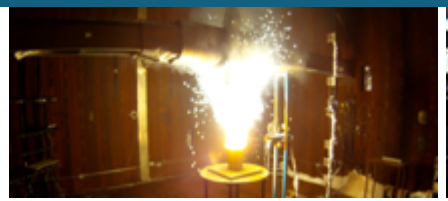
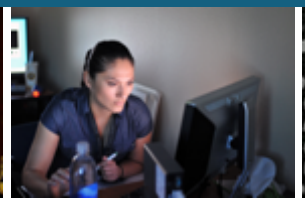
SAND2022-7046C

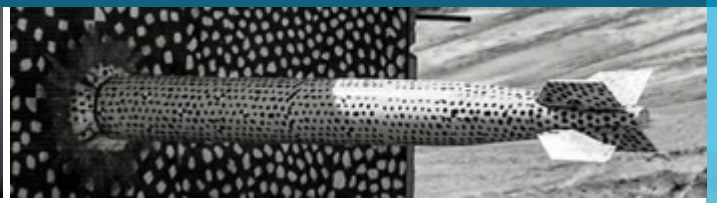
Sandia National Laboratories

Near-real-time Live and Dead Fuels Characterization:

A Case Study for Infrastructure Resiliency to Wildfire in Southern California







PI: Holly Eagleston PhD

Team: Daniel Krofcheck PhD, Forest Danford, Robert Garrett, Iyare Oseghae, Brian Pierre, Phillip Kay

U.S. DEPARTMENT OF ENERGY | NNSA

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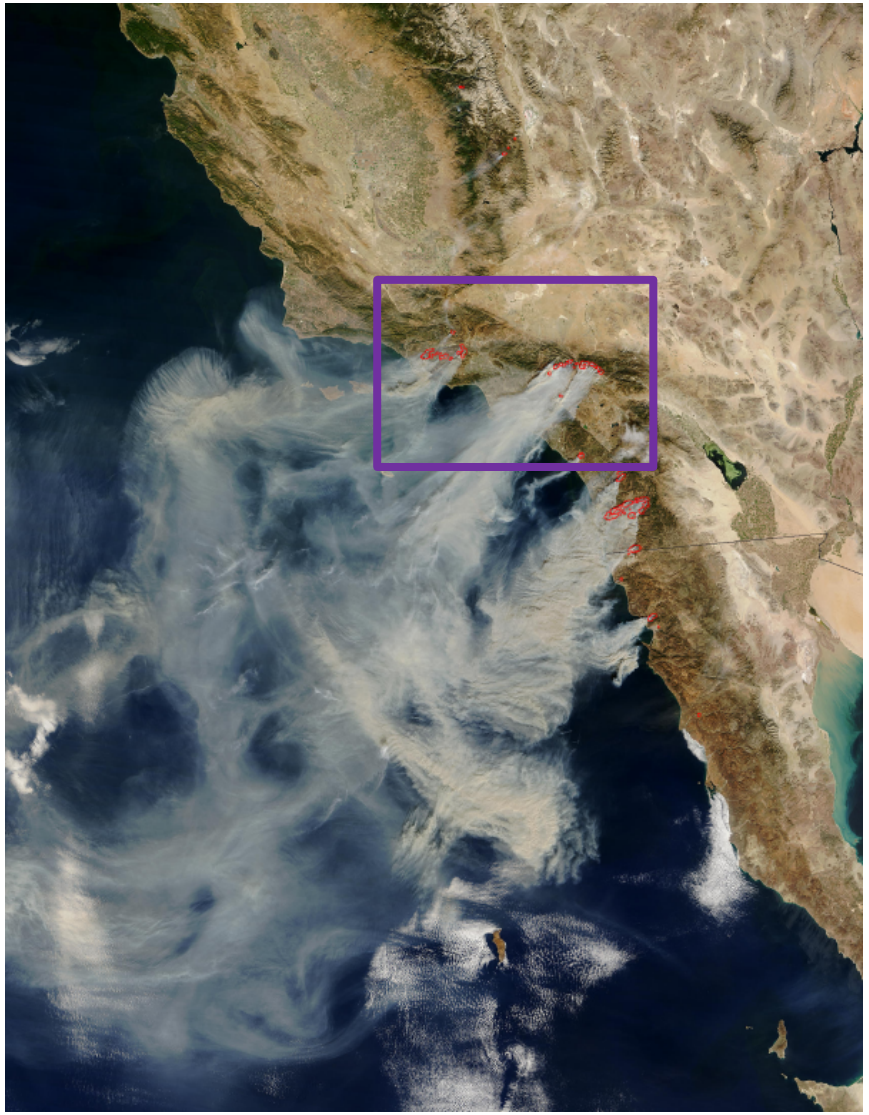
Wildfire Threat to Critical Infrastructure

- Wildfires are a growing problem in the western US with the 2018 fire season causing $150 billion in losses and 106 lives lost. Last year, CA experienced it's 2nd largest fire in history.

- Wildfire pose a national security threat by physically threatening critical infrastructure, and by ***intentional threat to the electrical grid by exploiting natural fire spread patterns.***

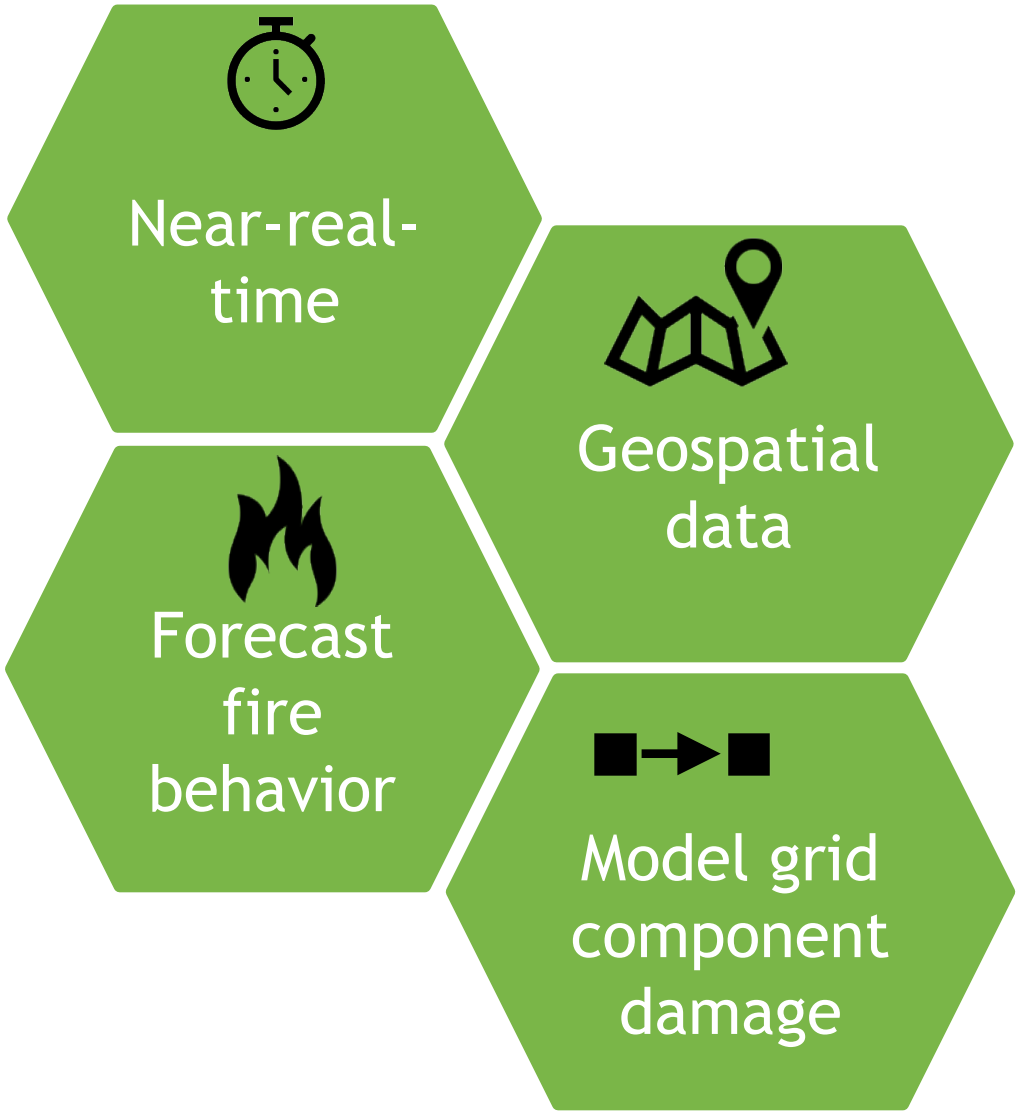
Project Goals

- Identify parts of the grid ***most vulnerable*** to intentional attack that uses fire as a vector
- ***Help utilities plan for, and mitigate a disaster*** from fire and identify grid response strategies
  - **Thrust 1:**
    - Capability to identify fuels conditions at a national scale in near-real-time
  - **Thrust 2:**
    - Quantifying uncertainty of impacts to electrical grid as a result of wildfire

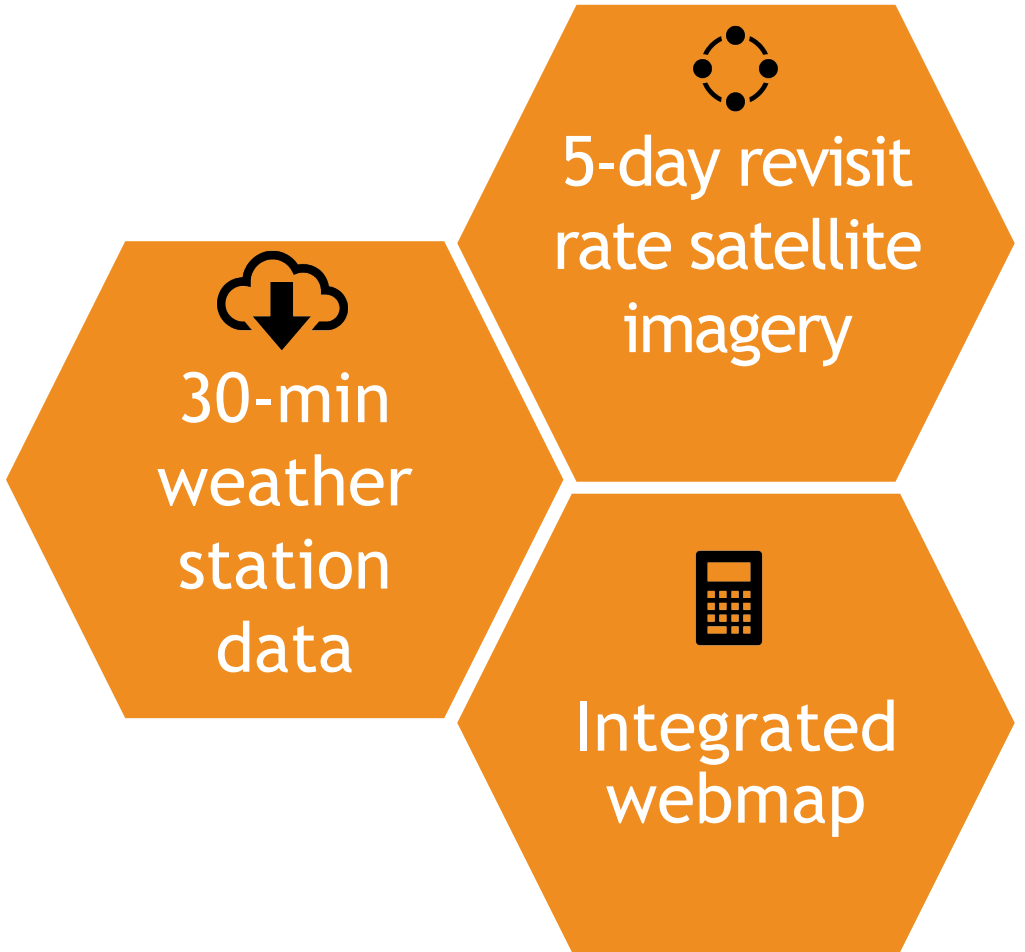


Situational Awareness and Planning Tool

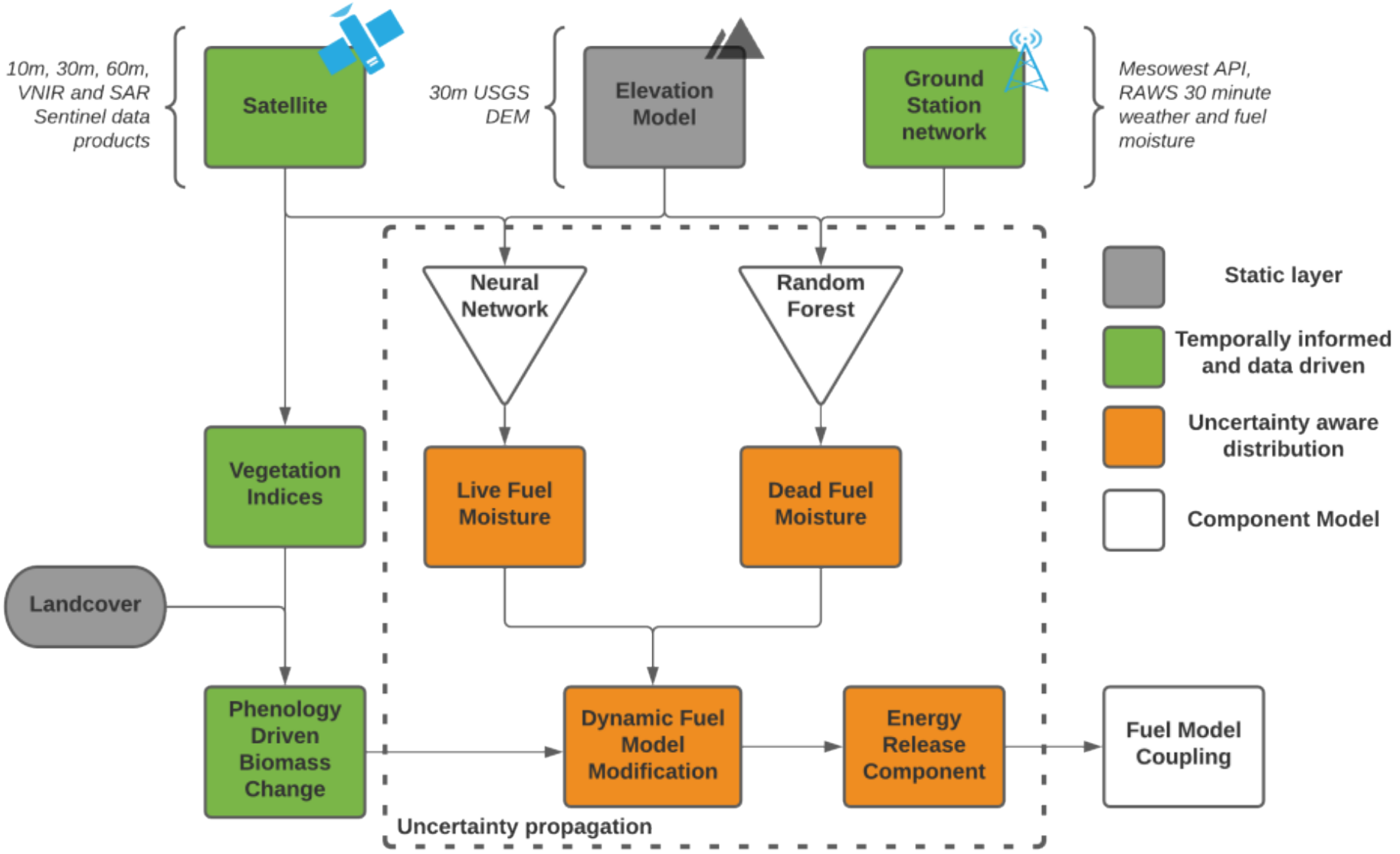
Requirements:



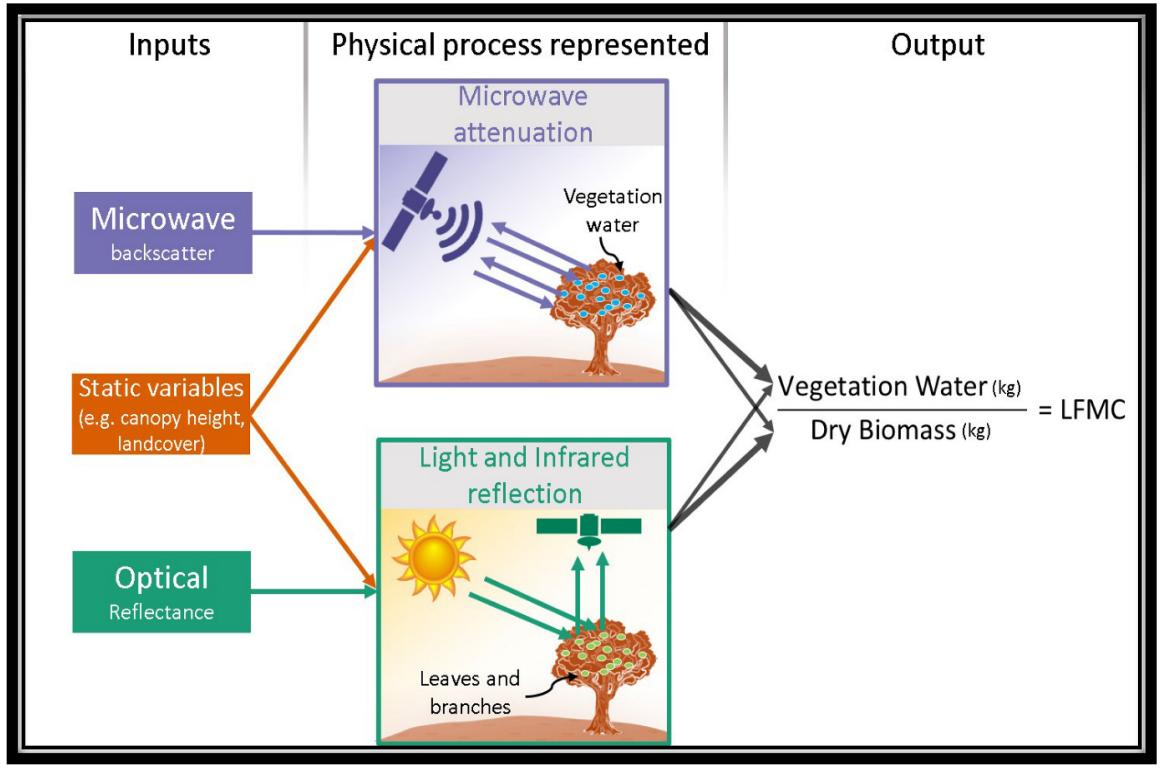
Approach:

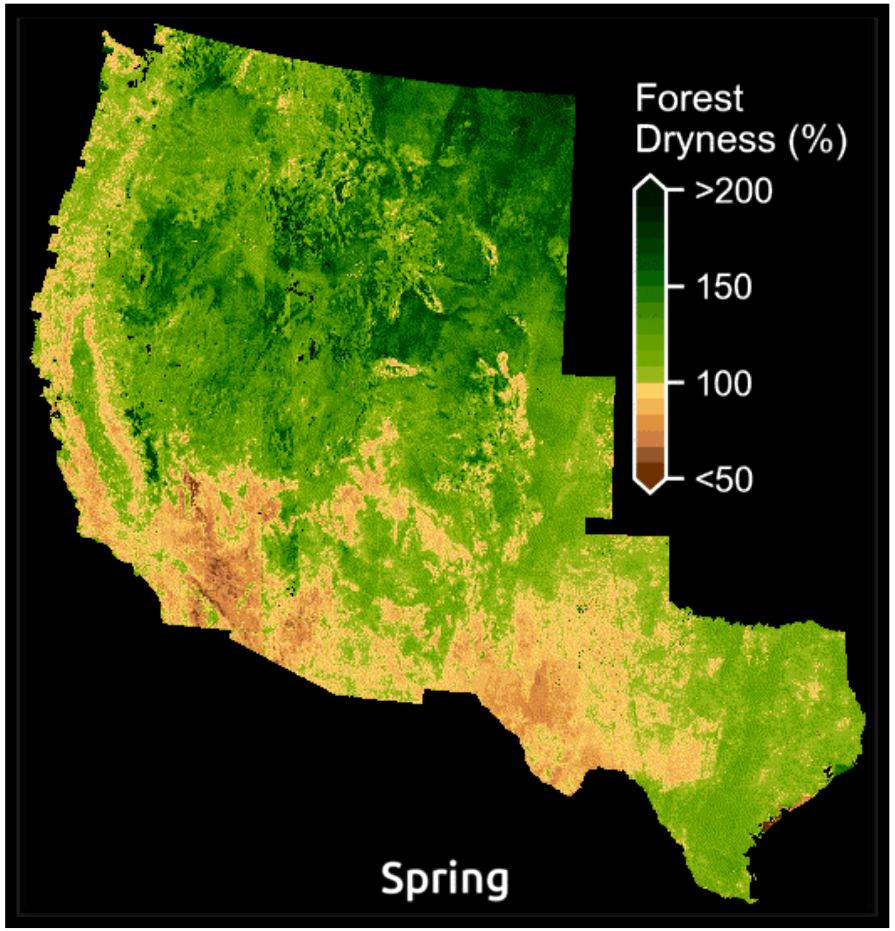


Algorithm for near-real-time fuels condition



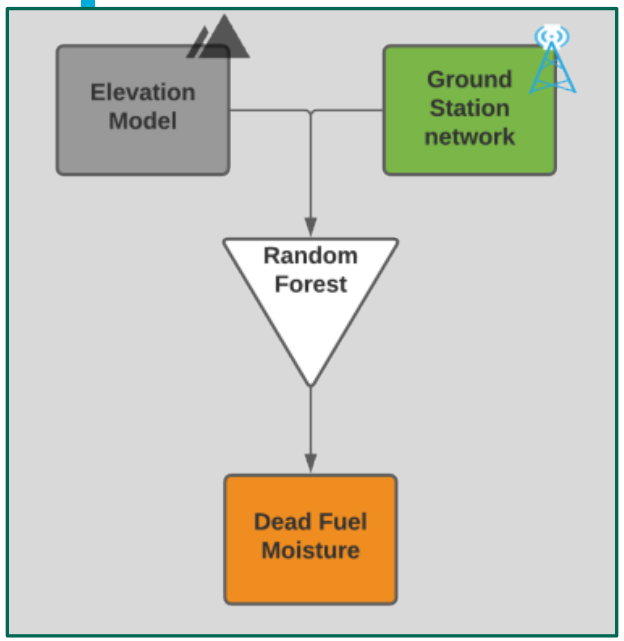
Calculating Live Fuel Moisture





Rao, Krishna; Williams, A. Park; Flefil, Jacqueline Fortin; Konings, Alexandra G. 2020. SAR-enhanced mapping of live fuel moisture content. Remote Sensing of Environment 245:111797.

Calculating Dead Fuel Moisture



Topographic Covariates

Latitude

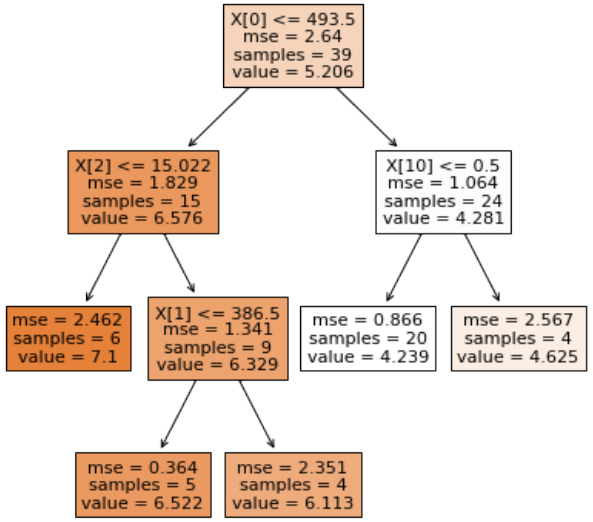
Longitude

Elevation (m)

Slope (deg)

Hillshade (deg)

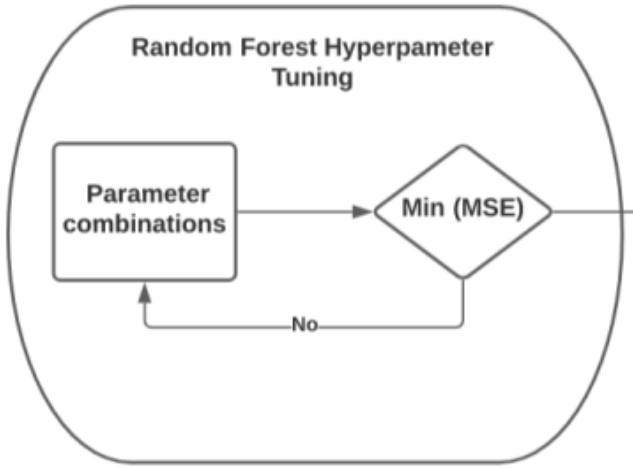
Aspect (factor)

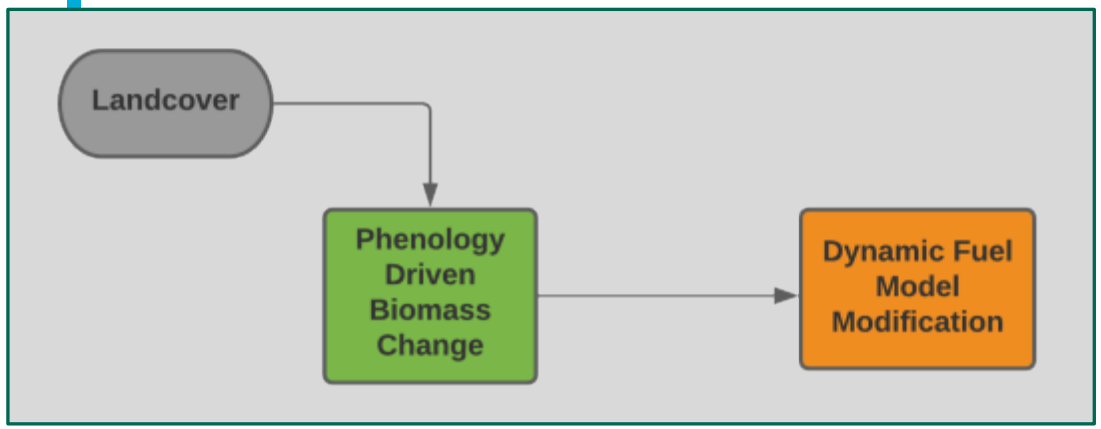


Aspect Bins

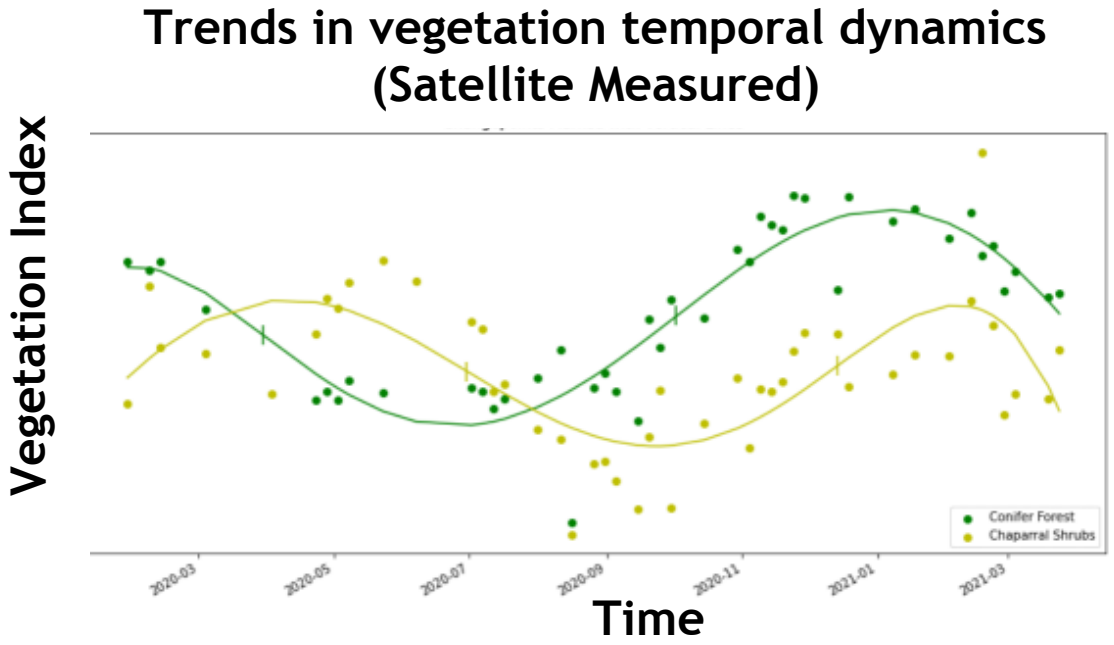
NW	N	NE
W	F	E
SW	S	SE

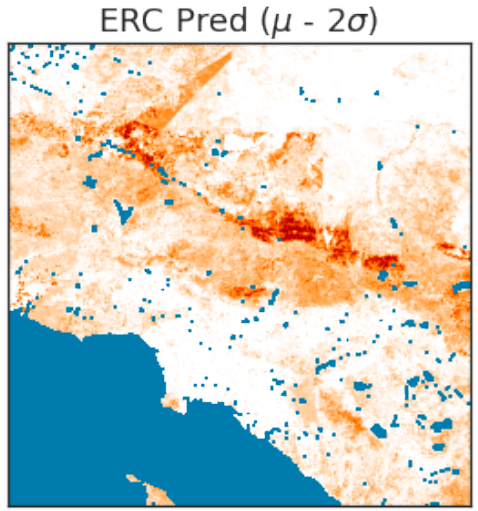
Hillshade

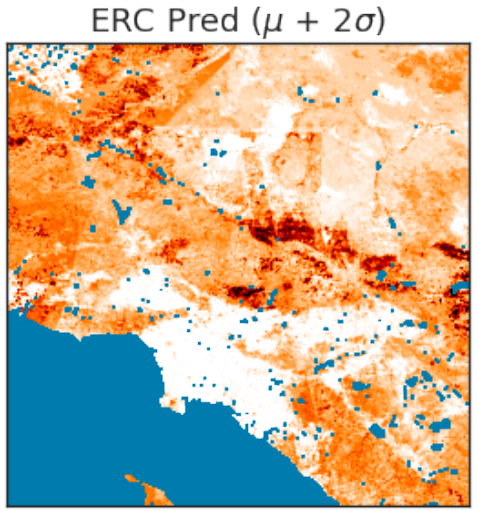




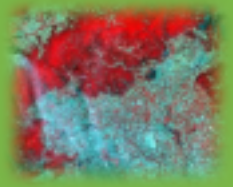
Plant lifestages represent a critical and dynamic part of fuel for fires







Sentinel-2
Multi-spectral Imagery



Sentinel-1 SAR
Backscatter

RAWS Weather Station
Data

Forest Inventory Plot Data

Spatial Statistics and Random Forest Regression Trees

Dynamic Fuel Model

Active Fire Perimeter

NASA FIIRMS

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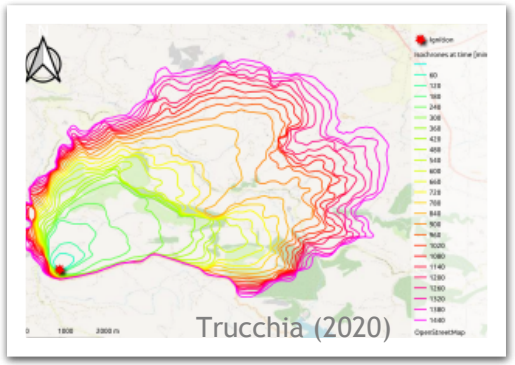
Current Weather Data



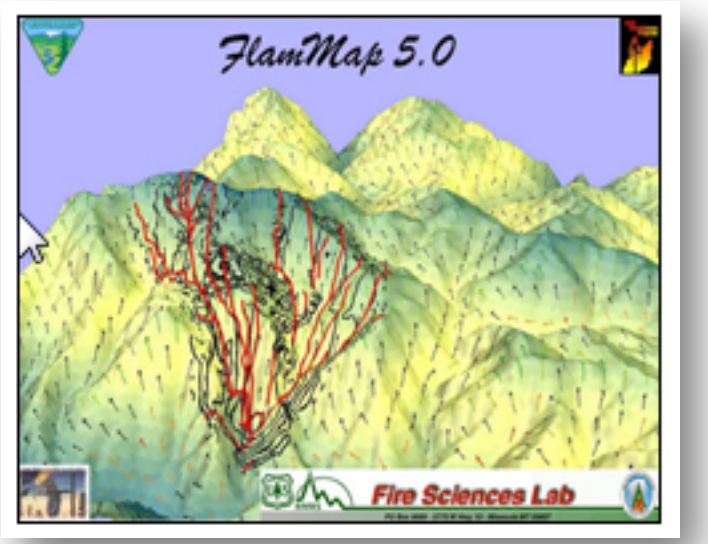
Model **fire arrival time contours** with fire behavior software (FlamMap, eventually QUICFire)

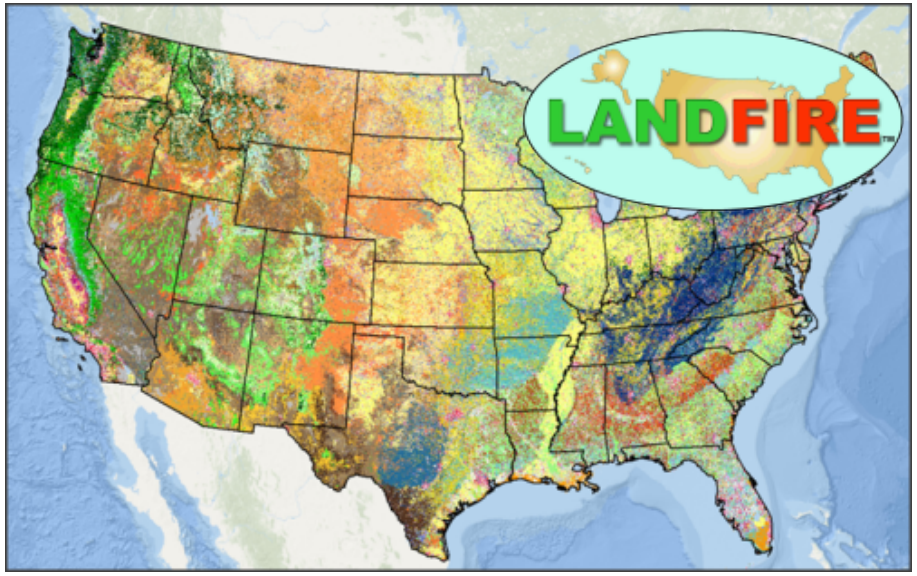
GIS data of infrastructure

Wildfire Resilience and Mitigation Strategies

- Cost/benefit of different vegetation management strategies
- Assess fire threat to area of future grid expansion and propose alternative locations.
- Cost of maintenance/ hardening of grid at key failure points.
- Monte Carlo simulation of wildfire spread, modelling components that would be turned off in pre-emptive blackouts
- Model the damage if those components stay on

Example of wildfire simulation





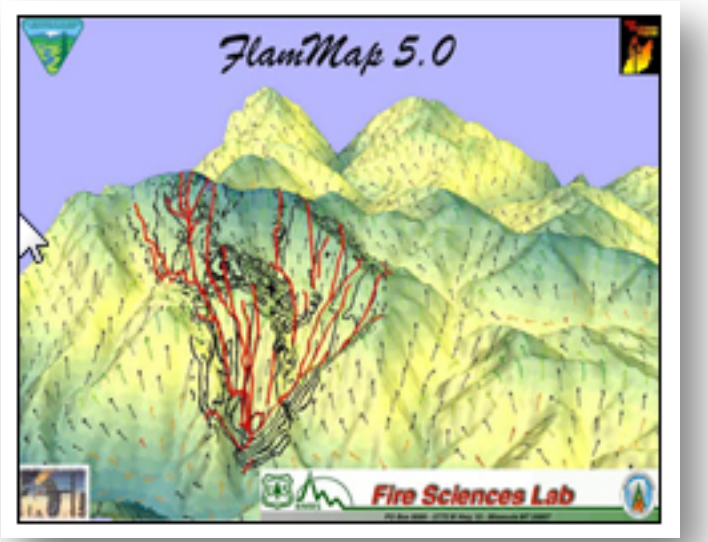
Raster Layers required to run fire spread simulation

Band #	Band Name	Units - GeoTIFF
1	Elevation	meters
2	Slope	degrees
3	Aspect	degrees
4	Fuel Model	categorical
5	Canopy Cover	%
6	Stand Height	meters * 10
7	Canopy Base Height	meters * 10
8	Canopy Bulk Density	kg/m^3 * 100

Parameters to run simulations:

- Live Fuel moisture by fuel class (1hr/1000hr)
- Dead Fuel moisture by fuel class (1hr/1000hr)
- Weather
  - Relative Humidity
  - Wind Speed
  - Wind Direction
  - Temperature

Example of wildfire simulation



Updated Data from Sentinel Imagery and Weather Stations to *Characterize Fuel Conditions in Near-real-time:*

Live and Dead Fuel Moisture
Canopy Cover
Canopy Base Height
Canopy Bulk Density

Raster Layers required to run fire spread simulation

Band #	Band Name	Units - GeoTIFF
1	Elevation	meters
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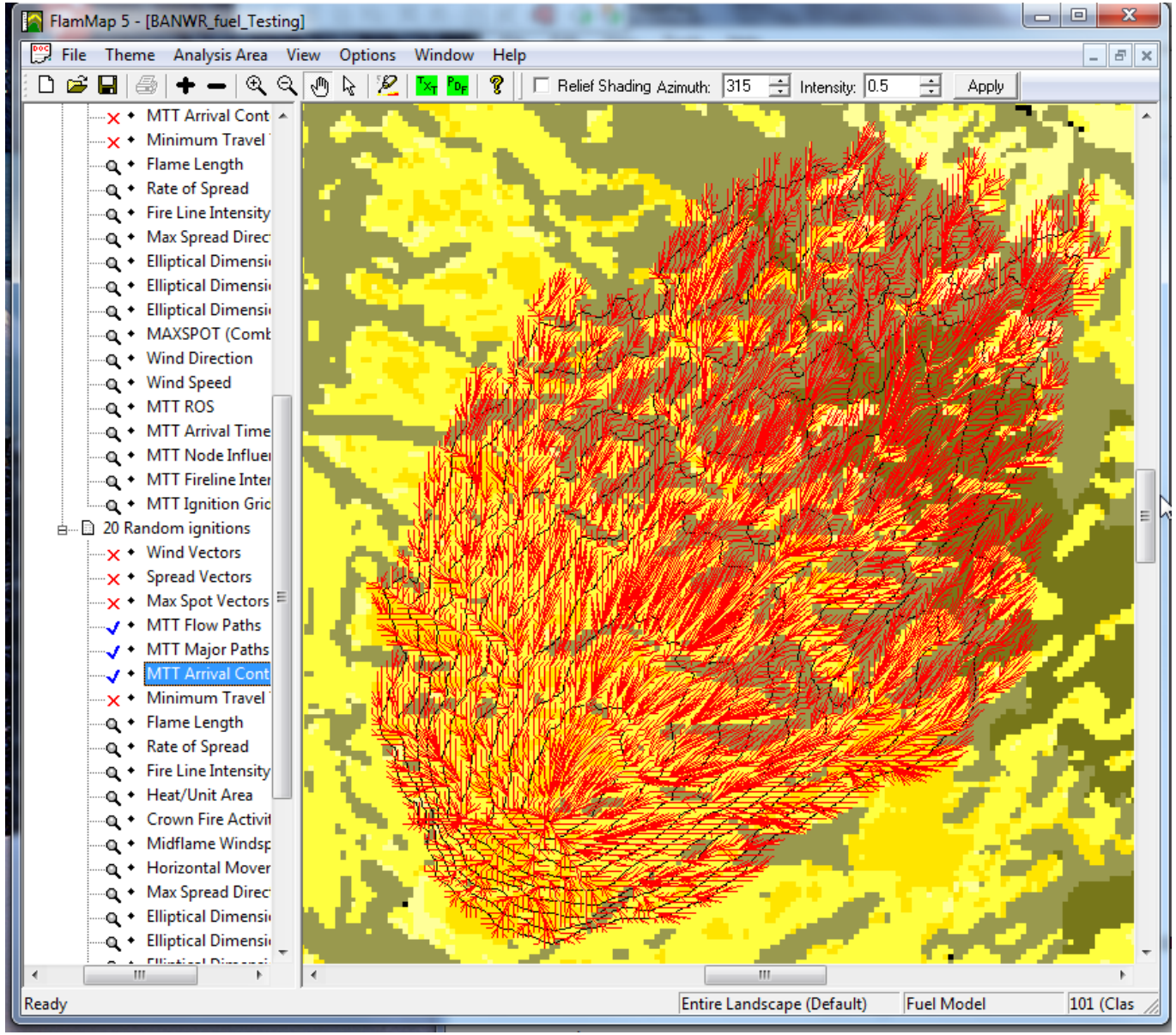
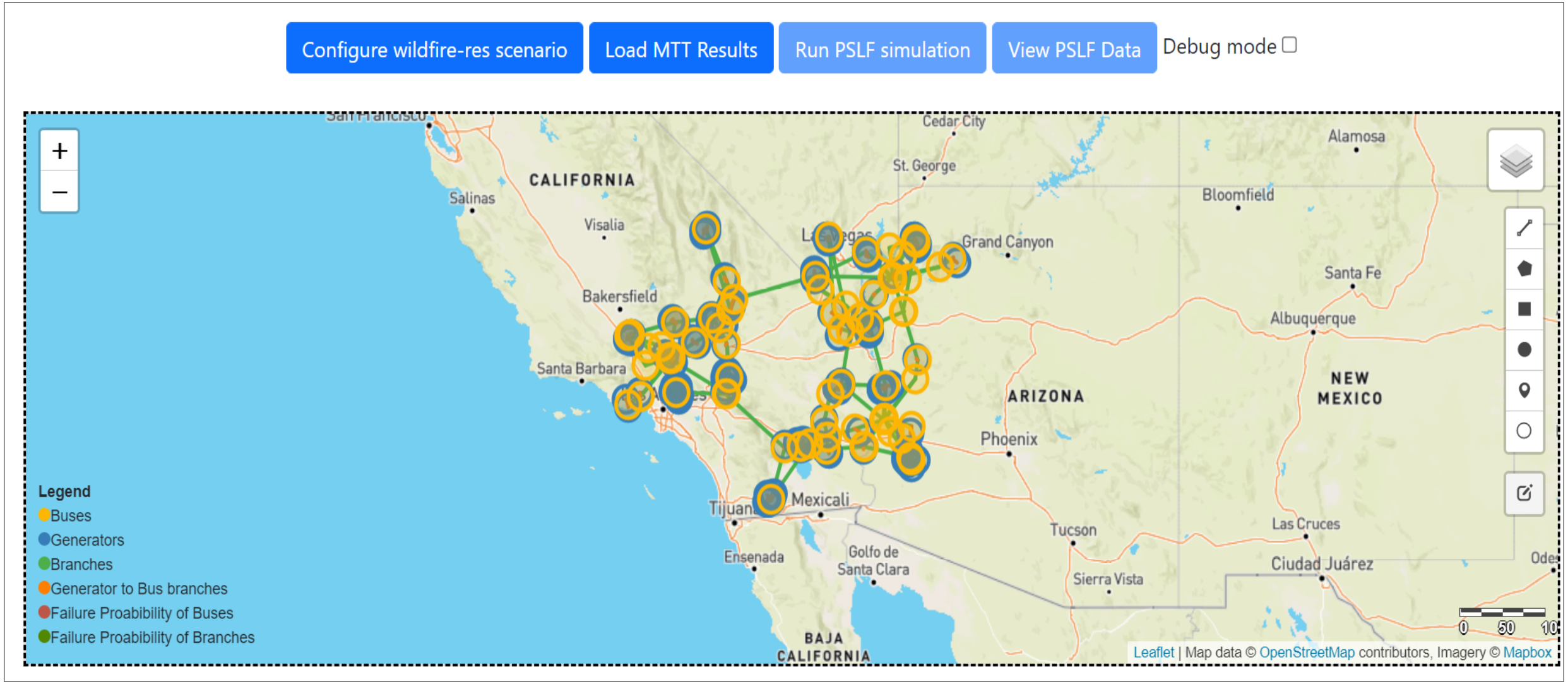
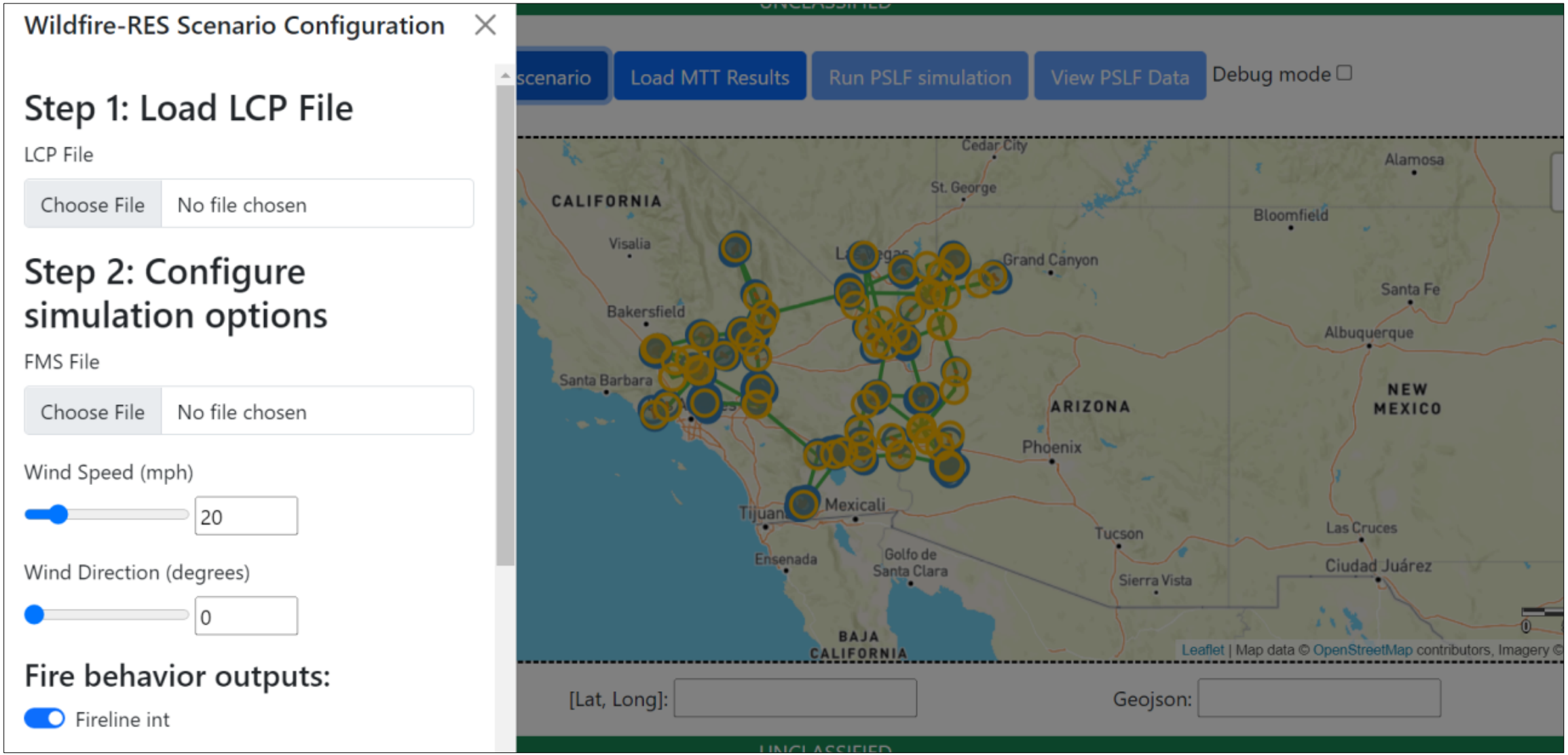


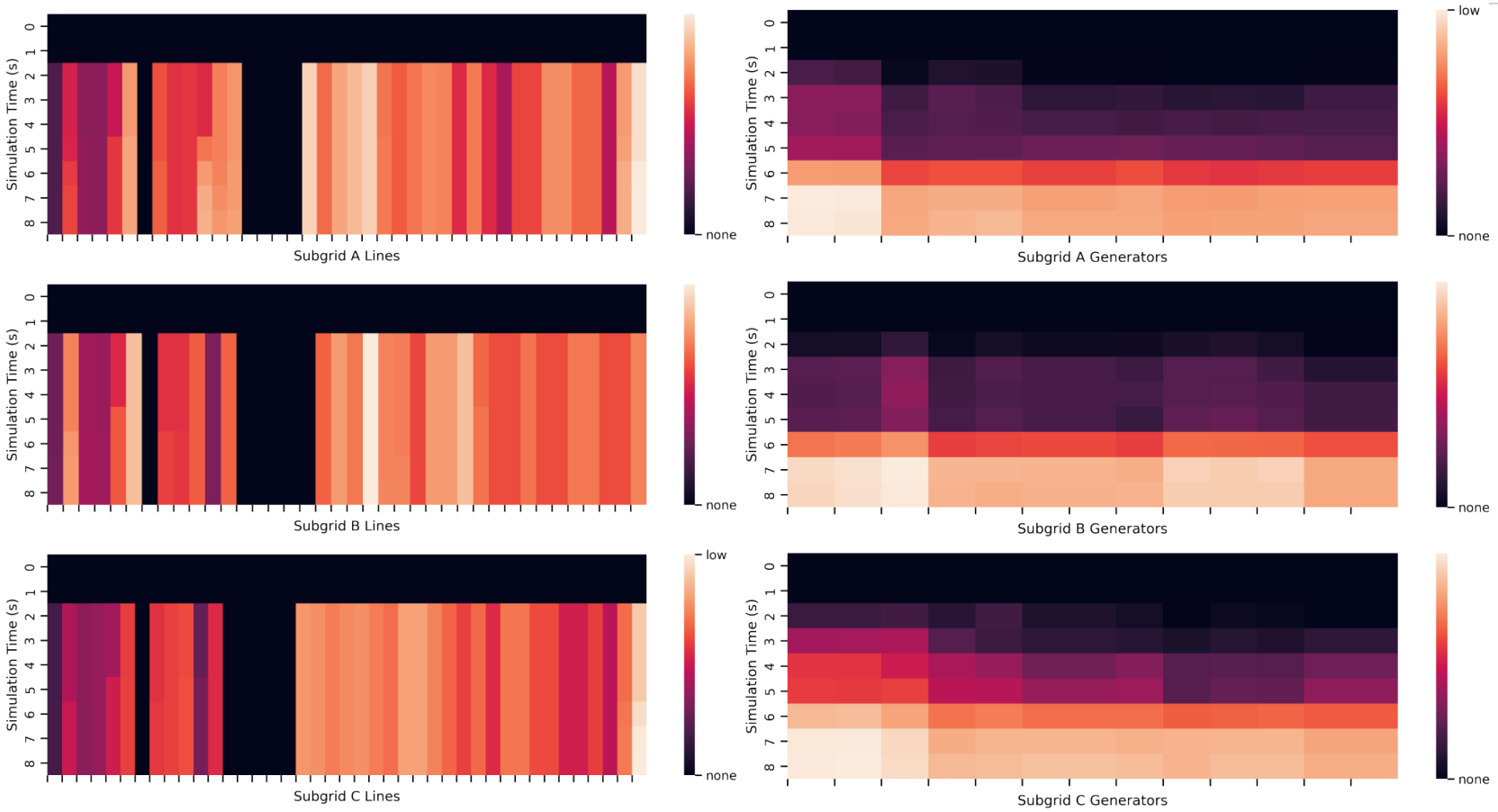
Interactive WebMap

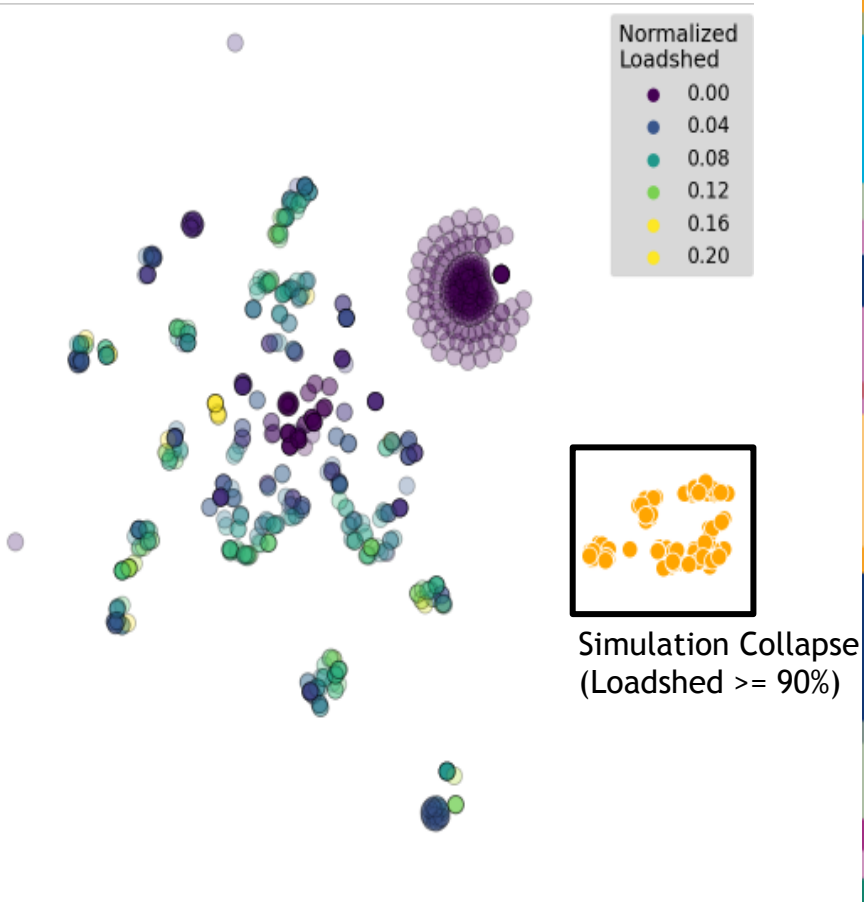


Running wildfire scenarios with updated fuel map



Probability of Component Failures Over Time

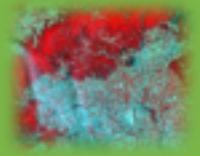




Simulation Collapse
(Loadshed >= 90%)

Next Steps: Grid mitigation recommendations

Sentinel-2
Multi-spectral Imagery



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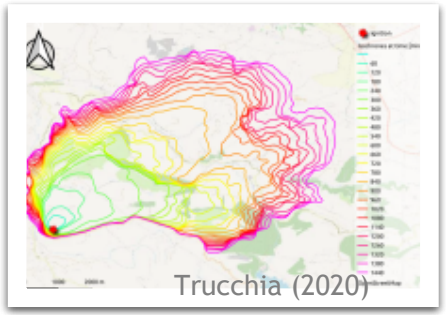

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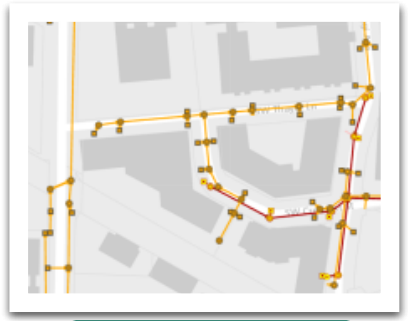

GIS data of infrastructure

Wildfire Resilience and Mitigation Strategies

- Monte Carlo simulation of wildfire spread, modelling components with highest probability of failure
- Model the damage if those components stay on
- Cost/benefit of different vegetation management strategies
- Cost of maintenance/ hardening of grid at key failure points.

Applications

- Through fire risk modelling and grid simulations, we will help utilities plan for and mitigate a disaster from fire and identify grid response strategies and resilient designs that reduce vulnerability leveraging past work on cascading failures.
- Current fuel models from LANDFIRE are refreshed once per couple of years and are taken from one point in time, our models refresh every 5 days for fuels, and every hour for live fuel moisture, providing more accurate datasets for wildfire behavior analysis
- Potential users:
  - Utility Managers – Southern California Edison, PG&E
  - Wildfire Response – USFS/CALFIRE
  - Wildfire Resilience – long-term planning applications for utilities, land management agencies and municipalities