UNC INSTITUTE FOR THE ENVIRONMENT

User's Guide for C-LINE Version 5.1
C-LINE: Community Line Source Model

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Over the years, the following members of the UNC-IE project team have worked on various components of the C-LINE development: Dr. Sarav Arunachalam, Ms. Liz Adams, Dr. Jo Ellen Brandmeyer, Mr. Brian Naess, Dr. Mohammad Omary, Mr. Nathan Rice, Ms. Catherine Seppanen, Dr. Michelle Snyder, Mr. Kevin Talgo, Mr. Alex Valencia, and Ms. Dongmei Yang.

Notice

Table of Contents

List of Tables

List of Figures

1. Introduction to C-LINE

Near-road and near-source monitoring studies have established that busy roadways and large emission sources, respectively, may impact local air quality near the source. Reduced-form air quality modeling is a useful tool for examining what-if model runs of changes in emissions, such as those due to changes in traffic volume, fleet mix, or vehicle speed. Examining various modeling runs of air quality impacts in this way can identify potentially at-risk populations located near roadways, as well as the effects that a change in traffic activity may have on those populations.

The Community LINE Source Model (C-LINE) is a web-based modeling system that is available to a community user to estimate local air quality impacts from on-road mobile sources (i.e., vehicles operating on public roads). C-LINE uses a reduced-form modeling approach appropriate for a screening-level model. Input data include roads, the mix of vehicle types on each class of road, and annual average daily traffic (AADT) from national datasets. Modeling results are displayed to the user on a map.

The remainder of this section provides a general overview of C-LINE, lists references relevant to this work, and describes how to access C-LINE.

1.1. Overview

A team at the UNC's Institute for the Environment, in collaboration with the U.S. Environmental Protection Agency (EPA), is developing a series of community tools (C-TOOLS) to study the effects of various emissions sources on local air quality. Each tool is a modeling and visualization system that accesses inputs, performs calculations, produces graphical results, provides options to manipulate select input variables, and performs basic data analysis through an intuitive, web-based user interface.

C-LINE, which is the first member of the C-TOOLS, analyzes road and vehicular data for any relatively small area in the continental U.S. (CONUS). The Graphical User Interface (GUI) is built on a Google mapping platform that is served over the Internet to the user's web browser. The road data are derived from HPMS (Highway Performance Monitoring System) 2013 data and include most road types (function classes 2 – 5). Data for California are based on HPMS 2014 data due to some problems with the 2013 dataset for that state. HPMS data are hosted by the Federal Highway Administration office in the Department of Transportation (http://www.fhwa.dot.gov/policyinformation/hpms/shapefiles.cfm).

C-LINE operates in two phases: modeling and analysis. During the **modeling** phase, the user selects the modeling domain, optionally edits properties of roads and traffic, specifies the meteorological conditions and pollutants, and runs the model. During the **analysis** phase, the user can view the results of a model run using *inspect mode* to see results at selected locations, display results for the Census block groups in the modeling domain, and display location and relevant information on air quality monitors. The user can analyze the differences between two similar modeling runs (e.g., same modeling domain, pollutant, and metric).

C-LINE computes dispersion of primary criteria and select mobile source air toxic (MSAT) pollutants related to on-road mobile sources. (A primary pollutant is directly emitted by the emissions source.) Currently, these pollutants are CO (carbon monoxide), NO_x (oxides of nitrogen), NO_2 (nitrogen dioxide), SO_2 (sulfur dioxide), $PM_{2.5}$ (particulate matter with aerodynamic diameter less than 2.5 µm), D-$PM_{2.5}$ ($PM_{2.5}$ emitted by diesel vehicles), $EC_{2.5}$ (elemental carbon portion of $PM_{2.5}$), $OC_{2.5}$ (organic carbon portion of $PM_{2.5}$), PM_{10} (particulate matter with aerodynamic diameter less than 10 µm), benzene, formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene. NO_2 concentrations are estimated by an approach using an empirical relationship between NO_x and NO_2 and fitting a fourth order polynomial as described in Arunachalam et al. (2015) and Valencia et al. (2018).

Emissions for each road are calculated by combining national database information on traffic volume (AADT), fleet mix, and emissions factors from EPA's Motor Vehicle Emission Simulator model (MOVES-2014) from the 2011 version of EPA's National Emissions Inventory (NEI-2011) (see https://www.epa.gov/air-emissions-modeling/2011-version-62-platform). The user can modify the emissions for one or more roads by changing the traffic composition via the fleet mix, the speed, and/or the AADT.

Dispersion calculations combine the calculated emissions with the meteorological conditions for the region of interest to compute air quality concentrations for the selected location and time period. The dispersion routines are based on the analytical version of R-LINE as described in Snyder, et al. (2013), and described further in Barzyk et al. (2015).

C-LINE calculates concentrations for select pollutants. An analysis can compute a representative, short-term concentration for one hour of selected meteorological conditions or a long-term concentration using an annual average of meteorological conditions for the selected locale. C-LINE uses the METeorologically-weighted Averaging for Risk and Exposure (METARE) approach to compute annual averages as described in Chang et al. (2015), wherein dispersion is modeled for 100 explicit hours and then a weighted average concentration is computed using those explicit 100 hourly concentrations and their frequency of occurrence during the entire year.

1.2. References

Arunachalam et al. (2015) Development and Evaluation of Model Algorithms to Account for Chemical Transformation in the Near-road Environment. Presented at the 25th Annual Meeting of the International Society of Exposure Science, Henderson, NV, October 18 – 22, 2015.

Barzyk, Timothy M., Vlad Isakov, Saravanan Arunachalam, Akula Venkatram, Rich Cook, and Brian Naess. "A near-road modeling system for community-scale assessments of traffic-related air pollution in the United States." *Environmental Modelling & Software* 66 (2015): 46-56.

Chang, S.-Y. , W. Vizuete, A. Valencia, B. Naess, V. Isakov, T. Palma, M. Breen, S. Arunachalam. (2015) A Modeling Framework for Characterizing Near-Road Air Pollutant Concentration at Community Scales, *Sci. Total Environ., 538:*905-921.

Snyder, Michelle G., Akula Venkatram, David K. Heist, Steven G. Perry, William B. Petersen, and Vlad Isakov. "RLINE: A line source dispersion model for near-surface releases." *Atmospheric Environment* 77 (2013): 748-756.

Valencia, A., S. Arunachalam, D. Heist, D. Carruthers, and A. Venkatram (**2018**). Development and Evaluation of the R-LINE Model Algorithms to Account for Chemical Transformation in the Near-road Environment, *Transp. Res. Part D: Transp. Environ.,* 59, 464-477.

1.3. Access to C-LINE

Access to C-LINE is granted to registered users of the CMAS Center. Go to the CMAS home page (https://www.cmascenter.org/) from a web browser and click "Log In" under the CMAS logo to navigate to the CMAS login page. Registered users must enter their email address and password. Next, press the *Submit* button. If you do not have a CMAS login, click the "***create one"*** link within the login message. This link takes you to the Create a CMAS Account page at https://www.cmascenter.org/register/create_account.cfm. Fill in the form and then mark your preferences at the bottom. When finished, click the *Create Account* button.

Once you have logged in to the CMAS Center, scroll down the page and look for the list of "Supported Products" on the CMAS home page. Click the link to "C-TOOLS" and then the "C-LINE" link. This action will display the primary information page for C-LINE. The login credentials are on the right side of the screen. Click the *Visit C-LINE* button and enter the login credentials (see Figure 1).

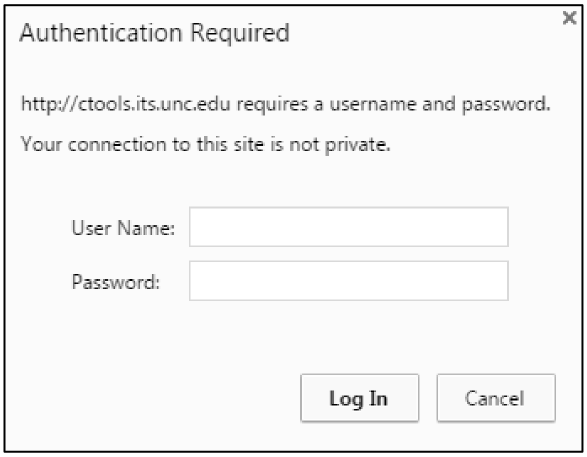


Figure 1. Enter your user name and password to access C-LINE.

The remaining sections of this document present the system requirements, a baseline analysis, editing inputs for an analysis, and managing model runs.

2. Software/Browser Requirements

The C-LINE application runs in any modern web browser and has been tested in Google Chrome, Firefox, and Safari. The most recent version of any browser is recommended. In order to use C-LINE, the browser must have JavaScript and cookies enabled. The recommended window size is at least 1200 by 800 pixels. The type and speed of your CPU or operating system is not important because the model runs are not executed on your local computer.

3. Baseline Analysis

This section provides step-by-step instructions for performing a simple, baseline analysis, which uses only those data that are provided with C-LINE. Many data were derived from national datasets such as the National Emissions Inventory (NEI) from EPA. In this example, the urban area is Charleston, SC and the pollutant is NO_x.

Start by logging in to C-LINE (see section 1.3). Figure 2 illustrates the C-LINE main page.

Figure 2. C-LINE's home screen showing satellite overlay with labels.

3.1. Overall Screen Layout

Some of the widgets are provided by the Google Maps interface. In the top-right corner of the map are two buttons labeled *Map* and *Satellite*. Figure 2 shows the satellite version of the map with labels turned on. If you want to remove the political boundaries and names from the map, hover your cursor over the *Satellite* button, and uncheck Labels. Figure 3 shows the map version of the map, which includes country, province, and state political boundaries and names; major cities; and interstate highways. If you want to include the terrain features and remove the interstate highways, hover your mouse over the *Map* button and check Terrain.

Figure 3. Home screen showing map overlay.

The set of buttons in the bottom-right corner of the screen change the zoom level. Click **+** to zoom in and **–** to zoom out. Just to the left of the zoom buttons, at the very bottom of the screen, is the distance measure: 

. As you change the zoom level, both the distance measure segment and value may change. Also, you can click the distance measure to change between units of kilometers (km) and miles (mi).

Navigation tiles are positioned vertically along the left side of the screen (see Section 3.2). Click on a tile to display the related data selection and editing frame; click the tile again to hide its frame. Each of these screens has associated on-line help. Click the icon for information on that frame, such as the one in the *Select your location* frame (see Figure 2 or Figure 3); click the icon when it appears next to a selection on the frame for information about that specific selection (see Figure 4). An example of a context-sensitive help box is shown in Figure 5.

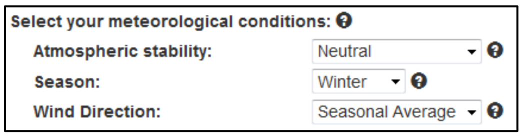


Figure 4. Example of item-specific help topics

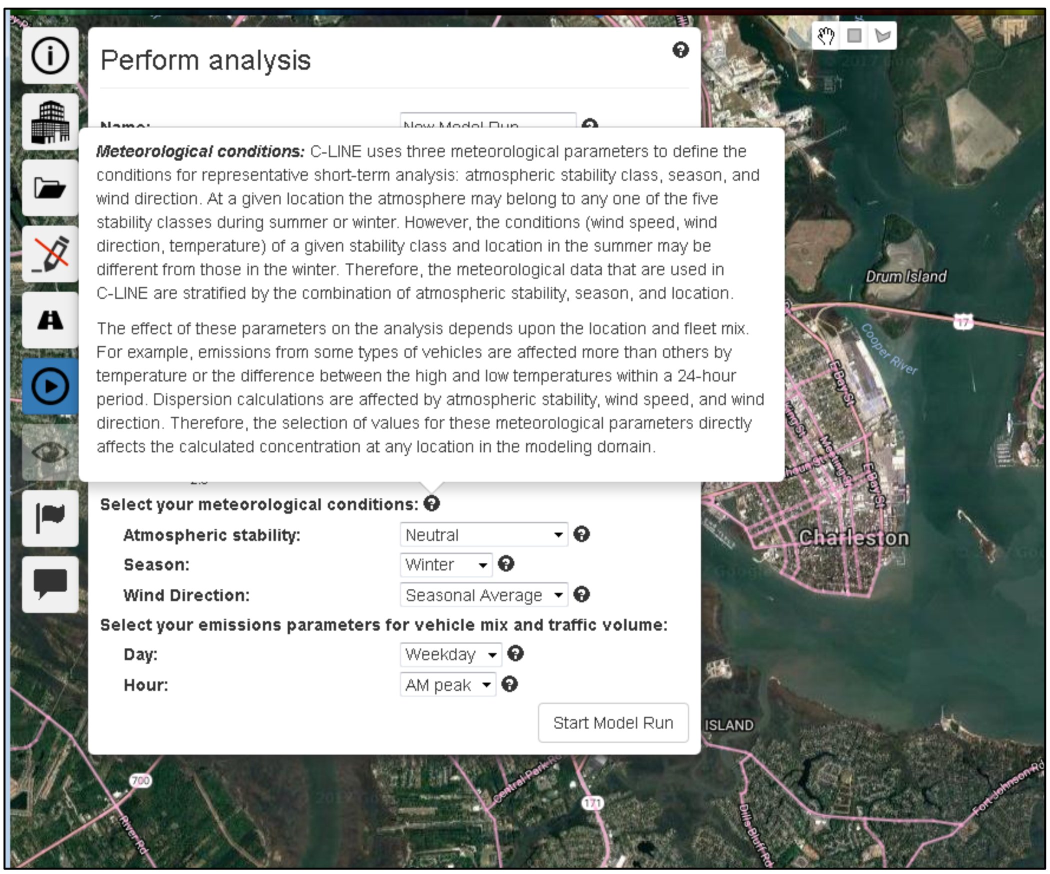
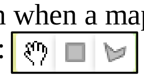


Figure 5. Example of context-sensitive help box for meteorological conditions

Three widgets appear in the top center of the screen when a map of road segments or modeling results is displayed. These are a *hand*, a *box*, and a *polygon*:  . The default widget is the hand. It can be used in several ways. To select a single roadway segment, carefully move the hand until it changes to look like it is pointing a finger at the desired segment; click your left mouse button to select the segment and it will appear in red in the *View and modify roads* frame. Click on other road segments to add them to your selection. To pan the map, place the hand and click (or click and hold), your left mouse button to change the hand to a fist; move your mouse to pan the map and then click the left mouse button again to stop panning.

The *box* widget facilitates selecting multiple road segments in one operation. Click on the square widget to change your cursor to a plus sign (+). Move your cursor to one corner of the geographic area that you want to select; click your left mouse button to start the selection process. A rectangle is displayed on the screen as you move your mouse. Position your cursor at the opposite corner of the rectangle and click your left mouse button to end the selection process. All the road segments within the rectangle are selected and shown in red in the *View and modify selected roads* frame.

The polygon widget also allows selecting multiple road segments. Instead of drawing opposite corners to define a box, draw any polygon by clicking each of its vertices. For the last vertex, double-click to close the polygon. At that point all the road segments within the polygon turn red and are shown in red in the *View and modify selected roads* frame. The polygon itself is not shown.

3.2. Navigation Tiles

The tiles shown down the left-hand side of the screen provide navigation to the various parts of C-LINE. The following table shows the list of tiles and an overview of each.

Table 1. Navigation tiles

Tile	Description
	About C-LINE. Display overview information about C-LINE, including its purpose, calculations, references, and version number.
	Select your location. Enter the name of a geographic location in the continental U.S. that Google Maps recognizes (e.g., Charleston, SC; Spokane, WA). **WARNING:** Edits since your last model run will be lost.
	View results. Load the results of a model run, create a new comparison, or view a completed comparison.
	Edit mode. Toggle edit mode to select individual road segments and then modify their characteristics. NOTE: The red line shows that edit mode is OFF. **WARNING:** Turning edit mode off deletes all edits and reloads fresh information from the database.
	View and modify roads. Selected roads are shown in red. Select sources by road class, add new sources, and upload new sources. You can change the AADT, average vehicular speed (mph), and the fleet mix on one or more selected road segments.
	Perform analysis. Select the type of analysis, pollutant, meteorological conditions, and time period for the traffic data. Enter a name and optional description for your model run. Lastly, click the *Start Model Run* button.
	Visualization options. Turn on inspect mode to see results at specific locations on the map. Toggle 2010 census block groups as a map overlay to view the average concentration within each. Toggle the concentration overlay to turn it on and off.
	Monitors and met stations. Turn on locations of air quality monitors that have observed concentrations for one or more pollutants modeled in C-LINE. Optionally, show background monitors only. Turn on markers for meteorological stations.
	Cancel adding new source. Tile appears when drawing a new source on the map. Press this tile to undo adding the new source.
	Give feedback about C-LINE. Answer a brief survey to provide feedback to its development team.

Click a tile to go to that section of C-LINE. When you are finished with that section, click the tile again. The frame then disappears, allowing you to see more of your map.

3.3. Select a Location

Enter the name of the city for your analysis. Note that C-LINE does not prevent you from entering a city outside the United States, such as Beijing. The selected city and its road network from Google Maps will be displayed for you. However, if this location is outside the CONUS, C-LINE will not have any traffic activity data to display on the road segments, and will not activate its other tiles (see Figure 6).

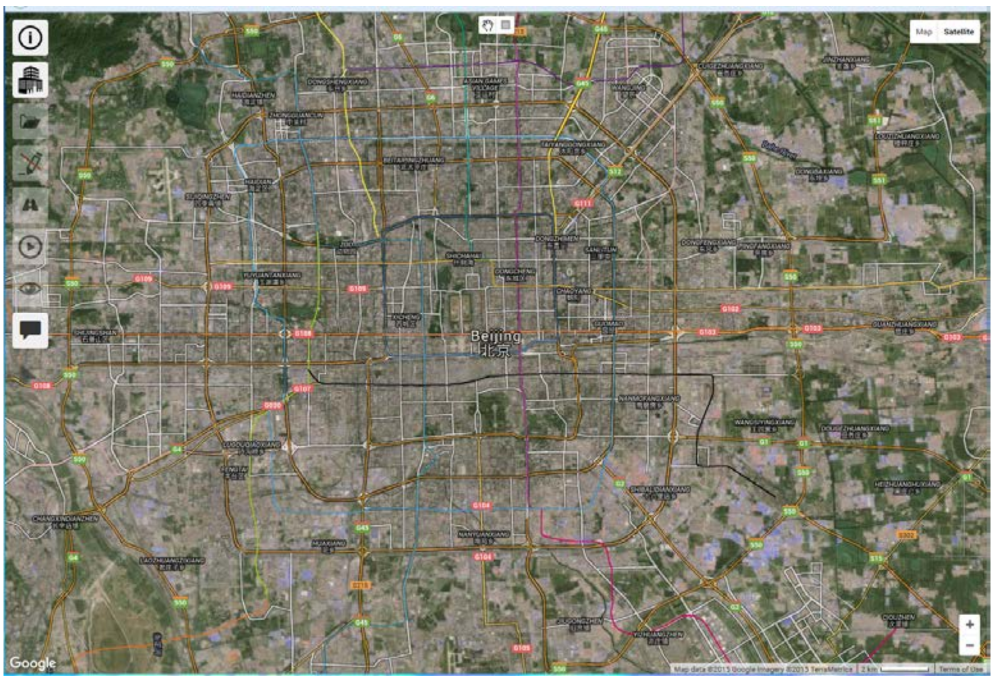


Figure 6. Example of a city outside CONUS selected in C-LINE

For this sample analysis enter **Charleston, SC** and press *Enter* or the *Select* button. C-LINE then pans the map to be centered on Charleston and adjusts the zoom level for an analysis (see Figure 7). The road segments that are in C-LINE for the selected area are shown in pink. You can adjust the zoom level to display your region of interest. If you zoom out too far, the road segments disappear from the map and you no longer see pink roads. Zoom back in until the road segments appear again. If they do not appear, go to the *Select your location* tile and select your location again to reset the map.

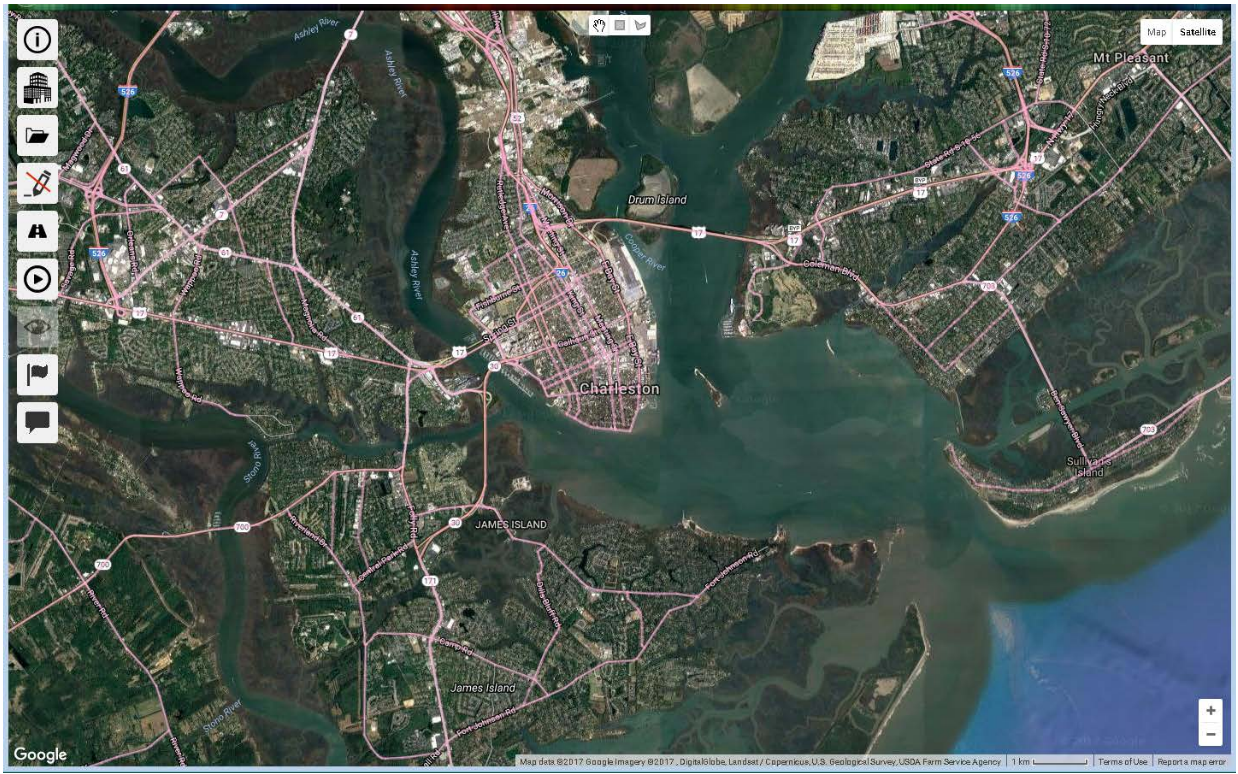


Figure 7. Selected location: Charleston, SC

3.4. Perform a Baseline Analysis

First, decide the type of analysis you want to perform. C-LINE can perform several types of analyses, as discussed below. All meteorological data have been preprocessed into categories based on statistical frequency of a variety of factors, including temperature, wind speed and direction, and atmospheric stability. This method supports short-term analyses as well as long-term analyses without needing to perform dispersion calculations for every hour of a year. See Chang et al (2015) for additional details on this approach. It also predicts short-term concentrations utilizing fast lookup of typical (median) values and information related to a combination of atmospheric stability, season, and wind direction. The meteorological station that is the closest to the center of your modeling domain is automatically selected for you.

Vehicular emissions are a function of many factors including speed, diurnal temperature range, engine load, fuel burned, age distribution of vehicles, and types of vehicles. These and other factors are input to the MOVES vehicle emissions model to calculate emissions factors. To reduce execution time required for a C-LINE simulation, the MOVES model has been executed for a wide range of conditions and its results are available as supporting tables for C-LINE's calculations.

Figure 8 shows all the selections that you can make for a short-term C-LINE simulation. Note that the *Name* of the analysis is how you will distinguish it in the *View results* frame, so a best practice is to give each simulation a unique name. The *Description* is also available in the *View results* frame (see Section 3.5). The following list of analysis inputs includes the required selections in the *Perform analysis* frame.

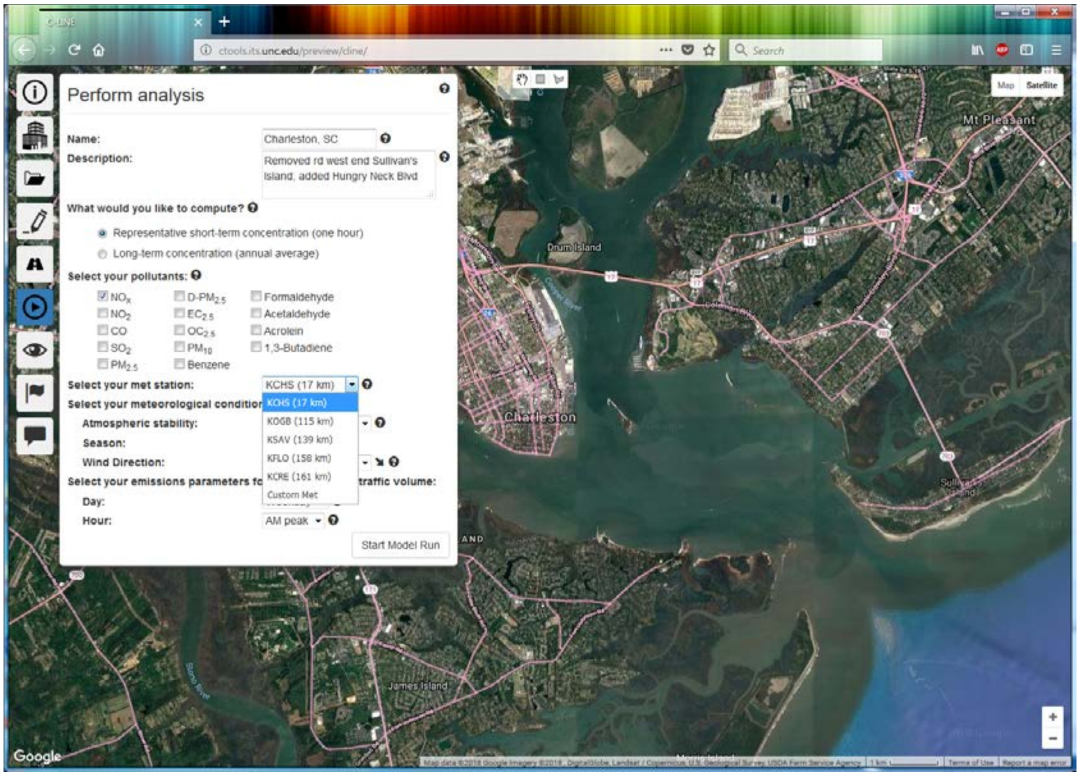


Figure 8. ***Perform analysis*** **frame for short-term, baseline simulation of Charleston, SC.**

- What would you like to compute: Select either short-term concentration (one hour) or long-term concentration (annual average).
- Select your pollutants: Select one or more pollutants. Click in the box to the left of each pollutant you want to model. C-LINE creates a model run for each pollutant when you click the *Start Model Run* button.
- Select your met station: C-LINE lists up to 5 meteorological stations with their respective distance from the center of your modeling domain. The station that is the closest to that center point is listed first and is automatically selected for you. You can select a different station from the drop-down list or select *Custom met* to upload meteorological data from a different location (see Figure 8). The *Custom met* option is currently available for representative short-term concentration model runs only.
- Representative short-term concentration (one hour): Figure 8 shows default values for meteorological conditions and vehicle selections.
  - Atmospheric stability: Select one item from the following list from lower to higher turbulence: *stable*, *slightly stable*, *neutral*, *slightly convective*, and *convective*.
  - Season: The two selections are *winter* and *summer*.
  - Wind direction: Select *Seasonal Average* for the average wind direction corresponding to the season you selected. Alternatively, select one of the sixteen compass directions (South to North, SSW to NNE, SW to NE, etc.). If you select a specific compass direction, an arrow is added to the right of the *Wind direction* widget indicating *from* and *to* directions.

- o Day: Select *weekday* (Monday through Friday) or *weekend* (Saturday and Sunday). Selection affects the traffic pattern (number and types of vehicles) to be modeled.
- o Hour: Select one of four possible time periods related to traffic patterns: *AM peak* (morning rush period), *Mid-day* (daytime period between rushes), *PM peak* (afternoon rush period), and *Off peak* (nighttime period between PM and AM peaks).

- Long-term concentration (annual average): None of the five selections listed for short-term concentration is available for long-term concentration. Instead, each set of conditions and its frequency of occurrence in the modeling domain are used to calculate the long-term concentrations. Also, the custom meteorology option is not available for long-term concentration model runs.
- Include background concentration: When you select *Long-term concentration* you have the option to turn on *background concentration*. This selection finds the nearest background air quality monitor for each selected pollutant and adds the background concentration to all modeled concentrations in your modeling domain. If you select to include background concentration and select more than one pollutant, a background value will be used for each available pollutant.

  Note that all of the pollutants are listed in the drop-down widget for background values, but many do not have a background value (i.e., the value is set to 0). If you have a better estimate of the background concentration you can edit the value to be used for the background. If you delete the background concentration without entering a new value, C-LINE with use 0. Also, the pollutant-appropriate units are displayed to the right of the background value.

If you are performing a *short-term concentration* analysis and you want to use your own meteorological data, use the drop-down widget for *Select your met station* to select *Custom Met*. Then the link *Manage custom met data* appears just below it. Click on that link to show the *Custom Met Data* frame (see Figure 9).

Figure 9. *Custom met data* frame. Download an example file or select a met data file to upload.

When you select the link *Download example file*, you can either open the file directly in one of your editors or save the file. The contents of the file are shown in Figure 10 and defined in Table 2.

```
season,disp,wd,ws,uStar,wStar,ziconv,zimech,Lmon,Zo,refHt,temp
Winter,Stab,10,0.8,0.075,-999,-999,46,14.6,0.12,10,288
Winter,sStab,10,3.6,0.272,-999,-999,325,59.7,0.065,10,288
Winter,Neutral,10,4,0.365,0.274,463,507,-2752.9,0.117,10,288
Winter,sConv,10,5.3,0.466,0.782,481,731,-254.7,0.092,10,288
Winter,Conv,10,2,0.207,0.38,60,217,-24.4,0.098,10,288
Summer,Stab,172,1.1,0.088,-999,-999,61,15,0.092,10,300
Summer,sStab,172,2.8,0.267,-999,-999,317,60.6,0.183,10,300
Summer,Neutral,172,4.5,0.383,0.448,1152,546,-1806.5,0.091,10,300
Summer,sConv,172,4.6,0.42,1.103,899,626,-124,0.098,10,300
Summer,Conv,172,1.4,0.151,0.351,82,135,-16.5,0.098,10,300
```

Figure 10. Contents of downloaded example meteorological data file met_data_example.csv.

NOTE: Your custom meteorological data file must conform to the following rules.

- You must include 10 complete lines of data in the .csv file that you upload to C-PORT.
- Each line of data must include a value for each of the 12 parameters.
- The season and stability class must be listed as per Figure 10.
- If uStar or wStar has a negative value it is treated as 0 by the dispersion model.
- The larger value of ziconv and zimech is used.
- Note that -999 can be used to signify missing data.
- The name, description, and units, when appropriate, are listed in Table 2.

Table 2. Name, description, and units for each parameter in a custom meteorological data file.

Parameter	Description	Units
season	Season of the year; must be Winter or Summer	
disp	Atmospheric stability; must be Stab, sStab[1], Neutral, sConv, or Conv	
wd	Wind direction (direction wind is from; 0 – 359)	degrees
ws	Wind speed	m/s
uStar	Surface friction velocity	m/s
wStar	Convective velocity scale	m/s
ziconv	Height of convective PBL[2] or convective mixing height	m
zimech	Height of stable PBL or mechanical mixing height	m
Lmon	Monin-Obukhov length	m
Z0	Surface roughness height	m
refHt	Reference height of wind speed and direction	m
temp	Temperature	°K

[1] Stable, slightly stable, neutral, slightly convective, convective
[2] Planetary Boundary Layer

When your custom meteorological data file is ready, return to the *Custom Met Data* frame (Figure 9) and select *Choose met data file*. Browse to your prepared .csv file and select it. You will see a confirmation that your data were loaded successfully, and those data will then be displayed in the *Custom Met Data* frame (Figure 11). Press *OK* to dismiss that frame and return to the *Perform analysis* frame. If you select the Custom meteorological station and do not upload a valid meteorological data file prior to clicking *Start Model Run*, an error window will open. You must select either a valid station or successfully upload a custom station prior to starting your model run.

Your custom meteorological data file is stored with your model run and is included in the downloaded data package. If you create a new model run from a reloaded run that used your custom meteorological data, then those data are used for that new model run. Otherwise, you must upload your custom meteorological data for a model run.

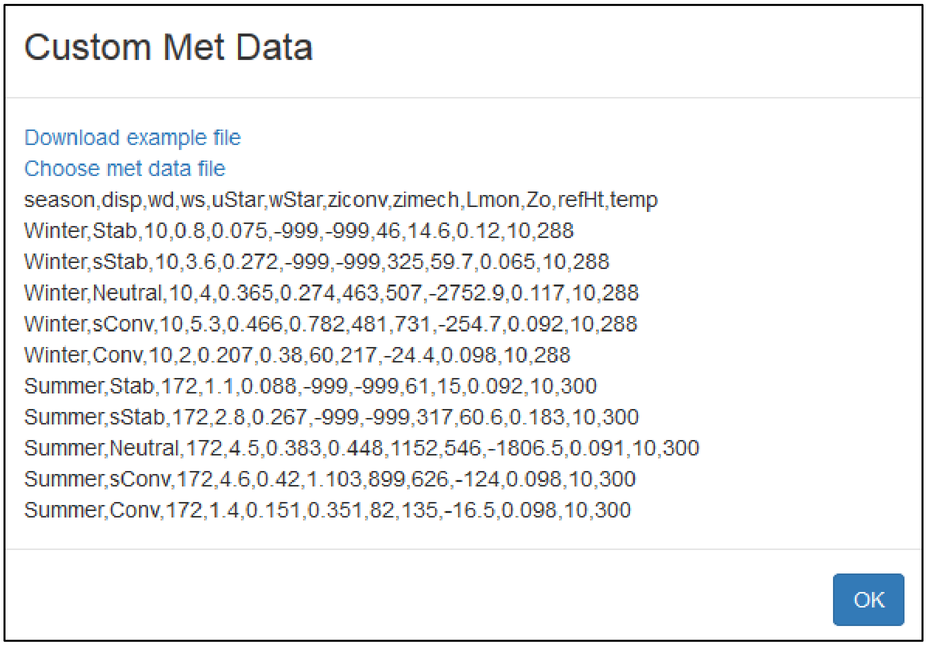


Figure 11. Custom Met Data frame after loading a meteorological data file.

Figure 12 shows selections for a long-term concentration model run for the pollutant NO_x using background concentration and the closest meteorological station. For a base model run name it "Charleston long-term base NO_x". Enter the description "long-term concentrations for NO_x, default roads and emissions, Charleston, SC". Click the *Include background concentration* switch to Off. Then, click the *Start Model Run* button.

After clicking the *Start Model Run* button, an icon of a rotating circle is displayed showing that C-LINE is preparing the model run and submitting it for analysis. After submission, another button Check Run Status appears in the bottom left corner of the frame; you can click that button instead of navigating to your list of results.

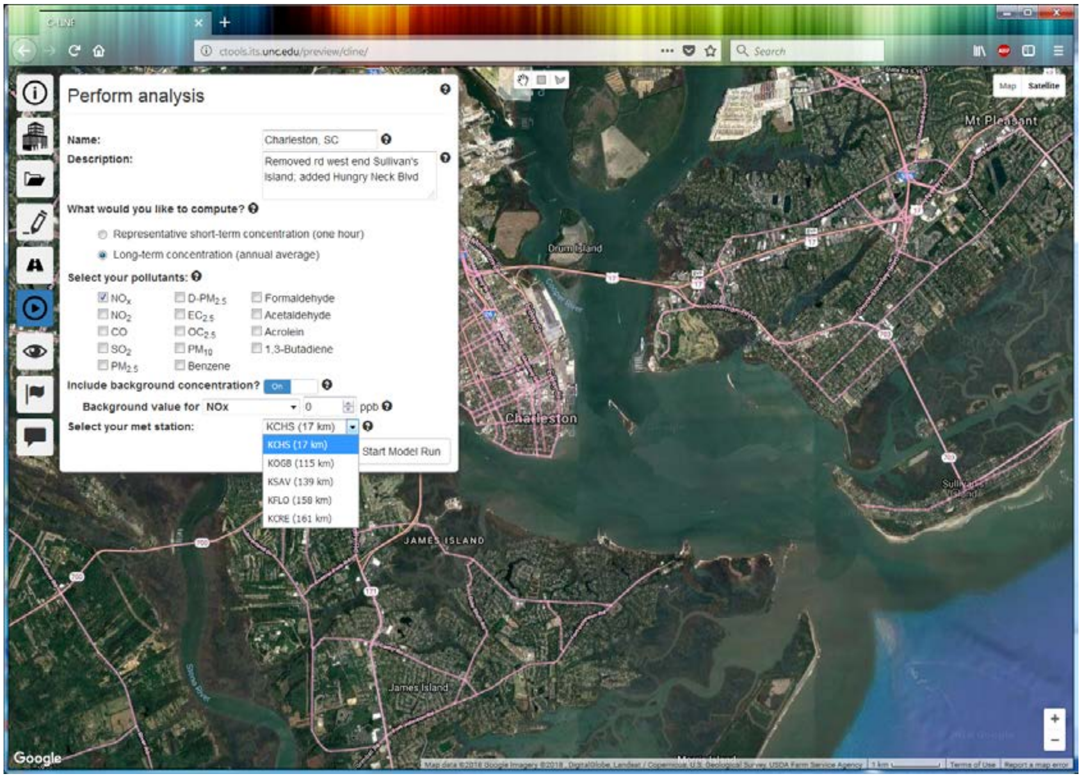


Figure 12. Selections in *Perform analysis* frame showing long-term, baseline selections.

3.5. View the Baseline Results

Click the *View results* tile to open its associated frame. All of your submitted model runs are shown in this frame. Your standard model runs are listed in the *Model Runs* tab in reverse chronological order (i.e., the model run with the most recent value in the *Last Updated* column is shown first). Create and track results of your comparison model runs in the *Comparisons* tab.

Figure 13 shows the top of the View results frame with the baseline model run as described above in Section 3.4. If the frame does not open to the *Model Runs* tab, select it. Click the *Refresh* button for the current information for all of your model runs. Your baseline model run then appears as the top line in your list. The following information is displayed for each model run.

- Name: The value that you entered for *Name* in the *Perform Analysis* frame.
- **V**: The Description that you entered in the *Perform Analysis* frame; note that you have must hover your mouse over the **V** to see the value for *Description*.
- Pollutant: The pollutant designated for this model run; note that if you selected multiple pollutants for a model run, then multiple model runs were created with one pollutant each.
- Custom: Checked if custom meteorological data were uploaded for this model run.
- Values: Short-term or Long-term model run; if Short-term then values are included for the following columns.

- Stability: Selected one of five values for Atmospheric stability.
- Season: Summer or Winter
- Wind: Wind direction as Seasonal Average or 1 of the 16 compass directions.
- Day: Weekday or Weekend.
- Hour: One of four time periods of a day

- Bg: Background: Contains a check mark (✔) if a long-term model run included background concentration and blank for all other model runs.

- Status: The current status of the model run. There are five possible values for *Status:* created, running, processing, completed, and failed. If the status shows *running* instead of *completed*, periodically press the *Refresh* button. NOTE: C-LINE's status for runs and comparisons does not automatically update.

- Last Updated: The most recent date and time that the status was updated.

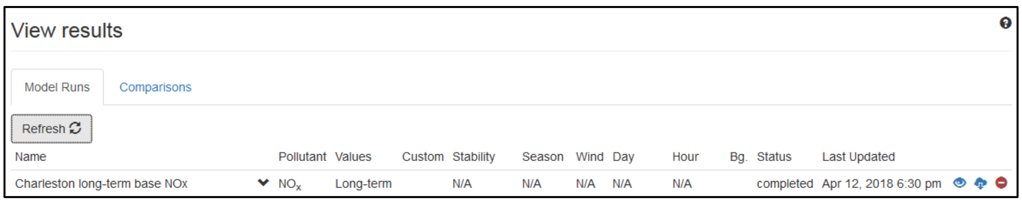


Figure 13. View Results frame, Model Runs tab showing completed baseline model run.

When the run is complete, click the blue eye ( ) on the right-hand side of that run's status line. The long-term concentration results are then displayed on the map (see Figure 14). The name of your model run, short-term or long-term, and pollutant are in the box in the top, right corner of the map. The legend of concentrations with the pollutant, short-term or long-term, unit of concentration, and name of the model run are in the box in the bottom, right corner of the map. The tiles, selection widgets, zoom widgets, and scale are still shown in their regular positions.

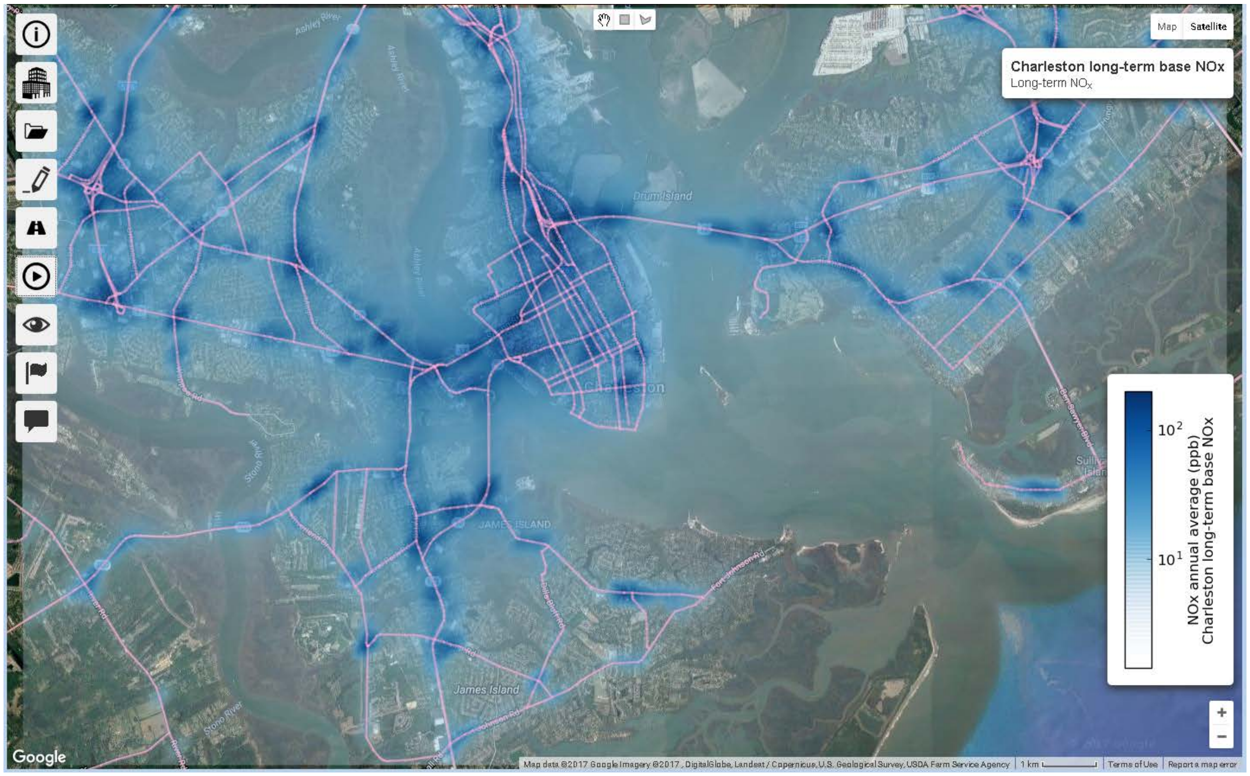


Figure 14. NO_x long-term average concentrations (ppb) for Charleston, SC baseline scenario

The results of the model run are displayed using a logarithmic scale. The legend in the lower, right corner shows the color range for the minimum through maximum values calculated. For all model run types, the minimum value that can be displayed is 10^{-6}. The actual minimum displayed depends upon the smallest values calculated in the model run. Calculated values above pollutant-specific maximums are displayed in the darkest color.

Just to the right of the blue eye is a blue cloud widget ( ). Select this widget to download a packaged set of results in tar.gz format. The downloaded file is saved to the location where your browser downloads files. A shapefile is generated for all model runs that complete successfully. This file contains the shapefile of the census block groups with the concentration in each. The four files are named census_block_groups.dbf, .prj, .shp, and .shx. Load these files into your favorite GIS. Also, the census_block_groups.kml file is the census block groups with concentration in Keyhole Markup Language (KML) format.

Finally, the location of each receptor and its concentration are provided in csv format. Note that the locations are provided in a UTM (Universal Transverse Mercator) projection as specified in the included ctools.prj file. If you import any of these csv files into a GIS, be certain to use the appropriate projection, which is
+proj=utm +zone=17 +datum=WGS84 +units=m +no_defs
where the zone number varies with location on the Earth.

The dbf file contains the relevant attributes associated with each polygon: Name (block group identifier), State_Name, Road_Conc (concentration value for that polygon), and Total_Conc (same as Road_Conc). Figure 15 shows the attributes for some of the census block groups associated with the above model run. Note that some of the names include the phrase *partial* to indicate that the complete block group is not within the modeling domain.

Attribute table - census_block_groups :: Features total: 135, filtered: 135, selected: 0

	NAME	STATE_NAME	POLLUTANT	UNITS	AREA_CONC	POINT_CONC	RAIL_CONC	ROAD_CONC	SHIP_CONC	TOTAL_CONC
0	450190020052	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	0.7736197976	0.0000000000	0.7736197976
1	450190027012	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	34.5811125000	0.0000000000	34.5811125000
2	450190019021	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	31.5382948108	0.0000000000	31.5382948108
3	450190026062	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	6.5654574800	0.0000000000	6.5654574800
4	450190028011 (partial)	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	5.2375116875	0.0000000000	5.2375116875
5	450190011002	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	111.2325000000	0.0000000000	111.2325000000
6	450190026111 (partial)	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	14.1570380000	0.0000000000	14.1570380000
7	450190046112 (partial)	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	1.6926997682	0.0000000000	1.6926997682
8	450190046122 (partial)	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	15.4705604000	0.0000000000	15.4705604000
9	450190020023	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	20.8528162941	0.0000000000	20.8528162941
10	450190048001 (partial)	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	2.0004253386	0.0000000000	2.0004253386
11	450190026112	South Carolina	NOx	annual average (...	0.0000000000	0.0000000000	0.0000000000	18.9313837500	0.0000000000	18.9313837500

Show All Features

Figure 15. Example of attribute table from downloaded shapefile of census block groups

Figure 16 shows average concentrations of diesel $PM_{2.5}$ for the census block groups in Google Earth. This graphic was produced by starting Google Earth and then opening the downloaded file census_block_groups.kml. Also, the 3D buildings and places of interest were turned off.

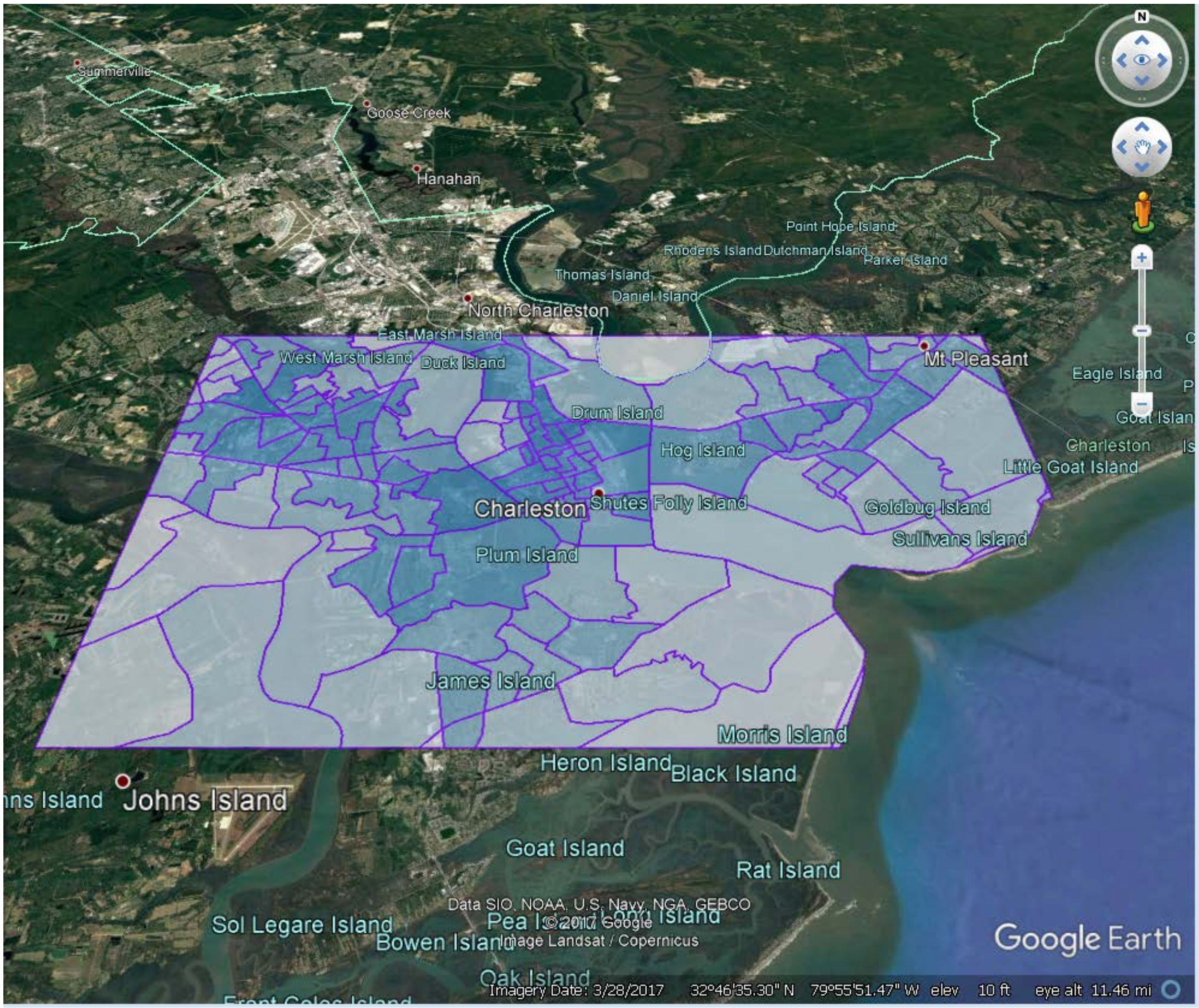


Figure 16. Charleston D-PM$_{2.5}$ short-term results for census block groups created from downloaded KML file.

The last of the three widgets (⛔) on the far right side of a model run deletes that model run and everything associated with it from the database.

WARNING: You cannot restore a model run after you delete it.

3.6. Visualization Options

When viewing the results of your analysis, click the *Visualization options* tile to display the *Visualization options* frame (see Figure 17). You have three types of functionality on this frame: *inspect mode*, *census block groups*, and *concentration overlay*. Set the respective widgets to *On* to view one or more options.

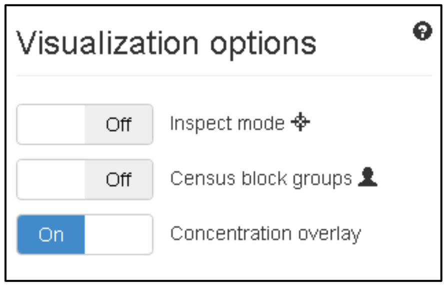


Figure 17. Visualization options frame when viewing scenario results.

Inspect mode displays the concentration at one or more selected locations on your map. To access this feature, set the *Inspect mode* widget to *On*. You can then click on one or more locations of interest. C-LINE then displays the concentration and the coordinates of the location in (latitude, longitude) degrees, not (longitude, latitude).

NOTE: The concentration is not interpolated. Instead, it is obtained from the value of the nearest receptor point (i.e., nearest neighbor method). Also, if the bubble of information would extend beyond the edge of the visible map, C-LINE scrolls the map to make the entire bubble visible. Currently, there is no way to manually reposition a bubble, such as when one hides part of another bubble; you need to close the top bubble to see the information in the hidden bubble.

Figure 18 shows the example results screen (see Figure 14) with *Inspect mode* turned *On*. Inspect mode was used on three locations. If you want to turn off one of the boxes, just click its X in its top right-hand corner. If you want to dismiss all of the boxes and end inspect mode, open the *Visualization options* frame again and set the *Inspect mode* widget to *Off*. This action also turns off all the inspect mode boxes.

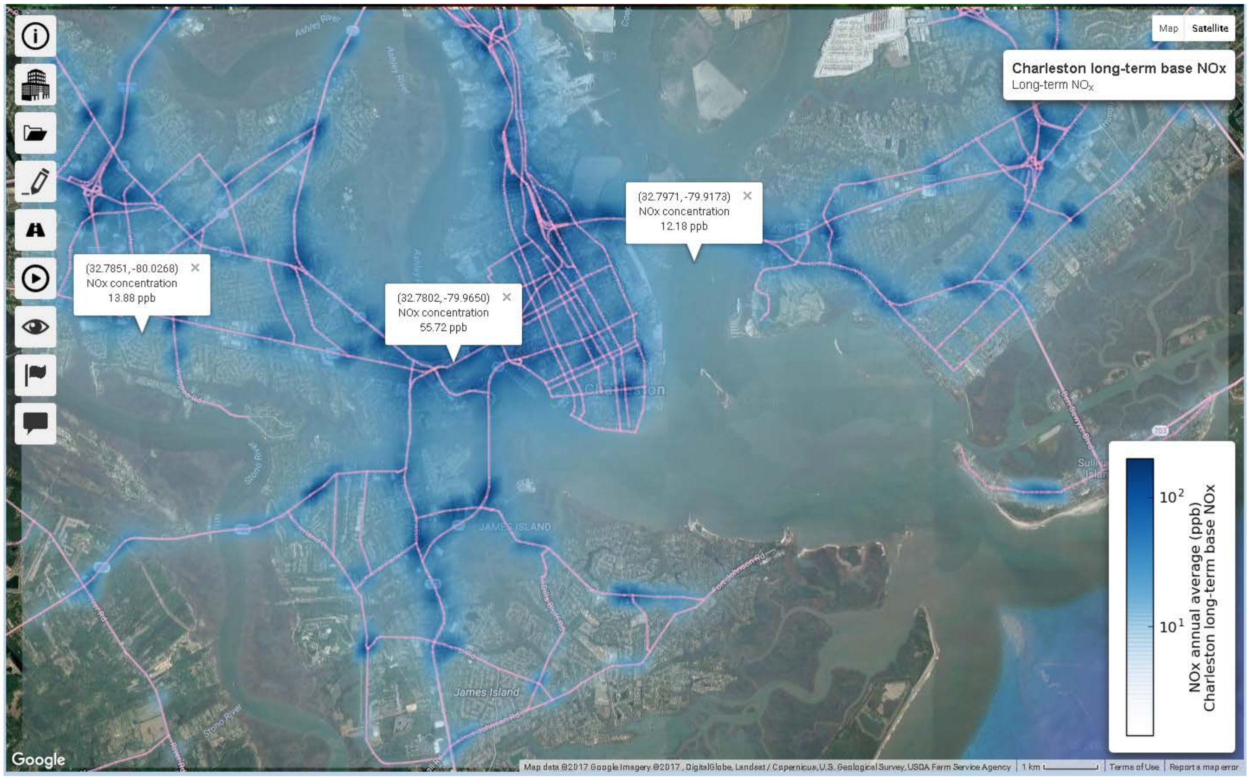


Figure 18. Inspect mode showing long-term average concentrations at three selected locations.

Set the *Census block groups* widget to *On* and the Concentration Overlay button to Off. This shows the overlay of the boundaries of the 2010 census block groups on your modeling domain. Figure 19 shows the census block groups for the long-term NO_x Charleston, SC model run with the underlying concentration field turned off. Four of the census block groups were clicked to show information relevant to that block group. Note that the block group closest to the top edge of the map shows a concentration greater than the cutoff value (i.e., > 200 ppb). Also, the block group at the bottom of the map shows a partial block group (i.e., the block group is partially within the modeling domain). The concentration shown for a partial block group was calculated using receptors located in the part of the block group lying within the modeling domain.

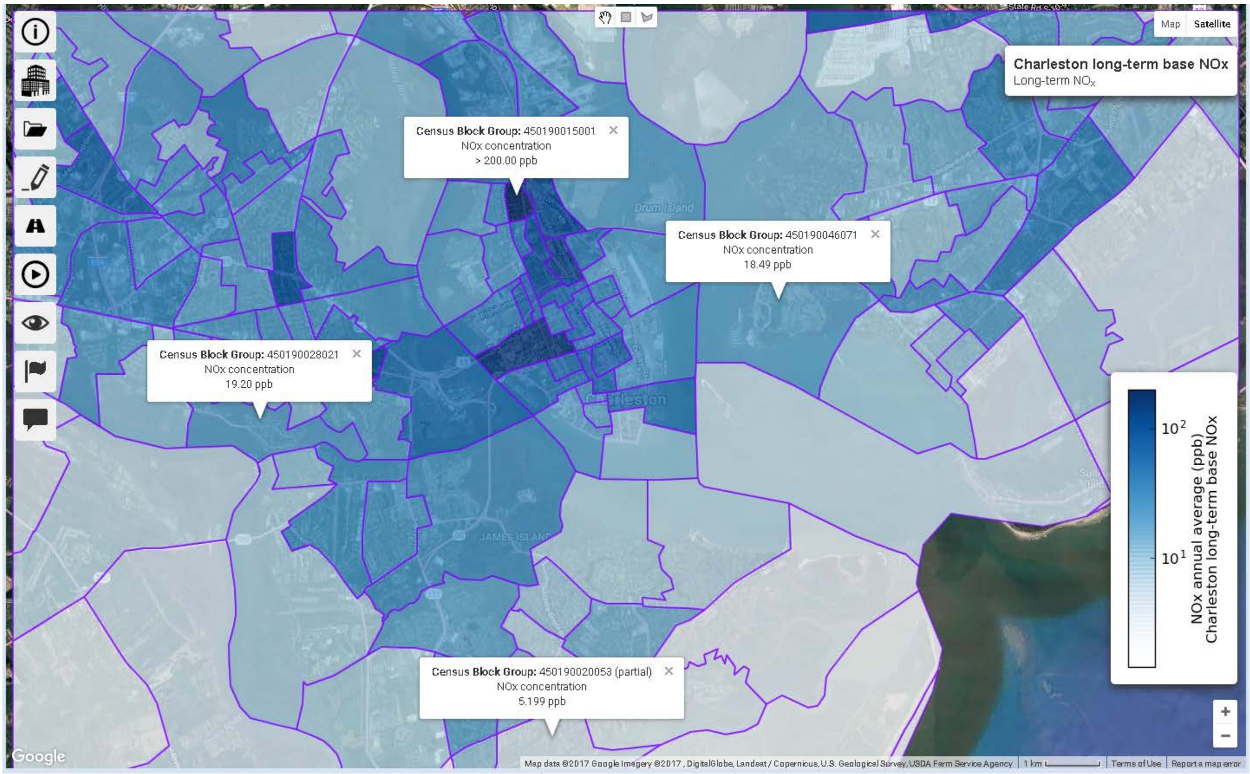


Figure 19. Charleston, SC showing census block group overlay with four concentrations and no concentration layer.

Figure 20 shows short-term concentrations of diesel $PM_{2.5}$ in Charleston, SC for the census block groups. Compare this figure with the Google Earth screenshot created from the downloaded KML file (Figure 16).

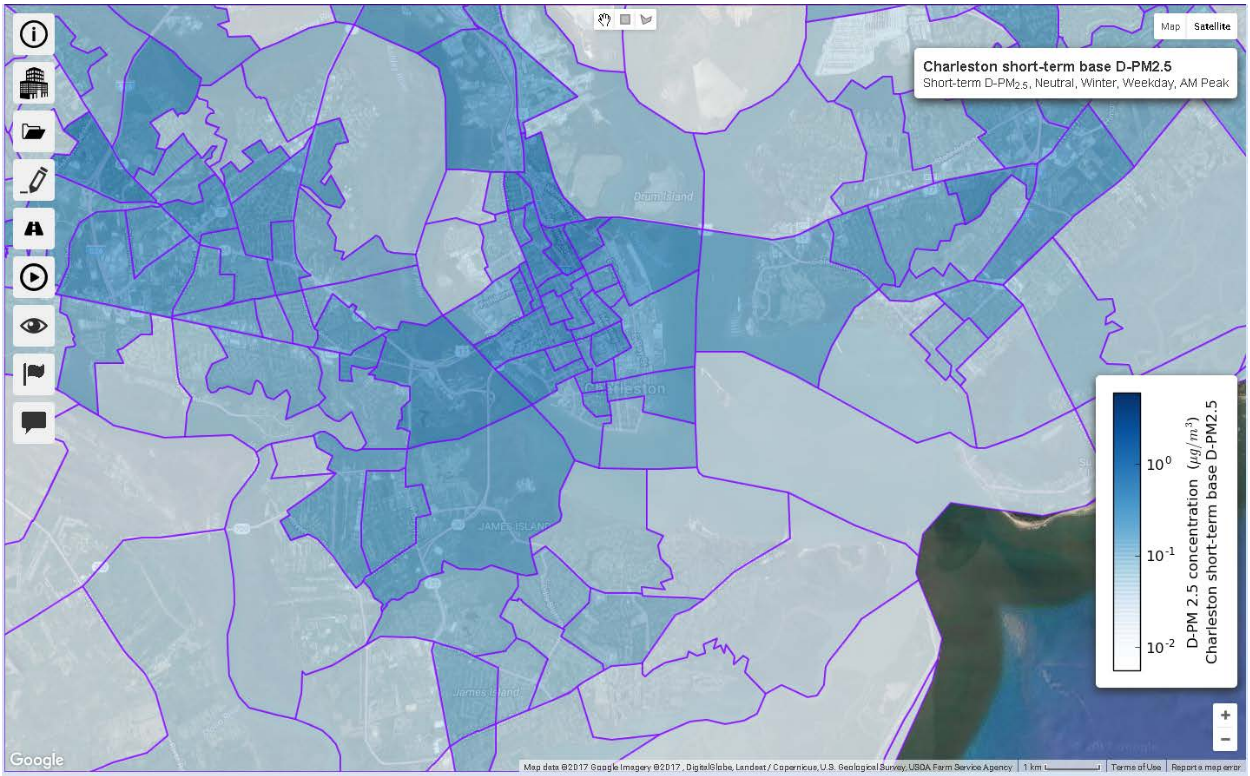


Figure 20. Concentrations of D-PM$_{2.5}$ for short-term concentration in Charleston, SC averaged to census block groups.

The *Concentration overlay* switch allows you to turn the overlay layer on or off. Note that when you turn this layer *Off* you are in *Map* view. If you prefer the *Satellite* view, click the *Satellite* button in the top-right corner of the map window. If you have the map in *Satellite* mode when you turn on the *Overlay layer*, the satellite mode remains as the visualization layer is drawn. You can change between *Map* and *Satellite* modes to fit your needs.

When you are finished working with the results on your map, open the *Visualization options* frame and set all of the widgets to *Off*. This removes the map of your modeling results, values from inspect mode, and census block group boundaries.

3.7. Monitors and Stations

Select the tile *Monitors and Stations* to locate air quality monitors and/or meteorological stations that may be available within or close to your modeling domain. C-LINE includes ambient concentration data from EPA's Air Quality System (AQS) and the locations of meteorological stations.

3.7.1 Air Quality Monitors

Figure 21 shows the types of ambient air quality monitors that can be displayed in C-LINE. Select the types of monitors that you want to display (e.g., NO_x monitor if you are modeling NO_x). Note the colors that designate each of the four pollutants; brown indicates that more than one pollutant is monitored at that site. A **B** within the circle indicates that it is a background monitor for one or more pollutants, as designated by the EPA/state agency for Monitor Objective. Click the *Show monitors* button to display the monitors on your map.

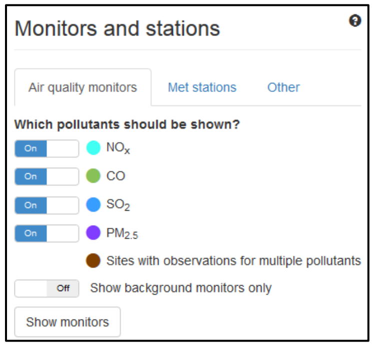


Figure 21. Air quality monitors by pollutant measured.

You can turn on the monitors to view the historical data (from 2010 – 2015, depending on monitor). Summary statistics in the form of maximum and mean concentrations are presented for each of these six years when available for a given pollutant. To display the mean and maximum concentrations for available years, click the monitor's circle on the map. To remove only the bubble information, you can either click again on the monitor's circle on the map or click on the **X** in the top right corner of the monitor information box. To remove both the monitors and their information from your map, click the *Hide monitors* button.

Figure 22 shows two monitors in the greater Atlanta region. The monitor designated by a bright blue circle is for SO_2 only. It is on the AQS network of monitors and recorded the given maximum and mean 1-hr concentrations of SO_2 for the years 2010 through 2014. The monitor designated by a brown circle has observations for four pollutants: NO_x, CO, SO_2, and $PM_{2.5}$ as 1-hr concentrations. The **B** within the circle indicates that it is a background monitor for one or more pollutants. The background monitor is for CO, which is identified by the word "background" within the Monitor Objective, as defined by the EPA/state agency. The $PM_{2.5}$ monitor does not have data for 2010.

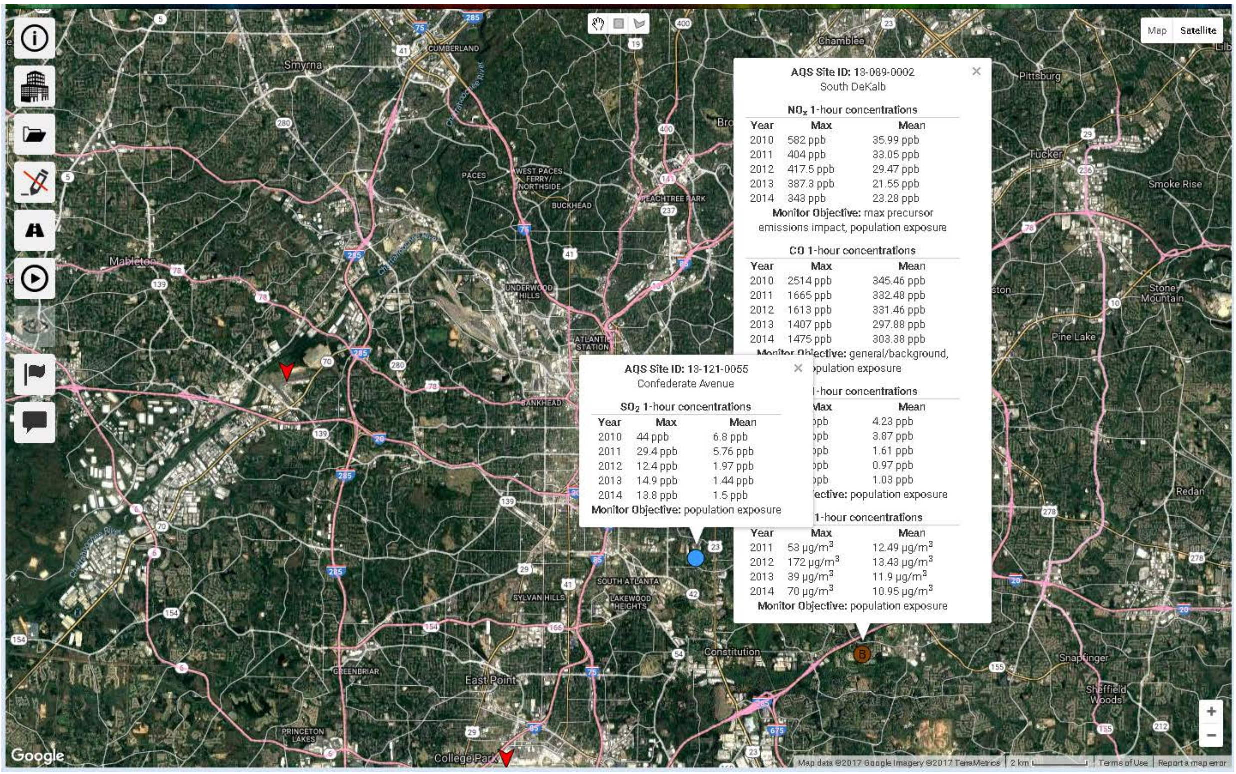


Figure 22. Air quality monitors and meteorological stations in greater Atlanta, GA.

3.7.2 Meteorological Stations

Figure 23 shows the contents of the *Met stations* tab on the *Monitors and stations* frame. Turn the widget to the *On* position to show the meteorological stations on the map. As shown at the bottom of Figure 24, there is a meteorological station in the vicinity of that NY/NJ modeling domain. The station's location is designated by the red, downward pointing arrow ( ). Hover your cursor over the station's arrow to change the cursor to a pointing hand. The World Meteorological Organization (WMO ID) and the International Civil Aviation Organization (ICAO ID) identifiers are then displayed.

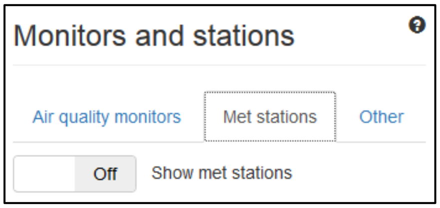


Figure 23. Turn on/off meteorological stations.

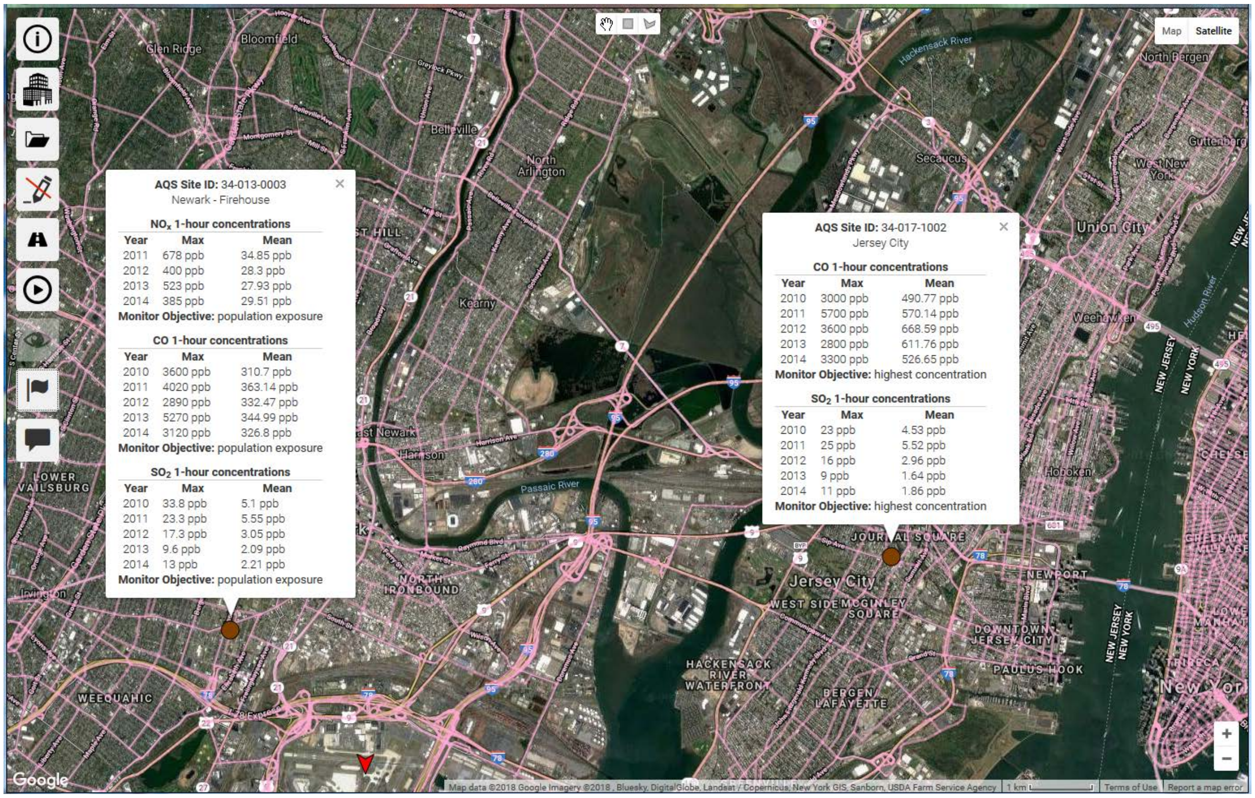


Figure 24. Example showing AQS monitors and data and meteorological station for selected sites in the New York/New Jersey area.

3.7.3 Other Monitors and Stations

Use the Other tab to enter two other types of data for your reference. These are air quality observations for one site and points of interest. You can enter one air quality observation site. For example, this may be a site associated with a facility or a temporary site affiliated with a field campaign. Figure 25 shows this tab after entering the location for a monitoring site. Click the *Download example file* link to download the file shown in Figure 26. Note that the *Choose file* button is visible only after entering a site's location in decimal degrees.

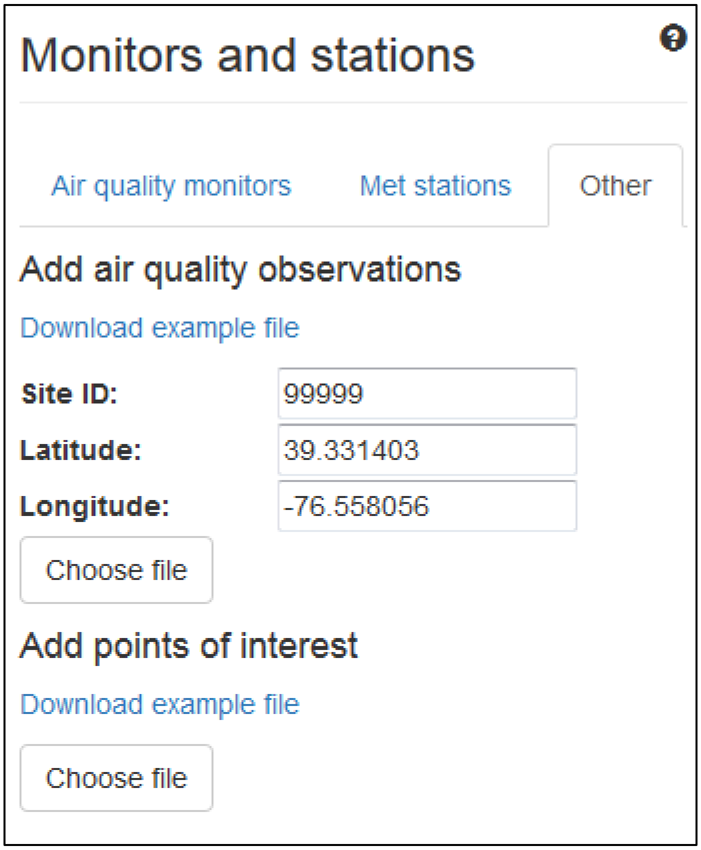
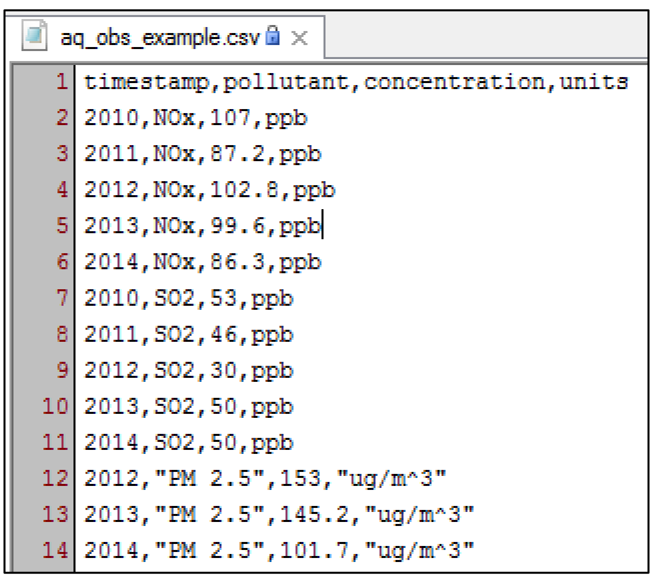


Figure 25. Monitors and Stations, Other tab for an air quality observation station and points of interest.

Figure 26 shows the example air quality observations file. Note that it can contain data for multiple years and pollutants, but for only one site. Also, quotation marks must be used when there is an embedded space in the pollutant or units field.


aq_obs_example.csv

```
timestamp,pollutant,concentration,units
2010,NOx,107,ppb
2011,NOx,87.2,ppb
2012,NOx,102.8,ppb
2013,NOx,99.6,ppb
2014,NOx,86.3,ppb
2010,SO2,53,ppb
2011,SO2,46,ppb
2012,SO2,30,ppb
2013,SO2,50,ppb
2014,SO2,50,ppb
2012,"PM 2.5",153,"ug/m^3"
2013,"PM 2.5",145.2,"ug/m^3"
2014,"PM 2.5",101.7,"ug/m^3"
```

Figure 26. Sample CSV file of air quality observation for multiple years and pollutants.

After entering the latitude and longitude in decimal degrees and a value for site ID, click the *Choose file* button just under the Longitude box and select your file to upload. For this example a location in Baltimore, MD that is between two existing monitoring sites was selected and the example file was uploaded. Figure 27 shows this site as a yellow dot. Click on the yellow dot to display the uploaded data. Also note that the one concentration per year and pollutant is shown as the maximum value; the mean value cannot be uploaded to C-PORT at this time.

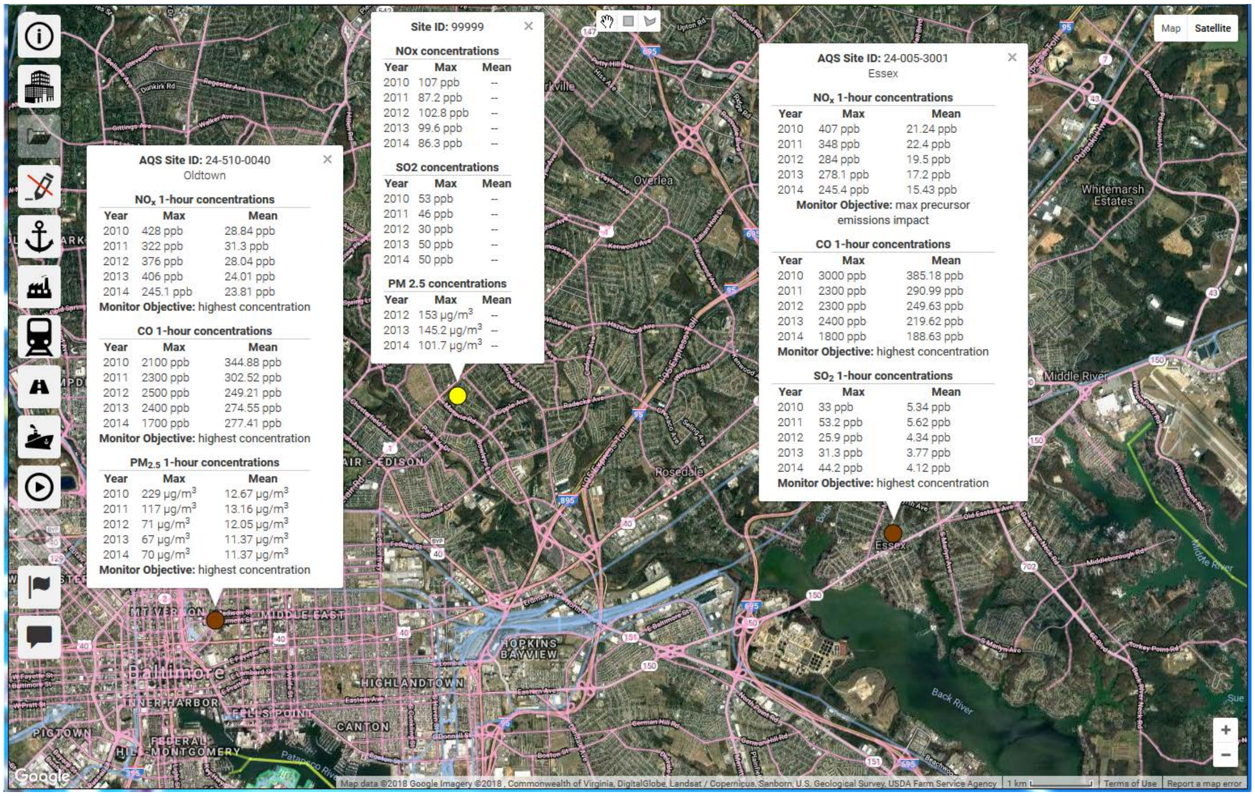
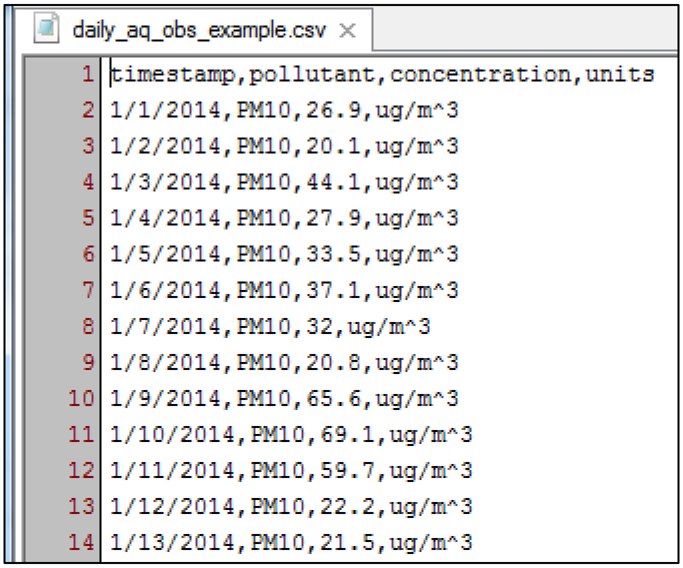


Figure 27. Baltimore, MD modeling domain showing AQS monitoring data for two monitoring sites (brown dots) and uploaded user-supplied air quality observation data (yellow dot).

You are, however, able to upload your air quality observations file for daily instead of annual concentrations. Figure 28 shows the format of the daily air quality observations file. Daily values can also be uploaded for multiple years and pollutants. After uploading the file, C-PORT calculates the maximum and mean concentrations on the daily basis. When the calculated annual observation values are displayed from uploaded daily data, each year is a link. Click the link to get a time series plot of concentrations for that year and pollutant (Figure 29). Days that are missing from your observations file are shown as 0 concentration on the time series plot.




```
timestamp,pollutant,concentration,units
1/1/2014,PM10,26.9,ug/m^3
1/2/2014,PM10,20.1,ug/m^3
1/3/2014,PM10,44.1,ug/m^3
1/4/2014,PM10,27.9,ug/m^3
1/5/2014,PM10,33.5,ug/m^3
1/6/2014,PM10,37.1,ug/m^3
1/7/2014,PM10,32,ug/m^3
1/8/2014,PM10,20.8,ug/m^3
1/9/2014,PM10,65.6,ug/m^3
1/10/2014,PM10,69.1,ug/m^3
1/11/2014,PM10,59.7,ug/m^3
1/12/2014,PM10,22.2,ug/m^3
1/13/2014,PM10,21.5,ug/m^3
```

Figure 28. Daily concentration format for air quality observations data.

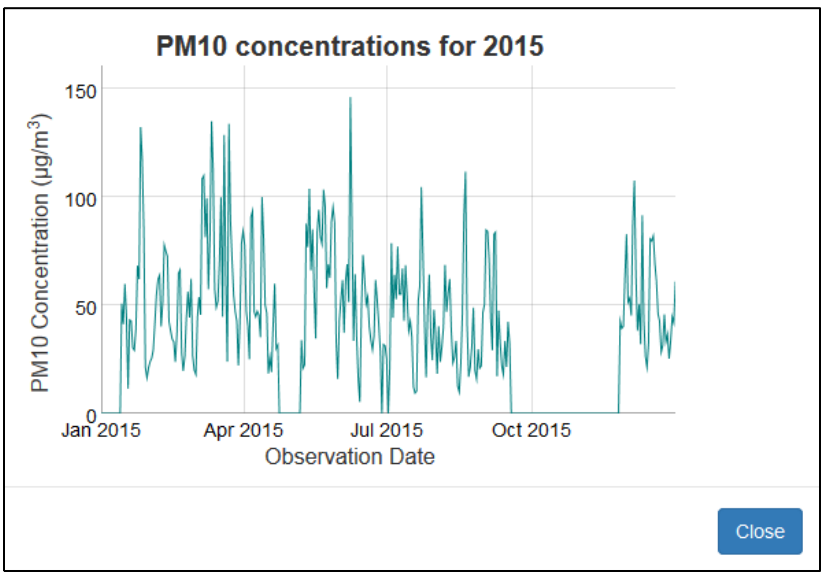


Figure 29. PM10 daily concentrations for 2015 from example daily dataset.

After uploading the csv file of air quality observations, the *Choose file* button (Figure 25) changes to the *Clear observations* button. Clicking this button removes the yellow dot and the observations values from the map, if currently displayed. Whether or not you clear the observations, they are not saved as part of your model run and are not available when you download your results or reload your model run.

The add points of interest section is after the add air quality observations section (Figure 25). Click the *Download example file* link to download the example points of interest file. Figure 30 shows the format of this file. You need the latitude and longitude in decimal degrees and the name of each location. If you have a space or a comma within the name, put that string within quotation marks.

```
points_of_interest_example.csv
1 latitude,longitude,name
2 39.2903848,-76.6121893,"Baltimore, MD"
3 31.1499528,-81.4914894,"Brunswick, GA"
4 32.7764749,-79.9310512,"Charleston, SC"
```

Figure 30. Sample CSV file for points of interest.

After loading a CSV file for three points of interest in Charleston, SC, each point of interest is displayed with a yellow, upward pointing arrow (Figure 31). The name of each point is not displayed on the map, but is displayed for one location if the mouse is hovered over it.

Figure 31. Charleston, SC with three points of interest displayed as yellow, upward pointing arrows.

4. Changes to Inputs for Comparative Analyses

A comparative analysis compares the concentration field from a baseline analysis (old) to an analysis with a different concentration field (new) throughout the modeling domain. The same modeling domain, which is defined by its geographic center and extent, pollutant, and metric must be used for both the old and new analyses.

Because the concentration field is calculated by C-LINE using on-road mobile emissions, the **new** analysis needs to change some of the emissions input values for long-term concentrations. For short-term concentrations, you can change either emissions or meteorological conditions. The following input changes affect the results produced by a C-LINE model run.

- Change the traffic (AADT)
- Change the average speed (mph)
- Change the vehicle mix (see Section 4.4)
- Edit a single road segment
- Edit multiple road segments
- Add a new road segment
- Remove a road segment
- Select different meteorological conditions

The remainder of this section presents the *View and modify roads* frame, provides details on these eight methods to change on-road mobile emissions, illustrates examples of the two types of comparative analyses available in C-LINE, and discusses the legend box.

4.1. *View and modify roads* Frame

Click the *View and modify roads* tile to display its associated frame. Figure 32 shows all of the data elements for roads. You can change the street name for new road segments only.

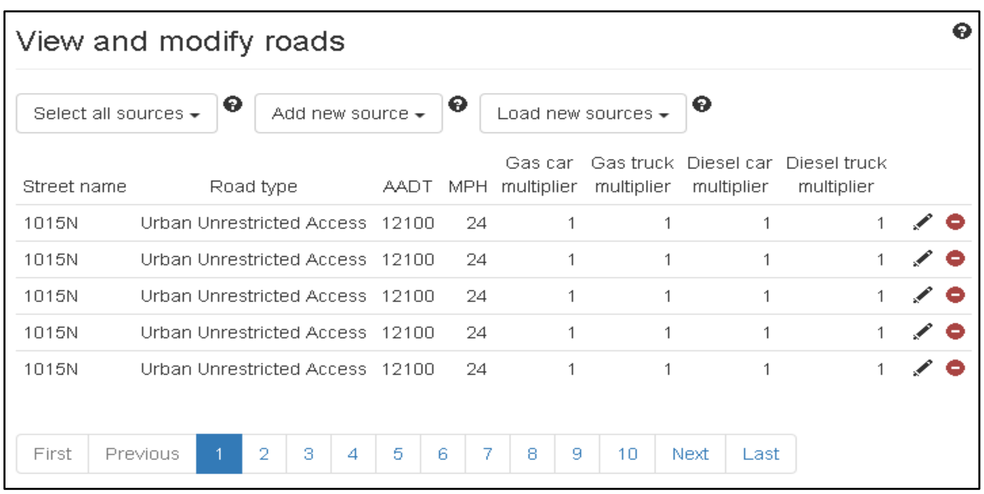


Figure 32. *View and modify roads* frame.

Use the *Select all sources* button to select all roads or all roads belonging to the selected road type. Figure 33 shows all roads selected for road type *urban unrestricted access*. Selected road segments are shown in the table in red; a new button *Unselect all sources* then appears between the *Select all sources* and the *Add new source* buttons. You can also unselect all sources using the *Clear selections* button in the lower left corner of the map window.

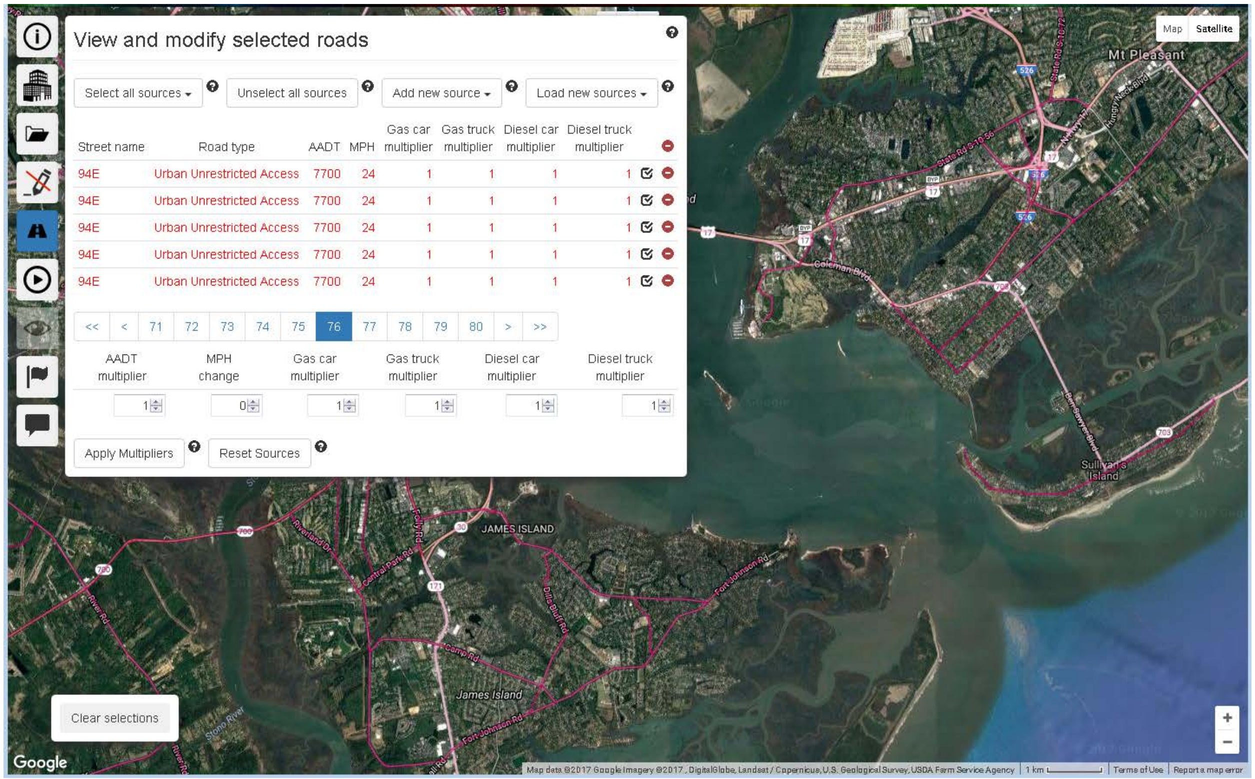


Figure 33. Charleston, SC with all *Urban Unrestricted Access* roads selected.

4.2. Change the Traffic (AADT)

AADT is the annual average daily traffic volume (number of vehicles) on a road segment. You can increase or decrease the AADT for one road segment by using the up/down arrows or by deleting the old value and typing in a new one. When more than one road segment is selected, use the AADT multiplier widget to change the AADT for all selected road segments by the same factor. For example, to decrease the AADT by 10% specify the multiplier **0.9**, and to increase the AADT by 25% specify the multiplier **1.25**.

Several types of studies may require a change in the AADT. You may need to look at general growth in traffic across the modeling domain or in a section of the domain. Examples of growth to expect include: a new subdivision, school, office complex, or sports arena to be built in one area. A new highway could be built or widened to handle increased traffic flow. You may need to compare the effects of several potential routes for a major thoroughfare during a planning phase and may need to shut down a major roadway for repairs and move the traffic to alternate routes.

4.3. Change the Average Speed (MPH)

Miles per hour (mph) represents the average speed on the road segment. Speed is one factor used to determine emissions for each vehicle type on a road segment. Although emissions are partially determined by average speed, the calculation is not sufficiently sensitive to warrant making changes to average speed on the order of 1 mph. For example, the difference in vehicular emissions is very small when comparing 36 and 37 mph. Therefore, C-LINE uses a binning approach to calculating vehicular emissions.

Emissions are calculated in 5-mph bins. This means that the assigned speed is rounded to the nearest 5-mph (e.g., 33 - 37 are all assigned the 35-bin, 38-42 are all assigned the 40-bin). The bins are 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, and 75 mph.

4.4. Change the Vehicle Mix

C-LINE uses four vehicle classes: gasoline car, gasoline truck, diesel car, and diesel truck. The vehicle mix represents the percentage of each of the vehicle classes on the road for the specified time period. The vehicle mix was obtained from a national vehicle emissions dataset. The default vehicle mix is determined for each road class in each county in your modeling domain. As shown in Figure 32, *All road segments*, start with "1" as the multiplier for each of these four vehicle classes, indicating that the default vehicle mix is to be used.

Adjust the vehicle mix by changing the multipliers. For example, to decrease the gasoline cars by 50% put 0.5 in the 'Gas car multiplier' box. This multiplier value would decrease the number of gasoline cars and would increase the number of all other types of vehicles (i.e., gasoline trucks, diesel cars, and diesel trucks) to keep AADT constant.

4.5. Edit a Single Road Segment

Select a road segment by clicking it on the map or in the *View and modify roads* frame. Refer to section 3.1 for more details on using the *hand* widget. Figure 34 shows how one selected road segment is displayed in red in the table; its color is also changed from pink to red on the map.

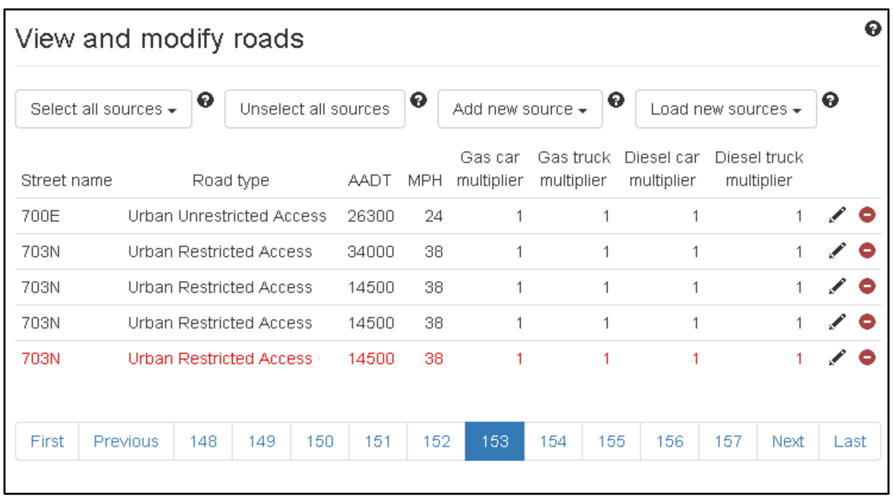


Figure 34. *View and modify roads* frame with one selected road segment.

Click the black pencil icon ( ) on the right side of the selected road segment; this action starts edit mode. Figure 35 illustrates the *View and modify roads* frame while changes are being made to the one selected road segment. The pencil changes to a green check ( ); press this icon when you are finished editing the line. After changing something on a line, a blue circular arrow ( ) appears on that line; press this icon to revert your changes back to their original values. If you want to delete a road segment from your analysis, press the red icon (⛔) on the far right side of that segment. You cannot select more than one road segment from the table to delete multiple segments.

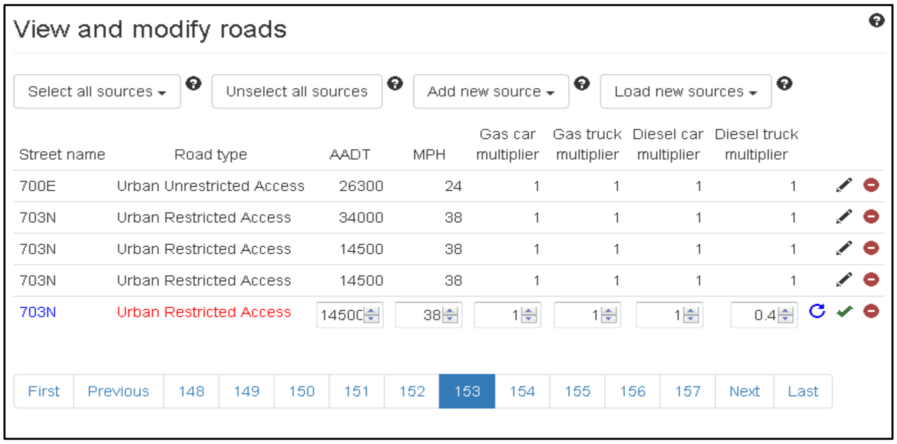


Figure 35. ***View and modify roads*** **frame showing one road segment being edited.**

Note how the vehicle distribution has been changed in Figure 35. Every road segment begins with all the vehicle type multipliers set to 1, signifying that C-LINE will use the preset distribution for that road class and county. But this road segment has been changed to decrease the proportion of diesel trucks. The number of vehicles belonging to the other three vehicle classes is increased so the AADT is not changed. Also note that the name of the road segment is now shown in blue, indicating that at least one value associated with this road segment has been changed.

4.6. Edit Multiple Road Segments

C-LINE provides several methods to select multiple road segments to edit as a group. To make the same change to all road segments in the modeling domain, use the *Select all sources* button on the *View and modify roads* frame (see Figure 32). Section 3.1 provides instructions on using the *hand* widget to select individual road segments or the *box* or *polygon* widget to select a geographic grouping of road segments. To deselect a link, find it in the table and click the black check mark (☑) on the right side of that link (see Figure 36). The red icon (⛔) on the far right side of a road segment deletes that segment from the analysis, whereas the black check mark only removes that segment from the group of road segments being edited.

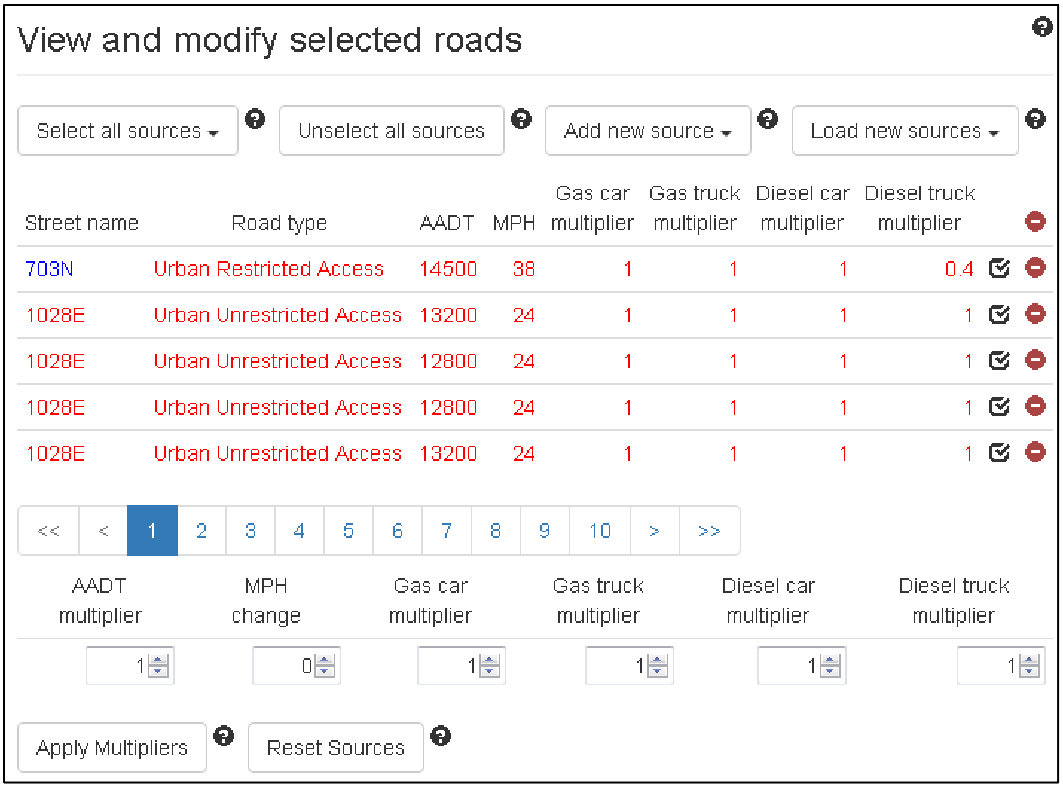


Figure 36. *View and modify selected roads* frame with multiple road segments selected.

Note how the widgets for changing values are now located at the bottom of the frame. Any change that you make here affects all the selected road segments whether or not they appear on the current frame. Also, you cannot change the AADT or the mph values to a specific value; those changes are relative to the existing values.

- AADT multiplier: This is a factor to be applied to the AADT of all selected road segments. To decrease the AADT, use a multiplier less than one. To increase the AADT, use a multiplier greater than one. If you do not want to change the AADT, set the multiplier equal to one.
- MPH change: This is a value to be added to the mph value for each selected road segment. Use the up and down arrows to change the average speed in increments of 5 mph. Use a positive value to increase the average speed, a negative value to decrease the average speed, and zero for no change to speed.
- Vehicle type multipliers: Information on these multipliers is discussed above (see Section 4.4). Note that these multipliers will be applied to all selected road segments regardless of road type and county.

When edits to this group of road segments are complete, press the *Apply Multipliers* button. NOTE: This button applies the mph change, as well as the values for the five multiplier widgets.

To discard changes, press the *Reset Sources* button. This reloads values from the database, but deleted segments are not restored.

4.7. Add a New Road Segment

This section describes how to add a new road segment (i.e., a source in C-LINE) to a modeling domain. Figure 32 through Figure 36 show the *View and modify roads* frames for several types of edits. Each of those figures shows the button *Add new source*.

First, click the *Add new source* button at the top of the *View and modify roads* frame. The drop-down list shows the four road classes supported in C-LINE (see Figure 37). Roads are categorized as *urban* or *rural* and then as functional classes within each of those. If a road segment is within a city limit, categorize it as *urban*; otherwise it is *rural*. The highest functional class is *restricted access*. The functional classifications are documented by the U.S. Department of Transportation, Federal Highway Administration, "Highway Performance Monitoring System (HPMS) Guidance for the Functional Classification of Highways (Updated)" available from https://www.fhwa.dot.gov/policy/ohpi/hpms/fchguidance.cfm

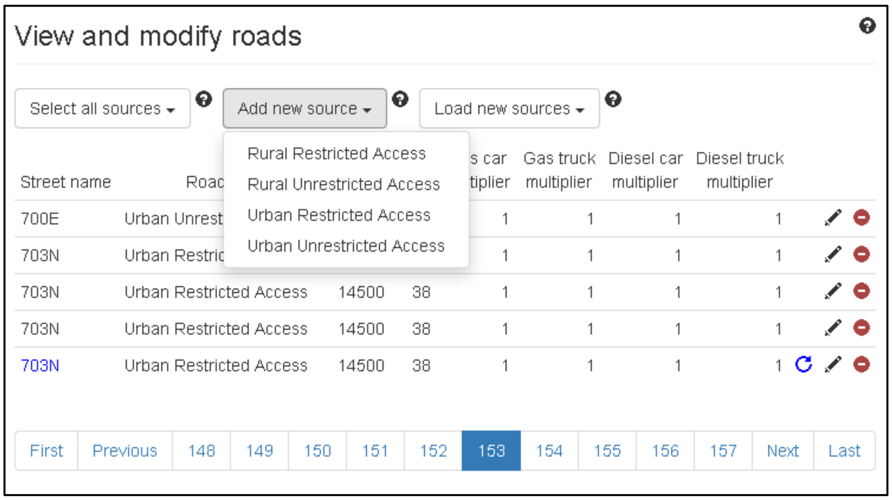


Figure 37. ***Add new source*** **drop-down list.**

- Select **urban unrestricted access**. The frame then disappears and the cursor changes into a plus sign (+). Also, note that a tile *Cancel adding new source* with a red X is added to the tiles list.
- Click the starting point of the new road segment and the number of times needed to define the road as a series of straight line segments. Double-click the end of the last line segment.
- The cursor changes back to a hand. Point the cursor to any part of the new road segment and click to select it. That road segment is displayed in red on the map.
- The *View and modify roads* frame then appears again and the new road segment is shown in red as the last road in the list (see Figure 38).

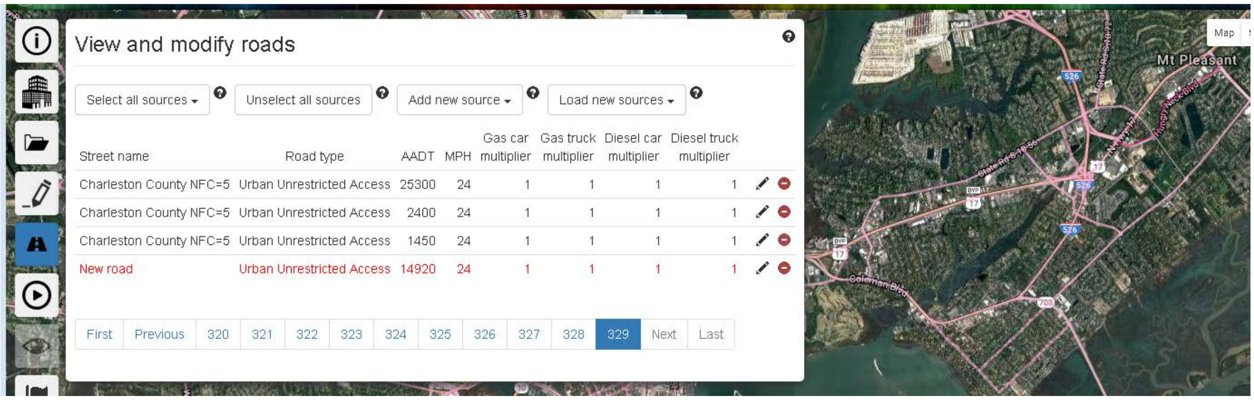


Figure 38. View and modify roads frame with new segment in red both in the table and on the map.

Note that the new road is shown in red in the top right corner of the figure. The map shows the road's name as "Hungry Neck Blvd". Click the pencil icon to edit the new source line. Edit the value for *Street name* so the new roads do not all have the name "New road". C-LINE assigned the AADT based on the road classification. In this example, the road is named "Hungry Neck Blvd", the *AADT* is set to "14920", and all vehicle multipliers are set to "1" (see Figure 39). Click the green check mark icon to save these changes for that road segment.

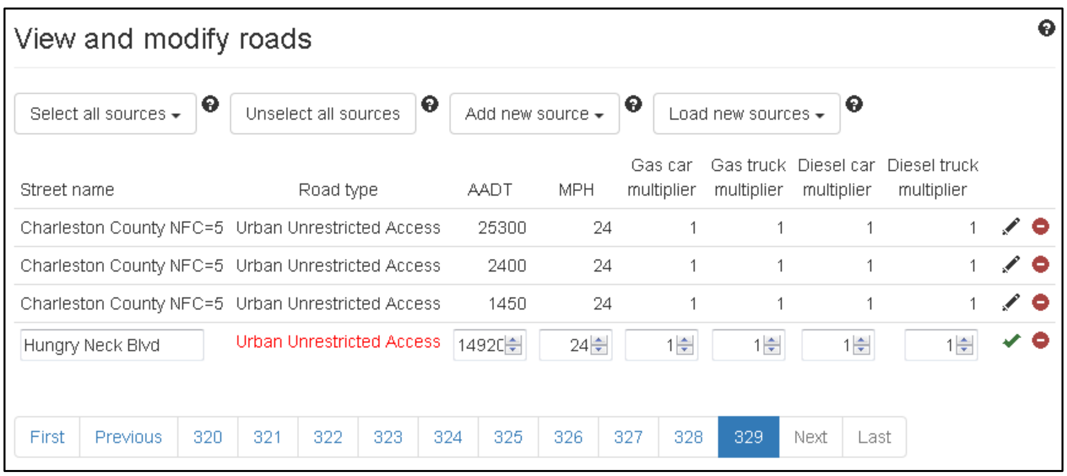


Figure 39. Add new road segment.

4.8.Load New Road Segments

If you have a small number of new roads to add to your model run, Section 4.7 described the interactive method to draw and enter the relevant information for each new road. Alternatively, C-LINE v5.1 offers a method to upload a file containing multiple new roads. Figure 40 shows the two options available in the *Load new sources* drop-down list on the *View and modify roads* frame.

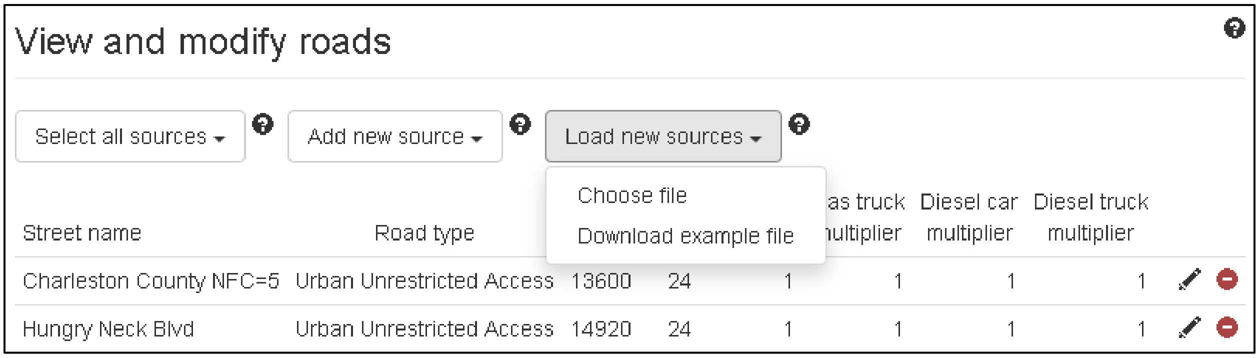


Figure 40. *Load new sources* drop-down list in *View and modify roads* frame.

The *Download example file* selection downloads the example file for road sources via your browser (see Figure 41). Your browser provides the functionality to save the file or to allow you to directly open the file with a text editor. In this example Firefox will save the file to its download directory. You can also see that the default text editor is Notepad.

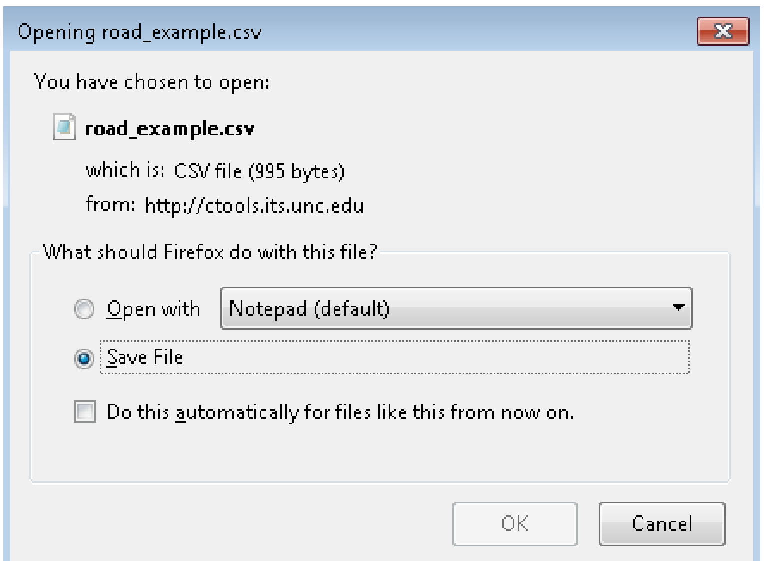


Figure 41. Dialog box to download and open or save the road_example.csv file.

Figure 42 shows an example of a road_example.csv file. When you create your file to upload, follow the format exactly so C-LINE can successfully load the data into your model run. Here are the rules to follow.

- The file must be in comma-separated value format (i.e. csv).
- The header (shown in Figure 42) is really on one line. It cannot contain end-of-line characters.
- The road class is an integer instead of the text shown in Figure 37. Locate the correct integer code for each road class in this list.
    - Rural Restricted Access: 2
    - Rural Unrestricted Access: 3
    - Urban Restricted Access: 4

   - Urban Unrestricted Access: 5

- Each road segment is defined by its 2 endpoints specified as decimal longitude and latitude in degrees.

- Each road segment is on its own line. NOTE: This is different from the roads that you can add manually, where you can easily draw a polyline (multiple, connected segments).

- State FIPS code and county FIPS code are in integer format (i.e., no leading zeros).

```
road name,road class,start longitude,start latitude,end longitude,end latitude,state FIPS
code,county FIPS code,AADT,MPH,gas car multiplier,gas truck multiplier,diesel car
multiplier,diesel truck multiplier
"231",4,-85.6603217314,30.160603377,-85.6603065893,30.1620548647,12,5,7700,24,1,1,1,1
"231",4,-85.6455741355,30.1861009538,-85.6442794689,30.1870186636,12,5,18100,24,1,1,1,1
"231",4,-85.6442794689,30.1870186636,-85.6429848022,30.1879363733,12,5,18100,24,1,1,1,1
"231",4,-85.6429848022,30.1879363733,-85.6416901355,30.1888540821,12,5,18100,24,1,1,1,1
"231",4,-85.6416901355,30.1888540821,-85.6410298547,30.1893221139,12,5,18100,24,1,1,1,1
"231",4,-85.6410298547,30.1893221139,-85.6409347389,30.1893895364,12,5,28500,24,1,1,1,1
"231",4,-85.6409347389,30.1893895364,-85.6403953278,30.1897716668,12,5,28500,24,1,1,1,1
"231",4,-85.6403953278,30.1897716668,-85.639734876,30.1902395447,12,5,28500,24,1,1,1,1
"231",4,-85.639734876,30.1902395447,-85.6391003242,30.1906890756,12,5,28500,24,1,1,1,1
```

Figure 42. Example text of road_example.csv

To upload your road segments file in csv format, select the *Choose file* in the *Load new sources* drop-down list. This opens a file chooser window for you to navigate to your file. Then, press the *Open* button to close the file chooser and upload your file. C-LINE processes the file and then pops up a box containing the number of sources loaded. Compare that value to the number of sources that you had listed in the file you uploaded to make certain that all of your sources uploaded successfully.

4.9. Remove a Road Segment

You can easily remove one or more road segments from a model run. **WARNING:** Once removed from the model run, the road segments cannot be put back in. Follow these steps.

- Start edit mode.
- Select one or more road segments. They will be shown in red on the map and as a group of red selected roads in the *View and modify selected roads* frame.
- Make certain that you want to remove all of the selected road segments.
- Click the *Delete source* icon at the right end of each segment. Alternatively, click the *Delete all selected* icon to the right of the "Diesel truck multiplier" heading and respond appropriately to the dialog box requesting confirmation of the deletion.

WARNING: If the browser brings up a dialog box asking if you want to prevent the current page from bringing up more dialog boxes, click *Okay* to allow C-LINE to bring up the dialog boxes; otherwise, you will not be able to delete more of your selected roads and you may need to reset your C-LINE session (see Figure 43).

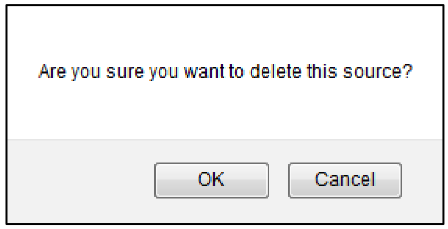


Figure 43. Click OK to delete the selected source, or Cancel to not delete the source.

Figure 44 shows the C-LINE screen with selected road segments at the western end of Sullivan's Island. The selected road segments are shown in red on the map and as the selected roads in the table. Delete each road segment and confirm deletion of each.

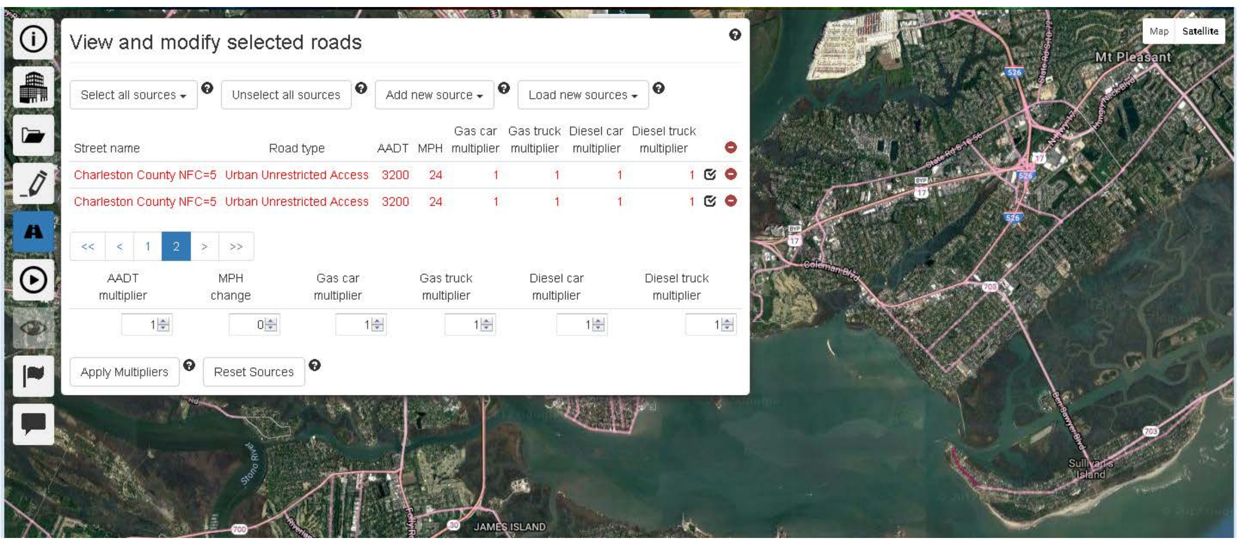


Figure 44. Selected road segments shown on map and *View and modify selected roads* frame.

After you finish deleting these road segments, click the *Perform analysis* tile, and then change the *Name* to "Charleston, SC - rd + Hungry Neck Blvd". Add "Removed rd west end Sullivan's Island; added Hungry Neck Blvd" to the *Description*. Click the *Start Model Run* button. Continue to use long-term NO_x settings. Figure 45 shows where the road was deleted (red) and those concentrations are lower than the same area in base case (see Figure 18). Also note where Hungry Neck Blvd. was added (yellow).

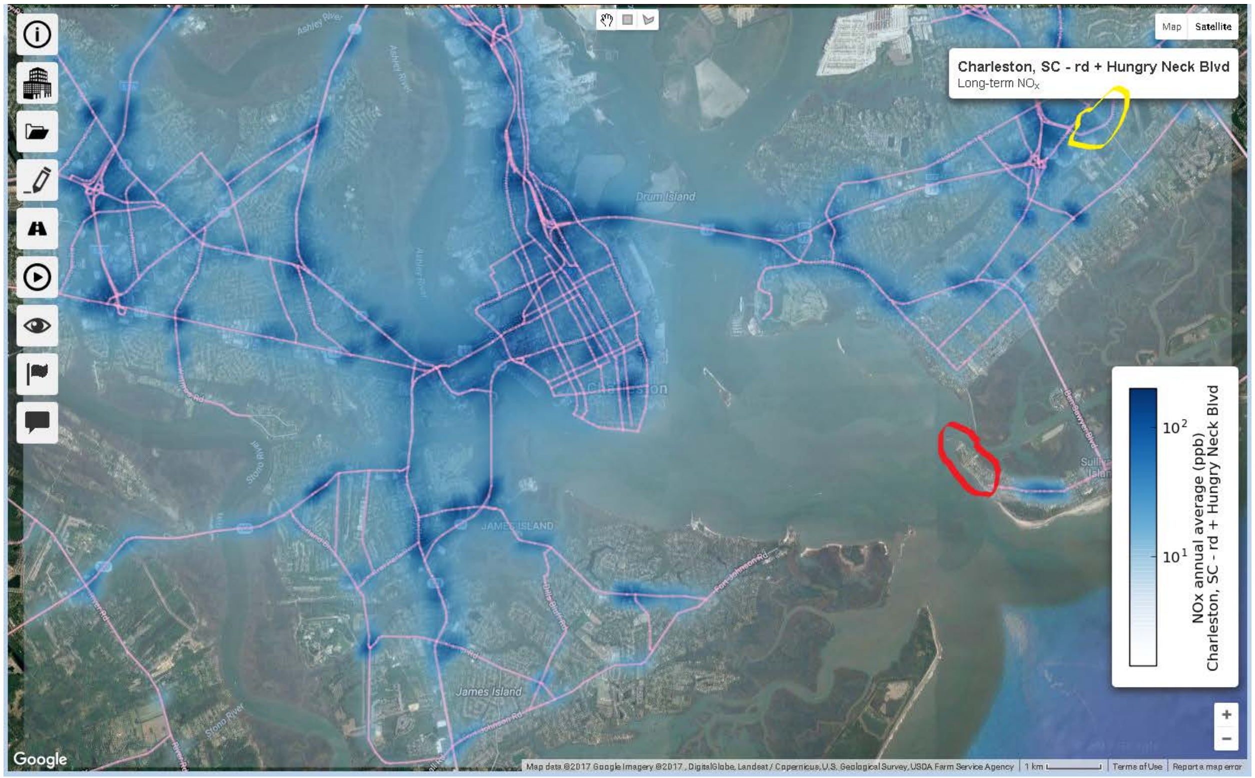


Figure 45. Results of long-term concentration scenario after deleting a road (red circle) and adding Hungry Neck Blvd. (yellow circle).

4.10. Select Different Meteorological Conditions

C-LINE can simulate a range of meteorological conditions as shown in Figure 8 and discussed in Section 3.4. Figure 46 shows the Perform Analysis frame when long-term concentrations are selected. Because calculating long-term average concentrations uses a statistical approach involving all meteorological conditions occurring at the selected site, you cannot select specific meteorological conditions for long-term computations.

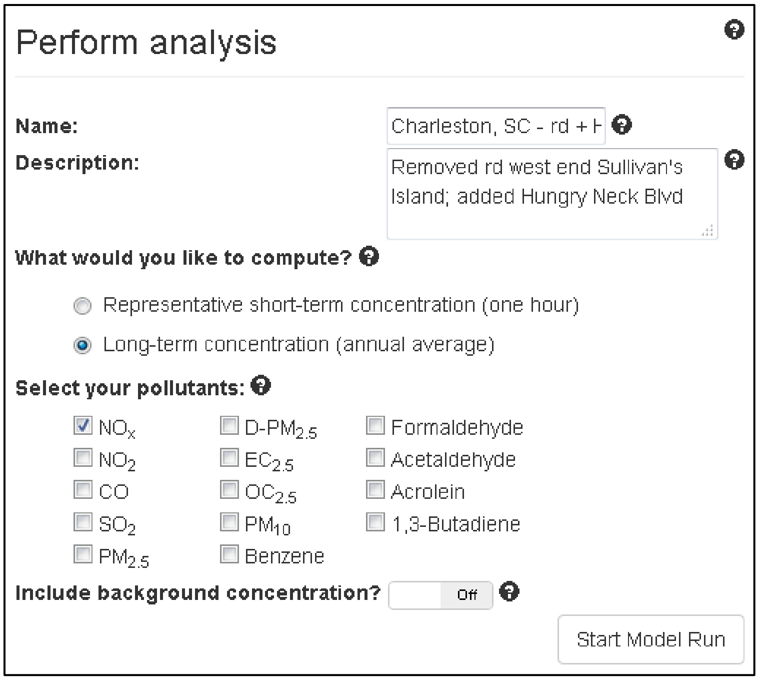


Figure 46. ***Perform analysis*** **frame for long-term meteorological conditions.**

Figure 47 shows selections for the same sources as used above (see Figure 45) but for a short-term (one-hour) time period. The meteorological conditions are for *neutral* atmospheric stability, *winter* season, *NW to SE* wind direction, *weekday*, during the *AM peak* traffic.

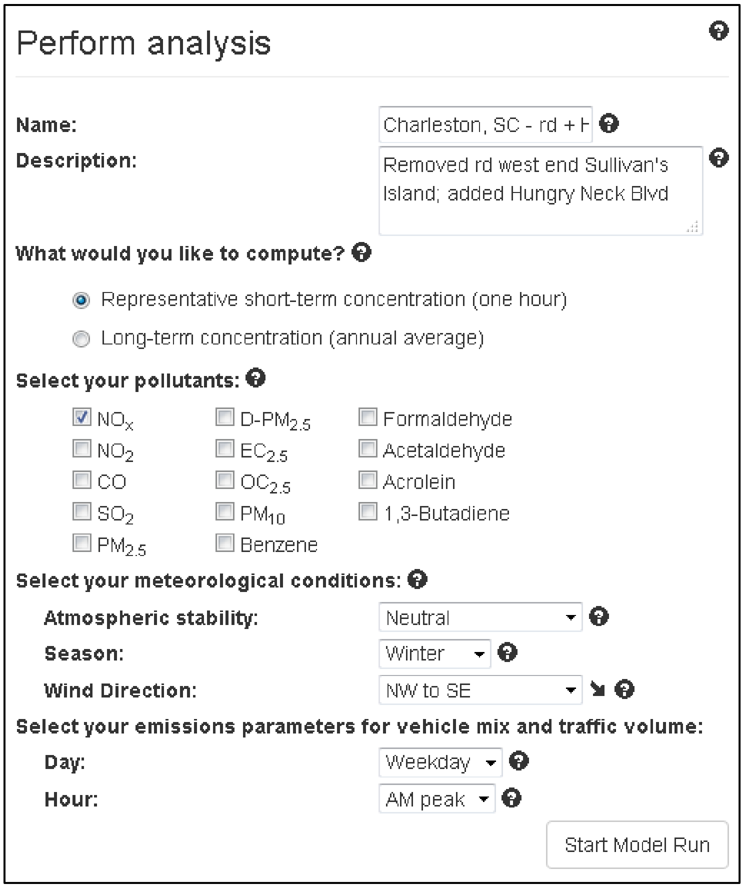


Figure 47. *Perform analysis* frame for short-term (one-hour) model run.

Figure 48 shows short-term modeled NO_x concentrations for weekday AM peak traffic under neutral atmospheric stability in the winter months using the seasonal average wind direction. Note that the legend shows "NO_x concentration (ppb)" indicating that the analysis was on a short-term basis and computed concentrations in units of ppb for the pollutant NO_x. The individual parameters that determined the meteorological conditions and the vehicular emissions are not included in the results map.

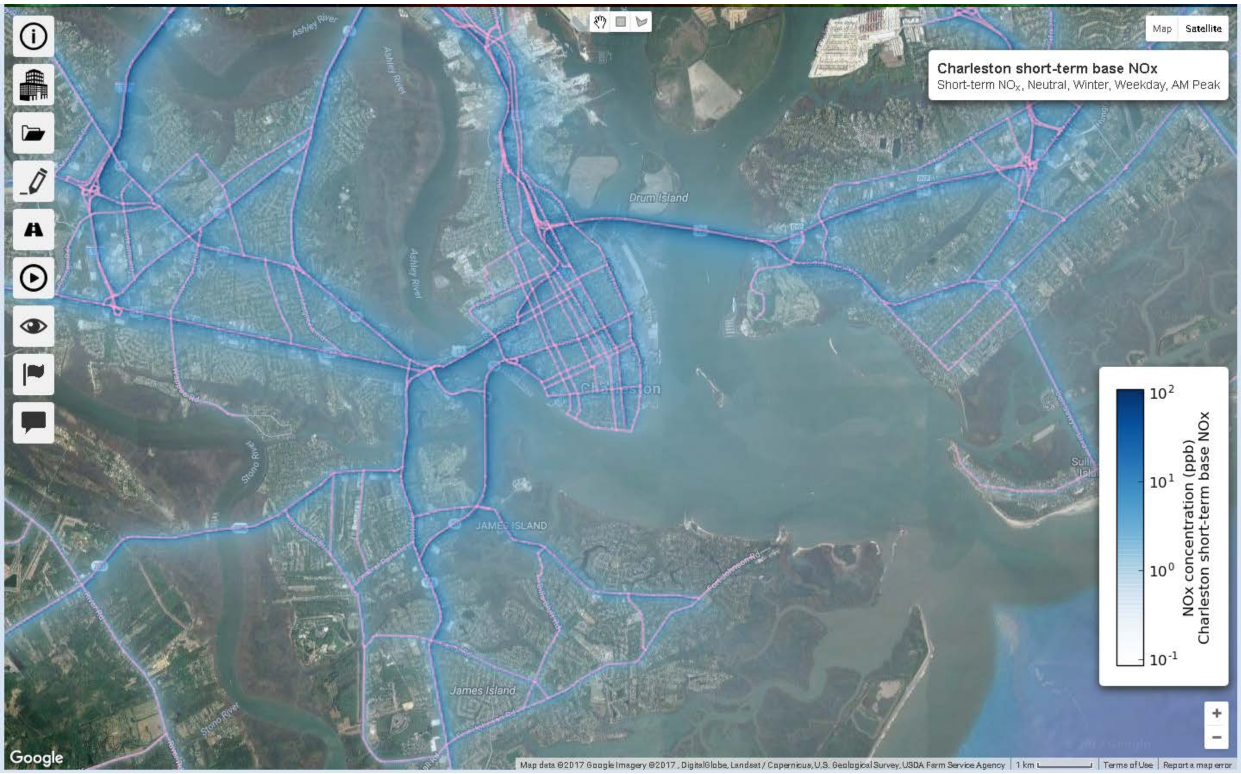


Figure 48. Results of short-term concentration scenario, neutral stability, winter, AM peak for NO_x

Visually compare Figure 14 and Figure 48 showing long-term and short-term results, respectively. Short-term concentrations are mostly to one side of the emissions sources, which are located on the roads, but long-term concentrations, are more spread around the emissions sources.

Figure 49 shows the selections for another short-term analysis. This one is for the stable atmospheric stability class during the winter season when the wind is blowing from the North to the South.

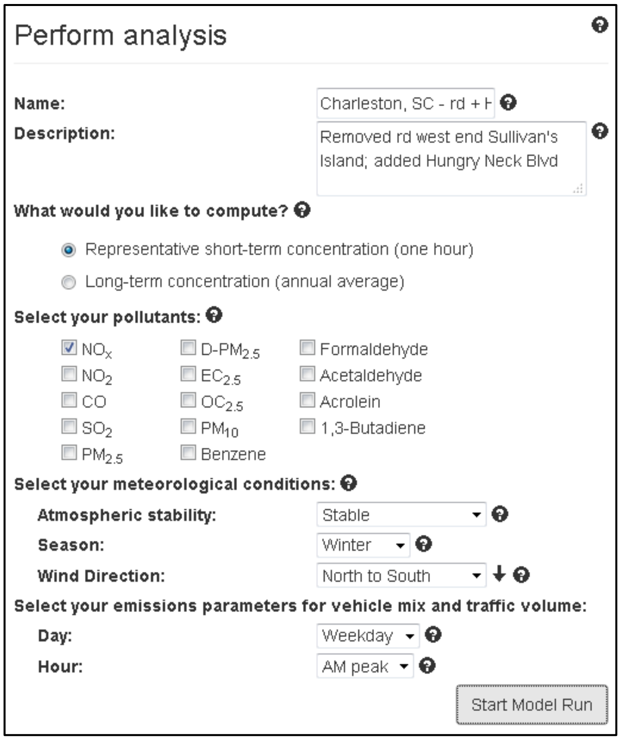


Figure 49. Define an analysis for a different set of short-term conditions.

Note that there are two methods to select the wind direction. Either use the Wind Direction drop-down box or click the arrow widget to the right of that box. Each time you click the arrow widget, the arrow shifts to the next wind direction in clockwise order. The model run with all of your selections and customized road segments is saved when you click *Start Model Run*. Figure 50 shows the results of this simulation.

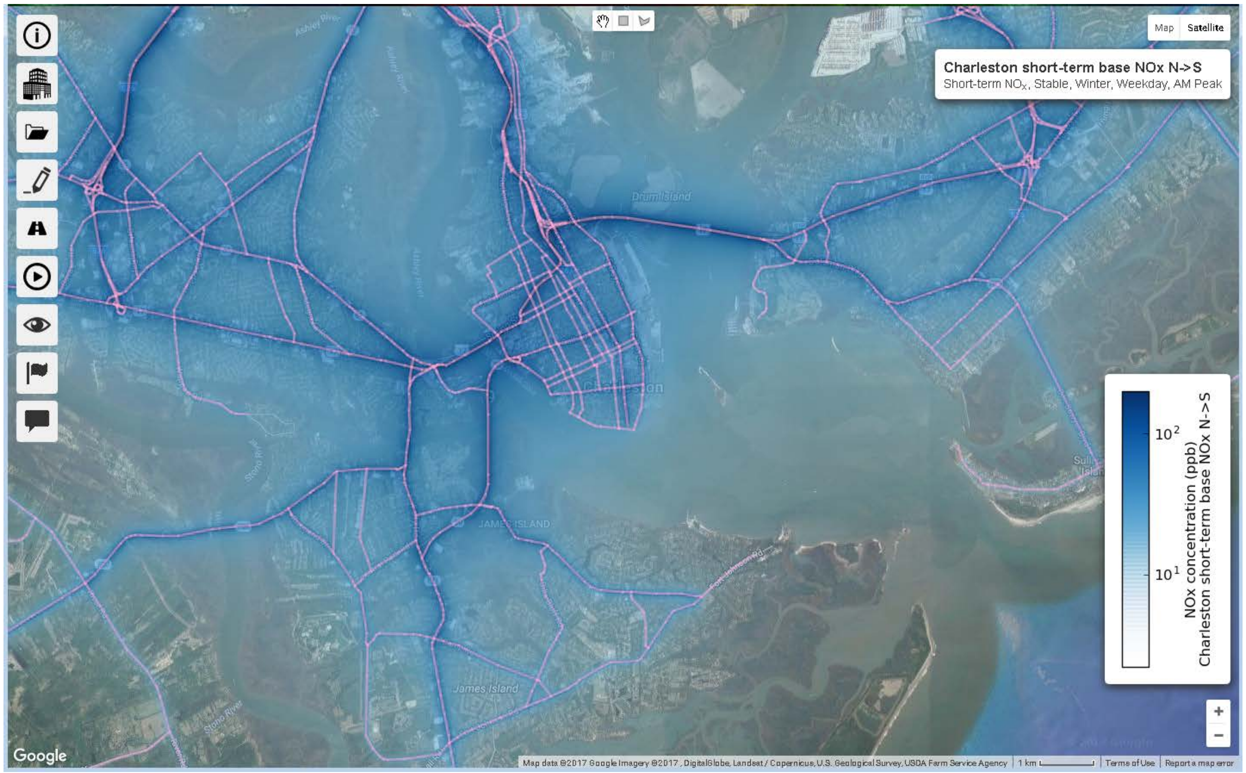


Figure 50. Concentrations of NO_x for short-term, stable, winter conditions, weekday, AM Peak, with the wind blowing from North to South.

4.11. Compare Model Runs – Raw Difference

This example compares the raw differences between two model runs. This means that the actual differences in concentration values throughout the modeling domain are mapped. To perform this analysis, load a single model run into C-LINE. This example uses default roads, vehicle mixes, AADT, weekday, and AM peak traffic volume for Charleston, SC. Meteorological conditions are the *stable* atmospheric stability class during the *winter* season. The sole difference between the two model runs is *wind direction*: North-to-South and South-to-North. Those model runs are named "Charleston NO_x short-term stable N-S" and "Charleston NO_x short-term stable S-N", respectively.

Go to the *View Results* frame and select the *Comparisons* tab. Select the *Raw Difference* mode, as shown in Figure 51. Note that both your base and new model runs must have been saved using different names. C-LINE calculates raw differences as (New – Base); in this example differences are calculated as concentrations with winds blowing from the south, minus concentrations with winds blowing from the north.

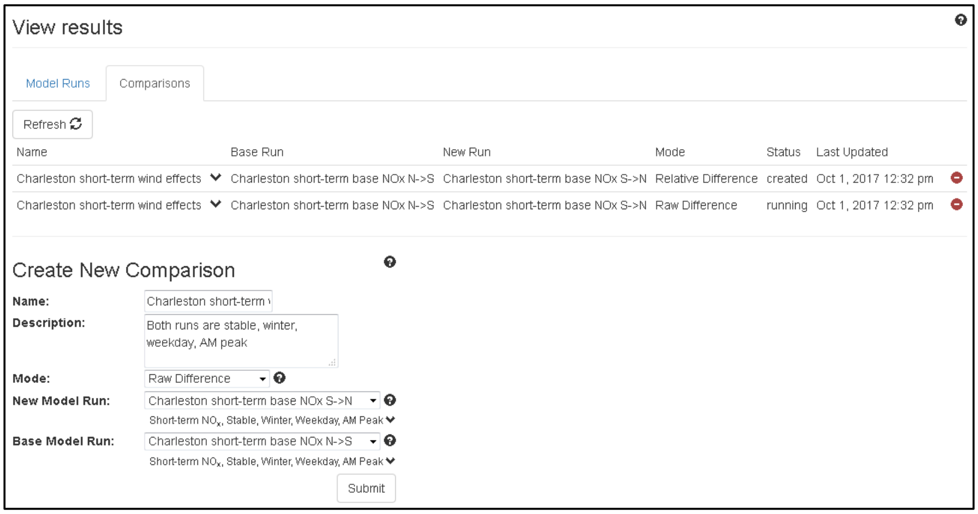


Figure 51. *View Results* frame, *Comparisons* tab for Raw Difference mode.

To see the results of your raw difference model run, click the Refresh button to see your most recent C-LINE runs (Figure 52).

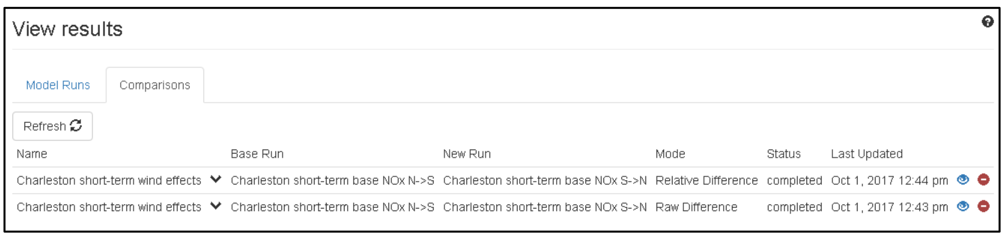


Figure 52. *View Results* frame for a *Comparison* analysis.

When the Status shows **completed** for your Raw Difference model run click the blue eye widget ( ) to display your map. Figure 53 shows the results from this model run. Note that brown colors indicate higher concentrations in the new model run (wind from the south) and blue colors indicate lower concentrations (wind from the north) (i.e., higher concentrations when the wind was from the north). The results for the raw difference comparison are displayed using a logarithmic scale. The logarithm of the magnitude of the difference is computed, and then the original sign of the difference is applied.

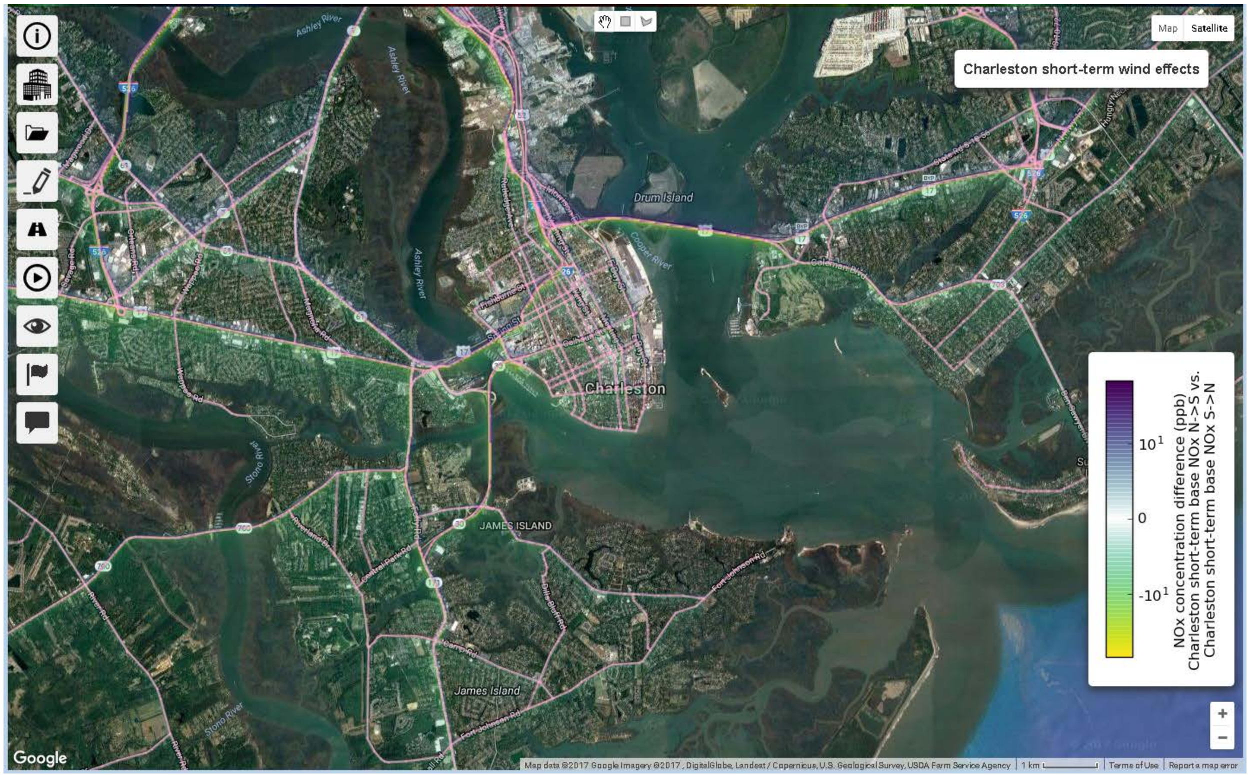


Figure 53. Example comparison analysis showing *Raw Difference* mode

4.12. Compare Model Runs – Relative Difference

Use the same steps to perform a Relative Difference as those described for a Raw Difference in Section 4.11. On the *Perform Analysis* frame, shown in Figure 51, select *Relative Difference* from the **Mode** drop-down list. The Relative Difference is calculated as a percentage based on the following equation.

$$\text{Relative Difference (\%)} = (\text{New} - \text{Base}) / \text{Base} \times 100$$

Figure 54 shows the relative difference in NO_x concentrations between the new and the base model runs. Note that the range in the legend is -100% to +100%. All relative differences outside this range are mapped as though they were at the appropriate extreme value.

Figure 54. Example comparison analysis showing *Relative Difference* mode

4.13. Visualization Options

The visualization options for comparative model runs are the same as those for regular model runs (see Figure 17, section 3.6).

5. User Feedback

By clicking on the  icon at the bottom left of the C-LINE system's navigation menu, you are directed to an interactive short survey with a few questions and may also provide comments. We encourage all users of the C-LINE system to provide feedback for future enhancements.