International Astronautical Congress – IAC 2021, Paris, France, 18-22 September 2022.

IAC-22,B5,2,8,x69019

Integrating Satellite Applications in Disaster Risk Management

Corneel Bogaert, Eurisy Project Officer
Annalisa Donati, Eurisy Secretary General
Eurisy, Paris, 52 Rue Jacques Hillairet, 75012, Paris, France, corneel.bogaert@eurisy.eu

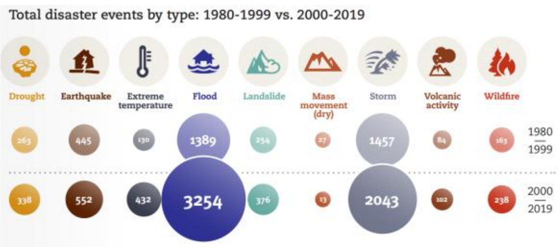
Abstract

In recent years, Europe faced the consequences of several natural hazards, resulting in human and economic losses. Extreme weather events due to climate change will only increase in the future. The rapid growth in the use of satellite applications has the potential to mitigate the impact of climate change and related hazards. Earth observations, Global Navigation Satellite Systems, and satellite communications all support crucial phases of disaster risk management, from prevention and preparedness to response and recovery.

This paper aims to shed light on the European stakeholders playing a role in the disaster risk management cycle and the contributions of satellite applications. It revolves around the current mechanisms to access and share international and European space-born information. An analysis of the main stakeholders will be provided, as well as their role and operative mechanisms. The research seeks to deepen the disaster risk management community among European states with regard to the integration of satellite applications. Several recent case studies on the use of satellite-based services during different disasters will be presented.

1. Introduction

Extreme weather events have come to dominate the disaster landscape in the 21st century. This is what can be concluded from the international disasters database EM-DAT which contains data on the occurrence and effects of mass disasters in the world from 1900 to the present day. A comparison between the occurrence of natural disasters between the period from 1980 to 1999 and from 2000 to 2019, shows a sharp increase in the number of recorded disaster events. While the increase in events might be partially explained by better recording and reporting, much of it is due to a significant rise in the number of climate-related disasters. In contrast to the decrease in mortality, the number of people affected by disasters, including injuries and disruption of livelihoods, especially in agriculture, and the associated economic damage are growing.



UNDRR, "The human cost of disasters 2000-2019"

Between 1980 and 1999, 4 212 disasters linked to natural hazards claimed approximately 1.19 million lives and affected over 3 billion people. Economic losses totaled US$ 1.63 trillion. Between 2000 and 2019, 7 348 disaster events claimed approximately 1.23 million lives, and affected a total of over 4 billion people. Additionally, disasters led to approximately US$ 2.97 trillion in economic losses worldwide.[1][1] The report "The Human Cost of Disasters 2000-2019" shows that over the last twenty years, floods and storms were the most prevalent events. Furthermore, major increases have been recorded in other categories, including drought, wildfires, and extreme temperature events. There has also been a rise in geo-physical events including earthquakes and tsunamis which have killed more people than any of the other natural hazards.

While advancements in disaster management have been made, as demonstrated by the decrease in mortality, modern day society faces disasters much more frequently. Extreme weather events due to climate change will only increase in the future. The rapid growth in the use of satellite applications over recent decades has the potential to mitigate the impact of climate change and related hazards. Earth observations, Global Navigation Satellite Systems (GNSS), and satellite communications can support

[1] UNDRR, "The human cost of disasters 2000-2019", 2020, https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019.

decision-makers in the development of adaptation and mitigation strategies.

While more and more national disaster management authorities are aware of the potential of satellite-based solutions, a lot of untapped potential remains. Lack of awareness, misinformation, limited access to data, fragmentation of services, difficulties to turn data into actionable information: these are just some of the barriers hampering the integration of satellite-based services. To overcome current barriers and to scale up the use of spaceborne information in disaster management, it is key to create a common understanding among European stakeholders of what is currently available and of how this information can be activated by field operators.

In what follows, we first take a closer look at the terminology and meaning of disaster risk management. Next, the focus is on how satellite applications can contribute to the different phases of disaster risk management. After this overview, the paper will describe how the use of space assets for disaster risk management is structured at the international and EU levels. The national and local levels are covered through the outcomes of a national workshop organised in Greece. In the last part of this paper, several case studies will be addressed with a focus on how satellite applications can be used for preventive and recovery activities.

2. Disaster risk management

Disaster risk management includes multiple domains, such as economic development, land-use planning, as well as climate change adaptation. This makes it a rather complex concept. Looking at some of the internationally recognised definitions can help to come to a better understanding of it. According to the European Commission's Joint Research Centre (JRC), disaster risk management policy addresses prevention, mitigation, and protection strategies and measures, as well as adaptation to longer-term natural and socioeconomic processes such as climate change and the development of capabilities for response and recovery.[2] The United Nation Office for Disaster Risks Reduction (UNDRR) defines it as the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.[3]

Both definitions emphasise the different phases before, during, and after a disaster takes place. This paper adopts the terminology of the European Commission which categorises disaster risk management policies in preventive, preparedness, response, and recovery actions.

3. Satellite applications for disaster risk management

Disasters do not take into account borders. They require international, regional, and national cooperation. This is exactly where space assets shine out. Satellites are the only real way of measuring and monitoring our world as a whole, while also revealing invisible-to-the-eye changes, enabling global connectivity, and providing crucial timing and positioning services.

Earth Observation has become a cornerstone of disaster risk management. With the environment becoming increasingly unreliable and prone to natural disasters, meteorological hazards can be better monitored, understood, and ultimately anticipated. Satellite remote sensing provides decision-makers and civil protection authorities objective and timely information. This is the case for early warning systems, but also for information on the extent of a disaster immediately after impact. Even through the thickest clouds, radar observations allow to monitor areas impacted by a disaster. Based on data of past events, Earth Observation can also provide information about potential vulnerable areas.

Satellite communications have become widespread for telecommunication services, as well as for broadcasting services and data communications. In disaster situations, communication is vital to organise and coordinate support systems and search and rescue operations. Whenever terrestrial communications are down, or to overcome congested networks, satellite communications are a major resource. They provide reliable and secure coverage anywhere on the planet and are crucial before, during and immediately after a disaster situation. Satellite communications ensure the connectivity of affected communities with first

[2] European Commission, Joint Research Centre, Science for disaster risk management 2020: acting today, protecting tomorrow, Poljanšek, K.(editor), Clark, I.(editor), Casajus Valles, A.(editor), Marín Ferrer, M.(editor), Publications Office, 2021, https://data.europa.eu/doi/10.2760/438998.

[3] UNDRR, "Disaster risk management", www.undrr.org/terminology/disaster-risk-management.

responders and support systems, and allow relevant authorities to stay up to date on the status of potential disasters.

Satellite navigation applications provide rescue teams with accurate positioning information on critical infrastructures and affected people. Additionally, GNSS sensors contribute to disaster risk management by allowing drones in hard-to-reach inaccessible terrain, detecting ground movements with millimeter accuracy, assessing seismic activity, or geolocating critical resources and facilities in times of crisis.

The technologies described above do not always provide standalone solutions. More and more **integrated solutions** benefit from a combination of multiple satellite applications. Moreover, satellite data can be combined with additional technologies such as artificial intelligence, in-situ sensors, Internet of Things, etc.

Throughout every phase of disaster risk management, different satellite applications have the potential to contribute. **Prevention** aims at reducing exposure and vulnerability of communities and ecosystems, at risk. This requires hazard maps assessing the vulnerability of certain areas in order to avoid or relocate assets in hazard-prone areas. Equally important is increasing the resilience of infrastructure.[4] To minimise the occurrence or impacts of future disasters, space assets can help urban planners to monitor critical infrastructure such as roads, dams, bridges and other buildings. Satellite applications can also boost the **preparedness** by providing accurate information for forecasts, simulations, and early warnings of potential impacts. Historical sets of information can help to observe patterns and to predict the impact of future cataclysms and damages in the same hit area. In relation to the **response** phase of a disaster, rapid mapping allows for a fast provision of geospatial information to activate the necessary resources and assistance immediately following a disaster. Additionally, GNSS and satellite communications allow response teams to deliver immediate assistance by helping them to reach disaster areas and to accurately locate people. Finally, during the **recovery** phase, satellite data can be used for damage mapping. This allows authorities to assess reconstruction costs and needs to more effectively plan the recovery of a disaster struck area.

4. Satellite services for disaster risk management at the international level

While satellite applications are used in many ways to support disaster risk management, synergies among prevention and post-disaster actions aiming at increasing resilience have been less considered.[5] In this context, the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) adds an important conceptual change. It introduced the international community to the identification of risk reduction as the central concern, shifting the focus away from disaster reaction.

At the international level, there are also instrumments specifically addressing space assets for disaster risk management. The UN-SPIDER is a programme of the United Nations Office for Outer Space Affairs (UNOOSA), which aims at ensuring "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". The UN-SPIDER programme is a gateway to space information for disaster management support, serving as a bridge to connect the disaster risk management bodies and space communities and by being a facilitator of capacity-building. Its uniqueness lies in the fact that it offers an open network of providers of space-based solutions to support disaster management activities. The UN-SPIDER supports emergency response efforts and facilitates access to space-based information through regional and global emergency mechanisms. These mechanisms include the International Charter "Space and Major Disasters", Sentinel Asia and the Copernicus Emergency Management Service Mapping.

Another example is the international charter for space and major disasters, a global effort between space agencies to place their satellite resources at the disposal of civil protection authorities to keep an eye on critical infrastructure in the event of a disaster. The Charter can be activated at the request of Authorised Users. Authorised Users are national

[4] European Commission, European Civil Protection and Humanitarian Aid Operations, https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-disaster-risk-management_en.

[5] G. Le Cozannet, M. Kervyn, S. Russo, C. Ifejika Speranza, P. Ferrier, M. Foumelis, T. Lopez, H. Modaressi, "Space-Based Earth Observations for Disaster Risk Management", Surveys in Geophysics (2020) 41: 1209-1235.

disaster management authorities such as representatives of national civil protection offices, rescue agencies, and security organisations,

5. Satellite services for disaster risk management at the European level

The EU Space Programme is strengthening the capacity of the European Union to act in disaster risk management. Over the last few decades, a number of flagship programmes have been developed.

The European GNSS (**EGNSS**) includes Galileo and EGNOS. It is widely used for search and rescue operations allowing for a quick response reducing the damages for those involved in a natural catastrophe or in a situation of distress, as well as the risks for the operators. Positioning services are especially relevant at sea and in remote areas. Through the GNSS system in mobile phones, emergency services can quickly geolocate the caller and reduce the action time. As of March 2022, all the new generation smartphones are integrated with Galileo in order to increase the accuracy of emergency calls. Since 1999 the European Emergency Number Association (EENA) has been implementing an effective 112 service to support those in distress. The development of the Advanced Mobile Location (AML) represents an improvement for both emergency services and the callers. The AML protocol of EENA automatically sends a caller's location directly to emergency services. The system does not require an app or any additional steps from the caller and is completely free of charge. The only requirement is the implementation of the system. As of February 2022, 30 countries worldwide have deployed AML.

Copernicus is the European Union's satellite remote sensing programme, and the world's leading provider of Earth observation data. With its free data policy, Copernicus is an enabler for solutions that could help authorities in disaster management mitigation and response. Copernicus also supports disaster management operations through the Copernicus Emergency Service (CEMS). The CEMS provides on-demand detailed information for selected emergency situations that arise from natural or man-made disasters anywhere in the world. It provides rapid mapping in order to support emergency management activities in the immediate aftermath of a disaster, but it also provides risk and recovery mapping in support of all other phases of disaster risk management. The rapid mapping service is often requested by local and national authorities during an emergency. The Copernicus rapid mapping service responds to the needs of the institutions that require the activation of the service to obtain Earth observation data in a time that spans between a minimum of 24 hours and a maximum of 5 days. In the last 10 years it has been activated mostly in conjunction with floodings, wildfires, windstorms, and humanitarian crisis. Furthermore, the CEMS provides early warnings and monitoring through continuous observations and forecasts for floods (EFAS, GloFAS), droughts (EDO, GDO), and forest fires (EFFIS).

GOVSATCOM will provide secure, cost-efficient communication capabilities to security and safety-critical missions, operations and infrastructure. Its users will include border and maritime authorities, law enforcement agencies, civil protection forces, search and rescue services, disaster relief and humanitarian missions, authorised infrastructure operators and military forces. Within ENTRUSTED, a research project funded under the EU Horizon 2020, governmental user requirements for the GOVSATCOM services will be established. The European Union has also put forward an ambitious plan for the development of a space-based secure connectivity system offering enhanced communication capacities to governmental users as well as to business users. The system will support a large variety of governmental applications, mainly in the domains of surveillance (e.g. border surveillance), crisis management (e.g. humanitarian aid) and connection and protection of key infrastructures (e.g. secure communications for EU embassies). The Secure Connectivity Programme should deliver initial services in 2024 to reach full operational capability by 2027.[6]

Finally, objects and natural phenomena coming from space can also have an impact on our planet. With what is called **Space Situational Awareness** (SSA), the infrastructure and environment in space are being monitored for potential hazards. It includes monitoring space weather events such as solar storms, Space Surveillance and Tracking (SST) of

[6] EU Defence Industry and Space, "EU Space-based Secure Connectivity System", https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-programme/boosting-secure-connectivity_en.

man-made objects, as well as natural near-Earth objects.

EU Space offers even more benefits when used in synergy. With the creation of the European Union Agency for the Space Programme (EUSPA), the EU space activities were brought under one umbrella. Satellite communications, working in synergy with Copernicus and EGNSS, can provide rescue teams with the spatial awareness, connectivity and highly accurate positioning and navigation they need to save lives. Galileo and EGNOS, Copernicus, and GOVSATCOM will further enhance the EU Space Programme's ability to keep European citizens safe and secure. While Copernicus and EGNSS provide the necessary data and positioning, some security accidents also require a means of communication that is robustly protected against interference, interception, intrusion and other risks. GOVSATCOM bridges the gap between the need for assured and secure communication and the capabilities already offered by Copernicus, Galileo and EGNOS.

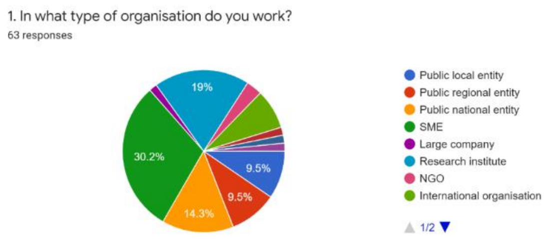
6. National and local disaster risk reduction

International agreements such as the Sendai Framework emphasise the importance of national and local disaster risk management strategies. One of the global targets of the Sendai Framework is to substantially increase the number of countries with national and local disaster risk reduction strategies. In the first 6 years of implementation of the Sendai Framework, there was a 1.5-fold increase in the number of countries with national and/or local disaster risk reduction strategies, up to 120 countries in 2020.[7]

Rather than a comparison between different national strategies, this chapter covers the approach in Greece. The geographic position of Greece exposes the country to the effects of extreme weather events. Forest fires and floods affect the territory with direct consequences on the environment and the safety of the population. Consequences are also visible on the economy, especially in those regions that rely on tourism and that are suffering from losses due to fires and smoke plumes, as it happened during the summer of 2021 on the island of Evia. The government is prioritising the implementation of disaster risk management solutions and measures to increase the resilience of the country to disasters, as well as to help local authorities to recover promptly after disasters.

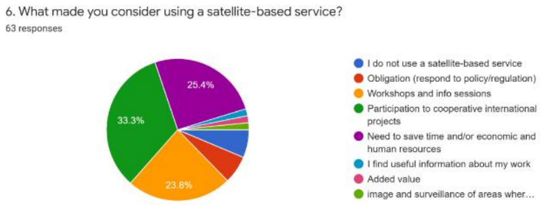
Together with EUSPA, in cooperation with the Greek Ministry for Climate Crisis and Civil Protection and the Ministry of Digital Governance, Eurisy organised the workshop "Satellite-based Services for Disaster Risk Management". The event was hosted in Athens on May 25th 2022, and aimed at creating a common understanding among Greek and European stakeholders of what satellite-based services can bring to the disaster management cycle and how to facilitate the access and use of such solutions at national and local levels. The workshop gathered national stakeholders to discuss the potential benefits of satellite-based services for disaster management and the challenges related to their operational use.

The workshop was also an opportunity to collect feedback from professional communities (farmers, civil protection, academia, forest managers) using satellite applications in their daily operations. In conjunction with the launch of the event, Eurisy prepared a survey addressing Greek stakeholders in the disaster management domain already using satellite-applications or interested in them. The survey has been completed by 63 respondents, among which SMEs, public entities and researchers working in different domains, ranging from environmental protection and disaster risk management to urban planning and energy.



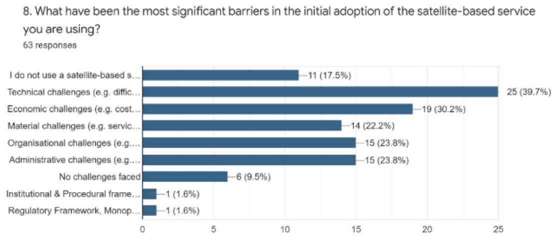
When asked about the main reasons that made them consider satellite applications, a lot of the respondents indicated the need to save time and/or economic and human resources. Participation to workshops and info sessions also appeared to be an important driver. However, the majority explored the use of satellite solutions thanks to their participation to international projects.

[7] UNDRR, "Global Assessment Report on Disaster Risk Reduction", 2022, 36.

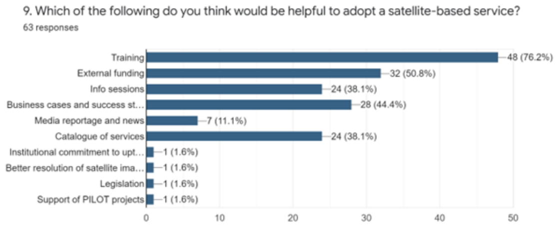


Participating in international cooperative projects brings the advantage of evaluating the benefits of satellite applications for specific challenges, while also allowing users to assess their internal capacity for the uptake of the tested solution. It allows the user to consider innovative services while limiting the risks and impact in case the solution would not properly respond to their needs.

Another outcome of the survey is that the most significant barriers faced in the adoption of satellite applications remain of technical nature. Although some services are open and free, the use of specific satellite solutions can also bring economic challenges related to the high cost of the satellite solutions.



To support the use of satellite applications, training is considered to be the most efficient way. Other highly valuable tools to overcome identified barriers are the dissemination of business cases and success stories, and a catalogue of services. Furthermore, info sessions can help potential users access satellite products and make them aware of what could be achieved. Here too, cooperative projects can provide users with better access to funding and expertise to familiarise themselves with space-based technologies and translate their needs into technical requirements.



Copernicus has been one of the most used technologies for disaster management by Greek authorities in the last years. The Emergency Planning, Prevention and Response Directorate in the General Secretariat for Civil Protection (GSCP) was appointed as the national focal point for Greece for the CEMS, given that it was the entity with necessary expertise and experience to handle satellite data and mapping products. From 2014 to August 2022, the CEMS has been activated in Greece 48 times. It has been activated 11 times for floods and 37 times for forest fires, mainly in the Attika and Peloponnese regions, following a growing trend that reached a peak in 2021 with 13 activations for wildfires. The challenges identified by the GSCP over the past ten years reflect some of the findings emerged in the survey: a lack of trained staff and limited awareness of satellite products' availability and potential.

According to the GSCP, the CEMS service has been mainly used for its rapid mapping services during the response and early recovery phases of the disaster management cycle, while rarely for risk and recovery mapping in support of prevention by local or national entities such as forestry services, insurances, services of the regions and municipalities, and utility network agencies.

7. Case studies

Throughout the previous chapters it has been described how satellite applications are used in many ways to support disaster risk management and to adequately react in times of crisis. However, one recurring observation is that there has been less emphasis on vulnerability and exposure mapping.[8] In the following case studies, the focus will be on prevention and recovery and the potential synergies between these phases.

[8] Voigt S, Giulio-Tonolo F, Lyons J, Kucera J, Jones B, Schneiderhan T, Platzeck G, Kaku K, Hazarika MK, Czaran L, Li SJ, Pedersen W, James GK, Proy C, Muthike DM, Bequignon J, Guha-Sapir D (2016) Global trends in satellite-based emergency mapping. Science 353 (6296): 247–252.

Reflecting on the collapse of the Morandi Bridge

On the 14th of August 2018, an approximately 240 m long section of the Morandi bridge collapsed, causing the death of 43 people. Following the incident, the Italian Civil Protection Department together with the Italian Space Agency (ASI) asked some Italian research groups highly qualified in Synthetic Aperture Radar Interferometry (InSAR) techniques to perform analyses based on the use of SAR data collected by the European C-band Sentinel-1 and the Italian X-band COSMO-SkyMed constellations and relevant to the pre-event time interval, in order to capture any possible early displacements associated with structural failures. Immediately after the bridge failure, such analyses did not reveal significant displacements in correspondence to the collapsed pier.[9]

However, a study published in 2019 carried out by a team of scientists from NASA – in partnership with the University of Bath and the Italian Space Agency - presented a methodology for the assessment of possible pre-failure bridge deformations.[10] Based on a detailed 15-year survey of the Morandi bridge, a displacement map for the structure from space-based SAR measurements revealed that the bridge was undergoing an increased magnitude of deformations over time prior to its collapse. The technique showed that the deck next to the collapsed pier was presenting since 2015 increasing relative displacements. The National Research Centre contradicted this outcome with a new study in 2020. It stated that there was no evidence of the pre-collapse displacements and found that the earlier study was an example of an InSAR deformation analysis affected by a false alarm.

Even if no conclusive evidence of pre-collapse displacements could be found, the collapse of the Morandi bridge started a European-wide reflection on how to modernise critical infrastructure monitoring tools. Visual and in-situ inspections result in complex and expensive surveys, which inevitably limit the surveillance to very restricted areas or to single infrastructure. InSAR techniques, on the other hand, provide millimeter accurate and all-weather imagery from space for the estimation of surface displacements caused by earthquakes, as well as the monitoring of unstable areas affected by subsidence and landslides. Rather than monitoring a single event, the historical evolution of the deformation of objects (such as roads, railroads, dams, etc.) can be retrieved with SAR imagery taken over different time series. The technique offers valuable solutions to provide systematic, large scale displacement measurements related to infrastructure, able to simultaneously detect and analyse the deformation of hundreds of road and railroad bridges at relatively low costs. Such measurements, properly integrated with in-situ investigations and damage assessment models derived from structural engineering, can support pre-emptive decision-making.

Stressing the need for adopting practices for an improved management of critical infrastructures, Genoa adopted in 2019 "Genova Lighthouse", a sustainable and resilience strategy favouring the use of modern technologies for the management of logistics and transport, the prevention of incidents, and the identification of mitigation actions. The shockwave event represented by the collapse of the Morandi Bridge, mobilised a large number of cities within the Liguria region's territory to provide mutual support and to share best practice in the use of smart technologies for risk analysis and prevention to increase the resilience of infrastructure. Satellite data are now used to identify landslides around the area of the Saint George Bridge, the viaduct which was inaugurated two years after the collapse of the Morandi Bridge. Satellite data in combination with in-situ IoT sensors are also being exploited to evaluate the oscillation in the bridge.

The potential of space data to boost the resilience of critical entities is being increasingly supported and recognised by regional and local authorities. In the last decades, a wide community of end-users coming from different scientific contexts started to exploit advanced InSAR techniques. While this trend should be welcomed, an important consideration remains the interpretation of the InSAR-derived products. Taking into account the serious legal implications of

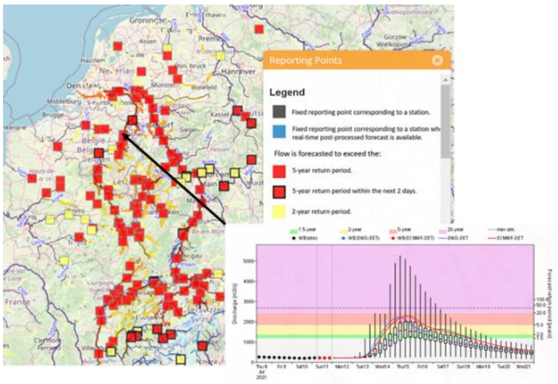
[9] Lanari, R.; Reale, D.; Bonano, M.; Verde, S.; Muhammad, Y.; Fornaro, G.; Casu, F.; Manunta, M. Comment on "Pre-Collapse Space Geodetic Observations of Critical Infrastructure: The Morandi Bridge, Genoa, Italy" by Milillo et al. (2019). Remote Sens. 2020, 12, 4011, https://doi.org/10.3390/rs12244011

[10] Milillo, P.; Giardina, G.; Perissin, D.; Milillo, G.; Coletta, A.; Terranova, C. Pre-Collapse Space Geodetic Observations of Critical Infrastructure: The Morandi Bridge, Genoa, Italy. Remote Sens. 2019, *11*, 1403, https://doi.org/10.3390/rs11121403.

failures or collapses of man-made structures, InSAR analyses should be carefully presented only after a deep and accurate assessment of the results and their interpretation.

Monitoring and preventing floods in Wallonia

On 9 and 10 July 2021, flood forecasts by the European Flood Awareness System (EFAS) of the CEMS indicated a high probability of flooding in the Rhine River basin and in the Meuse River basin. Through EFAS, the European Monitoring and Information Centre (MIC) was informed ahead of time of a potential large-scale flood crisis. Together with the national Civil Protection contact points, the MIC was able to explore different international aid and support options, checking contingency plans and availabilities of resources. The floods triggered four activations in the Copernicus Emergency Mapping Service, in Germany, Belgium, Switzerland and the Netherlands.



EFAS flood forecast from 12 July 2021

Until 14 July, more than 25 notifications were sent by EFAS to its members, composed of national floods forecasting centres, which would have in turn informed their national civil protection authorities. The Belgian National Crisis Centre (NCCN) requested the activation of the CEMS Rapid Mapping Component on 14 July to map the ongoing floods (EMSR518 Mapping Website). Crossed by many rivers, with a high population density and a significant interweaving of habitat and agriculture, floods represent a very concrete risk in Wallonia, the southern region of Belgium. During the extreme floods in the summer of 2021, 39 people died across the territory. The cost of the damage was estimated between 4 and 6 billion euros.

The European Directive on the assessment and management of flood risks encourages EU member states to undertake preliminary assessments of flood risks, map flood-prone areas and flood risks, and develop flood risk management plans. To comply with the European Directive, the Public Service of Wallonia relies on the WALOUS project generating new land cover and land use maps using existing geographic databases, aerial photos, and Copernicus imagery. The land use and land cover maps allow for the identification of vulnerable areas subject to flood risks. Based on the assessment of areas of economic activity potentially affected by a given flood scenario, measures can be proposed to reduce the risk in these areas.[11]

To enhance the use of cartographic products to better manage and prevent floods, all the information related to floods in Wallonia is now available on a website dedicated to flooding in Wallonia (inondations.wallonie.be). Resulting from a collaboration between many departments, the objective of this site is to centralise and provide all useful information on flooding to the citizens, administrations, as well as to building professionals. The land use map is consulted by the Walloon administrations to update the regional flood hazard map and assess the potential damage associated with flooding.

Detecting wildfires and mapping burnt areas in Greece

From 2014 onwards, the CEMS has been activated in Greece for a total of 37 times, of which 13 activations for wildfires in 2021 alone. The increase of activations for wildfires will likely continue over the next few years. Until August 2022, the service was activated another 11 times.

To counteract the increase in wildfires, the National Observatory of Athens (NOA) within the BEYOND EO Centre of Excellence developed the FireHub service. FireHub is an Earth observation-based fire early-warning service. Greece's mostly mountainous relief is covered with wide expanses of forests, some in remote areas. Monitoring these large areas can be very costly and time-consuming. The FireHub service allows to automatically map large areas and to monitor the extent of a fire in near real-time. Earth observation and artificial intelligence are used in

[11] Eurisy, "Monitoring and preventing floods in Wallonia", Copernicus & me, 2021, https://drive.google.com/file/d/1PGO5WKpX5jkc1ezJGUA8nT98LAo8TdGV/view.

combination to make a better assessment of which areas are more at risk than others.

FireHub provides timely fire detection data, enabling authorities such as the Hellenic Fire Corps to get a situation awareness picture and to effectively deploy available resources. During the fire season, the FireHub service generates daily maps to forecast the risks and to validate them with the fire brigade. In addition, it provides smoke dispersion forecasts and fire simulations with current wind directions and speeds in the next two to three hours. It also generates maps of burnt areas for damage and deforestation assessment. Through a dedicated web-GIS application, the service offers information on fires that occurred in Greece during the last 30 years to generate burnt scar maps for deforestation assessment. The maps can be used to implement relief activities, to estimate carbon balance, monitor fire and soil erosion risk, and to plan urban developments. All this is made available to citizens and public authorities to be consulted from the early warning phase to the post-disaster one, supporting preparedness and mitigation capacities of everyone involved.

Monitoring water turbidity during the port extension works at Port-la-Nouvelle

Port-la-Nouvelle is a French town in the Occitanie region, on the Mediterranean coast. In 2018, the Occitanie region decided to start works to adapt the commercial port of Port-la-Nouvelle to new traffics and allow for the development of new sectors. Notably, the regional plan foresees the installation of floating wind-turbines, the creation of a green hydrogen production plant, and a new basin to allow large ships to enter and exit the port. Carrying out such works implies dredging, which can bring back to the surface sediments on the seafloor, hence endangering the marine environment and the natural areas nearby. The region was particularly concerned with the risk of a turbid plume entering the pond of Bages-Sigean, which communicates with the sea by the inlet of Port-la-Nouvelle and the beach of the Vieille Nouvelle, today classed as a regional natural Reserve.

To avoid damage to the environment, the region needed data on the whole basin to prevent, monitor and rapidly intervene if a turbid plum would spread towards vulnerable areas. i-Sea, a company providing services for the surveillance of water and coastal environments, supported the port authorities. The company develops geo-information solutions for public administrations and private actors in the water and energy sectors, making use of data from the Copernicus Sentinel satellites to enhance environmental surveillance. Before the works started, satellite imagery allowed i-Sea and the region to better understand the hydro-sedimentary processes of the site. During the days of the works, Copernicus satellite imagery provided data on water turbidity to monitor water quality and to forecast water turbidity. The satellite-based predictive method provided the personnel responsible for the implementation of the works with daily information to monitor the impact of the works on water turbidity in the area, and to prevent the infiltration of a turbid plume in the pond of Bages Sigean.[12]

The GIS4Schools Project

Finally, an effective way to mobilise different groups that are traditionally not engaged in disaster risk management, is to integrate the topic in the educational curriculum.

An example of an ongoing project that could have such an impact on the European school system is GIS4Schools. The project introduces a scalable and reusable training package focused on the use of GIS in climate action, which is currently absent or rarely adopted. It provides secondary school pupils with the tools to use satellite data to tackle very concrete real-world issues. As part of the project, a training package has been developed. Teachers are trained to transfer to pupils the training package contents, exploiting Earth observation and other data to develop GIS products in order to address the impact of climate change on the local environment.

Currently, there are four schools where the project is piloting. Each school works around its own challenge. In Italy at the ITT Marconi, pupils learn to map the spread of the processionary caterpillar in the urban forest around the city of Rovereto. The challenge of the Portuguese Escola Secundaria Jose Afonso is the determination of the flood vulnerability index of the municipality area of Seixal. In Romania, at Colegiul National Ion Neculce, the focus is on the air quality topic and the

[12] Eurisy, Monitoring water turbidity during the port extension works at Port-la-Nouvelle, Copernicus & me, 2021, https://drive.google.com/file/d/1KGxslum6ZApvmkMCal2almiBqDTggGnV/view.

Danube delta. Finally, the pupils of the IES Marc Ferrer school work on environmental assessment of the wetlands on the Spanish island of Formentera.

Climate change represents the biggest challenge of our time. Youngsters are demanding more measures for the benefit of our world. The Fridays for Future movement demonstrates how much new generations are fighting to secure their future. GIS4Schools aims to give them the right tools, encouraging the use and exploitation of satellite data by students into climate action. Students learn the necessary digital tools to analyse various parameters related to the increase in surface temperature, desertification, and forest fires. Taking on specific challenges raises the awareness of pupils on the local environment. The project also boosts the interest in the teaching of STEAM subjects for future generations.

Conclusions

Over the next few years, an increase in extreme weather events is expected. At the same time, advancements in disaster risk management are also being made. Space technologies are part of the modern-day disaster risk management cycle, although they are not always used to their full potential. For the further integration of satellite applications in disaster risk management, public investments and incentives are key. In Europe this is demonstrated with the EU space programme. Bringing the different initiatives under one umbrella opens up new synergies in the use of Earth observation, satellite communications, and positioning services. Involvement of the private sector also increases the uptake of satellite applications for disaster risk management. The case study about monitoring water turbidity illustrates how private companies can provide essential services to civil protection and public authorities. Moreover, the private sector itself can benefit from satellite data in different economic domains, such as agriculture, insurance, and the implementation of innovative digital services.

The dissemination of cases and success stories can be a valuable tool to overcome limited awareness of how satellite-based services can increase disaster risk resilience. Within the disaster risk management cycle, satellite applications are not always considered by the end users. In particular during the phases of prevention and recovery, satellite applications have not been fully exploited. Rather than on response actions, the focus of the case studies in this paper was on satellite applications during the early warning phase and the post-disaster one. The case studies demonstrate how this applies to different scenarios, from monitoring the deformation of infrastructure and mapping flood-prone areas to mapping burnt areas for damage and deforestation assessment.

Another significant barrier in the adoption of satellite applications remains of technical nature. Info sessions, trainings, and workshops are crucial to facilitate the integration of space technologies in national disaster management decision-making processes. Overcoming a lack of trained staff can be achieved with a governmental approach towards the digitalisation of services, and a different mindset that would consider the increase of climate change effects. The future needs a diverse range of skillsets to undertake climate action and there is no better breeding ground for it than education. Furthermore, participating in international cooperative projects offers potential users a safe testbed to consider space-based technologies while limiting the risks and impact in case the solution would not properly respond to their needs.

Along with the usefulness of satellite-based services to better manage disaster risks, an untapped potential of the market has been demonstrated throughout this paper. Proper training and increasing the awareness of the capacity of satellite-based services are fundamental to boost user uptake. Eurisy will continue to undertake user consultations, bringing together networks of users to discuss current challenges and needs to capture unexploited market segments.

References

[1] UNDRR, "The human cost of disasters 2000-2019", 2020, https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019.

[2] European Commission, Joint Research Centre, "Science for disaster risk management 2020: acting today, protecting tomorrow", Poljanšek, K.(editor), Clark, I.(editor), Casajus Valles, A.(editor), Marín Ferrer, M.(editor), Publications Office, 2021, https://data.europa.eu/doi/10.2760/438998.

[3] UNDRR, "Disaster risk management", www.undrr.org/terminology/disaster-risk-management.

[4] European Commission, European Civil Protection and Humanitarian Aid Operations, https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-disaster-risk-management_en.

[5] Le Cozannet G.; Kervyn M.; Russo S.; Ifejika Speranza C.; Ferrier P.; Foumelis M.; Lopez T.; Modaressi H.; "Space-Based Earth Observations for Disaster Risk Management", Surveys in Geophysics (2020) 41: 1209-1235.

[6] EU Defence Industry and Space, "EU Space-based Secure Connectivity System", https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-programme/boosting-secure-connectivity_en.

[7] UNDRR, "Global Assessment Report on Disaster Risk Reduction", 2022, 36.

[8] Voigt S.; Giulio-Tonolo F.; Lyons J.; Kucera J.; Jones B.; Schneiderhan T.; Platzeck G.; Kaku K.; Hazarika M.; Czaran L.; Li SJ.; Pedersen W.; James GK.; Proy C.; Muthike DM.; Bequignon J.; Guha-Sapir D.; (2016) "Global trends in satellite-based emergency mapping", Science 353 (6296): 247–252.

[9] Lanari, R.; Reale, D.; Bonano, M.; Verde, S.; Muhammad, Y.; Fornaro, G.; Casu, F.; Manunta, M. Comment on "Pre-Collapse Space Geodetic Observations of Critical Infrastructure: The Morandi Bridge, Genoa, Italy" by Milillo et al. (2019). Remote Sens. 2020, 12, 4011, https://doi.org/10.3390/rs12244011.

[10] Milillo, P.; Giardina, G.; Perissin, D.; Milillo, G.; Coletta, A.; "Terranova, C. Pre-Collapse Space Geodetic Observations of Critical Infrastructure: The Morandi Bridge", Genoa, Italy. Remote Sens. 2019, 11, 1403, https://doi.org/10.3390/rs11121403.

[11] Eurisy, "Monitoring and preventing floods in Wallonia", Copernicus & me, 2021, https://drive.google.com/file/d/1PGO5WKpX5jkc1ezJGUA8nT98LAo8TdGV/view.

[12] Eurisy, Monitoring water turbidity during the port extension works at Port-la-Nouvelle, Copernicus & me, 2021, https://drive.google.com/file/d/1KGxslum6ZApvmkMCal2almiBqDTggGnV/view.