digital futures

EO-AI4Wildfire:

Earth Observation Big Data & AI for Early Detection and Near Real-Time Monitoring of Wildfires

Yifang Ban & Team
Professor & Director, Division of Geoinformatics
KTH Royal Institute of Technology
&
Associate Director – Dissemination & Impact, Digital Futures
Stockholm, Sweden
Email: yifang@kth.se

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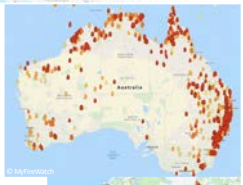
Wildfires



- Damage property and infrastructure
- Kill and displace people
- Burn vegetation, endanger wildlife, cause pollution
- Cost millions or billions of dollars to fight

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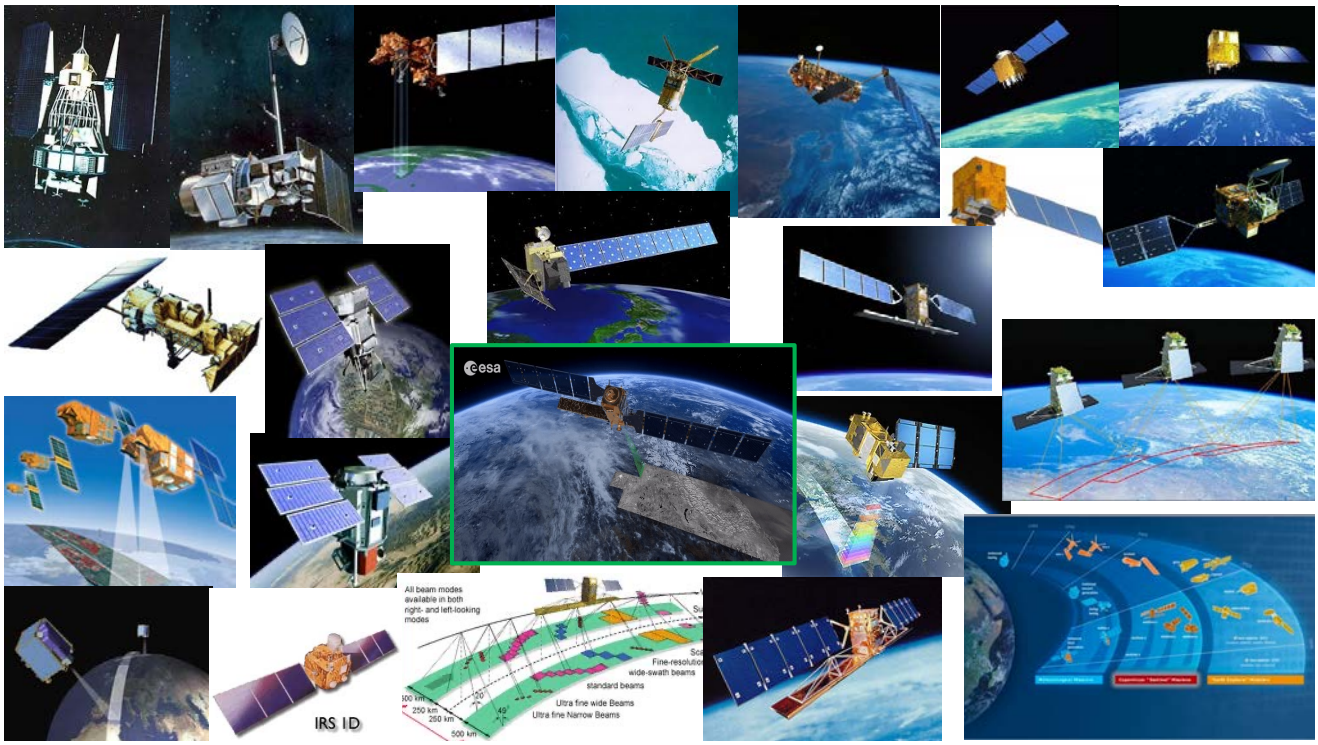

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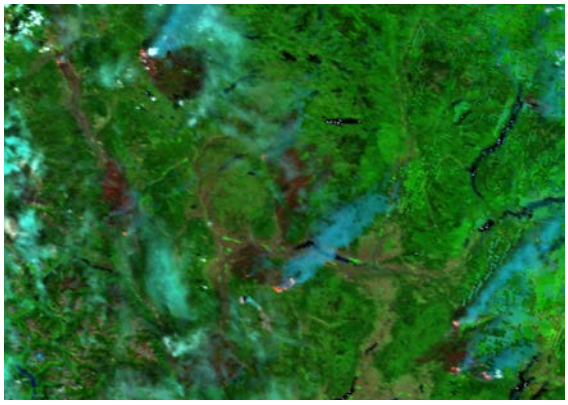
Research Objectives

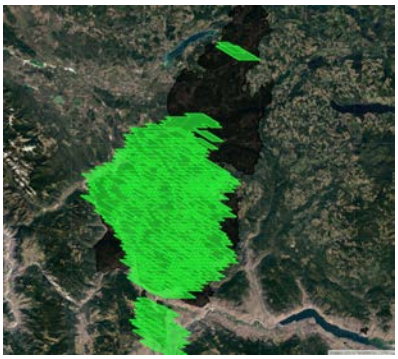
- The overall objective of this research is to develop innovative and globally applicable methods for *early detection, near real-time monitoring of wildfires and rapid damage assessment* using Earth Observation (EO) big data and deep learning.

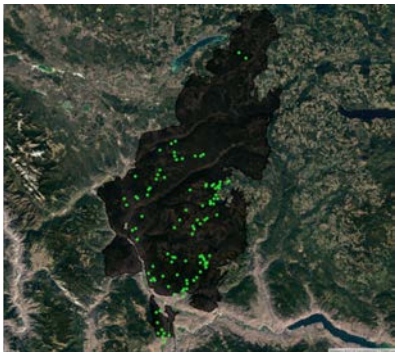
4

Introduction

- **For wildfire detection & monitoring**
  - VIIRS and MODIS Active Fire Hot Spots & burned area maps are often used for contextual awareness







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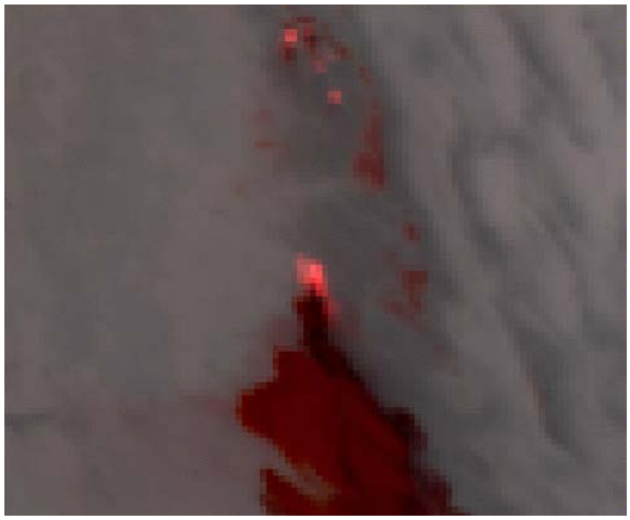
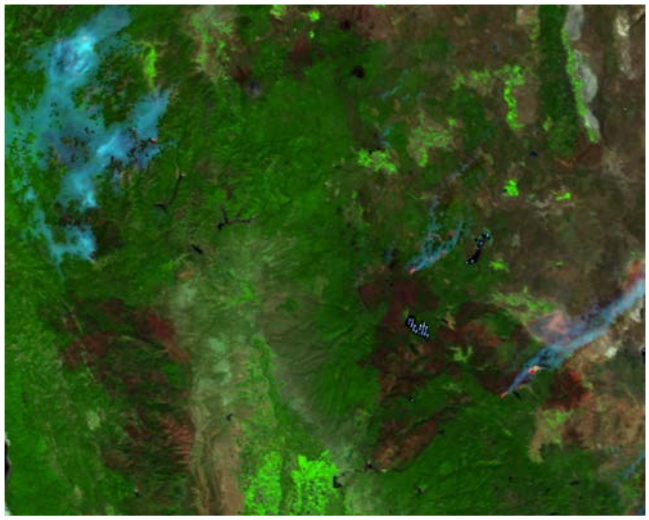
Multisensor EO Time Series for Wildfire Monitoring





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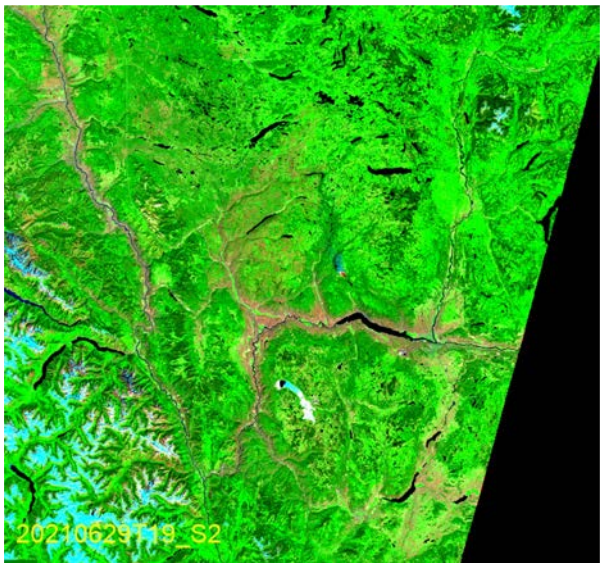
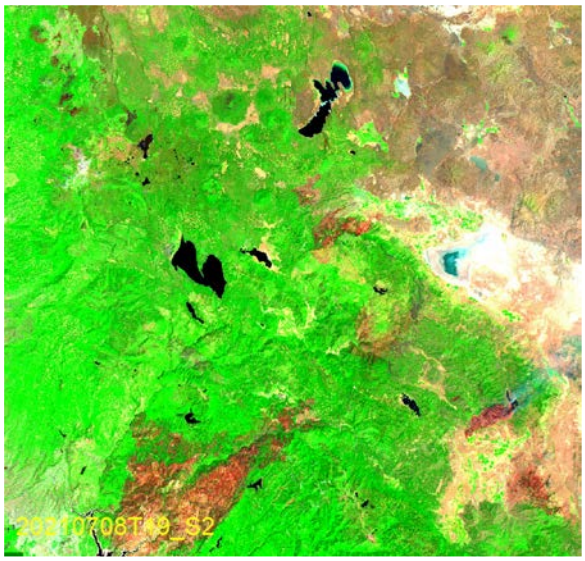
Multisensor EO Time Series for Wildfire Monitoring

2021 Lytton + Sparks Lake Fires, BC, Canada



2021 Dixie Fire, California, USA



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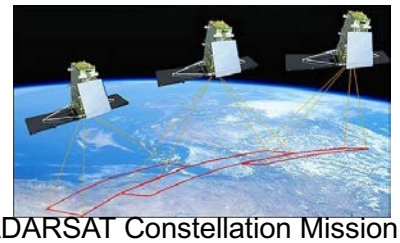
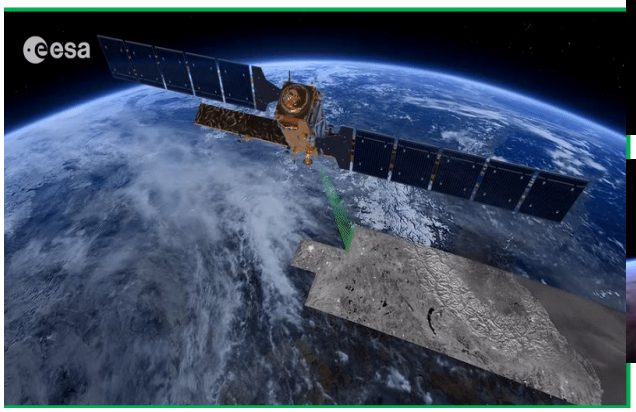
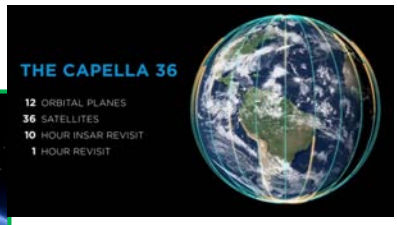
Spaceborne SAR Daily



RADARSAT Constellation Mission SAR

ESA Sentinel-1 SAR





ESA ROSE-L

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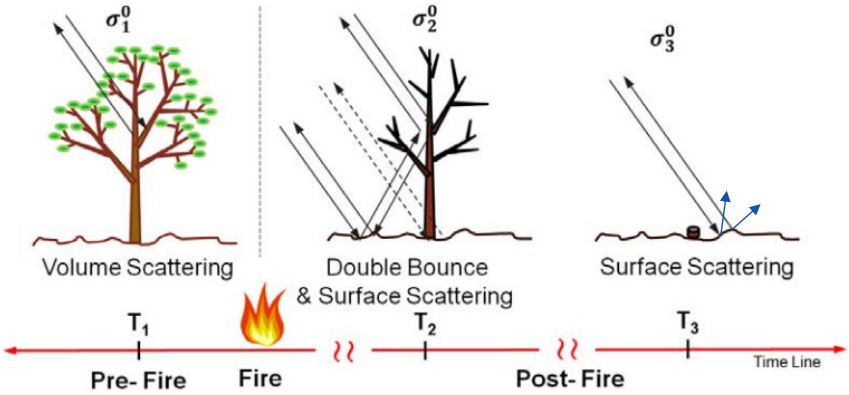
Physical Basis: *SAR Data for Wildfire*



- **Scene Properties**
  - ✓ Roughness
  - ✓ Surface Geometry
  - ✓ Moisture
  - ✓ Burn Severity
- **Sensor Properties**
  - ✓ Wavelength
  - ✓ Polarization
  - ✓ Incidence Angle
  - ✓ Imaging Geometry

$$RBR_{xy} = \frac{\gamma^0 \text{postfire}_{xy}}{\gamma^0 \text{prefire}_{xy}}$$

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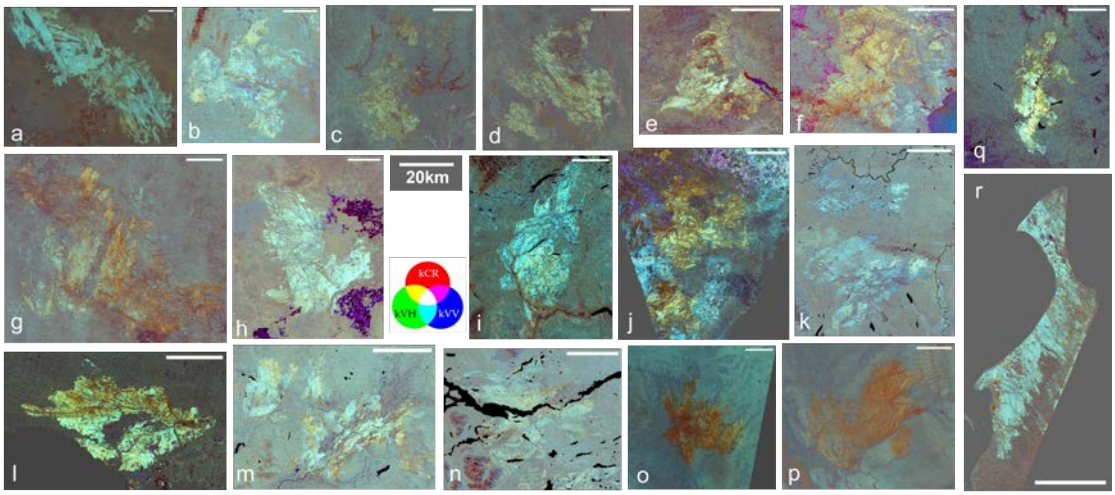
Sentinel-1 C-Band SAR Detection of Wildfires



SAR-based kMaps on 18 wildfire events, of which 16 events were used for training and validation, while the rest two (q and r) were used only for progression mapping. All kMap images are visualized in the false color composite of [kCR, kVH, kVV]. The yellowrish denotes kCR and kVH have higher values than kVV, while the cyanrish denotes kVH and kVV contribute more to highlighting burned areas.

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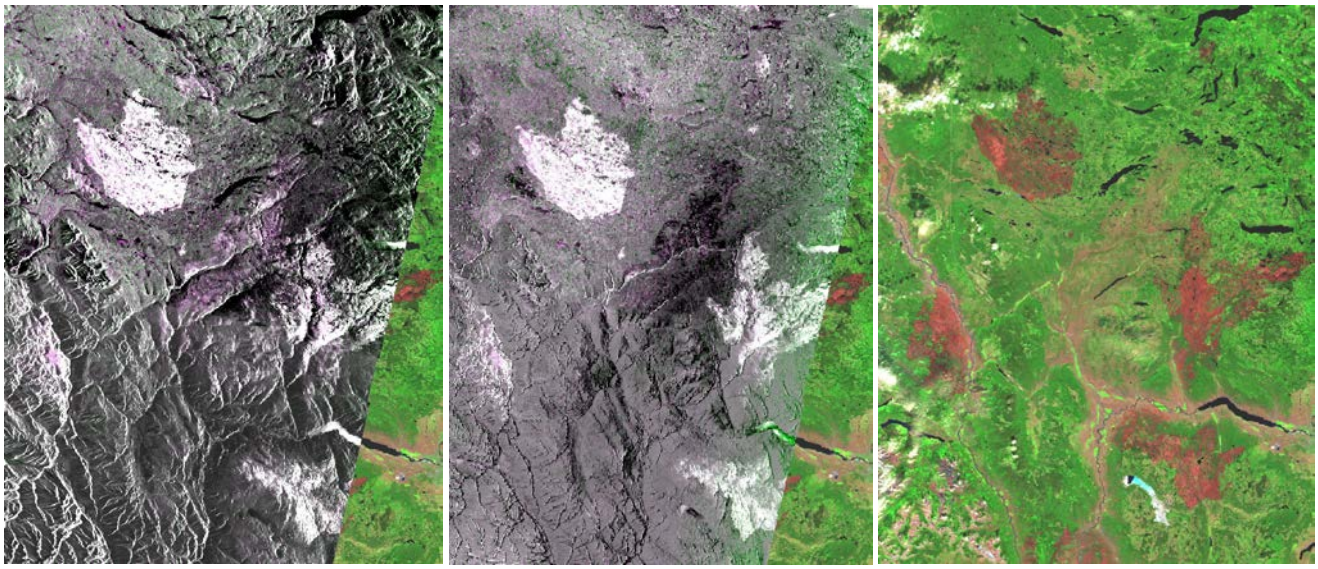
RCM SAR Detection of Wildfires



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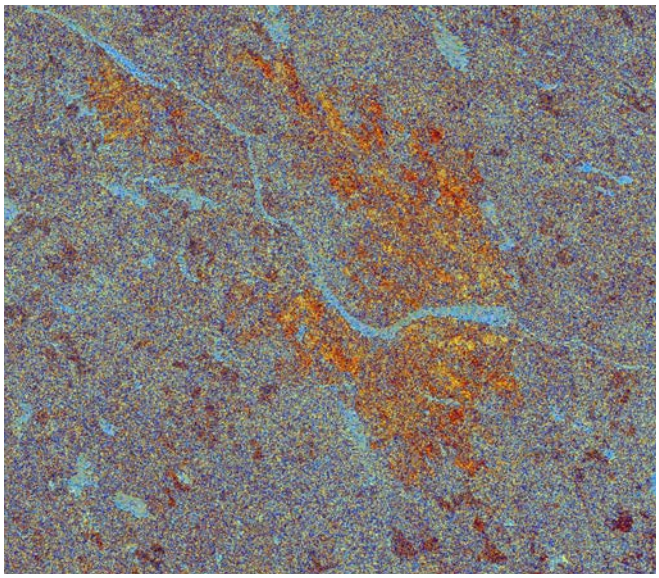
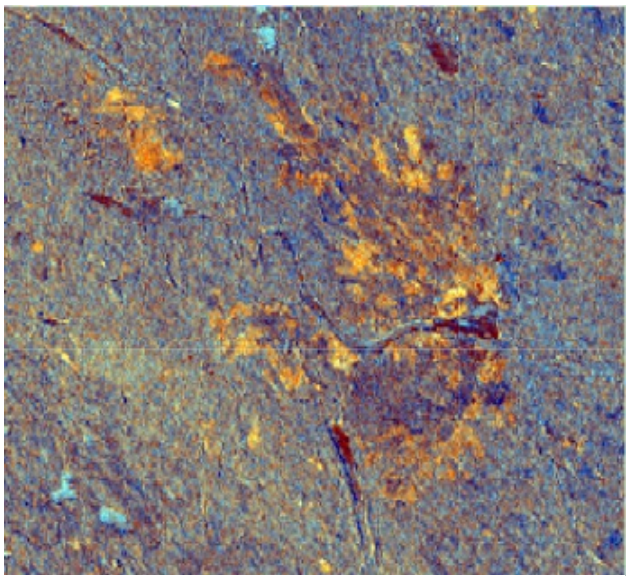
SAR Detection of Ljusdals-komplexet in 2018

Sentinel-1 C-Band SAR



ALOS L-Band PalSAR



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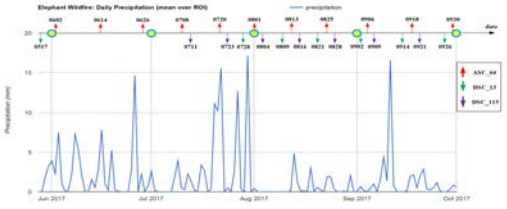
Validations



To quantitatively assess the SAR-based burnt area results:

- Sentinel-2 dNBR is segmented into a binary map of burnt and unburnt areas and used as the reference maps together field data and WorldView-3 imagery
- 10000 validation points are randomly selected from burnt and unburnt areas respectively

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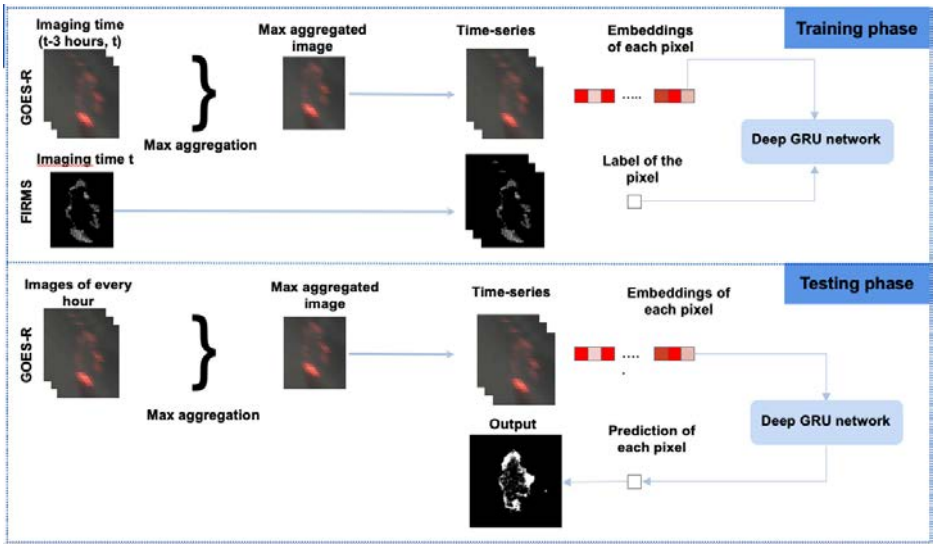
Early Detection of Wildfires with GOES-R Time Series & Deep GRU Network



Zhao, Y., Y. Ban and A. Nascetti. 2021. Early Detection of Wildfires with GOES-R Time-Series and Deep GRU Network. *Proceedings of IGARSS'2021*, Brussels, Belgium.
Zhao, Y. and Y. Ban. 2022. GOES-R Time Series for Early Detection of Wildfires with Deep GRU Network. Remote Sensing. *Remote Sensing*, 14(17), 4347. https://doi.org/10.3390/rs14174347

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Table 4. Comparison over all study areas for FIRMS detection time and Deep GRU network detection time, '+1' means the detection of the active fire happens on the next day of the start date. The name of the wildfire are either named after fire names from The Department of Forestry and Fire Protection of California, fire numbers from British Columbia Wildfire Service, fire numbers from 2020 Major Amazon Fires Tracker, developed by InfoAmazonia, and the location of the wildfire where it happens.

Location	Fires	Start Date	Location	FIRMS Time	GOES Time	Result
California, US	Creek fire	5 September 2020	(−119.30, 37.20)	09:06	06:00–07:00	Earlier
	Blue Ridge Fire	26 October 2020	(−117.68, 33.88)	09:06	06:00–07:00	Earlier
	Silverado Fire	26 October 2020	(−117.66, 33.74)	07:54	06:00–06:59	Earlier
	Bond Fire	2 December 2020	(−117.67, 33.74)	09:12	08:00–09:00	Earlier
	Glass Fire	27 September 2020	(−122.50, 38.57)	21:06	11:00–12:00	Earlier
	North Complex Fire	14 August 2020	(−120.12, 39.69)	05:47 +1 day	20:00–21:00	Earlier
	Camp Fire	8 November 2018	(−121.43, 39.81)	18:14	15:00–16:00	Earlier
	Tubbs Fire	8 October 2017	(−122.63, 38.61)	06:32	05:00–06:00	Earlier
	Carr Fire	23 July 2018	(−122.62, 40.65)	21:08	21:00–22:00	Similar
	Dixie Fire	14 July 2021	(−121.42, 39.81)	20:30	05:00–06:00	Earlier
Oregon State, US	Holiday farm fire	7 September 2020	(−122.45, 44.15)	09:00	05:00–06:00	Earlier
	Slater fire	7 September 2020	(−123.38, 41.77)	20:24	15:00–16:00	Earlier
	Beachie creek fire	17 August 2020	(−121.62, 44.77)	09:12	10:00-11:00	Later
Amazon, Brazil	brazil_fire_1214	5 September 2020	(−51.61, −9.894)	16:06	14:00–15:00	Earlier
	brazil_fire_668	1 September 2020	(−54.49, −10.52)	04:42	00:00–01:00	Earlier
	brazil_fire_675	31 August 2020	(−53.83, −10.80)	05:00	00:00–01:00	Earlier
	brazil_fire_1341	2 September 2020	(−54.07, −12.87)	04:06	00:00–01:00	Earlier
	brazil_fire_728	2 September 2020	(−52.10, −8.24)	17:00	14:00–15:00	Earlier
Washington State, US	Palmer fire	18 August 2020	(−119.56, 48.83)	22:00	22:00–23:00	Similar
	Cold spring fire	7 September 2020	(−119.49, 48.29)	11:00	06:00–07:00	Earlier

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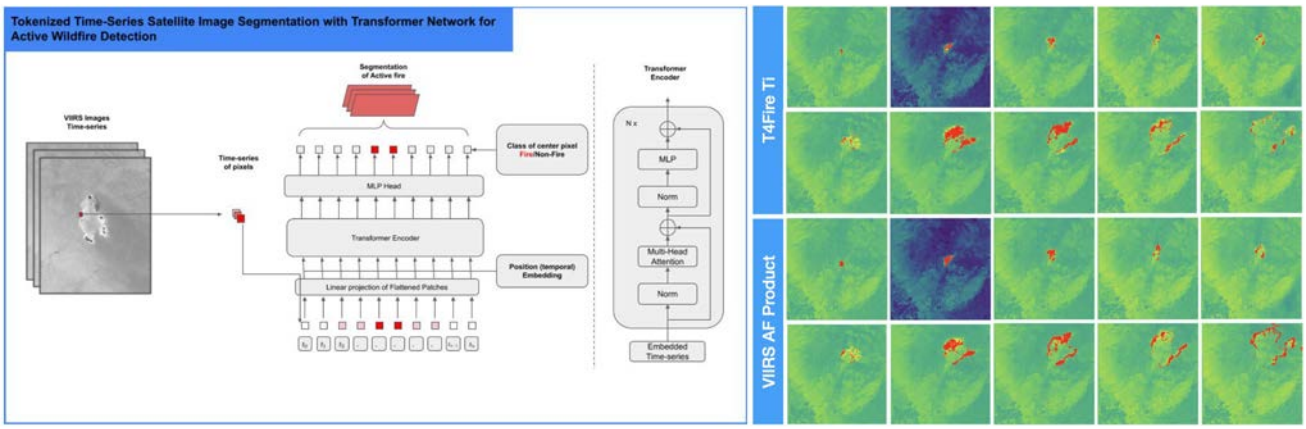
EO-AI for Early Detection of Active Wildfires



Zhao, Y., Y. Ban, H. Hu, & J. Sullivan. Tokenized Time-Series Satellite Image Segmentation with Transformer Network for Active Wildfire Detection. Submitted to IEEE Transaction on Geosicence and Remote Sensing.

Hu, X., Y. Ban, and A, Nascetti. 2021. Uni-Temporal Multispectral Imagery for Burned Area Mapping with Deep Learning. Remote Sens., 13, no. 8: 1509.

Hu, X., Y. Ban, and A, Nascetti. 2021. Sentinel-2 MSI data for active fire detection in major fire-prone biomes: A multi-criteria approach. International Journal of Applied Earth Observation and Geoinformation, 101, 102347.

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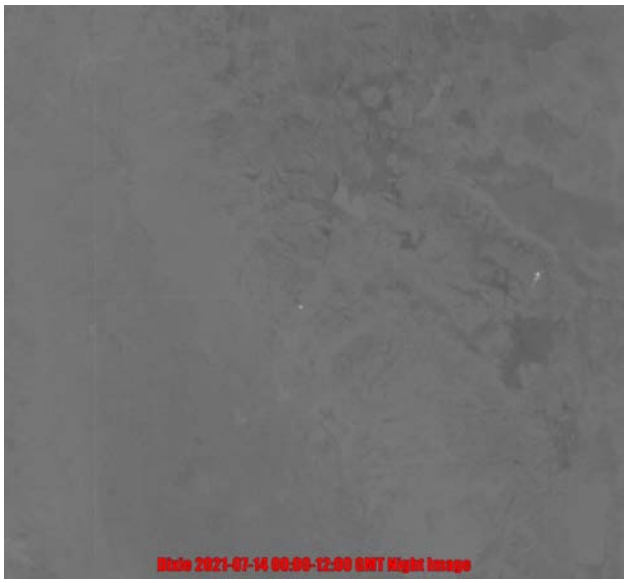
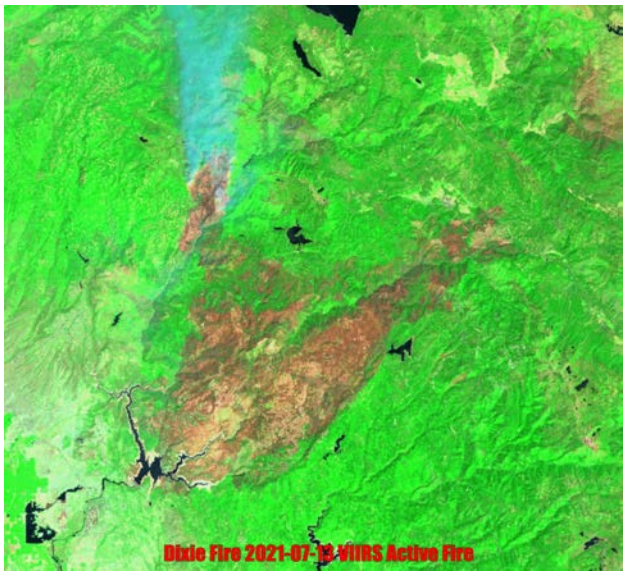
VIIRS Time Series for Early Detection of Wildfires





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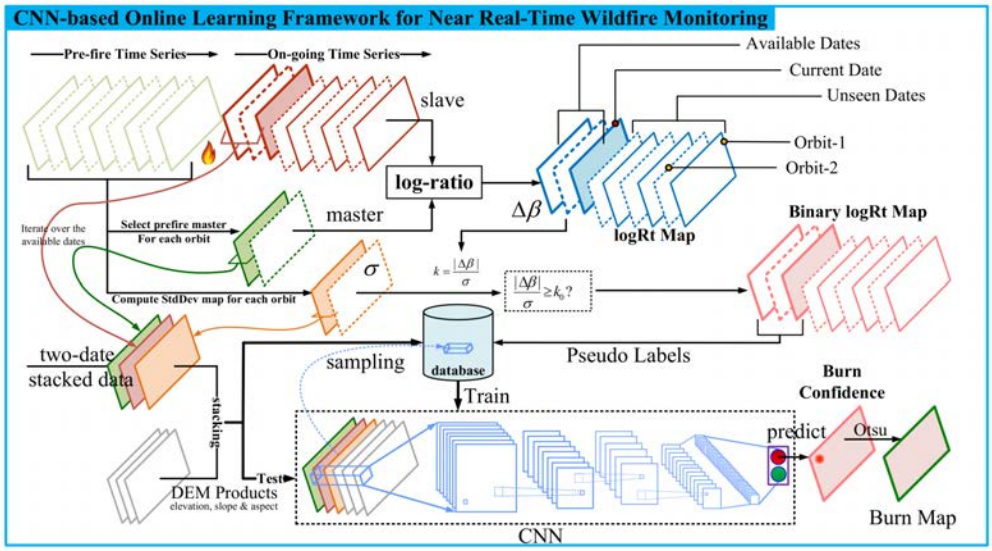
SAR-AI for NRT Monitoring of Wildfire



Ban, Y., Zhang, P., Nascetti, A., Bevington, A. R., Wulder, M. A., 2020. Near Real-Time Wildfire Progression Monitoring with Sentinel-1 SAR Time Series and Deep Learning. *Scientific Reports*, 10(1), 1–15. https://www.nature.com/articles/s41598-019-56967-x.

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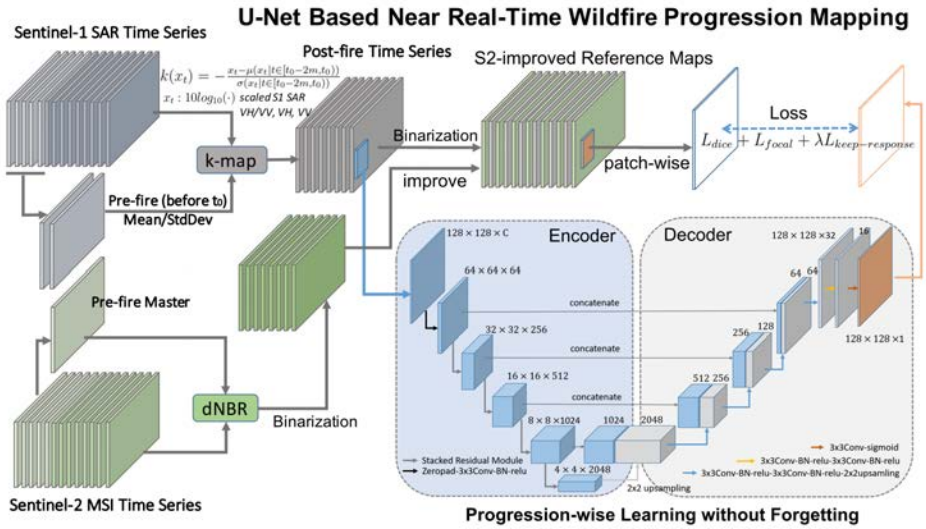
EO-AI for NRT Monitoring of Wildfire



Zhang, P., Y. Ban and A. Nascetti, 2021. Learning U-Net without forgetting for near real-time wildfire monitoring by the fusion of SAR and optical time series. *Remote Sensing of Environment,* 261, 112467.

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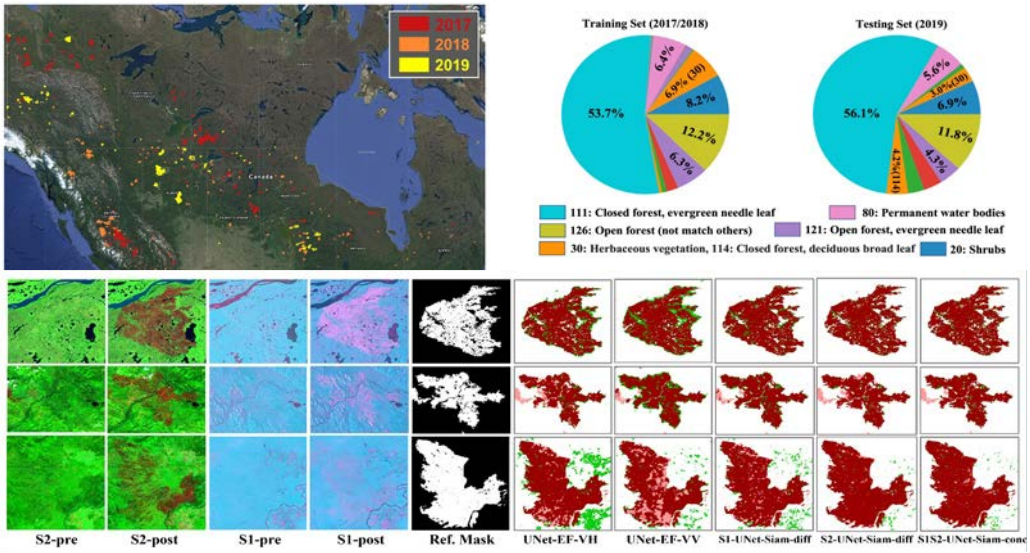
A Large-Scale Satellite Image Dataset for Deep Learning in Wildfire Monitoring



Zhang, P., X. Hu and Y. Ban. 2022. Wildfire-S1S2-Canada: A Large-Scale Sentinel-1/2 Wildfire Burned Area Mapping Dataset Based on the 2017-2019 Wildfires in Canada. *Proceedings of IGARSS 2022*.

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Evia - Greece

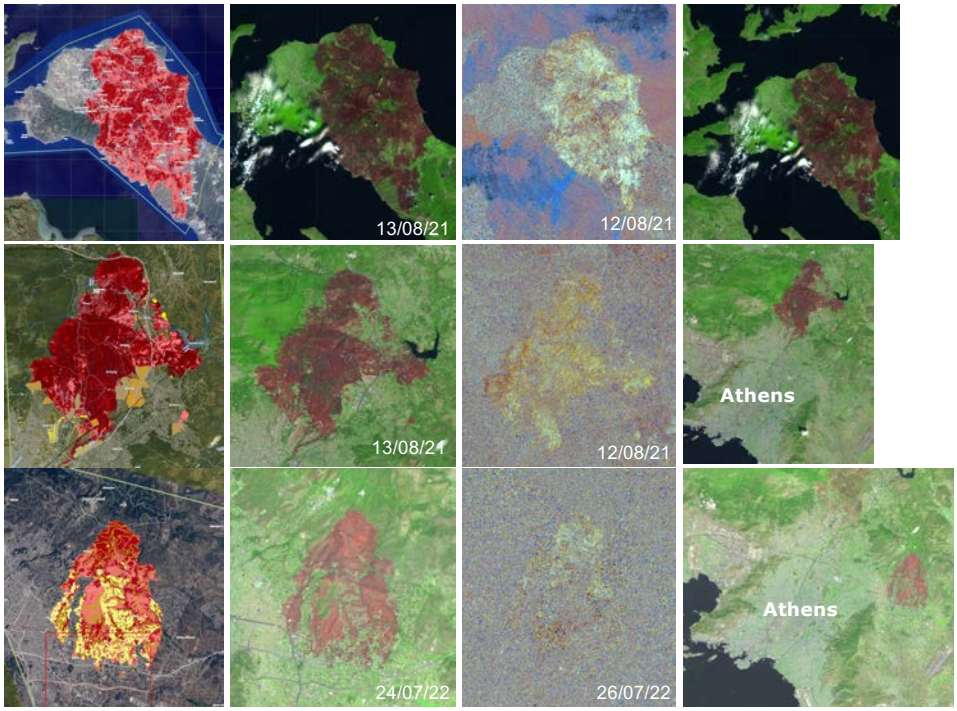
Event: 03/08/2021
Map: 18/08/2021
09:00

Attika - Greece

Event: 03/08/2021
Map: 09/08/2021
08:30

MOUNT PENTELI - GREECE

Event: 20/07/2022
Map: 21/07/2022
09:06



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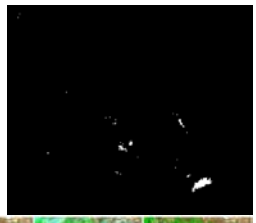
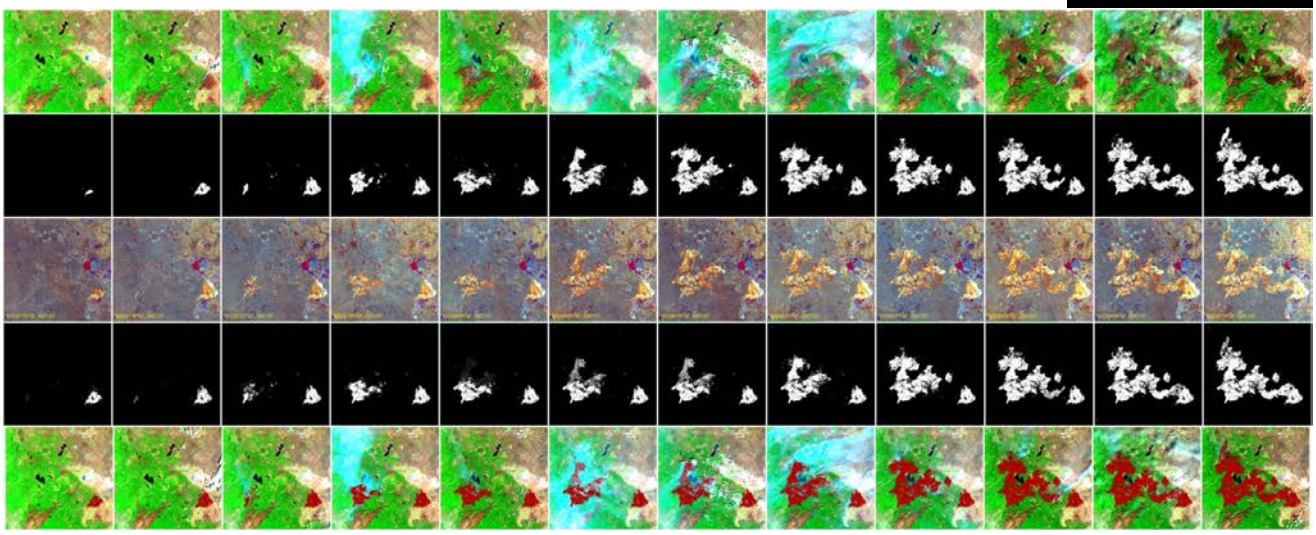
EO Time Series for Near Real-Time Wildfire Monitoring

2021 Dixie Fire, California, USA





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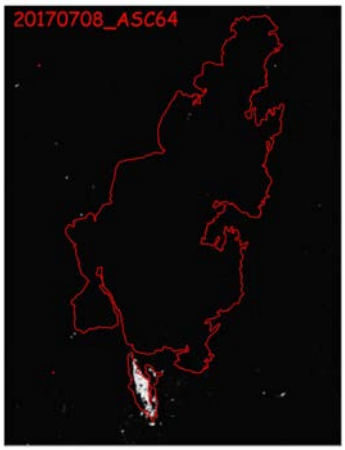
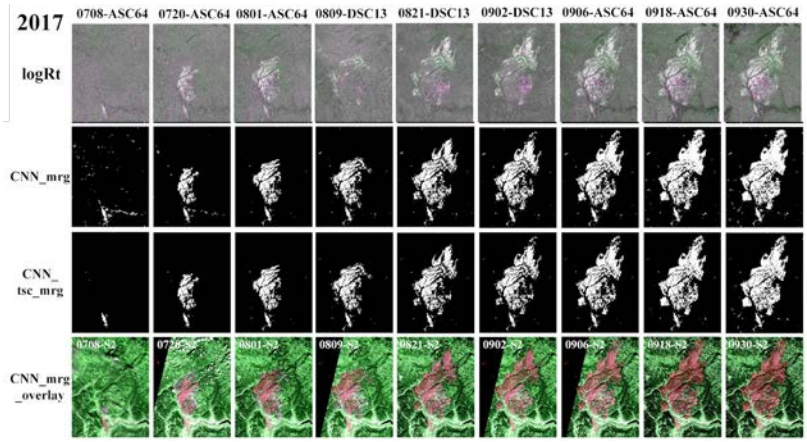
EO Time Series for Near Real-Time Wildfire Monitoring

2017 Elephant Hill Fire, BC, Canada





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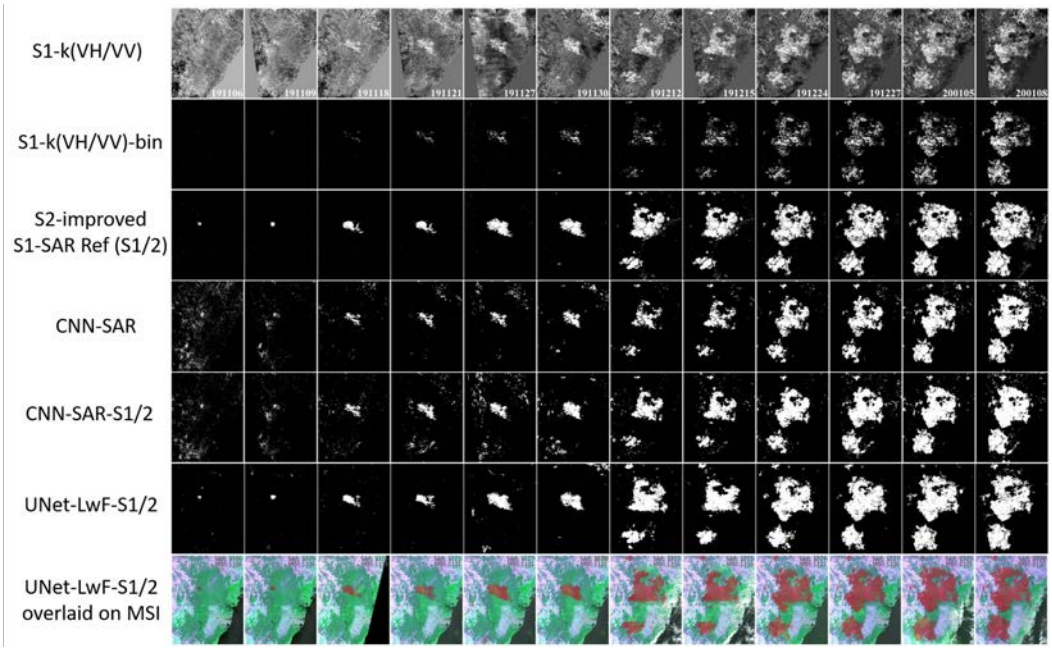
EO Time Series for Near Real-Time Wildfire Monitoring

2019-20 Bushfire near Sydney, Australia



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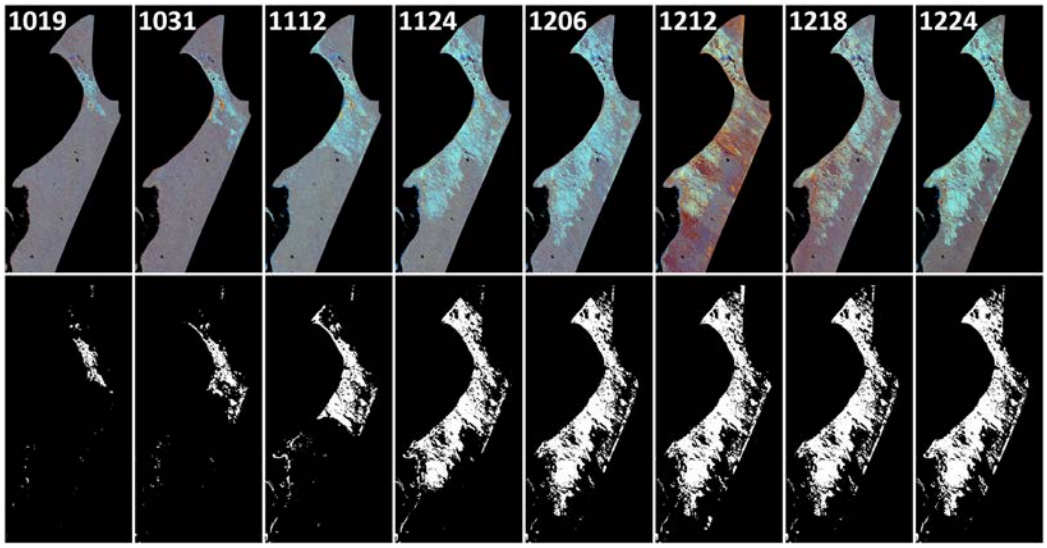
Transfer Learning for Fraser Island Fire, Australia (2020)



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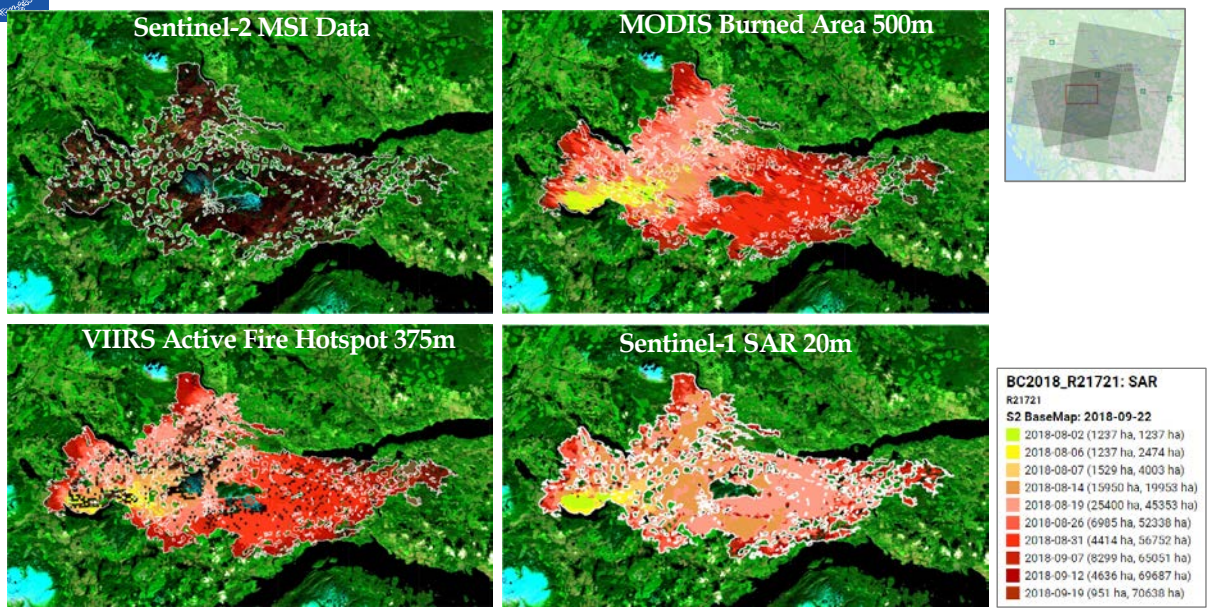
Comparisons



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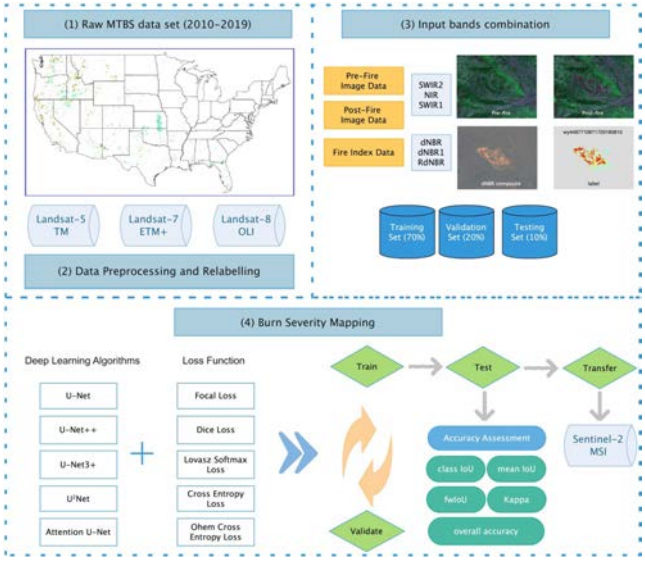
Burn Severity Mapping with Multispectral Imagery Using Deep Semantic Segmentation Models



Hu, X., P. Zhang and Y. Ban. 2022 Large-Scale Burn Severity Mapping Using Multispectral Imagery and Deep Semantic Segmentation Models. ISPRS Journal of Photogrammetry and Remote Sensing (Revised manuscript under review).

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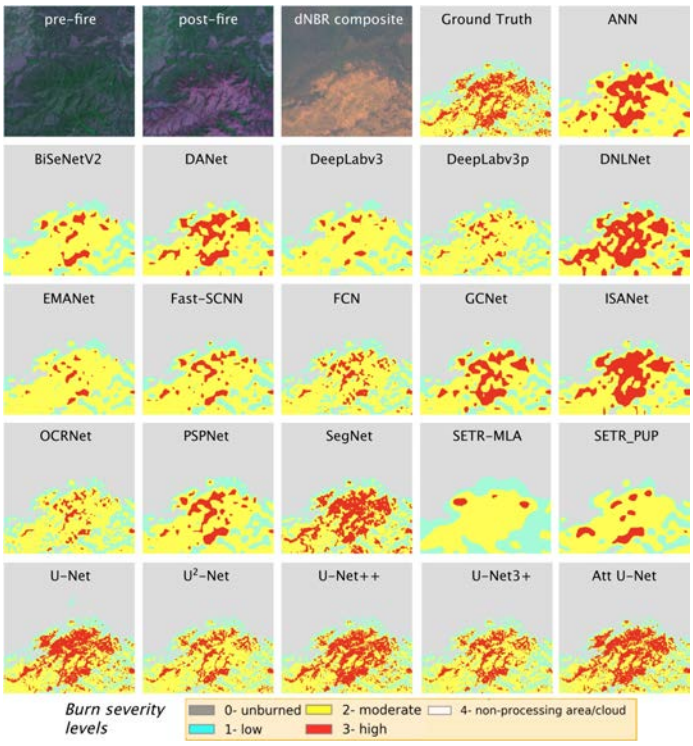

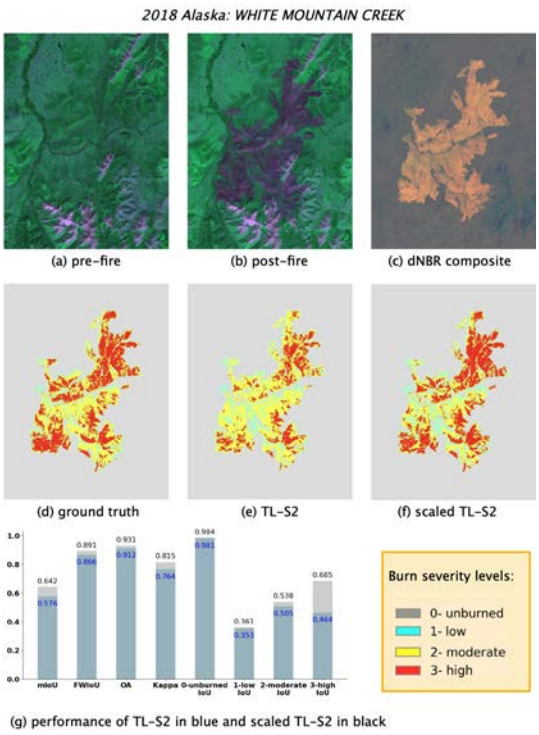

(g) performance of TL-S2 in blue and scaled TL-S2 in black

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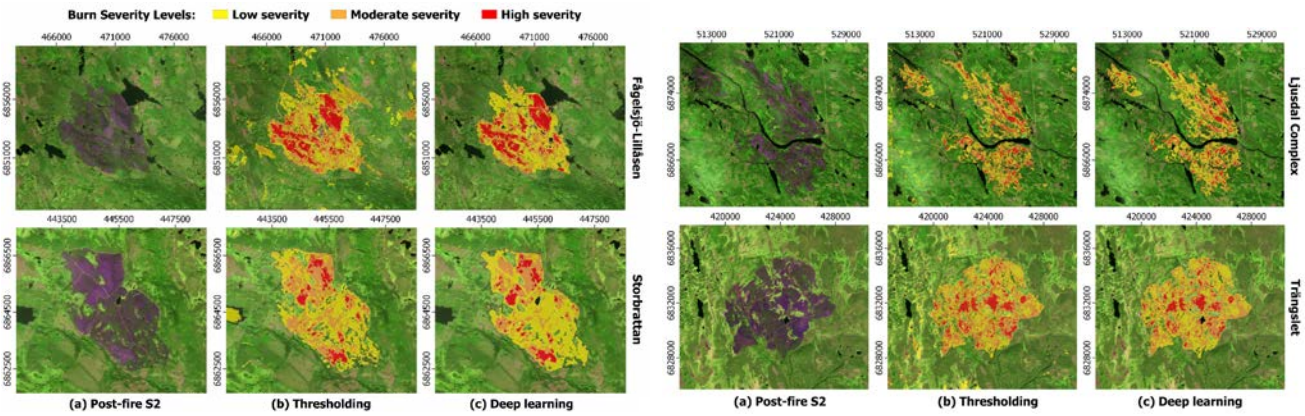
Sentinel-2 MSI Data for Burn Severity Mapping in Sweden with Deep Learning



Wildfire Monitoring App Based on Google Earth Engine - Examples in British Columbia, California & EU