UN-SPIDER / ZFL Regional Virtual Expert Meeting for Southern Africa

Background Information for participants

"Space-based Solutions for Disaster Risk Management and Emergency Response".

Virtual event,
13 to 15 July 2021

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Introduction

Like many regions of the world, Southern Africa is exposed to hydrometeorological, geological, biological and coastal hazards that can trigger disasters in vulnerable communities. Like the rest of the world, this region has been impacted by the COVID-19 pandemic and is forcing governments and societies to implement a variety of measures to cope with its impacts. In recent years, some countries of the region were affected by cyclones, floods, droughts, and recently a severe locust episode.

Recognizing the benefits of the use of space-based information, several space agencies joined forces in the year 2000 to establish the *International Charter Space and Major Disasters* as an emergency mechanism to support disaster management agencies in their response efforts due to sudden-onset hazards. Since its establishment, the Charter has been activated more than 700 times around the world. More recently, the European Commission established the *Copernicus Emergency Management Service*, which also supports disasters management agencies in their efforts to respond to disasters, and the *Risk and Recovery Service* to contribute to disaster risk reduction efforts.

Within the United Nations, the United Nations General Assembly established the UN-SPIDER programme in 2006 to provide universal access for all countries and relevant international and regional organizations to all types of space-based information and services relevant to disaster management in order to support the full disaster management, in particular for developing countries. The German Aerospace Centre (DLR) and the Centre for Remote Sensing of Land Surfaces of the University of Bonn (ZFL) contribute actively and extensively to the efforts carried out by UN-SPIDER in Africa.

Since more than a decade ago, some space agencies and institutions also began to implement open data policies to facilitate access to satellite imagery. These open data policies have allowed researchers and professionals in institutions around the world to access vast amounts of historical and near up-to-date satellite imagery. To facilitate the processing of such imagery, software companies, space agencies, volunteer technical communities, UN-SPIDER, and other institutions have developed dedicated step-by-step procedures.

More recently, faster processing capacities, cloud-based computing, artificial intelligence, and machine learning are allowing the space community, international and regional organizations, and national institutions to launch services or platforms that allow users to access pre-processed satellite imagery in combination ~~of~~ with other sources of data in the format or "analysis-ready-data". In addition, efforts are underway to facilitate access to a variety of data through "Data Cubes".

All these developments are contributing to an improved understanding of risks, to an enhanced visualization of geospatial trends regarding the exposure of vulnerable elements, to track the spatial and temporal evolution of hazards, to improve early warning systems, and towards a more efficient response in case of disasters.

In addition, the space community is continuing to develop and launch new satellites with wider capabilities. In a parallel fashion, researchers from the space and the geospatial communities are carrying out applied research to enhance the use of such novel satellites.

To enhance the use of all these opportunities, UN-SPIDER and its network of Regional Support Offices, as well as several universities and centres of excellence, are carrying out training activities. Other institutions carrying out training activities include the NASA ARSET programme, the EO College of the University of Jena, the Working Group on Capacity Building and Data Democracy of the Committee on Earth Observing Satellites (CEOS WG-CBD), etc.

The *UN-SPIDER / ZFL Regional Virtual Expert Meeting for Southern Africa: "Space-based Solutions for Disaster Risk Management and Emergency Response"* allowed participants from Southern African countries to take note of recent advances developed by the space community, UN-SPIDER and other stakeholder. In addition, the virtual expert meeting allowed several national disaster management agencies and regional and international organizations to present their work.

This document provides a technical introduction to the presentations, data sources, services, products, topics, and methods that were presented during this virtual expert meeting.

Contributions to development in Southern Africa: national and regional institutions

Every country in the Southern Africa region has a government agency that addresses disaster risk reduction, preparedness and response and recovery efforts. The Virtual Expert Meeting benefitted from the participation of staff from these government agencies, as well as from other ministries, NGOs, universities, and private companies. The virtual expert meeting included presentations by the National Disaster Management Centre of South Africa (NDMC) and the Directorate Disaster Risk Management of Namibia.

The NDMC of South Africa is coordinated through the implementation of the Disaster Management Act, 2002 (Act no 57 of 2002) as amended, as well as the accompanying Disaster Management Framework, 2005 across the three spheres of government. The NDMC also administers fire legislation (Fire Brigade Services Act, 1987).

The objective of the National Centre is **to promote an integrated and coordinated system of disaster management, with special emphasis on prevention and mitigation. by national, provincial and municipal organs of state, statutory functionaries, other role-players involved in disaster management and communities.**

In addition to the National Centre, a disaster management centre must be established in every Province and in every District & Metropolitan Municipality, to coordinate disaster management in its sphere of responsibility

The Act has explicit & distinct focus on DRR. It establishes adequate structures necessary for the management of disasters with special emphasis on prevention and mitigation by all spheres of government.

The Act calls for the establishment of institutional & governance structures to ensure integration of stakeholder participation & to adopt a holistic and organised approach to the implementation of policy and legislation.

The Act recognises the multi-sectoral & multi-disciplinary nature of DM in the country.

The Act also provides mechanisms for involvement in DM activities by private sector, traditional leaders, civil society, volunteers, etc

The Act also makes provision for the development of a National Disaster Management Framework.

Figure 1 presents the approach that is being implemented by the NDMC to address all phases of the disaster management cycle and corresponding enablers.

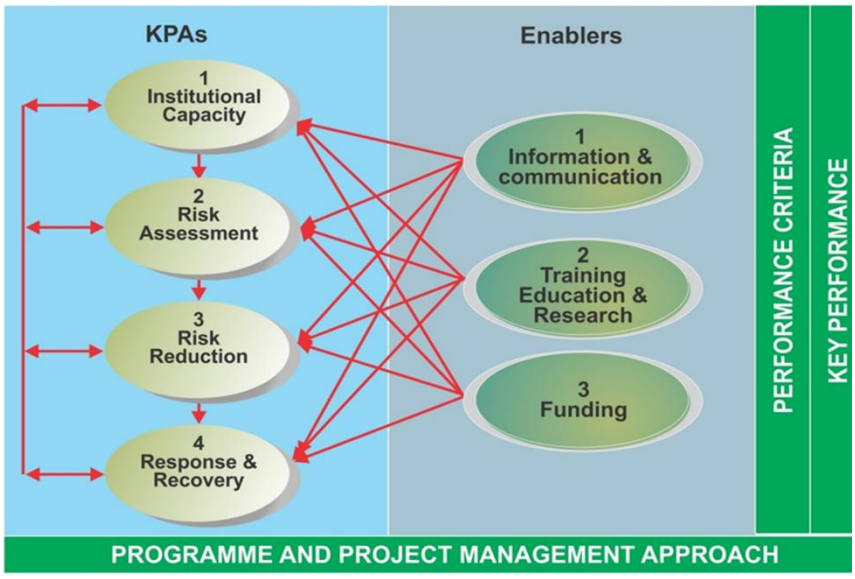


Figure 1: Programme and project management approach of the NDMC of South Africa.

With the support of the South African National Space Agency (SANSA), the NDMC makes use of space-based information to address the challenges of natural hazards.

The South African National Space Agency (SANSA) will be making a presentation on Earth observation in Disaster Management: Risk reduction and mitigation in South Africa.

RCMRD was established in Nairobi - Kenya in 1975 under the auspices of the United Nations Economic Commission for Africa (UNECA) and the then Organization of African Unity (OAU), today African Union (AU). RCMRD is an inter-governmental organization and currently has 20 Contracting Member States in the Eastern and Southern Africa regions: Botswana, Burundi, Comoros, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Namibia, Rwanda, Seychelles, Somalia, South Africa, South Sudan, Sudan, Swaziland, Tanzania, Uganda and Zambia. RCMRD is one of UN-SPIDER's Regional Support Offices.

I Musokotwane Environment Resource for South Africa (IMERCSA) has been established by the Southern Africa Research and Documentation Centre (SARDC), to inform, motivate and empower people at all levels of environmental decision-making in southern Africa to take positive actions to counter environmental degradation and move towards sustainable development paths by providing them with accessible information and knowledge on the environment. IMERCSA addresses several thematic areas including climate change, water resources management, river basin development, land and food security, and disasters triggered by natural hazards. It provides policy-relevant advice to governments in Southern African countries. IMERCSA is supporting capacity outreach work through the dissemination of regional publications such as Environmental Atlases and its flagship Environmental Outlooks**.** The institute aims to facilitate the uptake and interpretability of remote sensing information to stakeholders at all levels and facilitate the integration of data-driven solutions with indigenous knowledge systems. IMERCSA plans on using space technology in the Busi-Pungwe-Save (BuPuSa) transboundary community-focussed flood early warning system project. Outputs will include flood risk assessment maps and the establishment of a flood monitoring and early warning system which combines observations from hydrometeorological stations and remote sensing data in the tri-basin.

The Department of Earth and Environmental Sciences of the Botswana International University of Science & Technology (BIUST) has joined forces with researchers from the University of Aberdeen and other universities to implement the CONNECT4WR project. This project addresses the topic of transboundary floods in the Limpopo basin. Spatio-temporal mapping and monitoring of floods and droughts in the region have been held back by surface and groundwater resources being treated as separate entities, and in-situ gauging stations being sparse with data not readily available in real time. Remote sensing data is now being used to measure hydrometeorological data at high-spatial resolution in near real-time, and to pinpoint past events in the sedimentological record. Spatio-temporal data gaps for the Limpopo basin were filled using X-ray analysis of sediment archives to extend the temporal dataset of extreme historical events, and were coupled with remote sensing data including satellite imagery and Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) rainfall data. The final model based on remote sensing data, sediment archives and hydrometric data can be used for future scenario analysis to identify appropriate management solutions and enhance resilience to hydrological extremes in the Limpopo basin.

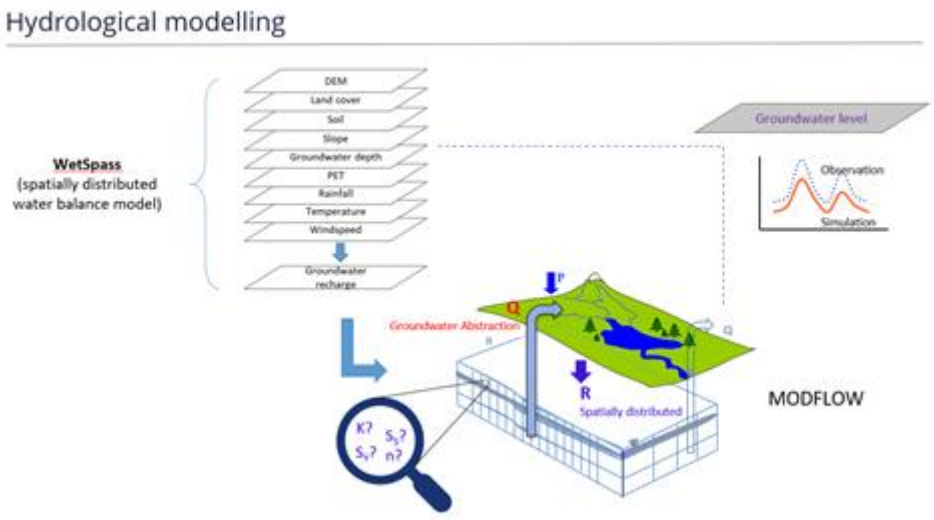
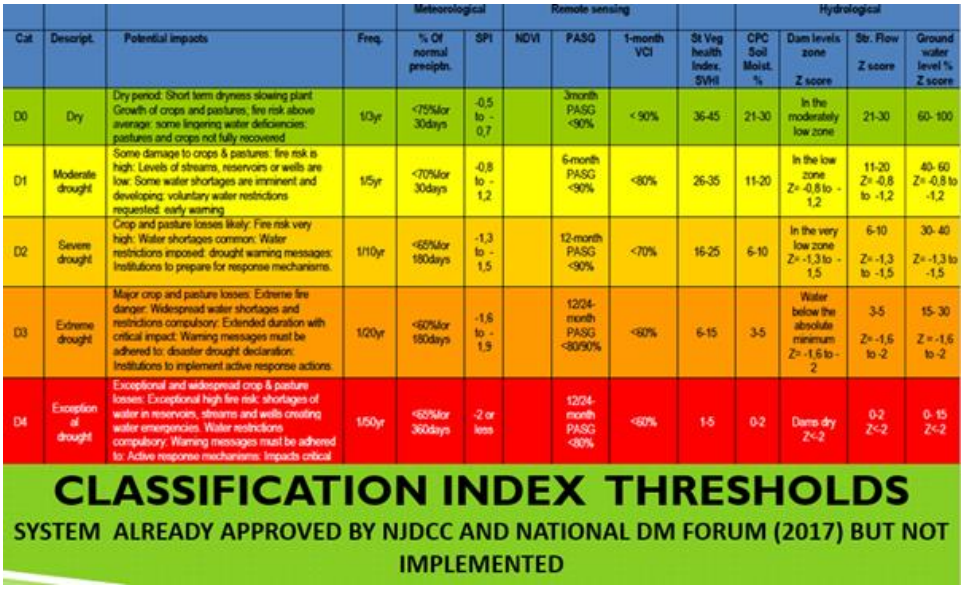


Figure : Historical flood and drought have a direct relation with groundwater recharge deviation, and hydrological modelling with space-based time series data is able simulate spatio-temporal hydrological extremes observed in the sediment archive. Image Courtesy of CONNECT4WR, Mustafa et al. 2021.

In addition, the Group of Earth Observations has set up a dedicated effort in Africa called AfriGEO. It aims to provide the necessary framework for African countries and organizations as well as international partners to access and leverage on-going local and international bilateral and multilateral EO-based initiatives across Africa, thereby creating synergies and minimizing duplication for the benefit of the continent.

Furthermore, non-government organizations and private companies such as Résilience Globale Pty Ltd and Airbus Defence and Space contribute to address the challenges posed by natural hazards in this region. Résilience Globale is developing resources to address the challenges posed by drought in this region, which aim to shift the focus from disaster response to drought risk reduction and disaster mitigation. Résilience Globale's integrated drought risk reduction and management plan for South Africa encompasses remotely sensed indicators, site specific indicators and the demarcation of monitor boundaries (from administrative to ecosystem/watershed) for enhanced monitoring of the slow onset disaster. The plan relies on a drought classification schema developed in 2017 which categorises droughts in four levels based on established meteorological, remote sensing and hydrological derived category-specific thresholds. The drought categories, which range from D0 (dry) to D4 (exceptional drought), are associated with a range potential impacts which will support the implementation of contingency plans. Major recommendations include for the monitoring information system to be integrated in a web platform.



				Meteorological		Remote sensing					Hydrological		
Cat	Descript.	Potential impacts	Freq.	% Of normal preciptn.	SPI	NDVI	PASG	1-month VCI	St Veg health Index. SVHI	CPC Soil Moist. %	Dam levels zone Z score	Str. Flow Z score	Ground water level % Z score
D0	Dry	Dry period: Short term dryness slowing plant Growth of crops and pastures; fire risk above average: some lingering water deficiencies: pastures and crops not fully recovered	1/3yr	<75%/or 30days	-0,5 to -0,7		3month PASG <90%	< 90%	36-45	21-30	In the moderately low zone	21-30	60-100
D1	Moderate drought	Some damage to crops & pastures: fire risk is high: Levels of streams, reservoirs or wells are low: Some water shortages are imminent and developing; voluntary water restrictions requested: early warning	1/5yr	<70%/or 30days	-0,8 to -1,2		6-month PASG <90%	<80%	26-35	11-20	In the low zone Z= -0,8 to -1,2	11-20 Z= -0,8 to -1,2	40- 60 Z= -0,8 to -1,2
D2	Severe drought	Crop and pasture losses likely: Fire risk very high: Water shortages common: Water restrictions imposed: drought warning messages: Institutions to prepare for response mechanisms.	1/10yr	<65%/or 180days	-1,3 to -1,5		12-month PASG <90%	<70%	16-25	6-10	In the very low zone Z= -1,3 to -1,5	6-10 Z= -1,3 to -1,5	30- 40 Z= -1,3 to -1,5
D3	Extreme drought	Major crop and pasture losses: Extreme fire danger: Widespread water shortages and restrictions compulsory: Extended duration with critical impact: Warning messages must be adhered to: disaster drought declaration: Institutions to implement active response actions.	1/20yr	<60%/or 180days	-1,6 to -1,9		12/24-month PASG <80/90%	<60%	6-15	3-5	Water below the absolute minimum Z= -1,6 to -2	3-5 Z= -1,6 to -2	15- 30 Z = -1,6 to -2
D4	Exceptional drought	Exceptional and widespread crop & pasture losses: Exceptional high fire risk: shortages of water in reservoirs, streams and wells creating water emergencies. Water restrictions compulsory: Warning messages must be adhered to: Active response mechanisms. Impacts critical	1/50yr	<62%/or 360days	-2 or less		12/24-month PASG <80%	<60%	1-5	0-2	Dams dry Z<-2	0-2 Z<-2	0- 15 Z<-2

CLASSIFICATION INDEX THRESHOLDS

SYSTEM ALREADY APPROVED BY NJDCC AND NATIONAL DM FORUM (2017) BUT NOT IMPLEMENTED

Figure : The proposed drought classifification scheme categorises droughts according to specific meterological, remote sensing and hydrological thresholds associated to a range of potential drought impacts. Image Courtesy of Résilience Globale Pty Ltd.

Emergency Response Mechanisms

Since the year 2000, the space community has begun to establish services to contribute to disaster response efforts.

The International Charter Space and Major Disasters

The International Charter Space and Major Disasters provides information derived from satellite imagery provided by member space agencies free of charge to disaster management agencies which respond to or coordinate the response in case of disasters. The Charter has been activated more than 700 times since it was established. In the case of Southern Africa, it has been activated in case of disasters in Angola, Madagascar, Malawi, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe.

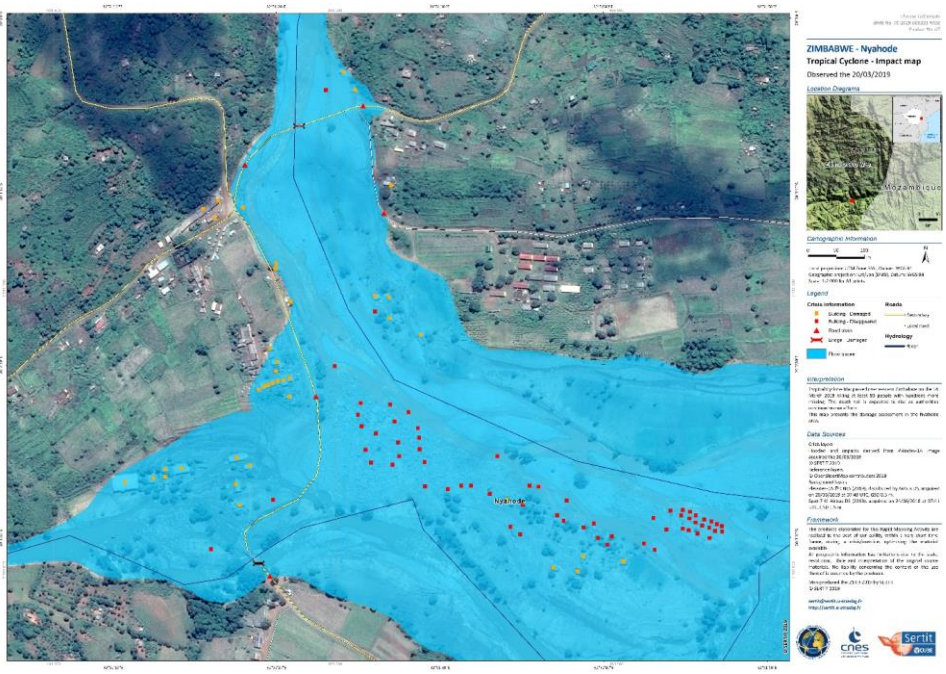


Figure 1: Example of a map generated as part of the activation of the International Charter to support disaster response efforts due to floods in the region of Nyahode in Zimbabwe triggered by Cyclone Idai in March 2019. Image courtesy of the International Charter Space and Major Disasters.

The German Aerospace Centre (DLR), which is one of the members of the International Charter, will make the presentation at the exert meeting.

More information on the International Charter is available in these links:

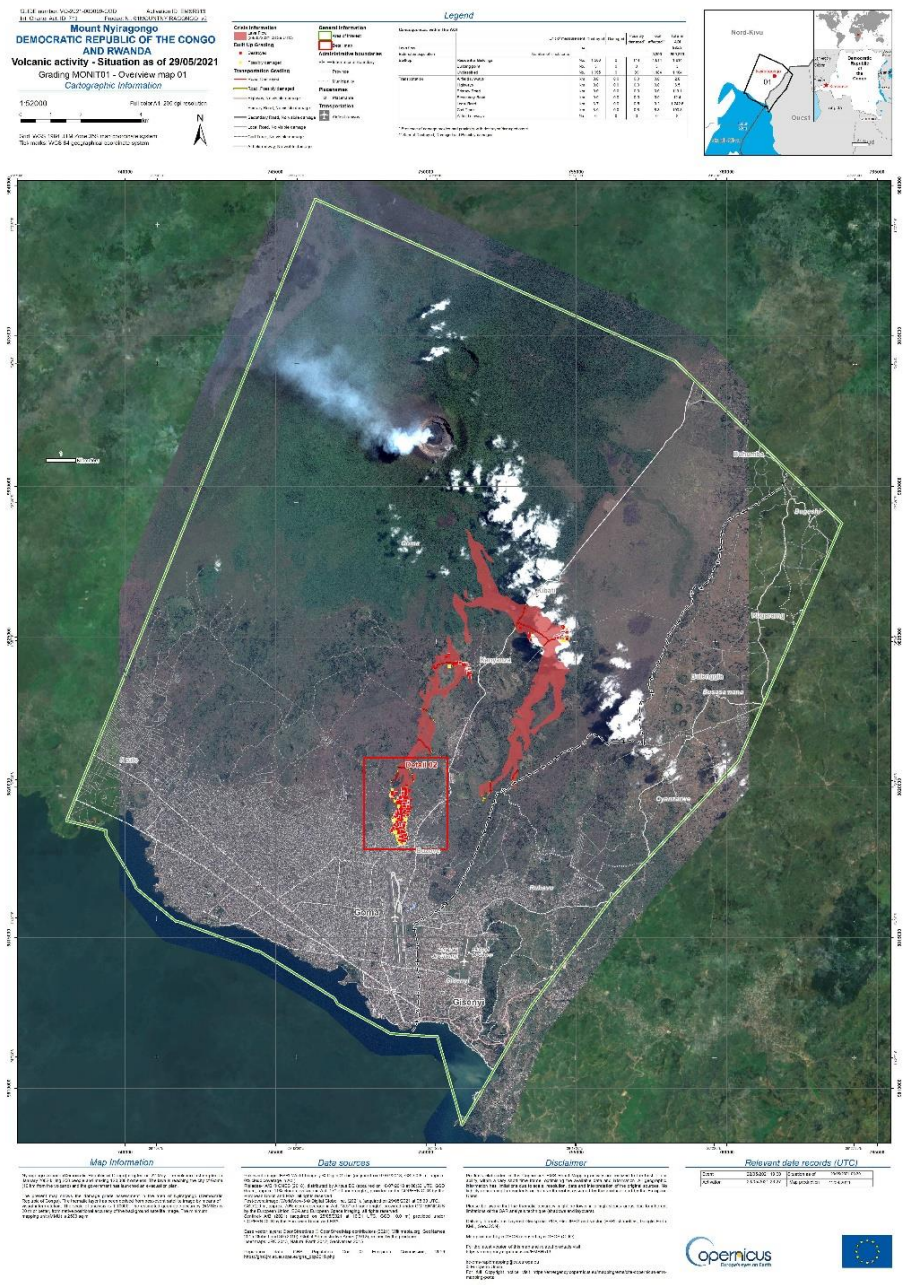
https://disasterscharter.org/web/guest/home

https://un-spider.org/space-application/emergency-mechanisms/international-charter-space-and-major-disasters

Copernicus Emergency Management Service

The Copernicus Management Service has been established by the European Commission as part of the Copernicus programme to contribute to sustainable development. The Emergency Management Service (EMS) provides an on-demand mapping service that consists of two components. These services need to be initiated through service requests in case of an emergency event. Firstly, the

Rapid Mapping shows active and recent Emergency Events within hours or days after occurrence on an interactive map and as a list, allowing for quick assessment of the situation and thus decision-support.



For all events, products showing the extent and providing in-depth information can be viewed and downloaded. Secondly, a similar service supporting disaster Management (Risk and Recovery Mapping) focuses more on the preparatory and recovery stages of events.

Figure 2: Example of a map generated as part of the activation of the Copernicus Emergency Management Service due to the eruption of Nyiragongo volcano in the Democratic Republic of Congo and Rwanda in May 2021. Image courtesy of Copernicus EMS.

The virtual expert meeting will include a presentation on the Copernicus Emergency Management Service during its plenary session on 14 July.

More information on the Copernicus Emergency Mapping Service is available in these links:

https://emergency.copernicus.eu/

https://un-spider.org/space-application/emergency-mechanisms/copernicus-gio-emergency-mapping-service

SERVIR

SERVIR is a joint initiative by the U.S. Agency for International Development (USAID) and NASA's Earth Applied Sciences Program that works with "leading regional organizations world-wide to help developing countries use information provided by Earth observing satellites and geospatial technologies for managing climate risks and land use". SERVIR both provides

access to EO data and offers capacity-building activities such as trainings to strengthen the use of EO data in decision-making efforts. Its work focuses on developing countries in Eastern and Southern Africa, West Africa, the Hindu-Kush region of the Himalayas, the lower Mekong River Basin in Southeast Asia, and the Amazon region of South America. On site, SERVIR is supported by its regional offices.

The SERVIR-Eastern and Southern Africa project builds upon RCMRD's existing strengths and augments their data management and training capability. Efforts complement RCMRD's core mission and provide a springboard for the development of applications customized for Member States.

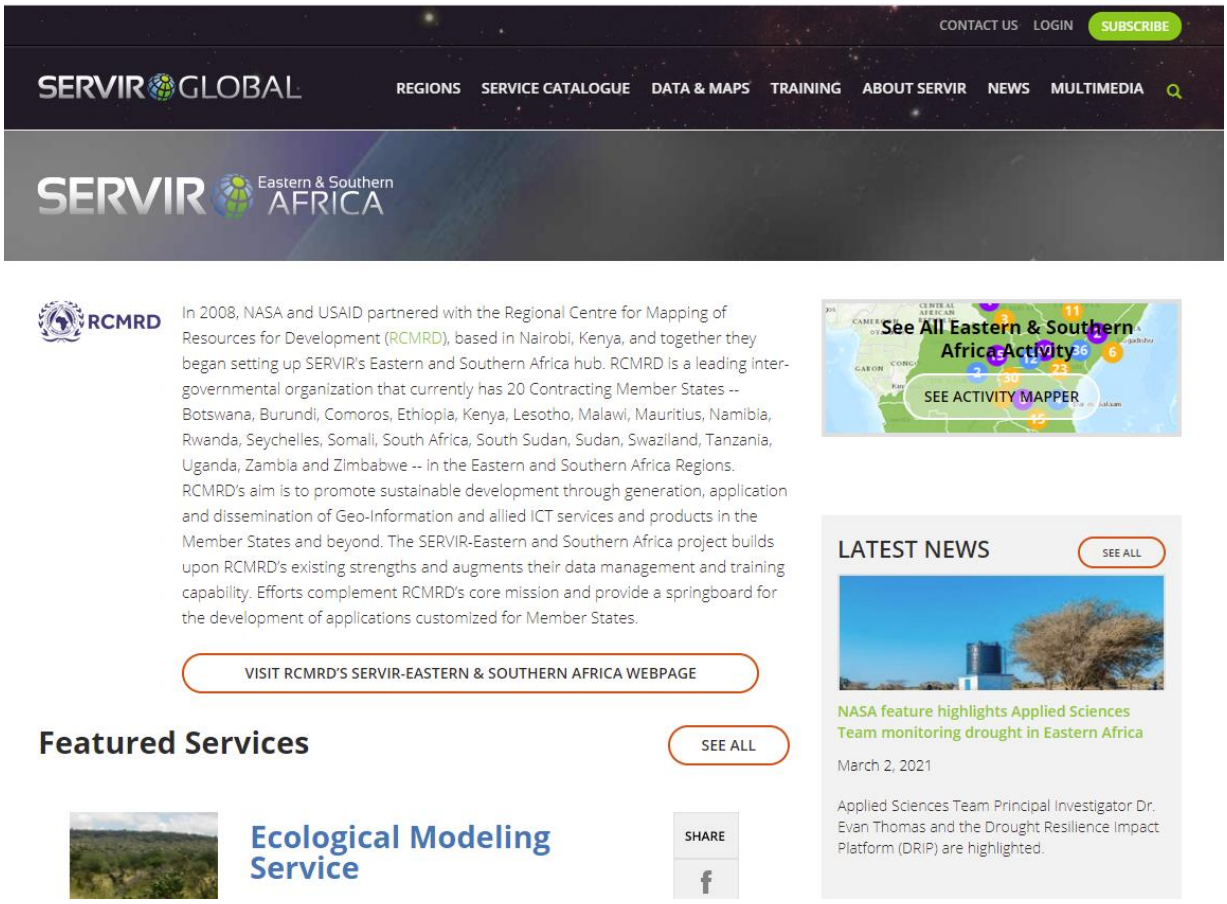


Figure 3: SERVIR webpage for Eastern and Southern Africa. Image courtesy of SERVIR GLOBAL.

More information on SERVIR is available in these links:
https://www.servirglobal.net/Regions/ESAfrica
https://un-spider.org/space-application/emergency-mechanisms/servir

Services for improved understanding of risk and for disaster preparedness

Many institutions have developed services that can be used for an improved understanding of risk and for disaster preparedness, including early warning systems.

Floods

In recent year, several international and regional organizations have developed services to facilitate the visualization and understanding of natural hazards.

The Global Flood Awareness System (GloFAS) is aimed at providing global information on flood and flood-related, environmental parameters. Through its "web viewer" online GIS, a large selection of parameters can be visualized to assess flood potential. Provided data include rainfall, hydrological model outputs as well as hydrological measurement from stations across the globe. Users can select parameters to visualize interactively, which allows for an assessment of active floods. Furthermore, forecast data are provided which can be used to assess future flood-potential. Direct data download is planned for the future.

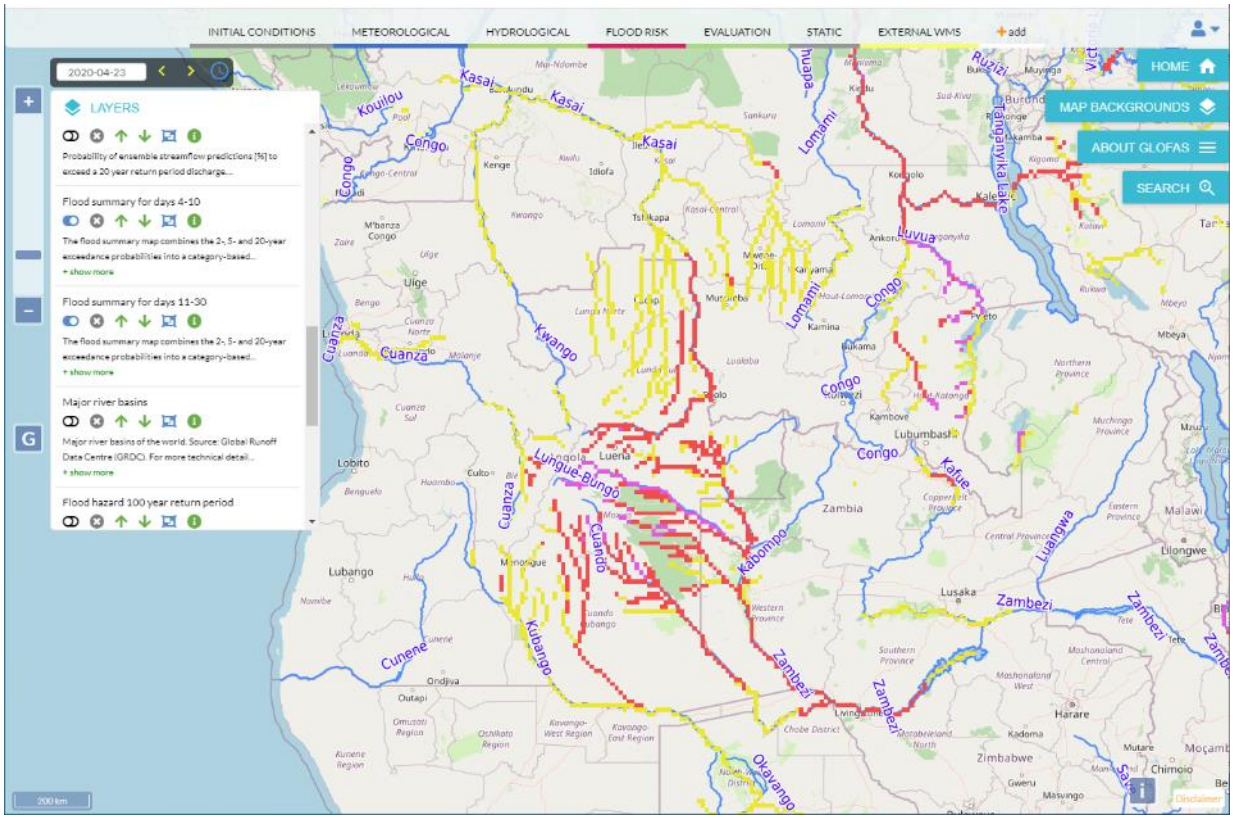


Figure 4: Example of potential floods in several tributaries of the Zambezi River as generated by the Global Flood Awareness System (GloFAS) Portal for the period at end of April of the year 2020. Image courtesy of GLOFAS.

More information on GLOFAS is available at: https://www.globalfloods.eu/glofas-forecasting/

The FloodHub system for flood early warning and monitoring

According to the 2021 report of the Centre for Research on the Epidemiology of Disasters & the UN Office for Disaster Risk Reduction, flood was by far the most frequent type of disaster worldwide, and the only one increasingly deadly in 2020. What is more, flood occurrence was significantly increased in 2020, compared to the 2000-2019 annual average. Therefore, policy and decision makers, more than ever, need efficient flood monitoring tools to facilitate their work towards increasing disaster resilience, especially in the urban and peri-urban areas, where most of the population and critical infrastructure are located.

For this purpose, the FloodHub system has been developed by the BEYOND Center of Earth Observation and Satellite Remote Sensing, at the National Observatory of Athens, Greece, (BCEORS/NOA) in the framework of the EuroGEO Disaster Resilience Action Group, supported by on-going actions (SMURBS / ERA-PLANET and Excelsior H2020 projects and the sponsor Hellenic Petroleum S.A.). The innovation of the system lies in the integration of different data sources, to deliver a reliable flood early warning system, and an operational awareness picture of the crisis every 5 minutes to the relevant authorities, namely on three levels: municipality, region, and national civil protection.

FloodHub allows the near-real-time ingestion and assimilation of hydrometeorological measurements from in-situ telemetric stations, Sentinel's data, and crowdsourced data, in a multi-source data fusion concept, using sophisticated hydrologic and hydraulic modelling and statistical regression techniques.

It offers increased reliability through a continuous validation and optimization of results, automation in assimilating flood modelling in real time, computational efficiency, openness, flexibility, scalability, transferability, and the speed to meet rapid awareness during the crisis.

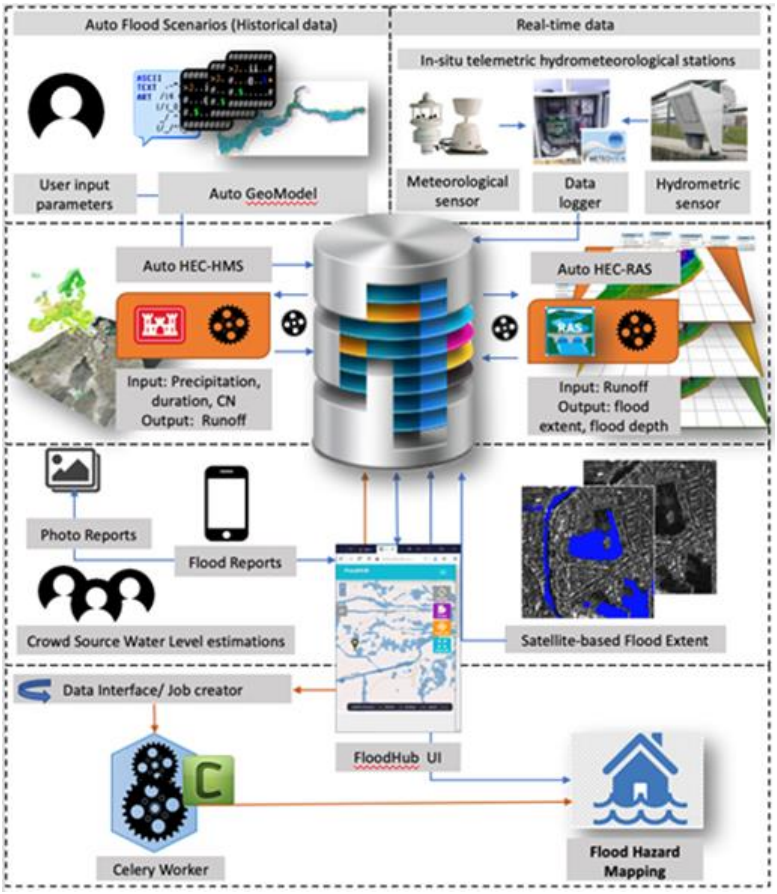


Figure 5: Architecture of the FloodHUB system. Image courtesy of the BEYOND Centre of NOA

Therefore, FloodHub is a useful tool in the hands of the relevant authorities and key stakeholders, contributing to an effective flood risk and crisis management. This is in line with the requirements for the implementation of the EU Floods Directive 2007/60/EC, the Sendai Framework for Disaster Risk Reduction, the UN SDGs, as well as the GEO's Societal Benefit Areas.

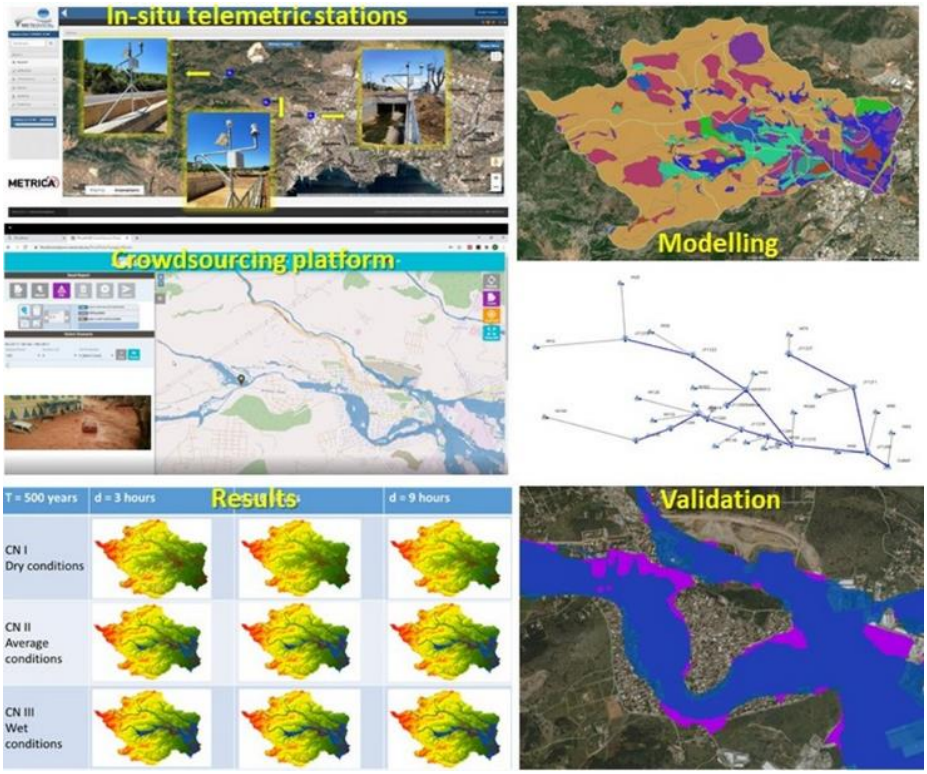


Figure 6: Input data, results and validation of the FloodHUB system. Image courtesy of the Beyond Centre of Earth Observation and Satellite Remote Sensing of NOA.

More information on FloodHUB is available in this link: http://beyond-eocenter.eu/index.php/web-services/floodhub

Forest fires

Several institutions have developed portals and services to view geospatial information regarding forest fires.

Global Wildfire Information System (GWIS)

The Global Wildfire Information System (GWIS) is aimed at providing information on active fires on a regional as well as national scale. It is made up of three main tools. The Current Situation Viewer offers an online map view of near-real time active fire information. Additionally, 24-hour lightning forecasts, as well as fire danger forecasts for up to 10 days in advance, are provided. Fire-emission estimations can also be accessed. The Country Profile tool provides national-level statistics and historical data on fires for the years 2002 to 2019. Data includes burnt area, fire frequencies and seasonality. Charts are created dynamically, and the data is free to download. Finally, the Data & Services platforms provides download links for each dataset used throughout GWIS.

Figure 7: The Global Wildfire Information System (GWIS) Portal. Image courtesy of GWIS.

More information on GWIS is available in this link: https://gwis.jrc.ec.europa.eu/apps/gwis_current_situation

The Forest Fire Information System for wildfire early warning and monitoring

BCEORS/NOA has also implemented the Forest Fire Information System for wildfire early warning and monitoring (FFIS) (http://ffis.beyond-eocenter.eu/) as an operational system that provides the most up to date and validated information on the current active fires and burn scar mapping in South Europe, North Africa and Middle East. The delivered products are produced in Near Real Time from the processing of NOAA NPP and JPSS satellite images received multiple times per day at NOA's Ground Segment in Athens.

The burned area detection is based on a 3 steps prototype Algorithm for Burnt Scar Mapping (BSM) classification and Land Use/Land Cover filtering. The basic pre-process of the acquired images is followed by the generation of cloud and sea masks and enhanced histogram matching of pre and post fire images.

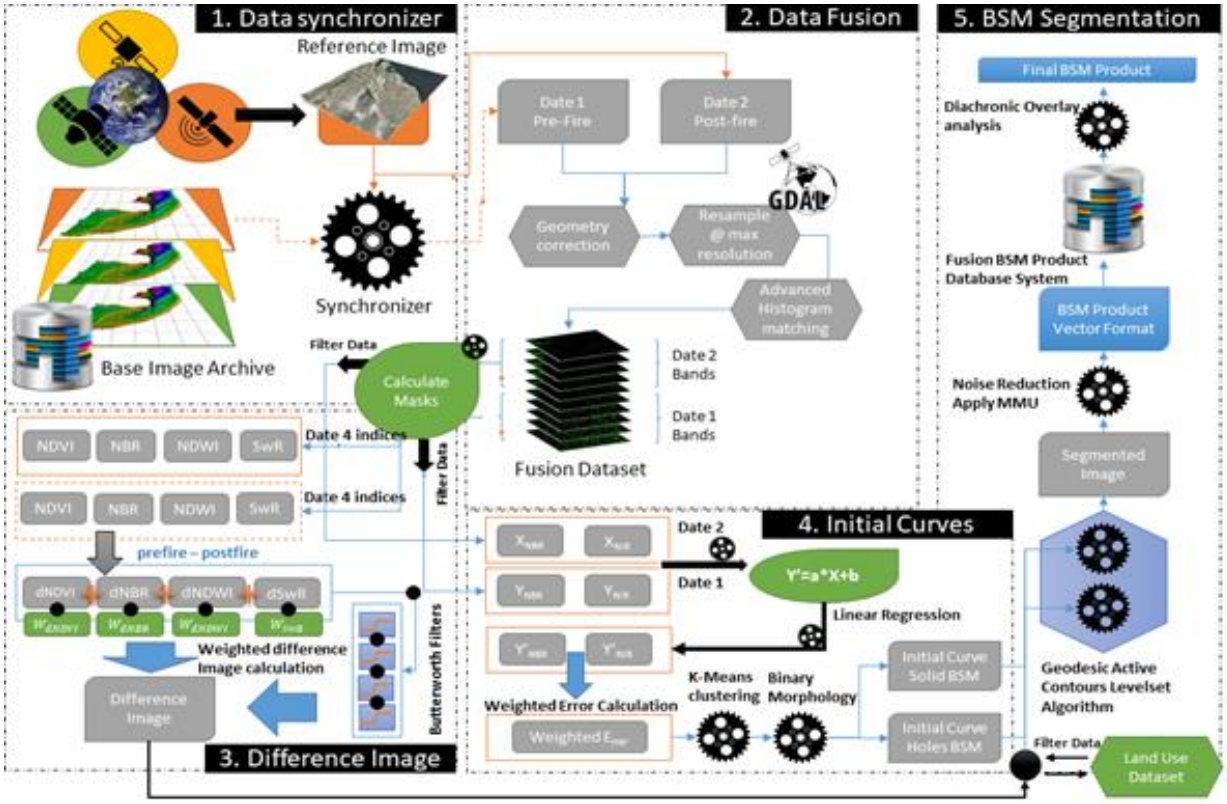


Figure 8: FFIS system architecture and processing. Image courtesy of the Beyond Centre of Excellence of NOA.

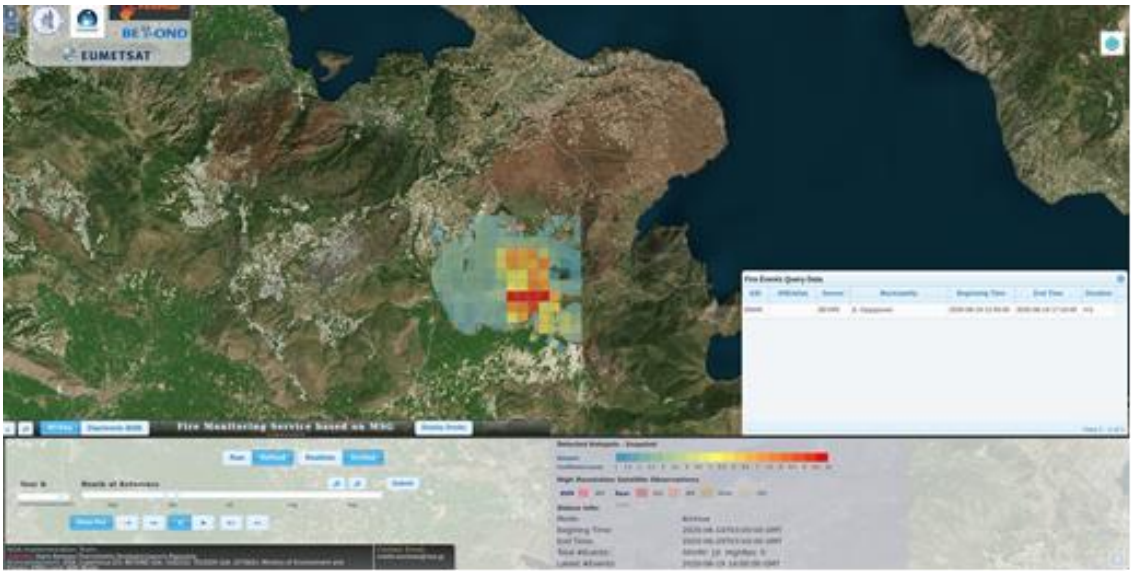
Temporal changes are detected in the second step by analysing several diverse spectral features for a base and reference image(s). Finally, a custom spatial database post-processing chain stores, attributes, validates and keeps track of the BSM polygons that are about to be published in the WebGIS platform.

FireHub for Greece

FireHub (http://195.251.203.238/seviri/) is a Real-Time 24/7 active fire detection service for effectively monitoring forest fires all over Greece. It is continuously ingesting real time satellite acquisitions every 5 minutes from Meteosat-SEVIRI geostationary satellite series (EUMETSAT). Enhanced processing allows improving the quality, reliability, and spatial resolution for detecting active fires over time. The system accounts for wind, ground morphology and altitudinal data, and integrates together with the satellite observations fuel and fire proneness data for deriving active fire predictions in the spatial

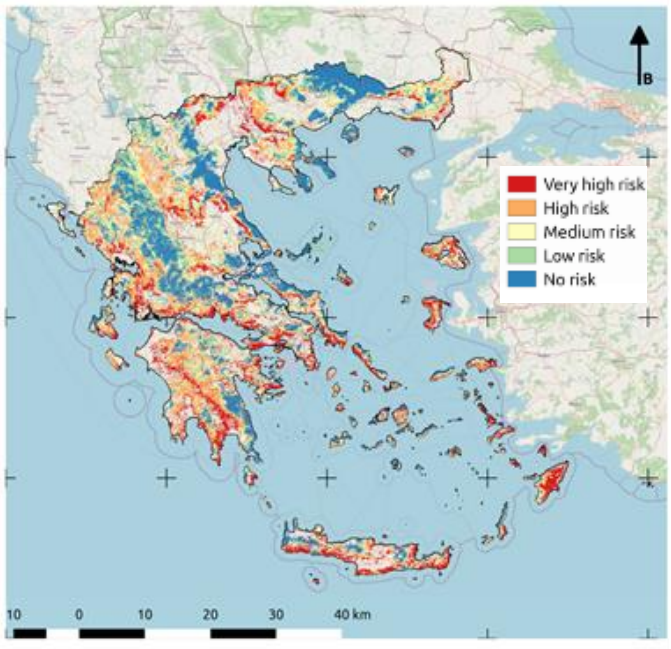
resolution of 500 m, that is 50 times better compared to the raw resolution of the ingested observations of the MSG SEVIRI sensor (3.5km). The web server is merging on-line the active fires with any available ancillary geospatial information including global datasets, e.g. Google Earth, Corine CLC, Toponyms, OSM and POI data. The system is also offering the capability to retrieve and playback any fire events from the last ten years for re-analysis and study.

Figure 9: FireHub detects a forest fire. Image courtesy of the Beyond Centre of Excellence of NOA



More information on FireHub is available in this link: http://beyond-eocenter.eu/index.php/web-services/firehub

Forest Fire Early Warning System for Greece



Like many other Mediterranean countries, Greece is exposed to forest fires that are becoming worse in frequency and severity. Since summer 2020, the Beyond Centre of Excellence, of the National Observatory of Athens has implemented a pilot fire risk forecasting system to predict the next day wildfire risk in the enhanced spatial resolution of 500m. The system exploits solely information obtained up until the previous day and is based on machine/deep learning technologies.

Figure 10: Example of a next day's fire risk prediction map. Image courtesy of the Beyond Centre of NOA.

A fire inventory for the years 2010-2019 was constructed, obtaining data from multiple sources including FireHub, FFIS and NASA and multiple fire drivers were extracted as features in the deployed ML algorithms. These features include NDVI, EVI, LST, temperature, dew temperature, wind, precipitation, Land use/ Land Cover, DEM, slope, and aspect.

Our methodology has been proven efficient and effective for next day fire prediction in the model assessment process. The Recall scores for the fire cells are maintained around 0.9 in the tests, which implies robust workflow and models with high generalizability.

Drought

The Global Drought Observatory (GDO) provides information on current and past drought events on regional and national scales. Its most central part is an online map view that provides easily accessible information on the estimated effects of drought on agriculture. Additional information such as precipitation, vegetation condition, mitigation measures and the effect on wetlands are available. Both the current and past situation from 2013 onwards can be accessed. Furthermore, a forecast for the next 3 months shows regions where extremely dry or wet conditions are expected. The second tool consists of in-depth reports on selected past drought events in Europe since 2011 and worldwide since 2017. The third tool is an overview on drought events worldwide since 1951, provided as a map and a table. All reports and data sets are free to download.

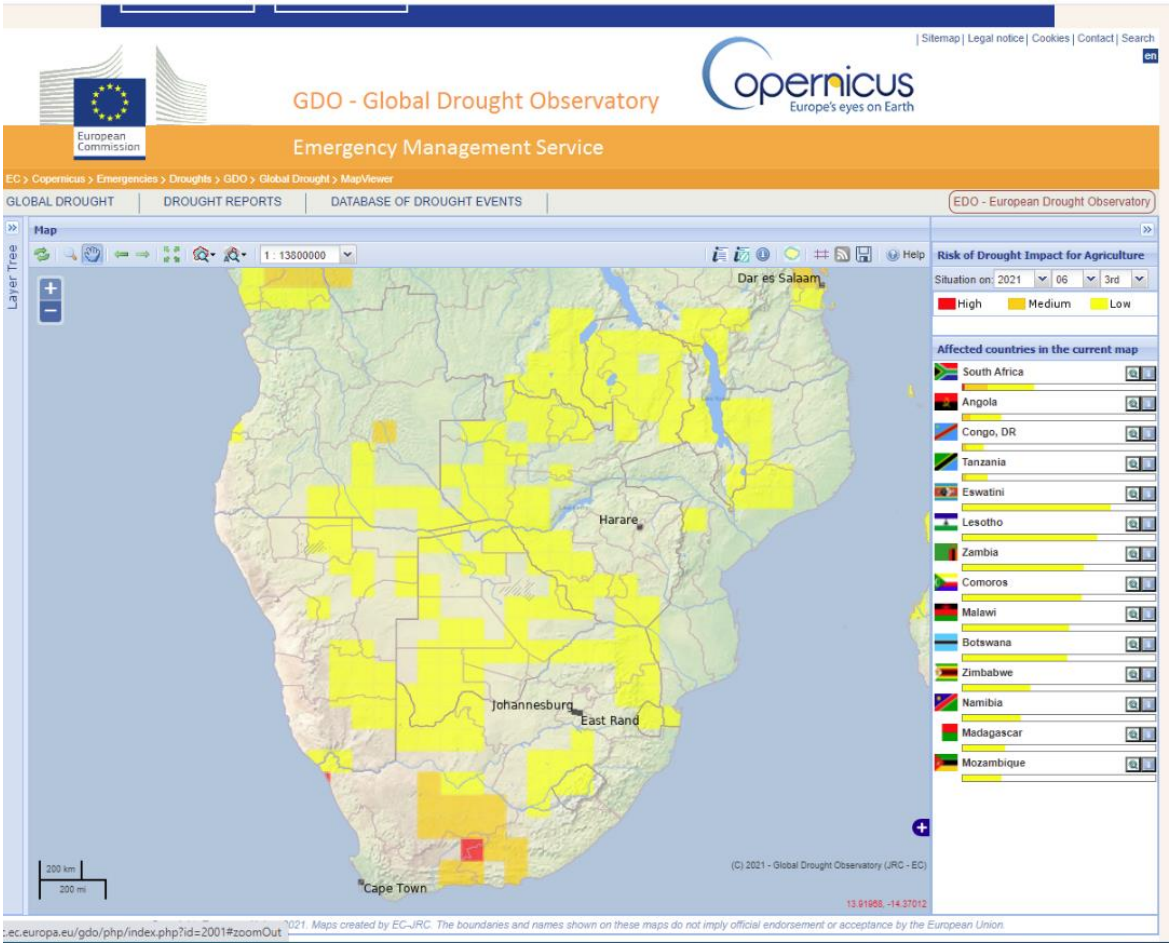


Figure 11: Global Drought Observatory (GDO) Portal. Image courtesy of the Global Drought Observatory.

More information on GDO is available in this link:

https://edo.jrc.ec.europa.eu/gdo/php/index.php?id=2001

Enhancing the use of space technologies in disaster management in Africa: UN-SPIDER and its network of Regional Support Offices, DLR and ZFL

Since its establishment in 2006, the UN-SPIDER programme has benefited from the strong contribution of the German Aerospace Centre (DLR) to carry out knowledge management efforts, to develop and

implement the UN-SPIDER Knowledge Portal and to provide advisory support to developing countries in Africa.

Since 2009, UN-SPIDER has also benefitted from the support provided by its network of Regional Support Offices (RSOs). Three of the twenty-six RSOs contribute actively to the implementation of activities of the programme in Africa: the Algerian Space Agency (ASAL), the National Space Research and Development Agency (NASRDA) and RCMRD.

Figure 12: Map of UN SPIDER Regional Support Offices

Since 2017, the Centre for Remote Sensing of Land Surfaces of the University of Bonn (ZFL) has been contributing with UN-SPIDER in the implementation of activities in Africa and in Germany and is one of several RSOs based in Europe.

Other RSOs that also contribute to activities in Africa include the Romanian Space Agency (ROSA), BCEORS/NOA, and the Federal University of Santa Maria of Brazil (UFSM).

For more information on UN-SPIDER and other opportunities provided by the space community to contribute to disaster management efforts, please visit the UN-SPIDER Knowledge Portal at: https://un-spider.org/

DLR's Research Institutes and its Space Agency

Through its 55 Research Institutes, DLR carries out research in aeronautics, space, energy, transport, security and digitalisation to develop technologies for a sustainable future. Several of these institutes contribute to UN-SPIDER, the World Food Programme and other UN agencies. Since 2006, DLR established its Crisis Situation Centre (ZKI) to contribute to disaster response efforts in Germany and worldwide. Furthermore, experts from ZKI and from the Earth Observation Centre actively contribute to the International Charter as project managers analysing satellite imagery to generate maps and other policy-relevant information to be used in disaster response efforts.

In a complementary fashion, the Space Agency at DLR implements the space strategy of the Federal Government of Germany, develops and manages the national space programme, and represents Germany in space-related international bodies. The Space Agency represents DLR in the Executive Board of the International Charter Space and Major Disasters. Recently, the Space Agency and ZFL launched a project to enhance the use of Copernicus services in Africa.

More information on DLR is available in this link: https://www.dlr.de/EN/Home/home_node.html

SPEAR: An UN-SPIDER and ZFL initiative to enhance the use of space technologies in Africa

In June 2019, ZFL and UN-SPIDER began to implement the project entitled *Spaceborne Earth Observation Applications for Emergency Response and Disaster Risk Reduction* (SPEAR). SPEAR includes the organization of awareness and outreach efforts including conferences and expert meetings, the provision of technical advisory support to African countries, the implementation of knowledge management efforts, applied scientific research to enhance the use of space technologies in disaster management and to contribute to UN-SPIDER networking activities.

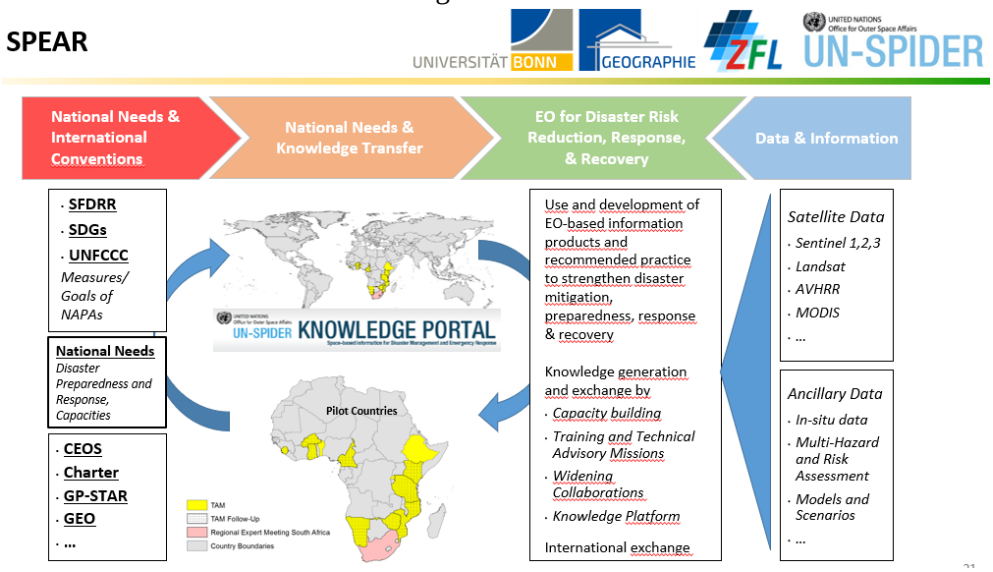


Figure 13: Conceptual design of the SPEAR project implemented by ZFL and UN-SPIDER.

More information on the SPEAR project is available in these links:

https://un-spider.org/projects/spear

https://www.zfl.uni-bonn.de/research/projects/spear/spear

Novel applications stemming from the research and academic communities

Through innovative research, space agencies and universities are developing procedures that will contribute to improved disaster risk reduction, preparedness, response, and recovery efforts.

Artificial intelligence for Humanitarian Action

During a crisis event, humanitarian aid organisations often do not have the appropriate spatial information at the required scale, which they would urgently need for many decision-making assessments. In the project Data4Human being implemented by the DLR, remote sensing data and other data sources are processed and implemented in a user-adapted way and developed for specific case studies.

One major case study is the flooding in Mozambique triggered by Cyclone Idai in 2019. Many humanitarian organisations were involved, and this offers the possibility to retrospectively explore potential humanitarian relief support. Scientists at DLR apply different data sources for this purpose, like remote sensing or web data and use innovative methods to explore the sourcing data all the way from satellites to the Internet and applying innovative techniques such as AI methods or web-harvesting.

Figure 14: Extraction of information on buildings that experienced different types of damages in the City of Beira in Mozambique. Image course of DLR.

NASA's Disaster Management Programme

Since decades ago, the National Air and Space Administration of the United States (NASA) implemented a dedicated programme to advance the use of space technologies in applications related to disaster management. The Disasters program area of NASA's Earth Science Applied Sciences Program uses Earth-observing data and applied research to improve the prediction of, preparation for, response to and recovery from hazards and disasters around the world. In case of disasters, experts from the programme coordinate with scientific and technical institutions in the United States, international organizations, and with decision makers and local governments to provide actionable information to prepare for, respond and recover in case of disasters.

NASA experts at its Langley Research Center and other research centres have been developing procedures to use data gathered from satellites to assess the amount and intensity of rainfall, as part of efforts to improve our understanding of the weather.

NASA also contributes to efforts carried out by RCMRD regarding the SERVIR Hub for Easter and Southern Africa.

When Mt. Nyiragongo volcano erupted in May of this year, the NASA Disaster Programme was activated. Researchers from the programme monitored the activity of the volcano from Space, carried out radar interferometric analysis to track deformation of the cone, and elaborated policy-relevant information for authorities in the affected region.

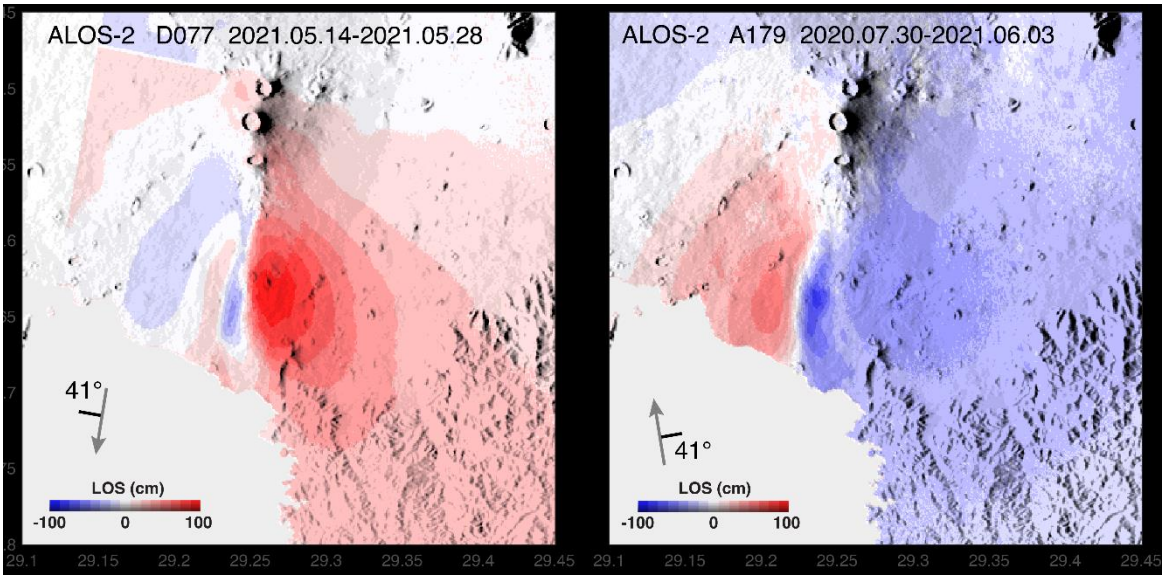


Figure 15: When Mt. Nyiragongo volcano erupted in May of this year, the NASA Disaster Programme was activated. One of the products developed by the programme as a map displaying geographic areas that experience uplift and areas which experienced subsidence. This can be done using radar interferometry. Image courtesy of NASA.

Researchers from NASA's Applied Sciences Disasters Program have been using space-borne remote sensing observations and reanalyses to support hail-storm risk assessment. The project is focussing on climatological hailstorm analysis to enable the development of hail catastrophe models (CatModels), which estimate risk to insurer's portfolios and enhance hailstorm resilience across the globe. Whilst hail is the costliest severe weather hazard for the insurance industry, hail climatologies defining hailstorm frequency/severity have been difficult to derive in developing nations without hail reporting or climate-quality weather radar observations.

However, hailstorms and the damage they produce generate unique patterns in satellite imagery that has been collected for 25+ years, offering new opportunities to identify hail-prone regions and improve severe storm understanding and warning in regions without adequate radar weather coverage. Furthermore, hailstorm damage signatures can be identified in high spatial resolution optical imagery and synthetic aperture radar (SAR) data which presents potential opportunities for post-disaster mapping and response. Developments in hail-storm risk assessment over Southern Africa now include the generation of a 15-year NASA database of MSG SEVIRI infrared convection detection and characterisation products for the period of 2005-2019, and the 2021 launch of a hail CatModel by Willis Re, which is now being used in insurance industry operations in South Africa.

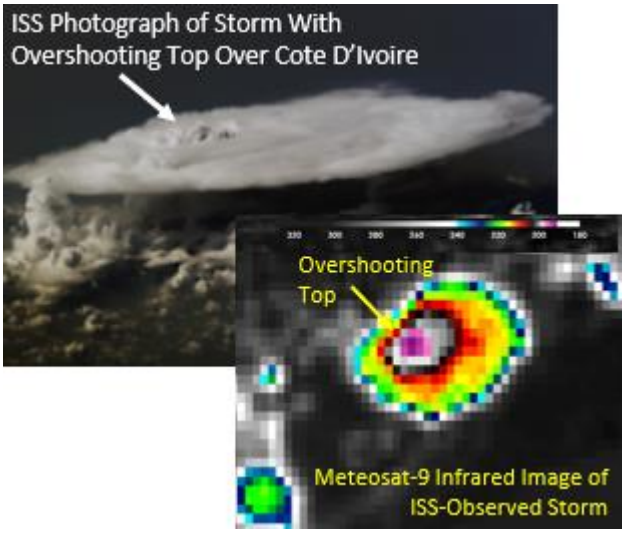


Figure : Hailstorm clouds can be detected at high temporal resolution (10-30 mins) in the visible and infrared wavelengths using geostationary satellites such as GOES and Meteosat, with the observational record spanning up to 25 years. Image Courtesy of Kristopher Bedka at NASA Langley Research Centre. Researchers at NASA are also developing a Model of Models (MoM) ensemble approach for integrating hydrodynamic models and remote sensing derived products for flood forecasting. The MoM integrates the Global Flood Awareness (GloFAS) and Global Flood Monitoring System (GFMS) flood models to forecast flood severity at sub-watershed level, allowing for the identification of flood risk at a regional level. Data from the Hurricane Weather Research and Forecast System (HWRF) and Dartmouth Flood Observatory (DFO) are also incorporated to update severity in real time. Alerts based on flood severity will be disseminated using Pacific Disaster Center's (PDC) DisasterAWARE® platform, and situational awareness information will be provided to impacted communities in near-real time. Model outputs are validated and calibrated using SAR-derived flood outputs.

More information on NASA's Disaster Programme is available in this link: https://appliedsciences.nasa.gov/what-we-do/disasters

Multi-temporal radar interferometry for early warning in case of volcanic activity

In May of this year, the Nyiragongo volcano erupted, affecting more than a quarter million people in the Democratic Republic of Congo, many of them in Goma City. Researchers at Mexico's National Autonomous University of the State of Mexico (UAEM) are carrying out research on the potential application of multi-temporal radar interferometry for early warning applications in case of volcanic activity. The research aims to assess in which cases such a technique can be used to detect an inflation process of the cone prior to an eruption.

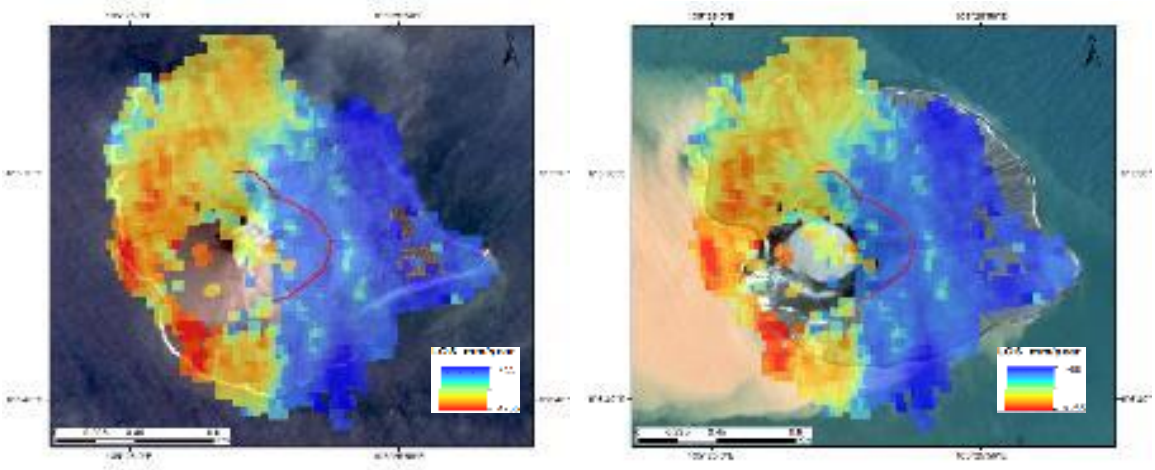


Figure 16: Example of the use of multi-temporal radar interferometry for a period covering the six months before its eruption of 23 December 2018.

It involves the combined processing of radar imagery compiled over a period of six months up to the time of an eruption to detect deformations.

More information on this example is available in this link: https://un-spider.org/space-application/user-stories/use-sbas-anak-krakatoa

Airbus Defence and Space

Airbus Defence and Space has been supporting UN-SPIDER in disaster management efforts. Airbus operates the TerraSAR-X satellites capable of detecting the presence of floods and the location of landslides and debris flows under cloudy conditions, and capable of detecting subsidence or uplift through radar interferometric applications. In addition, its WorldDEM™ digital elevation model offers interesting possibilities for landslide susceptibility analysis and other applications.

An interesting contribution from Airbus Defence and Space has been the elaboration of a Recommended Practice that makes use of digital elevation models for storm surge coastal flooding. Such maps benefit from the use of higher resolution digital elevation models (DEMs).

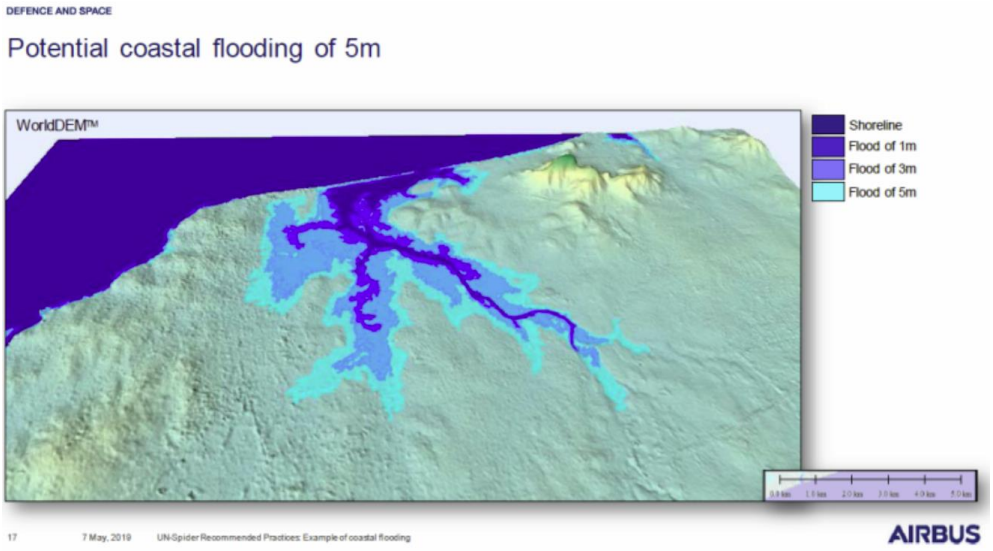


Figure 18: Use of digital elevation models for storm surge coastal flooding.

This Recommended Practice is available in this link: https://un-spider.org/advisory-support/recommended-practices/dem-storm-surge-coastal-monitoring-airbus

Procedures to map the extent of forest fires, floods, and to track the effects of droughts on vegetation over time

Many organizations including UN-SPIDER have developed step-by-step procedures to process satellite imagery to map the geographical extent of floods, landslides, forest fires, and other hazards; as well as to understand the spatial and temporal dynamics of droughts. Some of these procedures require the user to download satellite imagery and use either commercial or open software to process the imagery to generate the maps of areas impacted. With the introduction of cloud computing, private companies such as Google are offering the possibility of analysing satellite imagery using such cloud-based services. An example is Google Earth Engine.

Forest fires

Several space agencies often process satellite imagery to generate information on the geographical extent of forest fires and in some cases their burn severity.

Forest fire extent mapping by the Algerian Space Agency

The Algerian Space Agency (ASAL) uses optical satellite imagery from the Alsat-1 and Alsat-2 satellites to map the geographic extent of forest fires on an annual basis. The typical procedure uses satellite imagery acquired before and after the fire and complementary data on the location of forests ~~to identify burnt areas~~ from the National Forest Inventory to identify burnt areas, and exclude those recorded from the previous year. Supervised classification is conducted in ENVI software

using the red, green and near-infrared (NIR) spectral bands and the Normalised Difference Vegetation Index (NDVI) for the delineation of burnt areas. Results are validated in the field.

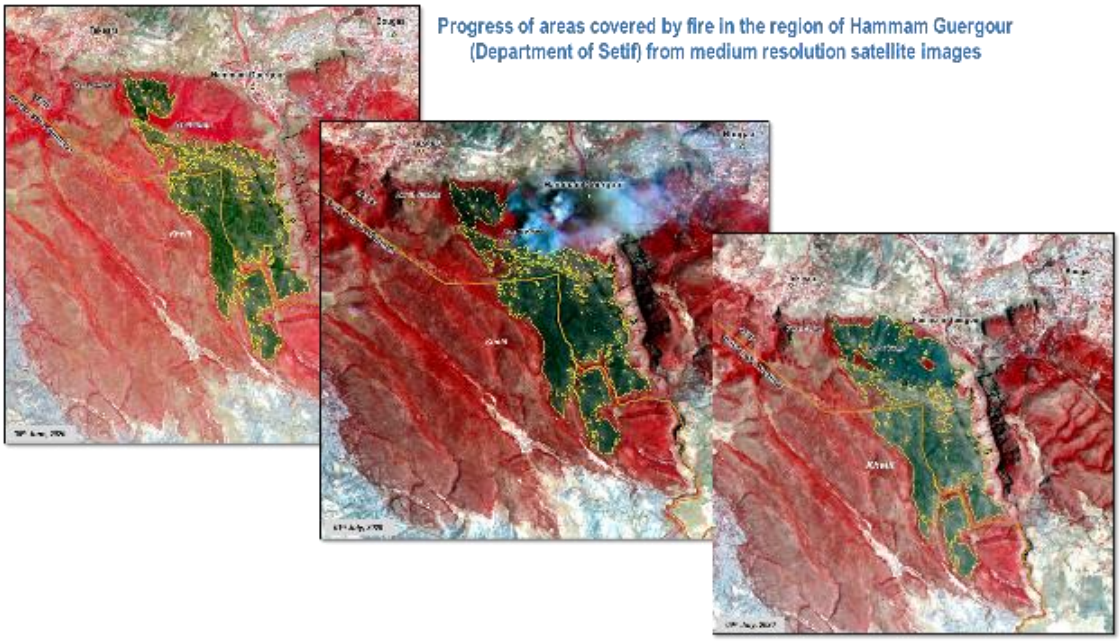


Figure 17: Extraction of information on the geographic location of forest fires in Algeria. Image courtesy of ASAL.

Floods

Since its establishment, several space agencies joined the UN-SPIDER programme as Regional Support Offices (RSOs). As part of their contribution, some of these RSOs have developed step-by-step procedures or "Recommended Practices" to map the geographical extent of floods using optical and radar imagery.

The Space Research Institute of the National Academy of Sciences of Ukraine developed in 2015 a Recommended Practice for flood mapping using radar imagery. The practice is developed to process radar imagery using the SNAP open software developed by the European Space Agency (ESA). The advantage of using radar imagery is that it can detect floods even under cloud cover. This makes it very useful in tropical countries where cloud cover is typical. However, it may not detect floods properly in urban areas or in areas covered by forests.

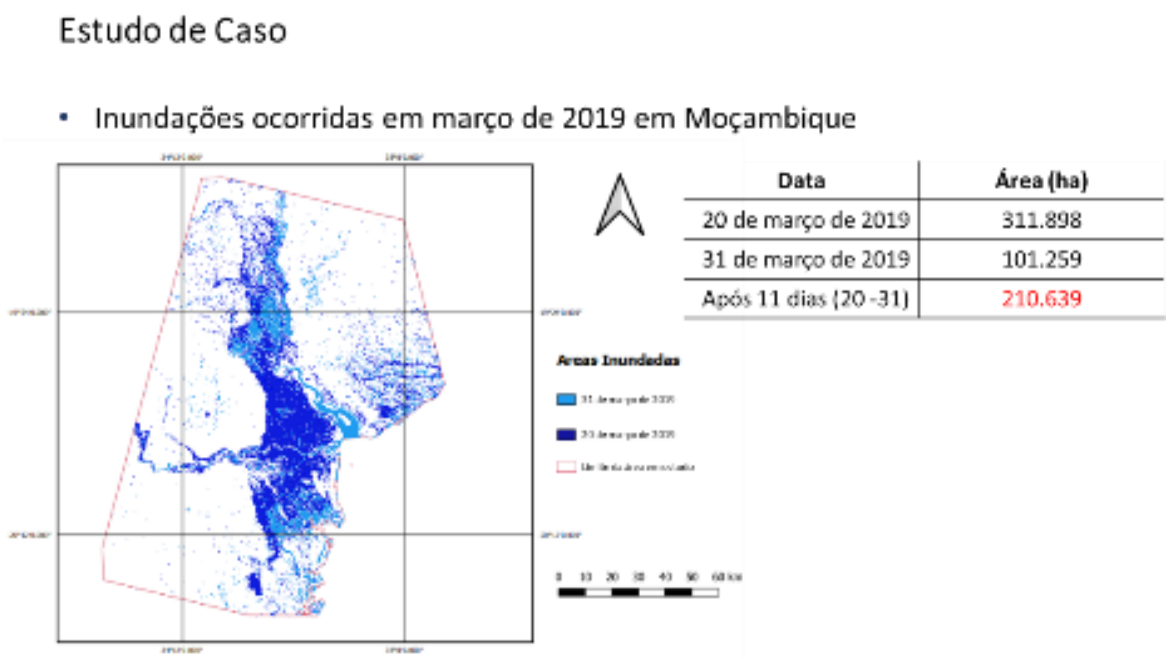


Figure 19: Example of the extension of floods on 20 and 31 March 2019 in the Beira region of Mozambique.

The Recommended Practice is available in this link: https://un-spider.org/advisory-support/recommended-practices/recommended-practice-radar-based-flood-mapping

Droughts

The Federal University of Santa Maria of Brazil (UFSM) developed a Recommended Practice to compare the severity of droughts over various years using composite products from the MODIS sensor such as the Enhanced Vegetation Index (EVI). The procedure calculates the EVI for 16-day periods covering the whole year, and then repeats the procedure for the entire period of observations of the MODIS sensing, that currently spans 21 years. The comparative procedure then allows for the comparison of areas impacted by droughts in various years. The procedure is useful to determine if the impacts of a specific drought are worse or not as bad as the impacts of droughts that may have taken place between the years 2000 and 2021.

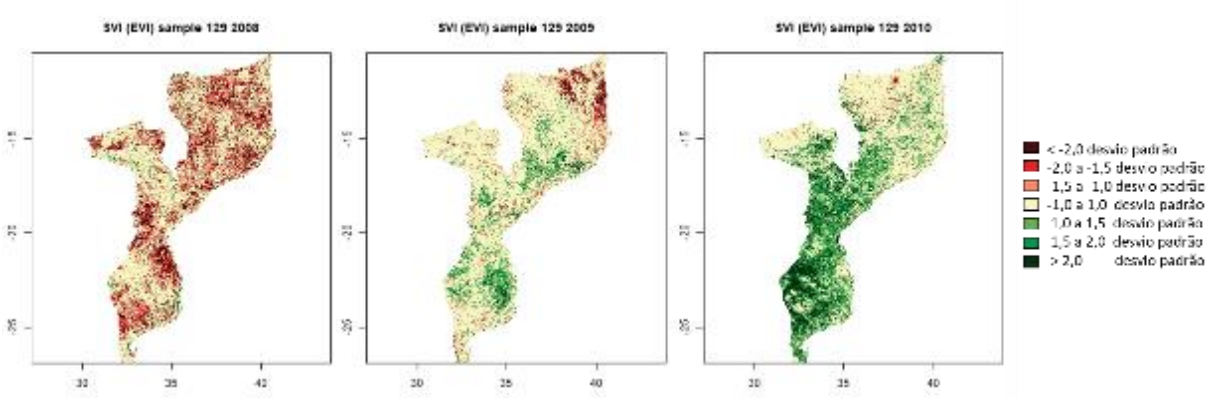


Figure 20: Example of maps of the Standard Vegetation Index using the Recommended Practice developed by UFSM for Mozambique, covering the period from 2000 to 2020.

The Recommended Practice is available in this link: https://un-spider.org/advisory-support/recommended-practices/recommended-practice-drought-monitoring-using-standard

Additional step-by-step procedures or UN-SPIDER Recommended Practices are available in the UN-SPIDER Knowledge Portal in this link: https://un-spider.org/advisory-support/recommended-practices

Other contributions from the UN-SPIDER Regional Support Offices

Several RSOs are contributing to the implementation of this expert meeting for Southern Africa.

NASRDA

The National Space Research and Development Agency (NASRDA) was implemented under the auspices of the Federal Ministry of Science and Technology in May 1999 with a board objective to pursue the development and application of space science technology for the socio-economic benefits in Nigeria. NASRDA operates the African Regional Centre for Space Science and Technology Education in English Language (ARCSSTE-E).

In recent years, NASRDA has been contributing to disaster management efforts. Last year the Niger river experienced extraordinary floods. NASDRA and UN-SPIDER joined forces to elaborate maps of areas impacted by floods which were provided to the National Emergency Management Agency of Nigeria (NEMA).

More information on NASRDA is available in this link: https://nasrda.gov.ng/

ROSA

The Romanian Space Agency (ROSA) is the coordinator of Romania's national and international space activities. It coordinates national space research and applications programs, promotes space development in Romania, and represents the Romanian Government in international space cooperation programmes. ROSA has been a strong supporter of the UN-SPIDER since it was implemented and contributes to the provision of advisory support to developing countries.

More information about ROSA is available in this link: http://www2.rosa.ro/index.php/en/

Capacity building opportunities

Several space agencies, universities and other regional and international organizations have launched capacity building activities to enhance the use of data, products and services offered by the space community.

EO College at the Friedrich-Schiller University at Jena, Germany

The EO College was launched in 2011 by the Institute of Geography of the Department of Earth Observation at the Friedrich-Schiller University at Jena to implement digital learning opportunities on the use of Earth observation, remote sensing and other topics. EO College offers online courses in several languages, access to several resources and knowledge, and currently benefits from the support of three initiatives to enhance its content: the SAR-EDU initiative, the Education Initiative coordinated by the Ruhr University Bochum, and the HYPERedu Education Initiative.

More information on EO colleague is available in this link: https://eo-college.org/about/

NASA's ARSET programme

NASA's Applied Remote Sensing Training (ARSET) programme was launched in 2009 and provides individuals and institutions with workforce development, training activities, and collaborative projects to strengthen understanding of Earth observations and expand their use around the world. The training programme covers the use of datasets, portals and tools to address air quality, agriculture, disaster, land, and water management. The programme offers virtual and in-person trainings.

More information about NASA's ARSET programme is available in this link: https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset

Copernicus Academy

The Copernicus Academy has been launched by the European Commission to increase awareness about the Copernicus programme, to facilitate the use of data and services offered by the programme and to support end-users. As stated in its website, the Copernicus Academy connects universities, research institutions, business schools, both private and non-profit organisations, in the Copernicus Participating Countries (EU28 + Norway & Iceland) and beyond. The goal of the network is to link research & academic institutions with authorities & service providers, facilitate collaborative research, develop lectures, training sessions, traineeships as well as educational and training material to empower the next generation of researchers, scientists, and entrepreneurs with suitable skill sets to use Copernicus data and information services to their full potential.

More information on the Copernicus Academy is available in this link: https://www.copernicus.eu/en/opportunities/education/copernicus-academy