SEE (Spatial Emissions Estimator): A New Tool for Estimating Link & Zone Emissions with MOVES

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ERG

Acknowledgments

- **Cambridge Systematics**: David Kall, Tarannum Rima (speed model work)
- **ERG**: Heather Perez, Mindy Mitchell

Overview

- Drivers for New Tool
- Approach
- Example Results
- Improving Inventory & Spatial Resolution
- Summary & Next Steps

Drivers for New Tool

- Update from MOBILE6 to MOVES
- Integrate link & trip activity from travel model
- Provide detailed spatial allocation of emissions
  - On-network: link-based
  - Start & evaporative emissions: travel analysis zone (TAZ) based
  - Heavy-duty truck extended idle (hoteling): truck stop locations
- Maintain consistency with MOVES County Scale
- Build hooks for improving inventory
  - Updated speed post-processing model
  - Accounting for heavy-duty “hot spots” not in travel model
  - Ability to account for road grade

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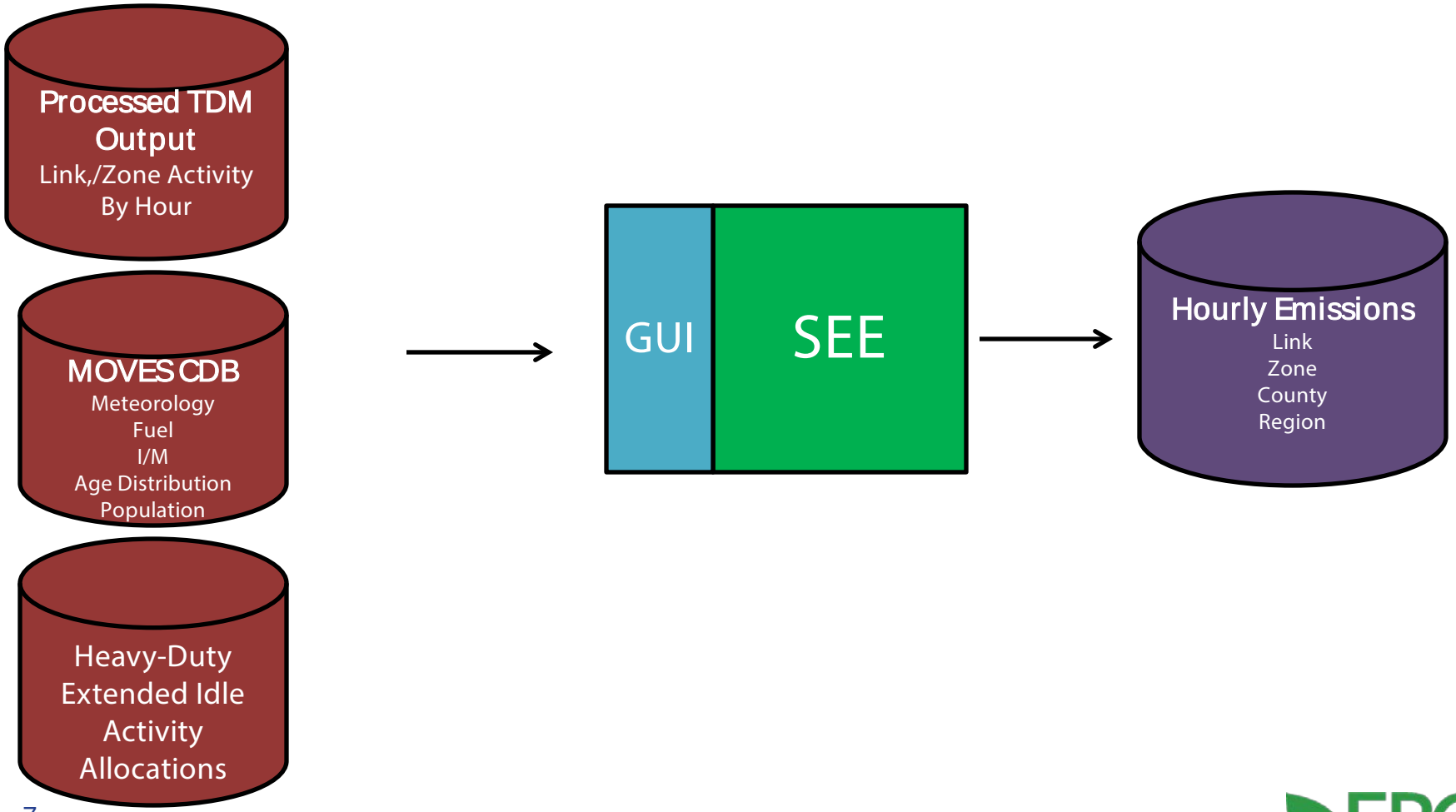
Approach

Spatial Emissions Estimator (SEE)

- Emission results at link, zone and county level
- Uses direct MOVES runs as much as possible, with supplemental scripting where necessary
- Makes full use of TDM spatial activity information
- Uses MOVES input tables (County/Project DB)
- On-network and off-network approaches different, but integrated into one system, with common input/output databases
- Simple user interface

SEE Overview



SEE: Under the Hood

- User makes basic input/output selections in GUI
- PERL scripts drive MOVES setup & runs
  - Project scale: link emissions
  - County scale: off-network emissions, ramp emissions, running loss evap
- PERL scripts post-process results
  - Emissions by link
  - Zone emission allocations
  - Spatial aggregation
  - TxLED emissions adjustment

On-Network Approach (Links)

- Running emissions estimated at link level by hour
  - ~45,000 links in 8-county HGB area
- SEE runs MOVES at project scale
  - Allows bottom up calculation from links
  - Flexibility for future improvements
- Scripts convert TDM output to MOVES project level database (PDB) link inputs
- To reduce model runtime, MOVES only runs unique combinations of roadtype & average speed, by hour
  - Actual vs. binned speed
- Script applies to rest of links based on individual link activity (Source Hours Operating, SHO)

On-Network Approach

Already exists

New

TRANSVMT Script

TDM Link Data

Link Input Script

Finds unique combinations of roadtype & average speed and converts to MOVES input

In Harris County example, ~25,000 links → 26 unique links if binned by avg speed

Unique links

MOVES Database: "Link" tables

MOVES runs on unique links only. Unique links could be used across hour of the day, except for meteorology

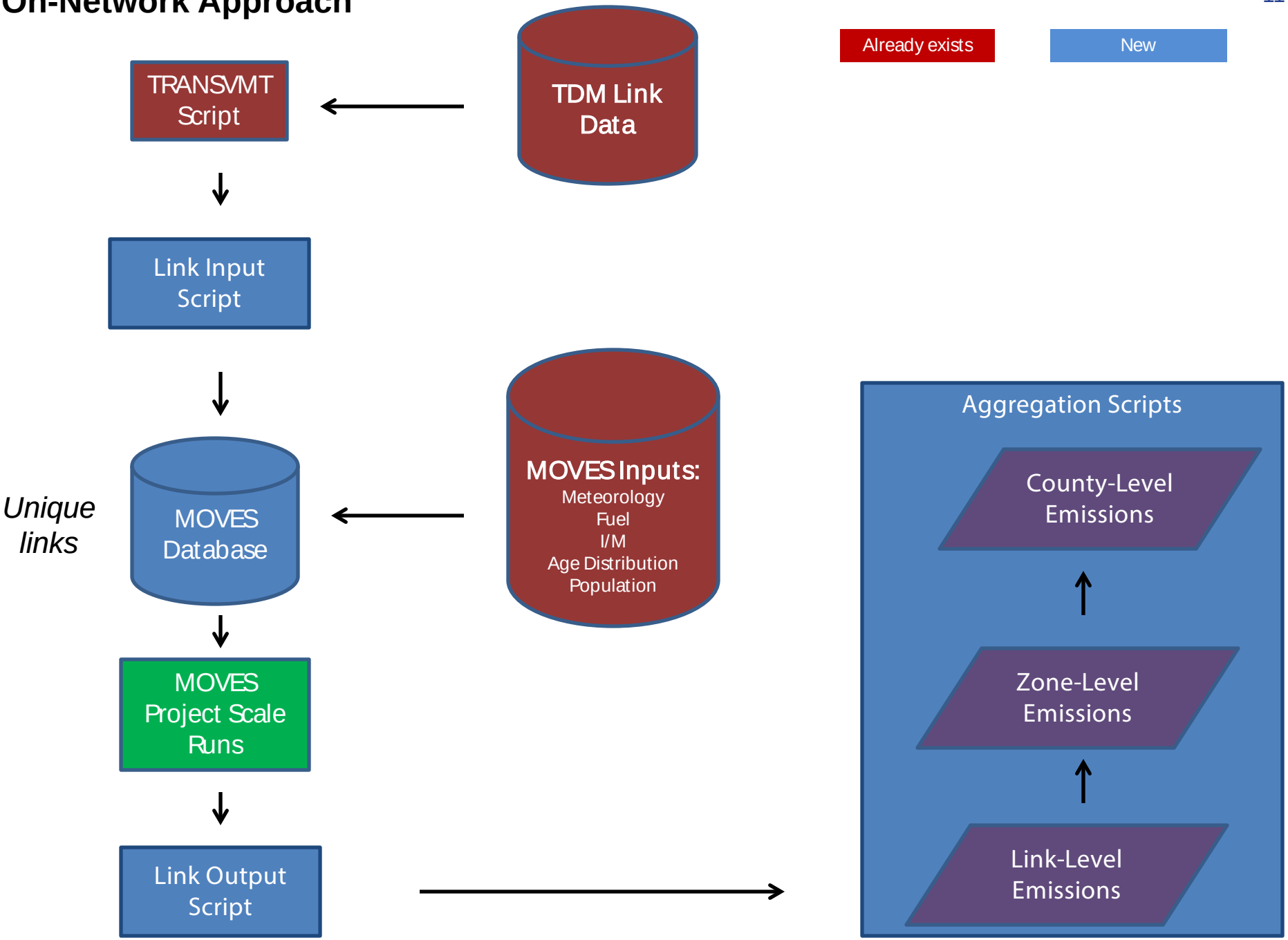
MOVES Project Scale Runs

Required to run each hour of the day individually (project scale only does 1 hour at a time)

Link Output Script

*Emissions from unique links scaled based on Source Hours Operating (SHO) to estimate emissions for all other links. SHO = link volume * (link length / avg. speed)*

On-Network Approach



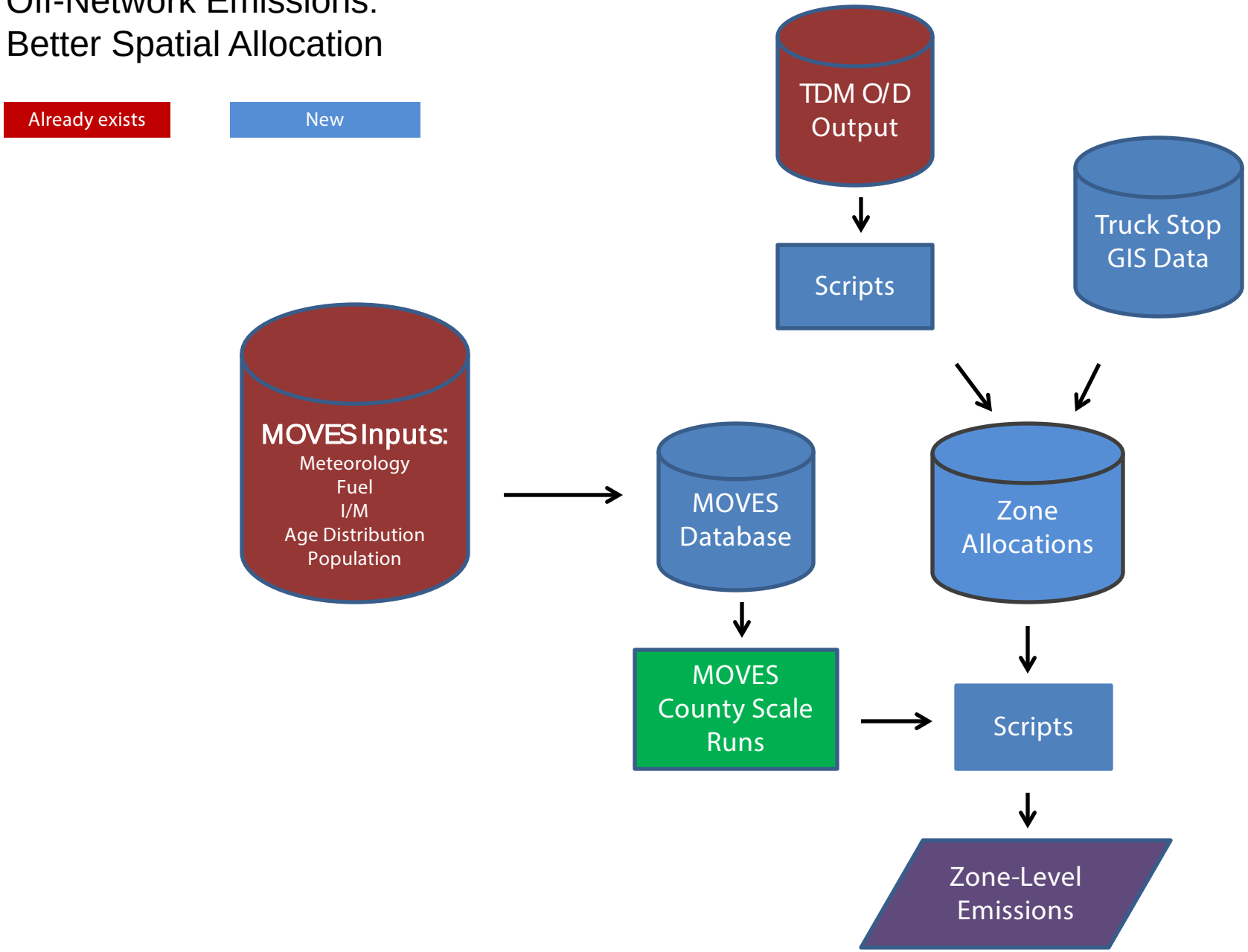
On-Network Challenges

- Differences in MOVES county and project scale led to some challenges in getting project–based run to match county-based
- Travel fraction
  - Project scale doesn't calculate travel fraction
  - Created additional scripting to replicate county scale travel fraction using source type hour fraction, revised age distribution input
- Ramps
  - TDM produces unique ramp activity, but not able to replicate county ramp emissions at link level
  - Current approach simply estimates ramps separately at county level
  - MOVES2014 updates may make link-level ramps easier
- Running Loss Evap
  - Project scale doesn't include evap emissions
  - Estimated at county level

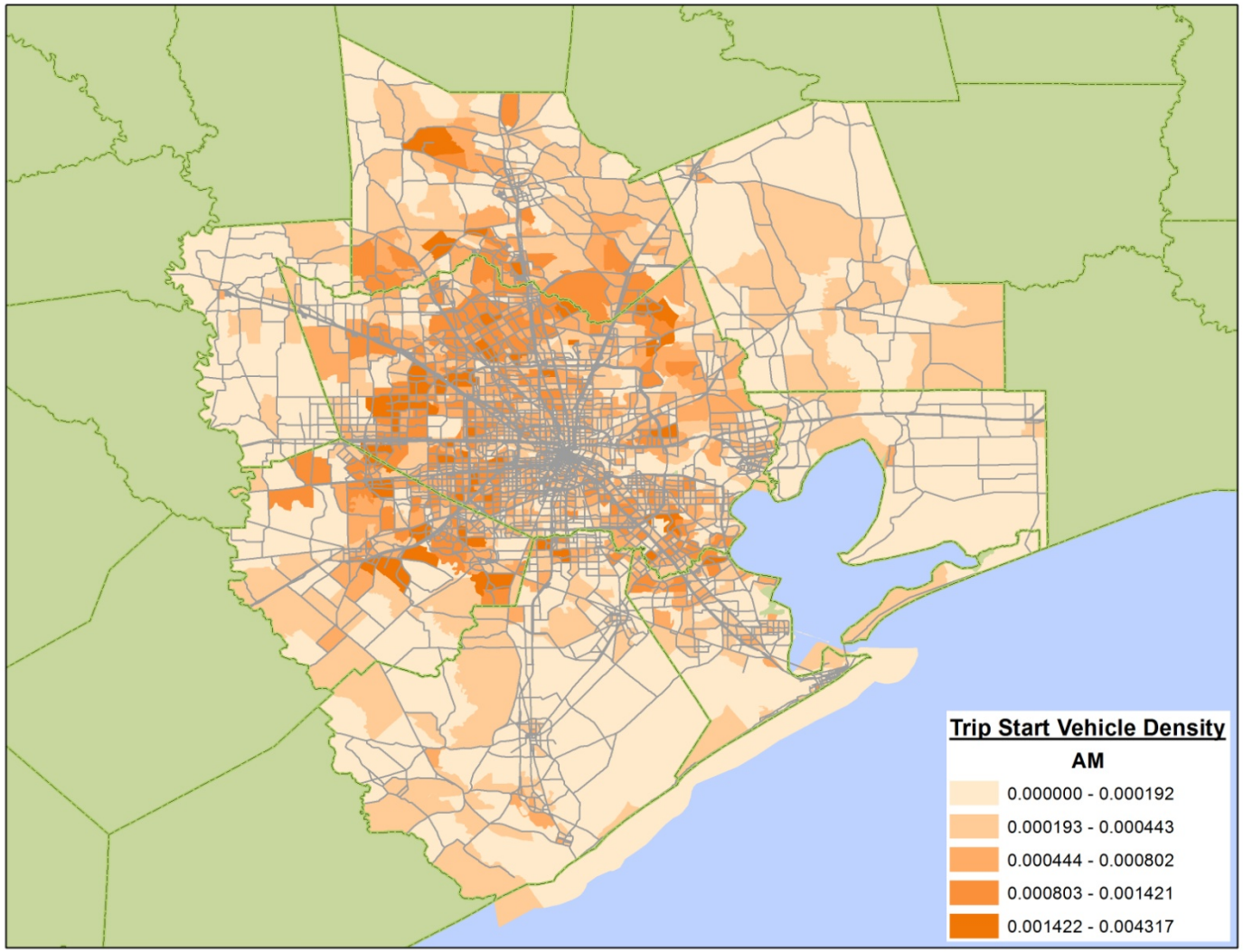
Off-Network Approach (Zones)

- Starts, Evaporative, Heavy-Duty Extended Idle emissions estimated at TAZ level by hour
  - ~3,000 zones in 8-county area
- SEE runs MOVES at county scale
- Scripts allocate county emissions to zones
  - Possible within MOVES, but longer runtime
  - Start allocations: TDM trip origins by zone, period
  - Park allocations: TDM trip ends by zone, period
  - Idle allocations: GIS analysis of truck/rest stop in 8 county area

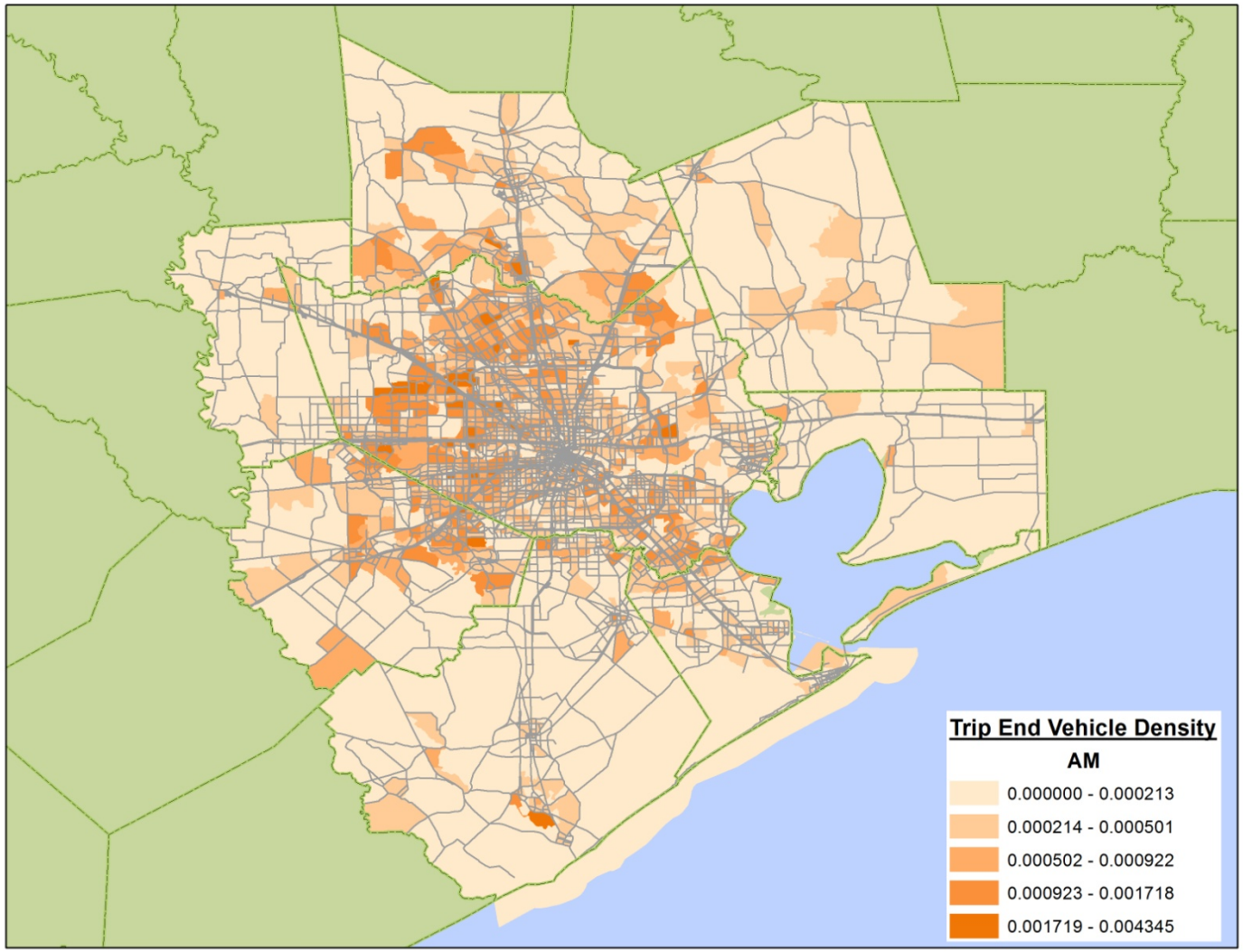
Off-Network Emissions: Better Spatial Allocation



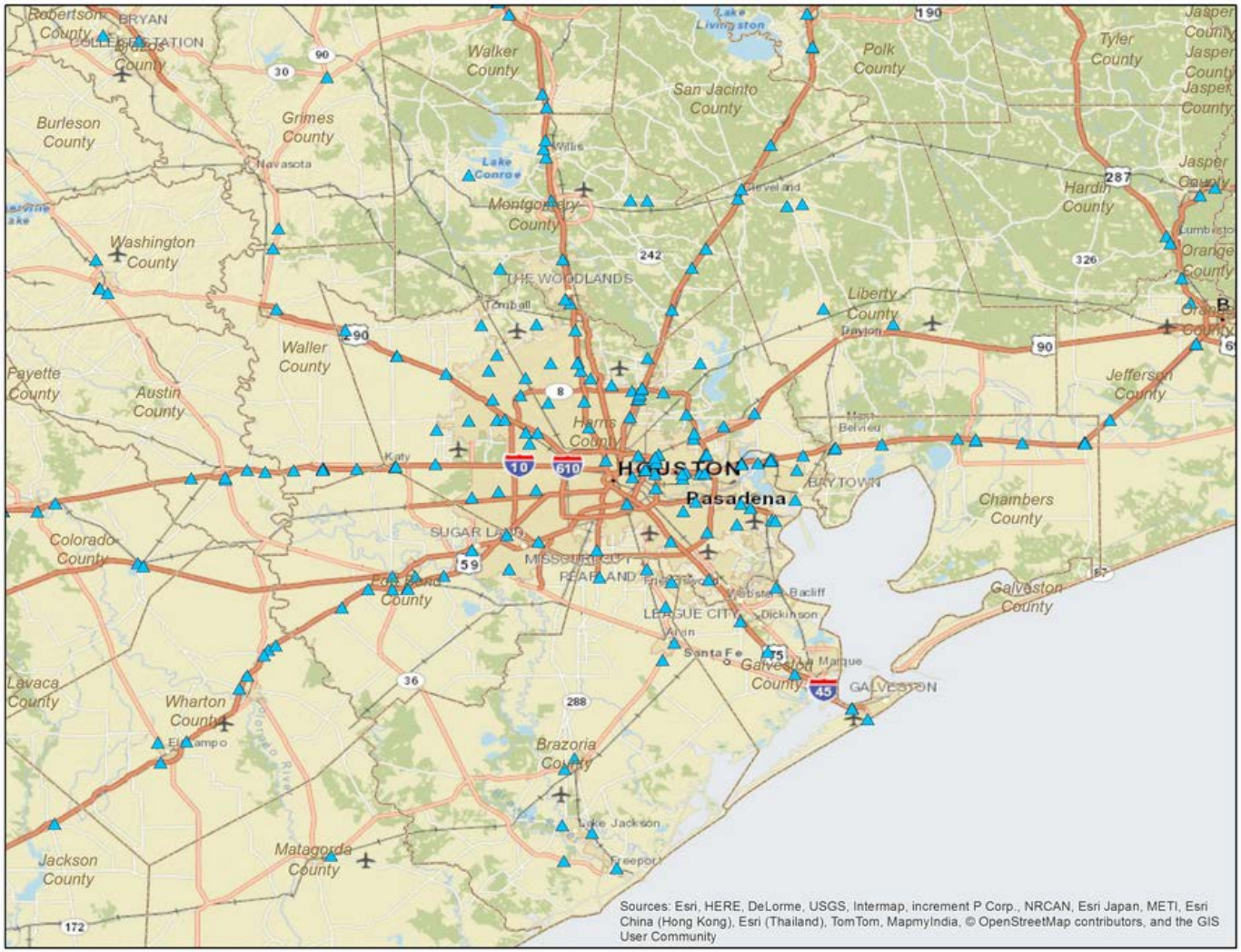
Start Allocation – AM Peak



Park Allocation – AM Peak

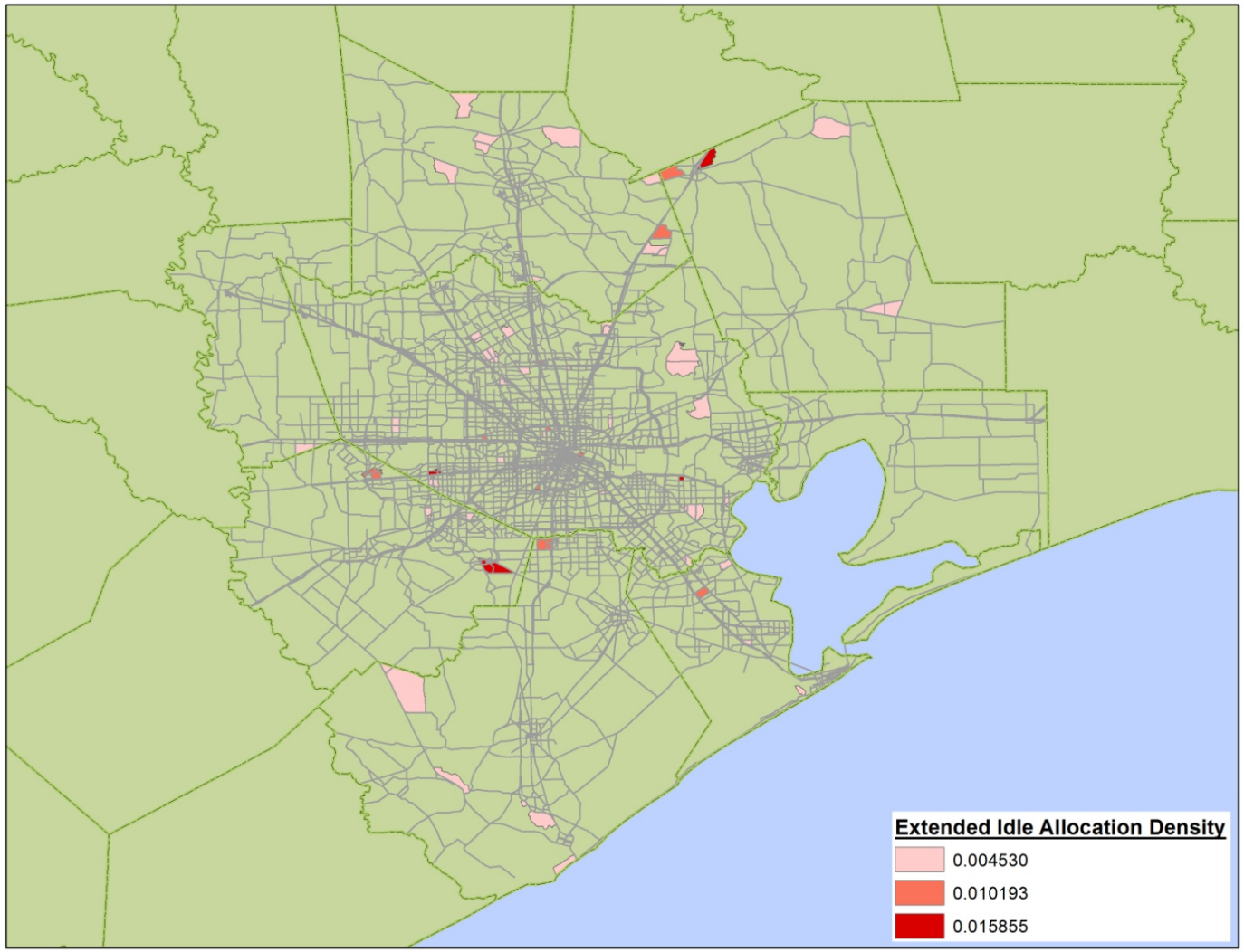


Extended Idle – Locations



Blue triangles show prospective extended idle locations (truck/rest stops, etc.) from Truck Stop Plus database

Extended Idle Allocation



Example Results

Example Results - Overview

- Benchmark vs. County Level Totals
  - SEE county totals compared to MOVES County Scale run
  - 2018 TRANSVMT runs provided by HGAC
    - Aggregated to county–level activity for MOVES county runs (VMT, speed distribution, road type distribution, hourVMTfraction)
  - Other 2018 inputs from TCEQ SIP runs
    - e.g. meteorology, I/M, fuels, age distribution
- Link/zone emissions map by hour
- Example hourly totals by process, vehicle type

Benchmark Results

Benchmark (*EPA's Guidance of running MOVES at County Domain/Scale*)

2018 Summer Weekday

County	CountyName	HC (TPD)	CO (TPD)	NOX (TPD)	VMT (Mi/day)	Population
48201	Harris	32.78	404.92	56.22	106,980,215	3,183,222
48039	Brazoria	3.05	31.35	4.54	7,236,298	327,273
48071	Chambers	0.88	10.29	3.65	3,275,260	42,386
48157	Fort Bend	4.91	49.20	6.83	11,892,122	587,414
48167	Galveston	2.28	24.86	3.17	5,849,575	250,959
48291	Liberty	1.30	13.67	2.90	2,966,501	84,882
48339	Montgomery	4.50	47.97	7.37	12,438,787	469,788
48473	Waller	0.70	9.12	1.74	2,322,507	39,278
8-County Total		**50.40**	**591.39**	**86.43**	**152,961,266**	**4,985,203**

HGB-SEE Results

2018 Summer Weekday

County	CountyName	HC (TPD)	CO (TPD)	NOX (TPD)	VMT (Mi/day)	Population
48201	Harris	32.78	405.04	56.10	106,980,205	3,183,222
48039	Brazoria	3.05	31.37	4.54	7,236,300	327,273
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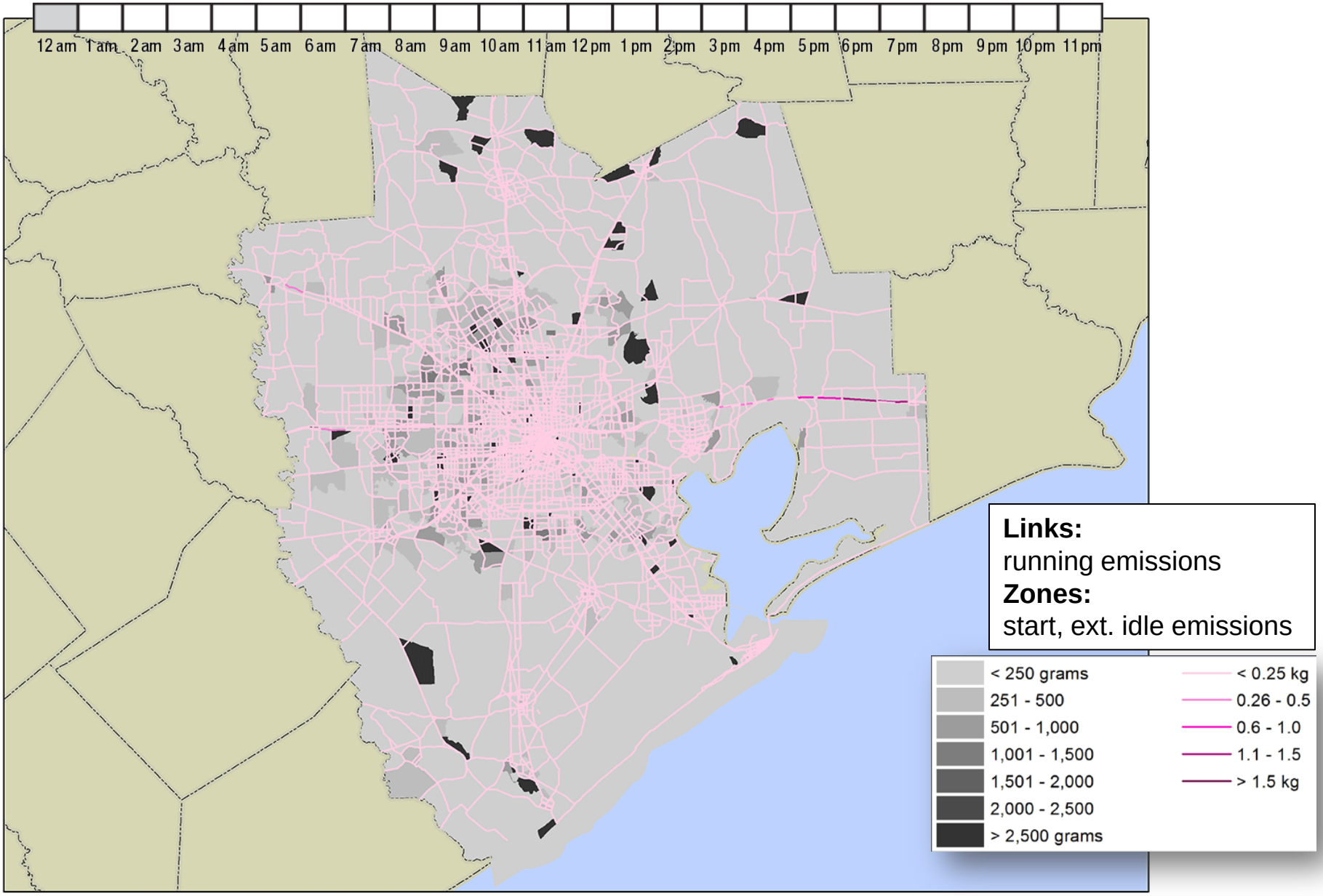
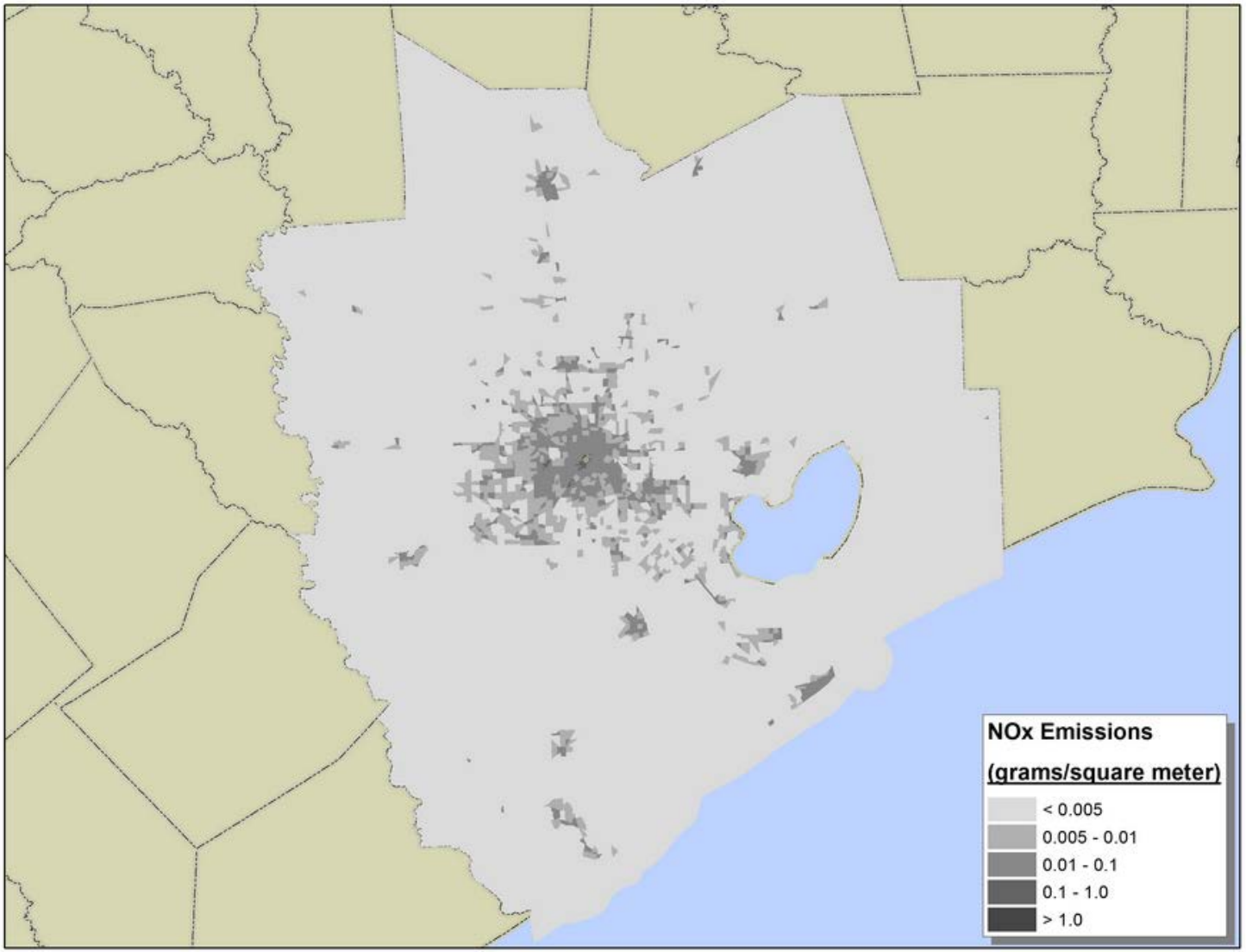
8-County Total		**50.40**	**591.61**	**86.25**	**152,961,252**	**4,985,203**

8-County Onroad NOx by Link/Zone/Hour

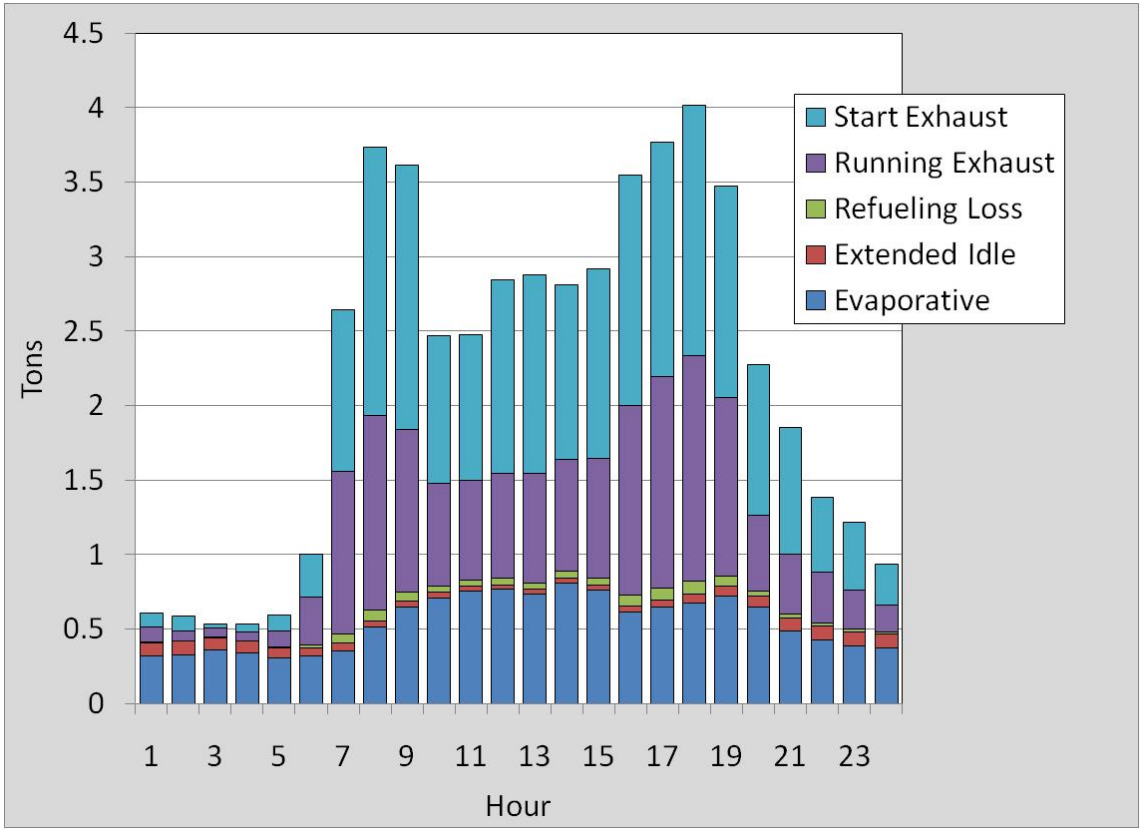
requires MS Powerpoint in slideshow mode to cycle through 24 hours



NOx Emissions Density (Noon)

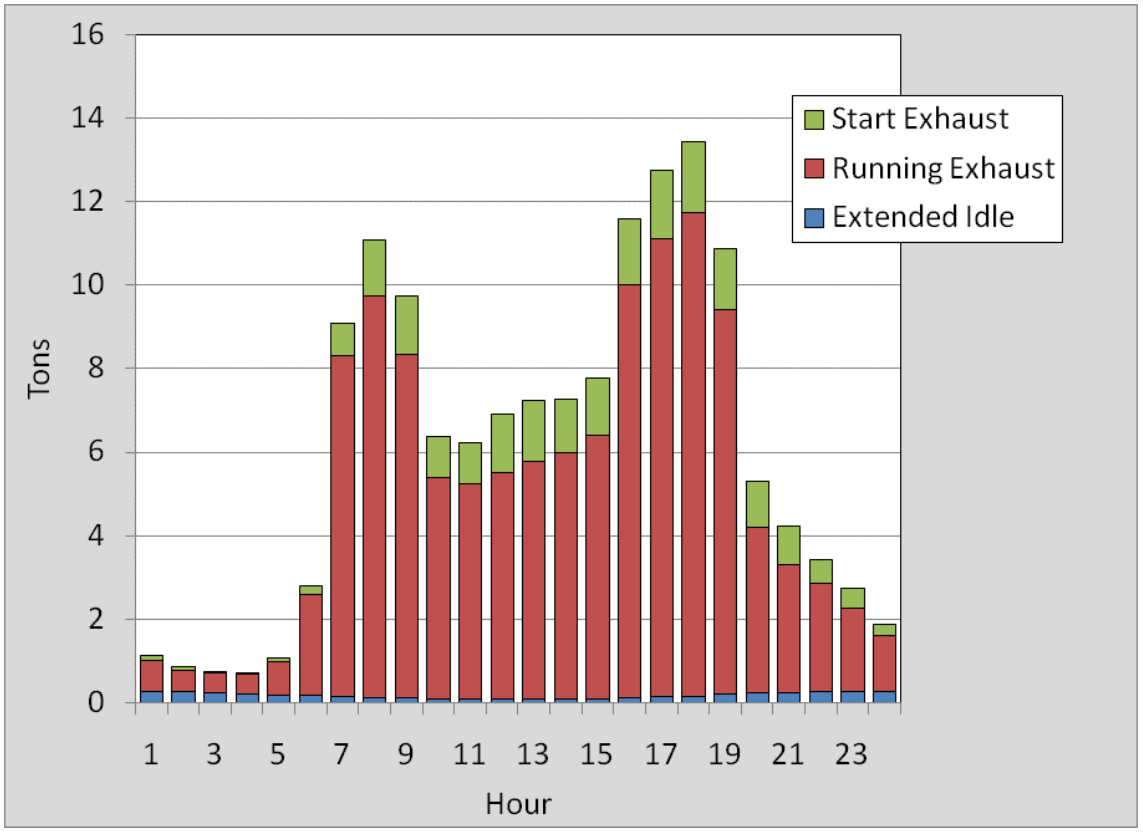


Harris County Hourly HC Emissions by Process



- HC emissions
- All source types
- HC Daily Average (CY2009):
  - 40% Starts
  - 30% Running
  - 25% Evaporative
  - 2% Refueling Losses
  - 3% Extended Idle

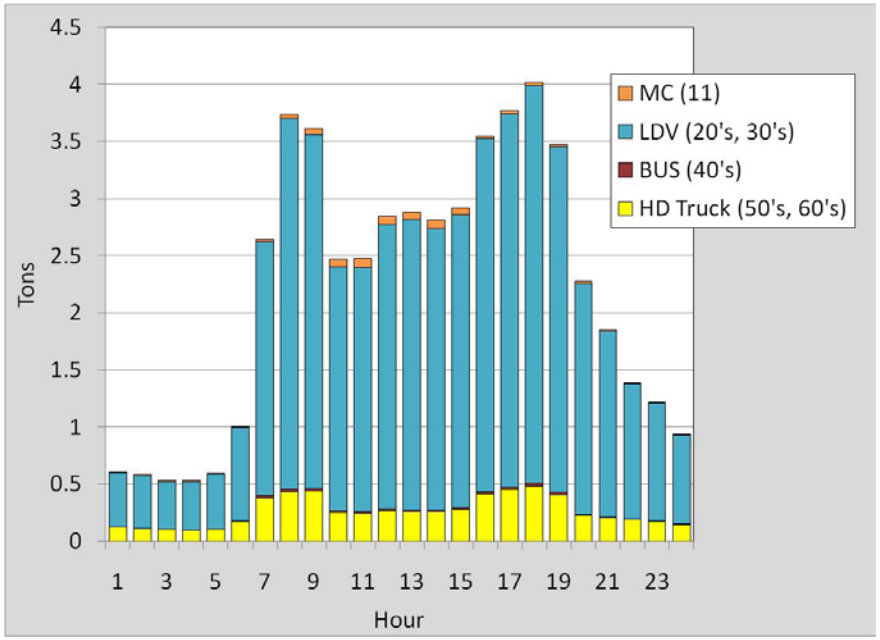
Harris County Hourly NO_x Emissions by Process



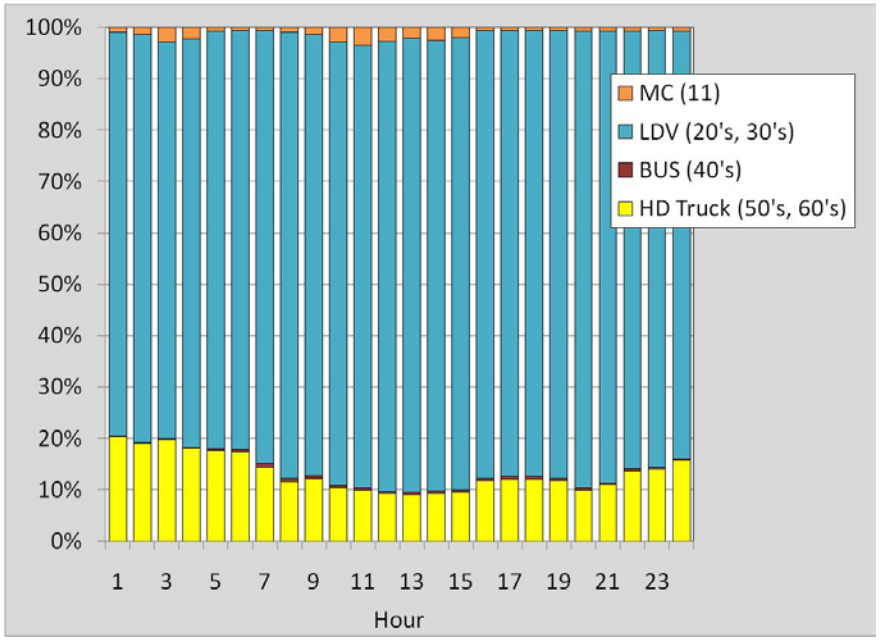
- NOx emissions
- All source types
- NOx Daily Average (CY2009):
  - 82% Running
  - 15% Starts
  - 3% Extended Idle

Harris County Hourly **HC Emissions** by Vehicle Type

Absolute Emissions (tons)

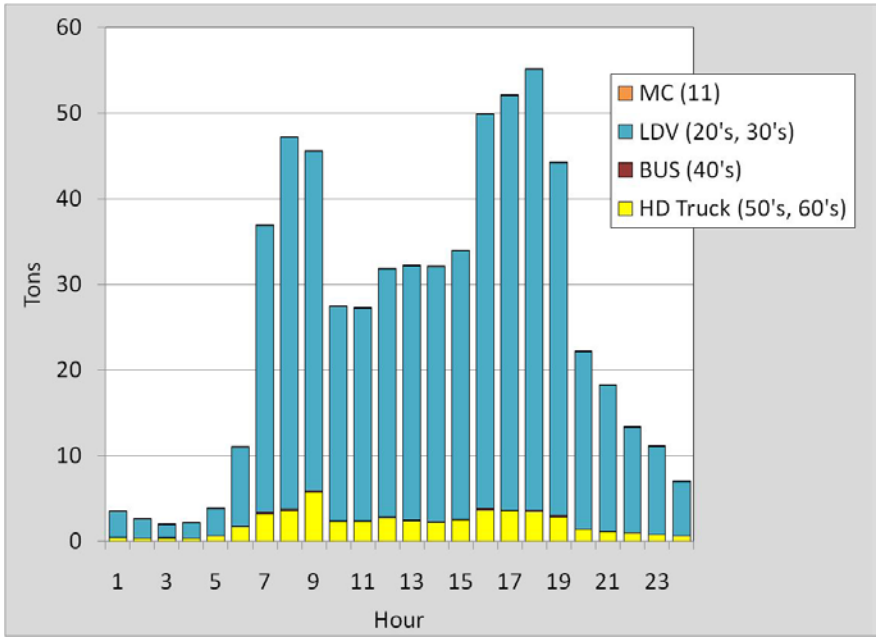


Relative Contributions

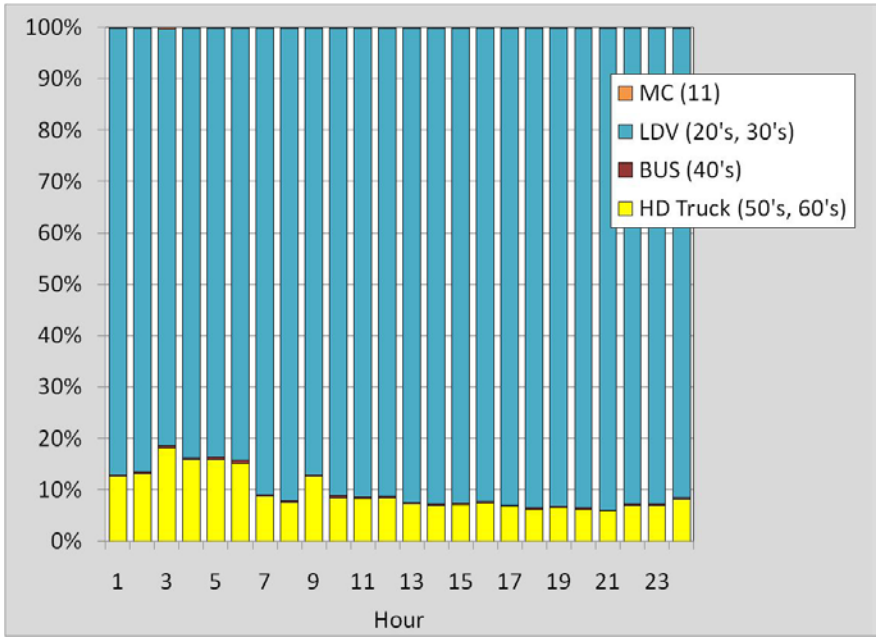


Harris County Hourly **CO Emissions** by Vehicle Type

Absolute Emissions (tons)

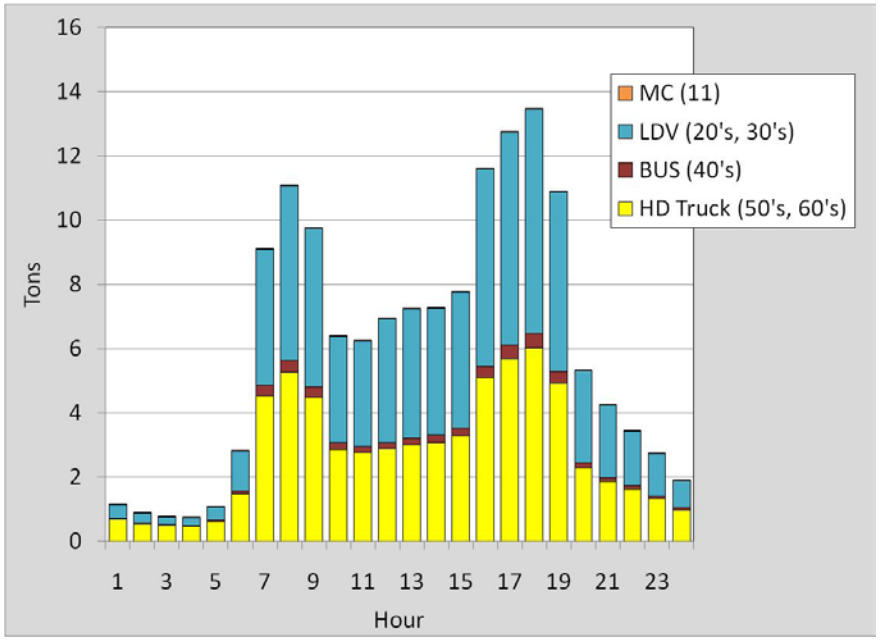


Relative Contributions

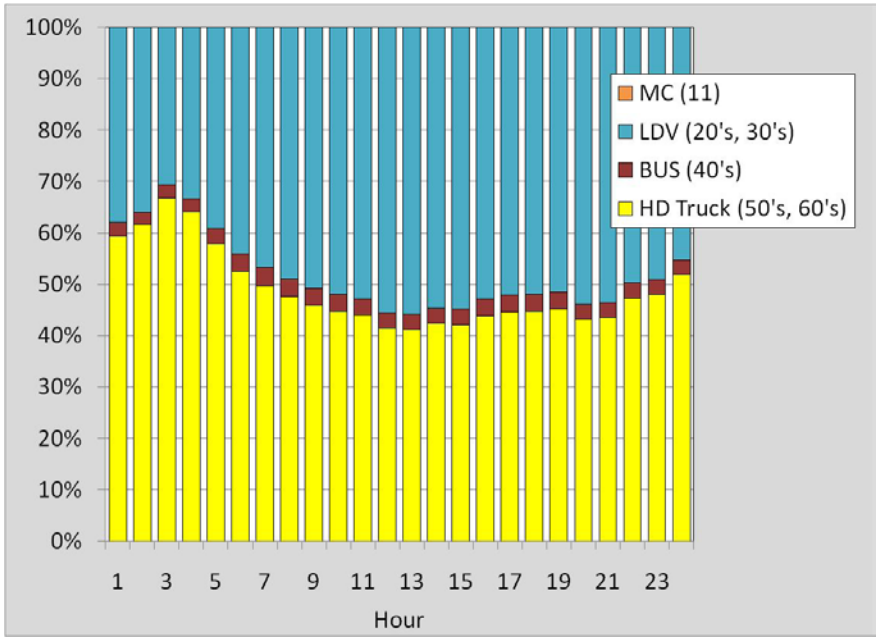


Harris County Hourly NO_x Emissions by Vehicle Type

Absolute Emissions (tons)



Relative Contributions



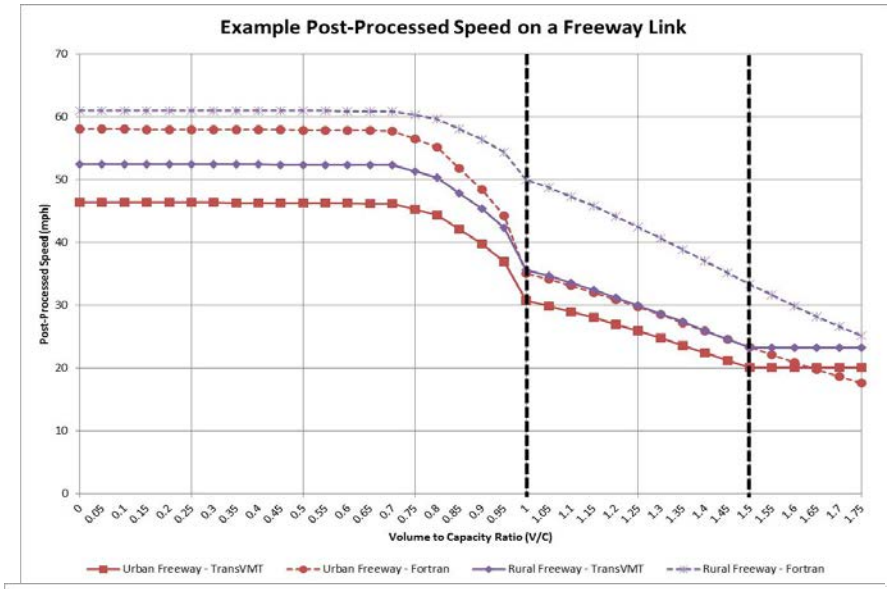
Improving Inventory & Spatial Resolution of Emissions

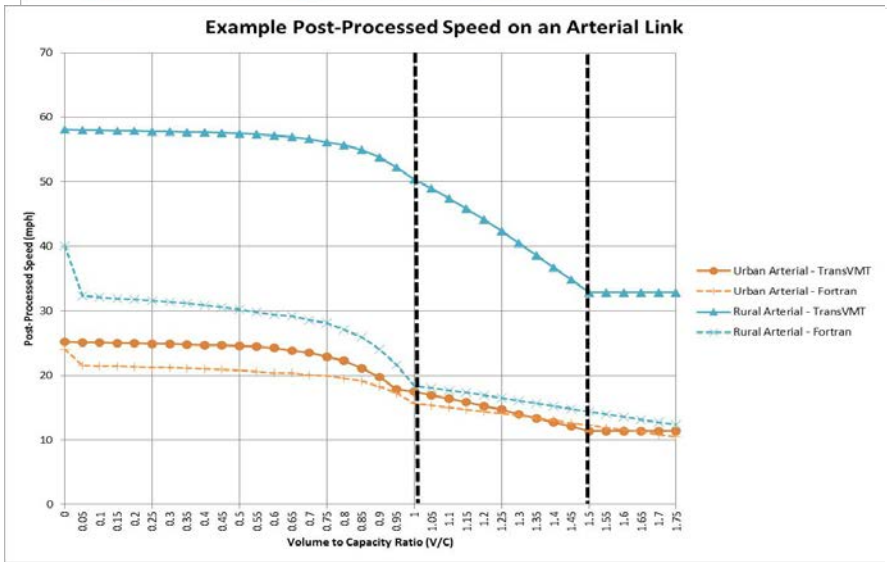
Opportunities for Improvement

- Updated TDM speed post-processing model
  - HGAC has updated model; Evaluated and implemented as choice in TDM script by Cambridge Systematics
- Adding Heavy-duty "hot spots"
  - Operation in ports (based on EPA/TCEQ/HGAC study)
  - Distribution centers, etc.
- Updating vehicle starts from TDM trips and/or HGAC surveys
- Improving Long-Haul Truck VMT based on updates currently being made for 2011 NEI
- Road grade

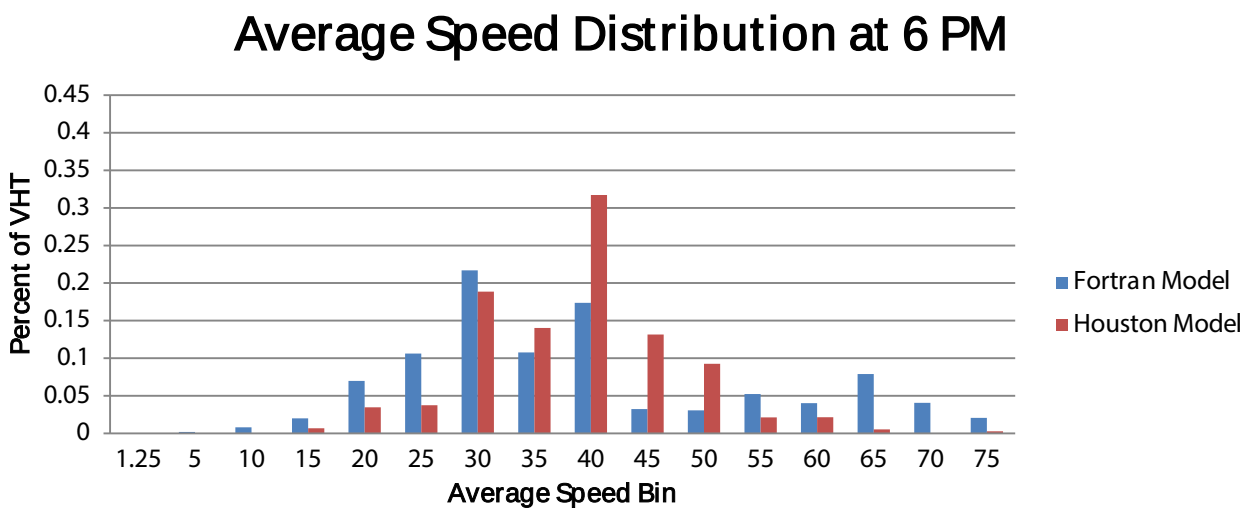
Differences in TRANSVMT and HGAC Speed Models (Cambridge Systematics)

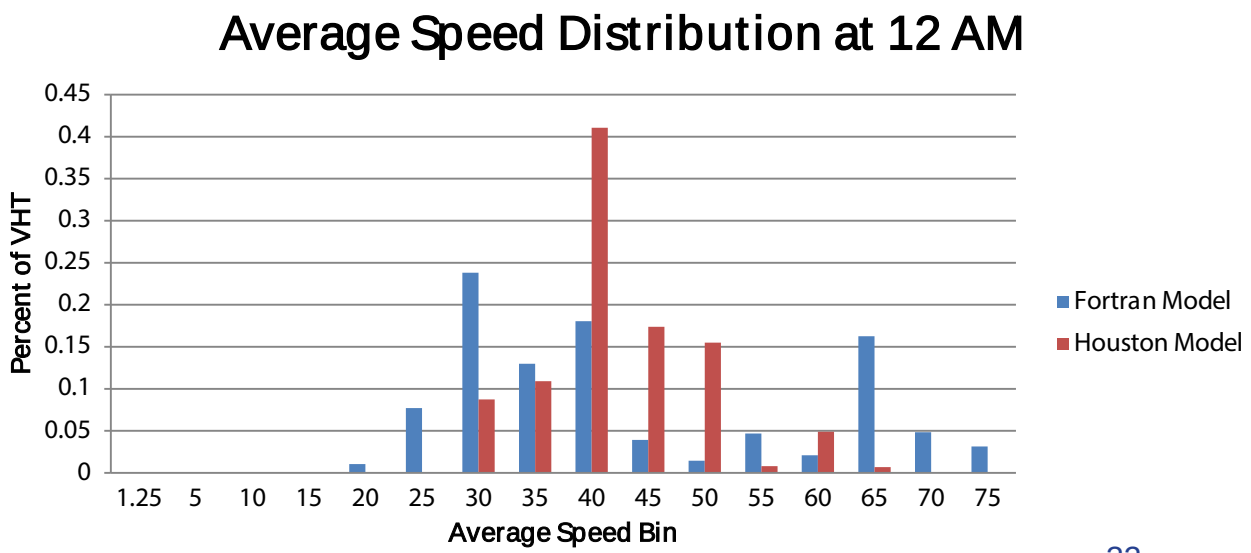
- HGAC considers signals in arterial speed calculations
- HGAC calculates free flow speed and LOSE speed for freeways differently
- HGAC continues to lower speed at v/c>1.5





Speed Model Impacts on Distributions

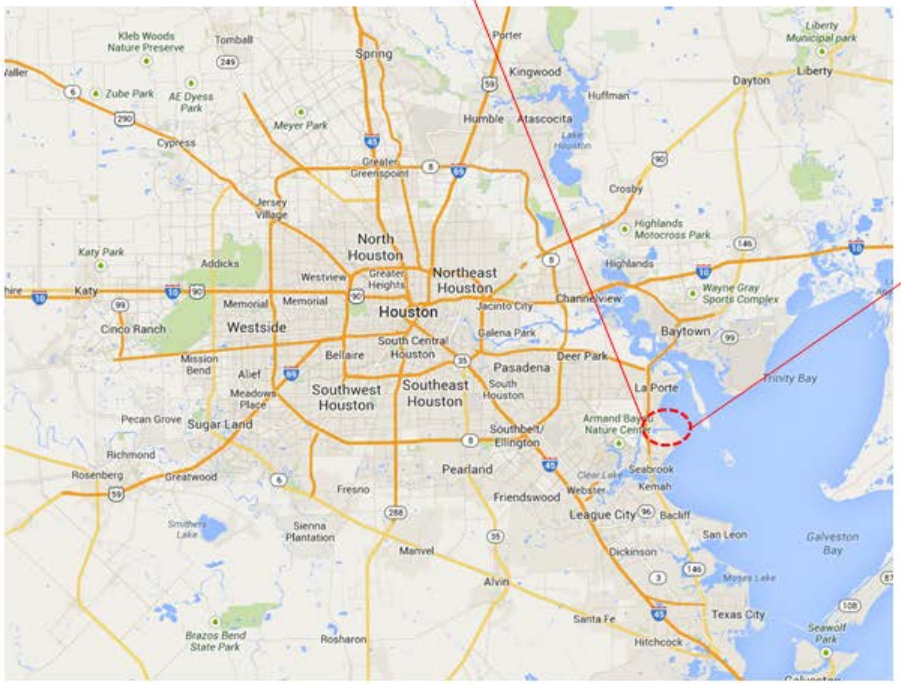




Adding Heavy Duty Hot Spots: Port Terminal (NCHRP 25-38)

Port of Houston

Bayport Terminal



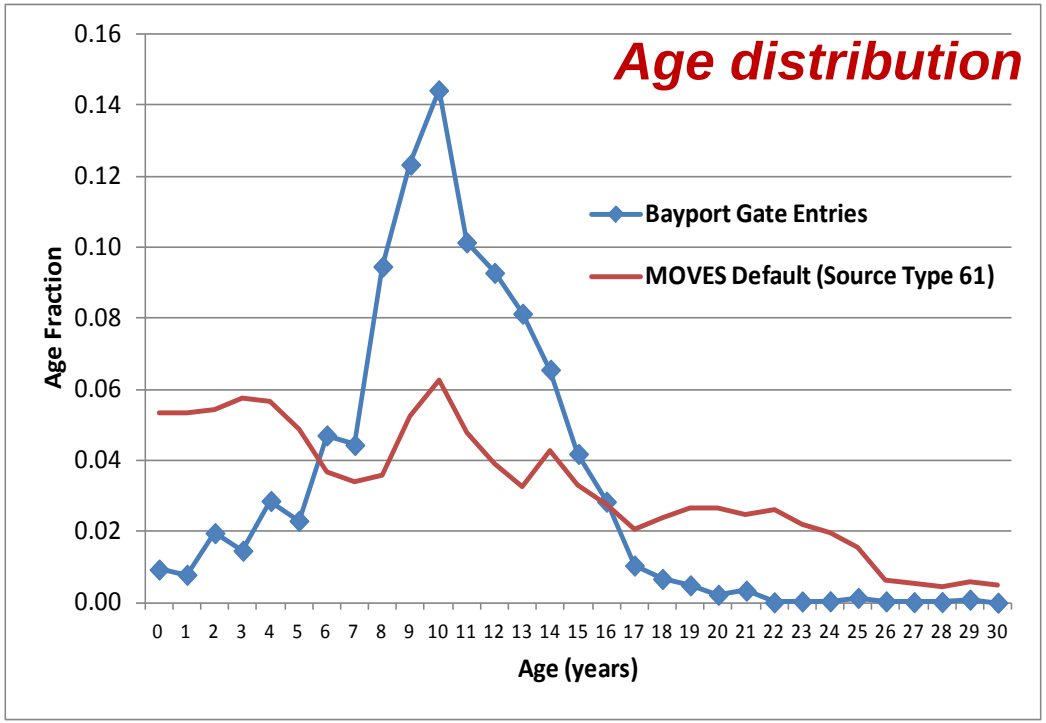
Entrance/Exit

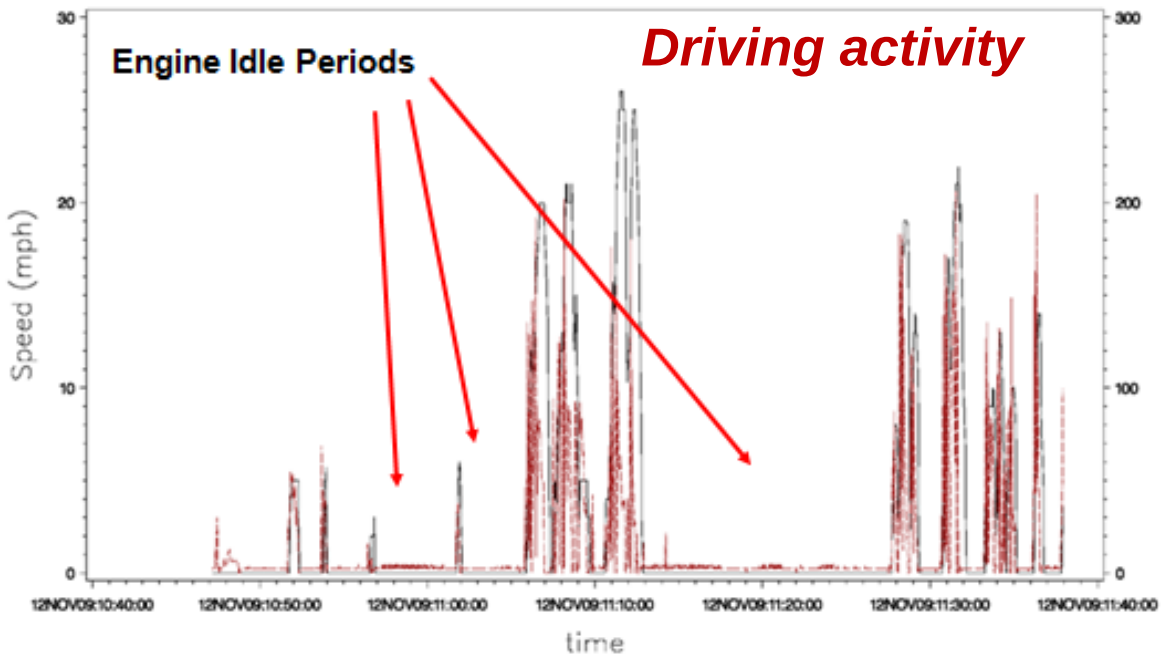
MOVES Project Setup

MOVES Project Input	Definition For This Project	Data Sources
Period	Weekday 10-11am June 2009	-
Link Volume	Number of trucks in the port	**Port Entry/Exit Data**
Link Source Types	100% Combination Short-Haul Trucks (Source Type 61)	-
Age Distribution	-	**Captured plate data (Denver U. RSD) matched with TXDOT registration records**
Meteorology	-	MOVES Default
Fuel Supply	-	MOVES Default
Fuel Formulation	-	MOVES Default
Fuel Type & Technology	Diesel	-
Operating Mode Distribution	Within-Port VSP Distribution (or use drive cycle directly)	**Portable data loggers**

Populated with data collected from EPA/TCEQ/HGAC Houston Port Study

Port-specific MOVES inputs





MOVES Results

Bayport Terminal NOx & PM ~ 2% of total areawide emissions for combination short-haul trucks

Other port terminals in area not included (e.g. Barbour's Cut)

Summary & Next Steps

Summary & Next Steps

- SEE is a new tool that allows MOVES emissions to be estimated at the link & zone level
- Matches county-level runs for conformity purposes
- Provides framework for including new elements, such as heavy-duty hot spots.
- Next steps:
  - Improve processing time
  - Add GUI
  - Documentation
  - TRB paper planned