Evaluating System-Level Impacts of Innovative Truck Routing Strategies

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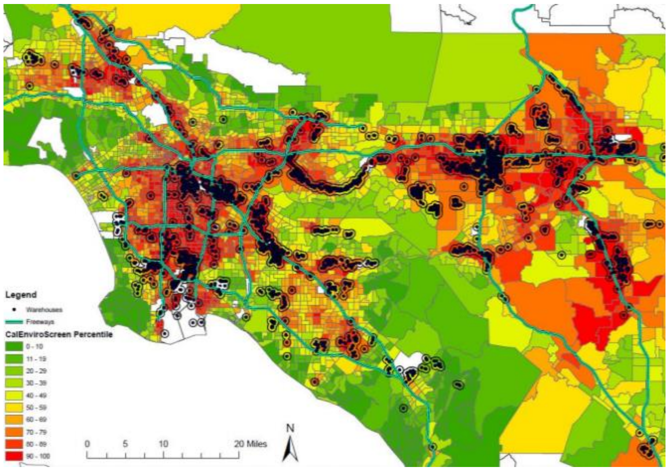
Problem Statement



Environmental justice communities (in red/orange areas) in close proximity to warehouses (black circles) experience more economic, environmental, and health burdens

Heavy duty-diesel trucks used in freight movement produce significant amount of fine particulate matter (PM2.5) and nitrogen oxides (NOx) emissions, which are harmful to public health. Communities close to freight hubs such as ports, railyards, and distribution centers often experience elevated levels of these pollutants. While emerging emission control technologies and alternative fuel vehicles are effective at reducing emissions from these trucks, the turnover of the current truck population to these advanced technologies will require a large amount of investment and a long time. In the near term, other efforts to reduce emissions of the existing trucks and mitigate their impacts on communities are needed.

Project Objective

Recently, there have been efforts to develop strategies to reduce the air pollution impacts of truck traffic, especially in disadvantaged communities. One such strategy, called low exposure routing (LER), is to route trucks in a way that reduces the exposure of community members to pollutant emissions from the trucks. LER considers a number of factors such as how much pollutant is emitted from the truck, how far the pollutant is blown away from the road and in which direction, and how many people live/work/play near that road. The LER strategy has already been evaluated at the vehicle level. In this research, we aim to quantify the impacts of LER under different levels of technology adoption rate. Specifically, the objectives are to: 1) estimate the potential of the LER strategy in reducing community-wide exposure to truck emissions when multiple trucks take low exposure route, 2) assess the impacts of such a large-scale adoption of the LER strategy on truck travel time and energy consumption.

Research Methodology

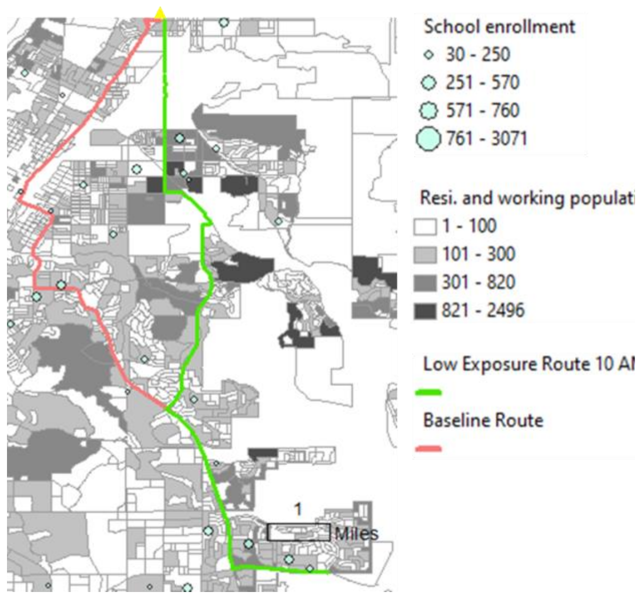
To achieve the project objectives, we use the city of Riverside, California, as a case study. The city has a gridded road network along two major freeways that carry a large amount of truck traffic through the city. It also has several densely-populated communities with a large fraction of children and seniors who are more sensitive to air pollution. We first fuse truck-related data from multiple sources to generate itineraries of 992 trucks that travel between 498 unique origin-destination (O-D) pairs in and around the city. These truck trip itineraries are incorporated into a transportation simulation model for the city, which is then used to simulate traffic conditions in the city, and subsequently, evaluate the impacts of LER. The evaluation is conducted for the typical weather conditions during the hour of 10-11 AM on weekday.

Before a low exposure route for any trip can be determined, calculations have to be made to estimate the amount of pollutants emitted from a truck that city residents would inhale if that truck travel on a specific road. This is the pollutant “exposure cost” associated with that road. Once the exposure cost is calculated for all the roads in the city, a low exposure route for a trip can be determined by finding a travel route with the total exposure cost lower than a conventional route such as the fastest route.

It is possible that for some trips, there is only one travel route between the origin and the destination. That route is thus the fastest route and the least exposure route. For other trips, there can be multiple route alternatives. The route with the least amount of total exposure cost may not be practical if it takes a very long detour that results in a significant longer travel time than the fastest route. In this research, we consider a low exposure route with travel time no longer than 10% of that for the fastest route to be *attractive*. If the travel time for a low exposure route is between 10% and 20% longer than that for the fastest route, we consider it to be *acceptable*. To evaluate the potential benefits and impacts of the LER strategy, we determine a low exposure route and the fastest route for each of the 992 truck trips that traverse the city of Riverside, and compare their various metrics.

Results

The results show that for 27% of the 498 unique O-D pairs, the fastest route for the trip is already the low exposure route. However, for 54% of the unique O-D pairs, an *attractive* low exposure route can be found. If a truck takes the low exposure route between these O-D pairs, the amount of PM2.5 and NOx emissions from the truck that would be inhaled by the residents would be reduced by 37% and 20% on average, respectively, as compared to taking the fastest route. On the other hand, the travel time and fuel consumption of the truck would increase by 3% and 3% on average, respectively.



The fastest route (red) and the low exposure route (green) of an example truck trip. Compared to the baseline route, the low exposure route would take less than a minute longer, but would reduce community exposure to PM2.5 and NOx by 73% and 31%, respectively. It would also reduce CO2 emission by 9%.

When evaluating the benefits and impacts of a large-scale adoption of the LER strategy among the 992 trucks traversing the city, it is found that both the reductions in air pollution inhalation by the residents and the increases in travel time and fuel consumption for the trucks are proportional to the technology adoption rate. If all the trucks always take an *attractive* low exposure route when one is available (i.e., 100% adoption rate), the amount of PM2.5 and NOx emissions from the trucks that would be inhaled by the residents could be reduced by 11% and 17%, respectively. In addition, these public health benefits could be gained without imposing significant costs to the truck operators and the climate as the increases in the overall travel time and fuel consumption (and equivalently, carbon dioxide emission) for the trucks are only 1%.

The evaluation results above indicate a high potential for the LER strategy to mitigate the air pollution impacts of trucks, especially in disadvantaged communities that are disproportionally affected by truck traffic. For the LER strategy to be impactful at the city or community scale, a technology adoption rate of more than 20% would be needed. Some incentives, policies, or regulations may be required to help reach that level of technology adoption.