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Tsunami Ionospheric Monitoring Across the Pacific Ocean and the Southern Atlantic

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As tsunamis propagate across open oceans, they remain largely unseen due to the lack of adequate sensors. To help better mitigate the tsunami risk, we use a detection method that takes advantage of the efficient coupling of tsunami waves with the atmosphere. Tsunami-induced internal gravity waves thus travel upward in the atmosphere, where amplitude amplifies by several orders of magnitude as the air density decreases with altitude. Once the waves reach the ionosphere, they put charged particles into motion, creating propagative phenomena known as Traveling Ionospheric Disturbances (TIDs). Thanks to the Global Navigation Satellites Systems (GNSS), such disturbances can be monitored and observed using the Total Electron Content (TEC) derived from the delay that the ionosphere imposes in the electromagnetic signals transmitted to the Earth's surface by the GNSS satellites. Here we show ionospheric TEC signatures following the passage of three ocean-wide tsunami events: the two tsunamis triggered by the March 4th, 2021 8.1 Mw Kermadec Islands, New Zealand, and the July 29th, 2021 8.2 Mw Perryville, Alaska earthquakes, as well as across the southern Atlantic following the tsunami generated by the August 12th, 2021 8.1 Mw Sandwich Islands earthquake. We classify the observed TEC signatures based on detection reliability and the potential connection to the tsunami wavefield. In addition, we utilize an analytical model to investigate the source of these identified TEC signatures. Thus, we ensure their gravity-waves origin and assess the characteristics (wavelength, period, etc.) of such gravity waves, which is necessary to confirm they originate from the tsunami. Finally, to better map the tsunami amplitude at the ocean level in various configurations, we examine, compare, and contrast the amplitude of the identified tsunami-induced TEC signatures from geographically sparse regions. We account for multiple parameters such as the local magnetic field, the azimuth, and the distance to the tsunami source. They all affect the TEC signature detection and the retrieval of the tsunami wavefield and, thus, potentially, the estimated risk.