

Title: Venusian Cloud Anomalies and the Search for Signs of Life in the Clouds

Janusz J. Pełkowski

Research Affiliate at the Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA

Scientists have been speculating on Venus as a habitable world for over half a century based on the Earth-like temperature and pressure in Venus' clouds at 48-60 km above the surface. The hypothesis that Venusian clouds may be inhabited by an aerial biosphere got recently bolstered by a tentative detection of a biosignature gas phosphine in the atmosphere of Venus. Phosphine however is not the only anomaly that suggests very unusual chemical processes in the clouds, and maybe even life. The presence of such chemical anomalies came to the forefront thanks to the recent efforts to re-analyze and re-interpret the legacy data collected by both the Pioneer Venus and Venera probes.

A new interpretation of the Venusian cloud anomalies suggests that the clouds are not entirely made of concentrated sulfuric acid, but of ammonium salts, which may be the result of biological production of ammonia in cloud droplets. As a result, the clouds are no more acidic than some terrestrial environments that harbor life. The new model explains many decades-long atmospheric anomalies including the observed SO₂ and H₂O abundance profiles, the presence of O₂ in the cloud layers and the potential existence of the "Mode 3 particles". Furthermore, the model's predictions for the abundance of gases in Venus' atmosphere matches observation better than any previous model and are readily testable.

An *in situ* Venus probe can support or refute our proposed view of Venus as an inhabited planet. New missions to Venus will add data to resolve some of the lingering questions. Venus Life Finder Missions (VLF, <https://venuscloudlife.com/>) are a series of focused astrobiology mission concepts to search for habitability and signs of life in the Venus atmosphere. VLF are cost-effective and highly-focused missions. The Venusian atmospheric anomalies are a major motivation for the VLF, and might be tied to habitability and life's activities or be indicative of unknown chemistry itself worth exploring. Our proposed series of VLF missions aim to study Venus' cloud particles and to build on the pioneering *in situ* probe missions from nearly four decades ago.