Field and Stream: Initial Testing of a Live-Streamed, Storm-Chase Course in Meteorology

P. Grady Dixon\textsuperscript{a}, Joshua D. Durkee\textsuperscript{b}, Jonathan Oglesby\textsuperscript{b}, Olivia Cahill\textsuperscript{c}, and Mary K. Wright\textsuperscript{d}

\textsuperscript{a}Werth College of Science, Technology, and Mathematics, Fort Hays State University, Hays, Kansas, pgdixon@fhsu.edu

\textsuperscript{b}Department of Earth, Environmental, and Atmospheric Sciences, Western Kentucky University, Bowling Green, Kentucky

\textsuperscript{c}Department of Geography, University of Georgia, Athens, Georgia

\textsuperscript{d}School of Geographical Sciences and Urban Planning, Arizona State University, Tempe, Arizona

Contact

P. Grady Dixon, Werth College of Science, Technology, and Mathematics, Fort Hays State University, 600 Park St, Hays, Kansas, 67601, pgdixon@fhsu.edu

Many STEM disciplines rely on experiential or applied-learning courses, camps, workshops, etc. to recruit and engage students. Field-based experiences are particularly important for those disciplines focused on readily observable earth features and processes. Studies by Tanamachi et al. in 2020, Milrad and Herbster in 2017, and Barrett and Woods in 2012 all show that undergraduate students gain a deeper understanding of scientific principles through field experiences. Unfortunately, field courses present significant barriers to participation for people who have job or family obligations, financial constraints, and need access to physical, learning, or other accommodations, as well as LGBTQ+ students with concerns about sleeping

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arrangements. Recent news and articles on field safety in the geosciences have highlighted the dangers facing students of minoritized identities related to race, ethnicity, sexual orientation, gender identity, religious affiliation, and disability. At-risk individuals report experiencing refused service, slurs and harassment, sexual and other assaults, and having the police called on them. This is leading to discussions in the scientific community and strategies to protect people of marginalized identities in the field.

In recent years, the authors have discussed the feasibility of offering a live-streamed storm-chase course. The initial reaction of many colleagues was rather negative. Concerns included the lack of physically experiencing sensible weather, such as in-person views of storms, sounds of the wind and thunder, sharp changes in humidity and temperature, and smells such as petrichor. There was also the question of having reliable data/internet connections in remote locations of the Great Plains.

The spring of 2020 offered an unusual opportunity to test our five-day streaming storm-chasing course after other university field trips were canceled and most on-campus courses transitioned to online formats. By late May, many states were beginning to “reopen” after the initial isolation caused by COVID-19. We determined that it was possible to conduct an abbreviated storm-chase trip with only instructors in the field and by planning for self-service or online purchases of fuel, food, and lodging.

Instructors Dixon and Durkee recruited three students with no previous storm-chase experience to participate in the course, including two female undergraduate STEM majors and a male
graduate student. Although none of the students reported disabilities, two confirmed that they would not have been able to participate in a traditional in-person storm-chase course even in a non-pandemic year.

Two primary concerns emerged that had the potential to negatively impact the quality of the course:

1. What would students do when we inevitably lost our data connection?
2. How would we be sure students could view the storm processes while the instructors were driving, navigating, and analyzing radar data?

Both issues required help from additional people. To address the first issue, we enlisted the help of four former students, including two female graduate students, who had participated in a combined total of 14 storm-chase courses. This group agreed to attend streaming sessions to provide support to the new students. If the instructors’ video feed were to be interrupted, the former students would lead conversations about live radar and the processes likely being observed in the field. As the storm situation evolved, the experienced students could help the new students adjust their expectations of what to see on the streaming video once the feed reconnected. Despite observing storms in very rural areas, including eastern Wyoming and northwestern Nebraska, the video feed (connected via wireless “hotspots” from two different providers) was never lost during a chase for more than 10 consecutive minutes.

The second challenge of providing the visual field experience for the online students was managed by employing an experienced technician to be responsible for in-transit video and connecting with the online group via text messaging throughout the day. The technician and the
two instructors shared one vehicle and the instructors shared duties at all stages of the course. When on the road, one instructor (usually Dixon) focused on navigation, radar-data analysis, and explanations to students of ongoing processes, while the other (usually Durkee) focused entirely on driving.

The university summer term began on 1 June 2020, and students taking the course completed online learning modules (e.g. lectures, demonstrations, assignments) and quizzes prior to the five-day field component (5–9 June 2020). After the virtual storm-chasing experience, students also completed a project applying their newly learned skills and understanding to a case study based on a storm that we observed coupled with hypothetical social impacts.

Each chase day began with a morning briefing where the instructors led a weather discussion and the group decided upon possible severe-storm locations, best strategies, expectations, and plans to reconvene later in the day. The instructors hosted the discussion due to a lack of appropriate experience among the new students, but future versions of this course will certainly incorporate student-led discussions. During the discussions, the instructors were typically in a hotel and the students were all in their respective homes or offices. The instructors then traveled toward the day’s forecast target before a second briefing in the early afternoon (1900-2000 UTC). The second briefing involved updates on the evolving forecast based on satellite imagery, surface observations, radar trends, and visual observations. This meeting concluded by agreeing on an approximate time for the third meeting, which indicated the beginning of the active chase period after the instructors were within view of a severe or potentially severe thunderstorm.
Once engaged on a storm, the instructors streamed from four or five devices to share various visual perspectives as well as their location on mapping software and any digital data (e.g., radar, atmospheric profiles, satellite imagery, etc.) supportive of understanding the situation. Chases lasted one to four hours. All discussions and chases were recorded and students had access to these recordings.

The same learning outcomes were in place for the virtual experience of this course as for the in-person experience, being able to:

1. Analyze radar data during severe weather
2. Apply pattern-recognition to visual observations of storms
3. Understand the types of severe thunderstorms and their various accompanying threats
4. Analyze basic, large-scale (i.e., synoptic) weather patterns for severe-thunderstorm and tornado potential
5. Evaluate safety measures during imminent severe weather

One of the storm-chase course’s greatest contributions to student growth and education, according to a decade of informal student feedback, has been related to the emotional investment in each day’s forecast. Students tend to spend more time on details, be more open to differing opinions, feel more comfortable sharing their insights, and display more “ownership” of the forecast generated by the “fear of missing out” on memorable, photogenic severe thunderstorms that many students will not get the opportunity to observe after the course ends.
As instructors, we felt confident that we could convey concepts such as forecasting strategies, severe-storm environment concepts, and the logistical considerations of storm chasing via an online format. Those learning outcomes could likely be accomplished without the emotional investment of being in the field; however, a remote storm-chase experience was seen as likely to diminish the impact and learning due to a lack of emotional investment, and therefore would be the most challenging aspect to overcome in a virtual storm-chasing course (Table 1). Student feedback suggests that this project successfully created a similar emotional investment for online and in-person experiences (Table 2).

We consider our course to be a success for multiple reasons. The group observed severe thunderstorms on all five days, and they documented phenomena usually anticipated in conventional storm-chase courses, including funnel clouds, shelf clouds, wall clouds, and wind shifts caused by the rear-flank downdraft of a supercell. They also experienced less-common events like 75-mph winds, close-range “power flashes” caused by wind-blown debris, and multiple “gustnadoes” caused by thunderstorm outflow winds.

In post-course surveys, all participants agreed the overall course and the weather discussions, specifically, were more valuable than in a traditional, non-field classroom setting (Table 2). All participants also agreed their emotional investment in each day’s forecast was greater than it would have been in a conventional classroom, and five of the seven considered their investment to be at least equal to an in-person field course. No components of the course were rated as being less valuable than a traditional classroom-based course. Open-ended comments suggest students believed that the course was better than a conventional storm chase because it allowed
participation from those who cannot travel, it was much more affordable, all students had “front row” access to instructors, and review of recorded discussions helped with understanding.

We think this project provides compelling evidence of the efficacy of streamed field courses in atmospheric science, and we plan to continue refining our methods in future years. Initial concerns about effective communication, video quality, and learning objectives were overcome, but the combined effort required more intense, continuous contributions by the instructors. There was little time to “enjoy the moment” as it took vigilance to ensure representative videos and explanations were being delivered to the students. By itself, an accessible field course is not going to solve the problems of underrepresentation in atmospheric sciences, but virtual courses can remove barriers for some. In our course, students who normally would not have been able to participate in an in-person storm-chasing course were able to join in. As technology improves, we expect the quality of these courses to do the same, so we must be prepared to take advantage of those advances. This is the first step.
Table 1: Responses (columns) to pre-trip survey questions (rows). Six participants completed the survey.

<table>
<thead>
<tr>
<th>Before beginning this course, my general expectations of the course can be characterized as:</th>
<th>As good/strong or better/stronger than a conventional field</th>
<th>Not as good/strong as a conventional field course, but more engaging and experiential than a lecture/classroom</th>
<th>Somewhat valuable, but no better than a lecture/classroom</th>
<th>Of little or no value</th>
</tr>
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<tbody>
<tr>
<td>2 4 0 0</td>
<td></td>
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<tr>
<td>Regarding the daily weather-forecast discussions, I expect the experience to be:</td>
<td>3 3 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regarding the identification of storm/cloud features and processes, I expect the experience to be:</td>
<td>1 4 1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regarding my personal investment (i.e., desire, hope, wish, etc.) in the occurrence/formation of severe thunderstorms in the locations predicted by the students and instructors in the course, I expect it to be:</td>
<td>3 2 1 0</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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Table 2: Responses (columns) to post-trip survey questions (rows). Seven participants completed the survey.

<table>
<thead>
<tr>
<th></th>
<th>As good/strong or better/stronger than a conventional field</th>
<th>Not as good/strong as a conventional field course, but more engaging and experiential than a lecture/classroom</th>
<th>Somewhat valuable, but no better than a lecture/classroom</th>
<th>Of little or no value</th>
</tr>
</thead>
<tbody>
<tr>
<td>After completing this course, my overall opinion of the course can be characterized as:</td>
<td>2 5 0 0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Regarding the daily weather-forecast discussions, I found the experience to be:</td>
<td>4 3 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regarding the identification of storm/cloud features and processes, I found the experience to be:</td>
<td>2 3 2 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regarding my personal investment (i.e., desire, hope, wish, etc.) in the occurrence/formation of severe thunderstorms in the locations predicted by the students and instructors in the course, I found it to be:</td>
<td>5 2 0 0</td>
<td></td>
<td></td>
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</tbody>
</table>
Figure 1: Photo of an instructor’s computer screen showing current radar of a severe thunderstorm near Crawford, Nebraska on 5 June 2020, video being streamed by other instructors, and student accounts on the streaming platform. Note that the view of the instructor, who is in the passenger seat, is mirrored.
Figure 2: Photo of an instructor’s mobile phone streaming a severe thunderstorm in Rock County, Nebraska on 8 June 2020.