



Evaluating the calculated dry deposition velocities of reactive nitrogen oxides and ozone from two community models over a temperate deciduous forest

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ABSTRACT

Hourly measurements of O₃, NO, NO₂, PAN, HNO₃ and NO_y concentrations, and eddy-covariance fluxes of O₃ and NO_y over a temperate deciduous forest from June to November, 2000 were used to evaluate the dry deposition velocities (V_d) estimated by the WRF-Chem dry deposition module (WDDM), which adopted Wesely (1989) scheme for surface resistance (R_c), and the Noah land surface model coupled with a photosynthesis-based Gas-exchange Evapotranspiration Model (Noah-GEM). Noah-GEM produced better $V_d(\text{O}_3)$ variations due to its more realistically simulated stomatal resistance (R_s) than WDDM. $V_d(\text{O}_3)$ is very sensitive to the minimum canopy stomatal resistance (R_i) which is specified for each seasonal category assigned in WDDM. Treating Sep–Oct as autumn in WDDM for this deciduous forest site caused a large underprediction of $V_d(\text{O}_3)$ due to the leafless assumption in ‘autumn’ seasonal category for which an infinite R_i was assigned. Reducing R_i to a value of 70 s m⁻¹, the same as the default value for the summer season category, the modeled and measured $V_d(\text{O}_3)$ agreed reasonably well. HNO₃ was found to dominate the NO_y flux during the measurement period; thus the modeled $V_d(\text{NO}_y)$ was mainly controlled by the aerodynamic and quasi-laminar sublayer resistances (R_a and R_b), both being sensitive to the surface roughness length (z_0). Using an appropriate value for z_0 (10% of canopy height), WDDM and Noah-GEM agreed well with the observed daytime $V_d(\text{NO}_y)$. The differences in $V_d(\text{HNO}_3)$ between WDDM and Noah-GEM were small due to the small differences in the calculated R_a and R_b between the two models; however, the differences in R_c of NO₂ and PAN between the two models reached a factor of 1.1–1.5, which in turn caused a factor of 1.1–1.3 differences for V_d . Combining the measured concentrations and modeled V_d , NO_x, PAN and HNO₃ accounted for 19%, 4%, and 70% of the measured NO_y fluxes, respectively.

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1. Introduction

Global atmospheric emissions of nitrogen oxide have increased dramatically during the past 150 years, and the supply of reactive nitrogen to ecosystems has doubled due to anthropogenic activities such as nitrogen fertilization, biomass burning, and fossil fuel combustion (Galloway et al., 2008). Dry deposition is responsible for a significant portion of the total (wet and dry) nitrogen deposition (e.g. 34%, Munger et al., 1998; 58%, Sparks et al., 2008). Up to 43% of

NO_x–N emissions over North America have been estimated to be removed from the atmosphere by dry deposition (Shannon and Sisterson, 1992). Reactive nitrogen oxides, called NO_y, is a class of oxidized nitrogen compounds including NO, NO₂, NO₃, N₂O₅, HNO₃, PAN (peroxyacetyl nitrate), other organic nitrates, and particle nitrate, which supply significant nutrient and acidic quantities to ecosystems. Augmented atmospheric deposition of NO_y associated with increased emissions of NO_x poses many environmental threats, including acidification of soil and surface water, eutrophication of lake, river and estuary, loss of biodiversity, damage to forests, and global climate change (Galloway et al., 2008). Increased anthropogenic emissions of NO_x combined with hydrocarbons have produced high levels of surface O₃ concentration. O₃ can penetrate the tissues

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