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* Present address: Laboratory of Molecular Biology, National Institute of Arthritis, Metabolism, and Digestive Diseases, National Institutes of Health, Bethesda, Md. 20014.
† Present address: Institut Laue-Langevin, B.P. 156, Centre de Tri, 38042 Grenoble, France.

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Aerosol Chemical Parameters and Air Mass Character in the St. Louis Region

Abstract. *Comparisons of the chemical character of ambient aerosols in St. Louis during the month of September 1973 with the trajectory of the air parcel before it arrived in St. Louis indicate that regional sulfuric acid–ammonium bisulfate aerosol was associated with maritime tropical air and that regional ammonium sulfate aerosol was associated with continental polar air.*

Recently reports have appeared indicating that H_2SO_4–NH_4HSO_4 and $(NH_4)_2SO_4$ were the optically dominant submicrometer aerosols in the St. Louis, Missouri, area during September 1973 (*1*). Further analysis of the data indicates that the occurrence of acidity (H_2SO_4–NH_4HSO_4) is associated with maritime tropical air and the occurrence of salt [$(NH_4)_2SO_4$] with continental polar air.

The University of Washington participated in the September 1973 preliminary Regional Air Pollution Study at St. Louis. The objective of the University of Washington team was to characterize the light-scattering properties of the aerosol and to measure the aerosol light-scattering as a function of relative humidity. A plot of light-scattering versus relative humidity is termed a "humidogram." In addition to indicating the hygroscopic nature of the aerosol, the humidogram can also provide information about the molecular or ionic composition of the aerosol (*2*).

For the period 4 to 27 September 1973, 99 percent of the humidograms of the aerosol at Tyson, Missouri (about 25 km west-southwest of St. Louis), exhibited either a monotonic, hygroscopic response or a deliquescent response with the deliquescent point at about 79 percent relative humidity. Data from 21 to 27 September (*1*) suggest that the hygroscopic humidograms consistently result from an aerosol containing a large fraction of acid as NH_4HSO_4 or H_2SO_4. The observed deliquescent point in the remaining humidograms identifies the aerosol as containing a large fraction of salt as $(NH_4)_2SO_4$.

In the data analysis a concentrated effort has been made to discover variables that are related to this difference in the aerosols. One variable examined was the aerosol history. Ninety air parcel trajectories terminating at St. Louis for the average flow in the 500- to 2000-m layer were obtained from the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (*3*). Examination of these trajectories revealed that 63 percent of the air parcels arriving from the south contained H_2SO_4–NH_4HSO_4 aerosols, whereas 66 percent of the air parcels arriving from the north contained $(NH_4)_2SO_4$ aerosol. This finding indicates that acid aerosols predominate in maritime tropical air masses whereas $(NH_4)_2SO_4$ aerosol predominates in air masses of continental polar origin. To further examine this relationship, we plotted coincidentally the percentage of the time during each day that the aerosol was $(NH_4)_2SO_4$ as compared with the percentage of the time during each day that the air mass was continental polar, consulting the trajectories and 500-mbar charts (Fig. 1). The correlation coefficient between the 20 pairs of data points is 0.72 with a probability of less than 0.1 percent that this effect is due to random occurrence (*4*).

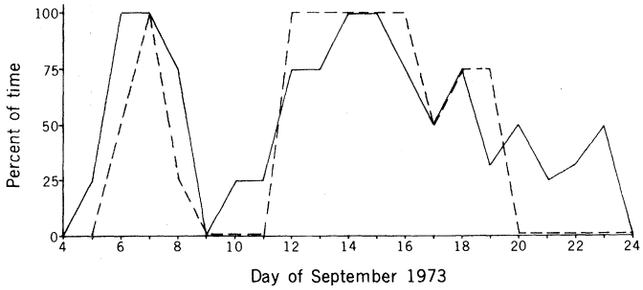

Fig. 1. Plot of the daily frequency of continental polar air masses in St. Louis (dashed line) with the daily frequency of $(NH_4)_2SO_4$ aerosol (solid line) for September 1973.

Although there is presently no model for a correlation of air mass and aerosol character, there are at least two possible causes for the observations reported here. First, there may be a lower NH_3 source strength for air masses arriving at St. Louis after following marine tropical flow trajectories than for those arriving at St. Louis after following continental polar trajectories. This premise is supported by Junge's results (*5*) which show that the concentration of NH_4^+ in precipitation for the midwestern states traversed by continental polar air masses is higher by as much as a factor of 10 than for the southeastern states traversed by marine tropical air masses. He suggests that the low NH_4^+ concentration in the southeastern states may be due to the low *p*H value of yellow-red laterite soils characteristic of the area. The second cause may be different aerosol production and modification processes for each air mass. Substantial differences in the thermal structure and moisture content of the two types of air mass suggest a variety of possible causal factors for the different aerosol character.

A. H. VANDERPOL, F. D. CARSEY
D. S. COVERT, R. J. CHARLSON
A. P. WAGGONER
Water and Air Resources Division, Civil Engineering Department, and *Institute for Environmental Studies, University of Washington, Seattle 98195*

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