

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

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Satellite-based Services for Disaster Risk Management

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Luxembourg



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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



https://dev.globalfloods.eu/glofas-forecasting/

Getting Started

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LIST



TECHNISCHE
UNIVERSITÄT
WIEN
Vienna | Austria



INITIAL CONDITIONS

METEOROLOGICAL

HYDROLOGICAL

FLOOD RISK

EVALUATION

STATIC

MONITORING

EXTERNAL WMS



HOME

MAP BACKGROUNDS

ABOUT GLOFAS

FLOOD MONITORING

DECISION SUPPORT

SEARCH

2022-05-24

LAYERS

Glofas

Flood hazard 100 year return period



Inundated areas for flood events with a return period of 100 years, based on GloFAS climatology. Per...

+ show more

GFM

Layers Date

2022-05-23

Reference Water Mask



Layer Date

2022-05-23

Observed Flood Extent



50 km

26.924 : 92.741

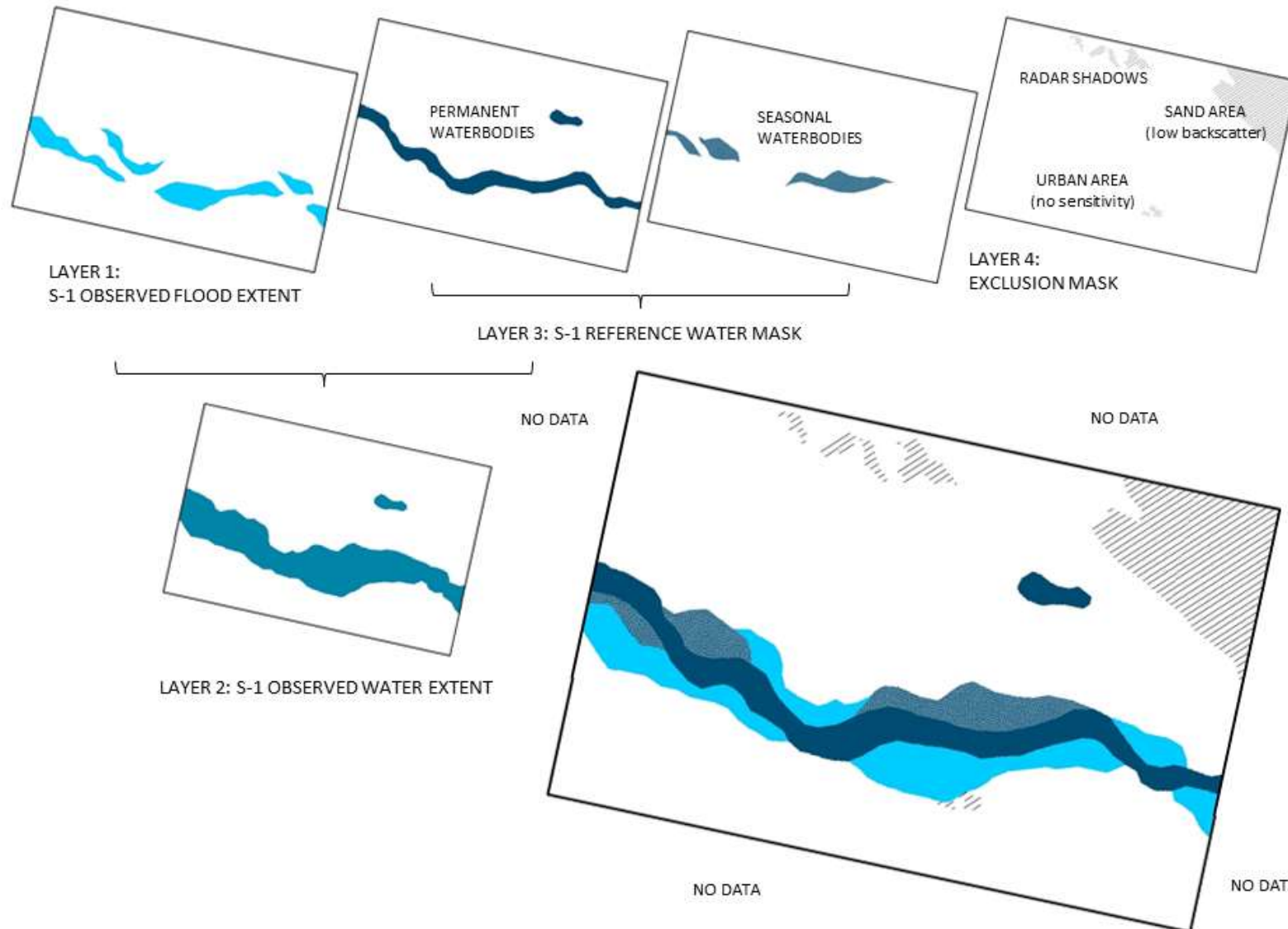


European
Commission



Disclaimer

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



11th September 2022

Pakistan has experienced severe monsoon weather since June 2022, according to information from the Pakistan Meteorological Department. Pakistan rainfall in August was 242% above average and the provinces of Balochistan and Sindh were particularly hard hit. The resulting floods have caused a human loss of 33 million people affected. The Copernicus Climate Change Service (CCSC) has been monitoring the situation.

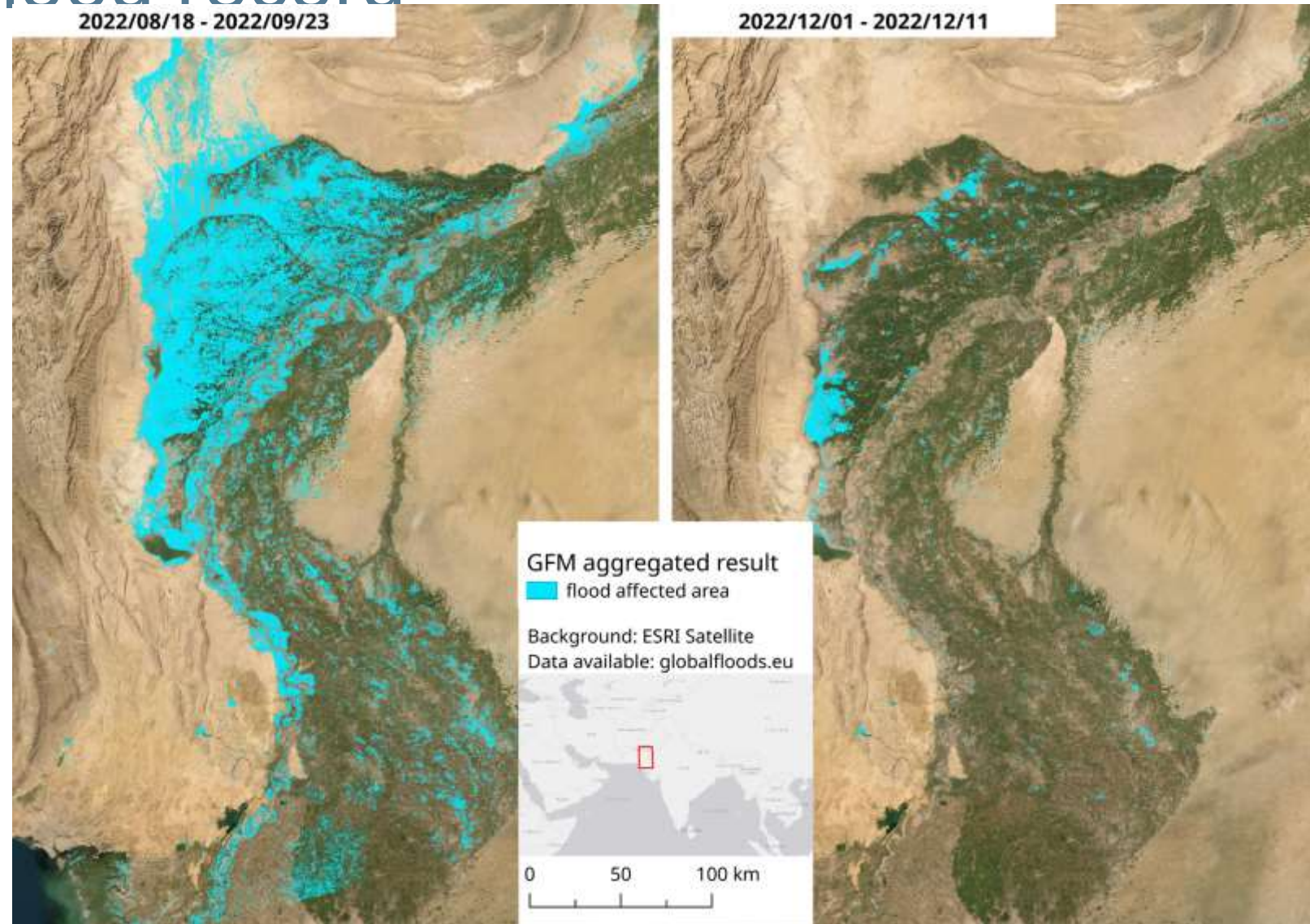
NEOSTART'S WORTHY CLIMATE SUSTAINABLE

WAVE CLIMATE POLICY

climate.copernicus.eu, 2022/09/21



Media Sub: News > Pakistan floods: Six months on, humanitarian needs remain dire



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

Sentinel-1 Derived Map of Flood Affected Urban Area - Valencia, Spain

0°36.0'W 0°30.0'W 0°24.0'W 0°18.0'W



The map illustrates the SAR-based inundation extent over bare soil derived from Sentinel-1 GRD data using the HASARD service as well as flood affected infrastructure derived from Sentinel-1 SLC data using the WASDI urban flood mapping service. The built-up area map has been derived from Sentinel-1 and Sentinel-2 data using a WASDI service. All services are based on scientifically validated retrieval algorithms developed by LIST. The processing was done by LIST via the WASDI platform. This map concerns disaster response for Charter Activation 924: Flood in Spain due to the extreme rainfall and flash flooding experienced from 29-31/10

Satellite Data:

Bare Soil Flood Map: Sentinel-1 GRD flood image acquired on 31/10/2024, Sentinel-1 GRD reference image acquired on 19/10/2024.
Affected/flooded infrastructures map: Sentinel-1 SLC flood image acquired on 31/10/2024, Sentinel-1 SLC pre-flood images acquired on 19/10/2024 and 7/10/2024. Basemap: Bing Aerial



Copyright: This map contains modified Copernicus Sentinel data. No liability concerning the content or the use thereof 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 algorithms.



HASARD



Legend

Bare Soil Flooding

Flood Affected Infrastructure

Urban Areas



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

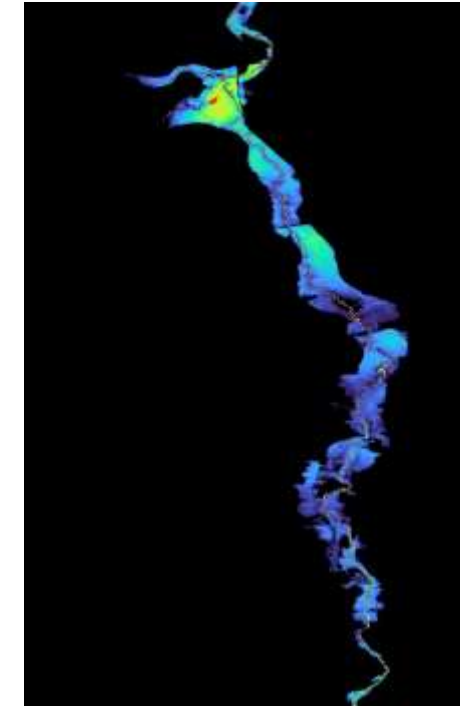
Physical Constraints

- ❑ 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

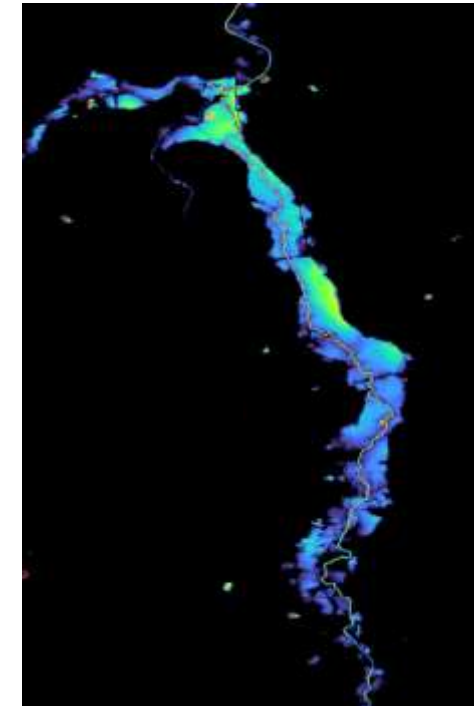
Luxembourg 2023



SAR Flood Map



Hydraulic Simulation



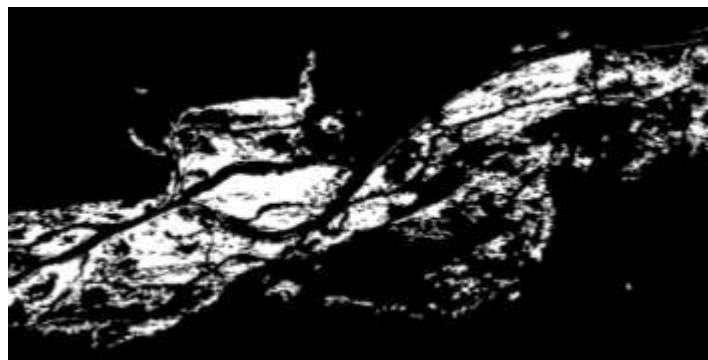
GradientHydro –
Water Depth

0m

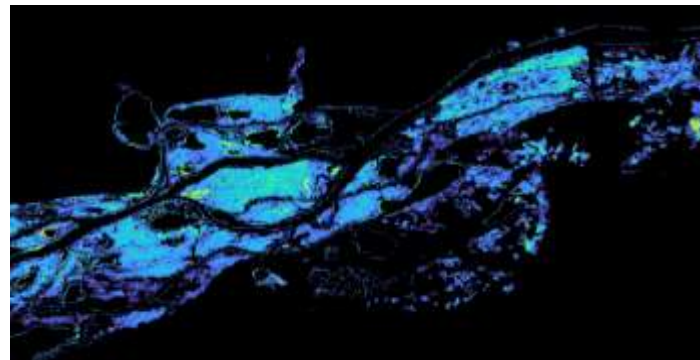
5m



floodwater depth estimation - GradientHydro

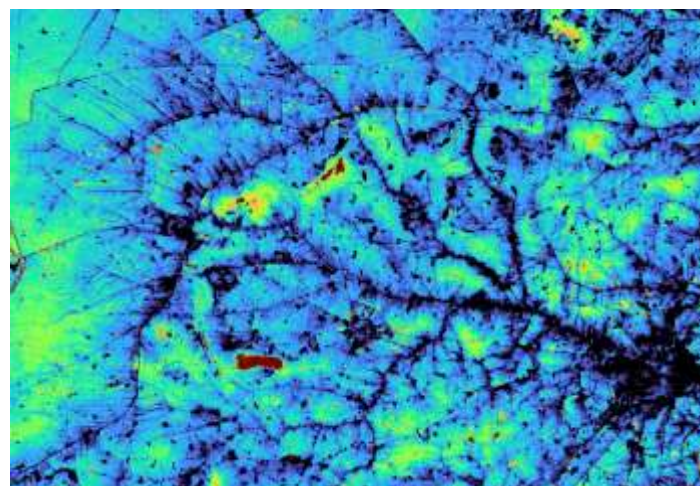


SAR Flood Map



**GradientHydro –
Water Depth**

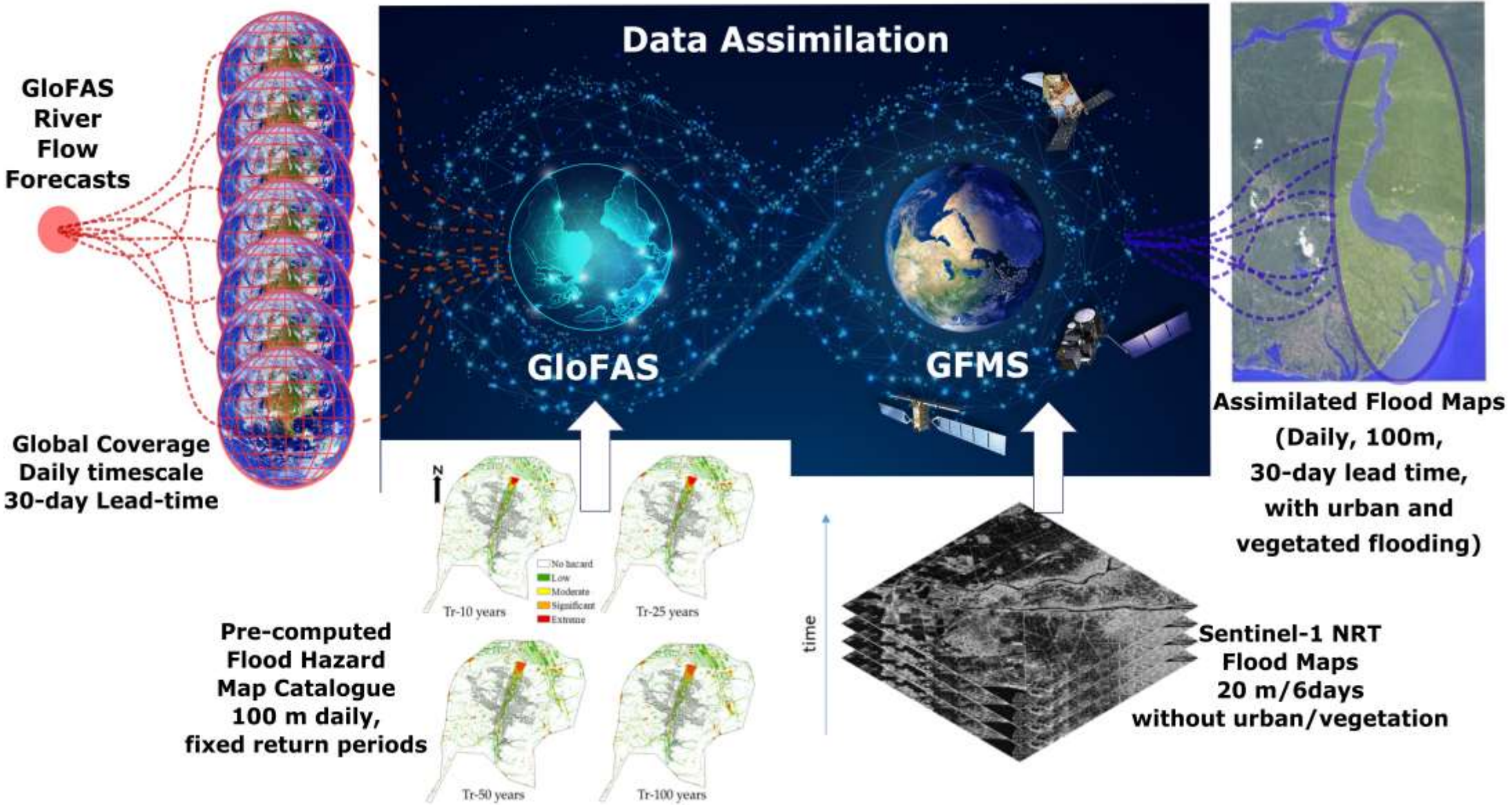
**Mariupol Dam Explosion,
Ukraine (06/06/2023)**



**Pakistan Floods
(08/2022)**

Improved global flood forecasts: integrating GloFAS and GFMS

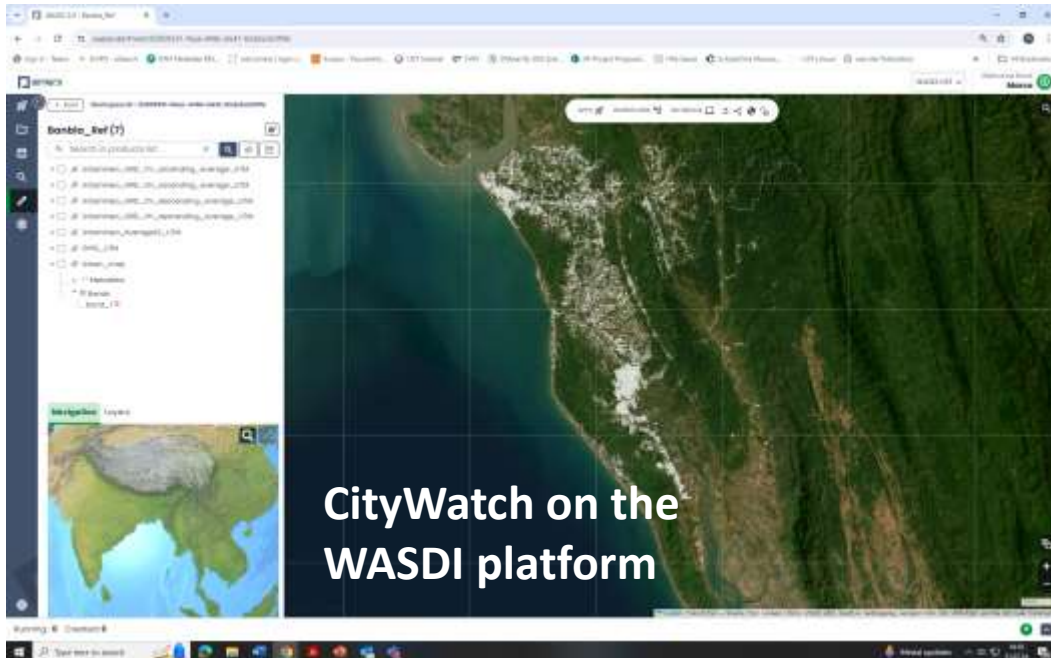
ESA Digital Twins Component - Urban



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.



VHR EO data



Baseline



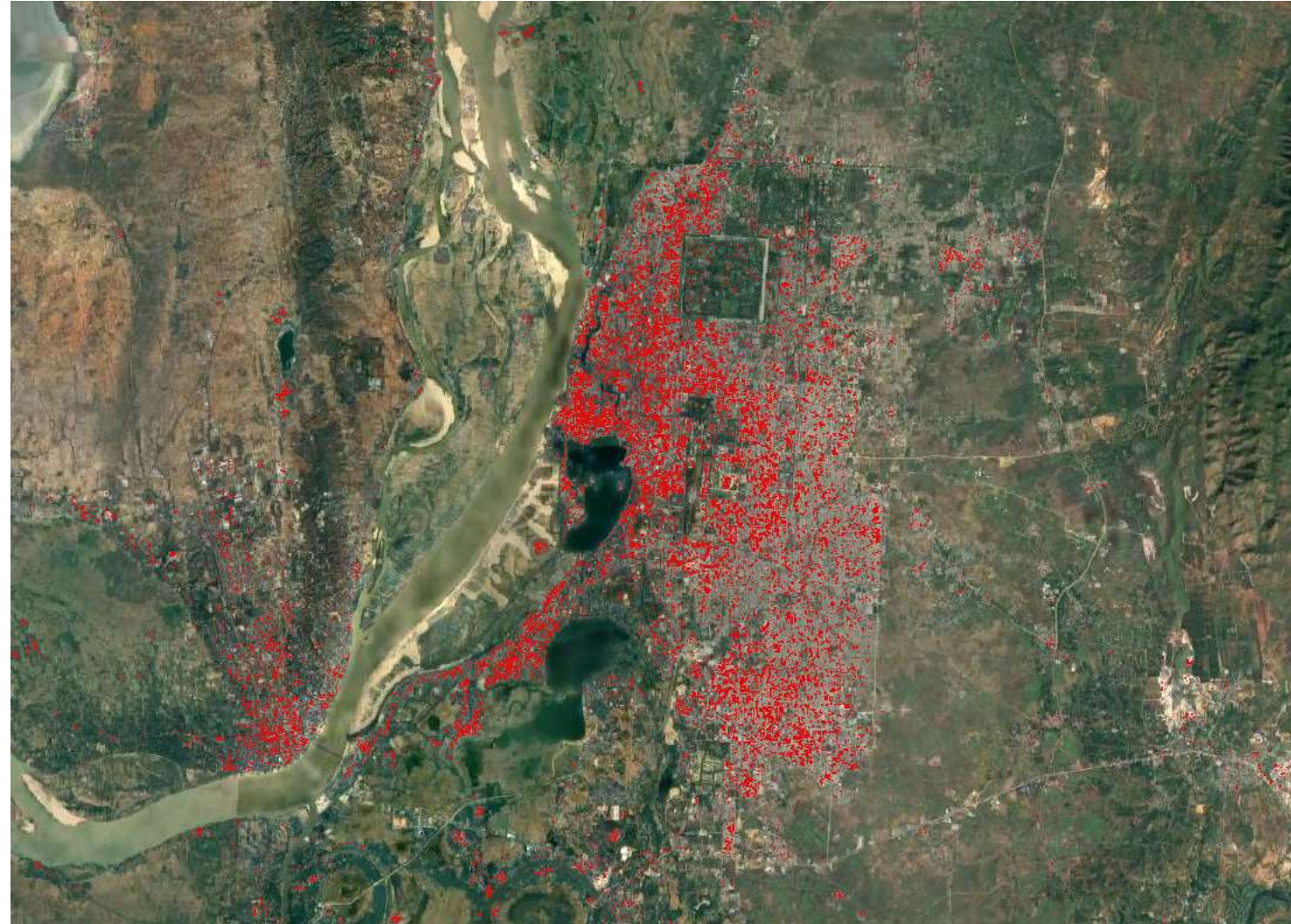
Premium



Building Damage Assessment

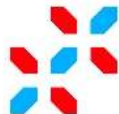
2025 Myanmar earthquake

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



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