

Flood mapping using satellite SAR data

Renaud Hostache
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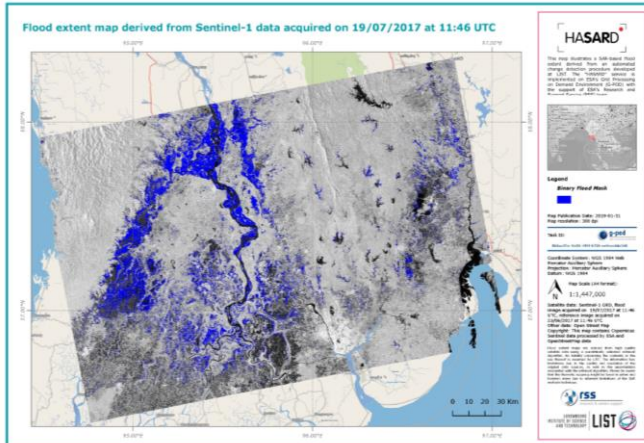


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Background



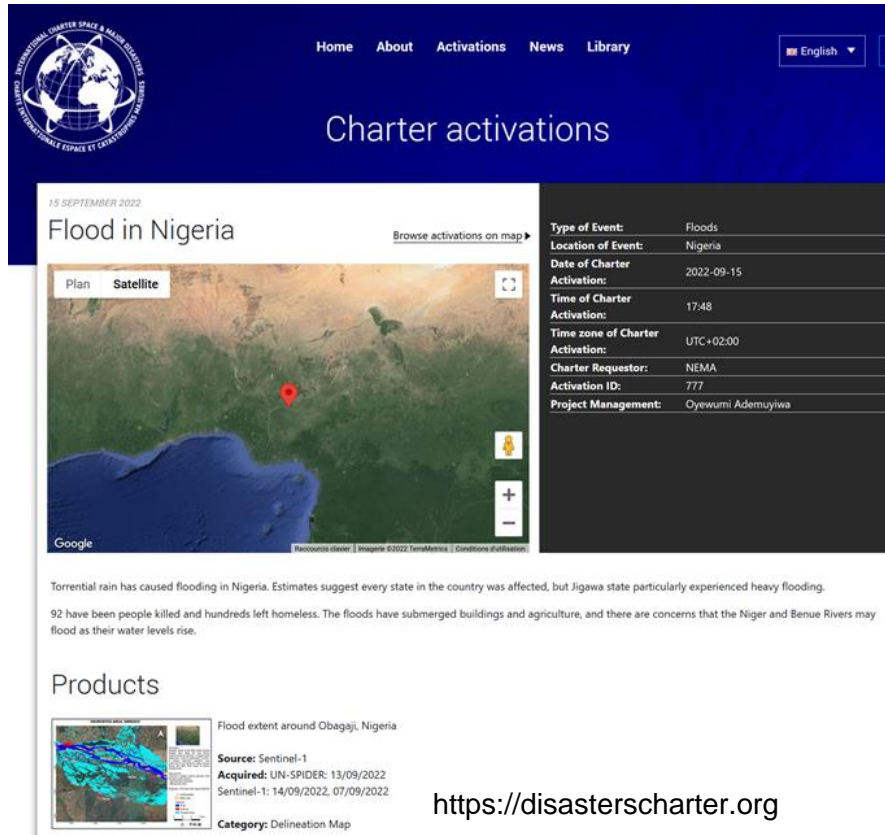
Flood hazard is one of the most disastrous (frequency and damages)

Need for observations to understand, anticipate and protect populations:

- Traditional observations are punctual (pb of representativeness).
- Ground observations are scarcely distributed and observation networks tend to be further reduced (e.g. stream gauges)
- Ground observations not always reliable during flood events.

⇒ Need for new observation techniques : satellite SAR flood images offers synoptic views, with rather high revisit and spatial resolution

Background



The screenshot shows the 'Charter activations' page on the Disasters Charter website. The page features a navigation bar with 'Home', 'About', 'Activations', 'News', and 'Library' links, along with a language dropdown set to 'English'. The main heading is 'Charter activations'. Below this, there is a section for a specific activation: '15 SEPTEMBER 2022 Flood in Nigeria'. A satellite map from Google Earth shows the location in Nigeria. To the right of the map is a table of activation details:

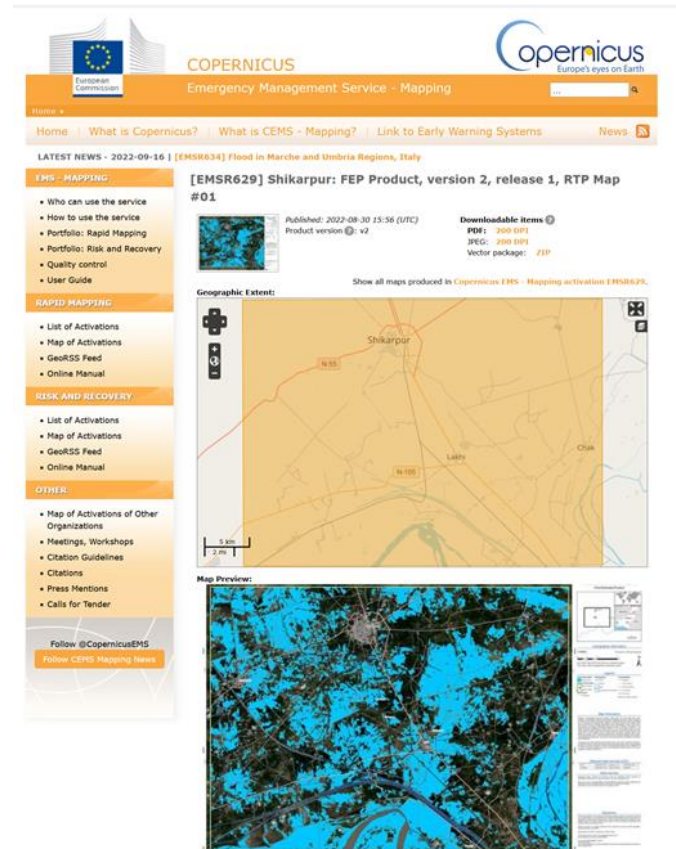
Type of Event:	Floods
Location of Event:	Nigeria
Date of Charter Activation:	2022-09-15
Time of Charter Activation:	17:48
Time zone of Charter Activation:	UTC+02:00
Charter Requestor:	NEMA
Activation ID:	777
Project Management:	Oyewumi Ademuyiwa

Below the map, there is a text block: 'Torrential rain has caused flooding in Nigeria. Estimates suggest every state in the country was affected, but Jigawa state particularly experienced heavy flooding. 92 have been people killed and hundreds left homeless. The floods have submerged buildings and agriculture, and there are concerns that the Niger and Benue Rivers may flood as their water levels rise.'

The 'Products' section at the bottom left shows a thumbnail of a flood extent map around Obagaji, Nigeria, with the following details:

- Source: Sentinel-1
- Acquired: UN-SPIDER: 13/09/2022
- Sentinel-1: 14/09/2022, 07/09/2022
- Category: Delineation Map

<https://disasterscharter.org>



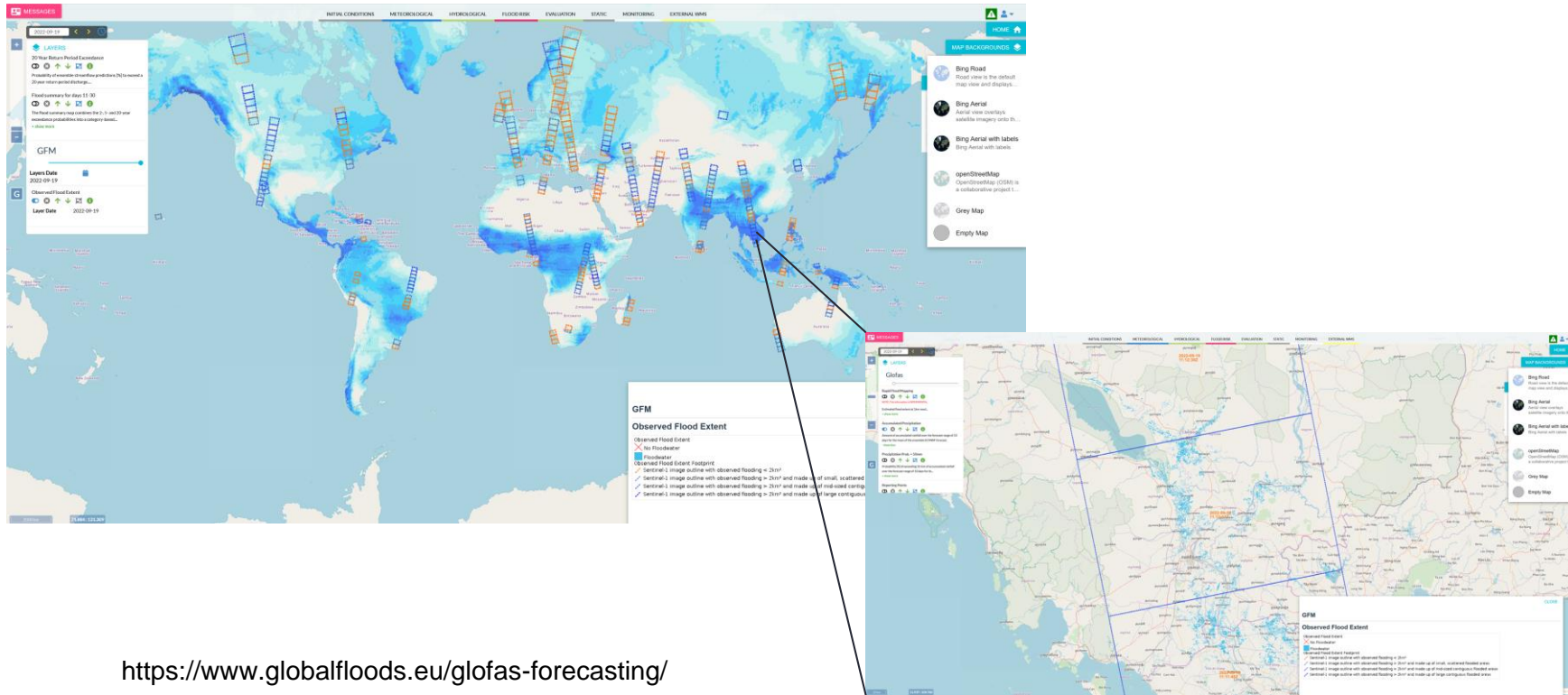
The screenshot shows the Copernicus Emergency Management Service (CEMS) website. The page features the Copernicus logo and the text 'Emergency Management Service - Mapping'. Below this, there is a search bar and a navigation bar with 'Home', 'What is Copernicus?', 'What is CEMS - Mapping?', 'Link to Early Warning Systems', and 'News' links. The main heading is '[EMSR629] Shikarpur: FEP Product, version 2, release 1, RTP Map #01'. A satellite map shows the location of Shikarpur, Italy. To the right of the map is a table of product details:

Published:	2022-09-30 15:36 (UTC)
Product version:	v2
Downloadable items:	
PDF:	200 000
REG:	200 000
Vector package:	ZIP

Below the map, there is a text block: 'Show all maps produced in Copernicus EMS - Mapping activation EMSR629.' The 'Map Preview' section shows a satellite map with a blue overlay indicating the flood extent.

<https://emergency.copernicus.eu/>

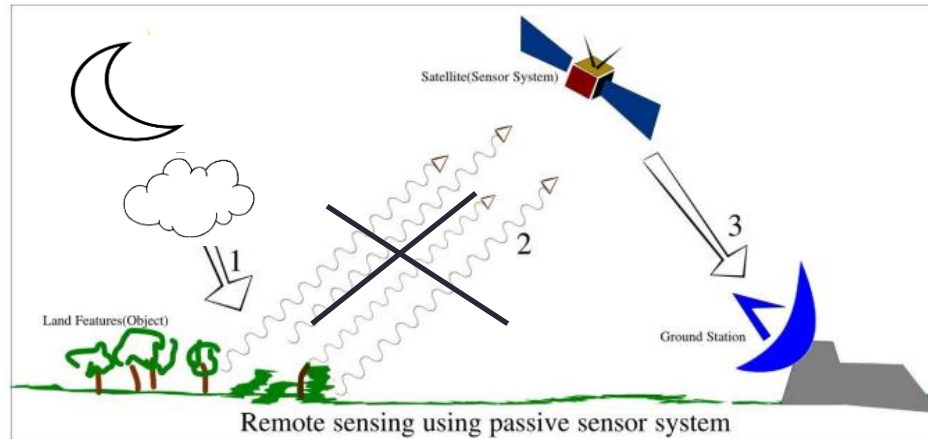
Background



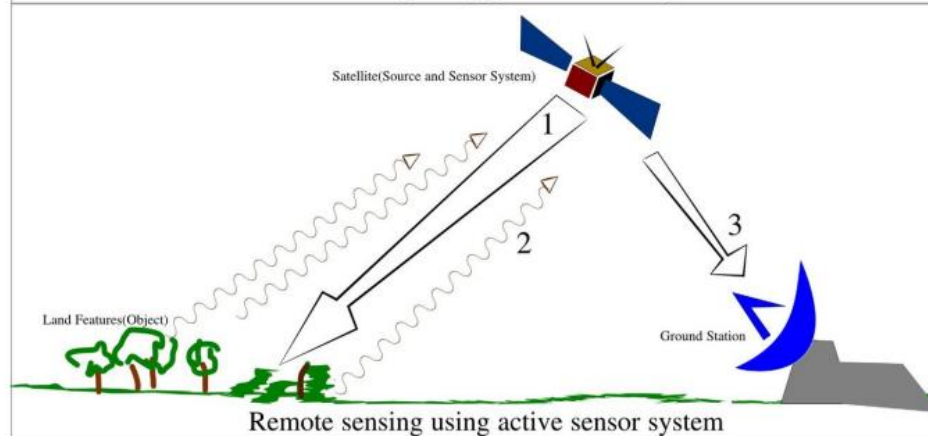
<https://www.globalfloods.eu/glofas-forecasting/>

Active and passive sensors for flood monitoring

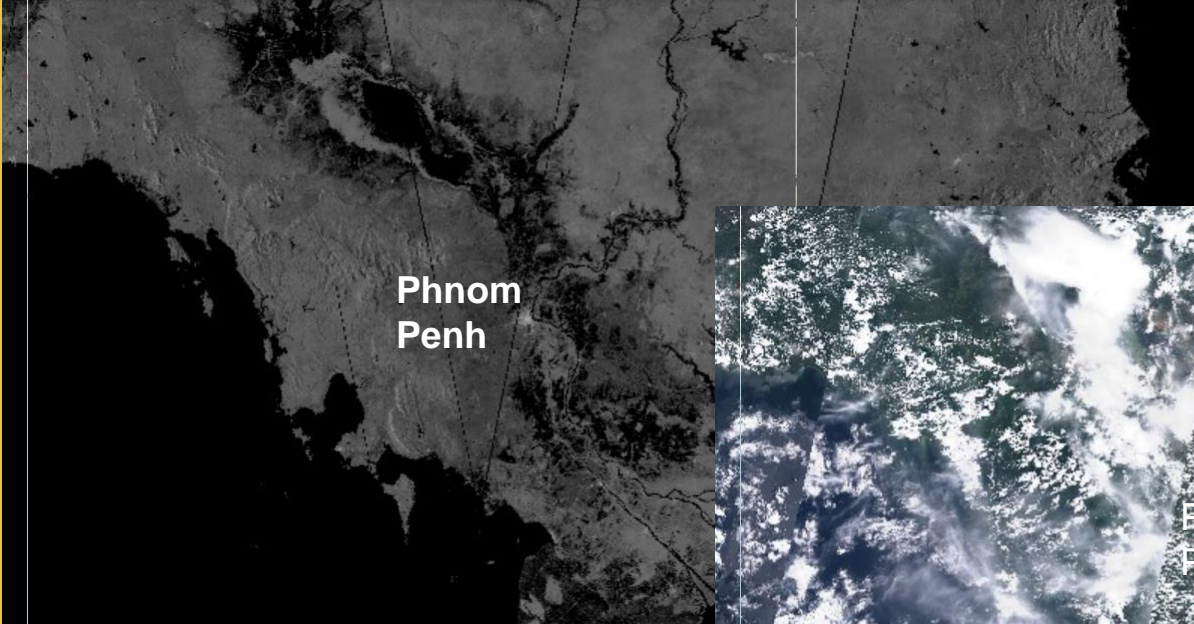
Optical remote sensing



RADAR remote sensing



Active and passive sensors for flood monitoring



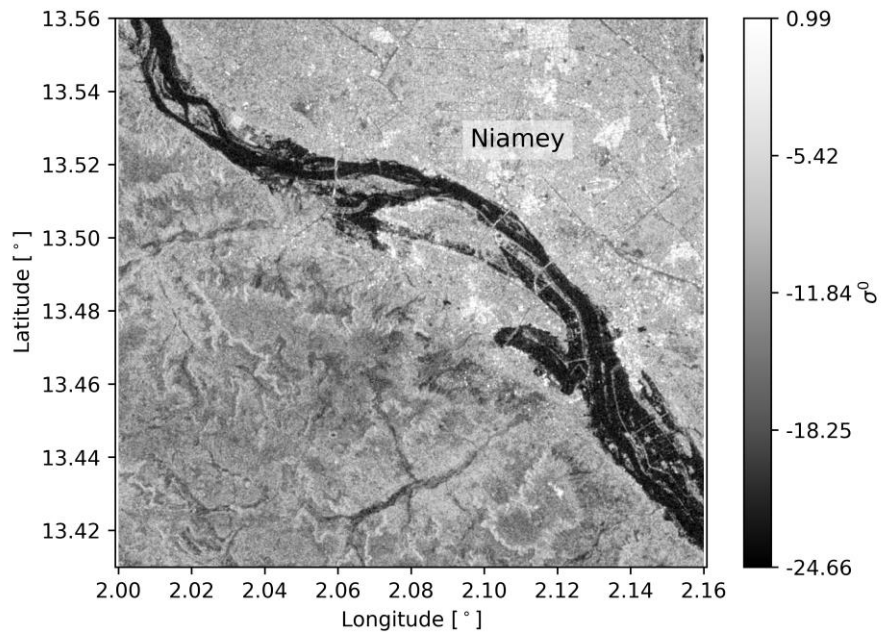
Phnom
Penh



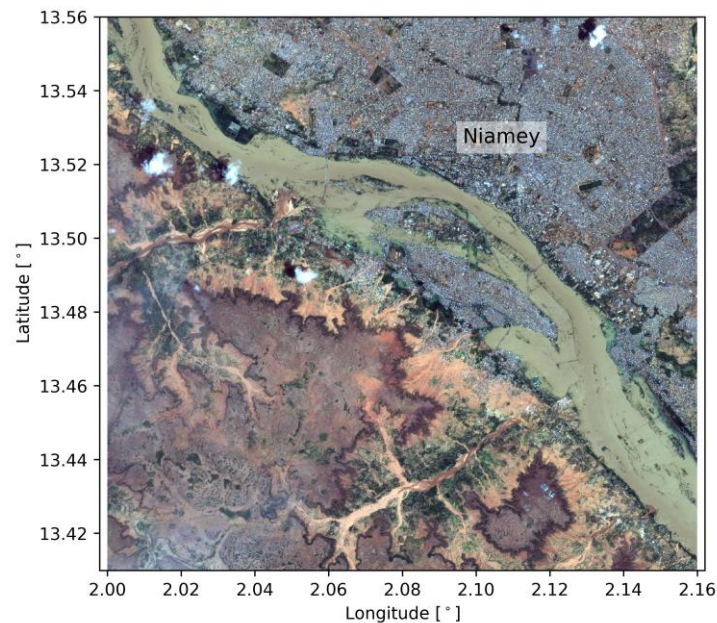
Phnom
Penh

« Bare Soil » floodwater mapping

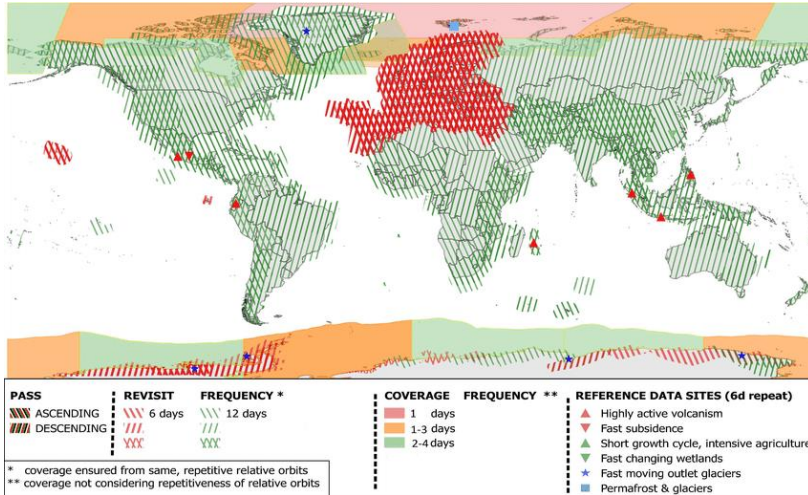
Sentinel-1 image (2020/09/15@18:04Z)



Sentinel-2 image (2020/09/15@13:06Z)



Sentinel-1 revisit time

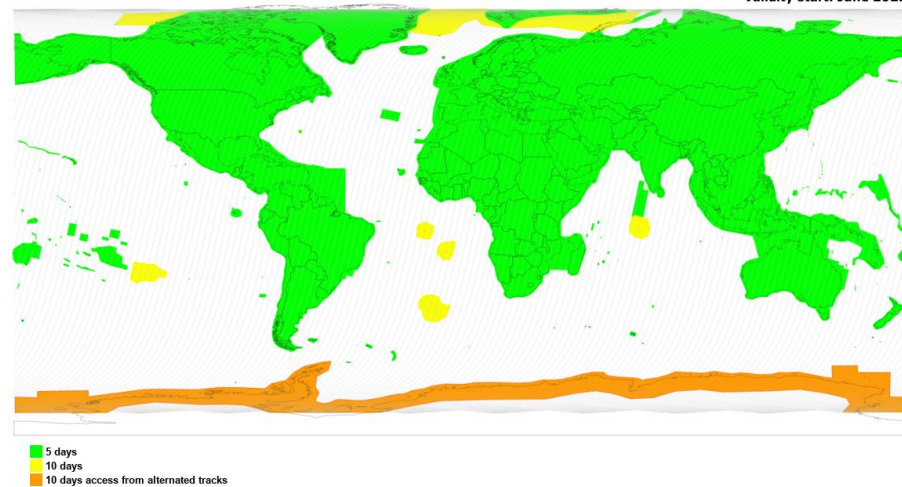


Sentinel-1 constellation observation, revisit and coverage scenario (April 2021), after Mullissa et al (2021)

Sentinel-2 Constellation Observation Scenario: Revisit Frequency

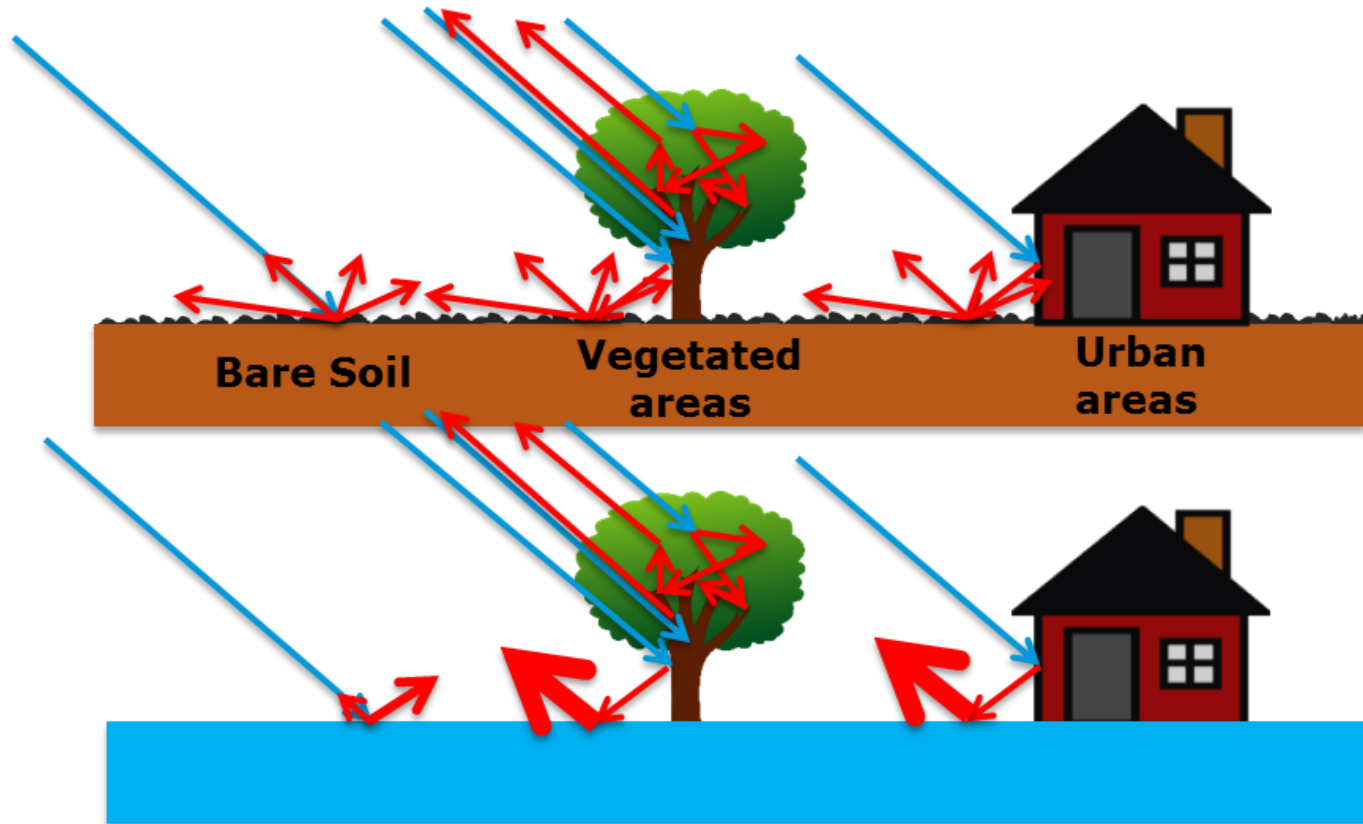


Validity start: June 2022



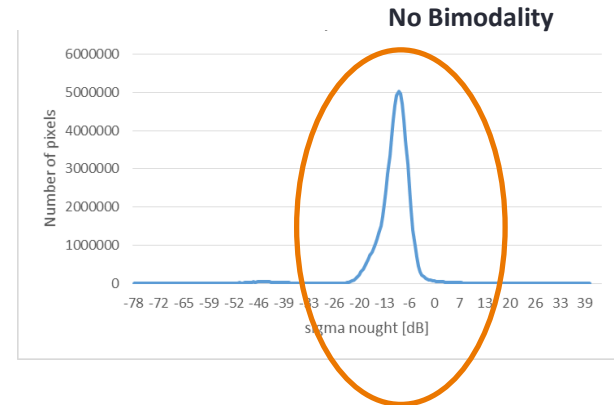
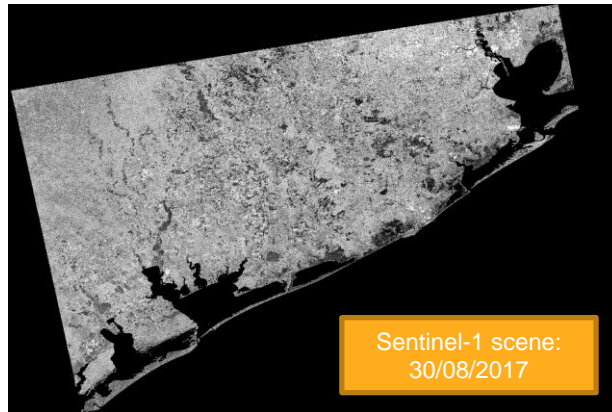
<https://www.esa.int/>

Detection of water on SAR images

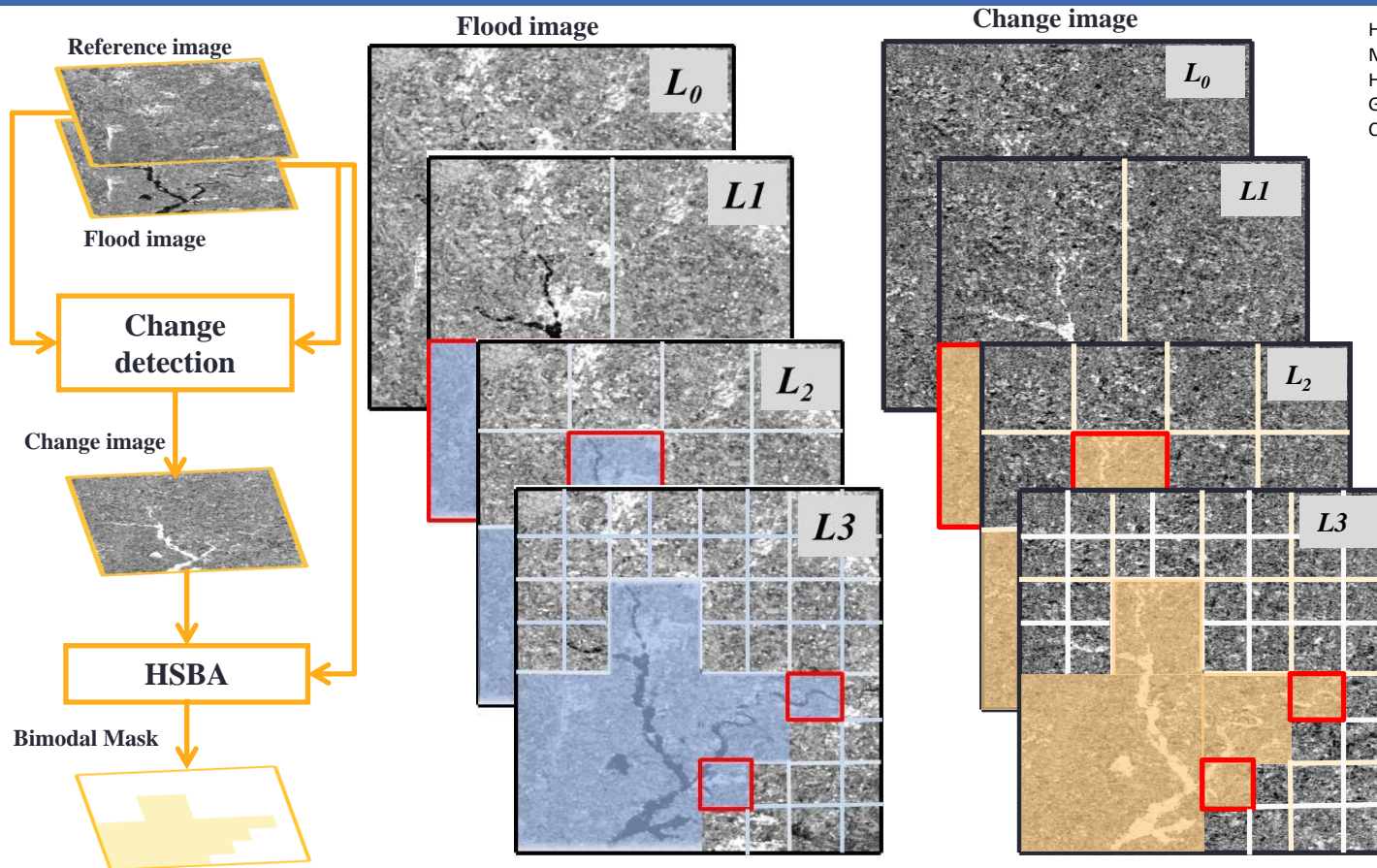


« Bare Soil » floodwater mapping

- **Backscatter Statistical modelling** : parameterization of two PDFs for water and non water (resp. Change / No Change)
- **Bottleneck**: floodwater only covers a limited area compared to a Sentinel Scene
→ very difficult to parameterize the two PDFs

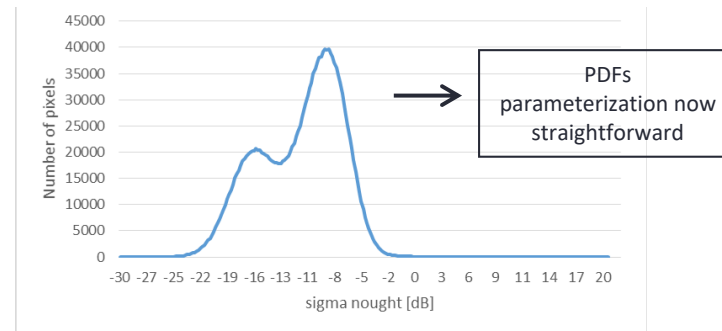
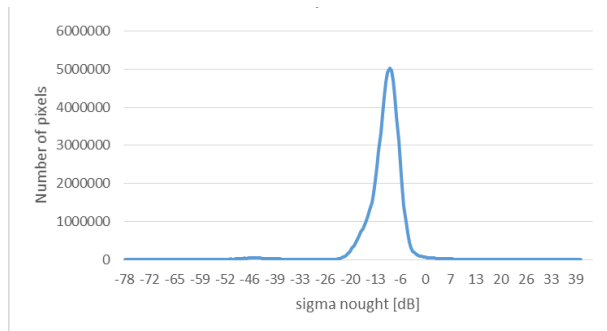
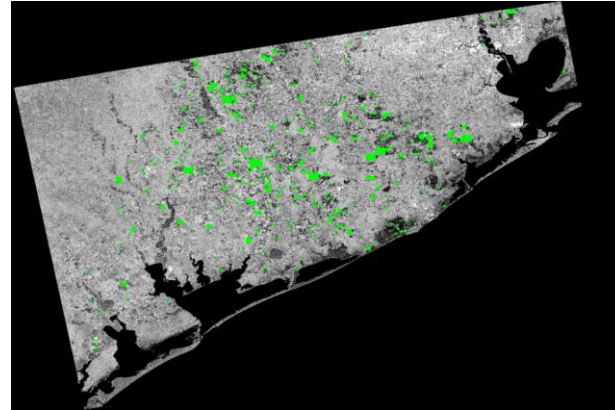
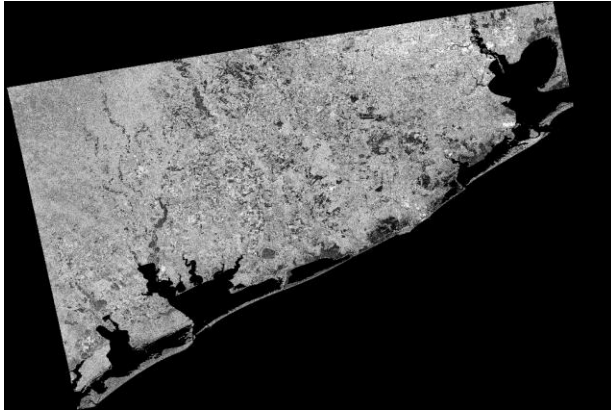


« Bare Soil » floodwater mapping



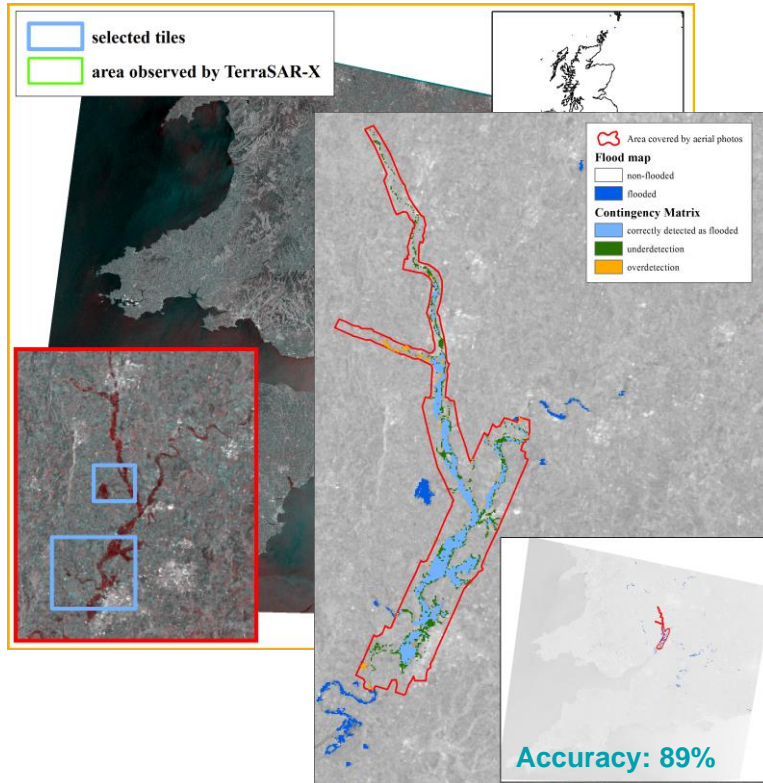
Hostache et al., IEEE TGRS, 2009
Matgen et al., PCE, 2011
Hostache et al., JAG 2012
Giustarini et al. IEEE TGRS2013,
Chini et al. , IEEE TGRS, 2017

« Bare Soil » floodwater mapping

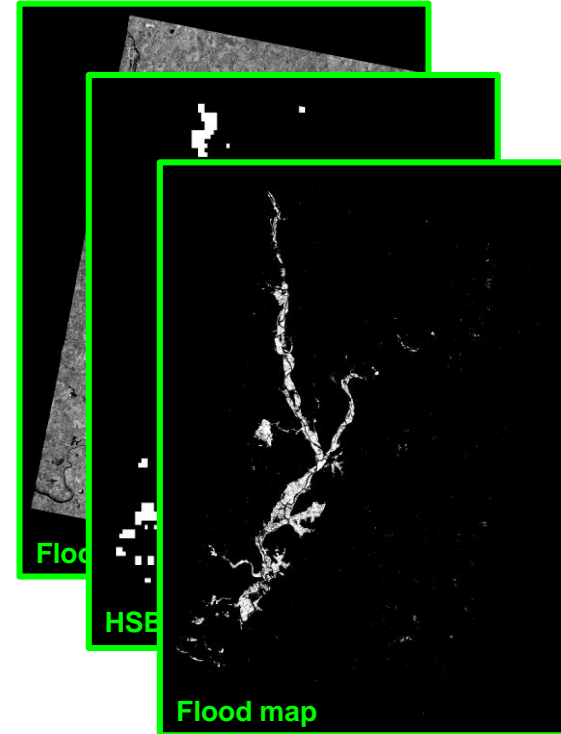


« Bare Soil » floodwater mapping

Envisat WSM (150m)

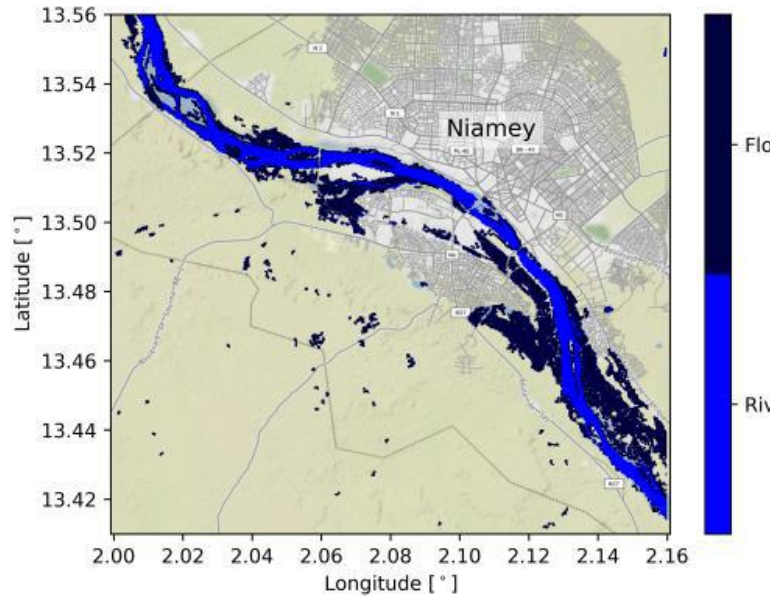


TerraSAR-X Stripmap (3m)

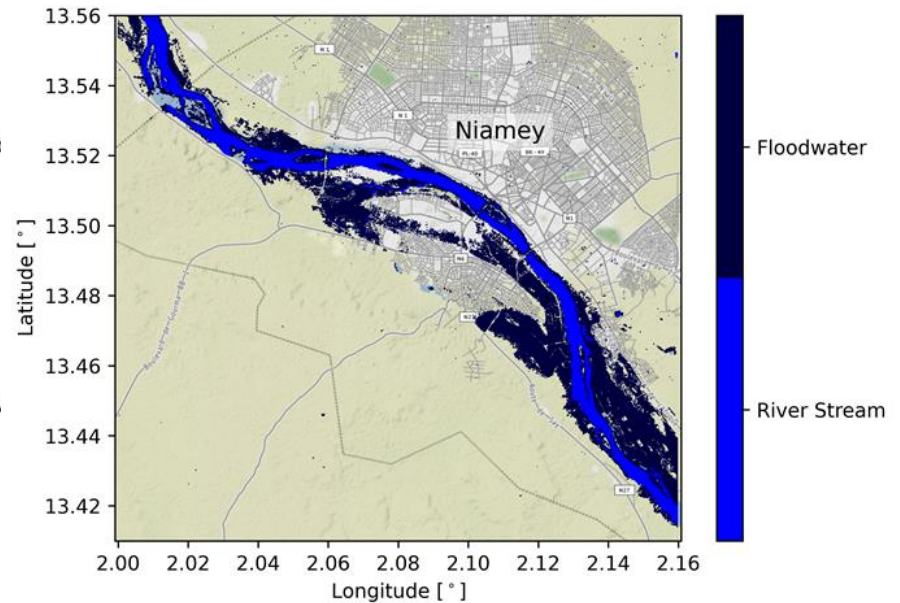


« Bare Soil » floodwater mapping

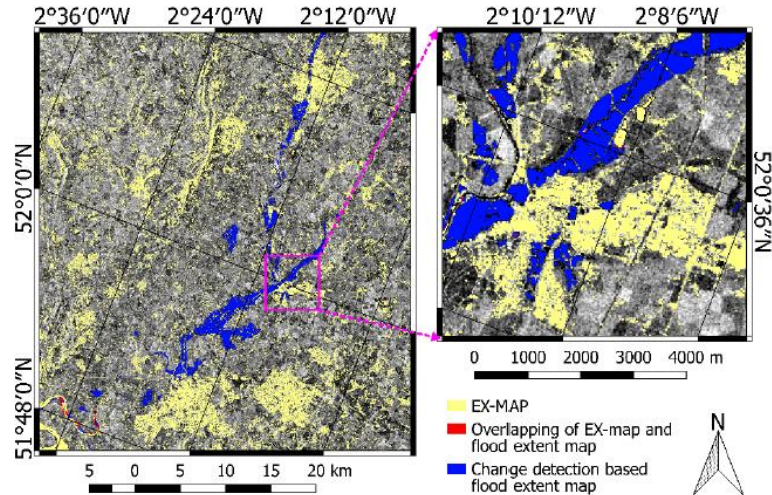
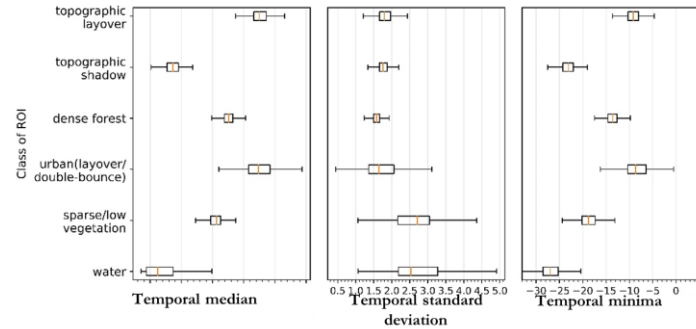
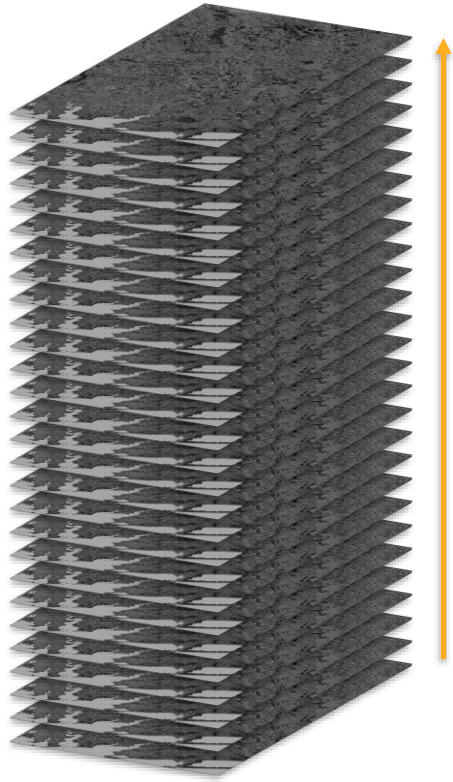
Flood Extent Map (Sentinel-1, 2020/09/15@18:04Z)



Flood Extent Map (Sentinel-2, 2020/09/15@13:06Z)

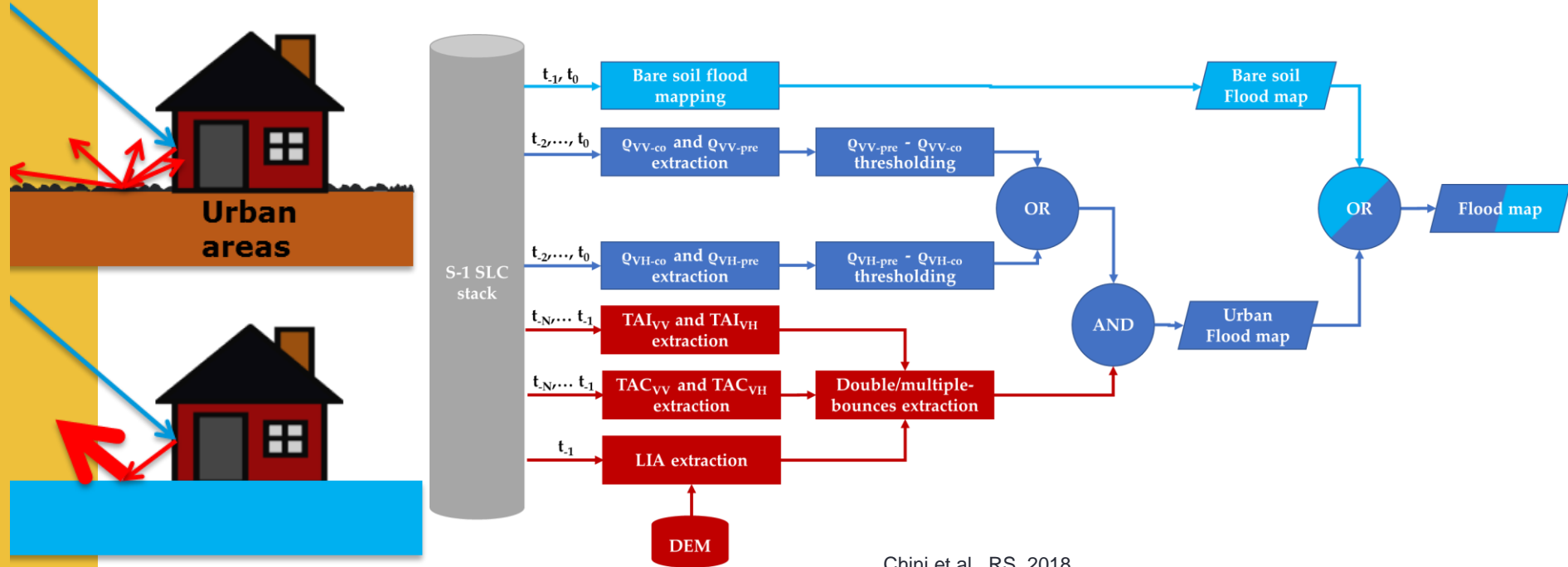


An exclusion layer for identifying areas where floodwater is undetectable



Zhao et al., RSE, 2021

Floodwater mapping in urban areas



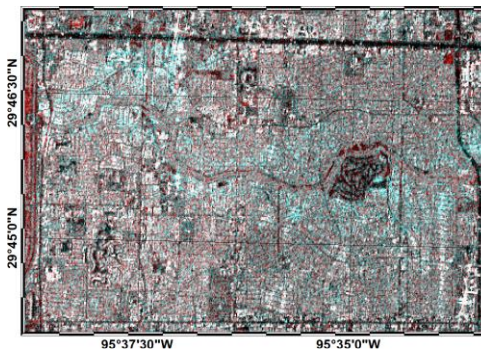
Chini et al., RS, 2018.

Chini et al., RS, 2019

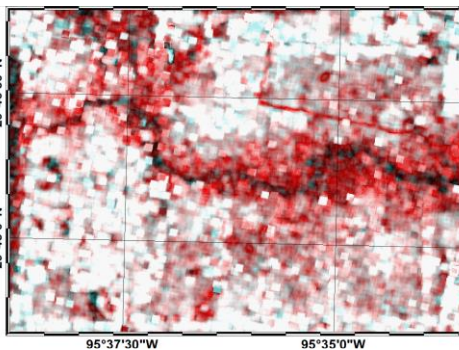
Pelich et al., IEEE TGRS letters, 2021

Urban water detection

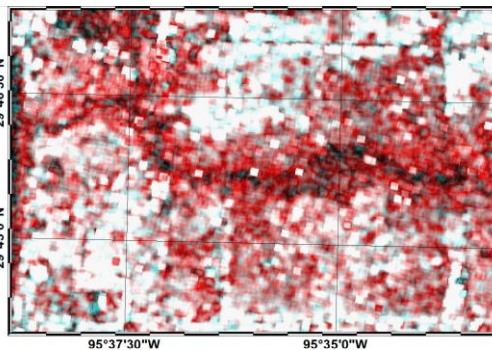
Intensity Pre-post RGB



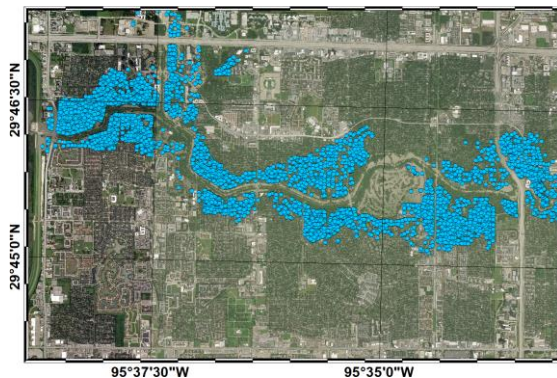
Coherence Pre-Co RGB (VV)



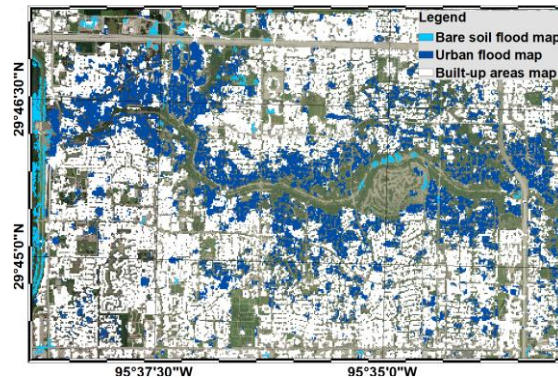
Coherence Pre-Co RGB (VH)



Digital Globe VHR imagery and crowdsourcing

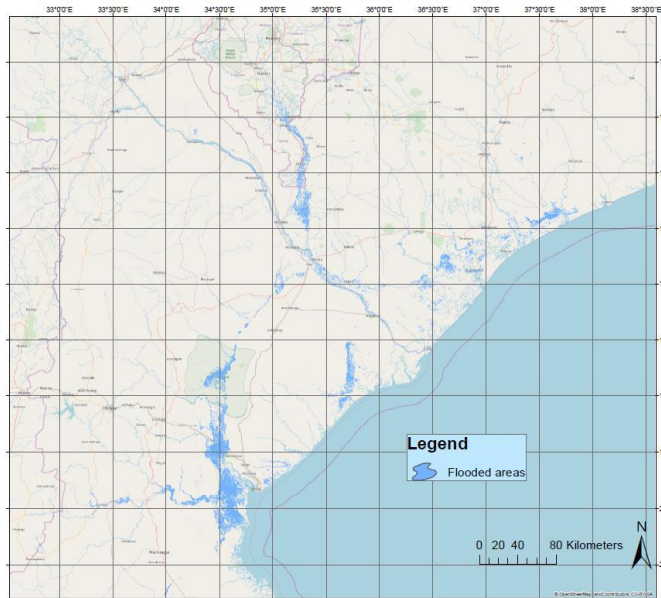


Flood map



Urban water detection

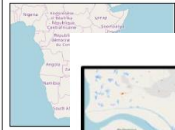
Maximum observed inundation extent derived from Sentinel-1 data acquired between 02/03/2019 and 20/03/2019



HASARD

This map illustrates SAR-based inundation extent derived from Sentinel-1 data using a scientifically validated retrieval algorithm developed by LIST. This algorithm uses a series of SAR intensity information. The "HASARD" service is implemented on ESA's Grid Processing on Demand Environment.

Reference: M. Cho, K. Hoshino, L. Guzzanti and P. Møller, A Scientifically Validated Approach to Sentinel-1 Processing of SAR Images: Flood Inundation as a Test Case. IEEE Transactions on Geoscience and Remote Sensing, 55(12):6975-6986, 2017.



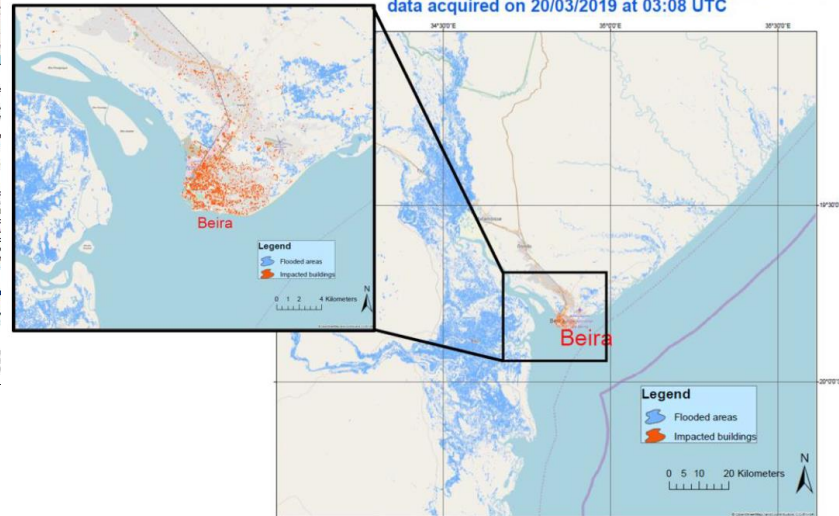
Coordinate System: WGS 1984 World Mercator
 Satellite data: Sentinel-1 SLC
 Acquisition dates: 02/03/2019 to 20/03/2019
 Other data: Open StreetMap
 Copyright: This map contains Copernicus Sentinel data processed by LIST and OpenStreetMap data.

No liability concerning the contents of the information is assumed by LIST. The information has limitations due to the quality and resolution of the original data sources, as well as the uncertainties associated with the retrieval algorithm. Please be aware that the thematic accuracy might be lower in urban and forested areas due to inherent limitations of the SAR analysis technique.



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Inundation extent and impacted buildings derived from Sentinel-1 data acquired on 20/03/2019 at 03:08 UTC



HASARD

This map illustrates SAR-based inundation extent and impacted buildings (flooded or damaged) derived from Sentinel-1 data using a scientifically validated retrieval algorithm developed by LIST. This algorithm uses SAR intensity and interferometric coherence information.

Reference: M. Cho, K. Hoshino, L. Guzzanti, P. Møller, A. M. Cho, K. Hoshino, L. Guzzanti and P. Møller, A Scientifically Validated Approach to Sentinel-1 Processing of SAR Images: Flood Inundation as a Test Case. IEEE Transactions on Geoscience and Remote Sensing, 55(12):6975-6986, 2017.

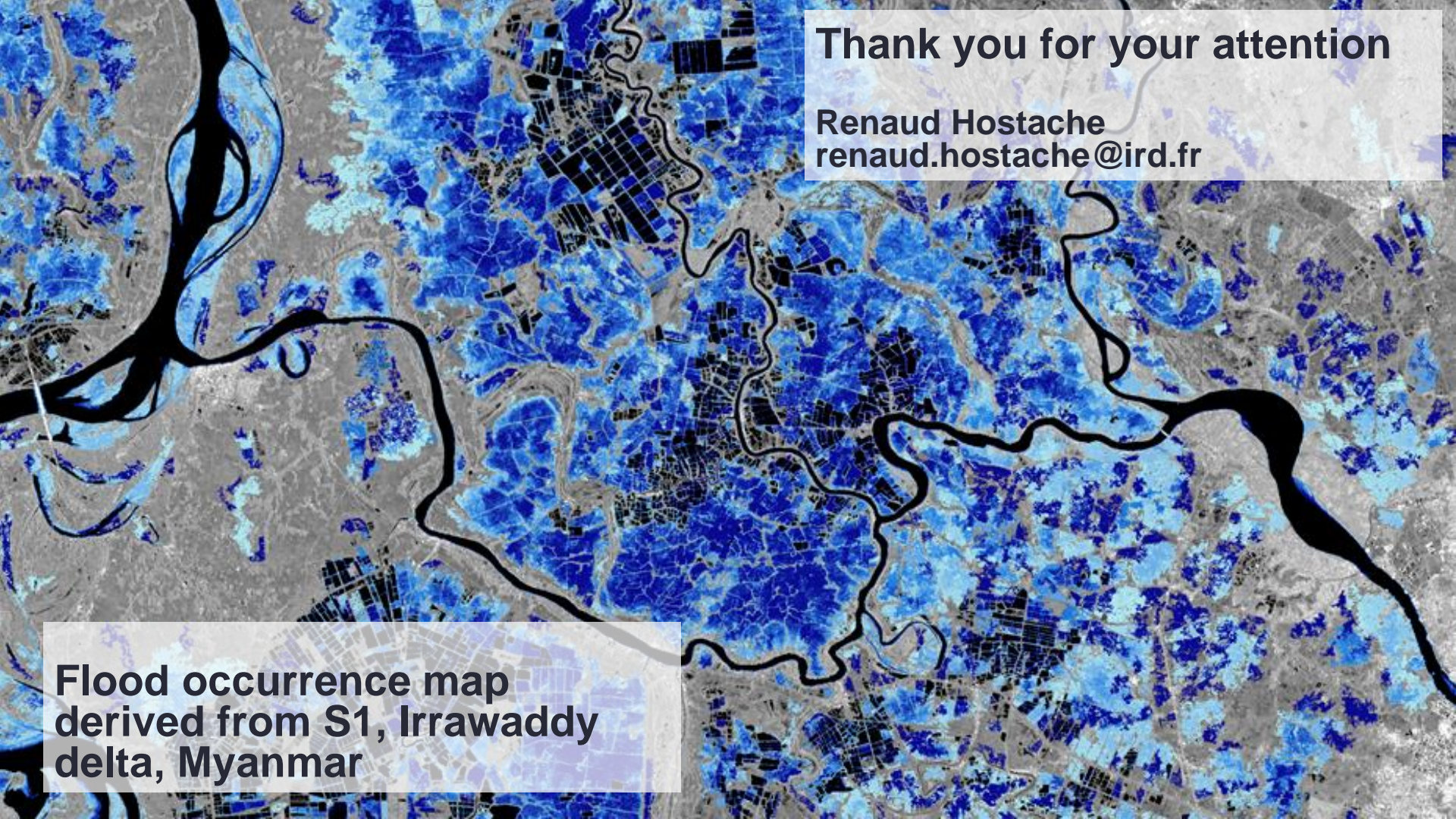


Coordinate System: WGS 1984 World Mercator
 Satellite data: Sentinel-1 SLC
 Acquisition date: 20/03/2019 at 03:08 UTC
 Other data: Open StreetMap
 Copyright: This map contains Copernicus Sentinel data processed by LIST and OpenStreetMap data.

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A satellite map of the Irrawaddy delta in Myanmar, showing a complex network of rivers and a dense urban area. The map is overlaid with a flood occurrence map, where flooded areas are colored in various shades of blue. The blue areas are concentrated in the central and right-hand portions of the image, following the river channels and surrounding lowlands. The urban area is visible as a dark, grid-like pattern in the center. The background is a grayscale satellite image showing the terrain and vegetation.

Thank you for your attention

Renaud Hostache
renaud.hostache@ird.fr

**Flood occurrence map
derived from S1, Irrawaddy
delta, Myanmar**