Diploma Thesis

ANALYSIS AND 3D VISUALISATION OF WILDFIRE USING EARTH OBSERVATION DATA

Objectives

Understanding the pattern and impact of these wildfires is necessary for rebuilding and rehabilitation to occur. 2023 saw an estimated 4 billion dollars' worth of global economic damage from wildfires, with the cost of rebuilding often being more significant than this. For the 2023 fires in Maui alone, an estimated 5.5 billion dollars is required for rebuilding efforts (PDC, FEMA, 2023). To undertake the process of rebuilding, it is therefore necessary to visually depict the spread and pattern of destruction.

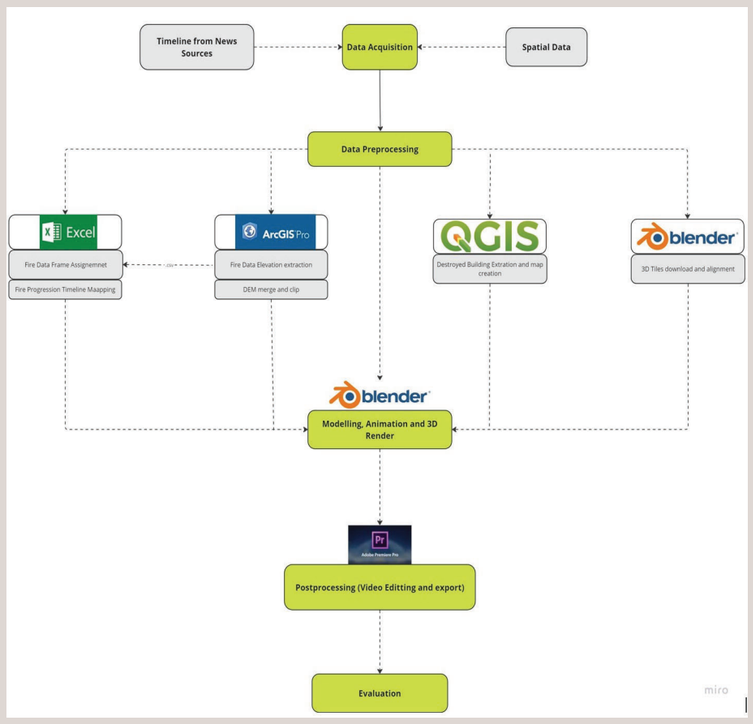
This current study aimed to retrospectively illustrate the pattern of occurrence of an extreme wildfire event in a 3D environment using such accurately measured EO-derived indicators as the Aerosol Optical Depth (AOD) to depict smoke plumes and sub-daily observations of active fire locations from MODIS. Through this, we hope to recreate the commencement and spread of the Maui Wildfires of 2023. For better understanding and relatability, this will be done using advanced 3D modeling software to better support rebuilding and rehabilitation efforts for this and similar fires.

The following objectives guided this study;

- Develop the workflow for modeling and visualizing real-time and remote-sensing derived parameters in a 3D environment
- for retrospective monitoring of a wildfire event.
- Identify potential issues with applying remote-sensing-derived parameters of a wildfire in a 3D modeling environment.
- Evaluate the viability of using satellite-derived Aerosol Optical Depth in representing smoke plumes in a 3D modeling environment.
- Document processes and workflows developed for easy replication and utilization.

Methodology

Two scales of the fire are modelled in this study. Maui Island and Lahiana. For each scale, the steps taken in the workflow span Data Preprocessing, Model Creation, Animation and Rendering, and Post Processing (Video Editing). Data preprocessing was done in ArcGIS/QGIS, 3D model creation, animation nd rendering was done in Blender, while the video editting was done in Adobe Premier pro.



Study Workflow Diagram

MAUI ISLAND FIRE ANIMATION

For this level, The preprocessing step involved assigning frame values to the active fire points based on acquisition date and time. The background terrain data was also created prpeared in GIS software. For teh 3D model creation, active fire data from NASA FIIRMS was imported into Blender using a python script as vertices. A mesh was instanced on the vertices and they were animated based on the FRP value and acquisition date/time. Suitable material was assigned, and enviroment elements like light and camera were animated. This was rendered and as image files which was then ingested into Adobe Premier Pro as an image sequence. Map elements such as the Title, Description, inset map, callouts, labels and inforgraphics were added here.

Fire model sample as displayedin a section of Lahaina.

LAHAINA FIRE AND SMOKE ANIMATION

The preprocessing step involed coding a timeline for the fire progression from verified news media. The required Google 3D Phortorealistic tiles were also downloaded and aligned to fit seamlessly. The fire and smoke model is the procedurally created within predefined fire regions. A tool that instances realistic fire/smoke material along the vertices of a bezier curve was used to instance the fire and smoke across the scene, instead of Blender's standard fluid simulations. This was done in the interest of modeling ease and resource conservation. Each created fire region was duplicated to form its corresponding smoke region. These were then animated (prestart, start, peak, decline, end) to mimick the likely fire progression (as referenced form real-time information). Five Seperate camera positions were rendered each depicting a different view of the fire progression.

Fire regions created and animated

Results

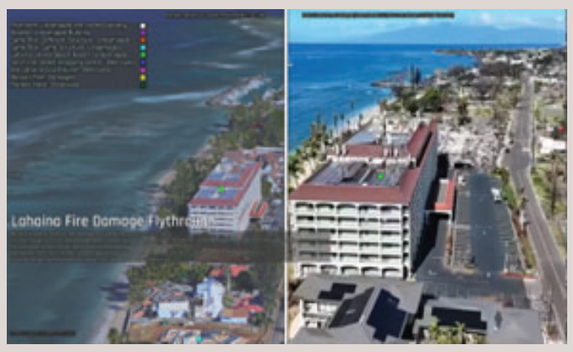
This study produced five video animations of teh fire's progression. One of Maui Island and four of Lahaina. 2 maps were also created one representing teh Historial Landmarks affected by the fire in Lahaina and one depicting the footprints of buildings destroyed/damaged by the fire, and their respective zones.

This is the result of the Maui Island Animation. It shows an overview map of the island and visualizes the active fire spots as bright objects animated to appear at the appropriate time stamp and disappear afterward.

This animation shows the initial 30 hours of the fire. Starting from 06:30 hours on August 8th, 2023 to 12:34 hours on August 9th, 2023. The camera looks from the southern coast of the island just beyond where the affected buildings start. This captures the entire burn zone and illustrates the fire in Lahaina starting and progressing.

This animation also shows the initial 30 hours of the fire. Starting from 06:30 hours on August 8th, 2023, to 12:20 hours on August 9th, 2023. The camera looks from the eastern hillside and offers a closer view from the fire ignition point. This view also captures the entire burn zone, albeit with a steady camera movement facing first to the south and then to the north. It shows the same fire progression as in the above animation.

The purpose of this animation is to focus more on the historical district on the west coast of Lahaina and how the fire spread there. Starting from 02:50 hours and ending at 23:48 on August 8th, 2023. The camera looks from just above the harbor and zooms in and centers on the Banyan Tree and the Old Lahaina Courthouse at the heart of the historical district. The view then shifts first to the left (towards the south), then to the west (towards the north) to see the fire burning landmarks like 505 Front Street Shopping Mall and Wohing Temple Museum.



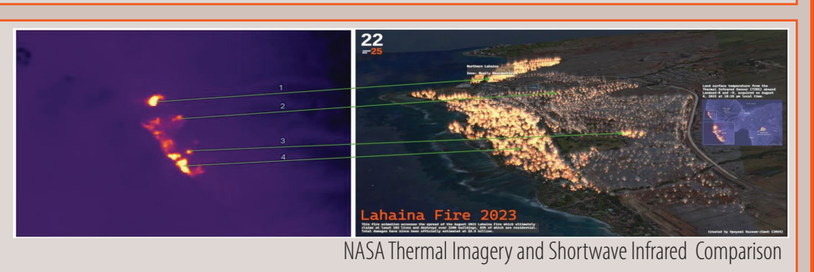
The purpose of this animation is to show the aftermath of the fire particularly in the historical district of Lahaina which was mostly destroyed. The animation is in 2 sections.

The first section shows a side-by-side view of a fly-through from the extreme southwestern part of the burn zone in Puamana Community. In this section of the flythrough, damaged and undamaged buildings were highlighted using individually colored points. The second section of the flythrough starts when footage from YouTube stops. Although there is no longer real-life footage available, the remainder of the flythrough depicts the 3D model of the historical area before the fire as rendered from Blender

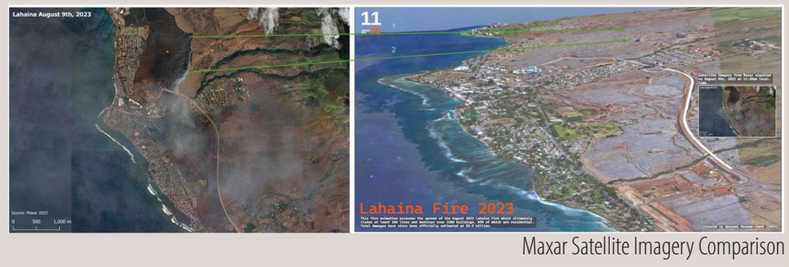
Evaluation

The resulting 3D animation is assessed based on remote sensing data and the most detailed official timeline so far from the Hawaii Department of the Attorney General(Hawaii DOAG, 2024). Evaluation was done against three separate datasources.

- NASA Thermal Imagery and Shortwave Infrared (acquired August 8th, 2024)
- Maxar Satellite Imagery (acquired August 9th, 2023)
- Lahaina Fire Comprehensive Timeline Report by Fire Safety Research Institute (2024)



NASA Thermal Imagery and Shortwave Infrared Comparison



Maxar Satellite Imagery Comparison

Watch Animations Here!

Thesis Website

View Storymap Here!

Author: Opeyemi Kazeem-Jimoh
UPOL Supervisor: RNDr. Jan BRUS (Ph.D.)
PLUS Supervisor: Prof. Dr. Stefan LANG
Department of Geoinformatics, Faculty of Science, Palacký University Olomouc
Department of Geoinformatics, Paris Lodron University Salzburg
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Appendix to diploma thesis number 2

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