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An integrated emission inventory and air quality dispersion model for Alberta

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ABSTRACT

The most recent Canadian Ambient Air Quality Standards (CAAQS) have air quality objectives for NO2 and O3 concentrations starting 2025. This work focuses on NO2, primarily from mobile (vehicle fleet, nonroad machinery) and stationary (industry, upstream oilsands, refineries) combustion sources.

Understanding primary sources of criteria air contaminants (CACs) including NO2 and O3 in Alberta using a detailed simulation model is the goal of this work. Meteorological conditions were captured by using Weather Forecasting and Research (WRF) model. An emission inventory file generated by Alberta Environment and Parks for the base year 2017 was used as an input of the modeling system. The emission file was processed using the US EPA Sparse Matrix Object Kernel (SMOKE) to generate chemical speciation and meshed outputs. It was linked to the Community Multiscale Air Quality (CMAQ) chemical transport model. The province of Alberta was used as the model domain with the spatial resolution of 4 km × 4 km. The model output was validated using air quality ground observation data provided by Alberta Airsheds. Model performance was satisfactory in replicating the hourly averages of NO2 and O3. A sensitivity analysis was carried out the determine the effect of different sources of anthropogenic emission like mobile sources, upstream oil and gas, power stations, and agriculture on the concentration of NO2. The impact of mobile sources emissions on NO2 concentrations was less than 20%. Concentration maps showed that the combustion-related stationary sources are responsible for a significant portion (60%) of NO2 concentrations leading to the exceedances of 2025 CAAQS NO2 objectives.

A comparison study was performed to evaluate the effect of winter and summer temperatures on both temporal and spatial emission concentration and assess the model's performance by using two weeks in January 2019 and July 2019. The episodes were simulated hourly, and the results were compared to ground station measurements. Analyzing the diurnal simulation data shows that the average daily NO2 concentration in winter (18~24 ppb) in the major cities is almost three times higher than (avg. 6~8 ppb) for summer. Industrial areas and oilsands also experience the same trend from 3~5 ppb in summer to 9~13 ppb in winter.

This simulation tool can now be used to examine scenarios to analyze the interactions of CACs concentrations with weather-related incidents, climate change, and technologies and policy changes.