Improved techniques for monitoring and investigating polar cap absorption: Understanding space weather effects on HF radio communication

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Instrument - Riometer

Day
Night
Quiet Day Curve
Absorption

Voltage (V)

Mar 06  Mar 07  Mar 08  Mar 09  Mar 10  Mar 11  Mar 12  Mar 13

UT time in 2014

Canada
Absorption

\[ A \ (dB) = 10 \log \frac{P}{P'} \]

- \( P' \) measured noise power
- \( P \) noise power that would have been received on a quiet day
Impacts to HF radio communication

- Absorption is of direct importance to the safety of transpolar flights which communicate using the affected radio signals
Solar protons are accelerated to near relativistic speeds by the CME shock front, reaching the Earth after a few hours.
Objective

- 2D modelling of ionospheric absorption at high-latitudes
- Development of an operational prototype to indicate where HF radio communication is likely to be compromised
Modelling absorption

\[ A = m \left[ J(E > E_0) \right]^{1/2} \]

- modelled absorption
- proportionality constant
- threshold energy
- integral proton flux

<table>
<thead>
<tr>
<th></th>
<th>( m ) [dB(cm(^2) s sr(^{1/2})]</th>
<th>( E_0 ) [MeV]</th>
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<tbody>
<tr>
<td>Dayside</td>
<td>0.115</td>
<td>5.2</td>
</tr>
<tr>
<td>Nightside</td>
<td>0.020</td>
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Sellers et al. (1977)
Modelling absorption: D-RAP

\[ A = \begin{cases} 
A_D = m_D \left[ J(E > 5.2 \text{ MeV}) \right]^{\frac{1}{2}} \\
A_N = m_N \left[ J(E > 2.2 \text{ MeV}) \right]^{\frac{1}{2}} \\
A_D \frac{\varepsilon + 10^\circ}{20^\circ} - A_N \frac{\varepsilon - 10^\circ}{20^\circ} 
\end{cases} \]

\[ \varepsilon \geq 10^\circ \]

\[ \varepsilon \leq -10^\circ \]

\[ -10^\circ < \varepsilon < 10^\circ \]

Sauer and Wilkinson (2008)
Modelling absorption: optimization

\[ A = \begin{cases} 
A_D = m_D \left[J(E > 5.2 \text{ MeV})\right]^{\frac{1}{2}} & \varepsilon \geq 10^\circ \\
A_N = m_N \left[J(E > 2.2 \text{ MeV})\right]^{\frac{1}{2}} & \varepsilon \leq -10^\circ \\
A_D \frac{\varepsilon+10^\circ}{20^\circ} - A_N \frac{\varepsilon-10^\circ}{20^\circ} & -10^\circ < \varepsilon < 10^\circ 
\end{cases} \]

Rogers and Honary (2015)
Prototype product
Prototype product: Summary

- NRCan PCA modelling software package and operational prototype Version 1.0
- Generalized ‘qualitative indicator’ of absorption, limited by D-RAP
- Exact values and small-scale resolution not currently possible
- Recommend continuing with a limited model and performing research to improve
Rethinking the model

\[ A = m \left[ J(E > E_0) \right]^{1/2} \]

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Rethinking the model
THANK YOU!