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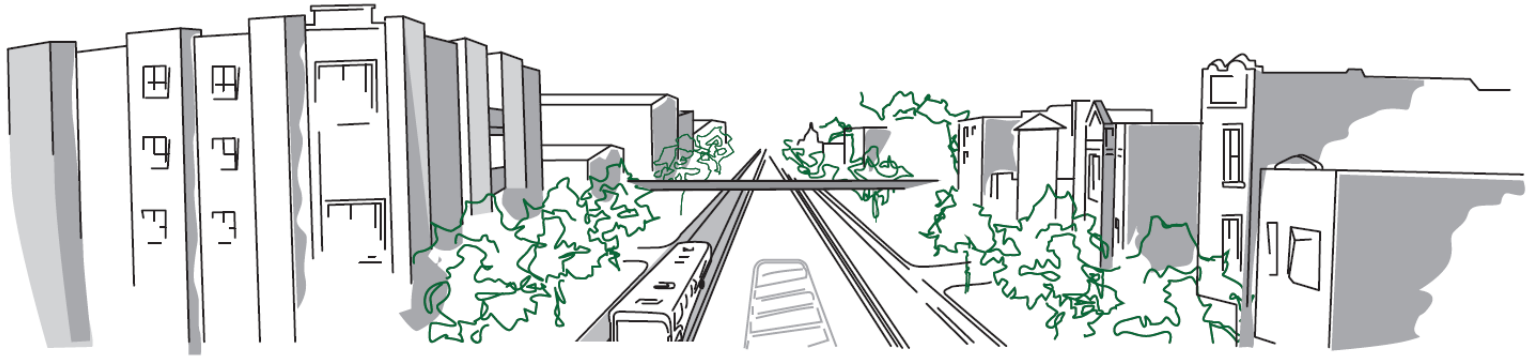

# Development of a New Emission Inventory for Mobile Sources in Large Metropolitan Regions: Application of Traffic Emission Prediction Scheme (TEPs) in Quebec and Ontario

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Transportation Research Institute

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# Introduction

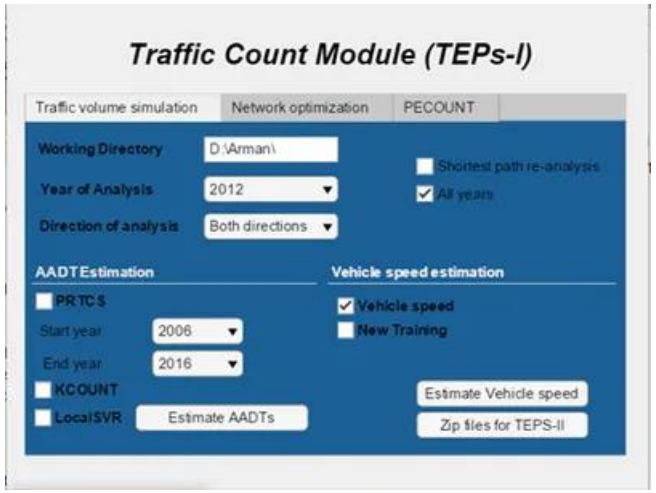
- With a changing urban mobility landscape (travel patterns and new vehicle types), it is critical to develop techniques for the generation of mobile source emission inventories at urban and regional scale.

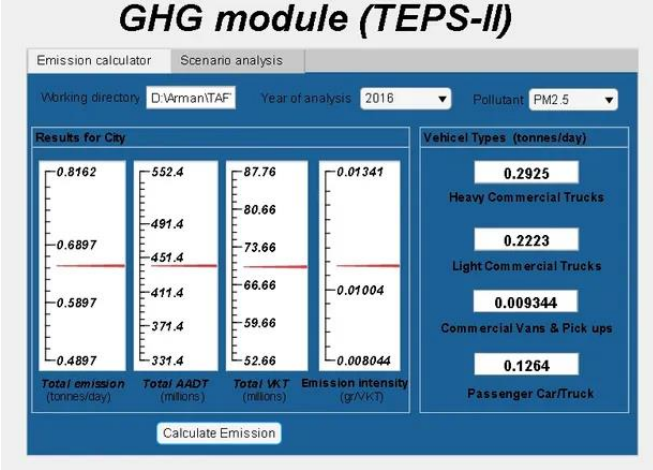
# Traffic Emission Prediction scheme (TEPs)

- TEPs improves the regional prediction of mobile source emissions through a combination of advanced spatiotemporal models and satellite-image processing. TEPs merges short-term on-road and satellite-based vehicle counts (extracted based on a combination of Convolutional Neural Networks and image processing techniques) with traffic count data at stations with long record lengths to predict traffic on roads with no traffic observations.

TEPS

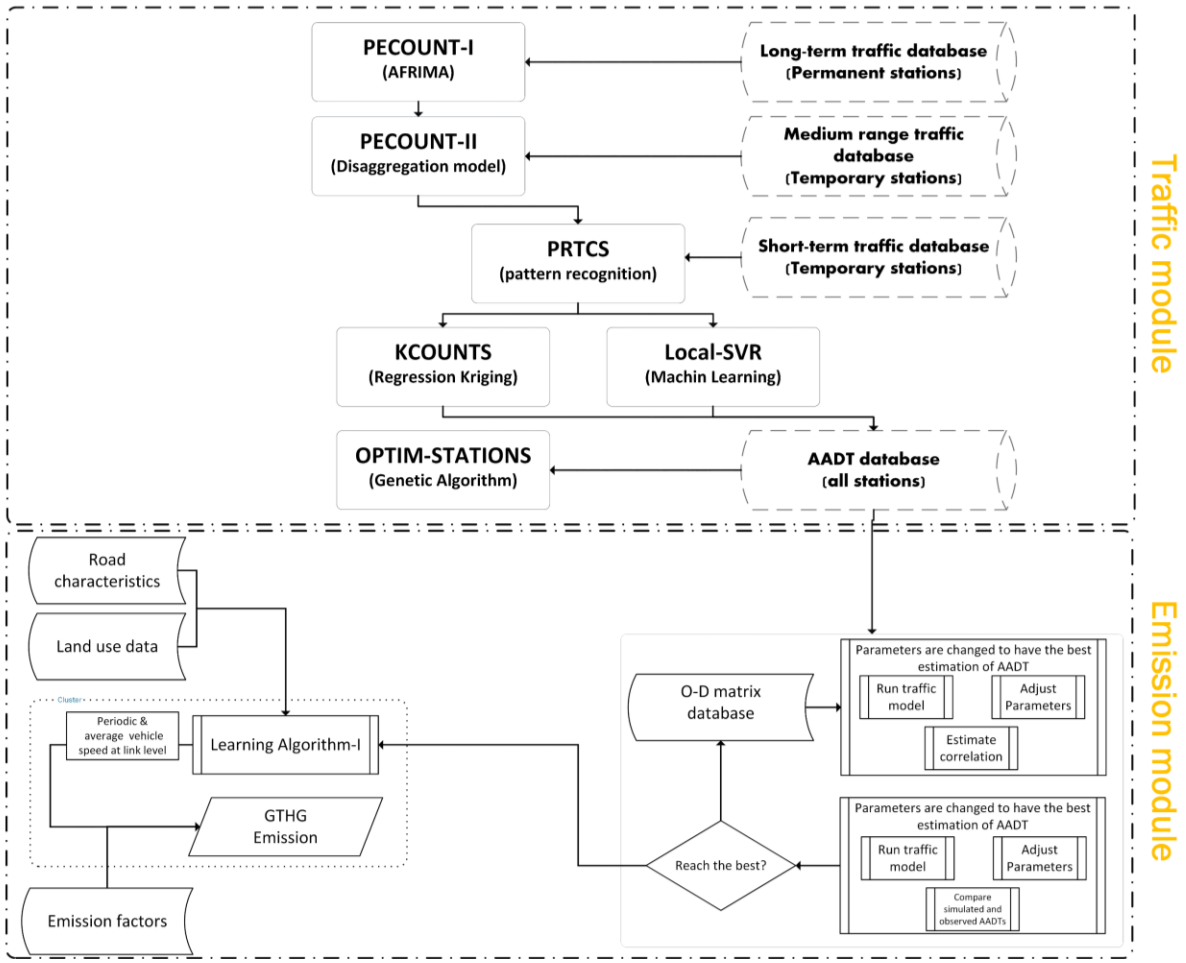
Traffic Emissions Prediction scheme



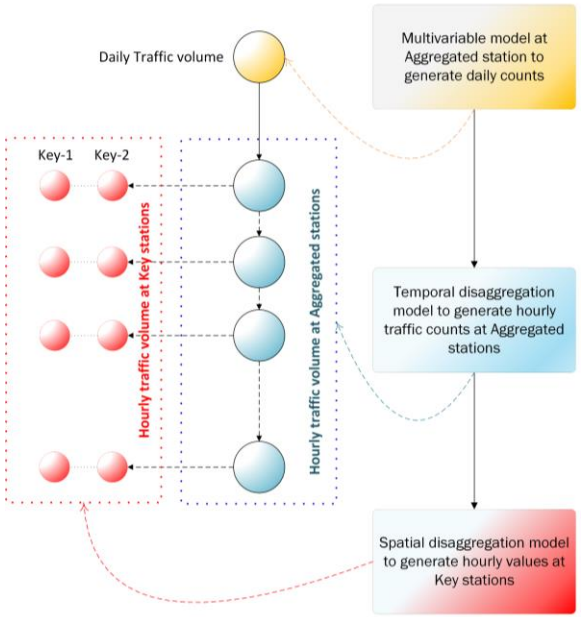



# Theoretical basis

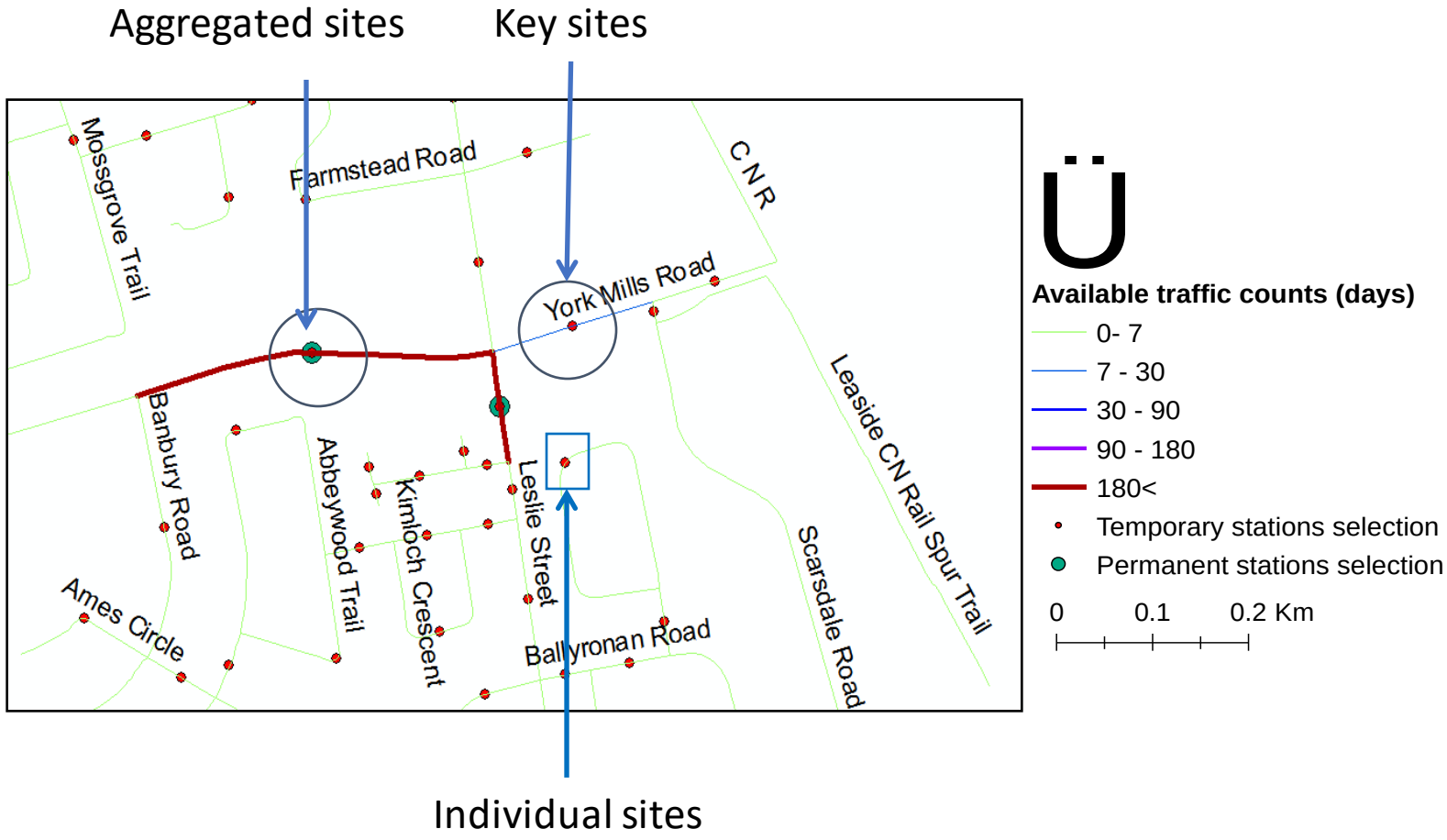
- The merging techniques include spatiotemporal disaggregation, pattern recognition, and trend analysis, which connect long and short-term counts. Subsequently, Annual Average Daily Traffic (AADT) is estimated for several years based on a combination of Supportive Vector Regression and Regression Kriging/Neural Network techniques for all roads across a network



# PECOUNT-I & PECOUNT-II



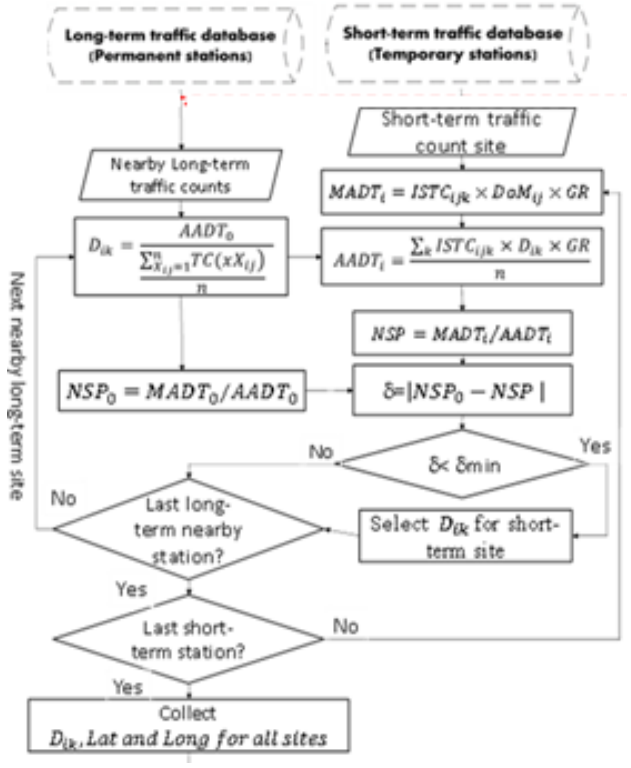

Spatio-temporal disaggregation model



# PRTCS

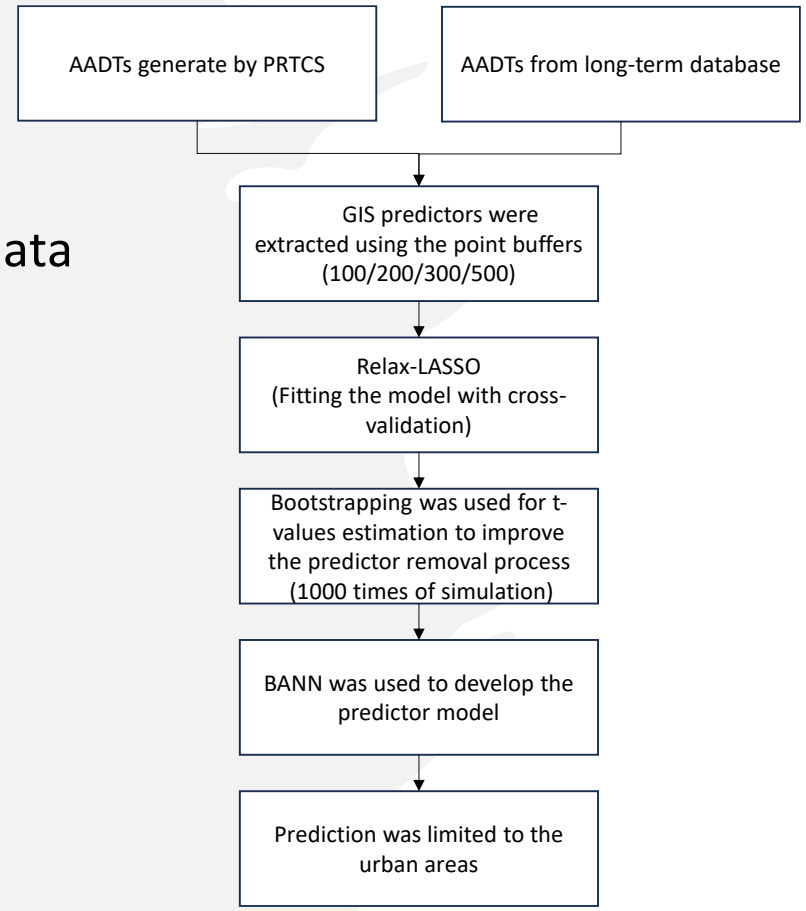
**AADT prediction using Pattern Recognition Traffic Counts model**

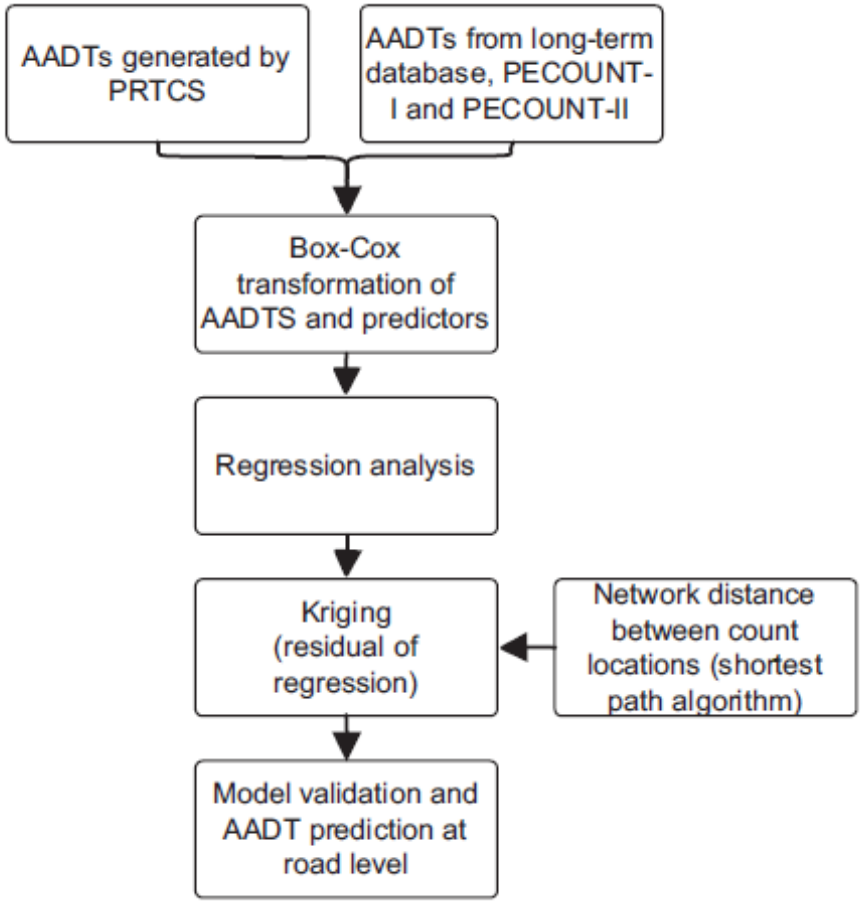
- Traffic Emission Prediction scheme (TEPs) uses a long record of traffic counts to extend downstream daily traffic counts; a pattern recognition approach further identifies a coefficient to estimate AADT from daily values. This technique provides a unique basis to use short-term traffic counts (e.g., one day) for long-term average traffic prediction (AADT).



# KCOUNT

For all location without data



# Satellite data- a new data source

**Expanding the database of short-term counts using aerial imagery**

*Vehicle detection from aerial images*

- *Convolutional neural network (CNN*

*Road detection and extraction of road characteristics*

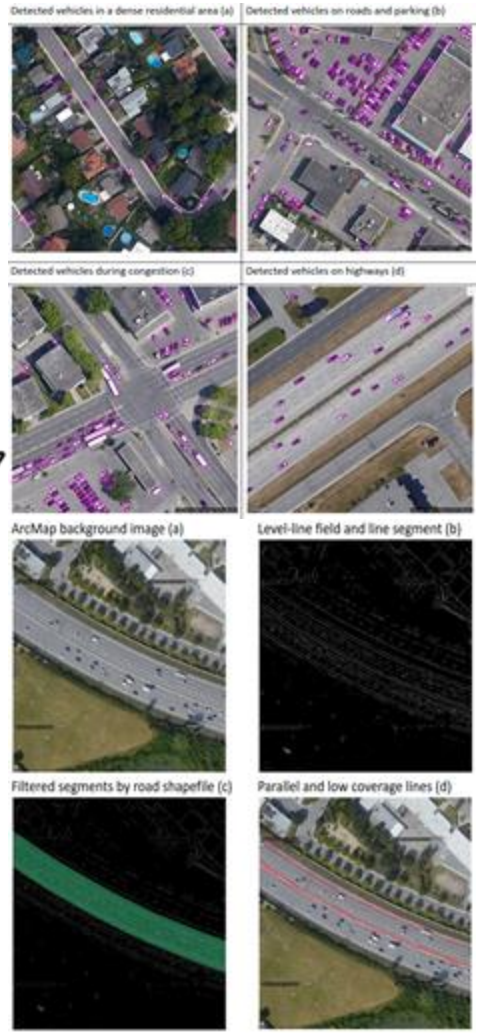
- *Image processing method*

*Time stamp of aerial images*

- *Based on shadows and sun position*

*Prediction of AADT from short-term image-based counts*

- *Neural Network and road characteristics*



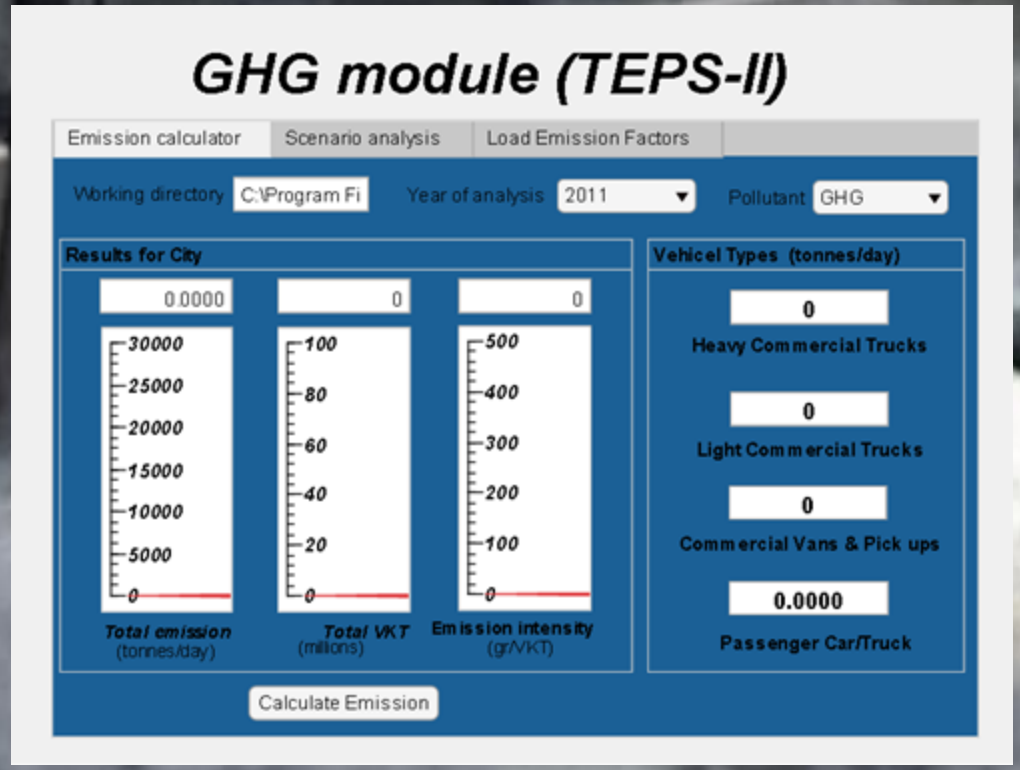

Vehicles detection

Daily traffic prediction

Road characteristic detection

# EMISSION PREDICTION

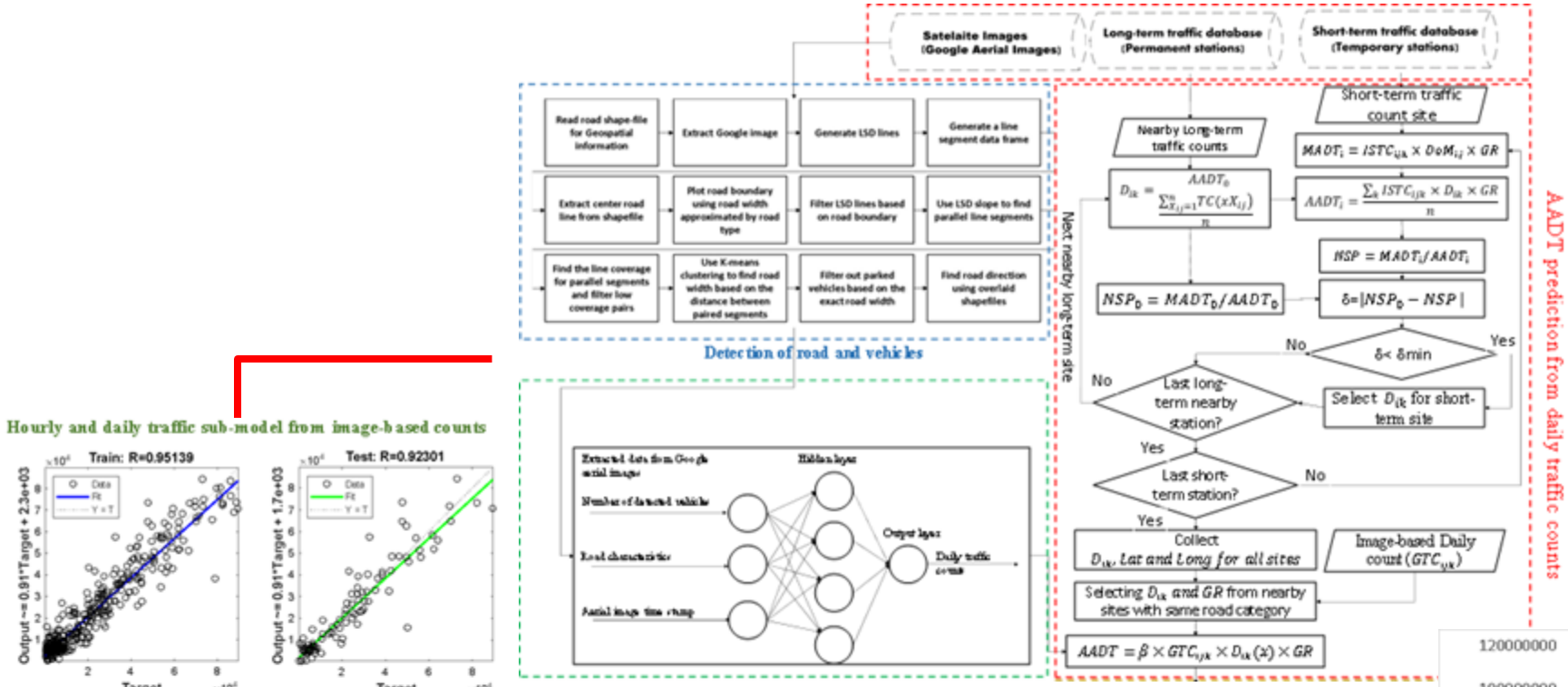
Segment-level vehicle kilometers traveled (VKT) were multiplied by the corresponding emission factors to obtain segment emissions. The emission factor database was derived from the Mobile Vehicle Emissions Simulator (MOVES) platform developed by the United States Environmental Protection Agency.



# Example for AADT and emission prediction at provincial scale

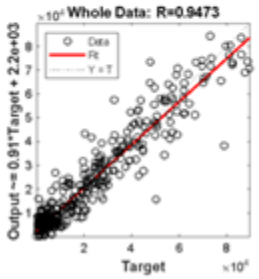
TEPs performance was evaluated in Quebec province and several Canadian metropolitan regions, including Toronto, Montreal, and Quebec. Multiyear road emission inventories for various pollutants were generated for all types of roads, including local and major roads and highways

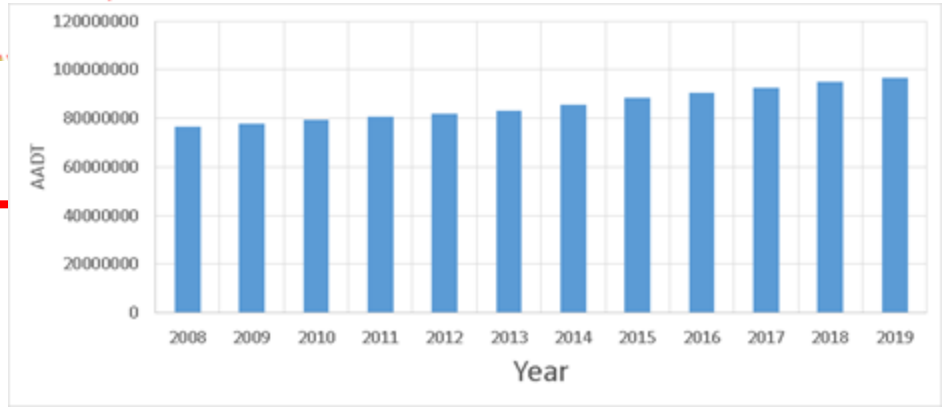
# AADT inventory for provincial roads



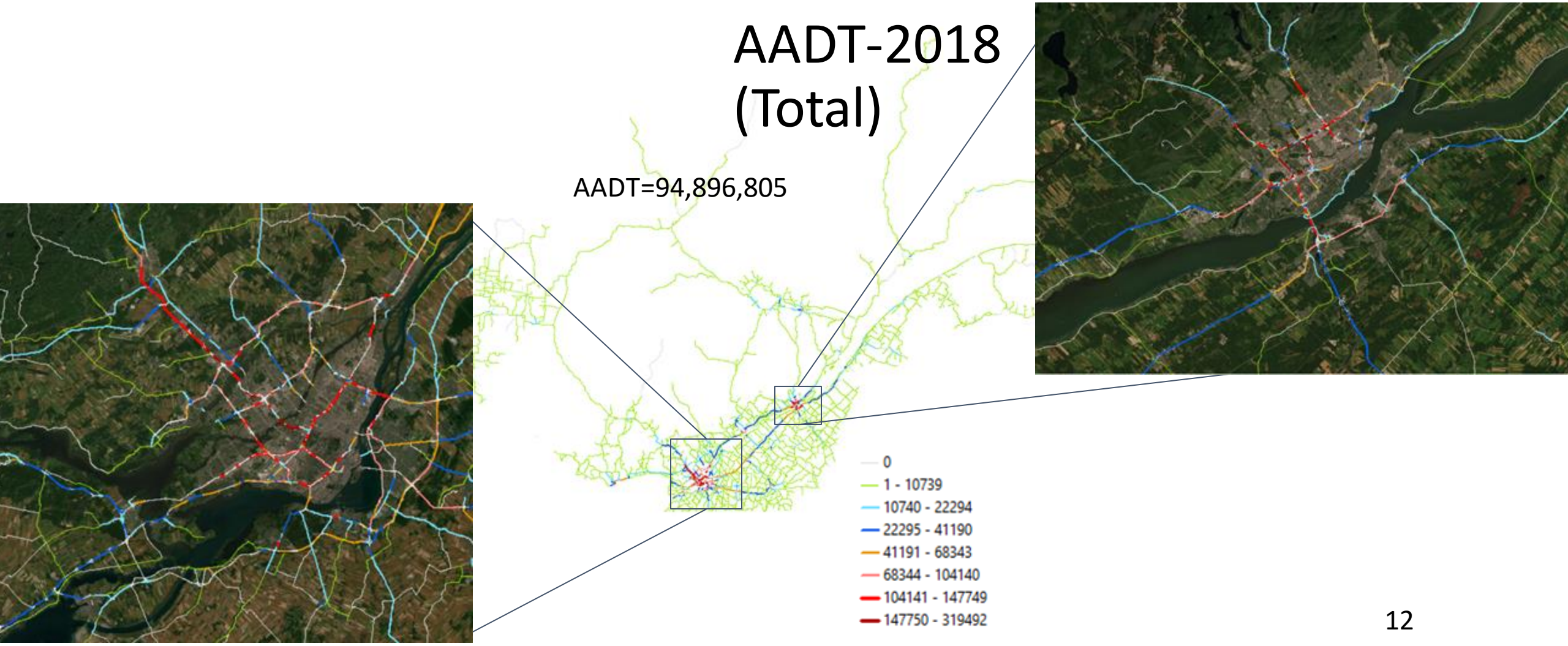

Hourly and daily traffic sub-model from image-based counts



# AADT inventory for provincial roads



# AADT inventory for provincial roads (2040 projection)

MK trend analysis based on the 2008-2019 inventory

↓

Finding the link with significant trends

↓

Estimate Sen's slope for the links with significant trends

↓

Prediction of 2040 AADT for each individual link based on Sen's slope values

Sen's slope (Veh/year)-West/Southbound direction

# AADT inventory for provincial roads (2040 projection)

MK trend analysis based on the 2008-2019 inventory

↓

Finding the link with significant trends

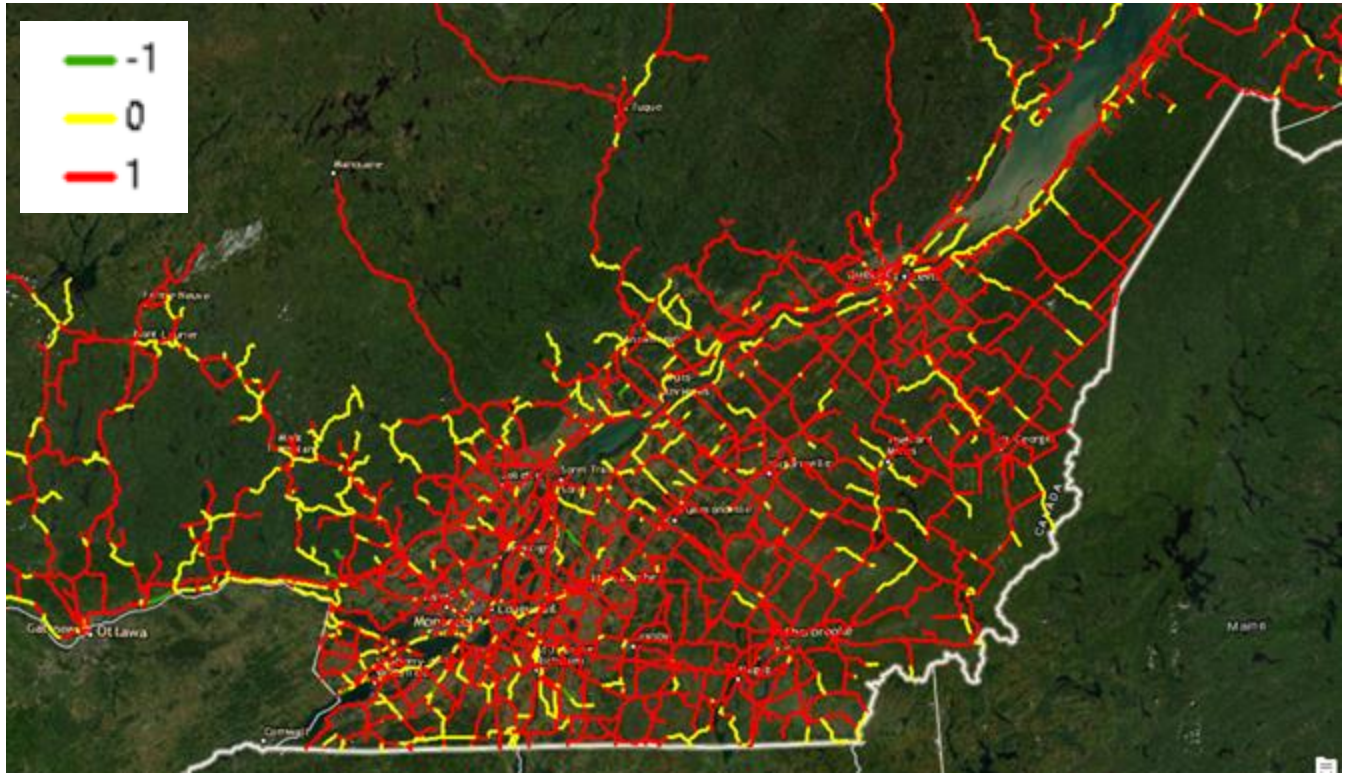
↓

Estimate Sen's slope for the links with significant trends

↓

Prediction of 2040 AADT for each individual link based on Sen's slope values

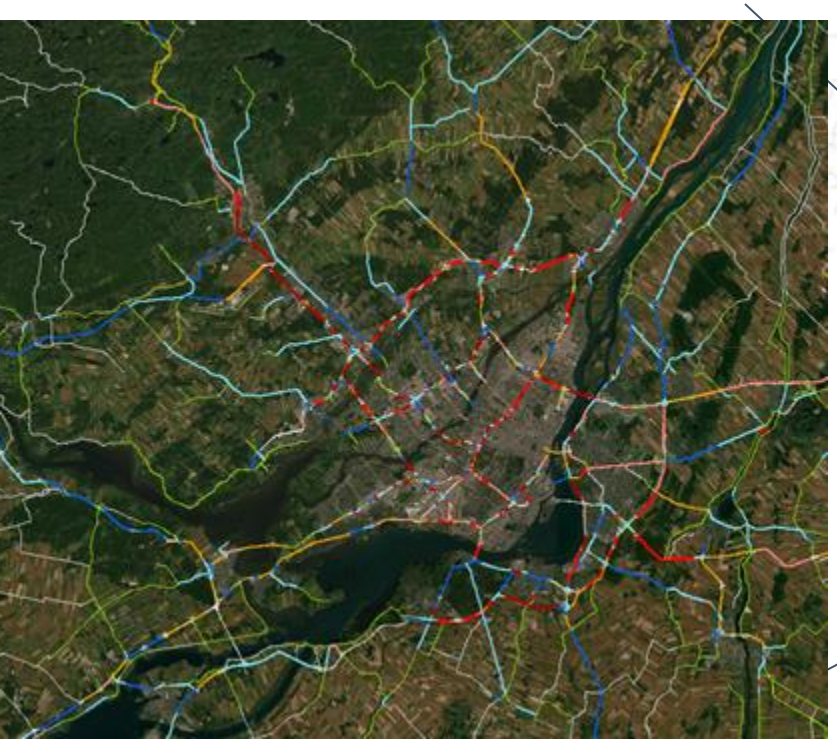
Links with statistically significant (1 and -1 for positive and negative slopes) and insignificant trends (0)

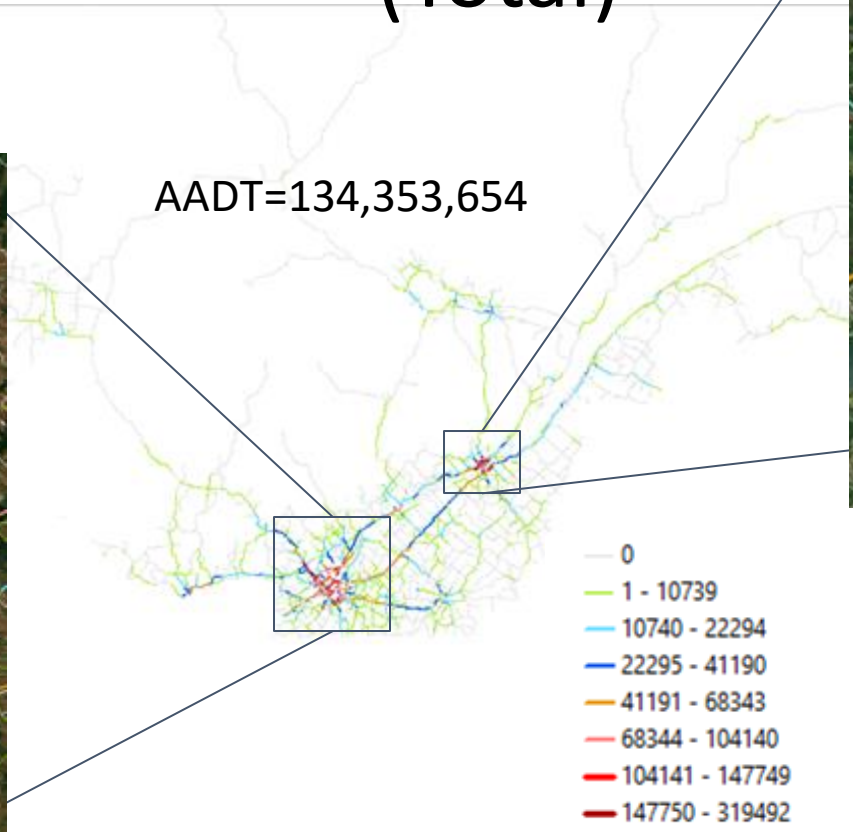



West/Southbound direction

# AADT inventory for provincial roads (2040 projection)

AADT-2040 (Total)





# Grid-based AADT over the entire modelling domain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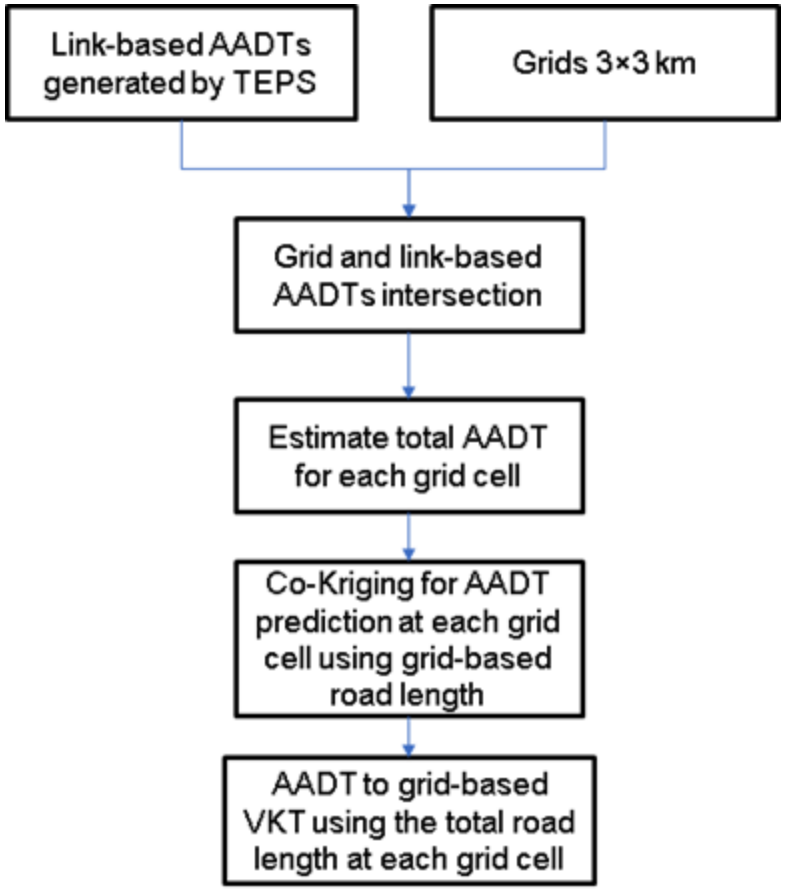
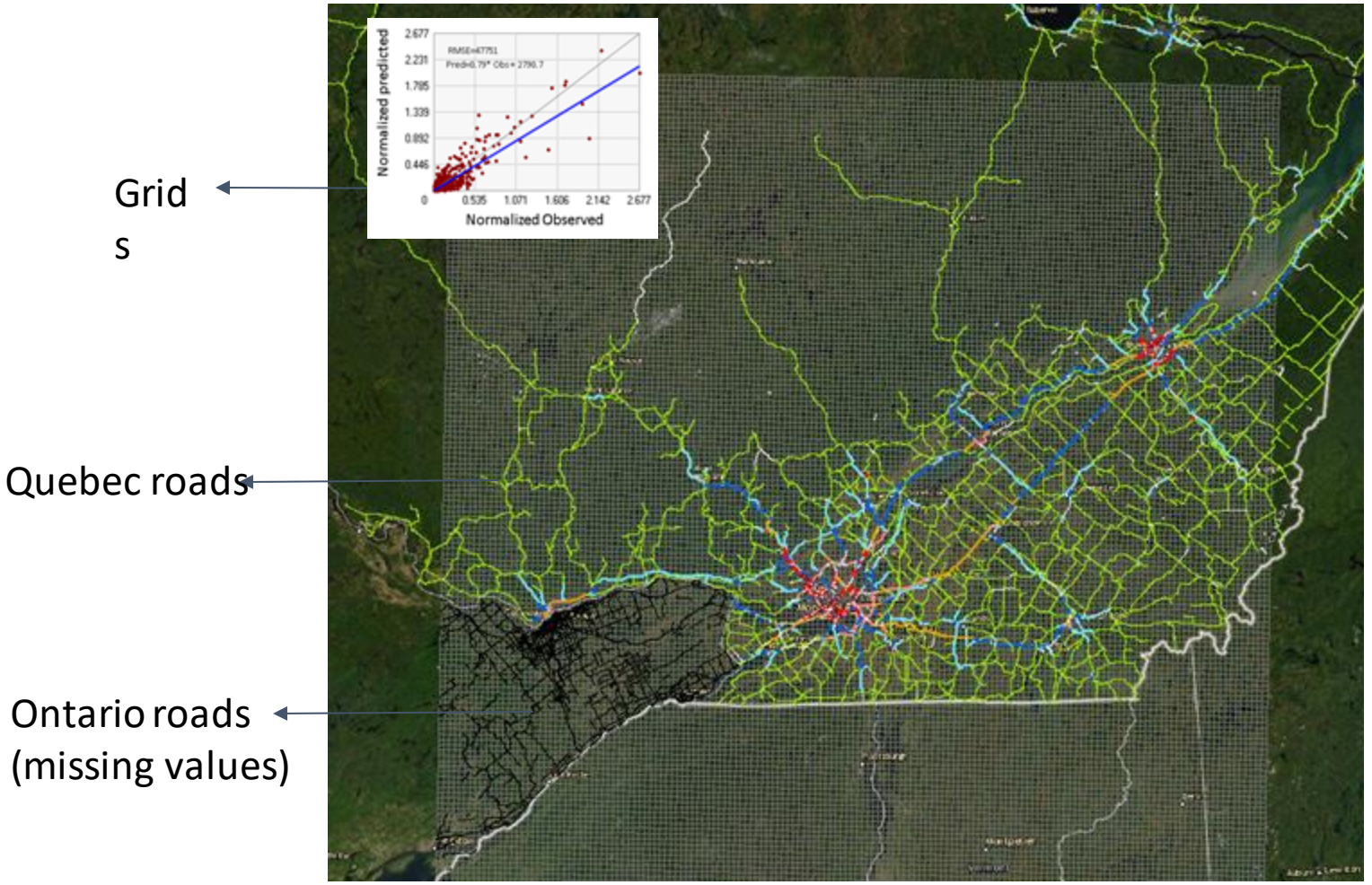
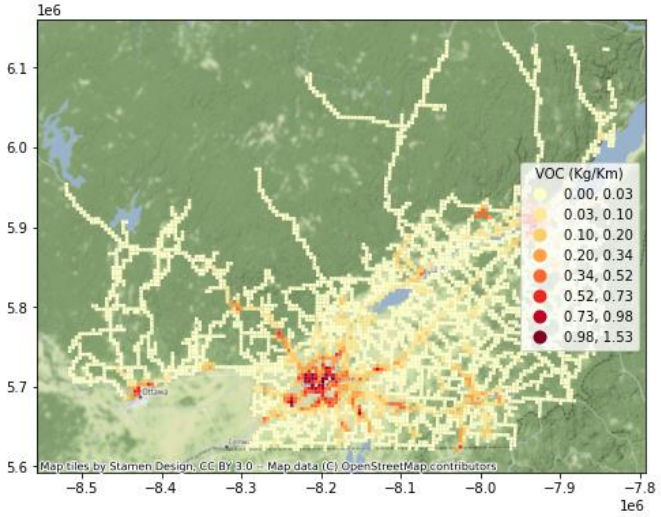
# Grid-based AADT over the entire modelling domain

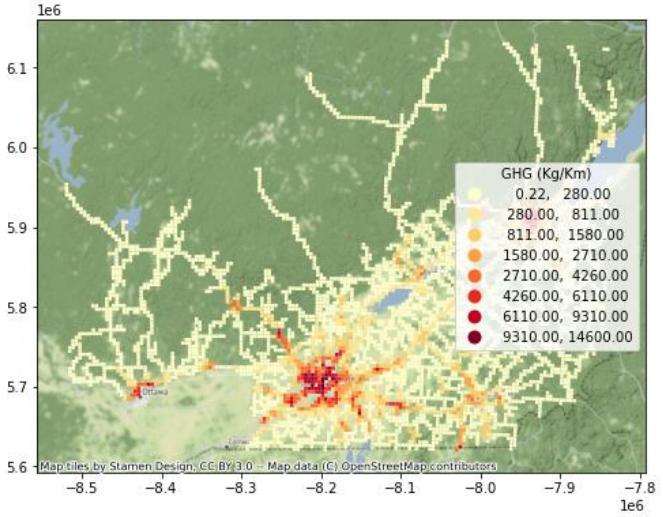


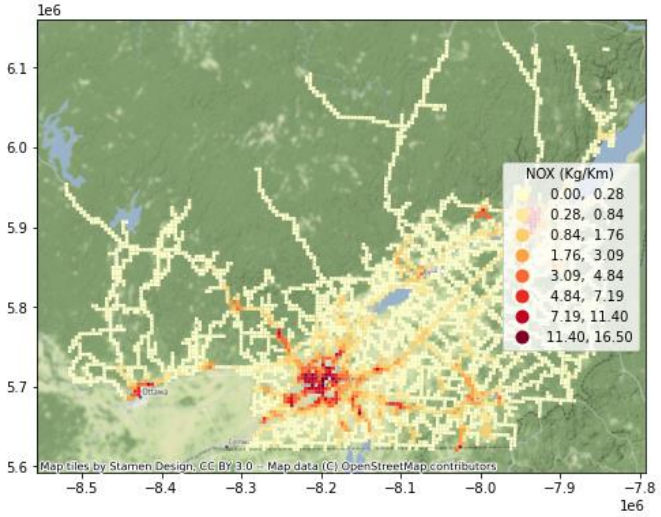
# Grid-based 2018-AADT over the entire modelling domain



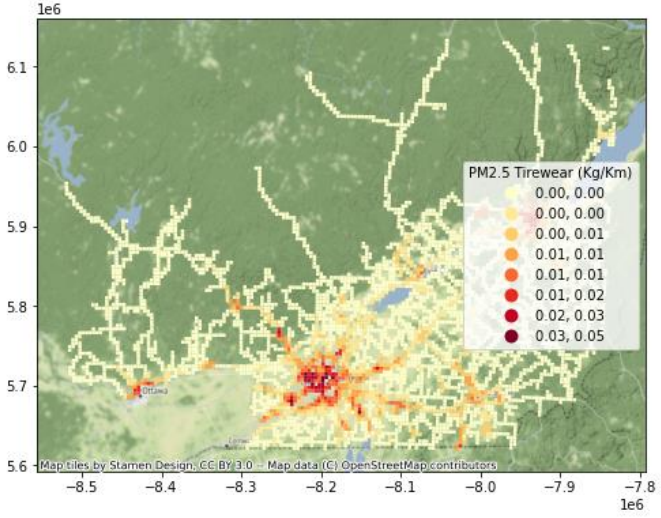

VOC- Gridded prediction (Kg)



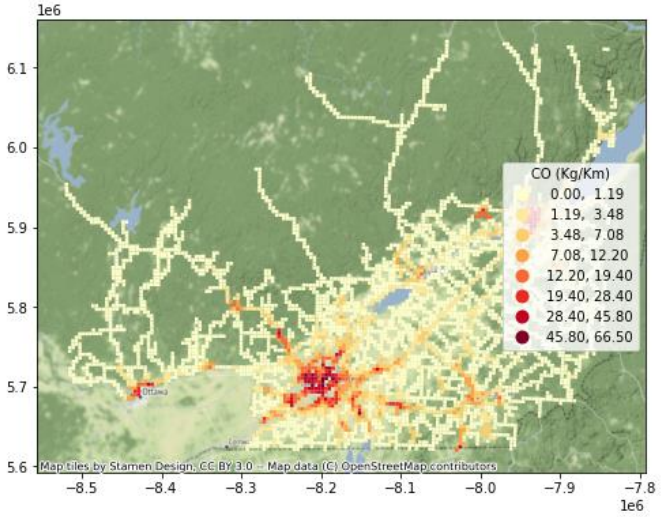

GHG- Gridded prediction (Kg)



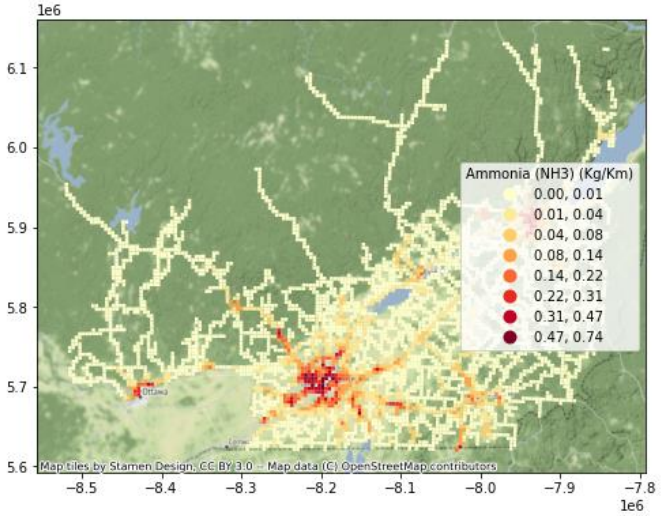

NOX- Gridded prediction (Kg)




FPT- Gridded prediction (Kg)




CO- Gridded prediction (Kg)




NH3- Gridded prediction (Kg)

# Traffic in the metropolitan areas and scenario analysis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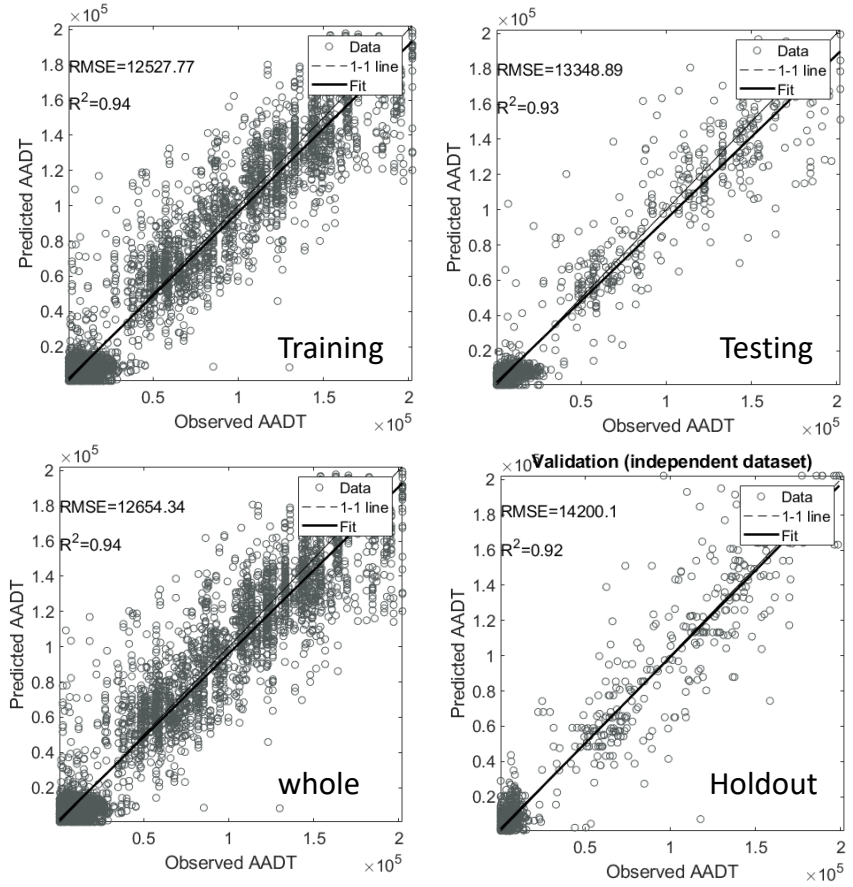
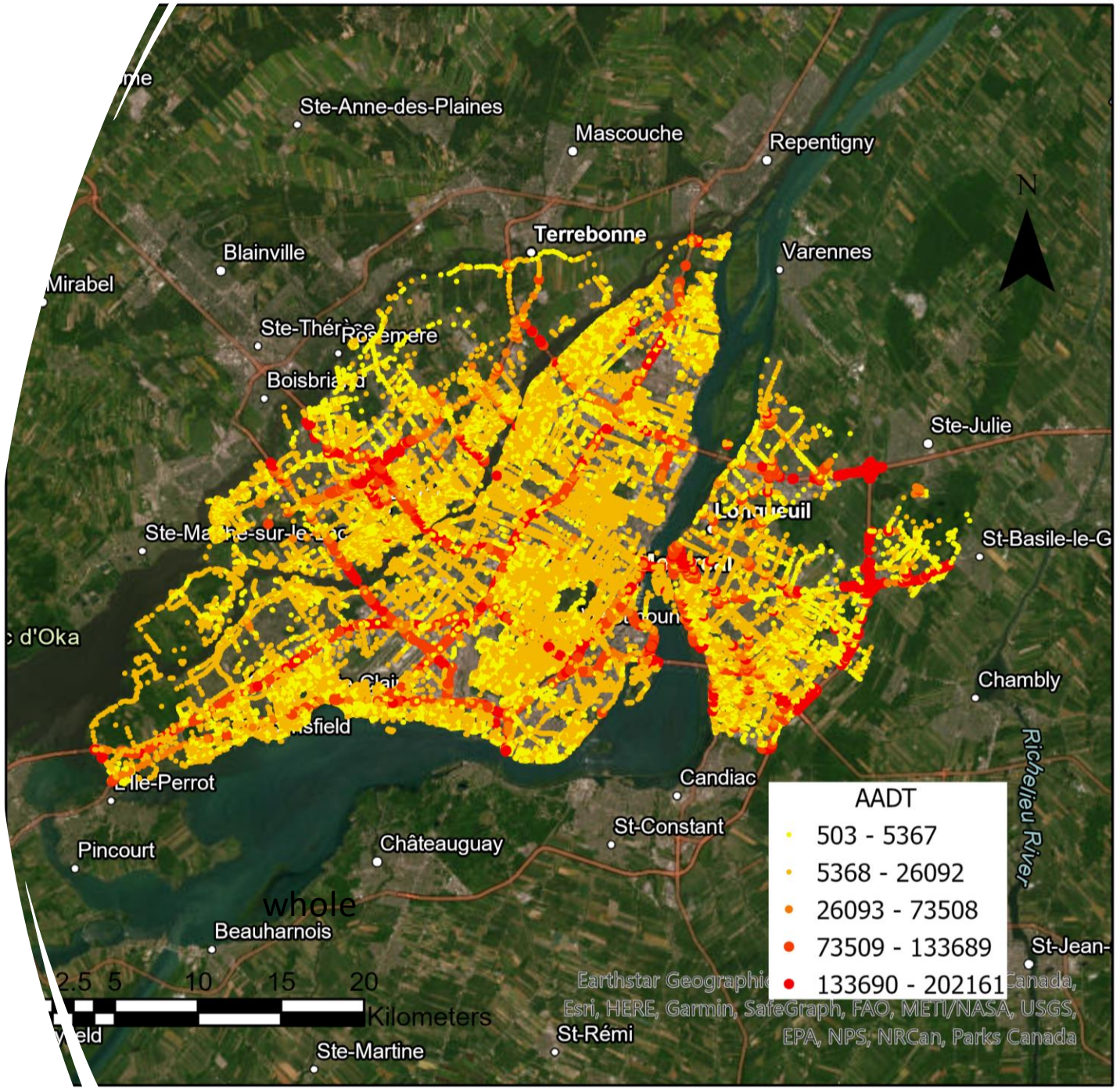
# Example for AADT and emission prediction at urban scale

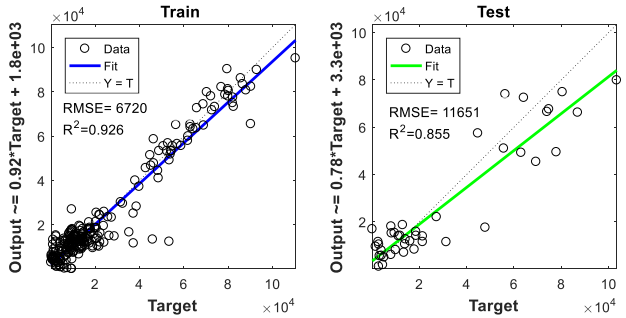


# Example for AADT and emission prediction at urban scale- Toronto (Including Satellite images)

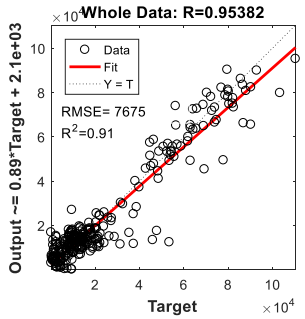
**Bayesian Regularization Artificial Neural Network (BR-ANN) for daily counts prediction from Satellite images**







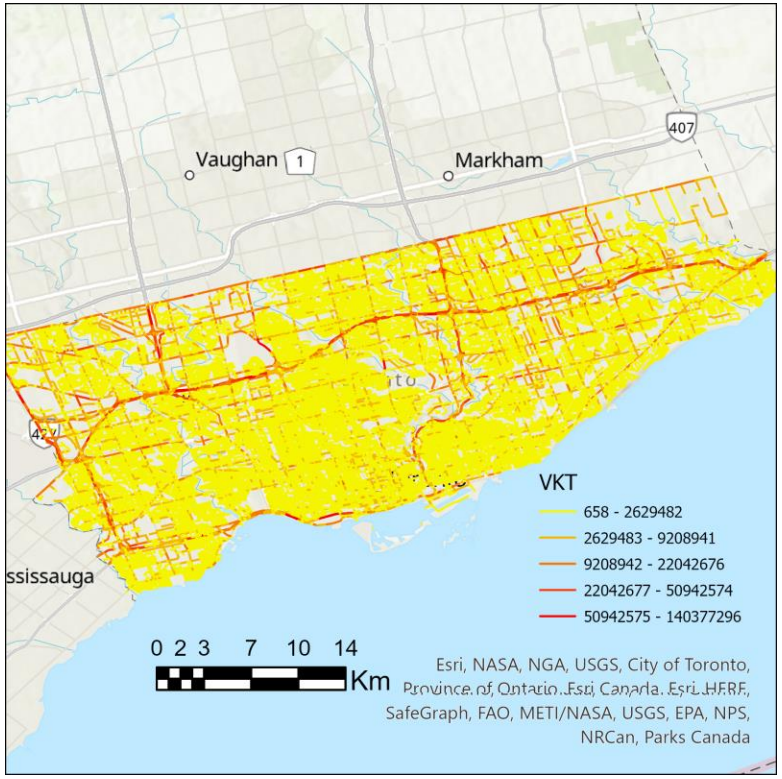


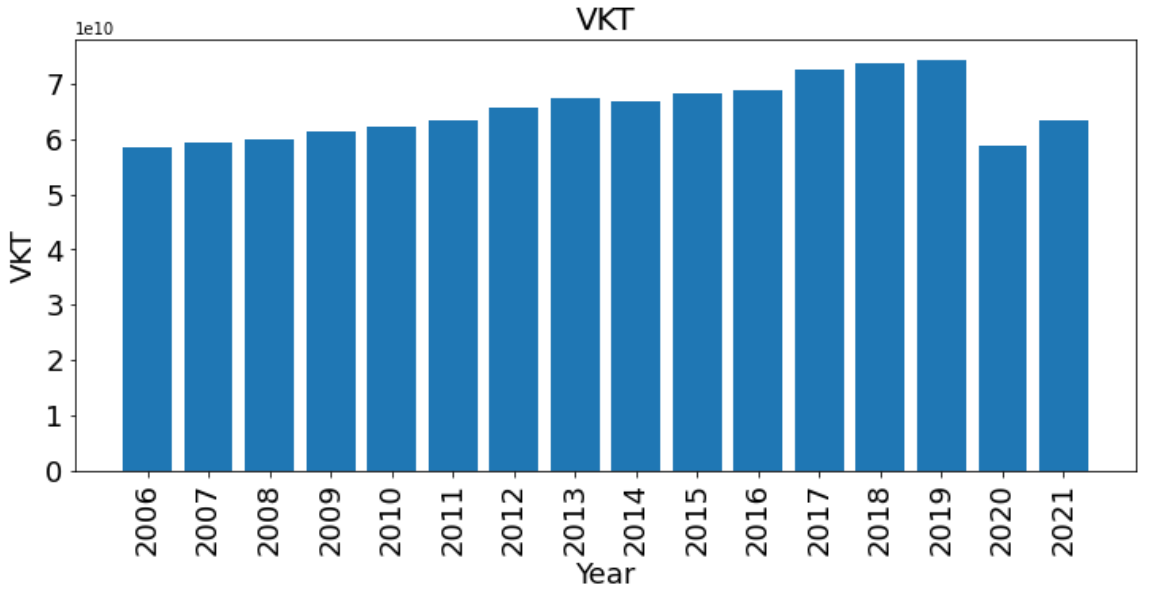


# VKT

(multiyear inventory) Prediction for Covid

- VKT2021= 63,414,342,332
- VKT2020= 58,660,000,000
- %increase compared to 2020= 8.1%

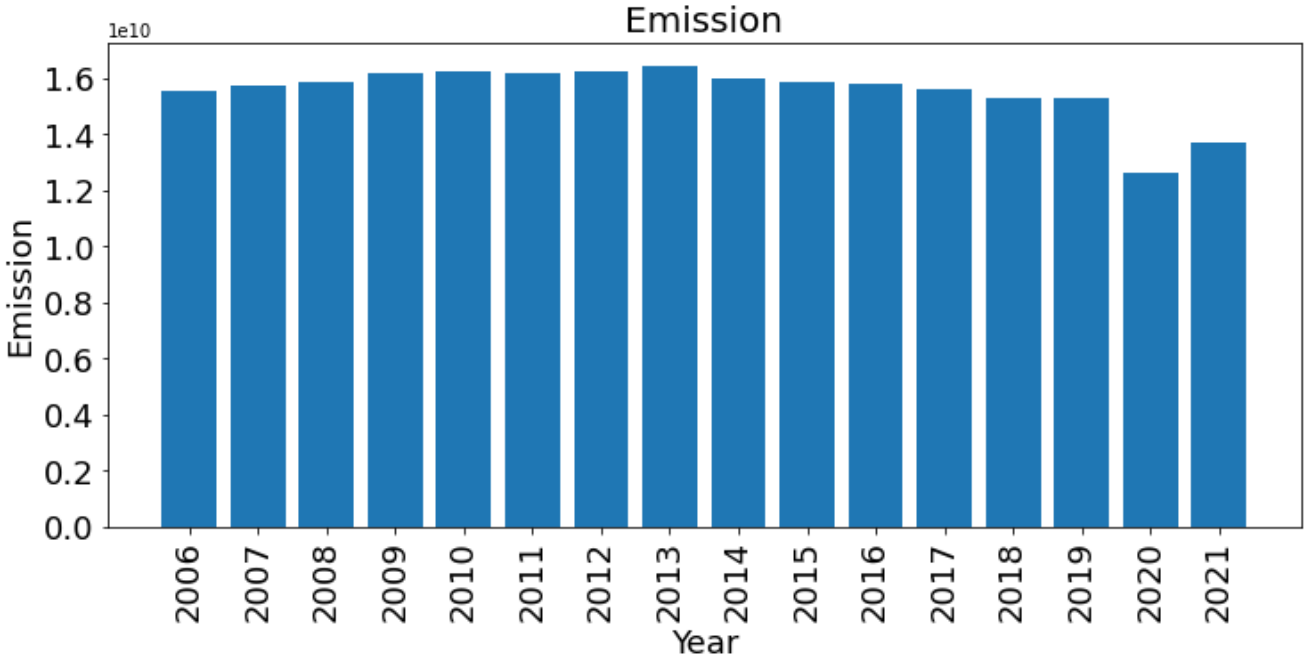


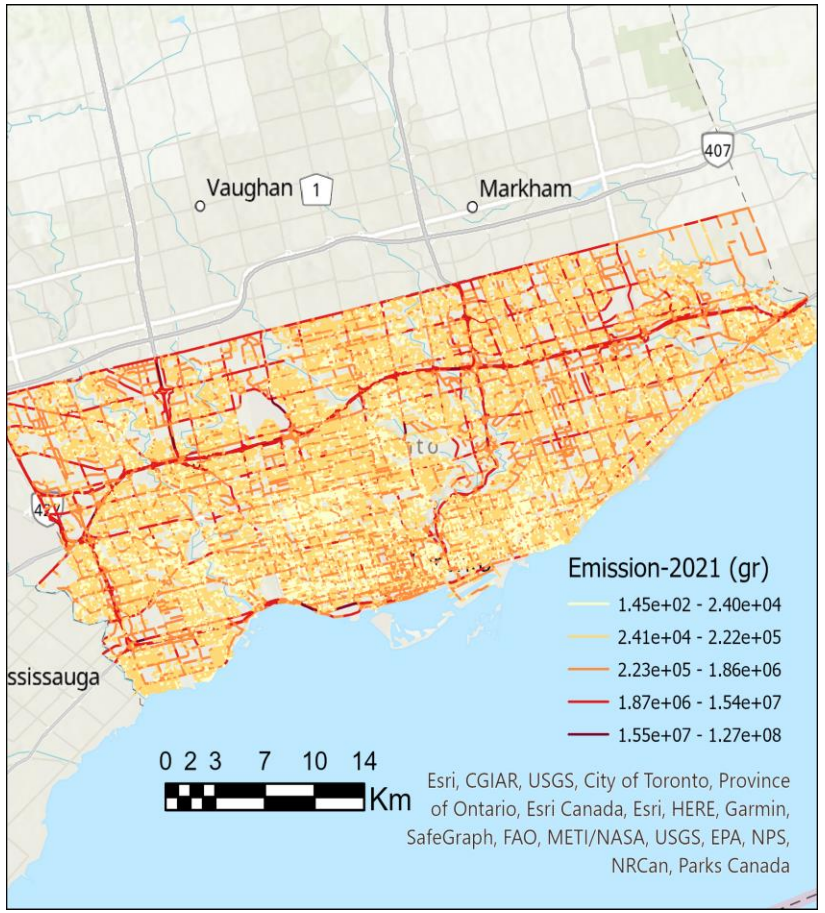



# GHG emission

(multiyear inventory)
Prediction for Covid

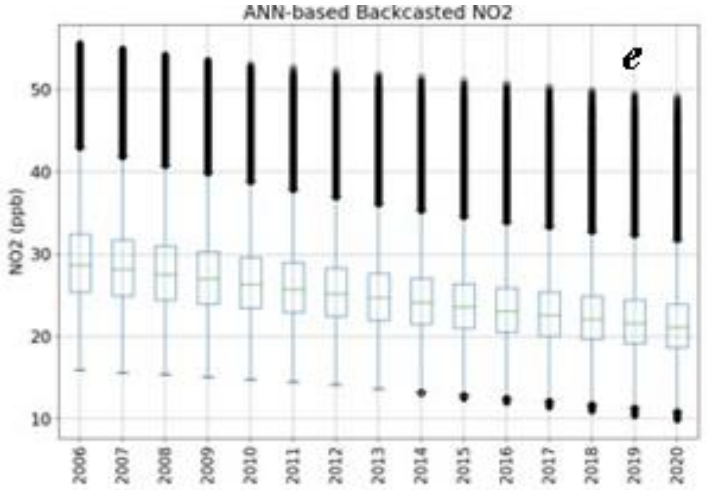
Emission2021= 13,720,540,000
Emission2020= 12,658,000,000
%increase compared to 2020= 8.4%

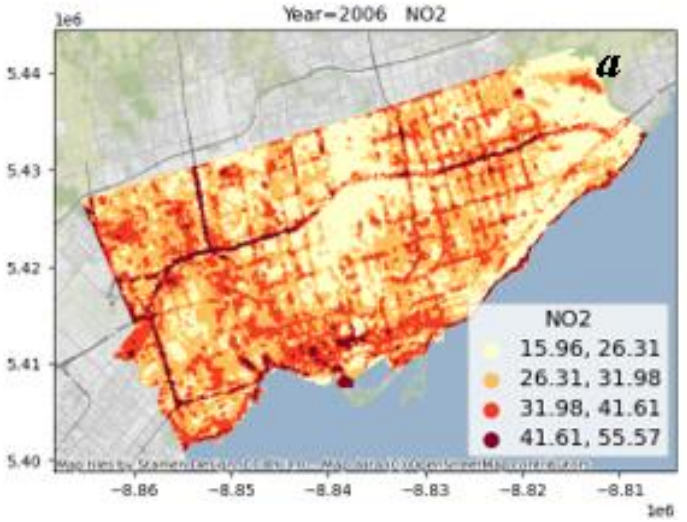


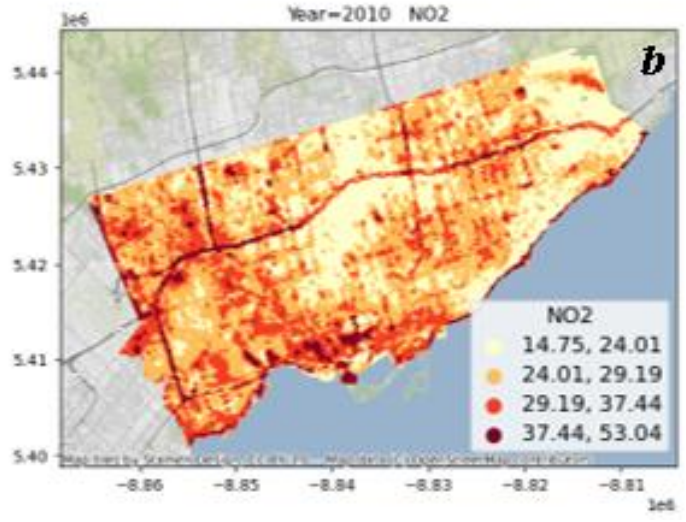



# Backcasting the air pollution

($NO_2$ concentration)



# Conclusion

- We developed a model (TEPs) of AADT, emission and air quality prediction based on vehicle counts, satellite-based road characteristics and vehicle detection.
- TEPs was developed to mine traffic count data in order to predict the emission across urban/provincial road network and over time.
- Since the proposed methodology works based on the observed traffic counts and images, using relationships that are extracted directly from the data, it is therefore transferable to other cities.
- As a benefit of using TEPs, it is possible to predict and backcast AADT, emissions and air pollution for any specific year.
- This scheme has the potential to truly shape the way urban transportation emission inventories are currently developed, providing robust vehicle activity data (through traffic counts) and the capability of tracking progress through time.