

A Cold Case for a Hot Planet: Pioneer Venus Data Restoration I. Belkhodja¹ and D. Williams², ¹Mount Holyoke College, belkh22i@mtholyoke.edu, ²NASA Goddard Space Flight Center, david.r.williams@nasa.gov.

Introduction: Restoring and preserving historical data sets is a crucial aspect of advancing scientific research. These past data sets serve as foundational benchmarks, allowing us to track changes over time, identify trends, and refine our methodologies to draw insights for future missions. Neglecting or underutilizing them could lead to significant gaps in our understanding, ultimately hindering the accurate interpretation of new data. For example, upcoming missions like DAVINCI and VERITAS are poised to deepen our understanding of Venus, but their success is intricately linked to the wealth of information from past missions. There have been past NASA missions to Venus but many of the various data sets have not been restored yet. One data set of interest being restored at the NASA Space Science Data Coordinated Archive (NSSDCA) is from the Large Probe Neutral Mass Spectrometer (LNMS) experiment on the Pioneer Venus mission. The restoration involves preparing and validating the data set to meet the standards for archive with the Planetary data System (PDS).

Overview: Pioneer Venus was launched in 1978 to study the interior, surface, atmosphere, and space environment of Venus, consisting of two spacecraft—the Pioneer Venus Orbiter and the Pioneer Venus Multiprobe. The Orbiter mapped the planet's surface and analyzed its atmosphere and near-space environment, while the Multiprobe sent one large and three small probes to gather atmospheric data. The large probe had a neutral mass spectrometer and was designed to measure the composition of the lower atmosphere by descending through air drag and a parachute [1]. The instrument was fully activated at 67 km above the surface and the probe released its parachute at around 47 km [2]. The descent lasted less than an hour and transmitted data continuously until it finally crashed onto the surface.

Original Data: The original data set was gathered by Principal Investigator, Dr. John H. Hoffman, and sent to NSSDCA in the form of hard-copy computer printouts. NSSDCA microfilmed these data and archived them along with the ancillary documentation (metadata) supplied by Hoffman. The data set consists of 51 rows, representing the data taken from each measurement cycle and altitude as the probe descended, and 240 columns, one for each atomic mass measured. The instrument included a low-mass detector and a high-mass detector, which operated simultaneously. The high mass data ranges from 15.01 to 232.019 amu, while the low mass data ranges from 1 to 15 amu [3].

Supplemental Data: Another experiment on this mission was called the “Atmospheric Structure

Experiment”, a version of this was carried on the large probe. The instruments included a single-axis accelerometer, pressure sensors, and temperature sensors [4]. These data were gathered by Principal Investigator, Dr. Alvin Seiff. The data set consists of 7 columns and 570 rows. Each row includes data about ground received time, altitude, pressure, temperature, density, and compressibility as the probe descended.

Restoring data: Several steps are involved in archiving data to PDS. The data were initially scanned from the archived microfilm. To get a PDF scan of the LNMS dataset, NSSDCA did an OCR scan and a cleanup of any random characters. As the two datasets had different altitudes, the next step was to interpolate with best-fit equations to use the Atmospheric Structure close-packed values (typically every four seconds) for temperature, pressure, density, and time with the corresponding altitude value of the LNMS dataset. Metadata from the original data submissions and collected from other sources was organized for inclusion with the data set. Next, with the final LNMS data set that includes the newly added columns for temperature, pressure, density, and time, a PDS bundle was created containing the metadata in the form of labels, units, and descriptions of each row and column. The last step before submitting to PDS was to develop a user-documentation guide for future users to understand the necessary details of the data and to enable them to generate similar best-fit equations and values of the interpolated added columns for their own use. This restoration is being done in collaboration with the PDS Atmospheres Node, who will oversee the final review and validation of the data bundle for archive in the PDS.

Acknowledgments: I would like to acknowledge my mentors David Williams and Stephanie McLaughlin who helped me throughout this restoration and archival process.

References:

- [1] D. Williams. (2022) *NSSDCA Master Catalog Search, Neutral Mass Spectrometer (LNMS)*. [2] D. Bolles. (2023) *Pioneer Venus 2*. [3] J. H. Hoffman and R. R. Hodges, Jr. (1980) *Pioneer Venus Sounder Probe LNMS Data Format Description*. [4] D. Williams. (2022) *NSSDCA Master Catalog Search, Atmospheric Structure (SAS)*.