Mobile phone tracking and traffic maps: in support of modelling traffic air pollution, exposure and health effects

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Introduction

Street traffic is a main source of air pollution in most urban areas and can cause negative health effects. Existing monitoring methods do not calculate personal exposure to air pollution caused by traffic. New mobile-phone-based technologies can be used to provide near real time personal exposure for global urban populations.

In a previous paper (Liu et al., 2013), we presented mobile phone tracking in support of modeling traffic-related air pollution contributions to individual exposure and its implications for public health impact assessment. In this paper, we explored combining mobile phone tracking and traffic maps data for modeling traffic pollution, exposure and public health impact, step-by-step through the causal chain.

Modelling

We developed the following eight models to calculate traffic-related air pollution, exposure and health impact:

- Vehicle tailpipe emissions
- Traffic flow velocity derived from traffic map data
- Traffic engineering model of vehicle density
- Gaussian plume steady advection-diffusion at a street segment and vehicle-induced turbulence
- Exposure using traffic flow velocity from traffic maps
- High and low exposure regimes for fixed route trajectories
- Exposure for fixed time trajectories with 10 parameters, i.e., wind speed, wind direction, vertical wake mixing height, turbulent wind speed correction, traffic flow density parameter, traffic flow density exponent, maximum traffic flow velocity, maximum traffic density, street segment length and average number of people per vehicle
- Health impact

Tailpipe emission curves were generated using traffic engineering correlations between traffic flow velocity and vehicle density.

Pollutant concentration was calculated by a dispersion model with vehicle-induced turbulent mixing.

Individual exposure was accumulated along mobile phone mapped trajectories in the pollution field.

Health risk modeled to be proportional to time-averaged exposure.

A freeway with 100 km/h free flow velocity was used as an example to test this approach.

Objective

- Evaluate the feasibility of near real-time worldwide modeling framework for traffic-related air pollution, exposure and health impact.

Methods

Mobile phone tracking and traffic maps

Combine traffic engineering and traffic maps to calculate near real-time traffic flow velocity and density, vehicle emissions, and traffic pollution concentration. Use individual mobile phone tracking to collect pollution exposure and analyze with regard to health impact.

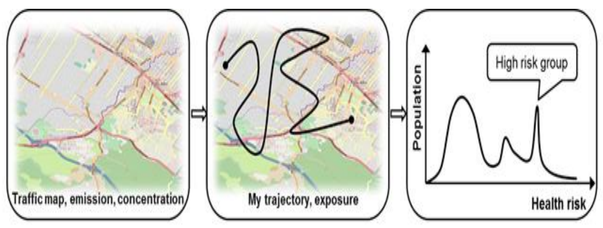

Figure 1. Modeling framework calculating a pollution map (left) in which mobile phone trajectories collect pollution exposure (middle) that are analyzed with respect to health risks (right).

Conclusions

- A near real time worldwide modeling framework for traffic-related air pollution, exposure and health impacts is technically feasible.
- Nearly every aspect of traffic pollution modeling depends on data derived from existing traffic maps.
- Our approach is:
  1) low cost: there is no added cost for observations as high quality traffic maps already exist.
  2) near real-time: calculation of both pollution and exposure can be done automatically.
  3) effortless citizen participation: availability is similar to mobile phone location tracking.
- This work paves the way for a new global paradigm in traffic pollution modeling.
- Current environmental policy regulations set limits on pollution concentrations. We find that this current practice is almost irrelevant for commuters. Low speed driving leads to higher exposure rates. Higher driving speeds, lowers exposure levels. This is true regardless of the actual concentration value.
- Therefore, increasing traffic network capacity has an large positive effect on reducing traffic pollution related health risks.

Results

- Given that mobile phone trajectories and traffic map data are available, it is feasible to model personal near real-time exposure and health impacts.
- Global traffic maps are super-efficient pre-processors for near real time pollution calculation.
- Traffic engineering models can bridge the gap covering the lack of street segment traffic flow density.
- Two general results can be extracted from the modeling:
  - fixed route trajectories have a high exposure regime for traffic flow velocities < 5 *km/h* dominated by travel time (Figure 2).
  - fixed time trajectories have a high exposure at velocities around 40 *km/h* dominated by vehicle density.
  - The population health risk per hour for groups in traffic at a velocity 25 *km/h* is 30 times greater than the risk per hour at 100 *km/h* (Figure 3).

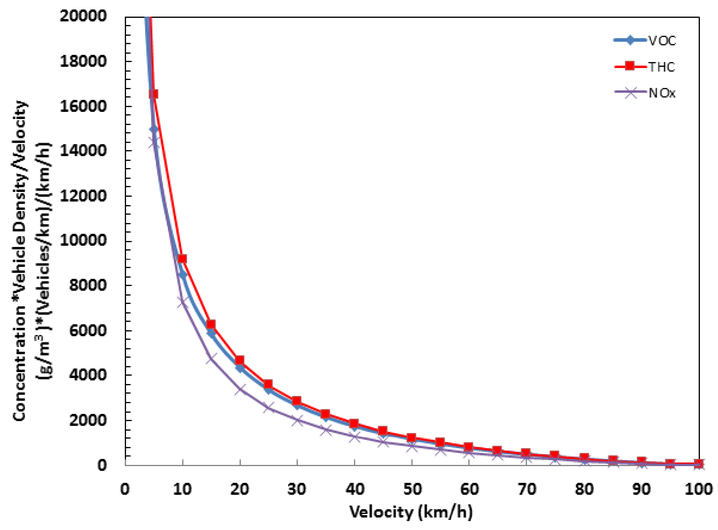

Figure 2. When travelling a fixed route, the exposure level is highly dependent upon your speed. Slower speeds result in higher risk.

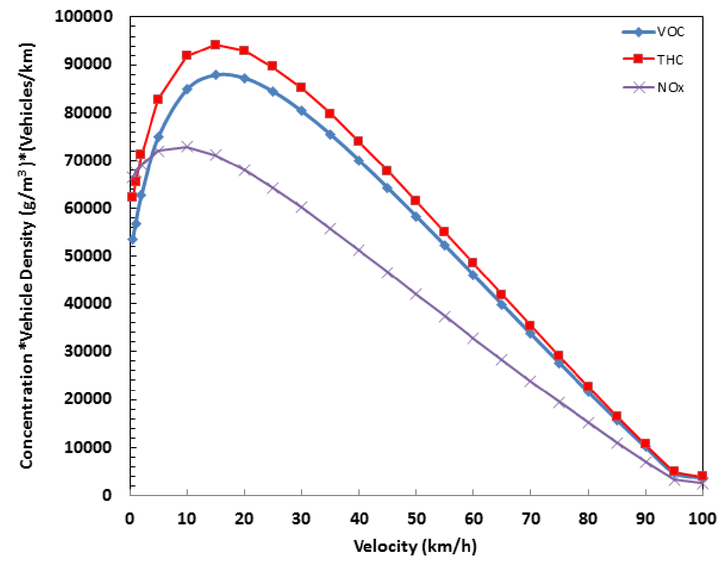

Figure 3. Highest avg. exposure occurs at 25 *km/h*. Faster speeds reduce risk of exposure.

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