MODELING FOREST FIRE IN THE WESTERN UNITED STATES

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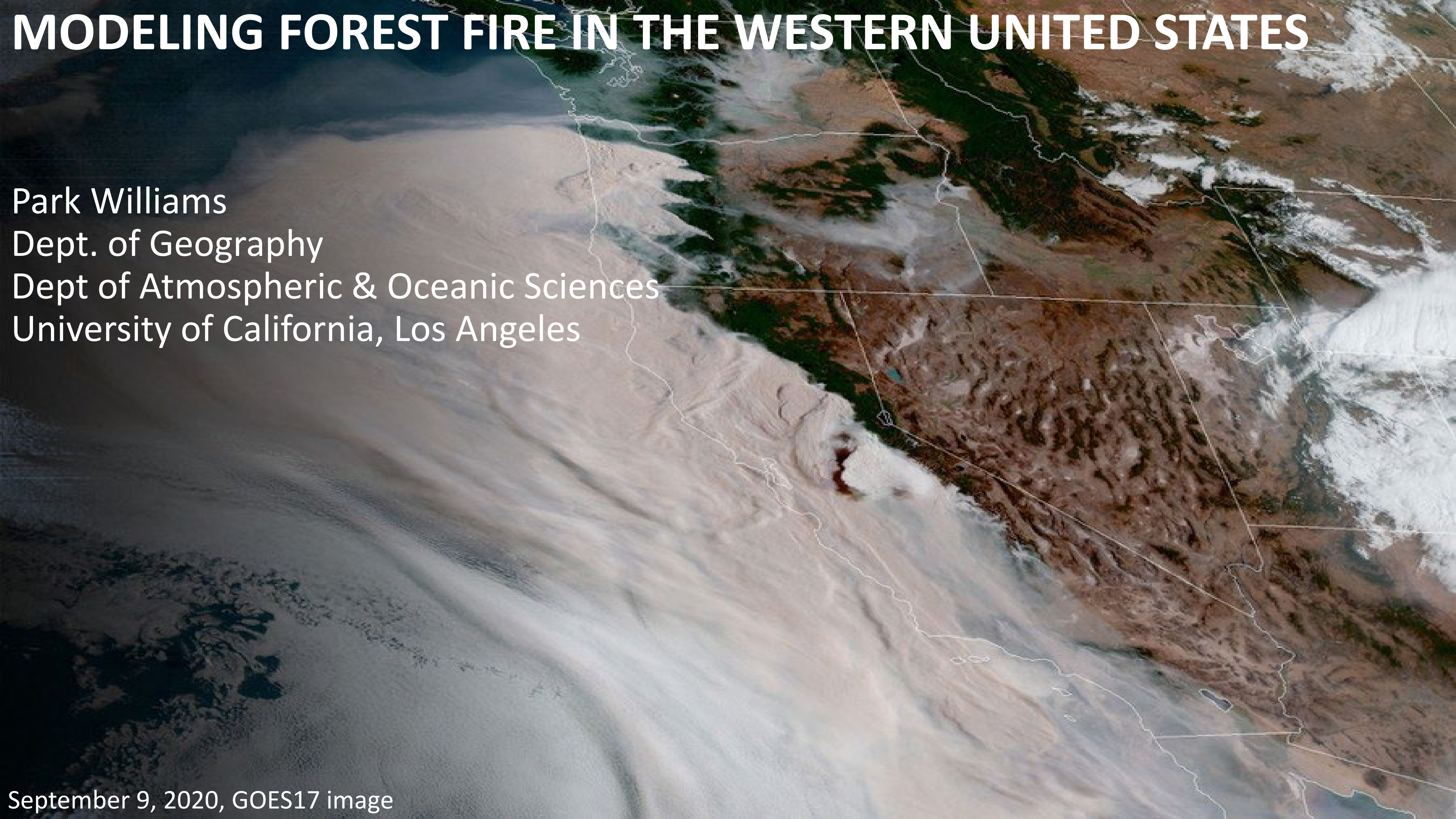
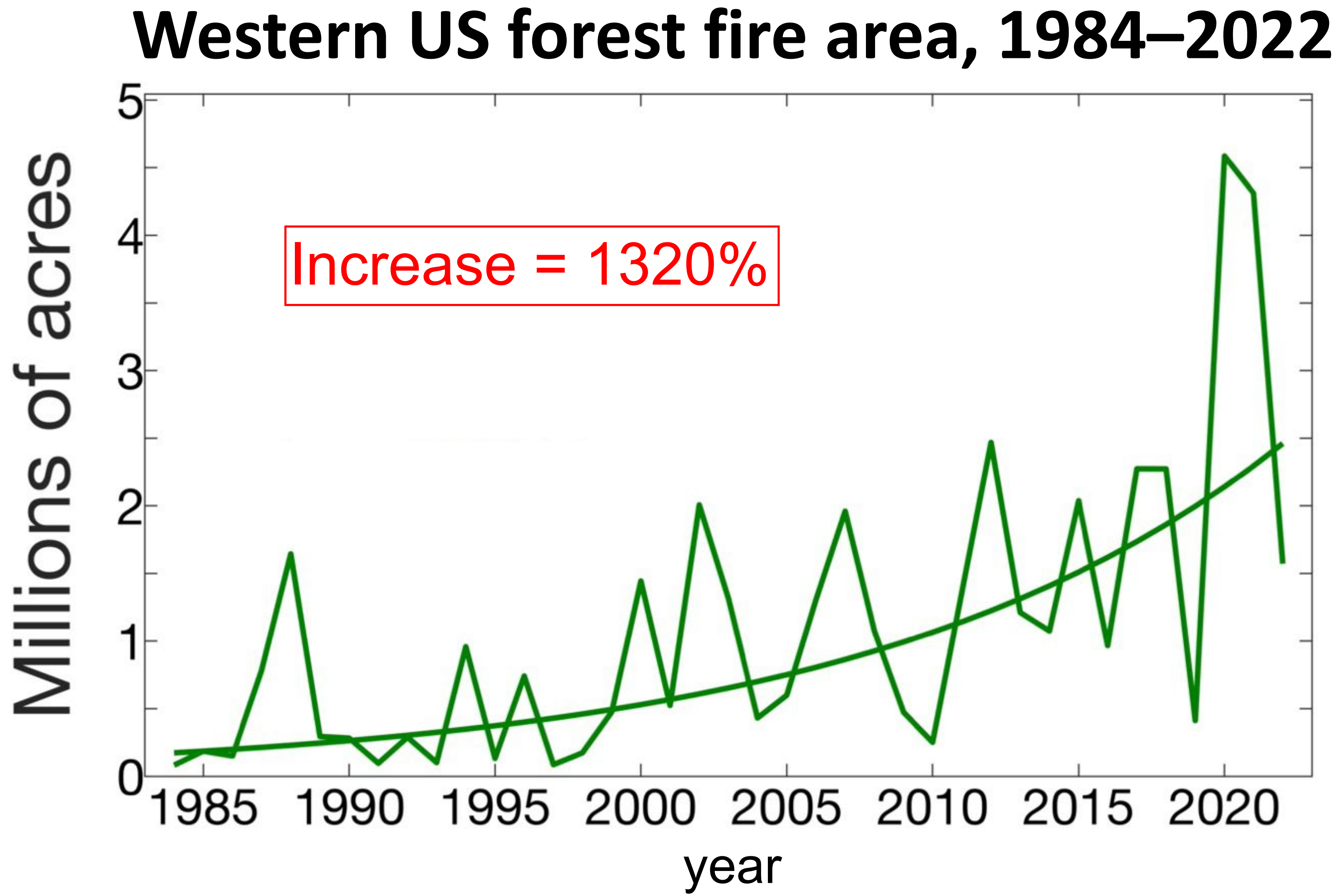


September 9, 2020, GOES17 image

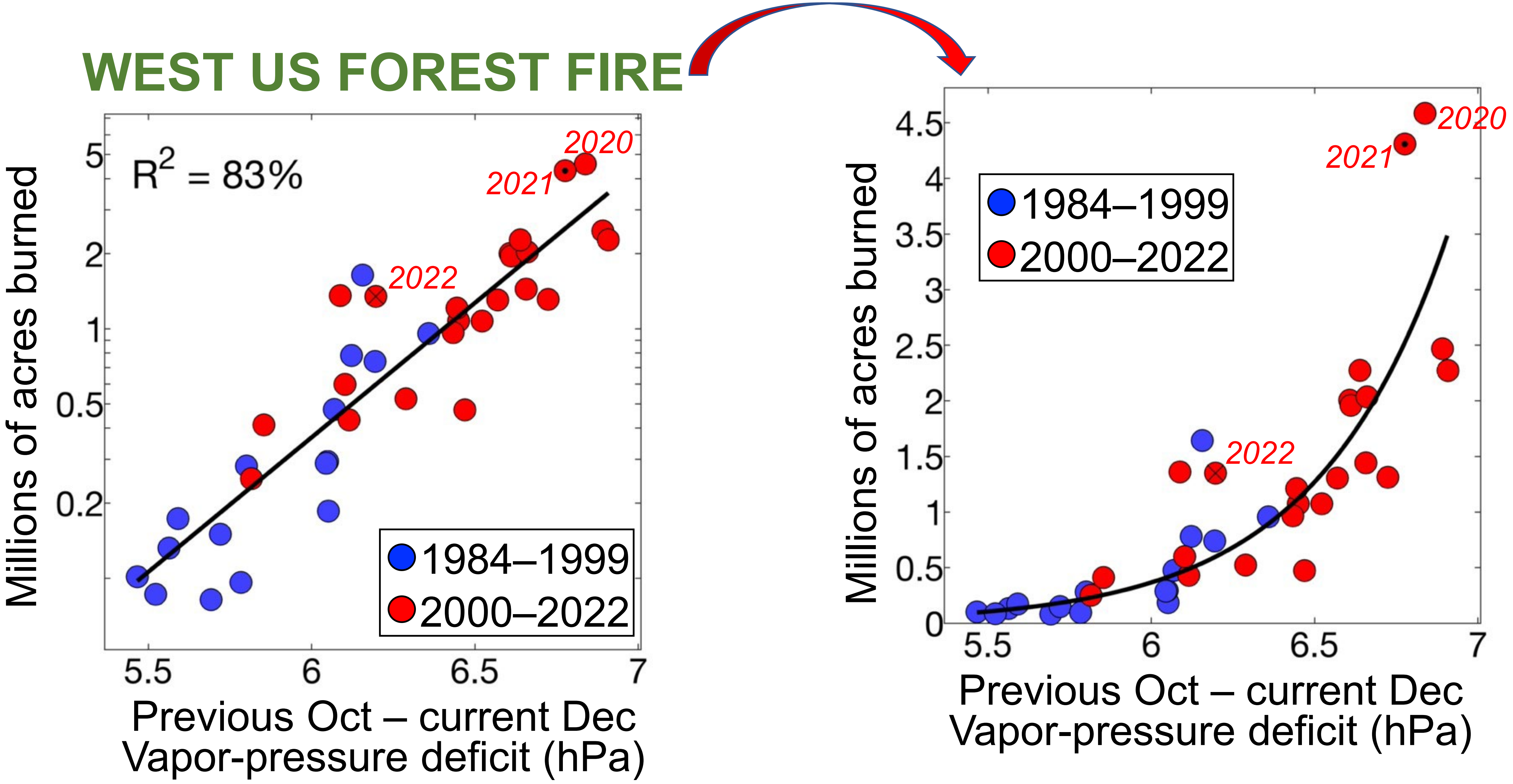
BURNED AREA INCREASING DRAMATICALLY IN FOREST



*Trend line based on the Theil-Sen estimator and whether a better trend fit was produced for $\log_{10}$(burned area) or untransformed burned area.

Wildfire dataset compiled by my group using satellite and government records

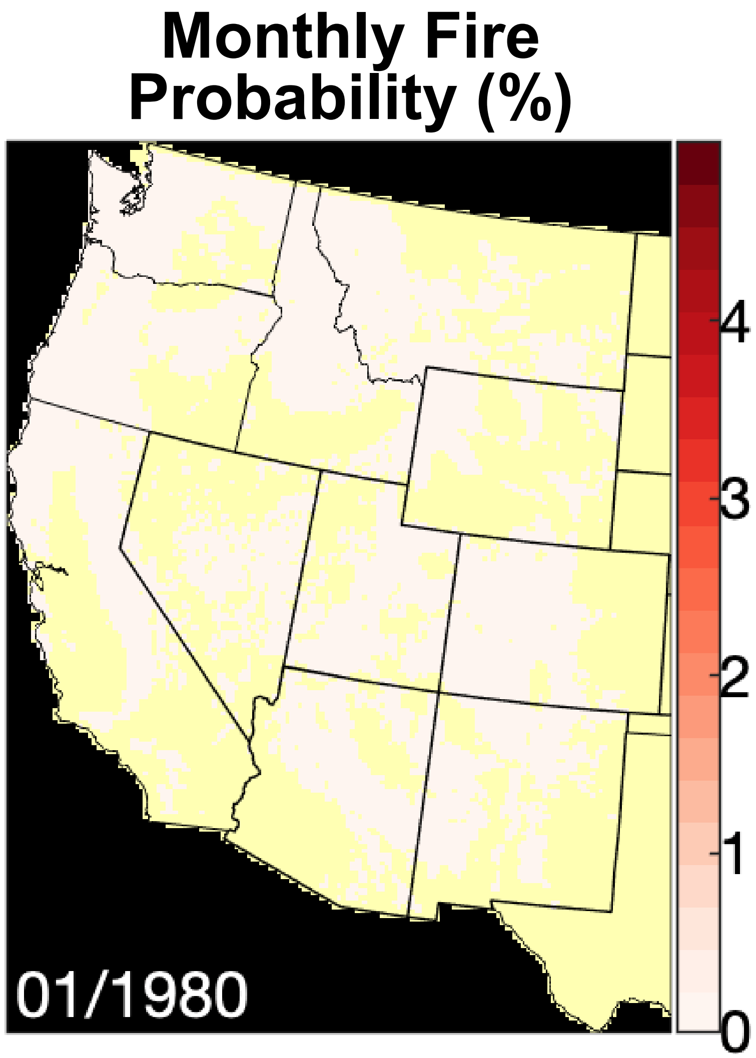
BURNED AREA RESPONSE IS EXPONENTIAL

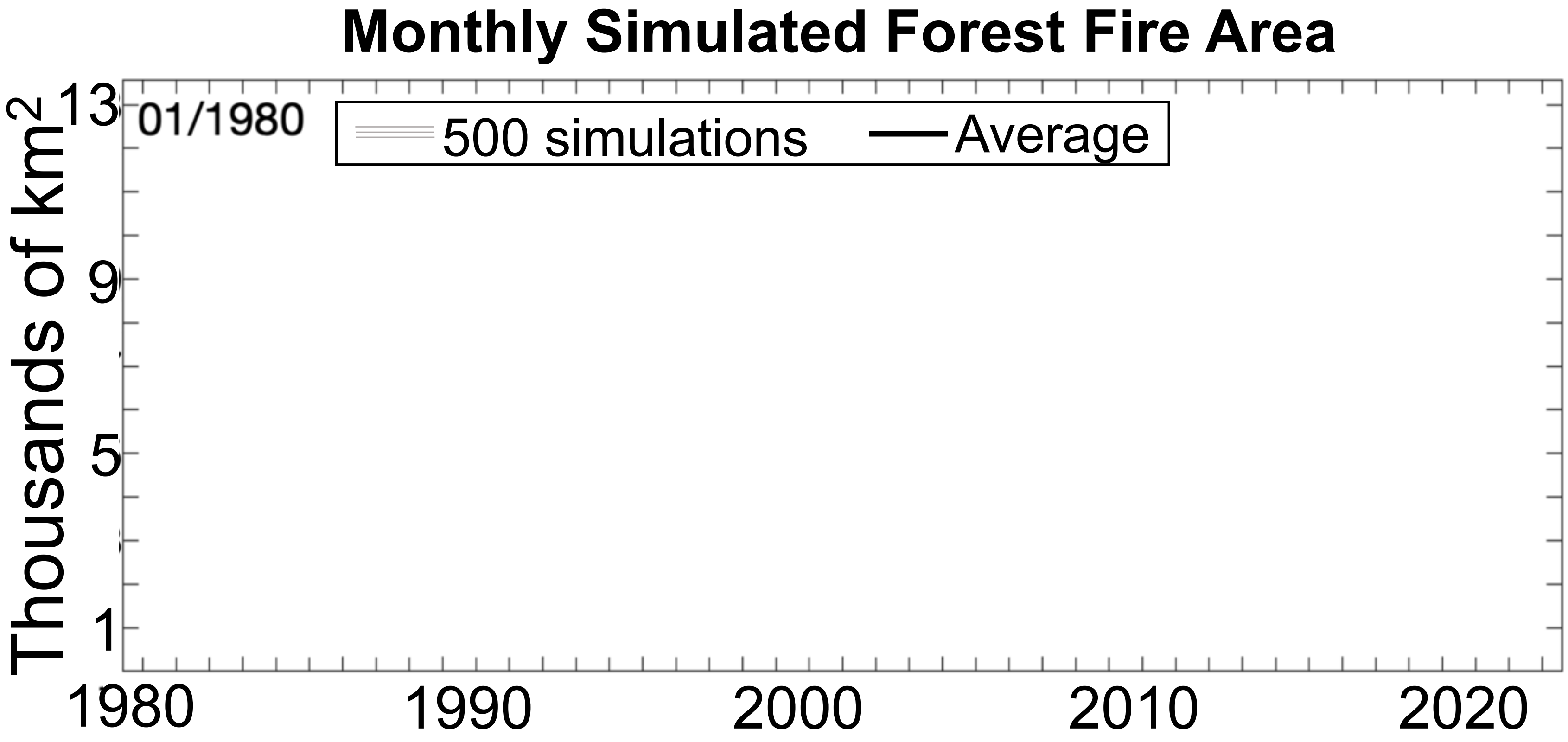


See paper by my graduate student, Carloline Juang et al. (2022) for explanation of exponential response: https://doi.org/10.1029/2021GL097131

A NEW WESTERN US FOREST-FIRE MODEL

A statistical model that simulates forest-fire occurrence and size as functions of climate, vegetation, and human population

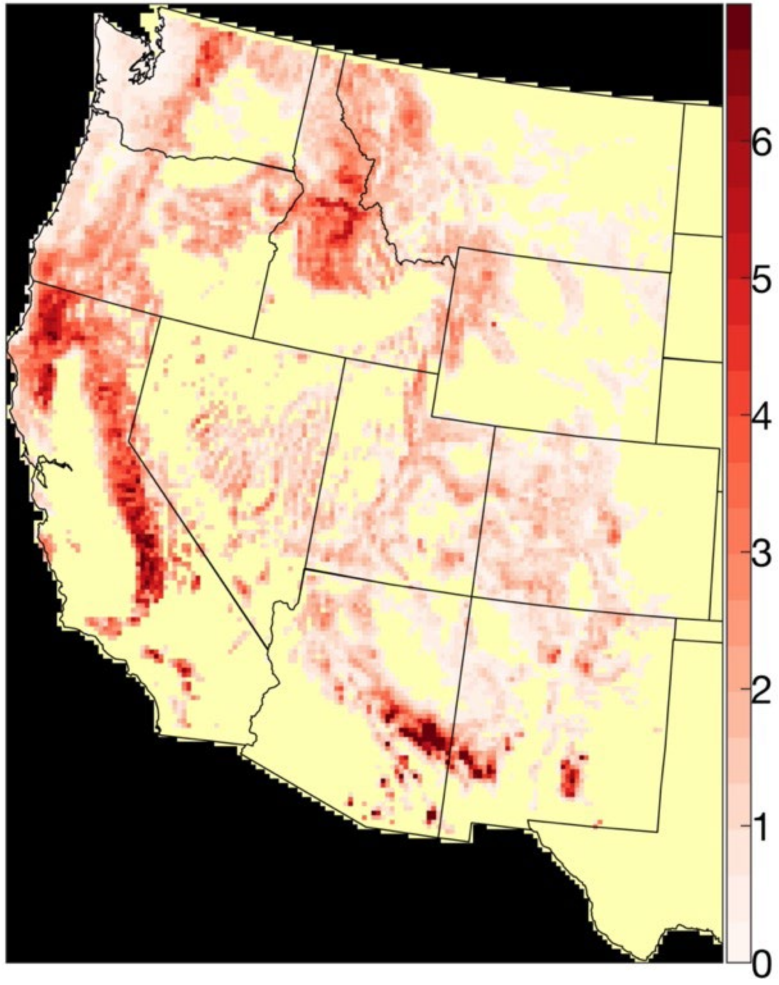




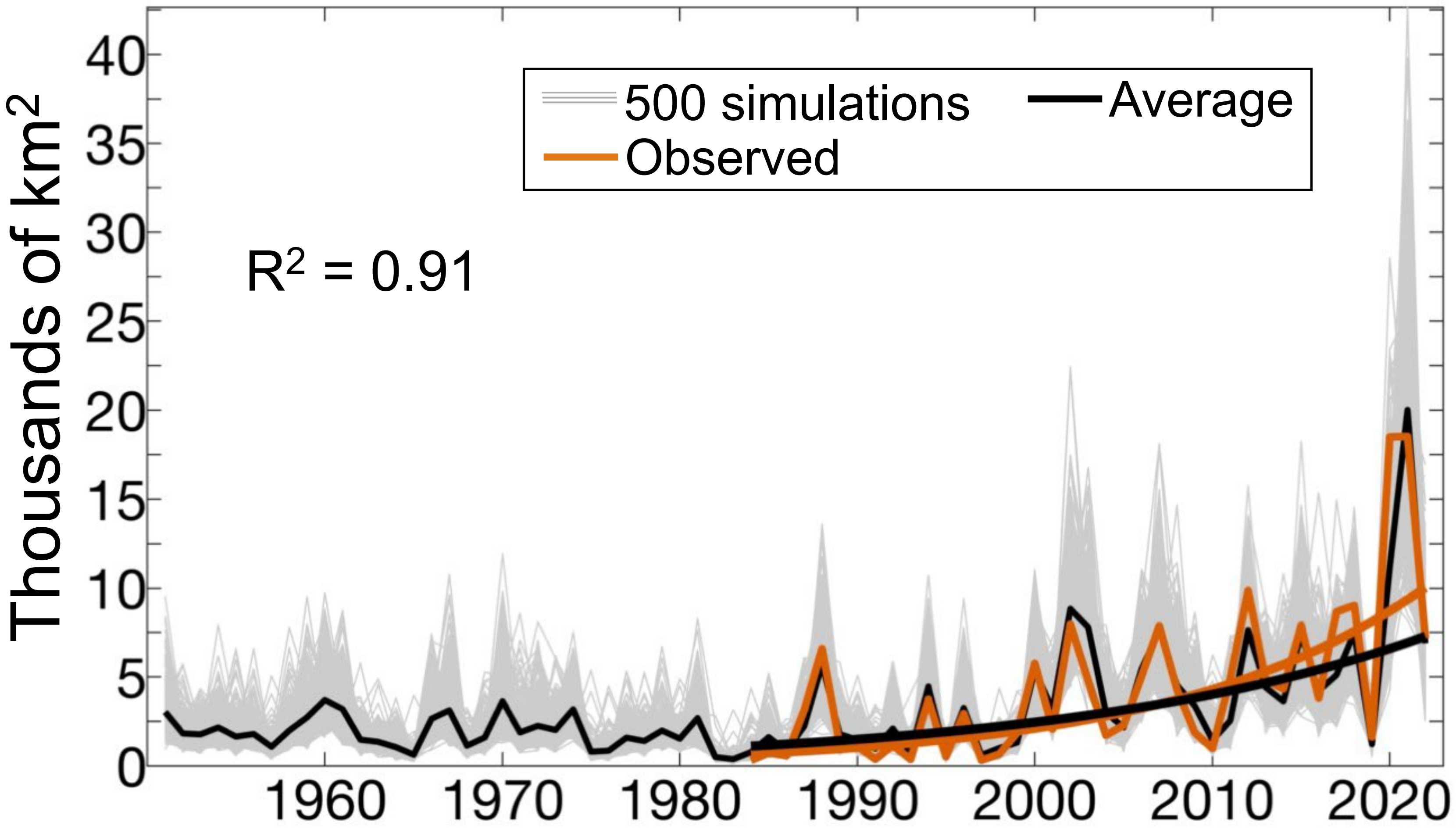
Williams et al. (In prep)

GOOD REPRESENTATION OF TEMPORAL VARIABILITY

Mean Annual Fire Probability (%)

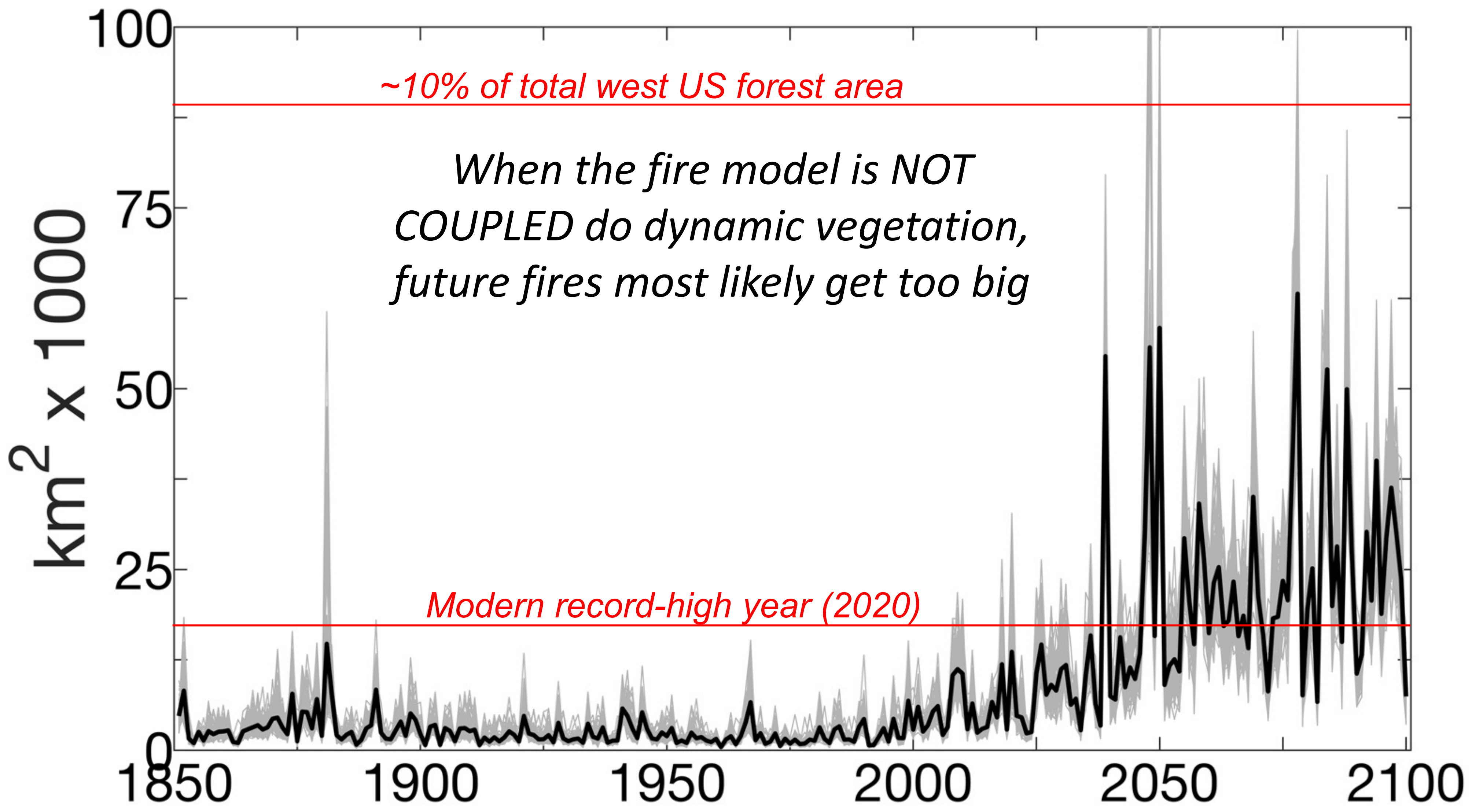


Annual Simulated Forest Fire Area Versus Observations



FUTURE FOREST-FIRE PROJECTIONS

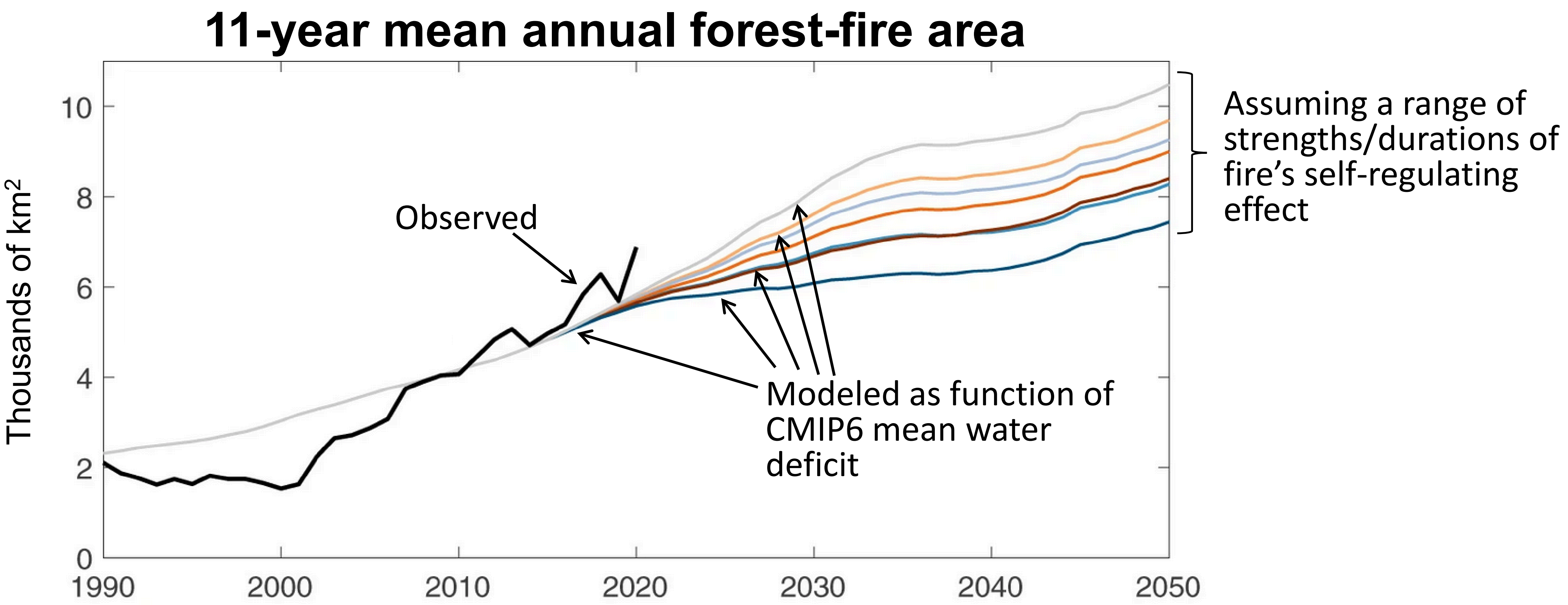
Here the fire model was run 100 times forced by statistically downscaled daily data from the CESM2 model: 1851–2100 (Historical – SSP245)



FUTURE FIRE IS COMPLICATED BY VEGETATION FEEDBACKS

HOW/WHEN/WHERE WILL FIRE BECOME SELF-REGULATING?

At the large, sub-continental scale of the western US, attempts to simulate the coupled interaction between fire and fuel required some major simplifying assumptions.



Abatzoglou et al. (2021; Comm Earth & Environ)
Also see Turco et al. (2023; PNAS) who adopted this approach

A NEW MID-RESOLUTION (1-KM) WESTERN US FOREST ECOSYSTEM MODEL

Contents lists available at ScienceDirect

Environmental Modelling and Software

journal homepage: www.elsevier.com/locate/envsoft

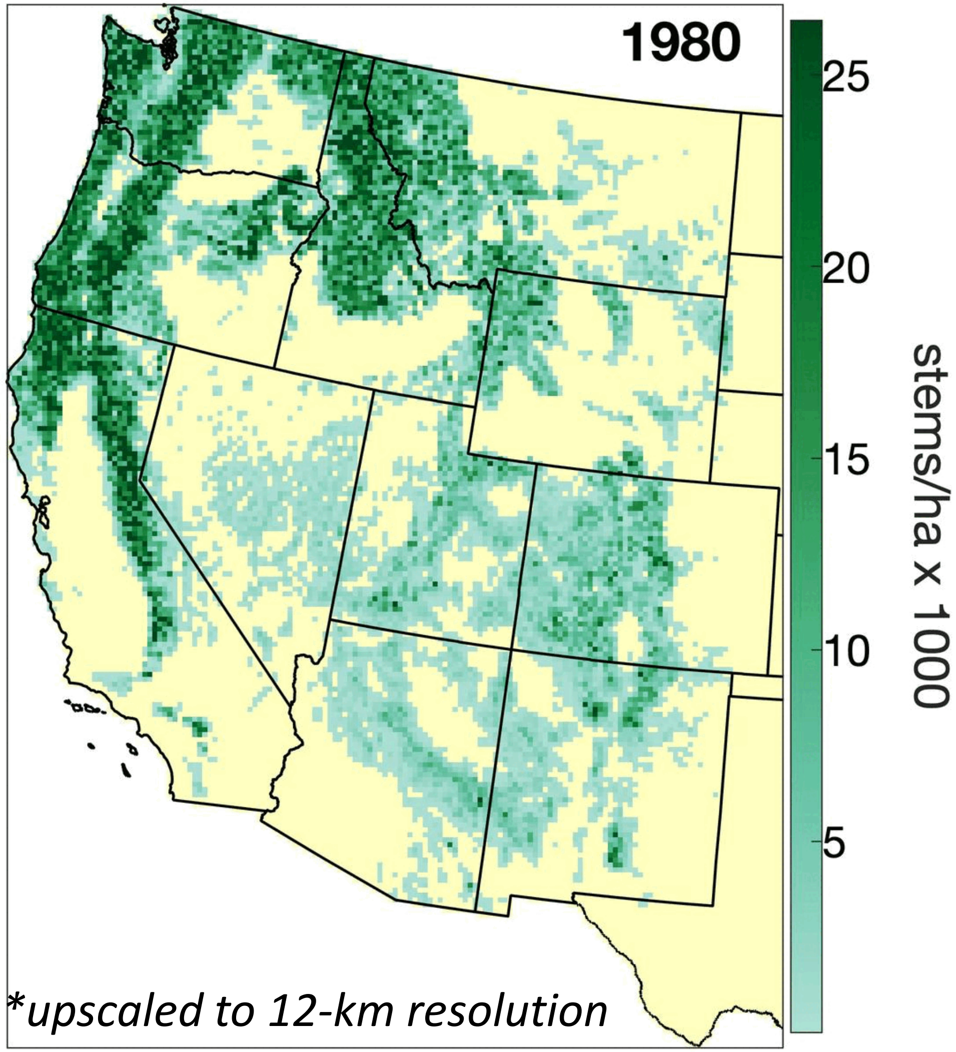
2022

The Dynamic Temperate and Boreal Fire and Forest-Ecosystem Simulator (DYNAFFOREST): Development and evaluation

Winslow D. Hansen[a,*], Meg A. Krawchuk[b], Anna T. Trugman[c], A. Park Williams[d,e]

Simulated tree density

forced by observed climate & fires

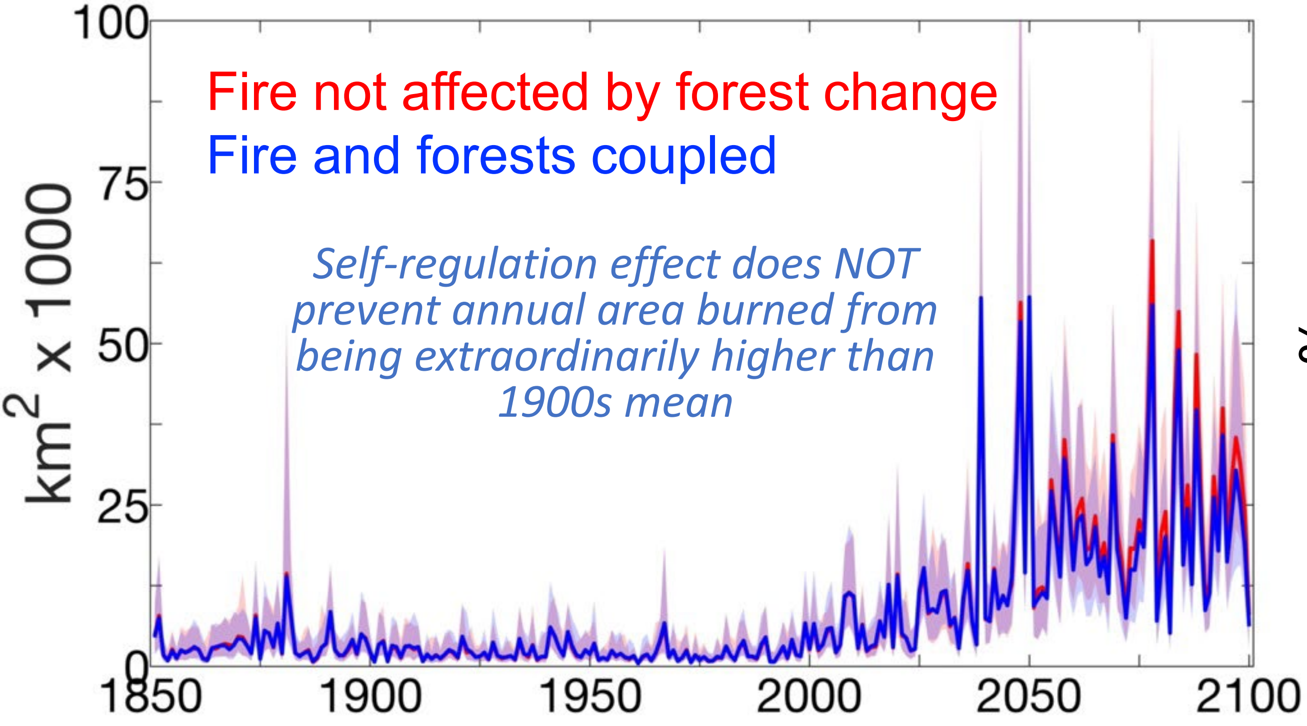


https://doi.org/10.1016/j.envsoft.2022.105473

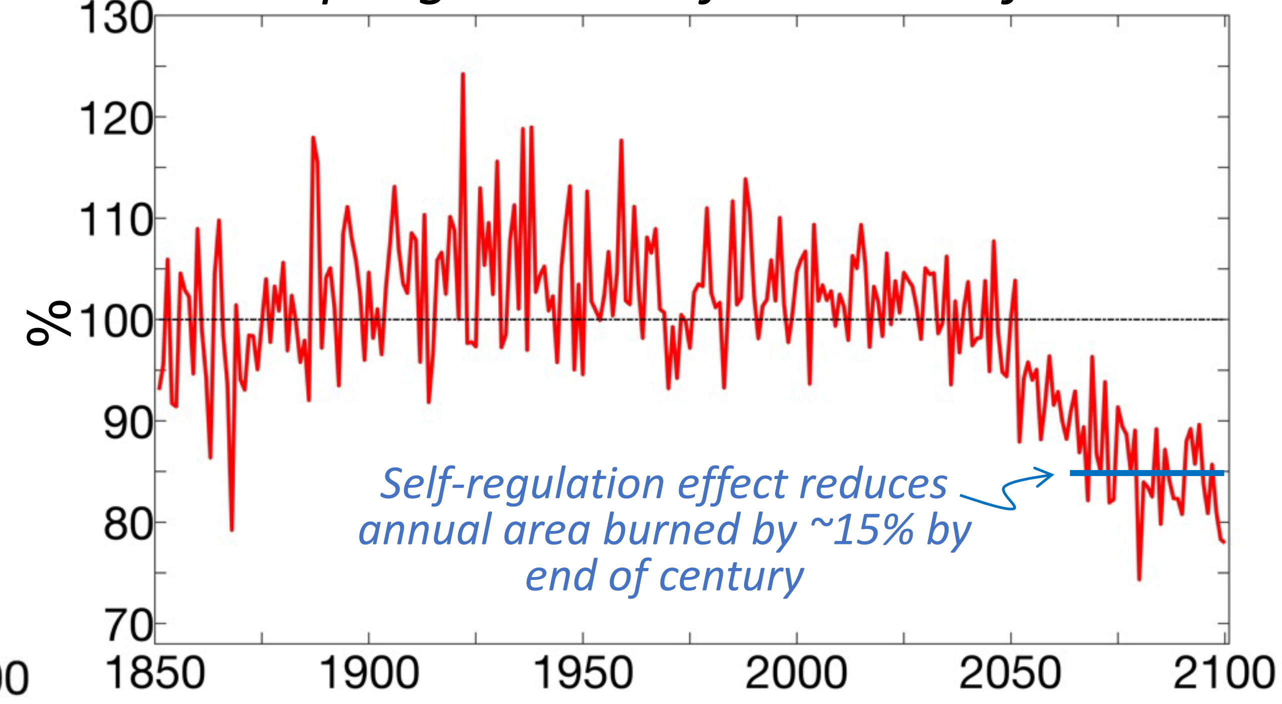
SMALL SELF-REGULATING EFFECT ON AREA BURNED EMERGES MID-CENTURY

Simulations forced by CESM2 Historical–SSP245 CMIP6 scenario

Simulated western US annual forest-fire area



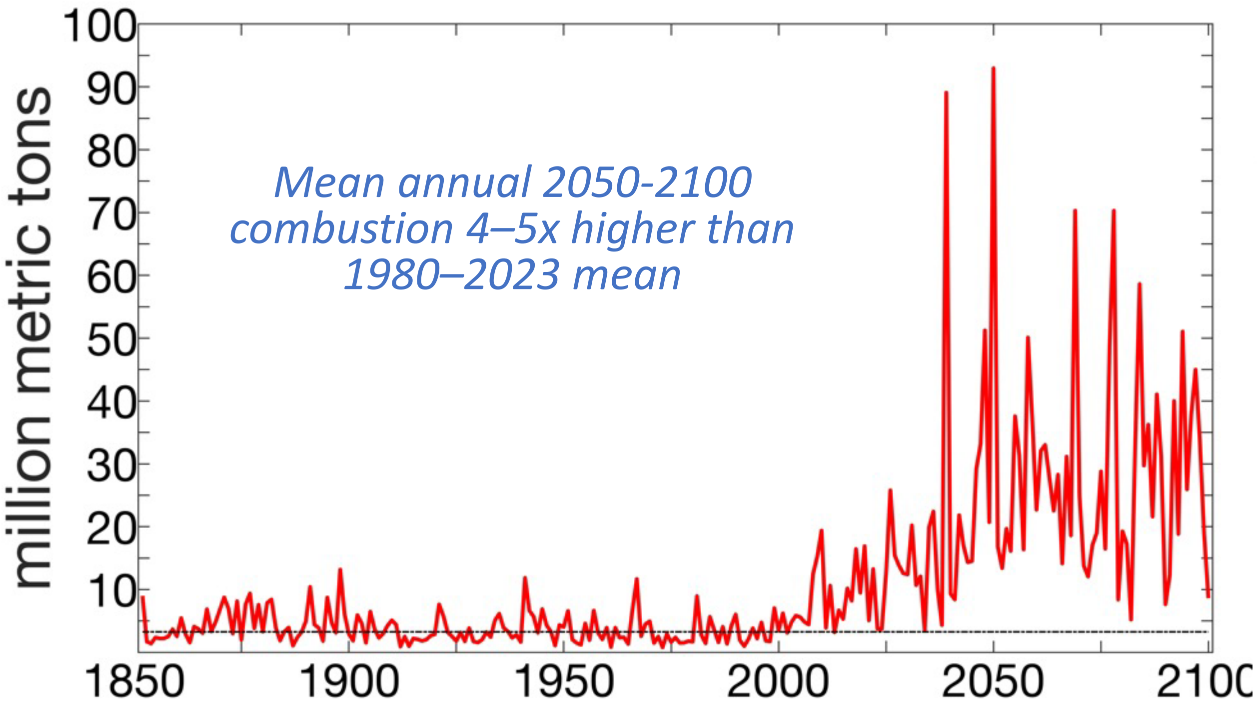
% difference in simulated burned area due to coupling between forests and fire



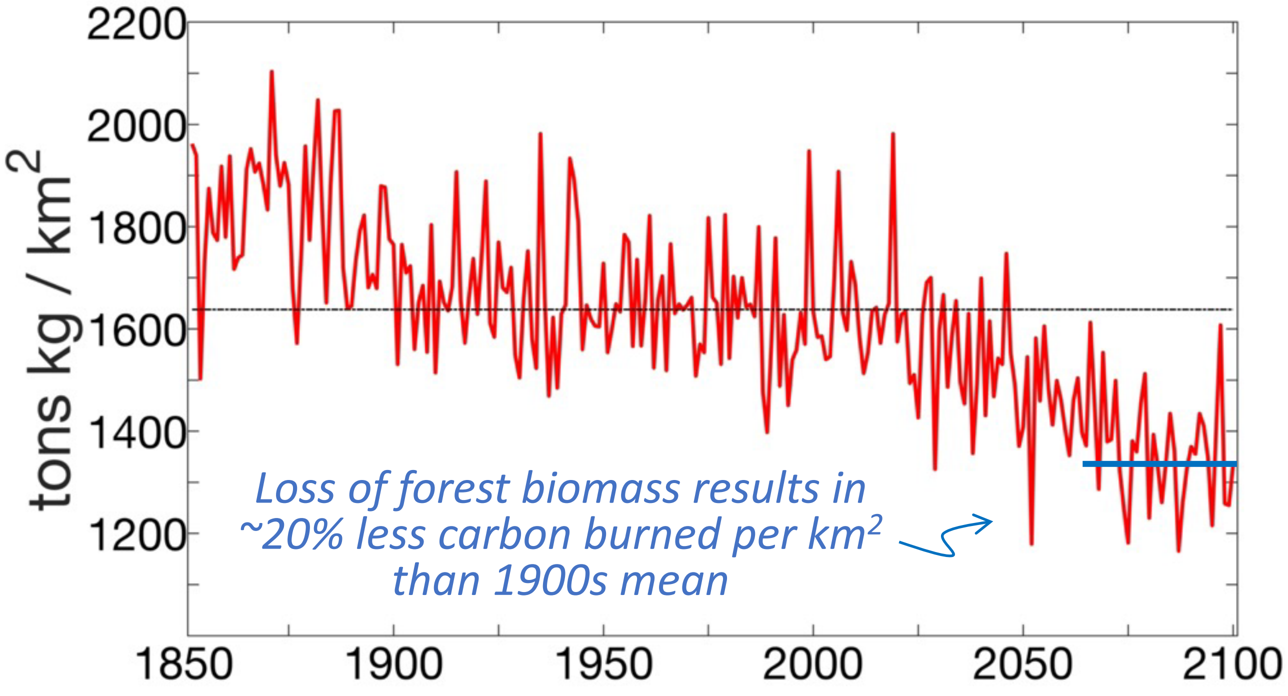
WHILE FIRES GROW MUCH LARGER THEY BECOME LESS POTENT CARBON EMITTERS

Simulations forced by CESM2 Historical–SSP245 CMIP6 scenario

Above-ground forest biomass combusted



Combustion per area burned



MAJOR LIMITATIONS

Our modeling approach is still young and developing

Fairly simple representation of fuels

- currently just one cohort in our model, so no specific effect of ladder fuels
- currently only simulates forest
- no insects or disease

Difficulty validating effects of prior burning on subsequent fire

- model has many opportunities to see how fire relates to fuel characteristics but relatively few opportunities to see effects of prior burns and how this evolves over time

Difficulty validating combustion

- very limited observations of biomass combusted for model validation

Difficulty isolating effect of suppression

- fire model trained on data from the suppression era, so hard to develop methods to perform experiments involving alternate suppression approaches.

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Did I mention CO_2 fertilization?

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MAJOR LIMITATIONS

Modeling wildfire at regional to continental scales probably requires industrial-scale investment similar to that of global climate modeling.

Expertise

- Understanding/modeling fire and emissions integrates across many disciplines. This requires large teams, broad knowledge bases, patience, and people who can manage complex projects.

Computational expense

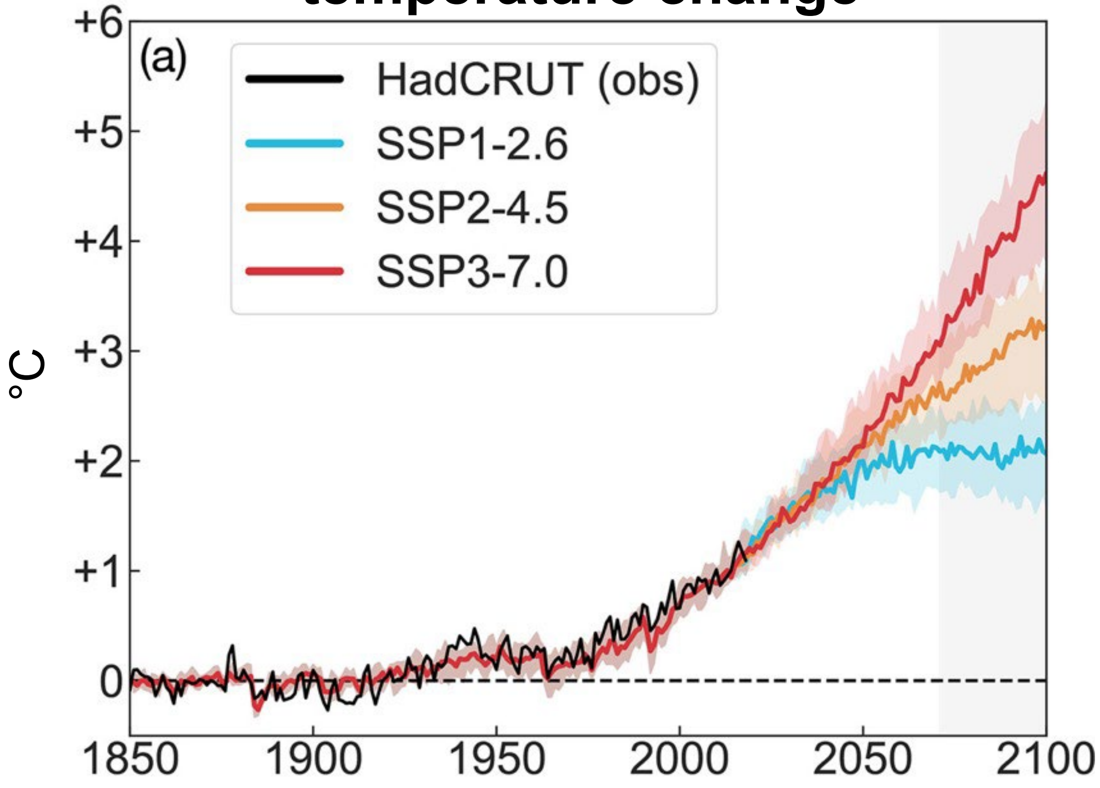
- Running our fire and forest models in coupled mode has us constantly scrambling for computer space and power.
- For future projections, carefully downscaled and bias-corrected climate projections are needed for many models, and multiple realizations per model. Dynamically downscaled projections are ideal.

MAJOR LIMITATIONS

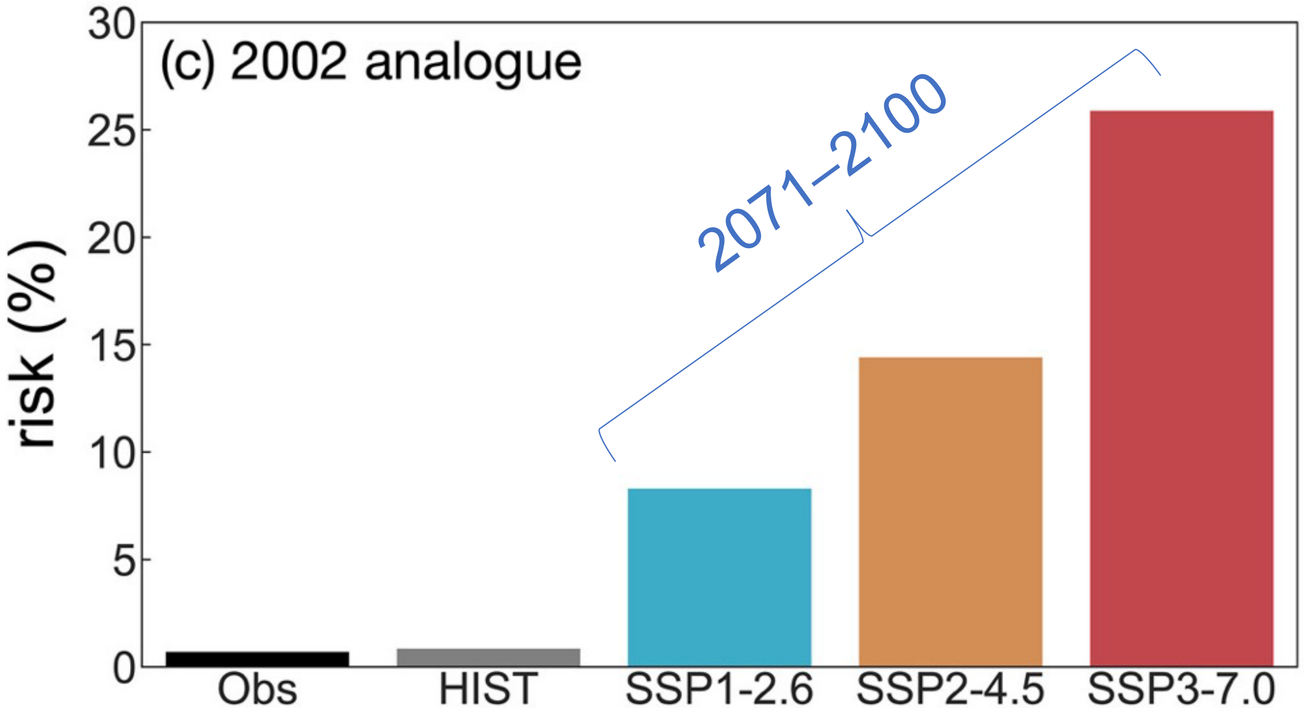
Uncertainty in future climate

1. Uncertainty in future emissions

Projected global temperature change



Annual probability of a 2002-like soil-moisture drought in Southwestern North America

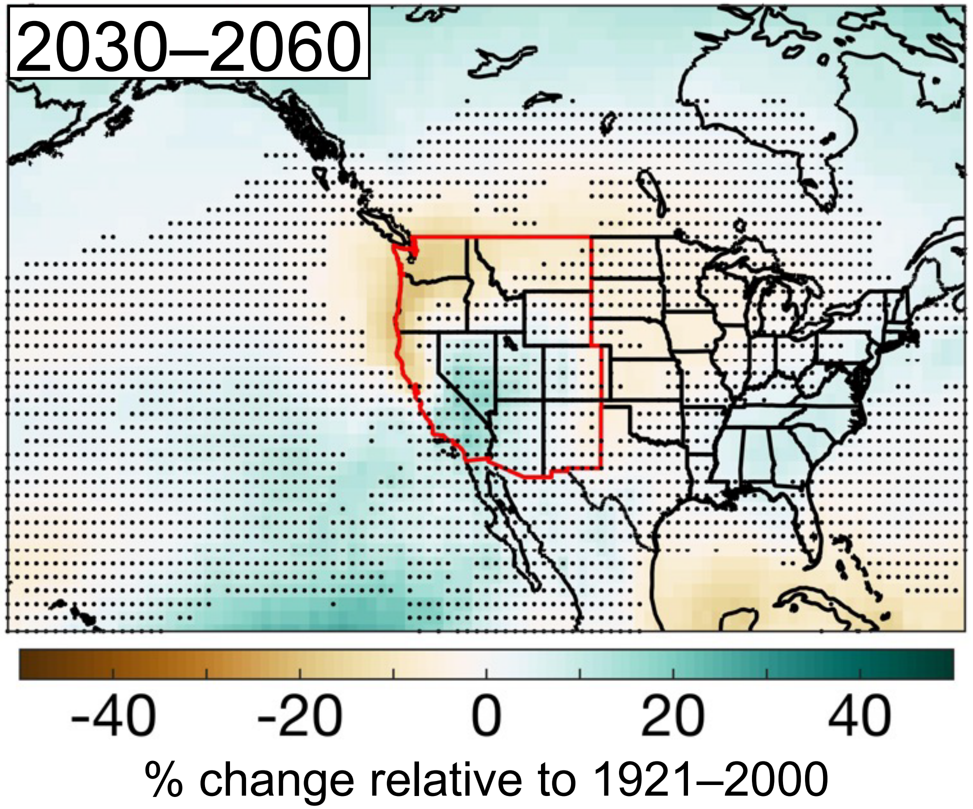


Cook et al. (2021; Earth's Future)

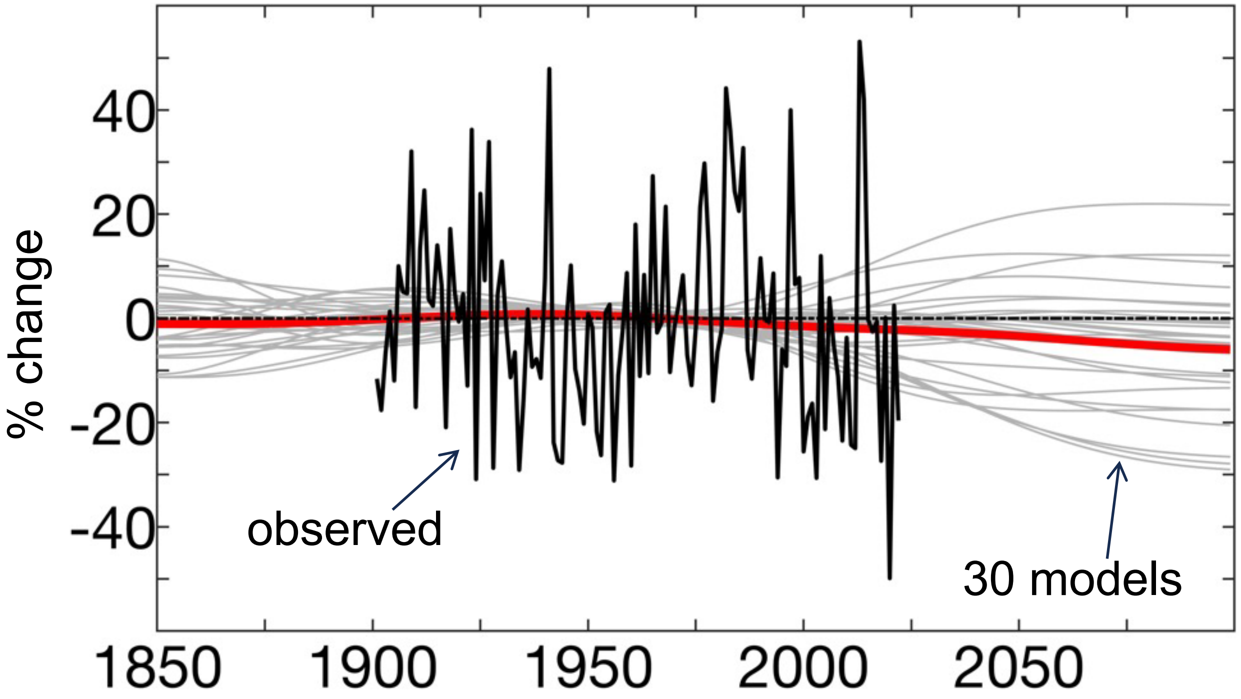
Uncertainty in future climate

2. Uncertainty in future climate for a given emission

30-model mean projection of change in summer precipitation



Western US simulated trends in summer precipitation



THANK YOU

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Gordon and Betty Moore Foundation

Western Fire & Forest Resilience Collaborative

Meadow Fire, Sep 2014
Photo: Peter B James