# Using Cold Plasma Theory and Whistler Mode Waves to Characterize the Antenna-Sheath Impedance of the Van Allen Probes EFW Instrument

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Cold plasma theory and parallel wave propagation are often assumed when approximating whistler mode magnetic field wave powers from electric field observations. Here, we present results that include the wave normal angle from the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) package on board the Van Allen Probes in the conversion factor, thus allowing for the accuracy of these previously implemented assumptions to be quantified. Results indicate that removing the assumption of parallel propagation does not significantly affect calculated plasmaspheric hiss wave powers; hence the assumption of parallel propagation is often valid. For whistler mode chorus waves, inclusion of the wave normal angle in the conversion factor leads to significant alterations in the distribution of wave power ratios (observed/ calculated); the percentage of overestimates decreases, the percentage of underestimates increases, and the spread of values is significantly reduced. Calculated plasmaspheric hiss wave powers are, on average, a good estimate of those observed, whereas calculated chorus wave powers are persistently and systematically underestimated.

Initial investigation of the ratio between observed and calculated wave powers as a function of frequency and plasma density, reveals a structure consistent with signal attenuation via the formation of a plasma sheath around the EFW spherical double probes instrument. A simple, density-dependent model is developed in order to quantify this effect of variable impedance between the electric field antenna and the plasma interface. This sheath impedance model is then demonstrated to be successful in significantly improving agreement between calculated and observed power spectra and wave powers, however some discrepancies still remain.

Further analysis reveals that the shorter spin axis antennas may measure 'too much' electric field at specific densities. This is accounted for in an improved sheath impedance model by introducing a density-dependent function to describe the relative effective length of the probe separation. This factor also allows for the 'shorting' effect to be accounted for at low densities. We display that this improved sheath impedance model leads to an extremely high level of agreement between observed and calculated whistler mode wave powers.

Whilst the sheath impedance model presented here is only valid for the Van Allen Probes EFW instrument, we note that this same methodology may be applied to other spacecraft missions in order to quantify, and correct for, instrument-plasma coupling effects.