Pressure anomalies detected by local barometers in Colombia due to Hunga Tonga-Hunga Ha'apai eruption event on January 15 2022.

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Abstract

On 15 January 2022 at 0402 UTC, ocurred an important event, Hunga Tonga-Hunga Ha'apai volcano erupted and pushed a giant plume of gases, water vapor, and dust into the sky, generating tsunamis and pressure anomalies worldwide. In Colombia we detected atmospheric pressure anomalies due to the volcano, finding a relation between distance from the volcano and unusual spikes of pressure in local barometers spread over national territory. Using available data from 3 meteorological entities in Colombia (IDEAM, SIATA and a proyect from University of Antioquia) it was concluded that speed of propagation of shock waves produced by Hunga Tonga is around $\approx$ 300 m/s, it took more than 10 hours to go 11.000 km to Colombia and the first measurement we have of the wave was recorded at 1427 UTC.

Key words

Atmosferic Pressure Anomalies, Hunga Tonga-Hunga Ha'apai, Propagation Speed, Shock Waves, Volcano.

Introduction

Hunga Tonga-Hunga Ha'apai is a submarine Volcano located in southwestern Pacific Ocean about 11.000 km from Colombia, it rises around 2.000 mts from the seafloor and above the water there is two islands (Hunga Tonga and Hunga Ha'apai) that increase and decrease it sizes as the volcano erupts. Its most resent major eruption on January 15 2022 at 0402 ± 1 UTC [1] generated disturbances like atmospheric shock waves, sonic booms, and tsunami waves all over the planet.

Scientist of recognized organizations found Tonga volcanic eruption effects at space, specifically hurricane-speed winds and unusual electric currents formed in the ionosphere through the National Aeronautics and Space Administration Ionospheric Connection Explorer (ICON) and European Space Agency Swarm satellites. [2]

The Journal of Tsunami Society International published an article about the impact of the tsunami generated by the volcano in Central an South America [3], there, they collected information about tsunamis that reached Pacific coast hours after the eruption.

In Colombia we detected atmospheric shock waves through barometers at meteorological weather stations that continuously measure atmospheric pressure. These stations are spread over part of national territory and are divided between 3 meteorological entities in the country.

The first one is the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM by its acronym in Spanish). In its available data there are 355 meteorological stations measuring atmospheric pressure, of those, only 65 measured on January 15 2022. The second one is the Early Warning System for Medellín and the Aburrá Valley (SIATA by its acronym in Spanish), on January 15 2022, they had 36 stations measuring atmospheric pressure but only on a small region of the country (Medellín and the Aburrá Valley). The last one is a project of University of Antioquia (UdeA) called 'Antioquia looks at its sky', they have at the moment 4 meteorological stations in university sectionals distributed throughout the department of Antioquia, 2 of them measured atmospheric pressure the day of the eruption.

Anomaly identification

In total we have a set of 103 stations with atmospheric pressure data on the required date. Time series were obtained for that day to know if these stations detected an increase in their usual values.

IDEAM stations:

Figures 1 and 2 represents some time series for IDEAM stations.

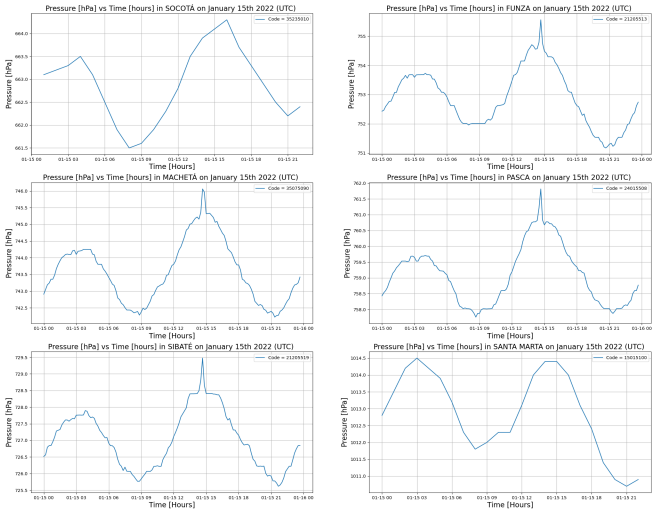

Figure 1. Time series for stations with codes: 35235010, 21205513, 35075090, 24015508, 21205519, 15015100 from IDEAM.

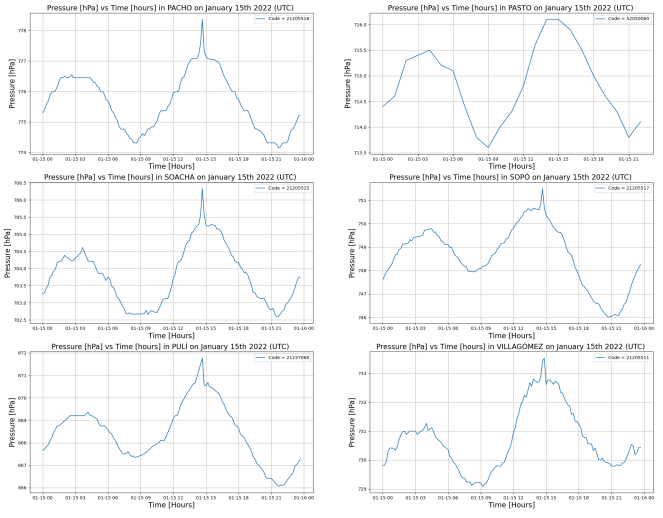

Figure 2. Time series for stations with codes: 21205516, 52050060, 21205515, 21205517, 21237060, 21205511 from IDEAM.

We can see that there is some stations with a spike that breaks with the regular tend of atmospheric pressure along a day, it is the anomaly that we are looking for. In total, the stations that detected the spike are 19 taking data every 10 minutes, that's because the rest of them took a measurement every hour and it's not enough to identify something.

SIATA stations:

Figures 3 and 4 represents time series for 18 stations from SIATA on January 15 2022

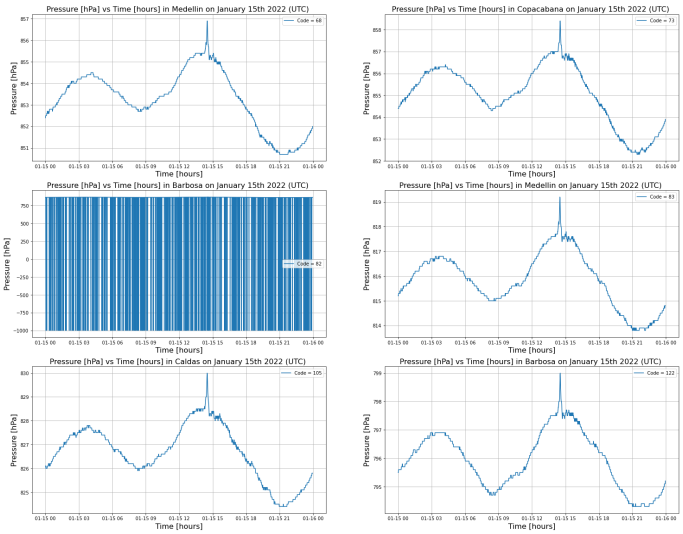

Figure 3. Time series for stations with codes: 68, 73, 82, 83, 105, 122 from SIATA.

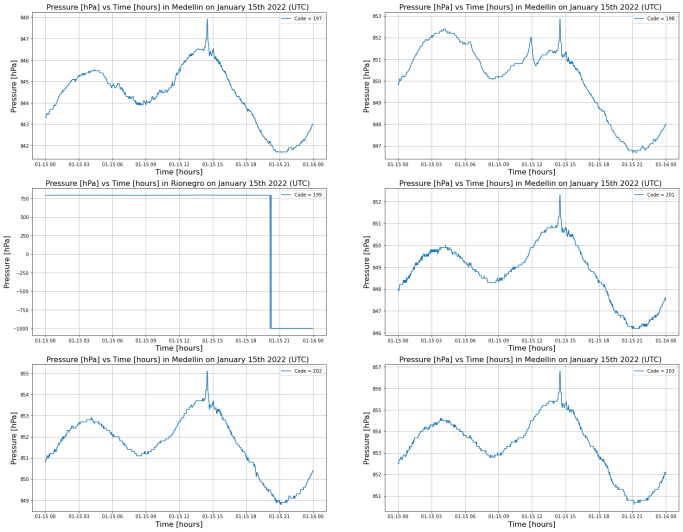

Figure 4. Time series for stations with codes: 197, 198, 199, 201, 202, 203 from SIATA.

As the same as IDEAM stations, some of the SIATA stations did not detect the anomaly, this time it seems to be due to errors in measurements, however, stations took data every minute. In total 28 of 36 have conclusive results.

UdeA stations:

Figure 5 represents the time series for 2 stations from University of Antioquia on January 15 2022.

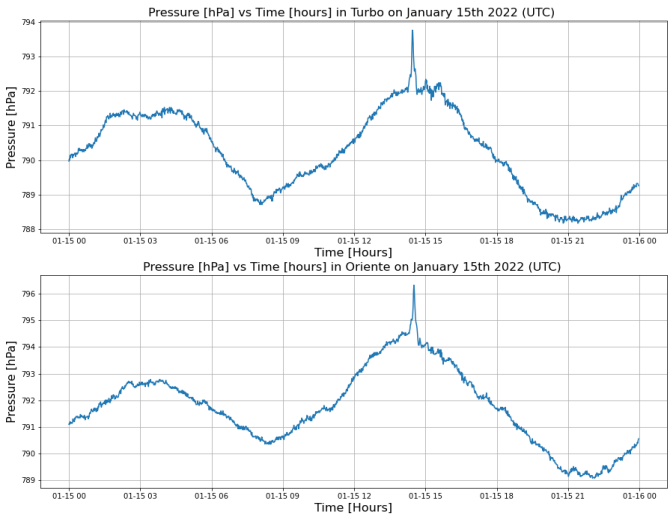

Figure 5. Time series for stations Turbo and Oriente from UdeA.

Both stations detected the anomaly and each one took a measurement every minute. We proceed to make a detailed analysis of the meteorological stations that detected the anomaly throughout the territory.

Analysis and Results

At the end, the anomaly was detected by 49 of 103 meteorological stations that we had at the beginning. We assume that the shock wave of the eruption must appear later and later the farther it goes, because it is moving around the planet. Figure 6 is a map where stations are located.

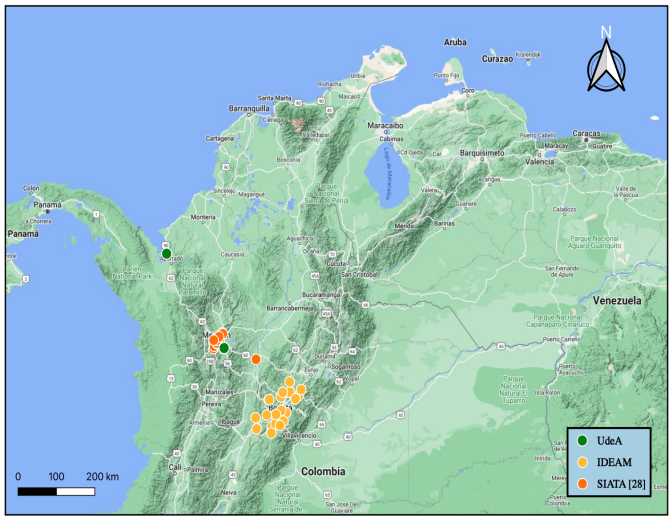

Figure 6. Map with the location of 49 meteorological stations

Time of maximum pressure spike in all stations was analyzed, obtaining Figure 7, which relates the distance from the volcano to each station with the time in which we detected the anomaly.

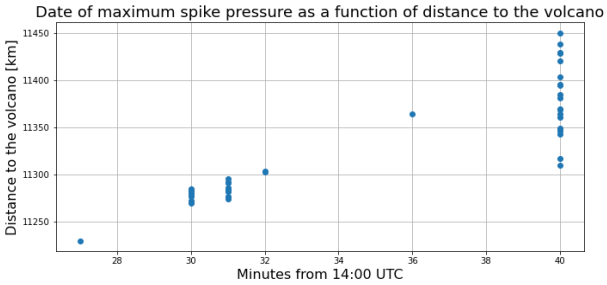

Figure 7. Relation of date of maximum spike pressure and distance from the volcano

There is clearly a relation between distance and the moment of detection of the anomaly. The first data we have detected in the country of the shock wave was recorded at 1427 UTC, more than 10 hours after eruption. Figure 7 shows that the wave is traveling through our territory, being detected by local barometers as time goes by.

3 important sectors were chosen on the map, a station in Turbo (from UdeA), a station in Copacabana (from SIATA) and a station in Simijacá (from IDEAM) to analyze speed (rate of expansion) of the wave using a simple expression of mechanics: $v = \frac{d}{t}$ velocity is equal to distance divided time. Figure 8 shows a map with time series of this 3 points, look that we chose it spread over territory.

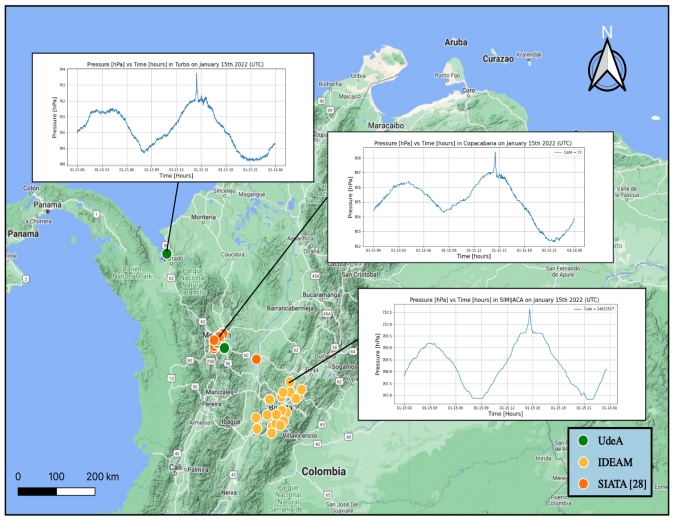

Figure 8. Map with the time series of the 3 strategically chosen stations

We calculated the spherical distance and the time it took for the wave to arrive to those 3 points, then the speed was calculated as said before. Table 1 shows the calculation results.

	Distance[km]	Time[h]	Speed[m/s]
Turbo	11.230, 160	10, 416	299, 471
Copacabana	11.292, 631	10, 483	299, 222
Simijacá	11.428, 613	10, 633	298, 553

Table 1. Distance, Time and Speed from Hunga Tonga - Hunga Ha'apai to those 3 strategically chosen stations.

As we expected, the further away the station is from the volcano, the longer it takes to arrive. It took about 10 hours and 30 minutes to go more than 11.000 kilometers, the wave propagation speed is around 300 meters per second which is close to the speed of sound at standard conditions.

Hunga Tonga-Hunga Ha'apai eruption was a wold event, people around the planet reported anomalies in their routine measurements, at United Kingdom, Harrison G. studied pressure anomalies from January 15 to January 19, finding wave pulses through time. He reported a propagation speed for the first pulse $\approx$ 315 m/s [4]. On the other hand, at United States, a group of researchers from different universities in the country analyzed the eruptive events before and after the major eruption of Hunga Tonga volcano, they reported speeds around $\approx 311 - 317$ m/s [5].

The results obtained at stations in Colombia are consistent with the information reported in other parts of the world, definitely this is an unsurpassed event, that reminds us how incredible our planet is.

References

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