Transportation Conformity Particulate Matter Hot-Spot Air Quality Modeling

Presented
By

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Disclaimer

- The research findings reflect the view of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Illinois Center for Transportation, the Illinois Department of Transportation, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Project Status Update

- Project started November 2010 and will end June 30, 2013
- Has been extended a number of times
- Submitted the final report draft to ICT, currently under final review and editing

Outline

- Study objective and scope
- Study approach
- Data requirements and gaps
- Major findings
- Lessons learned
- Future work

Study Objective and Scope

- Revised objective and scope:
  - To perform and demonstrate quantitative $PM_{2.5}$ hot-spot analyses in the Chicago and Metro East areas,
  - To identify data needs and gaps in $PM_{2.5}$ hot-spot modeling,
  - To gain technical insights into PM hot-spot modeling, and
  - To understand uncertainties and limitations of PM hot-spot modeling

Study Approach

1. Understanding PM hot-spot conformity analysis modeling technical requirements
    i. MOVES modeling at the project scale
        - Model setup
        - Sensitivity analyses
    ii. Air dispersion modeling
        - AERMOD and CAL3QHCR model setup
        - Model comparison

Study Approach (cont'd)

2. Pilot study to investigate and demonstrate the amount of modeling effort and technical requirements
   – Interchange of I-80/I-55

Study Approach (cont'd)

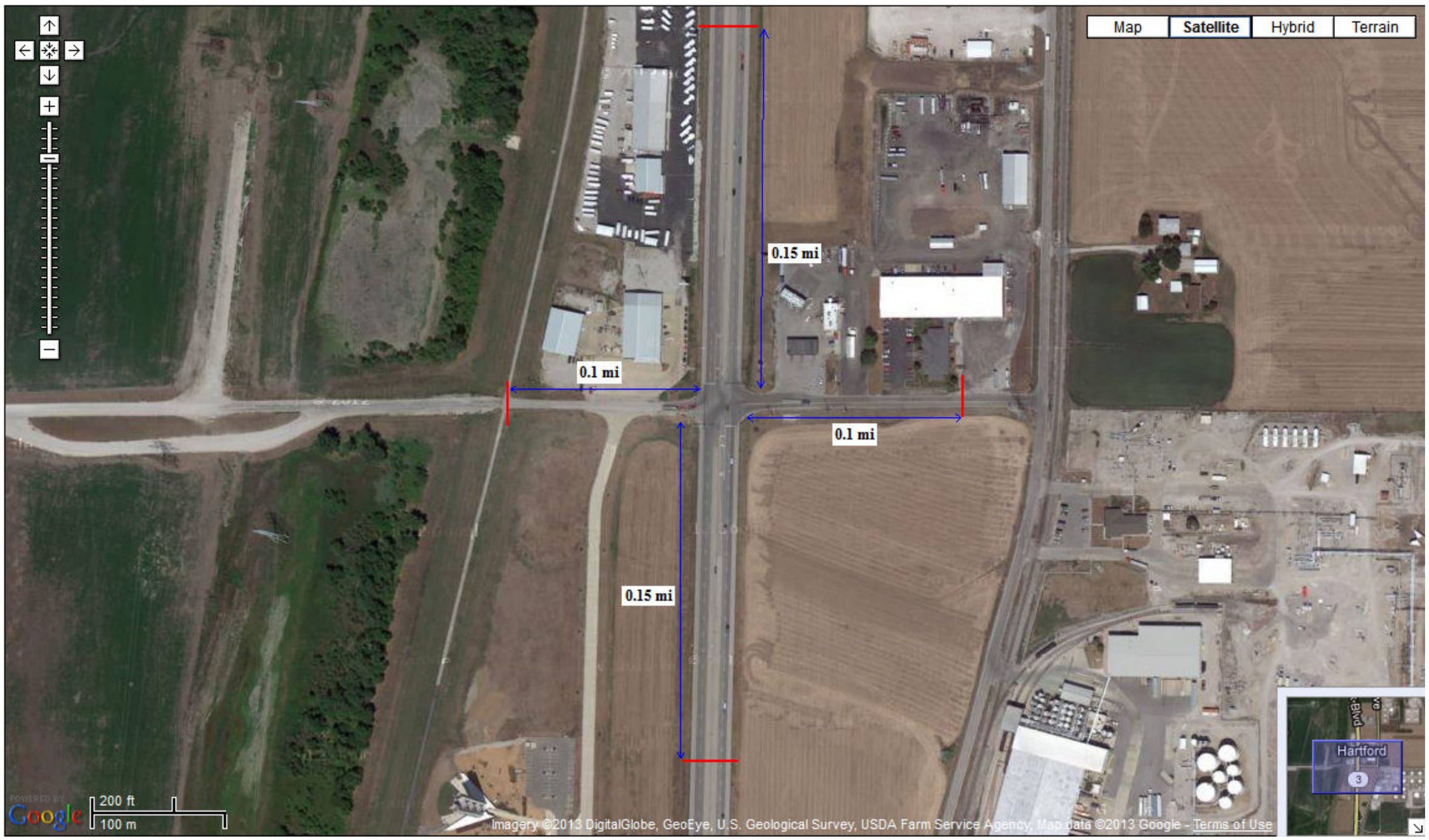
3. Case studies: model year 2015
   – Highway project: Poplar Street Bridge in Metro East

Study Approach (cont'd)

3. Case studies (cont'd)
   – Intersection of Algonquin and IL53, Chicago

Study Approach (cont'd)

3. Case studies (cont'd)
   – Intersection of State Route 3 and Piasa Lane, Metro East



Data Requirements

1. Drawing of the project site in form shape file, CADD drawing, or aerial photo (in bmp, jpeg, or gif format).
2. Location of the project site in terms of the geographical coordinates (latitude and longitude)
3. All dimensions of the project area (length, width, orientation of roadways, and radii for circular ramps).
4. The extent of the project area to be considered for the modeling process (e.g., what extent beyond the interchange or what extent beyond the exit/entrance ramp to be modeled).
5. Right-of-way distance from the edge of the roadways, where the first set of receptors can be placed.
6. Details on the land-use type of the project site.
7. Traffic volume for each time period of the day in base and future years—morning peak: 6 to 9 A.M.; afternoon: 9 A.M. to 4 P.M.; evening peak: 4 to 7 P.M.; overnight: 7 P.M. to 6 A.M.
8. Fleet composition by the four time periods of the day.
9. Traffic activity data for all roadway links by the four time periods of the day, in the form of either average speed or link drive schedule (second-by-second speed profile).
10. Age distribution of the vehicle fleet by vehicle type.
11. Fuel supply and formulation parameters.
12. One year of onsite meteorological data or 5 years of off-site meteorological data in a format compatible with AERMOD/CAL3QHCR, depending on which model is to be employed.
13. Background concentration from all sources other than the project.

Data Gaps

1. Some digital form of the project site's geometry (e.g., CADD drawings).
2. Current and future traffic activity data (total traffic volume and speed) by time of day and vehicle type.
3. Data on the fleet composition of the traffic volume, preferably in accordance to the 13 MOVES vehicle types.
4. Meteorological data in a format compatible to AERMOD and CAL3QHCR or a converter that could convert the data from one format into the other.
5. More recent traffic signal timing plan for the project sites.
6. Detailed traffic activity data in terms of drive schedule compared with average speed.

Major Findings

- For the limited-access roadway projects, the contribution from traffic ranges roughly from 0 to 4 $\mu g/m^3$ in Chicago and 0 to 3 $\mu g/m^3$ in Metro East. These results are comparable with studies in other parts of the country.
- For the arterial projects, the contribution from traffic ranges roughly from 0 to 3 $\mu g/m^3$ in Chicago and 0 to 1.5 $\mu g/m^3$ in Metro East. These results are comparable with studies in other parts of the country.
- The geographic location of a roadway project plays an important role in $PM_{2.5}$ hot-spot conformity.
  - Roadway projects in the Chicago area tend to have higher contributions to $PM_{2.5}$ concentrations near roadways, even after controlling for the geometry and traffic conditions.
  - One major cause is temperature because Chicago is on average 3°F to 9°F lower than Metro East. Because $PM_{2.5}$ emissions from diesel vehicles are not affected by temperature, this means the difference is attributed to gasoline vehicles.
- The background concentrations in both Chicago and Metro East are already very high, typically above 10 $\mu g/m^3$ in Chicago and above 11 $\mu g/m^3$ in St. Louis.
  - Even a small contribution from a roadway project in either region may push the project to exceed the annual $PM_{2.5}$ NAAQS standard. In that case, the build versus no-build analysis is required in determining a project of "potential air quality concern."

Major Findings

- Metro East and Chicago have comparable total $PM_{2.5}$ levels from roadway projects, after taking into account the background concentration levels.
  - Metro East has a higher background concentration level in general;
  - Metro East has generally lower traffic volumes and percent diesel trucks, as well as temperature, than Chicago.
- The urban/rural classification of a project site matters considerably because it directly determines which local meteorological inputs (from a nearby urban or rural representative weather station) to use in emission and air-dispersion modeling.
  - Our pilot study found that using the rural meteorological representation can result in 1.4 times that of the urban concentration levels (without the background level).
- In our investigation, AERMOD and CAL3QHCR show considerable discrepancies in model results for the same project setting.
- Most importantly, there are so many factors at work to various degrees in the case of $PM_{2.5}$ hot-spot conformity that it is generally difficult, if not nearly impossible, to generalize the findings of one case study to another.

Lessons Learned

- The PM hot-spot modeling procedure defined in the U.S. EPA guidance would require a considerable amount of time for state DOTs, MPOs, and transportation-consulting companies to understand fully, as well as a workforce to implement it.
  - MOVES and AERMOD are new to most of them
  - The great deal of technical details specific to the PM hot-spot conformity procedure defined in the guidance.
    - For example, the arterial street case studies presented in Chapter 8 required approximately 4 to 5 weeks to set up the model run, which does not even include the time spent on assembling the data required by the models.
    - That amount of time was after the research team had gained insightful modeling experience from the pilot study.
    - The amount of time could very well increase as the complexity of case study site increases such as the Poplar Street Bridge site.
- Based on our study, it is clear that careful selection of input parameters for all models (MOVES, AERMOD, and CAL3QHCR) is required to avoid possible variation in the concentration results.

Lessons Learned (cont'd)

- Technical Review Panel and interagency consultation are critical to the success of the $PM_{2.5}$ hot-spot conformity analyses.
  - In our study, the TRP members for this study came from IDOT, FHWA, U.S. EPA, Illinois EPA, and CMAP.
  - Having these agencies' continual and close engagement proved to be valuable to the PM hot-spot conformity analysis project.
- A considerable data gap exists between what the models (MOVES and air-dispersion models) need and what currently is being collected by transportation agencies (or what is being modeled, in the case of the regional transportation model).
  - Transportation agencies should revisit their data collection protocols and procedures and update them accordingly to meet the new modeling requirements.

Recommended Future Work

- More case studies to examine the effects of various project configurations and settings
- Further investigations in model performance with respect to key model input parameters (e.g., site geometry, traffic composition, fleet age distribution, and meteorology)
- Further comparison between AERMOD and CAL3QHCR
- Detailed documentation of activity data needs, potential sources, and methods to collect or generate the data