An Exploration of Nitrogen Total Deposition Budget Uncertainty at the Regional Scale

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Deposition loss processes cleanse the atmosphere resulting in loading of nitrogen to the Earth's surface and its ecosystems. Excess nitrogen above critical loads leads to ecosystem impacts. Models are used to estimate nitrogen deposition in support of critical load and other impact assessments. Dry deposition is not easily measured and the models can provide fields for both wet and dry deposition. Typically, dry deposition parameterizations follow the resistance conceptual model, with resistances in parallel and in series to represent the different pathways along which gases and particles are exchanged with the Earth's surface. We have examined several sources of uncertainty in the model parameterizations of dry deposition in the Community Multiscale Air Quality model (CMAQ) and the impact of these uncertainties on the total nitrogen budget. For oxidized nitrogen the uncertainty in stomatal, cuticular and aerodynamic resistances are most important. For reduced nitrogen, a major "uncertainty" in regional models we have examined is the switch from a unidirectional to a bi-directional formulation of surface ammonia flux. In the bi-directional formulation, uncertainties in the soil and stomatal compensation points are most important. For ammonia we show that there is compensation between wet and dry deposition pathways, resulting is a smaller change in the total budget than one would expect, but that in general the bi-directional formulation results in more ammonia being advected off the North American continent. Across both oxidized and reduced nitrogen species, we also show that the uncertainty analyses need to be conducted with the full chemical transport model, not stand-alone models of deposition velocity. The quantification of the changes in deposition velocity via a stand-alone model do not match the budget changes from the full model due to dynamic chemical interactions and the effects of transport.

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