FACTSHEET
GPS Technology

GITEWS

German Indonesian Tsunami Early Warning System

Establishment of a Tsunami Early Warning System in the Indian Ocean – The German Contribution

GFZ Helmholtz Centre Potsdam

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GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES

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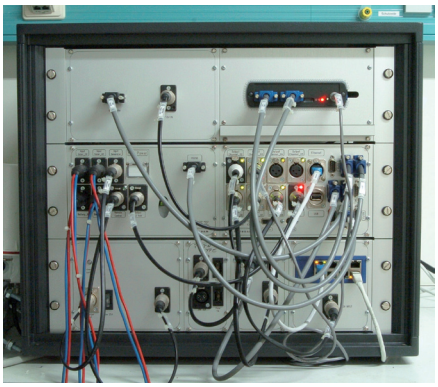
GPS Technology

Today more than 30 Global Positioning System (GPS) satellites are in earth orbit transmitting navigation signals to ground. These signals are widely used for precise positioning applications. Many new GPS-based methods are under development for a wide range of advanced applications. GPS technologies therefore offer a high potential to support tsunami early warning systems. The GITEWS project now, for the first time, has integrated GPS-based methods into an operational tsunami early warning system. The system uses new designed GPS sensor station networks covering landsides, coastal areas and open sea locations. A new near real-time processing, monitoring and information system was developed and implemented for the indonesian tsunami early warning system. GITEWS also prepares a possible next step into future systems. Concept studies for a space-borne warning system using GPS reflectometry as remote sensing technique have been accomplished.

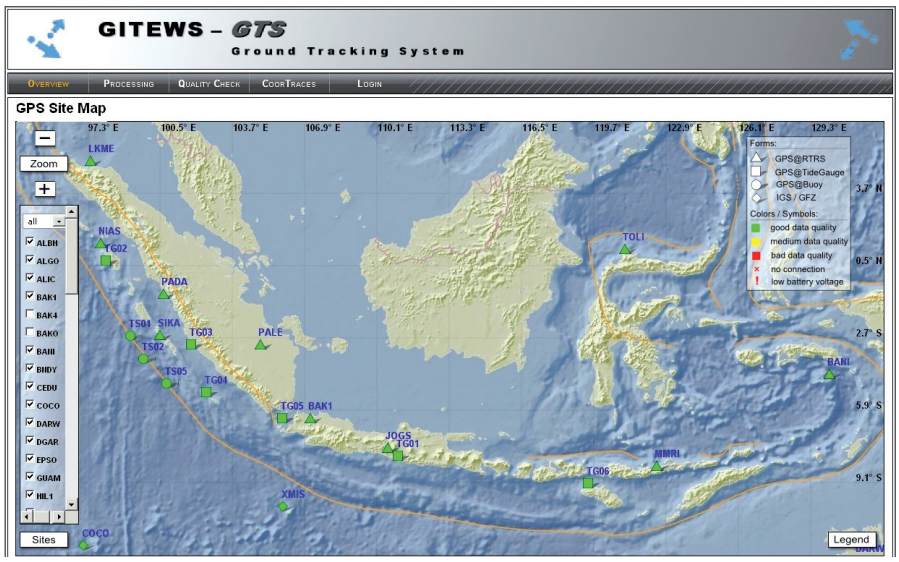
GPS sensor stations on land

These stations can detect ground motions due to plate tectonics and earthquakes. This information is a valuable source for a fast understanding of an earthquake's mechanism and its relevance for a potentially following tsunami. Precise ground motion monitoring with GPS already was a standard method before GITEWS, but did not fulfill the needs of an early warning system. An operational early warning system requires near real-time data processing and a high level of reliability. These necessities also required the installation of an inland GPS sensor reference network with real-time data transmission.



GPS sensors at tide gauges

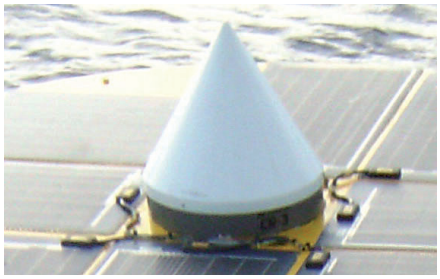
Like GPS sensor stations on land GPS sensors at tide gauges detect ground motions. In addition they can help to interpret the measurements of co-located tide gauge instruments which measure the sea level height at coastal locations. There is a potential danger to misread water height measurements in case the sensor station itself has moved with the ground at the same time. In other words: The GPS measurements can help to decide whether the sea level or the sensor station location has changed, e.g., due to a strong earthquake. The



obtained reliability of interpretation is the most significant benefit of a GPS equipped tide gauge sensor system.

GPS sensors on buoys

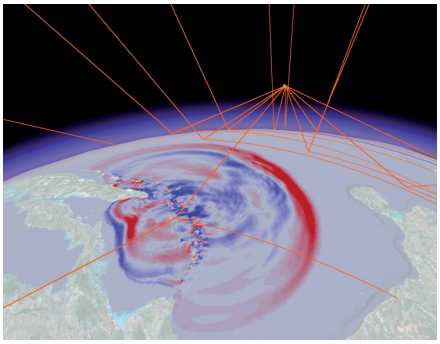
Another task for GPS technologies is the direct detection of tsunami waves on the open ocean. This can be done by GPS sensors on buoy systems. A buoy moves with



the tides and wind induced waves as well as tsunami waves. A GPS sensor mounted on a buoy follows these movements and thus measures the actual sea level. The challenge is to differ between a passing tsunami wave and wind induced waves or tides. This requires an advanced data processing system on land. Additionally, many solutions for communication and power supply under rough environmental conditions had to be found.

GPS sensors on satellites

GPS sensors installed on satellites have the potential to measure sea surface heights by using GPS signals reflected from the sea surface. The idea is to receive these reflected signals with special GPS instrumentation on satellites. Compared to conventional satellite radar altimetry such GPS reflectometry based systems offer a much higher resolution in time and space. A high resolution is essential to detect tsunami waves from space in time. Such a satellite-based system could be implemented to support a tsunami early warning system with global coverage.

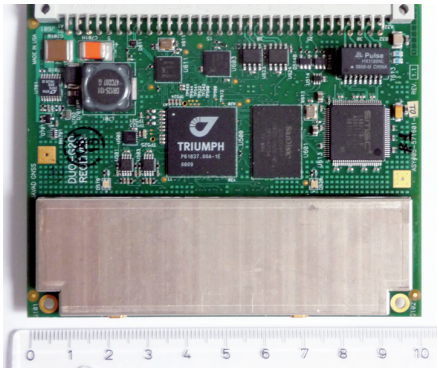


In-Orbit Simulations

Computer simulations have been carried out to evaluate an expectable tsunami detection performance. Different scenarios with various numbers of satellites at different orbit heights have been tested. The simulation not only includes reflected GPS signals, but also global navigation satellite system (GNSS) signals emitted by GLONASS and the future GALILEO system. The analysis shows that already 18 satellites in low earth orbits are sufficient to detect a Sumatra like tsunami within 20 minutes, assuming optimum receiving conditions.

Space Receiver Development

Such a constellation could be realized by a set of small and affordable satellites which are equipped with a GNSS instrumentation based on commercial off-the-shelf receivers. Standard receivers do not offer the functionality necessary to measure reflected GNSS signals. Within GITEWS the newest geodetic grade commercial JAVAD GNSS receivers are adapted and extended for this



purpose. As a major step forward compared to current space receivers, the new JAVAD receivers support tracking of the latest GNSS signals. Signal simulator tests show that the chosen receivers provide proper GPS measurements for orbit determination and scientific applications under the signal dynamics of a satellite in low earth orbit.

GPS reflectometry experiment

A ground-based experiment was performed to measure GPS signals reflected from a lake surface. The extended functionality of the adapted JAVAD GNSS receiver was approved. Height profiles of the reflecting water surface could be derived from the reflected GPS signals with cm-level accuracy. The data show good agreement with water level observations from a conventional tide gauge sensor.

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