L1-NORM AND WAVELET TRANSFORM TECHNIQUES FOR ESTIMATING INCOHERENT SCATTER POWER AND LAG-PROFILES IN THE PRESENCE OF INTERFERENCE OR A RAPIDLY VARYING IONOSPHERE.

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Incoherent scatter power and lag-profile measurements must be integrated over many samples in order to reduce the variance of the estimates to a useful level. Typically integration periods on the order of tens of seconds to a few minutes are required to measure ionospheric parameters with sufficient accuracy.

The measurements can be corrupted or rendered useless if they include a non-ionospheric component such as radio frequency interference (RFI) or a satellite in the beam. Little can be done if severe RFI persists throughout the integration, but frequently this type of interference occurs in bursts and lasts only a few seconds. Satellites also remain in the beam for much less than a typical integration period. We have implemented a technique which supplements the usual L2-norm (mean) estimate of the integrated lag-profiles with an L1-norm (median) estimate. Each integration is divided into up to 64 subintegrations and the median of each series of lag-products is computed. Then, either a range-dependent sliding median or L1 cubic spline fit can be computed for each lag-profile, which is particularly useful for alternating-code measurements. In practice, this procedure usually eliminates almost all external interference and sufficiently improves alternating-code measurements that we have been able to eliminate single-pulse measurements in most Millstone Hill combined E-F region experiments.

While it has proven very effective, this technique does not address changes in the ionospheric return which occur or a time scale shorter than the predefined integration period. These changes can be either truly temporal, or the result of antenna motion, as when an azimuth scan moves the beam through an ionospheric feature such as the mid-latitude trough. We have addressed this problem by applying wavelet denoising to long time-series of very short integration periods of, for example, 100 samples. This procedure can isolate changes greater than the inherent accuracy of the short integration (10% for 100 samples of the power profile) with a time resolution equal to the length of the short integration (1 s for 100 samples/s). This effectively amounts to adaptive integration, with the length of each integration period determined by the data instead of being a fixed period of time. A depth 7 wavelet transform of 1 s samples yields integration periods of 1 to 128 s, depending on how rapidly the signal is changing. Very short bursts of interference are also isolated with a resolution equal to the short integration period. Various wavelet transforms can be employed in this technique.

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2. G - Ionospheric Radio and Propagation

3. (a)

4. C - Contributed Paper, Program chair: John Sahr, Frank Lind

5. No special instructions