Abstract

eCYBERMISSION Team Name	The Ravenclaws
Team Grade	9
Project Start Date	January 6, 2014
Project Finish Date	January 23, 2014

Describe your project and explain how you used STEM (Science, Technology, Engineering and Mathematics) to improve your community (250 words or less)

After witnessing recent destructive tornadoes in Illinois, our team felt compelled to further investigate the cause of tornadoes, and what impacts their size. Researching this, we determined experimenting with the amount of air available to a tornado would greatly impact its size. Thus, our experimental purpose became determining which size slit allowing air into a tornado simulation chamber (5 cm, 2.5 cm, and 1.25 cm wide) allows the best circulation of air, causing the largest diameter of a simulated tornado. We hypothesized the 5 cm slit would allow the widest tornadoes because greater amounts of air create stronger updrafts and downdrafts which lead to larger storms and supercells.

Using the scientific method, technology in computers and cameras, construction of the simulation chamber, and mathematical computations and measurements, we were able to conduct our experiment efficiently and accurately.

After conducting 30 trials for each slit to determine each tornado's width, we determined the 2.5 cm slit allowed the largest diameter tornadoes to form, contrary to our hypothesis. We believe this is because the other slits did not have the correct balance of updrafts and downdrafts, creating an environment not structured enough to form large tornadoes.

The data from our experiment proved the level of updraft and downdraft in a tornado's cyclonic pattern must be in equilibrium for tornadoes to be large and destructive. This information can be used to predict the size and strength of an imminent tornado, allowing people to avoid as much devastation as possible from these natural disasters.

Tips for writing your abstract:
- Do not go into too much detail about one certain area - be brief!
- Include a problem statement and/or your hypothesis
- Summarize procedures and the important steps you took to solve your problem
- Briefly discuss your observations and results
- Summarize conclusions and/or next steps
- Do not go over 250 words!

*Please e-mail completed abstracts to swhitsett@ecybermission.com or fax to 703-243-7177 by April 15.

State	Illinois
Grade	9th
Mission Challenge	Environment
Method	Scientific Inquiry using Scientific Practices
Students	Eloise (Submitted on: 3/4/2014 5:30:19 PM) Sophia (Submitted on: 3/4/2014 5:31:31 PM) Fawkes (Submitted on: 3/3/2014 11:19:49 PM)

Team Collaboration

(1) Describe the plan your team used to complete your Mission Folder. Be sure to explain the role of each team member and how you shared and assigned responsibilities. Describe your team's process to ensure that assignments were completed on time and deadlines were met.

Our team split the responsibilities of the Mission Folder as equally as we were able. We each assigned ourselves different roles regarding the strengths each of us have, such as research, writing, and data analysis. However, we all agreed to perform the actual experiment together so as to be fair, and traded the rolls of the recorder, experimenter, and photographer. Our team is aiming for the deadline of January 25 for our experimentation and write up so that we had time to revise our Mission Folder before the definite due date of March 1st. Fawkes hosted the experiment in her basement and provided some materials like dry ice. Sophia and Eloise provided the rest of the materials like the hot plate and duct tape. All the team members worked together to analyze the data, research the topic, and answer the questions.

Uploaded Files:

- [**View**] **Experimentation as a Team** (By: Fawkes, 02/28/2014, .jpg)

A picture of how we divided the responsibilities during the trials of our experiment-the recorder, experimenter, and photographer.

Scientific Inquiry

Problem Statement

(1) What problem in your community did your team try to solve? Why is this problem important to your community?

We, The Ravenclaws, attempted to solve the problem of unpredictable tornado size and strength by researching and experimenting how the amount of wind and air affects the size of a tornado. By further understanding tornadoes and their strengths, lives can be saved throughout the country and the world. In addition to the fact that Illinois, our home state, borders Tornado Alley, we were also inspired by the tornadoes in downstate Washington, Illinois in November 2013.

(2) List at least 10 resources you used to complete your research (e.g., websites, professional journals, periodicals, subject matter experts).

See the attached file titled "References."

(3) Describe what you learned in your research.

See the attached file titled "Review of Literature."

Hypothesis

(4) State your hypothesis. Describe how your hypothesis could help solve your problem.

If 5 cm, 2.5 cm, and 1.25 cm size slits in a tornado simulation chamber are tested to see which one causes the tornado with the widest diameter, then the 5 cm slit will allow the simulated tornado to be the widest because more air causes stronger updrafts and downdrafts leading to the most severe storms and supercells. The information gained from this experiment can be used to better protect people from tornadoes since it will describe the amount of wind shear that forms the strongest tornadoes, providing them with the knowledge of which amount will cause the most damage, last the longest, and travel the farthest.

(5) Identify the independent variables and the dependent variables in your hypothesis.

The independent variable in our experiment is the size of the slit in the tornado simulation chamber-5 cm, 2.5 cm, and 1.25 cm.

The dependent variable is the width of the simulated tornado. This width was measured by a metric ruler (cm).

(6) How did you measure the validity of your hypothesis?

First of all, the validity of the hypothesis was measured by the results of the experiment. Each size slit had thirty trials, to gain enough results about the variables, and to keep the data constant. The research conducted previous to the experiment was all gained from valid sources like Scholastic websites and National Weather Service resources. The hypothesis was invalid because the results from the experiment proved our hypothesis wrong. It was initially thought that more air would be able to support a bigger mass for the tornado created from the 5 centimeter slit, but the 2.5 centimeter slit actually turned out to create the strongest tornadoes that were the widest and spun the fastest. The data from the trials proved the hypothesis wrong, and the research showed that the tornado created from the five centimeter slit was not as wide because the updraft was stronger than the downdraft. This caused the tornado to become taller instead of wider, as one attribute of tornadoes with stronger updraft is that they will reach higher altitudes in the atmosphere and cause more precipitation.

Experimental Design

(7) List the materials you used in your experiment. Include technologies you used (e.g., scientific equipment, internet resources, computer programs, multimedia, etc.).

See the attached file titled "Materials."

In addition to the physical materials addressed in this file, we utilized several internet and print resources that can be seen in the file titled "References."

(8) Identify the control group and the constants in your experiment.

A control group was not relevant for this experiment, since no slit in the tornado simulation chamber would not form a cyclonic airflow.

The constants of this experiment include the materials used (same tornado simulation chamber, hot plate, brand of dry ice, etc.), the environment, the temperature of hot plate, the performance of each trial, the number of trials for each slit (30), the size of dry ice pieces, and the type and amount of water.

(9) What was your experimental process? Include each of the steps in your experiment.

See the attached files titled "Procedure" and "Appendix."

Before conducting the experiment, we did extensive research about tornadoes, their qualities, how they form, etc., and took appropriate safety procedures before performing the experiment. Our research is presented in the attached file titled "Review of Literature."

Data Collection and Analysis

(10) Describe the data you collected and observed in your experiment. The use of data tables, charts, and/or graphs are encouraged.

See the attached file titled "Data Analysis and Discussion."

(11) Analyze the data you collected and observed in your experiment. Does your data support or refute your hypothesis? Do not answer with a yes or no. Explain your answer using one of the following prompts: 'Our data supports/refutes the hypothesis because...'

Our data refutes the hypothesis because the 5cm slit did not create the widest tornado. Instead, the 2.5cm slit formed the widest tornadoes. These results may be because the strongest tornadoes are created from an unstable updraft and downdraft. The wind shears must be around the same force so that their resistance causes a strong vertical air draft. If either the updraft or the downdraft is stronger than its counterpart, then the stronger force will have more influence, meaning that the tornado will be more unstable and the air will not be as focused, which creates a weaker vortex. In the case of the 5cm slit, the updraft was stronger than the downdraft. This lack of equilibrium caused the tornado to have a smaller vortex, but be taller. Attributes of tornadoes with strong updrafts include strong rains because of the higher altitudes. The tornado formed by the 5cm slit was taller, and thus it would have reached the upper atmosphere in the real world. The updraft and the downdraft must both be at about the same force, like in the 2.5cm slit, so that the tornado has a greater width, creating a larger span for destruction.

(12) Explain any sources of error and how these could have affected your results.

See the attached file titled "Conclusion."

This file also contains information pertaining to the next question section.

Drawing Conclusions

(13) Interpret and evaluate your results and write a conclusion statement that includes the following: Describe what you would do if you wanted to retest or further test your hypothesis. Evaluate the usefulness of the data your team collected. What changes would you make to your hypothesis and/or experimental design in the future, if any?

See the attached file titled "Conclusion."

This file also contains information pertaining to the previous question section.

Uploaded Files:

- [**View**] **Materials** (By: Fawkes, 02/28/2014, .doc)

  A list of the physical materials we used to perform the experiment.
- [**View**] **Procedure** (By: Fawkes, 03/03/2014, .doc)

  Step by step instructions for how we executed the experiment.
- [**View**] **Appendix** (By: Fawkes, 03/03/2014, .doc)

  The appendix to our procedure including step by step instructions for building the tornado simulation chamber.
- [**View**] **Review of Literature** (By: Fawkes, 03/03/2014, .doc)

  A document containing our background research prior to performing the experiment.
- [**View**] **Data Anaysis and Discussion** (By: Fawkes, 03/03/2014, .doc)

  An analysis of the raw data collected by our experiment.
- [**View**] **Conclusion** (By: Fawkes, 03/03/2014, .doc)

  A summation of all we discovered in our experiment. Includes our conclusive statement, future plans, and observations in addition to further analysis of the data.
- [**View**] **References** (By: Fawkes, 03/03/2014, .doc)

  A list of the print and online resources we used for our background research and experiment cited in APA format.
- [**View**] **Data, Graph, and Histogram** (By: Fawkes, 03/03/2014, .xls)

  A chart of the data we collected, a bar graph of the averages of that data, and a histogram of the occurrence frequencies of each datum.
- [**View**] **Trial Example** (By: Fawkes, 03/03/2014, .jpg)

  An example of one of our trials. One of the pictures we took of the model tornadoes for analysis.

Community Benefit

(1) How could your experiments and data help solve your problem and benefit your community? Describe next steps for further research/experimentation and how you have or how you could implement your solution in the future.

The data from our experiment proved that the level of updraft and downdraft in a tornado's cyclonic pattern must be balanced for the tornado to be strong, therefore enabling it to be destructive. This information is key in helping scientists and researchers get one step father into solving the mystery of unpredictable tornado size and strength. The results represent the air patterns in an environment that will create the most dangerous and destructive tornadoes. Scientists can use this information to predict the strength of a tornado efficiently and reliably, allowing inhabitants of the endangered area enough time to evacuate and take the necessary safety precautions. Lives can be saved throughout the country and the world by further understanding tornadoes and their qualities. After experiencing recent tornadoes in our area, we were inspired to help people avoid as much devastation as possible from these natural disasters.

This experiment could be further researched by being conducted with larger scale models to get a more accurate representation of a real tornado. This information can also be submitted to weather prediction companies and other meteorologists to be implemented in analysis of the weather. When these scientists use instruments such as anemometers, they can measure wind speed and velocity. They can then determine updrafts and downdrafts in the environment, and thus determine the strength and speed of an imminent tornado. Not only will this research save lives, but it is a more precise way for meteorologists to predict tornadoes.

Uploaded Files:

- [**View** **Destruction in Washington, IL** (By: Fawkes, 02/28/2014, .jpg)

A picture of the devastating destruction tornadoes left in Washington, IL the past November. Fawkes' church went on a volunteer trip in the aftermath, bringing back this picture.


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Materials

Cardboard (will be 4 pieces of 30x60 cm)

Clear, vinyl shower curtain

Black paint

Duct tape

Hot plate

Pie pan (at least 2.5 cm. deep)

Water

Dry ice

Light source

Metric tape measure

Swiss Army Knife

Scissors

Paint brush

Insulated oven mitt/glove (cloth)

Styrofoam cooler

Tongs

Safety goggles/glasses

Video camera or still camera (Sony) with tripod

Hammer

Source of AC power

Tape measure

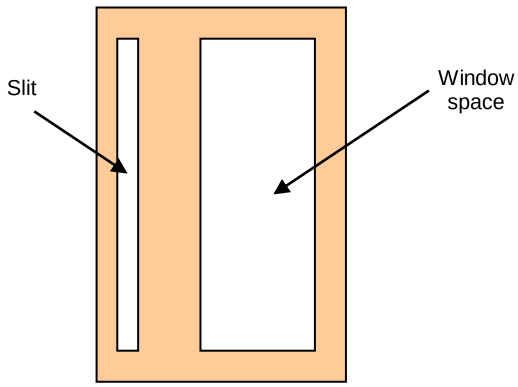
Procedure

1. Gather materials.
2. Construct simulation chamber (see Appendix).
3. Place the dry ice in a cooler to be available and safe to handle as needed.
4. Place hot plate on a firm surface, plug it into the AC power source, and turn the heat on to 315.5 degrees Celsius
5. Pour water into pie pan and place on hot plate. Wait until the water comes to a boil before proceeding.
6. Set up the camera/camcorder on the tripod 1 meter away from the testing area.
7. Position the simulator chamber around the hot plate with one window facing towards the camera/camcorder and one window facing towards the right side.
8. Position the light source so that it illuminates the inside of the simulation chamber by shining through the right side window.
9. Focus the camera/camcorder to where the tornado will form and where the centimeters are marked on the metric ruler.
10. Remove some dry ice from the cooler. Using the hammer and a towel if necessary, break the dry ice into chunks approximately 1x1x1 cm.
11. Using the tongs or the insulated mitt, carefully place one of the broken dry ice pieces into the pan of boiling water.
12. Keeping still so as not to disturb the air patterns in the simulator, take pictures/video of the simulated tornado and record observations.
13. Repeat steps 10-12 until 30 pieces of data are collected.
14. Remove the simulation chamber box from the testing site.

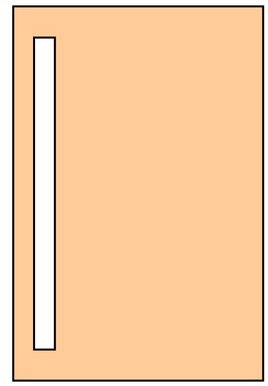
15. Using the knife, widen the slits so that each slit is 2.5 cm. Make the extension towards the window.
16. Repeat steps 7-12 until 30 pieces of data are collected using the newly modified simulation chamber.
17. Remove the simulation chamber box from the testing site.
18. Using the knife, widen the slits so that each slit is 5 cm. Make the extension towards the window.
19. Repeat step 7-12 until 30 pieces of data are collected using the newly modified simulation chamber.
20. Remove the simulation chamber box from the testing site.
21. Turn off the hot plate and light source, and clean up all materials.
22. Using the pictures/video, analyze the data collected for each width.

Appendix

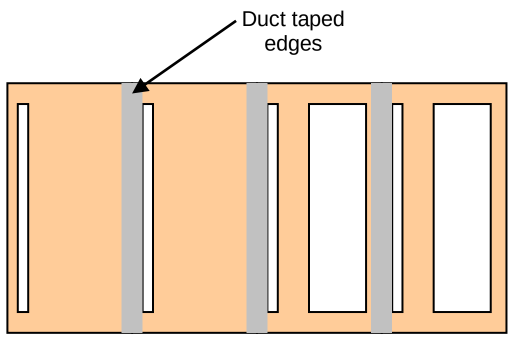
1. Using the Swiss Army Knife, cut the four sides of the simulator chamber out of cardboard so that each is 30 cm wide by 60 cm tall.
2. Cut a 1.25 cm wide slit each of the four 30x60 cm sides. The slit should begin and end 5 cm away from each of the 30 cm ends and 2.5 cm from the 60 cm side. (See figure)
3. Cut windows in two of the 30x60 cm sides. The windows start 7.5 cm away from each of the 30 cm sides and should be 12.5 cm away from the edge with the slit (7.5 cm away from edge of slit closest to 60 cm edge of side). (See figure)
4. Position the four sides so the 60 cm edges are touching each other and the four sides lay in a flat plane. The two sides with windows should be adjacent to each other. Duct tape these sides together from what will become the inside when assembled, but do not cover the slits or the windows. (See figure)
5. Paint the inside surfaces with black paint and let them dry thoroughly.
6. Cut the vinyl shower curtain to form the front of the windows. The vinyl pieces should be large enough to cover the window openings without covering the slits.
7. Duct tape the clear vinyl to the large cut openings to form the windows. (See figure)
8. Duct tape the outside corner of the simulation chamber which has not been attached to another side yet. This action should form a four sided figure (four faces, no top or base) with the black paint on the inside. The windows should be at 90 degree angles to each other.
9. Attach the metric ruler inside the simulation chamber using duct tape, making sure the numbers remain visible for determining the width of the tornado. (See figure)



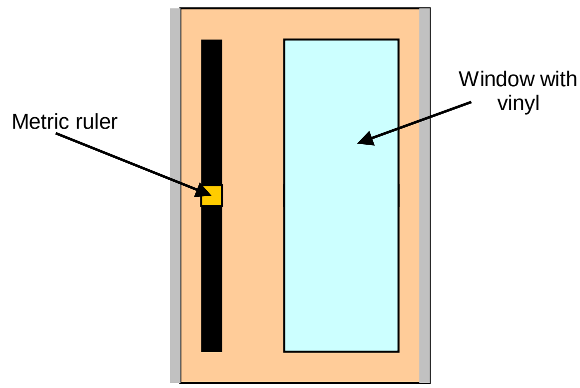
Single side of simulation chamber (window)



Single side of simulation chamber (no window)



Flat, planar simulation chamber sides with duct tape



Front view of assembled chamber

Review of Literature

Tornadoes are found most frequently in the United States, and they average 1,000 times per year in America. These destructive storms can cause insurmountable damage to cities all over the world. Because they have such a great impact on people and their safety, it is important to understand how tornadoes are formed and stimulated. All tornadoes are different, but they all share common properties in formation, such as they form in nature when the speed and direction of air reacts with thunderstorms to create a vortex effect. These winds are very strong, and they can destroy homes, cities, and property. Tornadoes form in all different shapes and sizes. The factors that affect the strength of a tornado are how they are formed, their measurements, and their type of wind shear.

To begin with, tornadoes form in very dangerous environments. These ferocious storms are created from powerful thunderstorms. Thunderstorms form from cumulonimbus clouds, and are associated with rain and lightning. This revolving cloud takes wind from all directions and spins it into a rotating motion much like a funnel (“Tornadoes”, 2013). Thunderstorms themselves are caused from moisture, lift, and unstable air. The moisture forms the clouds and rain, which gathers at high altitudes in the sky. The lift is caused by cold or warm fronts, sea breezes, mountains, or the sun’s heat. The unstable air makes for warm air that rises rapidly. Tornadoes pick up dust and debris, which enables people to see the tornado. Since they are made of wind, they are not clearly visible against the sky. Though the debris does help people see the tornado, it also has consequences. Debris is harmful because tornadoes can eject the debris, sending it spinning at a very fast pace. This can damage buildings and cause danger to many people.

Before a tornado begins, winds will have to create a horizontal spinning effect in the lower atmosphere by increasing speed and altitude. This spinning effect cannot be seen by the human eye, but it looks much like a sideways funnel. An updraft created from rising air in the thunderstorm will then change the direction of the rotating air from horizontal to vertical. This then gives the tornado its signature shape of a vertical spinning vortex. “An area of rotation, 2-6 miles wide, now extends through much of the storm. Most tornadoes form within this area of strong rotation” (“Nature’s Most Violent Storms”, 2014). It is at this point in the tornado’s life, after it has been fully formed, that it starts to travel around. Tornadoes can move around and last for a short while or a long while. It all depends on how strong it is, and how fast the wind is moving. When a tornado forms from an area of rotation that is larger than 6 miles, it has to have a faster wind speed to sustain its larger mass. This tornado is much stronger than the average tornado, and because it is larger it can cause much more destruction. This is why it is important to know how tornadoes are formed, so that one can estimate from the circumstances how strong the tornado will be.

Secondly, tornadoes are measured differently based on their strength. The scale used for their measurement is called the Enhanced Fujita (EF) Scale. This is a number scale based on the numbers 0-5, 0 being the weakest and 5 being the strongest. When tornadoes have a rating of 0 from the EF scale, they usually travel at an average of 75 miles per hour. A tornado with an EF rating of 1 travels about 100 mph. Tornadoes usually travel an average of 120 mph with an EF rating of 2. When it has an EF rating of 3, it travels about 150 mph. With an EF rating of 4, a tornado will travel about 180 mph.

The tornado will have to travel over 200 mph to get an EF rating of 5 (“Nature’s Most Violent Storms”, 2014). Scientists measure tornadoes based on the amount of damage that they cause. Most tornadoes, about 88 % of all tornadoes, are relatively weak and they last about 10 minutes or less. Strong tornadoes make up about 11 % of all tornadoes, may last twenty minutes or longer. Violent tornadoes, less than 1 % of all tornadoes, can exceed one hour (“EF Scale”, 2011). Tornadoes cause damage to homes, buildings, cars and other transportation, and even animals like cows and horses. A tornado with a rating of 0 will cause light damage. For example, it may affect chimneys or TV antennas. Tornadoes with a rating of 1 will cause moderate damage. This can break windows. Considerable damage is caused by tornadoes that are rated 2. They can tear off roofs and trees. Tornadoes rated a 3 will cause severe damage. This can overturn trains and demolish buildings. Devastating damage is caused by tornadoes rated with a 4. This can level houses, also other buildings with strong steel structures, and lift cars. Tornadoes rated with a 5 cause incredible damage. For example, it can damage steel-reinforced concrete structures (“Severe Weather and Natural Disasters”, 2014). All tornadoes come in different shapes and sizes, and they can all cause different types of damage. The rating that a tornado gets on the Fujita scale tells people how strong the tornado really will be. This is important for people’s safety because they will then have an idea of how much damage the tornado caused.

Last but not least, wind shear is an important factor in the strength of a tornado. “One characteristic that's generally necessary for a strong supercell — and subsequent tornado — is wind shear, a difference in the wind speed at varying altitudes or directions. Air currents are often more powerful at higher altitude...the supercell's powerful updraft must succeed in raising, sustaining and tightening the central vortex at a near vertical alignment” (Toothman, 2014). This updraft is important because it creates a pipe effect when it balances with the downdraft. The center of the vortex will have a low pressure, so this area draws in more air up into the storm and lengthens the funnel shape of the tornado (Toothman, 2014). As mentioned before, all thunderstorms need unstable air and lift. The atmosphere becomes unstable when the rising air in a cloud is warmer than its surroundings. This warmer air moves upward, thus becoming an updraft. The air cooler than the environment sinks, thus, this phenomenon is known as a downdraft. The atmosphere can have four situations relating to its instability: unstable updrafts and stable downdrafts, stable updrafts and unstable downdrafts, stable updrafts and downdrafts, or unstable updrafts and downdrafts. The intensity and strength of thunderstorms, and in turn tornadoes, depends greatly on how the air in the atmosphere is situated. A storm with a weak updraft and strong downdraft will create microbursts. Microbursts are storms that are short downdrafts of air which spread on the ground. They cause much alteration in the speed and direction of the wind. These are known to occur in high plains, like in western areas of the United States, where the environment is very dry. The next situation with air instability is when there is a strong updraft and a weak downdraft. This will not create damaging winds, but it will have heavy rains and sometimes even floods. These storms are found most commonly in areas with a very moist atmosphere. Also, another situation with air instability is when there is a weak updraft and a weak downdraft. These cause ordinary rain showers, and they do not cause severe storms. Lastly, there can be both a strong updraft and a strong downdraft in the atmosphere. “These storms frequently produce destructive downbursts, hail, heavy rain, and tornadoes. As one would expect, the most severe storms, including supercells, have strong vertical drafts and occur in the most unstable atmospheres" ("Updrafts and Downdrafts", 2010).

In conclusion, the factors that affect the strength of a tornado are how they are formed, their measurements, and their type of wind shear. The strongest tornadoes are the ones that are created from the most powerful updrafts and downdrafts which cause instability in the atmosphere. This information can be used to help better protect people from tornadoes because it will tell them the amount of wind shear that will cause the strongest tornado so they know which will cause the most damage, last the longest, and travel the farthest. If there is more wind in the atmosphere that is unstable, scientists will be able to quickly identify how strong the thunderstorm will be and the people will be able to take proper safety precautions. "The current average lead-time for tornado warnings is 13 minutes. NOAA Research is working to increase tornado warning lead-times much further … Tornadoes kill about 60 people each year" (Sullivan, 2014). This information is very important because it can help save lives by warning people about tornadoes earlier so that they have time to take the necessary safety precautions.

Data Analysis and Discussion

Throughout the course of this experiment, the different amounts of slits and updraft had different effects on the diameter of tornadoes. The different slits were tested at different times. Also, the pieces of dry ice had the reaction of uncontrollable spinning and bubbling when they were placed in the boiling water. They shot out random spurts of vapor before it started coming out in a smooth stream. This vapor was warm mostly because the hot plate heated the air and caused it to rise up. Hot air rises more quickly, so it made the tornado much more visible. When dry ice sublimed, the warm air from hot plate caused it to melt. These all had an effect on the width of the tornado and the wind speed.

The first test was when the slit was cut at 1.25 cm. The average width was 3.47 cm. All the widths were between 2.25 and 5.50 cm. By determining the standard deviation, we found that it is 70% certain that if the experiment is repeated one more time that the values would fall, for the slit length of 1.25 cm, 0.694 cm away from the mean. It is also 95% certain that if the experiment is repeated one more time, the value of the next measurement will be less than 1.388 cm away from the mean. These results were pretty consistent in the different trials. The carbon dioxide from the dry ice rose pretty quickly. This vapor rose fast from the reaction between the hot water and the dry ice so, as a result, the tornado was visible very quickly in the beginning but it started to fade swiftly. Even though the results were mostly frequent, it was noticed that the numbers kept increasing and decreasing in small waves. This could have been because when each new piece of dry ice was put in the water, it generated more fog in the very start. The amounts of fog differed based on the size of the piece of the dry ice. The sizes of the dry ice differed by only small amounts, as they were all about one cubic centimeter, but piece could have been chipped off. So in this case, the vapor would have evaporated more quickly, and the dry ice would have melted more quickly, so as a result there would not have been enough fog to sustain the visibility of the tornado. In this test, the tornadoes were the shortest of all. This was because there was less air coming in the updraft, so there was not enough air to have a swifter wind and a wider tornado.

The second test was conducted with a slit width of 2.5 cm. The average was 3.93 cm. These tornadoes extended higher above the test chamber because they had more air to sustain a bigger mass. As a result, the air spun faster and the tornado was much taller. The air was very focused in the vortex so the tornado was much clearer to see. The vapor from the dry ice took longer to rise than in the previous test. This was because there was more air so it took more time for the vapor to spread out to all of the air and cover the larger area. These numbers had a range of 2.50 to 7.00 cm. For the slit length of 2.5 cm, it is 70% certain that if the experiment is repeated one more time that the values would fall 0.905 cm away from the mean. It is also 95% certain that if the experiment is repeated one more time, the value of the next measurement will be less than 1.810 cm away from the mean. The numbers fluctuated a lot from small to large numbers. The width of the tornado started to become smaller near the end. This may have been because the temperature from so many different pieces of dry ice had affected the hot plate so that its temperature became cooler. This means that it would have taken longer for the carbon dioxide from the dry ice to make the tornado visible, and the width may have become smaller by the time the tornado became visible. This test had a higher average than the previous test because the wind had been well balanced between the updraft and the downdraft. When both of these forces react to each other, the wind will form a vortex that keeps the air spinning at a fast pace. It is important that one of these forces is not too much stronger than the other because then it will start to alter the strength and wind speed of the tornado. When the two forces are in harmony, the tornado will be stronger, wider, faster, and last longer. These were all attributes of the tornadoes from this test.

The last test was conducted with a slit 5 cm wide. This test had an average of 2.43 cm. The data points ranged from 1.50 to 4.50. For this test, it is 70% certain that if the experiment is repeated one more time that the values would fall 0.740 cm away from the mean. It is also 95% certain that if the experiment is repeated one more time, the value of the next measurement will be less than 1.480 cm away from the mean. This test had tornadoes that consisted of slower wind speeds and taller heights. Though they were tall, their widths were smaller than the previous tests because their updraft was stronger than the downdraft. Aspects of a tornado made of strong updraft and weak downdraft is that it will reach higher altitudes and cause more precipitation. So, because this tornado was taller, it could be inferred that it had a stronger updraft. The downdraft was consistent throughout the experiment since the box was open at the top. The experiment had not been moved, so the air would not have been affected by the atmosphere from the room. So these factors also did not have a big influence on any change in the downdraft. The wind speed from this test was the slowest from the experiment because the air could have been heavier. This would be explained by more moisture being present in the air, and thus causing it to take more force to spin the tornado in a vortex shape. There was much momentum because there was a lot of air coming through the large slit on all sides, but it would have taken more to move the air faster. The moisture from the air came from the vapor that the dry ice released. There were so many trials for the two previous tests. When a bit of vapor from each trial lingered in the air, it would have built up over time and the air would be heavier.

Conclusion

The purpose of this experiment was to determine how the size of a slit which admitted the amount of air into a simulated tornado chamber affects the size of a tornado. By adjusting the amount of air flowing through the slit, the experiment can accurately simulate how changes in wind would affect a real tornado. After experimenting with slits the sizes of 1.25 cm, 2.5 cm, and 5 cm, it was determined that the 2.5 cm slit formed the largest, most widespread tornado with an average of about 3.9 cm wide. The 1.25 cm slit formed simulated tornadoes with an average width of about 3.5 cm, and the 5 cm slit formed simulated tornadoes with an average width of about 2.4 cm.

Though not shown through measured data, it was also observed that as the width of the slit increased, the speed at which the simulated tornado revolved slowed. In addition, the 5 cm wide slit had the most enduring tornadoes, sometimes reaching three to four feet above the chamber before dissipating.

These results proved our hypothesis incorrect. The 5 cm slit did not demonstrate the widest tornado, despite proving to be the most enduring. Instead, the 2.5 cm slit formed the widest tornadoes. This may be because the strongest tornadoes are created from a strong updraft and downdraft. These wind shears must be around the same force so that their resistance causes a strong vertical air draft. If either the updraft or the downdraft is stronger than the other, then this will cause the stronger force to have more of an influence so that the tornado will be more unstable and the air will not be focused enough to make a sturdier vortex. In the case of the 5 cm slit, the updraft was stronger than the downdraft. This caused the tornado to have a smaller vortex and be taller. Attributes of a tornado with a strong updraft include strong rains and an increase in height because it is at higher altitudes. This tornado was taller, and thus would have reached the upper atmosphere in the real world. The updraft and the downdraft both have to be at about the same force, like in the 2.5 cm slit, so that the tornado would have a bigger width and cause more destruction.

From these results, it can be determined that the amount of air by which a tornado is fueled greatly affects the qualities of said tornado, such as width. By experimenting with an accurate model, real-world situations can be simulated, evoking the discovery of new knowledge and leading to the testing of other tornado qualities. This connects to the real world because finding how air affects the width of a tornado will help people survive. The strongest tornadoes are the ones that are created from the most powerful updrafts and downdrafts which cause instability in the atmosphere. Information from the test will inform people of the amount of wind shear that will cause the strongest tornado. This way, they know which circumstances creating a tornado will cause the most damage, cover the most area, and travel the farthest. If there is more wind in the atmosphere that is unstable, scientists will be able to quickly identify how strong the thunderstorm will be and the people will be able to take proper safety precautions. Scientists will also be able to predict, using their measurements, how dangerous a tornado can be. They can test the pressure or wind speed in the updraft and downdraft to see how these two forces relate. This can help people so that they will know what type of safety precautions they should take and plan ahead of time, since wider tornadoes result in more ground coverage, are more dangerous, and cause more destruction.

Some limitations and sources of error may be in the inconsistency of heat given by the hot plate. Since the hot plate maintains a temperature by heating and then cooling, and subliming dry ice causes the water to significantly cool, fluctuations in temperature may have affected the results. Also, carbon pockets in the dry ice popped and created wind currents after touching the boiling water, which sometimes caused small breaks in the simulated tornado. Human error may have also affected the results through inaccurate measuring and cutting of the cardboard forming the chamber, windows, and slits. Lastly, measuring the width of the tornado is an estimation, since the fog created by the dry ice would drift, causing blurry pictures and difficult estimations of width. Edges of these tornadoes were rarely evident, and therefore could not be measured exactly and rounded to the nearest quarter centimeter.

Future ideas or pursuits relating to this project may include furthering the experiment, such as measuring the widths of tornadoes in a similar fashion with additional sized slits, measuring for other qualities of the tornadoes, such as endurance or speed, experimenting with different scale models, or other environments that may mimic the real-world environment.

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