Automatic detection of Pc1 pulsations in Swarm's high-frequency magnetic measurements

Tamás Bozóki1,2, Balázs Heilig1,2

1HUN-REI Institute of Earth Physics and Space Science, Sopron, Hungary
2ELTE Eötvös Loránd University, Institute of Geography and Earth Sciences, Department of Geophysics and Space Science, Budapest, Hungary

I. Background

- Pc1 pulsations cover the 0.2-5 Hz frequency range. This frequency range is generally accepted to include waves that are referred to as electromagnetic ion cyclotron (EMIC) waves based on their excitation mechanism.
- In general, EMIC waves are generated as transverse, left-handed polarized waves, and reach the ionosphere by propagating along the geomagnetic field lines. In the ionosphere the initially transverse waves also generate compression waves, which can propagate long distances parallel to the Earth's surface.
- EMIC waves play an important role in the Earth’s magnetosphere (Fig. 1), as they can precipitate relativistic electrons from the outer radiation belt and energetic protons from the ring current. Hereby, their observation provides important information about the energy coupling between the ionosphere and the magnetosphere as well as the particle dynamics inside the Earth’s magnetosphere.

II. Detection

The automatic detection and characterization of Pc1 geomagnetic pulsations based on HR magnetometer data (MAGx_HR_1B) consists of five main steps (see also Fig. 2 presenting the process in a flowchart). First, the magnetic measurements are transformed into a field-aligned coordinate system. Then, the spectrograms of the field components are calculated and different types of noise are removed from the spectrograms. In the third step, Pc1 candidate events are determined based on peak finding and the coherence of the field components. Next, the spectral peaks are grouped into events. Finally, the mean properties of the identified Pc1 events are calculated.

III. Event characteristics

The extracted individual Pc1 events are characterized by the following quantities:

- Orbit number,
- Flight direction,
- Mean time of observation,
- Mean position in ITRF - Geocentric latitude,
- Mean position in ITRF - Geocentric longitude,
- Mean position in ITRF - Geocentric radius,
- Mean QD latitude,
- Mean QD longitude,
- Mean magnetic local time,
- Event duration,
- Mean frequency,
- Standard deviation of the spectral peak frequencies,
- Mean spectral peak halfwidth,
- Mean power,
- Mean prominence,
- Rate of frequency change,
- Overall quality.

Acknowledgement

The work was supported by Swarm DISC under the contract number 4000109587/13/I-NB. TB’s work was also supported by the UNKP-22-4 New National Excellence Program of the Ministry for Innovation and Technology from the source of the National Research, Development and Innovation Fund.

References

Reeves, G. D. et al. (2016), Energy-dependent dynamics of keV to MeV electrons in the inner zone, outer zone, and slot regions, JGR Space Physics, 121, 397–412
Kim, H. et al. (2018). Global characteristics of electromagnetic ion cyclotron waves deduced from Swarm satellites. JGR. Space Physics, 123, 1325–1336.