A Reduced-Form Model to Estimate Near-Road Air Toxics for Communities: The Community Line Source Modeling System (C-LINE)

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A reduced-form model was evaluated for its ability to estimate near-road air toxics concentrations for communities. The model uses a line source approach to estimate concentrations based on traffic activity and meteorological conditions. It is designed to be accessible and user-friendly, allowing users to input traffic and meteorological data to estimate concentrations for specific locations.

**What is C-Line?**

- **The Community Line Source (C-Line) modeling system** estimates toxic air pollutant (air toxics) concentration gradients within 500 meters of busy roadways for community-sized areas on the order of 100 km². It does not include any other pollution sources except roadway vehicles.
- C-Line accesses publicly available datasets with national coverage for model inputs; therefore, users are not required to supply input data, but user-supplied datasets can be uploaded and used if available.
- A user-friendly interface facilitates analysis of what-if scenarios. Users can modify traffic attributes on different road segments or area-wide meteorological conditions to evaluate respective changes in resulting air quality, such as an increase in the number of diesel vehicles on a given road segment.

C-Line is described as a modeling system because it includes inputs, analysis, and visualization in a single package. It is currently housed in ArcGIS as a standalone application, which requires users to download C-Line and have the appropriate software to run it; however, future work is geared toward making it an online application. C-Line cannot be used for regulatory applications but lends itself to community-based assessments related to overall characterization of conditions or relative changes in air toxics concentrations based on changes in traffic or meteorological conditions.

**Community Applications**

Community groups are becoming increasingly active in local initiatives that seek to ameliorate potentially harmful environmental conditions. These are independent, locally-based, solution-oriented studies, and as such, can utilize different types of information than required for regulatory procedures. For example, qualitative or semi-quantitative (e.g., relative conditions as opposed to absolute conditions) data can be sufficiently robust to make informed decisions. In these instances, reduced-form models can provide valuable insights to assist in the decision-making process.

**Reduced-Form Model**

Reduced-form models provide an opportunity to examine how changes in input parameters, such as vehicle counts or speed, can affect results. The structure of reduced-form models can vary depending on the developers or application; typically, they maintain the same major, core components as their more detailed counterparts, but are accurate for a prescribed set of conditions defined by the user, as opposed to predicting conditions based on a wide range of highly detailed input parameters.

**Future Work**

- Exposure and ports
- Web-based
- Full automation

**Steady-state Gaussian-based plume model**

The dispersion algorithm treats each lane of a highway as a line source located along the center of the lane. The contribution of the elemental point source, dC, located at (0, Y, Z) to the concentration at (X, Y, Z) is given by the Gaussian plume formulation:

$$C(X, Y, Z) = \frac{qF(Z)}{2\pi \sigma_x \sigma_z} \exp\left[-\frac{r^2}{2(\sigma_x \sigma_z)}\right]$$

**Meander**

Under low wind speeds, horizontal meandering of the wind spreads the plume over large azimuth angles, which might lead to concentrations upwind relative to the vector-averaged wind direction.

$$C(X, Y) = \frac{qF(Z)}{2\pi \sigma_x \sigma_z} \exp\left[-\frac{r^2}{2\sigma_x \sigma_z}\right]$$

**Modeling System**

1. **Emissions**
   - ArcGIS Standalone
   - Traffic sources only
   - National datasets
   - Traffic sources only

2. **Dispersion**
   - Steady-state Gaussian-based plume model
   - Reduced-form model
   - Meander

3. **Visualization**
   - Interpolation GIS Mapping Overlays
   - Overlay with income
   - Buildings & indoor air

**References**


**Table:**

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**Excerpts:**

- Example of modeled benzene concentrations for selected roads.
- Example of C-LINE model results: benzene concentrations are increased by 20% and overall speed by 10%.
- Benzene concentration differences when VMT is increased by 20% and overall speed by 10%.

**What-if Scenarios**

- Port area sources
- Benzene concentration differences when VMT is increased by 20% and overall speed by 10%.
- Benzene concentration differences when both gasoline and diesel trucks are increased by 20%.