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GPS-TEC of the Ionospheric Disturbances as a Tool for Early Tsunami Warning

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Recently, the GPS measurements were used for retrieving the information on the various types of ionospheric responses to seismic events (earthquakes, seismic Rayleigh waves, and tsunami) which generate atmospheric waves propagating up to the ionospheric altitudes where the collisions between the neutrals and charge particles give rise to the motion of the ionospheric plasma. These experimental results can well be used in architecture of the future tsunami warning system. The point is an earlier (in comparison with seismological methods) detection of the ionospheric signal that can indicate the moment of tsunami generation. As an example we consider the two-dimensional distributions of the vertical total electron content (TEC) variations in the ionosphere both close to and far from the epicenter of the Japan undersea earthquake of March 11, 2011 using radio tomographic (RT) reconstruction of high-temporal-resolution (2-minute) data from the Japan and the US GPS networks. Near-zone TEC variations shows a diverging ionospheric perturbation with multi-component spectral composition emerging after the main shock. The initial phase of the disturbance can be used as an indicator of the tsunami generation and subsequently for the tsunami early warning. Far-zone TEC variations reveals distinct wave train associated with gravity waves generated by tsunami. According to observations tsunami arrives at Hawaii and further at the coast of Southern California with delay relative to the gravity waves. Therefore the gravity wave pattern can be used in the early tsunami warning. We support this scenario by the results of modeling with the parameters of the ocean surface perturbation corresponding to the considered earthquake. In addition it was observed in the modeling that at long distance from the source the gravity wave can pass ahead of the tsunami.
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