Magnetospheric-density estimation from SuperDARN VLOS data to identify magnetospheric regions, by using FLR events in ionospheric or ground/sea backscatters

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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. By using the frequency of the eigen-oscillation, called the 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 small-amplitude FLR events and "hidden" FLR events which are superposed by non-FLR perturbations. In addition, there are lots of VLOS data to be analyzed.

Thus, we have been developing a computer code to automatically identify the FLR for any beam of any radars, by using the amplitude-ratio method and the cross-phase methods; these methods cancel out the superposed non-FLR perturbations by dividing the data from a Range Gate (RG) by the data from a nearby RG along the same beam, because the FLR frequency tends to depend on the latitude more strongly than the superposed non-FLR perturbations. Another advantage of applying these 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. In the early phase of the code development, we confirmed that the code identified FLR events which we had visually identified in a few beams of a few radars.

The code needs to automatically distinguish whether the identified FLR was in the ionospheric backscattered signal or in the ground/sea backscattered signal; for the latter, the code needs to find the ionospheric reflection point, which is the actual location of the observed FLR. We implemented these features and tested them for a few radars, and found that the ground/sea events tended to be located at latitudes fairly lower than those of simultaneously-observed ionospheric events. We also calculated, for each event, the corresponding magnetospheric equatorial density, and found that the ground/sea events tended to show pretty much lower density than the ionospheric events located at similar latitudes. We thought that these differences could come from the pretty low frequency resolution, thus we increased them by using the zero-padding method. As a result, these differences did get smaller. We will at least implement the zero-padding method into our code.

From another viewpoint, there exist more recent, more advanced methods to increase the frequency resolution. We intend to test them and show the results at the presentation.

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 distribution of the plasma density on the magnetospheric equator and identifying magnetospheric regions.