Consensus Report of the CEOS ad hoc Disaster Team (Issue 2.0)

Enlarged Actions Concerning Satellite EO and DRM

ISSUE 2.0

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CEOS ad hoc Disaster Team

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Executive Summary

Overview and Purpose

The Study Consensus Report on CEOS Support to Disaster Risk Management (DRM) has been prepared by the CEOS *ad hoc* Disaster Team, following a request from the CEOS Principals made during the 2011 CEOS Plenary. It contains a set of recommendations aiming at increasing and strengthening the role of CEOS space agencies in all phases of DRM.

The main objectives that led CEOS agencies to propose the current activities are threefold:

- To protect lives and safeguard property;
- To foster increased use of Earth observation (EO) in support of DRM, particularly Disaster Risk Reduction; and
- To raise the awareness of politicians, decision-makers and major stakeholders of the benefits of using satellite EO in all phases of DRM.

In 2010, disaster events caused the death of almost 300,000 people, affected another 220 million and resulted in more than $120 billion in economic damages. Impacts of disaster events on economic and human lives are increasing every year due to growing urbanization and an increase in the number and severity of weather-extreme events; by 2050, the number of people exposed to storms and earthquakes in large cities could double and by 2100, damages from weather-related hazards may triple. While 2011 saw a drop in fatalities (29,782), the damages tripled to over $366 billion (cf. figure 1, below). The Japanese earthquake and tsunami of March 2011 accounted for over half these damages on its own. Some 206 million people were affected by disasters in 2011, including 106 million by flooding and 60 million by drought, mainly in the Horn of Africa.[1]

[1] Source AFP as quoted at www.undp.org.

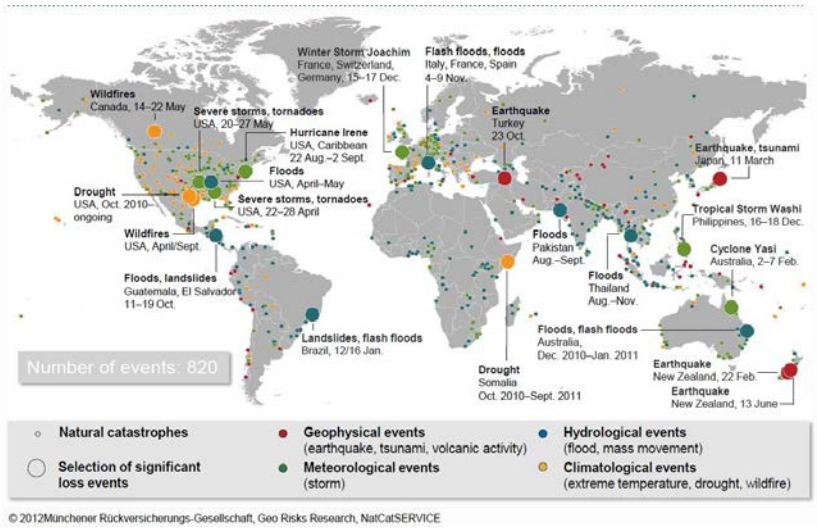

FIGURE 1. NATURAL CATASTROPHES IN 2011, COURTESY OF MUNICH RE (2012)

At the 25th CEOS Plenary Meeting in Lucca, Italy, CEOS principals discussed the need to examine activities of member Agencies across the disaster cycle and ensure a balanced effort across the cycle and amongst the agencies. CEOS Principals proposed that an *ad hoc* team be formed to look at a more effective CEOS contribution, by assessing gaps, overlaps and consideration of the balance of effort. The CEOS Disaster *ad hoc* team was formed early in 2012, and met in Frascati in February and in Tokyo in April, as well as several times by teleconference. The Team currently includes representatives from the following agencies: ASI, CSA, CNES, DLR, ESA, EUMETSAT, JAXA, NASA, NOAA and USGS, as well as from the CEOS Executive Office/Deputy Executive Officer and the CEOS Systems Engineering Office (SEO). The Team was mandated to report back to the SIT and Plenary in 2012, and this report is the work of that Team. Successful contribution from space agencies to DRM will:

1. Increase the awareness of decision-makers of the critical role of satellite EO; and
2. Reinforce the need for enhanced satellite EO programs to better address DRM needs.

Key Stakeholders and Users

There has been significant discussion around the table of the CEOS *ad hoc* Disaster Team meetings on the definition of the end user. The true end users for DRM services are local and national authorities. They are the first to be concerned by disasters affecting populations, and have a mandate to protect them. A global initiative requires international or regional champions that consolidate the needs of the users and serve as an intermediary for organisations such as CEOS. These organisations are not users, but rather stakeholders with a recognised interest in DRM and risk reduction in particular. Examples of such organisations include the Global Facility for Disaster Reduction and Recovery (GFDRR, hosted by the World Bank), the United Nations International Strategy for Disaster Reduction (UNISDR), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the United Nations Science, Education and Culture Organisation (UNESCO). Other relevant organisations that may serve as relays or partners include United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), United Nations Institute for Training and Research (UNITAR)/ Operational Satellite Applications Programme (UNOSAT) the World Meteorological Organisation (WMO), and the Group on Earth Observations (GEO).

Information Needs and Use of Satellite EO Today

Satellite EO is rarely used operationally to address DRM needs. Users do not view EO solutions as mature, and seek clearer demonstrations of the cost-benefit ratio that would convince their own management and stakeholders that EO represents a solution to Disaster Risk Reduction and DRM challenges. The *ad hoc* team examined existing statements of User Needs, including work of the past CEOS Disaster Management Support Group (DMSG) and the GEO Report

on "Use of Satellites for Risk Management – User Needs". The Consensus Study Report also contains an analysis of three representative areas (flooding, seismic hazards and landslides), which demonstrates a clear data gap where satellite-EO can make a difference by supplying missing information to DRM users. In order to succeed however, other gaps must be addressed, including awareness, availability and capacity gaps. Realistically, space agencies will not fill all gaps, but may make strategic contributions that highlight the effectiveness of EO applied to DRM.

Information needs cover both information on hazards and information on exposure and vulnerability, which is a very broad range of needs and associated geo-information solutions. The CEOS DRM activities must address both hazards and exposure and should provide data and tools to generate needed geo-information (*e.g.* on hazards), as well as linking to available EO capacities that provide such geo-information (*e.g.* Satellite EO resources for reference mapping, asset mapping, vulnerability mapping, etc.). In order to ensure the best possible use of CEOS resources, the actions will reuse existing assets and projects from space agencies.

Operational EO use in Disaster Risk Reduction will help prevent loss of life and support better understanding and possibly reduction of exposure of property to damage. It will also augment the effectiveness of existing response initiatives such as the International Charter 'Space and Major Disasters' (the Charter) by reinforcing institutional links with key users. Finally, high-profile application of EO in DRM generates political support for increased EO capacity over the long-term.

Need for an Integrated Approach

In order to bring providers and users of EO together, a concerted effort from the satellite EO community is required to demonstrate the value of EO to DRM Users, in particular by presenting EO in a non-satellite centric, 'integrated' solution that shows how satellite EO can be an enabler, bringing innovative solutions to traditional DRM challenges. This demonstration will build on and complement existing and emerging international flagship co-operation in this field of application, such as GEO's Geohazard Supersites and Natural Laboratories (GSNL) and the Charter, and can be made through cooperative pilots defined in close coordination with users. Once convinced of the utility of satellite EO, users will make the best champions for EO and may be prepared to bear the cost of integrating EO into their own systems.

The actions and recommendations proposed in the CEOS Study Report support these objectives. They build on existing initiatives and projects and offer a vision to weave together disparate initiatives into a comprehensive approach to support the needs of the DRM community.

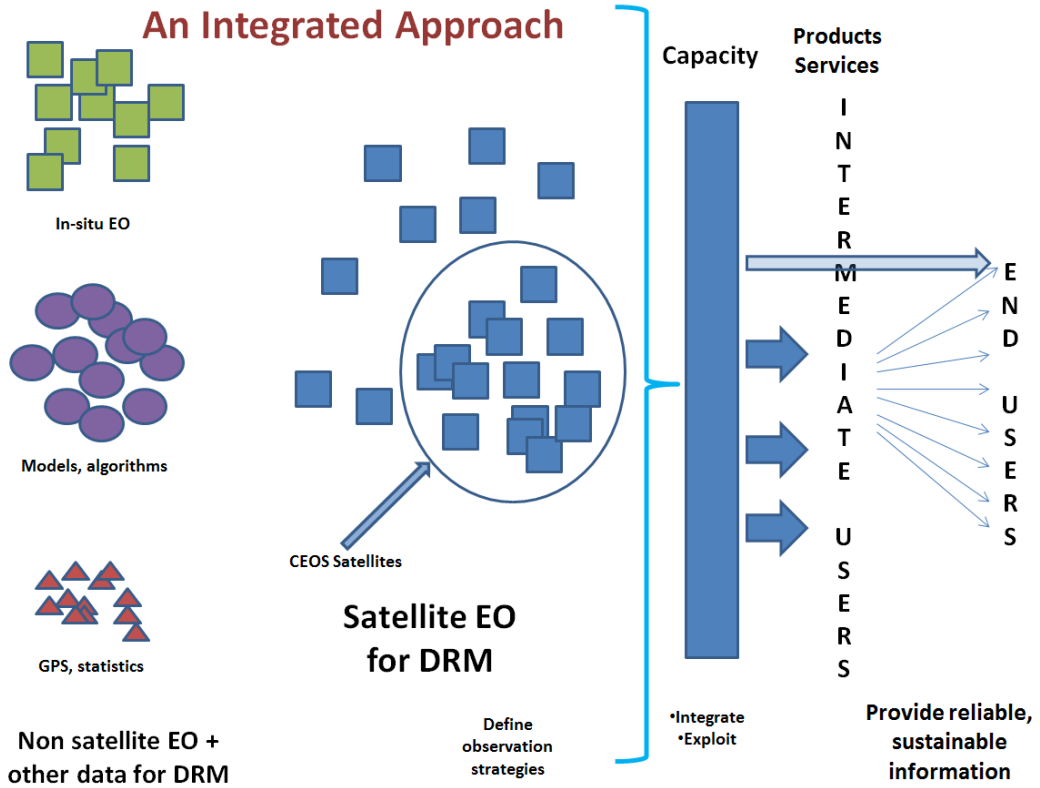

FIGURE 2. INTEGRATING SATELLITE-BASED EO INTO DRM PROJECTS AND SERVICES

There are many different actors involved in the DRM process at local, national, regional and international levels. Their capacity to integrate technology and information changes on a geographic and development basis, and their different mandates determine the nature of their varying needs for data and information. To date, there is no comprehensive global requirement established for DRM. Such a requirement could only be the compilation of needs of numerous stakeholders with varying regional and national interests. With regard to certain phases, such as disaster response, the requirement is much better understood, although here also, it is met only in so far as major disasters are concerned, and only with limitations, especially concerning delays in data delivery.

Existing DRM Projects within Member Agencies

In the context of the Consensus Report development, the team members were asked to present their most important DRM-related projects. A summary of these projects is included in Annex 3. The projects submitted concerned a variety of projects covering each element of the disaster cycle, a range of different disaster types, both operations and science a variety of geographic areas, as well as diverse thematic content. With regard to various hazards, a dozen projects were multi-hazard, while 14 dealt with a combination of geohazards, 11 with volcanoes specifically, eight with flooding, six with earthquakes, five with landslides, four with tsunamis, three with fires, two with windstorms and one with subsidence. From the analysis of the projects listed in Annex 3, there are areas where increased synergies may offer a greater benefit than proceeding in isolation. One clear area identified was volcanoes, where different agencies were imaging volcanoes without exploiting synergies and without coordination. A collaborative approach with shared efforts might lead to both savings of resources and increased results. There are also areas where specific methodologies or developed software may be shared across a broader group for increased benefit. The next phase of the *ad hoc* Disaster Team work involves matching these projects to the draft Implementation Plan to ensure that the proposed way forward makes most effective use of existing resources and projects.

Disaster Phases – Need for Renewed Focus on Disaster Risk Reduction

Much of the focus of disaster activity is currently on the high-profile response phase, during which rapid action can save lives. Satellite EO is a recognized solution for enabling more efficient relief actions and supporting aid actors with objective and up to date information. It is however widely accepted that increased efforts on risk reduction during the mitigation and warning phases of a disaster will save more lives and protect property by reducing the exposure of populations to the hazard. An enlarged CEOS action plan should consider the entire cycle of risk management (mitigation, warning, response and recovery), especially considering existing efforts with regard to response, principally through the Charter, Sentinel-Asia, GSNL and Europe's GMES Emergency Management Service.

Gap Analysis

Despite much broader application of satellite EO to DRM than a few years ago there are areas where clear opportunities exist for enhanced contributions. Although there are gaps in all areas of monitoring, it is important to consider where the most significant gaps are, both from the point of view of the disaster phase and *vis-a-vis* hazard specific communities. Perhaps the most significant area where disparities exist between available capacity and application of satellite EO is with regard to flood mitigation and warning. The development of a systematic imaging plan for areas of regular flooding in the world's largest rivers basins would represent a significant advance from what is undertaken today. Such a systematic imaging plan for flood prone areas does not exist today on a global, prioritised basis. For geohazards, the Santorini Conference in May 2012 was an opportunity for leading thinkers to come together and discuss the state-of-the-art in satellite-based EO and objectives for the community over the coming 5 to 10 years. EO was viewed as a critical tool to extend monitoring to unmonitored volcanoes. Currently planned missions would enable, for example, regular monitoring of some 1500 potentially active volcanoes. With regard to seismic hazards, while it was apparent that satellite EO will possibly never aid in the short-term prediction of earthquakes, new techniques and satellite systems would enable the development of a new global strain rate model at high spatial resolution that would incorporate InSAR and GPS based measurement. This would ideally include the provision of satellite interferometric data for continuous observations of the seismic belts worldwide. With regard to landslides, it was clear that InSAR techniques allow for mapping and inventories of areas at risk, and that the risk assessment services available so far on cover a small fractions of landslide risk regions. This analysis, begun during the drafting of the Consensus Report, will be further deepened and completed in the drafting of the Implementation Plan.

To summarize, the report has identified three major categories of gaps: data gaps, awareness gaps and capacity gaps.

Data Gap - (Actions # 1 and 2)

The first major category of gaps is gaps related to data. Although there are large number of satellites in orbit and planned for launch, certain data gaps remain principally because existing and planned satellites are not currently planning acquisitions to address specific categories of DRM users.

These gaps have been addressed in the thematic sections on plain flooding, seismic hazards and landslides, and will be further refined. More analysis is required to address potentially important gaps in relation to volcanoes and droughts, and perhaps other hazards as well. However, the identified hazards collectively represent the most promising areas for enlarged contributions in the opinion of the *ad hoc* Disaster Team.

Awareness Gap - (Actions # 3 and 5, 6 and 8)

It is clear from even a summary review of user needs and the activities of user organisations that awareness of the potential of satellite EO remains a major hurdle for increased uptake of EO data by the DRM community. This gap can be further subdivided into the following categories:

- Lack of awareness of means of finding EO data;

Within the user community, there is a lack of knowledge of how to access data, and more critically, how to determine whether appropriate data sets exists through consultation of metadata catalogues. In order to establish whether or not data is available, a user must consult many different archives from different data suppliers, even when searching for the same type of data. For example, a user trying to determine whether there is C-band synthetic aperture radar (SAR) data over a river system must consult the metadata archives of ERS-1 and 2, Envisat, the Canadian Space Agency (CSA) and MDA. In some cases, value-added providers can do this as a service for an end-user, however many value-added providers work with only subsets of data suppliers, meaning the answer to the user query will be incomplete.

- Lack of awareness of utility of data;

Even when data is known to exist, it is not clear within the user community that the benefit derived from EO usage warrants the investment.

- Lack of acceptance of EO as an official tool to deliver on governmental mandates;

There is a need for official recognition of the utility of techniques, so that they may become standard procedures. This requires full-scale trials with national authorities that demonstrate value.

- Lack of confidence in long-term data continuity/availability.

There is a need to promote existing and planned missions, which collectively offer much greater data continuity than in the past. CEOS could play a pro-active role in this respect.

Capacity Gap - (Actions # 4 and 7)

A third category of gaps refers to capacity. There is within the user community and to some extent within the value-added industry an inability or insufficiencies in the development of products or services for DRM derived from satellite EO data. For users, this usually refers to a need for increased training and resources; for the value added industry, this is related to wishes for access to advanced computing and processing resources beyond the scope of those available to individual companies.

Key Findings

In addressing gaps, members of the ad hoc Team strongly felt that a detailed implementation plan needed to be developed along the following principles:

- The proposed Actions are non-binding (some members will not support all actions);
- The proposed Actions are 'a la carte' (some members may support only parts of actions);
- The proposed Actions taken collectively form a CEOS vision for DRM action, but may take many years to implement;
- The implementation plan will include as a first step, further review of user information needs, CEOS prioritization of response to needs according to CEOS means and resources, and development of a clear observation strategy that addresses both the needs of users and the ability of data providers to contribute;
- The implementation plan will recognize that proposed Actions include a clear hierarchy; within the main Actions, Actions 1 and 5 begin after approval in principle, whereas Actions 2, 3 and 4 are provided for completeness but are subject to successful delivery of Action 1 and may be modified as CEOS continues its study of this area;
- The implementation will strike a balance between two clear goals – the desire to achieve ambitious objectives and the need to re-use to maximum extent existing activities to limit the need for new resources.

A CEOS Vision for DRM

Through the review of the information needs of users both in existing documents and through an analysis relating to flooding, earthquakes and landslides, the ad hoc Disaster Team was able to identify critical gaps in relation to data, awareness and capacity. These gaps offer CEOS an opportunity to demonstrate the effectiveness of EO for DRM users in targeted actions that will increase the visibility of EO and demonstrate the cost-benefit of satellite-based solutions. The summary review of CEOS Agency DRM-related projects shows great promise for identifying specific areas where existing projects can be re-used and collated for greater impact. The *ad hoc* Disaster Team has elaborated eight proposed actions (five enlarged actions and three supporting actions) that chart out a vision for future CEOS activity relating to DRM. This vision necessarily builds on existing and planned projects and capacity, avoiding duplication and weaving a comprehensive approach to enable satellite EO to support DRM needs. If approved for implementation, this vision requires an Implementation Plan that will identify the specific priorities in the near-term and limit the commitment of CEOS Agencies.

Five Enlarged Actions Concerning Satellite EO and Disaster Risk Management have been identified:

Action # 1: Define a Global Satellite Observation Strategy for DRM: Perform a detailed analysis of needs and gaps for a few selected "pilot" hazards that leads to the generation of a set of requirements to be addressed by space agencies. Then, define a strategy that addresses those requirements, in order to better use EO missions for an improved contribution to user communities; defining plans of data acquisition and delivery, including the definition of the DRM baseline data - ***a strategy to define which EO data support DRM.***

Action # 2: Implement the Global Satellite Observation Strategy for DRM: Implement the Global Satellite Observation Strategy defined in action # 1, focusing on building dedicated archives for DRM; – ***ensuring EO data are there.***

Action # 3: DRM Virtual Data Repository: Offer to any DRM user access to EO data; this shall include the delivery of a DRM Baseline Dataset (data at no cost for selected observations/selected themes and limited geography) and the development of a user-driven data selection tool – ***where and how to get EO data.***

Action # 4: DRM Data Processing Platform: Develop capacity to enable access to EO-based value-added products, tools and on demand processing - support science and services exploitation of Satellite EO (requires infrastructure for science data) – ***enable EO-based content generation and hosting user generated content.***

Action # 5: Positioning Satellite EO in the post Hyogo Framework for Action (HFA) activities: Ensure a major and visible contribution for EO satellites in the post-Hyogo Framework for Action (2015-2025 period) – ***raising the profile of EO.***

Three supporting actions are proposed, to build on existing activities and increase their impact. They are:

Supporting Action # 6: DRM Outreach and Evaluation of CEOS Actions: Animation of the scientific and technical content of the Virtual Repository and Exploitation Platform, linking to practitioners/users of DRM communities, measuring impact and evaluating effectiveness – ***manage, explain and promote the content.***

Supporting Action # 7: EO Capacity Building for DRM: Establish a network of regional capacity building partners to ensure that countries active in DRR have space-based EO related capacity to be applied to DRM – ***helping others use EO.***

Supporting Action # 8: Sat EO DRM Project Database: Create a searchable database to help CEOS Agencies (and eventually outside partners and user organizations) identify relevant space-based EO DRM projects – ***helping others find DRM projects that use EO.***

The collective contribution represented by the sum of these eight actions represents a significant new contribution to DRM, with a solid focus on Disaster Risk Reduction. These actions offer CEOS a visible new contribution (through the DRM Baseline Dataset in particular) that will be welcomed by international DRM stakeholders and users alike.

The actions are inscribed in a vision that incorporates existing successes such as the Charter, Sentinel-Asia and the developing GEO Supersites and Natural Laboratories. This vision rounds out current satellite-EO-based efforts by ensuring that EO supports the full cycle of disaster management and can be implemented globally on an incremental basis. The implementation of this vision will require that CEOS agencies set priorities with regard to both geographic and hazard-type areas of focus.

Recommendations

The CEOS *ad hoc* Disaster Team recommends that the CEOS decision bodies take the following actions:

1. Endorse the Study Consensus Report including the Enlarged Actions Concerning Satellite EO and DRM described in section 4;
2. Establish a CEOS DRM Project Team to produce Terms of Reference and a draft Implementation Plan for the March 2013 SIT meeting. The Terms of Reference and Implementation Plan for Project Team should describe relations with the Disaster SBA Coordinator, Space Data Coordination Group, the Working Group on Information Systems and Services, the Working Group on Capacity Development, and the Working Group on Calibration and Validation;
3. Extend the mandate of the existing *ad hoc* Disaster Team to the March 2013 SIT meeting to ensure continuity of the activity until the establishment of the Project Team;
4. Mandate the *ad hoc* Disaster Team to begin coordination with the UN ISDR in the lead-up to the May 2013 post-Hyogo Framework for Action activities, before transferring this activity to the CEOS DRM team when it becomes operational;
5. Mandate the *ad hoc* Disaster Team to liaise with UN ISDR and other major stakeholders and users to prepare the Implementation Plan, before transferring this activity to the CEOS DRM team when that Team becomes operational.

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1. Introduction and background

1.1 Purpose of the document

The Study Consensus Report on CEOS Support to Disaster Risk Management (DRM) has been prepared by the CEOS Disaster *Ad Hoc* team, following a request from the CEOS Principals made during the 2011 CEOS Plenary. It contains a set of recommendations aiming at increasing and strengthening the role of CEOS space agencies in all phases of DRM.

This version of the study report is intended for CEOS internal use only. The primarily readers of the document are the CEOS Principals, who are familiar with CEOS and with the topics being discussed during the CEOS Plenary sessions. Reading this document does not require any specific knowledge in DRM.

1.2 Why is DRM important?

In 2010, disaster events caused the death of almost 300,000 people, affected another 220 million and resulted in more than $120 billion in economic damages. Impacts of disaster events on economic and human lives are increasing every year due to growing urbanization and an increase in the number and severity of extreme of weather-extreme events; by 2050, the number of people exposed to storms and earthquakes in large cities could double and by 2100, damages from weather-related hazards may triple. While 2011 saw a drop in fatalities (29,782), the damages tripled to over $366 billion (cf. figure 1, below). The Japanese earthquake and tsunami of March 2011 accounted for over half these damages on its own. Some 206 million people were affected by disasters in 2011, including 106 million by flooding and 60 million by drought, mainly in the Horn of Africa.[2]

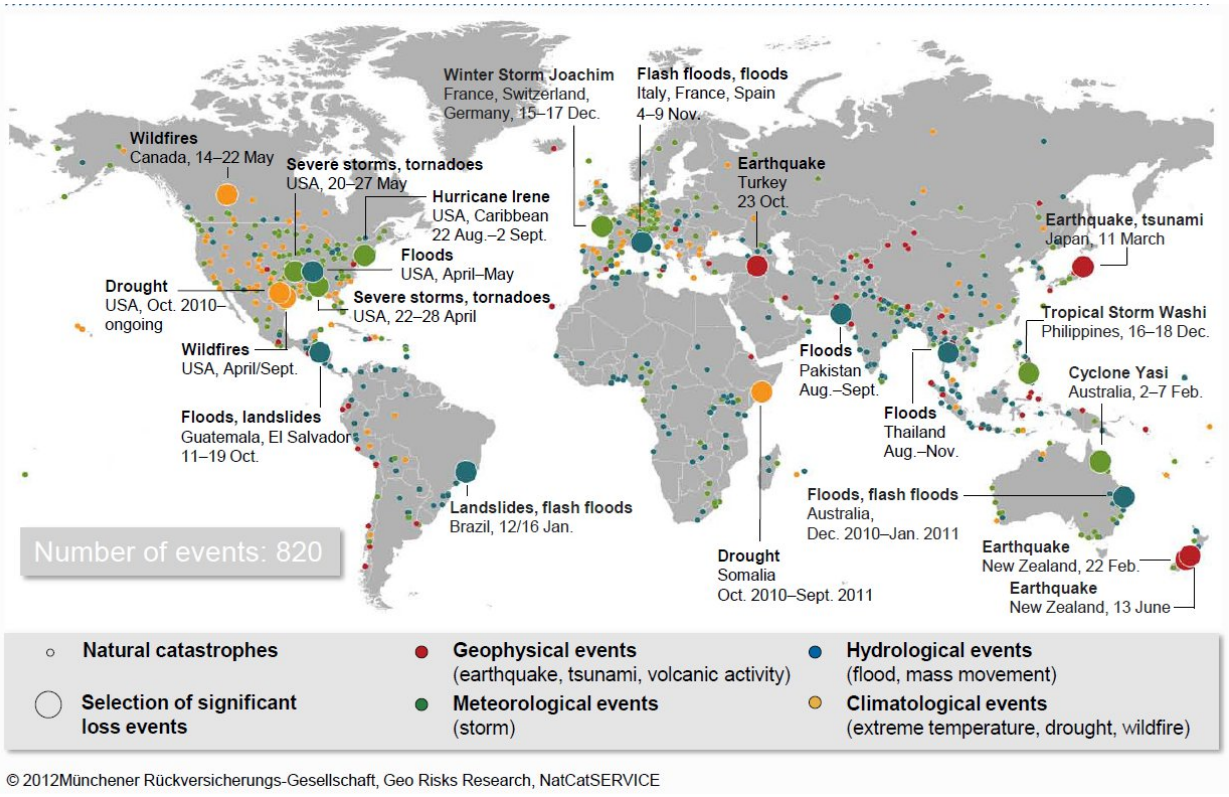


FIGURE 2. NATURAL CATASTROPHES IN 2011, COURTESY OF MUNICH RE (2012)

[2] Source AFP as quoted at www.undp.org.

Over the past 30 years, the proportion of world population living in flood-prone river basins has increased by 114%, while those living on cyclone-exposed coastlines have grown by 192%. Over half of the world's large cities, with populations ranging from 2 to 15 million, are currently located in areas highly vulnerable to seismic activity. Rapid urbanization will further increase exposure to disaster risk[3].

Analyses carried out by national governments, the United Nations (UN) and other international and non-governmental organisations have highlighted a growing vulnerability to disasters, partly as a consequence of increasingly intensive land use, industrial development, urban expansion and infrastructure construction[4].

In the last five years, the worldwide trend has been to invest more in preparedness and mitigation phases to reduce financial impacts of response and reconstruction. Until recently, international organisations have been mostly involved in the response phase but now they also work on other DRM phases, in particular preparedness and prevention. Independent studies for organisations including the World Bank have indicated that the return on investments in disaster prevention is between 400% and 700%.

National and local decision makers are very sensitive to consequences of disasters, not only for the economic and human impacts but also for their management of the crisis. They therefore must be ready to show leadership when a crisis strikes. This partly explains recent growing interest by politicians in DRM, now perceived as critical and more urgent than climate change mitigation and adaptation.

1.3 A CEOS Disaster Initiative – background and rationale

The increasing importance given by politicians, decision makers and stakeholders to DRM will result in an increasing demand to all actors such as Earth observation (EO) data providers, scientists and relevant value-added industry. Space agencies have demonstrated the added value of EO satellite value in DRM through some major international initiatives such as International Charter 'Space and Major Disasters' (the Charter), the GEO Geohazard Supersites and Natural Laboratories (GSNL) or Sentinel Asia, and through many national projects. The success of the international initiatives mentioned above has been made possible thanks to the international cooperation; no single space agency could have provided a global service with the same quality.

To date, much of the DRM effort of space agencies has been focused on disaster response, which by its nature attracts more attention and more resources. DRM experts globally recognize however that more lives can be saved and property can be better protected through pro-active investment in disaster risk reduction or mitigation.

The DRM framework is changing rapidly with the predicted increase of the human and economic impacts and with the new strategy of major stakeholders increasing their support to all DRM phases. There is an obligation but also an opportunity for the space agencies to bring adequate solutions to the increasing needs from the DRM community. With the coming 2015 post-Hyogo Framework for Action (post-HFA), there is a great opportunity for EO space agencies to position themselves. A prerequisite to this increased role that could be sought by space agencies is the demonstration of the benefits that can be obtained from timely access to satellite-derived data and information products. Agencies should highlight the fact that EO satellite data providers form one element of the end-to-end chain that starts with data acquisition and ends in beneficial user applications. Hence, CEOS Agencies need to find the right external partners to guarantee a successful contribution to DRM. CEOS Principals participating in the 2011 CEOS Plenary agreed to establish an *ad hoc* team tasked with preparing a report with findings and recommended enlarged cooperation actions aiming at reinforcing the role of CEOS space agencies in DRM. This report, to be presented at the next CEOS Plenary (Oct. 23-24, 2012), proposes a strategic, coherent and collaborative approach.

Successful contribution from space agencies to DRM will:

- Increase the awareness of decision-makers of the critical role of satellite EO; and

[3] UNISDR Global Assessment Report 2011: Revealing Risk, Redefining Development.
[4] ISDR, Global Trends Report, 2007

- Reinforce the need for enhanced satellite EO programs to better address DRM needs.

1.4 CEOS *ad hoc* Disaster Team establishment, mandate and objectives

At the 25th CEOS Plenary Meeting in Lucca, Italy, CEOS principals discussed the need to examine activities of member Agencies across the disaster cycle and ensure a balanced effort across the cycle and amongst the agencies. CEOS Principals proposed that an *ad hoc* team be formed to look at a more effective CEOS contribution, by assessing gaps, overlaps and consideration of the balance of effort. This could be achieved by a focused discussion of those agencies that are investing resources in the current disaster-related activities – reporting to a future CEOS meeting on the recommended way forward. The CEOS Disaster *ad hoc* team was subsequently formed early in 2012, and met in Frascati in February and in Tokyo in April, as well as several times by teleconference. The Team currently includes representatives from the following agencies: ASI, CSA, CNES, DLR, ESA, EUMETSAT, JAXA, NASA, NOAA and USGS, as well as from the CEOS Executive Office/Deputy Executive Officer and the CEOS Systems Engineering Office (SEO). The Team was mandated to report back to the SIT and Plenary in 2012, and this report is the work of that Team.

1.5 Historical context, other initiatives

Several CEOS Agencies have been or are involved in many projects and initiatives related to DRM either as CEOS or outside the CEOS framework (*e.g.* the Charter, GSNL and Sentinel Asia).

This section addresses only the involvement of the CEOS community as such either in CEOS standalone programs and initiatives, or sometimes as contribution to non-CEOS projects.

CEOS Disaster Management Support Group: from 1997 to 2002, the CEOS Disaster Management Support Group (DMSG) *ad hoc* working group was active, holding numerous meetings and workshops, and issuing reports. The goal of the DMSG was to support natural and technological disaster management on a worldwide basis by fostering improved utilization of existing and planned EO satellite data. The DMSG focused on developing and refining recommendations for the application of satellite data to selected hazard areas. Their final report is referenced in Appendix 1.

IGOS Geohazards: The Integrated Global Observing Strategy (IGOS) Geohazards Theme was a combined initiative of CEOS and two other IGOS members, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the International Council for Science (ICSU). The IGOS Geohazards theme intended to respond to the scientific and operational information needs for the prediction and monitoring of geophysical hazards, namely earthquakes, tsunamis, volcanoes and ground instabilities. The IGOS Geohazards Report is referenced in Appendix 1.

CEOS Disaster SBA team: after the establishment of the Group on Earth Observations (GEO), CEOS created a Disasters Societal Benefit Area (SBA) Team, chaired by the Canadian Space Agency (CSA). Through the Disaster SBA Team, CEOS has coordinated several critical contributions to GEO work, including the Caribbean Satellite Disaster Pilot (CSDP), the Namibian Flood Pilot (now Southern African Flood and Health Pilot), as well as the work of the team on User Requirements for the Use of Satellite Data for Risk Management (2008 report referenced in Appendix 1 and from which the tables in Annex 2 were taken).

2. Global Disaster Risk Management Activities

There has been significant discussion around the table of the CEOS *ad hoc* Disaster Team meetings on the definition of the end user. It has been pointed out that while Disaster Risk Reduction is necessarily a local or at least national activity, a global initiative requires international or at least regional champions that consolidate the needs of the users and serve as an intermediary for organisations such as CEOS. These organisations are not users, but rather stakeholders with a recognised interest in DRM and risk reduction in particular. Examples of such organisations include the Global Facility for Disaster Reduction and Recovery (GFDRR, hosted by the World Bank), the United Nations International Strategy for Disaster Reduction (UNISDR), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the United Nations Science, Education and Culture Organisation (UNESCO). Other relevant organisations that may serve as relays or partners include United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER), United Nations Institute for Training and Research (UNITAR)/ Operational Satellite Applications Programme (UNOSAT) the World Meteorological Organisation (WMO), and GEO.

The section below describes existing user types and the role of some major stakeholders. A more detailed description of the stakeholders taken from their own materials can be found in Annex 2 – Global Stakeholders.

2.1 DRM stakeholders and users

For Disaster Risk Reduction in particular, it is worth noting that decisions are taken at the local level, or through the impetus of a national initiative or legislation. DRR end-users are thus not regional or international, which poses challenges for coordinated global actions. The description below outlines the structure of the DRM user community.

A) Users at national level:

Different types of users segments are directly or indirectly involved in the implementation of DRM related policies and directives. DRM involves diverse and numerous actors that have different institutional mandates in the various phases of DRM, such as the Federal Emergency Management Agency (FEMA) in the US, but also and more critically state governments, which are responsible for response to disasters in federal systems, as was the case in the state of Louisiana during Hurricane Katrina.

FIGURE 3. FIRST RESPONDERS IN PAKISTAN, WORKING WITH CHARTER RAPID MAPPING PRODUCT AFTER BALOCHISTAN EARTHQUAKE OF OCTOBER 28, 2008. PHOTO CREDIT TELECOMS SANS FRONTIERE.

A basic principle in both prevention and emergency management is that all the civil protection actions must be taken at the appropriate hierarchical and geographical level, starting from the municipality and only in the case of emergency situations on the State level. Therefore civil protection responsibilities are delegated using a top-down logic, from the national level to the regional, provincial/state and finally municipal levels.

There are four main categories of user organizations:

- Policy decision bodies that include:

  - National-level authorities in charge of civil protection and risk prevention policies;

  - Sub-National authorities, which have a large decision power, at their territorial level, in risk management policy implementation and in resource assignment to operational services.

In addition to their policy/decision role, these organisations also have operational responsibilities (coordination, decision-making) during risk management, and thus have specific information requirements:

- Risk mapping/prevention services, the institutional services in charge of the risk analysis and risk prevention policies (*e.g.* regional environmental agencies, forestry services, river basin management authorities);

- Risk anticipation/forecasting services, the institutional services in charge of the risk anticipation and forecasting (services that work in close collaboration with meteorological services);

- Rescue management and fire fighting services, the local, regional and national (and sometimes supra-national *e.g.* EC level in Europe) Civil Protection and rescue services that are in charge of overall response management.

Example of user organisations at national level:

Civil Protection Agencies; Ministries of Internal Affairs / Civil Protection Department; Ministries of Environment; Ministries of Agriculture / Forest Services; National Environmental Agencies; National Forest Services; Regulators and national authorities involved with environmental impact assessment, land planning programmes, mining activities, emergency response, civil protection and risk management; Geoscience centres and, in particular, Geological Surveys.

Example of user organisations at sub-national level:

Regional Operational Centres for Civil Protection; Regional Environmental Authorities; Regional Forest Services; River Basin Authorities.

Example of user organisations at local level:

Municipalities; Local services for Fire Fighting and Rescue; Local Services for Agriculture and Forests; Local Services for Equipment; Authorities and administrations at city, local and national levels including specific technical committees formed by national or local authorities (planners, building control, environmental health, legal), environmental regulators, conservation regulators, nuclear installations inspectors, civil defence planners/authorities, river basin authorities, etc., who provide recommendations to legislative bodies.

Each hazard type has its own subset of users, with specific interests tied to the hazard. Examples of specific DRM user segments are described in Annex 2.

In addition Annex 1 provides examples of policies that drive information demand in DRM.

B) At the international level:

As stated above, most 'users' at the international level, are in fact stakeholders, introducing policy initiatives but not directly responsible for disaster risk reduction or disaster management *per se*. These actors include stakeholders in the international humanitarian community (with a focus on Disaster Response) and in the international development community (with a focus on Disaster Risk Reduction):

- The United Nations and other international organisations, specifically the agencies that have mandates related to disaster risk reduction (*e.g.* UNISDR, UNDP, UNEP, UNESCO, WMO, UNITAR-UNOSAT, UN-SPIDER);

- Donors Governments (including governmental agencies) and international/regional development banks such as International Financial Institutions (*e.g.* GFDRR, World Bank, Inter-American Development Bank (IADB), Asian Development Bank (ADB), etc.) or umbrella organisations for cooperation (e.g. GEO);

- Non-governmental organisations (NGOs), both national and international, including associations of NGOs (e.g. International Federation of Red Cross and Red Crescent Societies (IFRC), VOICE, CARE, etc.);

- Private sector companies (*e.g.* insurance sector as an end user, or value adding sector as intermediary user).

2.2 Potential partners and possible programme linkages

No single organization or government has a responsibility to meet international requirements for satellite-based DRM data. Indeed, there is no consensus on the existence of such international requirements, but rather a collection of compelling needs organised on a regional or national basis or along DRM sub themes such as seismic risk or flooding. No single organisation has 'ownership' of these requirements, making it difficult to objectively categorise them and prioritise them. That said, it is clear that there is a strong need for increased DRM data and information, and that satellites are uniquely positioned to provide much of these data. CEOS can serve a meaningful role in assisting international organisations in federating diverse requirements which can be addressed by space-based EO and defining key contributions for member agencies to make on a best efforts basis. Working with user organizations to identify resources to leverage initial 'in-kind' contributions of data, the international community may make meaningful progress towards increasing the use of EO in DRM. This activity may also enhance demand and funding authority for commercial imagery, and ultimately increase the number of satellites designed and built to support disasters.

It is clear from the texts of agreements such as the United Nations Framework Convention on Climate Change (UNFCCC) or other related conventions on biodiversity and desertification that satellite data can help infer a wealth of information to address monitoring and verification needs. United Nations agencies are currently planning for the post-2015 framework to succeed the HFA (period covered: 2005-2015), with renewed emphasis on concrete action to implement recommendations. In this new framework, satellites may play a critical role, particularly in reducing the underlying risk factors and strengthening disaster preparedness for effective response. Satellite data can supply regular, detailed updates on the status of hazards on a global, national, or regional basis.[5]

Identifying possible partners for the enlarged DRM actions presents certain challenges. As seen above, the end users for risk management activities are typically national users or local users. These are disaster management authorities or organisations with a thematic responsibility (*e.g.* a volcanic observatory). CEOS linkages need to be sought at a higher level to ensure that CEOS agencies can contribute in a comprehensive fashion, rather than through a series of very limited pilots. Global DRM stakeholders offer CEOS strong anchorage points for collaborative action, and will assist CEOS in its positioning efforts. The key stakeholders reviewed include: the GFDRR, UNISDR, UNDP, UNEP, UNESCO, WMO, GEO, UNOSAT and UN-SPIDER. CEOS also recognises the critical enabling role played by GEO as a framework for collaborative activity.

[5] From CEOS EO Handbook 2012.

Amongst all these stakeholders, there are some that work with end users on a regular basis. GFDRR is one of the most critical of these stakeholders, because of its strong role as intermediary between donor governments and national and local institutions. GFDRR is also in a position to set standards for internal EO-based DRM contributions, making it a desirable partner for CEOS. GFDRR is hosted by the World Bank but represents some 41 countries and eight international organisations. It has three main business lines to achieve its development objectives at the global, regional and country levels.

- Track-I: Global and Regional Partnerships
- Track-II: Mainstreaming Disaster Risk Reduction in Development
- Track-III: Standby Recovery Financing Facility for Accelerated Disaster Recovery

In addition to these business lines, GFDRR has initiatives such as the GFDRR Labs which may offer partnering opportunities for CEOS.

The activity areas of GFDRR where Satellite EO information can have an impact are:

Track-II: geo-information to support risk assessment;

Track III: geo-information to support Post Disaster Needs Assessment (PDNA).

Within the UN family, while not a user *per se*, UNITAR-UNOSAT is the leading supplier of EO-based solutions for UN agencies and can serve as a key relay of data, information and standards.

UNISDR is the United Nation's office for disaster risk reduction. It was created in December 1999 as part of the UN Secretariat with the purpose of ensuring the implementation of the International Strategy for Disaster Reduction. Its mandate is to serve as the focal point in the UN system for the coordination of disaster reduction and to ensure synergies among disaster reduction activities. Given UNISDR's critical role with regard to the drafting and now updating of the HFA, and the support offered to achieving the Millenium Development Goals, UNISDR is uniquely positioned to relay to the international community a strong message on the usefulness and effectiveness of EO-based DRM solutions.

The current 2005-2015 HFA has five priority actions:

Priority Action 1: Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.

Priority Action 2: Identify, assess and monitor disaster risks and enhance early warning.

Priority Action 3: Use knowledge, innovation and education to build a culture of safety and resilience at all levels.

Priority Action 4: Reduce the underlying risk factors.

Priority Action 5: Strengthen disaster preparedness for effective response at all levels.

EO can play an active role in supporting the objectives of the HFA at several levels. EO is the most cost effective means of reinforcing knowledge of hazards on a global a basis and compiling exposure data that assists in establishing the vulnerabilities of populations and environments. The components of the HFA where satellite EO information can have the largest impact are priority Actions 2 and 3, above.

UNISDR is leading a major international consultation process beginning in 2012 with a view to updating the HFA by 2015. CEOS has much to gain by becoming involved in this key process in a visible way.

As a result of the leadership roles they play in relation to global development practices and global environmental stewardship, organisations like UNDP and UNEP are also possible partners for CEOS in DRM. Each of them has

dedicated programmes for Disaster Risk Reduction (described in Annex 2), and each seeks to improve the integration of Information and Communications Technology (ICT) in their service delivery. Similarly, UNESCO and the WMO have active Disaster Risk Reduction programmes tied to specific elements of their mandates (water and landslides for UNESCO, weather and water for WMO).

Finally, UN-SPIDER has a clear mandate from the United Nations General Assembly to "ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle". Their focus is on serving as a bridge between the space community and the DRM community and by being a facilitator of capacity-building and institutional strengthening, particularly in developing countries. While UN-SPIDER has no operational mandate, it does offer partnering opportunities for capacity development on a region-by-region basis.

2.3 Information needs, observational requirements and major gaps

There are many different actors involved in the DRM process at local, national, regional and international levels. Their capacity to integrate technology and information changes on a geographic and development basis, and their different mandates determine the nature of their varying needs for data and information.

To date, there is no comprehensive global requirement established for DRM. With regard to certain phases, such as disaster response, the requirement is much better understood, although here also, it is met only in so far as major disasters are concerned, and only with limitations, especially concerning the timeliness of data delivery.

The observation needs can also be divided according to purpose along two broad lines: hazards and exposure. Hazard data relate to specific hazards and their likelihood of occurrence. These data include for example information on volcanoes, such as ground deformation, or atmospheric information on volcanic ash dispersal. Exposure information is the total value of elements at-risk. It is expressed as the number of human lives, and value of the properties, that can potentially be affected by hazards.

CEOS has twice undertaken to determine the type and volume of data required to meet the needs of disaster and risk managers, both in the CEOS DMSG begun in 1997 and concluded in 2002, and in the work of the CEOS Disaster SBA Team under GEO Task DI-06-09 (2006-2010).

The DMSG made detailed recommendations on specific types of measurements to be included in future missions, but fell short of recommending specific acquisitions. It concluded:

- Disaster management and response community willing to use space technology but reluctant to assimilate new technology and information quickly
- Technology demonstrated conceptually but not operationally
- Critical factors are timeliness, cost, accessibility, ease of use, reliability, repeatability, and operational capability (the last three factors having significant impact on user confidence and user investment)
- Need to integrate data (multiple agencies, mirroring, space and non-space data)
- Need for a broad-based data policy.

The hurdles listed by the DMSG some ten years ago remain largely valid today, though progress has been made, especially in addressing issues such as timeliness, cost, integration of data and operational capabilities. These barriers are revisited below and several of the Actions proposed in section 4 address them specifically.

The later CEOS work, under DI-06-09, was quite detailed and involved large numbers of representatives from user organisations. It produced tables of requirements for seven disaster types, but fell short of producing a prioritised list of user requirements. Such a list would in fact be highly subjective, given the broad range of users, the large number of hazards considered and the global scope of the exercise. The results of the GEO DI-06-09 User Requirements report are summarised in tabular format in Annex 2.

More recently, a number of organisations have made headway determining some clear "global" requirements in relation to a number of selected hazard themes, particularly in relation to geohazards. At the Santorini Conference in May 2012, the international geohazards community articulated a series of requirements for satellite observations to support an ambitious science and operations agenda for the coming years. CEOS agencies present at this conference included CNES, DLR, ESA, JAXA and USGS. Many of the information needs put forward at this conference have been included in this report, and led to the development of the Actions listed in section 4, below. These needs included a global strain map for seismic risk, comprehensive volcanic monitoring and landslide inventories and monitoring.

Within GEO, the GEO Summit has identified clear strategic targets for the Disasters SBA, and satellite EO can make a substantial contribution towards their achievement. The GEO Secretariat has worked closely with CEOS to better understand the needs of the global disaster management community for satellite-based data.

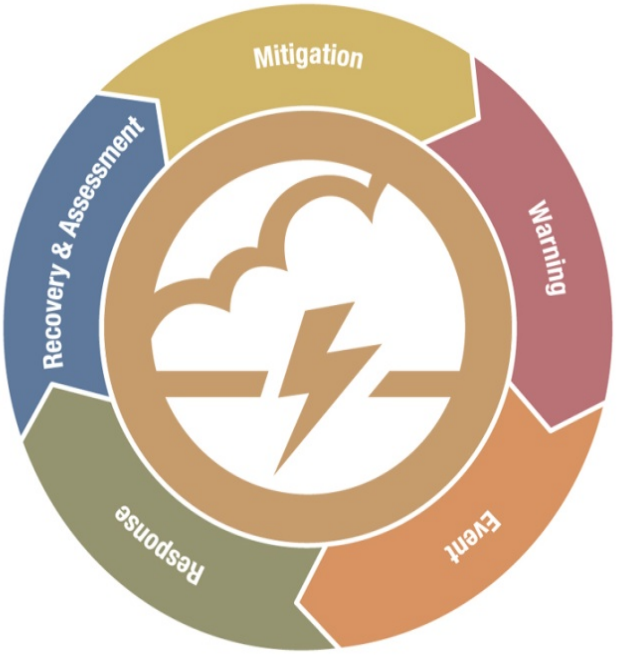
The International Forum on Satellite Earth Observation for Geohazard Risk Management (the Santorini Conference) was organized by ESA in association with GEO in Santorini, Greece, on 21-23 May 2012. The Santorini Conference formulated concrete objectives concerning what geohazard communities aim to achieve within 5-10 years and made recommendations concerning satellite EO data needed and the underlying observation strategies. The International Forum gathered over 140 participants from 20 countries including European countries, the US, Canada, Japan and China.

These needs led to observational requirements, which can be stated at varying levels of detail. Each of the thematic sections that follow provides detailed requirements flowing from information needs. These needs span multiple disaster types, the various phases of the disaster cycle and many types of satellite data, including:

- medium and high resolution optical data;
- medium and high resolution microwave radar data;
- interferometric SAR data products;
- infrared and thermal data;
- meteorological data sets and models.[6]

[6] From CEOS EO Handbook 2012.

2.3.1 Disasters by phase and existing capacity



Much of the focus of disaster activity is currently on the high-profile response phase, during which rapid action can save lives. Satellite EO is a recognized solution for enabling more efficient relief actions and supporting aid actors with objective and up to date information. It is however widely accepted that increased efforts on risk reduction during the mitigation and warning phases of a disaster will save more lives and protect property by reducing the exposure of populations to the hazard. An enlarged CEOS action plan should consider the entire cycle of risk management (mitigation, warning, response and recovery), especially considering existing efforts with regard to response, principally through the Charter, Sentinel-Asia and Europe's Global Monitoring for Environment and Security (GMES) programme. In this section, information needs are reviewed by phase and by hazard type. A clear conclusion is that DRM activities today would be greatly enhanced by a significant new contribution from the satellite-EO community. While much has been improved in the last ten years, major gaps remain with regard to critical disasters, especially in the area of disaster risk reduction.

FIGURE 4. THE DISASTER RISK MANAGEMENT CYCLE, FROM THE ATHENAGLOBAL EARTH OBSERVATION GUIDE, 2005

Reducing the severity of disasters requires the integration of observations, exploiting predictive modelling, and disseminating timely and accurate information needed by all actors involved in response and risk mitigation. EO's contribution to the provision of refined risk assessment includes up to date localisation and characterization of the asset at risk; information to support prevention plan elaboration; supporting anticipation (for instance forecasting and early warning/alert) as well as crisis management operations (rescue, recovery) and to help better understand the resulting environmental damages and natural recovery mechanisms.

It is true that many of the current generation of satellite systems were not designed specifically for DRM activities, with notable exceptions such as the Disaster Monitoring Constellation. However, the rapid pace of technology advance has led to the launch of increasingly flexible and powerful systems. These missions are now multi-purpose and offer exceptional coverage and scope. Taken collectively, the world's satellite systems offer a unique tool for DRM. CEOS has identified a number of key data requirements for disaster information that can be met by existing systems. For example, the requirements of disaster management centres concerning plain flood hazard have been gathered in consultation with national civil protection authorities: reference mapping are needed within the day of the hazard impact while rapid mapping of the flood extent is needed within a few hours or within a day, every day. Similar analysis has produced a characterization of requirements for other hazard types and other phases of DRM such as early warning - for a range of different hydro-meteorological or geophysical hazards - situational awareness during

and after disasters, precise damage assessment, support to recovery and reconstruction, etc.[7] While these needs are well-recognised at a high-level, they remain unmet today for a variety of reasons including lack of awareness of the benefits of EO, the complexity of the supply of EO, the cost of EO data and the lack of user capacity to assimilate data into systems. Chapter 4, below, proposes several actions to address these gaps.

Existing Capacity

Mitigation/Preparedness

Mitigation efforts offer DRM managers the best opportunity to save lives and protect property. It is however the most onerous phase of disaster management for data providers because of the large volumes of data and broad areas to cover; mitigation activity covers on-going monitoring of hazards and certain elements at risk between disasters. Comprehensive monitoring can lead to improved ability to warn before a disaster strikes. Mitigation also refers to science work undertaken to better understand the nature of the risks involved. This is the case for example of flood modeling or seismic strain modeling.

GEO's Geohazard Supersites and Natural Laboratories (GSNL)

The Geohazard Supersites, now GSNL, began with the "Frascati declaration" at the conclusion of the 3rd International Geohazards workshop held in November 2007 in Frascati, Italy. The recommendation of the workshop was "to stimulate an international and intergovernmental effort to monitor and study selected reference sites by establishing open access to relevant datasets according to GEO principles to foster the collaboration between all various partners and end-users". The supersites are supported by numerous partners including GEO, ESA, JAXA, NASA, DLR, ASI, NSF, UNAVCO and the European Plate Observing System (EPOS). Earthquake supersites exist in Istanbul (Turkey), Tokyo (Japan), Los Angeles (USA), and Vancouver/Seattle (Canada/USA). Hawaii is a volcano supersite. In addition, "event supersites" have been established after major significant earthquakes. Supersites were selected for scientific reasons but also to maximize the visibility of the project. They are not intended to be global in their reach, but to provide data for type examples of hazardous systems or natural laboratories.[1]

(http://supersites.earthobservations.org/)

One of the most important scientific developments for sharing large volumes of EO data over a limited number of sites has been the Geohazards Supersites initiative, now GSNL. These Supersites provide access to space-borne and *in-situ* geophysical data of selected sites prone to earthquake, volcano or other hazards.

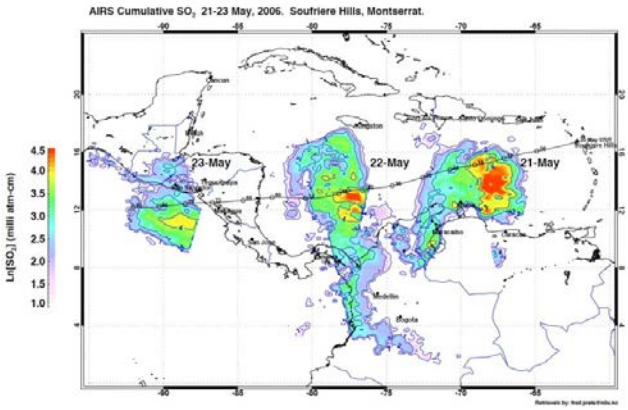


FIGURE 5. FIGURE 4. VOLCANIC ASH MONITORING FOR HAZARD WARNING. SOUFRIÈRE HILLS VOLCANO, MONTSERRAT, FOLLOWING THE ERUPTION OF 20 MAY, 2006. SO2 RETRIEVALS ON 7 CONSECUTIVE DAYS, FROM AIRS ON BOARD EOS-AQUA. CREDIT FRED PRATA.

Warning

Warning and alert activities flow directly from on-going mitigation. When a hazard is monitored on a regular basis, it is usually possible to determine that an event may be imminent, requiring different observation periods and the generation of information specifically tied to the predicted event. Today, the International Charter does not address warning activities, but a number of CEOS pilots do, including the GEO Regional End-to-end pilots led by NASA (CSDP, Namibia) and the ESA-led Volcanic Ash Initiative.

[7] From CEOS EO Handbook 2012.

Response

In the specific area of disaster response, the Charter has established a system to respond to global disasters on a best efforts basis, providing satellite-based information at no cost to disaster management agencies and the UN. Initiated by ESA, the French space agency CNES and the Canadian space agency CSA, the Charter began operations in 2000 and today has 14 members worldwide. Further to the International Charter, mechanisms such as Sentinel-Asia and SERVIR address similar concerns on a regional basis. In Europe, the European Commission has established Emergency Management Services to address the integration of satellite data for emergencies and is currently collaborating with the International Charter to provide Value Adding services to support the exploitation of imagery supplied via the Charter to European organisations for response in areas pertinent to the policy sectors of Europe, primarily in its territories and in regions where humanitarian assistance is invoked.

International Charter Space and Major Disasters

Globally the main mechanism to exploit space technology for response is the International Charter Space and Major Disaster (http://www.disastercharter.org), an international collaboration among Space Agencies to provide a unified system to access imagery for disaster response. With 14 members today the International Charter is able to provide rapid access to data from a virtual constellation of a series of satellites, optical and SAR, tasked in rush mode to help disaster management centres in relief actions. This activity is focused on hazards with rapid on-set scenarios, on the hazard impact, and aims to service operational users, not science users. In practice, this means that raw data are provided to "value adding providers", who then create products that are of practical use to response teams on the ground *e.g.*, flood extent maps, building infrastructure damage extent maps, oil spill extent maps, etc.). EO data provided by the International Charter was for example invaluable for the emergency response and situational awareness during the 2010 Haiti earthquake.

The use of satellite data for response is now well-established for both natural or man-made disasters. Indeed, it is hard to imagine how response to such man-made catastrophes as the Deepwater Horizon oil spill in the Gulf of Mexico would be possible without the synoptic overview offered by satellite EO. Satellite imagery can be used to track the extent and direction of oil flows for containment, and, over time, to identify coastal wetlands adversely affected by the accident.

In the immediate aftermath of a disaster, the primary issue is timeliness. Satellites can provide rapid situational awareness over a large area, typically on a daily basis. This objective, synoptic view of the theatre of operations offers the DRM community a powerful tool to support recovery over the days and weeks that follow a major catastrophe.

In Europe, the EU Framework programs have supported several important projects on emergency response, which are now integrated as part of GMES. Until 1st April 2012, the pre-operational emergency management service of GMES was provided through the EU-funded project SAFER. On 1st April 2012, the mapping component of the GMES Emergency Management Service (GIO EMS - Mapping) entered into Initial Operations (http://portal.ems-gmes.eu). This is the first implemented Service of the GMES Initial Operations programme 2011-2013 (GIO). The GIO Emergency Management Service has a worldwide coverage. It can provide data in "rush mode", which covers the on-demand, and fast, provision of geo-spatial information supporting the authorities in charge of crisis management, immediately

Post Disaster Needs Assessment (PDNA)

"The post disaster damage, loss and needs assessments conducted under the leadership of affected country governments are the most important tasks of the Standby Recovery Financing Facility [of GFDRR]. The flagship products of [the Standby Recovery Financing Facility] are the reports that these assessments generate. These are reports of the respective governments prepared with the assistance of GFDRR and the international community at large. They are increasingly being used by governments and the international development community to base the recovery and reconstruction plans and programs upon. They are also as the base document for discussions to determine international development assistance in cases requiring external assistance including leveraging of targeted or additional assistance from the World Bank and other traditional donors."

http://www.gfdrr.org/gfdrr/PDNA

After 8.8 magnitude earthquake in Chile, GFDRR used pre and post high resolution imagery to establish the asset and evaluate the damage. GFDRR labs is experimenting with various EO-based techniques, including INSAR, to evaluate damage rapidly after events. GFDRR labs is partnering with JRC and UNITAR-UNOSAT to provide better PDNA using satellite EO.

following natural or man-made disasters, including earthquakes. Products include: reference maps based on archived EO data and damage delineation and grading maps derived from EO data, acquired immediately after the event.

Recovery/Assessment

Recovery is one of the least publicised phases of DRM, but also has critical components. Satellite EO can offer cost savings in monitoring of large areas or especially complex disasters where large number of organisations are present in the field and where recovery operations remain in place for several years, such as after the Indonesian tsunami or the Haiti earthquake.

Thematic Analysis and Key Data Gaps

As underlying research to prepare the analysis in this report the information needs of DRM users have been investigated. A broad range of natural hazards types have been assessed that comprise: hydro-meteorological events (such as windstorms, flooding), geo-hazards (earthquakes, volcanoes and landslides) and climatological events (extreme temperature, drought and wildfires). For all these themes, satellite EO can contribute to improving knowledge of hazards and risks and providing objective and useful information to mitigate, prepare for and respond to disasters.

The following section of the report will examine a selection of natural hazards representative of priority DRM themes for which satellite EO can provide benefit. Three representative themes have been selected with the aim to describe the main information needs of the users and the possible EO-based capacity, which might address the need, the satellite observational requirements to obtain this information, the current status of application of EO in this area and major gaps. The areas covered by the report, at a high-level, are plain flooding, seismic hazards, and landslides. These themes were selected both on the basis of the impact of these hazards (floods and earthquakes cause the most loss of life and the largest damages globally both annually and over time), and on the potential contribution from satellite EO (in the case of landslides, where significant new contributions are possible). It is clear that other areas could be

Sentinel Asia is a voluntary basis initiative led by the APRSAF (Asia-Pacific Regional Space Agency Forum) to support disaster management activity in the Asia-Pacific region by applying the WEB-GIS technology and space based technology, such as earth observation satellite data.

Main Activities

- **Emergency observation by earth observation satellites in case of major disasters**
- **Acceptance of observation requests**
- **Wildfire monitoring, Flood monitoring and Glacier Lake Outburst Flood monitoring**
- **Capacity building for utilization of satellite image/data for disaster management**

Fast Sharing

- Satellite imagery (and data permitted by data provider) provided by space organizations
- Value-added images with extraction of stricken area, etc. created from satellite data
- On-site digital camera images
- Wildfire hotspot and rainfall information derived from satellite data
- Meteorological satellite information
- Basic map data
- Fine regional digital maps contributed to the network by national geography organizations, etc..

https://sentinel.tksc.jaxa.jp/sentinel2/MB_HTML/About/About.htm

considered, chief among them droughts (due to the related impact of famines) and volcanoes (again, where satellite contributions could be important). It is recommended in section 5, below, that further work take place on user requirements in consultation with user organisations, and that this work feed into the plan for coordinated global observations for DRM that is the subject of proposed Actions # 1 and 2.

2.3.2 Plain flooding

Plain flooding is important as it is the most common hazard on a frequency and area-affected basis, and affects the largest number of people, though large earthquakes and tsunamis are generally responsible for more fatalities over time. Plain flood risk is dynamic, and changes based on land use practices or subsidence for example.

DRM users are concerned by all emergencies not just mass disasters as indicated by the figure below. To illustrate the relationship between flood hazards and disasters, there were 33 significant flood events in the US between 2000 and 2011, according to FEMA, and 10 of them were covered by the Charter.

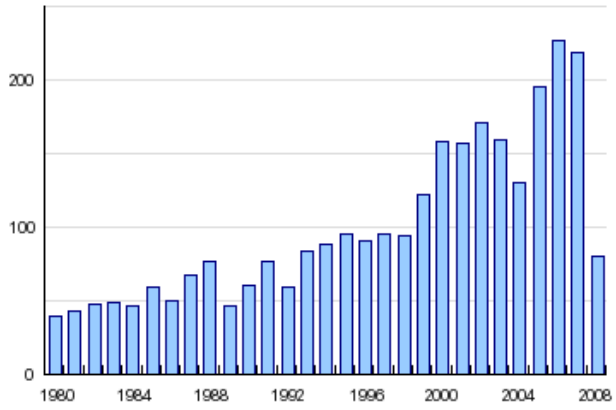


FIGURE 6. NATURAL FLOOD HAZARDS WORLDWIDE: SUMMARY OF FLOOD EVENTS FROM 1980 TO SEPTEMBER 2008 ACCORDING TO UN ISDR'S PREVENTIONWEB. AS A COMPARISON, OVER THIS PERIOD THERE WERE ON AVERAGE 5 FLOOD DISASTERS PER YEAR[8]

Satellite EO can play a meaningful role in reducing flood risk when integrated into a broader approach. Compared to other hazard types, global risk maps concerning flooding are subject to controversy. It is difficult to gather the required underlying data and information. Flood risk areas are immense as illustrated in figure 6 below. The map, generated in the framework of the GMES RESPOND and SAFER projects to indicate priority areas worldwide, illustrates areas of the world most affected by flood risk and where a coordinated strategy for regular data collects could make a significant difference, based on both dry season and wet season collects. It should be noted that while the map was generated by the RESPOND programme, the volume of required observations was such that the need remains unmet today. Ensuring satellite EO data are acquired is a challenge due to the seasonality of flood hazards and the vast areas considered. There are 33 major river basins in the world, covering huge areas. For comprehensive monitoring, these areas need to be imaged several times weekly during the flooding season, and at least once during the dry season, in order to build up a database of flood levels that can be used to properly evaluate flood risk on an on-going basis. While many of these areas are already imaged, a systematic approach is required to complement existing imaging efforts with missing data and effectively use the data collected.

[8] According to CRED's EM-DAT criteria: 10 or more people reported killed; 100 or more people reported affected; declaration of a state of emergency; call for international assistance.

Over half of the approximately 320 Charter activations of the 10 years concerned flooding, but this represents only a small fraction of the flood hazards to be monitored globally (cf. figure 7 below). Figure 5 shows the Charter activations for flooding, which are limited to disasters for a short response time. Flood hazards by contrast are monitored before and after events, over weeks, as well as periodically during the dry season to establish baseline imagery.

FIGURE 7. EXAMPLE OF GLOBAL PRIORITY AREA MAP CONCERNING THE FLOOD HAZARD USED BY EUROPEAN RESPOND AND SAFER RISK MANAGEMENT PROJECTS SEE DISCLAIMER BELOW[9]

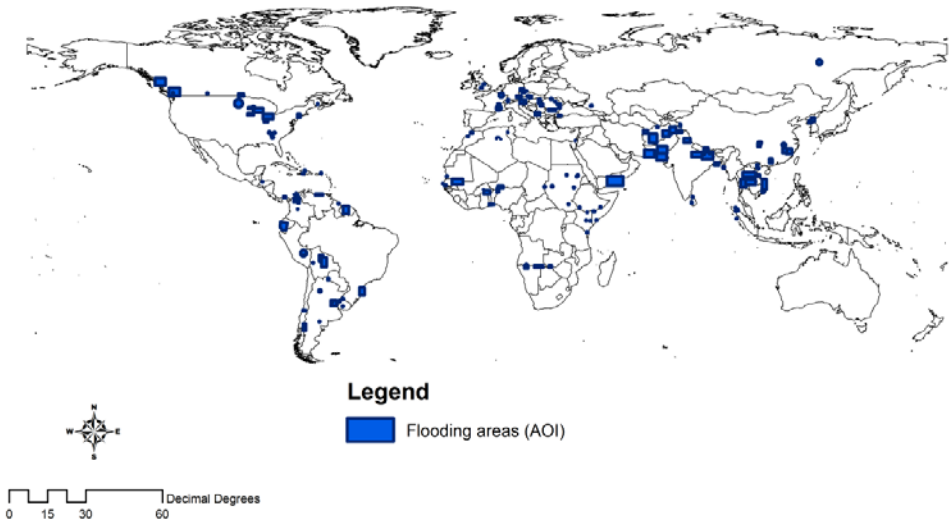


FIGURE 8. TOTAL CHARTER FLOOD ACTIVATIONS FROM 2000-2010. THEY REPRESENT A MARGINAL PORTION OF GLOBAL FLOOD HAZARDS

[9] Reference data taken principally from Columbia University and the World Bank, *Natural Disaster Hotspots: A Global Risk Analysis*. Columbia's Center for International Earth Science Information Network (CIESIN) does not guarantee the accuracy, reliability, or completeness of the data or information provided. Credits: Center for Hazards and Risk Research (CHRR), CIESIN and The World Bank.

Information Needs (Plain Flooding) and Ability of Satellite EO to address them

1) Flood monitoring and damage assessment to support risk management and insurance sectors

This is a reactive service similar to the International Charter but with a specific arrangement set to procure access to multiple EO missions in rush mode. It requires a multi-sensor approach with tasking in rush mode of several missions including SARs (requires redundancy although not the full redundancy of the Charter system). Output includes precise damage assessment and mapping of the maximum flood extent to support basin authorities, water management authorities and clients from the insurance sector. Data also needed to better characterise flood risk. Precursor operational services have been prototyped with insurance clients for instance in Europe. Users request a map of the flood maximum extent.

2) Alert/Early warning to support flood alert

Today, LEO SAR missions are not systematically used for alert. A 'constellation' approach of SAR missions, coordinating distributed capacity, would allow alert/warning using this approach. EO data is also provided by meteorological missions and satellite rainfall data (e.g. TRMM) to complement (or replace if unavailable) rainfall gauge measurement; includes flood simulations and flood forecasts using meteorological and hydrological forecasts.

3) Rapid mapping in response to flood disasters to support relief actions (International Charter)

This is a reactive service primarily based on redundant LEO mission data(SAR and optical used in combination) to obtain rapid access to imagery to map observable flooding traces. This includes rapid damage assessment and mapping of the maximum flood extent and helps Post Disaster Needs Assessment in recovery.

4) Asset mapping to support hazard and risk analysis with updated information concerning the elements at risk (infrastructures, population, crops, etc.).

Primarily concerns HR/VHR optical data to support asset mapping/modelling. Includes mapping/ cartography/DEM, land use/land cover monitoring (e.g. urban land use maps) and agricultural monitoring (e.g. crop inventories for insurance purposes).

The requirements for systematic observations to meet the information needs are:

A) Space-borne SAR: continuous observations to maximise temporal sampling irrespective of sensor options (although time series with same geometric characteristics and polarisation allow change detection; ascending and descending added to maximise observations; all polarisations are useful (HH and VV in preference).

B) Space-borne Optical: (i) for asset mapping purposes to provide background reference imagery: archive image (no more than 3-years old), panchromatic or true colour composite; (ii) for hazard monitoring purposes (including early warning and response): repeat data optical with frequency of monitoring frequency.

Concerning rapid mapping using the Charter, more than 13 EO mission owners/operators today provide EO data from 20+ EO missions 75% of which have dedicated tasking to obtain the most recent acquisitions following the activation request. Nevertheless, this capacity is limited to major disasters (in most recent years at around 50 activations per year), and is responsive. Addressing the global flood hazard -instead of only major disasters- will save

more lives but is significantly more challenging. All major international development agencies, beginning with UNDP, recognise the need for disaster risk reduction policies to enable sustainable development. Flooding, as the world's most prominent form of disaster, is an area where improvement can be achieved. For improved risk management, from a supply point of view, the data gap can appear daunting (as per figure 6 above). Existing initiatives fall far short of meeting imaging objectives, either in terms of area imaged (cf. SAFER) and temporal coverage, or in terms of resolution and data type (cf. Dartmouth Flood Observatory's daily MODIS flood map of the world).

Outside emergency-response actions, some space agencies are providing continuous observations via their satellites' background missions (building strategic datasets). But datasets generated by background missions but generally do not have the necessary temporal (e.g. daily) and geographical sampling for the world's flood prone areas, which are very extended globally. Floods generally are rapid events compared to the temporal sampling of EO missions and even when a background mission has generated data *a priori,* it does not always match the flood events. Due to these phenomena, a mission's archive is insufficient to generate historical flood maps for mitigation measures. There are examples of areas where pro-active data acquisition has been used successfully to improve flood mitigation efforts, saving lives and protecting property. This is the case for example in Namibia (cf. NASA-led Namibia Flood Pilot), in the Red River Valley in Canada and the US, and in the Mekong River Delta using Radarsat data collects (in the framework of a series of projects funded by the Canadian International Development Agency (CIDA)). These projects lack the support to provide services on a sustainable basis and in some cases have ceased to produce results once space agencies withdrew their pilot funding.

The systematic monitoring of areas prone to flood risk during the flood season: this is based on anticipated and systematic observation with a limited suite of EO Missions to provide reference data to help better understand the volumes and rates at which water discharges from a catchment (i.e. the hydrology), and assess how these waters move through and across the drainage system or floodplain (i.e. the hydraulics). It is useful to science users and users from the risk management sector concerning the elaboration of risk prevention maps (improve hazard knowledge and build risk reference data).

Mashup of Satellite Data and River

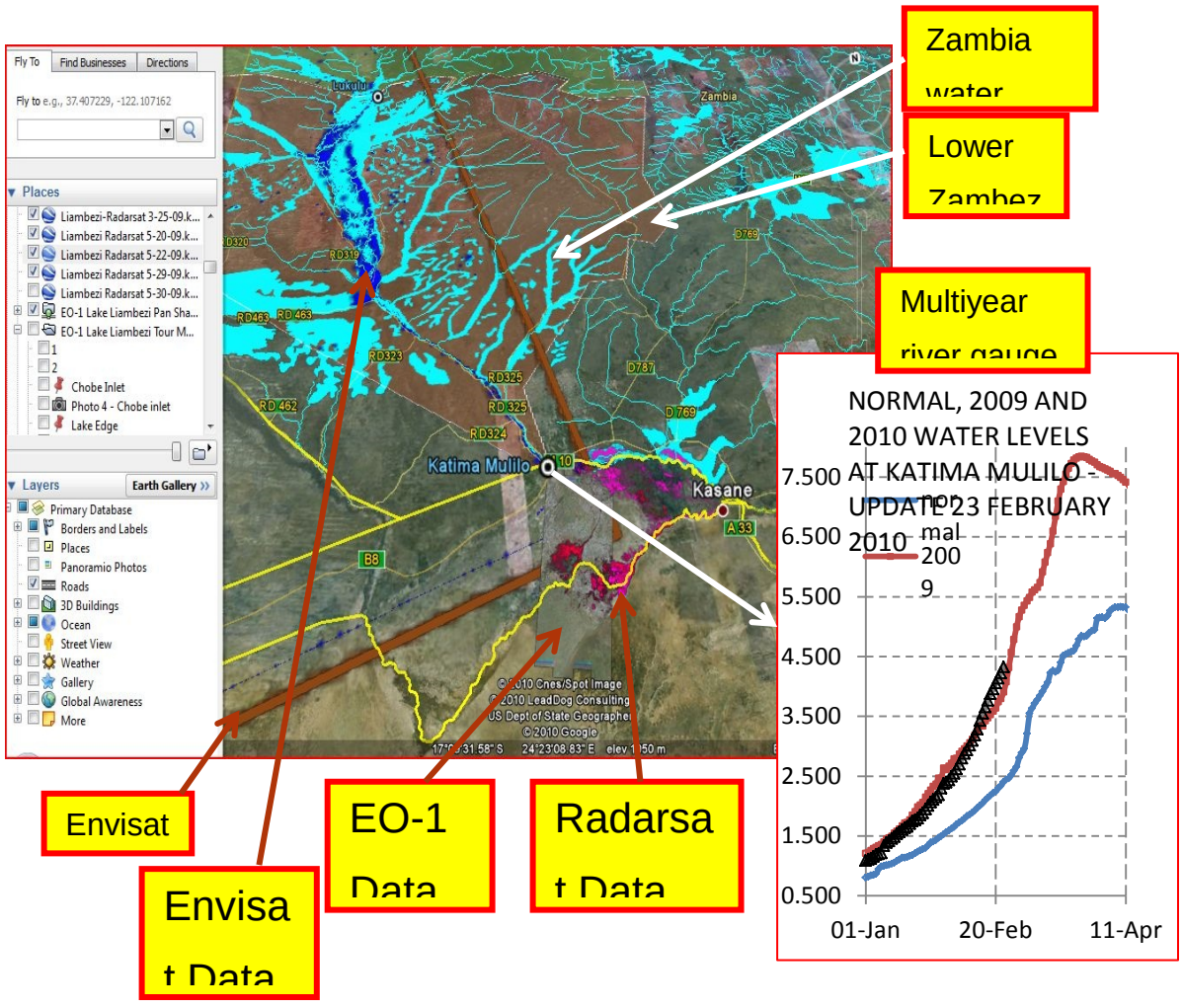


FIGURE 9. TIME SEQUENCE FLOOD MAPPING WITH MULTIPLE SATELLITE ASSETS BEFORE DISASTER ONSET. PRODUCT DEVELOPED IN CONTEXT OF NAMIBIA FLOOD PILOT, 2009.

Concerning information needs 1) and 3), above, the minimum sampling required typically is daily. This is very demanding in terms of space asset resources; this is the level of sampling provided through redundancy with the Charter. This is in place today on a reactive basis and for Charter Authorized Users in the occurrence of a major disaster. The EO capacity associated with component 3) does not concern low earth orbit missions (such as SAR missions although it is a key source of data for flood monitoring) because temporal sampling is insufficient.

Looking at the state of the application, globally, there are many hurdles to the operationalisation of flood mitigation on a global scale. Perhaps one of the biggest challenges is institutional; it resides in the wide array of varying actors and national authorities. Concerted global action, unlike in the cases of climate change or earth system modelling, requires a federated regional approach, where key regional and national players are identified and partnered with. Effective flood mitigation takes place at a national and local level, not globally. For this reason, partners for flood mitigation need to be identified at a regional and national level. In the absence of a coordinated global strategy for satellite EO acquisitions, national approaches appear as isolated initiatives and lack the profile to attract funding from key donors except in areas if dire need where local infrastructure is not able to consolidate success (*e.g.* Mozambique,

Bangladesh). This hints at the second major problem, a lack of capacity in the developing world in general, but also to a lesser extent in the developed world, to understand and properly integrate satellite EO in national flood management efforts.

Main gaps concerning EO capacities for plain flood monitoring:

1) Flood monitoring and damage assessment to support risk management and insurance sectors

A monitoring service for emergencies that are not major disasters is not available today and there are substantial costs associated; full scale trials providing data would help demonstrate value and achieve user awareness and acceptance. Anticipated acquisitions via a common observation strategy between mission owners/operators of reference data (according to seasonality) would improve flood mapping accuracy. The lack of long-term data sets over regularly flooded areas during both dry and wet seasons inhibits retrospective analysis. Collecting regular data sets would enable probabilistic analysis in coming years over key areas. (Main beneficiaries: civil protection agencies, regional and local governments, insurance companies)

2) Alert/Early warning to support flood alert

While some areas (e.g. Manitoba Red River floods, Namibia Pilot) use blanket SAR coverage in advance of flooding (in upper watersheds) to provide warnings, operationalisation requires systematic observations over broad areas and automated processing techniques and capacity (a platform). More data on rainfall would be useful to complement these observations. (Main beneficiaries: operational flood managers, civil protection agencies)

3) Rapid mapping in response to flood disasters to support relief actions (International Charter)

Rapid mapping in response to flood disasters is an operational service today, but some gaps remain, including the timeliness of information. Daily coverage would be required by users, rather than 2 to 3 days as currently. (Main beneficiaries: operational flood managers, civil protection agencies)

4) Asset mapping to support hazard and risk analysis with updated information concerning the elements at risk (infrastructures, population, crops, etc..).

Asset mapping for developing countries is either not available or requires commercial services. Techniques and data exist but linkages to service providers and demonstration of value of satellite solution is missing. (Main beneficiaries: development agencies, donor governments, national governments, insurance companies)

2.3.3 Seismic hazards

Earthquakes represent one of the world's most significant hazards in terms both of loss of life and damages, and are also responsible for many other related fatalities and damages through tsunamis which are triggered by earthquakes.

National and Regional Civil Protection authorities, Seismological centers, and National and Local authorities in charge of seismic risk management activities are concerned with the phases of prevention, preparedness, early warning, response, recovery, rehabilitation and reconstruction. Beyond operational users with a mandate in seismic risk management, there is a range of geoscience users focused on the scientific use of data with the main goal of understanding the physics that drive earthquakes, thereby improving our ability to characterize, understand, and model seismic risk.

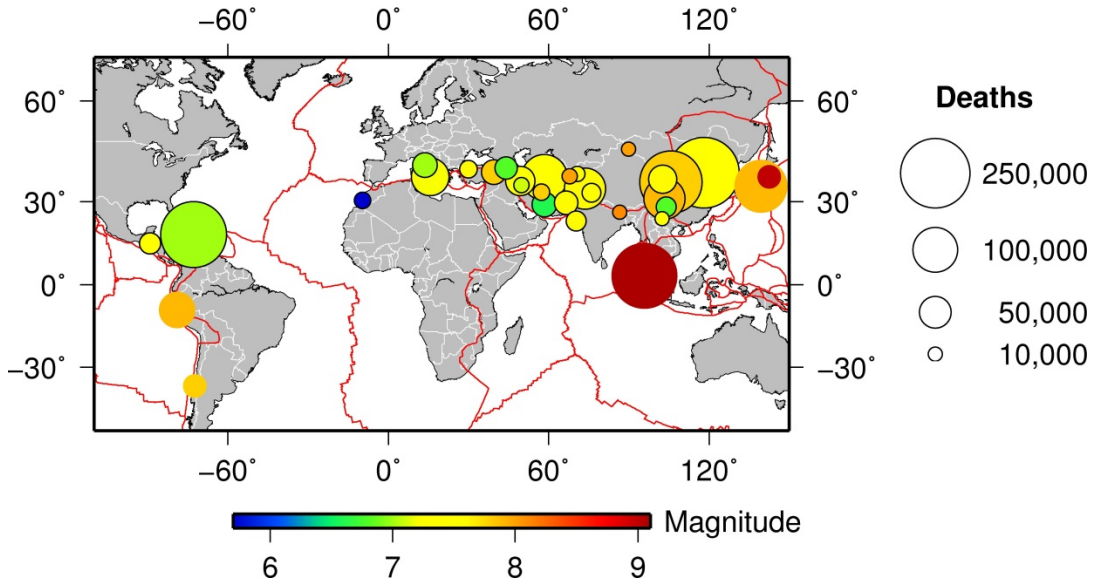


FIGURE 10. EARTHQUAKES FROM 1900-2012 THAT HAVE KILLED MORE THAN 10,000 PEOPLE (DATA FROM USGS); AREA OF THE CIRCLE IS PROPORTIONAL TO THE NUMBER OF DEATHS; COLOUR TO THE EARTHQUAKE MAGNITUDE. EARTHQUAKES WITH BLACK RIMS DID NOT OCCUR ON PLATE BOUNDARIES[10].

The science users of seismic risk management require satellite EO to support mitigation activities designed to reduce risk. They are carried out before the earthquake occurs, and are presently the only effective way to reduce the impact of earthquakes on society –short term earthquake prediction today offers little promise of concrete results. The assessment of seismic hazard requires gathering geo-information for several aspects: the parameterization of the seismic sources, knowledge of historical and instrumental rates of seismicity, the measurement of present deformation rates, the partitioning of strain among different faults, paleo-seismological data from faults, and the improvement of tectonic models in seismogenic areas.

Operational users of seismic risk management do have needs for geo-information to support mitigation, although the need for situational awareness during response often receives more attention. Satellite EO can contribute by providing geo-information concerning crustal block boundaries to better map active faults, maps of strain to assess how rapidly faults are deforming, and geo-information concerning soil vulnerability to help estimate how the soil is behaving in reaction to seismic phenomena. On an emergency basis, the first information needed after a large earthquake occurs is an assessment of the extent and intensity of the earthquake impact on man-made structures, immediately after which it becomes important to formulate assumptions on the evolution of the seismic sequence, i.e. where local aftershocks or future main shocks (on nearby faults) are most likely to occur.

A range of EO-based techniques have been developed to support the mitigation of earthquakes, for crisis management and for the analysis of the seismic risk, for instance:

- The use of high-resolution optical and topographic data sets for investigating tectonic geomorphology, paleo-seismology etc. This is particularly important for forensic investigations of previous major earthquakes.
- High resolution optical/radar image matching for deformation.
- SAR Interferometry (InSAR), in particular the Persistent Scatterer Interferometry (PSI) technique, to provide precise terrain deformation concerning seismic risk. These are of two types:

  A) Precise terrain deformation to support the analysis of *Crustal block boundaries*:

[10] Adapted from ENGLAND, P., HOLMES, J., JACKSON, J. and PARSONS, B. 2011. Report of an International Workshop held in the Department of Earth Sciences, University of Oxford on 28th and 29th January, 2011. University of Oxford.

a) *Major and local fault investigations* that concern the analysis of surface movements recorded at large scale by full resolution PSI products combined with *in-situ* data (Global Positioning System (GPS) measurements, optical levelling, geological mapping, seismological scenarios). This allows monitoring along and across major faults to measure fault slip rates and estimate locking depths, detection of local active faults reactivated soon after major seismic events and eventually identification of further surface effects triggered by major earthquakes.

b) *Earthquake cycle investigations* that are based on measurement of the surface deformation along the overall earthquake cycle, mostly pre- and post- seismic phases and using a comprehensive analysis of the earthquake cycle to better define the hazard in seismic areas. The post-seismic phase can be monitored to measure the amount and the surface extension of possible deformation rebound or residual strain release. Pre-seismic, or aseismic, deformation remains an open issue in particular for its modelling complexities; the service is aimed at providing dense geodetic data to investigate possible signals of the different phases of the earthquake cycle and to understand them.

c) *Investigations of vertical deformation sources in urban areas*: exploits the PSI analysis applied to measuring vertical surface movements in urban areas to support investigations of the cause of subsidence and to identify the source (tectonic vs. non-tectonic/man-made) of such effects. This is using the PSI-based motion data, the geological background, the seismicity and the geodetic measures.

B) Precise terrain deformation to support *Soil vulnerability mapping:*

The capability of PSI to obtain very dense spatial data and detailed measurement of surface displacements provides input data to be added and integrated into *in-situ* measurements to compute soil vulnerability maps and help discriminate between primary tectonic displacements and secondary, seismically-induced, movements.

The potential applications and services that could be offered based on state-of-the-art current research can be grouped into three categories of activity: (i) emergency response, (ii) long-term seismic risk estimation; and (iii) scientific research.

i. **Emergency response:** while several active projects and initiatives around the world use space technologies in the response, the main mechanism to access satellite EO data during the response phase is the International Charter. Geohazards Event Supersites have also shown the value of free and open access to pre- and post-event imagery for earthquakes. Value can be added by multiple, independent teams from around the world, without restriction (cf iii below).

ii. **(Long-term) seismic risk estimation:** satellite geodetic techniques (InSAR, GPS) have the potential to map tectonic strain, and high resolution optical and digital topographic data sets derived from satellite observations can be used to identify active faults, often 'blind' at the surface. For converting the hazard into risk, some data on exposure and vulnerability can also be derived from EO data. In both cases, the potential impact of the EO data sets is greatest in developing countries, where ground-based observations are sparse.

iii. **Scientific use of data for geohazard risk assessment:** Perhaps the most important scientific development for EO data in recent years has been the GSNL initiative (http://supersites.earthobservations.org/). It provides access to space-borne and *in-situ* geophysical data of selected sites prone to earthquake, volcano or other hazards. Its main focus is on the geoscience user with an interest in both the long-term risk assessment and the post-earthquake analysis of scientific data (rapid access to InSAR data). Due to its short-term response focus and to the data licensing policies of many of its participating agencies, the Charter is not designed to contribute to scientific research and analysis.

Information Needs (Seismic Hazards) and Ability of Satellite EO to address them

1) Terrain motion mapping for seismic risk estimation: crustal block boundaries mapping to support seismic fault investigations, earthquake cycle investigations and investigations of vertical deformation sources in urban areas; precise terrain deformation to support soil vulnerability mapping.

This is based on conventional INSAR and PSI techniques and is primarily based on space-borne SAR (HR or VHR). It requires repeat observations (typically multi-year). The specific aim is to deliver information on crustal faults, including their slip rates and locking depths.

Geoscientists require access to space-borne InSAR and *in-situ* geophysical data concerning earthquake risk areas and earthquake events. Users from the Santorini Conference identified the following needs:

- Development of a global strain map based on InSAR data, as well as access to pre- and post-event InSAR data;
- Automatic rapid creation and web publication of co-seismic productderived interferograms (wrapped and unwrapped) from all available sensors
- Simple identification of fault breaks combined with information about earthquake mechanisms to derive estimated surface offsets;
- (Semi-)automatic fault modelling – rapid production and web-publication of fault parameters using simple techniques;
- Rapid calculation of Coulomb Stress changes on neighbouring faults, a calculation used to assess likely locations of aftershocks or triggered earthquakes;
- Prediction of damage location based on fault models; and,
- Rapid estimation of earthquake damage using high resolution optical and radar imagery, and InSAR coherence.

2) Geoscience needs

Geoscience users recommend the creation of a new global strain rate model at high spatial resolution (a new seismic hazard map) that would incorporate InSAR- and GPS-based measurements. Current initiatives are only GPS-based. This would include the provision of satellite interferometric data for continuous observations of the seismic belts worldwide. To understand earthquake physics a long-term response involves acquiring radar data for years to decades after an earthquake in order to measure post-seismic deformation. This model would improve with time as new EO mission data become available but accuracies should be sufficient for a first release after 3-5 years of regular acquisitions. The primary model would show the average deformation rates during the observation period; areas showing significant deviations from steady-state deformation could also be identified.

3) Asset mapping for seismic risk estimation: asset mapping/modelling to support hazard and risk analysis with updated information concerning the elements at risk.

This primarily concerns HR/VHR Optical data to provide the most accurate knowledge of exposure (including population density, building stock, and the location of key infrastructure) and vulnerability (including construction type, building heights, and the response to past events) to map hazard into risk.

4) Rapid mapping in response to earthquakes to support relief actions (Charter).

This is a reactive service primarily based on redundant LEO mission data, primarily VHR optical to obtain rapid access to precise imagery to map the hazard impact and make a rapid zoning of damaged areas.

The observational requirements for InSAR applications for seismic hazards can be summarized as follows:

(A) SAR data:

- High Resolution InSAR: (i) for hazard inventory purposes (*e.g.* historical hazard mapping): continuous observations of descending and ascending mode repeat coverage (maximum images per year, C and L-band in stripmap mode. The focus is to extend and guarantee observations of the priority seismic belts); (ii) for hazard monitoring purposes: descending and ascending repeat coverage of hotspots (*e.g.* most critical faults) with more than 3 images per month C- or L-band.
- Very High Resolution InSAR: (i) for hazard inventory purposes such as global strain mapping the smaller swath width and cost limits VHR utility; (ii) for hazard monitoring purposes on hotspots (*e.g.* most critical faults): descending and ascending repeat coverage (*e.g.* TerraSAR-X every 11 days, COSMO-SkyMed every 1 to 16 days with consistent 8 day capabilities, etc..).

(B) HR Optical/VHR Optical:

(i) To provide background reference imagery: archive images (no more than one year old), panchromatic or true colour composite. (ii) VHR optical for disaster response mapping and for surface fracture mapping, this data should be better than 5m resolution panchromatic or multispectral and delivered in near-real-time.

In the longer term EO can contribute to the elaboration of a global strain rate model at high spatial resolution. Earthquakes almost always occur in areas with significant seismic strain. Today this strain is measured only fragmentally, in known fault areas. Using advanced SAR imaging, it is possible to map seismic strain globally.

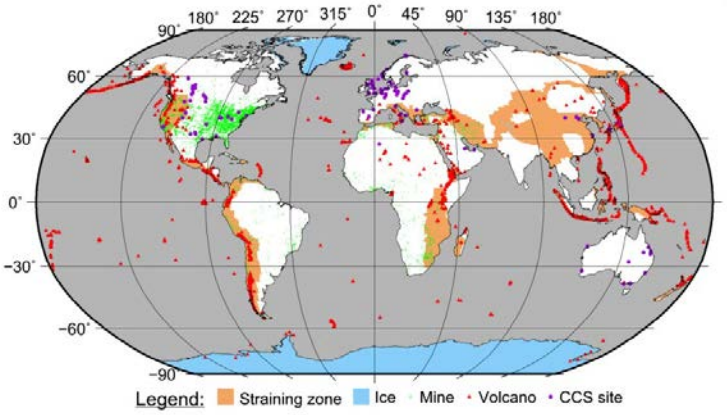


FIGURE 11. STRAINING AREAS AND VOLCANOES OF THE WORLD. THE AREAS COLOURED ORANGE HAVE STRAIN RATES OVER A DEFINED THRESHOLD IN THE GLOBAL STRAIN RATE MODEL DERIVED FROM GNSS DATA(KREEMER ET AL., 2003). FIGURE FROM THE GSNL STRATEGIC PLAN 2012.

A number of scientific projects and laboratories provide *ad hoc* earthquake source mechanisms from EO data. None, at present, would claim to provide an operational service, with the aim of investigating every single earthquake. Similarly, a number of groups have been using InSAR to map strain, and optical and topographic data to find hidden faults. Again, none of these groups are at the stage of providing operational services. However, the methodologies employed by these researchers are now reaching maturity.

Following the International Forum on Satellite Earth Observation for Geohazard Risk Management, geoscience users and practitioners of the seismic hazard community consider that an operational service could be provided in the next 5-10 years. According to them, a vision of an operational seismic risk program in five years' time could aim at providing satellite observations for continuous surface deformation measurements of the seismic belts - typically 15% of the land surface - and with the creation of a new global strain rate model at high spatial resolution (a new seismic hazard map) that would incorporate InSAR and GPS based measurement. Within the context of the Global Earthquake Model (GEM), work is underway to develop a global strain map based on GNSS data, but the InSAR map would provide a valuable complement to this. The GEM work does not yet recognize the value of satellite InSAR as a contributing measurement tool.

Main gaps concerning EO capacities for earthquake hazards (1/2):

1) Terrain motion mapping for seismic risk estimation: crustal block boundaries mapping to support seismic fault investigations, earthquake cycle investigations and investigations of vertical deformation sources in urban areas; precise terrain deformation to support soil vulnerability mapping.

Many users are not aware of the potential benefits from satellite EO. EO techniques to support seismic risk assessment have been delivered to DRM users in a few countries only (for instance, in Europe: Italy, Greece, and Turkey). A global strategy is needed to ensure HR SAR and VHR SAR acquisitions fit for INSAR exploitation are performed and data are made available. New missions will allow EO to be much more widely used in estimating seismic hazard and risk. Planned radar missions should acquire data as often as possible in the world's seismic belts (the entire belts, including the lower straining areas, cover ~15% of the imageable surface). Radar missions could build uniform catalogues in single modes of acquisition for long periods of time. Data should be made freely available to all, or widely licensable to the community, allowing multiple users to work on this task. A long-term response to earthquake elements that involves acquiring radar data for years to decades after an earthquake in order to measure post-seismic deformation. Mapping tectonic strain with the required accuracy to be useful for seismic hazard estimation requires regular repeated radar acquisitions over long time periods, ideally in several different viewing geometries. No single planned mission meets all the requirements, but upcoming missions (e.g. Sentinel-1A/B, ALOS-2 and the Radarsat Constellation Mission) have the potential to collectively fulfil the objective. (Main beneficiary: scientific seismic community)

2) Geohazard risk science

Gaps remain in the collection of scientific data for geohazard risk assessment, though the GSNL initiative is an important step forward. Science users feel that the areas covered remain too limited, either in coverage or in density of observations. A clearer definition of the science objectives of the GSNL and their selection criteria is needed. A data repository for this subset of data is a key aspect, long with the support of an exploitation platform such as the SuperSites Exploitation Platform (SSEP) to allow large data volume processing. On demand processing and cloud computing could make possible the exploitation of large datastacks to support this. An exploitation platform providing rapid and automated processing capacity could be used to improve the accuracy of predicted damage distributions, and for forecasting the likely distribution of aftershocks and triggered earthquakes. Much progress has been made possible by the decision of space agencies to task their radar satellites to have "background missions" (e.g. 15+ years of ERS and Envisat SAR data). This should be generalized with a global observation strategy by mission owners/operators. The projected global strain model for example would require a 3-5 year dedicated acquisition strategy for Sentinel 1 and RCM, which would require international coordination. (Main beneficiary: scientific seismic community)

Main gaps concerning EO capacities for earthquake hazard (2/2):

3) Rapid mapping in response to earthquakes to support relief actions (the Charter).

An operational EO capacity is in place to deliver rapid earthquake damage mapping, though users would like it to be more rapid, and quality could be improved through the use of VHRO imagery with oblique views (oblique sensors not common in current Charter stable of satellites). (Main beneficiaries: civil protection agencies, first responders)

4) Asset mapping for seismic risk estimation: asset mapping/modelling to support hazard and risk analysis with updated information concerning the elements at risk.

EO-based exposure mapping has been initiated in the framework of the GEM project. The portion ready and available today is limited. The information needs concern exposure (including population density, building stock, and the location of key infrastructure) and vulnerability (including construction type, building heights, and the response to past events) to map hazard into risk. Some, but not all, of these key data sets can be sourced from EO. (Main beneficiaries: development community, insurance companies)

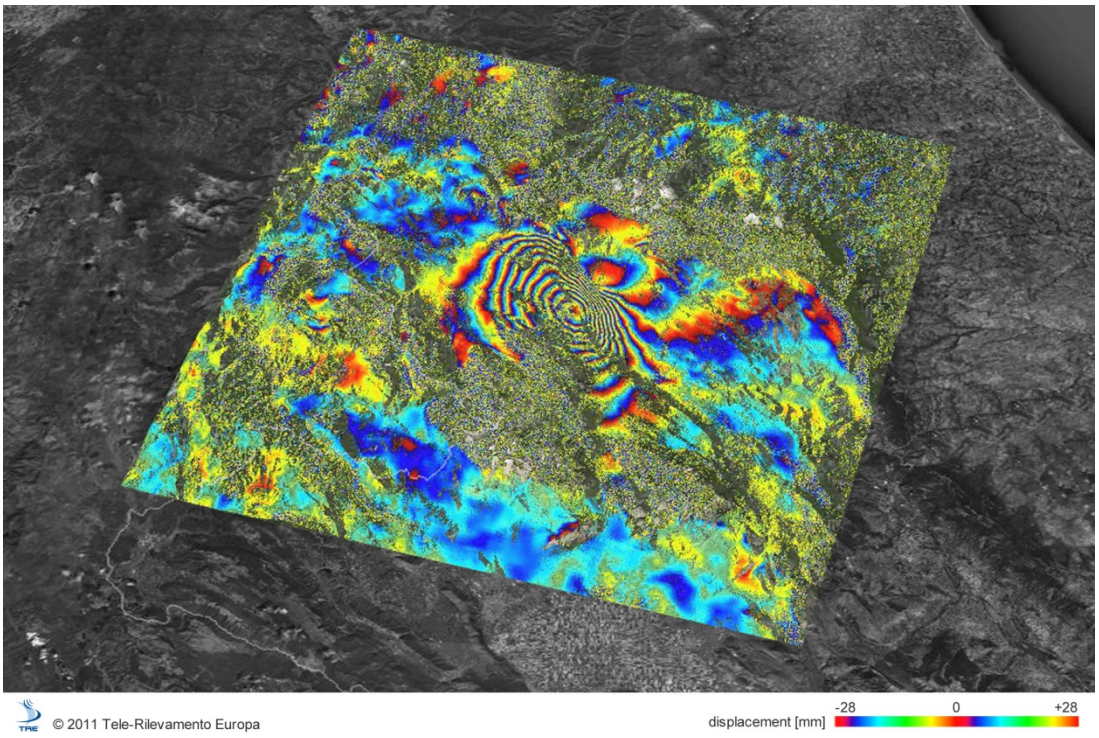


FIGURE 12. ENVISAT-BASED INTERFEROGRAM CO-SEISMIC INTERFEROGRAM AFTER THE EARTHQUAKE IN L'AQUILA (ITALY) ON APRIL 6, 2009 (M 6.3). SOURCE: TRE EUROPE.

2.3.4 Landslide hazards

Landslides are common in many countries. While they are not as broad reaching and damaging as flooding and earthquakes, they are rapid and catastrophic in scope and scale, yet they offer some advance warning signs if properly analysed before the event. Satellite-based EO offers a unique reach and scope to provide detailed landslide inventories and to track landslides on an on-going basis over very large areas.

The map below provides an overview of the areas most at risk.

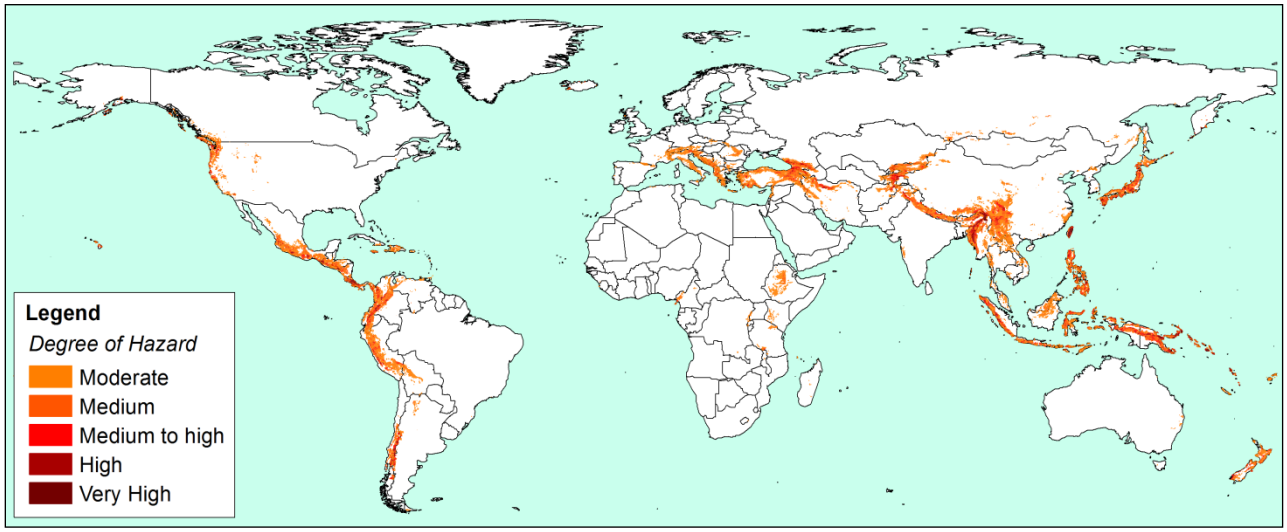


FIGURE 13. GLOBAL LANDSLIDE HAZARD MAPPING: THE GLOBAL LANDSLIDE HAZARD DISTRIBUTION, GDLND. THIS IS DERIVED FROM THE LANDSLIDE HOTSPOT MAP AT GLOBAL SCALE PUBLISHED BY NADIM ET AL. (2006)[11]

What practitioners and users need is both deferred time information (mapping and inventory of landslide, typology and kinematics, modeling and prediction, vulnerability assessment and modeling) alongside with near real time and real time information (mapping landslide events and their impact, definition of landslide triggers and related thresholds, location of safe areas for relocation of elements at risk, post-event motion assessment, residual risk zonation). This information allows for comprehensive monitoring of areas at risk and would in many cases offer some warning of an impending event.

Today, EO technologies already play a strong role as support for the hazard and risk applications concerning landslide processes, ranging from landslide mapping at the regional scale, monitoring of single slopes, to modelling of landslide motions and correlation with triggering factors.

[11] Based on a heuristic landslide hazard model considering slope, lithology, soil moisture, precipitation, temperature and seismicity as input variables (CHRR, NGI and CIESIN, 2005).

Information Needs (Landslide Hazards) and Ability of Satellite EO to address them

1) Rapid mapping in response to landslide disasters to support relief actions (International Charter).

This is a reactive service primarily based on redundant low earth orbit mission data, primarily optical used in combination to obtain rapid access to imagery to map the impact of a landslide event.

2) Landslide inventories providing terrain deformation mapping over large areas e.g. entire watershed basins integrated into a pre-existing landslide inventory created using conventional geo-morphological tools.

This is a historical mapping service primarily based on space-borne SAR (HR or VHR) using InSAR. It can be performed with limited in situ data.

3) Landslide monitoring providing terrain deformation mapping (hot spots) using up to date/continuous satellite observations.

This is a local level monitoring service with a temporal sampling typically in weeks (e.g. revisited cycle) focused on hotspots (e.g. most critical landslides). It also is InSAR based.

4) Alert/Early warning to support landslide alert.

The contribution of EO is primarily from meteorological missions as well as high resolution multispectral data to infer surface–subsurface water linkages for landslide activation early warning (identification of landslide producing agents or causal/triggering factors).

5) Asset mapping to support hazard and risk analysis with updated information concerning the elements at risk (infrastructures, population, crops, etc.).

Primarily concerns HR/VHR optical data to support asset mapping/modelling. Includes mapping/ cartography/DEM, land use/land cover monitoring (e.g. urban land use maps).

The requirements concerning the observations from space are:

A) space-borne SAR:

HR SAR (i) For landslide inventory and landslide hazard purposes: continuous observations descending and ascending repeat coverage (at least 2 images per month in interferometric mode), the focus is to extend and guarantee observations over mountainous and hilly terrain with priority areas defined in section 2. Narrow orbital tubes are required to get overall short spatial baselines and many pairs with very short spatial baselines. For Sentinel-1 all ascending and all descending orbits should be considered. Single (HH or VV) polarization would be sufficient.

VHR SAR: (i) For hazard inventory purposes: continuous observations descending and ascending repeat coverage (at least 2 images per month in interferometric mode). The demonstration that this is also possible with VHR SAR is given by the COSMO-SkyMed constellation which achieves over Italy full interferometric coverage with 16-day repeat intervals in both ascending and descending orbits. (ii) For hazard monitoring purposes on hotspots (*e.g.*. most critical landslides): continuous observations over one selected area in all descending and ascending repeat orbits (*e.g.* TerraSAR-X every 11 days) means that no data are then available for areas outside of this swath. If possible (*e.g.* using COSMO-SkyMed constellation of 4 satellites) a full spatial coverage with continuous observations descending and ascending repeat coverage (at least 2 images per month in interferometric mode) is required. If this is not possible (*e.g.* TerraSAR-X) the requirement is to pre-select for both ascending and descending geometry a set of modes which achieve full spatial coverage over the landslide areas and then to acquire as much interferometric data in these modes as possible.

B) Space-borne Optical:

HR Optical/VHR Optical: (i) For landslide inventory and landslide hazard purposes to provide background reference imagery: archive image (no more than 10-years old), panchromatic or true colour composite. (ii) For hazard inventory purposes (*e.g.* historical hazard mapping): VHR optical (no more than 1-year old), better than 5m resolution, panchromatic or true colour composite, stereo pair (max 1 year apart) useful for delineation; (iii) For hazard monitoring purposes (including early warning and response): repeat observations with HR and VHR optical sensors (panchromatic or multispectral, preferably with a resolution better than 5m).

Typically terrain deformation services to support landslide risk assessment require data processed from archives. For areas where data from archives are not available, campaigns over at least a 6-12 month time window are necessary to assemble HR or VHR SAR data stacks.

Many areas of the world do not have a sufficient archive of data suitable for INSAR (same viewing mode, geometry and polarisation). For instance what has been delivered so far in Europe is illustrated below: services have been delivered over a portion of the territories of Europe, similarly over North America and in several areas of the rest of the world but overall many areas have not been covered. In Europe there is a need to provide EO-based information in those areas that were not investigated so far (for instance Austria, Bulgaria, Romania, Serbia, Bosnia, Albania and Turkey).

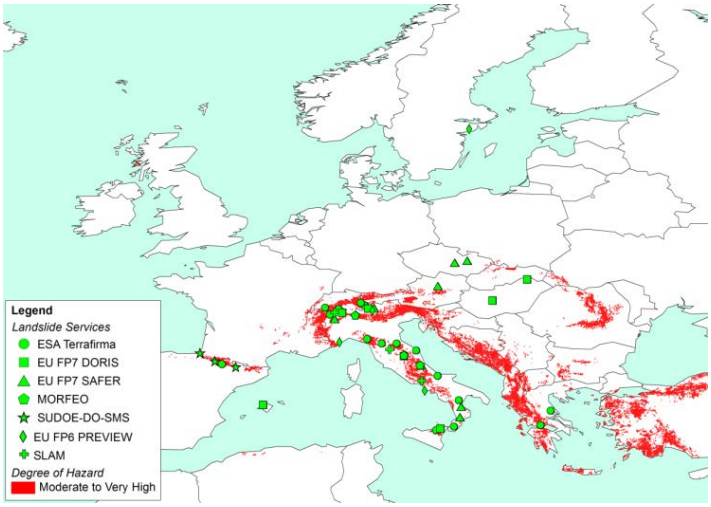


FIGURE 14. SATELLITE EO-BASED LANDSLIDE SERVICES AND APPLICATIONS AT EUROPEAN SCALE, OVERLAPPED ONTO THE LANDSLIDE HAZARD MAP OF THE GDLND (CHRR, NGI AND CIESIN, 2005).

Main gaps concerning EO capacities for landslide hazards:

1) Landslide inventories providing terrain deformation mapping over large areas, *e.g.* entire watershed basins integrated into a pre-existing landslide inventory created using conventional geo-morphological tools.

and

2) Landslide monitoring providing terrain deformation mapping (hot spots) using up to date/continuous satellite observations.

Methodologies to develop landslide inventories to support mitigation are mature and validated; they only have been delivered to a limited extent. Geographically the need is widespread in particular in North America, Latin America, Asia and South East Asia where very few services have been delivered so far. This is essentially an awareness/acceptance issue. In these regions adequate SAR data stacks have not been acquired. There are very few areas in the world that use operational EO monitoring for landslides (Switzerland, Alberta). Full scale trials providing data are needed to demonstrate value and achieve acceptance. Note the impact of component 2) potentially is large and the technique is not heavily relying on *in-situ*: the EO technology can achieve an important impact relying only on EO sector in a first stage. (Main beneficiaries: national and local governments, insurance companies)

3) Alert/Early warning to support landslide alert.

There is a need to strengthen the methodological approaches for EO-based landslide modelling and early-warning, which - in turn - will be clearly supported by the copious availability of EO data at MR, HR and VHR from both optical and radar sensors of the different space agencies. This application is still at the R&D phase. (Main beneficiaries: civil protection, first responders)

4) Asset mapping to support hazard and risk analysis with updated information concerning the elements at risk (infrastructures, population, crops, etc.).

Asset mapping solutions in developing countries are either not available or to be made available require commercial services. Techniques and data exist, but linkages to service providers and demonstration of the value of satellite solutions is missing. (Main beneficiaries: national governments, development community, insurance companies)

5) Rapid mapping in response to landslide disasters to support relief actions (the Charter).

An operational EO capacity is in place to deliver landslide damage mapping; this report has not identified gaps.

2.4 Observations concerning gaps

Despite much broader application of satellite EO to DRM than a few years ago, as seen in section 2.3 above, there are areas where clear opportunities exist for enhanced contributions. Although there are gaps in all areas of monitoring, as we consider the application of satellite EO to DRM, it is important to consider where the most significant gaps are, both from the point of view of the disaster phase (i.e. disaster response versus risk reduction and recovery) and *vis-a-vis* hazard specific communities (*e.g.* flooding versus geohazards or extreme weather events).

Perhaps the most significant area where disparities exist between available capacity and application of satellite EO is with regard to flood mitigation and warning. The development of a systematic imaging plan for areas of regular flooding in the world's largest rivers basins would represent a significant advance from what is undertaken today. Such a systematic imaging plan for flood prone areas does not exist today on a global, prioritised basis.

For geohazards, the Santorini Conference was an opportunity for leading thinkers to come together and discuss the state-of-the-art in satellite-based EO and objectives for the community over the coming 5 to 10 years. EO was viewed as a critical tool to extend monitoring to unmonitored volcanoes. Currently planned missions would enable, for example, regular monitoring of some 1500 potentially active volcanoes. With regard to seismic hazards, while it was apparent that satellite EO will possibly never aid in the short-term prediction of earthquakes, new techniques and satellite systems would enable the development a new global strain rate model at high spatial resolution that would incorporate InSAR and GPS based measurement. This would include the provision of satellite interferometric data for continuous observations of the seismic belts worldwide. With regard to landslides, it was clear that InSAR techniques allow for mapping and inventories of areas at risk, and that the risk assessment services available so far on cover a small fractions of landslide risk regions.

Overall different communities have information needs and concrete objectives concerning the role of newly available and planned EO mission data although more analysis is needed to assess what factors could accelerate take up of EO services. Missions such as Sentinel-1 will provide large volumes of data over geohazard risk areas. The practitioners and users need to collectively address the associated challenges considering the role of mandated organisations, of international organisations, of industry and potentially new partners.

The CEOS DMSG report of 2002 discussed above referred to a number of awareness and capacity related issues that should be flagged as gaps to address in implementing satellite-based EO solutions for DRM. Paraphrasing from the points listed above and completing the list, the key gaps to address are:

- Awareness of EO solution
- Awareness of EO data availability
- Awareness of partners (especially commercial) for operational solutions
- Capacity to transform EO data into information solution (integration, especially in value-added sector)
- Broadly-based EO capacity (especially in the developing world)

To summarize, the report has identified three major categories of gaps: data gaps, awareness gaps and capacity gaps.

Data Gap

The first major category of gaps is gaps related to data. Although there are large numbers of satellites in orbit and planned for launch, certain data gaps remain principally because existing and planned satellites are not currently planning acquisitions to address specific categories of DRM users.

These gaps have been addressed in detail in the thematic sections on plain flooding, seismic hazards and landslides. Further analysis is required to address potentially important gaps in relation to volcanoes and droughts. In the opinion of the *ad hoc* Disaster Team, these five categories represent promising areas for enlarged action. It should be noted that these gaps do not necessarily represent a gap in mission coverage, but rather in the planning of use of already

available or soon to be available satellites. In this sense, this is not a traditional data gap, but rather a need for increased international coordination. In some cases, planned capacity for imaging, as with the Sentinel-1 mission or RCM, greatly outstrips current usage of the data, and new user communities will need to be made better aware of the benefits of EO as their needs are better targeted by the satellite operators (cf. Awareness gaps below). With regard to the use of Charter data, many users have requested that these data be also made available outside Charter activations, and also be free of charge as during the activation by the authorised user. This again is not a data gap issue, but a disconnect between offer and demand. This disconnect has many causes, ranging from lack of awareness of EO availability to data policy and data cost. As illustrated below the main EO capacities for DRM today have the following characteristics:

- The Charter is dedicated to many hazard types and provides satellite observations for many places globally and anytime a major disaster occurs but only with a limited observation timespan;
- The GSNL initiative provides satellite observations dedicated to research on earthquakes and volcanoes for a few sites of limited extent and with very long observation timespans;
- Current EO applications relating to specific techniques such as InSAR only exploit a small portion of available radar archives.

Despite a clear need and the potential application of satellite data, there are major gaps in relation to specific hazards and certain phases of disaster risk management, especially risk reduction. While some needs are clear, a prioritised approach requires further discussion and consultation with user organisations to improve their understanding of what is possible and increase the satellite community's understanding of the relative priorities.

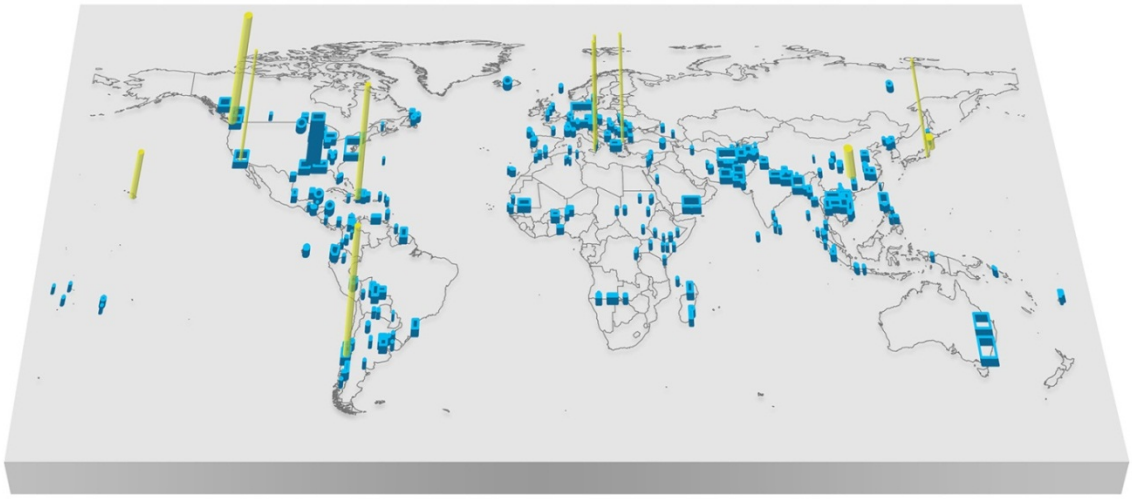


FIGURE 15. PERSPECTIVE VIEW OF THE TIMESPAN OF SATELLITE OBSERVATIONS OF CURRENT EO CAPACITIES FOR DRM: THE INTERNATIONAL CHARTER (300+ ACTIVATIONS OVER 2000-2009 REPRESENTED WITH THE AREA OF INTEREST OF EACH ACTIVATION) AND THE GSNL (REPRESENTED WITH THE 11 CURRENT SITES). CHARTER ACTIVATIONS DEPICTED IN BLUE, GSNL OBSERVATIONS IN GREEN. TYPICALLY THE TIMESPAN OF CHARTER ACTIVATIONS IS 2 WEEKS WITH A FEW EXCEPTIONS SUCH AS THE DEEP WATER HORIZON DISASTER (15 WEEKS OF OBSERVATIONS IN SPRING 2010) AND THE JAPAN EARTHQUAKE AND TSUNAMI OF 11 MARCH 2011 (4 WEEKS). THE GSNL TYPICALLY SPAN SEVERAL YEARS (5+YEARS OF OBSERVATIONS FOR 8 OF THE 11 CURRENT SUPERSITES).

This data gap is addressed by proposed Actions # 1 and 2, in section 4, below.

Awareness Gap

It is clear from even a summary review of user needs and the activities of user organisations that awareness of the potential of satellite EO remains a major hurdle for increased uptake of EO data by the DRM community.

Main gaps concerning EO awareness:

- Lack of awareness of means of finding EO data
  Within the user community, there is a lack of knowledge of how to access data, and more critically, how to determine whether appropriate data sets exist through consultation of metadata catalogues. In order to establish whether or not data is available, a user must consult many different archives from different data suppliers, even when searching for the same type of data. For example, a user trying to determine whether there is C-band SAR data over a river system must consult the metadata archives of ERS-1 and 2, Envisat, CSA and MDA. In some cases, value-added providers can do this as a service for an end-user, however many value-added providers work with only subsets of data suppliers, meaning the answer to the user query will be incomplete.

- Lack of awareness of utility of data
  Even when data is known to exist, it is not clear within the user community how to apply these data to operational DRM projects or existing management systems.

- Acceptance Gap
  For greatly enhanced use of EO data to support DRM, national authorities need to recognise the value of EO through legislation and regulation. This validates the utility of a given technique to collect information, and may even mandate a government organisation to collect the data. This is the case for landslide information in Italy, and may become the case for inactive mining and subsidence in Germany. Full-scale trials need to be undertaken with national authorities to demonstrate value.
- Lack of confidence in long-term data continuity/availability.

This awareness gap is addressed by proposed Actions # 3, 5, 6 and 8, in section 4, below.

Capacity Gap

A third category of gaps refers to capacity. This can be broken into two distinct capacity issues:

There is within the user community and to some extent within the value-added industry an inability to work with EO data or insufficiencies in the technical capacities (such as fast computing and advanced processing) to support the development of products or services for DRM derived from satellite EO data. This is a technology acceleration factor – support to increased technology capacity within the value-adding industry could lead to significant gains in effectiveness and enable new applications for EO in DRM.

The second capacity issue is the more traditional broadly-based EO capacity issue, still of concern in the developed world, though partly addressed through partnerships with value-adding industry. Of greater concern is capacity building within the developing world, where initiatives lack EO focus, lack project focus and are often not sustained, leading to a loss of capacity after the training is complete as resources move on to new opportunities.

Main gaps concerning EO capacity:

- Technical capacity gap (for fast computing and advanced processing)
  In order to produce advanced products and provide sustainable services, value-adding companies require access to advanced computing and processing facilities such as those offered on computing 'clouds'. Many new applications are not possible without the ability to collocate and process very large amounts of data very quickly. CEOS needs to address this technical capacity gap through the development of projects such as SSEP.

- Lack of broadly-based EO capacity, especially in developing world
  In many regions, there is a lack of EO capacity to understand and properly apply remotely sensed data. This human resource capacity gap can be addressed on a project-by-project and region-by-region level. While challenging, through bilateral best efforts partnerships, CEOS may have a significant role to play in this regard, building on existing and new cooperation.

These are in fact two different types of capacity gaps, and they are addressed by proposed Actions # 4 and 7, in section 4, below.

3. CEOS Agency Risk Management Activities

3.1 Overview of collective CEOS satellite capability as applied to DRM

Since 1984, CEOS has coordinated civil space-borne observations of the Earth, with over 50 member and associate members, and with access to a vast range of satellite resources. The world's leading satellite agencies are members of CEOS. In the CEOS database of satellite missions, there are over 250 missions dealing with a wide range of Earth observations. These instruments meets a wide range of scientific and operational objectives, and through CEOS can be brought to serve areas outside the initial mission design, providing collaborative contributions to international projects.

The area of DRM is no exception in this regard. Few if any of the current missions in orbit were specifically designed to address disasters (with the notable exception of the DMC satellites). In the context of the Consensus Report development, the team members were asked to present their most important Disaster Risk Management projects. A summary of these projects is included in Annex 3. While these agencies represent only a small number of satellite operators, they do represent some of the largest satellite operators and collectively can be considered to offer a representative view of how satellite EO is currently used with regard to DRM. A few conclusions can be drawn from the analysis of the reported projects.

Input was received from the following *ad hoc* team participants: ASI, CNES, CSA, DLR, ESA, JAXA, NASA, NOAA and USGS. This accounts for 46 contributions from nine agencies describing 41 projects (Charter, GSNL and Regional end-to-end projects [CSDP, Namibia] covered in multiple submissions). The projects submitted concerned a variety of projects covering each element of the disaster cycle, a range of different disaster types, both operations and science a variety of geographic areas, as well as diverse thematic content.

With regard to the disaster cycle, the projects showed a good distribution across the different phases, although the projects in relation to response were in general more developed. With regard to various hazards, a dozen projects were multi-hazard, while 14 dealt with a combination of geohazards, 11 with volcanoes specifically, eight with flooding, six with earthquakes, five with landslides, four with tsunamis, three with fires, two with windstorms and one with subsidence. Although no showcased projects dealt with drought, several partner agencies do have drought related projects, including NOAA. Of the projects cited, 31 were listed as operational and 12 dealt with science – several were cited as dealing with both science and operations. There were 22 global projects, while nine had a purely local focus Each continent had a number of projects of regional scope. In all, 28 projects claimed to offer a R & D product with a clear end date, 14 dealt with processing tools and nine with other aspects of processing. Eight projects claimed to offer a sustainable service, and 16 projects were focussed on data provision.

From the analysis of the projects listed in Annex 3, there are areas where increased synergies may offer a greater benefit than proceeding in isolation. One clear area identified was volcanoes, where different agencies were imaging volcanoes as parts of different projects, and shared resources might lead to both savings of resources and increased results. There are also areas where specific methodologies or developed software may be shared across a broader group for increased benefit.

The next phase of the *ad hoc* Disaster Team work involves matching these projects to the draft Implementation Plan to ensure that the proposed way forward makes most effective use of existing resources and projects.

3.2 Existing CEOS activities relating to Disasters

There are a number of existing CEOS initiatives related to disasters and these efforts should be considered as CEOS looks to enlarged actions. In addition to this, there are activities where a large number of CEOS agencies are involved, without the activities being undertaken under the aegis of CEOS. Two clear examples are the International Charter Space and Major Disasters, and Sentinel Asia. CEOS should ensure that in undertaking new actions, these actions are complementary to the existing activities and build on their success.

CEOS proper has a Disaster SBA Team, which has been active since 2006, under the chair of the Canadian Space Agency. The head of the Disaster SBA Team sits on the GEO Implementation Board for Societal Benefits, and actively leads the Disaster tasks on behalf of all GEO. The Disaster SBA Team is tasked with coordinating CEOS input to the GEO Workplan under the Disasters Area. The projects undertaken are generally very focussed in nature and have led to interesting developments in different thematic areas including flooding, volcanoes and windstorms. The current GEO Workplan includes four components:

DI-01 C1: Disaster management systems (including gap analysis)

DI-01 C2: Geohazards Monitoring, Alert, and Risk Assessment

DI-01 C3: Global Wildland Fire Information System

DI-01 C4: Regional End-to-End Pilots

Within these activities, CEOS leads C1 and C4 and makes contributions to C2.

4. Potential CEOS Contributions

The main objectives that lead CEOS agencies to propose the current activities are threefold:

- To protect lives and safeguard property;
- To foster increased use of EO in support of DRM, particularly risk reduction; and
- To raise the awareness of politicians, decision-makers and major stakeholders of the benefits of using satellite EO satellite in all phases of DRM.

Despite the clear successes of initiatives such as the Charter, which has brought satellite-based EO into mainstream disaster response management, much remains to be done. With regard to conventional methods for improving disaster risk reduction in particular, better use could be made of existing and planned satellite resources. Organisations such as CEOS encourage the use of satellite-based data in the assessment of risk and vulnerabilities. Disasters have been specifically recognised as a priority by the European Union since the Lisbon Treaty in 2007. Research initiatives such as the European Commission's 7th Framework Programme have specifically encouraged the development of new EO-based solutions that will allow disaster managers to use satellite data within the context of either science investigations to better characterize hazards and risks or operational systems to support disaster management authorities. For the 2014-2020 period, the proposed budget for the future European Emergency Response Capacity reaches some 455 million Euros. On a global basis, organizations such as GEO encourage the development of an international approach to forge greater ties between those that generate satellite-based information and those that need to use it. This institutional bridge-building includes both capacity development activities and the elaboration of a systematic approach for using global data sets in risk-prone areas. Achieving long-term results requires commitment both from data providers (in terms of data continuity, new sensors and evolving requirements) and from the users, who are often unfamiliar with the opportunities afforded by new technologies.

As risk reduction activities are increasingly undertaken with national and regional users, through the sponsorship and guidance of international players – be they international financial institutions such as the World Bank or development agencies such as the UNDP – the uptake of new systems and satellite-based data in operational support to disaster management will increase. There is nothing planning can do to reduce the number and severity of hazards. Ultimately however, while less prominent in the eye of the media, the integration of relevant, timely and comprehensive data sets into disaster mitigation activities will be the largest factor informing emergency service planners and providers, thus contributing to a reduction in the loss of life and damage to property. Improved understanding of risk and risk extent, improved planning, better preparedness and systematic efforts towards risk reduction based on long-term development and environmental concerns will achieve the ultimate goal of reducing the number and scale of actual disasters caused by hazards.

Within the satellite EO community, despite high profile activities with a strong impact such as the Charter, there is a sense that the tremendous potential offered by satellite observations is not fully exploited. The large existing EO data capacity is under-utilised, and many applications are unknown to target users. While cost is often cited as a hurdle, the true challenge is the lack of awareness within the user community. There are of course other hurdles, including difficulty of discovery/access, prohibitive cost/licensing conditions, lack of intermediary support for necessary product/information development, and lack of confidence in data continuity.

Satellite EO is rarely used operationally to address DRM needs. Many users do not view EO solutions as mature, and seek clearer demonstrations of the cost-benefit ratio that would enable them to convince their own management and stakeholders that EO represents a solution to risk and DRM challenges. This report's analysis of flooding, seismic hazards and landslides demonstrated a clear data gap where satellite-EO can make a difference by supplying missing information to DRM users. In order to succeed however, other gaps must be addressed, including awareness, capacity, and availability gaps.

Information needs cover both information on hazards and information on exposure and vulnerability, which is a very broad range of needs and associated geo-info solutions. The CEOS DRM activities must address both hazards and exposure and should provide data and tools to generate needed geo-information (*e.g.* on hazards), as well as linking to available EO capacities that provide such geo-information (*e.g.* Satellite EO resources for reference mapping, asset mapping, vulnerability mapping, etc.). In order to ensure the best possible use of CEOS resources, the actions should reuse existing assets and projects from space agencies.

Operational EO use in risk reduction will help prevent loss of life and better understand and possibly reduce exposure of property to damage. It will also augment the effectiveness of existing response initiatives such as the Charter by reinforcing institutional bonds with key users. Finally, high-profile application of EO in DRM generates political support for increased EO capacity over the long-term.

In order to bring providers and users of EO together, the satellite EO community should make a more concerted effort to demonstrate the value of EO to DRM Users, in particular by presenting EO in a non-satellite centric 'integrated' solution that shows how satellite EO can be an enabler, bringing innovative solutions to traditional DRM challenges. This demonstration will build on and complement existing and emerging international flagship co-operations in this field, such as the GSNL and the Charter, and can be made through cooperative pilots defined in close coordination with users. Once convinced of the utility of satellite EO, users will make the best champions for EO and may be prepared to bear the cost of integrating EO into their own systems.

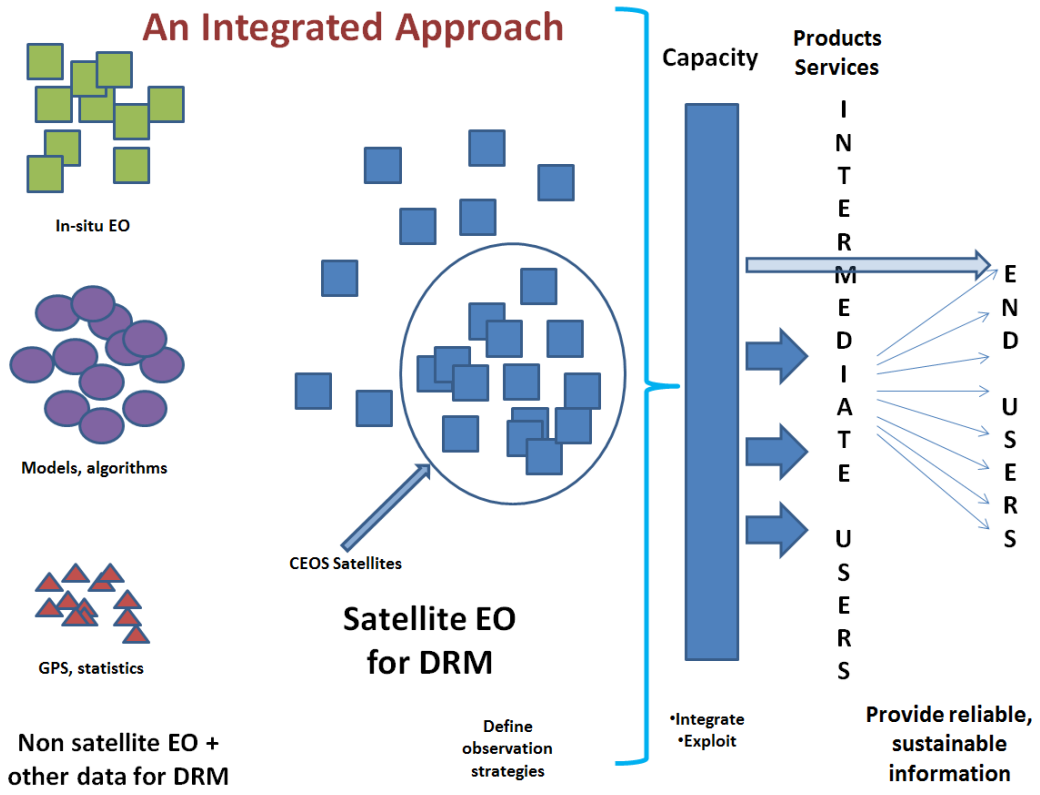


FIGURE 16. INTEGRATING SATELLITE-BASED EO INTO DRM PROJECTS AND SERVICES

This section provides a detailed description of five major actions and three supporting actions that flow directly from the analysis of major gaps that exist today in the DRM community. Though independent, these actions are intimately related and constitute a coherent framework. Their implementation is foreseen as a step-by-step approach where

actions 1 and 5 move forward first, to be followed by actions 2, 3 and 4 once action 1 is successfully completed. Taken collectively, the actions will ensure that proper EO data are collected, facilitate access to these data by the DRM community, offer certain data free of charge to encourage rapid uptake of satellite-based applications, offer tools and mechanisms that will enable the next generation of satellite-based EO applications on a global scale and position the EO community in broader DRM activities. The focus of these actions has been established through close study of the DRM community and clear linkages have been made to existing CEOS agency initiatives that serve as a solid starting point for the activities put forward. The actions have been defined to ensure that they can be reasonably implemented through a large reuse of existing projects and resources managed by several CEOS Agencies represented in the team, and existing CEOS bodies such as the Working Groups, the Disaster SBA Team, the Virtual Constellations or the Space Data Coordination Group, amongst others.[12]

It should be noted that these actions respect the data policies of the CEOS Agencies involved. CEOS Agencies may contribute to all or only a subset of actions, but each approved action shall be supported by at least two CEOS Agencies. In identifying future CEOS actions, the *ad hoc* Disaster Team has sought to ensure that actions:

- Are 'actionable' (i.e. can be executed by CEOS with a high chance of success);
- Re-use existing infrastructure and programmes as much as possible;
- Recognize the mandates and expertise of individual CEOS agencies;
- Respect the data policy of individual CEOS agencies.

The primary users to benefit from the CEOS enlarged actions are:

i) end users from DRM communities
ii) intermediary users that are either in-sector providers (from user organisations and with a capacity to exploit EO data *e.g.* British Geological Survey, UNITAR/UNOSAT, etc..) or value adding specialists (from the EO sector and suppliers of products/services combining EO with other sources)
iii) science users

The primary beneficiaries of DRM actions will be intermediary users and science users because their interest is focused on EO data and processing of EO data; the end to end solutions are much more downstream and require integration of *in-situ*, modeling, and interpretation. While the focus of the enlarged action is both on intermediary and local and national end-users, as for the International Charter Space and Major Disasters the bulk of the actions to be developed will concern intermediary users; this global approach is adapted to CEOS and recognizes the real position EO plays with regard to risk reduction and DRM more broadly. While EO is a critical enabler that allows DRM users to augment the effectiveness of their actions, taken alone EO cannot perform DRM.

A CEOS vision for DRM

Through the review of the information needs of users both in existing documents and through an analysis relating to flooding, earthquakes and landslides, the *ad hoc* Disaster Team was able to identify critical gaps in relation to data, awareness and capacity. These gaps offer CEOS an opportunity to demonstrate the effectiveness of EO for DRM users in targeted actions that will increase the visibility of EO and demonstrate the cost-benefit of satellite-based solutions. The summary review of CEOS Agency DRM-related projects shows great promise for identifying specific areas where existing projects can be re-used and collated for greater impact. The *ad hoc* Disaster Team has elaborated eight proposed actions (five enlarged actions and three supporting actions) that chart out a vision for future CEOS activity relating to DRM. If approved for implementation, this vision requires an Implementation Plan that will identify the specific priorities in the near-term and limit the commitment of CEOS Agencies.

[12] Currently focused on Forest Monitoring (FCT, GFOI) but possibly expanded to cover other major CEOS projects such as GEO-GLAM or DRM.

Five Enlarged Actions Concerning Satellite EO and Disaster Risk Management have been identified:

Action # 1: Define a Global Satellite Observation Strategy for DRM: Perform a detailed analysis of needs and gaps for a few selected "pilot" hazards that leads to the generation of a set of requirements to be addressed by space agencies. Then, define a strategy that addresses those requirements, in order to better use EO missions for an improved contribution to user communities; defining plans of data acquisition and delivery, including the definition of the DRM baseline data - ***a strategy to define which EO data support DRM.***

Action # 2: Implement a Global Satellite Observation Strategy for DRM: Perform a detailed analysis of needs and gaps for "pilot" hazards that leads to the generation of a set of requirements. Implement a Global Satellite Observation Strategy including all these requirements, focusing on building dedicated archives for DRM – ***ensuring EO data are there.***

Action # 3: DRM Virtual Data Repository: Offer to any DRM user access to EO data; this shall include the delivery of a DRM Baseline Dataset (data at no cost for selected observations/selected themes and limited geography) and the development of a user-driven data selection tool – ***where and how to get EO data.***

Action # 4: DRM Data Processing Platform: Develop capacity to enable access to EO-based value-added products, tools and on demand processing - support science and services exploitation of Satellite EO (requires infrastructure for science data) – ***enable EO-based content generation and hosting user generated content.***

Action # 5: Positioning Satellite EO in the post Hyogo Framework for Action (HFA) activities: Ensure a major and visible contribution for EO satellites in the post-Hyogo Framework for Action (2015-2025 period) – ***raising the profile of EO.***

Three supporting actions have been identified:

Supporting Action # 6: DRM Outreach and Evaluation of CEOS Actions: Animation of the scientific and technical content of the Virtual Repository and Exploitation Platform, linking to practitioners/users of DRM communities, measuring impact and evaluating effectiveness – ***manage, explain and promote the content.***

Supporting Action # 7: EO Capacity Building for DRM: Establish a network of regional capacity building partners to ensure that countries active in DRR have space-based EO related capacity to be applied to DRM – ***helping others use EO.***

Supporting Action # 8: Sat EO DRM Project Database: Create a searchable database to help CEOS Agencies (and eventually outside partners and user organizations) identify relevant space-based EO DRM projects – ***helping others find DRM projects that use EO.***

The collective contribution represented by the sum of these eight actions represents a significant new contribution to DRM, with a solid focus on risk reduction. These actions offer CEOS a visible new contribution (through the DRM Baseline Dataset in particular) that will be welcomed by international DRM stakeholders and users alike. The actions are inscribed in a vision that incorporates existing successes such as the Charter, Sentinel-Asia and the developing GSNL. This vision rounds out current satellite-EO-based efforts by ensuring that EO supports the full cycle of disaster management and can be implemented globally on an incremental basis. The implementation of this vision will require that CEOS agencies set priorities with regard to both geographic and hazard-type areas of focus.

The following section describes the proposed actions in detail.

Major Actions

Action # 1: Define a Global Satellite Observation Strategy for DRM

Objective: **Define a Global Satellite Observation Strategy for DRM**: Perform a detailed analysis of needs and gaps for a few selected "pilot" hazards that leads to the generation of a set of requirements to be addressed by space agencies. Then, define a strategy that addresses those requirements, in order to better use EO missions for an improved contribution to user communities; defining plans of data acquisition and delivery, including the definition of the DRM baseline data - ***a strategy to define which EO data support DRM.***

Description: This action addresses an agreed set of information needs (to be determined within CEOS), within a given geographic scope and for a given range of hazard types (beginning with those identified above in section 3), to support the full cycle of DRM, including risk reduction activities; this strategy will seek to unify methods and priorities for creating Satellite EO data – either via Background Missions or via dedicated campaigns/collections or existing initiatives such as the GSNL. The strategy will address both the datasets that can be accessed without any restriction as supported by the CEOS Data Democracy initiative (and in line with the GEO Data Sharing Principles) and the others such as commercial data. But the access to non-restricted data is considered as a major pillar of that strategy. Today there is no globally coordinated strategy for satellite EO collects for DRM for either disaster response or other phases of DRM. CEOS has begun to coordinate strategic acquisitions for Forest Carbon Tracking and for agricultural monitoring. Initiating a similar effort for the DRM community allows not only to ensure data will be acquired for critical risk reduction objectives but also to ensure resources are optimised and to minimise conflicts within missions for other applications, like those described above.

Many users and intermediary users of DRM are interested in exposure/asset and vulnerability information and not just hazard information. This leads to information requirements that go much beyond hazard information. Current EO capacities such as the Charter and the GSNL primarily focus on hazard mapping (either to support damage assessment or for scientific purposes). The information concerning Exposure/Asset and Vulnerability is also very important. The planning of data acquisition should address both the hazard information and 'exposure/asset and vulnerability' but will primarily focus on the hazard information. Proposed activities:

- The establishment of key user needs based on work already begun and identification of key data gaps;
- The identification of planning interfaces with user communities and major stakeholders (UN agencies, GFDRR, regional disaster coordination mechanisms, etc.);
- The definition of a Global Satellite Observation Strategy for DRM, including geographic priorities and observational requirements provided by users and practitioners and types of hazards. Partially based on informal consultation of major stakeholders.

The activity does not include:

- Access to the EO data.

Link to gaps: Action 1 addresses thematic gaps by compiling the relevant observational requirements, prioritizing them and addressing them in a comprehensive satellite observation strategy for DRM.

Benefits: Coordination will result in optimized use of resources from agencies, possibly resulting in saved resources, increased total imaged area or both. Data collects will be tailored to the needs of the DRM community. The knowledge of the needs from the community of users by each agency, coupled with a closer relationship with the major stakeholders (UN agencies, GFDRR, etc.) shall help refine the user information needs.

Related Projects and Initiatives: the GSNL activity to support science users in the domains of seismic and volcanic hazards; the Charter concerning those Charter partners/Parties that have a background mission (*e.g.* Radarsat-1, Envisat/ASAR) or those that have an operational scenario with systematic observations (*e.g.* the Sentinel

missions, Landsat Data Continuity Mission (LDCM)). It would also include all EO capacities that have a contribution to DRM and that require/conduct data acquisition campaigns, carpet coverage and/or that use the background missions for instance, GMES, SERVIR, Sentinel Asia, etc.

Stakeholder projects: TBD

Issues and limitations: Based on best-effort basis, there is no commitment to meet 'requirements' of the DRM community. The uptake within the DRM community will be hesitant if data flow is inconsistent or time-limited.

The identification of the information relies on information from a wide array of sources with varying needs. Identifying priorities within these needs may be challenging. It will be necessary to adopt a gradual strategy as not all hazards and geographical zones can be addressed at the outset.

The action is limited to instruments planning and data acquisition. Includes the planning of background missions. Some space agencies are not directly responsible for the planning and operation of some satellites (*e.g.* CNES and SPOT, DLR and TerraSAR-X, CSA and Radarsat-2).

It should be noted that this proposal does not address the creation of dedicated archives (Action # 2) nor the generation/distribution of data, addressed by the Virtual Repository (Action # 3).

Action # 2: Implement the Global Satellite Observation Strategy for DRM

Objective: Implement the Global Satellite Observation Strategy defined in action # 1, focusing on building dedicated archives for DRM – ***ensuring EO data are there.***

Description: based on the strategy developed in Action # 1, perform dedicated data acquisitions to ensure that the archives of CEOS Agencies are regularly populated with data of the right type for users over the areas of greatest interest.

This proposal includes:

- Data acquisition for designated areas.
- Data processing depending on the processing strategy by each agency.
- Data archiving.
- Generation of metadata (to populate the Virtual Catalogue – cf. Virtual Repository).

The activity does not include:

- Access to the EO data (cf. Action # 3).

Link to gaps: Action # 2 addresses the thematic gaps identified in section 2.3 of the report, by implementing the comprehensive satellite observation strategy for DRM and ensuring relevant data exist in archives.

Benefits: Populating the archives of CEOS agencies is a necessary step to enabling many DRM activities such as flood risk studies over time or the rapid generation of change detection products during the response phase. Today, technical intermediary users rely on informal consultations with mission managers from individual agencies to ensure archives are populated, with varying degrees of success. Agreeing on collective priorities would reduce overlaps, ensure better coverage and optimize existing resource allocation.

Related Projects and Initiatives: Mission planning for existing and planned missions.

Stakeholder projects: TBD

Issues and limitations: The action while necessary and useful is limited. In combination with Actions # 3 and 4 and the positioning activity of Action # 5 additional CEOS visibility at the political and policy level will be achieved.

Action # 3: DRM Virtual Data Repository

Objective: Offer to any DRM user access to EO data; this shall include the delivery of a DRM Baseline Dataset (data at no cost for selected observations/selected themes and limited geography) and the development of a user-driven data selection tool – *where and how to get EO data*

Description: This action would create a Virtual Data Repository based on a network of worldwide distributed data repositories from Satellite EO data owners/operators and service providers of the EO sector (individual space agencies, value adding companies). The Virtual Data Repository will allow the user to search for relevant EO data using geographic coordinates, hazard type and other user-defined criteria, and identify from referenced data sources the extent and availability of the archived data, as well as planned future data collects. The Virtual Data Repository searches through metadata libraries of satellite EO such as, for instance, the metadata catalogue of the International Charter.

The Virtual Data Repository will be able to operate with repositories of other data than satellite EO data that are used by the scientific community or in-sector providers (in the concerned communities), international organizations, etc. This includes for instance the Hazards Data Distribution System (HDDS) of USGS. The content of the Virtual Data Repository is visible by any user via a front-end web-based Virtual Catalogue/Data Selection Tool that needs to be implemented. It should be noted that this front-end does not substitute for the data access portals implemented by each EO data provider.

Access to the EO data, products and information is governed by the data policies from the data and service providers. A (centralized or distributed) physical repository element might be assembled by the EO space agencies to allow the providers to upload data to that storage place.

This proposal includes:

- The integration/coordination of a Virtual Data Repository based on a network of worldwide, distributed data repositories from EO space data distributors with a front-end web-based Virtual Catalogue or Data Selection Tool.
- The creation of a Virtual Catalogue or Data Selection web-based Tool that allows users to search metadata using user-defined criteria such as geographic coordinates, hazard type and other user defined criteria that are important for identifying instruments and corresponding products of interest (*e.g.* use of a matrix for hazards ←→ adequate instruments/missions)
- The download access of the EO data (archived or on-line). The physical access is to specific EO data ruled by the data policy of the provider of this EO data.
- The generation of metadata reflecting the content of the Virtual Data Repository.
- The data processing depending on the processing strategy by each agency (some agencies archive only the Level 0 data and provide upper level products only when requested by users).

The proposal does not include:

- The implementation and operations of the projects/ initiatives that will generate the EO data, products and information (cf. Action # 4).

Link to gaps: Action # 3 addresses the awareness and capacity gaps identified in section 2.4 of the report, by providing users with a clear path to EO data (through the Virtual Catalogue or DRM-tailored Data Selection Tool), providing a limited repository for key applications to enable easy treatment and use of data, and by bringing users and suppliers of data closer together in a distributed framework.

Benefits: Identifying whether or not data exists and where to find it and acquire it is in itself a significant challenge of the international DRM community. The Virtual Catalogue/Data Selection Tool and Data Repository offer users the possibility of identifying usable data sets through a single interface and linking directly to the providers of the data.

If approved, it could be presented as a contribution in kind from the space agencies to other relevant infrastructures such as the GFDRR Labs.

The identification of a DRM Baseline Dataset that is easily accessible to all at no cost is a highly visible and widely requested component. It must be defined sufficiently broadly to meet a minimum use threshold, but will not address all DRR needs. It is a mechanism to encourage EO data uptake and naturally leads to broader (paid) use of EO data by global DRM stakeholders and end users. It is not a commitment by CEOS agencies to make all DRR data available at no cost.

The Virtual Data Repository is an ideal complement to the Global Satellite Observation Strategy for DRM, the DRM Background Missions and Other Data Collects (Actions # 1 and 2) and the DRM Virtual Data Repository.

Related Projects and Initiatives: It is related to all the projects and initiatives that generate data. For instance, data acquired following an activation of the International Disaster Charter might be made visible through this Virtual Data Repository and accessible according to the individual access rules of the data provider. There is no assumption on the physical location of the data. As a minimum, the metadata catalogue of the International Charter may be a direct contribution, and there are other CEOS member projects that might serve as a basis for such a system (e.g. USGS' HDDS).

Stakeholder projects: TBD

Issues and limitations:

Data policies from the various providers need to be respected; not all CEOS agencies will be required to contribute to the DRM Baseline Dataset (the metadata library component is not affected by this issue).

The providers need to agree on a "standard" classification of the hazard types (for searching). Note that a given EO data set or product can be used for more than one hazard type.

Generating a single interface for the various physical catalogues (inventories) to the Virtual Catalogue is an issue due to varying metadata standards and various catalogue access protocols such as HMA, CWIC, etc..... Existing multi-catalogues systems will be reused as much as possible (*e.g.* at ESA, CNES, USGS, GEO, etc.)

The main issues from a user point of view are ease of discovery and access. These need to be clearly addressed.

Action # 4: DRM Data Processing Platform

Objective: provide a capacity to enable access to EO-based Value-added products, tools and on demand processing - support science and services exploitation of Satellite EO (requires infrastructure for science data) – *enable EO-based content generation and hosting user generated content*

Description: The intention is to link an exploitation platform to the Virtual Data Repository and provide additional capacity "vertically". It will address information needs concerning both *hazards* and *assets at risk/vulnerability*. Using data obtained through the Virtual Repository and from other sources (*e.g.* end users), the contributing agencies or partners would develop specific exploitation functions concerning tools (*e.g.* processing EO data), on demand processing (*e.g.* elaboration of EO-based geo-information) and upload/hosting of satellite based geo-information (*e.g.* readily available geo-information products generated by practitioners/users/third parties that can be used as reference or baseline in DRM applications) that address a given need in relation to a community of practice in the disaster area. The access to tools, processing chains, products and information would be governed by the policies from the software/data/service providers.

Such a capacity will aim at supporting international Satellite EO projects in DRM such as for instance the INSAR component of global strain map for seismic hazards, historical terrain deformation maps (*e.g.* PSI-based products), tools and maps for flood hazard assessment (*e.g.* archived flood extent maps, etc.).

This action includes:

- One or more "vertical" contributions, which target a specific user community and specific risk to be reduced.
- Links to external "vertical" contributions pertinent to DRM applications of Satellite EO.
- Access or links to tools, processing, end products or services in an open fashion and looking at both science and operational use; includes the upload of EO-based derived information and reference Value Adding products (*e.g.* provided by the various end-users, stakeholders, value-added service companies that are willing to share their production with the DRM-communities.
- Access to reports and publications concerning Satellite EO and DRM and the ability to link a publication to a satellite based geo-information product release (for instance scientific papers and related modeling or research).
- The ability for DRM practitioners or users to upload their EO-based results for broader information and awareness (data, derived products, processing, value-added products, etc.).
- Rights to use associated data to update the product if required.

The proposal does not include:

- The management of tools, processing and satellite based geo-information provided via the Data Processing Platform.
- A commitment for follow-on end-to-end service; it is platform to support exploitation but not a service. This service may be provided commercially or through other partnerships after an initial pilot period.
- The EO data used to generate the product or rights to use this data for other purposes – that is provided with the Virtual Data Repository (Action # 3)
- The implementation and operations of the projects/initiatives that will generate the EO data accessible via the Virtual Data Repository defined with Action # 3.

Link to gaps: Action # 4 addresses the capacity gaps identified in section 2.4 of the report, by providing technology acceleration assistance to support advanced processing and thematic product development.

Benefits: these vertical contributions are the heart of what the user community needs, given that most end users are not interested in generating their own applications based on EO data; for those users that do want raw data, the

Virtual Data Repository allows them to identify it and easily acquire it, and their application can become a vertical component as described above. For intermediate users, the Data Processing Platform offers tools and services not available in-house through a shared infrastructure at an affordable cost. Access in particular to fast computing services such as Cloud Computing will enable applications not possible using traditional computing methods. This action addresses the "last mile" issue of extracting information from EO data and putting it into a form people can readily use.

Without the Data Processing Platform, many end users or intermediate users will lack the tools and capacity to fully exploit data and new applications for DRM may receive little uptake. This will mean that even if the proper EO data are available through CEOS agency missions, and discoverable through metadata catalogues, data may remain unexploited. A properly established and promoted Platform provides the user community with the full tool set to exploit vertical applications for targeted segments of DRM.

Related Projects and Initiatives: numerous including the GSNL, projects involving value added specialists working with the Charter, etc. The Super Sites Exploitation Platform is an example of such an exploitation platform with a focus on geo-hazard risk applications for scientists. In the longer term, the concept can evolve and enable commercial access to e-services (on demand).

Stakeholder projects: TBD

Issues and limitations: Financing, updating, sustainability.

Action # 5: Positioning satellite EO in the post Hyogo Framework for Action (HFA) activities

Objective: Ensure a role for EO satellites post-Hyogo Framework for Action (2015-2025 period) - ***raising the profile of EO from space in Disaster Risk Management.***

Description: This action would ensure a recognized role for EO remote sensing data and for EO space agencies in the post-Hyogo Framework of actions. The UN-led process that will define the 2015 post-Hyogo FA has started and will last until 2015. Some of the key relevant events have been or will be: The Rio+20 UN Conference for Sustainable Development (Rio de Janeiro, June 2012), the High-level Conference on Large-Scale Natural Disasters (Sendai, July 2012), the Global Platform for Disaster Risk Reduction (Geneva, July 2013) and the World Conference on Disaster Risk Reduction (Japan, 2015). During that period there will be also several Ministerial Conferences and Regional Platforms on Disaster Risk Reduction.

- This action is critical to making the satellite EO community a recognized player in international DRR circles. It can serve as a springboard to bring satellite EO to the forefront of DRR use.

- In order to be effective, the action relies on the successful delivery (or at least clear progress) of several of the other actions, at least Actions # 1, 2 and 3 and ideally 4 as well.

This proposal includes:

- The identification of the several "right" interfaces among the various stakeholders and also at national level.
- A strong lobbying and communication activity.
- Close interaction with the space agencies' managers.
- A careful assessment of the rest of the actions defined in the post-Hyogo FA.

The proposal does not include:

- A formal engagement of the CEOS Agencies to implement whatever actions result from the post-HFA.

Link to gaps: Action # 5 addresses the awareness gaps identified in section 2.4 of the report, by ensuring satellite-based EO is recognized by the leading risk reduction initiatives globally, and supporting the broader positioning of CEOS as a broker for EO-based DRM solutions.

Benefits: This action would increase the awareness of the DRM stakeholders on the use of EO data in support to DRM. It might also lead to an increased role of EO space agencies in DRM and hence provide a justification for the timely development and operations of new assets.

Related Projects and Initiatives: This action is related to both to the Global Satellite Observation Strategy and Implementation (Actions # 1 and 2), the DRM Virtual Data Repository (Action # 3), and the DRM Data Processing Platform (Action # 4). A successful implementation of these activities will be an argument to convince major stakeholders involved in the definition of the post-Hyogo FA that EO data from space and space agencies can play a major role in risk reduction and hence to foster the use of EO data through the full cycle of DRM.

Stakeholder projects: TBD

Issues and limitations: finding the right interface in particular at UN agencies, World Bank, GFDRR, etc. to understand the needs and also to identify the areas that can form the object of partnerships with donors (if any).

Supporting Actions

Action # 6: DRM Outreach and Evaluation of CEOS DRM Actions

Objective: Animation of the scientific and technical content of the Virtual Repository and Exploitation Platform, linking to practitioners/users of DRM communities, measuring impact and evaluating effectiveness – *manage, explain and promote the content*.

Description: This action would ensure that the metadata or data products provided with the Virtual Repository are correctly meeting the priorities of the global observation strategy; make sure the tools, on demand processing and reference geo-information products provided with the Exploitation Platform are in accordance with the themes and priorities that are underlying the global observation strategy. Verify that the content provided by third parties has the required levels of permissions and credits.

This action includes:

- The loosely-coordinated management of tools, processing and satellite-based geo-information concerning both science and operations to support DRM; while the practitioners or users will select what is valid and fit for purpose for their use, the animation, outreach and evaluation action will have an loosely-controlled editing function to manage the content of what is provided.
- The animation of vertical elements of the Data Processing Platform through liaison with communities of practice and scientific leaders.
- The promotion of linkages between the science and service communities.
- An objective and documented evaluation of the impact of the DRM Actions against the objectives of the activity as defined in the CEOS DRM study report.

Link to gaps: Action # 6 addresses the awareness and capacity gaps identified in section 2.4 of the report, by supporting the broader communities interested in the results of Actions # 1 through 4 and encouraging objective evaluations that are applied to service delivery.

Benefits: in order to successfully implement Action # 4 above, a coordinated approach is required. The animation described in this action aims specifically at ensuring that the vertical components of the Data Processing Platform are implemented with a view to maximizing the efficiency of resources by targeting different applications from different agencies. This action would offer such animation and coordination. It also ensures that user contributions are integrated and that an evaluation mechanism is established to evaluate the usefulness of contributions.

Related Projects and Initiatives: Actions # 1-4, especially # 4 above.

Stakeholder projects: TBD

Issues and limitations: This supporting by definition will be limited in scope. As the Data Processing Platform grows, it may be challenging to ensure informal animation and coordination.

Supporting Action # 7: EO Capacity Building for DRM

Objective: Develop capacity building programs on a regional basis that support regional DRM users in the use of EO.

Description: This action would provide an overall framework in which space agencies can elaborate satellite EO capacity training that is relevant for DRM users and commit to specific capacity building on a regional basis.

This proposal includes:

- Development of capacity building materials specific to the need of the DRM community, in liaison with the CEOS Working Group on Capacity Building and Data Democracy (WGCapD).
- Establishment of regional "partnerships" between space agencies with varying levels of capacity with a view to ensuring DRM activities based on satellite EO can be delivered in country.
- Contribution of some relevant data sets to World Bank GeoNode programme.

The proposal does not include:

- Long-term commitment to capacity building beyond initial set-up (to be sought from donor agencies)

Link to gaps: Action # 7 addresses the capacity gaps identified in section 2.4 of the report, by organizing support to EO-based DRM on a regional basis, in partnership with existing players but with renewed momentum from CEOS Agencies on a bilateral best-efforts basis.

Benefits: This action would enable delivery of some DRM activities with strong national contribution; will excite national partners to make stronger contribution. It would also complement the Charter's recent initiative to provide Universal Access to qualified national users worldwide.

Related Projects and Initiatives: There is a possible tie-in with World Bank capacity building activities; and possible links with UN-SPIDER capacity development efforts (to be re-used when applicable).

Stakeholder projects: TBD

Issues and limitations: should be project driven and tied to specific DRM initiatives to avoid past capacity building mistakes where generic capacity was under-utilized and ultimately unsustainable.

Supporting Action # 8: Satellite EO DRM Project Database

Objective: Create a database of CEOS disaster-related projects.

Description: This action would create a web-hosted data base that CEOS Agencies and eventually users and stakeholders could search to find related DRM projects or potential partners for a specific activity. The database is meant to showcase existing DRM activities within CEOS Agencies.

This proposal includes:

- Adaptation of existing materials (developed in this report) to a web-hosted format for easy presentation and searching.
- Development of the structure to host the information.
- Maintenance of the structure and management of renewed content for a given period.

The proposal does not include:

- Development of materials for projects from non-CEOS agencies.

Link to gaps: Action # 8 addresses the awareness gaps identified in Section 2.4 of the report, by compiling the existing DRM-related projects and making them better known both within CEOS and for representatives of the user community.

Benefits: This action would showcase existing work and promote CEOS agencies activities in DRM.

Related Projects and Initiatives: This database could be highlighted on the CEOS website.

Stakeholder projects: TBD

Issues and limitations: This action will only be as useful as the information contained within the database; may highlight disparities in relative DRM contributions of different agencies.

5. Conclusions and Recommendations

5.1 Main conclusions of the *ad hoc* Team regarding opportunities and threats/risks

The *ad hoc* Team concluded that there are numerous gaps related to satellite-EO within the DRM community, and that it is not possible to address all of these in parallel. Some of the main gaps identified are listed below, along with the relevant actions proposed to address them.

In addressing gaps, members of the ad hoc Team strongly felt that a detailed implementation needs to be developed that would include the following principles:

- Proposed actions are non-binding (some members will not support all actions);
- Proposed actions are 'a la carte' (some members may support only parts of actions);
- The proposed Actions taken collectively form a CEOS vision for DRM action, but may take many years to implement;
- The implementation plan would include as a first step, further review of user information needs, CEOS prioritization of response to needs according to CEOS means and resources, and development of a clear observation strategy that addresses both the needs of users and the ability of data providers to contribute;
- The implementation plan will recognize that proposed Actions include a clear hierarchy; within the main Actions, Actions 1 and 5 begin after approval in principle, whereas Actions 2, 3 and 4 are provided for completeness but are subject to successful delivery of Action 1 and may be modified as CEOS continues its study of this area;
- The implementation will strike a balance between two clear goals – the desire to achieve ambitious objectives and the need to re-use to maximum extent existing activities to limit the need for new resources.

To summarize, the report has identified three major categories of gaps: data gaps, awareness gaps and capacity gaps.

Data Gap - (Actions # 1 and 2)

The first major category of gaps is gaps related to data. Although there are large number of satellites in orbit and planned for launch, certain data gaps remain principally because existing and planned satellites are not currently planning acquisitions to address specific categories of DRM users.

These gaps have been addressed in detail in the thematic sections on plain flooding, seismic hazards and landslides. Further analysis is required to address potentially important gaps in relation to volcanoes and droughts. These categories collectively represent the most promising areas for enlarged contributions in the opinion of the *ad hoc* Disaster Team.

Awareness Gap - (Actions # 3 and 5 and 6, 8)

It is clear from even a summary review of user needs and the activities of user organisations that awareness of the potential of satellite EO remains a major hurdle for increased uptake of EO data by the DRM community. This gap can be further subdivided into the following categories:

- Lack of awareness of means of finding EO data;

Within the user community, there is a lack of knowledge of how to access data, and more critically, how to determine whether appropriate data sets exists through consultation of metadata catalogues. In order to establish whether or not data is available, a user must consult many different archives from different data suppliers, even when searching for the same type of data. For example, a user trying to determine whether there is C-band SAR data over a river system must consult the metadata archives of ERS-1 and 2, Envisat, CSA and MDA. In some cases, value-added providers can do this as a service for an end-user, however many value-added providers work with only subsets of data suppliers, meaning the answer to the user query will be incomplete.

- Lack of awareness of utility of data;

Even when data is known to exist, it is not clear within the user community that the benefit derived from EO usage warrants the investment.

- Lack of acceptance of EO as an official tool to deliver on governmental mandates;

There is a need for official recognition of the utility of techniques to be baselined. This requires full-scale trials with national authorities that demonstrate value.

- Lack of confidence in long-term data continuity/availability.

There is a need to promote existing and planned missions, which collectively offer much greater data continuity than in the past. CEOS could play a pro-active role in this respect.

Capacity Gap - (Actions # 4 and 7)

A third category of gaps refers to capacity. There is within the user community and to some extent within the value-added industry an inability or insufficiencies in the development of products or services for DRM derived from satellite EO data. For users, this usually refers to a need for increased training and resources; for the value added industry, this is related to wishes for access to advanced computing and processing resources beyond the scope of those available to individual companies.

5.2 Structured list of recommendations

The CEOS *ad hoc* Disaster Team recommends that the CEOS decision bodies take the following actions:

1. Endorse the Study Consensus Report including the Enlarged Actions Concerning Satellite EO and DRM described in section 4;
2. Establish a CEOS DRM Project Team to produce Terms of Reference and a draft Implementation Plan for the March 2013 SIT meeting. The Terms of Reference and Implementation Plan for Project Team should describe relations with the Disaster SBA Coordinator, Space Data Coordination Group, the Working Group on Information Systems and Services, the Working Group on Capacity Development, and the Working Group on Calibration and Validation;
3. Extend the mandate of the existing *ad hoc* Disaster Team to the March 2013 SIT meeting to ensure continuity of the activity until the establishment of the Project Team;
4. Mandate the *ad hoc* Disaster Team to begin coordination with the UN ISDR in the lead-up to the May 2013 post-Hyogo Framework for Action activities, before transferring this activity to the CEOS DRM team when it becomes operational;
5. Mandate the *ad hoc* Disaster Team to liaise with UN ISDR and other major stakeholders and users to prepare the Implementation Plan, before transferring this activity to the CEOS DRM team when that Team becomes operational.

Appendix 1 – References and summary bibliography

Documents:

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Annex 1 – Global User Needs and related frameworks

The tables included below are extracted for information from the CEOS input to the GEO Task DI-06-09, Use of satellites for risk management – volume 1, User requirements (2008). They are included for reference and can be compared to the data included in the tabular summaries from this report in section 3, above. Please see attached document: User requirements tables_GEO_2008.

Some examples of users segmented by hazard type:

- Case of seismic hazard risk:

National and Regional Civil Protections, Seismological centres, National and Local authorities in charge of seismic risk management activities are concerned with the phases of prevention, preparedness, early warning, response, recovery, rehabilitation and reconstruction. Beyond operational users with a mandate in seismic risk management there is a range of geoscience users focused on the scientific use of data with the main goal of understanding the physics the drive earthquakes thereby improving our ability to characterize, understand, and model seismic risk.

There are essentially four main user communities involved in seismic hazard activity:

1. Emergency Response – this community is concerned with operational response to major seismic events, and needs data and information products geared towards damage analysis and situational awareness.

2. Hazard Science Response – this group uses applied science, advanced imagery analysis and models during events to help develop the situational awareness needed to help facilitate the Emergency Response Community, bringing the science into an operational context.

3. Operation Science – this group is concerned with the mechanisms triggering events.

4. Hazard Science Research – this group is focused on pure science research.

- Case of landslide risk:

- Civil Protection Authorities: in joint collaboration with the scientific community, the civil protection agencies coordinate and manage the forecast of landslide risk scenarios, monitoring and early warning systems, prevention activities aimed at minimizing damages, relief operations (rescuing people, ensuring early assistance to the population affected by disasters and overcoming the emergency), as well as training activities to ensure preparedness of citizens to emergencies.

- Policy makers and planners: include a wide range of government officials at the national, regional or local level, politicians, administrations, land use planners and all those authorities taking part in the selection of the best actions to be performed among several alternative scenarios, concerning issues as broad ashazard mitigation (*e.g.* through stabilization and remediation works) and risk management (*e.g.* implementation of land use planning strategies, regulation and controls driven by clear and firm laws) including response (alert and monitoring activities, identification of affected areas and residual risk zonation, selection of safe areas where affected population can be relocated, etc..

- Other end-users: include a wide range of end-users of all sectors (*e.g.* environment, economic and transport), such as insurance, engineering and construction companies, infrastructure operators and land owners. These users should be consulted during the land use planning phase and decision making processes, in a truly participatory risk management process.

- Citizens: are the ultimate beneficiaries of the geo-hazard related strategies, and need to be informed on where, when and to which extent ground instabilities will take place, in the short-term. Correct and thorough knowledge of a phenomenon is the first step in understanding and dealing with it properly to prevent possible dangers. Hence, one of the most important duties of the scientific community and responsible authorities is to make the population aware of proper behaviours to adopt if a landslide occurs, by adopting awareness and preparedness campaigns (increase the ability to be prepared during unpredictable events), and establishing simple rules on how to prevent or minimize the damage induced by landslide phenomena.

Scientific users of the landslide community include universities, geoscience research departments, environmental agencies, national geological surveys and, generally, those institutes dealing with slope instability and working on the prediction, monitoring and supervision of the various types of landslide processes. Their main goals are the collection of satellite EO data validation through on site measurements and their integration into geotechnical, hydrogeological and deformation models.

Geological surveys are involved in both education and capacity building activities and actions, as well as in risk assessment. They deal with long-term monitoring of geo-hazards, collection and analysis of data and information related to natural hazards on a daily basis, and represent primary providers of information products supporting decision makers, local and regional/county authorities, and the population when landslides occur, thus straddling both scientific and operational roles.

- Case of volcanic risk:

Conceptually, the monitoring of volcano dynamics is dealt with by volcano observatories which run monitoring arrays of instruments, and carry out multi-parameter networked measurement for constraining elastic, mass, geometric, magnetic, chemical and gas parameters, in time and space. As volcano assessment and forecasting are still supervised, a dominant part of monitoring relies on visual observation and terrain inspection.

By nature, a volcanic eruption is a locally-relevant event that may turn into a trans-boundary event. Consequently, there are two categories of users of geo-information on volcanic activity (monitoring) and volcanic hazards in general (risk exposure assessment and mapping):

- the first category is national, and should be selected case by case from those responsible for disaster and risk management, or of giving scientific advice to those who make decisions to protect lives and property. Typically, the former is a Ministry or a mandated National Agency, whereas the latter is a volcano observatory, a geological survey or its equivalent.
- the second category is transnational and, as such, has no ruling nor advising powers on the territory hosting the volcano. Typically represented by the Volcanic Ash Advisory Centres (VAACs), it is an intermediate link between the WMO, the International Civil Aviation Organisation (ICAO) and individual airlines, requiring timely warnings by volcano observatories –where they do exist– on major ash and gas emissions.

Thus, for each hazard type, in addition to the generic user, there will be hazard specific users.

Examples of DRM Policies:

The increase of the population density and the development of our society have brought in many areas an increase of the threat caused by natural hazards. The topic of natural hazards related to meteorological events has come over the last years to the political agenda of most of the European countries and to the opinion of their citizens, due to a series of major events with large effects such as the repeated floods in Central Europe and the recent devastating forest fires in the Mediterranean countries. These natural hazards are a major cause of loss of life and property, and may also impact some important environmental resources. Hence the need to better manage these hazards through a more

efficient use of geo-spatial observations, improving our ability to better predict, monitor, mitigate, and respond to these natural hazards.

Reducing the severity of these disasters requires a better integration of observations from various Earth Observing systems, some improved predictive modeling, and the dissemination of timely and accurate information needed by all actors involved the mitigation of these disasters. Actions shall be driven by the risk management policies (primarily at European National / Sub-National levels) and by the information needs of the organizations in charge of the policies implementation for what regards the prevention, prevision, response and recovery phases.

- Examples of National Policies:

While there are Policies at regional, international level the following is an illustration of policies at national and regional/local levels:

Policies
National Civil Protection Policies against Natural and Technological Disasters
e.g. Italian Directive from the President of the Council of ministers, 27 February 2004 (GU n.59 del 11-03-2004, suppl. Ordinario n.39)

Areas Of Concern
National laws and policies establishing the institutional framework in matter of civil protection at national level and the mandates of the various institutional actors for the protection of citizens, health and property against natural, technological and other disasters.

Policies
Forest Fires Fighting / Prevention Policies

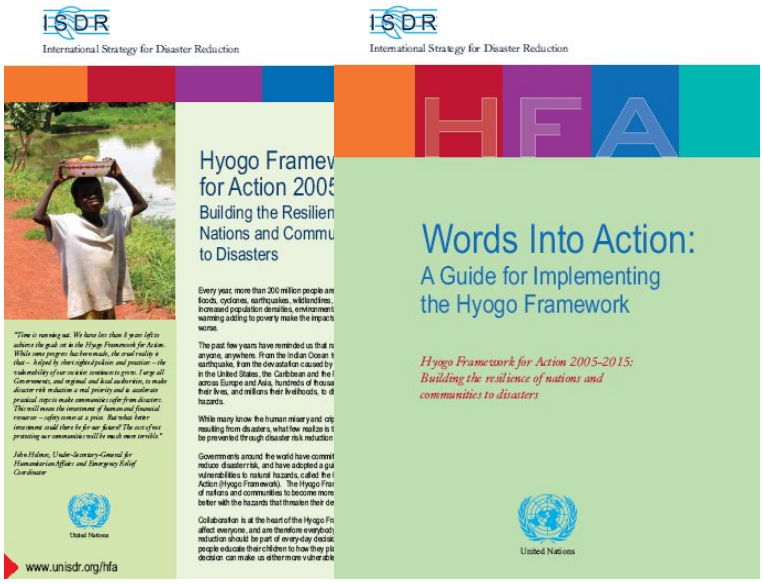
Areas Of Concern
National laws and policies governing fire-fighting actions for the protection and conservation of the forest against wildfires; Flood Defence Policies National laws and policies regarding the defence against river flooding.

- Examples of Regional/Local Policies:
  Policies
  Regional general Civil Protection Policies against Natural and Technological Disasters Regional Forest Fires Fighting Policies (Including forecasting plans, prevention plans and intervention plans); Regional Flood Defence Policies (Including forecasting plans, prevention plans and intervention plans)

  Areas Of Concern
  The Regions must approve the regional laws and policies related to prediction, prevention, fighting activities in response to forest fires and flood disasters, without any prejudice to the guidelines and directives adopted at national level. It is in general the responsibilities of the regional programmes and/or policies to define the areas at risk, the risk level per area and the areas affected by Forest Fires and Floods.

- The institutional framework – Hyogo Frame of Action:
  The international community, including the UN and EU systems, has undertaken a variety of initiatives on monitoring hazards, populations, and prevailing environmental conditions, to assist the most vulnerable nations to devise appropriate prevention and mitigation measures prior to such emergencies. This includes the World Bank/ISDR Global Facility for Disaster Reduction and Recovery (GFDRR) launched in 2006. Policy instruments and strategic guidelines: the UN Hyogo Framework for Action explicitly cites the need

for satellite-based applications and geo-information as important tools for disaster reduction (assess and monitor risks, strengthen preparedness). A strong requirement was expressed by African users during the Lisbon GMES Workshop on Security (December 07): improve access to EO to support disaster reduction.



Annex 2 – Global Stakeholders

Many of the listed organisations below are CEOS partners or associates. A CEOS disaster initiative may encourage re-engagement with CEOS.

GFDRR

At the global level, there are stakeholders that work with end users on a regular basis. These stakeholders include the GFDRR, hosted by the World Bank but representing some 41 countries and 8 international organisations.

GFDRR has three main business lines to achieve its development objectives at the global, regional and country levels.

- Track-I: Global and Regional Partnerships
- Track-II: Mainstreaming Disaster Risk Reduction (DRR) in Development
- Track-III: Standby Recovery Financing Facility (SRFF) for Accelerated Disaster Recovery

In addition to these business lines, GFDRR has initiatives such as the GFDRR Labs, which may offer partnering opportunities for CEOS.

The geo-information needs of GFDRR can be summarized as:

Track-II: Geo-information to support risk assessment;

Track III: Geo-information to support PDNA.

UNISDR

UNISDR is the United Nation's office for disaster risk reduction. It was created in December 1999 as part of the UN Secretariat with the purpose of ensuring the implementation of the International Strategy for Disaster Reduction. UNISDR's mandate is to serve as the focal point in the United Nations system for the coordination of disaster reduction and to ensure synergies among disaster reduction activities.

UNISDR's work is guided by its four strategic objectives:

- **Strategic Objective 1**: Strengthen support to the implementation and coordination of the International Strategy for Disaster Reduction and the Hyogo Framework of Action and improve coherence with climate change adaptation and the Millennium Development Goals.
- **Strategic Objective 2**: Produce and disseminate credible evidence to strengthen decision-making at local, national, and regional levels in support of disaster risk reduction, climate change adaptation, and achievement of the Millenium Development Goals.
- **Strategic Objective 3**: Increase public and private sector investments in DRR and CCA through advocacy and outreach.
- **Strategic Objective 4**: Deliver and communicate results with a more effective, results-oriented UNISDR to carry out its mandate.[13]

[13] http://www.unisdr.org/who-we-are/programme-and-reports

UNDP

In 1998 the UN General Assembly mandated UNDP to assume operational responsibility for natural disaster mitigation, prevention and preparedness. UNDP is present in 177 countries and nowadays employs more than 200 full time practitioners covering all regions with special attention to the 60 highest risk countries. UNDP programme expenditures on risk reduction average US$ 150 million annually.

Officially launched in 2007, the Global Risk Identification Programme (GRIP) has been adopted by the UN ISDR to support worldwide activities to identify and monitor disaster risks. Although hosted by the UNDP, dozens of organizations have been involved in its preparation, design and implementation. GRIP aims to promote sustainable development by reducing the impact of natural hazards on development.

With the mission of providing "Better risk information for sound decision making", it promotes the generation of evidence-based risk information and facilitates its application to improve the quality of policy/decision making in the public sector.

To achieve its objectives, GRIP mainly focuses its work on the following three aspects:

- Improve Coordination at global, regional and national levels to avoid duplication of efforts, optimize resources and increase effectiveness in disaster risk reduction.

- Promote Quality by developing minimum standards for risk information and establishing the necessary Quality Control mechanisms.

- Provide Integrated Support by compiling and coordinating capacity development resources that support risk assessment implementation at all levels.

Support and services to countries

GRIP has assisted about 40 countries in understanding their risks. It supports the countries to establish National Disaster Observatories and National Risk Information Systems to integrate all existing disaster and risk related information and make it available to all potential users.

Risk assessments are implemented at national and local levels to assist the countries in the preparation of National Strategies for Disaster Risk Management and Action Plans for the management of Urban and Sectoral risks. Risk considerations are integrated into development planning and investments. By supporting national institutions and engaging all sectors of society in these processes, UNDP develops local capacities and creates an enabling environment for implementing these strategies. The new knowledge of risks is often incorporated into school books and curricula to promote a culture of prevention.

Key Achievements to date

Better risk information for sound decision making:

- Laos has completed its National Risk Assessment and developed a comprehensive National Hazard Risk Profile for formulating its national Disaster Risk Management Strategy. Laos' is the first National Risk Profile of this kind in a high-risk developing country.

- Armenia, Mozambique, Lebanon, Nepal, and Tajikistan have completed their comprehensive Country Situation Analyses for risk assessment and are implementing National Risk Assessments for the development of their National Disaster Risk management Strategies.

- Local level: On behalf of the Emergency Shelter Cluster and in collaboration with UN-Habitat and the IFRC, GRIP supported Tijuana in Mexico, Kathmandu in Nepal and Maputo in Mozambique to carry out Urban Risk Assessments that were being applied to prepare Pre-Disaster shelter plans.

UNEP

UNEP's Disasters and Conflicts programme seeks to minimize environmental threats to human well-being from the environmental causes and consequences of conflicts and disasters.

UNEP works to prevent and combat future environmental threats based on early risk assessments by facilitating access to relevant environmental data for decision-making through monitoring, analyses and reports on the state of the global and regional environment and trends.

UNEP's Disasters and Conflicts programme focuses on countries that have been identified as vulnerable to natural hazards, as well as on human-made disaster events with environmental dimensions. In addition, UNEP seeks to reduce and/or avert future vulnerabilities by integrating environment and disaster risk reduction into recovery efforts.

As well as producing environmental risk assessments, UNEP:

Seeks to strengthen the hand of Member States for environmental management through developing responsive strategies, building capacity and implementing pilot projects to reduce identified risks, thereby contributing to long-term disaster risk reduction.

Contributes to global policy development by producing policy toolkits and training modules that demonstrate good practices and lessons learned in reducing risks.

Provides environmental data and expertise on sustainable management of shared natural resources.

As an effective means to disseminate policies into practice, UNEP coordinates the Partnership on Environment for Disaster Risk Reduction, a global level forum and a Platform of the ISDR, which seeks to advance an integrated approach to disaster risk reduction, climate change adaptation, ecosystem management and livelihoods.

UNEP's Disaster Risk Reduction is currently engaged in the following two areas of work:

RiVamp: Integrating Ecosystem and Climate Change factors in disaster risk assessment

Developing capacity for coastal zone managers

Recovery: In the aftermath of a crisis, UNEP implements environmental recovery programmes through field-based project offices to support long-term stability and sustainable development in conflict and disaster-affected countries.

Following a post-crisis environmental assessment, UNEP is available to assist national governments to address environmental priorities through recovery programmes that are tailored to country-specific needs.

From helping local and national authorities develop effective laws, policies and institutions, to providing training and equipment, UNEP seeks to help countries to manage their natural resources in a more effective and sustainable manner. UNEP can also coordinate clean-up efforts or catalyze community-based ecosystem restoration and sustainable reconstruction projects in sites damaged by or vulnerable to conflicts and disasters.

Where it is necessary and requested, UNEP can establish project offices in country to coordinate environmental work, as is currently the case in Afghanistan, Sudan, South Sudan and the Democratic Republic of Congo.[14]

UNESCO

[14] www.unep.org

Disaster preparedness and mitigation are among the key objectives in UNESCO's Strategy. Operating at the interface between education, science, the social sciences, culture and communication, UNESCO has a vital role to play in constructing a global culture of disaster risk reduction.

The Organization is engaged in the conceptual shift in thinking away from post-disaster reaction to pre-disaster action. Through its broad mandate and expertise, UNESCO is helping countries to reduce their vulnerability to natural hazards and build their capacity to cope with disasters. Furthermore, UNESCO provides to governments practical and scientific advice on disaster risk reduction and a forum to work together to find solutions in this area.

UNESCO has many programmes in place that deal in one way or another with the study of natural hazards (earthquakes, volcanic eruptions, landslides, floods, droughts, tsunamis, etc..) and the mitigation of their effects. These programmes help us understand the mechanisms of natural hazards and to analyse why some of these hazards turn into disasters.

The Organization is strongly committed to the Hyogo Framework for Action 2005-2015, adopted at the UN World Conference on Disaster Reduction held in Kobe, Japan in 2005, which aims at making societies safe from disasters

The purposes of UNESCO in the field of disaster risk reduction are to:

- promote a better understanding of the distribution in time and space of natural hazards and of their intensity,
- set up reliable early warning systems;
- devise rational land-use plans;
- secure the adoption of suitable building design;
- protect educational buildings and cultural monuments;
- strengthen environmental protection for the prevention of natural disasters;
- enhance preparedness and public awareness through education and training in communication and information;
- foster post-disaster investigation, recovery and rehabilitation;
- promote studies on the social perception of risks.

The themes linked to disaster risk reduction are crosscutting. Consequently, various Divisions, Sections and Programmes of UNESCO's Natural Sciences Sector are involved in the different aspects and challenges of natural disaster reduction. These include the Divisions of Water Sciences, Ecological and Earth Sciences, Basic and Engineering Sciences and Science Policy. The Intergovernmental Oceanographic Commission and UNESCO Field Offices are also engaged in disaster risk reduction.

The Section for Disaster Reduction in Headquarters serves as a focal point and carries out the following:

- promote and strengthen international and regional networking and partnership for assessing and mitigating risks from earthquakes, landslides, volcanic eruptions, etc..;
- promote advocacy and policy support for disaster preparedness and integration of risk reduction knowledge into educational and public awareness programmes.[15]

[15] http://www.unesco.org/new/en/natural-sciences/special-themes/disaster-preparedness-and-mitigation/about-the-programme/

UNESCO and Landslides:

The International Programme on Landslides (**IPL**) is a joint programme established by the International Consortium on Landslides (**ICL**), UNESCO, the WMO, the Food and Agriculture Organization of the United Nations (FAO), UN ISDR, United Nations University (UNU), ICSU, and the World Federation of Engineering Organizations (WFEO). It was established by the **2006 Tokyo Action Plan** **"**Strengthening Research and Learning on Landslides and Related Earth System Disasters for Global Risk Preparedness", the output of the Tokyo Round Table Discussion "Strengthening Research and Learning on Earth System Risk Analysis and Sustainable Disaster Management within UN-ISDR as Regards Landslides" held at the United Nations University, Tokyo, from 18th to 20th January, 2006.[16]

WMO

Disaster risk reduction is at the core of the mission of the WMO, and the National Meteorological and Hydrological Services of its 188 Members. WMO, through its scientific and technical programmes, its network of Global Meteorological Centres and Regional Specialized Meteorological and Climate Centres, and the NMHSs, provide scientific and technical services. This includes observing, detecting, monitoring, predicting and early warning of a wide range of weather–, climate- and water-related hazards. Through a coordinated approach, and working with its partners, WMO addresses the information needs and requirements of the disaster risk management community in an effective and timely fashion.

Every year, disasters related to meteorological, hydrological and climate hazards cause significant loss of life, and set back economic and social development by years, if not decades. Between 1980 and 2007, nearly 7500 natural disasters worldwide took the lives of over 2 million people and produced economic losses estimated at over 1.2 trillion US dollars. Of this, 90 per cent of the natural disasters, 71 per cent of casualties and 78 per cent of economic losses were caused by weather-, climate- water-related hazards such as droughts, floods, windstorms, tropical cyclones, storm surges, extreme temperatures, landslides and wild fires, or by health epidemics and insect infestations directly linked to meteorological and hydrological conditions (Global distribution chart).

Over the past five decades, economic losses related to hydro-meteorological hazards have increased, but the human toll has fallen dramatically. This is thanks to scientific advances in forecasting, combined with proactive disaster risk reduction policies and tools, including contingency planning and early warning systems in a number of high risk countries. [17]

To meet these new challenges, the crosscutting Disaster Risk Reduction Programme two-tier Work Plan (hereafter referred to as the Disaster Risk Reduction Work Plan) aims to facilitate better alignment of the activities of WMO constituent bodies and global operational network as well as strategic partners to assist NMHS through coordinated projects to:

a. Engage as relevant in national Disaster Risk Reduction, adaptation governance and institutional frameworks;
b. Identify, prioritize, establish partnerships and service delivery agreements with national DRR user community (users) and develop mechanisms for engagement with the users for identification of requirements, delivery of products and services and obtaining on-going feedback;
c. Establish partnership agreements with other national technical agencies (*e.g.* hydrological services, ocean services, etc.) as well as global and regional specialized centres (*e.g.* WMO Global Producing Centres, United Nations Educational, Scientific and Cultural Organization-Intergovernmental Oceanographic Commission, Regional Tsunami Watch Centers, etc.);

[16] http://www.iplhq.org
[17] http://www.wmo.int/pages/prog/drr/

d. Develop and deliver core and specialized products and services for DRR decision support (*e.g.* hazard/risk analysis, Multi-Hazard Early Warning Systems, sectoral risk management and disaster risk financing and risk transfer) in a cost-effective, systematic and sustainable manner;
e. Ensure that core operational capacities (*e.g.*, observing network, operational forecasting systems, telecommunication systems, data management systems, human resources, etc.) are built upon the principles of Quality Management Systems to support product and service development and delivery; and
f. Engage in regional and global efforts for development of risk information for large scale and trans-boundary hazards, through strengthened regional and global cooperation, information sharing, and engagement in regional DRR platforms, and Regional Climate Outlook Forums, etc.

The WMO, in association with the Global Water Partnership, through the Associated Program on Flood Management, has sought to introduce an Integrated Flood Management (IFM) approach that focuses on the entire water cycle to better mitigate and predict floods. There are pilot projects on several continents, with varying degrees of success. As a general rule, key satellite EO such as medium to high resolution synthetic aperture radar data collects are not used in the strategies elaborated under the IFM, although the usefulness of remote sensing data is usually recognised in principle.

UNOOSA/UN-SPIDER

"In its resolution 61/110 of 14 December 2006 the United Nations General Assembly agreed to establish the **"United Nations Platform for Space-based Information for Disaster Management and Emergency Response - UN-SPIDER"** as a new United Nations programme, with the following mission statement: "Ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle".

Whereas there have been a number of initiatives in recent years that have contributed to making space technologies available for humanitarian and emergency response, UN-SPIDER is the first to focus on the need to ensure access to and use of such solutions during all phases of the disaster management cycle, including the risk reduction phase, which will significantly contribute to reducing the loss of lives and property.

The UN-SPIDER programme is achieving this by being a **gateway** to space information for disaster management support, by serving as a **bridge** to connect the disaster management and space communities and by being a **facilitator** of capacity-building and institutional strengthening, in particular for developing countries.

UN-SPIDER is being implemented as an open network of providers of space-based solutions to support disaster management activities. Besides Vienna (where UNOOSA is located), the programme also has an office in Bonn, Germany and will have an office in Beijing, China. Additionally, a network of Regional Support Offices multiplies the work of UN-SPIDER in the respective regions."[18]

UNITAR-UNOSAT

"UNOSAT is the UNITAR Operational Satellite Applications Programme, implemented with the support of the European Organization for Nuclear Research (CERN) and in partnership with UN and non-UN organisations.

UNOSAT is a technology-intensive programme delivering imagery analysis and satellite solutions to relief and development organisations within and outside the UN system to help make a difference in critical areas such

[18] http://www.oosa.unvienna.org/oosa/unspider/index.html

as humanitarian relief, human security, strategic territorial and development planning. UNOSAT develops applied research solutions keeping in sight the needs of the beneficiaries at the end of the process.

The UNOSAT core team consists of UN fieldworkers as well as satellite imagery analysts and GIS experts supported by IT and database engineers. This unique combination gives us the ability to understand the needs of our users and to provide them with suitable, tailored solutions anywhere at any time.

UNOSAT created an extended network of public and private partners, and collaborates with the majority of UN agencies, space agencies and several international initiatives active in satellite technology geospatial information.

Our mission is to deliver integrated satellite-based solutions for human security, peace and socio-economic development, in keeping with the mandate given to UNITAR by the UN General Assembly since 1963.

Our goal is to make satellite solutions and geographic information easily accessible to the UN family and to experts worldwide who work at reducing the impact of crises and disasters and help nations plan for sustainable development."

"UNOSAT uses specialized skills to perform satellite analysis, design integrated solutions in GIS and geopositioning, develop the capacity of agencies and recipient counties via training and technical support. UNITAR-UNOSAT work is entirely based on a professional commitment to producing **concrete, tangible and usable results** in every activity we undertake.

UNITAR-UNOSAT is designed to produce concrete output for identified users and beneficiaries by turning technology into concrete and usable applications for UN agencies, member states, and communities in a variety of areas. UNITAR-UNOSAT addresses three main homogeneous user systems:

Humanitarian Affairs and Relief Coordination

- Crisis and Situational Mapping
- Damage and Impact Assessment

Human Security

- Monitoring
- Safety and Security
- Human Rights

Territorial Planning and Monitoring

- Capacity Development and Technical Assistance
- In-country Project Development and Implementation

Created in 2003, the UNITAR-UNOSAT humanitarian rapid mapping service is today fully developed and has been activated over 200 times in relief and coordination operations in the aftermath of disasters, complex emergencies and conflict crises. This work involves very rapid acquisition and processing of satellite imagery to generate geographic information and analytical reports in addition to GIS layers in support of UN emergency relief agencies. UNITAR-UNOSAT remains engaged beyond the emergency phase by supporting early recovery and reconstructions activities. A technology-based partnership with the European Commission Joint Research Centre and the World Bank provides standard operational procedures for vast damage assessment exercises using remote sensing and geospatial analysis.

UNITAR-UNOSAT uses satellite-derived geoinformation for human security in all areas in which monitoring, GIS, and remote sensing can offer a strategic advantage, from monitoring piracy activities to illustrating and documenting human rights cases in the context of complex emergencies.

A growing number of national and international development projects receive support from UNITAR-UNOSAT for strategic territorial planning and advanced GIS applications. The expertise accumulated in the field by our technical team combined with urban planning and knowledge generation skills allow us to provide a technological edge to local capacity development and in-country technical assistance. UNITAR-UNOSAT experience extends to developing capacity locally and helping communities retain this capacity by designing **integrated training** programmes and including specific modules in training and education curricula up to post-university Master level."[19]

GEO

"The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS.

GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and by the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.

GEO is a voluntary partnership of governments and international organizations. It provides a framework within which these partners can develop new projects and coordinate their strategies and investments. As of March 2012, GEO's Members include 88 Governments and the European Commission. In addition, 64 intergovernmental, international, and regional organizations with a mandate in Earth observation or related issues have been recognized as Participating Organizations.

GEO is constructing GEOSS on the basis of a 10-Year Implementation Plan for the period 2005 to 2015. The Plan defines a vision statement for GEOSS, its purpose and scope, expected benefits, and the nine "Societal Benefit Areas" of disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity.

The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS. (See also "Crafting geoinformation," the 2010 Progress Report, and the GEO brochure.)

Societal Benefits

GEOSS will yield a broad range of societal benefits, notably:

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

[19] http://www.unitar.org/unosat/

Understanding, monitoring and conserving biodiversity."[20]

[20] www.earthobservations.org

Annex 3 – CEOS Agency-by-Agency Disaster Activity Review

Agency Projects Table

October 10, 2012

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
International Charter www.disastercharter.org	• EO Data • VA products not in mandate but as best effort	14 agencies (including ASI, CNES, CSA, ESA, DLR, JAXA and USGS from ad hoc team)	Multiple	Immediate Response Phase only	Objective: Operational; Maturity: operational	Authorised users in member countries (41 today, in expansion) and aid users from United Nations	Global	Sampling: Days: reactive basis (one-off deliveries; continued surveillance of emergency hot spot in exceptional cases)/ Timeliness: rush tasking and production of imagery	Crisis mapping/ Damage assessment & Situation mapping in disaster area (large number of optical and radar sensors from 14 member agencies)	Need to explore options for earlier activation to ensure timeliness; linkages to other phases beneficial

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Geohazard Supersites and Natural Laboratories http://supersites.earthobservations.org	• Data • Database • Product (potentially through partners)	ESA and other CEOS agencies – ASI, CSA, DLR, JAXA, NASA, others TBD	Geohazards with strong initial focus on seismic faults and volcanoes	Full cycle though focus on science (i.e. mitigation/risk assessment).	Objectives: research; Maturity: Pilot / pre-operational	Geohazards community of practice – primarily researchers and academia	Global with focus on selected sites	variable	Many, but strong focus on InSAR measurements using C and X-band SAR sensors	Issues with regard to sustainability and criteria for selection; long-term transition from research to operations
Sentinel Asia https://sentinel.tksc.jaxa.jp/	Product	80 Agencies (including JAXA from ad hoc team)	Natural Disaster	Response	Objectives: Operational Maturity: Operational	Member Agencies	Asia&Pasific	Days/near-real time	IRS, THEOS, FORMOSAT, KOMPSAT, ALOS	To consider expansion of services(e.g. Phase, products)

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
GMES Emergency Management Services – Initial Operations	• Service	EC led with contributions from several agencies (ESA, national agencies)	Multi-hazard	Response and mitigation	Objectives: operational Maturity: operational	Civil protection agencies throughout Europe	Europe (focus); global (as required)	variable	Many, but strong focus on EO-based rapid mapping for situational awareness	Operational service to be established as on-going European capacity; long-term financial model to be developed.
Caribbean Satellite Disaster Pilot (CSDP)	• Data • Methods, processing • Product • Training • Services	NASA, CSA, others	Hurricane, extreme rainfall, floods	Warning Response Recovery/ Assessment Preparedness	Objective: pre-operational demonstration of EO capabilities; Maturity: Pilot	CDEMA, 5 national disaster & emergency mgmt agencies, CATHALAC	Caribbean, Central America (coastal)	Days/ near real time	Flood, possibly infrastructure damage, coastal erosion, (Radarsat-1, Radarsat-2) ~250 scenes, ~30 products to-date (2010 & 2011)	Rapid response info & image map products, raised EO awareness, improved understanding of user requirements and EO capabilities

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Global Flood Mapping http://floodobservatory.colorado.edu/ http://oas.gsfc.nasa.gov/floodmap/	Near Real Time Product	NASA, in partnership w/ Dartmouth Flood Observatory	**Flooding**	Response, Recovery/ Assessment	Objectives: Operational Maturity: **Pilot**	Global – FEMA, Pacific Disaster Center, International Red Cross, other In depth product evaluation with partners and users will follow completion of product development.	Near Global	Hours	Flood Extent (NASA MODIS instrument)	Initial products available. Resolving issues with georegistration, cloud and terrain shadow, water mask, other. Development of a comparable product based on VIIRS sensor - TBD
OPERA www.operaproject.it	• Model • Data processing tool • Product • Database • Sustainable service	ASI	**Plain floods / flash floods**	Mitigation/ Preparedness Warning Response Recovery/	Objective: Operational; Maturity: pilot	Italian Civil Protection	Local – 3 river basins in Italy Global – response, assessment	Temporal sampling: Days and Months (mitigation / preparedness) Days (response, assessment)	1st Funct. - Base knowledge for civil protection operation: Risk and vulnerability maps, warning and alarm thresholds, 3D virtual models of vulnerable areas. 2nd Funct - Soil moisture monitoring: soil moisture and soil saturation maps. 3rd Funct. - Flood forecasting and monitoring: EO products assimilation in operational	Improved efficiency with multi-sensor data; increased impact with multi-hazard capabilities; could support full cycle of disaster management with added functionalities. Need for continuous update of system algorithms to maintain efficiency. User training is needed for

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
				Assessment				Timeliness near-real time	flood forecasting models used in the National System of Functional Centres. 4th Funct. - Emergency management and damage assessment: Maps of flooded areas, damage maps, change maps (SAR data: COSMO-SkyMed, ENVISAT; Medium/high resolution optical data: MODIS, Landsat, Ikonos, Quickbird,GeoEye) In situ data.	optimal product usage
MORFEO www.morfeoproject.it	• Model • Data processing tool • Product	ASI	**Landslides**	Mitigation/ Preparedness Warning Response Recovery/ Assess	Objective: Operational; Maturity: pilot	Italian Civil Protection	Regional monitoring and site-specific mapping.	Temporal sampling: Months	Five goals. To detect and map landslides, exploiting images captured by medium to very high resolution satellite optical sensors. To monitor landslides, through the integration of ground based and satellite tech-nologies, including DInSAR and GPS.	Successful pre-operational demonstration of a set of products exploiting Earth Observation Technology to map, monitor, and forecast landslides. Need for long-term image time-series. Need for continuous update of system algorithms to maintain efficiency.

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
				ment					To model landslide susceptibility, hazard, and risk using information derived from optical and radar satellites. To ascertain vulnerability and damage, exploiting optical and radar data. And to forecast rainfall induced landslides using thresholds and satellite data (SAR data: COSMO-SkyMed, ENVISAT; Medium/high resolution optical data: Landsat, Ikonos, Quickbird,GeoEye). In situ data.	User training is needed for optimal product usage
PROSA www.prosaproject.it	• Model • Data processing tool • Product	ASI	**Hydrogeological risks - Satellite Observation and forecast products for**	Mitigation/ Preparedness Warning	Objective: Operational; Maturity: pilot	Italian Civil Protection	National monitoring and local mapping.	Temporal sampling: hours / days	Rainfall , soil moisture, snow coverage and status (measured and nowcasted) MSG, AMSU-A/B e MHS, SSMI e SSMI/S, AMSR-E, ENVISAT ASAR, MODIS, SPOT 4, ALOS PALSAR, COSMO SKYMED,	A better knowledge of meteorological parameters causing **flooding** event Assimilation of EO products (optical and radar) in Limited Area Model data (LAM) Provisioning of Microwave algorithms (MW) and Visible-Infrared (Vis-IR) for

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
			Meteorological Alert						GFS	precipitation retrieval. Combining ground data, atmospheric data and radar-satellite data to define features of nowcasting processes Development of algorithms to retrieve ground humidity data from satellites microwave sensors Assessment of snow cover extension and his water equivalent from satellites microwave and optical data
SIGRIS www.sigris.it	• Model • Data processing tool • Product	ASI	**Seismic**	Mitigation/ Preparedness Warning Response Recovery/ Assess	Objective: Operational; Maturity: pilot	Italian Civil Protection	Local (mitigation/ preparedness) Global (response, assessment)	Temporal sampling: Months (mitigation / preparedness) Days (response, assessment) Timeliness near-real	High resolution ground deformation maps, inter-seismic and co-seismic fault models, regional velocity and deformation map, maps of co-seismic surface effects, damage maps (SAR data: COSMO-SkyMed, ERS, ENVISAT, ALOS-PALSAR; high resolution optical data: Ikonos, Quickbird, EROS-B)	Successful pre-operational demonstration of prevention and emergency products. Need for long-term image time-series. Need for faster data acquisition. Integration of EO and ground data is fundamental. Product generation needs operators with scientific background. Need for continuous update of system algorithms to maintain

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
				ment				time		efficiency. User training is needed for optimal product usage
SRV http://srv1.rm.ingv.it/srv/srv/	• Model • Data processing tool • Product	ASI	Volcanic	Mitigation/ Preparedness Warning Response Recovery/ Assessment	Objective: Operational; Maturity: pilot	Italian Civil Protection	Local (Mt.Etna, Mt. Vesuvio, Flegrean Fields)	Days/ near-real time	Temperature anomalies, thermal flux, effusion rate, AOT, degassing plumes, deformation map, ash and lava distribution map (COSMO-SkyMed, ENVISAT, AVHRR, MODIS, ASTER, Hyperion)	Can support full cycle of disaster management. Integration of multi EO and ground data is fundamental. Need for thermal infrared camera and hyperspectral sensor for volcanic application. User training is needed for optimal product usage
QUITSAT www.quitsat.it	• Model • Data processing tool • Product	ASI	**Air quality**	Monitorig, planning and forecast	Objective: Operational; Maturity: Pilot	ARPA	Regional (North Italy)	Days/ near real time	MODIS (terra/aqua) OMI SCIAMACHY	Improved efficiency with EO, non EO data and forecast models;

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
									MOPIT	
PRIMI	• Model • Data processing tool • Product	ASI	**Oil spill**	Monitorig, planning and forecast	Objective: Operational; Maturity: Pilot	Coastal guard	Local	Days/ near real time	Cosmo SkyMed ERS ENVISAT MERIS MODIS	Improved efficiency with EO, non EO data and forecast models; Use of optical data for oil spill
Oceanic Islands (Radarsat-1 link only www.asc-csa.gc.ca/eng/satellites/radarsat1/data_background.asp)	• Substantive RADASAT-2 Archive creation	CSA	Background data for multiple hazards	Mitigation	Objective: R&D Maturity: Concept	Data acquired for archives	Monitoring of 66 small oceanic islands	4 times a year (February-May-August-November)	Multitemporal acquisitions of oceanic islands can be used as indicator of climate change.	Data acquired for archives. Processing upon user request only Or for International Charter

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Volcano Watch (Radarsat-1 link only www.asc-csa.gc.ca/eng/satellites/radarsat1/data_background.asp	• Substantive RADARSAT_2 Archive creation	CSA	Volcanoes	Mitigation	Objective: R&D Maturity: Concept Potential for Supersite.	No user engagement at this point. Data acquired for archives	Monitoring of 745 major volcanoes	4 times a year (March-June-September and December)	Multitemporal acquisitions of all major volcanoes for monitoring.	Data acquired for archives. Processing upon user request or for International Charter.
Disaster Watch	• Substantive RADARSAT-2 Archive creation	CSA	Disaster Watch	Response	Objective: Operational Maturity: Operational	No user engagement at this point. Data acquired for archives	Monitoring of disasters around the world.	Daily	Damage extent.	Data acquired for archives. Processing upon user request or for International Charter.
Hurricane Watch	• Substantive RADARSAT-2 Archive creation	CSA	Hurricane Watch	Warning Response	Objective: Operational Maturity: Operational	No user engagement at this point. Data acquired for archives	Monitoring of major tropical storms from June to November.	Daily, from June to November.	Tracking Damage extent.	Data acquired for archives. Processing upon user request or for International Charter.

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Rapid Information Products & Services (RIPS)	• RAD-2 Data • Product	CSA	Multiple	Response Preparedness Recovery/Assessment	Objective: demonstration of EO; Maturity: pre-operational	Cdn gvmt agencies, departments, foreign emergency response organizations	Canada, selected int'l. priority areas	Var. scales: Days/ near-real time to weeks	Mostly flood-related, InSAR app. (Radarsat-1 and Radarsat-2), ~50 scenes, ~ 12 products	Recent RIPS implementation, some demonstration products for users, raised awareness.
TerraSAR-X Science Service System http://sss.terrasar-x.dlr.de/	• Data	DLR	Multiple	Multiple (Scientific use of data)	Objective: R&D Maturity: mature	Scientists	Global		X-band radar data (TERRASAR-X, TANDEM-X);	Availability of radar data for scientific use (at minimal cost). Commercial exploitation: Astrium GEO-Information Services
RapidEye Science Archive http://resaweb.dlr.de	• Data	DLR	Multiple	Multiple (Scientific use of data)	Objective: R&D Maturity: mature	Scientists	Global		Optical data of RapidEye satellite constellation	Availability of data for scientific use (at minimal cost). Commercial exploitation: RapidEye AG.
TanDEM-X high-resolution digital elevation	• Data	DLR	Multiple	Multiple (Scienti	Objective: R&D	Scientists	Global		Digital Elevation Model (DEM) from TanDEM-X mission	Availability of global DEM data at a reduced 90 m resolution

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
model				fic use of data)	Maturity: not yet available (2014)					for scientists (at minimal cost). Commercial exploitation: Astrium GEO-Information Services
DLR Center for satellite-based crisis information www.zki.dlr.de	• Methods/ processing • Data processing tools • Training/ Capacity building • Product • Sustainable service	DLR	Natural and man-made disasters	• Response • Recovery/ Assessment	Objectives: • R&D, • Operational Maturity: operational/ mature	Civil Protection Agencies, Humanitarian Aid Organisations	• Global	• Days / Near-Real time	large number of EO sensors	Map products and services

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Early Warning system (e.g. German-Indonesian Tsunami Early Warning System www.gitews.de)	• Methods/ processing • Data processing tools • Training/ Capacity building • Product • Sustainable service	DLR	Tsunami (will be further developed for other hazard types)	• Warning	Objectives: • Operational Maturity: operational/ mature	Civil Protection (Indonesia)	• Regional (Indonesia and Indian Ocean Countries)	• Real-time		Warning messages
Risk and vulnerability assessment http://www.zki.dlr.de/research	• Methods/ processing • Data processing tools • Training/ Capacity	DLR	Tsunami, flood, fires	• Mitigation / Preparedness	Objectives: • R&D Maturity: • pre-operational	Civil Protection Agencies	• Regional (South-East Asia, Africa)	• Months	Variety of sensors used	Risk and vulnerability maps

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
	building									
E-DECIDER www.e-decider.org	• Training/Capacity building • Product	JPL, NASA, Indiana University, UC Davis	Earthquake	Response, Recovery/ Assessment	Objective: Operational; Maturity: Pilot	USGS	Global	Days to Weeks/ Days	NASA UAVSAR and InSAR, optical imagery (e.g., QuickBird, WorldView)	Deliver web-based infrastructure designed for ease-of-use by decision makers that will provide products for earthquake response using remote sensing
Advanced Rapid Imaging and Analysis (ARIA)	• Methods/processing • Data Processing Tools • Training/ Capacity building • Product	JPL, Caltech, NASA	Multiple	Mitigation/Preparedness Warning Response Recovery/Assessment	Objective: Operational; Maturity: concept	USGS, World Bank, USAID	Global	Hours to Days/ near-real time to Days	GNSS and SAR (ALOS, COSMO-SkyMed, Envisat)	Provide rapid and reliable monitoring and response products for earthquakes, volcanoes, floods, fires and other natural hazards using space geodetic imagery (GNSS, SAR, optical)

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
EO-1 Volcano Sensor Web	Product	JPL/GSFC	Volcanoes	Warning & Response	Objective: Operational; Maturity: Operational	Iceland Meteorological Office; multiple past/present university partners; HVO-CVO	Global	Hours-Days	Temperature anomaly/EO-1 Hyperion, ALI	Early detection of volcanic eruption; monitoring of ongoing eruption and eruption rate estimates.
Thailand Flood Sensorweb	Products	JPL, GSFC, HAII Thailand	Flooding	Warning & Response	Objective: Operational; Maturity: Operational	HAII Thailand, THaiflood.net	Regional, SE Asia	Hours-Days	Surface water extent, water depth, water volume	Detection and tracking of flooding, flood severity, damage estimation
ASTER Urgent Request Protocol	• Data • Methods/Processing • Product	JPL/ERSDAC/NASA/U. Pittsburgh	Volcanos	Warning & Response	Objective: Operational; Maturity: Pilot	National Weather Service/Alaska Volcano Observatory	Regional: Northern Pacific, Hawaii, Italy	Days/ near real time	Temperature anomaly/AVHRR,MODIS,GOES,ASTER	Early detection of possible volcanic eruption; monitoring of ongoing eruption and plume trajectory

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Plume Tracker	Data Processing Tool	NASA	Volcanoes	Warning & Response	Objective: Operational Maturity: Pre-Operational	Beta-Testing, Alaska Volcano Observatory	Global	Depends on data source: Days (i.e MODIS) to Weeks (i.e. ASTER)	Multispectral Thermal Infrared Radiance (MODIS, ASTER, AIRS, VIIRS, etc.)	Interactive Toolkit for Radiative Transfer (RT) –based mapping of volcanic heat, gas, ash, and aerosol emissions
NOAA Office of Satellite and Product Operations http://www.osdpd.noaa.gov/ml/products.html	Choose 1: • Data • Product	NOAA/ NESDIS	Multiple (including fires, heavy precipitation, airborne volcanic ash, tropical storms, oil spills)	Choose 1or several: • Mitigation / Preparedness • Warning • Response	Objectives: Operational, Maturity: operational/ mature	Various, but most commonly other government agencies	Regional (Geographic area varies by product area. For example tropical storm coverage is nearly global but fires are only covered in the US and neighboring areas.	Hours	Numerous. Commonly GOES, POES, MODIS, LANDSAT, ENVISAT (MERIS and ASAR until recent outage) and other nation's geostationary weather satellites (e.g, MTSAT, METEOSAT, etc.)	Integration of numerous satellite and non-satellite data sources by experienced 24 x 7 satellite analysis group can provide significant disaster mitigation information.

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
CIEST	• Product	CNES	Geohazards (Earthquake, Landslide, volcano, Tsunami)	• Mitigation / Preparedness • Response • Recovery/ Assessment	Objectives: • R&D, Maturity: • operational/ mature	8 French geology/geophysics labs	• Global	According to events	Data acquired by International Charter	Scientifically useful products generated – are they useful to civil security actors?
Kalhaiti	• Database	CNES, ANR	Haiti earthquake	• Mitigation / Preparedness • Recovery/ Assessment	Objectives: • R&D, Maturity: • pilot	French and local actors	• Local (Haiti)	Data acquired around Haiti earthquake	Data acquired by international Charter +many other actors	Data licensing issues to establish and open the database

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Geohazard events database	• Database	CNES	Geohazards (Earthquake, Landslide, volcano, Tsunami)	• Mitigation / Preparedness • Recovery/ Assessment	Objectives: • R&D, Maturity: • underdevelopment	Link to GEO Supersites users	• Global	• By event	SPOT / Pleiades data	
Risk chain based on OrfeoToolbox	• Data processing tools	CNES	All	• Mitigation / Preparedness • Warning • Response • Recovery/ Assessment	Objectives: Operational, Maturity: operational/ mature		• Global	• N/A	Any data type	

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Terrafirma http://www.terrafirma.eu.com	• Product • Sustainable service	ESA	Geohazards: geo-hazards/solid earth: tectonic, Landslides, Coastal lowland/flood defense, Groundwater management, Inactive mines	All, focus on mitigation and warning	Objective: Operational; Maturity: Operational/mature	Geohazards communities of practice (geoscience centres incl. geological surveys and civil protection authoritie) throughout Europe; 50+ operational user organisations engaged via SLA.	Europe – 27 member states	Variable by service	InSAR measurements of subsidence - HRSAR/ VHRSAR	- achieve user acceptance/certification of services e.g. landslide hazard maps; - advanced processing to achieve higher absolute accuracy, to reduce failure rate for higher rate motion detection (linear model) develop & validate automated PSinSAR chains: Wide Area Product (high precision & large throughput)
SAVAA http://savaa.niliu.no	• Model • Methods/ processing • Product • Sustainable service	ESA	Volcanic ash monitoring	Warning, response	Objective: operational Maturity: pilot	VAACS, airlines	Eventually global; initial focus over partner VAACS areas of responsibility (e.g. London VAAC northern	Variable	Atmospheric monitoring sensors (ERS, ENVISAT, METOP, etc.)	Major challenge identifying height of ash cloud; without EO global economy subject to huge risk with every major volcanic eruption

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
							Europe)			
E-SURGE http://www.storm-surge.info	• Product • Service	ESA	development & application of Level-2 geophysical products and services to the storm surge community	Mitigation	Objective: demonstration to test use for operational and experimental forecasting and warning systems	Completed user survey and is forming user group amongst interested community	Focus over historic surge events, initially in Europe	Variable	Altimeter & Scatterometer	Project just starting

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Oil Spill Monitoring www.esa.int	• Product (operational hazard monitoring) • Sustainable service (pollution monitoring/deterrence)	ESA	Oil spills - law enforcement (deterrence) and operational hazard monitoring (response)	Mitigation (operational monitoring) and response (for emergencies)	Objective: operational; maturity: operational	EMSA - basic detection and monitoring transferred to EMSA (CLEANSEANET) for EU waters pre-operational demonstrations conducted for other areas	Northern Europe, Southern Mediterranean, Canadian waters, Persian Gulf & Western Indian Ocean	Every few days	MRSAR/ HRSAR/ VHRSAR, some HRO/ VHRO	Improved drift forecasting (linking met-ocean data, local forecasting with oil spill evolution models); Development of methods for detection of other hazardous chemicals in the marine environment; Improve false alarm rate for oil slick detection
Globvolcano http://www.globvolcano.org	• Data processing tools • Sustainable service	ESA	Define EO based service for volcanic observatories Demonstrate the service	Focus on mitigation and early warning	Objective: operational Maturity: pilot ended	Volcanic observatories	Global	Variable	ENVISAT ASAR, ERS-1/-2 SAR, MODIS, ASTER, SPOT,GOME-2, OMI, SCIAMACHY, SEVIRI	Project completed.
ERS-2 ATSR World Fire Atlas	• Data • Database	ESA	Wildfires: multi-year	response	Objective: research	Wildfire community of	Global	NRT - continuous	ATSR on ERS-2, AATSR on Envisat	The ATSR Fire Atlas contains data covering November 1996

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
http://earth.esa.int/ers/eeo9/earth_esa.html			world fire atlas; monitors agricultural fires and wildfire distribution at global scale in NRT		Maturity: discontinued.	practice				through December 1998 and will cover the whole ERS-2 mission since 1995. Data capture continuity ensured by the AATSR instrument on-board ENVISAT.

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
Wildfire Research and Applications Partnership (WRAP) www.geo.arc.nasa.gov/sge/WRAP	• Methods/ processing • Training / Capacity building • Product	NASA / USFS	Wildfires	• Response • Recovery/ Assessment	• Operational • Operational/ mature	US Forest Service	Regional (United States/ possible to support North America through agreement)	• Hours • / near-real-time when on event	NASA AMS airborne sensor / coupled with MODIS RRS. Coverage / display with Google Earth or any web-tool visualization capability (OGC-compliant data format).	Real-time observations from aerial sensor provides improved timeliness, efficiency and cost-savings when managing fire events. Improve timeliness by ~5-10X over current methods. AMS sensor currently being transferred to USFS for operations loan on their platforms.
Hazards Data Distribution System http://hdds.usgs.gov	• Data • Other: Data Distribution, Product Distribution	USGS	Multiple	Full cycle	Objectives: operational; Maturity: operational	Global response community	Global	Hours to years: Timeliness: variable – near-real time for response and warning	Large number of airborne and satellite sensors	Timeliness, download capabilities

Name and web link (if available)	Project Focus	Agency	Disaster Type	Phase	Use Objectives & Maturity	User and Partner Engagement	Geographic Coverage	Temporal sampling/ timeliness	EO-based measurement (and sensors used)	Outcome & Issues/ Lessons Learned
DOI BAER Remote Sensing Support	• Data	USGS/ DOI	Emergency Response Wildfire Burn Mapping and treatment monitoring.	• Response Recovery/ Assessment	Objectives: choose 1 • Operational Maturity: Choose 1 operational/ mature	USGS is collaborating and responding to all DOI Bureaus	Global as USGS responds to national and global wildfires	• Days	Multiple indices based upon VINIR & SWIR bands, including dNBR, NDVI, etc. Primary sensor is Landsat ETM/TM. Secondary are SPOT, and all others.	With loss of Landsat 5 we are now more dependent upon commercial sensors.
USGS Landslides program	•	USGS Earthquakes, Hurricanes, Typhoons	Landslides, Faulting	Full Cycle	Objectives: operational; Maturity: operational	Prepare inventory and hazard maps	Global	Hours to years: Timeliness: variable – near-real time for response and warning	Large number of airborne and satellite sensors	Timeliness, download capabilities

Annex 4 – CEOS *ad hoc* Disaster Team membership and acknowledgements

ASI	Stefano Bruzzi, Laura Candela
CNES	Steven Hosford
CSA	Christine Giguere, Ahmed Mahmood, Surendra Parashar, Guy Seguin
DLR	Jens Danzeglocke
ESA	Philippe Bally, Maurice Borgeaud, Stephen Briggs, Simonetta Cheli, Ivan Petiteville (Team Chair)
EUMETSAT	Paul Counet
NASA	Brian Killough, Francis Lindsay, Shelley Stover.
NOAA	Yana Gevorgyan
JAXA	Takao Akutsu, Osamu Ochiai
USGS	Brenda Jones

CEOS ex officio – Tim Stryker, Kerry Sawyer

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Annex 5 – Glossary and Acronyms

Glossary of relevant disaster risk reduction terms, reproduced from documentation of the World Meteorological Organisation[21].

Acceptable Risk	The level of loss a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions [Source: ISDR Terminology of disaster risk reduction]
Capacity	A combination of all the strengths and resources available within a community, society or organization that can reduce the level of risk, or the effects of a disaster [Source: ISDR Terminology of disaster risk reduction]
Disaster	A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources [Source: ISDR Terminology of disaster risk reduction]
Exposure	Exposure is the total value of elements at-risk. It is expressed as the number of human lives, and value of the properties, that can potentially be affected by hazards. Exposure is a function of the geographic location of the elements [***Source: UNDP (2004): Reducing Disaster Risk: a challenge for development. A global report (M. Pelling, A. Maskrey, P. Ruiz, L. Hall, eds.). John S. Swift Co., USA, 146 pp,]***
Hazard	Potentially damaging physical event that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins. Each hazard is characterised by its location, intensity, and probability. [Source: ISDR Terminology of disaster risk reduction]
Hazard Analysis	Identification, studies and monitoring of any hazard to determine its potential, origin, characteristics and behaviour. [Source: ISDR Terminology of disaster risk reduction]
Hydrometeorological Hazards	Natural processes or phenomena of atmospheric, hydrological or oceanographic nature, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. [Source: ISDR Terminology of disaster risk reduction]
Intensity	Physical parameters describing the severity of the hazard. For major hydrometeorological hazard phenomena, standards have been developed by WMO and adopted by 188 Member States for monitoring and reporting of hazard phenomena. [Source: Global Change and Environmental Hazards,[Source: http://www.aag.org/HDGC/_www/hazards/units/unit1/html/unit1frame.html]
Natural Hazards	Natural processes or phenomena occurring in the biosphere that may constitute a damaging event. [Source: ISDR Terminology of disaster risk reduction]
Probability	Likelihood of an event happening. Probability is statistically higher for low-intensity hazards. Probability reflects the future frequency of occurrence of hazard event, and cannot be drawn using historical statistics alone. For hydro-meteorological hazards, probability assessments need to reflect trends related to ongoing evolutions (i.e. climate change, deforestation, etc..) [Source: United Nations University, Comparative Glossary for Core Terms of Disaster Reduction, p.16]
Resilience	Capacity to recover the normal functioning and development after being hit by a

[21] http://www.wmo.int/pages/prog/drr/resourceDrrDefinitions_en.html

	disaster. A high resilience reduces indirect impacts of disasters, such as business and services interruptions in the aftermath of a disaster. [Source: ISDR Terminology of disaster risk reduction]
Risk	Probable impacts, expressed in terms of expected loss of lives, people injured, property, livelihoods, economic activity disrupted or environmental damage. [Source: ISDR Terminology of disaster risk reduction]
Risk Assessment / Analysis	A methodology to determine the nature an extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. [Source: ISDR Terminology of disaster risk reduction]
Risk Identification	The process used to determine what can happen, why and how events arise. [Source: http://www.preventionweb.net/english/themes/risk-identification/]
Risk Management	The systematic management of administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards. [Source: http://www.preventionweb.net/ english/professional/terminology/]
Risk Reduction	The conceptual framework of elements considered with the possibilities to minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development. [Source: http://www.preventionweb.net/english/ professional/terminology/]
Risk Transfer	Insurance and reinsurance both for physical damage and business interruption, coverage that would provide cash compensation immediately after a disaster. [Source: http://www.preventionweb.net/english/themes/risk-transfer/]
Vulnerability	Physical, social, economic, and environmental factors which increase the susceptibility to be impacted by hazards. Vulnerability engages resistance and resilience. [Source: ISDR Terminology of disaster risk reduction]

Acronyms

ADB	Asian Development Bank
ALI	Advanced Land Imager (NASA's EO-1)
ALOS	Advanced Land Observing Satellite (Japan)
ASAR	Advanced SAR (ENVISAT)
ASI	Italian Space Agency
CEOS	Committee on Earth Observing Satellites
CIESIN	Center for International Earth Science Information Network
CNES	Centre National d'Etudes Spatiales
CSA	Canadian Space Agency
CSDP	Caribbean Satellite Disaster Pilot
DEM	Digital Elevation Model
DLR	Forschungszentrum der Bundesrepublik Deutschland für Luft- und Raumfahrt (German Aerospace Centre)
DMSG	Disaster Management Support Group (CEOS)
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EO	Earth Observation or Earth Observations
EPOS	European Plate Observing System
ERS	European Remote Sensing Satellite
ESA	European Space Agency
ETM	Enhanced Thematic Mapper (Landsat)
EU	European Union
FAO	UN Food and Agriculture Organisation
FCT	Forest Carbon Tracking
FEMA	Federal Emergency Management Agency (FEMA)
FP7	7th Framework Programme (EU)
GDLND	Global Landslide Hazard Distribution
GDP	Gross Domestic Product
GEM	Global Earthquake Model
GEO	Group on Earth Observations
GEOSS	Global Earth Observing System of Systems

GFDRR	Global Facility for Disaster Reduction and Recovery
GFOI	Global Forest Observation Initiative
GHCP	Geohazards Community of Practice
GIO EMS	GMES Initial Operations Emergency Management Services
GMES	Global Monitoring for Environment and Security
GSE	GMES Service Element programme
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GRIP	Global Risk Identification Programme (UNDP)
GSE	GMES Service Element
GSRM	Global Strain Rate Model
HDDS	Hazards Data Distribution System
HFA	Hyogo Framework for Action
HH	Horizontal/Horizontal – polarizations for SAR
HV	Horizontal/Vertical – polarizations for SAR
IADB	Inter-American Development Bank
ICAO	International Civil Aviation Organisation
ICL	International Consortium for Landslides
ICSU	International Council for Science
ICT	Information and Communication Technologies
IFM	Integrated Flood Monitoring (WMO)
IFRC	International Federation of Red Cross and Red Crescent Societies
IGOS	International Global Observing Strategies
INGV	Istituto Nazionale di Geofisica e Vulcanologia (Italy)
InSAR	Interferometric Synthetic Aperture Radar
IPL	Intenrational Programme for Landslides
HR	High Resolution
JAXA	Japan Aerospace Exploration Agency
JRC	Joint Research Centre (EU)
LDCM	Landsat Data Continuity Mission (Landsat-8)
MDA	Macdonald, Dettwiler Associates

MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration (USA)
NGO	Non Governmental Organisation
NOAA	National Oceanographic and Atmospheric Administration (USA)
OECD	Organisation for Economic Cooperation and Development
PDNA	Post Disaster Needs Assessment
PSI	Persistent Scatterer Interferometry
RCM	Radarsat Constellation Mission (Canada)
SAFER	Service and Applications For Emergency Response
SAR	Synthetic Aperture Radar
SBA	Societal Benefit Area
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
SSEP	SuperSites Exploitation Platform (ESA)
UN	United Nations
UNAVCO	University Navstar Consortium (Boulder, Colorado)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	UN Institute for Training and Research
UNOSAT	UNITAR'S Operational Satellite Applications Programme
UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
UNU	UN University
USGS	United States Geological Survey
VAACs	Volcanic Ash Advisory Centres
VHR	Very High Resolution
VV	Vertical/Vertical – polarizations for SAR
WFEO	World Federation of Engineering Organisations
WOVO	World Organisation of Volcanic Observatories
WGCapD	Working Group on Capacity Building and Data Democracy
WMO	World Meteorological Organisation