

# INCREASING THE DIVERSITY OF YOUR GRADUATE PROGRAM

## Translating Best Practices into Success

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Through a concerted effort over 10 years, the Department of Atmospheric Science at Colorado State University has quadrupled the number of graduate students from historically underrepresented groups.

Over the last decade, the science community has slowly developed a set of best practices for recruiting and retaining diverse students, which include, among others, an early exposure to research, mentoring, and supportive campus environments (Estrada 2014). Despite this knowledge, the geosciences continue to lack diversity in our workforce and student body. In 2014 only 8.5% of students enrolled in atmospheric science graduate programs were from traditionally underrepresented groups (i.e., African American, Hispanic, and American Indian students; NSF 2015), even though

these groups represent almost one-third of the overall U.S. population (Colby and Ortman 2015). In 2005, the Department of Atmospheric Science at Colorado State University (CSU), which is a graduate-only program, had a minority enrollment of 3.5%, which was lower than the national enrollment statistics of 6.0% (Fig. 1; retrieved from CSU Institutional Research). A year later, the National Science Foundation–funded Science and Technology Center for Multiscale Modeling of Atmospheric Processes (CMMAP) opened its doors at CSU, and with it came a 10-yr plan for broadening participation in the atmospheric science department. As the plan approaches its end, the Department of Atmospheric Science has quadrupled its graduate enrollment by ethnic minorities, boasting a figure around 16%. A key part of this success has been supporting and strengthening faculty commitment to diversity and mentoring.

This commitment was achieved through the development of an inclusive and supportive Research Experience for Undergraduates (REU) program that introduced diverse students to CSU and supported faculty in working with them. The REU served us in a number of ways. First, students conducted cutting-edge science in conjunction with university faculty mentors. Exposure to genuine research experiences has been shown to be a key to engaging minority students (Lopatto 2009) but also has benefits for the

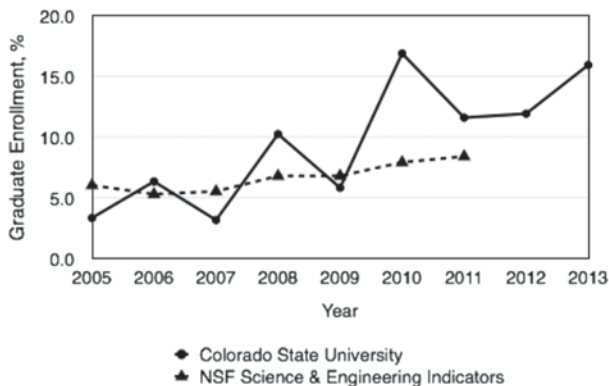
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**FIG. 1. Graduate enrollment in atmospheric science by students from historically underrepresented groups for CSU's Department of Atmospheric Science compared to the NSF Science and Engineering Indicators 2014.**

faculty, through an increase in conference presentations and publications. Second, the REU served to introduce minority students to CSU and build trust relationships between students, CSU faculty, and faculty at their home institutions. Third, the REU served as a training vehicle for creating a culture of mentoring and support, both for the students who took their leadership training, mentoring, and support experiences back to their home institutions, as well as for the faculty mentors. Explicit training in mentoring and diversity, offered to the REU mentors, fed directly into creating a welcoming and inclusive graduate school environment. A key component for the success of this concerted effort was hiring a full-time education and diversity manager who focused on implementing the best practices and strategies and brought forth the department's commitment to diversity.

### EXCELLING AT MEANINGFUL RESEARCH.

Studies show that undergraduates who participate in research and identify as being part of the scientific community gain confidence in their skills and abilities and are more likely to continue and succeed in the field (e.g., PCAST 2012; Laursen et al. 2010; Hancock and Russell 2008). Each year, 10–12 students in our REU, recruited nationally from about 120 applicants, worked on a wide range of cutting-edge research projects in the atmospheric sciences. They presented this work in poster, presentation, and paper formats. In addition to their summer work, 10 interns continued their research throughout the academic year with the support of their mentors, as part of their senior theses, resulting in publications. Three peer-reviewed papers so far have included results from REU summer projects. Seventy students have attended national conferences such as the American Geophysical Union's

(AGU) Fall Meeting or the AMS Annual Meeting to present their findings.

### BUILDING TRUST RELATIONSHIPS.

We have found that a key component of increasing diversity is building a relationship of trust with faculty at minority-serving institutions (MSIs), through long-term, regular contact and research collaborations. The CMMAP education and diversity manager made regular visits to MSIs around the country, met with department faculty and campus leaders, and held many informal conversations with current and prospective students. With these relationships in place, MSI faculty committed to the program and helped to recruit strong applicants, while also providing ongoing support for their students after they participated in a summer research experience at CSU. In addition, we have been active participants at national conferences such as the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) and served on national leadership committees, such as the AMS Board of Women and Minorities. As the CMMAP REU built a reputation for being welcoming to minority students, it attracted applicants from a wide variety of schools, including MSIs and junior and community colleges. Between 2007 and 2014 minority participation averaged 32.5% ( $n = 80$ ), more than 3 times the average for NSF geoscience-funded REUs (Rom et al. 2012). As the literature suggested, our recruitment costs dropped significantly after a critical mass of diverse students was reached and a positive reputation was established (Dalbotten et al. 2014).

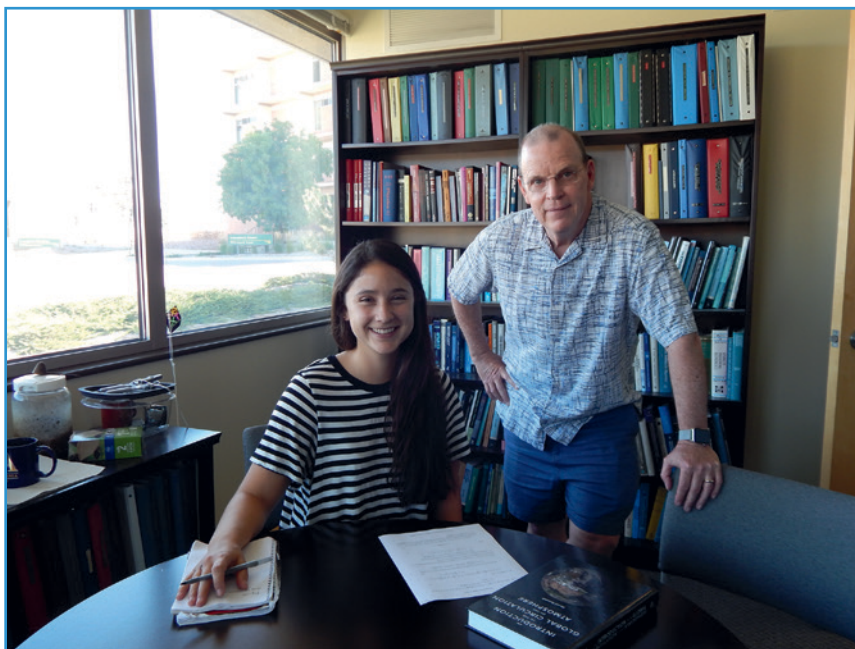
In addition to our own REU, a formal partnership with the Significant Opportunities in Atmospheric Research and Science (SOARS) program has also supported our plan. SOARS is a multiyear internship and mentoring program, based at the National Center for Atmospheric Research, with a mission to broaden participation in the atmospheric and related sciences. SOARS has been running for 20 years and brought immediate connections to the minority community. They have provided ongoing guidance in the development of our diversity strategy. This partnership has worked in both directions, as CMMAP has also invested in SOARS—funding 16 students and their participation in SOARS, identifying students to serve as SOARS mentors, and, since 2006, recruiting seven SOARS protégés into graduate school at CSU. The protégés' extensive leadership and peer mentor training have brought these skills into the graduate program. Several students from the CMMAP REU have also gone on to participate in SOARS, completing the circle.

**FACULTY TRAINING.** Part of building a supportive and welcoming culture at CSU has been faculty and staff personally engaging with students from a wide range of backgrounds. The CMMAP REU and collaboration with the SOARS program have enabled individual connections to be developed between mentors (and administrators) and students from backgrounds that include ethnic minorities, nontraditional students, and students with disabilities. We supported the mentors in this process with formal training on diversity and undergraduate mentoring during which we addressed expectations for mentors, designing an educational and useful project, setting up an intern for success, developing a work plan, and supporting and sponsoring intern career development. To help interns succeed academically and professionally, each intern had a team of three research mentors, including one faculty member, one research scientist or postdoc, and one graduate student. Not only did the mentoring orientation allow us to train both the current faculty, students, and postdocs on diversity issues, but comprehensive, multidimensional mentoring is a key contributor to the continued success of the interns, as it provides the student with a broad sense of support and multiple opportunities to make a meaningful personal connection (Laursen et al. 2010).

This mentoring model was built after the comprehensive SOARS mentoring system (Windham et al. 2004). During the summer, interns met with at least one of their mentors every day to discuss the project, clarify research methods, and troubleshoot code. Frequent meetings and continued contact have also been shown to contribute to continued success (Laursen et al. 2010). So far, 83% (16 of 19) of the Department of Atmospheric Science faculty, as well as 50 professional research scientists, postdocs, and graduate students, have participated as mentors in the program. Mentoring an intern is valued by the department and recognized in annual faculty evaluations, and has created a supportive community of practice for faculty (Fig. 2).

## **PIPELINE INTO GRADUATE SCHOOL.**

Students from traditionally underrepresented backgrounds often experience isolation in their undergraduate studies and may feel unprepared to apply to graduate school. We have found that individualized, continuous mentoring helped overcome these challenges and is one of the most important elements of our strategic plan. At the undergraduate level, within and following the REU and participation in SOARS, students were provided with mentoring in academic and career development. CMMAP instituted leadership training for interns, peer mentoring from more experienced graduate students, seminars, and social activities. Program leads and faculty checked in with students throughout the academic year, connecting with students as they began applying for graduate school, and planned meet-ups at professional conferences and events, such as AMS or AGU meetings. Since the inception of our REU, 20 participants are still in undergraduate programs, and 52 are either in graduate school or have completed a graduate degree, which represents a 75% success rate for students moving on to a graduate degree. Ten of those who chose to get a graduate degree did so at CSU. Once the students joined us for graduate school, we continued to provide



**FIG. 2.** Dr. David A. Randall, professor in the Department of Atmospheric Science, with M.S. student Andrea Jenney, who participated in the REU in 2014 and is now a graduate student at CSU. Faculty members have attested to the benefit of mentoring undergraduate students. Said Randall, “I have never taught an undergraduate class and can hardly remember what it was like for me to be an undergraduate almost 50 years ago. Working with these undergraduates has been a pleasure, and I have probably learned more from them than they have learned from me.”

a welcoming atmosphere as they began their challenging first semester.

**FUNDING LANDSCAPE AND FUTURE WORK.** Funding for CMMAP will end in 2016 and CSU has been preparing by diversifying its support for the education initiatives. The current REU program is funded by the NSF REU Site program and graduate students are supported by university fellowships and National Science Foundation (NSF) Division of Human Resource Development diversity funding opportunities (e.g., Alliances for Graduate Education and the Professoriate, Bridge to the Doctorate programs). We are also partnering directly with faculty to include more students from diverse backgrounds in their research grants. The CSU Department of Atmospheric Science and the College of Engineering have committed resources to help support continued efforts of a diversity manager to sustain the success within the atmospheric sciences and broaden those successful efforts across the College of Engineering. Formal evaluation of the plan to broaden participation was critical for program development, improvement, and ongoing support. The CSU School of Education and STEM Center served as the independent evaluators of the education and diversity programs. The evaluation team assessed demonstrable impacts and achievements both qualitatively and quantitatively. Formative data (at least once per year or as needed) helped adjust program components, and any program changes were documented by the evaluation team to add context to summative evaluation findings. As CMMAP comes to an end, summative data will be reported through a final report and forthcoming publications.

In proving that a concerted effort can indeed increase the diversity in an atmospheric science department, we hope that our findings present a model that can be replicated in other geoscience departments across the nation.

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