On a Revised Formulation for the Multi-Layer Model (MLM) for Inferring Dry Deposition to Vegetated Surfaces: Impact on Inferred HNO3 Dry Deposition

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The Multilayer Model (MLM) has been used for many years to infer dry deposition fluxes from measured trace species concentrations and standard meteorological measurements for national networks in the U. S., including the U. S. Environmental Protection Agency's Clean Air Status and Trends Network (CASTNet). MLM utilizes a resistance analogy approach to calculate deposition velocities appropriate for whole vegetative canopies, while employing a multilayer integration within the canopy to account for vertically varying meteorology, canopy morphology and radiative transfer. However, the MLM formulation, as it was originally presented and as it has been subsequently employed contains a non-physical representation related to the leaf-level quasi-laminar boundary layer resistance, which affects the calculation of the total canopy resistance. In this presentation, the non-physical representation of the canopy resistance as originally formulated in MLM is presented and analyzed and a revised, physically consistent, formulation is suggested as a replacement. The revised canopy resistance formulation results in HNO3 deposition velocities that are reduced by as much as 38% during mid-day as compared to values generated by the original formulation. Inferred deposition velocities for SO2 and O3 are not significantly altered by the change in formulation (< 3%); however, it is shown that any trace gaseous species with large effective Henry's law coefficients (> 104-105 M atm-1) or high vegetative surface reactivityand consequently small cuticular and mesophyllic resistances have smaller calculateddeposition velocities with the revised formulation than are generated by the originalformulation. Inferred deposition loadings of oxidized and total nitrogen from CASTNetdata may be reduced by 10-20% and 5-10%, respectively, for the Eastern U. S. whenemploying the revised formulation of MLM as compared to the original formulation.

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