

# Sentinel-1 multitemporal InSAR coherence to map floodwater in urban areas

—  
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Patrick Matgen*

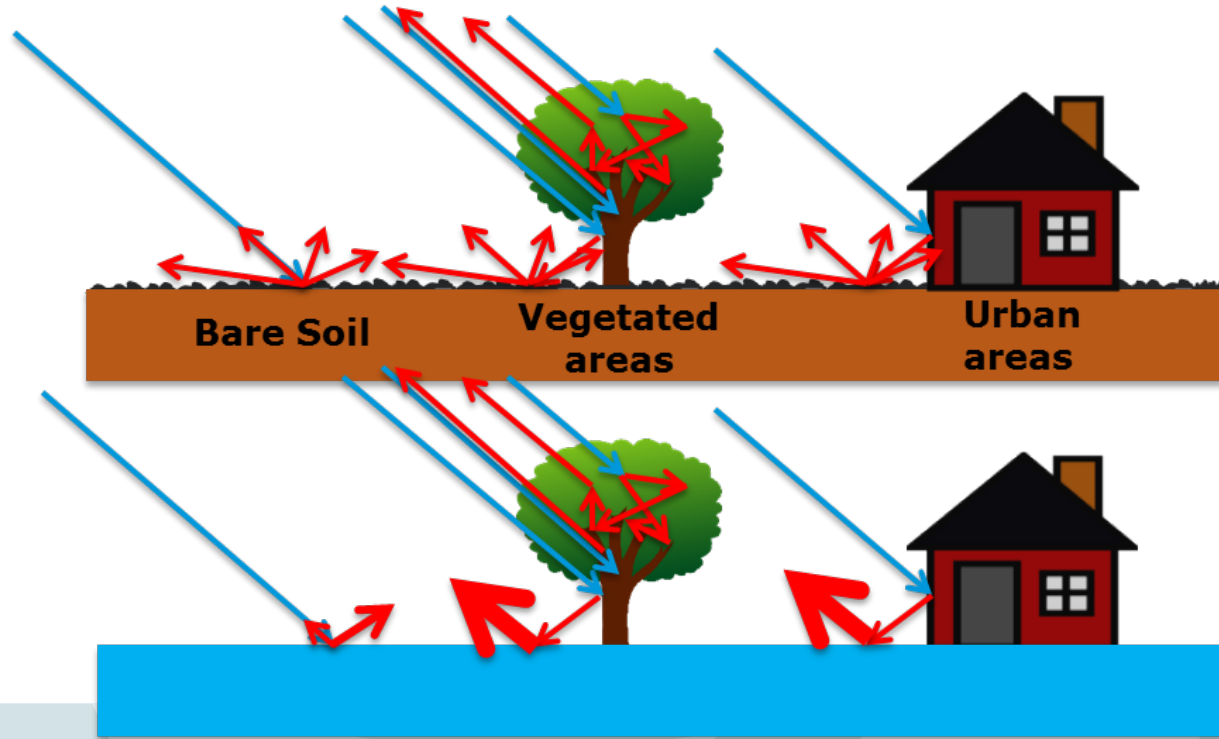
GFP- 4 November 2020

LUXEMBOURG  
INSTITUTE OF SCIENCE  
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# SAR SCATTERING MECHANISMS

## FLOOD VS NO FLOOD



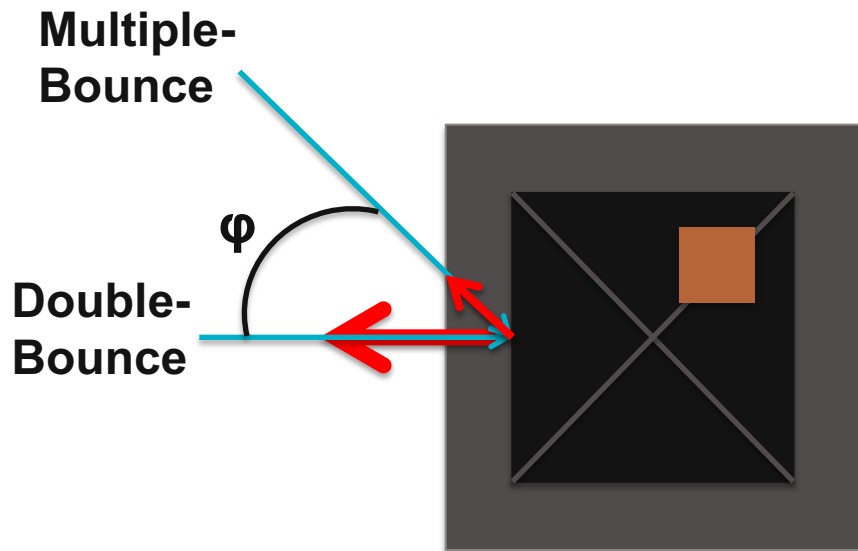
# SAR INTENSITY LIMITATIONS

- If we consider the angle between the flight direction and the street alignment, the increase is high for small angles, while it is reduced for higher angles.
- As a consequence, the increase of the Double-Bounce due to the presence of floodwater may not be sufficiently high if buildings are not parallel to the SAR flight direction. This type of increase is hardly detectable using only the backscatter intensity in a complex urban environment.

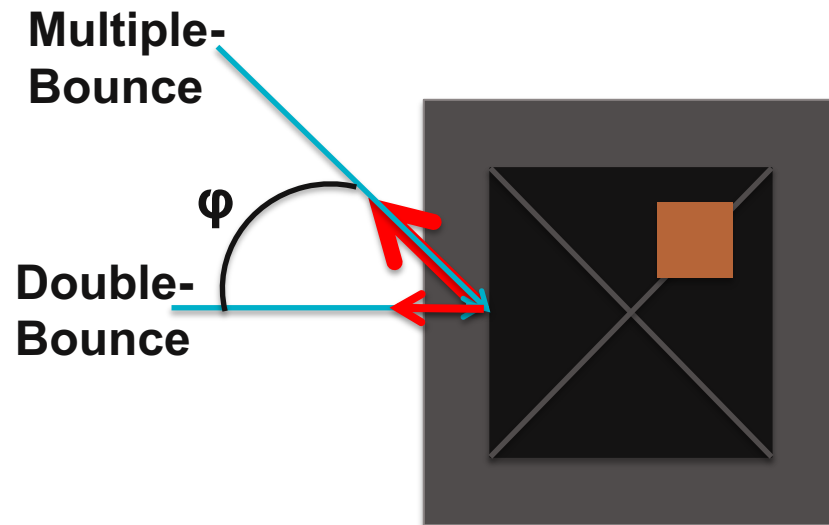


# THE ROLE OF VV AND VH POLARIZATIONS

## VV



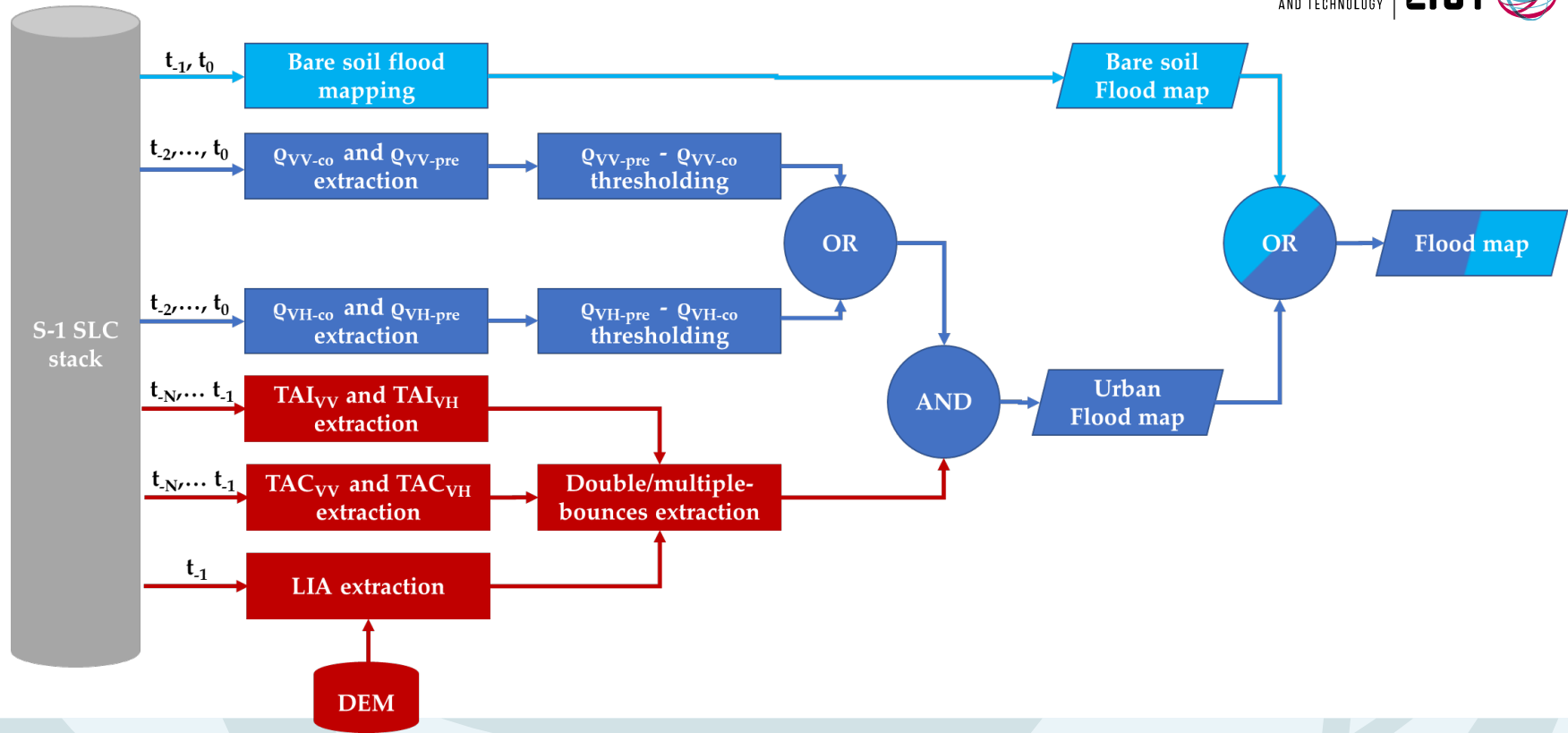
## VH





- Two peculiar scattering mechanisms are present in urban areas:
  - **Double-bounce** occurring for orthogonal illumination of building facades
    - **High co-polarization** backscattering
  - **Multiple-bounces** occurring for oblique illumination of buildings facades
    - **High cross-polarization** backscattering
- Backscattering increase in both polarizations may not be sufficiently high to highlight the presence of water.
- The multi-temporal **InSAR coherence** from co- and cross- polarizations can be profitably used to detect the presence of **floodwater in urban area**.

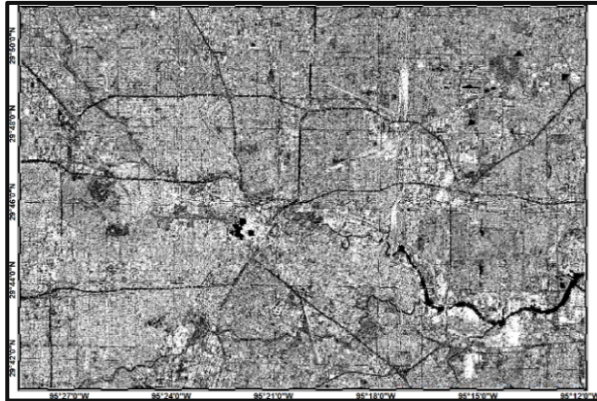
# METHODOLOGY



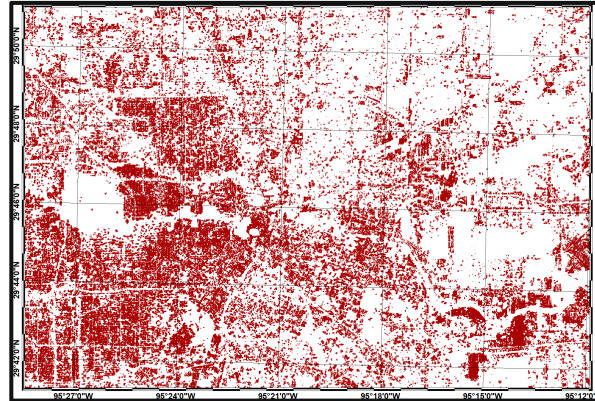
- M. Chini et al., "A Hierarchical Split-Based Approach for parametric thresholding of SAR images: flood inundation as a test case", *IEEE Transactions on Geoscience and Remote Sensing*, 55 (12), 6975-6988, 2017.
- M. Chini et al., Towards a 20 m Global Building Map from Sentinel-1 SAR Data , *Remote Sensing*, 10 (11), 1833, 2018.
- M. Chini et al., "Sentinel-1 InSAR Coherence to Detect Floodwater in Urban Areas: Houston and Hurricane Harvey as A Test Case , *Remote Sensing*, 11 , 107, 2019.
- R. Pelich et al., "Mapping floods in urban areas from dual-polarization InSAR coherence data", *IEEE Geoscience And Remote Sensing Letters*, Submitted.

# URBAN MAPPING

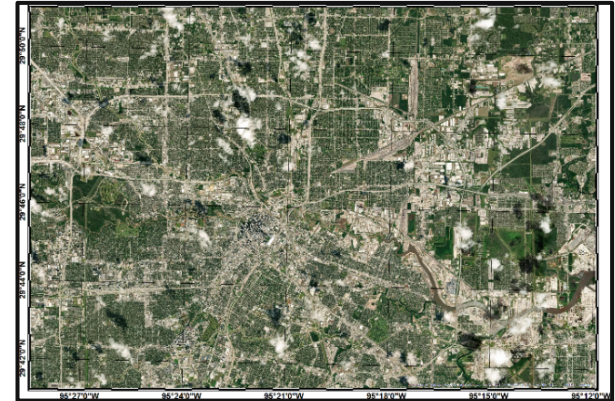
**Sentinel-1**



**Building map**

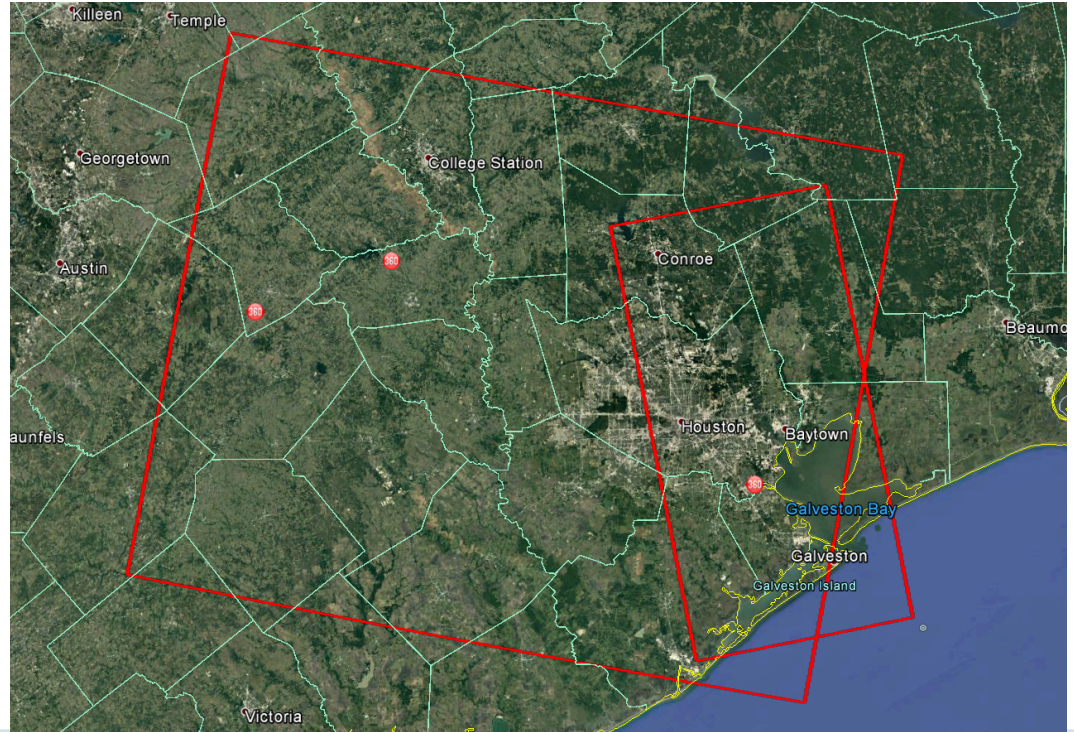


**Optical image**



# TEST CASE 1: HOUSTON 2017

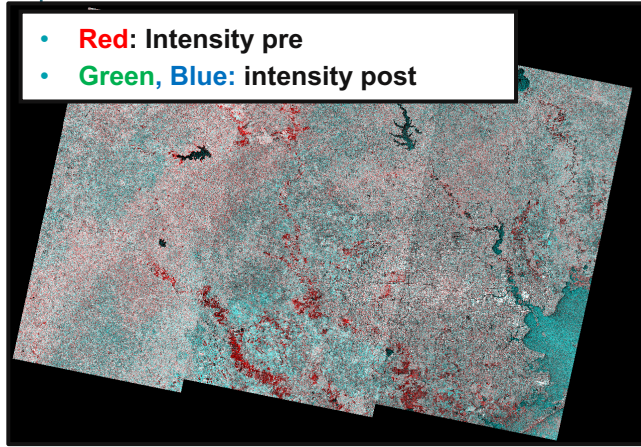
| Satellite  | Date                |
|------------|---------------------|
| S1-A<br>IW | 18/08/2017<br>12:22 |
| S1-B<br>IW | 24/08/2017<br>12:22 |
| S1-A<br>IW | 30/08/2017<br>12:22 |



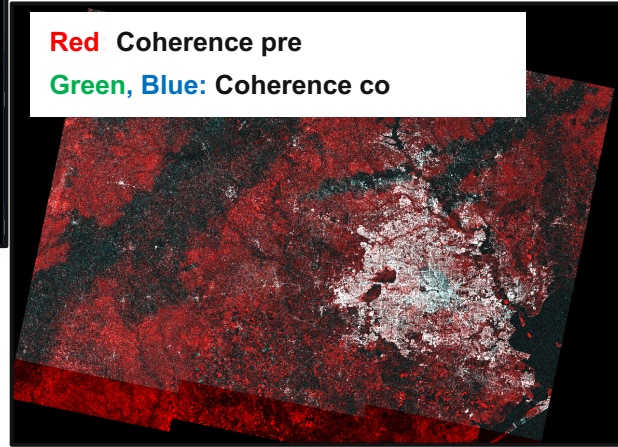


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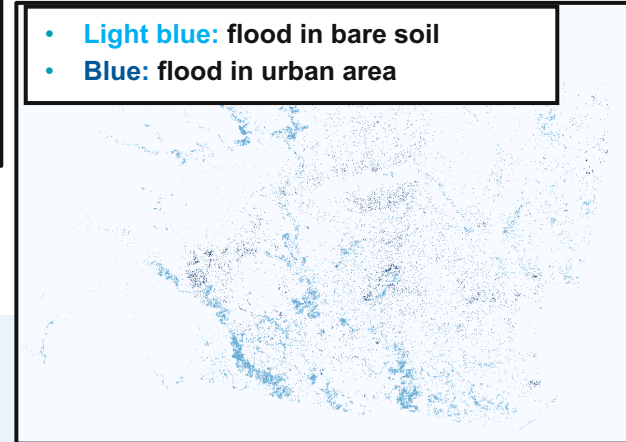
- **Red:** Intensity pre
- **Green, Blue:** intensity post



- **Red** Coherence pre
- **Green, Blue:** Coherence co



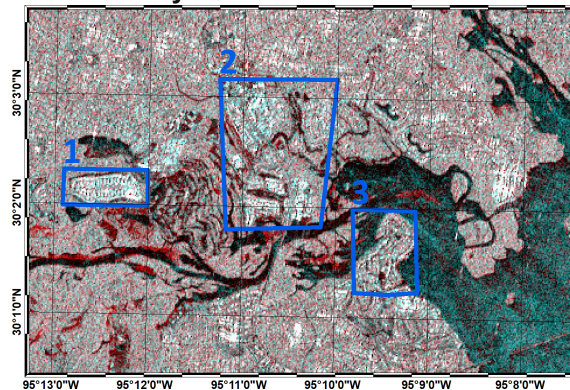
- **Light blue:** flood in bare soil
- **Blue:** flood in urban area



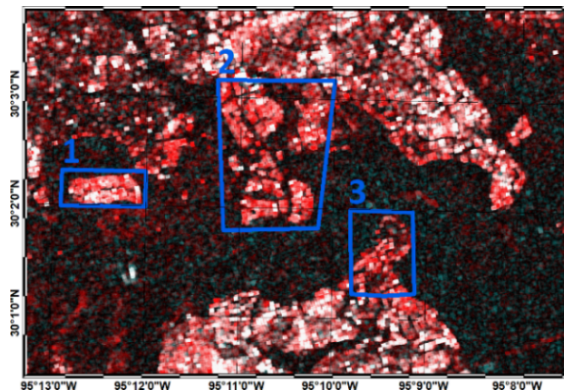
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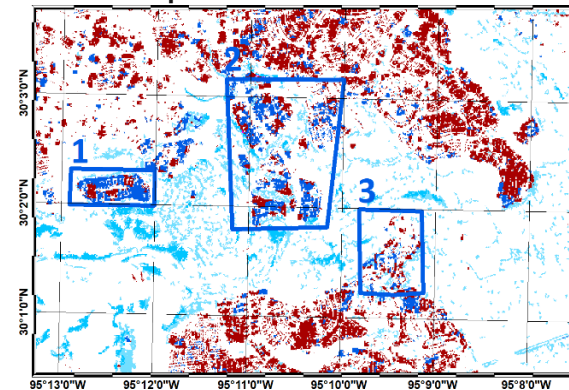
RGB Intensity



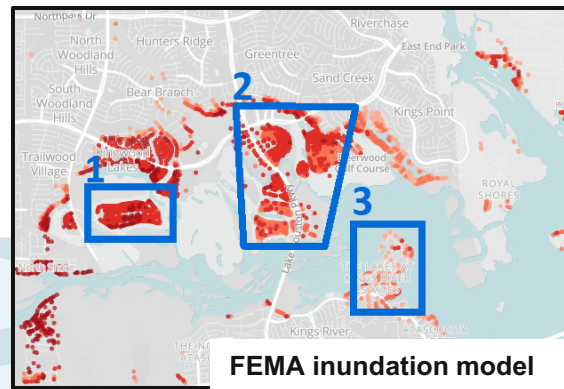
RGB coherence



Flood map



Crowdsourcing



FEMA inundation model

Aerial photo of AOI 1

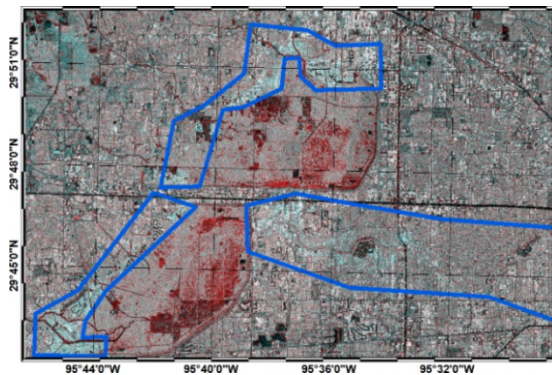




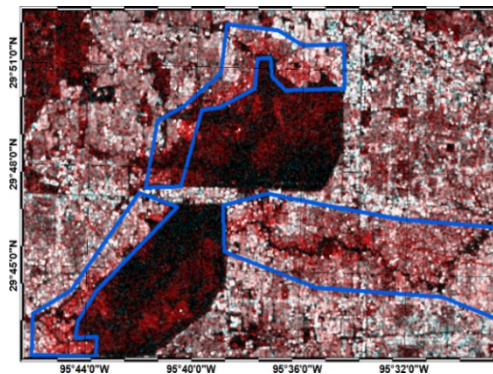
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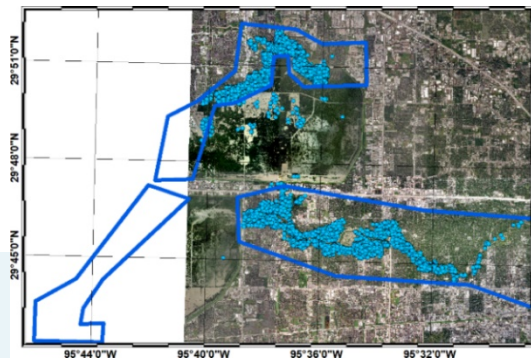
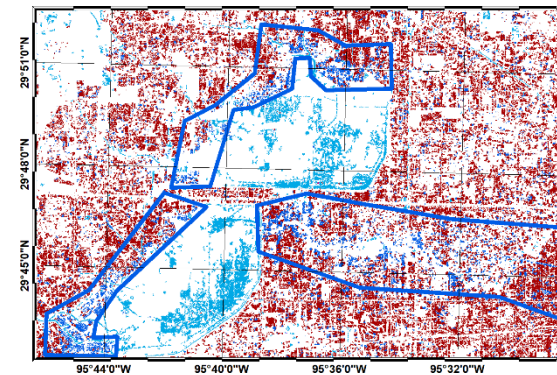
RGB Intensity



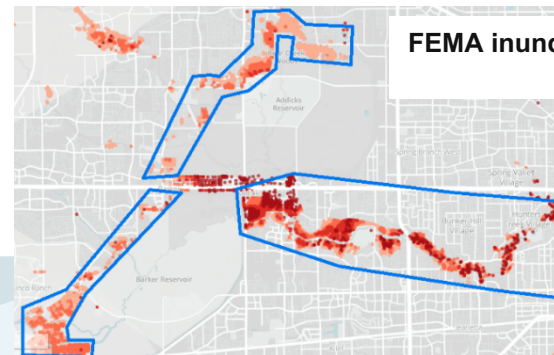
RGB coherence



Flood map

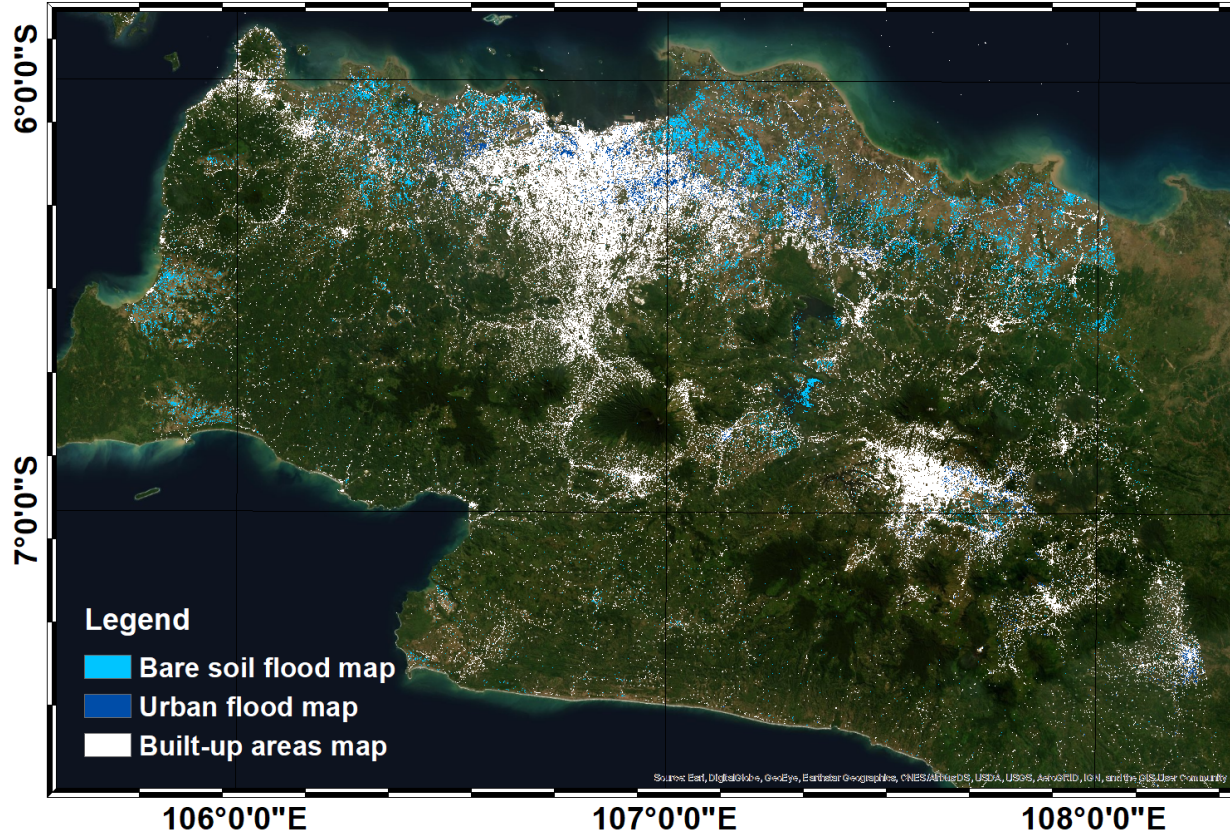


Digital Globe VHR imagery and crowdsourcing



FEMA inundation model

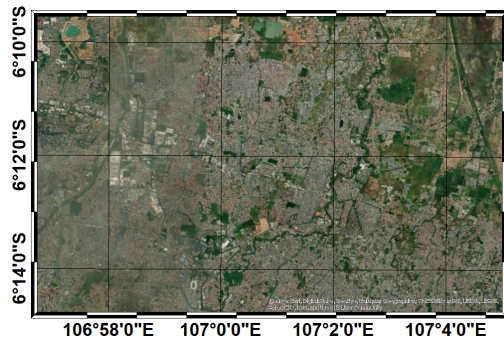
# TEST CASE 2: JAKARTA 2020



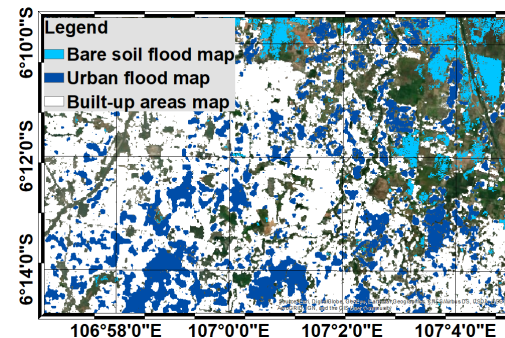
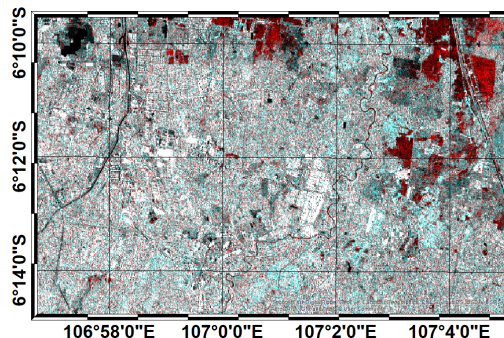


# TEST CASE 2: JAKARTA 2020

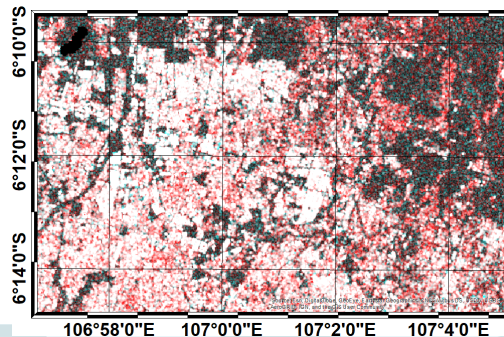
## Optical image



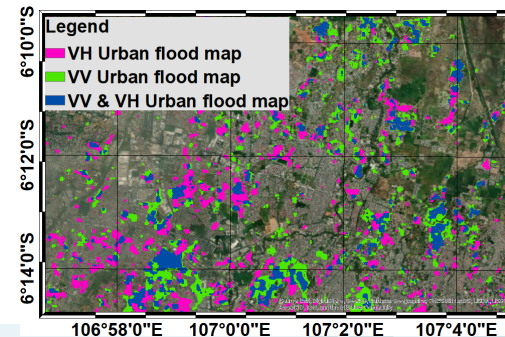
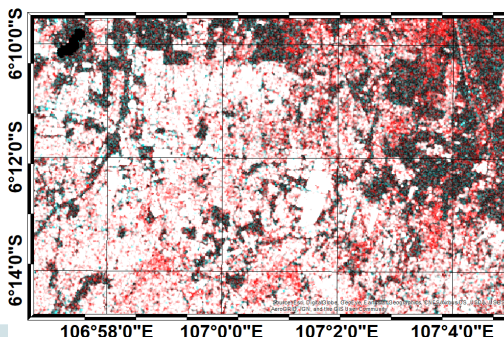
## Intensity Pre-Post RGB



## Coherence Pre-Co VH RGB



## Coherence Pre-Co VV RGB



# CONCLUSIONS

- An automatic algorithm capable of mapping floodwater in urban areas using 20m Sentinel-1 InSAR coherence has been presented.
- It exploits:
  - the short temporal and small spatial baselines of Sentinel-1 image pairs;
  - the intensity and the InSAR coherence from both VV and VH polarizations.
- The algorithm was tested using Sentinel-1 images acquired during different flood events from recent years.
- Results show the necessity of using both co- and cross-polarizations multitemporal InSAR coherence to detect floodwater in urbanized areas.

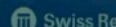
# e-DRIFT

## DISASTER RISK FINANCING AND TRANSFER

LUXEMBOURG  
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The e-DRIFT project has created a strong network between providers of EO-based value-added services, In-Sector service providers for the insurance market and reinsurance companies. Thanks to this network new products and solutions for the Insurance sector have been developed and operationally tested. The e-DRIFT project created sustainable solutions that will open market opportunities for companies and users.



### COORDINATOR:

**CIMA Research Foundation** - lead company and responsible of the design of the Virtual Platform which will enable an easy and timely access to the value added services: the main deliverable of the project.

### DEVELOPERS:

**LIST** - responsible of the flood area detection algorithms.

**DLR** - responsible of the population characterization layers.

**Deltares** - responsible for the integration of EO data into hydrologic/hydraulic model results.

### USERS & APPLICATIONS:

**Swiss Re** - major reinsurance company and in sector provider.

**RMS** - in sector provider and world leading company in cat modelling for insurance market.

The **SEADRIF** platform integrated and tested operationally services from e-DRIFT into its web client to trigger insurance payments in case of flooding in Laos, Cambodia and Myanmar under the supervision of **The World Bank**.

e-DRIFT SERVICES are powered by **WNS** and **HASARD**  
wasdi.net

[www.list.lu/en/news/an-automatic-satellite-image-processing-tool-for-flood-hazard-prevention-on-a-global-scale/](http://www.list.lu/en/news/an-automatic-satellite-image-processing-tool-for-flood-hazard-prevention-on-a-global-scale/)

# PILOT 2: SATELLITE EO-DERIVED WATER BODIES AND FLOODWATER RECORD OVER EUROPE

## SAR-BASED FLOOD MAPPING PRODUCTS

— Demonstration data set : Monsoon-related flooding in Myanmar (2017 – 2018)

### Google Earth Engine APP:

<https://yuli.users.earthengine.app/view/myanmarflood>

