



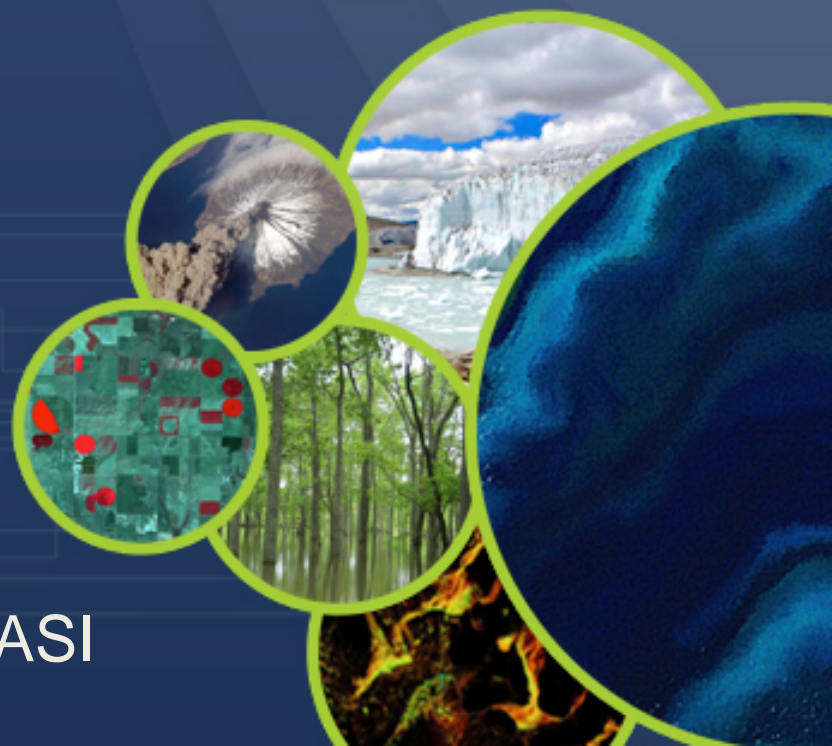
Committee on Earth Observation Satellites

Recovery Observatory (RO)

Haiti Hurricane Matthew RO Status and Next Steps

Presentation to WGD #9
Brussels March 14th, 2018

Boby Piard, CNIGS
Agwilh Collet, CNES
Helene de Boissezon, CNES
Jens Danzeglocke, DLR
Deodato Tapete, Francesca Cigna , ASI
Andrew Eddy, RO Secretary

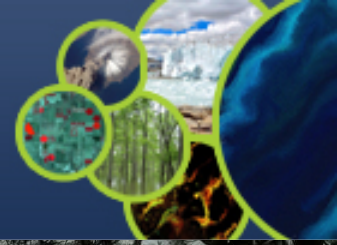




□ Haiti Recovery Observatory

- Status Overview
- Feedback after one year
- December Technical Mission
- DLR – TerraSAR-X contribution
- ASI – Terrain motion products
- Copernicus EMS R&R activations
- Links with NOAA, ESA, WG CapD
- Next Steps

□ RO concept on other areas

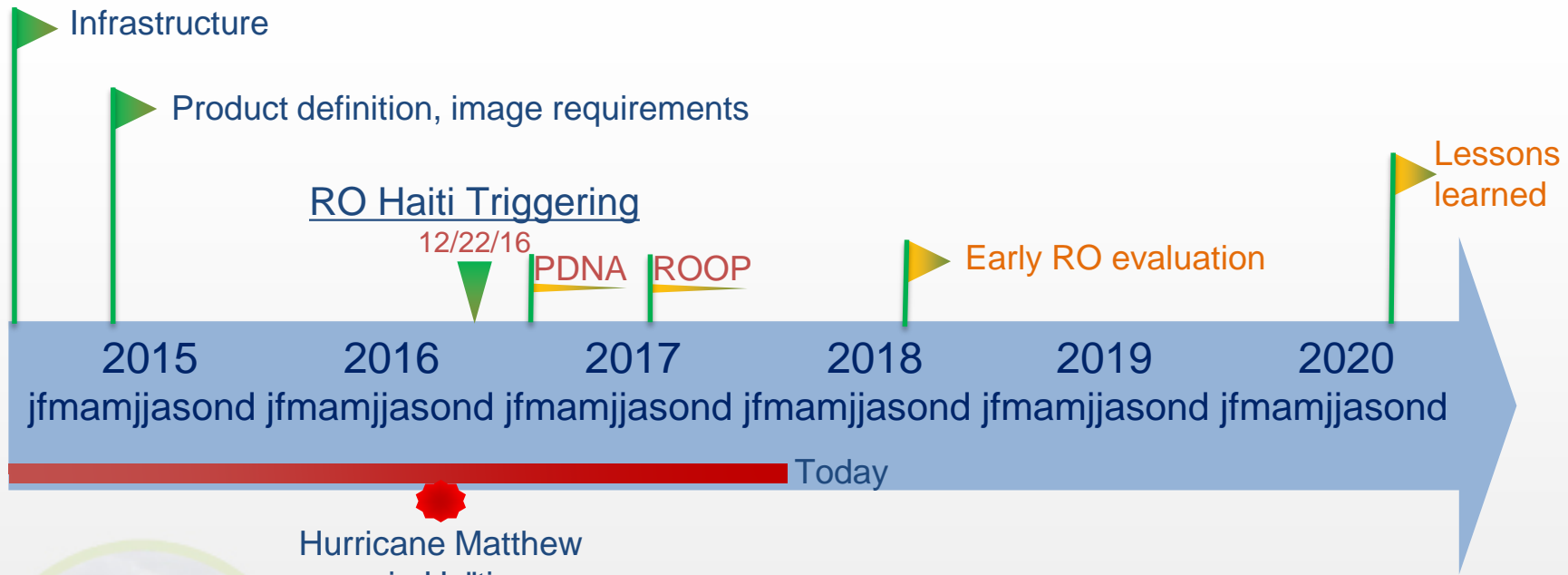


A Reminder of Haiti's diversity

- **Triggering of the RO decided by CEOS Chair in consultation with CEOS Principals, December 22, 2016, after Hurricane Matthew - October 2016**
- **Mission #1 to Haiti - end January 2017** Definition of activities in Haiti
- **Mission #2 to Haiti 29 May – 2 June 2017** 1st RO users workshop feedback on sample products
- **Mission #3 to Haiti 5 Dec - 8 Dec 2017** technical review , link universities

Haiti RO covers three departments: Grand'Anse, Sud, and Nippes





Hurricane Matthew
in Haïti
10/04/16

Malawi, Nepal
Demonstrators

Missions to Haiti
(2 to 3 per year)

External Mission



Technical Review

5-8 Dec

1st
31 Jan – 3 Feb

1st User Workshop
29 May – 2 June

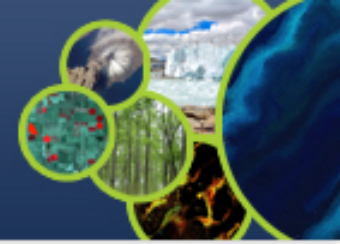
2nd User Workshop
8 – 11 May

Generic RO discussion
WB + UNDP DC + NYC (date TBC) 5

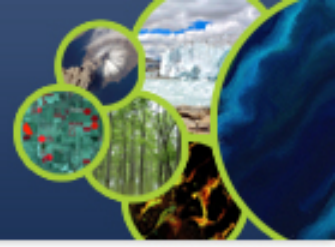


Feedback, involvement and goals

Boby Piard – Head of CNIGS
David Telcy - CNIGS



| Produit | Key User | First Elaboration | Satellite data | Focal Point | Institution |
|---|---|---|---|--|---------------------------|
| Cartography of the building (Jérémie, Les Cayes, route d'Aquins) | CIAT/Ministry of Planning (MPCE) | Copernicus EMS; SERTIT (methodology); CNIGS (production); | Optical THR | Rose-May GUIGNARD | CIAT |
| | | | | Pierre Alexilien Versaille MPCE/ CNIGS | |
| Land Use | All (reference data) | CNIGS/CESBIO /SERTIT | Sentinel-2, HR Optical | Jacques Philemon MONDESIR | MPCE / CNIGS |
| Forest Evolution / Environmental Impact | Ministry of Environment (MDE) | Copernicus EMS | Sentinel-2, SPOT, Optique THR | Pierre Emmanuel PHILIPPE | MDE/ Directeur des forêts |
| | | | | Saint Phar JEAN | MDE/ ONEV |
| Agriculture | Ministry of Agriculture (MARNDR) | Copernicus EMS ; CNIGS/SERTIT | Sentinel-2, Optical HR, zoom THR | Ognel PIERRE-LOUIS | MARNDR/ DRFS |
| | | | | David TELCY | MPCE / CNIGS |
| State and monitoring of the Macaya Park | ANAP / ONEV (MDE) | Copernicus EMS ; SERTIT | Optical THR, radar THR | Sait Phar JEAN | MDE/ ONEV |
| State and monitoring of watersheds | ONEV (MDE) - Ministry of Agriculture (MARNDR) | CIMA Foundation | Digital terrain model 1m/20cm and Radar THR | Jean André PIERRE | MPCE/ CNIGS |
| | | | | Pradel FORMONVIL | MPCE/ CNIGS |
| | | | | Saint Phar JEAN | MDE/ ONEV |
| Landslide / Quarry monitoring | BME / Ministry of Public Works (MTPTC) | EOST | Optical HR/THR, Radar TerraSAR-X | Samuel GENEVA | MTPTC/ BME |
| | | | | Eric CALAIS | ENS France |



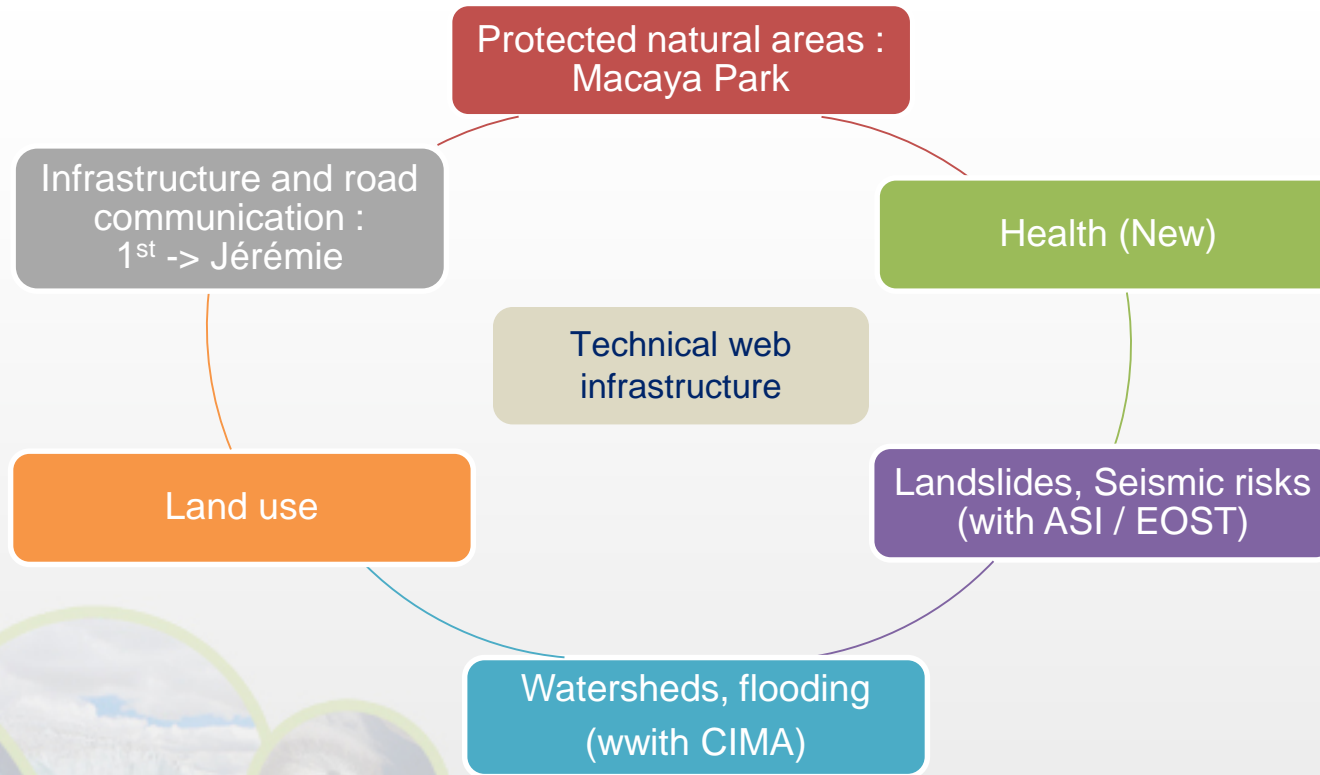
Technical Mission : 5 to 8 December, 2017



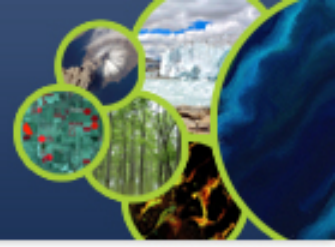
Working Session with ONEV and
Health Ministry, December 2017

- Technical Work on each thematic between experts
- Inclusion of Universities
- RASOR training (ONEV, CNIGS, DPC) and RO platform presentation
- Steering committee #2

CNES : Frederic Moll, Agwilh Collet,
SERTIT : Robin Faivre,
CIMA : Giorgio Boni,
RO Secretary : Andrew Eddy



- 7 working session in Haitian offices (CNIGS, CIAT, ONEV, BME...)
- Second loop on several products (Watersheds, Building in Jérémie, Macaya Park)
- Definition of needs on Health thematic



- Strong Haitian presence and support for RO concept
- The university session provided an overview of the training and capacity development needs.
- There is a strong desire to provide additional training in remote sensing, geomatics and more generally on the possible applications of remote sensing.
- A one-day training session on the contribution of geomatics and remote sensing could be organized in the fall of 2018, with preparation for the spring 2018 mission. During the week of the 2nd User Workshop, several small training sessions are being organised.

PRODUCTION SCHEME :

Data used :

- Orthophoto 2014
- Pléiades - 07/10/2016
- Pléiades - 18/10/2017

Input data :

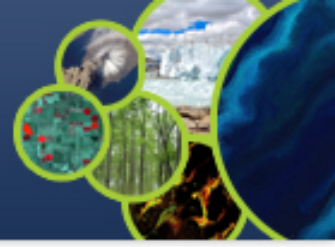
- Building from Copernicus EMSR185 action (polygon with damage)
- Building from Open Street Map (polygon)

Method :

The geometry of the polygons (OSM + previous site) is recaled compared to that of the orthophoto 2014, which is considered as the absolute reference.

Technical Meeting #1 :

Example - Infrastructure around Jérémie



Infrastructure and road communication :
1st -> Jérémie



Technical Meeting #1 :

Example - Infrastructure around Jérémie



7584 buildings

Infrastructure and road communication :
1st -> Jérémie

4 states :

- Not affected
- In Construction
- Not Existing
- Damaged
- Destroyed

| 2014 | 2016 | 2017 | Total |
|-----------------|--------------|-----------------|-------------|
| Not affected | Destroyed | | 3219 |
| In construction | Destroyed | | 54 |
| Not existing | Destroyed | | 59 |
| Not affected | Damaged | | 1196 |
| In construction | Damaged | | 62 |
| Not existing | Damaged | | 49 |
| | Not affected | Not affected | 2037 |
| | Destroyed | Not affected | 2843 |
| | Destroyed | In construction | 111 |
| | Destroyed | Not existing | 303 |
| Not affected | | Not affected | 5719 |
| Not affected | | Not existing | 346 |

Technical Meeting #1 :

Example - Infrastructure around Jérémie



Infrastructure and road communication :
1st -> Jérémie

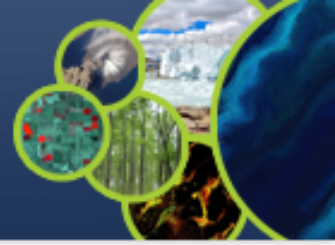


Neighborhoods that have access problems

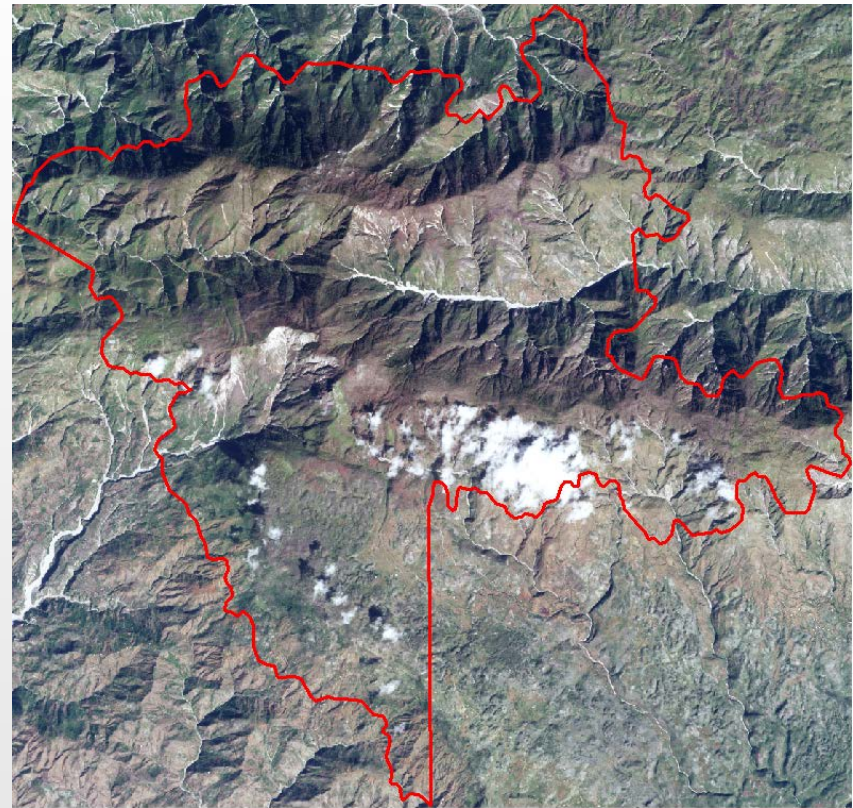


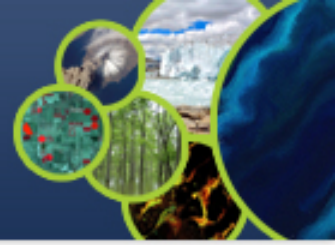
- SPOT 6 image of January 8, 2016
- SPOT 7 image of June 25, 2016
- SPOT 7 image of February 14, 2017
- Use of the 4 Multi-spectral band at 6m (R-G-B-PIR)



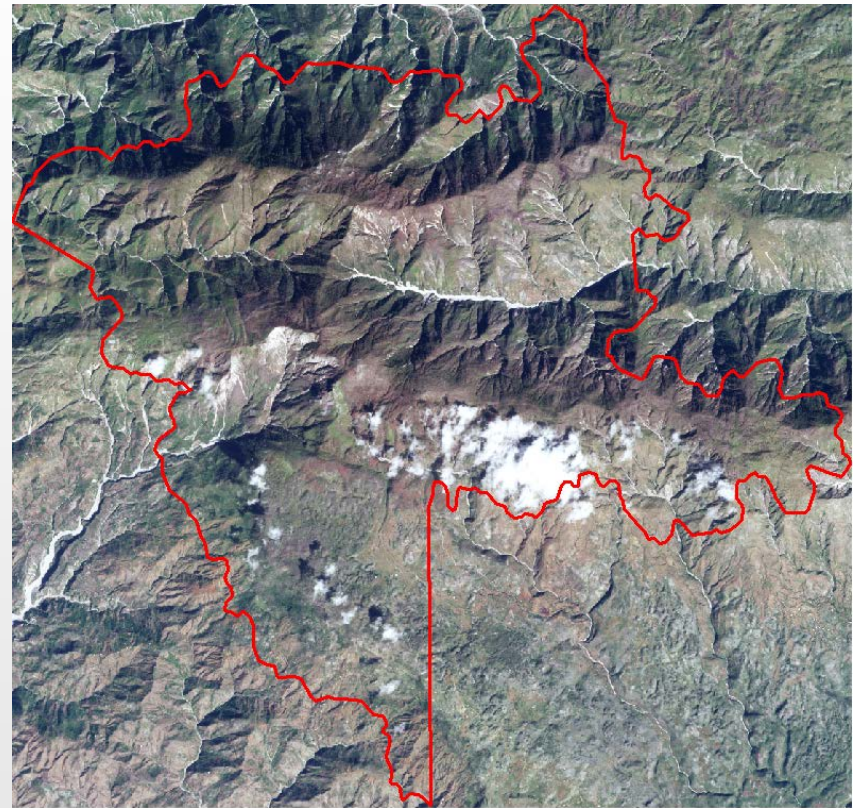


- Taking samples on the ortho-photo of 2014:
 - Treed vegetation (31)
 - Shrub vegetation (32)
 - Vegetation dominated by grass (33)
 - Open space without or with very little vegetation (51)
- Data set for training, a second for validation





- Calculs of NDVI and Shadow Index
- Indices Calculs of texture (Haralick Texture Extraction) : Entropy and Homogénéité (Inverse Different Moment)
- Useful to delate cloud and smooth classification
- Random sampling in the reference database: 2000 points divided according to the proportion of each class
- Crossing with the corresponding R-V-B-PIR-NDVI-SI-ENT-HOM values at the point



Technical Meeting #1 :

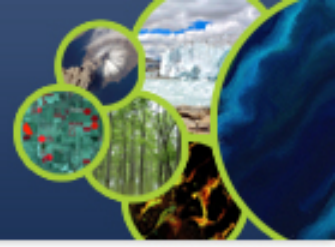
Example Vegetation monitoring / Macaya Park



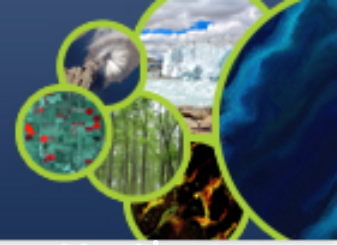
January 2016



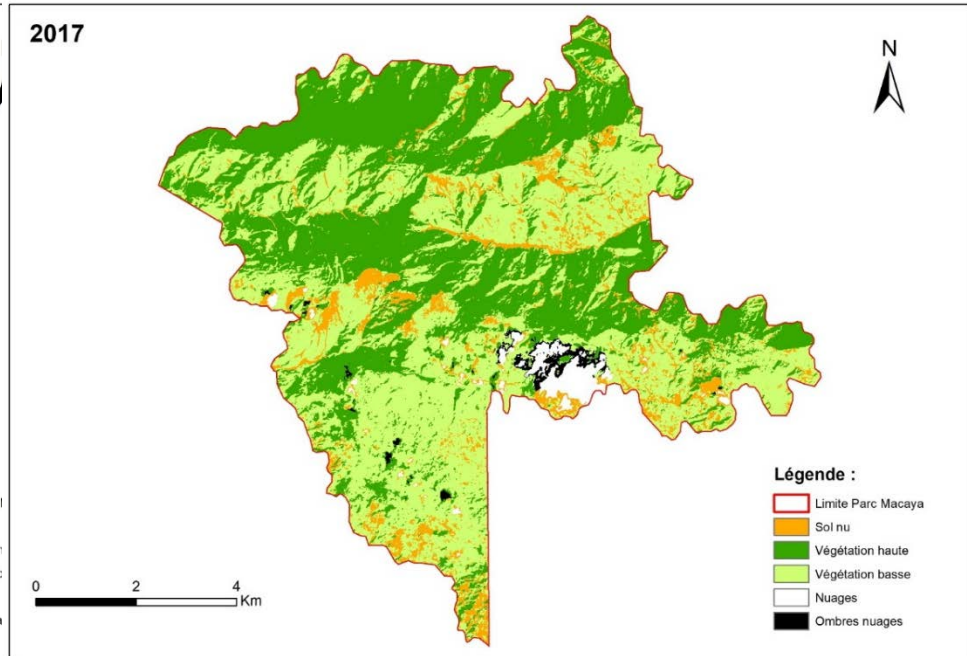
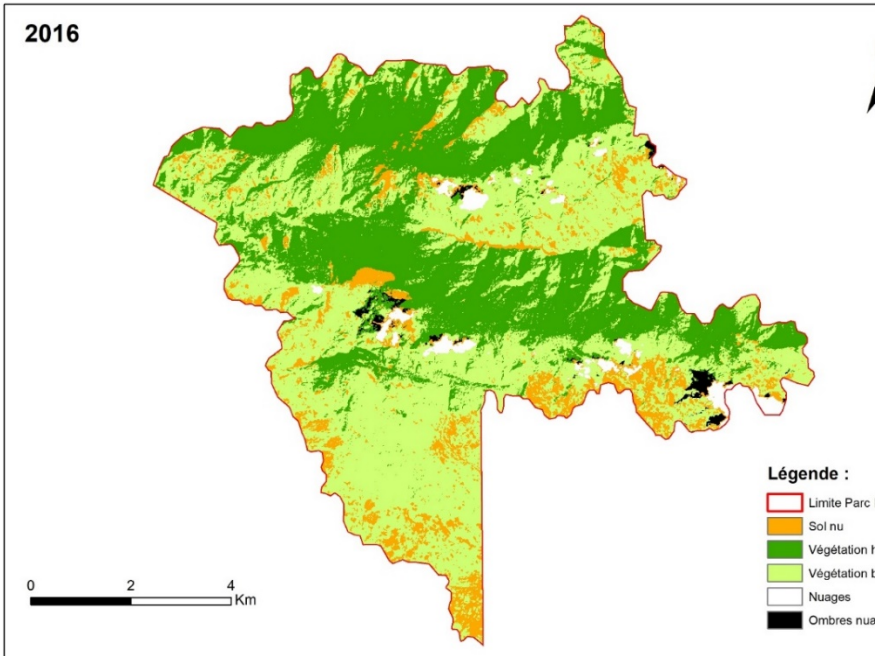
June 2016



February 2017



2. Preliminary Results



Bare land : 7,34 km²

High Vegetation : 26,71 km²

Low Vegetation : 35,83 km²

Other : 2,17 km²

Bare land : 6,18 km²

High Vegetation : 30,04 km²

Low Vegetation : 33,73 km²

Other : 2,11 km²

Parc Macaya : 72,06 km²



2. Preliminary Results

- No identification of plant species ... but type of vegetation (high and low)
- No cloudless images on this area (clouds on the ridges)
- Loss of information related to cloud shadow, steep slopes
- Need to have a very precise Digital Terrain Model to avoid a geometrical shift between images
- Confusion between bare soil and low vegetation, because dates in the dry season
- Confusion on the shaded slopes => better to work with summer images
- No significant trend between 2016 and 2017



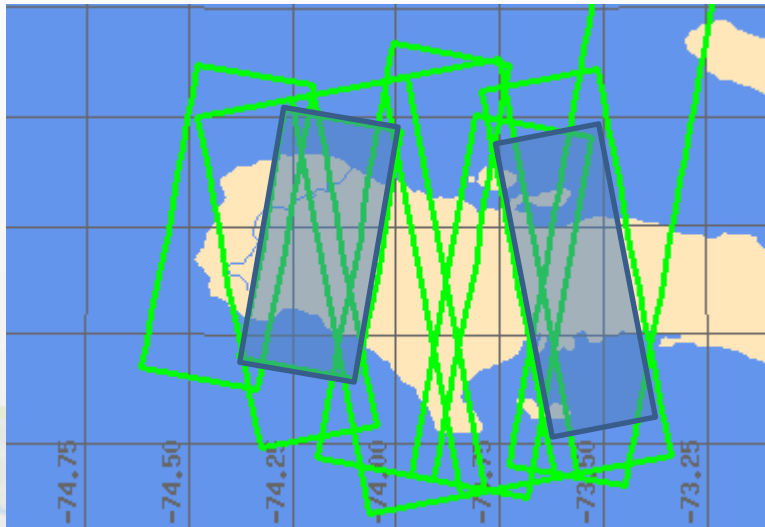
TerraSAR-X contribution to RO

Jens Danzeglocke, DLR

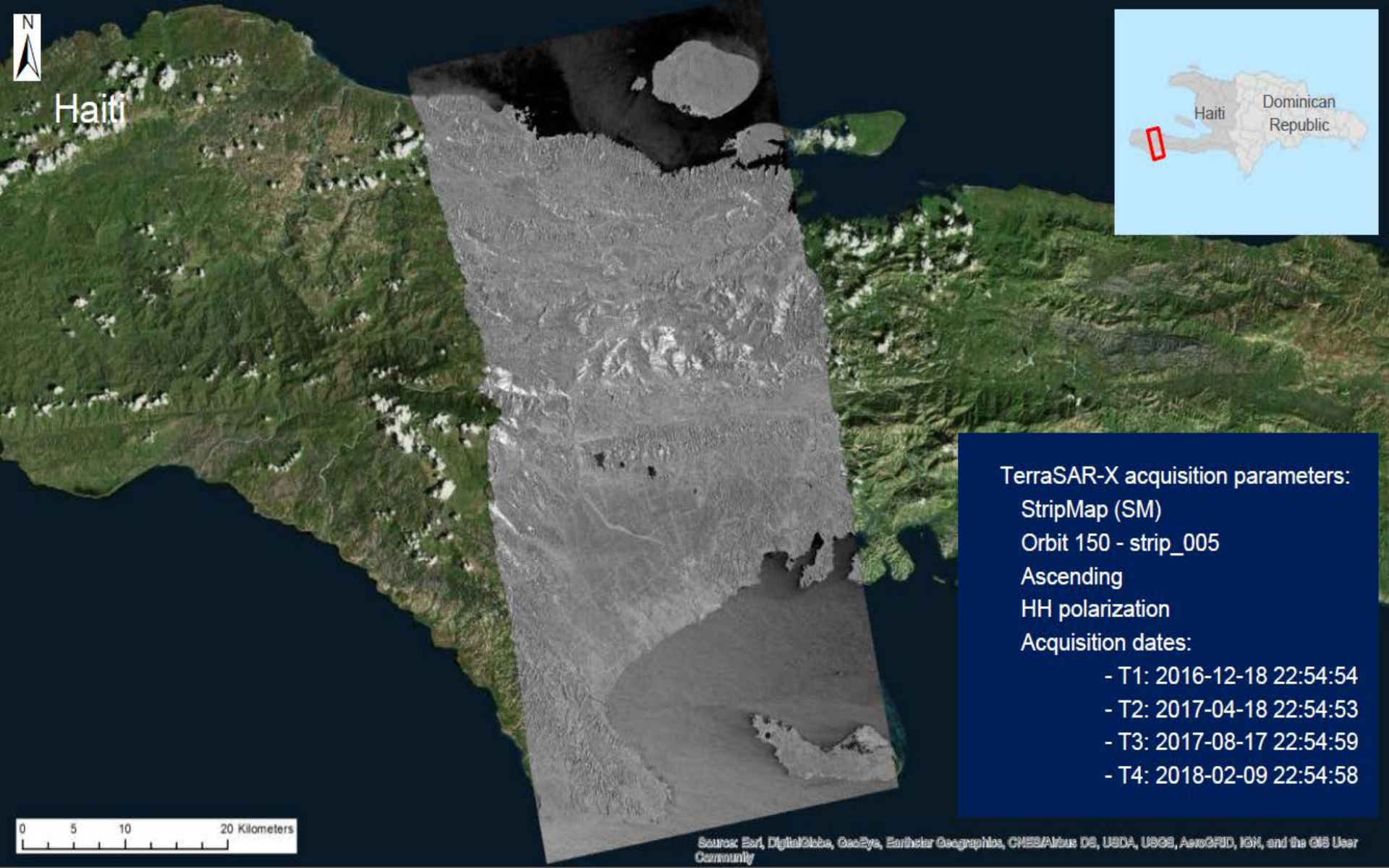
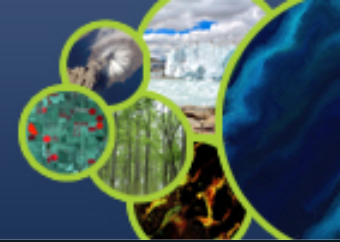




- Background acquisitions have started in Nov. 2016
- TSX Stripmap data in 3m spatial resolution allows coverage of the complete Haiti AOI in regular intervals



- 5 descending strips and 4 ascending strips have been acquired 3 times until now (4th coverage almost complete)
- Usage of the same satellite orbit with different view angles limits the possible repetition rate...
- Observations will go on (changes in the obs. planning possible)



TerraSAR-X acquisition parameters:

StripMap (SM)

Orbit 150 - strip_005

Ascending

HH polarization

Acquisition dates:

- T1: 2016-12-18 22:54:54

- T2: 2017-04-18 22:54:53

- T3: 2017-08-17 22:54:59

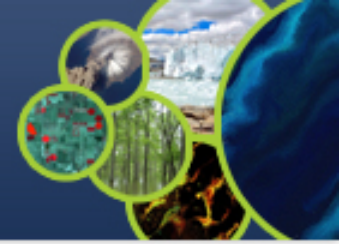
- T4: 2018-02-09 22:54:58



- General question: can 3m radar data be of help for recovery related issues?
 - relatively coarse images
 - + 30km swath width
 - + no clouds and cloud-shadows (AOI in humid tropics)
- Change Detection could help identifying recovery-related issues and sub areas of special interest
 - Infrastructure and settlement changes?
 - Agricultural changes?
 - Inland waters / frequently inundated areas?
 - Smaller catastrophic events...
- Meaningful contributions to disaster recovery and reconstruction?
- Valuable synergies using TSX Stripmap together with VHR optical sensors?



ASI-CIMA activities for RO

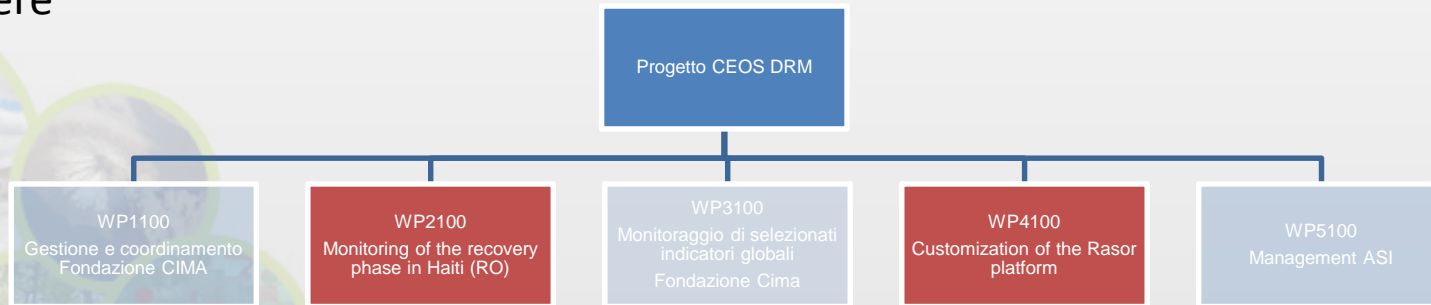


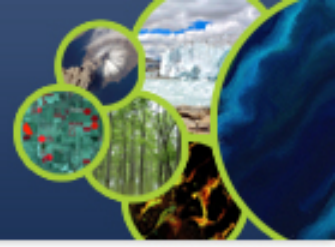
Planning:

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | |
|--------------|----------|---|---|-----|---|---|---|---|---|----|----|----|-----|----|----|----|----|----|-----|----|----|----|----|----|----|
| WP1100 | [Orange] | | | | | | | | | | | | | | | | | | | | | | | | |
| WP2100 | [Green] | | | | | | | | | | | | | | | | | | | | | | | | |
| WP3100 | [Orange] | | | | | | | | | | | | | | | | | | | | | | | | |
| WP4100 | [Green] | | | | | | | | | | | | | | | | | | | | | | | | |
| WP5100 (ASI) | [Orange] | | | | | | | | | | | | | | | | | | | | | | | | |
| | KOM | | | RA1 | | | | | | | | | RA2 | | | | | | RA3 | | | | | | RF |



We are here





- Choice of the AOI
- Change detection algorithm integrating CSK and Pleiades
- Experimentation on case studies, for monitoring post-Hurricane Matthew changes

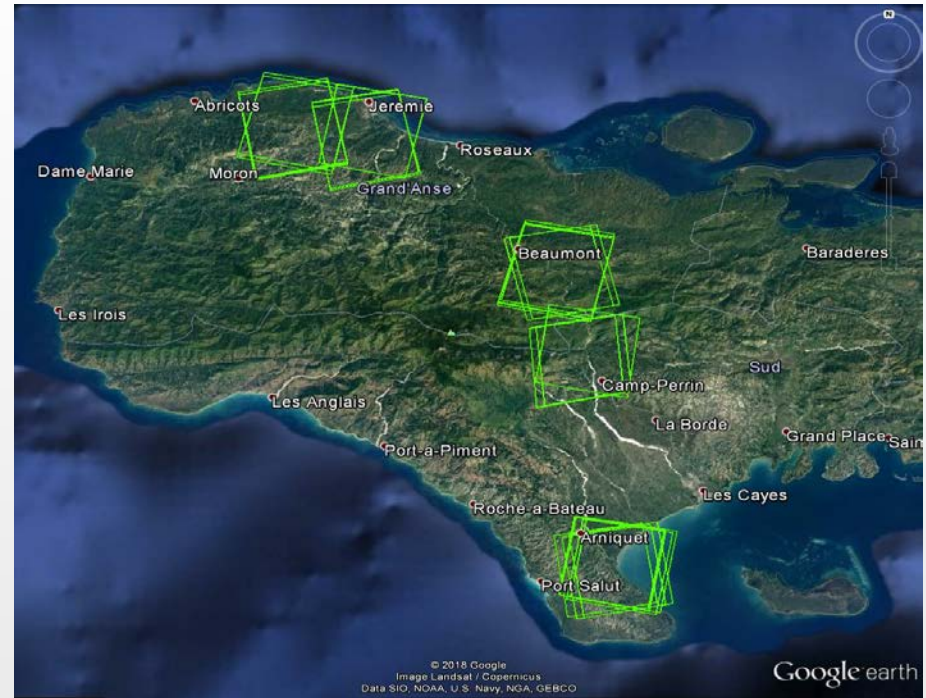




- Aquisition plan

CSK Archive2009-2018

Only Spotlight in the period of interest post Matthew

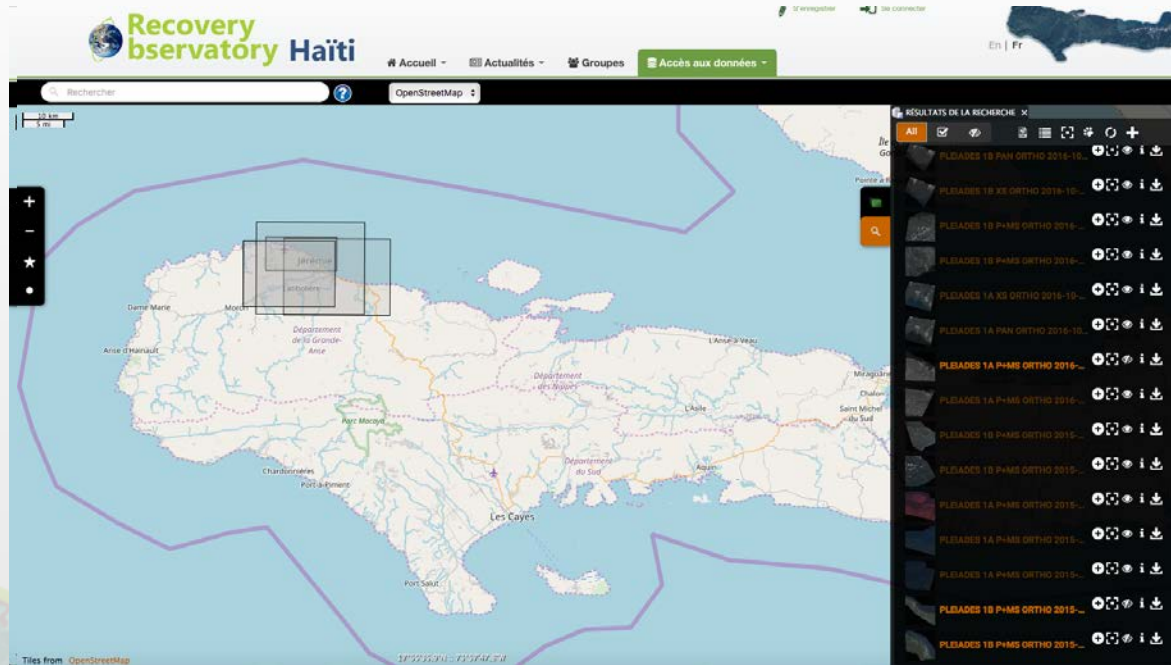


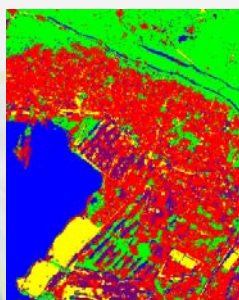


- Acquisition plan

Pleiades RO - 2018

Overlap with CSK archive





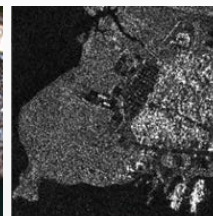
GeoEye-1 (canale R)

Mappa di classificazione

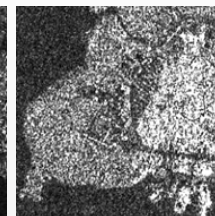
e Case study on Port-au-Prince, Haiti, land cover classification at 2.5 m spatial resolution from a GeoEye-1 RGB image and a COSMO-SkyMed stripmap image



Pleiades

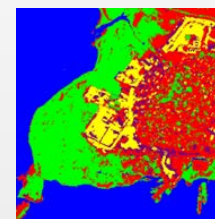
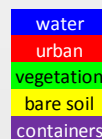


COSMO-SkyMed



RADARSAT-2

Case study on Port-au-Prince, Haiti, 50 cm spatial coverage land cover classification from an image Pleiades (pansharpened), a COSMO-SkyMed spotlight image and an ultrafine RADARSAT-2 image

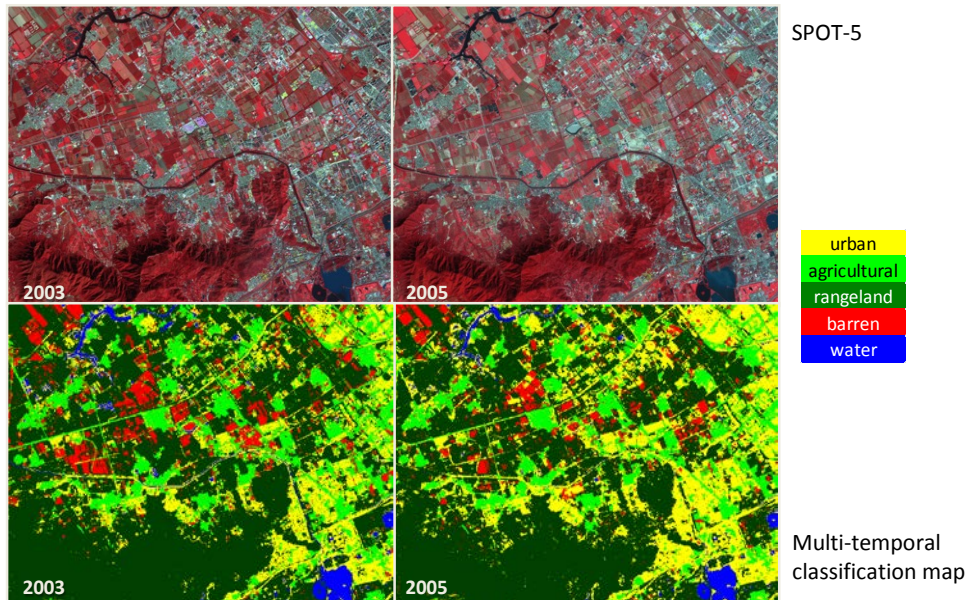


Mappa di classificazione

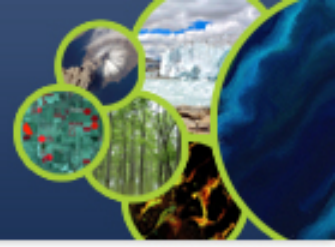
Change detection SAR/optical VHR

Preliminary Examples: classification SAR/optical VHR

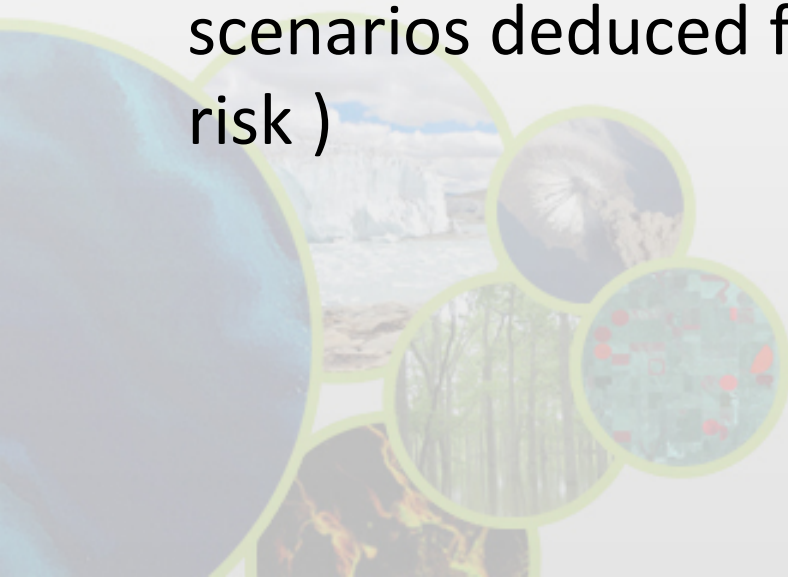
Case study on Beijing, China, supervised change detection at spatial resolution of 10 m starting from SPOT-5 multi-temporal images



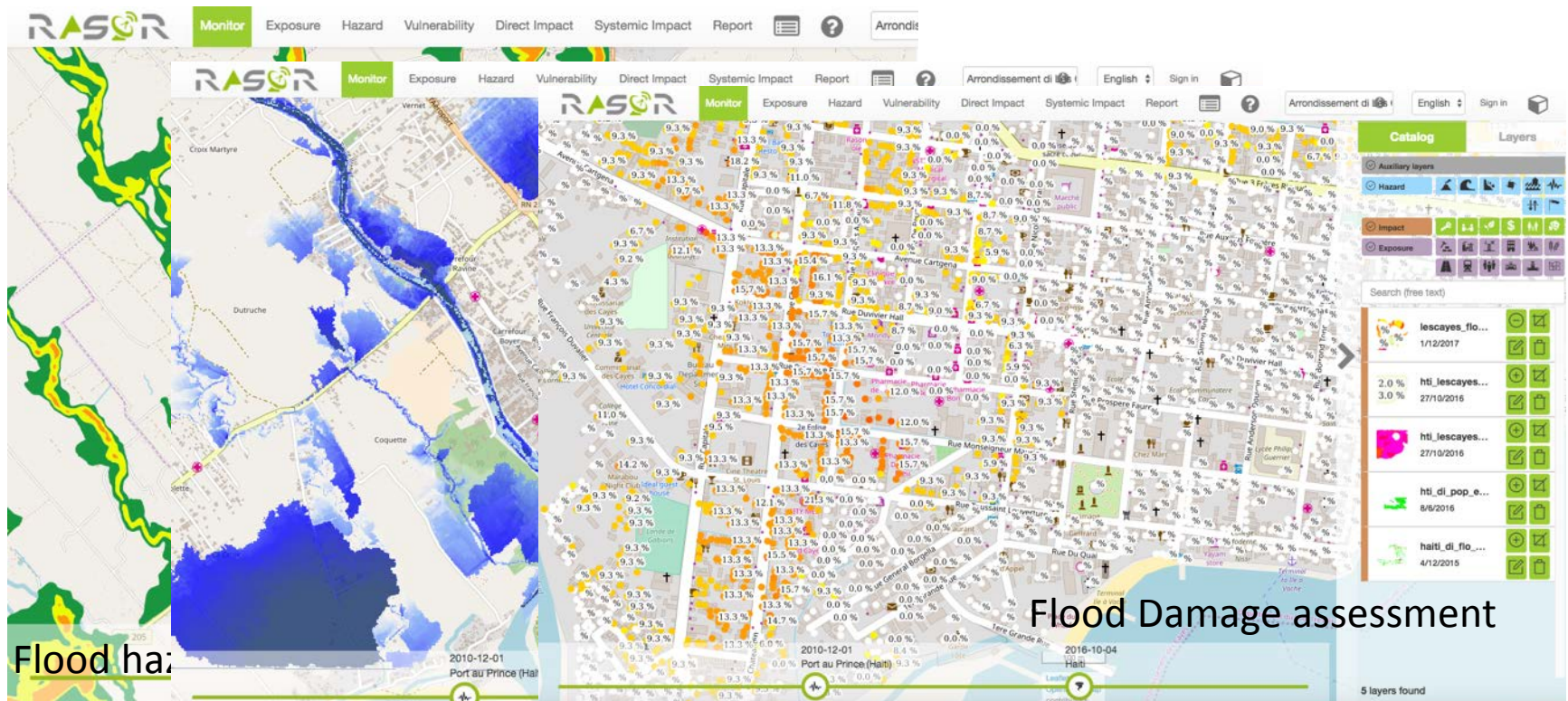
Change map



- Implementation in RASOR of flood hazard maps
- Implementation in RASOR of exposure layers
- Modification of the exposure in accordance with the results of WP 2100
- Evaluation of potential damage for certain hazard scenarios deduced from the maps (focus on Flood risk)



Examples of application of the RASOR platform on RO Haiti (Les Cayes)

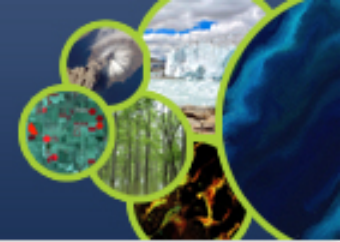




ASI's Scientific contribution to the RO

Terrain motion products based on satellite SAR

Deodato Tapete, ASI
Francesca Cigna, ASI



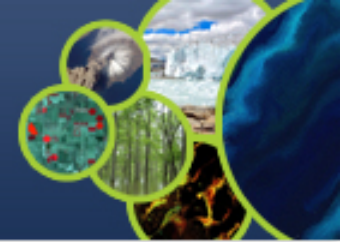
Scientific goals

- Develop experimental scientific products tailored to obtain useful information on ground stability and motions for target areas of the RO
- Test VHR SAR for hotspot mapping via:
 - bespoke COSMO-SkyMed SpotLight campaign in different recovery contexts
 - InSAR processing within ESA Geohazards Exploitation Platform (GEP)

Target areas (stakeholders' priorities)

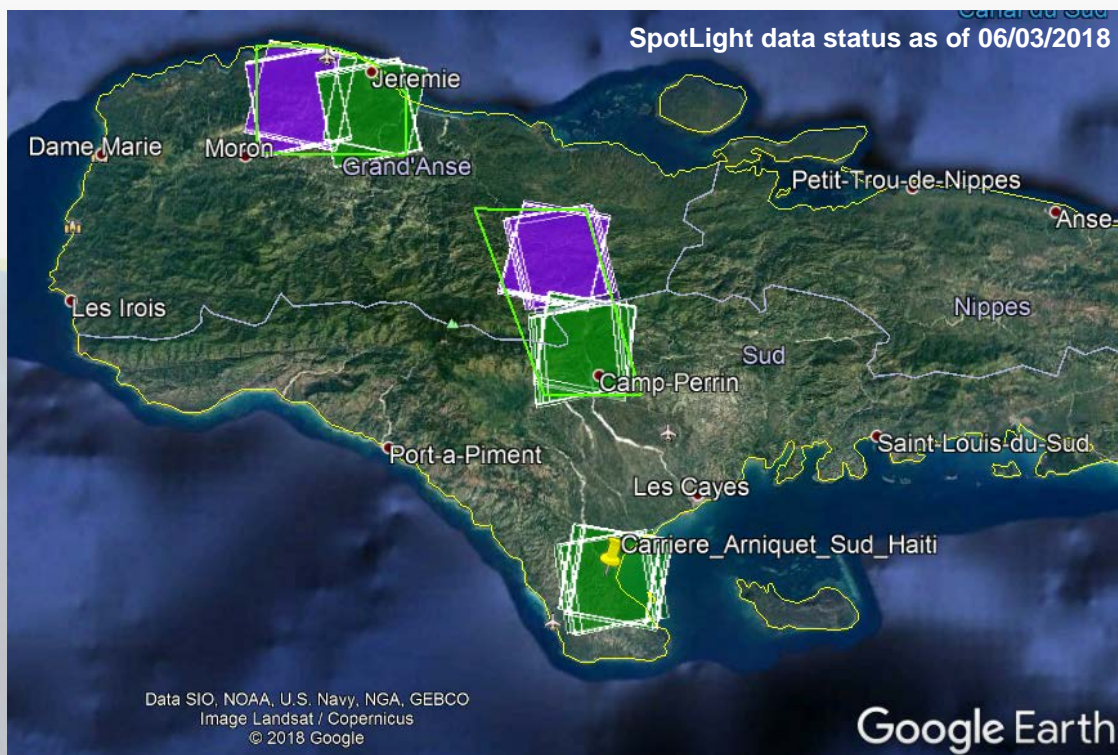
- Jeremie (urban + rural)
- Camp-Perrin (rural + road network)
- Carriere Arniquet (rural + mining)





Satellite data → newly acquired ASI's COSMO-SkyMed X-band data

- 3-year long tailored monitoring campaign [[started on 1st Dec 2017](#)]
- SpotLight images at very high spatial resolution (1 m)
- Ascending and descending mode acquisition geometries, 16 days revisit time



More than 50 COSMO-SkyMed SpotLight scenes already acquired for the target areas

~5/6 scenes per site, per geometry

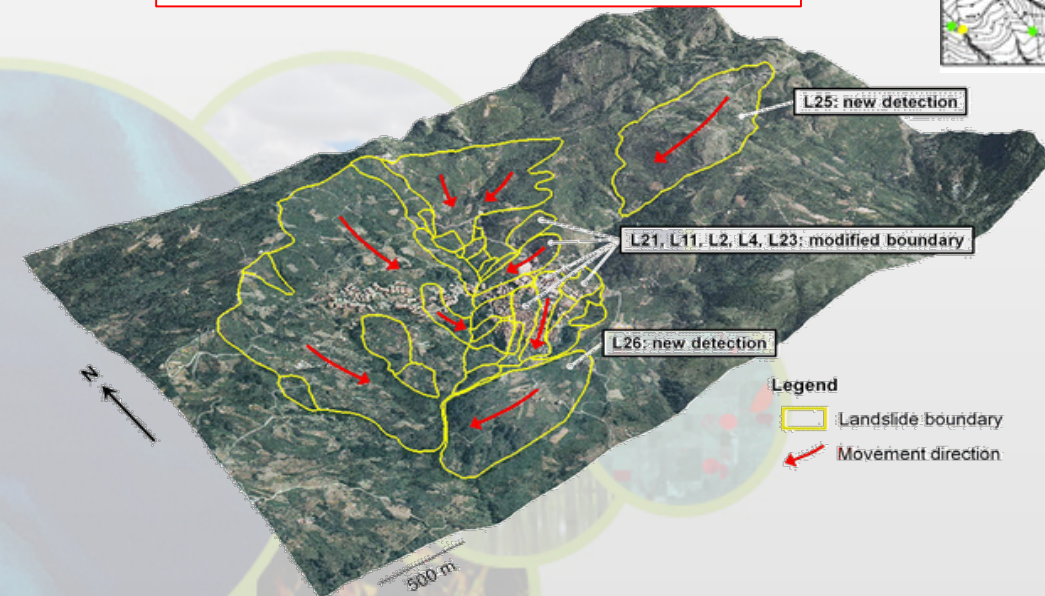
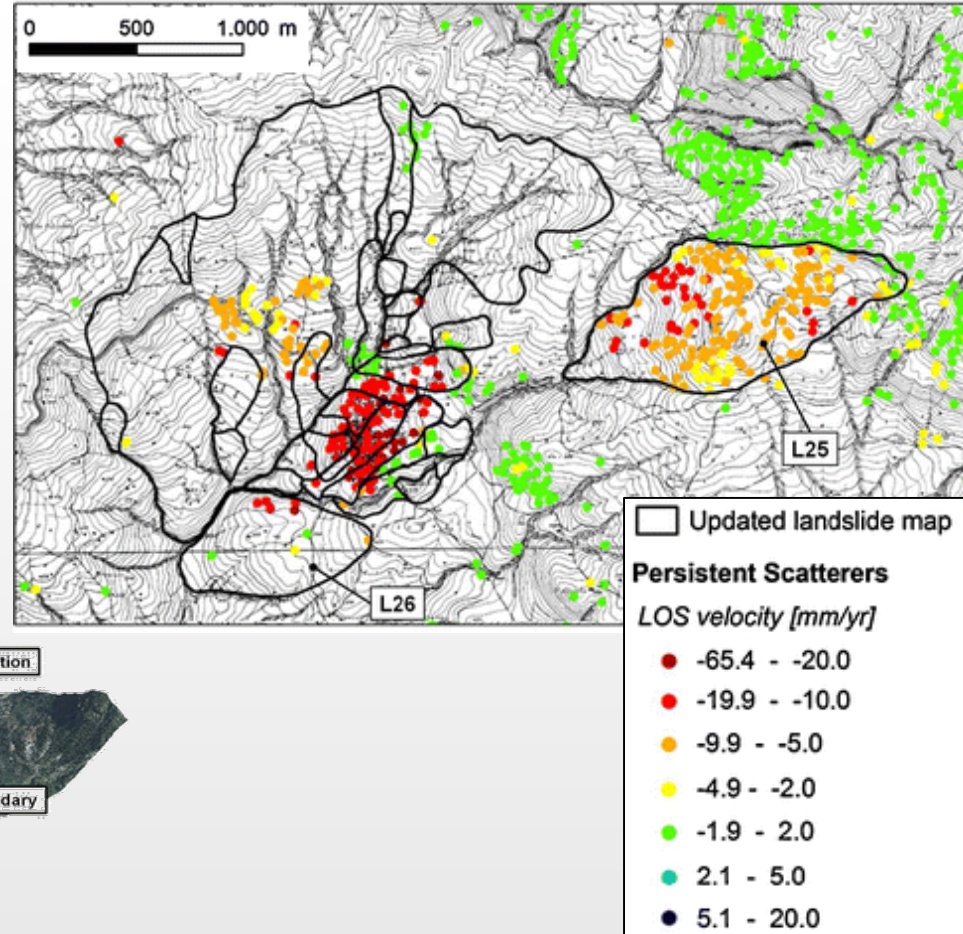
(as of mid March 2018)



Methodologies

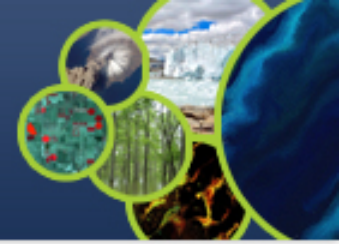
- SAR interferometry (InSAR) and change detection methods
- Advanced multi-temporal InSAR and landslide motion time series

Assessment of landslide velocity and state of activity



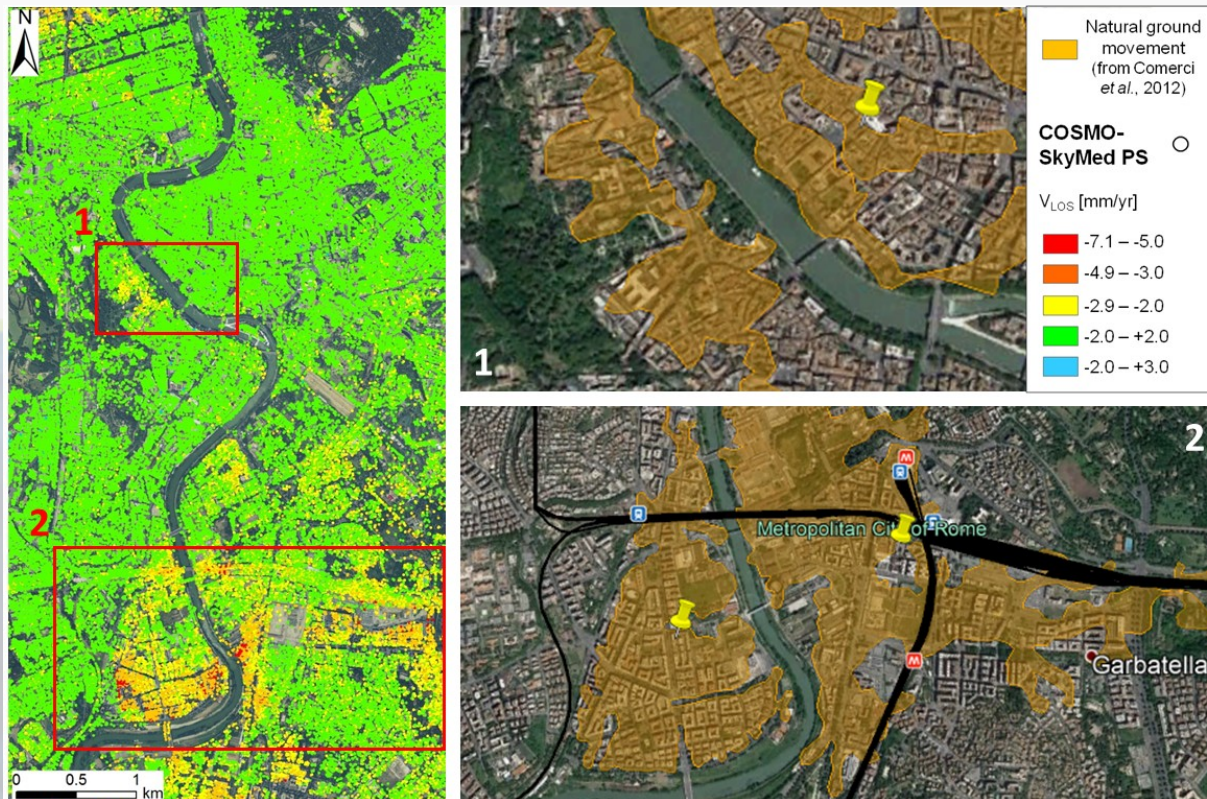
Example of InSAR-based mapping of landslide motion

Source: CIGNA *et al.* (2013) *Landslides* 10: 267-283.
doi: [10.1007/s10346-012-0335-7](https://doi.org/10.1007/s10346-012-0335-7)



Methodologies

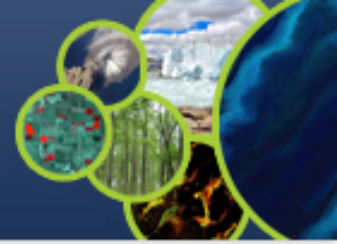
- Advanced multi-temporal InSAR and terrain motion mapping in urban areas
- Geospatial analysis to correlate with natural and anthropogenic hazards



Detection of ground instability in urban environments

Terrain motion mapping with COSMO-SkyMed and correlation with city subsurface and anthropogenic activities

Source: CIGNA *et al.* (2014) *Remote Sensing* 6: 12593-12618.
doi:[10.3390/rs61212593](https://doi.org/10.3390/rs61212593)

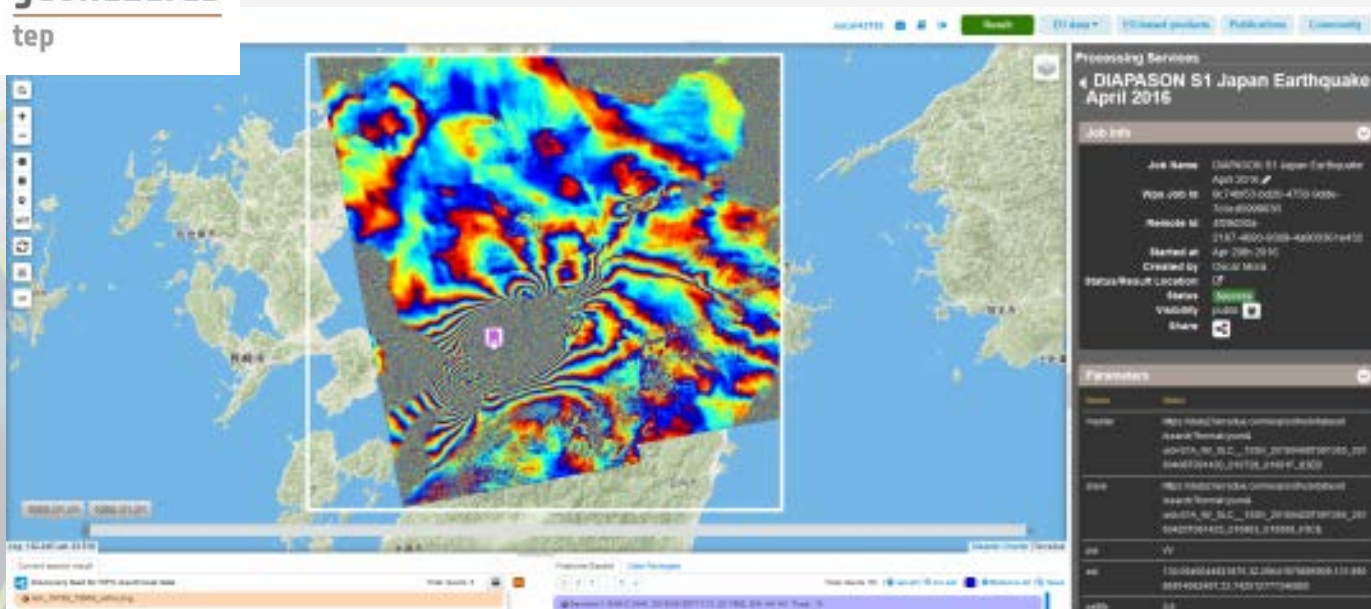


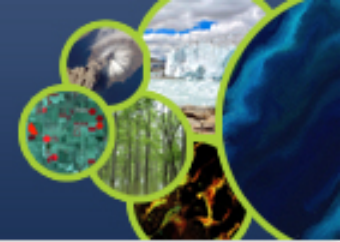
Exploitation of ESA's Geohazards Exploitation Platform (GEP)

- Testing of hosted processing services available in the GEP
- Both conventional and advanced InSAR methods to detect terrain motion
- Generation of GIS-ready digital products
- Also to be tested with DLR's TerraSAR-X StripMap scenes



geohazards
tep



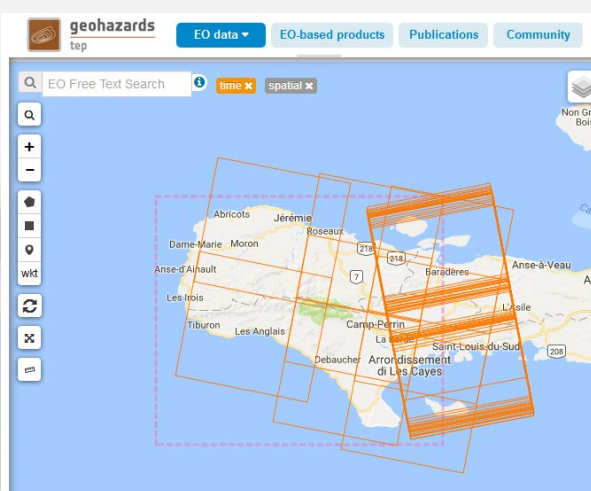


Exploitation of ESA's Geohazards Exploitation Platform (GEP)

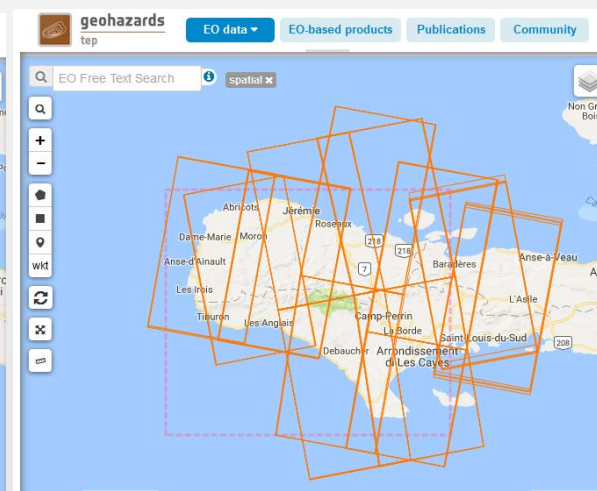
- Submitted GEP project proposal for evaluation by ESA and Terradue
 - Project approved on 09/02/2018, activities kicked-off & GEP account setup
- Task 1: Ingestion of new SAR data into GEP
- **COSMO-SkyMed**: regularly uploaded by ASI and ESA onto ESA's ftp since Feb. 2018
 - **TerraSAR-X**: link with DLR server established by DLR and ESA in Feb. - Mar. 2018



COSMO-SkyMed SpotLight



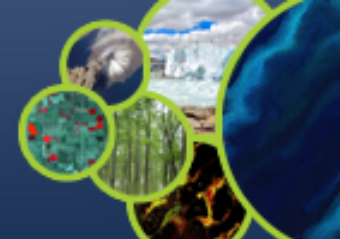
COSMO-SkyMed StripMap



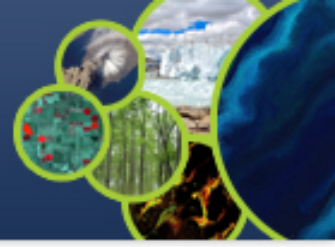
TerraSAR-X StripMap



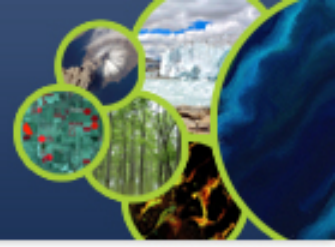
- Copernicus EMS support sought in May of 2017. Internal confusion at the World Bank/GFDRR led to long delay in activation. Direct contact taken by CNIGS with EU delegation in January 2018. Activation now underway:
 - Activation EMSN050 - Post Matthew damage assessment and monitoring of recovery activities in the south region of Haiti.
 - Activation EMSN051 – post Matthew monitoring on rural areas, south region of Haiti.



- This activation covers the following:
 - General reference content
 - Damage assessment of assets with a focus on buildings in 2 areas of interest (AOI: 1 and 2)
 - Identification of Internally Displacement Person (IDP) camps close to secondary cities (AOI: 1 and 2).
 - Monitoring of reconstruction activities of the assets and monitoring of evolution state of the IDP camps
- Call is focused on areas around Jeremie and Les Cayes.
- Call was released 6th March. Firms have ten days to respond, and 20 days to deliver product.



- This activation covers the following:
 - Detailed damage assessment of Parc Makaya
 - Monitoring of Parc Makaya rehabilitation and possible illegal logging
 - Agricultural changes, especially in Les Cayes plain
 - Coast zone changes
- Call will be released soon. Firms have ten days to respond, and 20 days to deliver product.



- NOAA

- Interest of NOAA (Felix Kogan NOAA/NESDIS) to provide satellite-based Vegetation Health (VH) products
- Teleconf organized held to refine haitian needs and organize data access

- ESA

- Haitian partners should use GEP to process SAR-derived products developed by ASI team
- Data access through GEP

- WG CapD

- Presentation of RO needs in capacity Building at the last WG CapD Meeting (March 7th)
- Analysis of WG CapD possible contribution to RO : TBD

- RO Capacity Building plan dedicated to develop
 - “RO products” local producers
 - “RO products” local users
- Workshop #2 from May 7 to 11
 - In Port-au-Prince and Les Cayes (local user workshop and awareness activities)
 - Consolidate links with Universities (training during next mission)
- Solicitation of new funding and new partners to augment product and Capacity Building offering
- RO promotion/dissemination
- Development of Generic RO Concept
- Definition of Haiti RO legacy



Satellite support for Risk Management in Haiti – an innovative example

- **The event aims to showcase the very rich experience currently underway in Haiti:**
 - **International Charter Authorised User request;**
 - **Hurricane Matthew RO;**
 - **Copernicus Work in Haiti – rapid mapping and risk and recovery;**
 - **RASOR Phase II;**
 - **UNDP Risk Assessment Work;**
 - **HaitiData.Org and the World Bank.**
- **Tuesday, 15 May 09:00 – 11:00 in Capilla Room**



Satellite support for Risk Management in Haiti – an innovative example

- 9:00 Welcoming Remarks – CNIGS - *Boby Piard*
- 9:10 Haitian Civil Protection Department and the use of satellite data for hurricane response: the Charter experience – DPC Haiti - *Jerry Chandler*
- 9:25 World Bank and GFDRR support to Geomatics capacity building in Haiti: HaitiData.Org and other examples – WB/GFDRR - *Roland Bradshaw*
- 9:40 UNDP Risk Management activities in Haiti – UNDP - *Samira Philip*
- 9:55 The Post-Matthew Recovery Observatory (RO) in Haiti: a pilot – CNES - *Helene de Boissezon*
- 10:10 Early achievements of the RO project – CNIGS - *Boby Piard*
- 10:30 RASOR (Rapid Analysis and Spatialisation of Risk) in Haiti: an advanced tool for risk assessment and risk information integration – CIMA – *Giorgio Boni*
- 10:45 Next steps for satellite data exploitation in Haiti: a round table discussion – moderator *Andrew Eddy*



□ Haiti Recovery Observatory

- Status Overview
- Feedback after one year
- December Technical Mission
- DLR – TerraSAR-X contribution
- ASI – Terrain motion products
- Copernicus EMS R&R activation
- Next Steps

□ RO concept on other areas



Expressions of interest :

- World Bank in **Nepal**, for assessing the situation of reconstruction after the 2015 EQ - Waiting for Nepal government decision to express needs
- **Vietnam** ministry of agriculture / UNDP / WB / IRD for post typhoons agricultural situation management

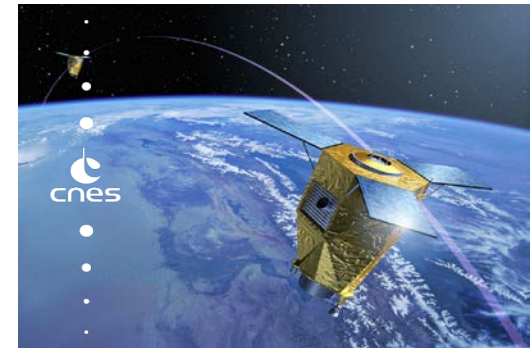
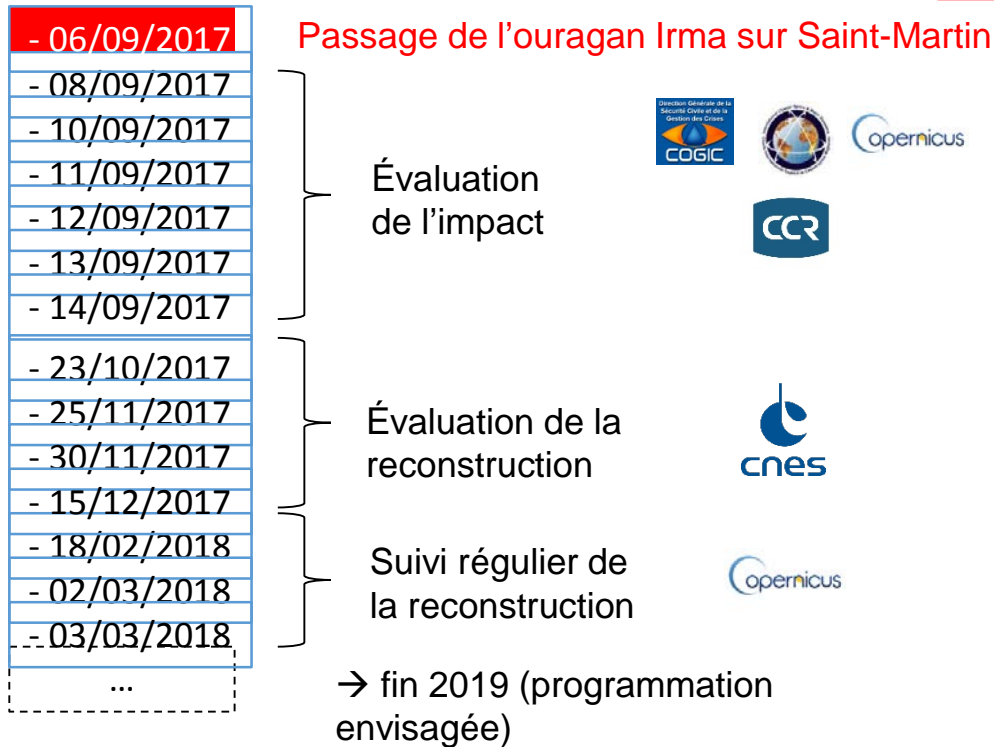
RO concept for post Irma management in France :

- Further to EMS RMS & Charter activations , decision by CNES to secure Pleiades acquisitions for guaranteeing “Recovery imaging”
- French “Delegation Interministerielle à la Reconstruction” triggered EMS RRM mid February – work to start mid March
- Anticipation by CNES for 1st results “EMS RRM like” at the 5th Committee held March 12th with French Prime Minister

Ouragan Irma – Suivi de la reconstruction de l’île de Saint-Martin par imagerie satellitaire Pléiades – Comité interministériel 12 mars 2018

Les moyens : images Pléiades disponibles pour l’évaluation

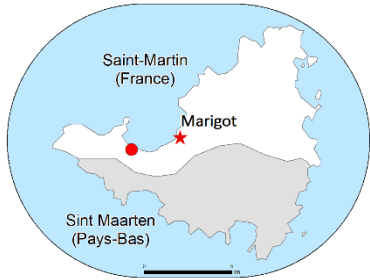
Lancement par le CNES d’une campagne d’acquisition systématique d’images satellite Pléiades



- Pléiades**, un système d’observation de la Terre :
- 2 satellites français lancés et opérés par le CNES
 - très haute résolution (70 cm)
 - capacité d’acquisition journalière en tout point du globe
 - capacité d’acquisition d’images stéréoscopiques pour la réalisation de modèles numériques de terrain

Ouragan Irma – Suivi de la reconstruction de l'île de Saint-Martin par imagerie satellitaire Pléiades – Comité interministériel 12 mars 2018

Que voit-on avec Pléiades ?



Évolution de la situation Bâtiments endommagés en cours de reconstruction Sandy Ground (Ouest St-Martin)

Post-Irma, septembre 2017



Situation avant ouragan



Bâtiments et toits endommagés

15 décembre 2017



Bâtiments reconstruits ou en cours de reconstruction

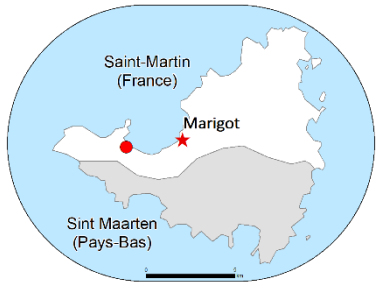
18 février 2018



Situation quasi-stationnaire

Ouragan Irma – Suivi de la reconstruction de l'île de Saint-Martin par imagerie satellitaire Pléiades – Comité interministériel 12 mars 2018

Que voit-on avec Pléiades ?



Situation
avant
ouragan



Évolution de la situation
Dépôt de gravats / débris
Baie Nettlé (Ouest St-Martin)

Post-Irma, septembre 2017



23 octobre 2017



Apparition du dépôt de
gravats

25 novembre 2017



Réduction du dépôt de
gravats

15 décembre 2017



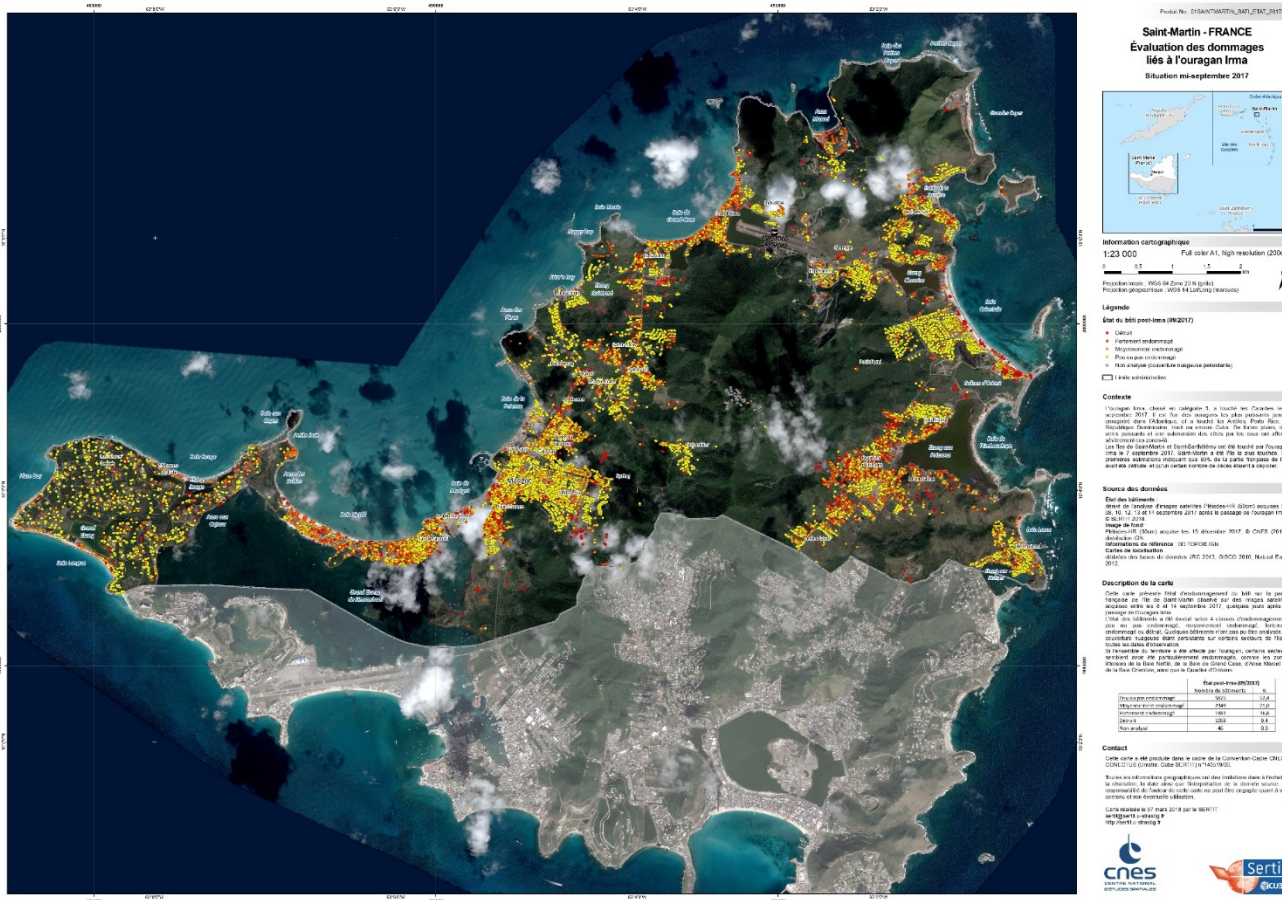
Réduction du dépôt de
gravats

18 février 2018



Disparition du dépôt de
gravats

Ouragan Irma – Suivi de la reconstruction de l'île de Saint-Martin par imagerie satellitaire Pléiades – Comité interministériel 12 mars 2018



État du bâti post-Irma septembre 2017

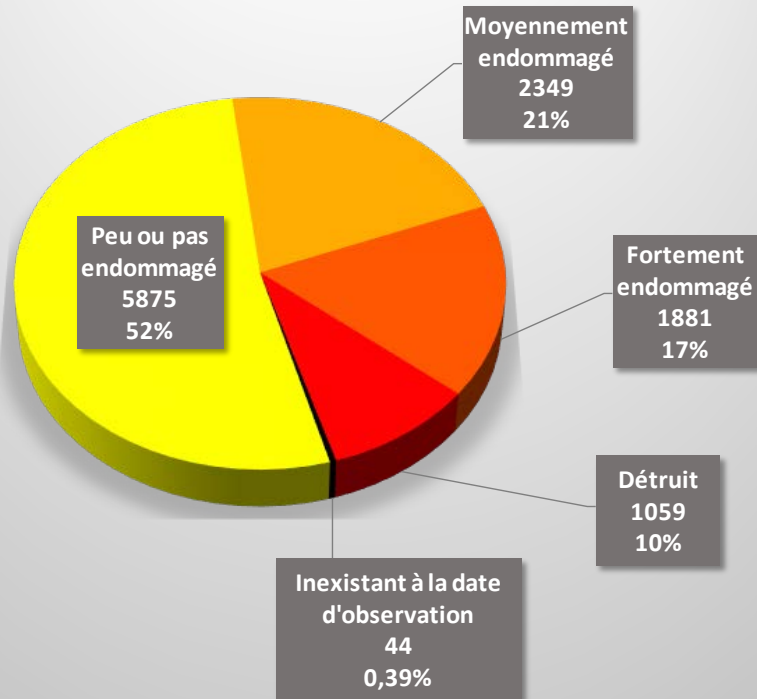
Vue globale de la partie française de Saint-Martin

État du bâti post-Irma (09/2017)

- Détruit
- Fortement endommagé
- Moyennement endommagé
- Peu ou pas endommagé
- Non analysé (couverture nuageuse persistante)

Cartographie au 1:23 000
Echelle de travail : jusqu'au 1:2 000

État du bâti post-Irma, septembre 2017



Nombre de bâtiments cartographiés : 11 254

État du bâti post-Irma septembre 2017

Estimations réalisées par photo-interprétation d'une série d'images satellite Pléiades, acquises entre le 8 et le 14 septembre 2017 (passage de l'ouragan sur St-Martin le 6 sept).



Ouragan Irma – Suivi de la reconstruction de l'île de Saint-Martin par imagerie satellitaire Pléiades – Comité interministériel 12 mars 2018



État du bâti le 15 décembre 2017

Vue globale de la partie française de Saint-Martin

Suivi de la reconstruction

État du bâti au 15/12/2017

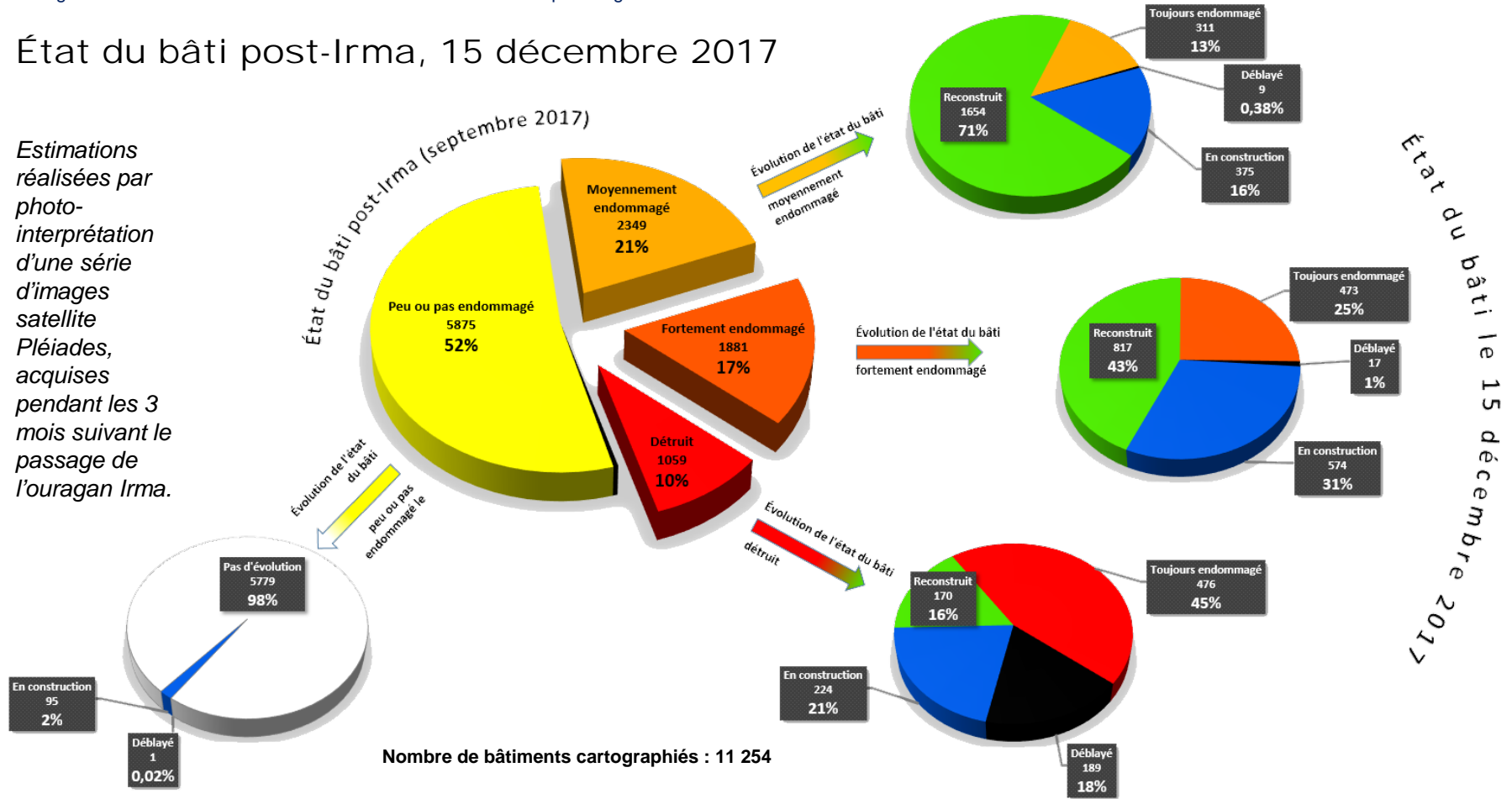
- Déblayé
- Endommagé
- En construction
- Etat normal

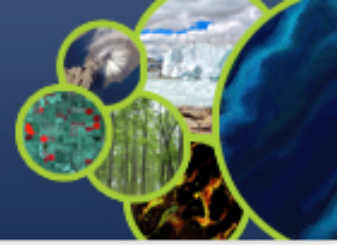
Cartographie au 1:23 000
Echelle de travail : jusqu'au 1:2 000

Ouragan Irma – Suivi de la reconstruction de l'île de Saint-Martin par imagerie satellitaire Pléiades – Comité interministériel 12 mars 2018

État du bâti post-Irma, 15 décembre 2017

Estimations réalisées par photo-interprétation d'une série d'images satellite Pléiades, acquises pendant les 3 mois suivant le passage de l'ouragan Irma.





THANK YOU!
MERCI!

