AI4Copernicus 2023

Accurate and automatic flood maps based on SAR and optical data

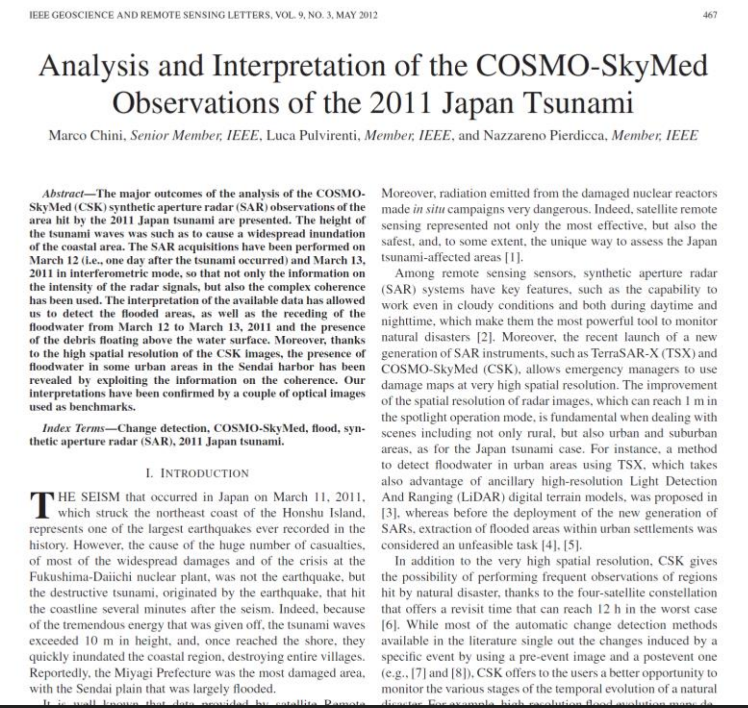
WASDI

Paolo Campanella 25/05/2023

EO Flood Maps - SAR On Demand

SAR have been used since the late 1980s, early 1990s to map floods.

11 March 2011



IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, VOL. 9, NO. 3, MAY 2012 467

Analysis and Interpretation of the COSMO-SkyMed Observations of the 2011 Japan Tsunami

Marco Chini, *Senior Member, IEEE*, Luca Pulvirenti, *Member, IEEE*, and Nazzareno Pierdicca, *Member, IEEE*

***Abstract*—The major outcomes of the analysis of the COSMO-SkyMed (CSK) synthetic aperture radar (SAR) observations of the area hit by the 2011 Japan tsunami are presented. The height of the tsunami waves was such as to cause a widespread inundation of the coastal area. The SAR acquisitions have been performed on March 12 (i.e., one day after the tsunami occurred) and March 13, 2011 in interferometric mode, so that not only the information on the intensity of the radar signals, but also the complex coherence has been used. The interpretation of the available data has allowed us to detect the flooded areas, as well as the receding of the floodwater from March 12 to March 13, 2011 and the presence of the debris floating above the water surface. Moreover, thanks to the high spatial resolution of the CSK images, the presence of floodwater in some urban areas in the Sendai harbor has been revealed by exploiting the information on the coherence. Our interpretations have been confirmed by a couple of optical images used as benchmarks.**

***Index Terms*—Change detection, COSMO-SkyMed, flood, synthetic aperture radar (SAR), 2011 Japan tsunami.**

I. Introduction

THE SEISM that occurred in Japan on March 11, 2011, which struck the northeast coast of the Honshu Island, represents one of the largest earthquakes ever recorded in the history. However, the cause of the huge number of casualties, of most of the widespread damages and of the crisis at the Fukushima-Daiichi nuclear plant, was not the earthquake, but the destructive tsunami, originated by the earthquake, that hit the coastline several minutes after the seism. Indeed, because of the tremendous energy that was given off, the tsunami waves exceeded 10 m in height, and, once reached the shore, they quickly inundated the coastal region, destroying entire villages. Reportedly, the Miyagi Prefecture was the most damaged area, with the Sendai plain that was largely flooded.

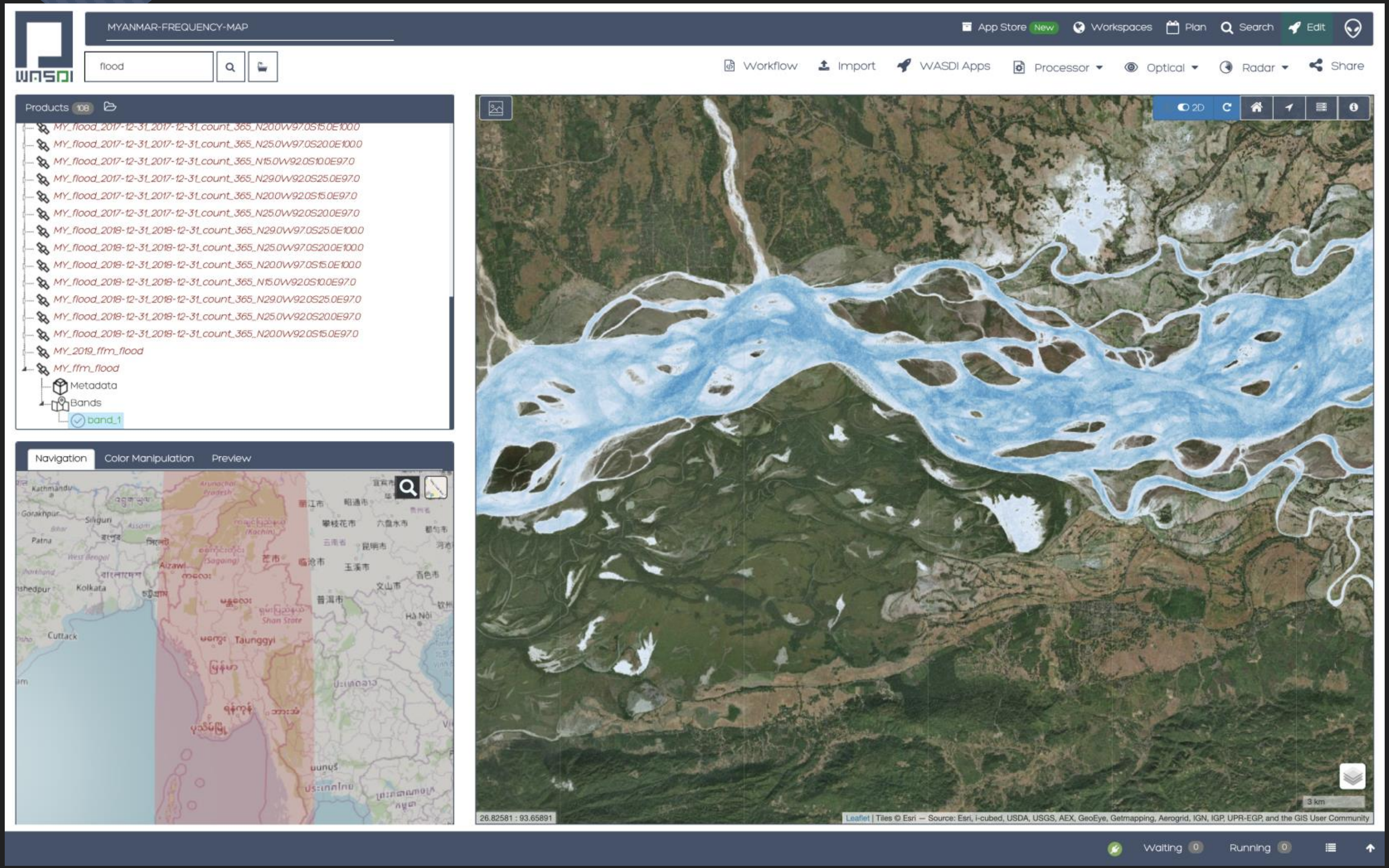
Moreover, radiation emitted from the damaged nuclear reactors made *in situ* campaigns very dangerous. Indeed, satellite remote sensing represented not only the most effective, but also the safest, and, to some extent, the unique way to assess the Japan tsunami-affected areas [1].

Among remote sensing sensors, synthetic aperture radar (SAR) systems have key features, such as the capability to work even in cloudy conditions and both during daytime and nighttime, which make them the most powerful tool to monitor natural disasters [2]. Moreover, the recent launch of a new generation of SAR instruments, such as TerraSAR-X (TSX) and COSMO-SkyMed (CSK), allows emergency managers to use damage maps at very high spatial resolution. The improvement of the spatial resolution of radar images, which can reach 1 m in the spotlight operation mode, is fundamental when dealing with scenes including not only rural, but also urban and suburban areas, as for the Japan tsunami case. For instance, a method to detect floodwater in urban areas using TSX, which takes also advantage of ancillary high-resolution Light Detection And Ranging (LiDAR) digital terrain models, was proposed in [3], whereas before the deployment of the new generation of SARs, extraction of flooded areas within urban settlements was considered an unfeasible task [4], [5].

In addition to the very high spatial resolution, CSK gives the possibility of performing frequent observations of regions hit by natural disaster, thanks to the four-satellite constellation that offers a revisit time that can reach 12 h in the worst case [6]. While most of the automatic change detection methods available in the literature single out the changes induced by a specific event by using a pre-event image and a postevent one (e.g., [7] and [8]), CSK offers to the users a better opportunity to monitor the various stages of the temporal evolution of a natural

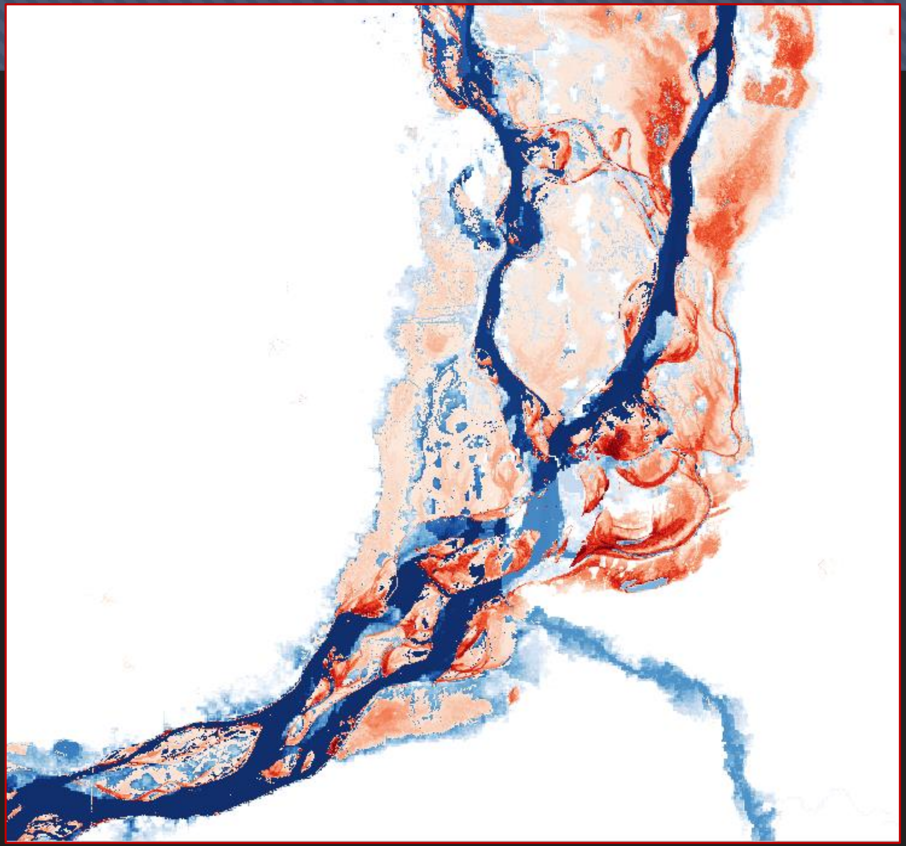
EO Flood Maps – SAR Automation

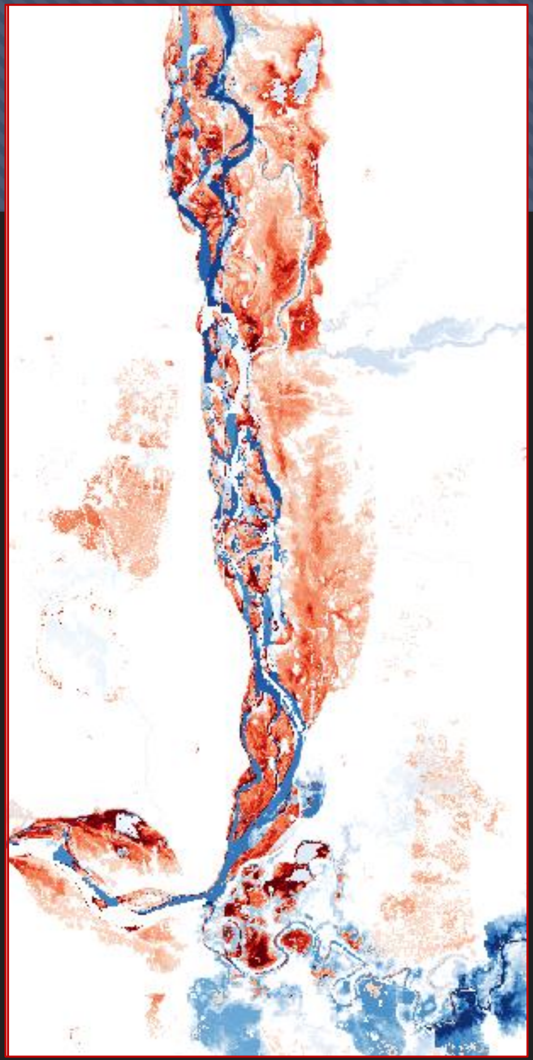
Sentinel Missions enabled the automation of the Flood Delineation maps production on vast AOIs (continuously updated) and full flood Archives production.



EO Flood Maps – Observations and Models

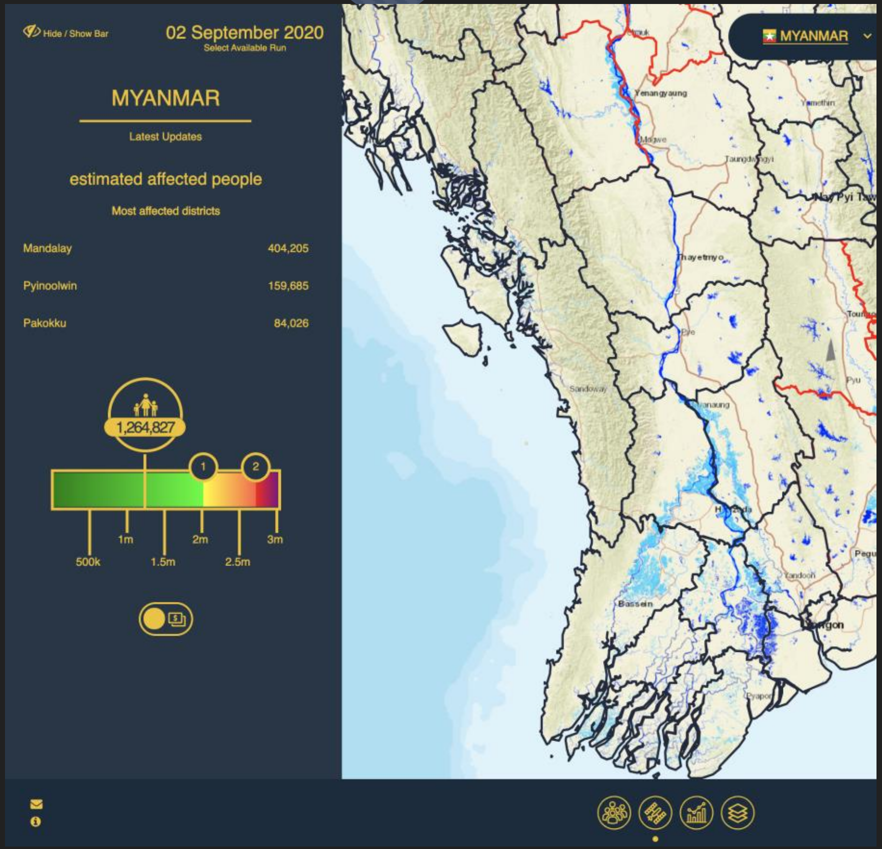
Validation of the flood Models.

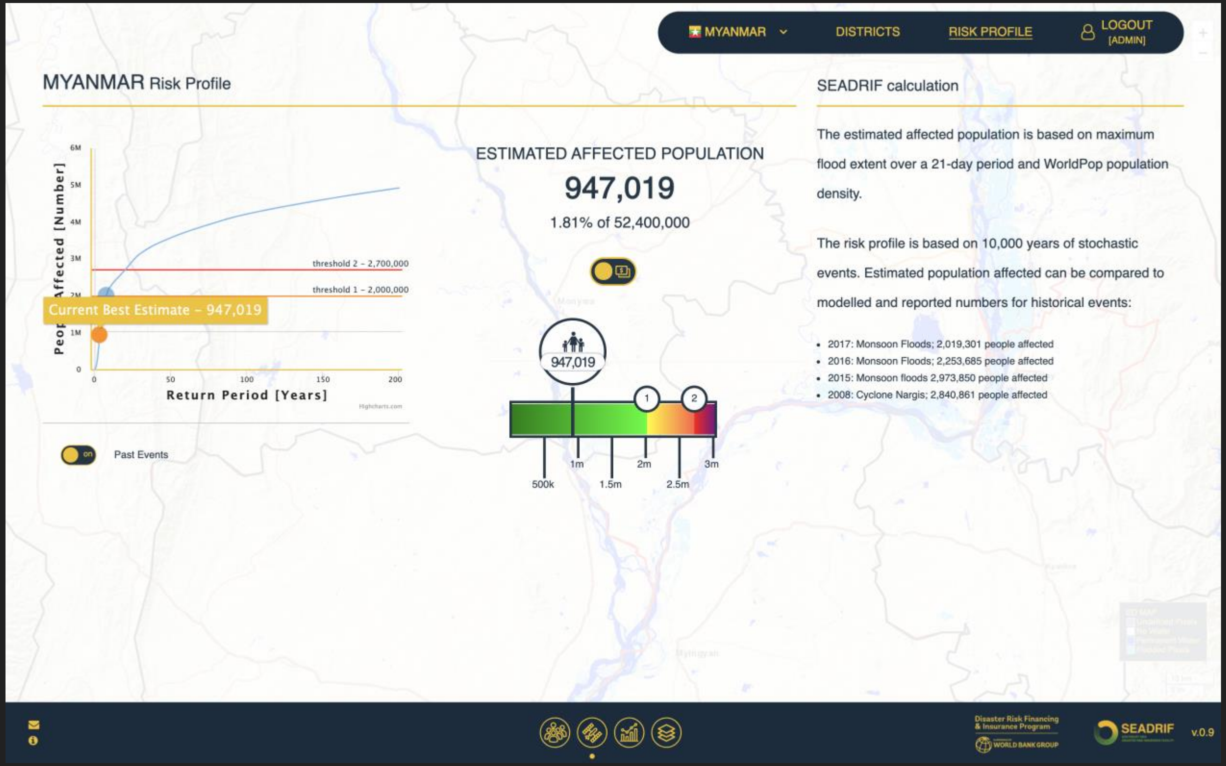




EO Flood Maps – Climate Change Challenges

Disaster Risk Financing offers a lean way to unlock resources for a fast and prompt reaction when a disaster occurs. This is particularly important when sovereign risk is considered in countries where the magnitude of flood events often overcomes the response capacity of the institutions.





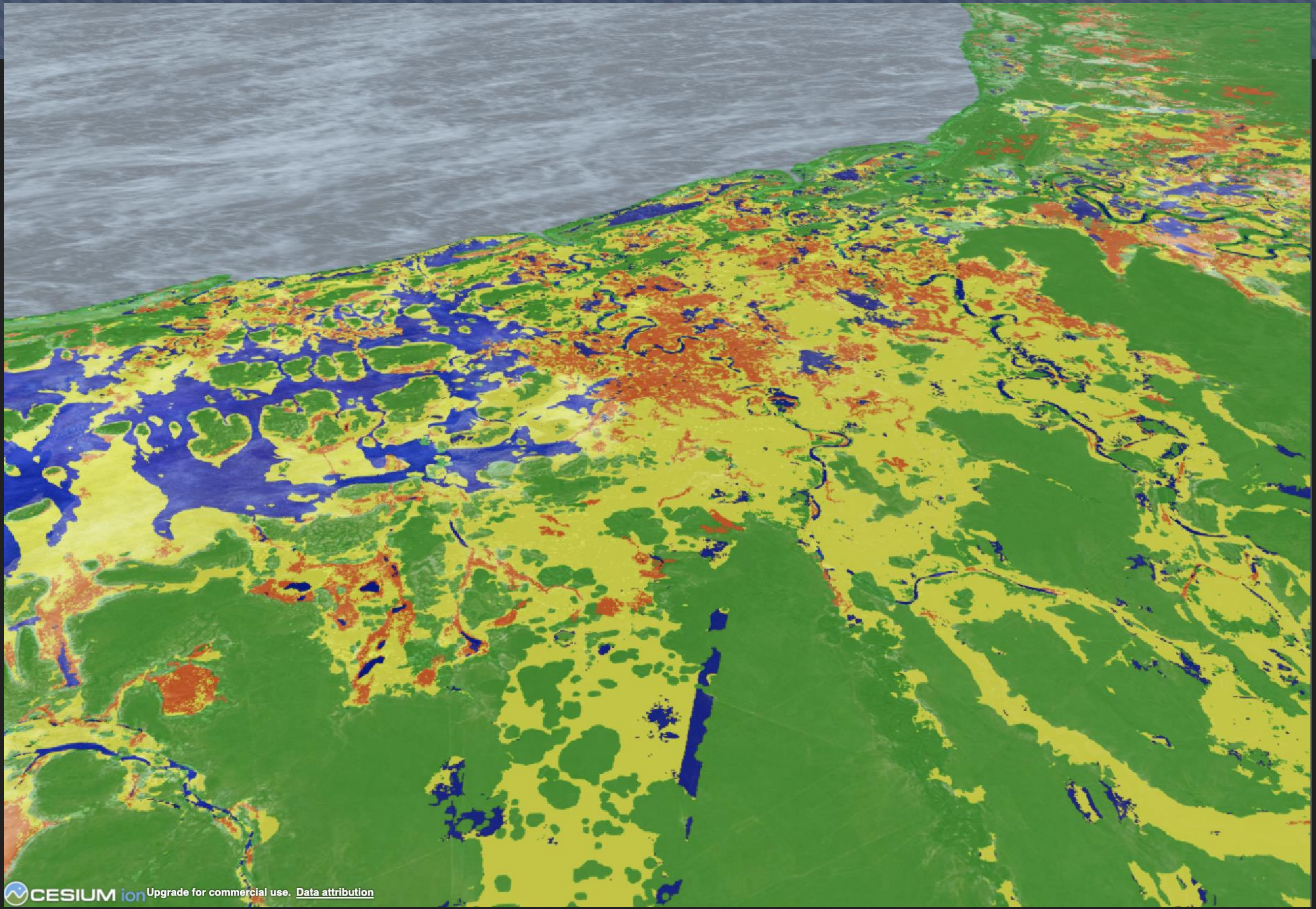
e-DRIFT

SEADRIF
SOUTHEAST ASIA
DISASTER RISK INSURANCE FACILITY

Disaster Risk Financing & Insurance Program
SUPPORTED BY WORLD BANK GROUP

EO Flood Maps – Optical Detection

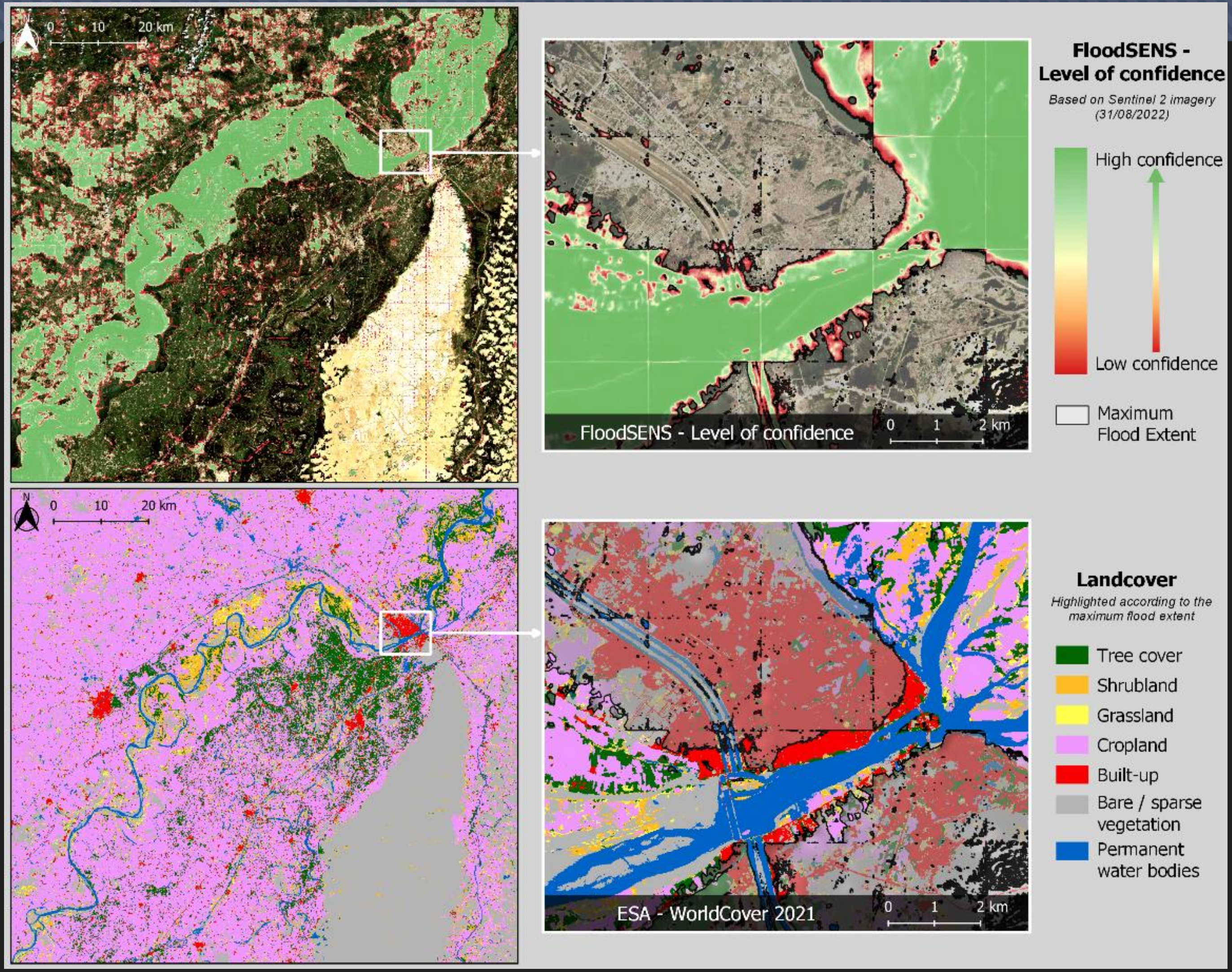
Despite the abundance of sensors, the Acquisition frequency remains a challenge. Augmenting the number of satellites to be used automatically would improve detection skills.



Blue – Permanent Water
Red – flood detected by both
Orange – detected by only one
Yellow – detected by one/not detecetd by the other

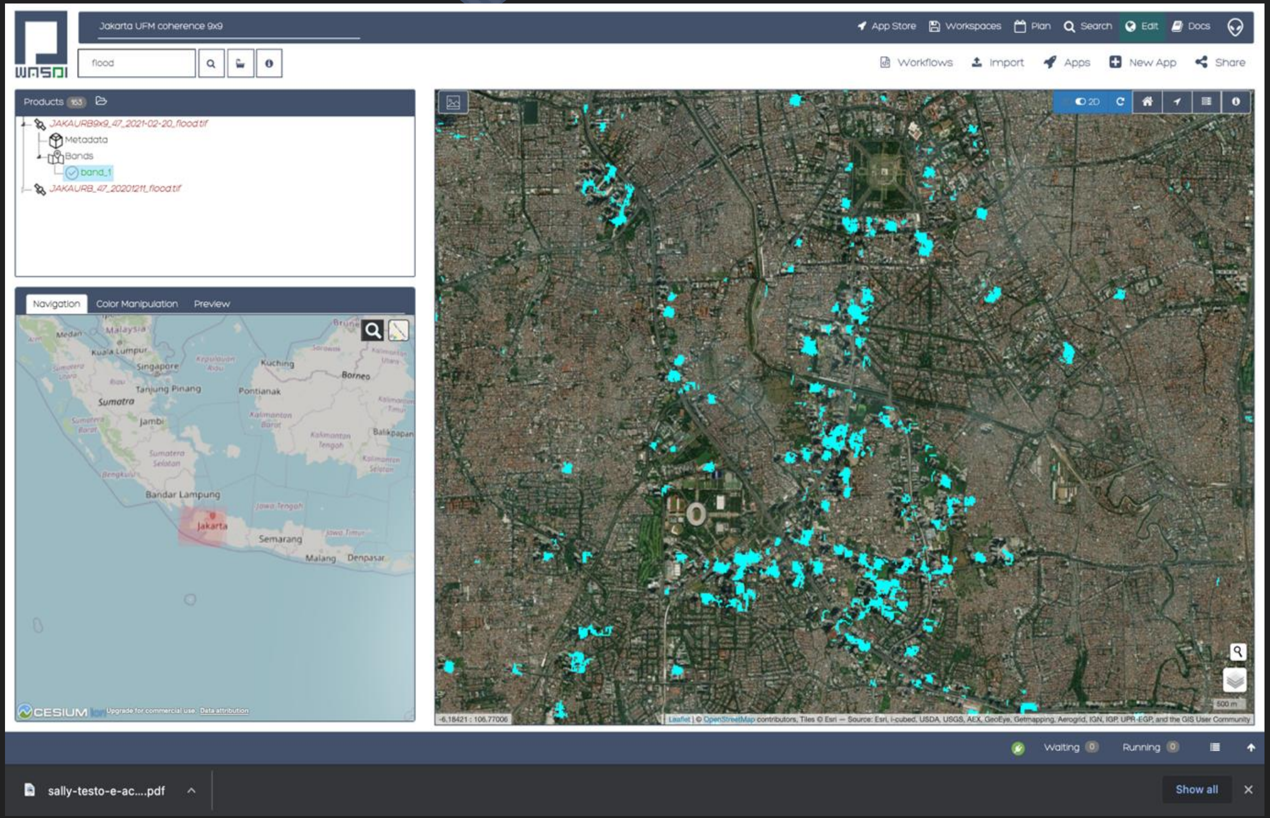
EO Flood Maps – AI Under Clouds

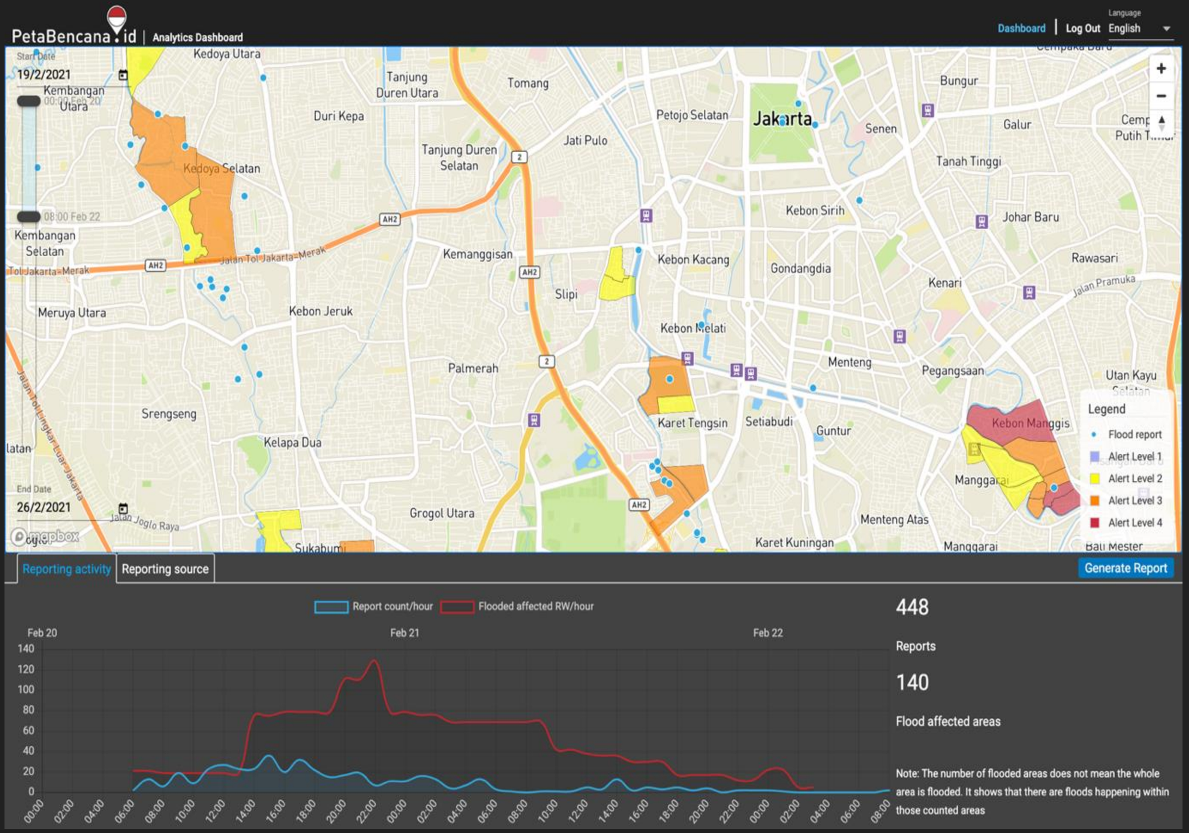
FloodSENS uses ML to infer flood impact areas from S-2 flood images, with no cloud, low cloud...



EO Flood Maps – Urban Floods

The combination of coherence and intensity can help detecting floods in Urban Areas



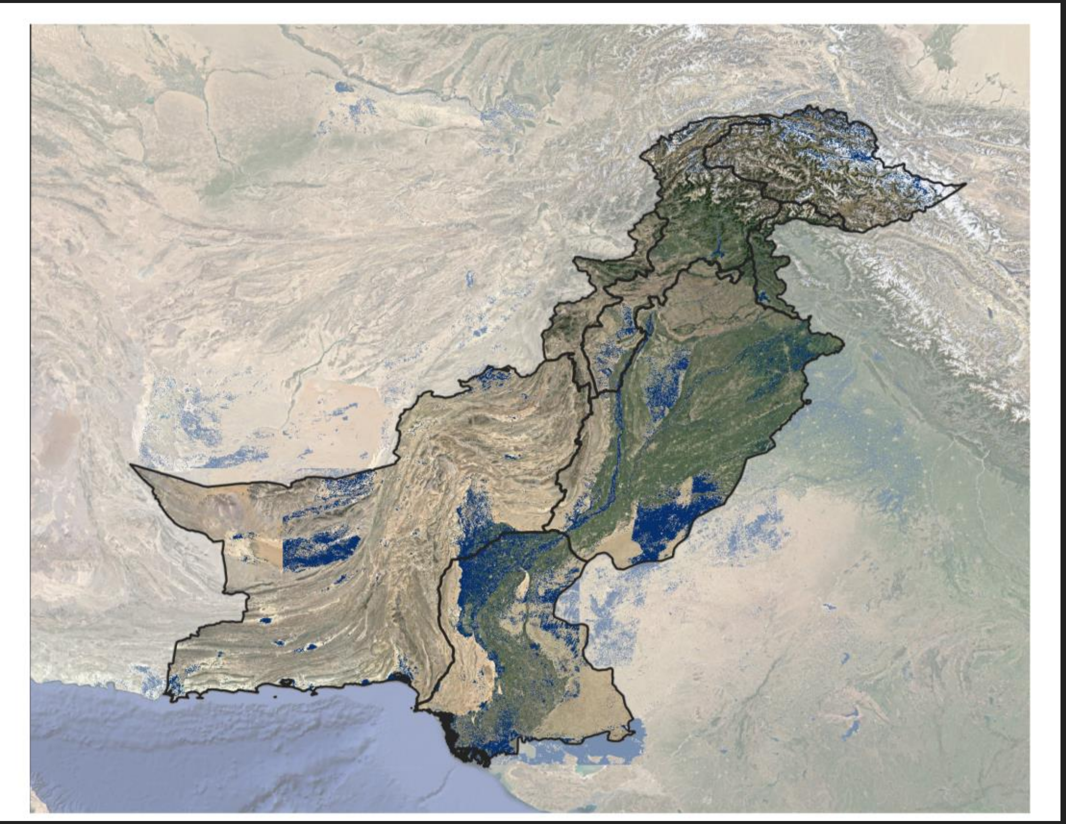


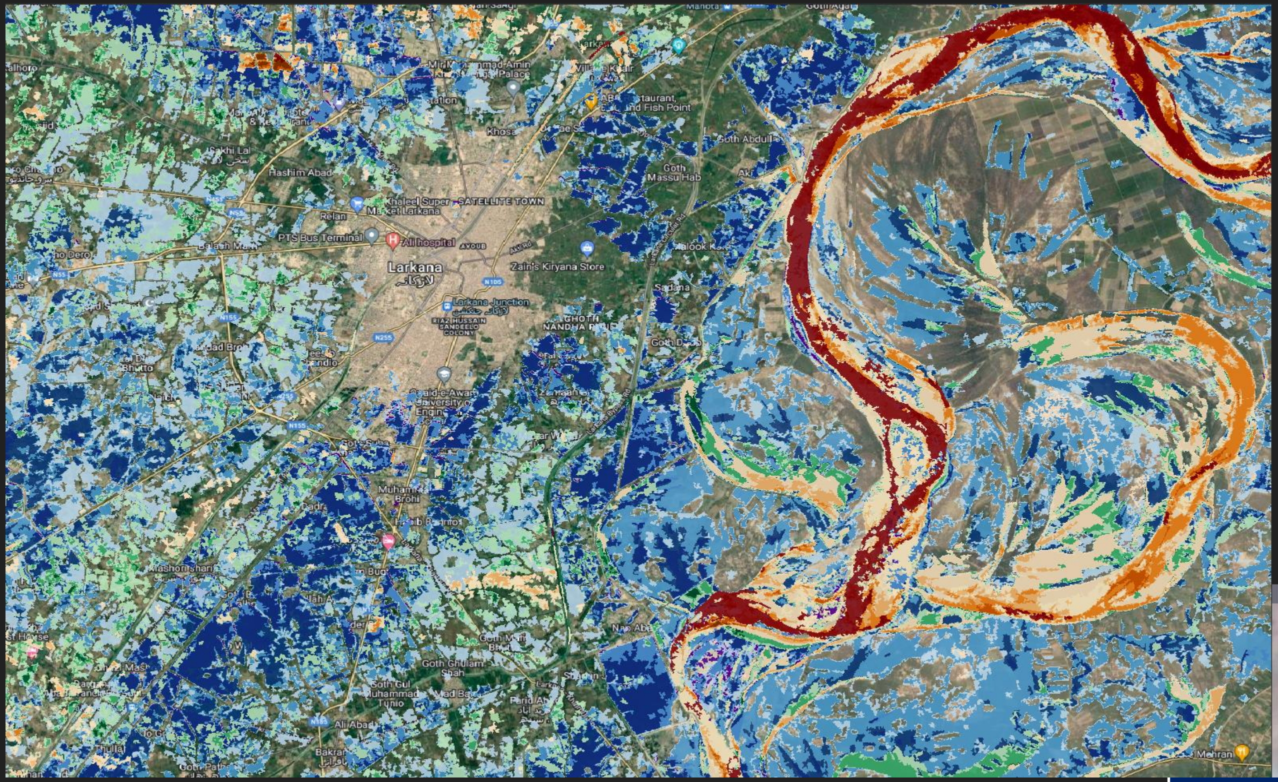
Jakarta 02/2021

EO Flood Maps – Flood Evolution

Pakistan Activation 2022: Synoptic View and Flood Temporal Monitoring (LARKANA Detail)

15/6 – 5/7 → 5/7 – 25/7 → 25/7 – 15/8 → 15/8 – 5/9 → 5/9 – 15/9



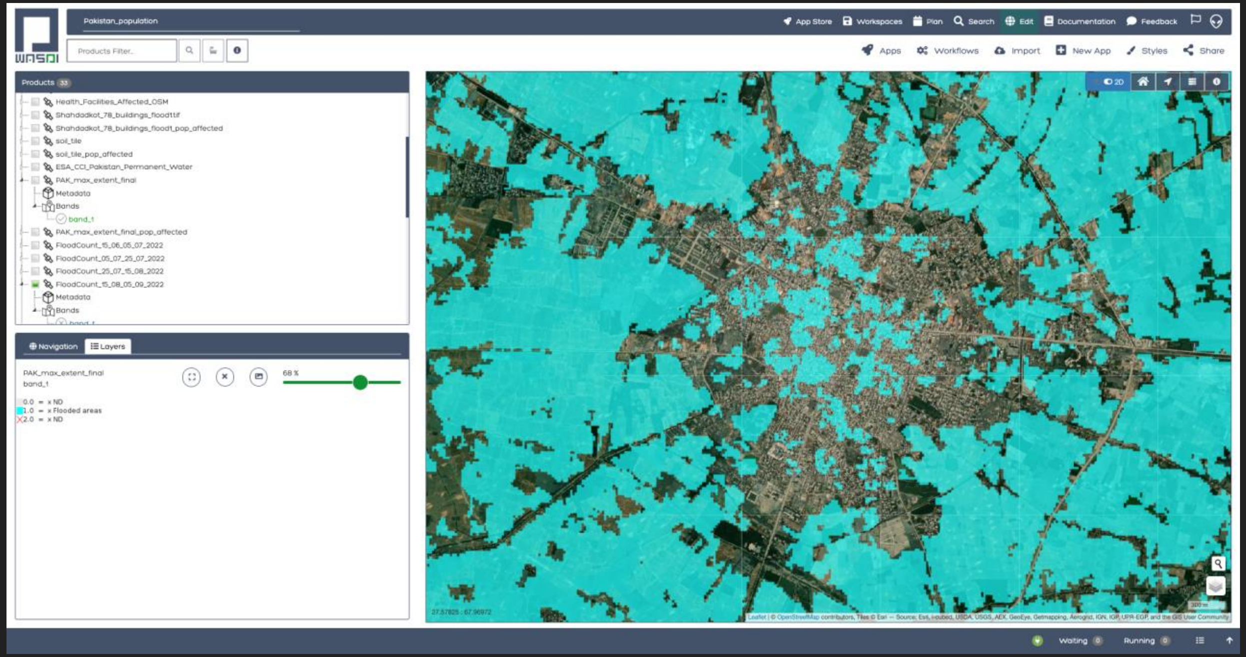


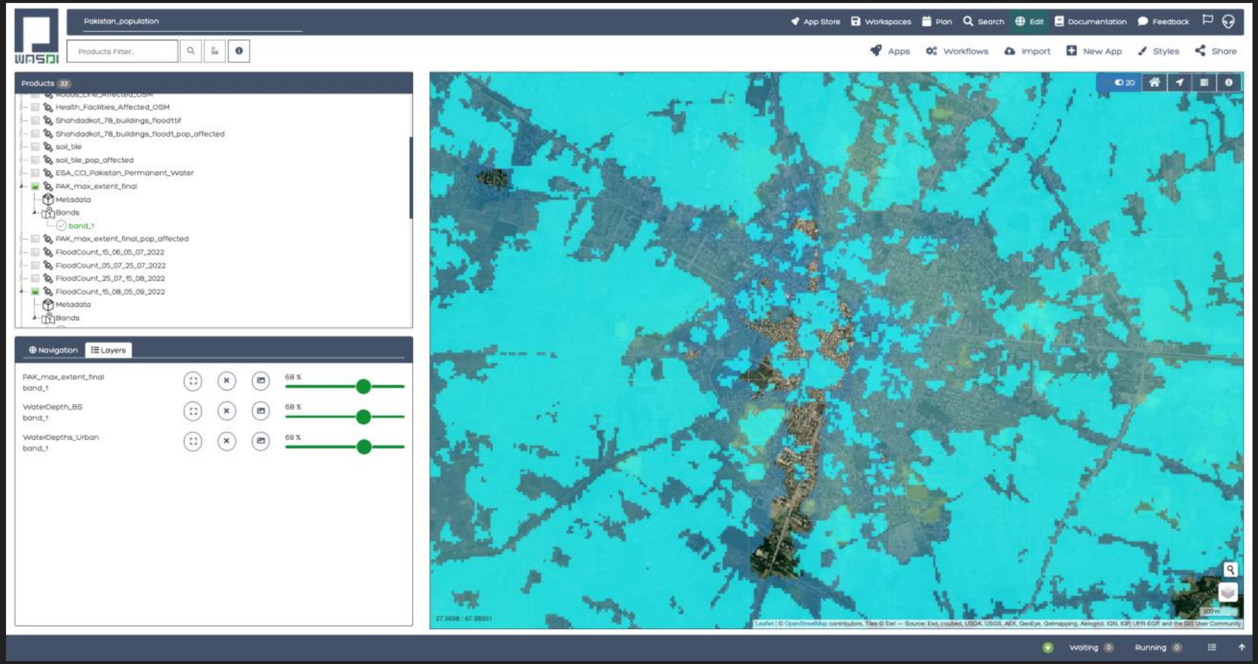
Pakistan 06-09/2022

ADB

EO Flood Maps – Water Depths / Gap Filling

The combination of flood delineation maps with local DEM (and Artificial Intelligence?) can help to derive water depths and fill the gaps



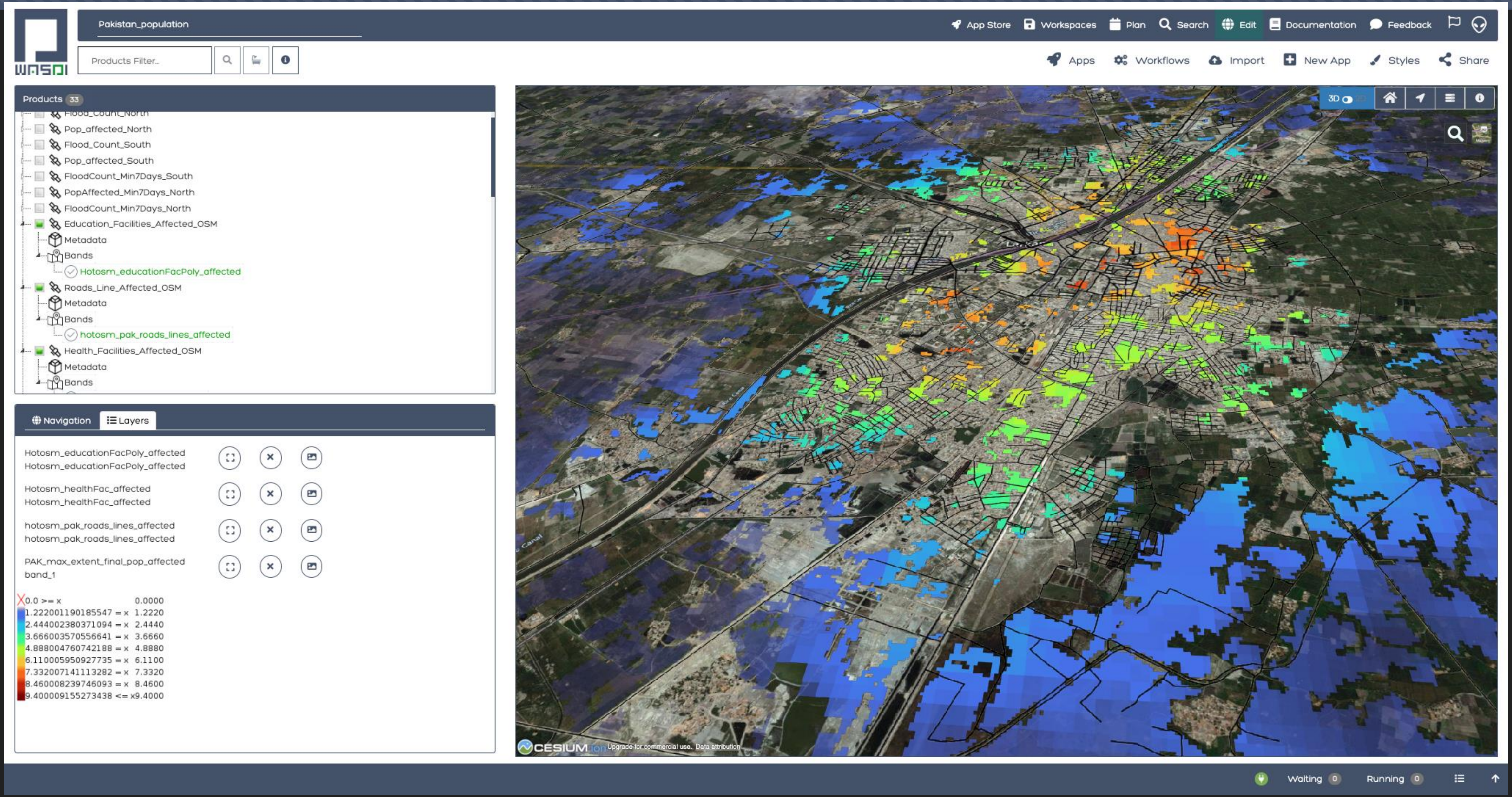


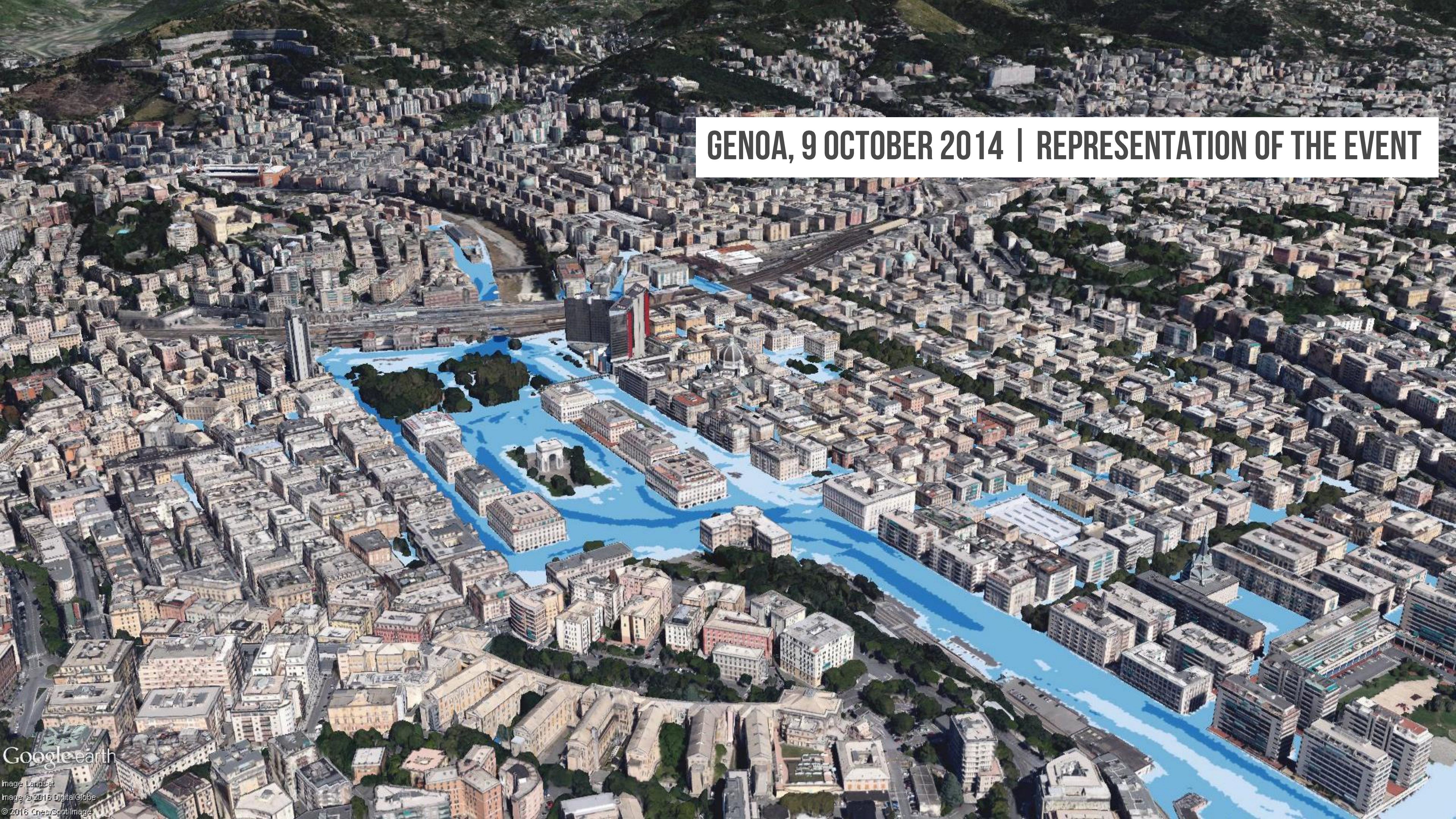
Pakistan 06-09/2022

ADB

EO Flood Maps – Population Affected

Integration with worldwide available layers can help to derive useful information




GENOA, 9 OCTOBER 2014 | REPRESENTATION OF THE EVENT
Google earth
Image Landsat
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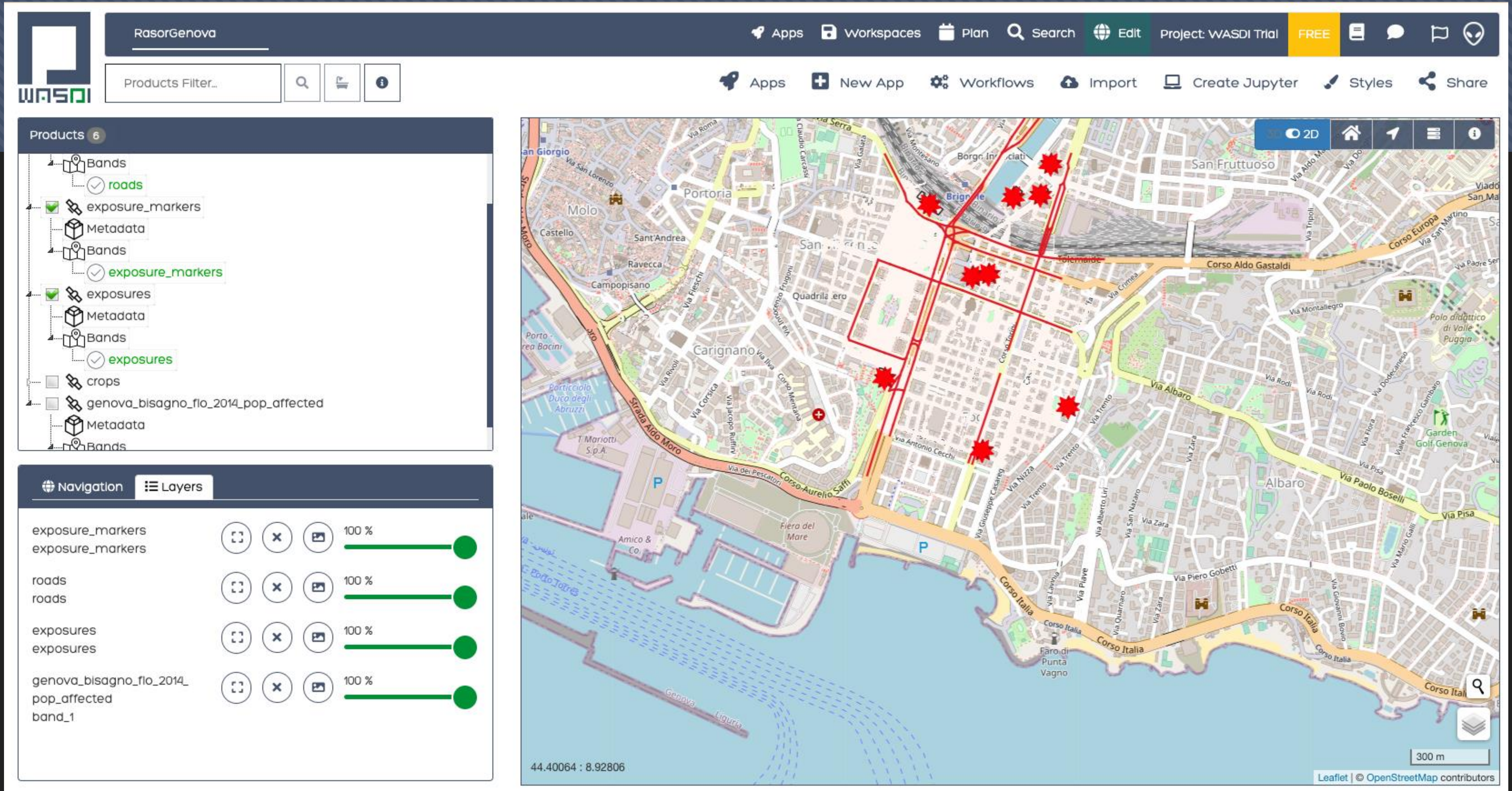
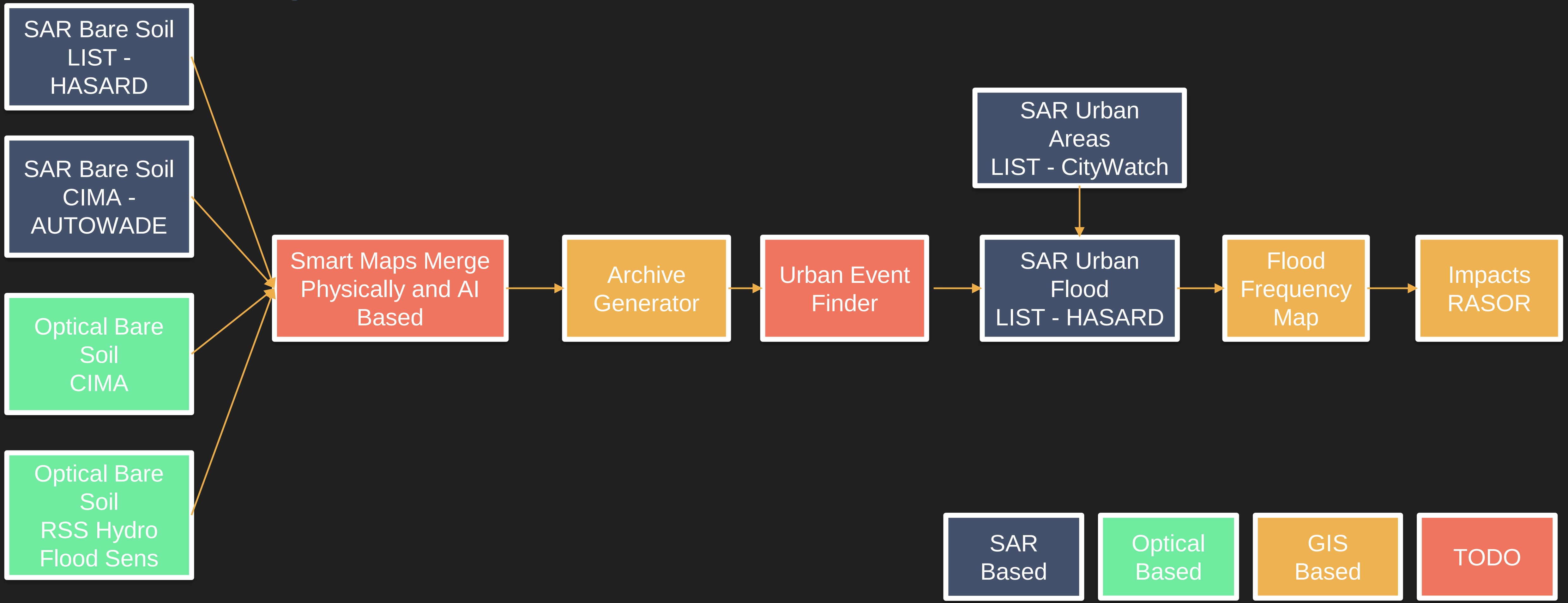
EO Flood Maps – Impacts



EO Flood Maps – What's next?

Putting all together in an automatic chain can leverage and speed up existing applications. Artificial Intelligence can help to merge different maps and to analyze the archives to trigger the automatic execution of detections in Urban Areas



Always thanks to our beloved Partners:

Q&A

Thanks for your attention !

Any doubt?