How is the Size of a Tornado Affected by Water Temperature?

Tyler Orr and Davey Robinson

November 30, 2012

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Background Information

Tornados result from the collision of warm, tropical air and cold, polar air in a storm that is often called a supercell. Because of the natural entity of warm air rising and cold air dropping, the collision between the two currents is eventually spiraled into a funnel. The rising warm and moist air is cooled to form condensation as a result. The various atmospheric winds are then able to form the funnel we know as a tornado. Once the funnel touches the ground, the atmospheric pressure in the funnel is significantly low and tries to bring more air into itself; sometimes, it can even suck in nearby objects.

Tornados occur all around the world from Argentina, who reports just twenty tornados a year, to Bangladesh, who holds the record for the most deadly tornado in recorded world history. However, tornados in the United States are predominate in a location we dub "tornado alley." Tornado Alley, which is located in the southern and central United States, is a perfect place for the creation of tornados because of the currents from the warm Gulf of Mexico and the cold Rocky and Appalachian Mountains collide.

In a system called the Fujita scale, tornados are ranked on a scale from F1 to F5 based on the damage they cause. For example, 50% of tornados fall into the F1 category, or moderate damage, in which the funnel can reach wind speeds of 73-112 MPH. On the other hand, an F5 tornado causes "incredible damage." With only 1% of tornados being classified as so, an F5 tornado can reach speeds of 261 MPH that can lift houses from their very foundations.

Dry ice, or CO_2 (s), never enters the liquid state. The carbon dioxide transfers directly from its solid state to a gaseous state, or vice versa. This process is known by scientists as sublimation. In order to make this change, dry ice must obtain heat from its environment;

therefore, hot water speeds the change of dry ice into carbon dioxide gas faster than that of cold water because of the energy differences.

Purpose

The purpose of the experiment is to understand the relationship between the temperature of water and the size of the tornado in which it produces. It is also to mimic the natural recurring pattern of the collision of warm, moist tropical air with cold, polar air that is frequent in tornado-producing systems.

Materials

- 4 x Plexiglas® of about 8in X 12in
- 2 x Wooden boards of about 10in X 10in x 1in
- Measuring tape
- 6 Pounds of dry ice
- H_2O (of varying temperatures)
- Gloves
- Stopwatch
- Table saw
- Circular saw
- Black Sharpie®
- Superglue
- Computer fan
- Thermometer
- Scale

Method

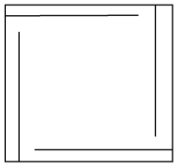
1. Crafting the tornado chamber

1) Using a table saw, cut 2 wooden boards of 10in x 10in x 1in.

2) Using a table saw, cut four quarter-inch ruts about one inch from each edge of the wooden boards. This cut should not sever the board for it will only be used to hold the Plexiglas® firmly in place.

3) Cut a square opening in the center of the top of the one of the 10in x 10in x 1in wooden boards. This opening should be approximately 3in x 3in depending on the fan in which you are using. This opening will eventually act as the air intake, or suction, to form the tornado.

4) For this step, use the wooden board that does not have the opening. Begin to place the 8in side of the Plexiglas® pieces into the ruts and superglue three of them into place, for the fourth piece must be removable to access the chamber. Align all the Plexiglas® pieces to the right along the wooden board to allow for circulating airflow. Overall, the layout of the Plexiglas® from the aerial view should resemble the one below:



5) For this step, use the wooden board that does have the opening. Place superglue in the ruts on three sides of the board. Then, with the ruts facing downwards, gently place the board onto the Plexiglas® pieces until it firmly falls into place. Make

sure the sides you glued on the top correspond to those on the bottom so that one piece of the Plexiglas® may slide out to act as a door.

6) Allow adequate time for the superglue to dry. Place the fan on the top opening in the wooden board so that air is sucked out of the chamber.

7) Using a black Sharpie® and a ruler, draw marks on the front of the Plexiglas® for measurement of the tornado's diameter in inches during the experiment.

2. Carrying out the experiment

1) In this experiment, your independent variables will be the water temperatures. For adequate results, each of the 0°C, 20° C, 40°C, 60°C, 80°C, and 100°C samples should be created just before the adding of dry ice. These desired temperatures can be acquired by adding ice to the H_2O, placing it in the freezer, boiling it on the stove, or placing it in the microwave. Make sure to use a metal bowl when acquiring these temperatures because the addition of hot water to a glass bowl may cause a glass fracture or shattering.

2) Once your sample is prepared and the H_2O has been tested for the correct temperature, remove the sliding Plexiglas® door and place the metal bowl inside.

3) Using gloves to remove the dry ice, measure out seven ounces of the dry ice into another metal bowl.

4) Using gloves once again, pour the dry ice into the bowl containing the H_2O sample and reposition the Plexiglas® door.

5) Turn on the computer fan and wait approximately ten seconds to measure the diameter of the tornado funnel in inches using the marks you made on the Plexiglas® door. It is vital that use a specific part of the tornado every time. For

example, don't measure at the top of the funnel one time and then near the base the next.

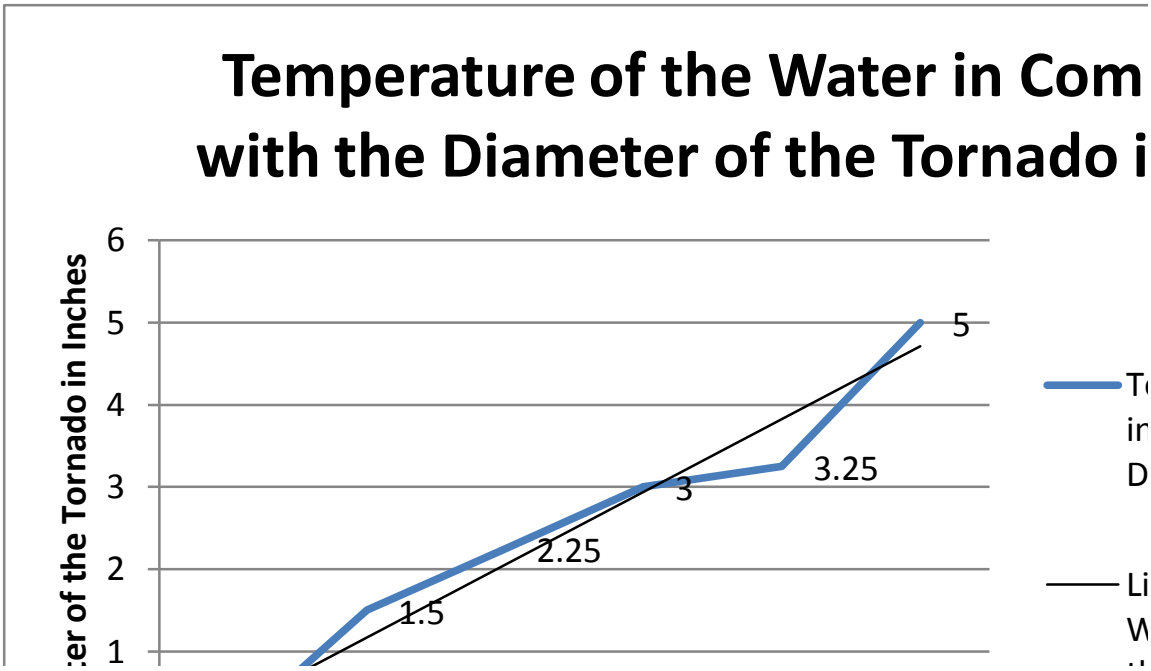
6) Record observations and remove the sample.

7) Repeat steps 2-6 for each H_2O sample of 0°C, 20° C, 40°C, 60°C, 80°C, and 100°C.

Results

The diameter of the tornado increases as water temperature increases.

Temperature of Water	Diameter of the Tornado
0° C/32° F	Not Big Enough to Draw a Conclusion
20° C/68° F	1 ½ in or 3.81 cm
40° C/104° F	2 ¼ in or 5.72 cm
60° C/140° F	3 in or 7.62 cm
80° C/176° F	3 ½ in or 8.89 cm
100° C/212° F	5 in or 12.7cm



We found that an increase in temperature will result in the increase of the diameter of the tornado's core. At zero degrees Celsius, the reaction was inconsequential because it ultimately did not produce enough condensed water vapor to form a substantial, measurable result.

Discussion

We both feel like the project went considerably well. We thought that making the tornado chamber would be difficult and time consuming, but we actually found it to be quite enjoyable and extensively easy to build. The chamber ended up looking somewhat different than the one we were observing online, but it actually ended up being a good thing because our results were better than theirs due to our idea of cutting the ruts in the wooden boards.

The experiment itself went much better than expected and was a great deal of fun. Everything seemed to run perfectly the entire time with no problems whatsoever which saved a lot of time throughout the process. Due to our innovative ideas, the process seemed to be more fun than what we had previously witnessed online. We were also able to use the excess dry ice to make more tornados after the experimentation was complete, which was very nice since we could experiment with the different variables more.

Honestly, we both thought that the tornado would only be affected by water temperature in a very minor way, but we were proved wrong. As the temperature increased, the diameter of the funnel began to increase substantially as well. We read on the website how the diameter of the funnel would start to diffuse and start getting smaller at around 60°C, so we assumed that was the case; however, our tornado actually began to grow even larger, even after reaching 60°C, which shows how our results differ from the results online.

Conclusion

Overall, our experiment seemed to go very well. We were very happy with our results and are fully convinced that water temperature does in fact influence the factor of tornado funnel diameter. We were convinced even before we did the experiment due to the tests that we read online; however, our results were even more accurate than theirs which further proves the fact that water temperature affects tornado diameter.

The connection between tornados and dry ice with water is actually pretty simple once you know the background information. Since tornados are formed by two currents of different temperatures and altitudes colliding, it only makes sense that it can be compared to dry ice and water, due to how dry ice and water react. When the dry ice comes in contact with the water, the reaction is similar to a real tornado due to it having two substances of different temperatures reacting.

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