PROVINCE-WIDE PHOTOCHEMICAL MODELLING OF AMBIENT AIR QUALITY WITH CMAQ

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Alberta

Background

Photochemical Modelling

Previous Studies

Current Study Overview

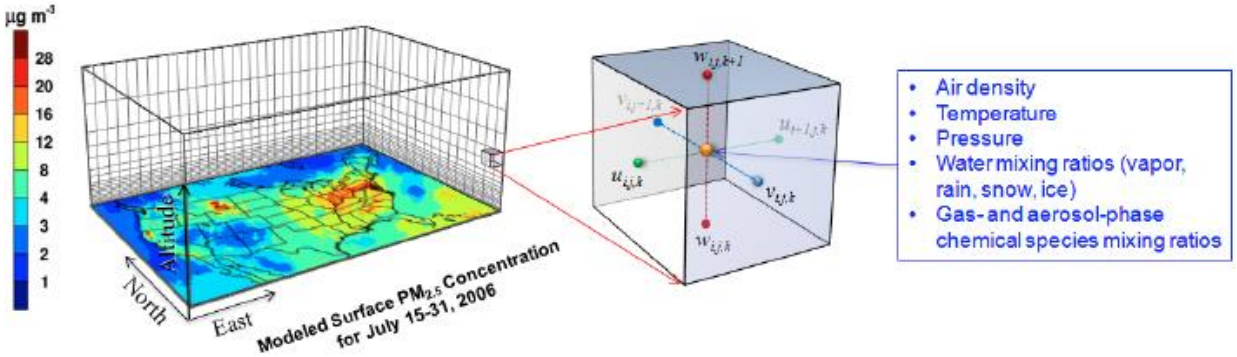
Alberta

Background: Photochemical Modelling

- Computed predictions of ground level air quality using:
  - Measured/estimated emissions information
  - Input meteorology
  - Measured ambient data for ground-truthing
- Uses photochemical reactions to transform emissions over time

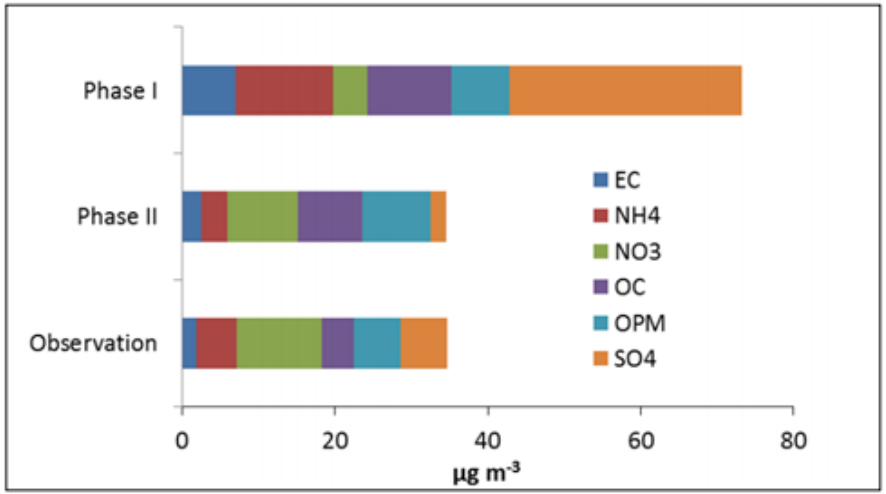
Background: CMAQ

- **C**ommunity **M**ulti-scale **A**ir **Q**uality model
  - Eulerian model
  - Grid model: Three dimensional advection between cells of discrete size



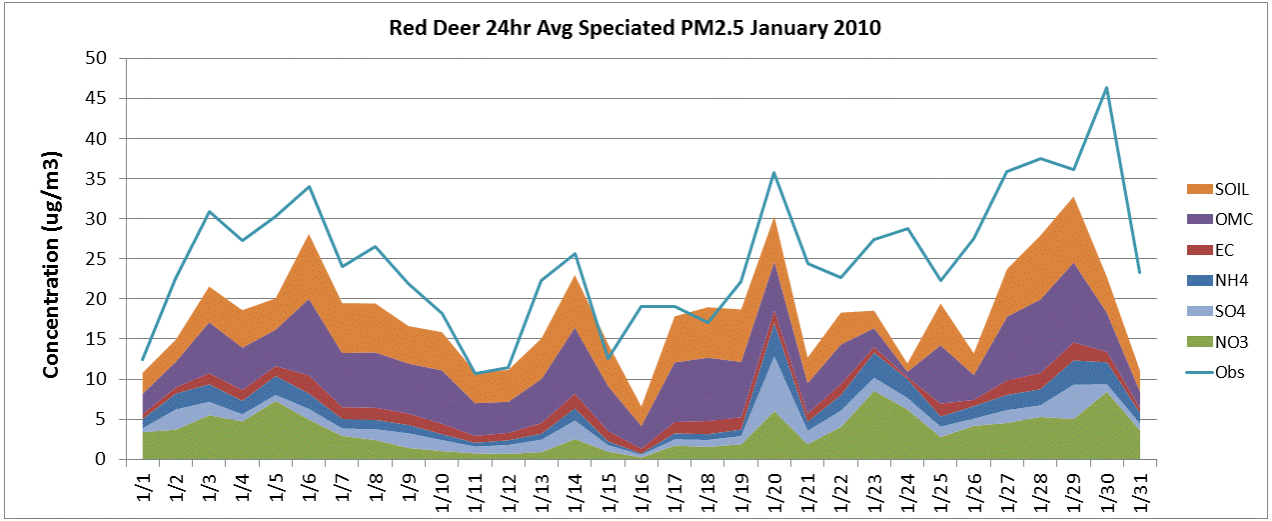
Background: Previous Studies

- **Phase 1:** *Capital Region Particulate Matter Air Modelling Assessment*
- **Phase 2:** *Formation of secondary $PM_{2.5}$ in the capital region*

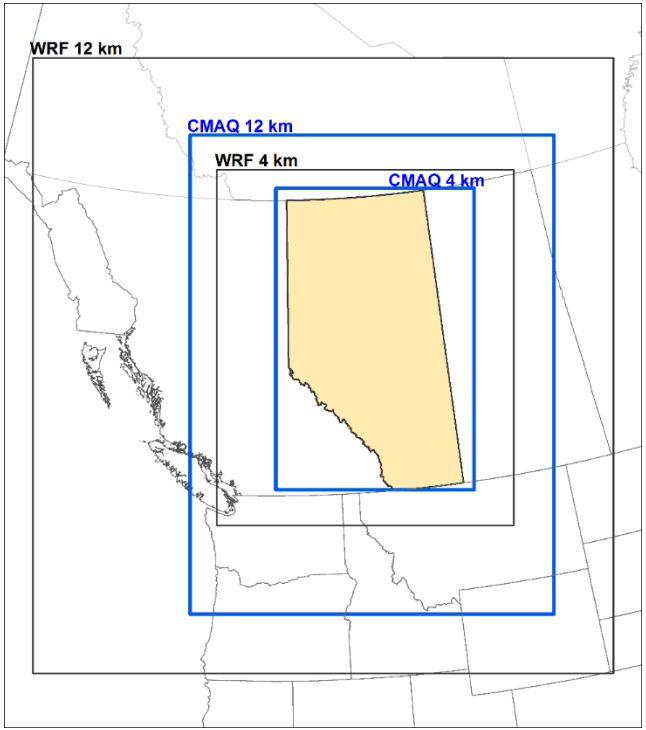


Background: Previous Studies

- **Phase 3:** *Source Apportionment of Secondary Fine Particulate Matter in Central Alberta Using CMAQ*



Background: Current Study



- Provincial-scale initiative of AEP Operations Division
  - Contracted RAMBOLL/NOVUS Environmental
  - December 2017 – June 2018
- Objectives:
  - Improve emissions inventory
  - Model entire calendar year
  - “Source apportionment”

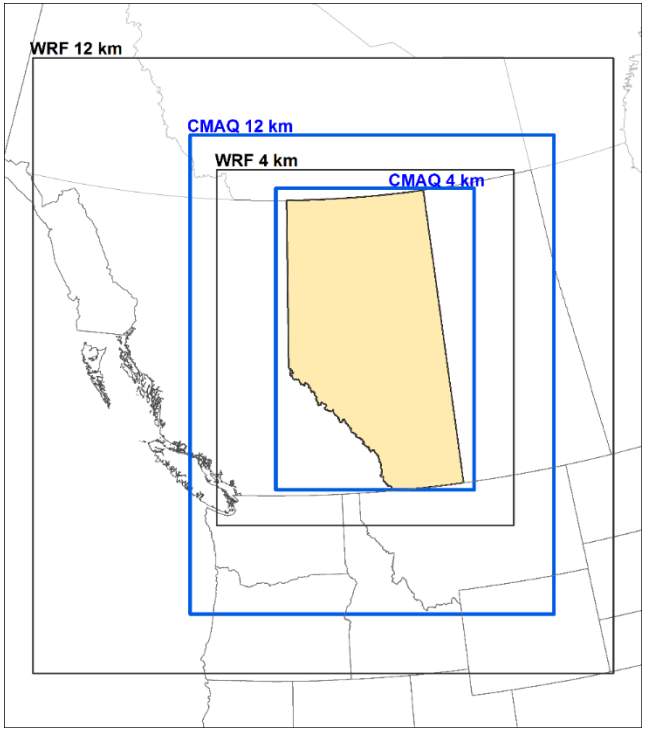
Novel Outcomes

Spatial and Temporal Domain

Emissions Inventory

Source Apportionment

Novel Outcomes: Spatial Domain

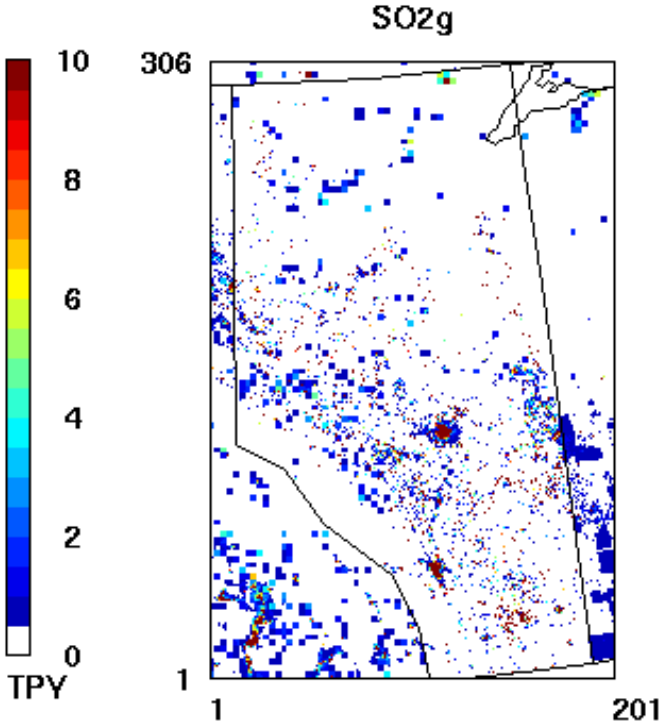


- Considered entire province at 4km x 4km
  - Consistent provincial approach enables regional comparisons
  - Areas poorly served by monitoring modelled
  - Previous studies focused on smaller domains
  - 4km x 4km selected to balance computation time with spatial resolution

Novel Aspect: Temporal Domain

- One complete calendar year modelled
  - Enables discussion on source impact year-round; aligning with CAAQS
  - 2013 selected due to interest around 2011-2013 CAAQS
  - Additional meteorology produced for 2011 and 2012
  - Previous studies were limited to the winter months of 2010

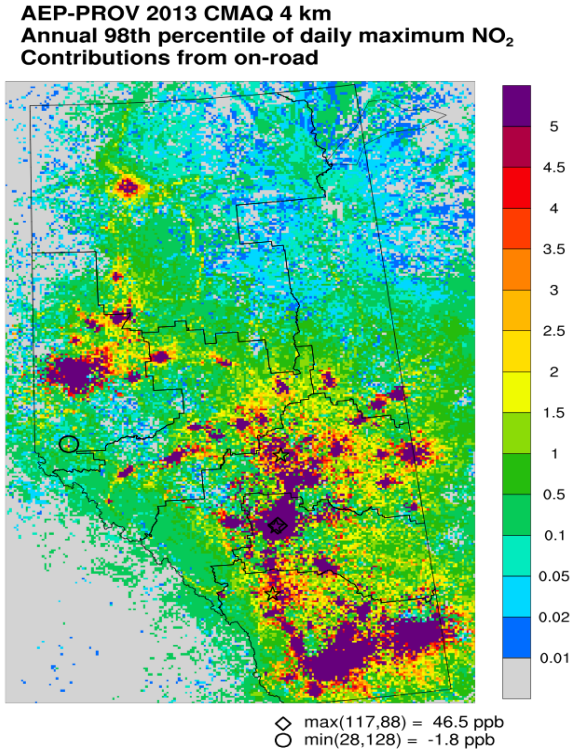
Novel Aspect: Emissions Inventory



Most up-to-date modelling emissions inventory

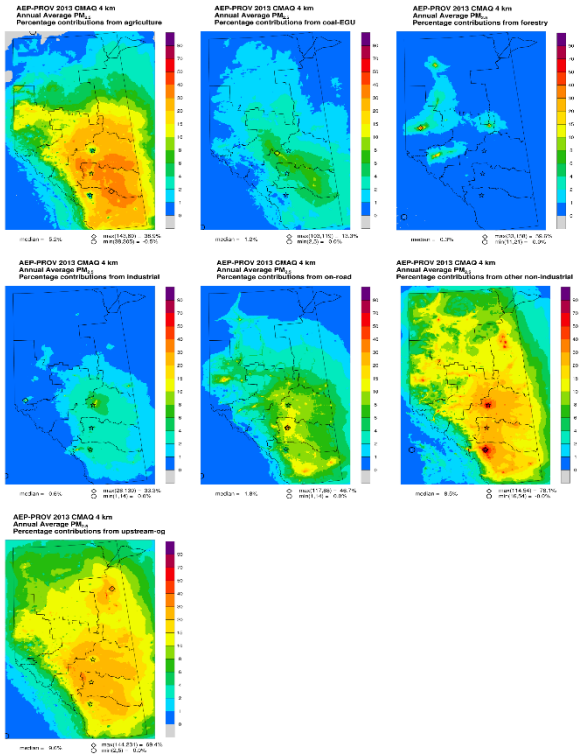
- Enabled the most faithful source apportionment to-date
- Improvement over previous studies:
  - *2013 as base year*
  - *Major point sources updated*
  - *UOG sources consolidated*
  - *AB Transportation supplied data*

Novel Aspect: Ambient Air Quality



- Predictions for secondary pollutants:
  - $PM_{2.5}$ species
    - *NO_3,SO_4, EC, OC, NH_4, OPM*
  - *O_3*
- Predictions for primary pollutants:
  - NO_2, SO_2, VOCs

Novel Aspect: Source Apportionment



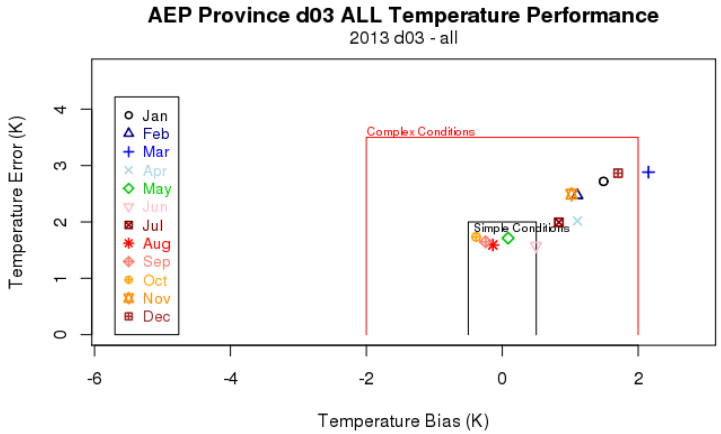
- "Source apportionment" by zero-out scenarios
- Sector-based
  - Agriculture, Coal-fired power plants, Forestry, Upstream oil and gas, Other industrial, On-road mobile, Non-industrial non-point sources

Discussion of Results

Model Performance

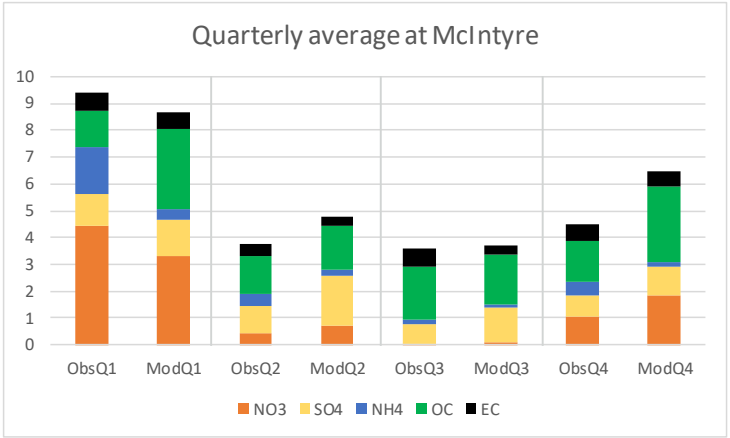
Source Apportionment Results

Results: Model Performance



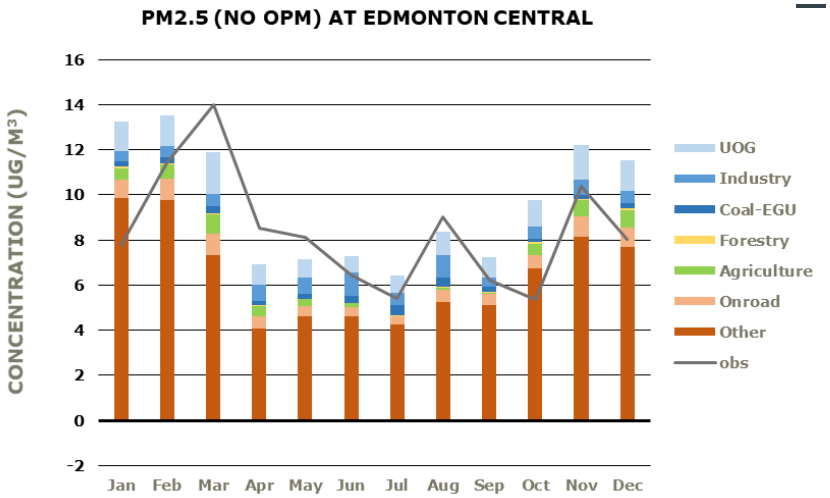
- Meteorology
  - Consistent with past studies
  - “MYJ” PBL Scheme
  - “ERA” nudging
  - Meteorological parameters all have some positive bias
    - *Small bias for wind speed/direction*
    - *Larger but acceptable bias for temperature/humidity*

Results: Model Performance



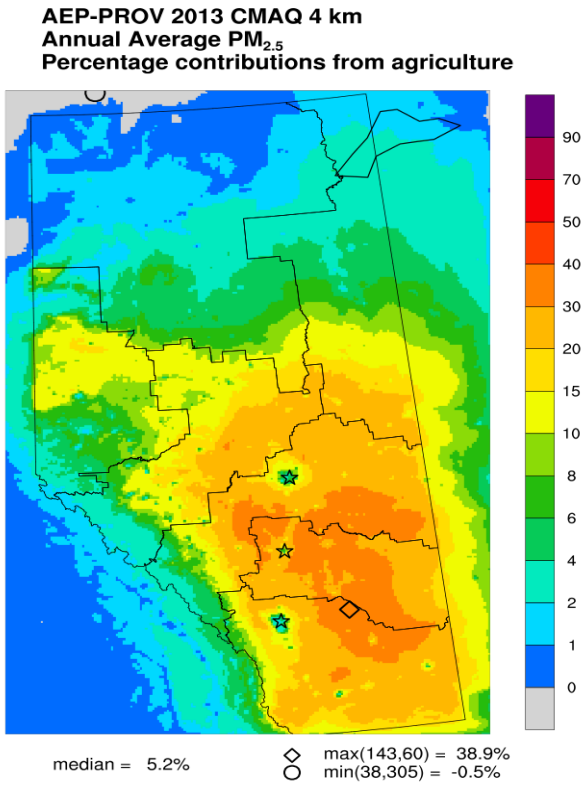
- $PM_{2.5}$
  - Performance is comparable to past studies
    - *Meets performance criteria for bias and error*
  - Good speciation profile reproduction

Results: Model Performance



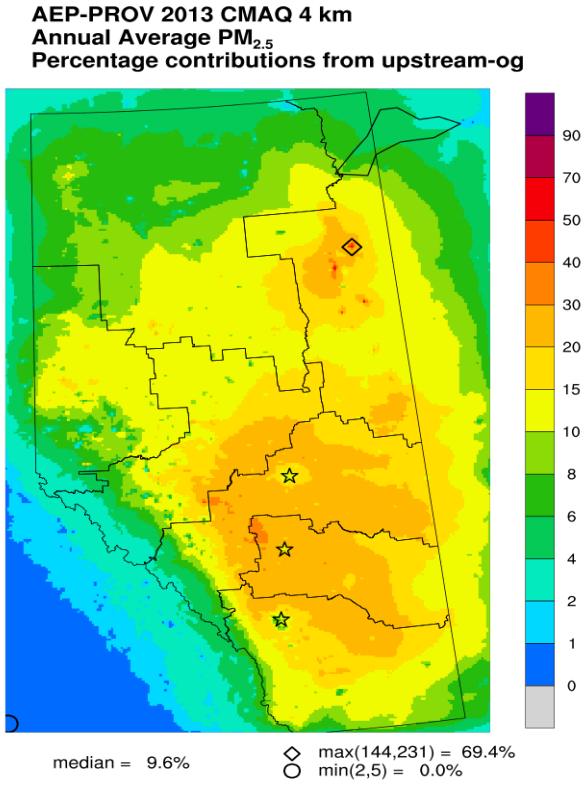
- $PM_{2.5}$
  - $PM_{2.5}$ over-predicted in urban areas
    - *Result of inventory and methodology*
    - *By correcting affected species, $PM_{2.5}$ predictions appear reasonable*

Results: Source Apportionment



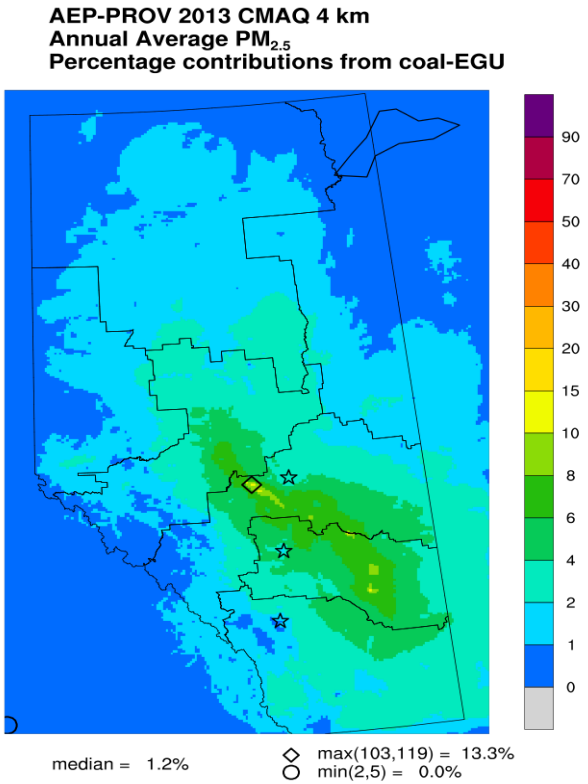
- Agriculture
  - Important $PM_{2.5}$ contributor outside of urban areas
    - *Central and Southern Alberta*
  - Within urban areas, contribution is offset by other sources
    - *E.g. other sources of NH_3*

Results: Source Apportionment



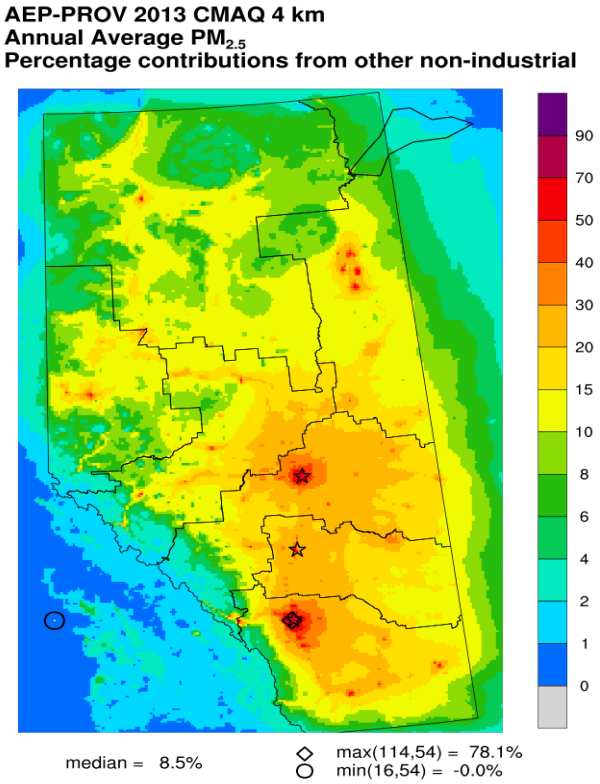
- Upstream oil and gas
  - Large province-wide contributor to $PM_{2.5}$
    - *Focussed near oil and gas activity*
    - *A background contributor in urban areas*
  - An important contributor to other pollutants: NO_2, VOCs and O_3

Results: Source Apportionment



- Localized industrial sources
  - Have a limited contribution to province-wide $PM_{2.5}$
    - *Due to localized nature of the industrial activity*
    - *Due to favourable dispersion*
  - Are important contributors to local ambient air quality
    - *Contributions can be the dominant source of $PM_{2.5}$ locally*

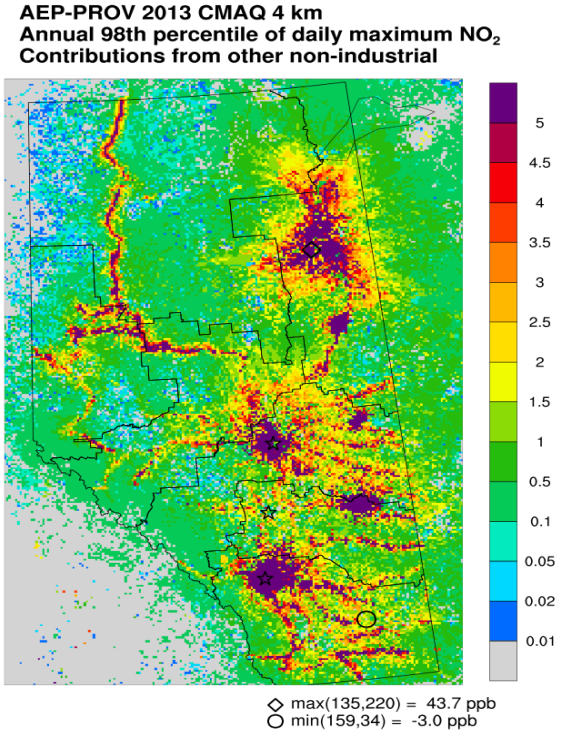
Results: Source Apportionment



- Non-industrial non-point sources
  - Dominant contributors in urban areas
    - *Remain important outside of cities*
  - Sources include:
    - *Off-road mobile sources*
    - *Small engines*
    - *Railway locomotives*
    - *Dust (e.g. construction, un-paved roads)*
    - *VOCs (e.g. paints, plastics),*
    - *Stationary fuel combustion (e.g. heating wood combustion)*

Future Considerations

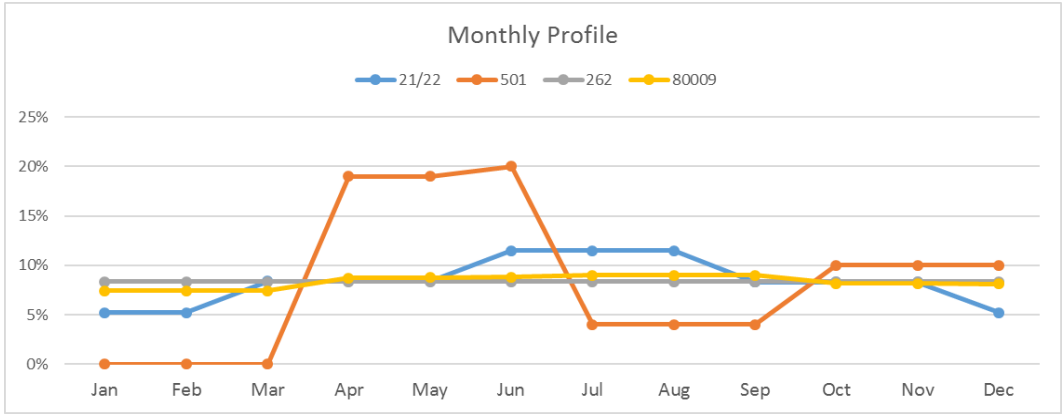
Emissions Inventory



- Spatial and temporal allocation
  - Need refined surrogates for some sectors
    - *E.g. rail, provincial highways*

Emissions Inventory

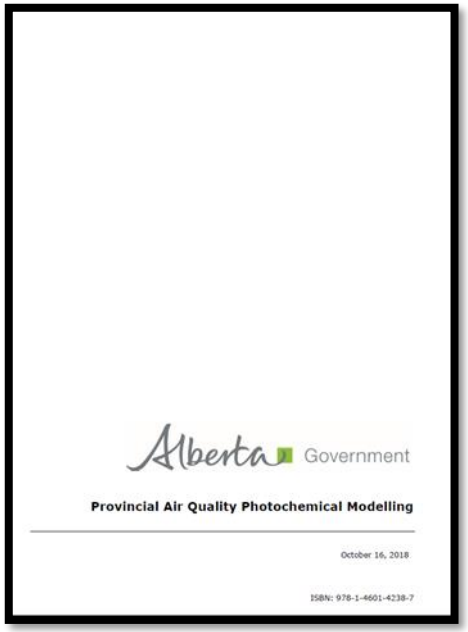
- Spatial and temporal allocation
  - Accurate temporal profiles not available for some sources
    - *E.g. Seasonality is not appropriate for Alberta context*



$PM_{2.5}$ Species Measurements

- As of 2018
  - $PM_{2.5}$ Species measurements are being collected
    - *Edmonton McIntyre*
    - *Ross Creek*
    - *Red Deer (Riverside, Lancaster, Horn Hill)*
    - *Hinton*
  - Opportunity to ground-truth the model at several locations
  - Provide model predictions for a relevant present case

Published Report



- Provincial-scale modelling of $PM_{2.5}$ and precursors with sector-based source apportionment
- Summary, Final Report and Appendix now available online
- https://open.alberta.ca/publications/9781460142387

Questions?