Deep Water Asteroid Impact

ENGR-E 584 Scientific Visualization

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Group Members

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Introduction

1. Study for Planetary Defense Planning (NASA)
2. Intensity of hazard to produce tsunami
3. Harm ocean floor -> ocean basin
4. Tsunami propagation distance

Interesting

1. NASA -> Sentry system
2. What can we control and till what extent?
3. Implementation and exploration of the concepts we learned

STRUCTURE AND FORMAT OF THE DATA

Simulation	Type	Time steps	Fields	Asteroid diameter	Asteroid angle	Airburst height	Size
yA11	Uniform Rectilinear Grid	209	Prs, tev, v02,v03	100m	45deg	No airburst	21.1 GB
yA31	Uniform Rectilinear Grid	473	All	250m	45deg	No airburst	193.8 GB
yA32	Uniform Rectilinear Grid	487	Prs, tev, v02,v03	250m	60deg	No airburst	114.4 GB
yB11	Uniform Rectilinear Grid	162	Prs, tev, v02,v03	100m	45deg	5km	126.6 GB
yB31	Uniform Rectilinear Grid	173	Prs, tev, v02,v03	250m	45deg	5km	57.3 GB
yC11	Uniform Rectilinear Grid	176	Prs, tev, v02,v03	100m	45deg	10km	13.3 GB
yC31	Uniform Rectilinear Grid	265	Prs, tev, v02,v03	250m	45deg	10km	49.6 GB

SCIENTIFIC TASKS

1) Are tsunamis generated by an asteroid impact?

2) To determine the specific parameters of an asteroid impact which would actually pose a significant threat of a devastating tsunami, based on the ensemble data. The parameters are:

- Size - diameter of the asteroid (most important)
- Angle of entry - determines the propagation of the wave
- Elevation of Airburst - affects outcome of the resulting tsunami

3) If generated, what are the near and far field effects(impacts on coastlines) of the impact?

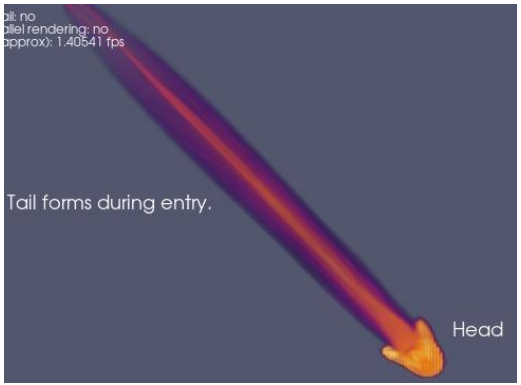
1) Are tsunamis generated?

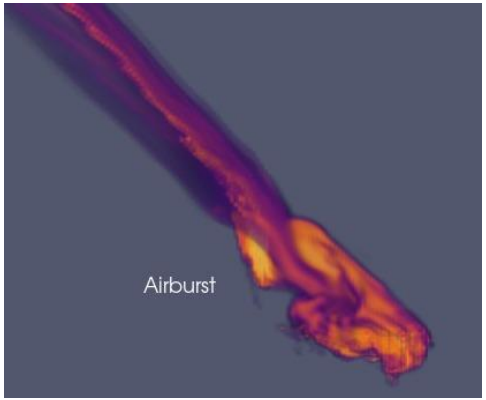
Definition - A tsunami is a series of waves in a water body caused by the displacement of a large volume of water, generally in large water bodies.

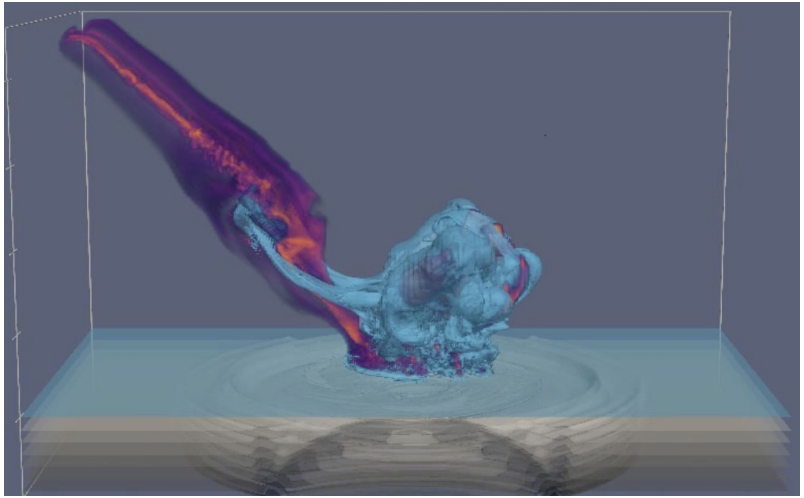
We visualized all 7 datasets, and found a specific set of parameters that clearly leads to the formation of tsunamis:

- **<u>Asteroid Size</u>** is the most important factor in determining the outcome of an impact.

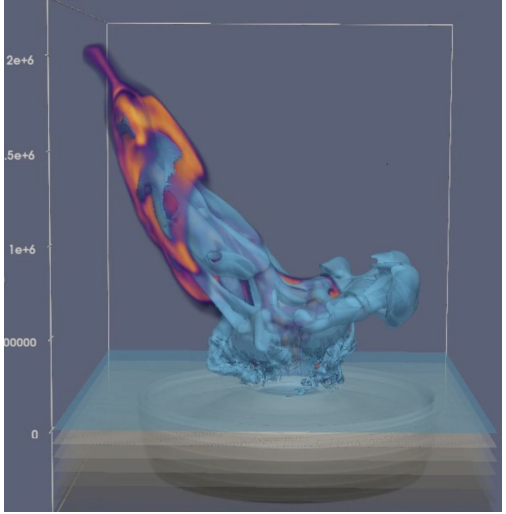
We are searching for the smallest asteroid that would generate a tsunami that could reasonably travel 100's of kilometers to reach distant shores.





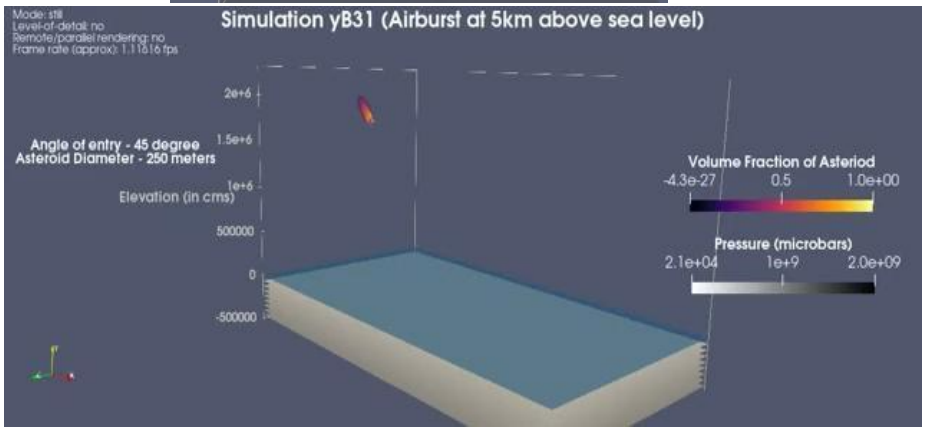


yA31



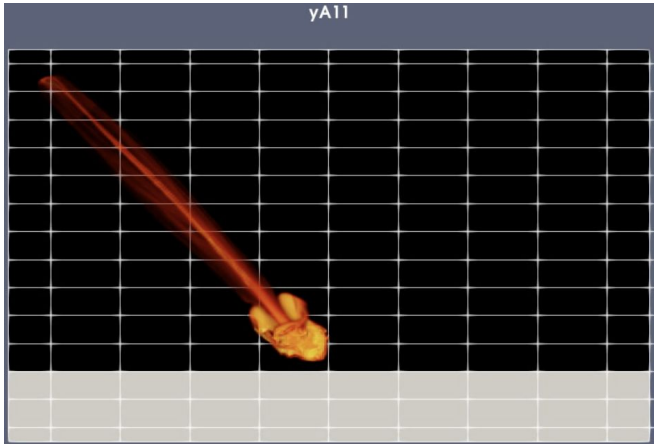
yA32

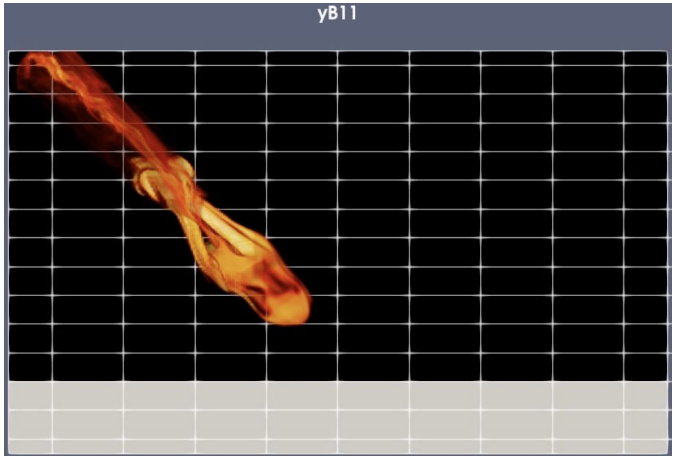
All these simulations have one commonality - the asteroid is 250 meters in diameter. Notice that the asteroid poses a threat even with an airburst.

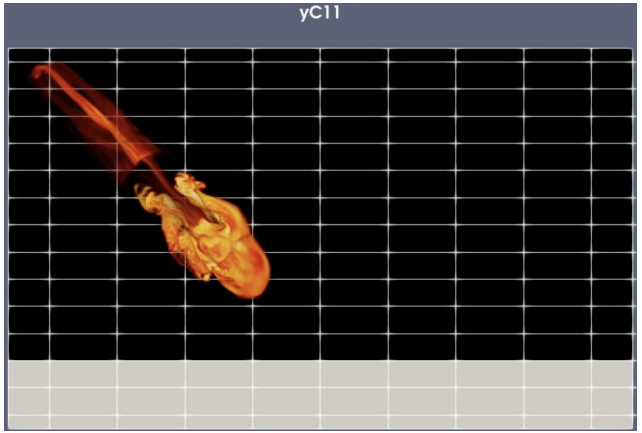


yB31

On the other hand, if the asteroid is 100 meters in diameter, the asteroid or its fragments never reach the surface of the water. This configuration poses no threat.







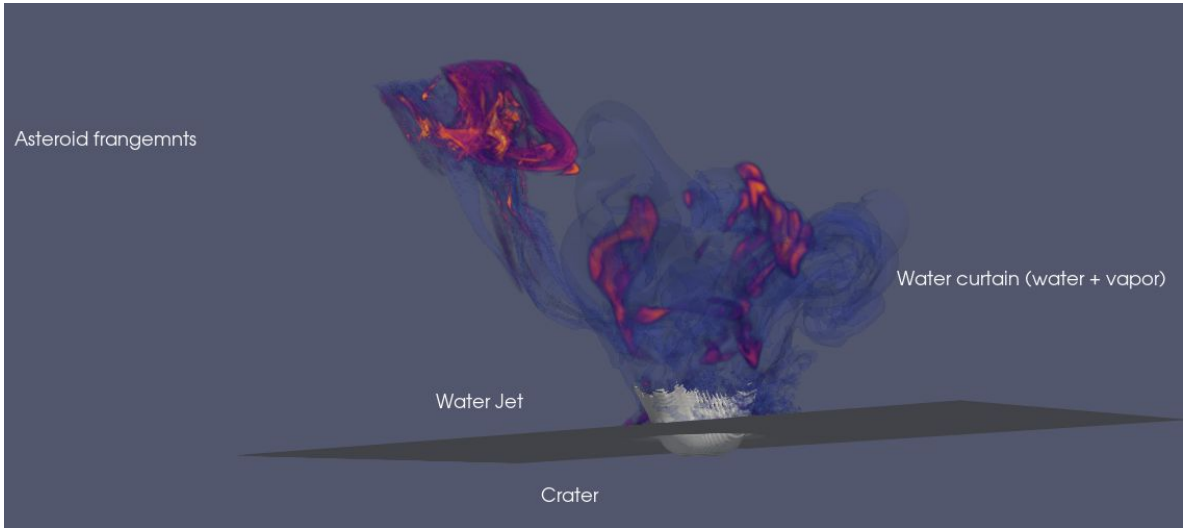
Note that in yA11, even without an airburst, the asteroid doesn't reach the water.

Angle of impact is another important factor.

Oblique angles could push the water in a more definite direction increasing the likelihood of tsunami generation.

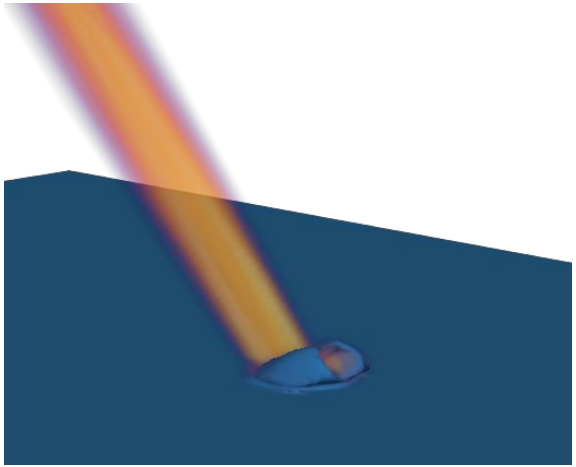
It also means that the asteroid travels for longer in the atmosphere and is subject to decay.

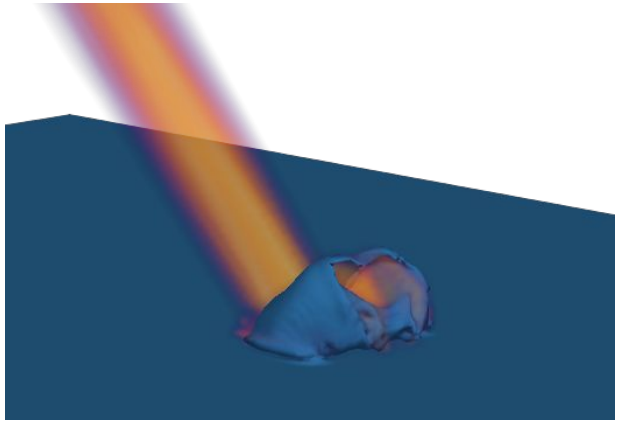
Determines how far the wave travels and how strong its impact on shorelines is.

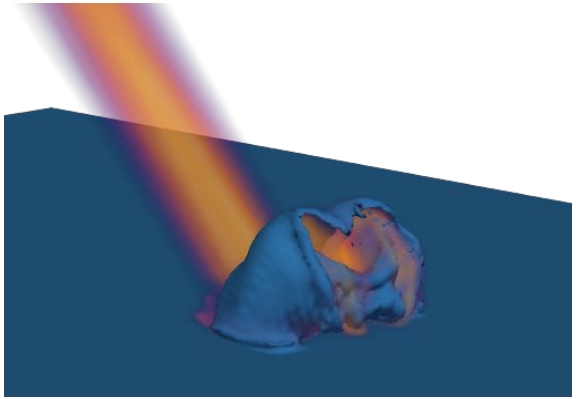


Less steep angles push the water uniformly in a particular direction

yA31 - Angle of entry - 45 degrees (Initial time steps)

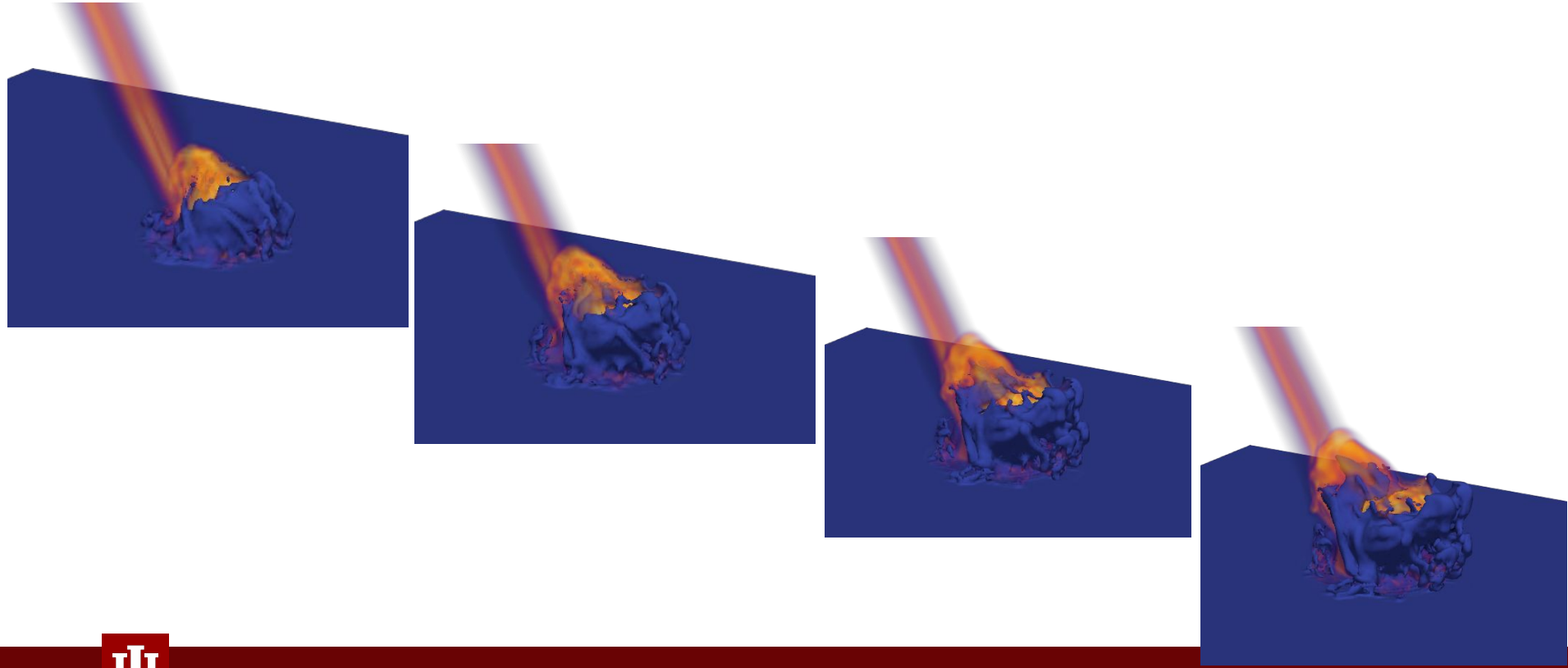






Steeper angle of impact forces the water in an upward direction

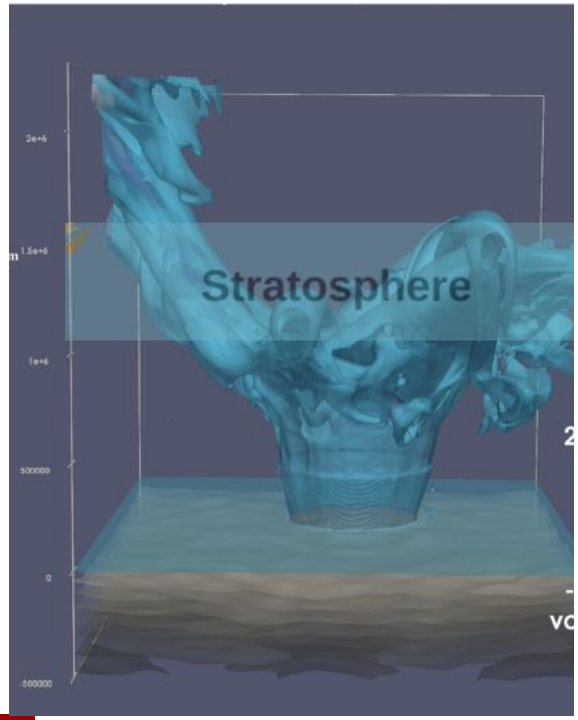
yA32 - Angle of Entry - 60 degrees

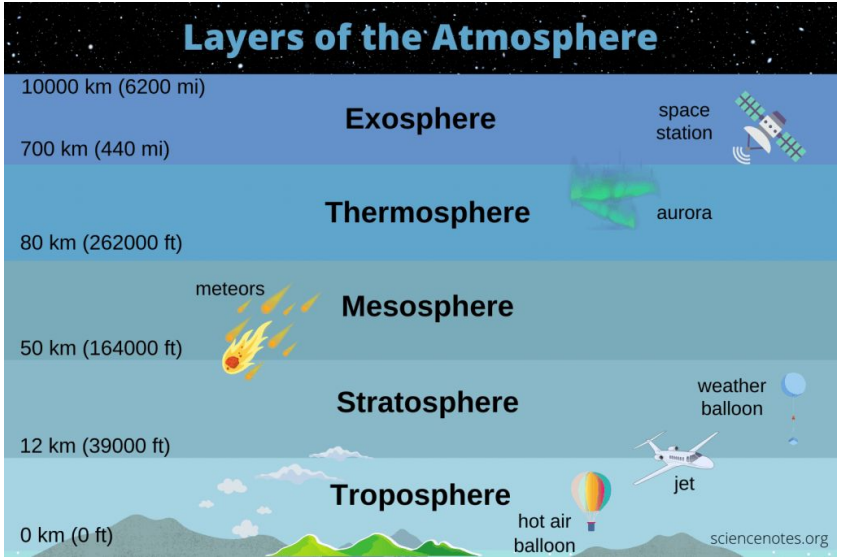


Simulation	Observations
yA11	No airburst, yet no impact due to the small size.
yA31	Oblique angle of impact (45 deg), directional waves. Significant impact due to size. No Airburst
yA32	Oblique angle of impact (60 deg), more vertical splash curtains. Significant impact due to size. No Airburst
yB11	Airburst, no impact due to the small size.
yB31	Airburst, yet there is an impact due to the large size.
yC11	Airburst at a higher elevation, no impact due to the small size.
yC31	Airburst at a higher elevation, yet there is a minor impact due to the large size.

Near Field Effects

We observed that trajectories with steeper entry angles excavate deeper craters, as expected.





https://sciencenotes.org/layers-of-the-atmosphere/

In the case of a large impact, the dominant hazard is likely to be from global climatic change. Much of this water vapor is lofted into the stratosphere, where it may linger for months to years worsening the greenhouse effect.

Far field effects - Impacts on coastlines

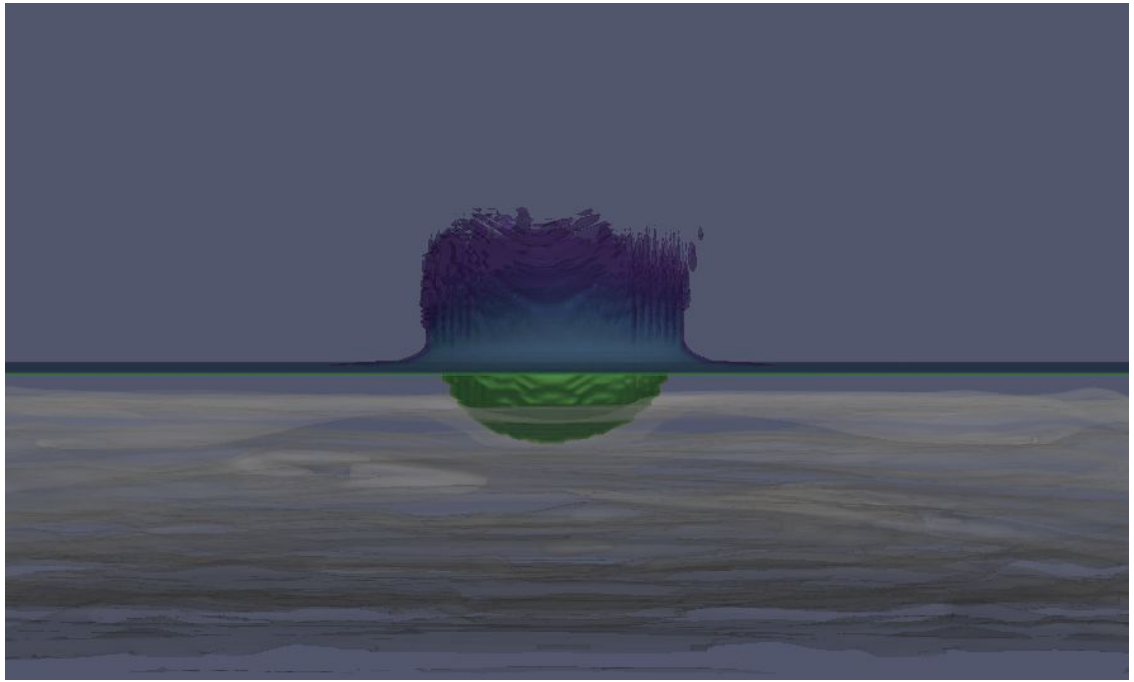
- Far field effects are the long range propagation of the tsunami after impact.

Through our research, we could only observe the initial cratering and tsunami wave formation, but we can make some claims. We are restricted by the bounds of the data – 5 km depth and 23 km of atmosphere.

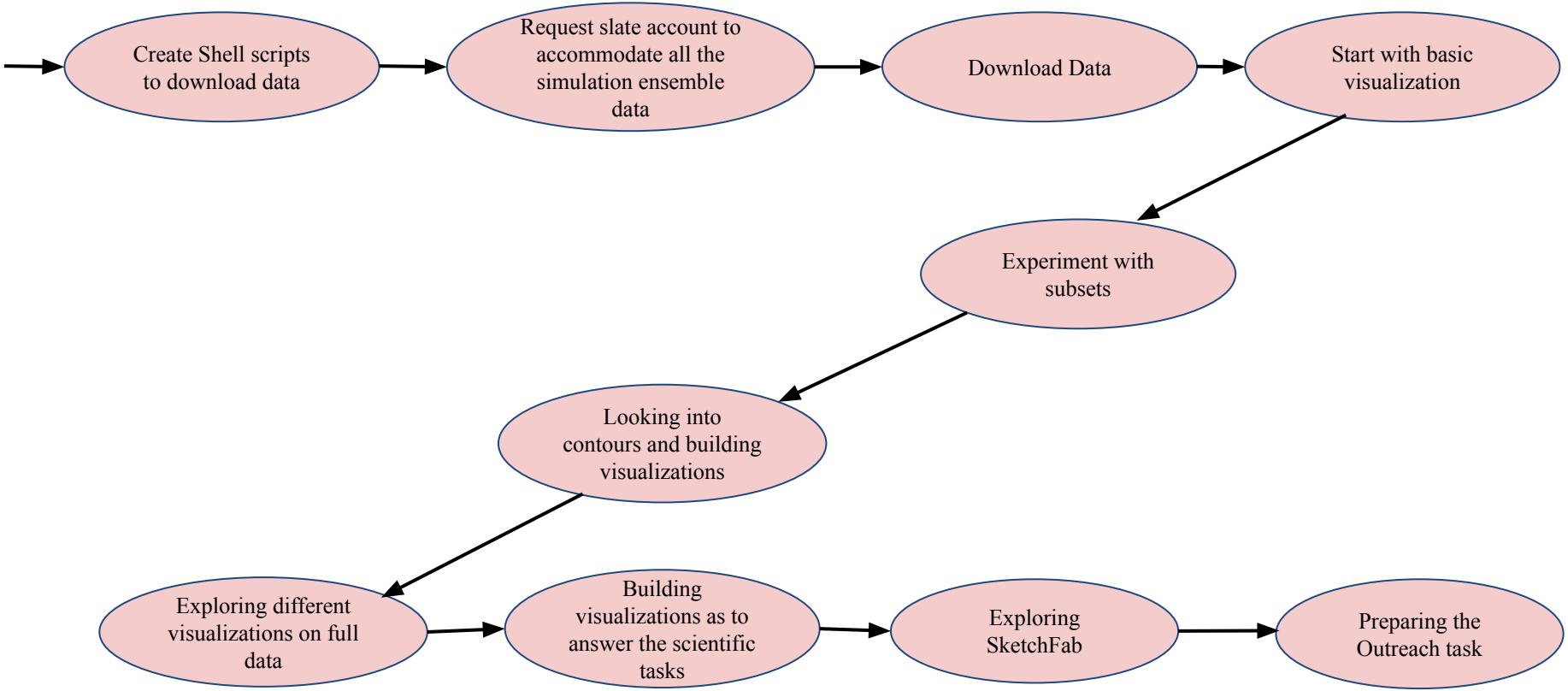
- Two possibilities: Close to the shore vs Far away from the shore.

If impacts can create tsunami waves that can propagate efficiently over long distances, they could pose a significant risk. Even though slowly decaying propagating waves reduce in amplitude, they could still cause calamities on the shoreline.

An ocean impact within a few tens of kilometers of a populated coastline would be locally devastating. The initial splash and rebounding jet reach many kilometers into the air and will lead to severe flooding. Impacts that are close to shore dont have enough travel time to sufficiently degrade the waves.



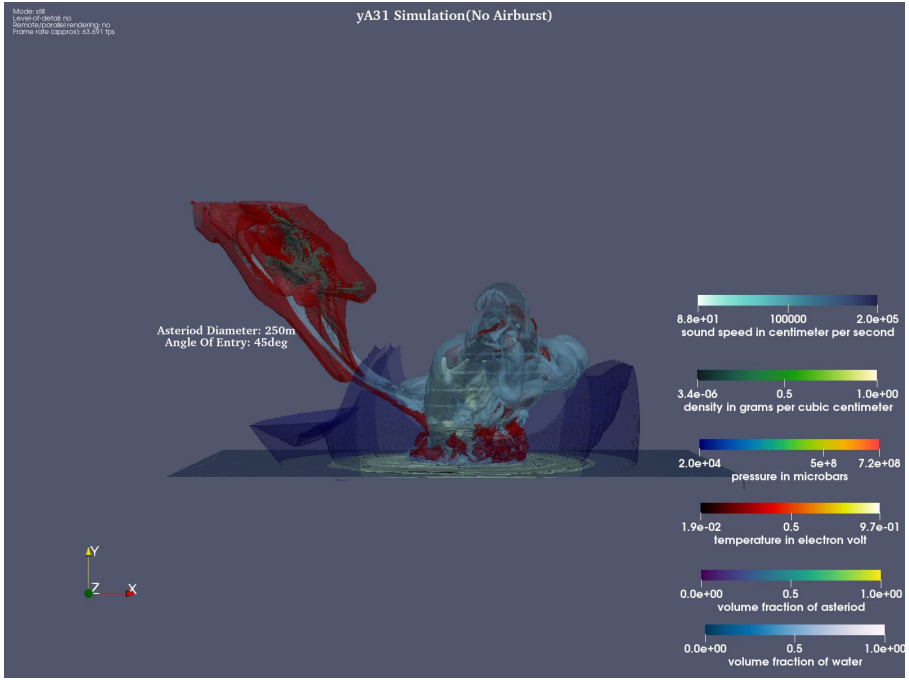
WORKFLOW


Create Shell scripts to download data
Request slate account to accommodate all the simulation ensemble data
Download Data
Start with basic visualization
Experiment with subsets
Looking into contours and building visualizations
Exploring different visualizations on full data
Building visualizations as to answer the scientific tasks
Exploring SketchFab
Preparing the Outreach task

VISUALIZATION STYLES

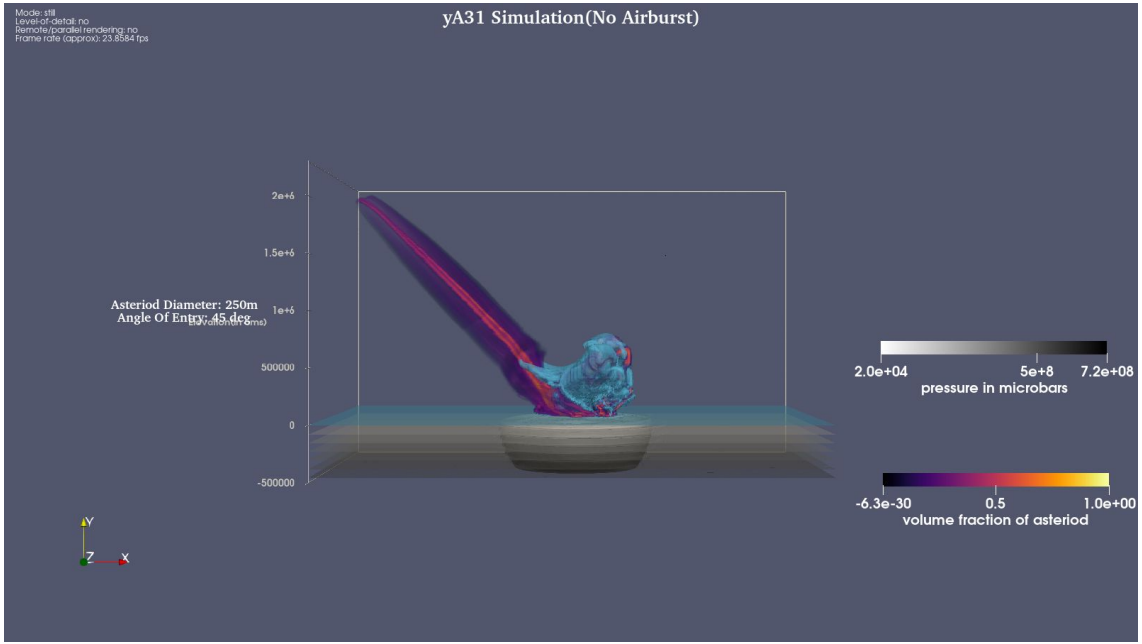
1. **Contours:** There were multiple nested parameters which occlude each other. In order to analyse the impact of the various parameters, we decided to use contours with varying opacity.

Intermediate Results:

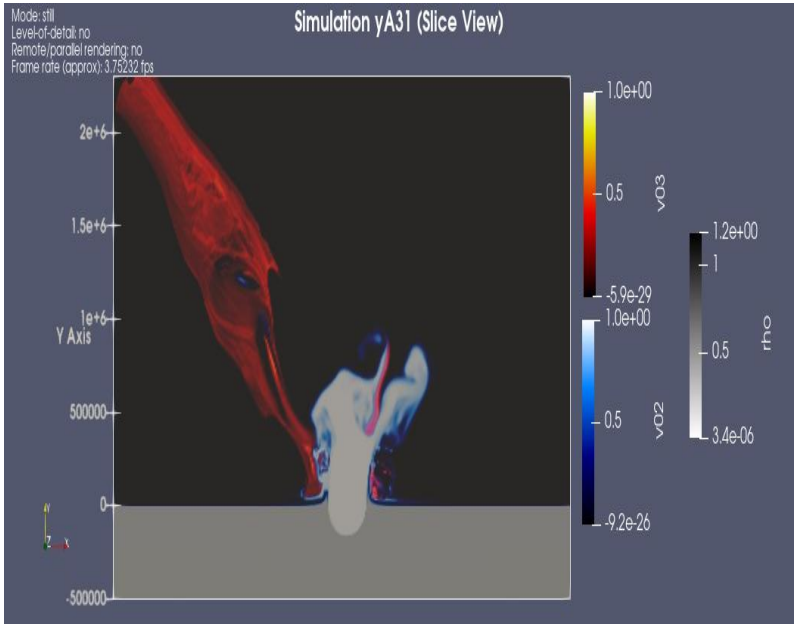


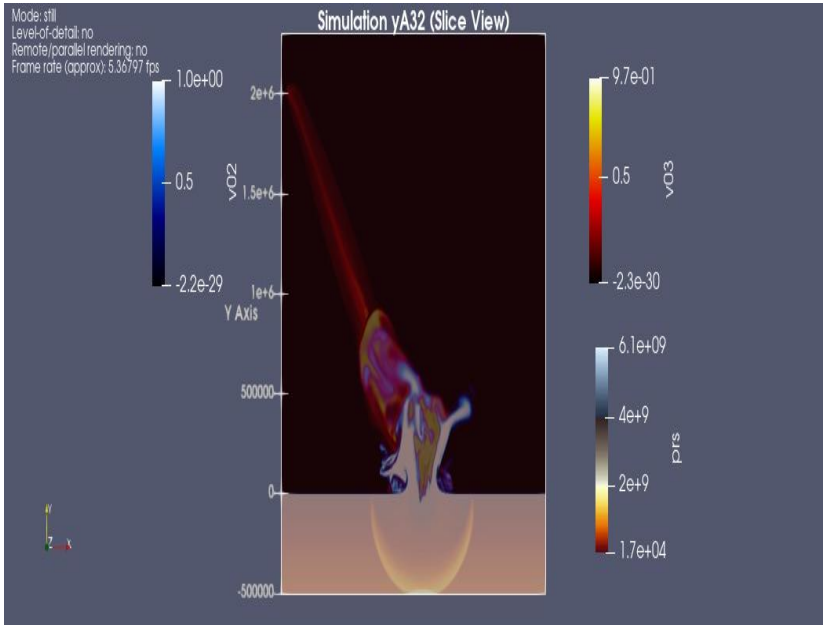
- There were overlapping colour maps, so hard to decipher which contour shows what so we decided to split the variables and analyze the visualizations and tried to limit the number of parameters in one visualization.
- We considered few variables which seem effective for visualization, but now for the whole data not just a subset.

Final Results:

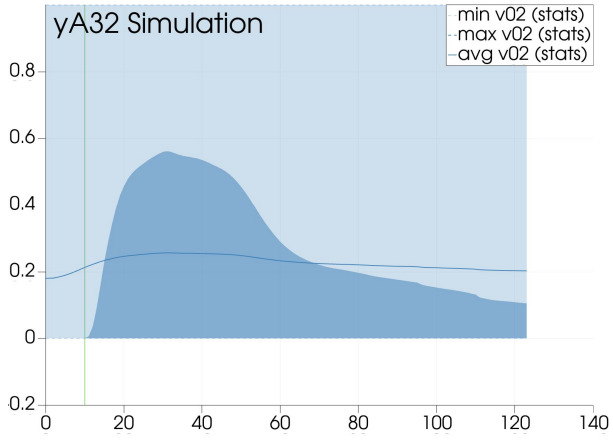


Slices: For clear visualization of the crater and the pressure of asteroid on water we considered a slice view of the visualization.

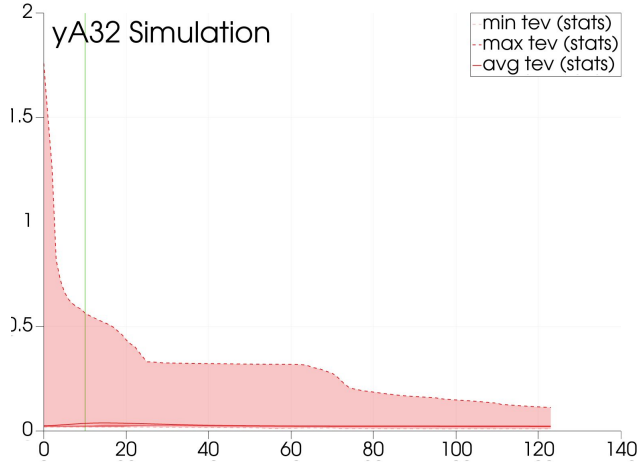




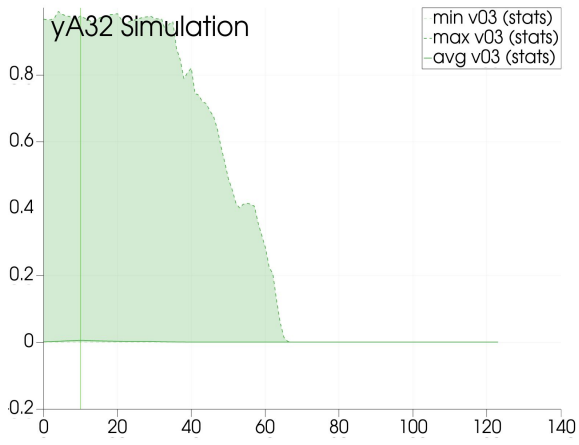
Line Charts: We plotted data over time to check the maximum and minimum values of the variable to analyze the near and far field effects of the impact.



Volume fraction of water with respect to time

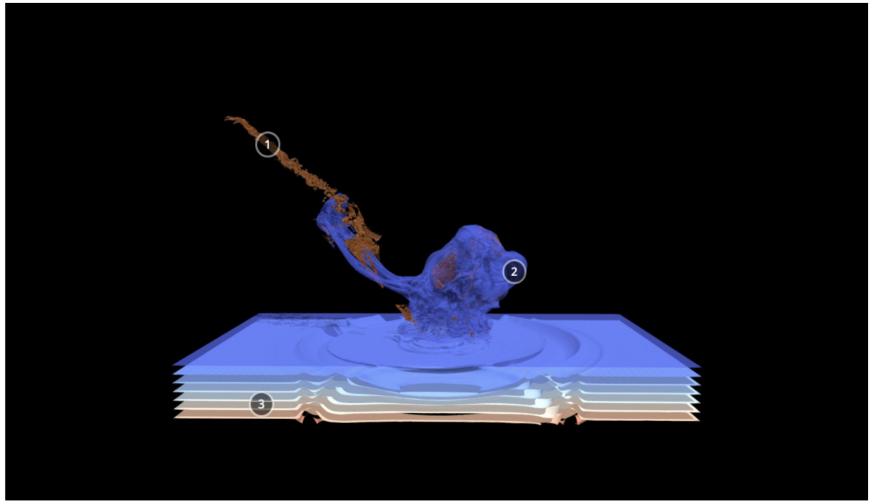


Temperature in electron volt with respect to time

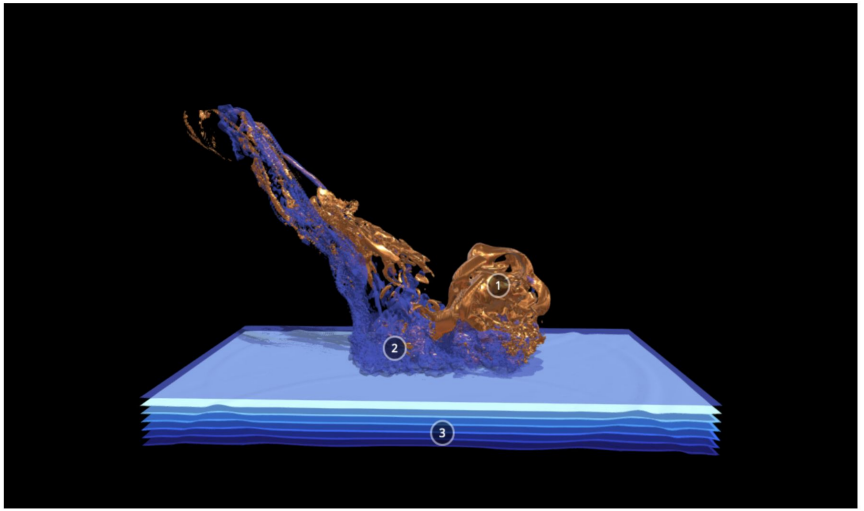


Volume fraction of asteroid with respect to time

SketchFab: We have exported gltf file of the impact scene to sketch fab and enhanced our visualization by taking differentiating colors. This visualization can be accessed through VR.



Deep water Asteriod Impact (Simulation yA31)
3D Model



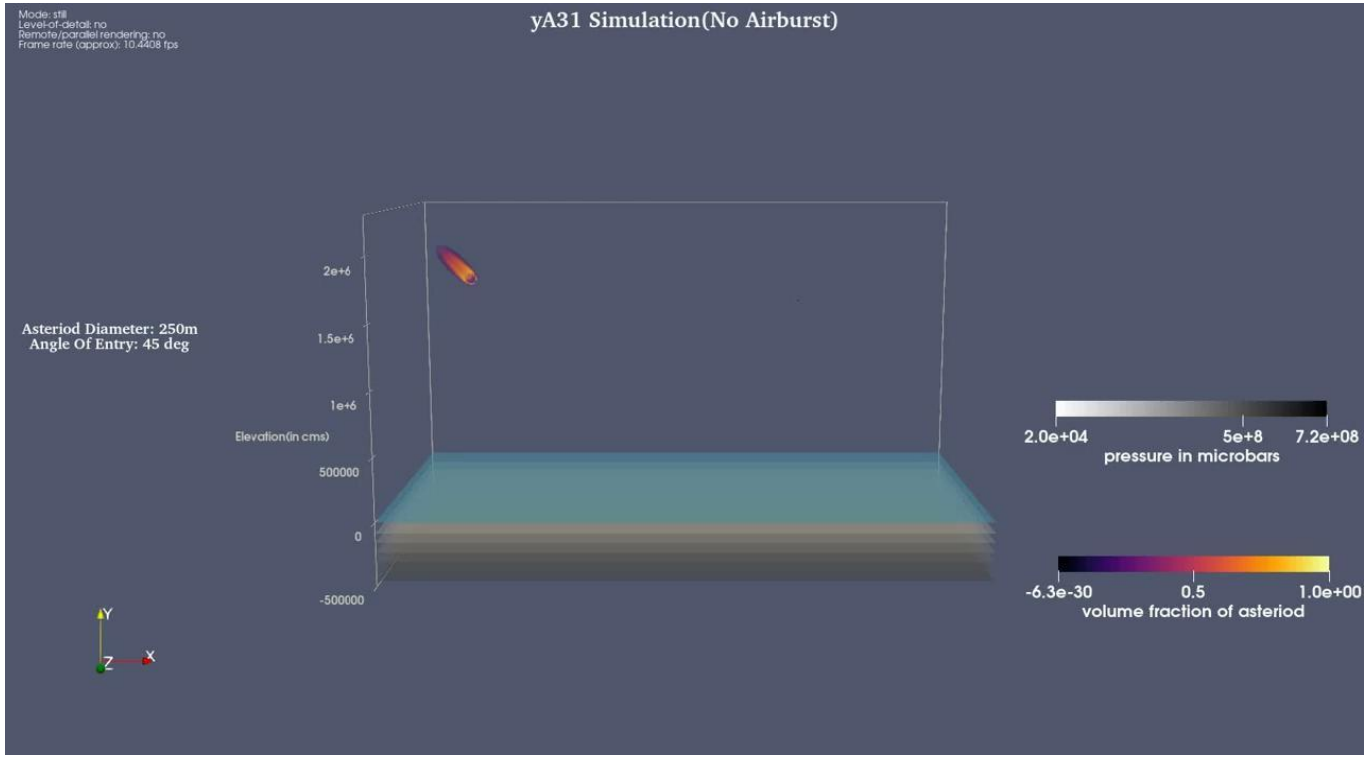
Deep water Asteriod Impact (Simulation yB31)
3D Model

DELIVERY FORMAT:

We represented the visualization in the following forms:

- **.avi, 3d video** - This aids us in analyzing all the simulation parameters and process, which is simple to understand, that grabs people's attention.
- **3D sketchfab Model** - interactive model with annotations which can be accessed through VR to enhance the viewers learning experience
- **Infographic** - outreach, aid in communicating the project easily to laymen audiences.
- **2D pictures .png** - slices and graphs to observe the in depth details i.e., values of parameters of simulation.

yA31 Simulation 3D video (avi file)



OUTREACH/EDUCATION TASK:

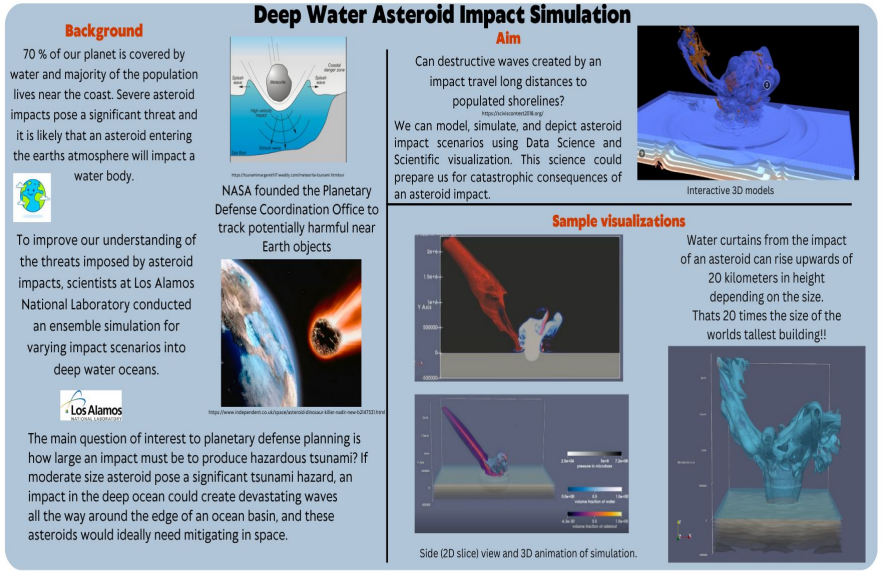
We created an infographic, sketchfab model as outreach/education task.

Audience: Through the infographic we aim to reach a layman audience who just knows what an asteroid is and also through sketchfab we would address domain specific audience.

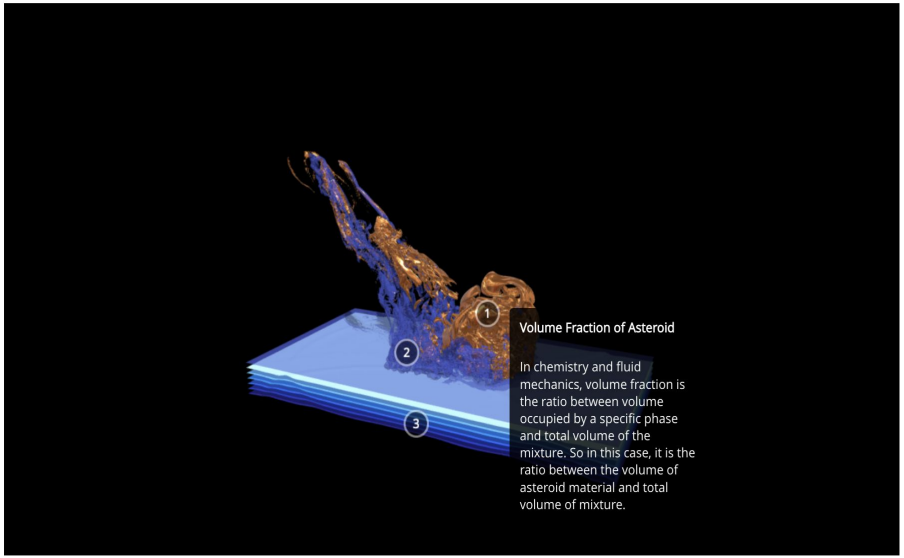
Message: We would like to communicate the possibility of a disasters that could happen when an asteroid hits the water. We expect audience to be educated about the possibility of the event and its impacts so they could be prepared for it without any loss of human resources.

Visuals: We have shown the difference of outcomes through infographic and sketchfab. Infographic is aimed to reach school kids below 12 years of age and laymen audiences. While, SketchFab aims high school kids and any domain specific students, in which we could show them what is exactly volume of water, asteroid, pressure generated with technical information.

Infographic



SketchFab Model



Deep water Asteriod Impact (Simulation yB31)
3D Model

Infographic for school age kids younger than 12 years of age. Also for laymen audiences.

SketchFab for high school kids and other domain specific students.

GROUP REFLECTION

- We initially believed that the data would prevent us from knowing about the asteroid's impact on the deeper layers of the ocean.
- But, when we added layers to the pressure isosurface, the impact was clearly distinct for different levels of ocean depth.
- The initial challenge was getting this massive amount of data and interpreting it in order to create simple-to-understand graphics.
- However, additional investigation revealed that the easiest part was to add isosurfaces and examine various data attributes, but the most difficult part was to choose non-overlapping colors, isosurface values, and isosurface opacity to make the viz self-explanatory and aesthetically pleasing.

GROUP REFLECTION

- One another challenge was to generate graphs to study the variation in pressure and temperature.
- If, we had more time we would have generated high resolution simulations with the help of dataset available to do relative comparison of height of water splash to different skyscrapers and mountains to study the adversity of the calamity comprehensively.
- If our group were to redo the project, we would use the same workflow because it allowed us to explore the project and comprehend the concept in every aspect.
- However, one thing we would change to improve our approach is to discover a means to generate animations from several datasets parallely at the same time.

THANK YOU