ANALYSIS OF AIRBORNE PARTICLES SAMPLED IN THE
SOUTHERN APPALACHIAN MOUNTAINS

LAWRENCE M. REISINGER

Atmospheric Science Department, Tennessee Valley Authority, Muscle Shoals, AL 35660, U.S.A.

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Abstract. Over 3 yr of particulate measurements were made at two high elevation sites in the southern Appalachian Mountains of Tennessee and Virginia. Both dichotomous samplers and filter packs were used to obtain day and night, week-long samples for subsequent elemental and ionic analysis. Total NO\(_3\) (HNO\(_3\) + NO\(_2\)) and SO\(_4^{2-}\) averaged, respectively, 1.1 and 5.0 µg m\(^{-3}\) at Look Rock, Tennessee and 2.0 and 6.4 µg m\(^{-3}\) at Whitetop Mountain, Virginia. At Whitetop Mountain, the spring and summer seasons had the highest average SO\(_4^{2-}\) concentrations. Seasonally, total NO\(_3\) varied little. The diurnal variation of elements and SO\(_4^{2-}\) was small. Only total NO\(_3\) varied substantially with highest values during the day. The fine fraction (particle diameter < 2.5 µm) accounted for about 67% of the total mass. Fine mass and elemental concentrations were generally higher at Look Rock. The elements comprising the principal mass fraction of the coarse samples (2.5 µm < particle diameter < 10 to 15 µm) were of crustal origin (e.g., Al, Si, Ca, Fe) while the element comprising the principal mass fraction of the fine samples (i.e., S) was of manmade origin. Cluster analysis identified two groups of elements at Whitetop Mountain. These groups, in both the coarse and fine fraction, were associate with a soil and an automobile emission component. At Look Rock, only a soil component was obvious.

1. Introduction

The measurement of particulate composition and concentration in remote, high elevation areas of the southeastern United States is important because of the contribution particles make to regional acid deposition, visibility degradation, and climate change. Firstly, as polluted air ages, transformation processes and differences in deposition velocities increase the importance of particles as acidifying agents. Remote, high elevation areas in the southeastern United States frequently experience aged airmasses (Reisinger et al., 1989; Reisinger and Valente, 1985) and research has shown that particles are the primary acidifying agents in these areas (Reisinger and Imhoff, 1989). Secondly, fine particles are the major cause of visibility degradation in the mountainous areas of the southeastern United States (Reisinger and Valente, 1985; Stevens et al., 1984). Finally, the amount and distribution of ambient particles may impact regional climate by substantially changing the radiative properties of the atmosphere either directly through light absorption or refraction or indirectly by changing the characteristics of clouds.

To date, however, only a few studies have evaluated the concentration and composition of particles at high elevations in the southeastern United States (Davidson et al., 1985; Stevens et al., 1984; Weiss et al., 1982; Ferman et al., 1981). These studies were typically of a short, intensive nature lasting from a few days to several weeks. While valuable in elucidating many of the unknowns about particle
composition and origin, they did not adequately describe the spatial and long-term temporal variation of particles at high elevations in the Southeast.

This study augments the results of the others by providing a more spatially and temporally representative data base. Measurements for this analysis were obtained over several years at two widely separated, high elevation sites located within the southern Appalachian Mountains. One site is atop Chilhowee Mountain (35.633° N, 83.950° W), 792 m above mean sea level (amsl). Known as Look Rock (because of its panoramic view of the Great Smoky Mountain National Park-GSMNP), this site is located in southeastern Tennessee near the western edge of the GSMNP and at the boundary separating two regions of sharply differing terrain - the Tennessee Valley to the west and the Great Smoky Mountains to the east. Pollution sources in relatively close proximity include the city of Knoxville (35 km north) and the TVA Watts Bar, Kingston, and Bull Run coal-fired power plants (60 to 80 km distant and located west, northwest, and north, respectively). Particulate measurements were made at Look Rock from July 1980 through December 1981.

The other site is located atop Whitetop Mountain, Virginia (36.639° N, 81.605° W). Whitetop Mountain, located in a forested area in the southwestern part of the State, is the second highest peak in Virginia at 1689 m amsl. The closest significant populated area is 50 km west at Bristol, Tennessee and the closest power plant is the TVA John Sevier facility 125 km west-southwest. Particulate measurements at Whitetop Mountain were made from March 26, 1986 through December 22, 1987. The distance separating the two sites is about 250 km. Prevailing airflow is generally from west to east at both locations.

2. Methods and Materials

DICHOTOMOUS SAMPLER MEASUREMENTS

Suspended particles were collected in two size ranges using Anderson Instruments dichotomous samplers. Relatively coarse particles, with diameters between 2.5 μm and 15 μm (10 μm for the Whitetop Mountain measurements) and fine particles, with diameters less than 2.5 μm were collected on Teflon filters and then analyzed for elemental composition by either of two X-ray techniques. Particle (H+) induced X-ray emission (PIXE) (Johansson and Johansson, 1976) was used for the Look Rock samples and X-ray fluorescence (XRF) (Wagman et al., 1977) was used for the Whitetop Mountain samples. The X-ray techniques vary somewhat in their sensitivity to certain elements but, in general, can quantify the majority of elements with atomic numbers ranging from 11 to about 90.

Sample weight was also determined to give a measure of mass loading. For the samples collected at Whitetop Mountain, a Cahn model 28 electro-microbalance was used to measure mass loadings at the microgram level. No such instrument, however, was available when the Look Rock samples were collected. Instead, estimates of mass were made from a multiple regression analysis technique that