International Charter

'Space and Major Disasters'

ESA Charter Mapper

Review report of services and functions*

July 2022

Version: 2.0

Authors: Jolanda Patruno, j.patruno@rheagroup.com, Mauro Arcorace, mauro.arcorace@terradue.com, Philippe Bally, Philippe.bally@esa.int

*This report will be regularly updated by ESA, PLES and Terradue

Table of Contents

1. Introduction

The purpose of this document is to provide an assessment of the utility of the ESA Charter Mapper for operations. A user utility report is needed to complete and validate this assessment. The outcomes and observations presented in this document can be shared to help the Charter community to understand the impact of the ESA Charter Mapper solution.

2. Method and scope of the assessment

Starting from real value-added products from VAs (not generated on the Charter Mapper and provided in the frame of a specific activation), PLES team has tried to reproduce similar and/or additional products in the ESA Charter Mapper operational environment. The assessment has been performed for both visualization (Visualization - Scenario 1) and processing (Processing – Scenario 2) purposes. This document contains also examples provided by Terradue (refer to EO data processing use cases).

The assessment has been performed over a set of 7 Activations (Table 1), based on the available satellite data in the ESA Charter Mapper.

Activation ID	Disaster type/events	Activation status
Act-756/Call-869 Tropical Storm Megi in the Philippines	Flash Flood, Landslide, Storm & Hurricane (Urban areas & Infrastructure)	Closed
Act-748/Call-859 Tropical storm Ana in MOZAMBIQUE	Flood (large area), Storm & Hurricane (Urban areas & Infrastructure)	Archived
Act-747/Call-858 Flooding in Madagascar	Flood (large area), Landslide	Archived
Act-746/Call-857 Flooding in Sao Tome and Principe	Flood (large area), Landslide	Archived
Act-673/Call 587 Earthquake, Tsunami in Indonesia	Earthquake, Tsunami	Archived
Act-759/Call-872 Oil spill in Gambia	Oil spill	Closed
Act-743/Call-854 Volcanic Eruption in Ecuador	Volcanic eruption	Archived

Table 1. List of Activations analyzed

Moreover, further examples based on hazard type are presented and namely: Wildfires, Tsunami, Oil spill use cases.

3. Assessment of the services and results

3.1. Act-756/Call-869 - Tropical Storm Megi in the Philippines

The assessment for this this call started from an example of Flood damage map provided by UNOSAT by using Pleiades data in the frame of the on-going activation (Figure 1).

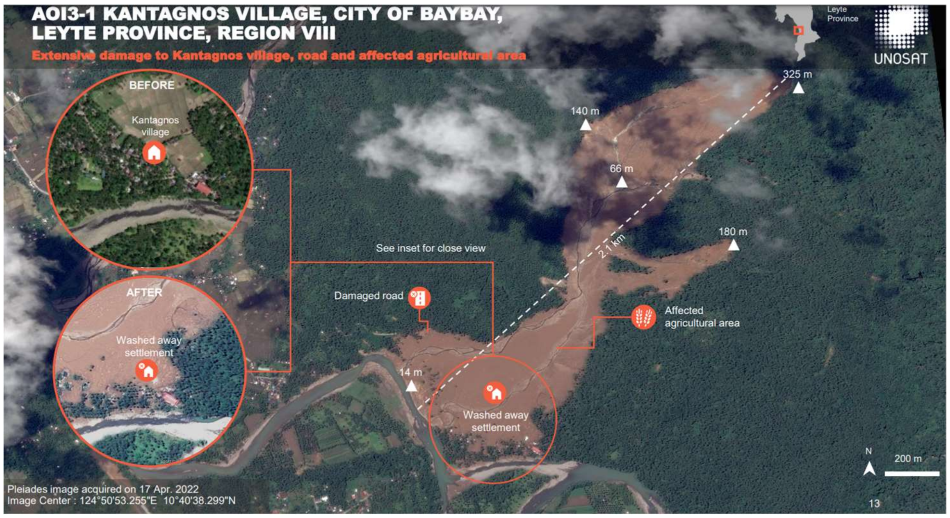


Figure 1. Flood damage, @UNOSAT (https://disasterscharter.org/documents/10180/11915894/vap-869-3-product.pdf/b78a9280-8385-443d-bee3-a86052f4adb5?version=1.0)

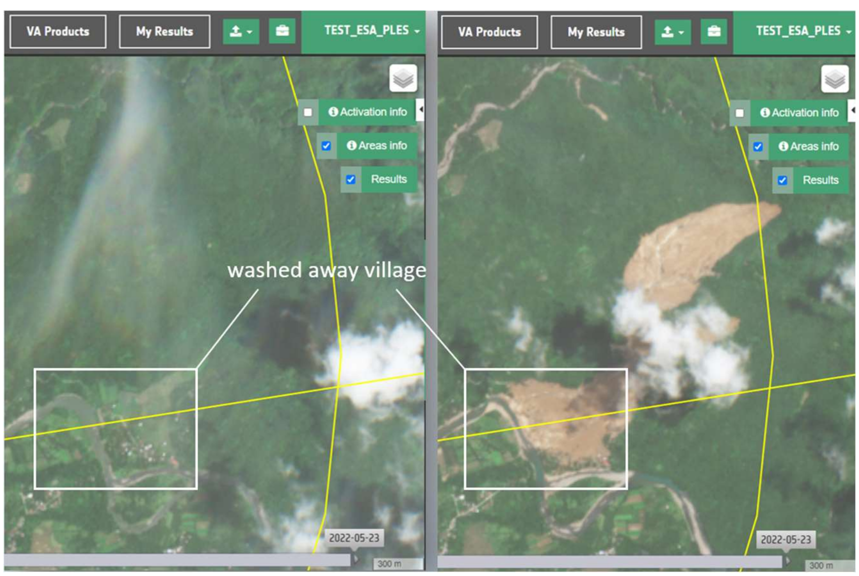


Figure 2. Landslide visualization in the ESA Charter Mapper, Sentinel-2 data

The same event has been visualized without any processing (Visualization- Scenario 1) on the ESA Charter Mapper through Sentinel-2 data (Figure 2). To compare the visualization of the landslide over the same area (AOI 3-1, Kantagnos Village, City of BayBay) with a processed result on the ESA Charter Mapper, the IRIS (Change Detection

Analysis – see shared jobs here) has been processed with the same pair of Sentinel-2 data in input used for the Visualisation use case (Figure 3).

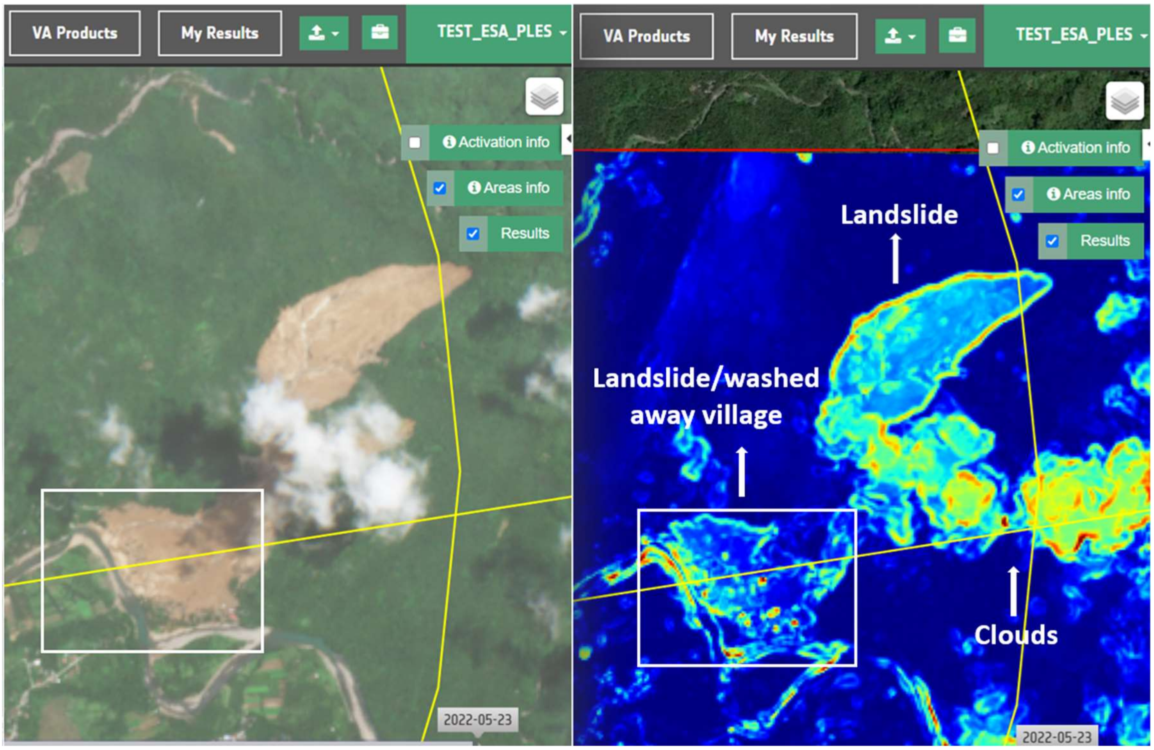


Figure 3. Left: Landslide in S-2 imagery, Right: Output of the IRIS service in the ESA Charter Mapper

Since the IRIS service is not handling cloud coverage and for the moment there is no masking clouds yet implemented, for cloudy images the changes that are highlighted the most are related to the clouds in each image (see right image, where clouds in the input Sentinel-2 pair have been recognized as major changes). The changes for other elements (such as the landslide) are however still shown with IRIS even if the values associated to these changes are lower than the ones related to clouds.

By using the Co-located Stacking (STACK) service, red-cyan band composites showing the change in NDVI using VHR data from WV2 and Pleiades (Figure 4) and from WV2 data (Figure 5) have been generated. Area affected by the landslide is highlighted in red due to a drop in the NDVI.

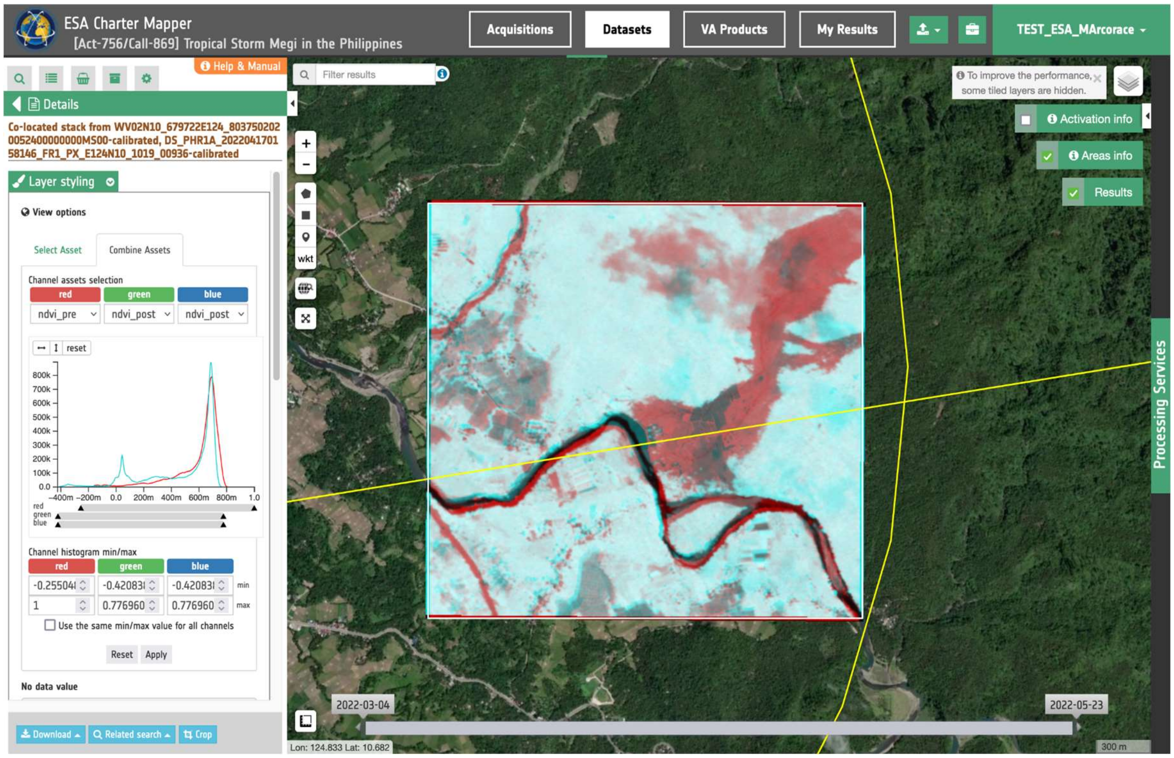


Figure 4. NDVI product highlighting the landslide in BayBay area, WV2 and Pleiades data, STACK service

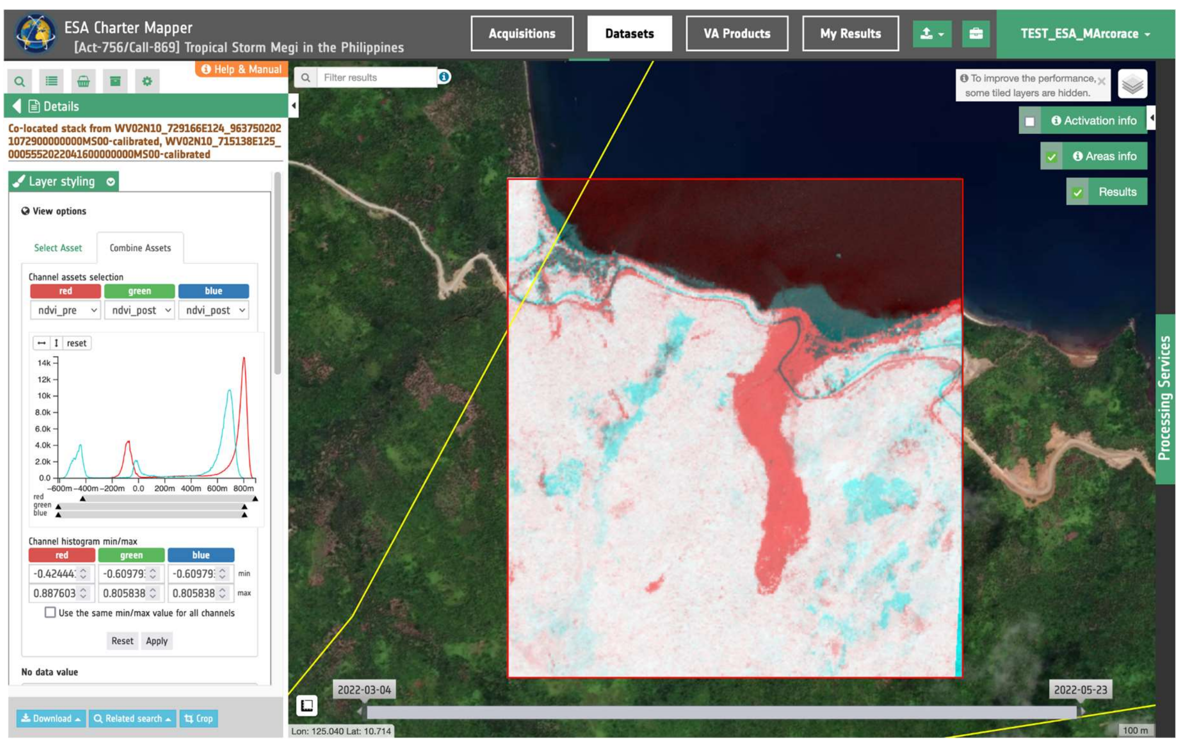


Figure 5. NDVI product highlighting the landslide in Bahay area, WV2 data, STACK service

Over a different area of the same Activation (AOI 5), a Flood situation map has been generated by Geoinformation Systems, outside of the Charter Mapper, using KOMPSAT-5 and TANDEM-X data (Figure 6) for the PM report related to the activation.

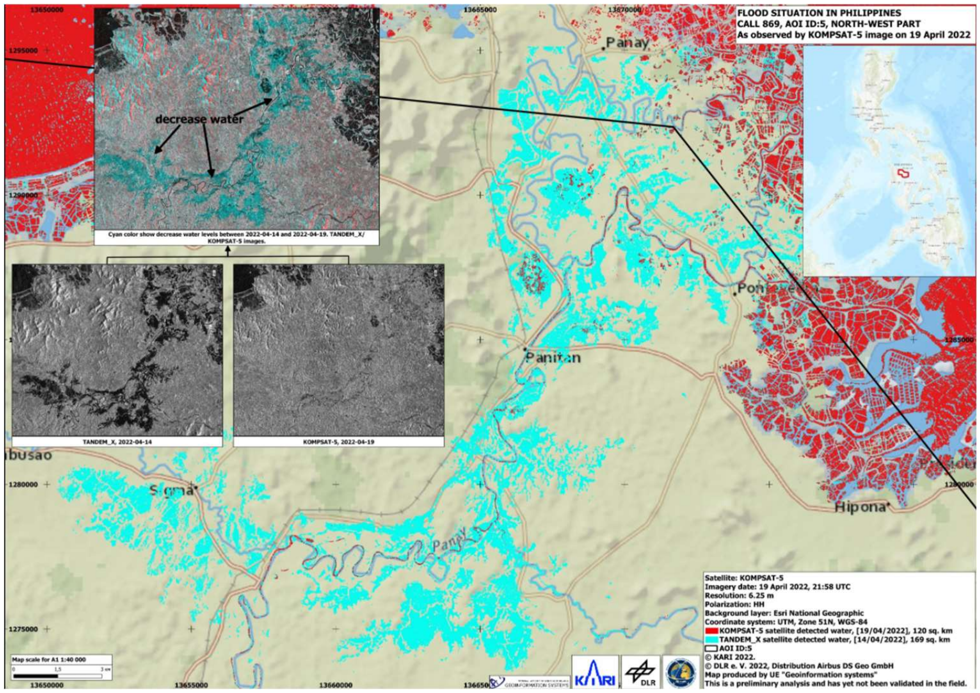


Figure 6. Flood situation map, @Geoinformation Systems (https://disasterscharter.org/documents/10180/11915894/vap-869-4-quicklook.jpg/96307474-8746-4d50-b25b-76fefdd7f359?version=1.0)

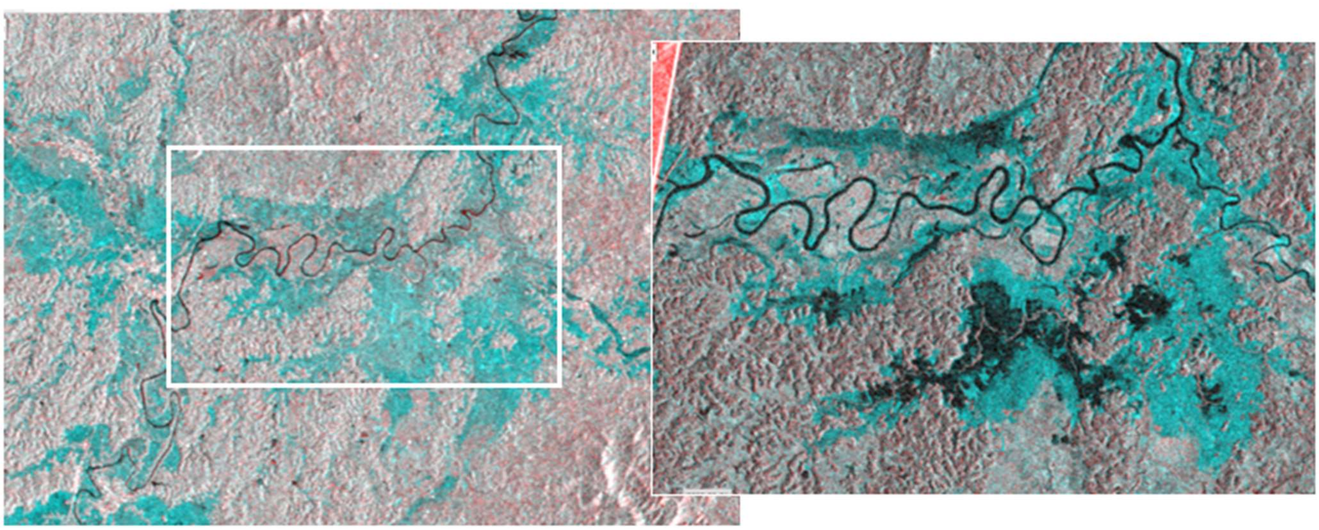


Figure 7. Flood extent maps obtained through the SAR Amplitude Change service. Left: Sentinel-1 pair (11-23/04/2022); Right: RCM data (14-16/04/2022)

At the moment of the assessment, these data were not available in the ESA Charter Mapper activation dataset, but different products (Sentinel-1 and RCM data) have been used as input to the SAR Amplitude Change processing service (Figure 7). The flood water decrease maps generated in the ESA Charter Mapper (see processed Sentinel-1 images here and RCM data here) clearly show the water extent, more precisely, the change in cyan color represents the water decrease over the area, as shown in Figure 6 (upper left part of the Geoinformation Systems Flood situation map generated outside the ESA Charter Mapper).

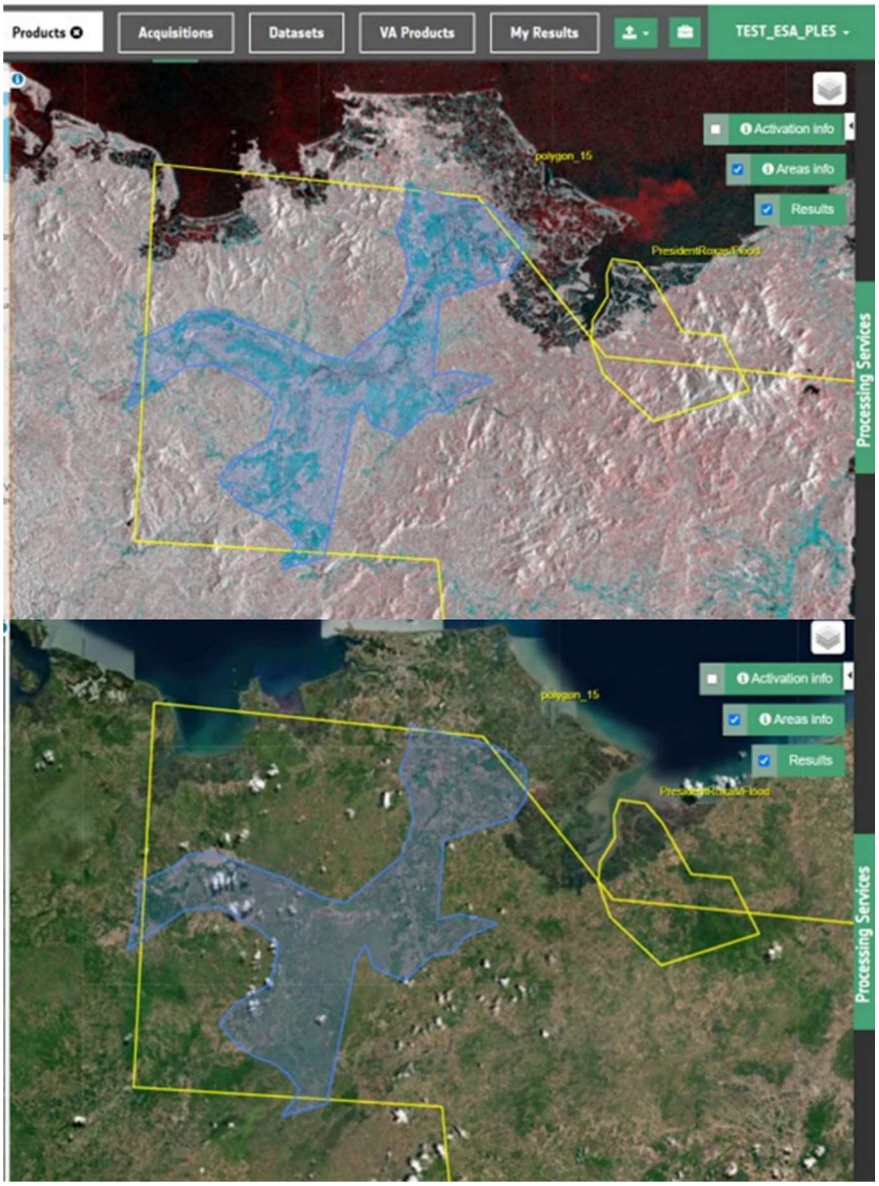


Figure 8. Upper image: Water decrease extent measured in the ESA Charter Mapper over the processed Sentinel-1 data. Lower image: Water extent area overlapped to the optical satellite layer of the geobrowser for a quick visualisation of the damage.

After processing, it is possible to retrieve the extent area of the flood (about 300 Sq Km) through the Measurement tool and use this information for an immediate visual and qualitative analysis of the damage (Figure 8).

For the same activation, a Red-Cyan band composite using sigma nought at HH polarisation derived from different SAR sources has been performed, showing the extent of the flood over the area (Figure 9).

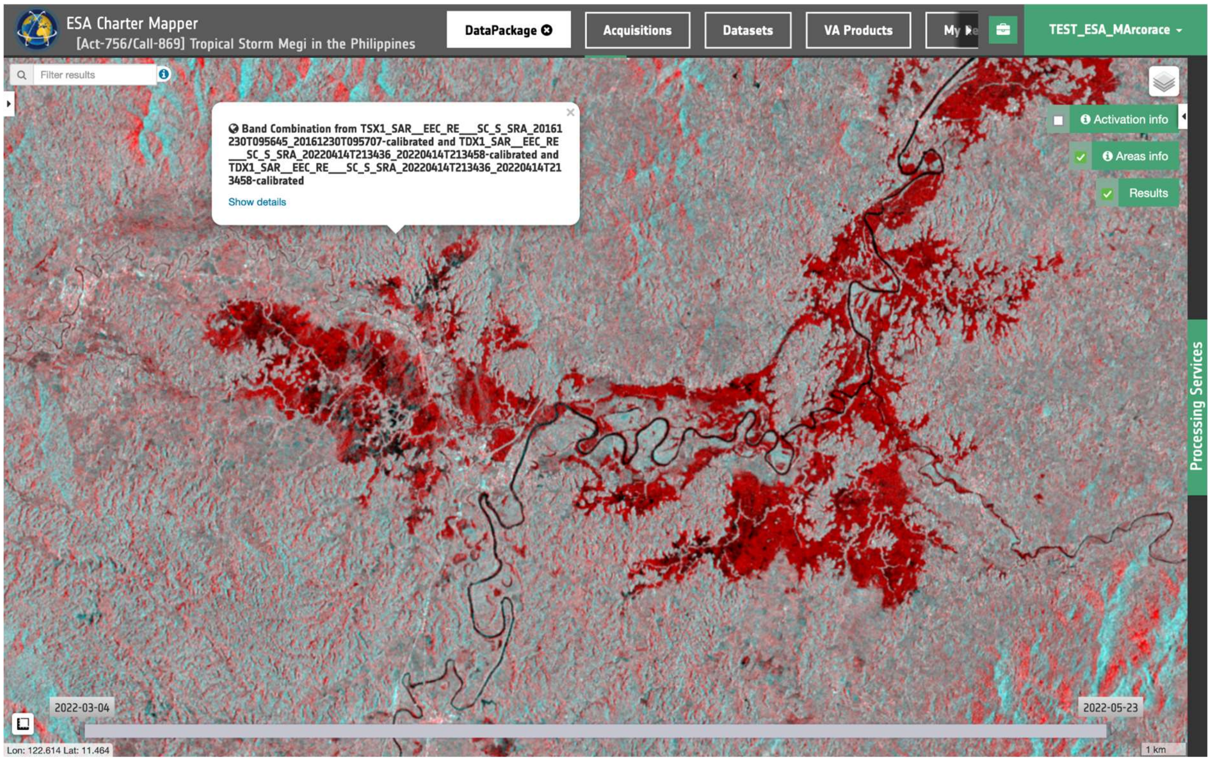


Figure 9. Red-Cyan composite derived from TerraSAR-X acquired on 30 Dec 2016 and TanDEM-X acquired on 14 Apr 14 2022, SAR Change service.

3.1.1. Observations and comments

Summarizing, to visually compare backscatter changes before and after a flood event the SAR Amplitude Change (SAR-Change) service can be used to generate a Red/Cyan band composite from a SAR pair acquired from the same sensor and being at the same polarisation.

The band arithmetic functions included in the Advanced Band Combination (COMBI-Plus[1]) Co-located stacking (STACK), and the Co-registration (Co-Register) services can be used by PM/VAs to perform binarization of sigma nought before and after a flood event to estimate un-filtered satellite detected water, as well as the IRIS service can be used to detect changes with optical data. The Optical Spectral Index (OPT-Index) and Co-located stacking (STACK) services can be used by PM/VAs to derive multitemporal spectral indexes and evaluate changes into indexes (thanks to s-expressions) to be used under preliminary landslide delineations.

[1] The Advanced Band Combination service is considered the precursor of the STACK service

3.2. Act-748/Call-859 Tropical storm Ana in MOZAMBIQUE

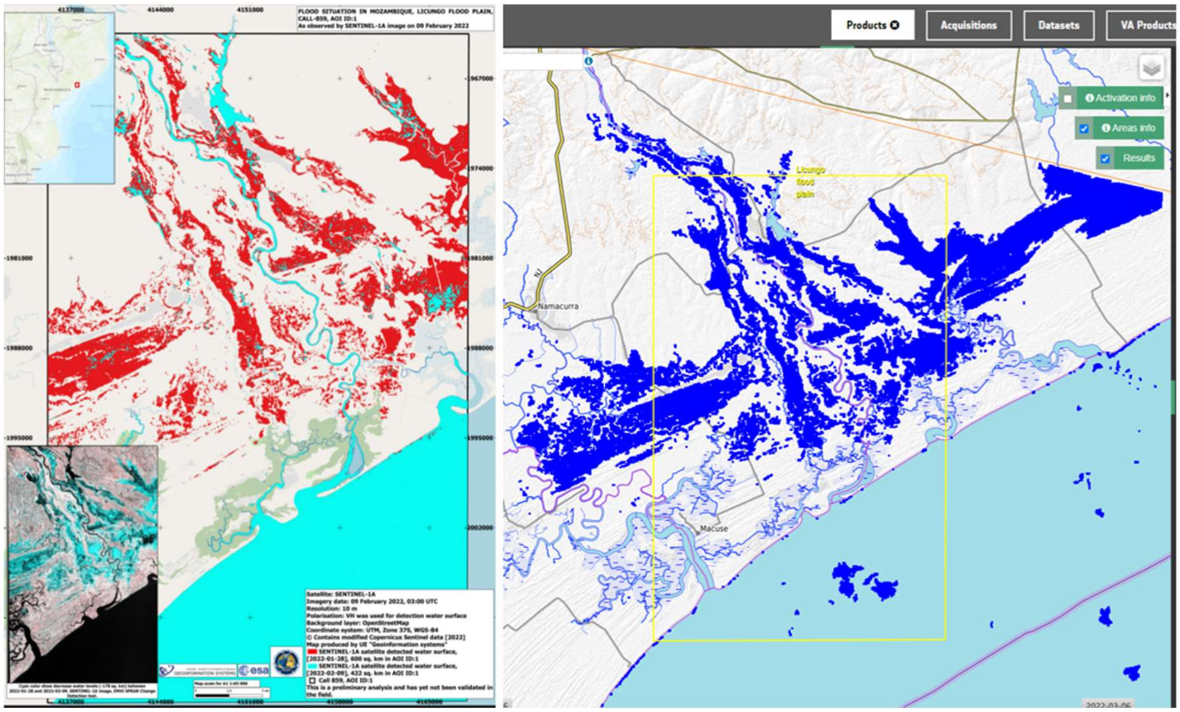


Figure 10. Left: Flood map from Geoinformation Systems, https://disasterscharter.org/image/journal/article.jpg?img_id=11959600&t=1650883296895. Right: HASARD flood bitmask generated in the ESA Charter Mapper

The analysis carried out for this activation has shown that very similar products to the ones produced by VAs in the frame of an on-going activation can be generated with the ESA Charter Mapper.

In Figure 10 (left), the flood extent map observed in the Value-added product (Sentinel-1 data) generated for the Charter PM report by Geoinformation Systems, is quite comparable to the bitmask generated through the HASARD service (Figure 10, right - see processing job here) in the ESA Charter Mapper.

Moreover, a similar result can also be achieved through another service (COMBI+, see processing jobs here) that performs an advanced multi-bands combination using band math's operations (backscatter thresholding) as shown in Figure 11 .

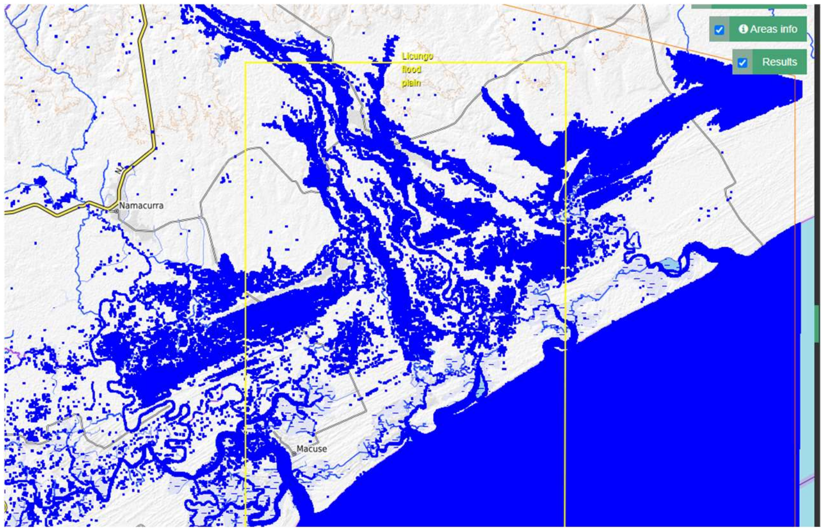


Figure 11. Water mask (binarization of radar backscatter using Sentinel-1 GRD imagery) generated through the Advanced multi band combination service in the ESA Charter Mapper

3.2.1. Observations and comments

The obtained result is quite similar to the previous example, even if it includes all water bodies (then including sea/rivers etc) and does not provide a real flood extent product. This difference is due to the algorithms of the two services: HASARD performs a SAR change detection removing pre-flood water and applying spatial filtering, while COMBI+ performs detection and binarization (water/no water).

Similarly, binarization can be performed using SAR data (Sigma nought assets) with band arithmetic also in Co-located Stacking (STACK) service or Co-registered Stacking (Co-Register) services. Instead, the employment of Flood Delineation (HASARD) to derive flood extent with other missions than Sentinel-1 is currently not supported in the ESA Charter Mapper.

3.3. Act-747/ Call-858 - Flooding in MADAGASCAR

A further example of the usefulness of the COMBI+ service is the one obtained from the analysis performed for this activation. Where a flood disaster occurs over an area naturally lacking in water, this tool can easily produce a valuable flood map-like as reported in the example below, for visualization purposes.

Starting from the analysis of the flood delineation map product generated by GAF (RCM data overlapped to Sentinel-2 imagery, Figure 12 left), the COMBI+ service has been used to produce the corresponding flood map (water mask) with RCM data (see processing job here) in the ESA Charter Mapper (Figure 12, right).

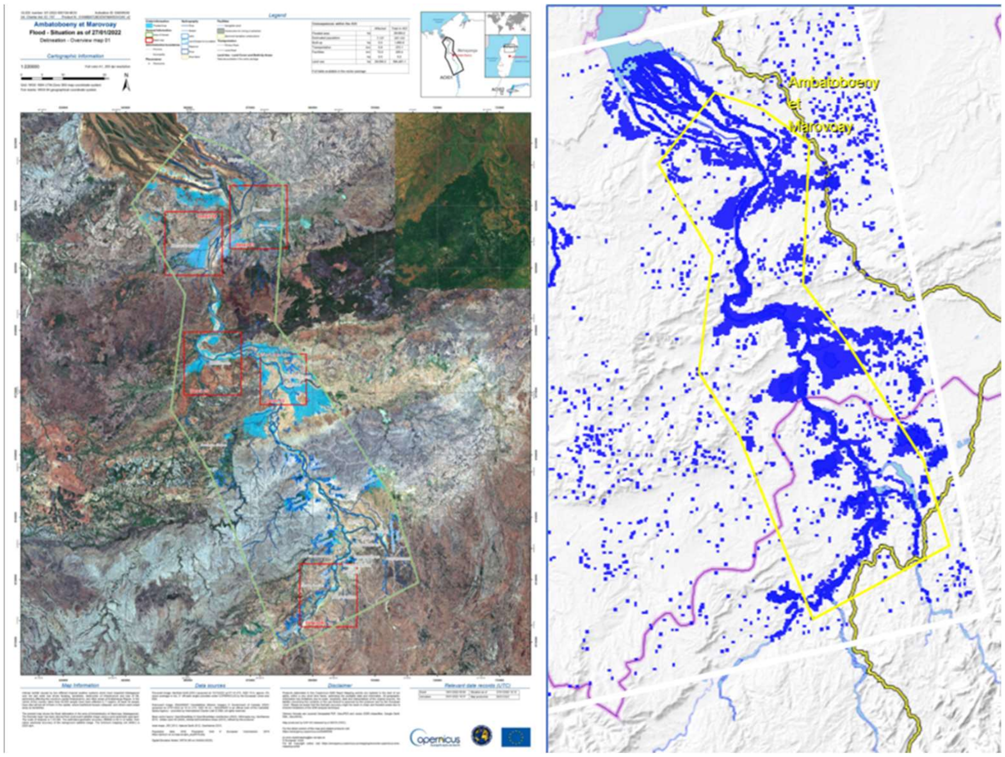


Figure 12. Left: Delineation map, RCM data, @GAF, https://disasterscharter.org/image/journal/article.jpg?img_id=11067174&t=1643626274269; Right: Water mask generated with COMBI+ in the ESA Charter Mapper, RCM data.

The ESA Charter Mapper allows to visualise the obtained product superimposed over the optical satellite layer of the geobrowser.

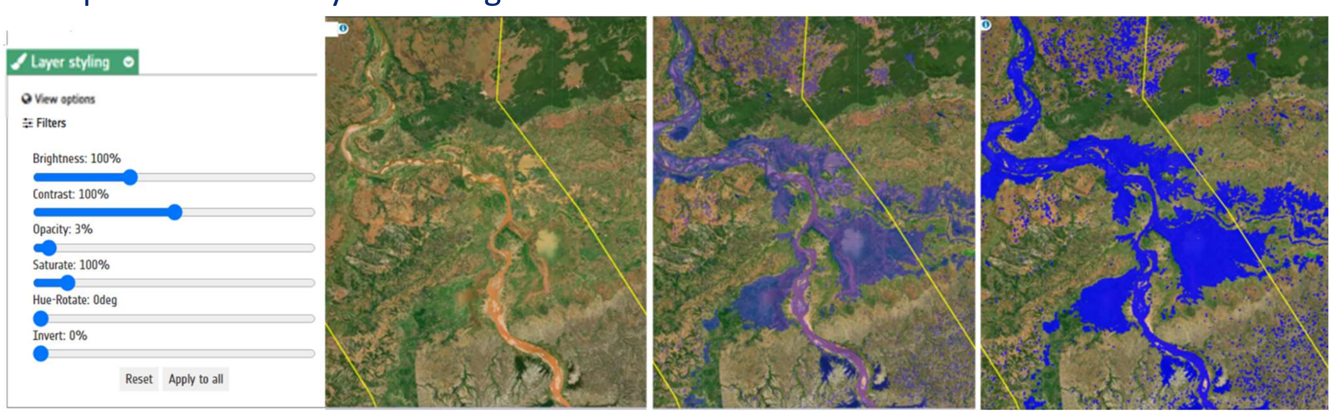


Figure 13. Layer Styling function in the ESA Charter Mapper: SAR water mask visualised over the area of interest

3.3.1. Observations and comments

Apart from the already mentioned usefulness of the COMBI+ service for binarization performed using SAR data in case of floods, the user can benefit from advanced visualisatrion functions, such as the Layer Styling. The user can adjust the display of images and products and visualise changes in transparency (Figure 13). This function can be used for visualization, training and dissemination purposes.

3.4. Act-746/Call-857 – Flooding in Sao Tome and Principe

In order to observe landslides/mudflows in Lemba district (Sao Tome) due to a flood occurred in Jan 2022 over the area, a landslide impact analysis has been generated by UNOSAT (Figure 14).

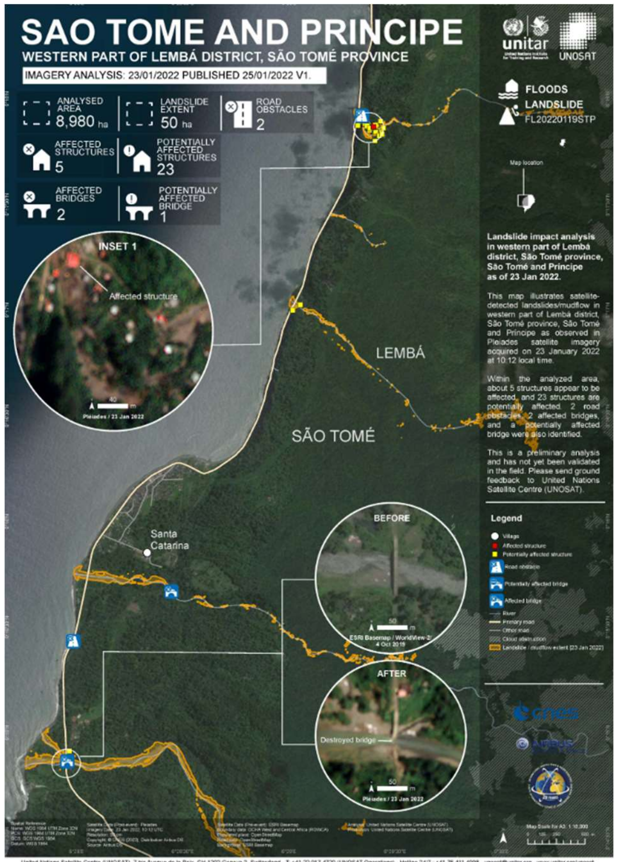


Figure 14. Landslide impact analysis generated by UNOSAT outside the ESA Charter Mapper. https://disasterscharter.org/image/journal/article.jpg?img_id=10989708&t=1643120355124

As part of the analysis on the capability of the ESA Charter Mapper to obtain similar-value added products to the ones produces for the PM reports, a red-cyan band composite showing the NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index) using VHR data from Pleaides-1B data acquired on 23 Jan 2022 has been generated in the ESA Charter Mapper.
Areas along the rivers affected by the landslides/mudflows can be identified by looking at the NDVI and the NDWI difference (Figure 15).

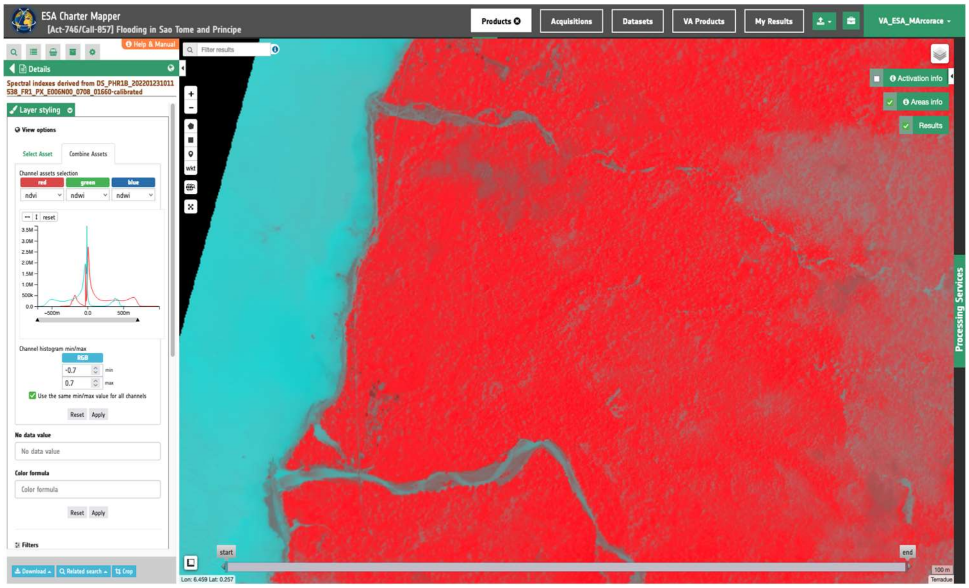


Figure 15. Red-cyan composite generated from Pleiades imagery in the ESA Charter Mapper, as output of the Optical Index service: Red: NDVI, Cyan: NDWI

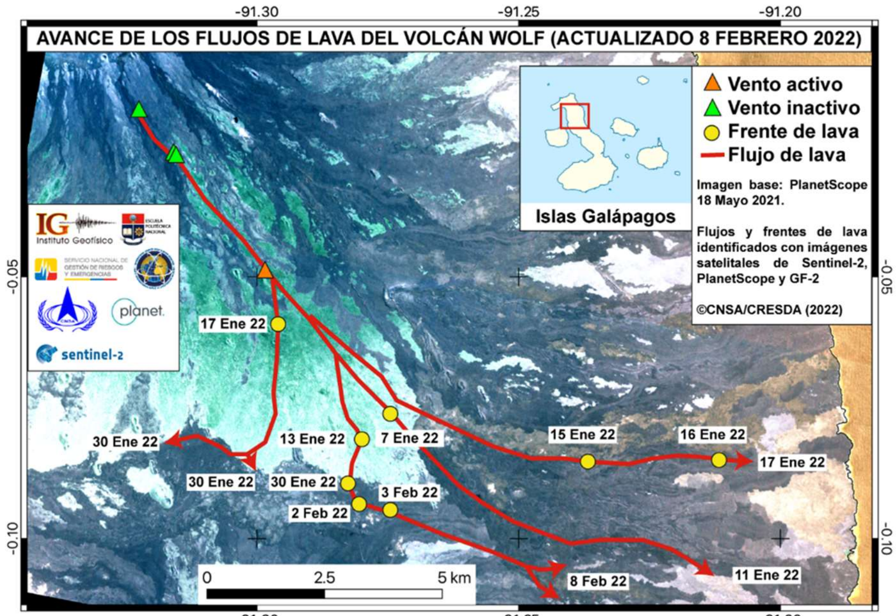
3.4.1. Observations and comments

The Optical Index service is useful for landslide damage mapping because the NDVI analysis helps to identify the occurred landslides, represented by areas that have lost vegetation, and their extent to further create and disseminate maps.

3.5. Act-743/Call-854 - Volcanic Eruption in ECUADOR

The VAp selected for the analysis on this activation is a lava flow map generated by CNSA/CRESDA based on Sentinel-2, Planetscope and GF-2 data (Figure 16, upper image). For this activation, a Landsat-8 acquisition (20220113) has been visually analysed through the Layer styling function and in particular selecting the overview-sir asset (Figure 16, lower image).

The remaining optical data available were acquired far from the eruption event (Sentinel-2, Planetscope data), or they are not suitable for processing (for instance, the Worldview images available have strong cloud coverage).



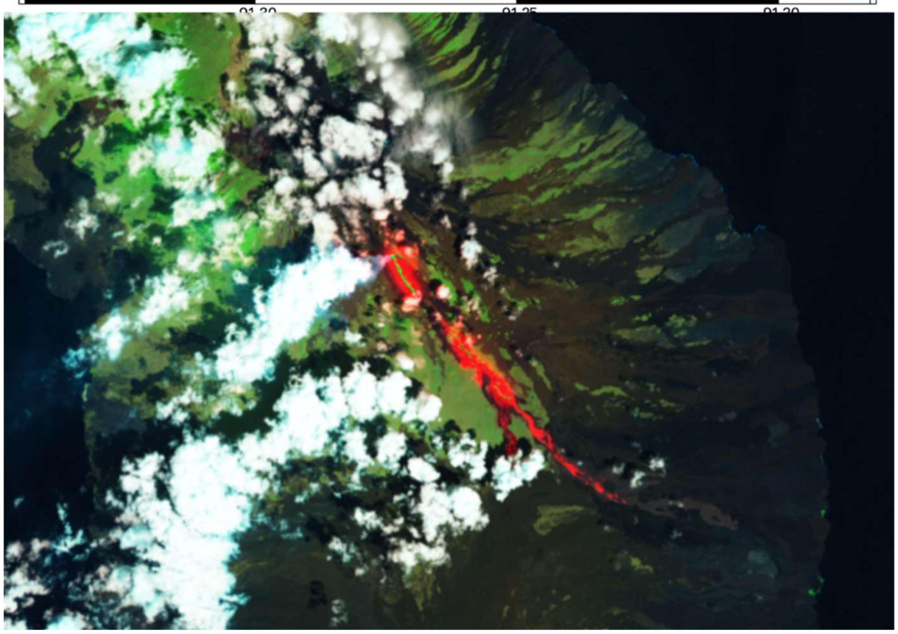


Figure 16.Upper image: Lava flow map generated by CNSA/CRESDA outside the ESA Charter Mapper, https://disasterscharter.org/image/journal/article.jpg?img_id=11960474&t=1650892559127, lower image: shortwave Infrared (SIR) RGB composite from Landsat-8 visualised in the ESA Charter Mapper.

3.5.1. Observations and comments

Thanks to the Layer styling and combine assets functions in the ESA Charter Mapper, the PMs and VAs can easily visualise the lava flow by selecting the overview-sir (shortwave infrared) visualization in the list of the available overviews. It has to be noted that the SAR Change service or the STACK services also can help in the visualization of the lava flow feature, for instance providing a red-cyan composite from a pair of Sigma Nought images in HH polarisation (no SAR acquisitions were available over the area).

3.6. Wildfires scenario

The series of examples listed here below show the potential of usage of the ESA Charter Mapper in case of wildfires.

The first example is the one represented below concerning the fires in Catalunia, Spain (June, 2022).

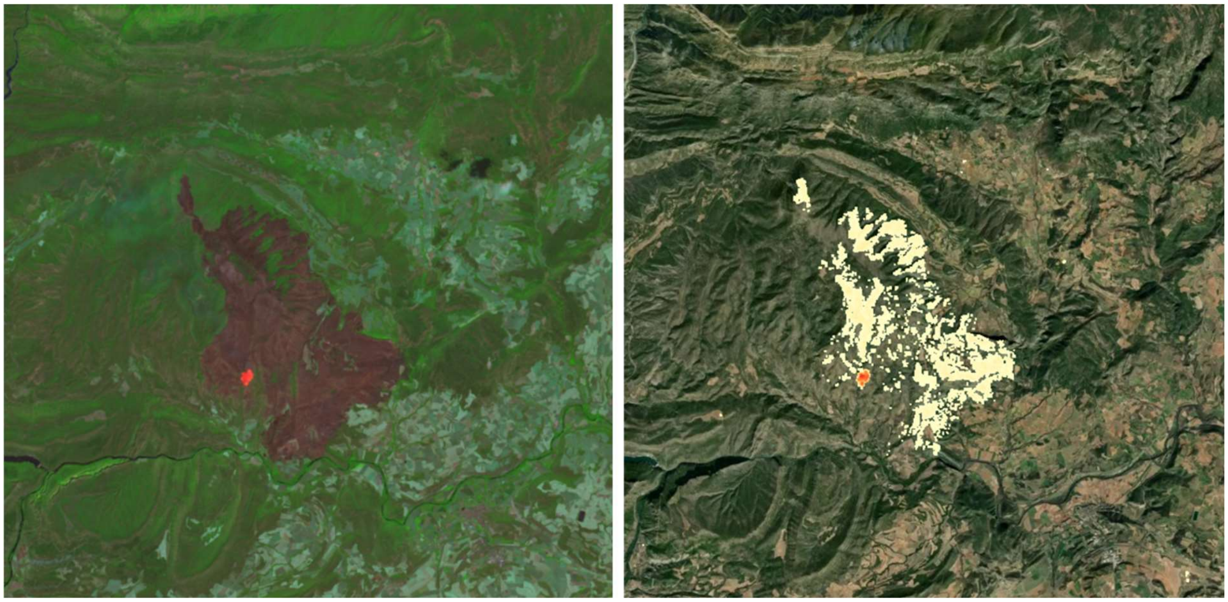


Figure 17. RGB overview-post (left) and overview of the severity product (right) generated in the ESA Charter Mapper using the BAS service.

The Burned Area Severity service output generated from a pair of Sentinel-2 MSI imagery (Sentinel-2 reflectance assets before and after the event) shows the burnt area in the region at the date of June 19th, while fires were not yet completely extinguished by firefighters. The map shows a classification of the RBR index into low to high severity classes with a yellow to red colour bar (Figure 18, Figure 19 upper image).

For the example of the Dixie Fire event of 2021 in Northern California, US, the STACK service has been used to create a multi-temporal co-located stack of TOA Reflectance NIR and SWIR22 Assets from 6 Sentinel-2 images acquired over the area affected by the event and to generate from it 5 dNBR assets to be used for multi-temporal burnt area analysis. Such dNBR assets can be then used to make on the fly RGB composites showing the evolution of the burnt area, where burnt vegetated areas are mapped in red during the early stage of the event, in green and in blue late in following stages of the events (Figure 19 lower image).

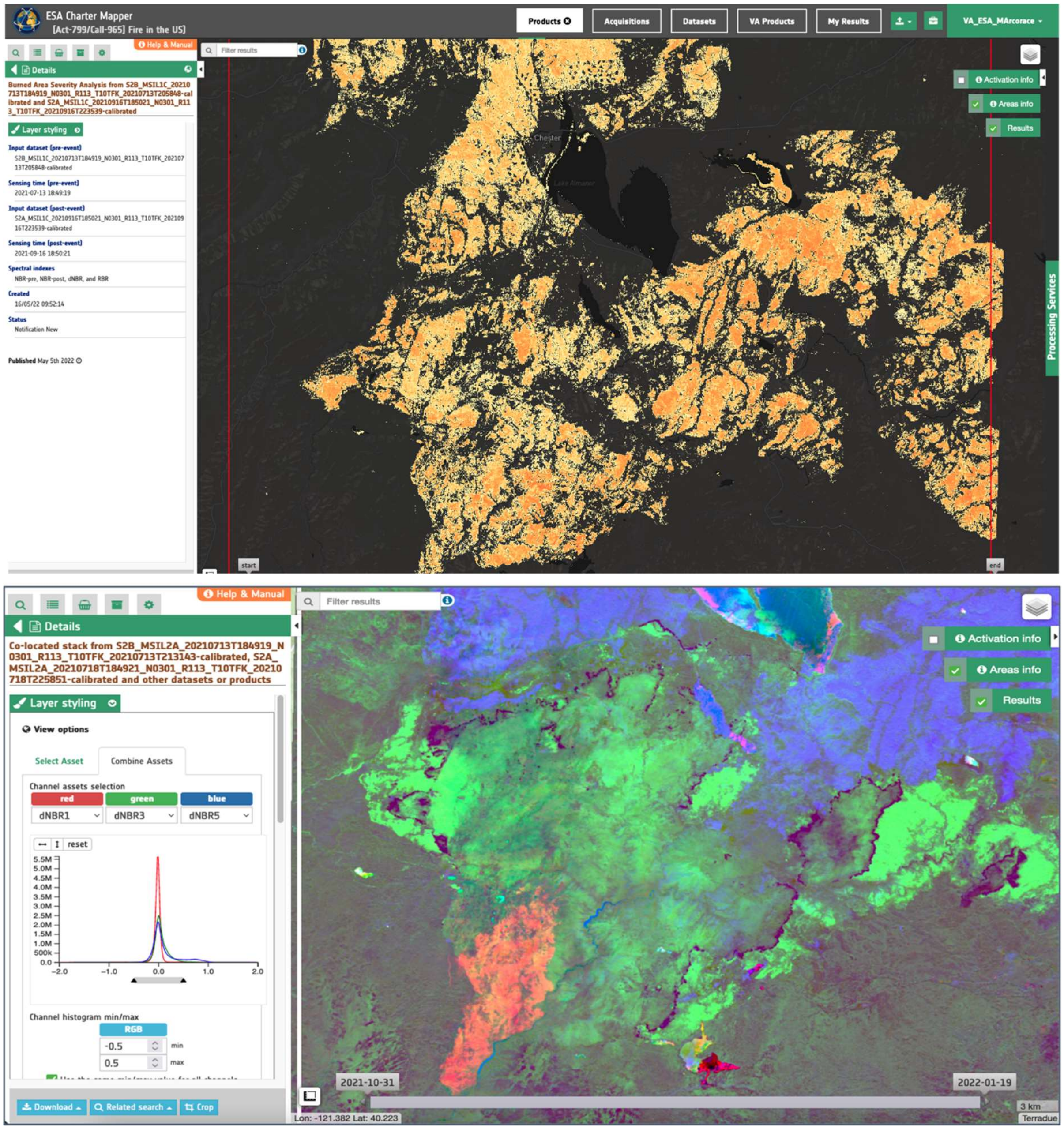


Figure 18. Upper image: BAS severity index generated using the BAS service. Lower image: STACK service for multi-temporal burnt area analysis. Normalized burnt ratio has been generated time series of 6 Sentinel-2 images.

The last example about wildfire is the one reported below in the frame of the monitoring of natural or human-induced risks affecting cultural landscapes, outside of a specific activation. In August 2020, a wildfire occurred close to the archaeological area of Gabi (Rome, Italy), where burnt areas where not only recorded over vegetation, but also over some structures of the site. By importing a Sentinel-2 pair (pre and post event imagery) in the ESA Charter Mapper, it has been possible to qualitatively (visually) assess of the damage (Figure 20).

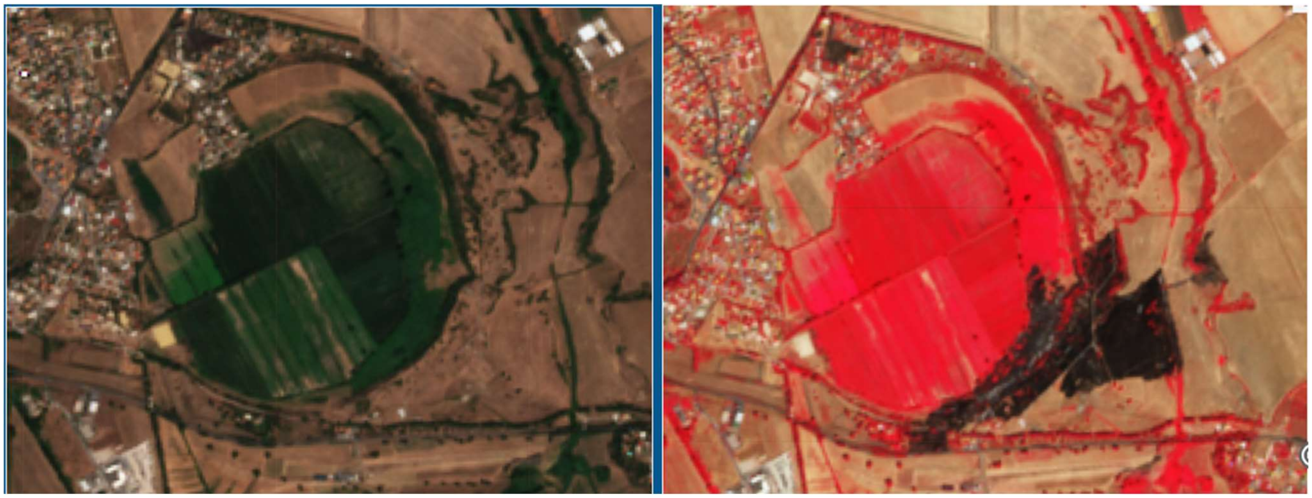


Figure 19. Archaeological area of Gabii. Visual pre (left, 20200818) and post (right, NIR band, 20200907) analysis over a Sentinel-2 pair in the ESA Charter Mapper.

As a further step of analysis, the Sentinel-2 pair has been processed for change detection outside the ESA Charter Mapper through a SSIM algorithm. The product generated is a binary mask that clearly shows how the SE part of the site has been heavily affected by the fire.

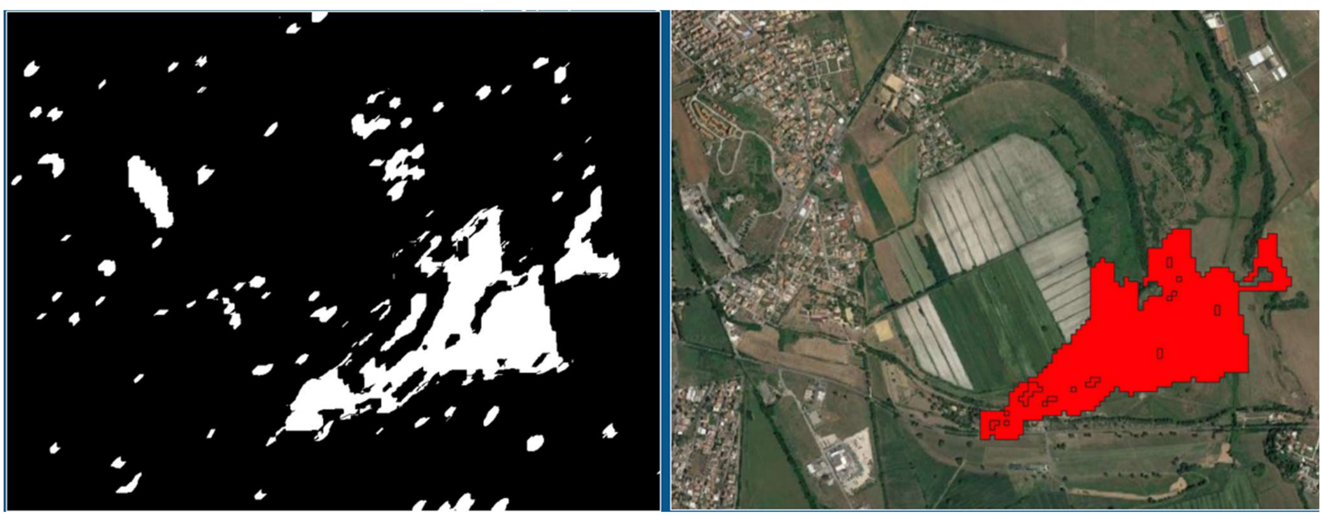


Figure 20. SSIM binarization output (left) and vector of the burnt area generated in QGIS environment (right).

In QGIS environment, the output has been then vectorized generating a value-added product and transforming into polygons the burnt area calculating an extension of about 45 ha (Figure 21).

3.6.1. Observations and comments

The examples presented in this section show how PM/VAs can benefit from the set of services of the ESA Charter Mapper:

- The Hotspot Detection (HOTSPOT) service can be used to derive hotspots from a single calibrated multispectral dataset.
- The Burnt Area Mapping (BAS) service can support PM/VAs for burnt area analysis using a pair of calibrated optical images (pre and post event), providing a full resolution overview of Sentinel-2 and Landsat-8 imagery plus the full resolution raster of the burnt area severity.
- The Co-located Stacking service can be used to make multitemporal analysis during a large wildfire to better assess the spatial evolution of the event employing dedicated spectral indexes such as the dNBR one. Optical EO data currently supported in the ESA Charter Mapper having NIR and SWIR assets are only available from the Sentinel-2 or Landsat-8 missions.

In addition, the possibility of performing the entire chain of damage visualization – processing – value added product generation (Gabii use case) directly in the ESA Charter Mapper would improve the support this tool can provide in the frame of Charter activation for the Value-added products generation.

3.7. Tsunami scenario

The co-registered stacking (Co-register) service currently available in the testing environment of the ESA Charter Mapper (UAT) has been tested for the Palu earthquake/tsunami disaster event (Act-673/Call 587 – Earthquake, Tsunami in Indonesia).

Thanks to the use of the Compare Layers function, it is possible to retrieve an immediate comparison of couples of data. As shown in Figure 22, there is a planimetric shift over the area on the left image (KOMPSAT-3) of about 100 meters.

Figure 21. Kompsat-3 (Left) and Kompsat-3A (Right) comparison in the ESA Charter Mapper through the Compare Layers function. The 100 m shift is clearly visible

The co-registration service has been used to correct this shift in the Kompsat-3 acquisition for multi EO data sources comparison.

In particular, the Kompsat-3 (2018/10/02) shifted acquisition has been co-registered with a Sentinel-1 image (2018/10/11). In figure 23, it is possible to appreciate the difference between the pre-coregistration comparison (Figure 23, upper image) and the post-coregistration comparison (Figure 23, lower image).

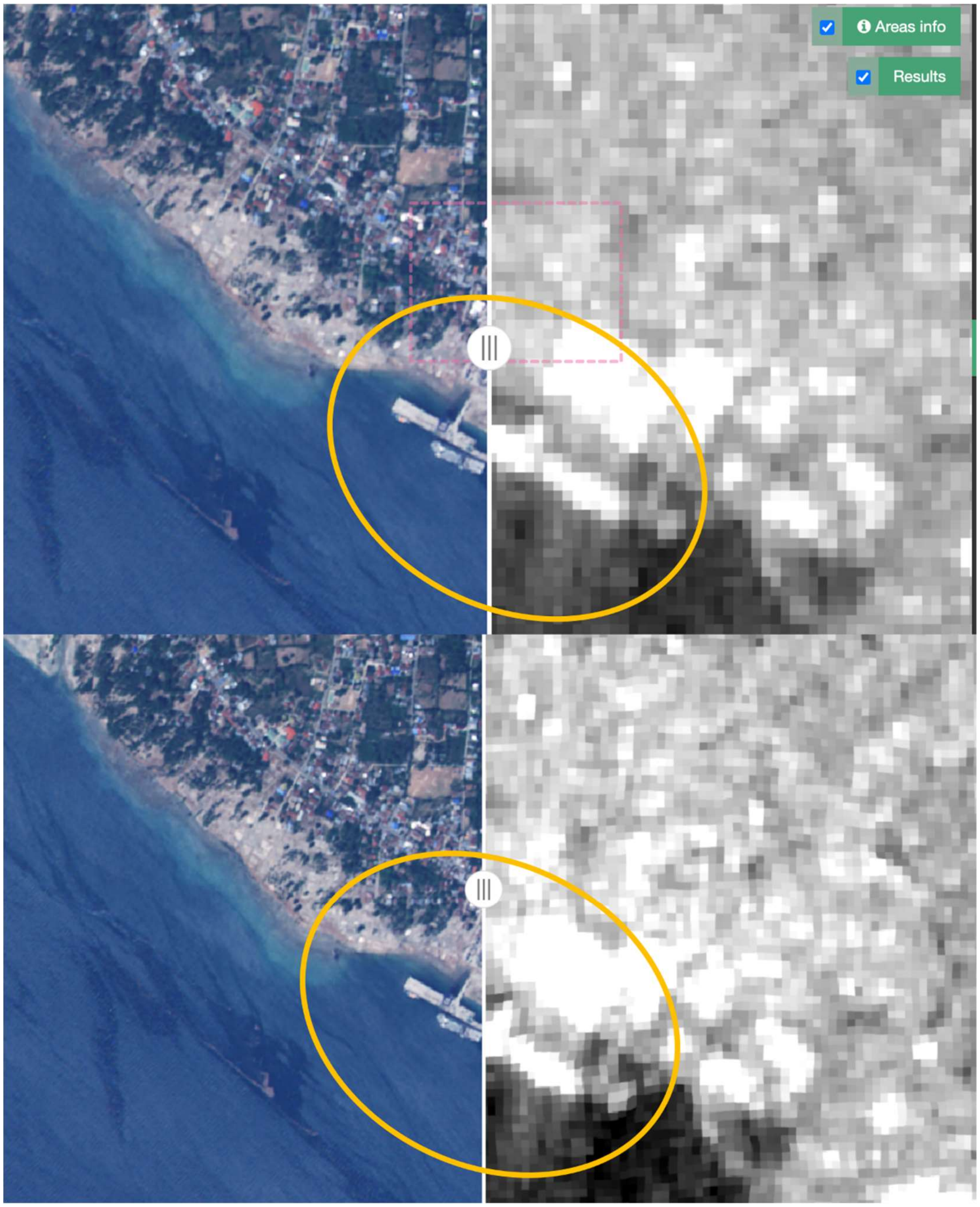


Figure 22. Comparison between the non coregistered Kompsat-3 (upper image) and the co-registered Kompsat-3 image with Sentinel-1 (lower image)

The same service has been used to generate a red-Cyan band composite showing coastline changes after the earthquake/tsunami using GeoEye (2018/08/17) and WorldView-2 (2018/10/01) co-registered panchromatic imagery (Figure 24). In red is shown coastline erosion because of the damage (co-registration based on the GeFolki software after a co-location and co-registration of calibrated TOA reflectance).

Figure 23. Co-registered red-cyan composite on the ESA Charter Mapper

3.7.1. Observations and comments

In the above examples, the Co-registered Stacking (Co-register) service allowed to perform multi-sensor visualization (Sentinel-1 and Kompsat-3 data) and to visually compare panchromatic assets before and after the event by significantly reducing the mismatches of satellite image pairs from different sensors and incidence angles.

3.8. Oil spill scenario

For this scenario, the [Act-759/Call-872] Oil spill in Gambia has been selected. Starting from a VAp generated by UNOSAT in the frame of the activation (Figure 25, left), a binarization of radar backscatter from Sentinel-1 data acquired on 29/05/2022 has been generated, revealing potential oil spill extent highlighted in yellow in Figure 25 (right). This result has been obtained with the COMBI-Plus service using band arithmetic with s-expressions (see the processing job here).

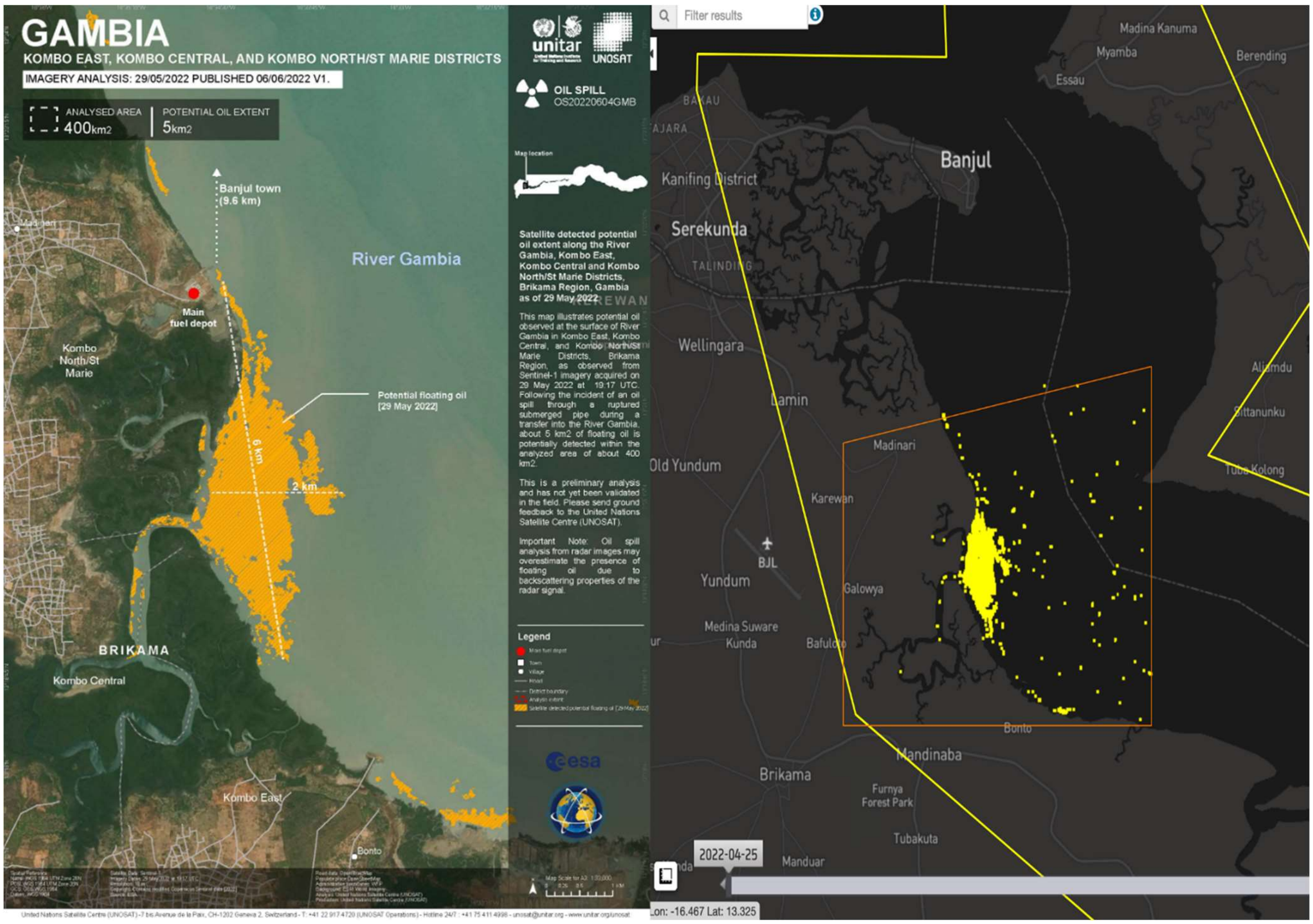


Figure 24. Delineation map generated by UNOSAT (left, https://disasterscharter.org/image/journal/article.jpg?img_id=12114678&t=1655304628064) and oil spill binarization generated in the ESA Charter Mapper (right).

3.8.1. Observations and comments

Band arithmetic included in the Co-located stacking (STACK), Advanced Band Combination (COMBI-Plus) services can support PM/VAs to make backscatter binarizations and estimate oil extent. In the current version of the ESA Charter Mapper the function to generate raster to vector product is not yet implemented.

4. Conclusions

This report lists a series of different use cases that have been tested for the assessment of the utility of the ESA Charter Mapper. The services can help with visualization, with image analysis (but GIS functions are lacking to complete an analysis on-line) and VA processing (some VA services have been tried, as Advanced band combination or BAS, for instance). The report shows useful results from the Mapper to support or expand the analysis performed by the PMs/VAs, but user reports are needed to validate this testing analysis.

A factor that is critical for operations is the rate of success in data ingestion, calibration and latency, which are regularly measured and reported in specific performance documentation (out of the purpose of this document).

Indeed, the ingestion/calibration rate was good.

Overall, the ESA Charter Mapper provides for all the activations considered a good visualization experience, for some of them thanks to specific processing chains, it also allows to extract information from data as basic value-added services. Concluding, the feedback of users (PMs and VAs) is of crucial importance to confirm the usefulness of such a tool.