Burned Area Detection in Greece

Leveraging Deep Learning and Sentinel-2 data

The Challenge

Wildfire Impact

Greece, with its Mediterranean climate and diverse ecosystems, faces increasingly severe fire events due to climatic changes and human activities.

Monitoring Need

Ground surveys are costly and time-intensive. Precise, regularly updated burned area maps are essential for effective wildfire management.

Remote Sensing Solution

Satellite remote sensing provides a cost-effective alternative for monitoring vast, inaccessible landscapes.

Why Sentinel-2 for Fire Detection?

Spatial Resolution

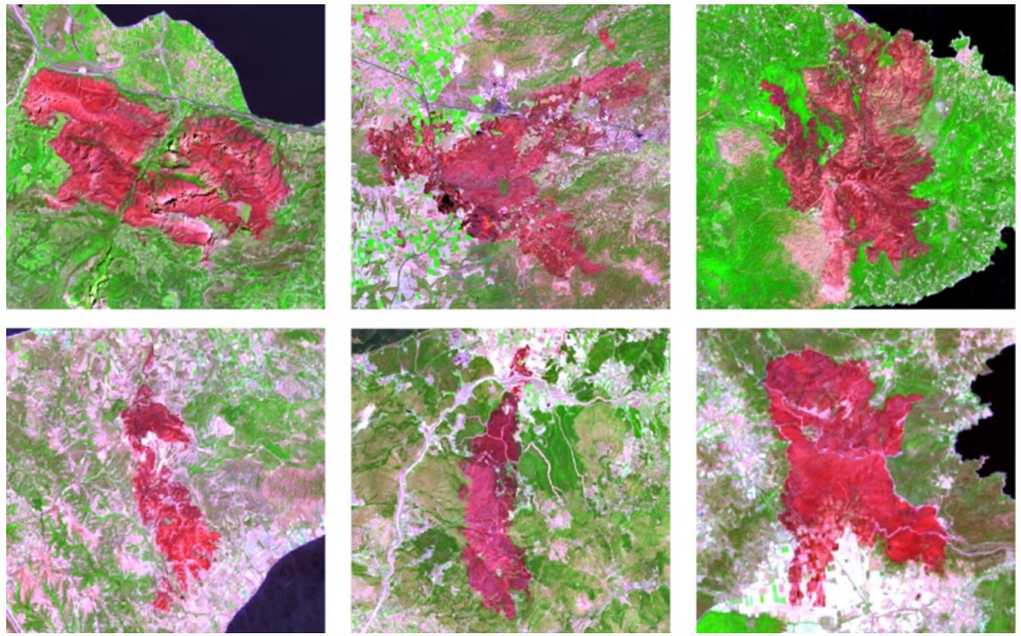
10-meter spatial resolution enables detailed burned area mapping across diverse landscapes

Revisit Time

5-day revisit cycle provides timely data for post-fire assessment and monitoring

Multispectral Capabilities

Sensor that detects subtle spectral changes in burned vegetation



Examples of wildfire events displayed in a false color composite (R: SWIR-2; G: NIR; B: Red).

Deep Learning Revolution in Remote Sensing

Traditional methods for burned area detection rely on spectral indices like Normalized Burn Ratio (NBR) and basic classification techniques. However, these approaches have limitations in distinguishing burned areas in heterogeneous landscapes.

Traditional Methods

Spectral indices, SVMs, Random Forests - limited accuracy in complex terrain

Deep Learning

Architectures for semantic segmentation with superior classification results

Study Area & Data

Geographic Coverage

Greek territory including mainland and islands, characterized by diverse topography and Mediterranean climate with hot, dry summers. Coastal regions, mountainous terrains, and dense vegetation contribute to spectral diversity.

Satellite Data Source

Twenty Sentinel-2 Level-2A images from 2023-2024 that cover fire events catalogued by Copernicus Emergency Management Service (CEMS).

Images characteristics

- High data quality
- No cloud coverage over burned areas

Wildfire Events Dataset

A dataset that includes 21 significant wildfire events across Greece, ranging from small localized fires to massive regional disasters affecting tens of thousands of hectares.

93,881

Largest Event

East Macedonia fire (EMSR686) - hectares burned

21

Total Events

Major wildfires catalogued over two years

20

Sentinel-2 Images

High-quality, limited cloud coverage scenes

Methodological Framework

01

Data Preprocessing

Sentinel-2 imagery resampled and stacked (SWIR-2, NIR, Red bands) for uniform spatial resolution

02

Binary Classification

Manual classification of areas as burned or not burned, with representative samples selected across scenes to capture spectral variability and visual inspection validation

03

Training Data Generation

Converted classified images to vector format, retaining burned area polygons and manually reviewing to eliminate false positives. Prepared training samples in 64×64 tile size with 32×32 stride (50% overlap) for pixel classification

04

Model Training

GPU-accelerated training for enhanced feature extraction

Model Validation Results

~8,500

Training Samples

Total samples used for training and validation across all models

96%

Peak Accuracy

U-Net with ResNet encoders achieved highest overall accuracy

0.95

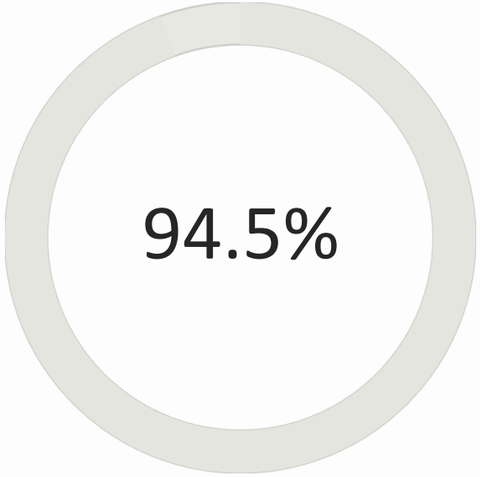
F1-Score

Balanced precision and recall metrics for U-Net models

Model	Encoder	F1-Score	Training Time
U-Net	ResNet18	0.95	24' 36"
U-Net	ResNet34	0.95	24' 50"
DeepLabV3	ResNet18	0.90	39' 49"
MMSegmentation	HRNet	0.92	1h 58' 26"

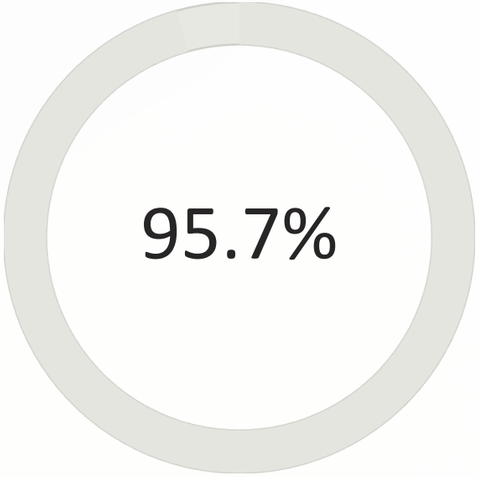
Test Results

The trained U-Net model was tested on two wildfire events (EMSR747 and EMSR767) with overlap analysis, comparing results with Copernicus EMS reference products.



EMSR747 Overlap

Agreement between U-Net predictions and EMS reference data

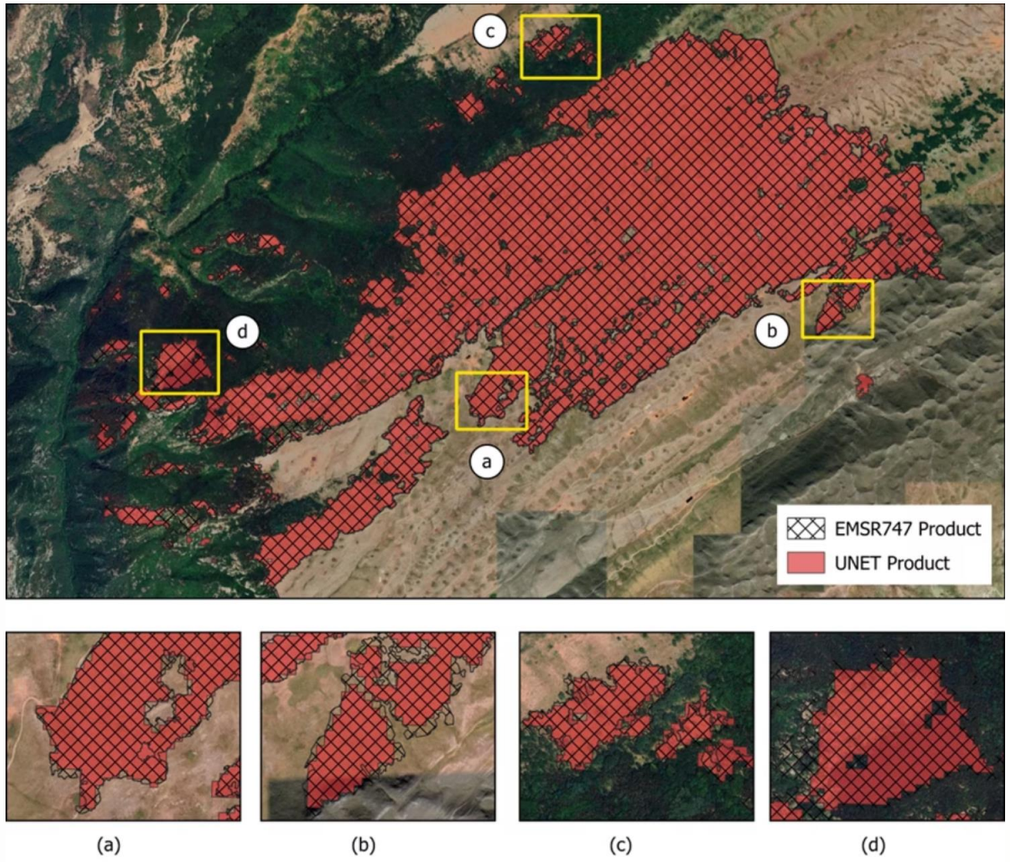


EMSR767 Overlap

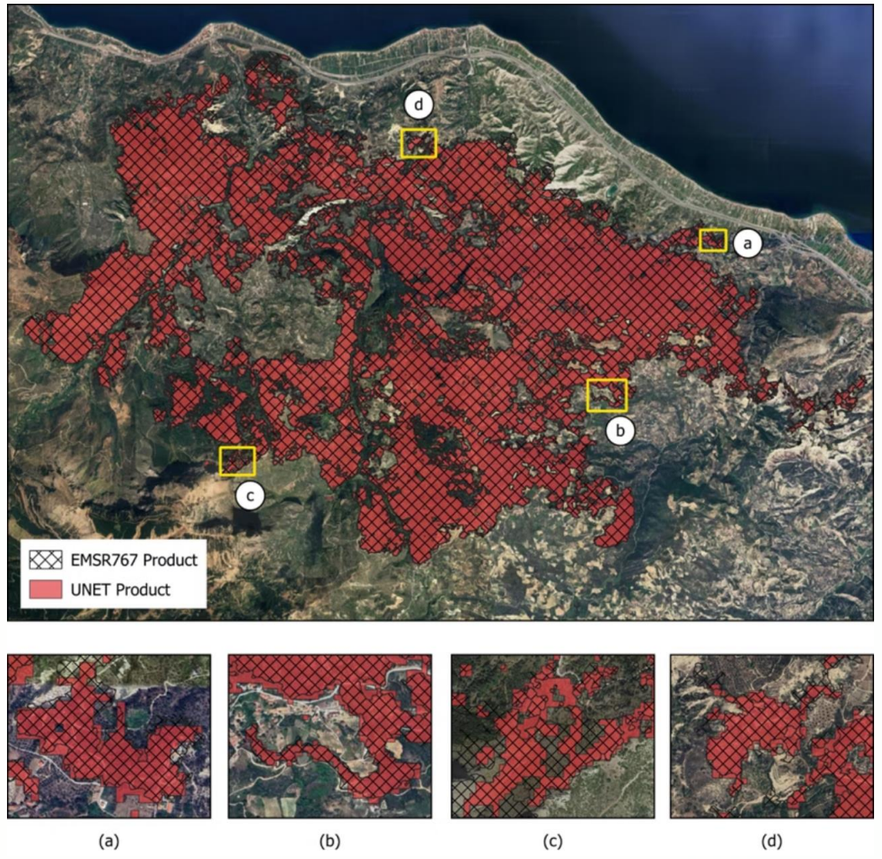
High accuracy across diverse landscape conditions

Event	U-Net Area (ha)	EMS Area (ha)
EMSR747	1,088.8	1,138.4
EMSR767	5,619.2	5,829.9

Overlap Analysis



Burned area delineation for EMSR747: Comparison between the Copernicus EMS reference product and the burned area map generated by the U-Net model, including zoom-in views.



Burned area delineation for EMSR767: Comparison between the Copernicus EMS reference product and the burned area map generated by the U-Net model, including zoom-in views.

Key Advantages

This deep learning framework enables rapid, accurate burned area mapping across Greece's entire territory, supporting critical disaster response and recovery efforts.

Computational Efficiency

U-Net demonstrated significantly fast training times while maintaining high accuracy.

Scalable Solution

Framework designed for nationwide application with potential extension to other Mediterranean regions facing similar wildfire challenges.

Emergency Response

Burned area detection provides critical information to public authorities and stakeholders for disaster response coordination.

Recovery Planning

Accurate delineation supports post-fire assessment, enabling effective resource allocation and long-term recovery initiatives.

Future Directions & Broader Impact

Wildfire Response AI

Integrate More Data

Future research will focus on incorporating more data for improved generalization across varying conditions.

Broader Use

The insights gained extend beyond Greece to other Mediterranean regions facing analogous wildfire risks, demonstrating the broader applicability of this methodology.

Operational Deployment

To support operational deployment, integration with existing emergency management systems, cloud-based processing infrastructure for rapid analysis, and continuous monitoring capabilities with regular updates.