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A Modeling Framework for Estimating Ionospheric HF Absorption Produced by Solar Flares

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Over-the-Horizon communication is strongly dependent on the state of the ionosphere, which is susceptible to solar flares [1]. Trans-ionospheric high frequency (HF, 3–30 MHz) signals can experience strong attenuation following a solar flare that lasts typically for an hour, commonly referred to as shortwave fadeout (SWF). In this study, we examine the role of dispersion relation and collision frequency formulations on the estimation of SWF in riometer observations using a new physics-based model framework. The new framework first uses modified solar irradiance models incorporating high-resolution solar flux data from the GOES satellite X-ray sensors as input to compute the enhanced ionization produced during a flare event. The framework then uses different dispersion relation and collision frequency formulations to estimate the enhanced HF absorption. The modeled HF absorption is compared with riometer data to determine which formulation best reproduces the observations. We find the Appleton-Hartree dispersion relation in combination with the averaged collision frequency profile reproduces riometer observations with an average skill score of 0.4, representing 40% better forecast ability than the existing D-region Absorption Prediction model. Our modeling results also indicate that electron temperature plays an important role in controlling HF absorption. We suggest that adoption of the Appleton-Hartree dispersion relation in combination with the averaged collision frequency be considered for improved forecasting of ionospheric absorption following solar flares [2].

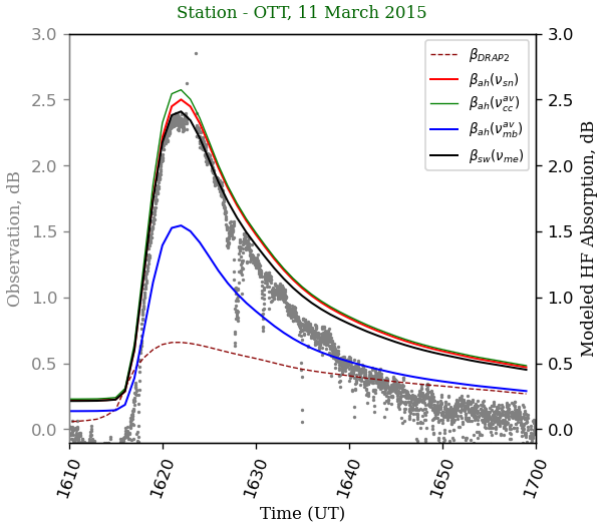

Figure 1. A data-model comparison of high frequency absorption for an shortwave fadeout event observed using Ottawa riometer (gray dots) following a solar flare on March 11, 2015. The prediction of the new model using the four different dispersion and collision frequency formulations are shown by the solid red, green, blue, and black curves, respectively, while the prediction by D-region Absorption Prediction is shown with the dark-red dashed curve.

References

[1] S. Chakraborty, J. M. Ruohoniemi, J. B. H. Baker, and N. Nishitani, "Characterization of short-wave fadeout seen in daytime superdarn ground scatter observations," *Radio Science*, vol. 53, no. 4, pp. 472–484, 2018.

[2] S. Chakraborty, J. B. H. Baker, R. A. D. Fiori, J. M. Ruohoniemi, and K. A. Zawdie, "A modeling framework for estimating ionospheric hf absorption produced by solar flares," *Radio Science*, vol. 56, no. 10, p. e2021RS007285, 2021.