A PROTOTYPE OF A QUICK INFORMATION SYSTEM FOR SPACE WEATHER EVENTS EFFECTS ON THE IONOSPHERE

10TH EUROPEAN SPACE WEATHER WEEK

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1. Introduction

We present a prototype of a Quick Information System aimed at warning about the ionospheric effects following a geomagnetic storm and based on the daily analysis of the ionospheric behaviour.

A geomagnetic storm can produce an ionospheric storm characterized by a variation of the electron density of the ionosphere. As these perturbations cause negative effects on transionospheric communications and satellite positioning errors (Buonsanto, 1999), the development of resources oriented to alert to the ionospheric anomalous situation appears as a valuable task.

2. Data

In this work we have used RINEX files from 13 GNSS permanent stations located on the South of Europe and the North of Africa and belonging to the International GPS Service, IGS, and the EUREF Permanent networks (Figure 1). This RINEX files have been processed with a calibration algorithm to obtain vertical total electron content, vTEC (Ciraolo, 2012) . This processing technique assumes ionospheric thin shell model (located at 350km of altitude) to obtain vTEC from slant total electron content (sTEC) at the Ionospheric Pierce Point, IPP.

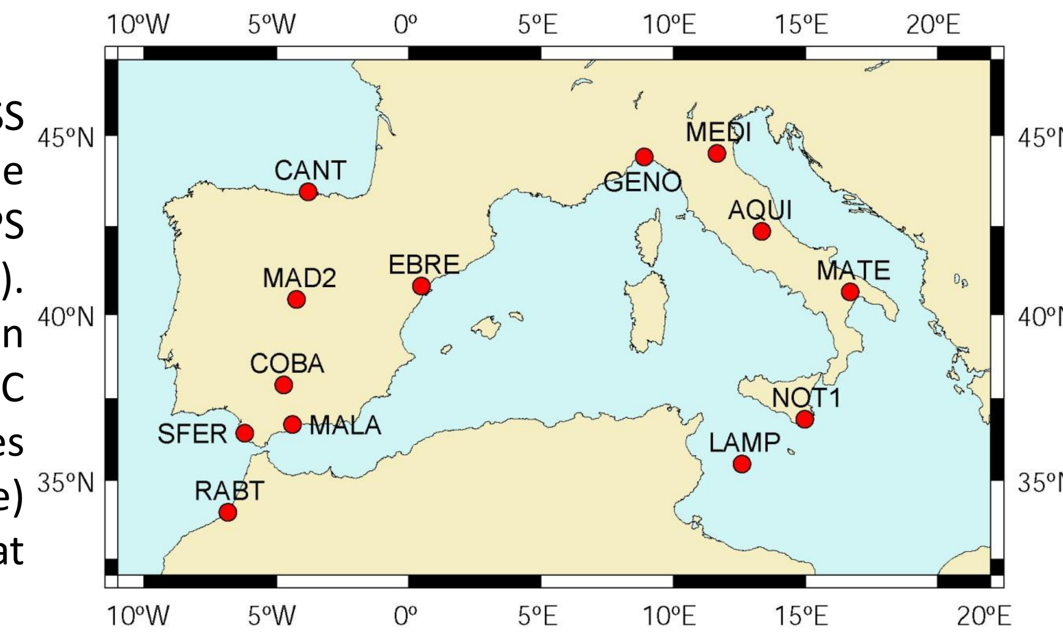

Figure 1: GNSS stations.

3. Metodology

The prototype consists of 4 steps: downloading, processing, analysis and testing.

The system uses RINEX for the day of interest and 10 previous days to calculate the mean value of the vTEC, vTECmean, epoch by epoch.

The parameter analyzed is the relative deviation of the vTEC, vTECrel, given by:

$$vTECrel\ (\%) = (vTEC - vTECmean)/(vTECmean) \qquad (1)$$

If the vTECrel exceeds the threshold value, 50%, at least in the 50% of the stations the information, a message is issued.

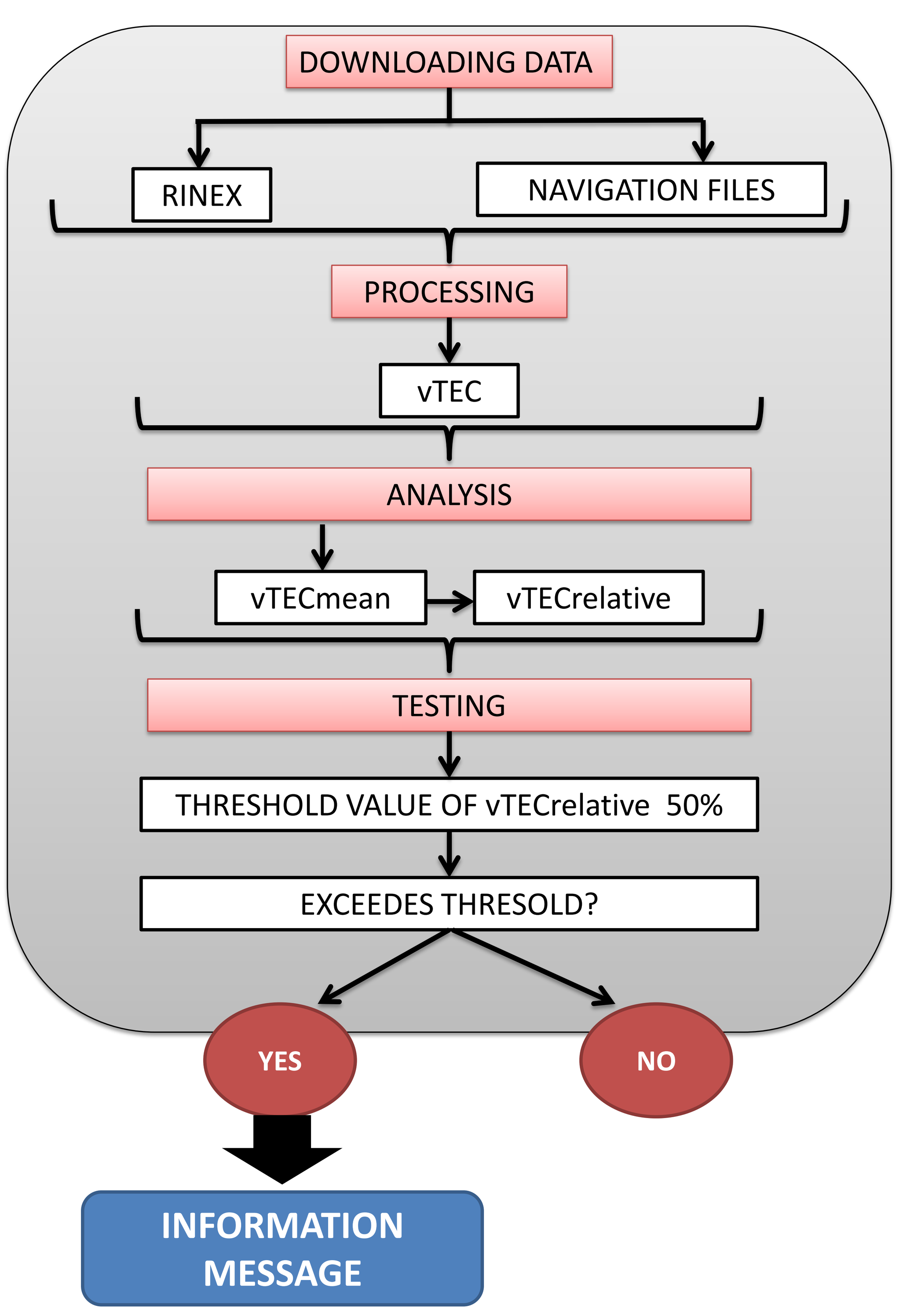

Figure 2: Flow chart of the prototype

4. Test

We have tested our prototype with 5 known moderate to intense geomagnetic storms (Table 1) occurred in the current solar cycle. We have classified the geomagnetic storm following Gonzalez et al. (1994) criteria.

For each storm we have studied 24 days around the day when the Dst index reached its minimum value.

In our study we have calculated the vTECmean using 20 quite days (Dst value higher than -30nT) around the starting of the geomagnetic storm, and we have obtained the vTECrel with the same expression (1).

As an example, Figure 3 displays the vTECrel values obtained at all the stations for the July 15th 2012, storm.

Date	Minimum value of Dst index	Classification
October, 25th 2011	-132nT	Intense
January, 25th 2012	-73nT	Moderate
April, 23th 2012	-104nT	Intense
July, 15th 2012	-133nT	Intense
November, 14th 2012	-108nT	Intense

Table 1: Geomagnetic storms studied.

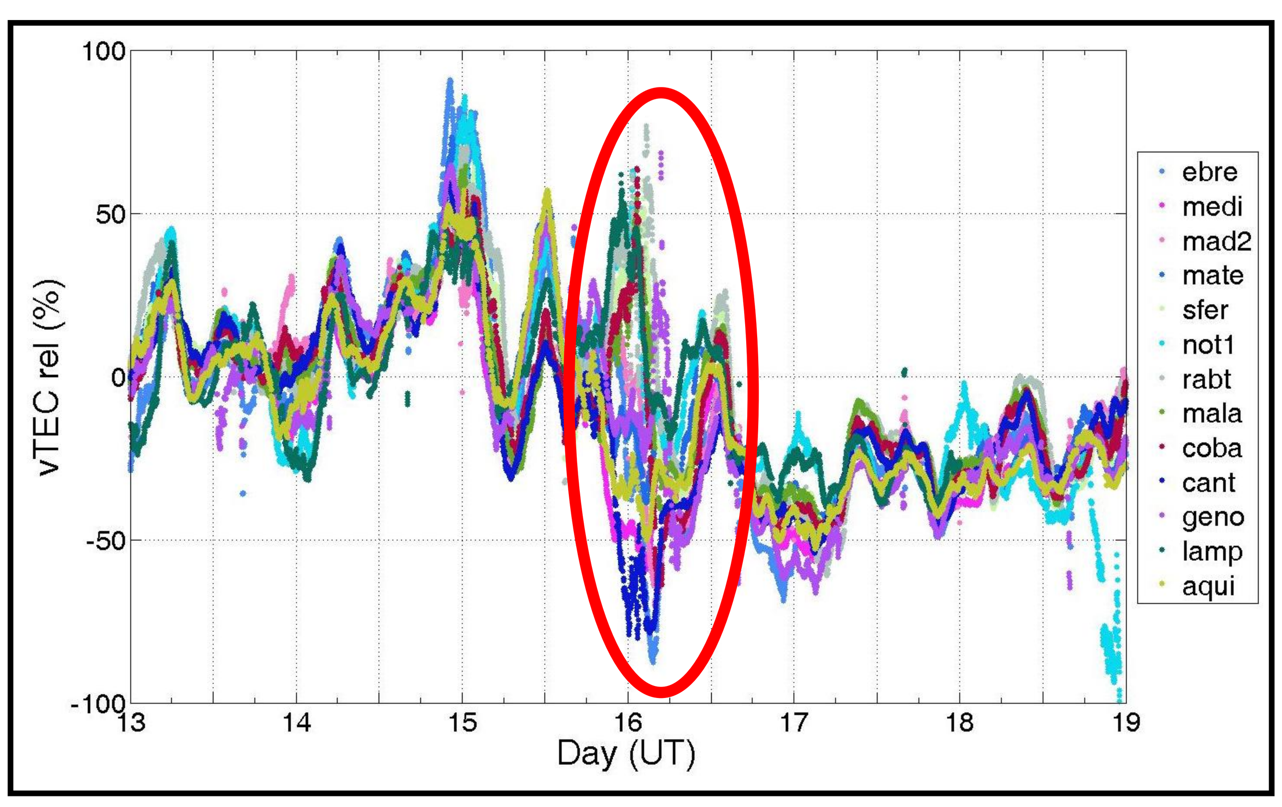

Figure 3: vTECrel for the period 13-19 July, 2012.

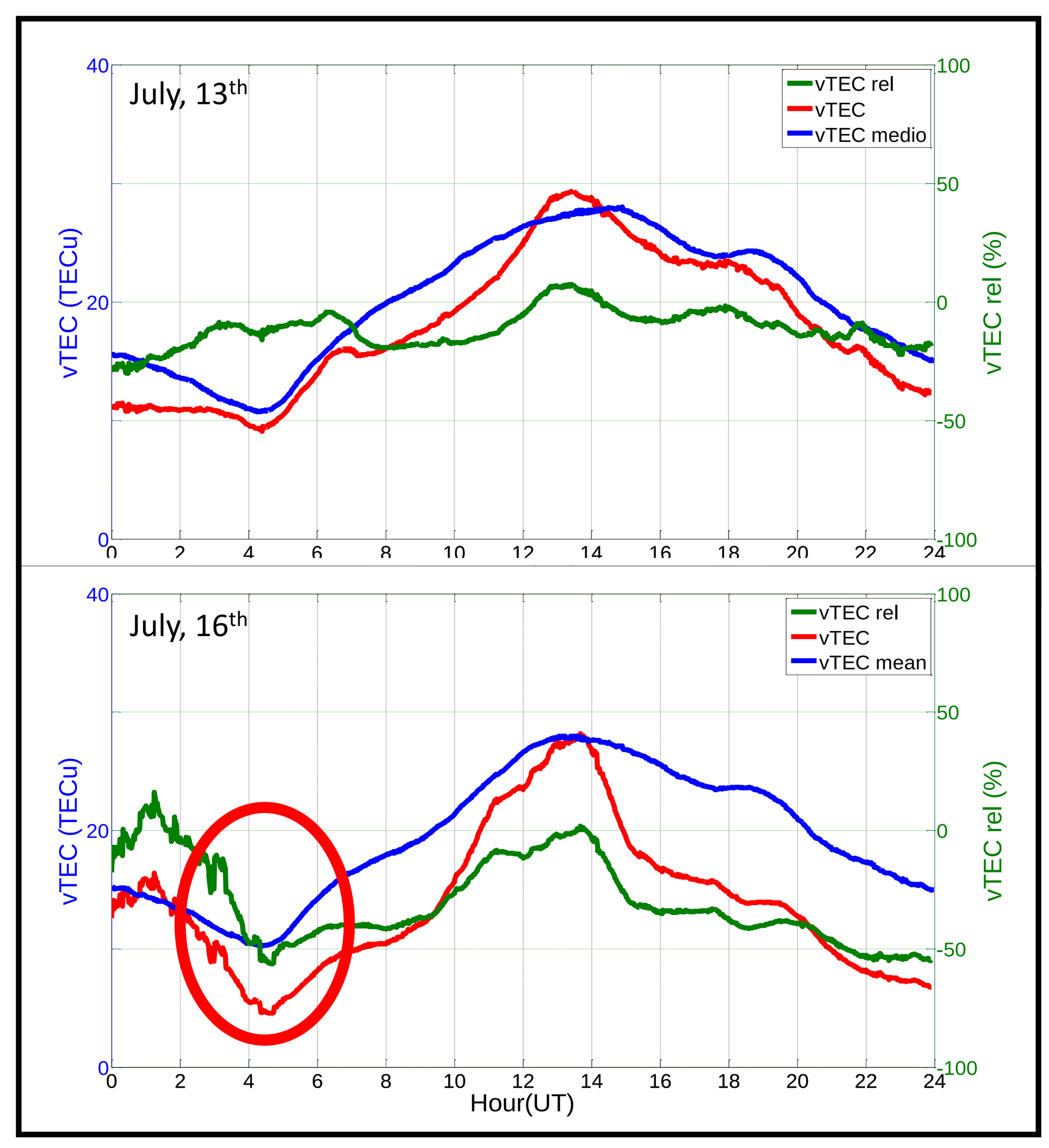

Figure 4: vTECrel at MALA station on 13 and 16 July 2012, obtained with the prototype.

Figure 3 shows a positive phase (vTECrel increases more than 50%) for all the stations in the night of 14th to 15th July. Another strong perturbation, with a clear different behavior depending on the latitudinal distribution of the stations, occurred in the first hours of the 16th July.

The outputs from the prototype for one station (MALA) and two days of interest have been depicted in Fig. 4. Comparing these results we can observe that the prototype gives similar values to those obtained in the general analysis, detecting the same phases of the ionospheric storm.

5. Results

Table 2 resumes the capability of the system to detect the ionospheric perturbations associated to geomagnetic storms. An ionospheric storm day refers to a day when we have detected a ionospheric perturbation (vTECrel over 50% at the majority of the stations).

For the 5 geomagnetic storms there were 26 days with ionospheric storm and our prototype detected 22 of them. In its turn, 78 out of the 94 quite days have been correctly detected.

	Information message	No Information message
Ionospheric storm days	22	4
Quite days	16	78

Table 2: Contingency table for the 5 geomagnetic storm studied and the results given by the prototype.

6. Conclusions and Future Work

Prototype tests have given very satisfactory results; we have obtained that in 83% of the cases the warning system gave the right message (a warning message for geomagnetic storm days or no message for quiet days).

Future works involve an improvement in the prototype and an implementation of hourly RINEX files to issue the warning message as soon as possible. We also work in an online software designed to automatically send the message to the interested users.

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