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Title: **Semantic detection and segmentation of fires in multispectral images using tensor methodology and AI**

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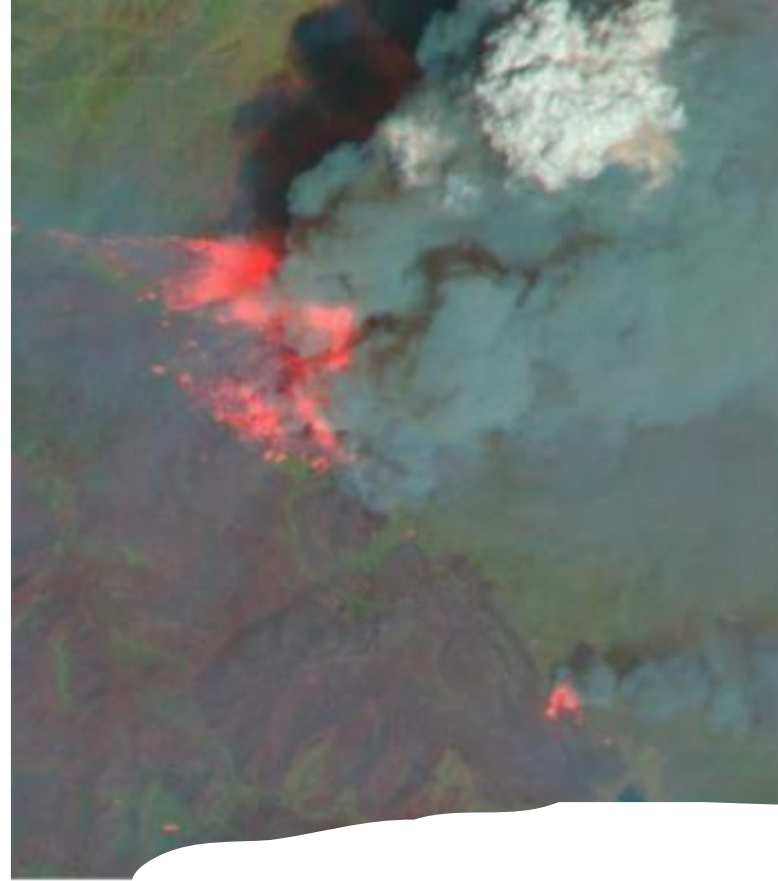
Holdings

Mexico	Colombia	Guatemala
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Spain	El Salvador	of Congo
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Peru	Paraguay	

Agenda

- Motivation
- State of the art
- Problem statement
- Objectives
- Introduction
- Framework
- Big picture
- Result
- Conclusion
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Motivation

State of the art

Author	Method	Date	Classifier	Comment
M. Gargiulo, DAG	CNN-based super-resolution technique for detecting active fires from Sentinel 2 data.	Sentinel 2	CNN	super-resolution data fusion based on convolutional neural networks.
Dmitry Rashkovetsky	Detection of forest fires from multisensory satellite images using deep semantic segmentation.	Sentinel 1, Sentinel 2, Sentinel 3 y MODIS	U-net	Detection of areas affected by forest fires using multisensory satellite imagery and semantic segmentation techniques.
Jose German	Analysis of satellite images and application of spectral indices in forest fires.	Images de Landsat, MODIS, VIIRS, etc.	Aplication of spectral indices	Spectral signatures, applying NVI, performing signature blending.
Osman Gunay	Adaptive decision fusion framework based on entropy function.	cámaras PTZ	SVM	Real-time weight adjustment using entropy and projections.

Problem statement

Detection and segmentation of areas affected by wildfire based on multispectral and hyperspectral images in temporal space (before, during, and after) by analyzing the information using tensor algebra algorithms, allowing for reduction in spatial and spectral spaces.

Objectives

General objective

Develop and evaluate a model for early detection and segmentation of wildfire based on deep learning and tensor algebra algorithms, using multispectral and hyperspectral information in a spatiotemporal approach, in order to optimize the extraction of active hotspots and affected areas, providing effective tools for the management and mitigation of forest fires in areas that are difficult to access.

Objectives

Specific objectives

- Obtain multispectral and hyperspectral images of forest areas affected by fires, considering the periods before, during, and after the events. Implement statistical analysis.
- Implement dimensionality reduction algorithms based on tensor algebra.
- Implement an AI algorithm to perform semantic segmentation.

INTRODUCTION

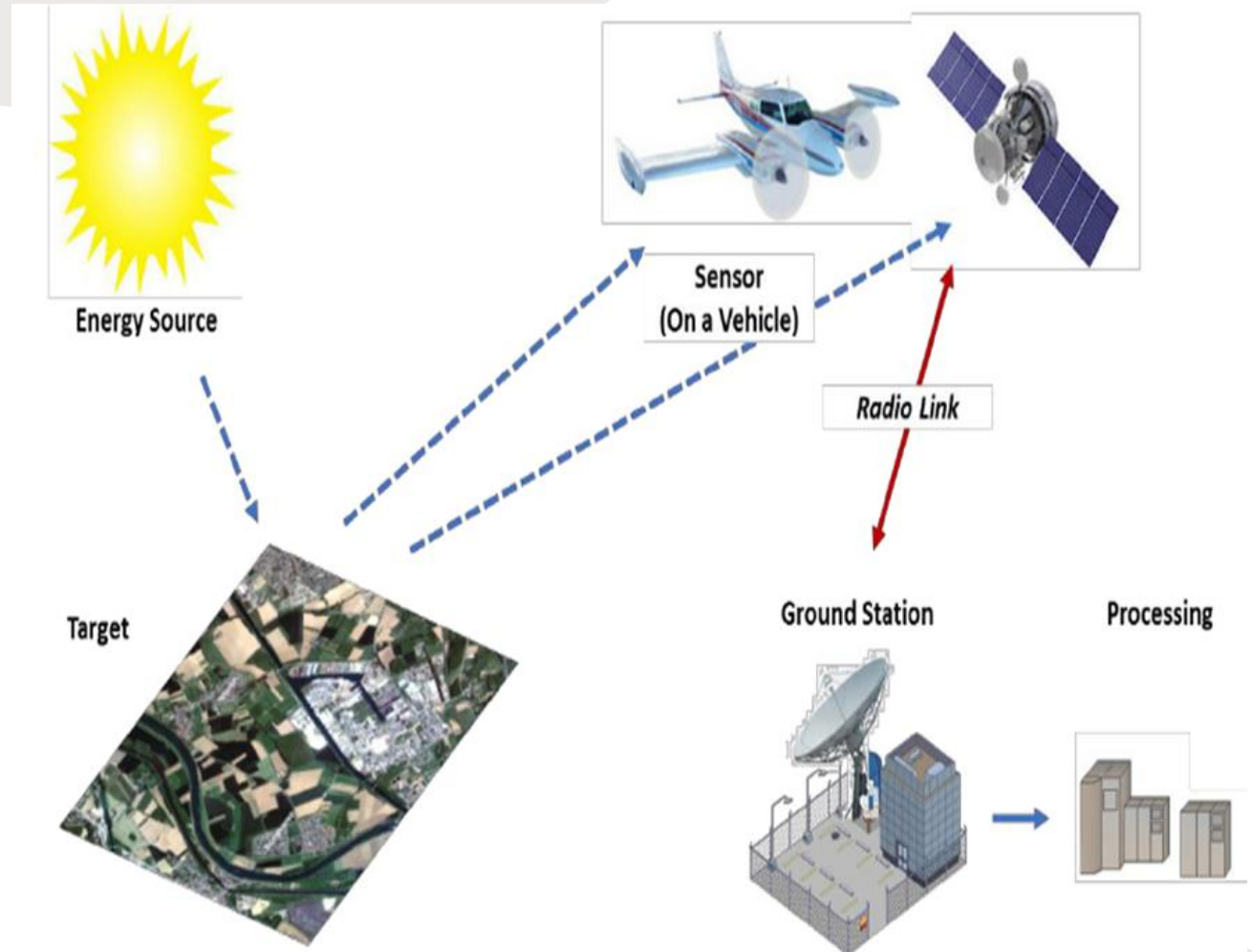
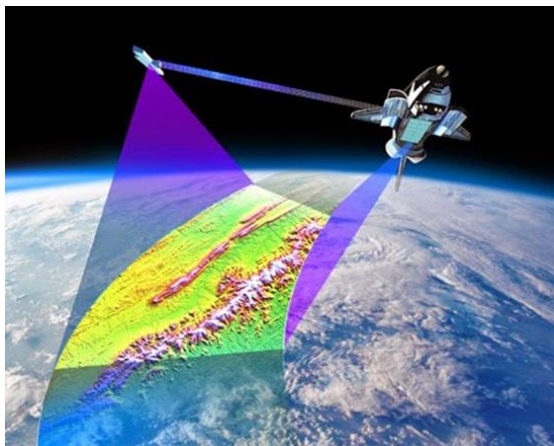
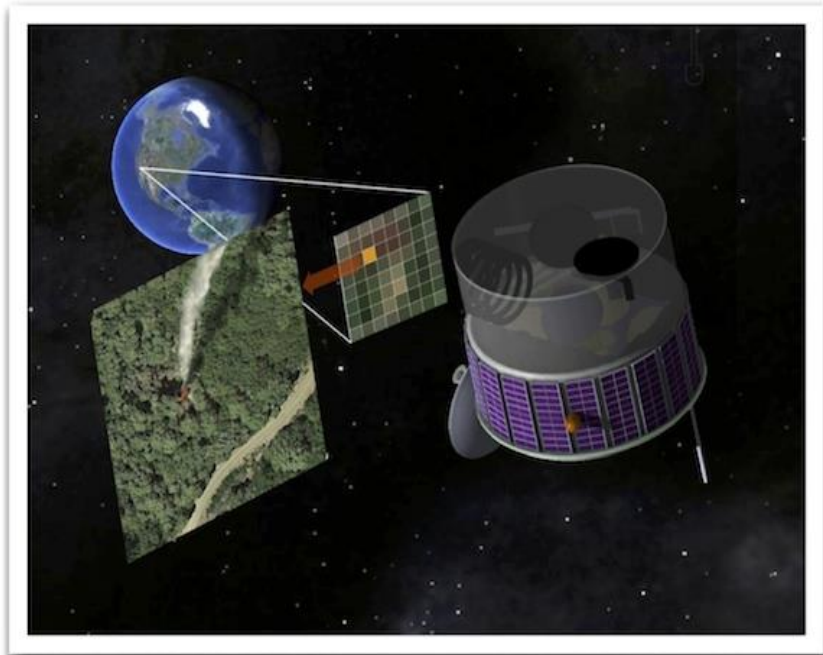
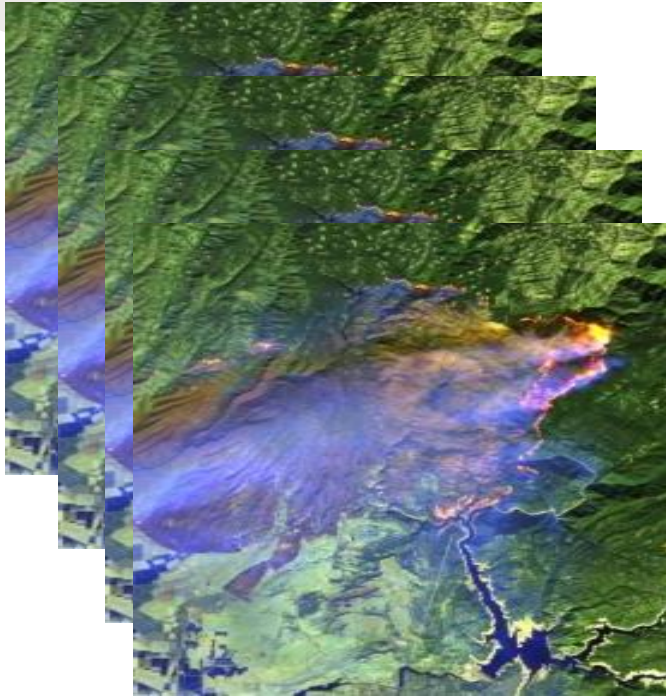


Fig.1. Remote sensing.

FRAMEWORK



Sentinel-2 bands	Central wavelength (μm)	Resolution (m)
Band 1 – Coastal aerosol	0.443	60
Band 2 – Blue	0.490	10
Band 3 – Green	0.560	10
Band 4 – Red	0.665	10
Band 5 – Vegetation red edge	0.705	20
Band 6 – Vegetation red edge	0.740	20
Band 7 – Vegetation red edge	0.783	20
Band 8 – NIR	0.842	10
Band 8A – Vegetation red edge	0.865	20
Band 9 – Water vapour	0.945	60
Band 10 – SWIR – Cirrus	1.375	60
Band 11 – SWIR	1.610	20
Band 12 – SWIR	2.190	20

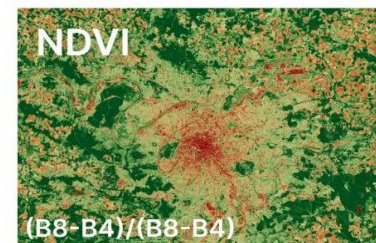
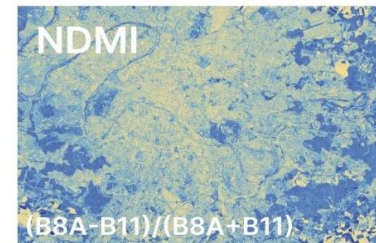
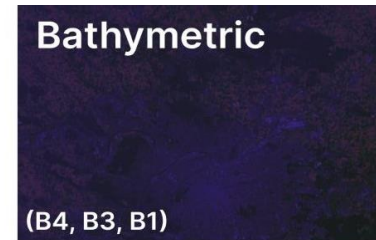
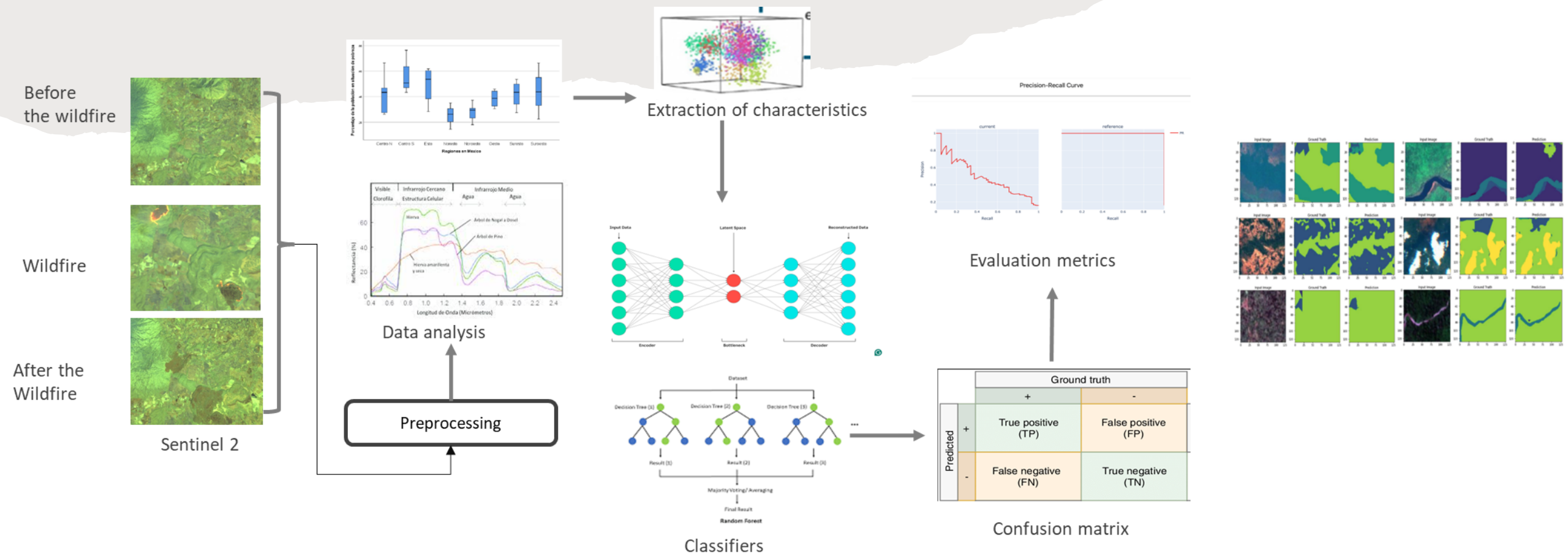


Fig.2. Multispectral image.

BIG PICTURE



REGION OF INTEREST

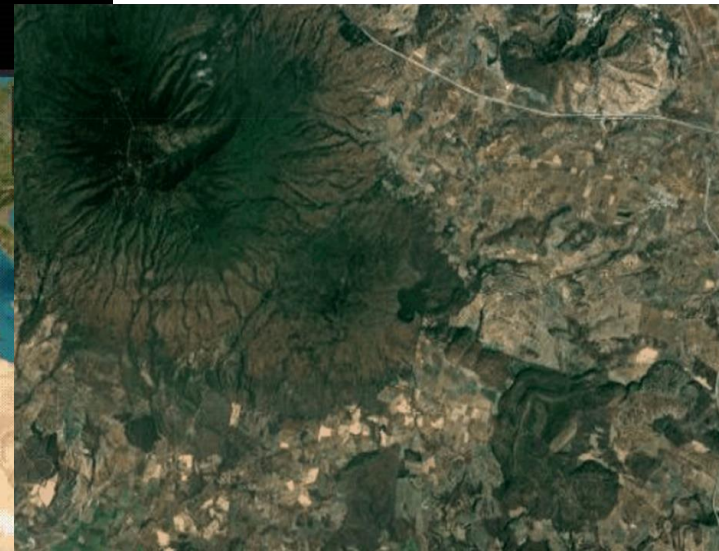
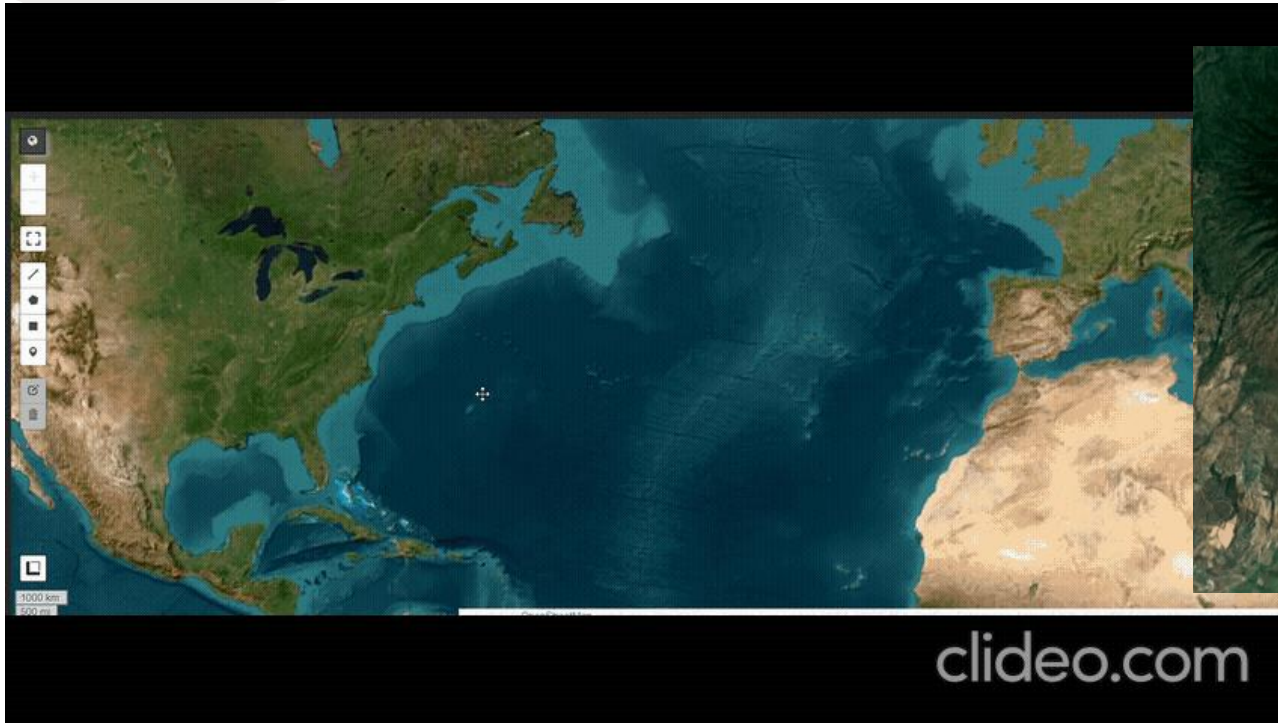


Fig.3. Tequila volcano

REGION OF INTEREST

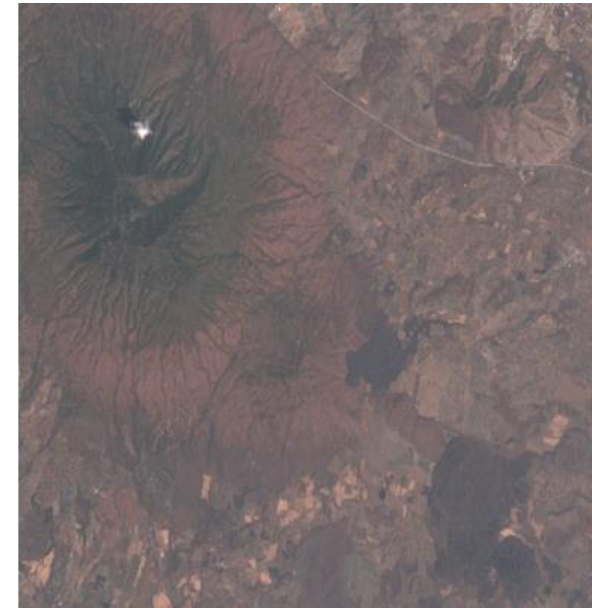
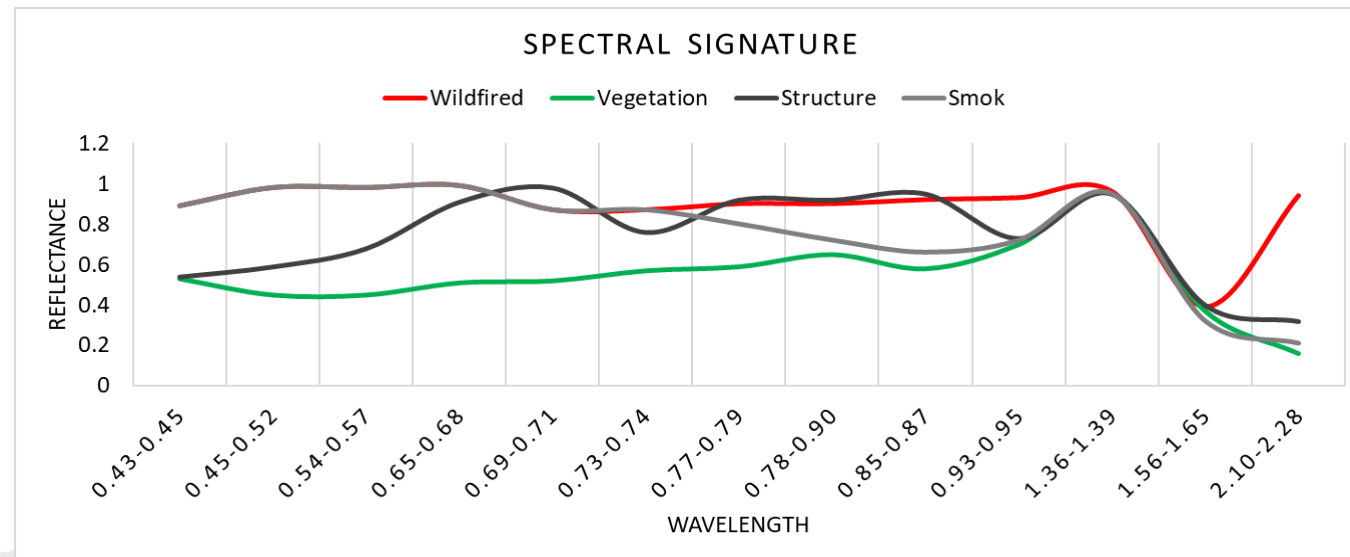
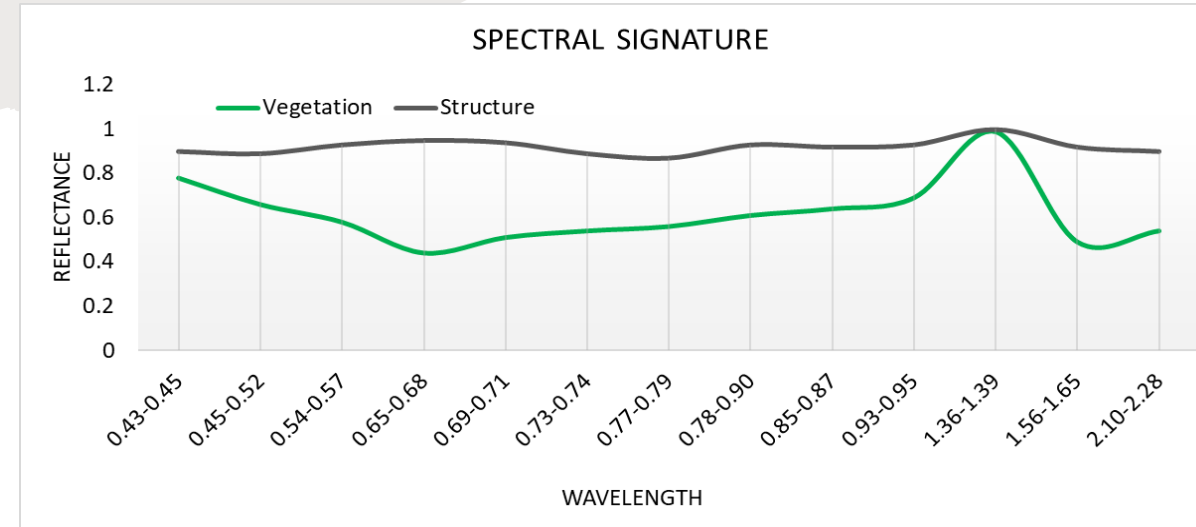
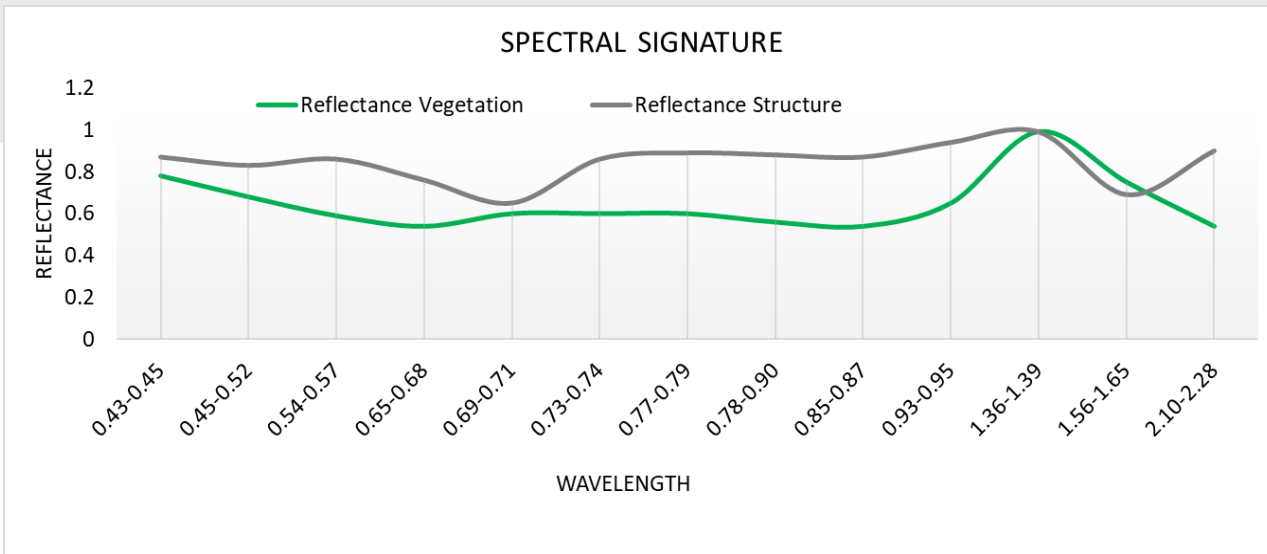
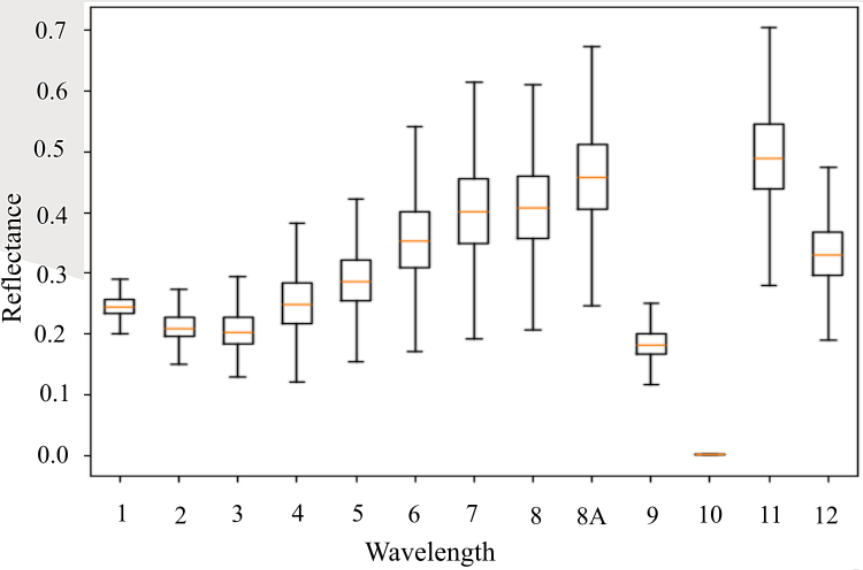


Fig.4. Tequila volcano

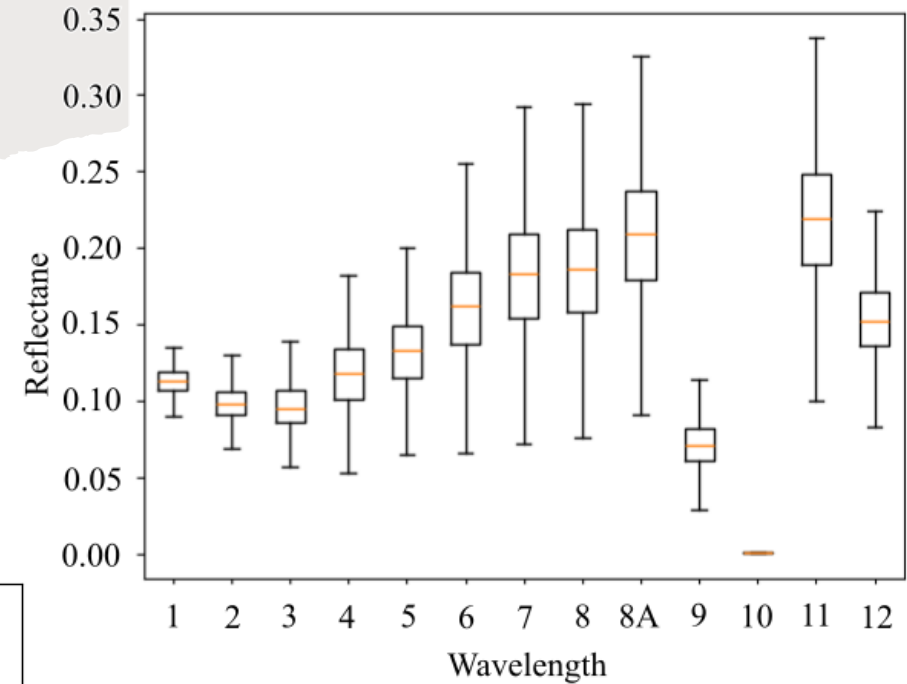
SPECTRAL SIGNATURE



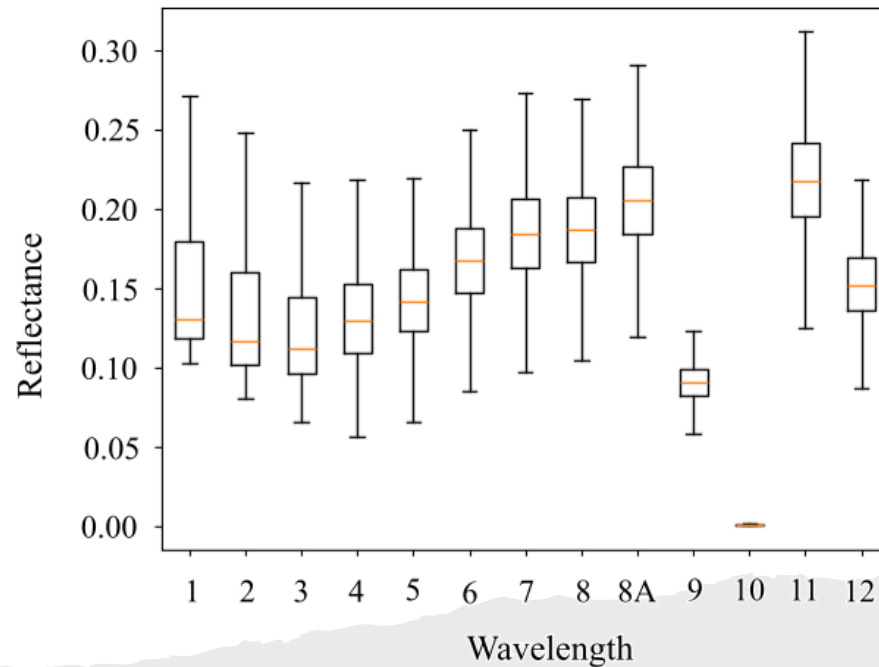
BOX AND WHISKERS



a) Before the wildfire



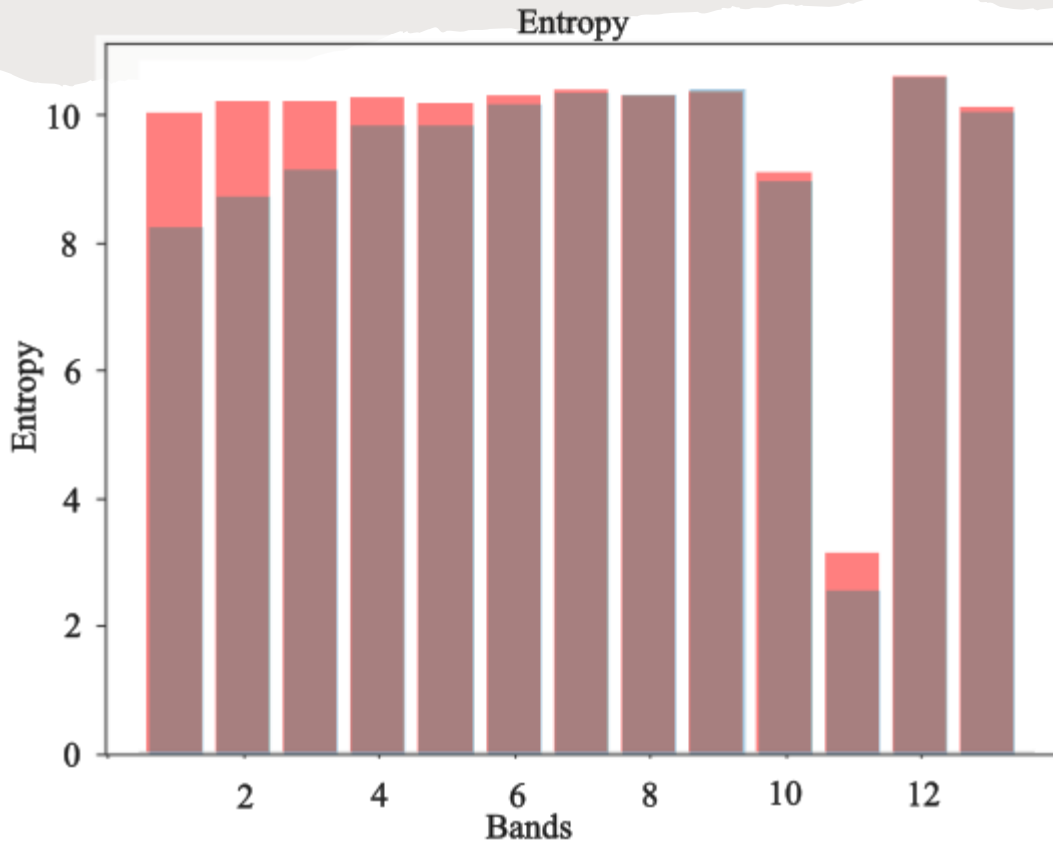
c) After the wildfire



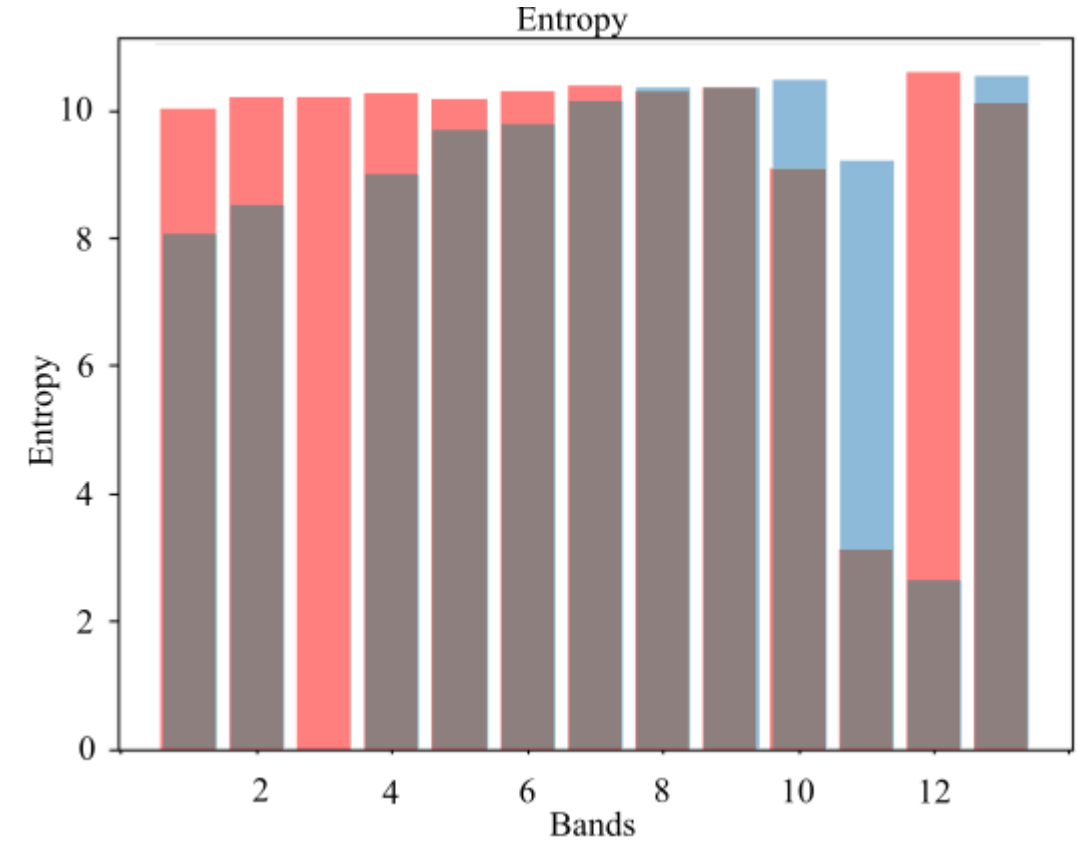
b) Wildfire

ENTROPY

$$\text{Entropy} = -\sum P(i) \log(p_i)$$



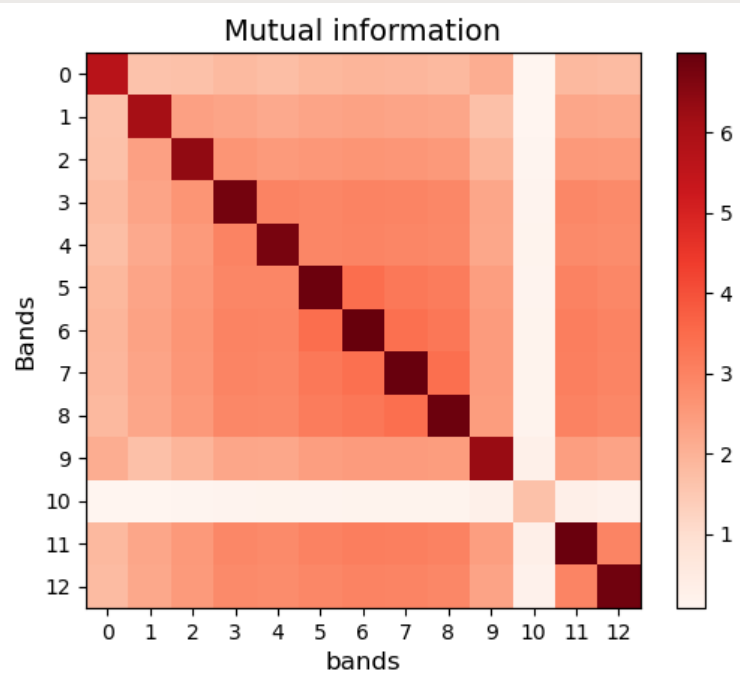
a)



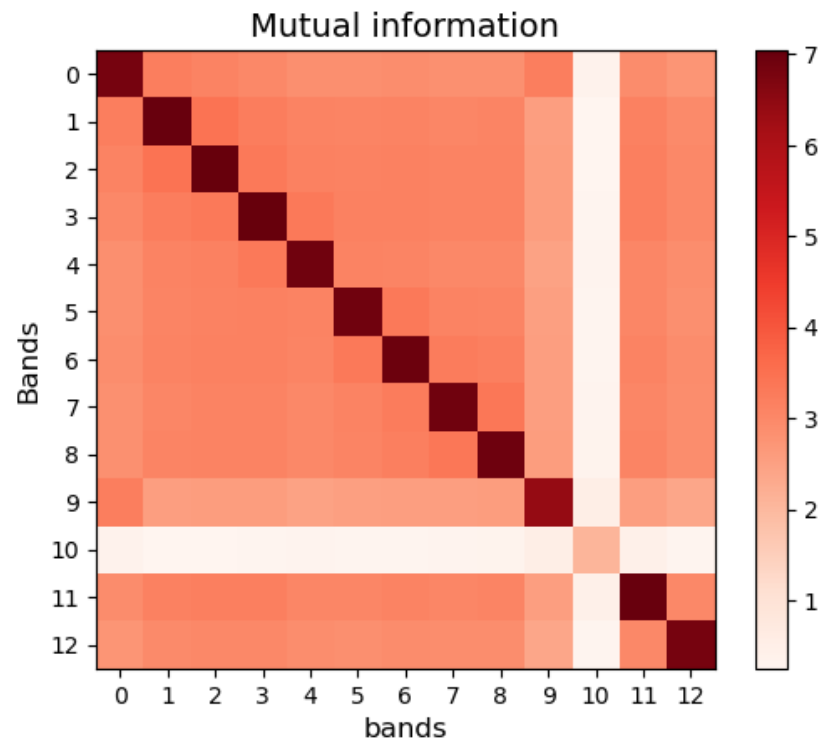
b)

Fig.7. Entropy a) before and wildfire b) wildfire and after

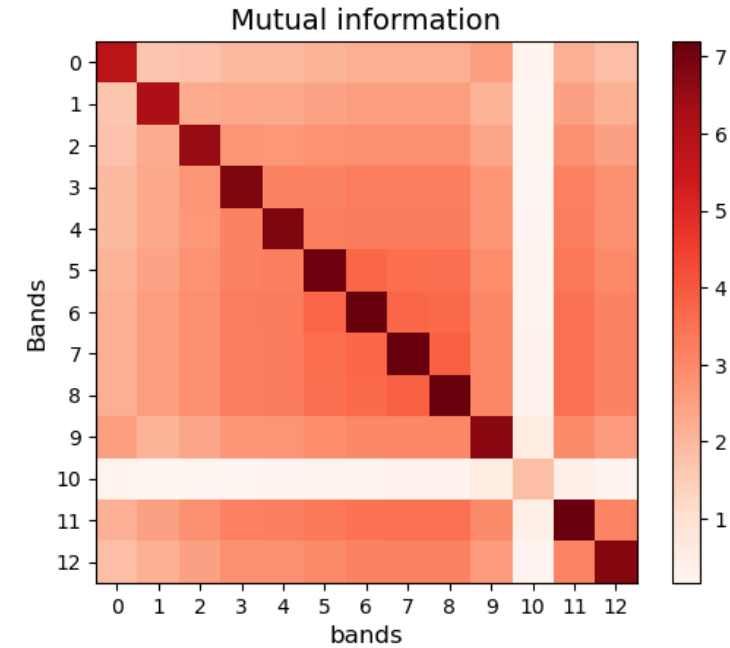
MUTUAL INFORMATION



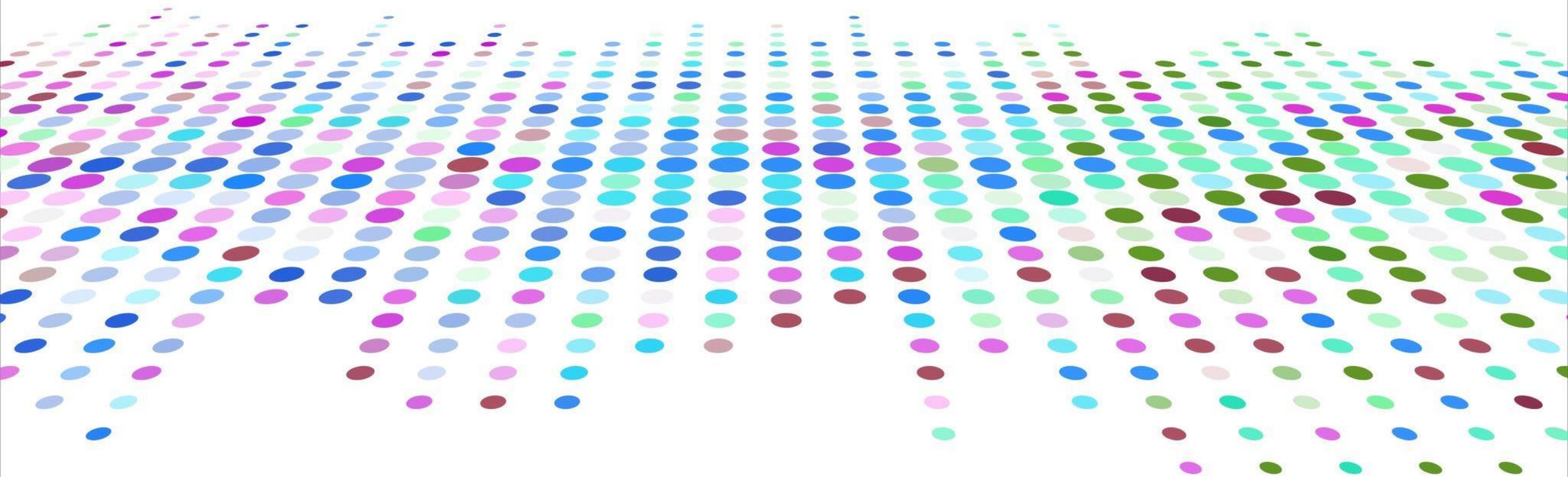
a) Before the wildfire



b) Wildfire



c) After the wildfire



SPECTRAL INDEX

SPECTRAL INDEX

Normalized Difference Vegetation Index: $NDVI = \frac{NIR - RED}{NIR + RED}$

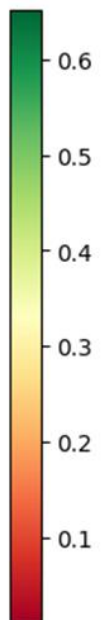
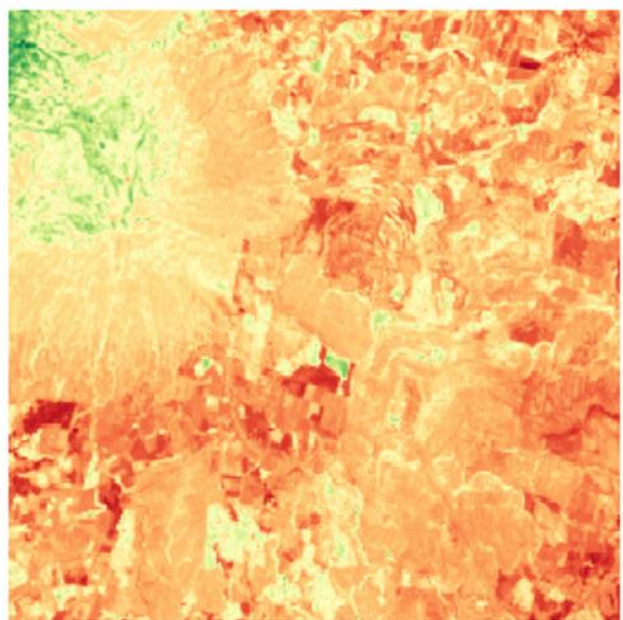
Normalized Burn Ratio: $NBR = \frac{RED - SWIR}{RED + SWIR}$

Normalized Difference water index: $NDWI = \frac{GREEN - SWIR}{GREEN + SWIR}$

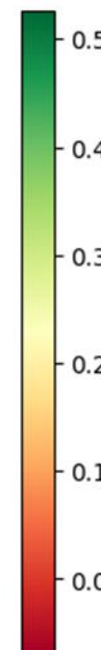
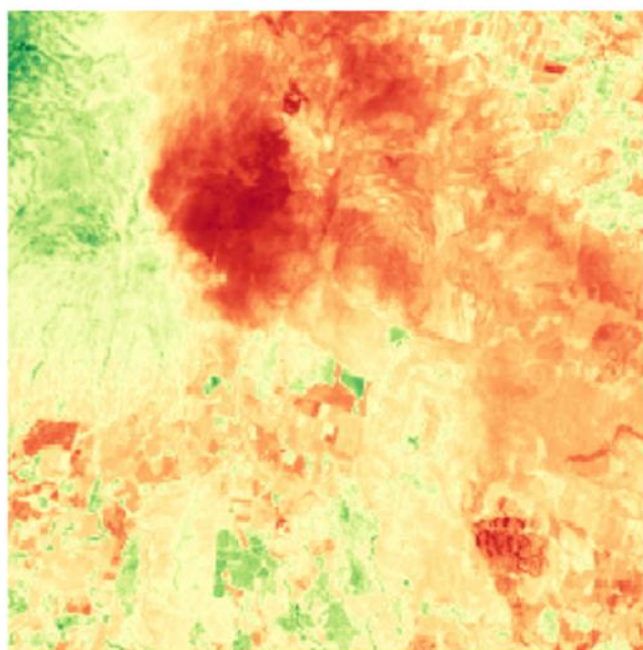
Wildfires Detection: $DWI = \frac{SWIR}{VEGETATION\ RED\ EDGE * WATER\ VAPOUR}$

Wildfires Limint: $WL = \frac{8.5 * SWIR - SWIR}{SWIR + SWIR + 0.25}$

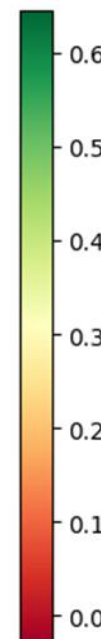
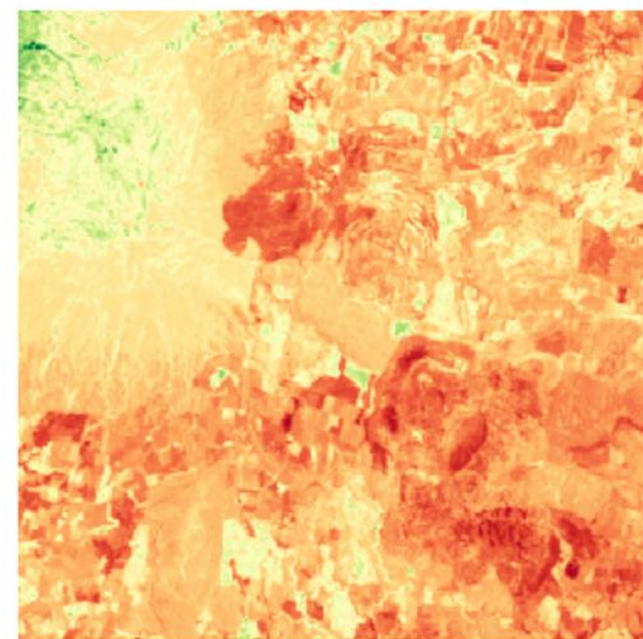
NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)



NDVI(23-03-2023)

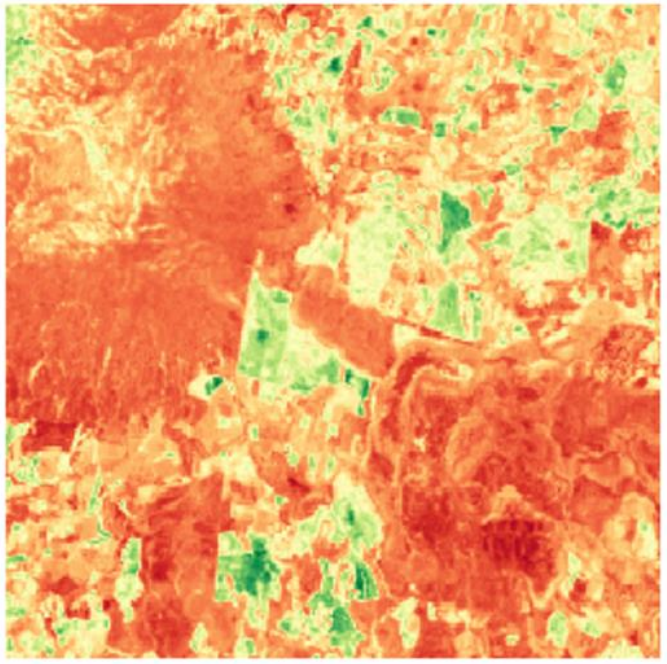


NDVI(28-03-2023)

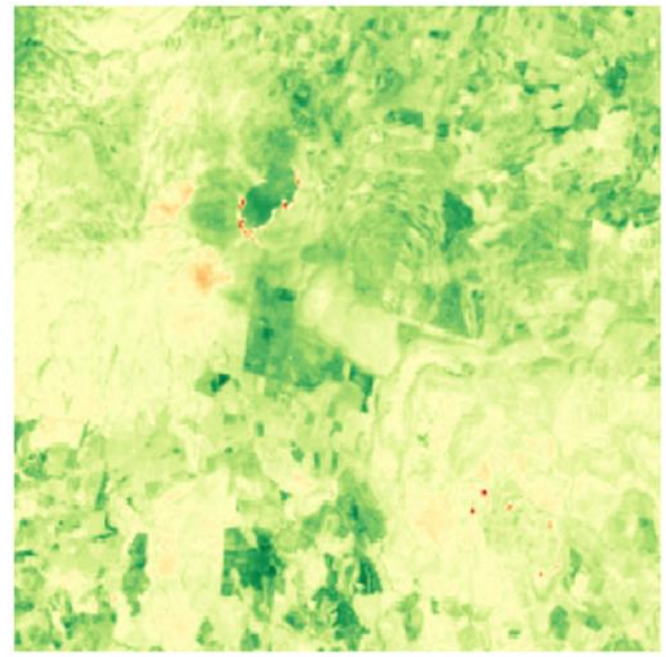


NDVI(07-04-2023)

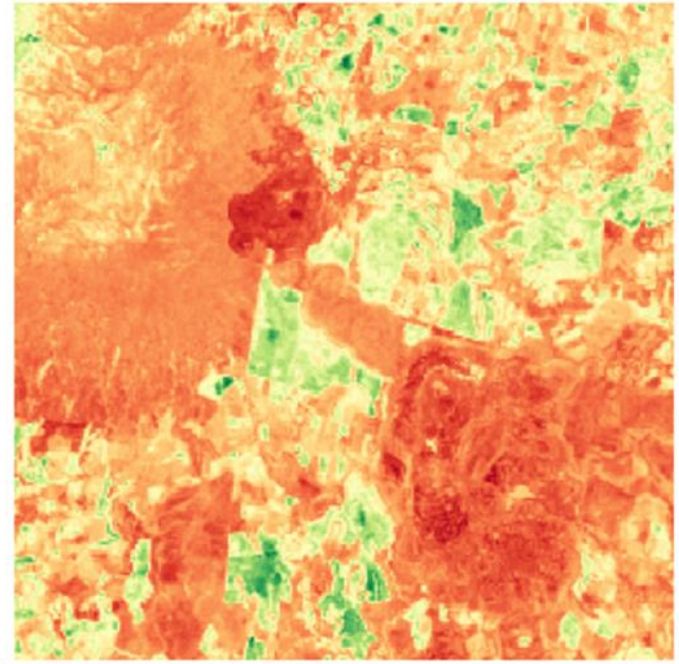
NORMALIZED BURN RATIO (NBR)



NBR
(23-03-2023)

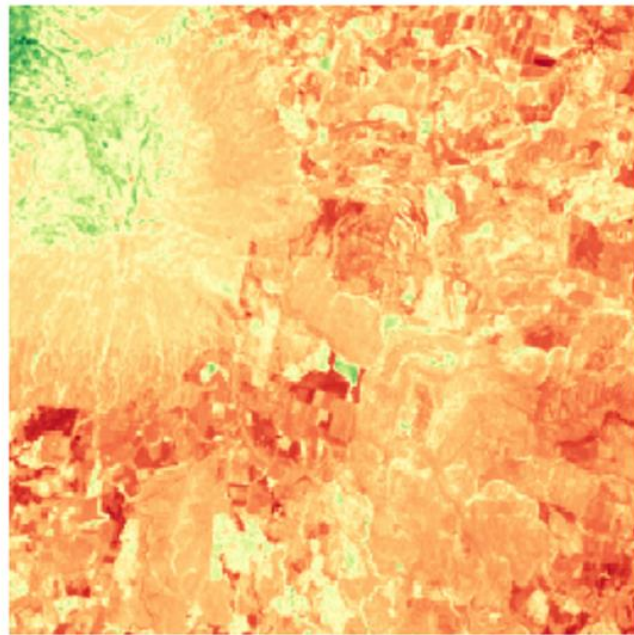


NBR
(28-03-2023)

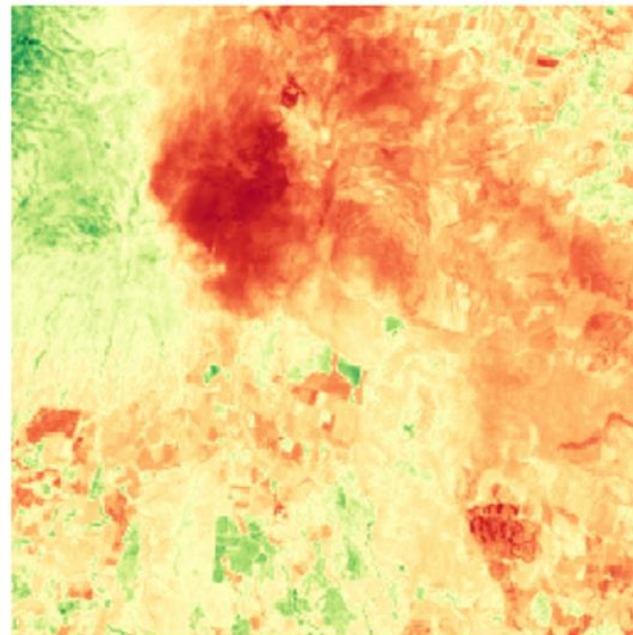


NBR
(07-04-2023)

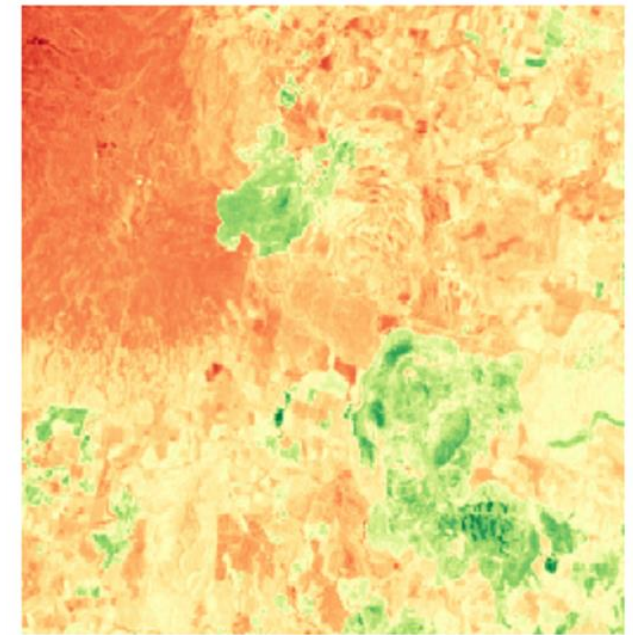
NORMALIZED DIFFERENCE WATER INDEX (NDWI)



NDWI
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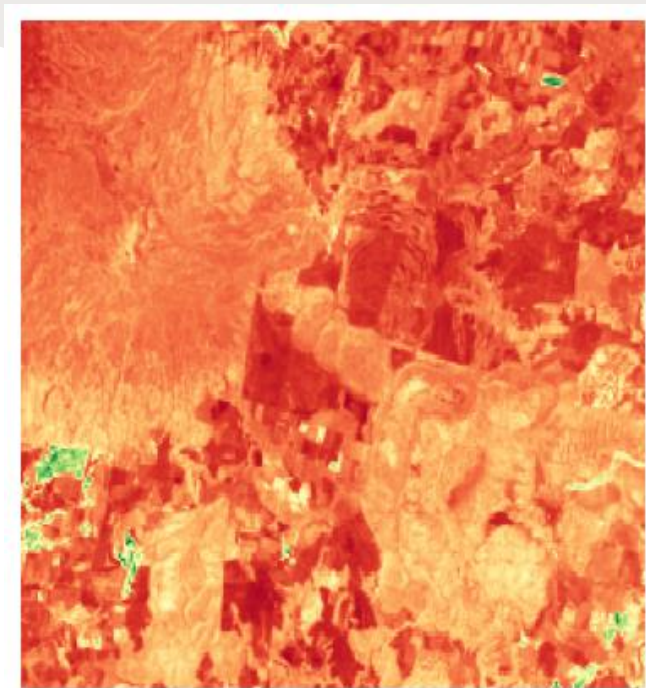


NDWI
(28-03-2023)

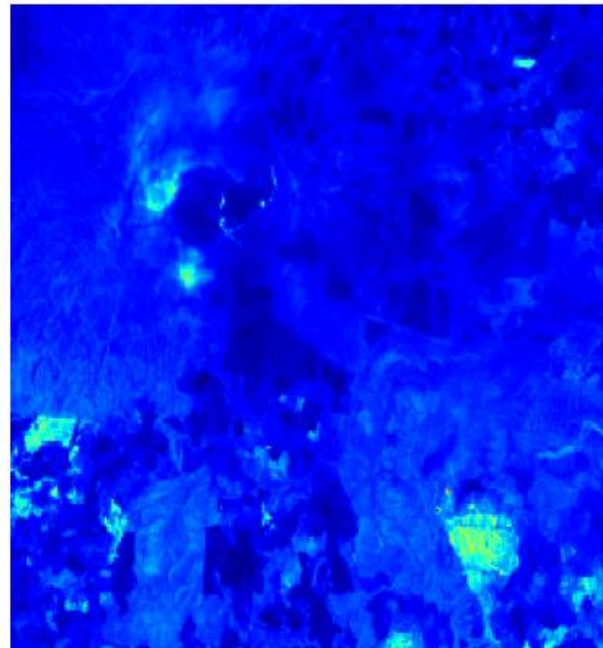


NDWI
(07-04-2023)

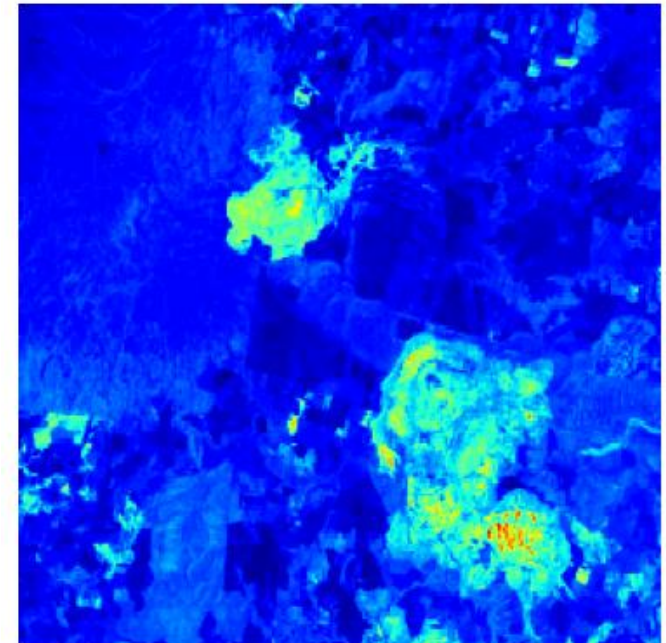
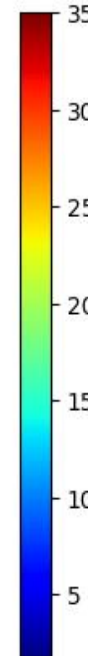
WILDFIRES DETECTION (DWI)



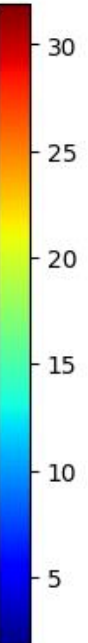
DWI
(23-03-2023)



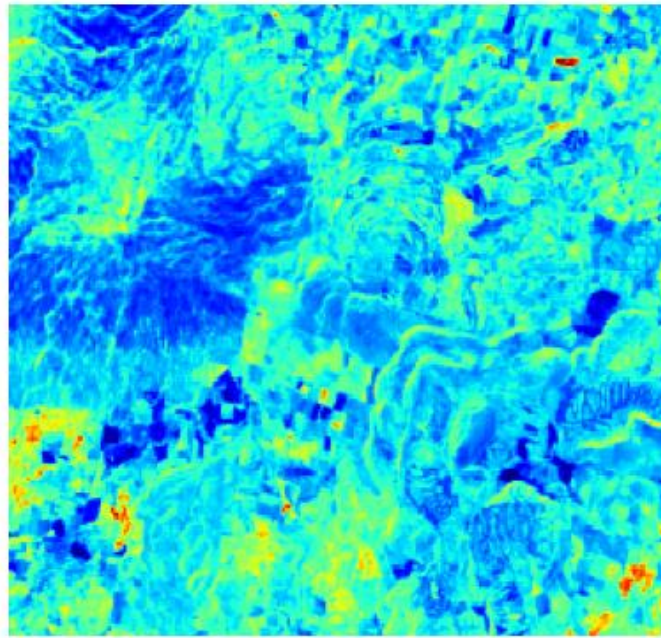
DWI
(28-03-2023)



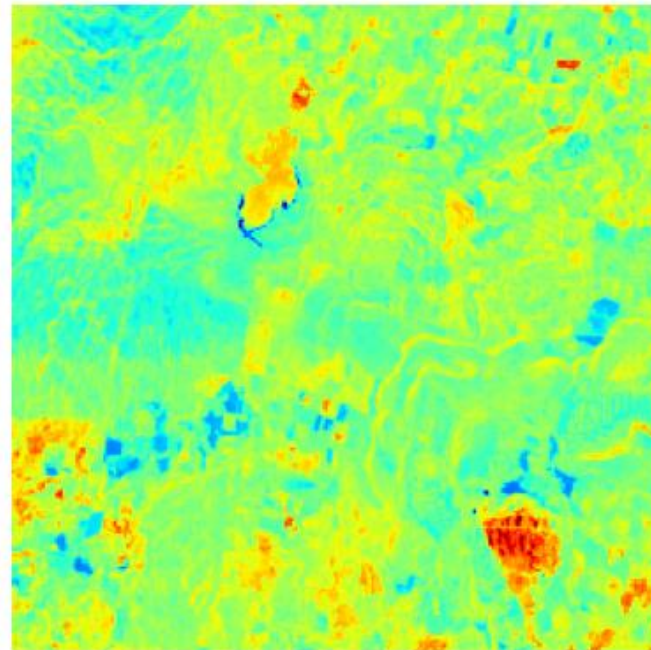
DWI
(07-04-2023)



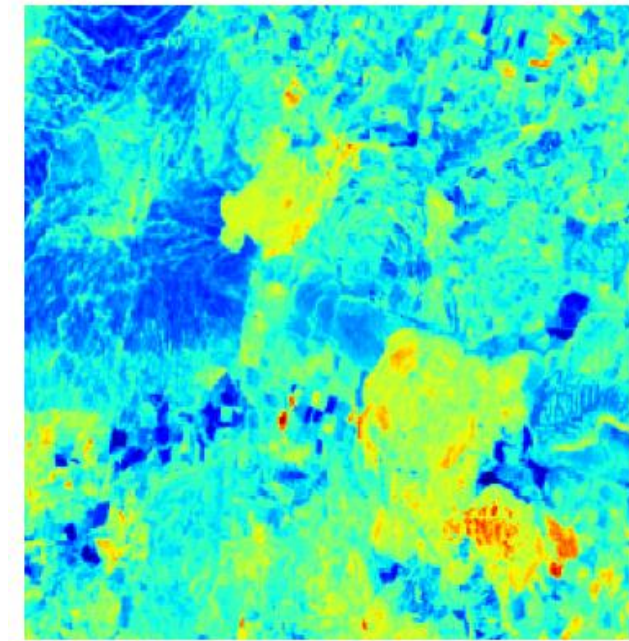
WILDFIRES LIMINT (LW)



LW
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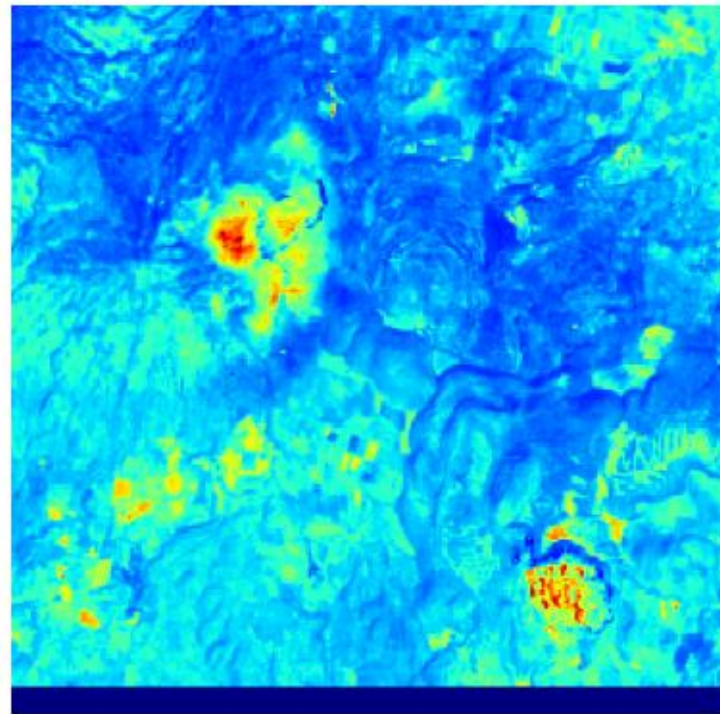


LW
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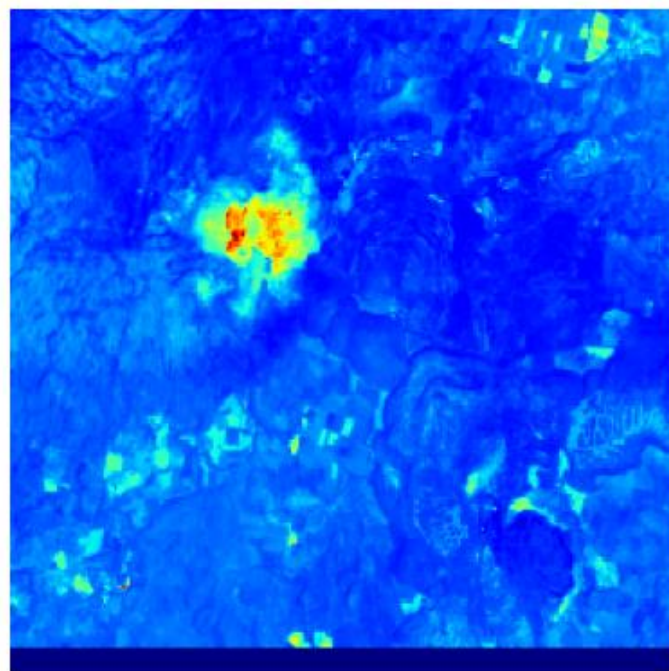
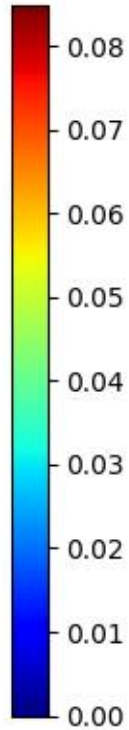


LW
(07-04-2023)

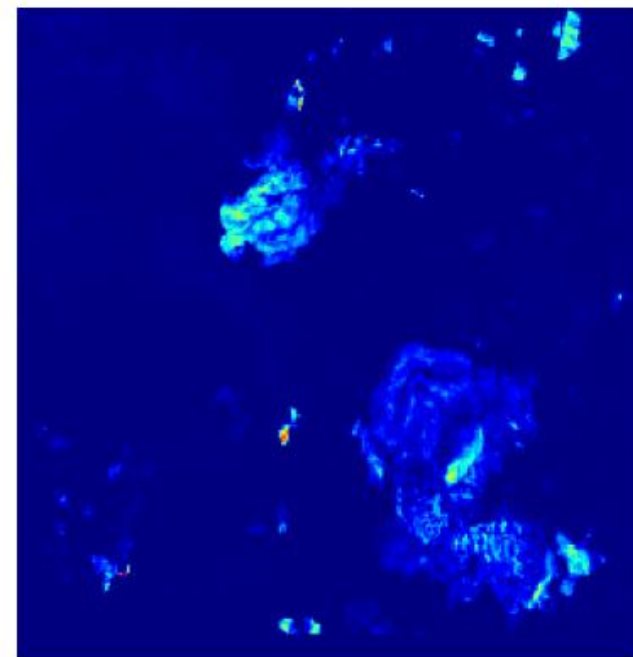
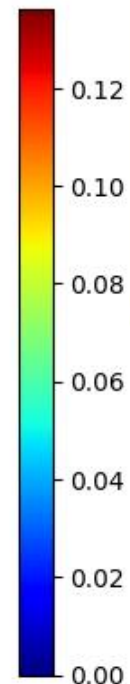
CHANGE DETECTION



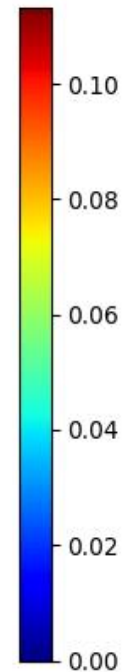
a) Before and wildfires

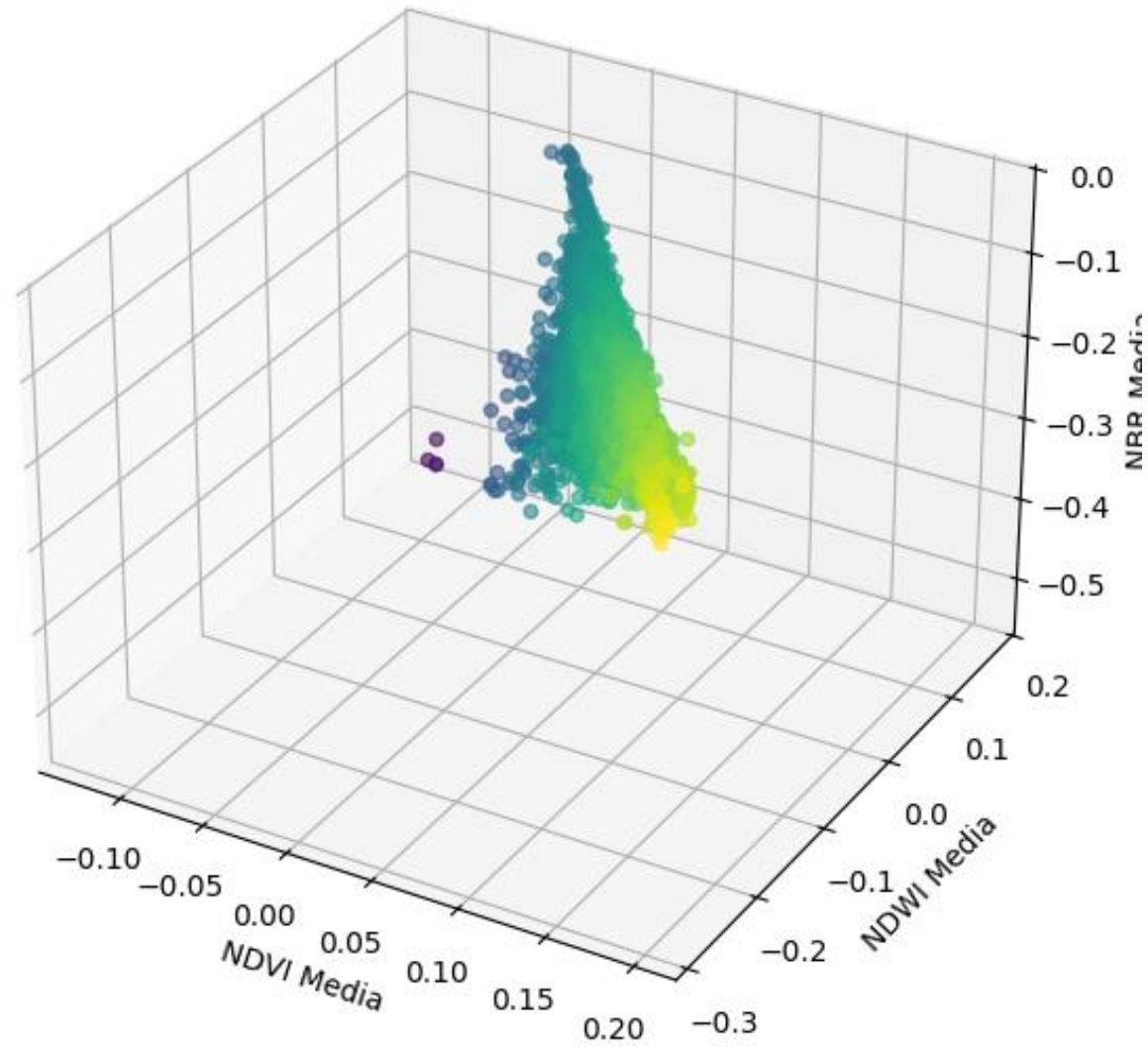


b) Wildfire



c) After the Wildfire





EXTRACTION OF CHARACTERISTICS

Fig.16. Spectral Characteristics

CONCLUSION

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