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# USING GPS TECHNOLOGY FOR GEODYNAMICS RESEARCHNIN COLOMBIA, SOUTH AMERICA

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**Abstract.**

## 1 INTRODUCTION

GEORED, the acronym for Geodesia: Red de Estudios de Deformacin has been adopted for the project "Implementation of the National GPS Network for geodynamics. Initiated in 2007 by the Colombian Institute of Geology and Mining (INGEOMINAS), GEORED is a research and development project based on GPS technology which takes a multifaceted approach to cataloging and defining the geodynamics of Northwest South America in order to reduce the associated hazards within a wide plate margin deformation zone. Under these considerations, we have initiated a study plan in order to learn and to understand the behavior of the ionosphere and its relationship with the earthquakes occurrence. Our current endeavors are focused on the acquisition of high quality GPS data to be shared by intergovernmental institutions and university research centers within Colombia as well as collaborative international research efforts including reciprocal data sharing between the neighboring countries of Panama, Ecuador and Venezuela.

Currently, the GEORED Project is managing 21 continuously operating stations including: 19 GEORED GPS continuously operating stations, composed of Trimble NetRS receivers and Trimble choke-ring antennas, the San Andres Island station (SAN0), installed under the MOU between UCAR and INGEOMINAS and the Bogota IGS GPS station (BOGT), (Ashtech receiver and antenna), installed under the agreement between JPL-NASA and INGEOMINAS). In addition to the permanent installations, more than 120 GPS campaign sites have been constructed and are being occupied one time per year. Planned for the year 2010 is the installation of 11 GPS continuously operating stations, and construction of 20-30 GPS campaign sites.

On January 12, 2010, an earthquake occurred in the boundary region separating the Caribbean plate and the North America plate, affecting the Hispaniola Island, the major island in the Caribbean, containing the two sovereign states of Haiti and the Dominican Republic. More than 200,000 people killed, about 200,000 injured, and 1 million displaced and severe to extreme damage in the Port-au-Prince are, the main city of Haiti. The earthquake was felt throughout Haiti and the Dominican Republic, in Turks and Caicos Islands, southeastern Cuba, eastern Jamaica, in parts of Puerto Rico and the Bahamas, and as far as Tampa, Florida and Caracas, Venezuela. (USGS, 2010).

The history of seismo-ionospheric coupling studies has passed through several stages starting from astonishment after initial discovery, enthusiastic but often speculative publications, and defeat by severe critics, to ultimately consecutive and systematic studies which have led to a substantiated physical model. [2]. The ionospheric analysis has been carried out using GPS data since several years ago, implementing the pseudorange and phase carrier codes as the main tools for the TEC estimation based on the refraction phenomena. [3], [4]. According to different authors, we have understood that the retrieved total electron content (TEC) data along numerous ray paths between ground based receivers and GPS satellites has shown clear earthquake related signals for selected earthquakes of magnitudes larger than 6. For that reason, we were interested in observing what happened with the Haiti earthquake with respect to the ionospheric disturbance.

## 2 DATA AND METHOD

Using a basic math approach in order to estimate the TEC at some locations where there are GPS permanent receivers, we used data of the SAN0 STATION (San Andres Island, Colombia) and ALPA station (Almirante Padilla Airport, Riohacha city, Colombia), that are part of the GEORED Project, and the data of the stations GTK0 (Grand Turk Island) and MOPR (Mona Island, Puerto Rico), in order to make some comparisons for January, 2010. We have considered the difference between the C and P pseudorange codes, modulated on L1 and L2, respectively. We have no taken in account by now, the residual errors, instrumental delay and we have no filtered the data. This is a preliminary observation.

The equations that describe the observables are given by [5]:

$$\begin{gathered} P = \rho + \Delta\rho_{ion} + \Delta\rho_{irop} + c(\Delta t_C^S - \Delta t_C^R) + c(b^S + b^R) + \varepsilon \qquad (1) \\ L = \rho - \Delta\rho_{ion} + \Delta\rho_{irop} + c(\Delta t_C^S - \Delta t_C^R) + \lambda B + \varepsilon \end{gathered}$$

Where, $\rho$: Geometrical range between the satellite and receiver, $\Delta\rho_{ion}, \Delta\rho_{irop}$: ionospheric and tropospheric refraction, $\Delta t_C^S, \Delta t_C^R$: receiver and satellite clock errors, $b^S, b^R$: hardware delays (receiver-satellite), $c$:speed of Light in a vacuum, $\lambda$: wave length, $\varepsilon$:residual random errors, $B$: frequency-specific phase ambiguity bias.

The equation that describes the TEC estimation is

$$TEC = (P_2 - P_1)\left[\alpha\left(\frac{1}{f_1^2} - \frac{1}{f_2^2}\right)\right]^{-1} \qquad (2)$$

$$TEC = (P_2 - P_1)9.52$$

Where, $f_1, f_2$: Carrier frequencies (1575.42 MHz and 1227.60 MHz), $P_1, P_2$: Pseudorange codes, 9.52: Klobuchar constant.

With respect to the epicenter, GTK0 is located 340 km to the north; MOPR, 480 km to the east; ALPA, 757 km to the south and SAN0 1200 km to the southwest, Figure 1.

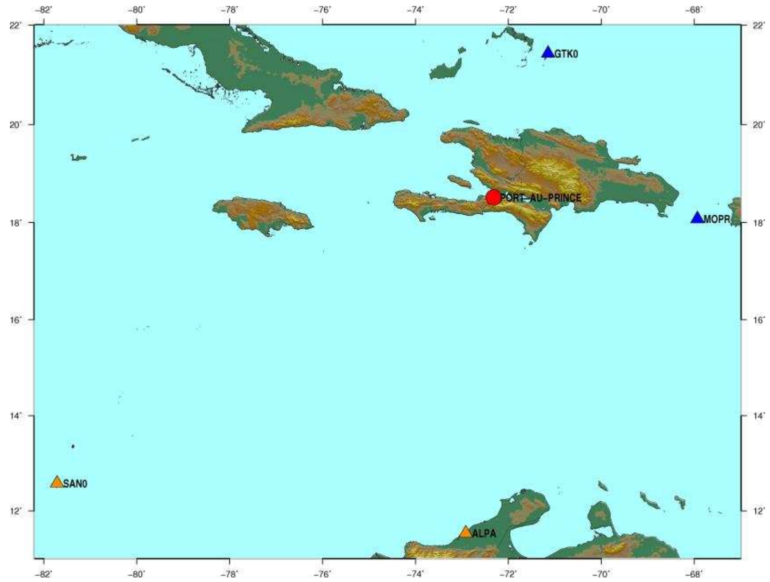


Figure 1: GPS stations used in the preliminar analysis

## 3 PRELIMINARY RESULTS

According to the Figure 2, it is possible to observe a peak about 24 hours before the occurrence of the earthquake. As a conclusion, it is not clear for us if it is possible to say that exists a correlation between the earthquake and the behavior of the TEC estimation. We know, as a conclusion, that it is required to continue studying this topic, in order to gain knowledge that permits a strong application of this type of studies in our country, doing a reasearch under international cooperation.

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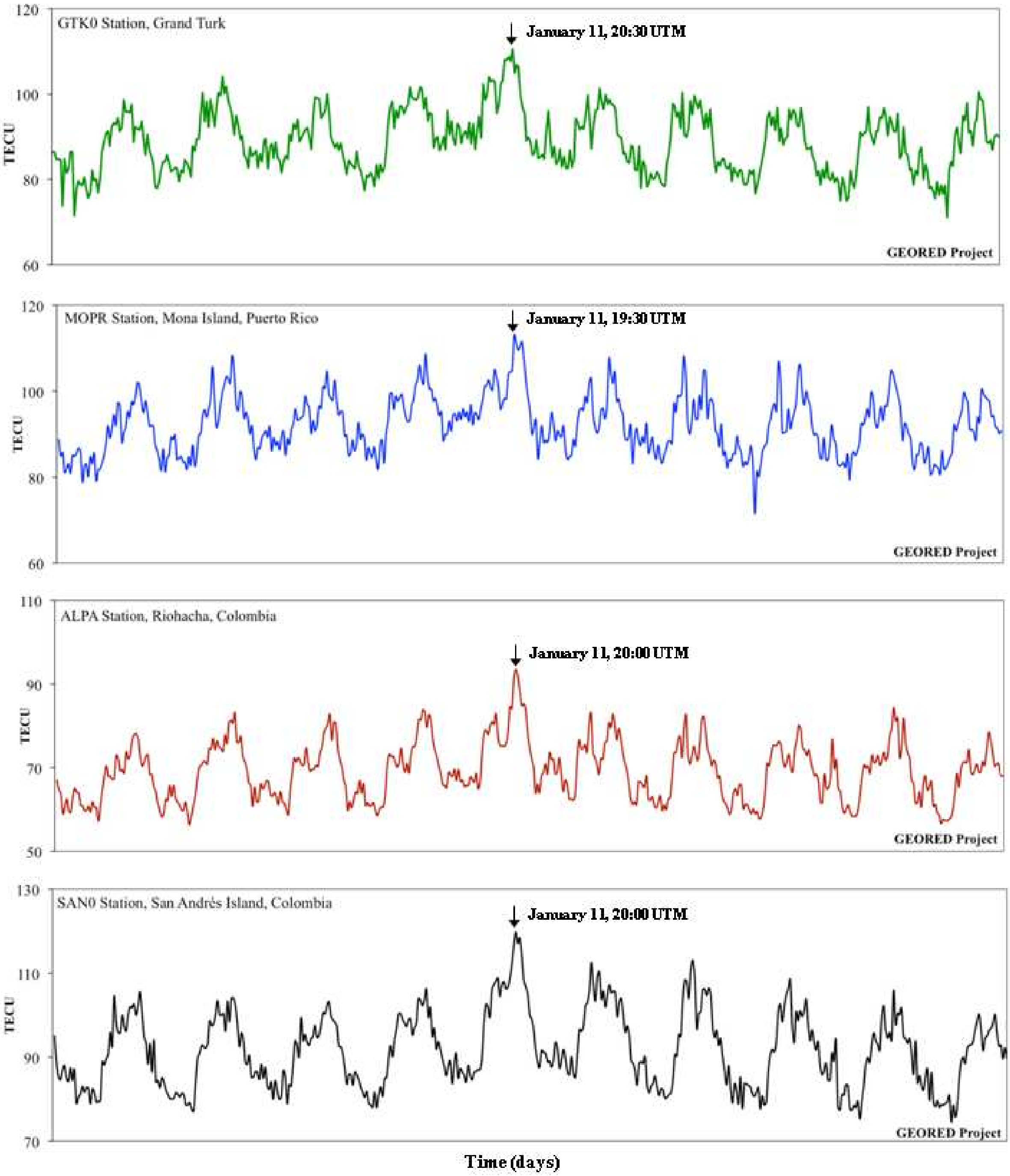


Figure 2: TEC estimation seven days before the earthquake occurrence. The peaks are about 24 hours before the event.