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CANVAS: A CubeSat Mission to Measure VLF Waves above the Ionosphere from Lightning and VLF Transmitters

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VLF waves play an important role in controlling the evolution of energetic electron distributions in near-Earth space. However, an accurate quantification of the amount of VLF energy which penetrates from the ground, through the ionosphere, and into the magnetosphere is critical to our understanding of the effects of ground-based electromagnetic sources in the space environment. The Climatology of Anthropogenic and Natural VLF Wave Activity (CANVAS) CubeSat mission will make continuous observations of VLF waves in low-Earth orbit originating from lightning and ground-based transmitters. The CANVAS CubeSat will observe five components of the VLF waves in the 0.3-40 kHz frequency range. CANVAS will deploy a three-axis magnetic search coil on the end of a 1-meter carbon fiber boom and deploy two electric field dipole antennas, all from a 4U CubeSat platform. Together, these five wave components will be used to calculate spectral matrix components using real-time 1024-pt FFTs calculated in an onboard FPGA. The resulting spectra and cross-spectra will then be averaged onboard to obtain 1 second time resolution and frequency resolution better than 10%. The averaged spectral matrix will be sent to the ground to determine the full set of wave parameters, including polarization, planarity, and k-vector direction, utilizing methods detailed by Santolík, et. al. 2003.

Using these wave observations, CANVAS will provide inputs to modeling trans-ionospheric attenuation profiles as a function of frequency through the observation of broadband VLF waves from lightning, using sferics observed by ground-based VLF receivers as the source function. These measurements are critical for an understanding of the effects of VLF wave energy in the magnetosphere, including its effects on radiation belt electron populations. CANVAS will include a combination of student-built and commercial off the shelf components for a low-cost, compact VLF-sensing instrument. In this paper, we present the overall mission design, science observables, details of the design and current status of the instrument and data processing algorithms for CANVAS. CANVAS is funded by the National Science Foundation and is currently planned to launch in mid-2022.

References

[1] Santolík, O., M. Parrot, and F. Lefeuvre (2003), Singular value decomposition methods for wave propagation analysis, *Radio Science*, *38*(1).