Automatic FLR identification and density estimation from SuperDARN VLOS data to identify magnetospheric regions

Hideaki Kawano[1], Akira Sessai Yukimatu[2], Nozomu Nishitani[3], Yoshimasa Tanaka[2], Satoko Saita[4], Tomoaki Hori[3], and Mark Lester[5]

[1]*International Center for Space Weather Science and Education, Kyushu University, Japan*

[2]*National Institute of Polar Research, and Department of Polar Science, SOKENDAI, Japan*

[3]*Institute for Space-Earth Environmental Research, Nagoya University, Japan*

[4]*National Institute of Technology, Kitakyushu College, Japan*

[5]*University of Leicester, UK*

Where the frequency of waves coming into the magnetosphere matches the eigenfrequency of a geomagnetic field line, which runs through the ground, the ionosphere, and the magnetosphere, FLR (field-line resonance) can cause the eigen-oscillations of the field line. The FLR-generated eigen-oscillation can be identified from the combination of the maximum in its power and the steepest change in its phase at its eigen-frequency (called the FLR frequency below). From thus identified FLR frequency one can estimate the density along the magnetic field line, because, in a simplified expression, 'heavier' field line oscillates more slowly.

Since the pulsations oscillate the ionospheric plasma, too, there could exist cases in which SuperDARN radars monitor the two-dimensional (2D) distribution of the FLR frequency, from which we can estimate 2D plasma-density distribution on the magnetospheric equatorial plane, including the location of the plasmapause. However, visual identification of the FLR in the SuperDARN VLOS (Velocity along the Line of Sight) data is time-consuming, and the visual identification could miss FLR events superposed by non-FLR oscillations of VLOS (which could be called 'hidden' FLR events). In addition, there are lots of VLOS data to be analyzed.

We have therefore been developing a computer code to automatically identify the FLR by using the Gradient methods, as explained just below. The term "Gradient methods" refers to both the amplitude-ratio and the cross-phase methods. This method cancels out the superposed perturbations by dividing the data from a Range Gate (RG) by the data from a nearby RG along the same beam, since the FLR frequency tends to depend on the latitude more strongly than the superposed perturbations. Another advantage of applying the Gradient methods to the SuperDARN VLOS data is that we can choose any pair of RGs (along the same beam) with different distances, and thus can identify what distance is the best to identify the FLR. This distance reflects the resonance width, which is an important quantity reflecting the diffusion and dissipation of the FLR energy.

We have so far developed a code specific to the HAN and PYK radars, applied the code to their VLOS data in an interval near the occurrence time of a Sudden Commencements (SC). In this interval we had visually identified an FLR event in a few beams by visually examining the raw amplitude and phase distribution along the beams.

We have confirmed that our automatic code identifies them at the same locations, if we use RG pairs whose RG numbers are different by two. We also note that the PYK radar, which was located near the noon for this event, observed a large area near the noon with wavy perturbations which did not show clear FLR features with the visual examination. In this area, our code has identified possible 'hidden' FLR at a RG pair along a beam.

We are now generalizing the code so that it can be applied to any VLOS data from any SuperDARN radar. By using the code we expect to identify much more FLR events than by visual identification; the automatically identified FLR events would include events simultaneously observed at several locations by several radars, increasing the possibility of monitoring the 2D distributions of plasma density distribution on the magnetospheric equatorial plane.