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Design of Millimeter-wave Radiometer for Measuring Water Vapour in Venus Atmosphere

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Water vapor is of one of the most important constituents of Venus atmosphere because of its involvement in the formation of cloud, thermal balance and atmospheric chemistry. Water vapour abundance is approximately 30 ppm from ground up to an altitude of approximately 40 km, which is also the limit for Venus clouds. Infrared radiometer (PVOIR) measurements [1, 2, 3] from the 1978–1979 Pioneer Venus Orbiter show that cloud top water vapor has a strong diurnal variation. This variation could be ± 5 ppmv at night for 10 ppmv water vapour content, and daytime values could vary at ± 15 ppmv for values of 90 ppmv. In contrast, 15 Fourier Transform spectrometer (FTS) data from 1983 Venera [3, 4] show that cloud top water vapour abundances is of 7-17 ppmv, with no diurnal variability. Similarly, Earth-based infrared spectroscopy [5] measurements indicate that water vapour mixing ratios is in the range of 0.5 to 40 ppm in the altitude range 62–65 km. Despite the multiple measurements sources, accurate information about water vapour variations is still not available. This variation in the available information may be due to difference in the sounded altitude range, experimental and modeling errors.

The goal of this study is to measure water vapour profile from 55 to 75 km above ground level using LIMB viewing radiometer operating at 140-165 GHz. The measurement frequency range for the instrument have been selected based on a simulation based study where brightness temperatures for various altitudes have been simulated using water vapour and temperature profiles for night time. The brightness temperatures at 160-165 GHz and 183-187 GHz show a significant sensitivity to water vapour. This is particularly high for radiometer pointing at altitudes of 55-75 km above ground level. Another goal of this study is to develop a model for the water vapour distribution in the Venus atmosphere from 55 to 75 km. The results of the simulation based study will be discussed in more detail and instrument design specifications will also be discussed. In addition to that, the water vapour retrieval algorithm to be used for the estimation of water vapour will be presented.

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