Funding Agencies: NOAA, ASO, CADWR

Evaluating and addressing fire-induced skill changes in Noah-MP and WRF-Hydro

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NSF NCAR RAL & PS1

June, 2024

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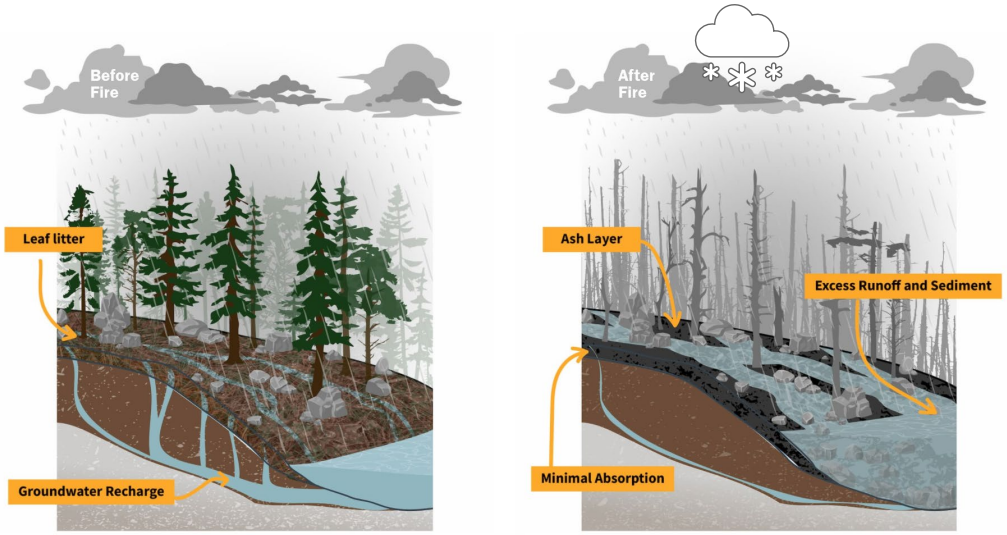
This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsor ed by the National Science Foundation under Cooperative Agreement No. 1852977.

Fire impacts on hydrology overview

Fire impacts on vegetation & soil



https://www.usgs.gov/media/images/fire-hydrology-data-viz-story-carousel

Grocery list of impacts: infiltration, runoff, soil moisture, interception, evapotranspiration, snow albedo, surface radiation budget, below-canopy wind … i.e., ALL variables an LSM solves for related to terrestrial water and energy budgets

These fire impacts are not explicitly considered in the Noah -MP LSM or WRF -Hydro modeling system

Project Goal

Research Goals:

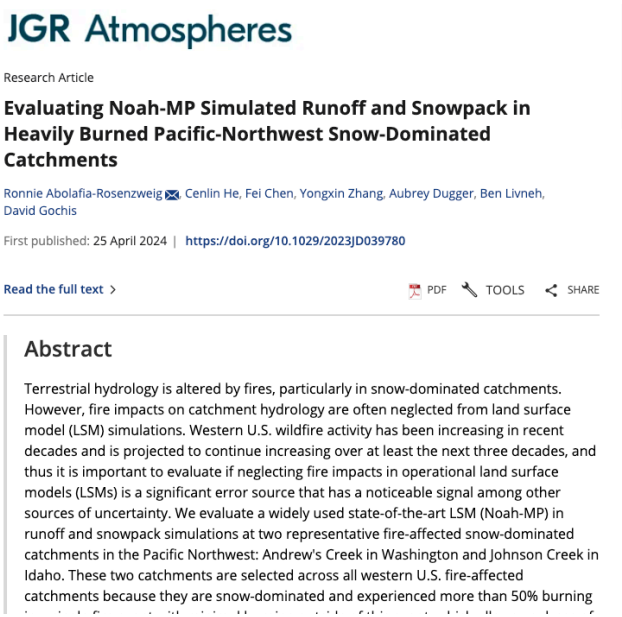
(1) Quantify fire-induced changes to the skill of Noah-MP LSM

(2) Explicitly account for fire impacts to the land surface and consider:

(i) how sensitive are simulations to fire-perturbations, and

(ii) whether LSM skill is improved in post-fire periods when representing fire impacts

Abolafia-Rosenzweig et al. (*in review)*



JGR Atmospheres

Research Article

Evaluating Noah-MP Simulated Runoff and Snowpack in Heavily Burned Pacific-Northwest Snow-Dominated Catchments

Ronnie Abolafia-Rosenzweig, Cenlin He, Fei Chen, Yongxin Zhang, Aubrey Dugger, Ben Livneh, David Gochis

First published: 25 April 2024 | https://doi.org/10.1029/2023JD039780

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Abstract

Terrestrial hydrology is altered by fires, particularly in snow-dominated catchments. However, fire impacts on catchment hydrology are often neglected from land surface model (LSM) simulations. Western U.S. wildfire activity has been increasing in recent decades and is projected to continue increasing over at least the next three decades, and thus it is important to evaluate if neglecting fire impacts in operational land surface models (LSMs) is a significant error source that has a noticeable signal among other sources of uncertainty. We evaluate a widely used state-of-the-art LSM (Noah-MP) in runoff and snowpack simulations at two representative fire-affected snow-dominated catchments in the Pacific Northwest: Andrew's Creek in Washington and Johnson Creek in Idaho. These two catchments are selected across all western U.S. fire-affected catchments because they are snow-dominated and experienced more than 50% burning

Quantify fire -induced changes in the skill of Noah-MP LSM – study domain

Selection criteria

(1) catchments that are selected for analysis of fire effects on water supply across the entire WUS by Williams et al. (2022) – 72 fire-impacted catchment considered

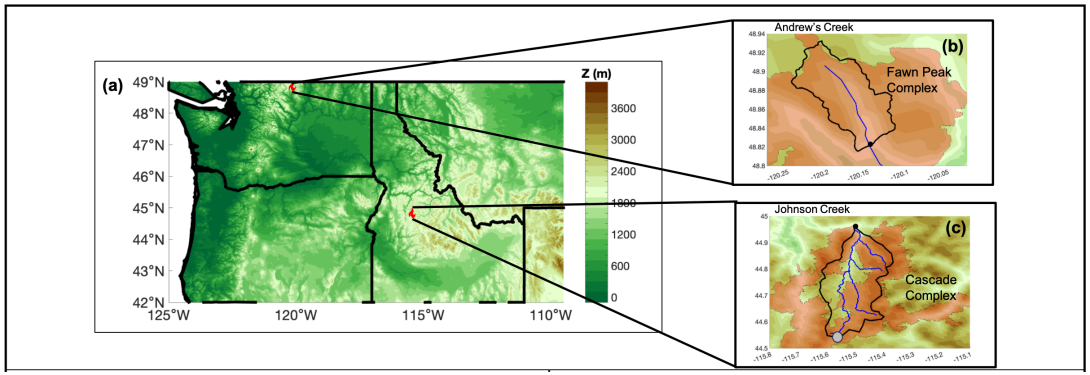
(2) catchments that are snow-dominated

(3) catchments that had a single major fire event that occurred during the MODIS-era that burned at least 50% of the watershed area

(4) catchments that had no other significant fire events (i.e., burning more than 15% of the catchment) in the analysis periods.

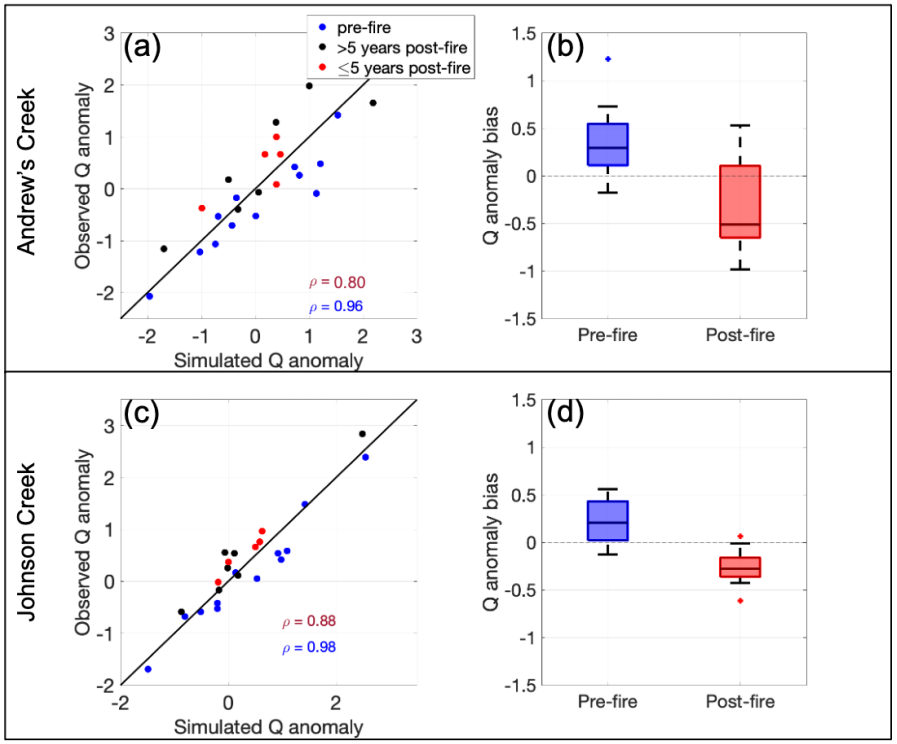
→ <u>2 selected catchments:</u>
Andrew's Creek (58 km^2; 96% burned in 2003)

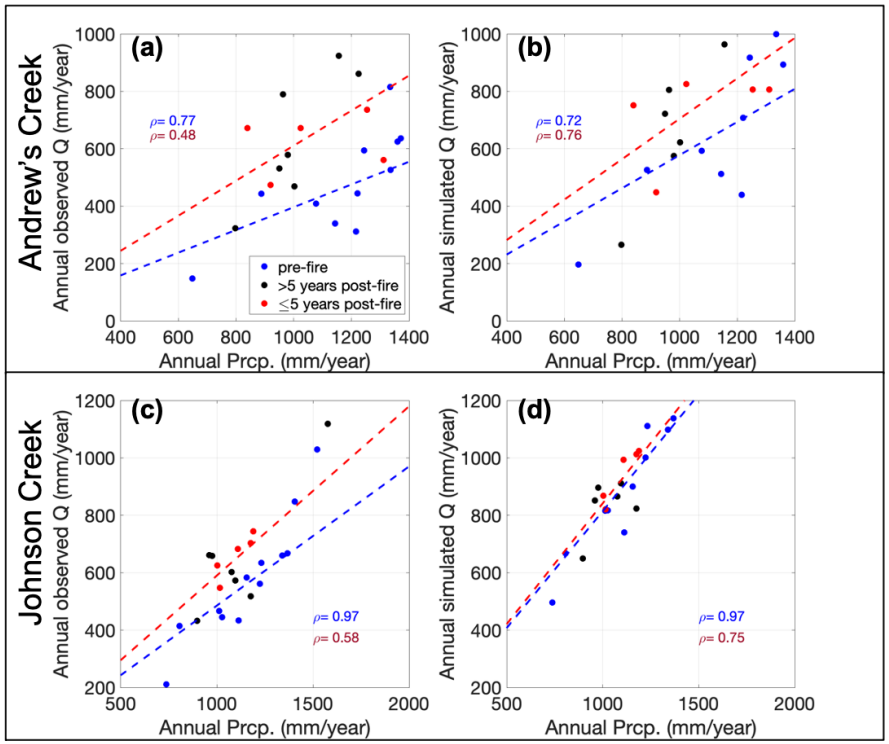
Johnson Creek (562 km^2; 60% burned in 2007)



Abolafia-Rosenzweig et al. (2024, *JGR-Atmos.*)

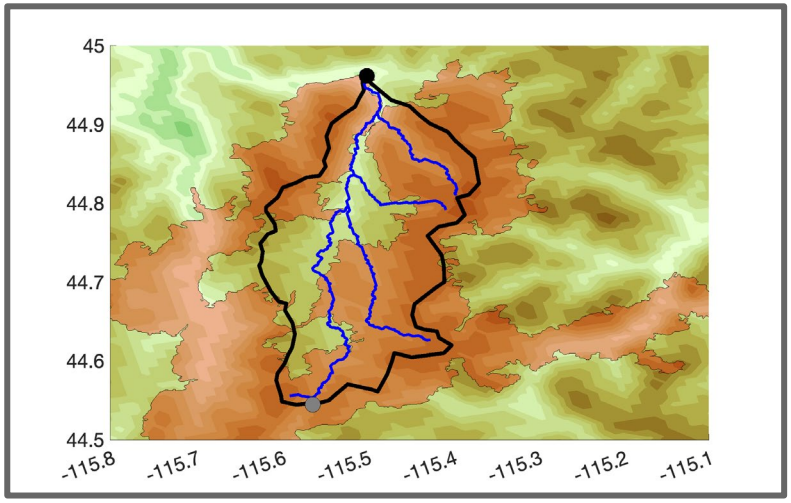
Quantify fire -induced changes in the skill of Noah-MP LSM – annual Q





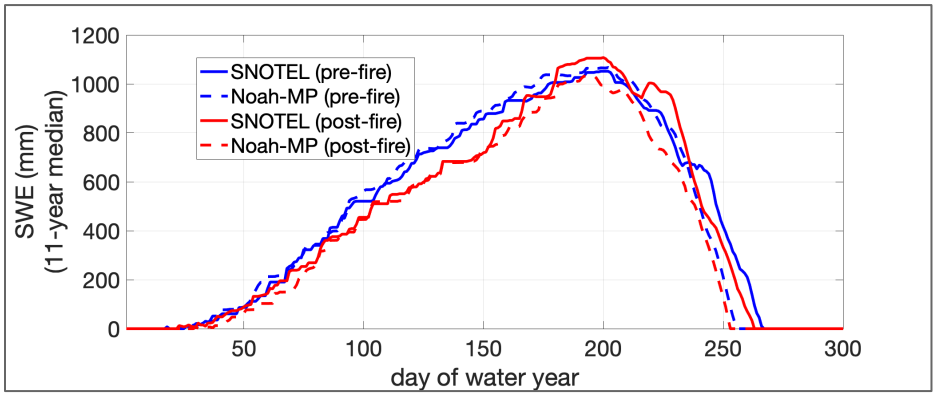
Abolafia-Rosenzweig et al. (2024, *JGR-Atmos.*)

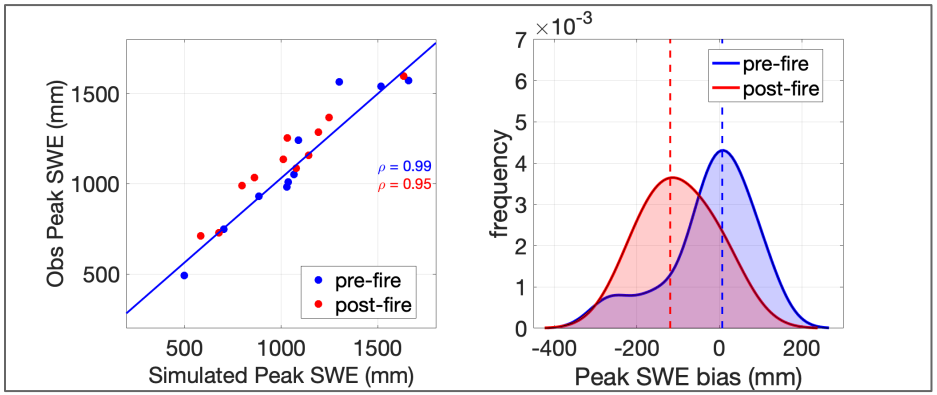
Quantify fire -induced changes in the skill of Noah-MP LSM – snow

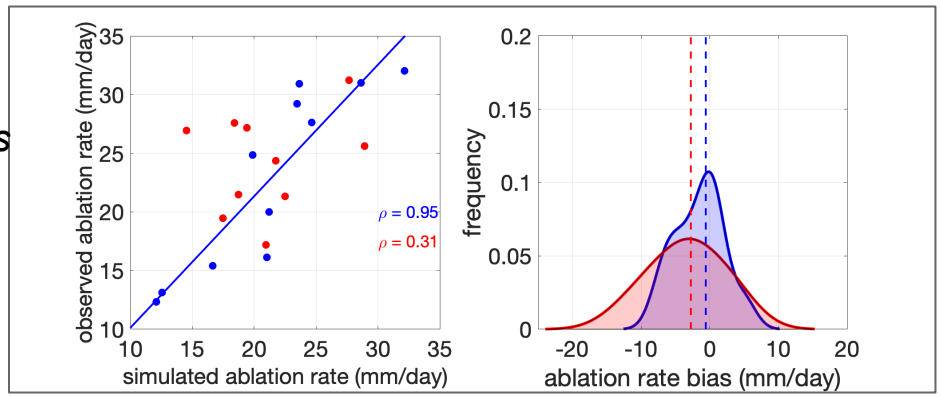


SNOTEL analysis at Deadwood SNOTEL station

Noah-MP fails to simulate a post-fire snowpack which is deeper and melts faster







Abolafia-Rosenzweig et al. (2024, *JGR-Atmos.*)

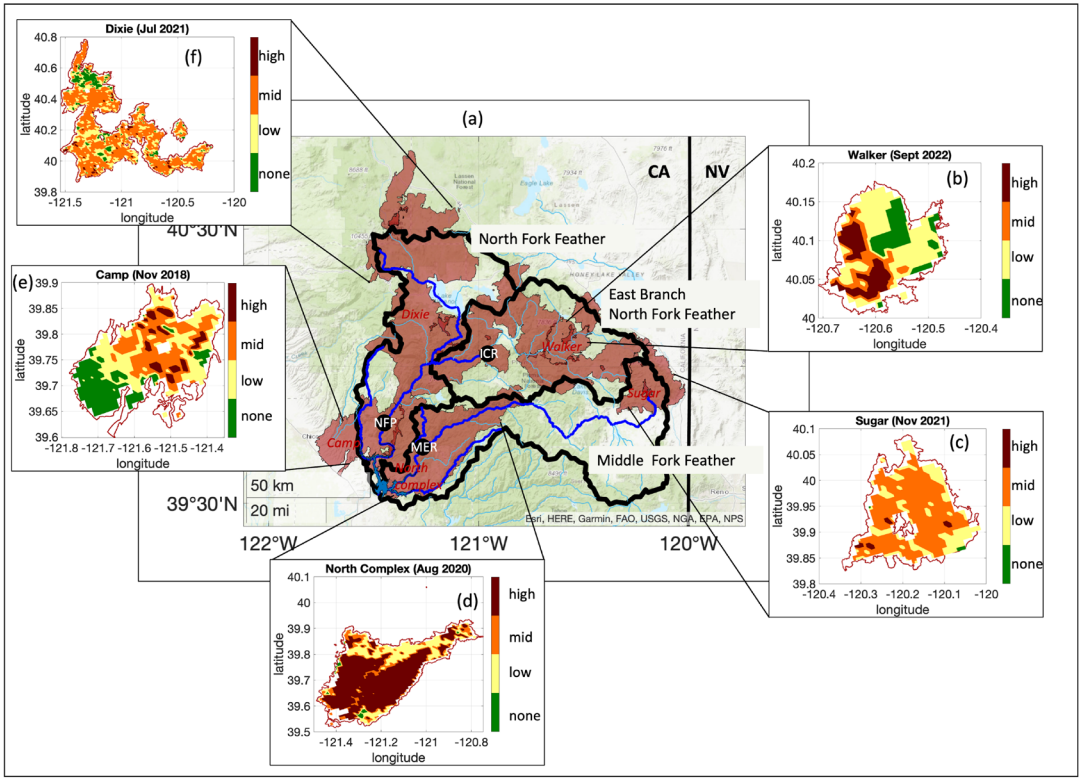
How sensitive are simulations to fire-perturbations? – Study Domain

Fires in the Feather River Basin

- **57%** of the Upper Feather River Watershed has burned since 2018
- **27%** burned at high severity (75% tree mortality)

California State Water Project

- The Feather River Watershed is the primary source for the SWP
- Oroville Dam is a 3.5 million acre-foot reservoir and is the primary storage facility
- Snowpack storage is important to operations, earlier runoff can often not be stored



How sensitive are simulations to fire perturbations?

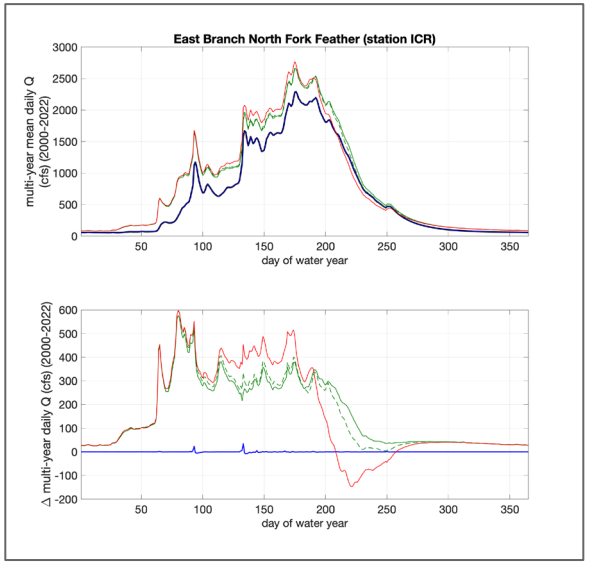
5 modeling experiments

Experiment 1: Baseline
Experiment 2: Mod-params
Experiment 3: Mod-params+GVF
Experiment 4: Mod-params+GVF+veg-class
Experiment 5: Mod-params+GVF+veg-class+Snow-alb

Abolafia-Rosenzweig et al. (*in review)*

How sensitive are simulations to fire-perturbations?

Streamflow (Q)

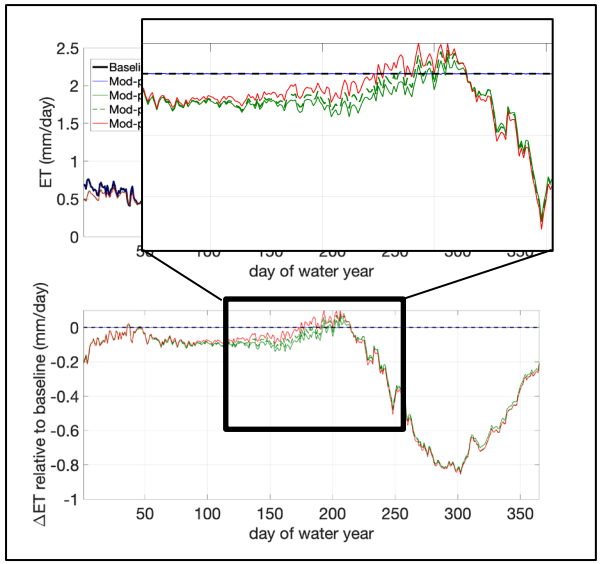


Reducing vegetation enhances Q

Veg-class conversion enhances Q during snow accumulation period, reduces Q during ablation period

Snow darkening enhances Q during snow accumulation period, reduces Q during ablation period

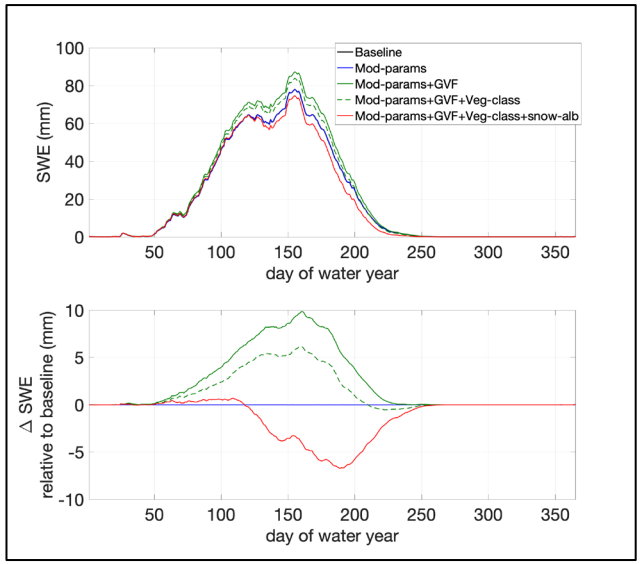
Evapotranspiration (ET)



Reducing vegetation decreases ET

Modest impacts from veg-class and snow darkening, with greater sublimation in winter-spring

Snow water equivalent (SWE)

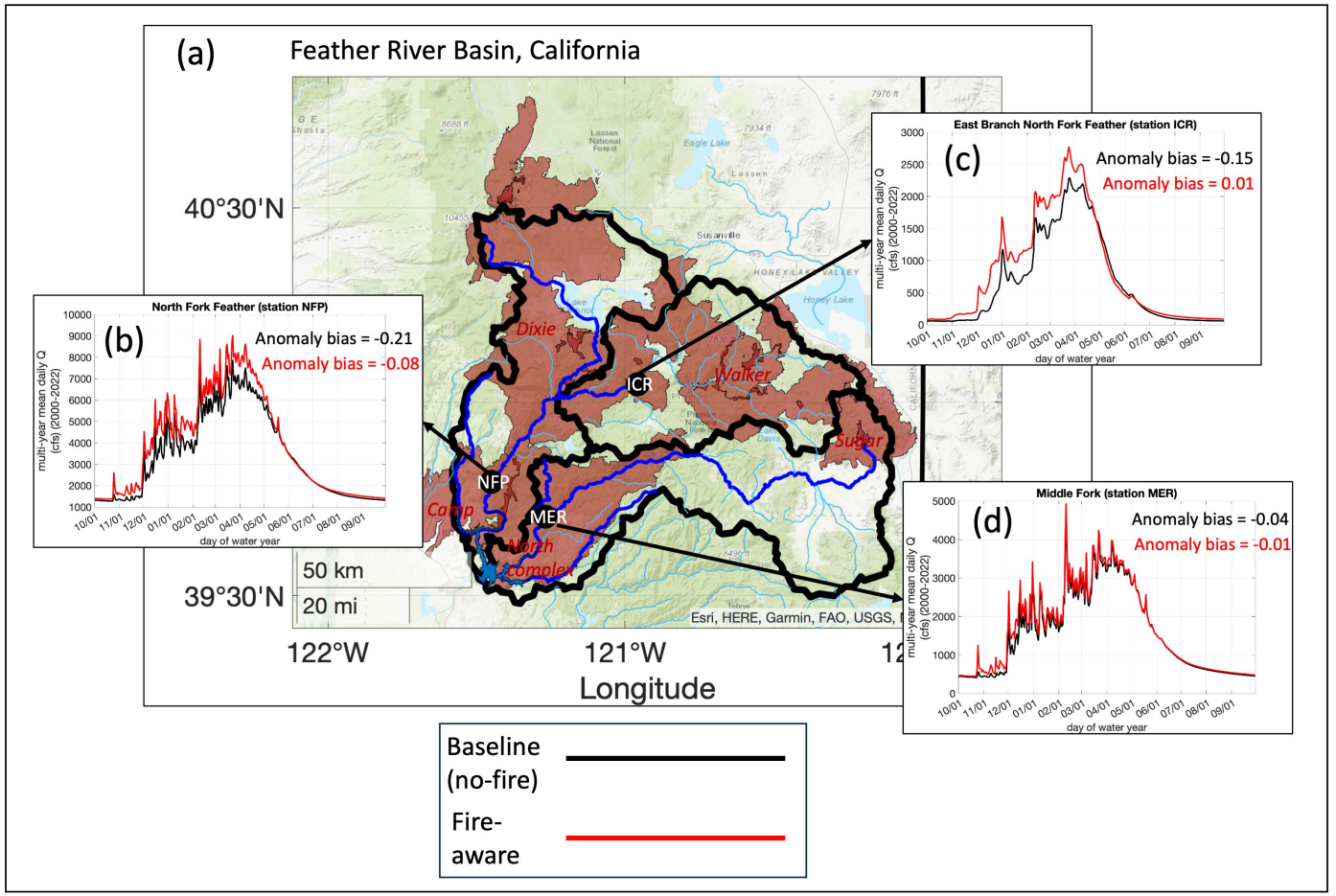


Reducing vegetation increases SWE

Veg-class conversion enhances ablation, reducing SWE

Snow darkening enhances ablation, reducing SWE

How sensitive are simulations to fire-perturbations?



Challenges and opportunities

How to best parameterize fire impacts on vegetation and soil in land surface models?

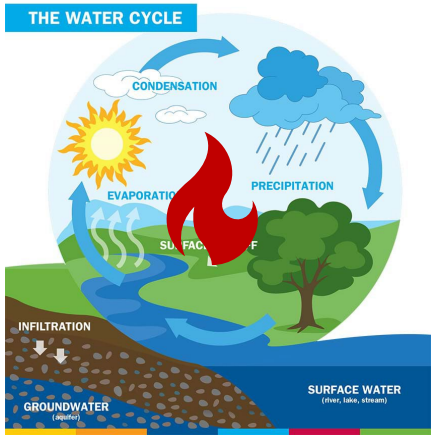
What data can best inform these parameterizations? ASO, MODIS vegetation, in-situ streamflow and snowpack, others?

Future work: develop fire -module for Noah -MP

Burn severity

F(burn-severity, time since fire) to Update vegetation and soil parameters

Noah-MP®



Future research recently funded under NASA grant, P.I. Dr. Cenlin He

Thank you!

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