Data Mining Applied to the Analysis and Prediction of Ionospheric Scintillation

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Abstract. *This paper describes the application of Data Mining to the survey and prediction of ionospheric scintillation over the Brazilian territory. Ionosphere scintillation is a phenomenon that occurs in the equatorial region. It affects the telecommunications and Global Positioning System (GPS) accuracy for positioning and aerial navigation. Data Mining can be defined as the process of extraction of hidden, previously unknown, and potentially useful high-level information from low-level data.*

Resumo. *Este artigo descreve a aplicação de técnicas de Mineração de Dados para a análise e predição de cintilação ionosférica sobre o território brasileiro. A cintilação ionosférica é um fenômeno que ocorre na região equatorial e afeta as telecomunicações e a precisão do Global Positioning System (GPS) para posicionamento e navegação aérea. Mineração de Dados pode ser definido como o processo de extração de informação de alto nível, que é implícita, previamente desconhecida e potencialmente útil, a partir de dados de baixo nível.*

1. Introduction

In the post-sunset equatorial ionosphere, plasma depleted regions/bubbles with associated irregularity structures of scale sizes varying from centimeters to kilometers are generated due to plasma instability processes (DE PAULA et al., 2007). The ionospheric irregularities present a large dependence on the solar flux, the local time, the season, the latitude and longitude and the magnetic disturbances (DE PAULA et al., 2007). Ionosphere scintillation occurs when a radio wave crosses the ionosphere and suffers a distortion of phase and amplitude. This produces amplitude and phase fluctuations. Several studies have demonstrated that the equatorial ionospheric scintillations affect the performance of GPS receivers (KINTNER et al., 2001; BANDYOPADHAYAY et al., 1997). The aim of this work is to propose a method for predicting ionospheric scintillation using Data Mining techniques.

2. Methodology

Data mining may be defined as the process of discovering patterns in data. The process may be automatic or (more usually) semi-automatic. Data Mining involves data base,

statistics, neural network, machine learning, pattern recognition and data visualization. The patterns discovered must be meaningful. Useful patterns allow us to make non-trivial predictions on new data. The rules summarize the information about the phenomenon, expressing it in a different and more concise way (WITTEN et al., 2000). The attributes for this work are the scintillation in the magnetic equator, scintillation in São José dos Campos, magnetic activity through Kp index and the vertical drift velocity of plasma in the equator. The scintillation intensity is quantified through S4 index that is defined as the normalized variation of the signal intensity of GPS satellites. The vertical drift velocity is obtained by DGS256 Digisonde - Digital Portable Sound (DPS) installed in São Luís. It provides the electronic density profile in function of sounding frequency and it is calculated by the equation 2.0.

$$V_D = \frac{\Delta h' F}{\Delta t} \qquad (2.0)$$

Where *h'F* is the minimum hight of ionosphere F and Δt = 15 minutes.It was defined three classes for drift velocity: high, medium, e slow; two classes for magnetic activity: disturbed or quiet; four classes to scintillation: strong, medium, weak and no. The data of this work were from the solar maximum period, in the months October-March, for years 2000, 2001 and 2002.

3. Preliminary results

Several classification and association algorithms were tested. Association algorithms have show relations between: drift velocity in Equator, magnetic activity and scintillation (REZENDE et al., 2007). As shown in Table 3.1, some rules were found and allow to predict the occurrence of scintillation in the São José dos Campos region (*scintilAP*).

Table 3.1 – Results with the Apriori algorithm

ANTECEDENT	CONSEQUENT	CONF.	SUPORTE
velocity=high magneticAct=quiet scintilEq=strong 67 cases	scintilAP=strong 64 cases	0,96	0,48
velocity=high magneticAct=quiet 100 cases	scintilAP=strong 95 cases	0,95	0,72
magneticAct=quiet scintilEq=strong 72 cases	scintilAP=strong 68 cases	0,94	0,51

Velocity = drift velocity of plasma magneticAct = magnetic activity scintilEq = scintillation in the equator scintilAp = scintillation in São José dos Campos (under Anomaly Peak)

4. Conclusion and remarks

Considering solar maximum and the scintillation season, when vertical drift velocity was high and magnetic activity was quiet then scintillation occurred at the Equator. The tendency was to have strong scintillation under the Anomaly Peak, in the São José dos Campos region. An important observation is that for disturbed magnetic activity days, the scintillation becomes less predictable (sometimes strong, others weak). One of the next tasks is to employ the time of the magnetic activity disturbance to improve the

prediction: check if it triggers or inhibits the scintillation. Another task is to use the ratio of the Total Electron Content (TEC) in the magnetic equator (EQ) and in the São José dos Campos (SJC) region. If the ratio TEC_{EQ} / TEC_{SJC} is larger than 2, occurrence of scintillation is probable. Finally, other Data Mining algorithms will be experimented in order to improve scintillation prediction.

5. References

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