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

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Fire impacts on vegetation & soil


**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)
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.

→ 2 selected catchments:
Andrew’s Creek (58 km²; 96% burned in 2003)
Johnson Creek (562 km²; 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

[Diagram showing maps of the Feather River Basin and surrounding areas]
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

\[ F(\text{burn-severity}, \text{time since fire}) \] to update vegetation and soil parameters

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Thank you!

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