



# Analysis of The Impact of Extreme Cold Climate on Particulate Emissions from On-road Urban Passenger Transportation

Negar Razzaghi<sup>1</sup> and Vahid Hosseini<sup>1</sup>

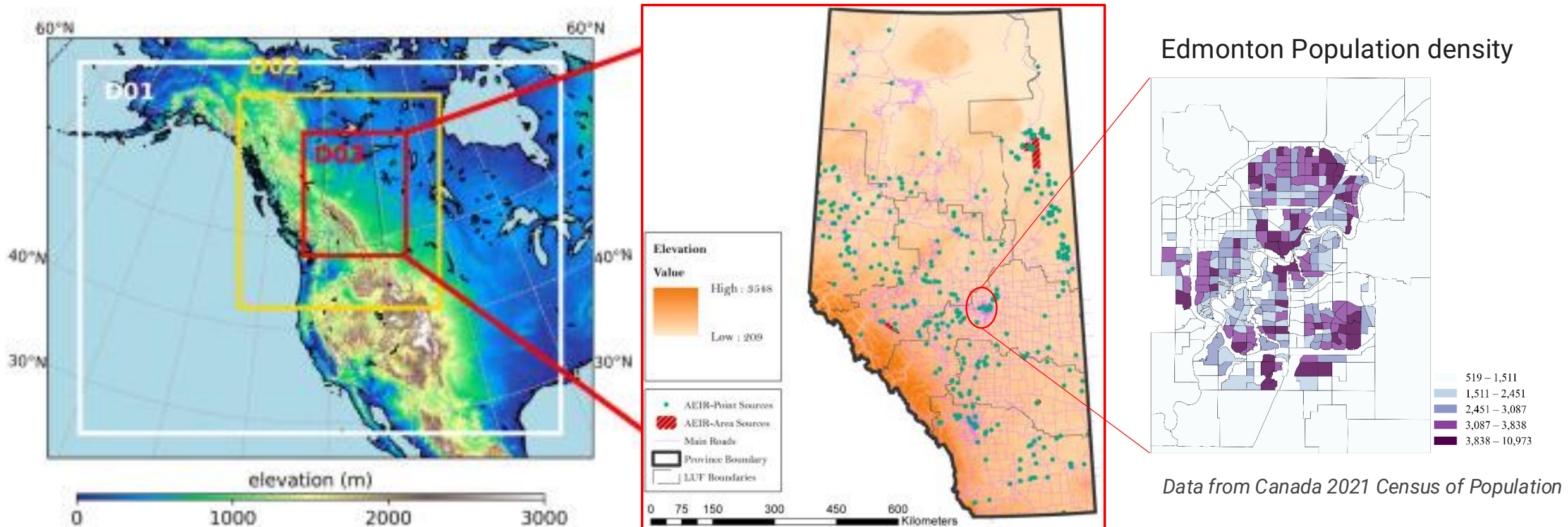
29<sup>th</sup> ETH-Nanoparticles Conference (NPC-2026) | Track: Emission Control of Combustion Engines  
May 31-June 3 2026, Zurich

1. School of Sustainable Energy engineering | Simon Fraser University

**Simon Fraser University  
acknowledges the unceded  
traditional territories including  
Semiahmoo, Katzie, Kwikwetlem  
(kwikʷəłəm), Kwantlen, Qayqayt and  
Tsawwassen First Nations.**

# Case Study: City of Edmonton

Province of Alberta, Canada, from Chemical Transport Modeling nested domain <sup>1</sup>

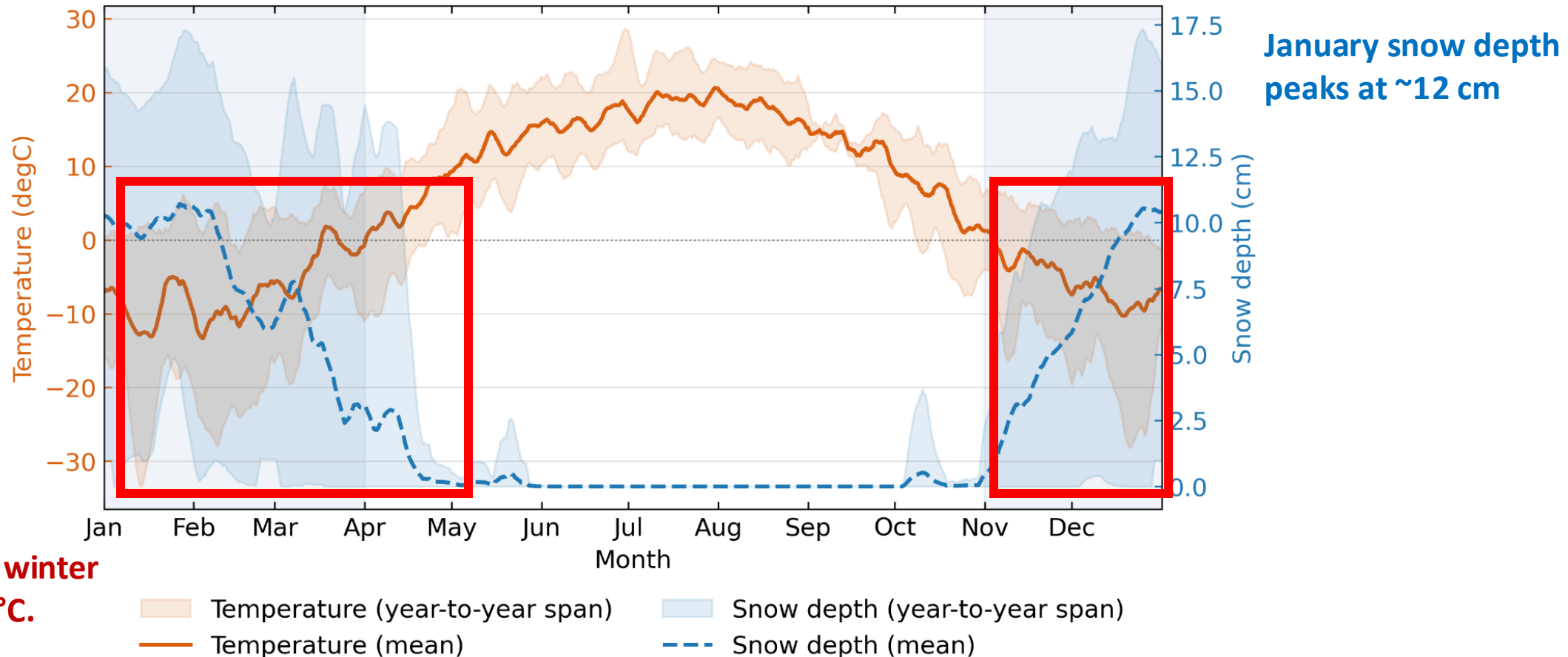


1. Hajjparvaneh, Erfan, Hossein Alizadeh, Vahid Hosseini, and Charles Robert Koch, *Atmospheric Environment* 331 (2024): 120582.

# Edmonton is an extreme cold climate city

Population ~ 1 million , # of vehicle on the road ~ 1 million

## Edmonton hourly temperature and snow depth



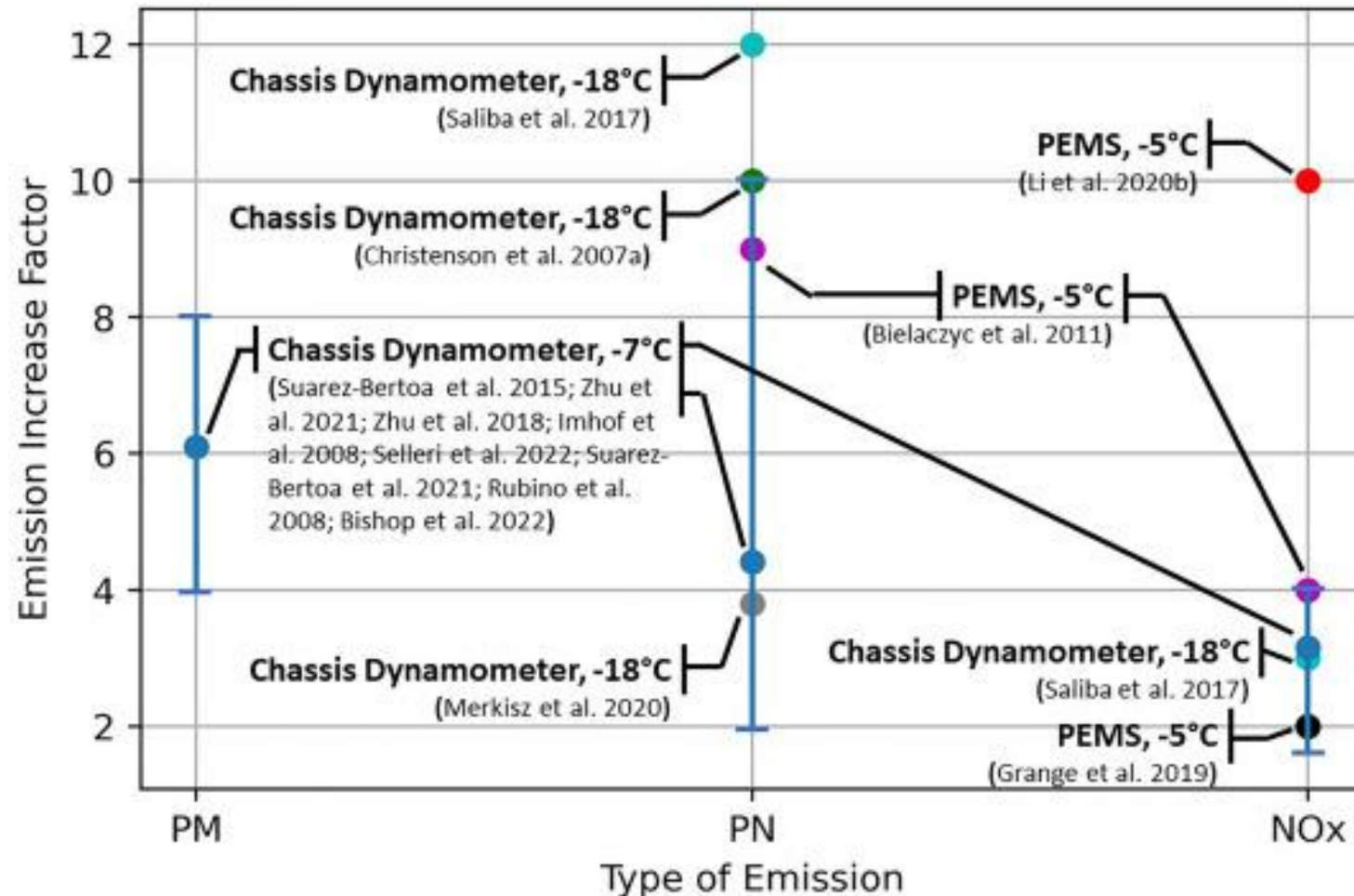
**3/4 of Edmonton's winter hours are below 0 °C.**

Data from Alberta climate Information Service

# Background & Motivations-

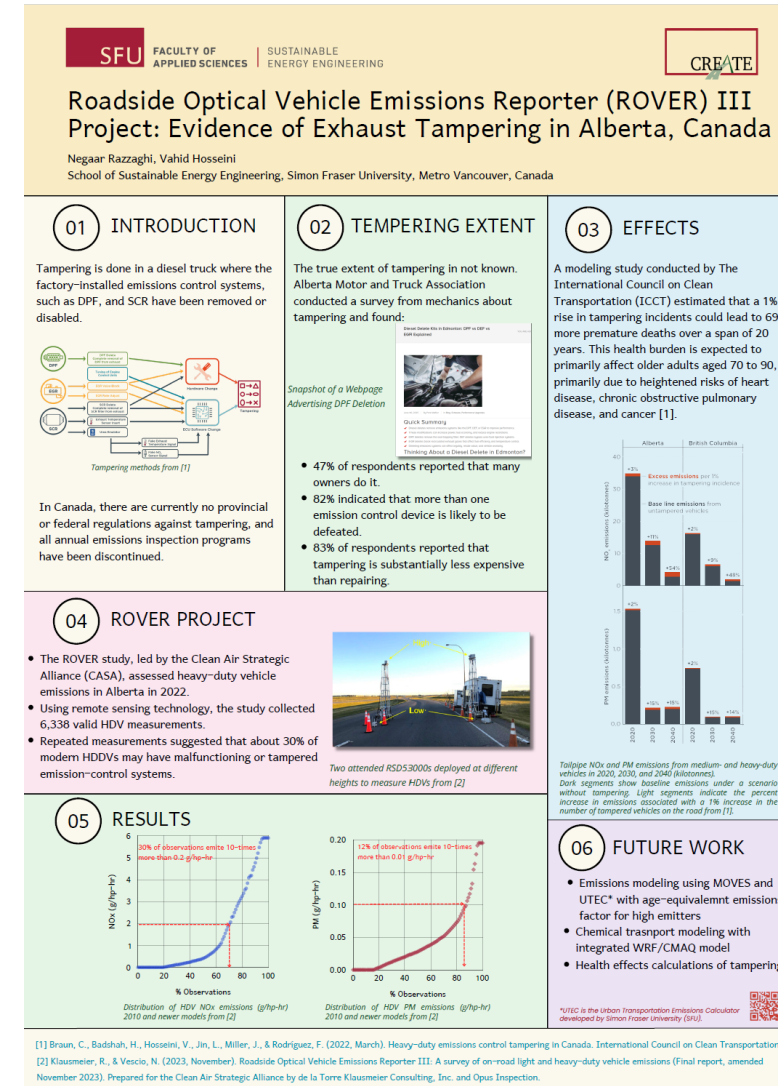
- Review of all available emissions factors in cold climate (*Abediast et al., 2023*)
- Atmospheric pollution in extreme cold climate (*Alizadeh & Hosseini, 2026*)
  - Even with the same emissions input as summer, modeling showed **twice** the pollutants concentrations in extreme cold

Increase of emissions due to low ambient temperatures



# Background & Motivations

- Exhaust tampering in cold climate (*Braun et al., 2022, ICCT*)
- ROVER III project looked into cases of high emitters in HDV sector in Alberta, Canada with remote sensing
- For more information on this part of the study see our poster @ NPC2026



Hosseini & Razzaghi, poster presentation, NPC2026

# Research Objectives

- The hypothesis is that the change in baseline emissions is impacted by
  - Extreme cold climate
    - Change of driving behavior
    - Change of emissions factors (cold exhaust, prolonged cold start, mode idling, more cabin heating, ...)
    - Change of urban traffic (traffic volume and speed due to compromised roads)
  - Exhaust tampering (removal or alteration of exhaust filters)\*

\* There is no anti-tampering regulation, there is no annual emissions inspection

The Objective is to develop and validate an emission model that captures the reality of cold-climate cities.

# Methodology

# Research Objectives

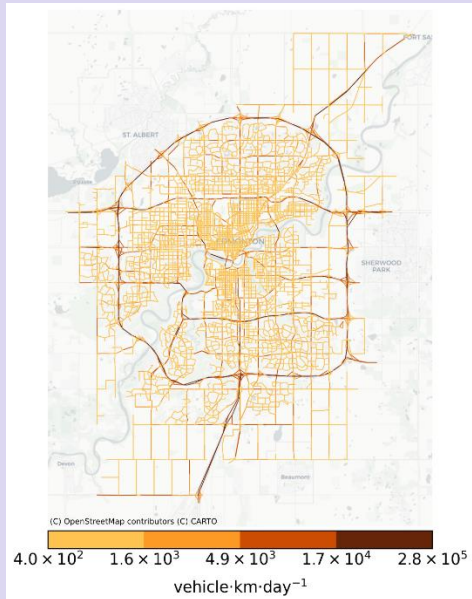
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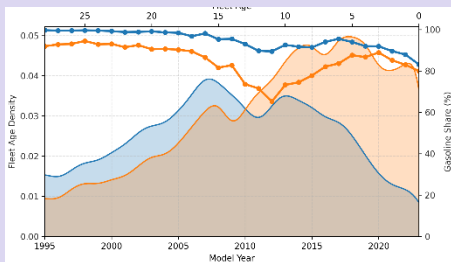
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# The Emission Model

## Traffic & Road features

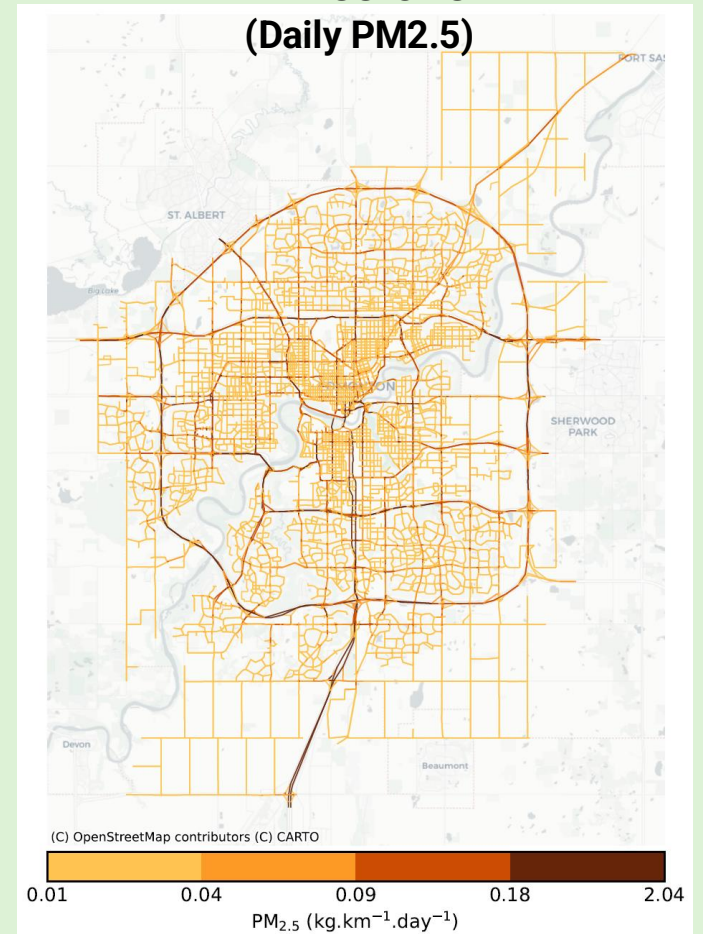


## Age and fuel distribution



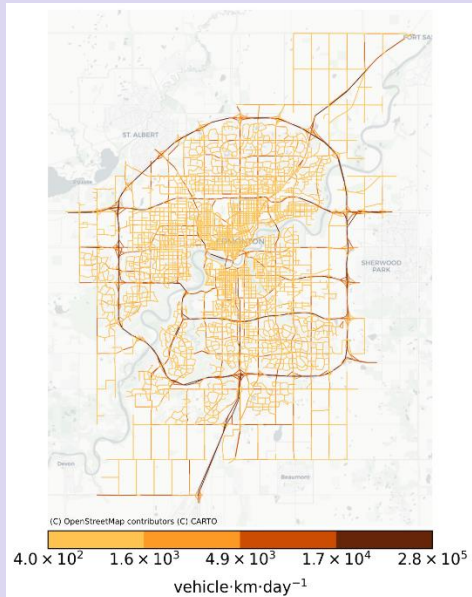
Regulatory Approved  
Emission Model for  
Vehicles

## Emissions (Daily PM<sub>2.5</sub>)

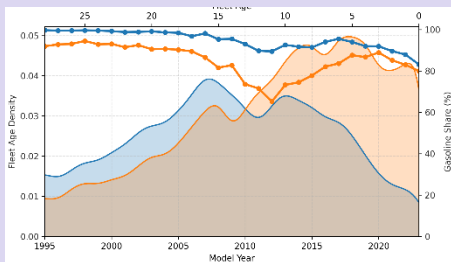


# Weather-sensitive Emission Model

## Traffic & Road features



## Age and fuel distribution



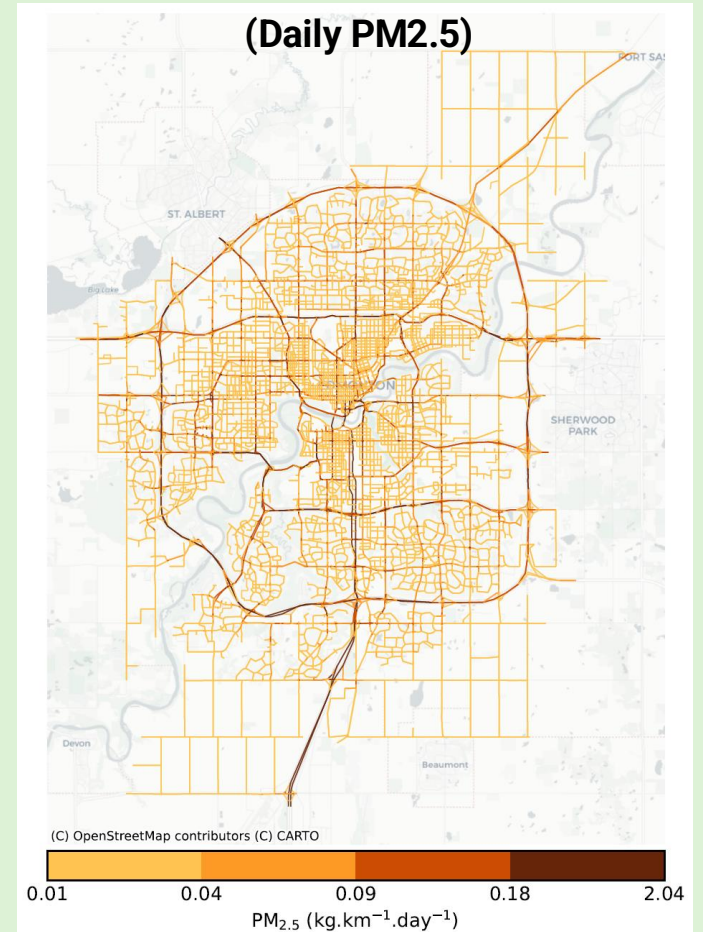
Cold Climate  
Traffic ML Model



Regulatory Approved  
Emission Model for  
Vehicles

Cold Climate  
Emission Rate  
Multipliers

Emissions  
(Daily PM<sub>2.5</sub>)



# Data Gap

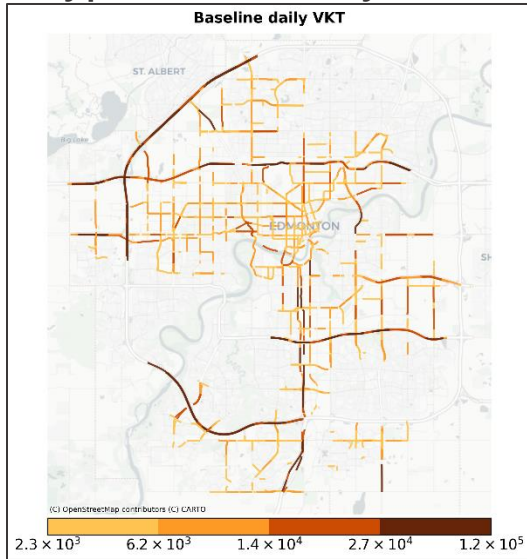
- All traffic model outputs (traffic volume & speed, fleet composition) are available for a typical fall working day. (e.g. mid-October)
- Limited winter traffic data is available from traffic data analytics.
- Emission rate shifts: cold ambient air affects combustion and aftertreatment performance even after engine warm-up.

# Traffic in Cold Climate

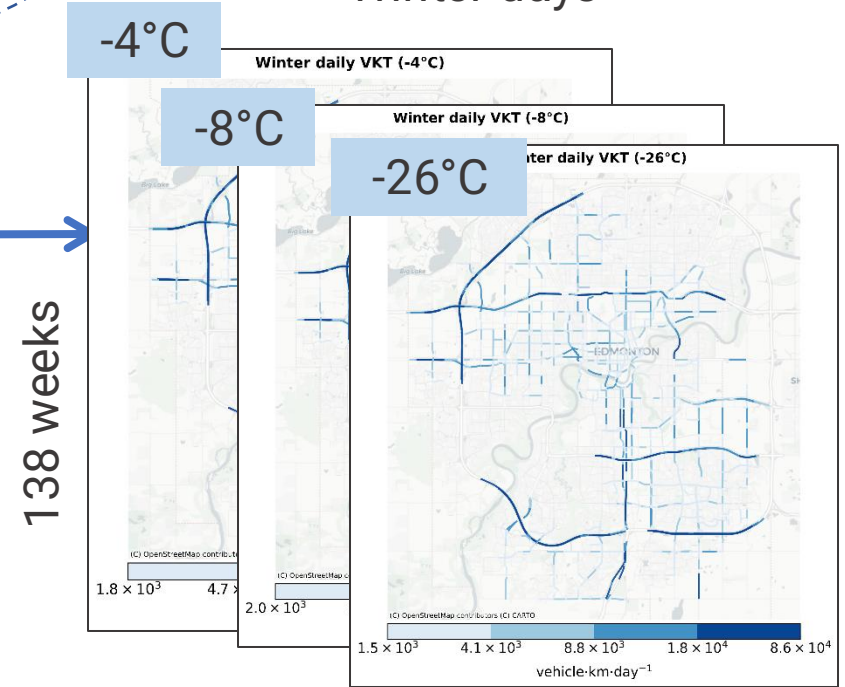
Road functionals,  
weather features,  
baseline traffic

$$f(x)$$

StreetLight Traffic Data  
Typical weekday in fall



StreetLight Traffic Data  
Winter days



# Traffic in Cold Climate

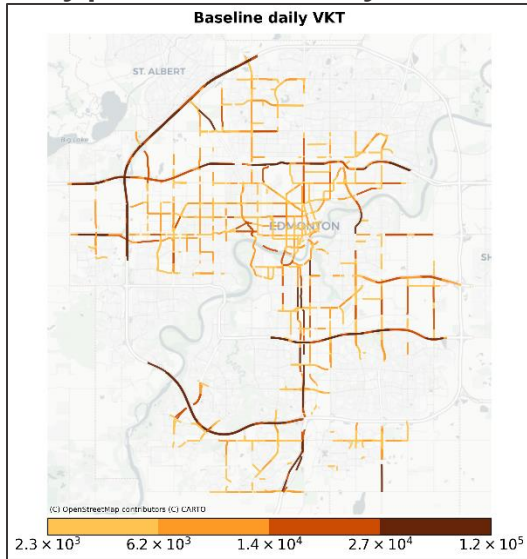
Road functionals,  
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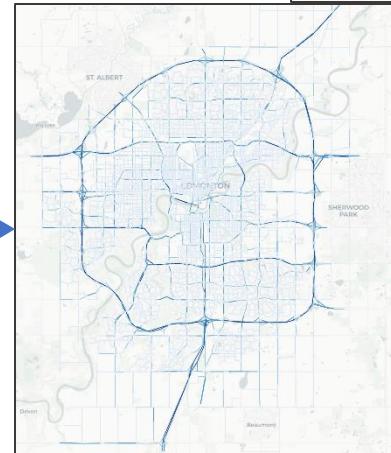
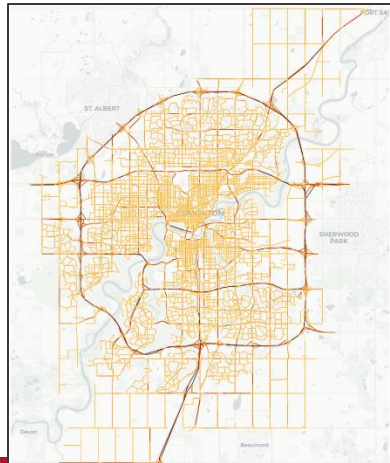
StreetLight Traffic Data  
Winter days

3,400 major links

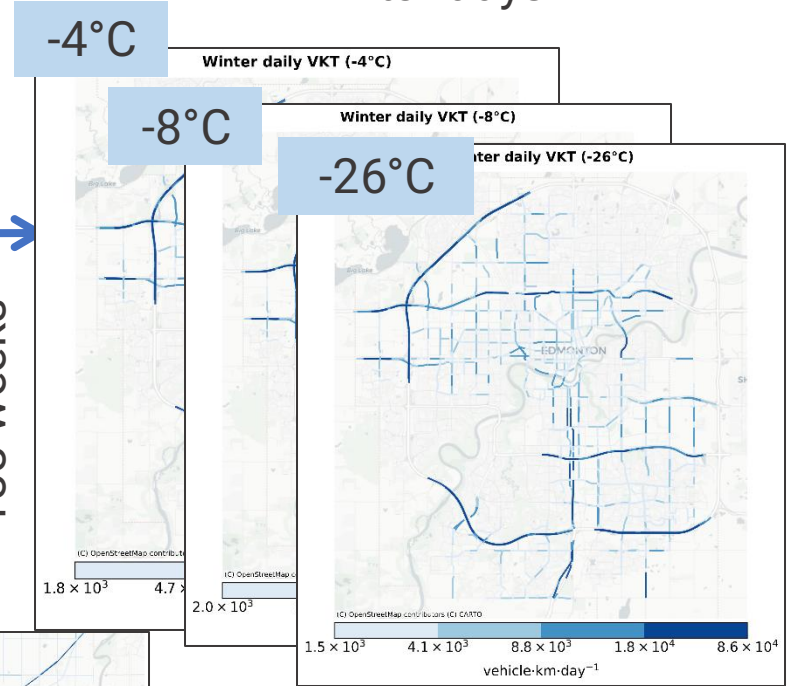
StreetLight Traffic Data  
Typical weekday in fall



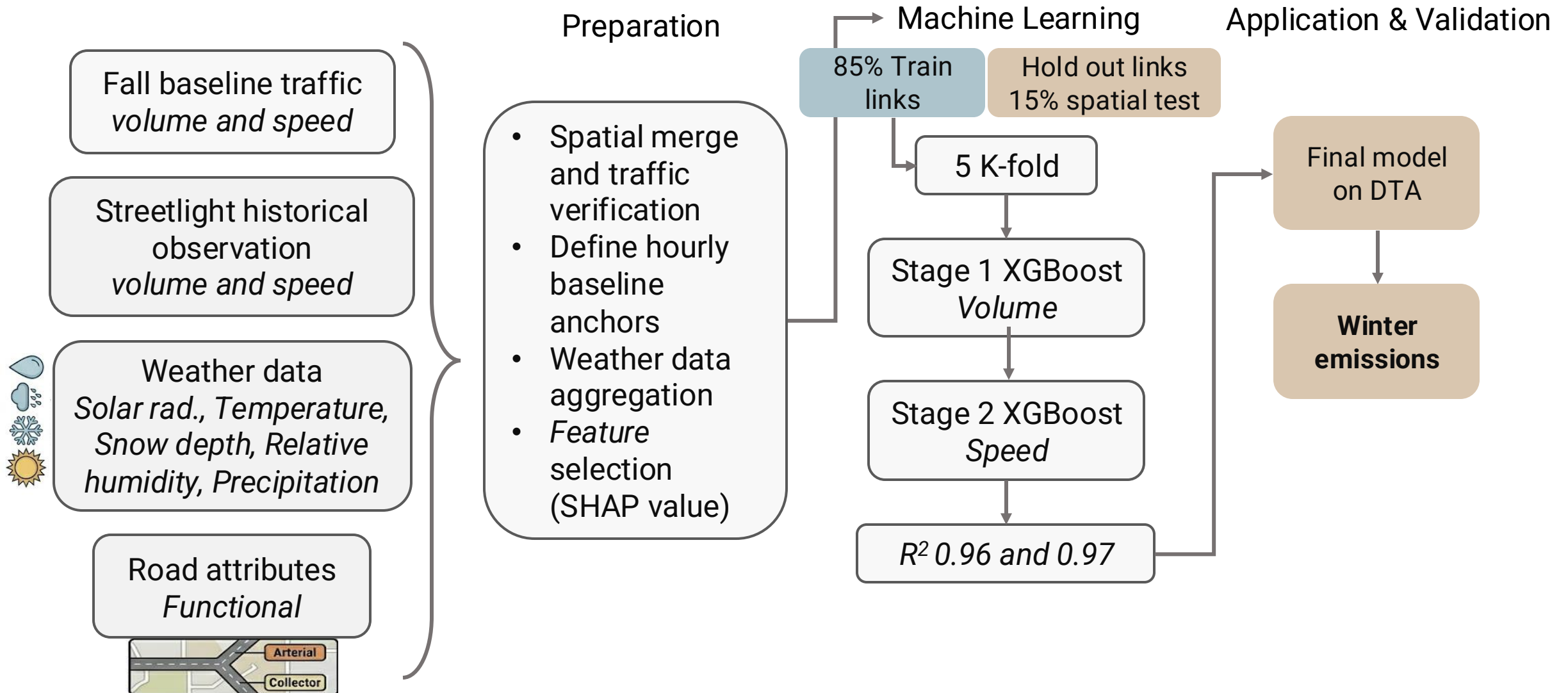
15,000 major links



138 weeks



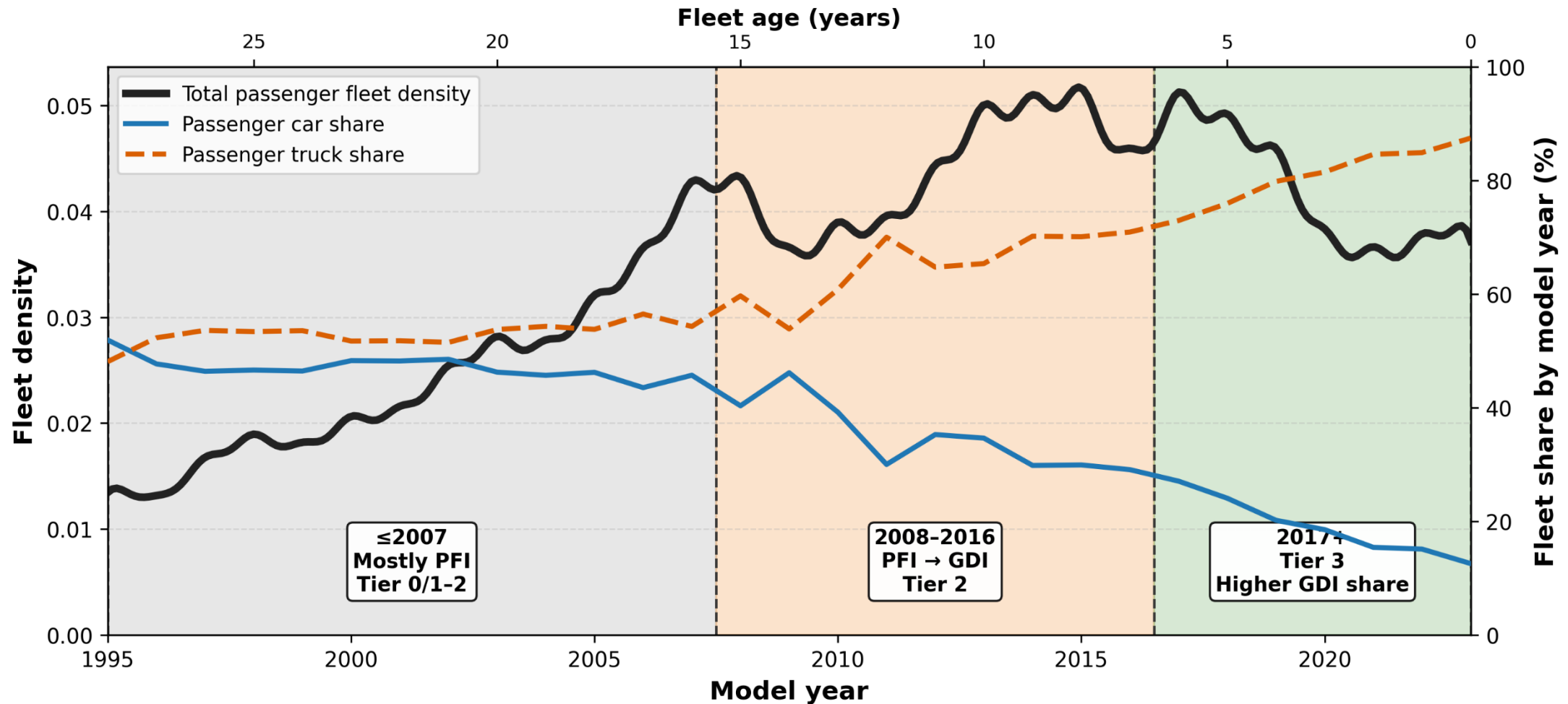
# Traffic in Cold Climate



# Cold Climate Emission Rate Multipliers

## Fleet Composition

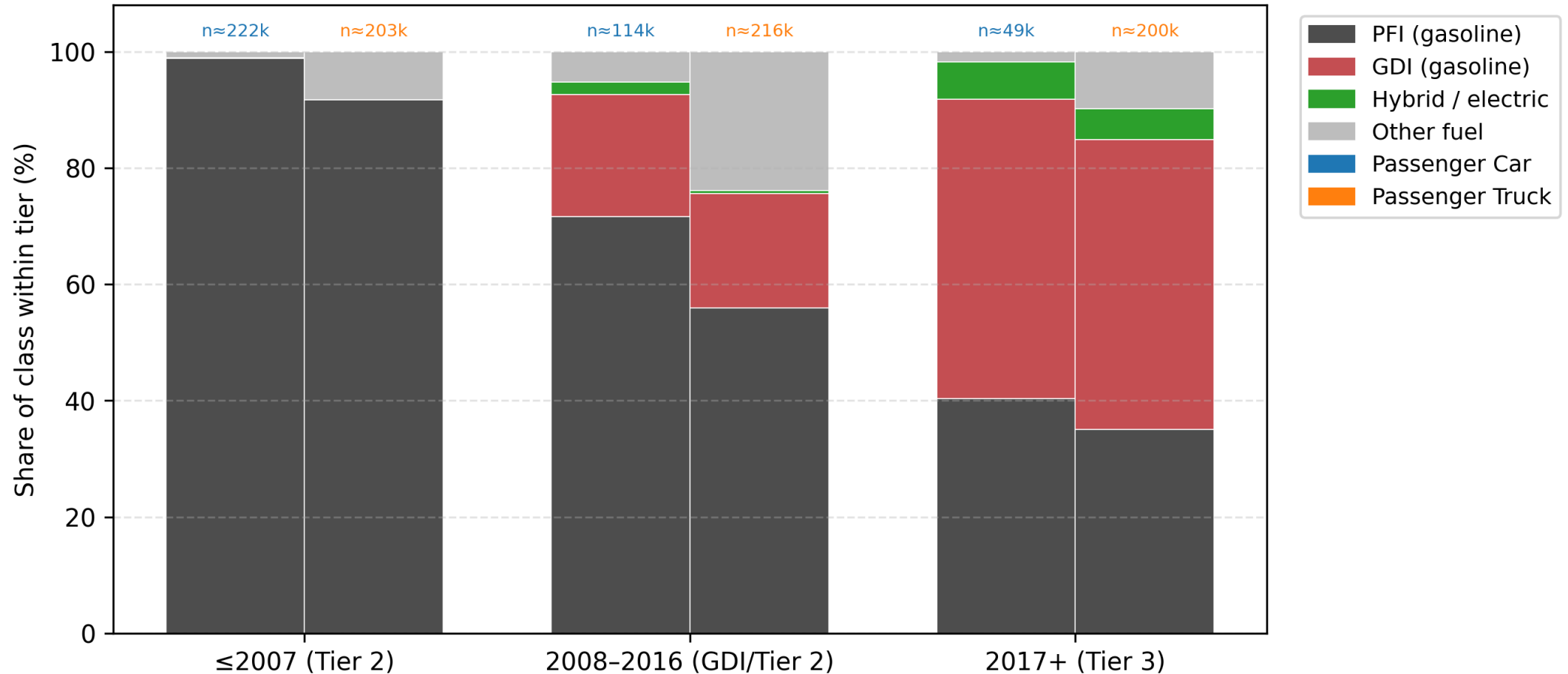
Passenger fleet model-year distribution, vehicle-class share, and emission-standard tiers



# Cold Climate Emission Rate Multipliers

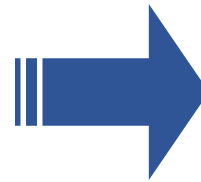
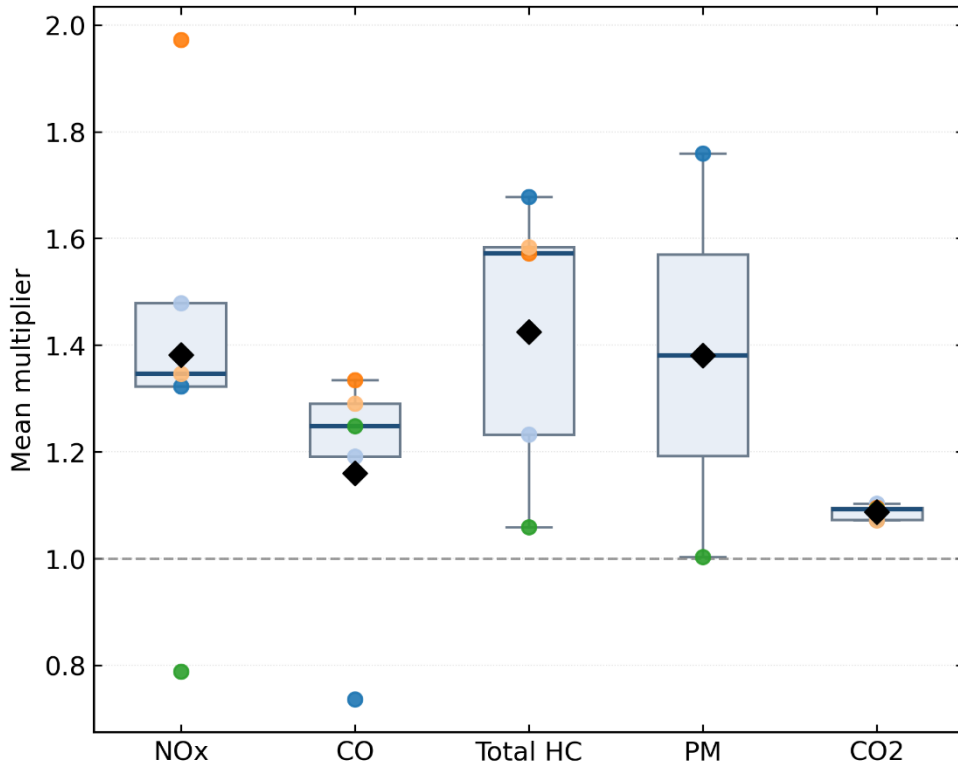
## Fleet Composition

Implied engine technology by emission tier



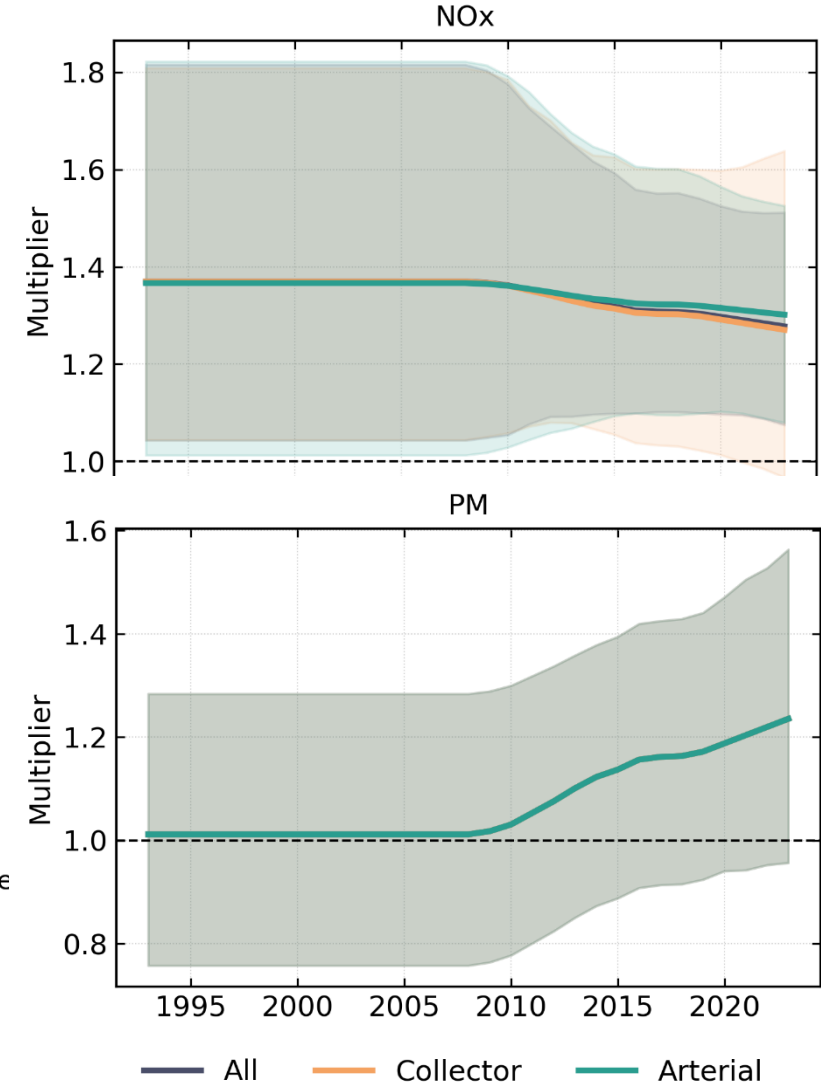
# Cold Climate Emission Rate Multipliers

Literature Mean Multipliers by Pollutant (Box Plot)



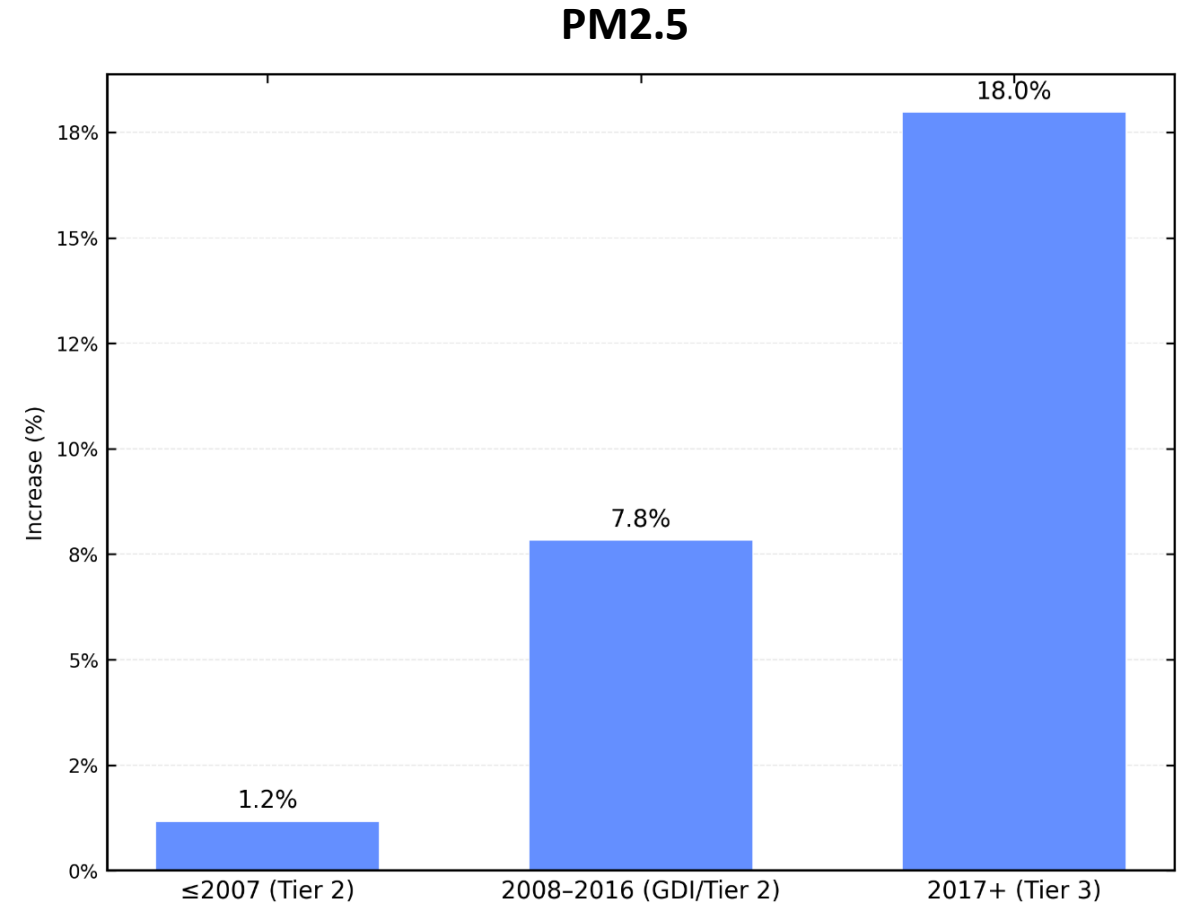
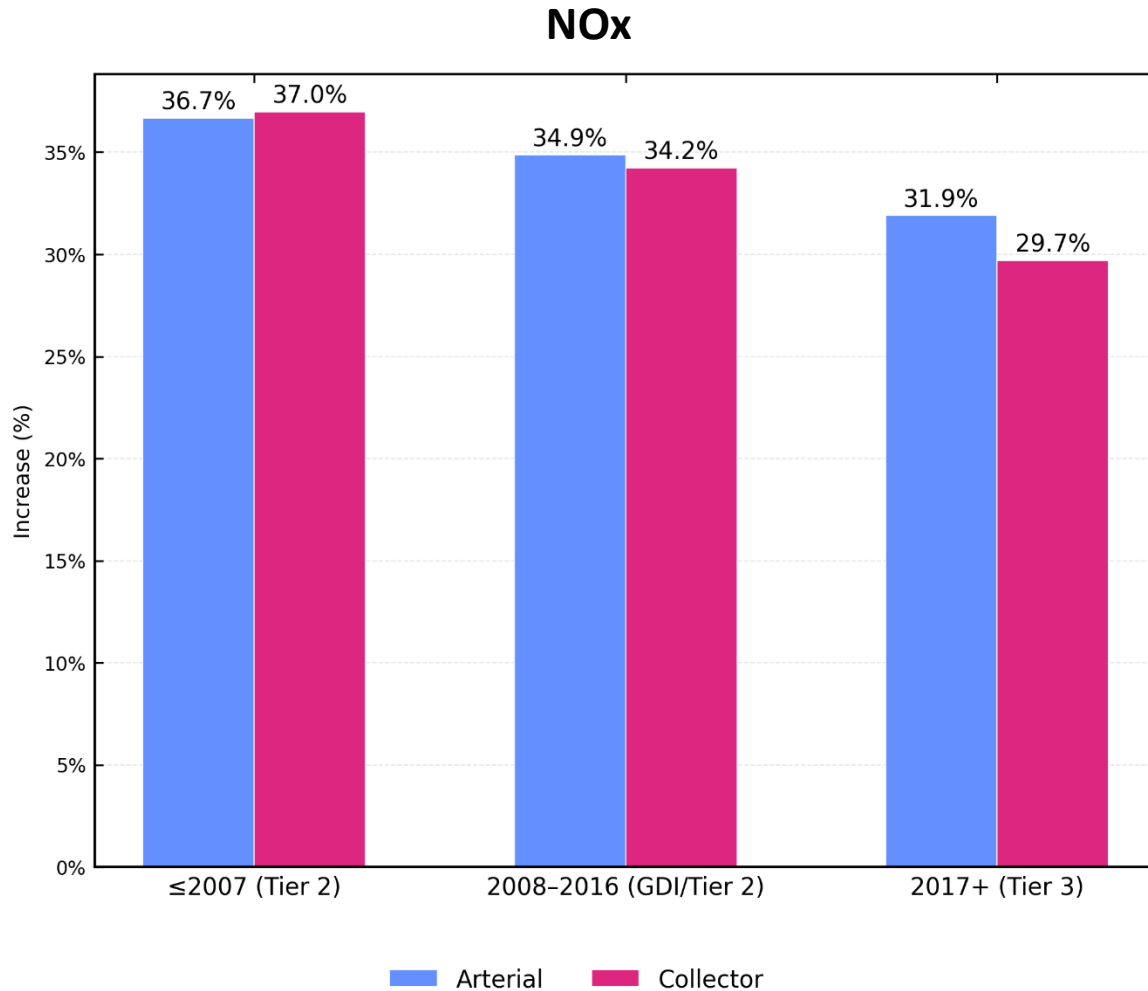
- Chan et al., 2013
- Dardiotis et al., 2013
- Dardiotis et al., 2015
- Suarez-Bertoa et al., 2018
- Weber et al., 2019
- ◆ Pollutant mean (across studie)

## Fleet Multipliers

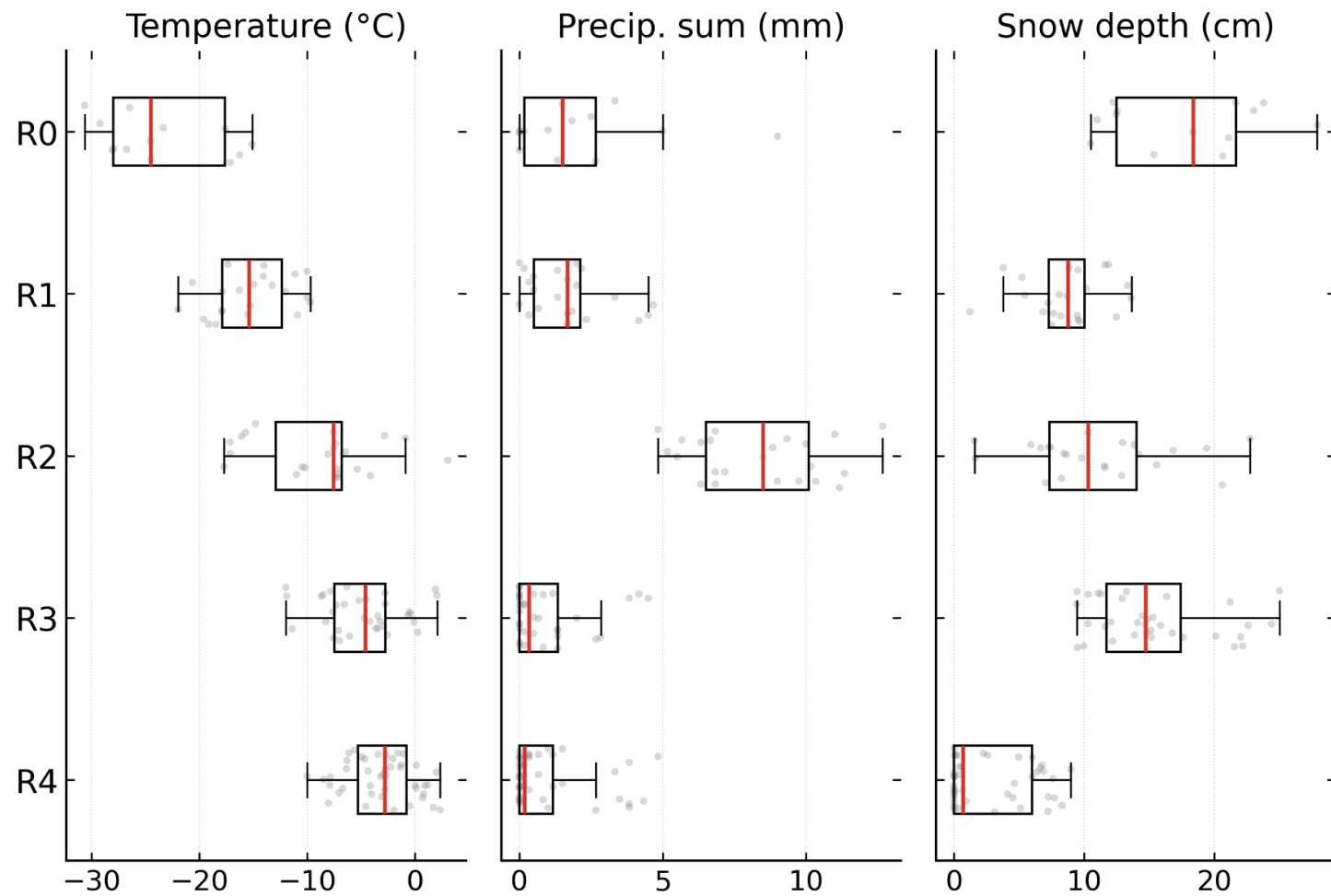


# Results

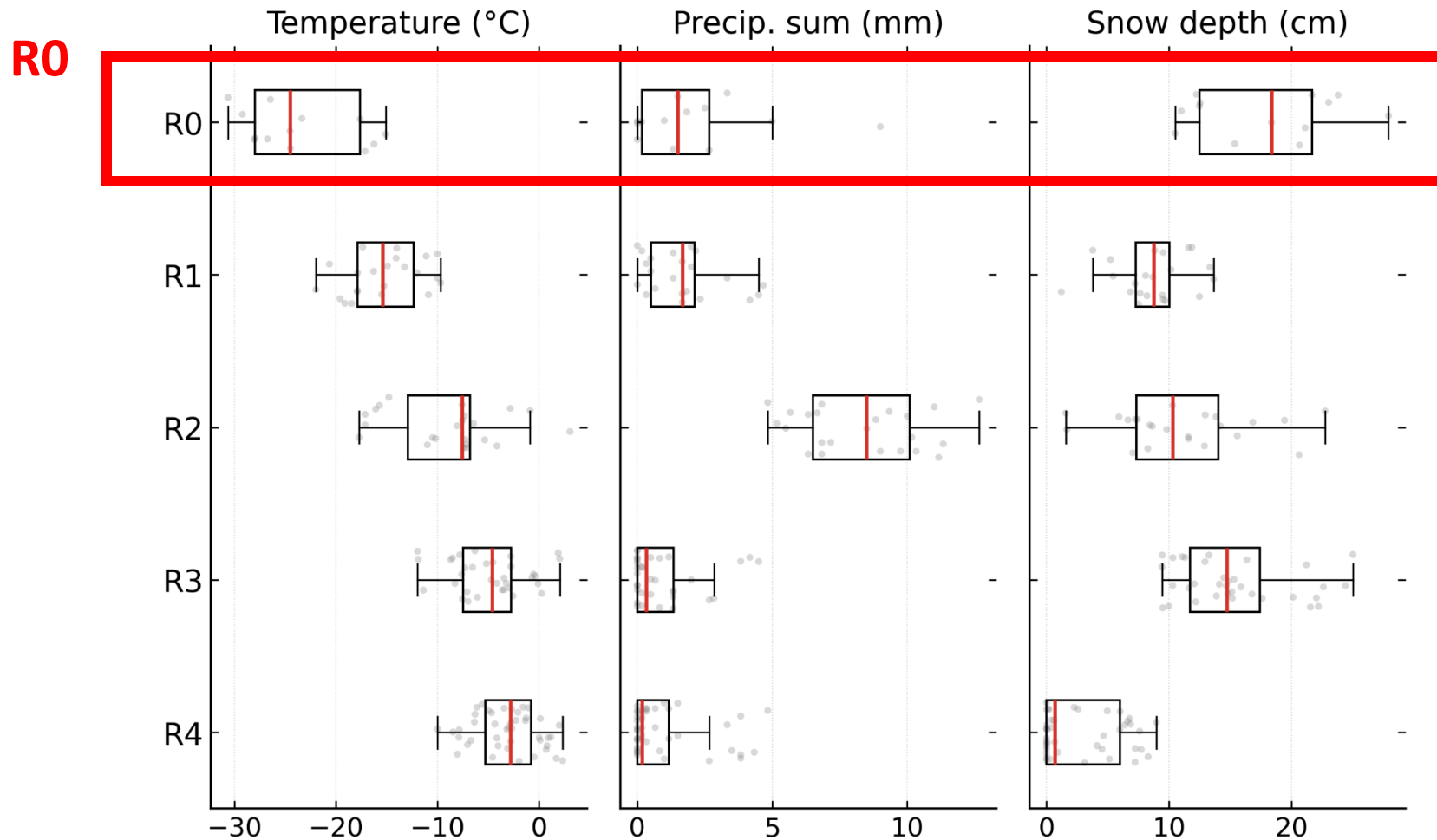
# Increase of Emissions after emission rate correction Gasoline passenger cars and passenger trucks



# Weather Classification Using K-means Clustering

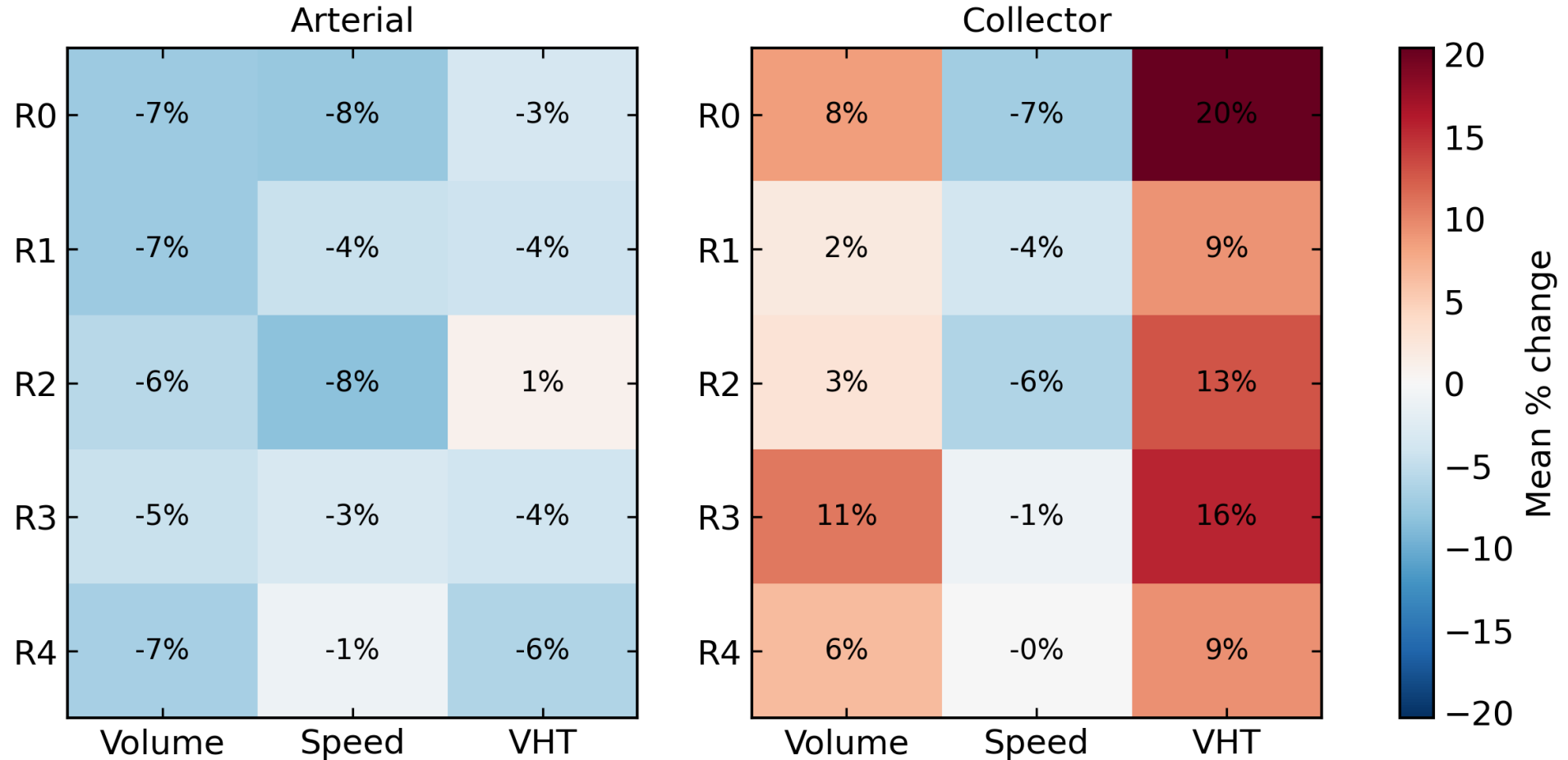


# Weather Classification Using K-means Clustering



# Traffic Metrics & Weather Regimes

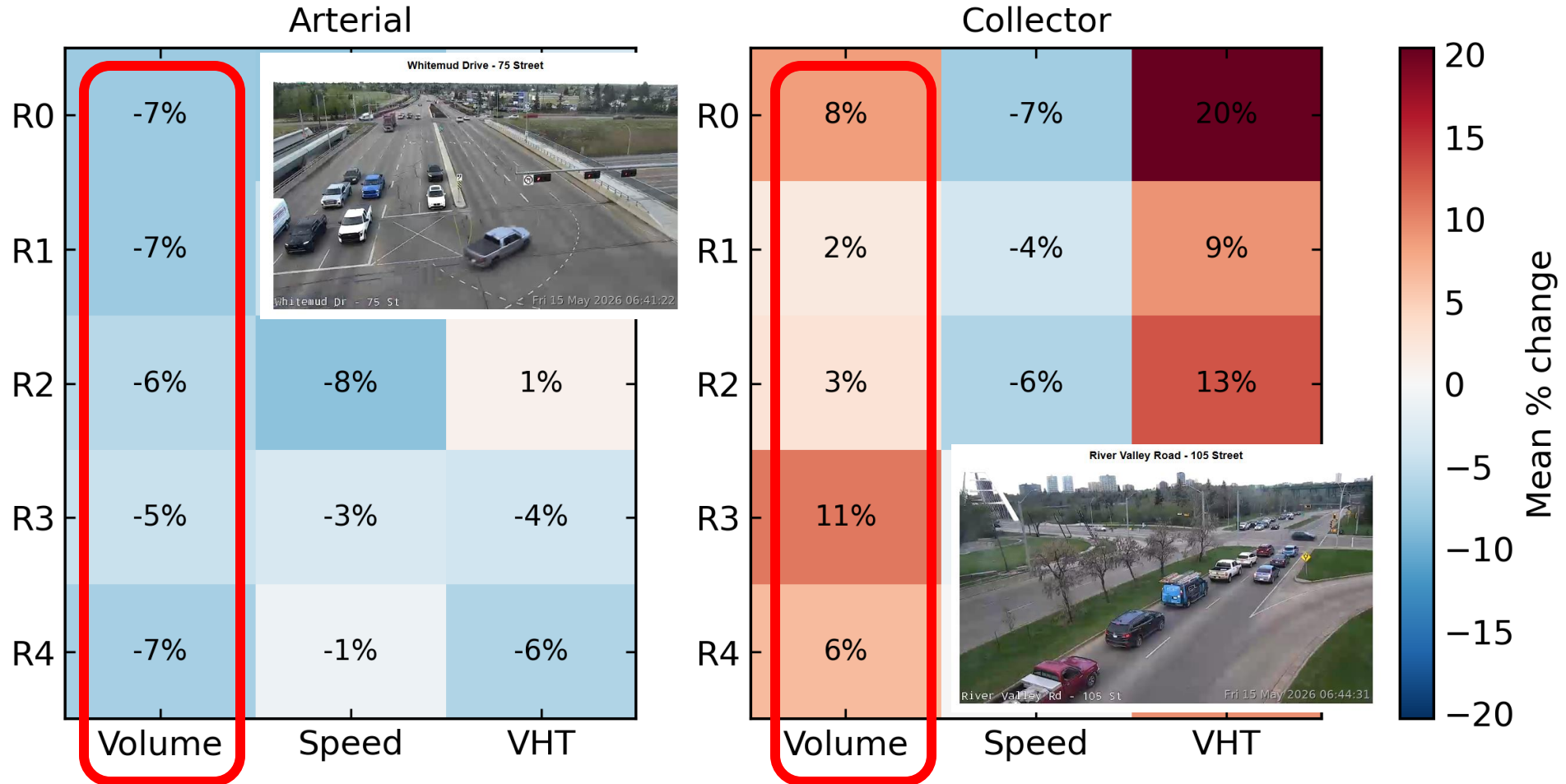
## Impacts by regime and metric



# Traffic Metrics & Weather Regimes

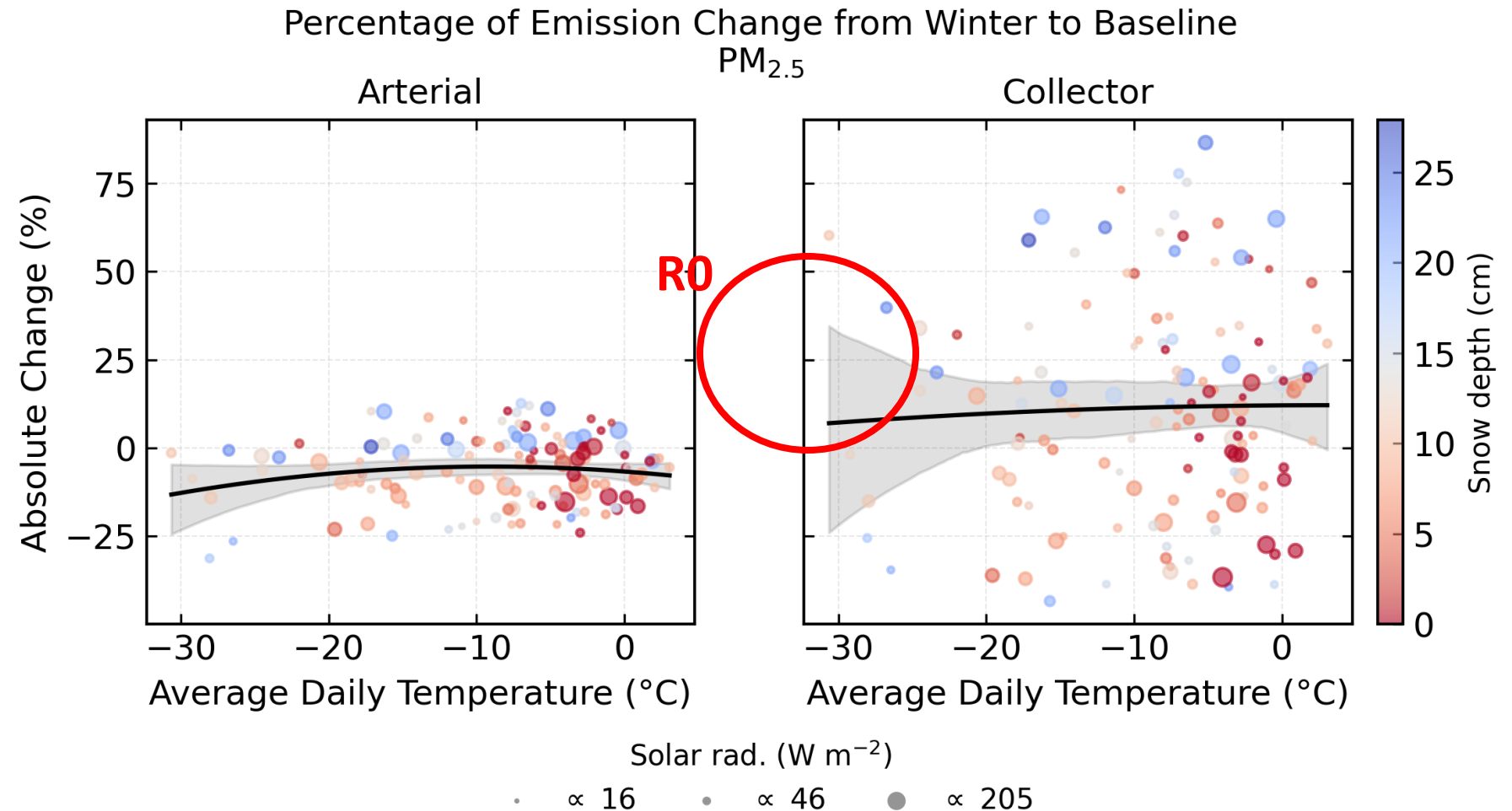
Traffic redistribution from arterials to collectors

## Impacts by regime and metric



# Effects Of Increased Emissions Factor And Change Of Traffic

At the weather regime R0 that is extreme cold day, snow on the ground, sunny, no precipitation, PM<sub>2.5</sub> of the passenger fleet increased by ~30%, despite lower traffic volume



# Conclusions

- Our preliminary modeling results based on emission factors from literature shows that newer technologies (GDI and newer) are more sensitive to the extreme cold climate.
- In winter, traffic shifts from highways to more local roads, which is a concern for increased air pollution in communities near roads.
- Despite lower traffic volume, vehicles remain longer on the road which caused increased emissions.
- PM<sub>2.5</sub> of the light duty gasoline fleet increases as much as 30% in cold winter days. Combined with local atmospheric stability (*Alizadeh & Hosseini, 2026*), the pollution in the ground is increased by two-fold.

# Future work

- PEMS / RDE test in cold climate for multiple technologies
- Expansion of work to HDVs
- Feeding the data into our atmospheric chemical transport models (*Alizadeh, Hosseini, 2026*)

Malekloo's PEMS setup, SFU



# Acknowledgement

- This project was undertaken with the financial support of the Government of Canada - **Environment and Climate Change Canada** (Project number 1000496479).
- The project is a collaboration between **Simon Fraser University** and **University of Alberta**. Project partners include:
  - **Government of Alberta**
  - **City of Edmonton**



# Q & A



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