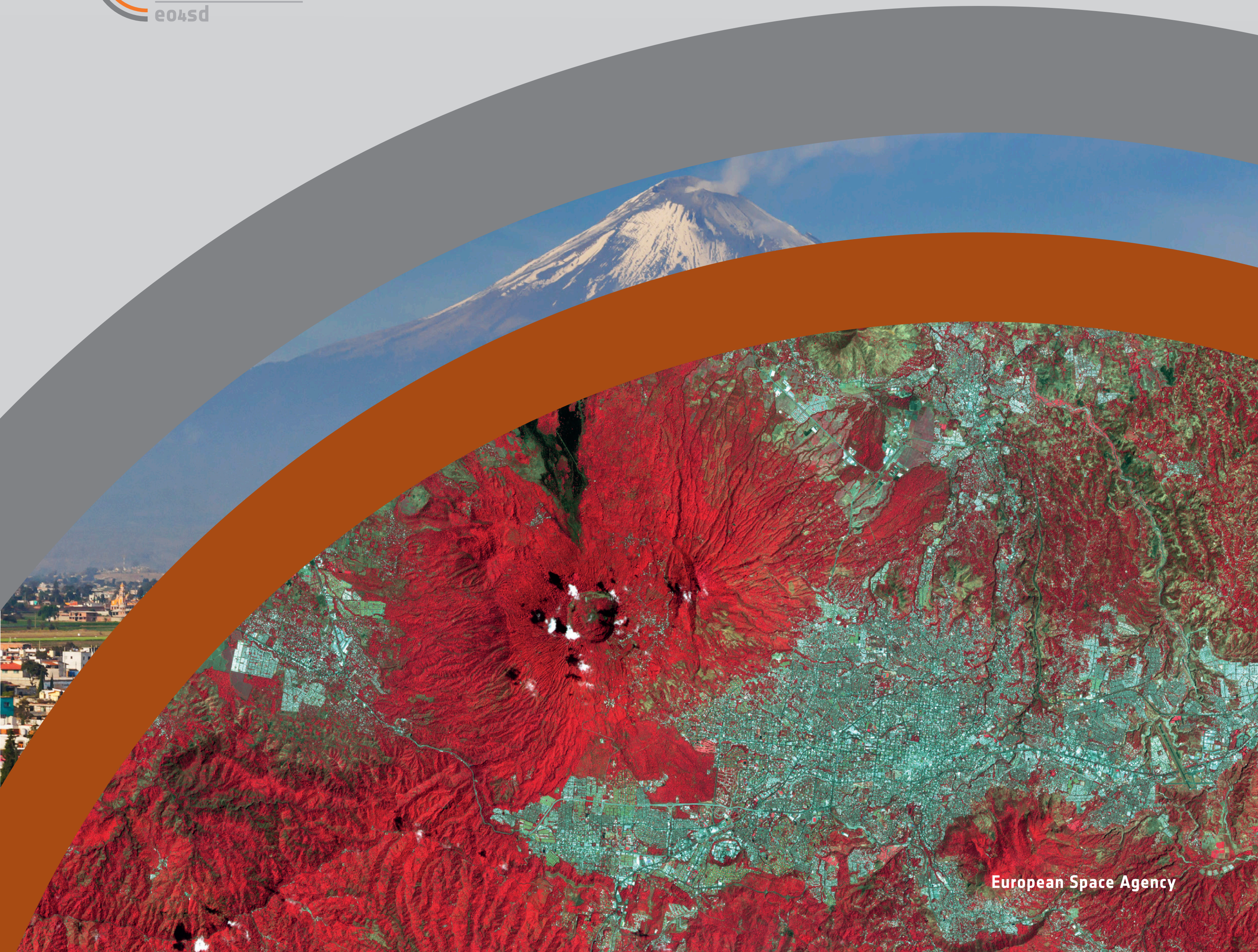
esa

→ EO4SD – EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Disaster Risk Reduction | Service Portfolio

LARGE SCALE EXPLOITATION OF SATELLITE DATA IN SUPPORT OF INTERNATIONAL DEVELOPMENT

disaster risk reduction
eo4sd



European Space Agency

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DESCRIPTION
This service provides the background geographic reference contents and spatial distribution of the landscape and population

USE
› Reference mapping
› Providing key inputs to support hazard and risk mapping

INPUT PRODUCTS
› Satellite imagery
› Digital Terrain Models
› Ancillary data (e.g.: national census data, cartographic databases, open source data)

SPATIAL RESOLUTION AND COVERAGE
From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

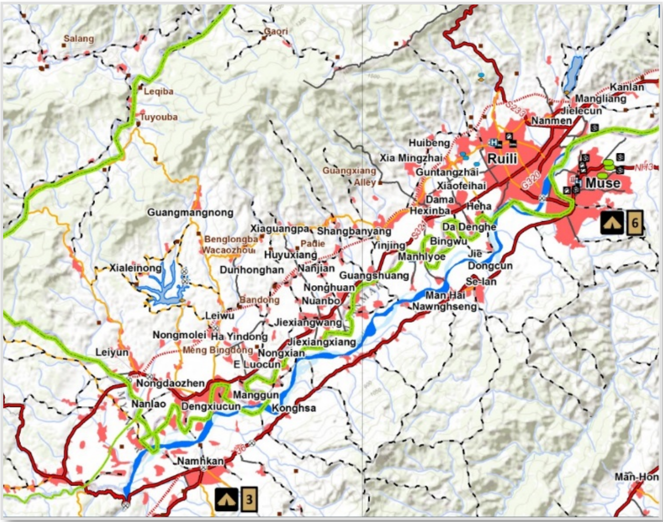
BENEFITS
Supporting IFIs managers and DRM authorities with updated geographic information for the elaboration of funded projects in the Preparedness or Reconstruction phases

DELIVERY FORMAT
› Thematic and reference maps
› GIS data in standard vector and raster formats
› Analytical reports
› Web services

FREQUENCY
› Depending on user needs:
  - Single date selection
  - Customizable according reference dates for change monitoring

Reference mapping products derived from Earth Observation data provide an updated background of the geographic representation of the areas under study. It includes the following products:

- Land use and land cover mapping and change mapping
- Settlement characterization and change assessment
- Assets/exposure mapping (eg: built-up areas, buildings, infrastructures)
- Population density mapping
- Topographic information (Digital Terrain Models, spot heights, contour lines)



Reference mapping, Myanmar, EMSN-015. Credit: Copernicus Emergency Management Service (© 2015 European Union)

Digital Elevation Model, Pyrenees. Credit: EU-DEM Project, European Environment Agency (EEA).

→ SUBSIDENCES MONITORING

Many populations live near mountain slopes prone to landslides or volcanoes that may become active. Therefore it is important to monitor land movements or deformations as a preventive measure to alert of a possible risk event.

Ground based sensors can be deployed to monitor such terrain deformations in risky areas but these infrastructures are expensive and vulnerable (e.g.: power supply, communications, weather conditions or robbery).

Earth Observation techniques like DinSAR and PSI based on SAR (Synthetic Aperture Radar) images have demonstrated the potential to monitor any remote areas at different time intervals facilitating in a non-intrusive, non-structural way the measurement of superfi cial displacements and their trends to raise risk awareness and assess mitigation measures for DRM authorities.

EO-based derived measurements may also be complementary to those ground-based measurements where such infrastructures may be present.

Trend analysis of a terrain´s subsidence. Credits: Planetek

DESCRIPTION

This service provides quantitative assessments of terrain deformation in prone areas to subsidence

USE

› Trend analysis of terrain deformations
› Identification of hotspots areas
› Evaluation of the impact of interventions

INPUT PRODUCTS

› SAR images
› EO supporting services

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm))

BENEFITS

› Improved awareness on subsidence risks in hotspot areas
› Improved information for planning and mitigation measures

DELIVERY FORMAT

› Standard vector and raster formats
› Through a web portal
› Statistics in tables and/or graphs

FREQUENCY

Depending on user needs: it can range from customized high frequency for large scales to single dates for local scales

LANDSLIDES ANALYSIS

DESCRIPTION
The service provides landslides inventories, identification and monitoring of landslide-prone areas and hotspots to support risk level estimation and reduction. Furthermore, delineation of landslide extent and damages in support of post-event situation assessment

USE
- Building landslide inventories
- Definition of risk zones and estimation of exposed population and existing assets
- Risk assessment for newly planned built-ups (buildings, infrastructure)
- Support to engineering of preventive, risk reduction measures and formulation of regulation plans
- Post-event situation assessment

INPUT PRODUCTS
- Optical and SAR satellite images
- EO supporting services
- Available ancillary data (lithology, existing inventories, reports, etc)

SPATIAL RESOLUTION AND COVERAGE
From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS
- Efficient means of hazard mapping and monitoring
- Improved understanding of landslide susceptibility and related risk
- Improved strategy and decision making for IFIs projects & DRM managers

DELIVERY FORMAT
- Thematic and situation maps
- GIS data in standard vector and raster formats
- Analytical reports
- Web services

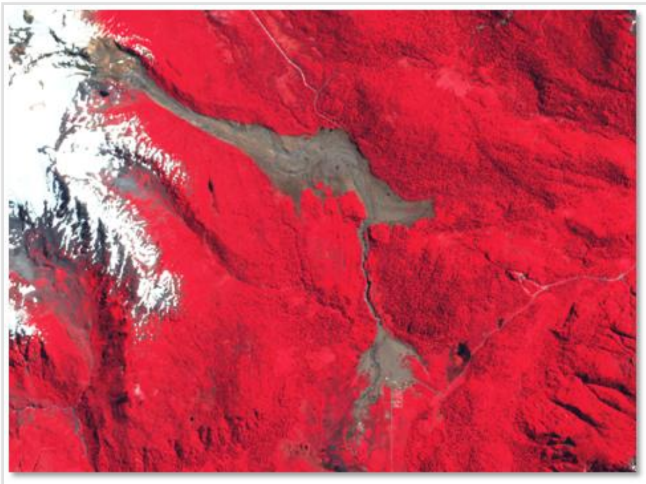
FREQUENCY
- Depending on user needs:
  - Range of selected years for landslides inventories
  - Selected period for hazard monitoring
  - Single date/period for identification of susceptible areas and post-event situations

The use of Earth Observation (EO) is a powerful tool for DRM authorities and international development projects tackling both preparedness and post-event recovery phases of risk management cycle related to landslides.

EO can provide thematic situation maps and statistics with synoptic inventory of past and recent landslide activities. Furthermore, EO can help in the identification of landslide-prone areas by involving (multivariate) approaches based on modelling, multi criteria analysis of statistical or physical data using landslide inventories, ancillary information and variables derived from satellite imagery and digital elevation models.

Persistent scatterers InSAR technique may be applied to monitor slope and infrastructure deformation trends both in large scale and for hot-spots.

For reconstruction projects after a landslide event, EO provides means to delineate the extent of the event using analysis of optical or SAR imagery by change detection and correlation of images before and after the event. Landslide impacts and magnitude are assessed to estimate damage grading and related losses.



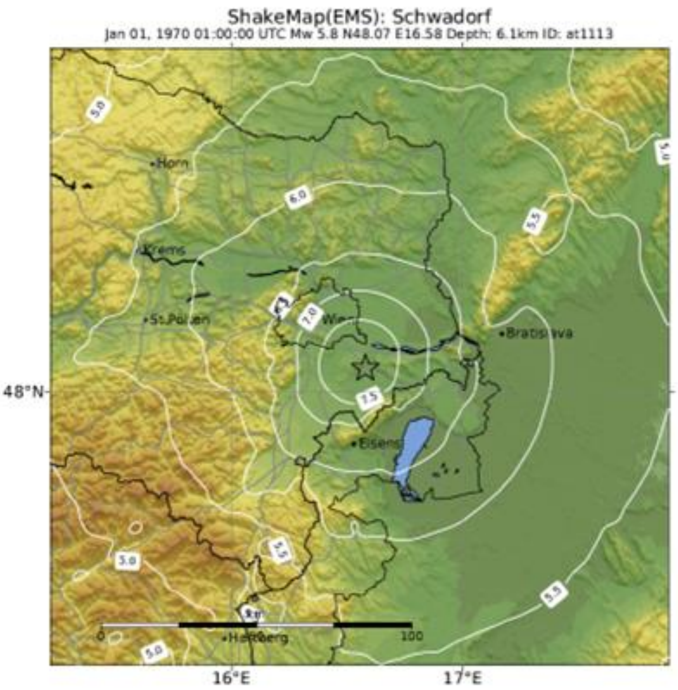
Extent of a large landslide in Santa Lucia, Chile using a Sentinel-2 image acquired within days after the event.

→ EARTHQUAKE HAZARD SCENARIOS

For the Preparedness Phase, having existing seismic hazard maps of the study areas would be a good starting point for seismic risk assessment.

Earthquake hazard scenarios can be defined through epicentre x and y-location, and depth, magnitude and epicentre intensity including approximate propagation of intensity. These scenarios can provide simulated seismic wave propagation considering best available geological data, as well as soil information.

The results of these scenarios combined by GIS analysis with the information provided by the Supporting EO services (topographic information, population density, land use/land cover) including available auxiliary data (buildings characterization and infrastructures) can be helpful to estimate the possible impacts on assets and population such as: affected or damaged urban/sub-urban areas due to immediate impacts on buildings, affected or damaged transport infrastructure due to bridge failure, landslides and related events, affected energy infrastructure due to interrupted lines or social vulnerability related to the classified urban typologies.



Example of an erthquake scenario. **Credits: ZAMG**

DESCRIPTION

This service provides base scenarios of a post-earthquake situation

USE

› Earthquake scenarios
› GIS analysis combined with assets mapping

INPUT PRODUCTS

› EO supporting services
› Available auxiliary data (geological data, soil information, structural building characteristics, including construction type and building material, building heights, local and international earthquake catalogues)

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS

In terms of benefit for decision makers it can be addressed the potential of these earthquakes scenarios with different intensities and characteristics as a base scenario of a post-earthquake situation

DELIVERY FORMAT

› Thematic and situation maps
› GIS data in standard vector and raster formats
› Analytical reports
› Web services

FREQUENCY

› Once for each earthquake scenario according to user needs

➔ TSUNAMI HAZARD MODELLING

DESCRIPTION

This service provides base scenarios of a post-tsunami situation and hazard mapping (response & recovery)

USE

› Tsunami scenarios
› GIS analysis combined with assets mapping

INPUT PRODUCTS

› Satellite EO images
› EO supporting services
› Available ancillary data (bathymetry, buildings characterization, coastline)

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, >200 sqkm)

BENEFITS

Production of scenario maps (e.g. propagation timing, wave height) with different intensities and characteristics as a base scenario of a post-tsunami situation to support decision-makers

DELIVERY FORMAT

› Thematic and situation maps
› GIS data in standard vector and raster formats
› Analytical reports
› Web services
› Videos

FREQUENCY

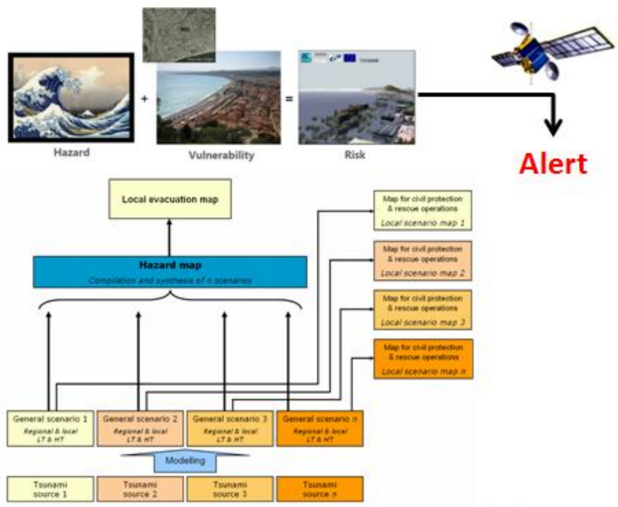
› Once for each tsunami scenario according to user needs

Coastal regions are strongly urbanized and hence the importance of DRM authorities having updated coastal flood maps for evacuation routes and critical infrastructure protection measures near the shoreline.

Tsunami hazard scenarios can be defined through the generation of the water column disturbance and its propagation towards the coast considering the bathymetric information available.

The results of these scenarios combined by GIS analysis with the information provided by the Supporting EO services (topographic information, population density, land use/land cover including buildings characterization and infrastructures) are helpful to generate coastal flood maps.

Example of a tsunami scenario. SCHEMA Project. Credit: ARGANS



General mapping methodology for tsunami hazard assessment. Credit: ARGANS

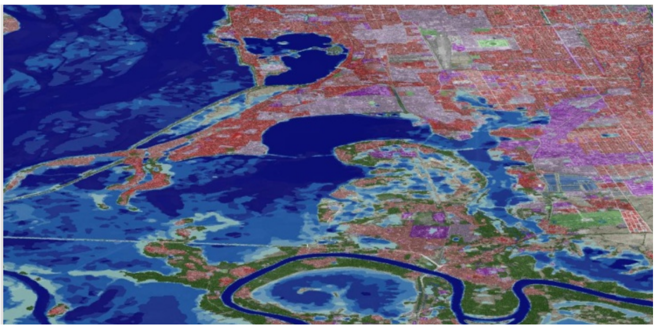
→ FLOODING HAZARD MODELLING

Earth Observation (EO) is a powerful tool to generate maps and spatial data indicating flood hazard susceptibility. Identified flood-prone areas may be overlaid and assessed in conjunction with land use zoning maps, key assets and population distribution maps. If flood vulnerabilities of evaluated elements are known they can be combined with flood hazard intensity derived from historical satellite data or by modelling to estimate flood risk to support better understanding of impact patterns to exposed infrastructure assets, population, properties and key economic sectors such as agriculture.

Flood hazard exposure is achieved by various means:

- Analysis of flood inundation extent and frequency from historical EO data coinciding with past flooding events.
- Analysis of flood inundation extent and damages for recent or on-going events using current on-demand EO data
- Geomorphic analysis using topographic properties derived from DEM for estimation of large scale flood susceptibility.
- Modelling inundation extent and depth using auxiliary data (eg. rainfall, runoff and discharge patterns, river morphology and land cover)

As such, results represent for IFIs projects & managers a tool helping with elaboration of appropriate and scalable prevention plans, mitigation measures and contingencies.



Flood inundation and frequency based on analysis of current and archived EO data for Mandalay, Myanmar. Visualization combines hazard with land use city master plan and contains derivative products from ALOS Palsar-1 and Sentinel-1 imagery. EOTAP-K. Credit: Gisat

DESCRIPTION

The service provides flood hazard maps with inundation extents, depths or frequencies for study areas by utilization of either modelling or retrospective analysis of historic events using archived imagery.

USE

- › Key input into flood risk assessment: definition of risk zones and estimation of exposed population and existing assets
- › Support to engineering of preventive, risk reduction measures and formulation of regulation plans
- › Post-event situation and damage assessment

INPUT PRODUCTS

- › Optical and SAR satellite images
- › Digital Elevation Models
- › Other supporting EO services
- › Ancillary data (rainfall, runoff and discharge patterns)

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS

- › Improved strategy and decision making
- › Efficient means of hazard mapping and monitoring
- › Improved understanding of flood susceptibility and related risks
- › Synoptic overview of flooding patterns and trends in the areas where flooding systematically occurs.

DELIVERY FORMAT

- › Thematic and situation maps
- › GIS data in standard vector and raster formats
- › Dynamic visualizations
- › Analytical reports
- › Web services

FREQUENCY

- › Depending on users needs:
  - Range of selected dates for historical analysis onspecific areas
  - Single date/period for identification of susceptible areas and post-event

→ STORM SURGE/COASTAL FLOOD ANALYSIS

DESCRIPTION

The service provides coastal flood hazard analysis due to the influence of events like storm surge or climate change

USE

› Coastal flooding hazard maps
› Key input to combine with assets mapping to produce coastal flood risk mapping

INPUT PRODUCTS

› Digital Elevation Models
› Other supporting EO services
› Bathymetry data (when available)
› Auxiliary data (reference local values of astronomical tide)

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS

EO based products for flooding risks in coastal areas can support IFIs managers in the form of pre-disaster situation analyses, and maps to provide thematic information supporting planning for contingencies on vulnerable coastal areas

DELIVERY FORMAT

› Thematic and reference maps
› GIS data in standard vector and raster formats
› Analytical reports
› Web services

FREQUENCY

Once for each hazard scenario modelling in a given area

Main urban areas are located in coastal areas or river deltas where exposure to flood risks are increasing due to climate change or environmental degradation. Extreme meteorological events such as storm surges may cause serious coastal floods affecting population and infrastructures that settle near the coastline. Detailed understanding of this phenomenon at local scale requires very expensive field campaigns (beach topographic surveys, detailed studies of soil drainage behavior).

EO based products for flooding risks in coastal areas at a large geographic scale can support international development activities in a pragmatic approach in the form of pre-disaster situation analyses to provide thematic and statistic information supporting planning for contingencies on vulnerable coastal areas.

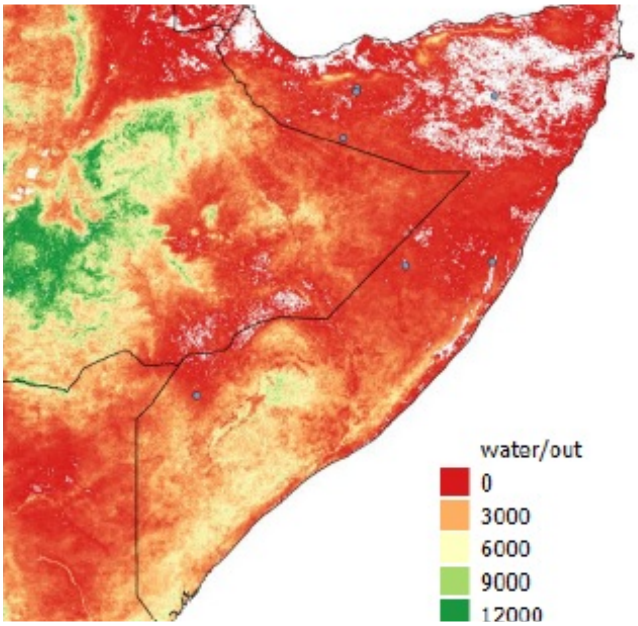
Caparica (Portugal) Coastal flood risk map. EMSN-034. **Credit: Copernicus Emergency Management Service (©2015 European Union)**

→ DROUGHT MONITORING

Drought and its adverse effects on agriculture and environment represent serious issue not only at global, but also at country and regional scales while inflicting economic loses and food insecurity. Implementation of effective and targeted countermeasures requires timely access to accurate geoinformation describing spatial patterns of drough impacts and their spatial-temporal evolution. Earth Observation provides means to evaluate impacts of drought on various environmental elements: vegetation, crops, land use and land cover patterns. The results are provided in tailored formats ranging from situation maps, on-line services to briefing reports with summary of statistics providing key indicators for the implementation of drought relief development projects:

- Vegetation conditions from vegetation indices
- Inter- and intra-seasonal variability in vegetation extent and vigor
- Agriculture condition and evolution of crop types
- Land cover condition and structure evolution

Furthermore, progress of construction works related with drought mitigation measures and evaluation of their impacts in near- to long-term might be monitored from EO to complement field inspections.



Situational maps of vegetation status at different harvesting seasons in Somalia. EMSN-027. Credit: Copernicus Emergency Management Service (© 2015 European Union)

DESCRIPTION

This service provides quantitative assessments of the drought impacts evaluated from time series of EO data: seasonal variations annually and within annual seasonal cycle (rainy vs. dry season) when comparing vegetation or crop status using vegetation indices.

USE

› Detailed knowledge of patterns, hot-spots and trends by assessments of vegetation status and its evolution

› Assessment of progress of construction works related to drought mitigation measures

INPUT PRODUCTS

› SAR/optical satellite images

› Supporting EO services

› Ancillary data (e.g.: rainfall statistics, local crop calendars, in-situ observations)

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS

› Improved strategy and decision making for IFIs projects and DRM managers

› Improved understanding of drought evolution and its impact patterns

› Efficient monitoring of activities and their effects

DELIVERY FORMAT

› Thematic and situation maps

› GIS data in standard vector and raster formats

› Dynamic visualizations

› Analytical reports

› Web services

FREQUENCY

Monitoring frequency depends on requested detail and satellite data availability affected by cloud coverage:

› Regular range of dates for retrospective and ongoing monitoring of specific areas

› Selected dates for progress monitoring of constructive works

→ WILD FIRES ANALYSIS

DESCRIPTION
This service provides mapping and statistics of fire extent and grading of a post event

USE
- Spatial distribution of the fire extent and grading
- Providing key inputs for fire damage assessments
- Identification of secondary risks (e.g.: landslides, flooding, etc)

INPUT PRODUCTS
- Optical satellite images
- Supporting EO services

SPATIAL RESOLUTION AND COVERAGE
From local scales (3m, < 200 sqkm) to large scales (30m, >200 sqkm)

BENEFITS
Improved understanding of the fire extent to accomplish recovery actions in the affected areas

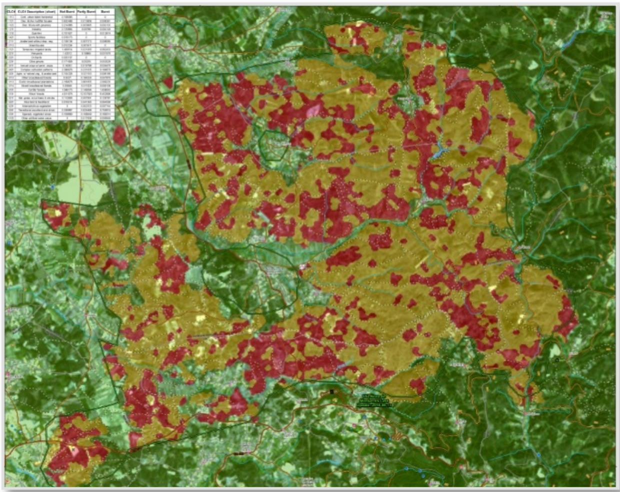
DELIVERY FORMAT
- Thematic and situation maps
- GIS data in standard vector and raster formats
- Analytical reports
- Web services

FREQUENCY
Single date for a post event

Wild fires cause important annual losses to the affected inhabitants, their properties and environment in terms of biomass loss. Reconstruction projects on the affected areas need to have initial information on their extent, degree of affectation and estimation of the losses caused by the fire.

The use of satellite Earth Observation can be an important tool to identify the extent of the affected areas, its grading (partially or totally burnt), the affected assets (agricultural, environment, infrastructures) and indication of secondary risks such as landslides or flash floods due to soil erosion.

The results of this situational picture can be an interesting starting point to identify risk mitigation measures corresponding to intervention typologies: removal of burnt wood and soil protection, regeneration of vegetation cover or hydraulic technics.



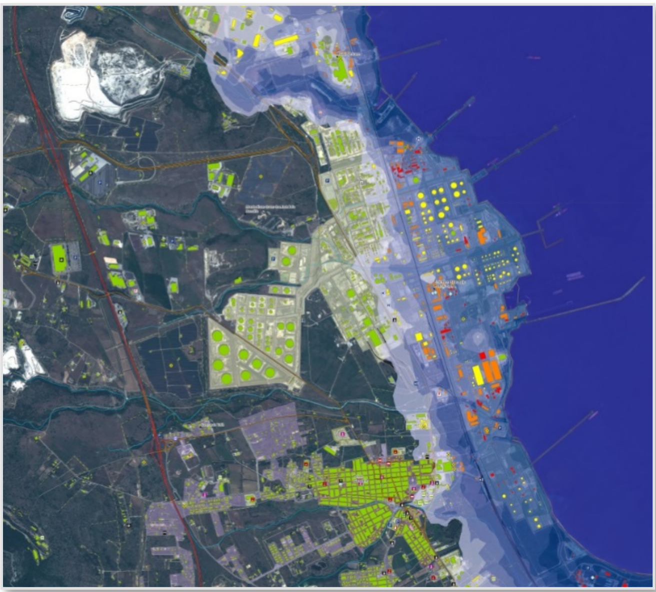
Fire delineation and grading map example, Portugal. EMSN-032. Credit: Copernicus Emergency Management Service (©2015 European Union)

→ EXPOSURE, VULNERABILITY AND RISK ASSESSMENT

Obtaining exposure and vulnerability indexes derived from supporting EO services (population density, land use/ land cover, settlements, infrastructures) and auxiliary data (census with socio-economic data) is a key value for all type of Disaster Risk Reduction analysis.

Exposure can be estimated quantitatively in the number of people or assets that are present in (potential) hazard zones that are thereby subject to potential adverse impact or damage/losses. Vulnerability represent the characteristic and specific context of any given exposed asset (including population and built environment) that make it susceptible to the damaging effects of the particular hazard that it is exposed to.

Geospatial information can give valuable input on the characterization of assets, though for detailed analysis additional in-situ data is commonly required (e.g: census data, UN statistics). Risk assessment can be obtained as the combination of hazard, exposure and vulnerability.



Tsunami risk of assets map (infrastructures, building areas, population). Priolo (Italy). EMSN-043. Credit: Copernicus Emergency Management Service (© 2015 European Union)

DESCRIPTION

Provision of risk and damage assessments for any type of disaster based on quantitative indexes of exposure and vulnerability

USE

- Exposure indexes: estimated affected population and assets
- Vulnerability indexes: in terms of fragility and resilience for both physical and socioeconomic dimensions
- Risk and damage assessments

INPUT PRODUCTS

- Optical satellite imagery
- Supporting EO services
- Ancillary data (depending on availability e.g.: census data, socio-economic statistics, structural building characteristics, building heights)

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS

Risk and damage assessments based on EO services can be a powerful tool to include into the working processes of IFIs funded projects that seek to prevent or mitigate the adverse impacts of natural disasters in developing countries.

DELIVERY FORMAT

- Thematic and situation maps
- GIS data in standard vector and raster formats
- Dynamic visualizations
- Analytical reports
- Web services

FREQUENCY

Single date for the user selected hazard scenario

RECONSTRUCTION MONITORING

DESCRIPTION

Provision of damage assessment at different stages over the time and progress monitoring statistics of the reconstruction works

USE

› Progress status of reconstruction activities
› Damage assessment at each monitoring stage

INPUT PRODUCTS

› Optical satellite images
› Supporting EO services

SPATIAL RESOLUTION AND COVERAGE

From local scales (3m, < 200 sqkm) to large scales (30m, > 200 sqkm)

BENEFITS

Progress monitoring of reconstructions works based on EO services can be a powerful tool to include into the working processes of IFIs funded projects

DELIVERY FORMAT

› Thematic and situation maps
› GIS data in standard vector and raster formats
› Dynamic visualizations
› Analytical reports
› Web services

FREQUENCY

Number of stage monitoring periods depending on user needs

EO based services can support IFIs projects dealing with reconstruction activities after an disaster event by monitoring the progress status of the works.
Geospatial information can be provided at different stages:

- Assets mapping of Pre-event reference situation (t_0)
- Monitoring of reconstruction activities of the affected assets at Post-event situations (t_1, t_2, ... t_n)
- Number of damaged assets at each stage t_i and calculation of statistics and progress reconstruction rates

Reconstruction monitoring of St. Martin and St. Barthelemy islands (Post Irma). EMSN-049. Credit: Copernicus Emergency Management Service (©2015 European Union)

MAIN PARTNERS

- World Bank (WB)
- Asian Development Bank (ADB)
- Inter-American Development Bank (IADB)
- African Development Bank (AfDB)
- Green Climate Fund (GCF)
- Development Bank of Latin-America (CAF)
- Caribbean Development Bank (CDB)

MAIN THEMATIC COMPONENTS AND EO-BASED INFORMATION

Hazard modelling for specific themes within Disaster Risk Management:

- **Geo-hazards**: subsidence, landslides, earthquakes, volcanoes and tsunamis
- **Hydro-meteorological hazards**: flooding, storm surge and other meteorological events
- **Climatological hazards**: droughts, wildfires

High emphasis on **exposure, vulnerability and risk assessments**.

EO supporting services: Land Use/Land Cover, population density mapping, settlement characterization, change assessment, or Digital Elevation Models.

PRELIMINARY LIST OF CANDIDATE REGIONS

- Africa, specially vulnerable to droughts and floods
- Latin America, vulnerable to practically all disasters (earthquakes, volcanoes, floods, landslides, hurricanes)
- Asia, specially vulnerable to flooding and tropical cyclones.

Specific countries will be selected in liaison with IFIs within 2018

MAIN DEVELOPMENT PROGRAMS AND INITIATIVES

A non-exhaustive list of DRR-related initiatives:

- Disaster Risk Analytics and Solutions (D-RAS)
- Disaster Risk Finance (DRF)
- Hydromet program
- Open Data for Resilience initiative
- The African Risk Capacity (ARC)
- Integrated Disaster Risk Management Fund (IDRF)
- United Nations Office for Disaster Risk Reduction
- Other initiatives in LATAM/Asia/Africa

Partners of the DRR Cluster

For more information, please contact:

ESA Technical Officer: Philippe Bally - Philippe.Bally@esa.int

Project Lead: Angel Utanda - autanda@indra.es

Alberto Lorenzo - alorenzoa@indra.es

eo4sd.esa.int/DRR