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The Contribution of the Global Earth Observation System of Systems to Disaster Management

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Introduction

The catastrophic impact of natural and man-made disasters is increasing day by day. The number of floods, hurricanes, cyclones, typhoons and other phenomena has, indeed, significantly augmented in the last 15 years by causing the death of millions of people and the destruction of entire areas of the world.
The huge damages generated by such phenomena have urged the international community to take appropriate measures and to develop a common strategy in order to mitigate their dramatic effects. The setting up of a plan establishing the Global Earth Observation System of Systems (GEOSS) represents the more recent and most ambitious attempt in this respect. GEOSS may be defined as an international effort aimed at achieving comprehensive and sustained observation of the Earth through the combined use of all the available Earth observation systems, such as remote sensing satellites, sensors, communication devices, storage systems, etc. The implementation of the GEOSS project will generate a new level of understanding of the Earth system and of how it works, which is likely to produce a large amount of benefits both at political and social level. Thanks to the simultaneous use of Earth observation systems, indeed, it will be possible to constantly monitor the state of the Earth and to take required measures in due time, for instance with regard to problems related to issues like global warming, energy resources management, health, security, sustainable development, etc. As to the contribution of GEOSS to disaster management activities, this is expected to be significant and of major importance. Thanks to the enlarged knowledge of our planet and to the permanent monitoring of the Earth that GEOSS is expected to generate, indeed, we will be able to better comprehend the nature and characteristics of natural phenomena, to follow their evolution, to share data and information, and to warn in due time the populations who are likely to be affected by them. In this way, it will be possible to save many human lives and to better coordinate rescue and disaster management operations.
Therefore, GEOSS has to be seen as a mean for producing a positive revolution in the field of disaster management operations. As a consequence, although GEOSS is still in its infant stage, the analysis of its evolution and its characteristics is of particular relevance for the purpose of this Conference.

1. Why GEOSS? The need for a comprehensive and coordinated Earth Observation System

The Earth is changing. Human activities are constantly and inexorably modifying the Earth's climate and are progressively eroding the fragile balance which allows the Earth to be a perfect environment for human presence. The most visible evidence of this change is represented by the increasing number of natural disasters which is striking our planet. It has been estimated, for instance, that 430 natural disasters have occurred during 2007. The problem is that not only the number of

disasters is increasing year by year but also that the level and amount of damages and destruction generated by them is significantly growing as well.

This dramatic situation has pushed the international community to find solutions and to set out common strategies to deal with this state of affairs. The positive aspect in this respect is that, mainly because of the global impact and nature of natural disasters, States have showed a positive attitude towards the possibility to cooperate for improving the general ability to face and manage a disaster. In the last decade, indeed, the majority of States has collaborated to develop plans and common actions aimed at reducing the destructive effects of such disasters. One of the key points in this respect has been the need to develop technologies allowing to better respond to a disaster and to improve the efficiency of pre-and post-disaster operations. The use of space technologies has proven to be functional and proper for this purpose. Thanks to the observation of the Earth by remote sensing satellites, it is possible to constantly monitor the state of the Earth and, in this way, to locate natural hazards, to warn the populations which are likely to be affected by them, and to better prepare a pre-and post-disaster strategy. As a result many human lives have been saved and the impact of natural disaster has been to a certain extent reduced. Thus, it is unquestionable that the use of space technologies and other Earth observation systems has contributed to improve the quality of disaster response and disaster management activities.

However, there are still several difficulties related to the use of these systems which need to be solved in order to improve their efficiency and the level of pre and post disaster operations. First of all, Earth observation systems do not work together. Most of the time, there is no coordination among them and this generates many problems, such as delay in warning people about the arrival of an hazard and the impossibility to organise a prompt response to a disaster once it has already occurred. Moreover, there are still many legal and political obstacles to the dissemination and sharing in due time of the data related to Earth observation. It may also happen that the States affected by a disaster do not have the technical ability to read or understand satellite data and to transform them in useful information. Additionally, there are problems related to our knowledge about the functioning of the Earth system which is still limited. We don't know, for instance, when and why a hazard will take place and which will be its evolution.

In order to solve all these problems starting from 2003 more than 70 countries, the European Commission, some governmental and non-governmental organisations have begun to work together to establish a Global Earth Observation System of Systems (GEOSS). GEOSS is a political and scientific initiative which is aimed at reaching a better understanding of the Earth system and of how it works through the concerted and combined use of Earth observation systems. GEOSS is expected to achieve comprehensive and sustained observation of the Earth which will result in an advanced monitoring of the state of the Earth, in a better comprehension of the Earth processes and in an enhanced prediction of the behaviour of the Earth system. Thanks to the coordinated utilisation of the Earth observation systems it will be possible, thus, to improve their interoperability, to address the critical gaps that have prevented so far to get an accurate and proper observation and understanding of the Earth system, to better share information, and to improve delivery of information to users. In this way, GEOSS will constitute a global network of content providers allowing decision makers to access an extraordinary range of information at their desk.

It is important to point out that GEOSS will be built on the existing national, regional, and international systems supplementing but not supplanting their mandates and governance arrangements (this is the reason why GEOSS is called a "system of systems"). In this respect, GEOSS will provide the institutional mechanism for ensuring the necessary level of coordination among the existing Earth observation systems.

In consideration of its global and multifunctional characteristics GEOSS is expected to be used for a wide range of purposes and it is supposed to generate a large number of social and scientific benefits. For instance, GEOSS will find application for supporting sustainable development, improving management of energetic and water resources, combating desertification, facing climate changes, etc. The sector in which GEOSS is predicted to produce the most positive benefits is that of disaster management. GEOSS will significantly contribute to reducing loss of life and property from natural and human-induced disasters. As a consequence of the combined use of systems it will be possible to improve our ability to manage a disaster by means of a more efficient early warning system, an enhanced sharing of the data regarding a disaster, and better coordinated and implemented pre and post disaster activities.

2. Evolution of GEOSS

The first step leading to the setting up of the GEOSS project was made during the 2002 World Summit on Sustainable Development held in Johannesburg, South Africa. Here, it was clearly stated that environmental protection and social and economic development are fundamental to sustainable development. The participants to the Conference stressed the urgent need to tackle crucial issues like climate change, desertification, poverty, preservation of resources, and natural disaster management. In order to do so, the participants solemnly committed themselves to increase and better implement the coordination of their efforts related to the observation of the state of Earth[1].

Afterwards, at the 2003 Meeting of the Heads of State of the G8 Group held in Evian, France, the eight most industrialized States recognised the need for a Plan of Implementation to support the development of cleaner, sustainable and more efficient technologies. Among the purposes of this Plan was the coordination of global observation strategies. As a result of this strengthened cooperation, States planned to develop closer coordination of their respective global observation policies, to improve the world-wide reporting, sharing and archiving of data concerning atmosphere, land, fresh water, and to reinforce interoperability among the observation systems[2].

The path towards the definition of GEOSS was definitely laid down during the First Earth Observation Summit held in Washington D.C. in July 2003. 33 countries, led by the US, the European Commission and many international organisations made clear that to produce and manage better information regarding the environment had become a top priority. A Declaration expressing the political commitment towards the development of a comprehensive and coordinated Earth Observation System aimed at collecting and disseminating improved data and information was adopted. An *ad hoc* intergovernmental Group on Earth Observation (*ad hoc* GEO) was formed to carry out this purpose. The *ad hoc* GEO was charged to set out a "Framework Document", the so-called 10-Year Implementation Plan, plus a report describing how the collective efforts could be organised to continuously monitor the state of the Earth, to increase our understanding of the Earth processes, and to enhance forecasts on our environmental conditions. During four meetings of the *ad hoc* GEO from late 2003 to April 2004, the document was prepared. When the Second Earth Observation Summit was held in Tokyo in April 2004, a Framework Document defining the scope and intent of the Global Earth Observation System of Systems was adopted. GEOSS was defined as an international effort to bring together existing and new hardware and software, making it all

[1] This commitment was expressed in the Johannesburg Declaration on Sustainable Development. The text of the Declaration is available at http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POI_PD.htm.

[2] See Sicence and Technology for Sustainable Development A G8 Action Plan at http://www.g8.fr/evian/english/navigation/2003_g8_summit/summit_documents/science_and_technology_for_sustainable_development_-_a_g8_action_plan.html.

compatible in order to supply information and data at no cost. During the Third Earth Observation Summit, held in Brussels, Belgium, in February 2005, the GEOSS 10 Year Implementation Plan was endorsed and the Group on Earth Observation (GEO) was established to implement it. Further support to GEOSS was provided by the G8 Gleneagles Plan of Action[3] released during the 2005 G8 Summit held in Scotland, in which the will to move forward the implementation of GEOSS at national level and to support efforts to help developing countries to get full benefits from GEOSS was stated.

3. The Group on Earth Observation

Before analysing in detail the 10 Year-Implementation Plan and describing, thus, the characteristics and the functioning of GEOSS, it is useful to say a few words about the Group on Earth Observation (GEO).

As previously analysed, GEO was established in 2005 during the Third Earth Observation Summit with the mandate to implement the Global Earth Observation System of Systems in accordance with the 10 Year-Implementation Plan[4]. As of November 2007, GEO includes 72 member countries, the European Commission, and 52 participating intergovernmental, international and regional organisations with a mandate in Earth observation. GEO is composed by a GEO Plenary[5], which is the GEO's primary decision body and comprehends the designated representatives of the member States and participating organisations, an Executive Committee, whose role is to facilitate the decision of the GEO Plenary, and a Secretary. The GEO Plenary may also establish Committees and Working Groups to deal with specific aspects of GEOSS implementation.

Soon after its creation, it was agreed that GEO would be a coordinating body and would not create a new international organisation. In this way, the option of creating a new UN organization was excluded, although the collaboration with UN Specialized Agencies is essential for the proper functioning of GEO. While it is not a UN body or formal international organisation, GEO has always been considered to be an intergovernmental organisation.

GEO is built on a voluntary and legally non-binding basis, with voluntary contributions to support its activities. It represents the framework in which its members and participants can develop projects and coordinate strategies for the realisation of GEOSS.

The First GEO Ministerial Meeting was held on 30 November 2007 in Cape Town, South Africa.

4. GEOSS and Space Law

Although GEOSS is more a political than a legal initiative, it is possible to identify some connections with space law rules, particularly those contained in the 1967 Outer Space Treaty. As it has already been said, the main purpose of GEOSS is to improve our understanding of the Earth system through the combined use of the Earth observation systems. GEOSS is expected, thus, to generate several positive benefits on a social and political level, in particular in the field of disaster management. GEOSS, indeed, will advance our ability to face and manage a disaster and to better organize a response to it. Among the Earth observation systems, space technologies have a key role in consideration of the fact that their use may guarantee the constant monitoring of the entire Earth surface. The use of space technologies for disaster management activities represents, in our opinion, a way to put into practice the terms of Article I of the Outer Space Treaty. Article I establishes that "the exploration and use of outer space shall be carried out for the benefit and in the interests of all mankind". The employment of remote sensing and communication satellites for disaster

[3] For the text of the Gleneagles Plan see: www.fco.gov.uk/Files/kfile/PostG8_Gleneagles_CCChangePlanofAction.pdf.

[4] For the text of the Plan see http://www.earthobservations.org/documents/10-Year%20Implementation%20Plan.pdf

[5] The GEO Plenary meets annually.

management purposes represents a "use of outer space for the benefit of all mankind". The benefits and advantages which come from the utilisation of these technologies, indeed, are spread among all countries and contribute to the betterment of the living conditions and safety of all people on Earth.
Moreover, it may be added that GEOSS represents a practical implementation of the principles contained in Article IX of the Outer Space Treaty which states that: "States Parties shall promote international cooperation in the peaceful exploration and use of outer space and to inform the UN Secretary General, the public and the international scientific community, to the greatest extent feasible and practicable of the nature, conduct, locations and results of such activities". GEOSS, indeed, is based upon the cooperation and coordination among States in the use of space technologies for disaster management and other social oriented purposes. In this regard, cooperation may be defined as the key and essential element for the success of the whole GEOSS project. Additionally, GEOSS puts into practice the last part of Article IX because States and international organisations when accepting to take part into the GEOSS initiative have declared their commitment to share data and information regarding the state of Earth.

5. The 10-Year Implementation Plan

The 10-Year Implementation Plan was adopted in 2005 during the Third Earth Observation Summit. Its analysis is of particular relevance because it defines the purpose and scope of GEOSS and explains the benefits which GEOSS is expected to generate.
The scope of the Plan is to summarise the required steps to be undertaken by a global community of nations and intergovernmental, international, and regional organisations in order to put in place a Global Earth Observation System of Systems (GEOSS).

Preamble

The Preamble of the Plan stresses the fundamental role the understanding of the Earth systems plays "*in enhancing human health, safety and welfare, alleviating human suffering including poverty, poverty, protecting the global environment, reducing disaster losses, and achieving sustainable development*". The Observation of the Earth system represents, in this respect, a critical element for advancing this understanding. The Preamble also points out that interested countries and organisations have to collaborate closely to develop the Plan in order to ensure comprehensive and sustained Earth observation. The Plan will be built on and will "*add value to existing Earth observation systems by coordinating their efforts, addressing critical gaps, supporting their interoperability, sharing information, reaching a common understanding of user requirements and improving delivery of information to users*".

Purpose and scope of GEOSS

As mentioned earlier in this paper, the purpose of GEOSS is to reach comprehensive, coordinated and sustained observation of the Earth so as to improve monitoring of the state of the Earth, increase understanding of the Earth processes, and improve the possibility to predict the behaviour of the Earth. In this way, GEOSS will be able to generate timely and quality long-term global information which will provide a significant help for sound decision making.
As to the scope, the Plan states that GEOSS will provide the "*overall conceptual and organizational framework to build towards integrated global Earth observation to meet user needs*". It will furnish the institutional mechanism for making sure the necessary level of coordination among existing Earth observation systems.

Benefits

GEOSS is a perfect example of science serving society. Its primary focus, indeed, is to generate social benefits through more coordinated observation of the Earth and better management and sharing of data.

GEOSS will produce a broad range of information which will be used as a basis for policy and decision making in every sector of the society.

The 10 Year-Implementation Plan identifies nine areas of societal benefits that would provide the initial focus for GEOSS:

- Reducing loss of life and property from natural and human-induced disaster;
- Understanding environmental factors affecting human health and well-being;
- Improving management of energy resources;
- Understanding, assessing, predicting, mitigating, and adapting to climate variability and changes;
- Improving water resources management through better understanding of the water cycle;
- Improving weather information, forecasting, and warning;
- Improving the management and protection of terrestrial, coastal, and marine ecosystem;
- Supporting sustainable agriculture and combating desertification;
- Understanding, monitoring, and conserving biodiversity.

The Plan indicates how and to which extent GEOSS is expected to have a positive impact in all these areas.

GEOSS and natural and human-induced disasters

It is striking that the reduction of loss of life and property from natural and human-induced disaster represents is the first area in which GEOSS is predicted to produce positive benefits.
The Plan makes clear that disaster losses can be reduced through observation of hazards such as: wildland fires; volcanic eruptions; earthquakes; tsunamis; floods; landslides; etc. Every year these hazards are responsible for the killing of thousands of people and for the destruction of several properties. When a disaster takes place rapid access to data on land and ocean conditions, as well as maps of transport links and hospitals, weather forecast, and other information on socio-economic factors can help in saving numerous lives.
The Global Earth Observation System of Systems will combine Earth observation systems with other information in order to reduce vulnerability, to strengthen preparedness and early-warning measures and, after disaster occurs, to rebuild housing and infrastructure. It will also help in reducing the risks related to hazards by providing a better understanding of the relation between natural disasters and climate change. By combining different types of disaster-related data and information, GEOSS will reinforce analysis and decision making for disaster response and risk reduction.
During the recent GEO Ministerial Summit held in Cape Town in November 2007, the expected Early Achievements of the GEOSS project have been presented to Ministers and senior officials. These Early Achievements represent the first 100 steps to GEOSS and have to be considered a major milestone in the development of GEOSS itself. Among them there are the construction of a Global Wildland Fire Early Warning System, an improved use of satellites for risk management, the German-Indonesian Tsunami Early-Warning System, and the Networks of Centres of the Italian Civil Protection System.
In order to facilitate the fulfilment of the purposes which GEOSS is expected to reach, a 2007-2009 GEO Work Plan[6] has been established. This plan foresees the attainment of several tasks such as the betterment of risk management for floods, the implementation of a fire warning system at global level, a multi-hazard approach definition and progressive implementation (which is aimed at promoting cooperation towards the definition of a multi-hazard approach to systematically address all risks), and the

[6] For the text of the 2007-2009 Work Plan see http://www.earthobservations.org/documents/wp0709_v4.pdf

implementation of a tsunami early warning system at global level.

The 10 Year-Implementation Plan also sets out two, six, and ten year targets for conducting the disaster-related work on GEOSS. Among the two year targets there are the strengthening of the functioning of the Charter on Space and Major Disasters and other related activities in order to improve response to disasters, the expansion of seismic monitoring networks, and to produce an analysis of the status of the existing capacity-building programmes and initiatives. As to the six year targets, we may quote the strengthening of interoperability among all satellite systems providing global positions such as the US GPS, the European GALILEO, the Russian Global Orbiting Navigation Satellite System (GLONASS) and Japanese Quasi-Zenith Satellite System (QZSS), the enhancement of the automatic processing and evaluation of satellite imagery, the development of models to better support disaster management response, and facilitating access to real-time data for all hazards. Among the 10 year tasks are the further expansion of real-time monitoring of submarine seismic and volcanic activity and of tsunami propagation by use of surface and subsurface sensors, and the improvement of the quality of the services provided by satellites.

It is also possible to quote two recent interesting developments in the field of disaster management that have occurred during the last two months of 2007. The first is a Memorandum of Understanding[7] signed by GEO and the International Telecommunication Union (ITU) which aims at improving cooperation on remote sensing of the Earth, particularly in the field of disaster management and preparedness. Key benefits that this collaboration will generate at global level are the protection for the dedicated radio frequencies that remote sensing satellites and Earth-based monitors use for collecting high quality data on the global environment, and the enhanced application of Earth observations to disaster management. The second development is represented by the Brazil and China joint effort to distribute satellite imagery to Africa at zero cost[8]. The China Brazil Earth Resources Satellite Programme (CBERS) has launched a new service which will provide images of the state of the Earth to end-users in Africa free of charge. Along with these images, this service will also furnish image-processing software, geographic information systems, and training to all the users who demand it.

Challenges for GEOSS

The biggest challenge of the GEOSS project is to ensure the proper and needed level of cooperation and coordination among all the subjects involved. GEOSS will only be successful if all State members and other participants accept to collaborate and work together for the benefit of all. This is particularly true with regard to certain aspects of the GEOSS initiative such as that regarding a broader access and sharing of environmental and disaster data. Many States support the idea of enlarging the diffusion of Earth observation data. However, such States become more restrictive when it comes to sharing their own data.

Another challenge is to make environmental data accessible to all nations in a cost-effective and efficient manner. Considering the volumes of data and their diversity, this will not be an easy task. Nevertheless, GEOSS is expected to produce global dissemination and coordination of data at low or zero price.

GEOSS will have to make sure the needed level of implementation and coordination which is required for the fulfilment of its purposes. In this regard, it is important that States members and other participants act in a

[7] The text of the Memorandum of Understandings is available at http://www.earthobservations.org/documents/pressreleases/pr_0712_itu_geo_mou.pdf. The Memorandum was signed in Geneva on 10 December 2007.

[8] The main text regarding this joint initiative is available at http://www.earthobservations.org/documents/pressreleases/pr_0711_cape_town_cbers.pdf. This document has been signed in Cape Town on 28 November 2007.

cooperative way and adhere to the commitments they made when joining the GEOSS initiative. It is important to point out that States have showed great will to cooperate in order to contribute to the fulfilment of the GEOSS objectives. They are supporting GEOSS through several initiatives. Europe, for instance, is contributing with the GMES initiative, which is aimed at better coordinating, analysing, and preparing for end users observation data received from Earth observation satellites and ground based information. Thanks to GMES the state of the Earth will be constantly monitored and this will support policy decisions and investments[9].

The Asia-Pacific Region is contributing to GEOSS with the Sentinel Asia project. Sentinel Asia is a "voluntary and best effort basis initiative" whose aim is to broaden the sharing of disaster information in the Asia-Pacific region and to make the best use of Earth observation satellite data for disaster management in that region possible[10].

Conclusion

GEOSS represents a great and unique opportunity for all mankind. The benefits and advancements that it is expected to produce will contribute to the betterment of the living conditions and of security of millions of people around the world. In the field of disaster management, GEOSS will generate a "positive" revolution. Thanks to its implementation, our understanding of the Earth systems and of its processes would significantly increase and, in this way, it will be possible to better manage a disaster.

The use of Earth observation systems, such as remote sensing satellites, sensors, communication devices, storage systems, have contributed to improve our ability to manage a natural disaster and has made possible a better coordination and implementation of emergency operations once a disaster has occurred. Thanks to the use of such systems, today we can locate potentially dangerous natural phenomena, constantly follow their evolution, and warn States which are likely to be affected by it. As a consequence, it is possible to organise a proper response to such phenomena in due time, which will contribute to reduce its catastrophic effects.

The importance of the use of Earth observation systems for disaster management activities is unquestionable; however, there are some technical and political aspects related to the utilisation of these technologies that need to be improved in order to make them more efficient and effective for disaster management strategies. The major problem in this respect is the lack of coordination among the systems involved in Earth observation. GEOSS is expected to solve this problem. Therefore, the whole international community should cooperate for the success of the GEOSS initiative. States, non-governmental entities, and private operators, as a consequence, should put aside their own interests and act in a responsible way in order to generate worldwide benefit and to increase security for millions of people all over the world.

[9] Another European contribution for the realisation of GEOSS is represented by the Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). The INSPIRE Directive entered into force on the 15 the May 2007. INSPIRE intends to create a European spatial information infrastructure which is able to deliver to the users integrated spatial information services. These services will allow the users to identify and access spatial and geographical information from a large range of sources, from the local to the global level.

[10] Information on Sentinel Asia available at http://dmss.tksc.jaxa.jp/sentinel/