GITEWS – STRATEGY, INSTRUMENTATION AND NEW TECHNOLOGIES

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ABSTRACT: GITEWS is a project financed by the Federal Ministry of Education and Research (BMBF) to build up elements of a Tsunami Early Warning System in Indonesia. The different objectives are accomplished by a consortium of nine institutions. By the end of 2008 the system will be ready to start operations and will be passed to Indonesia in March 2010.

The system conception integrates terrestrial observation networks of seismology and geodesy with oceanographic instrumentation as well as satellite observations. Besides the technical infrastructure for Early Warning, GITEWS also provides an education and training program for scientists, technicians, and the population as well as for involved Indonesian institutions.
Different sensors such as seismic stations, GPS stations, tide gauges and GPS-buoys are installed and online, the sensor net will be completed in 2009. Key milestones such as the development of the automatic seismic data processing software SeisComP3, and the simulation of a tsunami wave including the source modelling have been completed. SeisComP3 is already operational at BMG since 2007 and successfully in use for rapid nation wide earthquake information. More than 1000 pre-calculated Tsunami simulations for the Indian Ocean coast line of Indonesia are already calculated and stored in a database to provide immediately the best solution matching the actual situation and to pre-estimate the risk for the different coastline segments. Information from the different sensor systems converge in a central Early Warning and Mitigation centre in Jakarta. Using a Decision Support System the sensor data are matched with the pre-calculated Tsunami scenarios and additional geospatial data and maps to enable the officer on duty to appraise the danger and to release warning dossiers or warning cancellations respectively. In this context the education and training of local authorities and population is an important task of the capacity building program.

An early warning system for the Indian Ocean

The Sumatra earthquake of December 2004 was the second largest ever detected rupture in the Earth's crust. Already after about 12 minutes the seismic waves were automatically recorded and analysed at the GFZ in Potsdam (Germany) and at other seismological centres worldwide. At this point in time, the first tsunami waves had not yet reached the coastlines of Northern Sumatra. But there were no possibility to pass the warning on to the population in time.

Shortly after the Tsunami Disaster where almost a quarter of a million humans lost their lives, Germany offered technical support for the installation and implementation of a tsunami Early Warning System in Indonesia. GITEWS is a project of the German Government at the reconstruction of the tsunami-prone region of the Indian Ocean. It is accomplished by a consortium of German research institutions. Since March 14, 2005 Indonesia and Germany have been officially working together to implement a Tsunami Early Warning System in Indonesia. This implementation will be largely completed this year. A joint cooperation on the optimization, operation and maintenance of the system is further planned up to March 2010.

The Strategy

Looking at the geological situation in the Indian Ocean the most prominent active continental margin is the so-called Sunda-Arc structure, a large subduction zone which spreads almost parallel to the coast line of Indonesia. This implies that we have an almost comparable situation for the entire Indian Ocean coast line of Indonesia with Tsunami travel times between 20 – 40 minutes from their origin somewhere along the active margin to the nearest coast line. This situation is a challenge for the design of the technical components and the operational procedures of an Early Warning system. Having in mind the short Tsunami travel times to the coast line of Indonesia the early warning time has to be considerably shorter in the order of 5 – 10 minutes. This is reflected in the technical system layout with a dense network of seismic stations, the deployment of buoy systems very close to the subduction zone and the use of a near real-time GPS network for the determination of post seismic crustal deformation. Especially the extraction of proper pre-calculated Tsunami scenarios from a database is designed to take into account all different sensor information through direct comparison of measured and calculated sensor responses in the matching process. This new strategy enables the system to produce situation pictures already shortly after Tsunami generation although based only on few parameters which still have a relatively high uncertainty at this early stage.

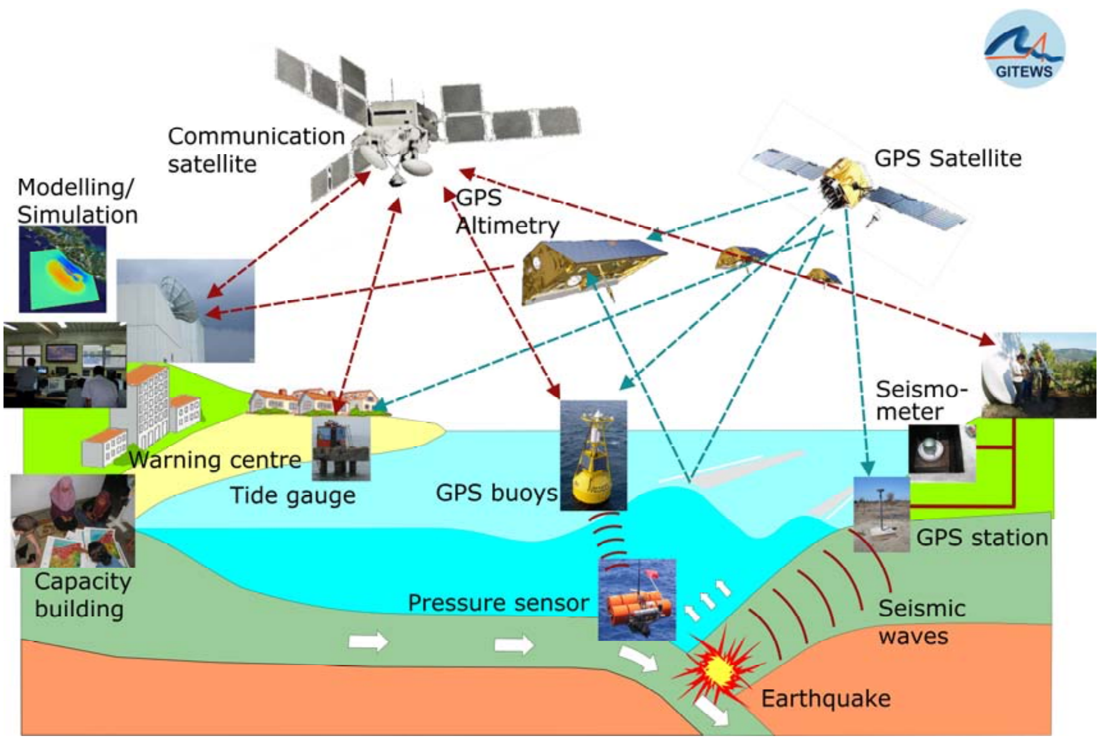

Fig. 1: Concept of the GITEWS component parts. The conception integrates terrestrial observation networks of seismology and geodesy with marine measuring processes and satellite observation.

The Components
The system includes a seismological network consisting of broadband seismometers as well as GPS stations and a network of GPS buoys additionally equipped with ocean bottom pressure sensors and a tide gauge network. The respective sensors are connected by satellite communication to the Early Warning and Mitigation Centre operated by the Indonesian Meteorological and Geophysical Agency (BMG) in Jakarta.

In this Warning Centre the on-line data streams are processed, and, on the basis of the sensor data, tsunami simulations can be provided rapidly and used in a Decision Support System for the generation of a fast and detailed picture of the actual situation. Using risk and vulnerability maps of the affected coastal regions detailed warning dossiers are produced and disseminated to the respective authorities, agencies and population.

The system is designed in an open and modular structure based on the most recent developments and standards of information technology. Therefore, the system can easily integrate additional sensor components or can be expanded for other purposes using large parts of the infrastructure in a sustainable manner.

An integral part of the project is capacity building which concentrates on academic and engineering training and education for the operation of such a system. This training is accompanied by various activities in the field of preparedness and awareness of the people as well as support for institutional capacity building.

Earthquake monitoring
In more than 90% a tsunami is caused by a submarine earthquake. A fast and correct seismological recording and evaluation is therefore essential for the warning system. With the seismic sensors installed so far in Indonesia and with the newly developed software system SeisComP3 which was launched in May 2007, there is now a tool available to quickly register and evaluate even strong earthquakes. Meanwhile SeisComP3 is established as quasi standard in several countries bordering the Indian Ocean.

Oceanographic components
Based only on seismological measurements it is mostly impossible to decide whether a tsunami has been generated or not. Therefore a tsunami has to be detected directly on the ocean using ocean bottom pressure instruments, buoys and tide gauges. The newly developed buoys have two functions: they work as a relay station for the data of the ocean bottom pressure sensors transmitting their data from the sea floor to a modem close to the water surface and from there via the satellite to the central warning centre. Furthermore the buoys are equipped with GPS to be able to detect a tsunami at the surface independent of the measuring instruments on the ocean floor. This is an important technical improvement compared to other buoy systems in operation so far. The combination of underwater and surface measurements guarantees a higher availability and less breakdowns or even false alarms.

Modelling
Tsunami-simulations are of particular importance for the whole warning process. Based on a few measured data an overall picture has to be calculated. A couple of seconds after the earthquake the modelling results will give an estimate of the expected wave height, the time of arrival and the inundation areas. Combined with the information on the settlement structure in affected coastal stretches this is valuable information for the authorities and the population. Since warning times in Indonesia are extremely short, thousands of different scenarios are pre-calculated and collected in databases.

Warning Centre
All different sensor data converge in the warning centre at BMG in Jakarta, from here all the instruments are controlled, the synthesis of all data and the pre-calculated simulations is done and the

alarm is given or cancelled respectively. The different activities are integrated in a decision support system (DSS), which provides the responsible officer with an overview of the available data, an assessment of the situation and proposals for decision. Thus the data centre, located at the Meteorological and Geophysical Agency of Indonesia (BMG) in Jakarta, is the only institution to issue the nation-wide warnings.

Capacity Building Activities

The fastest warning is useless as long as the gap to the so called "last mile" is not closed. The population in the threatened area needs to be informed in time, but they also need to be trained how to react properly. The people need to be instructed about evacuation plans and how to behave in a case of emergency. In three pilot regions the project enhances civil defence activities which aim in particular to the development of necessary institutional and organisational capacities. This program goes along with the consulting on the national level.

In addition, there is an academic education and training program with regular training courses for different sensor groups or risk modelling for experts and scientists. Also, a PhD and post doc programme is carried out to guarantee the operation and future upgrading of the GITEWS from the scientific and technological point of view.

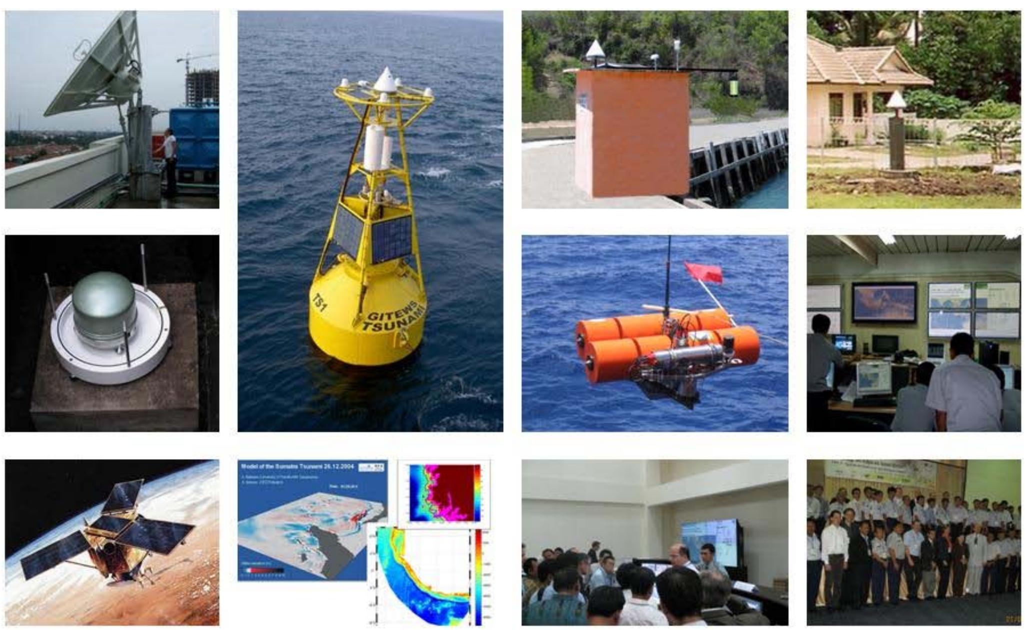

Fig.2: The different GITEWS sensors and component parts. From top left hand side to the bottom right hand side: Satellite hub at BMG, Jakarta; GPS-buoy; Tide gauge station; GPS station; seismometer; Ocean bottom unit; SeisComp3, Warning Centre; New Earth Observation Technology; Simulation/Modelling; Decision Support System, Warning Centre; Capacity Building, Training.

International Cooperation

The German-Indonesian activities are fully integrated into the overall UN plans and strategies for the establishment of global and regional Early Warning Systems. These activities are coordinated by the Intergovernmental Oceanographic Commission (IOC) of UNESCO with four so-called Intergovernmental Coordination Groups (Indian Ocean, North East Atlantic and Mediterranean, Caribbean, Pacific Ocean).

Furthermore, the activities are brought to the attention of the global coordination activity GEOSS (Global Earth Observing System of Systems).

Concrete co-operation work in numerous fields for the establishment of the Early Warning System in Indonesia are underway with a number of other countries, i.e. Japan, China, France and USA.

In the Indian Ocean Region the German Project co-operates with Sri Lanka, the Maldives, Yemen, Madagascar, Tanzania and Kenya to build up equipment mainly for seismological monitoring and processing. Close ties have been established to Australia, South Africa and India for the real-time exchange mainly of seismological, but also of sea level data.

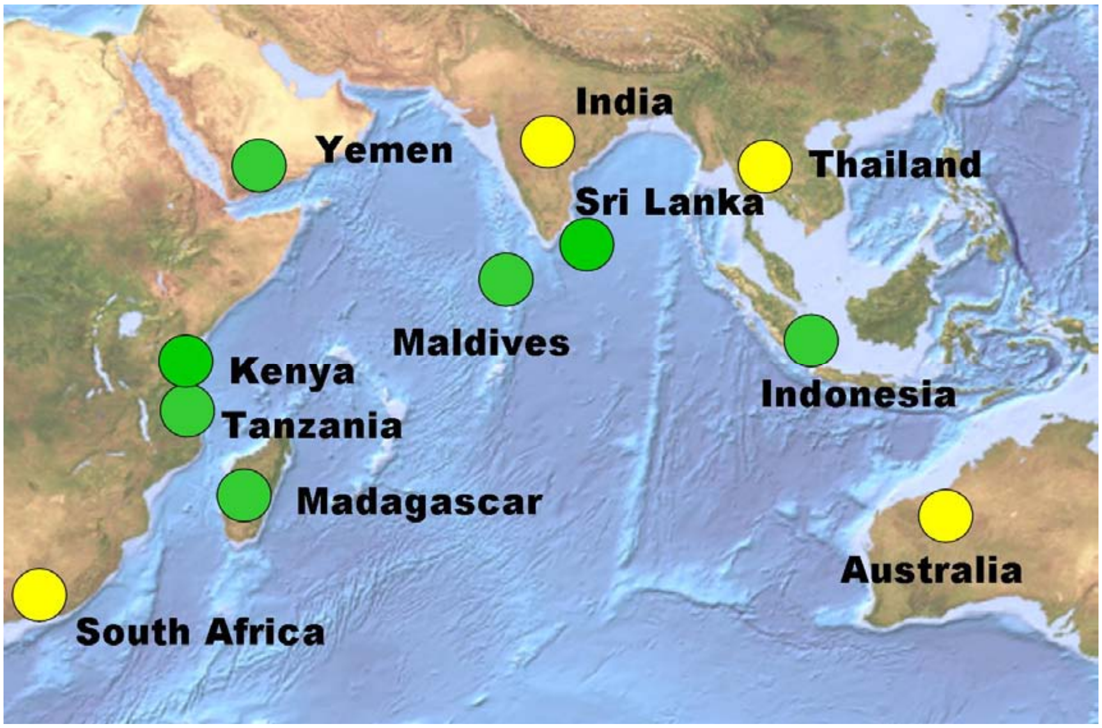

Fig.3: GITEWS co-operates with several countries in the Indian Ocean region mainly for seismological monitoring and processing, but also for sea level data.

Important Note:

Natural hazards such as the tsunami catastrophe 2004 cannot be prevented by a tsunami early warning system, but through GITEWS the number of victims in the event of a tsunami wave can be kept at a minimum.

Further information:

http://www.gfz-potsdam.de

http://www.gitews.org