SCIENTISTS IN THE FIELD

Where Science Meets Adventure

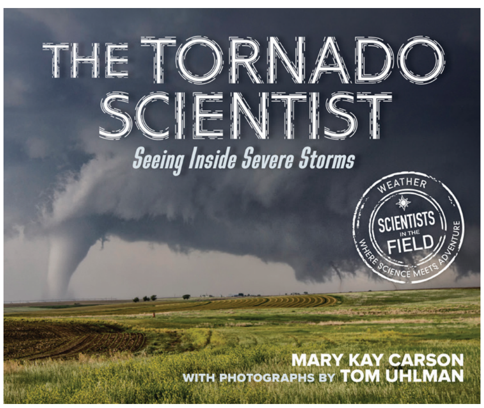
DISCUSSION AND ACTIVITY GUIDE

The Tornado Scientist

by Mary Kay Carson, photographs by Tom Uhlman

About the Series

The Tornado Scientist is part of the award-winning Scientists in the Field series, which began in 1999. This distinguished and innovative series examines the work of real-life scientists doing actual research. Young readers discover what it is like to be a working scientist, investigate an intriguing research project in action, and gain a wealth of knowledge about fascinating scientific topics. Outstanding writing and stellar photography are features of every book in the series. Reading levels vary, but the books will interest a wide range of readers.



The Tornado Scientist
by Mary Kay Carson
Photographs by Tom Uhlman
9780544965829

About the Book

Robin Tanamachi has been captivated by tornadoes and extreme weather her entire life. She now studies tornadogenesis, or how tornadoes form, and what causes them to weaken versus strengthen. For her, driving around in a Doppler radar truck aiming toward storms is a normal day in the office. The data she collects is then modeled and studied on computers—with math, physics, and computer science working hand in hand with meteorology. At the end of the day, knowing exactly how, when, and where these violent storms happen can give more warning time for everyone involved.

About the Author

Mary Kay Carson has always loved science and earned her college degree in biology. After serving in the Peace Corps, Mary Kay began her award-winning writing career by working on a classroom magazine, *SuperScience,* for Scholastic. She became a freelance writer and has written more than thirty books for young people. She lives in Cincinnati with her photographer husband Tom Uhlman. This is the sixth book in this series that she has done with Tom.

About the Photographer

Tom Uhlman has been a freelance photographer for more than twenty years. He enjoys taking all kinds of photographs but his favorite is nature photography. He often works with his wife, Mary Kay Carson, on books for young readers. This is Tom's seventh book in this series.

Pre-reading Activities

Perhaps some of your students have seen *The Wizard of Oz* or *Twister*. These movies and other folklore about tornadoes have spawned much misinformation about tornadoes, how they form, and steps for staying safe. Brainstorm with students about the definition of a tornado, how they form, and how to stay safe. Your list is likely to include a mix of factual, partly true, and totally false information. Keep this list on hand as you proceed through the book, and remove, validate, and revise as required.

What does the word *weather* mean? How is weather different from climate? What does meteorology mean? Make a list of weather terms, including basic words such as storm or storm chaser. Before reading, make sure students are well versed in the vocabulary they are likely to see in this book.

Since much of the focus in this book involves changes in the way information is collected, it may be useful to have a discussion about the value and limitations of technology. What advantages does experiencing an actual storm in person provide over watching one online? What are the risk factors of chasing a storm? When does the risk outweigh the benefit of gathering information? Does technology blind us to certain aspects of storms? Is the United States at the forefront of climate, weather, and tornado science? What are other countries doing in terms of meteorology research?

Have students write down predictions about what would happen to their town should a tornado visit. Does your town have an emergency response system? Would all residents be notified in time to move to shelter? Would there be safer places to be? Would folks know what to do? Obviously, this activity may require editing depending on your location and depending on its past experiences with tornadoes. If used, make sure to correct or supplement information that is not accurate. Predictions are not about being wrong or right, but predictions that are based on a completely false premise can be dangerous. Correct the premise (gently) and have students make a new prediction.

It may also be useful to have a discussion about our fears and phobias. Some students are terrified by lightning and that other students will love nothing better than a thunderstorm. Establishing a safe environment for discussing our fears and our misunderstandings and our knowledge is always useful.

Make a list of all the times students have done something outside of their comfort zones. What, if anything, do these activities have in common? Were there any activities that were worth the adrenaline rush? Are there activities that were not worth the risk?

Make a list of jobs that students would refuse to do regardless of the rewards. Are any of these jobs ones that involve physical risks? How many students are afraid of heights, confined spaces, severe weather, or being completely in the dark?

Discussion Questions

Scientists are often called upon to state the facts germane to irrational fears. However, scientists must be very careful when disseminating facts lest they cause folks to panic. What is the role of scientists in issuing something like an evacuation order? Some folks insist that it is not the job of scientists to issue evacuation orders. The job of scientists is to observe what is happening and discuss potential outcomes, including the likelihood of each outcome. It is the job of public officials to issue things like evacuation orders. What happens, however, when science and government disagree? Should the scientific arms of government, places like the National Weather Service, EPA, NOAA, or NASA, be allowed to have the final say on evacuation orders and similar orders?

The mission of VORTEX Southeast, to which Robin and other scientists belong, is to save lives through science and to educate the public on how to keep safe. The news is full of claims that risks of severe weather or global warming are greatly exaggerated. What is the role of science in confronting skepticism about scientific exploration? What should the government response be in terms of weather science? When does science demand perfection and when does science ask us to take bold risks? Is it harder for scientists to confront popular perceptions? What should happen when scientists confront government policy that is not supported by current scientific research? Reread the first two paragraphs of Seeing with SWIR on page 56 and the last paragraph on page 62.

Have you or anyone with you ever panicked in severe weather? What about in a dark or unfamiliar place? What calmed you or the person with you down?

What steps did you take or would you take to remain calm in the face of danger? Think about chasing a tornado or flying into a hurricane. On a scale of one to ten, with ten being not comfortable and one being extremely comfortable, rank the likelihood of your following in the footsteps of these scientists.

Think about a career that you can see yourself doing. What are the risks of that job in comparison to the risks faced by the storm chasers?

Many people regularly complain that we underestimate their abilities. What one person sees as a risk, someone else sees as being relatively safe. What is something you do that other people may not understand? If this question does not seem to apply to you, explain why chasing a tornado is safe.

Think about something you enjoy doing. Now think about the sacrifices you would be willing to make in order to keep doing this activity. How much are we willing to sacrifice in order to do a job we enjoy? When does the price of the sacrifice force us to move on to other activities? Now change the terminology from "something you enjoy doing" to "something that must be done." Is there still a point at which the sacrifices are just too much?

What do we need to do as a country to make sure that the average citizen has a better understanding of what is involved in an ongoing research project as complicated as one that tries to predict tornadoes in Dixie Alley? What steps would you take to explain to a non–science oriented group of people what we mean when we speak of a scientific theory versus the way this group may use the word *theory*?

One of the main thrusts of this book is using information to make sure people take the necessary steps to be safe. This need to use information as the basis for action, however, is balanced against the harm that one may cause by overstating the problem. What would you do to make sure that the tragedy that threw Andrew Ellis about a quarter of a mile and killed his entire family does not happen again without causing serious economic and social problems by overstating the likely risks?

Applying and Extending Our Knowledge

Tornadoes are storms of swirling winds that at their most powerful are capable of lifting homes into the air and completely destroying them. Yet many children have difficulties understanding and explaining our invisible air. Imagine you are in charge of finding ways of showing very young students that air exists, has a weight, and is able to move at a variety of speeds in different, sometimes swirling, directions.

- In groups, come up with three different ways to demonstrate the existence of invisible air.
- Explain to these young students how to weigh air and (assuming that your group can access scales, etc.) teach them how to weigh air.
- Set up two fans that will not influence each other. At varying distances, put other students whose job it is to signal when they feel the air from the fans. Have one fan operate at low speed and the other at high speed. Play around with the distances until students are able to determine a method for measuring wind speed.
- Tornadoes are classified by their estimated wind speed inferred from damage and other factors. Have students write a skit that shows the differences among breezes, drafts, winds, strong winds, Santa Ana winds, as well as the levels of tornado winds. Compare tornado winds to hurricane winds, typhoon winds, and other weather phenomena that produce winds. Create graphs that show the ranges of wind speeds. Have students predict the speeds of benign winds, such as breezes. When is a breeze too slow to be considered a breeze? When is a breeze too fast to be called a breeze? Etc. Groups may have different ideas about speeds of various winds, which should produce interesting arguments. Students who have read carefully may even introduce other factors that influence how winds gain or lose speed. Arguments should refer to specific page numbers in the text that supports their rationales.
- Have students select music for different types of winds, tornadoes, and speeds. Different wind speeds may need different types of music to serve as a model for ranges of wind speed. Add dance movements. Create a variety of dances that explain the differences in the wind depicted. Have groups add a rationale for the music selected

as well as the moves. Make sure the group can explain the differences that would be needed to distinguish a tornado from a high wind advisory, a typhoon, hurricane, etc.

Common Core Connections

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CCSS.ELA-Literacy.SL.7.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.
CCSS.ELA-Literacy.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
CCSS.ELA-Literacy.W.6.1(a-d) Write arguments to support claims with clear reasons and relevant evidence.
CCSS.ELA-Literacy.W.6.2 Write informative texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of content.
CCSS.ELA-Literacy.RI Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

Many students will be familiar with the movie, *The Wizard of Oz*. If not, show the clip in which Dorothy is leaving the traveling medicine man up to the scene showing the house landing on the witch in Oz. You may have students who have experienced trauma caused by tornadoes, either personally or in their family. Be ready to listen and provide other ways to explore the power of tornadoes.

- Students will be the fact checkers for the movie. Have them evaluate the evacuation procedure of Dorothy's family, the video of the tornado (Is it a realistic video and to what degree?), the dropping of the house from one location to another that happens to be on top of a person. Have students annotate and evaluate using the Pinocchio scale (or make up your own). Have students fact-check sites for models of how to write annotations of what is known, unknown, or questionable in the movie's presentation of factual materials. Encourage students to cite sources.
- In a twist, have students figure out the weight, the air seal, and the shape of a house that a tornado could lift intact and drop in a different location. If the houses have the same shape, weight, and construction materials, what is the smallest tornado that could lift and move a house, or is it impossible? Play around with the weights, shapes, and materials of the houses. Have students use Animoto (or other video software) to show how the tornado would lift the house.
- There are several websites that show how the Oz movie makers made the tornado and how they tested it before producing the movie. Have students construct a realistic tornado (as well as possible). Assign different groups to make tornadoes of different powers using the Enhanced Fujita (EF) Scale.

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On page 3 we read: "Alabama, Georgia, and Tennessee might not be the first places you'd name when thinking about dangerous tornadoes. But they should be." Where do we find tornadoes?

- Show a map of the United States and have students point out where they believe tornadoes have touched down and when.
- Use a map printout of the United States and place push-pins in it to show all the places in the country that have experienced a tornado. Think about using color-coded pushpins to show the strength of each tornado. Make sure to use a large enough map. You may need to add a filter to reduce the number of pins. (Note: There are approximately 1,200 tornadoes that touch down each year. Part of the rationale for this activity is to see how students handle information overload and adjust.)

When the map is completed, have students inspect it and write a paragraph on what they think it shows. Share all of these reflections to create a classroom document explaining the map. Do a video using this map and explain to viewers where they are not likely to experience a tornado and where the risks are the greatest.

- Using your map, have students attempt to find the times that these tornadoes hit. Using a world map, show other places in the world that experience tornadoes and the times.
- Make a map with an overlay showing all types of weather-related occurrences that involve high winds. In this case, you may wish to distinguish the type of event in addition to or in place of the strength of the weather phenomenon.
- Create a presentation that describes the various types of tornadoes and show where they are most common, and when they are most likely to occur. Make sure the presentation shows how various types of tornadoes form and build strength using the Enhanced Fujita (EF) Scale. Compare tornadoes in this presentation to other types of destructive weather events.

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GPS devices locate precisely where tornadoes touch down, using longitude and latitude lines. These measurements function as the guides that allow the tornado scientists to monitor precisely where each tornado is located.

- Find the longitude and latitude of your school.
- Using Google Maps, zoom in to the location of your school. Print out maps for students and have them insert and label a grid showing the precise location of the classroom.

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Starting on page 2 and continuing throughout this book, Robin and her team are described as storm chasers. The phrase "storm chaser" means something quite different than it did even ten years ago.

- Take a look at the long-range weather forecasts from *Farmers' Almanac* and other sources. Would anyone use these predictions for planning purposes? How has weather forecasting changed from a hundred years ago to today?
- How much faith do we have in tornado predictions? Ten years ago, what would "storm chaser" imply? How much faith do we have today in other severe weather predictions? Make sure students consider Robin's computer calculations of the Greensburg tornado.
- Look at short-term weather predictions (forty-eight hours or less). How accurate are these and what value do they have for planning purposes? Make a chart showing all the different ways we use and rely on weather predictions. Attempt to track the reliability of using these predictions. If we wish to have citizens evacuate their homes, is there a percentage of accuracy required? How should a community handle a situation in which, say, a family relies on a government prediction of a tornado and evacuates their home, the tornado does not hit, and while the family is away, their house is robbed. Debate this in class.
- Discuss how difficult it can be to predict the weather, even if you are a trained meteorologist. Discuss the challenges scientists might likewise face in predicting whether or not a tornado will touch down and its potential strength..
- We see in the text that predicting tornadoes in the Midwest seems to be easier than it is in the South. Have students research whether Robin and the team of scientists investigating Dixie Alley have made any progress since this book was published.

The Tornado Scientist

BY MARY KAY CARSON, PHOTOGRAPHS BY TOM UHLMAN

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We learn that VORTEX, or the Verification of the Origins of Rotation in Tornadoes Experiment, attempted to discover the causes of dangerous tornadoes. We also learn that in 2009 and 2010 VORTEX2 "took tornado research to the next level" (p. 14). One of the findings of VORTEX2 is the fact that tornadoes have life cycles.

- Using Animoto (or similar animated software or illustrations), make a video showing the life cycle of a tornado. Either in the video or in the annotation of the video, have students explain the difference between convection cells and supercells. Have groups of students make videos based on the Enhanced Fujita (EF) Scale. Or students could make a video comparing and contrasting an EF-0 tornado with an EF-5 tornado. Students could create a biographical sketch of Tetsuya Fujita.
- Make trading cards that define categories of tornadoes and the vocabulary that meteorologists use when discussing tornadoes. Use the terms found in the sidebar on page 21. Add words such as, convection cells, supercells, mesocyclone, thunderhead, and CAPE.
- Make an online presentation showing the life cycles of other severe weather events. Compare and contrast thunderstorms, typhoons, cyclones, hurricanes, and even something as different as a tsunami or volcanic eruption or earthquake. These natural events often have a genesis (compare with tornadogenesis) that includes a similar amount of known and unknown factors, along with a working theory.
- Make a glossary of all the different natural disasters that the class brainstorms together. Have students put together a soundtrack and dance moves that help younger students understand the differences between tornadoes and other types of natural disasters that involve strong winds.
- Chapter 7 states that "Robin's testing some new equipment that could help get tornado warnings out faster" (p. 55). Later it goes on to describe a special camera set-up that includes a regular video camera and a SWIR (shortwave infrared) camera. Prepare an online or graphic description of this new SWIR camera showing how it works and how it coordinates with the camera.

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The discussion questions include queries about what we know versus what we think we know. Climate science is full of misinformation about what we mean by things such as global warming or the difference between climate and weather. Students may not be able to distinguish between what a tornado is when compared to a twister, typhoon, or cyclone. Do we have deep knowledge or a casual understanding of these terms? Do we know the ways that scientists use vocabulary? What is the state of meteorological information in your area?

- Have students design short surveys that capture information about how well your area understands science terms. Do folks in your area know the difference between a tornado and a typhoon? Tornado and hurricane? Do they know the difference between an EF-0 tornado and an EF-5 tornado? Try to limit the questions so that it does not take the person answering the survey more than five minutes.
- If necessary, share some of the many online tools with students on how to design useful surveys and how to display and share the results. In general, questions that have specific answers are easier to graph and share. Yet specific questions often do not reveal misunderstandings about concepts. When the surveys are completed, have the students spend time exploring the limitations of the information.
- After analyzing your data collected, have students design lessons or presentations that correct common misunderstandings or provide deeper understandings.

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Perhaps the first reports of a tornado will include a description of the dollar amount of the destruction. Several photographs in this book attest to the devastation. The federal government as well as state governments will quickly attempt to provide financial aid to areas impacted by tornadoes.

- Research news reports and other government documents that show the monetary damage inflicted by various tornadoes. Can students find the most costly tornado? Remember that any discussion of the harm caused by a tornado cannot factor in a monetary value for the loss of life. Depending on your students' experience with tornadoes, this activity may require adjustment. Graph the financial loss resulting from ten of the larger tornadoes. How does this loss influence the way we value tornado research?
- Compare the destruction caused by a tornado with the destruction from other natural disasters. Make sure students factor in the cumulative destruction that approximately 1,200 yearly tornadoes may cause, ignoring those that touch down in remote areas causing little or no damage.

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Other Websites to Explore

In addition to the web resources listed on page 68, students may find these sites useful.

National Geographic has a webpage with links to videos and other information about tornadoes: www.nationalgeographic.com/environment/natural-disasters/tornadoes

NASA has all kinds of links, including a link comparing hurricanes, typhoons, and cyclones: pmm.nasa.gov/education/articles/what-hurricane-typhoon-or-tropical-cyclone

And so does the Smithsonian: ocean.si.edu/planet-ocean/waves-storms-tsunamis/hurricanes-typhoons-and-cyclones

Live Science has current information on the debate over the ways in which tornadoes form: www.livescience.com/64309-weird-way-tornadoes-form.html

Fun Stuff takes an interesting look at the tornado in *The Wizard of Oz*: how did movie makers make the tornado in the *The Wizard of Oz*? fun-stuff.americablog.com/2013/05/how-they-created-the-tornado-in-the-wizard-of-oz

The National Weather Service has information on various types of severe weather: www.weather.gov

Further Reading

In addition to the books listed in the bibliography on pages 70–71:

Carson, Mary Kay. *Inside Tornadoes.* New York: Sterling, 2010. Mary Kay Carson's Inside series features clear explanations of the science behind many topics related to meteorology. These books span grade levels of approximately third grade through middle school. Seek out *Inside Weather* or *Inside Hurricanes*, etc., for other useful sources related to this book and this guide.

Simon, Seymour. *Tornadoes*, revised edition. New York: HarperCollins, 2017.
Like Mary Kay Carson, Seymour Simon has a long history of writing excellent nonfiction books for elementary through middle school students. He does a series for the Smithsonian that includes *Earthquakes, Volcanoes*, and others. He also has his own weather and hurricane titles.

Simons, Kevin M. *Economic and Societal Impacts of Tornadoes.* Boston: American Meteorological Society, 2011.

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