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Modelling the impacts of ammonia emissions reductions on North American air quality

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Abstract. A unified regional air-quality modelling system (AURAMS) was used to investigate the effects of reductions in ammonia emissions on regional air quality, with a focus on particulate-matter formation. Three simulations of one-year duration were performed for a North American domain: (1) a base-case simulation using 2002 Canadian and US national emissions inventories augmented by a more detailed Canadian emissions inventory for agricultural ammonia; (2) a 30% North-American-wide reduction in agricultural ammonia emissions; and (3) a 50% reduction in Canadian beef-cattle ammonia emissions. The simulations show that a 30% continent-wide reduction in agricultural ammonia emissions lead to reductions in median hourly $PM_{2.5}$ mass of <1 μg m^{-3} on an annual basis. The atmospheric response to these emission reductions displays marked seasonal variations, and on even shorter time scales, the impacts of the emissions reductions are highly episodic: 95th-percentile hourly $PM_{2.5}$ mass decreases can be up to a factor of six larger than the median values.

A key finding of the modelling work is the linkage between gas and aqueous chemistry and transport; reductions in ammonia emissions affect gaseous ammonia concentrations close to the emissions site, but substantial impacts on particulate matter and atmospheric deposition often occur at considerable distances downwind, with particle nitrate being the main vector of ammonia/um transport. Ammonia emissions reductions therefore have trans-boundary consequences downwind. Calculations of critical-load exceedances for sensitive ecosystems in Canada suggest that ammonia emission reductions will have a minimal impact on current ecosystem acidification within Canada, but may have a substantial impact on future ecosystem acidification. The 50% Canadian beef-cattle ammonia emissions reduction scenario was used to examine model sensitivity to uncertainties in the new Canadian agricultural ammonia emissions inventory, and the simulation results suggest that further work is needed to improve the emissions inventory for this particular sector. It should be noted that the model in its current form neglects coarse mode base cation chemistry, so the predicted effects of ammonia emissions reductions shown here should be considered upper limits.

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