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SHORT COMMUNICATIONS

European space agency's strategic contribution to seismology

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Abstract The impacts of disaster events such as earthquakes on economic and human lives are increasing every year, in particular due to the growing urbanization. Until recently, stakeholders involved in disaster risk management focused their efforts mainly on the response phase, immediately after the crisis. Following the recommendations of several recent studies and in order to minimize the increasing impacts of natural disasters, decision-makers and major stakeholders have showed an increasing interest in mitigation activities. Earth Observation (EO) data from space could bring a significant added value to the various phases of the seismic risk management cycle from the mitigation and preparedness phases. Space agencies need to better contribute to the management of geohazards in response to the growing request from the community of users (e.g. seismologists, insurance companies, urban planners). To foster the use of EO remote sensing data, satellite data providers have to take the appropriate measures to remove the policy and technical barriers related to the data access. They have also to increase the awareness of the community of users on the potential benefits that could be gained from the use of EO satellite data. This paper will provide examples of areas where EO remote sensing data from space could bring an added value to the current management of risks and crisis related to earthquakes. Then, the paper will describe the strategic measures undertaken by the European Space Agency in an international framework, to foster the use of satellite data by the various relevant stakeholders.

Keywords European space agency · Earth observation · Satellite · Remote sensing · Earthquake · Data policy · Data interoperability · Disaster risk management · Geohazard

1 Potential added value of EO

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

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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.[1] In the recent years, politicians, decision-makers and major stakeholders have showed an increasing interest in disaster risk management and especially in mitigation. Until recently, the focus was on the response through some major initiatives such as the International Charter on Space and Major Disasters.[2] Participants to major events organized by ESA such as the 3rd International Geohazards workshop[3] and the International Forum on Satellite Earth Observation for Geohazard Risk Management[4] recognized that Earth Observation (EO) data from space are insufficiently exploited by the community of users dealing with disaster risk management, and have called an increased contribution of space agencies in the field, for the coming years. In front of this recent increasing interest for EO satellite data, there is an opportunity and maybe an obligation for space agencies to better contribute to disaster risk management.

In the specific seismic domain, the scientific community and the major stakeholders gradually appreciate the added value of EO data from space. EO satellite data are used as a complement to ground data in developed countries but sometime, but it may be the only source of information in developing countries. As highlighted in the Santorini Community paper,[5] most seismic hazard assessments are carried out in a probabilistic fashion using data from historical and instrumental catalogues of seismicity, supplemented with geological data on active fault location and slip rates where available;[6] the Alpine-Himalayan belt stretches for 10,000 km from the European Alps to western China, and in places is over 2,000 km wide. Many earthquakes in this region occur on faults that were not identified prior to the event or whose hazard had been previously underestimated. For example, the Bam earthquake (M6.5, Iran, 2003), which killed around 30,000 people, occurred on a fault that could not have been identified prior to the earthquake, in a city that had not experienced strong shaking for at least 2,000 years.[7] In developing countries and in remote regions where there is a lack of reference data, the contribution of EO satellites covers a broader range of phases of the seismic risk management cycle from the mitigation and preparedness phases, where EO can help provide asset and exposure mapping, to the immediate emergency response and recovery phases where rapid access to space-borne optical imagery can support rapid mapping and damage assessment (see Footnote 5). Satellite EO data are a pertinent source of information to assist both the science and operational communities dealing with earthquakes, with different but complementary objectives and requirements.

[1] Joint Report on "Natural Hazards, UnNatural Disasters—The Economics of Effective Prevention" by World Bank and United Nations, 2010.

[2] See www.disasterscharter.org/.

[3] Organized by Group of Earth Observation (GEO) and European Space Agency; held at ESRIN, Frascati, Italy—November 2007.

[4] Santorini, Greece—May 2012.

[5] "Perspectives concerning Satellite EO and Geohazard risk management: the way forward." Salvatore Stramondo and Tim Wright.

[6] Reiter (1990).

[7] Jackson et al. (2006).

2 Remove the barriers

Space-borne data are not fully exploited yet by the user community including the seismologists, partly because of the lack of awareness of many stakeholders and partly by the difficulties they might encounter to obtain relevant datasets. The restrictions imposed by the data policies of some EO satellite missions can be a barrier to the use of EO data. One of the major recommendations made during the 3rd International Geohazards workshop (see Footnote 3) to stimulate an international effort to monitor and study selected reference sites was for the space data providers, to establish open access to relevant datasets according to GEO data sharing principles to foster the collaboration between the various stakeholders including the end-users. The example of Landsat advocates for a free and open data policy: during the commercial era of Landsat, at the best, 53 images were sold every day (best annual average). In 2008, USGS opened the Landsat archive at no charge over Internet; the daily average of downloaded scenes jumped from 53 per day to 5776[8] and the number of applications relying on Landsat exploded in a similar way. An analogous trend was observed at ESA when the EO data policy of ERS-1, ERS-2, Envisat and Earth Explorer missions was revised in 2010 to offer a non-restricted access to all the on-line EO data to all registered users. The current ESA EO data policy is derived from the full and open access approach established in the Sentinel Data Policy.

Besides, ESA and other major space agencies members of the Committee on Earth Observation Satellites are deploying significant efforts to ease the discovery and physical access to space-borne datasets. Moreover, combining data from different space and in situ data sources is sometimes necessary to provide accurate scientific results. Besides, the use of multiple remote sensing data sources for long-term projects can minimize the risk associated with the premature and unexpected end of a given satellite mission. Data interoperability and harmonization of interfaces are major issues for the data providers; through the Ground Segment Coordination Body,[9] ESA and its European partners undertake series of measures to tackle those issues, in coordination with the work undertaken by other international bodies such as Committee on Earth Observation Satellites (CEOS), Open Geospatial Consortium (OGC) and Consultative Committee for Space Data Systems and also through regular consultation with industry and commercial missions.

3 Foster the use of EO data and increase the awareness of potential users

Removing the barriers is not sufficient to stimulate the use of EO data. Since the early days of ERS-1, ESA has taken a series of actions aiming at offering to the scientific community an easier access to data, a permanent support through various teams such as the EO helpdesk, and opportunities for them to present their achievements in the many workshops and symposia organized each year.

To stimulate a live exchange of experiences and knowledge between researchers and other relevant stakeholders, ESA organizes dedicated thematic workshops and symposia every year. During these gatherings, ESA collects user feedback and recommendations for new products, new initiatives and input for improved scientific exploitation of the

[8] "Benefits of Open Availability off Landsat Data", presentation by Jean Parcher (USGS), 49th session of Scientific and Technical Subcommittee (2012), UNOOSA.

[9] See http://earth.esa.int/gscb/.

missions. Scientific results presented during those events are published in the scientific literature. The 3rd International Geohazards workshop (see Footnote 3) (2007), the series of FRINGE workshops (every 2 years since 2003) and the International Forum on Satellite Earth Observation for Geohazard Risk Management (see Footnote 4) (2012) are examples of events related to geohazards and in particular earthquakes, organized by ESA to gather space agencies, in situ data providers, scientists, end-users, value added companies, other stakeholders, etc.

The removal of the data access barriers does not mean an open-ended provision of data to whoever for whatever purposes. It is essential for ESA to demonstrate the usefulness of its EO missions to the decision-makers and to receive positive feedback from the user community, in order to justify the need for new instruments and future missions.

Since the early days of ERS-1, ESA has released 30 Announcements of Opportunity (AO) to exploit ERS, Envisat and Earth Explorers data, with the goal of fostering scientific knowledge and our understanding of the Earth's environment. The primary objectives of all of the AOs were to support scientific research, stimulate the development of algorithms and products, and support application demonstrations. In addition, they facilitated the transfer of scientific results into sustainable applications/services and supported the transfer of technology. A total of 251 projects related to earthquake have been conducted by the scientific community in response to the 30 AOs.

The policy of space agencies such as ESA and CSA (Canadian Space Agency) to maintain repeat image acquisitions over many seismically active areas worldwide (via the so-called—background mission) has allowed the wide diffusion of EO data in seismology. The enormous amount of data in archive (15+ years considering C-Band SAR) illustrate the potential of SAR missions for the monitoring of the strain accumulation along active fault zones now that new InSAR analysis techniques have been developed and made progressively more available (see Footnote 5).

ESA data also serve large international science programs such as the GeoHazard Supersites and National Laboratories (GSNL) initiative. Overall, ESA has made some 50.000 ERS and Envisat SAR scenes available in support of the GSNL initiative. ESA considers that the science objectives of the international projects it supports such as GSNL need to be clearly defined and that the progress and achievements on the related activities are sufficiently made visible.

ESA supports those major projects and initiatives either alone or through international coordination with other GEO or CEOS partners. At the 25th CEOS Plenary meeting (November 2011), following a proposal by ESA, CEOS principals discussed the need to examine activities of member Agencies across the disaster risk management cycle and ensure a balanced effort across the cycle and among the agencies. The CEOS Disaster ad hoc team lead by ESA and formed early in 2012 with representatives from several space agencies (ASI, CSA, CNES, DLR, ESA, EUMETSAT, JAXA, NASA, NOAA and USGS) made a series of recommendations, one of them being the establishment of a 3-year demonstration demonstrator with an initial focus on three types of hazards, one of them being earthquake.

4 Conclusions

Recent experience has demonstrated that the data access conditions imposed by previous EO data policies at ESA might have been perceived in the past as barriers by some scientists who have preferred free and open access data irrespective of their quality. The

Sentinel data policy proposed by ESA and the current data policies for the other ESA EO missions can only foster the use of EO data by the scientific community. More suitable data policies are not sufficient: scientific users still have difficulties in accessing and using data, in particular for scientific projects that rely on the use of multiple sources of EO data. Data interoperability is a long-term objective that still requires major efforts by all data providers.

Eventually, the demonstration by the scientific community of the added value of satellite remote sensing data is essential for space agencies like ESA for programmatic and budget planning. For those reasons, the publication of scientific achievements is the field of seismology obtained thanks to the use of satellite data and the regular iteration between the scientific community and the space data providers is fundamental.

The European Space Agency is fully engaged to support seismology through a series of well-defined strategic measures that go beyond the mere provision of data, with the conviction that space-borne data represent an enormous potential that has not been exploited yet by the worldwide community of users.

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