Commission on Geophysical Risk & Sustainability
International Union of Geodesy and Geophysics

STATEMENT

OF THE IUGG COMMISSION ON GEOPHYSICAL RISK AND SUSTAINABILITY

on

the Greatest Earthquake and Tsunami of the Early XXI Century,

and

the Need for Urgent Action to Reduce the Effects of Natural Disasters
in the Indian Ocean Region and Elsewhere

ABOUT THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

The International Union of Geodesy and Geophysics (IUGG), founded in 1919, is dedicated to the scientific study of the Earth and the application of the knowledge gained by such studies to the needs of society, such as more rational use of mineral resources, reduction of the effects of natural hazards, and environmental protection. The Union's objectives are the promotion and coordination of physical, chemical, and mathematical studies of the Earth and its environment in space. These studies include the dynamics of the Earth as a whole and of its component parts, the Earth's internal structure, the hydrologic cycle including snow and ice, all aspects of the oceans, the atmosphere, the ionosphere, magnetosphere, and solar-terrestrial relations.

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ABOUT THE IUGG COMMISSION ON GEOPHYSICAL RISK AND SUSTAINABILITY

The IUGG Commission on Geophysical Risk and Sustainability (IUGG Georisk Commission) is dedicated (i) to promoting scientific studies applied to the reduction of risk from natural hazards in an increasingly urbanized world and sustainability and (ii) to reducing death and destruction from natural and technological hazards by providing hazards data and information to emergency managers, policy-makers, scientists and the general public in the most timely and effective manner as possible. This includes the integration of knowledge concerning environmental, social and economic processes. The fundamental scope of this Commission is to facilitate communications – between scientists via meetings, workshops and publications, as well as between scientists and decision makers, between scientists and the public, and between scientists and schools.

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The following statement sets forth the basis for the position of the IUGG GeoRisk Commission, and illustrates the importance of urgent measures to reduce the effects of natural hazards in the Indian Ocean region and elsewhere. The following statement was adopted by the IUGG Commission on Geophysical Risk and Sustainability on January 7, 2005. The Commission believes that this statement summarizes the views of geophysicists with expertise in matters related to risk and sustainability.

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A magnitude 9 great earthquake occurred on December 26, 2004 off the west coast of northern Sumatra, South Asia. According to the preliminary estimates, the earthquake's hypocenter was located at a depth of about 30 km below the oceanic floor. This devastating megathrust earthquake occurred at the interface of the India and Burma plates and was caused by the release of tectonic stresses that develop as the India plate subducts beneath the overriding Burma plate.

Huge oceanic waves (tsunami) were spawned by this great earthquake. Not all large earthquakes beneath the ocean floor generate tsunamis, but this one did. The M=9 Sumatra-Andaman Islands earthquake was an event of a low probability but high dramatic consequences. Nobody expected such a great earthquake in the Indian Ocean, and such a powerful trans-oceanic tsunami was never previously observed in the Indian Ocean. More information related to the December 26, 2004 earthquake and tsunami event is available at the joint IUGG/TC-ITIC-ICG/ITSU site (http://tsun.sscc.ru/tsulab/20041226.htm) [1].

The coastal zones around the Indian Ocean were assailed by the mountainous violent tsunami, which brought a great Tragedy to the region. According to News reports, as of 01/06/2005, more than 150,000 people were killed by the tsunami in Indonesia, Sri Lanka, India, Thailand, Somalia, Maldives, Malaysia, Myanmar, Tanzania, Seychelles, Bangladesh, and Kenya. More than 500,000 people were injured, and up to 5 million are lacking for basic services. The number of victims increased each passing day as more casualties were found and as disease and food shortages claimed survivors. The tsunami crossed into the Pacific Ocean and was recorded along the west coast of South and North America. The M=9 Sumatra-Andaman Islands earthquake was felt (intensity VIII) at Banda Aceh and (V) at Medan, Sumatra. It was also felt in Bangladesh, India, Malaysia, Maldives, Myanmar, Singapore, Sri Lanka and Thailand. This is the fourth largest earthquake in the world since 1900 and is the largest since the 1964 Prince William Sound, Alaska earthquake. This has been a great tragedy of the early XXI century! Our hearts go out to those in the surrounding countries of the Indian Ocean who have suffered losses of loved ones and personal property during the geophysical disasters of December 26, 2004.

It is common knowledge that timely warnings save lives. It is also common knowledge that tsunami warning systems in the Pacific Ocean have proved to be effective over several decades [2, 3, 4]. It was a surprise to many to learn that there are no regional tsunami warning systems and stations in the Indian Ocean. *These days the world faces tragedies caused by ignorance and irresponsibility*.

After the great 1755 Lisbon earthquake, Immanuel Kant wrote: "Providence cannot be blamed if we are erecting edifices at places with earthquake dangers" [5]. Even in the XVIII century it was recognized that preventive measures at earthquake prone regions have to be undertaken before the disaster happens. For the first time in history, the Lisbon earthquake forced governmental institutions to take responsibility for the consequences of a disaster.

The level of preparedness to the disaster events of December 26th in all affected countries turned out to be extremely low, partly, because it happened without any warning. But even if the warning had been sent to the appropriate national authorities, it is unlikely that it would have been delivered to the public on beaches and in water-front hotels in a timely manner. It is also unlikely that people would have responded to it in appropriate manner, since most of them did not believe that such a disaster could affect them.

Who is responsible for the low preparedness to such disasters in this region? The scientists who did not expect such large events in the region or the Governments who had not thought about such natural disasters or had not considered setting up a tsunami-warning network in the region? As an example, Indian geoscientists did not expect such a great earthquake in the ocean and such a powerful tsunami along its southeast coastline. Hence no measures were undertaken in the region by the Indian Government to alert the public to the danger (e.g. a development of tsunami watch or tsunami network). Meanwhile, the Government exerts efforts to monitor other types of natural hazards (e.g. a radar warning system was set up in early 1970s to monitor cyclones in the Bay of Bengal).

Between 1900 and 25th December 2004, the largest earthquake along the subduction zone from southern Sumatra to the Andaman Islands occurred in 2000 and had a magnitude of 7.9. A magnitude 8.4 earthquake occurred in 1797, a magnitude 8.5 in 1861 and a magnitude 8.7 in 1833 and were all followed by powerful tsunamis (300, several thousand and 36,000 fatalities, respectively) (see http://www.gps.caltech.edu/~sieh/publications/a10.html and http://tsun.sscc.ru/tsulab/20041226tsun.htm).

Therefore, the IUGG Commission on Geophysical Risk and Sustainability *recommends*:

1. *The countries around the Indian Ocean should set up a Disaster Management Center in order to monitor land, ocean and atmosphere in relation to all kinds of natural hazards*, especially those related to coastal regions since we now have evidence of a strong coupling between land-ocean-atmosphere. In fact, such Centers should be established in any disaster-prone coastal region if they do not already exist (e.g., Mediterranean Sea and Atlantic Ocean). Improving our ability to monitor, forecast, mitigate, and respond to natural hazard events is crucial to reducing the occurrence and severity of disasters.
2. In many developed nations, immediately after earthquakes, in less than a few minutes, the news media begins broadcasting predictions of the tsunami height and arrival time according to predictions provided by meteorological, seismological or other responsible agencies. But, unlike the Pacific Ocean; there is no Tsunami Warning System in the Indian Ocean, hence there were no predictions of the December 26, 2004 tsunami. Obviously, a *Tsunami Warning System should be set up in the region*. This would be costly, but information is the only way to save human lives. The tourist and other industries in the areas affected should urgently assist financially the national and international institutions in order to install monitoring and early warning systems. Before such a warning system is in operation in the region, the Pacific Tsunami Warning Center in Hawaii [4] should extend its warnings to cover all vulnerable areas in the Indian Ocean.
3. *Multidisciplinary and multinational research programs and research networks on geophysical hazards and risks* (e.g. [6]) *should be developed in the Indian Ocean countries* to integrate diverse data streams, to improve understanding of the natural phenomena associated with the disasters, to develop predictive modeling capability, and to generate and disseminate timely and accurate information needed by decision makers and the public.

The IUGG Commission on Geophysical Risk and Sustainability *considers*:

4. *Information alone cannot save human lives if no management procedures, public preparedness, hazards maps, evacuation routes and shelters are prescribed prior to any natural disaster*. This is an education and training exercise. Scientists can help with the design of those plans and practices. There are many hazards maps available in many countries (e.g. [7]) and regions (including the northern Indian Ocean) on earthquakes,

volcanic eruptions, floods, landslides etc. *Research on temporal changes of vulnerability to natural disasters is essential to update periodically natural hazard and risk maps.*

5. *Coordination of observation systems and data will reduce the losses due to natural disasters*. Improved monitoring of hazards and delivery of information about them are critical for preventing hazards from becoming disasters. Natural hazards have a disproportionate impact on developing countries where they are major barriers to sustainable development. *The IUGG GeoRisk Commission supports the GEOSS (Global Earth Observation System of Systems) 10-year Implementation Plan* [8] *especially related to geophysical hazards and risks in developing countries*. An integration of InSAR technology for topography into disaster warning and prediction systems is crucial for floods and coastal hazards. Real-time monitoring of submarine seismic and volcanic activity and tsunami propagation should be developed including re-use of submarine telephone cables. Extensive use of satellite data as well as airplane laser scanning data is an important component of the disaster management. Space Agencies should release the data to scientists and disaster agencies.
6. After a disaster occurs, *rescue agencies and civil defense managers need immediate quantitative estimates of the extent of the disaster and losses*. Recent technological and communication advances are improving the speed and accuracy of loss estimates immediately after natural disasters (e.g. earthquakes, tsunamis, etc.) so that injured people may be rescued more efficiently. Underestimations of the extent of earthquake and tsunami disasters lead to delays in rescue operations and hence to an increase in casualties. In many developing countries, urbanization and population are increasing at an unprecedented pace. Therefore, it is necessary for loss estimation to include information on the present population as well as current quality of buildings and the soil properties. The IUGG GeoRisk Commission supports the International Association of Seismology and Physics of the Earth's interior (IASPEI) Commission on Earthquake Hazard, Risk and Strong Ground Motion, which fosters the development of rapid worldwide earthquake loss estimates [9].
7. *Scientists can and should help to save human lives by providing governmental institutions with accurate predictions on natural disasters with a good lead time*. Real-time earthquake prediction experiments (e.g., quantitative predictions of large earthquakes by M8 algorithm [10]) have proved statistically that seismic activity is not totally random. Thus scientists and decision makers have a probabilistic advantage in predicting large earthquakes. And hence scenarios (quantitative models) of tsunami can be analyzed for such large earthquakes. In the modeling of tsunami the measurements of the focal mechanism (seismic moment tensor) and radiated energy of earthquakes are important. These measurements are now possible by using the present global/regional digital seismological networks. False tsunami alerts can also be reduced by systems such as the Deep-Ocean Assessment and Reporting of Tsunamis (DART) Project developed by NOAA's Pacific Marine Environment Laboratory (PMEL) [11]. Because science is responsible for providing proper predictions of natural phenomena that cause disasters, *reduction of predictive uncertainty is the most important challenge in natural hazards mitigation* [12]. IUGG Commission on Geophysical Risk and Sustainability is focusing on this objective as a common mission in all the GeoRisk community.

Furthermore, the IUGG Commission on Geophysical Risk and Sustainability <u>*considers*</u>:

As the global population continues to increase, our vulnerability to natural disasters is magnified with each passing year. The tragic events at the end of 2004 have illustrated once more the vulnerability of humankind to natural threats. Scientists must apply their expertise and experience to the mitigation of these disasters. To mitigate and adapt to large-scale disasters, the scientific community must be involved in an extensive campaign of knowledge exchange and communication with the various groups involved including government officials, the general public, etc. Risk evaluation must rely heavily on modeling and visualization of physical, technological, biological and social processes and their implications. The results must be easily grasped by emergency planners, the insurance industry, policy makers, and the public.

Scientists also need a deeper understanding, based on work across disciplines, of all of the processes that are involved. Scientists and their institutions have an obligation to work with the public to earn their trust and understanding. They must also be mindful of public concerns and the risk perceptions that underlie them. In many cases the interaction between science, risk, and society takes place within the legal system. Ongoing communication between the various groups needs to integrate the human dimensions. Scientific knowledge and scientific initiatives can be useful as a basis for public policy when they are acceptable to society from moral and ethical points of view. The science must interface coherently with public policy and social expectations, again illustrating the need for more carefully planned communication and consultation.

Living in an often turbulent and unpredictable public environment, scientists can contribute to decision-making through a risk management framework that examines natural, technical and social issues related to sustainability and consists of the following:

- Anticipates natural and human-made risks through widespread *consultation*.
- Determines *concerns* by using risk assessment techniques for various scenarios.
- Identifies the *consequences* by systematically cataloguing hazards.
- Undertakes *calculations using* appropriate models.
- Evaluates the *certainties***,** uncertainties, and the probabilities involved in the calculations of the vulnerability and of the exposure.
- Determines and acts on options to *control***,** mitigate and adapt to the risk.
- *Communicates* the results to those who need to know.
- Promotes and guides *monitoring* systems to collect, assimilate and archive data relevant to the determination of sustainability and risk, now and in the future.
- Integrates the knowledge and understanding from all relevant disciplines to provide society with the tools to *review* the sustainability and the risks of proposed policies and plans.

Though rational scientific methods hold the promise of an improved science of risk and sustainability, it must be remembered that the priorities for analyses are likely to be heavily influenced by the public and political agenda of the day. This means that implementation of risk management to achieve sustainability can be achieved only through an interaction of theory and praxis.

Further progress in natural hazard and risk reduction requires answers to *key questions*:

- What technologies and methodologies are required to assess the vulnerability of people and places to hazards and how might these be used at a variety of spatial scales?
- How have humans altered the geosphere, the biosphere and the landscape, thereby promoting and/or triggering certain hazards and increasing societal vulnerability to such hazards?
- How do hazards compare relative to each other regarding current capabilities for monitoring, prediction and mitigation and what methodologies and new technologies can improve such capabilities to help civil protection at local and global scales?
- What are the barriers to the utilization of risk and vulnerability information by governments (and other entities) for risk and vulnerability reduction policies and planning (including mitigation) from various hazards?

References

1. The IUGG Tsunami Commission (IUGG/TC) is an Inter-Association (IASPEI, IAPSO, IAVCEI) Commission responsible for international coordination of tsunami related meetings, research, field surveys and other tsunami related efforts. The Commission membership includes 33 members representing 12 countries (Australia, Canada, Chile, Greece, Italy, Japan, Korea, Portugal, Russia, Turkey, United Kingdom, USA). http://ioc.unesco.org/itsu/
2. International Coordination Group for the Tsunami Warning System. Under the auspices of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), an International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) was established in 1968. The system disseminates tsunami information and warning messages to national authorities at over 100 points scattered across the Pacific. Currently, 26 countries (including the U.S.) are members of ICG/ITSU. http://ioc.unesco.org/itsu/
3. The International Tsunami Information Center (ITIC) was established in 1965 by the UNESCO/IOC. The ITIC, hosted by the United States and located in Honolulu, Hawaii, at NOAA/National Weather Service Pacific Region Headquarters, monitors and evaluates the performance and effectiveness of the International Tsunami Warning System in the Pacific (TWSP) on an everyday basis. ITIC is responsible, among other functions, for:
    - Monitoring the international tsunami warning activities in the Pacific and recommending improvements with regard to communications, data networks, data acquisition, and information dissemination;
    - Bringing to Member and non-member States information on tsunami warning systems, on the affairs of ITIC and on how to become active participants in the activities of ICG/ITSU;
    - Assisting Member States of ITSU in the establishment of national warning systems and improving preparedness for tsunamis for all nations throughout the Pacific Ocean;
    - Gathering and promulgating knowledge on tsunamis and fostering tsunami research and its application to prevent loss of life and damage to property.
    - http://www.prh.noaa.gov/itic/
4. Pacific Tsunami Warning Center and West Coast/Alaska Tsunami Warning Center. NOAA’s Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, is the operational center of the Tsunami Warning System in the Pacific (TWSP). The PTWC provides timely tsunami warnings for large earthquakes (M6.5 or greater) to countries in the Pacific as specified in its operational Communications Plans for the TWSP. It also acts as a National warning center for all other U.S. interests in the Pacific outside of Alaska and the U.S. West Coast, and as a Regional warning center for the state of Hawaii. Alaska, the U.S. West Coast, and Canada are served by the West Coast /Alaska Tsunami Warning Center (WC/ATWC) in Palmer, Alaska. In addition to the United States, National or Regional Warning Centers are also operated by Japan (Japan Meteorological Agency), France in French Polynesia (located in Tahiti, CEA/DASE (Commissariat à l ’Energie Atomique/ Département d’Analyse et Surveillance de l ’Environnement), Chile (Servicio Hidrografico y Oceanografico de la Armada), and Russia (Hydrometeorological Service). http://www.prh.noaa.gov/pr/ptwc/ http://wcatwc.arh.noaa.gov/
5. Kant, I., Geschichte und Naturbeschreibung der merkwuerdigsten Vorfaelle des Erdbebens welches an dem Ende des 1755sten Jahres einen grossen Theil der Erde erschuettert hat. Koenigsberg, 1756.
6. APN (the Asia-Pacific Network for Global Change Research) is an international project with participation of the scientists from Japan, Philippines, Russian Federation, Thailand, USA in Southeast Asia in order to assist people in the region to have more information about the coastal zone georisks in their countries (http://www.apn.gr.jp/en/activity/project_brief/2004-16.html for more information on the project). Many water quality and associated problems influencing coastal environments around the world today are related to past and on-going contamination of terrestrial groundwater because this groundwater is now seeping out along many shorelines. Such inputs thus contribute to the increased occurrences of coastal hypoxia, nuisance algal blooms, and associated ecosystem consequences. It is proposed to initiate direct measurements of groundwater discharge in selected areas of the Philippines. These studies, which will engage scientists from nearby countries, will form a base for more extensive research in the region and will represent an important element of

our capacity building activities. Another major training component of our project consists of a regional workshop (in Thailand) on management implications, measurement implications, measurement techniques, climatic effects, and the impact of the direct inflow of groundwater into the sea. The first GeoRisks SGD Coastal Zone international experiment is planned in the Philippines (January 5-15, 2005) and a workshop to be organized in Thailand (February 5-15, 2005).

7. The U.S. National Oceanic and Atmospheric Administration (NOAA), National Geophysical Data Center (NGDC). NGDC is the World Data Center Boulder for Solid Earth Geophysics and Tsunamis. NGDC maintains historical global geologic hazards database including significant earthquakes and tsunamis. These data are stored in a relational database and accessible online via text-forms interfaces and interactive maps. Auxiliary information such as global population density and topography/bathymetry are also integrated with the hazards data. NGDC has recently developed password-protected access for updating and managing the databases via the web. As a result of this new system, participating scientists worldwide who have access to the web can access and update the databases from anywhere in the world. The new system leads not only to improved access but more reliable databases. For more information, please see the following web-sites: http://www.ngdc.noaa.gov/seg/hazard/hazards/shtml and http://www.mitp.ru/georisk
8. In accordance with the agreed schedule, the *ad hoc* GEO Implementation Plan Task Team (IPTT) circulates the third version of the GEOSS 10-Year Implementation Plan Reference Document (GEO 203-1). Would it be possible to spell out the GEOSS acronym? This draft takes into account the negotiated text for the draft GEOSS 10-Year Implementation Plan (GEO 303-1) agreed at GEO-5, as well as comments received on the previous draft of the Reference Document (GEO 202-1). More information is available at GEO Secretariat Office (geosec@noaa.gov)
9. Wyss, M., Earthquake loss estimates in real time begin to assist rescue teams worldwide, *EOS, Transactions of the American Geophysical Union*, **85** (52) 565 (28 December 2004).
10. The M8 algorithm for prediction of large earthquakes was suggested by Keilis-Borok and Kossobokov (*Phys. Earth Planet. Inter., 61*, 73-83, 1990). The case history of 04 June 2000, Ms8.0 Sumatra earthquake suggests that the epicentral area of 26 December 2004 earthquake was capable of producing a magnitude 8.0+ event already in 2000 (Fig. 4.16 in Keilis-Borok, V.I., and Soloviev, A.A., Eds, *Nonlinear Dynamics of the Lithosphere and Earthquake Prediction*. Springer, Heidelberg, 2003) and bypassed this state by the end of 2001, when it entered time of increased probability of a magnitude 9.0+ earthquake.
11. NOAA’s Pacific Marine Environment Laboratory (PMEL), located in Seattle, Washington, carries out interdisciplinary scientific investigations in oceanography and atmospheric science, including tsunami research. The PMEL tsunami research effort includes tsunami inundation mapping, tsunami modeling, collecting new tsunami event data, and serving as the lead agency of the U.S. National Tsunami Hazard Mitigation Program (NTHMP). PMEL also developed the Deep-Ocean Assessment and Reporting of Tsunamis (DART) Project. The DART project is an ongoing effort to develop and implement a capability for the early detection and real-time reporting of tsunamis in the open ocean. http://www.pmel.noaa.gov/
12. In International Association of Hydrological Sciences, Predictions in Ungaged Basins (PUB) is its 10 year science plan to reduce the hydrological predictive uncertainty, especially in ungaged and information poor basins by assembling all the available observations, from space to Earth, and the advanced process studies and understanding. Floods, droughts, water contamination, landslides, debris flows etc. are the targets of such prediction, World Water Council (WWC) Science and Technology Panel takes this Space to Earth program as one of its associate programs and plans to bring it to the 4th World Water Forum in Mexico, 2006.