Hurricane Matthew Recovery Observatory

Recovery Observatory Operations Plan

Version 4

As of October 2nd, 2017

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PURPOSE OF DOCUMENT AND EXECUTIVE SUMMARY

Purpose of document

The aim of this document is to provide an overview of the planned operations for the Haiti post Hurricane Matthew Recovery Observatory (RO). It lists the objectives of the RO, the users, partners and practitioners involved in RO establishment and operations. It provides a summary listing of planned products to support recovery planning and monitoring, as well as high-level associated data requirements. It provides an outline of planning for capacity building activities. It also provides a vision for RO management and the timeline for establishment and operations.

This version of the Operations Plan combines previous ROOP updates, in particular v2.4 generated after the user workshop with input received from partners as a results of the new needs identified at the workshop.

Executive Summary

The post-Matthew RO was triggered by the CEOS Executive end December 2016. It will run for four years (2017-2020 inclusive) and addresses the needs of the recovery community involved in recovery and rehabilitation after the impact of Hurricane Matthew in the three departments of southwest Haiti that were most affected: Grand'Anse, Sud and Nippes.

The project is jointly managed by a Steering Committee made up of CNIGS, CIAT and ONEV on the Haitian side; by GFDRR/WB and UNDP on the international DRM stakeholder side; and by CNES, ASI and CSA on the CEOS side. The project leader is CNIGS, with technical support from CNES.

This 4 years real life demonstrator is the first and unique RO led in the framework of CEOS WG Disasters. It is a no exchange of funds project where each partner brings an in-kind contribution financed from their own resources. It is an open partnership of volunteer organizations and new members are welcome to propose contributions that enhance the functionality of the RO. The aim is (i) to address issues related to a concrete project led with local users and stakeholders, and (ii) through lessons learnt, to define a concept of generic and replicable RO, for further use outside CEOS context.

The RO aims to offer free and open access to data and information useful in planning and monitoring recovery, but also to serve as a forum of exchange and collaboration on recovery related issues to foster resilience at the community level.

In particular, the RO will:

- Create an easy to access, interactive forum for recovery users to access data and information products, exchange on results and objectives, and generally better understand how EO can support long-term recovery planning and monitoring;
- Serve as a focal point for satellite image experts and local specialists to better serve the region and answer local needs effectively;
- Offer a source of shared value to foster the development of tailor-made information;
- Serve as a link to mobilize public institutions and stakeholders around recovery goals.

After an initial period of operations, the post Matthew RO will be evaluated in late 2017 or early 2018. Lessons learned will be documented to improve the operations of the post Matthew RO until 2020 and to define a generic concept of RO that should result in broader use of EO during the recovery phase for future major disasters events.

The near term products to be produced by fall 2017 for the RO are listed in the table below. According to the users' needs and to partners' capabilities, other products may be envisaged in the mid-term. In the same way, other value-adding capabilities can be provided by RO partners in the future.

Product	Key user	Value adding	Satellite data, other key data
Built area status	CIAT/Ministère de la planification	Copernicus Risk and Recovery SERTIT (methodology) / CNIGS (production)	Optical very high-resolution (less than 1m)
Land cover whole zone	Couche de base tout utilisateur	CNIGS / CESBIO /SERTIT	SPOT-6-7, Sentinel-2
Forest change and environmental impact	ONEV	Copernicus Risk and Recovery Other TBD	SPOT-6-7, Sentinel-2, hot spots with optical very high resolution
Agriculture	Ministère de l'agriculture	Copernicus Risk and Recovery CNIGS / SERTIT Other TBD	SPOT-6-7, Sentinel-2, hot spots with optical very high resolution
Macaya Parc	ANAP/ONEV	Copernicus Risk and Recovery Other TBD	Optical very high-resolution, SAR medium to high resolution
Watershed changes	ONEV/ Ministère de l'agriculture	CIMA Foundation	LIDAR DEM 1m/20cm vertical, SAR
Terrain displacement	BME	EOST, NASA, other TBD	SAR interferometry, Pleiades optical very high-resolution

In addition to the value adding products identified above, the RO aims to work with local users to develop capacity relating to geospatial information.

Capacity building in the context of the RO refers essentially to building capacity within the Haitian government for improved use of satellite EO in the thematic areas. This includes training in relation to EO data treatment (for CNIGS) and product generation, as well as training in the use of thematic products within line ministries – Civil protection, agriculture, environment, etc.

This capacity building effort will include a significant component for Haitian universities, which are viewed as a critical relay for capacity in country. In addition to training, the RO plans some university-based activities tied to RO usage such as Hackathons and App development prizes to encourage local uptake of data and products in the RO.

1. OBJECTIVES AND OVERVIEW OF THE RECOVERY OBSERVATORY

The Recovery Observatory pilot has been created within CEOS WG Disasters in 2014 with the following objectives:

- Demonstrate in a high-profile context the value of using satellite Earth Observations to support Recovery from a major disaster:
    - near-term (e.g. baseline for recovery); and
    - long-term (e.g. major recovery planning and monitoring, estimated to be about 3 to 4 years).
- Work with the recovery community to define a sustainable vision for increased use of satellite Earth observations in support of recovery.
- Establish institutional relationships between CEOS and stakeholders from the international recovery community.
- Foster innovation around high-technology applications to support recovery.

The Recovery Observatory activities began with a preparatory phase in 2014-15, during which the IT infrastructure to receive an Observatory was conceived and developed, and during which satellite agencies refined their vision to receive products and data, and host a portal, which will serve as a forum for information exchange around the recovery.

Figure 1. Screen capture of demo RO platform, loaded with data from Haiti earthquake response

In 2016, CEOS finalised the generic IT infrastructure (DotCloud, figure 1) necessary to trigger a RO, and began a series of demonstration activities showcasing different applications. Several of these, including housing reconstruction (Nepal), transportation infrastructure monitoring (Malawi), and agricultural change detection (Malawi), are expected to prove directly relevant to the RO in Haiti.

The 4-year, real life RO demonstrator was triggered by the CEOS Executive end December 2016, for addressing the post Hurricane Matthew situation in Haiti. It will run for four years (2017-2020 inclusive) and addresses the needs of the recovery community involved in recovery and rehabilitation after the impact of Matthew in the three departments of southwest Haiti that were most affected: Grand'Anse, Sud and Nippes.

The RO aims to offer free and open access to data and information useful in planning and monitoring recovery, but also to serve as a forum of exchange and collaboration on recovery related issues to foster resilience at the community level. The RO is an open partnership of volunteer organizations and new members are welcome to propose contributions that enhance the functionality of the observatory.

In particular, the RO will:

- Create an easy to access, interactive forum for recovery users to access data and information products, exchange on results and objectives, and generally better understand how EO can support long-term recovery planning and monitoring;
- Serve as a focal point for satellite image experts and local specialists to better serve the region and answer local needs effectively;
- Offer a source of shared value to foster the development of tailor-made information;
- Serve as a link to mobilize public institutions and stakeholders around recovery goals.

The planned support to thematic sectors includes:

- Agriculture and food security;
- Forests and protected areas;
- Coastal zone monitoring and coastal settlements;
- Population displacement and rural settlements;
- Health and vector-borne diseases;
- Road networks and accessibility;
- Landslides and water system monitoring (river bed and river discharge monitoring).

After an initial period of operations, the post Matthew RO will be evaluated in late 2017 or early 2018. Lessons learnt will be documented to improve the operations of the post Matthew RO until 2020.

In a more general way, the post Matthew “real-life” demonstrator will contribute to:

- identify where EO can bring useful information in the Recovery phase and define “best practice” for the DRM community;
- demonstrate usefulness of satellite EO, together with other datasets, on a large scale for long-term recovery monitoring;
- demonstrate applications tied to very high resolution imagery and to high frequency high resolution images, to open the way to broader use of satellite EO after smaller and more regular events.
- define a generic and replicable concept of RO, that should result in broader use of EO during the recovery phase for future major disasters events.

2. IMPACT OF MATTHEW IN HAITI

This section presents the overall impact of Hurricane Matthew. For greater clarity, it should be stated that post Matthew RO covers the area of the three departments in the southwest part of Haiti: Grand'-Anse, Sud, and Nippes departments (cf figure 2).

Figure 2. Area of Interest of the Recovery Observatory

While the impact of Hurricane Matthew was felt throughout Haiti, the impact was most devastating in the southwest portions of the country, as seen in figure 3, below.

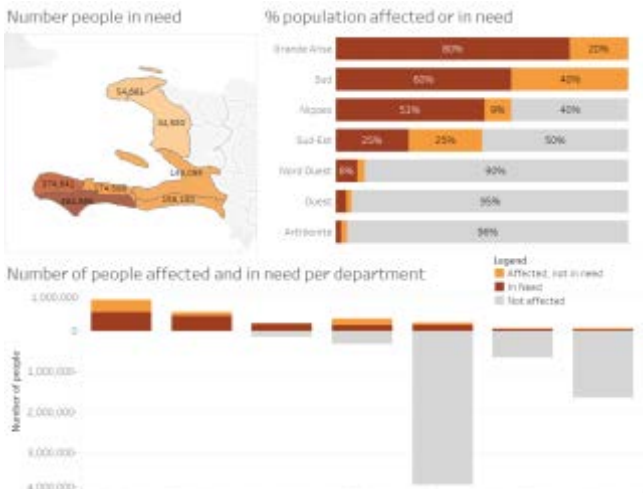


Figure 3. People affected and in need as % of total. Source UNDA October 2016.

Hurricane Matthew formed on September 28th, 2016 north of Columbia and dissipated on October 10th, in the Canadian Maritimes. At its peak, it was the first Category 5 hurricane in the Caribbean since 2007. It caused widespread damage from Columbia through Jamaica, the Dominican Republic, Cuba, the Bahamas, and the US.

Nowhere was the damage more acute than in southwest Haiti, where it struck as a Category 4 storm on October 4th, the first Category 4 hurricane to strike Haiti since Hurricane Cleo in 1964. With upwards of 1,300 lives lost across the Caribbean, and more than a 1,000 lives lost in Haiti, the storm is the deadliest hurricane to strike since Jeanne in 2004 in the Caribbean, or Stan and Katrina in 2005 in Central America, Mexico, or the US.

Figure 4. Hurricane track of Matthew, courtesy NOAA/NHC. Background image courtesy NASA.

Figures 5 and 6, below, show a track of Hurricane Matthew during the period that it was classified as a hurricane, with estimated rainfalls in major areas affected, and estimated wind strength in areas most affected. While flooding caused significant damage and loss of life, the main impact was felt from the wind, which in some regions has destroyed more than 95% of buildings and has completely destroyed trees and agriculture. In addition, widespread environmental damage has been caused, especially in protected areas where forests have been flattened and in coastal areas.

It is worth noting that the area most affected has the largest concentration of natural protected areas in Haiti. It is also worth noting that nine months after the event, there is still widespread destruction in the affected areas, especially around Jeremie, and that many locals have moved to precarious, temporary dwellings, increasing vulnerability.

Figure 5. Est. rainfall of Matthew (NOAA)

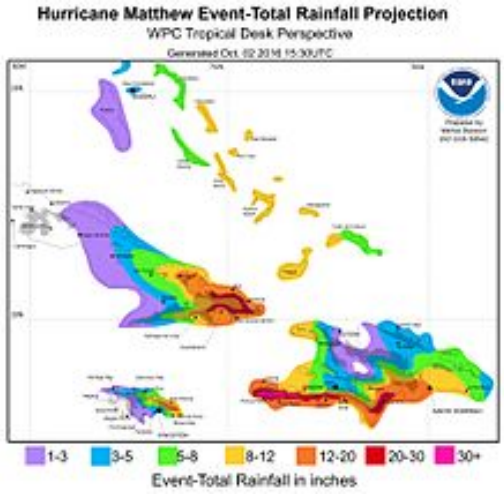


Figure 6. Est. cumulative wind of Matthew (NOAA)

Early response:

Both the International Charter and the Copernicus Emergency mapping Service were activated, as well as the Humanitarian Open Street Map Team (HOT) in Haiti. The maps in figures 6 and 7, below, show areas for which emergency response products were generated in the context of the Charter and Copernicus. It is worth noting that while a large number of areas were surveyed, the entire area is not covered and that it is necessary for the RO to develop a comprehensive baseline pre-event and post-event with data separate from the Charter and Copernicus data.

Charter areas in Haïti

Figure 7. Areas of Charter activation in Haiti. Main impact in southwest Haiti.

Copernicus EMS areas in Haïti

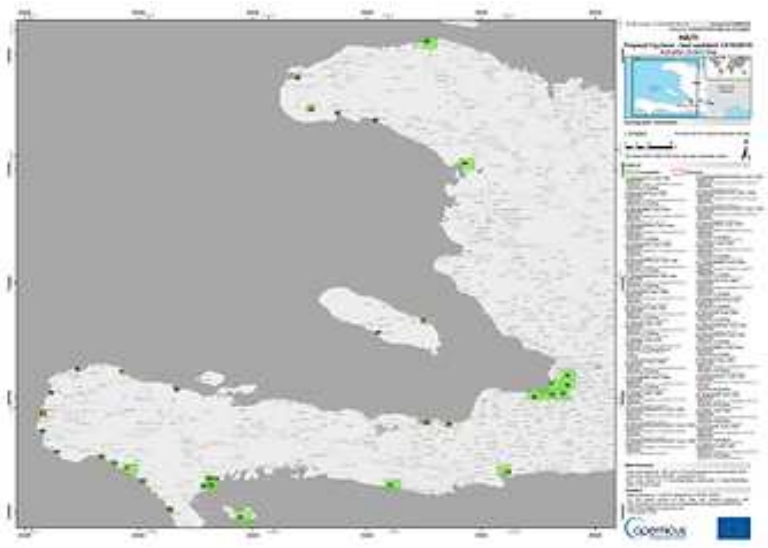
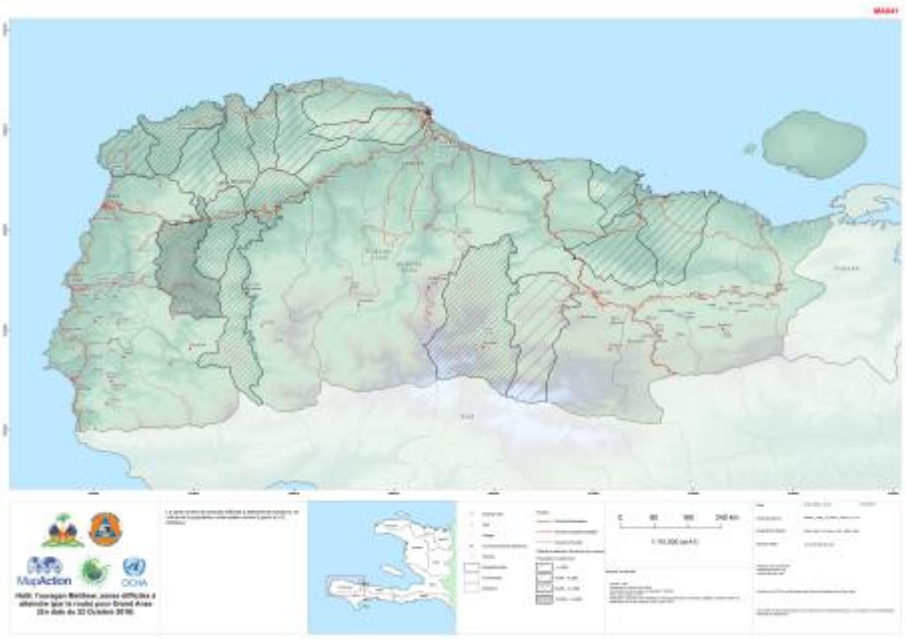


Figure 8. Copernicus EMS product areas. Some 30 areas selected for grading and delineation mapping.

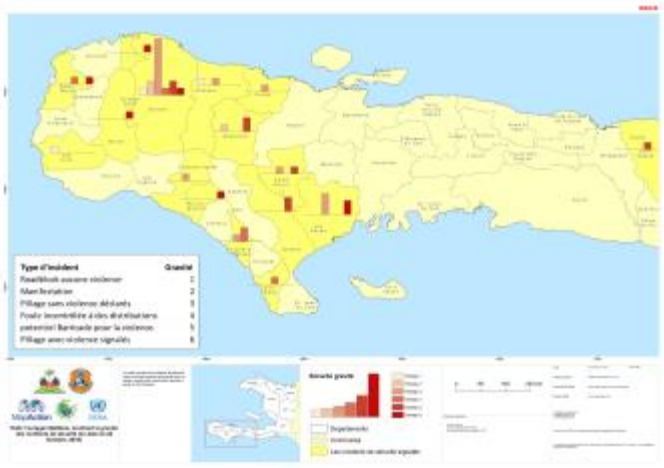
The official death toll exceeded 1,000 (unofficial estimates place the deaths at 1,300). There are 2.1 million people estimated to be affected by hurricane Matthew countrywide, of whom 1.4 million are in need of assistance (DPC 10/10/2016). Damage to housing in the two most affected departments is severe, reaching 90% of built infrastructure, and in agricultural areas the destruction is qualified as “90” in Sud and “total” in Grand’Anse (161014 Situational Analysis UN). Reports indicate a large number of improvised shelters or gatherings of displaced persons, which are often spontaneous and not centrally coordinated. This demonstrates the value of satellite EO imaging, which presents an up-to-date and unbiased assessment of the situation.

Figure 9. Hard to reach areas in Grand'Anse, late October, courtesy MapAction.



In the days and weeks following Hurricane Matthew's passage, large areas remained inaccessible due to damaged roads (cf. figure 8, left). Consultations with CIAT in early 2017 indicated that while roads have now returned to 'normal', there remains a significant challenge in regard to road access after major rainfall in the area. Many of the roads are small dirt tracks that become impassable after major rainstorms.

In addition, the widespread damage increased the vulnerability of populations. Rainstorms in the weeks following Matthew caused deaths and further damage. Food remains in short supply and humanitarian assistance is the main source of food for the affected area. In the weeks and months following the hurricane, security incidents erupted as shown in figure 9, below. More than six months after the event, the area remains vulnerable and susceptible to further damage after rainstorms.



There is widespread devastation in rural areas, including destruction of agricultural plantations and livelihoods. Reconstruction is expected to last years, and with difficult communications and a large affected area, satellite imagery remains one of the most effeective means of obtaining a holistic assessment of the situation.

Figure 10. Main security incident distribution late October 2016, source MapAction

3. RO USERS, PRACTITIONERS AND PARTNERS

The creation of the post Matthew RO provides both Haitian (local/community-level and national) and international recovery specialists and disaster managers with data and products relating to recovery planning and monitoring. Satellite-based information provides a holistic view of the recovery process and serves to complement other information types.

The RO is expected to be integrated in the Haitian data and information system provision. It offers a unique capability to distribute and access large data sets over a single geographic area, and search for and compare data and products.

At the recent user workshop (end May 2017), it was agreed that the RO will be linked to other information system and tools in Haiti, such as the Haiti Data portal, RASOR (Rapid Analysis and Spatialisation of Risk web tool) and the KAL-Haiti data base. This will be enabled through a common access portal to be established by CNIGS for all the portals.

The main benefits from the establishment of the RO are listed below.

- provide key information (analytical, geospatial) about the Recovery to support Haitian governmental organisations in their decision-making processes and progress monitoring;
- obtain access to regular imaging of South West Haiti over 4 years, especially for higher resolution data not typically available;
- demonstrate usefulness of frequent satellite EO (both high and very high resolution, radar and optical), together with other datasets, through key thematic products specified by Haitian users;
- compile in a single framework the key data sets (both satellite images and large number of other data) and use them seamlessly thanks to DotCloud, in connection with Haitian data infrastructures;

The post Matthew RO is strongly linked to the governmental and international organizations responsible for recovery activities in the affected areas, with a champion within the national government and strong local relays.

National Users: three key national users and partners have been approached in October 2016 as early RO partners. They have expressed a strong interest in it and have agreed in coordinating input from other national users. These are:

"Comité interministeriel de l'aménagement du territoire" (CIAT): The CIAT mission is to define government policy for land use planning, for protection and management of water sheds, water management, urbanism and public works. The institution was created in response to a need for greater coordination between government departments. The CIAT has been approached to play a federating role with regard to user requirements for the RO. CIAT has expressed strong support for the RO concept in an official letter to the RO Team, identifying a need for a recovery baseline documenting damage in the zone, and regular monitoring in relation to agriculture, forests and protected zones, coastal zones and coastal settlements, population movements and rural habitat, as well as landslides and changes to water courses.

"Centre national d'information geo-spatiale" (CNIGS): The National Centre for Geo-Spatial Information has agreed to be the champion for the RO within the Haiti government, ensuring both delivery of the RO infrastructure in Haiti and serving as a catalyst for capacity building and EO use for disaster recovery within Haiti.

"Observatoire national de l'environnement et de la vulnérabilité" (ONEV) : under the Ministry of Environment, the ONEV has as objective to create an institutional and technical mechanism for the production, analysis and dissemination of environmental information necessary to support decision making.

These three early partners coordinate the participation of a large number of national users, including: Ministère de la Planification et de la Coopération externe (MPCE) ; Ministère de l'Environnement (MDE) ; Ministère des Travaux Publics, Transports et Communications (MTPTC); Ministère de l'Agriculture, des Ressources Naturelles et du Développement Rural (MARNDR) ; Ministère de l'Intérieur et des Collectivités Territoriales (MICT); Direction de la Protection Civile (DPC).

In addition, Haitian universities and institutes of higher learning are expected to play a role as centers of excellence and partners in the RO. These include: UEH, UNIQ, Université Notre-Dame des Cayes.

The RO partners include the users listed above, and the organizations delivering data or products to the RO. This refers to both CEOS space agencies and other organisations having expressed a desire to contribute. This list of other organizations is expected to grow after the RO is announced, as the ROOT makes efforts to consolidate the RO establishment and promote the RO both in Haiti and internationally.

CEOS Agencies:
The following CEOS agencies have expressed a willingness to contribute to the RO:

- **ASI**: CSK archived and newly acquired data; ASI researchers will also provide terrain displacement products based on TSX and CSK data analysis; support to Italian providers of value-added products. CIMA Foundation to provide implementation of flood risk scenarios, based on the high resolution DEM, in RASOR for full RO area; monitoring of changes; and management support. Coordination of discussions with CONAE for possible SAOCOM validation work in RO area.

- **China/AOE/CAS**: scientific research on RO area of interest and possible data contribution (not confirmed).

- **CNES**: archived and newly acquired Pleiades and SPOT data; IT infrastructure; project management support; ROOT secretariat and general coordination support; value adding support to French industry (SERTIT to provide support in several thematic areas including agriculture, transport networks, and environment).

- **ESA**: ESA is proposing the following contribution in the course of year 2017; the ESA contribution is to be defined in the successive years:

    - Sentinel-1, 2 and 3 data and technical advice

    - Tools and services for terrain motion mapping, landslide hazard mapping and possibly other relevant geohazard types to support the exploitation of different EO data sources such as for instance some national EO missions from European partners and the Sentinel-1 and 2 missions' data of EU's Copernicus programme; to acheive this the ESA funded Geohazards Exploitation Platform (GEP) will be made available to provide access to an EO data processing environment allowing pre-defined specialist users from the RO team and additional pre-defined users to access value adding chains such as optical based terrain motion chains (e.g. the MPIC OPT chain of CNRS EOST), conventional InSAR chains (e.g. the one from CNES DIAPASON), advanced InSAR chains (e.g. the SBAS chain of CNR IREA) and other relevant tools.

- **NASA**: NASA landslide monitoring product over RO AoI; GFMS for flood near casts and forecasts in AoI; MODIS flood monitoring in AoI after new events; EO-1 historical archive; support in accessing CEOS flood pilot data and products produced over the area in the past.

- **USGS**: Landsat-8 data.

- **NOAA**: support from previous flood pilot work in the area; coordination with meteorological community and HRC flash flood warning; coastal zone monitoring for reef health; vector-borne disease research using algorithms developed for other regions.

- **CSA**: possible contribution of RADARSAT imagery.

- **DLR**: contribution of TSX imagery – complete imaging of RO area in successive coverages (two acquired so far, several more planned) to support change detection.

Several DRM stakeholders have expressed a willingness to work with local partners and CEOS in implementing the RO, including:

- UNDP (which coordinates the input of other UN agencies),

- World Bank,

- GFDRR,

- UNEP,

- UNOPS,

- UNOOSA.

A number of research institutes have indicated a possible willingness to contribute should the RO be triggered, in various disciplines: CIMH (Caribbean Institute for Hydrology and Meteorology), CIMA (Italy - hydrology, exposure, and vulnerability assessment), IRD (France – Research Institute for Development), CIRAD (France – Agricultural Research for development), CESBIO (France – Centre d'etudes spatiales de la biosphere).

Other organizations active in Haiti that have offered support for the RO include NGO Potentiel 3.0, as well as OSM-Haiti community, which has offered to collaborate by using high resolution satellite imagery to improve base maps and chart humanitarian actions and agricultural indices, working with local actors in the field, especially the University Nouvelle Grande Anse.

4. RECOVERY PLANNING AND RO REQUIREMENTS

In its letter of support for the RO (29th November 2016), the CIAT identified the key sectors for which support was required for recovery planning and monitoring. The planned support to thematic sectors included:

- Agriculture and food security;
- Forests and protected areas;
- Coastal zone monitoring and coastal settlements;
- Population displacement and rural settlements;
- Health and vector-borne diseases;
- Road networks and accessibility;
- Landslides and water system monitoring (river bed and river discharge monitoring).

EO based value added products:

Figure 11 below shows the currently planned products (as of July 2017) that will be developed in relation to these sectors, and the frequency of production.

Figure 11. Planned RO products over 2017-2020

Sector	Product	Frequency	Data required	Area of interest	Main users	Priority	Development lead & Comments
Baseline mapping	Pre-event baseline landcover map of area of interest	1	HR optical	Entire AoI	Baseline for all users	Critical	SERTIT/ CNIGS (CEOS Nepal demonstrator experience)
Baseline mapping	Damage map showing categories of damage over AoI	1	VHR optical	Entire AoI	Baseline for all users	Critical	SERTIT/ CNIGS (CEOS Nepal demonstrator experience)
Agriculture and Food Security	Agricultural change assessment (science product)	From early to 2016 to after event and once yearly afterwards	HR and VHR optical	Base product over whole area and spotlight product in Les Cayes plain.	Ministry of Agriculture , MARNDR, MINFIN	Very important	Copernicus EMS R&R SERTIT/ CNIGS/ CESBIO Change in landcover Crops inventory in main crop land areas Crop replanting
Forests and Protected Areas	Status of regeneration in protected areas – SPOT-based classification and change detection (routine product)	Yearly	HR and VHR optical	Protected areas Parc Macaya (20 km²) and surrounding s	ONEV, UNEP	Very important. Sample product over Parc Makaya for User Workshop.	Copernicus EMS R&R SERTIT/ CNIGS

Coastal area monitoring and coastal settlements	Coastal zone monitoring (focus on coastline change – science product)	Yearly	HR and VHR optical	Southern coast only	ONEV, UNEP	Important; sample product for User Workshop between Dame Marie and Les Irois.	SERTIT/ CNIGS
Population displacement and rural settlements	Progress of housing reconstruction and location of temporary dwellings (routine product)	Before/After Spring 2017 Fall 2017 Spring 2018 Fall 2018 if required	VHR optical	Most affected areas near Jeremie	Ministere de l'Interieur, UN Habitat, IOM	Important; sample product for User Workshop near Jeremie	Copernicus EMS R&R SERTIT/ CNIGS Damaged building removal and construction Change in urban land use, morphology and density Temporary dwellings Indicate type of dwelling reconstruction
Health	Mapping of risk of vector-borne diseases	Baseline i2017 update once per year	TBD	High risk areas	Ministry of Health, WHO/ PAHO	TBD	TBD
Road networks and Accessibility	Status of critical transportation points (input to Rural Access Index – routine product)	Yearly + update after major tropical storm or hurricane impact	VHR Optical and VHR or HR SAR (after storms)	Critical points from RAI – to be identified and prioritised with CIAT and UNOPS;	CIAT, UNOPS	Important; sample product for User Workshop over Grand' Anse	SERTIT/ CNIGS (CEOS Malawi demonstrator experience usingPleiades data)
Landslides	Ground movements: (landslide and fault mapping and monitoring (science product)	Baseline and daily – detailed InSAR over long periods on demand in limited areas	VHR and HR InSAR, HR optical	Whole area low resolution and selected "hotspots" with InSAR	Protection civile	Important	EOST CEOS landslide pilot linkage. NASA landslide product; InSAR landslide monitoring products.
Water System Monitoring	Water basin monitoring	1 baseline and update after major storms	VHR and HR SAR, and optical	Entire area with hotspot identification for SAR-based change detection products	ONEV, UNEP	Very important	CIMA Foundation. Visualization in RASOR

This table 11 was initially produced after early discussions with stakeholders in early 2017. It was subsequently modified based on discussions held at the May 2017 user workshop, where specific sample products were produced before the workshop, and presented for discussion.

These products start from the baseline assessment necessary as a starting point for damage. These baseline assessments will be derived from data collected during the early response to hurricane Matthew in the context of the International Charter and the Copernicus Emergency Management Service activations.

In describing these products, an effort has been made to distinguish routine products, which are typically produced during response and could be generated for a longer period to support recovery monitoring, and science products, which represent more experimental products where tailoring may be required to obtain useful results over the RO lifetime. In some cases, science products may also be routinely generated, such as for interferometric analysis of landslides, to address a science use as opposed to an operational use.

This table is expected to evolve over the lifecycle of the RO, with new products developed based on the same imagery sets as new value-added providers are identified.

Figure 12 shows a subset of the figure 11 products with a view to showing which products have been designed as priorities during the May 2017 user workshop, and will be produced and available by fall 2017.

Figure 12. Priority RO products defined during the May 2017 user workshop

Product	Key user	Value adding	Satellite data, other key data
Built area status	CIAT / Ministère de la planification (MPCE)	CEMS Risk&Recovery SERTIT (methodology) / CNIGS (production)	Optical very high-resolution (less than 1M)
Land cover whole zone	Couche de base tout utilisateur	CNIGS/CESBIO /SERTIT	SPOT-6, Sentinel-2
Forest change and environmental impact	ONEV / Ministère Environnement (MDE)	CEMS Risk&Recovery	SPOT, Sentinel-2, hot spots with optical very high resolution
Agriculture	Ministère de l'agriculture (MARNDR)	CEMS Risk&Recovery CNIGS/SERTIT	SPOT, Sentinel-2, hot spots with optical very high resolution
Macaya Parc	ANAP & ONEV / Ministère Environnement (MDE)	CEMS Risk&Recovery SERTIT	Optical very high-resolution, SAR medium to high resolution
Watershed changes	ONEV (MDE) & Ministère de l'agriculture (MARNDR)	CIMA Foundation	LIDSAR DEM 1m/20cm vertical, SAR
Terrain displacement	BME / Ministère Travaux Publics (MTPTC)	EOST, NASA, other TBD	SAR interferometry, Pleiades optical very high-resolution

There are a number of existing projects and tools in Haiti, which will be directly linked to the RO to ensure complementarity and synergistic use of resources. These include:

- KAL-Haiti and Kalideos;
- www.haitidata.org ;
- RASOR Haiti.

These projects are described in detail in the annex of this document.

Capacity Building:

In addition to the products identified above, the RO aims to work with local users to develop capacity relating to geospatial information.

Capacity building in the context of the RO refers essentially to building capacity within the Haitian government for improved use of satellite EO in the thematic areas. This includes training in relation to EO data processing (for CNIGS) and product generation, as well as training in the use of thematic products within line ministries – Civil protection, agriculture, environment, etc. This capacity building effort will include a significant component for Haitian universities, which are viewed as a critical relay for capacity in country. In addition to training, the RO plans some university-based activities tied to RO usage such as Hackathons and App development prizes to encourage local uptake of data and products in the RO.

A number of CEOS agencies have agreed to play an active role in management and implementation of the RO. These include CNES, ASI and CSA, who sit on the Steering Committee. For targeted activities, other agencies may join to support capacity building and other needed activities. These agencies will coordinate a best efforts project to deliver training in country, with the following timeframe:

- End 2017 or early 2018 – definition and development of Capacity Development Plan, based on output of early evaluation mission and steady state operation of RO from end 2017;
- Spring 2018 – approval of Capacity Development Plan by Haiti RO Steering Committee;
- Fall 2018 – first training and RO related events in Haitian universities.

The Capacity Development Plan component will address development of both governmental and academic capacity relating to EO imagery and derived products.

5. DATA ACQUISITION PLAN

The table below describes the main types of satellite data required, the coverage of data types per acquisition, and main applications for data use. The data acquisition plan also requires other types of data to be provided, such as in-situ data, socio-economic data and other data sets. Each partner will examine which data might be most useful to the RO.

Figure 13. Generic sensor needs over 2017-2020

Data Types	Possible sensor contribution	Images	Main applications
VHR Optical Pixel size: < 1 m	Pleiades, Geoeye, Wordlview-1, Worldview-2, Worldview-3, QuickBird	GeoEye, Worldview-1/2/3: approx. 225 km², swath approx. 15 km Pleiades: 400 km², swath 20 km Could be tasked per sq km to fit specific AOIs	Housing, transport, health and education Agriculture, landcover, environmental monitoring
HR Optical Pixel size: 1 m < 30 m	Landsat-8, Sentinel-2, SPOT 6m	SPOT: 3,600 km², swath 60 km Landsat-8: 34,000 km², swath 185 km, Sentinel-2: 84,100 km², swath 290 km	Agriculture, landcover, landslides, environmental monitoring
Medium/Low Resolution Optical Pixel size: > 30 m	Sentinel-3, MODIS	MODIS: 5,428,900 km², swath 2330 km Sentinel-3: 1,612,900 km², swath 1270 km	Coastal apps, environmental monitoring
VHR SAR Pixel size: < 4 m	Cosmo-SkyMed, ALOS-2 TerraSAR-X, Radarsat-2	Cosmo-SkyMed,TerraSAR-X, Radardat-2, in Spotlight mode the swath is 10 km. ALOS-2 Spotlight mode: Swath 25 km Sentinel-1, SM full res. mode: Swath 80 km	Focus on science products (interferometry, polarimetry) Landslides Ground movements Fault mapping Flood products
HR SAR Pixel size:	Cosmo-SkyMed, ALOS-2, Sentinel-1	Cosmo-SkyMed, TerraSAR-X, ALOS-2 Stripmap modes or	Focus on science products (interferometry, polarimetry)

4 m < 30 m	TerraSAR-X, Radarsat-2 (to be confirmed)	ALOS-2 fine mode: Swath from 30 km to 50 km Cosmo-SkyMed, TerraSAR-X, ALOS-2, Radarsat-2 ScanSAR modes and Sentinel-1 in SM/IW high res mode: Swath from 200 km to 350 km	Ground movements (fault mapping, landslides) Flood products
DEM	World DEM, Lidar DEM	Entire AoI	Flood and landslide hazard products

Working from the data table above and the products table in section 4, above, CEOS has developed a detailed assessment of the first data sets required to begin work on the RO. This assessment is captured in Figure 14, below. The table is meant to be presented for approval by CEOS Plenary in fall 2017, and will be resubmitted in an updated form based on evolving needs at the SIT meeting in spring 2018. The table does not include images that have open access policies such as Landsat-8 or Sentinel imagery.

In conjunction with this, resources are being identified for the value adding work, which will require a combination of contributions in kind through research institutes and academia, and resources committed through CEOS agencies, donor organisations and development agencies to support value-adding work.

The table below was developed considering the applications and products listed in tables 11 and 12, and the following broader considerations:

- The complete AOI of three departments (100 km x 80 km, 8000 km²) is systematically completely covered by HR sensors (Sentinel-1 and 2, Landsat-8), and these data are in addition to the table below

- A recovery monitoring activity based on VHR optical imagery is expected over 4 affected areas. The extent of each area is 15 km² x 15 km².

- A recovery monitoring activity based on VHR SAR imagery is expected over 4 areas. The proposed extent of each area is 15 km² x 15 km².

- During the period of 4 years, it is assumed that 2 subsequent events may have a major impact on the affected area, requiring opportunistic imaging.

Figure 14. CEOS data request

Figure 14, below, describes the current understanding of data needs based on planned applications and products. It is currently under discussion with CEOS partners and subject to change.

Period/Sensor	SPOT	Pleiades	Cosmo-Skymed	TerraSAR-X
Baseline Data				
Pre-event	10		27	8
Post-event	4	8	5	11
Monitoring Data				
2017	8	30	154	30
2018	8	30	154	30
2019	8	30	154	30
2020	8	30	154	30
Total	**46**	**128**	**624**	**139**
Main Applications	Agriculture, Forests and protected areas, health	Coastal zone monitoring, population displacement, road networks, rural settlements	Water system monitoring – rapid change detection/ obstructions, Terrain displacement science products based on InSAR (landslides, subsidence, land motion); 24 desc + 24 asc scenes per year for each of the 3 AOI; total number of scenes TBC based on final acquisition plan	Landslides (wide area coverage for detection of sensitive areas of change

Period/Sensor	RADARSAT-2	ALOS-2	ROSKOSMOS VHR	Sentinel 2
Baseline Data				
Pre-event	3	6		3
Post-event	7	6	4	6
Monitoring Data				
2017	10	6	15	30
2018	10	6	15	30
2019	10	6	15	30
2020	10	6	15	30
Total	**50**	**36**	**64**	**129**
Main Applications	Water system monitoring, post event status	Change detection (also landslide coherence)	Coastal zone monitoring, population displacement, road networks, rural settlements	Land Use (all topics), Agriculture, Forests and protected areas

6. TIMELINE AND SCHEDULE

To September 2017 – RO Establishment:

RO establishment will run from January through end of summer 2017. This includes solicitation of new partnerships (especially for value-adding), preparation of MOUs with Haitian users and partners, establishment of IT infrastructure and a user workshop in Haiti (which was held May 30 and 31) to provide further input to the Operations Plan and finalise the RO baseline.

During this set up period, work includes the following activities:

- First operations: upload of Charter and Copernicus data and products, and creation of damage baseline from imagery and PDNA, development of first products for recovery planning and monitoring;
- Interface with stakeholders for precise definition of needs and identification of national entities to involve, MOU discussion; establishment of national "champion" for RO in Haiti.
- Interface with the national institutions for definition of the project, product needs, coordination with other initiatives; validation of product list, user validation process;
- Definition of the acquisition plan and initial liaison with agencies;
- Establishment of formal institutional relationship with national entities (definition of role and responsibilities, identification of funding sources if available);
- Elaboration of the RO activity grid (products, events, forum);
- Reporting to CEOS on development of RO and recommendations on issues to address.

To end February 2018 – RO Commissioning fall 2017 and early 2018:

RO commissioning involves incorporating the first products into the RO and ensuring easy access; animating the user forum; encouraging and promoting RO use. This activity will include the first "early evaluation", with a report to the Steering Committee on issues and recommendations going forward. Building of research, science plan, and capacity development and training activities.

To end 2020 – RO Steady-state Operations:

RO operations ensure IT updates, engage in capacity building activities, generate regular products, report on RO annually to stakeholders and partners. On an on-going basis, the RO will require:

- Liaison and development of institutional relationships, new relationship building;
- Promotion and outreach (including long term promotion of RO within country);
- Development of lessons learned and replication of RO model (in other countries);
- Value-adding coordination and new product development raising from research and R&D activities; new value added partners;
- Regular Report of technical results to national institutions;
- Support to national users (technical and policy), including new service development;
- Coordination and animation of new research activities around RO concept;

- Management of the activity (applications) grid in coordination with the project manager;
- Formal report to CEOS on RO (annual)**;**
- Management of the acquisition plan and tasking with CEOS agencies;
- Management of RO content (data, product, news, documents);
- Management of data processing;
- Technical reporting;
- Updating of long-term plan for RO after initial set-up (1-3 years);
- Maintenance of the RO IT (corrections, evolutions);
- VA generation;
- Preparation of closure, including evaluation and legacy strategies.

7. RO MANAGEMENT

The set-up and regular oversight of the RO will be ensured by the Recovery Observatory Steering Committee (RO SC).

The SC is made up of :

- The three Haitian champions: CIAT, CNIGS, and ONEV;
- International stakeholders: GFDRR/WB and UNDP;
- CEOS agencies: CNES, CSA and ASI.

Other CEOS agencies or stakeholders are welcome at the SC as observers.

The SC meets via teleconference once every four months, or at the request of any member. The first meeting of the SC was held on September 29th, 2017.

The day-to-day technical management of the RO requires a technical project leader. This role is played by CNIGS, with technical support provided by CNES through their RO project team. The CNES project team ensures technical support for data ingestion and product coordination for the DotCloud portal. The two technical leads will report jointly to the SC on RO status and progress once every three months.

Day-to-day management of the RO project elements take place on a decentralised basis by the technical team, made up of representatives from all collaborating organizations.

The other Haitian partners, international donors active in Haiti and in the RO, as well as CEOS agencies making active contributions are invited to provide representatives for this Haiti RO technical team.

8. CONCLUSIONS

The benefits and challenges of the Recovery Observatory have been summarised in the table below:

	Benefit	Challenge
Recovery Planning	Large-scale event with significant long-term impact; environmental and agricultural damage over large (but not excessively large) areas make the RO relevant as a tool to understand scope and impact of damage and plan appropriately.	Planning already begun and in some cases completed. RO can however lead to changes in plan as RO can monitor all changes in area, and help Haitian government understand NGO actions in the affected area and adjust planning accordingly.
Recovery Monitoring	RO will bridge gap between users and satellite providers, ensuring satellite data is available over the long-term; without RO, unlikely that satellite data will play a key role in monitoring. In this case, much of damage is environmental and agricultural, and many areas are remote with regular access issues; RO offers a very complementary tool to field validation and assessment. Haiti is a very vulnerable country (the poorest in the western hemisphere) and humanitarian action is likely to receive some visibility.	Large number of sectors affected requires significant resources for value-adding in addition to CEOS data. Some agencies are willing to make contributions; more partners need to be sought out to grow impact of RO. There are many other organizations active in Haiti and the visibility of the RO may be lesser than in an environment where less organizations are helping.
Institutional Cooperation	RO offers a neutral forum for collaboration between national and international actors, and seems quite complementary to existing tools such as the data portal www.haitidata.org and the risk modelling tool RASOR (www.rasor.eu), as well as comprehensive Haiti-wide project Kaleidos/KAL-Haiti. RO beings valuable complement.	Development and recovery work has in the past proven to be challenging (cf. Haiti earthquake 2010)
Resources for Value-adding	There are existing projects in the areas with which synergies might be sought (Kal-Haiti now Kalideos/Haïti, RASOR, SEAS-Haiti); Haiti is a constant concern of donor organisations such as the EC and World Bank.	No specific budget established; specific commitments made will only accomplish a modest RO, and obtaining new commitments without triggering is difficult (chicken and egg issue).
Usefulness of Satellite EO	Area to be covered is large (but not unduly so) and difficult to access from the capital where most capacity is; satellite EO would be critical for long-term monitoring of recovery for agriculture sector and coastal changes.	Area is large enough (approximately 100 x 80 km) to mean significant investment for satellite agencies and significant value-adding resources, but size of area and remoteness of some affected areas means satellite data is useful complement to ground based information.
Capacity Building	The RO represents a significant opportunity to develop EO-based capacity in Haiti, both within the CNIGS and within line ministries.	A Capacity Development Plan is required with identified resources and clear beneficiaries that include government ministries and local universities and NGOs.

ANNEX 1. MAIN REFERENCES

Hurricane Matthew Recovery Activities in Haiti

Governmental Organizations:

The EC/UNDP/WB are supporting the Government of Haiti in the development of a Post Disaster Needs Assessment. This is expected to be available in early December.

Non-governmental Organizations:

Aid for Haitian farmers – the Smallholder Farmers Alliance

http://www.csrwire.com/press_releases/39382-Aid-for-Haitian-Farmers-Affected-by-Hurricane-Matthew

Impact of Hurricane Matthew

On Matthew:

https://en.wikipedia.org/wiki/Hurricane_Matthew

On impact in Haiti:

https://en.wikipedia.org/wiki/Effects_of_Hurricane_Matthew_in_Haiti

ECHO Daily Map of the 1st of November

http://erccportal.jrc.ec.europa.eu/emaildailymap/title/ECHO%20Daily%20Map%20of%201%20November%202016

On agricultural impact in Haiti:

http://www.wfp.org/news/news-release/wfp-delivering-food-assistance-survivors-hurricane-matthew-haiti

Satellite assessments:

Charter Activation, https://www.disasterscharter.org/web/guest/activations/-/article/cyclone-in-haiti

UNOSAT Preliminary Damage Assessment Report Grand-Anse, https://www.disasterscharter.org/documents/10180/349905/UNOSAT_PreliminaryDamageAssessment_GrandAnse_Haiti_14Oct2016_TC20161003HTI.pdf

Copernicus EMS Activation, http://emergency.copernicus.eu/mapping/list-of-components/EMSR185

ANNEX 2. KAL-HAITI AND KALIDEOS

Urban thematic information derived from Pléiades imagery using object-oriented method.
Port-au-Prince (Haiti) Pléiades @CNES 2012, distribution Airbus DS, @Sertit

KAL-HAÏTI, A DATABASE TO FACILITATE RESEARCH FOR RISK MANAGEMENT AND SUSTAINABLE REBUILDING IN HAITI

Following the 12th January 2010 earthquake in Haiti, the French National Research Agency (ANR) funded a 5 years project named KAL-Haiti which aimed at gathering remote sensing imagery, completed as possible with in-situ measurements and exogenous data, into a knowledge base. The project began in December 2010 for a period of 5 years. It received €681,830 in ANR support for an overall cost of €1.4M. The project is now being pursued in the framework of the Kalideos programme of CNES.

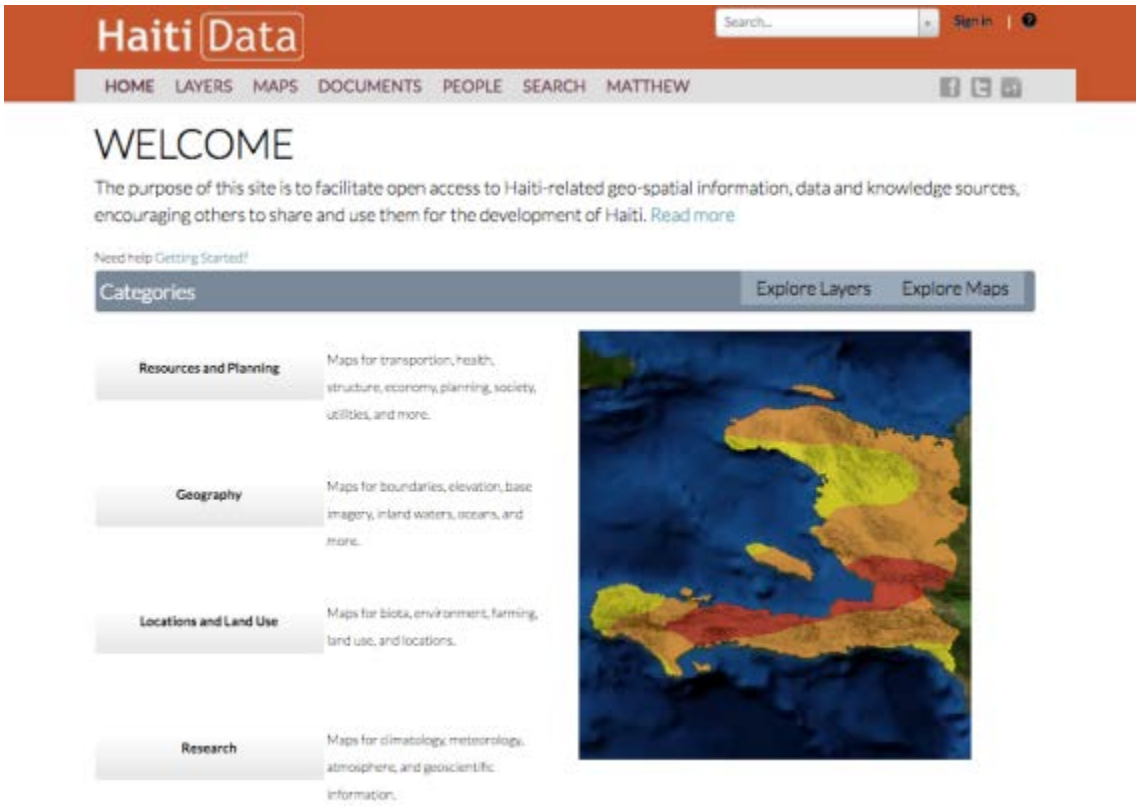
KAL-Haiti / Kalideos Haïti is an applied research project giving scientists, researchers and organisations in charge of rebuilding in Haiti access to a database of remote sensing images and additional information (in situ measurements, maps, etc.) useful both for understanding the earthquake of 12 January 2010 and its consequences, and for rebuilding activities. These qualified and homogeneous data are accessible free of charge (with conditions) via a Web server (https://haiti.kalideos.fr/).

The project is a tool that offers relevant information for a better understanding of the earthquake and its consequences as well as the rebuilding process. By bringing together scientists, researchers, students and development stakeholders (Haitian institutions, associations, society, international organisations, etc.), KAL-Haiti is a platform that provides support and assistance in validating and promoting activities for basic research and for developing solutions related to the crisis in Haiti and beyond, to disaster management in general.

One of KAL-Haiti's main activities has been to identify potential uses of such a database in the field of risk management. To this end, a user network has been established to link scientists able to provide methods and solutions with disaster managers (international NGOs, local associations), Haitians in charge of geographical information and land development operations. As an example, KAL-Haiti made it possible to create a cartographic description and monitoring of 17 displaced persons camps for the French Red Cross just after the earthquake; under a cooperation between the Strasbourg Urban Community, IRCOD and the city council of Jacmel in Haiti, KAL-Haiti has supported the completion of a project to bolster Jacmel's fiscal capacities.

KAL-Haiti has helped launch 30 projects or demonstrators, 23 of which have succeeded, from post-crisis management to basic research, training and rebuilding. Joint efforts or partnerships have been carried out with international organisations (Politecnico di Milano, the American Red Cross and UNDP). Five workshops have been conducted, including two in Port-au-Prince, dedicated to preparing and strengthening delivery of the project and data infrastructure in Haiti.

ANNEX 3. WWW.HAITIDATA.ORG



Screen capture of Haiti Data home page

From the website:

"The purpose of this site is to facilitate open access to Haiti-related geo-spatial information, data and knowledge sources, encouraging others to share and use them for the development of Haiti.

Geospatial data can be used for many purposes: establishing baseline data, conducting risk assessments, planning, project monitoring, and tracking progress. Access to high quality information is critical for planners, policy makers, and other stakeholders involved in the reconstruction process in Haiti. This site is intended to facilitate more effective support to the country's rehabilitation, recovery and longer- term sustainable development.

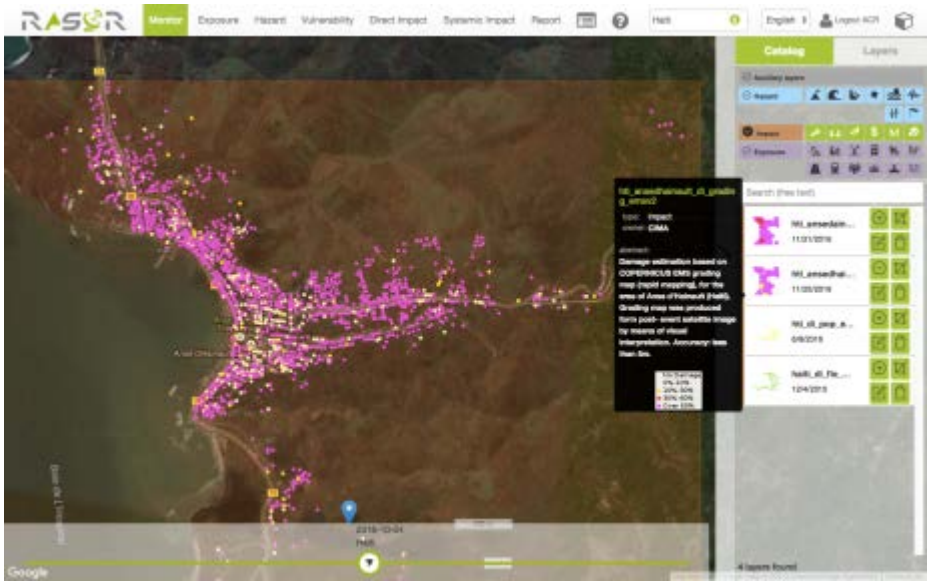
Following the January 12, 2010 earthquake a large amount of geo-spatial data was created, noting information including earthquake intensity, flooding likelihood, landslide and tsunami hazards, and overall damage. The enormity of the current need for material assistance, support to reinforce the governance structure, and innumerable international and local organizations joining to assist in reconstruction and development processes, also poses a significant challenge to the government and other agent's ability to coordinate to benefit the people of Haiti. This site hopes to help inform decision makers at all levels and in all sectors, for now and in planning for the future, including to manage the risk derived from natural hazards."

After Hurricane Matthew, a new tab was placed on the GeoNode-based database with maps and information relating to Hurricane Impact. This website is a critical baseline data source for the RO and should be interlinked with the RO to facilitate interoperability.

ANNEX 4. RASOR-HAITI

The Rapid Analysis and Spatialisation Of Risk (RASOR) project developed a platform to perform multi-hazard risk analysis to support the full cycle of disaster management, including targeted support to critical infrastructure monitoring and climate change impact assessment. RASOR adapts the newly developed 12m resolution TanDEM-X Digital Elevation Model (DEM) to risk management applications, using it as a base layer to interrogate data sets and develop specific disaster scenarios. RASOR overlays archived and near-real time very-high resolution optical and radar satellite data, combined with in-situ data for both global and local applications.

RASOR uses a scenario-driven query system to allow users to simulate future scenarios based on existing and assumed conditions, to compare with historical scenarios, and to model multi-hazard risk both before and during an event. RASOR allows managers to use real scenarios when determining new mitigation or prevention measures, and integrate new, real-time data into their operational systems during response activities.



Haiti was one of six case study areas chosen on a global basis for RASOR demonstration. Following Hurricane Matthew, the RASOR team worked on adapting Copernicus EMS products for ingestion in the RASOR platform.

RASOR platform over southwest Haiti.

Assessment of damage caused by strong winds was computed in several ways:

- Damage estimation based on COPERNICUS EMS grading map (rapid mapping), for the area of Anse d'Hainault (Haiti). Grading map was produced from post-event satellite image by means of visual interpretation. Accuracy: less than 5m.
- Direct economic damage assessment was computed on the basis of percentage damage directly estimated from the grading map, and through asset feature characterization (asset value per m2, No of storeys, etc.)
- Matching hazard and exposure through vulnerability curves. Hazard was obtained through numeric weather prediction models, computing the maximum wind field.

The methodologies led to almost the same economic damage estimation (around 20% difference).

The RASOR platform can be accessed directly at www.rasor.eu . For permission to use RASOR as a value-added user, access the platform tab at http://www.rasor-project.eu. and complete the request form. The RASOR team has been approached for a possible RO contribution and have agreed to work with the RO team to ensure linkages and maximise interoperability of the two tools.

ANNEX 5. RO DISTRIBUTION LIST

The following e-mail list of institutional stakeholders from Haiti and the international community has been compiled based on discussion held to date in preparation of the RO Operations Plan draft. To be added to the list, please contact andrew.eddy@athenaglobal.com.

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