Monitoring Magnetospheric boundaries using the statistical properties of SuperDARN radars echoes
G. Lointier¹, T. Dudok de Wit¹, C. Hanuise¹, J-P Villain¹

¹CNRS-LPCE UMR 6115/Université d’Orléans (FRANCE)

Justification and Motivation:
- Several studies of the SuperDARN radars have revealed a dependence between the statistical properties of the radar echoes and the ionospheric footprint of magnetospheric boundaries (esp. Auroral oval).

Our objective: Detect and Monitor magnetospheric boundaries in real time.
- Application of the Singular Value decomposition (SVD) method (see lower right hand panel) by R. André & T. Dudok de Wit (2002) to fitted data revealed the possibility to characterise different boundaries (see pictures right) based only on key parameters such as the spectral width.
- In order to monitor in real time, we propose to apply this approach directly to the raw data (Complex Autocorrelation Function - CAF) instead of the more usual physical parameters which require specific modelling.

Characterization of the CAF component
We take a case study based on a sample covering four days of measurements, one day for each season.

We apply the Singular Value Decomposition to the modulus of the CAF (see figure (a) for an example of CAF). The CAFs are thereby decomposed into separable functions of time, and time lag.

- Figure (b) represents the weights of 18 modes found with the SVD method.
  Three modes stand out, i.e most of the variability is captured by three modes.

- Figure (c) shows these 3 modes.
  By linear combination of these three modes, we can reconstruct the salient features of all observed CAFs.

Conclusion & Perspective
- Different statistical properties of the radar echoes coincide with the ionospheric footprint of different magnetospheric boundaries.
- Owing to the redundancy of the shape of the CAFs, the latter can be fitted
  By a linear combination of 3 modes only.
- As a by product: bad data in the CAFs can now be corrected more easily.
- Next step: use these 3 modes to perform real-time classification of the CAFs and thereby locate magnetospheric boundaries.

Singular Value Decomposition
Our database is a two-dimensional array. The first dimension represent the sample number of the CAF (i.e one event i) and the second dimension is the time lag.

The SVD decomposes this array into a set of separable modes. In doing so, it concentrates the salient features into the first modes, i.e those that have the largest weights $w_k$.

$$A(i, \tau) = \sum_k w_k f_k(i) g_k(\tau)$$

$$<f_k, f_l> = <g_k, g_l> = \delta_{kl}$$

- The $f$ and $g$ modes are orthogonal.