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RAPID GROWTH OF FRESHLY FORMED NANOPARTICLES IN THE REMOTE TROPOSPHERE

R. J. Weber[1], P. H. McMurry[2], F. L. Eisele[3], L. Mauldin[3], and D. Tanner[3]

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[1] Environmental Chemistry Division, Bldg 815E, Department of Applied Science, Brookhaven National Laboratory, Upton, NY 11973.
[2] University of Minnesota, Dept. of Mechanical Engineering, Minneapolis, MN 55455.
[3] National Center for Atmospheric Research, Boulder, CO 80307.

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Rapid Growth of Freshly Formed Nanoparticles in the Remote Troposphere

R. J. Weber[1], P. H. McMurry[2], F. L. Eisele[3], L. Mauldin[3], D. Tanner[3]

1 Environmental Chemistry Division, Bldg 815E Brookhaven National Lab, Upton NY 11973, rweber@bnl.gov.
2 University of Minnesota, Dept. of Mechanical Engineering, Minneapolis MN 55455, mcmurry@me.umn.edu.
3 National Center for Atmospheric Research, Boulder CO 80307, eisele@ncar.ucar.edu, mauldin@acd.ucar.edu, tanner@ncar.ucar.edu.

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Measurements of nanoparticles (3 to 10 nm diameter) at various sites in the remote troposphere have shown that the rate at which freshly formed particles grow is much faster than can be explained by condensation of sulfuric acid (H_2SO_4) and associated water (H_2O). The cause of this enhanced growth is unknown.

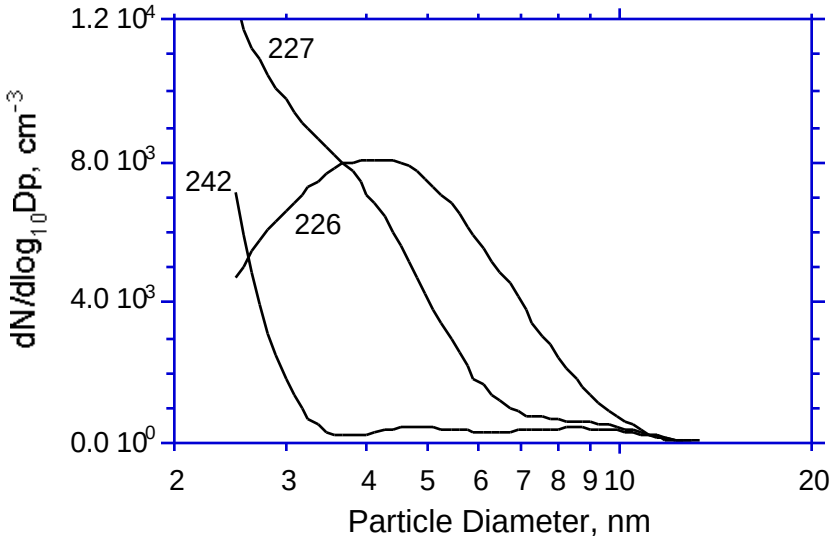

Figure 1: Airborne measurements of nanoparticle size distributions downwind of a penguin rookery on Macquarie Island. Measurements are identified by sample number. The sequence of measurements with increasing downwind distance from the rookery is 242, 227, and 226. The measurements show growth of freshly formed particles as they are advected away from the island.

Evidence for nanoparticle growth has been observed at the Mauna Loa Observatory, Hawaii (Weber et al., 1995), at Idaho Hill, a remote site in the Colorado Rocky Mountains (Weber et al., 1997), and at a remote marine site downwind of penguin rookeries on Macquarie Island during the first Aerosol Characterization Experiment (ACE 1). In these studies, gas phase H_2SO_4 concentrations were measured by Chemical Ionization Mass Spectroscopy (Eisele and Tanner, 1993) and nanoparticle spectra by inversion of Ultrafine Condensation Particle Counter (UCPC) photo detector pulse height distributions (Weber et al., 1998).

Different approaches can be used to estimate observed growth rates from nanoparticle concentrations. For example, Figure 1 shows the evolution of the nanoparticle size distribution offshore of Macquarie Island as the aerosol was advected away from a region of new particle formation. Growth rates are estimated from the change in the distribution and transport time between measurements. Alternatively, at Idaho Hill, Colorado, growth rates were estimated from the time delay between the rise in H_2SO_4 concentrations at sunrise and the rise in nominally 3 to

4 nm diameter particles, see Figure 2. This delay was consistently observed and interpreted as the time for a vapor molecule of ~1 nm diameter to reach the UCPC lower detection limit of ~3 nm diameter. Growth by condensation of H_2SO_4 and associated H_2O can be calculated from measured H_2SO_4 and H_2O concentrations. Comparisons show that observed particle growth rates were 4 to 17 times higher at Macquarie Island, and 5 to 10 times higher at Idaho Hill than could be explained by H_2SO_4 - H_2O condensation.

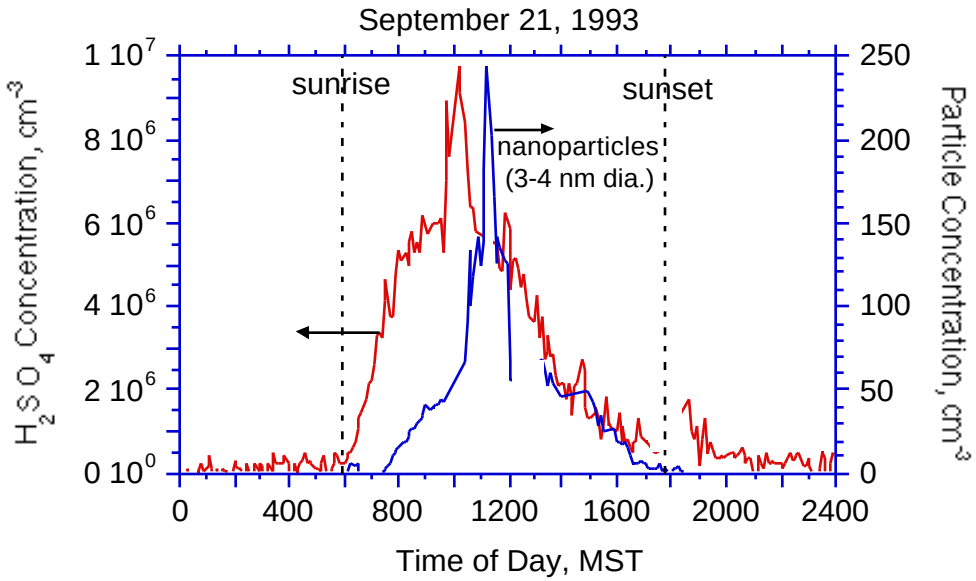

Figure 2: Diurnal variation of gas phase H_2SO_4 and nanoparticle concentrations at Idaho Hill Colorado, a ground-based remote continental site. The delay in rise of nanoparticle concentrations following the H_2SO_4 concentration increase near sunrise was one technique used to estimate observed nanoparticle growth rates.

The cause for fast growth is not know. It may be that other species participate, or the discrepancies may be due to a poor understanding of the microphysics of particle growth. This paper will present comparisons between observed and calculated nanoparticle growth rates at our various measurement sites and explore possible causes for observed discrepancies.

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