Committee on Earth Observation Satellites

NH6.3
Application of remote sensing and Earth-observation data in natural hazard and risk studies

SAR-based scientific products in support to recovery from hurricanes and earthquakes: lessons learnt in Haiti from the CEOS Recovery Observatory pilot to the demonstrator

Deodato Tapete [1], Francesca Cigna [2], Agwilh Collet [3], Hélène de Boissezon [3],

Robin Faivre [4], Andrew Eddy [5], Jens Danzeglocke [6], Philemon Mondesir [7],

David Telcy [7], Esther Manasse [7], Boby Emmanuel Piard [7], Samuel Généa [8]

[1] Italian Space Agency (ASI), Rome, Italy
[2] Institute of Atmospheric Sciences and Climate (ISAC), National Research Council (CNR), Rome, Italy
[3] National Centre for Space Studies (CNES), Toulouse Cedex 9, France
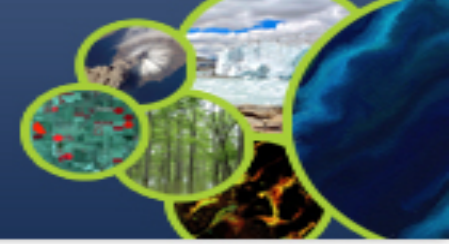[4] ICube-SERTIT / University Of Strasbourg, Illkirch-Graffenstaden, France
[5] Athena Global
[6] German Aerospace Center (DLR), Space Administration, Bonn, Germany
[7] National Center for Geo-spatial Information (CNIGS), Port-au-Prince, Haiti
[8] Bureau des Mines et de l'Énergie d'Haïti (BME), Port-au-Prince, Haiti

Committee on Earth Observation Satellites

CEOS
http://ceos.org/

Working Group on Disasters
http://ceos.org/ourwork/workinggroups/disasters/

The CEOS WG Disasters ensures the sustained coordination of disaster-related activities undertaken by the CEOS Agencies and acts as an interface between CEOS and the community of stakeholders and users involved in risk management and disaster reduction.

Slide adapted from UNOSAT Luca dell'Oro; courtesy CNES RO Team
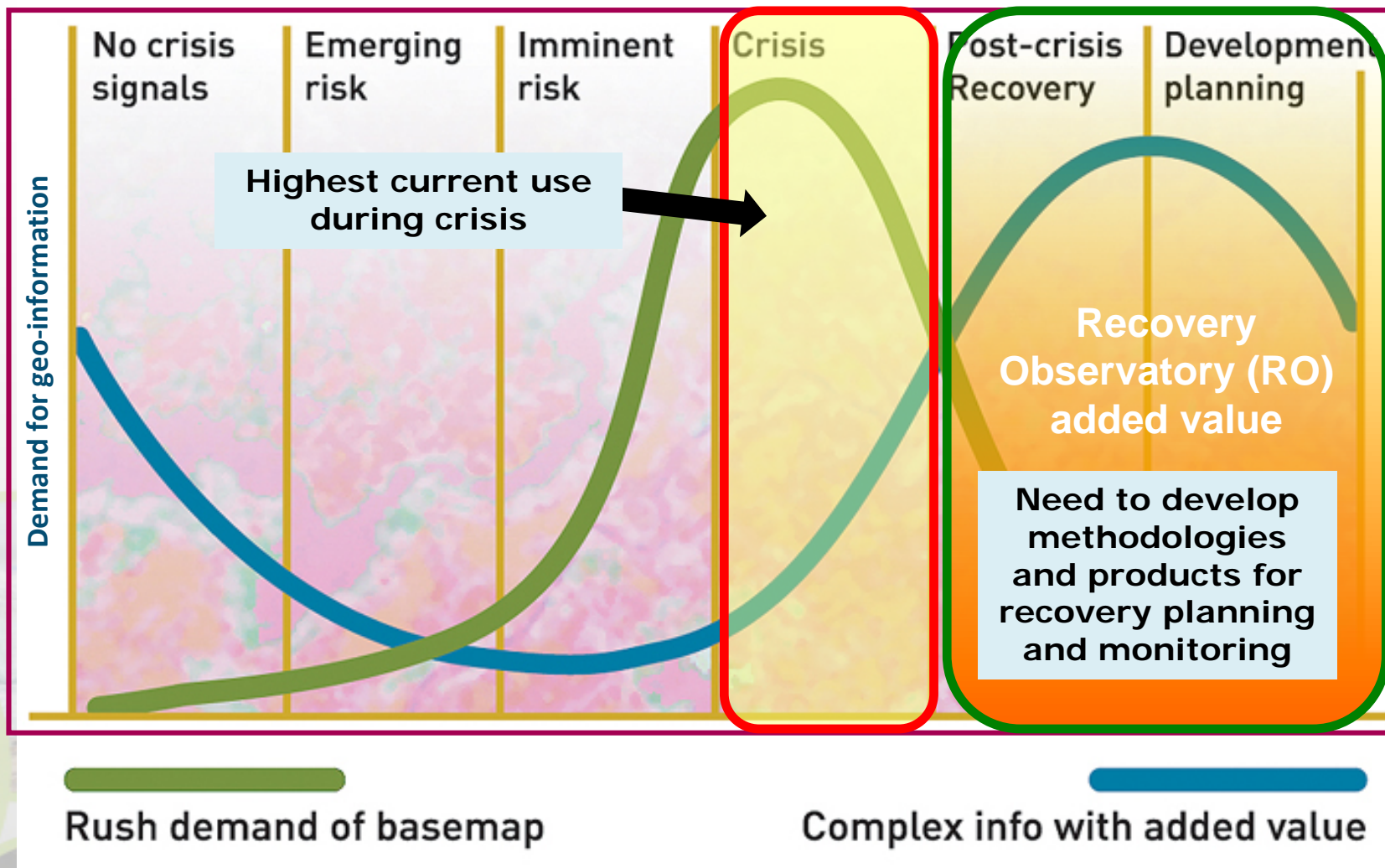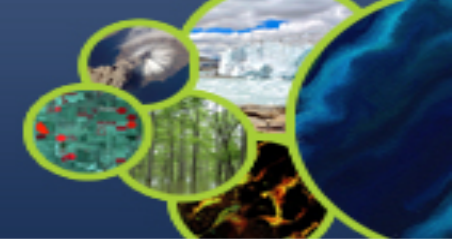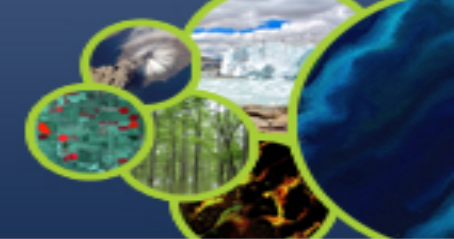
Triggering of the RO in Haiti decided by CEOS Chair in consultation with CEOS Principals, December 22, 2016, after Hurricane Matthew - October 2016
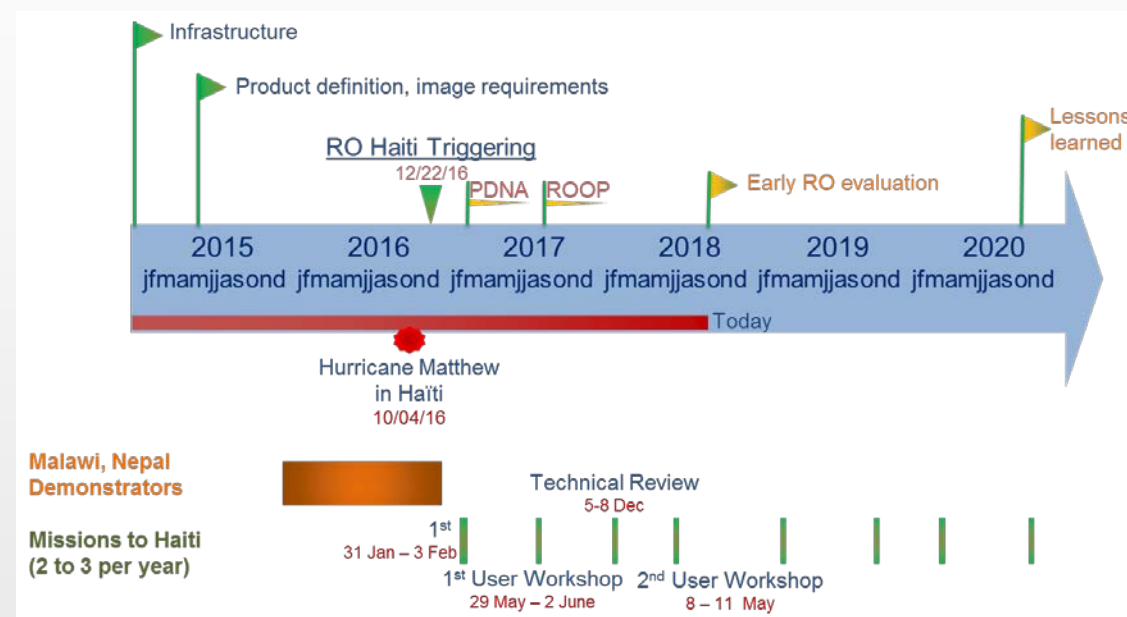

Damage in Les Cayes (source: www.abc.net.au)

Damaged caused by Hurricane Matthew in SW Haiti (October 2016)

RO Haiti timeline [2017-2020]

CEOS Recovery Observatory in Haiti

https://www.recovery-observatory.org/drupal/en
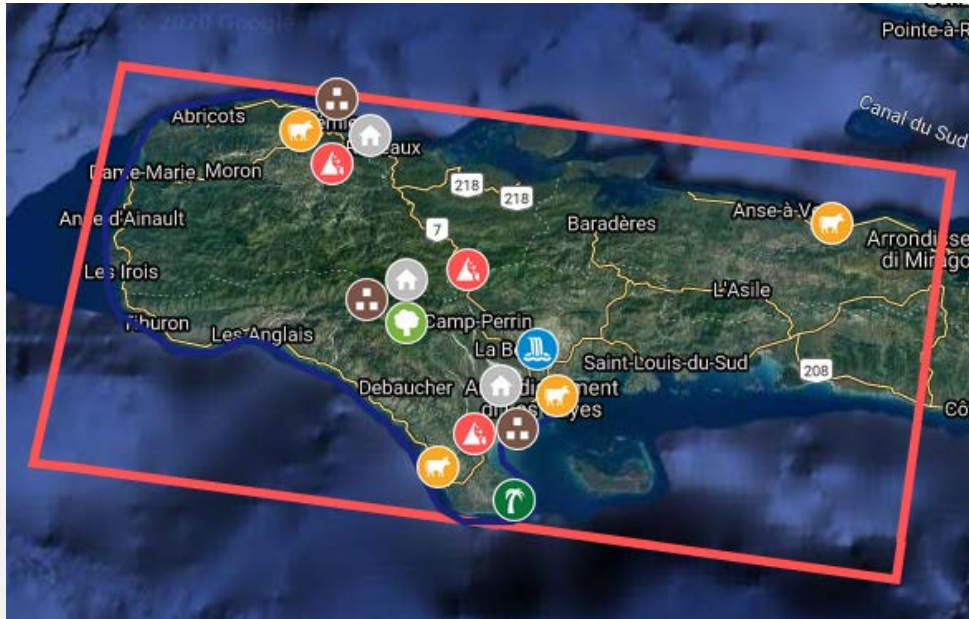
| Produit	Utilisateur-clef	Elaboration	Données satellites
Land Use	All	CNIGS, CNES	Sentinel-2
Buildings Mapping	CIAT / Planning Ministry	CNES/SERTIT, Copernicus EMS R&R	Pléiades, WorldView-3
Terrain Motion Change Detection	BME / URGeo	ASI, CNES/EOST	COSMO-SkyMed, Pléiades, Spot 6/7, TerraSAR-X
Watershed / Flood	ONEV / Agriculture Ministry	ASI/CIMA Foundation	Pléiades, COSMO-SkyMed
Agriculture	Agriculture Ministry	Copernicus EMS R&R	Sentinel-2, Spot 6/7, GeoEye-1, WorldView-2
Macaya National Park Monitoring	ANAP / ONEV / Environment Ministry	Copernicus EMS R&R, CNES/SERTIT	Spot 6/7, Pléiades
Environmental Impact	ONEV / Environment Ministry	Copernicus EMS R&R	Sentinel-2, Spot 6/7, Pléiades, WorldView-2

Scan the QR code for further info

Value adders

Local Partners (on the Recovery Observatory Steering Committee)

Coordinate satellite SAR observations
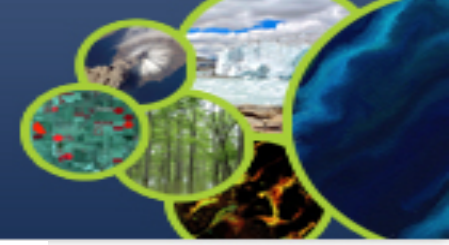
Sentinel-1 → European constellation of the Copernicus programme; C-band (5.6 cm wavelength)
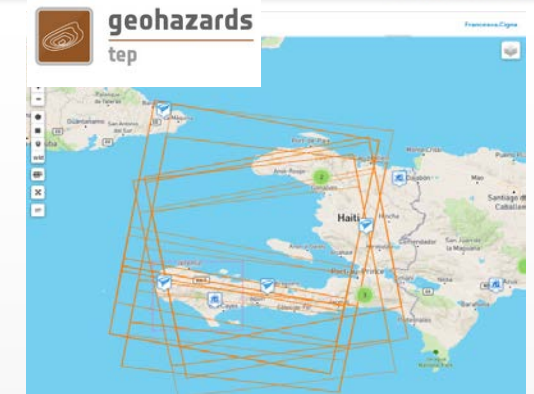Data for the RO: spatial resolution: **~20-25 m**; site revisit: **12 days**

TerraSAR-X → German Space Agency (DLR)'s constellation; X-band (3.1 cm wavelength)
Data for the RO: spatial resolution: **~3 m**; site revisit: **6 months**

COSMO-SkyMed → Italian Space Agency (ASI)'s constellation; X-band (3.1 cm wavelength)
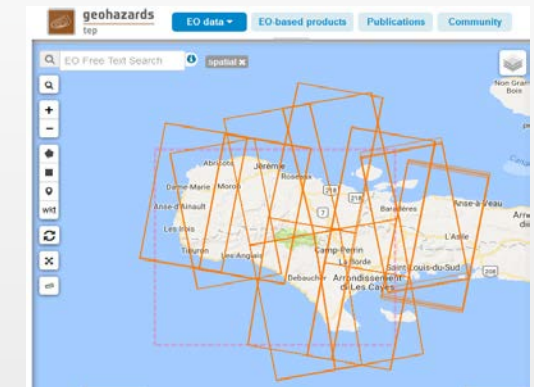Data for the RO: spatial resolution: **~1 m**; site revisit: **16 days**
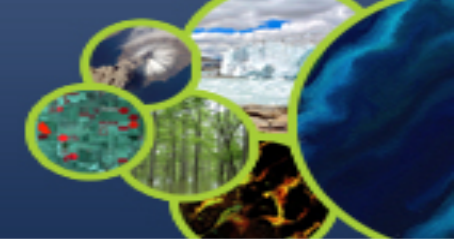

S1 IW TOPS Full national

TSX StripMap Full RO
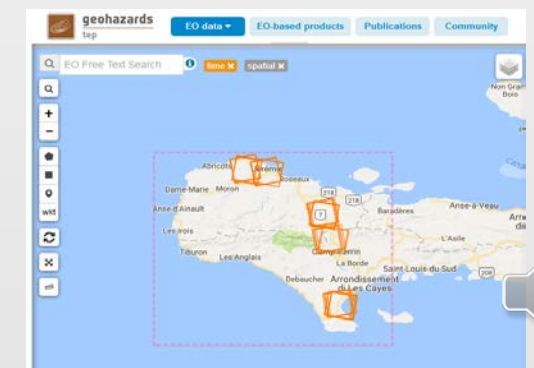
CSK SpotLight RO priority areas

Timeline

- Infrastructure
- Product definition, image requirements
- **RO Haiti Triggering** 22 Dec 2016
- PDNA
- ROOP
- Early RO evaluation
- Lessons learned

2015 | 2016 | 2017 | 2018 | 2019 | 2020
jfmamjjasond jfmamjjasond jfmamjjasond jfmamjjasond jfmamjjasond jfmamjjasond

Today

Hurricane Matthew in Haïti 4 Oct 2016

Sentinel-1

Mission observation scenario includes Haiti since 2014

DLR's TerraSAR-X

ASI's COSMO-SkyMed

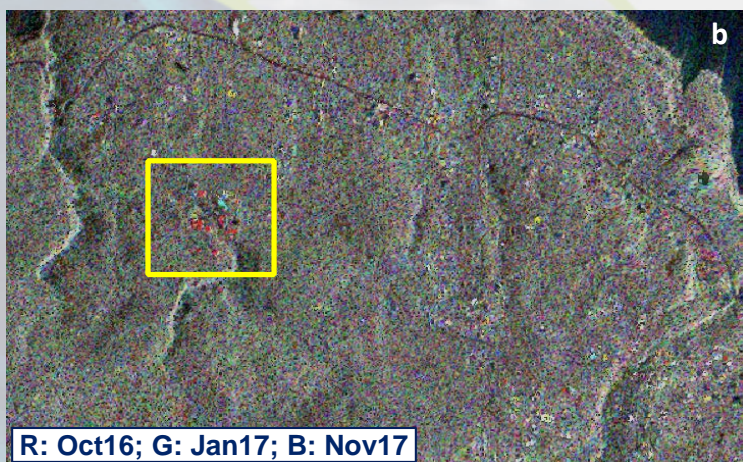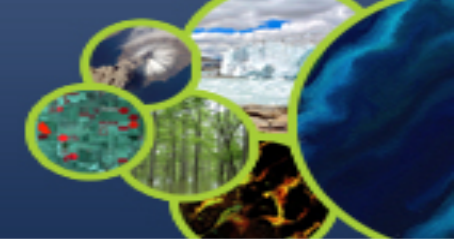**Dedicated SAR acquisition campaigns for the duration of the RO**
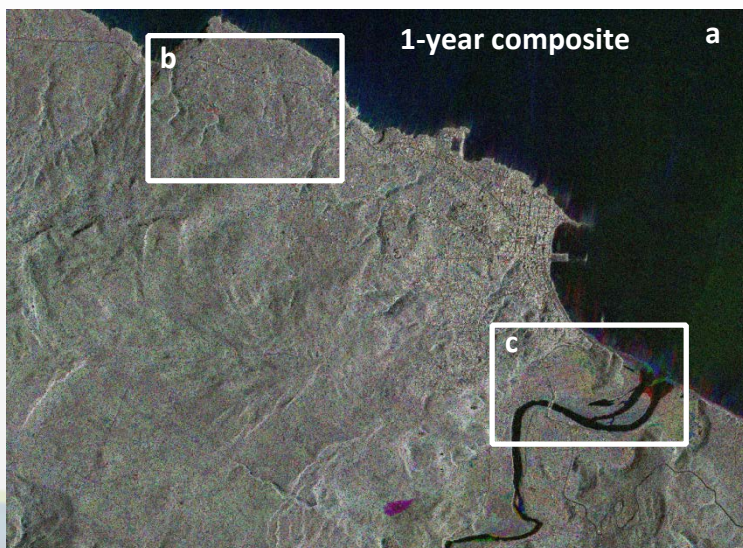
TerraSAR-X change detection maps – temporal evolution of <u>flooding in Troupeau</u> (1 year)
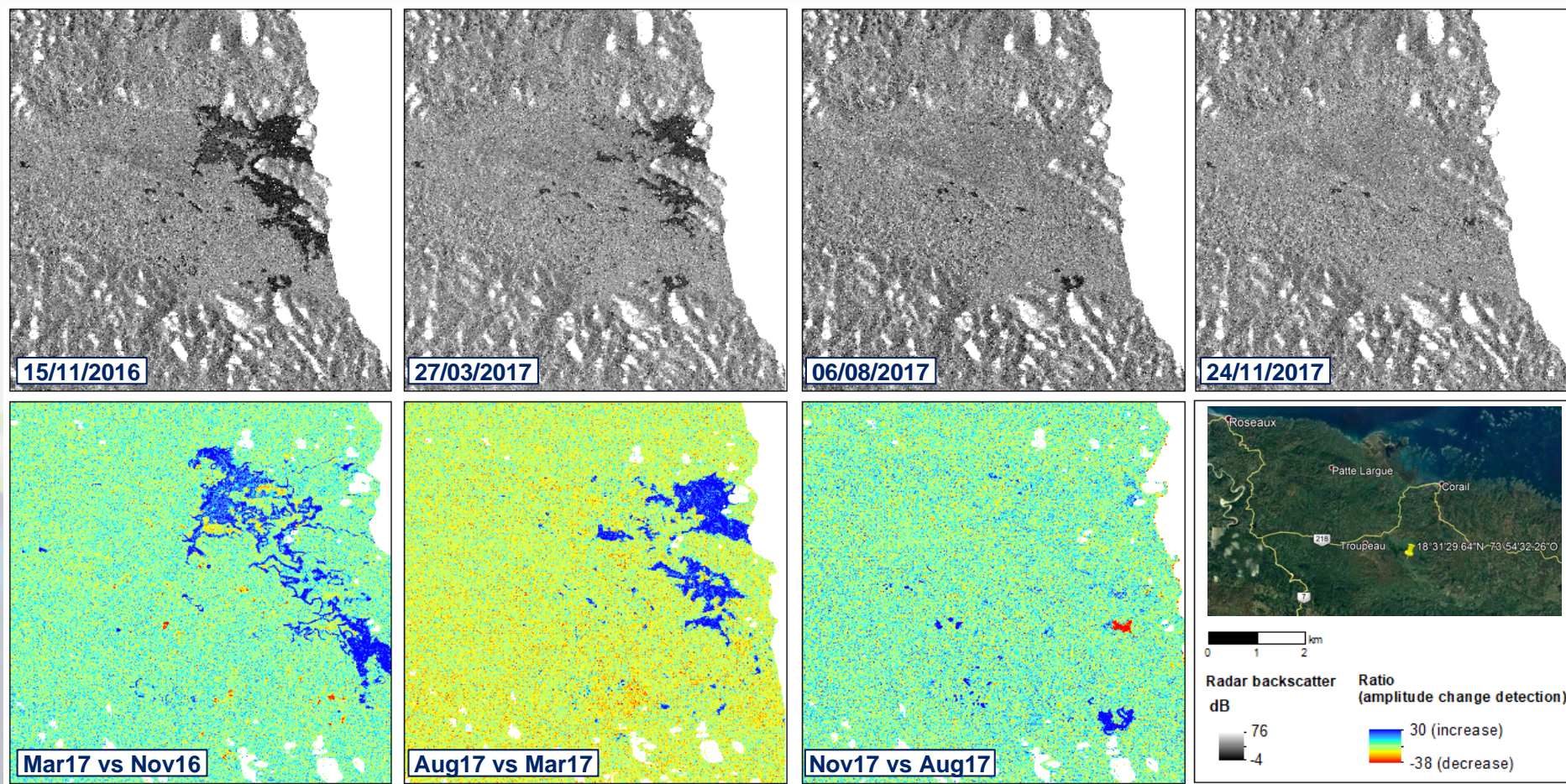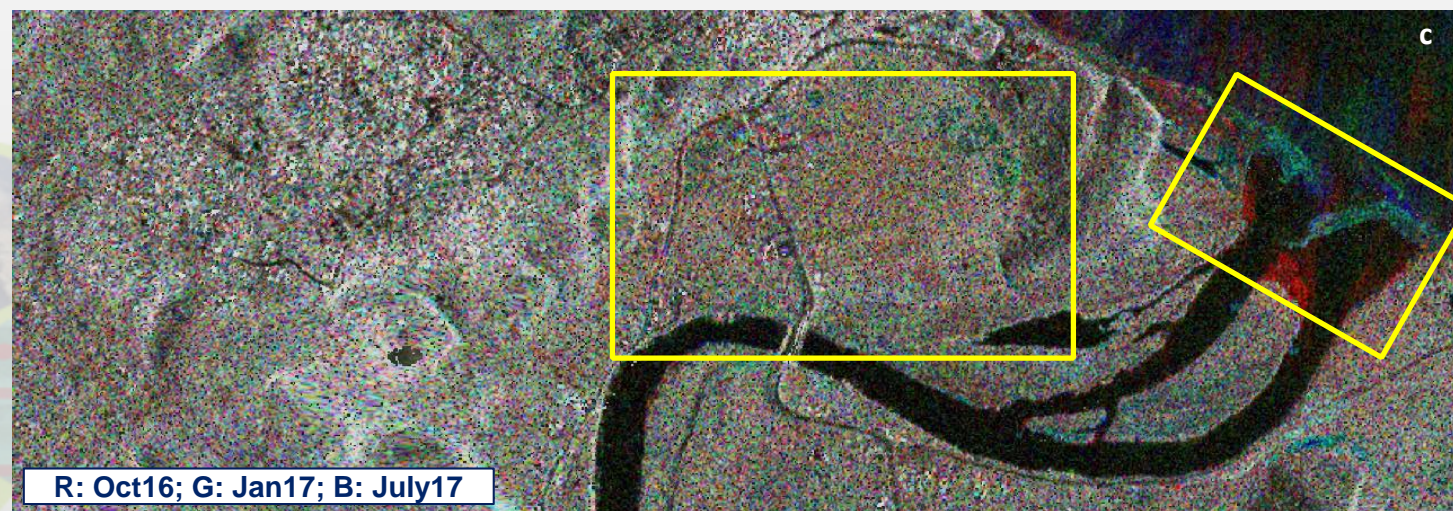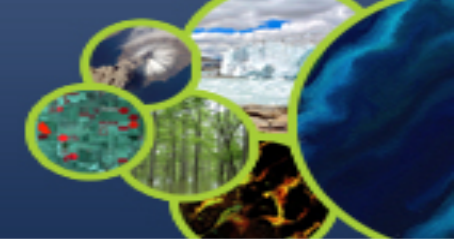
TerraSAR-X RGB false-coloured maps – changes in urban areas in <u>Jérémie</u> (1 year)

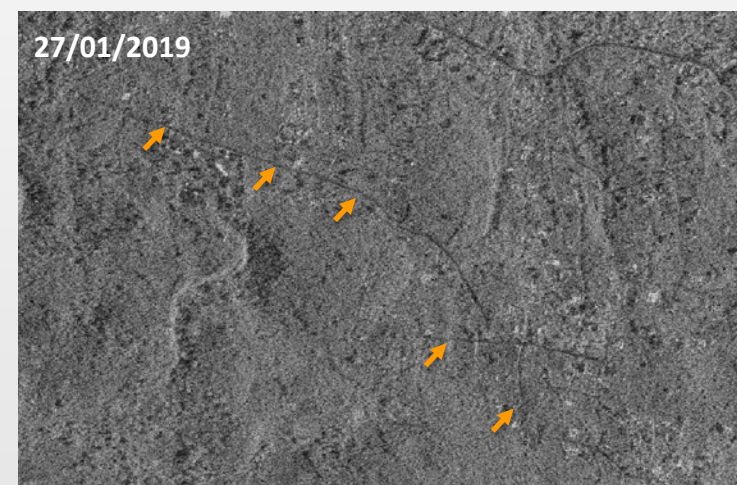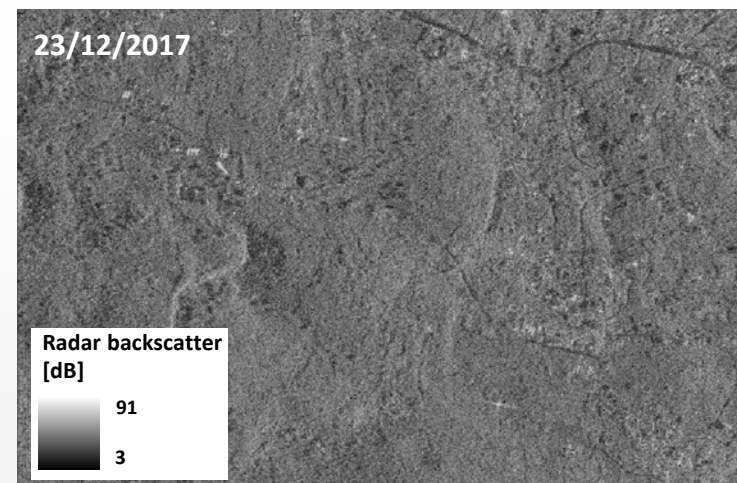1-year composite a

b

c

R: Oct16; G: Jan17; B: Nov17

b

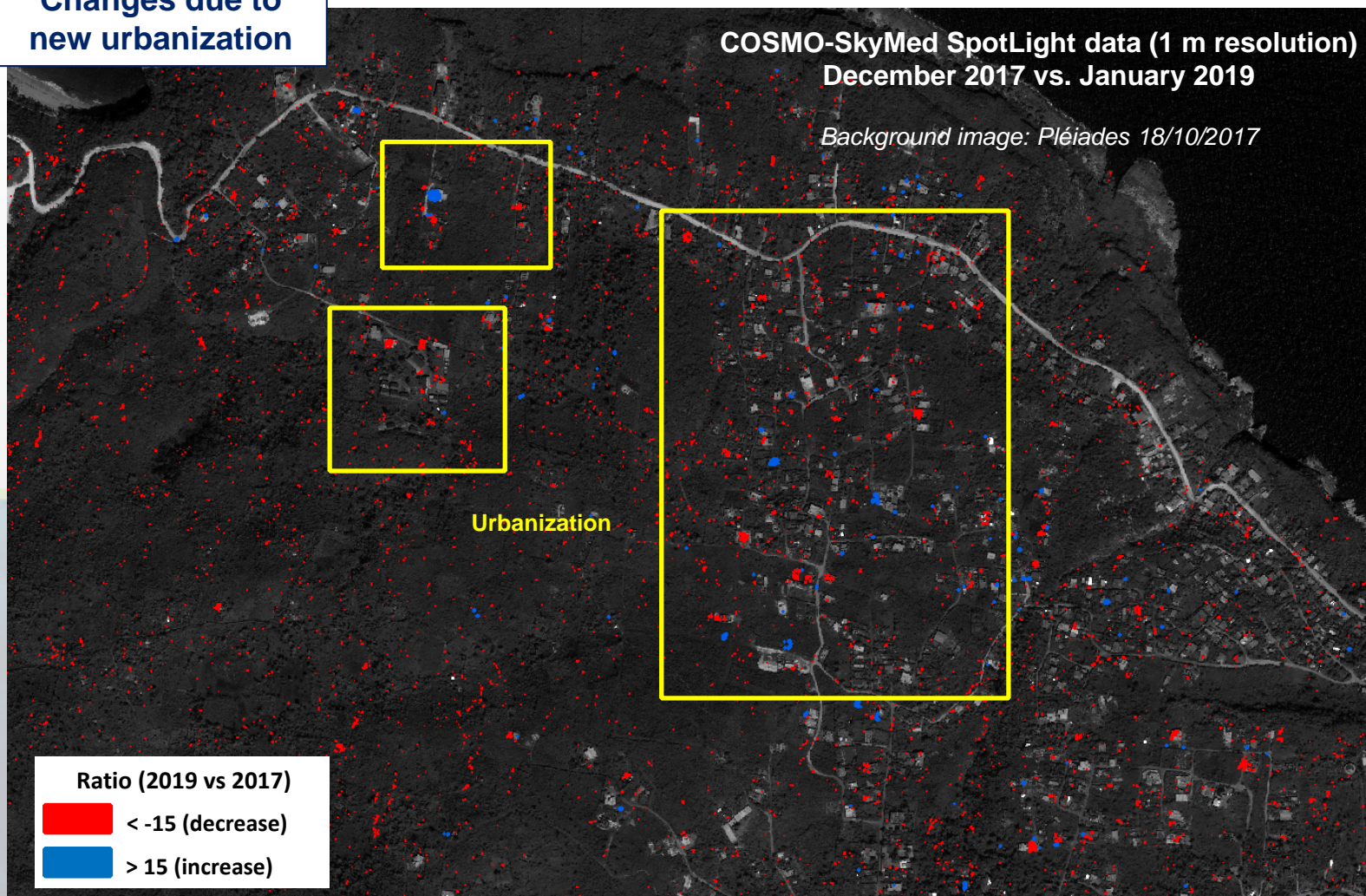➢ In the year after Hurricane Matthew (October 2016 – November 2017), 6-month basis monitoring at regional scale allowed temporal tracking of major changes in urban features

➢ Local urban changes were observed in:

❑ the rural areas surrounding Jérémie (picture **b**)

❑ the southern-eastern peripheries close to the Grande-Anse River, including fluvial and coastal dynamics (picture **c**)

c

R: Oct16; G: Jan17; B: July17

Changes due to new urbanization

COSMO-SkyMed SpotLight data (1 m resolution)
December 2017 vs. January 2019

Background image: Pléiades 18/10/2017

Urbanization

Ratio (2019 vs 2017)

< -15 (decrease)
> 15 (increase)

23/12/2017

Radar backscatter [dB]

91
3

27/01/2019

Longer-term surface changes (urban & environmental)

Changes due to urban and fluvial processes

COSMO-SkyMed SpotLight data (1 m resolution)
December 2017 vs. January 2019

Background image: Pléiades 18/10/2017

Urban changes

Fluvial and coastal dynamics

Ratio (2019 vs 2017)

< -15 (decrease)

> 5 (increase)
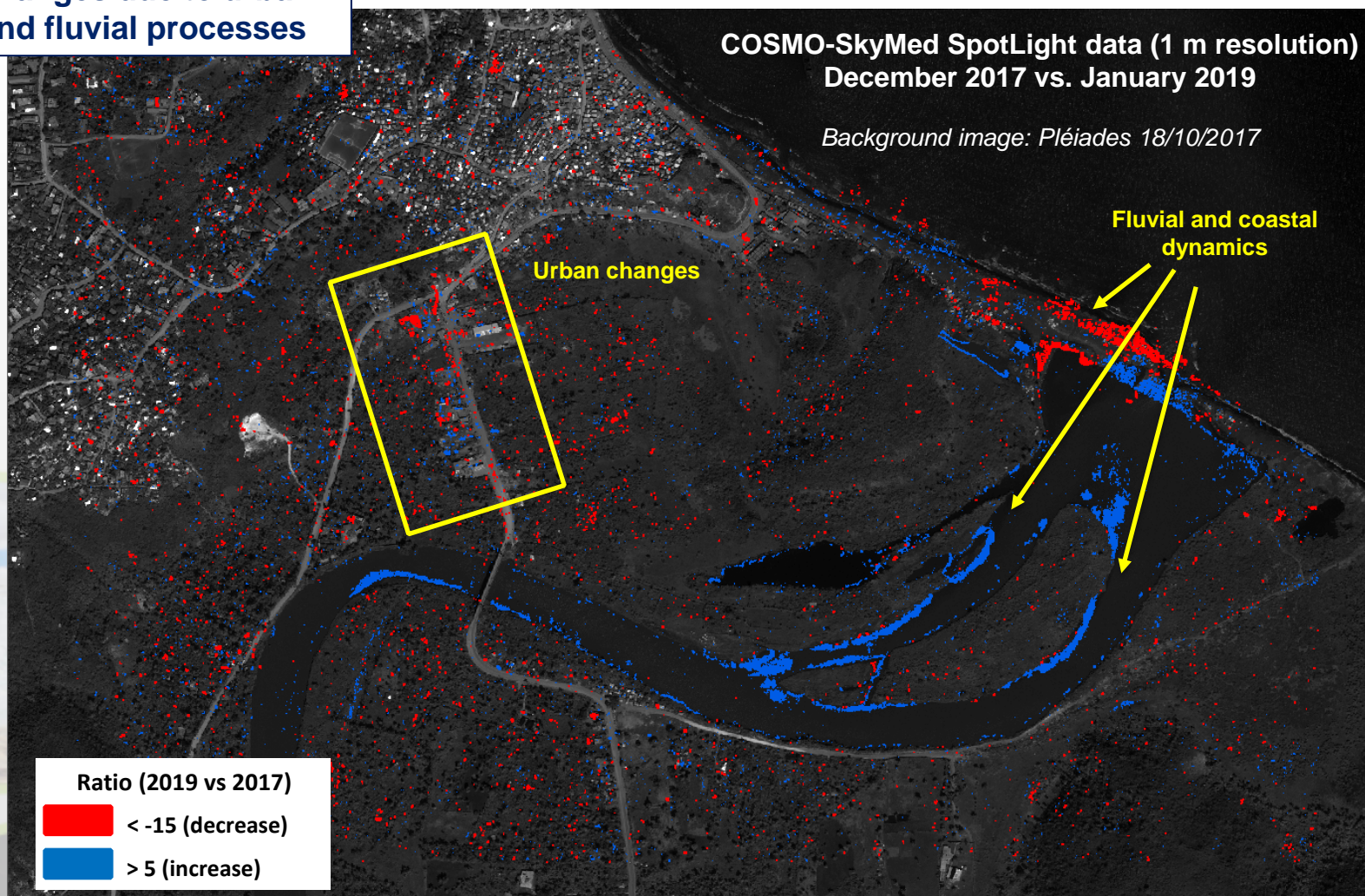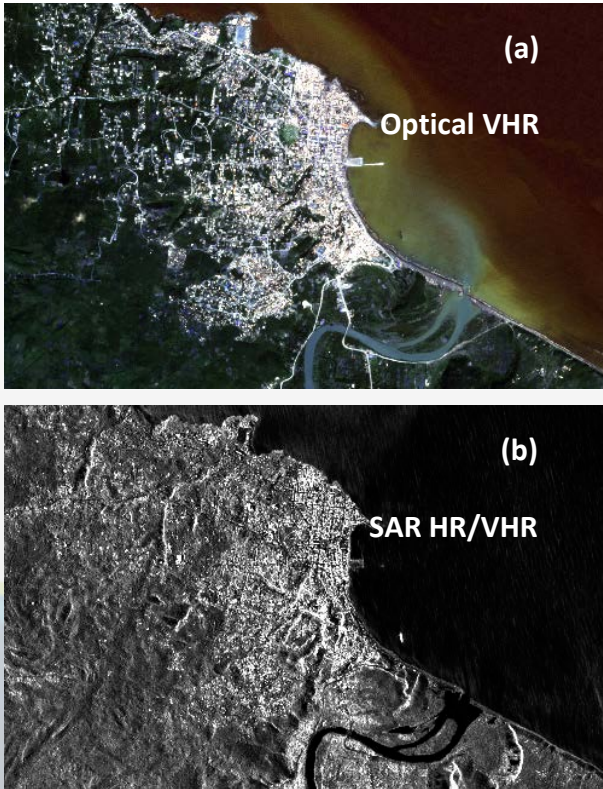
MARKOVIAN MULTI-TEMPORAL REGION-BASED MODELLING

(a)

Optical VHR

(b)

SAR HR/VHR

(c)

De Giorgi et al. (2021)
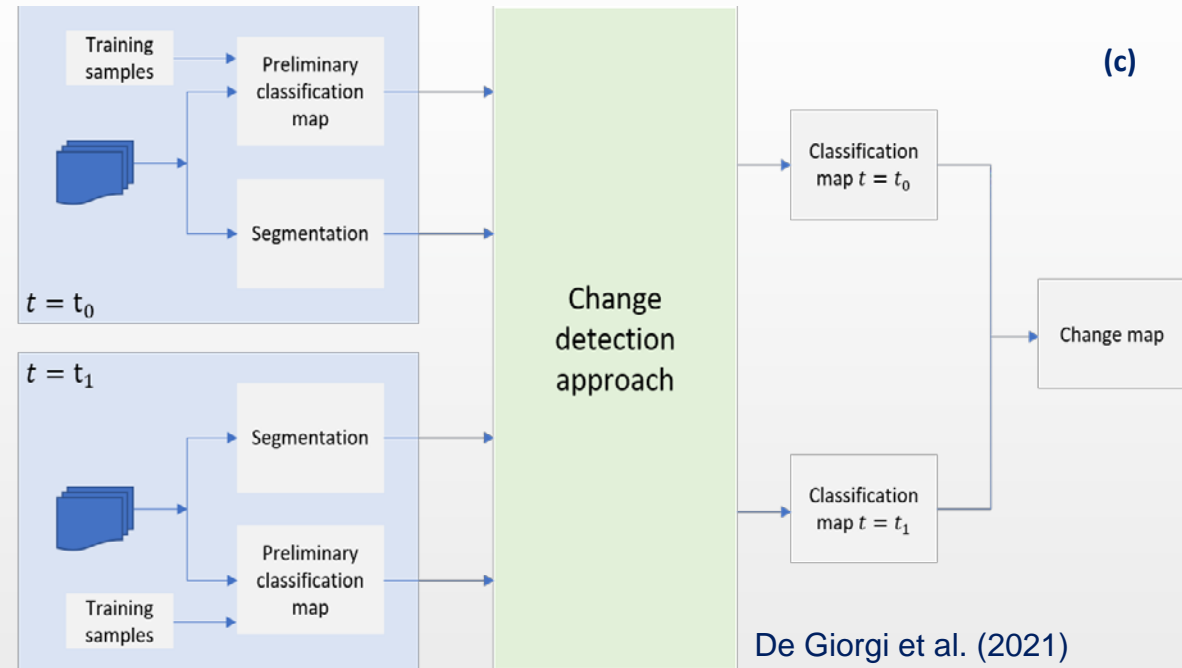
(a) RGB true-color composition of the multispectral Pléiades acquisition (image © CNES 2017, distribution Airbus DS)
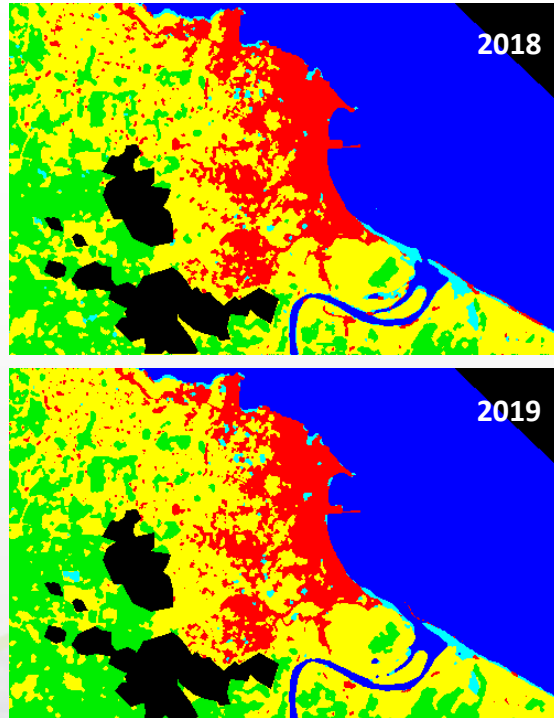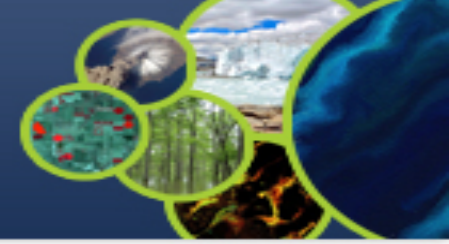
(b) Enhanced Spotlight SAR acquisition (COSMO-SkyMed Product © ASI—Italian Space Agency—2017. All rights reserved)

(c) Block diagram of the classification method.

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Monitoring post-hurricane urbanization in Jérémie

2018

2019

Class	Jérémie 2018		Jérémie 2019	
	PA	UA	PA	UA
Water	100%	100%	100%	100%
Urban/Anthropogenic	98.4%	100%	98.4%	100%
Tall Veg.	99.4%	100%	100%	100%
Low Veg.	100%	98.0%	100%	98.5%
Bare Soil	100%	100%	100%	100%
OA		99.5%		99.6%
AA		99.6%		99.7%
kappa		99.3%		99.5%

De Giorgi et al. (2021)

Land cover transitions: (a) 2017 → 2018; (b) 2018 → 2019

(a)

(b)

- Unclassified
- No Change
- Low Veg. – Tall Veg.
- Tall Veg. – Low Veg.
- Low Veg. – Urban/Anthropogenic
- Bare Soil – Low Veg.
- Bare Soil – Low Veg.
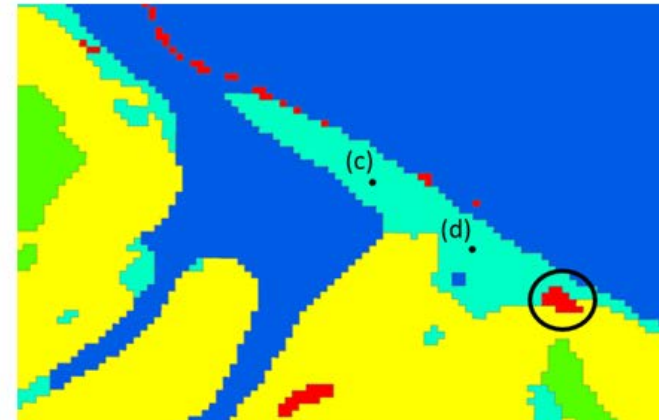- Low Veg. – Bare Soil

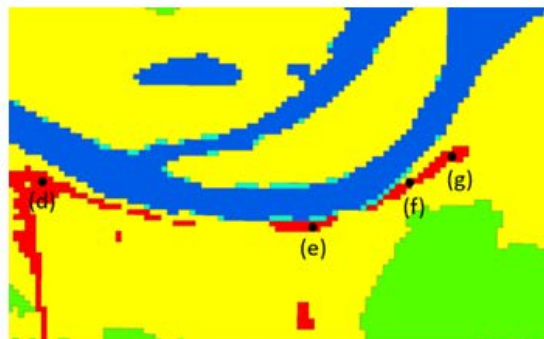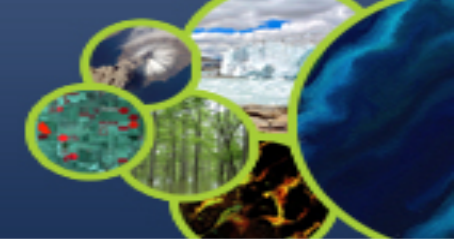*Scan the QR code to download the full paper*


12
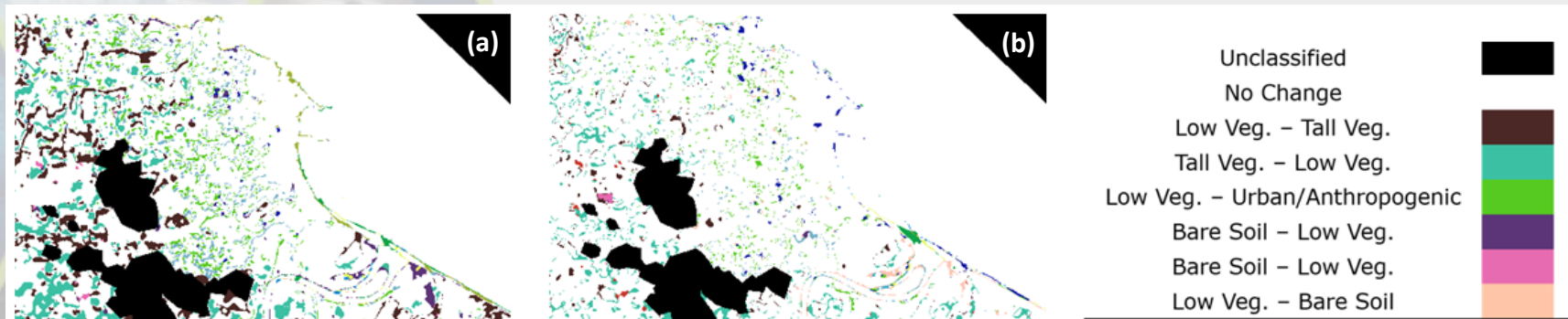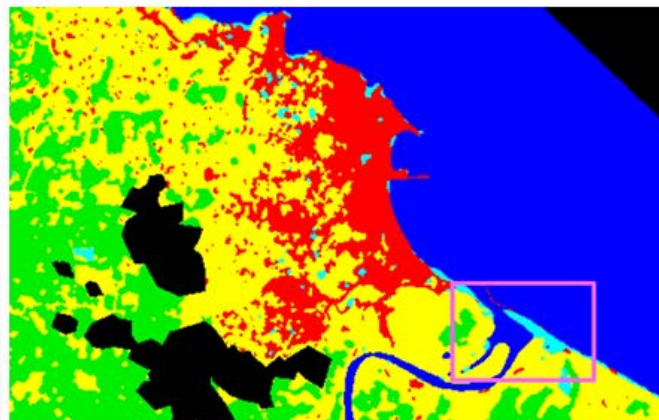
(a)

(b)

(c)

(d)

De Giorgi et al. (2021)

*Scan the QR code to download the full paper*

(a) The 2019 classification map with indication of **(b)** the bare-soil land cover transition at the mouth of the Grande Anse River and along the coast, south of Jérémie. Black dots mark the GPS locations of the ground-truth photographs showing **(c)** the sand and gravel river mouth bar interspersed with widespread rubbish and waste and **(d)** mining and quarrying activity occurring on-site in April 2019

13

(a)
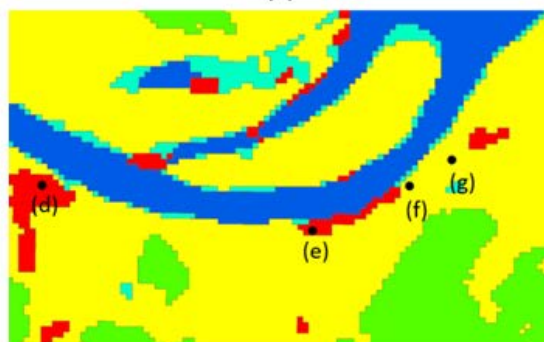
(b)
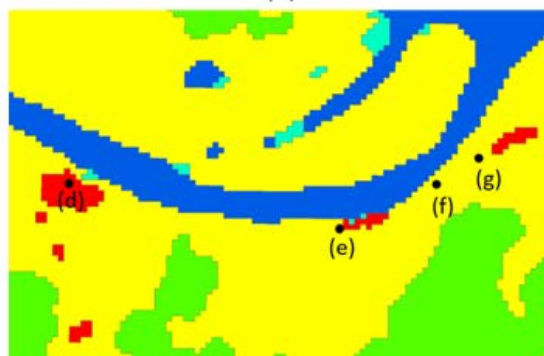
(c)

(d)

(e)

(f)

(g)

Right bank of the Grande Anse River, south of Jérémie

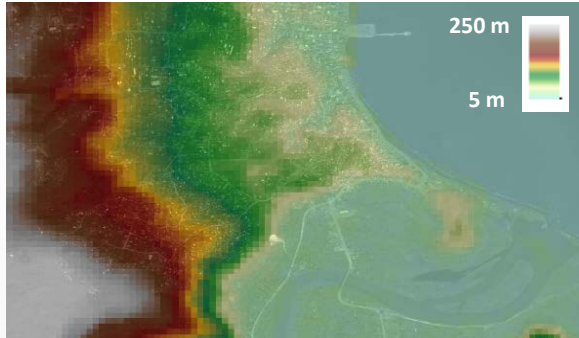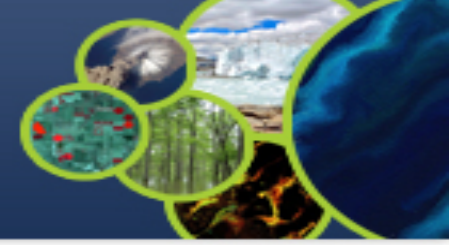classification maps corresponding to:

(a) 2017

(b) 2018

(c) 2019

with indication of **(d)** dirt road leading to rural shacks and **(e)** unregulated and uncontrolled dump site, interspersed with **(f)** low vegetation and bush and where **(g)** garbage and plastic waste are also burnt
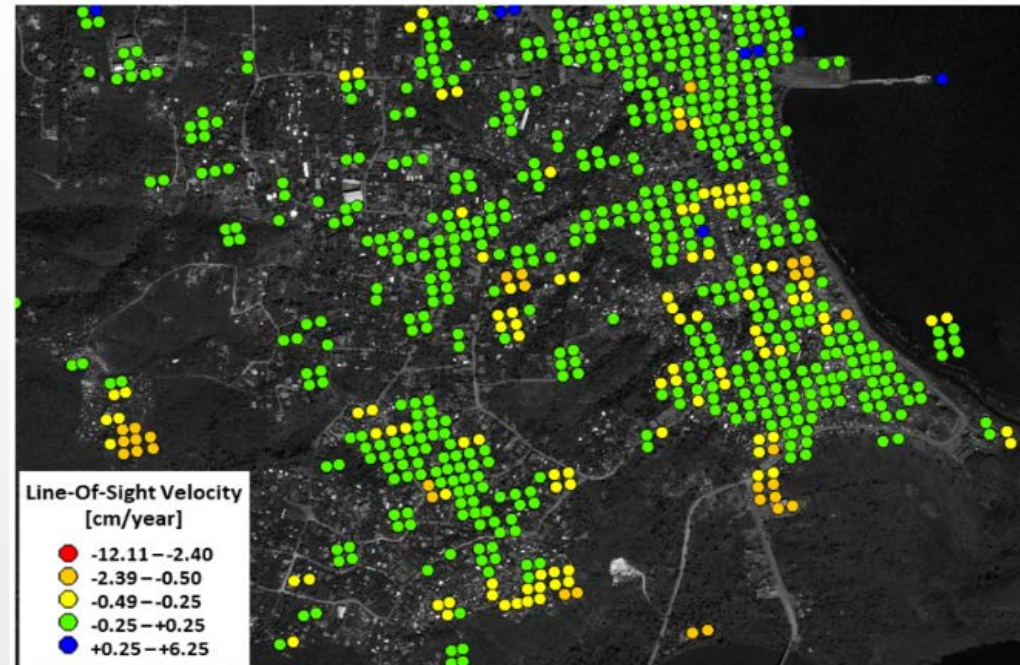
Scan the QR code to download the full paper

Ground deformation PS-InSAR analysis with more than 50 Sentinel-1 IW SAR descending scenes (2017-2018) accessed and processed using the FASTVEL service in ESA's GEP.

Background image: Pléiades 18/10/2017 (© CNES 2017, distribution Airbus DS)

Cigna et al. (2020)
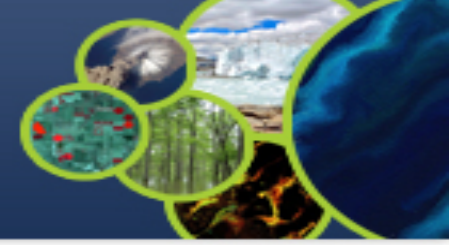
geohazards tep — FASTVEL — FASTVEL for displacement velocity map generation

Scan the QR code to request a copy of the full paper

Line-Of-Sight Velocity [cm/year]
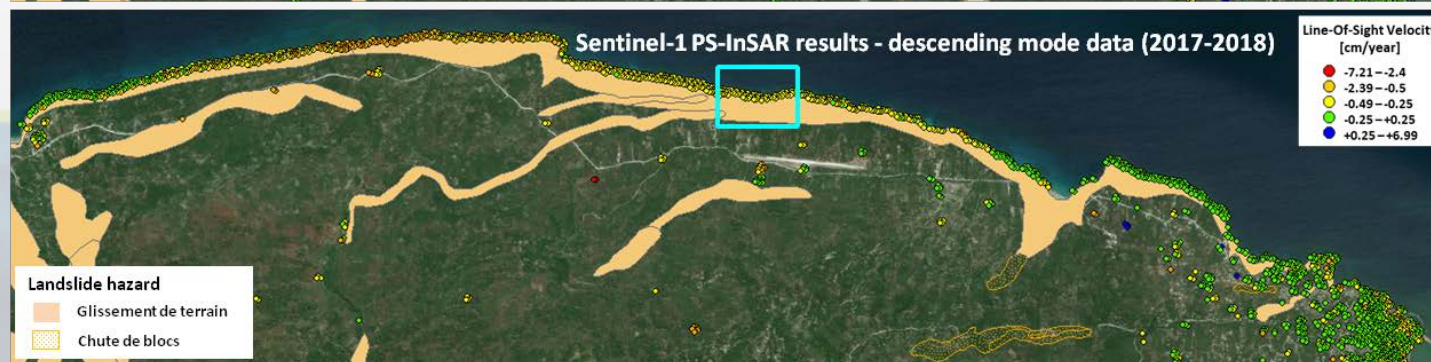- ● -12.11 – -2.40
- ● -2.39 – -0.50
- ● -0.49 – -0.25
- ● -0.25 – +0.25
- ● +0.25 – +6.25

250 m

5 m

Fieldwork during the technical mission in Haiti
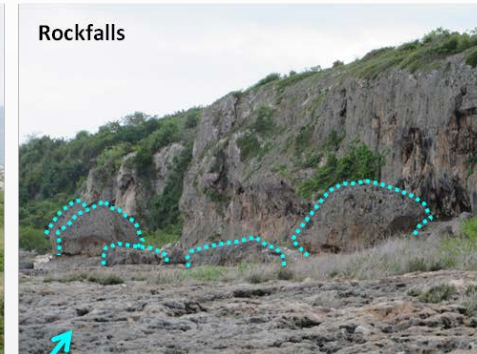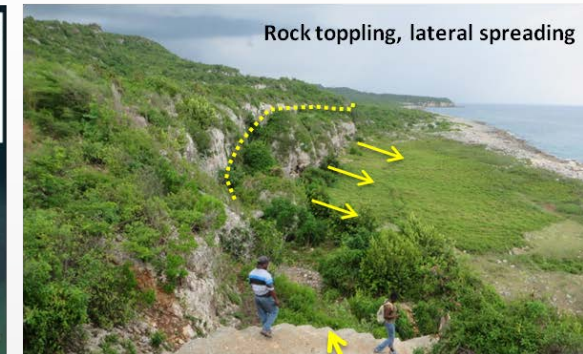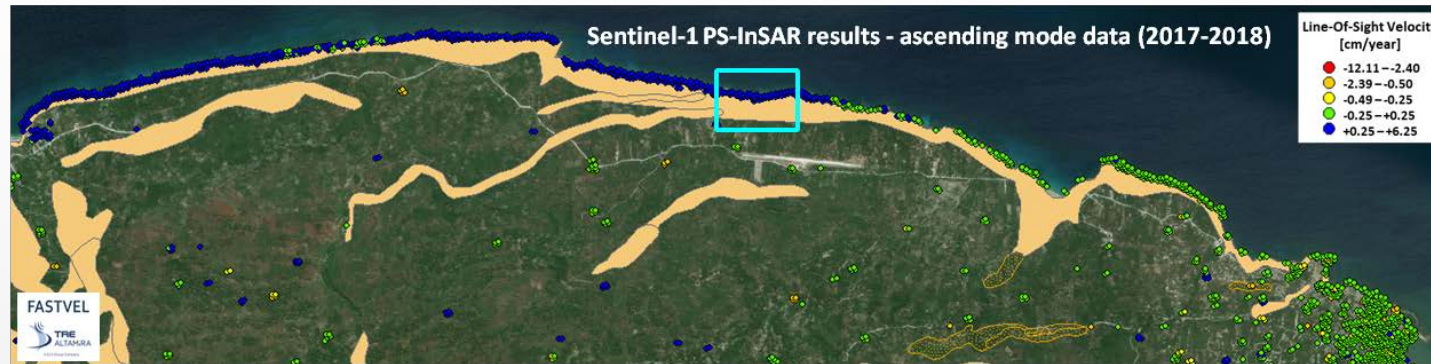
Haiti RO Local User Workshop, Regional Haitian Civil Protection Offices, Jérémie, April 2019

University training at Port-au-Prince in 2019 with SERTIT/CNES and ASI

Haiti RO Users Workshop, Port au Prince, May 2019

SAR and Land use training in Jérémie by ASI (left) and Port-au-Prince by CNES (right)

17

1. Coordination of satellite observations ('virtual constellation') to meet user requirements

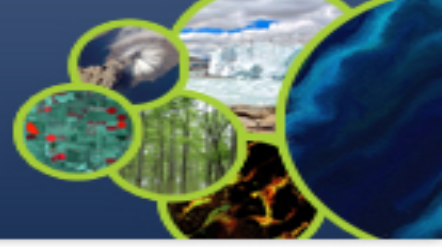2. Multi-scale and multi-temporal integration of derived products vs. RO timeline

3. Interpretation of observed changes accounting for local environmental and socio-anthropological context

4. Validation/ground-truth collection directly engaging local value-adders & stakeholders

5. EO exploitation platforms as a potential sustainable mean, however require IT facilities & training

6. Capacity building
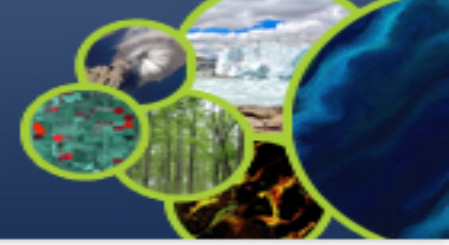
Thank you for your attention!

deodato.tapete@asi.it

References

CIGNA, F.; TAPETE, D.; DANZEGLOCKE, J.; BALLY, PH.; CUCCU, R.; PAPADOPOULOU, T.; CAUMONT, H.; COLLET, A.; DE BOISSEZON, H.; EDDY, A.; PIARD B.E. (2020) Supporting Recovery after 2016 Hurricane Matthew in Haiti with Big SAR Data Processing in the Geohazards Exploitation Platform (GEP). In: *IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium*, 2020, pp. 6867-6870, doi: 10.1109/IGARSS39084.2020.9323231.

DE GIORGI, A.; SOLARNA, D.; MOSER, G.; TAPETE, D.; CIGNA, F.; BONI, G.; RUDARI, R.; SERPICO, S.B.; PISANI, A.R.; MONTUORI, A.; ZOFFOLI, S. (2021) Monitoring the Recovery after 2016 Hurricane Matthew in Haiti via Markovian Multitemporal Region-Based Modeling. *Remote Sensing*, 13, 3509, doi: 10.3390/rs13173509