A statistical characterisation for quasi real-time tracking of magnetospheric regions with SuperDARN

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With its global coverage, high time resolution and real-time data access, SuperDARN is one of the most appropriate instruments for identifying the ionospheric footprints of the various magnetospheric regions. Several studies have revealed a clear dependence of the backscatter properties with geomagnetic location, and shown, for example, that the Doppler spectral width seems to be a reliable proxy for the open-closed field line boundary, at least in the morning sector. A single parameter is nevertheless not sufficient, and Andre and Dudok de Wit (2002) introduced a multivariate statistical method in order to characterise these regions using three keys parameters (Doppler spectral width, power error and phase error). Using no prior physical information, their results revealed a strong connection between specific geophysical regions and the statistical characteristics of the radar echoes. This provides an interesting basis for developing a model capable of monitoring magnetospheric boundaries in near real-time.
In order to operate in near real-time, it is desirable to stay as close as possible to the raw data. Consequently, we propose to apply the same data reduction method as in the aforementioned study (i.e. the Singular Value Decomposition - SVD), on the modulus of the autocorrelation functions (ACF). Starting from the 18 lags defining the ACF modulus, we perform a reduction of the ACF power dimension and characterize the signal in each radar gate with 3 coefficients. The ratio of the first two coefficients describes the spectral width while the third coefficient seems to be related to the shape. By linearly combining these three modes, we can reconstruct the salient features of all observed ACFs.
We study the spatial distribution of these three statistical parameters in order to determine which ionospheric regions can be identified by the method. Then, we use the new proxy of the spectral width to characterize the open/closed field-line boundary, which appears as a latitudinal gradient in spectral width. We define a Bayesian classifier in order to identify the two classes of spectral widths and their boundary without needing to define a specific threshold. The results agree quite well with former studies, while our method is better suited for tracking a boundary with sparse data and does not need any a-priori model of the ACF shape. Our final objective is to develop a model, based exclusively on the statistical properties of the autocorrelation functions, while being able to identify magnetospheric boundaries.