→ THE ESA EARTH OBSERVATION Φ-WEEK

EO Open Science and FutureEO

12–16 November 2018 | ESA–ESRIN | Frascati (Rome), Italy

Generating InSAR products with COSMO-SkyMed and TerraSAR-X imagery in the Geohazards Exploitation Platform (GEP) to support the CEOS Recovery Observatory in Haiti

Cigna F., Tapete D., Danzeglocke J., Bally Ph., Cuccu R., Papadopoulou T., Caumont H., Collet A., de Boissezon H., Eddy A., Piard B.E.

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European Space Agency

Generating InSAR products with COSMO-SkyMed and TerraSAR-X imagery in the Geohazards Exploitation Platform (GEP) to support the CEOS Recovery Observatory in Haiti

Cigna F.[1], Tapete D.[1], Danzeglocke J.[2], Bally Ph.[3], Cuccu R.[4,5], Papadopoulou T.[6],

Caumont H.[7], Collet A.[8], de Boissezon H.[8], Eddy A.[9], Piard B.E.[10]

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Committee on Earth Observation Satellites

62 Agencies operating 160 satellites!

http://ceos.org/

Established in 1984

Mission: to ensure international coordination of civil space-based Earth observation programs and promote exchange of data to optimize societal benefit and inform decision making for securing a prosperous and sustainable future for humankind
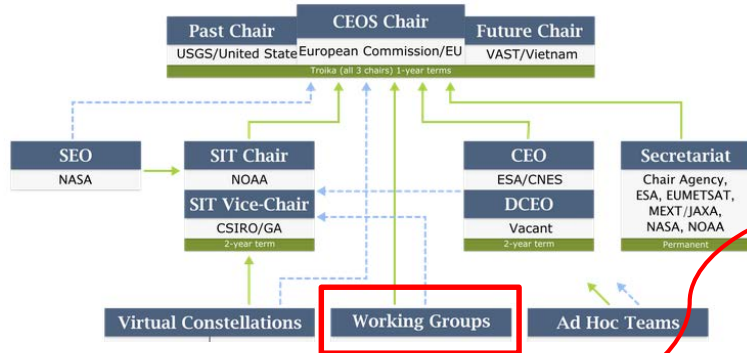
CEOS WG on Disasters

Established in 2013

Over 20 member organizations involved in the use of satellite imagery for disaster risk reduction, response and recovery

CEOS Recovery Observatory in Haiti

Path of Hurricane Matthew
(credit NOAA/NHC - NASA)

Post-Matthew RO

Triggered in Dec 2016 by the CEOS Executive, the RO aims at monitoring recovery and rehabilitation in the areas of southwest Haiti affected by Hurricane Matthew

Recovery Observatory Haïti

https://www.recovery-observatory.org

Overseen by Steering Committee made up of CEOS agencies (CNES, CSA and ASI), international DRM stakeholders (GFDRR/WB and UNDP) and national partners:

- CNIGS (National Center for Geo-spatial Information)
- CIAT (Inter-Ministerial Committee for Land Management)
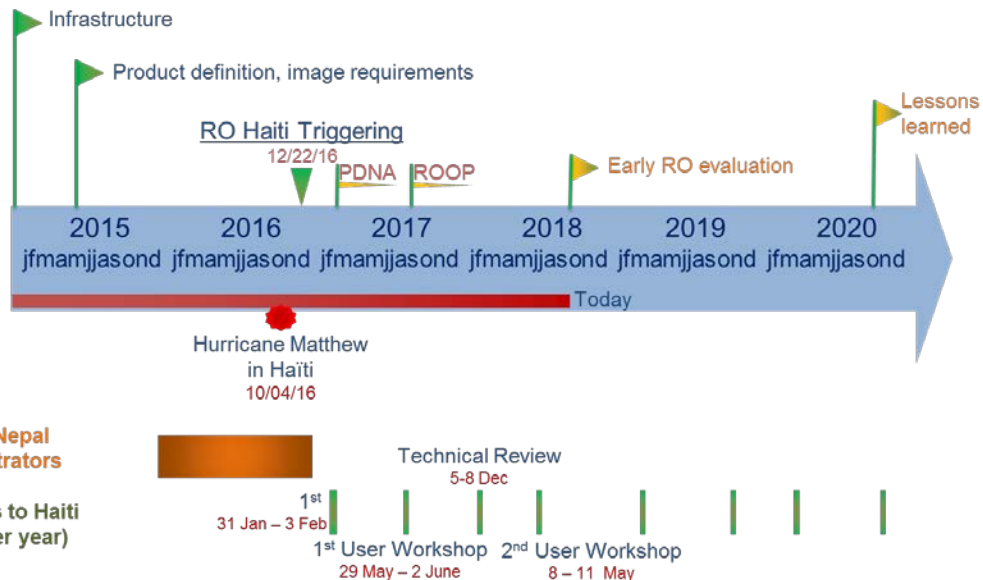- ONEV (National Observatory of Environment and Vulnerability)

Damage caused by Hurricane Matthew in Haiti (Oct 2016)

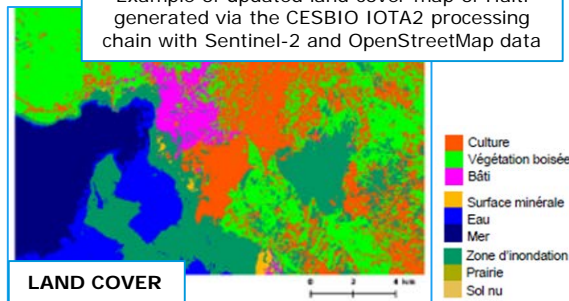Damage in Les Cayes (source: www.abc.net.au)

RO Haiti timeline [2017-2020]

RO thematic products

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

Example of updated land cover map of Haiti generated via the CESBIO IOTA2 processing chain with Sentinel-2 and OpenStreetMap data
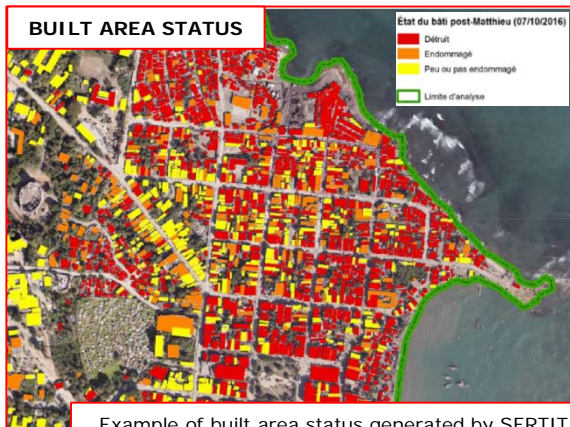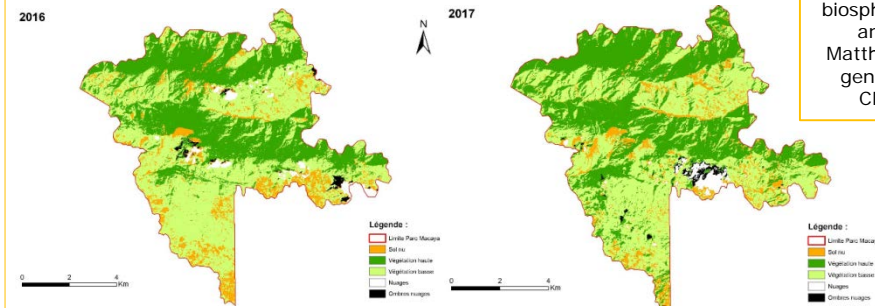
WATER SYTEM MONITORING

LAND COVER

Culture
Végétation boisée
Bâti
Surface minérale
Eau
Mer
Zone d'inondation
Prairie
Sol nu

Example of flood risk map for Les Cayes, derived by CIMA (contract ASI) based on CNES Pléiades and ASI COSMO-SkyMed data

BUILT AREA STATUS

État du bâti post-Matthieu (07/10/2016)
Détruit
Endommagé
Peu ou pas endommagé
Limite d'analyse

Example of built area status generated by SERTIT (contract CNES) based on CNES Pléiades data

MACAYA NATIONALPARC
(UNESCO Biosphere Reserve, since 2016)

2016

2017

Légende :
Limite Parc Macaya
Sol nu
Végétation haute
Végétation basse
Nuages
Ombres nuages

Assessing direct impacts of the hurricane, understanding how the biosphere regenerated and identify any anthropic activity: pre-Matthew and post-Matthew states generated by SERTIT (contract CNES) using SPOT6/7 data

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CEOS Recovery Observatory in Haiti

RO thematic products

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

Produit	Utilisateur-clef	Elaboration	Données satellites
Buildings	CIAT/ Planning Ministry	SERTIT, Copernicus EMS	Pléiades, WV
Land Use	ALL	CNIGS/CNES	Orthophotos, Sentinel-2
Forest	ONEV /Environnement Ministry	Copernicus EMS	S2, Spot6/7, Optique THR
Agriculture	Agriculture Ministry	Copernicus EMS	Sentinel-2, SPOT
Macaya Park Monitoring	ANAP / ONEV / Env. Min.	Copernicus EMS SERTIT	Optic THR, radar THR
Suivi bassins versants	ONEV/ Agriculture Ministry	CIMA Foundation	MNT 1m/20cm and radar THR
Terrain Motion / Mining career	BME / Public Work Ministry	EOST, ASI	CSK, Pléiades, Spot6/7
Vector Borne Disease	Heath Minister/ OMS	NOAA	L8, Images NOAA + statistic needs
Air pollution	ONEV / Ministère Santé	NASA	S5P Tropomi Interest pronounced

TERRAIN MOTION

Mapping and monitoring land subsidence, landslides, and other mass movements and landscape changes

Automatic Landslide Detection and Mapping (ALADIM) based on satellite optical data

led by CNRS-EOST

Application of ALADIM to pre/post-Matthew images (SPOT6 & SPOT7) Les Anglais Cordillera (West Haiti)

SPOT 6 – Pre Matthew 2016 January

SPOT 7 – Post Matthew 2017 February

500m
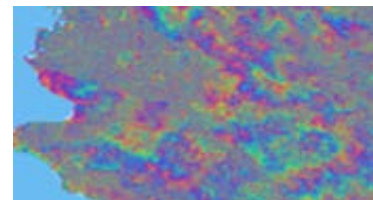
Satellite SAR data processing, including change detection, conventional InSAR & advanced InSAR (e.g. SBAS, PSI)

led by ASI

CEOS Recovery Observatory in Haiti

Target areas (<u>stakeholders' priorities</u>)
- Jeremie (urban + rural)
- Camp-Perrin (rural + road network)
- Carriere Arniquet (rural + mining)

TERRAIN MOTION – SAR data analysis

Scientific goals

➢ Develop <u>experimental scientific products</u> tailored to obtain useful information on ground stability and motions for target areas of the RO

➢ Test <u>VHR satellite SAR for hotspot mapping</u> via

- Tailored TerraSAR-X StripMap acquisition campaign over wide area

- Bespoke COSMO-SkyMed SpotLight campaign for 3 hotspots in different recovery contexts

- InSAR processing within ESA's Geohazards Exploitation Platform (GEP)

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Geohazards Exploitation Platform (GEP)

https://geohazards-tep.eo.esa.int

Initiated in 2014 and evolved through ESA funding as part of the Thematic Exploitation Platforms (TEP)

GEP follows the Supersites Exploitation Platform (SSEP), originally initiated in the context of the Geohazard Supersites & Natural Laboratories initiative (GSNL)

A platform sourced with data, tools, and processing services, developed to support the exploitation of satellite EO for geohazards

GEP contributes to the CEOS WG Disasters to support its thematic Pilots, Demonstrators and Recovery Observatory

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Geohazards Exploitation Platform (GEP)

Geohazards Exploitation Platform (GEP)

Dr F. Cigna, *Italian Space Agency (ASI)* | ESRIN | 16/11/2018 | Slide 11

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GEP hosted tools for SAR data processing

esa

Examples of GEP hosted processing services for <u>InSAR and change detection</u>

SNAP Sentinel-1 IW SLC Interferogram and Displacements

Provides the InSAR processor for Sentinel-1 TOPSAR IW SLC data performed through SNAP (Sentinel Application Platform) - S1TBX

SNAP is a common architecture for all Sentinel Toolboxes, ideal for EO processing and analysis

https://terradue.github.io/doc-tep-geohazards/tutorials/rss_snap_s1_insar.html

SNAC - SNAP S1 GRD Amplitude Change

Provides RGB color composites of radar backscattering from a pair Sentinel-1 TOPSAR (IW, EW) GRD products processed in SNAP

https://terradue.github.io/doc-tep-geohazards/tutorials/rss_snap_s1_snac.html

DIAPASON InSAR Sentinel-1 TOPSAR (IW,EW)

Developed by CNES and maintained by TRE-ALTAMIRA

Performs an InSAR workflow on Sentinel-1 TOPSAR (IW, EW) SLC data, producing interferograms, amplitude and coherence maps
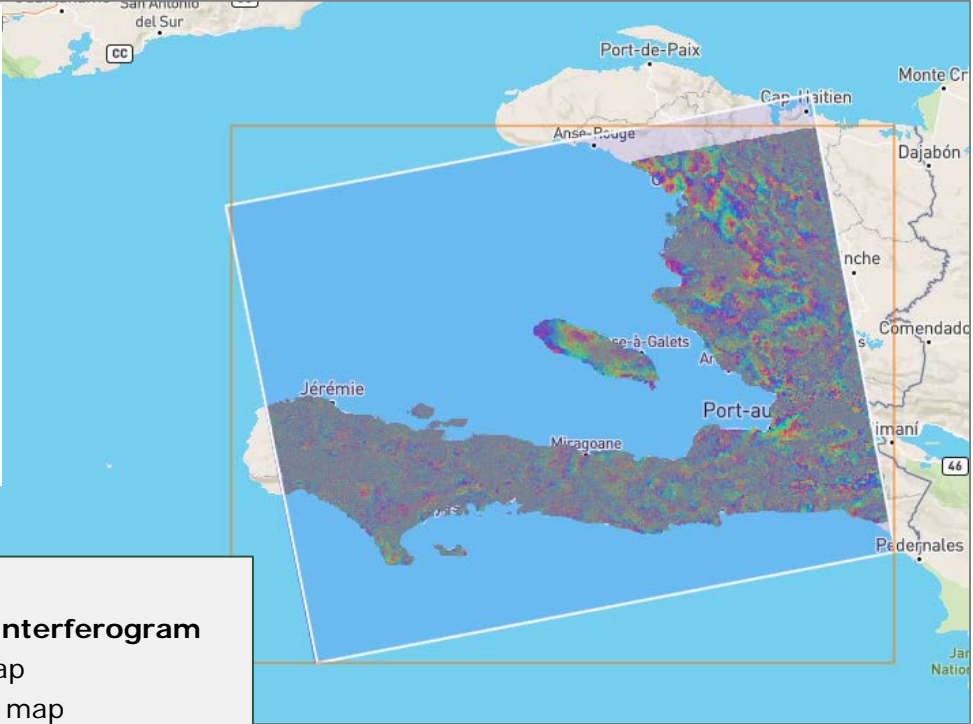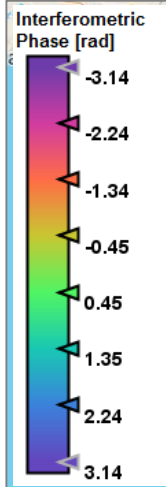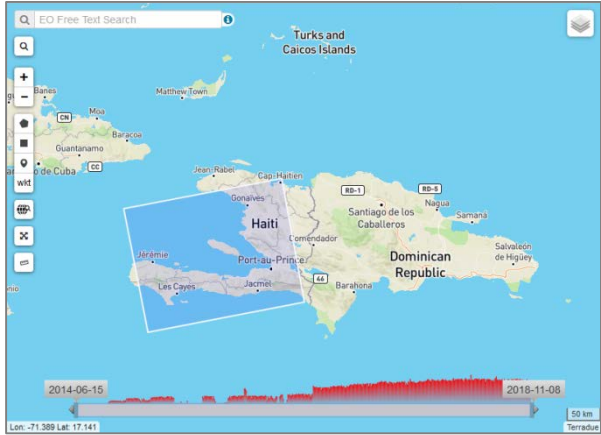
https://terradue.github.io/doc-tep-geohazards/tutorials/diapason-iw.html

GEP outputs – S1 on-demand processing

SNAP Sentinel-1 IW SLC Interferogram and Displacements

Inputs [*pre vs post Hurricane Matthew*]
1) S1 IW SLC 24/09/2016 (master)
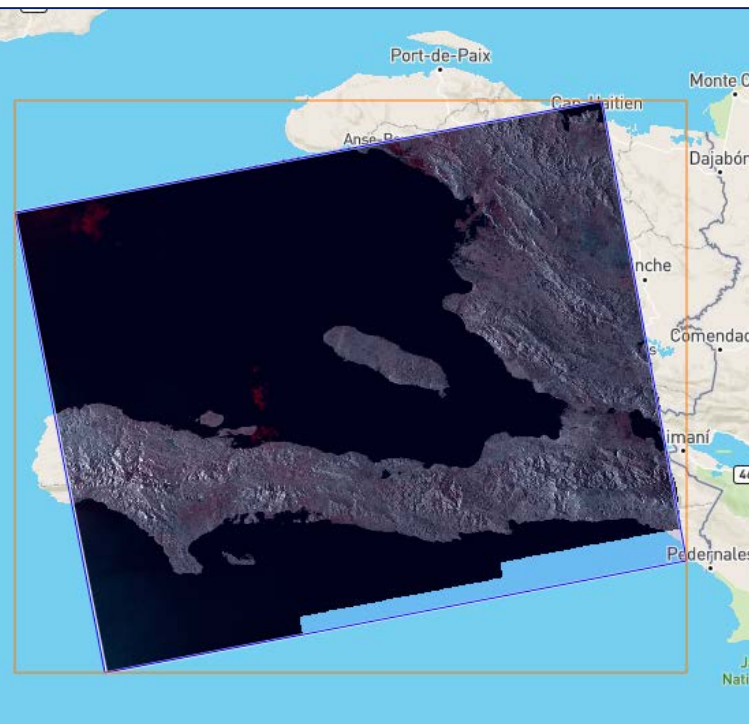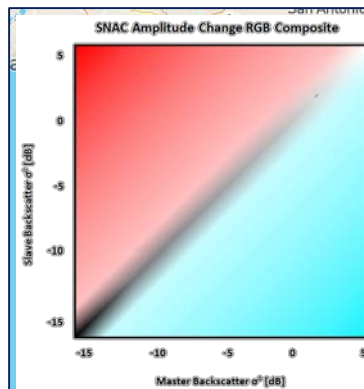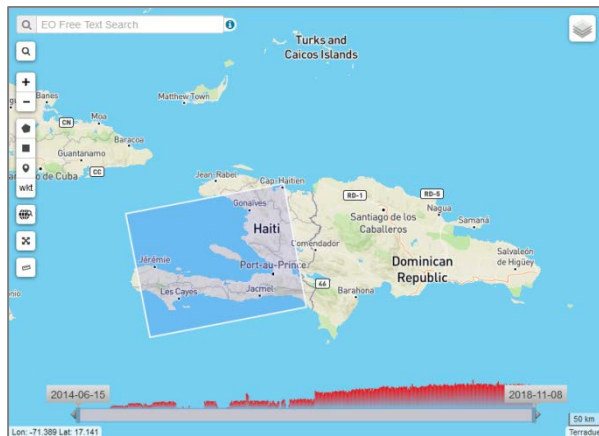2) S1 IW SLC 18/10/2016 (slave)

Outputs:
• **Differential interferogram**
• Coherence map
• Displacement map

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SNAC - SNAP S1 GRD Amplitude Change

Inputs [*pre vs post Hurricane Matthew*]
1) S1 IW GRD 24/09/2016 (master)
2) S1 IW GRD 18/10/2016 (slave)

Outputs:
- **RGB color composite**
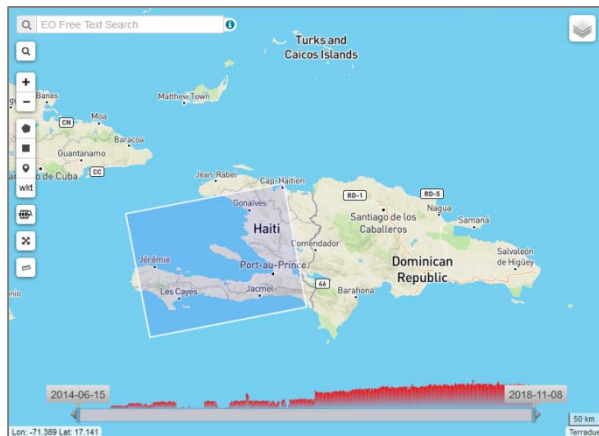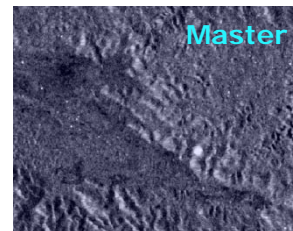- Master amplitude
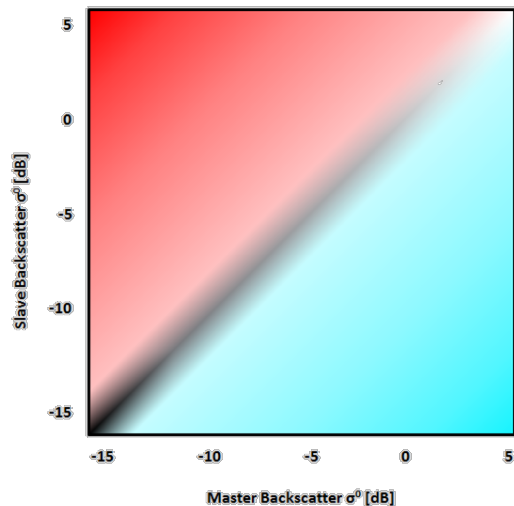- Slave amplitude

SNAC
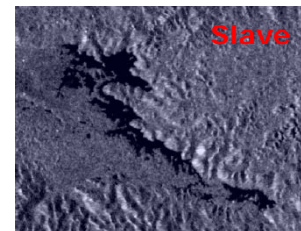
SNAC - SNAP S1 GRD Amplitude Change

Inputs [*pre vs post Hurricane Matthew*]
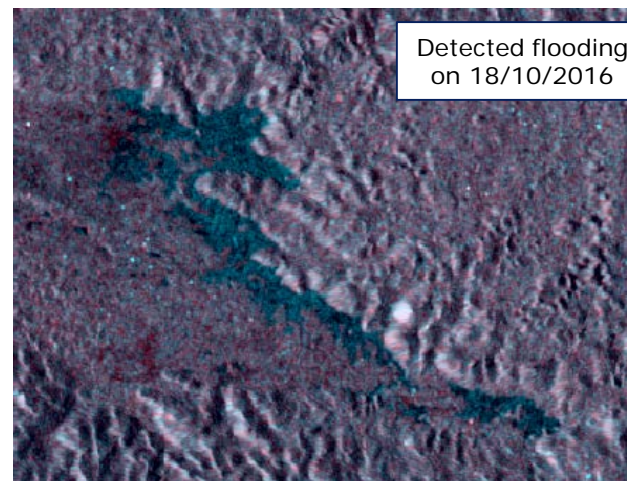1) S1 IW GRD 24/09/2016 (master)
2) S1 IW GRD 18/10/2016 (slave)


SNAC Amplitude Change RGB Composite

Master Backscatter σ⁰ [dB]

Slave Backscatter σ⁰ [dB]

Outputs:
- **RGB color composite**
- Master amplitude
- Slave amplitude

Master

Slave

Detected flooding on 18/10/2016

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Newly acquired DLR's TerraSAR-X data

➢ DLR is acquiring a mosaicked coverage of the AOI [since 2016]

➢ X-band StripMap images at very high spatial resolution (3 m)

➢ Ascending and descending mode acquisition, 3-4 months revisit

➢ 6th complete coverage achieved
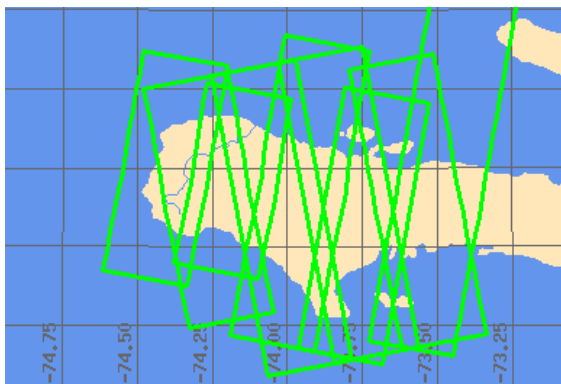
TerraSAR-X data ingested into GEP via linking with DLR server
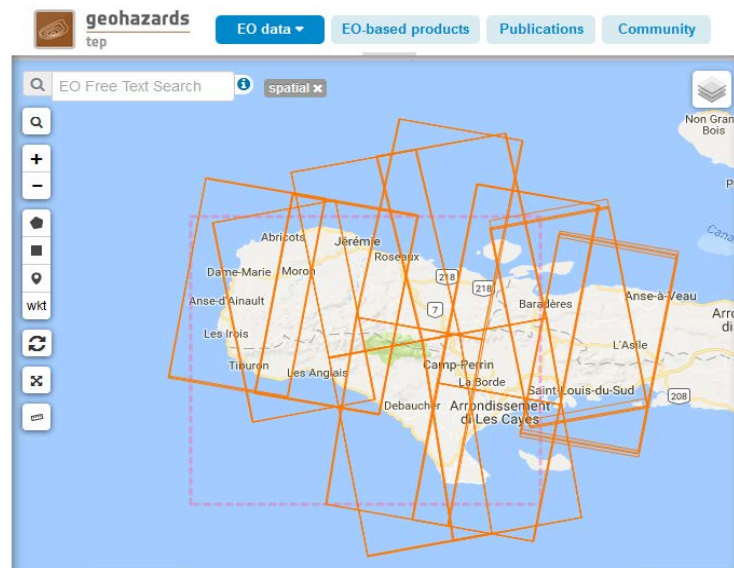

TerraSAR-X data will be processed with **change detection** approaches to identify landscape changes (roughness, soil moisture, ground movement) occurred

Tailored VHR SAR campaigns: COSMO-SkyMed

Newly acquired ASI's COSMO-SkyMed data

> 3-year long tailored monitoring campaign [started on 1st Dec 2017]

> X-band SpotLight images at very high spatial resolution (1 m)

> Ascending and descending mode acquisition, 16 days revisit
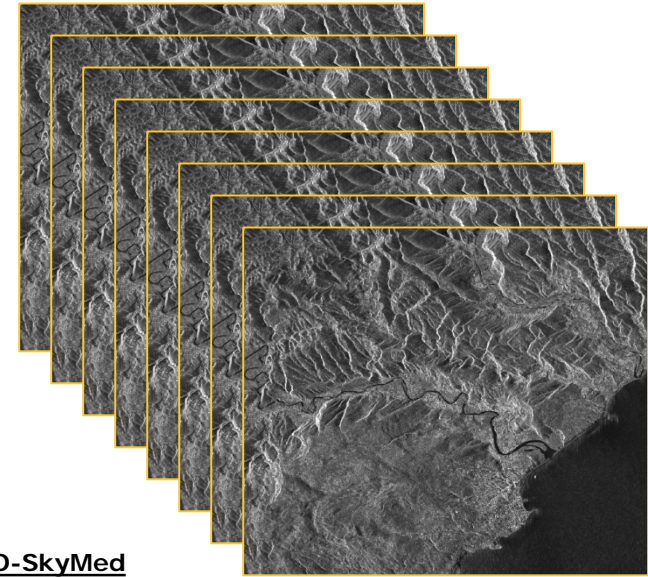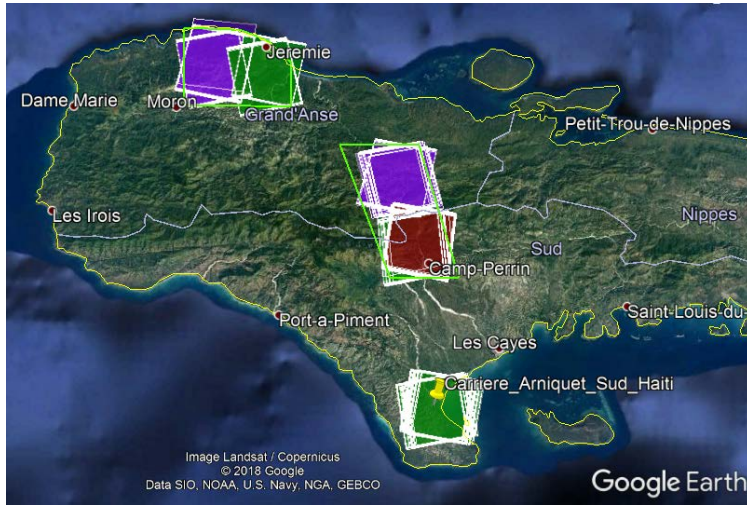
More than 200 COSMO-SkyMed
SpotLight scenes already acquired

~20 scenes per site, per geometry

(as of mid Nov 2018)

Ongoing and future work

- ➤ **SAR data processing in GEP**
  - ▪ Assessing advanced InSAR services (e.g. P-SBAS, FASTVEL, StaMPS)
  - ▪ Development of tools for TerraSAR-X and COSMO-SkyMed analysis

SNAP+StaMPS

- ➤ **Assessing new opportunities**
  - ▪ H2020 funding: BETTER project providing a mechanism to select new "data challenges"
  - ▪ Setup of systematic processing chain delivering analysis-ready data (ARD)

- ➤ **Capacity building**
  - ▪ Training Haitian partners and end-users on the use of GEP, basic processing tools and approaches for interpretation of outputs towards hazard and risk assessment, and enhanced land use planning and recovery after Matthew

Dr F. Cigna, *Italian Space Agency (ASI)* | ESRIN | 16/11/2018 | Slide 18

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