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

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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**.

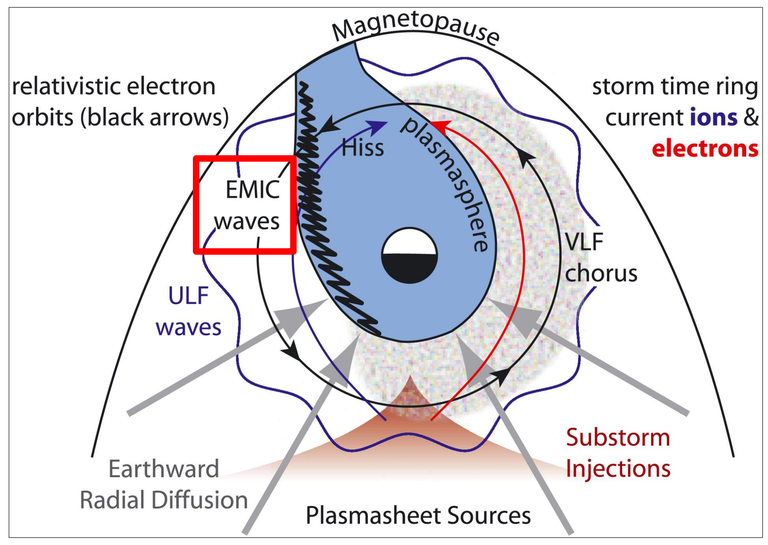

Fig.1 A schematic illustration of radiation belt structures and processes (Reeves et al., 2016).

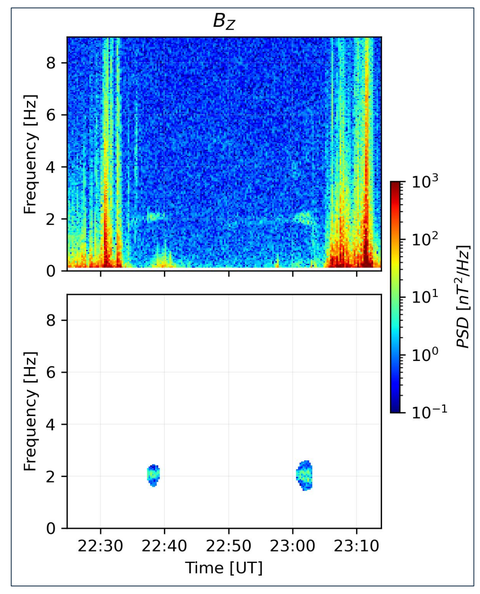

Fig.3 Visual example for the detection of Pc1 events.

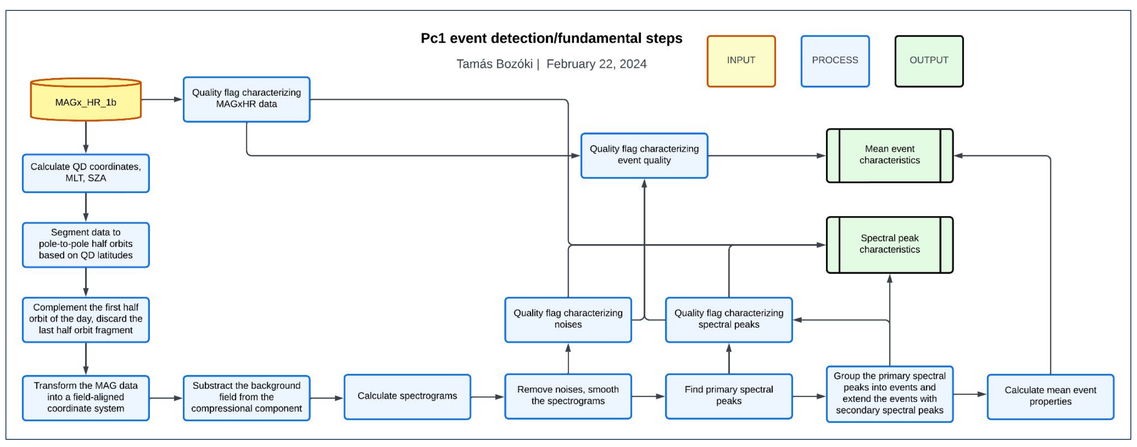

Fig.2 Flowchart showing the main steps of Pc1 detection.

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.

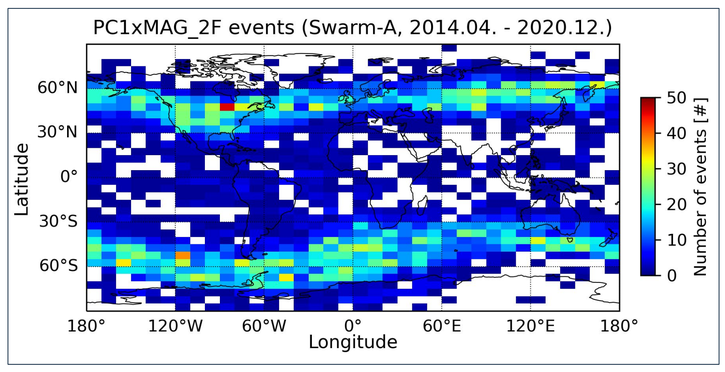

Fig.4 Geographic distribution of Swarm A PC1xMAG_2F events from April 2014 to December 2020.

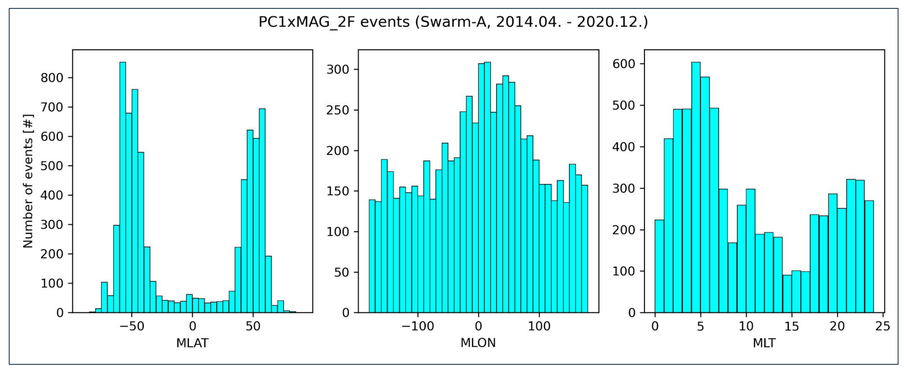

Fig.5 Spatial distribution of Swarm A PC1xMAG_2F events from April 2014 to December 2020 as a function of magnetic latitude (MLAT), magnetic longitude (MLON) and magnetic local time (MLT).

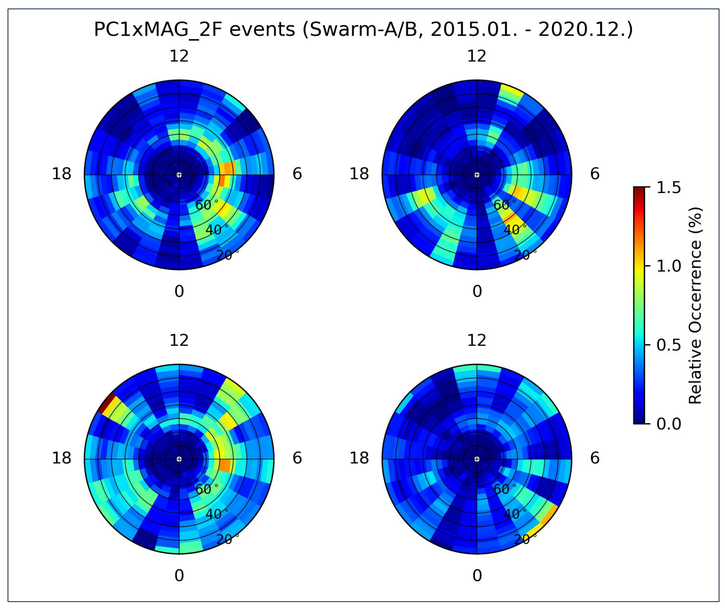

Fig.6 Geomagnetic distribution of ducted PC1xMAG_2F events as a function of MLT and MLAT observed by Swarm A (top row) and Swarm-B (bottom row) in the SH (left column) and NH (right column) between January 2015 and December 2020.

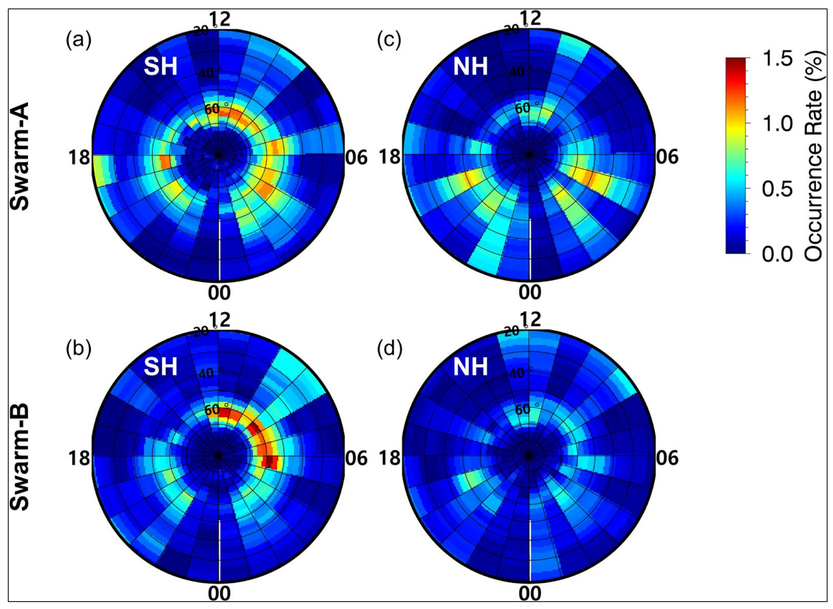

Fig.7 The same as Fig.6 as presented by Kim et al. (2018a).

Acknowledgement

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