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POSSIBLE SIGNATURE OF LSTID GENERATED ON THE POLAR REGION OBSERVED IN LOW LATITUDES AFTER AN INTENSE GEOMAGNETIC STORM

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ABSTRACT

Large Scale Travelling Ionospheric Disturbances (LSTIDs) were detected in low latitudes after an intense geomagnetic storm, which occurred in April 2000. The LSTIDs were verified in Natal, Cachoeira Paulista, Ramey and Eglin, where the ionosphere showed an anomalous behaviour on April 7th. The analysed ionograms were provided by the Global Ionosphere Radio Observatory (GIRO). The magnetic activity and the geomagnetic storm were characterized by Kp, AE and Dst indexes data. The intense storm occurred on April 6th, with Dst_{min}=-288nT. The Bz component of the interplanetary magnetic field was also analysed in order to verify the occurrence of magnetic reconnection. Besides that, the effects of the geomagnetic storm on the polar regions were verified in images from the POLAR satellite, which showed an increase in the density of particles in the auroral oval and its expansion toward lower latitudes.

INTRODUCTION

Travelling Ionospheric Disturbances (TIDs) are periodic irregularities that propagate through the ionospheric plasma with velocities of tens to a few hundreds of kilometers per hour and are more commonly seen at mid latitudes (RISHBETH & GARRIOTT, 1969). They are classified as small, medium or large scale TIDs (SSTIDs, MSTIDs, LSTIDs, respectively) (RIEGER & LEITINGER, 2002).

The LSTIDs have periods ranging from 30 minutes to 3 hours (FRANCIS, 1975), wavelength of 1000 km or more, and velocity of 400~1000 m/s. They are the ionospheric expression of gravity waves (HUNSUCKER, 1982; HAJKOWICZ, 1990).

Upon the occurrence of geomagnetic storms, LSTIDs are formed due to the Joule heating resulted from the entry of electrically charged particles through the polar cusps, causing the intensification of the auroral electrojet currents (CÂNDIDO, 2008; CAZUZA, 2014). Because of the gradient of pressure, the LSTIDs propagate from the poles toward the Equator (HARGREAVES, 1992).

Our objective was to analyze the occurrence of LSTIDs in low latitudes during an intense (GONZALEZ et. al., 1994) geomagnetic storm, occurred in April 2000.

METHODOLOGY

For the analysis, it was used data from ionosondes located in Natal, RN (Brazil), Cachoeira Paulista, SP (Brazil), Ramey (Puerto Rico) and Eglin (USA). The data regarding to Ramey and Eglin were provided from the Global Ionosphere Radio Observatory (GIRO - *http://giro.uml.edu/*).

Figure 1 shows the location of the cities Eglin (~30°N), Ramey (~18°N), Natal (~6°S), and Cachoeira Paulista (~23°S).

The magnetic activity and the geomagnetic storm were characterized by the indexes Kp, AE, and Dst, as well as the Bz component of the interplanetary magnetic field. Those data were obtained from the Goddard Space Flight Center's website (*https://omniweb.gsfc.nasa.gov/form/dx1.html*).

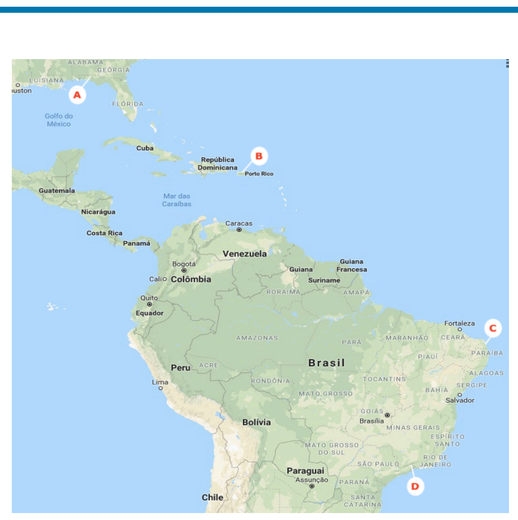

Figure 1: Illustrative figure showing the location of the ionosonde stations in Eglin (A), Ramey (B), Natal (C) e Cachoeira Paulista (D). Adapted from Google Maps (march, 2018).

In order to observe the effects of the geomagnetic storm in the polar ionosphere, auroral images of the North Pole showing the density of protons were considered. Those images were from the POLAR satellite and were also obtained on the Goddard Space Flight Center's website (*https://cdaweb.sci.gsfc.nasa.gov/index.html/*).

RESULTS

The geomagnetic storm occurred on April 6th, 2000. Therefore, we analysed data regarding to the 6th and 7th in order to observe the storm and its effects in the following hours.

Figure 2 shows the behaviour of the interplanetary magnetic field and the geomagnetic indexes.

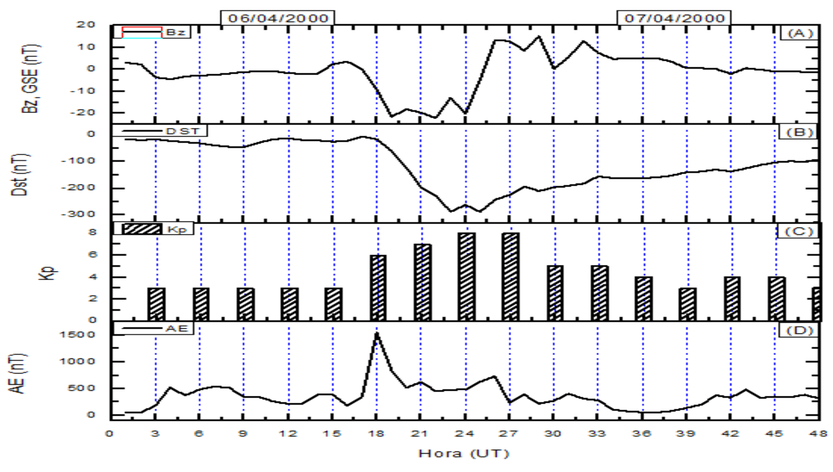

Figure 2: Behaviour of the interplanetary magnetic field (Bz) and the geomagnetic indexes Dst, Kp, and AE regarding to the days 6th and 7th of April 2000.

Effects in the polar ionosphere

In the polar ionosphere, it was observed the intensification of the auroral electrojet, which is represented by the increase in both values of the AE index (Figure 2) and particle density on the poles. Figure 3 shows the protons density on the North pole on April 6th.

RESULTS

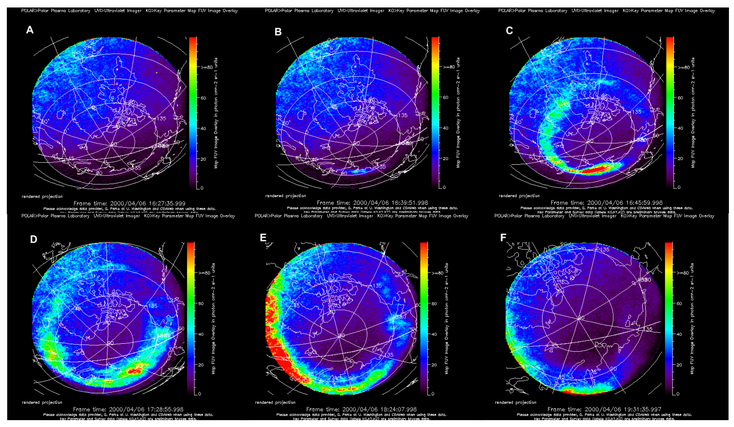

Figure 3: Images of distant UV obtained by the experiment UVI of the satellite POLAR, showing the protons density in the North auroral region. Taken from https://cdaweb.sci.gsfc.nasa.gov/cgi-bin/eval2.cgi. Accessed in November 2017.

Effects in the equatorial ionosphere

In the equatorial region, it was observed the lifting of the ionospheric layers due to the passage of the LSTID. Figure 4 shows the isodensity curves over Eglin, Ramey, Natal and Cachoeira Paulista for April 6th and 7th. In the northern hemisphere, the LSTID passes over Eglin and then, over Ramey. In the southern hemisphere, the LSTID is first seen at Cachoeira Paulista and then, at Natal.

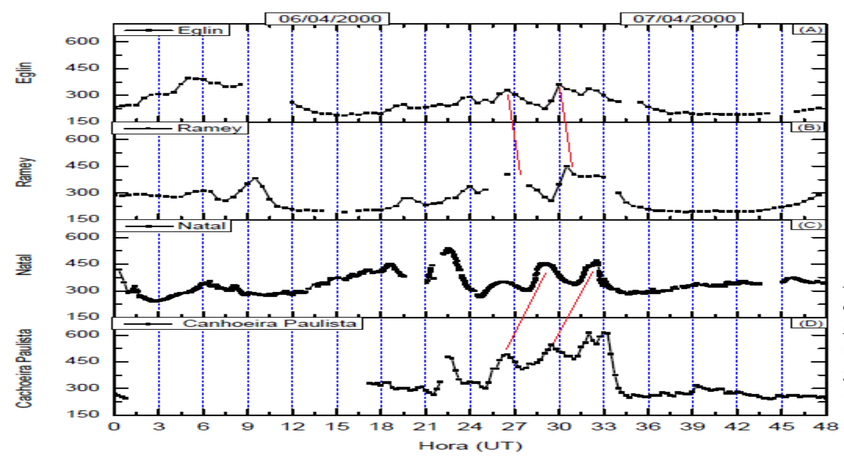

Figure 4: Isodensity curves over Eglin, Ramey, Natal, and Cachoeira Paulista regarding to April 6th and 7th, 2000.

From the isodensity curves (figure 4), it is possible to observe a period of approximately 3 hours for the LSTID. In Natal, the disturbance was observed from ~4 UT on April 7th. Considering the start of the auroral oval expansion at 16:40 UT in the day before, a velocity of ~370 m/s was calculated for the propagation of the LSTID.

CONCLUSIONS

A large scale travelling ionospheric disturbance (LSTID) was recorded by ionosondes located in low latitudes after an intense geomagnetic storm occurred on April 6th, 2000. The passage of the LSTID over the stations was characterized by the periodic lifting of the ionospheric layers, first over the cities of Eglin and Cachoeira Paulista, in latitudes of ~30°N and ~23°S, respectively; and then, over Ramey (~18°N) and Natal (~6°S).

That feature suggests that the disturbance was originated in both North and South poles and propagated toward the low latitudes as a consequence of the Joule heating due to the injection of particles through the polar cusps during the storm.

A period of approximately 3 hours and a velocity of ~370 m/s were measured for the periodic disturbance, which agree with the characteristics of LSTIDs established by our references.

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