Using air quality model to support Canadian policy making: two applied cases

Environment and Climate Change Canada

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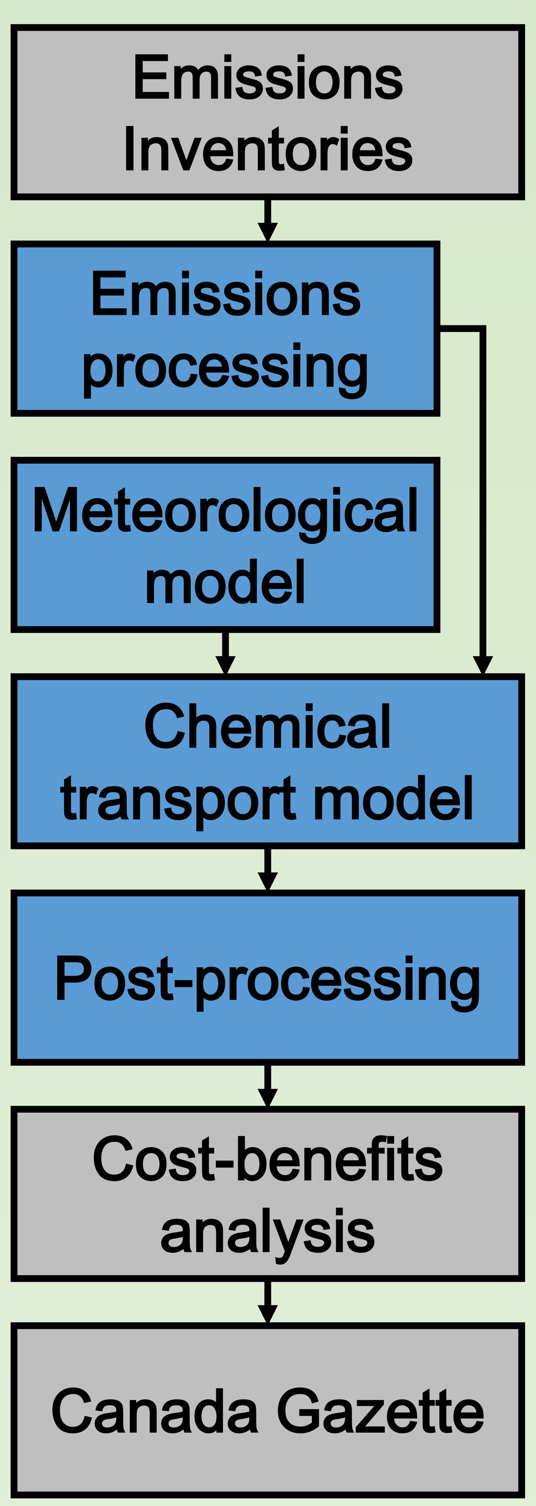
Introduction

The main mandate of the Environment and Climate Change Canada (ECCC) Air Quality Policy-Issue Response Section (REQA) is to support the development of Canadian regulations and standards related to air pollutants. Air quality (AQ) model scenarios analysis is the most common tool used to estimate the impact of emission changes on atmospheric pollutant concentrations.

This poster gives an overview of the modelling platform and methodologies used by REQA for AQ scenario analyses. Two applied cases demonstrate the usefulness of these analyses.

REQA platform workflow

REQA has developed a comprehensive modelling platform that has been extensively used in the past years to model AQ regulations and standards. AQ model scenarios analysis is usually done by comparing a Business As Usual (BAU) case with a scenario. The BAU simulates the AQ if there are no changes in emissions whereas, in the scenario, emissions are increased or decreased to reflect, for example, a proposed regulation.



BAU and scenarios emissions inventories are delivered by ECCC Science and Technology branch. The scenario inventories are based on the BAU, with changes to specific sectors like transportation, industries, agriculture, etc.

The Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System is used to process these inventories. Chemical speciation, spatial and temporal allocation are applied to the emissions to produce a set of CTM-ready emissions files.

The meteorological drivers come from ECCC's Global Environmental Multi-scale (GEM) model. The meteorological year corresponds to 2006 and is kept constant for all simulations. This allows to determine improvements or deteriorations of air quality caused by emissions changes, not meteorology.

A Unified Regional Air quality Modelling System (AURAMS) is a multi-pollutant off-line CTM that describes the formation of ozone, PM (12 bins) and acid deposition[1]. It is run on a continental 45-km resolution grid and in 12 monthly parallel segments.

The AURAMS hourly concentration outputs are post-processed to produce metrics of interest to REQA's partners : Rolling average, daily/monthly/annual maximum and average, critical loads, differences between scenarios, etc.

For regulation purposes, in partnership with ECCC Strategic Policy Branch and Health Canada (HC), AQ modelling results are used to produce environmental and health cost-benefit analyses that are included in Regulatory Impact Analysis Statements (RIAS).

When the RIAS demonstrates positive outcomes for a regulation, it is published in the Canada Gazette, the Government of Canada official newspaper. This Gazette informs Canadians of new statutes, new and proposed regulations, etc.

Figure 1: REQA platform (blue) and partners (grey)

Accelerated Coal Phase-Out

In 2016, the Office of the Minister of Environment and Climate Change Canada announced that they would accelerate the transition from traditional coal power to clean energy by 2030[2].

Coal-fired electricity generating units are the highest emitting stationary sources of GHGs and air pollutants in Canada. The proposed "Amendments to the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations" would require such units to comply with an emissions performance standard of 420 tonnes of CO_2 per GW hour of electricity produced by 2030. Of the 36 units operating in 2017, 20 are expected to shut down before 2030, as they will reach their end of life under the Regulations[3]. To determine the impact of this regulation on air quality, a cost-benefit analysis was performed. A 2030 BAU case and an Accelerated Coal Phase-Out (ACPO) scenario were compared. The units that should shut down after 2029 are included in the BAU emissions, whereas they are absent from the ACPO scenario emissions. A major reduction of SO_2 emissions at these units locations is expected in the ACPO scenario (see Figure 2 BAU-ACPO red values). Lost generating capacity was replaced by new natural gas-fired units, reduced exports, increased imports and increased output from existing units. This should cause a minor increase in NO_x and SO_2 emissions (see Figure 2 BAU-ACPO blue values).

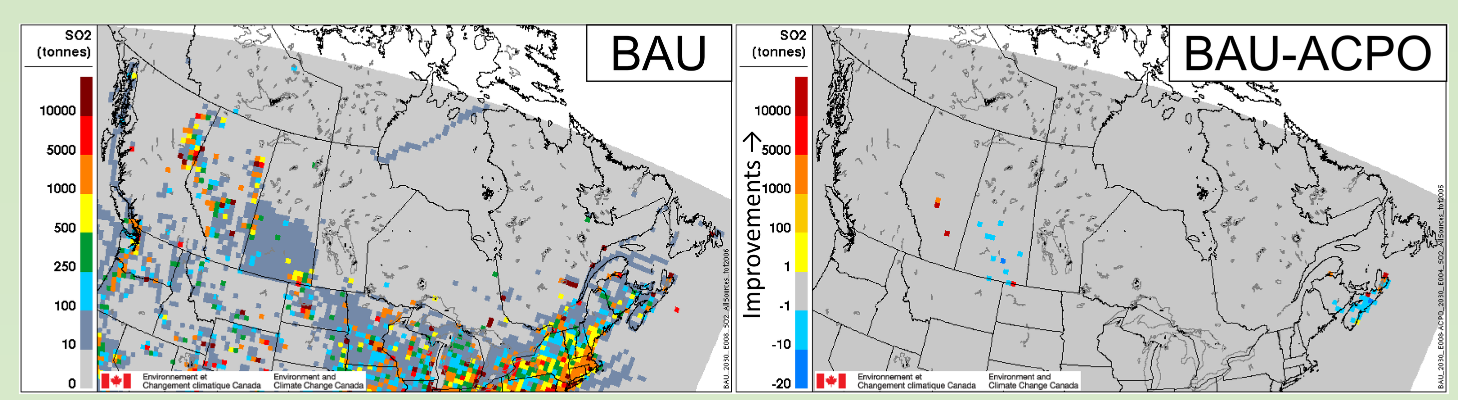
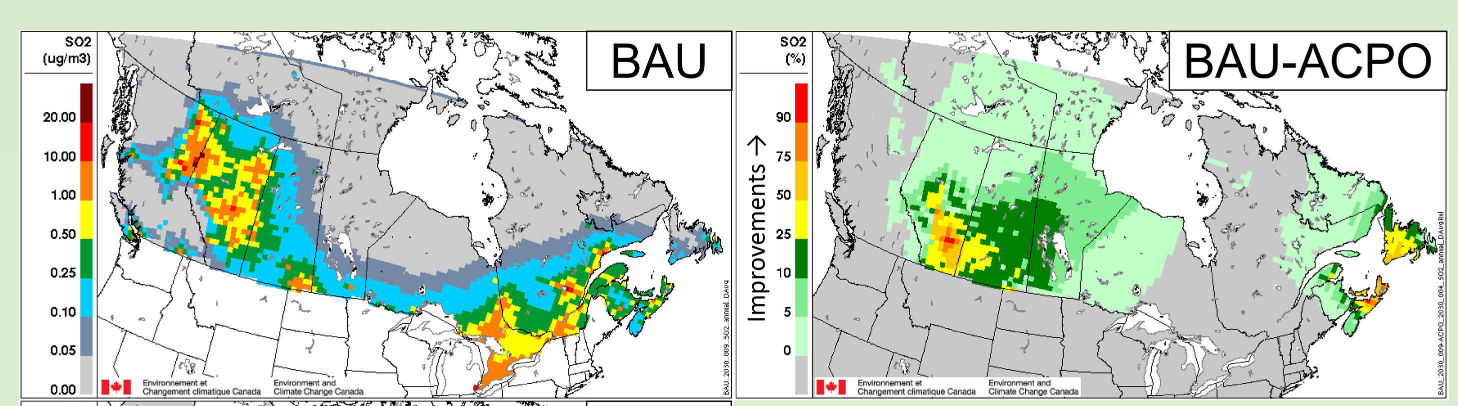


Figure 2: 2030 annual total of all sources gridded SO_2 emissions

The results of the emissions reduction (Figure 2 BAU-ACPO) are highlighted by comparing the ACPO and BAU pollutant concentration forecasts produced by AURAMS (Figure 3 BAU-ACPO). The ACPO Regulations impact in 2030 is represented by the difference between these two scenarios.



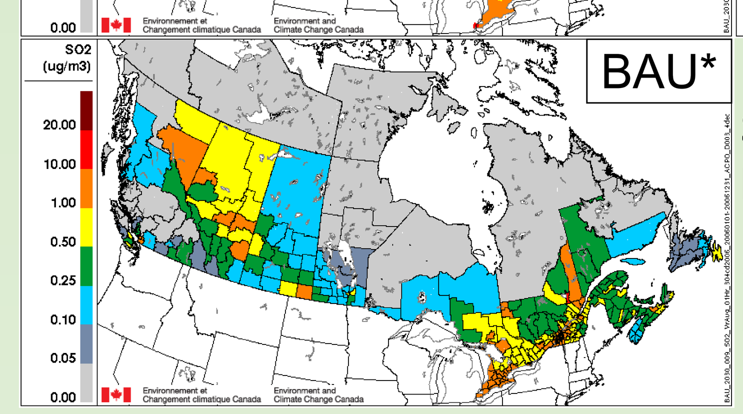


Figure 3: 2030 annual average of SO_2 concentrations based on hourly model output

* Interpolated on Canadian 2006 Census Divisions

Different annual CO, NO_2, O_3, $PM_{2.5}$ and SO_2 products calculated from hourly concentrations were interpolated on the Canadian 2006 Census Divisions shapefile and were delivered to our HC partners. HC used these data and population density as AQBAT inputs to produce a health cost-benefit analysis. For example, Figure 3 (BAU*) represents the SO_2 product delivered to HC.

The cost-benefit analysis showed that these Regulations will, in the near future, have a big impact on the achievement of a healthy air quality. The total expected benefit was estimated to be $4.9 billion, including $3.6 billion in avoided climate change damage benefits and $1.3 billion in health and environmental benefits from air quality improvements. These Accelerated Coal Phase-Out Amendments were published in the Canada Gazette (Part I) in February 2018[3].

CAAQS NO_2

In December 2017, the Canadian Ambient Air Quality Standards (CAAQS) for NO_2 were published in the Canada Gazette Part I[4].

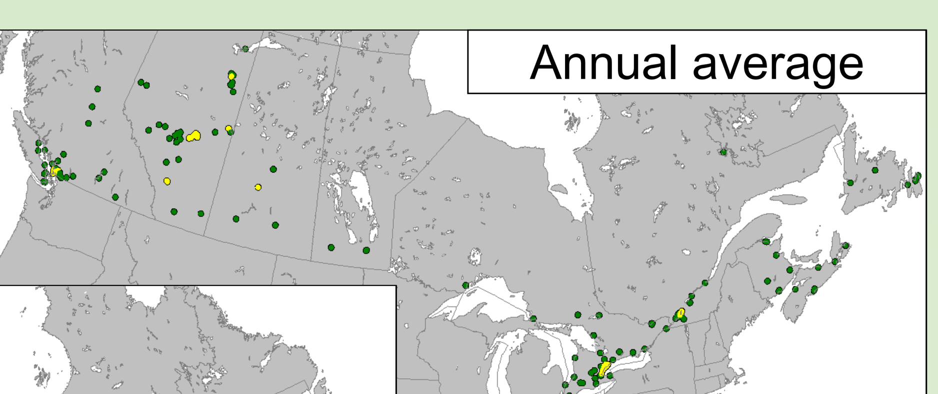
The CAAQS are one of the key elements of the Air Quality Management System (AQMS). They are established as ambient air quality objectives. They were endorsed by the Canadian Council of Ministers of the Environment (CCME), a forum directed by the ministers of environment of the federal, provincial and territorial governments. These standards are the result of a consensus-based process by HC, ECCC, provinces, territories, Indigenous peoples' representatives, and stakeholders from industry, health, and environmental organizations. The CAAQS include four air quality management levels that encourage progressively more rigorous actions by jurisdictions as air quality approaches or exceeds the CAAQS. These levels should be revised every 5 years and progressively decreased if possible. Achieving the CAAQS will then drive continuous improvements in air quality across Canada.

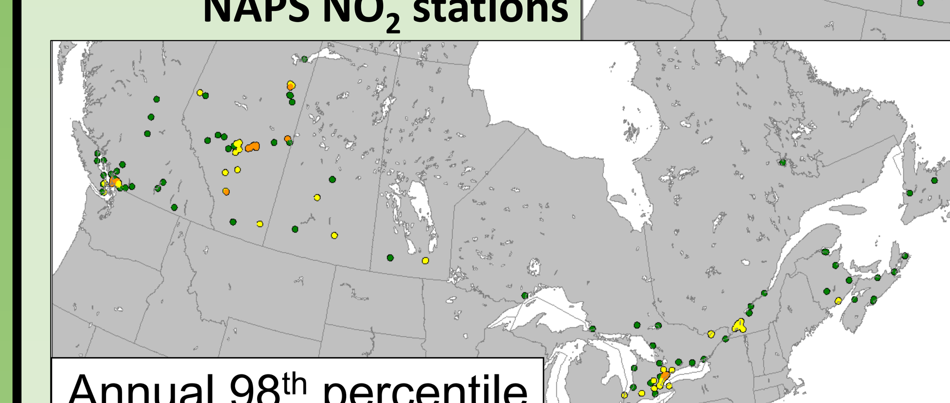
CAAQS NO_2 Metric	Year	Green	Yellow	Orange	Red
3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations (ppb)	2020	<20	20-31	31-60	>60
	2025			31-42	>42
Annual average of all 1-hour average concentrations (ppb)	2020	<2	2-7	7-17	>17
	2025			7-12	>12

Table 1: CAAQS NO_2 management levels[5]

Information on NO_2 concentrations in Canada is provided mainly by the National Air Pollution Surveillance (NAPS) monitoring stations network. As such, CAAQS metrics should be regularly calculated from NAPS data to keep track of the evolution of air quality at various locations across Canada. As there are no future observation data, the CCME had to rely on AQ modelling data to determine the CAAQS metrics that should be achievable in the future at these NAPS stations sites. Figure 4 represents the 2025 modeled CAAQS NO_2 products, originating from BAU emissions inventories that included future Regulations and took into consideration the stakeholders feedback. These modelling products helped the policy makers determine the CAAQS NO_2 management levels.

Figure 4: Projected 2025 BAU CAAQS NO_2 metrics at NAPS NO_2 stations





- Results are colored as in Table 1.
- No 3-year average is calculated for 2025.

References

1. Chen, J. (2010). *2006 Annual operational evaluation of the Environment Canada air quality modelling system*. 9th Annual CMAS conference abstract. Retrieved from https://www.cmascenter.org/conference/2010/abstracts/chen_2006_annual_2010.pdf
2. Office of the Minister of Environment and Climate Change (2016). *The Government of Canada accelerates investments in clean electricity*. News Release. Retrieved from https://www.canada.ca/en/environment-climate-change/news/2016/11/government-canada-accelerates-investments-clean-electricity.html
3. Government of Canada (2018). *Regulations Amending the Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*. Canada Gazette Part I, Vol. 152, No. 7, ISSN 1494-6076. Retrieved from http://gazette.gc.ca/rp-pr/p1/2018/2018-02-17/pdf/g1-15207.pdf
4. Government of Canada (2018*). Canadian Ambient Air Quality Standards for nitrogen dioxide*. Canada Gazette Part I, Vol. 152, No. 7, ISSN 1494-6076. Retrieved from http://www.gazette.gc.ca/rp-pr/p1/2017/2017-12-09/pdf/g1-15149.pdf
5. Canadian Council of Ministers of the Environment (2017). *Canadian Ambient Air Quality Standards*. Retrieved from http://airquality-qualitedelair.ccme.ca/en/