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Inversion of HF radar backscatter data in order to map and model the ionosphere

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Methods of inverting HF backscatter ionograms to obtain ionospheric profiles offer an important means of remotely sensing the distant ionosphere. In the case of ground backscatter, the received signals are reflected from distant locations on the Earth's surface. The ionosphere is the medium through which both the transmitted and received signals traverse. The signals backscattered from the sea or land contain useful information regarding the state of the intervening ionosphere at the time and over the range of the returned signal, which could be a few thousand kilometers from the transmitter/receiver location. We have developed a new backscatter inversion technique requiring the elevation angle and group path of the received signals. The technique derives quasi-parabolic ionospheric layer parameters by inverting layer echo traces consisting of the measured elevation angle versus group path profile. The quasi-parabolic segment (QPS) ionospheric model consists of 5 QPSs representing the E, F1, and F2 ionospheric layers. At least 3 data points are required from each of the layer echo traces. The maximum elevation of each of the ionospheric layer echo traces is also required. The technique can work for both fixed frequency radar and frequency scanning radar. The advantage of frequency scanning radar is that the down-range gradients in electron density can also be determined.

This new inversion technique is robust enough to use on measurements of elevation angle versus group path obtained with SuperDARN radars. Here we illustrate the technique using synthetic data, and fixed- and multi-frequency measurements made with the TIGER Bruny Island radar (43.4°S, 147.2°E; 55°Λ). The HF radar cross section is usually greater for the sea than land or ice, and the sea scatter observed using TIGER is often continuous and intense, thereby improving the quality of results. Since the multi-frequency measurements were also made on all 16 beams, the inversion technique can be used to recover information about the 3-dimensional structure of the ionosphere. Thus global scale reconstruction of the ionosphere using the radar network will be enhanced by the deployment of new radars with footprints which encompass remote oceanographic regions. These are also regions which are usually poorly covered by vertical ionosonde measurements. Finally, the accuracy of the inversion results are determined by the accuracy of the elevation angle data which, in turn, are determined by the accuracy of phase differences measured between radar receivers. The latter measurements will be more consistent and reliable using fully digital SuperDARN radars.