Enlightenment Strikes!
Broadening Graduate School Training through Field Campaign Participation

Kristen L. Rasmussen, Melissa A. Burt, Angela Rowe, Rebecca Haacker, Deanna Hence, Lorena Medina Luna, Stephen W. Nesbitt, and Julie Maertens

ABSTRACT: This article provides an overview of the Advanced Study Institute: Field Studies of Convection in Argentina (ASI-FSCA) program, a 3-week dynamic and collaborative hands-on experience that allowed 16 highly motivated and diverse graduate students from the United States to participate in the 2018–19 Remote Sensing of Electrification, Lightning, and Mesoscale/Microscale Processes with Adaptive Ground Observations (RELAMPAGO) field campaign. This program is unique as it represents the first effort to integrate an intensive Advanced Study Institute with a field campaign in atmospheric science. ASI-FSCA activities and successful program outcomes for five key elements are described: 1) intensive field research with field campaign instrumentation platforms; 2) recruitment of diverse graduate students who would not otherwise have opportunities to participate in intensive field research; 3) tailored curriculum focused on scientific understanding of cloud and mesoscale processes and professional/academic development topics; 4) outreach to local K–12 schools and the general public; and 5) building a collaborative international research network to promote weather and climate research. These five elements served to increase motivation and improve confidence and self-efficacy of students to participate in scientific research and field work with goals of increasing retention and a sense of belonging in STEM graduate programs and advancing the careers of students from underrepresented groups as evidenced by a formal program evaluation effort. Given the success of the ASI-FSCA program, our team strongly recommends considering this model for expanding the opportunities for a broader and more diverse student community to participate in dynamic and intensive field work in atmospheric science.

KEYWORDS: South America; Deep convection; Mesoscale systems; Orographic effects; Education; Field experiments

https://doi.org/10.1175/BAMS-D-20-0062.1
Corresponding author: Kristen L. Rasmussen, kristenr@rams.colostate.edu
In final form 2 April 2021
©2021 American Meteorological Society
For information regarding reuse of this content and general copyright information, consult the AMS Copyright Policy.
Many successful scientists in atmospheric science were drawn into this area of study through participation in field campaigns, often when they were students. Atmospheric science has a long history of including both graduate and undergraduate students in field campaigns to provide scientific training, career-broadening, and networking opportunities (Hallett et al. 1990; Stith and Rogers 2004; Rauber 2007; Kristovich et al. 2017). For example, the leaders of the Rain in Cumulus over the Ocean (RICO) field campaign developed a robust educational plan that included having students direct a complete scientific mission for the first time (Rauber et al. 2007). Airborne, ground-based, and ship-based platforms have all been used in educational efforts to include graduate and undergraduate students in field research (Fabry et al. 1995; Hallett et al. 1993; Borys and Wetzel 1997; Wetzel et al. 2003; Rauber et al. 2007; Kristovich et al. 2017).

Building on this tradition, the leadership of the RELAMPAGO (Remote Sensing of Electrification, Lightning, and Mesoscale/Microscale Processes with Adaptive Ground Observations) field campaign (Nesbitt et al. 2021) created a robust and unique plan to include students from diverse backgrounds and institutions in a facilitated Advanced Study Institute (ASI)—the first of its kind associated with a field campaign in atmospheric science. Advanced Study Institutes are funded by the National Science Foundation’s (NSF) International Research Experiences for Students (IRES) program and are short 3-week courses intended to “engage advanced graduate students in active learning and research at the frontiers of knowledge” www.nsf.gov/funding/pgm_summ.jsp?pims_id=505656). The RELAMPAGO field campaign was conducted from 1 November to 15 December 2018 in west central Argentina and, to date, has been the largest land-based international field campaign conducted in atmospheric science (Nesbitt et al. 2021). This region arguably has among the most intense convective systems in the world with respect to the frequency of large hail, high storm tops, and extreme lightning activity (Zipser et al. 2006; Houze et al. 2015; Rasmussen et al. 2014; Rasmussen and Houze 2011, 2016), yet the processes that give rise to such extremes are unclear because of a scarcity of observations. Given the critical role of clouds in Earth’s climate system in determining a large proportion of water and energy budgets (Allen and Ingram 2002), a greater understanding of cloud and mesoscale processes in remote regions of the globe is important for understanding the global distribution and impacts of convective storms (Zipser et al. 2006; Houze et al. 2015).

Although some opportunities for undergraduate and graduate student participation in field research are sometimes available [e.g., the Saharan Dust Aerosols and Ocean Science Expeditions (AEROSE) program1], major international field campaigns of this type do not happen often and are typically only accessible to student advisees of the campaign Principal Investigators (PIs). It is often the case that students from institutions that do not typically conduct field work [e.g., smaller atmospheric science programs or minority-serving institutions (MSIs)], or those doing computational or theoretical research projects, may not have the opportunity to participate in a major field campaign in an international setting. When students are given the opportunity for hands-on research through laboratory or field activities, many students excel and rapidly expand their interest in research (Dahlberg et al. 2008), regardless of their background. The International Institute of Education’s (2009) report, “Promoting study abroad

---

1 http://ncas.howard.edu/research-programs/aerose/
in science and technology fields,” says “curricular innovation, international collaborative research, development of dual/joint-degree programs across borders and distance learning will all be needed to provide students with an international perspective and to produce globally competent professionals.” Given the significant benefits of participating in international field work, including networking and career-advancement opportunities, the primary goals of the Advanced Study Institute: Field Studies of Convection in Argentina (ASI-FSCA) program were to provide a dynamic and highly collaborative international research experience for 16 diverse and motivated graduate students to promote career advancement through professional development activities, participate in intensive field research, improve scientific understanding of cloud and mesoscale processes of the atmosphere, and interact with the local community and K–12 students to communicate the science of RELAMPAGO. In addition, these elements serve to increase motivation and improve self-confidence of students to participate in scientific research and field work with goals of increasing retention in STEM graduate programs and advancing the careers of students from underrepresented groups.

**ASI-FSCA overview**

With support from the NSF International Research Experiences for Students (IRES) program, the ASI-FSCA program provided an opportunity for 16 graduate students from diverse backgrounds and a wide variety of institutions to participate in the RELAMPAGO field campaign in Argentina for 21 days in November 2018 (Fig. 1). The ASI-FSCA program was coordinated by U.S.-based atmospheric scientists involved in RELAMPAGO (Table 1). The ASI-FSCA program provided a dynamic and highly collaborative international research experience by focusing on five key elements: (i) intensive field research with active field campaign instrumentation platforms under the guidance of the instrument PIs; (ii) recruitment of diverse graduate students, including those from underrepresented groups in the geosciences, first generation, and from MSIs, who would not otherwise have opportunities to participate in intensive field research; (iii) tailored curriculum focused on scientific understanding of cloud and mesoscale processes of the atmosphere and professional/academic development topics; (iv) outreach to the local K–12 schools and organized cultural activities; and (v) building a collaborative international research network between the United States, Argentina, and Brazil to promote weather and climate research.

One of the primary goals of the ASI-FSCA program was to recruit diverse graduate students, including students from smaller atmospheric science programs and MSIs, including Hispanic-serving institutions.

![Fig. 1. ASI-FSCA students and leadership pictured (a) in front of the Doppler-on-Wheels radar (31 Oct 2018, Cordoba, Argentina) and (b) visiting the DOE G-1 aircraft as part of the CACTI field campaign (15 Nov 2018, Rio Cuarto, Argentina). Photo credits: Kristen Rasmussen.](image-url)
(HSIs) and historically Black colleges and universities (HBCUs), who would potentially not have opportunities to participate in intensive field research through their home institutions. We also aimed to build a cohort with other diversity metrics, including gender, historically

<table>
<thead>
<tr>
<th>Name</th>
<th>Role in ASI</th>
<th>University/research laboratory</th>
<th>Research specialties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rachel Albrecht</td>
<td>International collaborator</td>
<td>Univ. São Paulo, Brazil</td>
<td>Atmospheric electrification</td>
</tr>
<tr>
<td>Eldo Avila</td>
<td>International collaborator</td>
<td>National Univ. of Cordoba, Argentina</td>
<td>Mesoscale meteorology, electrification</td>
</tr>
<tr>
<td>Michael Bell</td>
<td>Fall Workshop Lecturer</td>
<td>Colorado State Univ.</td>
<td>Radar and tropical meteorology</td>
</tr>
<tr>
<td>Howie Bluestein</td>
<td>Lecturer</td>
<td>Univ. of Oklahoma</td>
<td>Severe storms, radar observations</td>
</tr>
<tr>
<td>Melissa Burt</td>
<td>ASI-FSCA Assistant Director, Lecturer, Fall Workshop organizer and lecturer, Mentor</td>
<td>Colorado State Univ.</td>
<td>Climate modeling, diversity in STEM</td>
</tr>
<tr>
<td>Larry Carey</td>
<td>Lecturer, Lightning team leader, Mentor</td>
<td>Univ. of Alabama</td>
<td>Atmospheric electrification</td>
</tr>
<tr>
<td>Chris Davis</td>
<td>Lecturer, Mentor</td>
<td>NCAR/Mesoscale and Microscale Meteorology Laboratory</td>
<td>Mesoscale meteorology, tropical cyclones</td>
</tr>
<tr>
<td>Wiebke Deierling</td>
<td>Lightning team leader, Mentor</td>
<td>NCAR/CU Boulder</td>
<td>Atmospheric electrification</td>
</tr>
<tr>
<td>Francina Dominguez</td>
<td>Lecturer, Hydrometeorology team leader, Mentor</td>
<td>Univ. of Illinois</td>
<td>Hydrometeorology</td>
</tr>
<tr>
<td>Brody Fuchs</td>
<td>Mentor</td>
<td>Colorado State Univ.</td>
<td>Radar meteorology</td>
</tr>
<tr>
<td>Rebecca Haacker</td>
<td>Recruiting Coordinator, Lecturer, Mentor</td>
<td>NCAR/ASP/SAORS</td>
<td>Professional development and outreach</td>
</tr>
<tr>
<td>Deanna Hence</td>
<td>Professional Development Coordinator, Lecturer, Mentor</td>
<td>Univ. of Illinois</td>
<td>Tropical convection; Mesoscale analysis</td>
</tr>
<tr>
<td>Karen Kosiba</td>
<td>Mentor, Mesonet and DOW team leader</td>
<td>Center for Severe Weather Research</td>
<td>Severe weather; radar observations</td>
</tr>
<tr>
<td>Matthew Kumjian</td>
<td>Lecturer</td>
<td>Penn State Univ.</td>
<td>Radar observations, severe weather</td>
</tr>
<tr>
<td>Lorena Medina Luna</td>
<td>Mentor, Outreach organization, Fall Workshop Lecturer</td>
<td>NCAR Education and Outreach</td>
<td>Professional development and outreach</td>
</tr>
<tr>
<td>Luiz Machado</td>
<td>Lecturer, International collaborator</td>
<td>National Institute for Space Research (INPE), Brazil</td>
<td>Convective processes, modeling</td>
</tr>
<tr>
<td>Stephen Nesbitt</td>
<td>Lecturer, Radar and sounding team leader, Mentor</td>
<td>Univ. of Illinois</td>
<td>Satellite and radar obs.; severe storms</td>
</tr>
<tr>
<td>Kristen Rasmussen</td>
<td>ASI-FSCA Director, Lecturer, Radar team leader, Fall Workshop organizer and lecturer, Mentor</td>
<td>Colorado State Univ.</td>
<td>Cloud and mesoscale processes; severe storms; radar meteorology</td>
</tr>
<tr>
<td>Angela Rowe</td>
<td>Field Experience Coordinator, Lecturer, Radar team leader, Mentor</td>
<td>Univ. of Wisconsin–Madison</td>
<td>Radar observations, cloud and mesoscale processes</td>
</tr>
<tr>
<td>Paola Salio</td>
<td>International collaborator, pre-ASI-FSCA lecturer</td>
<td>Univ. of Buenos Aires</td>
<td>Mesoscale systems; severe storms</td>
</tr>
<tr>
<td>Russ Schumacher</td>
<td>Mentor, Sounding team leader</td>
<td>Colorado State Univ.</td>
<td>Mesoscale meteorology; heavy precipitation</td>
</tr>
<tr>
<td>Jeff Trapp</td>
<td>Lecturer, Sounding team leader, Mentor</td>
<td>Univ. of Illinois</td>
<td>Severe weather; mesoscale meteorology</td>
</tr>
<tr>
<td>Adam Varble</td>
<td>Mentor, CACTI team leader</td>
<td>Univ. of Utah</td>
<td>Convection and modeling</td>
</tr>
<tr>
<td>Josh Wurman</td>
<td>Mentor, DOW/COW team leader</td>
<td>Center for Severe Weather Research</td>
<td>Severe weather; radar observations</td>
</tr>
</tbody>
</table>
underrepresented groups in the geosciences, first generation, and a broad representation of institutions. A partnership with the National Center for Atmospheric Research’s (NCAR) Advanced Study Program (ASP), in collaboration with the Significant Opportunities in Atmospheric Research and Science (SOARS) Program, helped recruit graduate students from diverse backgrounds. Both programs have a history of success in recruiting and mentoring diverse students, graduate visitors, and postdoctoral fellows. NCAR-ASP led the recruitment efforts by advertising the opportunity on the ASP website, via social media, with professional societies such as the American Meteorological Society (AMS) and the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), through the ASP and SOARS Program alumni networks (many include faculty at smaller colleges and MSIs), and through UCAR member organizations.

Recruiting through these extensive networks provided a set of student applications from a wide range of backgrounds. However, out of 46 applications, we only received three applications from students at HSIs and no applications from students at HBCUs, despite advertising at several HBCU institutions. The remainder of the students who applied to the program were from well-established programs in atmospheric science of varying sizes. With that being said, many ASI-FSCA students of color attend larger predominantly White institutions (PWIs). The experience as a student of color or from another historically underrepresented group can be challenging at large PWIs. Although we did not have as many students who were from MSIs as hoped, recruiting diverse students from PWI schools can provide them with a sense of community and belonging, and in addition access to other opportunities that they may not have had otherwise.

Students submitted applications to the program and included 1) information on prior participation in field campaign opportunities, 2) a personal statement on what they hoped to gain from the ASI and field experience, 3) what it would mean to them to participate in an international field school and campaign, 4) how their participation in the ASI would help with their graduate school journey and career aspirations, and 5) preferences for instrumentation platform placements. The ASI-FSCA leadership team and one outside member (total of six people) participated in a two-part review process to select applications. Evaluation criteria for the selection of students included a priority for students with no prior field campaign experience to maximize the impact of the program, representation of schools (including MSIs, HSIs, and HBCUs), demographics, and a balance of instrument platform preferences. The first round consisted of a process where each application was reviewed by a minimum of four evaluators based on the criteria mentioned above. Dr. Rasmussen evaluated all of the applications to ensure consistency in the selection process. Once the first round was completed, the second round of evaluations was conducted as a phone call in which all reviewers were present. The committee discussed how each student would fit into the overall ASI objectives and used the evaluation criteria described previously to meet our diversity goals from the applications we received. The demographics of the 16 graduate student participants selected for the ASI-FSCA program included attracting students from historically underrepresented groups in STEM (50% female, 13% LGBTQ, 25% Hispanic/Latino, 38% first-generation students, 7% American Indian/Alaska Native, and 7% African American), from 13 different institutions, including three MSIs highlighted in italics (Colorado State University, Columbia University, Louisiana State University, Massachusetts Institute of Technology, Montana State University, The Pennsylvania State University, San Jose State, University at Albany, University of California, Santa Barbara, University of Kansas, University of Oklahoma, The University of Texas at El Paso, University of Wisconsin–Madison), and 50% M.S. and 50% Ph.D. students.

In preparation for the field campaign, students participated in four workshops to build their scientific and cultural knowledge prior to traveling to Argentina. Topics of the workshops included 1) The Science of RELAMPAGO (10 September 2018), 2) Instrumentation Overview (24 September 2018); 3) Professional Development (8 October 2018), and 4)
Cultural Overview (22 October 2018). These four lectures served as important and necessary preparation for the scientific and cultural aspects of the international RELAMPAGO field campaign. In addition, students were provided with a Spanish language summary document of commonly used phrases prior to their departure for Argentina to assist with in-country communication.

Once the students arrived in Córdoba, Argentina, at the start of the RELAMPAGO campaign, the intensive and immersive ASI-FSCA program included coordinated educational and scientific activities with RELAMPAGO instrument facilities, as well as those from the Department of Energy (DOE) Clouds, Aerosols, and Complex Terrain Interactions Complementary Field Campaign (CACTI; Varble et al. 2021). This wide variety of activities included instrument training sessions, scientific seminars/lectures, professional development activities, direct integration with the field campaign observational teams, a field trip to visit the DOE G-1 aircraft (Fig. 1b), and cultural exchange opportunities with local K–12 students. A summary of the scientific and professional development lectures given during the ASI-FSCA program is provided in Table 2. At the start of the program, the students participated in facilitated team-building sessions with an external expert (www.yarbgroup.com) and the RELAMPAGO Code of Conduct and Sexual Harassment training session led by RELAMPAGO leadership (Fischer et al. 2021). During the project, the students attended all RELAMPAGO campaign forecast briefings that occurred daily at 0900 and 1700 local time. In addition to the planned activities, networking with the instrument teams and RELAMPAGO scientists was an opportunity for the students in building their professional networks. To synthesize their field experience, the students gave a short 5-min presentation at the end of the program on the observations they collected and any insights into the science of RELAMPAGO gained during their immersive time in the field.

The program culminated with an ASI-FSCA Fall Workshop 1 year after the field campaign in October 2019 in Boulder, Colorado. Fourteen of the 16 students who participated in the field campaign were able to attend the workshop. The workshop focused on professional development activities, research discussions, and career-oriented panels that were not possible in the short 3-week intensive program in Argentina (Table 3).

**ASI-FSCA objectives**
The ASI-FSCA program was the first NSF-IRES-funded Advanced Study Institute conducted in concert with a major international field campaign in atmospheric science. A robust curriculum and syllabus (available at https://rasmussen.atmos.colostate.edu/asi/) were developed to

**Table 2. ASI-FSCA seminars and professional development activities during RELAMPAGO.**

<table>
<thead>
<tr>
<th>Speaker(s)</th>
<th>Lecture topic(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kristen Rasmussen</td>
<td>Global perspectives on convection; RELAMPAGO science overview</td>
</tr>
<tr>
<td>Melissa Burt and Rebecca Haacker</td>
<td>Professional Development Series: Stress management and culture shock, Building a supportive network and finding mentors, How to bring this experience to your curriculum vitae</td>
</tr>
<tr>
<td>Jeff Trapp</td>
<td>Convective storms</td>
</tr>
<tr>
<td>Francina Dominguez</td>
<td>Hydrometeorology of the La Plata Basin</td>
</tr>
<tr>
<td>Larry Carey and Brody Fuchs</td>
<td>Lightning science; Lightning instrumentation</td>
</tr>
<tr>
<td>Matthew Kumjian</td>
<td>Hail science</td>
</tr>
<tr>
<td>Chris Davis</td>
<td>Mesoscale convective systems; Mesoscale meteorology</td>
</tr>
<tr>
<td>Deanna Hence</td>
<td>Communicating your science</td>
</tr>
<tr>
<td>Howie Bluestein</td>
<td>Convective storms and tornadoes; Low-level jets</td>
</tr>
<tr>
<td>Stephen Nesbitt</td>
<td>RELAMPAGO radar applications</td>
</tr>
</tbody>
</table>
ensure positive and meaningful outcomes for all student participants. The primary objectives of the ASI-FSCA were as follows:

1) Recruit a diverse set of graduate students who would not otherwise have opportunities to participate in intensive international field research.
2) Teach students how to observe the atmosphere through operation of a variety of state-of-the-art instruments and conduct successful field research to collect high-quality data during the RELAMPAGO field campaign.
3) Provide active learning experiences on how multiplatform field campaigns are conducted in terms of understanding the complex communications and decision-making from experienced PIs such that this group can become future leaders in this field.
4) Professional networking with top scientists in atmospheric science that can provide future employment and collaboration opportunities.
5) Increase students’ knowledge of cloud physics, mesoscale dynamics, convective weather forecasting, and mountain meteorology.
6) Guide students to complete a student-led project during the ASI that may include observations from their field experience instrument platform.
7) Enhance the students’ professional and academic development.
8) Build a collaborative international network of young scientists between the United States, Argentina, and Brazil to promote weather and climate research.
9) Increase student motivation and self-confidence in scientific research and field work.
10) Increase retention in STEM graduate programs and further the careers of underrepresented student groups.

These objectives were developed to enhance the students’ scientific identity and self-confidence (Carlone and Johnson 2007; Cooper et al. 2019), encourage persistence through graduate school and in STEM careers (Trott et al. 2020), and provide deeper insight into the research process associated with field campaigns (Trott et al. 2020) as has been found for long-term student outcomes for undergraduate students participating in coordinated research opportunities (e.g., Research Experiences for Undergraduates programs).

**RELAMPAGO field campaign**
The NSF-sponsored RELAMPAGO field campaign was conducted from 1 November to 15 December 2018 in west central Argentina in the general vicinity of the Sierras de Córdoba and the Andes foothills (Nesbitt et al. 2021). RELAMPAGO, leveraging the repeatability of...
storms in the region, aimed to address science questions related to the pre-initiation to
initiation, initial organization/severe-weather generation, and growth/backbuilding stages
of storm development, all of which are poorly understood. New insights into connections
between the extreme hydroclimate, high-impact weather, and atmospheric dynamical
processes in meteorological and geographical settings unique to this region were obtained
by bringing together NSF facilities with 1) new operational dual-polarization radars in
Argentina; 2) significant contributions from Argentina, Brazil, Chile, NOAA, and NASA;
and 3) a major, complementary U.S. DOE field campaign (CACTI). For more details on the
RELAMPAGO field campaign, see Nesbitt et al. (2021), and for more details on CACTI, see
Varble et al. (2021).

From beginner to expert: Collecting and analyzing observations during RELAMPAGO
A primary component of the ASI-FSCA educational and research experience (ASI-FSCA pro-
gram goals 2 and 3) included each student being placed with an observational platform or
the international forecasting team involved in RELAMPAGO. Students were placed with the
following instrument platforms: radars [Colorado State University’s C-band radar;
Center for Severe Weather Research’s Doppler-on-Wheels X-band (Fig. 3b) and
C-band-on-Wheels (COW) radars], mesonet/sounding teams (mobile teams launching
weather balloons and collecting in situ weather observations; Fig. 2), lightning
team (Lightning Mapping Array observations; Lang et al. 2020; Fig. 3d), hydrome-
terology team (acoustic Doppler current profiler; Fig. 3a), and real-time data anal-
ysis and interpretation in the RELAMPAGO Operations Center (Fig. 3c). The students
were assigned to an instrument platform or forecasting team based on their previously
stated preferences and helped conduct RELAMPAGO operations. Due to the length
of the program and training required for each platform, each student was placed
with one platform. However, if time permitted the students to work with more than one
observational platform, this activity was encouraged to broaden their experiences. These
experiences provided an opportunity for the students to work with diverse and international
teams that exemplifies that productive and innovative science benefits from diverse teams
(McLeod et al. 1996) and generally met the ASI-FSCA goals 2, 3, 4, 5, 7, 8, and 9.

Learning from the scientists: ASI-FSCA scientific seminar series
One advantage of hosting the ASI-FSCA program alongside the RELAMPAGO field cam-
paign was the unique opportunity to interact with and learn from a wide range of scien-
tific experts (Table 1). To achieve the ASI-FSCA program objectives (ASI-FSCA goals 2,
4, and 5), a seminar series with 12 in-field lectures was organized and took place during
the 3-week ASI-FSCA program in Argentina (Table 2). While a schedule was created for
the 3-week program, flexibility was critical, as the formation of severe storms sometimes
meant scientists and students needed to rapidly deploy on field missions and thus the lec-
tures were rescheduled. The lecture topics included a general introduction to the science

![Fig. 2. ASI-FSCA students (a) Jeremiah Piersante and Scott Purdy and (b) Elisa Murillo launch atmospheric soundings (weather balloons) as part of the RELAMPAGO field campaign. Photo credits: (a) Scott Purdy and (b) Brandi Gamelin.](image)
of RELAMPAGO and continued with more specific topics such as mesoscale convective systems, lightning, low-level jets, radar meteorology, and hydrometeorology. Scientists incorporated RELAMPAGO-related themes into most of the presentations and the PowerPoint slides were made available to the students after the ASI-FSCA program through a shared Google Drive folder and at the following ASI-FSCA website: https://rasmussen.atmos.colostate.edu/asi/index.php.

Learning from the experts: Professional development

Experts on scientific education, outreach, and career development formed an intentional and major part of the ASI-FSCA leadership team (Table 1). Access to and availability of professional development and career-enhancing training is not the same for all students across institutions in the United States. A key component of the ASI-FSCA program was to integrate a variety of professional development lectures and activities into the curriculum to meet our program objectives (Fig. 4; ASI-FSCA goals 4, 6, 7, 9, 10). The lectures began with a student-requested session on stress management and culture shock, and continued with discussions on building a supportive network and finding mentors, how to represent the ASI-FSCA experience on your curriculum vitae/resume, and science communication (Table 2). In response to feedback from the students, the ASI-FSCA Fall 2019 Workshop was organized to provide enhanced professional development opportunities and career perspectives for the students (Table 3). Professional development lectures during the workshop focused on scientific writing and
communication, how to think like a scientist, time management skills, finding and applying for academic/research jobs, work–life balance, and mentor mapping and beyond, as well as networking opportunities. In addition, two career panels were organized that focused on 1) postdoctoral researchers and 2) careers in atmospheric science that included a wide range of scientists from the public, private, and government sectors.

**Cultural immersion and science outreach**

As the first international travel experience for several of the ASI-FSCA students, the program in Argentina provided students with cultural broadening and opportunities for professional networking and outreach to K–12 students in the local community. RELAMPAGO student participants from Argentina and Brazil were invited to all ASI-FSCA lectures and outreach events to facilitate networking and cross-cultural discussions among the students (estimated at ~25 additional participants). ASI-FSCA leadership created bilingual brochures and handouts that provided an overview about the field campaign and general atmospheric science topics (i.e., hail, tornadoes, thunderstorms). These materials were widely distributed by RELAMPAGO students and scientists when conducting field work, at outreach events, and to the local community who often inquired about instruments operating on roadsides during operations.

ASI-FSCA students interacted with the local community, experienced cultural activities in Villa Carlos Paz, Argentina, and were active participants in the K–12 outreach activities organized by RELAMPAGO leadership (ASI-FSCA goals 7–10). As is described in Nesbitt et al. (2021), the RELAMPAGO outreach program included a media day and open house for K–12 students to explore various RELAMPAGO instruments (Fig. 5a) prior to the start of the field campaign, and four K–12 outreach events at local schools (Fig. 5b) organized by Prof. Carlos Marcelo Garcia of the University of Cordoba. It is estimated that a total of 2,000 K–12 students were reached by the RELAMPAGO outreach.
Finally, the ASI-FSCA program partnered with the NCAR Explorer Series program, which was created in 2016. The goals of the program are to share science conducted at NCAR and partnering institutions, to inspire, inform, and engage the public in society-relevant research and studies of atmospheric and related scientific phenomena. The NCAR Explorer Series consists of monthly lectures, expert panels, and short science videos that have attracted hundreds of attendees at in-person and virtual events, and have received several thousand views on YouTube. A total of eight 3-min videos were filmed during the RELAMPAGO field campaign. These videos highlight the science of RELAMPAGO, the science and engineering challenges of field work, and feature the scientists, engineers, technicians, and students who participated and led different components of the field campaign, with interviews in both English and Spanish (http://bit.ly/NCAR_ExplorerSeries_FieldCampaigns_RELAMPAGO). In addition, a short video profiled the ASI-FSCA program (http://bit.ly/RELAMPAGO-ASI-Program), including interviews with student participants and the leadership team.

**Student experiences**
The ASI student objectives were as follows:

1. Enhance basic knowledge on cloud and mesoscale processes and mountain meteorology.
2. Participate in a major international field campaign at the frontier of atmospheric research.
3. Operate and collect data from an instrument platform or participate in forecasting during a major field campaign.
4. Develop advanced professional development skills for transitioning to the next stage of their career.

To evaluate the experiences of the ASI-FSCA students, an external evaluator with the Colorado State University STEM Center implemented three surveys that were conducted several weeks before the ASI-FSCA program began, several weeks following the conclusion of the ASI-FSCA program, and 6 months after the conclusion of the program. According to the pre-survey, students sought to participate in the ASI experience with the objectives of gaining hands-on experience in research, meeting other graduate students in their field, and networking with scientists. The students were also hoping to enhance their curriculum vitae and clarify whether they wanted to pursue a science career, but these objectives were less important overall.

At post-survey, students were asked about areas where they felt they experienced the most gain during the ASI-FSCA program. Beyond conducting field research, several areas that students indicated the most gain were in giving oral presentations, explaining their project to others, conducting field observations, and managing time (ASI-FSCA goals 2, 3, 6, 9, 10). It is important for students to develop confidence in, as well as skills for conducting research during their graduate school years (ASI-FSCA goal 9). Students were asked at post-survey about their overall satisfaction with their ASI experience (Table 4). Overall, students were very satisfied, indicating that it was an important and applicable learning environment that will be useful to them in the future. Students were asked about the most and least valuable aspects of their research experience, along with any improvements they would recommend. Students most valued the opportunity to collect data in the field and additionally noted that the ability to work with “big” scientists and engage in professional networking was helpful and beneficial (ASI-FSCA goals 4, 7, 8).

In the survey conducted 6 months following the end of the ASI-FSCA program, students were asked whether they had the opportunity to use any of the information or skills they
Table 4. Students’ general satisfaction with the ASI-FSCA program (post-survey only; \( n = 8 \)).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree (( n ))</th>
<th>Disagree (( n ))</th>
<th>Neither (( n ))</th>
<th>Agree (( n ))</th>
<th>Strongly agree (( n ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Advanced Study Institute (ASI) lived up to my expectations</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>The content of the ASI was relevant to me</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>The ASI activities stimulated my learning</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>The ASI activities gave me sufficient practice and feedback</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>I will be able to use what I learned in this ASI</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>The ASI was a good way for me to learn this content</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

learned during their ASI-FSCA experience. Of all students who answered this question (not just those who had a completed pre- and follow-up survey; \( n = 9 \)), seven agreed that they had used teamwork and networking skills, improved their curriculum vitae, developed proposals or presentations, and applied field work skills. Though students’ confidence levels did not decrease below their baseline level over time, they did not generally maintain post-program levels 6 months later. This suggests that “booster” training or supplemental information updates to promote additional learning and/or skills may be helpful for maintaining confidence gains. At follow-up, students mentioned that a bigger focus on writing skills and job application information may be helpful for similar future programs.

A recent study explored the long-term academic and career impacts of hands-on undergraduate research experiences (Trott et al. 2020). Their study showed that 4–7 years after the research experience, students described key long-term impacts of their undergraduate research experiences in three categories: 1) research/science, 2) graduate school, and 3) careers. The combination of mentors and other significant relationships formed during these experiences and increased self-confidence and self-awareness of career aspirations either retained or gained significance over time (Trott et al. 2020). Participants in our program were graduate students, but similar long-term impacts may be expected based on our curriculum of hands-on field research, networking with scientists of RELAMPAGO, mentoring from the ASI-FSCA leadership team and instrument mentors, professional development exercises designed to help students find their science identity, and career discussions at the Fall 2019 Workshop. Our leadership team organized informal meet-ups at the AMS Annual Meetings in 2019 and 2020, and we will continue this activity in future in-person conferences. In addition, the student participants’ professional networks were expanded through participation in the ASI-FSCA program, including working with international and U.S. scientists in the field and through the Earth Science Women’s Network meet-ups at the AMS Annual Meetings. Further connections on social media (i.e., Facebook, Twitter) has enabled continued cohort interactions that will likely persist well into the future.
Lessons learned

The ASI-FSCA program consisted of a variety of programmatic and hands-on field experiences for 16 graduate student participants and was successful with strategic and collaborative efforts from experts at various institutions in the United States, Argentina, and Brazil. Through active surveys, mentoring, and final project presentations, we were also able to assess the success of the program in providing students with an experience that they would not have otherwise been able to participate in. They only had a few recommendations for improvement, including adding a few lecture topics of interest, splitting up the lecture time, and allowing more time for presentation of final projects. More specifically, the students requested that more professional development topics be covered, including career-related topics like job applications and interviewing. This request was the primary motivation for the 2019 Fall Workshop, where we were able to spend a considerable amount of time on specific professional development topics requested by the students in the survey responses (Table 4).

Although we broadly advertised the ASI-FSCA program to UCAR Member Organizations, the NCAR ASP and UCAR SOARS alumni networks, professional societies, and via social
media, we only received three applications from HSIs and HBCUs combined out of 46. Based on previous recruiting experiences, we hoped to get a pool of applications from a diverse set of institutions. Although we generally met our program’s diversity goals (ASI-FSCA goal 1), one recommendation for future programs of this type in the atmospheric sciences is to individually reach out to the leadership of more MSIs and smaller colleges with relevant programs to encourage their students to apply for opportunities of this type. In addition, intentional recruiting should be carefully considered using established resources like the “Diversifying Study Abroad and Expanding Equity for MSI Students”2 published by the Center for MSIs at The University of Pennsylvania.

Given the success of the ASI-FSCA program, our team strongly recommends this model for expanding the opportunities for a broader and more diverse student community to participate in dynamic and intensive field work in atmospheric science. The student outcomes and lessons learned in the field are unmatched by typical classroom activities as mentioned by several students. One of the most notable achievements we can make to the advancement of science is to inspire the next generation of scientists in atmospheric science. Field campaigns provide unique hands-on and dynamic environments that allow for the students to understand the value of observations and models, learn how science is conducted, and develop new questions about the world around them. As the first ASI organized in collaboration with a major field campaign in atmospheric science, the ASI-FSCA program provides a model for future programs that can potentially improve access to a broader demographic of students to the unique environments in field campaigns. The benefits of participating in hands-on field research should also be considered for upper-level undergraduate students in addition to graduate students to reach a broader population of students who may be interested in careers in atmospheric science, but are from smaller programs or colleges. Beyond increasing student exposure to and enthusiasm for atmospheric observations, experiential programs can serve to potentially increase diversity and retention of underrepresented students in atmospheric science through increasing professional networking opportunities and building science identity and confidence.

Acknowledgments. Funding for graduate student participation as part of the ASI-FSCA program during RELAMPAGO was provided by the National Science Foundation International Research Experiences for Students (IRES) Program under grant OISE-1828935. Major funding for RELAMPAGO was provided by the National Science Foundation. Kristen Rasmussen acknowledges support from NSF AGS-1661657 for research and scientific outreach associated with the RELAMPAGO field campaign and NSF HRD-1835055 for supporting the harassment training program for RELAMPAGO. The authors thank the many RELAMPAGO scientists who mentored and trained the graduate students to collect observations and interpret the data.

2 https://cmsi.gse.rutgers.edu/content/diversifying-study-abroad-and-expanding-equity-minority-serving-institution-students
References


