Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

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Cluster Analysis and Air Quality Effects of Policy Change

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Cluster Analysis and Air Quality Effects of Policy Change

- Identify trends in ambient air quality to understand long term relationships with activities in the region
  - added interest if air quality has improved.
- Analysis conducted a historical data review
  - from 1982 to 2018
  - for the NAPS (National Air Pollution Surveillance) stations in Alberta (all 66 locations)
  - 8,353,248 hours monitored

Cluster Analysis and Air Quality Effects of Policy Change

- Focus was placed on four long-term stations:
  - Calgary Northwest
  - Edmonton East
  - Beaverlodge
  - Fort Chipewyan

Cluster Analysis and Air Quality Effects of Policy Change

- Looking for long term trends in the ambient data for:
  - NO_2 (nitrogen dioxide)
  - SO_2 (sulphur dioxide)
  - O_3 (ozone)
  - $PM_{2.5}$ (particulate less than 2.5 microns in diameter)
- We adjust observations to go from periods <1990, 1990-2000, 2000-2010, and >2010
  - look for different patterns and conditions in each period of time

Management Level	Management Actions	Proposed Air Management Threshold Values					
		Ozone (ppb)		$PM_{2.5}$ Annual ($\mu g/m^3$)		$PM_{2.5}$ 24h ($\mu g/m^3$)	
		2015	2020	2015	2020	2015	2020
RED	**Actions for Achieving Air Zone CAAQS**						
Threshold		63 ppb	62 ppb	10.0 µg/m3	8.8 µg/m3	28 µg/m3	27 µg/m3
ORANGE	**Actions for Preventing CAAQS Exceedance**						
Threshold		56 ppb		6.4 µg/m3		19 µg/m3	
YELLOW	**Actions for Preventing AQ Deterioration**						
Threshold		50 ppb		4.0 µg/m3		10 µg/m3	
GREEN	**Actions for Keeping Clean Areas Clean**						

Substances	Averaging Period	AAAQO [a]	CAAQS [d]	
		Effective 2019	Effective 2020	Effective 2025
Ozone (O_3) [b]	1-hour	300 µg/m³	-	-
		76 ppb		
Nitrogen Dioxide (NO_2)	1-hour	159 ppb	60 [e] ppb	42 [e] ppb
		300 µg/m³	113 [j] µg/m³	79 [j] µg/m³
	Annual	24 ppb	17 [f] ppb	12 [f] ppb
		45 µg/m³	32 [j] µg/m³	23 [j] µg/m³
Sulphur Dioxide (SO_2)	1-hour	172 ppb	70 [g] ppb	65 [g] ppb
		450 µg/m³	183 [j] µg/m³	170 [j] µg/m³
	24-hour	48 ppb	-	-
		125 µg/m³		
	30-day	11 ppb	-	-
		30 µg/m³		
	Annual	8 ppb	5 [h] ppb	4 [h] ppb
		20 µg/m³	13 [j] µg/m^3	10 [j] µg/m^3
Fine Particulate Matter ($PM_{2.5}$)	24-hour	29	27 [c] µg/m^3	-

- No level

[a] - Alberta Ambient Air Quality Objectives and Guidelines (AB Government 2019)

[b] - There are CAAQS for 8hr Ozone and Annual $PM_{2.5}$

[c] - The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations

[d] - Canadian Ambient Air Quality Standards (CAAQS) (CCME 2017)

[e] - CAAQS (CCME 2017): The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations

[f] - CAAQS (CCME 2017): The average over a single calendar year of all 1-hour average concentrations

[g] - CAAQS (CCME 2017): The 3-year average of the annual 99th percentile of the SO2 daily maximum 1-hour average concentrations

[h] - CAAQS (CCME 2017): The arithmetic average cover a single calendar year of all 1-hour average SO2 concentrations.

[i] - CAAQS (CCME 2017): The 3-year average of the annual average of all 1-hour concentrations

[j] - Units converted from ppb to µg/m³

After all those numbers – what is it we need to know

Everything to know about Air Quality

How long can you hold your breath…

Rule of 3s

30 days = food, 3 days = water

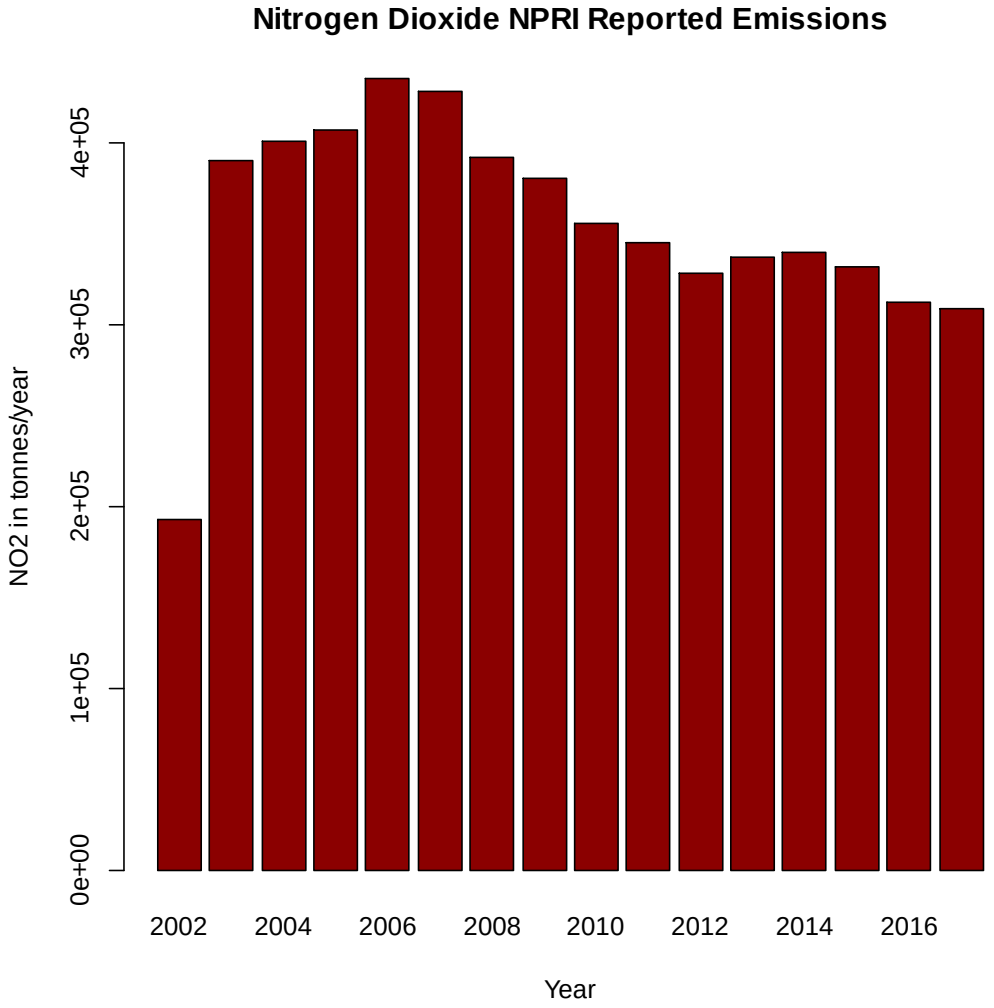
3 minutes = air

In all seriousness…

- Lets take a look at the emissions being reported in Alberta
- Then Lets take a look at the sampling conducted in Alberta
- Then we can look at the potential trends that we see from the monitoring
- For sake of time and sanity we focused on NO_2

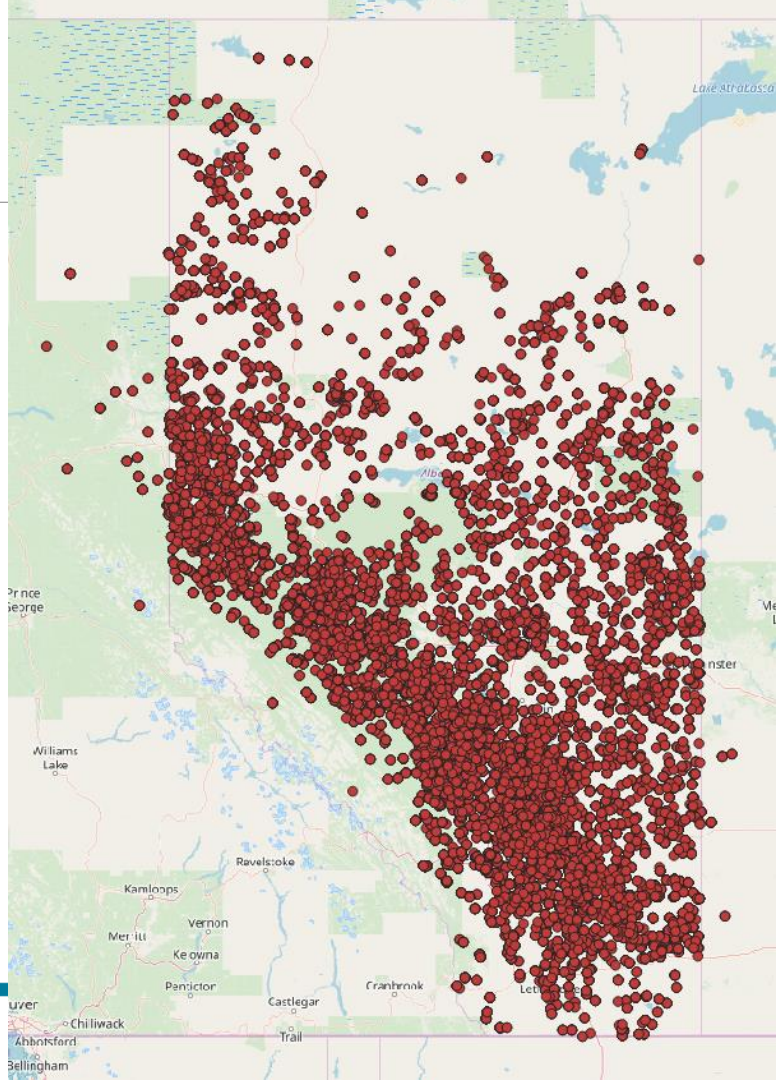
NPRI NO_2 emissions

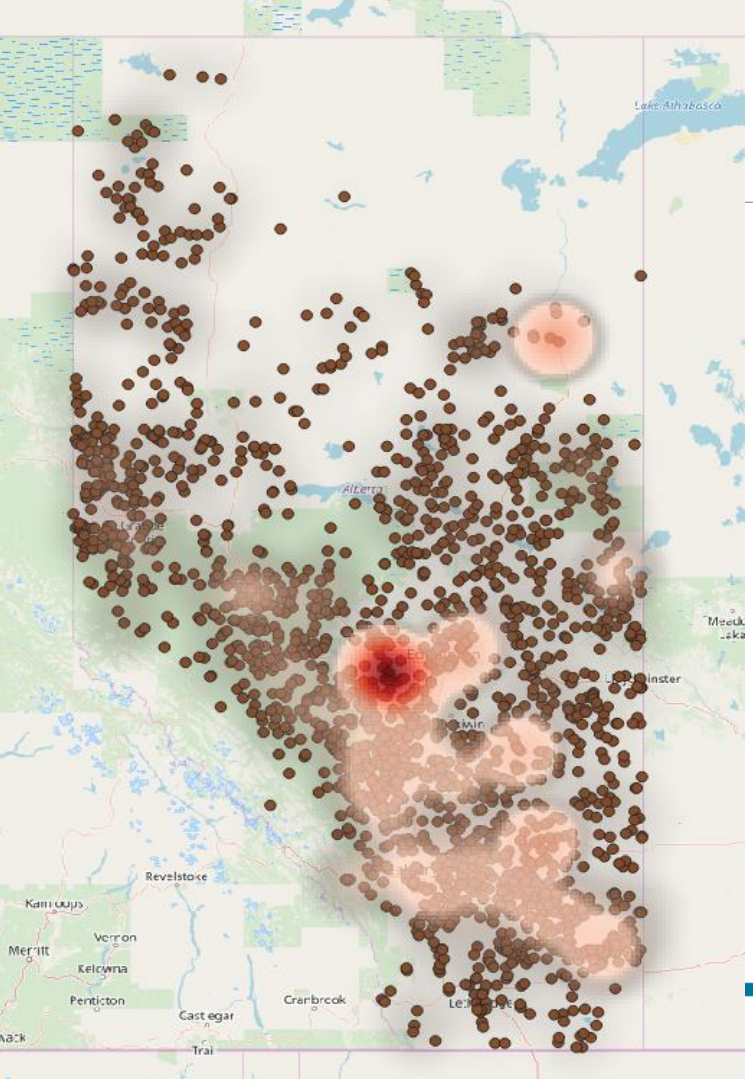
First year of emission reporting for NO_2 was 2002, with 2017 the most recent emission data



Alberta NPRI reports

- Based on 2017 NPRI data the following shows every location registered to AB
- What we learn right away is that Alberta has annexed parts of BC and SK



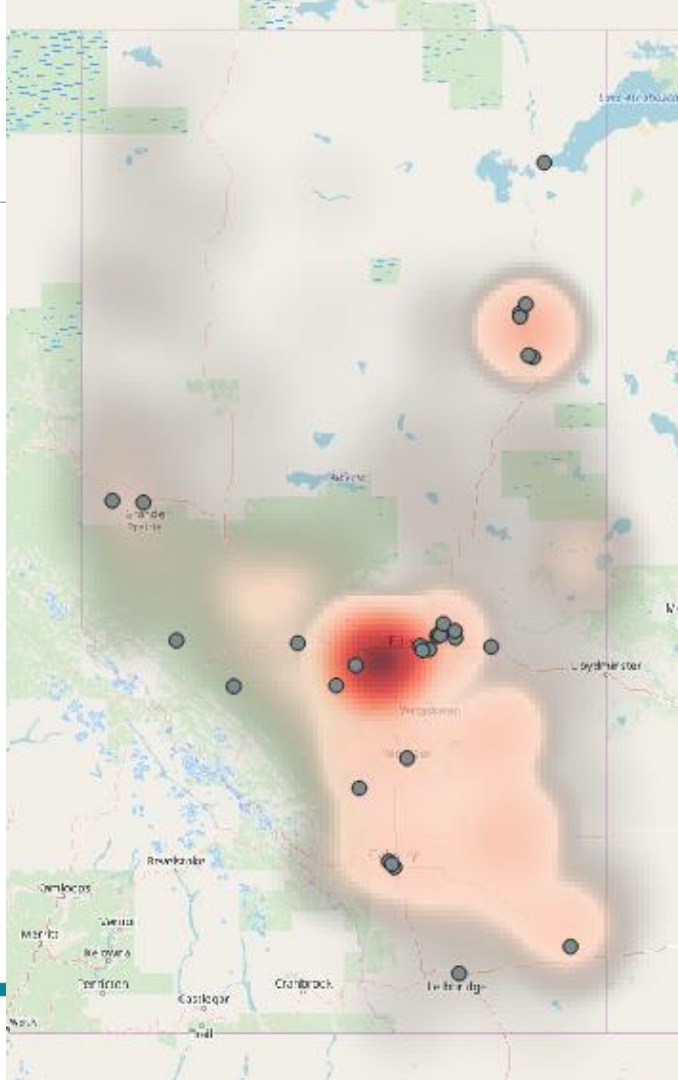


NPRI reported emissions for NO_2

- Figure on left is reported locations in 2003 with a heat map showing emissions
- Figure is updated with data from 2017
- From the two figures we note a shift in western provincial emissions

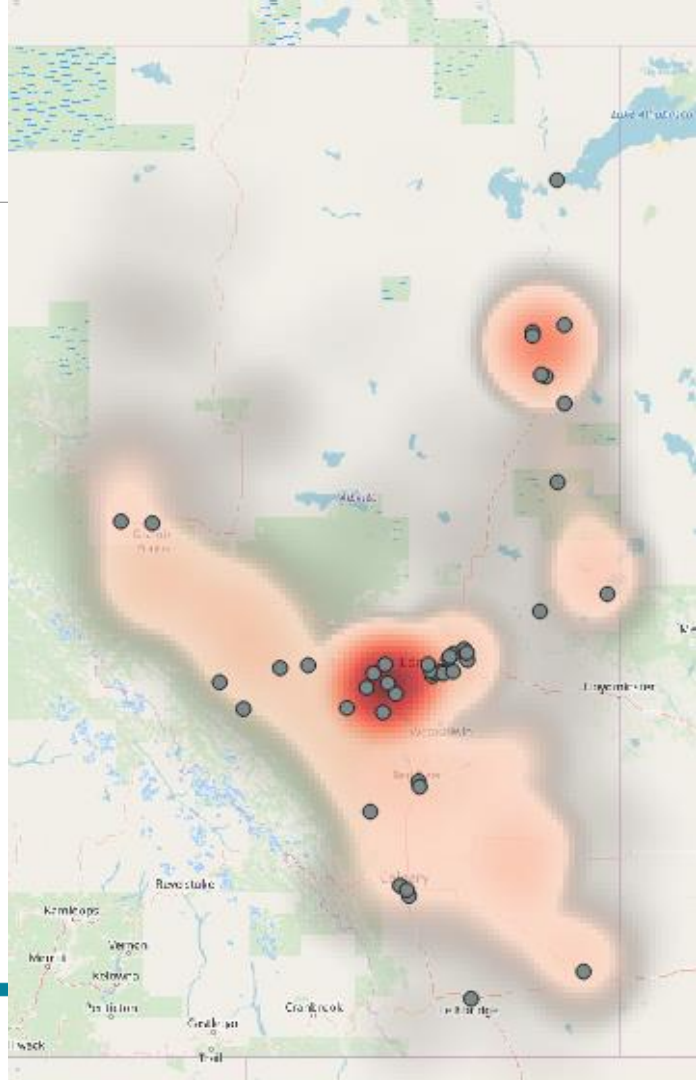
NAPS monitoring 2005

- Looking at the long term NAPS monitoring compared to 2005 NPRI emission data we see the monitoring stations compared to emission heat map
- Overlaying the NAPS monitoring data we identify our highest concentrations

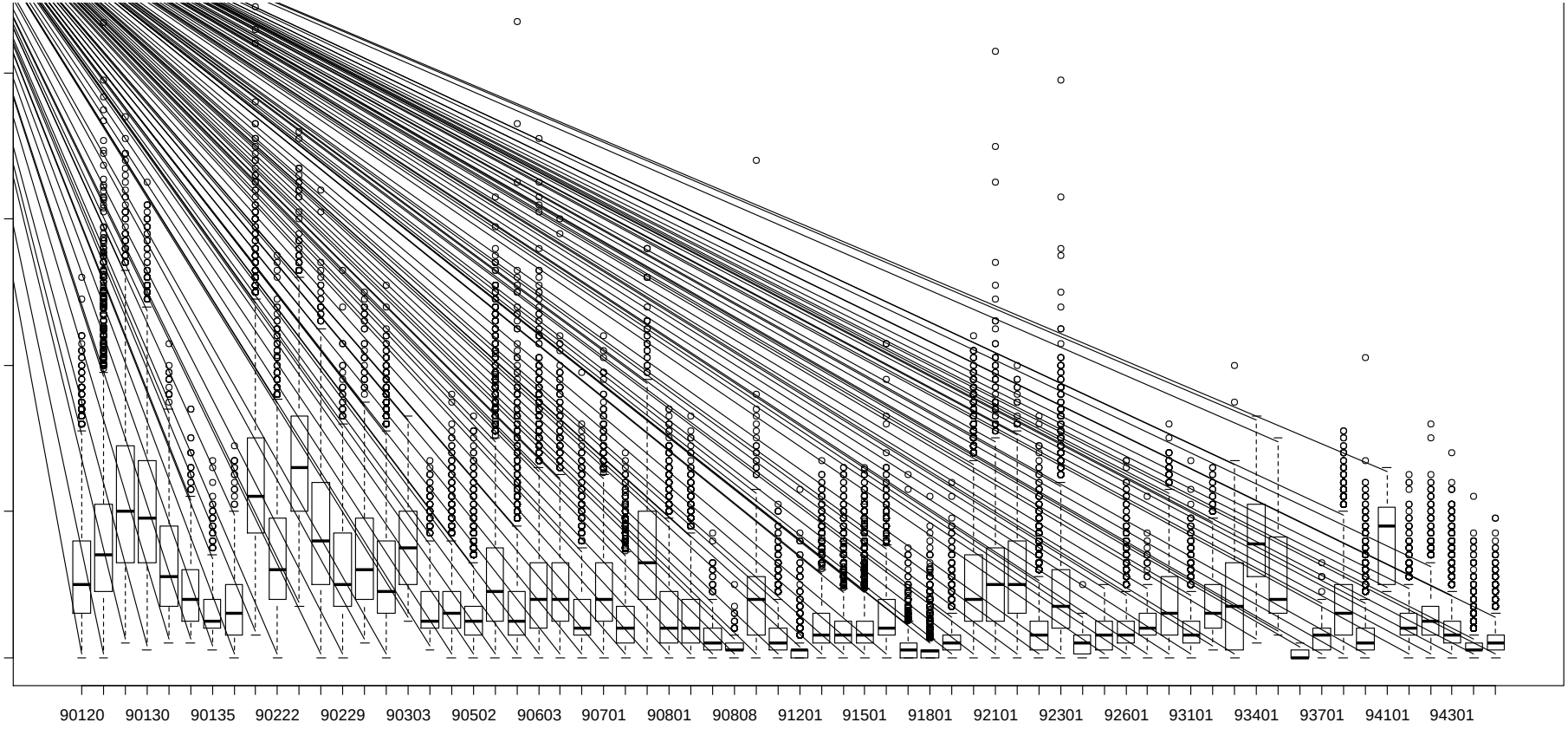


NAPS monitoring 2015

- Updating the current NAPS stations with the 2015 NPRI emissions we see changes in emission profiles
- Overlaying the NAPS monitoring data we again identify our highest concentrations

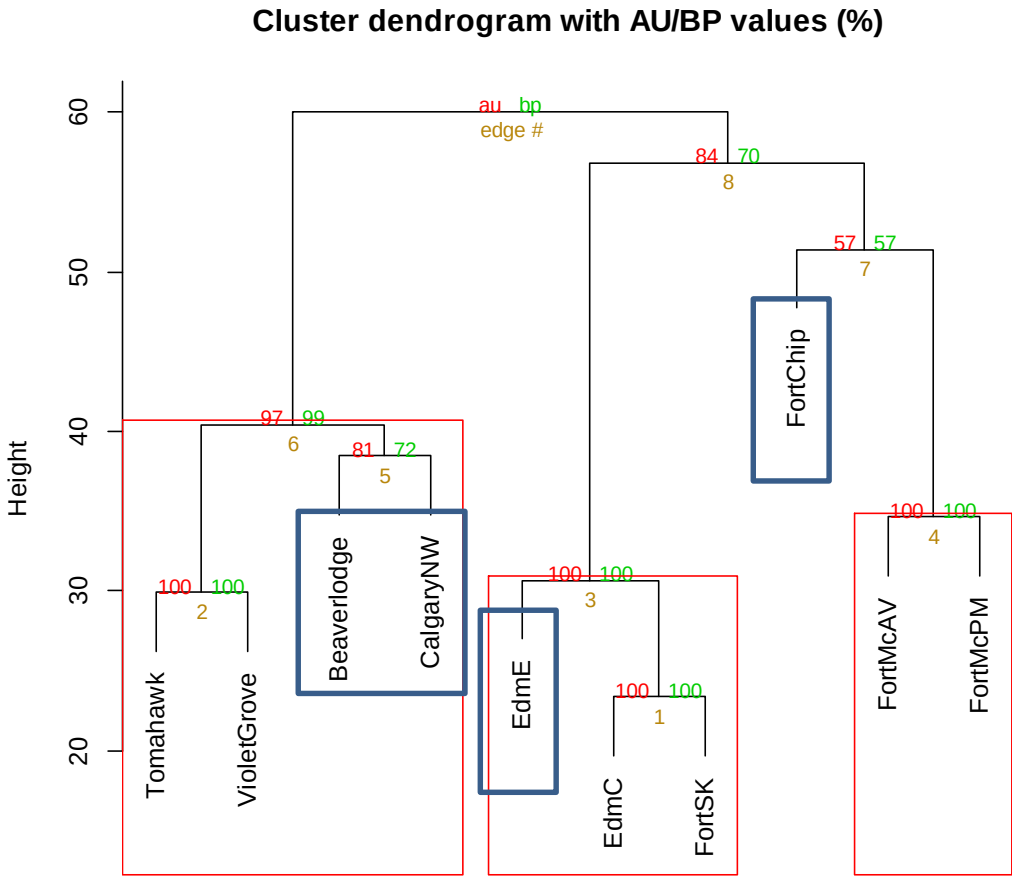


NAPS monitoring stations in Alberta



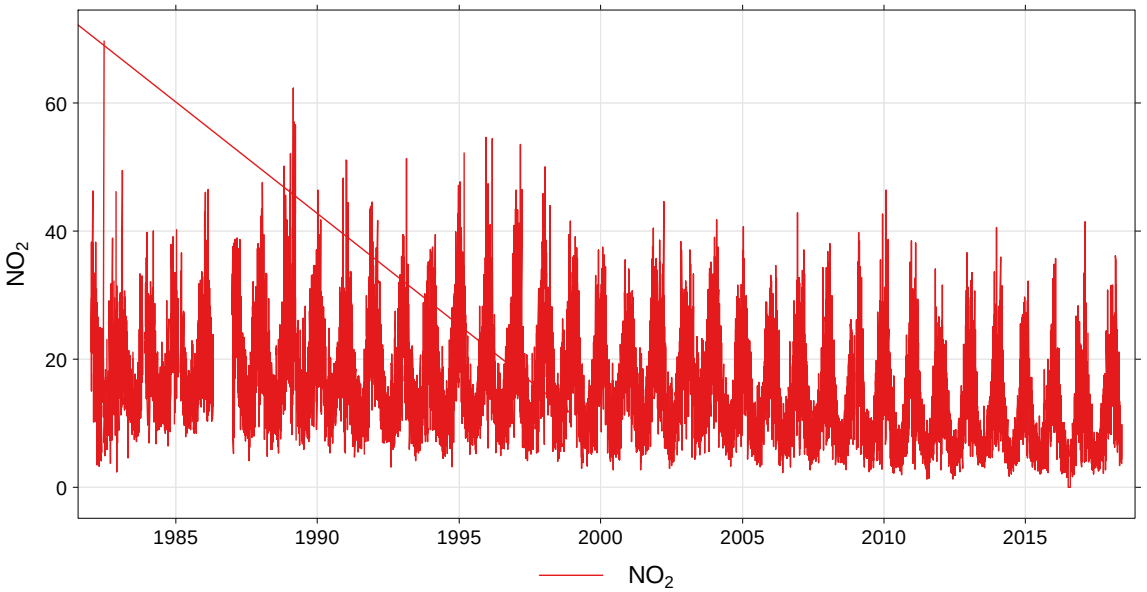
Cluster analysis

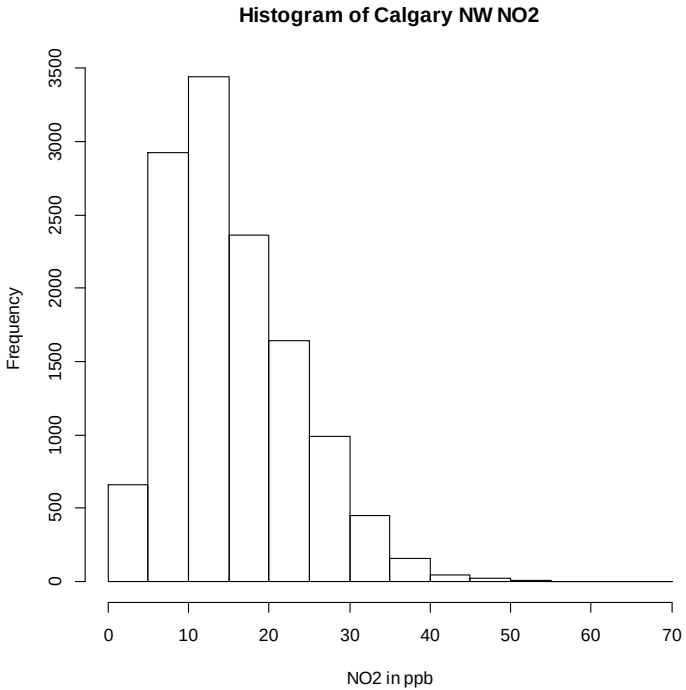
By looking at the long term monitoring NAPS stations – we identified which stations we wanted to investigate further based on how they clustered



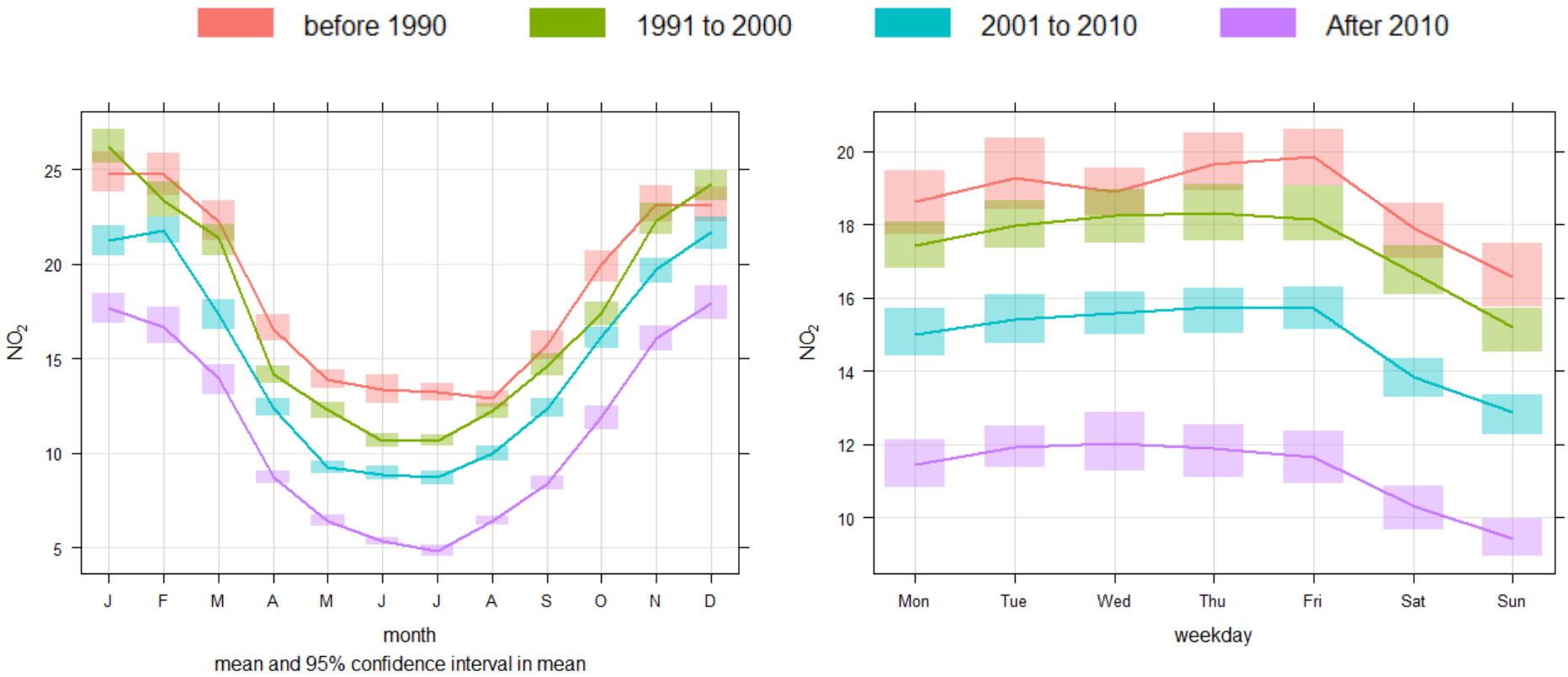
Lets look at a station - Calgary NW

Long monitoring history – so we can look for reductions over time





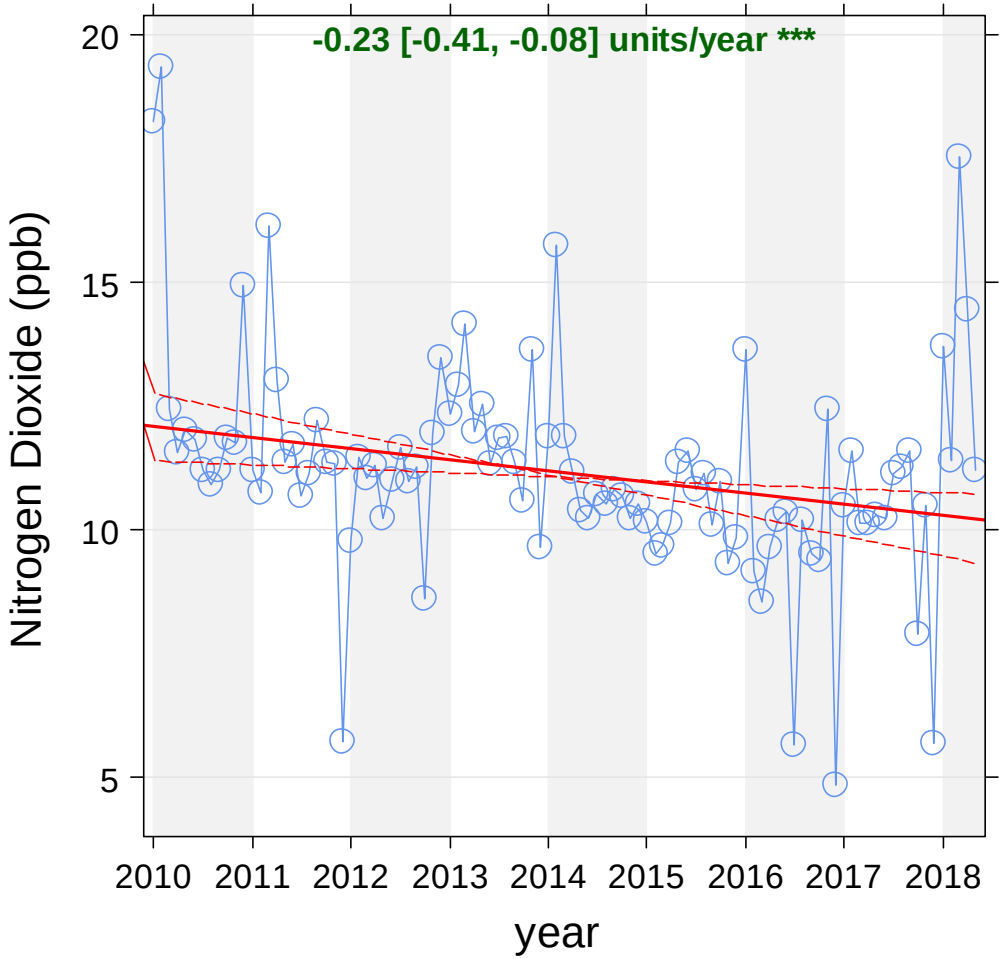
NO_2 profile using Calgary NW



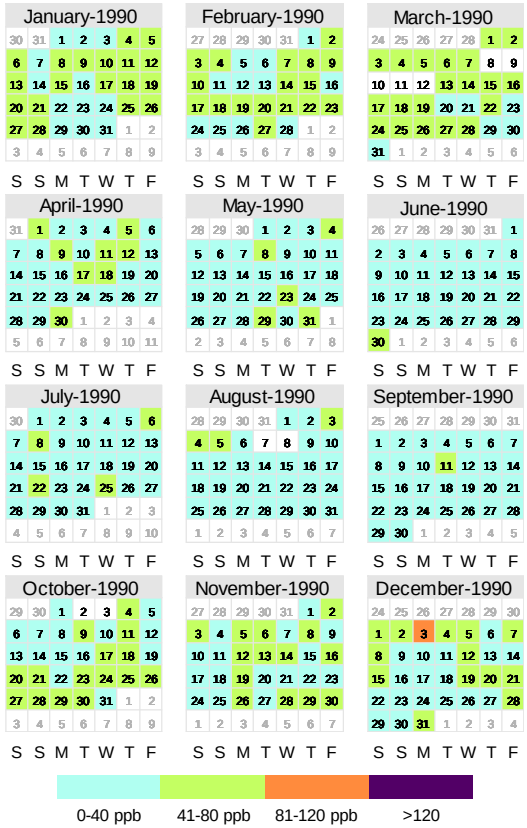
Trends - Calgary

The 24-hr trend of NO_2 at Calgary NW station shows significant reductions from 1982-2010 24-hr trend of NO_2

From 2010+ we are still seeing a significant reduction potential

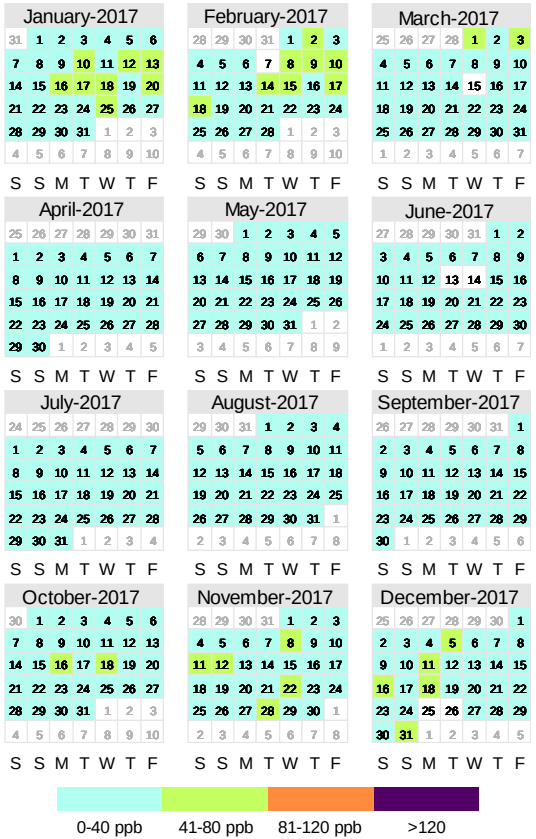


For Fun we compared 1990 to 2017



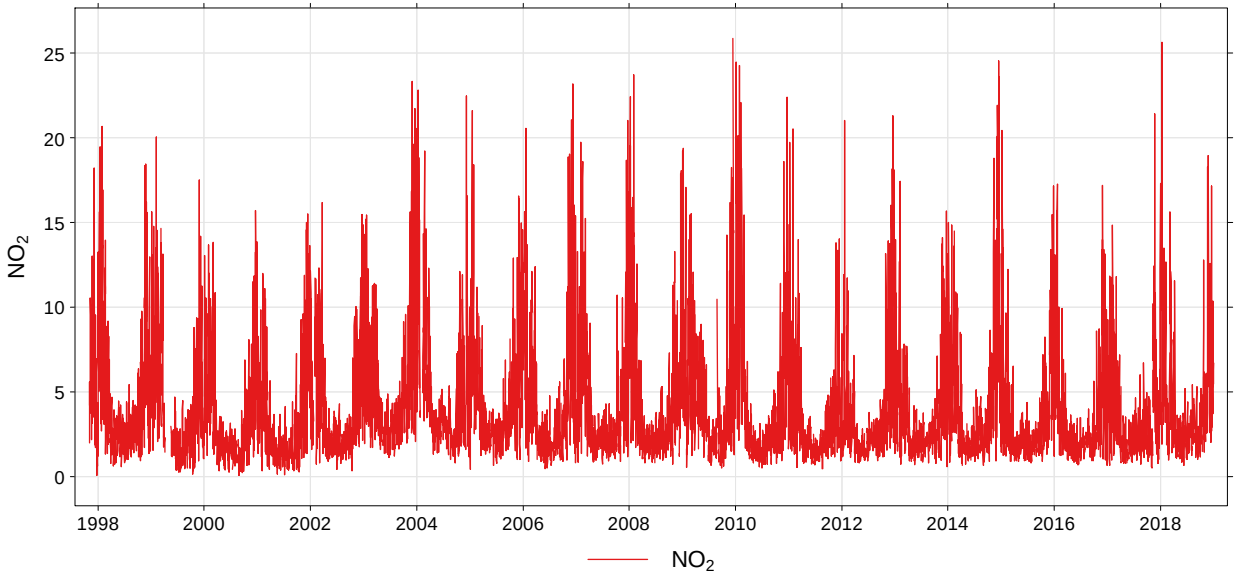
What do we see with this comparison

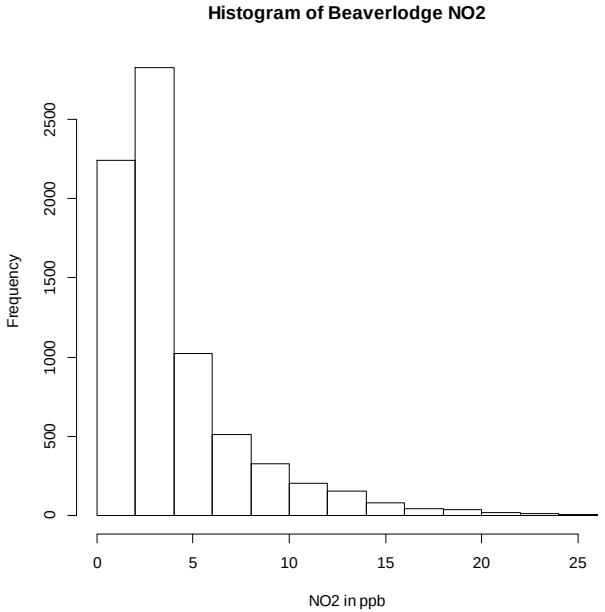
Just wait…



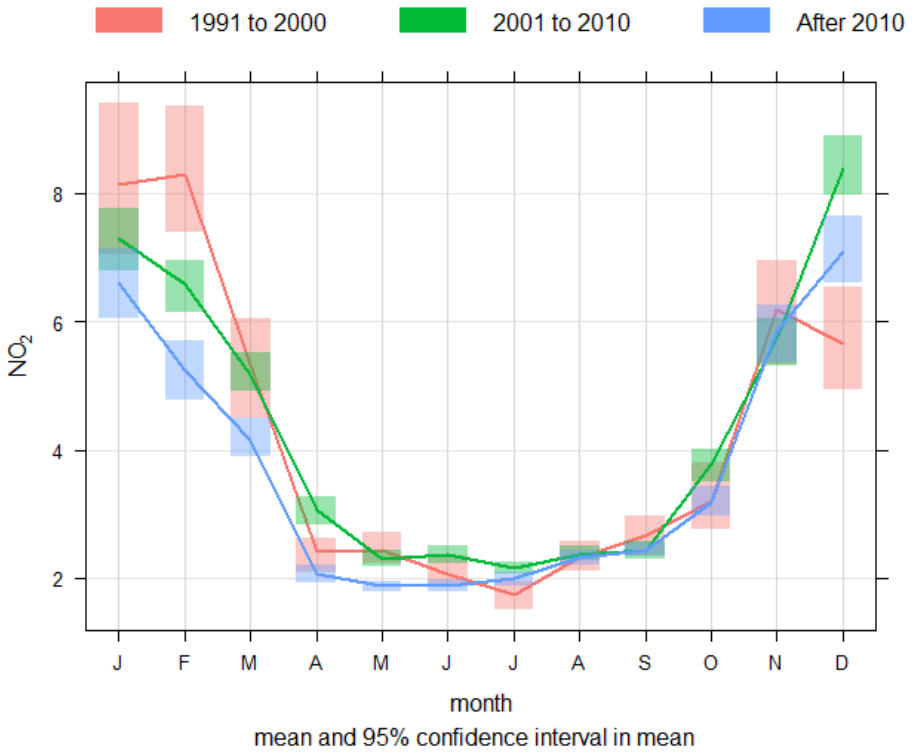
Lets look now at Beaverlodge

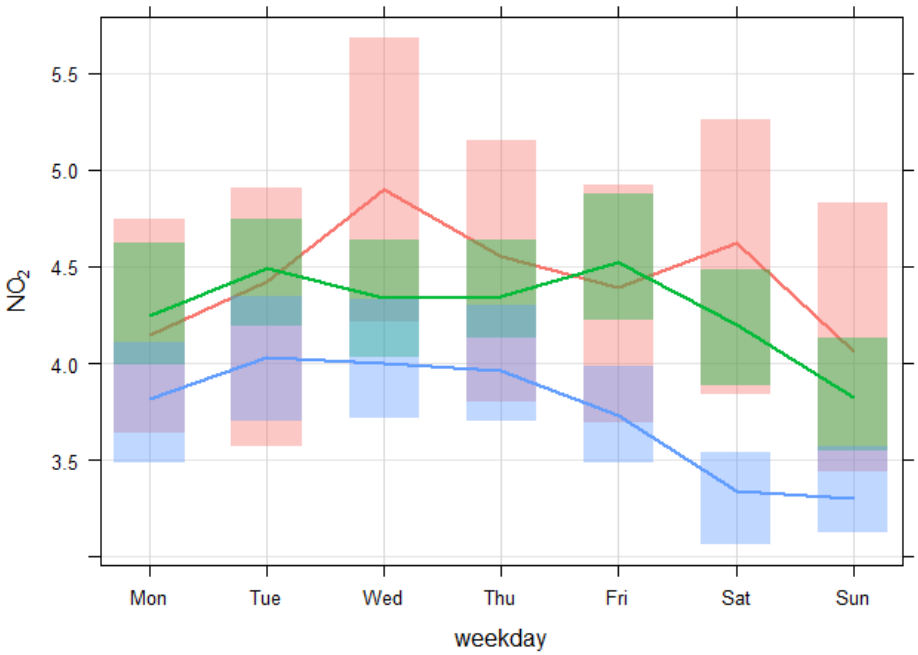
This station is located west of Grande Prairie….





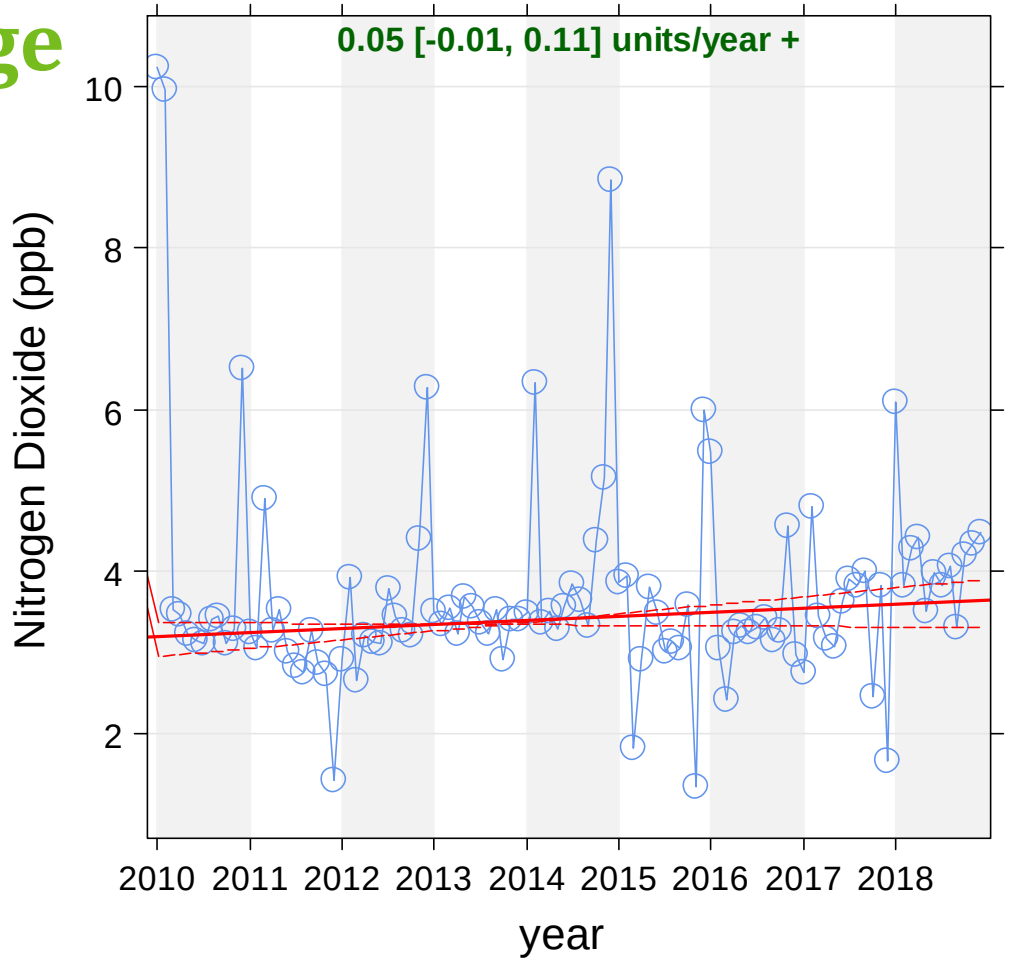
NO_2 profile using Beaverlodge





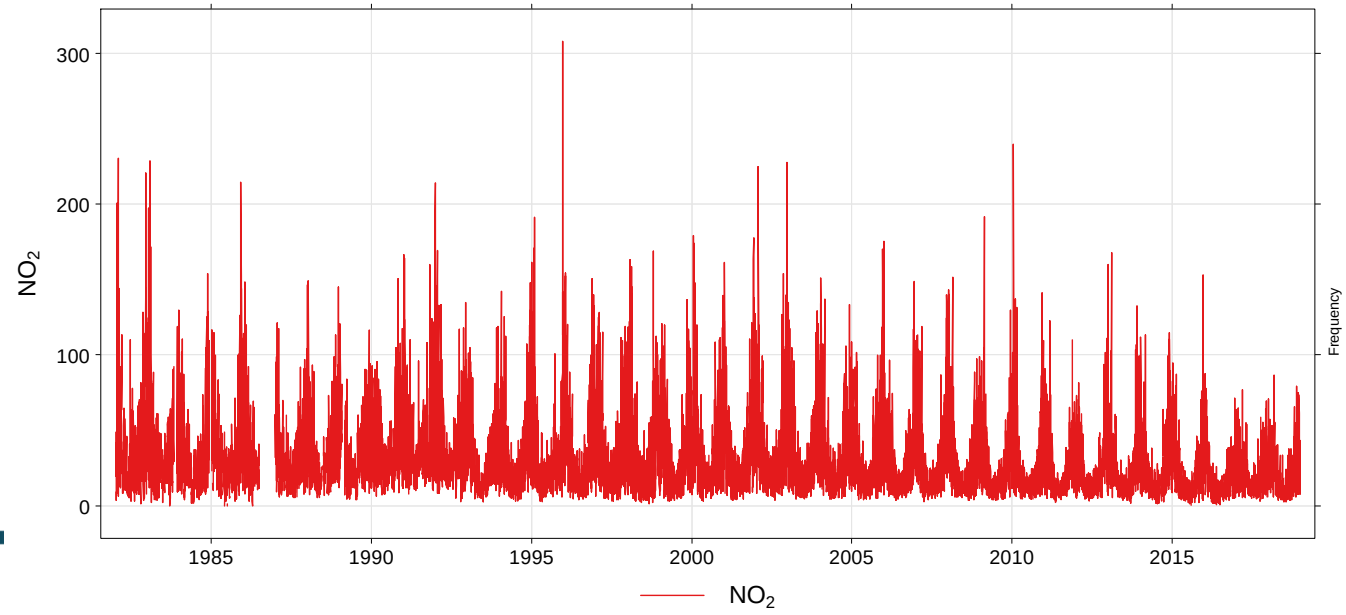
Trends - Beaverlodge

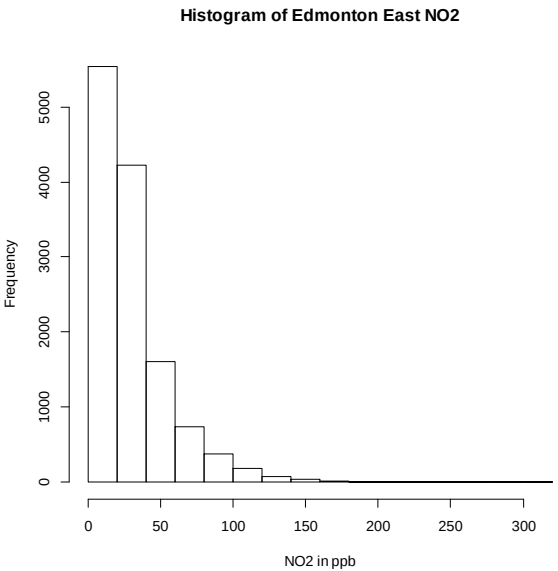
The 24-hr trend of NO_2 at Beaverlodge, does not show a decreasing trend from 1998-2010, and following post 2010 we continue to see a rather flat trend



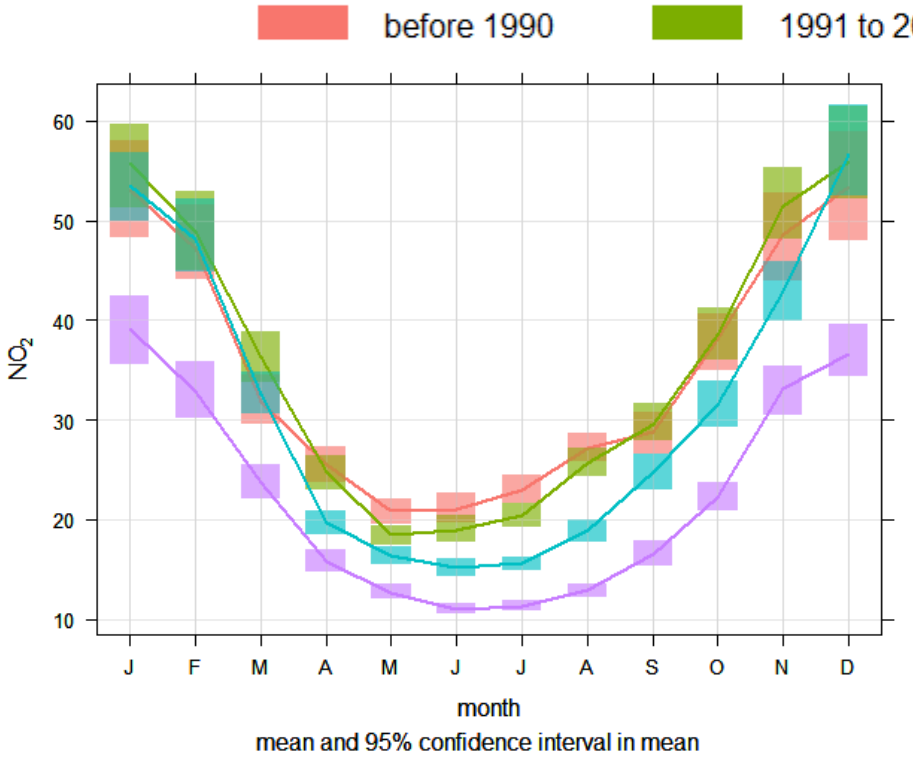
Lets look north to Edmonton East

We see higher NO_2 values at this station, with peaks declining as we move into 2019



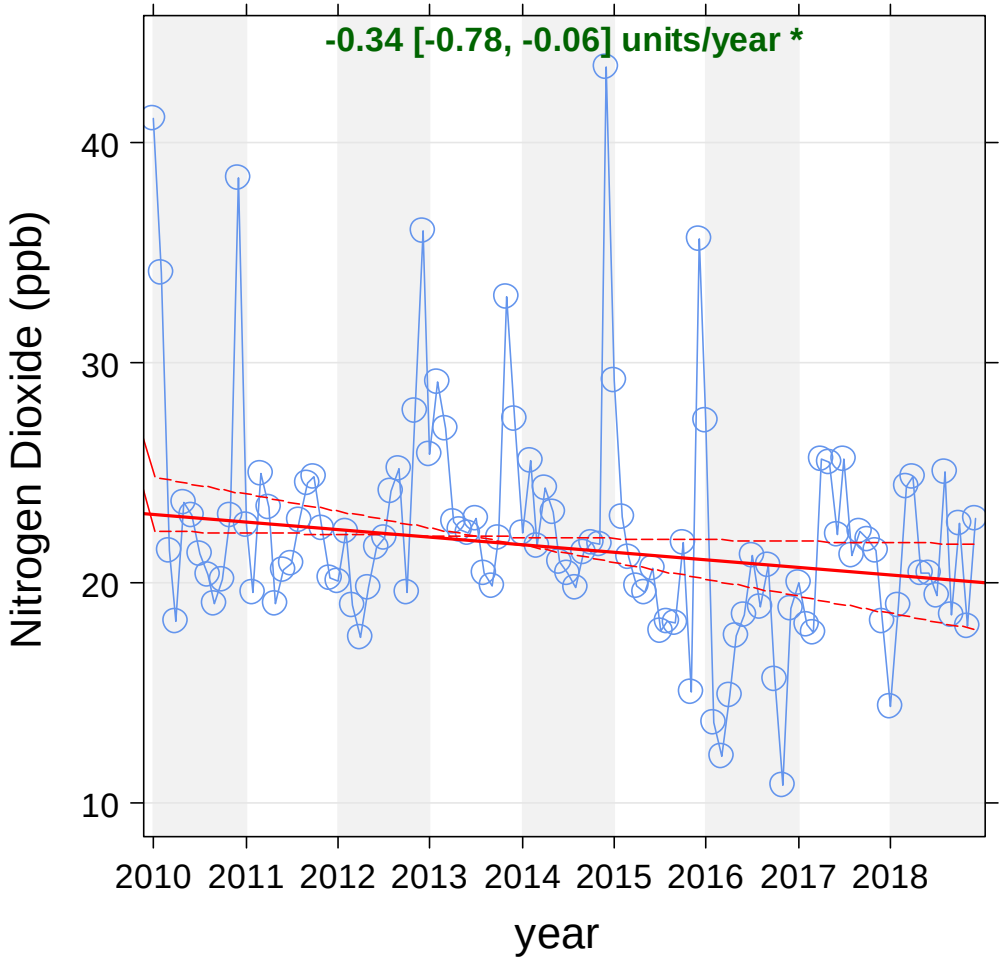


NO_2 profile using Edmonton East

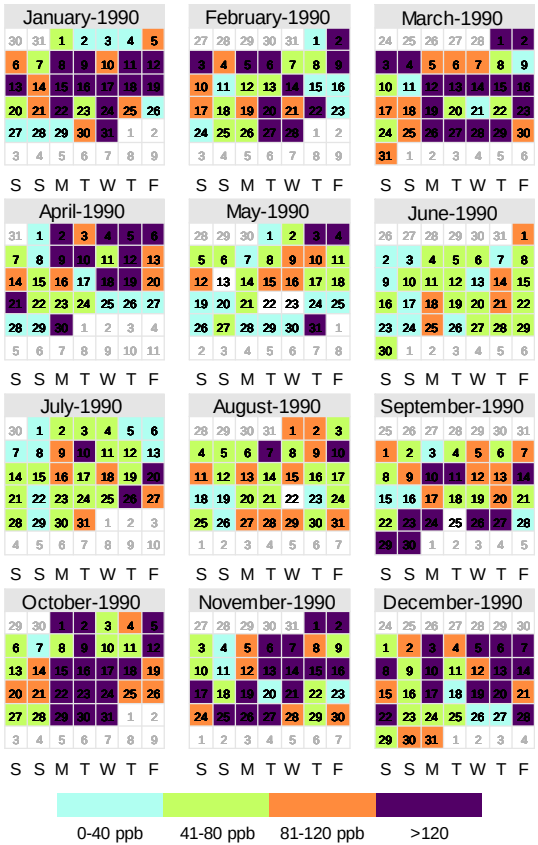


Trends Edmonton

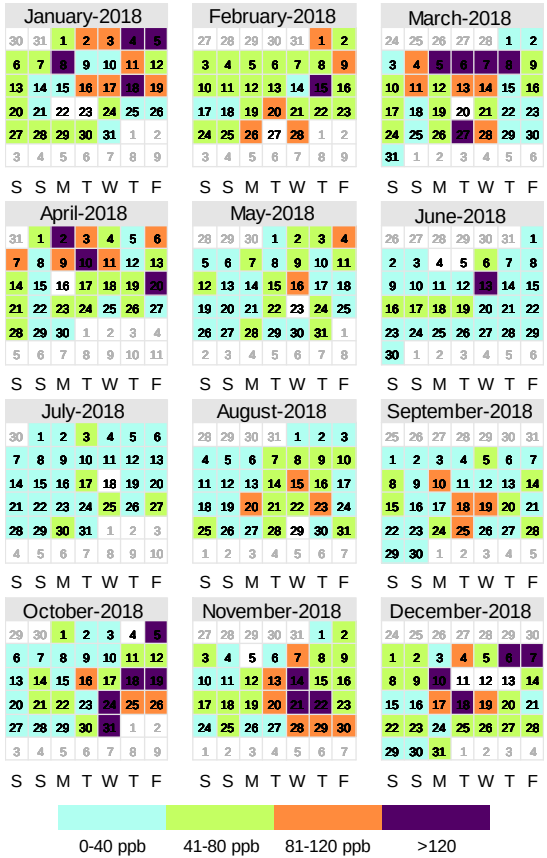
The 24-hr trend of NO_2 at Edmonton East shows significant decreasing trends from 1982-2010 Post 2010 we do not see as significant of reduction as opposed to the monthly and weekday trend appears



From Calgary – this is what we were waiting for

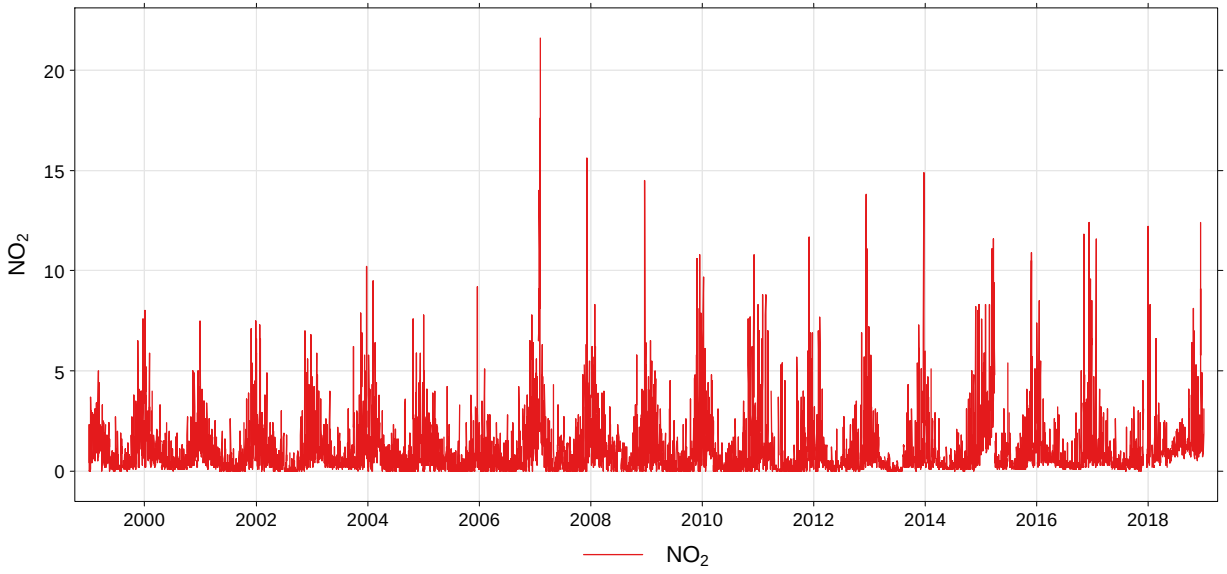


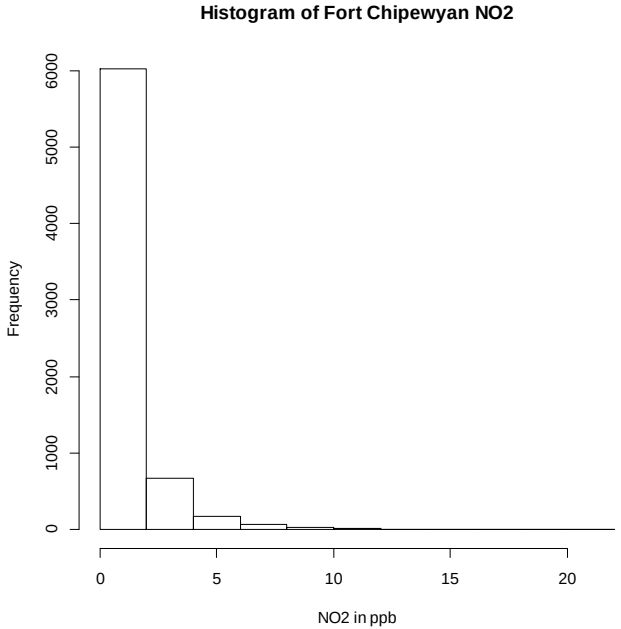
1990 compared to 2018 number of days …



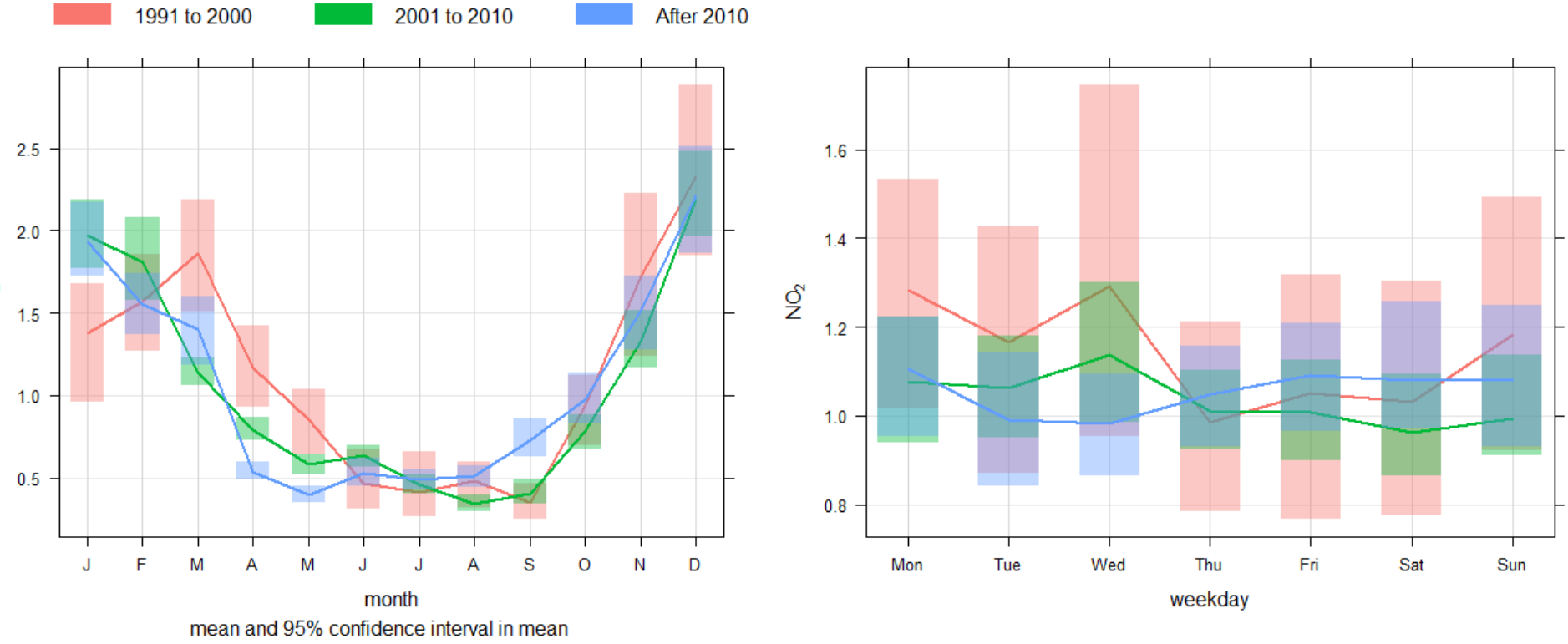
NO_2 profile using Fort Chipewyan

Profile identifies long term trends with the histogram showing low values



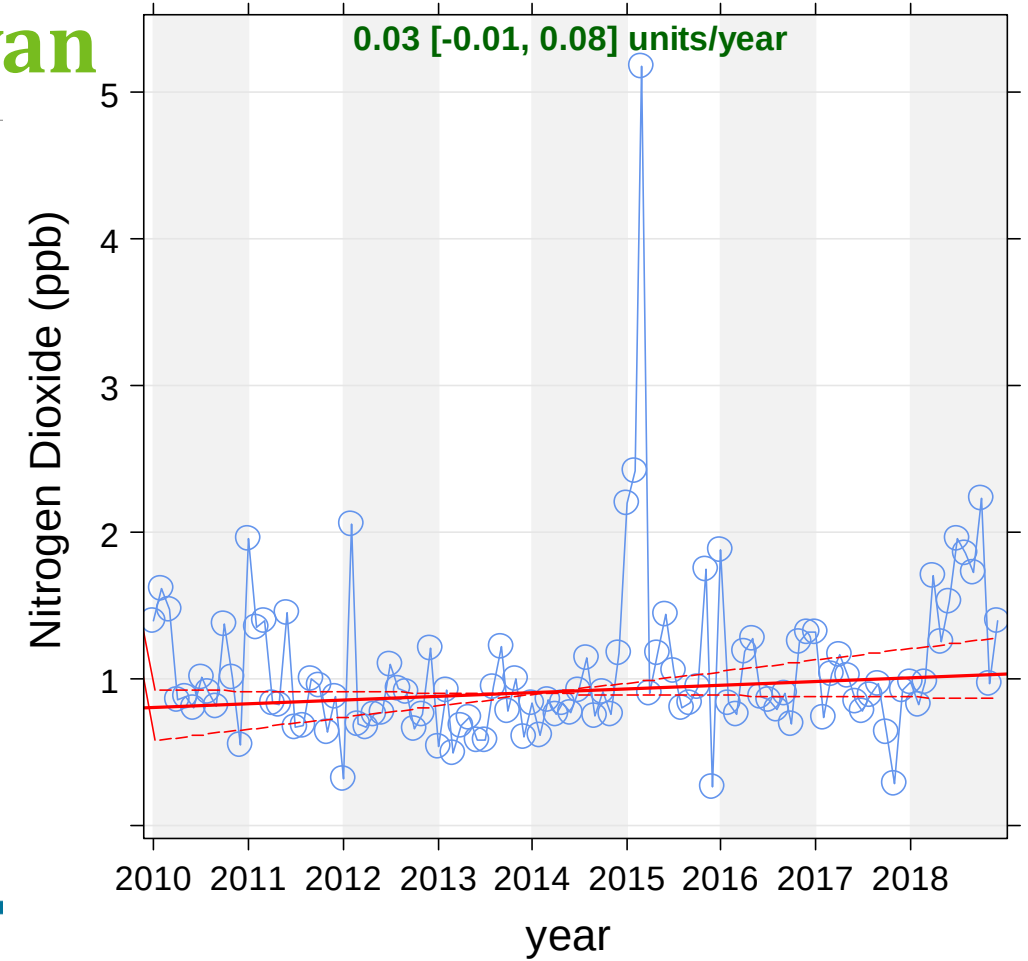


NO_2 profile using Fort Chipewyan



Trends Fort Chipewyan

The 24-hr trend of NO_2 at Fort Chipewyan is similar to Beaverlodge and does not show a decreasing trend pre-2010, and following we continue to see a rather flat trend



Summary

- Based on Trends – best day to run in Calgary or Edmonton is Sunday
- Calgary has lower NO_2 levels than Edmonton and is continuing to decrease
- Both policy change and vehicle fleet improvement appears to have helped contribute to decreased NO_2 concentrations in urban centers in Alberta
- Little change is noted in rural sites over time based on NO_2 concentrations, consistently low values through time

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Questions?