Data driven fire prediction

Some updates

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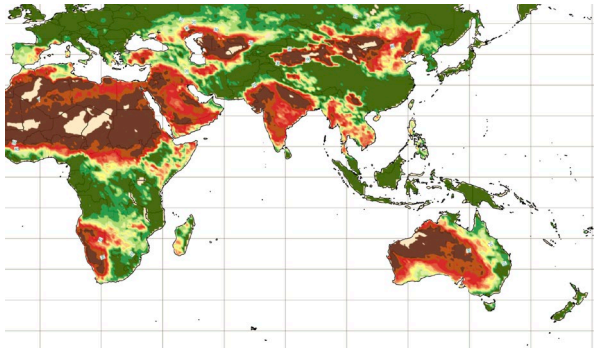
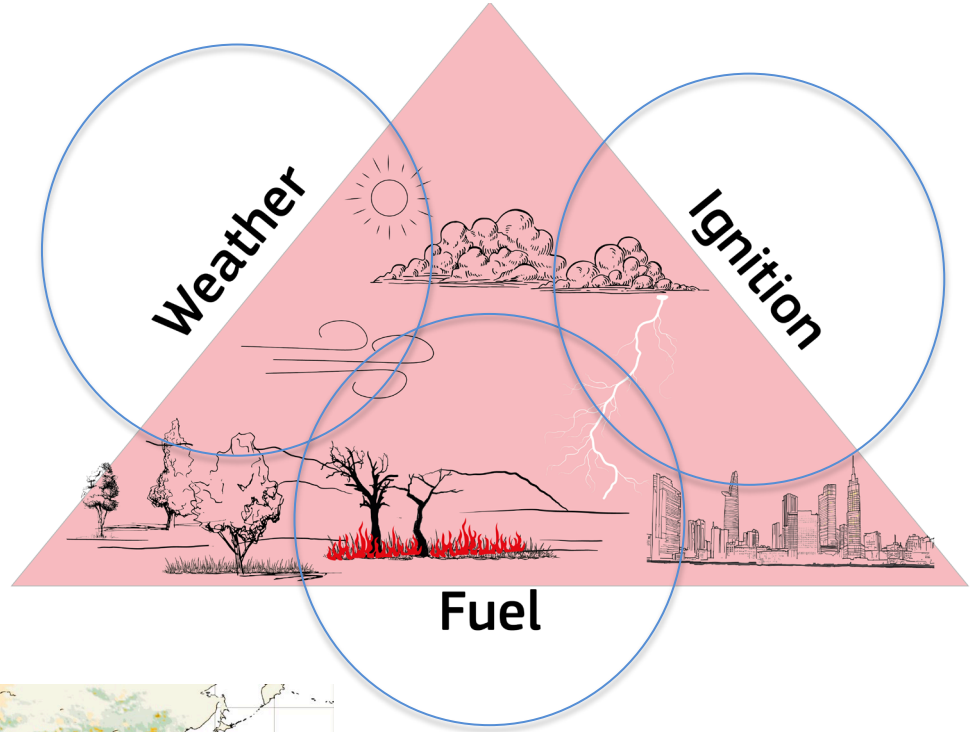
What are the causes of landscape fires

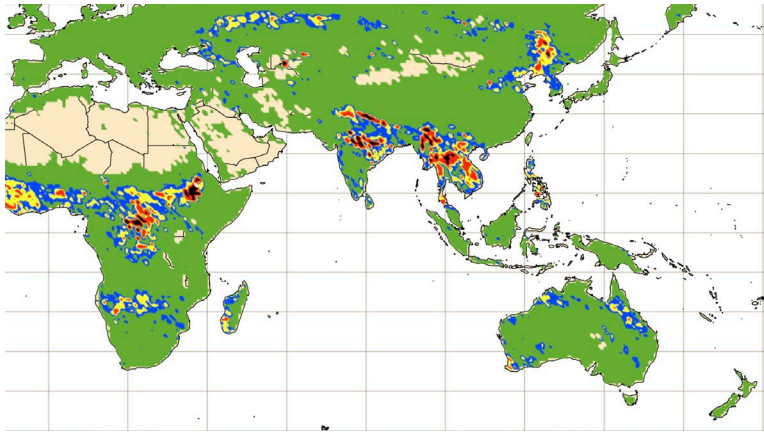
Fire Weather index
Only weather is accounted for

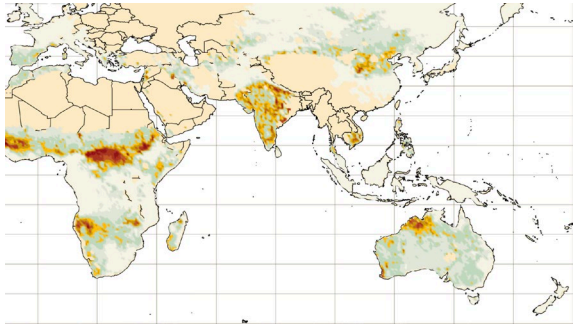
- It correlates with fire activity in **weather** limited biome
- It has limitation in **fuel** limited biomes





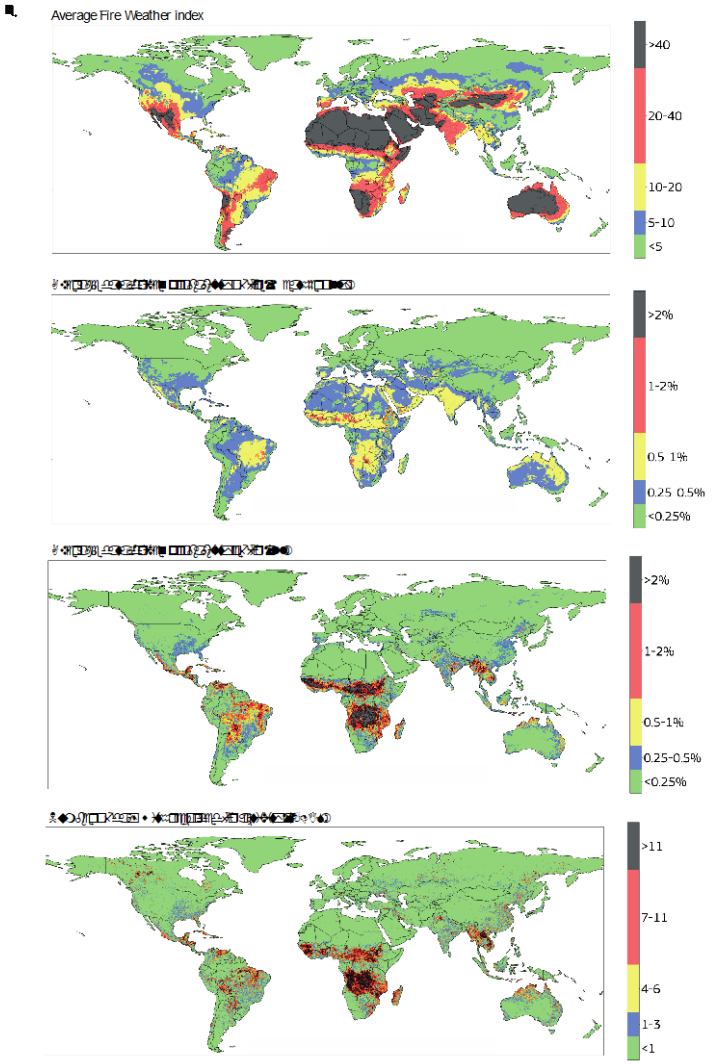
Probability of Fire
Data –driven model
Mc Norton et al (2024) GRL





Fire Occurrence probability Index (based on rescaling the FWI to account for fuel through VOD obs)
Di Giuseppe (2023) ERL

Is not only about using ML: the Importance of training data



Yearly climatology of FWI

Yearly climatology of data driven fire activity using FWI weather variables
Reduces the high danger in barren areas but does not really improves the prediction

Yearly climatology of data driven fire activity using ALL imput variables
Reduces the high danger in barren areas but does not really improves the prediction

Total active fire recorded by MODIS

A Data-driven Probability-of-Fire (PoF) Model

Variable	Input Category	Frequency	Source	Reference
Precipitation	Weather	Daily	ERA5-Land	Muñoz-Sabater et al. 2021
2m Temperature	Weather	Daily	ERA5-Land	Muñoz-Sabater et al. 2021
2m Dewpoint Temperature	Weather	Daily	ERA5-Land	Muñoz-Sabater et al. 2021
10m Wind Speed	Weather	Daily	ERA5-Land	Muñoz-Sabater et al. 2021
Live Leaf Fuel Load	Fuel	Daily	Fuel Model	McNorton et al. 2024a
Live Wood Fuel Load	Fuel	Daily	Fuel Model	McNorton et al. 2024a
Dead Foliage Fuel Load	Fuel	Daily	Fuel Model	McNorton et al. 2024a
Dead Wood Fuel Load	Fuel	Daily	Fuel Model	McNorton et al. 2024a
Dead Fuel Moisture Content	Fuel	Daily	Fuel Model	McNorton et al. 2024a
Live Fuel Moisture Content	Fuel	Daily	Fuel Model	McNorton et al. 2024a
Low Vegetation LAI	Fuel	Monthly	Satellite (multi-sensor)	Boussetta and Balsamo, 2021
High Vegetation LAI	Fuel	Monthly	Satellite (multi-sensor)	Boussetta and Balsamo, 2021
Vegetation Optical Depth	Fuel	Monthly	Satellite (SMOS)	Wigneron et al 2021
Type of Vegetation	Ignition	Fixed	ECLand	Boussetta et al., 2021
Urban Fraction	Ignition	Fixed	ECLand	McNorton et al. 2023
Orography	Ignition	Fixed	ECLand	Boussetta et al., 2021
Lightning	Ignition	Daily	ERA5	Hans
Population Density	Ignition	Fixed	Gridded Population of the World (GPW) v4 – SEDAC (2020, 2.5 arcmin to 9km)	Center for International Earth Science Information Network - CIESIN
Road Density	Ignition	Fixed	Global Roads Inventory Dataset – 2018	Meijer et al., 2018

Input data can be grouped into 3 categories:

- **Weather** (IFS)
- **Fuel Load and State** (McNorton *et al.*, 2024)
- **Sources of ignitions** (various)

- Model based on Extreme Gradient Boosting library (XGBoost), using a probabilistic classifier.
- Trained on MODIS Collection 6.1 Active Fire 2010-2014 (new version added VIIRS)
- PoF, the probability of MODIS fire detection within 1 km^2 gridcell (underestimation of true fire count)
- Daily 10 Day Forecast
- Global - 1km^2 / 9km^2

ESS OPEN ARCHIVE

A Global Probability-of-Fire (PoF) Forecast

ENVIRONMENTAL SCIENCES | METEOROLOGY

FIRE FORECASTING | FUEL MODELLING | HAZARD FORECASTING | LAND SURFACE MODELLING | MACHINE LEARNING | WILDFIRES

Joe Ramu McNorton, Francesca Di Giuseppe, Ewan Mark Pinnington, Matthew Chantry, Chris Barnard

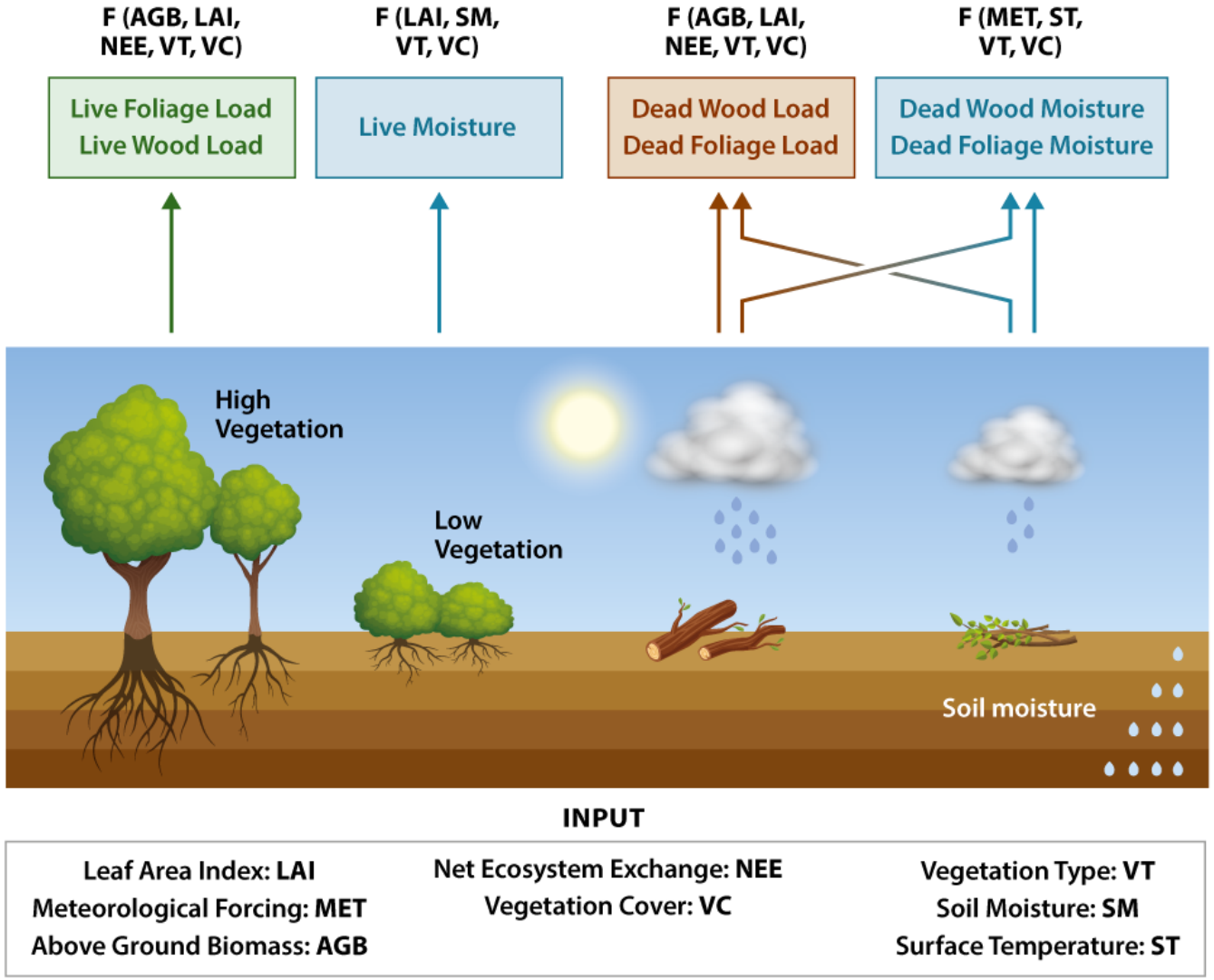
Forecast Input : Fuel is the most important component

Vegetation Load/Moisture informed by:

- Satellite Observations
- Land Surface Modelling
- NWP Variables

Real-time and in historic:

- Global
- 9km Resolution (1km in prep.)
- Daily
- 2010-2021 (ext. in prep.)



McNorton and Di Giuseppe 2024

https://doi.org/10.5194/bg-21-279-2024

Article | Peer rev

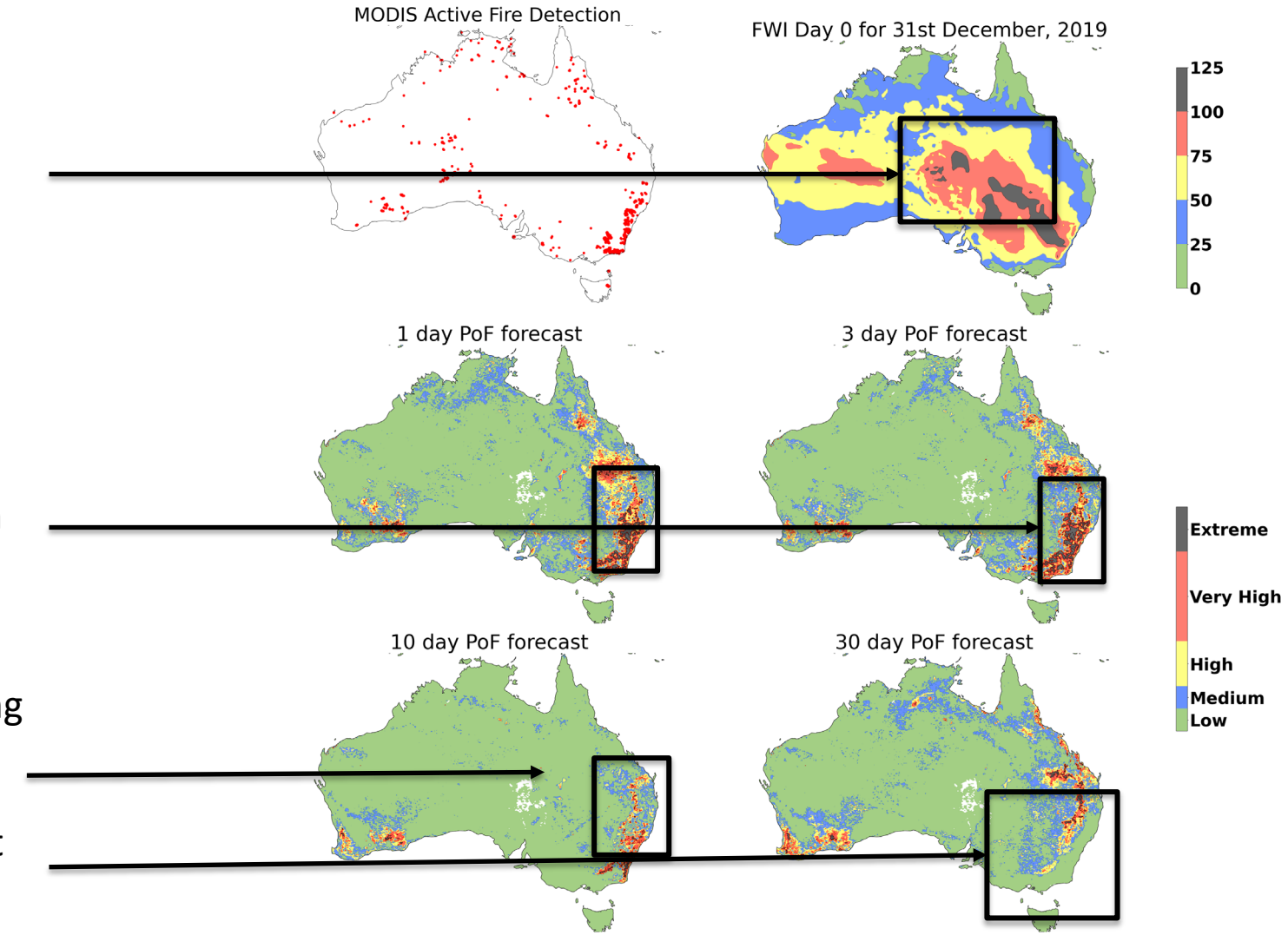
Research article |

A global fuel characteristic model and dataset for wildfire prediction

Joe R. McNorton and Francesca Di Giuseppe

How Does PoF Compare to Existing Forecasts?

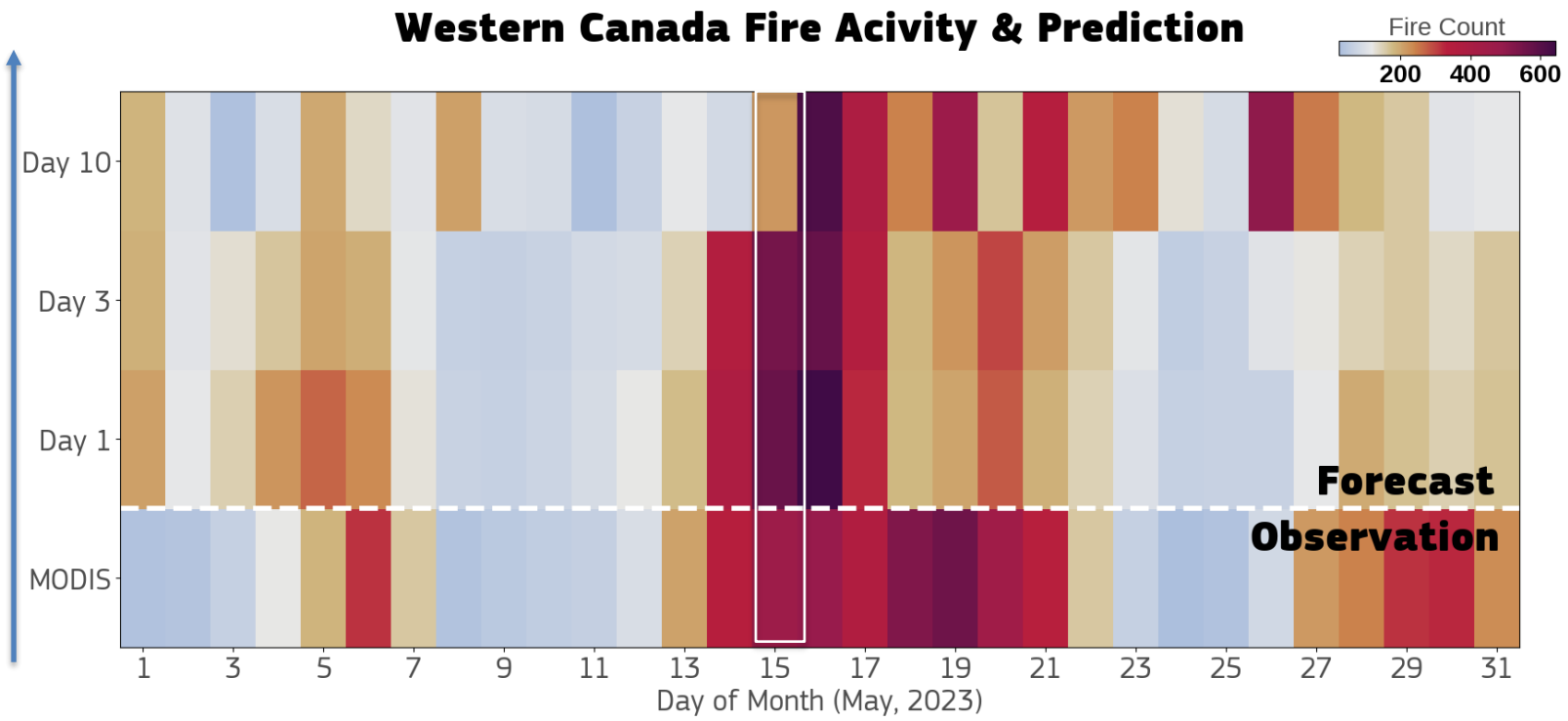
- The inclusion of fuel load prevents high danger forecasts over fuel sparse regions.
- A real-time representation of live fuel moisture content better captures fire danger in regions with live fuel fires.
- The use of machine learning techniques noticeably improves long range forecast skill.
- Accuracy of input data can still limit performance in some regions.



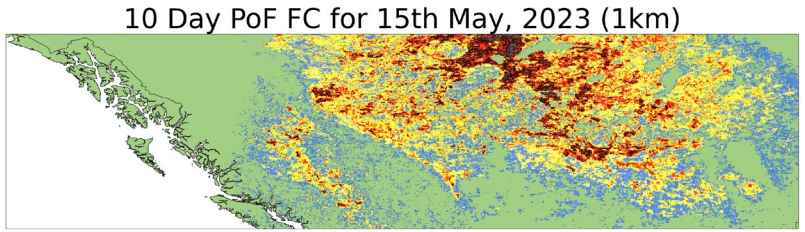
Does the Model Forecast Extreme Events?

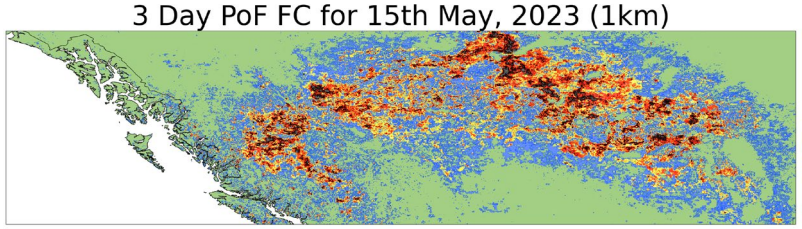
A key limitation of data-driven models is the inability to represent extreme events.

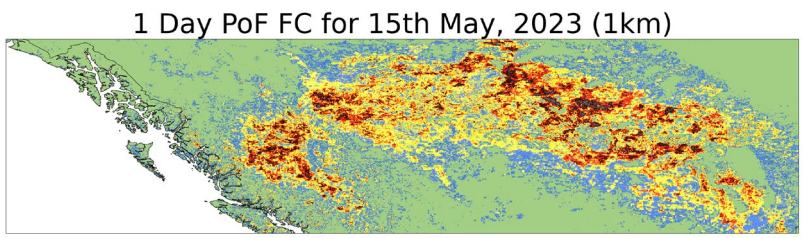
How ahead of time

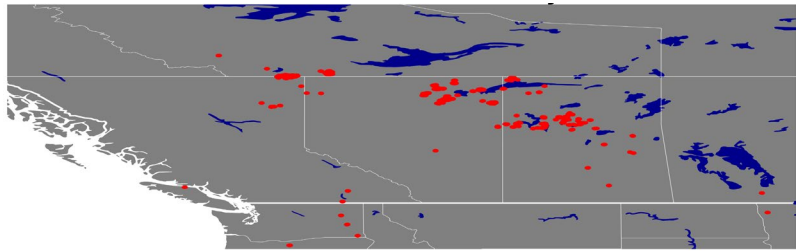


Day of the month



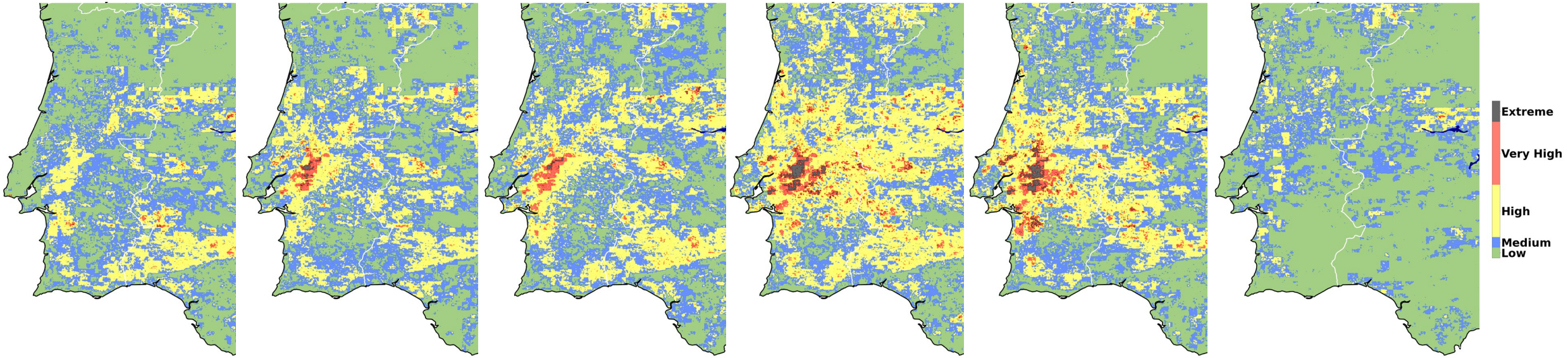






	PoF V1	PoF V2
Features	Vegetation cover/type (4) Leaf area index (2) Fuel Load (4) Fuel Moisture (3) Meteorology (4) Orography (1) Urban Cover (1)	Vegetation cover/type (4) Leaf area index (2) Fuel Load (4) Fuel Moisture (3) Meteorology (4) Orography (1) Urban Cover (1) Population Density (1) Road Density (1) Lightning (1)
Observations	MODIS	MODIS VIIRS GOESE (geostationary) GOESW (geostationary) MSG (geostationary) Himawari (geostationary)
Resolutions	1KM & 9KM, Daily	1KM & 9KM, Daily
Training Period	2010-2014	2020-2021

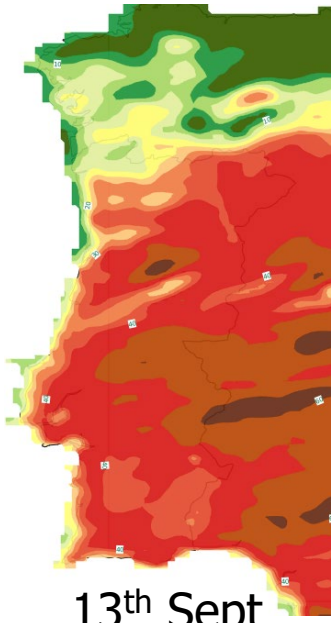
3 Day PoF2 1KM Forecast



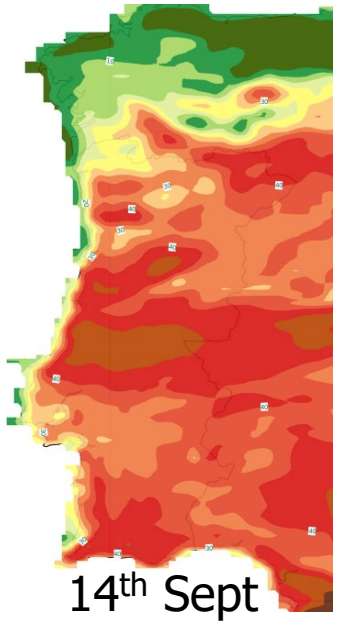
13th Sept | 14th Sept | 15th Sept | 16th Sept | 17th Sept

NASA FIRMS Observations MODIS/VIIRS

3 Day FWI 9KM Forecast



13th Sept



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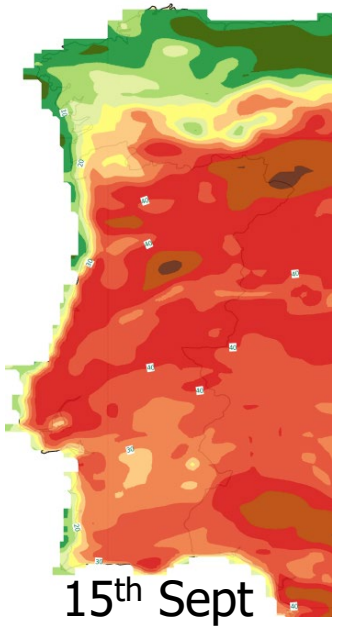

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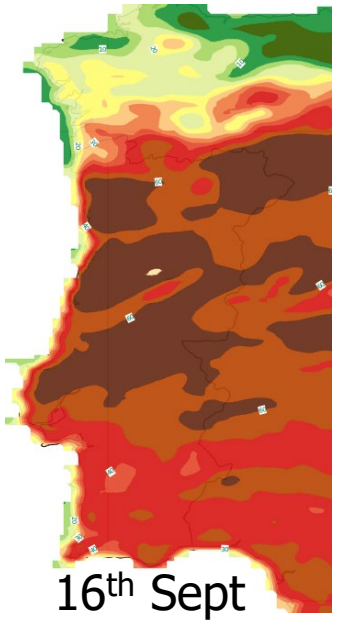

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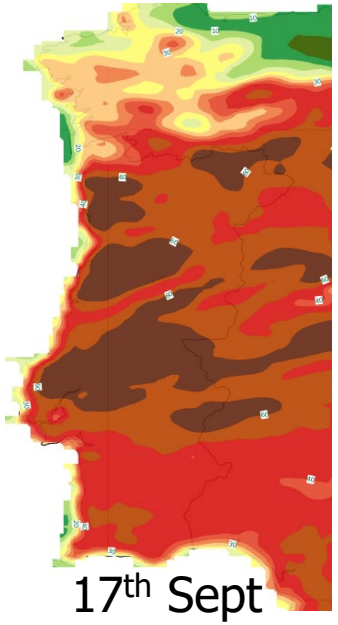
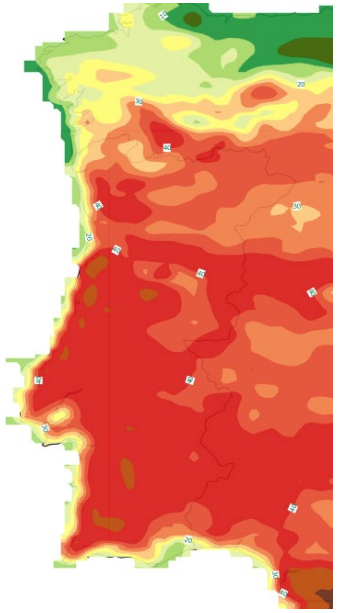
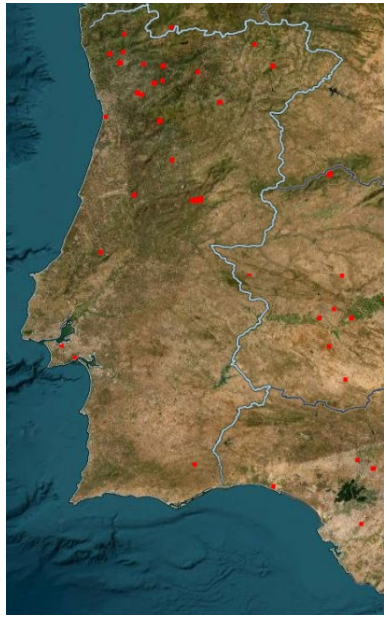
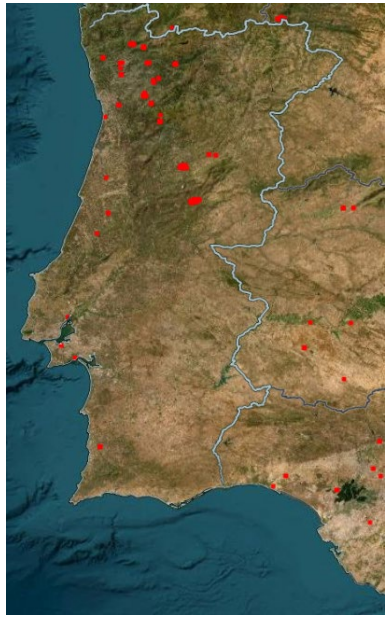
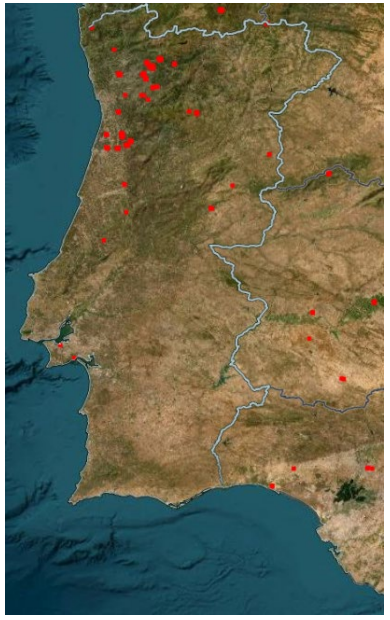


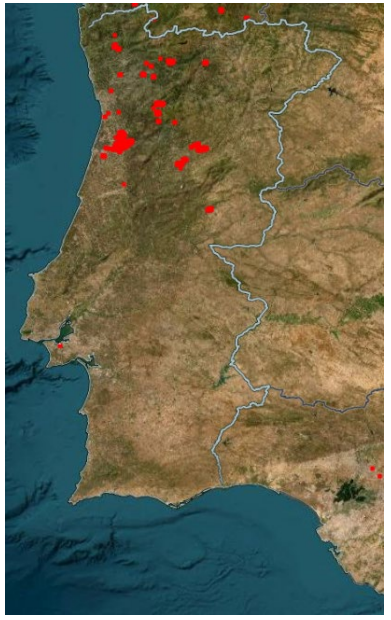
17th Sept

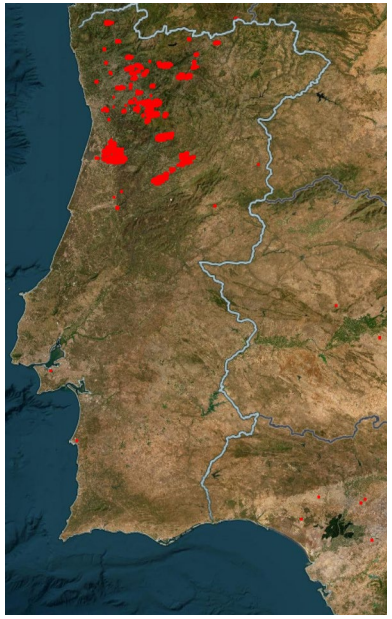






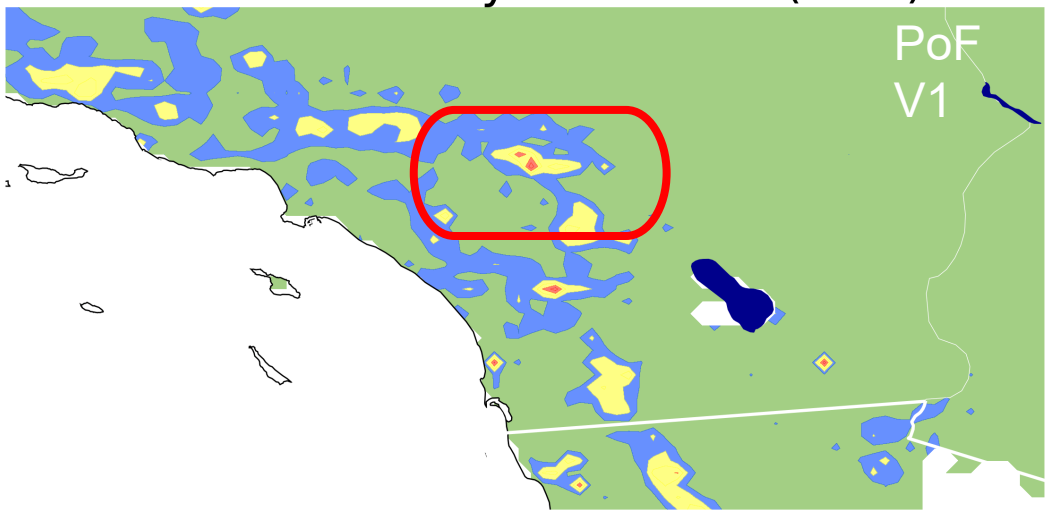




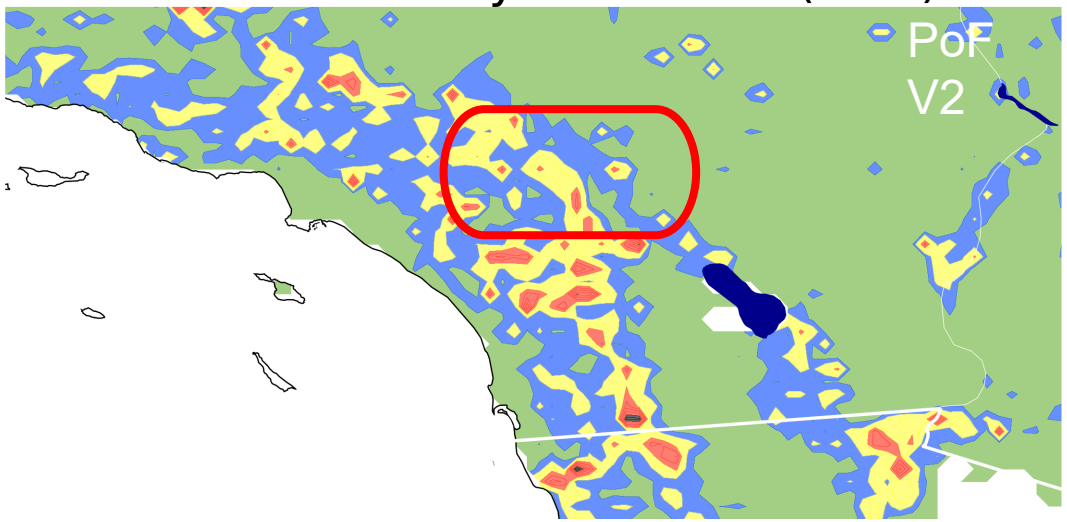


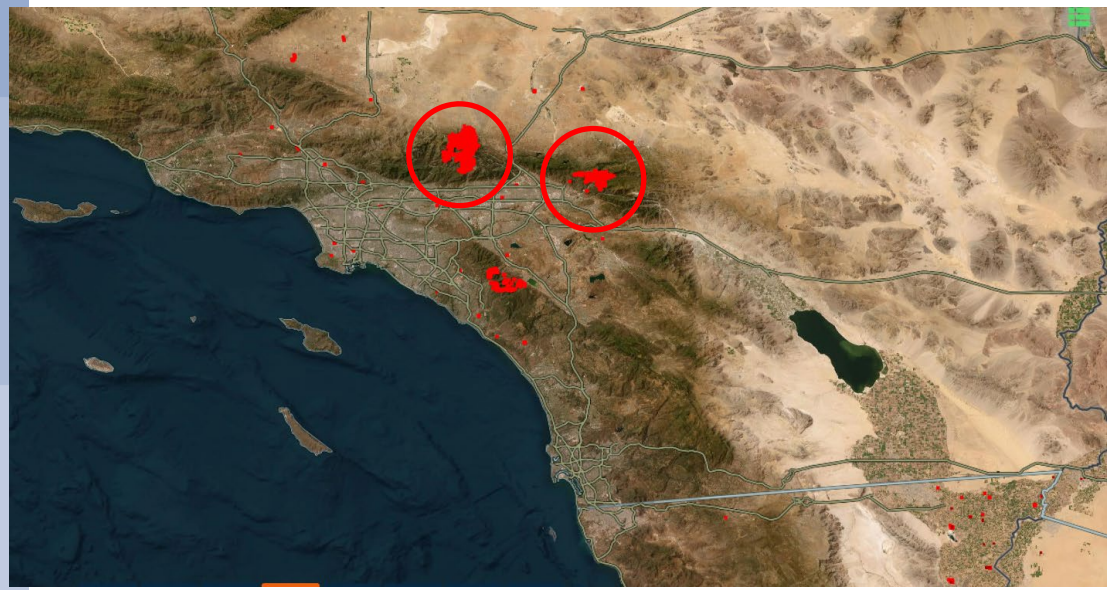
NASA FIRMS Observations MODIS/VIIRS

11-09-2024 Day 0 Forecast (9km)

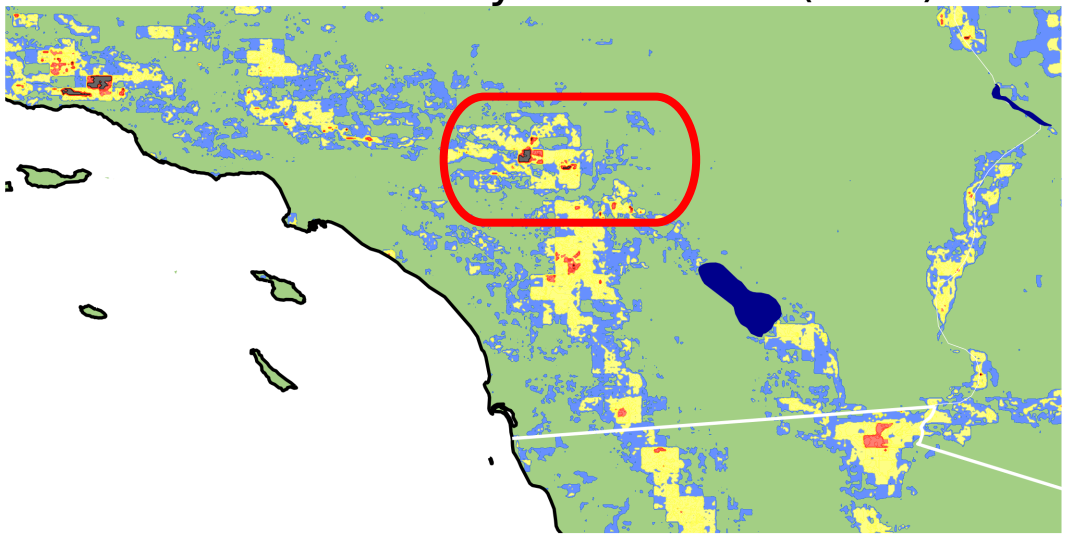


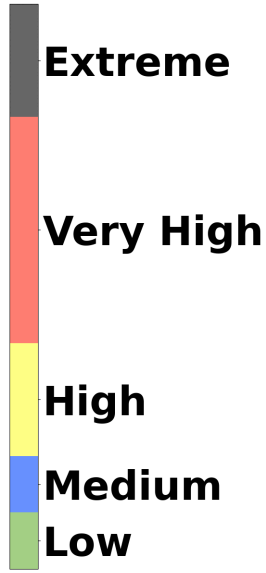
11-09-2024 Day 0 Forecast (9km)



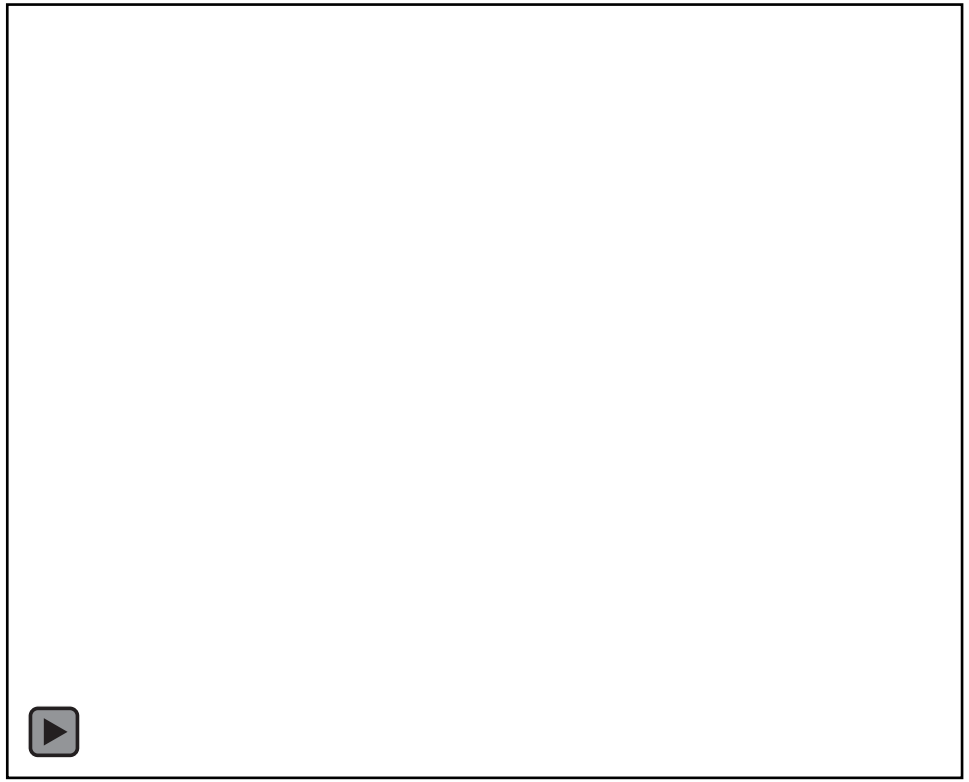


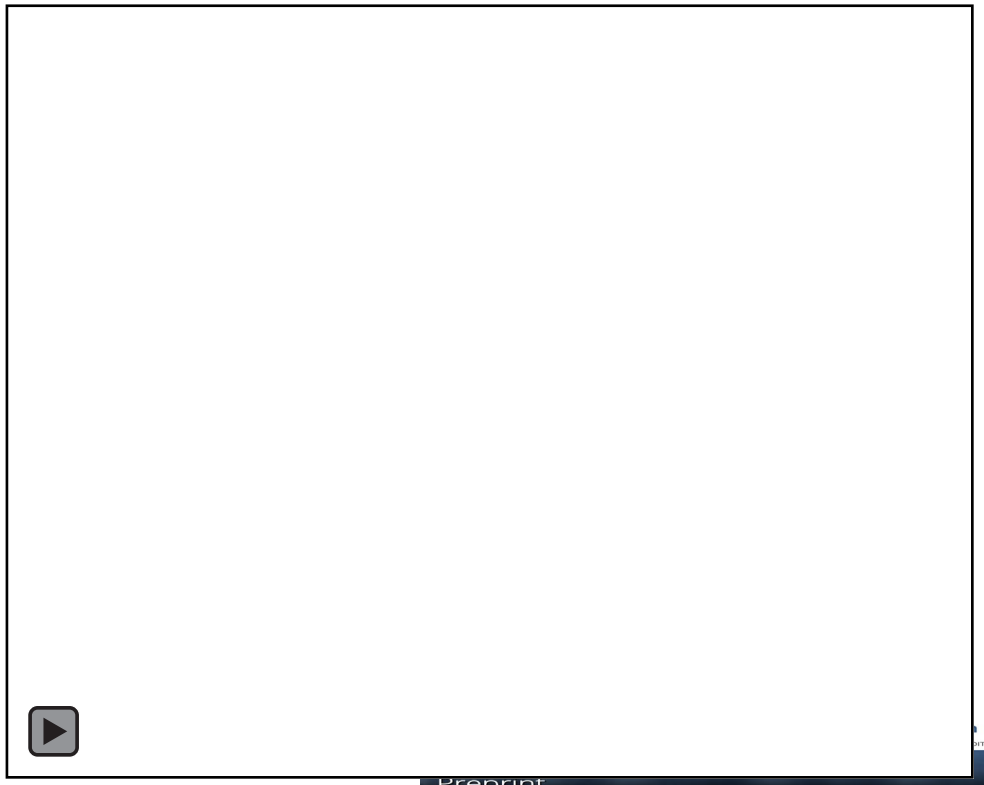
11-09-2024 Day 1 Forecast (1km)





State of wildfires 2023-2024





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CFA

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University of Maryland

University of California Merced

NASA

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utad Universidade de Trás-os-Montes e Alto Douro

The University of Melbourne

Universidad de Alcalá

European Commission Joint Research Centre

VU Vrije Universiteit Amsterdam

University of Exeter

What next ? A Rate of Spread module currently provides a 15 minute forecast of FRP

Uses a convolution neural network based on input data from target and neighbouring cells on

Meteorology, Land Surface Variables, Fuel Variables,
Climate Fields, Ancillary Data and Geostationary FRP observations