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Correlation of Geomagnetic Storms with Infrasound Observation Data from International Monitoring System Stations Located in South America

Arthur S. de Macêdo, Elder Yokoyama, Lucas V. Barros, Darlan P. Fontenele and Juraci M. de Carvalho
University of Brasília

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INTRODUCTION

The Earth is hit by solar storms, and its magnetic field protects against radiation. Ions from these storms create auroras in polar regions: the aurora borealis in the north and the aurora australis in the south. The movement of these ions generates bow waves that can be detected by acoustic sensors.

METHODS/DATA

For this study, the solar storm on April 23, 2023, was chosen based on its PLANETARY K-INDEX (Kp) value. The data was obtained from ISIG. To ensure good coverage in South America, ten IMS infrasound stations were selected. Additionally, three stations in the northern hemisphere were chosen for temporal series comparison. The occurrence of an aurora on April 23, 2023, was reported by NOAA, serving as the data source.

START

RESULTS

In the study, we obtained frequency, velocity, and date/time-related results correlated with the selected auroras. These results provide valuable information about the characteristics of these specific auroras. By analyzing this data, we can gain a deeper understanding of the patterns and behaviors of the auroras at a infrasound time series

CONCLUSION

During geomagnetic storms associated with auroras, signals similar to those described in the literature as indicative of auroral activity were observed in terms of frequencies and velocities. The number of signal detections during these storms tends to increase with the number of sensors and proximity to the aurora zone. However, not all stations participating in the study detected the event. Among the ten selected stations in the Southern Hemisphere, only two recorded the event, while all three stations in the Northern Hemisphere detected it.

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INTRODUCTION

The Earth is sporadically bombarded by solar storms, and its magnetic field acts as a protective shield, deflecting the radiation (Dal Poz, 2006).

It is known that ions propagated by these storms enter in polar regions, and they are responsible for the generation of auroras (**Fig. 1**), as follows:

(i) the aurora borealis, formed in the northern hemisphere; and

(ii) the aurora australis, formed in the southern hemisphere.

The movement of these ions in the atmosphere generates bow waves (Wilson, 2005), which can be detected and recorded by acoustic sensors.

Fig. 1 – Auroral Phenomena (NOAA, 2023)

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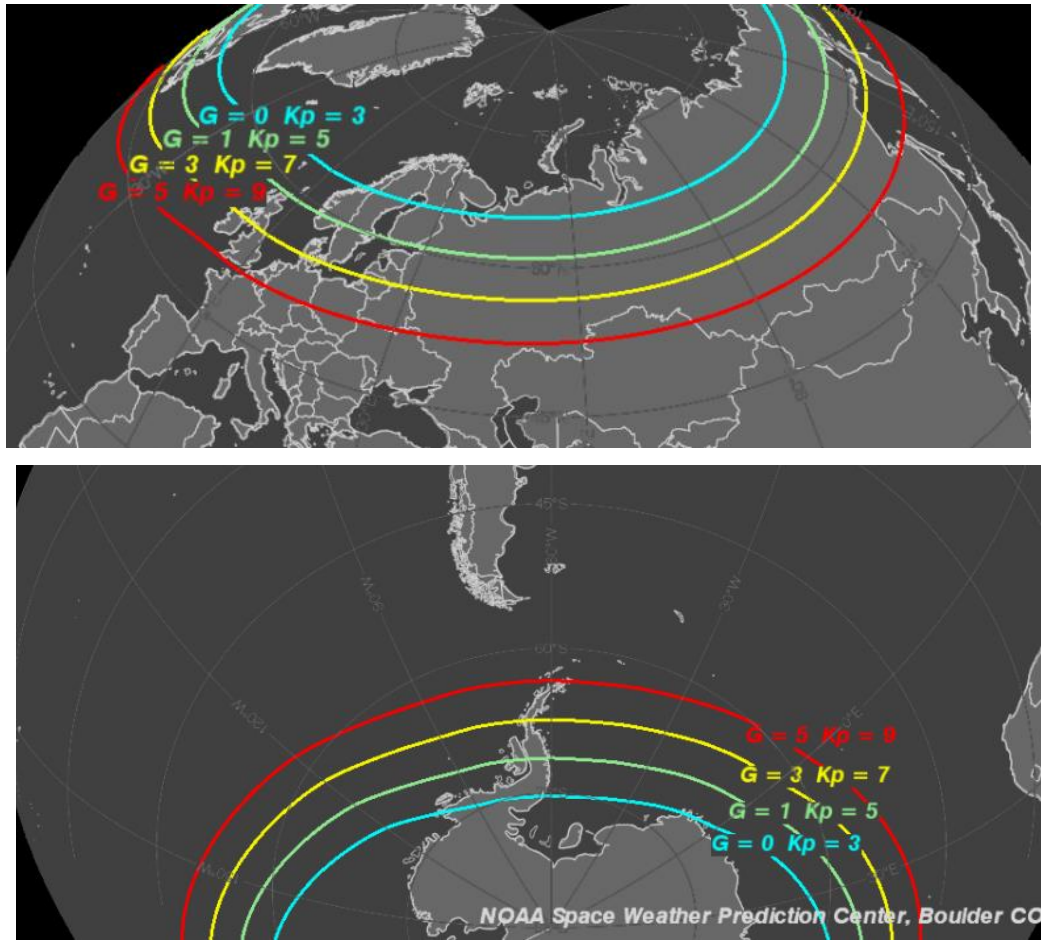

Fig. 2 - Map displaying the widest range of aurora observations based on the Kp indices of geomagnetic storms (NOAA, 2023).

This study aims to correlate the occurrence of Auroras with signals detected at IMS infrasound stations, mainly located at South America.

In the **Fig. 2** is shown how far the auroras can be observed in both hemisphere.

However, according to Le Pichon et al., (2010) and Wilson (2005) the auroras, generated by geomagnetic storms, can be detected by infrasound stations located outside of the auroras range observation, i.e., inside the auroras visual effect.

This phenomena was studied by Wilson et al (2005), using infrasound microphones array located at Fairbanks - Alaska.

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The solar storm that occurred on April 23, 2023, was selected for this study based on its Kp = 8 (PLANETARY K-INDEX) indice. The data was provided by ISIG (http://isgi.unistra.fr).

In order to provide good coverage of the South America, ten IMS infrasound stations were selected (**Fig. 3**).

Additionally, three stations in the northern hemisphere (I37NO, I42PT and I56US) were chosen for the purpose of comparing the temporal series.

The source of data was information about the occurrence, on April 23 2023, of an aurora detected by NOAA.

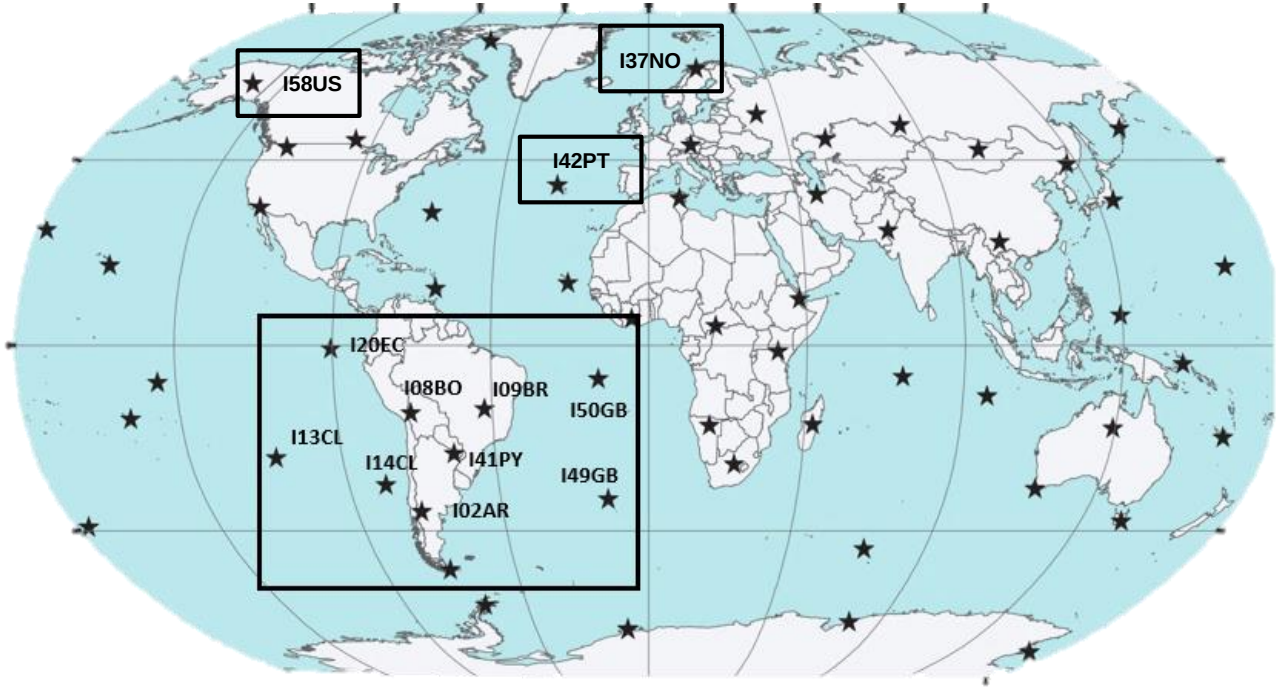

Fig. 3 – The IMS infrasound stations used in this study are inside in boxes. (Adapted from Neri, 2019)

Several detections can be seen in the record of **Fig. 4** (below). The families associated to this detections show the following: predominant frequencies 2.5 - 4Hz; azimuth 190º and speed 330 m/s.

Fig. 4 – Record of an event detected by I37NO (Norway) on April 23, 2023. In the Figure is shown 6 hours of data, from 00:00 to 06:00

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The record displayed in **Fig. 5** show multiple detections. These detections exhibit the following characteristics: dominant frequencies ranging from 1.9 to 4 Hz, azimuth of 180º, and a speed of 340 m/s.

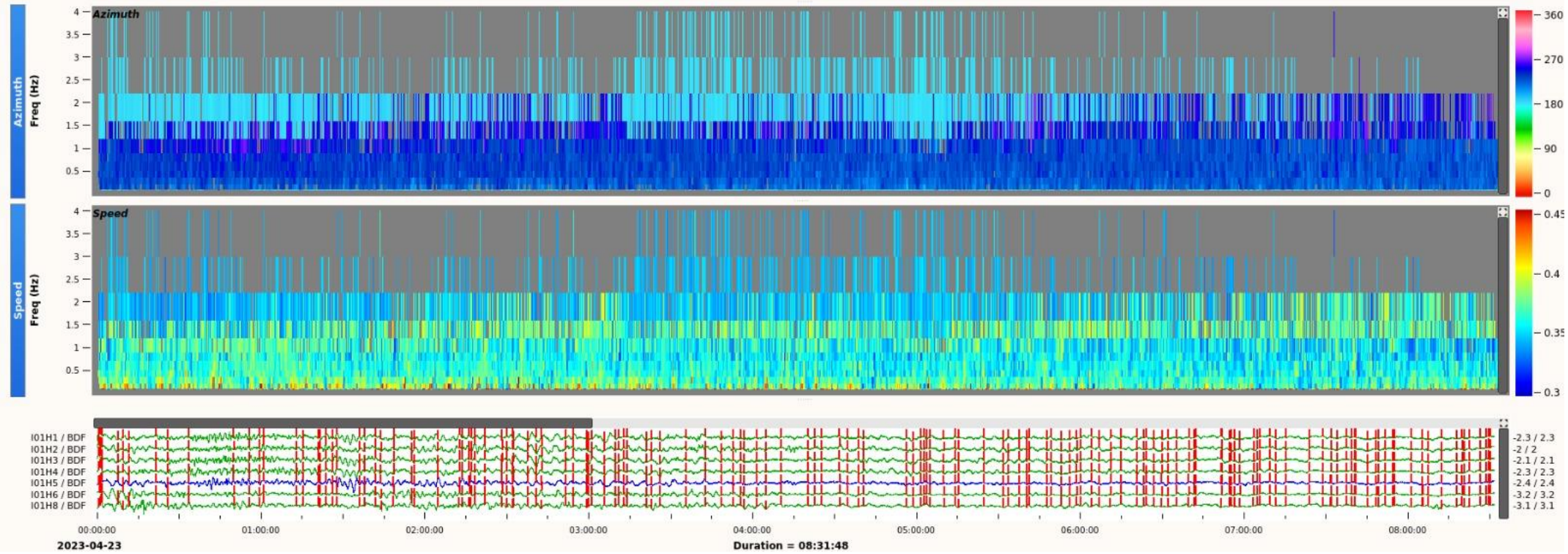

Fig. 5 – Record of an event detected by I01AR (Argentina) on April 23, 2023. In the Figure is showing 8 of data, from 00:00 to 08:00

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The record depicted in **Fig. 6** reveals numerous detections, demonstrating the following characteristics: dominant frequencies ranging from 2.3 to 4 Hz, an azimuth of 330º, and a speed of 340 m/s.

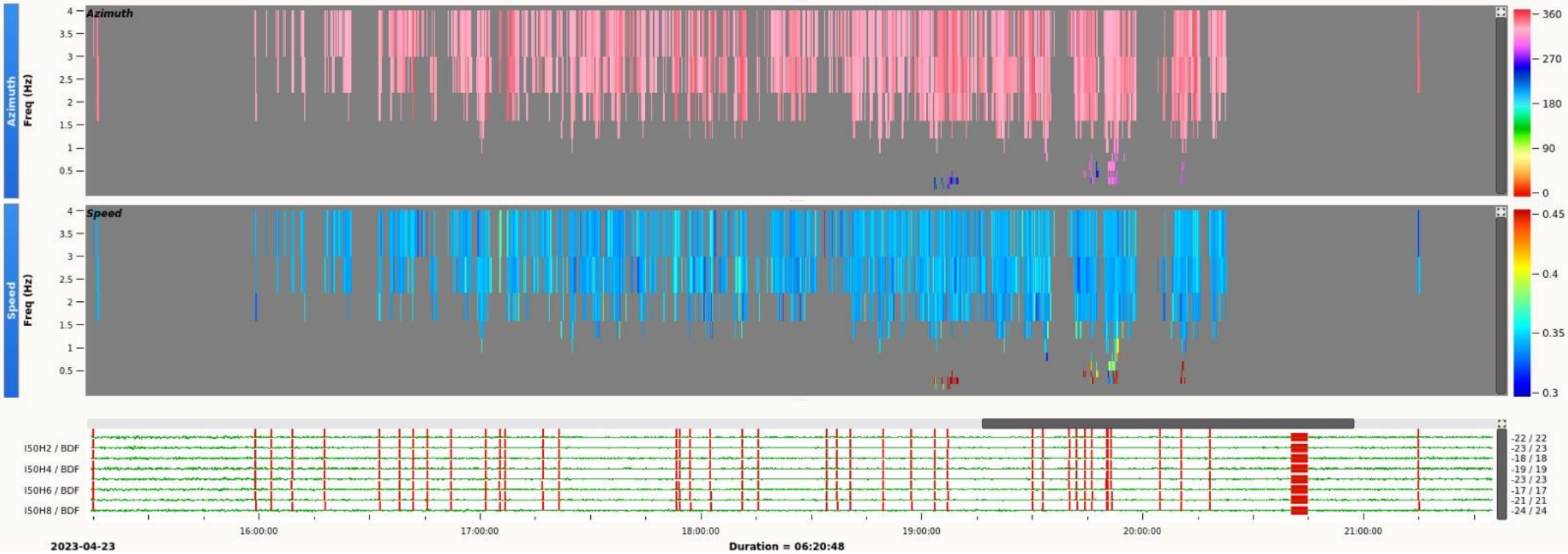

Fig. 6 – Record of an event detected by I50GB (Ascension Island) on April 23, 2023. In the Figure is showing 6 haurs of data, from 15:00 to 20:00

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Table 1 - Summary of parameters observed in all IMS infrasound stations that detected the event of this study in the Southern Hemisphere (SH) and Northern Hemisphere (NH).

	I01AR (SH)	I37NO (NH)	I41PT (NH)	I50GB (SH)	I56US (NH)
Frequency (Hz)	1.9 - 4	2.5 - 4	1.5 - 4	2.3 - 4	1.4 - 4
Back Azimuth (º)	180	190	1	330	200
Velocity (m/s)	340	330	340	340	340
Duration (hours)	6	6	3	6	6
Nº of Elements	8	10	7	8	4

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During geomagnetic storms that give rise to auroras, signals with frequencies and velocities similar to those described in the literature as auroral activity were observed.

It is noticeable that the number of detections of signals generated during geomagnetic storms increases proportionally with the number of sensors and the proximity to the aurora zone occurrence. Following the data on the **Table 1**.

Not all stations involved in this study detected the event. Only two stations from ten selected for the Southern Hemisphere (I01AR and I50GB) detected the event, while all three stations (I37NO, I42PT and I56US) from the Northern Hemisphere detected the event.

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