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GEOMAGNETIC STORM EFFECTS ON THE SIGNATURES OF EQUATORIAL ELECTROJET PLASMA IRREGULARITIES

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ABSTRACT

A 50 MHz coherent back-scatter radar, also known by the anachronism RESCO, has been operated in Brazil since 1998 at São Luís (2.33° S, 44.2°W, DIP: -0.5), on the dip equator to study the equatorial electrojet dynamics. Spectral analyses of the received echoes from equatorial electrojet (EEJ) irregularities allow us to identify the dominant type of plasma instabilities in the electrojet bulk. From the frequency distribution of the irregularities echoes power spectra; we are also able to deduce the Doppler shift caused by the irregularities drift in relation to the radar beam. Such drift is close related to the electric fields that drives the plasma instabilities. Through the analysis of the spectrograms (each one corresponding to one range gate) in disturbed periods, it has been possible to observe effects in the EEJ electric fields associated with possible prompt penetration (PP) electric fields. The PP electric fields show themselves as increases or decreases in the generation of 3-meter plasma irregularities, according to its polarity in relation to the EEJ electric fields. This paper shows the RESCO spectrograms with increases/decreases of 3-meter EEJ irregularities generation associated with possible PP electric fields in geomagnetic disturbed days as well as the results of EEJ in quiet days. The methodology and the results are discussed and analyzed.

INTRODUCTION

At about 105 km of altitude in the Brazilian equatorial E region and covering a latitudinal range of ±3º around the dip equator flows an intense electric current named equatorial electrojet (EEJ) driven by the E region dynamo (Fig. 1). Studies of the equatorial ionosphere using VHF radars have shown echoes back-scattered from plasma irregularities in the EEJ which have shown distinct spectral signature for two observed irregularities, Type 1 and Type 2, also known as two-stream [3, 4] and gradient drift [5], respectively. They have been studied in order to explain the phenomenology [1, 2, 6, and references therein] and also in order to understand the E region electric fields [7, 8, 9]. Since 1998, when the Brazilian 50 MHz coherent back-scatter became fully operational, such studies have also been conducted in the Brazilian longitude sector [10, 11, 12, 13].

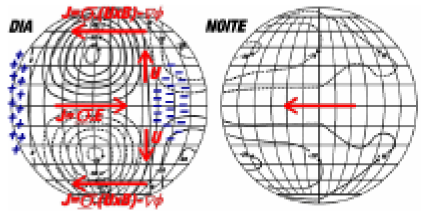

Fig 1 – Generation of the Sq current system, based on the theory of the atmospheric dynamo. The neutral winds U, the high latitude currents, **J** = s . ((**U** x **B**) - ?f), and the EEJ, **J** = s . **E**, are showed in the scheme.

MATERIALS AND METHODS

The RESCO coherent back-scatter radar (Fig. 2) is operated routinely during two weeks per month. It is usually set for EEJ sounding transmitting one pulse each 1-2 ms with pulse width of 20 ?s and time delay of 600 ?s. Therefore, the power spectra within the Doppler frequencies (related to Doppler shift) obtained from Fast Fourier Transform (FFT) have aliasing frequency of 250-500 Hz. The frequency resolution is determined by the number of subsequent pulses taken for the FFT analysis and by the aliasing frequency.

Fig 2 – The RESCO 50 Mhz coherent back-scatter radar installed at the São Luiz Space Observatory, OESLZ/INPE – MCT.

From each spectrum, two Gaussian curves are estimated through curve fitting, each one related to one type of irregularity, Type 1 or Type 2. The relationship between E_y and the east-west electron drift velocity of the Type 2 plasma irregularity V_e, given by E_y ˜ $-6 \times 10^{-6} V_e$ [14], allow us to analyze the variations of the horizontal electric fields.

RESULTS

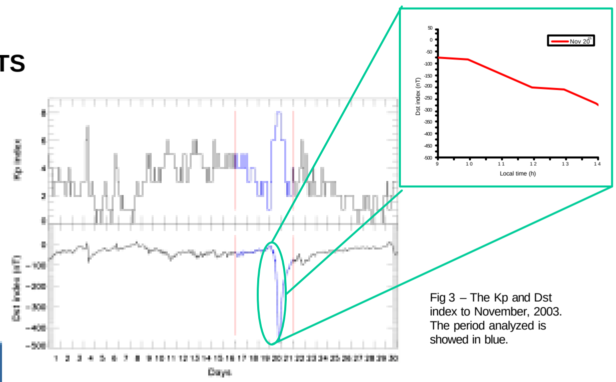

Fig 3 – The Kp and Dst index to November, 2003. The period analyzed is showed in blue.

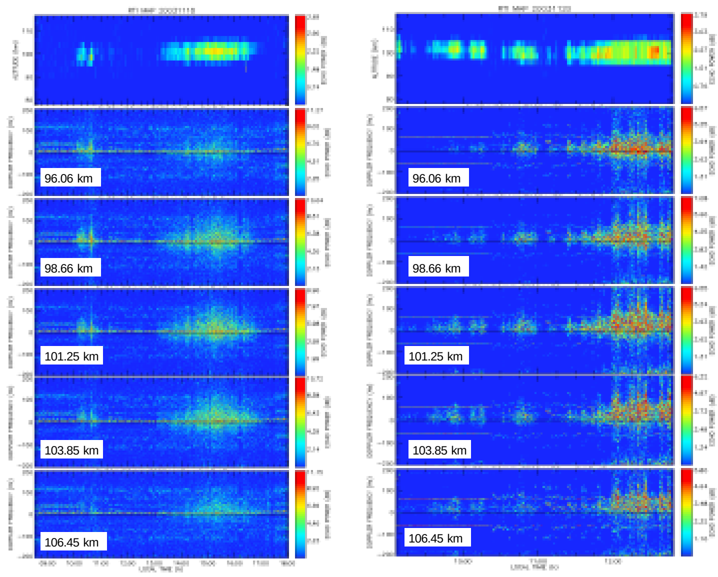

Fig 4 – Range Time Intensity (RTI) maps and spectrograms from two days: November 18th and 20th.

CONCLUSIONS

- The spectrograms from November 18th (calm period) seems to be Type 2 irregularities dominant between 14h30 e 16h30 local time and it does not present signature of Type 1 irregularities;
- The EEJ is stronger in November 20th (perturbed period) between 12h-13h local time. The spectrograms show many cases of signature of Type 1 irregularities. In some cases, it can be seen the presence of drift velocities above of the maximum value of irregularities drift, the ion acoustic velocity, 360 m/s;
- The gap of data of all the period prejudiced the analyze, since we do not have data after 13h from November 20th;
- The high level of noise prejudices the analyze, because it contaminates the spectra and spectrograms.

FUTURE

- Apply digital filters to remove the noise resulting in better spectrograms;
- Expands the analyzes to one complete year and study the statistics of ocurrence of this events;
- Using the relation among vertical electric fields and Type 2 drift velocities determine the E_y.

REFERENCES

[01] **Forbes, J. M.**, 1981, The Equatorial Electrojet: Reviews of Geophysics and Space Physics, Vol. 19, No. 3, p.469-504.
[02] **Fejer , B. G. and Kelley, M. C.**, 1980, Ionospheric Irregularities: Reviews of Geophysics and Space Physics, Vol. 18, No. 2, p.401-454.
[03] **Farley, D. T.**, 1963, A plasma instability resulting in field aligned irregularities in the ionosphere: Journal of Geophysical Research, Vol.68, No. A22, p.6083-6097.
[04] **Buneman,O.**, 1963. Excitation of field aligned sound waves by electron streams: Physical Review Letters, Vol. 10, No. 7, p.285-287.
[05] **Rogister , A. and N. D'Angelo**, Type II irregularities in the equatorial electrojet, J.Geophys. Res., 75, 3879-3887, 1970.
[06] **Reddy, C. A.**, 1981, The equatorial electrojet: a review of ionospheric and geomagnetic aspects: Journal of Atmospheric and TerrestrialPhysics, Vol. 43, No. 5/6, p.557-571.
[07] **Reddy, C. A., Vikramkumar , B. T. and Viswanathan, K. S.,** 1987, Electric fields and currents in the equatorial electrojet deduced from VHF radar observations – I. A method of estimating electric fields: Journal of Atmospheric and Terrestrial Physics, Vol. 49, No. 2, p.183-191.
[08] **Hysell, D. L., Larsen, M. F. and Woodman, R. F.**, 1997, JULIA radar studies of the electric field in the equatorial electrojet: Geophysical Research Letters, Vol. 24, No. 13, p.1687-1690.
[09] **Hysell, D. L. andBurcham , J. D.**, 2000, Ionospheric electric field estimates from radar observations of the equatorial electrojet: Journal of Geophysical Research, Vol. 105, No. A 2, p.2443-2460.
[10] **Abdu, M. A., Denardini, C. M.,Sobral , J. H. A., Batista, I. S., Muralikrishna, P. and de Paula, E. R.**, 2002, Equatorial electrojet irregularities investigations usin g a 50 MHz back-scatter radar and a Digisondeat São Luís: Some initial results: Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 64, No. 12-14,p.1425-1434.
[11] **Abdu, M. A., Denardini, C. M.,Sobral , J. H. A., Batista, I. S., MuralikrishnaP., Iyer , K. N., Veliz , O. and de Paula, E. R.**, 2003, Equatorial electrojet 3 m irregularity dynamics during magnetic disturbances over Brazil: results from the new VHF radar atSão Luís: Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 65, No. 14-15, p.1293-1308.
[12] **Denardini, C. M., Abdu, M. A. andSobral, J. H. A.**, 2004, VHF radar studies of the equatorial electrojet 3-m irregularities over São Luís: day-to-day variabilities under auroral activity and quiet conditions: Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 66, n17, p.1603-1613.
[13] **Denardini, C. M.**, 2004, Estudo da eletrodinâmica da ionosfera equatorial duranteo período de máxima atividade solar (1999-2002): São José dos Campos, Instituto Nacional de Pesquisas Espaciais, Thesis.
[14] **Balsley, B.B. and R.F.Woodman**, IonosphericDriftVelocity Measurements at Jicamarca, Peru (July 1967 - March 1970). 1971,World Data CenterA - UpperAtmosphereGeophysics:Asheville,North Carolina, USA. p. 1-45.

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