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Supplementary material

Effects of fuel spatial distribution on wildland fire behavior

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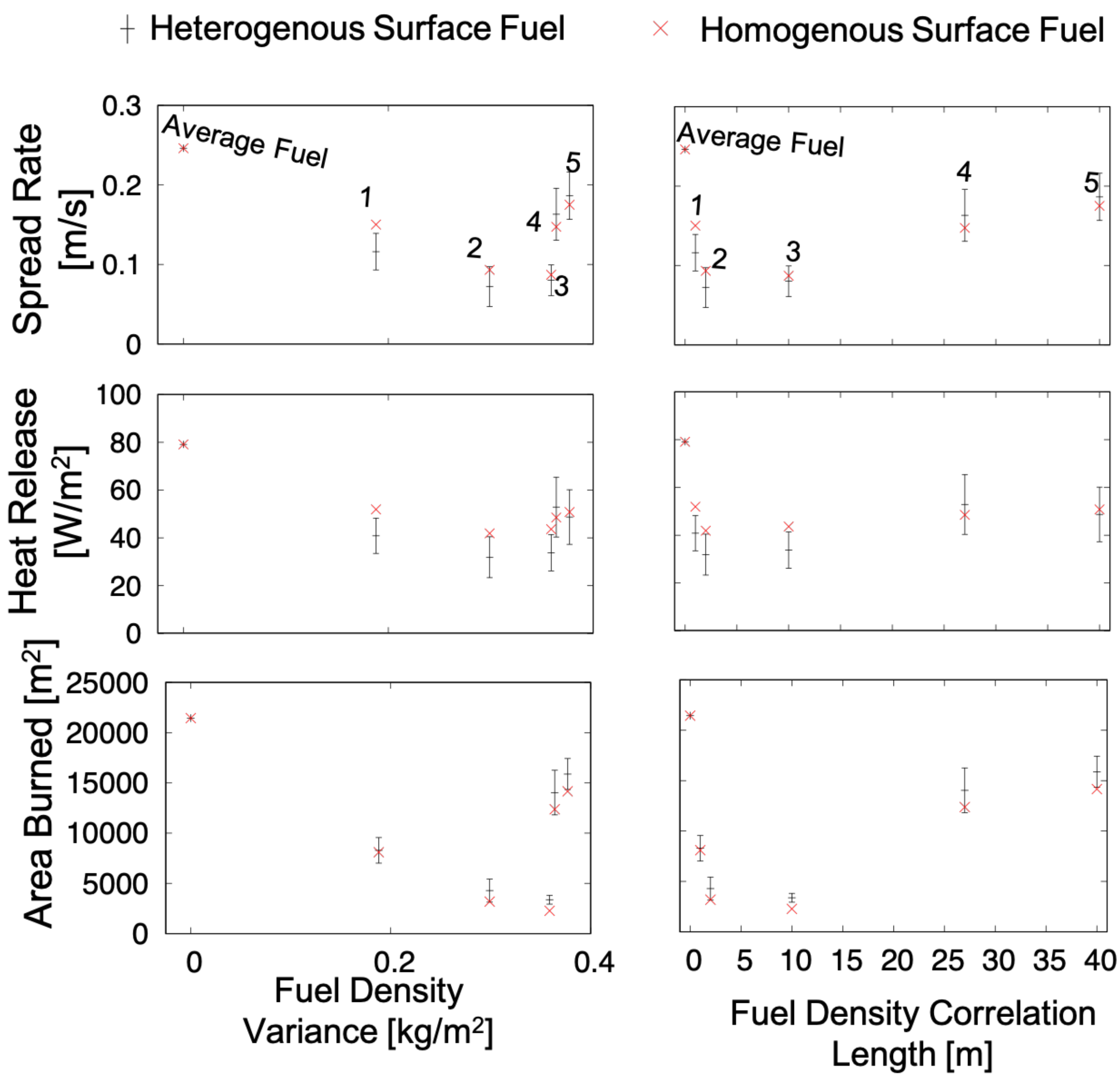
Evaluation of surface fuel heterogeneity on fire behavior results:

Here we present an additional analysis to investigate the role that heterogenous surface fuel parameterization has on fire behavior. Surface fuel configuration and the difference between litter and grass parameterization is likely to impact the role of fire behavior. For our study grass with a fuel density of 0.35 kg m^{-3} and assumed height of 0.7 m was placed on the domain in areas without a canopy and therefore can make up large continuous patched in the ensembles with high correlation lengths. Conversely, litter with a fuel density of 0.5 kg m^{-3}, and a height of

10cm dominates under canopies. Given that grass is less dense, it will likely increase fire spread in open gaps, and therefore contribute to increased fire behavior at larger correlation lengths, whereas higher density litter could slow fire spread and may decrease fire behavior when fuel density variation is high, but correlation lengths of that density is low.

In order to separate the influence of the surface fuel heterogeneity implemented in this study from the canopy fuel heterogeneity, we simulated an additional set of ensembles with homogenous surface fuels and compared them to the ensembles with the heterogeneous surface configuration. To maintain overall domain fuel density, we parameterized the surface fuels as a homogenous mix of grass and litter representing domain average fuel conditions (as applied in the 'Average Fuel domain'). We selected this approach because domains with either grass or litter only would result in a step-wise decrease or increase in domain fuel loads, which would have further complicated the comparison. We ran 10 realizations for each homogeneous ensemble type shown below in red and compared to the original heterogeneous 20-member ensemble results (with error bars).



For all three fire behavior metrics (spread rate, heat release, and area burned), we see that the overall response of fire behavior to fuel spatial heterogeneity holds. An increase in canopy fuel heterogeneity fidelity decreased fire behavior, and at large correlation lengths fire behavior metrics responded as well. Spread rate and heat released showed a muted decrease at 1 to 10m correlation lengths – and a similar muted increase at high correlation lengths – compared to the ensembles with heterogenous litter and grass fuel loads. As we expected, pure grass in the open areas should increase spread rate; therefore, with the homogenous mix we would similarly expect a slightly slower spread rate at larger correlation lengths. Likewise, switching from litter to a homogenous grass/litter mix under the trees could increase spread rates as seen in the Average tree and forest data ensemble. For area burned, the decrease for small correlation lengths was more pronounced, but the increase in area burned, or rebound at correlation lengths above 10m was less pronounced. We attributed this at least in part to a muting of the actual fuel density heterogeneity (an average surface condition resulted in slightly less spatial heterogeneity). However, there may be more complicated processes causing a general decrease in area burned across all ensembles. For example, the increase in heat released, especially at the lower correlation length scales may cause increased airflow in from the sides due to increased buoyancy that would then work to narrow the fire width and reduce the overall area burned.

This additional analysis demonstrated the importance and role that both the canopy and surface fuel configuration played on fire behavior. Here we highlight the dominate role that forest canopies can have on determining effective wind conditions that drive fire behavior, and note that this surface fuel configuration, which we believe reflect probable conditions in nature (litter under trees, and grass in gaps) worked to positively reinforce fire behavior caused by the forest canopy. However, this analysis is by no means a complete investigation of the role that surface fuel plays in fire behiavor and conceivably, there are many instances where surface fuels will govern fire behavior.