ELF Whistler Dependence on a Sunlit Ionosphere

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Abstract

Whistler-like spectral features in the extremely low frequency (ELF) range have been observed at the South Pole Station. Analysis of the first full year of data reveal a correlation between the occurrence of ELF whistlers and the solar zenith angle (SZA). ELF whistlers stop appearing for the duration of the polar winter, when the SZA increases to greater than 80°. Previous studies at lower geographic latitudes all observed a noon-time peak in the occurrence rate, which led to speculation of source mechanisms in the dayside magnetosphere, the extended polar winter allows for a separation of "dayside" and "sunset" conditions. The absence of ELF whistlers in the polar winter implies that ELF whistler explicitly depend on local ionospheric conditions.

1. Introduction

ELF whistlers are narrow-band dispersive spectral features in the lower ELF range (1-250 Hz) that descend monotonically in frequency, typically over timescales on the order of a minute. Observations were first reported at auroral latitudes [Heacock, 1974], and have since been reported at mid-latitudes [Sentman and Ehring, 1994], low latitudes [Wang et al., 2005], and polar latitudes [Kim et al., 2006].

Wang et al. [2011] demonstrated that ELF whistlers are most likely right-hand polarized ion cyclotron waves. However, there is still no established physical basis for why these signatures tend to appear only on the dayside.

The work in this poster examines the first full year of data taken at the geographic south pole and reveals behavior that appears to be the occurrence of ELF whistlers in a sunlit ionosphere.

Objectives

- Demonstrate connection between occurrence of ELF whistlers at the geographic south pole and a sunlit ionosphere
- Determine correlation between solar flux levels and the occurrence rate of ELF whistlers
- Examine ionosphere conditions during detection of ELF whistlers

2. Methodology

ELF power spectra were manually inspected in 1-hour plots for whistler signatures. Events were individually expanded in 2 minute spectra to determine $\delta t$ and $\Lambda$.

3. 2004 ELF Whistler Statistics

Frequency range of ELF Whistlers at South Pole

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 Hz</td>
<td>126</td>
<td>7</td>
</tr>
<tr>
<td>1 - 30 Hz</td>
<td>259</td>
<td>15</td>
</tr>
<tr>
<td>30 Hz - 1 Hz</td>
<td>126</td>
<td>7</td>
</tr>
<tr>
<td>&gt; 1 Hz</td>
<td>259</td>
<td>15</td>
</tr>
</tbody>
</table>

Average Values

<table>
<thead>
<tr>
<th>Data</th>
<th>Pct.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>94%</td>
</tr>
<tr>
<td>Sun</td>
<td>57%</td>
</tr>
<tr>
<td>Cloud</td>
<td>22%</td>
</tr>
</tbody>
</table>

4. Initial results

- ELF whistlers stop appearing for the duration of the polar winter, when the SZA increases to greater than 80°.
- Previous studies at lower geographic latitudes all observed a noon-time peak in the occurrence rate, which led to speculation of source mechanisms in the dayside magnetosphere.
- Polar winter allows for a separation of "dayside" and "sunset" conditions.
- Absence of ELF whistlers in the polar winter implies that ELF whistler explicitly depend on local ionospheric conditions.

5. Comparison to F10.7 solar flux index

- ELF whistler data compared to daily occurrence rate of ELF whistlers at South Pole Station during 2004 and 2010. Chart shows correlation between SZA and solar flux levels.

6. Comparison with IRI

- Diagram showing correlation between ELF whistler occurrence and IRI model output.

7. Bimodal/Diurnal Behavior

- Prior ELF whistler observations exhibit a diurnal variation in the occurrence times, which fits with the connection to a sunlit ionosphere.
- South pole data also displays a diurnal pattern, but the SZA is nearly constant over the course of a single day.

8. Conclusions

- ELF whistlers are connected to the effects of a sunlit ionosphere.
- Higher solar flux levels (as illustrated by F10.7 solar flux index) increase probability of occurrence.
- Trends in ionospheric composition during occurrence of ELF whistlers matches at both low and polar latitudes.

Outstanding Questions:

- What causes daily change of ion composition at south pole?
- Why does diurnal variation of ELF whistlers track the dayside location of geomagnetic south pole?
- What is different about events in 100 Hz bin that causes the cluster in the post-midnight sector?

Caveat: An apparent drift in system time is corrected using 6 hour offset it 2nd half of year. Time offset is verified by technician records at SP station and corroborated by 2010 data set.