Giant Earthquakes' Effects on the Ionosphere

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Introduction

At 05:46 UTC on March 11, 2011, a massive 9.0 earthquake hit the Tōhoku region of Japan and lasted around 6 minutes before coming to an end. Around the same time, satellites and ground receivers in the Global Positioning System (GPS) **[1]** detected a large spike in Total Electron Content (TEC) **[2]** in the Ionosphere surrounding the region. For my PHYS 4900 project I decided to analyze the GPS data collected around the area to determine how much of an effect the earthquake had on the Ionosphere.

Methods

I chose to initially focus on the area around Sendai (38,141) as it was located just west of the offshore epicenter. Using the open-source database Madrigal **[3]**, along with Spyder, I was able to collect GPS data from all over the globe for the days in question and then analyze the area around Japan.

1. The first step was to extract the specific regional data based on latitude and longitude.
2. Next, I had to replace missing data points with empty values which allowed me to take the average of the 4 days before March 11th.
3. Finally, the calculated average was compared to the 11th and the quiet days to determine if the difference between them was notable.

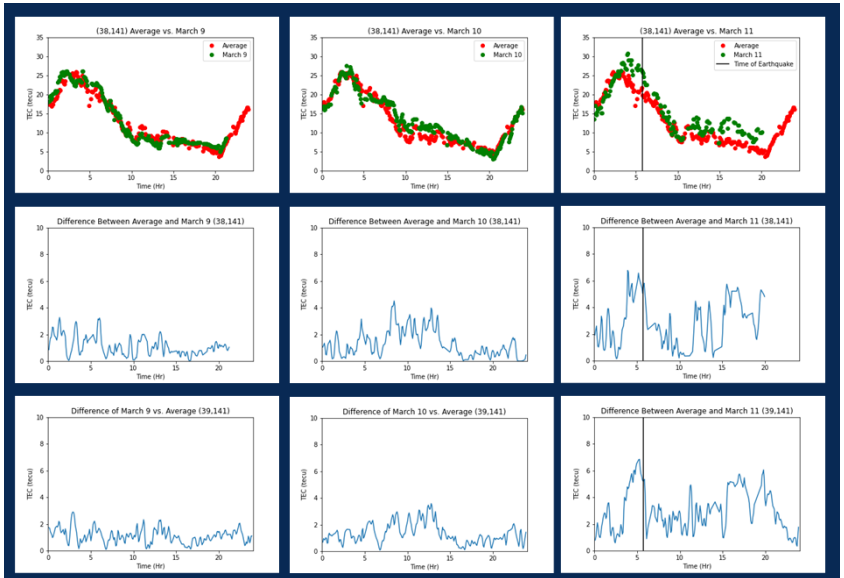

Figure 1. The TEC on March 11 and 2 days prior compared to the 4-Day Average above the city of Sendai at (38,141), and immediately north at (39,141).

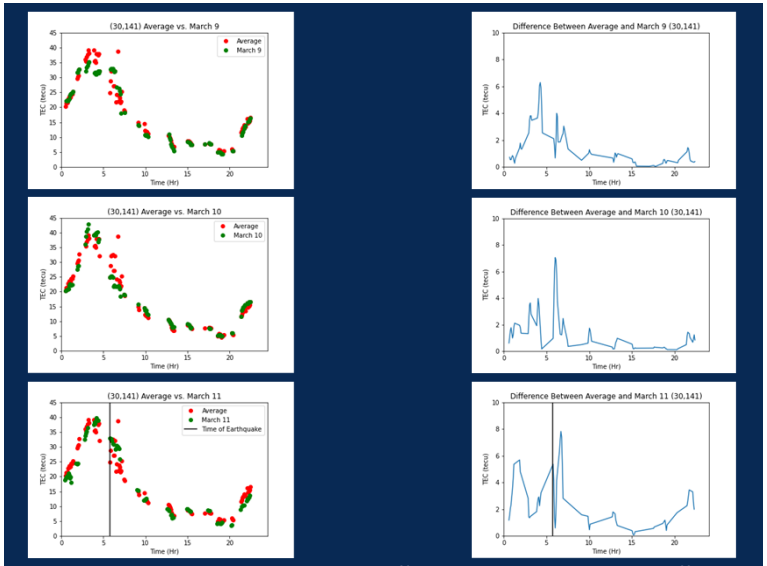

Figure 2. Location where the notable difference in TEC begins to drop off.

Results

After analyzing a multitude of coordinates over and around Japan, the results are all approximately identical to what can be seen in Figure 1, and it is evident that the earthquake did cause a notable rise in TEC ($\sim 7 \pm 0.5$) in the region it occurred. Looking further, figure 1 shows that the rise in TEC occurs just before the earthquake and then seems to drop afterwards. This pattern is similar to what you would see with air pressure prior to a storm. Figure 2 shows the closest area I found where there was no noticeable effect. The rise in TEC seems to be much further out towards the north and west which infers that the epicenter of the earthquake is not the center of the ionospheric disturbance.

Sources

[1]https://en.wikipedia.org/wiki/Global_Positioning_System#Fundamentals

[2]https://en.wikipedia.org/wiki/Total_electron_content

[3]http://cedar.openmadrigal.org/index.html

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