AI-Based Framework for Rapid Extraction of InSAR Coherence from COMET-LiCSAR Portal

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Keywords: AI-Assisted, InSAR, Coherence, Google Colab, COMET-LiCS-portal

Abstract

Interferometric Synthetic Aperture Radar (InSAR) coherence analysis is a powerful remote sensing technique for detecting ground surface changes caused by natural disasters like wildfires. However, its application has been limited by the large file sizes and high computational demands of Synthetic Aperture Radar (SAR) data, which makes processing on standard personal computers difficult and time-consuming. While the COMET-LiCS Portal democratized access to open-source InSAR data, its complex database created a new bottleneck, making it difficult for users to navigate and download the correct data frames efficiently.
To address these challenges, this study introduces a novel AI-based framework, developed in the Google Colab cloud environment, designed to streamline the rapid extraction and analysis of InSAR coherence data from the COMET-LiCS Portal. The framework uses an AI tool to parse the database and presents the data through a simplified, user-friendly interface that bypasses local computational limitations. Key features of the tool include automated batch downloading to acquire multiple datasets simultaneously. It also integrates OpenStreetMap for overlaying the data and satellite basemaps to improve spatial orientation with province and district boundaries. Additionally, a real-time overlay of active fire detections from the NASA FIRMS API enables immediate cross-comparison between coherence changes and known fire events. The model's effectiveness is demonstrated through case studies of large-scale wildfires in Türkiye, including in Antalya-Manavgat and Muğla-Mazıköy. The analysis confirms that the tool can reliably visualize burned areas by identifying the significant increase in coherence that occurs post-fire due to vegetation loss. The study also identifies a key limitation: the 8-bit data conversion used by the COMET-LiCS Portal reduces data precision, which can hinder the detection of smaller-scale fires. Ultimately, this work delivers a practical, fast, and highly accessible tool that makes coherence-based analysis for disaster monitoring available on both standard computers and mobile devices

1. Introduction

The methodologies for assessing damage, analysing risks and visualizing the impact of natural disasters worldwide are emerging. This shift is driven by the increasing sophistication of active and passive remote sensing technologies, which provide an effective view of affected areas and often reduce the need for slow, hazardous, and sometimes impossible field data collection in-person (Aydin-Kandemir and Demir, 2023; Kaku, 2019).). These two types of remote sensing offer complementary, yet distinct capabilities in the disaster management cycle. Passive remote sensing captures solar energy reflected from the Earth's surface. In disaster studies using passive sensors (such as those on Landsat or Sentinel-2 satellites), the analysis is focused primarily on the visible and infrared bands of the electromagnetic spectrum. Common methods include the use of spectral indices (e.g., the Normalized Burn Ratio), which mathematically combine different spectral bands to highlight fire scars, and change detection, which compares "before" and "after" images to map changed landscapes. Although powerful for post-disaster assessment, passive sensors have a critical drawback: their reliance on clear atmospheric conditions. They are mainly ineffective due to heavy smoke, dense cloud cover, and the absence of daylight. As a result, in situations such as large-scale forest fires, reliable and accurate analysis is typically possible only after the fire has been put out and smoke has dispersed, which restricts their application to immediate response efforts.

In contrast, active remote sensing technologies, particularly Radio Detection and Ranging (RADAR) and Synthetic Aperture Radar (SAR), operate by transmitting their own energy pulses and recording the signal that bounces back. Because these microwave signals can penetrate smoke, clouds, and darkness, active sensors are not constrained by atmospheric conditions or the day-night cycle. This all-weather, 24/7 imaging capability allows for near real-time monitoring of disasters as the technology allows.

The open-access Sentinel-1 satellite constellation, with its C-Band SAR sensor, has become a milestone of modern disaster response due to its regular and frequent revisit times over any given area (Liu et al., 2024). This reliability has made its data a frequently applied resource for immediate damage assessment. Among these methods, coherence derivation provides decision-makers with critical information by enabling the mapping of changes in the disaster area and the quantitative tracking of these changes via coherence-based histograms. Given that rapid results are critical in large-scale disasters, methods that yield practical and reliable results are particularly important. At this point, significant convenience is provided by open-source platforms such as NASA FIRMS, Copernicus Climate Data Store, and COMET-LiCS-portal (Lazecký et al.,2020), while access to results has been greatly accelerated using widely available AI tools such as GPT, Claude, and DeepSeek (Liu et al., 2024).

https://doi.org/10.5194/isprs-archives-XLVIII-4-W18-2025-83-2026

In this study, the open-access database of the COMET-LiCS portal platform was utilized using artificial intelligence tools, and a more practical and user-friendly interface was designed to enable the downloading of coherence data. Through the developed interface, all coherence data within Türkiye's borders have been made available from 2014 to today, due to active updating of the database. Furthermore, to support near-real-time wildfire situational awareness and post-event analysis, the interface integrates active fire detections from NASA's Fire Information for Resource Management System (FIRMS) via its API, allowing the overlay of hotspots on the coherence frame map and seamless cross-comparison with pre- and post-event coherence products. The resulting interface is presented in Figure 1 in comparison with the original COMET-LiCS portal.

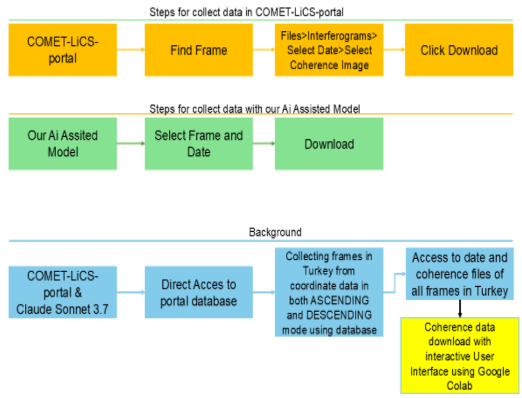

Figure 1. Comparison of the COMET-LiCS platform and our AI-assisted model and the principle of the model

Since the interface is developed on Google Colab, it runs seamlessly on low-spec computers by leveraging a cloud environment. In addition, it is accessible on mobile devices, providing users with access to coherence imagery for any region.

2. Methodology and Case Studies

Using the open-access database URL of COMET-LiCS-Portal, the appropriate folder was selected based on the relevant Frame_ID; for example, for the 006A_03658_131313 frame, folder 6 was accessed, followed by the folder named 006A_03658_131313, and then the interferograms directory. Within this structure, acquisition dates were obtained in the YYYY/MM/DD format, and files with the geo.cc.tif extension were selected. To identify frames covering Türkiye, all Frame_IDs in the database were scanned and the same steps were applied for each; however, in this case, the -poly.txt files were used to exclude frames located outside of Türkiye's coordinates based on their coordinate information. The steps performed are summarized in Figure 2.

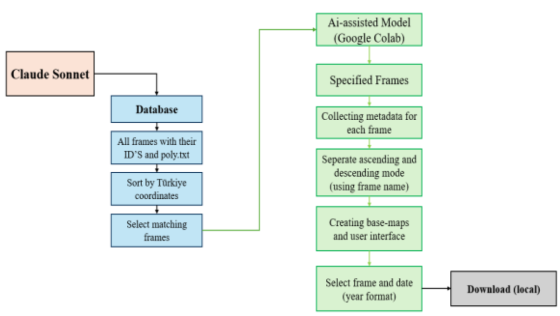

Figure 2. Model Background

To create anefficient user experience, the initial step involved a comprehensive identification of all data frames covering the geographic area of Türkiye, which were then integrated into the interface. A key feature of the tool, which was developed in Google Colab, is its dynamic nature. The interface reconnects to the database at each execution, a process that automatically retrieves up-to-date data from COMET-LiCS-Portal. This ensures that users are always working with the most current satellite acquisitions available, a critical advantage for time-sensitive applications like disaster monitoring, without having to manually check the source portal for new uploads.
Compared to the conventional manual download approach, which can be time-consuming, the AI-assisted interface introduces several technical improvements designed to streamline the entire workflow from data discovery to download.

2.1 Key Technical Improvements

Automated Metadata Extraction: The system is designed for efficiency in automating the retrieval of essential information. For every data set, crucial details such as frame coverage and acquisition dates are dynamically retrieved upon each execution. This eliminates the error-prone manual step of looking up metadata for each individual frame, presenting the user with all necessary information in a clear and accessible format.

Batch Downloading: Recognizing the need to analyze data over the selected timeline, the interface contains a powerful batch processing feature. Users can select multiple temporal pairs simultaneously, queueing them for download in a single operation. This capability is a significant enhancement over one-by-one downloads, significantly reducing processing time and allowing the user to focus on analysis rather than data acquisition.

Real-Time Fire Overlay: To provide immediate action for environmental analysis, the tool features direct integration with the NASA FIRMS API. This allows for the dynamic overlay of active fire detections on the coherence frame map. A user can therefore instantly visualize whether a detected change in ground coherence corresponds to a known fire event, enabling rapid validation and assessment of fire progression.

Cross-Platform Access: The cloud-based design of the system ensures compatibility with mobile devices and low-performance computers. Since all intensive computations and data handling are processed on Google's servers, the user's local hardware requirements are minimal. This democratizes access, allowing researchers and decision-makers to utilize powerful geospatial tools from a tablet in the field or a standard office laptop, without the need for a specialized, high-performance workstation.
Ultimately, this methodological structure not only simplifies data acquisition, but also establishes a scalable model for similar applications in other regions. The underlying framework is geographically agnostic and can be readily adapted to any area of interest around the world by modifying the initial spatial parameters.
To demonstrate the practical application of these features, the prepared interface and the usage steps are presented in the figures below.

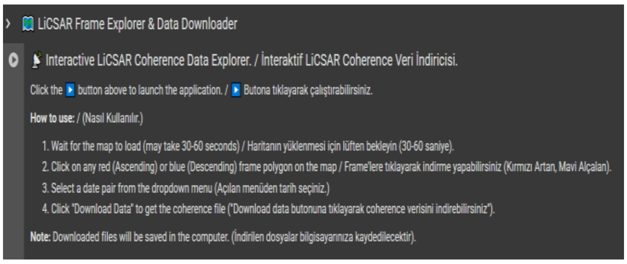

Figure 3. How to use instructions

By following the instructions, the interface has become simpler and more user-friendly. Furthermore, the download process now supports batch downloading, allowing users to retrieve multiple datasets from the same year simultaneously.

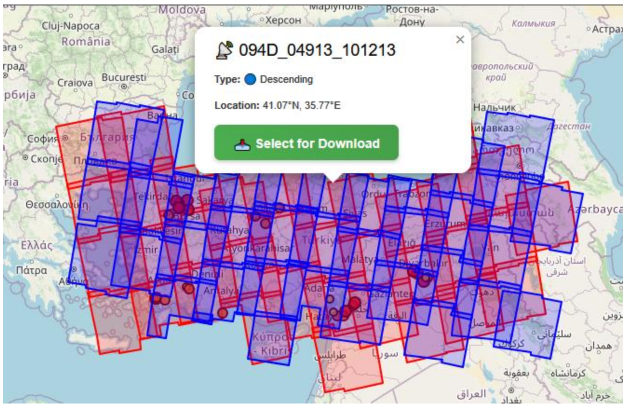

Figure 4. Base map, layers and selected Frame

The basemap was replaced with OpenStreetMap, Satellite View, and Terrain View, thereby enabling the display of provincial and district information covered by the frames. Both acquisition modes were integrated into the map. Consequently, datasets named in the xxxA format were classified as Ascending, while those in the xxxD format were classified as Descending. When a sample frame is selected and the "Select for Download" icon is clicked, the name of the corresponding frame is automatically transferred to the "Download Center" interface. Figure 5 presents the "Download Center" interface after frame selection.

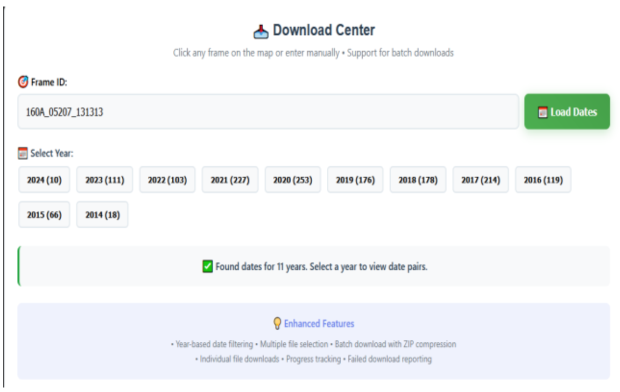

Figure 5. Download UI of the Download Center

The years shown in Figure 5 indicate the number of datasets available for each year. After the relevant year is selected, all coherence datasets for that year are listed in the YYYYMMDD_YYYYMMDD format. From this list, it is possible to download single or multiple coherence datasets.

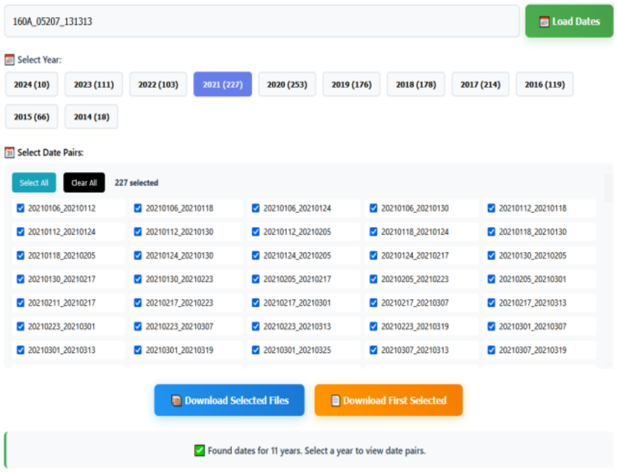

Figure 6. Download options

"The Download Selected Files" button enables downloading all selected data, while "Download First Selected" downloads only the first selected item. The downloaded data are saved directly to the computer through the browser. The data downloaded from here are in .tiff format.

To enable real-time monitoring of fire data in the Türkiye region, current fire events have been integrated into an interactive map using the NASA FIRMS API. This integration aims to make it easier to clearly observe potential fire areas that might otherwise go unnoticed.

We used the API to instantly visualize the fire alerts recorded by the VIIRS sensor on the NASA FIRMS platform. Each fire alert was classified into three different confidence levels (Low Confidence, Medium Confidence, and High Confidence) according to criteria defined by NASA FIRMS (using the NASA FIRMS direct scaling methodology).

Based on NASA FIRMS documentation, this classification system indicates the following:

- Low Confidence alerts represent false positives, such as sun glare or transient hot surfaces, which may potentially be misinterpreted as fire events.

- The Medium Confidence class indicates the presence of fire-related data or, less commonly in Türkiye, volcanic activity.

- The High Confidence class generally represents active fire areas.

The colors corresponding to these confidence levels are applied as Yellow (Low), Orange (Medium), and Red (High), respectively. The final interactive map that incorporates the added NASA FIRMS data is presented in Figure 7.

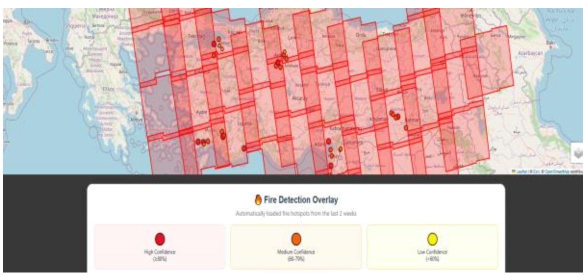

Figure 7. NASA FIRMS and Aı-asissted model

Furthermore, the interactive map, supplemented with NASA FIRMS data, significantly enhances the practicality and speed of both real-time monitoring of wildfires and analysis of fire events using the InSAR Coherence data from the COMET-LiCSAR platform.

Various analyzes have been conducted on the coherence data obtained through the interface. In the studies, samples selected from forest fires that occurred in Türkiye were compared using coherence data. Cukurlu et al. (2024) visualized the Antalya/Manavgat Forest fire using a manual coherence calculation and demonstrated the impact of the fire by examining changes in coherence values before and after the event. In the figures below, the same analysis was replicated using the coherence data downloaded via the interface.

Figure 8. Antalya/Manavgat Optic image (Sentinel-2 Google Earth Engine).

At this stage, satellite data on forest fires has been added as an example. In scenarios where satellite images are obscured by clouds or smoke during large-scale fire changes, the fire area can be clearly visualized through changes in InSAR coherence values and coherence-based maps (obtained via the COMET-LiCS portal) (Figures 9, 10, 13, and 14).

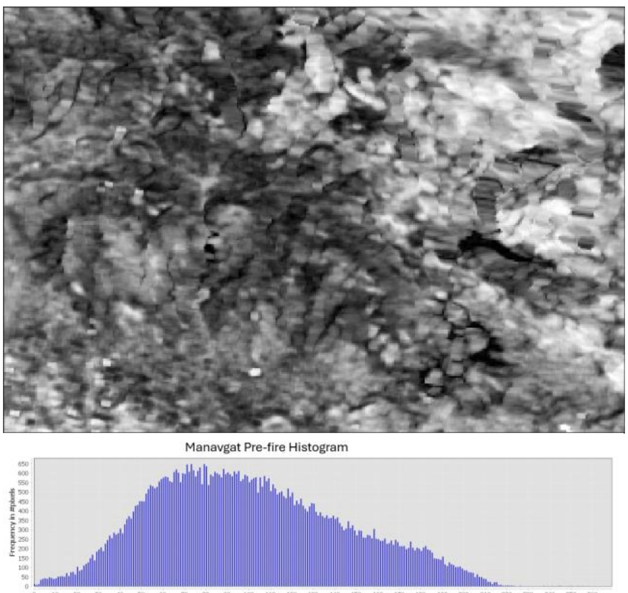

Figure 9. Coherence Based map and histogram for Antalya/Manavgat (Pre-fire)

We mentioned that low (inconsistent) phases would be observed in coherence values due to scatterings occurring in forested areas. In line with this, the COMET-Lics-portal data obtained using the model showed the expected low coherence values in the data obtained before the Manavgat Forest fire (June 29, July 5). After the fire, an increase in this low value is expected in the data obtained.

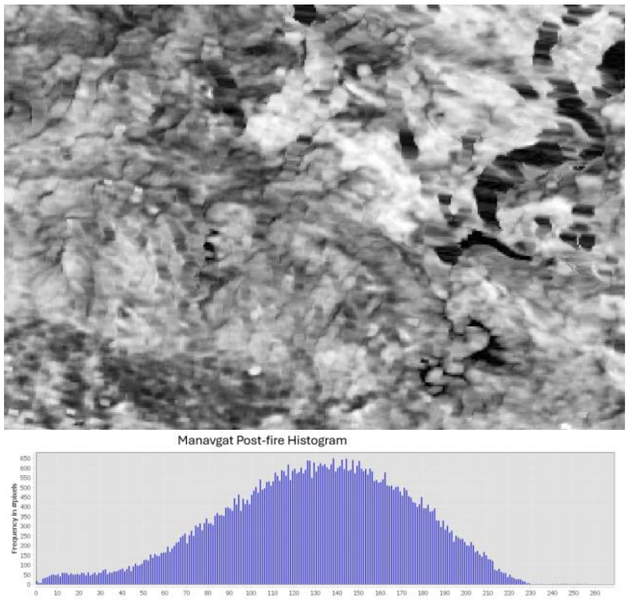

Figure 10. Coherence Based map and histogram for Antalya/Manavgat (Post-fire)

After the fire, it was expected that coherence values would increase because there would be no scattering from branches or tree crowns (due to the area being damaged).

In forested areas, radar signals scatter from tree crowns, branches, and fruit, causing phase decorrelation and low InSAR coherence when scenes are imaged at different times. After a fire, vegetation loss reduces scattering, yielding more consistent phase and higher coherence. As shown in Figure 9 and 10, regions with low pre-fire coherence exhibit markedly higher values post-fire. This pattern enables effective fire detection and visualization using InSAR coherence within our AI-supported model. Cukurlu (2025) reported similar results with traditional methods, underscoring the reliability and consistency of COMET-LiCSAR coherence data. Based on this knowledge, several additional test areas were identified, and the pre-fire and post-fire values of the data obtained through the COMET-LiCS portal were analyzed.

One of these test areas was the forest fire that occurred on August 15, 2024, in the Yamanlar Mountain (Aegean region) in Izmir. According to news sources, it was reported that approximately 3,000 hectares of forest area were damaged. Unlike the fires in the Mediterranean region, this fire in the Aegean region was selected to test the InSAR Coherence method. Satellite data (Sentinel-2) and Coherence-based maps for the fire area are provided in Figures 11 and 12.

This contribution has been peer-reviewed.
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Figure 11. Burned area on Yamanlar/Izmir

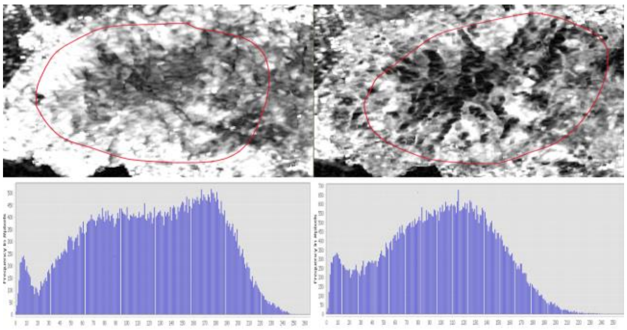

Figure 12. Coherence change on Yamanlar Forest Fire

To ensure a robust evaluation, the limitations of the model created with this selected test area were also tested. The investigation revealed that the model's sensitivity is directly influenced by the pre-processing of its source data. Specifically, because the InSAR Coherence data obtained from the COMET-LiCS portal was subject to 8-bit conversion, a process that reduces data precision to save space, a consistent result could not be observed in a relatively small-scale fire.

This 8-bit conversion compresses the original, more detailed satellite measurements into a smaller range of 256 values. While this is efficient, it can obscure subtle environmental changes. In the case of a small fire, the delicate drop in coherence—the signal of the disturbance—was likely lost during this quantization process, resulting in an ambiguous or noisy output from the model. This is supported by a comparative analysis. While Cukurlu et al. (2025) observed the expected coherence changes in analyses performed in the same region using directly downloaded Sentinel-1 SLC data, which retains the full radiometric resolution, an inconsistent result was observed in the COMET-LiCS portal data. This confirms that the underlying SAR methodology is sound for detecting such events, but the pre-processed, 8-bit data from the portal lacks the sensitivity required for disturbances of a smaller magnitude.

To test the model's performance under different conditions, another large-scale fire examined was the Muğla/Mazıköy forest fire. This fire, which started at the same time as the forest fire in Antalya, is considered a large-scale fire despite the lack of clear area information in news sources. In this case, the landscape alteration was so extensive and severe that the resulting drop in coherence was significant enough to be clearly detected even within the constraints of the 8-bit data. The strong signal of this major event was not masked by the reduction in data precision, demonstrating that the model remains effective for assessing large-scale disasters where the environmental impact is substantial.

Figure 13. Mugla/Mazı köy Optical image (Sentinel-2 Google Earth Engine)

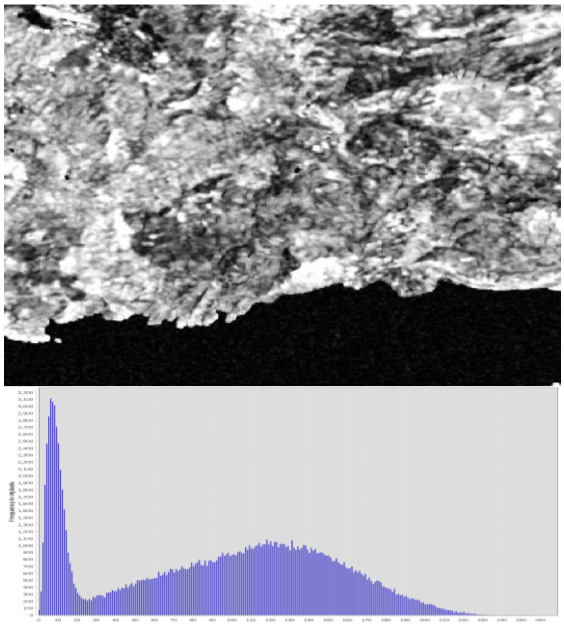

Figure 14. Coherence Based map and histogram for Mugla/Mazı köy (Pre-fire)

Coherence values for the pre-fire period were observed as expected within the Muğla region.

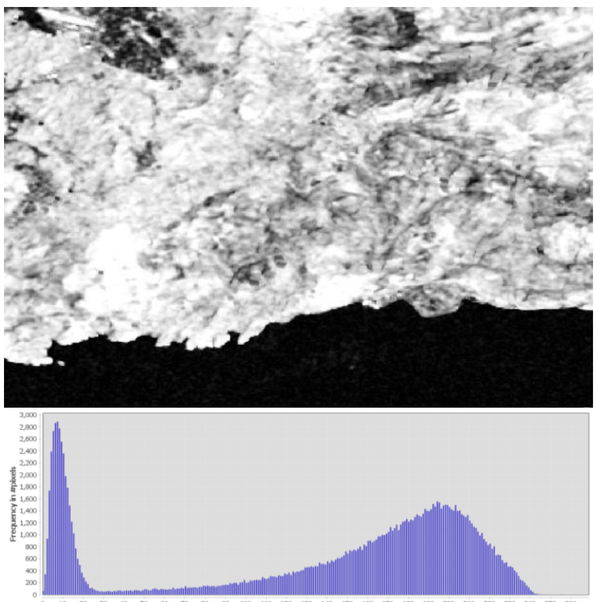

Figure 15. Coherence Based map and histogram for Mugla/Mazı köy (Post-fire)

Following the analysis of the large-scale Muğla/Mazıköy fire as shown in Fig 13-15, similar results were observed in the post-fire Coherence histogram and map, confirming the model's effectiveness in identifying significant landscape changes. The coherence map clearly delineated the burn scar as a region of substantial coherence loss.

3. Conclusions

Case studies highlight the model’s applicability to wildfire analysis. In the Manavgat fire, pre-fire coherence values were generally low due to dense vegetation scattering, while post-fire coherence significantly increased, confirming vegetation loss. For the Yamanlar fire, Sentinel-2 optical imagery was combined with coherence maps to validate burned area extent. However, limitations were observed in detecting smaller-scale disturbances due to 8-bit conversion applied in COMET-LiCSAR products. A statistical comparison of pre- and post-fire coherence values demonstrated consistency across case studies, suggesting that the AI-assisted model can reliably support wildfire monitoring in diverse ecological zones.

Thanks to the interface designed on the Google Colab platform and developed using COMET-LiCS Portal data, conducting coherence-based analyses has become much faster and more practical. Moreover, streamlining and clarifying the data acquisition process aimed to create a more user-friendly data download tool.

In this regard, the AI-assisted model developed was observed to operate with high consistency and speed. Coherence data can now be obtained not only on computers but also via mobile devices.

Acknowledgements

This study has been supported and financed by Scientific and Technological Research Council of Türkiye (TUBITAK) with the Project Nr. 123Y274 with coordination and support from the COST Action CA20118. Additionally the authors acknowledge Dr.Atticus Stoval, Dr.Fulya Kandemir and Dr.Pol Kolokoussis for their feedback during the project tasks. We also acknowledge that LiCSAR contains modified Copernicus Sentinel data [Year of data used] analysed by the Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics (COMET). LiCSAR uses JASMIN, the UK’s collaborative data analysis environment (http://jasmin.ac.uk). Google Gemini was used in writing to improve readability and language.

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