A statistical study of the magnetic signatures of the unique Tonga volcanic explosion of 15 January 2022

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Summary

This manuscript analyses geomagnetic effects of the 15 January 2022 eruption of the Hunga Tonga–Hunga Ha'apai volcano in the Tonga archipelago using data recorded at 19 nearby geomagnetic observatories.

The analysis identifies six small disturbances that are recorded in each observatories' X (North), Y (East), and Z (Vertical) time series and are assumed to be caused by the eruption, measuring:

1. the time from the volcano eruption taken for each of the six "bay" disturbances to reach the observatory (Δt_n, n=1 to 6)
2. the time from the volcano eruption taken for the most pronounced disturbance to reach the observatory (τ_X, τ_Y, τ_Z) (Table 4)
3. the peak deviation of the disturbances (ΔX, ΔY, ΔZ) (Table 4)
4. the total length of time the six disturbances lasted in each component (ΔT_X, ΔT_Y, ΔT_Z) (Table 4)

The paper then uses these measurements to calculate:

5. the apparent speeds of these disturbances (v'_n, n=1 to 6) when travelling to each observatory (Table 3)
6. the linear relationship between the arrival times of the most pronounced disturbances (τ_X, τ_Y, τ_Z) and the observatories' distance from the volcano (Figure 21)
7. the linear relationship between the duration of the disturbances (ΔT_X, ΔT_Y, ΔT_Z) and the observatories' distance from the volcano (Figure 22)
8. the most probable values of the peak disturbances (ΔX, ΔY, ΔZ) (Figure 23)
9. the linear relationships between the arrival times of the six bay disturbances (Δt_n, n=1 to 6) and the observatories' distance from the volcano (Figure 24)
10. the time (Δt_0) taken for the disturbance generated by the volcano to reach ionospheric E-region heights
11. the distribution of apparent speeds (v'_n, n=1 to 6) of the bay disturbances (Figure 25)
12. the average speeds of the bay disturbances (v_n, n=1 to 6)

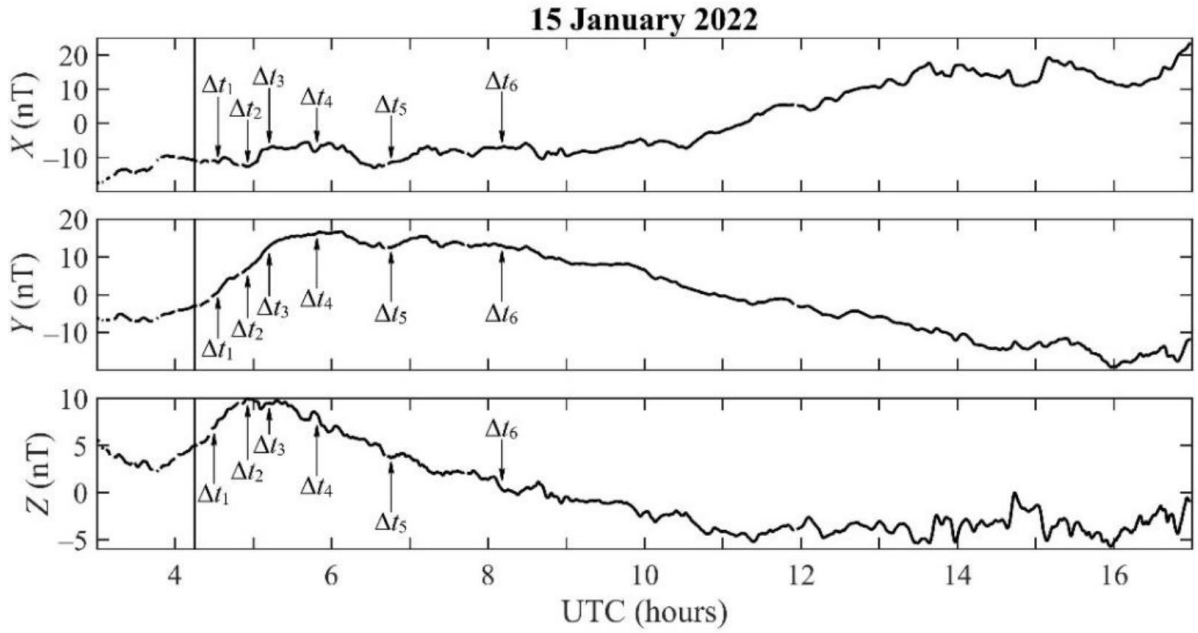
The calculations are interpreted to confirm that the disturbances observed in the observatory time series were caused by effects related to the volcanic eruption.

Comments

An assessment of the magnetic effects generated by the Hunga Tonga–Hunga Ha'apai volcano is a worthwhile endeavour. The author is to be congratulated on the careful and detailed description and analysis of a significant amount of information from 19 geomagnetic observatories.

Unfortunately, I could not understand what disturbances were being identified at the observatories on the day of the eruption. Figures 2 to 20 identify six disturbances in each in each of the magnetic-field components at each observatory, using the symbols Δt_n (n=1 to 6) and arrows to point to the disturbance (see example figure below for PPT observatory). I could not see obvious disturbance features in the manuscript figures or in publicly available original data for the Australian observatories. The manuscript also refers to peak deviations and pronounced disturbances at the observatories, none of which were clearly identified. This lack of clarity about the basic data used in

later analysis is a significant concern and a serious flaw of the manuscript. It would be very helpful if the manuscript clearly showed and described each disturbance feature being identified and why that feature is considered likely to be a volcanic effect.



Figures 2 to 20 take up a lot of page space. It seems to me that the inclusion of plots for the quiet days 13 and 17 January, and their description in the text, does not add significant context to the analysis of the data of 15 January. I suggest consideration be given to omitting these parts of the figures and sections of the text. If higher-resolution plots of the 15 January observatory data assisted in identifying the disturbance features, perhaps this additional space would allow room for such plots.

The units Mm are not common. I suggest changing the units and related quantities to equivalent km.

Line 134 of the manuscript refers to the use of Fourier and wavelet transforms but there is no later evidence of the transformed data being used.

Consistently use either [] or () for parenthetical citations throughout the manuscript.

Corrections

Some details that should be addressed:

1. Line 42,43 (L 42,43): correct the citations format
2. L 53: change 14 to 19 stations
3. L 88: change volcanic to volcano

Conclusion

The investigation of magnetic-field effects related to the 2022 Tonga volcano eruption is worthwhile. However, the manuscript should clarify exactly what geomagnetic disturbance features are being identified in the observatory data. Measurements made about these features are the basis for all later analysis in the manuscript. This clarity will assist in understanding the veracity of the analysis. I suggest the manuscript be returned to the author requesting these clarifications.