A PHOTOSYNTHESIS-BASED DRY DEPOSITION MODELING APPROACH

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Abstract. We present a dry deposition modeling approach that includes vegetation-atmosphere interactions through photosynthesis/carbon assimilation relationships. Gas deposition velocity (V_d) is calculated using an electrical resistance-analog approach in a coupled soil-vegetation-atmosphere transfer (SVAT) model. For this, a photosynthesis-based surface evapotranspiration and gas exchange model is dynamically coupled to an atmospheric model with prognostic soil hydrology and surface energy balance. The effective surface resistance (composed of aerodynamic, boundary layer, and canopy-based resistances) is calculated for a realistic and fully interactive estimation of gaseous deposition velocity over natural surfaces. Based on this coupled framework, the photosynthesis-based gas deposition approach is evaluated using observed deposition velocity estimates for ozone over a soybean field (C3 photosynthesis pathway) and a corn field (C4 photosynthesis pathway). Overall, observed V_d and modeled V_d show good qualitative and quantitative agreement. Results suggest that photosynthesis-based physiological approaches can be adopted to efficiently develop deposition velocity estimates over natural surfaces. Such a physiological approach can also be used for generalizing results from field measurements and for investigating the controlling relationships among various atmospheric and surface variables in estimating deposition velocity.

Keywords: air pollution, biosphere-atmosphere interaction, dry deposition, photosynthesis, soil-vegetation-atmosphere transfer, terrestrial ecosystem

1. Introduction

Atmospheric deposition plays an active role in determining the air, water, and soil quality on a regional scale. A toxin deposited over land or water can, through the soil-vegetation-atmosphere continuum, affect regional hydrology and air quality at both diurnal and climatic scales (Niyogi and Raman, 2000). These interactions introduce variability and uncertainty in the regional ecosystem response to changes in the pollutant loading. Further, gaseous deposition is known to be actively responsible for various environmental problems associated with soil acidification, nutrient loading in watershed regions, and agricultural productivity at a regional scale (Hampp, 1992). Hence, understanding the deposition and fate of gaseous compounds over natural surfaces is an important component of environmental assessment programs.

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