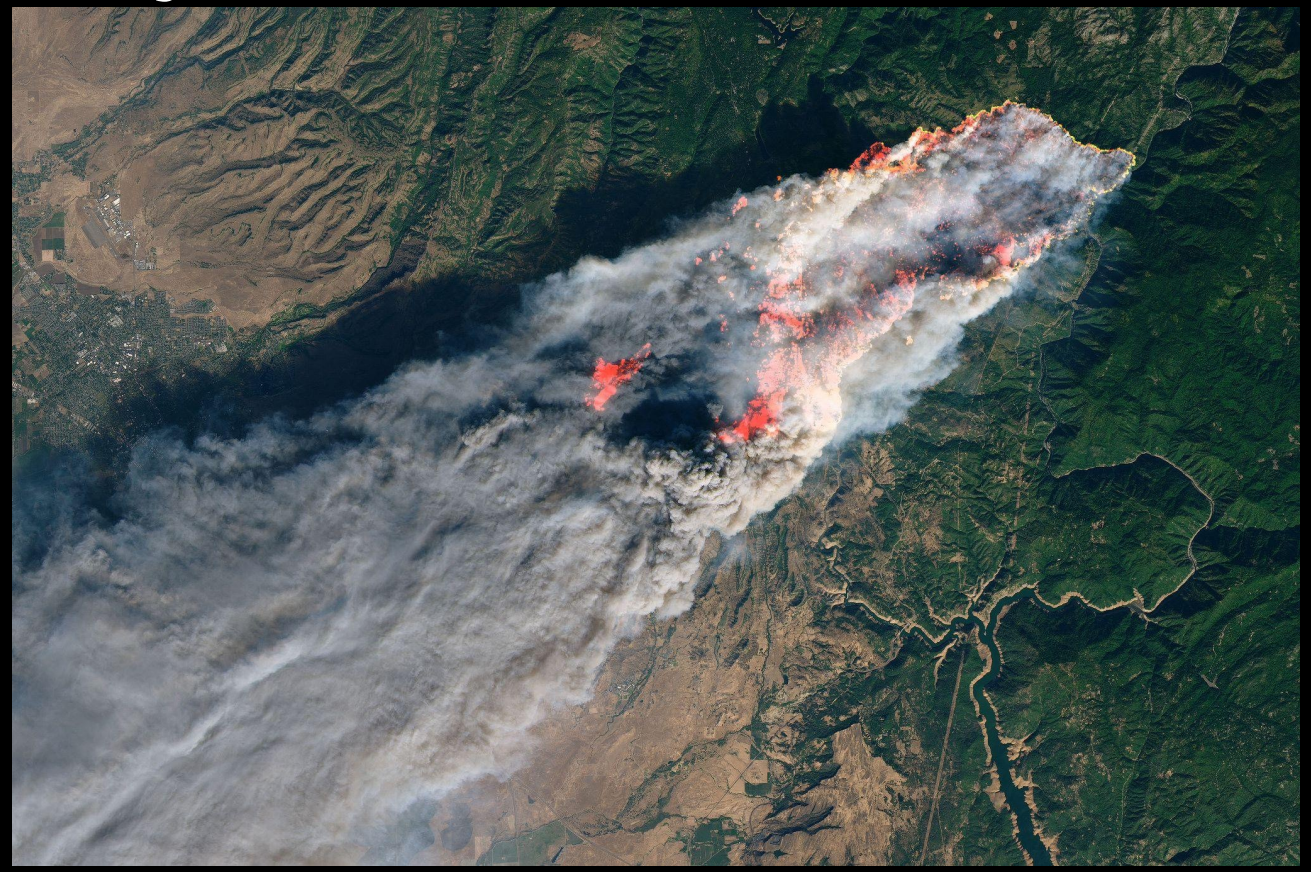
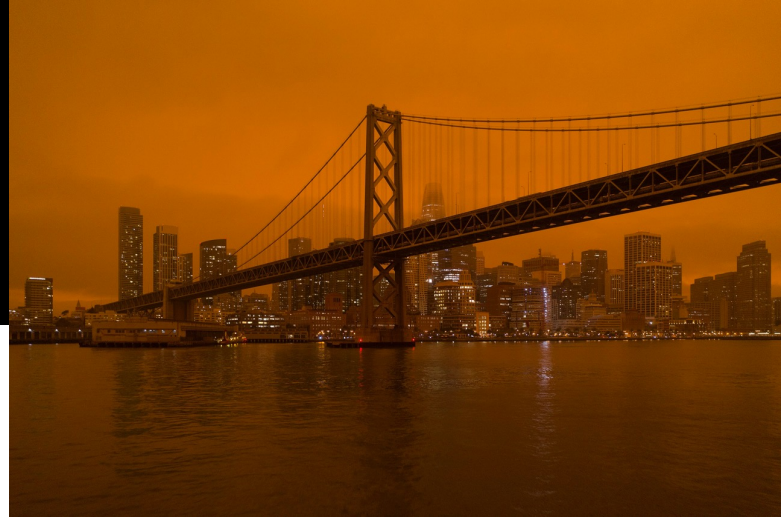
ECOSTRESS reveals pre-fire vegetation controls on burn severity for Southern California Wildfires



Jet Propulsion Laboratory
California Institute of Technology

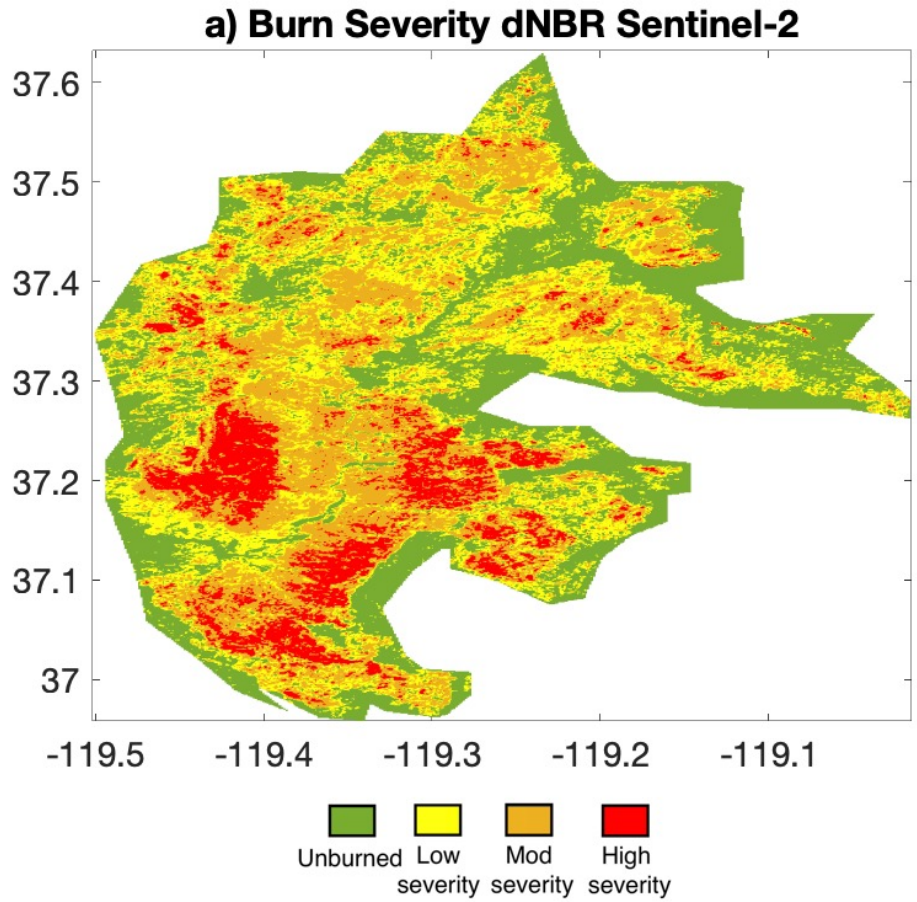
Madeleine Pascolini-Campbell (JPL), Christine Lee (JPL), Natasha Stavros (CU Boulder)
Josh Fisher (Chapman U)

2020 Fire Season California



- 4.1m acres burned
- North Complex Fire *5th most destructive* on record
- August Complex *greatest area burned* on record
- 1200 excess deaths and 4800 hospital visits in 2020 due to smoke inhalation

How can we predict patterns of burn severity?



- Burn Severity = damage done to soils and plants

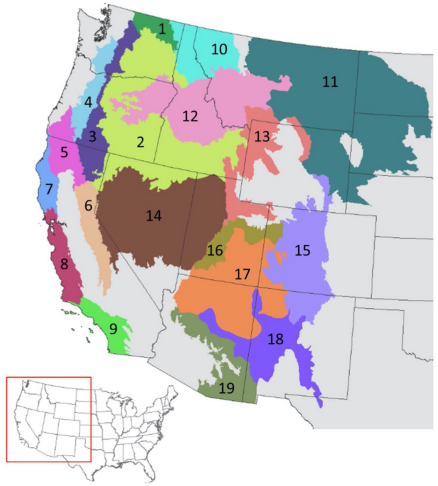
Topography, climate and vegetation controls on burn severity

Environmental Research Letters

LETTER

High-severity fire: evaluating its key drivers and mapping its probability across western US forests

Sean A Parks[1,4], Lisa M Holsinger[1], Matthew H Panunto[2], W Matt Jolly[2], Solomon Z Dobrowski[3] and Gregory K Dillon[2]



esa

ECOSPHERE

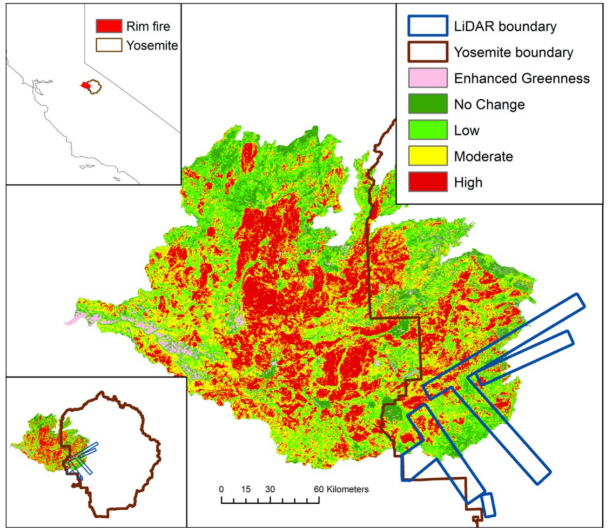
Both topography and climate affected forest and woodland burn severity in two regions of the western US, 1984 to 2006

Gregory K. Dillon,[1,†] Zachary A. Holden,[2] Penelope Morgan,[3] Michael A. Crimmins,[4] Emily K. Heyerdahl,[1] and Charles H. Luce[5]

Mixed severity fire effects within the Rim fire: Relative importance of local climate, fire weather, topography, and forest structure

CrossMark

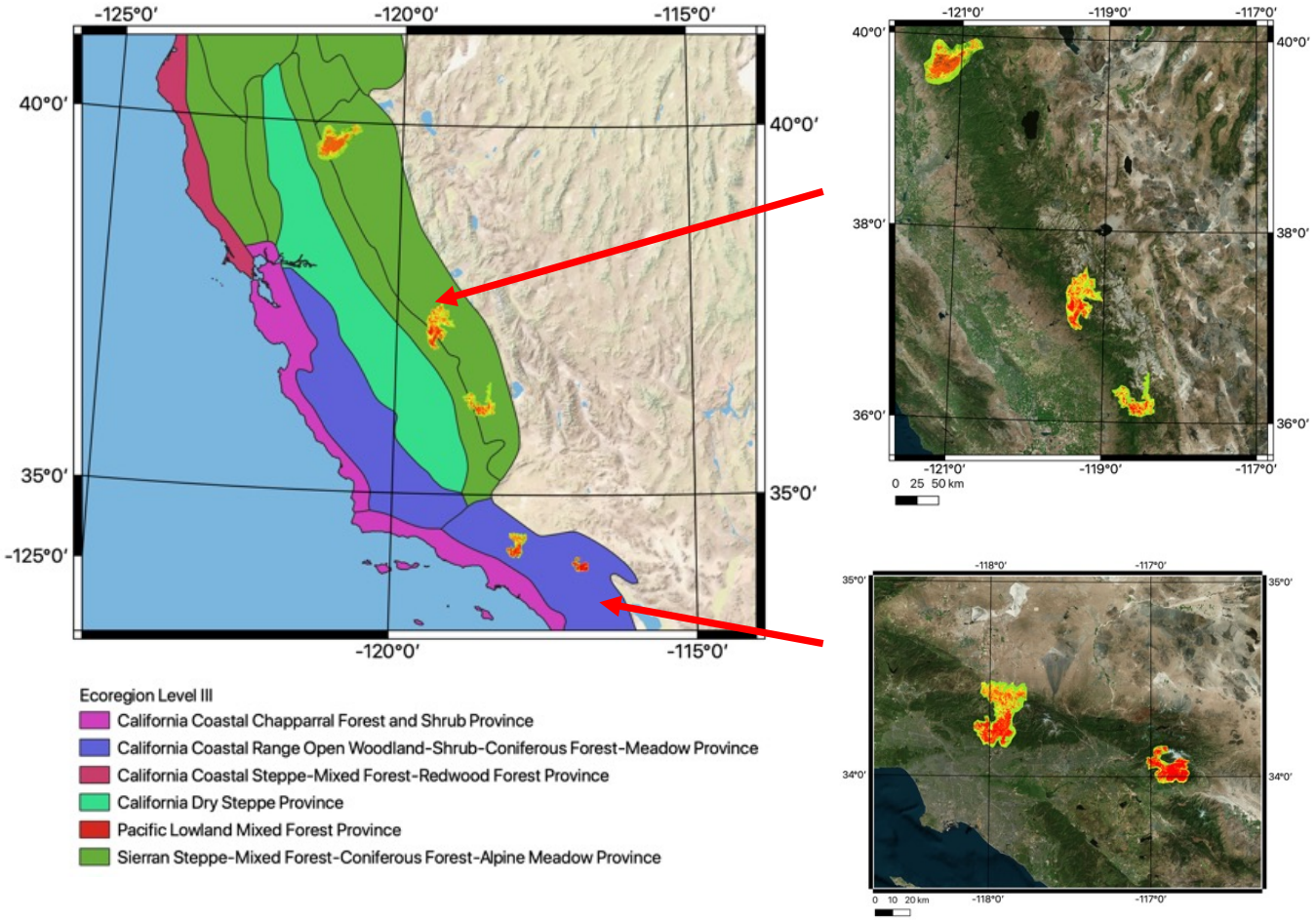
Van R. Kane[a,*], C. Alina Cansler[a], Nicholas A. Povak[b], Jonathan T. Kane[a], Robert J. McGaughey[c], James A. Lutz[d], Derek J. Churchill[a], Malcolm P. North[e]



Fine-scale satellite information on plant water stress to predict patterns of burn severity

Credit: NASA

Methods



2 Ecoregions in California:

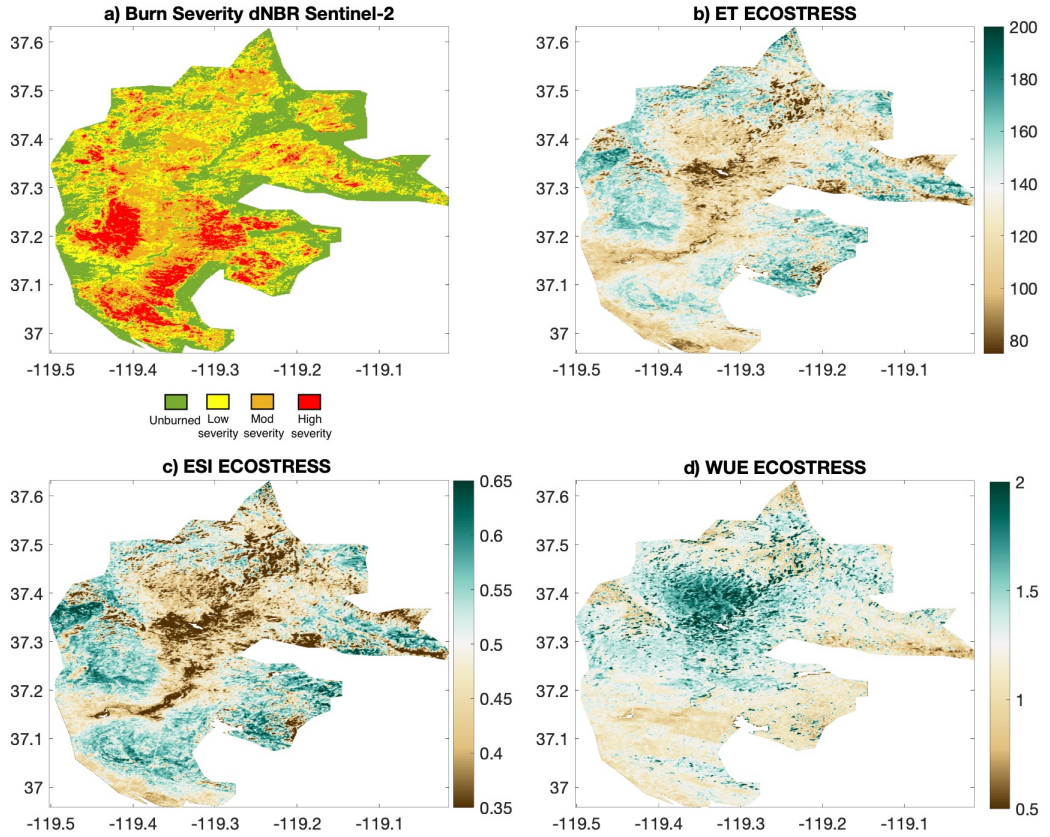
1) **Sierran Steppe – Mixed Forest – Coniferous Forest – Alpine Meadow Province**

    1) Creek Fire
    2) Sequoia Complex Fire (SQF)
    3) North Complex

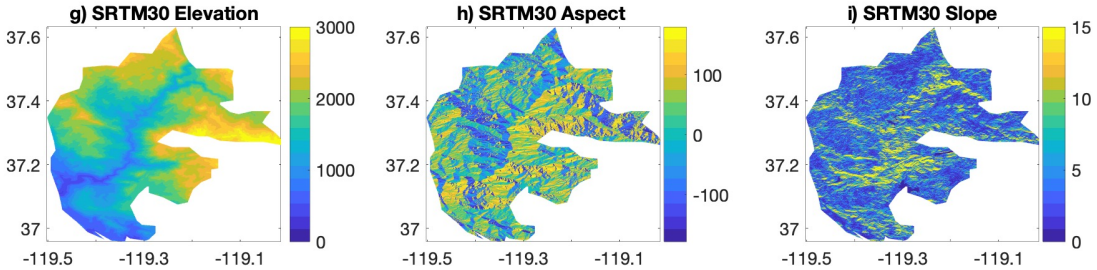
2) **California Coastal Range Open Woodland – Shrub –Coniferous Forest Province**

    1) Bobcat
    2) Eldorado
    3) Apple

Hydrological, topographic, land cover data for each fire

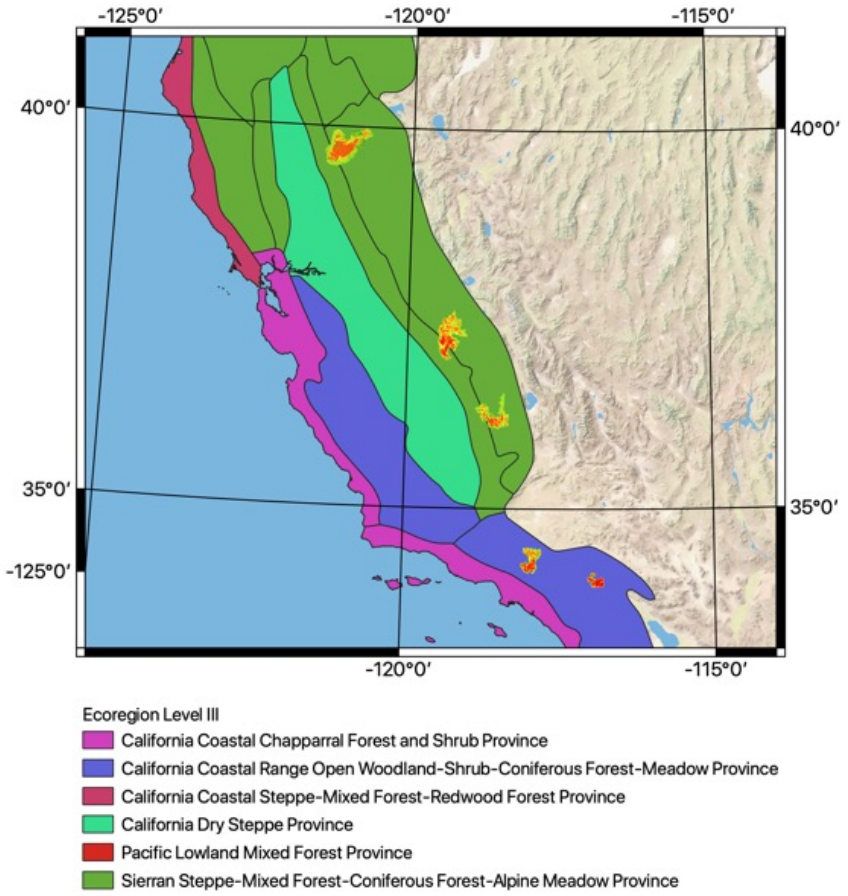


- ECOSTRESS 70 m daily ET_PT-JPL, ESI_PT-JPL, WUE from year prior to fire outbreak, inst. ET-PTJL AM/PM
- Topographic variables:
  - Elevation
  - Aspect (N, S)
  - Angle (degrees)
- Landcover MODIS
- Spatial autocorrelation



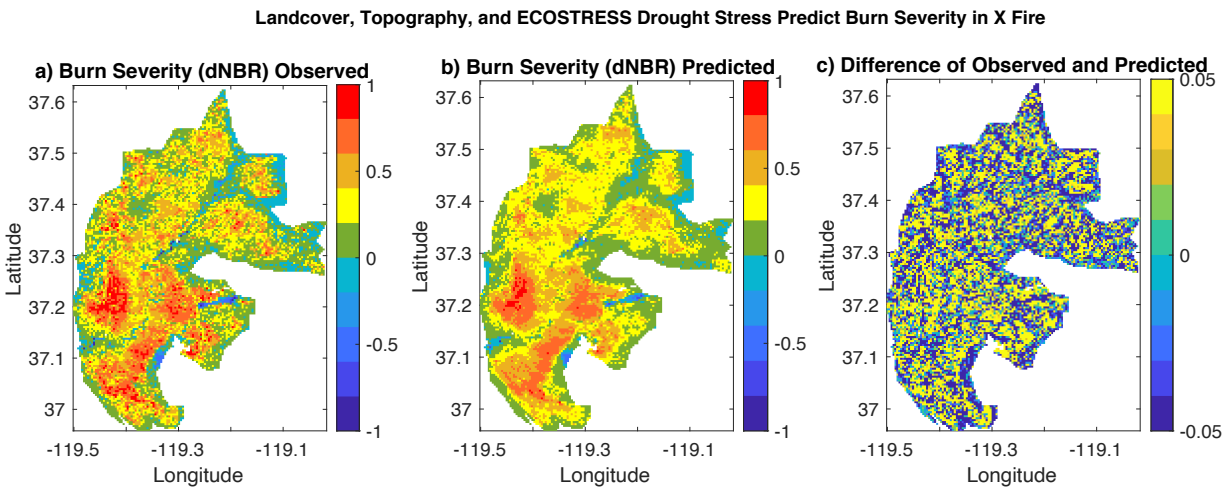
Random Forest Regression

- Use random forest regression algorithm (Breiman et al. 2001) to model severity
- Run analysis for different grid spacing
- Group fires by ecoregion

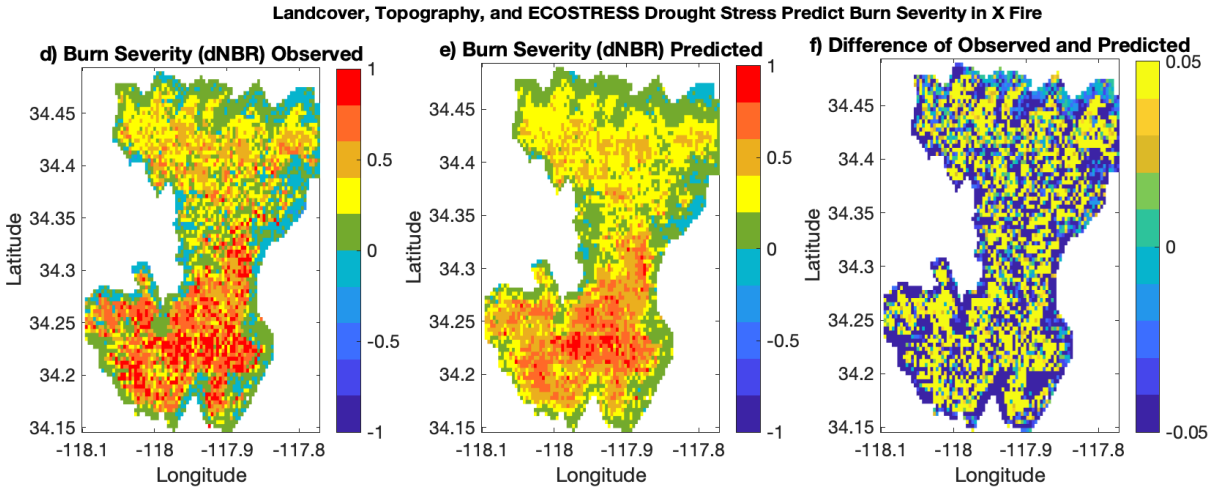


Results: random forest predicts the spatial patterns of burn severity

Sierran Steppe

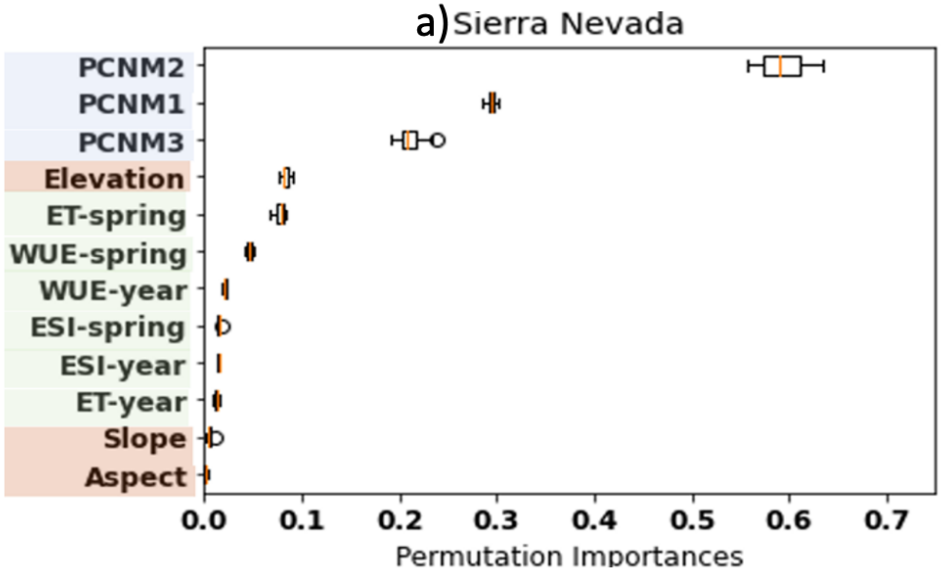


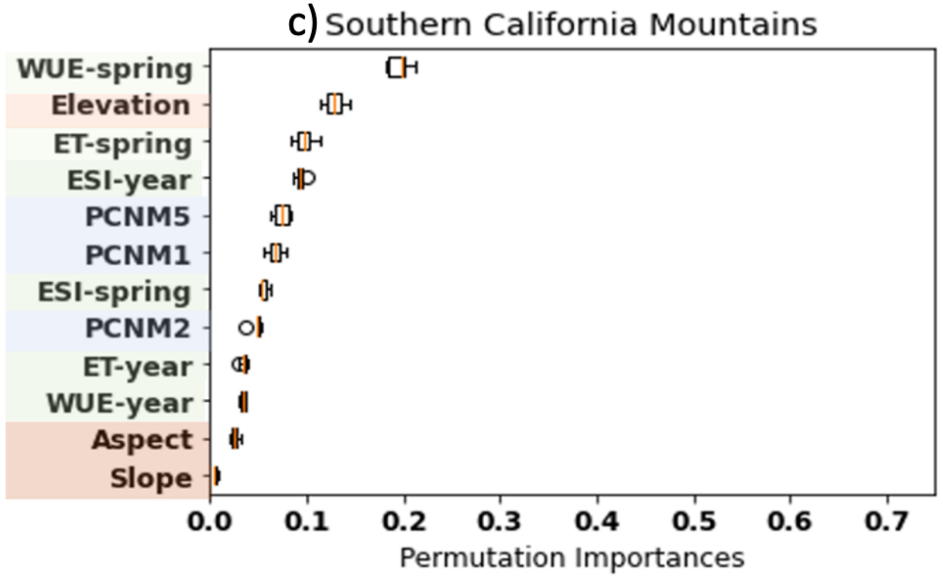
California Coastal



Generally good agreement, in either case burn severity *underpredicted* by RF

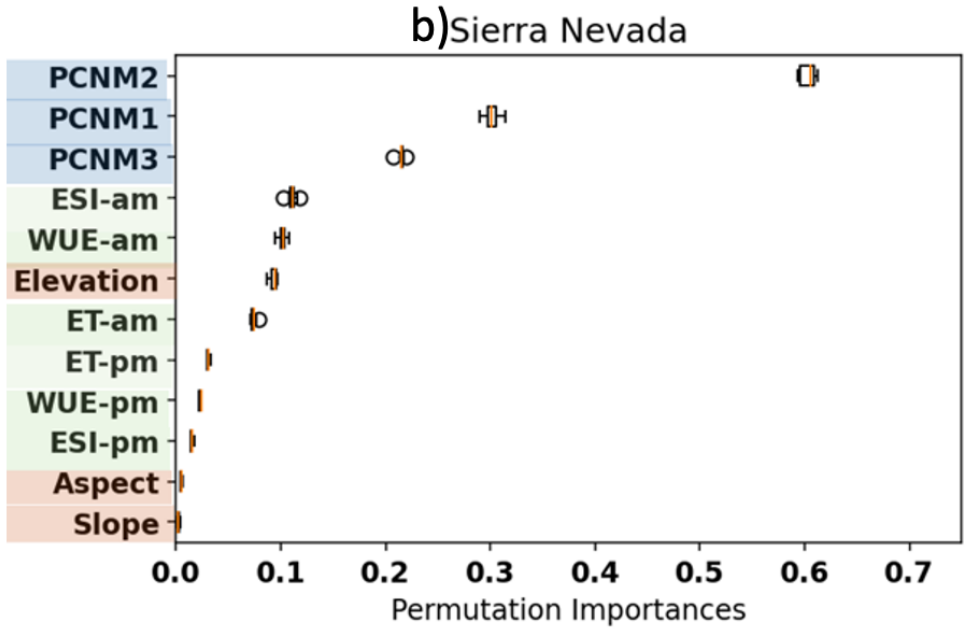
Sierra Nevada is dominated by spatial autocorrelation, plant stress is most important for So Cal

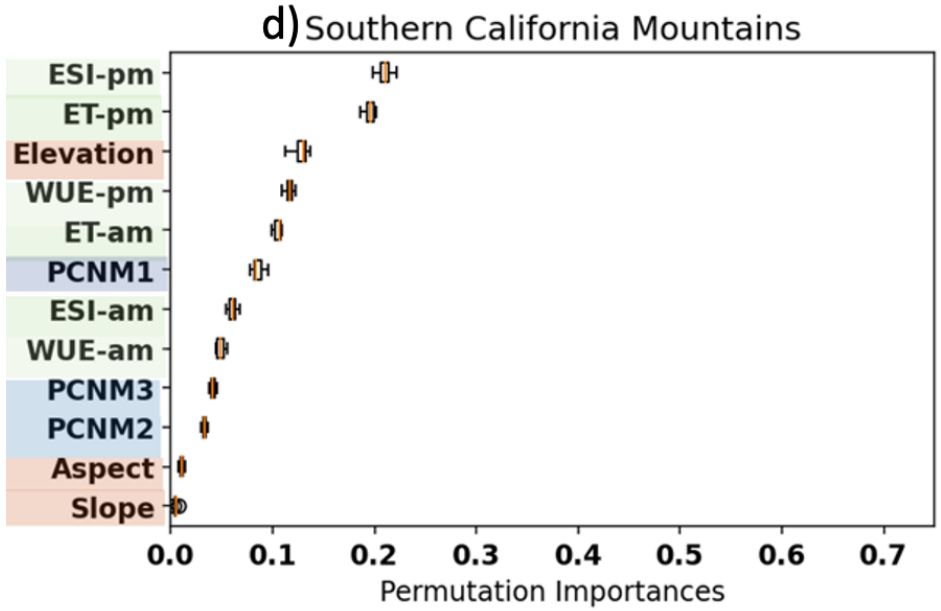




Spatial autocorrelation
Plant stress [Year/Spring-summer]
Topography

Afternoon predictors are more important for So Cal





Spatial autocorrelation

Plant stress [AM/PM]

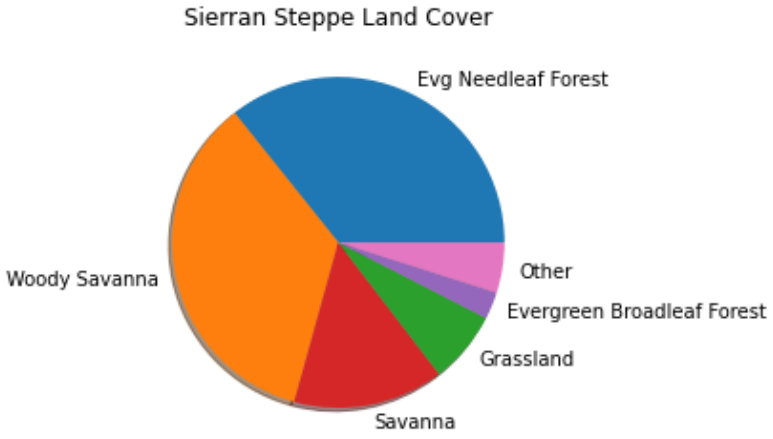
Topography

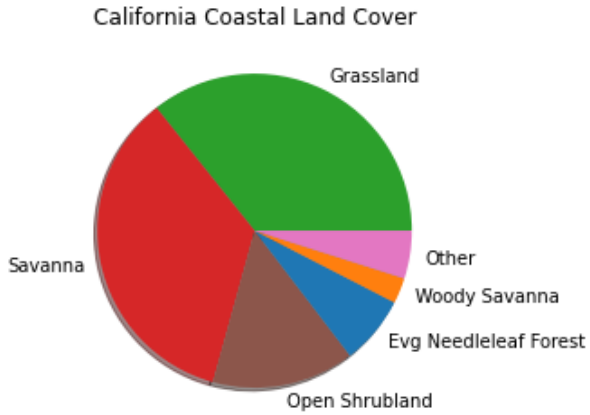
Results: Repeat the analysis sub-setting the two ecoregions by 1) land cover, 2) topography

Subset data by

1) Land Cover Type
    1) Evergreen Needleaf Forest
    2) Woody Savanna
    3) Savanna
    4) Grasslands

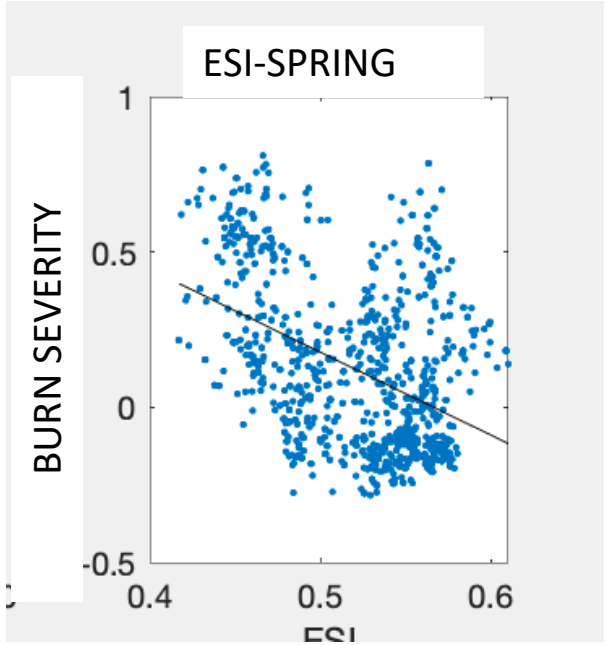
2) Topographic setting
    1) High Elevation (>1500 m)
    2) Steep Terrain (>15deg)





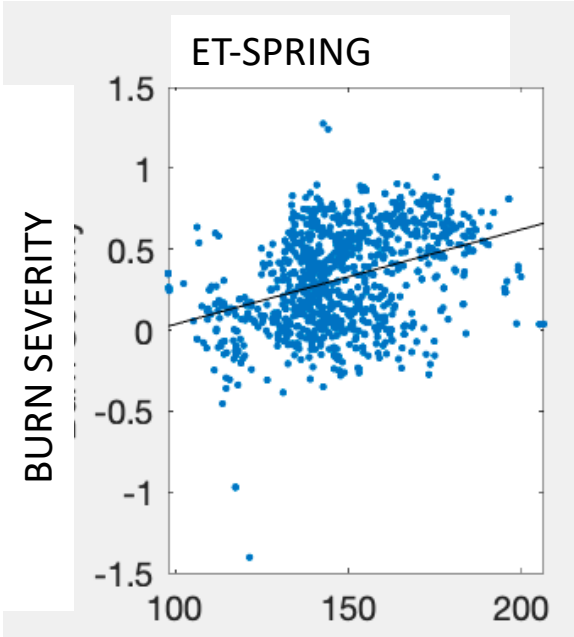
Different vegetation types have different burn severity responses to plant stress

Evergreen Forests



Evergreen forest burn severity increases for more stressed vegetation, especially in the spring before the fire

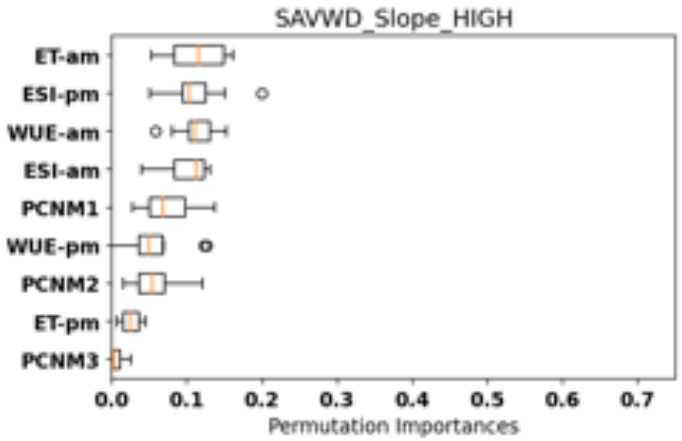
Grasslands



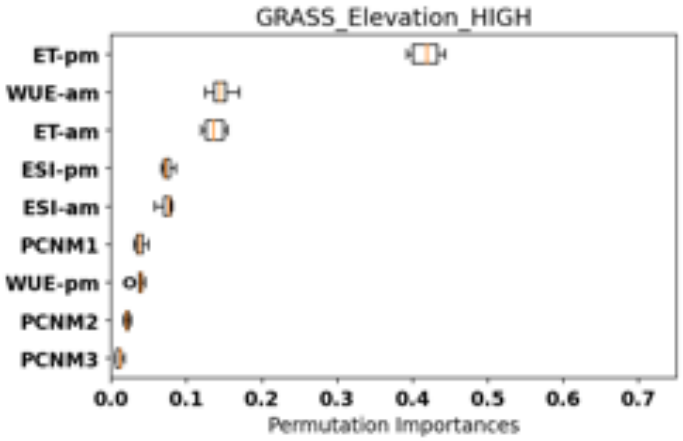
Burn severity in grasslands instead responds to amount of fuel – more grass leads to higher burn severity

Time of day of plant stress observation is also important and varies with land cover type

Woody Savanna



Grasslands



Summary
Questions? madeleine.a.pascolini-campbell@jpl.nasa.gov

- The Sierra Nevada was dominated by spatial autocorrelation – Southern California plant stress was most important
- Elevation is leading variable explaining burn severity
- For both Sierran Steppe and Coastal California, predictability is greater at more severe terrain (i.e. steeper slopes, higher elevation)
- These results indicate importance of drought monitoring during growing season (spring-summer) before the fire season to inform burn severity

Results: For each ecoregion, *elevation* is found to be most important predictor of burn severity overall

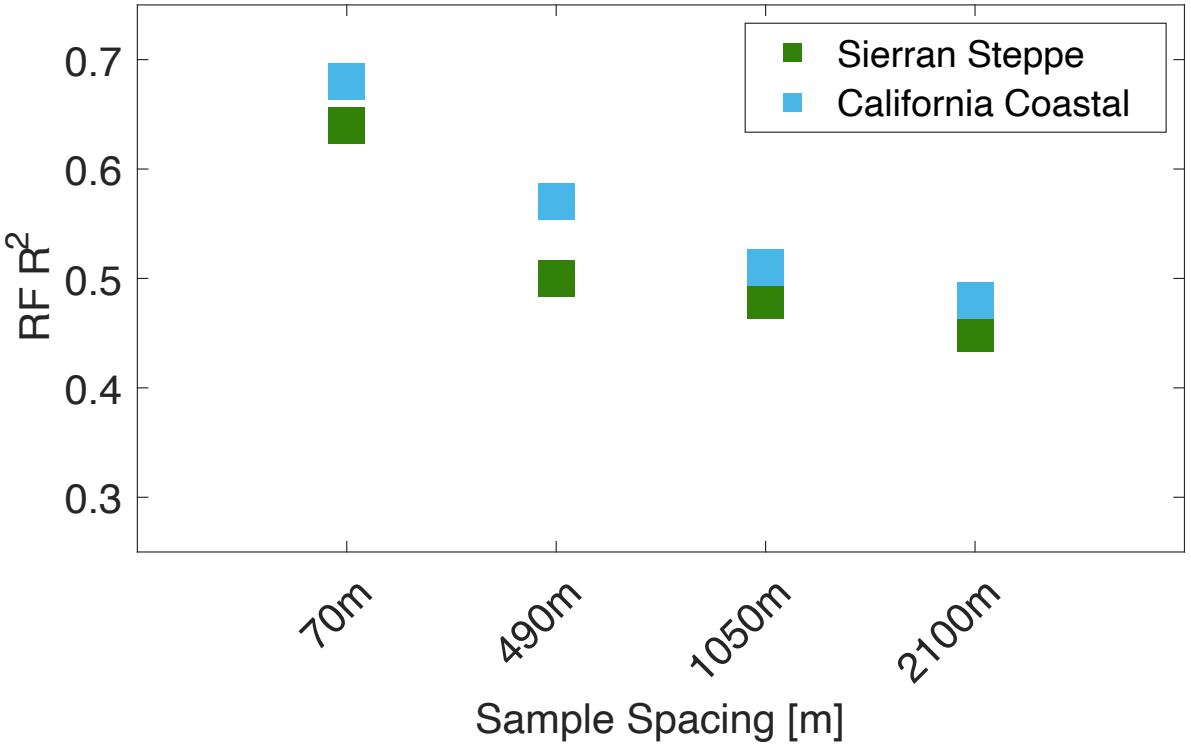


Table 1: Sierran Step

	N = 0.5 X = 70 m	N = 0.5 X = 490 m	N = 0.5 X = 1050 m	N = 0.5 X = 2100m
Var Important R2	Elevation R2 = 0.64	Elevation R2 = 0.50	Elevation R2=0.48	Elevation R2 = 0.45

Table 2: California Coastal

	N = 0.5 X = 70 m	N = 0.5 X = 490 m	N = 0.5 X = 1050 m	N = 0.5 X = 2100m
Var Important R2	Elevation R2 = 0.68	Elevation R2 = 0. 57	Elevation R2=0.51	Elevation R2 = 0.48