Status quo of the tsunami early warning system for the Indian Ocean

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The German-Indonesian Tsunami Early Warning System for the Indian Ocean (GITEWS) runs on track. Main milestones like the development of the automatic data processing software SeisComP3, as well as the underwater communication for the transmission of the pressure data from the ocean floor to a warning centre are already finalised. Furthermore the calculations of the ocean modelling including the source modelling were completed and are available in a data base so that the system can be set into operation at the end of 2008. This positive conclusion is drawn by the GITEWS consortium consisting of different German geo and marine scientists on the occasion of the third anniversary of the tsunami catastrophe on December 26, 2004.

After the severe earthquake, where almost a quarter of a million people lost their lives, the German government requested the Helmholtz Association of National Research Centres, represented by the GeoForschungsZentrum Potsdam (GFZ, Germany's National Lab for Geosciences) to develop a tsunami early warning system. Already three weeks after the natural disaster a task group headed by the GFZ submitted a concept for GITEWS to the German government. This concept is based on different kinds of sensor systems on land and on the ocean and goes along with an intensive education and training programme. "The GFZ is working in Southeast Asia since 1992 so these broad geoscientific results could flow into the proposal in a quick reaction" explains Professor Reinhard Hüttl, chair of the executive board of the GFZ. "We would also like to establish this warning system in other endangered regions, such as in the Mediterranean and in the

Atlantic."

The tsunami early warning system is financed with 45 Mio. Euros by the Federal German Ministry for Science and Education and come from the 500 Mio. Euro budget of the German Federal Government for reconstruction activities in the tsunami region.

Seismological components

In 90% a tsunami is caused by a submarine earthquake. The quake in December 2004 had magnitude of 9.3, the second largest ever detected rupture in the earth crust. A fast and correct seismological recording and evaluation is therefore essential for the warning system. The biggest challenge is the failure-free recording and the exact quantification of strong quakes close to the epicentre. With the seismic sensors installed so far in Indonesia and with the GFZ developed software system SeisComP3 which was launched in May 2007, there is now for the first time a tool to quickly register and evaluate even strong earthquakes. Its capacity and functionality has been demonstrated several times: the magnitude of 8.0 and the location of the Bengkulu quake in the southern part of Sumatra on September 12, 2007 could be determined within four minutes. Based on that information the Geophysical Survey in Jakarta (BMG) released a tsunami warning based on these data for the first time.

Meanwhile SeisComP3 is established as standard in several states bordering the Indian Ocean such as in the Indian tsunami warning centre. The tsunami warning centre for the Mediterranean and the North Atlantic will also go into service in 2008 with this software. "With the software technical and methodical development within GITEWS we set new standards not only specifically for earthquake monitoring but also for the tsunami warning" said Dr. Winfried Hanka, project leader for the GITEWS earthquake monitoring at the GFZ.

Oceanographic components

Based only on seismological measurements it is impossible to decide whether a tsunami has arisen or not. Therefore the detection of a tsunami is carried out directly on the ocean floor using oceanographic instruments. These measurements are also important to give the all-clear, because not every earthquake generates a tsunami. This additional information is very important for Indonesia, because earthquakes are easily sensible at the coast and could give rise to panic reactions. So a warning and an all-clear warning respectively need to be given very fast. To meet these expectations different components are established in the GITEWS concept.

Buoy systems

The final system will consist of 10 buoys, which will be deployed along the Sunda arch off the Indonesian coast. The buoys have two functions: they work as a relay station for the data of the underwater pressure sensors (OBU - ocean bottom unit) transmitting their data from the sea floor to a modem close to the water surface and from there via the satellite connection of the buoy to a warning centre. Furthermore the buoy has different sensors to determine meteo data and the sea swell. But the pioneering aspect of the buoys is the GPS functionality: through GPS measurements it is also possible to detect a tsunami independent of the measuring instruments on the ocean floor. This is an important progress compared to other buoy systems used for example in the Pacific Ocean. The combination of underwater and surface measurements guarantees a higher availability and less breakdowns. Dr Tilo Schöne, GFZ Potsdam, leader of the GPS buoy working group as well as of the tide gauges working group announced: "Based on the experiences made with two test systems in Indonesia eight more systems will be prepared and deployed in summer 2008 along the coastline of

Sumatra and Java. These buoys will be important components for the early warning system."

Ocean bottom units (OBUs)

To recognise water pressure changes caused by tsunami waves, ocean bottom units are installed on the ocean floor. In addition to this standard measuring method GITEWS uses specific seismometers to detect an earthquake directly on the sea floor. The challenge is not only the measurement but also the transmission of the data through the 4 km large water column. The first tests with commercial modems did not fulfill the technical requirements because transmitting the signal in thermally and salinary layered ocean water through more than four kilometres is not trivial. In co-operation with small and midsize enterprises it was possible to develop a new transmission technology.

"The so-called PACT bottom pressure system (Pressure based acoustically coupled Tsunami detector) is used for the real-time detection of sea level changes in the deep ocean. In November 2007, the PACT system successfully passed a deep-sea test close to the Canaries" emphasises Dr. Olaf Boebel, PACT project leader from the Alfred-Wegener Institute for Marine and Polar Sciences.

Tide gauge measurements

In deep water a tsunami propagates with the same speed as an aircraft. But in shallow water the tsunami wave looses its speed and gains height - up to 30 meters - close to the coastline. Therefore, it is important to register a tsunami in suitable regions e.g. offshore islands. Meanwhile seven GITEWS tide gauges have been installed in the Indian Ocean, not only in Indonesia, but also in riparian states. Reliable tide gauges data are available from South Africa (Marian Island), Yemen (Aden) and Iran

(Chabahar). "Tide gauges measurements allow for a reliable prognosis if a tsunami wave is expected and in which dimension. So it is possible to receive detailed information of the inundation, which is especially of importance for densely populated areas such as Padang" explains Tilo Schöne

Simulations

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 minutes after the earthquake the modelling results will give an estimation on the 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. According to measured event data the best-fit scenarios are selected from this data base which compriseall the necessary data like arrival time, wave height and risk evaluation. This assessment of the situation will be continuously improved taking more and more measured data into consideration.

The data gained from this simulation also provides the basis for the alarm of remote areas threatended by the tsunami such as India, Sri Lanka or East Africa. "The concurrent utilisation and analysis of all available data allows - for the first time - a precise prediction of the inundation in the influenced regions in an extremely short time scale. TsunAWI, the new tsunami simulation software based upon calculations on unstructured triangle grids which was developed at AWI and the innovated GFZ modelling of the earth crust deformation/movement, are the basis for this new achievement" underlines Dr. Jörn Behrens coordinator of the GITEWS simulation group.

The Warning Centre

The core of the early warning system is the warning centre. All sensor data converge here, from here all the instruments are controlled, and here the synthesis of all data and the pre-calculated simulations is done and the alarm is given. These different activities are integrated in a decision support centre (DSS), which provides the responsible officer with an overview of the available data, an assessment of the situation and proposals for decision.This system, seen from the viewpoint of conceptual design and complexity, is unique worldwide. The development of the DSS is done by the German Aerospace Centre (DLR) and is in good progress. At the beginning of 2008 the first prototype will be installed in Indonesia.

Civil defence, Education and Training programme

The fastest warning is useless as long as the gap to the so called "last mile to the beach" 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 informed about evacuation plans and how to behave in the case of emergency. Japan carries out this kind of training in schools, plants and companies on a regular basis. The establishment of such an education programme in the areas bordering the Indian Ocean has only just started.

In addition, there is an academic education and training programme with regular training courses for different sensor groups or risk modelling for experts and scientists.

Furthermore the "Gesellschaft für Technische Zusammenarbeit" (GTZ) in three pilot regions enhances civil defence activities which aim in particular to the development of necessary institutional and organisational capacities. Members of the German Federal Agency for Gesciences and Ressources (BGR) continue with this consulting on the national level.

Also, a PhD and post doc programme is carried out by the United Nations University (UNU) to guarantee the operation and future upgradingof the GITEWS from the scientific point of view. "Offering this variety of education possibilities makes an important contribution to the early warning system for Indonesia and other bordering states of the Indian Ocean", says Prof. Torsten Schlurmann, Director of the Franzius Institute for Hydraulic and Civil Engineering at the Leibniz University in Hannover. Prof. Schlurmann leads the Capacity Building programme on behalf of the UNU together with colleagues from the GTZ.

A Look into the Future

"The technical system of GITEWS will be established till the end of 2008, on the condition that no unpredictable events occur such as the natural disaster in December 2004 . At the beginning of 2009 we will operate the system together with our Indonesian colleagues. In 2010 the system will be handed over completely to the Indonesian partners", explains the project co-ordinator Dr. Jörn Lauterjung of the GFZ.

Vulnerability analyses, carried out in Indonesia within the GITEWS project, indicate that it is essential but also possible to be prepared. However, complete protection will ever be impossible, even with a technically perfect warning system. Natural hazards such as earthquakes clearly demonstrate the elemental forces of our planet . "Our aim is to minimize the number of victims", says Dr. Lauterjung and explains: "Even more than eight hours after the severe earthquake in 2004 and more than 6000 of kilometres away from the epicentre, over 300 of people were killed. Natural catastrophes of such a size will always claim many lifes. But this huge number of victims could have been reduced very much with an Early Warning System."

Source: Helmholtz Association of German Research Centres