Sentinel-1: A Game Changer in the Disaster Risk Management Cycle

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LIST

earth observation satellites

- Over the past few decades, Earth Observation (EO) satellites have emerged as a major data source for observing key environmental variables and providing critical information during disasters.

- EO satellites have the capability of repetitively acquiring data in a globally consistent and coherent way.

- Synthetic Aperture Radars (SARs) are of special importance because due to their sensitivity to variations in land cover and their near all-weather, day-and-night imaging capability.

Setting the scene

- **Sentinel-1 satellite(s) enabling systematic, high-frequency radar observations at global scale.**
- Automated SAR-based change detection retrieval algorithms have reached high technical readiness level
- Fast & easy access to imagery
- Fast (pre-)processing of data via cloud-based platforms

Scientific and technological challenges in disaster risk response

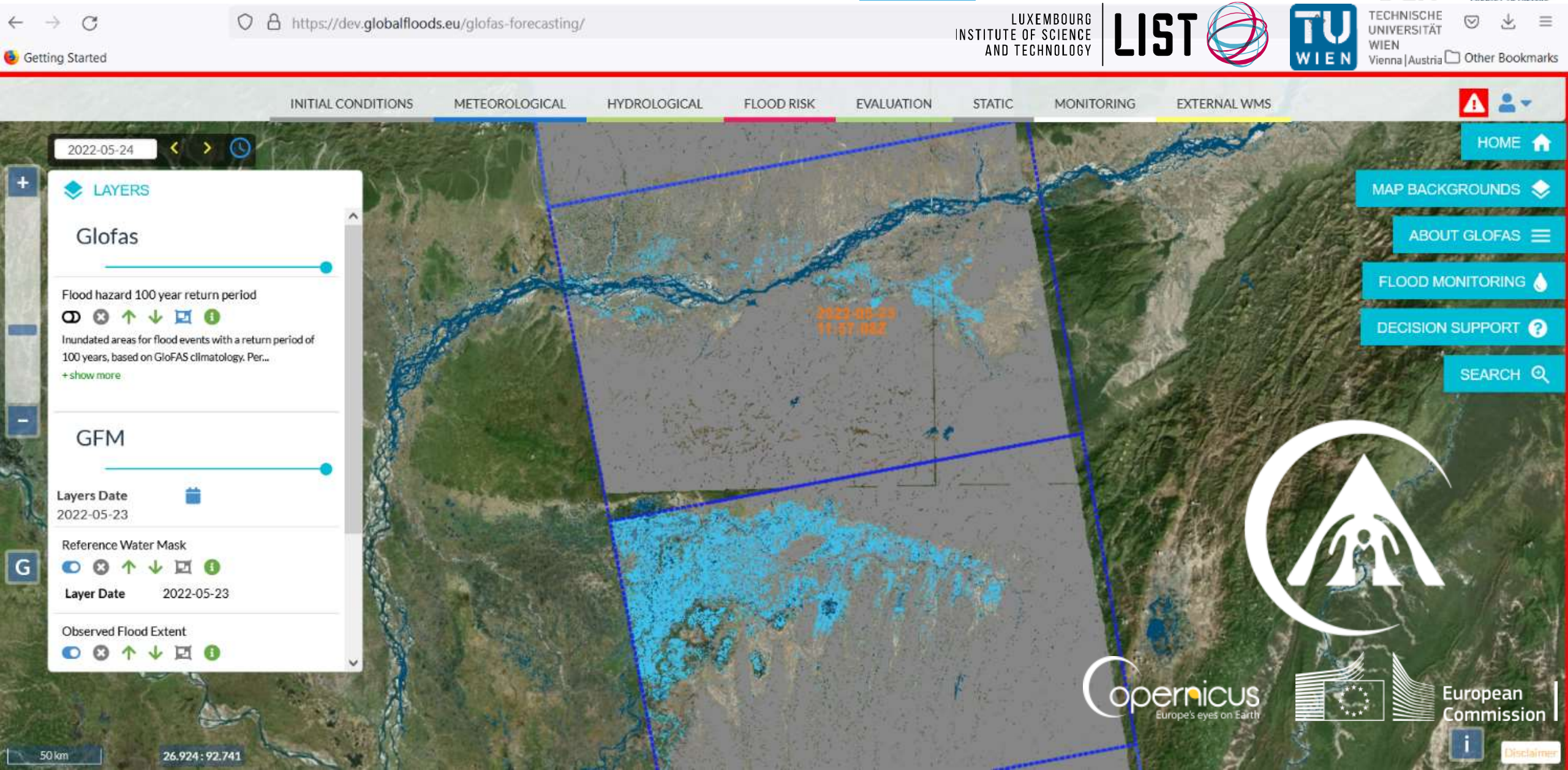
Challenge #1

- The retrieval algorithm needs to be efficient and robust and achieve high classification accuracies in diverse landscapes and different acquisition conditions

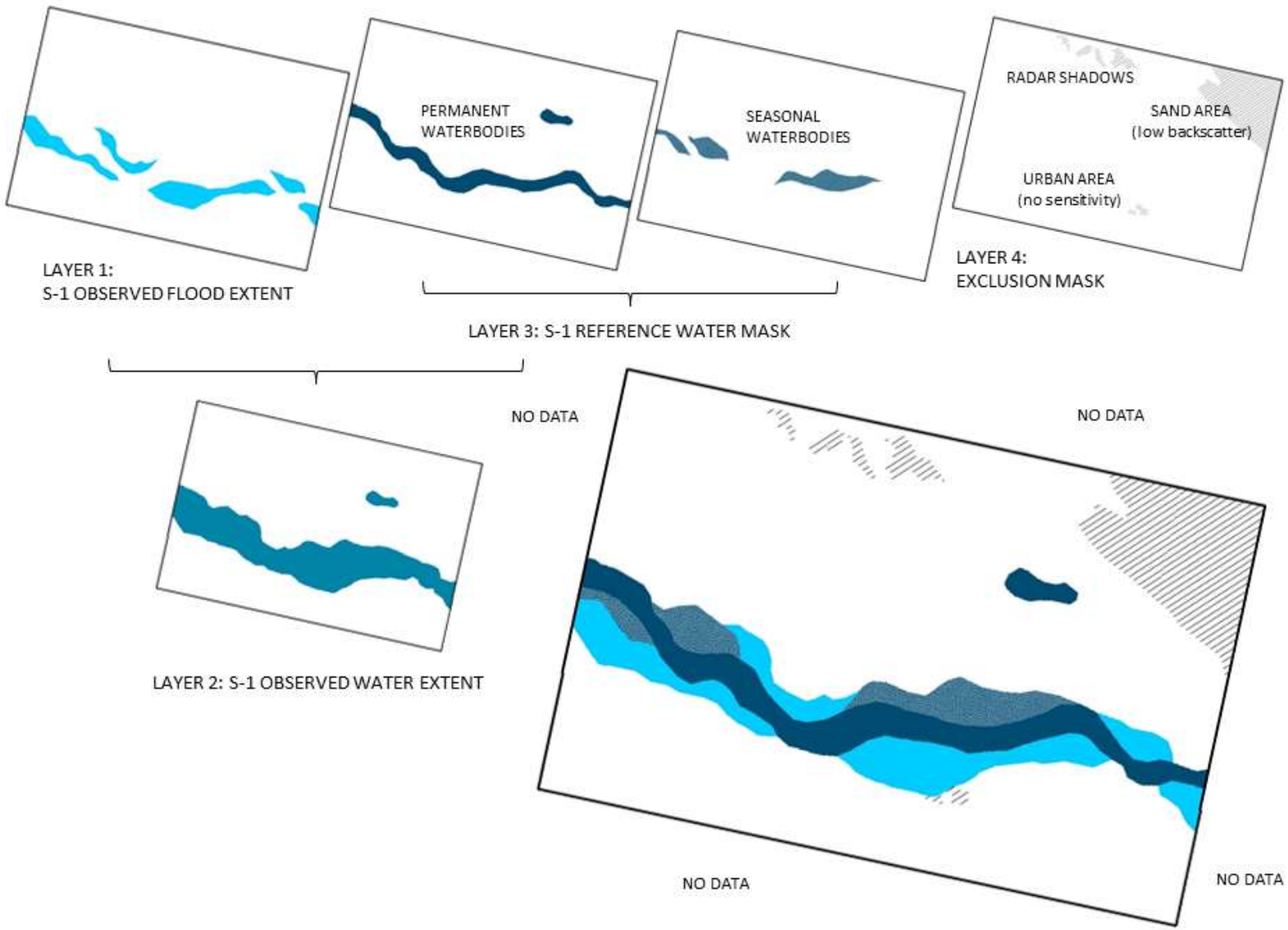
Challenge #2

- Fast access to imagery and high-performance computational resources to respond to needs of emergency responders and disaster risk financing sector.

Global flood monitoring (GFM system)



Global flood monitoring (GFM system)



Floodwater products:

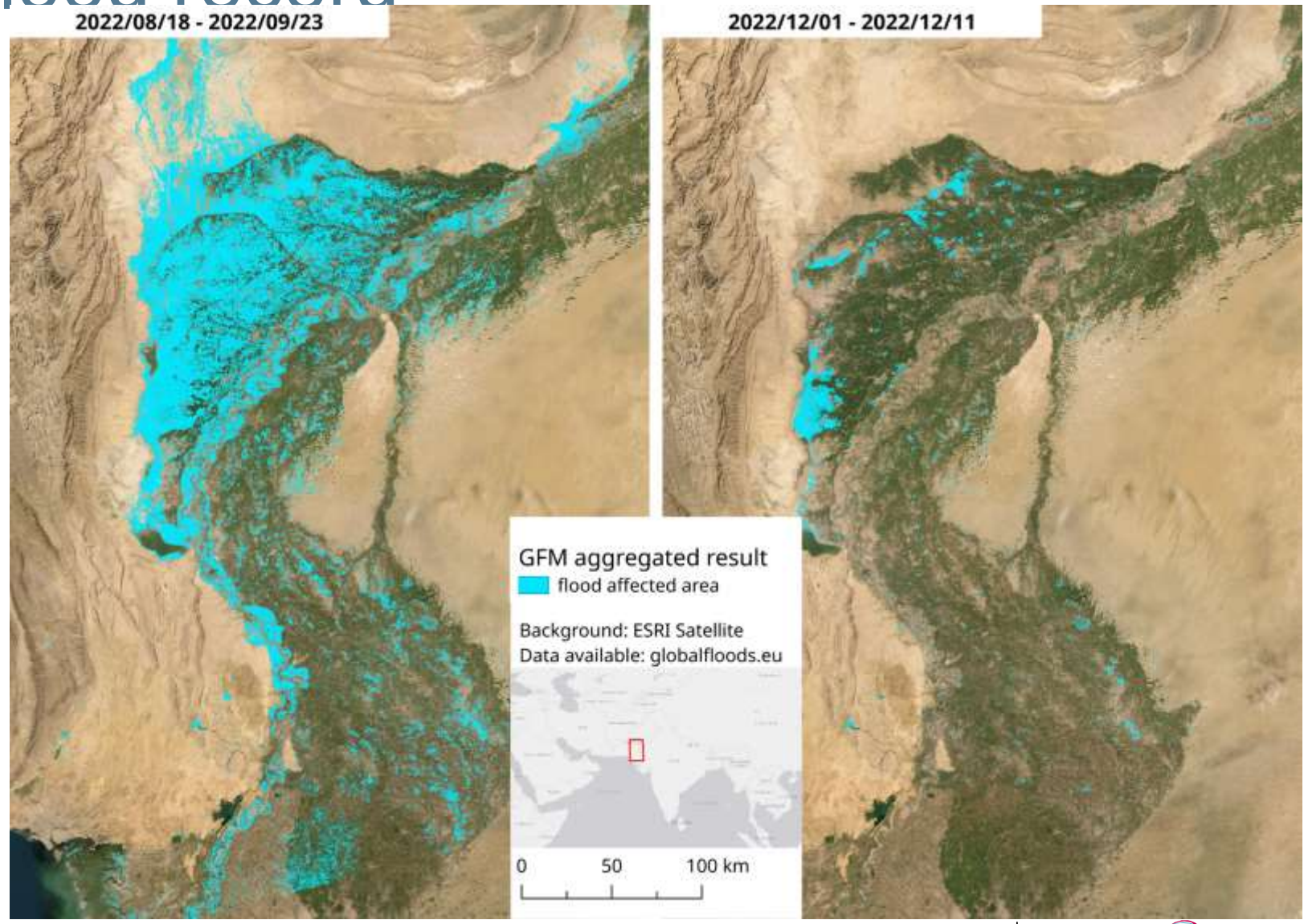
- **Flood extent**
- **Permanent water**
- **Seasonal water**

Derived products: flood record

Pakistan Flood 2022

- extremely large event
- crisis persisted into 2023

climate.copernicus.eu, 2022/09/21



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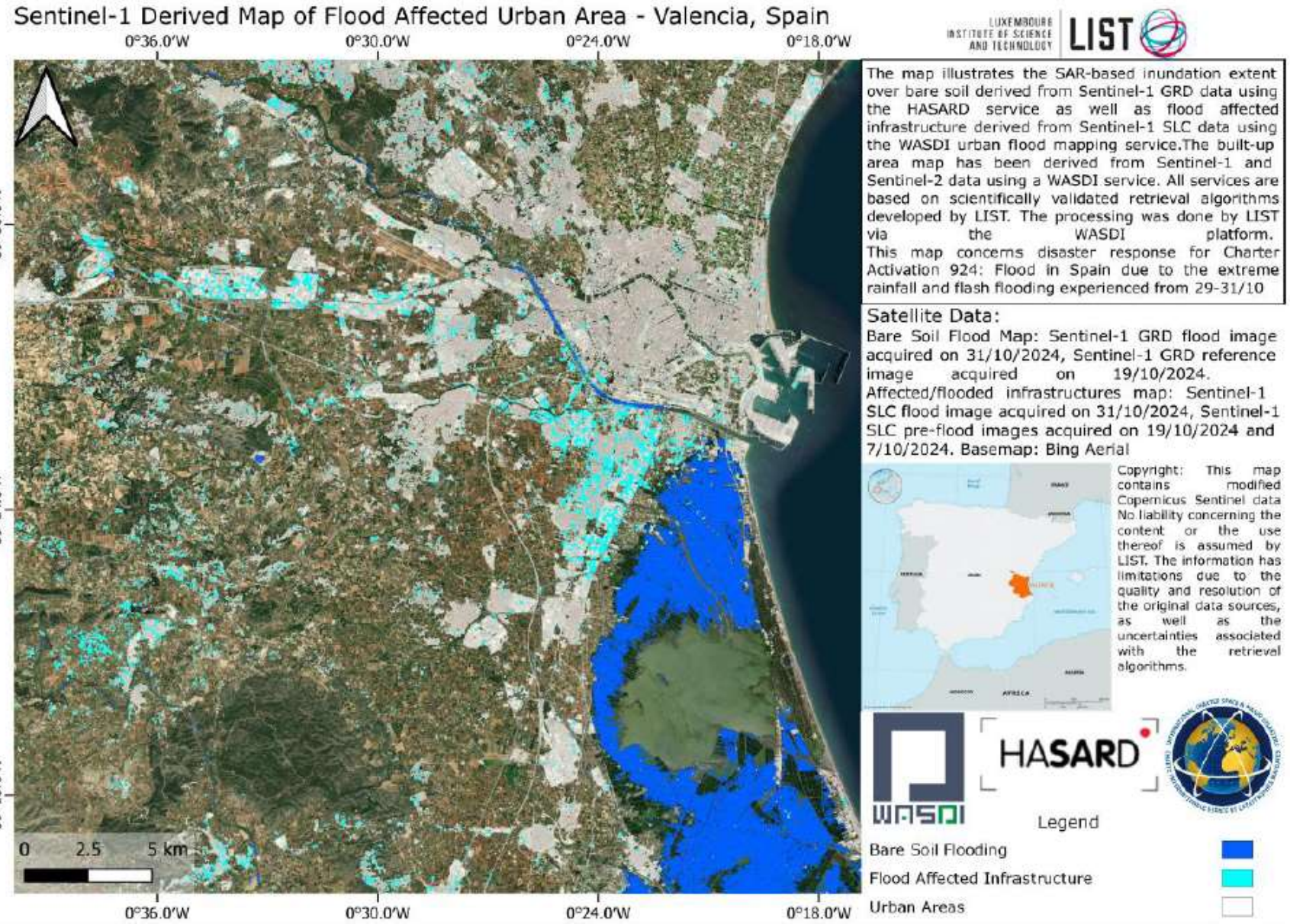
Sentinel-1 insar coherence-based mapping of floods in urban areas

- The InSAR coherence is the normalized cross correlation between images and it is related to the change in the spatial arrangement in time of the scatterers within a SAR image pixel.
- A coherence image can be built using either two images taken before the event (pre-event coherence) or with one before and one during the flood event (co-event coherence).
- The InSAR coherence is generally affected by temporal decorrelation, which means that it may decrease also for reasons other than catastrophic events.
  - It is mandatory to focus the analysis only on stable objects.
- The InSAR coherence is generally affected by spatial decorrelation, so that it decreases with the increase of the perpendicular baseline
  - Sentinel-1 is a perfect candidate given its relatively narrow orbit tube (i.e. small perpendicular baseline of interferometric acquisitions)

Sentinel-1 insar coherence-based mapping of floods in



October 2024
Flood in Valencia

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floodwater depth estimation - GradientHydro

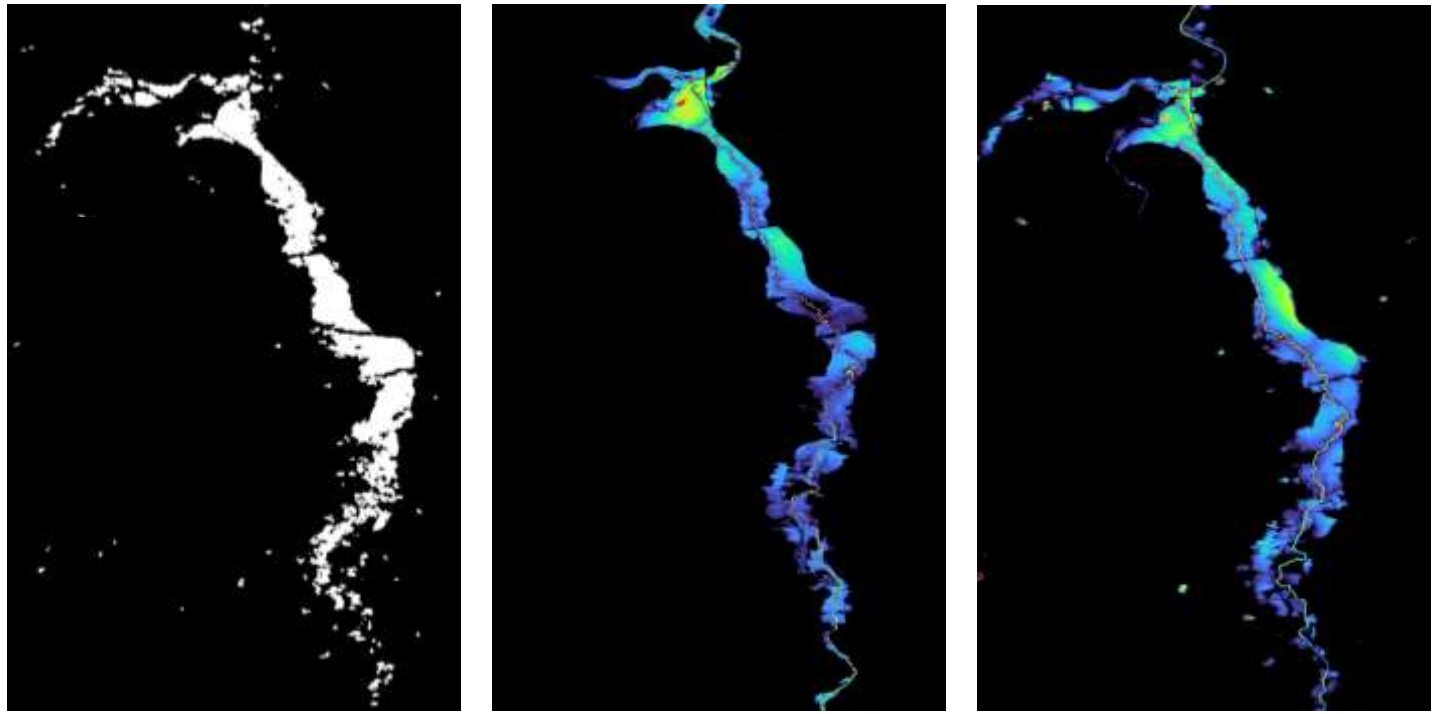
Data Fidelity

- ❑ Ensure the extent of the predicted water surface aligns with the input observed flood extents

Physical Constraints

- ❑ Gradient penalty (∇W)
  - ❑ Penalizes steep slopes that contradict realistic water flows
- ❑ Laplacian (Curvature) penalty ($\nabla^2 W$)
  - ❑ Controls rapid curvature changes, preventing unnatural “ripples” in the water surface

Luxembourg 2023



SAR Flood Map | Hydraulic Simulation | GradientHydro – Water Depth

0m — 5m

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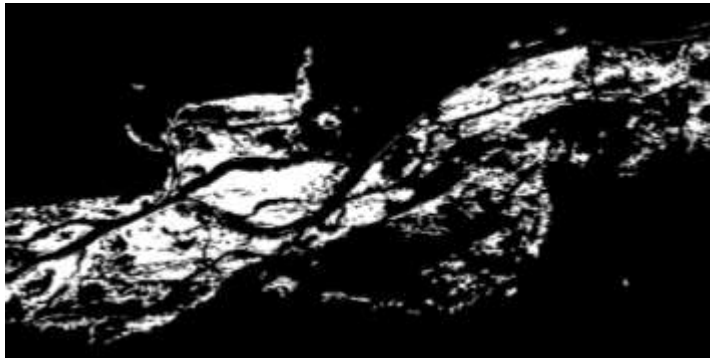
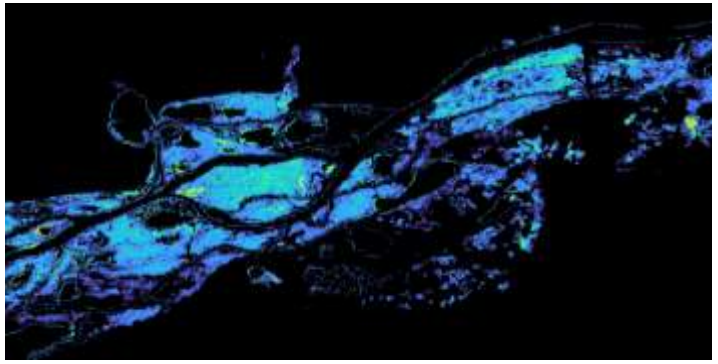
floodwater depth estimation - GradientHydro

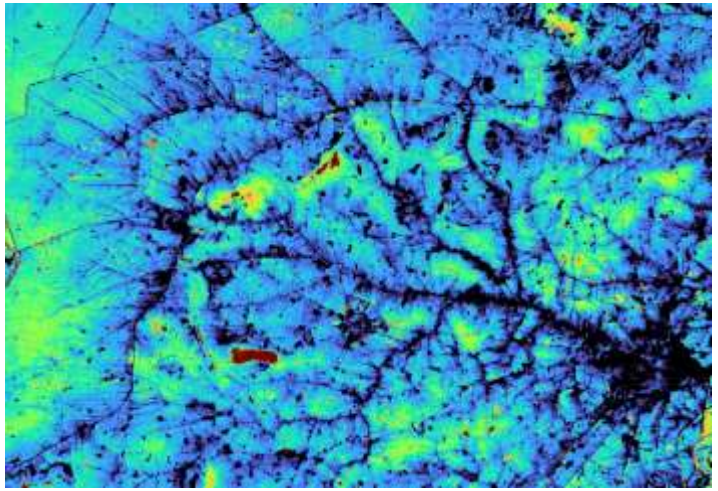


SAR Flood Map



GradientHydro – Water Depth

Mariupol Dam Explosion, Ukraine (06/06/2023)



Pakistan Floods (08/2022)

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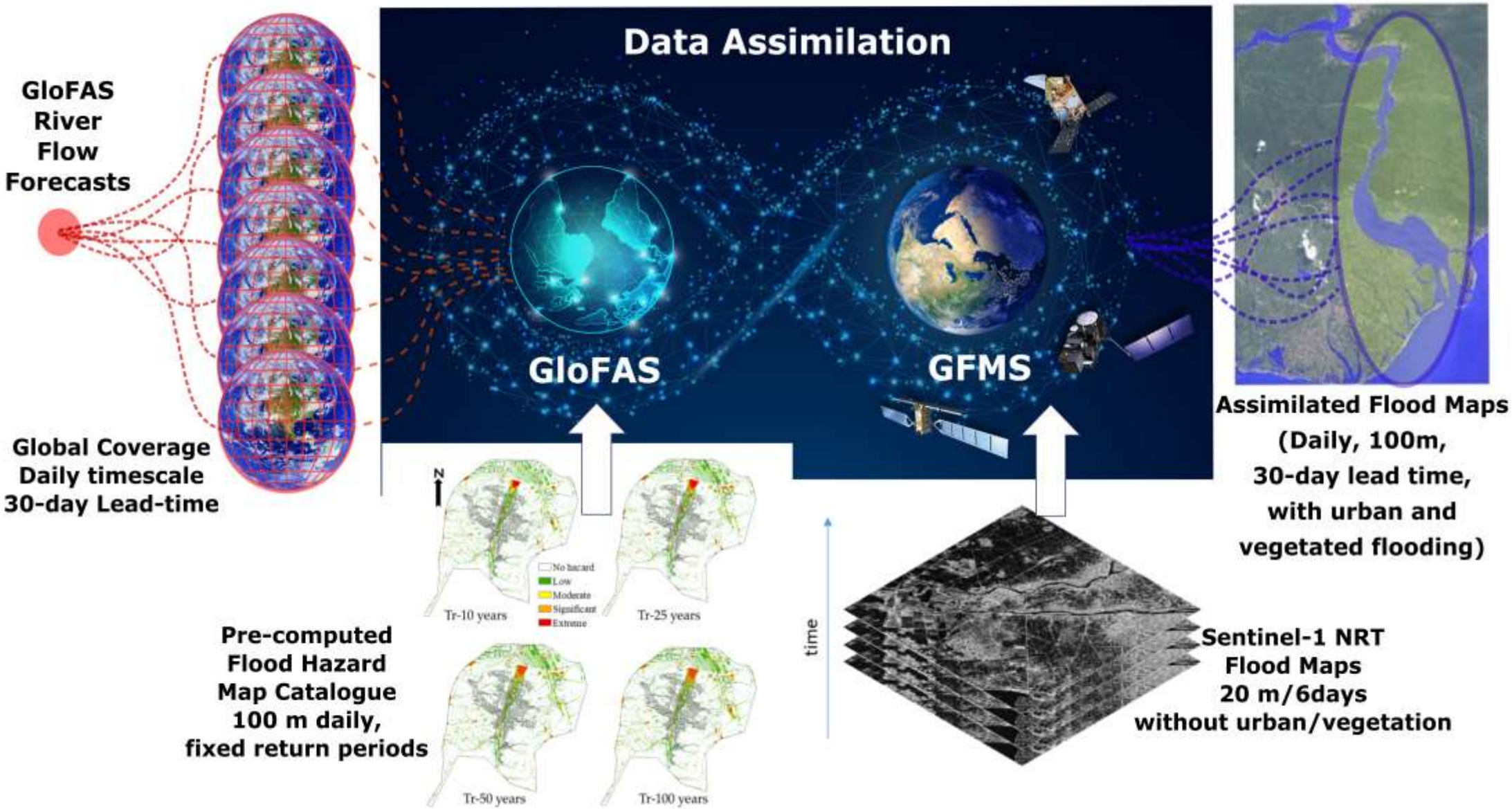
Improved global flood forecasts: integrating GloFAS and GFM

ESA Digital Twins Component - Urban



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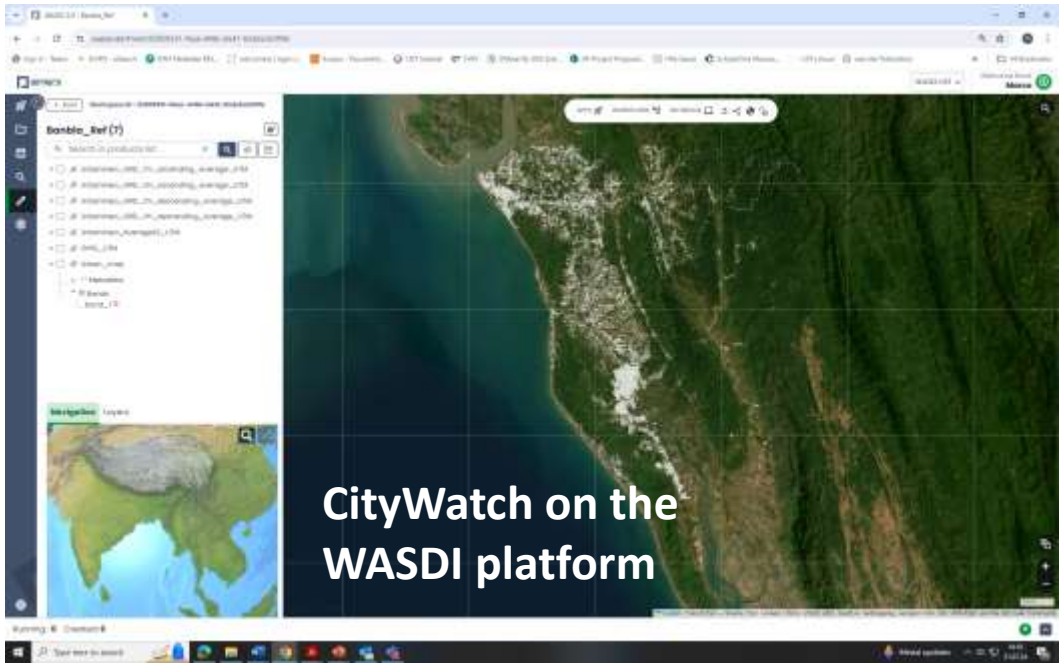
Built up area mapping – from hazard to impact/risk assessment

CityWatch provides fully automated global-scale monitoring of urban areas using EO data and cloud computing platforms (WASDI):

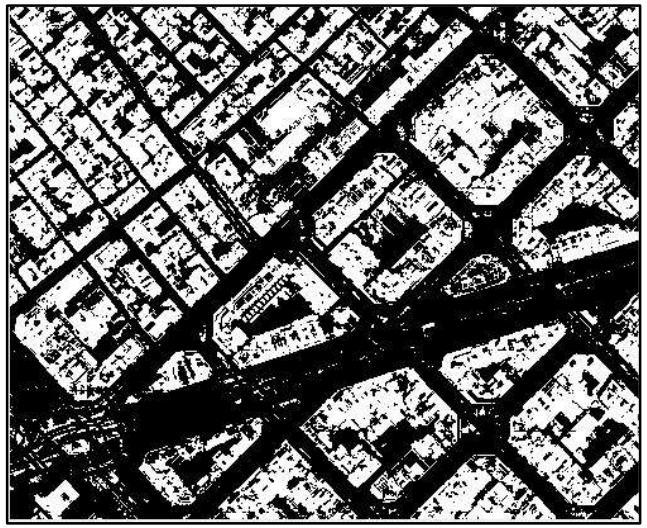
- **CityWatch - Baseline: 10 m spatial resolution building maps from Sentinel 1&2.**
- **CityWatch - Premium: Up to 0.5 m spatial resolution building maps using VHR images.**



Baseline

VHR EO data

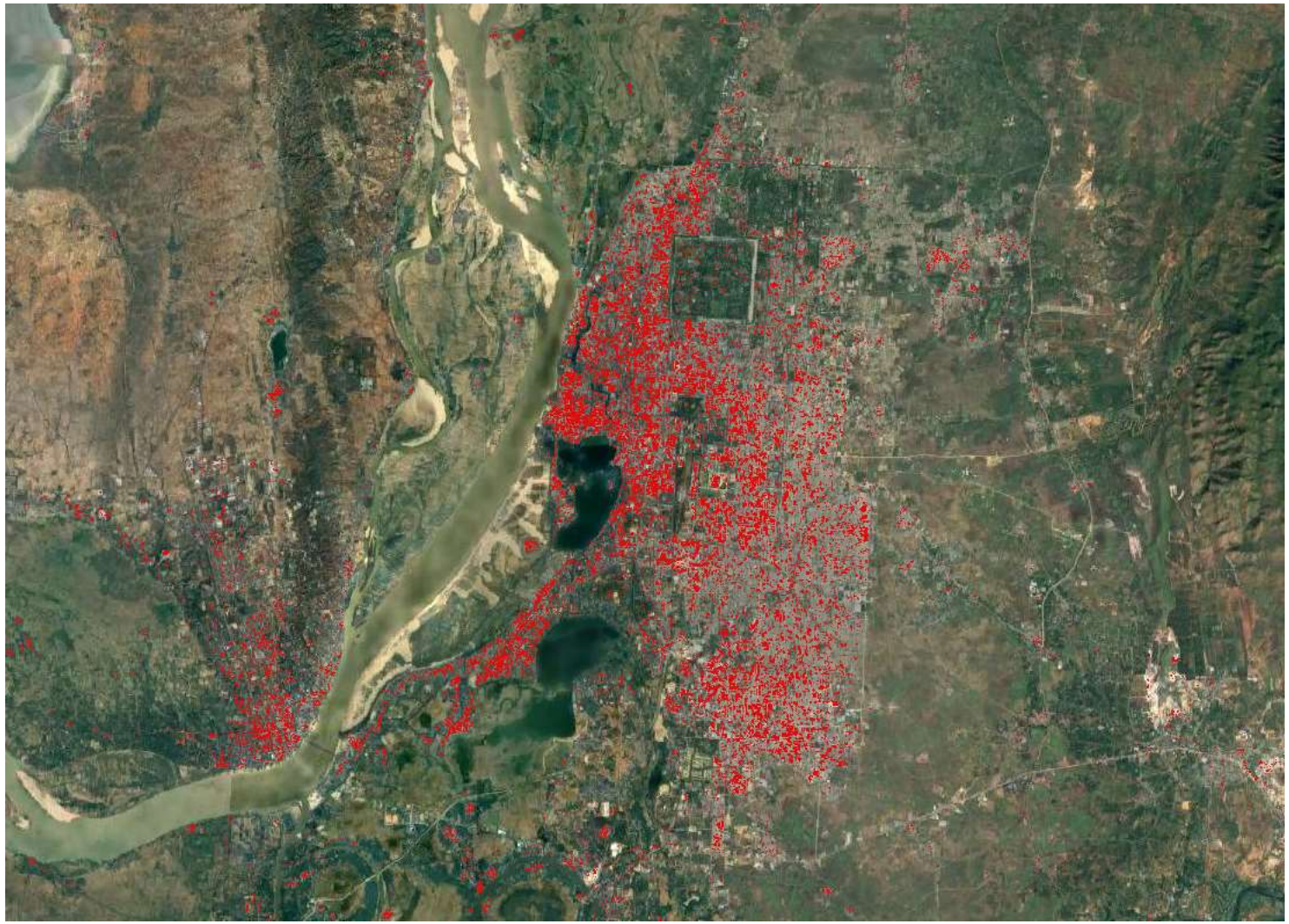
Premium



Building Damage Assessment

- ❑ **All-Weather, Radar-based Near Real-Time Monitoring**
- ❑ **Rapid, Large-Scale Assessment**
- ❑ **Adaptable & Generalizable AI**
- ❑ **Efficient Self-Supervised Learning**

2025 Myanmar earthquake



UN WFP World Food Programme
INNOVATION ACCELERATOR

LUXEMBOURG AID & DEVELOPMENT

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