COMPARISON OF DRY DEPOSITION VELOCITIES FOR SO$_2$, HNO$_3$ AND SO$_4^{2-}$ ESTIMATED WITH TWO INFERENTIAL MODELS

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Abstract. Dry deposition velocity estimates of SO$_2$, HNO$_3$ and SO$_4^{2-}$ were computed for six locations in eastern North America using two different inferential models; a Big-Leaf model utilized by the U.S. National Dry Deposition Network (NDDN) and, a land-use based model (LUM) that has been used in the past to estimate the relative importance of dry versus wet deposition over selected Canadian regions. There were consistent differences between models that were related to the surface type, chemical species and time of year. Mean monthly dry deposition velocities based upon the 1990–91 time period were compared at two locations. The seasonal cycles in deposition velocity were similar between models, but there were considerable differences in the amplitude of the cycles. The LUM predicted about a 400% increase in SO$_4^{2-}$ deposition velocity from the winter to the summer months, while there was a 50 to 100% increase in the NDDN model estimates, depending upon location. According to the LUM, HNO$_3$ deposition to crop land increased by about a factor of 6 from winter to summer, while the big leaf model predicted a 50% increase. Overall, there was better agreement for SO$_2$. Averaged over 12 months, the differences in deposition velocity between models were smaller and generally within the range of uncertainty associated with inferential models. For all six sites, the mean percent difference between models in deposition velocity for SO$_2$, HNO$_3$ and SO$_4^{2-}$ were 13, 35 and 79, respectively. These differences highlight the effect of using different methods for estimating dry deposition and the importance of applying the same model when examining regional patterns in dry/total deposition rates.

1. Introduction

Anthropogenic and natural air pollutants are delivered to the earth's surface through wet and dry processes. However, research on dry deposition rates has lagged behind that of wet deposition. This is due to the relative complexity of the available techniques for making direct measurements of dry deposition. The instrumentation is costly and requires considerable supervision. Hicks et al. (1980) recognized the feasibility of calculating dry deposition fluxes as the product of a modeled deposition velocity and a measured air concentration. Subsequently, much attention has been paid to the development and implementation of models for estimating dry deposition velocities. In the United States, the Big-Leaf inferential dry deposition model (Hicks et al., 1987; Meyers and Baldocchi, 1988; Meyers et al., 1991) was developed to estimate dry deposition to a representative area about a site based on in situ meteorological measurements and hourly to weekly concentration measurements. Dry deposition flux data obtained from this approach are available.
for the National Oceanic and Atmospheric Administration CORE program (Hales et al., 1987; Meyers et al., 1991) and the Environmental Protection Agency National Dry Deposition Network (NDDN) (Edgerton et al., 1992; Clarke et al., 1992).

Voldner et al. (1986) developed a climatological land-use classification model to determine monthly dry deposition velocities over eastern North America. This model was used to estimate mean monthly dry depositions within 100 km of selected Canadian Air and Precipitation Monitoring Network (CAPMoN) sites and to assess the relative roles of dry and wet deposition (Sirois and Barrie, 1988; Sirois and Vet, 1988, Sirois and Summers, 1989).

Consistency in dry deposition estimates from models used on opposite sides of the Canada-U.S. border is important to ecological studies and transboundary flow issues. Meyers et al. (1991) showed CORE annual dry deposition rates from the Big-Leaf model for Whiteface, NY, to be consistent with values determined for the closest CAPMoN sites in eastern Ontario and south-central Quebec using the climatological land-use classification model (Sirois and Barrie, 1988). However, since the CORE and CAPMoN sites are separated by large distances it was not possible to determine the true differences between the two approaches. In this paper, we briefly discuss the differences in the formulation of the climatological land-use classification model (Voldner et al., 1986) and the Big-Leaf inferential model applied in the NDDN program (Clarke et al., 1992). Annual deposition velocities estimated using these two different approaches are compared at six sites and monthly dry deposition velocities are compared at two of the sites. These comparisons indicate how much of the difference in dry deposition velocities across the Canada-U.S. border arises from the application of two different, but currently used models, as opposed to from true spatial differences in dry deposition rates.

2. Methods

The six NDDN sites used in the comparison are listed in Table I along with information on their locations (see Figure 1). These sites were selected because of their proximity to Canada. The climatological land-use classification model (LUM) and the Big-Leaf NDDN model (referred to as the NDDN model) were used to calculate dry deposition velocities \( (V_d) \) for \( \text{SO}_2 \), \( \text{SO}_4^{2-} \) and \( \text{HNO}_3 \) at all of the six sites. The monthly values calculated by the LUM and the hourly values calculated by the NDDN model were aggregated to annual dry deposition velocities for comparison of model performance at the six sites. Monthly \( V_d \) values are presented at Ann Arbor and Unionville, MI, so that the model differences can be examined in more detail.

The land-use and vegetative data associated with each site were compiled by the developers of the NDDN network. The predominant surface conditions are summarized in Table I. Except for the provision of more detail in the NDDN model (i.e. different crop and forest species), these data were used by both approaches.