Advances in Separating Gravity Waves Induced by Natural Hazards from that of Background Ionospheric Variability

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Natural hazards, including earthquakes and tsunamis, pose significant threats to human life and properties. Fortunately, such natural hazards are also detectable from space due to their wave coupling with the Earth's upper atmosphere [Komjathy et al. 2016; Vergados et al. 2020]. Our ability to identify and characterize their impacts as they travel vertically in the atmosphere is key to developing space based early warning systems. In this research, we use dual-frequency GNSS receivers and Deep Ocean Assessment of Tsunami (DART) buoys to analyze the properties of the acoustic and gravity waves induced by earthquake and tsunami events. In our presentation (1) we explain how earthquake and tsunamis generate acoustic and gravity waves that can induce ionospheric perturbations, (2) we show preliminary results of a novel technique to identify and separate earthquake/tsunami from naturally occurring traveling ionospheric disturbances, and (3) we report on automated methodology for the characterization of wave parameters such as velocity, wavelength, wave propagation direction and periodicity. Finally, we discuss how GNSS-based remote-sensing together with DART network can be used as early warning system for earthquake/tsunami induced ionospheric disturbances.

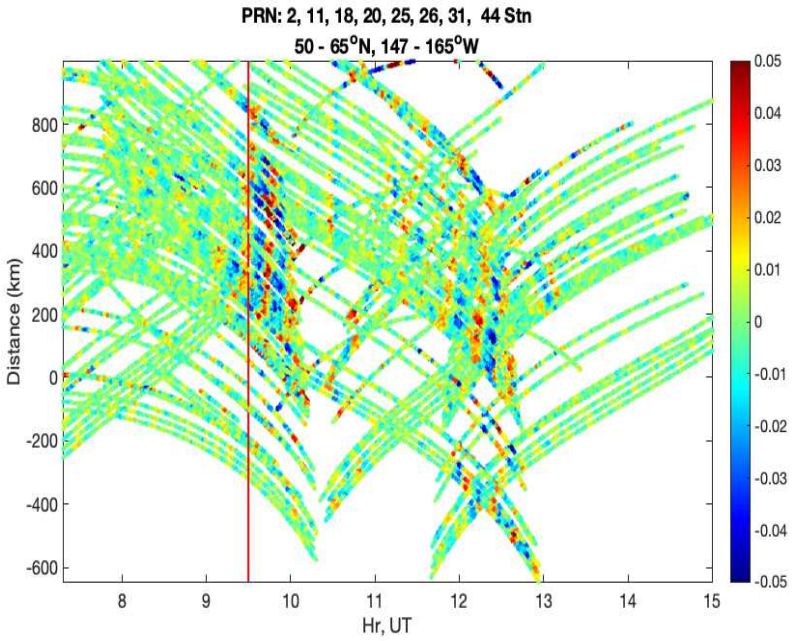

Figure 1. Example of acoustic and gravity waves generated by earthquake and subsequent tsunami events of January 1, 2018 at Kodiak Alaska (56°N and 149°W). The red line represents the onset of the earthquake at ~9.30 UT.

An example is shown in Figure1 for acoustic gravity wave induced total electron content perturbations first observed around the commencement of the earthquake and persisting for up to 30 mins. A second appearance of wave front perturbations is observed about 80 minutes later moving with slower velocity compared to the previous wave front. The later wave is presumed to be gravity wave generated by the tsunami induced by the earthquake. Further details about the result and related analysis will be discussed in our presentation.

References

[1] Komjathy, A., Yang, Y.-M., Meng, X., Verkhoglyadova, O., Mannucci, A. J., & Langley, R., Review and perspectives: Understanding natural-hazards-generated ionospheric perturbations using GPS measurements and coupled modeling. Radio Science, 2016, 51, 951–961. https://doi.org/10.1002/2015RS005910

[2] Vergados, P., Komjathy, A. and Meng X. "GNSS Observation for Detection, Monitoring, and Forecasting Natural and Man-Made Hazardous Events", *Book Chapter in* Position, Navigation, and Timing Technologies in the 21st Century, Integrated Satellite Navigation, Sensor Systems and Civil Applications, 2020, https://doi.org/10.1002/9781119458449.ch32