Improved hodograph method (to identify field-line resonance on the ground) and error estimates

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Magnetospheric magnetic field lines eigen-oscillate with frequencies in the ULF range. The main power source of the eigen-oscillations are low-frequencey waves in the solar wind: Where the frequency of a wave coming from the solar wind region into the magnetosphere matches the eigen-frequency of a magnetospheric field line, the field line resonance (FLR) causes the field line in question to eigen-oscillate. Thus generated eigen-oscillations are useful for us to estimate the magnetospheric plasma mass density from the ground, because the eigen-frequency (FLR frequency below) decreases with increasing plasma mass along the field line.

However, FLR frequencies are often difficult to identify in the ground magnetometer data, because different kinds of waves with large amplitudes are often superposed onto the FLR signal and mask the FLR signal.

As countermeasures to this problem, methods called amplitude-ratio method and cross-phase method have been used; these methods take the difference between the data from two magnetometers that are latitudinally separated by an order of 100km. However, a problem here is that the two methods can yield different values of the FLR frequency from the same dataset. Another problem is that neither method can provide an estimation error (error bar) of the estimated FLR frequency.

Hodograph method is a solution to the former problem, because it merges the amplitude-ratio method and the cross-phase method into one method. Furthermore, it can estimate the resonance width. However, the resonance width is assumed to be a constant of latitude in the hodograph method, while in reality the resonance width can be a function of latitude. Furthermore, the hodograph method is still unable to provide an estimation error of the FLR frequency.

In this paper we improve the hodograph method to solve the above-stated problems. That is, we introduce a latitude dependence of the resonance width into the hodograph method, and we also introduce into the method a framework to estimate errors. We have tested the validity of these modifications by applying the modified method to simulated datasets, and the result is successful. That is, as a result of applying the improved method to the simulated datasets, we obtain the latitude-dependence of the resonance width and an error bar of the FLR frequency that are close to those already input into the simulation data.