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Study on the Propagation Characteristics of the NWC Signals Detected by the Arase Satellite

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It has been suggested that very low frequency (VLF) signals transmitted from ground stations can interact with particles in the plasmasphere. In particular, the signal from the North West Cape (NWC) station in Australia is transmitted at 19.8 kHz with a transmission power of approximately 1 MW. Therefore, it is crucial to investigate wave properties such as the power spectrum, wave normal angle (WNA), and Poynting flux to assess the effects of wave-particle interactions by this artificial signal.

In this study, we report the propagation characteristics of the NWC signals measured by the Arase satellite. First, we extract time periods when the magnetic footprint of Arase was within ±10 degrees of geographic latitude and longitude from the position of the NWC station. We then collect NWC signal events captured by the Waveform Capture (WFC), which measures waveforms below 20 kHz aboard the Arase satellite.

In general, the Means' method or the SVD method is used to determine the wave normal angle (WNA), but these methods primarily require all three orthogonal magnetic field components. However, since October 2018, the Arase satellite has been unable to measure one component of the magnetic field due to the degradation of its onboard triaxial search-coil magnetometer. To overcome this limitation, we apply the MUSIC (Multiple Signal Classification) method, which utilizes the amplitude and phase relationships among electromagnetic components derived from the dispersion relation of plasma waves. A statistical analysis of the WNA of NWC signals revealed that the WNA initially decreases as the signal propagates from the transmission station toward the magnetic equator and then increases again as the distance from the NWC station increases. This trend is consistent with results derived from ray tracing calculation.

Additionally, we analyzed the spatial distribution of NWC transmitter signals by examining the power spectrum of the electromagnetic field observed by the Onboard Frequency Analyzer (OFA) aboard the Arase satellite. The results reveal a day-night asymmetry in signal intensity, with greater intensity on the nightside and weaker intensity on the dayside. Finally, we calculate the Poynting flux of the NWC signals by combining WNA measurements with the magnetic field power spectrum. The Poynting flux of the signal remains nearly constant near the transmitting station and its conjugate point but slightly decreases in the equatorial region, indicating that the energy experiences small attenuation along the propagation paths.

In this presentation, we introduce the wave power, WNA, and Poynting flux of the NWC VLF transmitter signals detected by the Arase satellite and discuss the contribution of man-made VLF signals to wave-particle interactions in the inner magnetosphere.