Wildfire reburns and diminishing returns of existing forest management policies

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Computational Earth and Environmental Sciences (EES-16)

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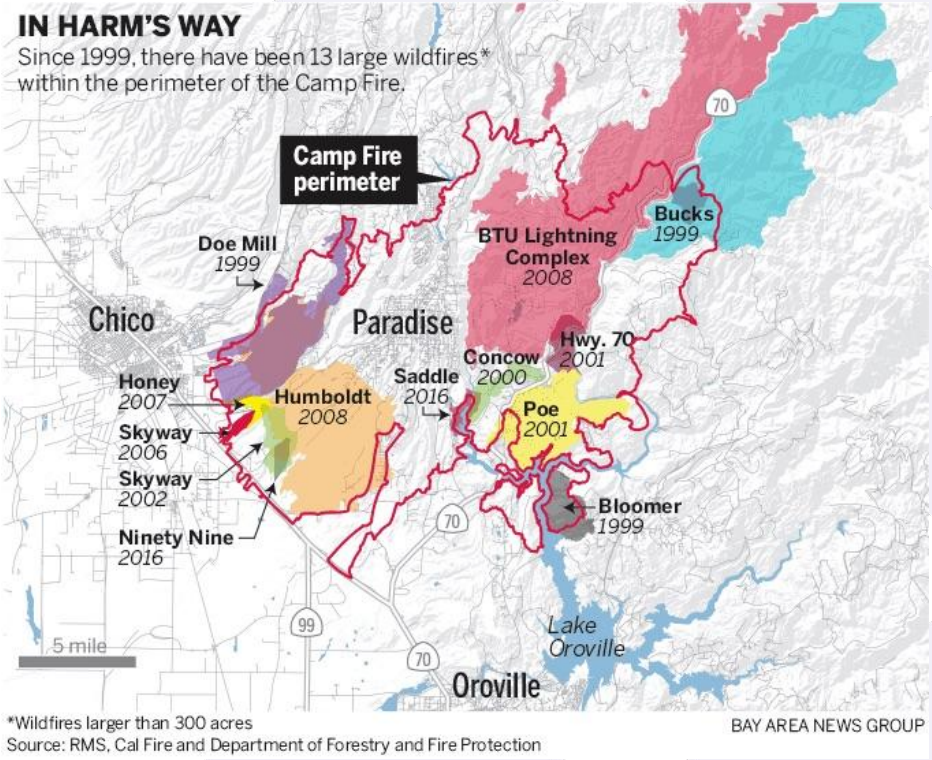
Motivation

- Growing evidence that re-burns occur every 10-15 years following wildfire
- This means to protect the Wildland Urban Interface (WUI), an area equivalent to size of Indiana, must be ‘treated’ at this frequency to safely ward off fire from destroying homes
- We need to come up with novel ways to predict where re-burns are likely to occur to prioritize forest treatment and management

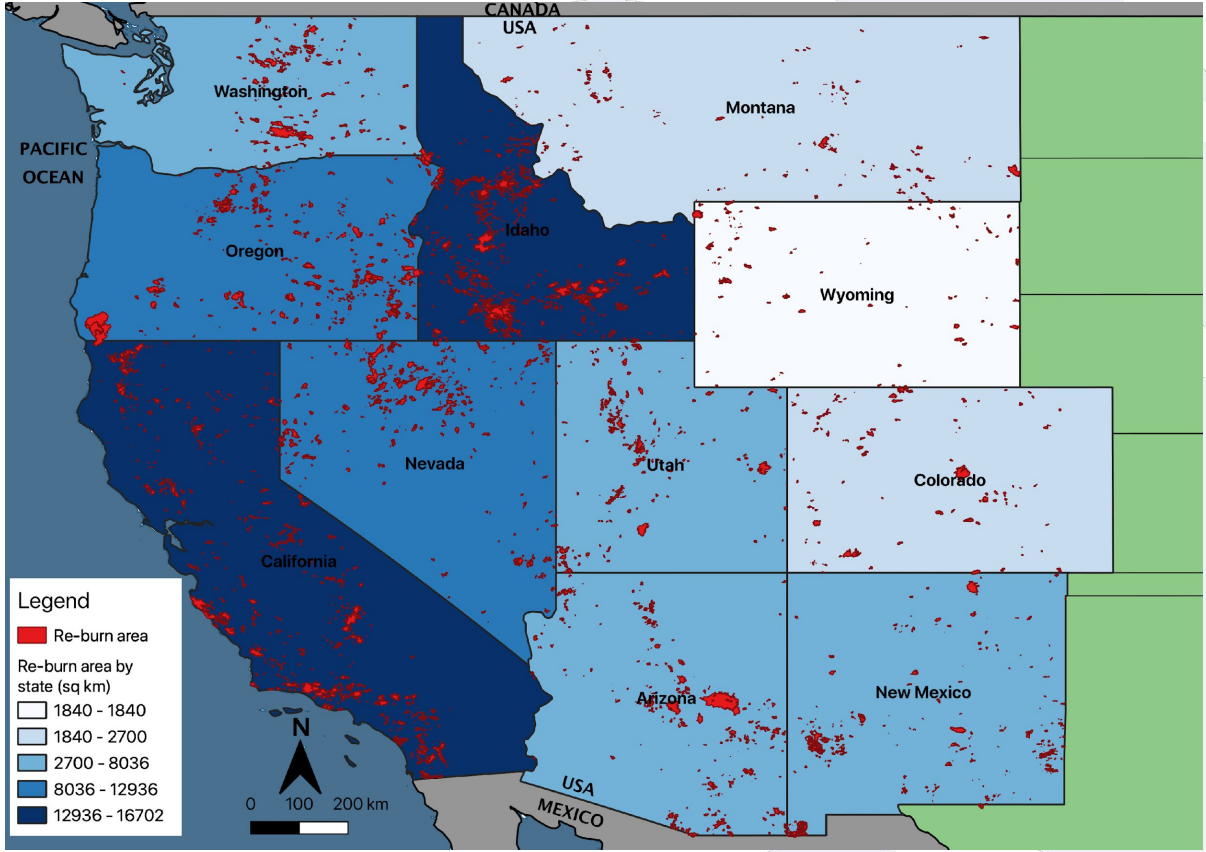


Objectives

- Evaluate predictability of wildfire re-burns using potential climate drivers combined with LANL-developed unsupervised physics-informed ML
- Compare model performance to other ML methods
- To get at human-component of re-burn drivers, calculate trends in re-burns both within and outside of WUI throughout the western US

Estimation of wildfire re-burns

- Re-burns calculated using Monitoring Trends in Burn Severity (MTBS) data product
- 1984-2018, 30m resolution
- 22,000+ fires represented
- Landsat-based product
- Only 405 ha fires are included, removes classification errors associated with small fires



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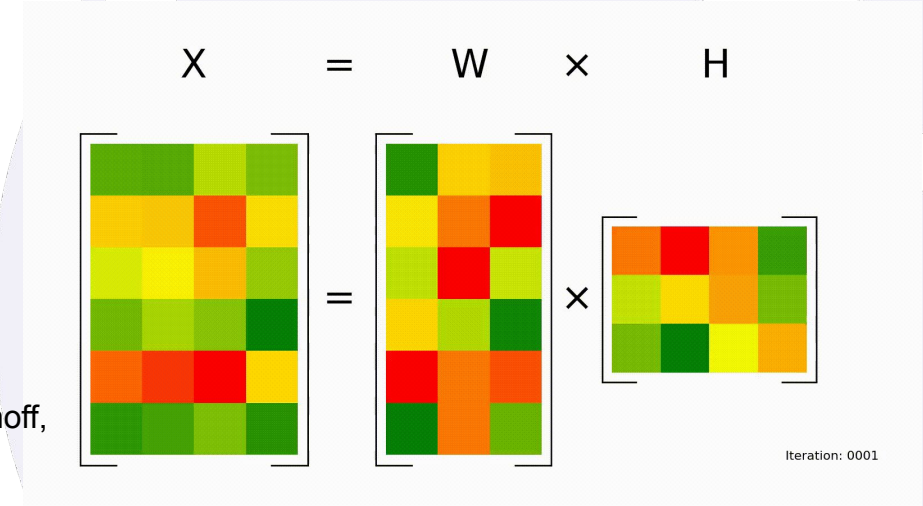
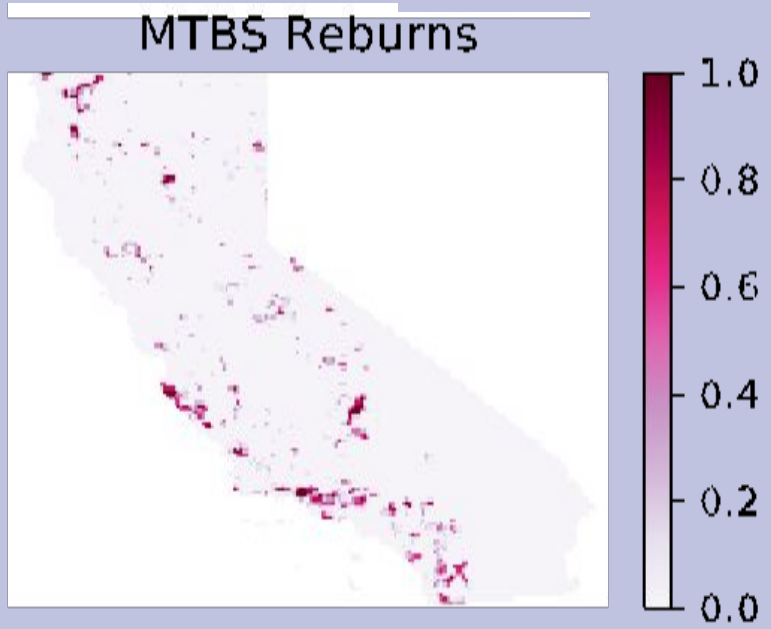
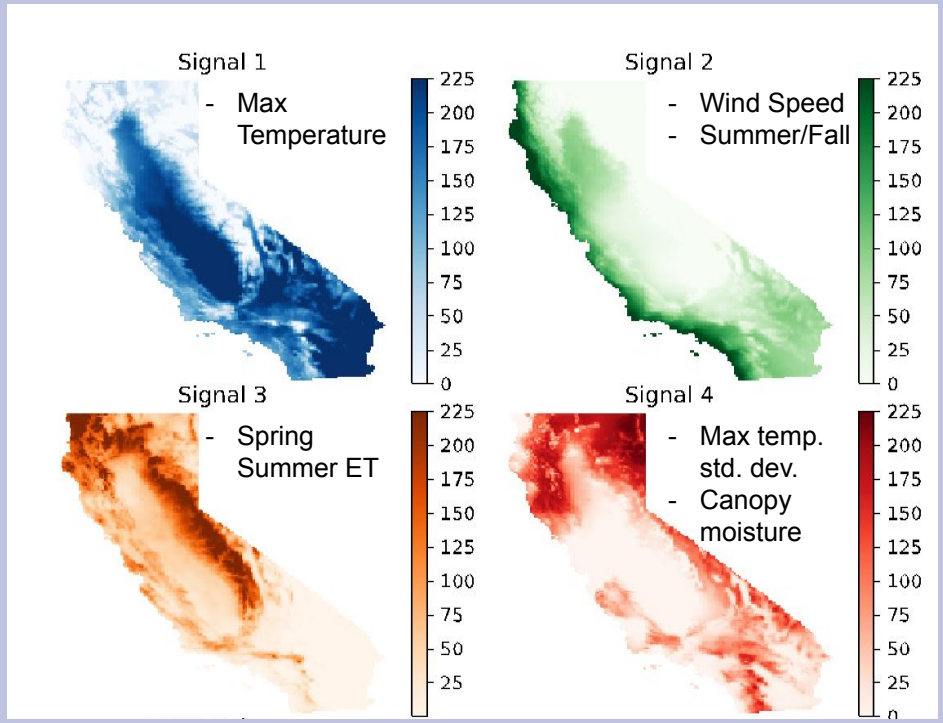
NMFk: Non-Negative Matrix Factorization using K-means clustering

- Non-Negative Matrix Factorization
  - Data Matrix is decomposed into a Feature matrix (W) and a mixing matrix(H)
  - We are able to extract the optimal number of constituent signals based on the input feature data
  - Custom K-Means clustering used to group matrix columns
- Input Data
  - Livneh near surface meteorological and derived hydro-meteorological data
    - Canopy moisture, soil moisture, prec., runoff, SWE, Evapotranspiration, etc.
  - 4-km Multivariate Adaptive Constructed Analogs (MACA) climate grid cells
    - Temperature, Wind Speed, precipitation
  - Monthly and Annual Data

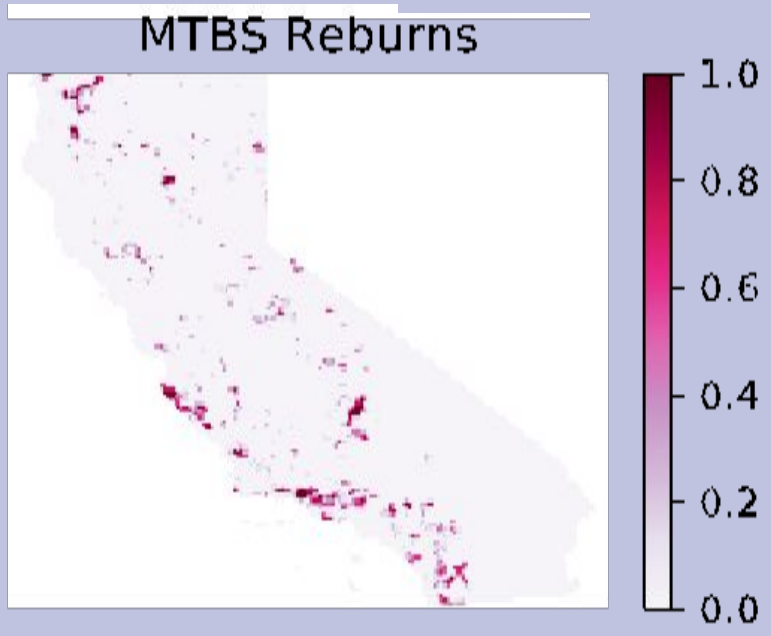


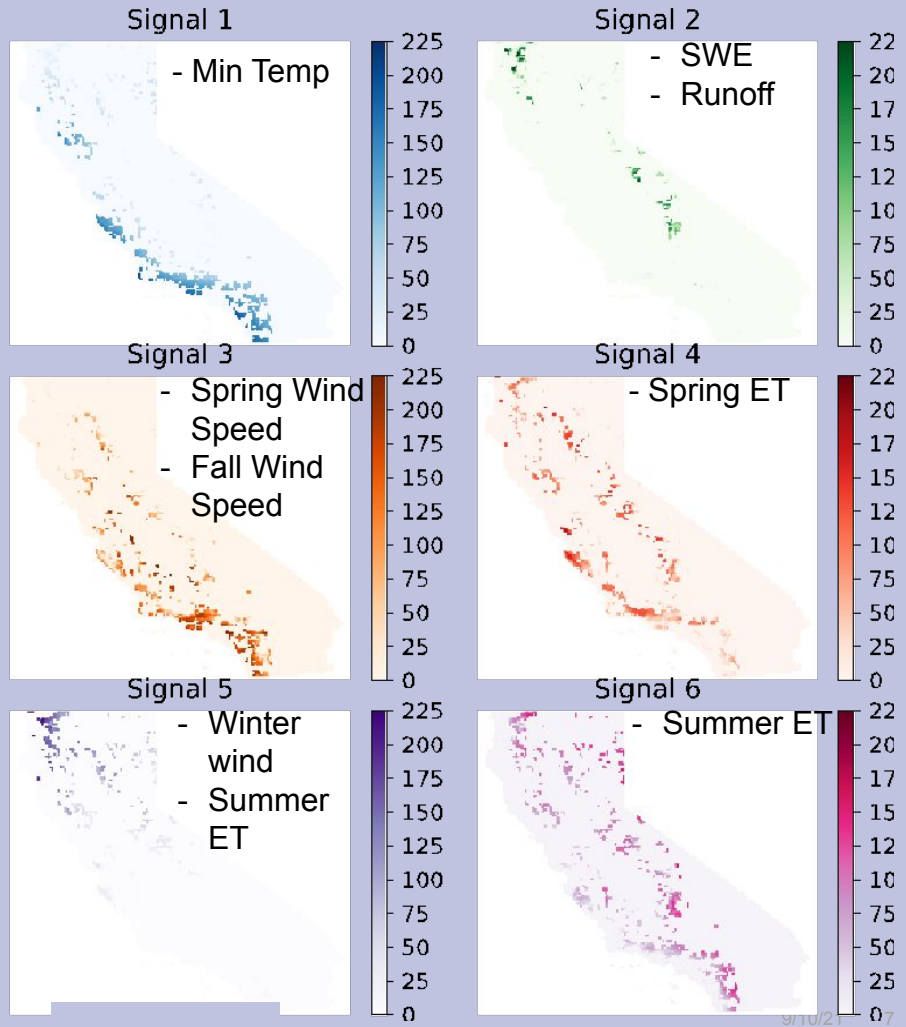
NMFk Unsupervised Clustering: Climate and Hydrologic Data





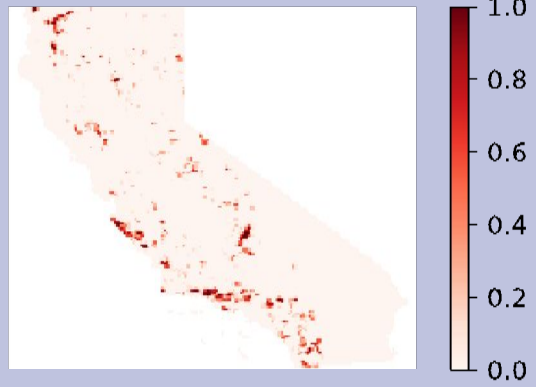
NMFk Unsupervised Clustering: Reburn Data Only





Re-burn Predictions using Random Forests

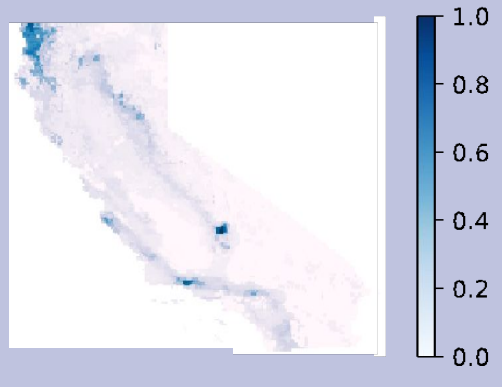
Observed Re-Burns



Random Forest Classifier

Training F1 Score = 0.68
Testing F1 Score = 0.60

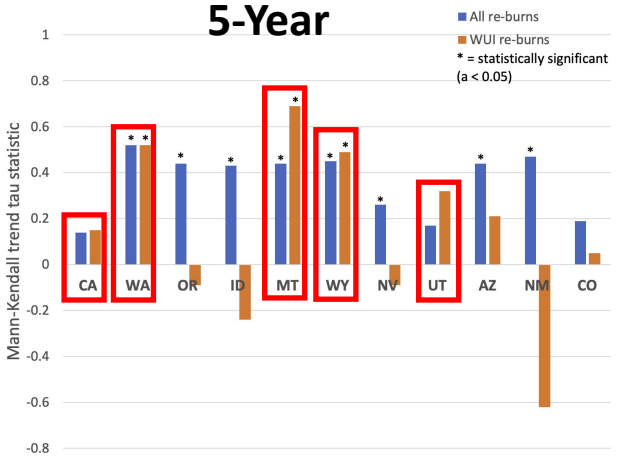
Random Forest Regressor

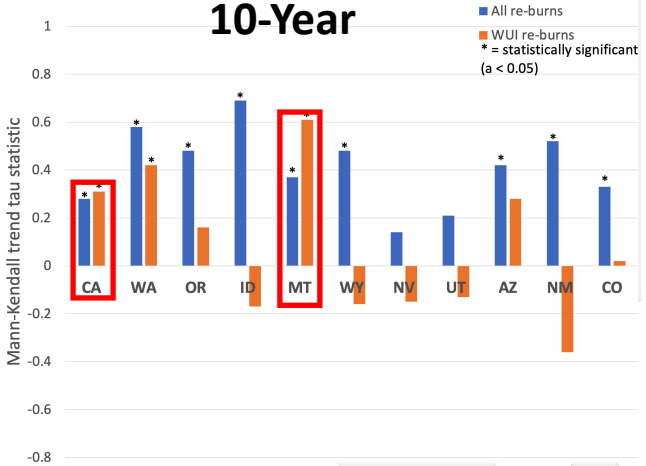


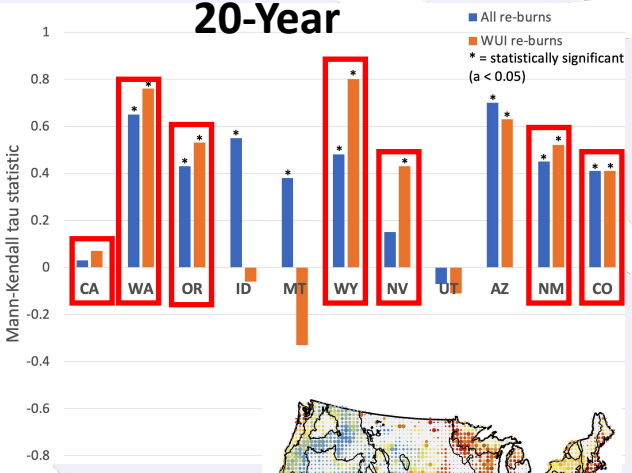
Training r^2= 0.694
Testing r^2= 0.53

Impact of Wildland Urban Interface (WUI) on Trends

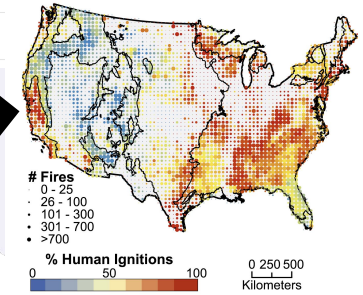
- Re-burn trends were estimated using standard statistical methods over 5- 10- and 20-year moving windows







- Strength of increasing trends tend to be higher in WUI (red box) at longer moving windows; also consistently higher in CA where most fires human-caused
- More decreasing trends noted in WUI, possibly due to stronger fire suppression
- Longer moving windows tend to reveal more robust trends due to fuel limitations for wildfires over shorter return intervals



Balch et al., 2017 PNAS

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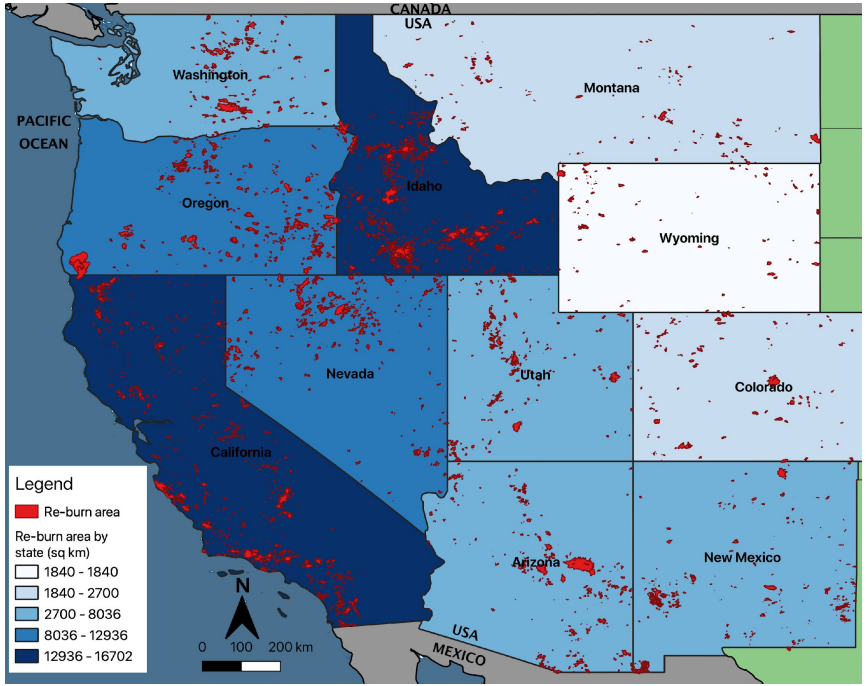

Re-burn perimeters (red) calculated from the Monitoring Trends in Burn Severity (MTBS) data from 1984-2018. States are shaded according to the re-burn area that occurs within their borders.

Project Description

- Evaluating the predictability of re-burns from climate drivers using Machine Learning and link to human activity through trends in WUI

Project Outcomes

- In California, Re-burns most associated with wind speed in south and evapotranspiration
- Stronger re-burn trends within WUI in CA and when 20-year windows are considered
- Solander et al., manuscript in prep (see below)

PI: Solander
Total Project Budget: $60,000
ISTI Focus Area: Computational and Data Integrity

Solander, K.C., Talsma, C.T., and Vesselinov, V., The drivers and predictability of wildfire re-burns in the western United States (US), 2021, Environ. Res. Lett. (in prep).

END