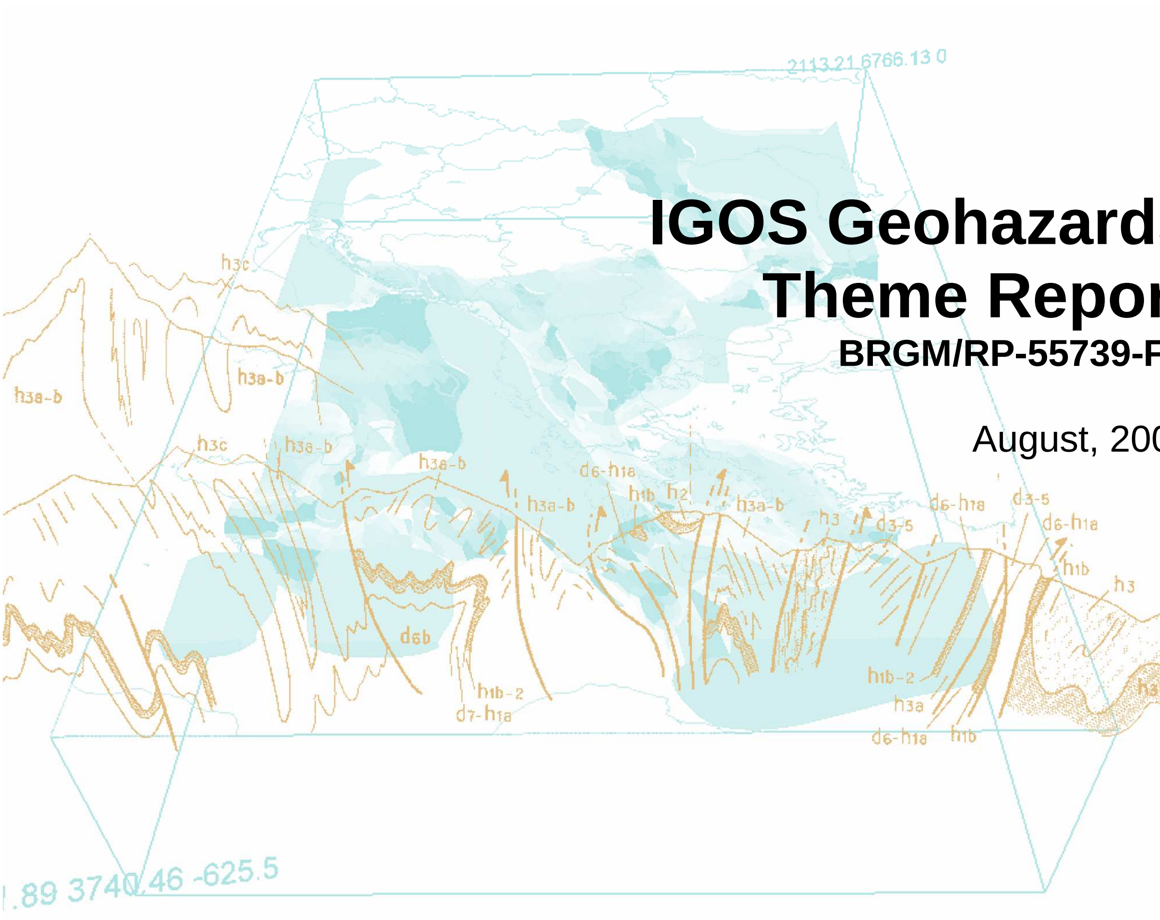

IGOS Geohazards Theme Report

BRGM/RP-55739-FR

August, 2007

IGOS Geohazards Theme Report

BRGM/RP-55739-FR

August, 2007

J. Salichon, G. LeCozannet, H.Modaressi BRGM
S. Hosford, CNES
R. Missotten, UNESCO
K. McManus, S.Marsh BGS
M.Paganini, ESA
C. Ishida, JAXA
H.P.Plag, GGOS
J.Labrecque, C. Dobson, NASA
J.Quick, USGS
D.Giardini, FDSN
K.Takara, H.Fukuoka, N.Casagli, ICL
W.Marzocchi, WOVO

with collaboration of
A.Gibson, H.Reeves, BGS

Checked by:	**Approved by**:
Name: John Douglas	Name: Hormoz Modaressi
Date: 21/08/2007	Date: 28/08/2007
Original signed by:	Original signed by:
J. Douglas	**H. Modaressi**

Keywords: Geohazards, IGOS, Integrated Global Observing Strategy, Earth Observations, in situ data, remote sensing, disaster mitigation

In bibliography, this report should be cited as follows: 2nd IGOS Geohazards Theme Report, 2007

Contents

Figures Index

Table Index

Annexes

1. About this document

The Integrated Global Observing Strategy Partnership (IGOS-P) is a group of international organisations that are concerned with global environmental change issues and with the need to better integrate Earth Observation with existing and future ground models as well as with geohazard and geotechnical databases. It links research, long-term monitoring and operational programmes, bringing together the producers of global observations and the users that require them, to identify products needed, gaps in observations and mechanisms to respond to needs in the science and policy communities. Its principle goal is to integrate satellite, airborne and in situ observation systems. The IGOS-P is comprised of the international organisations that sponsor the Global Observing Systems, the Committee on Earth Observation Satellites (CEOS), and international global change science and research programmes.

The IGOS-P recognises that a comprehensive global earth observing system is best achieved through a step-wise process focused on practical results. The IGOS Themes allow for the definition and development of a global strategy for the observation of selected environmental issues that are of common interest to the IGOS-P and to user groups. The current IGOS Themes include the oceans, the carbon cycle, the atmospheric chemistry, the geohazards, the cryosphere, the water cycle, the coastal zone and a coral reef sub-theme.

The IGOS Geohazards theme was initiated in 2001 by the National Oceanic and Atmospheric Administration (NOAA), the United Nations Educational, Scientific and Cultural Organisation (UNESCO), CEOS and the International Council for Science Unions (ICSU) in Paris. The IGOS Geohazards Theme was developed under the IGOS Chairmanships of José Achache (then at ESA), Greg Withee (NOAA) and Walter Erdelen (UNESCO). The objective of the IGOS Geohazard initiative is to respond to the societal, scientific and operational geospatial information needs for the prediction and monitoring of earthquakes, volcanoes, tsunamis (since 2005) and land instability using a multi-hazards and risks approach.

The scope of the IGOS Geohazards was refocused in this first period. In response to altered international priorities following the events 2004 tsunami in South East Asia, tsunami was included. Secondly, as Earth observation provides useful information at all phases of the disaster cycle, the scope was enlarged to include all phases of the disaster cycle. Finally, as Earth observation is not only able to provide useful information for hazard assessment, but also for vulnerability evaluation, a multi-risk approach is proposed.

The 1st IGOS Geohazards workshop was hosted by ESA on 4-6 March 2002. It gathered key professionals with an active interest in global geohazards issues. The first Geohazards Theme Report was released by ESA in April 2004. The IGOS Geohazards Bureau was subsequently established and co-funded by ESA and BRGM in 2004, and the Geological Applications of Remote Sensing (GARS)[1] and IGOS Geohazards steering committees were gathered into a Joint Committee, chaired by UNESCO.

While the initial partnership gathered Space agencies (CEOS, ESA, NASA, JAXA and CNES), Geological Surveys (USGS, BRGM and BGS), CEOS and UNESCO, it was extended in 2006 to include additional science organisations and in situ monitoring networks: the International Federation of Digital Seismograph Networks (FDSN), the Global Geodetic Observing System (GGOS), the World Organization of Volcano Observatories (WOVO) and the International Consortium on Landslides (ICL). As a consequence of this, the Joint Committee reinforced its links with science communities. The 2nd International Geohazards Workshop was organised in Orléans (France) in 2005 and regional workshops and meetings were organised in Latin America (2006), South East Asia (2006), and Africa (2007).

The present second theme report is released in 2007 to the IGOS Partnership and to GEO, the Group on Earth Observations. As a complement to the first theme report, this document enlarges its scope to

[1] The Geological Applications of Remote Sensing is an IUGS/UNESCO joint programme funded in 1984 with the aim to assess the value of remotely sensed data for geological research and to enable institutes of developing countries to participate in the use of modern technology for their own research.

additional in situ instrumentation. It also takes risk into account whereas the previous theme report was more dedicated to hazard observations. Finally, the report is a first attempt to assess the benefits of Earth Observations over the entire disaster management circle.

In parallel, the 3rd International Geohazards Workshop is being organised in 2007. This workshop aims at fostering new issues and progresses. Following the recommendations of the implementation plan decided in 2004, most of the IGOS Geohazards objectives scheduled for the 2004-07 period were successfully realised. IGOS Geohazards furthermore actively participated to the Group on Earth Observation (GEO) and contributed to the implementation of the Global Earth Observing System of Systems (GEOSS) through its participation and leadership of GEO tasks. Taking into account these achievements, this theme report will provide a new impulse and objectives for an updated strategy of the IGOS Geohazards initiative for the period 2007-2010.

Implementation plan status

The IGOS Geohazards Theme report 2004 released objectives for the 2004-2006 and 2007-2010 periods. These objectives are repeated below. An overview of the actual IGOS Geohazards achievements for the period 2004-2007 is provided as well.

IGOS Geohazards framework

- Establishment of a Joint Committee in 2004 and Working Groups in 2005
- Establishment of the IGOS Geohazards Bureau by ESA and BRGM in 2004
- First IGOS Geohazard theme report published by ESA in April 2004
- IGOS Geohazards website created and updated by ESA and BRGM, with comments from the Joint Committee during the 2004-2007 period
- Theme Launch Workshop organised in Orleans, France (2005)
- GARS Program developed as implementation mechanism (2004)

Capacity Building

- Regional outreach: IGOS Geohazards organised and supported regional workshops: South America (2006), South-East Asia (2006), Africa (2007, coordinated by GARS), and Europe (2007)
- The Bureau and members of the Joint Committee participated to relevant International Conferences with dedicated sessions, e.g. Cities on Volcanoes 2006, International Conference for Disaster Reduction (2005, 2006)
- The implementation mechanism was transferred to the Group on Earth Observations, GEO. IGOS Geohazards participated to the Global Earth Observing System of Systems, GEOSS, through participation to GEO tasks and committees (2004-2007).

Observations and Key Systems

- The international charter “Space and Major Disasters” was activated to provide an unified system of space data acquisition and delivery for major geodisasters such as the Merapi eruption (2006), the tsunami in South East Asia (2004), the Kashmir Mw 7.6 earthquake (2005), or the Leyte landslide in the Philippines (2006)
- High level GEO, USGS, GGOS and IGOS Geohazards representatives advocate for the release of high resolution SRTM topography products (2004-2006)
- Geohazards measurements resources (InSAR, positioning systems, ASTER, broadband seismometers, geodesy, etc…) have been promoted by the Bureau and by Joint Committee members such as FDSN and GGOS. The IGOS Geohazards INSAR-GPS integration project is implemented through the GEO task DI-06-03 “Integration of InSAR technology” (2004-2007) The improvement of the in situ instrumentation networks are promoted through the GEO task DI-06-02 “Seismographic networks improvement and coordination” (2006-2007)
- The Japan Space Agency (JAXA) launched the Advanced Land Observing Satellite (ALOS). Along with the start of the regular operations, JAXA also started providing observation data (called "ALOS data") to the public and promoted data availability, in particular L band SAR data, with the creation of a worldwide cooperative data distribution network (2006-2007)
- An evaluation of the existing and emerging observational sensors for geohazards has been released in the Theme Reports 2004. This is updated with additional space and in situ instrumentations, observational requirements within the 2007 theme report

Databases and infrastructures status

- The GeoHazData project (2004-2007) demonstrated the concept of a Geohazards hazards map inventory. It was performed by the Bureau, with support of Joint Committee members within the GEO task DI-06-07 “Multi-hazard zonation and maps”
- A stronger support to WOVO to implement WOVOdat is an objective of the 2007-2010 period.

Integration and modelling

- The existing gaps in information, observation and key systems addressed in the 2004 Theme Report have been critically reviewed and updated in the 2007 theme report
- A user requirements review was included in the 2004 Theme Report and updated in the 2007 Theme Report
- Assessment of the existing data potential for products and services addressed in the 2007 Theme Report

Underpinning science

- The 2004 Theme Report recommended the initiation of flagship Research and Development projects. In 2006, ESA launched the Globvolano project. IGOS Geohazards also supports the implementation of the TerraFirma project via a dedicated workshop to be held together with the 2007 IGOS Geohazards workshop (2004-2007)

2007-2010 IGOS Geohazards new objectives summary

Objectives for 2007-2010 have been listed in the 2004 Theme Report. These objectives have been partially achieved, while the need for other actions emerged. As a consequence, new objectives for the implementation of IGOS Geohazards for the 2007-2010 period are listed below:

GeoHazData

- Improve the existing hazards maps demonstrator. Provide information on data and databases distributed by national geological surveys. Create strategic data sets
- Support the WOVOdat project implementation
- Follow the recommendations of the GEO Data and Architecture Committee and participate to the GEOSS implementation

GeoHazNet

- Organise and participate to international and regional workshops with focuses on exchanges between the geohazard communities and authorities, and on geohazards databases interoperability
- Stimulate fund raising for regional and international geohazards coordinated activities
- Improve the geohazards community links with IGOS Geohazards; update website and regularly publish the "GeoHaz update" Newsletters as well as other communication papers.
- Participate to GEO community building activities through the GEO tasks DI-06-02, DI-06-03, DI-06-07, DI-06-08, DI-06-09
- Consolidate the GEO Geohazards Community of Practice

Geohazards observations

- Support and initiate easier access to high resolution DEM
- Promote the L-band SAR data and InSAR continuity
- Support and promote in situ instrumentation networks (Broadband seismometers network extension to oceans)
- Promote existing observations InSAR, GPS, Broadband seismological networks, SRTM and ASTER

IGOS Geohazards infrastructure

- Increase coordination in order to improve IGOS Geohazards representation in meeting and conferences
- Contribute to increase knowledge on geohazards observations through support to research projects such as Globvolcano
- Promote knowledge and information sharing within the IGOS Geohazards group
- Disseminate scientific advice on disaster management
- Adopt a permanent structure for IGOS Geohazards after 2010

2. Societies resilience to geohazards

INTRODUCTION

Natural hazards affect human societies every day on every continent causing each year thousands of casualties and dramatic economic impacts. Some of the most serious disasters are a consequence of the regular occurrence of geohazards such as earthquakes, landslides, ground deformation, volcanoes and tsunamis.

Today, the increasing vulnerability to natural disasters comes mostly from values to be potentially lost. The impact of a disaster critically affects the growth of developing countries that suffer from a lack of mitigation measures. Other areas where numerous values are accumulated such as Tokyo are also exposed to major disasters that could lead to a global economic crisis.

Over the last century, land use practices have completely changed, drastically increasing the exposure of our societies to geohazards. With the growth in the worldwide population passing six billion people, a single major disaster is more likely than before to disrupt the life of a society and its economy for years or decades. Therefore, substantial efforts are being made and are planned to prevent human and economic losses due to these events.

This chapter firstly provides a brief overview of the impact of geohazards on our societies. Then, the approaches for disaster reduction that involve IGOS Geohazards stakeholders over the last three years are presented.

2.1. IMPACT OF GEOHAZARDS ON SOCIETY

Significant efforts have been made to publish reliable statistics on the impact of hazards on society[2]. In this section, we briefly describe each kind of geohazard and provide an example of their effects on human society.

2.1.1. Volcanic disasters

Volcanic eruptions are one of the Earth's most dramatic and violent agents of change (Table 1). Powerful explosive eruptions can alter large areas of land around a volcano and gas emissions erupting into the stratosphere can temporarily change the climate. Furthermore, eruptions often cause nearby populations to temporarily or permanently abandon their houses. Inhabitants living further from the volcano area can be affected by eruption-induced effects, such as tephra[3],

---

[2] Among these efforts, EM-DAT (Emergency Disaster Management Database) contains essential core data on the occurrence and effects of over 12,800 disasters in the world from 1900 to present.

[3] **Tephra** is a general term for fragments of volcanic rock and lava regardless of size that are blasted into the air by explosions or carried upward by hot gases in eruption columns or lava fountains. Such fragments range in size from less than 2 mm (ash) to more than 1 m in diameter. Large-sized tephra typically falls back to the ground on or close to the volcano and progressively smaller fragments are carried away from the vent by wind. Volcanic ash, the smallest tephra fragments, can travel hundreds to thousands of kilometres downwind from a volcano. (Source: USGS)

lahars[4], and flooding, as a result of damage to the infrastructure and economy of the region. Volcanic activity since 1700 A.D. has killed more than 260,000 people, destroyed entire cities and altered landscapes population at risk from volcanoes is likely to be at least 500 millions[5]. During the 1990's, more than 2100 lives were lost because of volcanic eruption, and two cities were completely devastated [6].

	Number of Events	Killed	Homeless	Affected	Total Affected	Damage US$ (000's)
Africa	**15**	**2,213**	**180,710**	**318,800**	**500,353**	**9,000**
Americas	**69**	**67,841**	**35,680**	**1,082,150**	**1,123,587**	**2,808,697**
Asia	**80**	**21,456**	**97,900**	**2,565,980**	**2,668,287**	**696,549**
Europe	**11**	**783**	**14,000**	**12,200**	**26,224**	**44,300**
Oceania	**20**	**3,665**	**46,000**	**202,391**	**248,422**	**400,000**

Table 1: Volcanic damage sorted by Continent from 1900 to 2006[7]

2.1.2. Seismic disasters

Earthquakes are one of the most deadly natural geological disasters (Table 2) due to the fact that they can occur without warning, affect wide areas and can involve very large releases of energy. Precise prediction is not yet feasible even with the most advanced technology. A strong earthquake and its induced effects can suddenly and brutally devastate homes and civil infrastructure, causing huge human and economic loss over large areas. For example, on 23rd January 1556 in Shansi, China a magnitude 8 earthquake is reported to have killed about 830,000 people[8].

---

[4] **Lahar** is an Indonesian term that describes a hot or cold mixture of water and rock fragments flowing down the slopes of a volcano and (or) river valleys. When moving, a lahar looks like a mass of wet concrete that carries rock debris ranging in size from clay to boulders more than 10 m in diameter. Lahars vary in size and speed. Small lahars less than a few meters wide and several centimetres deep may flow a few meters per second. Large lahars hundreds of meters wide and tens of meters deep can flow several tens of meters per second--much too fast for people to outrun. As a lahar rushes downstream from a volcano, its size, speed, and the amount of water and rock debris it carries constantly change. The beginning surge of water and rock debris often erodes rocks and vegetation from the side of a volcano and along the river valley it enters. This initial flow can also incorporate water from melting snow and ice (if present) and the river it overruns. By eroding rock debris and incorporating additional water, lahars can easily grow to more than 10 times their initial size. But as a lahar moves farther away from a volcano, it will eventually begin to lose its heavy load of sediment and decrease in size. Numerous terms are used by scientists to describe the properties of lahars (for example, mudflows, debris flows, hyper concentrated flows, and cohesive and non-cohesive flows). (Source USGS)

[5] Source: USGS volcano Hazards Program; http://volcanoes.usgs.gov/Hazards/What/hazards.html U.S. Department of the Interior, U.S. Geological Survey, Menlo Park, California, USA

[6] Witham C S, Volcanic disasters and incidents: a new database. J Volc Geotherm Res, 148: 191-233, 2005.

[7] Events recorded in the CRED EM-DAT: Source: "EM-DAT: The OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussels, Belgium", web site: http://www.em-dat.net/disasters/profiles.php

[8] Source USGS, http://earthquake.usgs.gov/regional/world/most_destructive.php

According to the U.S. National Earthquake Information Center (NEIC)[9], more than 10,000 seismic events are reported each year, with approximately an average of 10 of magnitude 7-7.9 and one with a magnitude of 8 or more. In comparison to more localised and less frequent volcanic eruptions, earthquakes are more widespread with the majority occurring at plates boundaries and thus affecting a very large number of countries (Figure 1).

Progresses in seismology and earthquake engineering technology has made developed countries more resilient to earthquakes than developing countries, which remain vulnerable and so are subject to the highest risk. The impact of earthquakes on societies differs from one country to another. Fatalities caused by the earthquakes at Northridge, United States in 1994 (magnitude 6.7) and Kobe, Japan in 1995 (magnitude 6.5) varied from a factor 100 with 57 and 5,500 fatalities respectively, and their huge economic costs differed from more than a factor two ($40 and $100 billion respectively). In developing countries, general preparedness policy and risk management are not yet as developed and so the consequences of an earthquake can be dramatic in terms of death toll and economic loss. The earthquakes in Izmit, Turkey in August 1999 (magnitude 7.4) and at Gujarat, India in 2001 (magnitude 7.8) caused approximately 17,000 and 20,000 deaths respectively and had a devastating impact on their economies. Such important losses are not purely the consequence of the energy released by the earthquake but are also attributable, to a large extent, to lenient or badly applied building codes.

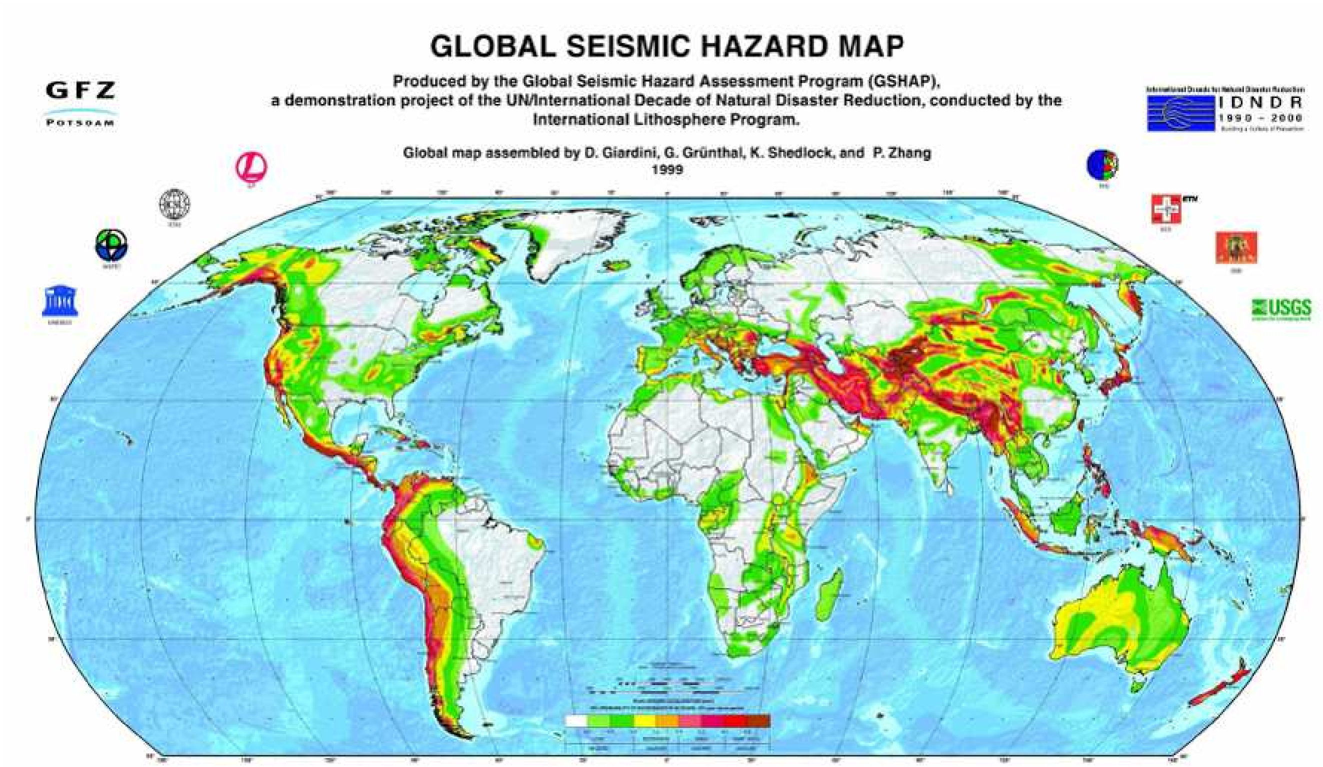

Figure 1: The Global Seismic hazard map. (Source: EM-DAT and Global Seismic Hazard Assessment[10])

[9] USGS NEIC website at http://earthquake.usgs.gov/regional/neic/

[10] The Global Seismic Hazard Assessment Program (GSHAP) was launched in 1992 by the International Lithosphere Program (ILP) with the support of the International Council of Scientific Unions (ICSU), and endorsed as a

	Number of Events	Killed	Homeless	Affected	Total Affected	Damage US$ (000's)
Africa	69	21,021	894,874	701,023	1,655,360	11,073,899
Americas	236	214,789	3,515,418	20,847,620	24,809,145	46,262,306
Asia	471	1,381,982	10,803,308	57,125,017	68,982,332	186,372,001
Europe	217	363,929	2,280,947	9,567,683	11,984,231	72,795,316
Oceania	38	439	19,820	67,574	88,161	2,509,419

Table 2: Seismic damages sorted by continent from 1901 to 2006 (Source: EM-DAT)

2.1.3. Tsunami disasters

While tsunamis are able to cause dramatic effects on coastal zones in the vicinity of the source, the devastation caused by these sea waves can occur up to thousands of kilometres away from their point of origin. These large sea surface disturbances are infrequent and are commonly generated by earthquakes, but also can be triggered by landslides or volcanic eruptions.

Though not common, tsunamis rank highly on the scale of natural disasters because of their destructiveness. Tsunamis can impact greatly on the human, social and economic sectors of our societies (Table 3). The latest great tsunami (Figure 2) occurred in the Indian ocean on 26th December 2004 and killed approximately 130,000 people close to the earthquake and 58,000 people on distant shores[11]. Other tsunamis though less destructive were reported over the same area since 2004 and struck off the same area of southern Indonesia[12]. Historical records show that enormous destruction of coastal communities has taken place throughout the world and that the socio-economic impact of tsunami in the past has been significant. In the Pacific Ocean where the majority of tsunamis occur, the historical records show tremendous destruction with extensive loss of life and property[13]. Since 1850, tsunamis have been responsible for the loss of over 420,000 lives and billions of dollars of damage to coastal structures and habitats, most of which as a result of local tsunamis. In Japan, which has one of the most populated coastal regions in the world and a long history of earthquake activity, tsunamis have destroyed entire coastal populations. The Mediterranean Sea is also an area that has been affected by large tsunami disasters such as the earthquake-triggered event in 1908 that almost completely destroyed the city of Messina in Italy, killing 2,000 to 5,000 people amongst the 75,000 reported deaths[14].

Nevertheless, once a tsunami is generated, its arrival and impact can be forecasted through measurement and modelling technologies. There is still a critical lack of development and

---

demonstration program in the framework of the United Nations International Decade for Natural Disaster Reduction (UN/IDNDR). The GSHAP project terminated in 1999. Web site: http://www.seismo.ethz.ch/GSHAP/

[11] Source NOAA, http://www.tsunami.noaa.gov/tsunami_story.html

[12] Source : http://www.adrc.or.jp/view_disaster_en.php?lang=&KEY=982

[13] G. Pararas-Carayannis, Impact of Science on Society, Vol. 32, No.1,pp p 71-78, 1982.

[14] Baratta, M., La catastrofe sismica calabro-messinese(28 dicembre 1908), Rel. Soc. Geogr. It., Roma, pp. 496, 1910 and http://www.tsunami-alarm-system.com/en/phenomenon-tsunami/occurrences_mediterranean.html

deployment of such systems, especially in the most vulnerable countries prone to tsunami disasters. With an increasing ratio of the world's population living in the vicinity of a coastline[15], coastal areas are experiencing rapid urban growth and their populations are more exposed being potentially inundated by a tsunami.

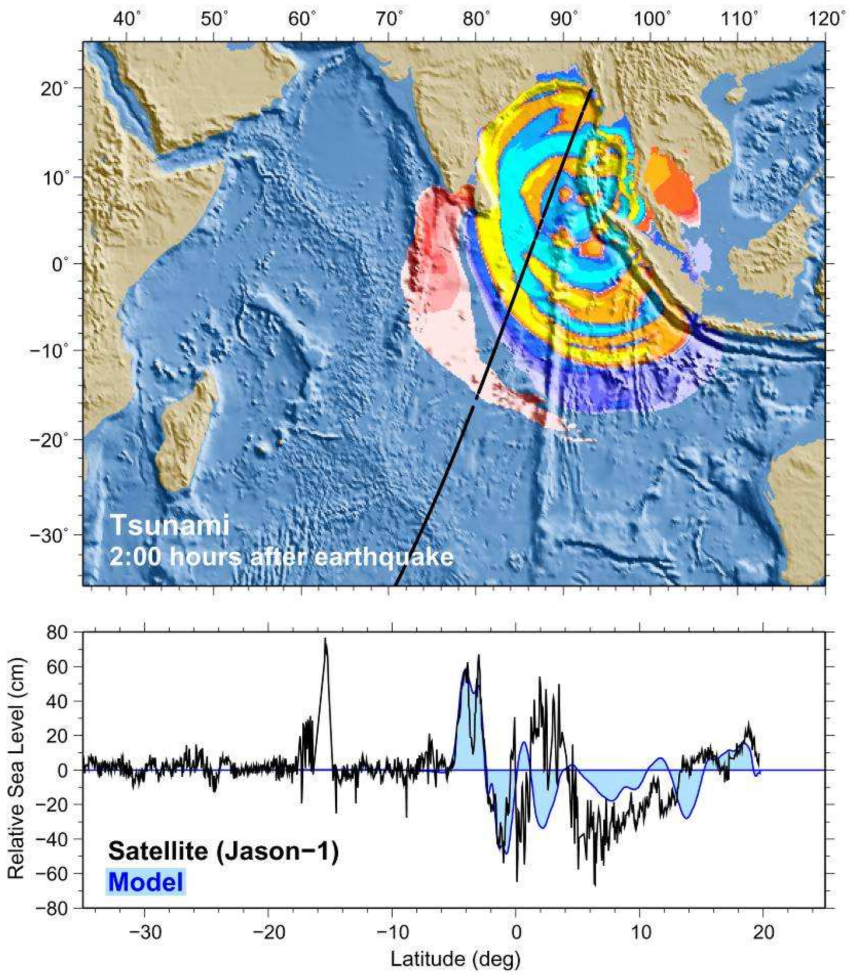

Figure 2: National Oceanic and Atmospheric Administration (NOAA) scientists modelled sea surface height of the 26th December 2004 tsunami. These modelled height were compared to the satellite measurments of Jason-1. This tsunami was triggered by the Sumatra Mw>9 earthquake. The figure shows the measurement and the modelled height 2 hours after the earthquake. The wave spreading over the ocean raised up to 60 cm height[16]

[15] Source: United Nation environment Program (UNEP)

[16] Source NOAA : http://www.noaanews.noaa.gov/stories2005/s2365.htm

	Number of Events	Killed	Homeless	Affected	Total Affected	Damage US$ (000's)
Africa	**5**	**312**	**70**	**111,560**	**111,913**	**30,050**
Americas	**9**	**455**	**1,850**	**1,720**	**3,572**	**900**
Asia	**36**	**235,843**	**1,079,844**	**1,284,791**	**2,406,835**	**7,731,127**
Europe	**4**	**2,376**	**0**	**0**	**2**	**0**
Oceania	**5**	**2,455**	**0**	**9,199**	**9,867**	**0**

Table 3: Wave / Surges damages (including tsunamis) sorted by continent from 1901 to 2006 (Source: EM-DAT)

2.1.4. Landslide and ground instability disasters

Among the geological hazards, landslides and ground instabilities are the most widespread hazards.Though destruction and number of lives lost are small compared to earthquakes, mass movements cause approximately 1000 deaths per year, and cause damage of several billions of dollars[17](Table 4). Landslides, ground instabilities and slope movements occur in a wide variety of geological environments and can be triggered by earthquakes and other major natural disasters, meteorological conditions, or human-induced factors (Figure 3).

Landslide disasters are the most destructive in developing countries, particularly those with high population growth, intensive land use and deforestation or mining practices. As an example, the 17 February 2006 huge landslide on the island of Leyte in the Philippines caused about two hundred deaths and about 1000 people disappeared in the debris[18]. Nevertheless, the problem also affects developed countries such as Japan, where approximately 3000 people have been killed by landslides over the last century. Most of the landslides occurred in Asia (244 events were recorded during the last century), but the economic costs of landslides are the highest[19] in Europe.

---

[17] Committee on Earth Observation Satellites final report, November 2002, http://www.ceos.org/pages/DMSG/pdf/CEOSDMSG.pdf

[18] Source ICSU: http://www.icsu-asia-pacific.org/resource_centre/Sassa-paper.pdf
http://www.disasterscharter.org/disasters/CALLID_114_e.html

[19] Source: see reports of Office of Foreign Disaster Assistance of the United States (OFDA) or the Centre for Research on the Epidemiology of Disasters (CRED) – OFDA/CRED International Disaster Database

	Number of Events	Killed	Homeless	Affected	Total Affected	Damage US$ (000's)
Africa	**23**	**745**	**7,936**	**11,748**	**19,740**	**/**
Americas	**144**	**20,651**	**186,752**	**4,480,037**	**4,671,598**	**1,226,927**
Asia	**244**	**17,554**	**3,784,351**	**2,389,151**	**6,177,032**	**1,477,893**
Europe	**80**	**17,349**	**8,810**	**41,281**	**50,822**	**2,157,389**
Oceania	**16**	**541**	**8,000**	**2,963**	**11,015**	**2,466**

Table 4: Landslides damages sorted by Continent from 1903 to 2006 (Source EM-DAT)

Figure 3: December 1999 debris-flow damage to the city of Caraballeda, north coast of Venezuela. (Photo by L.M. Smith, Waterways Experiment Station, U.S. Army Corps of Engineers). Source: Robert L. Schuster and Lynn M. Highland, U.S. Geological Survey Open-File Report 01-0276 2001

2.1.5. Trend in Geodisasters

As recorded in EM-DAT, there has been a clear increase of natural disasters since 1900 (Figure 4). However, these data should be interpreted cautiously as disaster reporting has improved over time, thus introducing a bias in the observed trend.

As a potential result of climate change, the probability of the occurrence of meteorological events has increased since 1900. As a consequence, landslides are most probably the only example of geohazard whose intensity and probability of occurrence could have changed in the past century. However, the disasters trend is not only affected by changes in severe precipitation events but also by major changes in land use and land cover.

Hazard and risk are very different concepts, while hazard is the potential to cause harm, risk is the likelihood of harm. Risk is therefore a combination of hazard, vulnerability and exposure, i.e. exposed elements and exposed populations. The raising trend of geodisasters impacts can be explained by the fact that risk has increased with vulnerability while hazard remained the same (except for landslides as precipitation changes can account for an increased hazard). Vulnerability has mainly increased because of extensive settlements and building of infrastructure in hazardous areas. This is particularly important in areas exposed to large earthquakes, close to volcanoes or prone to lanslides where vulnerability is increased because the hazards, for which often information is available, are ignored.

Socio-economic facts can account for an increase in the vulnerability of populations to geohazards. As an example, the island of the Taal volcano in the Philippines is considered a permanent danger area, so that immigration to this island is forbidden by the authorities. Nevertheless, people continue to settle on the island as many resources are available there. These people know perfectly well the nature of the volcanic risk, but they consider that the risk of famine would be higher if they had to settle in other areas[20]. This gives an example on how societal vulnerability leads to a vulnerability to geohazards. There is therefore a need to identify constraints of local populations and to adapt mitigation measures to their culture.

[20] See for example: “Traditional Societies in the Face of Natural Hazards: The 1991 Mt. Pinatubo Eruption and the Aetas of the Philippines”, Jean-Christophe Gaillard, in International Journal of Mass Emergencies and Disasters, March 2006, Vol. 24, No. 1, pp. 5-43

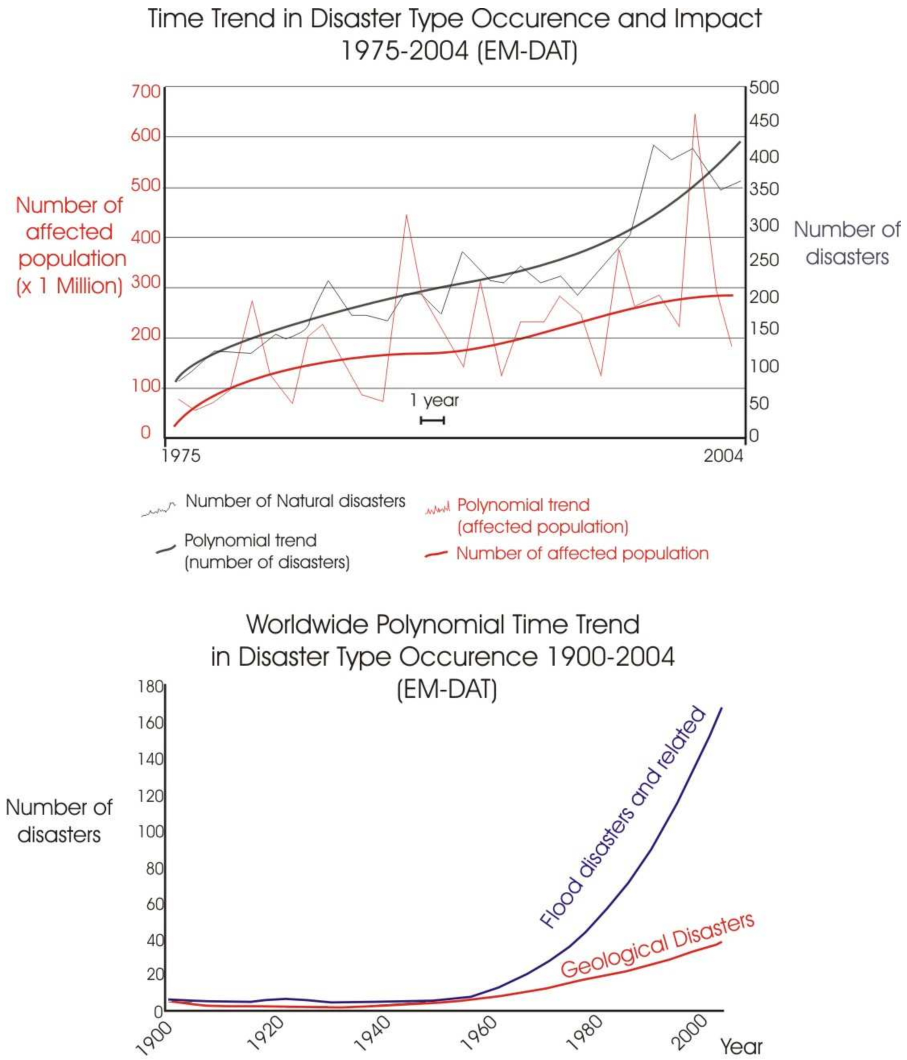

Figure 4: Trends in disaster occurrence and impacts (After *GUHA-SAPIR et al, 2004).* Source: Centre for Research on the Epidemiology of Disasters (CRED) Université catholique de Louvain[21] web site: www.cred.be

2.2. GEODISASTERS REDUCTION STRATEGIES

With an increasing impact of geohazards on our societies, the implementation of appropriate disaster reduction methods requires improved Earth observations and coordinated hazards research activities as mentioned by in the ICSU Planing Group on Natural and Human-Induced Environmental Hazards and Disasters[22]. Over the last 3 years, IGOS Geohazards has promoted

[21] GUHA-SAPIR., D. HARGITT, D. HOYOIS, Ph. (2004). *Thirty years of natural disasters 1974-2003: The numbers,* Presses Universitaires de Louvain: Louvain-la Neuve.

[22] International Council for Science Unions. Web site: http://www.icsu.org/index.php. Revised preliminary report of ICSU Planning Group on Natural and Human-induced Environmental Hazards and Disasters, Web site: http://www.icsu.org/5_abouticsu/STRUCT_Comm_Adhoc_hazards.html

the idea that the resilience of our societies to geohazards would strongly increase through balancing investment among the phases of the disaster management cycle, and through the adoption of a multi-hazards/risks approach, a regional approach and interdisciplinary procedures.

2.2.1. Need for Earth observation information

The land-use policies have an impact on the potential impact of geohazards on disaster scenarios. Appropriate mitigation measures and land use practices can reduce the impact of geological hazards. In order to take these measures, authorities require improvements in reliable and seamless information on the hazards, on the exposed elements, and on the vulnerability of exposed populations and elements (such as buildings, roads, reservoirs, hazardous materials, pipelines, etc...)

Earth observation can help:

- To better estimate the hazard itself. The authorities can then adopt an adapted land-use strategy, or even reduce the hazard itself (for some landslides).

- To map the exposed elements. Remote sensing techniques are used in developing countries for this purpose, but face difficulties following a constantly growing urban environment.

- To estimate the vulnerability of the exposed elements, through for example the retrieval of geometric features.

Earth observation can help improve knowledge of geological hazards and reduce their impact when a large amount of geological, geophysical information as well as information on infrastructure and population is combined and translated into recommendations for end users. Responsible authorities can adopt and impose appropriate land-use practices based on this information. This outlines the crucial need for strong connections between exposed populations, responsible authorities, users of Earth observation data and data providers. Community building is therefore a key criterion of success for IGOS Geohazards. Much work has been done in this field over the last three years by IGOS Geohazards members and will be addressed in Chapter 3. A key role for the International Global Observing Strategy for Geohazards is to identify where and when Earth observation can improve the quality of information that is made available to the decision makers.

2.2.2. The Disaster Management Cycle

The Disaster Management Cycle (Figure 5) represents the process by which disaster management authorities can reduce the impact of disasters by acting before, during and immediately after them in order to recover a normal level of functioning. It consists of a number of phases, each requiring a different range of response activities. These phases are grouped in three main categories:

- **Pre-emergency phases** that aim to: i) reduce the vulnerability of communities to the impact of natural phenomena, ii) reduce the exposure of these communities to the hazards or iii) even reduce the hazard itself though, for example, reforestation of slopes that could become unstable. These phases involve stages of prevention, mitigation and preparedness.
- **Emergency phases** that require automated early warning, rescue, damage assesment and response mechanisms. This phase generally takes a few seconds to a few days.

- **Post-emergency phases** that comprise recovery and development stages, where communities return to their normal level of functioning and where lessons learnt from the disaster are integrated into development policies.

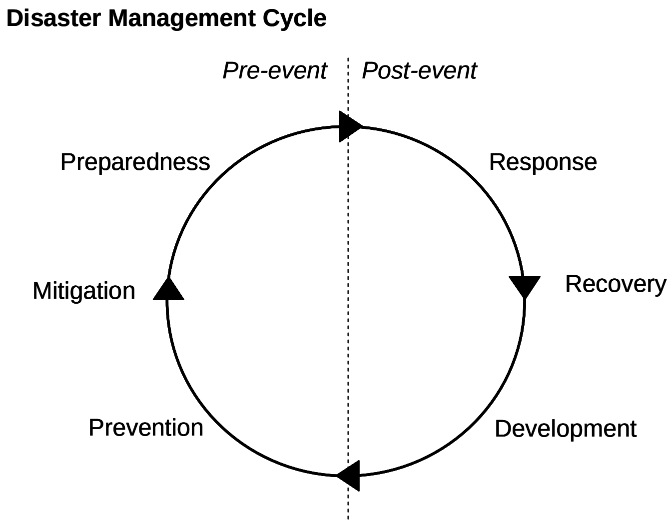

Figure 5: Disaster management cycle. The focus of IGOS Geohazards, is recognised as being of importance throughout all phases of this cycle.

Appropriate actions at all phases in the cycle lead to reduced vulnerability of communities, improved preparedness, the deployment of warnings systems and improved efficiency of response and recovery along phases. IGOS Geohazards focuses on developing the understanding of geohazard phenomena through better use of Earth observations. This fosters improvements in hazard evaluation that can be exploited through nearly all stages of the disaster management cycle:

- ***Prevention***: Prevention measures "provide outright avoidance of the adverse impact of hazards and means to minimise related environmental, technological and biological disasters" (UN-ISDR[23]). Observation provides input information to estimate the level of the threat and, once assimilated into modelling tools, help provide land use planning recommendations.
- ***Mitigation***: Mitigation measures are "structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards" (UN-ISDR). Direct mitigation of geohazards can really only be applied to ground instability. In this case, structural methods can be used to reduce the hazard. For other geohazards, mitigation of risk can take the form of structural (*e.g.* building codes, and reinforcement techniques) or non-structural (public education or hazard avoidance) activities. Observations help to identify the vulnerability of exposed elements.
- ***Preparedness***: refers to "activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuing of timely and effective early

[23] United Nations-International Strategy for Disaster Reduction, http://www.unisdr.org/isdrindex.htm; For the definition of the different stages of the disaster management cycle refer to http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm

warnings and the temporary evacuation of people and property from threatened locations" (UN-ISDR). The development of scenarios is a key area where geohazard professionals have an important role to play in disaster preparedness. These scenarios are often used by civil security organisations to plan and carry out exercises.

- ***Response***: is "the provision of assistance or intervention during or immediately after a disaster to meet the life preservation and basic subsistence needs of those people affected. It can be of an immediate, short-term, or protracted duration." (UN-ISDR). The response phase, which comes during and after the event, involves action to reduce the impact of the disaster on those who have survived it. The focus is on saving lives and protecting property. Examples of geohazard information being used in this stage would be for the definition of alternative transportation routes using information on potential post-event hazards (for example landslides induced by ground shaking or aircraft avoidance of volcanic ash clouds based on in situ and space based data).
- ***Recovery***: are "decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk" (UN-ISDR). This phase involves all the work associated with returning the affected community back to its pre-event level of functioning. This will involve restoration of essential services, infrastructure and housing. In this rebuilding phase, information on hazards is critical to minimise the likelihood of similar events occurring in the future by, for example, improved land-use planning.
- ***Development****:* Similar to the *Recovery* phase, the development of the community must take into account hazard information in order to minimise the impact of future events. This involves taking into consideration information on hazards in the building of housing and infrastructure, but also minimising anthropogenic actions that may increase the risk (*e.g.* land-use patterns).

An improved knowledge of the hazard is a necessary input throughout the disaster management cycle. It is essential in prevention, mitigation and preparedness before the event occurs. However, it is equally important to provide hazard impact and damage assessment in post event crisis management[24]. Nevertheless, while our understanding of hazards is greatly improved by the use of Earth observation, most operational activities on this theme remain based on a subset of the potentially useful data. Recent studies have been carried out to provide information on observational requirements, such as the United States decadal survey that proposes a vision for a program of Earth science research and applications in support of society[25]. Chapter 4 and 5 will examine the current geohazards observing systems and initiate a gap analysis.

During the last three years, IGOS Geohazards emphasised the importance of pre-event hazard evaluation and promoted the use of both space-based and in situ Earth observations in this work. Earth observation can be used to improve our knowledge on the hazard itself, but also on the vulnerability of exposed elements. Once provided to end users, such as disaster management agencies, this information can be translated into land-use practices. In order to implement this efficiently, end users must be able to establish priorities among the threats. The user requires therefore a multi-hazards and risks approach, and the Earth observation supply chain has to adapt to this approach to better comply with the user needs.

---

[24] As an example, earth observations can here help identifying safe evacuation routes and potential zones for temporary accommodation.

[25] Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (2007) Space Studies Board (SSB), pre-publication available at: http://www.nap.edu/catalog/

2.2.3. Multi-hazards and multi-risks approaches

Geohazards are indeed complex phenomena that can often be triggered by one another, such as earthquakes and tsunamis or volcanoes and landslides. Common instrumentations and observation means such as GPS or seismic stations can deliver sets of data that can potentially be used for the assessment of different types of natural hazards (Figure 6). As an example, already existing seismological survey and GPS[26] networks can be used to develop and implement tsunami early warning systems[27]. One of the benefits of the multi-hazards approach is therefore cost reduction through the sharing of Earth observation instrumentations and data records[28]. A multi-risks approach is more difficult to implement since different risks can be evaluated differently. Nevertheless, additional facts drive geohazards communities to a multi-risks approach:

- First, vulnerability studies include tasks such as assessment of building stock or population density and these can be used in the evaluation of risk induced by diverse hazards.

- In addition, it is necessary to help end users to establish priorities among the threats: this requires to establish methodologies that enable comparing the risks associated with various hazards. Multi-risks approaches have the advantage of enabling end users to prioritise the threats, which is a prerequisite of mitigation actions.

Such multi-risk methodologies are proposed and applied by Grünthal et al. (2006) as well as by Thierry et al. (2007).

Parallel to this multi-risks approach for geohazards, cooperation mechanisms with the meteorological community, are needed for the following reasons:

- First of all, there are triggering mechanisms and cascading effects that bring together both communities. Landslides can be triggered by heavy rainfall and volcanic ash can have an impact on weather of an entire region and be an obstacle for airlines. Meteorological organisations have developed reliable monitoring, modelling and forecasting tools, even if some meteorological episodes such as extreme precipitations remain difficult to predict.

- In addition, this cooperation is expected to avoid duplication of investment dedicated to common disaster management infrastructure, for example, in the domain of early warning. Such measures are already in place in many developing countries.

---

[26] See for example "Rapid determination of Earthquake magnitude using GPS for Tsunami Warning Systems", G. Blewitt, C. Kreemer, B. Hammond, H-P. Plag, S. Stein, E. Okal, available at http://www.igosgeohazards.org/WS_ASIA_speakers.asp

[27] This aspect is pointed out in U.K. report (Defra, 2005. The threat posed by tsunamis to the UK, edited by D. Kerridge, British Geological Survey, Edinburgh, Study commissioned by Department for Environment, Food and Rural Affairs (Defra) Flood Management and produced by British Geological Survey, Proudman Oceanographic Laboratory, Met Office and HR Wallingford. Available at http://www.defra.gov.uk/environ/fcd/studies/tsunami/tsurp.pdf)

[28] See for example: Douglas J., Physical vulnerability modelling in natural hazard risk assessment, in Natural Hazard and Earth System Science, 2007

- Finally, certain aspects of vulnerability assessment can be cautiously mutualised among many hazards.

IGOS Geohazards has been in contact with the World Meteorological Organisation (WMO)[29] to examine this issue.

The implementation of a multi-risks approach faces many challenges. There is a general lack of consensus among the various communities with regards to risk terminology and the large variety of methodologies used to estimate risk often has different characteristics (such as reliability). Therefore, the quality of information is heterogeneous. This causes conflict in the relationship between information providers and end users.

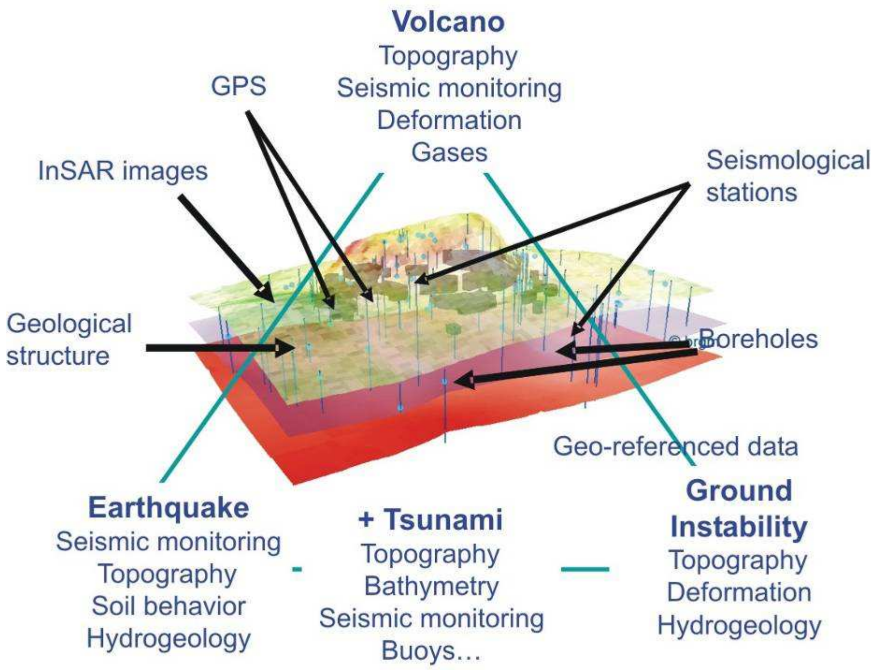

Figure 6: Benefits of the multi-hazards approach for an integrated geohazards observing strategy

2.2.4. Regional approach

Where the effect of a geohazard is not local, the organisation of a response on a purely national basis might be inefficient. In the past years, GEO and IGOS Geohazards, among others, promoted the idea that politically supported regional cooperation would help the strategies for disaster reduction. In order to promote this approach, it is crucial to encourage joint research, data exchange/integration, information co-ordination, workshops, technical training, etc. on a regional scale. Much effort has been invested worldwide to federate neighbouring countries around common disaster policies or actions. However creating links between neighbours is not always straightforward. The proper forum for this work is under the umbrella of the United

[29] The World Meteorological Organization (WMO) is a specialised agency of the United Nations. It is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources. Web site: http://www.wmo.ch/

Nations within the various disaster-related initiatives (UN-ISDR, UNOOSA SPIDER[30], UNESCO, GEO Disaster SBA and IGOS Geohazards).

As an example, a regional approach is implemented in the Pacific area where 26 countries participate towards the Pacific Tsunami Warning System (PTWS), an international program involving the coordination of many seismic, tide, communication, and dissemination facilities operated by most of the nations bordering the Pacific Ocean. The Pacific Tsunami Warning Center (PTWC) collects and evaluates data provided by participating countries, and issues appropriate bulletins regarding the occurrence of a major earthquake and possible or confirmed tsunami generation to both participants and other nations, states or dependencies within or bordering the Pacific ocean basin[31]. In the Asian Region, a good example of cooperative arrangement is the Asian Disaster Preparedness Centre (ADPC), whose main role is to enhance the national and regional disaster management capacities through implementation of a variety of risk reduction measures[32]. Additional initiatives in South Asia such as the South Asian Association for Regional Cooperation (SAARC) regroups states of Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka that support regional studies on environment and disasters and have established regional centres of excellence in the field of the environment such as the Coastal Zone Management Centre in the Maldives[33]. In the Caribbean region, the Association of the Caribbean States (ACS) promotes regional cooperation with a Special Committee on Natural Disasters that focuses mainly on fostering cooperation between the bodies responsible for disaster planning and response in the region[34]. For South-America, the Multinational Andean Project contributes to reduce the negative impact of natural hazards with a focus on land use planning and natural hazard mitigation[35]. Countries from Central America have instigated the CEPREDENAC[36] as a coordination for strengthening the risk reduction capacity of the region.

Such regional approaches toward disasters should be strongly encouraged and promoted since there is an important need for regional coordinated approaches worldwide. As mentioned during the GEO South East Asia Geohazards Workshop[37], a regional interdisciplinary approach on natural disasters would provide better understanding and mitigation of geohazards through improved sharing of data and land-use practices. Additionally, regional responses to geohazards

[30] UNOOSA is the United Nations Office for Outer Space Affairs, based in Vienna. Its SPIDER programme stands for United Nations Platform for Space Based Information for Disaster Management and Emergency Response (http://www.unoosa.org)

[31] See http://www.prh.noaa.gov/ptwc

[32] "Regional Cooperation on Disaster Management and Preparedness » report of the "Senior Officials' Meeting on Central Asia Regional Economic Cooperation 28–29 August 2006 Urumqi, XUAR, People's Republic of China; http://www.adb.org/Documents/Events/2006/senior-official-meeting-carec/Disaster-Preparedness-Management-eng.pdf

[33] http://www.saarc-sec.org/main.php?t=2.5

[34] http://www.acs-aec.org/disasters.htm

[35] The M.A.P. project: Geoscience for Andean Communities began June 28, 2002 and includes Argentina, Bolivia, Canada, Colombia, Chile, Ecuador, Peru, and Venezuela. Web site: http://www.pma-map.com

[36] Centro de Coordinacion para la Prevencion de los Desastres Naturales en America Central established in 1988. Website: http://www.cepredenac.org/convenio.htm

[37] http://www.igosgeohazards.org/WS_ASIA_objectives.asp

will allow efficient use and deployment of existing infrastructures. Such initiatives should be supported by a regional interest group or 'community of practice' that brings together scientists, data providers and users and governmental officials from the area. As an example, a major regional initiative, Sentinel Asia, a WebGIS-based disaster information sharing system for the Asia-Pacific region started in 2006[38]. It involves a total of 45 space agencies and disaster management organisations from 19 countries.

2.2.5. Interdisciplinary procedures

Interdisciplinary procedures are able to efficiently support the geohazards reduction efforts at all stages of the disaster management. As an example, the international charter "Space and Major Disasters"[39] aims at providing a unified system of space data acquisition and delivery to those affected by disasters or also threaten by hazards. This initiative requests the involvement of the space and associated ground resources (RADARSAT, ERS, or others) of members such as space agencies, to obtain data and information on a threat or a disaster occurrence. For example, during the eruption of Merapi in 2006, the USGS invoked the International Charter one week before the eruption began and member agencies contributed with space-based observations throughout the response. It was the first case that the Charter was invoked before a disaster occurred, and the data received was useful in the preparedness part of the cycle as well as the continuing response.

2.3. CONTRIBUTION OF IGOS GEOHAZARDS TO GEODISASTER REDUCTION STRATEGIES

This chapter has underlined the fact that the vulnerability of our societies to geohazards has increased drastically over the past century, in part because of severe changes in land use practices. In the specific case of landslide hazard, climate change is expected to increase the frequency of heavy rainfalls and therefore the hazard. Seamless access to Earth observation data and the capacity to transform these data to pertinent information for decision makers is critical in order to implement better land use practices and to be efficiently prepared for crisis management. This brief overview on the impact of geohazards on our societies leads to the following conclusions:

- Promotion of increased use of Earth observations at all phases of the disaster management cycle, building on pre-existing initiatives. This can be done by the promotion and support of global initiatives and projects such as Globvolcano[40].
- Further support the progressive implementation of multi-risks methodologies in the scientific community that uses Earth observations for disaster management
- Encouragement for regional cooperation

---

[38] Source JAXA: Sentinel Asia is a "voluntary and best-efforts-basis initiatives" led by the APRSAF(Asia-Pacific Regional Space Agency Forum) to share disaster information in the Asia-Pacific region on the Digital Asia (Web-GIS) platform and to make the best use of earth observation satellites data for disaster management in the Asia-Pacific region. Web site: http://dmss.tksc.jaxa.jp/sentinel/

[39] The Charter was initiated by the European and French space agencies (ESA and CNES) and the Canadian Space Agency (CSA) in October 2000, and joined by numerous agencies afterwards.
Web site: http://www.disasterscharter.org/

[40] The GlobVolcano Project will provide satellite monitoring in support to early warning of volcanic risk. It aims at demonstrating EO based integrated services to support the Volcanological Observatories and other mandate users in their monitoring activities. Particular emphasis will be addressed to prevention and early warning.
Web site: http://www.globvolcano.org/

A prerequisite of these recommendations is to consolidate a multi-risks community concerned with geohazards. For this reason, one of the key activities of IGOS Geohazards over the past three years has been the setting up of the organisational structure which allows the development of such a community. The next chapter will give more information on the constituent communities, the beneficiaries of this community building, and how this work fits into a larger international context.

3. Communities of practice and international context

3.1. IGOS GEOHAZARDS AS A PARTNERSHIP OF VARIOUS COMMUNITIES CONCERNED WITH EARTH OBSERVATION

In order to achieve its goals, IGOS Geohazards needs to fully involve communities concerned with production, assimilation and use of Earth observation data[41]. An initial group was originally formed in 2002 around UNESCO, ICSU, geological surveys and space agencies. This group benefited from the well-organised space community, which operates efficient coordination mechanisms through partnerships such as CEOS[42], and which depends on developing effective links with users to implement operational Earth observation services. In addition, the participation of geological surveys in this initial group brought experience of their transverse activities connected to geohazards, from data acquisition to hazard and risk assessment, and contacts with exposed populations and responsible authorities, both at a local and national scale. Finally, UNESCO's coordination role in the IGOS process has been widely recognized as essential.

An important focus in the recent work of IGOS Geohazards since 2004 has been on developing and consolidating a broad geohazards community. While there was broad participation across the community in the development of the first theme report, the common denominator of this group remained remote sensing. One of the main aims of the work of the IGOS Geohazards has been to engage the ground-based community and promote the utility of a forum such as IGOS Geohazards for geohazards experts. This forum stimulates interactions within this broad community and provides a bridge between policy makers and scientists.

In order to proceed appropriately in this community-building task it has been necessary to analyse the constituent parts of the geohazards community. The dispersion of a community is increasing with the number of available monitoring tools, the parameters to monitor, and the potential study zones. Thus, the volcanological or the ground instability communities appear to be highly dispersed up to now. On the other hand, in seismology, the community is traditionally well structured around the operational activities of earthquake detection and characterisation (location, depth, magnitude…). For volcanology the effect of many observations and small study zones is mitigated somewhat by the fact that the number of hazardous zones is limited and known. This has allowed a structuring of the community through a grouping of volcano observatories (WOVO) under the auspices of the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).

In order to accommodate fully all these aspects of the broader geohazards community, a number of organisations representing these groups have been invited to take an active role in

---

[41] Other organisations with broader remits such as the International Association for Engineering Geology and the environment (IAEG) are also involved in that process: "*Engineering Geology is the science devoted to the investigation, study and solution of the engineering and environmental problems which may arise as the result of the interaction between geology and the works and activities of man as well as to the prediction and of the development of measures for prevention or remediation of geological hazards.*" (IAEG statutes, 1992). Source: http://www.iaeg.info/

[42] Committee on Earth Observation Satellites. CEOS membership encompasses the world's government agencies responsible for civil Earth Observation (EO) satellite programs, along with agencies that receive and process data acquired remotely from space.

the steering of the IGOS Geohazards initiative. This has lead to the participation of four organisations representing four key areas of the geohazards in the IGOS Geohazards steering group. These are:

- The International Federation of Digital Seismograph Networks (FDSN)[43], including the Global Seismographic Network (GSN)[44]
- The World Organisation of Volcano Observatories (WOVO)[45]
- The International Consortium on Landslides (ICL)[46]
- The Global Geodetic Observing System (GGOS)[47]

A key criterion of success for IGOS Geohazards in the next years will be its ability to sustain and to further enlarge these partnerships across representative communities concerned with geohazards observations. In order to prepare this action, a map of these target communities is proposed.

3.2. A SIMPLIFIED MAP OF STAKEHOLDERS, BENEFICIARIES, AND USERS

There are many ways to map the various communities concerned with geohazards. An objective of IGOS Geohazards is to better identify groups and their interactions in an attempt to improve Earth observation information produced (data flow) and needed (requirements) by the different actors involved in the geohazards management. These groups can be gathered in five main categories that are detailed in the following paragraphs: exposed populations, end users, in-

---

[43] The **FDSN** is a global organization. Its membership is comprised of groups responsible for the installation and maintenance of seismographs either within their geographic borders or globally. Membership of the FDSN is open to all organizations that operate more than one broadband station. Members agree to coordinate station settings and provide free and open access to their data. The Global Seismographic Network (GSN) constitutes a major component of the FDSN and of the Incorporated Research Institutions for Seismology (IRIS) that deploys seismic recording stations worldwide. Cooperation through the FDSN helps scientists all over the world to further the advancement of earth science and particularly the study of global seismic activity. The FDSN also holds commission status within the International Association of Seismology and Physics of the Earth's Interior (IASPEI). (www.fdsn.org)

[44] Web site: http://www.iris.edu/about/GSN/

[45] **WOVO** is an organization of and for volcano observatories of the world. Members are institutions that are engaged in volcano surveillance and, in most cases, are responsible for warning authorities and the public about hazardous volcanic unrest. Interaction with WOVO is ideal for IGOS Geohazards as the observatories are, to a very large degree, based on the use of measured parameters in monitoring. This coupled with their status as operational entities makes them the ideal partner in volcanology. In addition, WOVO has been developing a database of worldwide volcanic unrest, WOVOdat, for a number of years. This project aims to centralise information on episodes of volcanic unrest in order to better understand the possible evolutions in events and links between distinct events. (www.wovo.org).

[46] **ICL**'s main objectives are the promotion of landslide research for the benefit of society and the environment; the integration of geosciences and technology in landslide hazard evaluation and the coordination of the global landslide community. Its central activity is the International Programme on Landslides (IPL) within which supported activities include international co-ordination, exchange of information and dissemination of research activities and capacity building through various meetings, dispatch of experts, landslide database, and publication of "Landslides": Journal of the International Consortium on Landslides (http://icl.dpri.kyoto-u.ac.jp).

[47] **GGOS** is the Global Geodetic Observing System of the International Association of Geodesy (IAG). It provides observations of the three fundamental geodetic observables and their variations, that is, the Earth's shape, the Earth's gravity field and the Earth's rotational motion. GGOS integrates different geodetic techniques, different models, and different approaches in order to ensure a long-term, precise monitoring of the geodetic observables. GGOS provides the observational basis to maintain a stable, accurate and global reference frame and in this function, is crucial for all Earth observation and many practical applications (www.ggos.org).

sector providers, data providers and facilitators. Figure 7 summarises and sketches their relationships with regard to the data and requirements exchange and expectation. This approach is used to spot the strengths and gaps in the current IGOS Geohazards membership.

3.2.1. Beneficiaries of improved Earth observation of geohazards

A critical objective for the IGOS Geohazards initiative will be its ability to help populations exposed to geohazards benefit from improved Earth observation. However, factual messages on a potential threat are often insufficient to ensure that local population will translate recommendations into new practices. The resilience of societies to geohazards depends on factors such as the nature of the hazard, the pre-disaster socio-cultural context and resilience of the community, the geographical setting and the rehabilitation policy set up by the authorities. The importance of each of these factors varies with the importance of the threat.

The transfer of information to exposed populations is usually relayed by a large group of professionals in charge of education, capacity building and alert management. These groups act as an interface between exposed populations and those who study hazard phenomena using data derived from Earth observation. They produce efficient alerts, information and education tools to reduce the consequences of natural disasters. In addition, the media plays a key role in informing citizens about potential threats.

Most of these groups are indeed closely linked to the existing IGOS Geohazards Joint Committee. Geological surveys are involved in education and capacity building actions as well as risk assessment studies. Examples include projects led by BRGM on seismic, volcanic or tsunami risk assessment in North Africa, in the mount Cameroon area, or in Sri-Lanka which include socio-economic studies, education and capacity building actions. USGS provides support to many countries exposed to geohazards around the world, for example in volcanic areas in South East Asia. BGS coordinated and participated in landslide studies, earthquake and tsunami assessments in many countries from South-East Asia, Pacific Area, and other exposed countries. UNESCO brings a recognised added value to the initiation or coordination of education and capacity building actions. Finally, all these organisations have consolidated their relationship with the media over the last few decades.

3.2.2. End users

End users are concerned with the most important questions related to natural disasters: what will happen, where, when, how and for how long? To reply to this question, they need homogeneous and reliable information derived from Earth observation data and models.

Public authorities are responsible bodies in direct contact with exposed populations and include a wide range of governmental and operational state organisations that work from the international to local scales and are responsible for the management of disasters from prevention to recovery phases**.** Government officials and Ministries are supported in this task by operational state civil protection agencies, land use planners, and disaster risk reduction organisations.

Private users include a wide range of beneficiaries of an improved risk assessment such as engineering and construction companies, infrastructure operators, mining and exploration companies, insurance and reinsurance companies. Those users potentially require both long term and information on geohazards near-real time. They translate this information into land-use practices, procedures to prepare for potential threats, or to model financial risk.

Due to the wide range of activities and the differences in scientific, technical and socio-economical background of these users, many challenges exist in bringing them together to interact with each other in a “Geohazards Community of Practice“. The strategy adopted must reflect the nature of the user solicited. In addition, for most users, geohazards are only a part of a larger “multi-risks” approach that includes meteorological disasters as well (See Chapter 2). One of the key roles of IGOS Geohazards will be to further promote the idea that end users, such as civil protection or defence agencies, will benefit from improved Earth observation.

3.2.3. In-sector providers

In-sector providers are organisations that use Earth observation data in order to produce information for end users. Once a new monitoring or modelling method is identified by scientists, in-sector providers try to progressively move from science to an operational service. This process is undertaken within research organisations, geological surveys or private service providers.

The main task of the geological survey services consist of monitoring the geohazards over the long term, by analysing the data and collecting information related to natural hazards on a daily basis. They represent the primary providers of hazard information products that aim at supporting the decisions of end users. They also have a key role to supply authorities and populations with interpretations and recommendations when disasters occur. Mandated to study some specific hazards, the survey services are typically governmental agencies such as geological surveys involved in earthquake, landslides, tsunamis and volcanoes monitoring. The US, British and French geological surveys are represented in the Joint Committee. Other organisations such as watershed authorities, ORFEUS[48] and EMSC[49] also act in sector provider as well.

Research scientists are major users of earth observation data. This group is the main creator of knowledge on geohazards, including how best to mitigate their effects and to improve the capacity to predict such events. Their technical and engineering requirements are different compared to survey services. Nervetheless, strong interactions exist with geohazard survey services that have often the chance to gather scientists involved both in hazard research teams and in survey tasks consisting in running operational and continuous networks. Most organisations involved in research on hazard assessment are universities and public laboratories. Research scientists are well represented in the geohazards Community of Practice (CoP) through member organisations of the IGOS Geohazards Joint Committee.

Service providers are specialised in supplying processed and interpreted data or providing studies about geohazards and are currently an important source of derived information products. According to the needs of the end users, they are in charge of providing available expertise at local or regional scales for public and private concerns. As an example, there are many small

---

[48] ORFEUS (Observatories and Research Facilities for European Seismology), founded in 1987, is the non-profit foundation that aims at co-ordination and promoting digital, broadband (BB) seismology in the European-Mediterranean area. http://www.orfeus-eu.org/

[49] The European Mediterranean Seismological Centre is a scientific boby established in 1975 by the European Seismological Commission. Its activity consists in the rapid determination of earthquake epicentre and the dissemination of the seismic alert message in the Euro-Mediterranean region. Website: www.**emsc**-csem.org

and medium sized companies that produce software and services for InSAR processing to monitor ground deformation. They are very concerned with establishing science-based, free operational information services, as their viability depends on their relationship with users, who are their customers. Therefore, they naturally share the objectives of IGOS Geohazards. As another example, many companies are performing seismic hazard assessment on a commercial basis.

During the last three years, IGOS Geohazards has also organised specific regional events forming a “Geohazards Working Group” in 2007, with geological surveys unions such as the Coordinating Committee for Geosciences Programmes in East and South East Asia (CCOP)[50] or EuroGeoSurveys[51]. The relationship with these organisations is vital to ensure that IGOS Geohazards remains linked to regional communities of practice.

3.2.4. Data providers

Data providers are specialised in the development and maintenance of Earth observation instrumentation and the acquisition and distribution of Earth observation data. They comprise organisations in charge of operating in situ networks, space agencies, scientific organisations, national authorities (i.e. national mapping authorities) and geological surveys in charge of permanent or temporary monitoring infrastructure.

Encouraging the involvement in IGOS Geohazards of the in situ community has been a priority for the Bureau in the last three years. In the field of geohazards, permanent and temporary instrument networks provide the basis for the majority of the science produced. As well as providing good data accuracy and resolution, they provide continuity of measurements in time. Limited by the fact that point measurements provide limited spatial resolution, they can be used in a synergistic way with space-based measurements to improve accuracy (for example the combination of InSAR, GNSS[52], GPS and levelling data). Organisations operating ground based instrumentation constitute a very broad community. Creating links between these organisations is a major challenge, which requires an increased role and involvement of geological surveys (USGS, BGS, BRGM and other surveys) in IGOS Geoahazards. IGOS Geohazards partner organisations such as the International Federation of Digital Seismograph Networks (FDSN), the International Consortium on Landslides (ICL), the Global Geodetic Observing System (GGOS) and the World Organisation of Volcanoes Observatories (WOVO) each work in their own domain at structuring the community. These organisations are key actors that provide access to these communities. The participation of these organisations within the IGOS Geohazards Joint Committee was approved in June 2006[53] and they are essential contributors to the Geohazards Community of Practice.

---

[50] The CCOP is a 40 year old intergovernmental agency that is actively involved on natural hazards which seem to be more intense in the last decade. A significant challenge to the governments of the CCOP region has been posed by the intense natural hazards, the rapid urbanisation and the development of their, often fragile, coastal zones. CCOP has displayed its flexibility by adjusting its programme to support the investigation of natural systems and the management of vulnerability through applied geosciences, appropriate technologies and knowledge management.

[51] EuroGeoSurveys is the Association of the European Geological Surveys, representing over 7,500 persons working in the numerous applications of geosciences to the EU society and economy. It is a non-profit organisation working solely in the public interest. Web site: http://www.eurogeosurveys.org/

[52] GNSS stands for Global Navigation System of Systems. Its main components are constellation of navigation satellites (GPS, Glonass and in the future, Galileo) as well as geostationary telecommunication platforms (e.g. EGNOS), which provide information about the quality of service of these constellations.

[53] Cf. IGOS Geohazards Mid Term Report, July 2006

Space agencies are responsible for data acquisition and management through the development, the launch of satellites and the control of onboard instrumentation. Satellite-based systems provide regional coverage and high spatial resolution of measurements. In addition, national or international survey services (GGOS, USGS…) provide airborne systems and airborne measurements that monitor intermediate scale of spatial coverage and higher resolution data. Satellite data useful for geohazards are made available by organisations such as the National Aeronautics and Space Agency (NASA), the European Space Agency (ESA), the Canadian Space Agency (CSA), the Japanese Space Agency (JAXA) or the French Space Agency (CNES). Other countries are already operating or planning systems, such as India, China, Brazil and Russia. A coordinated approach through CEOS contributes to efficiently providing the data needed to satisfy user requirements. NASA, ESA, JAXA and CEOS are presently represented within the IGOS Geohazards Steering Committee.

As outlined above, a number of these data providers, particularly space agencies, have historically played a key role in the IGOS Geohazards process. The definition of user requirements implies a dialogue between users and the technology providers, and the participation of data providers of both in situ and space-based data is and should remain strong in the IGOS Geohazards initiative. IGOS Geohazards therefore intends to further promote a well balanced involvment from both these groups in the GEO[54] initiative.

3.2.5. Facilitators

Many organisations are not direct actors in the geohazards information flow, but can nevertheless facilitate the IGOS Geohazards process through their political significance, funding or coordination mechanisms.

Funding bodies linked with the financial sector such as the World Bank, the Islamic Bank, the Asian Development Bank or with national development agencies such as USAID or the Canadian International Development Agency (CIDA) regularly support specific geohazards projects. These organisations could therefore play an important political role in the IGOS Geohazards, if they could be associated with the initiative. In the future, the “Donor workshop” organised by GEO for its capacity building activities could be used for getting these organisation interested.

International organisations from the United Nations system have been very beneficial in helping to initiate and manage coordination mechanisms. An example of this is UNESCO’s commitment to the IGOS Partnership by coordinating the development of a new regional tsunami early warning system for the Indian ocean region[55]. UN-ISDR aims at building disaster resilient

[54] The **Group on Earth Observations**, **GEO**, was established by a series of three ministerial-level summits. GEO includes 66 member countries, the European Commission, and 46 participating organizations working together to establish a Global Earth Observation System of Systems. Source: http://www.earthobservations.org/

[55] Following the tsunami disaster, the United Nations Education Scientific and Cultural Organization’s Intergovernmental Oceanographic Commission (UNESCO-IOC) took advantage of its involvement in the Pacific Tsunami Warning and Mitigation System, and provided the basis, together with Member States, to design and implement the Indian Ocean Tsunami Warning and Mitigation System (IOTWS). The IOTWS formally came into existence in 2005 with the establishment of an Intergovernmental Coordination Group to govern it. This Intergovernmental Coordination Group is serving as the regional body to plan and coordinate the design and implementation of an effective and durable tsunami warning system. The approach includes hazard detection and forecast, threat evaluation and alert formulation, alert dissemination of public safety messages, and preparedness and response. The success of this regional initiative relies on national and regional coordination, but also on capacity building actions. The 23rd Assembly of UNESCO’s Intergovernmental Oceanographic Commission (IOC) also

communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters. UN-ISDR promotes an integrated strategy for disaster reduction, the Hyogo Framework for action 2005-2015, whose observation component is supported by the GEO Disaster Societal Benefit Areas and IGOS Geohazards among other initiatives. Another example is the UNOOSA recently launched SPIDER programme which aims at providing access to all types of space based information and services for disaster management. Equally, the participation of other international organisations such as the OECD[56] would be highly beneficial to IGOS Geohazards.

Finally, the European Commission has an impact on disaster management at the world level through its framework programme activities on natural disasters provided by initiatives such as the Global Monitoring for environment and Security (GMES)[57]. There is therefore a political challenge to encourage their association with IGOS Geohazards. This is done through support and synergies between the IGOS Geohazards Bureau and the Geohazards Working Group of Eurogeosurveys.

adopted resolutions establishing similar bodies for the Caribbean and adjacent regions as well as the North-East Atlantic, the Mediterranean and connected seas.

[56] Organisation for Economic Co-operation and Development

[57] The 'Global Monitoring for Environment and Security' (GMES) represents a concerted effort to bring data and information providers together with users, so they can better understand each other and make environmental and security-related information available to the people who need it through enhanced or new services.
Web site: http://www.gmes.info/

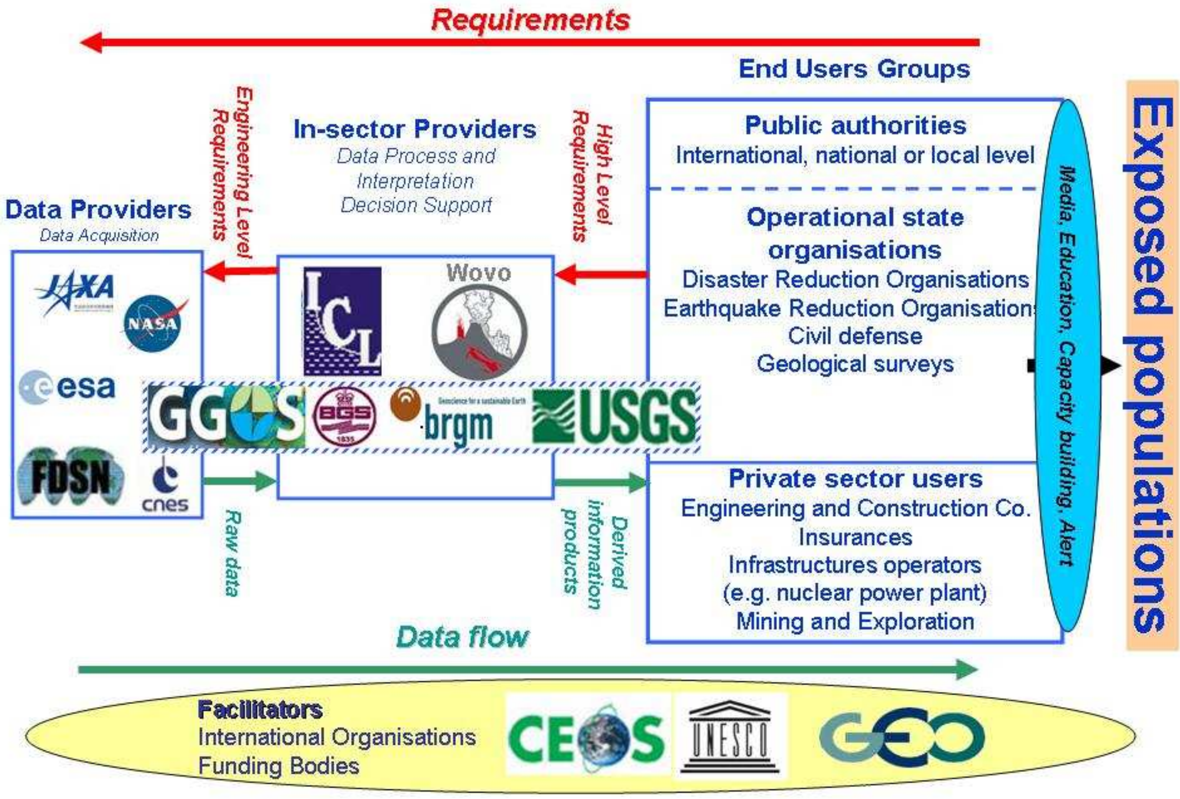

Figure 7: End-to-end chain between data providers to users targeted by IGOS Geohazards. This sketch is an overview of the different organizations concerned with geohazards. Data flow (green arrows) corresponds to the observations and products regarding geohazards. Requirements (red arrows) correspond to the information and observational needs for geohazards

3.2.6. IGOS Geohazards added value

Improving access to global Earth observations and meeting the requirements of end users and in-sector providers are a challenge that demands a profound change in the way international cooperation and coordination is conducted. IGOS Geohazards seeks to create links between a number of existing organisations and initiatives and acts as an interface between them in order to foster this change within the geohazards community.

In the next three years its role will be to consolidate the relationships established and build toward concrete cooperative projects. More details on the objectives that have been set for the next period are provided in Chapter 4. IGOS Geohazards must achieve this in the context of the intergovernmental initiative Group on Earth Observations (GEO) by leading certain actions and providing support in others.

3.3. FITTING INTO THE GROUP ON EARTH OBSERVATIONS

3.3.1. Participating in the GEO Process

Since its inception, the IGOS geohazards theme has been a bridge between high level policy makers such as UNESCO and the geohazard community. This role has gained weight through the interaction with the Global Earth Observing System of Systems (GEOSS) [58] currently established by GEO. The GEOSS project helps production and management of observations in a way that benefits environment and humanity. GEOSS is envisioned as a large national and international cooperative effort to bring together existing and new hardware and software, making it all compatible in order to supply data and information at no cost.

Improving access to Earth observations is one of the main objectives of GEO and complements the IGOS Partnership initiative with larger scopes. GEOSS will be developed in order to respond to the needs of the society for:

- Easier and more open data access;
- Informed decision making;
- A better Earth Observing System;

While IGOS objective was to define a strategy, GEO is in charge of the implementation of GEOSS. To implement GEOSS, GEO defines tasks that are endorsed by Members States or organisations, or even expert groups. Each task reports to a specific committee:

- The User Interface Committee (UIC) aims at engaging users in the development and implementation of a sustained GEOSS. Users' requirements in terms of data and information are gathered from user groups across the "societal benefit areas" on national regional and global scale. IGOS Geohazards is represented by its Bureau in this committee.

- The Architecture and Data Committee (ADC) aims at supporting GEO in all architecture and data management aspects of the design, coordination, and implementation of the GEOSS. From a geohazards perspective, ADC provides requirements on how to perform inventories of geohazards data and sensors in an interoperable way.

- The Science and Technology Committee (STC) explores new science breakthroughs in Earth observation science. IGOS Geohazards is represented by BGS in this committee.

- The Capacity Building Committee (CBC) explores the capacity building needs, in particular to increase capabilities of Earth observations and interpretation in developing countries. IGOS Geohazards is represented by UNESCO in this committee.

IGOS Geohazards has been represented in these four committees. Participation in the UIC is a requirement for being involved in the user requirement process of GEO. Participation in the Architecture Committee is necessary to make the GeoHazData system[59] interoperable with other systems. Participation in STC is necessary to report on work undertaken to promote InSAR and

[58] GEOSS web site: http://www.epa.gov/geoss/

[59] GeoHazData is an IGOS Geohazards project to develop a catalogue of metadata focused in a first step on an inventory of hazard maps

in-situ integration. Participation to the CBC is necessary to stimulate cooperation and exchange of knowledge with developping countries.

Figure 8: Within the GEO organisation, IGOS Geohazards acts as an initial kernel for a Geohazards Community of Practice (« Expert Communities »), and has taken leadership in two tasks of the User Interface Committee, and participates in three others

IGOS Geohazards has been participating in the GEO process since late 2005 through the leadership of two GEO tasks[60]. These include the setting up of a global inventory of hazard maps (Task DI-06-07) and a task focused on improving the integration of InSAR technology in disaster management (Task DI-06-03). IGOS Geohazards Member Organisations also participate actively in the implementation of GEOSS: as an example, GGOS and FDSN contribute or co-lead GEO tasks and ESA plays a key role in the Architecture and Data Committee's task implementing the GEO Clearing House. Finally, geohazard observing systems such as the Global Seismological Network and GGOS have already been identified as components of GEOSS.

Since early 2006, IGOS Geohazards has been recognised as an initial kernel of a Geohazards Community of Practice (CoP), i.e. as a group of experts concerned with the scientific and operational geospatial information needs for the prediction and monitoring of geohazards. The concept "Geohazards CoP" should be used very cautiously as there are in fact many communities of practice, that have various Earth observations requirements. According to the definition, Communities of Practice are informal groups of people, sharing the same objectives, and with various degrees of involvement. To illustrate this, various Geohazards CoP including observation providers and end users are shown in Figure 8, which outlines their link with IGOS Geohazards. The precise role of IGOS Geohazards Joint Committee in this context is to be the active kernel of the Community of Practice concerned with Earth observations for geohazards.

GEO can be of benefit to the Geohazards CoP through the following aspects:

- Through the division of the GEOSS implementation into small tasks, GEO helps attract and bring together experts in specific fields and this leads to very useful exchange of knowledge

- GEO can help emerging technologies to reach user groups through the User Interface Committee

[60] Cf. Appendix 11.2: IGOS Geohazards contribution to the GEO initiative

- Through the Architecture and Data Committee, GEO can help geohazards communities of practice to ensure interoperability of the systems they need to develop (e.g. various inventories)

- GEO provides political support to raise awareness of the decision makers of the need for performing inventories of hazards databases and on the difficult task it represents

- GEO offers an international platform for outreach actions

- GEO offers a political exposure with nations that support the GEO tasks adopted in bi-annual workplans

- GEO provides financial supports for the participation of experts from developing countries at international workshops

- GEO offers facilities such as contact lists and an FTP server which are very useful for the task implementation and help reach various communities of data providers and users

GEO provides a common framework within which:

- Diverse interest groups can put in place means for making their data available to the wider community. While they may not realise the benefits of this sharing in the short term, synergy between different types of data will becomes clear in the longer term

- Countries can contribute with instrumentation or observing systems that can be integrated seamlessly to a larger Earth observation system. Users can no longer accept Earth observation systems that operate with different incompatible formats, which happens frequently in developing countries that are not sufficiently involved in the definition of the systems they require[61]

- GEO is to offer obvious bridges between various communities concerned with an efficient use of Earth observation data

In this context, IGOS Geohazards endeavours to raise awareness and encourages the geohazard community to participate in the work of GEO in order that their needs in terms of Earth observations are taken into consideration.

More generally, IGOS Geohazards must work to represent the geohazards community by stating and defending their requirements. This update of the IGOS Geohazards theme report provides an opportunity to review requirements in a formal way.

3.4. NEW COMMUNITY BUILDING ROLE FOR IGOS GEOHAZARDS IN 2007/2010

The previous section stressed the advantages in establishing partnerships with various communities of practice in the frame of IGOS Geohazards, which has made much progress on this issue since 2004. Mechanisms to bring together these communities have been identified in this period and this work will continue through:

[61] As an example of this, the final report of the GEO Geohazards Workshop in South East Asia showed that seismometers provided by France and Germany to Indonesia were not interoperable. http://www.igosgeohazards.org/WS_ASIA_objectives.asp

- Thematic regional or international workshops to bring together the various communities
- Information means: Newsletters and web site to serve as a window for this community
- Regular publication of Theme Reports updates to establish state of the IGOS Geohazards objectives, strategy and workplan
- Involvement within GEO in order to benefit from this initiative that addresses the problem of Earth observations in the broadest sense.

3.4.1. Workshops and meetings

A series of workshops has been organised by the IGOS Geohazards Bureau since its foundation to implement its geohazards reduction strategies (Cf.Ch 2.2):

- The first International Geohazards Workshop, held in Frascati, Italy in 2002, was an opportunity to meet and discuss geo-spatial information issues with representatives from all geohazards communities, to raise issues where priorities are to be placed, to influence the decision of the funding agencies, to be pro-active in a multi-national and multi-disciplinary context.
- The "Second International Geohazards Workshop" took place in Orléans, France, in June 2005 and brought together around fifty experts from across the globe. This "Kick-off" workshop, which marked the beginning of the second phase of the IGOS Geohazards initiative, also saw a number of working groups (Capacity building, observations, modelling and integration, infrastructure databases and access, underpinning science) established.
- The "Cities on Volcanoes " Workshop was held in Quito, Ecuador, 23rd-27rd January 2006 aimed at stimulating participation from among the volcanology community.
- The "GEO South East Asia Geohazards" Workshop that took place in Kuala Lumpur, Indonesia, established a regional geohazards Community of Practice and stressed the need to facilitate access to data to strengthen regional cooperation and to L band SAR data over vegetated areas such as South East Asia.
- In November 2007, the 3rd International Geohazards Workshop will be held in Frascati, Italy.

The added value of the IGOS Geohazards workshops is to bring together all communities mentioned above. IGOS Geohazard's first task for the community building action will therefore be to regularly organise such workshops, with the objective to progressively improve Earth observation information flow across these communities.

3.4.2. Information means

An important outreach tool has been initiated in the form of the semesterly IGOS Geohazards newsletter, "GeoHaz Update". The aim of this document is to inform the geohazards community about the current activities of the IGOS Geohazards initiative and its partner organisations. This newsletter can serve as a window for IGOS Geohazards stakeholders. In addition, the IGOS Geohazards web site: http://www.igosgeohazards.org/ enables contacts and communication with a wider community.

3.4.3. Theme report publication

The regular publication of the theme report is a mechanism to update objectives of IGOS Geohazards, to bring together the multi-risks communities, to review the different Earth observation systems and their complementarity, and finally, to establish a workplan for the initiative.

3.5. CONCLUSIONS

In the last three years, the GEO initiative has been set up. The GEO Members have adopted a ten years workplan, which is an overall roadmap to implement the strategy that the IGOS partnership promoted. In order to achieve its objectives, IGOS Geohazards contributed since the begining to GEO, and it adopted a transition paper from IGOS to GEO in June 2007.

In order to consolidate the Geohazards Community of Practice, IGOS Geohazards proposes to:

- Further fulfill its commitments to IGOS (Theme report), but within the GEO context
- Serve as initial kernel of the Geohazards Community of Practice
- Use its coordination mechanisms (International and regional Workshops, communication means, information system) to contribute to the implementation of GEOSS
- Invite groups of users and facilitators to participate in the Community of Practice

The Communities of Practices described in this chapter have been introduced in the light of the data flow mechanisms. In the next chapters, these data flows and the corresponding data and information requirements will be examined.

4. End user requirements

4.1. END USER NEEDS ANALYSIS

4.1.1. Geohazards characteristics

End users need to acquire basic knowledge about the potential threatening natural hazards in order to prevent, mitigate, prepare, respond and finally recover from a disaster. As outlined in Chapter 2, one of the purposes of IGOS Geohazards is to identify some connections between earthquakes, landslides, volcanoes and tsunamis hazards and to propose a global approach using information supports usually delivered by scientists and geological survey agencies. Nonetheless, each hazard has its own distinct characteristics in terms of event occurrence, prediction likelihood, time and spatial extent and effects that are briefly summarised in Table 5.

4.1.2. User needs among all phases of the disaster management cycle

Once natural hazards are identified for an area, the main requirement of the end users is to be provided with realistic answers to critical questions: what will happen, when, how and for how long? Survey agencies endeavour to address these questions at all phases of the event or the disaster, using *in situ* and space-based Earth observations data, modelling and socio-economic studies. Depending on the phase of a disaster cycle (mitigation, crisis management or response)[62] the end users will have different approaches and requirements where one can distinguish:

- The mitigation and preparedness policies during the pre-emergency phases, that demand information on exposure of populations or infrastructures, in addition to information on hazards. While mitigation will focus on land use policies, preparedness will focus on developing operational tools for crisis management.

- Short term to very short term mechanisms in a time range from minutes to days enabling crisis management emergency phase to assess or face an impending hazard. This phase is critical for the end users though not yet operational for many types of natural hazards such as earthquakes.

- The crisis response where disaster management and post-emergency concerns aim at supplying end users with critical information to reduce consequences of a disaster and to monitor the extent of the damage.

[62] The different phases of the disaster cycle are described in the 2nd IGOS Geohazards Theme Report, 2007.

	Earthquakes	Landslides and land subsidence	Volcanoes	Tsunamis
Hazard description	Sudden ground ruptures occurring from an epicentre and propagating along faults The fault rupture causes seismic waves	Ground instabilities (deformation and displacement) under direct influence of gravitational forces acting on the surface or at shallow depth Heterogeneous types of movements such as rock falls, failure of slopes, debris flow, swelling or shrinking of clay subsoils.	Opening or vent in the ruptured Earth's surface or crust through which molten rock, ash and gases are extruded from depth Volcanic hazard depends on the nature of volcano and the type of eruption making hazard unique for each location and event	Series of catastrophic ocean waves generated by submarine movements. The waves may travel at speeds up to 800 kilometres per hour and become dramatic with increasing height, up to 30 metres, when approaching shallow water along coasts
Prediction	The sudden break from an epicentre and the propagating rupture cannot yet be predicted	Possible to anticipate: The triggering factors are well known: weather conditions or another major natural disaster or human induced origin such as mining, blasting, digging or pumping.	Possible to anticipate: Warning of impending volcanic event with gradual awaking from a dormant to an active period. Precise warning is nevertheless complicated as the alert might persist many months before the major event	Possible to anticipate at distance: Alert systems monitoring triggering events (earthquake, landslide…) and ocean surveys. Local tsunamis are very difficult to predict
Time and Spatial extent	Minute scale ruptures and tremors Ruptures can extend as much as 1000 kilometres along faults. Ground shaking decreases quickly with distance but seismic waves travel far from the source.	Very variable in time and spatial extent. A landslide can be reactivated after many years, or huge landslides can be suddenly triggered by another event such as an earthquake.	Time extent is highly variable and eruption may occur for decades. The spatial extent of an eruption is generally limited. The location of the volcanic area, its geological history, and the affected regions are generally identified. There might be distant effects such as ash clouds.	Very variable spatial extent: Capability of causing disaster up to thousands of kilometres away from the source a couple of hours after initiation.
Distinct Characteris tics	“Site effects” generated by local amplification of ground motion even far from the source.	Soil properties such as geological or hydrological conditions are strongly correlated with landslide occurrence.	Different types of volcanism make eruptions inoffensive or on the contrary critical.	“Site effects”: The amplitude of the tsunami wave strongly depends on the morphology of the coast.
Relationships to other natural hazards	Liquefaction which is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Earthquakes often trigger landslides, land subsidence and permanent topographic changes. Most tsunamis waves are generated by earthquakes	Landslides may trigger tsunamis when in coastal or offshore locations	Volcanic activity combines various hazards such as earthquakes, lava flows, ground explosions, landslides, lahars, tsunamis, gas emission and meteorological phenomena. Hazards occurrence such as landslides while no ongoing volcanic activity is reported.	Various triggering factors due to other natural hazards mainly large earthquakes but also volcanic eruptions, and landslides along the coast or beneath the ocean.

Table 5: Geohazards characteristics

These approaches need to be specified for all geohazards: earthquakes, landslides, volcanoes and tsunamis. Each geohazard and exposed site present specific features that are critical to identify in order to provide the most relevant products that satisfy end users requirements at each phase of a disaster management cycle. As an example during a pre-emergency phase for landslide hazard[63], a mitigation policy can aim at:

- **Reducing hazard** through specific measures such as reinforcement of the slope, reforestration, etc... Here, observations allows the creation of an inventory of existing landslides and the level of threat.

- **Reducing exposure** where observations provide inputs to alert systems and information to land use planning.

- **Reducing vulnerability** where observations contribute to the assessment of systemic and physical vulnerabilities, through, e.g., the provision of inputs information for inventories of vulnerable elements.

The end users demand is therefore not only focused on the hazard itself, but also on the vulnerability of exposed elements. For instance, the structural engineers evaluating the building vulnerability to earthquakes for which additional products can be available require *in situ* observations such as noise measurements using portable seismometers to identify site effects or space and airborne observations to retrieve building parameters (such as building heights, or 3D models) and to map the different typology classes for large urban areas.

One of the approachs of IGOS Geohazards is to outline the most common products for end users for all geohazards. This multi-hazards approach is expected to improve the efficiency of information provision to end users, and to identify issues that should be taken into account for developing new Earth observation services for the benefit of exposed populations. Four types of products have been identified:

- Hazard maps and risk maps are a source of input information for pre-disaster phases of the disaster management cycle

- Scenarios help authorities to prepare for a crisis, as it helps them to produce automated procedures

- Forecasting and early warning systems

- Response mechanisms, such as rapid mapping, which is addressed by the International Charter: “Space and Major Disasters”. Generic end users products for the pre-disaster phases

4.1.3. Hazard maps

Scientists can help end users to identify threatening hazards and the best land-use strategy through hazard maps that are the first step in the evaluation of risk. This represents a critical requirement to mitigate risk and a useful product for local to national authorities, land use planners and building companies that are developing new infrastructures. Table 3 indicates the different characteristics of earthquake, volcano, landslide and tsunami hazard maps.

[63] USGS landslide hazard program has developed intensive real-time monitoring in the USA at several critical locations such as highways, or cities: http://landslides.usgs.gov/monitoring/ and “*National Landslide Hazards Mitigation Strategy – A Framework for Loss Reduction*” by E.C. Elliot and P.L. Gori, USGS Circular 1244, 2003.

End users need to integrate different hazard maps into a multi-hazards approach in order to become resilient to any potential catastrophic event. More precisely, land use planners need scientific support to establish priorities between different hazards that exhibit different spatial and time scales and various triggering factors. However, it is very difficult to perform appropriate comparisons of probabilities of occurrence between different hazards. As an example, the earthquakes hazard map of Switzerland developed by the ETH[64] (Figure 2) shows the level of horizontal ground motion with a return period of 475 years (10% chance of exceedance in 50 years). Volcanic hazard can be expressed very differently: For example, the lava flow hazard can be expressed using the location and frequency of past eruptions, the topographic features and the assumption that future eruptions will be similar[65]. While seismic hazard maps are based on the probability of exceedance during return periods of events, volcanic hazard map focus on the next event, as volcanic features such as topography might have changed completely after the next event[66]. Finally, this example shows that if an end user has to establish a land use strategy, he will need to compare probabilities that cannot be easily compared. The task of producing practical multi-hazards maps is therefore very challenging because of the characteristics of each natural disaster. A certain degree of harmonisation in the terminologies across all geohazards is therefore needed. With better homogenised information, public and private organizations can chose between different land use options to minimise the risk once the infrastructure is built. In the specific case of landslides, it is even possible to reduce the hazard itself through e.g. reforestation. Finally, the complexity of the information provided through hazard maps clearly shows that land use planners should be assisted by multi-hazards experts to take the best decision before planning new infrastructures in high risk areas.

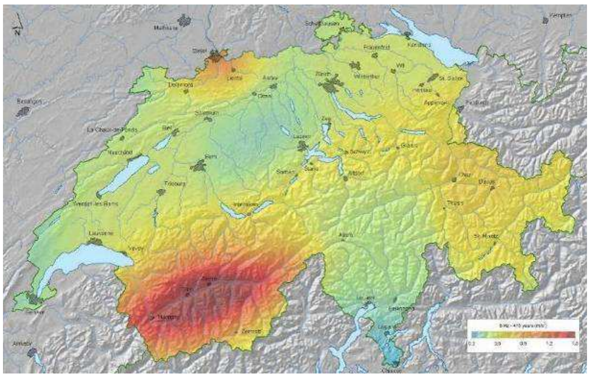

Figure 9 : The seismic hazard map of Switzerland depicts the level of horizontal ground motion (in units of the 5% damped acceleration response spectrum at 5Hz frequency) with a return period of 475 years (10% exceedance chance in 50 years)[67]

[64] Swiss Federal Institute of Technology Zürich, http://www.ethz.ch/index_EN

[65] We take as an example the lava flow hazard zone maps performed by USGS for the island of Hawaii: http://pubs.usgs.gov/gip/hazards/maps.html , Reference: "Volcanic and seismic hazards of the island of Hawaii", on line edition, U.S. Dpt. of the Interior and USGS.

[66] See for example the hazard assessment in Mount St Helens after the 1980 eruption, which completely changed the topography. http://vulcan.wr.usgs.gov/Volcanoes/MSH/Hazards/OFR95-497/OFR95-497.html, Reference: E. W. Wolfe and T. C. Pierson, *Volcanic-Hazard Zonation for Mount St. Helens, Washington*, U.S. Geological Survey Open-File Report 95-497, 1995.

[67]Source: http://www.earthquake.ethz.ch/research/Swiss_Hazard/Maps_plots/Hazard_Maps/hazard_map.pdf, ETH Zurich (Switzerland), Earthquake statistics group.

Earthquakes	**Volcanoes**	**Landslides**	**Tsunamis**
The relevant identification of the seismic or potentially seismic areas is critical for end users to evaluate the seismic hazard of a country, a region or a city. The availability of earthquake frequency maps is the minimum requirement in order to reduce exposure. For improved assessment of the seismic hazard, seismic zoning is implemented to obtain quantitative information for design, construction, and planning of the built areas. These maps provide end users with inferred ground motion intensity and, but not systematically, an earthquake return period.	Volcano hazard assessment and zonation maps are the main tools to address the questions of long-term planning and mitigation of volcanic hazards for all the monitored and identified sites. It requires information on the magnitudes, patterns and frequencies of the past eruptions. Thus, volcanologists dedicate a large amount of work to produce various maps to inform end users specifically on each type of volcanic related hazards. These documents need to be constantly updated with permanent studies and acquisition of new data related to the activity of the volcano. This information is produced by a wide range of science fields such as meteorology, geochemistry, geology or geophysics and hydrology.	Landslides and ground instability hazard maps are based on inventory of all types of ground instabilities, their possible evolution and their triggering factors. A hazard map may propose only the locations of old landslides to indicate potential instability, or maybe more complex and then based on variables such as rainfall, slope angle or soil type. As it is often impossible to make an exhaustive inventory of all cavities in a specific region, geological maps, expert opinion, and inventories of existing cavities are used to draw maps showing the probability of existence of cavities, their probability of collapsing and the zones likely to be affected. Hazard maps of swelling or shrinking of clay subsoils are based on the analysis of already existing geological maps.	Tsunamis are rare events making their behaviour difficult to determine and dependant on extensive research activities. End user requirements for the tsunami hazard mitigation are basically inundation maps that take into account the topography of the sea shore and the amplitude of the waves. More complex hazard maps are likely to consider the historical tsunami and earthquakes recordings in addition to the local specificity of the bathymetry, and the characteristics of the coast that influences amplitudes of the hazardous waves. This needs integrated studies of different scientific fields such as oceanography and seismology.

Table 6: Geohazard map processing; After IGOS Theme report 2004

4.1.4. Risk maps

End users need risk maps as improved indicators offering a combination of hazard and vulnerability and providing, therefore, an estimation of a level of damage. The risk depends on the hazard, but also on the elements at risk and their vulnerability. For instance, the world process of urbanisation increases geological risk, unless appropriate land-use policies are applied. In many cases, areas of low or moderate seismicity can be even more vulnerable to earthquakes than high seismic zones due to earthquake risk not being taken into account. For similar reasons to those developed above, multi-risks[68] assessment is a matter of concern for end users concerned with mitigation and preparedness to disasters, building renovation and insurance companies. All these users need to know which elements and populations are at risk, and to estimate their vulnerability to various events. The lack of information received by exposed populations is a socio-economical component of vulnerability and can strongly increase the risk.

[68] Such methodologies are proposed and applied in Grünthal et al. (2006): Comparative risk assessments for the city of Cologne – storms, floods, earthquakes, in Natural Hazards and Pierre Thierry et al (2007) An example of multi hazard risk mapping and assessment on an active volcano: the GRINP project on Mount Cameroon, in Natural Hazards

The accessibility to vulnerability databases can be very different pending on the considered country. As an example, the CEDIM[69] was able to estimate the value of exposed elements in Germany and the expected losses in case of floods, earthquakes or storms.

However, the situation is often far less favourable, even in developed countries. In those cases, earth observation can play a key role in performing rapid automated inventories of exposed elements and their discrimination by their vulnerability to each kind of hazard. In order to do this, building engineers and earth observation scientists need to exchange information on the parameters retrieved using observations that allow the estimation of the vulnerability for hazards. In France, for example, many parameters are used in the determination of building vulnerability, to earthquakes, among them the height of the building and their construction date. One of the expected benefits of a multi-risks approach is to save costs through mutualising the vulnerability assessment to many hazards (Douglas, 2007). However, it is imperative that specificities of each hazard should be taken into account. As an example, fragility curves are an essential parameter for vulnerability assessment to earthquakes as the strongest losses are not due to the earthquake itself, but to from damage to buildings. On the other hand, vulnerability assessment to volcanic hazards might not focus on retrieving building parameters, but rather on the exposed populations, the possibility to evacuate them rapidly, and possible cascading effects due to the industrial environment. This shows that despite the potential to save costs through vulnerability assessment to hazards exists, vulnerability parameters remain specific to each hazard.

In addition, interpreting risk maps implies understanding the types of vulnerability that are addressed. In fact, there are infinite possibilities for risk maps as one can consider the vulnerability of buildings, of populations, of the GDP (Gross Domestic Product), of building value, etc… Nevertheless some research efforts have been made such as the ARMONIA project[70] where new methodologies for multi-risks assessment and harmonisation of different natural risk maps are investigated.

Finally, only direct losses due to a disaster can be mapped. The deficiency or the collapse of vital infrastructures after a natural disaster such as transport may result in indirect losses that are impossible to map, and often difficult to even quantify. Disaster scenarios can help in understanding these effects.

4.1.5. Damage scenarios

Disaster scenarios are based on a simulated event and on an estimation of the vulnerability to help to understand what will be the challenges during a crisis triggered by a hazard. The scenarios usually combine information provided by the hazard maps, observations and modelling of possible consequences. Building a disaster scenario therefore in the inference of a chain of events based on modelled ongoing hazards that lead to losses with an associated frequency and severity. This contributes to end user requirements to identify and understand disaster triggering and cascading effects, such as the occurrence of an earthquake and the associated landslides or tsunamis. This kind of tool allows the identification of possible weaknesses in the response mechanisms. Table 7 presents the different characteristics of disaster scenarios for natural hazards.
Nevertheless, end users have to be very cautious when using this product. In order to build a scenario, scientists must choose a certain number of parameters, such as the scale of the event considered, possibly its location and the cascade effects. It is therefore necessary to make

[69] CEDIM: Centre for Disaster Management and Risk Reduction Technology http://www.cedim.de/english/13.php

[70] Applied Multi-Risk Mapping Of Natural Hazards for Impact Assessment, European Community Project n°511 208, see http://www.armoniaproject.net

different scenarios of various probable events. As a consequence scientists have to interact with users to define the probability of occurrence of an event scenario that fits the end user requirements. The issues related to the interpretation of scenarios further stress the need to support scientific advisory of decision making.

Earthquakes	**Volcanoes**	**Landslides**	**Tsunamis**
Earthquake scenarios provide end users with information about potential damages to buildings, human loss, or effects on urban activities. Earthquake risk scenarios require many types of information such as geodesy, geology, historical and instrumental seismology, but also geotechnical parameters and engineering designs. Such studies are performed at present for many cities[71].	Eruption scenarios can be implemented according to the available knowledge of the past volcanic episodes. Examination of several possible eruption scenarios can help identify the possible vent location, the potential hazardous areas and the different types of eruptions. Nevertheless there are still many active volcanoes for which the lack of information on their eruptive history has to be addressed. The accuracy and robustness of such scenarios critically depends also on the integration of realistic volcano modelling and enhanced volcano instrumentation or monitoring such as gas or geodetic measurements.	The estimation of damage and loss according to a risk scenario is based on observations and modelling of the ground instabilities. These scenarios provide predictive tools on the ground displacement and their effects to environment, urban areas, or infrastructure in terms of spatial, temporal extent and damage. A large field of science is required to produce such scenarios: earth sciences (geology and geomorphology, geophysics), water sciences (hydrology and hydraulics), and engineering sciences (civil and mining engineering, forest and agricultural engineering).	Tsunami scenarios are simulated given multiple conditions such as seismological, geographical or societal conditions. The results of a hypothetical tsunami inundation scenario should include meaningful information about the wave height and the current speed as a function of location, as well as time series of wave height at different locations indicating waves arrival time. Tsunami scenario simulations are being performed by survey centres such as the NOAA Centre for Tsunami Research.

Table 7: Geohazards scenarios; After IGOS Theme report 2004. This table does not depicts subsidence scenarios. Such scenarios exist (for example, geomechanical scenarios in mining areas), and identifying them would allow the establishment of a strategy to better integrate Earth observation data in these models. This could be a task for a next Geohazards Earth Observation requirement process.

4.1.6. Early warning

During the preparedness phase of the disaster management cycle, end users prepare for crisis management, based on the existing information (e.g. hazard maps, risk maps, and scenarios). Furthermore, efficient crisis management policies require some additional inputs that can be provided by real-time *in situ*, airborne or space-based Earth observation systems. Data are integrated to acquire the relevant information for forecasting, for alerts or for response mechanisms in order to reduce the risk of exposure of societies.

ISDR defines early warning as "the provision of timely and effective information, through identifying institutions, that allow individuals exposed to a hazard to take action to avoid or

[71] See the Central United States Earthquake Consortium Six Cities Study using FEMA 's HAZUS software: http://www.cusec.org/Hazus/sixcities/six_cities.htm

reduce their risk and prepare for effective response" [72]. Table 8 attempts to summarise the end users' needs for information for early warning. As an example, according to USGS reports, only about 20 of the 550 historically active volcanoes in the world are monitored adequately. Examples of *in situ* instrumentation for landslide monitoring and tsunami early warning are presented in Figures 3 and 4 respectively

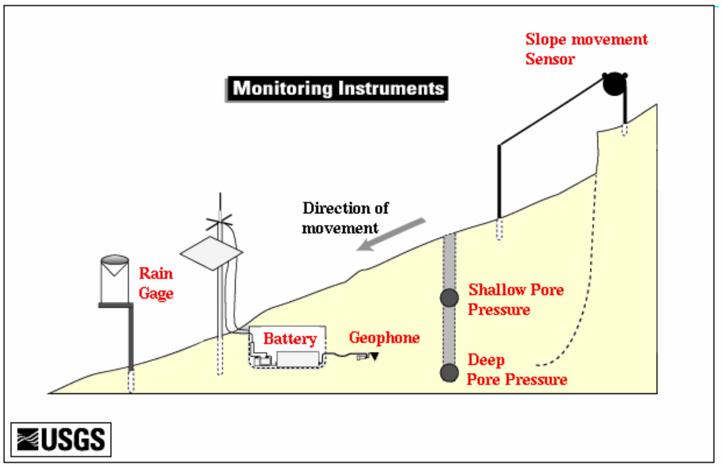

Figure 10: Real time Landslide Monitoring–Landslide Instrumentation[73]

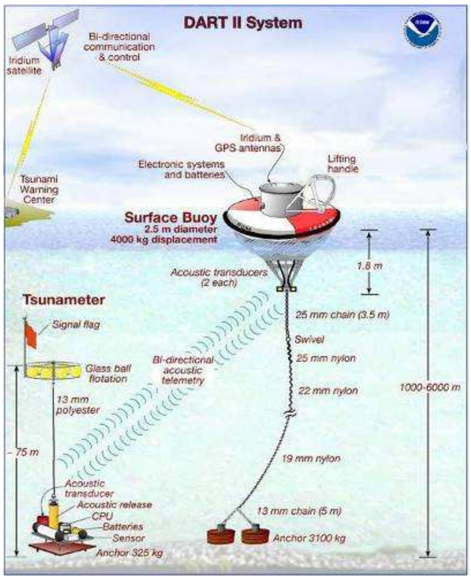

Figure 11: The Deep-ocean Assessment and Reporting of Tsunamis (DART) buoy system is an instrument for the early detection, measurement, and real-time reporting of tsunamis in the open ocean. Developed by the US NOAA Pacific Marine Environmental Laboratory, the DART system consists of a seafloor bottom pressure recording system capable of detecting tsunamis as small as one cm, and a moored surface buoy for real-time communication[74].

---

[72] ISDR 2004 Terminology: basic terms of disaster risk reduction. http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm, International Strategy for Disaster Reduction secretariat, Geneva.

[73] Source USGS Landslide hazard program, http://landslides.usgs.gov/monitoring/hwy50/rtd/

[74] Source NOAA National Data Buoy Center, http://www.ndbc.noaa.gov/dart/dart.shtml

Earthquakes	Volcanoes	Landslides	Tsunamis
Existing early warning systems rely on a measure of the time delay (up to tens of seconds) between arrivals of earthquake's first waveforms and the most destructive ones. This delay is used to shut down critical facilities and to trigger emergency activities[75]. New methods based on the monitoring precursory phenomena, such as foreshocks, ground property changes or on precursory phenomena in the atmosphere[76] remain a research area.	Early warning systems have been set up for hazardous volcanoes such as Etna or Mount St Helens. End users usually require the volcano observatory to provide them with the current activity of the volcano. The level of the threat is represented by a certain alert level. Earthquakes are precursory phenomena of volcanic eruptions. The ground deformation, hydrogeologic changes and the analysis of gas are also used to monitor an eruption.	End users may have access to: - The occurrence of various triggering factors such as regional or local weather and soils conditions or human activity such as mining - Appearance of precursory evidence monitored over hazardous unstable areas such as the rapid increase of ground slide velocity or cracks initiation.	Efficiency of early warning systems for tsunami depends mainly on the distance between the tsunami's triggering factors, generally an earthquake, and the exposed population. The time delay before the waves' arrival can range from a few minutes to ten or more hours. Therefore, close to the source the early warning relies only on the population and authorities' awareness of tsunami potential occurrence immediately after earthquake ground shaking or a brutal sea recession. At distance, implementation of tsunami warning centres such as the Pacific Tsunami Warning Centre is critical in giving alerts on potentially ongoing waves.

Table 8: Geohazards early warning systems; After IGOS Theme report 2004

4.1.7. Response

As soon as a natural disaster occurrs, a crisis response requires a large involvement of end users in charge of damage assessment, and relief operations. Therefore, international and national organizations, government officials, and the potentially affected population must be informed, even partially, by the scientific community and the survey agencies about the damage caused by the disaster and about the level of the threat. Table 9 is an attempt to summarise the needs of end users during the crisis response. In any case, rapid and continuous mapping is necessary for all types of disasters and is addressed by the international charter "Space and Major Disasters"[77] that aims to provide a unified system of space data acquisition and delivery to affected countries.

[75] Refer for example to the USGS Advanced National Seismic System (ANSS) : http://earthquake.usgs.gov/research/monitoring/anss/

[76] DEMETER, Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions, is a scientific mission of CNES, the French Space Agency.

[77] See http://www.disasterscharter.org/main_e.html

	Earthquakes	**Volcanoes**	**Landslides**	**Tsunamis**
Critical needs of end users during crisis response	Critical needs are: -Rapid evaluation of the damage -Location and the magnitude of the event. -Likelihood of induced effects such as tsunami or landslides. -Extent of the fault rupture. -Time frame of the aftershock sequence.	Critical needs are: -Rapid evaluation of the damage -Real-time assessment of the ongoing eruption -Rapid deployment of intensive survey.	Critical needs are: -Rapid evaluation of the damage -Updated maps of the affected areas. -Real-time scenarios of ongoing instabilities.	Critical needs are: -Rapid and overall assessment of the extent of the tsunami disaster -Estimation of loss and damage to structures.
Brief overview of the response mechanism	Immediately after an earthquake some products can be available to end users such as damage assessments models. In densely instrumented areas such as California (USA) shake maps are quickly generated within a couple of minutes after an earthquake. These allow an estimation of the intensity of the ground shaking and the expected damage in the area surrounding earthquake location thanks to the dense and permanent networks of *in situ* instrumentation.	A volcanic crisis is highly variable and can last from hours to years. Volcanic areas therefore must be intensively monitored using different *in situ* and remote instrumentation according to the diversity of the volcanic hazards such as ash clouds monitored by meteorological satellites or lava flows observed with thermal imagery.	Rapid information supply requires important effort to integrate various observations provided with space, aerial and *in situ* instrumentations in order to deliver effective disaster imagery with different resolution and timescale to support disaster reduction relief efforts.	The evaluation of the loss and the extent of damages are performed through *in situ* local reporting where possible but also through space and aerial observations that map the detail of sea shores and overall changes such as soil conditions, topography and damage to structures.
Possibilities to improve the current procedures	Integration of more instrumentation such as geodetic Global Positioning System, strong-motion monitoring systems or satellite radar or optical imagery would improve and complete such near to real time maps with additional information like co-seismic deformation, or structural damage.	Improvement of the volcanic crisis response can be promoted by initiatives such as the USGS Volcanic Disaster Assistance Program a unique mobile volcano-response team that helps to quickly deploy *in situ* portable survey equipment on a developing volcanic crisis and already succeeds in reducing fatalities.	Information and analysis of the disaster requires a global and integrated input of various scientific domains such as meteorology, geotechnics, geophysics or hydrology.	An efficient global monitoring is able not only to provide an extensive imagery of the inundation but also is likely to give insights for more complete understanding of tsunami behaviour, effects and impact on coastal shores.

Table 9: Geohazard crisis response; After IGOS Theme report 2004. It is recognised that the most urgent need is a seemless damage assessment in all cases. However, to improve knowledge on the hazard itself, in situ and space observation are also required.

4.2. GEOHAZARDS DATA REQUIREMENTS

4.2.1. Scope

The previous chapter stressed the need of Earth observation information for geological disaster management.

The most commonly required information and the monitoring tools that allow their monitoring are provided in the tables below for each geological natural hazards that concerns the IGOS Geohazards partnership. In a second paragraph, an attempt to present these requirements together is proposed, in order to enable users to identify how each data can be used for various hazards.

These data requirements are based on the work undertaken under the IGOS theme Report 2004. This work was focused on the observation of the hazard itself, and was not extended to the vulnerability assessment and to the estimation of damage.

With respect to the evaluation of vulnerability, earth observations data can certainly play a major role. However, little literature was found in this field, and it was not possible to assemble a comprehensive and seemless spectrum of requirements on this topic in the 2004-2007 period. In order to improve these observation requirements, it will be necessary to assemble in a holistic way the research currently being undertaken in this field.

With respect to the estimation of damage, it is recognised that remote sensing plays a major role in rapid damage assessment. However, these aspects have been the scope of the International Charter: “Space and Major Disasters”.

Therefore, the most required observations provided bellow do not include observations for vulnerability assessment.

4.2.2. Most required observations for each type of geohazard

a. Volcanic hazard

REQUIRED OBSERVATIONS	BACKGROUND MONITORING/ASSESSMENT	DURING AND AFTER THE CRISIS
Characterise seismicity (magnitude, 3-D location, and type of earthquake) of volcano or group of volcanoes	Individual volcanoes require at least 3-6 seismometers, ideally with 3-directional sensors, to detect and locate earthquakes of magnitude 0.5, with digital data relayed/processed in real time	Repairs as needed and feasible
	Regional network good enough to detect and locate earthquakes of magnitude 2.5, data relayed and processed in real time	Additional stations, deployed near or on the volcano, to detect and locate earthquakes of magnitude 0.5
Characterise deformation of volcanic edifice (horizontal and vertical); monitor changes in gravity; characterise topography; determine location of faults, landslides and ground fractures	EDM and/or permanent GPS network of stations, either continuously transmitting or reoccupied as necessary	Additional GPS stations as needed to capture deformation; more frequent occupation (if data not continuously transmitted)
	Levelling and tilt networks surveyed as needed. Borehole strainmeters (continuous recording). Gravity surveys (1-5 years)	More frequent occupation (if not continuously recorded and transmitted)
	SAR interferometry	Request more frequent tasking plus search data archives for additional possible image pairs
	Map existing geologic structures on volcanoes using high spatial resolution satellite, aerial photography, aerial surveys and geological and geophysical ground surveys as needed.	Request repeat overflights to check for new cracks; possibly install strainmeters across selected cracks
Characterise gas and ash emissions of volcanoes by species (SO_2, CO_2) and flux (tons per day)	COSPEC, LICOR surveys at regular intervals (weekly, monthly or annually).	More frequent surveys, perhaps using small aircraft if plume not accessible by road
	Routine checks through appropriate satellite imagery. (LEO and GEO)	Additional requests tasking for higher-resolution data, check archives for usable Imagery
Characterise and monitor thermal features of volcanoes (their nature, location, temperature and possibly heat flux)	Map and monitor hot springs, fumaroles, summit craters, crater lakes, and fissure systems for temperature variations using ground-based instruments and high spatial resolution satellite data.	More frequent observations, including visible and IR photography and pyrometry as appropriate
	Systematic acquisition and analysis of imagery from airborne digital IR cameras, moderate resolution to higher-resolution resolution satellite imagery for thermal background and thermal flux.	More frequent overflights with digital IR camera; additional requests tasking for higher resolution satellite data, check archives for time series of thermal data
Characterise eruptive style and eruptive history of volcanoes	Characterise, map and date all young eruptive deposits of the volcano	Observe eruption columns, plumes and surface deposits (using overflights with visible and IR photography, video). Monitor their motions (speed, direction, areas covered and threatened), character, and thickness. Update maps

Table 10: Volcanic hazard observations most commonly required and the best available observational system. (After IGOS Theme report 2004). This table only includes data needed for hazards observations. The assessment of damage through remote sensing means falls within the scope of the International Charter "Space and Major Disasters". However, due to the lack of holistic scientific litterature in this field the data requirements for the assessment of vulnerability could not be presented in this users requirement table.

b. Earthquake hazard

REQUIRED OBSERVATIONS	BACKGROUND MONITORING/ASSESSMENT	DURING AND AFTER THE CRISIS
Characterise seismicity of seismically active region (magnitude, 3-D location, and type of earthquake)	Global monitoring network including ocean bottom seismometers able to characterise earthquakes of magnitude 3.5 with data relayed and processed in real time	Network is being put in place, developed to verify the Comprehensive Test Ban Treaty
	Regional network of strong-motion detectors, capable of surviving ground motions	If none deployed, add stations afterwards to capture aftershock sequence
Characterise baseline topography and ongoing deformation of region (horizontal and vertical)	EDM and/or permanent GPS network of stations, either continuously transmitting or reoccupied as necessary	Additional GPS stations as needed to capture post-earthquake deformation; more frequent occupation (if data not continuously transmitted)
	Borehole strainmeters (continuous recording) Strainmeters on critical structures such as dams, bridges, etc	More frequent occupation (if not continuously recorded and transmitted); additional strainmeters on critical structures to monitor their structural integrity during aftershock sequence
	SAR interferometry	Request more frequent satellite tasking plus search archives for additional possible image pairs
Characterise thermal signature of region	Obtain and process time series of low/medium resolution IR imagery from polar and geostationary satellites for thermal background characterisation	Evaluate time series for possible thermal anomalies
Determine location of faults, landslides and ground fractures. Characterise historical seismicity and palaeo-seismicity of a region	Map existing structures in the region using high spatial resolution satellite and airborne imagery, aerial photography and geological and geophysical ground surveys. Study and date features that provide evidence for major previous earthquakes	Request over-flights to check extent of ground breaking and offset, for new cracks, landslides, patterns of liquefaction and building collapse, etc

Table 11: Earthquake hazard observations most commonly required and the best available observational systems (After IGOS Theme report 2004) This table only includes data needed for hazards observations. The assessment of damage through remote sensing means falls within the scope of the Interational Charter "Space and Major Disasters". However, due to the lack of holistic scientific litterature in this field the data requirements for the assessment of vulnerability could not be presented in this users requirement table.

c. Landslide hazard

REQUIRED OBSERVATIONS	BACKGROUND MONITORING/ASSESSMENT	DURING AND AFTER THE CRISIS
Characterise deformation with high accuracy and frequency (horizontal and vertical)	GPS network of stations continuously transmitting or reoccupied as necessary	Additional GPS stations as needed to capture deformation. More frequent occupation (if data not continuously transmitted)
	Satellite, airborne and ground-based SAR interferometry at various wavelengths. Frequency depending on the type of ground instability (1 month to 1 year)	Request more frequent satellite tasking plus search archives for additional possible image pairs
	Other surveys e.g. levelling, laser scanning (terrestrial and airborne), aerial photography and high-resolution stereo satellite data, borehole inclinometers. Frequency depending on the type of ground instability (1 month to 1 year)	More frequent occupation of all ground-based instrumentation (if data not continuously recorded and transmitted)
Map landslides, geomorphology, land-use, land cover, geology, structures, drainage network	Map existing landslides, depositional/erosional processes, geologic structures, landuse and land cover using high spatial resolution satellite and airborne imagery, aerial photography and geological and geophysical ground surveys	Request over-flights to check extent and distribution of landslides
Topography/elevation (incl. slope angle, slope length, slope position)	High quality DEM from LiDAR, photogrammetry or high-resolution satellites	Rapid local update needed of how the landscape has changed
Soil strength parameters and physical properties (incl. pore water pressures)	Regularly updated when necessary. Geotechnical field logging and sampling, *in situ* and laboratory tests to determine specific site conditions and engineering parameters Variation of pore water pressure is monitored by piezometers over time	Request more frequent observations and if possible continuous recording of soil moisture
Triggering precipitation, (rainfall, snow, magnitude, intensity, duration), temperature	Meteorological data field measurements. Meteorological satellite data	Continuous recording
Earthquake triggering (intensity, duration, peak acceleration, decay of shaking level with source distance (source, propagation shaking and site effects))	Accelerometer network monitoring. (Frequency: continuous or reoccupied as necessary) Models (Pseudo-static stability, Dynamic instability…)	Continuous recording

Table 12: Ground instability hazard observations most commonly required and the best available observational systems (After IGOS Theme report 2004) This table only includes data needed for hazards observations. The assessment of damage through remote sensing means falls within the scope of the Interational Charter "Space and Major Disasters". However, due to the lack of holistic scientific litterature in this field the data requirements for the assessment of vulnerability could not be presented in this users requirement table.

d. Tsunami hazard

REQUIRED OBSERVATIONS	**BACKGROUND MONITORING/ASSESSMENT**	**DURING AND AFTER THE CRISIS**
Characterise seismicity of tsunami prone region (magnitude, location, and type of earthquake)	Global monitoring network able to characterise earthquakes with data relayed and processed in real time to make possible alerts and early warning.	Permanent networks to ensure aftershocks survey and possible tsunami alerts
	Broadband ocean bottom seismometer networks to complete seismological survey networks	
Ensure early detection of tsunamis and acquire data critical to real-time forecasts	Tsunami waves survey according to sea level height observations with deployment of buoys networks in all the oceans such as Deep-ocean Assessment and Reporting of Tsunamis (DART) stations in Pacific.	Develop extensive buoy networks within all oceans and seas prone to tsunamis for permanent survey
Determine location of faults, landslides or volcano edifices likely to trigger tsunamis	Map existing structures in the region using high spatial resolution satellite and airborne imagery, aerial photography, geological and geophysical surveys. Study and date features that provide evidence for previous historical tsunamis.	Request over-flights and permanent *in situ* survey to check extent of ground breaking and offset, for new cracks, landslides, etc..
Determine coastal areas exposed to tsunami waves	Extensive topographic mapping of coastal areas using high spatial resolution satellite, airborne imagery, aerial photography, radar altimetry and *in situ* monitoring (levelling, GPS)	Request over-flights and additional satellite tasking to monitor extent of tsunami damage

Table 13: Tsunami hazard observations most required and the best available observational systems. This table only includes data needed for hazards observations. The assessment of damage through remote sensing means falls within the scope of the Interational Charter “Space and Major Disasters”. However, due to the lack of holistic scientific litterature in this field the data requirements for the assessment of vulnerability could not be presented in this users requirement table.

4.2.3. Integrated approach

IGOS Geohazards seeks an approach to assess the feasibility of integrating the primary users' requirements into a multi-hazards observation system, in order to ensure interoperability of data, an easier access to observations, and a reduction of data acquisition costs. Improvement of observation system capacities are critical to support mitigation of geohazards and to provide relevant information to private sector users, operational state organizations and public authorities. For instance, the Committee on Earth Observation Satellites (CEOS) supports the idea of new observation systems made of a constellation of satellites that could be dedicated to specific needs such as geohazards. As another example based on a "system of systems" approach, the International Charter "Space and Major Disasters", is already in place for enhanced crisis response. However, new developments are necessary to move toward operational services. To achieve this, the primary users (research scientists, survey agencies and service providers) have to closely interact with data providers in order to address their engineering requirements in terms of observation needs and technical issues.

One of the main challenges of an integrated global system is to identify and promote the more relevant observation systems that firstly, provide relevant data in order to inform and improve ground models and secondly, ensure a better monitoring of geohazards. The integrated approach must include a geological framework (usually GIS), attributed, where possible, with hazard and geotechnical information. Within this geological framework, links between ground-based and remote instrumentation must be established, to ensure that the monitoring systems are feeding into a ground model, providing focussed and relevant information. Table 10 is an attempt to present an integrated multi-hazards approach and the existing key systems as well as their use at each phase of a disaster cycle. The most commonly required observations are:

- The topography and the active ground deformation monitoring of seismically active areas, of the volcanoes shapes, of the landslide prone areas, and of the morphology of coastal shores, continents or sea beds.
- The geological monitoring, which is critical to identify and to characterise the type, the activity or the level of threat of earthquakes, volcanoes or landslides and additionally provide a permanent survey on triggered, induced or ongoing hazards.
- The meteorological observations presenting critical issues for scientists to infer climatic triggering factors for ground instabilities, to assess the threats of a volcano through ash clouds or lahars or to provide early warnings on tsunami waves.

In addition, new observation data and demonstrator systems, whose efficiency is still under assessment, have been included in the table.

Most Required Instrumentation			Pre-Emergency Hazard maps and Disaster Scenarios	Emergency Forecasting / Early Warning Systems	Crisis Response Disaster Response
Topography	In situ	Levelling	Inventories, base maps and Digital Elevation Models: -Geometric properties of faults and volcanic areas -Assessment of sea shorelines and landslide prone areas		-Rapid Mapping and inventories of affected areas for damage assessment - DEM and measurement of the permanent ground deformation such as shorelines and volcanoes edifices.
		GPS stations			
	Remote	High Resolution Optical Stereo Imagery			
		Radar Altimeter			
Active Deformation Monitoring	In situ	Inclinometer /Tiltmeter arrays	- Inventories and hazard surveys with updated deformation maps: Active faults, landslide areas or volcanic edifices - Archive data acquisition	- Real time deformation maps for precursory events and ongoing hazards such as landslides -Warning for cascading effects such as lahars.	- Post disaster monitoring such as induced landslides - Real time survey on continuous hazards such as volcanic eruptions - DEM and measurements of the permanent ground deformation - Characterisation of the event size - Damage assessment
		Extensometer arrays			
		Temporary or Permanent GPS Network			
		Strain Meter Networks			
	Remote	Very Long Baseline Interferometry & Satellite Laser Ranging			
		Differential Interferometric SAR or Persistent Scatterers Interferometry (Band L,C)			
		High resolution imagery (image correlation)			
Geological Classification and Surveys	In situ	Fieldwork	- Hazard zonation maps - Hazard assessment - Continuous monitoring of geological, geophysical or geochemical parameters - Characterisation of geological, environmental background with determination of type, size and recurrence intervals over different time scales - Archive data acquisition	- Real time monitoring of geological, geophysical and geochemical parameters - Warning for precursory events, triggering factors, ongoing hazards and induced effects such as tsunami	- Post disaster monitoring such as aftershocks survey - Real time survey on continuous hazards such as volcanic eruption -Characterisation of the event size and type - Damage assessment
		Hydrologic monitoring systems			
		Continuous gas monitoring			
		Piezometer arrays			
		Shallow Boreholes			
		High Resolution Optical Imagery			
		Broadband Worldwide Seismometer Permanent Networks			
		Ocean Bottom Seismometer Temporary Networks			
		Short Period Regional Permanent Networks			
		Really Short Period Regional or Local Seismometer Networks			
		Local Temporary Portable Seismometer Arrays			
	Remote	High Resolution Optical Imagery			
		Hyperspectral Imagery			
		Synthetic Aperture Radar			
New Observation Data	In situ	Experiments on Active Faults (boreholes)	- Characterisation of geological, geophysical, geochemical parameters related to hazard occurrence	- Research on relevant triggering factors or precursory evidences	- Characterisation of geological, geophysical, geochemical parameters related to hazard occurrence
	Remote	Global Strain Fields Measurements			
		Earth's Gravitational Field Measurements			
		Infra-Red Imagery			
		Earth's Electromagnetic Field Measurement			
Meteorological monitoring	In situ	Meteorological stations	- Continuous monitoring of geophysical or geochemical parameters - Characterisation of triggering factors such as weather conditions for landslides or volcanic eruptions	- Real time monitoring of geophysical and geochemical parameters - Warning for precursory events, triggering factors, ongoing hazards and induced effects such as tsunami	- Post disaster survey on induced or cascading effects such as volcanic ash clouds
		Deep-ocean assessment and reporting Tsunamis "DART" Buoys			
		Sea Level Gauges			
	Remote	Radar or Optical Meteorological Imagery			

Table 14: Requirements of the primary user (research scientists, survey agencies and service providers) during disaster phases. In the table, the in-situ *relies on ground based instrumentation. Remote relies on space and aerial instrumentation.*

4.3. CONCLUSIONS

Because a really wide range of scientific expertise is necessary to provide end users with proper information during each step of a disaster management cycle, a common and global capacity building intiative should and must be implemented. As an example, the potential benefits of coupling earthquake survey monitoring facilities with the tsunamis warning centres are obvious. Consequently, a multi-hazards approach is required to allow the integration of an increasing number of observations, data, and instrumentation that could in return improve the knowledge, the observation and the instrumentation dedicated to one single hazard.

The concern of IGOS Geohazards is to support the establishment of reliable Earth observation services for the benefit of populations exposed to geohazards. This implies breakthroughs in Earth observation science and techniques, but also that the information routinely provided to end users and decision-makers are unambiguous and well understood.

It is proposed to undertake the following:

- In order to ensure that Earth observation services are properly integrated into risk management, multi-risks approach should be progressively adopted.

- Identify how Earth observation can be used for identification of exposed elements and for vulnerability assessment and stimulate projects on this topic.

- Support the emergence of an efficient process to collect user requirements within GEO

5. FILLING THE EARTH OBSERVATION GAPS

This chapter assesses the current provision of observations against the requirements in these areas. As IGOS Geohazards members also contributed to the GEO work plan, most of these gaps are also addressed by existing GEO tasks (Tables 16 and 17). This chapter shows how synergies between GEO and IGOS Geohazards provide a benefit for this gap filling.

5.1. INFORMATION NEEDS AND EXISTING INITIATIVES

The gaps in information systems and the synergies with other initiatives are analysed here.

5.1.1. Pre-disaster phases

A critical gap that has been identified by IGOS Geohazards is the need for information on pre-disaster phases, i.e. hazards, vulnerability, risk maps and scenarios.

Architecture and data inventory system

In order to facilitate the diffusion of hazard maps in a first step, and to progressively move toward harmonisation, IGOS Geohazards produced a proof of concept system (GeoHazData), in 2005. As part as the IGOS strategy for 2007-2010, an updated programme must be defined to move toward an operational system and to stimulate the insertion of content in this system. This is addressed through GEO task DI-06-07, “Multi-hazards Zonation and Maps”, which is led by IGOS Partnership and the World Meteorological Organisation (WMO). This task aims at conducting an inventory of existing geologic and multi-hazards zonation maps, identify gaps and needs for digitisation and progressively develop related products. It will include reference geographic products as the basis for production of hazard maps.

Multi-hazards approach

The multi-hazards approach is addressed through the GEO task DI-06-08 “Multi-hazards Approach Definition and Progressive Implementation” in which IGOS Geohazards participates.

5.1.2. Crisis management

The need for forecasting and for early warning systems is addressed through various initiatives and GEO tasks. WOVOdat will be a system to share information and data on volcanoes. The International Oceanographic Commission (IOC)[78] and UNOSAT[79] coordinate a GEO task for the

[78] The IOC is a commission of UNESCO and assists governments to address their individual and collective oceans and coastal problems through the sharing of knowledge, information and technology and through the coordination of national programs. Web site: http://ioc.unesco.org/

[79] UNOSAT is a United Nations programme created to provide the international community and developing countries with enhanced access to satellite imagery and Geographic Information System (GIS) services. These tools are used mainly in humanitarian relief, disaster prevention and post crisis reconstruction.

implementation of a tsunami early warning system at global level. The GMES programme contributes to risk management with mapping and forecasting services[80].

5.1.3. Post-disaster phases

The post-disaster phases are addressed by a number of organisations and programmes. As examples, the volcanic disaster assistance programme of USGS and the GMES support services in response, recovery and development after disaster.

Task	Task title	Leaders	Description
DI-06-07	Multi-hazards Zonation and Maps	IGOS-P and WMO	To conduct an inventory of existing geologic and multi-hazards zonation maps, identify gaps and needs for digitisation and progressively develop related products. It will include reference geographic products as the basis for production of hazard maps.
DI-06-08	Multi-hazards Approach Definition and Progressive Implementation	IGOS-P and WMO	Promote the cooperation of national and international agencies towards the definition and implementation of a multi-hazards approach to systematically address all risks. The task supports ISDR in the implementation of the Hyogo framework for action and includes, as an important complement to the on-going programs on the implementation of a Tsunami Early Warning System. A pilot project on the implementation of a risk management system for geohazards in the South East Asian Region being undertaken. This project will be constructed in coordination and in support of existing organisations and projects (such as ASEAN, APEC and Sentinel Asia), with the participation of the community of practice rather active in the area. The task will include links with relevant international research programs, such as the one being launched by ICSU.
DI-06-04	Implementation of a Tsunami Early Warning System at Global Level	IOC and UNOSAT	Support the IOC implementation plan, through: (i) promotion and facilitation of free and unrestricted exchange of all Earth observation data relevant to Tsunami Early Warning Systems (ii) contribution in terms of GEO developed operational capabilities, and (iii) definition and implementation of standards.

Table 15: GEO tasks in support of filling the Geohazards information needs. IGOS Geohazards or its stakeholders participate in all these tasks

[80] Cf. to notice 60. Web site: http://www.gmes.info/

5.2. OBSERVATIONS, KEY SYSTEMS AND EXISTING COORDINATION MECHANISMS

The needs of information and key systems is analysed here. The synergies with existing programmes, especially GEO tasks, are mentioned.

5.2.1. Integration of data

There is still a need to facilitate the access to the data themselves, which is identified as a second phase of GeoHazData, to be performed in 2007-2010. In order to do this, it is proposed to focus on sensors-based architecture.

5.2.2. Topography and active deformation monitoring

A gap which has been clearly identified in this area is the need to facilitate the integration of in situ and InSAR or advanced InSAR data. This is addressed through the task DI-06-03 "Integration of InSAR Technology".

5.2.3. Geological classification and surveys

The coordination and the improvement of seismographic networks are addressed through GEO task DI-06-02 "Seismographic Networks Improvement and Coordination", led by GSN, FDSN and the USA. This task aims at facilitating and improving current capabilities of global seismographic networks such as GSN, FDSN, DAPHNE[81], the GNSS navigation networks and new ocean bottom networks such as VENUS and NEPTUNE[82] and sharing of data and event products among GEO members. In addition, a task dedicated to the integration of satellite data into risk management procedures has been approved (DI-06-09).

---

[81] Acronyms for Deployment of Asia-Pacific Hazard-mitigation Network for Earthquakes and volcanoes Project. Web site: http://www.daphne.bosai.go.jp/

[82] VENUS and NEPTUNE are cable linked seafloor laboratories projects for Ocean bottom exploration. Web sites: http://www.venus.uvic.ca/ and http://www.neptunecanada.com/network/index.html

Task	Task title	Leaders	Description
DI-06-03	Integration of InSAR Technology	IGOS-P and Greece	Support the improved integration of InSAR (Interferometric Synthetic Aperture Radar) technology for disaster warning and prediction. The task will also address the integration of GNSS and InSAR.
DI-06-02	Seismographic Networks Improvement and Coordination	GSN, FSDN and the USA.	Facilitate improvement of capabilities for global seismographic networks such as GSN, FDSN, DAPHNE, GNSS networks and new ocean bottom networks such as VENUS and NEPTUNE and sharing of data and event products among GEO members.
DI-06-09	Use of Satellites for Risk Management	Canada, China and UNOOSA	With reference to a multi-hazards approach, define and facilitate implementation of a virtual constellation for risk management

Table 16: GEO tasks in support of filling Geohazards data needs. IGOS Geohazards or its stakeholders participate in all these tasks.

5.3. IGOS GEOHAZARDS CONTRIBUTION TO FILLING THE GAPS IN 2007-2010

This user requirement process allowed the identifcation of gaps in the current systems. Many of these gaps are tackled by various initiatives and GEO tasks. The GEOSS 10 year Implementation Plan is the reference document, and contains a certain number of tasks to which IGOS Geohazards members such as JAXA, NASA, CNES, ESA and FDSN contribute. This includes:

- An extensive deployment and continuous recordings of space and ground-based instrumentation. This includes
    - the deployment of seismological digital broadband networks, under the coordination of FDSN
    - the long-term, precise monitoring of the geodetic observables, under the leadership of GGOS, is also a priority
    - the development of the GNSS (Global Navigation Satellite System)
    - the public release of high resolution digital elevation model such as SRTM 30 is needed.
- Space and airborne instrumentation with high temporal and spatial resolution to efficiently complement the *in situ* observation systems or replace them in poorly-equipped areas. Among others, the Interferometric Synthetic Aperture Radar techniques,

especially L band[83], and the high resolution imagery play a major role in the hazard assessment, global survey and rapid disaster responses.

- Standards in inventories proposed in the GEO architechture committee should be implemented to perform geohazards data inventories. In this perspective, the WOVOdat project to build a worldwide volcanic unrest database should be supported.

- Future and ongoing progress that rely also on new relevant scientific instrumentation in the electromagnetic, thermal, or gravitational domains that benefit from the advances in space technologies and will document, infer or find out possible precursors to earthquakes, or volcanic eruptions.

IGOS Geohazards and its member organisations will further be involved in the corresponding GEO tasks in 2007-2010.

In order to move toward a better geohazards data and information architecture, the IGOS Geohazards Bureau developed the GeoHazData hazard maps demonstrator and proposes to progressively move toward operational applications. In addition to this, the development a new GeoHazData sensor component should be considered.

[83] The ALOS system provides geohazards experts with L band SAR data since late 2006.

IGOS Geohazards strategy 2007-2010

5.4. INTRODUCTION

The objective of the IGOS Geohazards initiative is to respond to the societal, scientific and operational geospatial information needs for the prediction and monitoring of geohazards, namely earthquakes, volcanoes, tsunamis and land instability. The multi-hazards/risks approach has been justified in previous chapters[84]. This very broad challenge has been divided into two projects[85]:

- GeoHazData, which aims at building a system of systems to help the access to geohazards data

- GeoHazNet, which corresponds to community building activities

This chapter is a strategy for IGOS Geohazards for the period 2007-2010. It provides a contextual and internal analysis, then goes on to describe strengths and weaknesses and finally establish objectives, a policy, an action plan and success criteria.

5.5. CONTEXTUAL ANALYSIS

This contextual analysis aims at identifying opportunities and threats of the environment in which IGOS Geohazards works.

5.5.1. Opportunities

The following opportunities have been identified:

- **Support of International organisations:** the support of international initiatives, mainly GEO[86], and also organisations from the UN system[87] helps IGOS Geohazards to promote its approach at the international level. In addition, it provides a leveraging effect as most of the objectives of IGOS Geohazards are also objectives of GEO. The opportunity for IGOS

---

[84] It corresponds to a user need and it allows costs reduction of data exchange and observations.

[85] IGOS Geohazards mid term report, 2004

[86] GEO offers the opportunity to promote Earth observations and architecture requirements specific to geohazards. One of the added values of GEO is its very broad spectrum, which allows the bringing together of communities concerned with all aspects of Earth Observation coordination: data and architecture, user interface, capacity building and science.

[87] UNESCO chairs IGOS Geohazards. In addition, the UN SPIDER programme focuses on Space Information provision for disaster management. This programme is supported by the UN, and in particular by the German and Chinese governments, who support the initiative with local offices. The added value of SPIDER is its focus on spaceborne data, and a workplan is available and will be progressively updated. The SPIDER programme interacts with GEO. Finally, WMO is concerned with Earth observations for meteorological disaster management. There are strong possibilities of cooperation with geohazards.

Geohazards exists through the interface between GEO and other international organisations on the one side, and the geohazards communities on the other.[88]

- **Increasing societal need for homogenised information on hazards and risks:** the populations exposed to geohazards and authorities require information about the threat, how to prevent disasters, prepare for them and manage the crisis. This is an opportunity for IGOS Geohazards, which aims at responding to this need.
- **Increasing authorities attention to sustainable land-use:** authorities and decision makers often need scientific assistance in developing land-use practices. In order to do this efficiently, the land-use practices that help reduce geodisasters need to be supported at all levels: local, national, regional and international. This is an opportunity for IGOS Geohazards, which aims at responding to this need.

5.5.2. Threats

The following threats have been identified:

- **Lack of political interest:** There is sometimes a lack of political interest of decision makers on geodisasters. As an example, meteorological hazards are often considered as more critical because of their probable link with climate change. This approach is false for two reasons. Firstly, the vulnerability to geohazards has greatly increased in the last century due to land-use changes. In addition, no coordination mechanism exists for geohazards, while the meteorological community benefits from very efficient coordination mechanisms through WMO. Nevertheless, this constitutes a threat for IGOS Geohazards.
- **Lack of political awareness:** In many regions where the recurrence of geohazards is low, there is a lack of awareness on the threat by exposed populations and local. This can account for a higher societal and physical vulnerability to geohazards. One of the challenges for IGOS Geohazards would be to raise awareness in these regions.
- **A very disperse geohazards Community:** A role for IGOS Geohazards will be to act as an interface between the diverse geohazards community.

[88] More precisely, GEO works with expert communities. The "Community of Practice" for geohazards is being represented by IGOS Geohazards.

ANALYSIS OF STRENGTHS AND WEAKNESSES OF IGOS GEOHAZARDS

The strengths and weaknesses of IGOS Geohazards are aspects internal to the group involved in the Joint Committee.

5.5.3. Strengths

The major strength of IGOS Geohazards is, in fact, its members. They are:

- **<u>A representative group of multi-disciplinary organisations concerned with geohazards observations[89]:</u>** The major strength of IGOS Geohazards is to bring together 3 major communities concerned with geohazards observations, but with different objectives, interests, and priorities:
  - Space Agencies, which are major data providers
  - Geological Surveys, which are involved at all steps of data and information flow (from in situ monitoring and data assimilation into models to scientific advisory to local authorities and exposed populations)
  - Scientific organisations that are representative for the large variety of scientific fields concerned with geohazards, such as GGOS, ICL, FDSN, or WOVO

  The need to strengthen this cooperation has been stressed in Chapter 2. This success is the result of continuous efforts of IGOS Geohazards members since 2002 and of the bureau since 2005.

- **<u>A management level group:</u>** The second strength of IGOS Geohazards is to be a group of management level representatives. This has several advantages. Firstly, IGOS Geohazards members have a very broad knowledge of geohazards in their countries, of their communities liaising with other relevant initiatives (projects, programmes….). They are therefore able to share this broad experience. Secondly, the members are also able to translate ideas into practice within their own organisations. At last, members can influence their communities, promote the IGOS Geohazards strategy and implement it.

- **<u>An ability to bring together the Geohazards communities:</u>** The third strength of IGOS Geohazards is its ability to organise regular international geohazards workshops that are useful to stimulate exchanges between the communities. The wide distribution of the IGOS Geohazards Newsletter is also an aspect of this strength.

5.5.4. Weaknesses

The weaknesses of IGOS Geohazards are mainly consequences of the limited work capacity due to limited financial resources and the heterogeneity of the communities involved in the Joint

[89] It should be reminded that there are coordinated, international bodies representing engineering geology and related disciplines which need to be consulted in addition to Geological Surveys such as the International Association of Engineering Geologists.

Committee:

- **<u>Limited coordination capacity:</u>** IGOS Geohazards is formed of an Executive Bureau accounting for one person per year in charge of the animation of the initiative. The Executive Bureau is complemented by the GARS[90] Secretariat that provides a useful support for the organisation of the steering committees. At last, the IGOS Geohazards governing structure formed by the Joint Committee regroups members that have high responsibilities within their own organisations and consequently little time dedicated to IGOS geohazards actions.

- **<u>Limited capacity and support to implement actions:</u>** Consequently, IGOS Geohazards has a limited capacity to manage specific projects, as the Joint Committee meets only twice a year and as the work capacity is limited.

- **<u>Divergent interests:</u>** Members of IGOS Geohazards have sometimes divergent interests. Some members, for example, are more focused on prevention measures while other focus on disaster response.

5.6. SWOT ANALYSIS

The strengths and weaknesses, the opportunities and threats, are inserted into a SWOT matrix that helps define objectives and strategies. The Table 17 gives a theoretical approach of what can be inferred from a SWOT matrix. Table 18 applies this approach to foster a strategy for IGOS Geohazards.

<table>
<tr><th colspan="2" rowspan="2">SWOT-analysis</th><th colspan="2">Internal analysis</th></tr>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td rowspan="2">External Analysis</td><td>Opportunities</td><td>S-O-Strategies:
Develop new methods which are suitable to the strengths.</td><td>W-O-Strategies:
Eliminate weaknesses to enable new opportunities.</td></tr>
<tr><td>Threats</td><td>S-T-Strategies:
Use strengths to defend threats.</td><td>W-T-Strategies:
Develop strategies to avoid weaknesses that could be targeted by threats.</td></tr>
</table>

Table 17: Standard SWOT matrix

[90] Geological Applications of Remote Sensing, an IUGS/UNESCO joint programme funded in 1984 with the aim to assess the value of remotely sensed data for geological research and to enable institutes of developing countries to participate in the use of modern technology for their own research.

<table>
<tr><th colspan="3" rowspan="3">SWOT-analysis</th><th colspan="5">Internal analysis</th></tr>
<tr><th colspan="3">Strengths</th><th colspan="2">Weaknesses</th></tr>
<tr><th>A representative group</th><th>A management level group</th><th>An ability to bring together the geohazards communities</th><th>Limited coordination-work capacity</th><th>Limited capacity to manage projects</th></tr>
<tr><td rowspan="5">External Analysis</td><td rowspan="3">Opportunities</td><td>Support of international organisations (GEO, UN)</td><td>Possibility to coordinate when representing IGOS Geohazards toward GEO and possibly the UN Spider programme.</td><td></td><td>Possibility to act as an interface between GEO and the largest geohazards communities</td><td>Need to avoid duplication of work with these international organisations</td><td rowspan="3">Need to avoid duplication of projects with these international organisations and to focus on the added value that IGOS Geohazards can bring</td></tr>
<tr><td>Increasing societal need for information</td><td>Potential ability to produce consensus papers on response to this societal need.</td><td>Potential ability to translate these societal needs into coordinated projects within the IGOS Geohazards members organisations (GeoHazData)</td><td>Potential ability to collect information on the societal needs for information in the larger community.</td><td rowspan="2">Need, when possible, to distribute the work among the partners.</td></tr>
<tr><td>Increasing attention for sustainable land-use</td><td>Potential ability to produce consensus papers on expected benefits of scientific advisory at all phases of disaster management.</td><td>Potential ability to translate this authorities needs into members organisations (GeoHazData)</td><td>Potential ability to collect information on the benefits of mitigation policies in the largerr community.</td></tr>
<tr><td rowspan="2">Threats</td><td>Lack of political interest in geohazards</td><td>Possibility to increase this interest through the promotion of consensus strategies to reduce disasters</td><td rowspan="2">Ability to reach decision makers</td><td rowspan="2">Potential ability to bring together decision makers and the wider geohazards community together</td><td rowspan="2" colspan="2">Prepare a new governance for the IGOS Geohazards initiative</td></tr>
<tr><td>Lack of political awareness of geohazards threats</td><td>Possibility to increase this awareness through the promotion of consensus views on the benefits of scientific advisory at all phases of disaster management strategies</td></tr>
</table>

Table 18: SWOT analysis for the IGOS Geohazards

5.7. OBJECTIVES FOR IGOS GEOHAZARDS

5.7.1. Methods building on the strengths

Table 19 helps to define objectives. The most realistic and easily achievable objectives are Strength-Opportunity strategies. These strategies consist of the following objectives:

- GeoHazData: IGOS Geohazards members have the capability to make a wide inventory of their data. Geological surveys such as USGS, BGS and BRGM participate in IGOS Geohazards and are likely to provide to a huge amount of data, whose inventory can be done through GeoHazData or any other OGC[91]-compliant system.
- GeoHazNet: IGOS Geohazards has a recognised capability to contribute to community building activities through the regular organisation of the international geohazards workshops. It can build on these workshops and promote their outcome. In addition, IGOS Geohazards could serve as a platform to promote and support awareness of key international projects such as Globvolcano[92].
- Coordination within the Joint Committee: IGOS Geohazards has the ability to share the invaluable experience and knowledge within the IGOS Geohazards group: as examples, specific sessions could be organised at the IGOS Geohazards Joint Committee to share knowledge and experience on: (1) the benefits of scientific advisory to decision making at all steps of disaster management and (2) how Earth observation information can reduce geodisasters.
- Coordination toward other international organisations: IGOS Geohazards has the ability to efficiently coordinate its contributions to GEO and possibly the UN SPIDER programme.

5.7.2. Eliminate weaknesses and to enable new opportunities

The Weaknesses-Opportunities part of the matrix indicates strategies that IGOS Geohazards should develop a new structure in order to eliminate weaknesses and to enable new opportunities:

- Sharing coordination tasks throughout the partners: the limited work capabilities implies finding out innovative working methods, for example through the sharing of coordination tasks with members of the Joint Committee as this has been done with the GARS Secretariat. It also implies to focus on the IGOS Geohazards tasks to avoid duplications, e.g. GEO work to build the Global Earth Observations System of System.
- Increasing exchange of knowledge within the IGOS Geohazards Joint Committee in order to sustain and strengthen this unique international transdisciplinary group

[91] OGC stands for Open Geospatial Consortium www.opengeospatial.org

[92] The GlobVolcano Project will provide satellite monitoring in support to early warning of volcanic risk. Web site: http://www.globvolcano.org/

5.7.3. Use strengths to defend threats

The Strengths-Threats part of the matrix indicates strategies that IGOS Geohazards should develop, in order to use strengths to defend threats:

- Use and promote IGOS Geohazards: IGOS Geohazards has been promoted as a coordination mechanism in the geohazards community in the past years. Its ability to provide synthetic information is outlined by the previous reports and newsletters.
- GeoHazNet: the workshops and newsletters can be used to stimulate exchange within the geohazards community.
- Raising political awareness: the potential ability to bring together politicians and the wider geohazards community as high level managers participate on the IGOS Geohazards Joint Committee

5.7.4. A new governance for IGOS Geohazards

Finally, Threats-Weaknesses part of the matrix indicates strategies that IGOS Geohazards should develop, in order to avoid weaknesses that could be targeted by threats. The response to this is to prepare a new governance for IGOS Geohazards.

Up to 2010, the Bureau will be co-funded by ESA and BRGM. After 2010, there will be a need to continue to operate and develop GeoHazData, to organise an International Geohazards Workshop every 2 years, and to support the IGOS Geohazards Joint Committee for its projects and administrative matters.

Three options are proposed:

- A bureau funded by one or more organisations participating in IGOS Geohazards. The Bureau will have no legal entity. This will be exactly the same situation as present.
- An association of French law also called “Secretariat”. Members of this association elect a President and a Bureau every year. A funding is assumed to be contributions by members. It is possible to provide support to the association “in-kind” (office, computer…) and as work force (Head of the secretariat, information system manager (GeoHazData), workshop organisation manager).
- An office within an international organisation such as UNESCO

5.8. ACTION PLAN

An action plan is inferred from these objectives. It should be underlined that this workplan reflect a very synthetic view of the actions planned. As an example, GeoHazData development is here referred as a single line whereas this requires many inputs from the IGOS Geohazards members and the very active work of the Bureau.

<table>
<tr><th></th><th>Present status</th><th>Objective in 3 years</th><th>2007-2008 objectives</th><th>2009-2010 objectives</th><th>Importance</th><th>Difficulty</th><th>Relevance</th></tr>
<tr><td rowspan="2">GeoHazData</td><td>A demonstrator of hazard maps inventory is available</td><td>Perform an inventory of data available throughout the partners</td><td>IGOS Geohazards Steering Committee to share information on their databases</td><td>2007-2008: Bureau to link these databases to GeoHazData, under the leadership of the Bureau</td><td>Critical</td><td>Easily achievable</td><td>GEO Task DI-06-07</td></tr>
<tr><td>Preliminary thoughts on sensor based data architecture exist</td><td>Define a system and develop a demonstrator throughout the partners</td><td>System definition</td><td>Implementation</td><td>Critical</td><td>Medium</td><td>GEO Task DI-06-07</td></tr>
<tr><td rowspan="2">GeoHazNet</td><td>The International Geohazards workshop is regularly organised</td><td rowspan="2">Stimulate exchange within the Geohazards Community, with political decision makers and authorities</td><td>A workshop dedicated to fund-raising for geohazards</td><td>A workshop with a strong focus on databases interoperability</td><td>High</td><td>Medium</td><td>GEO Tasks DI-06-09 DI-06-07 DI-06-03</td></tr>
<tr><td>The newsletter is distributed regularly</td><td colspan="2">Progressively increase contributions from external partners</td><td>Medium</td><td>Easily achievable</td><td>GEO Tasks DI-06-09 DI-06-07 DI-06-03</td></tr>
<tr><td rowspan="3">Joint Committee coordination</td><td>Sometimes gaps or duplication when representing IGOS Geohazards in various meetings</td><td>Avoid these gaps and duplications</td><td colspan="2">Using the steering committees and e-mails, all members can share knowledge on meetings, conferences and workshop where IGOS Geohazards could be represented. They can then agree on who will be present, in order to avoid duplication of travel.</td><td>Low (but can account for costs reduction)</td><td>Easily achievable</td><td>GEO Committees UN SPIDER programme Conferences Workshops</td></tr>
<tr><td>Need to increase the sharing of knowledge and experience within the IGOS Geohazards Group</td><td>Raise awareness on the benefits of scientific advisory to decision making at all steps of disaster management</td><td>Produce a consensus report on the benefits of scientific advises for decision making at all steps of disaster management</td><td>Promote the adopted consensus approach</td><td>High</td><td>Difficult</td><td>GEO User Interface Committee</td></tr>
<tr><td>The Theme Report provides information, but this can be improved through a coordination among the Members of the Joint Committee</td><td>Increase accuracy of the IGOS Theme report</td><td>Produce consensus reports on how Earth observation information can reduce geodisasters.</td><td>Include this information within the next Theme report</td><td>High</td><td>Medium</td><td>GEO User Interface Committee</td></tr>
<tr><td>IGOS Geohazards Governance</td><td>The Joint Committee has a Chairman and Co-Chairs assisted by a Bureau</td><td>The Joint Committee Bureau should be organised to respond to all coordination tasks</td><td>Adopt one of the options for a permanent structure of partners</td><td>Put in place a permanent structure</td><td>High</td><td>Difficult</td><td></td></tr>
</table>

Table 19: IGOS Geohazards objectives summary for periods 2007 to 2010

5.9. PERFORMANCE INDICATORS

Two performance indicators are proposed, one for GeoHazData, the other for GeoHazNet:

- How many geohazards databases are linked to GeoHazData?
- How many people participate in GeoHazNet? (i.e. participate at IGOS geohazards activities and meetings)

5.10. CONCLUSION

IGOS Geohazards has proven its capability to build and sustain a cooperation mechanism across geohazards communities. The challenge in the next three years will be to strengthen this cooperation mechanism and to move toward an operational tool to identify existing Earth observation data for Geohazards (GeoHazData).

References

Previous IGOS Geohazards Reports

IGOS Geohazards Theme Report, 2004

Hosford, S., IGOS Geohazards Bureau Year 1 Review, BRGM 2005

Hosford, S., Le Cozannet G., IGOS Geohazards Bureau Mid Term Review, BRGM 2006

Relevant Documentation

Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond, Committee on Earth Science and Applications from Space: A Community Assessment and Strategy for the Future, National Research Council (U.S.)**,** ISBN: 978-0-309-10387-9, 400 pages, 2007, prepublication available at the National Academies Press: http://www.nap.edu/catalog/

Global survey of early warning systems, Pre-print version released at the Third International Conference on Early Warning, Bonn, 27-29 March 2006

Les risques telluriques, Géosciences nr. 4, BRGM édition, September 2006

Living on a restless planet, Solid Earth Science Working Group report, 2002, http://solidearth.jpl.nasa.gov/PAGES/report.html

Grand Challenges for Disaster Reduction, Subcommittee on Disaster Reduction Report, National Science and Technology Council, June 2005, http://www.sdr.gov/SDRGrandChallengesforDisasterReduction.pdf

Improved Observations for Disaster Reduction – Near Term Opportunity Plan, United State Group on Earth Observation, Pre-publication Report, September 2006, http://usgeo.gov/docs/nto/Disaster_Observations_NTO_2006-0925.pdf

Primer on Natural Hazard Management in Integrated Regional Development Planning, Department of Regional Development and Environment Executive Secretariat for Economic and Social Affairs Organization of American States, Washington D.C., Bender S. 1991

Revised preliminary report of ICSU Planning Group on Natural and Human-induced Environmental Hazards and Disasters http://www.icsu.org/5_abouticsu/STRUCT_Comm_Adhoc_hazards.html April 2007

The use of earth observing satellites for hazard support: assessment and scenarios, Committee On Earth Observation Satellites, final report of the CEOS Disaster Management Support Group, http://www.ceos.org/pages/DMSG/index.html

Quoted references

Baratta, M., La catastrofe sismica calabro-messinese(28 dicembre 1908), Rel. Soc. Geogr. It., Roma, pp. 496, 1910.

Okal E., Blewitt G., Kreemer C., Hammond B., Plag H-P., Stein S.: “Rapid determination of Earthquake magnitude using GPS for Tsunami Warning Systems: a role for space Geodesy in Tsunami warning”, presented at the GEO Geohazards Workshop in South East Asia http://www.igosgeohazards.org/WS_ASIA_speakers.asp

Defra, The threat posed by tsunamis to the UK, edited by D. Kerridge, British Geological Survey, Edinburgh, 2005.

Douglas J., Physical vulnerability modelling in natural hazard risk assessment, in Natural Hazard and Earth System Science, 2007

Elliot, E.C. and P.L. Gori, National Landslide Hazards Mitigation Strategy - A Framework for Loss Reduction, USGS Circular 1244, 2003.

Gaillard, J.C., Traditional Societies in the Face of Natural Hazards: The 1991 Mt. Pinatubo Eruption and the Aetas of the Philippines International Journal of Mass Emergencies and Disasters, Vol. 24, No. 1, pp. 5-43, March 2006.

Grünthal, G., A. H. Thieken, J. Schwarz, K. S. Radtke, A. Smolka and B. Merz, Comparative risk assessments for the city of Cologne – storms, floods, earthquakes, vol. 38, pp 21-44, Natural Hazards, 2006.

Guha-Sapir, D., Hargitt, D., Hoyaois, Ph., *Thirthy years of natural disasters 1974-2003: The numbers,* Presses Universitaires de Louvain: Louvain-la Neuve, 2004.

Pararas-Carayannis,G., Impact of Science on Society, Vol. 32, No.1,pp. 71-78, 1982.

Thierry, P, et al, An example of multi hazard risk mapping and assessment on an active volcano: the GRINP project on Mount Cameroon in Natural Hazards, 2007.

U.S. Dpt. of the Interior and USGS, Volcanic and seismic hazards of the island of Hawaii, on line edition, http://pubs.usgs.gov/gip/hazards/maps.html.

Wolfe, E. W. and T. C. Pierson, Volcanic-Hazard Zonation for Mount St. Helens, Washington, U.S. Geological Survey Open-File Report 95-497, 1995.

Witham C S, Volcanic disasters and incidents: a new database. J Volc Geotherm Res, 148: 191-233, 2005.

Acronyms and Abbreviations

ARMONIA Applied Multi-risks Mapping Of Natural Hazards for Impact Assessment
ALOS Advanced Land Observing Satellite
ASAR Advanced Synthetic Aperture Radar
ASTER Advanced Spaceborne Thermal Emission and Reflection Radiometer
COSPEC Correlation Spectrometer
DART Deep-ocean assessment and reporting of tsunamis
DAPHNE Deployment of Asia Pacific Indian Ocean Hazard Mitigation Network for Earthquake and Volcanoes
DEM Digital Elevation Model
DEMETER Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions
DInSAR Differential SAR Interferometry
EDM Electronic Distance Measurement
ENVISAT ENVironmental SATellite
EO Earth Observation
ERS European Remote Sensing
GDP Gross Domestic Product
SRTM Shuttle Radar Topography Mission
GEOWARN Geo-spatial warning system
GLOBVOLCANO Satellite Monitoring in Support to Early Warning of Volcanic Risk
GNSS Global Navigation Satellite System
GPS Global Positioning System
InSAR SAR Interferometry
IR Infra Red
LEO Low-Earth-Orbiting
LiDAR Light Detection and Ranging
NEPTUNE North-East Pacific Time-series Undersea Networked Experiments
RADARSAT RADAR SATellite
SAR Synthetic Aperture Radar
Sentinel Asia Disaster management support system in the Asia Pacific region
SLR Satellite Laser Ranging
SRTM Shuttle Radar topography Mission
VENUS Victoria Experimental Network Under the Sea

Organisations, Networks and Programmes

ADPC Asian Disaster Preparedness Center
ANSS Advanced National Seismic System
APEC Asia Pacific Economic Cooperation
ASEAN Association of South East Asian Nations
BGS British Geolo gical Survey
BRGM Bureau de Recherche Géologique et Minière
CEDIM Center for Disaster Management and Risk Reduction Technology
CIDA Canadian International Development Agency
CIMA Centro de Investigaçao Marinha e Ambiental (Portugal)
CNES Centre National d'Etude Spatiale
CCOP Coordinating Committee for Geosciences Programmes in East and South East Asia
CCRS Canadian Center for Remote Sensing
CEOS Committee on Earth Observation Satellites
CRED Centre for Research on the Epidemiology of Disasters
CSIRO Commonwealth Scientific & Industrial Research Organisation
CSA Canadian Space Agency
CTBT Comprehensive Test Ban Treaty.
CUSEC Central United States Earthquake Consortium Six Cities Study
EC European Commission
EM-DAT OFDA/CRED Emergency Events Database
EMSC European Mediterranean Seismological Centre
ESA European Space Agency
Eurogeosurveys Association of the European Geological Surveys,
FDSN Federation of Digital Seismograph Networks
GARS Geological Applications of Remote Sensing
GEO Group on Earth Observations
GEOSS Global Earth Observation System of Systems
GGOS Global Geodetic Observing System
GMES Global Monitoring for Environment and Security
GSHAP Global Seismic Hazard Assessment Program
GSN Global Seismic Network
GTOS Global Terrestrial Observing System
IAG International Association of Geodesy
IASPEI International Association of Seismology and Physics
of the Earth's Interior
IAVCEI International Association of Volcanology
and Chemistry of the Earth's Interior
ICL International Consortium on Landslides
ICSU International Council of Scientific Unions
IDNDR International Decade For Natural Disaster Reduction
IGOS Integrated Global Observing Strategy
IGS International GPS Service
ILP International Lithosphere Program
INGV Istituto Nazionale di Geofisica e Vulcanologia
IPL International Programme on Landslides
IOC Intergovernmental Oceanographic Commission
IOTWS Ocean Tsunami Warning and Mitigation System
IRIS Incorporated Research Institutions for Seismology
ISDR International Strategy for Disaster Reduction
ITC International Tsunami Center
IUGG International Union of Geodesy and Geophysics
IUGS International Union of Geological Sciences
JAXA Japanese Aerospace Exploration Agency
JPL Jet Propulsion Laboratory
NASA National Aeronautics And Space Administration
NEIC National Earthquake Information Center
NOAA National Oceanic and Atmospheric Administration
OECD Organisation for Economic Co-operation and Development
OFDA Office of Foreign Disaster Assistance (US)
ORFEUS Observatories and Research Facilities for European Seismology
PTWC Pacific Tsunami Warning Center
SAARC South Asian Association for Regional Cooperation
SPIDER UN platform for Space Based Information for Disaster Management and Emergency Response
TerraFirma ESA GMES project for risk reduction
UN United Nations
UNAVCO The University NAVSTAR Consortium
UNEP United Nations Environment Program
UNESCO United Nations Educational, Scientific
and Cultural Organization
UN-ISDR: United Nations International Strategy for Disaster Reduction
UNOOSA United Nations Office for Outer Space Affairs
UNOSAT United Nations programs for access to satellite imagery
USAID US Agency for International Development
USGS United States Geological Survey
SERTIT Service Régional de Traitement d'Image et de Télédétection
VDAP Volcano Disaster Assistance Program
WMO World Meteorological Organization
WOVO World Organisation of Volcano Observatories

IGOS Geohazards Theme Team

Joint Committee Chair:

Robert Missotten, UNESCO

IGOS Geohazards co-chairs:

Marc Paganini, ESA

Hormoz Modaressi, BRGM

Stuart Marsh, BGS

IGOS Geohazards Bureau:

Gonéri Le Cozannet, BRGM

Jérôme Salichon BRGM

GARS Secretariat:

Kay Mc Manus, BGS

Committee Members:

Nicola Casagli, ICL

Craig Dobson, NASA

Hiroshi Fukuoka, ICL

Domenico Giardini, FDSN

Steven Hosford, CNES

Chu Ishida, JAXA

John Labrecque, NASA

Warner Marzocchi, WOVO

Hans-Peter Plag, GGOS

Jim Quick, USGS

Kaoru Takara, ICL

IGOS Geohazards Reviewers

John Douglas, BRGM

Andy Gibson, BGS

Steven Hosford, CNES

Chu Ishida, JAXA

Kay Mc Manus, BGS

Warner Marzocchi, WOVO

Robert Missotten, UNESCO

Hormoz Modaressi, BRGM

Marc Paganini, ESA

Hans-Peter Plag, GGOS

Helen Reeves, BGS

This paper was reviewed by IASPEI (Domenico Giardini, Robert Engdahl, Mohsen Ashtiany, and Peter Suhadolc. IASPEI proposed to participate in the IGOS Geohazards initiative, in order to contribute to the next theme report.

IGOS Geohazards Executive Bureau Missions (2004-2007)

Destination	Date	Aim
Paris	November 2004	ESA - Bureau meeting
Paris	December 2004	GeoHazNet project proposal meeting
Kyoto-Kobe	January 2005	International Conference on Disaster Reduction
Paris	January 2005	GeoHazNet project proposal meeting
Paris	February 2005	Bureau IUGG meeting
Brussels	February 2005	GEO I Plenary session of the Group on Earth Observation
Paris	March 2005	GeoHazNet project proposal meeting
Frascati	April 2005	Joint Comittee Meeting
Alger	May 2005	UNOOSA-ASAL conference
Geneva	May 2005	IGOS P12
Brussels	May 2005	Tsunami Early Warning and Alert Systems (TEWS) workshop
Paris	May 2005	UNESCO Meeting
Bonn	November 2005	Open Geospatial Consortium Meeting
Paris	December 2005	Bureau-ESA meeting
Kobe	October 2005	EU Week 2005
London	November 2005	3rd IGOS Joint Committee Meeting
Geneva	December 2005	GEOII 2D Plenary session of the Group on Earth Observation
Quito	January 2006	Cities on Volcano 2006
Rome	March 2006	User Interface Committee GEO
Paris	April 2006	Meeting GEO Science and Technology
Geneva	April 2006	GEO / WMO Meeting
Geneva	May 2006	IGOS P and Joint Committee meetings

Destination	Date	Aim
Kuala Lumpur	May 2006	GEO IGOS Geohazards South East Asia WS
Paris	May 2006	ICSU Geo Unions / IGOS Geohazards Meeting
Davos	August 2006	International disaster reduction conference
Ottawa	September 2006	User Interface Committee
Bonn	November 2006	GEO III, User Interface Committee, IGOS Geohazards Joint Committee
Rome	January 2007	3rd International Geohazards Workshop Organising Committee meeting
Brussels	February 2007	Eurogeosurveys Geohazards Working Group
Vienna	February 2007	44th session of UNOOSA Technical and Scientific sub-committees
Geneva	April 2007	User Interface Committee
Paris	May 2007	Eurogeosurveys Geohazards Working Group IGOS Geohazards Joint Committee
Rome	July 2007	ESA – IGOS Geohazards Bureau meeting

IGOS Geohazards contribution to GEO inltiative

Brief Description

The IGOS-P Geohazards Theme responds to the scientific and operational geospatial information needs for the prediction and monitoring of geological hazards. During the 2003-2007 periods, the priority was: (1) to bring together a representative Community of Practice of scientists, engineers and users concerned with Geohazards and (2) to update “Geohazards Theme Reports” in 2004 and 2007, and (3) to develop a demonstrator of a comprehensive system allowing the inclusion of geohazards data in the GEOSS Clearing House.

Added Value

The IGOS-P Geohazards Theme provided the core for gathering a Geohazards Community of Practice (CoP), within which Earth Observation requirements have been collected over the time frame from 2003 to 2007. It contributes to the GEOSS Clearing House through its GeoHazData system, which is based on a hazard maps inventory. GEO provides a common framework for the Theme and CoP within which means for data exchange between diverse interested groups have been put in place making data available to the wider community. Countries are contributing instruments or systems for integration into a larger earth observation system, thus improving interoperability. Particularly for developing countries, interoperability of systems is very important since they often do not participate in the definition of the systems they receive. GEO facilitates the building of bridges between the communities concerned with an efficient use of Earth Observation data in disaster prevention and mitigation.

Relevance to GEO

The IGOS-P Geohazards Theme contributes to the Disaster Societal Benefit Area. It acts as an initial kernel of the Geohazards CoP. It leads two tasks, namely DI-06-07 through which it provides a pilot OGC-compliant catalogue and web service for hazard maps inventory (GeoHazData), and DI-06-03, to which it contributes by organizing workshops and raising awareness on InSAR and advanced InSAR techniques in the Geohazards CoP. It has also actively contributed to tasks DI-06-02 through user feedback from regional workshops; DI-06-08 through the promotion of an integrated approach at meetings and conferences; DI-06-09 by helping the task group to identify geological high risk areas; DI-06-12 through organizing user workshops in Latin America and South East Asia; and AR-06-05 with GeoHazData.

Participants

UNESCO (co-chair), ESA (co-chair), BRGM (co-chair and Executive Bureau), BGS (co-chair), NASA, CNES, CEOS, USGS, GGOS, WOVO, FDSN and ICL.

Current Status and Next Steps

Long term continuity relies on sustainable community building. The IGOS-P Geohazards Theme represents the diversity of scientists, engineers and users that are involved in geohazards, and thus is pivotal in community building in the Disaster SBA. The Joint Committee of the Theme includes representative of the diverse communities relevant for the SBA. International Geohazards Workshops are regularly organised to gather the main geohazards communities on a broader basis. The 3rd International Geohazards Workshop has been organised in November 2007 as a GEO event. In order to support this approach, a better data policy is needed. Geohazdata is a "proof of concept", that should be critically reviewed by GEO participating Countries before moving toward an operational application. The choice of an OGC compliant conceptual model for Geohazards such as GeoScienceML is needed. The actual implementation of an operational clearing house requires the commitment of national organisations in charge of Geohazards assessment in GEO Member countries and the alignment of associated resources at the national level.

Main IGOS Geohazards GEO tasks:

- DI-06-07 *"Multi-hazards Zonation and Maps"* through which it provides a pilot OGC-compliant catalogue and web service for hazard maps inventory (GeoHazData)

- DI-06-03 *"Integration of InSAR Technology"* to which it contributes by organising workshops and raising awareness on InSAR and advanced InSAR techniques in the Geohazards CoP.

- DI-06-02 *"Seismographic Networks Improvement and Coordination"* through user feedback from regional workshops

- DI-06-08 *"Multi-hazards Approach Definition and Progressive Implementation"* through the promotion of an integrated approach at meetings and conferences

- DI-06-09 *"Use of Satellites for Risk Management*" by helping the task group to identify geological high risk areas

- DI-06-12 *"Initiate a knowledge-transfer on the use of Earth observations for disaster management"* through organising user workshops in Latin America and South East Asia

- AR-06-05 *"Initiate development of a publicly accessible network-distributed clearinghouse"* with the implementation of GeoHazData.

BRGM Scientific and Technical Centre
Development Planning and Natural Risks division
3, avenue Claude-Guillemin - BP 6009
45060 Orléans Cedex 2 – France – Tel.: +33 (0)2 38 64 34 34