%	3%	3%	3%	3%	4%	14%	17%	1%	2%	1%	1%	1%	1%
-1	2%	3%	3%	2%	2%	2%	3%	7%	6%	3%	3%	2%	2%	2%	1%
-2	2%	2%	2%	1%	2%	2%	4%	6%	5%	2%	3%	2%	2%	2%	2%
-3	2%	1%	1%	2%	2%	2%	4%	4%	4%	2%	2%	2%	2%	2%	2%
-4	1%	1%	2%	2%	2%	3%	4%	4%	4%	2%	2%	2%	2%	2%	2%
-5	1%	2%	2%	2%	2%	3%	4%	3%	4%	2%	1%	2%	2%	2%	2%
-6	2%	2%	2%	2%	2%	3%	4%	3%	4%	2%	1%	2%	2%	2%	2%
-7	2%	1%	2%	2%	2%	3%	4%	2%	3%	3%	1%	1%	2%	2%	2%

Table 9. 2008 Attributable Percent Contribution of PDK to NO_2 Concentrations

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10% highest attributable percentage values.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	1%	1%	0%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
5	1%	1%	1%	0%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%
4	1%	1%	1%	1%	0%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
3	1%	1%	1%	1%	1%	1%	1%	2%	2%	1%	0%	0%	0%	0%	1%
2	2%	2%	2%	1%	2%	1%	2%	3%	5%	2%	1%	0%	0%	1%	1%
1	2%	2%	2%	2%	2%	2%	3%	10%	1%	2%	0%	1%	1%	1%	1%
0	2%	3%	3%	3%	3%	4%	4%	13%	17%	2%	2%	2%	1%	1%	1%
-1	3%	3%	3%	3%	2%	2%	2%	5%	5%	4%	3%	2%	2%	2%	1%
-2	2%	2%	2%	2%	1%	1%	3%	4%	3%	3%	3%	2%	2%	2%	2%
-3	2%	2%	2%	1%	1%	2%	4%	3%	3%	2%	3%	2%	2%	2%	2%
-4	2%	1%	1%	1%	1%	3%	3%	3%	2%	2%	2%	2%	2%	2%	2%
-5	1%	1%	1%	1%	2%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%
-6	1%	1%	1%	1%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%
-7	1%	1%	1%	2%	3%	2%	2%	2%	2%	2%	1%	2%	2%	2%	2%

Table 10. 2009 Attributable Percent Contribution of PDK to NO_2 Concentrations

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10% highest attributable percentage values.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
5	1%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
4	1%	1%	1%	1%	0%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
3	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	0%	0%	0%	0%	1%
2	1%	1%	1%	1%	1%	1%	1%	2%	5%	1%	1%	0%	0%	0%	1%
1	2%	2%	2%	2%	2%	2%	2%	9%	1%	2%	0%	0%	0%	1%	1%
0	2%	2%	2%	2%	3%	3%	3%	10%	14%	1%	1%	1%	1%	1%	1%
-1	2%	2%	2%	2%	2%	2%	2%	4%	5%	4%	2%	2%	1%	1%	1%
-2	2%	2%	2%	1%	1%	1%	2%	4%	3%	3%	3%	2%	2%	1%	1%
-3	1%	1%	1%	1%	1%	2%	2%	4%	2%	2%	2%	2%	2%	2%	1%
-4	1%	1%	1%	1%	1%	1%	2%	3%	2%	2%	2%	2%	2%	2%	2%
-5	1%	1%	1%	1%	1%	1%	2%	3%	2%	2%	2%	2%	2%	2%	2%
-6	1%	1%	1%	1%	1%	1%	2%	3%	2%	1%	2%	2%	2%	2%	2%
-7	1%	1%	1%	1%	1%	1%	2%	3%	2%	1%	2%	2%	1%	1%	2%

Table 11. 2010 Attributable Percent Contribution of PDK to NO_2 Concentrations

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10% highest attributable percentage values.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	1%	1%	1%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
5	1%	1%	1%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
4	1%	1%	1%	1%	0%	0%	1%	1%	1%	0%	0%	0%	0%	0%	0%
3	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	0%	0%	0%	0%	0%
2	1%	1%	1%	1%	1%	1%	1%	2%	5%	2%	1%	0%	0%	0%	1%
1	2%	2%	2%	2%	2%	2%	2%	8%	1%	2%	0%	1%	1%	1%	1%
0	2%	2%	2%	2%	3%	2%	3%	11%	18%	2%	1%	1%	1%	1%	1%
-1	2%	2%	2%	2%	2%	1%	2%	5%	5%	4%	2%	2%	2%	1%	1%
-2	2%	2%	1%	1%	1%	2%	3%	4%	3%	3%	2%	2%	2%	2%	1%
-3	1%	1%	1%	1%	2%	2%	3%	3%	2%	2%	2%	2%	2%	2%	1%
-4	1%	1%	1%	1%	1%	2%	3%	3%	2%	2%	2%	2%	2%	1%	2%
-5	1%	1%	1%	1%	1%	2%	3%	2%	2%	2%	2%	2%	2%	2%	1%
-6	2%	1%	1%	1%	2%	2%	3%	2%	1%	2%	2%	2%	2%	2%	2%
-7	1%	1%	1%	1%	2%	2%	3%	1%	1%	2%	2%	2%	2%	2%	2%

Table 12. 2011 Attributable Percent Contribution of PDK to NO_2 Concentrations

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10% highest attributable percentage values.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	1%	1%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	1%	1%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
5	1%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	1%	0%	0%	0%
4	1%	1%	1%	0%	0%	0%	1%	1%	0%	0%	0%	1%	0%	0%	0%
3	1%	1%	1%	1%	1%	0%	1%	2%	1%	1%	0%	0%	0%	0%	1%
2	1%	1%	1%	1%	1%	1%	1%	2%	5%	2%	1%	0%	0%	1%	1%
1	2%	2%	2%	2%	2%	2%	2%	8%	1%	2%	0%	1%	1%	1%	1%
0	2%	2%	2%	3%	3%	3%	4%	11%	14%	1%	1%	1%	1%	1%	1%
-1	2%	3%	3%	2%	2%	2%	2%	4%	5%	3%	2%	2%	1%	1%	1%
-2	2%	2%	2%	2%	1%	2%	2%	3%	3%	3%	2%	2%	1%	1%	1%
-3	2%	1%	1%	1%	1%	2%	3%	2%	2%	3%	2%	2%	1%	1%	1%
-4	1%	1%	1%	1%	2%	2%	3%	2%	2%	2%	2%	2%	1%	1%	1%
-5	1%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%
-6	1%	1%	1%	2%	1%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%
-7	1%	1%	2%	1%	2%	2%	2%	1%	1%	1%	2%	2%	2%	2%	1%

The top 10% highest NO_2 concentration localities were not consistent from year to year. Generally, the highest values occurred in the South-Western quadrant of the receptor network grid. The range of the top 10% NO_2 concentration values for all six years was 2% to 18% of the NO_2 emissions recorded at the receptor. The highest values for each year's model was located at the (1 km, 0 km) receptor.

IV. Discussion

The goal of this study was to analyze the effects of PDK on the air quality of surrounding residential neighborhoods using a steady-state plume model. A 15 km x 15 km receptor network grid was modeled to analyze the impact of PDK Airport and Highways I-85 and I-285 on the surrounding residential community.

This study provides a preliminary model for monitoring and evaluating the effects of PDK on air quality. A primary motivation for this study was to determine where real time active air monitors should be placed to assess the greatest impact on air quality. The aims of this study were to:

- Model and analyze the impact of air contaminant exposure experienced by residential neighborhoods around PDK Airport.
- Project the impact of the airport and surrounding highways on the local community using already existing data on temperature, air pressure, wind speed, wind direction and other meteorological parameters.
- Aid in the data collection, monitoring and evaluation of air pollutants and the impact of these exposures on the surrounding community.

Through analysis of the first aim, we can assess where the highest concentration values of NO_2 are in the residential neighborhoods around PDK airport. We can also analyze what are the factors that are contributing to the NO_2 emissions and estimate the expected concentration values of NO_2 in the residential neighborhoods around PDK airport. The second aim serves to further examine the contributing sources of NO_2 emissions in the model. We compare the impact of the airport versus the impact of the highway on the surrounding residential neighborhoods and where the impact of PDK is greatest. Lastly, the third aim serves examine the impact of air pollution from aviation-related sources on the residential community and advise strategic placement of air monitors in the field.

Aim 1: Model and analyze the impact of air contaminant exposure experienced by residential neighborhoods around PDK Airport

The highest NO_2 concentrations were in the neighborhood between PDK and I-85 and I-285. This neighborhood is surrounded by pollution sources with PDK to the West, I-85 to the East and I-285 to the North. Several of the highest values were in violation from the model were in violation of the National Ambient Air Quality Standards (NAAQS) set forth by the EPA. The standard for NO_2 is set at 53 ppb or about 100 $\mu g/m^3$ over an averaging time period of one year (US EPA 2011). The highest value of 525 $\mu g/m^3$ is not considered a valid measurement because it is located within the airport area and AERMOD cannot accurately model concentration values of receptors located in area sources. It was thought that some of the other concentration values were artificially inflated due to an error in the model. Since the highways were modeled as long and narrow area sources, AERMOD warns that when an aspect ratio (L/W) of an area source is greater than 100 then the input parameter may be out-of-range or invalid in the model. Therefore, we split I85V1 into 21 segments that were within aspect ratio of 100 (44 m x 440 m) and ran the model. The high concentration values still existed after running this modified model. We also re-oriented the heading direction of the highways, but this resulted in the high concentration values changing receptor locations. The locations of the highest concentrations in our model are at areas known to be sources of high pollution. For example, the 330 $\mu g/m^3$ NO_2 at the (3 km,3 km) receptor and the 167 $\mu g/m^3$ at the (4 km,2 km) receptor are both located near “Spaghetti Junction,” a high traffic volume area where I-85 and I-285 intersect. The (0 km,7 km) and (0 km,6 km) receptors are located near I-285. The lowest NO_2 concentrations were found in the southwest corner of the receptor grid, furthest from the highways

The magnitude of the highway area source NO_2 emission rates are 2 magnitudes higher than the PDK area source NO_2 emission rates. Our calculations did not include the idling or taxiing steps of the LTO cycle because the runways at PDK were deemed too short for long wait periods between landing and arrival. Beech 99A Airliner, a turboprop twin engine aircraft, was used in our model because it is indicative of the smaller aircrafts seen at PDK Airport. However, newer models are likely to have more efficient engines that do not emit as many air pollutants as the Beech 99A.

The highway source emission rates are modeled after only passenger car emission rates and do not take into account the rates of diesel engines or trucks. Therefore, the calculation is conservative of the values likely to be seen in reality.

Aim 2: Project the impact of the airport and surrounding highways on the local community using already existing data on temperature, air pressure, wind speed, wind direction and other meteorological parameters.

The PDK area source NO_2 emission rate was divided by the area source emission rates from the combined PDK and highway model to calculate a percent contribution of aviation-related NO_2 emissions. The contributable percentage varied greatly from 2% to 18%. However, several of the highest contributable percentages were located within the PDK perimeter and are not valid assumptions. The highest concentration values were found south and southwest of the receptor network grid. These areas are typically furthest from the highways; however the contribution by PDK is still low. PDK contributes up to 7% in these areas. One possibility is that I-85 is modeled through the south and southeast area and could be contributing to the air pollution in the southern region of the network grid and thus pushing down the attributable percent contribution of NO_2 by PDK. The localities of the receptors for the top 10% highest NO_2 concentrations were also inconsistent from year to year. We hypothesize that one contributing factor could be the varying source emission rates from PDK each year. The annual operations per year from have ranged from 220,576 operations to 155,189 operations in 2006- 2011. This increases the variability between source NO_2 concentrations each year and may also change the distribution pattern of the highest NO_2 concentrations. However, the overall concentration of 6.4 $\mu g/m^3$ places the NO_2 concentrations in these areas well below the NAAQS. Therefore, while the contribution of NO_2 emissions by PDK Airport may be meaningful, they are unlikely to pose a significant health risk to the community.

Aim 3. Aid in the data collection, monitoring and evaluation of air pollutants and the impact of these exposures on the surrounding community.

In the third aim, we examine the effectiveness of the model in aiding future data collection and strategic placement of air monitors in the community around PDK.The preliminary modeling from AERMOD has helped answer the research questions about the impact of the highway and PDK airport on the air quality of surrounding residential neighborhoods. The model has identified areas affected most by poor air quality from these sources. Specifically, the neighborhood that is surrounded by PDK, I-85 and I-285 has the highest concentration of NO_2 values. Although the evidence does not suggest that NO_2 emissions from PDK alone violate the EPA's NAAQS, it does show that there are neighborhoods in danger of suffering from poor air quality due to area sources.

V. Conclusion

The results of the study increase our understanding of how air pollution from PDK Airport, I-85 and I-285 is distributed around the surrounding residential communities. The study shows that residents east of the airport and west of Spaghetti Junction receive the highest concentrations of NO_2 from area sources. However, residents south and southwest of the airport are impacted the greatest by PDK-related air pollution. However, the NO_2 concentration values in these neighborhoods are below the standards for concerns on health effects. The model suggests that several locations nearby I-85 and I-285 could experience concentrations of NO_2 that may pose health concerns to residential neighborhoods.

The results of this study provide opportunities for future studies. Future models could build off the model in this study and include terrain data and elevated terrain effects on receptors through another preprocessor program called AERMAP (citation). Monitoring of these sites should also be conducted to measure real concentrations of NO_2 for further evidence on whether air pollution from the highways and PDK are posing health concerns in neighborhoods. Future modeling could also take into account health effects of noise along with air quality to determine the quality of health in residential neighborhoods around PDK. This study demonstrates how modeling can be an effective tool for preliminary research on field data collection and analysis and can promote the efficient use of study resources.

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VII. Appendix

Table A-1. Monthly Climatic Wind Data for Atlanta, GA (NCDC 1999)
Cardinal Directions: North (N), South (S), East (E) and West (W)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Direction	NW	NW	NW	WNW	NW	W	W	E	E	E	NW	NW
Speed (mph)	10	11	11	10	9	8	8	7	8	9	9	10

Table A-2. Days of Year 2006- 2011 Categorized into Seasons

	2006	2007	2008	2009	2010	2011
Winter	1-79	1-80	1-80	1-79	1-79	1-79
Spring	80-171	81-171	81-171	80-171	80-171	80-171
Summer	172-266	172-266	172-266	172-265	172-266	172-266
Fall	267-356	267-356	267-356	266-355	267-355	267-356
Winter2	357-365	357-365	357-366	356-365	356-365	357-365

Table A-3. Annual Operations from 2006- 2011 at PDK Airport

Year	Annual Operations
2006	207,981
2007	220,576
2008	187,006
2009	151,714
2010	160,948
2011	155,189

Table A-4. Daily Vehicle Miles Traveled (mi/day) in Thousands (000's)

	2010	2009	2008	2007	2006
I-85	9,401	9,556	9,686	10,096	9,862
I-285	10,099	10,373	10,461	10,696	10,768

Table A-5. 2011 Winter Average Concentration of NO$_2$ (µg/m^3) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	3	3	3	4	5	8	272	11	7	6	5	5	5	6
6	3	4	4	7	6	7	9	272	13	9	8	7	7	9	21
5	4	5	8	29	14	9	9	14	37	13	10	10	10	17	19
4	4	5	6	8	20	19	11	11	16	60	16	14	17	25	12
3	4	4	5	7	9	17	26	14	15	19	385	24	38	15	9
2	4	4	5	6	9	13	21	49	24	23	27	154	25	12	8
1	3	4	4	6	8	11	19	26	464	31	71	26	20	13	9
0	3	3	4	4	5	5	7	10	14	42	19	12	10	8	7
-1	2	2	2	2	3	3	3	3	4	6	7	7	6	5	5
-2	1	1	1	1	1	1	2	2	3	3	4	4	5	4	3
-3	1	1	1	1	1	1	2	1	2	2	3	3	3	3	3
-4	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
-5	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2
-6	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1
-7	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1

Table A-7. 2011 Spring Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	2	4	5	5	6	9	269	12	8	7	6	5	6	7
6	2	2	5	10	8	7	9	272	15	10	8	7	7	9	23
5	2	3	5	25	16	10	10	16	43	16	11	10	10	18	17
4	2	3	4	6	17	21	13	13	16	67	19	14	17	23	10
3	2	2	3	4	7	15	29	17	15	19	377	24	35	13	8
2	2	2	3	4	5	12	22	54	27	25	30	140	22	11	7
1	2	3	3	4	7	10	16	22	442	26	72	23	15	8	6
0	2	2	3	3	4	5	7	10	13	34	14	10	8	5	4
-1	2	2	2	2	3	3	4	4	5	6	6	5	5	4	3
-2	1	1	1	2	2	2	2	3	4	4	4	4	3	3	2
-3	1	1	1	1	1	2	2	3	3	3	3	3	2	2	2
-4	0	1	1	1	1	1	2	2	2	2	2	3	2	2	2
-5	0	0	1	1	1	1	1	2	2	2	2	2	2	2	1
-6	0	1	1	1	1	1	1	1	2	2	2	2	2	2	1
-7	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-8. 2011 Summer Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	2	3	4	4	5	6	8	313	13	9	7	6	6	6	8
6	3	3	7	9	8	8	9	315	16	11	9	8	8	10	23
5	3	4	6	30	17	11	10	15	45	17	12	10	11	18	21
4	3	4	5	8	20	22	14	13	18	71	20	15	18	27	12
3	3	4	4	6	9	17	31	17	16	21	428	27	42	16	10
2	3	3	4	6	8	14	23	58	29	26	31	168	28	14	9
1	3	3	4	5	7	11	18	27	511	33	76	31	22	13	9
0	2	2	3	3	4	5	7	10	15	40	21	15	12	9	7
-1	1	1	2	2	2	3	4	5	6	7	8	8	8	7	6
-2	1	1	1	1	2	2	2	3	4	5	5	5	5	4	4
-3	1	1	1	1	1	1	2	2	3	3	4	4	4	3	3
-4	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3
-5	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
-6	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2
-7	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2

Table A-9. 2011 Fall Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	3	4	5	5	6	8	11	250	11	7	6	5	5	5	6
6	3	4	10	8	8	8	12	253	13	9	7	7	7	9	26
5	4	6	10	40	14	11	12	18	36	13	10	9	10	20	15
4	4	5	8	11	27	20	13	13	20	59	16	13	18	20	9
3	4	5	6	8	12	23	27	16	16	22	409	24	32	11	8
2	5	6	7	8	10	17	26	49	25	25	32	169	20	11	7
1	5	6	7	9	13	17	26	35	501	35	91	28	20	10	7
0	4	5	6	6	7	9	11	15	20	57	19	13	11	8	6
-1	3	4	4	4	4	5	5	6	6	9	8	8	8	6	5
-2	2	3	3	3	3	3	3	3	5	5	5	5	6	5	4
-3	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4
-4	1	1	1	1	1	1	2	2	2	2	3	3	3	3	3
-5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
-7	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2

Table A-10. 2010 Winter Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	1	2	2	2	3	3	5	253	10	6	5	4	4	4	4
6	1	2	4	5	4	4	5	256	11	7	6	5	5	5	12
5	1	2	3	18	10	6	6	7	33	10	7	6	6	10	16
4	1	2	2	4	12	15	8	6	9	55	12	9	10	21	10
3	1	1	2	3	4	10	23	10	9	11	364	17	32	13	9
2	1	1	2	2	3	7	12	41	17	14	17	126	22	12	8
1	1	1	2	2	3	5	13	19	441	26	47	26	24	14	9
0	1	1	2	2	2	3	4	6	11	31	20	13	11	10	8
-1	1	1	1	1	1	2	2	2	3	5	8	9	8	7	7
-2	1	1	1	1	1	1	1	1	2	3	4	5	5	6	5
-3	1	1	0	0	1	1	1	1	1	2	2	3	3	4	4
-4	0	0	0	0	1	1	1	1	1	1	1	2	2	3	3
-5	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2
-6	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
-7	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1

Table A-11. 2010 Spring Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	1	2	4	4	4	5	8	273	11	8	6	6	5	6	7
6	1	1	4	9	6	6	7	276	14	9	8	7	7	8	20
5	1	2	3	18	15	9	8	11	44	15	10	9	9	15	16
4	1	1	2	4	12	21	12	10	13	69	17	12	15	21	9
3	1	1	2	3	5	11	30	15	13	15	381	22	34	12	8
2	1	1	2	3	3	9	17	54	24	21	24	122	23	12	8
1	1	2	2	3	3	6	12	18	446	25	64	23	16	11	7
0	1	1	2	2	2	3	5	6	10	25	17	12	9	7	6
-1	1	1	1	1	2	2	3	3	4	6	6	6	5	5	4
-2	1	1	1	1	1	2	2	3	3	4	4	3	3	3	3
-3	0	1	1	1	1	2	2	2	2	3	3	2	2	2	2
-4	0	0	1	1	1	2	2	2	2	2	2	2	2	2	1
-5	0	0	1	1	1	1	1	1	1	2	2	2	1	1	1
-6	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
-7	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-12. 2010 Summer Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	3	3	7	7	8	9	14	319	14	10	8	7	7	7	9
6	3	4	6	13	10	11	14	321	18	13	10	9	10	12	31
5	4	6	9	42	20	14	15	27	50	19	14	13	14	24	20
4	4	5	7	12	29	26	18	19	24	76	22	17	23	27	11
3	4	4	6	8	12	26	36	23	22	26	459	31	42	14	9
2	4	5	6	8	10	19	33	65	35	32	40	197	25	12	8
1	4	5	7	8	11	17	25	35	543	35	102	31	20	9	7
0	3	3	4	5	6	9	11	15	21	57	20	14	10	7	4
-1	2	3	3	3	4	5	6	7	9	11	11	8	6	5	4
-2	2	2	2	2	3	4	4	6	6	7	7	6	4	3	3
-3	1	1	2	2	2	3	4	4	5	5	6	5	4	3	2
-4	1	1	1	2	2	3	3	3	4	4	4	4	4	3	2
-5	1	1	1	2	2	2	2	3	4	3	3	3	3	3	2
-6	1	1	1	2	2	2	2	3	3	3	3	3	2	2	2
-7	1	1	1	2	2	2	2	2	3	2	2	2	2	2	2

Table A-13. 2010 Fall Average Concentration of NO_2 (μg/m^3) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	1	2	4	4	4	4	8	307	12	8	6	5	5	5	6
6	1	2	3	7	5	5	7	310	14	9	7	6	6	7	16
5	1	2	4	26	14	8	8	11	42	14	9	8	8	13	19
4	1	2	3	6	18	20	12	10	15	68	16	11	13	26	11
3	1	2	2	4	7	16	29	14	13	17	423	20	40	14	9
2	1	2	2	3	5	10	18	51	21	20	24	162	24	13	9
1	1	2	3	4	6	10	20	28	510	34	68	37	28	16	10
0	2	2	3	3	4	5	7	11	17	44	28	19	15	12	10
-1	1	2	2	2	3	3	4	6	8	11	12	11	10	8	7
-2	1	1	1	1	2	2	3	5	5	6	7	7	8	6	5
-3	1	1	1	1	2	2	3	3	4	5	5	5	5	5	4
-4	1	1	1	1	2	2	2	2	3	3	4	4	4	4	4
-5	1	1	1	1	2	1	2	2	3	3	3	3	3	3	3
-6	1	1	1	1	1	1	2	2	2	2	2	2	2	3	3
-7	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2

Table A-14. 2009 Winter Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	2	3	3	3	4	5	8	272	11	7	6	5	5	5	6
6	3	4	4	7	6	7	9	272	13	9	8	7	7	9	21
5	4	5	8	29	14	10	10	14	37	13	10	10	10	17	19
4	4	5	6	8	20	19	12	11	17	60	16	14	17	25	12
3	3	4	5	7	9	17	26	15	15	19	385	24	38	15	9
2	4	4	5	6	9	13	22	50	25	23	27	154	25	12	8
1	3	4	4	6	8	11	18	27	464	31	71	26	20	13	9
0	3	3	4	4	4	5	7	9	14	42	19	12	10	8	7
-1	2	2	2	2	3	3	3	3	4	6	7	7	6	5	5
-2	1	1	1	1	1	1	2	2	3	3	4	4	5	4	3
-3	1	1	1	1	1	1	2	2	2	2	3	3	3	3	3
-4	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2
-5	0	1	1	1	1	1	1	1	1	1	2	2	2	2	2
-6	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1
-7	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1

Table A-15. 2009 Spring Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	2	4	5	5	6	9	269	12	8	7	6	5	6	7
6	2	2	6	10	8	7	9	272	15	10	8	7	7	9	23
5	2	3	5	25	16	10	10	16	43	16	11	10	10	18	17
4	2	3	4	6	17	21	13	13	16	67	18	14	17	22	10
3	2	2	3	4	7	15	29	17	15	19	377	24	35	13	8
2	2	2	3	4	5	12	22	55	27	25	30	140	22	11	7
1	2	3	3	5	7	10	16	22	442	27	72	23	15	8	6
0	2	2	3	3	4	5	7	9	13	34	14	10	8	5	4
-1	2	2	2	2	3	3	4	4	5	6	6	5	5	4	3
-2	1	1	1	2	2	2	2	3	4	4	4	4	3	3	2
-3	1	1	1	1	1	2	2	2	3	3	3	3	2	3	2
-4	0	1	1	1	1	1	2	2	2	2	2	3	2	2	2
-5	0	0	1	1	1	1	1	2	2	2	2	2	2	2	1
-6	0	1	1	1	1	1	1	1	2	2	2	2	2	2	1
-7	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-16. 2009 Summer Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	3	4	4	5	6	8	313	13	9	7	6	6	6	8
6	3	3	7	9	8	8	9	315	16	11	9	8	8	10	23
5	3	4	6	30	17	11	10	15	45	17	12	10	11	18	21
4	3	4	5	8	20	22	14	13	18	71	20	15	18	27	12
3	3	4	4	6	9	17	31	17	16	20	428	27	42	16	10
2	3	3	4	6	8	14	23	58	29	26	31	168	28	14	9
1	3	3	4	5	7	11	18	27	511	33	76	31	22	13	9
0	2	2	3	3	4	5	7	10	15	40	21	15	12	9	7
-1	1	1	2	2	2	3	4	5	6	7	8	8	8	7	6
-2	1	1	1	1	2	2	2	3	4	5	5	5	5	4	4
-3	1	1	1	1	1	2	2	2	3	3	4	4	4	3	3
-4	1	1	1	1	1	1	1	2	2	3	3	3	3	3	3
-5	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
-6	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2
-7	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2

Table A-17. 2009 Fall Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	3	4	5	5	6	8	10	250	11	7	6	5	5	5	6
6	3	4	10	8	8	8	12	253	13	9	7	7	7	9	26
5	4	6	10	40	14	11	12	18	36	13	10	9	10	20	15
4	4	5	8	11	27	20	13	13	20	59	16	13	18	20	9
3	4	5	6	8	12	23	27	16	16	22	409	24	32	11	8
2	5	6	7	8	10	17	26	49	25	25	32	169	20	11	7
1	5	6	7	9	13	17	26	35	501	35	91	28	20	10	7
0	4	5	6	6	7	8	11	15	21	57	20	13	11	8	6
-1	3	4	4	4	4	5	5	6	6	9	9	8	8	6	5
-2	2	3	3	3	3	3	3	3	5	5	5	5	6	5	4
-3	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4
-4	1	1	1	1	1	1	2	2	2	2	3	3	3	3	3
-5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
-7	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2

Table A-18. 2008 Winter Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	4	5	6	6	7	9	12	315	15	10	8	7	7	7	9
6	3	4	13	11	9	9	12	320	18	13	10	9	9	12	27
5	3	4	7	31	20	13	12	19	55	19	14	12	13	22	20
4	3	3	5	8	21	27	16	16	19	87	22	17	21	27	12
3	3	3	4	6	9	19	39	21	18	21	501	31	41	16	11
2	2	3	3	5	7	15	25	71	33	29	35	164	30	16	12
1	2	3	3	5	7	10	18	28	583	36	87	32	25	15	10
0	2	3	3	3	4	5	6	10	15	38	22	15	12	10	8
-1	2	2	2	2	2	2	3	4	5	7	9	8	7	7	6
-2	1	1	1	1	1	2	2	3	3	4	5	5	5	5	4
-3	1	1	1	1	1	1	1	2	3	3	3	3	4	4	3
-4	0	1	1	1	1	1	1	2	2	2	2	2	3	3	3
-5	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2
-6	0	0	1	1	1	1	1	1	1	2	1	1	1	2	2
-7	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1

Table A-19. 2008 Spring Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	3	4	5	6	7	8	11	308	14	10	8	7	7	7	9
6	3	4	11	12	10	9	12	308	18	12	10	9	9	11	27
5	3	4	6	30	18	12	12	19	50	18	13	12	12	20	18
4	2	3	4	8	21	24	15	15	19	77	21	16	19	24	11
3	2	3	3	5	9	19	34	20	18	21	446	29	38	14	9
2	3	3	4	5	7	16	26	65	33	30	35	161	25	13	8
1	1	2	2	4	5	8	15	24	517	30	82	26	19	10	6
0	1	2	2	2	3	4	6	9	14	34	17	12	9	7	5
-1	1	1	1	2	2	2	3	4	5	8	8	7	6	5	4
-2	1	1	1	1	2	2	2	3	4	5	5	5	4	4	3
-3	1	1	1	1	1	1	2	2	3	4	4	3	3	3	3
-4	1	1	1	1	1	1	2	2	3	3	3	3	3	2	2
-5	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
-6	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2
-7	0	0	1	1	1	1	1	1	2	2	2	2	1	1	1

Table A-20. 2008 Summer Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	3	3	5	6	6	7	12	306	13	9	7	6	6	6	8
6	3	4	7	10	9	9	12	311	17	11	9	8	8	11	28
5	4	5	8	40	19	13	13	22	49	17	12	11	12	22	20
4	4	5	7	10	28	25	16	16	21	75	20	16	21	27	12
3	4	4	6	8	11	24	35	20	18	24	467	28	42	16	11
2	4	5	6	8	10	17	28	61	30	28	35	193	27	15	10
1	4	5	6	8	10	16	25	36	551	39	97	37	26	15	11
0	3	3	4	5	6	8	11	15	21	58	24	17	14	10	7
-1	2	2	3	3	4	5	6	7	9	10	11	8	8	8	6
-2	2	2	2	2	3	3	4	5	5	6	7	6	5	5	5
-3	1	1	2	2	2	3	3	3	4	5	5	5	4	4	3
-4	1	1	1	2	2	2	3	3	3	3	4	4	3	3	3
-5	1	1	1	1	2	2	2	2	3	3	3	3	3	3	2
-6	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
-7	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2

Table A-21. 2008 Fall Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	4	3	4	5	6	10	273	11	7	6	5	5	5	5
6	3	3	8	7	7	7	10	274	13	9	8	7	7	9	23
5	4	6	9	37	14	10	11	16	38	13	10	9	10	18	18
4	4	5	7	10	25	20	13	13	18	61	16	14	18	25	11
3	5	5	6	8	11	21	28	15	16	21	423	24	38	15	10
2	5	5	7	8	10	15	24	49	25	23	29	177	26	14	10
1	5	5	6	8	11	16	26	35	510	37	85	33	25	15	10
0	4	4	5	6	6	8	10	14	20	56	23	16	12	10	8
-1	3	3	3	4	4	5	5	5	7	9	9	8	8	8	6
-2	2	2	2	2	3	3	3	3	4	5	5	5	5	5	5
-3	2	2	2	2	2	2	3	2	3	3	4	4	3	4	4
-4	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3
-5	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	1	2	2	1	1	1	2	2	2	2
-7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-22. 2007 Winter Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	2	2	4	4	4	5	8	288	12	8	6	5	5	5	6
6	2	3	4	8	7	7	8	291	14	10	8	7	7	7	18
5	2	2	4	24	15	9	9	13	41	14	10	8	9	14	18
4	2	2	3	6	17	20	12	11	14	65	17	12	14	24	11
3	2	2	3	4	6	15	29	15	13	16	404	22	37	14	9
2	1	2	2	4	5	11	20	53	25	21	25	147	24	13	9
1	1	1	2	2	3	7	15	23	486	28	62	28	22	12	8
0	1	1	2	2	2	4	5	8	14	34	20	13	11	9	7
-1	1	1	1	1	2	3	3	4	6	8	9	8	7	7	6
-2	1	1	1	1	1	2	3	3	4	5	5	5	5	5	4
-3	1	1	1	1	1	2	2	2	3	3	3	4	4	3	3
-4	1	1	1	1	1	2	1	2	2	2	3	3	3	3	3
-5	0	1	1	1	1	1	1	1	2	2	2	2	2	2	2
-6	0	1	1	1	1	1	1	1	1	1	2	1	2	2	2
-7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table A-23. 2007 Spring Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	4	5	7	8	9	10	15	263	13	9	8	7	7	8	10
6	5	7	10	14	11	11	15	267	16	12	10	9	9	12	34
5	5	7	11	41	20	14	14	24	46	17	13	12	13	26	13
4	5	6	8	12	29	25	17	18	23	72	20	16	23	18	7
3	5	6	7	9	13	26	36	21	20	25	452	30	29	10	6
2	5	5	7	9	12	22	33	66	34	31	38	164	18	8	5
1	3	3	5	6	8	12	20	31	543	31	104	22	15	7	5
0	2	3	3	4	4	6	8	11	16	43	15	11	8	6	4
-1	2	2	2	2	3	4	4	5	6	8	8	7	5	4	4
-2	1	2	2	2	2	2	3	3	5	5	5	4	4	3	3
-3	1	1	1	1	2	2	2	3	4	3	3	3	3	3	2
-4	1	1	1	1	1	1	2	2	3	3	2	2	2	2	2
-5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	2	1	2	2	2	2	2	2	1	1
-7	0	1	1	1	1	1	1	1	2	1	1	1	1	1	1

Table A-24. 2007 Summer Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	3	6	7	7	8	14	371	17	12	10	9	9	9	11
6	2	3	5	15	12	11	14	374	21	15	12	11	11	14	34
5	3	5	8	38	23	16	16	29	62	23	16	15	16	27	26
4	3	4	6	11	27	31	20	22	25	95	27	21	26	35	16
3	4	4	5	8	12	24	45	27	24	27	525	37	54	20	13
2	3	4	6	8	10	18	33	82	42	37	44	215	35	17	10
1	5	5	6	8	12	18	27	39	629	43	112	38	24	14	9
0	3	4	5	6	7	10	12	18	23	60	26	17	12	9	7
-1	3	3	3	4	5	6	7	8	10	12	12	10	8	7	5
-2	2	2	2	3	3	4	5	7	7	8	7	7	5	5	5
-3	1	1	2	2	3	4	4	5	5	6	6	5	4	3	3
-4	1	1	1	2	3	3	3	4	4	5	4	4	3	2	2
-5	1	1	1	2	3	3	3	4	4	4	4	3	3	2	2
-6	1	1	1	2	2	2	2	3	3	3	3	2	2	2	2
-7	1	1	2	2	2	2	2	3	3	3	3	2	2	1	1

Table A-25. 2007 Fall Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
7	3	3	4	5	6	7	11	280	11	7	6	5	5	5	6
6	4	4	5	9	8	9	12	280	13	9	8	7	8	10	31
5	5	7	11	43	15	11	13	20	37	14	11	10	12	23	17
4	6	7	9	13	29	21	14	15	22	61	17	15	21	24	10
3	5	6	8	10	14	25	29	18	18	24	426	27	37	13	9
2	5	6	7	9	12	17	29	53	29	27	34	186	23	12	8
1	6	7	8	11	15	21	30	42	534	41	103	31	21	12	8
0	5	6	7	8	9	11	13	18	25	65	21	14	11	9	7
-1	4	4	5	5	6	6	7	8	6	8	9	9	7	6	6
-2	3	3	3	4	4	4	4	4	5	5	5	5	6	5	4
-3	2	3	3	2	2	2	2	4	3	4	4	4	4	4	3
-4	2	2	2	2	1	2	2	2	3	3	3	3	3	3	3
-5	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	2	1	2	2	2	2	2	2	2	2
-7	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1

Table A-26. 2006 Winter Average Concentration of NO_2 (μg/m^3) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	3	6	6	6	7	12	331	15	11	8	7	7	7	10
6	1	2	6	13	9	8	10	334	18	13	10	9	9	11	27
5	1	2	4	27	20	12	10	14	53	19	14	12	12	21	20
4	1	2	3	5	18	27	15	13	17	83	21	16	20	27	11
3	1	2	2	3	7	16	38	19	17	20	461	29	42	15	9
2	1	2	2	3	4	13	23	72	31	27	32	157	25	12	8
1	1	2	2	3	4	6	15	23	605	31	83	29	22	11	7
0	1	2	2	2	2	3	6	9	14	36	21	14	12	9	7
-1	1	1	1	1	2	2	3	4	6	9	10	9	8	7	5
-2	1	1	1	1	1	1	2	3	4	5	6	6	7	5	5
-3	1	1	1	1	1	1	1	2	3	4	4	4	4	5	4
-4	0	1	1	1	1	1	1	2	3	3	3	3	3	3	3
-5	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3
-6	0	0	1	1	1	1	1	2	1	2	2	2	2	2	2
-7	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2

Table A-27. 2006 Spring Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	2	4	5	5	6	9	317	14	10	8	7	7	7	9
6	2	2	4	11	9	8	9	320	17	12	10	9	9	10	23
5	2	2	4	26	20	12	11	15	50	18	13	11	12	19	24
4	2	2	3	6	17	26	15	14	16	77	21	16	19	32	15
3	1	2	3	4	7	15	37	19	17	19	419	28	50	19	12
2	1	2	2	3	5	11	22	67	32	28	32	167	32	16	11
1	1	2	2	3	4	8	15	22	549	32	75	31	20	12	8
0	1	1	2	2	3	5	6	9	13	35	20	13	10	8	6
-1	1	1	1	2	2	3	4	5	6	8	8	7	6	5	5
-2	1	1	1	1	2	3	3	4	4	5	5	5	4	3	3
-3	1	1	1	1	2	2	3	3	3	4	4	4	3	3	2
-4	1	1	1	1	1	2	2	2	2	3	3	3	2	2	2
-5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
-6	1	1	1	1	1	1	2	2	2	2	2	2	2	2	1
-7	0	1	1	1	1	1	2	2	2	2	2	2	1	1	1

Table A-28. 2006 Summer Average Concentration of NO_2 ($\mu g/m^3$) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	6	7	9	10	11	13	20	330	17	12	11	10	10	11	15
6	6	9	15	18	14	15	19	338	21	15	13	12	13	17	45
5	6	8	14	55	27	18	19	31	61	22	17	16	18	34	23
4	6	7	10	16	37	36	23	23	28	94	26	22	32	32	14
3	5	7	9	12	17	33	50	29	26	32	548	40	51	18	11
2	4	5	7	10	14	26	42	92	47	42	50	223	31	15	9
1	4	5	6	8	10	17	25	39	728	44	136	34	20	12	8
0	3	3	4	5	6	8	11	16	20	56	23	16	11	8	6
-1	2	3	3	4	5	6	7	9	8	10	9	8	7	6	5
-2	2	2	3	3	4	4	4	5	6	6	6	5	4	4	4
-3	2	2	2	3	3	3	3	4	5	5	4	3	3	3	3
-4	2	2	2	2	2	3	3	4	4	4	3	3	2	2	2
-5	1	1	2	2	2	2	3	3	3	3	3	2	2	2	2
-6	1	1	1	2	2	2	2	3	2	2	2	2	2	1	1
-7	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1

Table A-29. 2006 Fall Average Concentration of NO_2 (μg/m^3) From PDK and Highways.

Note that PDK is located at the origin and surrounded by the darker border.
Labeling of the rows and columns are in km.
Highlighted cells are receptors with top 10 highest NO2 concentration value.

(km)	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7	2	3	4	5	5	6	9	316	11	8	6	6	5	6	7
6	3	4	7	9	7	7	10	316	14	9	8	7	7	9	22
5	3	5	8	40	15	10	10	21	38	14	10	9	10	17	20
4	3	4	6	10	27	21	13	14	19	62	16	13	17	28	12
3	4	4	5	8	11	22	30	17	16	21	423	23	44	15	10
2	3	4	5	7	10	15	26	56	26	24	29	192	25	13	9
1	2	3	3	4	6	12	23	34	579	35	88	36	25	13	9
0	2	2	3	4	5	6	9	14	21	56	26	17	13	10	8
-1	2	2	2	3	4	4	6	7	10	11	11	11	9	7	6
-2	2	2	2	2	3	3	4	6	7	6	7	7	7	6	5
-3	1	1	2	2	2	2	4	4	5	4	5	5	5	5	5
-4	1	1	1	2	2	3	3	3	3	3	4	4	4	4	4
-5	1	1	1	1	2	3	2	2	3	3	3	3	3	3	3
-6	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
-7	1	1	1	2	1	2	1	2	2	2	2	2	2	2	2