EXPOSURE TO ATMOSPHERIC SCIENCE IN COURSES AT MINORITY-SERVING INSTITUTIONS

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Content analyses of courses at 180 minority-serving institutions (MSIs) showed that atmospheric science courses were available at 91% of MSIs, of which half provide opportunities to explore the human dimensions of atmospheric science.

The dearth of ethnic minority students in science, technology, engineering, and mathematics (STEM) has occasioned much discussion about why underrepresented minority (URM) groups are less likely to pursue degrees in these fields (National Academy of Sciences 2011). Although a number of solutions have been proposed and programs implemented over the last several decades, this crisis persists (National Science Foundation 2015). The lack of URMs is particularly acute in atmospheric science relative to other STEM disciplines (Hartten and LeMone 2010; Huntoon and Lane 2007): Of undergraduates who are enrolled in atmospheric science degree programs, fewer than 2% are Black (Czujko et al. 2008) and 5% are Hispanic (Czujko and Nicholson 2010).

This study focuses on one potential “leak” in the STEM pipeline leading to a graduate degree in atmospheric science: whether course offerings at minority-serving institutions (MSIs) provide sufficient opportunities for underrepresented students to become engaged with atmospheric science as a discipline and a career option. Assuming that graduate programs in atmospheric science are better positioned to recruit capable minority students by collaborating with MSIs (National Academy of Sciences 2011), such recruitment efforts may be stymied if MSIs do not offer courses that attract students to atmospheric science. Thus, the present study’s purpose was to examine systematically MSIs’ course offerings in atmospheric science.

Given that a large segment of minority STEM doctorates are earned by individuals who received their undergraduate degree at an MSI, multiple federal...
agencies and professional associations have advocated for closer links between graduate programs in STEM and MSIs as a means to recruit more students of color into science and engineering (e.g., National Academy of Sciences 2011). Specific to geoscience-related fields,1 such initiatives have been developed by the American Meteorological Society (2016), the National Oceanic and Atmospheric Administration (NOAA)’s Educational Partnership Program with Minority Serving Institutions (Robinson et al. 2007), and the National Science Foundation’s Opportunities for Enhancing Diversity in the Geosciences initiative (Hunton and Lane 2007). These collaborative efforts take many forms but often involve field experiences and internships, mentoring, colloquia, and collaborative research (National Academy of Sciences 2011; Robinson et al. 2007; Walter et al. 2007). As well, Williams et al. (2007) proposed the creation of more academic programs in geosciences at MSIs given that only five of them offer a degree related to geoscience (Czujko et al. 2008), two of which are in atmospheric science.

Opportunities to take engaging atmospheric science courses are one component of efforts to forge links between MSIs and graduate programs in atmospheric science. This assertion is based on theory as well as research on turning points in career development. Social cognitive career theory (e.g., Quimby et al. 2007) focuses on the interplay of personal factors, such as academic self-efficacy, and opportunity structures in the environment that shape students’ academic interests and career plans. For instance, if a minority student believes that she is competent in math and science but does not have the opportunity to work in a mentor’s laboratory or take geoscience courses, then her career options in that field are likely diminished. This conclusion is supported by Levine et al.’s (2007) critical incident study, which identified specific aspects of these opportunity structures that either awakened or discouraged minority students’ interest in STEM careers. Among these important factors were course selection, specifically required STEM courses, and examples that were pertinent to the students’ lives.

However, the few extant studies suggest that MSIs provide limited course offerings in atmospheric science. For instance, an earlier perusal of 160 MSIs’ home pages found that 12.5% of historically Black colleges and universities (HBCUs) and 21% of Hispanic-serving institutions offered a weather course (Geer et al. 2004). In response to this lacuna, the American Meteorological Society (2016) developed the AMS Climate Studies introductory course, which to date has been implemented at nearly 70 MSIs. Unknown is whether a single geoscience course is sufficient exposure to attract minority students onto a path leading to a graduate degree in atmospheric science, given that majors in geoscience at MSIs also are rare (O’Connell and Holmes 2011).

In the field of geoscience more generally, the content of courses and method of delivery may be critical determinants of whether minority students are drawn into the field. Introductory courses in geoscience are more likely to attract URMs if the material is engaging (McDaris et al. 2013), especially if the information is relevant to their experiences and goals (Kozoll and Osborne 2004; Levine et al. 2007; Mark et al. 2013). The literature on what matters in the classroom to URMs who choose geoscience for a career points to active, inquiry-based learning (Levine et al. 2007; National Academy of Sciences 2011); attention to community priorities and needs (National Academy of Sciences 2011; Riggs and Alexander 2007; Stokes et al. 2007); and critical discussions of implications for climate change, social justice issues, and policy challenges (Neito Ferreira et al. 2012; Hundebøl and Nielsen 2014; Mark et al. 2013) that contribute more broadly to environmental literacy (Mourad 2012). Some research suggests that placing greater emphasis on environmental literacy may draw URMs into geosciences. For instance, Quimby et al. (2007) found minority students were less concerned than White students about environmental problems and that this variable, as well as anticipated rewards from earning a degree in environmental science, predicted interest in environmental science. Given the assertion that geoscience is more interesting when its relevance to society is emphasized (Hunton and Lane 2007), one focus of the current study was on attention in geoscience courses at MSIs to policy issues or humans’ impact on the environment.

The current study focused on the possibility that URMs do not consider career pathways requiring a graduate degree in atmospheric science because of limited exposure to the discipline in their undergraduate curricula (National Academy of Sciences 2011). In an update and extension of Geer et al.’s (2004) perusal of MSIs’ home pages for weather-related courses, this potential explanation was evaluated by examining the content of atmospheric science courses at minority-serving universities.

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1 Throughout, geosciences refers more broadly to the disciplines included in the National Science Foundation Directorate for Geosciences (2017)—atmospheric and geospace sciences, Earth sciences, and ocean sciences—whereas atmospheric science is used when the focus is on that specific discipline.
METHOD. Sampling of MSIs. To be eligible for inclusion in this sample, a university had to be on the list of Hispanic-serving institutions (HSIs) from the Hispanic Association of Colleges and Universities (2015) or on the list of historically Black colleges and universities (HBCU 2015). Exclusion criteria for both types of institutions included 1) located in the Virgin Islands; 2) had a small enrollment of fewer than 200 students or were narrowly focused (i.e., Bible or technical colleges), making it unlikely that geosciences courses were offered; and 3) duplicate university on both lists. Of 106 HBCUs, 16 were omitted from consideration because of exclusion criteria. The final sample of HBCUs included 90 institutions, 8 of which were 2-yr colleges. The average ethnic composition (undergraduate) of the 90 HBCUs was 84.6% Black (range = 9.5%–100%). Of the 264 HSIs, schools were randomly selected until 90 meeting the selection criteria were in the sample, resulting in \( n = 44 \) colleges with a 2-yr plan and \( n = 46 \) universities with a 4-yr plan. The average ethnic composition of these 90 institutions averaged 47.5% Hispanic (range = 25.2%–94.6%).

Coding of course content. Courses related to atmospheric science were identified initially by means of searching the course catalog on each of the 180 institutions’ websites. Course listings in biology, chemistry, environmental science, geography, geology, physics, and physical science were searched for course titles and descriptions containing the words atmospheric, climate, global environment, and related terms. Courses in environmental engineering and professional meteorology were not included, the former because such courses were rarely found and the latter because weather forecasting does not require a graduate degree, although 16% of broadcast meteorologists hold a graduate degree (Reynolds et al. 2008). If a course catalog or course descriptions could not be found on a website, information about pertinent courses was requested from department chairs of the relevant science departments.

The course title and course description of each identified course were then content coded using directed content analysis (Hsieh and Shannon 2005). This type of content analysis is informed by previous research that identifies key variables, in the present case different disciplines that contribute to geosciences as well as potential applications to policy and teaching. Content analysis in this case is “not an impressionistic, off-the-cuff analysis based on a superficial look at [text]. It is a piece of systematic research conducted with demanding, though not necessarily standardized, procedures” (Taylor and Bogdan 1998, p. 9). Thus, rigorous qualitative research must explicate how themes are identified.

Course titles are listed in Table 1. Up to five content themes were coded for each course description. For instance, a typical Earth sciences course would be coded for global environment or ecology, geology, atmospheric science, and oceanography, if each of these terms or closely related phrases appeared in the course description. In addition, the presence of each of the following themes was coded: 1) human impact or human–environment relationship, 2) policy implications (including “sustainability” or “remediation”), 3) ethics or philosophy, 4) for nonscience majors, and 5) for teacher certification. The first three were coded in order to collect information about the applied orientation of the course; the second two were coded because nonscience majors and students pursuing teacher licensure are less likely to apply to or enroll in graduate programs in atmospheric science (MacPhee and Canetto 2015). Interrater reliability for two independent coders of 20% of the MSIs, across all categories, was high, \( \kappa = 0.92. \)

RESULTS. Presence of atmospheric science courses at MSIs. The first question addressed was how often courses related to atmospheric science were in the curricula at minority-serving institutions. Of the 180 HSIs and HBCUs, 16 had no courses focusing on atmospheric science; 3 of these infused some atmospheric science content across various core courses. Thus, 91.1% of the institutions offered at least one course that included content on atmospheric science, with Hispanic-serving institutions (95.6%) being significantly more likely than HBCUs (86.7%) to offer such courses, \( \chi^2(1, N = 180) = 4.39, \) \( p = 0.032. \)

Of schools that offered at least one course, the 86 HSIs had a total of 399 courses that were content analyzed and the 78 HBCUs provided 240 courses. The number of courses offered differed significantly by level, with 4-yr institutions (\( M = 3.67 \) courses) offering more courses than 2-yr colleges (\( M = 2.28 \) courses), \( F(1, 176) = 7.73, \) \( p = 0.006. \) As well, the HSIs offered more courses than the HBCUs (\( M = 3.82 \) vs \( M = 2.50 \)), \( F(1, 176) = 13.64, \) \( p < 0.0001, \) controlling

\[ 2 \] According to the National Center for Education Statistics, 50% of all HSIs and 9% of all HBCs are 2-yr institutions.
Table 1. Representation of geoscience disciplines in course titles and course descriptions at MSIs.

<table>
<thead>
<tr>
<th>Content code</th>
<th>Title (%)</th>
<th>Description (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth (physical)</td>
<td>23.7</td>
<td>41.6</td>
</tr>
<tr>
<td>Humans and the environment</td>
<td>16.1</td>
<td>——</td>
</tr>
<tr>
<td>Geography (physical)</td>
<td>13.6</td>
<td>14.0</td>
</tr>
<tr>
<td>Oceanography</td>
<td>9.7</td>
<td>25.0</td>
</tr>
<tr>
<td>Atmospheric science</td>
<td>18.0</td>
<td>69.2</td>
</tr>
<tr>
<td>Geology (environmental)</td>
<td>5.5</td>
<td>23.8</td>
</tr>
<tr>
<td>Chemistry (environmental)</td>
<td>4.8</td>
<td>13.4</td>
</tr>
<tr>
<td>Physics (atmospheric)</td>
<td>0.8</td>
<td>6.7</td>
</tr>
<tr>
<td>Marine biology</td>
<td>5.6</td>
<td>——</td>
</tr>
<tr>
<td>Natural disasters (catastrophes)</td>
<td>2.2</td>
<td>——</td>
</tr>
</tbody>
</table>

* Content codes refer to discipline or topic; terms in parentheses refer to either a more specific course in that discipline, as in atmospheric physics, or a synonym. Title column provides the frequency with which the content code (discipline or topic) appeared in the course title. Description column provides the frequency with which the content code appeared in the course description. The frequencies for description sum to more than 100% because multiple topics could be content coded for each course. Here \( N = 639 \) courses at 164 MSIs.

* Content code includes titles and course descriptions that mentioned atmosphere, meteorology, or climate.

for level of institution. The most common course title that included content related to atmospheric science was Earth science; another introductory course, humans and the environment, also appeared frequently in the various curricula (see Table 1). Courses specific to atmospheric science, including meteorology, represented 18% of the 639 courses in the sample.

Next, course descriptions were examined in relation to how often atmospheric science content was incorporated. The second data column of Table 1 reports the frequency with which different atmospheric science disciplines or content areas were mentioned in the course descriptions. Given the criteria for inclusion in the sample of courses, it is not surprising that atmospheric science, including “climate” and “meteorology,” is the most common theme. The data also show that although relatively few courses focus exclusively on atmospheric science, as indicated by the course title, atmospheric science, meteorology, and climate change are addressed in other courses, especially Earth science.

Courses that might entice graduate study. Given that students at MSIs have multiple opportunities to be exposed to course content on atmospheric science, might that information prompt them to apply to graduate programs in atmospheric science? This question was addressed in two ways. First, underrepresented students are more likely to pursue STEM careers that are socially meaningful. To this end, course descriptions were coded for whether humans’ impact on the environment was mentioned, or whether policy implications were a focus. Human–environment relationships were addressed in 44.9% of the courses; policy implications, including sustainability and remediation, were a theme in 11.4% of the courses. Four-year institutions were significantly more likely than 2-yr colleges to address i) humans’ impact on the environment (47.3% vs 37.4%), \( \chi^2(1, N = 164) = 4.66, p = 0.033 \); and ii) policy issues (13.8% vs 3.9%), \( \chi^2(1, N = 164) = 11.45, p < 0.0001 \). Overall, nearly half (45.4%) of the atmospheric science courses at minority-serving institutions also were socially relevant.

Second, how many atmospheric science courses are offered to ethnic minority students who are most likely to apply to graduate school in atmospheric science? Such courses are apt to be offered to students i) at 4-yr institutions who are ii) science majors (7.6% of courses were limited to nonscience majors) and iii) not seeking a teaching credential (4.4% of courses were related to teacher certification). When courses were selected using these three criteria, there were 434 courses at 34 HSIs (23.3% had atmospheric science or meteorology in the course title) and 72 HBCUs (18.3% had atmospheric science or meteorology in the course title). Of the courses that included atmospheric science in the title or description, 50.7% also addressed humans’ impact on the environment. Thus, multiple opportunities are available at minority-serving institutions to attract students into graduate programs in atmospheric science.

**DISCUSSION.** One remedy proposed to the underrepresentation of minority students in atmospheric science is greater collaboration between graduate programs in atmospheric science and minority-serving institutions (National Academy of Sciences 2011). This solution presupposes that MSIs offer sufficient opportunities for their students to take courses that stimulate interest in atmospheric science as a discipline and a career option (Levine et al. 2007). Earlier research indicated that such opportunities were limited (Geer et al. 2004), which prompted the current examination of MSIs’ course offerings. Based on a sample of 180 MSIs, it was found that nearly all MSIs offered at least one course emphasizing atmospheric science and that the curricula of 4-yr institutions included on average nearly four such...
courses. These numbers are likely an underestimate given that courses in broadcast meteorology were excluded. The typical course related to atmospheric science or climate change was Earth science, with many additional courses focused on humans and the environment. Thus, based solely on the widespread availability of course offerings at MSIs, it does not appear that restricted exposure to atmospheric science at the undergraduate level accounts for the chronic limited presence of URMs in atmospheric science graduate programs.

The content of geoscience courses also may be important to attracting minority students into the field (McDaris et al. 2013), especially if the material is pertinent to their experiences and goals (e.g., Kozoll and Osborne 2004). Atmospheric science may be particularly attractive to URMs if courses attend to implications for climate change and policy challenges (Neito Ferreira et al. 2012; Mark et al. 2013). Such critical discussions also may promote environmental literacy and interdisciplinarity because climate change is complex, both as a scientific problem and a social issue (McCright et al. 2013). Given this assertion, the current study also focused on the extent to which atmospheric science course descriptions at MSIs mentioned policy issues or human’s impact on the environment. Half of the courses related to atmospheric science incorporated some content on human–environment relationships and 11.4% mentioned policy implications, suggesting that MSIs do provide opportunities to explore the human dimensions of atmospheric science. Yet it remains to be seen how accessible are such courses, how many students enroll in them, and how engaging they are perceived to be.

The mere presence of atmospheric science courses at MSIs, however, does not signify how well they are taught. As McDaris et al. (2013) observed, underrepresented minorities are more likely to gravitate to the geosciences when courses are engaging and collaborative, with individual attention from instructors. For this reason, they recommend that the department’s best instructors be assigned to introductory geoscience courses. More generally, undergraduates often struggle to discern the connection between theory and practice, in part because they prefer to progress from concrete experience to theoretical insights. Thus, Roebber (2005) suggested that introductory courses in atmospheric science may best be taught through an experiential and problem-solving lens, which may be at odds with faculty members’ preference to begin with theory and defer applications until later in the curriculum. Additional research is needed to determine how well atmospheric science courses at MSIs and other universities incorporate strategies that appeal to underrepresented students in atmospheric science (National Academy of Sciences 2011).

The presence of several geoscience courses at MSIs also does not indicate that undergraduates in such courses have completed the prerequisites for graduate programs in atmospheric science. One limitation of the current study is that the curricula at MSIs were not examined to determine whether an adequate number of courses in mathematics, physics, computer sciences, and so forth are offered, nor do we know of the enrollment in such courses. An additional limitation is that course catalog descriptions may not be veridical with instructors’ syllabi or method of delivery, such that students may be exposed to different, more engaging content depending on the particular instructor (e.g., Levine et al. 2007).

Social cognitive career theory reminds us that multiple factors play a role in shaping career development, one of them being opportunities to take courses that kindle passion for a field (Quimby et al. 2007). On this one criterion, it appears that such opportunities are in place at most MSIs that may entice students into atmospheric science. However, many other personal characteristics and experiences also shape underrepresented minorities’ interest in STEM more broadly and the geosciences specifically, including academic self-efficacy, outcome expectations, performance in key courses, role models, and perceived supports and barriers (Levine et al. 2007; National Academy of Sciences 2011; Quimby et al. 2007). Given that attracting underrepresented minorities to atmospheric science involves a convergence of manifold skills and opportunities, more comprehensive efforts than a single introductory course (American Meteorological Society 2016) will likely be required to capitalize on partnerships with MSIs.

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