The precision of the FLR frequency and the magnetospheric density obtained by applying the DTFT to the SuperDARN VLOS data

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Some of the fluctuations in the solar wind, including those causing sudden impulses (SI), propagate into the magnetosphere and excite eigen-oscillations of the magnetic field lines and the frozen-in plasma via the mechanism called field-line resonance (FLR). It is known that the gradient methods enable us to effectively extract FLR signals from observed data. From the identified FLR frequency, one can estimate the mass density of plasma along the magnetic field line because, in a simplified expression, 'heavier' field line oscillates more slowly.
We have been applying the gradient methods to the VLOS (Velocity along the Line of Sight) data of the SuperDARN radars. The radars emit azimuthally-collimated beams of radio waves in the HF range, and some of them are backscattered by the ionosphere, while some others are backscattered by the ground and sea surface. From the Doppler shift of backscattered signals, one can calculate VLOS. Ionosphere-backscattered signals yield VLOS of the horizontally-moving ionospheric plasma (at mid- to low latitudes, VLOS also has a vertical component because the ambient magnetic field is tilted), while ground/sea-backscattered signals yield VLOS corresponding to the vertical motion of the ionospheric plasma because the length of the ray path of a beam can only be changed by the vertical motion of the ionosphere.
We have so far applied the gradient methods to VLOS for a few events after SI's, and identified an FLR event in which ionosphere-backscattered signals and sea surface-backscattered signals were simultaneously observed. The mass density was thereby estimated using both scatters. As a result, the latter was significantly smaller than the former in the nearby place. This significant difference could come from a fairly large frequency spacing of the FFT analysis due to the fairly small duration (30 min) of the event.
Thus, we have developed codes to apply the Discrete-Time Fourier Transform (DTFT) method to timeseries data in general. This method is designed to be applied to timeseries data with a constant sampling time. An advantage of this method is that it uses provided data only; that is, it accepts data gaps, unlike the FFT. Another advantage of this method is that it can calculate the Fourier Transform (FT) at any frequency (below the Nyquist frequency).
We have so far developed the Discrete-Frequency DTFT (DF-DTFT), which calculates DTFT with a constant frequency spacing. The DF-DTFT results can easily be compared with the FFT results when the frequency spacing of the DF-DTFT is set the same as that of the FFT. We have been applying the DF-DTFT to the SuperDARN VLOS data for an event, and the results suggest preciseness at any frequency spacing.
We will present the results with details at the meeting.

