UNITED NATIONS
Office for Outer Space Affairs
UN-SPIDER
www.un-spider.org

NEWSLETTER

March 2015 Vol. 1/15

In Focus

Post 2015: Space-based information for disaster risk reduction

Disasters triggered by natural hazards are an unparalleled threat to sustainable development. In March 2015, experts and representatives of countries from all over the world are gathering in Sendai, Japan, to strengthen disaster risk reduction on a global scale. From this Third UN World Conference on Disaster Risk Reduction (WCDRR) a new international agreement will emerge, the post-2015 framework for disaster risk reduction, aiming to guide national, regional, and international efforts to reduce the vulnerability and the exposure of people, infrastructures and resources to disaster risks.

In doing so, disaster risk managers and decision-makers depend greatly on the detailed and reliable assessment of risks. Satellite-based technologies such as Earth observations provide advanced products and tools that support these efforts. Such products can be used to monitor and measure indicators related to infrastructure and land use (e. g. topography, urbanization, or transportation networks), to measure atmospheric and environmental variables (e. g. soil moisture, precipitation, or temperature) and to detect changes over time caused by both planned development and unforeseen crises.

Floods, as in this case in Haiti in November 2014, affect millions of people every year (Image: UN Photo/Logan Abassi)

As disasters do not stop at national borders and national datasets from different countries are not always comparable, it is important to go beyond the national scope. Satellite-derived datasets facilitate the large-scale assessment of risk exposure and thereby help map the uneven distribution of risk across national borders in an objective way.

In the last ten years, the quality of satellite sensors and the accessibility of satellite imagery as well as of derived products and information services has improved immensely. Due to faster and more efficient computing and data processing capabilities, the archives of satellite imagery are constantly growing.

Today, we can access time series covering almost 50 years. Also, products derived from satellite imagery such as global land-cover classifications, precipitation estimates, vegetation indices, or soil moisture are available for free, in some cases even as near-real-time products.

This newsletter aims to showcase selected examples of Space-based applications and success stories that demonstrate the high relevance of Earth observations for global disaster risk reduction.

In this issue

How can Space-based information contribute to disaster risk assessment?....................................2

Risk knowledge in tsunami early warning: the GITEWS project..........4

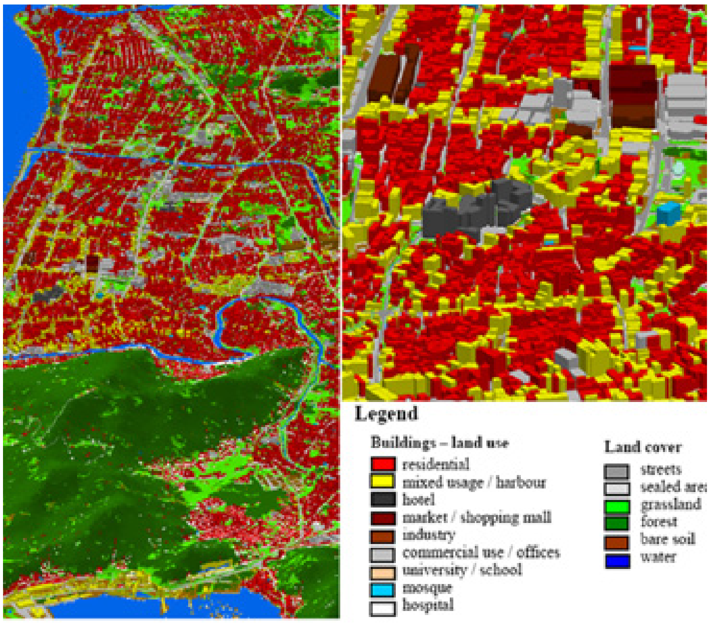
Modelling changes in the behaviour of floods using Earth observations..5

Editorial: The future key role of Earth observations in disaster risk reduction...6

How can Space-based information contribute to disaster risk assessment? Four examples of satellite-based applications

Space-based information can significantly support disaster risk assessment by helping to produce hazard assessment and monitoring, as well as exposure and vulnerability assessment. It can furthermore provide valuable input for damage assessment and recovery monitoring. This overview presents four examples of applications.

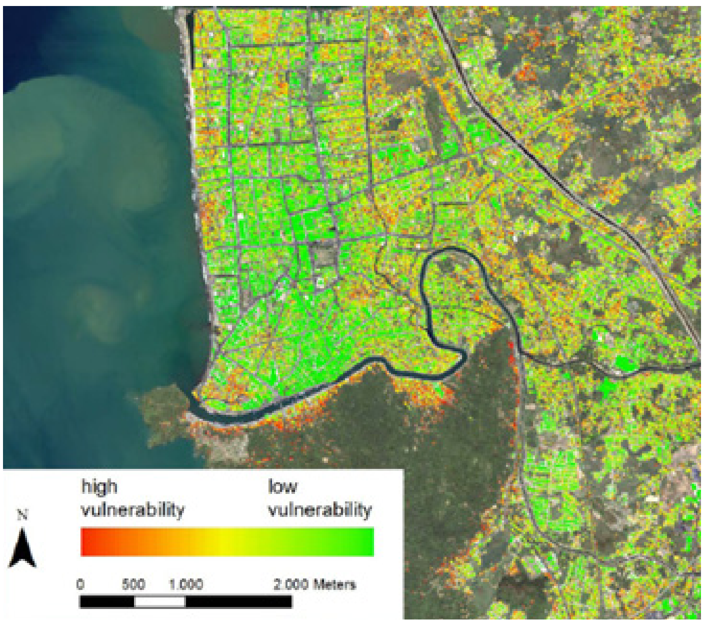
Exposure assessment



Physical exposure and 3-D model of Padang City (Indonesia) as derived from high resolution satellite data and a digital elevation model (Image DLR-DFD)

For disaster risk managers, it is essential to have up-to-date information on elements at risk. This information can be obtained through the assessment of the exposure to hazards. Space-based information has the capability to provide up-to-date and area-wide data capturing the small scale and complex landscape. Particularly important are object-based classification methodologies for the extraction of land cover information like buildings and the derivation of population information, based on very high resolution satellite data in combination with socio-economic and census data. The Global Urban Footprint, a project of the German Aerospace Center DLR for worldwide mapping of settlements with unprecedented spatial resolution, shows the distribution of urban and non-urban areas at a spatial resolution of ~12m. This product can be used to assess built environment and population exposure on a coarse scale level.

Vulnerability Assessment



Area wide seismic building vulnerability assessment (high vulnerability in red to low vulnerability in green) using combined in-situ and satellite remote sensing-derived information for Padang City, Indonesia. (Image DLR-DFD)

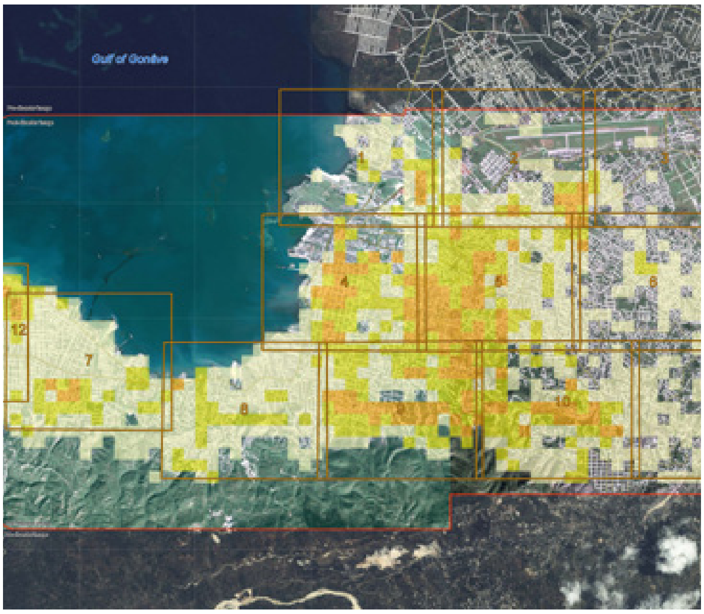
Space-based information can contribute to vulnerability assessments considering the physical, infrastructure and environmental components of vulnerability and also in the social and human vulnerability domain. One example to be highlighted is vulnerability assessment of buildings in the context of earthquakes and tsunamis. An assessment of the structural vulnerability of the building inventory with building-by-building analysis by structural engineers is too resource-intensive to cope with the high spatio-temporal dynamics and extents of urban environments. Remote sensing can greatly support the vulnerability assessment of built environment when combined with in-situ information. The result shown in the image refers to a seismic building vulnerability assessment. In the context of tsunamis, for example, the results gained provide crucial information on buildings featuring no or low vulnerability being potentially suitable for vertical evacuation. This information supports risk assessment, risk reduction, and evacuation planning.

Hazard assessment and monitoring

Sendai, Japan, after the tsunami on March 11, 2011, based on TerraSAR-X radar images. Inundated areas appear in blue, debris in magenta and affected infrastructure in cyan blue. (Image: DLR-DFD, ZKI)

The provision of detailed information on natural and man-made hazard extents and on their spatio-temporal properties such as intensity or probability of occurrence are essential for disaster risk management. In this domain, many relevant applications are available for several hazard types. Multi-scale flood monitoring systems are used to accomplish continuous, near-real time inundation monitoring at a daily interval, for example by using medium resolution (250-500m) satellite data of the MODIS sensor on NASA's Terra Satellite. Based on MODIS information, Synthetic Aperture Radar (SAR) sensors like TerraSAR-X can be programmed to derive more detailed information with improved spatial resolution (~1-14m) on the flood situation (see map of Sendai) for defined areas of interest at local to regional scales.

Damage assessment and recovery monitoring



Rapid damage assessment showing three damage grades (sparse/light yellow – severe/yellow – very strong/orange) based on very high resolution optical satellite imagery for the Haiti Earthquake 2010. (Image: DLR-DFD, ZKI)

In the past, acquiring damage information was limited to field surveys and/or aerial photographs which could not be acquired quickly. By taking advantage of satellite-based remote sensing, the spatial distribution of structural damage can be identified. The advantage of using high resolution optical satellite images for damage interpretation is the possibility of understanding structural damage visually. These images also enable us to comprehend the spatial extent of damage at the regional scale that post-disaster surveys hardly ever cover because of limited survey time and resources. Similarly, recovery processes can be monitored and evaluated through time-series analysis of satellite-based remote sensing data.

Risk knowledge in tsunami early warning: the GITEWS project

Satellite images of Aceh province, Indonesia, one week after the tsunami, in January 2005 (left), and ten years later in December 2014 (right) (Image: DLR/EUSI)

In disaster risk reduction, early warning systems play a key role. Their ultimate aim is to enable those in danger to make decisions and to take action to save their lives. These systems commonly aggregate and generalise data from sensors into reliable information and disseminate the warning to relevant authorities and to the population. Satellite-based remote sensing (e.g. for early detection of a hazard), satellite-based telecommunication and navigation technologies play a crucial role in this context.

The German Indonesian Tsunami Early Warning System (GITEWS) project, a joint Indonesian-German cooperation effort, was established after the devastating tsunami in the Indian Ocean in December 2004. Space-based information played a significant role in the GITEWS project. The detailed analysis of past tsunami and earthquake damage patterns through remote sensing helped to better understand processes and tsunami disaster impacts on the population and on infrastructure. Tsunami inundation patterns alongside with up-to-date high resolution exposure and vulnerability information derived from remote sensing contributed significantly to the tsunami early warning system.

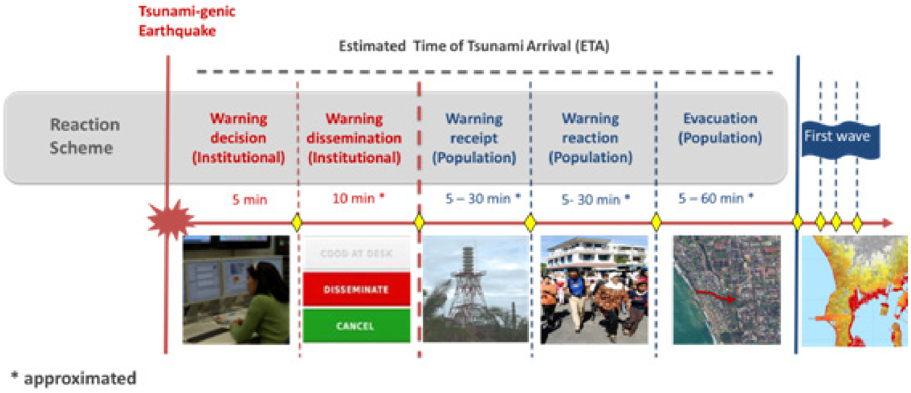
Dynamic human exposure information (day and night-time distributions) could be derived through satellite-based up-to-date land use and land cover information in combination with census data and socio-economic statistics. With this, the expected impacts on the population could be quantified depending on day- or night-time occurrence of a tsunami.

The information is integrated into the decision support system (DSS) of the Tsunami Early Warning Center in Jakarta, Indonesia. Key numbers such as the number of affected people and infrastructural elements are displayed on an event-specific basis. Additionally, the risk information is linking national level early warning information with tsunami risk information available at the local level, e.g. by combining information on warning messages on expected intensity with respective tsunami hazard zone maps at the community level for an effective evacuation.

As a conceptual basis for the risk assessment, a tsunami early warning reaction scheme has been developed. It provides an overview of a sequence of hierarchical processes that need to be accomplished for saving lives within the given time span from the detection of a tsunami event until the materialization of a tsunami at the coast. The result is a quantification of the spatial risk of loss-of-live and can be presented, almost in real-time, in the form of maps or time-dependent casualty numbers per administrative unit. The products are produced quickly to support timely decision-making in early warning and emergency response.

The methods developed and implemented for risk assessment follow the assessment of hazards, vulnerabilities, and risks. The generated results and products link directly to the reaction scheme components in the warning chain and the risk management tasks.

Read more: www.gitews.de/en

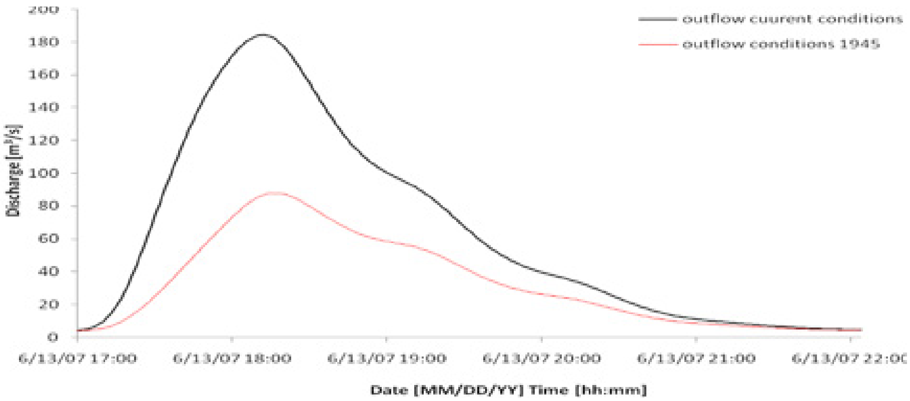


Reaction scheme of a people-centred tsunami early warning system developed in the context of GITEWS (Image: DLR)

Modelling changes in the behaviour of floods using Earth observations

Several cities around the world have recently experienced more frequent and more intense floods. These are not always linked to climate change but to rapid growth. This is the case for cities such as La Paz in Bolivia, Quito in Ecuador, San Salvador in El Salvador, or San Antonio de Belen in Costa Rica, located in valleys at the foothills of steep mountains or volcanic cones to which the cities have expanded. The urbanization process reduces the capacity of the soil of the mountains surrounding the cities to temporarily absorb rainfall, leading to larger amounts of runoff that are discharged into the channels of rivers and into artificial drainage systems in the cities. However, the urban drainage systems or channels of rivers can no longer handle the large discharges caused by strong rainfall, leading to floods.

As a way to assess the amount of runoff that is generated when rainfall impacts a certain region, experts have developed hydrological models. One of them is the SCS Curve Number Loss Model that takes into consideration the type of land-use and land-cover in the region, the type of soil, and the slope. The use of satellite imagery helps identify and locate areas of different land-use or land-cover. In combination with in-situ data on the type of soil, these models simulate the transformation of rainfall into discharge flooding the cities.



Amount of discharge for San Antonio de Belen modelled for the years 1945 and 2005

In order to model how the changes in land-use/land-cover affect the spatial and temporal behaviour of floods, one would compare hydrological models of periods before and after urban growth. Such modelling was carried out in the city of San Antonio de Belen in Costa Rica for floods of the Quebrada Seca river using the HEC-HMS software developed by the Hydrological Engineering Center of the US Army Corps of Engineers.

Aerial photography from 1945 was used to characterize different regions of the basin according to the type of land-use and land-cover. The same was done for the year 2005 using satellite imagery. The hydrological model was tested for the 1945 and the 2005 conditions using as input data precipitation for a particular day in 2007. The comparison of the peak flows shows an increase from 88 m^3/s in 1945 to 184 m^3/s in 2005 due to land cover changes. So the peak of the discharge at this special event has more than doubled. Even more interesting is the amount of water flow during the flood event. The total amount of floodwater in 1945 was around 620,000 m^3 while in 2005 it was 1,190,000 m^3. The simulation of the water level under a bridge in the downtown area of San Antonio de Belen shows that the discharge in 1945 would not have triggered a flood. The discharge for the land-use/land-cover conditions existing in 2005 would however indeed trigger a flood overtopping the banks of the Quebrada Seca river at this bridge with the level of the water for the same rainfall episode at this location increased by 1.70 metres.

When cities surrounded by mountains start to expand onto the hills and slopes, this process can cause larger amounts of runoff which in turn can lead to floods

The use of archived and contemporary imagery allows hydrologists to assess how the spatial and temporal behaviour of floods changes when cities undergo large growth processes. In a similar fashion, archived and contemporary imagery can be used to track changes in exposure of vulnerable elements to natural hazards over time. UN-SPIDER's network of Regional Support Offices promotes the use of such methods and has developed step by step procedures so that they can be used worldwide to minimize the impacts of floods as proposed in the post-2015 framework for disaster risk reduction to be launched during the WCDRR.

Read more: www.un-spider.org/advisory-support/recommended-practices

The future key role of Earth observations in disaster risk reduction

by Simonetta Di Pippo, Director of the United Nations Office for Outer Space Affairs (UNOOSA)

UNOOSA Director Simonetta Di Pippo (Image: UNIS Vienna)

In the last decade we have witnessed significant advances in the use of Earth observations for all phases of the disaster management cycle from prevention, to response, to recovery.

Satellite imagery is now routinely processed to generate information regarding the geographical extent and location of floods or forest fires, of landslides, of earthquake damages, of oil spills, or of the effects of tsunamis. Earth observations are also used in hazard monitoring. Meteorological agencies are using satellites to track the paths of hurricanes, typhoons and cyclones around the world. Satellite-based sensors can track volcanic activity even under cloud cover, detect short-term temperature increases along seismic faults prior to earthquakes, or estimate the amount of rainfall in specific geographic regions. Data gathered from Earth observations is also contributing to the estimation of some hazards. Digital Elevation Models and land-use/land-cover data can be used in combination with in-situ data to assess flood and landslide hazards.

Recognizing the benefits of the use of Earth observation products in a variety of applications, including in the case of disaster risk reduction and emergency response, Space agencies and other data providers have increasingly made their data and products available to the public. For example, all archived Landsat data are open for use free of charge and companies providing web-based mapping such as Google and Esri are now facilitating access to such imagery. The European Space Agency has established an open-data policy regarding the imagery being generated by its new Sentinel satellites.

As a way to enhance the application of such imagery, a variety of institutions and organizations including the UN-SPIDER programme under the United Nations Office for Outer Space Affairs (UNOOSA), the Regional Centres for Space Science and Technology Education affiliated to the United Nations, UNITAR-UNOSAT, ESCAP and others are conducting training activities in many countries around the world to increase the capacity of professionals in institutions involved in disaster risk management and emergency response.

The post-2015 framework for disaster risk reduction reiterates the relevance of Earth observations, satellite-based applications and geo-spatial information and promotes their applications at the local and national levels through capacity building, transfer of knowledge and access to technologies. UNOOSA is working with several national, regional, and international organizations to build a global partnership for enhancing the use of Earth observations and Space-based technologies worldwide. This partnership will address challenges raised by the disaster risk management community regarding access to and use of Earth observations.

In addition, UNOOSA is joining forces with WMO, UNESCO-IOC, UNDP, UNITAR/UNOSAT, ITU, ESCAP, IFRC, GFZ, and GIZ to launch an International Network for Multi-Hazard Early Warning.

These two international networks will be presented during dedicated working sessions at the Third UN World Conference on Disaster Risk Reduction (WCDRR) in Sendai as voluntary commitments on behalf of the agencies and organizations which are proposing them. An additional session in the public forum organised with DLR, JAXA, and Tohoku University will also be used to present these networks and the benefits of the use of Earth observation in disaster risk reduction and emergency response applications.

We foresee an increased use of Earth observations as a result of the open-data policies of data providers, technological advances, and training efforts. We also foresee the use of such Earth observations on a more frequent basis to track the effects of measures implemented by nations in the context of the post-2015 framework for disaster risk reduction and to track the effects of climate change. Similarly, Earth observations will play a significant role in tracking the progress of the Sustainable Development Goals.

Considering the efforts of data providers to facilitate the use of Earth observations and other Space-based applications and the views and needs of the disaster risk management community, UNOOSA, through its UN-SPIDER programme, looks forward to bringing these two communities closer together as a way to bring the benefits of space to humanity.

UNITED NATIONS

The United Nations Office for Outer Space Affairs (OOSA) implements the decisions of the General Assembly and of the Committee on the Peaceful Uses of Outer Space and its two Subcommittees, the Scientific and Technical Subcommittee and the Legal Subcommittee. The Office is responsible for promoting international cooperation in the peaceful uses of outer space, and assisting developing countries in using space science and technology. In 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 to be implemented by OOSA. UN-SPIDER is the first programme of its kind to focus on the need to ensure access to and use of space-based solutions during all phases of the disaster management cycle, including the risk reduction phase which will significantly contribute to the reduction in the loss of lives and property.