



Acid Deposition Simulations for Alberta, Saskatchewan, and the Canadian Oil Sands, using the Global Environmental Multiscale – Modelling Air-quality and CHEMISTRY (GEM-MACH) System

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The Global Environmental Multiscale – Modelling Air-quality and CHEMISTRY (GEM-MACH) system (version 2) was used to carry out simulations of acid deposition for the Canadian provinces of Alberta and Saskatchewan. These model predictions include the hourly deposition of four sulphur and eleven nitrogen containing species ($\text{SO}_2(\text{g})$, $\text{HSO}_3^-(\text{aq})$, $\text{SO}_4^{2-}(\text{aq})$, particulate sulphate, and $\text{NH}_3(\text{g})$, $\text{NO}_2(\text{g})$, $\text{HNO}_3(\text{g})$, $\text{NH}_4^+(\text{aq})$, $\text{NO}_3^-(\text{aq})$, $\text{HONO}(\text{g})$, $\text{PAN}(\text{g})$, $\text{HNO}_4(\text{g})$, particulate nitrate, particulate ammonium, and gaseous organic nitrate, respectively).

A two-bin aerosol size distribution configuration of GEM-MACH was used to estimate the annual deposition of these chemicals, for the period August 1, 2013 through July 31, 2014, at two resolutions—a 10km resolution North American domain and a 2.5km resolution Alberta and Saskatchewan domain. The model estimates of acid deposition from both resolutions (version 2), were used to determine the relative contributions of the different species towards total sulphur and nitrogen deposition, and to evaluate the effect of model resolution on estimates of acid deposition. The potential ecosystem impacts of acid deposition were examined via comparison of model-predicted total deposition to different sources of sulphur and nitrogen critical load data, for forest and lake ecosystems in northern Alberta and Saskatchewan. The deposition estimates were compared to observations of snowpack sulphur and nitrogen ions, collected during the winter of 2013.

The processes underlying acidifying deposition in the vicinity of the Canadian oil sands were examined in more detail using the 12-bin aerosol size distribution configuration of GEM-MACH (version 2), for a period from mid-August to mid-September 2013. This time period corresponds to an aircraft measurement intensive campaign designed to examine emissions, transportation, and deposition associated with air pollution sources in the Canadian oil sands. Multiple model simulation scenarios were carried out for this period, in order to study the effect of the use of successively more advanced emissions data on model predictions of deposition, as well as the relative impact of employing 12 versus 2 bins for the model's aerosol size distribution. These model scenarios were compared to aircraft-based estimates of SO_2 and particulate sulphate deposition.