REANALYSIS OF THE PIONEER VENUS LARGE PROBE NEUTRAL MASS SPECTROMETER DATA.

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Introduction: The Pioneer Venus Large Probe neutral mass spectrometer (LNMS) measured the composition of the Venusian atmosphere from ~64 km to the surface. Digitized data from the LNMS were recently released by the NASA Space Science Data Coordinated Archive (ID: PSPA-00649) [1]. Prior to this release, these data had not been re-examined since the 1990s. We set out to determine whether more information can be extracted from these data using modern techniques.

The LNMS dataset has historically been difficult to interpret due to the inclusion of methane as an internal calibration gas as well as possible external contamination from sulfuric acid droplets [2]. Furthermore, no calibration data is known to exist for this instrument, and in general, instrument parameters such as resolution and sensitivity are poorly constrained. As such, we apply the methods developed for the Cassini Ion and Neutral Mass Spectrometer [3], which is similarly lacking in calibration data, to the LNMS dataset. These methods allow us to determine the most likely mixing ratios and fragmentation patterns for the molecules included in our atmospheric models, as well as isotope ratios for the elements in the models.

We tested a variety of atmospheric composition models. Our base model includes carbon dioxide, nitrogen, hydrogen, oxygen, water, sulfur species, halogens, and noble gases. Other species included in our models are various oxidized species such as mineral acids, phosphorus oxides, and nitrogen oxides, as well as hydrogen-bearing species like hydrocarbons, phosphine, and ammonia.

Multiple models fit the data satisfactorily, and there is no unique solution to this inversion problem. We find that reduced species (except for the methane calibration gas) are not necessary to produce satisfactory fits to the observed data. Including such molecules tends to increase the complexity of the model while only producing minimal gains in model accuracy.

We also report the first mixing ratio profiles of major and minor species from this data set. Whereas previous investigations reported only altitude-averaged mixing ratios (besides water [4]).

Our analyses highlight the fact that mass spectrometer data (especially low-resolution data) are not diagnostic on their own, and future missions to Venus should include additional atmospheric chemistry instruments such as an infrared spectrometer to reduce degeneracies in mass spectrometer data.

References: **[1]** https://nssdc.gsfc.nasa.gov/nmc/dataset/display.action?id=PSPA-00649 **[2]** J. H. Hoffman, R. R. Hodges, T. M. Donahue, and M. B. McElroy, "Composition of the Venus lower atmosphere from the Pioneer Venus Mass Spectrometer," *JGR*, 85, A13, 7882, 1980. doi: 10.1029/JA085iA13p07882. **[3]** T. Gautier, J. Serigano, J. Bourgalais, S. M. Hörst, and M. G. Trainer, *R. Comm. Mass Spec.*, 34, 8, 2020, doi: 10.1002/rcm.8684. **[4]** T. M. Donahue and R. R. Hodges, "Venus methane and water," *GRL*, 20, 7, 591–594, 1993, doi: 10.1029/93GL00513.