

Ionospheric Plasma Ripples of the 15 January 2022 Tonga Volcanic Eruption Observed by FORMOSAT-7/COSMIC-2 IVM



Ching-Chung Cheng¹ (j097980@gmail.com), Jann-Yenq (tiger) Liu^{1,2,3}, Kevin Kan¹, Chi-Yen Lin^{1,2}, Po-Han Lee¹, and Tien-Chi Liu^{1,2}

¹ Department of Space Science and Engineering, National Central University, Taiwan ² Center for Astronautical Physics and Engineering, National Central University, Taiwan ³ Center for Space and Remote Sensing Research, National Central University, Taiwan

Abstract

The ion density (N_i) observed by FORMOSAT-7/COSMIC-2 is used to study response of traveling ionospheric disturbances (TIDs) to the 15 January 2022 Tonga volcanic eruption and tsunami. We examine parameters of N_i , differential N_i , standard deviation, and coefficient of variance (Cv), as well as the ratio of Cv to the monthly median in January 2022. Results show that the parameters become very prominent one day right after the Tonga volcanic eruption. The receiver operating characteristic curve is further employed to find the relationship between Cv ratio and various TIDs. Statistical results show that the TIDs with propagation speeds of 200 and 310 m/s are the most significant, which indicates that tsunami waves and Lamb waves play important roles. Moreover, short-lasting TIDs with high speeds of 480-540 m/s and long-lasting TIDs with low speeds less than 100 m/s mainly appear within 6000 km from the Tonga volcano.

1. Lamb wave and tsunami

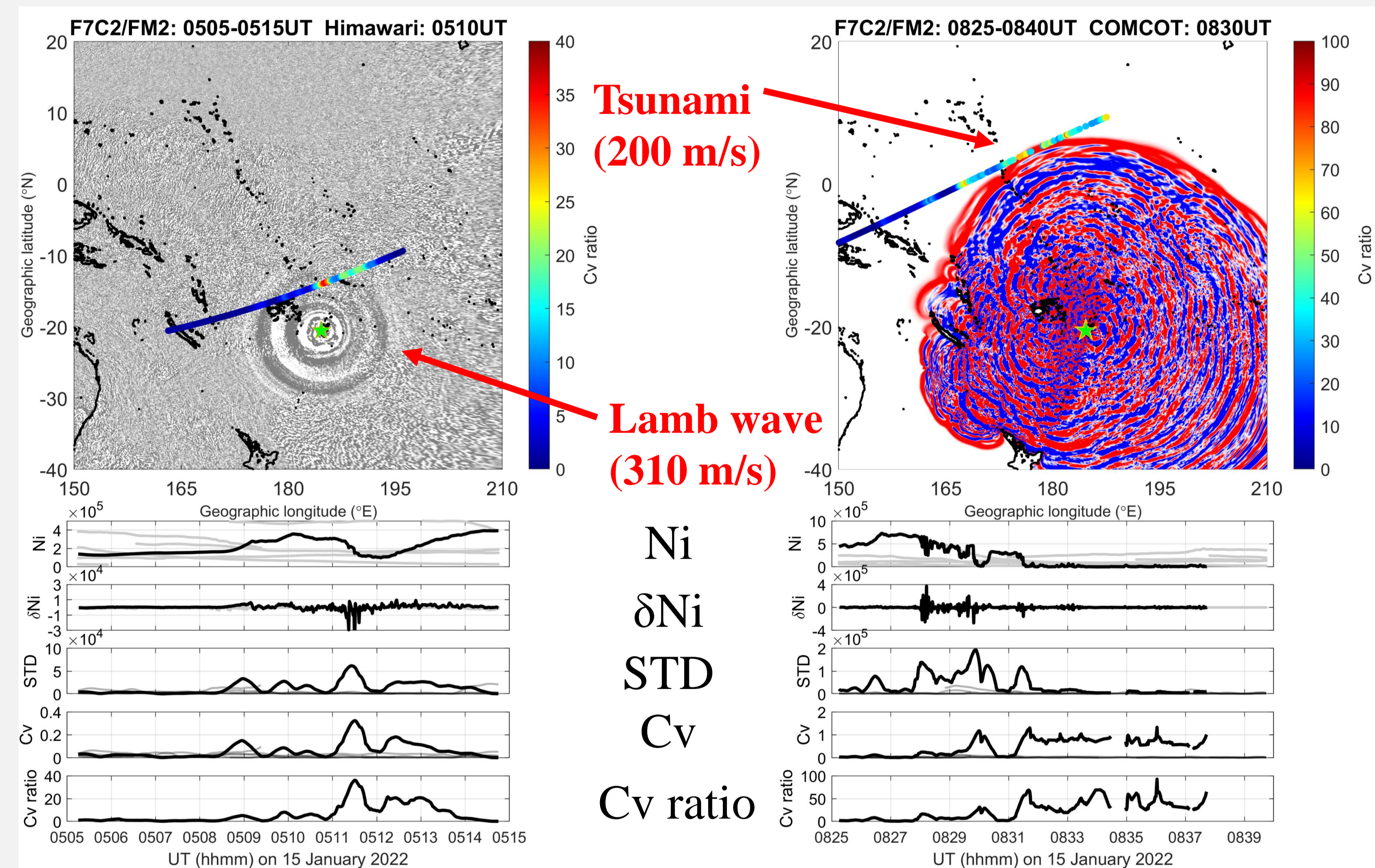


Figure 1. Typical cases of F7/C2 IVM measurements, Himawari-8 image, and COMCOT simulation. Black solid lines are F7/C2 N_i , δN_i , STD, Cv, and Cv ratio on 15 January, and the gray solid lines represent the associated monthly data.

2. F7/C2 ion density on 13-17 January

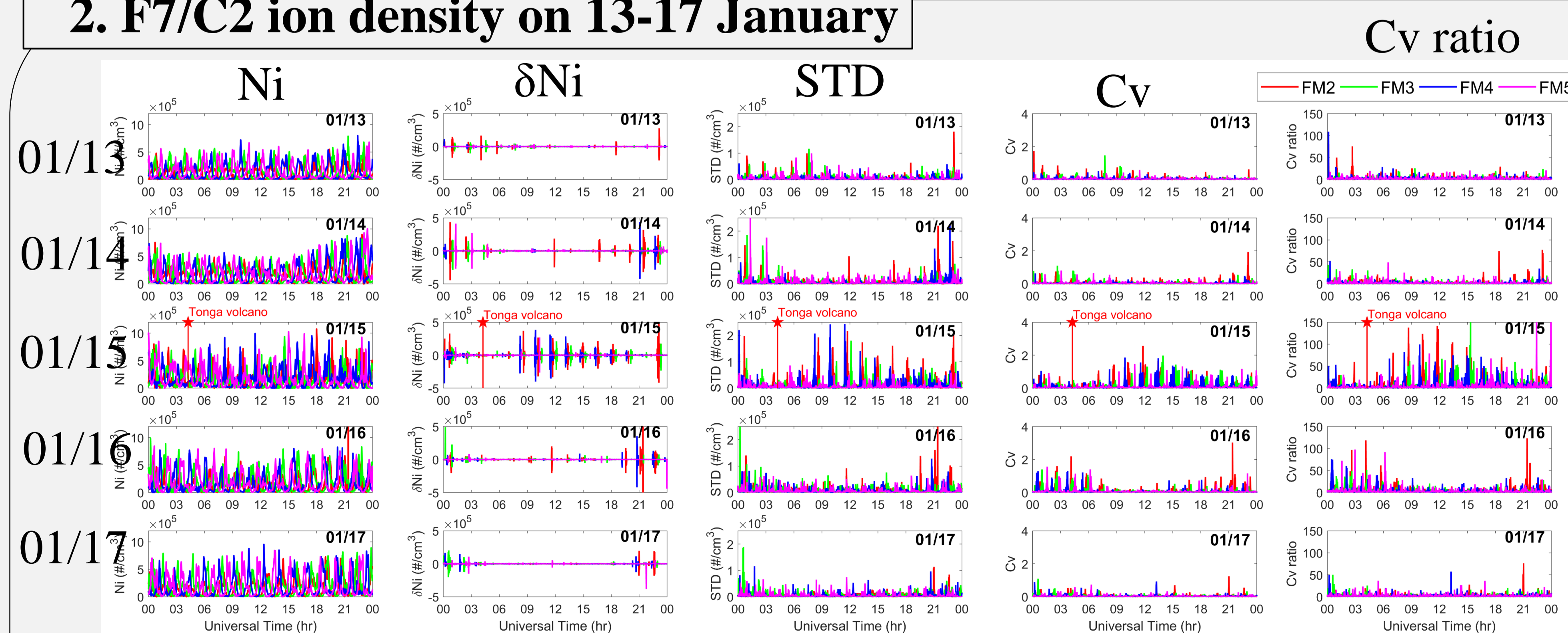


Figure 2. F7/C2 N_i , δN_i , STD, Cv, and Cv ratio in various satellites on 13-17 January.

3. Receiver operating characteristic curve

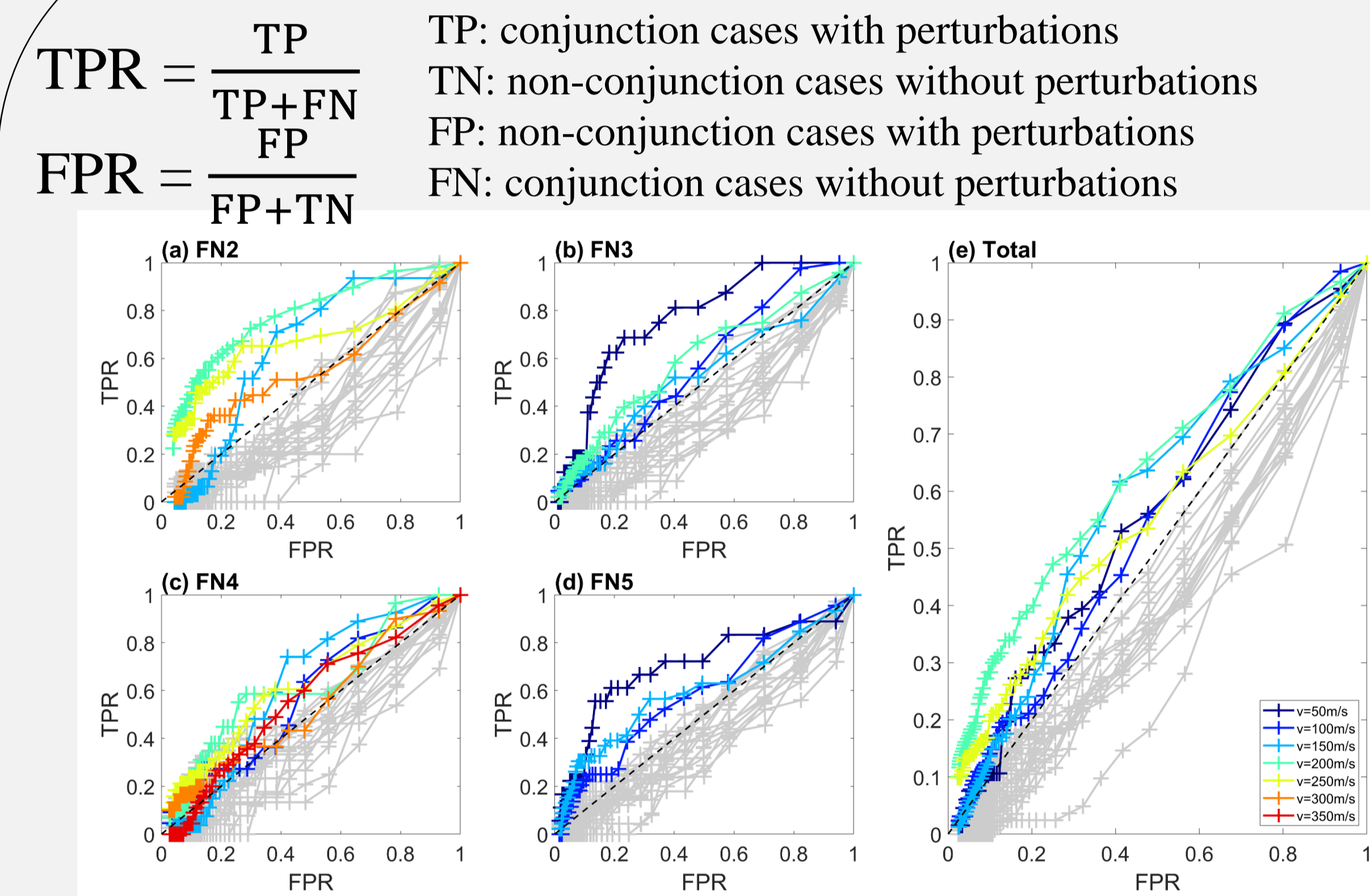


Figure 3. ROC curves for various Cv ratio thresholds at various front speeds. Colored ROC curves stand for the curves within 95% confidence interval.

Area under ROC curve (AUC)

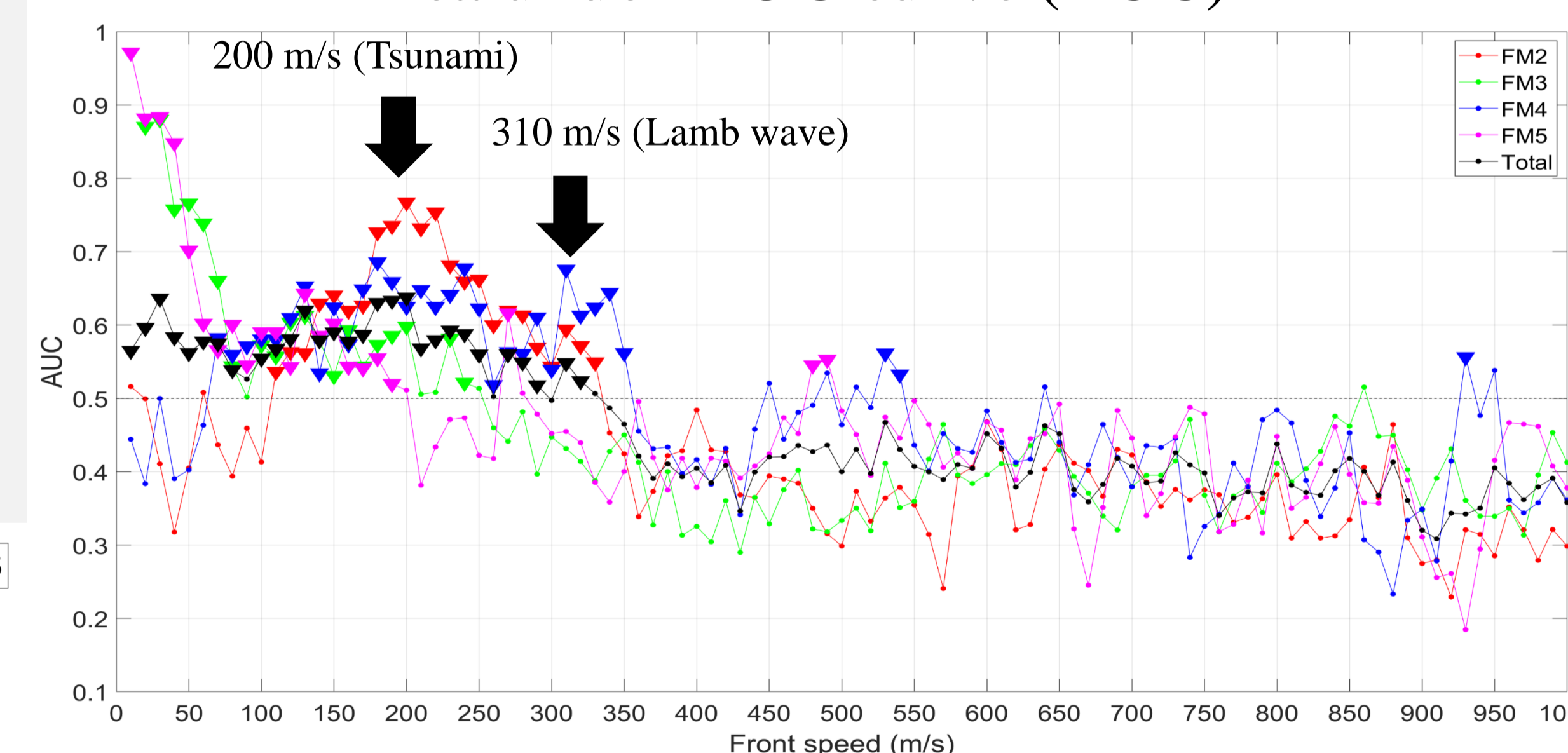


Figure 4. The distribution of AUCs every 10 m/s front speed. The triangle symbols stand for AUCs > 0.5 and associated p values < 0.05.

$$Cv = \frac{STD}{Average Cv}$$

$$Cv \text{ ratio} = \frac{Cv}{\text{Monthly average of Cv}}$$

4. Distance-UT-Cv ratio

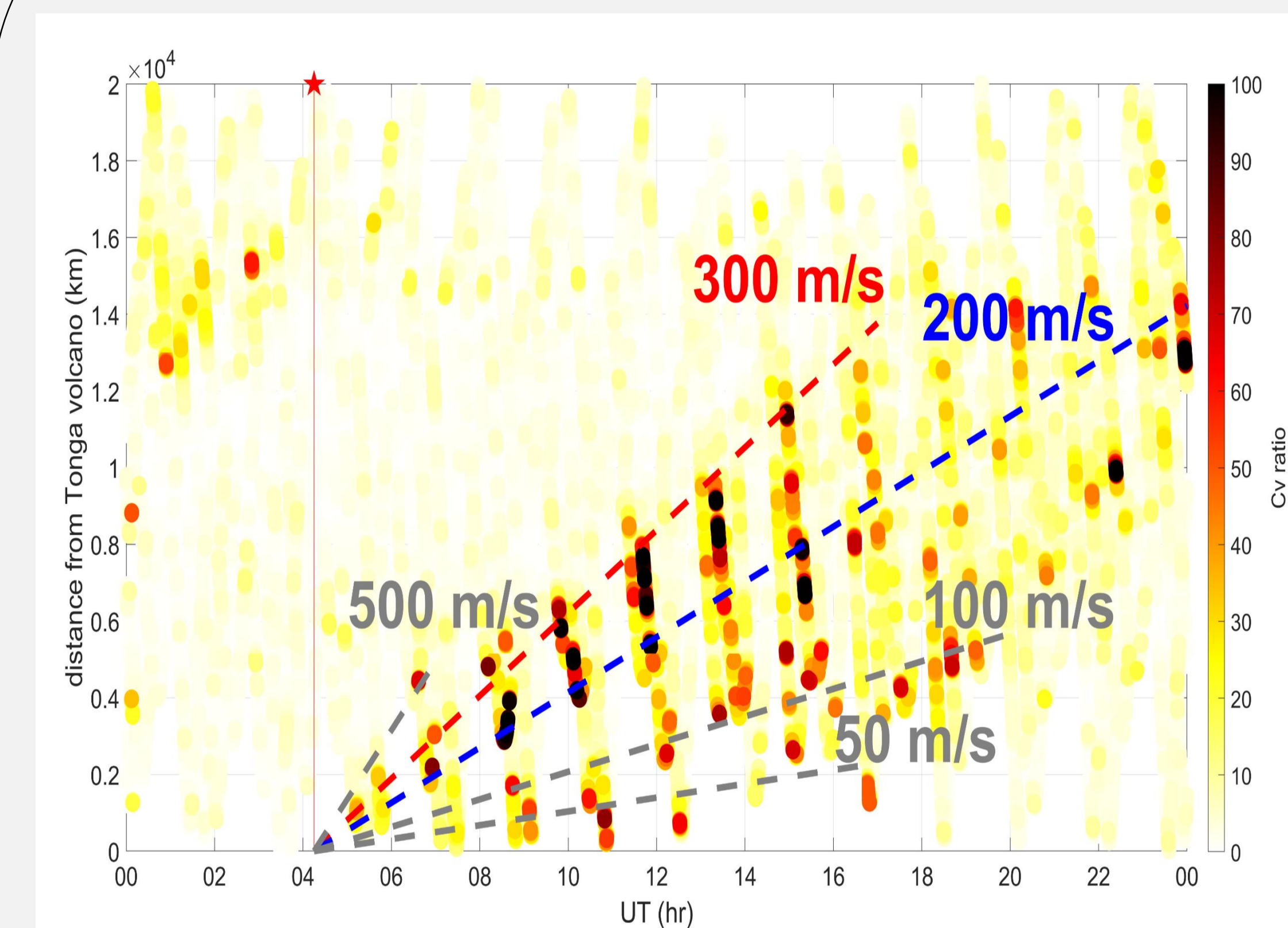


Figure 5. Scatter plot of Cv ratio-time-distance on January 15. The distances shown in the vertical axes are great circle distances between F7/C2 satellites and the location of the Tonga volcano. Red solid line represents the onset of the Tonga volcanic eruption. Red, blue, and gray dashed lines denote various propagation speeds of TIDs.

Conclusion

- TIDs with propagation speeds of 200 and 310 m/s are the most significant, which indicates that tsunami waves and Lamb waves play important roles.
- Short-lasting TIDs with high speeds of 480-540 m/s and long-lasting TIDs with low speeds less than 100 m/s mainly appear within 6000 km from the Tonga volcano.