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The acidity of clouds and fogs around the world

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The initial acidity of a fog or cloud drop is determined by the balance between inputs of acids and bases that enter the drop through particle scavenging and uptake of soluble gases, with subsequent changes from aqueous chemical reactions that release or consume H^+ ions. While inputs of sulfuric and nitric acids and ammonia are often the principal determinants of fog or cloud pH, other compounds can also be important contributors to droplet acidity or alkalinity. Among important pH-altering constituents are carbon dioxide, carboxylic and dicarboxylic acids, and soil dust. Because individual droplets in a fog or cloud form on different cloud condensation nuclei and because gas uptake efficiency can vary with drop size, one expects some degree of variability among droplet pH within a single cloud or fog.

This presentation will review measurements of cloud and fog pH over the past several decades. Observations will be included from North and South America, Europe, Asia, Africa, and Australia, as well as from maritime clouds. We will examine regional patterns in observed acidity and highlight temporal changes in fog pH driven by changing air pollution emissions over recent decades. The presentation will further review variations in pH as a function of drop size in a single cloud/fog and consider reactions, such as aqueous phase sulfuric acid production, that can strongly affect droplet pH. We will examine the importance of internal and external buffering agents, including organic acids, phenols, ammonia, and carbonates, that help limit pH changes otherwise expected as a result of strong acid addition.