Wavelet-Based ULF Pulsation Index for Studying Conjugate ULF Pulsation at High Latitudes and Its Applications to Space Weather

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Abstract
A wavelet-based index is described in this study and applied to present geomagnetic Ultra Low Frequency (ULF) pulsations observed in Antarctica and their magnetically conjugate locations in West Greenland. The index is effective for identification of pulsation events in the Pc4-5 frequency range, which is related to the Geomagnetically Induced Currents (GICs) shown by many researchers, and measures important characteristics of ULF pulsations in both the temporal and frequency domains. We discuss how the wavelet indices can be used to monitor geomagnetic pulsations in both hemispheres simultaneously.

I. Introduction
Geomagnetic pulsations: Ultra-low-frequency (ULF), lower than the natural frequencies of the plasma, like plasma frequency and the ion gyrofrequency.

Typical classification scheme (Jacobs et al., 1964):

<table>
<thead>
<tr>
<th>Pulsation Classes</th>
<th>Irregular pulsations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type T Pq1 Pq2 Pq3 Pq4 Pq5 Pq6</td>
<td>5-10s 10-45s 45-150s 150-600s 600s 1-40s 40-450s</td>
</tr>
<tr>
<td>f Hz</td>
<td>0.2-5 0.1-5 22-75 7-20 0.025-2 2-20</td>
</tr>
</tbody>
</table>

Geomagnetically-induced currents (GICs)
GICs are produced by a naturally induced geoelectric field during geomagnetic disturbances, which varying along electric power-transmission systems and other electrically-conducting infrastructure. As an example, during the great magnetic storm of March 1989, these currents caused wide-spread blackouts across the Canadian Hydro-Quebec power grid, resulting in the loss of electric power to more than 6 million people (Allen, 1989, Thomson, 2010).

II. Data and Method
Fluxgate Magnetometer DATA
Autonomous Adaptive Low-Power Instrument Platform (AAL-PIP) operated by Magnetosphere-Ionosphere Science Team (MIST) Group at SPACE@VT (http://mist.riar.org/).

West-Coast Greenland ground network. (Operated by DTU Space (http://www.space.dtu.dk/English/Research/Scientific_data_and_models/Magnetic_Ground_Stations.aspx)

Wavelet Analysis
It allows decomposing the geomagnetic data into the different frequency bands which still keep localized time-varying features. This provides the possibility to separate the variations according to the frequency bands of their drivers which are from the current systems in ionosphere and magnetosphere.

III. Results: examples of wavelet-based indices on conjugate ULF pulsations caused during SI events on 20130119

IV. Discussion and conclusion
1. The results indicate that the wavelet-based index of (ULF) pulsations is effective for identification of pulsation events in the Pc4-5 frequency range in both hemispheres. It presents important characteristics of ULF pulsations in both the temporal and frequency domains for inter-hemispheric comparisons at conjugate locations.
2. The comparison of geomagnetic pulsations in both hemispheres simultaneously reveals the similarities and differences of ULF pulsations in both hemispheres. Especificaly, vertical magnetic field (Bz) perturbations were observed more evident since the Greenland chains are located near the coastal area, while the Antarctic chains are over thousands meters of the ice-sheet on the East Antarctic plateau.
3. Using additional observations and simulations, inter-hemispheric comparisons can be used to reveal how sensitive ULF pulsations are to ground conductivity, further more, applied to space weather monitoring.

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