Tornado Alley Film
Summative Evaluation Report

September 15, 2014

RMC RESEARCH

Tornado Alley Film
Summative Evaluation Report

Submitted to:
Deborah Raksany
Giant Screen Films
500 Davis Street Suite 1005
Evanston, IL 60201

Submitted by:
Elizabeth Goldman
Kim Streitburger
RMC Research Corporation
1000 Market Street, Bldg. #2
Portsmouth, NH 03801

September 15, 2014

CONTENTS

CONTENTS

Appendices

Executive Summary

Tornados can occur anywhere in the U.S., but most occur in “tornado alley”—a broad swath of the country’s heartland that stretches from Georgia in the East to the Rocky Mountains in the West. And despite decades of research, tornados remain scientific mysteries.

The VORTEX2 research project, funded by NSF and NOAA, is the most ambitious attempt yet to understand tornados—their origins, structure, and evolution. Directed by Sean Casey of TV tornado chasing fame and featuring the scientists and missions of VORTEX2, the *Tornado Alley* film and the surrounding project elements were designed to “bring science to life”, engaging audiences in the excitement of scientific research and the stupendous technologies involved in investigating these awe-inspiring and terrible weather phenomena, and model science as a “cool” career for young people. The *Tornado Alley* project contained five elements:

- The 3-D, large format *Tornado Alley* film;
- A *Tornado Alley* Educator’s Guide, website, and resources;
- Professional development workshops utilizing cybertechnology to allow museum-based informal science educators and formal educators interact remotely with VORTEX2 researchers and experience visualizations of weather data, and to subsequently conduct related educational programs in their own communities;
- Outreach using the tornado intercept vehicles (TIV) and Doppler on Wheels (DOW) to bring scientists and weather-monitoring technology into direct contact with audiences at museums and science centers; and
- Outreach using scientists, the TIV and DOW and a traveling 3D projection system to present elements of the *Tornado Alley* film and featured weather research technology to tornado-affected and underserved communities.

Each element of the project was evaluated independently using a mix of quantitative and qualitative data gathered through surveys, interviews, and focus groups. Findings are presented here in terms of project goals; individual descriptions of each *Tornado Alley* element appear in following sections.

Within the project’s overarching goal of **communicating weather science research and information to public and professional audiences,** eight specific goals were enunciated:

- to increase audience members’ **factual knowledge** of science
- to increase audience members’ understanding of the **scientific process** and **the work scientists do**
- to increase audience members’ **knowledge of technologies used in weather science**
- to increase audience members’ **interest in participating in scientific endeavors**
- to increase **student interest in weather science and careers**
- to increase **teacher confidence in teaching weather science and related STEM topics**
- to increase scientists’ **confidence and interest in sharing their work** with wider audiences
- to incorporate project resources in **educational curricula or programming**

The *Tornado Alley* project addressed the overarching goal through all five elements, most directly through the film itself and the outreach efforts. Introduced in 2011, the film was seen by more than 5 million viewers as of the date of this report, and is anticipated to reach over 7 million during its theatrical life. Educator materials, including an educator guide, posters, and a website, have reached thousands. (Nearly 600,000 visitors have accessed the website to date.) The museum-based outreach efforts significantly supported the film in the majority of US venues: 67 museums or science centers, or over 80% of exhibitors, hosted the TIV and/or the DOW vehicles, and over 200 unique events were held at the 79 institutional theaters. A very conservative estimate for the audience directly reached through these activities (those who physically toured a vehicle, had a conversation with a scientist, etc.) is 150,000 across the US, although at least 250,000 likely experienced at least a passive interaction. Outreach to tornado-affected communities included activities at 7 sites in 2012, considered a pilot phase, and at 20 sites in 2013. Venues ranged from small museums without theaters to community centers and school gymnasiums to challenging "untraditional" sites—such as a warehouse space located adjacent to trailers being used as temporary classrooms in a town that had been completely leveled by a recent tornado, or a special section of a Lowe's Home improvement store which hosted the screenings indoors and provided a community resource fair featuring researchers, first responders, etc. outdoors in its parking lot. The program's second phase in 2013 emphasized outreach to economically underserved areas—both urban and rural. Programs were held in areas of Missouri, with high minority populations, such as Ferguson, MO, as well as Indian Reservations in South Dakota, located in the nation's poorest county (Buffalo County, SD). The professional development program enabled the development of at least fourteen new models for informal science practitioners who seek to engage audiences (teachers, students, or families) with tornado science, the nature of scientific research, or data analysis content.

Factual Knowledge of Science

Surveys from potential and actual viewers and focus groups with viewers of the *Tornado Alley* film highlight some key knowledge gains reported by audience members. Primary among them were a greater understanding of the scientific process and more, and new knowledge about how tornados form. Following the film viewing, most participants could describe the process of tornado formation as "warm, moist Southern air colliding with the jet stream" [focus group participant]; some offered more detailed descriptions, noting factors such as air pressure differentials. Many gained new insights into issues such as storm intensity as well. Asked for specific topics they wished to know more about, focus group participants named tornado frequency and variations in tornado strength. Most film viewers contacted said they intended to continue learning about tornados, including conducting online research and observing weather more carefully. Topics they anticipated exploring included Vortex 2 research findings, information about studying tornados, and the science behind tornados.

All nine educators surveyed on their use of the *Tornado Alley* educator guide rated the activities somewhat or very highly. Two-thirds of them reported using the "Make a Tornado" activity, chiefly with elementary school students; one-third used activities related to wind speed and direction ("How Fast is the Wind Blowing" and "Which Way is the Wind Blowing") and pressure differentials ("Under Pressure") in teaching middle school students. Educators typically used the activities before screening the film, explaining that the activities built prior knowledge and generated interest in the film and in learning more about tornados. Noted one teacher, "[the activity] increases the retention of the information from the film," adding that students were able to recall information about tornados in the days following their viewing. One educator pointed to the merits of hands-on activities, such as those in the educator guide, in student learning: “The need to see for themselves how things work”. Educators were also able to tie science content related to tornados and weather to other curricular areas, such as Earth science, electricity, and mathematics (for example, calculating the ratio of tornado strength to tornado damage).

Educators who took part in the professional development workshop also registered gains in their knowledge of tornado formation, confirmed by their grantee partners, half of whom said teachers probably gained weather content knowledge through exposure to their *Tornado Alley* project. And judging by the kinds of questions rural and tornado-affected outreach audiences asked the scientists, understanding the science of tornados was important in their lives and it may be assumed that they knew more science after the event than before.

It should be noted, however, that scientists involved in the outreach effort were surprised by the extent of inaccurate and outdated knowledge of tornados and appropriate precautions among audiences, and worked to reverse those misunderstandings.

The Scientific Process and the Work of Research Scientists

As distinct from gaining factual scientific knowledge, participants in *Tornado Alley* also registered very strong gains in their understanding of the scientific process and how scientific research proceeds. Film viewers identified a greater understanding of the work of weather researchers, particularly with respect to the length of time a research project entails and massive amounts of data collection for such a project. A major take-away from viewers was the impact and importance of studying tornados. All focus group participants correctly identified the goal of the Vortex 2 research project as to better understand tornados in order to alert people and give them more time to prepare.

Educator and secondary school focus group participants also emphasized the amount of work involved in studying tornados and the length of time analyzing all that the data entails. Some expressed surprise at how well-organized and extensive tornado research is; others cited a new understanding of tornado study as a serious occupation. Participants also described insights into factors that impel scientists into weather research, such as the scientists’ passion and determination. Some participants expressed interest in knowing about the “next steps” in tornado research.

Professional development participants also expressed surprise at learning the extent and scale of tornado research. They noted increases in their understanding of collecting data on tornados and in the data analysis methods used in weather research and a Phase II outreach scientist reported that audiences seem to come away from the *Tornado Alley* events with increased respect for the necessity of tornado preparation and the challenges in collecting scientific data about tornados.

Knowledge of Technologies Used in Weather Science

The technologies used in studying tornados, particularly the DOW (Doppler on Wheels) and TIV (Tornado Intercept Vehicle), had an undeniable “wow” factor for audiences. The vehicles provided a rare glimpse of a tornado’s interior for film viewers. Post-viewing survey respondents showed considerable gains in identifying a host of technologies used in weather science, including those used to create three-dimensional maps of winds and supercell storm structures. Asked what they learned about conducting research on tornados, most focus group participants cited the advanced tracking technologies; students also inquired about how the equipment is secured during a tornado and how scientists retrieve lost pods.

At live events on the outreach tours, the presence of the vehicles—especially coupled with drivers and scientists who used them—was a powerful draw, bringing increased numbers to museum and community events. The fact that participants were able to explore the vehicles first-hand and ask questions of experts on site increased media and social media coverage as well as interest in viewing the film. As *Tornado Alley* staff explained in interviews, the "cool car" aspect of the vehicles—"they look like tanks and drive into tornados", according to one scientist—appealed to students strongly and was a natural entrée into discussions of careers in weather science.

Capacity and Interest in Participating in Scientific Endeavors

The issue of actually participating in scientific research as citizen scientists came up in surveys and conversations with film viewers, although chiefly as a less daunting alternative to the kind of work *Tornado Alley* scientists do. Even so, fewer than half of all survey respondents said they would decline practicing citizen science, citing the possible dangers, lack of time, and age constraints.

Student Interest in Weather Science and Careers

Post-viewing survey respondents rated their interest in weather science careers more highly than pre-viewing respondents, and previous knowledge of *Storm Chasers* or the *Tornado Alley* website appeared to increase interest in weather science careers. Overall, a quarter of survey respondents reported that after viewing the film, they could see themselves working in severe weather research. Student focus group participants expressed great admiration for the weather scientists: for some, the work looked exciting and adrenaline-filled while for others it seemed terrifying. Notably, interest in weather science careers grew for males but dropped strongly for females, although in the *Tornado Alley* outreach efforts, the female research scientist seemed effective in reaching women with weather science content and technologies.

Students who took part in outreach events may have had their interest in weather science and STEM careers especially strengthened by the encounter with the TIV and DOW vehicles. The community coordinator in North Dakota described her students' experience as "fun, engaging, and a good introduction to STEM careers." Outreach presentations to elementary schools sought to evoke students' interest in the vehicles as a way to introduce the work of weather science researchers; presentations to secondary school audiences had a strong focus on career pathways. Scientists noted that student audiences in Joplin, MO, were very receptive to discussions about STEM careers. Two younger scientists noted strong interest in meteorological careers among high school students. The project technician noted that the presentations also opened students' eyes to a range of ancillary careers related to weather science research, such as mechanical engineering, AV technologies, filmmaking, and logistics management.

Teacher Confidence in Teaching Weather Science and Related STEM Topics

Museum grantees in the professional development workshop and projects noted that while each project was different, all projects aimed at offering formal educators knowledge and tools for teaching weather science using Vortex-2 research as context. Half of the grantees surveyed suggested that exposure to the project had increased participating educators' content knowledge about weather science and their overall confidence in teaching science.

Educator participants in the professional development workshop found their personal interactions with Dr. Kosiba supportive and a highlight of the workshop. A few still sought more grounding in basic science, however. The grantee who conducted a session on IDV software and Vortex 2 data felt that the session increased participants' capacity to analyze real weather data and piqued interest in using real data in classroom teaching. Indeed, the one grantee who dedicated considerable time to learning how to use the IDV software and data sets went on to create a teacher's guide for working with this complex data.

Educators surveyed about the educator guide rated it highly as an introduction to the study of weather, weather terminology, data collection, and the work of scientists and was a valuable support in teaching the science behind the *Tornado Alley* activities. Suggestions offered by educators concerned ways to enrich the study of weather science—for example, more explicit lesson plans for using the project activities and additional resources on specific aspects of weather science research.

Outreach to tornado-affected areas was characterized by a stronger focus on STEM education and careers, particularly in Missouri, where the project partnered with the state Math and Science Coalition to stress the importance of the STEM study and careers in *Tornado Alley* school presentations.

Scientists' Confidence and Interest in Sharing Their Work

All of the Tornado Alley scientists were skilled communicators, with considerable experience presenting their work to both professional and general audiences: their confidence and interest in sharing their work were high even before the *Tornado Alley* project. The project touched many of them personally as well. Particularly in communities such as Joplin, scientists found the exchange with residents mutually rewarding, useful, and meaningful. The community coordinator in Missouri observed the acute sensitivity with which scientists described their work to Joplin residents, mindful of their recent losses. Fauteux noted that none of the other work he had done in his 12-year career was "quite as worthwhile" as his *Tornado Alley* outreach experience. This suggests that this work had an emotionally fulfilling component that went beyond confidence and interest.

Incorporation of Project Resources into Educational Curricula or Programming

The *Tornado Alley* project created a wealth of resources, both for formal and informal educators and science center programmers. In addition to the resource of the film itself, project staff developed posters and a *Tornado Alley* website, the educator guide, and professional development in teaching weather science. Most of these resources also contained links or connections to other resources to expand participants' study of tornados and weather science. *Tornado Alley* project resources were obviously used by educators who conducted *Tornado Alley* activities and also linked the materials to related curricula such as math. Educators involved in the professional development workshop reported learning a great deal about available resources for teaching weather science. Non-material resources also made available to educators were assistance from Dr. Kosiba and other weather science researchers at the National Center for Atmospheric Research, in addition to the in-person interactions with the project outreach staff.

Conclusion

Tornado Alley has proven to be a very effective platform for reaching audiences with weather science content and students with compelling STEM content. Science centers that hosted the project reported attracting unusually large audience and in particular, new and diverse audiences. Over the course of the project, *Tornado Alley* and project scientists were featured in more than 100 media outlets (radio, television, print, Web). At the same time, the project enabled scientists to learn more about public audiences' interests and needs.

Viewers of the *Tornado Alley* film reported knowledge gains in their understanding of tornado formation, the scientific process, technologies used in weather science research, and the work of research scientists. Student interest in STEM study and careers was piqued by exposure to the project through a rich combination of visually dynamic film footage, encounters with tornado research technologies, and encounters with professional scientists.

Educators also registered knowledge gains through participation in the project and, critically, grew more comfortable teaching STEM topics through the study of weather and tornados. Scientists took part in informative dialogues with audiences that enriched their understanding of science content relevant to general audiences and found the project personally meaningful. The *Tornado Alley* resources and materials are still in wide use.

Evaluation Methodology

Film Evaluation

In order to understand the impact of the *Tornado Alley* film on wide audiences, RMC employed a quantitative study design using pre-viewing and post-viewing surveys. Survey data were collected on-site at the Science Museum of Minnesota (SMM) and the McWane Science Center (MCW) in Birmingham, AL. In addition, the study was augmented by qualitative research using focused discussion groups. Qualitative data were collected from post-viewing groups from The Maritime Aquarium (MA) in Norwalk, CT and the Arizona Science Center (ASC) in Phoenix.

The study employed a quasi-experimental design, in which responses of viewers and pre-viewers of *Tornado Alley* were compared to illuminate the film's effects on learning and interests.

The pre-viewing group comprised individuals randomly selected online to see the film, and the post-viewing or viewer group comprised people who were leaving the theater after seeing the film. This design ensured that respondents were not pre-disposed to look for specific information by pre-viewing questions, while also ensuring that pre-viewing and post-viewing groups resemble one another not just in terms of demographics, but in terms of a shared interest in seeing the film.

Distinct questionnaires were developed for pre- and post-viewers, although there were overlapping knowledge and attitude questions for comparison purposes. These included questions in which respondents in both groups were asked to identify a correct answer from a series of options related to factual information presented in the film, and to provide the names of technology tools presented in the film.

On other questions, respondents were asked to assess their current knowledge of the research and science of tornados and the responses of pre-viewing and post-viewing audiences were compared. To obtain possible previous knowledge about tornados, respondents were asked about their exposure to the *Storm Chasers* TV series and the *Tornado Alley* website. In addition, a number of questions were designed specifically for post-viewers and included ratings of the film and of particular content themes. See Appendix A and B for viewer surveys.

Six focus groups (52 participants) watched 2- or 3-D versions of *Tornado Alley* at The Maritime Aquarium in Norwalk, CT (2-D) and the Arizona Science Center (ASC) in Phoenix (3-D). Because technical issues prevented the screening at the time of scheduled focus groups, ASC focus groups were conducted via videoconference. Focus group participants were recruited by the museums. The focus group survey and protocol can be found in Appendix C and D.

Educators' Review of Educator Guide

Nine educators (5 elementary, 4 middle school level) used the educator materials associated with Tornado Alley before and/or after bringing their class to view the film and completed an online survey. The survey questions are listed in Appendix F.

Professional Development Workshop and Grant-Funded Community Projects

The Franklin Institute in Philadelphia, PA, and the Center for Severe Weather Research developed a professional development curriculum for a two-day workshop for invited informal science and K-8 educators. RMC Research developed a survey to obtain information about the knowledge gains from participants and reflections on the workshop experience. The participant survey can be found in Appendix G. The RMC Research evaluator observed the workshop and administered a paper survey to participants at the end of the workshop.

In addition, reflection questions were sent to Karen Elinich, the workshop developer and facilitator to obtain her perspectives on the strengths and challenges of the workshop. The facilitator questions are listed in Appendix H.

Workshop participants were encouraged to apply for a mini-grant to conduct local community projects associated with *Tornado Alley* (see Appendix I for grant application). The Franklin Institute forwarded the project applications to RMC Research for informing the development of an interview protocol for project coordinators once their projects were completed (see Appendix J). The evaluators conducted eight 20-minute interviews with project coordinators about the successes of their projects, challenges, and perceived impacts on their audiences.

On-Site Outreach Evaluation

After visiting each outreach site, Deborah Raksany of Giant Screen Films requested museum host(s) and site coordinators to take an online survey about their outreach experience. (See the online survey for museum hosts in Appendix L and the site coordinator survey in Appendix M). Eighteen surveys were received by representatives of 15 museums and 14 surveys were received from representatives of 12 outreach sites, which could be a school, community center, or other site. Telephone interviews were also conducted with site coordinators; one from Joplin, MO and one from a Native American Indian school in South Dakota. The interview protocol is presented in Appendix O.

Giant Screen Films provided RMC Research with the contact information for *Tornado Alley* project staff, including the Vortex2 scientists. Evaluators conducted half hour interviews with three scientists and two technicians. The interview protocols are found in Appendix N.

I. Tornado Alley Film Evaluation

METHODOLOGY

In order to understand the impact of the *Tornado Alley* film on wide audiences, RMC employed a quantitative study design using pre-viewing and post-viewing surveys. Survey data were collected on-site at the Science Museum of Minnesota (SMM) and the McWane Science Center (MCW) in Birmingham, AL. In addition, the study was augmented by qualitative research using focused discussion groups. Qualitative data were collected from post-viewing groups from The Maritime Aquarium (MA) in Norwalk, CT and the Arizona Science Center (ASC) in Phoenix.

Pre-Viewer Post-Viewer Questionnaire

The study employed a quasi-experimental design, in which responses of viewers and pre-viewers of *Tornado Alley* were compared to illuminate the film's effects on learning and interests.

The pre-viewing group comprised individuals randomly selected online to see the film, and the post-viewing or viewer group comprised people who were leaving the theater after seeing the film. This design ensured that respondents were not pre-disposed to look for specific information by pre-viewing questions, while also ensuring that pre-viewing and post-viewing groups resemble one another not just in terms of demographics, but in terms of a shared interest in seeing the film.

Distinct questionnaires were developed for pre- and post-viewers, although there were overlapping knowledge and attitude questions for comparison purposes. These included questions in which respondents in both groups were asked to identify a correct answer from a series of options related to factual information presented in the film, and to provide the names of technology tools presented in the film.

On other questions, respondents were asked to assess their current knowledge of the research and science of tornados and the responses of pre-viewing and post-viewing audiences were compared. To obtain possible previous knowledge about tornados, respondents were asked about their exposure to the *Storm Chasers* TV series and the *Tornado Alley* website. In addition, a number of questions were designed specifically for post-viewers and included ratings of the film and of particular content themes. See Appendix A and B for viewer surveys.

Survey Data Analysis

All survey data were entered, validated, and stored in an SPSS data file. Pre-viewing and post-viewing group equivalency tests were performed on the demographic data by using chi-square analyses. Likewise, chi-square tests were performed on the categorical data to identify differences in knowledge levels between the groups.

Responses were disaggregated by gender and age to uncover any differences in respondent characteristics. In addition, assertions of prior knowledge of the *Storm Chasers* TV series and the *Tornado Alley* website were analyzed for potential differences in respondents' awareness. Findings across groups and significant differences within groups are presented within the report.

Open-ended survey questions were coded and entered into the SPSS data file. The frequency of the various responses could then be calculated.

Findings are presented in the sections below, and include survey results relevant to the film's overall appeal and effect on learning. Note that subgroup (e.g., gender, age, knowledge of *Storm Chasers* TV series, and knowledge of *Tornado Alley* website) analysis of quantitative data is included only when results vary significantly from one group to the next. A significant difference is defined within this report as having a p-value less than or equal to .05. Findings from the focus group discussions follow the survey results.

SURVEY RESPONDENTS

A total of 300 pre-viewer surveys (150 each from SMM and MCW) and 296 post-viewer surveys (146 from SMM and 150 from MCW) were completed. Across all demographic dimensions the two groups were roughly equivalent except for age and educational background. There were significantly more respondents under the age of 18 and fewer older respondents in the post-viewer group compared with the pre-viewing group. Due to the age difference in groups it is not surprising to also see a significant difference in the educational levels of the viewer and pre-viewer respondents. About one third of the viewer group (35%) had not yet obtained a high school degree, compared with the pre-view group, of whom 14% had not yet attained this educational level. Table I1 presents the demographics on the respondents.

Table I1. Number and Percentage of Respondents for Demographic Characteristics by Film Viewing Time

		Pre-Viewers % (n)	Post-Viewers % (n)	Total % (n)
Gender				
	Male	41% (111)	37% (101)	39% (212)
	Female	59% (157)	63% (172)	61% (329)
Age*				
	Less than 18	15% (40)	38% (103)	27% (143)
	18-30	25% (68)	25% (68)	25% (136)
	Over 30	60% (160)	37% (100)	48% (260)
Education*				
	Elementary	7% (19)	12% (32)	9% (51)
	Middle School	7% (19)	23% (61)	15% (80)
	High School	25% (66)	13% (35)	19% (101)
	College Graduate	43% (114)	41% (112)	42% (226)
	Graduate Degree	18% (49)	11% (30)	15% (79)
Familiarity with IMAX films				
	None	15% (40)	10% (28)	13% (68)
	1-3	50% (135)	47% (127)	48% (262)
	4-6	20% (55)	24% (64)	22% (119)
	7+	15% (39)	19% (52)	17% (91)

		Pre-Viewers % (n)	Post-Viewers % (n)	Total % (n)
Knowledge of *Storm Chaser* TV series				
	Know nothing	43% (127)	46% (128)	45% (255)
	Know something	46% (136)	44% (122)	45% (258)
	Know a lot	11% (32)	10% (27)	10% (59)
Knowledge of *Tornado Alley* website				
	Know nothing	77% (225)	74% (203)	75% (428)
	Know something	20% (55)	22% (60)	21% (117)
	Know a lot	3% (10)	4% (12)	4% (22)

*Significantly different

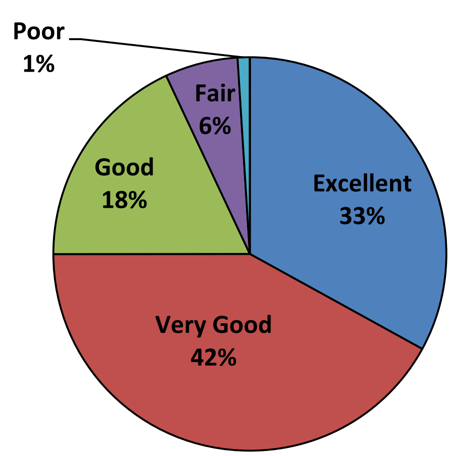
SURVEY FINDINGS

Appeal and Interest: Film Ratings

Respondents who had seen the film were asked to indicate their rating of the film overall on a scale from 1=poor to 5=excellent. The overall mean rating for the film was 4.0 (very good).

Three out of four viewers (75%) rated the film either excellent or very good. An additional 18% rated it as good, and the remaining seven percent rated the film as either fair or poor. Graph I1 below presents the detailed results.

Graph I1. Percentage of Post-Viewers by Film Rating



Subgroup Differences (Age). Adults over 50 gave the film the highest ratings (4.2), followed by 31-50 year olds (4.1), and those 18-30 (4.0). The most critical group, those under 18, rated the film between good and very good (3.8).

Rating Comments. Viewers were asked to provide any comments about why they gave the rating that they did. Comments were gathered by the rating level and examined for similarities and differences. Of those giving the film an excellent or very good rating, the most commonly used words were: “informative”, “educational”, “entertaining”, “interesting”, and “exciting.” Many of these viewers also reported giving this rating because of the visual effects. In addition, some mentioned that the film was "well presented" overall. Typical comments from this group include:

> *Engaging/interesting depiction of technologies and difficulties with learning about tornados*
>
> *I like looking at what's going on in our world.*
>
> *It was gripping and informative at the same time.*
>
> *My family has been through tornados and it was awesome to learn the science behind it.*
>
> *Kept my interest throughout, made me want to learn more*
>
> *I gave it this rating because it kept you engaged and was very interesting*
>
> *A wealth of information!*
>
> *It put me into their perspective and was personable*
>
> *The shots were amazing*
>
> *Beautifully captured and explained well*
>
> *I'm a storm chaser myself, very good info, great that we are getting to the point of getting closer to earlier notification.*
>
> *I used to live in Tornado Alley- so I am extremely familiar with the subject matter; very well done.*
>
> *Great photography and explanations*

A few viewers who gave a "very good" rating also said it was "a little slow but good", "good pace, good info, interesting but had slow points", "it needed more information about the science of tornados", "would have liked more actual footage and less story." One respondent commented, "I only wish there was more aftermath footage."

Of the 18% of viewers giving the film a "good" rating, some explained their rating in terms of already knowing the information presented in the film, boredom, lack of interest in tornados, and wanting more information or more footage. Responses included:

> *It was repetitive and I knew many of the things.*
>
> *Mostly about people chasing tornados not about the research.*
>
> *Interesting info but a bit slow at times.*
>
> *I wish they would have shown more actual footage of storms, even if they were not tornados.*

For those who rated the film "fair" or "poor" and offered reasons, generally comments concerned the film's slow pace, a lack of excitement, and a desire for better visuals.

I felt there was too much focusing on the trucks and equipment and not enough storm footage – lighting, thunder, rain would even help!

Recommend the Film. On an open-ended question about whether viewers would recommend the film to others and why or why not, the majority said yes, they would recommend the film to others (90%), and very few reported they would not (6%) or only maybe (4%) recommend the film.

Those who would recommend the film to others explained that the film was “educational”, “informative”, “interesting”, and overall presented well. In addition, the theme of educating the public about safety was mentioned as a reason for telling others about the film. These are similar reasons as to why viewers gave the film a high ranking. Quotes from viewers include:

Absolutely! It was educational and presented in an interesting fashion.

Already have [recommended]; great look at how the process works.

Yes, because it creates an understanding of weather issues; should be shown to Congress.

Yes, because it has excitement and info. It can also get people into weather.

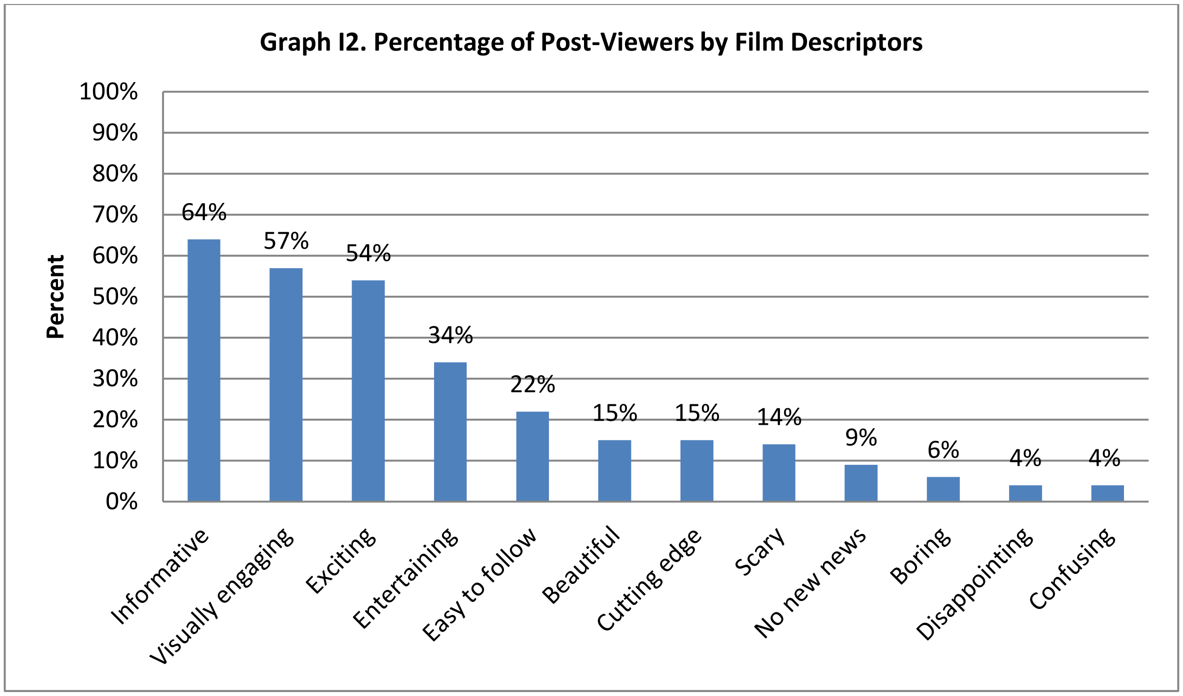
Yes, it allows a deeper appreciation for those that are willing to do the research and protect lives.

Yes, so they can understand why it is important to stay clear and they can see the inside of a tornado.

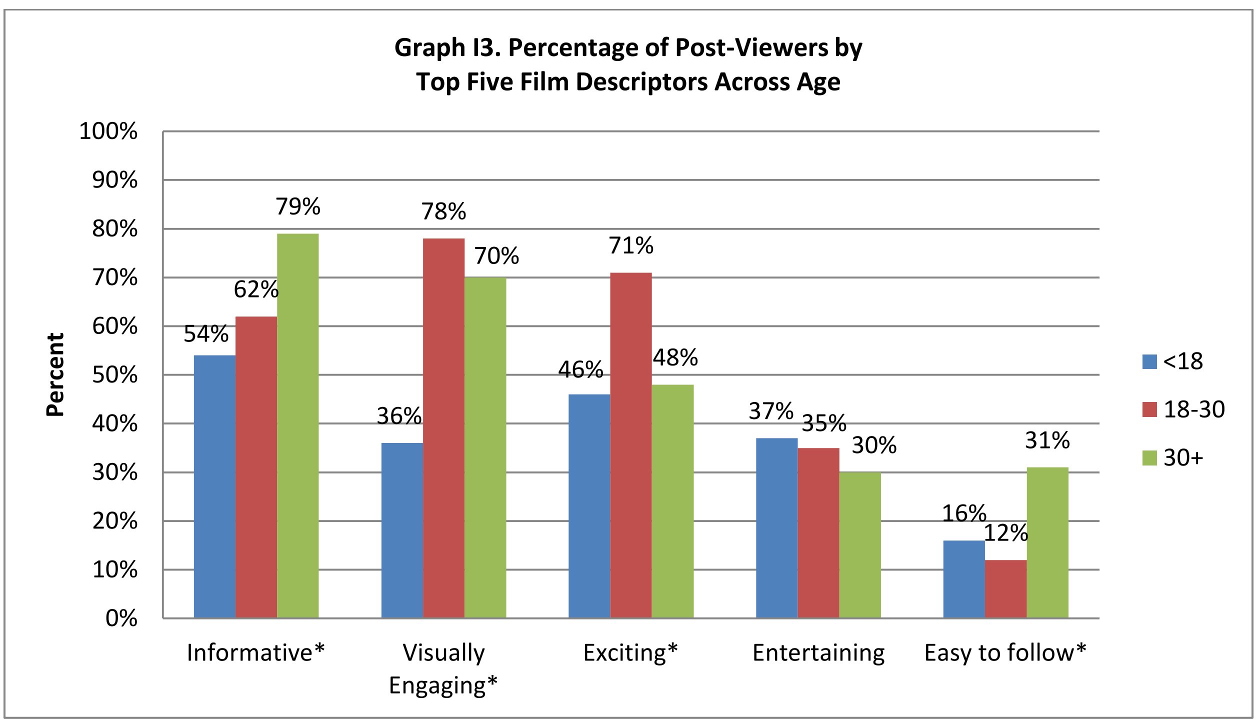
The few comments from those who said they would not recommend the film generally described the film as “boring” or “dull”. Several viewers noted that recommending the film to others would depend on the person’s interest in science or weather.

Appeal and Interest: Descriptors

Viewers were asked to select the three descriptors that best fit the film from a list of twelve words or phrases. The following phrases were the top selections of the group overall: Informative (64%), Visually engaging (57%), Exciting (54%), Entertaining (34%), and Easy to follow (22%). Each of the remaining descriptors was selected by fewer than fifteen percent of the viewers. Complete results are presented in Graph I2.



Subgroup Differences (Age). Although the top five descriptors were selected for each of the three age groups, their importance to each group significantly differed, except for the descriptor "entertaining". The older a respondent was the more likely he or she chose "informative" as a descriptor. The phrase "visually engaging" was more apt to be selected by those 18 or older. Respondents between 18 and 30 years old were much more likely to use the descriptor "exciting" than those younger or older. The descriptor "easy to follow" was selected by significantly older respondents than younger respondents. The chart below presents the comparative results for the top five descriptors.

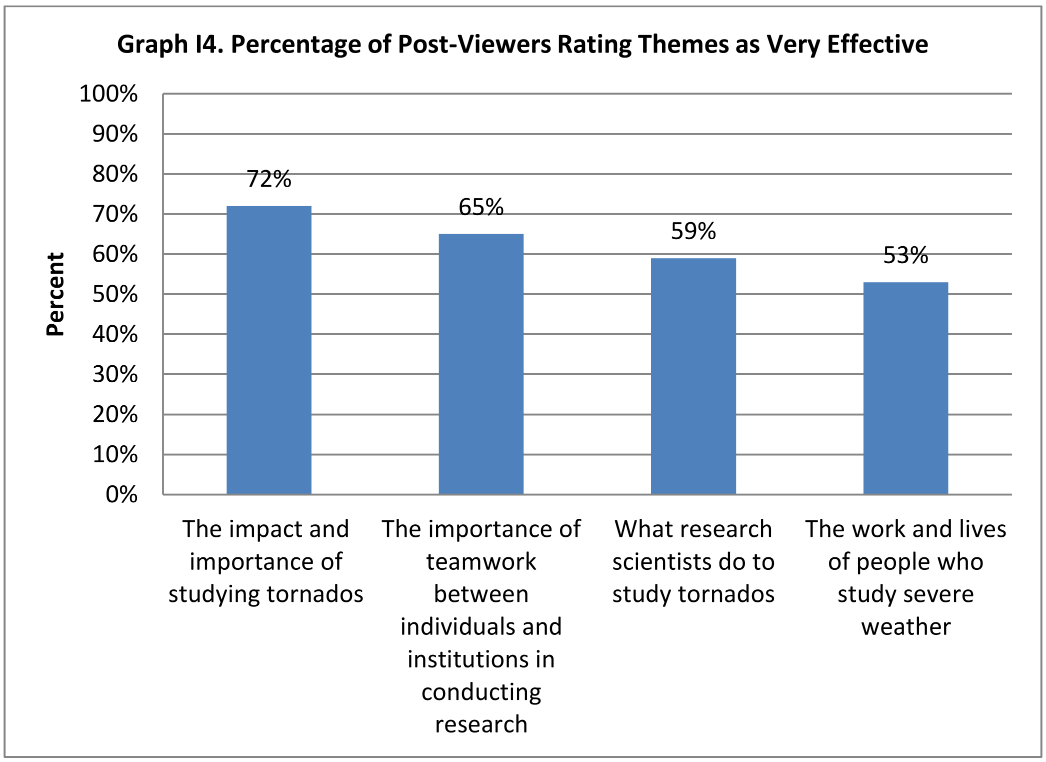


*Significantly different

Appeal and Interest: Science Content Themes

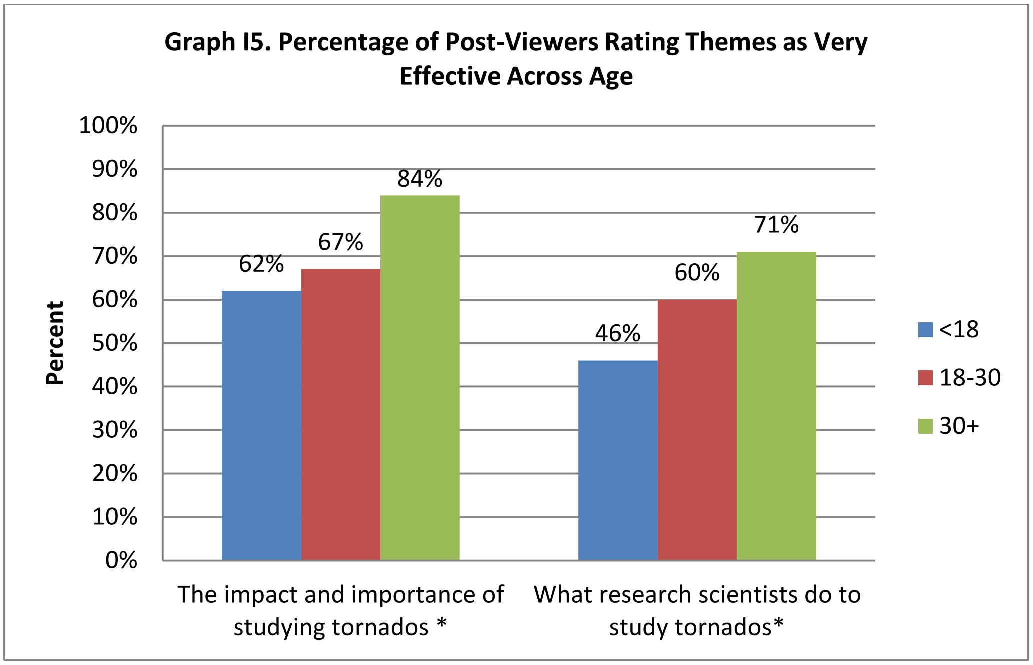
Viewers were asked to rate the effectiveness of the themes presented in the film on a scale of 1= not effective, 2= somewhat effective, and 3= very effective. All themes received strong ratings, with means falling mid-way between somewhat effective and very effective (2.5-2.7), and only minor variations in means from one question to the next.

Responses are presented in terms of frequencies of "very effective." The most effective theme was the impact and importance of studying tornados (72%); followed by the importance of teamwork among individuals and institutions in conducting research (65%); what research scientists do to study tornados (59%); and lastly the work and lives of people who study severe weather (53%). Graph I4 presents the results.



Subgroup Differences (Gender, Age, Knowledge of *Storm Chasers* TV Series). Female viewers rated two of the four themes significantly higher than their male counterparts. For the effectiveness of showing what research scientists do to study tornados, females were much more likely to give a "very effective" rating (66%), compared with males (49%). Similarly, a higher percentage of females felt the work and lives of people who study severe weather was very effectively presented in the film (58%), compared with males (46%).

Survey results show that the older a respondent was the more likely he or she was to indicate that the presentation of what research scientists do to study tornados was very effectively covered in the film (less than 18, 46%; 18-30, 60%; over 30, 71%). Older respondents were also more apt to give the highest effectiveness ratings to how the film presented the impact and importance of studying tornados (less than 18, 62%; 18-30, 67%; over 30, 84%).



*Significantly different

Those viewers who had some or a lot of knowledge about the content of the Storm Chasers TV series were significantly different in their ratings of the effectiveness of the film's presentation of the work and lives of people who study severe weather. More than three-fifths of viewers with knowledge of the TV series (63%) rated this theme as very effective, while less than half of viewers with no knowledge of the TV series (42%) gave the theme a "very effective" rating.

Learning: Topic Knowledge (Self-Ratings)

Pre-viewing and post-viewing respondents were asked to rate their knowledge of various topics addressed in the film on a scale from 1 to 3 where 1= don't know anything, 2=know something, and 3=know a lot.

The majority of pre-viewing respondents rated their current knowledge as "not knowing anything" about the Vortex2 research project (77%) and the length of time it takes for a weather research project to be conducted (73%). Topics a bit more familiar to pre-viewers were the scientific process (48% don't know anything), and technologies used in researching tornados (40% don't know anything). Fewer than 30% of pre-viewers reported not knowing anything about what severe weather researchers do (29%) and the forces that contribute to tornado events (27%) prior to watching the film.

Respondents indicated significant knowledge increases in all topic areas between pre- and post-viewings of *Tornado Alley*. The percentage increases from "don't know anything" to "know something" or "know a lot" are as follows:

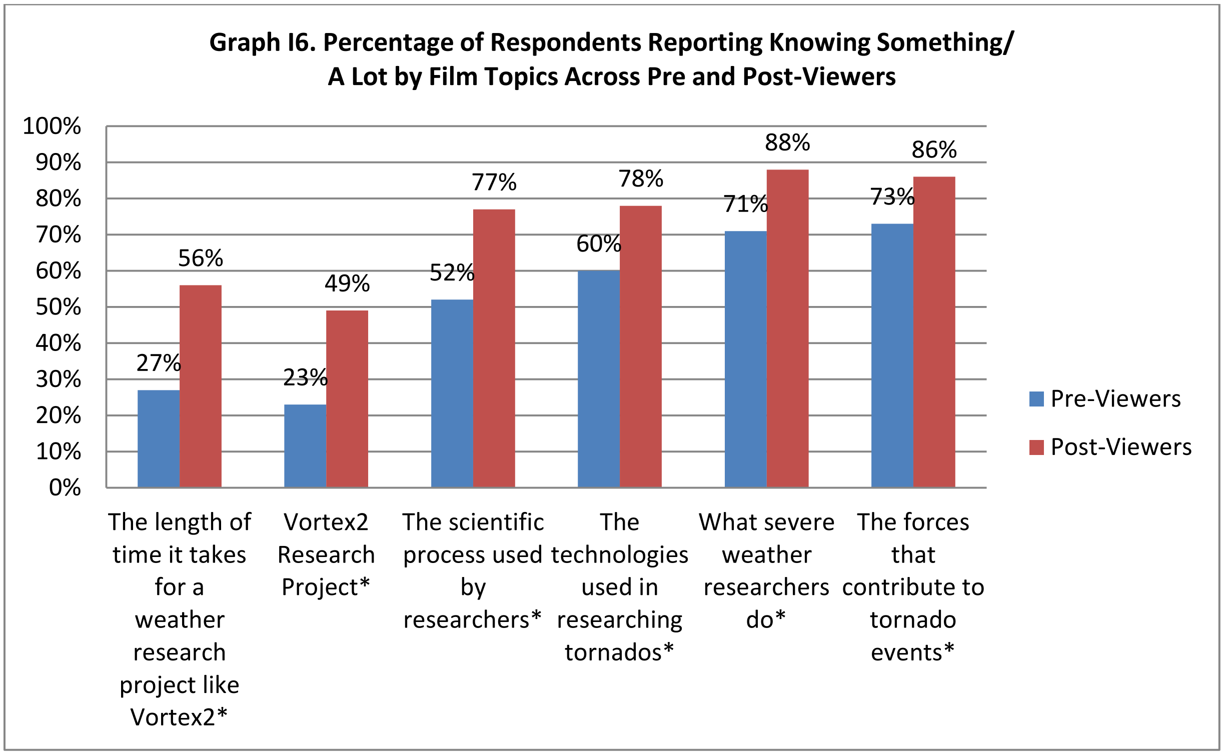
Greatest Gain in Knowledge

- *The length of time it takes for a weather research project like Vortex2 (29% increase)*
- *Vortex2 Research Project (26% increase)*
- *The scientific process used by researchers (25% increase)*

Moderate Gain in Knowledge

- *The technologies used in researching tornados (18% increase)*
- *What severe weather researchers do (17% increase)*
- *The forces that contribute to tornado events (13% increase)*

Graph I6 below presents results for the comparison of pre-viewing and post-viewing respondents with regard to self-identified knowledge levels. Topics have been ordered from greatest to least change in knowledge, based on the increase in the total percentages of "knows something" and "knows a lot".



*Significantly different

Subgroup Differences (Age). Significant knowledge gains were seen across all three age groups on:

- The *scientific process* used by researchers

Significant knowledge gains were seen for the older age groups on the remaining topics:

- The *length* of time it takes to develop a weather research project like Vortex2
- *Vortex2* Research Project
- The *technologies* used in researching tornados
- *What severe* weather researchers do
- The forces that contribute to tornado events

Table I2 below indicates significant knowledge gains by topic and age subgroup. An asterisk '*' represents a significant knowledge gain.

Table I2. Significant Knowledge Gain by Topic Across Age Group

	Age		
	18 or younger	18-30	Over 30
The length of time it takes for a weather research project like Vortex2		*	*
Vortex2 Research Project		*	*
The scientific process used by researchers	*	*	*
The technologies used in researching tornados		*	*
What severe weather researchers do		*	*
The forces that contribute to tornado events		*	*

*Significant knowledge gain

Learning: Tornado Science Facts (Multiple Choice Questions)

Pre-viewing and post-viewing respondents were asked a couple of multiple choice factual questions based on topics addressed in the film.

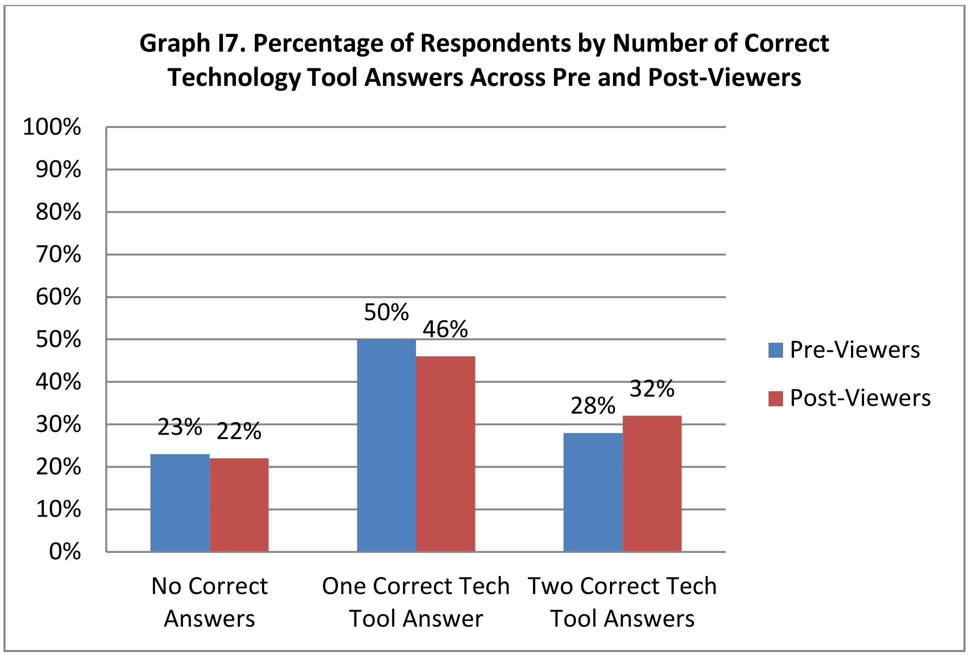
1. Which of the following factors might contribute to the formation of a tornado:
    a. Winds moving in different directions at different speeds
    b. Temperature of a downdraft wrapping around the rear of a storm
    c. Warm, buoyant air at the surface of a storm
    d. All of the above (CORRECT ANSWER)
    e. One of the above
2. Which of the following conditions is NOT studied by scientists researching tornado genesis (formation):
    a. Temperature
    b. Humidity
    c. Wind speed
    d. Acidity of rainfall (CORRECT ANSWER)

Over 80% of all survey respondents answered these questions correctly. The first question asked about factors that might contribute to the formation of a tornado. A higher percentage of pre-viewers answered this question correctly (85%) than did post-viewers (78%). As discussed in the previous section, many pre-viewing respondents (73%) reported knowing at least something about the factors/forces that contribute to tornado events which may explain the high percentage of respondents answering correctly.

Similarly, the question on conditions not studied by scientists researching tornado genesis was answered correctly by slightly more pre-viewers (89%) than post-viewers (87%).

Learning: Use of Technology by Scientists (Open-ended Questions)

Pre-viewers and post-viewers were asked to name two technologies or tools that scientists use to study severe weather. Correct answers included: Doppler radar, pods, mobile mesonets, anemometer, computer, stick nets, barometer, thermometer, camera, or general terms such as rain/wind meters or gauges. Incorrect answers included: satellite, sensors, and any mentions unrelated to technology tools. A respondent's answers were scored into three ratings: no correct answers, one correct answer, and two correct answers. There were no differences between the pre-viewers and post-viewers with regard to correct answers to this question. About half of all respondents answered with one correct response. A slightly higher percentage of post-viewers provided two correct answers than did pre-viewers, but the difference was not significant. Graph I7 presents the percentage of respondents by pre- and post-viewing for the number of correct answers.



The second open-ended question posed to respondents was to name the technology scientists use to create 3-D maps of the winds and structure of supercell storms. Answers that included Doppler radar, radar, or Doppler were considered correct. Although fewer than half of all the post-viewers answered correctly (47%), that was a significant difference from the percentage of correct answers by respondents who had not seen the movie (23%).

Subgroup Differences (Gender, Age, Knowledge of *Storm Chasers* TV Series, Knowledge of *Tornado Alley* Website). While significantly more post-viewers answered the question correctly for each subgroup studied, the increase varied within subgroups. The subgroups showing positive knowledge increases were aggregated by gender, age, knowledge about *Storm Chasers* TV series, and knowledge about the *Tornado Alley* website. A substantial gain is identified by a pre-post percentage change of 35% or more.

Females tended to have a substantial knowledge gain when comparing pre-viewers answering correctly (26%) and post-viewers (74%).

The subgroup with the largest gain in answering this question correctly was that of respondents under 18 years of age. Only 14% of pre-viewers answered it correctly, compared with 86% of post-viewers, a knowledge gain of 72 percentage points. The 18-30 year olds also had a substantial gain of 46 percentage points: 27% of pre-viewers answered it correctly, compared with 73% of post-viewers.

Respondents who reported not knowing anything about the content of the *Storm Chasers* TV series showed a substantial gain in knowledge. One third of pre-viewers answered the open-ended question correctly, compared with 68% of post-viewers.

Those respondents who said they knew something or knew a lot about the content of the *Tornado Alley* website had larger knowledge gains (38 percentage point increase) than those who reported not knowing anything (30 percentage point increase). However, those not knowing anything also had significant knowledge gains as a result of seeing the film.

The results of the subgroup analysis are summarized in Table I3 below. As mentioned above, all subgroups had significant knowledge gains, indicated by '*'. Those with a percentage point increase of 35% or more are indicated by '**'.

Table I3. Significant Improvement in Knowledge Gain about Doppler Radar

Gender		
	Male	*
	Female	**
Age		
	18 or younger	**
	18-30	**
	Over 30	*
Knowledge of *Storm Chasers* TV Series		
	Know Nothing	**
	Know Something/A lot	*
Knowledge of *Tornado Alley* Website		
	Know Nothing	*
	Know Something/A lot	**

*Significant gains <35 percentage points **Significant gains 35 percentage points or more

Motivation: Interest in Tornado Topics

Pre-viewing and post-viewing surveys contained questions for rating current interest levels in some of the film's topics, including the hobby of storm chasing, careers of weather science professionals, technologies used in research tornados, and the forces that contribute to tornado events. Respondents were asked to rate the topics from 1 to 3 where 1=not at all interested, 2=somewhat interested, and 3=very interested.

The only topic with a significant gain in interest was that of the careers of weather science professionals. Less than half of the pre-viewers (49%) indicated they were somewhat or very interested in the careers compared with almost 60% of post-viewing respondents (58%).

Subgroup Differences (Gender, Age, Knowledge of Storm Chasers TV Series, Knowledge of Tornado Alley Website). Survey results indicate that females' interest in the hobby of storm chasing significantly decreased after viewing the film. Pre-viewers were more apt to be somewhat or very interested (69%) compared with post-viewing respondents (54%).

Males had significant gains in interest in the careers of weather science professionals. A little over half of the pre-viewers were somewhat or very interested in the careers (51%) in comparison with more than sixty percent of post-viewers (64%).

For respondents with some knowledge about the content of the *Storm Chasers* TV series, interest in careers significantly increased. The percentage of pre-viewers indicating they were somewhat or very interested in the careers (56%) was much lower than the percentage of post-viewers (66%).

There was a significant positive interest in weather science careers among those who knew nothing about the Tornado Alley website. Fewer than half of the pre-viewers were at least somewhat interested in the careers (42%), compared with more than half of the post-viewing respondents (53%).

Motivation: Interest in Work of a Severe Weather Researcher

Almost three quarters of the viewers could not see themselves doing the work of a severe weather researcher (74%). There were significant differences by gender, knowledge of the *Storm Chasers* TV series, and knowledge of the *Tornado Alley* website on this question. Over forty percent of the males could see themselves doing this work (42%), compared with females (16%). Those with some or a lot of knowledge about the content of *Storm Chasers* were more likely to say they could see themselves as researchers (32%) in comparison to those with no knowledge (21%). Similarly, viewers who knew something about the Tornado Alley website were more apt to report a positive reaction to being a researcher (41%) than their counterparts with no knowledge of the website (22%).

The most frequent reason given by viewers who pictured themselves as researchers was the excitement the job would bring and their personal interest in tornados and weather. Other reasons cited were interest in science or other related careers, such as, engineering, physics, or photography; being part of scientific study team; and work that fulfills a social need.

Most of those who could not see themselves working as a severe weather researcher felt it was "too dangerous", "scary," or "risky." Other reasons were of a practical nature, such as, "no interest", "too time consuming", "already in/headed for another career", or "age prohibitive."

Motivation: Interest in Participating as a Citizen Scientist

Post-viewers were asked if they could see themselves participating in a science research activity as a "citizen scientist" and why or why not. More viewers tended to potentially see themselves as citizen scientist (42%) than a severe weather researcher (26%) described above. However, there were no differences by gender or knowledge of *Storm Chasers* or the *Tornado Alley* website.

Those who indicated an interest in being a citizen scientist generally cited the learning opportunity and the importance of contributing to scientific research. Viewers were interested in learning more about storms, weather, science, the environment, and scientific research. Others felt participating would be helpful in saving lives and adding to science research.

Almost half of the post-viewers indicated they would **not** be interested in participating in science research as a citizen scientist (47%); a small number (11%) said maybe. Their reasons were similar to those who could not see themselves doing the work of a severe weather researcher, such as no interest in the topic, the potential danger involved, the time required, and age limitations.

A few viewers reported not knowing if they would be interested, due to unfamiliarity with the term "citizen scientist."

Motivation: Curiosity about Tornados

More than 60% of the viewers said they were not left with any questions or curiosity about tornadoes as a result of watching the film (63%). The older a viewer was the more likely he or she was to indicate curiosity about tornados (under 18, 21%; 18-30, 44%; over 30, 48%). Those who were not familiar with the Tornado Alley website at all were more likely to indicate curiosity (42%) compared with those with at least some knowledge of the website (26%).

Of those viewers indicating a curiosity after watching the film, most were interested in knowing about the findings from the research project and whether improvements been made to warning systems. A few viewers wanted to know more specifics about the film, such as the speed of the tornadoes and the vehicles in the film or the location of the filming.

Motivation: Website

In an open-ended format, viewers were made aware of the Tornado Alley website and asked whether they would likely visit the website, why or why not, and what they would be interested in finding there.

Almost half of all viewers indicated they would visit the website (46%) because generally they are interested in learning more about storms, tornado formation, and weather information. A few viewers said it would be a way to share with kids; one viewer thought sharing the website with local teachers was a good idea.

As to what they hoped to find on the website, most specified wanting to find current status of the project or Vortex2 research updates. Some indicated an interest in seeing scientist profiles, more about the technologies used, additional information about tornadoes (e.g., forces, wind speed), and tornado safety messages. A few respondents said they hoped to see more footage and pictures of tornadoes. The viewer who would recommend the website to teachers hoped basic weather information would be available at the K-12 education levels.

Of the 37% who reported they would not visit the website, few gave reasons. Those who did most commonly cited lack of interest, having learned enough from the film, time restraints, and lack of Internet access.

FOCUS GROUP PARTICIPANTS

Focus groups were conducted to illuminate quantitative findings and provide additional detail on the film's success. Focus group questions were designed to elicit film highlights, learning, and provide insight into any confusing or unclear aspects of the film.

In summer, 2013, RMC Research Corporation conducted six focus groups with a total of 52 participants who watched either 2-D or 3-D versions of *Tornado Alley*: The Maritime Aquarium in Norwalk, CT, where the film was presented in large 2-D format, hosted three focus groups; one with middle school age students (n=7) and two with adults (n=16). Participants at the Aquarium were recruited through invitations on the institution's website and Facebook and Twitter accounts.

The Arizona Science Center (ASC) in Phoenix, which showed the film in 3-D format; educators, adults, and middle school age summer campers were originally recruited to participate in one of three in-person focus groups. However, due to unusually high humidity, the film could not be shown during the day scheduled for the focus groups. RMC worked with the Science Center to reschedule and conducted the discussions virtually using a webinar format. ASC hosted one focus group with high school age interns (n=9); one with post high school staff members (n=7); and one with adults, primarily educators (n=13). All participants were given $20 as a thank you for their time and input.

The table below presents demographic background of the focus group participants by location and film format.

Table I4. Percent and Number of Focus Group Participants by Background and Film Format

		Location (Film Format) MA (2-D)	ASC (3-D)	TOTAL
Gender				
	Male	35% (8)	17% (5)	25% (13)
	Female	65% (15)	83% (24)	75% (39)
Age	Under 18	30% (7)	31% (9)	31% (16)
	18-30	22% (5)	31% (9)	27% (14)
	31-50	22% (5)	28% (8)	25% (13)
	51 and older	26% (6)	10% (3)	17% (9)
Current Education Level				
	Middle School	30% (7)	-	14% (7)
	High School	22% (5)	41% (12)	33% (17)
	College	48% (11)	38% (11)	42% (22)
	Graduate Degree or Higher	-	21% (6)	11% (6)
# of IMAX Films Seen				
	None	26% (6)	3% (1)	14% (7)
	1-3	30% (7)	45% (13)	38% (20)
	4-6	30% (7)	31% (9)	31% (16)
	7 or more	13% (3)	21% (6)	17% (9)

Notes:

- Although three out of four participants were female; more females participated in the 3-D discussions than in the 2-D discussions.
- Focus group participants in the 3-D groups tended to be younger than 31 years old, with at least a college degree, whereas the 2-D discussion group was divided almost evenly between those 30 years or younger and those over 30. Education levels ranged from middle school for 2-D participants and graduate degrees for 3-D participants. (Middle schoolers and educators were specifically targeted for this study.)
- Participants who saw the 3-D version group tended to have more experience seeing large format films than did participants who saw the 2-D version.

The focus group discussion followed the format shown in Appendix C, with initial conversations about overall impressions and favorite scenes and images, followed by a discussion of what participants learned in the course of watching the film (guided by specific questions about the research process), reactions to the research scientists, and the factors contributing to tornado formations. The discussion ended with questions about the medium and whether participants would recommend the film, and a request to finish the sentence: "before I thought________ and now I know _____________."

FOCUS GROUP FINDINGS

Motivation for Viewing the Film/ Attending the Focus Group

More than half of the Norwalk participants were drawn to the screening because of the subject matter, referencing long-standing (and recent) interests in storms and weather and in how tornado research is conducted. Five participants said the film sounded interesting or that the tickets were free. Individual responses included: learning how tornado predictions can save lives, trying something new, having seen an advertisement, "when I grow up I want to be a meteorologist," taking advantage of an opportunity to see severe weather phenomena on a large screen, and "impacting the showing."

Because of the unusually high humidity, which prevented screening *Tornado Alley* on days when focus groups had been arranged, focus groups were conducted with available museum staff (young adults), museum interns (high school students), and local adults/educators.

Seven of the Arizona Science Center interns explained their attendance as part of their internship at the Center. One said he or she wanted to learn about tornados and one was interested in offering an opinion on *Tornado Alley*.

The young adult staff at the Arizona Science Center also saw their participation as part of their work: 5 described it in those terms. One saw it as a "nice break" in the middle of the day and one was motivated by the prospect of offering his or her opinions "in hopes of contributing to an improved filmmaking experience in the future."

Three of the educators said they attended in order to offer feedback and share ideas. One regarded the focus group as a learning experience. Four were motivated by the money or gift card, although one intended to use the money for class supplies. Three educators were teaching or had just taught about weather; one intended to bring students to the film and another used a reading passage on *Tornado*

Alley in class. Three educators identified themselves as weather or tornado enthusiasts; one of them was also drawn by the 3D IMAX experience.

Overall Appeal of *Tornado Alley*

Asked about the overall appeal of *Tornado Alley*, participants were generally enthusiastic.

Many adults described it as "interesting," adding observations such as "the aerial shots were amazing; it felt like we were moving," and "[it was] nice to see [weather] from a different perspective." The photography came in for special praise by adult participants, who used terms such as "dramatic," "awesome," and "incredible." One called it "unique compared to other storm movies." Several adults wished the film had been longer—"with more action and more chasing," according to three. A small number wanted more scientific information and information about what the scientists had done with the data they collected. One adult did not like *Tornado Alley* because "There was no character development" and "[the researchers] also seemed insensitive to something that hurts so many people…I would have liked a back story to explain why these people want to chase these storms."

The middle school students appeared to enjoy the film, especially the view from inside a tornado; one student was excited to see a tornado because he or she had never seen a real one and another said he or she had wondered why tornados occur in the south but not New England, and the film "partially answered" that question.

Enthusiasm was milder among the high school interns. Four called it overall good, but had concerns about the film's neglect of people in the communities who experienced tornados. Two said they found it boring, which one attributed to overly high expectations.

While most of the young adults found the film informative (despite some motion sickness) and "a cool insight into research," with good cinematography and clear visual explanations, several found it boring, particularly at the end, which they agreed was "underwhelming."

All of the participating educators indicated they enjoyed the film; two had seen it before. One educator mentioned the clarity, and another the intensity, of the tornado visuals at the beginning for special praise. One educator especially liked how the film portrayed the life of a scientist. There was consensus, however, that the ending did not meet expectations: several participants said they wanted more "action" and tornado chasing. "I wanted to feel the suspense of being inside the tornado with the guy," said one. Many educators also expressed a wish that the film had been longer, with more tornado footage and more detail about how the researchers work and the actual locations where the tornados in the film struck. Four educators suggested that the film was better suited to educational audiences than to the general public. "There was a lack of wow!" one said.

Most Memorable Part of the Film

Six Norwalk participants found the scenes filmed from inside the tornado the most memorable in *Tornado Alley*. Five participants cited the shots of clouds, sky, and tornados generally as most memorable, while four found the scenes of post-tornado devastations most memorable. Three named the scenes of the scientists' excitement. Individual statements included attention to photography in general, learning how much work the storm chasers did, and the time-lapse sequences of storm clouds and “amazing” lightning.

Four of the high school interns at the Arizona Science Center said they found the footage from inside the tornado most memorable. Two cited scenes when “[Sean Casey] finally reached his dream” and two cited the opening scenes of tornado formation. One high school intern rated the last tornado scene most highly.

The young adult participants in Arizona also favored scenes from inside the tornado (cited by two); two of these participants also mentioned the TIV. Individual responses included Bill Paxton’s “calm and collected” narration, “oil barrels being tossed around,” and footage of the crew trying to win stuffed animals.

The educators were most varied in what they found memorable about the film. Only two cited the scenes from inside the tornado; three mentioned the filming of weather—wind, hail, clouds—and one added he or she also found memorable the computer visuals explaining how a tornado is formed. Two cited chase scenes; individual responses included “amazing visuals, clarity,” the “action” scenes, and the aftermath of the tornado. One educator identified meeting the researcher Karen Kasiba as the most memorable part of her *Tornado Alley* experience.

Favorite Images and Scenes

Three image sequences seemed to stand out for most participants overall: the sky darkening before a tornado forms, the perspective of approaching or being right inside the tornado, and the aerial scenes of post-tornado devastation.

Most educators mentioned the opening images of the sky turning from light to violent dark as the wall of cloud begins to spin and the tornado forms as most arresting. One referenced a childhood memory of a tornado: “the sky changed so quickly…that was real and was chilling from my childhood.” Adult participants used terms such as “ominous,” “eerie,” and “gave me goose bumps” in describing the darkening sky. “On TV you see the aftermath and the actual storm, but never how the storm progresses from blue sky into a storm,” said one. Some adults also named the scenes of destruction as memorable. One described the post-storm scene as “raw and eye-opening.” For a middle school student, the damage evoked memories of Hurricane Sandy.

Participants also identified the “incredible perspective” of watching the storm from the inside. Nearly all of the high school interns cited those scenes, remarking on the power evident in a tornado. Two high school interns were drawn to footage of the storm-chasing equipment. One young adult cited scenes of things flying through the wind and another cited the devastation as testimony to the power of a tornado. One high school intern and one young adult cited a scene in which conversation among researchers was audible. Calling it suspenseful, the young adult said, “It was cool to hear the background [voices], to know what goes on.”

Some middle school students and young adults were also drawn to images of the equipment and machinery. One young adult compared the TIV to a “Batmobile,” and expressed a wish to know why certain materials were used and how it was engineered. Several young adults also mentioned enjoying scenes of the tornado vehicles drive down the street with other cars and another described parts of the film as like a "fun road trip." One also mentioned the scene with the family.

Images noted as favorite by individual adults included the hail, the train, the claw scene, and cows walking backwards.

Prior Familiarity with *Storm Chasers*

All of the adult focus group participants, most of the high school interns, young adults and educators, and a small number of middle school students were familiar *with Storm Chasers*. Only a few educators and one or two adults, young adults, and high school interns had actually watched *Storm Chasers*, however. Most respondents were unaware that Sean Casey of *Storm Chasers* was involved with *Tornado Alley*.

Of the small number of focus group participants who knew of the connection, only one adult was aware of some of the backstory and Sean Casey's involvement in *Tornado Alley*. One felt Casey "short-changed" himself by only making a 40-minute movie and another felt that Casey did not convey as much excitement about his work in *Tornado Alley* as he did in other venues. One young adult indicated that *Storm Chasers* had influenced his or her view of *Tornado Alley* in that *Tornado Alley* provided greater detail about the chase and how data are collected.

While other respondents said *Storm Chasers* had not influenced their viewing of *Tornado Alley*, educators offered numerous instances of how it had influenced their viewing:

> *I watched all the episodes … I knew [Sean Casey] was filming an IMAX film and was eager to see it alluded to on* Storm Chasers*. The film wasn't as exciting on IMAX as I hoped. It was interesting to see how the scientists' lives interacted with others. It was similar to* Storm Chasers *but it lacked the IMAX punch.*
>
> *I understand the difference between Hollywood and education.* [Tornado Alley] *did a good educational job. There is a fine line between Hollywood and IMAX.* They could have pushed the border a little to be more entertaining.
>
> *I liked how it put Sean in a more positive light. Sometimes he is seen as less patient. He got to live his dream, it was what he lived for*.
>
> *At the end, [Sean Casey] says he waited eight years for that moment. …. I feel sorry for him. He did all this work and didn't get that much.*
>
> *This film seemed family friendly, not scary. Everybody was very professional.* Storm Chasers *seems more like reality TV. …. I didn't want this film to portray "crazy people" going out there.*

Likelihood of Recommending *Tornado Alley* to Others

Some adult focus group participants were vocal about recommending this film. "Amazing" and "Absolutely!" said some, noting that there are "more tornados in this area [New England] and it helps give us perspective" and "weather patterns are changing and we should know more about this." Others felt the film was good for people who would like the visuals, describing them as “cool,” “captivating,” and “fascinating.” One said he or she would recommend the film on Facebook. Other adults were more measured. “Depends on the audience,” said one, and another added, “I have seen better IMAX films…weather is not as dynamic as animals.” One adult stated he or she would not recommend the film; two others saw the information presented as too entry-level and could be boring for people who are knowledgeable about tornados.

Some adults said they saw the film as appropriate for elementary school students; one would recommend it to scientific colleagues, and a third to people who would want to see Sean Casey reach his goal. They also identified groups to which they would not recommend the movie, including people not interested in science and people (including high school students) who already know a lot about this topic. One adult would not recommend it to children and one conjectured that “people who live in Tornado Alley might laugh” at it.

All members of the focus group of middle school students said they would recommend the film, giving it five stars and calling it “amazing.” High school interns said they would also recommend the film, primarily to friends, but many cautioned that, while they might recommend it, some of their friends don’t like science. “They would have to be like me and like science,” noted one. Added another, “I’d recommend it even if they got annoyed.” Some said they would recommend it to people who are really “into weather” and one specified that “Third grade up would enjoy it…they would think it is cool.” One middle school student said he or she would recommend it to a family in Tornado Alley but not to someone in a city where tornados don’t happen. Several said they would recommend the film based on the vehicles and how they were constructed, although one felt there should have been more information on the TIV**.**

The young adults unanimously would recommend the film to friends, but not to very young children or to people “who actually had had tornado experiences,” as one said. Referencing a camp for students ages 6 to 12 held at the Phoenix Science Center, one young adult noted that all campers went to the show and “wanted to see it again.” A couple of educators said they would recommend the film but not as one “you gotta see.” Educators recommended the film for a range of students—about second grade level, fifth grade, and fourth grade on up. They felt the film was educational and a good way to learn about data. “The film is not great but I would have them watch it,” said an educator. Another said it would depend on cost, that it shouldn’t exceed two dollars.

Medium: 2-D and 3-D Format

The adult focus group participants watched the film in 2-D and many seemed relieved, saying “3-D may have been too intense,” and that the IMAX treatment alone was “gripping enough.” One adult noted that “if it had been 3-D, I would not have come,” and elicited broad agreement.

The middle school students, who also saw the film in 2-D, were more open to the 3-D experience. Although all of the middle school students felt that the film in 3-D “would have been awesome, or cooler,” they found the IMAX 2-D version fine and preferable to a “regular movie or TV screen.” Many pointed to the film’s realism, particularly the sound effects. The high school student interns were a little less enthusiastic about 3-D; several calling the IMAX vision alone overwhelming, particularly the closeups of people's faces; others, however, said they liked the large-screen format, and while some parts were overwhelming, "some parts were good on the large screen."

The young adult and educator focus groups were held in Phoenix, Arizona, and both groups screened a 3-D version of *Tornado Alley*. Young adults were mixed on the value of 3-D. One person said he liked it and thought "kids and families would be more interested" in the 3-D version. Others either do not like -3D in general, report that it gives them headaches, and that "3-D increases your expectations, so I went into expecting to have a crazy tornado experience in 3-D. I was underwhelmed. 2-D would have been better."

The educators appeared to like 3-D somewhat better; only one person dismissed 3-D and prefers 2-D. However, 3-D appeared to raise expectations for educators as well: "I expected to feel it hitting us," said one, and "3-D invites the whole idea of wanting more, like more action." One educator said the film felt more like a simulation, that "you're not there but this is what it would be like" and another referenced a forthcoming Sean Casey 3-D film shot with two lenses, explaining that *Tornado Alley* was shot with one lens.

Points of New Learning

Asked to identify some of the most interesting new things they learned from the film, focus group participants most often named learning about how tornados form, followed by learning about collecting data on tornados. (Two adult participants said they did not learn much about tornado formation and would have liked more information.)

Middle and high school focus group participants also named learning how tornados form as a point of new learning. A few middle school students cited learning about the role of the Gulf of Mexico in tornado formation and the role of mountains in blocking them. Several of the high school interns expressed interest in learning how powerful and harmful tornados actually are. There was also general agreement among young adult participants that they learned primarily about how tornados form—"what has to happen [with] the warm and cold air," as one put it.

By far the greatest impression on students, however, was the amount of work involved in studying tornados, and how long it takes to analyze data. "I didn't know studying them was so difficult or risky or what was involved in chasing them," offered one student. Educators were also intrigued by how data are collected "and how much work it is to chase that data down."

For most adults in focus groups, the number of people collecting data, and "how organized … and devoted they are" was a new insight. One adult mentioned learning about how big "Tornado Alley" really is: "Your first reaction is to stop living [there] but then you realize that Tornado Alley is actually a very large area."

Both students and educators were also intrigued by the equipment—how the scientists learned to use radar, how they secured the equipment, and the many approaches they took to gather tornado data. One educator planned to use the story of building the TIV with students.

For another educator, a chief point of learning was how "a real scientist would gather this kind of knowledge, how they surround it to measure it from all angles." Another educator reported that *Tornado Alley* deepened his or her understanding of tornados: "The computer-generated graphics explained in detail the formation of a tornado and showed different angles," adding that *Tornado Alley*'s treatment was more thorough than other visuals.

Understanding Forces and Factors that Contribute to Tornados

Asked to discuss the forces and factors that contribute to the formation of tornados, most focus group participants offered variations on "warm, moist air from the South colliding with the jet stream." The young adult participants offered the most detailed descriptions, adding factors such as air pressure differentials and "tail-end spin" in describing forces that create tornados.

Many adult participants noted that they were already familiar with this information from television explanations. For middle and high school students, the material about forces and factors was a mix of old and new information; some had learned details in school and others in science centers. One middle school student knew some of the information but had been unaware of the role of the Gulf Stream, and two stated that they were unfamiliar with or did not understand the technology.

No focus group participants said they had any confusion about the information presented on tornado forces and factors. One adult participant noted that the film would have been less interesting if it had been too technical and another said the film made him or her curious to watch more films about tornados. Middle school students felt that the information presented was "fine," not boring, and held their interest, while some high school interns observed that they already knew some of the information present. Young adults praised the graphics as "not too technical" and presenting the material very clearly.

Adults agreed that the film was informative and easy to understand. Said one, "They explained a lot of information at the beginning to allow us to know what was going on during it." Another noted the good balance between documentary aspects and action, such that "it was not boring." One adult referenced his or her knowledge of the topic through *Twister*, the Weather Channel, and news stories following recent disasters.

Middle schoolers did not respond to this question. Young adults had few comments, apart to note that the film was not "too technical." Asked to offer suggestions, one educator proposed that adding satellite images (as in *Storm Chasers*); another would have liked a short discussion of the data, or a more visual presentation of the data "so that you can see it as it happens."

Understanding Scientific Research

Asked what they learned about conducting research on tornados, most focus group participants cited the advanced technologies used to track tornados.

The middle school students identified the major technologies in use: radar, video cameras, and the pods and expressed some interest in learning more about the technologies. The hydraulic lift came in for special praise as "cool" by a middle school student and a high school intern. A high school intern also cited the conversation among scientists in the research vehicles.

“I knew this technology was out there but I did not realize how they coordinated it all,” said one adult; another compared it to the older technology used in *Twister*. One adult wondered what happened when a truck lost power. An educator recently exposed to a workshop on encrypting data was intrigued by “how we can use technology and increase our knowledge.” One adult commented on the value of in terms of lives saved of even a 15-minute increase in warning time that new data can provide.

Several students and some adults wished to know more about each piece of equipment, for example, how the equipment stays down, whether the pods got sucked up by tornados, and if scientists used GPS technology to retrieve lost pods.

The young adults were most strongly drawn to the scientific work, describing it as “really cool,” “the kind of job you can only do if you’re passionate about it”, and “It was good to see [the scientists] follow their passion.” High school students also noted the researchers’ dedication, fearlessness, and clarity. One noted that the scientists did “a lot of work.”

Across all focus groups, only high school student confessed to finding the scientific process difficult to follow: “the process wasn’t obvious. You had to look for it.”

Understanding the Goal of the Vortex 2

All focus group participants identified the goal of the Vortex 2 research vehicle as to better understand tornados in order to alert people and give them more time to prepare.

One adult was enthusiastic that such research was being undertaken because “we are starting to get tornados around [New England].” Two adults had questions about the relationship between the Vortex 2 and TIV scientists—one wished to know how they got along and another sought more about “the network of researchers.”

The educators added details about the need for longer warning times (strong assent) and “better predictions” to counter the “many false warnings people ignore.” An educator with previous tornado experience, added, “It’s a learning experience if you live in those states; the technology can’t give a longer window of warning. Hopefully, in another movie they will [show more] about public safety” and reconstruction.”

Understanding and Appreciating the Role of the Scientific Researchers

All participants found the work of the scientists exciting and engaging. Most used the word “passionate” to describe the scientists’ relationship to their work. (There was unanimous agreement with this statement in one adult group.) Other terms adult respondents used about researchers were “determined” and “brave”—researchers routinely risking their lives to help others. The middle school students offered similar descriptions of the scientists: “brave, dedicated, courageous, crazy, and useful.” Both middle and high school students cited the researchers’ courage and dedication. Respondents also traced a strain of obsession. One adult and one young adult echoed the students in describing the scientists as crazy.

Some adults, and some educators, did note the absence of character development. Said an educator, “It felt like you know they’re there but don’t feel connected to them,” although one adult said he or she did not need character development “because I knew it was science.” For a number of the young adults, on the other hand, the scientists “seemed like real people.” They cited instances when the scientists stopped and visited families, and tried to win stuffed animals. “They were very relatable,” said one, “It showed that anyone can do science. It’s not about being a ‘crazy scientist’.”

Asked whether they would be interested in being a severe weather researcher, participants’ interest was balanced with trepidation. While some high school student interns found the work appealing, for example, “I think it would be like a rollercoaster because I have been on zero gravity and it was awesome” and “I think it would be fun …. I have an interest in becoming a meteorologist,” others were more drawn to the TIV experience. “I’m all about sitting in the TIV,” said one high school student. Other high school students admitted to some interest but referenced their fears, as in “I would be screaming ‘get me out of here!’ I would be too scared to go in a tornado,” a sentiment echoed by three others.

Several adults said they would be drawn to the work if their life circumstances were different—if they were younger, or good at math, or could tolerate a lot of “down time.” One said the work “looked cool” and seemed real. To at least one adult the work was “scary” and he or she preferred the role of “spectator,” watching from a distance. Another noted that the film was good about showing the safety precautions.

The young adults were split in their view of the scientists with a slight preference for the scientific life. For another, it was tremendously appealing: “I want to go into a tornado. I’d love to sit inside one,” declared one; another said, “I think it was awesome.” Others were more hesitant. Confessed one, “I didn’t go into research for a reason. I’m not passionate enough about tornados,” and another said, “I would rather not go near one.”

All of the educators found the work of the scientists exciting. Specific comments included, “I was surprised by how primitive it seems, with the minivans, how they jump in and out, and all the driving around;” another affirmed, “There was a lot of running around and guessing.” One educator was drawn to more quiet moments in the scientists’ lives, “in bars, listening to music, playing with babies. It was realistic to see that it’s not all work all the time” and another praised the character development with “the guy playing the game with the ball.” However, none of the educators saw themselves doing this kind of work, noting the high degree of passion it requires.

Points of Possible Confusion

No adults, educators, or young adults identified points of confusion. One adult explained, “I felt like I knew a lot about it from *Twister*, Weather Channel, and news pieces after recent disasters.” A high school intern indicated that the representation of the scientific process was difficult to follow: “The process wasn’t obvious. You had to look for it.”

Changed Perspectives

Participants were asked to complete the statement “I used to think ____________and now I know __________.” They reflected primarily on gains in scientific knowledge, with a few comments about their expectations of the film itself.

Science-based shifts for adult participants included: “[I thought] people were only given 5-minute warnings…they can have almost 15 minutes of lead time,” noted by an adult participant. Another adult noted, “[I thought] I knew the intensity [of tornados] … [now I know] more about the intensity.” Other reflections addressed the seriousness of the tornado data collection efforts: “[I thought] it was small groups of people that did this… [now I know] that there are large groups of organized researchers out there. (All participants in one adult focus group agreed with this statement.)

Middle school students cited knowledge shifts related to how tornados form, how they are tracked, and when tornados form. For example,

> *I thought all tornados formed in a field.*
>
> *I thought storms formed from a tornado [now I know] tornados form from a storm.*
>
> *I thought they would be more common in the summer because of humidity and thunderstorms… I was surprised to learn they are more common in the spring.*
>
> *I thought tornados happened everywhere. I didn't know about Tornado Alley.*
>
> Two high school intern offered knowledge shifts:
>
> *I didn't know people actually studied tornados. Now I know what goes into it.*
>
> *I thought chasing storms was a hobby, I thought people did it for fun.*

Young adults identified three shifts:

> *I thought tornados were completely unpredictable; now know there's a little predictability, like in how warm air meets cold.*
>
> *I was surprised what a hard time they had actually getting to see a tornado. I thought there would be tornados everywhere.*
>
> *Before I thought there was a stationary weather center. I didn't know it was mobile and they went out into the field. I thought it was more like a spaceship. I didn't know that they went from state to state.*

One educator spoke for some others in noting: “Before I thought we know more than we do; we actually know less. I mean us collectively.”

Some adult participants also commented on the film experience itself, as in,

> *[I thought] it was a drama…it is a documentary.*
>
> *[I thought] I would learn something…I didn't.*
>
> *I thought it would be really interesting …I was underwhelmed.*

Interactions with Related Exhibits

No adult or middle school participants had occasion to interact with related exhibits at the science center where they watched *Tornado Alley*. Within the high school interns, only a small number interacted with the exhibits. One who had was unimpressed: "There was a giant fan, which doesn't feel like the real thing." Members of both the young adult and educator focus groups interacted with exhibits. Two young adult participants cited an exhibit that used connected water bottles to simulate the action of a tornado; another described spending time on tornados at the nature show. Most educators had seen the exhibits but had no comments about them in connection with the science of tornados.

Most of the discussion about exhibits concerned whether to interact with them before or after seeing the film. Two high school interns who interacted with exhibits recommended seeing them after the film because it might be more enjoyable. Most young adult participants thought that interacting with the exhibits would be more beneficial before viewing the film. One described how having a hands-on experience first would enhance the movie for kids and families: "They could feel the winds and talk about tornados. It would be more than just watching the movie. They could touch a tornado, feel it, play with it. It would be more concrete. That would enhance the movie." Educators also agreed that seeing the exhibit before the film enhanced the film experience.

Extent to which *Tornado Alley* Piqued Interest in Science and Science Careers

Some adults expressed interest in learning more about tornados, such as checking out the NOAA website, "watch[ing] nature more carefully even when thunderstorms come through." One said he or she might start watching *Storm Chasers* and another hoped to find out more about the research team and Sean Casey.

Many middle school students expressed interest in knowing more about the TIV. Others said they might Google more information and do research on severe weather. High school interns suggested they might look for pictures of tornados, and pay more attention to weather, looking for "differences and similarities." One intern said he or she has family in Tornado Alley and "now understands it a bit more."

Young adults expressed some interest in the TIV and Sean Casey. One said he or she would look for tornado footage on YouTube, and another expressed a desire to see "a tornado up close and really experience one," perhaps traveling specifically to see one.

An educator noted, "I'll be looking at storms differently, recognizing that [nascent tornado] shape and pattern. I'll pay more attention to clouds and storms." Three other educators expressed interest in how the film could inspire students to have science careers; one, who was able to interact with Dr. Kosiba said "it was exciting to see how it played into her life."

Suggestions and Additional Comments

Asked if they wished to make any further comments or address topics they had not been asked about, most participants expressed a wish for more details in the context of a longer film. "Forty minutes seemed short," an adult noted, suggesting *Tornado Alley* "should have been a mini-series to provide us with more depth." Other adults said they wished for more footage and information learned from data collection. One adult would have liked "time lapse notes—is the formation really that quick?" Other questions adults raised concerned the frequency of tornados, how their strength is measured, and how the tornados depicted in *Tornado Alley* were related.

Students also would have liked the film to have been longer and to provide more details, describing the details provided as "a little shaky." Like the adult participants, they also wished to know more about variations in tornado strength and how they are categorized. Students conjectured that the film was kept "basic" in order to appeal to all ages, characterizing *Tornado Alley* as more of a "starter film" for learning about tornados. Asked to rate the film on a scale of 1 (low) and 5 (high), most students rated it a 3 or 4, largely because it lacked details.

An educator who identified as from the Plains states and noted that "some people don't believe a tornado is coming until they hear it," suggested that if tornado technology were shown on "regular TV" more people would be apt to use the warning information.

Several educators noted the lack of connection to the characters. One adult suggested the film could have focused on "the guy who devoted his life to it," with descriptions of changes in the research he has seen over time. Another praised the fact that there were women in the film "[people] always think of storm chasers as men so it was good to see women scientists. It can inspire young girls to pursue jobs in science," a point on which there was general agreement. Added an educator: "I'd be interested in the next version of the film where they take some of the data and present the findings."

SURVEY SUMMARY

Three-quarters of post-viewers rated *Tornado Alley* as excellent or very good. Adults >50 rated the film most highly, with ratings diminishing with youth. Lower ratings were attributed to over-familiarity with the content and the film's slow pace. The majority of respondents (90%) would, however, recommend the film to others, chiefly for its educational value. More than half of respondents chose "informative," "visually engaging," and "exciting" to describe *Tornado Alley*.

The film's most effective themes, named by more than two-thirds of respondents, were the impact and importance of studying tornados and the importance of teamwork among individuals and institutions in conducting research. Female viewers rated the film's effectiveness in showing the lives, work, and research of severe weather scientists more highly than did males; older viewers rated the treatment of how scientists study tornados and the impact and importance of studying volcanos more highly than did younger viewers. Viewers with prior knowledge of the *Storm Chasers* TV series rated Tornado Alley's representation of the work and lives of people who study severe weather more effective than those with no knowledge of the series.

In rating their knowledge of topics addressed in the film, pre-viewers were most ignorant of the Vortex2 research project and the length of time needed to conduct weather experiments. They were somewhat more knowledgeable about the scientific method and technologies used in researching tornados and most knowledgeable about the work of severe weather researchers and the forces that create tornados.

The greatest gains in knowledge between pre- and post-viewers were in the length of time a weather research project takes, the Vortex2, and the scientific process used by researchers. Older viewers registered the greatest knowledge gains in the domains of time involved in a weather research project, Vortex2, technologies used to research tornados, the work of severe weather researchers, and the forces that create hurricanes. All three age groups registered gains in knowledge of the scientific process used by researchers.

Asked factual questions about tornado formation and the scientific study of tornados, more than 80% of all respondents answered the questions correctly. Although slightly more pre-viewers answered the questions correctly than did post-viewers, high numbers (74%) of pre-viewers reported knowing something about tornado formation before viewing the film. Pre- and post-viewers did not differ in the accuracy of naming technologies used to study severe weather, such as Doppler radar, pods, and anemometer. Another knowledge question concerned technologies scientists use to create 3-D maps of winds and structure of supercell storms. Considerably more post-viewers identified technologies correctly than did pre-viewers. Females registered greater pre- post gains in answering this question than did males and the age group with the greatest pre-post gains was the <18 group. Other subgroups that registered significant pre- post gains were those unfamiliar with *Storm Chasers* and those with some previous experience with the *Tornado Alley* website.

Post-viewers rated their interest in weather science careers somewhat higher than did pre-viewers. Females' interest in these careers fell from pre- to post-viewers, while males registered gains, resulting in an interest gap of 28 percentage points. Respondents familiar with the *Storm Chasers* TV series and the *Tornado Alley* website also registered increased interest in weather science careers. However, only a quarter of respondents overall saw themselves working in this field. There were differences by sub-groups: twice as many males could see themselves working in this field as females and more respondents familiar with *Storm Chasers* and the *Tornado Alley* website also saw themselves as weather researchers compared with those unfamiliar with either. Among respondents who could see themselves as researchers, the excitement of the job and personal interest in tornados and weather were the most frequently cited reasons. Other reasons included interest in science careers broadly, being part of scientific study team; and work that fulfills a social need. Those who could not see themselves working as severe weather researchers saw the work as too dangerous or risky. Some cited practical reasons such as a lack of time or interest or having already chosen a profession. Respondents were more open to participating as "citizen scientists" than as weather science researchers, but nearly half of all respondents indicated they would not be interested in citizen science paths either, citing lack of interest, danger, lack of time, and age constraints. There were no differences by gender, age, or familiarity with *Storm Chasers* or the *Tornado Alley* website.

While nearly two-thirds of respondents said the film satisfied their curiosity, older viewers and those unfamiliar with the TV show or website registered more curiosity than others. Key points of curiosity were a) the research findings and b) improvements to warning systems. Almost half of all viewers indicated they would visit the *Tornado Alley* website because of interest in learning more about storms, tornado formation, and weather. Expectations for website content included project status updates, scientists' profiles, and information about technologies used to study tornados as well as the science behind tornados. Those who would not visit the website cited lack of interest, time, or Internet access.

FOCUS GROUP SUMMARY

Participants were typically drawn to the screening of *Tornado Alley* by interest in the topic, although interns attended as part of their work at the museum. Generally enthusiastic about the film, participants cited the dramatic footage and camera angles. While younger viewers were enthralled by views of a tornado's interior, educators and adult viewers found the film educational but lacking in "wow." That said, scenes of tornado formation and post-tornado devastation were most memorable for most participants. Some middle school students and young adults were also drawn to images of the equipment and technology.

Although all of the adult focus group participants, most of the high school interns, young adults and educators, and a small number of middle school students were familiar *with Storm Chasers*, most were unaware that Sean Casey of *Storm Chasers* was involved with *Tornado Alley*. Only educators suggested that familiarity with *Storm Chasers* influenced their viewing of *Tornado Alley*, chiefly in terms of *Tornado Alley*'s less sensationalistic treatment.

All middle school students and young adults said they would recommend the film, with exceptions for very young children, people without interest in the topic, and people who had lived through tornados. Adults were more mixed: while some praised the visual effects and described the film as "amazing," others felt its reception depended on viewers' interest in the topic. Educators in general would recommend the film as educational but not "must-see."

Among participants who saw the 2-D version of Tornado Alley, adults felt 2-D was sufficiently realistic and engrossing, while middle school students would have welcomed the 3-D version. Young adults and educators were also mixed—for some the experience evoked headaches and for others it was engaging. Both young adults and educators agreed that 3-D heightened expectations, perhaps unrealistically.

Key areas of new learning for focus group participants overall were about how tornados form and how tornado data are collected. Educators and middle and high school students also stressed learning about the amount of work involved in studying tornados and how long it takes to analyze data. Asked to discuss forces and factors in tornado formation, most focus group participants offered variations on "warm, moist Southern air colliding with the jet stream." Young adult participants offered somewhat more detailed descriptions, noting factors such as air pressure differentials. Although many adult participants said they were familiar with tornados from television, students found some information familiar from science study and other information, such as the technologies used, new.

No focus group participants indicated any confusion about the information on tornado forces and factors. Most found the film informative, easily understood, and not overly technical. Asked what they learned about conducting research on tornados, most focus group participants cited the advanced tracking technologies. Several students and some adults wished to know more about each piece of equipment, for example, how the equipment stays down and if scientists used GPS technology to retrieve lost pods. All focus group participants identified the goal of the Vortex 2 research project as to better understand tornados in order to alert people and give them more time to prepare.

All participants found the work of the scientists exciting and engaging, frequently using "passionate" to describe the scientists' relationship to their work. Other terms adult respondents used were "determined" and "brave," while middle school students added "crazy." While some adults and some educators noted the absence of character development, young adults found the characters more real and not typical "crazy scientists." Asked whether they would be interested in being a severe weather researcher, most participants' interest was balanced with trepidation. For some, the work looked exciting and adrenaline-filled; for others the work seemed terrifying. The educators all found the work of the scientists exciting—although they would not choose the work themselves.

In completing the statement "I used to think ____________and now I know __________," participants reflected primarily on gains in scientific knowledge, with a few comments about their expectations of the film itself. Science-based shifts for adult participants concerned new information about lead time and storm intensity. Some expressed surprise that tornado research was so extensive and well-organized. Middle school students cited knowledge shifts related to how and when tornados form and how they are tracked. Interns cited learning that tornado study was a serious occupation, while young adults noted shifts in understanding about how tornados form and the work of the researchers. Some adult participants, commenting on the film itself, noted that the film did not meet their expectations.

Although no adult or middle school participants, and only a few high school interns, interacted with related exhibits at the science centers where they watched *Tornado Alley*, young adult and educator participants did. The exhibits discussion focused on whether to interact with them before or after seeing the film. Most concurred that interacting with the exhibits before the screening would enhance the film experience.

Most participants expressed interest in learning more about tornados, such as checking out the NOAA or other websites, observing weather more carefully, and tuning in to *Storm Chasers*. Middle schoolers and young adults were especially interested in knowing more about the TIV.

Invited to make any further comments or address topics they had not been asked about, most participants overall expressed a wish for more details in the context of a longer film, citing specific topics they would like to learn more about, such as tornado frequency and variations in their strength. Some suggested showing tornado technology on TV to encourage people to follow warning information and others wished for full characterizations of the scientists. There was also some interest in the next steps of tornado research.

II. Educator Guide Evaluation

INTRODUCTION

Recruitment and Survey Respondents

With the cooperation of the Science Museum of Minnesota and Fort Worth Museum of Science and History, RMC Research recruited formal educators in the upper-elementary and middle school grades to participate in evaluating the *Tornado Alley* website, classroom posters, and the activities within the teacher's guide. A total of nine educators (4 from Minnesota; 5 from Fort Worth) used the educator materials for teaching about weather science and research before and/or after bringing their class to view the film. Once the lesson unit was completed, educators were asked to take an online survey about the actual use of materials and the strengths and weaknesses of the materials. Upon survey completion, each educator was sent $150 for their participation in the evaluation.

The following table presents background information on the participating educators. It includes the number of educators by grade level, subjects taught, number of years teaching, and number of other educational guides used for science media.

Table II1 Number of educators by Subjects Taught, Years of Teaching, and Number of Other Guides Used by Grade Level Taught

	Educator's Grade Level	
	4-5	**6-8**
All	5	4
Subject(s) Taught		
All	2	1
Science	2	1
Math	3	1
Social Studies	2	
English Language Arts	1	1
Years Teaching		
1-2	2	1
3-4	1	3
5	2	
Number of Other Guides Used		
1-2	3	2
3	2	2

SURVEY FINDINGS

Activities Associated with Seeing Tornado Alley

How did teachers prepare their students for viewing the film Tornado Alley? All educators reported utilizing some or all of the materials in the Tornado Alley curriculum prior to seeing the film. Six out of nine educators had their students access the Tornado Alley website. Most of the students conducted the "Make a Tornado" activity and several educators incorporated the safety information from the guide into their pre-viewing lessons.

Which topics did educators discuss? Which activities did educators conduct with students? Educators were presented with a list of topics and activities suggested in the guide and asked to indicate which they engaged in with their students. Table II2 shows the number of educators who covered topics and conducted specific activities from the guide.

Table II2. Number of Educators Who Discussed Topics or Conducted Guide Activities

Topics Discussed	**Number of Educators**
Safety	9
Background information	7
Technology used in the film	6 (more elementary)
Scientists' background	5
Activities	
Read or had students read recommended books about tornadoes	6 (more elementary)
Make a Tornado	6 (more elementary)
Tornado Math!	5
Where in the World?	4
Puzzle(s) from the website (Word Search, Maze, Crossword)	3 (all elementary)
How Fast is the Wind Blowing	3 (more middle school)
Under Pressure	3
Which Way is the Wind Blowing	2

All educators discussed the safety issues about tornadoes with their students and most addressed the background information. Elementary school teachers were more apt to discuss the technology, to have students read books about tornadoes, to conduct the *Make a Tornado* activity, and to use the puzzles from the website compared to middle school teachers.

Materials and Activity Ratings

Educators were asked to choose two activities they conducted with their students and rate the activities on science content, student engagement, age appropriateness, and amount of time to implement the activity. Rating options included poor, fair, good, very good, and excellent. The table below presents the activities chosen by at least two educators. The results for activities chosen by one educator are reported after the table summary.

Table II3. Number of Educators' Ratings of Chosen Activities for Specific Features

Activity Number of Responses	Rating of Activity Feature			
	Fair	Good	Very Good	Excellent
Make a Tornado **n=6**				
Science Content		1	3	2
Student Engagement			3	3
Age Appropriateness			3	3
Amount of Time to Implement		1	3	2
Discussed Safety **n=4**				
Science Content	1		2	1
Student Engagement		1	2	1
Age Appropriateness			4	
Amount of Time to Implement		1	1	1
Tornado Math! **n=2**				
Science Content			2	
Student Engagement	1		1	
Age Appropriateness	1			1
Amount of Time to Implement		1		1

Of the educators choosing to rate the activity *Make a Tornado*, most felt the activity was at least very good in terms of all the features. The same holds true for discussing safety issues with their students; however single educators did rate the science content, student engagement, and amount of time to implement less favorable. Except for rating the science content for the *Tornado Math!* activity as very good, the two educators were on opposing sides of rating the other features.

An elementary school teacher felt it was above the fourth grade students' math level, while a middle school teacher rated the age appropriateness as excellent. This teacher reported using the activity during a class project looking at numbers relating to world facts, explaining, "*Tornado Math!* put in perspective the resources that are needed to the project and the value of using the resources in order to save lives."

One middle school teacher noted that their class revisited the safety guidelines and the power of tornados the day after a tornado hit Moore, OK, which sparked great discussion on the importance of safety.

Puzzle(s) from the website were rated as excellent by one elementary school teacher for the science content, student engagement, age appropriateness, and the amount of time to implement the activity.

Which Way is the Wind Blowing activity was also rated excellent across the board by an elementary school teacher.

Another elementary school teacher rated discussing the background information from the educational guide as excellent for student engagement and very good for the science content, age appropriateness, and time to cover the topic.

The *How Fast is the Wind Blowing* activity was rated very good on all accounts by a middle school teacher.

Teachers were asked to rate the overall value of the activities they conducted for enriching the film experience. All but one teacher thought the activities were very valuable; that teacher ranked them as somewhat valuable. This middle school teacher wished there was more time in the curriculum to incorporate the activities, concluding that, "Next time I will make more time as the activities were well put together."

The teachers who rated the activities as excellent explained that providing prior knowledge about tornadoes makes students 1) interested in seeing the film, 2) motivated to learn more about tornados, and 3) able to relate to the film. One teacher felt that doing the activities before and after the film viewing "increases the retention of the information from the film. The students were able to recall information they viewed in the days following the film." Another teacher stressed the importance of hands-on activities: "Whenever you can have students do hands-on activities it is worth it. They need to see for themselves how things work rather than just seeing it in a movie".

What were the strengths and weaknesses of the educator's guide? On a scale from 1 to 4, (1=strongly disagree, 2=disagree, 3=agree, 4= strongly agree) educators were asked to rate their agreement with statements about the educators guide. Table II4 below presents the mean rating by strongest agreement to weakest agreement.

Table II4. Mean Agreement Score by Strongest to Weakest Agreed Upon Statements

	Mean
The Guide is relevant to the Tornado Alley film.	**3.9**
The Guide helped me to prepare students for viewing film.	**3.7**
Activities are interesting to students.	**3.6**
The format of the Guide is well organized.	**3.6**
The Guide is worth recommending to other Teachers.	**3.4**
The Guide gave me ideas for class discussion after viewing.	**3.4**
The science content is relevant to your curriculum.	**3.4**
The Guide is valuable for lessons not directly related to the film.	**3.2**
Instructions for activities are clear.	**3.2**
Activities are easily adaptable to my classroom (materials and time).	**3.2**
Activities are appropriate for middle school students.	**3.2**
Activities are appropriate for elementary school students.	**3.1**
The Guide helped generate ideas for related or new activities to use in my classroom.	**3.1**
Materials are easy to obtain for activities.	**2.8**

Educators strongly felt the guide was relevant to the film and helped them prepare their students for seeing the film. They also reported the activities were interesting to the students and the guide was well organized. Respondents were less likely to believe the guide helped generate additional activities for the classroom. Most educators felt the materials for activities were not easy to obtain.

Addition comments about the guide were reported by several educators. One middle school teacher felt the guide was more appropriate for eighth grade students while another middle school teacher thought it was geared more for the elementary grades.

Another middle school teacher found the guide “a great place to jump in about weather” and is successful in preparing students for understanding the film. An elementary teacher agreed that using the guide helped students “recognize terminology” and understand the purpose of the data collection efforts. In addition, this teacher appreciated the guide’s organization in sections. He or she grouped students and assigned each group a section to read and research. The groups then shared their learning with the rest of the class.

One middle school teacher praised the presentation of the background information, noting, “I loved the way at the beginning of the guide the scientists were introduced and then it went on to explain and show why they were doing this movie. This is a great way to demonstrate to kids that all of us have things we do not know and the best way to find the answers is to experiment and get those questions answered. It was also good that it took him eight years to get into the eye of the storm and he did not give up”.

What other kinds of information, activities, or resources would educators like to see in future educator’s guides? Only one teacher from an elementary school made a suggestion; it was to “incorporate more math curriculum into the guide and provide a broader variety of age appropriate material”.

What was the value and use of the TIV and DOW posters? Unfortunately only one elementary teacher received the TIV poster, only two elementary teachers had the DOW poster, and only one middle school teacher received both, so opinions on the posters are based on very few responses. Those teachers using the posters all said the labeling and descriptions of the vehicle(s) were most valuable. Explanations of the value of this component included the ease of teaching from the poster and students’ ability to understand and expand on the vocabulary terms. The Tornado Alley map and historical information sections were also mentioned as being valuable. Overall, teachers said, the posters gave students more background knowledge about the “vehicles and their purpose in the film and in real life situations.” All teachers felt the posters were very valuable in enriching the film experience.

Teachers also reported using the posters during classroom discussions and left them up for student exploration. One teacher said the vehicle sides of the poster helped students recall what they saw during film viewing and “how the vehicles were made and the components that made them so resistant to the high winds.” A couple of elementary teachers used the activity side of the poster, including The Enhanced Fujita Scale and historical tornado data, to teach math and *Make a Tornado!*

All teachers gave both posters a very good to excellent rating in terms of science content, clarity of language, attractiveness, organization of ideas, and overall design. One teacher gave a rating of good to the overall design of the TIV poster. The only suggestion given for improving the posters was to have the poster printed so that when it was hung the non-vehicle side would not have sections that were upside-down.

What was the use and value of other website resources? Most of the teachers used the *Web Weather for Kids-Thunderstorms* and Tornadoes website and found it a very valuable teaching tool, although one middle school teacher rated it "somewhat valuable". Half of the teachers used the *About the Doppler on Wheels* and most found it very valuable; one middle school teacher found it somewhat valuable. Half of the teachers accessed National Doppler Radar sites and the Vortex2 site. Most rated it very valuable for their teaching; one elementary school teacher felt the sites were somewhat valuable. A few teachers used the National Severe Storms Laboratory-Education Resources and Tornado Handbook; a couple of teachers rated these sites as very valuable while one middle school teacher gave a rating of somewhat valuable.

Learning Goals

How important were the Tornado Alley project learning goals for teachers and students and to what extent did the film and educator materials assist in meeting those goals? These findings are based on eight teachers' responses. One teacher did not complete the survey on this question to the end. All but one elementary teacher felt teaching the location of Tornado Alley was a very important goal for their students and found the film and educational materials very valuable in achieving that goal. Likewise, all but one elementary teacher reported that teaching students about the work of scientists (teamwork in data collection, observations, drawing conclusions) was a very important learning goal and the film was very valuable in meeting this objective. However, two elementary teachers rated the educational materials as not at all valuable and somewhat valuable in teaching about the work of scientists. The goal of learning about the tools and technology used by scientists to study tornadoes was least important to a couple of elementary school teachers and rated the film as somewhat valuable in meeting this goal, while three elementary school teachers found the educational materials only somewhat or not at all valuable. It should be noted that one elementary school teacher reported that having her fourth grade students exposed to the vocabulary of the technology and tools and a basic understanding of the work of weather scientists was important.

What connections do educators see between the Tornado Alley project and other curriculum areas? Most of the teachers cited other science-related topics that they tied into this area of study, such as water cycles, weather forecasting, weather maps, seasons, and weather patterns. One teacher noted, "it worked well with our Earth unit and it also tied in with our electricity unit as well". Cross-curriculum teaching, such as combining math and weather science was noted as an important teaching approach. The example one math teacher gave was "using ratios to compare the strength of the tornado to the amount of damage that is caused [and] using proportions to predict the amount of damage caused by different wind speeds".

Project Ratings

Based on an overall five point rating, where 1= poor and 5=excellent, teachers rated components of the Tornado Alley project they experienced. The table below presents the mean ratings listed by the highest to lowest score.

Table II5. Overall Mean Rating of Tornado Alley Project Materials

	Mean
Tornado Alley Film	4.8
Posters	4.8
Educators Guide	4.4
Activities	4.1
National Science Standards	4.1
Tornado Alley Website	4.1
Recommended Resources	4.0
Additional Background Information	4.0

On average, all components were rated at least very good, with the film and posters being close to excellent, followed by the educators guide.

How well integrated were the project materials (film, educators guide, poster, activities, book lists, etc.)? Teachers were given the option of rating the integration of materials as poorly integrated, integrated, or well integrated. Half of the respondents said "integrated", three teachers said "well integrated," and one said "poorly integrated". The teacher giving the "poorly integrated" response also commented that his or her class was under time constraints and wished that they had been able to do more with the materials. Another teacher noted that "after looking through all the materials a couple of times, I began to connect the links between each component and its location."

Is there other information that would have been beneficial to teachers and students in preparing for or following the film viewing. One teacher suggested having a type of lesson plan showing possible uses of each component with the lesson. Another teacher suggested that having a few more links or information on thunderstorms that lead to tornadoes and why would have been valuable. This teacher's students were very interested in what the storm chasers and scientists do, so more background on building their careers and how/when the storm chasers work were also suggested.

SUMMARY

Nine educators (5 elementary, 4 middle school level) used the educator materials associated with Tornado Alley before and/or after bringing their class to view the film and completed an online survey. Half of the respondents identified as science or math teachers; most had been teaching three or four years. All used Tornado Alley materials, with *Make a Tornado* the most common activity. The educators rated the education guide very highly in terms of: its relevance to the film, value in preparing students for the film, organization, and interest level of activities. Specific values of the guide were its use as an introduction to the study of weather, weather terminology, data collection, and the work of scientists.

All of the educators discussed safety, and most discussed background information, in connection with *Tornado Alley*. All but one found the activities excellent or very valuable in enriching the film experience.

Lack of time was a factor for one. Educators said the activities were especially valuable in developing students' prior knowledge and interesting them in the film. The sole suggestion for improving the materials was to add more math content and expand the range of ages appropriate for the materials.

Most of the teachers used the associated website and most ranked it very valuable. Unexpectedly low numbers of educators were able to use the posters; however, those who used them rated them positively for science content, clarity of language, organization, and design. Most respondents found the project effective in meeting the goals of locating "tornado alley" and portraying the work of scientists. The film appeared less successful in teaching about tools and technology.

Most respondents connected the *Tornado Alley* project with other curricular areas, chiefly weather and water cycles but also with Earth study and electricity. The project's value in cross-curricular teaching in science and math came in for special notice.

All elements of the projects were rated highly to very highly, with the film and posters rated most highly, followed by the educator guide. Most rated the integration of the many elements as integrated or well-integrated. Suggestions for additional information of use to teachers included more explicit lesson plans for using each project element and for additional links, particularly on the storm chasers and the thunderstorm – tornado evolution.

III. Professional Development Workshop and Grant-Funded Community Projects

INTRODUCTION

Professional Development Background

This component of the project's outreach built on the Franklin Institute's extensive experience in utilizing technology to support professional development. Previous work included a Teacher Professional Continuum project called Investigating Internet2: A New Channel for Science Education (TPC #0455784), which demonstrated the potential for cyberinfrastructure to provide immersive professional development that connects in-service teachers of science in grades 6-8 with real science research and data. A proof-of-concept project funded by NSF Award # 0455784 (Investigating Internet2: A New Channel for Science Education), proved the value of interactive, virtual professional development events (facilitated through cyberinfrastructure) that connected practicing scientists and real scientific data with educators, resulting in meaningful impacts on K-8 teacher confidence.

The project's PD component was designed to utilize live, interactive videoconferencing at The Franklin Institute to allow educators to engage with researchers at the Center for Severe Weather Reasearch, observing and asking questions as professional scientists demonstrated data sets gathered by the VORTEX2 project. Karen Kosiba, project advisor and VORTEX 2 researcher with an M.A.T. in teacher education, liaised with fellow VORTEX 2 researchers to collect appropriate data for the sessions. She collaborated with co-PI Karen Elinich of the Franklin Institute to develop a workshop curriculum appropriate for K-8 educators and ISE professionals.

Based on interest expressed to the film's distributor, theaters leasing *Tornado Alley* were invited to send a museum educator and a teacher advisor or regional science coordinator for a school district to the Franklin Institute for the two-day film preview and Professional Development seminar. These attendees were asked to then plan, advertise and host a similar session for educators at their institution. The project provided a site grant to each participating venue to support these activities.

During the first day of the session, educators previewed the film, reviewed the project's Educator Guide and Classroom Poster, discussed strategies for incorporating the material into their curriculums, and aligned the material to their state's standards. The following day featured an interactive videoconference with Karen Kosiba. This session was designed to provide deeper exploration of the science content and concepts featured in the film, offering numerous opportunities to observe the use, manipulation and visualization of actual data collected through VORTEX 2 research activities. Participants also learned how to use the same open-source software, Integrated Data Viewer, to engage students and audiences with the data sets collected by the VORTEX 2 researchers.

Workshop Participants

The two-day professional development workshop was held December 6-7, 2011 at The Franklin Institute in Philadelphia, PA with 22 individuals in attendance. Table III1 below shows the institutions represented, locations, and team make-up.

Table III1. Workshop Attendees' Institution, Location, and Team Composition

Institution	Location	Team Composition
Carnegie Science Center	Pittsburgh, PA	1 Program Presenter 1 Math Teacher
Denver Museum of Nature and Science	Denver, CO	1 Museum Educator 1 Science Teacher
Fort Worth Museum of Science and History	Fort Worth, TX	2 Museum Educators
Discovery Place	Charlotte, NC	2 Museum Educators
North Carolina Museum of Natural History	Raleigh, NC	2 Museum Educators
Orlando Science Center	Orlando, FL	1 Museum Administrator 1 Museum Educator
Tennessee Aquarium	Chattanooga, TN	1 Program Coordinator 1 Science Teacher
Louisville Science Center	Louisville, KY	1 Program Manager 1 School Program Coordinator
Saint Louis Science Center	Saint Louis, MO	2 Museum Educators
Science Museum of Minnesota	Saint Paul, MN	1 Museum Educator 1 District Science Coach
Oregon Museum of Science and Industry	Portland, OR	1 Museum Educator 1 Science Teacher

Karen Elinich, Director of Educational Technology and Integrated Learning at The Franklin Institute and Co-Principal Investigator of the *Tornado Alley* project, facilitated the workshop, which entailed viewing *Tornado Alley*, learning about the VORTEX2 project, reviewing educational materials, and interacting via Skype with Dr. Karen Kosiba, a VORTEX2 scientist from the Center for Severe Weather Research. Workshop participants received laptops pre-installed with Integrated Data Viewer (IDV) software and actual severe weather data; Dr. Kosiba presented background on data collection through the VORTEX2 project and demonstrated how to access and manipulate web-based weather data and create data visualizations. Participants were also given resources and time to discuss plans for local film-related projects that would use their newly acquired knowledge of VORTEX2 research.

Before leaving the workshop, participants were asked to fill out a paper survey which is presented in Appendix G. End-of-workshop surveys suggest that overall, workshop participants were grateful for the opportunity to attend the workshop and access resources to implement a local community project.

SURVEY FINDINGS

Factors in Workshop Success

The workshop facilitator was asked to answer reflection questions a couple of weeks after the workshop. The questions are listed in Appendix H. The workshop facilitator noted that after some initial confusion about the workshop expectations, participants appeared to "relax" and focus on developing their local professional development projects. Both the facilitator and participants noted that networking with fellow educators and exchanging project ideas were engaging aspects of the workshop.

Based on evaluation surveys, nearly all the participants gave very high ratings to the time spent planning their own site workshop (96%), reviewing the educational resources (91%), and video-conferencing with Dr. Kosiba, the VORTEX2 scientist (90%). Participants rated less highly the presentation of data visualizations (82%), introduction to the VORTEX2 data (77%), and viewing the film (73%), which some participants had already seen. The facilitator observed that Dr. Kosiba was an "engaging, colorful presenter" whose first-person perspective was a highlight of the workshop. Participants described their interaction with Dr. Kosiba as providing valuable context. Some participants stated they were gratified that Ms. Elinich and Dr. Kosiba would be available for project planning consultation and that Dr. Kosiba offered in-person or teleconference presentations.

Participants were less enthusiastic about the technology portions of the workshop. Fewer than half (46%) rated the introduction to the IDV software and data sets as very helpful; only 41% reported practicing with the software as very helpful. Suggestions for improving future workshops included, in order of highest frequency: 1) more workshop time for learning and practice, 2) pre-workshop exposure and practice, and 3) more hands-on activities. A small number of participants also suggested including more group dialogue, more advance information, and a review of basic science related to tornados. The facilitator noted that in the future she would approach the software and data set training more methodically and in smaller increments. Dr. Kosiba suggested that holding the workshop before the movie premiere and outreach activities may have enriched outreach activities.

Impacts on Workshop Participants

Upon completing the workshop participants were asked to indicate their level of knowledge (1=low; 5=high) on topics addressed in the film or presented by Ms. Elinch or Dr. Kosiba. Table III2 presents average knowledge levels before and after the workshop by topic.

Table III2. Average Knowledge Level Pre and Post Workshop by Topic (n=22)

Topic	**Average Knowledge Level Pre and Post Workshop**				
	1 Low	**2**	**3**	**4**	**5 High**
Data collection efforts by Doppler on Wheels (DOW)	1.9		3.9		
Data collection efforts by Tornado Intercept Vehicle (TIV)	1.9		3.7		
Data analysis methods used in weather research	1.9		3.6		
Research of tornados		2.2	3.7		
Available resources for teaching weather science		2.4		4.1	
Overall weather science research		2.7		4.0	
The work/careers of weather scientists		2.7	3.9		

Participants' knowledge increased at least one level on all topics, with the greatest knowledge gains made on data collection efforts by the research vehicles (DOW and TIV), followed by data analysis methods used in weather research and available resources for teaching weather science. Dr. Kosiba saw participants as making the greatest knowledge gains in terms of available resources and personal insight into severe weather research.

Comments about the Effectiveness of the Workshop

Overall, participants were very pleased with the PD session and appreciative of the opportunity to attend. They felt the combination of time allocated to sharing with other professionals, having real-time access to a scientific researcher associated with the VORTEX2 Project, and learning about the existing resources were effective aids in developing their community projects. Participants' statements are listed below by comment category.

Group Sharing, Access to a Research Scientist, and Exposure to Resources:

> *Playing with the data, hearing from Karen and viewing Tornado Alley; brainstorming and sharing ideas.*
>
> *Resources for workshop, especially the computer; opportunity to learn from others was key component to success; access to data & both Karens; ability to access materials via web page.*

Group Sharing and Access to a Research Scientist:

> *Group discussion and planning; videoconference and presentation!*
>
> *Film viewing, Karen K's overview of the Vortex project, and sharing ideas with group.*
>
> *It allowed me to be a better classroom teacher through exposure to current research and research scientists as well as collaboration with museum educators.*
>
> *The interaction between the various participants was invaluable as well as the opportunity to conference with Karen.*
>
> *Background science knowledge, exposure to scientists in the field, planning with fellow museum educators.*
>
> *Teaming with the Science Museum broadens the possibilities for products. Having time to interact with a primary researcher on the project was critical.*

Group Sharing and Exposure to Resources:

> *Working together with educators from other science centers and listening to their ideas about incorporating the movie & resources to benefit their area (and public schools) helped. Also getting to work on the IDV software with other educators was helpful.*
>
> *Seeing what resources are out there, ideas from other teams.*
>
> *Being introduced to resources; sharing of ideas.*
>
> *Resources made available to us so we can share with our local educators to reach greater audiences.*
>
> *Learning about data collection methods and interpretation and*

meeting educators from other museums with whom I can collaborate.

Group Sharing:

The ability to plan with team members and share ideas.

Great to listen and share ideas amongst the different centers represented. Discussions about themes to be drawn out of the movie were helpful and effective.

Discussion with other science center employees & program directors—sharing experiences & ideas; lots of post-workshop support offered is a plus!

Access to a Research Scientist and Exposure to Resources*:*

The use and practice of IDV software and the lecture from Karen Kosiba.

Talking to a professional in the field; discussions with the film creator/advisors.

The combination of watching the movie, speaking with Karen and working with the software.

Being introduced to scientists in the field and that data—also increased my tornado knowledge.

Other Comments:

Thanks to Karen [Elinich]*, The Franklin Institute, NSF & Giant Screen Films for making this a project that will educate and excite the imagination of future scientists.*

It was great to meet everyone and share ideas. Great!! Karen was a wonderful host!

Thank you for professional treatment, productive use of time, meals, laptop, etc. I'm glad to be connected to this group of educators.

Thank you for everything! The resources provided were great—accommodations and staff were wonderful!

Thank you for this opportunity, and I look forward to working with staff and participants from this conference in the future.

Thank you for everything—it was a very informative workshop and I'm excited to follow up at my museum.

Thank you for this great opportunity. I am more excited now that I have viewed the film & understood the science research in greater context!

GRANT-FUNDED COMMUNITY PROJECTS

The goals of the local projects were to promote awareness of the VORTEX2 research and engage local audiences with the VORTEX2 researchers. Resources available to workshop participants for these projects comprised 1) Franklin Institute support, 2) Severe Weather Research Center support, 3) access to VORTEX2 data sets, and 4) $500 in grant money. In addition, workshop participants had been given laptops pre-installed with Integrated Data Viewer (IDV) software and actual severe weather data. By the end of February 2012 nine projects were approved and grantees received funding to implement projects over the next nine months. The project application can be found in Appendix I.

Although each project plan was unique, they generally sought to provide formal educators with knowledge and tools for teaching students about weather science, using VORTEX2 research as context. Plans included hands-on activities, *Tornado Alley* screenings, and teleconference or in-person interactions with Dr. Kosiba. Only a small number of projects aimed to access weather science data sets or create data visualizations, given participants' challenges in learning the IDV software. Two projects targeted unique audiences: 1) in-service and pre-service teachers and 2) homeschool educators and their children/students.

Table III3 below presents an overview of the proposed community projects, including the institution, location, targeted audience(s), and dates and descriptions of activities planned.

Table III3. Overview of the Proposed Community Projects

Institution Location	Target Audience	Activity Date(s) Activity Description
Carnegie Science Center Pittsburg, PA		
	Science teachers	March 2012 Film background, viewing, discussion of VORTEX2 focusing on inquiry and design, and technological devices; use of IDV software and data
Denver Museum of Nature & Science* Denver, CO		
	Teachers of 2nd + 6th grades	February 2012 Film viewing, Q+A with Karen K., develop classroom activities focused on scientific process
	Students of 7th grade	March 2012 Film viewing and meet Sean Casey
	Students	April 2012 Students engage in project-based unit; meet with Karen K.
	Other teachers	Fall 2012 Offer free 60-minute webinar with Karen K.
	Teachers and Students	Fall 2012 Within existing program, Scientists in Action, DMNS produces and distributes 20-minute DVD on Karen K. to schools for viewing. Post-viewing virtual meeting with Karen for Q+A
Discovery Place Charlotte, NC		
	Teachers of 5th grade	April 2012 Film viewing, Q+A with Karen K. via Skype; focus on VORTEX2 data, data-driven, evidence-based science and the integration of math and literacy in science.
	Students	April 2012 Offer film viewing at school in the touring exhibition theater.

Table III3. Overview of the Proposed Community Projects (cont.)

Institution Location	Target Audience	Activity Date(s) Activity Description
Fort Worth Museum of Science and History Fort Worth, TX		
	Homeschool educators and 5th-8th grade students	April 2012 Film introduction, viewing. Educators Group: focus on resources and availability of VORTEX2 research. Student Group: hands-on activities for understanding weather systems. Both groups: Q+A with Karen K.
	Teachers	September 2012 View the film; presentation by Karen K.; access grade-level appropriate resources; hands-on activities to be used in the classroom
Louisville Science Center Louisville, KY		
	Teachers and their families	January 2012 Preview Event: film viewing, Skype session with a Vortex scientist; weather- related actives made available for field trip extensions.
Oregon Museum of Science and Industry Portland, OR		
	Students	March – June 2012 Existing Camp-In Program: Natural disasters. Engage in activities around theme; build weather measurement tools, discuss weather concepts; view film.
	Teachers in-service and pre-service	August – November 2012 5 two-hour classes View film and discuss; background; work with Science on a Sphere; design weather measurement tools; build Vernier Probeware; Q+A session with Karen K. ; work with software and data for integration into classroom

Table III3. Overview of the Proposed Community Projects (cont.)

Institution Location	Target Audience	Activity Date(s) Activity Description
Orlando Science Center **Orlando, FL**		
	Teachers	June, September 2012 Film viewing, presentation and Q+A with Karen K. via Skype. IDV software class offered; tour Planet, Our Universe and satellite imagery on Science on a Sphere. Teachers provided with sample classroom activities, DVDs of the IDV software and VORTEX2 data with reference sheets.
Tennessee Aquarium **Chattanooga, TN**		
	Teachers of grades 4-6 science	February 2012 Hands-on activities from educator's guide; film viewing; discussion; presentation from Karen K. or Tim Troutman (NOAA); demonstration of how VORTEX2 research data is analyzed using IDV software; demonstration of how weather data can be used in classroom settings .
Science Museum of Minnesota **St. Paul, MN**		
	Teachers of 8th grade earth science	April 2012 Preview Event: introduction to Vortex 2 project, data sets, and educational materials for Tornado Alley. Focus will be on relationship between science and engineering as related to meteorology and data visualization. Possible opportunity to interact with Karen K.
	Girls	September 2012 Add to existing Girls in Science Program: event with interaction with Karen K.

*in addition to NSF funding this institution leveraged other resources to support the projects

Grantee Reflections on Project Planning

Project evaluators administered an interview protocol, found in Appendix J, with grantees once their community projects were completed, conducting eight 20-minute interviews from June to November, 2012. Table III4 and the notes below present findings on time spent, contacts made, and resources used.

Table III4. Number of Grantees by Response Category (n=8)

	Hours **Fewer than 25**	**25-50**	**51-99**	**100 or more**
Individuals' Time Spent for Project Planning	3	2	1	2
	Did Not Contact	**Helpfulness of Information Received** **Very**	**Somewhat**	**Not at All**
Contacts Made for Project Planning				
Karen Elinich at The Franklin Institute		5	1	2
Karen Kosiba at Severe Weather Research Center	2	6		
Contacts within organization	2	6		
Other workshop participants	4	2	2	
	Did Not Use	**Helpfulness of Resource Used** **Very**	**Somewhat**	**Not at All**
Resources Used for Project Planning				
IDV software and data set*		1	6	2
Tornado Alley website	1	5	2	
Education guide		4	4	
Posters**	1	5	3	

*n=9; one interviewee reported the dataset somewhat helpful and the software not at all helpful.

**n=9; one interviewee reported the Vortex2 information on the poster as very helpful and the weather information as somewhat helpful.

Two projects involved 100 or more staff hours: one entailed developing a teacher guide to using IDV software and included time spent learning the software; the other had several components, with funding from multiple sources. Most grantees found contacts with The Franklin Institute very helpful; a small number reported communication mishaps. All interviewed grantees who contacted Dr. Kosiba found her responsive and informative. Contacts within grantees' organizations were typically with public relations staff or program development coordinators. Grantee contact with other workshop participants concerned proposal logistics more than project ideas. For Ms. Elinich, facilitating cross-site communication was challenging and perhaps "overly ambitious". Three grantees contacted meteorologists for project planning assistance; one contacted the National Center for Atmospheric Research (NCAR).

With the exception of the sole grantee who learned how to use the IDV software and data sets to create a teacher's guide, other grantees found the software time-consuming to learn and difficult to use with teachers. Most of those who used the *Tornado Alley* website for reference found that information very helpful. Grantees were mixed about the education guide. Half thought it was very helpful and half found it somewhat helpful. Most found the posters very helpful. Other resources tapped were state standards and the IDV online tutorial.

Challenges and Successes of the Community Projects

Five interviewed grantees reported their projects went as planned. Those who changed projects had planned more than one activity and ultimately omitted one for logistical reasons. A couple of activities based on interactions with Dr. Kosiba had scheduling conflicts; one educator workshop was cancelled due to low registration.

Seven out of eight grantees faced implementation challenges, including miscommunication concerning educator outreach, internal logistics, and time lags in approval processes and funding.

Several grantees felt a success of their project was increasing teachers' and students' content knowledge and interest in severe weather, crediting success to the film, interactions with Dr. Kosiba, teacher resources such as classroom activities and IDV software, and leveraging school and NCAR partnerships. Half of the grantees sought to engage new audiences; among them, successes included increased teacher attendance, reaching distant districts, introducing teachers to other programs at their institution, and leveraging partners. The grantee who conducted a forum for homeschool educators and students rated it a success and will continue with this model.

Perceptions of Student and Teacher Impacts

Two grantees conducted activities for students and teachers on-site and observed that student awareness of and interest in tornados increased, largely through the film and in-person interactions with Dr. Kosiba and Sean Casey.

All eight grantees sponsored educator events featuring a *Tornado Alley* screening and professional development sessions. Anecdotally, several grantees felt the educators benefited from learning how to integrate weather content into classroom curricula and aligning it with State standards. Grantees also provided educators with classroom resources, such as *Tornado Alley* posters, an educator guide, and CDs, for which educators expressed appreciation. Half of the grantees suggested that educators' weather content knowledge probably increased as did some educators' confidence in teaching science. The grantee who conducted a workshop on IDV software and VORTEX2 data believed the session built participants' capacity to analyze real weather data and stimulated interest in using real data in the classroom.

Sample of Comments Regarding Successes and Impacts

The following comments are a sample of statements by project coordinators on the perceived impacts.

Student engagement with the film and speakers:

> *All the programs went really well. The kids' awareness and interest were enhanced. The teachers' knowledge and interest was too. We leveraged several partnerships with the two schools, and worked with the NCAR.*

I think what contributed [to the success] was the subject of tornados and a good film, being able to use existing partnerships with a school, and grant money to support new partnerships.

I think the [students'] interest and awareness increased. Not only did Karen [Kosiba] get to meet the students, but they met the producer and Sean Casey, and they answered the kids' questions. Sean added an extra pizazz, and Karen was a good presenter as well.

Their [teachers'] content knowledge increased. The one school in particular had 4 workshop sessions, and the one group applied the information to a whole unit on weather (2nd grade teachers).

Reaching new audiences:

Main success was getting the teachers watching the film, and introducing them to some of the programs the Science Center offers. Also giving them access to the education guide and other resources we have in town.

Some of the comments were that they [teachers] didn't know these resources existed. So any time they can get something that helps in the classroom is good and it excites them.

Teacher professional development session modeled after the Franklin Institute Workshop:

The success of the project was [having teachers] seeing the film and asking Karen Kosiba questions. Having teachers taking home the IDV software. We tied all components together. Good model [model from the Franklin Institute workshop] to use for one day.

Teacher professional development:

Having Karen K available was pretty awesome. The teachers enjoyed that, and her presentation was great. I think that was the highlight. We did activities afterward too, some from the workshop, and some from other weather services.

Hopefully, they would be able to bring the information to their students. We targeted the workshop toward the science standards they teach about weather, so they'd have what they need, and to make it fun, and they could have activities. We had a lot of tornado damage before the workshop, so we could talk about the "why" of the research is being done and it really hit home.

Homeschool educator professional development and student engagement:

This was the first forum for homeschoolers where the educators attended with their students— [a] model we will use again. Working *with Karen K—ability to bring in an expert—that she was in the film and they got to interact with a practicing scientist – it would not have been as content rich if it were just us presenting.*

We separated students from homeschool educators and they could look up weather data around the country by zip-code. My hope is they recognized there are tools online to use and the use of activities later.

Homeschool educators appreciated the resources we gave them—educators' guide and posters. We gave them a lot of resources to be used afterwards.

Grantees' Personal Impacts

The majority of interviewed grantees felt their knowledge about tornados, specifically about tornado formation and the number, strength, and timing of tornados, increased as a result of project involvement. Tornado research, particularly the extent and scale of research underway, was new to grantees. All said they gained knowledge about the technology and equipment used to gather tornado data.

Two grantees reported greater confidence in teaching weather science to teachers, although two did not. Two other grantees felt the use of real data had enhanced their teaching to teachers, and two who worked on the same project intend to incorporate more science process or inquiry into their teaching rather than simply presenting facts.

Overall, grantees acknowledged being previously unaware of the many weather science careers available beyond meteorology and storm chasing.

Sample of Comments on Personal Impacts

A sample of comments is presented below by the type of knowledge increase and attitude change.

Increased knowledge about tornados:

Yes. I had no idea what the research was that was going on. It was fun to look at the data and hear what researchers are looking for.

Yes, just understanding the data more—formation and what researchers do, the equipment they use, tornado season, level of destruction and weather in general (rain, hail, and wind).

Yes, I was very impressed with ease of software—you could still get real world applications; it gave you a better idea of what scientists are doing now. And, the technology they have developed.

Yes. The whole technology about collecting data, and what the researchers go through to get that information.

Yes, even though we live in Texas I learned about the number, strength, and tools to measures tornadoes.

Increased knowledge about research of tornados (i.e., data collection, visualization, and analysis):

> *Yes, before this I didn't know much about tornado research at all beyond that it existed. So it was really interesting to hear why they were doing what they were doing, and not just chasing storms.*
>
> *Learned a lot—how they collect data and what for; size of team; and how long it will take to analyze the data.*
>
> *Yes, understanding the data collected, what kinds of questions researchers are trying to answer, who some of the researchers are, and it was interesting to see the equipment.*
>
> *In talking with Karen [Kosiba] I see the excitement; all the data going into all the work—learning about how long it takes in the field, crunching all the data, number of team members involved.*

Change in attitudes about teaching weather science to teachers:

> *I would say yes. We offer weather programming, so the topic itself wasn't new, but it did give me more places and ideas about partnering. There are local universities and colleges that I didn't realize had a research team. So being able to have potential partners in town was a great thing to learn.*
>
> *My comfort level is better and I have more resources. Weather isn't something we normally teach here because we do natural history. So my comfort and knowledge base is going to make it easier in the future.*
>
> *We showed teachers a new way of teaching weather; simulate actual real tools to use—gravitate toward real world—real data in the hands of teachers.*
>
> *I guess this was a first. First time I've done weather science for teachers, so it was enlightening, more fun than I thought it would be. Science teachers are fun people.*

Change in attitudes about careers in weather science:

> *Only think of meteorology and storm chasers—see all the pieces involved—other aspects—creating devices—data analysis—software development; there are a lot of career opportunities.*
>
> *I don't know. I think Karen does an awesome job. I guess I didn't realize how many people are involved in collecting data.*
>
> *Never thought about researchers before as being involved in weather science as meteorologists are.*

Plans to Continue Project Activities

A couple of grantees indicated they did not plan to continue any aspects of their projects; others intend to use the resources (posters, educator guide, CDs) in workshops or make them available on request. The grantee who hosted homeschool educators and students plans to use this program model and present more researcher interaction via Skype.

Other Comments:

> *Deborah was very helpful. She answered a lot of questions and helped make things happen. Very grateful for the opportunity. Would have liked the Franklin Institute workshop to have been better organized, more focused on why they brought us together—missed opportunity for supporting each other and making those sorts of contacts. But in all was happy to be a part of it.*
>
> *I really appreciate the opportunity to be a part of the workshop. Always nice to get more out of the films than just the education guide. We don't usually have any resource we can go to beyond the guide. It's also nice to get a gathering of minds working together, and people who understand the work we do and what works and what doesn't. So I appreciate them working with us to help us make good programming*.
>
> *I think everything went well, just want to remind them that if they want us to use the IDV software, more focus on how to use it would have been good. Hard to learn in a short time, and it was even harder to think how we would have taught it to teachers to use.*
>
> *Yeah, you meet someone like Karen K and you think wow—everyone is really nice, and they just opened their doors. They gave us additional film footage for the call with Karen in the fall.*
>
> *I and the museum have better relationships with these two schools as a result. Can look forward to future collaborations with them and the Severe Weather Research Center.*

SUMMARY

Formal and informal educators together attended a professional development workshop at the Franklin Institute. Intended to strengthen science center partnerships with local schools and to foster collaboration, the workshop engaged formal and informal educators in designing an educator professional development project related to VORTEX2.

End-of-workshop surveys suggest that workshop participants appreciated the opportunity to attend the workshop and access resources to implement a local community project. They felt the combination of time for sharing with other professionals, real-time access to a scientific researcher associated with the

VORTEX2 Project, and learning about existing resources were effective aids in developing their community projects.

Nearly all the participants gave very high ratings to the time spent planning their own project workshop, reviewing the educational resources, and video-conferencing with Dr. Kosiba, a VORTEX2 scientist. Data visualizations, introduction to the VORTEX2 data, and viewing the film (some participants had already seen it) received less high ratings. Dr. Kosiba's first-person perspective was a highlight of the workshop, providing valuable context. Some participants expressed gratitude that Ms. Elinich (workshop facilitator) and Dr. Kosiba would be available for project planning consultation and that Dr. Kosiba offered in-person or teleconference presentations.

Participants were less enthusiastic about the technology portion of the workshop. Fewer than half rated the introduction to and practice with the IDV software and datasets as very helpful. Suggested improvements, in decreasing order of frequency, were 1) more workshop time for learning and practice, 2) pre-workshop exposure and practice, and 3) more hands-on activities. A small number of participants also suggested including more group dialogue, more advance information, and a review of basic science related to tornados. The facilitator noted that in the future she would approach the software and data set training more methodically and in smaller increments. Dr. Kosiba suggested that holding the workshop before the movie premiere and outreach activities may have enriched outreach activities.

Participants' knowledge increased at least one level on all topics covered by the workshop, with the greatest knowledge gains made on data collection efforts by the research vehicles (DOW and TIV), data analysis methods used in weather research, and available resources for teaching weather science. Dr. Kosiba saw participants as making the greatest knowledge gains in terms of available resources and personal insight into severe weather research.

The local projects were intended to promote awareness of the VORTEX2 research and engage local audiences with the VORTEX2 researchers. Projects had access to support from the Franklin Institute and the Severe Weather Research Center and to VORTEX2 data sets, and received $500 in grant money. Workshop participants also received laptops pre-installed with Integrated Data Viewer (IDV) software and actual severe weather data. By the end of February 2012 nine projects were approved and grantees received funding to implement projects over the next nine months.

Although each was unique, project plans generally sought to offer formal educators knowledge and tools for teaching students about weather science, using VORTEX2 research as context. Plans included hands-on activities, *Tornado Alley* screenings, and teleconference or in-person interactions with Dr. Kosiba. Only one project used IDV software and data sets. Two projects targeted unique audiences: in-service and pre-service teachers and homeschool educators and their children/students.

Interviews were conducted with eight of the nine funded project coordinators. Most grantees found contacts with The Franklin Institute very helpful; a small number reported communication mishaps. All interviewed grantees who contacted Dr. Kosiba found her responsive and informative. Three grantees contacted meteorologists for project planning assistance; one contacted the National Center for Atmospheric Research (NCAR). Contacts within grantees' organizations were typically with public relations or program development staff. Grantee contact with other workshop participants concerned logistics more than project ideas.

With the exception of the sole grantee who learned how to use the IDV software and data sets to create a teacher's guide, others found the software time-consuming to learn and difficult to use with teachers. Most of those who accessed the *Tornado Alley* website found that information very helpful. Half of grantees found the education guide helpful; half found it very helpful. Most found the posters very helpful. Other resources tapped were state standards and the IDV online tutorial.

Several grantees reported success in increasing teachers' and students' content knowledge and interest in severe weather, crediting the film, interactions with Dr. Kosiba, teacher resources such as classroom activities and IDV software, and leveraging school and NCAR partnerships for the success. Half of the grantees sought to engage new audiences and reported increasing numbers of teacher attendees, reaching distant districts, and introducing teachers to other programs at their institution. The grantee who conducted a homeschooler forum rated it a success and will continue with this model. Two grantees conducted activities for students and teachers on-site and attributed high levels of student interest to the film and in-person interactions with Dr. Kosiba and Sean Casey.

All eight grantees sponsored educator events featuring a *Tornado Alley* screening and professional development sessions and provided classroom resources such as detailed posters, CDs, and an educator guide. Grantees reported that teachers expressed appreciation for these materials and appeared to benefit from learning how to integrate weather content into classroom curricula and align it with state standards. Half of the grantees thought that exposure to the project probably increased educators' weather content knowledge and confidence in teaching science. The grantee who conducted a workshop on IDV software and VORTEX2 data believed the session increased participants' capacity to analyze real weather data and provoked interest in using real data in the classroom.

Grantee described the successes of their projects in terms of:

- Student engagement.
- Reaching new audiences.
- Teacher professional development.
- Homeschool educator professional development.
- Modeling professional development after the Franklin Institute workshop.

Tornado research, particularly the extent and scale of current research was new to grantees. They also acknowledged their previous ignorance of the many weather science career options beyond meteorology and storm chasing. Most grantees reported increases in their knowledge of tornados, specifically about tornado formation and the number, strength, and timing of tornados; all said they learned more about the technologies and equipment used to gather tornado data.

Personal impacts on grantees from the workshop/project experience included:

- Increased knowledge about tornados.
- Increased knowledge about research of tornados (data collection, visualization, analysis).
- Increased confidence in teaching weather science to teachers.
- Positive attitudes about integrating inquiry and scientific method in their own teaching.

A couple of grantees indicated they did not plan to continue any aspects of their projects, while others intend to use the *Tornado Alley* resources in future in workshops or make them available on request. The grantee who hosted homeschool educators and students intends to continue this program model.

IV. Educational Outreach and Vehicle Tour Evaluation

Funded by NSF grant # 1010884 and a cooperative agreement with GEO, the *Tornado Alley* educational outreach tour was a significant component of the project. Visits from the Tornado Intercept Vehicle (TIV) and the Doppler on Wheels (DOW) tornado chasing vehicles allowed audiences to experience the tools (and the excitement) of weather research in person mediated by passionate science role models. In addition, high-profile appearances featuring vehicles and scientists delivered a meaningful PR opportunity for VORTEX2, generating visibility and enthusiasm for cutting-edge research and science careers.

The educational vehicle tour had two primary components: one focused on institutional (science center) venues that hosted and promoted the film, and one intended to reach underserved audiences (those without access to museum cinemas or informal science learning venues), with a particular emphasis on communities in regions with potential to be affected by tornadoes. As a general model, events included science presentations and media appearances by members of the VORTEX2 research project, featuring the DOW and additional portable weather measurement tools at the researchers' disposal (ie. tornado pods, computer models, etc.), and/or an appearance by the film's director, Sean Casey (supported through the film's marketing budget and contributions from museums) and the highly visible TIV. Exhibitors that hosted the DOW and/or the TIV were encouraged to use creativity to maximize educational and promotional value in their own markets. Contests with local media partners to win a ride in the vehicle and/or to attend special, exclusive events featuring researchers not only reached thousands of potential viewers, they delivered tremendous value in media and exposure for the film and the VORTEX2 research project.

Outreach to rural, tornado-affected communities was a more challenging undertaking given that these areas lacked resources and manpower to support planning and implementation. The project team employed several strategies for executing outreach in these communities. In the first, pilot phase, the team relied in part on contacts made by director and storm chaser Sean Casey and his team during the field shooting season. The next phase of outreach was planned in association with educational partners in areas that had experienced tornado outbreaks, but not within the past year.

Outreach to museums and science centers took place from 2011-2012; rural and tornado-affected programs were run from 2011-2013.

The project’s museum-based outreach program significantly supported the film in the majority of US venues: 67 museums or science centers, or over 80% of exhibitors, hosted the TIV and/or the DOW vehicles, and at least 200 unique events were held. A very conservative estimate for the audience directly reached through these activities (those who physically toured a vehicle, had a conversation with a scientist, etc.) is 150,000 across the US, although at least 250,000 likely experienced at least a passive interaction. The project team was extremely pleased that virtually every theater interested in hosting an outreach program featuring storm chasing vehicles and scientists was able to do so—and the outreach schedule surpassed the project team’s expectation for events at the time of the project’s proposal, which accounted for only 40 site visits.

Outreach to tornado-affected communities included activities at 7 sites in 2012, considered a pilot phase, and at 20 sites in 2013. Venues ranged from small museums without theaters to community centers and school gymnasiums to challenging "untraditional" sites—such as a warehouse space located adjacent to trailers being used as temporary classrooms in a town that had been completely leveled by a recent tornado, or a special section of a Lowe's home improvement store which hosted the screenings indoors and provided a community resource fair featuring researchers, first responders, etc. outdoors in its parking lot. The program's second phase in 2013 emphasized outreach to economically underserved areas—both urban and rural. Programs were held in areas of Missouri with high minority populations, such as Ferguson, MO, recently the subject of media attention due to racial tensions, as well as Indian Reservations in South Dakota located in the nation's poorest county (Buffalo County, SD). As with museum-based outreach, these activities also exceeded the project team's outreach goals in terms of reach: the project proposal estimated only 20 events total.

METHODOLOGY

After visiting each outreach site, Deborah Raksany of Giant Screen Films, requested museum host(s) and site coordinators to take an online survey about their outreach experience. (See the online survey for museum hosts in Appendix L and the site coordinator survey in Appendix M. Sixteen surveys were received by representatives of 14 museums and 16 surveys were received from representatives of 13 outreach sites (a school, community center, or other site). Telephone interviews were conducted with three Tornado Alley staff scientists and two technicians. Project Co-PI Deborah Raksany also provided written comments derived from event notes, log sheets, and personal observations. (The interview protocols appear in Appendix N. Phone interviews were also conducted with two site coordinators, one from Joplin, MO and one from a Native American Indian school in South Dakota. (The interview protocol appears in Appendix N.)

INSTITUTIONAL OUTREACH

The table below identifies museums that responded to the online survey from the programs that screened the film in large format theaters (IMAX and other immersive cinemas).

Table IV1. The 15 Museums Involved in Outreach Projects (2011 – 2014)

Location	Museum Host	Evaluation
Shreveport, LA	Sci-Port: Louisiana's Science Center	Survey
Boston, MA	Museum of Science	Survey
Cincinnati, OH	Cincinnati Museum Center	Survey
Birmingham, AL	McWane Science Center	Survey
Charlotte, NC	Discovery Place	Survey (3)
Raleigh, NC	North Carolina Museum of Natural Sciences	Survey
Garden City, NY	Cradle of Aviation Museum	Survey
Austin, TX	The Bob Bullock Texas State History Museum	Survey
Hutchinson, KD	Kansas Cosmosphere and Space Center	Survey
Milwaukee, WI	Milwaukee Public Museum	Survey
San Diego, CA	Reuben H. Fleet Science Center	Survey
Portland, OR	Oregon Museum of Science and Industry	Survey
Chicago, IL	Museum of Science and Industry	Survey
Chattanooga, TN	Tennessee Aquarium	Survey

Of the 16 museum host respondents,

- most worked in marketing or communications (n=10), and
- some were theater managers or event planners (n=6).

The table below lists the museum location, name of institution, and their description of the programming that happened at their site.

Table IV2. Programming Descriptions by Location and Museum Host

Location	Museum Host Venue	Programming Description (by museum representation)
Shreveport, LA	**Sci-Port: Louisiana's Science Center**	In addition to permanent exhibits on tornadoes inside the Center, we implemented new programs and demonstrations, as well as a camp theme. We also partnered with a local news station, KSLA StormTracker 12, to bring awareness to not only the film, but to dangerous weather in general.
Boston, MA	**Museum of Science**	We had a press/VIP preview, as well as an advance screening with our promotional partner, the Boston Globe. We also had live presentations available (Hurricane Hunting, Blame it on El Nino, Extreme Weather) and podcasts on our website (Better Hurricane Forecasting, Massachusetts Tornadoes, Tornado Outbreak).
Cincinnati, OH	**Cincinnati Museum Center**	We had Sean, Marcus, Brandon and the TIV at Museum Center for the weekend, greeting fans, fixing the TIV(!), introducing shows, and simply entertaining ecstatic visitors. We also had Karen Kosiba, Andrew Arnold and the DOW, out meeting visitors, showing the science side with radars running in the DOW and entertaining visitors. We had Marcus, Sean and the TIV out a second time as well. That trip we took the TIV to a Cincinnati Reds (MLB) game and had the TIV inside the stadium.

Table IV2. Programming Descriptions by Location and Museum Host, cont.

Location	Museum Host Venue	Programming Description (by museum representation)
Birmingham, AL	**McWane Science Center**	We hosted the National Weather Service's annual convention for a Weatherfest event. We had approximately 30 vendors, meteorologists, etc. who demonstrated weather technology and provided programming. We had both the Doppler and the TIV on hand. Sean Casey did meet and greets as well as introduced five screenings of Tornado Alley in our theater.
Charlotte, NC	**Discovery Place**	TIV demos on street, special screening and Sean Casey presentation. Public interaction on the street with the TIV Media interviews Special screening hosted by Sean Casey. The DOW visit from September 22- September 24. The DOW arrived with Josh Wurman and Andrew. We held a VIP/Donor event that showcased the DOW and Josh Wurman spoke during dinner. On Friday, 92 students from under-privileged schools visited Discovery Place and the DOW free of charge. Each school group heard a short presentation from Josh and was able to investigate the DOW. On Saturday, the DOW remained onsite for visitors to experience and ask Josh and Andrew questions. After the afternoon screening of Tornado Alley, Josh held a question and answer session with the visitors who attended the screening.
Raleigh, NC	**North Carolina Museum of Natural Sciences**	On site included a full day of screenings (7), mostly sold out, introductions and autograph sessions with Sean Casey and the TIV on display outside.
Garden City, NY	**Cradle of Aviation Museum**	Truck inspection, devices on display, introduction to film by scientist with Q & A afterwards.
Austin, TX	**The Bob Bullock Texas State History Museum**	TIV tours with Marcus Gutierez, Tornado Alley screening with introduction and Q&A.
Hutchinson, KD	**Kansas Cosmosphere and Space Center**	TIV rides, Sean Casey meet & greets, weather related services and demonstrations, educational presentations.
Milwaukee, WI	**Milwaukee Public Museum**	Special lectures, rides, and demonstrations.

Table IV2. Programming Descriptions by Location and Museum Host, cont.

Location	Museum Host Venue	Programming Description (by museum representation)
San Diego, CA	**Reuben H. Fleet Science Center**	The DOW visited for 1 week during which time we showcased the DOW and CSWR scientists in TV news segments, private screenings for media and donors, and Jr. Scientist from CSWR took the DOW to 15 local schools for student outreach. CSWR scientists also participated in public presentations and one-on-one discussions with youth as part of the San Diego Science Festival. The TIV came to town late summer and we showcased it and Sean Casey on local TV news and at a public event at the museum.
Portland, OR	**Oregon Museum of Science and Industry**	We hosted an invitation only event that included a tour of the Doppler on Wheels, tornado science demonstrations, meet & greet with Dr. Kosiba, and a viewing of the film. We also hosted the DOW onsite for two days, when the film opened.
Chicago, IL	**Museum of Science and Industry**	Opening weekend we hosted the TIV and Doppler on Wheels. Sean Casey and most of the scientists featured in the film were at the Museum for two days of events. These events included, Q&A before and after the film, introducing Guests to the vehicles featured in the film, panel discussions with our Science Minors and Science Achievers students, and a panel discussion with museum guests. Students from Valparasio University were also on hand doing weather experiences with families.
Chattanooga, TN	**Tennessee Aquarium**	Red Cross benefit screening, media visits, local television station weather radio programming / sales event tied to live remote broadcasts. Two education outreach visits with DOW and Dr. Kosiba. One school group at the theater who toured the DOW and had a classroom presentation with Dr. Kosiba. Weekend of "open house" activities with NWS, Red Cross, DOW and TIV.

Table IV3 below presents the number of respondents and percentages reporting on which of the program components happened and which audiences were served by the program.

Table IV3. Number and Percentage of Museum Respondents Reporting on Program Components and Audience Served

	n=	%
Components of the Program		
Appearance of the TIV-2	12	75%
Appearance of the DOW	12	75%
Film screening	12	75%
Scientist/TIV-2 Driver Presentation	11	69%
Audience Served by the Program		
Families (mixed ages)	15	94%
Adults	13	81%
Students	10	63%
Those Serving Students		
Elementary School Age	3	30%
Middle and High School Age	2	20%
Kindergarten through High School Age	4	40%
Not Sure	1	10%

More than two thirds of respondents reported using all four components—film screening, TIV-2s and DOW appearances, scientist presentations, and audience interaction. Families comprised the greatest audience. Somewhat more elementary level students were served than secondary level students.

Impacts on Hosting Organizations

Almost all of the institutions (11/13) reported engaging new partners in their projects, such as news affiliates and weather broadcasters, and to a lesser extent, the Red Cross, local universities, and emergency management, and National Weather Service personnel.

Nearly three-quarters of respondents reported reaching new audiences (10/14), such as “weather geeks” and school teachers and students.

Factors in Programming Success

More than half of the respondents felt having the vehicles onsite and providing public interaction with the drivers was key to making the events a success. About one third noted having the scientists’ presentations and questions and answer sessions and the media presence as positive aspects to the programming. Sample respondent comments follow.

> *Allowing our visitors to explore the TIV II resulted in a great response. People drove to Sci-Port from across the region to take a look inside. Having the vehicle on site was a huge boost in numbers.*

> *Having the DOW, TIV, Sean Casey, Marcus TIV Driver, and the handful of CSWR scientists visit our market to support the film made our launch successful. Having multiple spokespersons who know*

science to speak at public talks, in schools, and on-camera brought us significant media coverage and attendance.

Media visits with Dr. Kosiba and DOW. Education outreach programs. Red Cross Screening Direct contact with people through static displays of TIV and DOW at Theater in a prominent downtown location on a very busy weekend.

The VIP/Donor event on Thursday evening was successful. Everyone attended was engaged in Josh's presentation and learned a great deal about Tornados. This audience is a collection of lifelong learners and having a knowledgeable scientist explain in more detail the dynamics of tornados was definitely successful. On Saturday, providing free admission and an educational program to under-privileged school group was a great success b/c it gave these children an opportunity to experience hands on science

The press/VIP preview event seemed to be the most successful because of the great coverage that we received, excellent reviews, and the number of photo ops. Having the WCVB meteorologist, the Doppler vehicle, and the scientists available to answer questions for the press and give context to the film was very beneficial.

Other aspects reported:

Attached it to our climate change exhibits and added a hurricane simulator.

The private viewing was very popular and well received. It was a unique opportunity to bring together our members, donors and local partners.

We also included the film in a mailer to educators and in their e-newsletter so they would be aware of the educational content.

Most respondents felt that having the vehicles on site increased awareness and interest in seeing the film. Some said the TIV was a draw since many people are familiar with it from television. Others noted that the vehicles made a visual connection to the film and "brought science to life for many," particularly students. The vehicles' presence also increased media and social media coverage of the film. A sample of the respondents' comments follows.

Increased Interest in the Film:

TIV had a huge draw because people are familiar with it and anyone interested in weather was drawn to the vehicles. Having the vehicles here probably peaked interest in the movie and the event/museum.

Definitely increased awareness of the film at Discovery Place and numbers that wanted to view it.

The TIV was part of the "WoW factor" for the public. They were excited to see up close what they have seen on TV.

Increased Media and Social Media Coverage:

> *Having the Doppler on Wheels helped our outreach as we were able to use it as a backdrop for interviews, as well as a photo opportunity. With most Omni films, we don't have much to use in terms of visuals, so the vehicle helped us generate more visual coverage for the film. We were not able to get the TIV around the opening, so there wasn't much else we would have done with the Doppler that impacting our general marketing activities.*
>
> *Having the TIV onsite got us much more media exposure than we usually get for IMAX family days.*
>
> *We LOVED having both vehicles here. They drew crowds, photo opportunities (which increases word of mouth and online awareness through photo sharing) and increased our media coverage.*

Visual Connections to the Film:

> *The vehicle visits … brought in people that might not have chosen that weekend to visit the museum. They attracted a lot of people passing by on Lake Shore Drive who came to the museum just to see what they were. Having the vehicles at the museum brought science to life for many guests that might not have thought twice about weather or meteorology.*
>
> *The TIV2 allowed visitors to make a visual connection to the film and it was a great draw to get visitors inside our facility.*

A few respondents described impacts the project had on students, such as engagement, curiosity, and learning.

Educational Engagement:

> *We were able to bring research tools, DOW & pods, to schools to show students not only how scientists are investigating severe storms, but how careers in STEM fields can be exciting. Having a scientist and a power point presentation is one thing. But I believe having the opportunity to interact with the scientist, climb inside the DOW, see radar data and get hands-on with the tornado pods will leave a more lasting impression on these students.*

Although some respondents said the media coverage for their outreach programming did not differ from other events, most felt media coverage was higher or more widespread than usual. Some museums staged live weather broadcasts from the venue or provided on site or studio interviews with scientists for television or radio broadcasts. Engaging weather professionals in the media coverage was new for many respondents. Where relevant, museum hosts noted the sensitive nature of media coverage due to recent tornadoes in their areas.

Increased Media Coverage:

> *Got meteorologists involved. Also, offered select media the chance to ride in the TIV and have a one-on-one conversation with Sean & Marcus -- our local meteorologists LOVED this.*
>
> *Coverage by WRAL was integral and extensive - they broadcast numerous stories over a three-day period. Their meteorologists were all over it.*
>
> *We had significantly higher media coverage for this film vs. other films because of the number of scientists available to us, who visited on different dates allowing us to stretch out the media coverage over a longer span of time. And having two visually captivating storm chasing vehicles made for exciting TV interviews and the media loved showcasing the vehicles on camera.*

Sensitivity in Media Coverage:

> *The April 2011 tornado outbreak hit our area particularly hard. We tried to focus on the science aspect of the film and how researchers are trying to improve warnings and potentially construction methods. Residents in our area, including some in tornado ravaged areas, seemed to appreciate the film as more than a "thrill ride", although some posted on social media outlets that they preferred not to see the film due to their recent experiences. One man, who lost his home in April, was interviewed by a local television station. He said he would come to see the film because he wanted to know more about tornadoes.*

Invited to share any other thoughts about the outreach event, all respondents spoke positively about the experience. Most commonly noted was the professionalism of the *Tornado Alley* project team members.

Tornado Alley Project Team:

> *I can sit and talk till I am blue in the face about* Tornado Alley *and how much I love it, but the guys and the TIV bring a whole new aspect. They can tell their first hand stories that don't come out in the show or film that people love to hear. They are literally meeting a celebrity and people just love that. We posted pictures from their visits of Sean just signing autographs and people would tag themselves in it, just adding to the reach of people who see the publicity. Our Facebook page hit 10,000 and increased very quickly with our first TIV, Sean, Marcus, and Brandon visit. I loved having*

the guys out and getting such great feedback. Also, a huge thank you to Deb for helping us with the craziness of the first visit and being so flexible!

Seeing the kids interact with the vehicle and Dr. Kosiba was great! They were so curious as to what was inside and out. Their eyes would just light up as they learned new things and it was a joy having the crew here.

Great program especially for us when we were so affected by the storms in April. The program that we took to the local school was amazing and the kids were definitely excited and engaged.

Our opening weekend was enhanced 100% by the outreach provided. There is one thing about just seeing a movie, but something totally different and immersive when you are able to experience the science first hand and actually talk to the people you just saw on the big screen. It was amazing!

Impacts on the VORTEX2 Scientists

The Vortex2 scientists were all experienced and comfortable in sharing their knowledge via presentations at professional conferences or educational settings. The new and exciting element, for them, was the addition of a giant screen film. All agreed the film was an effective platform for disseminating weather science information to the public, and reported learning more about film companies and science centers/museums. Some scientists expressed new-found appreciation for how informal science organizations promote science and technology education.

Reflections by Tornado Alley Project Staff

Interviews were conducted with five members of the Tornado Alley project staff and Deborah Raksany, Co-PI, provided written commentary. The table below lists the people who participated in the on-site outreach activities. Feedback was gathered as indicated.

Table IV4. On-Site Outreach Staff, Role, and Participation in the Evaluation

Outreach Staff	Role	Evaluation Method
Deborah Raksany	VP, Development and Partnerships, Giant Screen Films	Written notes/logs
Sean Casey	Film Director; Storm Chaser	
Marcus Gutierrez	TIV-2 Driver, mechanic	
Brandon Ivey	Meteorologist	
Josh Wurman	President; Center for Severe Weather Research	
Don Burgess	Research Scientist; Oklahoma University; NSSL Severe Storms Lab	Interview (2)
Karen Kosiba	Scientist; Center for Severe Weather Research	Interview
Terra Thompson	PhD Candidate; Oklahoma University	Interview

Factors in Implementation Success. Raksany noted differences in institutional structure amongst participating venues. In some cases, film promotions were well integrated with other departments of the museums—educators participated with PR teams and marketing staff to plan programs that met promotional and educational goals. However, at some sites, the museum theater was not well connected to mission activity and was managed primarily as a source of revenue. Raksany heard reports from scientists who were disappointed to have participated in multiple media interviews only to see buses of school groups arrive in the parking lot and enter the museum without interacting with them or the vehicles at all, simply because they were unaware of the opportunity. The project team learned over the course of the initiative that it was essential to encourage communication between all operational areas of AISL institutions to best leverage the resources of this program.

All scientists participating in the outreach activities noted that event success ultimately depended on the hosting museum's pre-event publicity and activities scheduled around the premiere and screening of the film. Unsurprisingly, the scientists reported that museums with extensive publicity, including media interviews with the scientists, reached more new and diverse audiences while events with weak planning and publicity were less successful.

The team also quickly recognized the value of collateral literature about *Tornado Alley* and produced materials, with photographs and descriptions of earlier presentations that they used to market the *Tornado Alley* project. In addition, the team successfully retrofitted the vehicles for extended public contact; the vehicles and appearances by Sean Casey and other "tornado chasers" drew very strong public interest. Representatives from hosting organizations believed having the vehicles (TIV and/or DOW) on site with the TIV drivers and/or the scientists gave audiences a "real life" connection and context for the film, and enhanced audience engagement.

REMOTE AND UNDERSERVED OUTREACH

The project team also conducted outreach visits to 7 pilot sites (2012) and 20 Phase II sites (2013), conducting 26 programs in all. Five sites served Native American populations.

Table IV4 below lists the locations of for the community and underserved outreach sites and indicates whether a site representative participated in the evaluation by completing an online survey about the experience or was interviewed by the evaluator.

Table IV5. Location, Outreach Site, and Participation in the Evaluation

Location	Outreach Site	Evaluation
Birmingham, AL	Daniel Payne Middle School	
Smithville, MS	United Way Warehouse	
Fayetteville, NC	Ben Martin Elementary School	
Chapel Hill, NC	North Chatham Elementary	Survey
Ringgold, GA	Bright School	Survey
Ringgold, GA	Heritage Middle School	Survey
Jay, OK	Jay Community Center	Survey
Cartersville, GA	Tellus Science Museum	Survey (2)
Broken Arrow, OK	Lowe's Broken Arrow	Survey
Berkeley, MO	Airport Elementary School	
Ferguson, MO	Johnson Wabash Elementary School	Survey
Camdenton, MO	Camdenton HS	
Waynesville, MO	Waynesville HS	Survey
Rolla, MO	Missouri University Science & Technology	
Rolla, MO	Eugene Northern Community Hall	
Rolla, MO	Rolla Public Schools - High School	
Joplin, MO	East Middle School	Survey
Joplin, MO	North Middle School	
Joplin, MO	Joplin Administration Building--PD session	Survey
Joplin, MO	Missouri Southern State University-Billings Student Center	Interview
Joplin, MO	South Middle School	
North Platte, NE	Osgood Elementary	Survey
North Platte, NE	North Platte High School performing Arts Center	
Kennebec, SD	Lyman School	
Kimball, SD	Kimball Colony School	
Kimball, SD	Grass Ranch School	Survey
Lower Brule	Lower Brule High School	
Fort Thompson, SD	Crow Creek Tribal School	
Chamberlain, SD	St. Josephs Indian School	Interview
Signal Mountain, TN	Nolan Elementary	Survey
Jefferson City, MO	Math + Science Curriculum Specialist	Survey
Jefferson City, MO	Center for Education Safety	Survey

16 surveys were received from 13 sites, 9 were school-based and 4 community-based setting.

Of the 16 outreach respondents,

- most were school staff members, such as teachers or principals (n=9);
- some were community organization staff, such as managers or directors (n=4);
- two were science content specialists (astronomer, science program manager); and
- one was a parent volunteer.

All respondents reported that their program included a scientist/ TIV-2 driver; more than three quarters also featured the DOW. More than half of respondents also screened the film and showed the TIV-2. Students comprised by far the largest audience, followed by adults and families (mixed ages). See Table IV5 below.

Table IV6. Program Components and Audience

	n=	%
Components of the Program		
Scientist/TIV-2 Driver Presentation	16	100%
Appearance of the DOW	14	88%
Appearance of the TIV-2	10	63%
Film screening	9	56%
Audience Served by the Program		
Students	14	88%
Adults	7	44%
Families (mixed ages)	5	31%

Of the 14 respondents who reported their program served students, six served elementary school age students; four served middle school; three served kindergarten through high school age students; and one served high school only. When asked whether the community served included first responders or tornado survivors, 8 out of 16 indicated yes to either group.

Respondents were asked to report on the number of children and adults who participated in the program. The table below presents the results.

Table IV7. Number of Respondents by Number of Program Participants

Number of Children Served by the Program	n=
None	1
< 100	2
100-300	8
600-700	2
1,560	1
Number of Adults Served by the Program	
< 10	6
10-30	4
100-200	4

Respondents were asked to rank the relevance of the presentation for their community. All respondents, with one exception, ranked the program as very relevant for their community. (The other respondents ranked it somewhat relevant.) The majority of respondents attributed the relevance to the experiences community members have directly or indirectly had with tornadoes. Some of comments include:

> *The year previously our town was hit with an EF3 tornado. We are in Tornado Alley.*
>
> *All our students & faculty were impacted in some way by our May 2011 tornado. We still have mental health counselors working with students & staff to minimize impact.*
>
> *It also helps our students understand about storms and tornados etc. Our community has suffered from tornadoes in the last few years.*

Tornado sheltering for schools in Missouri is a major "safety" challenge, and understanding the physical aspects of tornados helps greatly in addressing this issue.

The Tornado Alley Outreach tour crossed the state of Missouri over a 7 day period. During that time the team met with students, educators and citizens in communities that had been impacted by severe weather /tornados. From areas like Ferguson /Florissant where a small EF1 tornado touched down in April 2011, to the most notable, Joplin EF5 tornado [that] touched down in May 2011, and everywhere between.

We have violent weather often, the event touched hundreds. Many were involved, but did not watch the screening.

Our area has been hit by tornadoes three times in the last six years. The last storm was the one that spawned the Joplin tornado in May 2011. This presentation helped our people understand better the formation of a storm, the critical components, to understand better how to be prepared in the event of severe weather, and to see the film and understand the destruction a tornado can cause as it is happening. It also piqued an interest in many to study more about weather science.

We have had tornadoes in the area, so it was nice for the students to hear how tornadoes are tracked.

Having just experienced close encounters with tornadoes roughly 6 months earlier, the children had lots of questions. They are, also, naturally curious about weather events, how they are predicted and what makes them happen.

A couple of respondents felt the presentations were valuable for their curricular relevance.

Directly meets a number of curriculum areas.

Our focus as a district is STEM and STEM related careers.

Respondents were asked to identify what was most valuable about the outreach event for their community and what element participants most interested in. Most respondents cited the presentations or question and answer sessions conducted by the scientists as being important to participants. Educational aspects, such as learning about science careers, were also cited as being valuable to participants. Respondents reported community members were very interested in the on-site vehicles and seeing the 3D film. Comments include:

It was all very valuable. Of course the video captured the kid's attention, but the vehicle was awesome for them to see. The *question and answer period made it all real. Couldn't have been better!*

Most valuable was the educational content of the film and the presentation by the scientist. The most interesting features were the DOW and the 3D/IMAX experience.

The scientist presentations about the physics of tornados, as well as the group discussions after the presentations.

Having the diverse group of people that developed the film and the vehicles that they used to track and capture data from the severe weather events.

The presentation, including scientist, filmmaker, and 3D film, were the most VALUABLE to our community. The single item that drew the most interest, of course, was the TIV-2, which had a constant flow of observers around it throughout the day.

I think there were a lot of successful aspects: the 3D movie was very popular on Saturday, people loved talking to Marcus and Andrew, people loved seeing the TIV and DOW, I think that having Marcus here really boosted the media presence (name recognition), also I think that our visitors were more likely to watch the movie after talking to the guys and seeing the vehicles.

The actual vehicles being on-site with the personnel responsible for using them. The 1:1 conversations that were generated between the adults and students were tremendous.

Initially, my students were most interested in seeing the tornadoes on screen. However, after the film they were all excited about seeing the DOW. They want to know more about the satellite data and how they work. They also wanted to know what you had to do to become "that kind of scientist"! Many were frightened beforehand when you mentioned tornadoes. The film helped them understand what was going on and how to prepare.

Many of our students are not from this region and are therefore unfamiliar with local severe weather events. They now have a new respect for the power of tornadoes.

Understanding that massive tornados are rare.

Reflections by Tornado Alley Project Staff and Community Coordinators

As described above, interviews were conducted with five members of the Tornado Alley project staff and two community coordinators. The on-site community coordinators were Brian Crouse, from the statewide Chamber of Commerce in Missouri, and Jona Ohm, Public Relations Director of St. Joseph's Indian School, in Chamberlin, SD. Deborah Raksany, Co-PI, also provided written comments summarizing her event notes and logs. The table below lists the people who participated in the on-site outreach activities. Interviews were conducted as indicated.

Table IV8. On-Site Outreach Staff, Role, and Participation in the Evaluation

Outreach Staff	Role	Evaluation Method
Deborah Raksany	VP, Development and Partnerships, Giant Screen Films	Written notes/logs
Sean Casey	Film Director; Storm Chaser	
Marcus Gutierrez	TIV-2 Driver, mechanic	
Brandon Ivey	Meteorologist	
Josh Wurman	President; Center for Severe Weather Research	
Don Burgess	Research Scientist; Oklahoma University; NSSL Severe Storms Lab	Interview (2)
Karen Kosiba	Scientist; Center for Severe Weather Research	Interview
Terra Thompson	PhD Candidate; Oklahoma University	Interview
Andrew Arnold	DOW Driver and Research Technician; Center for Severe Weather Research	Interview
Ab Pfeiffer	DOW Technician, Center for Severe Weather	
Scott Fauteux	Technician, D3D Cinema	Interview

Factors in Implementation Success. According to Raksany, outreach to remote, rural and tornado-affected communities proved challenging due to a variety of factors, from planning the logistics of installing a projector to advertising events to rural communities without tools typically used for promotion, such as email lists. The project's pilot phase was valuable in identifying a number of key factors that influenced success and in planning strategy and content for subsequent programs.

During the pilot phase, the team relied in part on contacts made by director and storm chaser Sean Casey and his team during the field shooting season. These communities were familiar with the film and with the project, and were eager to see Sean and the scientists return to reflect on the experience of tornado impacts and re-connect with affected individuals. After recognizing the severity of the damage in these areas, however, the project team determined that subsequent outreach might be better suited to areas with less immediate need. For example, a site in Smithville, MO, that had experienced severe damage did not even have buildings for school activities—classes were operating in temporary trailers. In all cases, there were concerns that young children might find the film experience more frightening than educational. Given the extreme and proximate nature of weather events in these communities, the project team and partners were equally concerned with approaching the experience and subject matter with sensitivity for all audiences. While local contacts were eager to bring enrichment opportunities to their communities, it was also apparent that limited, valuable human resources were being dedicated to support project activities. Based on this experience, the team determined that the project might best serve areas that had not experienced immediate, tragic damage, but those that had rebuilt and recovered somewhat, as well as remote, at-risk areas.

Raksany also noted that the time and energy required to plan a single event was significant, and local partners were essential: they provided a trusted connection to communities that were unfamiliar with the project, many of which had sensitivities related to traumatic weather events. They also played a critical role in event planning, promoting and implementing events. For instance, these partners were able to identify local mechanisms of communication—such as school newsletters or local businesses that were willing to distribute flyers about events—that would have been impossible for the project team to utilize without assistance. They were able to locate sites for events and liaise with local educators and families to plan for dates and to distribute information, permission slips, etc. to ensure that groups were enthusiastic and prepared for programs. Based on learning from the pilot phase, for the second year of outreach, the team established several key partnerships as well as a straightforward event format and description, and worked actively with school administrators and parents to ensure children were prepared to discuss severe weather topics. Content was adapted to strongly emphasize research and safety rather than storm chasing (which often meant a diminished role for the film's director, Sean Casey).

Having project team members experienced in pilot events in previous years proved very valuable in ongoing activity. While the project had a very competent team in place to implement project activities on the ground, if resources had been available, it would have been valuable to have a project PI or high-level team member at many programs in order to immediately leverage lessons being learned in the field to inform subsequent programs. The demands of managing activities on the ground left little time to adapt plans while in the field.

With respect to content, the *Tornado Alley* team developed a four-part presentation that included screening *Tornado Alley* or selected clips from the film (depending on the age of the audience and sensitivities to weather events) , experience with the vehicles, a presentation by a Vortex2 scientist, and a question and answer session with audience members. The quality of the programming and participation was very high, said Brian Crouse, of the Missouri Chamber of Commerce, and fulfilled his goal of promoting STEM awareness and careers. *Tornado Alley* staff described a rapid evolution in the presentation's quality and impact as the team worked together and saw how the four elements fit together, culminating in a smooth and efficient production that maximized participant contact with each element. Fauteux observed that enabling audiences to hear about the science, then tangibly experience it with one of the vehicles, immerse themselves in it through the film, and then come back at the end and ask and answer questions was a very successful format.

Fauteux described how presentations changed according to students' age: at the elementary level, he said, the team didn't get into the "heavy science" but instead tried to provoke interest in what the team was doing and how the Tornado Alley research could ultimately help them. With older students, the effort was more one of "planting seeds," engaging students in the "cool car" aspects of the vehicle to prompt questions like "How can I be involved in something like this?" and steering students to think about STEM study and careers. With adult audiences, the team did short presentations and allowed time for extended communication with and by audience members.

Kosiba noted that the film provided critical context for participants and gave them enough background knowledge to be able to ask questions. Burgess also noted that community receptivity—especially in

Missouri, where several towns had recent tornado experience—was also a factor in the project's success. Arnold concurred that smaller, more intimate settings enabled some participants to speak up and pose questions while larger settings might have been more inhibitory.

Improvements raised by interviewees primarily concerned finding more time to do everything the project team and community groups wanted to do. Burgess wished for more time for hands-on activities, while others, such as Ohm, wished for more time to let classroom teachers prepare students for the *Tornado Alley* experience.

Raksany noted that limited resources and staff turnover at some of the most remote sites (ie. tornado affected and reservation communities) made it difficult to facilitate participation in surveys and interviews. A key lesson learned from this experience would be to develop on-site instruments to gather feedback during and immediately after the outreach programs to improve capture of valuable information, and with increased resources, to survey or interview public event participants on-site to gather more direct information about impacts on the audience.

Impacts on Vortex2 Scientists. Interview responses suggest a widespread need among audiences for accurate information. Arnold noted that most people's understanding of tornados and how to respond was either inaccurate or outdated. He valued the exchanges with audiences that addressed safety strategies—such as warnings not to leave the car and go into a ditch, a one-time recommendation for tornados. Some participants thought the Southeast is protected against tornados by hills and valleys, he said, and he worked to overturn inaccurate ideas and urged audiences to wake up and take precautions.

Others did not know the difference between a warning and a watch. "We cracked the misconceptions of interpretations on TV", Kosiba noted.

Arnold said that as a scientist, it was good to hear people's tornado stories; it emphasized the importance of ongoing research to extend lead time. He called the experience good for both victims and scientists. One scientist heard young students who experienced tornado damage affirm the work researchers do to expand warning lead time and regarded the interaction as "therapeutic" for the scientist and the students. For Fauteux, no other project in his 12-year career was "quite as worthwhile" as the *Tornado Alley* tour.

The scientists also learned about what interests members of the public. Many were surprised by the depth of interest in tornados and weather in communities they visit. Although outreach participants appeared intrigued about the work of a DOW driver and the level of danger it entails—their curiosity stoked by storm-chasing television shows—some scientists were also surprised to find that audiences posed questions not about the storm chasing adventure but rather about the science and technology used in researching tornados.

Burgess noted that he now included more STEM content in his presentations as a result of his week in Missouri, where interactions with school teachers and administrators showed him the importance of stressing STEM content and careers.

Impacts on Audiences. Intended audiences for the project were fairly broad, including students and teachers, families, and community leaders. Because the *Tornado Alley* presentations were tailored for community circumstances, audience impacts ranged from "informative" to "therapeutic" as presentations focused variously on safety, STEM careers, and the science of tornados.

Outreach scientists overall felt that participants came away with more appreciation for tornado preparation, research about storms and tornados, and the challenges in collecting scientific data. Kosiba described the chief audience benefits of the project as learning about the scientific process and interacting with a live scientist. "They don't have to weed through the Internet to get answered questions" with an expert on hand, she added. Fauteux estimated that "95% of audience members were thrilled" by the presentations and were strongly engaged in the content. Crouse noted that opportunities for participation in community learning events are rare in rural communities and *Tornado Alley* drew sizable crowds. For Ohm of St. Joseph's Indian School (Chamberlain, SD), highlights of the team's visit were the scientists evident passion for their work and the enactment of a "tornado dance" which had all participants imitating the wind direction shifts as a tornado forms.

Arnold noted that his background—a B.A. degree rather than a Ph.D.—was encouraging to students to know "you don't have to go to school for years and years" to do this kind of research. Fauteux also noted some exchange of technical knowledge with hosts as together they trouble-shot power, lighting, sound, and other technical production issues. He added that the main benefit to audiences was understanding that researchers are trying to help communities vulnerable to tornados and learning that many career options are open to students. Noting the many skills involved in making the tour a success, he pointed to the medic, the camera man, and technicians: "there [are] a lot of ways that you can get involved in something other than the completely traditional one," he said.

Raksany noted that audiences in tornado affected areas showed a high level of engagement and that presenters often had to end sessions due to time constraints rather than audience desire—there were usually more questions from the audiences than presenters were able to answer. Raksany also described differences between questions asked by audiences without actual experience of severe weather vs. those from survivors: while traditional viewers often asked about the experience of being in the TIV during a tornado, survivors asked about their own personal observations or experiences of weather—for instance, why does a tornado demolish one house and leave another immediately beside it untouched? How far can a tornado carry a car?

Raksany also received personal feedback (provided to her and to program presenters) with positive observations from event facilitators and educators, regarding the appeal of the material to audiences and the enthusiasm participants showed for interactions with the scientists. Examples include:

> *I keep thinking back to the screening at MSSU on Thursday evening when the first question from the audience came from a very cute, 5 or 6 year old girl that asked Karen, are there a lot of women storm chasers out there? And Karen said, why yes, I am one and in fact I would say there is almost more women storm chasers than men storm chasers out there. The girl's response, "oh good!"*
>
> *I think back to when I was a student in high school and wonder what impact a presentation like yours would have had on me. I'm sure I*

would've gone into a meteorological field as a result! Many, many students approached me later in the day and told me that it was the best school presentation that they had ever had.

I hope to be in contact with you next year regarding any potential research opportunities with my science research course….Considering my passion for severe weather, I'm hopeful to have a student who could have some type of interaction with someone in your facility in the coming years.

The program was great! It was a thrilling educational adventure! Students had the opportunity to see how much fun science can be. Not only did it increase severe weather awareness, but it also demonstrated just how destructive weather can be. More importantly, it showed how scientists are studying and tracking these tornados. The program fit very well with our science curriculum. We do not have a 'formal' testing situation set up for 4th grade science standards, however, I took an informal survey, and many of the students (90%) could recall how tornados form, and how they are tracked.

SNAPSHOT: JOPLIN, MO

Joplin, MO, was devastated by a powerful tornado that touched down in April 2011, causing more than $3 million in damages, more than 1,000 casualties, and 161 deaths. The outreach team spent two full days in Joplin; for many it was the most moving and meaningful stop on the tour. In Joplin the team visited six schools and reached more than 1,000 students in addition to conducting a professional development session (led by Kosiba) for 15 educators and a presentation at the Missouri Southern State University.

Kosiba conducted a professional development session with a group of 10 teachers Joplin, aided by a local corporation's donation of ten laptops (with database software installed) to Joplin schools. The team visited elementary school students and middle and high school students. Presentations to secondary school students were focused on career pathways, including media production and automobile mechanistic as well as meteorology and research science. While students were drawn to careers as *Storm Chasers*, Burgess said, the team tried to steer conversations more toward university STEM education and careers such as meteorology. He also noted that while administrators seemed hesitant to host the show, Joplin students were not as traumatized as anticipated and in fact expressed great interest in learning about tornados—how they form, how often they occur, and how people study them.

Public forums were held in the evening for all members of the community and the TIV/DOW vehicles were on display throughout the team's Joplin stops. Crouse found the team exceptionally "mindful" of the community's losses and described the exchange with citizens as therapeutic. He noted that participants took comfort in the knowledge that the probability of other tornados of that strength was very low. Fauteux recalls that in Joplin, presentations were less about the science and more about storytelling and an open invitation to discuss their experiences. "It was like, ok, I just want to hear from you guys, here is a great forum let's just talk for a while." Those conversations were the most memorable, he said., adding, "it's pretty amazing when you come and you just kind of open the door to something that means so much to these folks, how much are willing to share with you and how much you can kind of see that it helps them to share". Refer to Appendix O for site visit documents.

SUMMARY

INSTITUTIONAL OUTREACH

Host Organizations. Among evaluation participants, fifteen museums or science centers across the country together hosted more than 50 *Tornado Alley* events on site. Museum staff members, mostly marketing and communications specialists and theater and event planners, with a couple of science content experts, responded to an online survey.

More than two thirds of respondents used all four components—screening, TIV and DOW appearances, scientist presentations, and question and answer sessions. Families comprised the greatest audience representation. Somewhat more elementary level students were served than secondary level students.

Almost all of the organizations (11/13) engaged new partners in their projects, including news affiliates and weather broadcasters, and to a lesser extent, the Red Cross, local universities, and emergency management and National Weather Service personnel. Nearly three-quarters of respondents reported reaching new audiences. (10/14). New audiences included "weather geeks" and school teachers and students.

Factors in Success

More than half of respondents felt having the vehicles onsite and providing public interaction with the drivers was key to making the events a success; about one third attributed success to the scientists' presentations, questions and answer sessions, and the media presence. In explanations, respondents cited public interaction with the vehicles as a particular strength, "bringing science to life" and drawing participants from outside the immediate region. The vehicles and presentations also appeared to increase interest in the film and drew increased media and social media coverage. Some centers hosted weather broadcasts or conducted interviews on site or in studio interviews with members of the *Tornado Alley* team. At some centers, *Tornado Alley* was linked to climate change exhibits; others made concerted efforts to engage educators and show students possibilities of STEM careers. First-hand experience with the actual research technology was very compelling for students.

All respondents found the *Tornado Alley* experience positive. Most commonly noted were the professionalism of the *Tornado Alley* team members on-site and the great value in having actual scientists and researchers available for questions and answers. With the element of personal experience, engagement levels were high.

All interviewees noted that event success ultimately depended on the hosting museum's pre-event publicity and activities scheduled around the premiere and screening of the film. Unsurprisingly, museums with extensive publicity, including media interviews with the scientists, reached more new and diverse audiences while events with weak planning and publicity were less successful.

Impacts on Vortex2 Scientists. The Vortex2 scientists were all experienced and comfortable in presenting to audiences; for them the new element was the large format film. All agreed the film was an effective platform for disseminating weather science information to the public, and reported learning more about film companies and science centers/museums. Some expressed new-found appreciation for how informal science organizations promote science and technology education.

Interviewees also noted the prevalence of inaccurate and outdated information about tornados and how best to prepare for them. Presenters especially valued exchanges with audiences that addressed safety strategies—such as warnings not to leave the car and go into a ditch, a one-time recommendation for tornados. They clarified the science and urged audiences to take precautions.

REMOTE AND UNDERSERVED OUTREACH

The project team conducted outreach visits to underserved science audiences at 7 pilot sites in 2012 and 20 additional sites in 2013. The team conducted 27 programs in all, five of which served Native American populations. Respondents to an online survey were chiefly school teachers or administrators, with smaller numbers of community organization staff and individual volunteers. All presentations at these locations included a scientist presentation, TIV-2 and/or DOW and driver, and Q&A more than half screened the film. Elementary school students were the most common audiences, followed by middle and high school students. Almost half (6/14) of respondents noted that participants included first responders or tornado survivors. More than half (8/14) served between 100 – 300 children (students). Three served fewer than 100 students and three served more than 600 students. Nearly half (6/14) respondents reported serving adult audiences of fewer than ten people. Half of the remaining respondent organizations served audiences of more than 100 people and half served groups of 10 – 30 people.

While media coverage was strong in communities that had experienced recent tornados, coverage was very sensitive, respondents reported.

All of the respondents judged the presentation relevant; most called it very relevant, because community members had had direct or indirect experience with tornados. A few also noted the project's relevance to STEM and other curricula.

In the view of most respondents, the presentations and Q&A sessions were most valuable to participants, with additional value to students in terms of careers and interests.

Improvements raised by interviewees primarily concerned finding time for the many activities associated with *Tornado Alley*, including more time for hands-on activities and teacher preparation.

Reflections by *Tornado Alley* Staff and Community Contacts

Interviews were conducted with five members of the Tornado Alley staff (3 scientists, 2 technicians) and with two community members who served as local contacts for the team in Missouri and South Dakota.

Factors in Implementation Success. The quality of the *Tornado Alley* programming was very high, according to the Missouri site coordinator, and met the goal of promoting STEM awareness and careers. *Tornado Alley* staff described a rapid evolution in the presentation's quality and impact as the team worked together and saw how the four elements fit together, culminating in a smooth and efficient production that maximized participant contact with each element. Fauteux observed that enabling audiences to hear about the science, then tangibly experience it with one of the vehicles, immerse themselves in it through the film, and then come back at the end and ask and answer questions was a very successful format.

The film provided critical context and gave participants enough background knowledge to ask questions, leading to high audience engagement. Additionally, small and more intimate settings seemed to evoke greater audience participation.

Presentations changed to accommodate audiences' developmental levels. For elementary level students, the team tried to provoke interest in their work and how the *Tornado Alley* research could benefit local communities. With older students, the team sought to engage students in the "cool car" aspects of the vehicle to prompt questions like, "How can I be involved in something like this?" to prompt students to think about STEM study and careers. With adult audiences, the team did short presentations and allowed time for extended communication with and by audience members. Especially in Missouri, where several towns had recent tornado experience, audience receptivity was also a factor in the project's success.

Impacts on Vortex2 Scientists

Hearing people's tornado stories was valuable for scientists; it emphasized the importance of ongoing research to extend lead time and benefited both victims and scientists. More than one scientist described conversations with tornado victims as mutually therapeutic. For one team member, no other project in his career was "quite as worthwhile" as the *Tornado Alley* tour.

The scientists also learned about what interests members of the public. Many were surprised by the depth of interest in tornados and weather in communities they visited. Although participants appeared intrigued about the work of a DOW driver and the level of danger it entails, some scientists were also surprised to find that audiences posed questions not about the storm chasing adventure but rather about the science and technology used in researching tornados. One scientist now includes more STEM content in his presentations as a result of his week in Missouri, where interactions with school teachers and administrators demonstrated the importance of STEM content and careers.

Impacts on Audiences. Intended audiences for the project were fairly broad, including students and teachers, families, and community leaders. Because the *Tornado Alley* presentations were tailored for community circumstances, audience impacts ranged from "informative" to "therapeutic" as presentations focused variously on safety, STEM careers, and the science of tornados.

Outreach scientists overall felt that participants came away with more appreciation for tornado preparation, research about storms and tornados, and the challenges in collecting scientific data; participants also benefited from interacting with practicing scientists. For some rural audience members, the project was a rare opportunity to take part in a science learning experience. Participants were also struck by the team's passion and professionalism.

In addition to learning about tornados, the outreach efforts also stressed STEM careers and engaged students and teachers in learning STEM content and exploring avenues to conducting scientific research. The team, by its own makeup, demonstrated a wide range of careers associated with science research, such as camera operators and technicians, opening new possibilities for students.

Appendix A:
Tornado Alley PreViewing Survey

Tornado Alley – Pre-Viewing Survey

Thank you for taking the time to complete this survey.
Your feedback helps the producers create interesting and engaging films.

For Questions 1 and 2 below please CIRCLE ONE answer.

1. Which of the following factors might contribute to the formation of a tornado:

    a. Winds moving in different directions at different speeds
    b. Temperature of a downdraft wrapping around the rear of a storm
    c. Warm, buoyant air at the surface of a storm
    d. All of the above
    e. None of the above

2. Which of the following conditions is <u>NOT</u> studied by scientists researching tornado genesis (formation):

    a. Temperature
    b. Humidity
    c. Wind speed
    d. Acidity of rainfall

3. Name two technologies or tools that scientists use to study severe weather.

    ____________________ and ______________________________

4. What technology do scientists use to create a 3D map of the winds and structure of supercell storms?

    ____

5. Indicate your current knowledge level about the following:

	Don't know anything	**Know something**	**Know a lot**
Content of *Storm Chasers* TV series			
Content of the *Tornado Alley* website			
Vortex2 Research Project			
What severe weather researchers do			
The scientific process used by researchers			
The technologies used in researching tornados			
The forces that contribute to tornado events			
The length of time it takes for a weather research project like Vortex2			

Continue ===➔

6. Rate your current interest level in the following topics. Place an X in the box which best describes your current interest level.

	Not at all interested	**Somewhat interested**	**Very interested**
Hobby of storm chasing			
Careers of weather science professionals			
The technologies used in researching tornados			
The forces that contribute to tornado events			

Please tell us about yourself.

Please check the categories that describe you.

Your gender:
______ Male
______ Female

Your age:
______ Under 18
______ 18-30
______ 31-50
______ 51+

The number of IMAX 3D films you have seen prior to this one.
____ 0
____ 1- 3 films
____ 4 – 6 films
____ 7 or more films

Highest education level <u>completed:</u>
_____ Elementary school
_____ Middle school
_____ High school
_____ College
_____ Graduate degree

Thanks for your help!

Your answers will assist film producers in continuing to make effective, entertaining science films in the future.

Appendix B:
Tornado Alley PostViewing Survey

Tornado Alley – Post Viewing Survey

Thank you for taking the time to complete this survey.
Your feedback helps the producers create interesting and engaging films.

---

1. What overall rating would you give this film? (circle one)

   Excellent Very Good Good Fair Poor

   Why did you give this rating?

   ____

2. Please check the **<u>THREE</u>** words that best describe this film.

___ Exciting	___ Boring	___ Entertaining
___ Informative	___ Scary	___ Visually engaging
___ Disappointing	___ Cutting edge	___ Confusing
___ Easy to follow	___ No new news	___ Beautiful

For Question 3-4 below CIRCLE ONE answer.

3. Which of the following factors might contribute to the formation of a tornado:

   a. Winds moving in different directions at different speeds
   b. Temperature of a downdraft wrapping around the rear of a storm
   c. Warm, buoyant air at the surface of a storm
   d. All of the above
   e. One of the above

4. Which of the following conditions is **<u>NOT</u>** studied by scientists researching tornado genesis (formation):

   a. temperature
   b. humidity
   c. wind speed
   d. acidity of rainfall

5. Name two technologies or tools that scientists use to study severe weather.

   ___________________ and ______________________________

6. What technology do scientists use to create a 3D map of the winds and structure of supercell storms?

____

7. Indicate how effectively each of the following themes was presented.

	Not effective	**Somewhat effective**	**Very effective**
The work and lives of people who study severe weather.			
The impact and importance of studying tornadoes.			
What research scientists do to study tornadoes.			
The importance of teamwork between individuals and institutions in conducting research.			

8. Indicate your current knowledge level about the following:

	Don't know anything	**Know something**	**Know a lot**
Content of *Storm Chasers* TV series			
Content of the *Tornado Alley* website			
Vortex2 Research Project			
What severe weather researchers do			
The scientific process used by researchers			
The technologies used in researching tornados			
The forces that contribute to tornado events			
The length of time it takes for a weather research project like Vortex2			

9. Rate your current interest level in the following topics. Place an X in the box which best describes your current interest level.

	Not at all interested	**Somewhat interested**	**Very Interested**
Hobby of storm chasing			
Careers of weather science professionals			
The technologies used in researching tornados			
The forces that contribute to tornado events			

10. Could you see yourself doing the work of a severe weather researcher? Why or why not?

11. Could you see yourself participating in a science research activity as a “citizen scientist”? Why or why not?

12. Would you recommend the film to others? Why or why not?

13. Are you left with any questions or curiosity about tornadoes due to watching the film?

14. There is a website associated with this film. Do you think you will you visit the site, and why or why not? What information or what kind of experience would you most like to find on the website?

Please tell us about yourself.

Please check the categories that describe you.

Your gender:
______ Male
______ Female

Your age:
______ Under 18
______ 18-30
______ 31-50
______ 51+

The number of IMAX 3D films you have seen prior to this one.
____ 0
____ 1- 3 films
____ 4 – 6 films
____ 7 or more films

Highest education level <u>completed:</u>
_____ Elementary school
_____ Middle school
_____ High school
_____ College
_____ Graduate degree

Thanks for your help!

Your answers will assist film producers in continuing to make effective, entertaining science films in the future.

Appendix C:
Tornado Alley Focus Group Survey

Tornado Alley
Brief Focus Group Member Survey

What interested you in participating in a focus group about Tornado Alley?

What is the most memorable part of the film?

Your gender:
_______ male
_______ female

Your age:
_______ Under 18
_______ 18-30
_______ 31-50
_______ 51+

Highest education level completed:
______ elementary school
______ middle school
______ high school
______ college
______ graduate degree

The number of 3D IMAX films you have seen prior to this one.
_____ 0
_____ 1- 3 films
_____ 4 – 6 films
_____ 7 or more films

Tornado Alley
Brief Focus Group Member Survey

What interested you in participating in a focus group about Tornado Alley?

What is the most memorable part of the film?

Your gender:
_______ male
_______ female

Your age:
_______ Under 18
_______ 18-30
_______ 31-50
_______ 51+

Highest education level completed:
______ elementary school
______ middle school
______ high school
______ college
______ graduate degree

The number of 3D IMAX films you have seen prior to this one.
_____ 0
_____ 1- 3 films
_____ 4 – 6 films
_____ 7 or more films

Appendix D:
Tornado Alley Focus Group Questions

Tornado Alley 3D Arizona Science Center
Focus Group Questions

1. Overall, what did you think of the film?

2. Is anyone familiar with the Discovery Channel series Storm Chasers? If so:

   - Did this influence your feelings about the film? How?

3. Which scenes were your favorites?
   - Which images were the most memorable?

4. What were some of the most **interesting** new things you learned from the film?

5. What do you think the overall goal of the Vortex 2 research project was?

6. What did you learn about the process of conducting research about tornadoes from the film?
   - Reactions to the field work?
   - Collecting data and the use of technology?
     - Describe any of the data collection tools and what they are used for?
   - The importance of data and analyzing it?
   - Was there anything confusing about how the scientific process was presented in the film?
   - Were there any strengths in how the scientific process was presented in the film?

7. How would you describe the scientists and researchers you saw in the film?
   - Does their work seem appealing to you? Why or why not?
   - Could you imagine doing the work of a severe weather researcher? Why or why not?
   - Could you imagine doing the work of a storm chaser? Why or why not?

8. Specifically, what did you learn about the forces and factors contributing to the creation of tornados?
   - Name the forces?
   - Describe the interaction?
   - Was there anything confusing about how this information was presented?
   - Were there any strengths in how the information was presented?

9. Do you feel the film used the large format 3D medium well?
   - Which scenes or images stand out due to the format?

10. IF APPROPRIATE – Did anyone interact with any floor exhibits having to do with weather? If yes, did the exhibit enhance or detract from seeing the film? How?

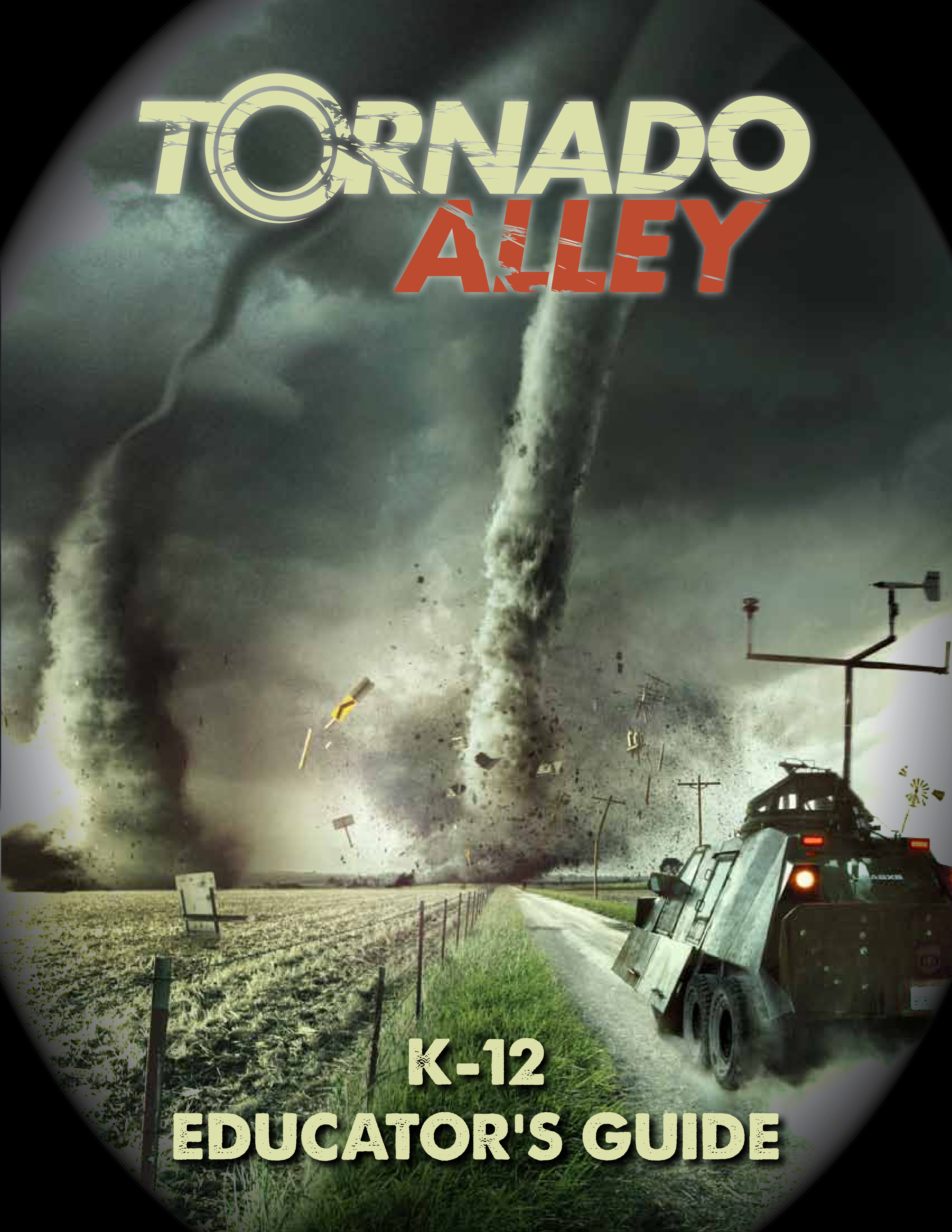
11. Would you recommend this film to others? Why or why not?
   - What types of people would you recommend the film to?
   - What types of people would you not recommend the film to?
   - IF APPROPRIATE – Would you recommend interacting with the exhibits before seeing the film?

12. With regard to learning something new from the film, please complete the following:

    Before seeing the film I thought _______________ and now I know ____________.

13. Did the film spark interest in wanting to find out more about severe weather or field research? If so, what resources will you use? (Web sites, books, television, other documentaries, museum exhibitions, etc.)

Appendix E:
Tornado Alley K-12 Educator's Guide


TORNADO
ALLEY
K-12
EDUCATOR'S GUIDE

TORNADO ALLEY

Traversing the "severe weather capital of the world," "Tornado Alley" documents two unprecedented missions seeking to encounter one of Earth's most awe-inspiring events—the birth of a tornado. Filmmaker Sean Casey's personal quest to capture the birth of a tornado with a 70mm camera takes viewers on a breathtaking journey into the heart of the storm. A team of equally driven scientists, the VORTEX2 researchers, experience the relentless strength of nature's elemental forces as they literally surround tornadoes and the supercell storms that form them, gathering the most comprehensive severe weather data ever collected. This science adventure reveals the beauty and the power of some of our planet's most extreme—and least understood—weather phenomena.

"Tornado Alley" showcases the teamwork that makes scientific discovery and advancement possible. In this case, an international team of scientists have joined together to pool their resources and efforts in an attempt to understand tornadogenesis—the birth of a tornado from a supercell storm cloud. They converge on the area of the United States known as Tornado Alley during the prime tornado seasons of 2009 and 2010.

Learning Goals for K-12 Students:

- To understand where Tornado Alley is located.
- To understand the tools that scientists use to study tornadoes.
- To understand how scientists work together to gather data, make observations, and draw conclusions about severe weather events.

BACKGROUND INFORMATION

VORTEX2

"Tornado Alley" features the VORTEX2 scientific team as they work on their mission to capture information about how tornadoes form—the process called tornadogenesis. VORTEX2 was the largest and most ambitious effort ever made to understand tornadoes. Over 100 scientists and over 50 science and support vehicles participated in the unique, fully nomadic, field program during May and June of 2009 and 2010. The National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA) contributed over $10 million towards the effort. Participants came from over a dozen universities, and several government and private organizations.

The VORTEX2 team wanted to answer these important questions:

How, when, and why do tornadoes form? Why are some violent and long-lasting while others are weak and short-lived?

What is the structure of tornadoes? How strong are the winds near the ground? How exactly do they do damage?

How can we learn to forecast tornadoes better?

Currently, 70% of tornado warnings are false alarms. For the other 30% of warnings, people have only 13 minutes, on average, between hearing the warning and getting hit by the tornado.

Can we make warnings more accurate?

Can we increase the warning time so that people have 30, 45, or even 60 minutes to prepare?

Doppler Radar

Doppler Radar transmits and receives microwaves to calculate the speed and direction of moving objects, like raindrops in a thunderstorm. Doppler Radar allows meteorologists to calculate not only the location of storms, but the speed and direction of the winds within a storm as well. Doppler Radar has significantly improved the forecasting of severe weather events.

Tornado Season

Tornadoes can form at any time of the year, however there are certain times when conditions tend to be more favorable for the development of the supercell storms that generate tornadoes. For this reason, research scientists focus their efforts on tracking storms during the times when tornadoes are most likely to form. In "Tornado Alley," when the VORTEX2 scientists talk about tornado season, they are referring to the months of May and June.

The Enhanced Fujita Scale

The Enhanced Fujita (EF) scale is a six-level (EF0-EF5) scale for rating tornado intensity, based on the damage tornadoes inflict on human-built structures and vegetation. Though each damage level is associated with a wind speed, the Enhanced Fujita scale is a damage scale, and the wind speeds associated with the damage listed are unverified.

BACKGROUND INFORMATION

The Enhanced Fujita Scale

	Wind Speed	Damage Profile
EF0	40-72 MPH	Minor Damage - Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
EF1	73-112 MPH	Moderate Damage - The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	113-157 MPH	Considerable Damage - Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	158-206 MPH	Critical Damage - Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted and thrown.
EF4	207-260 MPH	Severe Damage - Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
EF5	261-318 MPH	Total Destruction - Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air; trees debarked; steel-reinforced concrete structures badly damaged.

SIGNIFICANT HISTORICAL TORNADOES

This is the oldest known photograph of a tornado. It was taken on August 28, 1884 approximately 22 miles southwest of Howard, South Dakota.

Tornadoes can be deadly. The scientists in “Tornado Alley” chase storms and gather data to study because they want to improve our ability to predict when and where a tornado might strike. When we have more time to prepare and get to safety, tornadoes become less deadly.Here is a timeline of some of the deadliest tornadoes ever to strike in the United States.

1896 *May 27 – 255 people died in the Great St. Louis Tornado which struck Missouri and Illinois.*

1899 *June 12 – 117 people died when a tornado struck New Richmond, Wisconsin.*

1902 *May 18 – 114 people died in Goliad, Texas.*

1925 *March 18 – 695 people died in the Tri-State Tornado that raced across Missouri, Indiana, and Illinois.*

1936 *April 5 – 216 people died when a tornado struck Tupelo, Mississippi.*

1936 *April 6 – 203 people died when a tornado struck Gainesville, Georgia.*

1947 *April 9 – 181 people died when a tornado raced across Texas, Oklahoma, and Kansas.*

1953 *May 11 – 114 people died in Waco, Texas.*

1953 *June 8 – 115 people died in Flint, Michigan.*

2011 *April 27 – at least 300 people died when tornadoes touched down across Alabama and Mississippi.*

SPOTLIGHT ON SCIENTISTS


Donald Burgess


Joshua Wurman


Karen Kosiba

Many people work together in “Tornado Alley” to capture data and information about tornadogenesis. Not everyone we see is a scientist, but many are. These three scientists have dedicated their careers to learning about severe storms in hopes of finding ways to provide more accurate warnings for people who may be in harm’s way.

Donald Burgess

Donald Burgess began studying the weather while growing up in the state of Oklahoma. His fascination with weather inspired him to become a meteorologist by earning science degrees at the University of Oklahoma. Today, he is a research scientist at the Cooperative Institute for Mesoscale Meteorological Studies and an Adjunct Professor of Meteorology, both at the University of Oklahoma. He also currently serves on the Steering Committee for the Verification of the Origins of Rotation in Tornadoes Experiment, Part 2 (VORTEX2). His research interests lie in the areas of severe weather and techniques for improving warnings of weather hazards, particularly techniques using Doppler radar for tornado detection and warnings. Because an important part of being a scientist is sharing information with others, he has also helped to write an award-winning book called “The Tornado: Its Structure, Dynamics, Prediction, and Hazards.”

Joshua Wurman

Joshua Wurman is an atmospheric scientist and inventor noted for tornado, hurricane, and weather radar research. After receiving science degrees from the Massachusetts Institute of Technology, he began working at the National Center for Atmospheric Research and was inspired to invent the Doppler on Wheels as well as other new technological tools used to track severe storms. He founded the Center for Severe Weather Research in Boulder, Colorado where he works today. He spends most of his time chasing severe storms around the country, especially during tornado season each year when he may travel 15,000 miles up and down Tornado Alley in search of the right conditions for his research.

Karen Kosiba

Karen Kosiba is a research meteorologist at the Center for Severe Weather Research in Boulder, Colorado. Her research mainly focuses on characterizing the low-level wind structure in tornadoes and in hurricanes. This is accomplished through the use of mobile radar observations and numerical modeling. She believes in studying weather, even severe weather, by experiencing it first-hand so she spends a lot of time doing field research and chasing storms. She prepared for her career by earning an advanced degree in science at Purdue University in Indiana.

SPOTLIGHT ON TECHNOLOGY

The VORTEX2 mission featured in “Tornado Alley” used an unprecedented fleet of cutting-edge instruments to surround tornadoes and the supercell thunderstorms that form them. By joining forces and combining their equipment, the scientists were able to capture the most complete picture of a tornado ever recorded.

The fleet included an armada of mobile radars, mobile mesonet instrumented vehicles, and deployable instruments including Stick-Nets, Tornado-Pods, disdrometers, weather balloon launching vans, and unmanned aircraft.

Mobile Radar Systems

Mobile radar systems are Doppler weather radar systems mounted on rugged, heavy-duty trucks that are able to get up close to severe storms, providing data about winds in tornadic storms, hurricane rain bands and eyewalls, and other structures inside severe storms.

Doppler On Wheels

SMART-Radar

NOX-P Radar

Mobile Mesonets

Mobile Mesonets

The mobile mesonet is a set of vehicle-borne weather sensors. The vehicles use global positioning satellites to determine the time and exact position of the instrument when it records conditions. The conditions include temperature, relative humidity, air pressure, and wind speeds.

Stick-Nets

Stick-Nets

A Stick-Net is a versatile, rapid-deployment meteorological observing station. Affectionately named for its resemblance to a stick figure, the Stick-Nets collect high resolution meteorological data, including temperature, relative humidity, air pressure, and wind speeds. The platforms are designed to be deployed in large numbers, in a short period of time (three minutes or less) by a small number of people.

Tornado Pods

Tornado Pods

Tornado Pods are instruments mounted onto 1 meter (3 foot) towers which measure wind velocity and direction in the center of the tornado.

SPOTLIGHT ON TECHNOLOGY


Disdrometers


Weather Balloon Launching Vans


Tempest Unmanned Aircraft

Disdrometers

Disdrometers are instruments used to measure the drop size distribution and velocity of falling precipitation. Some disdrometers can distinguish between rain, snow pellets, and hail.

Weather Balloon Launching Vans

These vans carry the equipment needed to launch high altitude weather balloons which carry instruments aloft to send back information on atmospheric pressure, temperature, humidity, and wind speed.

Tempest Unmanned Aircraft

The Tempest unmanned aircraft system is designed to fly into severe convective storms including supercell thunderstorms and record data from the inside.

SPOTLIGHT ON SAFETY

Tornado behavior is very hard to predict. VORTEX2 scientists are among those working to help find better ways to predict where they may strike.

Since prediction is a challenge, it is all the more important to be prepared and to know what to do if you find yourself in the path of a tornado. Below are safety tips for several different locations.

Small Buildings with Basements

Go to the basement. If there is a sturdy table or work bench, get beneath it. If not, look for something that would cushion you from any falling debris. Some families keep an old mattress in their basement for this purpose. Also, think about what is on the floor above you. Try not to be beneath the kitchen where heavy appliances might fall through to the basement.

Small Buildings without Basements

Go to a small room or closet at the center of the ground floor. If you don't have a room or closet, look for a space beneath a stairwell or at least an interior hallway. Crouch down as close to the ground as you can. Keep your face down and cover the back of your head with your hands. If you have something that might cushion you, get below it. If you have a bathroom in the center of the house which has a heavy bathtub, crouch inside it.

Multi-Story Buildings

Generally speaking, you should follow the same ideas as for small buildings. Get as close to the ground as possible. If the building has a basement, that is the best place to be. If not, get as close to the center of the ground floor as you can. If you are on a high floor and don't have time to get to the ground, find the smallest interior room near the center of the building as you can. Sometimes, there might be a central stairway to hide beneath. Never use the elevators!

Cars or Trucks

Vehicles are very dangerous during a tornado. If you can see a tornado far away in the distance, you may be able to drive to safety away from its path. However, if you see the tornado closely approaching, you should get out of your vehicle. Try to park safely at the side of a road so that you are not blocking the road for emergency vehicles. If at all possible, get inside a building. If that is not possible, though, your chance to survive is better out in the open than inside a vehicle.

SPOTLIGHT ON SAFETY

Mobile Homes

Get outside! Your chance to survive a tornado strike is better out in the open than inside a mobile home.

Out in the Open

If it's impossible to get to a safe place inside a sturdy building, lie flat and face-down on the ground out in the open and cover the back of your head with your arms. Pick a place that is away from trees, parked cars, or other objects that may topple over onto you. Do not seek shelter beneath a bridge or overpass.

In all cases, no matter where you are, avoid being near windows! The flying glass from breaking windows is always the cause of many injuries during tornado strikes. Also, no matter where you are, try not to panic! Stay calm, remember these safety tips, and follow leaders—like schoolteachers, security guards, or parents—who best know the shelter plans for the building where you are.

After the Tornado Passes

If you are inside a building that was struck, try to get outside, especially if the damage was severe and it may collapse. Stay with your group and wait for emergency workers to arrive. Beware of broken glass and other sharp objects. Stay away from power lines and other sources of electricity. Beware of puddles that may be covering wires—remember that water is a powerful conductor of electricity! Tornado damage may also have broken natural gas supply lines which makes open flame extremely dangerous. Do not use lighters or matches!

This information is derived from content provided by the National Oceanic and Atmospheric Administration's Storm Prediction Center.

TRY THIS!

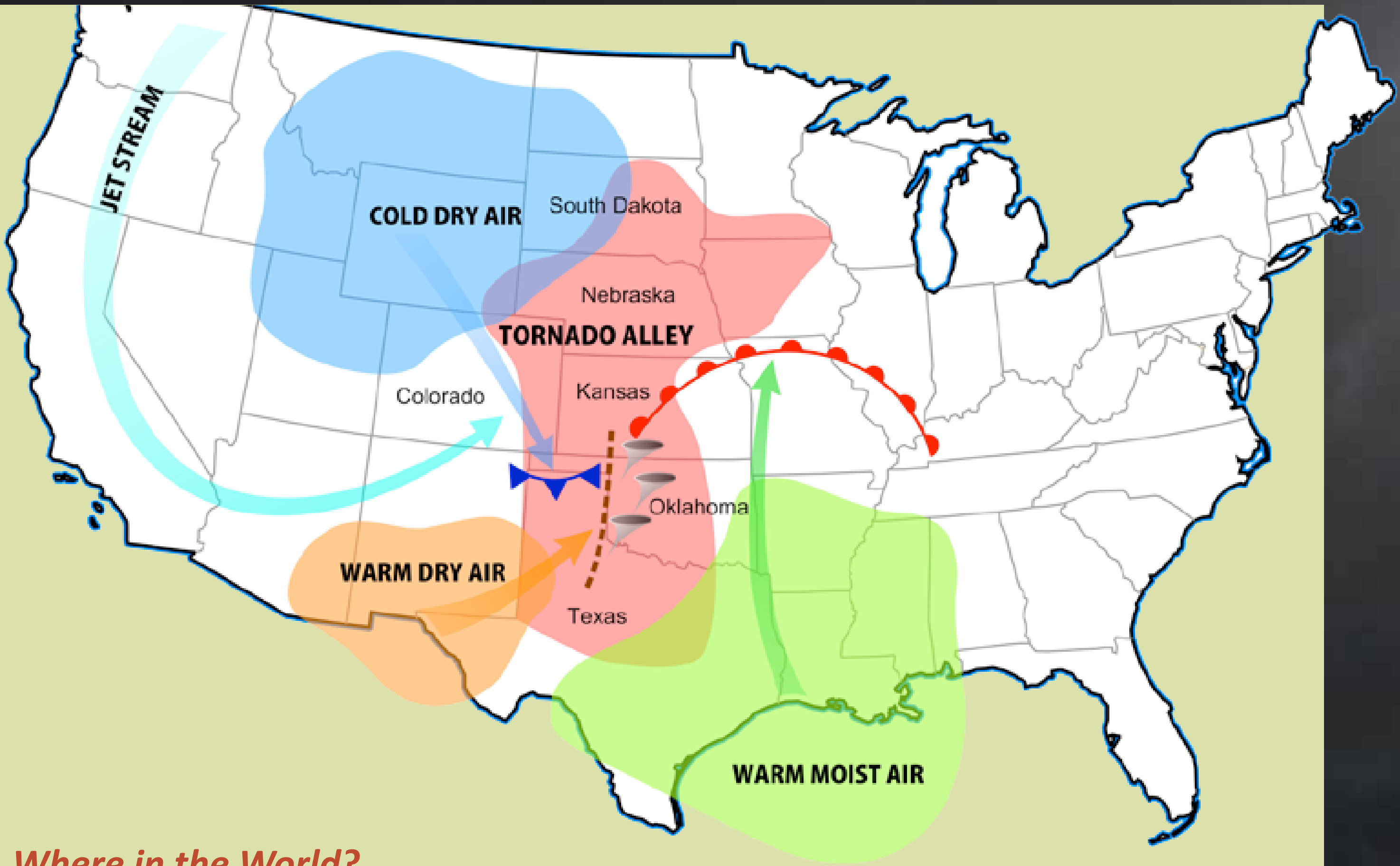


Image courtesy Dan Craggs

Where in the World?

Tornado Alley is a nickname given to an area in the southern plains of the central United States that consistently experiences frequent tornadoes each year. Tornadoes in this region typically happen in late spring and occasionally the early fall. Although the actual boundaries of Tornado Alley are debatable and the National Weather Service does not consider it to be an official term, the core of Tornado Alley consists of the Texas Panhandle, Oklahoma, Kansas, Nebraska, eastern South Dakota, and the Colorado Eastern Plains. However, Tornado Alley can be also be defined as an area stretching from central Texas to the Canadian prairies and from eastern Colorado to western Pennsylvania. Meteorologically, the region known as Tornado Alley is ideally situated for the formation of supercell thunderstorms which are often the producers of violent tornadoes.

No matter where your school is located, students should know that tornadoes are possible at any time of year. The scientists in “Tornado Alley” spend the months of May and June chasing storms in the field, but only because that is the best time to do their research. They know that severe weather can happen at any time, in any location.

Discussion Questions

Younger students should be introduced to the map of Tornado Alley and asked to identify the states pictured in red. Is your school located in Tornado Alley?

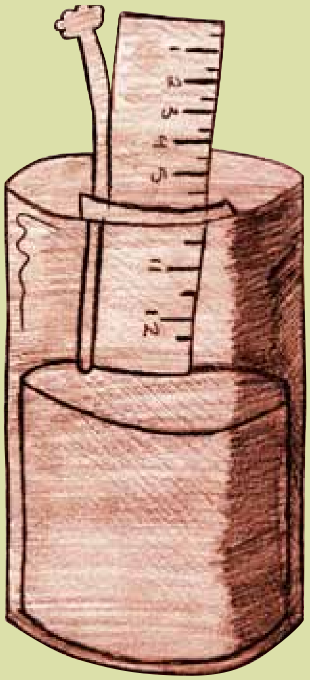
Older students should be encouraged to think about the other factors on the map.

What is the source of the warm moist air pictured in green?

Where is the warm dry air pictured in orange coming from?

Why do many tornadoes form in the Alley during the late spring and early summer months?

TRY THIS!



Under Pressure

Use these directions to make our own barometer in order to detect and observe changes in atmospheric pressure. Since barometers are very sensitive to minor changes in weather conditions, you'll want to keep the barometer indoors to get more accurate readings.

Things You Need:

glass or beaker with straight sides

ruler (12 inch)

tape

one foot of clear plastic tubing (could be a tall plastic drinking straw, but it must be clear)

stick of chewing gum

water

Begin by standing the ruler in the empty glass or beaker and holding it against the side. Tape the ruler to the inside of the glass. Make sure that the numbers on the ruler are visible.

Stand the plastic tube against the ruler in the glass. Make sure that the tube is not touching the bottom of the glass by positioning the tube up a half inch on the ruler. Secure the tube by taping it to the ruler.

Chew the stick of gum so that it is soft. While you're chewing, fill the glass about half way with water. Use the plastic tube like a straw and draw some water half way up the tube. Use your tongue to trap the water in the tube. Quickly move the gum onto the top of the tube to seal it.

Make a mark on the ruler to record where the water level is in the tube. Each time you notice a change in the water level, make another mark. You'll notice, over time, that the water level rises and falls. Pay attention to the change in weather as the water level changes.

The water in the tube rises and falls because of air pressure exerted on the water in the glass. As the air presses down (increased atmospheric pressure) on the water in the glass, more water is pushed into the tube, causing the water level to rise. When the air pressure decreases on the water in the glass, some of the water will move down out of the tube, causing the water level to fall. The change in barometric pressure will help you to forecast the weather. Decreasing air pressure often indicates the approach of a low pressure area, which often brings clouds and precipitation. Increasing air pressure often means that a high pressure area is approaching, bringing with it clearing or fair weather.

Tracking the Pressure

At all grade levels, students can use their barometer to collect data and keep a log of rising and falling air pressure.

K-3 students can simply observe the movement of water level in the tube and keep a classroom chart to see if they notice patterns. Students in grades 4-8 can keep individual charts and use the readings to create graphs. How high does the pressure get? How low? Which results in nicer weather? High school students can also access local online weather services to compare data and see if the local barometric pressure corresponds to the official readings for the area.

TRY THIS!

Tornado Math!

The VORTEX2 fleet covered 26,000 miles during its research mission.

1. There were 40 vehicles in the fleet.
   If each of those vehicles drove the entire mission, how many total miles did the mission log?

   ___________vehicles x ________________ miles = ________ total mission miles

2. On average, the fleet covered 10 miles per gallon of fuel. Keep in mind that the smaller, lighter vehicles in the fleet are more fuel efficient than the heavier vehicles, so they got more miles per gallon. But, the fleet-wide average was 10 miles per gallon of fuel.

   Use your answer from the question above to see how many gallons of fuel were used.

   ___________total mission miles ÷ 10 miles per gallon = ___________ gallons of fuel

3. During its total mission, VORTEX2 observed 25 tornadoes.
   How many miles of searching, on average, did it take to find a tornado?

   ___________total mission miles ÷ 25 tornadoes =_ miles of searching per tornado

4. When the entire VORTEX2 team stopped for a restroom break, how many minutes did they need?

   There were 150 people. Assume 1.5 minutes per person.

   How long would it take if there is…
   1 restroom =________________________
   2 restrooms =________________________
   3 restrooms =________________________

   If the team only has 45 minutes for their rest break, how many restrooms do they need to find?________________

5. The VORTEX2 mission collected 30 terabytes (TB) of data to analyze.

   1 terabyte (TB) = 1,000 gigabytes (GB)

   1 gigabyte (GB) = 1,000 megabytes (MB)

   1 megabyte (MB) = 1,000 kilobytes (KB)

   1 kilobyte (KB) = 1,000 bytes

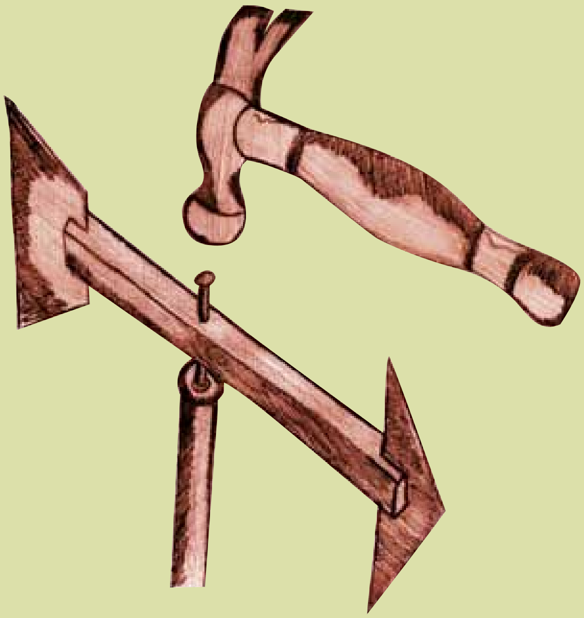
   1 byte = 8 bits

   How many bits of data did VORTEX2 collect? ____________

Tornado Math Answer Key

1.) 1,040,000 total mission miles; 2.) 104,000 gallons of fuel;
3.) 41,600 miles per tornado; 4.) 225 minutes; 113 minutes; 75 minutes; 5 restrooms
5.) 240,000,000,000,000 bits

TRY THIS!



Which Way is the Wind Blowing?

Use these directions to make your own simple wind direction indicator.

Things You Need:

long wooden dowel (about the size of a broom stick)

aluminum pie plate

12-inch long piece of wood (a sturdy ruler would work)

nails

metal washer

hammer

glue

small saw (or serrated knife)

wire (for mounting)

scissors (strong enough to cut the aluminum plate)

Begin with the 12 inch piece of wood. Use the small saw (or serrated knife) to cut a vertical slit at each end of the stick. The slit should be about one half inch deep. At the midpoint (exactly halfway) of the top of the stick, hammer one nail all the way through the stick. Then turn the wood around the nail several times until the stick turns easily around the nail.

Refer to the pattern pictured and cut the head and tail from the aluminum plate. Glue the head into the slot at one end of the wooden stick. Glue the tail into the other end. Allow time for the glue to dry before you take the arrow-shaped vane outside.

Attach the vane to the long wooden dowel by placing the metal washer on the end of the dowel and then hammering the nail through the wooden stick and into the wooden dowel. (Refer to the picture.) Make sure that the vane moves freely and easily around the nail.

Now you are ready to mount your weather vane outside. Find a location where the vane will have room to move and catch the wind. The top of a wooden fence often works well. Attach the vane with wire. Try to get the vane as high as you can while still keeping the dowel steady and secure.

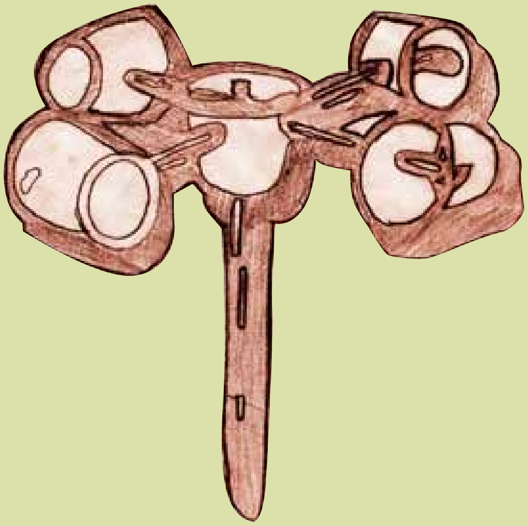
The head of the arrow/vane will always point to the direction from which the wind is blowing. For example, if the head points to the Northeast, then the wind is blowing from the Northeast. It's as simple as that.

Chasing the Wind

At all grade levels, students can use their wind direction indicator to collect data and keep a log of which way the wind is blowing.

K-3 students can simply observe the movement and keep a classroom chart to see if they notice patterns. Students in grades 4-8 can keep individual charts and use the readings to calculate averages. From which direction does the wind blow most often? Least often? High school students can also access local online weather services to compare data and see if the local conditions correspond to the official readings for the area.

TRY THIS!



How Fast is the Wind Blowing?

Use these directions to make your own simple anemometer. An anemometer helps you determine changes in wind speed. Use it with your wind direction indicator vane to see when the wind is blowing faster or slower.

Things You Need:

five 3 ounce paper Dixie cups

two straight plastic soda straws

a pin

scissors

paper punch

small stapler

sharp pencil with an eraser

Take four of the Dixie cups. Using the paper punch, punch one hole in each, about a half inch below the rim.

Take the fifth cup. Punch four equally spaced holes about a quarter inch below the rim. Then punch a hole in the center of the bottom of the cup.

Take one of the four cups and push a soda straw through the hole. Fold the end of the straw, and staple it to the side of the cup across from the hole. Repeat this procedure for another one-hole cup and the second straw.

Now slide one cup and straw assembly through two opposite holes in the cup with four holes. Push another one-hole cup onto the end of the straw just pushed through the four-hole cup. Bend the straw and staple it to the one-hole cup, making certain that the cup faces in the opposite direction from the first cup. Repeat this procedure using the other cup and straw assembly and the remaining one-hole cup.

Align the four cups so that their open ends face in the same direction (clockwise or counterclockwise) around the center cup. Push the straight pin through the two straws where they intersect. Push the eraser end of the pencil through the bottom hole in the center cup. Push the pin into the end of the pencil eraser as far as it will go. Your anemometer is ready to use.

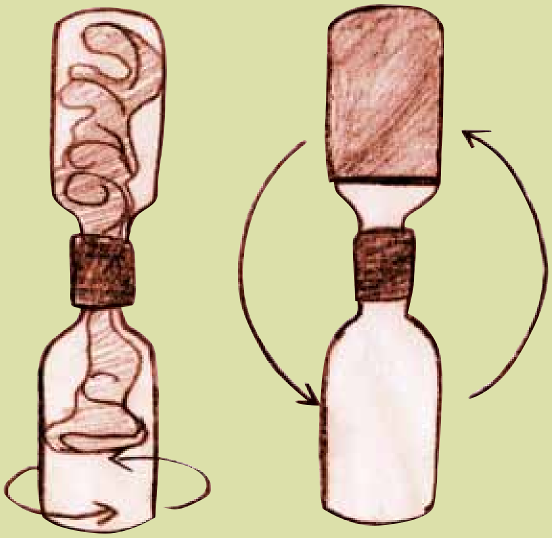
Your anemometer is useful because it rotates with the wind. You can not use this elementary device to measure wind speed, but it will spin faster when the wind speed increases and slower when it decreases. Therefore it is useful for noticing changes and patterns.

Spinning with the Wind

At all grade levels, students can use their anemometer to observe changes in wind speed. The anemometer is an example of a vertical-axis wind collector. It need not be pointed into the wind to spin.

K-3 students can simply observe the movement and keep a classroom chart to see if they notice patterns. Students in grades 4-8 can keep individual charts and include both the readings from the anemometer and the wind direction indicator. How do direction and changes in speed correspond? Are there any patterns between the two? High school students can calculate the velocity at which the anemometer spins, by determining the number of revolutions per minute (RPM). Next calculate the circumference (in feet) of the circle made by the rotating paper cups. Multiply your RPM value by the circumference of the circle, and you will have an approximation of the velocity of at which your anemometer spins (in feet per minute). (Note: Other forces, including drag and friction, influence the calculation but are being ignored for this elementary illustration. The velocity at which your anemometer spins is not the same as wind speed.)

TRY THIS!



Make a Tornado!

Make a tornado in a plastic bottle to visualize tornado funnel formation.

This simple demonstration shows students how water spouts form as fluid rushes from one space to another.

Things You Need:

2 clear plastic bottles, two-liter size

1-inch metal washer

Waterproof tape, like duct tape

Water

Food coloring for enhanced visualization (optional)

Glitter to simulate debris (optional)

Remove all labels and plastic parts from the outside of the bottles. Make sure they are washed and clean inside.

Stand one of the two bottles on its base on a table and fill about 2/3 full with water. It is not necessary, but you can add a drop or two of food coloring to the water to enhance the visualization. Likewise, a little bit of glitter will simulate the movement of debris in a tornado's funnel cloud. Both of these enhancements are optional, but should be added now if desired.

Place the metal washer at the bottle's opening. Turn the second empty bottle upside down and align it with the washer. The hole in the washer will restrict the movement of water between the bottles during the demonstration. Have someone hold the bottles together firmly while you tape the two together securely. It is important that the bottles be perfectly aligned in order to prevent leakage. The empty bottle should stand straight up without any tilting.

Lift the bottles and give the water a firm swirl while flipping them so that the water is in the top bottle. The water will flow rapidly into the empty bottle, through the hole in the washer. As it does so, it will form a strong vortex that makes it easier to displace the air in the empty bottle that now suddenly has to compete with the water for space.

Once the water has settled in the bottom and the vortex has dissolved, you can repeat the process.

Teacher Tip: Many teacher supply stores sell a simple plastic device called a tornado tube connector. If you have one of those, it can be used to connect the two bottles instead of the washer and duct tape. It functions the same way by forcing the water to flow through a small hole between the two bottles.

MOBILE WEATHER INSTRUMENTS

The Tornado Intercept Vehicle

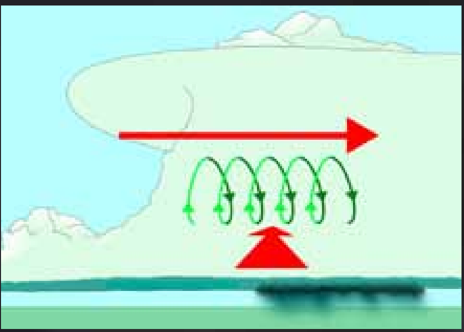
"Tornado Alley" tells the story of stormchaser Sean Casey's quest to film the inside of a tornado. In order to get safely into position to do so, he designed and built his Tornado Intercept Vehicle which he nicknamed TIV.

The TIV began its life as a standard Dodge 3500 pickup truck before being enhanced to withstand tornado-force storms. To protect the safety of the team inside, Sean added bulletproof glass and armored steel plates. The turret at the top was designed especially for the IMAX© film camera that he would use to film tornadoes.

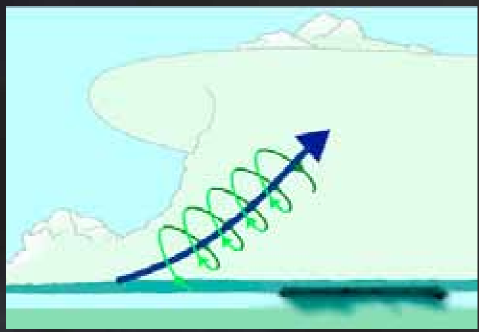
The TIV also has weather instruments mounted on it, including a wind direction vane, an anemometer, and barometer. Sean consulted with the VORTEX2 scientists to see which instruments would be most useful and to decide where best to mount them on the TIV. The instrument mast that sticks up from the top of the TIV holds the instruments which collect data including wind speed, temperature, relative humidity, and air pressure.

After you make your own weather instruments, you can begin to imagine someday making your own storm chasing vehicle!

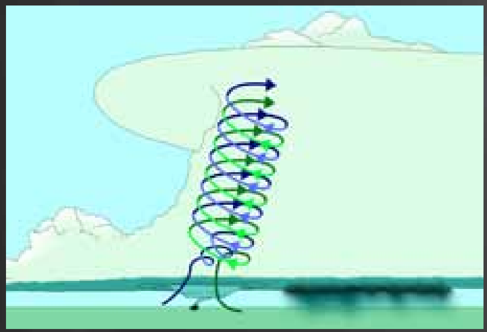
TORNADO FORMATION



The difference in speed and direction of high-level winds compared to low-level winds causes rotation or spin.



As warm moist air rises, it tilts the rotation into the vertical.



The rotation can be stretched or influenced by cool downdraft air forming a funnel cloud.

In “Tornado Alley,” the scientists wait and watch for supercell thunderstorms to form. When they see one begin to form, they spring into action because they know that supercell storms often generate tornadoes. Not every supercell storm will produce a tornado, and not every tornado comes from a supercell. But, if you’re a scientist looking for the best place to collect data about tornadoes, being near a supercell storm is a pretty good place to start.

During storm season in the region known as Tornado Alley, a unique combination of geography and converging air masses provide the perfect environment for these supercell storms to form and, ultimately, lead to tornadogenesis. With no southern mountain range to block the flow, warm moist air from the Gulf of Mexico moves northward, under the dry, cool, fast moving winds of the jet stream. If the warm air rises, it cools, and moisture condenses into clouds, reaching as high as ten miles into the atmosphere, and a storm is born.

The swirling in the clouds comes from the combination of winds that are blowing very fast in the cool high-altitude air and winds closer to the ground which are much warmer, moister, slower, and coming from a different direction. The difference in the wind speed and/or direction in layers is called wind shear. Wind shear is one source of vorticity, the amount of spin in the air.

Inside a storm, areas in which warm, moist air rises are called updrafts. Supercell thunderstorms have very strong updrafts. The updraft winds can tilt vorticity into a vertical direction. This is the source of rotation in supercell storms. Another key characteristic of a supercell is an area of cool, dry, descending air known as the Rear Flank Downdraft (RFD). The RFD wraps precipitation around the back of the rotation in the supercell and produces the classic hook shaped echo on Doppler radar. The convergence of the warm updraft air and the cool downdraft can cause a rotating wall cloud to form. For this reason, the RFD is critically important in tornadogenesis but scientists are still working to understand the exact conditions that cause tornadoes to form.

RECOMMENDED RESOURCES

Recommended Resources for Teachers

Websites

About the Doppler on Wheels
www.cswr.org/contents/aboutdows.html

National Doppler Radar Sites
radar.weather.gov

Web Weather for Kids – Thunderstorms and Tornadoes
www.eo.ucar.edu/webweather/thunderhome.html

National Severe Storms Laboratory – Education Resources
www.nssl.noaa.gov/edu

Tornado Handbook
dsc.discovery.com/tv/storm-chasers/handbook/handbook.html

Recommended Reading for Children and Young Adults

Grades K-3

"Tornado" by Catherine Chambers. ISBN 1403495904.

"Tornadoes!" by Gail Gibbons. ISBN 0823422747.

Grades 4-8

"Tornadoes" by Seymour Simon. ISBN 0064437914.

"Tornado Alert!" by Wendy Scavuzzo. ISBN 0778716031.

"Anatomy of a Tornado" by Terri Dougherty. ISBN 1429662816.

"Hurricane Hunters and Tornado Chasers" by Gary Jeffrey. ISBN 1404214593.

"Horror from the Sky: The 1924 Lorain, Ohio, Tornado" by Bonnie Highsmith Taylor. ISBN 078915837X.

Grades 9-12

"Adventures in Tornado Alley: The Storm Chasers" by Mike Hollingshead and Eric Nguyen. ISBN 0500287376.

"The Cambridge Guide to the Weather" by Ross Reynolds. ISBN 0521774896.

"The Tornado: Nature's Ultimate Windstorm" by Thomas P. Grazulis. ISBN 0806132582.

"The Tri-State Tornado: The Story of America's Greatest Tornado Disaster" by Peter S. Felknor. ISBN 0595311881.

"Tornado! The Story Behind These Twisting, Turning, Spinning, and Spiraling Storms" by Judy Fradin and Dennis Fradin. ISBN 1426307799.

"Tornado Hunter: Getting Inside the Most Violent Storms on Earth" by Stefan Bechtel, Tim Samaras, and Greg Forbes. ISBN 1426203020.

"Tornado Alley: Monster Storms of the Great Plains" by Howard B. Bluestein. ISBN 0195105524.

NATIONAL SCIENCE EDUCATION STANDARDS

"Tornado Alley" and the accompanying activities suggested in this guide can be used to support student learning as called for by the National Science Education Standards. The following presentation offers details of where the content aligns.

Unifying Concepts and Processes – K-12

STANDARD: As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

SYSTEMS, ORDER, AND ORGANIZATION

The natural and designed world is complex; it is too large and complicated to investigate and comprehend all at once. Scientists and students learn to define small portions for the convenience of investigation. The units of investigation can be referred to as ''systems.'' A system is an organized group of related objects or components that form a whole.

EVIDENCE, MODELS, AND EXPLANATION

Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work.

CONSTANCY, CHANGE, AND MEASUREMENT

Although most things are in the process of becoming different—changing—some properties of objects and processes are characterized by constancy, including the speed of light, the charge of an electron, and the total mass plus energy in the universe. Changes might occur, for example, in properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. Changes vary in rate, scale, and pattern, including trends and cycles.

CONTENT STANDARD D – EARTH AND SPACE SCIENCE

GRADES K-4

CHANGES IN THE EARTH AND SKY

- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
- Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

GRADES 5-8

STRUCTURE OF THE EARTH SYSTEM

- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.
- Clouds, formed by the condensation of water vapor, affect weather and climate.
- Global patterns of atmospheric movement influence local weather.

GRADES 9-12

ENERGY IN THE EARTH SYSTEM

- Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

CONTENT STANDARD E – SCIENCE AND TECHNOLOGY

GRADES K-4

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. This understanding focuses primarily on teams working together and secondarily, on the combination of scientist and engineer teams.
- Women and men of all ages, backgrounds, and groups engage in a variety of scientific and technological work.
- Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do.

GRADES 5-8

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

- Many different people in different cultures have made and continue to make contributions to science and technology.
- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.

GRADES 9-12

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

- Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.
- Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people’s beliefs and practical explanations concerning various aspects of the world.

NATIONAL SCIENCE EDUCATION STANDARDS

CONTENT STANDARD F – SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

GRADES K-4

CHANGES IN ENVIRONMENTS

- Environments are the space, conditions, and factors that affect an individual's and a population's ability to survive and their quality of life.
- Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Some environmental changes occur slowly, and others occur rapidly.

SCIENCE AND TECHNOLOGY IN LOCAL CHALLENGES

- People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people.

GRADES 5-8

NATURAL HAZARDS

- Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides, wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids.

RISKS AND BENEFITS

- Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions).

SCIENCE AND TECHNOLOGY IN SOCIETY

- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
- Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.

GRADES 9-12

PERSONAL AND COMMUNITY HEALTH

- Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards.

NATURAL AND HUMAN-INDUCED HAZARDS

- Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular.
- Natural and human-induced hazards present the need for humans to assess potential danger and risk. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

NATIONAL SCIENCE EDUCATION STANDARDS

CONTENT STANDARD G – HISTORY AND NATURE OF SCIENCE

GRADES K-4

SCIENCE AS A HUMAN ENDEAVOR

- Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.
- Many people choose science as a career and devote their entire lives to studying it. Many people derive great pleasure from doing science.

GRADES 5-8

SCIENCE AS A HUMAN ENDEAVOR

- Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.

NATURE OF SCIENCE

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

GRADES 9-12

SCIENCE AS A HUMAN ENDEAVOR

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.

NATURE OF SCIENTIFIC KNOWLEDGE

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

NATIONAL SCIENCE EDUCATION STANDARDS

	K-4	*5-8*	*9-12*
UNIFYING CONCEPTS & PROCESSES	*Systems, order, and organization* *Evidence, models, and explanation* *Constancy, change, and measurement*		
EARTH & SPACE SCIENCE	***CHANGES IN THE EARTH & SKY*** *Rapid changes, weather, measurement – temperature, wind direction*	***STRUCTURE OF THE EARTH SYSTEM*** *Atmosphere, clouds, atmospheric movement*	***ENERGY IN THE EARTH SYSTEM*** *Heating of atmosphere, air currents*
SCIENCE & TECHNOLOGY	*Questions about the world, tools to help answer questions, scientists work in teams*	*Reciprocity between science and technology, unintended consequences, constraints*	*Process of research, motivations, risk and reward*
SCIENCE IN PERSONAL & SOCIAL PERSPECTIVE	***CHANGES IN ENVIRONMENTS*** *Some are natural, Some are rapid* ***LOCAL CHALLENGES*** *Inventing new ways to address local challenges*	***NATURAL HAZARDS*** *Storms* ***RISKS & BENEFITS*** *Tornadoes* ***SCIENCE & TECHNOLOGY IN SOCIETY*** *Research funding, Settings, Ethics*	***PERSONAL & COMMUNITY HEALTH*** *Hazards* ***NATURAL AND HUMAN-INDUCED HAZARDS*** *Severe weather, Risk*
HISTORY & NATURE OF SCIENCE	***SCIENCE AS A HUMAN ENDEAVOR*** *Men & Women, Never be finished, Devote their lives, Great pleasure*	***SCIENCE AS A HUMAN ENDEAVOR*** *Diversity, Collaboration, Intellectual honesty, Tolerance, Skepticism* ***NATURE OF SCIENCE*** *Observation, Experimentation, Models, Debate*	***SCIENCE AS A HUMAN ENDEAVOR*** *Individuals & teams, Ethical traditions* ***NATURE OF SCIENTIFIC KNOWLEDGE*** *Criteria, Criticism*

TORNADO ALLEY

www.tornadoalleymovie.com

Tornado Alley is a co-production of Giant Screen Films and Graphic Films, in collaboration with the Giant Dome Theater Consortium. Major funding was provided by the National Science Foundation.

GIANT SCREEN FILMS

NSF

This material is based upon work supported by the National Science Foundation under Grant No. 1010884. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

An Educational Product of

THE FRANKLIN INSTITUTE

Appendix F:
Tornado Alley Educational Materials Survey

Tornado Alley - Educational Materials Survey

Please Respond:

Name:

Mailing Address:

Town/City:

State:

ZIP:

Email Address:

Where did you see *Tornado Alley*:

- ◯ Science Museum of Minnesota
- ◯ Fort Worth Museum of Science and History

I. TELL US ABOUT YOURSELF

We'd like some information about you and the kind of teaching or educational work you do.

1. What is the name of your school?

2. Indicate the grade(s) you teach:

☐ 1	☐ 5	☐ 9
☐ 2	☐ 6	☐ 10
☐ 3	☐ 7	☐ 11
☐ 4	☐ 8	☐ 12

3. Indicate the subject areas you teach:

- ☐ all subjects
- ☐ science specialist for one or more elementary grades
- ☐ junior high/middle school science
- ☐ junior high/middle school biology
- ☐ senior high biology
- ☐ other senior high science
- ☐ other:

4. How long have you been teaching?

5. Before this one, how many educator guides for science films, television or other visual media have you used?

6. How helpful have these guides that accompany films etc. been to you and your students to work with the content of the visual media?

Explain your rating:

II. JOURNAL YOUR ACTIVITIES

*In each section below, please describe the activities you conducted with your students in association with seeing the*Tornado Alley *film.*

1. Prior to Science Center Visit

How did you prepare your students for seeing the film?

a. Did you have students visit the web site?

- Yes
- No

b. List any specific activities from the *Tornado Alley* educational materials you conducted OR new activities adapted from the educational materials.

c. List any activities from other recommended resource websites you conducted.

d. Describe any other activities you conducted to prepare students for the film.

2. Science Center Visit

Describe your science center visit.

a. Did the museum offer any related workshops or exhibits to view during your visit?

b. If your students engaged in related programs, please describe the topics covered or exhibits visited.

3. After Your Science Center Visit

What activities did you conduct after seeing the film?

a. Did you discuss the film? If so, what did you talk about?

b. List any specific activities from the *Tornado Alley* educational materials you conducted OR new activities adapted from the educational materials.

c. List any activities from other recommended resource websites you conducted.

d. Did you conduct any other activities to reinforce or extend learning from the film? Describe.

Tornado Alley - Educational Materials Survey

III. RATE THE MATERIALS AND ACTIVITIES

Each section below includes questions about one of the educational products or sections of the Tornado Alley *website.*

1. Educator's Guide

A. Please check the rating for each statement about the *Tornado Alley Educators Guide.*

	Strongly Disagree	Disagree	Agree	Agree Strongly
The *Guide* helped me to prepare students for viewing film.	◯	◯	◯	◯
The *Guide* is worth recommending to other Teachers.	◯	◯	◯	◯
The *Guide* is relevant to the Tornado Alley film.	◯	◯	◯	◯
The *Guide* gave me ideas for class discussion after viewing.	◯	◯	◯	◯
The *Guide* is valuable for lessons not directly related to the film.	◯	◯	◯	◯
Activities are easily adaptable to my classroom (materials and time).	◯	◯	◯	◯
Activities are interesting to students.	◯	◯	◯	◯
Activities are appropriate for elementary school students.	◯	◯	◯	◯
Activities are appropriate for middle school students.	◯	◯	◯	◯
Instructions for activities are clear.	◯	◯	◯	◯
Materials are easy to obtain for activities.	◯	◯	◯	◯
The *Guide* helped generate ideas for related or new activities to use in my classroom.	◯	◯	◯	◯
The science content is relevant to your curriculum.	◯	◯	◯	◯
The format of the *Guide* is well organized.	◯	◯	◯	◯

Additional Comments about the *Educators Guide:*

B. Place a check next to the activities you conducted and/or topics you discussed with your students.

- [ ] Puzzle(s) from the website (Word Search, Maze, Crossword)
- [ ] Read or had students read recommended books about tornadoes
- [ ] Make a Tornado
- [ ] How Fast is the Wind Blowing
- [ ] Which Way is the Wind Blowing
- [ ] Tornado Math!
- [ ] Under Pressure
- [ ] Where in the World?
- [ ] Discussed Safety
- [ ] Discussed Technology used in the film
- [ ] Discussed Scientists' Background
- [ ] Discussed Background Information
- [ ] Other Activities:

Please choose TWO of the activities you checked above and rate the activity in terms of the listed attributes.

i. Activity ONE:

Activity ONE

	Poor	Fair	Good	Very Good	Excellent
Science Content	○	○	○	○	○
Student Engagement	○	○	○	○	○
Age Appropriateness	○	○	○	○	○
Amount of Time to Implement Activity	○	○	○	○	○

Other Comments:

ii. Activity TWO:

Tornado Alley - Educational Materials Survey

Activity TWO

	Poor	Fair	Good	Very Good	Excellent
Science Content	◯	◯	◯	◯	◯
Student Engagement	◯	◯	◯	◯	◯
Age Appropriateness	◯	◯	◯	◯	◯
Amount of Time to Implement Activity	◯	◯	◯	◯	◯

Other Comments:

C. Overall, how valuable were these activities for enriching the film experience?

Please Explain.

D. What other kinds of information, activities, or resources would you like to see in future educator's guides?

2. Posters

A. Describe how you used the front side of the posters featuring the TIV/DOW. (e.g. discussion starter, independent work, classroom visual...)

i. Which posters did you receive?

◯ TIV

◯ DOW

◯ Both

◯ None

ii. Which components of each poster were most valuable?

iii. Explain how you used each poster in relation to teaching units or curriculum elements.

iv. If you weren't able to use it in association with seeing the film, how might you use each one in the future?

B. Please rate the TIV POSTER in terms of each of the following aspects:

	Poor	Fair	Good	Very Good	Excellent
Appropriateness of science content	◯	◯	◯	◯	◯
Clarity of language	◯	◯	◯	◯	◯
Attractiveness	◯	◯	◯	◯	◯
Organization of ideas	◯	◯	◯	◯	◯
Overall design	◯	◯	◯	◯	◯

Comments:

C. Please rate the DOW POSTER in terms of each of the following aspects:

	Poor	Fair	Good	Very Good	Excellent
Appropriateness of science content	◯	◯	◯	◯	◯
Clarity of language	◯	◯	◯	◯	◯
Attractiveness	◯	◯	◯	◯	◯
Organization of ideas	◯	◯	◯	◯	◯
Overall design	◯	◯	◯	◯	◯

Comments:

D. Overall, how valuable were the posters for enriching the film experience?

Please Explain.

3. Additional Web Site Resources

A. For each of the resources below, describe if used, how valuable they were in teaching your students.

	Did Not Use	Not At All Valuable	Somewhat Valuable	Very Valuable
About the Doppler on Wheels	◯	◯	◯	◯
National Doppler Radar Sites	◯	◯	◯	◯
Web Weather for Kids- Thunderstorms and Tornadoes	◯	◯	◯	◯
National Sever Storms Laboratory- Education Resources	◯	◯	◯	◯
Tornado Handbook	◯	◯	◯	◯
Vortex 2	◯	◯	◯	◯

IV. TELL US ABOUT YOUR LEARNING GOALS

1. For each of the learning goals below, indicate how important the goal was for you and your students and the extent to which the film and educator materials were valuable in achieving that goal.

A. Teaching students about the work of scientists, including the role of teamwork in gathering data, making observations, and drawing conclusions about severe weather events.

	Not At All	Somewhat	Very
Importance of this goal for your students	◯	◯	◯
Value of the film	◯	◯	◯
Value of the web/educational materials	◯	◯	◯

B. Teaching about the tools and technology used by scientists to study tornadoes.

	Not At All	Somewhat	Very
Importance of this goal for your students	◯	◯	◯
Value of the film	◯	◯	◯
Value of the web/educational materials	◯	◯	◯

C. Teaching where Tornado Alley is located.

	Not At All	Somewhat	Very
Importance of this goal for your students	◯	◯	◯
Value of the film	◯	◯	◯
Value of the web/educational materials	◯	◯	◯

Tornado Alley - Educational Materials Survey

2. What learning goals were the most important for you in your use of these materials (either from the list above or others)? Explain your response.

3. What connections do you see between the content of the *Tornado Alley* project (film and educator materials) and other curriculum units you have or will cover with your students?

V RATE THE PROJECT

1. Please give your overall rating to each of the components of the *Tornado Alley* project. How did they compare to similar products associated with other educational projects you have used?

	Poor	Fair	Good	Very Good	Excellent
Tornado Alley Film	◯	◯	◯	◯	◯
Educators Guide	◯	◯	◯	◯	◯
National Science Standards	◯	◯	◯	◯	◯
Recommended Resources	◯	◯	◯	◯	◯
Activities	◯	◯	◯	◯	◯
Additional Background Information	◯	◯	◯	◯	◯
Posters	◯	◯	◯	◯	◯
Tornado Alley Website	◯	◯	◯	◯	◯

Comments:

2. How well integrated were the various materials (film, educators guide, poster, activities, book lists, etc.)?

Comments:

3. What other information would have been valuable for you or your students in preparation for or following the viewing of the film?

Thank you for your time and comments!

Appendix G:
Tornado Alley The Franklin Institute/Center for Severe Weather Research Form

RESEARCH CORPORATION

Tornado Alley Professional Development Evaluation
The Franklin Institute/Center for Severe Weather Research
December 6-7 2011

1. Where is Tornado Alley being shown in your area?__________________
2. Scheduled Date(s):__________

3. Please indicate you gender:
   _____ Female _______ Male

4. Please indicate your age range:
   _____ under 30 _____50-59
   _____ 30-39 _____ 60 or older
   _____ 40-49

5. Please indicate your primary professional role (choose only ONE):

_____ Museum Educator
_____ Museum Administrator
_____ Other Museum Staff
____

_____ School Teacher Grade:_____
Discipline: ___________
_____ School Administrator Grade level: ____
_____ Other School Staff
____

6. How long have you been in this professional role? _____________

7. Are other professionals from your area attending the workshop?

	a. Others Attending?		b. If Yes, have you partnered with them before?		c. If Yes, in what ways have you worked together?
Museum staff	Yes	No	Yes	No	
Formal Educators	Yes	No	Yes	No	

8. Please rate your knowledge of the following topics before and after the workshop:

	Knowledge coming IN …..						Knowledge at the END…				
	Low				High		Low				High
Research of tornados	1	2	3	4	5		1	2	3	4	5
Data collection efforts about tornados by Tornado Intercept Vehicle (TIV)	1	2	3	4	5		1	2	3	4	5
Data collection efforts about tornados by Doppler on Wheels (DOW)	1	2	3	4	5		1	2	3	4	5

Overall weather science research	1	2	3	4	5		1	2	3	4	5
The work/careers of weather scientists	1	2	3	4	5		1	2	3	4	5
Data analysis methods used in weather research	1	2	3	4	5		1	2	3	4	5
Available resources for teaching weather science	1	2	3	4	5		1	2	3	4	5

9. Please rate the workshop sections with regard to its usefulness to you?

	Not Very Useful	Somewhat Useful	Very Useful
Viewing Tornado Alley	1	2	3
Reviewing Tornado Alley Educational Resources	1	2	3
Introduction to Data Sets and IDV Software	1	2	3
Video Conference	1	2	3
Introduction to Vortex2 Data	1	2	3
Presentation of Visualizations	1	2	3
Practicing with the Software	1	2	3
Site Workshop Planning	1	2	3

10. What made this workshop effective for you?

____
____
____

11.What suggestions do you have to improve future workshops?

____
____
____

12. At this point, what plans do you have for bringing educational workshops back to your community?

____
____
____
____

13. Any other comments:

____
____
____
____

PLEASE INDICATE YOUR EMAIL ADDRESS FOR FUTURE EVALUATION INQUIRIES:

____

Thank you for your responses.

Appendix H:
Tornado Alley The Franklin Institute/Center for Severe Weather Research Facilitator Questions

RMC RESEARCH CORPORATION

Tornado Alley Professional Development Evaluation
The Franklin Institute/Center for Severe Weather Research
December 6-7 2011

The Franklin Institute Facilitator: Karen Elinich

General Questions: What went well for participants?
What went well for you as the facilitator?
In retrospect, what would you change to improve the workshop?

Areas to Address:

- Recruitment for the professional development. Workshop.
  - Teaming of informal and formal
  - Type of museums represented
  - Partnerships
  - Types of communities represented

- Workshop sections
  - Introduction to Tornado Alley, viewing, reactions to viewing
  - Laptop distribution and start up
  - Technology set up and video conference experience
  - Session with Karen Kosiba
    - Introduction to Vortex2 data
    - Visualizations

- Practicing with IDV Software

- Development of Site Projects (i.e.; realistic)

- Post-workshop communication – content, questions/concerns

- Any other comments

Appendix I: Tornado Alley Local Project Planning Application

LOCAL PROJECT PLANNING

Background Information

The VORTEX 2 Research Initiative is the largest and most ambitious field project ever to collect data on tornadoes. Involving nearly one hundred scientists and students and an armada of as many as forty science and support vehicles, this once-in-a-decade effort will rely on a fleet of cutting-edge instruments to literally surround tornadoes and the supercell thunderstorms that form them. The NSF and the National Oceanic and Atmospheric Administration (NOAA) together are contributing over $10 million towards this effort intended to provide an incremental increase in knowledge relating to the formation, structure and behavior of tornadoes.

Project Goals

The goals for your local program/event are:

- ✓ To promote awareness of the VORTEX2 research.
- ✓ To engage local audiences with VORTEX2 researchers.

Resources

You will have access to:

- ✓ Support from The Franklin Institute and the Center for Severe Weather Research.
- ✓ VORTEX2 data sets.
- ✓ Site grants: $500.

Requirements/Timeline

January 10, 2012 – Deadline for Program Plan submission.

December 1, 2012 – Deadline for program completion and final report submission.

This material is based upon work supported by the National Science Foundation under Grant No. 1010884. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

LOCAL PROJECT PLAN

Primary Contact Info

Name_____________________________

Organization_____________________________________

Email Address____

Tentative Dates

Please offer three options, in order of preference.

Budget

How will you spend your site grant?

Summary of Proposed Program/Event

What will you do?

This material is based upon work supported by the National Science Foundation under Grant No. 1010884. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Appendix J:
Tornado Alley Community Project Interview

Tornado Alley PD Projects Spring-Fall 2012
Evaluation Questions for Vortex2 Project Coordinators

Interviewer: _____ Date: _______

Interviewee: __________________________ Organization: __________________________

Position within Organization: _______________________________

Other Project Member: _____________________ Organization: _____________________________

Position within Organization: _______________________________

Attach Project Plan for Reference

1. Approximately how much time was devoted to planning the project for each team member involved? Was this sufficient?

2. After attending the workshop at The Franklin Institute, did you contact any of the following people in helping you plan the project? If yes, how helpful was the information you obtained for your planning?

	Yes	No	If yes, how helpful		
			Very	Somewhat	Not at All
Karen Elinich at The Franklin Institute					
Karen Kosiba or other researchers at The Center for Severe Weather Research					
Contacts within your organization					
Other workshop participants					

Others: ____________________

3. After attending the workshop, did you utilize any of the following resources in helping you plan the project? If yes, how helpful was the resource for your planning?

	Yes	No	If yes, how helpful		
			Very	Somewhat	Not at All
The IDV software and datasets					
Tornado Alley website					
Education guide					
Posters					

Other resources: _________________________

4. Were the project activities implemented as planned? ___Yes ___No
   4a. If no, what were the changes?

5. Were there any challenges in implementing any of the project activities and how were they addressed?

6. What were the successes of the project? What contributed to the success?

7. If student audience, what do you think the impacts were on the students who attended? Is that your perception or did you conduct evaluations?

8. If teacher audience, what do you think the impacts were on the teachers who attended? Is that your perception or did you conduct evaluations?

9. From your experience working on this project, did you experience any changes on the following topics? If yes please explain.

    a. Your knowledge about tornados

    b. Your knowledge about research of tornados (i.e. data collection, visualization, and analysis)

    c. Your attitudes about teaching weather science to teachers

    d. Your attitudes about teaching weather science to students

    e. Your attitudes about careers in weather science

    f. Any other changes: ___________________________________

10. Do you have any plans to continue any aspects of this project? If so, what are they?

11. Any other comments.

The research team is also interested in having formal educators evaluate the educational materials, poster, and website. Do you know of any teachers that may be willing to participate in this effort?

If yes, who and contact information. Can we use your name as a referral?

Appendix K:
Tornado Alley Outreach Log

Tornado Outreach Log
(to be completed by Tornado Outreach Staff)

OUTREACH DETAILS

Site: ________________________________

What type of host site: Was this a ___museum ___ school ___other: _____________

City, State: ____________________________________

Which of the following components were a part of this outreach event?
___ TIV
___ Doppler Vehicle
___ Scientist Presentation: ____
___ Screening
___ Other Presenters: ____

Briefly describe the nature of the outreach event:

PARTICIPANTS

Briefly describe who was served by this program? (students, families, first responders, etc)

If the group included students, what ages? __________

Approximately how many participants were there?

What was this audience most interested in? Please provide examples of discussions or questions asked.

What kinds of questions did they ask? (please record their questions below)

Appendix L:
Tornado Alley Outreach Museum Host Survey

Tornado Outreach: Museum Host Survey

Museum Hosts: Thank you for taking the time to reflect on and record your experiences as a host site for the Tornado Alley Outreach. The results will be used in two ways: 1) to document the successes of the outreach and 2) to offer best practices and lessons learned from your experiences. We are interested in learning both how your community benefited from the experience and what you learned about conducting outreach activities. Summative evaluation of Tornado Alley is being conducted by RMC Research Corporation, based in Portsmouth, NH. This survey is one piece of a broader evaluation of the Tornado Alley project, which includes study of the learning impacts related to the film, educational materials, and other outreach. The questions on this survey are intentionally broad, since the survey is being used to capture the experiences and feedback from a range of museums and outreach activities. Please relate as much detail as possible about your events. And thank you again for sharing your experiences and thoughts with us.

1. What is the name of your museum?

2. City, State

3. What is your title?

4. Do you have a large format (IMAX) theater?

- ○ Yes
- ○ No

5. Which of the following components was a part of your outreach efforts?

- ☐ TIV
- ☐ Doppler Vehicle
- ☐ Scientist Presentation
- ☐ Screening
- ☐ Other (please specify):

6. Who was served by this program?

- ☐ Adults
- ☐ Family groups (mixed ages including adults and children)
- ☐ If students, what ages:

7. Please describe the programming at your site:

8. Did you engage new partners (e.g., Red Cross, weather broadcasters, etc.) because of the subject matter of the film?

- [ ] No
- [ ] Yes

If Yes, please name the partners you worked with:

9. Did you reach out to any new audiences for this programming?

- [ ] No
- [ ] Yes

If yes, please describe any new audiences reached by these programs:

10. What aspects of the programming around Tornado Alley were most successful? Please describe what these programs were and what made them successful.

11. How, if at all, did the media coverage for this outreach initiative differ from the coverage you have received for other events?

12. How did having the vehicle visit affect your outreach and/or marketing activities for this film?
(What were you able to do that you wouldn't have done otherwise?)

13. Please share any other thoughts you have about the outreach.

Appendix M: Tornado Alley Outreach Site Survey

Tornado Outreach Site Survey

Site Contacts: Thank you for taking the time to reflect on and record your experiences as a host site for the Tornado Alley Outreach. The results will be used in two ways: 1) to document the successes of the outreach and 2) to offer best practices and lessons learned from your experiences. We are interested in learning about the value of the outreach for your community and what you learned about conducting outreach activities. This summative evaluation of Tornado Alley is being conducted by RMC Research Corporation, based in Portsmouth, NH. This survey is one piece of a broader evaluation of the Tornado Alley project, which includes study of the learning impacts related to the film, educational materials, and other outreach. The questions on this survey are intentionally broad, since the survey is being used to capture the experiences and feedback from a range of schools and community organizations that have hosted outreach events, as well as a variety of outreach activities. Please relate as much detail as possible about your events. And thank you again for sharing your experiences and thoughts with us.

YOUR ORGANIZATION

1. What is the name of your school/organization?

2. How would you best describe the organization:

☐ Museum

☐ School

☐ Other (please specify):

3. City, State

4. What is your title and/or your role in coordinating this event?

5. Who was served by this program?

☐ Adults

☐ Family groups (mixed ages including adults and children)

☐ If students, what ages:

6. Please indicate whether the community served included any of the following:

☐ First responders

☐ Tornado survivors

☐ Other (please specify):

Tornado Outreach Site Survey

7. Approximately how many participants were there?

Children

Adults

THE EVENT

8. Which of the following components were a part of this outreach event?

- [ ] Tornado Intercept Vechicle (TIV)
- [ ] Doppler Vehicle
- [ ] Scientist Presentation
- [ ] Screening
- [ ] Other Scientist Presentation/Presenter:

9. Was this presentation relevant for your community?

- [ ] Not at all relevant
- [ ] Somewhat relevant
- [ ] Very relevant

Please explain your response:

10. What was most valuable about this outreach event for your community? What were participants most interested in?

Appendix N: Tornado Alley Outreach Evaluation Questions for Scientists

RMC Research Corporation

Tornado Alley Outreach Campaign Spring-Fall 2011
Outreach Evaluation Questions for Scientists

1. What is your background and expertise?

2. How did you become part of the Tornado Alley outreach campaign?

3. How many events did you participate in? What was your role?

4. Looking back, were there logistical issues that could have been improved (i.e.; timing, communication, outreach preparation)?

5. Have you participated in similar outreach activities before? If yes, please describe? If no, what aspects were new for you?

6. From participating in the outreach, what "take-aways"/lessons learned did you experience in these areas:

    a. Interacting with students (lecture, question and answer, etc.)
    b. Interacting with general audiences
    c. Communicating your work with the audiences

7. What do you think audiences gained by having a person in your role involved in the outreach?

8. What settings or conditions made for the best outreach reception?

9. What surprised you most from the outreach experience?

10. How could the outreach activities be improved for future informal science films?

RESEARCH CORPORATION

Tornado Alley Outreach Campaign 2012-2014
Outreach Evaluation Follow-up Questions for Scientist

1. How many events did you participate in during 2012-2014? Was your role the same as in 2011?

2. Were any of the logistical issues different than in 2011 (i.e.; timing, communication, outreach preparation)? Improved, more challenges?

3. After several years of participating in the outreach, what made for the best experience for audiences?

    a. Interacting with students (lecture, question and answer, etc.)
    b. Interacting with general audiences
    c. Communicating your work with the audiences
    d. Geographic location/type of community

4. Did any of the content you delivered change over time? If so, what factors led to the change?

5. What configuration of the outreach teams worked best at providing information for audiences?

6. What settings/places or conditions made for the best outreach reception?

7. What surprised you most from the outreach experience?

8. How could the outreach activities be improved for future informal science films?

Any other comments on your experience.

RESEARCH CORPORATION

Tornado Alley Outreach Campaign 2012-2014
Outreach Evaluation Follow-up Questions for Research Technician

1. How many events did you participate in during 2011-2014? Please describe your role over that time and did it change?

2. Describe the technical research and planning needed to engineer the 3D projection system to work in all of the traditional contexts.

3. Describe the technical research and planning needed to engineer the 3D projection system to work in all of the non-traditional contexts.

4. Describe any logistical issues during the project (i.e.; timing, communication, outreach preparation). Did they improve, more challenging, different over time? Were they different depending on type of site? How so?

5. After several years of participating in the outreach, what made for the best experience for audiences? (geographic location/ type of community)

6. What settings/places or conditions made for the best outreach reception?

7. Other than audience members, who else may have been impacted by the outreach activities in the sites? How so?

8. What surprised you most from the outreach experience?

9. How could the outreach activities be improved for future informal science films?

Any other comments or suggestions from your experience.

Appendix O: Tornado Alley Documentation of On-Site Outreach in Joplin, Missouri

May 7, 2013
Missouri Chamber of Commerce and Industry
428 East Capitol Avenue
Jefferson City, MO 65101

Contact: 573-634-3511
Karen Buschmann, Vice President of Communications

MEDIA ADVISORY

Missouri Mathematics and Science Coalition and Lenovo help to bring Technology and the Science behind Weather into the Classrooms

The Missouri Mathematics and Science Coalition, in conjunction with Lenovo, Giant Screen Films and the National Science Foundation are working together to bring the science behind severe weather into classrooms for students by providing teachers with free tablet/laptops loaded with weather research software.

Lenovo, a leader in personal and business computing, has provided equipment for the Center for Severe Weather Research (CSWR), whose scientists are featured in the documentary *Tornado Alley*. The company enthusiastically extended its commitment to furthering science education by donating Lenovo Yoga 13 Ideapads for science teachers in the Joplin School District who are participating in a special professional development program facilitated by CSWR's Dr. Karen Kosiba. Funded by the National Science Foundation, this special program is an educational component of the *Tornado Alley* film project, and was developed by Dr. Karen Elinich of the Franklin Institute in Philadelphia. Through hands-on use of technology, the program offers educators meaningful insight into the collection and use of real weather data.

The Yoga 13 combines the experience of a laptop with the functionality of a tablet, and its powerful Intel processor and Windows 8 functionality make it an ideal tool for research, workshops and classroom learning. The donated computers are loaded with the same cutting edge software that leading scientists like Dr. Kosiba and others use to track and analyze severe weather events such as tornadoes and hurricanes. Participating educators attended an introductory workshop where they learned about Dr. Kosiba's research and explored software and weather data collected by CSWR and researchers around the world. The donated laptops will allow educators to use this software to teach about weather and to facilitate ongoing interactions between students and Dr. Kosiba through videoconferences.

"We are pleased to have this opportunity to bring cutting edge technology both in the form of Lenovo's new Yoga 13 tablet/laptop and severe weather tracking software to educators and students in Missouri schools, most particularly the Joplin Schools. The more that we all understand how technology can better assist our daily learning and living then the better off we all are," stated Brian Crouse, executive director of the Mathematics and Science Coalition.

"Lenovo is a fantastic partner in our efforts to extend *Tornado Alley's* educational impact," said Deborah Raksany, vice president of development and partnerships for Giant Screen Films, producer of *Tornado Alley*. "Not only has Lenovo supported the real research that may provide increased warning times for communities like Joplin where severe weather poses a threat—they're also committed to inspiring a new generation of scientists by supporting programs like this one. We're very happy to see the recovery in Joplin and we're excited to continue to work with educators in the region."

On March 7, 2013 science and math teachers from Joplin area schools took part in an introductory severe weather professional development workshop sponsored by the Missouri Mathematics and Science Coalition during Missouri's week long recognition of the importance that Science, Technology, Engineering and Mathematics (STEM) holds for education and workforce development in Missouri.

Members of the media are welcome to attend any portion of the event. Please contact the Joplin School District directly to set up.

The Missouri Mathematics and Science Coalition is a group of business, education, government and community stakeholders who have formed an association to foster collaboration and ensure Missouri citizens are equipped with knowledge and skills in mathematics, engineering, technology and science to prosper in a global economy. The Missouri Mathematics and Science Coalition is facilitated by the Missouri Chamber of Commerce and Industry.

The Missouri Chamber of Commerce and Industry (www.mochamber.com) was founded in 1923 and is the largest business organization in Missouri, representing almost 3,000 employers, providing more than 425,000 jobs for Missourians. ###

MISSOURI Mathematics and Science Coalition
ADVANCING SCIENCE, TECHNOLOGY, ENGINEERING AND MATH CAREERS

Missouri Tornado Alley Outreach Trip Agenda
March 4-9, 2013

Day	Date	Time	Location	Activity
Sunday	March 3, 2013	Noon	St. Louis	Scott Fauteux- Arrives in St. Louis and set up at Johnson Wabash
Monday	March 4, 2013	10:00am to 12:00pm And 1:15pm to 3:00pm	Ferguson / Florissant Schools	Ferguson-Florissant School District- Eric Hadley -POC **10:00am – noon** Johnson Wabash Elementary School **3D** (685 January Ave., Ferguson, MO 63135)- *Robin Witherspoon, Principal , 314-524-0280* -Grades 3-6 Total: **240** students *(Box lunch provided)* **1:15pm** 3:15pm Airport Elementary School- (8249 Airport Rd., Berkeley, MO 63121)- *Tangie Oglesby, Principal , (314) 524-3872-* -Grades 2-6 Total: **190** students
		Evening	Camdenton	Overnight Camdenton
Tuesday	March 5, 2013	8:30am – 11:30am	Camdenton	Camdenton HS- *662 Laker Pride Road, Camdenton, MO 65020- Brett Thompson, Principal, 573-346-9232* *(Box lunch provided)* **2D** *current system* 2 groups of 100 students each- rotating after 50 minutes to 1 hour- Total: **200** students -1 group to see movie and presentation (900 seat Auditorium) -1 group to see vehicles
		11:30am- 12:30pm	St. Roberts	Drive to Waynesville
		1:00pm – 3:30pm *School ends at 2:30* *May have to do after school programs…*	St. Roberts	Waynesville HS (Ft. Leonard Wood) *200 Gw Ln Waynesville, MO 65583* *573-842-2400 ext. 3171- Travis Bohrer POC also, Courtney Long, Principal* - Vehicles to pull up in the front of School- will be blocked off 2 Groups of 75 Students each- rotating after 50 minutes to 1 hour- Total: **150** students -1 group to see movie and presentation (Auditorium) -1 group to see vehicles
		4:00pm - 4:30pm	Rolla	Drive to Rolla
		6:00pm – 9:00pm	Rolla	Missouri University Science & Technology- Havener Center *(1346 Bishop Avenue, Rolla, MO 65409)* Havener Center- Student Union- Seating 80 Tornado Alley Showing- Community and Student Q&A - place for Tornado vehicles in front of center – will be roped off *-2D will be determine prior to event*
		Evening	Rolla	Overnight In Rolla
Wednesday	March 6, 2013	9:00am – 12:00pm	Rolla	**Tornado / Severe Weather Emergency Sheltering Workshop-** Eugene Northern Community Hall - *(400 West 4th Street, Rolla, MO 6540)* *POC Paul Fenniwald 573-680-5230 or Brian Crouse- 573-619-4349*

Day	Date	Time	Location	Activity
		12:00pm to 12:30pm	Rolla	Drive to Rolla High School
		1:30pm – 3:30pm	Rolla	**Rolla Public Schools- High School** *900 Bulldog Run, Rolla, MO 65104- POC- Jim Pritchett, Principal, 573-458-0140, cell- 573-578-7050* ***3D*** 2 Groups 92 and 100 Students each- rotating after 50 minutes - Total: **192** students -1 group to see movie and presentation -1 group to see vehicles
		3:00pm to 6:00pm	Joplin	Drive to Joplin (3 hours)
		Evening	Joplin	Overnight in Joplin – Holiday Inn Express Reservations Made- Brian Crouse 2 Rooms Comp
Thursday	March 7, 2013	8:45am to 3:30pm 8:45am to 11:00am 1:00pm to 3:00pm	Joplin	**Joplin Public School District- Middle Schools-** *Dr. Angie Besendorfer* *Joplin School Dist. Receives modify presentation with only video clips.* 8:45am- East Middle School- *7501 E. 26th Street, Joplin, MO 64804- POC- Bud Sexson, Principal- 417-625-5280* 2 Groups of 80 students- 7th Graders- Total: **160** students -1 group to see presentation focus on science and STEM Careers -1 group to see vehicles 1:00pm- North Middle School- *102 Gray, Joplin, MO 64801- POC- Brandon Eggleston, Principal, 417-625-5270* 2 Groups of 110/5 students- 7th Graders- Total: **215** students -1 group to see presentation focus on science and STEM Careers -1 group to see vehicles
		3:30 to 5:30pm Karen Kosiba Karen Elrich via skype	Joplin / SW MO	**Science Educator Data Pilot Work Shop – The Franklin Institute / GSF Inc.** North Middle School- *Computer Lab- 102 Gray, Joplin, MO 64801- POC- Brandon Eggleston, Principal, 417-625-5270 POC- Terri Hart* -15-18 Middle and HS Science educators (8 Attended- 1 a history teacher)
		7:00pm to 9:00pm	Joplin	**Missouri Southern State University- Billings Student Center- 3D** *3950 E. Newman Rd. • Joplin, MO 6480- POC- Cary Beasly- Joplin Chamber and Aaron Lewis at MSSU Student Center 417- 625-9674* -Seats 150 -3D film
		Evening	Joplin	Overnight in Joplin – Holiday Inn Express Reservations Made- Brian Crouse 2 Rooms- Comp'd by Joplin Chamber

MISSOURI Mathematics and Science Coalition
ADVANCING SCIENCE, TECHNOLOGY, ENGINEERING AND MATH CAREERS

Day	Date	Time	Location	Activity
Friday	March 8, 2013	9:00am to 11:00am	Joplin	**Joplin Public School District- Middle Schools-** *Dr. Angie Besendorfer* *Joplin School Dist. Receives modify presentation with only video clips.* 9:00am- South Middle School- *900 E. 50th St., Joplin, MO 6480- POC- Steve Gilbreth, 417-625-5250* 2 Groups of 110/5 students- 7th Graders- Total: **215** students **-** *same as North on Thur.* -1 group to see presentation focus on science and STEM Careers -1 group to see vehicles
Friday	March 8, 2013	Noon	Joplin	**Team can begin journey home or stay overnight.**
		Evening	Joplin	Overnight in Joplin – Holiday Inn Express Reservations Made- Brian Crouse 2 Rooms
Saturday	March 9, 2013	TBD	TBD	Leave Joplin Return Home

Brian Crouse: **Cell# 573-619-4349**

Office# 573-634-3511

MISSOURI Mathematics *and* Science Coalition
ADVANCING SCIENCE, TECHNOLOGY, ENGINEERING AND MATH CAREERS

K-12 Educator Data Visualization Professional Development Event

Greetings:
We invite you to participate in our community-focused professional development program to help learners of all ages understand the nature of scientific investigation, data collection, and visualization involved in the quest to understand the origins of severe weather.

Middle school and high school educators are invited to participate in an interactive afternoon session in Joplin on Thursday, March 7, 2013. The PD program focuses on the nature and process of science with a particular emphasis on data collection, analysis, and visualization. During the workshop, team members will learn how to use free data analysis software and will work with real meteorological datasets collected through the VORTEX2 research mission that is featured in the film Tornado Alley—as well as data collected by director Sean Casey and the Tornado Intercept Vehicle—to examine weather data and plan simple activities for classroom environments.

Each team member will receive a laptop computer to take home use to support their local classroom activities.

Session Leaders
Dr. Karen Elinich – The Franklin Institute
Dr. Karen Kosiba – Center for Severe Weather Research

For more information contact: Deborah Raksany - draksany@gsfilms.com or
Brian Crouse - BCrouse@Mochamber.com

The *Tornado Alley* Professional Development program will enable participants to develop their own professional skills and increase their capacity to provide learning experiences that support the achievement of national science and educational technology standards.

National Science Education Standards
K-12 Unifying Concepts & Processes:
Evidence, models, and explanation
Constancy, change, and measurement
K-12 Content Standards:
Science & Technology
History & Nature of Science

National Educational Technology Standards – For Students
Research and Information Fluency
Critical Thinking, Problem-Solving, and Decision Making

National Educational Technology Standards – For Teachers
Design and Develop Digital-Age Learning Experiences
Model Digital-Age Work and Learning
Engage in Professional Growth and Leadership

National Educational Technology Standards – For Administrators
Digital-Age Learning Culture
Excellence in Professional Practice

Tornado/Severe Weather Emergency Sheltering in Schools Workshop

Identifying Best Practices and Developing Model Emergency Plans

Wednesday, March 6, 2013 9:00am to 3:30pm

Eugene Northern Community Hall

400 West 4th Street Rolla, Missouri

MISSOURI Mathematics *and* Science Coalition
ADVANCING SCIENCE, TECHNOLOGY, ENGINEERING AND MATH CAREERS

CES MISSOURI CENTER FOR EDUCATION SAFETY

MSBA

MISSOURI S&T University of Science & Technology

AGENDA

Tuesday, March 5

7:00 pm	Pre-event Community- Movie Screening and Discussion Location: Missouri S&T Havener Center

Wednesday, March 6 Severe Weather Workshop

9:00 – 9:45	Doors open/Registration/Networking
9:30 – 9:45	Introduction Missouri University of Science & Technology Missouri Mathematics & Science Coalition Missouri School Boards' Association – Center for Education Safety
9:45 – 11:45	The Science of Tornados and Severe Weather - Lessons Learned National Science Foundation & NOAA – National Weather Service
11:45- 12:00	Break *-NSF Team Leaves for Rolla High School-*
Noon – 12:30	**Lunch and Preparation for Round Table Discussion** *(we may need more than 30 minutes to get 80 people through the buffet line)*
12:30 – 12:45	Red Cross Resource Presentation
12:45 – 1:00	Special/Functional Needs Considerations Presentation
1:00 – 2:30	Round Table Discussion on Tornado Sheltering Considerations Guidelines for Consideration (What's Important) Identification of Components School Emergency Planning Identification of Resources for School Emergency Planning Discussion of Special/Functional Need Considerations
2:30 – 3:30	Report out and Closing Remarks

BIOGRAPHIES

Donald Burgess is a research scientist at the Cooperative Institute for Mesoscale Meteorological Studies at the University of Oklahoma, where he also serves as an Adjunct Professor of Meteorology. He is the chief scientist on one of VORTEX2's mobile radars, as well as a member of the project's steering committee.

Burgess has spent forty-one years studying severe weather. In the nineteen-seventies, he pioneered the concept of "nowcasting," making accurate weather forecasts for a very short period of upcoming time, by using radar to direct a research team during a tornado intercept. This discovery introduced, in turn, the frequent use of the tornado vortex signature seen in radar displays.

A lifelong resident of Oklahoma, Burgess began working as a student employee of the National Severe Storms Laboratory in 1970, was promoted to a full-time position in 1972, and continued there in various capacities until 1991. From 1991 to 2000, he managed operations and training in the NEXRAD Operational Support Facility, serving for a year as Acting Director, before returning to the NSSL as a division chief in 2000. He retired in 2003, after thirty-two years of federal service. Prior to his retirement from NSSL, Burgess also served as Director and Chief of Operations at the NEXRAD Radar Operations Center and Chief of National Weather Service Radar Training.

Sean Casey, IMAX filmmaker and professional storm chaser made his feature-length directorial debut with Tornado Alley, a film in which he also stars and serves as first unit cinematographer. Over the course of his career, Casey has filmed volcanoes, hurricanes, and earthquakes, and the depth of his experience working in severe weather—as well as the impressive library of IMAX tornado footage he has amassed leading up to ***Tornado Alley***'s release. Casey has directed a number of television documentaries and music videos, including *Marine: Earning The Title, The Art of Camouflage*, *The U.S. Army Ranger*, *Tonight* (Violent Femmes), *Machine* (Violent Femmes), and *Glass Sparkles In their Hair* (Pond). In addition, Casey is an inventor of sorts, having designed two tornado intercept vehicles, or TIVs, the second of which seems unwittingly poised to be one of ***Tornado Alley***'s biggest stars.

After graduating from the University of California Santa Barbara in 1992, with a degree in Film Studies, Casey immediately began working in the IMAX format. His credits include *Ring of Fire, Search for the Great Sharks, Africa: The Serengeti, Alaska: Spirit of the Wild, Amazing Journeys,* and *Forces of Nature*.

In 2008, *Discover* magazine named Casey one of the fifty best minds of the year.

Josh Wurman is the president and founder of the Center for Severe Weather Research in Boulder, Colorado. He also serves as a chief scientist and coordinator of the VORTEX2 project, operating three of the project's Doppler on Wheels vehicles, the fast-scanning radar trucks featured in ***Tornado Alley***, which he invented in the mid-nineties. Wurman appears regularly in the Discovery Channel's *Storm Chasers* series.

In the early nineties, frustrated by the instruments then being used to study severe weather, Wurman began to conceive of radar he could "modernize, toughen up, and get up onto a truck platform." Short on funds, his first DOW vehicle, he says, was made of "a U-Haul full of a junk," cast-off parts from the National Center for Atmospheric Research.

Today, Wurman's fleet of radar trucks is the backbone of the VORTEX2 project. They're equipped with state-of-the-art computers that require constant monitoring. In addition to creating the DOW mobile radars, Wurman also invented bistatic radar networks, and he owns nine patents related to this and other DOW technology. He received both his undergraduate and doctorate degrees from the Massachusetts Institute of Technology and was a tenured faculty member at the University of Oklahoma, where he taught and did research for close to a decade. In 1998, Wurman founded the Center For Severe Weather Research, which he runs with his wife, Ling.

Karen Kosiba is an atmospheric scientist at the Center for Severe Weather Research in Boulder, Colorado. As a member of the VORTEX2 team, she operates DOW 7 and coordinates the mission's pod teams—a job, she says, that has taught her "very good multitasking skills." Her efforts helped secure VORTEX2's successful Goshen County storm intercept at the end of Tornado Alley. She received a B.S. in physics at Loyola University, an M.S. in physics and a M.A.T. in teacher education at Miami University, and a Ph.D. in atmospheric science at Purdue University.

A strong believer in experiencing weather firsthand, she has participated in many field projects, including Radar Observations of Tornadoes and Thunderstorms Experiment (ROTATE), Hurricanes and Landfall (HAL), Convectively and Orographically-Induced Precipitation Study (COPS), and VORTEX2.

Over the course her academic career, Kosiba has won multiple awards for her outstanding performance as a teacher. She is passionate about science education and has recently maintained the National Science Foundation's VORTEX2 blog.

PARTNERS

MISSOURI Mathematics and Science Coalition
ADVANCING SCIENCE, TECHNOLOGY, ENGINEERING AND MATH CAREERS

CES
MISSOURI CENTER FOR EDUCATION SAFETY

MSBA™

MISSOURI S&T
University of Science & Technology

GIANT SCREEN FILMS

NSF

Center for Severe Weather Research

American Red Cross

SPONSORS

at&t

Westinghouse

SERVPRO®
of Missouri
Fire & Water - Cleanup & Restoration™

CenturyLink®