Prince George Air Quality Emissions and Modelling (2014-2016)

Presentation for Prince George City Council Meeting – 2021/02/08

Brayden Nilson[1], Peter Jackson[1], Bruce Ainslie[2], Gail Roth[3]

1. University of Northern British Columbia
2. Environment and Climate Change Canada
3. British Columbia Ministry of Environment and Climate Change Strategy

Outline

1. Purpose and Background
2. Updated Micro Emission Inventory
3. Dispersion Modelling (CALPUFF)
4. Observation Site Comparisons
   - Monthly averages
   - Hour-of-day/Month-of-year averages
5. Model Annual $PM_{2.5}$ Averages by Neighbourhood
6. Upcoming Work: AirQuest
7. Main Findings
8. Main Limitations

Air Pollution – $PM_{2.5}$ is a major environmental risk to health

- The WHO estimated that about 2/3 of environment-related global deaths are from indoor and outdoor air pollution and in 2016 outdoor air pollution caused 4.2 Million deaths
- While Canada has excellent air quality, some areas have challenges
- Prince George (like other BC Interior towns) can have elevated levels of $PM_{2.5}$ due to a combination of sources, geography and meteorology
- Consequently PGAIR (Prince George Air Improvement Roundtable) has focused on reducing $PM_{2.5}$

Information for science-based decisions to improve outdoor air quality

- Strategies to reduce $PM_{2.5}$ need information on **emissions** (what goes into the air), but also on how those emissions impact outdoor air quality **concentrations** where people breath
- Consequently this project updates a 2005 **Micro Emission Inventory** of all $PM_{2.5}$ sources in Prince George to reflect current emissions
- But, **emissions ≠ concentrations** and concentrations are what matters
- So, emissions are input to a **dispersion model** that calculates hourly concentrations every 500m across Prince George from 2014-2016*
- $PM_{2.5}$ concentrations are attributed to specific sources
- This is the information needed to manage air quality

(* chosen as years with limited wild fire smoke)

*Light blue indicates the apparent change in emissions as a result of changes to the modelling method

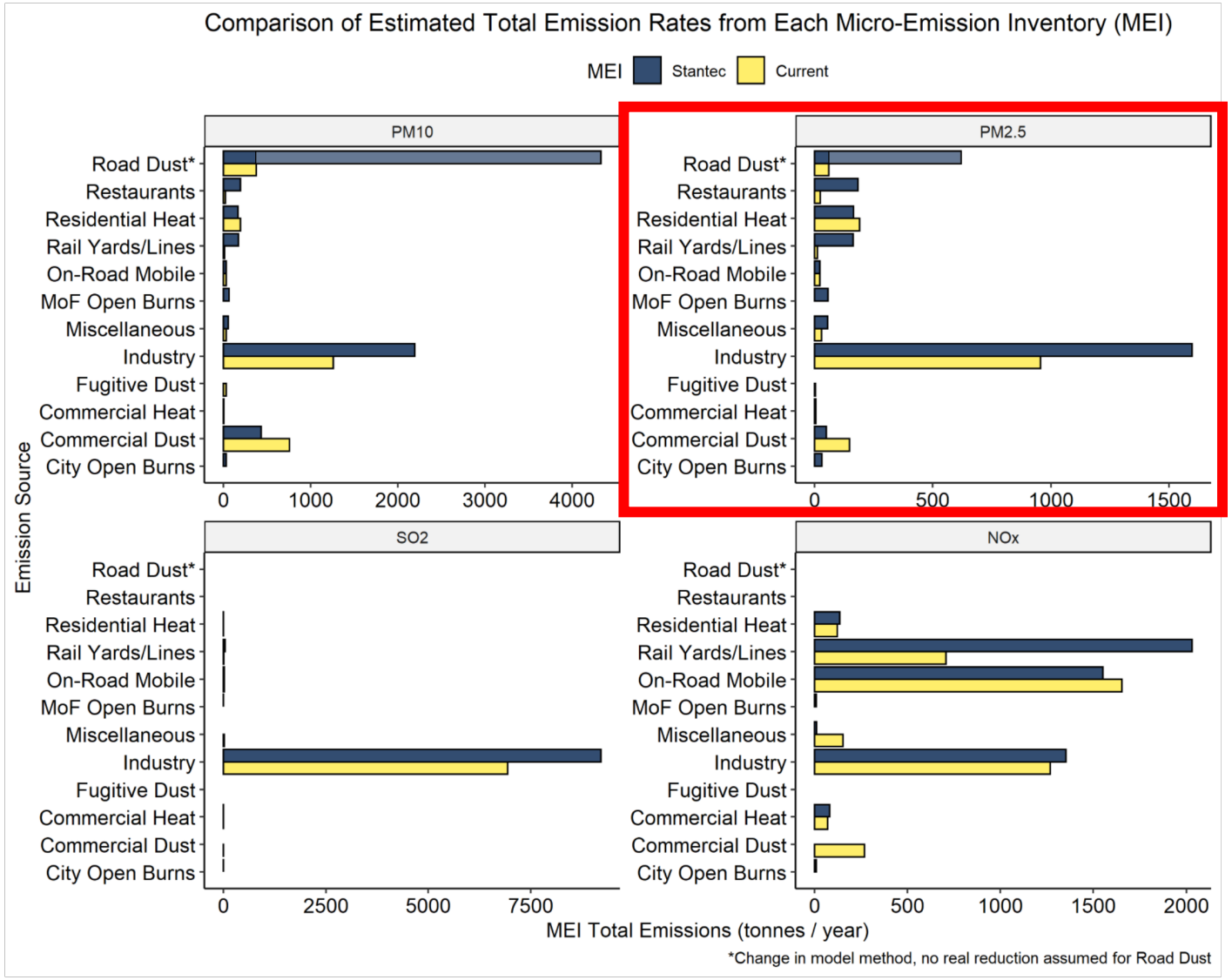
Micro-Emission Inventory

Emission parameters were assigned for individual emission source categories (Residential Heat, Industry, Road Dust, etc)

Recent updates focused primarily on the industrial emissions

Source Emission Rates:

- **PM_{10}:** Industry > Commercial Dust > Road Dust > Residential Heating > Other…
- **$PM_{2.5}$:** Industry > Residential Heating ≈ Commercial Dust > Other…
- **SO_2:** Industry > Other.. (On-road mobile, Misc., Rail, …)
- **NO_x:** On-road mobile > Industry > Rail > Commercial Dust > Other…



Atmospheric Dispersion Modelling

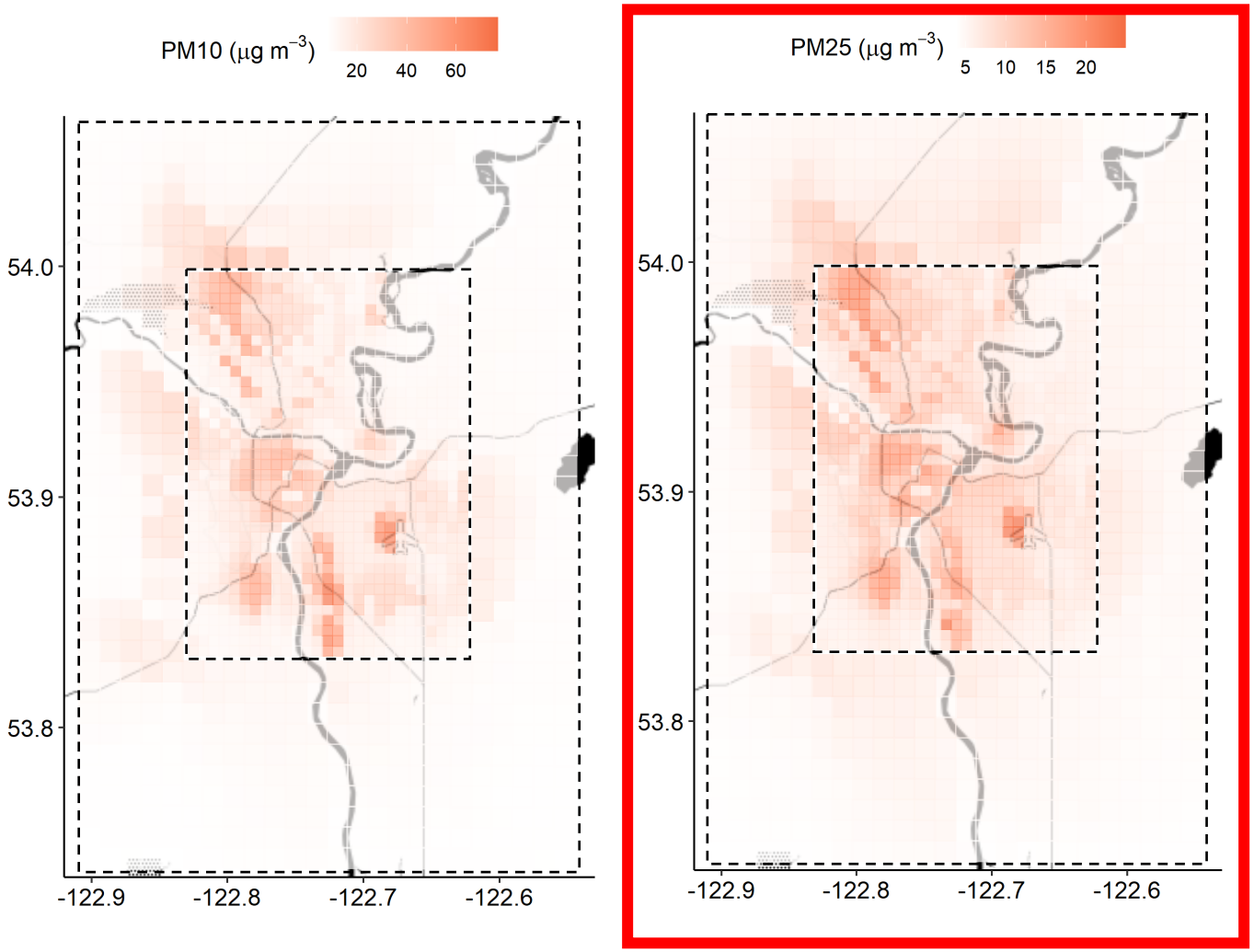
Simulated the concentrations 1.5 m above the surface of PM_{10}, and $PM_{2.5}$ for each hour using the CALPUFF model (v6.42).

SO_2 and NO_x ($NO + NO_2$) were also simulated and for modelling the secondary formation of PM

Individual source emissions detailed in the MEI are emitted and then dispersed by the simulated winds and weather from CALMET

Total concentrations for each hour (in a grid) are determined by the sum of the individual source concentrations + secondary formation PM + simulated background concentrations at each grid cell

3-Year Annual Average Simulated **Concentrations** (2014 – 2016)

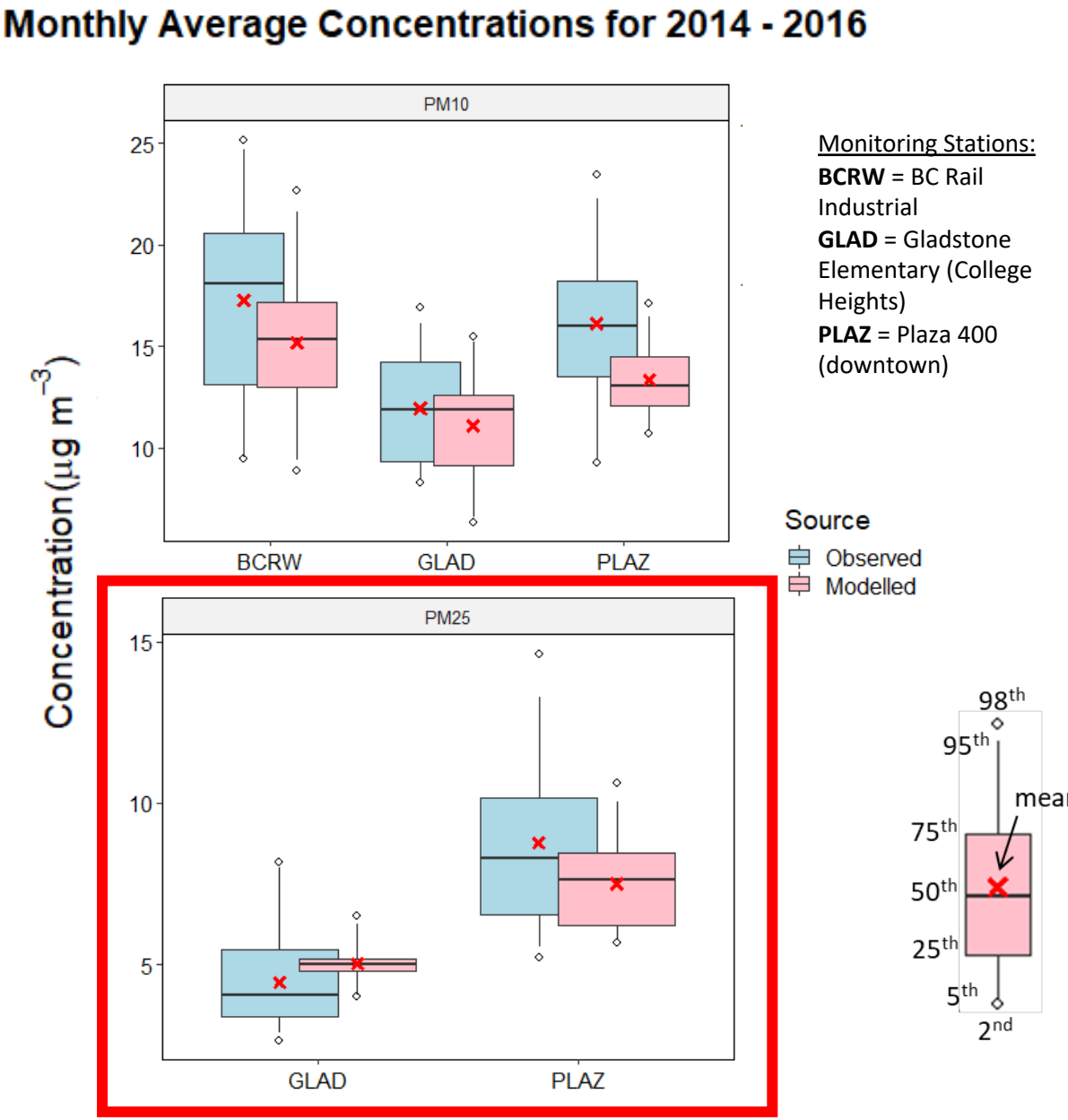


Site Comparisons: Monthly Concentration Averages

Compared monthly averages for three years at observation station locations

- **PM_{10}**
  Good performance, model typically underpredicts
- **$PM_{2.5}$**
  Good performance, model overpredicts at Gladstone and underpredicts at Plaza 400.

The model underpredicts the variability of both pollutants at all locations – especially so for Gladstone $PM_{2.5}$



Site Comparisons: Temporal Concentration Variation

Averages by hour-of-day and month-of-year for three years at observation station locations

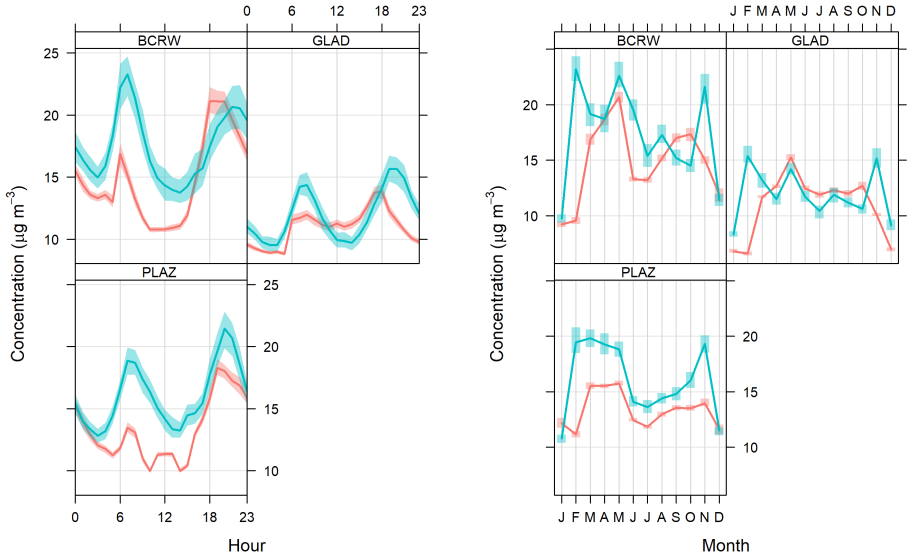
PM_{10}:

- 3 Stations (BCRW, GLAD, PLAZ)
- Model tends to underpredict
  - Except at GLAD for some periods
- Month-of-year better than hour-of-day

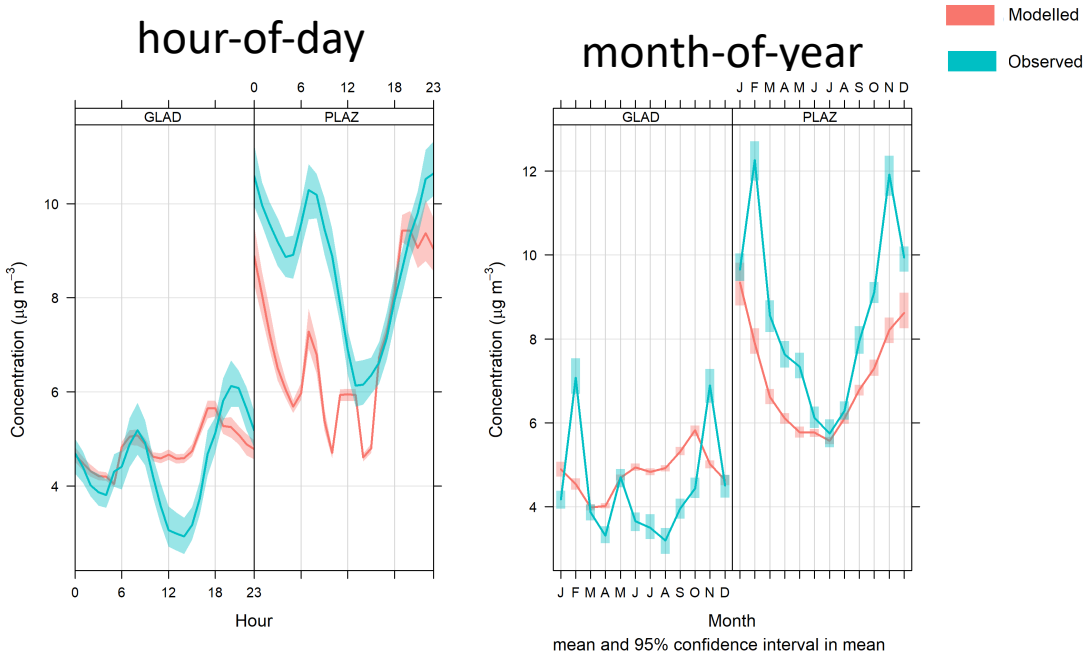
$PM_{2.5}$:

- 2 Stations (GLAD, PLAZ)
- Similar to PM_{10}…
- Except: Monthly is better at PLAZ and worse at GLAD for $PM_{2.5}$

PM_{10}

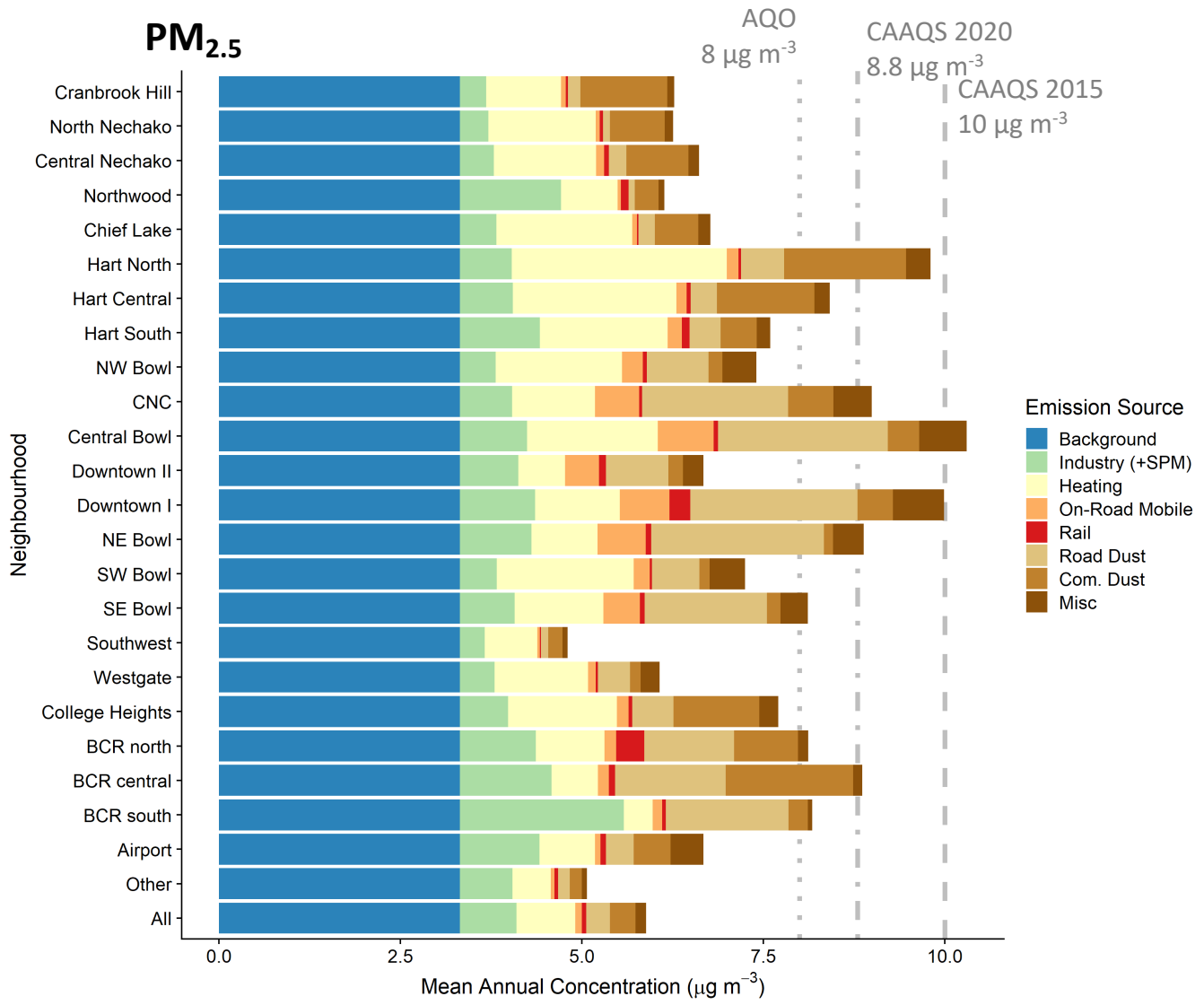


$PM_{2.5}$



$PM_{2.5}$ Annual Concentration Neighbourhood Analysis

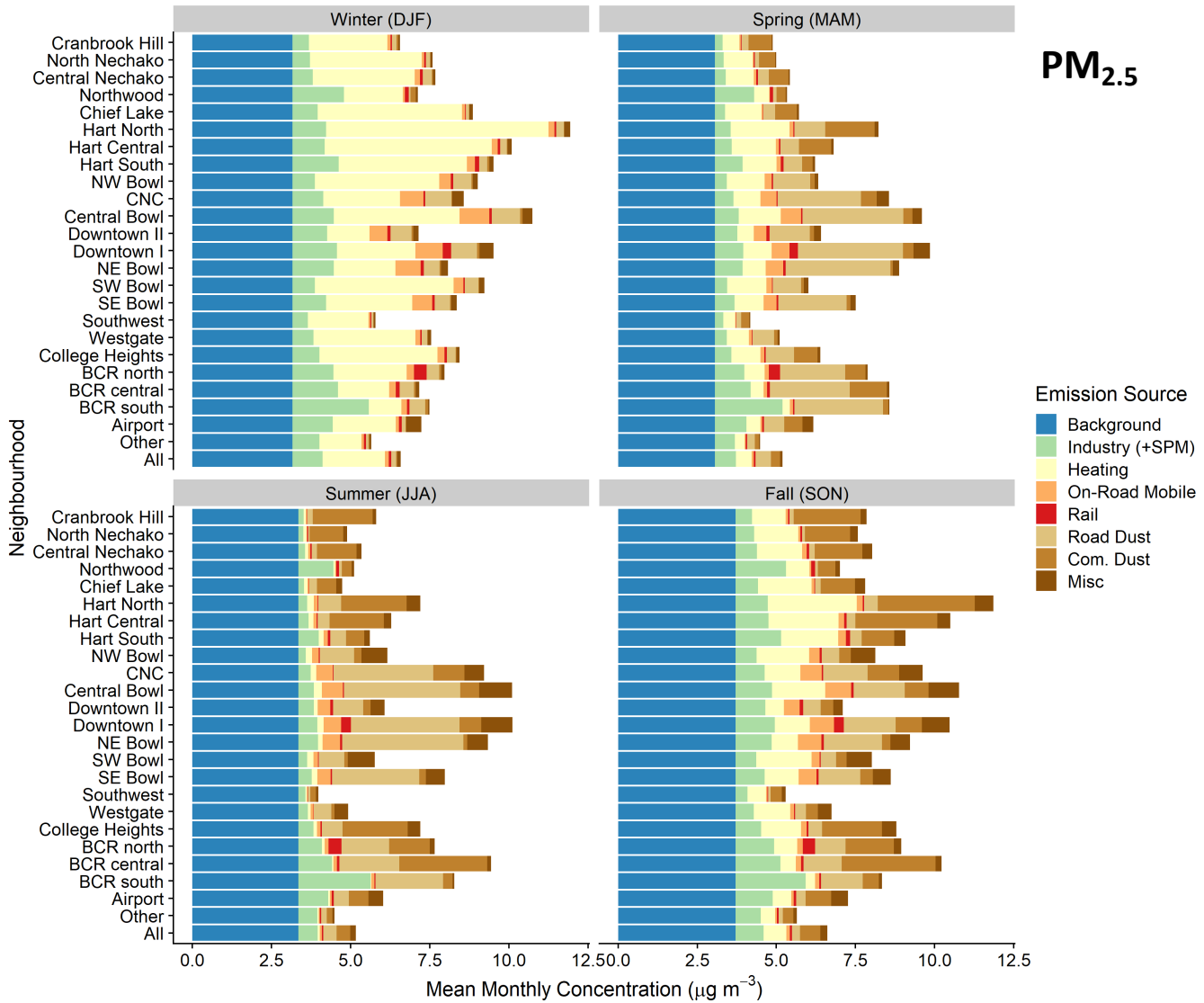
- Background > Industry ≈ Heating > Road Dust > Commercial Dust > Other..
- Neighbourhoods in the 'Bowl', in the 'Hart' near the Heavy Industry Area, and near the BCR Industrial site exceed the annual AQO
- Only a few neighborhoods in the 'Bowl' and one in the 'Hart' exceed the 2015 3-year average annual CAAQS



$PM_{2.5}$ Seasonal Concentration Neighbourhood Analysis

For $PM_{2.5}$:

- Winter is dominated by the Heating source
- Industry is a main contributor, but is reduced in the Summer
- Road Dust greatest in the Spring & Summer
- Commercial Dust influences Summer and Fall more



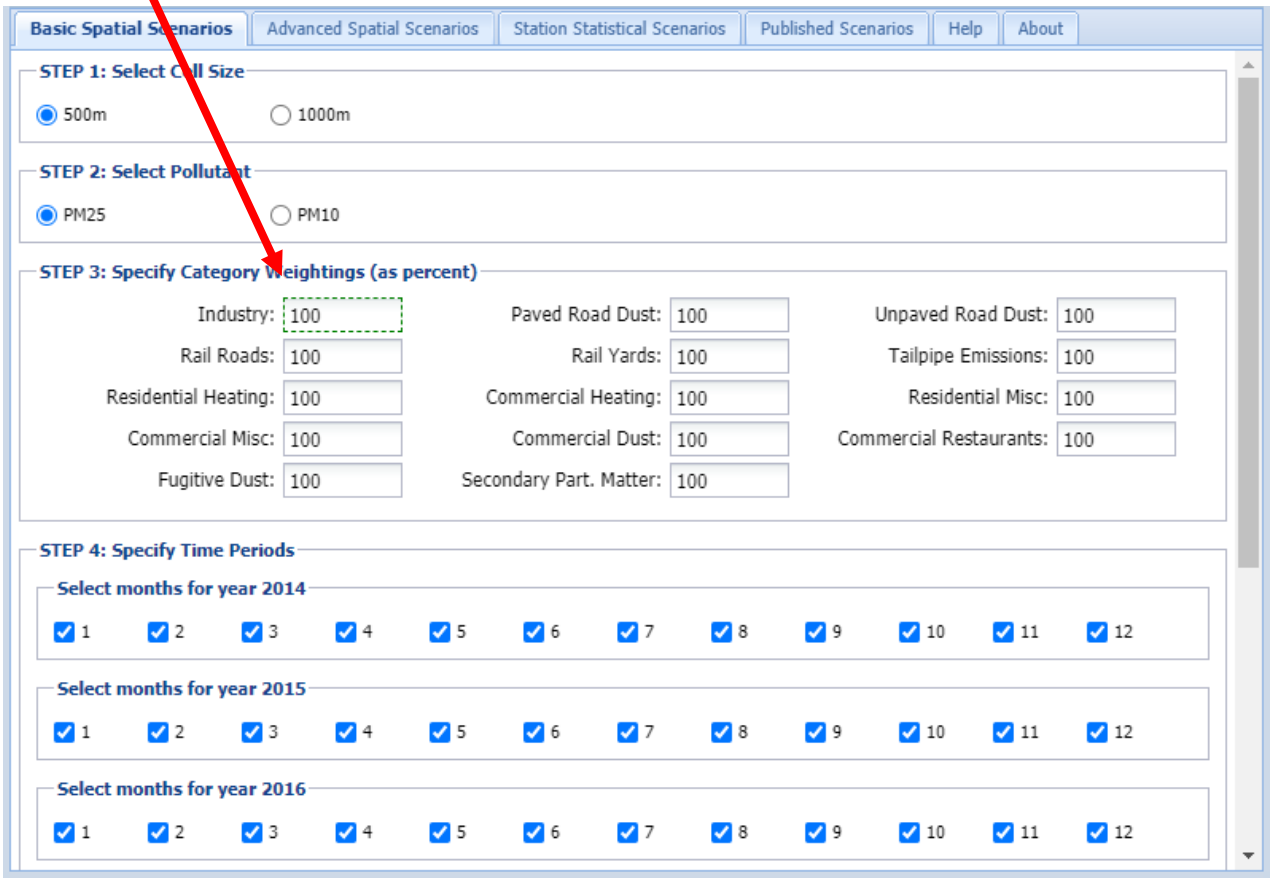
Upcoming Work: AirQuest Analysis Tool

Ongoing work to update the AirQuest web tool for visualizing the model results (with and without “tuning factors” applied)

Allows for the creation of emission reduction scenarios and the visualization of the resultant impacts on (modelled) airsheds air quality

Currently working with a third party to complete the final pieces

Make reductions to specific emission sources



Main Findings

1. The dispersion model compares well with monthly average measurements
2. The model tends to be underpredict PM and its variability at measurement sites
3. Modelled PM is primarily from background concentrations, industry, heating (mainly residential wood burning), road dust, and commercial dust
4. Most neighbourhoods are below the 2015 & 2020 Annual CAAQS for $PM_{2.5}$, those near the BCR industrial site and the Bowl exceed the Annual AQO for $PM_{2.5}$
5. Seasonal changes are important (i.e. heating mainly in the winter, road dust in the spring/summer, commercial dust in the summer/fall..)

Main Limitations

1. Several sources not updated since 2005 MEI (although impacts are likely minimal)
2. Rail emissions are likely underestimated (terminal expansion to inland port not accounted for in MEI)
3. Emissions from industry seem underestimated (based on wind sector analysis), although a separate study (Jackson et al 2016) showed decreasing concentrations from heavy industrial zone
4. Residential heating emissions (woodstoves) seem overestimated

Acknowledgements

Thanks to C. Corbel, D. Fudge, A. Veira, and J. Spagnol for their previous contributions to the project.

Funding sources:

- The City of Prince George
- PGAIR
- Northern Health