Severe Weather Field Experience: An Undergraduate Field Course on Career Enhancement and Severe Convective Storms

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ABSTRACT

Undergraduate students acquire a deeper understanding of scientific principles through first-hand experience. To enhance the learning environment for atmospheric science majors, the University of North Carolina at Asheville has developed the severe weather field experience. Participants travel to Tornado Alley in the Great Plains to forecast and observe convective storms for two weeks. The objectives of the course encompass far more than observing severe storms. On days with non-threatening weather in the Great Plains, students participate in an array of activities that provide exposure to facilities and interaction with professionals in various sectors of meteorology. While the allure of chasing storms initially prompts the students to enroll in the course, the focused career-development aspect of the curriculum increases awareness for the varied career options in the atmospheric sciences and helps students discover where their own capabilities and interests might best suit the discipline. The course thus offers students a comprehensive career-development experience woven within a thrilling adventure. © *2011 National Association of Geoscience Teachers*. [DOI: 10.5408/1.3604823]

INTRODUCTION

Studies consistently show that undergraduate students gain a deeper understanding of scientific principles through field experiences (e.g., Fletcher, 1994; Richardson *et al*., 2008; Knapp *et al*., 2006; Lathrop and Ebbett, 2006; Aitchison and Ali, 2007; Elkins and Elkins, 2007). Several undergraduate-level meteorology degree programs have incorporated field courses into their curricula. For many years, The City College of New York offered an instrumentation course in which students traveled to the Colorado Rocky Mountains to collect cloud droplets at Storm Peak Laboratory (Hindman, 1993). In 1999, an undergraduate course at the University of Arizona allowed enrolled students to actively investigate the heat island effect in Tucson via vehicle-mounted measurements (Comrie, 2000). The recent Rain in Cumulus over the Ocean (RICO) field campaign made a special effort to involve undergraduate students in all aspects of the project (Rauber *et al*., 2007). These and similar courses and projects actively engage undergraduate students in the learning process through measurements, analyses, and writing exercises.

Although these classes each contained a field component, the learning environment remained primarily classroom-based and students spent relatively limited time in the field. Several colleges and universities currently offer field-based storm chasing courses in meteorology, including the State University of New York (SUNY) at Oswego, Valparaiso University, College of DuPage, and Virginia Polytechnic Institute and State University (Virginia Tech). These schools all offer courses that bring students to the Great Plains of the United States to observe severe weather. Each of these courses remains principally field-based, with a forecasting component as the primary goal. The course at College of DuPage includes a forecasting and analysis focus, while the course at Valparaiso and the program at SUNY Oswego both provide students with opportunities to take measurements of the atmosphere and observe storm development. Virginia Tech approaches their field course, offered by the Geography Department, from a physical geography perspective by visiting various landscape features during periods of relatively quiet weather. With available time, instructors at each of these schools make an effort to include educational activities, such as visits to meteorological research and operational forecasting facilities, to gain exposure to job opportunities. However, in all cases this remains a secondary objective (P. Sirvatka, S. Steiger, and B. Wolf, personal communication, 2010).

To promote inquiry-based learning at the undergraduate level, the Department of Atmospheric Sciences at the University of North Carolina at Asheville (UNCA) has developed an innovative new course that couples field-based activities with professional development. Severe Weather Field Experience (SWFEx) participants travel to Tornado Alley in the Great Plains to forecast and observe convective storms for two weeks. The main components of the course include (a) advanced Skywarn storm spotter training, (b) daily synoptic weather discussions led by students and faculty, (c) afternoon storm-chasing activities, (d) tours of major National Oceanic and Atmospheric Administration (NOAA) operational and research facilities, (e) visits to private-sector and broadcast meteorology companies, and (f) presentations and discussions from nationally-recognized atmospheric scientists on topics such as severe convective storms, career opportunities in the atmospheric sciences, graduate school, and undergraduate research. Together, these components actively engage students in

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multiple stages of the scientific method, including hypothesis development, observations and analysis, and formulation of conclusions based on observations. The curriculum thus satisfies National Science Education Standards for modern science education (National Research Council, 1996). Since the course provides exposure to various career possibilities in the field of atmospheric sciences, and involves informal discussion of both introductory and advanced concepts, the course targets undergraduate atmospheric science majors at all levels. The curriculum emphasizes critical thinking skills through daily examination of numerical weather prediction (NWP) model output and observational data such as surface, upper-air, radar, and satellite measurements. Engaging students in these critical-thinking activities benefits students, particularly early in their major curriculum (Lathrop and Ebbett, 2006). The hands-on nature of the course reinforces important content, such as map analysis and interpretation, parcel lifting mechanisms, and basic thermodynamics, which students learn in their introductory-level coursework (Noll, 2003; Knapp *et al.*, 2006). This reinforcement is especially beneficial given that the teaching methods commonly used in introductory meteorology courses are only "adequate for content learning" and do not accomplish the goal of "application learning" (Kahl, 2008).

The course satisfies all seven of the principles for good practice in undergraduate education identified by Chickering and Gamson (1999): extended periods of rich student–instructor interaction, cooperation among students, active learning, prompt feedback, an emphasis on task, a clear communication of high expectations, and respect for diverse learning styles. Furthermore, the course moves undergraduate student involvement in scientific inquiry from the role of a passive learner to that of an active colleague (Kremer and Bringle, 1990). Participation in content-rich, interactive programs, such as those provided by this course, significantly increases undergraduate students' interest in further pursuing a research career (Gonzalez-Espada and LaDue, 2006). The higher-order thinking skills practiced by students during this course span the geosciences, independent of the specific activity, and training students to use these skills effectively benefits them on the job market (e.g., Manone *et al.*, 2003). This course highlights the transferability of meteorological skills to other disciplines, which is especially important given that the population of undergraduate meteorology majors has reached an all-time high (Knox, 2008), while the growth in career options remains more limited (U.S. Department of Labor, 2008).

Course Structure and Content

The SWFEx course goals extend beyond following and observing severe storms. On days with nonthreatening weather in the Great Plains, students participate in an array of activities that provide exposure to facilities and professionals in various sectors of meteorology unavailable at UNCA. Combined with the academic aspects of the course, students ultimately (a) learn to use effectively the broad array of observational and numerical weather prediction tools available to the meteorological community to forecast severe weather, (b) learn to make daily short-term forecasts of the expected location and mode of anticipated severe weather, (c) interact closely with peers and faculty members in both formal and informal settings, (d) enhance their writing skills, and (e) discover a wide variety of career options within the field of meteorology, including the government, private, broadcast, and academic sectors.

A student applies for participation in the SWFEx course by submitting an application essay that concisely addresses his or her desire to participate in the course, describes the ways in which the course may influence his or her career path, explains the role the applicant can play as a member of the chase team, and illustrates the student's impression of the characteristics of an effective storm chaser. Prior to departure on the actual two-week field program, participants engage in two activities to enhance their understanding of severe weather. First, students complete advanced Skywarn spotter training, presented by a professional meteorologist from the local National Weather Service forecast office. Though community members may attend the spotter training, the meteorologist specifically tailors the content of the presentation for participants in the SWFEx course. Second, participants attend a predeparture informational meeting and lecture to discuss the logistical aspects of the course and to learn about storm structure, target area selection, meteorological data sources, forecast resources, and storm-chasing etiquette. While stepping hour by hour through a case study and viewing short-term forecasts, surface observations, and radar and satellite images, the students look at road maps, refine target areas, and select a storm to chase in an exercise that replicates what they will eventually experience while chasing storms. Students also receive a reading assignment (i.e., Doswell, 2001) to broaden their theoretical knowledge of severe storms.

Although technically a summer class, the field component of the course takes place prior to the start of the official summer session in order to take advantage of the climatological maximum in tornado frequency in the Great Plains during mid- to late May (Brooks *et al.*, 2003). Initially, the group travels by van from Asheville, NC to the National Weather Center (NWC) in Norman, OK. The NWC houses 15 University of Oklahoma, NOAA, and research and development organizations entirely devoted to meteorology and is the only facility of its kind in the world. Federal agencies exclusive to the NWC, such as the NOAA National Severe Storms Laboratory and NOAA Storm Prediction Center, lie at the forefront of severe weather research and operational forecasting. The NWC provides a unique environment for exploring research, graduate school, and careers in meteorology. Central Oklahoma accommodates a rich collection of private-sector meteorology companies and television stations, and visits to several of these organizations reinforce the career-development objectives of the course. On days with nonthreatening weather, students participate in discussions and attend presentations with professional meteorologists and tour government, academic, and private facilities throughout the Great Plains (Table I). The instructor schedules many of these activities months in advance of the trip, while others materialize on short notice through the instructor's professional contacts as schedules and weather conditions allow.

Early in the morning on days with probable severe weather, participants gather (usually in a hotel room) and engage in an informal map discussion. Instructors review the latest NWP model forecasts and the surface, radar, and satellite observations, pausing frequently to answer

TABLE I: Enrichment activities provided for SWFEx students in year 1 (2008) and year 2 (2009).

Tours	**Year 1**	**Year 2**
NOAA Storm Prediction Center, Norman, OK	✓	✓
National Weather Center, Norman, OK	✓	✓
Weather Decision Technologies, Inc., Norman, OK		✓
KSBI-TV 52, Oklahoma City, OK	✓	✓
KTXS-TV 12, Abilene, TX		✓
National Weather Service Forecast Office, Norman, OK	✓	✓
NOAA Radar Operations Center and WSR-88D Radome, Norman, OK		✓
Oklahoma Mesonet Site, Norman, OK	✓	✓
Phased-Array Radar, Norman, OK	✓	✓
University of Oklahoma Aviation Department at Max Westheimer Airport, Norman, OK	✓	✓
Events	**Year 1**	**Year 2**
0000 UTC Rawinsonde Launch, Norman, OK	✓	✓
Advanced Skywarn Spotter Training, Asheville, NC	✓	✓
Lectures and Discussions	**Year 1**	**Year 2**
Dr. Charles Doswell, "Assume Ownership of Your Education and Career"	✓	✓
Ms. Celia Jones, "The Graduate School Application Process"	✓	✓
Ms. Daphne LaDue, "Undergraduate Research and Summer Internship Opportunities"	✓	✓
Mr. David Imy, "Overview of the NOAA Storm Prediction Center"	✓	✓
Mr. Dave Hotz, "The GFE Forecast Monitor"	✓	
Mr. Ron Przybylinski, "Overview of the 2 April 2006 Tornadic Squall Line Event"	✓	

questions and pose new questions to students. At the conclusion of the map discussion, the students determine a target area with the highest probability of convection initiation. The students often agree on the approximate target location, though the instructors offer some guidance and likely bias the decisions in the course of the map discussion. Nevertheless, students gain valuable forecasting experience through their involvement in the process.

As the group travels to the target area, and particularly once convection initiates or appears imminent, participants actively engage in the pursuit of storms. Passengers in the van operate laptops with Internet connectivity and share radar updates, read the latest text products from the NOAA Storm Prediction Center, monitor current weather conditions, operate the weather radio, and help with navigation. They also record events with still and video cameras and assist the National Weather Service by reporting observed severe weather. During stops, students also enjoy measuring the latest temperature, dewpoint, and surface wind speed with portable Kestrel wind and weather meters. Students actively participate in class activities and trade roles to afford every person the chance to engage in each task. Students also rotate positions in the van daily to encourage socialization and total participation.

STUDENT POPULATION AND ASSESSMENT METHODS

UNCA offered the three credit-hour SWFEx course during the summer of 2008 (year 1) and 2009 (year 2). Enrollment included a total of 11 students in year 1 and 8 students in year 2, with 2 students repeating the course in year 2 for nondegree credit. Participants included three females and two nontraditional students, including a retiree. Of the traditional students in both years, a total of seven freshmen, five sophomores (including the two returning students), four juniors, and one senior enrolled in the course. Prior course experience varies for each student, though all freshmen at UNCA complete an introduction to meteorology course in their first semester, sophomores generally gain experience with basic weather analysis, juniors typically complete courses in atmospheric thermodynamics and dynamics, and seniors complete two semesters of synoptic meteorology training, as well as courses in physical meteorology and meteorological instrumentation. The small enrollment precludes a detailed quantitative analysis of the SWFEx course outcomes, though several methods allow a qualitative assessment of the course. The primary assessment methods include (a) a predeparture survey to provide a baseline assessment of prior knowledge and career aspirations, (b) a daily journal, (c) a case study for a convective weather event witnessed by the students, (d) a return survey, and (e) student evaluations.

During the field component, students keep a journal of their daily experiences as part of the student performance assessment. This forces them to critically analyze their thoughts and experiences throughout the course. When applicable, this journal includes the student's own target area forecasts and the reasoning behind those forecasts. The journal also narrates the student's observations throughout the day, both meteorological and with regard to the storm chasing or learning experience. The journal provides students a means to communicate to the instructor any lessons learned with regard to career aspirations or meteorology, and gives the students an opportunity to improve writing skills.

Upon return to UNCA, participants complete a 4- to 6-page case study that analyzes the synoptic environment and the timing, location, and occurrence of storms for a chase day during the trip. Students are encouraged to include their own photographs in the case study to demonstrate storm structure and areas of interest. This final paper facilitates students' integration of their personal experiences during a particular severe weather event with NWP forecasts, analyses, observations, storm reports, radar and satellite data, and daily forecast discussions. The case study additionally reinforces the concepts learned in other atmospheric science courses and allows the instructor to gauge the student's understanding of relevant data sources, official forecast's and the synoptic environment. This summary, unlike an analysis from a typical synoptic meteorology classroom, combines student's own forecasting and chasing experiences with their technical knowledge for an exceptional learning experience.

COURSE IMPLEMENTATION

The group travels in a rented 15-passenger van with a complete suite of supplemental insurance coverage. The students provide funds (approximately $1300 per person) directly to the instructor for gasoline, hotel, and equipment purchases. The instructor deposits these funds in a dedicated account with a debit card for use on the road. This approach avoids the hassle and delay involved with reimbursement of a significant amount of the instructor's personal funds. With the exception of one celebratory meal provided by the instructor, all participants pay for their own food for the duration of the trip. Lodging costs for the instructor and navigator are derived from the funds provided by the students.

Safely chasing storms requires special equipment, including navigation aides such as detailed paper and electronic maps, a GPS vehicle navigation system, power inverters to charge laptops and video equipment, wireless broadband modems for Internet connectivity on the road (AT&T provides excellent cellular coverage throughout the Great Plains), and a cellular amplifier to boost the signal in remote areas (Table II). To address complaints of isolation in the back of the van during the first year of the course, the instructor occasionally wears a wireless headset to communicate with students in the rear of the vehicle. This headset connects to an FM transmitter that broadcasts the instructor's voice to the back of the van via the vehicle's speakers. This effective solution improves student learning by allowing participants to hear important conversation and instruction throughout the van. In stark contrast to the feedback from year 1, no students in year 2 complained about communication problems in the van.

An experienced navigator plays a crucial role in the success of the field component of the course. The navigator's primary responsibilities include monitoring severe weather via observations and short-term forecasts, directing the driver to the safest and most visually appealing location near a storm (with one or more exit routes), locating and reserving numerous hotel rooms on short notice, finding restaurants and gas stations, serving as a relief driver, and assisting the instructor by answering questions, requesting thoughts and opinions from the students, and explaining the decisions of the instructor. The navigator must also remain calm in high-stress environments and have a compatible personality with the instructor.

Several techniques and suggestions for future field courses became apparent during the organization and execution of the SWFEx course. The most important tip for a roving multiday course with many expenses is for the students to pay at least part of the course fee directly to the professor. The professor sets up a special dedicated bank account and uses a debit card for all transactions en route. This approach circumvents the pre-approval and personal reimbursement processes for thousands of dollars in fuel and hotel costs, allows ample flexibility when obtaining equipment and services, and provides accounting transparency through the added benefit of an itemized statement. The small remaining balance goes to the professor's academic department for use in the following year. The instructor should retain all receipts and maintain accurate financial records to avoid any semblance of questionable ethical behavior. Second, the instructor should confirm details of both the rental agreement and insurance coverage with the van rental company prior to departure. Certain rental companies may prohibit driving the rental vehicle in individual states. Only after returning the van in year 1 did the instructor realize that the loss-damage waiver included in the UNCA contract with the rental company has a $5000 deductible. In year 2, the instructor purchased the full suite of available insurance coverage to completely protect the van and its passengers with no deductible. Third, when searching for hotel accommodations, locate an establishment that offers both free breakfast and high-speed Internet access for morning map discussions. This prevents the need for participants to search for food

TABLE II: List of selected special equipment purchases for the SWFEx course.

Item	Manufacturer/Provider
15-passenger van	Enterprise Rent-A-Car
USBConnect 881 (now outdated) and service contract	AT&T
Microtalk FRS two-way radios	Cobra
Cellular amplifier	Wilson Electronics, Inc.
Maestro 4000 portable GPS	Magellan
PI-400 power inverter	Whistler
Street Atlas USA and state maps	DeLorme

outside the accommodations before regrouping at the hotel for the map discussion. Assign same-gender rooms to each participant on a rotating basis to avoid potential interpersonal conflicts, prevent cliques from organizing, and force students to interact with a variety of others. Fourth, do not rely solely on GPS maps or mapping software when chasing storms, but instead have detailed paper maps on hand for more complete geographical awareness. Note that many maps do not discriminate between paved, gravel, and dirt roads, and may even show a road where none exists. Use caution with road selection as certain types of dirt roads become extremely hazardous under wet conditions, especially for a large 15-passenger van. Fifth, establish a fund that covers a portion of highway tolls and simultaneously reduces the propensity of students to use inappropriate language. Each time a participant slips a foul word during the trip, he or she contributes a dollar to the fund. Contributions to the fund tend to decrease sharply after the first week and personal videos remain clean during stressful weather conditions.

The travel experiences in years 1 and 2 reveal the benefit of fewer participants. Cramming 13 people and their luggage into a fifteen-passenger van for a two-week excursion can lead to disagreements about personal space and seating arrangements and makes viewing storms difficult. In contrast, 10 people in the same van have plenty of room, everybody has a window seat to view storms, and the smaller group in year 2 generally displayed stronger camaraderie between the participants. However, participants benefit financially with more classmates, particularly with the first offering of the course, since everyone shares fuel, hotel, and durable equipment costs. With more participants, a trailer-hitch mounted storage container would likely relieve anxiety and increase comfort for the passengers. A roof-mounted luggage carrier, however, would raise the vehicle's center of gravity sufficiently to increase the risk of a roll-over accident.

Above all, successful execution of the course requires ample flexibility on the part of all participants. While the professor scheduled several tours and speakers in advance, many of the speaking engagements and tour arrangements crystallized on short notice. Additionally, casual conversations and encounters with colleagues at the NWC led to several fruitful enrichment activities. During fair weather, visits to other attractions can offer students a glimpse into local history and culture (Table III).

ASSESSMENT RESULTS

When asked in formal course evaluations if students found the daily journal and case study useful as learning tools, every student replied positively. Students write that reviewing the material helps them to gain a better understanding of atmospheric processes, helps them remember events and add thoughtful insight, and allows them to combine theoretical knowledge and first-hand experience into a written product. The case study provides excellent research experience, since similar studies often appear in refereed journals in the atmospheric sciences.

The information offered by the students in responses to the same questions asked both before and after the course in year 2, along with the course evaluations from both years, gives some insight into the overall experience from the students' perspectives. The survey provides an opportunity for each student to elaborate on his or her understanding of important concepts in atmospheric science, forecasting tools, plans for graduate school and career aspirations, and perceptions of research. This assessment gauges the effectiveness of the course in meeting its goals of science instruction and professional development.

While some questions simply gauge a basic understanding of thunderstorms (e.g., "What is an updraft?" and "Describe mammatus.") and career choices (i.e., "Can you have a full-time job as a storm chaser?"), the key assessment questions on the survey appear in Table IV. These questions measure any change in each student's perceptions of career opportunities in the atmospheric sciences and ability to identify important convective forecast parameters. The questions specifically target the knowledge and perceptions that the course aims to influence during the trip.

TABLE III: Attractions visited in year 1 (2008) and year 2 (2009) while waiting for severe weather.

Attractions	Year 1	Year 2
Bricktown, Oklahoma City, OK	✓	✓
Gateway Arch, St. Louis, MO	✓	
Greensburg, KS	✓	
Hackberry Wind Farm, Albany, TX		✓
KDFX NEXRAD WSR-88D, Del Rio, TX		✓
Oklahoma City National Memorial, Oklahoma City, OK	✓	✓
Oklahoma National Stockyards, Oklahoma City, OK	✓	
Oklahoma State Capitol Building, Oklahoma City, OK		✓
Pops Restaurant and Soda Ranch, Arcadia, OK	✓	✓
Round Barn, Route 66, Arcadia, OK	✓	
The Alamo, San Antonio, TX		✓
Twister (The Movie) Museum, Wakita, OK	✓	
Wichita Mountains Wildlife Refuge, southwest OK	✓	✓

TABLE IV: Survey questions asked of the students both before departure and upon return in year 2. Ratings use a scale of 1–10, where 1 is "not a chance" and 10 is "definitely will."

Survey Questions	
1.	Please rate the likelihood that you will pursue a career in meteorology.
2.	Please rate the likelihood that you will pursue a career in any scientific field that involves research.
3.	Please rate the likelihood that you will pursue a career in meteorological research.
4.	Please rate the likelihood that you will pursue a career in broadcast meteorology.
5.	Please rate the likelihood that you will pursue a career in private sector meteorology.
6.	Please rate the likelihood that you will pursue a career in academia.
7.	Describe your career aspirations.
8.	What types of meteorological research are you currently aware of? A brief list will suffice.
9.	List several important parameters or weather maps that would be useful for forecasting severe weather.

Most students provided a very general list of forecast parameters in the initial responses to item 9 on the survey (see Table IV), but nearly everyone listed a considerably more thorough and much more detailed array of forecast products and observations useful for forecasting severe weather in the second response (not shown). This clearly indicates that the course met the goal of teaching students how to locate and use available forecast tools. Students also generally produced a more complete list of current meteorological research topics in the second response to the survey. Students learned of these additional research activities, including opportunities for summer undergraduate research experiences, through several lectures and casual conversations during the trip.

Table V summarizes the responses of the seven traditional undergraduate students in year 2, both before and after the trip, regarding each individual's likelihood of following a particular career path in meteorology. After returning from the trip, all students indicated that they will definitely pursue a career in meteorology. This likelihood changed from the initial response only for student #4 (Olivia, profiled below). For some, participation in the SWFEx course appears to have reinforced particular career aspirations. Conversely, it appeared certain before the trip that student #2 would pursue a career in the private sector. After visiting a private sector firm, this student completely reversed course and appears headed for a research or broadcast meteorology career. Missing from the list of specific career options in the survey, unfortunately, is a career in operational meteorology, though many students classified this goal as "meteorological research."

One student writes in a separate course evaluation that the experience "opened my eyes up to fields and sectors in meteorology that I didn't even know existed." Another student writes, "I realized a lot on this trip…my interests in meteorology extend well beyond severe weather." A third respondent indicates in the course evaluation that the "private sector is definitely not for me…operational forecasting is my calling."

The SWFEx course clearly influenced how several participants view their futures in meteorology. The following selected responses highlight the impact of the course on the education and future career paths of two particular students, with pseudonyms substituted for real names to protect confidentiality.

Olivia participated in the course as an underclassman intending to major in atmospheric science. Prior to the trip, Olivia writes that she has been confused lately about her career aspirations. In her journal, Olivia shares an epiphany after listening to presentations from Dr. Doswell and Ms. Jones: "I always saw myself as average and mediocre, but I can be better than that. I am ready to take ownership of my life and education and I am ready to take on new and harder challenges. I have never felt so excited and capable of being successful." After the trip, Olivia shares an enthusiastic description detailing why she wants to work in the private sector. The course has met the goal of providing Olivia with potential career options and her renewed passion for the science of meteorology will carry into her future coursework and beyond.

Ethan had already graduated from UNCA with a Bachelor of Science degree in atmospheric sciences before

TABLE V: Responses from the seven traditional undergraduate students to items 1–6 listed in Table IV both before departure ("Dep") and upon return ("Ret") in year 2. The asterisk indicates unfamiliarity with the term "academia."

	Student 1		Student 2		Student 3		Student 4		Student 5		Student 6		Student 7	
Career Type	Dep	Ret	Dep	Ret	Dep	Ret	Dep	Ret	Dep	Ret	Dep	Ret	Dep	Ret
1. Meteorology	10	10	10	10	10	10	8	10	10	10	10	10	10	10
2. Any Research	3	7	10	9	10	10	8	6	10	10	5	4	7	5
3. Meteorological Research	3	7	10	10	10	10	6	7	10	10	5	4	7	4
4. Broadcast	2	6	5	8	3	2	6	3	5	4	8	9	1	1
5. Private Sector	9	10	10	1	3	3	8	9	7	7	8	5	3	3
6. Academia	3	4	2	1	5	9	*	6	8	7	3	4	6	6

departing for the class trip. He has no employment prospects, but his list of career aspirations falls generally within the realm of private sector meteorology. When asked if his participation in the course changed how he views his future in meteorology, he responds "absolutely," and that the course drove him to pursue graduate school: "I hadn't really been considering [graduate school]. Now I'm setting up meetings and seeking out funding to make it happen." Keeping his options open, he also applied for a position in a private sector firm immediately after returning to Asheville. He writes, "I am totally motivated to get my career going." Ethan's comments further demonstrate that the course has met one of its major objectives, in particular the goal to expose the students to a variety of career possibilities and professional-development opportunities.

CONCLUDING REMARKS

The SWFEx class brings undergraduate atmospheric science majors to Tornado Alley to observe severe weather firsthand. While the allure of chasing storms may initially prompt the students to enroll in the course, the focused career-development aspect of the curriculum gives participants a deeper understanding of the varied career options in the atmospheric sciences and where their own capabilities and interests might best suit the discipline. Participants learn about severe weather forecasting, enhance writing skills, gain exposure to professional meteorologists, and explore a wide variety of career options through lectures, discussions, and tours. By completing the journal and case study, students reflect on their experiences throughout the course and integrate previous concepts to draw new conclusions through an analysis of a severe weather event. Through an end-of-course survey and evaluation, students share how the course has had a profound impact on their education and future in meteorology. The nearly constant accessibility of atmospheric science professors, especially during long rides in a van, provides a unique opportunity for the participants to ask questions and establish meaningful professional relationships.

After completing the course, participants often express a reinvigorated interest in the field of meteorology and in other atmospheric science courses. Students gain a more complete understanding of atmospheric processes while viewing the evolution of a thunderstorm after having learned the theoretical underpinnings in the classroom. Even if a student has yet to complete upper-level coursework, such as thermodynamics, the field experience provides a foundation for connecting theory covered in future courses with their own observations of the relevant processes.

The class traveled 5762 miles in year 1 and 5198 miles in year 2 in pursuit of ideal severe weather conditions, averaging over 365 miles per day for 30 days over two years. For safety, the navigator often relieved the primary driver over extremely long stretches of travel. In year 1, the group departed from North Carolina and traveled through Tennessee and Arkansas to visit professional meteorologists and intercept storms in Oklahoma, Texas, Kansas, Nebraska, and Colorado, returning through Missouri, Illinois, Kentucky, and Tennessee. Participants observed two tornadoes during an outbreak in Kansas. The class in year 2 again traveled to Oklahoma for the professional-development portion of the course and then spent a significant amount of time chasing marginal severe weather throughout Texas. At the end of the trip, the group passed through Arkansas, Tennessee, and Kentucky to observe severe thunderstorms in Illinois and Indiana before returning home.

Overall, the SWFEx course successfully accomplishes the goals outlined above by integrating hands-on exposure to severe weather with professional development. Students learn how to select a target area for convection initiation, interact with peers in a stressful environment, and discover the complicated logistics of chasing severe thunderstorms. Students also hone their writing skills through the daily journal and case study. Participants make valuable professional contacts through interactions with prominent meteorologists at eminent institutions in an innovative and unique variation on a traditional field course. Despite selling itself as a "storm chasing" class, the SWFEx course offers students a comprehensive career-development experience woven within a thrilling adventure.

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