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Title: Advancing coupled fire-atmosphere research with HIGRAD/FIRETEC (w20_firetec) - 2021 Institutional Computing Annual Progress Report

Author(s): Jonko, Alexandra

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CY 2021 Institutional Computing Annual Progress Report

Advancing coupled fire-atmosphere research using HIGRAD/FIRETEC (w20_firetec)

Principal Investigator: Alex Jonko* (EES-16)

Co-investigators: Rod Linn, Adam Atchley, Eunmo Koo, Alex Josephson, Marlin Holmes, David Robinson, Julia Oliveto, Jenna McDanold (EES-16), Sara Brambilla (A-1)

Collaborators: Scott Goodrick, Russell Parsons, Carolyn Sieg, Kara Yedinak (USDA Forest Service); Chad Hoffman (Colorado State University); Francois Pimont (French National Institute for Agricultural Research); Ginny Marchall, Dan Thompson (Canadian Forest Service); Kevin Hiers (Tall Timbers Research Station); Jason Sharples (University of New South Wales); Sean Michaletz, Elizabeth Klynhans (University of British Columbia)

*ajonko@lanl.gov, 505-667-7832

Multi-scale simulation of British Columbia 2017 megafires

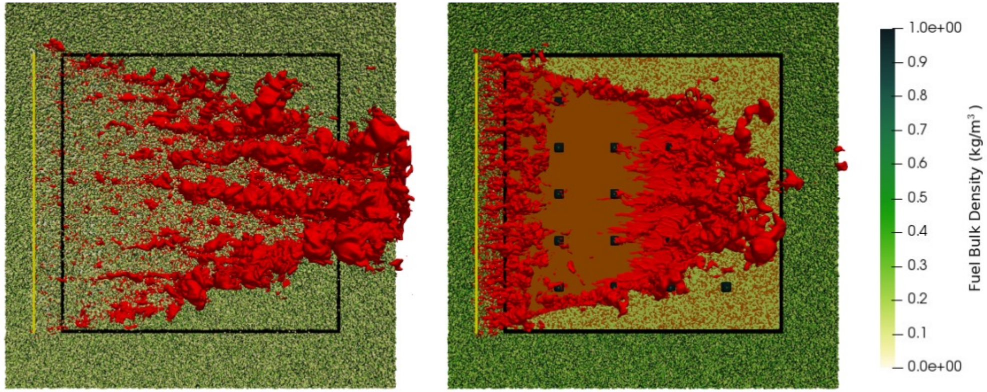

Figure 1. FIRETEC simulations of relatively homogenous forest fuels (a), compared to slash piles present in the British Columbia 2017 megafires (b) 50 seconds after ignition. Initial ignition line is shown in yellow. These FIRETEC simulations provided a localized source term for regional HIGRAD simulation of Pyro-Cummulonimbus (Pyro-Cb) formation.

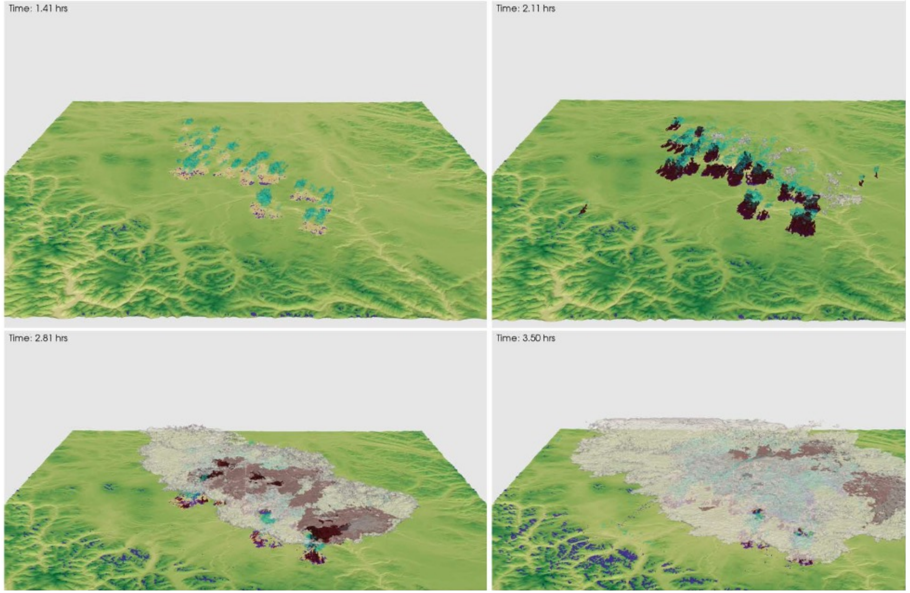

Figure 2. HIGRAD simulation of Pyro-Cb formation during 2017 BC fires. Cloud water (turquoise), cloud ice (white), dust/ash (blue), organic aerosol (brown), black carbon (black) are shown 1.5 hrs, 2 hrs, 2,5 hrs, and 3 hrs into the simulation.

LANL's HIGRAD and FIRETEC models were used in a multi-scale simulation framework to investigate impacts of small-scale fuel heterogeneities on large-scale Pyro-Cb formation.

Reisner, J. M., A. J. Josephson, K. J. Gorkowski, E. Koo, D. K. Thompson, D.Schroeder, and M. K. Dubey. Informed Multi-scale Approach Applied to the British Columbia Fires of Late Summer 2017. JGR: Atmospheres, in review. LA-UR-22-20272

Forest structural diversity impacts crown fire & tree mortality

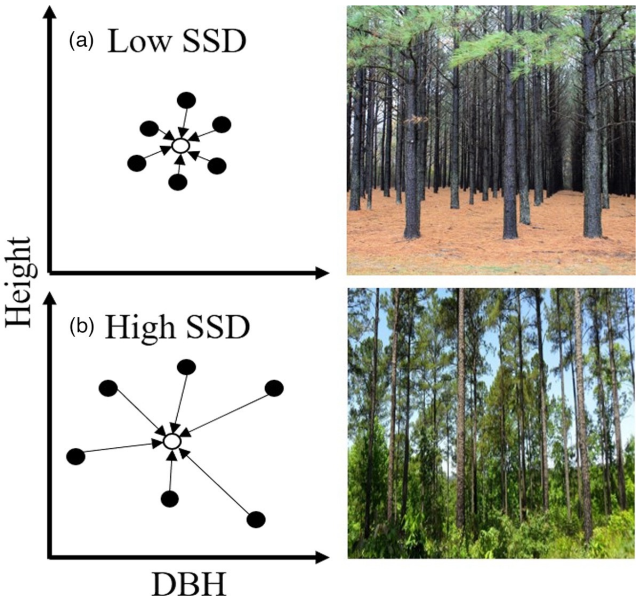

Figure 1. Comparison between loblolly pine stands of low (a) versus high (b) structural diversities. Conceptual diagrams based on 2D space defined by tree diameter at breast height (DBH) and tree height. Black points represent DBH and height of a individual trees, and empty points represent centroids of all individuals in a sampling unit. Arrows represent distance from the location of an individual to the centroid.

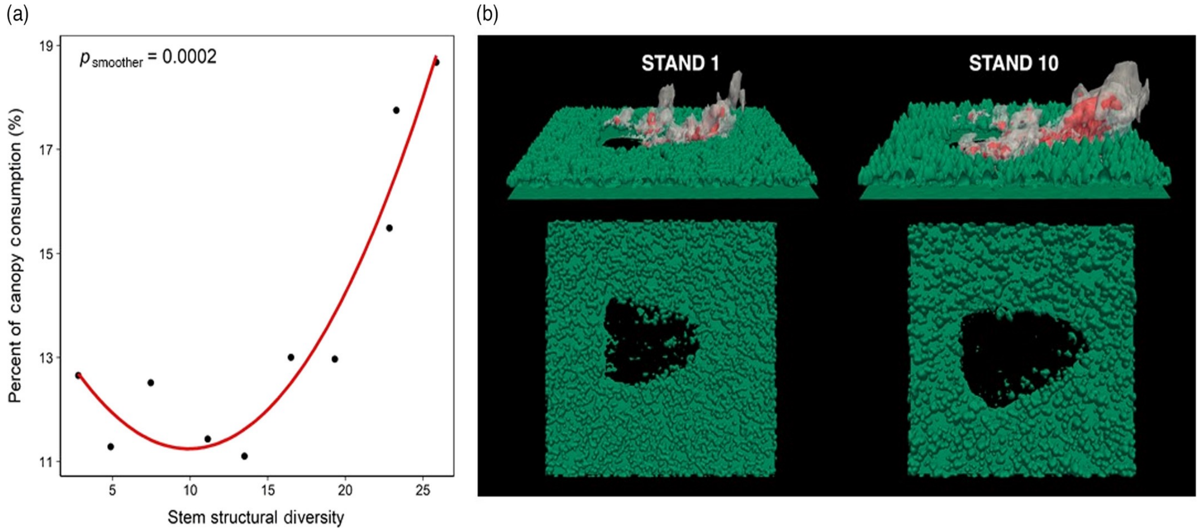

Figure 2. (a) We find a nonlinear relationship between stem structural diversity and percent of canopy consumed by fire. The regression line was fitted by a general additive model with span = 2.535, which was determined by the general additive model. (b) Visualizations of canopy fire and area burned in stands of the lowest (Stand 1) and highest (Stand 10) SSD.

<u>Forest structural diversity is found to increase canopy fire spread, and thus risk of tree mortality in FIRETEC simulations. Structural diversity is associated with an increase in ladder fuels, which facilitate fire spread into the canopy.</u>

Ref 1: Zhai, L., Coyle, D. R., Li, D., & Jonko, A. (2022). Fire, insect, and disease-caused tree mortalities increased in forests of greater structural diversity during drought. Journal of Ecology. https://doi.org/10.1111/1365-2745.13830. LA-UR-21-28195

Low-intensity fires are sensitive to small variations in winds

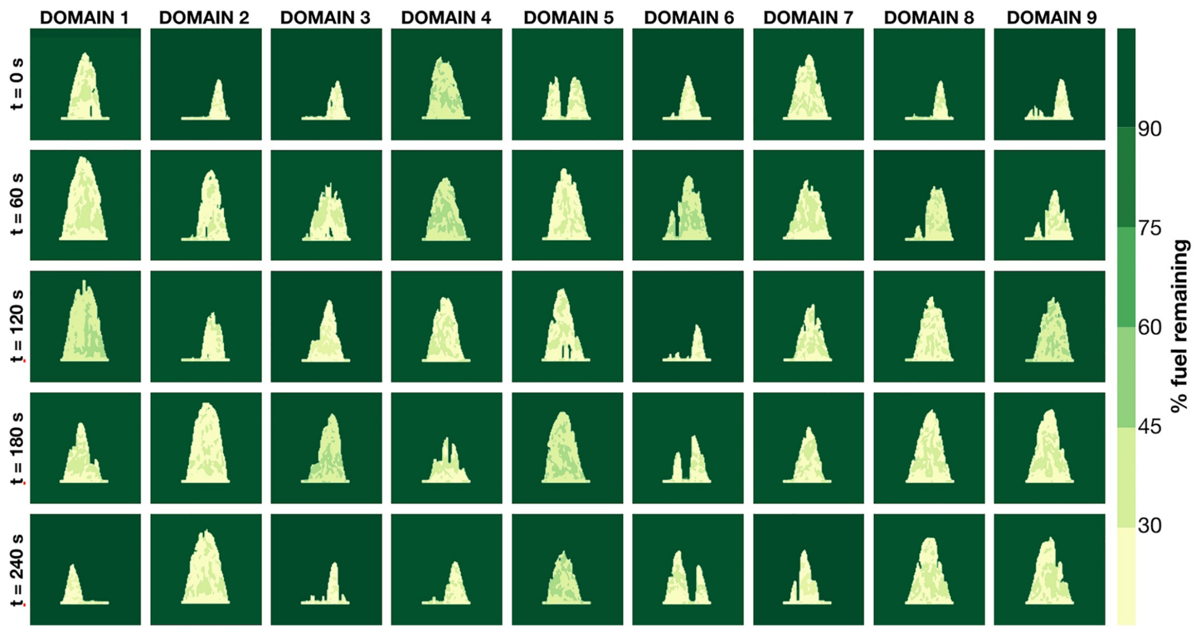

Figure 1. Final fire perimeters for 45 ensemble member simulations, run in nine subdomains with five ignition staggered in time, highlight a wide range of fire outcomes due to small perturbation in atmospheric conditions

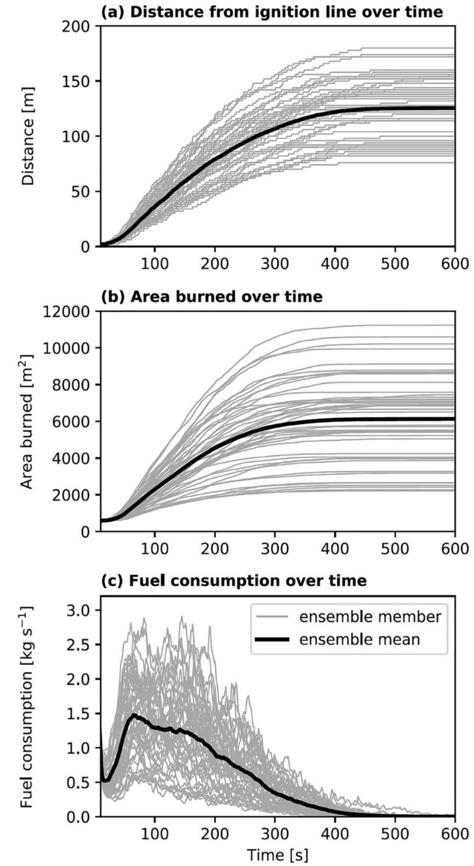

Figure 2. Time evolution of fire propagation distance, area burned, and fuel consumption for the 45 ensemble members.

Low-intensity fire burning in marginal conditions is highly sensitive to small perturbation in atmospheric turbulence. These results highlight predictive limitations of individual fire simulations, and emphasize the need for ensemble simulations, especially for low-intensity, prescribed fire.

Jonko, A. K., Yedinak, K. M., Conley, J. L., & Linn, R. R. (2021). Sensitivity of grass fires burning in marginal conditions to atmospheric turbulence. Journal of Geophysical Research: Atmospheres, 126(13), e2020JD033384. https://doi.org/10.1029/2020JD033384. LA-UR-20-23811