Opportunity Title: Fundamental studies of the Venus clouds as two-phase flows with phase change
Opportunity Reference Code: 0224-NPP-NOV23-JPL-PlanetSci

Organization National Aeronautics and Space Administration (NASA)

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Application Deadline 11/1/2023 6:00:59 PM Eastern Time Zone

Description The clouds of Venus are its defining characteristic. Whereas the surface of other solid-surface planets, i.e., Mars and Mercury, can be seen, that of Venus is obscured by thick clouds. Infrared observations initiated in the 1970s indicated the presence of sulfur dioxide in the upper cloud layers, a fact confirmed by further spacecraft instruments. The slightly yellow color of the visual images may be indeed due to suspended sulfur particles in the upper atmosphere. The present understanding is that Venus clouds are primarily composed of sulfuric acid droplets (75-96%). The sulfur may have originated from early volcanic activity. It is presumed that since the temperatures remained high after the volcanic eruptions, sulfur could not be trapped out into solid compounds on the surface as for example it happened on Earth. Indeed, the melting point of sulfur is 386K, and thus the Venus surface temperature, which is 750K, well exceeds the sulfur melting point; however, due to the high Venus surface pressure of 92 atm, sulfur would not boil but would be sufficiently volatile to evaporate and form the sulfur dioxide which would then remain suspended in the atmosphere. The pressure in these clouds is between 0.1 bar and 1 bar, and the temperature is range 173 K - 273 K.

No current fundamental simulations of the Venus cloud layer, or portions of it exist to describe the interaction between the carrier gas and drops. However, there is expertise in fundamental modeling and simulations of turbulent two-phase flows with phase change [1-5]. These fundamental models use an Eulerian-Lagrangian approach whereby the carrier gas is followed using the Navier-Stokes equations complemented by the energy and species-mass equations, and the drops are followed on their trajectory as they evaporate. The two frameworks are entirely coupled: the flow influences the drops, and the drops influence the carrier gas. In one study [5], 71 million drops were followed on their individual trajectories while evaporating. The present study will adapt the previous framework, which was in the realm of fluid mechanics and combustion, to the Venus clouds.

Experience with fluid dynamics modeling, Direct Numerical Simulation, Large Eddy Simulation, numerical techniques, coding, and supercomputing is required; a solid background in thermodynamics, chemistry and in multi-phase flows is desirable.

[1] N. Okong'o and J. Bellan, Consistent Large Eddy Simulation of a temporal mixing layer laden with evaporating drops. Part 1: Direct Numerical Simulation, formulation and a priori analysis, J. Fluid Mech., 499, 1-47, 2004

[2] A. Leboissetier, N. Okong'o and J. Bellan, Consistent Large Eddy Simulation of a temporal mixing layer laden with evaporating drops. Part 2: A posteriori modeling, J. Fluid Mech., 523, 37-78, 2005

[3] N. Okong'o, A. Leboissetier and J. Bellan, Detailed Characteristics of Drop-Laden Mixing Layers: LES Predictions compared to DNS, Physics of Fluids, 20(10), 103305 (16 pages), 2008

[4] S. Radhakrishnan and J. Bellan, Influence of computational drop representation in LES of a mixing layer with evaporating drops, Computers and Fluids, 58, 15-26, 2012

[5] S. Radhakrishnan and J. Bellan, Explicit filtering to obtain grid-spacing independent and discretization-order independent Large Eddy Simulation of two-phase volumetrically-dilute flow with evaporation, J. Fluid Mech., 719, 230-267, 2013

Location:
Jet Propulsion Laboratory
Pasadena, California

Field of Science: Planetary Science

Advisors:
Josette Bellan
Josette.Bellan@jpl.nasa.gov
818-354-6959

Applications with citizens from Designated Countries will not be accepted at this time, unless they are Legal Permanent Residents of the United States. A complete list of Designated Countries can be found at: https://www.nasa.gov/oiir/export-control.

Eligibility is currently open to:

- U.S. Citizens;
- U.S. Lawful Permanent Residents (LPR);
- Foreign Nationals eligible for an Exchange Visitor J-1 visa status; and,
- Applicants for LPR, asylees, or refugees in the U.S. at the time of application with 1) a valid EAD card and 2) I-485 or I-589 forms in pending status

Eligibility Requirements

- **Degree:** Doctoral Degree.