FACTSHEET
Simulation

German Indonesian Tsunami Early Warning System

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

AWI

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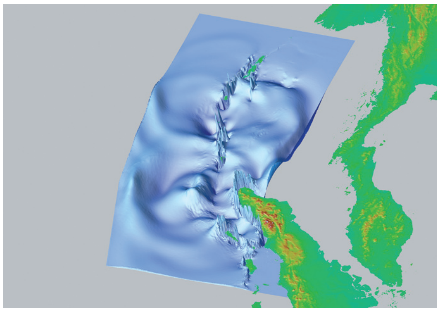
Why Simulation?

The simulation system is like the heart of the tsunami early warning system. Since no direct continuous and globally covering observation of the ocean surface exists, all sensors only give point-wise information. The simulation system evaluates this point-wise information to give a complete picture of the situation. Additionally and apart from the warning process, simulation results like detailed inundation maps, can be used for planning and mitigation. Hazard zones can be determined, vulnerable infrastructures can be identified.

Innovation

The simulation system within GITEWS offers several very innovative and unprecedented features:

1. An advanced tsunami source model has been introduced that is especially suited for realistic modeling of near-field tsunamis as well as for novel technique of GPS-based real-time source inversion.
2. A new unstructured mesh finite element tsunami simulation software has been developed, which can incorporate wave propagation and detailed inundation modeling in a seamless and accurate way.
3. A new method for evaluating the limited number of sensor data in short time has been developed, which allows for a precise situation perspective for near field tsunamis.
4. A new automated simulation system (database) has been implemented, which integrates scenario data from different institutions providing fully automatic map generation and evaluation.

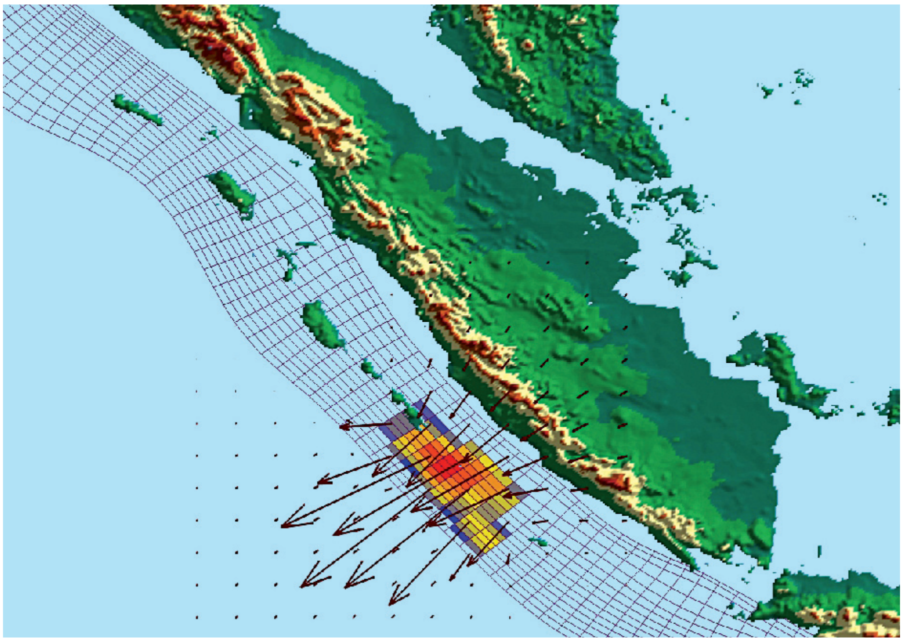


5. A new GUI-based Process Simulator has been designed for interactive modeling and visualization of full earthquake- and tsunami scenarios with application for Decision Support System testing and verification as well as for personnel teaching and training.

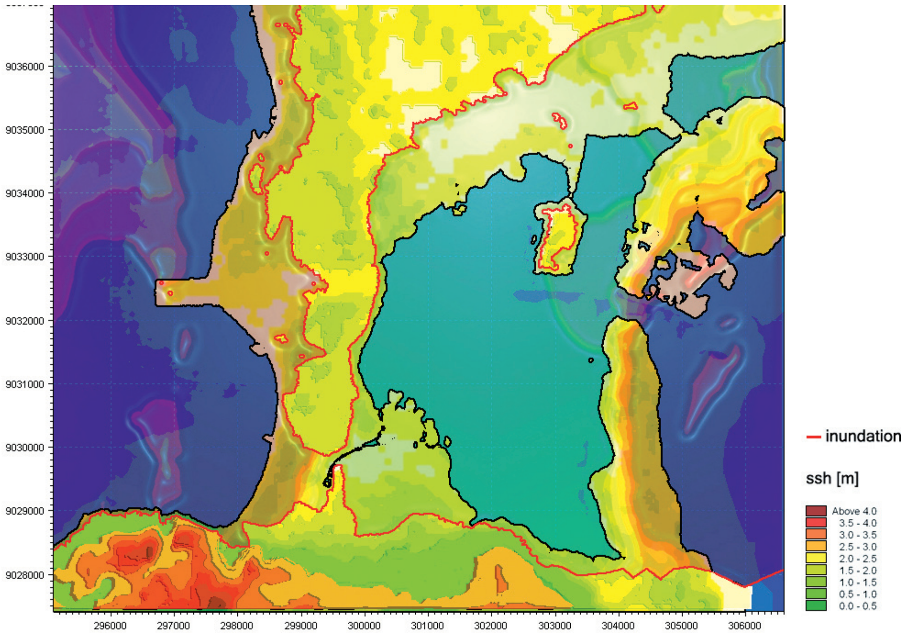
These features make the GITEWS simulation system especially valuable for the situation in Indonesia, where large subduction zone earthquakes are frequent and occur very close to the coast. In the early warning environment, the simulation system is capable to return an evaluation for given sensor data within seconds. In this process it compares the incoming measurements with thousands of pre-computed tsunami scenarios.

Integration

One of the major outstanding features of the GITEWS simulation system is its capability to integrate scenario data from diverse



Rupture- and deformation model for the 12 Sept 2007 Bengkulu earthquake



Kuta, Bali: inundation and run-up (sea surface height) scenario with source at tile 41 10, magnitude 8.5

data providers. Diverse data formats, Tsunami simulation software systems, and versions can be supported seamlessly. Unavailable data items are taken into account automatically. By this means, the system is very flexible, extendible and adaptable to special requirements.
First partners for the integration of tsunami scenarios are the Institut Teknology Bandung (ITB), and the Agency for the Assessment & Application of Technology (BPPT).

Source Modeling

An advanced tsunami source model that has been developed in the framework of the GITEWS project, is especially suited for the realistic modeling of near-field tsunamis. It steps beyond the traditional Okada single fault approach and introduces a multi-patch discretization of the seismogenic plate interface. A 3D model of the interface between the subducted oceanic and continental plate utilizes geophysical and geological data and is subdivided into 2250 rectangular patches with dimensions of about 40 x 15 km each. Green's function approach in layered media is then employed to pre-compute 3D surface deformations according to unit slip at each patch. These unit sources are then linearly combined to predict tsunamigenic sea-floor uplift for arbitrary complicated rupture.
It is important to note that the multi-patch source model is also a part of a novel technique of the GPS-based real-time source inversion, first suggested and developed in the GITEWS project.

Unstructured Mesh Model

Traditionally, tsunami wave simulation has been split in two phases: a (linear) wave propagation phase and a non-linear and complex inundation phase. For far field tsunamis (i.e. tsunamis in which the effects are taken into consideration far away from the source) this approach is sufficiently accurate and physically sound. For near field tsunamis the non-linear complex effects from non-uniform sources and complex bathymetry and topography are too important to be neglected in the linear propagation phase. Therefore, the GITEWS simulation system employs an unstructured mesh tsunami simulation software, which can handle propagation and inundation in a seamless fashion. The unstructured mesh is refined to very high resolution (approx. 100 m) in coastal areas of interest, while it stays relatively coarse in the deep ocean. The applied finite element method allows for accurate simulation of the physical wave propagation and interaction. The data derived from the unstructured mesh computations are also taken as input to even higher resolved local inundation studies carried out in the GITEWS project.

Multi-Sensor Selection

Most tsunami warning systems employ a decision matrix approach for the early warning. This means the warning is based on seismic (earthquake) measurements and several simple criteria and thresholds to generate a warning. This approach produces a large number of false warnings, since only a small fraction of medium scale earthquakes does generate a tsunami. The GITEWS approach to overcome this weakness is to evaluate diverse and pair-wise complementary data simultaneously.
This approach has been used in weather forecasting and is known as analog forecasting method: A large number of pre-computed scenarios are stored in a database and form the range of possible assumed tsunami events. Once a wave is detected, incoming true measurements are then compared with the scenario data. Such distinct values as epicenter location, magnitude, wave height, wave arrival time, and earth crust deformation are matched in a meaningful manner. Those scenarios with the best overall match give a precise situation description

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Indonesian and International Partners:

Agency for the Assessment and Application of Technology (BPPT),
Technical Institute Bandung (ITB)