UNDERSTANDING THE SUPERCRITICAL STATE ON VENUS AND DAVINCI+ OPPORTUNITY. A. Bhattacharya[1], N. R. Izenberg[2], and P.R. Mahaffy[3], [1]Sardar Vallabhbhai National Institute of Technology Surat, India, ananyo0806@gmail.com, [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD, US, [3]NASA Goddard Space Flight Center, Greenbelt, MD US

Introduction: Thermal properties of the lower atmosphere of Venus has been studied from atmospheric probes and lander missions. In-situ measurements have provided valuable information about the atmospheric composition [1]. However, little reliable information or reproducible results are available for the near surface environment. It is known to be composed of supercritical mixture of major constituents i.e. carbon dioxide and nitrogen.

VeGa-2 probe descent measurements of atmospheric temperature, which are the only reliable sources of temperature measurements below 12.5 Km altitude [2], due to high uncertainties in temperature measurements by other missions. There is an indication of gradient in the concentration of major constituent species with altitude in the average molecular mass derived [2], with no known evidence for sinks of nitrogen [3].

Table 1: N_2 concentration measurements by some instruments onboard previous missions [1]. MS = mass spectrometer, GC = gas chromatograph.

Missions and instruments	N_2 conc. (%)	error (%)	Altitude/ region measured
Pioneer Venus MS; Venera 11/12 GC combined	3.5	0.8	< 100 km
Venera 12 GC	2.5	0.5	< 42 km
Venera 13/14 MS	4	-	26 km to the surface
Venera 11/12 MS	4	0.3	23-1 km

Table 1 shows that the in-situ measurements do not vary much with altitude, but have significant error bars.

The Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging Plus (DAVINCI+) mission now in Phase A led by Principal Investigator Dr. James B. Garvin and NASA Goddard Space Flight Center is the first opportunity in 35 years to study the deep atmosphere of Venus, and will measure physical properties as well as chemical constituents of the near surface environment.

Supercriticality on Venus: Studies based on experiments [4] and computational chemistry [5] have investigated the supercritical mixture of major atmospheric constituents at pressure and temperature conditions approximating those near the surface of Venus.

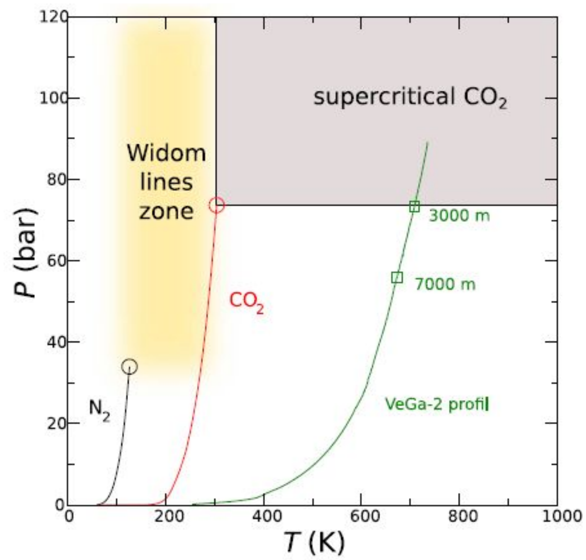

Figure 1. Pressure vs. Temperature for N2, CO2 and measurements of Venus atmosphere by VeGa 2 from [5].

Figure 1 shows that a supercritical state is expected approximately below 3 km altitude. The CO2 and N2 lines in red and black show the vapor-liquid equilibrium lines. The Widom lines zone refers to the region consisting of regimes that separate liquid like behaviour and gas like behaviour in fluids around the critical point. Exact information about these regimes would predict the characteristics of fluid mixtures in the phase diagram. However, much of the studies done on supercritical fluids in Venus are yet to be supported by in-situ measurements, and the current knowledge gap highlights some important questions about Venus:

(i) At what altitude is the transition to a supercritical state expected? What are the possible mechanisms for such a transition?

(ii) Is the concentration gradient in nitrogen observed by VeGa 2 real, and is it a local or global phenomenon?

(iii) What are the potential impacts of volcanic activity or other degassing processes on the physical state of the atmosphere?

(iv) What are the possible heat, momentum, and mass transport characteristics in the supercritical environment?

DAVINCI+: The mission proposed to the NASA Discovery Program is designed to study the atmospheric composition of different chemical species and to gather more knowledge about the atmospheric evolution [6]. As a part of the mission, the deep atmospheric chemistry probe armed with instruments for in-situ measurements would explore the lower atmosphere of Venus and study potential non-equilibrium processes and surface atmosphere interactions.

DAVINCI+ science goals are to study the origin of Venus atmosphere and its evolution, rate of volcanic activity and history of surface processes [6]. Thus, it can be seen that the science objectives are directly in line with questions (i), (ii) and (iii) in relation to the supercritical state.

The mission's one-hour atmospheric descent will be an opportunity to explore the questions related to the physical state of Venus' atmosphere. The Venus Mass Spectrometer (VMS), a quadrupole mass spectrometer and the Venus Tunable Laser Spectrometer (VTLS) provide the isotopic composition and concentration of major constituents [7]. Further, the Venus Atmospheric Structure Investigation (VASI) suite of instruments provides temperature and absolute pressure measurements. The knowledge of chemical composition and thermal properties would constrain the physical state of the expected supercritical environment. The combined measurements would then be analyzed to get temperature and chemical concentrations of nitrogen and carbon dioxide. These measurements will be used in mathematical models to understand properties of the physical state. Co-incident measurement of the final descent would help in identifying the factors influencing the supercritical st8ate.

DAVINCI+, combined with future atmospheric probes and lander opportunities with the ability to explore the near surface environment are also needed to answer superciricality question (iii) completely and constrain question (iv).

References:

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