Wild Fire Visualization
Group 4

Carter Bailey, Christopher Allred, Dongyun Han

March 2022

Abstract

Predicting how a forest fires will behave is an extremely difficult task because of all the non-linear interactions that occur. To help predict wildfires more accurately, the Los Alamos National Laboratory (LANL) has created software to replicate wildfires in simulation 1. This software will help researchers to better understand how wildfires spread so that they can be contained quickly and safely. LANL has launched a competition to create visualizations using results provided by their software to better understand how geography, fuel moisture, wind speed, and other factors affect wildfires. We intend to participate in this contest by creating visualizations that show a visual narrative of the events that occur during a wildfire.

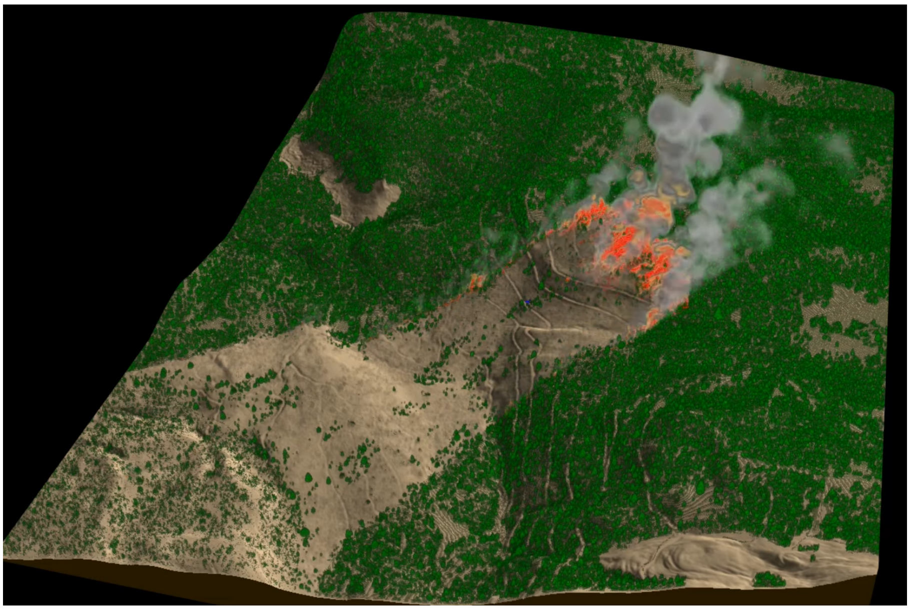

Figure 1: A simulated wildfire using software created by the Los Alamos National Laboratory

1 Introduction

The study of wild fires is important not only for academic reasons but also real-life situations. Understanding how wild fires behave, for example, allows firefighters to put out forest fires with less risk to their lives. However, it is challenging because wild fire's behavior results from complex interactions of physical and chemical phenomena such as combustion, atmospheric dynamics, and a multi-phase turbulent flow.

Visualizing wild fires has the potential to improve our understanding of the environmental factors that affect its behavior. In this project, we are planning to visualize wild fires in three different situations, head curve and back curve fire on mountains and fire in a valley. We are going to use the Vorticity-Driven Lateral Spread (VLS) Ensemble data-set [1] which is provided for the SciVis 2022 Contest [2]. We intend to complete two of the six tasks that Los Alamos National Laboratory (LANL) has presented for this contest. The two tasks that we intend on completing are:

- Generate a visual narrative of the events within the time series of one or more simulations.
- Examine the influence of vegetation structure and atmospheric turbulence on fire spread

By completing this project we hope to become more proficient at using Paraview to visualize time step data, analyzing data through visualizations, and using different types of filters in Paraview to present different parts of a data-set.

2 Data-Set

The data-set we will be using is provided by the IEEE SciVis 2022 Contest [2]. It provides two different scenarios: fire in mountain and valley. The mountain simulations are then labeled as either a head curve or back curve, depending on whether the fire starts as a head fire or a backing fire. Each mountain simulation is associated with a radius of curvature at the top. The given curvatures are 40, 80, and 320. A higher curvature value indicates a more rounded ridge-line. Compared to the mountain scenarios, the valley scenario is not associated with any values like curvature. It provides a total of seven simulation data-sets (six for the mountain scenarios and one for the valley scenario). They are provided in a .vts extension.

We plan on using three datasets: mountain_headcurve40, mountain_backcurve40, and valley_losAlamos for this project. Each simulation consists of multiple time series of 3D scalar fields on a 600 $\times$500 $\times$61 curvilinear grid. Cells in the volume metric data-set include scalar fields such as the atmospheric velocity components, potential temperatures, density of fuel (vegetation), and oxygen concentrations.

2.1 Scalar Fields

The wild fire simulation data-set includes 9 scalar fields [3] as following:

1. O2: oxygen concentration
2. convht_1: convective heat transfer (W/m^3)
3. frhosiesrad_1: fire-induced radiative heat transfer to the fuels (W/m^3)
4. rhof_1: bulk density of dry fuel (kg/m^3)
5. rhowwatervapor: bulk density of the moisture released to atmosphere as result of fire (kg/m^3)
6. theta: potential temperature (K)
7. u: vector component of wind aligned horizontally in the general direction of the upper level mean wind (streamwise)
8. v: vector component of wind aligned horizontally perpendicular to the general direction of the upper level wind (crosstream)
9. w: vector component of wind in the vertical direction

3 Schedule

During the initial week we will download the data-sets and learn how to merge them together since the data-sets come in 1 GB chunks. Once the datasets are merged in paraview then we can start testing different ways to visualize the forest fires over time. The second week entails using the wind, heat transfer, and density of dry fuel variables to examine how they influence a fires spread.

For the third week we will spend the time creating visualizations based off of our findings from week two. If we finish this part early then we will download the other data-sets and explore how different curvatures of the mountains effect fire spread.

In the fourth and fifth week, we will write our project report, create our presentation and practice presenting. We are mainly leaving week five as buffer room in case we aren't able to finish everything that we are aiming to in the first four weeks.

4 Goals

We will gauge the success of our project by the completion of the two tasks that we set out to complete and how simple our visualizations are to understand. Our objective is to build visualizations that are basic enough that when we present our results in class, our peers will grasp what is going on in the visualization without us having to explain it too much.

We intend to submit at least two distinct visuals for each data-set. These two visualizations will include a movie depicting the spread of a fire over time, as well as videos/images depicting the effects of wind and geography on how a fire spreads.

References

[1] https://oceans11.lanl.gov/firetec/. https://oceans11.lanl.gov/firetec/. Accessed: 2022-03-14.

[2] Ieee scivis 2022 contest. https://www.lanl.gov/projects/sciviscontest2022/. Accessed: 2022-03-14.

[3] Vorticity-driven report. https://www.lanl.gov/projects/sciviscontest2022/report.pdf. Accessed: 2022-03-14.