# Scientific Visualization Project Report

# Visualizing Natural Disasters

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## Overview

Our project's goal is to understand and visualize natural disasters. We want to show the properties of a natural disaster and explore how they appear through various stages. Using some of the tools and software we have learned in this class, such as ParaView and VTK, we showed our proficiency by creating compelling and meaningful visualizations. We were able to create interactive and meaningful visualizations of a tornado and show the effect a volcano has on the atmosphere.

## Project Goals

The main objective of this project was to create visualizations that were visually appealing and answered scientific questions. Another goal was to become familiar with ParaView and VTK and be able to go through the entire visualization pipeline. Our goal with the tornado dataset was to show the different properties of a tornado, such as wind speeds at different points, wind direction, vorticity, and angular velocity. Another goal of the tornado data was to create an interactive visualization where the user can explore seed points and streamlines. With the volcano dataset, we want to show what effects a volcanic eruption has on the atmosphere and whether those effects stay in the atmosphere for a long time or dissipate shortly.

## Background

With VTK, the main resource we used was [https://kitware.github.io/vtk-examples/site/](https://kitware.github.io/vtk-examples/site/). This site proved to be very valuable, as we had to incorporate several techniques we have not used in any other assignment.

We also looked up several questions on how to do specific things in ParaView. We found the most help from forums on https://discourse.paraview.org/ answering and about certain questions we had.

Another useful resource was http://www.viscontest.rwth-aachen.de/data.html. This website contained the dataset which was used for the 2014 IEEE Scientific Visualization Contest. This website also provided useful information and documentation about the data which was extremely valuable when first loading into ParaView.

## Description and Implementation

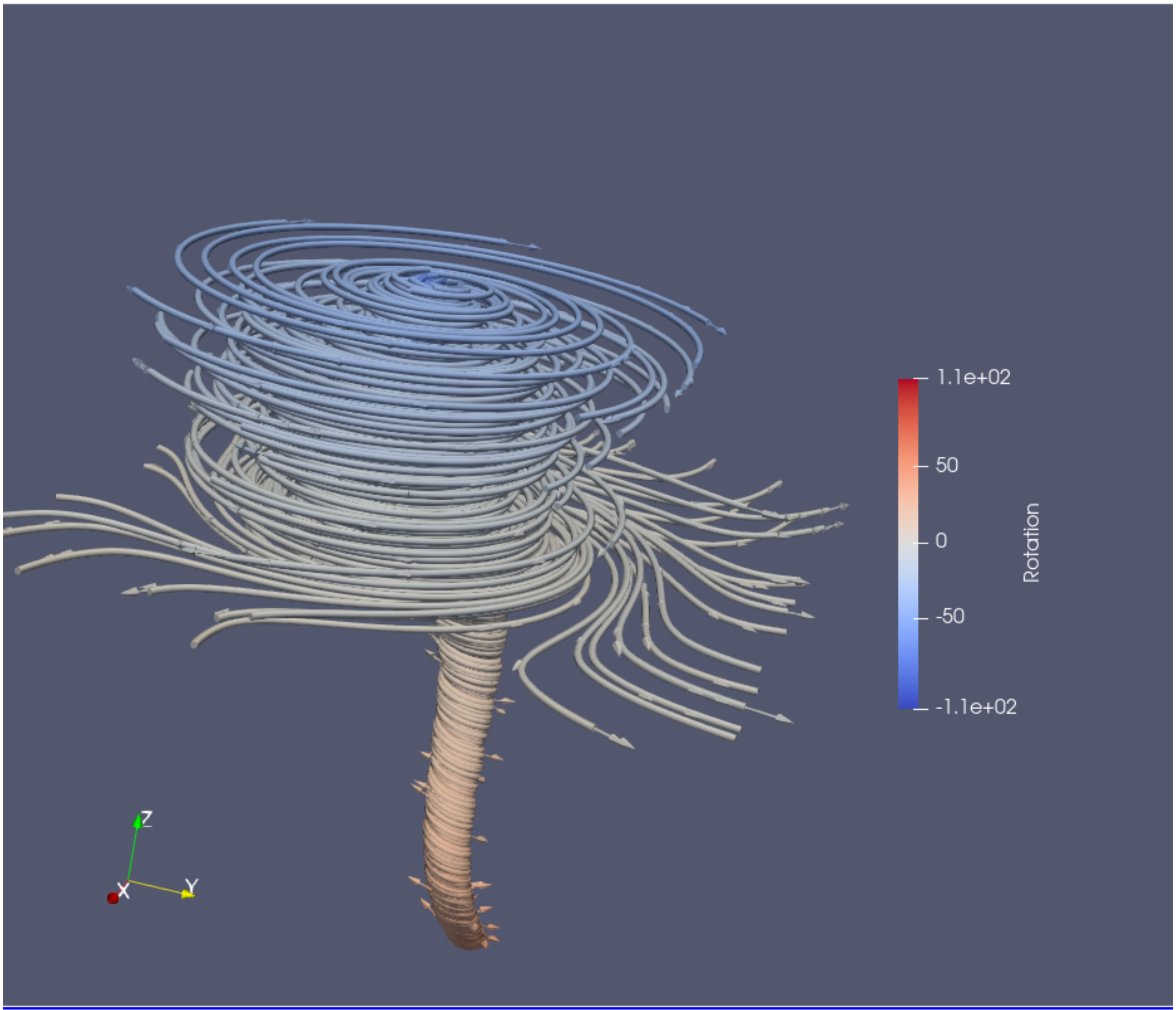
The datasets used for our project were a tornado simulation and a dataset containing volcanic eruptions and their atmospheric aftermath from 2011. The tornado dataset is located here: https://cgl.ethz.ch/research/visualization/data.php which contained the tornado.vti file. The volcano dataset is located here: http://www.viscontest.rwth-aachen.de/. To download the volcano data, a bash script had to be curled from the website, and then that script had to be run on the command line to download the dataset.

The scientific questions we were able to answer were the following:

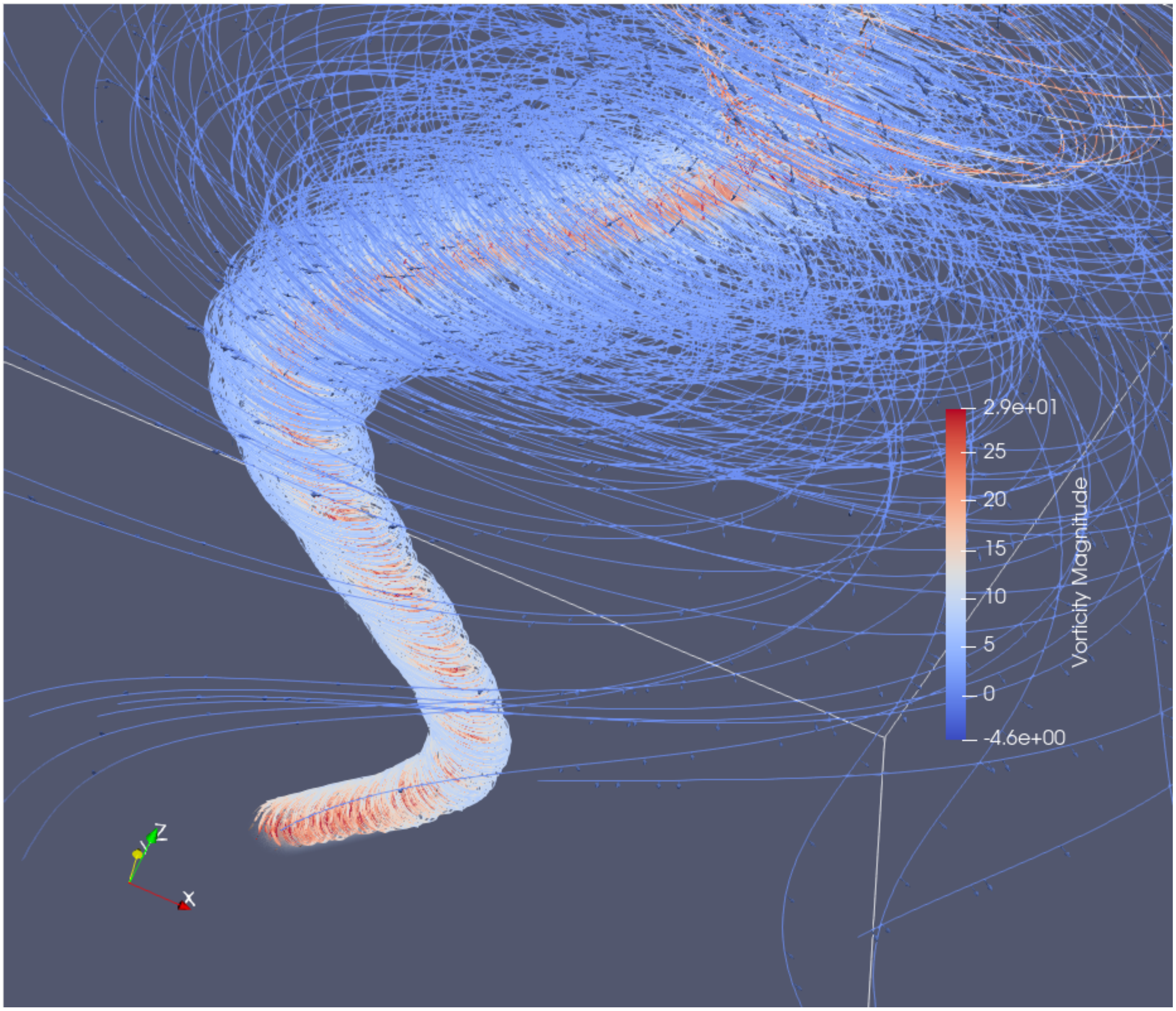
- Where are the rotation speeds of a tornado the fastest?
- Where is the vorticity of a tornado the greatest?
- Where is the angular velocity of a tornado the greatest?
- How do the seed points of the streamlines affect the visualization?
- What effects do a volcanic eruption have on the atmosphere?
- Are the effects localized or can they be seen across the globe?
- How long do these effects stay in the atmosphere?

The answers to these questions will be shown below along with our implementation details.

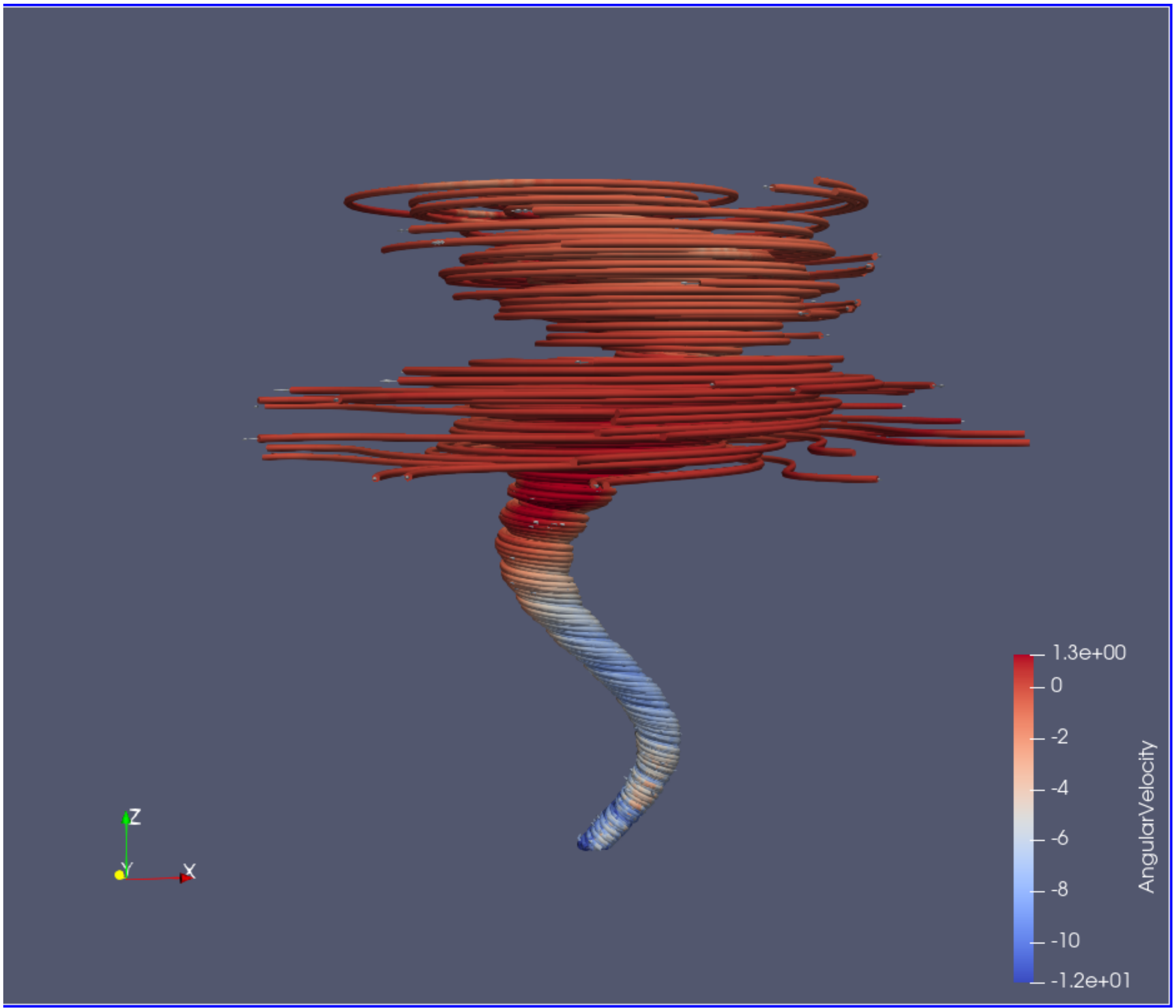
For the tornado dataset we were able to find out where the rotation speeds of a tornado are the fastest. The rotation speeds or a tornado increase nearer to the ground and are slower the higher up you go.



The vorticity of the tornado was higher closer to the center tube of the tornado and the closer to the ground.



Angular velocity of the tornado was greater the further up it was and further out from the center tube of the tornado.




The seed points of the streamlines played a major role in the visualization of the tornado. The VTK visualization was able to show that.

We implemented the Tornado data set by making multiple visualizations and save states in ParaView. As shown above, three save states were made showing off angularVelocity, vorticity, and rotation speeds of the tornado. We also were able to create a python vtk file that displays a window of the tornado. You can change the number of streamlines and seed points through keyboard input.

For the volcano dataset, our first question was: what effects do a volcanic eruption have on the atmosphere? Volcanic eruptions emit S02 and Ash that can stay in the air over weeks and spread all across the globe.

Our next questions were: Are the effects localized or can they be seen across the globe? How long do these effects stay in our atmosphere, and are there any long-lasting effects? The S02 and Ash in the atmosphere travel great distances across the world and stay in the atmosphere for weeks. SO2 for Chile's Puyehue-Cordón Caulle stayed in the atmosphere for around 15 days and the ash for 20 days. For the volcano in Africa, Nabro, the S02 stayed for around 15 days in the air. Ash for the Nabro volcano was hard to calculate due to noise in the data from the Sahara desert. The sand and dust were showing up as ash in the dataset and the second eruption was very close to the Sahara Desert.

The volcano dataset was implemented by creating separate save state files in ParaView. Both states have the world map as a background and are a time series of the data. One save state shows the S02 in the atmosphere created by the eruptions. The other is ash in the atmosphere created by the eruptions. GIFs were made of these time series and are in our slides.

## What we Learned

We were able to further our skills in ParaView and VTK. We learned about how the ash spreads from a volcano by looking at our ParaView visualizations and stepping through the timesteps. We were also able to see how long that S02 stays in the atmosphere after an eruption. Using VTK the team was able to expand our knowledge on color scales, streamlines, and keyboard interfaces. Experimenting with the volcano dataset, we were able to learn more about how wind moves around in a tornado, and where it moves the fastest.

## How the final differs from our description

We followed our original description and proposal extremely close and were able to answer all questions we set out to. Our description had the following questions: What does a tornado look like? What are the speeds of the tornado at specific areas of the tornado? Where is the tornado moving the fastest? What effects does a volcanic eruption have on our atmosphere? Are the effects localized or can they be seen across the globe? How long do these effects stay in our atmosphere, and are there any long-lasting effects? We were able to answer all of these questions with our visualizations and will be including images and gifs of them in our final PowerPoint presentation.

## Evaluation

As a team we felt successful with the visualizations created and the project which we produced. We were able to answer almost all questions we originally came up with before we started on the project. Every member contributed their part in making this project.

Strengths of our project

- Able to load all data into ParaView
- VTK friendly
- Time series for the volcano data made a compelling visual
- Questions were answered by the visualizations created

Weaknesses of our project

- Volcano data did not have full coverage of the world but instead bands/stripes of coverage collected by satellites on that day.

## How work was distributed

Work was distributed evenly among the team members with each team member having their specialty. Carson was the VTK expert and handled everything VTK, he was able to make an interactive python script with the tornado dataset. He was also in charge of downloading the volcano data and figuring out how to get it loaded correctly into ParaView. Connor was the ParaView expert who was in charge of all things ParaView. He made sure the visualizations looked good and had nice color schemes. Brennon was in charge of setting up the repository as well as the shared documents and getting the templates laid out. He also helped out with the ParaView. Each team member was always available to help the others with what they were working on, so we were always working as part of a team.

## Software

Our main programming resource was ParaView. We hoped to utilize ParaView with both datasets to show a meaningful view of a tornado, and visualization over time of the effects volcanoes have on our atmosphere.

We also utilized VTK and were able to create a python script to create an interactive visualization of the tornado.

To reproduce our work you will need ParaView installed along with a Python environment set up with VTK and numpy. You will also need both datasets downloaded that were outlined above. The python script will run with the python environment, and the .pvsm files can be opened with ParaView.

## Additional Comments

none

## Link to repo

https://github.com/bnetz15/SciVisProject