Improving Atmospheric Deposition Processes in CMAQ for Ecosystem Applications (5.1)

Jesse Bash, Prakash Bhave, Jonathan Pleim, Robin Dennis, Christopher Nolte, Ellen Cooter

Collaborators: Jeff Arnold (EPA/NCEA)*; James Kelly (California Air Resources Board)*; John T. Walker (EPA/NRMRL); Matthew Jones (DOE/ Oak Ridge Institute for Science and Education); Uma Shankar (UNC at Chapel Hill); Anthony Wexler (UC Davis); K. Max Zhang (Cornell Univ.); Winston Luke, Tilden Meyers, and LaToya Myles (NOAA/ARL); Robert Mason (Univ. of Connecticut)

Excessive loading of nitrogen from atmospheric nitrate and ammonia deposition to ecosystems can lead to soil acidification, nutrient imbalances, and eutrophication. Accurate nitrogen deposition estimates are important for biogeochemical cycling calculations performed by ecosystem models to simulate ecosystem degradation and recovery. Due to the lack of available monitoring data, creating these estimates is a high priority for water and soil chemistry modeling of nutrient loading, soil acidification, and eutrophication.

In collaboration with the atmospheric measurement community, we have conducted work to advance nitrogen air-surface exchange (dry deposition and evasion from soil and vegetation surfaces) modeling of ammonia and the treatment of coarse-mode nitrate chemistry in the Community Multiscale Air Quality (CMAQ) model. This process has included the following steps: (1) Develop testable hypotheses from the literature, in the form of new modules or routines for CMAQ. (2) Assist in the design of the field campaign needed to collect measurements of the parameters required to further develop these algorithms and to conduct robust evaluations of them. (3) Use the resulting field measurements to refine and evaluate the model algorithms for the development of an operational model.

Atmospheric loadings of mercury to sensitive ecosystems can lead to methylation and bioaccumulation, adversely affecting wildlife and becoming a vector for human exposure to methylmercury. The transport of mercury in the environment exhibits bidirectional surface exchange, similar to ammonia, and a bidirectional surface exchange model of mercury has been developed and is being used to assist in the design of field experiments to improve modeled air-surface exchange algorithms following the methodology of the refinements made to the bidirectional ammonia exchange algorithms.

Field experiments were planned and executed in collaboration with modeling and instrumentation communities. The resulting data are being used in various ways: (1) They have been applied to evaluate the dynamic gas-to-particle mass transfer treatment in CMAQ (Tampa BRACE field campaign); (2) they are being applied to develop and test the CMAQ bidirectional NH_3 surface exchange algorithms (NH_3 flux intercomparison studies at Lillington and Duke Forest, NC, in collaboration with EPA/NRMRL); and (3) they will be applied to develop bidirectional mercury exchange algorithms (collaboration with the University of Connecticut's Department of Marine Sciences). Collaborative work between EPA/AMAD scientists and measurement communities has resulted in the collection of variables needed for robust model evaluation, the development of improved mechanistic air-surface exchange model algorithms, and a productive transfer of knowledge between the two communities. The advanced model algorithms that resulted have improved CMAQ and maintained its functionality at the state-of-the-science for ecosystem applications.

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* Formerly of NERL/Atmospheric Modeling and Analysis Division