AnomaLEE

Dynamic fire propagation in the Bridger Foothills

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Interactions with complex topography have the potential to dramatically alter the development of bushfires. This is particularly true in the vicinity of ridgelines, where steep slopes are prominent, and wind-fire interactions contribute to dynamic fire propagation such as **Vorticity-driven Lateral Spread** (VLS) whereby certain conditions drive fires located on the more protected (lee) side of a ridge to spread at near right angles to ambient winds flowing across that ridge (Fig. 1).

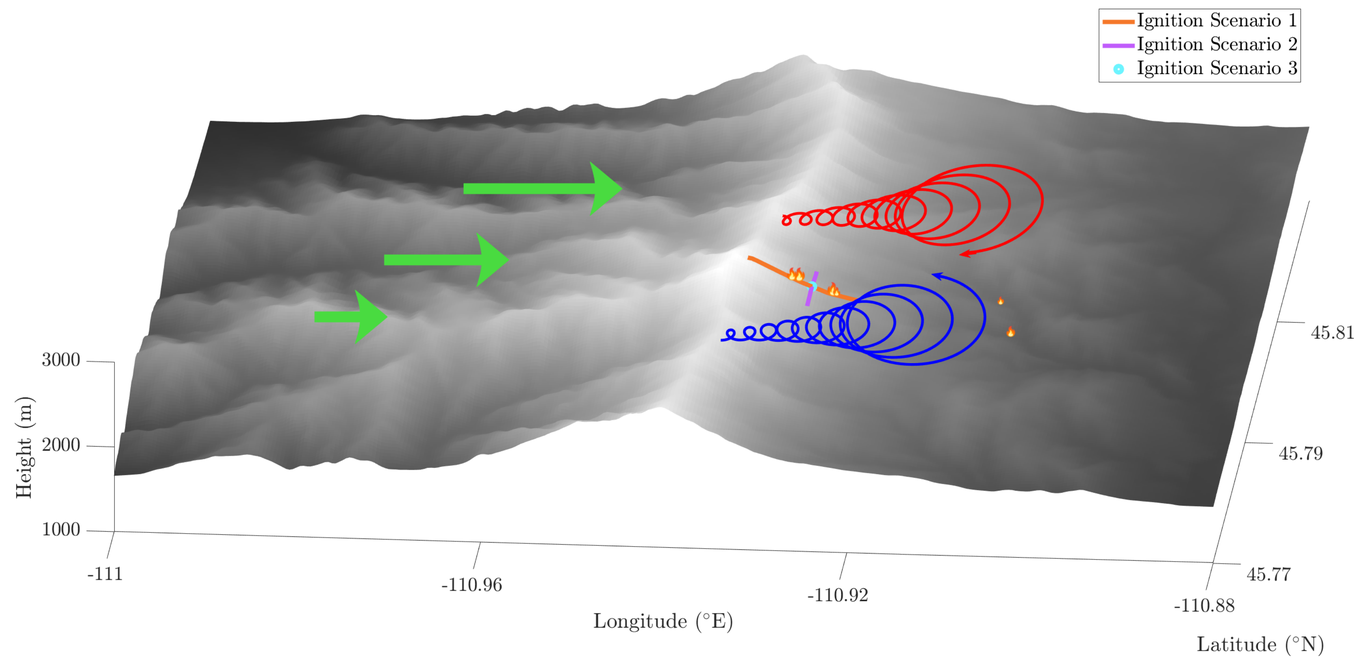

Fig. 1: Exaggerated schematic of the VLS process on a leeward slope, as proposed by [1]. The large green arrows indicate the direction of ambient winds that allow the development of a horizontal vorticity roll in the lee (not shown). Coloured twisters indicate the pair of counter-rotating vortices that result when this roll interacts with a nearby fire source. A vortex pair enable the lateral spread of fire with concomitant spotting downhill.

Wildfire in the Bridger Foothills (Montana, USA)

Lightning ignited a wildfire on the windward (western) side of Bridger Ridge in Sept 2020 but hot dry conditions and strong westerly winds caused that fire to spread over the ridge and onto a leeward slope by Sept 5. There the fire grew rapidly to the north, almost perpendicular to prevailing winds. A crew deployed to contain this fire on its northern flank was unable to be extracted and were forced to deploy shelters. Numerical WRF-SFIRE [2] simulations strongly indicated that the dangerous escalation was caused by VLS [3] and subsequently, the impact of various ignition scenarios were explored [4].

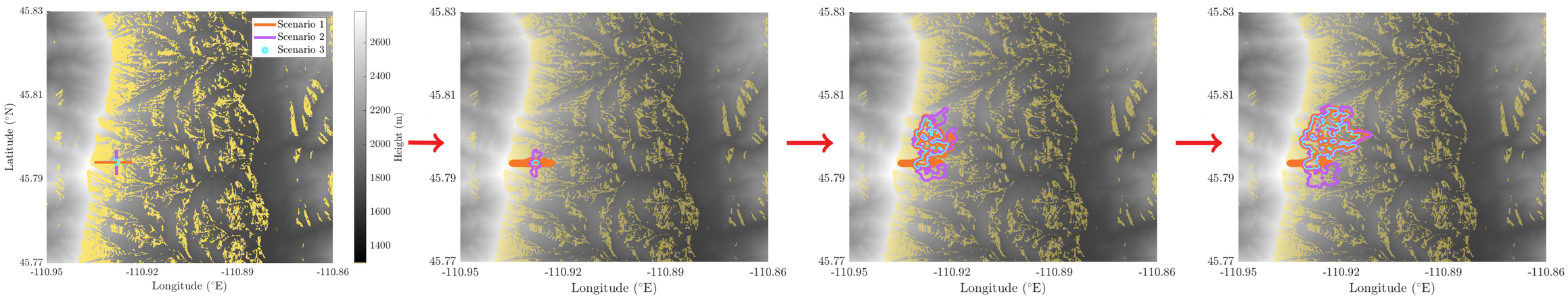

Fig. 2: Evolution of fire area perimeter as indicated by relevant scenario coloring (far left) at 1, 6 and 10 (left to right) hours post ignition.

Significant lateral spread to the north is evident in Fig. 2 whilst temporal evolution to the north and south is quantified in Fig. 3 (far left). Fig. 3 further illustrates how closely the lateral spread follows VLS prone regions for each ignition scenario.

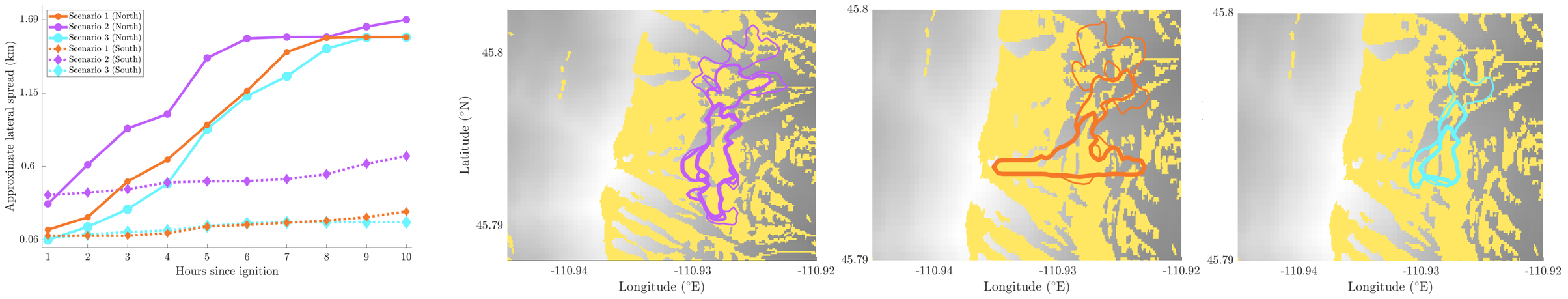

Fig. 3: Maximal linear distance spread to the north and south parallel to the ridgeline (far left) with temporal evolution for each scenario shown over three early time intervals where decreasing linewidth indicates increasing time since ignition. VLS prone regions are indicated in yellow.

REFERENCES

[1] C. C. Simpson, J. J. Sharples, and J. P. Evans. "Resolving vorticity-driven lateral fire spread using the WRF-Fire coupled atmospherefire numerical model". eng. *Natural hazards and earth system sciences* 14.9 (2014), pp. 2359–2371. ISSN: 1684-9981.

[2] J Mandel et al. "Recent advances and applications of WRF-SFIRE". *Natural Hazards and Earth System Sciences* 14.10 (2014), pp. 2829–2845.

[3] K K W Cheung et al. "Dynamic fire-atmosphere interaction in the 2020 Montana Bridger Foothills Wildfire as revealed by WRF-SFIRE simulations". *npj Natural Hazards* 2.75 (2025). DOI: https://doi.org/10.1038/s44304-025-00132-0.

[4] C Blachut et al. "The effect of ignition protocol on dynamic fire propagation in the Bridger Foothills fire". *(forthcoming)* (2025).

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