Improved Fitted Data and Errorbars for SuperDARN

Ashton S. Reimer\(^{(2)(1)}\), Glenn C. Hussey\(^{(1)}\), and Kathryn A. McWilliams\(^{(1)}\)

\(^{(1)}\) Institute of Space and Atmospheric Studies (ISAS), Department of Physics and Engineering Physics, University of Saskatchewan, Saskatoon, SK, Canada
\(^{(2)}\) SRI International, Menlo Park, CA, USA

Extended Abstract

An improved fitting methodology for better determining the fitted parameters and fitted parameter errors from SuperDARN radar data has been developed and validated. The current Super Dual Auroral Radar Network (SuperDARN) fitted data lacks statistically rigorous error estimates. At the present, the error-weighted least-squares fitting algorithms implemented by SuperDARN utilize \textit{ad hoc} data rejection criteria and \textit{ad hoc} estimates of the variances for the lags of the mean autocorrelation functions (ACFs) that are fitted. For ionospheric signals with large signal-to-noise (SNR) ratios, problems associated with using the \textit{ad hoc} criteria do not significantly affect the fitted data. This represents the vast majority of SuperDARN fits available at the present. However, in low SNR (typically rejected at the present due to the low SNR) and/or low signal-to-clutter regimes the \textit{ad hoc} criteria often produces significantly underestimated fitted parameter errors and in some cases, erroneously fitted data. The \textit{ad hoc} criteria do not properly account for the relative contributions of signal, noise, and clutter to the variance of each lag of the mean ACF.

Instead of using \textit{ad hoc} estimates of the variance, the new methodology presented here utilizes estimates of the variance of the real and imaginary components of the lags of the mean ACF. These estimates were derived from first-principles by [1] and include the relative contributions of signal, noise, and clutter. Clutter is estimated using a maximal power-based self-clutter estimator derived by [2]. The improved fitting methodology was validated using synthetic mean ACFs that were produced using the SuperDARN radar data simulator of [3].

The improved fitting methodology results are self-consistent and reliable quantitative measures of the uncertainty in the fitted parameters. Some case studies and statistical comparisons between the improved fitting methodology and the current SuperDARN fitting technique are presented and it is shown that the improved fitting methodology consistently produces reliable errorbars for SuperDARN fitted data. Additionally, the statistical study found that the improved fitting methodology (for fitted data with a SNR in excess of 3 dB and a velocity error below 100 m/s) produces 52% more data compared to the current SuperDARN technique.

References

