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Session 5B Paper 2
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Ensemble Inversion Method for ISIS II Topside Ionograms

The ISIS II topside sounding satellite was launched in 1971 and provided data until 1990. Topside data were recorded and archived on magnetic tape. A substantial portion of the data set was reproduced on 35mm film to enable manual analysis, but it is difficult to integrate film data with modern data analysis methods. Thus Space Environment Corporation (SEC) carried out a pilot project to convert films covering selected space weather events to digital form. Software has been developed to extract ionogram frames from the film and determine the virtual range and frequency scales. The geographic latitude, longitude, and altitude of the satellite is computed from the time stamps on the ionograms.

The ionogram inversion code originally developed by J. E. Jackson (Proc. IEEE, 57, 960, 1969) for the analysis of the topside datasets has been updated to run in the Linux environment. In addition, a new inversion code has been developed by C. Torre from first principles for comparison. The original code uses the ionogram X trace for its inversion; that trace is usually relatively well defined, but the inversion procedure is more complicated. The new method can use the X trace, but it can also use the O trace, which is often more difficult to identify clearly. Thus two independent analysis methods are available which can use two representations (O and X) of the topside ionogram.

Topside ionogram traces often have significant thickness in virtual range, particularly at high latitudes. Additionally, the presence of plasma resonance lines can make the determination of the critical frequencies at the satellite (fxS and foS) imprecise. To quantify the uncertainties involved in specifying the traces, upper and lower bound traces are specified and inverted, providing a set of bounding electron density profiles (EDPs) for each trace and method. This set of six EDP estimates (two each from Jackson X, Torre O, and Torre X) can be further augmented by utilizing different analysis options in the Jackson code, and the estimates can be weighted according to the quality of the traces used for the inversion. The ensemble analysis of these EDP estimates provides a best estimate of the EDP including uncertainties.

SEC has previously demonstrated the ability to extract EDPs from bottomside ionograms archived on 35mm film so it would be possible to obtain bottomside profiles from archived high-latitude ionosonde data. However, high-latitude ionograms tend to be complicated by

absorption, sporadic/auroral E, and spread F, particularly during space weather disturbances. Once good bottomside profiles have been obtained, there may be challenges in harmonizing bottomside and topside data; these challenges will be reviewed briefly.

This study presents several examples of ionogram inversions using the Jackson and Torre methods for different levels of geomagnetic activity at high latitudes. The practicality of converting and analyzing large quantities of the archived topside sounding film archives to online data collections is discussed.