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# Vehicle Routing to Mitigate Human Exposure to Traffic-Related Air Pollutants

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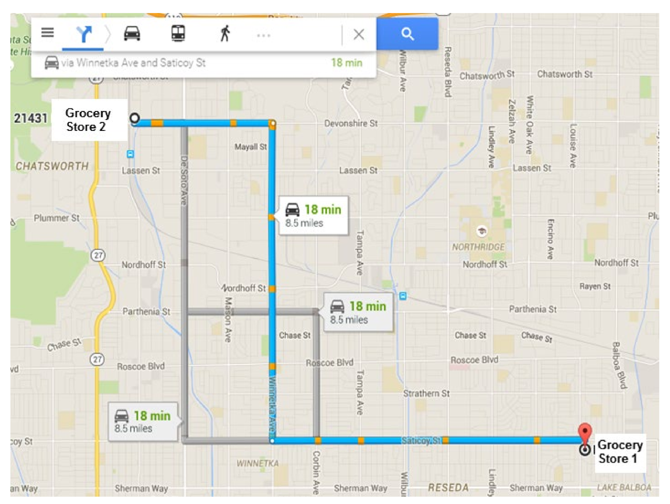
## Introduction

- ITS technology often aims at improving traffic safety and mobility.
- Recently, more ITS applications have also focused on reducing mass emissions (e.g. $CO_2$, NOx) and improve environmental performance.



- For example, Eco-signal operations and Eco-routing applications. (see Barth *et al.*, Boriboonsomsin *et al.*, Ahn *et al.*, Rakha *et al.*)
- However, the applications have not considered from a pollutant exposure/burden point of view.

Different routes result in different travel time, distance, and environmental impacts, e.g., CO2/pollutant emissions

**Route options will lead to different emission/exposure for :**


Susceptible population, e.g. school children, older adults


Active travelers, e.g. pedestrians, cyclists


Residential communities

### Objectives

- The pollutant exposure of local populations near roadways is estimated and used as a weight for vehicle routing to reduce overall exposure, while also considering economical travel duration.
- Considers a range of details regarding spatial and temporal factors.
- The concept is particularly valuable for routing or regulating high-emitting vehicles near sensitive communities such as schools or disadvantaged neighborhoods.

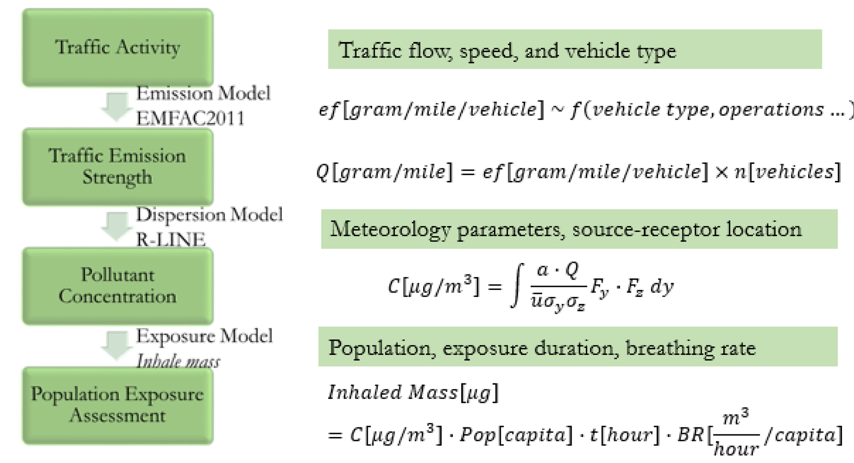
## Modeling Method

### Scope

- Only primary fine particle (PM2.5) directly coming out of tailpipes
- Only emissions when vehicles running on roadways
- Time resolution of one hour
- Three case studies in Southern California
- Analysis range from 2010 to 2018 calendar year

### Modeling tools

- Traffic model: Riverside County Transportation Analysis Model
- Emission model: EMFAC2014 (http://www.arb.ca.gov/emfac/)
- Dispersion model: R-LINE (https://www.cmascenter.org/r-line/)

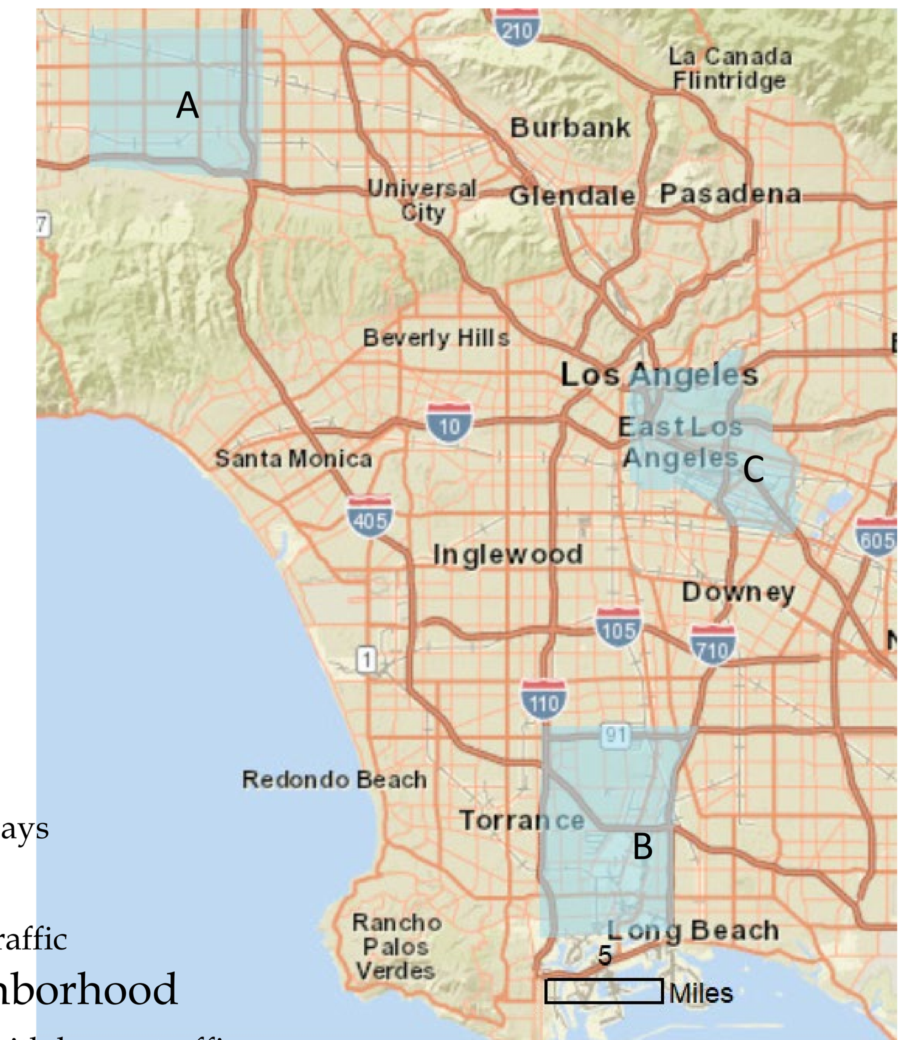



Apply spatial analysis to characterize roadway network with *IM* and develop intelligent routing applications

Flow diagram of modeling method

Three case studies in Southern California

- A: Reseda – Northridge Area
  Dense residential zones with bounding freeways & highways
- B: Long Beach - Carson Area
  Mixed industrial and residential zones with heavy truck traffic
- C: East Los Angeles – Boyle Heights Neighborhood
  Dense residential zones around major freeway junctions with heavy traffic

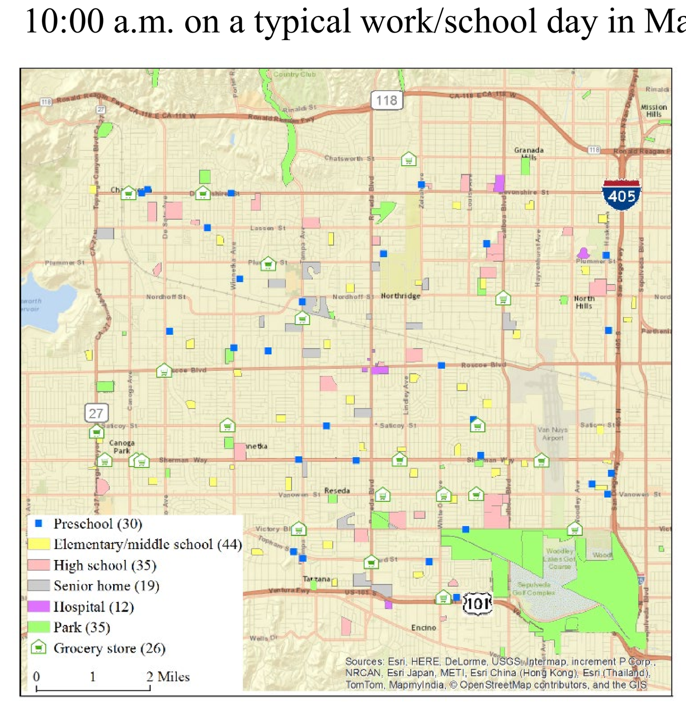



Locations of three case studies in Southern California

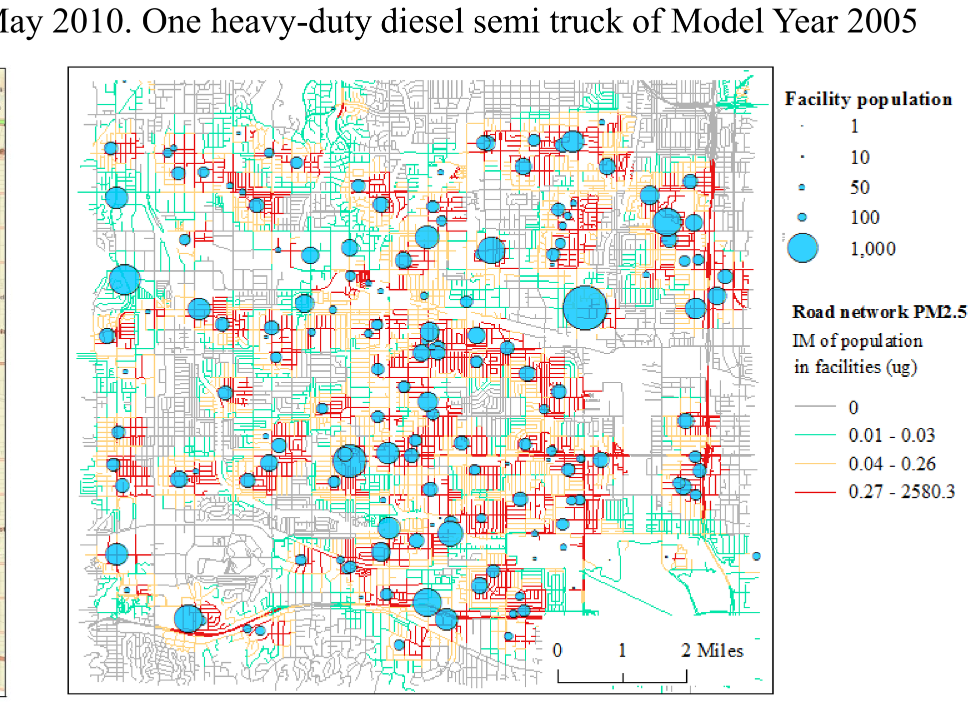
## Case Studies

### Case A: Reseda – Northridge Area

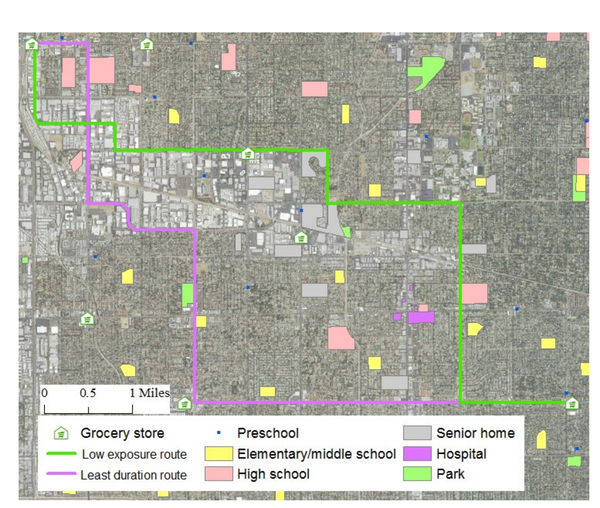
10:00 a.m. on a typical work/school day in May 2010. One heavy-duty diesel semi truck of Model Year 2005



Reseda-Northridge area and facilities



Sensitive population's $PM_{2.5}$ inhaled mass (*μg/link*)



Example trip: when comparing Green Route (Low Exposure Route) to Pink Route (Least Duration Route), the travel duration increases 40 seconds (3%) while the IM values reduce by 87%.

To better understand the effects of LER, the *IM* and duration results for all the 400 LER trips are compared with their LDR counterparts.

For 30% of the routes, the LER and LDR are identical,

About 40% of the trips lead to more than 30% inhalation reduction.

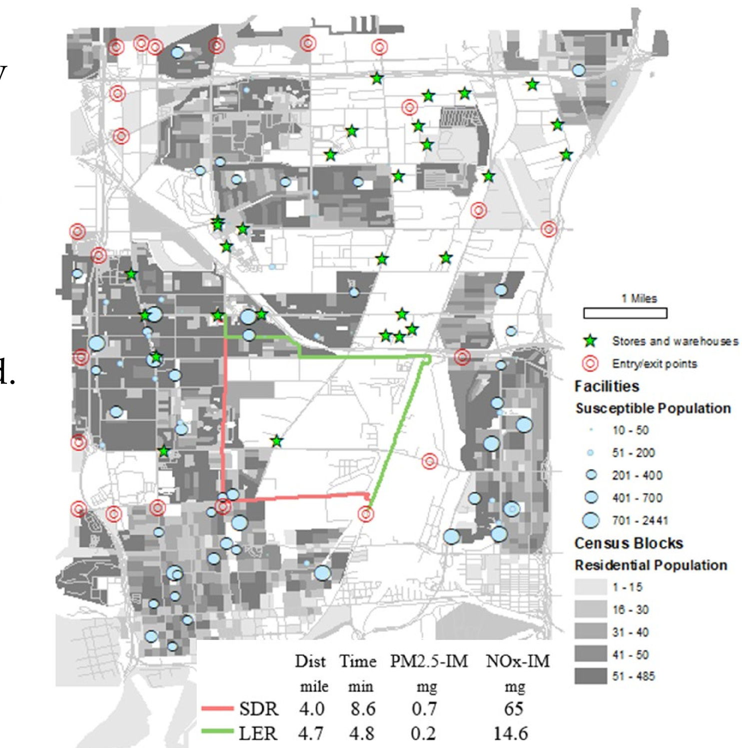
### Case B: Long Beach Area

10:00 a.m. on a typical work/school day in May 2018. One heavy-duty diesel semi truck of Model Year 2012.

Example trip: when comparing Green Route (Low Exposure Route) to Red Route (Shortest Distance Route, enforced based on city truck route), the travel duration decreased 3.8 min (44%) while the IM values reduce more than 71%.

1276 trips connecting stores/warehouses and entry/exit points within Carson City are analyzed.

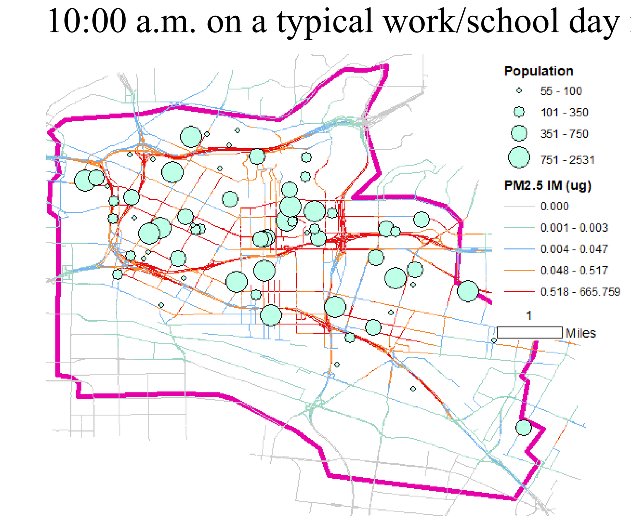
898 (70%) trips lead to more than 55% inhalation reduction.

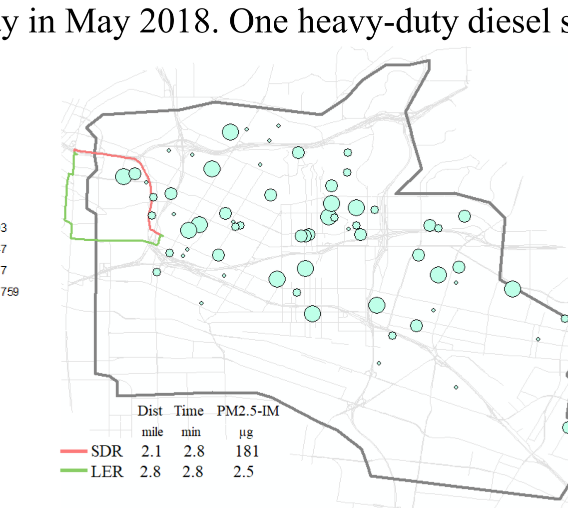


Facilities, origins, destinations, and example trips in Long Beach Area

### Case C: BH Neighborhood

10:00 a.m. on a typical work/school day in May 2018. One heavy-duty diesel semi truck of Model Year 2012.





224 trips connecting stores/warehouses and entry/exit points within the neighborhood are analyzed.

9.5% of the trips can be found with low exposure alternatives within 35% increase of travel distance.

## Conclusions and Future Improvements

- It is found that the total pollutant exposure by target population groups can be greatly reduced with small adjustments to route choice.

**Areas for future improvements:**

- Collect traffic, weather, and population activity datasets in real time. More population groups, such as workers, commuters' exposure can be accounted for.
- Fuel consumption, carbon dioxide emissions, and economic impacts should also be evaluated.
- Microscopic traffic simulation and/or probe vehicles can be used to better represent the modal operation (acceleration, deceleration, cruising, and idling) of vehicles on the roads. In addition, road grade and vehicle weight data can also be incorporated in conducting microscale, power-based emission modeling to improve the accuracy of emission estimates and subsequent pollutant exposure assessment.

## Acknowledgement

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