Impacts of Climate Change in Venice

Modeling Extreme Events to Enhance Preparedness

This booklet was produced by a team of students from Worcester Polytechnic Institute as part of a project completed in the fall of 2021.

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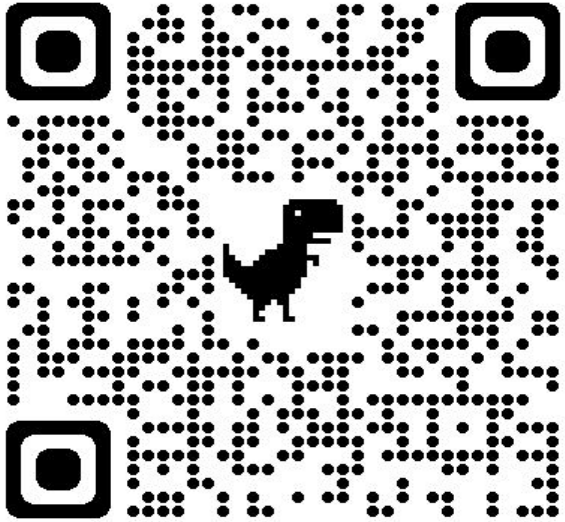
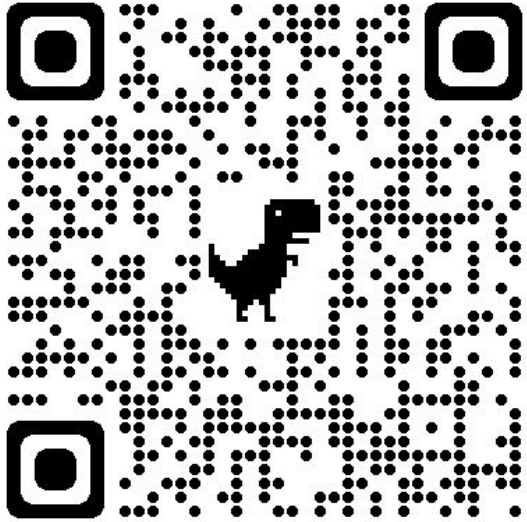
Introduction

This booklet showcases examples of simulations of extreme climate events in Venice using a tool called Simtable, which can be used to model extreme events such as flooding, wildfires, and toxic gas releases.



This **QR** code leads to the simulation repository from this project. And is an exemplary example of creating a website filled with **Simtable** simulations for better citizen outreach.



This **QR** code leads to the team website where main deliverables are linked and the students' experience in Venice is documented.

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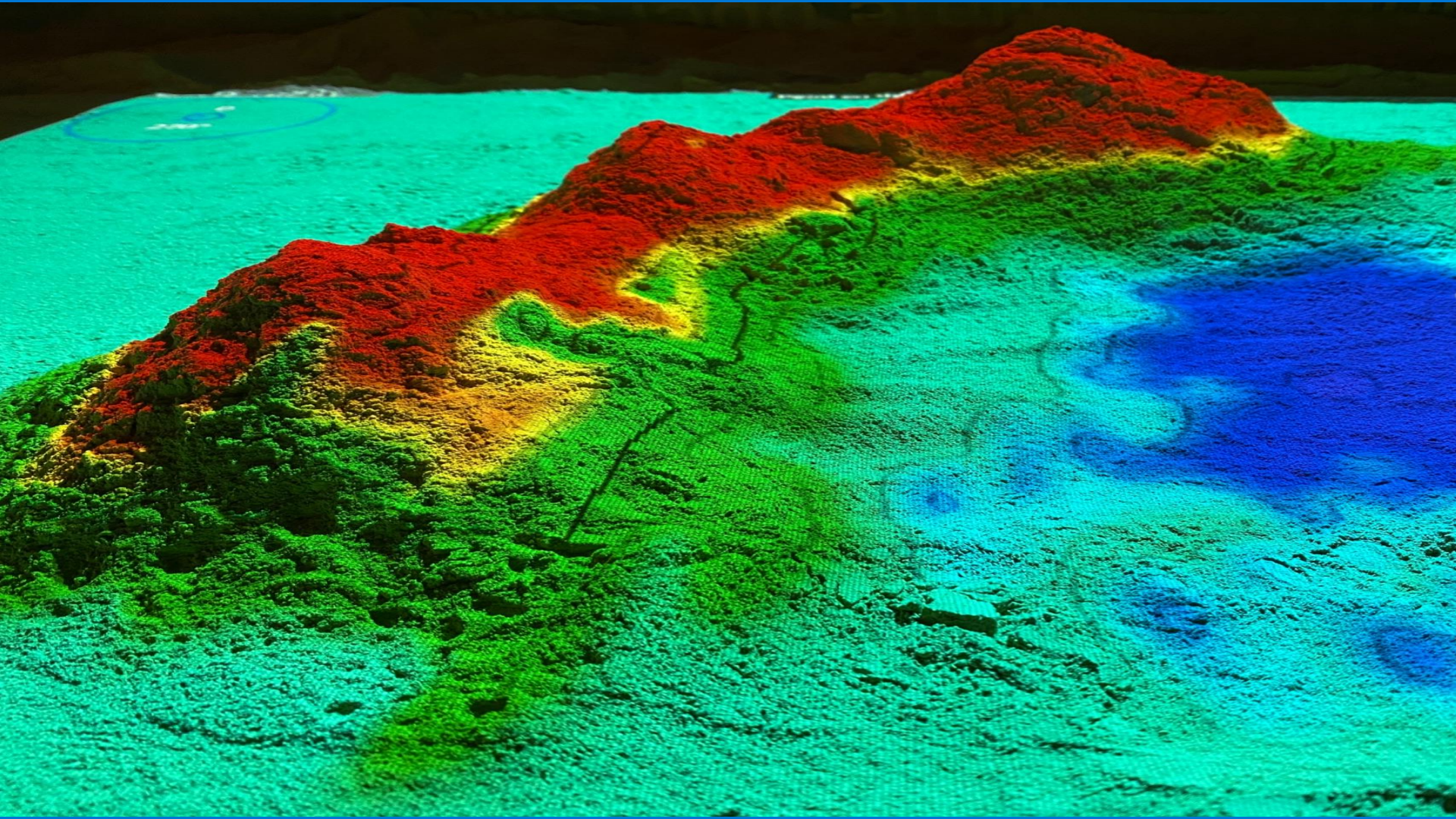


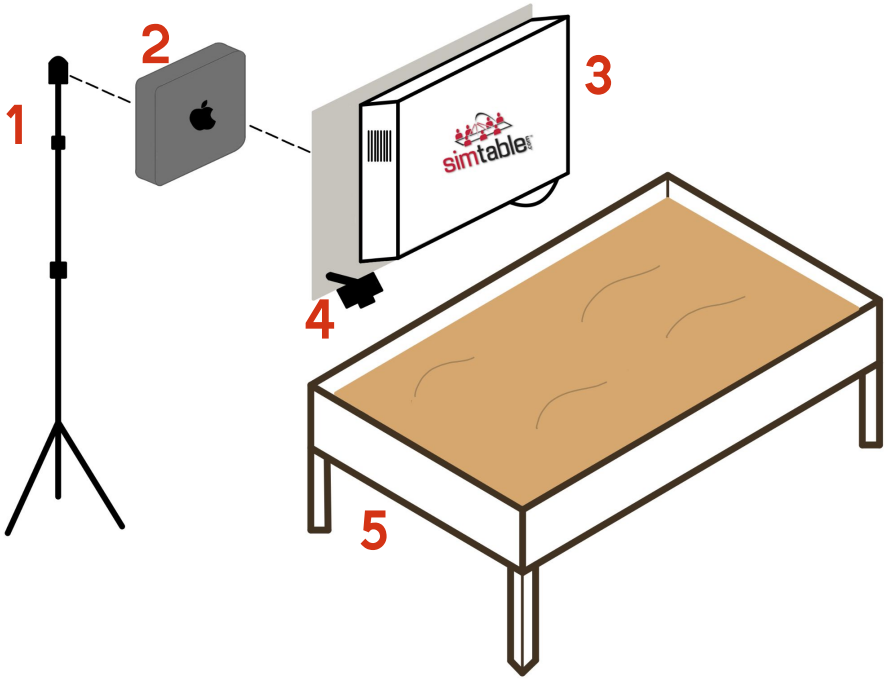
1 THE SIMTABLE SYSTEM

What it does and how it works

01 SIMTABLE

SIMTABLE SYSTEM

The Simtable set-up consists of a sandtable, computer, camera, projector, projector stand, and the AnyHazard software. These parts work in unison to create the three dimensional models. The infrared camera (4) detects the elevation of the “sand” which sends a message to the computer (2). The projector (3) displays the information from the computer onto the table (5) with RGB values to show the different elevations.



1 PROJECTOR STAND

2 MAC MINI

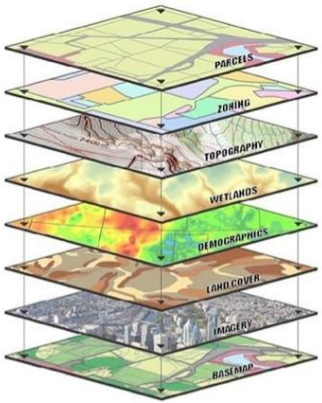
3 PROJECTOR

4 CAMERA

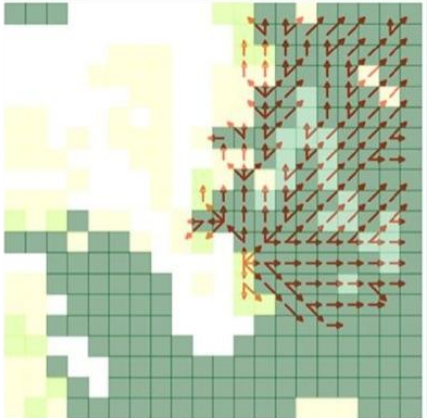
5 TABLE HOLDING CRUSHED WALNUT SHELLS

SIMTABLE COMBINES MAPS WITH MODELS TO SIMULATE EVENTS

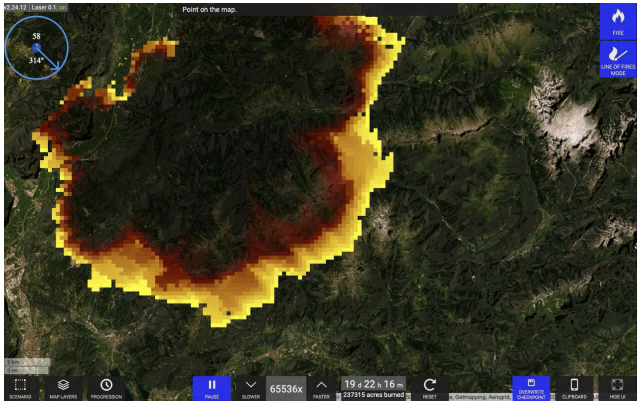
Simtable uses information about the terrain, environmental data, and interactive inputs from the user to simulate extreme events. This information is read by AnyHazard and the software used by Simtable to simulate events outputs a real-time, interactive visualization.



Data layers include fuel type, elevation, weather, and slope.

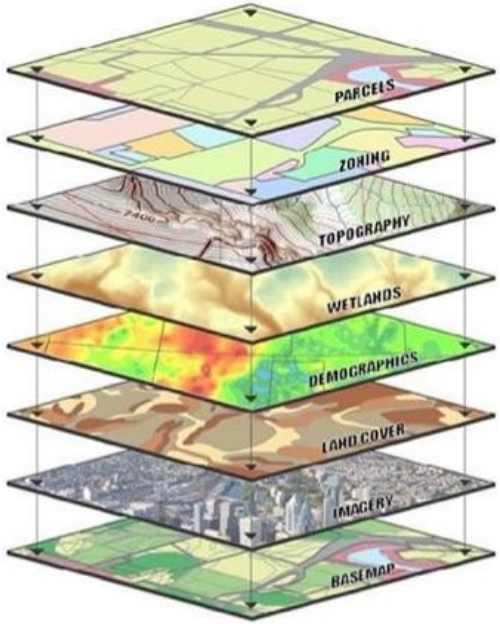


Fire propagation model repeated through pixels.

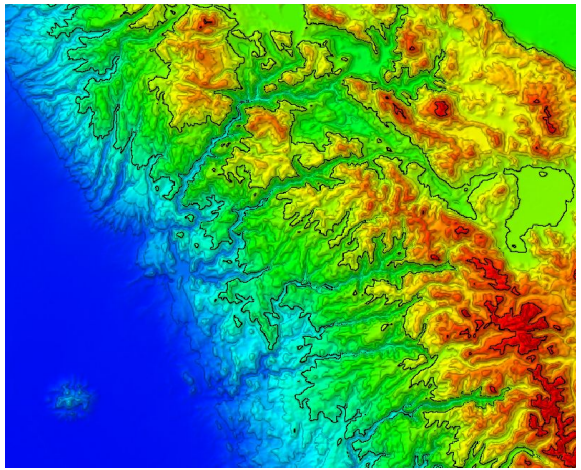


Fire simulation in the Veneto region.

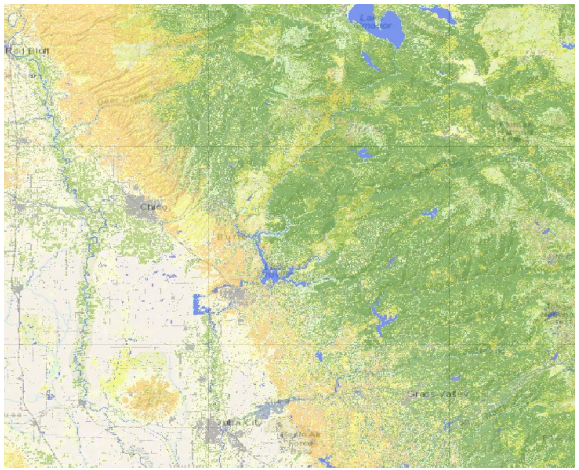
MAPS AND DATA



Simtable uses a variety of geographic information systems to integrate elevation, land-cover, topography, and zoning maps into AnyHazard. The data layers are composed of these maps, and are essential for the model to process to simulate different environmental scenarios. Elevation and land-cover maps are shown of Butte County, California, location of the devastating Paradise Fire in 2018.

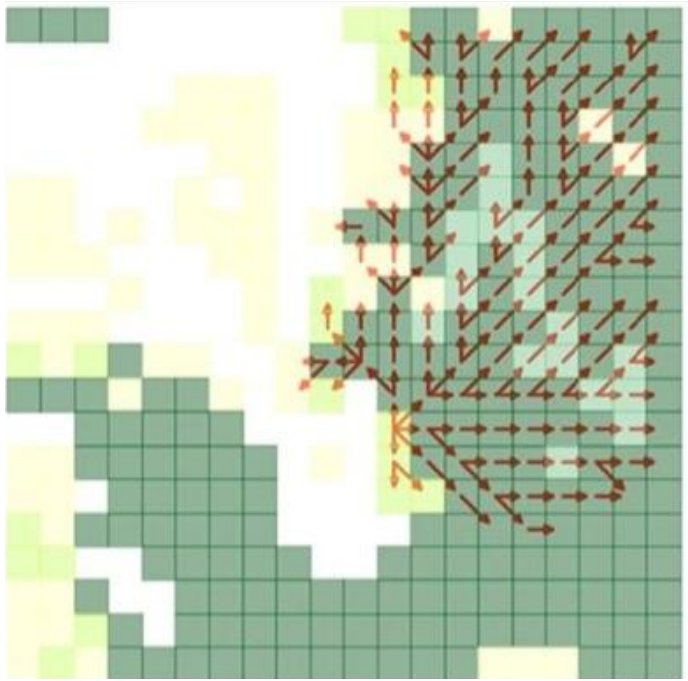


Elevation layer of Butte County.



Land-cover map of Butte County.

BEHAVIOR MODELING



AnyHazard uses three different “behaviors” to model events for fire, plumes, and water..

The first of which applies to fire. The model reads the fuel types and elevation values of a pixel (provided by the maps), and decides whether or not to burn that area. The speed at which a fire burns is dependent on the direction of the wind, the slope of the area, the land-cover data, temperature, humidity, and moisture presence. For example, a fire in a flat, urban area with no wind will spread much more slowly than a fire in a wooded area pushed uphill by intense wind.

For a toxic gas release, the plume travels in the speed and direction set by the wind dial. The cloud of gas separates when it encounters a structure, and moves around the object in its way.

The last of the models is used for the water module. AnyHazard analyzes the elevation value for each pixel, and decides whether or not to flood an area if the height of the water is greater than the elevation value of the pixel.



2 APPLICATIONS OF SIMTABLE

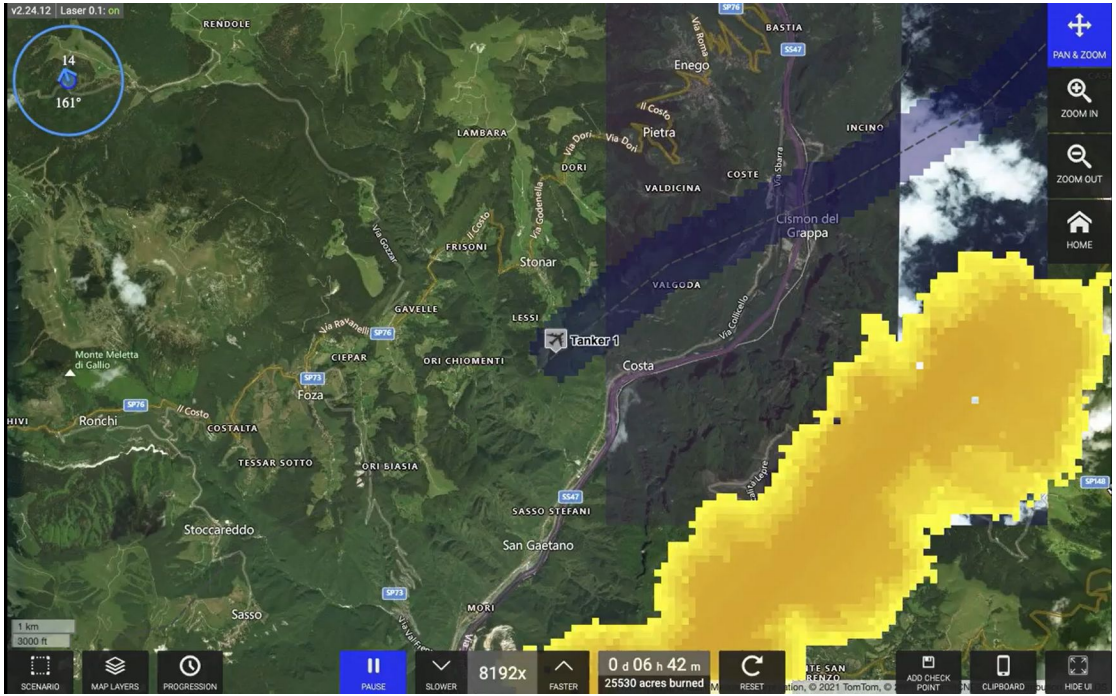
Simulating fires, toxic plumes and flooding scenarios

02 APPLICATIONS of Simtable

SIMULATING WILDFIRES ON SIMTABLE

The Wildland Fire Module allows for interactive simulations for fire using wind, elevation, and fuel types. The module is primarily used for emergency training and fighting active fires. Simtable was initially created to model fires and has since expanded its modeling capabilities to other disasters.

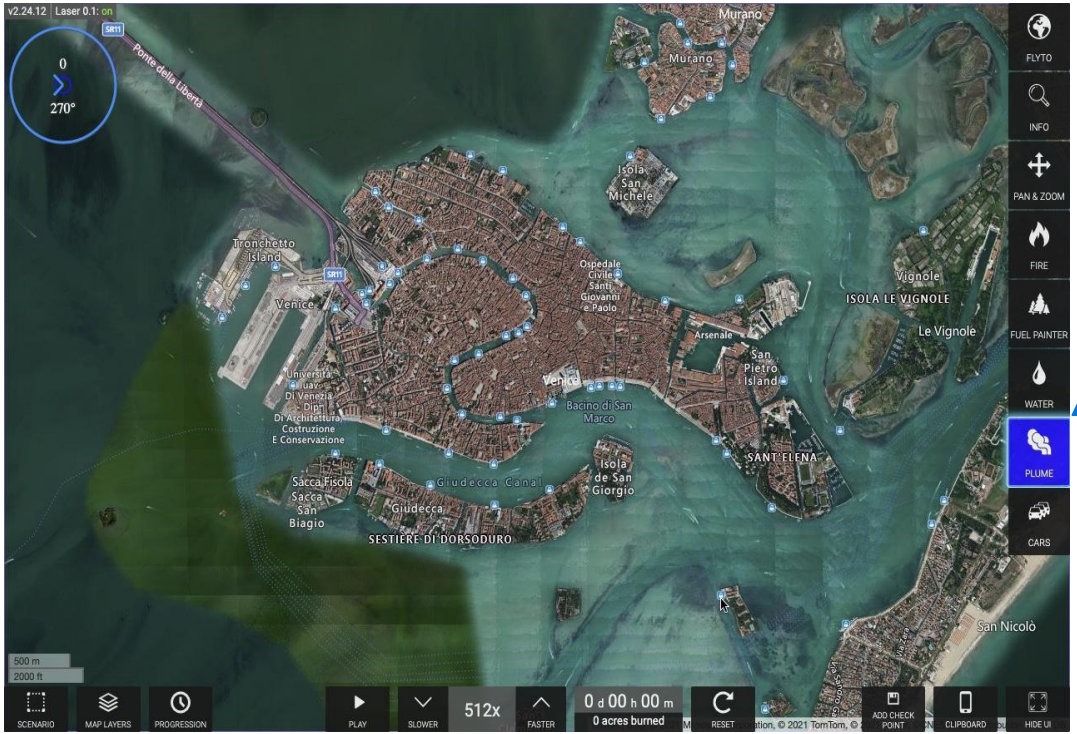
SIMULATING FIREFIGHTING STRATEGIES

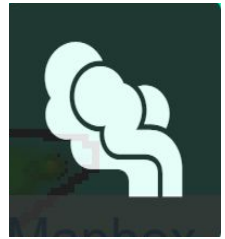


Fire Module Interface

The fire module includes options to place fire barriers and emergency response teams on the map. The module will also display the time elapsed along with acres burned The main buttons used when creating our team's fire simulations were the tanker, dozer, and the crew.

SIMULATING TOXIC PLUME RELEASES

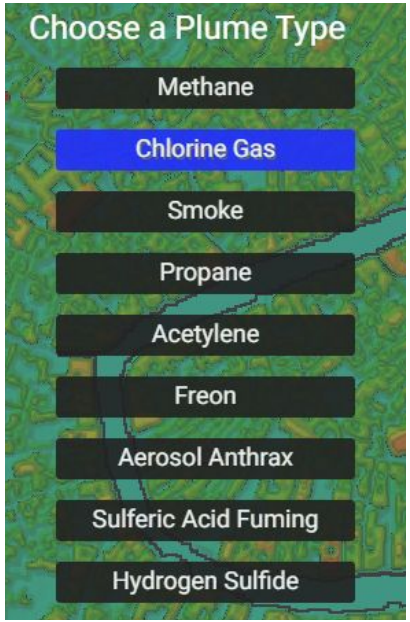




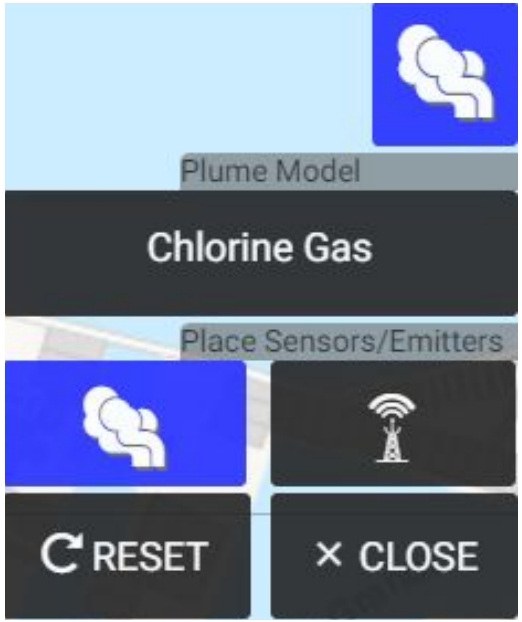
Hazmat Module

The Chemical Plume Module, or the Hazmat Module is used primarily to aid in minimizing the spread of chemical agents to other locations or people near the site of the hazardous event. The module includes agent-based chemical plume modeling, strategic and tactical resource allocation, and dynamic wind and behavior inputs.

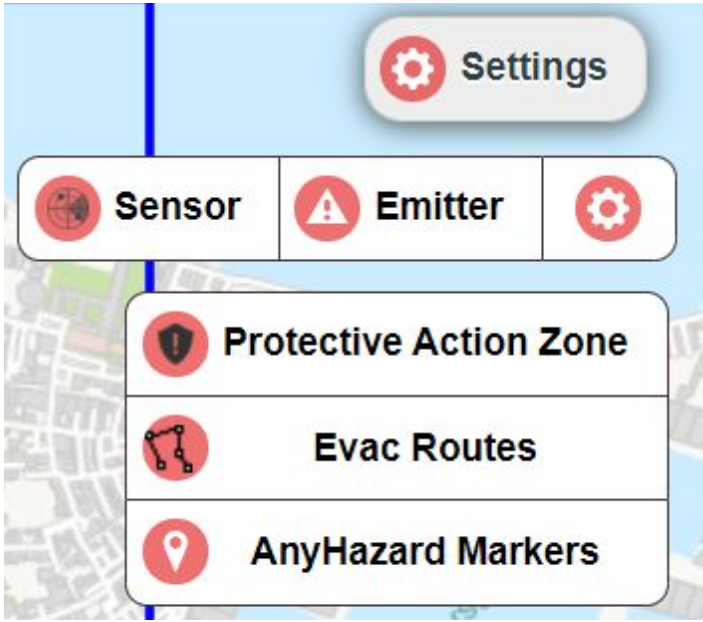
SIMULATING RESPONSES TO TOXIC PLUMES



Plume Types



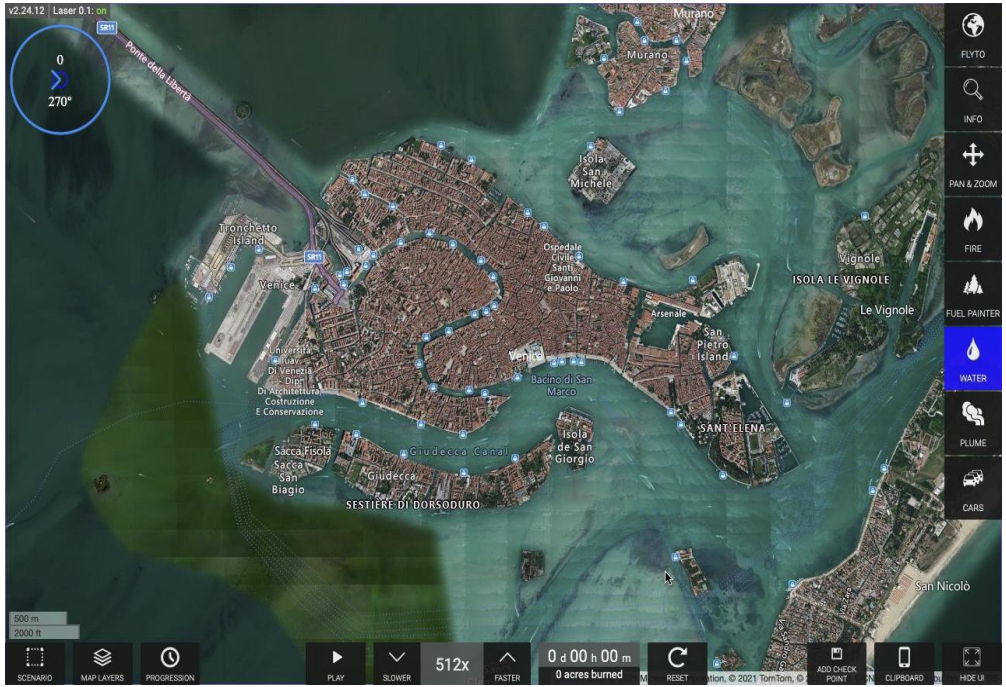
Hazmat Module



Clipboard Feature

The user can specify the type of gas released from the options on the left. The main hazmat module includes options to add a sensor or an emitter to the map. A sensor will display the plume density at any given instant of time. Using the clipboard, the user can also set a protective action zone, evacuation routes, and AnyHazard markers.

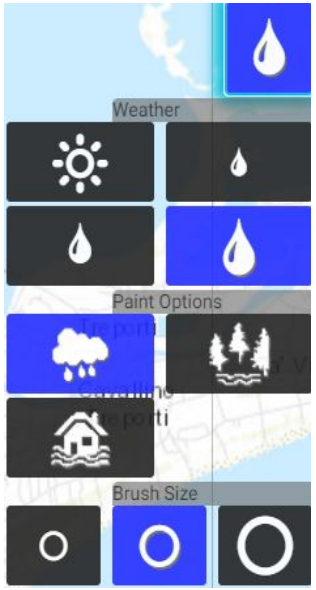
SIMULATING FLOODS WITH SIMTABLE



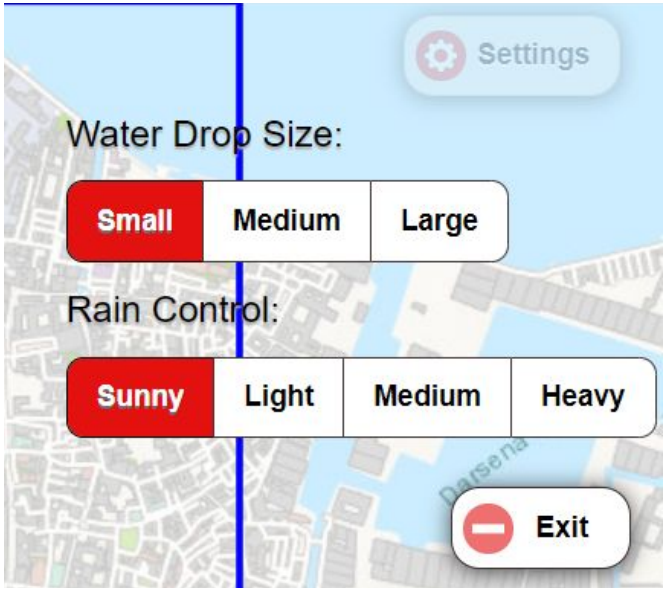
Water Module

AnyHazard includes a water module designed for simulating rainstorms, water releases, and watersheds.

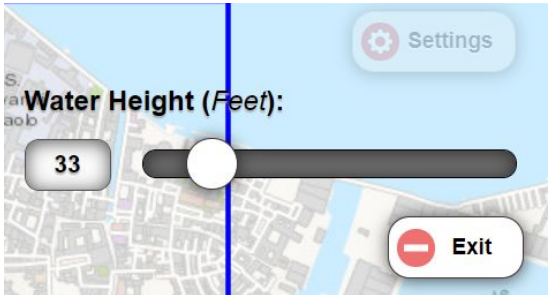
SIMULATING FLOODING SCENARIOS



Water Module

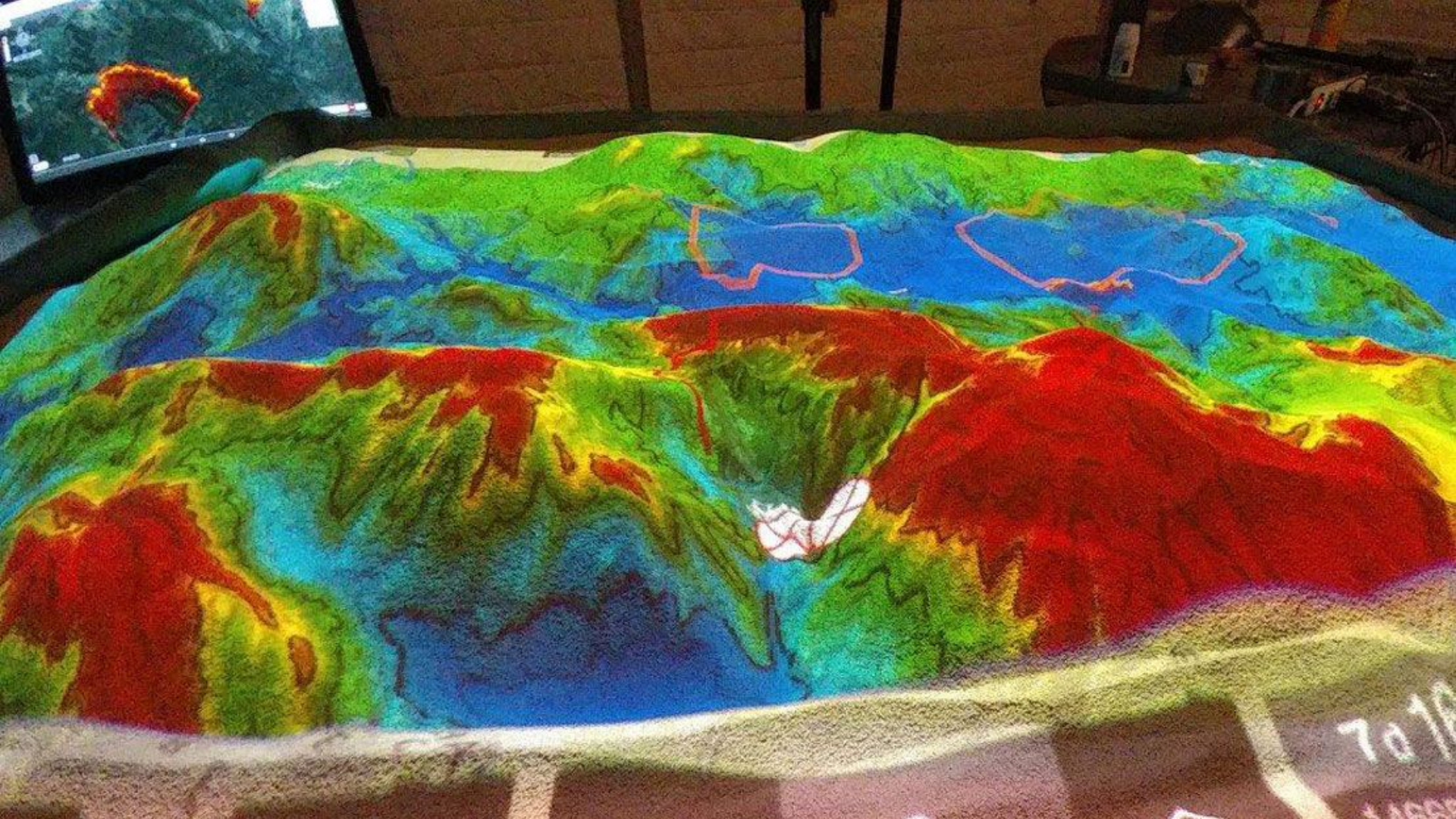


Rainstorm Feature



Release Feature

The water module shown on the left includes options to change rain storm intensity,, select between types of water simulations, and select different brush sizes for the rain feature. Using the clipboard, the user can control the same functions as the table while also having the ability to adjust the water release height in whole feet or meters.



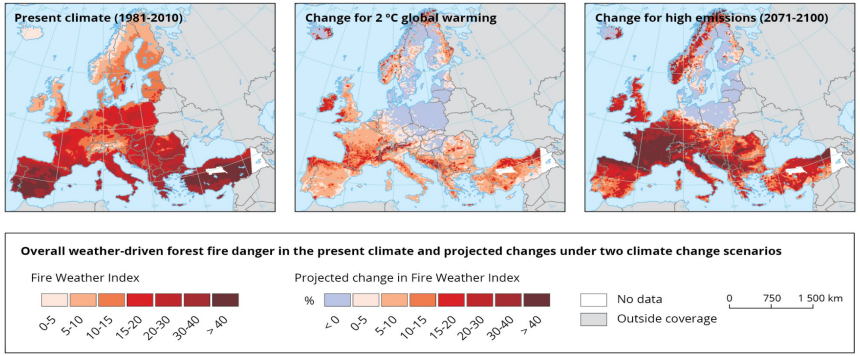
3 BENEFITS OF SIMTABLE

Science, emergency training, citizen outreach, and education

O3 BENEFITS

SCIENCE

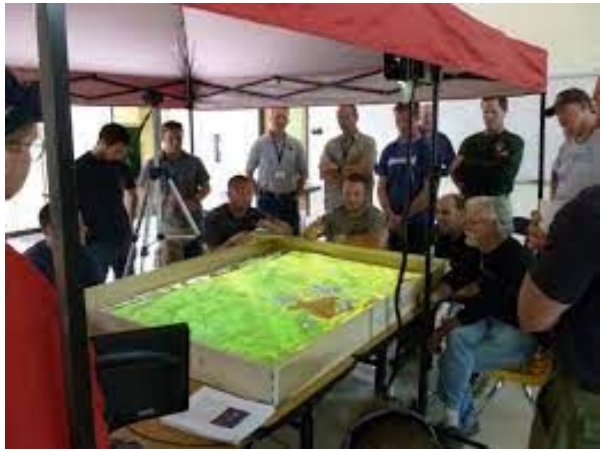
The Simtable has the capabilities to simulate possible scenarios for future flooding in different countries throughout Europe. Similar to the flood simulations explored in Venice, simulating floods would showcase what mitigation measures are needed and when the current ones would become ineffective.



Prior to our use of the Simtable, located in New Mexico, USA, the Northern New Mexico College made use of the Simtable by creating Acequia waterflow and distribution simulations in the area, essentially estimating water availability in the region. Also using the simtable, this group initiated a climate change simulation and forecasted how wildfires would develop based on changes in variables affected by the climate crisis.

EMERGENCY TRAINING

The technology assists emergency teams in disaster preparation and awareness during hazardous events. The Simtable models are customized designs based on data obtained from "local communities...for floods, wildfires, evacuations and storms" (Guerin, 2021).



Simtable allows users to switch between simulations quickly.

Simulating extreme events has the capacity to better prepare society in the case of an environmental hazard. Using Simtable to model events allows the user to display inundation maps and create evacuation routes for extreme events such as floods and fires.

Emergency responders discuss tactics for fighting a wildfire.

Housing and building layouts can be incorporated into the design in order to predict how local populations will be affected. GIS data is integrated into the Simtable in order to accurately simulate the climate scenarios in that region (Guerin, 2021).

CITIZEN OUTREACH

Thousands of communities across the globe are impacted by potential fire, flooding and gas release dangers. Through the use of Simtable, different regions can utilize the interactive 3-D modeled maps to better get in touch with citizens that are at risk. The advanced imaging and capabilities of the Simtable helps to give a more external and overarching view of different communities. By reaching out to citizens with this hardware, Simtable adds an uncommon perspective that can help to protect many populations.

Looking at the 2020 wildfires that occurred in Australia, the fires took months to gain control of. With better use of the Simtable the fires may have been eliminated earlier by training through simulation. Australia now has multiple Simtables in their possession and has stimulated the bushfires with the hope of preventing the spread in future cases.

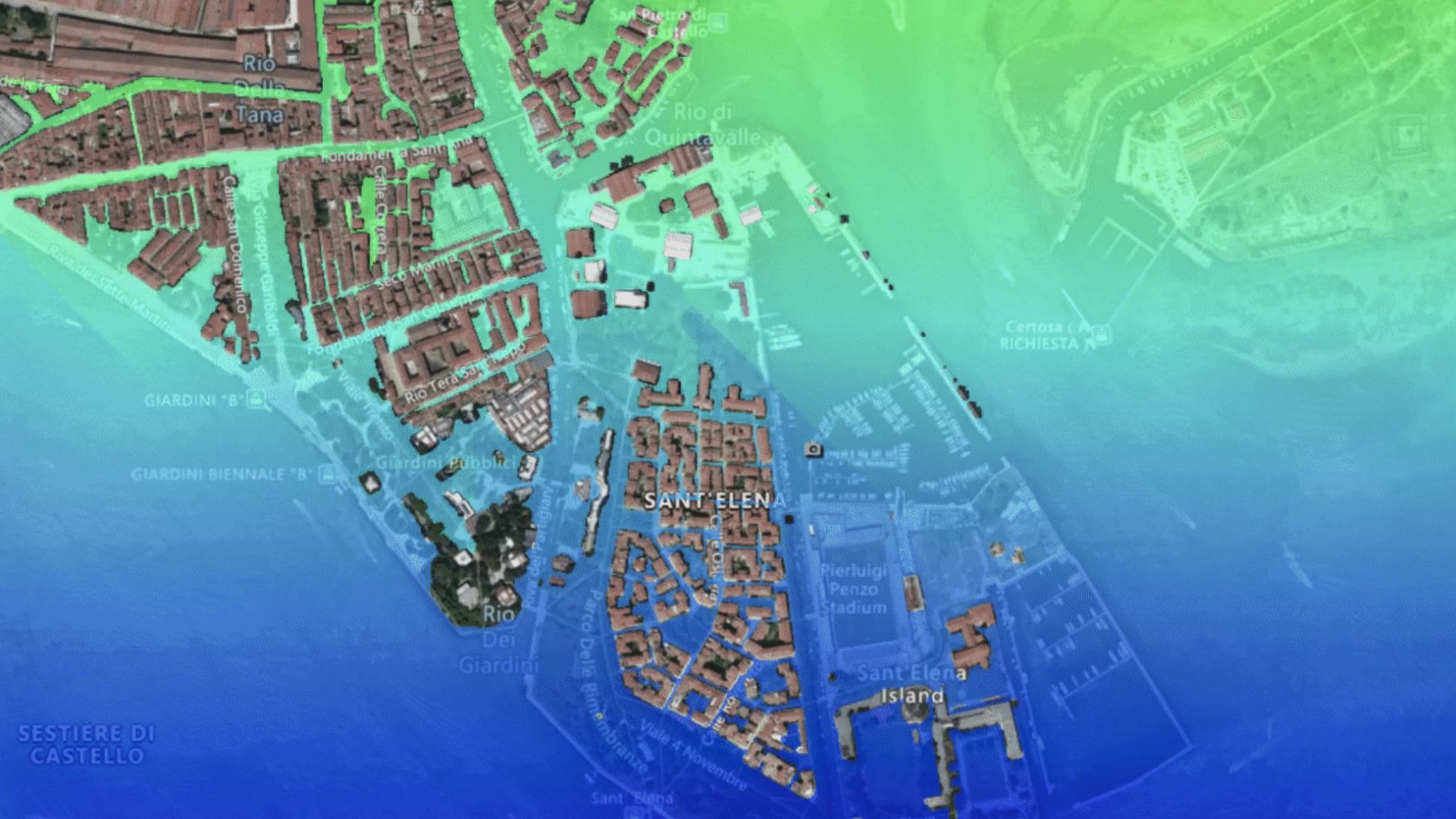
Simtable is a very productive method for **showcasing** environmental events **planning, mitigation and prevention.**

EDUCATION

Simtable is a modern method of educating the average person about the hazards and management techniques to protect different neighborhoods. The Simtable is a very powerful way to represent **GIS data** and create simulations based on the data for presentation purposes (Guerin, 2021).

Simtable created simulation models that visualize ecological issues affecting the 19 pueblos of New Mexico under the STEM outreach program for the Santa Fe Indian School.

Simtable has developed numerous custom simulations for the the Northern New Mexico College. Two of which include an Acequia Water Flow and Distribution Simulation


Rio
Della
Tana
Rio di
Quintavalle
Rio Terà San Pietro
GIARDINI "B"
GIARDINI BIENNALE "B"
Giardini Pubblici
SANT'ELENA
Pierluigi
Penzo
Stadium
Rio
Dei
Giardini
Sant'Elena
Island
SESTIERE DI
CASTELLO

4 APPLICATIONS OF SIMTABLE for VENICE AND THE VENETO

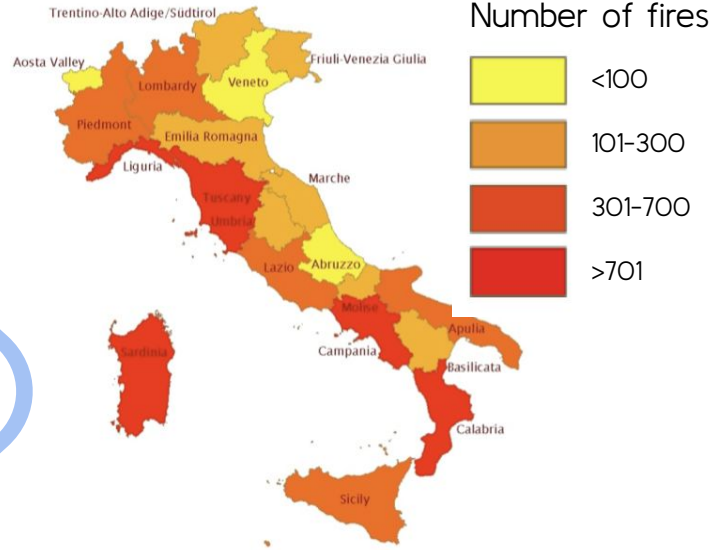
Fires, toxic gases, rivers, dams, and tides

04 SIMTABLE for VENICE and the VENETO

Venice is an ideal location to model flooding scenarios due to the frequency of high tides and the city's tendency to flood because of its low elevation. Sirocco winds carried up the Adriatic greatly affect Venice by pushing tides higher against the city.

The Veneto region experienced wildfires occasionally, and these will become increasingly common in the future due to global warming.

Simtable can help to model and prepare for these extreme events

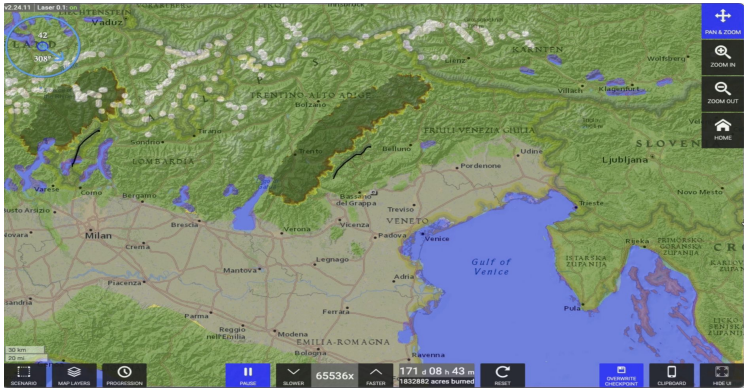


MODELING FIRES in the VENETO

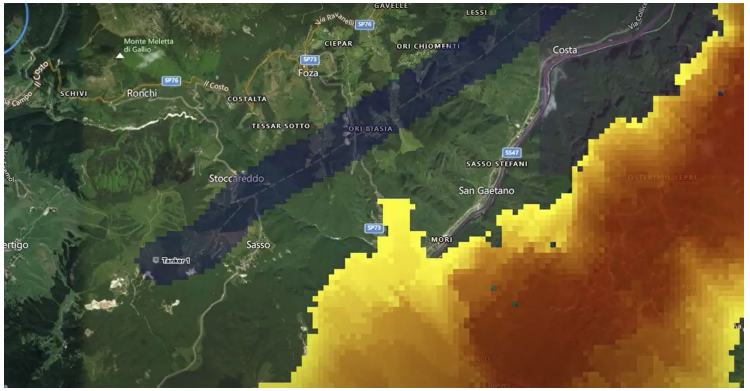
As the global climate continues to get warmer, the scale and frequency of fires will increase. Areas which previously experienced an abundance of precipitation may begin to see droughts, leading to the drying up of natural vegetation, which is the perfect fuel for fires.

Southern Italy and other countries bordering the Adriatic Sea already deal with numerous fires every year throughout the summer months, and increased temperatures and a decrease in precipitation could make fires in the northern regions more common as well.

Seen in the top right image are two simulated fires across the mountains in the Veneto region of Italy. This region of Italy contains many forests, providing perfect fuel for a fire. Since fires spread more quickly uphill, if combined with strong winds, a fire in this region would be extremely dangerous and difficult to control.

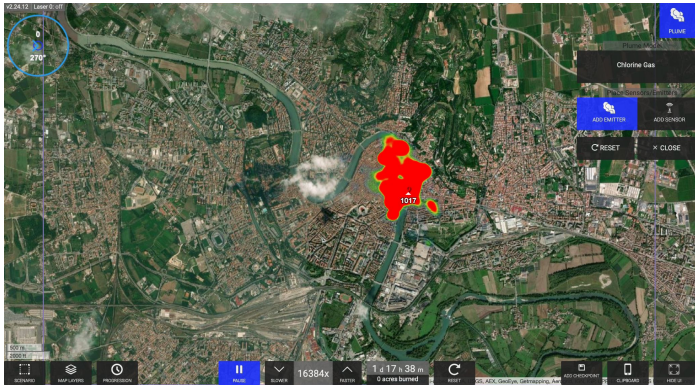


Fire simulation in the Veneto region.

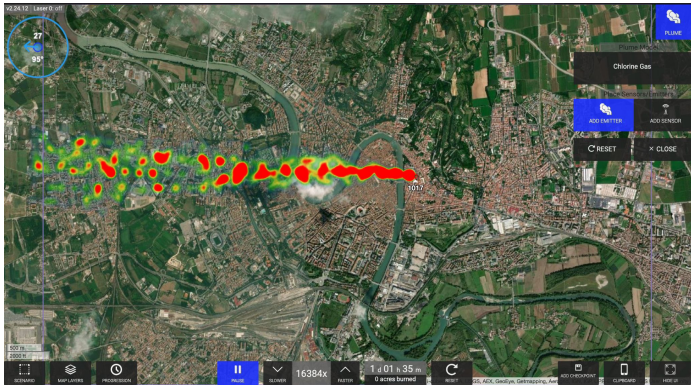


Blue shaded line shows where a **tanker** was drawn to **mitigate** the fire.

MODELING TOXIC SPILLS



Plume simulation in Verona with **no wind**.



Plume simulation in Verona with **mild wind** to the **west**.

In the left image, the wind speed is 0 mph. Looking at the red plume, one can see that the gas is creating a cloud around where the sensor is located, because there is no other factors impacting its path.

In the image on the right, a plume of chlorine gas (shown in red) flows with the wind. As time passes and the wind speed and direction change, the gaseous plume will adjust in conjunction.

Like any other simulation produced by the Simtable, the Hazmat Module can provide extremely useful information to educate both the public and emergency responders on how to adapt and solve problems like this that may occur.

MODELING DAM FAILURES

Release feature near the Vajont Dam.

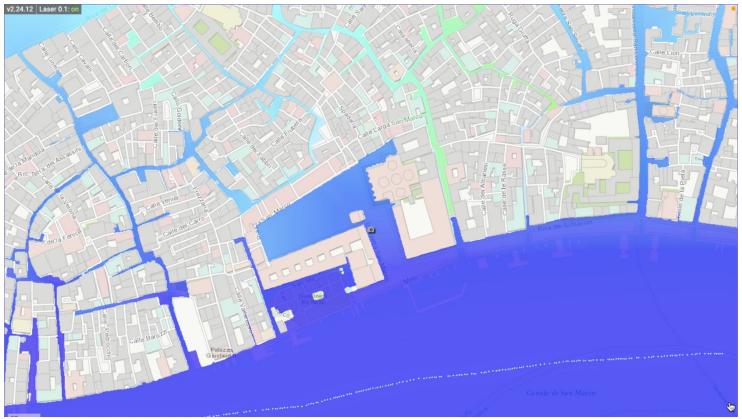
The **Vajont Dam** water release occurred in **1963**, and flooded the **entire valley** beneath.

The Simtable release feature is showing here where the water would go from the Vajont Dam and down the mountain.

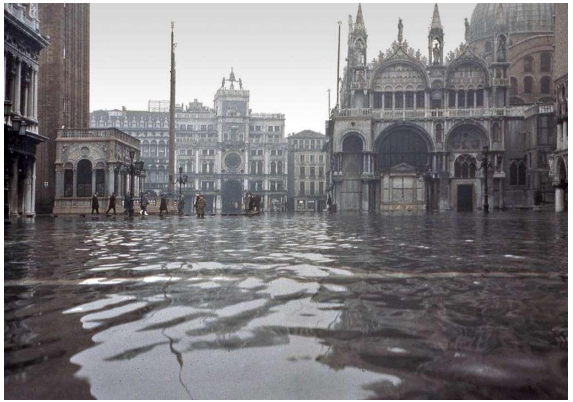
MODELING HISTORIC TIDAL EVENTS

Venice has experienced many floods during its long history. The two highest floods happened in 1966 and 2019. Both had a profound effect on the entire city and caused widespread damage to homes and businesses.

1. November 4, 1966 (194 cm)
2. November 12, 2019 (187 cm)



Simulation of a **180 centimeter** tide in Saint Mark's Square



Saint Mark's Square during the **1966 flood**

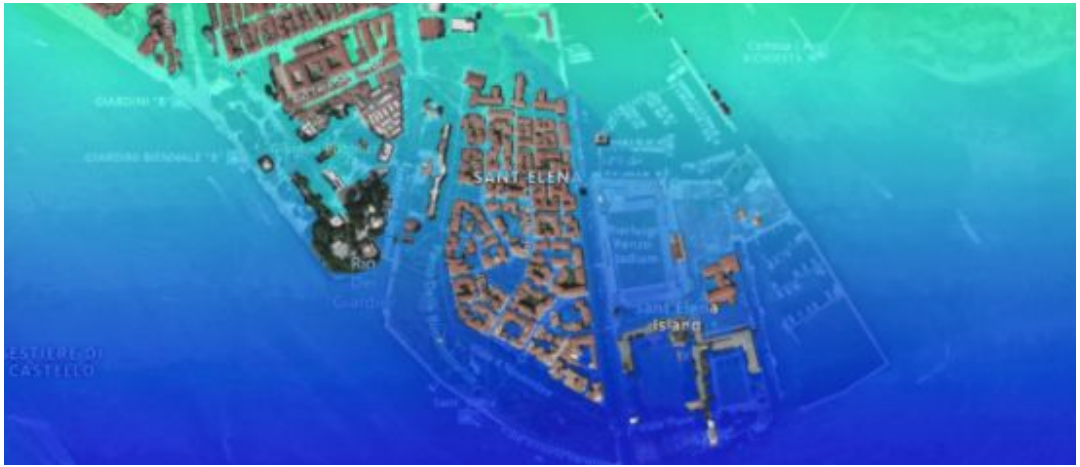
Saint Mark's Square during the **2019 flood**

MODELING EFFECTS OF SEA LEVEL RISE

Mose barriers raised in the North Lido inlet

The **murazzi**

Due to sea level rise, the height of Mose and the murazzi could become insufficient for protecting the lagoon. Currently, Mose is made to **protect from tides up to 3 meters**, and the murazzi is around that as well. Because of events such as the 1966 and 2019 floods, we know that tides of nearly 2 meters are possible. Once mean sea level rises 1 meter, we could waters **higher than Mose can protect against**. Simtable could help to simulate what floods of that magnitude would look like, allowing people to better prepare.



A **three meter tide** simulation for Sant Elena