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Simulation Study on Tsunami Detection from Space Using GNSS-R

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The Sumatra earthquake of December 2004 was the second largest earthquake ever recorded by instruments and the following tsunami took more than 200,000 lives. The German Federal Ministry of Education and Research (BMBF) commissioned the Helmholtz Association of National Research Centres (HGF) directly after the disaster with developing the German Indonesian tsunami early warning system (GITEWS) for the Indian Ocean. While this early warning system is being established concept studies and new technology developments using Global Navigation Satellite System reflectometry (GNSS-R) for tsunami detection from space have been initiated. This technique uses ocean reflected GNSS signals for sea surface altimetry. With a Low Earth Orbit (LEO) constellation of small satellites equipped with multi-frequency GNSS receivers densely spaced grids of sea surface heights could be established to detect tsunami waves within minutes. The simulation study analyzes the performance of various LEO satellite constellation scenarios with respect to tsunami detection time for two different tsunami events and with different GNSS-R concepts. Therefore, a reflection point calculation is combined with a tsunami wave propagation model. Different orbit heights, orbit inclinations and numbers of satellites are investigated. GPS, GLONASS and Galileo signals are used as signal source. The impact of signal elevation angle and altimetric accuracy on the detection performance is evaluated. It can be shown that only a large number of LEO satellites can monitor the sea surface with sufficient high resolution in space and time when a detection time of 5 to 15 minutes is needed.