SciVis Contest 2022: Vorticity-driven Lateral Spread Ensemble Data Set

Divya Banesh [1] Rodman Linn [1] John Patchett [1]

[1]Los Alamos National Laboratory

Scientific Background and Motivation

Wildfire behavior is a result of complex nonlinear interactions between a variety of physical processes and chemical reactions. Understanding the coupling between these components and the ways in which their interactions are influenced by their surrounding environment (e.g. winds, fuels, and topography) is a challenging undertaking.

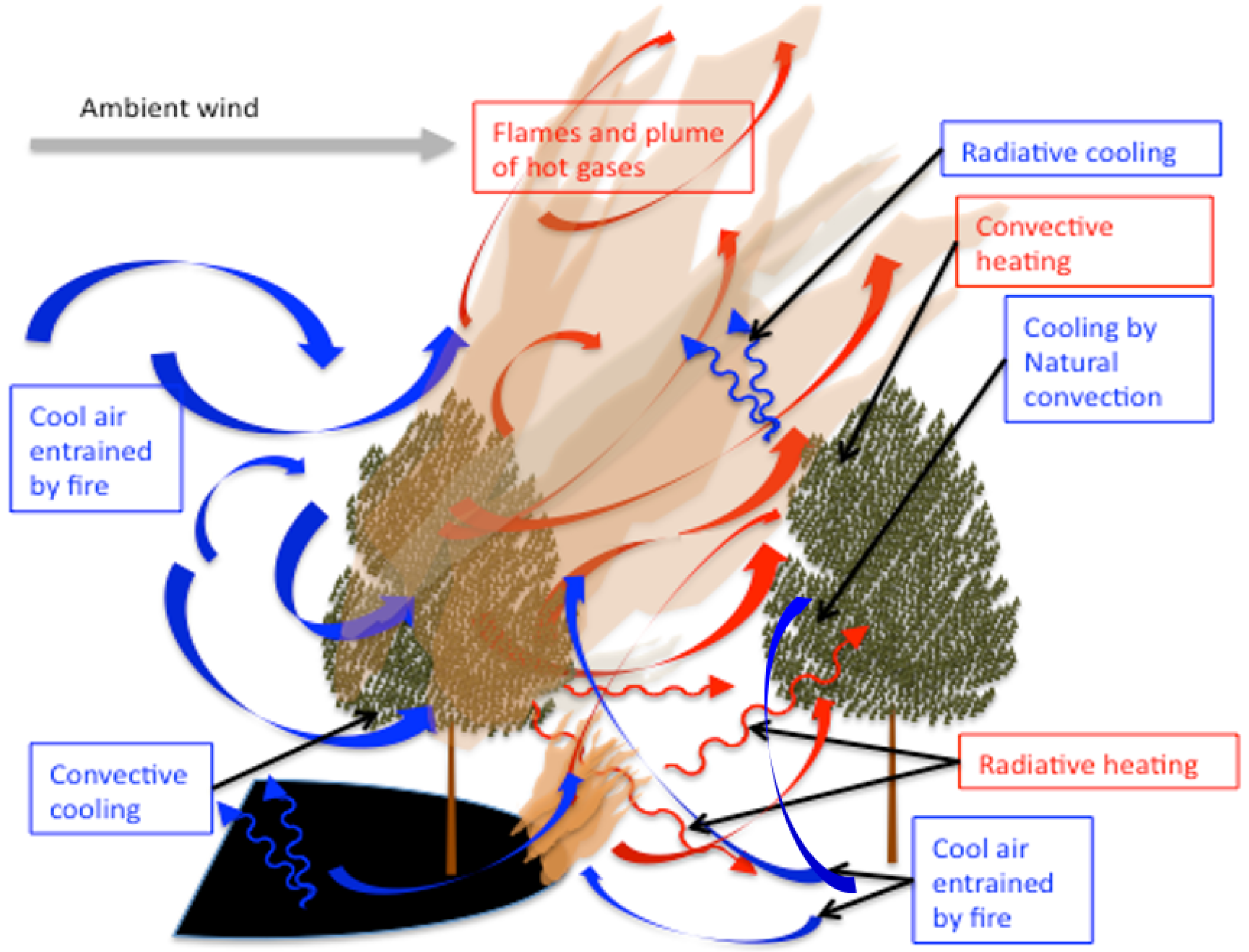

Figure 1:Many factors contribute to the behavior of a wildfire

Vorticity-driven lateral spread (VLS) is a wildfire phenomena involving rapid lateral (cross stream respect to the ambient wind) fire propagation across steep, leeward slopes [3]. VLS is driven by the complex dynamic interactions between the fire-induced buoyancy-driven updrafts and topographically-induced flow patterns, specifically the cross stream vorticity or re-circulation on the leeward side of a ridgeline or strong break in slope. More specifically, VLS develops from wind-terrain-fire interactions as the fire induced updrafts reorient the topography-induced re-circulations creating vertically vorticity, including strong lateral velocities. This drives rapid lateral fire spread across steep slopes in a direction almost perpendicular to the ambient wind direction. This behavior has recently been highlighted as a major factor in several fire blow up events behind ridgelines, but emerging research illustrates that this behavior can also exist in other scenarios such as steep canyons. In order to prepare for and potentially manage such behavior it is important that we continue to increase our of understanding of the environmental factors that affect this behavior and what wind, topography and fuel combinations pose significant risk of VLS occurrence.

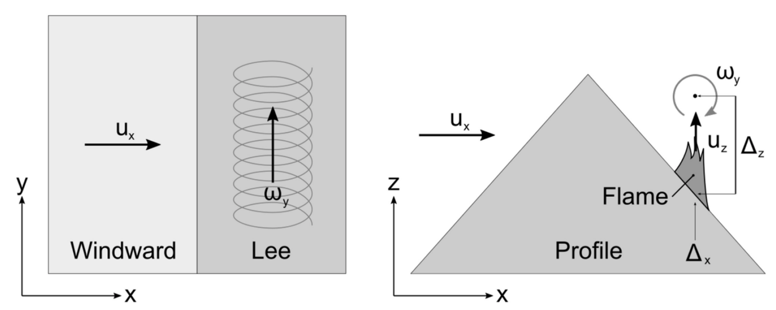

Figure 2:A diagram of vorticity-driven lateral spread. Figure credit Sharples et al. [3]

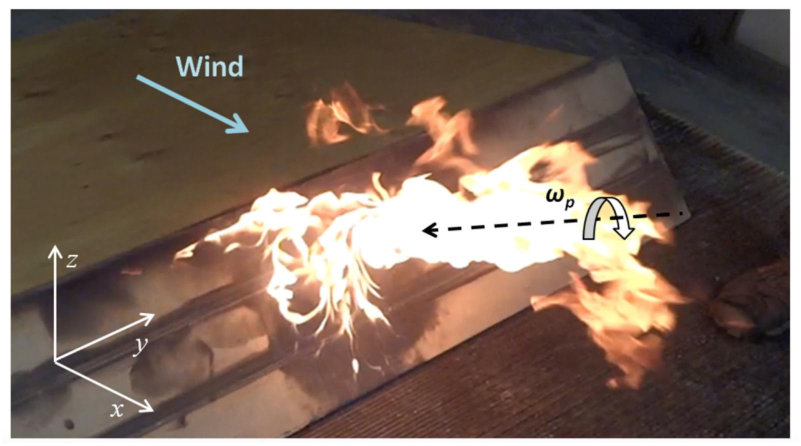

Figure 3:Experimental fire in a wind tunnel showing a fire vortex on the leeward slope of an idealized ridge. Figure credit Sharples et al. [3]

Higrad/Firetec Simulations

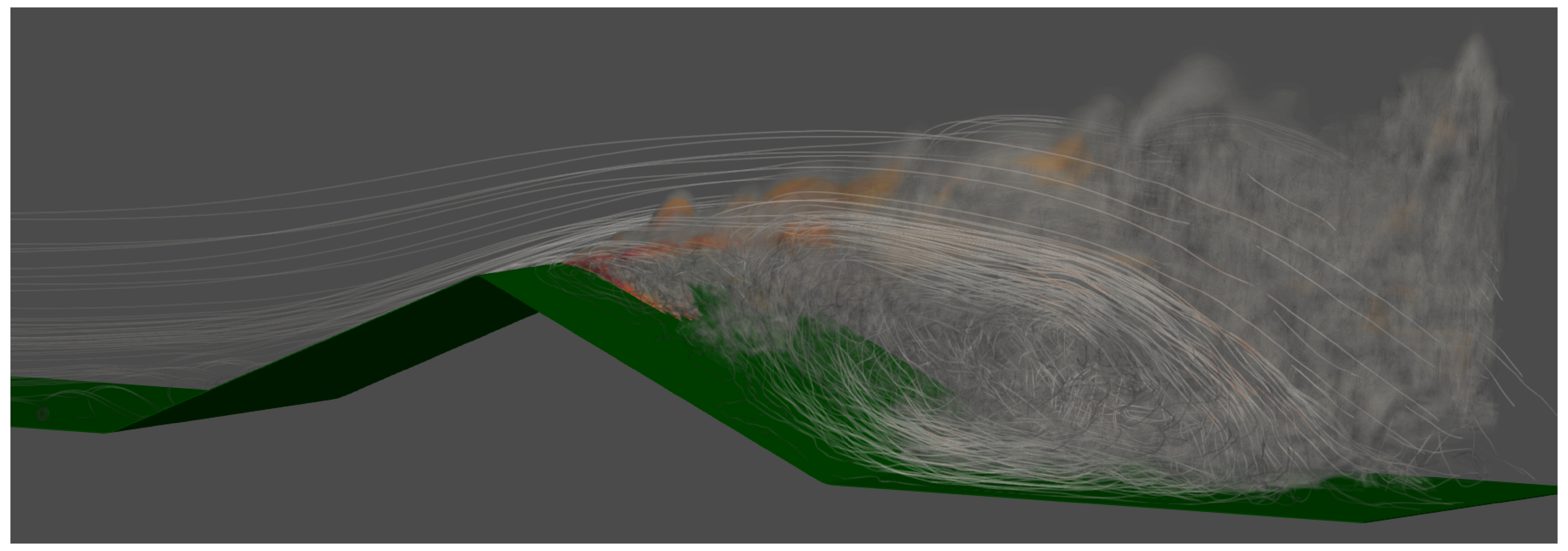

Figure 4:Higrad/Firetec Simulation of a fire on a mountaintop. The fire starts on the peak and progresses towards the leeward side. The vortices on the leeward side are clearly visible.

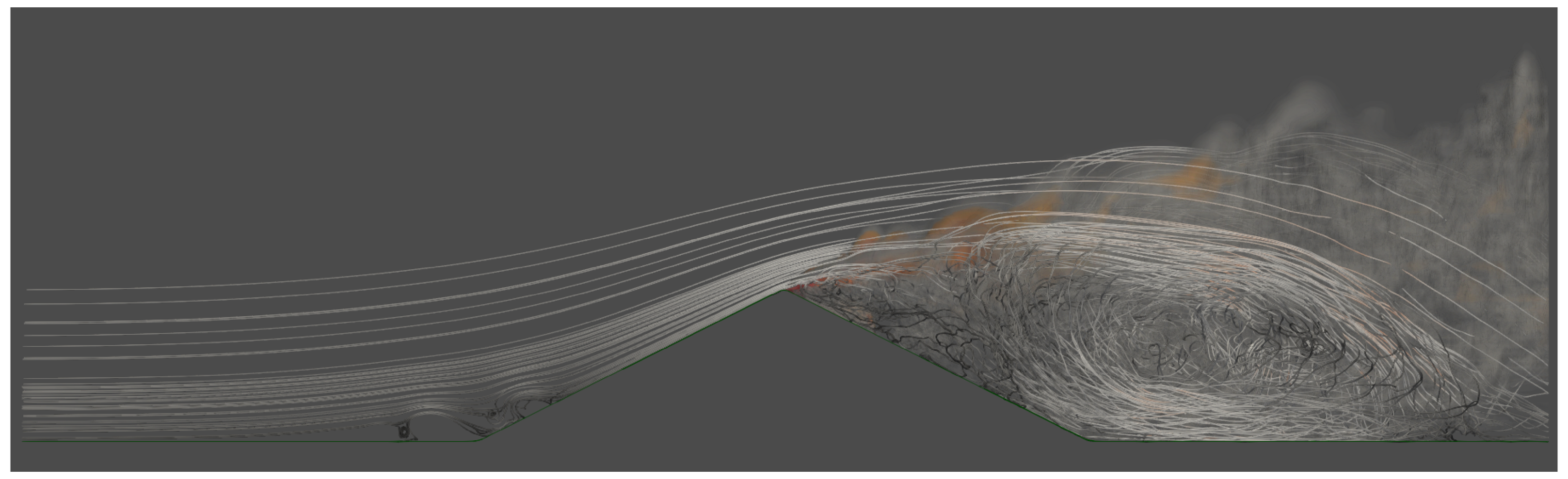

Figure 5:The vortices on the leeward side are clearly visible in the profile view.

Data

The data for the IEEE SciVis 2022 Contest will consist of multiple time series (each 500 times steps) of 3D scalar fields on a $1000 \times 500 \times 61$ curvilinear grid from coupled Higrad/Firetec simulations [2, 1]. The computational cells will also include information about the atmospheric velocity components, temperatures, turbulence levels, heat transfer magnitudes, and oxygen concentrations. The number on the file represents the time elapsed since the start of the simulation, in seconds. Each file is saved in Paraview's *.vts* format. Scalar fields include:

- **convht_1:** convective heat transfer ($\mathrm{W/m^3}$)
- **rhof0_1:** bulk density of dry fuel at time zero ($\mathrm{kg/m^3}$)
- **rhof_1:** bulk density of dry fuel ($\mathrm{kg/m^3}$)
- **rhow_1:** bulk density of the moisture associated with the fuel ($\mathrm{kg/m^3}$)
- **temps_1:** temperature of the fuel in a cell (K)
- **u:** vector component of the wind in direction x
- **v:** vector component of the wind in direction y
- **w:** vector component of the wind in direction z

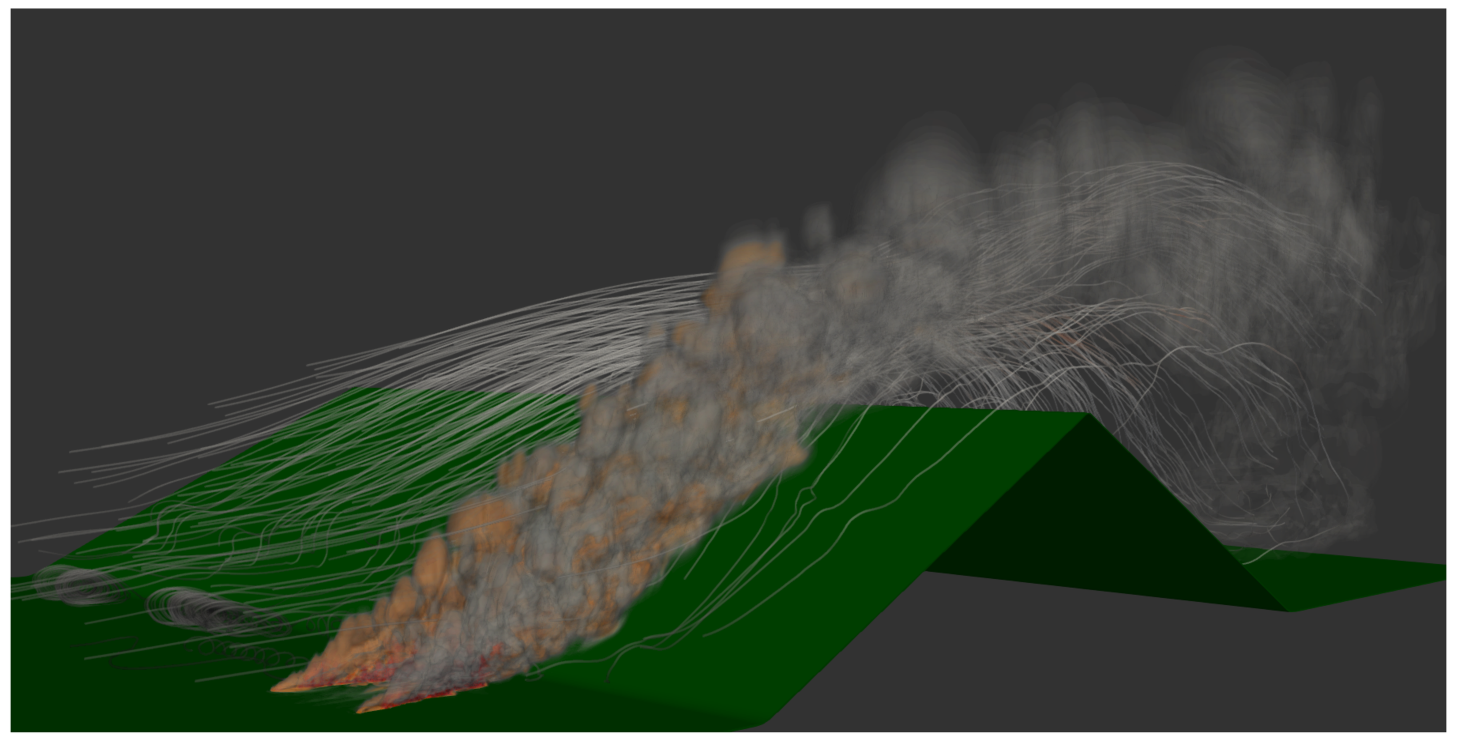

Figure 6:Higrad/Firetec mountain fire simulation

Tasks

This contest is looking for state-of-the-art visualizations to help domain scientists better understand wildfires in general, and more specifically, vorticity-driven lateral spread. A list of possible tasks a submission may pursue include but are not limited to:

- Produce a summary of the data, to describe the ensemble of simulations, a particular simulation or specific details within a simulation.
- Generate a visual narrative of the events within the time series of one or more simulations.
- Analyze how the terrain impacts VLS
- Examine the influence of vegetation structure and atmospheric turbulence on VLS
- Build tools to help explain the VLS phenomena and ways that the different factors (topography, ambient conditions, vegetation) might change the potential of VLS
- Determine how your analysis and visualizations may help firefighters make decisions (bonus points for fast solutions that help firefighters in the field).

In addition to the overall first, second, and third place winners, awards will be given for the:

- best report cover visualization
- best visualization for explaining the VLS phenomena
- best vector analysis

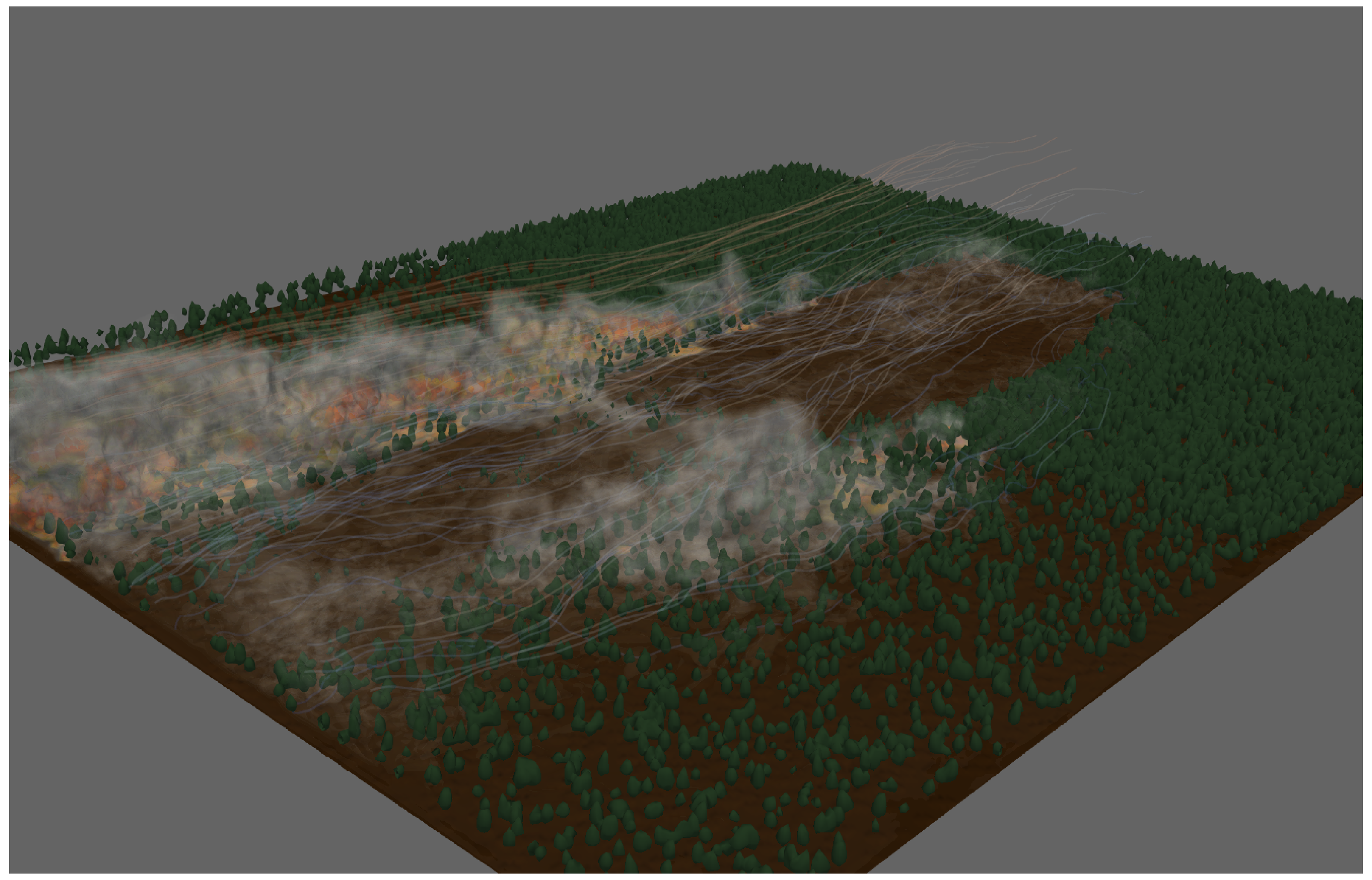

Figure 7:Higrad/Firetec forest fire simulation

Deadlines

The **deadline for the contest is July 31, 2022**. The winners will be notified on August 31, 2022 and invited to submit a full journal article to IEEE Computer Graphics and Applications Journal. Official announcement of the results will be made at IEEE Vis 2022 in October.

References

[1] Rodman Linn, Jon Reisner, Jonah J Colman, and Judith Winterkamp. Studying wildfire behavior using firetec. *International journal of wildland fire*, 11(4):233–246, 2002.

[2] Rodman Ray Linn. *A transport model for prediction of wildfire behavior*. New Mexico State University, 1997.

[3] Jason J Sharples and James E Hilton. Modeling vorticity-driven wildfire behavior using near-field techniques. *Frontiers in Mechanical Engineering*, 5:69, 2020.