H_2O-H_2SO_4 SYSTEM IN VENUS' CLOUDS AND OCS, CO, AND H_2SO_4 PROFILES IN VENUS' TROPOSPHERE

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A coupled problem of diffusion and condensation is solved for the H_2SO_4-H_2O system in Venus' cloud layer. The position of the lower cloud boundary, profiles of the H_2O and H_2SO_4 vapor mixing ratios and of the H_2O/H_2SO_4 ratio of sulfuric acid aerosol and its flux are calculated as functions of the column photochemical production rate of sulfuric acid, Φ_{H2SO4}. Variations of the lower cloud boundary are considered. Our basic model, which is constrained to yield f_{H2O}(30 km) = 30 ppm [1], predicts the position of the lower cloud boundary at 48.4 km coinciding with the mean Pioneer Venus value, the peak H_2SO_4 mixing ratio of 5.4 ppm, and the H_2SO_4 production rate $\Phi_{H2SO4} = 2.2\times10^{12}$ $cm^{-2}s^{-1}$. The sulfur to sulfuric acid mass flux ratio in the clouds is 1:27 in this model, and the mass loading ratio may be larger than this value if sulfur particles are smaller than those of sulfuric acid. The model suggests that extinction coefficient of sulfuric acid particles with radii of 3.7 μm (mode 3) is equal to 0.3 km^{-1} in the middle cloud layer. The downward flux of CO is equal to 1.7×10^{12} $cm^{-2}s^{-1}$ in this model. Our second model, which is constrained to yield f_{H2SO4} = 10 ppm at the lower cloud boundary, close to that measured by the Magellan X-band radiooccultation [2], predicts the position of this boundary at 46.5 km, f_{H2O}(30 km)= 90 ppm close to the Venera 11-14 data [3] at this altitude, $\Phi_{H2SO4} = 6.4\times10^{12}$ $cm^{-2}s^{-1}$ and $\Phi_{CO} = 4.2\times10^{12}$ $cm^{-2}s^{-1}$. The S/H_2SO_4 flux mass ratio is 1:18, and extinction coefficient of the mode 3 sulfuric acid particles is equal to 0.9 km^{-1} in the middle cloud layer. A strong gradient of the H_2SO_4 vapor mixing ratio near the bottom of the cloud layer drives a large upward flux of H_2SO_4 which condenses and forms the excessive downward flux of liquid sulfuric acid. This flux is larger by a factor of 4-7 than the flux in the middle cloud layer. This is the mechanism of formation of the lower cloud layer. Variations of the lower cloud layer are discussed. Our modeling of the OCS and CO profiles measured in the lower atmosphere [1] provides a reasonable explanation of these data and shows that the rate coefficient of the reaction SO_3 + CO → CO_2 + SO_2 is equal to $10^{-11}\exp(-(13100\pm1000)/T)$ cm^3/s. The main channel of the reaction between SO_3 and OCS is CO_2 + $(SO)_2$, and its rate coefficient is equal to $10^{-11}\exp(-(8900\pm300)/T)$ cm^3/s. In the conditions of Venus' lower atmosphere $(SO)_2$ is removed by the reaction $(SO)_2$ + OCS → CO + S_2 + SO_2. The model predicts a OCS mixing ratio of 28 ppm near the surface.

[1] Pollack J. B. et al. (1993) *Icarus, 103,* 1; [2] Jenkins J. M. et al. (1994) *Icarus* (submitted); [3] Moroz V. I. et al. (1983) *Cosmic Res., 21,* 246.

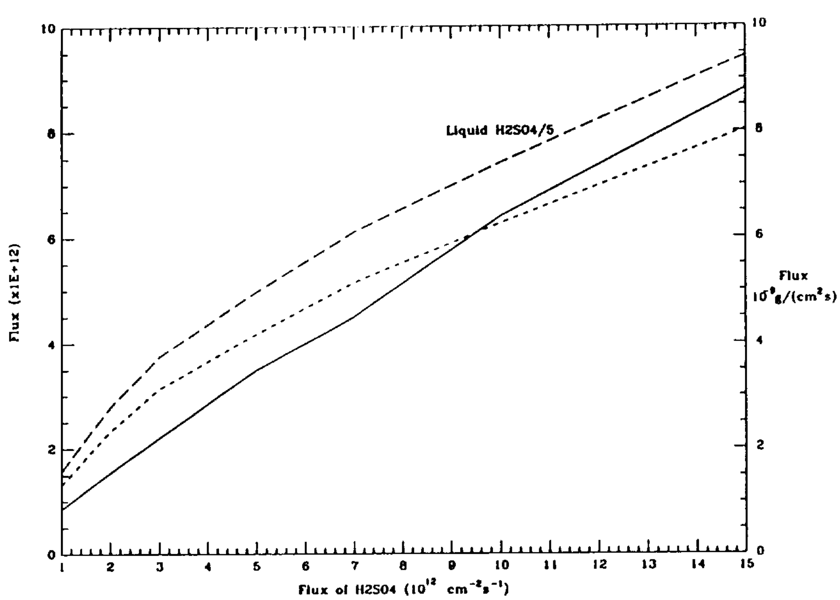

Fig. 1. Fluxes of CO (solid) and of liquid H_2SO_4 (reduced by a factor of 5 to be on scale, long dashes), and flux of sulfuric acid aerosol (the right scale, short dashes) as functions of the column photochemical production of H_2SO_4. All fluxes are given at the lower cloud boundary.

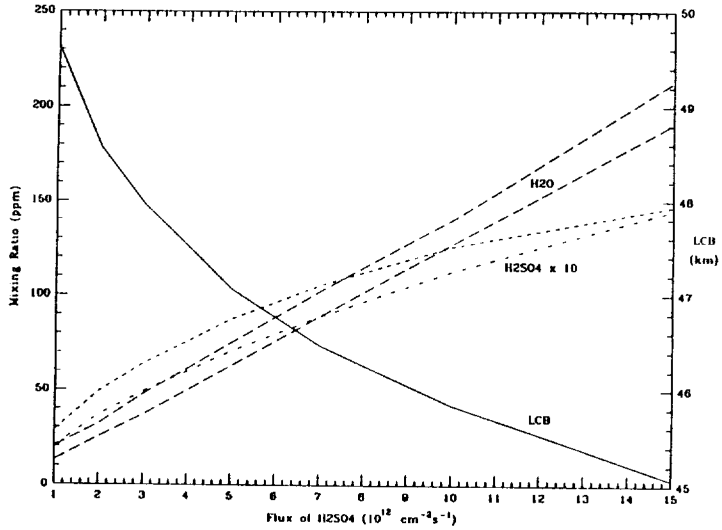

Fig. 2. H_2O mixing ratios at 30 km which meet the requirement f_{H2O}(62-65 km)=1-10 ppm, the position of the lower cloud boundary and the H_2SO_4 mixing ratio at this boundary (short dashes) and at 45 km (dot-dashes) as functions of the column photochemical production of H_2SO_4.

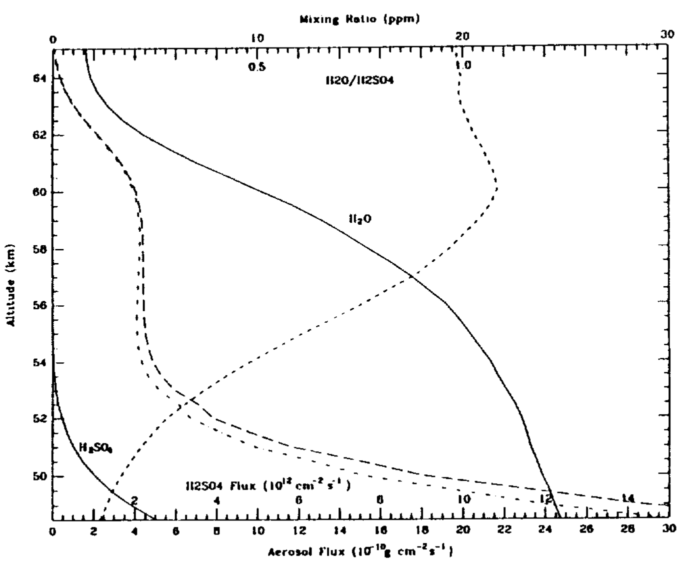

Fig. 3. Model 1 results: H_2O and H_2SO_4 mixing ratios (solids), H_2O/H_2SO_4 ratio in the cloud particles (short dashes), the downward flux of H_2SO_4 in the liquid phase (long dashes), and the downward flux of sulfuric acid droplets (dot-dashes).

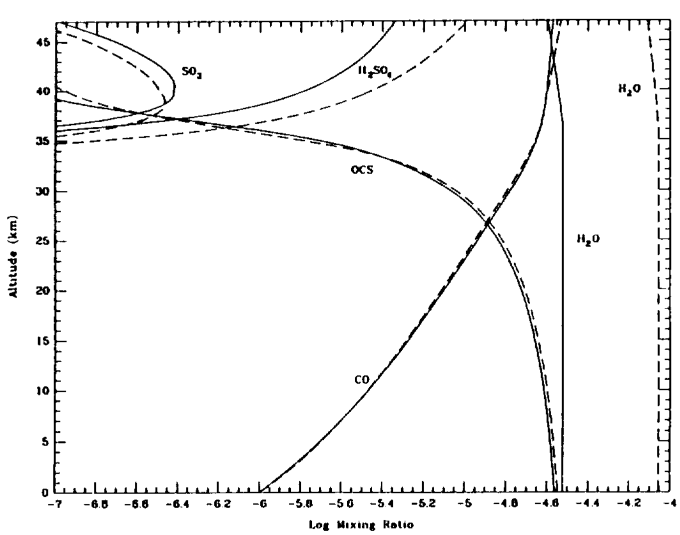

Fig. 4. Profiles of OCS, CO, H_2SO_4, SO_3, and H_2O calculated for Model 1 (solids) and Model 2 (dashes).