CHEMICAL DEPOSITION TO A HIGH ELEVATION RED SPRUCE FOREST

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Abstract. A preliminary analysis of O₃, SO₂, SO₄²⁻, and total NO₃⁻ deposition to the red spruce forest on the summit of Whitetop Mountain, Virginia, illustrates uncertainties in analysis methodologies, establishes the relative importance of three deposition pathways, and suggests areas for further research. Results are presented here for an analysis of the dry, wet (precipitation), and cloud water deposition pathways for the four chemical species during a 26-day period in April and May 1986. Dry and cloud water depositions are estimated using available models along with air and cloud water chemistry measurements made at the summit. For water soluble species, depositions by precipitation and cloud interception are found to be comparable in magnitude, while dry deposition appears to be about an order of magnitude less. High levels of atmospheric O₃ lead to a large estimate of O₃ deposition (on a mass flux basis) when compared to the estimated deposition of gaseous SO₂. This is in spite of the fact that computed SO₂ dry deposition velocities exceed those for O₃. Model uncertainties are large for both dry deposition velocity and cloud water flux computations, and some bias in computations probably exists because of the application of the models to a complex terrain situation. Field evaluation of the cloud water deposition model is of greatest priority because of the apparent relative importance of that deposition pathway.

1. Introduction

The Tennessee Valley Authority (TVA), as a contributor to the National Acid Precipitation Assessment Program (NAPAP) through Task Group II, is currently studying chemical inputs to high-elevation red spruce forests in the southeastern United States. Chemical inputs to these forests occur by way of dry deposition and precipitation, just as they do at lower elevations. However, the high-elevation spruce forests are also known to frequently experience periods when clouds bathe the trees in a shroud of very small drops containing concentrated levels of various acids, such as H₂SO₄ and HNO₃, and other chemical species. Spruce needles are good collectors of cloud drops, and as such provide the forest with a significant source of water and chemicals.

It is desirable, in studying forest vitality, to know how much of the various chemical species are deposited in the canopy by way of cloud water, precipitation and direct dry contact. TVA is collecting data to characterize the various deposition pathways in terms of their relative magnitudes for individual chemical species, frequency of occurrence, maximum short-term (hourly) deposition rates, seasonal/annual deposition totals, and occurrence in conjunction with other forest environmental stress factors. The objective of the analysis described herein was to determine the relative magnitudes of deposition for four chemical species (O₃, SO₂, SO₄²⁻, and NO₃⁻) of the three deposition pathways. It was not known beforehand whether O₃ dry deposition was comparable in magnitude to that of the other species, or whether wet or cloud deposition provided greater inputs of SO₄²⁻ and NO₃⁻ to the high elevation forest.
Whitetop Mountain, Virginia, is the location of the TVA research station. The Whitetop Mountain/Mount Rogers area has been designated one of the primary research sites for the Mountain Cloud Chemistry Project (MCCP) sponsored by the U.S. Environmental Protection Agency (EPA) and the Spruce-Fir Research Cooperative of the U.S. Forest Service. These research efforts are both designed to study issues being confronted by the NAPAP.

Fig. 1. Locations of the Whitetop Mountain research station operated by TVA and the nearest weather observing stations.