



Emergency Management

CEOS working group on Disasters

13 - 15 March 2018

Peter SPRUYT

European Commission - DG Joint Research
Centre



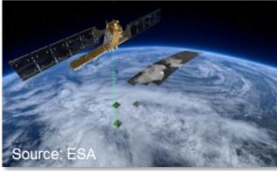


- *a growing number of **disaster management organizations** are using **Earth Observation (EO) images** and **Geographic Information Systems (GIS)** for **disaster management**,*
- *the challenge lies in **supporting these efforts with relevant policy** also at **regional and international level**.*

In this context the **European Commission** is offering to actors involved in the emergency management the **Copernicus Emergency Management Service** (Copernicus EMS), **a fully operational service** which provides geospatial information addressing emergency response, prevention, preparedness, disaster risk reduction or recovery phases



Satellites: Sentinels & Contributing Missions



In-situ measurements



... added value products

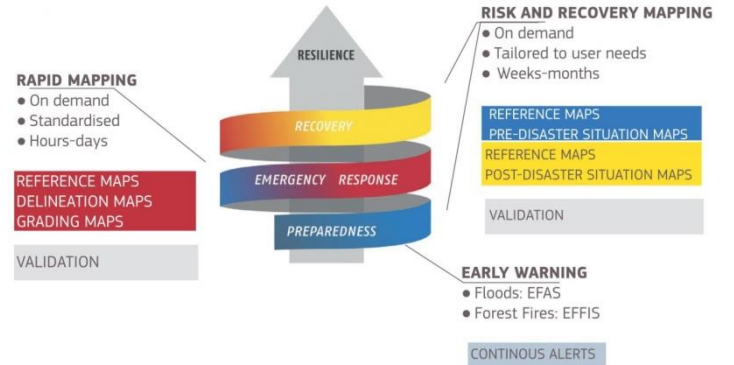
Operational since 2012

Managed directly by the Joint Research Centre (JRC) of the European Commission

Provides disaster information on the impact of natural & man-made disasters

Supports all phases of the disaster management cycle:

- Warnings & risk assessments
- Information on the impact of natural and man-made disasters





Emergency Management

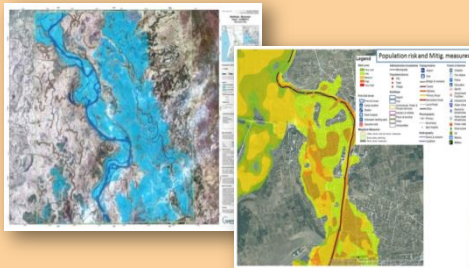
Scope

- Complementary to national efforts
- Supporting the EC's Emergency Response and Coordination Centre (ERCC)
- Focus on Europe but available globally

On-demand Mapping

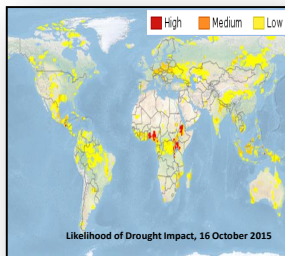
Any disaster

On-demand provision of geospatial information in support of preparedness, emergency response, recovery for any type of disaster



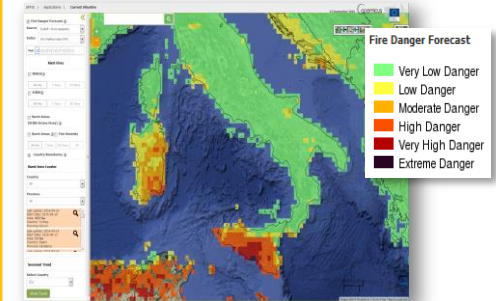
Drought Observatory

Early warning, monitoring & forecasting of droughts & their impacts



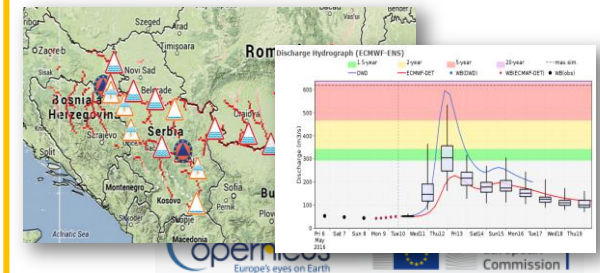
European Forest Fire Information System (EFFIS)

Near real-time & historical information on forest fires & forest fire regimes in the European, Middle Eastern & N-African regions



European Flood Awareness System (EFAS)

Flood monitoring and forecasting across Europe





- On-demand
- Can only be directly activated by Authorised Users (see schema)
- JRC role: technical coordination & contract management
- Map production by European consortia through service contracts
- All products available at emergency.copernicus.eu/mapping

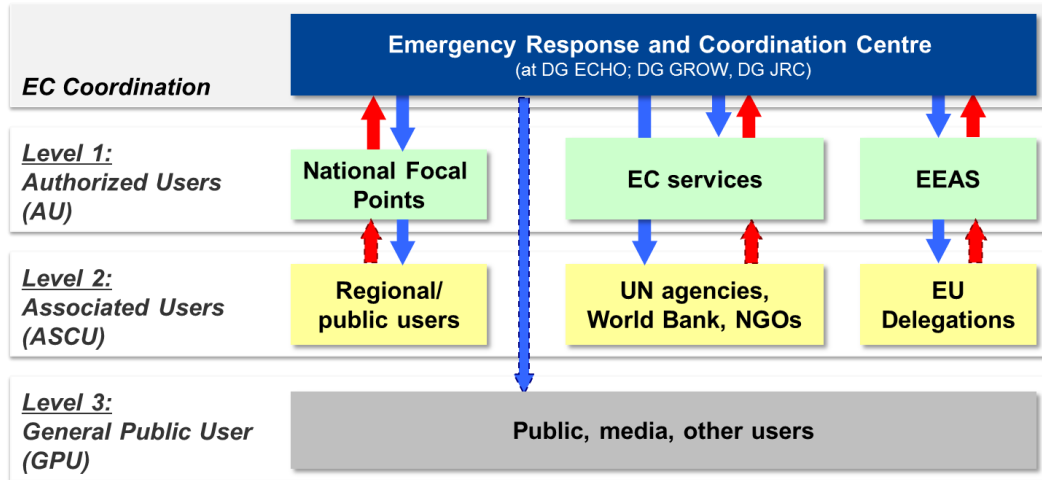
Two temporal modes

Rapid Mapping

- 24/7/365
- Supporting emergency response
- Highly standardised workflow & products
- Rapid tasking & delivery of satellite images
- Delivery in hours/days (avg. 24-48h)

Risk & Recovery Mapping

- During working hours
- Supporting situations which do not require immediate action
- Tailored to user needs (case specific)
- Delivery in weeks/months



↑ trigger ↓ inform



Provision of image data

Copernicus is a European Union Programme, coordinated and managed by the European Commission, aimed at **developing European information services based on satellite Earth Observation and in situ (non-space) data.**

Sentinels

SENTINEL-1A/1B

- All-weather, day-and-night radar imaging satellites for land and ocean services
- Able to "see" through clouds and rain
- Data delivery within 1 hour of acquisition
- Airbus Defence and Space developed C-band radar instrument

SENTINEL-2A/2B

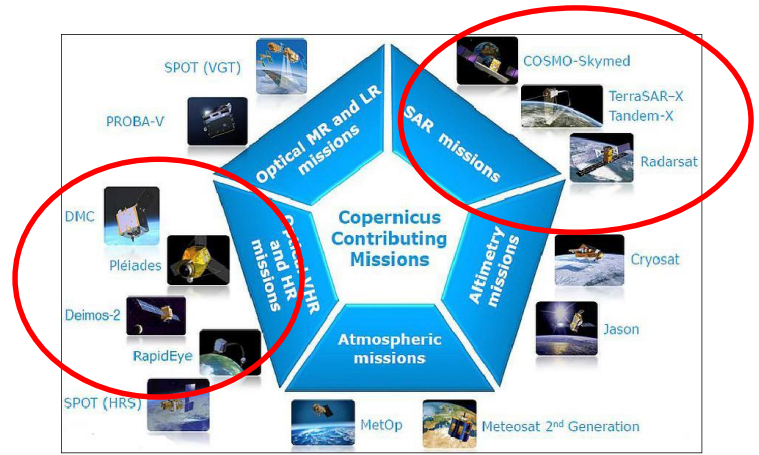
- Medium Res Multispectral optical satellite for observation of land, vegetation and water
- 13 spectral bands with 10, 20 or 60m resolution and 290km swath width
- Global coverage of the Earth's land surface every 5 days
- Airbus Defence and Space prime contractor for satellites and instruments

Aerial (drones, planes)

Through a pilot project in order to evaluate possible operational integration in CEMS



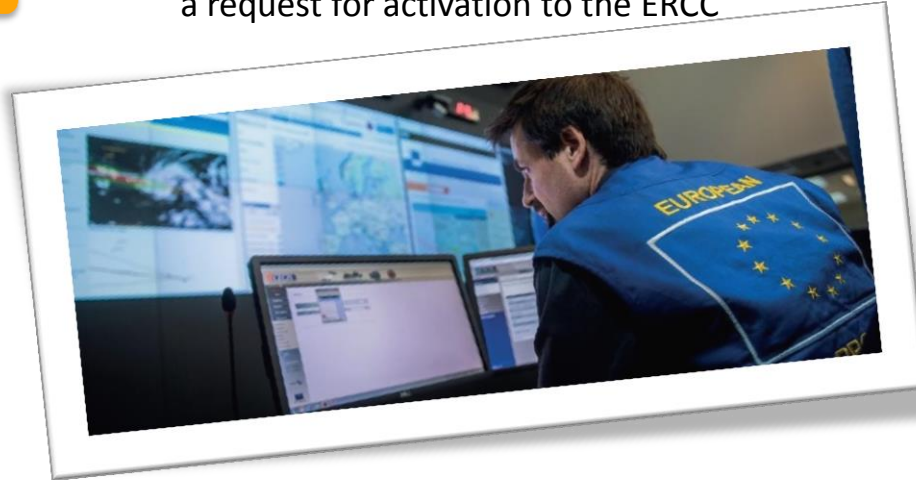
Copernicus Contributing Missions: missions from ESA, their Member States, and other European & international 3rd party missions





Authorized Users

Generally Civil Protection Authorities or other National Focal Points, they can submit a request for activation to the ERCC



DG JRC

Joint Research Centre of the European Commission, technical supervision of operations, management of dissemination platforms

ERCC @DG ECHO

The Emergency Response Coordination Centre, entry point for the EMS activations, providing 24/7 responses to all request coming from the EMS users

ESA

The European Space Agency, providing the REACT, a fully dedicated team to promptly support EO data to the EMS mapping team

Service Provider

Private sector consortia, in charge of the EMS activation coordination and mapping tasks



Emergency
Management

Rapid Mapping

24/7/365 service

Supporting emergency response

Highly standardised workflow & products

Standardised products (three map types)

Two production modes (service levels SL)

Rapid tasking & delivery of satellite images

Delivery in hours/days

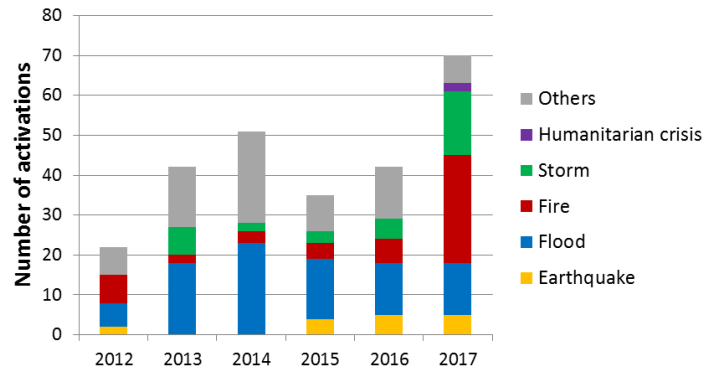


Service Portfolio

Map type	Content	SL1*	SL5*
Reference	Reference situation	9h	5 days
Delineation	Impact area	12h**	5 days
Grading	Damage assessment	12h**	5 days

* Time after image delivery ** First Available Map after 3h

268 Activations since April 2012



Geographic location activations

53% Regional (EU)

47% International (Outside EU)

Who is activating the service?

40% EC Services

60% EU National Focal Points (also outside EU)



Rapid Mapping (RM)

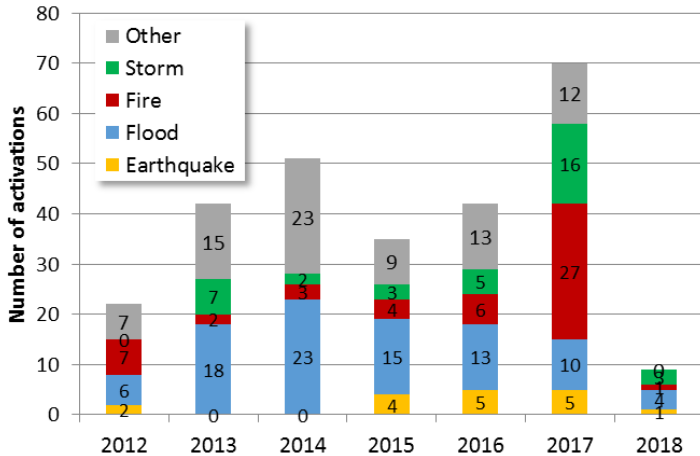
Emergency Management

- Volume 2017: 62 activations, mainly for fires (42%) & storms (23%)
- Intensive start in 2018 with 9 activations (fires (1), floods (4), storm (3), earthquake (1))
 - Several large activations for TC Madagascar & GITA (Tonga), storm Friederike (D), floods in N-France
 - Latvia and Lithuania activated RM for the first time since 2012 (floods)
- Finalisation of a first draft procedure on the collaboration with the Int. Charter

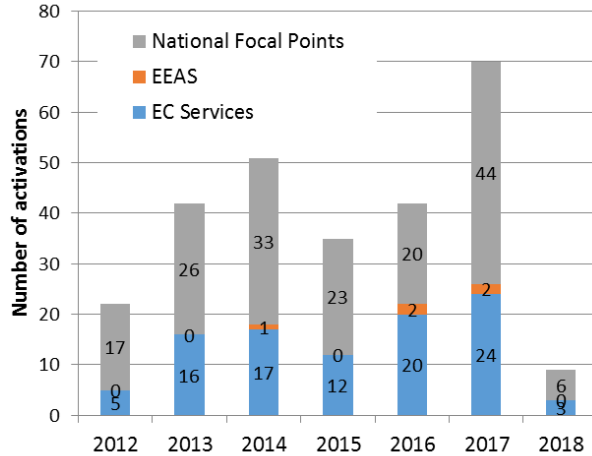


Overall service statistics: 271 activations since 04/2012

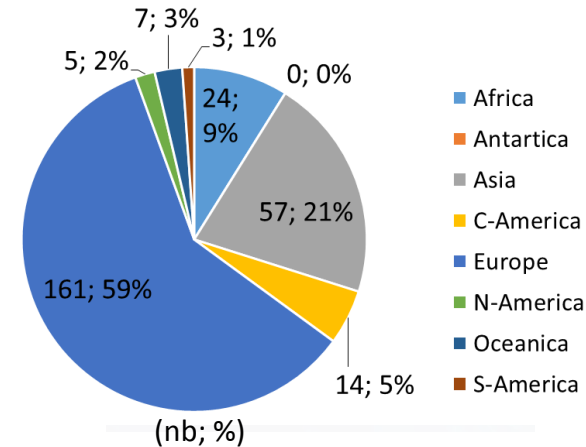
Disaster Types



Triggering Entity



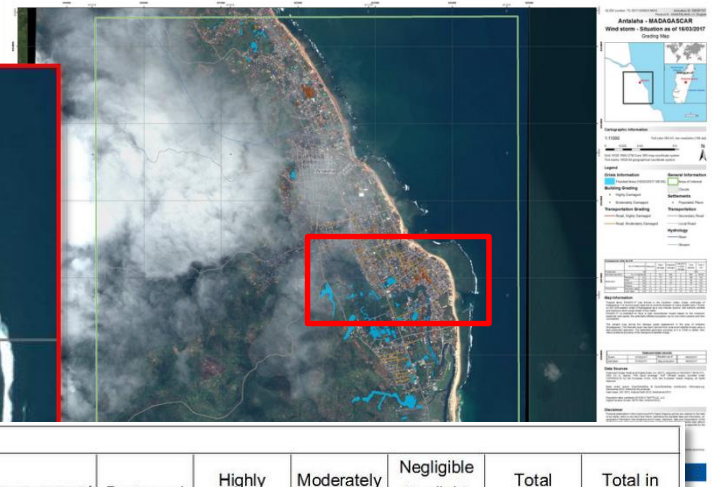
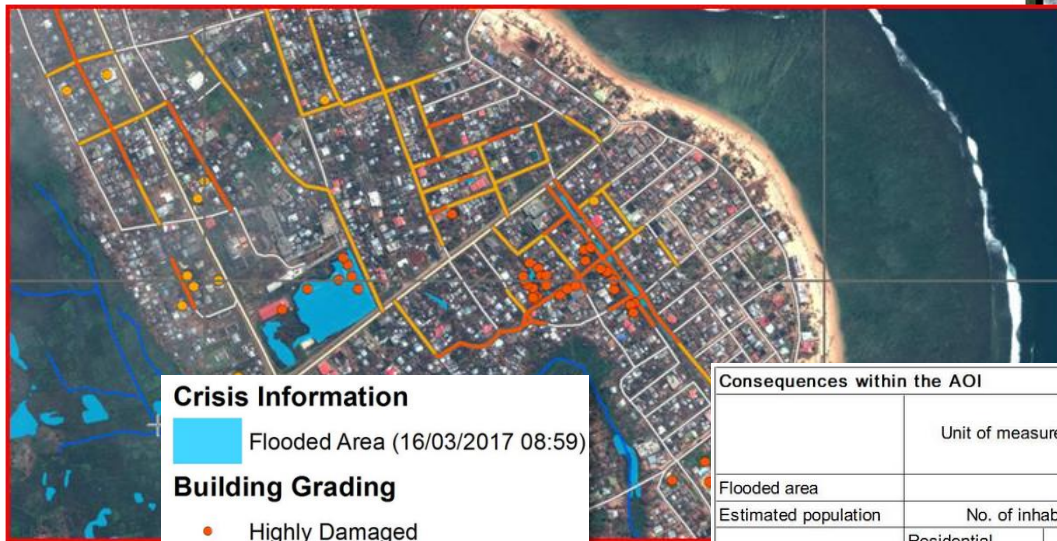
Disaster location





Tropical Cyclone ENAWO-17 in Madagascar (EMSR197)

Grading Map



Crisis Information

 Flooded Area (16/03/2017 08:59)

Building Grading

-  Highly Damaged
-  Moderately Damaged

Transportation Grading

-  Road, Highly Damaged
-  Road, Moderately Damaged

Consequences within the AOI

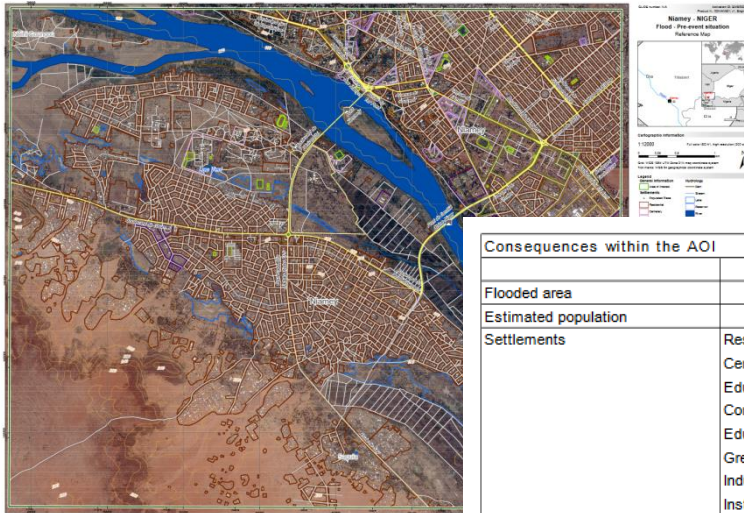
	Unit of measurement	Destroyed	Highly damaged	Moderately damaged	Negligible to slight damage	Total affected	Total in AOI	
Flooded area	ha					28.8		
Estimated population	No. of inhabitants	0	513	369	0	882	53160	
Settlements	Residential	No.	0	171	123	0	294	N/A
	Other	No.	0	16	13	0	29	N/A
	Industrial	No.	0	13	26	0	39	N/A
	Religious	No.	0	0	1	0	1	N/A
Transportation	Secondary roads	km	0.0	0.0	0.0	0.0	15.1	
	Local roads	km	0.0	3.3	6.7	0.0	10.0	64.1



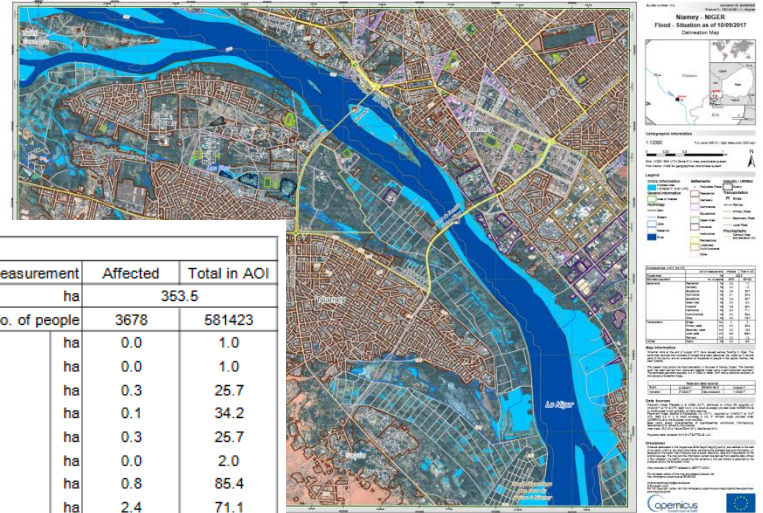
Floods in Niger - (08/2017)

Torrential rains have caused serious flooding in Niger at the end of August 2017. The authorities reported that hundreds of houses have been destroyed, key roads cut in several parts of the country and ordered thousands of people to leave their homes in the capital, Niamey.

Reference Map



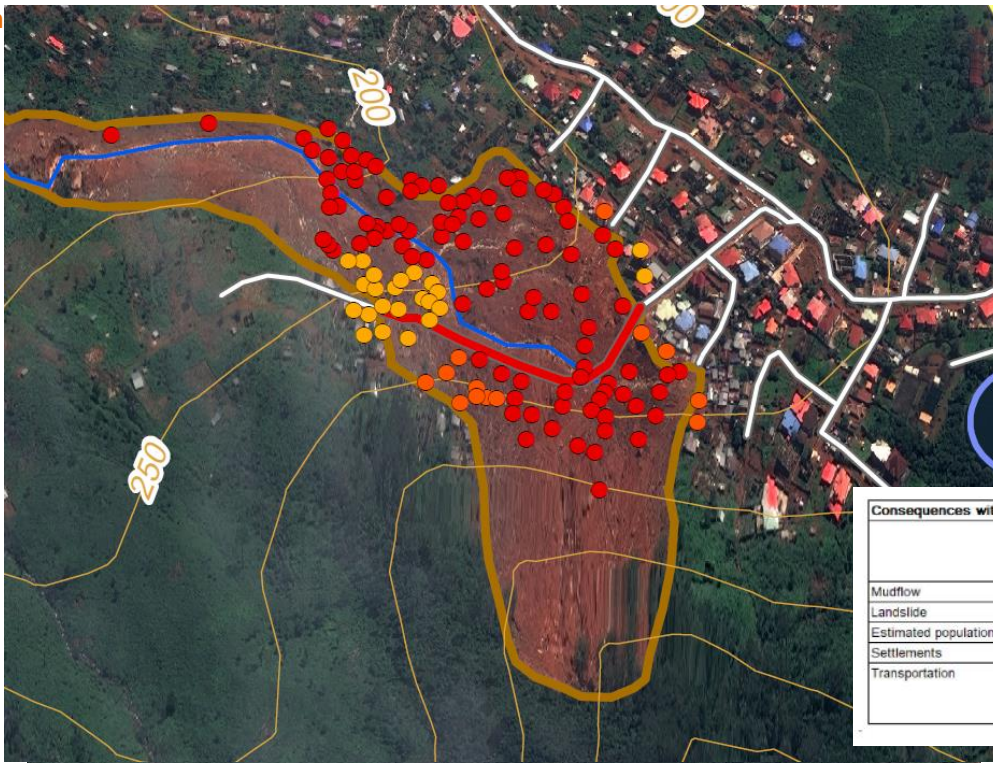
Delineation Map



Consequences within the AOI				
		Unit of measurement	Affected	Total in AOI
Flooded area		ha	353.5	
Estimated population		No. of people	3678	581423
Settlements	Residential	ha	0.0	1.0
	Cemetery	ha	0.0	1.0
	Educational	ha	0.3	25.7
	Commercial	ha	0.1	34.2
	Educational	ha	0.3	25.7
	Green Area	ha	0.0	2.0
	Industrial	ha	0.8	85.4
	Institutional	ha	2.4	71.1
	Multi-functional	ha	0.0	63.2
	Other	ha	0.0	102.7
Transportation	Bridge	No.	0	2
	Primary roads	km	0.0	29.3
	Secondary roads	km	0.0	19.5
	Local roads	km	8.2	395.0
	Railways	km	0.0	1.2
Utilities	Quarry	ha	0.0	8.9



Mudflow – Freetown Area – Sierra Leone- (15/08/2017)



Crisis Information

- Landslide (15/08/2017 11:25 UTC)
- Mudflow (15/08/2017 11:25 UTC)

Building Grading

- Destroyed
- Highly Damaged
- Moderately Damaged

Transportation Grading

- Bridge, Destroyed
- Road, Destroyed



Consequences within the AOI								
	Unit of measurement	Destroyed	Highly damaged	Moderately damaged	Negligible to slight damage	Total affected	Total in ACI	
Mudflow	ha					31.9		
Landslide	ha					4.5		
Estimated population	No. of inhabitants					2005	8405	
Settlements	Residential	No.	151	25	38	0.0	214	N/A
Transportation	Bridge	No.	0	0	0	0	4	4
	Primary roads	km	0	0	0	0	0.0	6.5
	Local roads	km	1.5	0.0	0.0	0.0	1.5	55.4



Grading map example (forest fires)

Detailed damage assessment, estimation of affected population & assets

Fire of Pampilhosa (PT) June 2017 (EMSR207)

Transportation Grading

— Road, Negligible to slight damage

Building Block Grading

Highly Damaged

Moderately Damaged

Negligible to slight damage

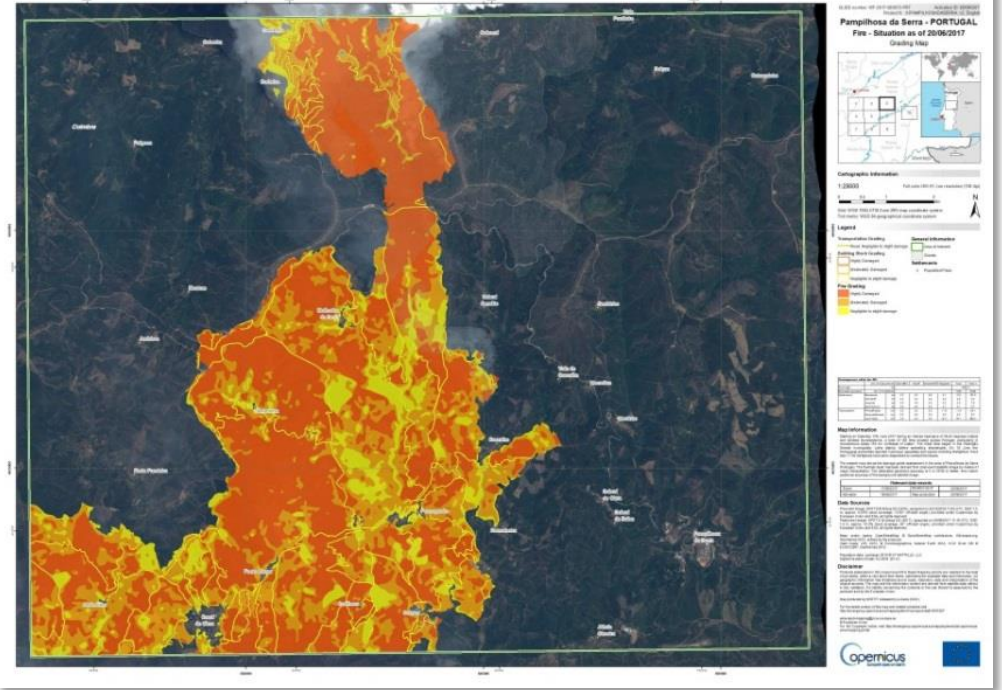
Fire Grading

Highly Damaged

Moderately Damaged

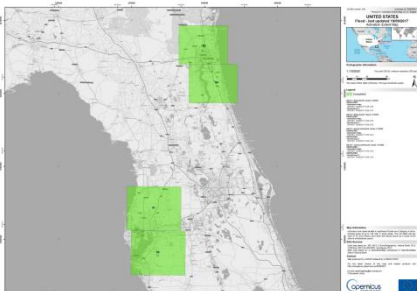
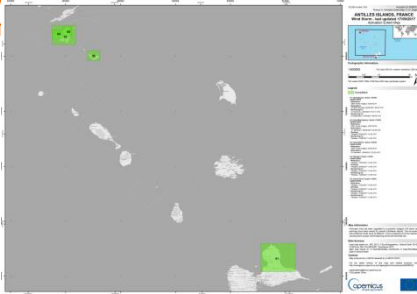
Negligible to slight damage

Consequences within the AOI							
	Unit of measurement	Destroyed	Highly	Moderately	Negligible	Total	Total in
Burnt area	ha					6445,2	
Estimated population	No. of inhabitants					1054	3348
Settlements	Residential	0,0	0,3	6,6	6,1	13,0	187,6
	Cemetery	0,0	0,0	0,2	0,0	0,2	0,2
	Industrial	0,0	0,0	0,0	0,0	0,0	7,8
	Sport Ground	0,0	0,0	0,0	0,1	0,1	0,7
Transportation	Primary roads	0,0	0,0	0,0	11,6	11,6	45,1
	Secondary roads	0,0	0,0	0,0	0,0	0,0	0,0
	Local roads	0,0	0,0	0,0	137,1	137,1	582,0





Irma hurricane 2017



Legend

Crisis Information

Building Grading

- Destroyed
- Highly Damaged
- Moderately Damaged
- Negligible to slight damage

Industry / Utilities Grading

- Storage Tank, Destroyed
- Storage Tank, Highly Damaged
- Storage Tank, Negligible to slight damage
- Industrial Facility, Highly Damaged
- Industrial Facility, Moderately Damaged
- Industrial Facility, Negligible to slight damage

Transportation Grading

- Bridge, Negligible to slight damage
- Harbour, Moderately Damaged
- Harbour, Negligible to slight damage

General Information

- Area of Interest
- Clouds

Administrative boundaries

- International Boundary

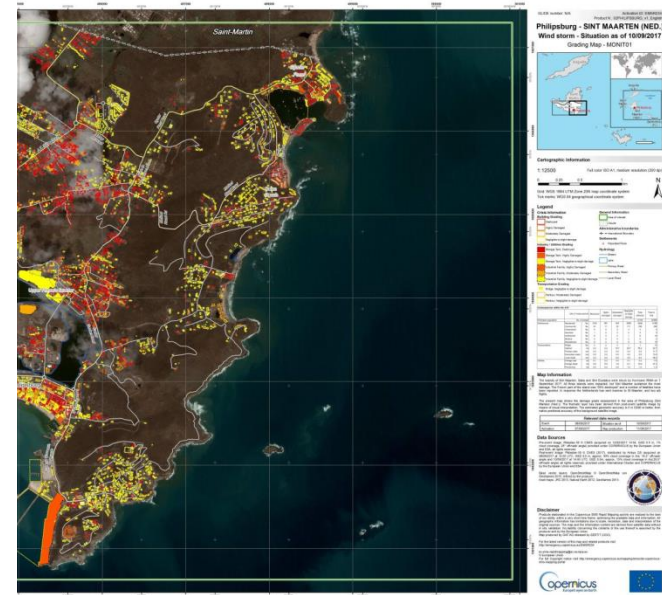
Settlements

- Populated Place

Hydrology

- Stream
- Lake
- Primary Road
- Secondary Road
- Local Road

Consequences within the AOI						
	Unit of measurement	Destroyed	Highly damaged	Moderately damaged	Negligible to slight damage	Total affected
Estimated population	No. of people					23140
Settlements						6488
Residential	No.	3129	551	849	3959	9159
Commercial	No.	91	11	22	111	235
Religious	No.	0	0	0	4	4
Industrial	No.	1	0	0	2	3
Institutional	No.	5	0	2	1	8
Medical	No.	0	0	0	2	2
Recreational	No.	5	0	0	5	10
Transportation						14
Bridge	No.	0	0	0	1	1
Harbour	ha	0.0	0.0	16.7	38.7	55.4
Primary roads	km	0.0	0.0	0.0	0.0	11.7
Secondary roads	km	0.0	0.0	0.0	0.0	13.4
Local roads	km	0.0	0.0	0.0	0.0	56.0
Utilities						0.3
Storage tank	ha	0.1	0.2	0.0	0.1	0.4
Storage depot	ha	0.0	9.9	1.9	8.1	19.9
Processing	ha	0.0	0.0	0.0	1.2	1.2



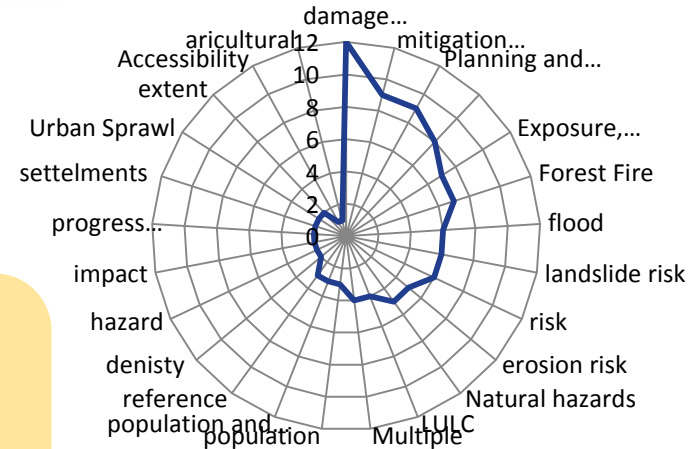


Risk and recovery mapping

- Not constrained by the need for rapid delivery
- Serves prevention, preparedness, disaster risk reduction, reconstruction, recovery
- Service is customised to suit the user requirements specific to each activation
- Product delivery in several weeks
- More dependent on the integration of relevant ancillary layers



Most common EMSN subjects of interest (2012-2017)

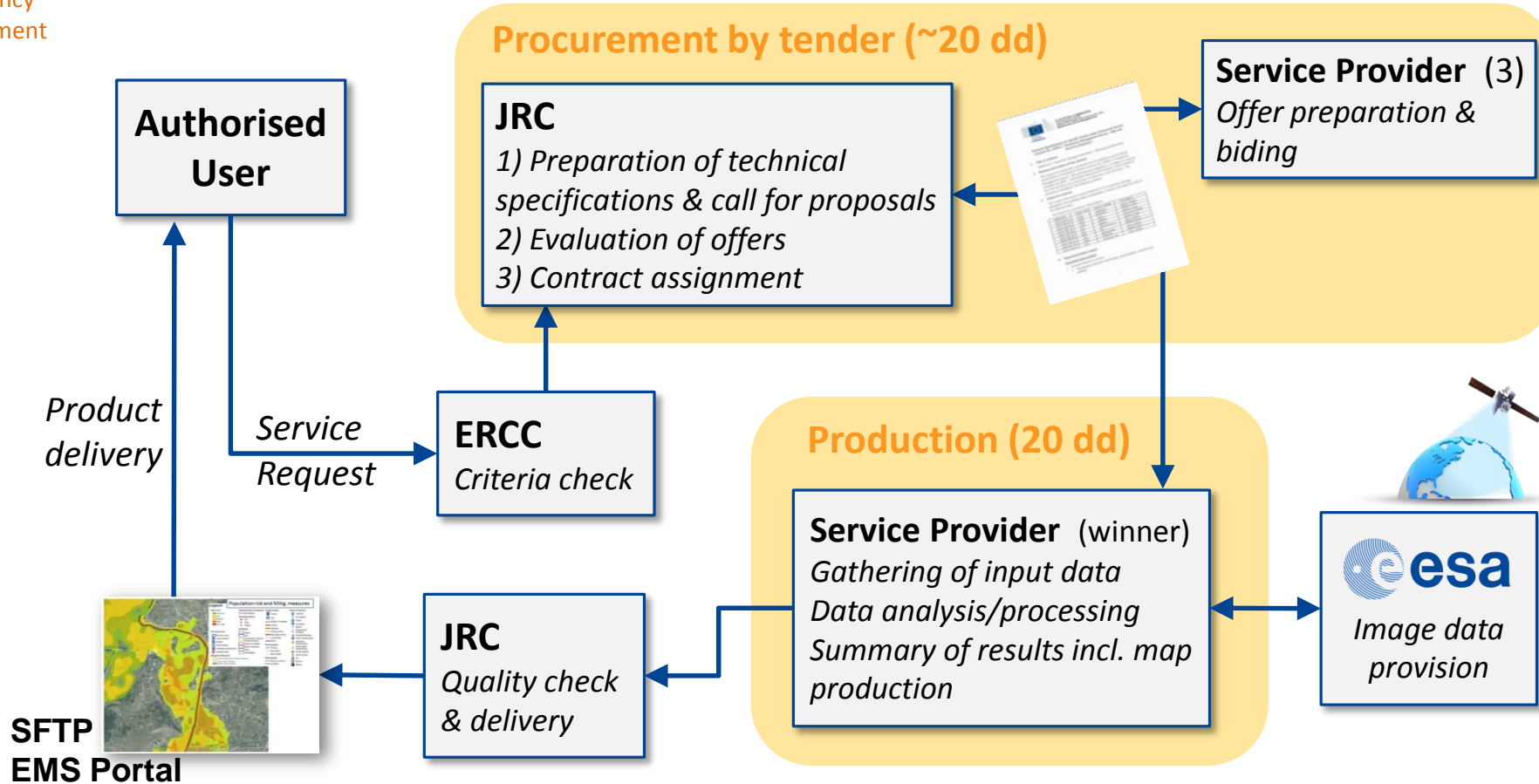


Post-disaster Mapping

- Changes of Vulnerability & resilience of urban settlements
- Risk status for new assets
- Post-disaster needs assessment
- Recovery plans
- Reconstruction/rehabilitation monitoring

Pre-disaster Mapping

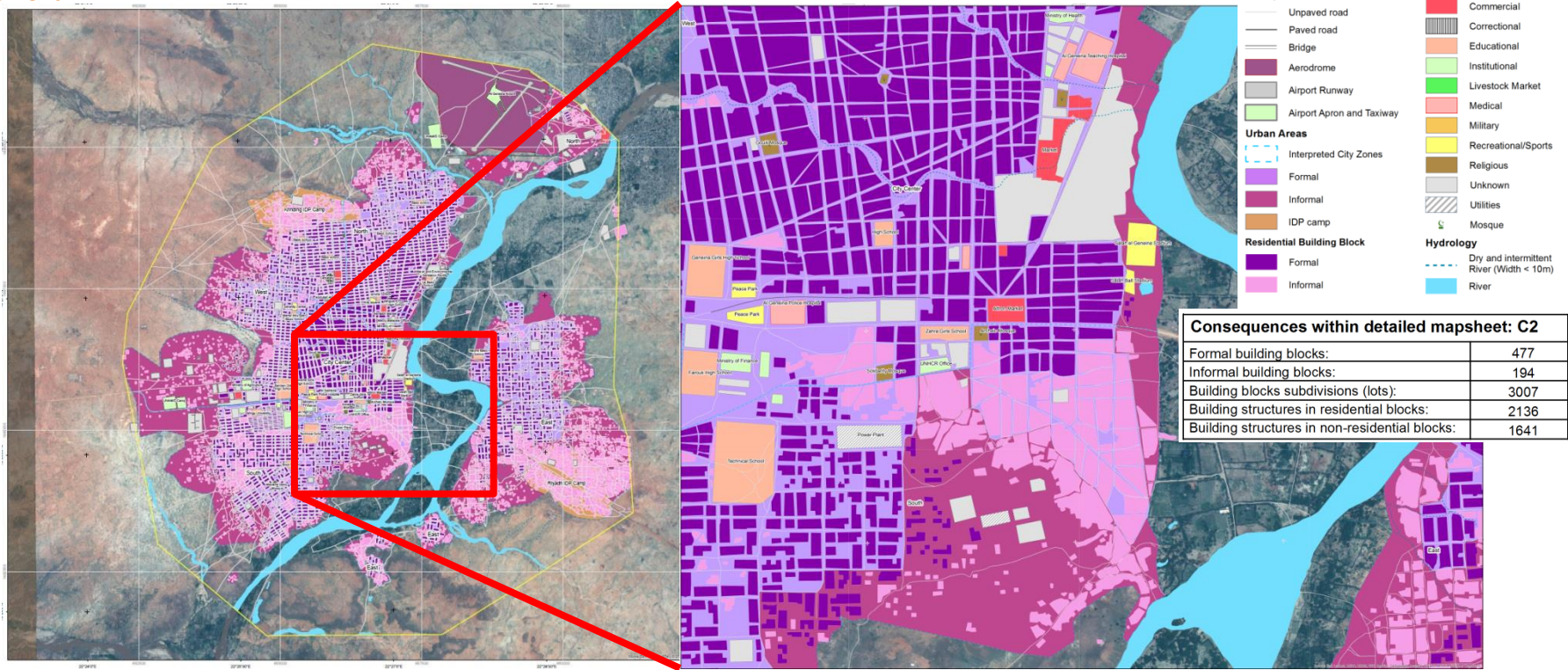
- Hazard exposure
- Vulnerability & resilience of buildings or people
- Risk status for population and assets
- Evacuation plan
- Probabilistic risk assessment based on likely hazards





R R M examples in Africa

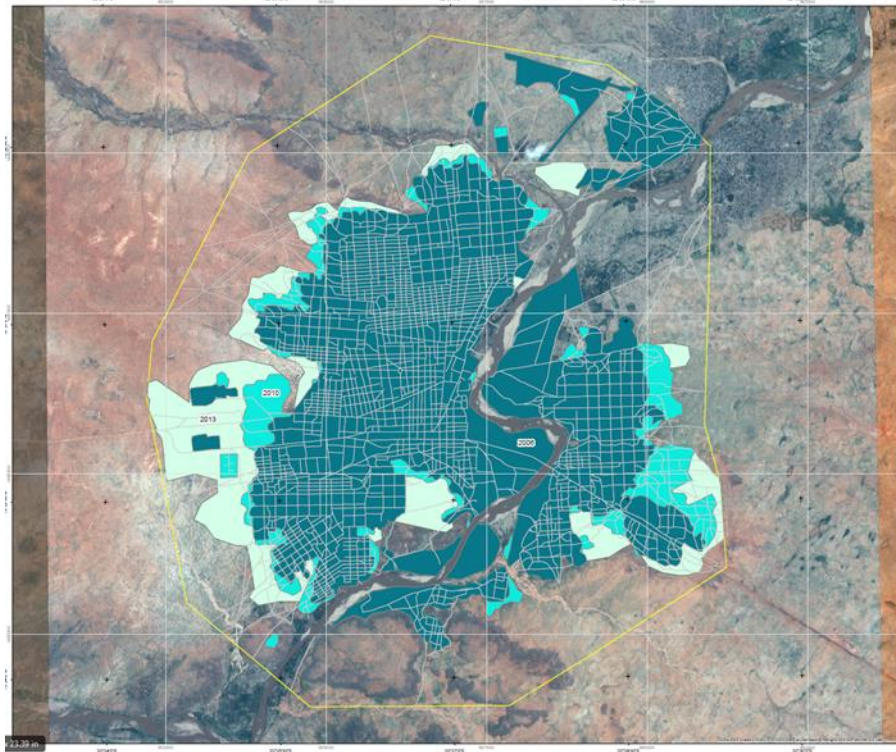
Emergency Management Population density estimation and land-use database for Al Geneina and El Daein, Sudan





URBAN SPRAWL (CITY GROWTH)

Emergency
Management



30.000 contour 500
Autorité de l'Information Géographique
Produit à l'IGP, Université de
Cairo, Egypte

Al Geneina - Sudan

Map 1:20 000
City growth

Projection: UTM
Projection date: 2014-01-01

Cartographic Information
Scale: 1:20 000 (to 1:100 000)
Scale: 1:20 000 (to 1:100 000)
Map Coordinate System: UTM, Zone 38N
Data Source: 2012-13 (to 2012-13)
Map Date: 2012-13 (to 2012-13)

Legend

- Area of Interest
- Transportation
- City Growth Interpretation

Consequences within the city growth map

Area (ha)	%
2994	
3397	
4018	
403	34
621	18

Map Information
Data Sources
Copernicus
European Commission

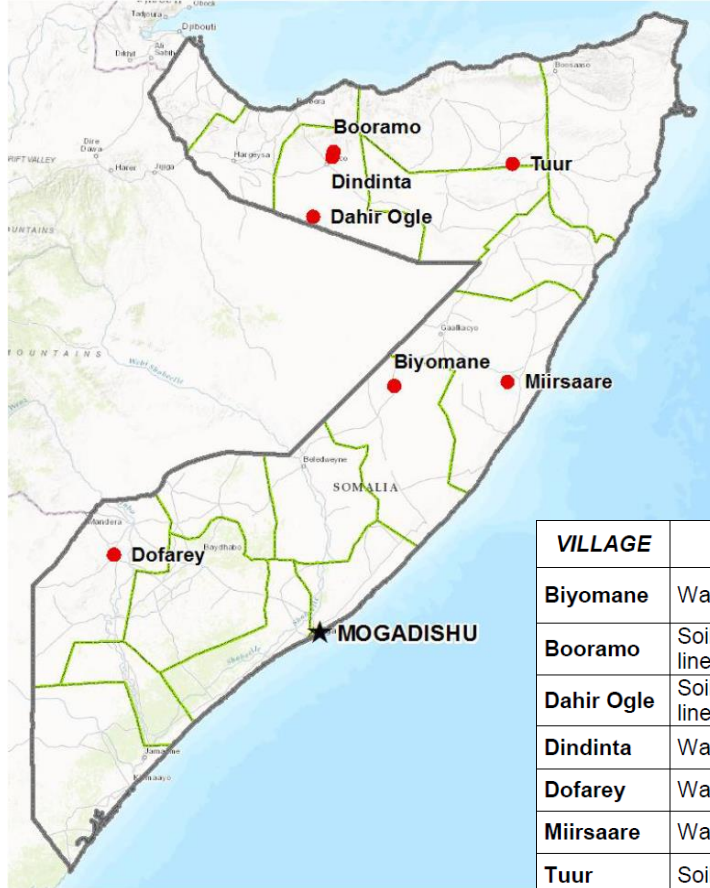
City Growth Interpretation

- Built-up in 2004
- Built-up 2004 - 2012
- Built-up 2012 - 2013

Consequences within the city growth map	Area (ha)	%
Built-up 2004	2994	
Built-up 2012	3397	
Built-up 2013	4018	
Built-up change 2004-2012	403	34
Built-up change 2012-2013	621	18



Monitoring and assessment of local humanitarian recovery construction projects in Somalia



Activation output requested by World Food Program (WFP)

- Detailed maps of the constructions of interest
- Overview reference maps
- Vegetation maps for analysing the impact of the drought mitigation measures on the surrounding vegetation

VILLAGE	ACTIVITY
Biyomane	Water Catchment
Booramo	Soil bund and stone lines
Dahir Ogle	Soil bund and stone lines
Dindinta	Water catchment
Dofarey	Water Catchment
Miirsaare	Water Catchment
Tuur	Soil bunds

Figure 1: Location of the 13 sites (in red).



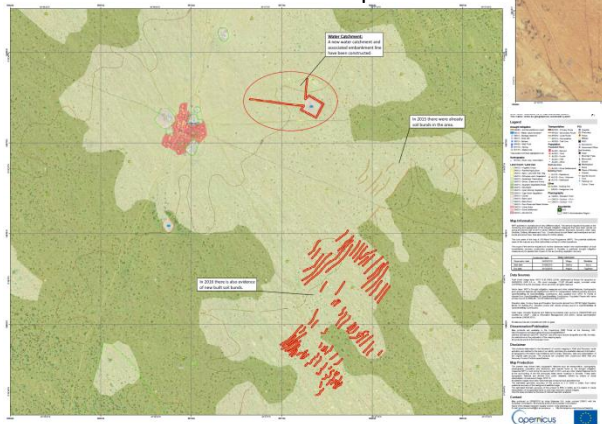
Village of Dindinta

Emergency Management

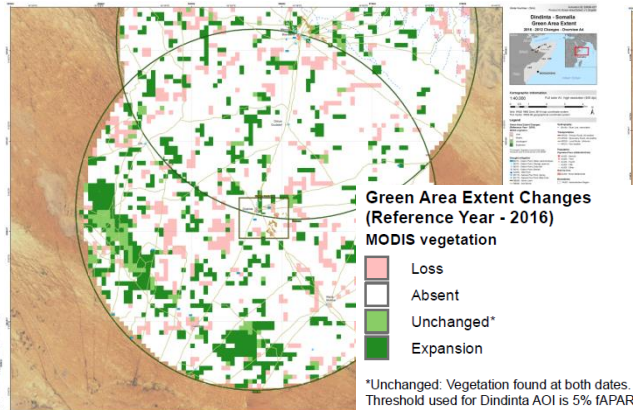
Draught mitigation

- BI010 - Cistern Point, Water catchment/pan
- BI010 - Cistern Point, Storage reservoir
- BI010 - Cistern Point, Solar still
- BI010 - Cistern Point, Berkad
- AA050 - Well Point
- BH170 - Natural Pool Point, Spring
- BH170 - Natural Pool Point Water-hole
- DB090 - Stone Lines
- DB090 - Soil Bunds

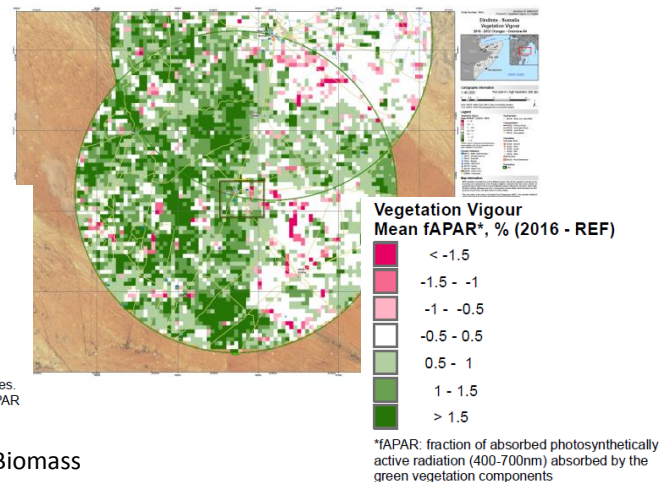
Reference Map



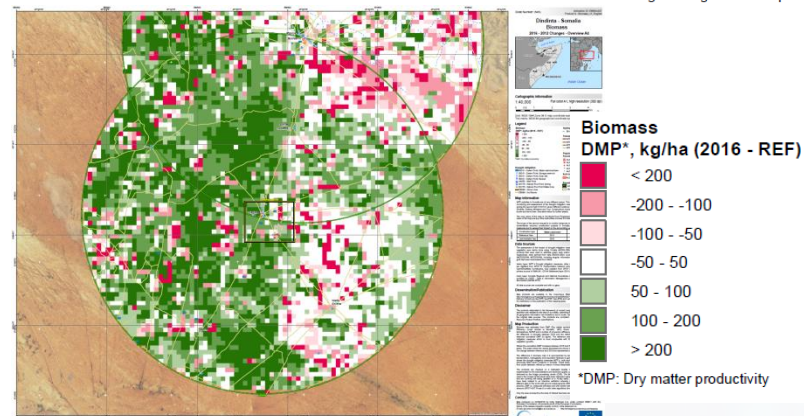
Green area extent



Vegetation Vigour



Biomass





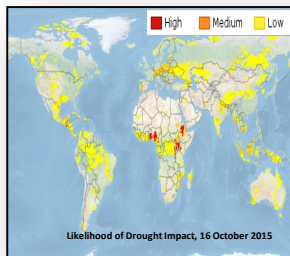
- Status of RRM Activations

Code	Activation name	Status
Activations 2017		
EMSN033	Satellite based conflict damage assessment of two selected cities in Libya	Finished
EMSN034	Coastal flood risk analysis for population and assets, Portugal	Finished
EMSN035	Economic impact of floods on agriculture sector, France	Finished
EMSN037	Multiple natural hazards risk assessment for UNESCO in three cities	Finished
EMSN038	Post-disaster situation analyses of flood and landslides in Lima, Peru	Finished
EMSN039	Seismic risk assessment in Croatia	Finished
EMSN040	Nation-wide asset map Finland (relaunch of EMSN036)	Finished
EMSN041	Forest fire risk assessment in Croatia	Finished
EMSN043	Tsunami Risks in Italy (relaunch of EMSN042)	Finished
EMSN045	Forest damage assessment in Saxony, Germany	Cancelled
EMSN046	Flood delineation in Hildesheim, Germany	Finished
EMSN047	Volcanic Hazard in DR Congo (relaunch of EMSN044)	Ongoing
EMSN048	Flood risk assessment in Sardinia, Italy	Finished
Activations 2018		
EMSN049	Reconstruction monitoring of St Martin and St Barthelémy islands (post IRMA)	ongoing
EMSN050	Post Matthew damage assessment and monitoring of recovery activities in the South Region of Haiti	ongoing
EMSN051	Post Matthew monitoring on rural areas, south region of Haiti	ongoing



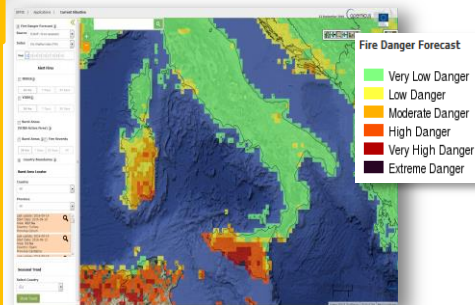
Drought Observatory

Early warning,
monitoring &
forecasting of
droughts &
their impacts



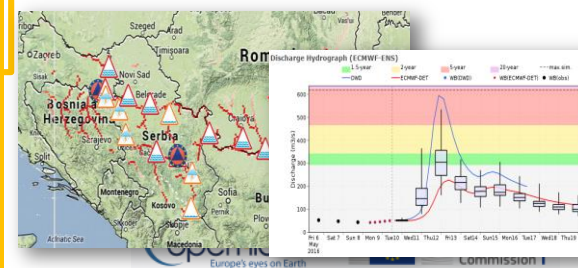
European Forest Fire Information System (EFFIS)

Near real-time & historical information on forest fires & forest fire regimes in the European, Middle Eastern & N-African regions



European Flood Awareness System (EFAS)

Flood monitoring and forecasting across Europe





Drought observatory



Agriculture



Public Water Supply



Human Health



Terrestrial & Freshwater
Ecosystems



Energy
Production



Waterborne Transport



Forest/Wild Fires



Forestry



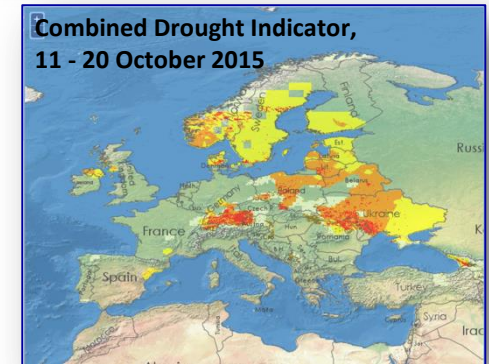
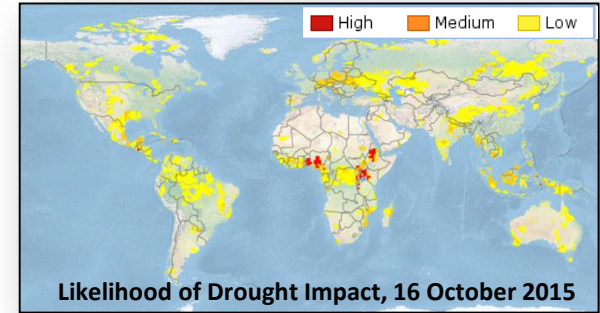
Tourism

Drought
Impacts



EUROPEAN (EDO) & GLOBAL (GDO) COMPONENTS

- Why? *Droughts are ...*
 - increasing in frequency and severity in many parts of the world, including parts of Europe.
 - a transboundary problem.
 - a global hazard with significant economic, societal and environmental impacts (~3 billion Euros/year in Europe).
- What?
 - European and global early warning, monitoring and forecasting of drought and their impacts, based on satellite data, hydro-meteorological modelling and in-situ observations.
 - Satellite data play a key role for monitoring vegetation stress, soil moisture and land surface temperatures.
 - The combination of different indicators can provide decision support to policy makers and different economic sectors.





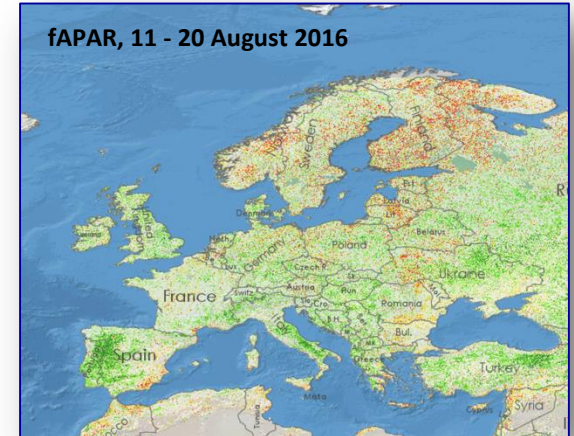
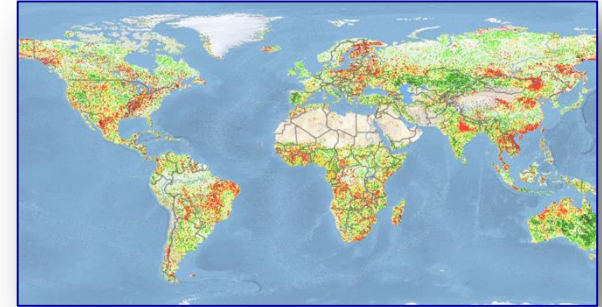
EUROPEAN (EDO) & GLOBAL (GDO) COMPONENTS

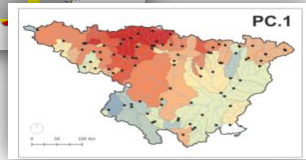
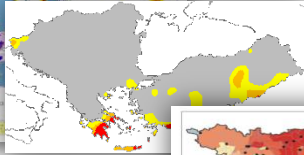
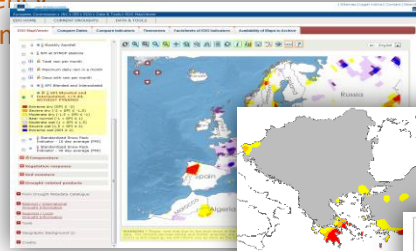
- Users:

- Commission services (e.g., ECHO, ENV, REGIO, CLIMA)
- National and Regional Authorities
- River Basin authorities (especially international RBs)
- Agriculture, water-related industries (including energy production), water-borne transportation, public water supply, ...
- Nature conservation (e.g., wildfires, wetlands)
- European and national aid services, international organizations and industries

- Synergies:

- Copernicus Land Service
- Copernicus Climate Change Service





Web-based Platform

Multi-scale approach

De-central data holding and management

Interoperable
Data
Infrastructure

- Streamlined with other EMS services (EFAS, EFFIS)
 - meteorological data, soil moisture, river flow
 - drought indicators
- Link to Copernicus Land Service → Land Cover, NDVI/fAPAR, Water Bodies
- Link to C3S → temperature, soil moisture, snow cover (once regularly available)
- Uptake of outputs from research projects (DROUGHT R&SPI, GlobSnow, EGSIEM, ...)
- Contribution to GEO GIDIS as European node



European Forest Fire information system (EFFIS)

- Provides transnational assessments during pre- & post-fire phases
 - Complementing national systems through provision of harmonised data, methods & standards
- **European Forest Fire Information System (EFFIS)**
- Expansion to global scale is ongoing (in cooperation with GEO) => **Global Wildfire Information System (GWIS)**

- ✓ Fire danger forecast
 - ✓ Short and long-term fire danger forecast
 - ✓ Monthly and seasonal fire weather forecast
- ✓ Fire detection & burnt area mapping
 - ✓ Active fire mapping – MODIS/VIIRS/Sentinels
 - ✓ Burnt area mapping:
 - ✓ Medium spatial resolution (approx 300 m) near-real time (2/day in pan-European region) (MODIS/VIIRS/Sentinel3)
 - ✓ High spatial resolution (S-2, Landsat res.) weekly (or bi-weekly)





EFFIS vs. Rapid Mapping of Fires

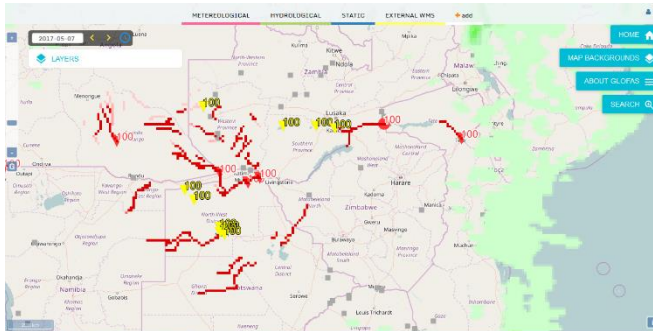
Emergency
Management

	EFFIS	Rapid Mapping
Aim of the service	Monitoring of all forest wildfires, providing pre-fire and post-fire products, including burnt areas.	Mapping of selected (by the user) wildfire events (not limited to forests).
Activation of the service	Not needed – continuous monitoring of all forest fires	Needs to be activated by an authorised user
Frequency in the updates of burnt area maps	Updated up to 3 times every day	In the same activation updates are done on request only. The requested map shows the affected area at the requested date.
Spatial resolution	250 meters – provides a map of the burnt area based of an automatic classification supervised by an operator	Typically <10 meters – provides a detailed map of the burnt area by either visual interpretation or semi-automatic processing of very high resolution imagery
Grading (fire severity)	5 levels of fire severity are provided by automatic classification of the pre-fire and post-fire images	On request impact assessment is provided (3 levels of grading) on the basis of visual interpretation or semi-automatic processing of the post-fire imagery
Strong points of the service	Provides a continuous monitoring of the evolution of all forest wildfires, with a high frequency update, at medium spatial resolution. Maps are available shortly after the satellite pass.	Provides an accurate map of a single wildfire event at high spatial resolution, within the next 24/48 hours of the activation. Is not limited to forest fires.

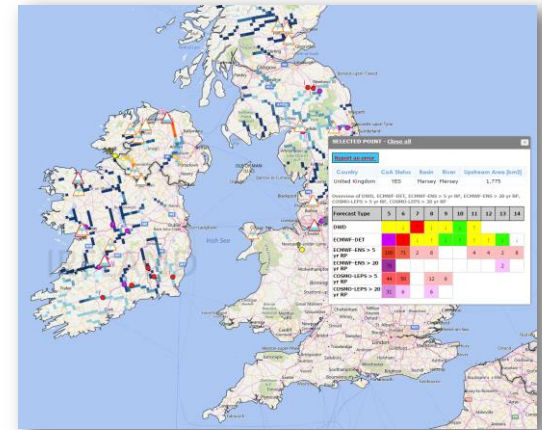


- **European & Global Flood Awareness Systems EFAS & GloFAS**
- Probabilistic, transnational, river basin wide flood forecasting, monitoring and early warning information
- Users: ERCC, national/regional/local hydro-met authorities, civil protection, intern. organizations & NGOs, industry
- EFAS NRT forecasts currently not publicly accessible – ongoing efforts to provide all historic and in the future also more NRT data
- GloFAS is publicly accessible

<http://globalfloods.eu>



<http://efas.eu>





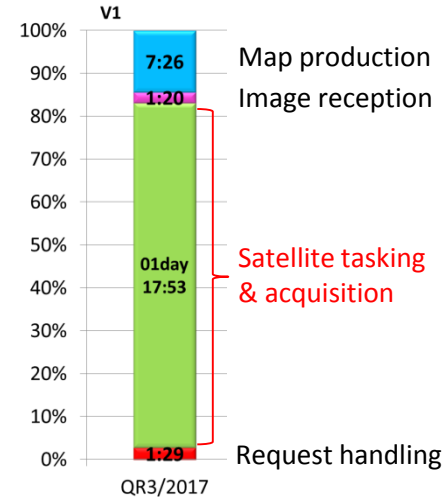
Flood Warning based pre-tasking (Floods)

Why?

- Reduce time for image tasking & acquisition (currently covering ca. 80% of RM workflow)
- Optimise acquisition time with respect to event time

What?

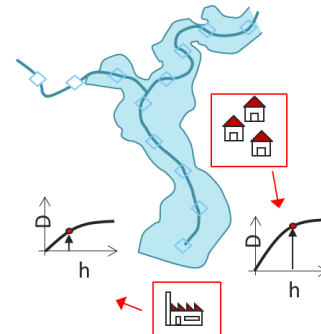
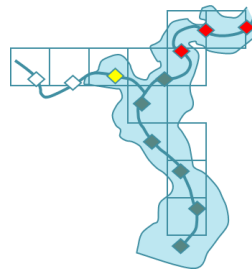
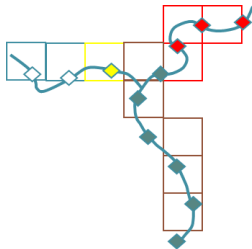
- EFAS warning based pre-tasking of images (in absence of user activation)
- Warning issued on forecast-based flood hazard mapping & risk assessment
 - Warning is sent 24h before the expected event to RM service provider: Event time, AOI with high potential impact, suggestion of acquisition dates
 - As a consequence radar satellites are tasked (10-30m resolution)



Flood location & magnitude Flood prone areas Exposure => potential impact

Flood return periods

- high
- medium
- low





Study aerial component

- A study for the use of aerial components for image provision has been requested by the Copernicus users and by consequence included and accepted in the Copernicus work-program 2015.

Framework contract established for 2 lots

- Request by DG JRC through a dedicated order form
- After signature by both parties the contractor has 48 Hr to deliver
- Communication protocol to monitor the work

Manned aerial component



- 10 – 20 cm resolution
- Ortho rectified imagery (RGB and NIR + Digital surface model)
- Max 625 km² per module
- Price per module

Unmanned aerial component



- 10 cm resolution
- Ortho rectified imagery (RGB and NIR + Digital surface model)
- Up to 40 km²
- Price per km²



Conclusion and recommendations

unmanned

Need for a “emergency Notam” to be able to fly in a segregated airspace for time x without altitude limitation in the Area Of Interest

Higher flight altitude means less time on site for data acquisition and less time for data processing, this is key to the success of UAV missions

Need for European regulation with the same procedure in all countries

Can be integrated as an operational service in Copernicus EMS in rapid mode → still some issues with regulations needs to be resolved.

manned

Mature market segment since decades

Flight permissions are well established

Ability to cover large areas (up to 625 km²) with superior resolution

Important for high quality damage assessments in urban areas

Perfectly compatible with using VHR

Could be integrated as an operational service in Copernicus EMS as we speak.

We suggest to continue with the feasibility study as written down in the work program 2018 and to consider a full operational aerial component for image acquisition for the work program 2019.

Advantages aerial imagery

Higher flexibility of deployment and better timeliness

Superior resolution over VHR satellite imagery

After processing accurate ortho rectified imagery and digital surface model

Quick deployable (when flight permissions are solved)

Rapid revisit opportunities (monitoring)

Can fly under cloud canopy (ex. To outline floods in urban areas)

Rapid revisit opportunities (monitoring)



Emergency
Management

Some examples – italy EQ







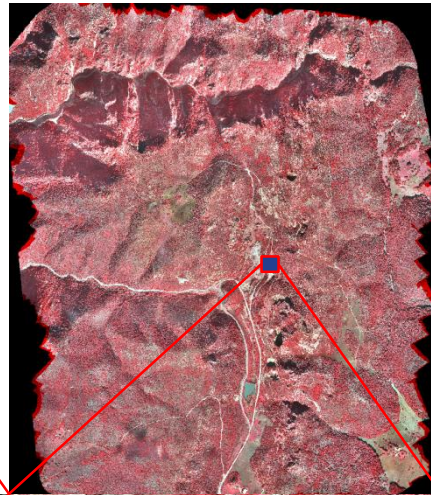
Some examples – UAV Acquaresi mining site

Deliverables per UAV flight (lightweight fixed wing) – 10 km² - 10 cm resolution

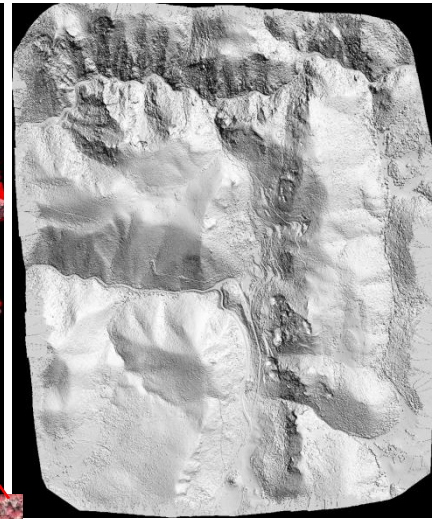
RGB true color ortho



NIR false color ortho



Digital surface model





Possible synergy with HAPS

- Quick data transmission to local servers from terrestrial UAV derived imagery over disaster area
- Depending on the payload of the HAPS device
 - Optical sensors (superior resolution then VHR)
 - Radar
 - Video streaming