

Effects of Sulfur Emissions from Popocatepetl Volcano on the Central U.S. in June 1997

Carmen M. Benkovitz, Mark A. Miller, and Stephen E. Schwartz
Brookhaven National Laboratory, Upton, NY 11973
Richard C. Easter
Pacific Northwest National Laboratory, Richland, WA

Abstract

Tropospheric sulfate from the degassing of SO₂ from volcanos can represent a major fraction of sulfate in impacted areas and can contribute disproportionately to tropospheric sulfate burdens globally because of elevated release height, resultant greater conversion of SO₂ to sulfate, and long lifetime in the atmosphere. Popocatepetl is a continually degassing volcano located in Central Mexico (98.62°W, 19.02°N); on June 16, 1997 it had a major degassing event, emitting $\sim 2 \times 10^7$ kg sulfur. Emissions from Popocatepetl along with other volcanic, anthropogenic, and biogenic sources of sulfur, and their transport and transformation have been represented in an Eulerian model driven by observation-derived meteorological data. The sulfur plume from Popocatepetl has been followed in the model using the sulfate column burden (vertical integral of the concentration). Initially sulfate burden built up and remained relatively stationary over the source region (June 17-23); during this period the synoptic scale flow was dominated by a col between a strong ridge to the west of the volcano and a trough to the east; the low level flow was weak and nearly stagnant over the source region. On June 23, a moderately strong trough with its axis along the California coast slipped southward along the Baja Peninsula creating a band of southwesterly winds over the source region. These southwesterly winds extended well into the continental United States, providing a means for the large sulfate burden to advect to the northeast. On June 25 the leading edge of the volcano plume arrived at the AERONET (<http://aeronet.gsfc.nasa.gov:8080/>) optical thickness measuring station at Sevilleta, NM (106.88°W, 34.35°N); as the plume passed over this location modeled sulfate column burdens rose from 27 $\mu\text{mol m}^{-2}$ (5% from volcanos) to a peak of 220 $\mu\text{mol m}^{-2}$ (51% from volcanos) on June 27 12UT. Measured aerosol optical thickness (AOT) increased from ~ 0.04 on June 25 to a peak value of ~ 0.17 on June 26 at 18UT. Corresponding values of the Ångström exponent increased from < 1 to ~ 2 . Vertical profiles of the modeled sulfate mixing ratios (MRs) on June 25 showed a maximum value of 0.47 ppb at the surface, all from anthropogenic emissions in North America. On June 27 12UT the maximum MR was 1.9 ppb at an altitude of ~ 4 km, with the volcano emissions contributing over half. On June 27 the leading edge of the volcano plume arrived at Denver, CO (105.01°W, 39.43°N); modeled sulfate column burdens rose from ~ 44 $\mu\text{mol m}^{-2}$ (1% from volcanos) to a peak of 122 $\mu\text{mol m}^{-2}$ (51% from volcanos) on June 28. Vertical profiles of the modeled sulfate MRs on June 27 showed a maximum MR of 0.5 ppb at the surface, with anthropogenic emissions from North America contributing almost 100%. On June 28 the maximum MR was ~ 1.7 ppb at a height of ~ 4 km, with the volcano emissions contributing over 80%. Comparisons between modeled column burdens and measured AOT establish confidence in the model results. The model allows attribution of the increase in AOT and surface concentrations to volcanic sources and demonstrates the long range transport of these aerosols.