US EPA ARCHIVE DOCUMENT

NEAR-ROAD AIR QUALITY MODELING STUDY IN ATLANTA

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EPA REGION 4 MODELERS WORKSHOP
ATLANTA, GA
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Background

- Technical support/partnership request from Atlanta Regional Commission
  - Dispersion modeling for Atlanta Roadside Emissions Exposure Study (AREES)
- Fulfillment of GA EPD's mission
  - NO2 1-hour NAAQS Analysis
    - Traffic-induced exposure; likely near-road
  - PM2.5 State Implementation Plans
    - Understanding mobile source contributions to urban monitors

ATLANTA REGIONAL COMMISSION

Establishing Common Technical Ground for Planning Process

DEPT. OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA

Atlanta Roadside Emissions Exposure Study

- Project Goal
  - Examination of ambient air quality changes due to emission changes from implementation of regional transportation plans for 20-county Metro Atlanta areas

- Methodology
  - Obtaining current traffic data
  - Predicting future traffic changes with travel demand models
  - Estimating current/future emissions with MOVES
  - **Modeling current/future air quality due to vehicle emissions**
  - Assessing near-road exposure with modeled air quality data
  - Reflecting results into regional transportation planning process

Selection of Model

- Selection Criteria
  - Model performance
  - Burden of computation and data handling
  - Future usability
  - In-house capability of running models
- Candidate Models
  - AERMOD (Volume/Area) and RLINE
- Final Choice: RLINE v1.2
  - Initial mixing characteristics improvement
    - Literature review
    - Evaluation with near-road monitor data
  - GA EPD actively participated in the beta-testing process and provided technical comments.
  - V1.2 released on Nov 13, 2013 (https://www.cmascenter.org/r-line/)

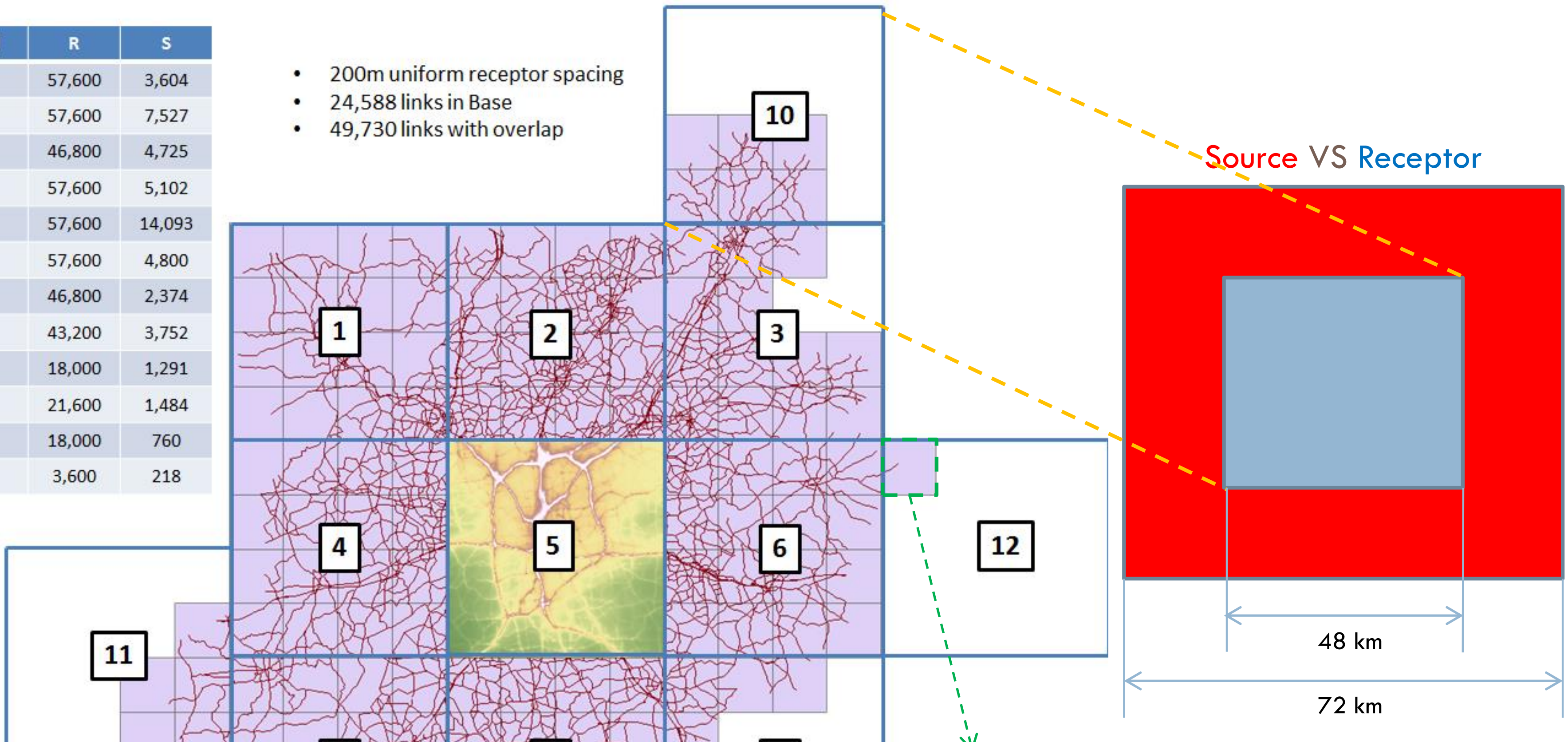
Selection of Modeling Approach

- Technical challenges
  - Computational time
    - Initial estimation of computation time with standard modeling practice (i.e. single CPU, 8760 hours) would result in simulation time over months or even years on modern desktop computers.
  - Spatial limit of near-source dispersion model's validity
    - AERMOD (therefore, likely RLINE) is often recommended to use for near-source (< 50 km) modeling cases.
  - Aggregation of run outputs from decomposed modeling domains for overlapping receptors depending on the design of subdomain runs
- Solution
  - Modeling domain decomposition
    - No overlapping receptors in decomposed domains
  - Utilization of multi-thread computing
  - Use of representative meteorological data for long-term simulation
    - Adopting "STability ARray (STAR)" approach from Chang et. al., 2013

Modeling Domain Decomposition

Grid	R	S
1	57,600	3,604
2	57,600	7,527
3	46,800	4,725
4	57,600	5,102
5	57,600	14,093
6	57,600	4,800
7	46,800	2,374
8	43,200	3,752
9	18,000	1,291
10	21,600	1,484
11	18,000	760
12	3,600	218

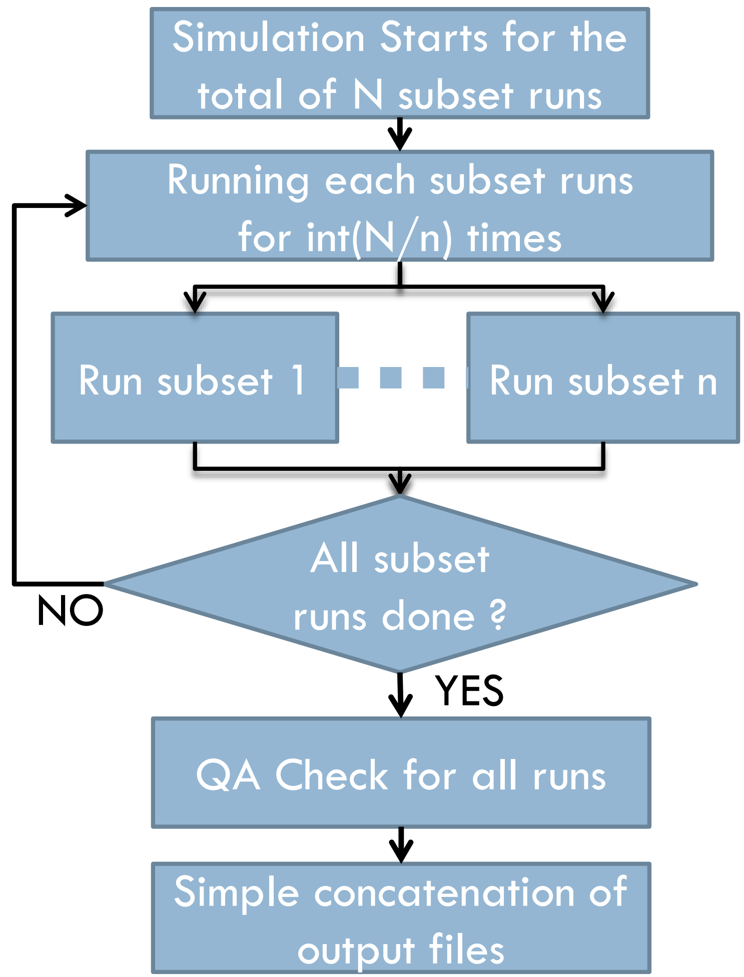
- 200m uniform receptor spacing
- 24,588 links in Base
- 49,730 links with overlap



Small green box represents a 12 km cell in the CMAQ modeling domain used for GA's Attainment SIP modeling.

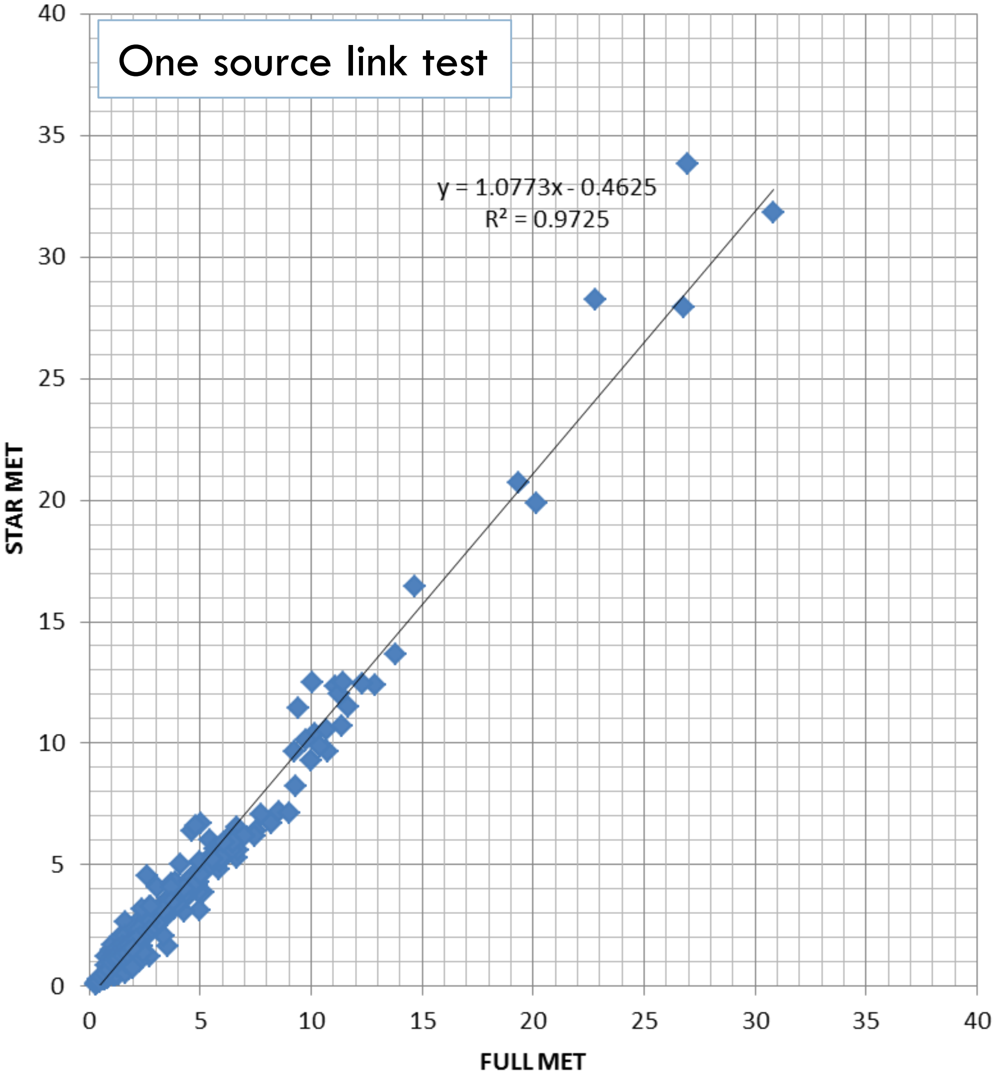
Utilization of Multi-thread Computing

- Most of modern CPUs equipped with multi-cores.
  - Note that hyper-threading or virtual CPU does not help because of heavy-numeric nature of the problem.
- Modern computer languages such as Python provide tools to control system processes.
  - With a real 8-core machine, about 8x speed up effect can be expected.
- We decided to utilize Python's 'subprocess' module
  - Each process handles a run package which consists of a met input, a set of receptors (i.e. modeling subdomain), and link-level emissions corresponding to the receptor set.
  - If desirable, the run can be configured the other way; i.e. running each hour simulation for the entire domain.



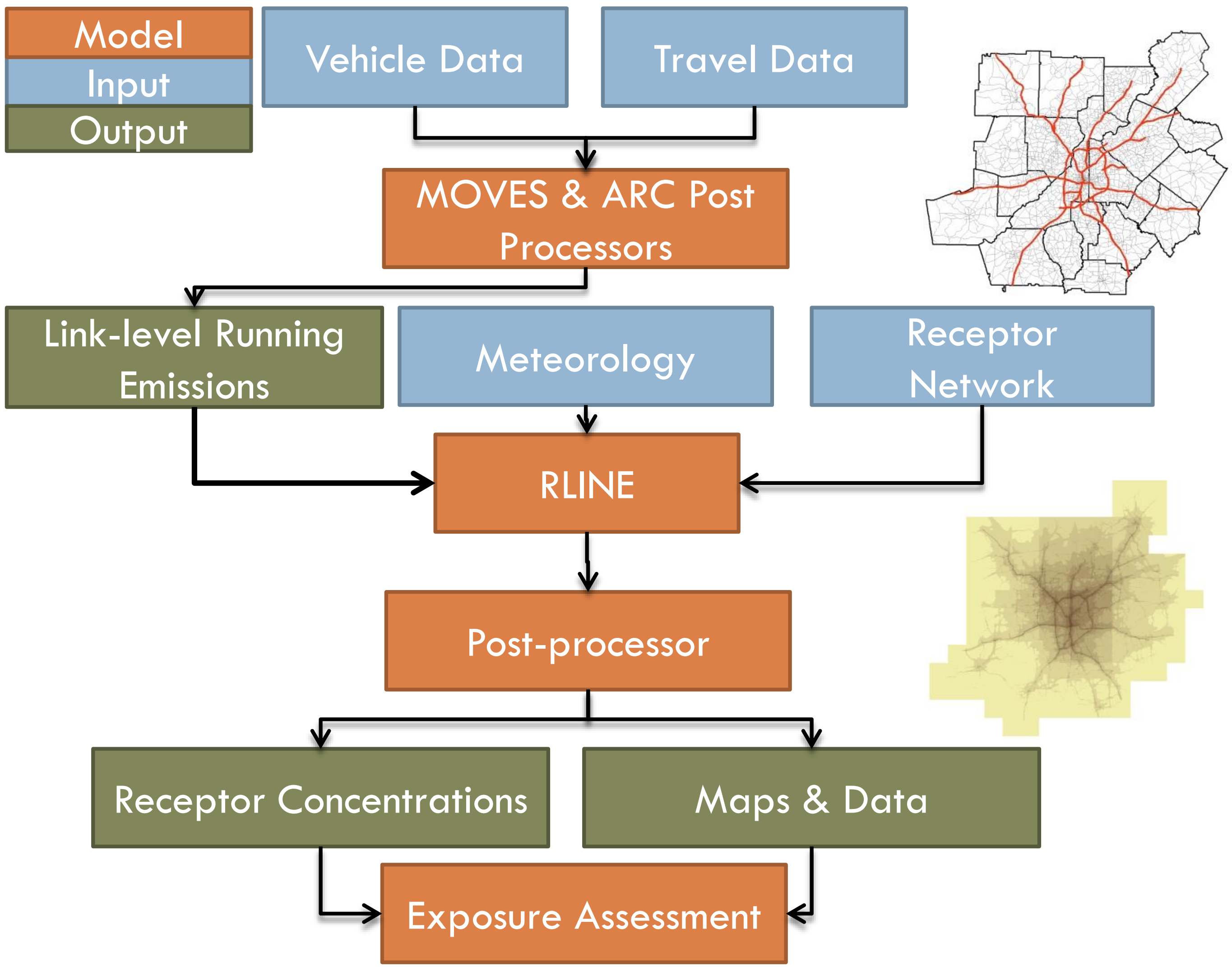
STAR Approach

- Binning hourly meteorological data based on wind speed, wind direction, atmospheric stability, etc.
- Reduced 8760 hours data to ~100 hours; ~90x speed up effect



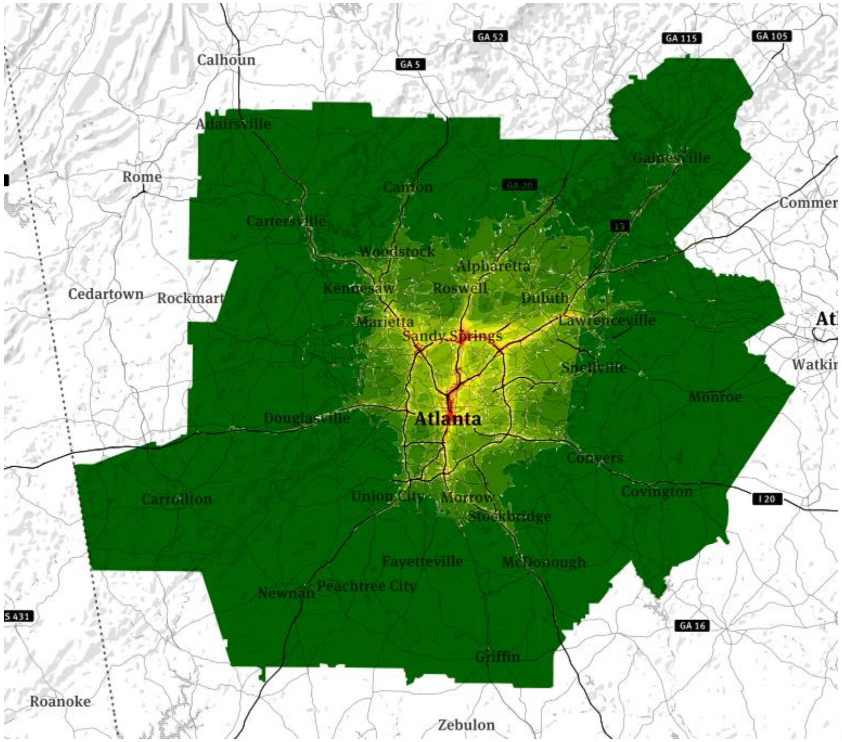
Modeling Flow

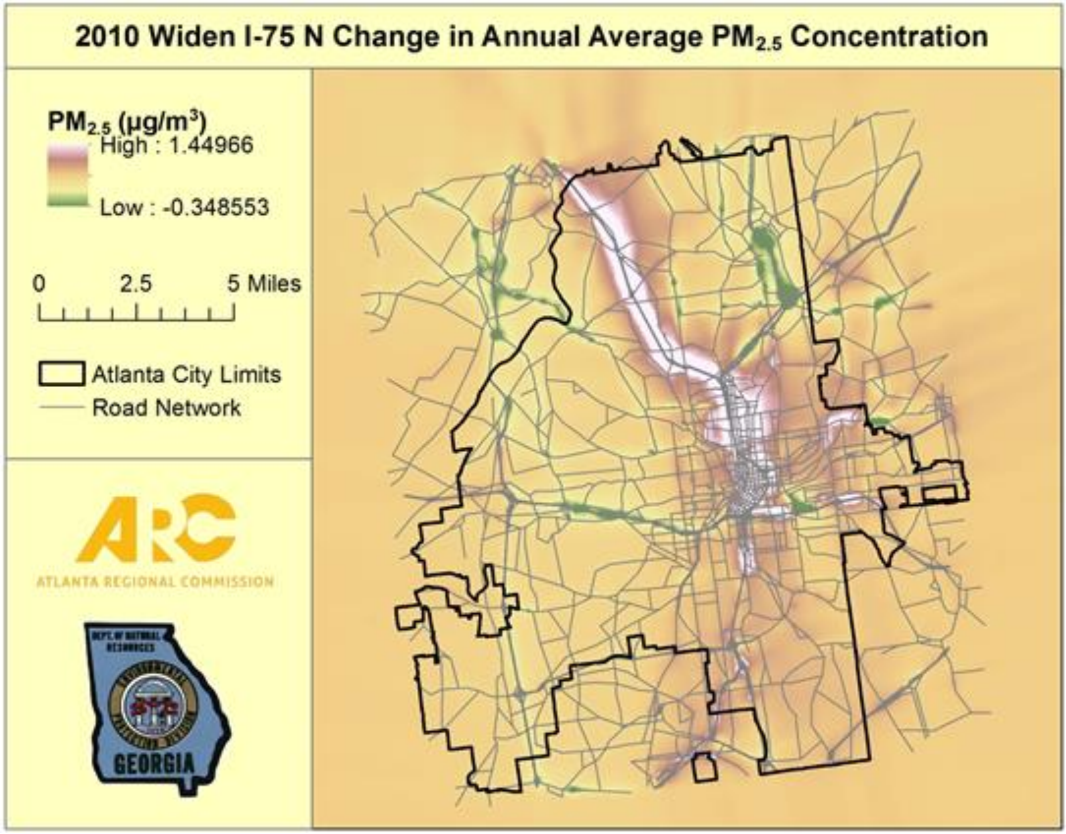
- Emission inputs
  - Year 2010
  - MOVES inventory mode
  - No temporal variation in emissions
  - Weekday emissions
  - PM2.5 primary
- Meteorological inputs
  - Year 2011
  - STAR approach with Atlanta airport station data
- Modeling Platform
  - Window 7 PC with command-line execution of RLINE
- Runtime
  - 10 days with seven cores
- Post-processing
  - In-house Python tools
  - ArcGIS



Results

- Interactive tool to explore simulation outputs
  - http://atlregional.github.io/dispersion/





Comparison with monitoring data

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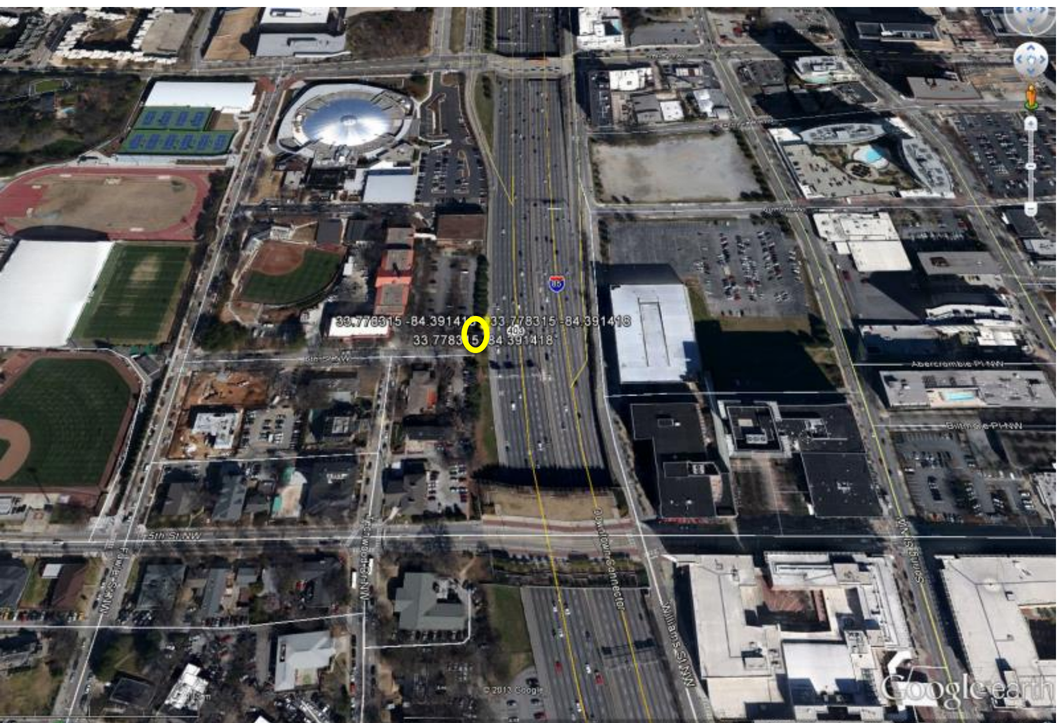
Monitor	AREES ZONE	PM 2.5- AREES*	PM2.5 - Monitor**	AREES % of Total
Kennesaw	1	3.23	11.5	28%
Powder Springs	4	2.69	11.3	24%
Doraville	5	7.04	11.6	61%
E. Rivers	5	7.05	11.7	60%
Yorkville	4	0.30	10.7	3%
Gwinnett	3	6.38	11.0	58%
Fire Station 8	5	5.77	13.1	44%
Forest Park	5	4.91	12.7	39%
S. DeKalb	5	4.57	12	38%

- **Adjustment to RLINE results may need to be made based on the RLINE performance evaluation results with actual datasets.**

Evaluation with near-road monitor data

- Importance of RLINE performance evaluation with local monitor data
  - RLINE developers performed evaluation with campaign data under somewhat controlled environment but these evaluations were mostly limited to short-term period modeling cases with non-reactive tracers.



2.13 Site Details

The following information provides the site details, including proposed site identification number, street address, latitude/longitude, and details regarding each parameter that will be monitored at the proposed near-road site.

Proposed Site ID: 13-121-0049
Street Address: Georgia Institute of Technology, 6th Street, Atlanta, Fulton County, GA
Latitude/Longitude: 33.778315/-84.391418

Parameter	Monitoring Objective	Sampling Schedule	Sampling Method	Analysis Method	Spatial Scale
NO_2	Source Oriented	Continuous	EPA Approved Automated Reference Method	Chemiluminescence	Micro
CO	Source Oriented	Continuous	EPA Approved Automated Reference Method	Non-dispersive Infrared	Micro
$PM_{2.5}$	Source Oriented	Continuous	Thermo 2025	Gravimetric	Micro
Black Carbon	Source Oriented	Continuous	Thermo 5012 MAAP	Multi-Angle Absorption Photometer (MAAP)	Micro
Wind Speed	Source Oriented	Continuous	RM Young	Sonic Anemometer	Micro
Wind Direction	Source Oriented	Continuous	RM Young	Sonic Anemometer	Micro

Table 6: Detailed Site Information

Future Plan

- Conduct detail model performance evaluation and comparison
  - Evaluation with data from the newly installed near-road monitor
- Perform more modeling with diverse meteorological inputs
- Continue to collaborate with ARC for regional projects
- Apply modeling results to health impact assessment studies
- Expand modeling capabilities
  - Faster modeling platform development
  - Multiple meteorological station data and Mesoscale Model Interface Program (MMIF)
  - Multi-year meteorological inputs
  - Emission variation such as diurnal, daily, monthly, etc.
  - MOVES rate-mode to account for meteorological impact on emissions

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