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# Making Sense of the Atmospheric Science Gender Gap: Do Female and Male Graduate Students Have Different Career Motives, Goals, and Challenges?

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## ABSTRACT

There is a persisting gap in the participation of women in atmospheric science (ATS), particularly at the higher levels of ATS education and occupations. This gap raises questions about ATS women's career motives, plans, and challenges relative to men's. To explore these questions, in-depth interviews were conducted with 10 female and male ATS graduate students. Both women and men described their ATS choice as the result of random events—though both also mentioned memories of childhood severe weather experiences, as well as interest and confidence in math and science, as critical milestones in their path to ATS. Both women and men also commented on the impact of hands-on, ATS-related research, including field experiences as well as the positive influence of models and mentors on their ATS educational choice and persistence. However, for women, experiences with mentors included instances of neglectful and undermining behavior. Women and men also differed with regard to career goals, with women emphasizing service and social impact, and men emphasizing employability. Finally, women and men anticipated different career obstacles, with women focusing on family, and men focusing on financial responsibilities. The findings of this study suggest that ATS women and men may have similar early motives for ATS career choice but different experiences once they enter ATS. ATS women and men may also differ in terms of career goals and perceived obstacles. Many themes surrounding ATS women's experiences in this study are similar to themes that have emerged in studies of women in other science, technology, engineering, and mathematics (STEM) disciplines. At the same time, this study also generated information and questions specific to the ATS experience, affirming the importance of examining STEM women's issues by discipline.  [DOI: 10.5408/12-296.1]

*Key words:* women, men, atmospheric science, education, career, motives, goals, challenges

## INTRODUCTION

In the United States (U.S.) in the 1960s and 1970s, the field of atmospheric science (ATS) was male dominated. At the time, there were very few (median = 5%) women earning ATS undergraduate degrees, and even fewer (median = 3%) women among ATS doctorate earners (National Science Foundation [NSF], 2008).

Since then, there has been major growth in women's participation in ATS education. Starting in 1998, the percentage of women earning ATS undergraduate degrees has been at least 23%, with a peak of 36% in 2008 (NSF, 2012a). Women started earning at least 25% of ATS doctorates in 2002, with a peak representation of 38% in 2007, but a decline to 20% in 2008 (NSF, 2012b) (see Fig. 1).

At the same time, women's participation in ATS remains limited in many important ways. For example, ATS has the widest gap in the geosciences with regard to undergraduate-degree (Charlevoix, 2010; NSF, 2012a) and doctoral-degree (NSF, 2012b) completion by women, relative to men. Of the women with ATS doctorates, only a small proportion enters academia, and even fewer women progress to senior academic ranks (Winkler et al., 1996; Tucker et al., 2009). In addition, the percentage of women in ATS occupations lags behind the percentage of women completing degrees in the discipline (Gonzales, 2010). Data from the NSF Scientists and Engineers Statistical Data System (SESTAT) indicate that in 2006, women represented only 15% of ATS/space scientists, with oceanographers recording the highest percentage (28%) of women in geosciences occupations (see Fig. 2).

These data raise questions about what may motivate women, as compared to men, to choose ATS as a field of study, and also what the career plans of ATS-educated women may be relative to ATS-educated men. It may be that women enter ATS studies for different reasons and with different career expectations than men, with possible consequences for recruitment and retention in the field.

There has been substantial research on factors that motivate women and men to choose, and to persist in, a variety of science, technology, engineering, and mathematics (STEM) disciplines (e.g., Sax, 1994, 2001; American Association of University Women [AAUW], 2010; Bernstein, 2011). By contrast, few studies have explored women's and men's choice of, and retention in ATS, and in the geosciences in general. Three of these studies (i.e., Sax, 1994; Charlevoix, 2010; Hartten and LeMone, 2010) simply reported on the demographic characteristics of ATS students. The study by Charlevoix (2010) also examined whether ATS students intended to stay in the major, and found that women were slightly more likely than men to consider changing majors. So far only one study has explored how geoscientists choose their career (Levine et al., 2007). The limitation of Levine and colleagues'

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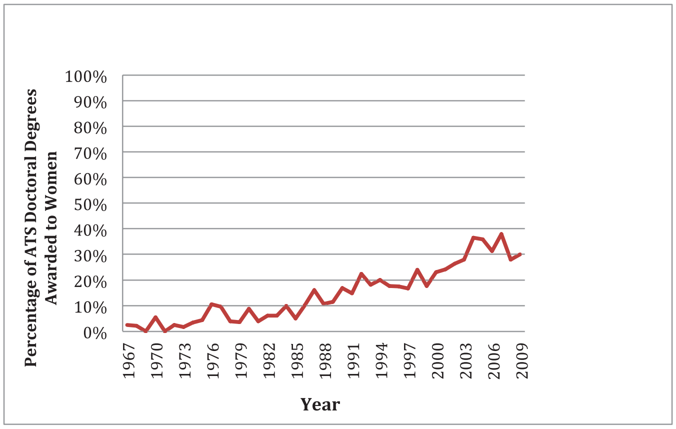


**FIGURE 1:** Percent of ATS doctoral degrees awarded to women, 1967–2009. Sources: Data from the National Science Foundation, Division of Science Resources Statistics: Table 7–2: Science and engineering doctoral degrees awarded to women, by field: 2001–09 (NSF, 2012b), and Table 30: Science and engineering degrees: 1966–2006 (NSF, 2008).

qualitative study is that it was retrospective; its sample ($N = 14$; 6 women and 8 men) consisting almost exclusively ($n = 12$) of senior scientists (11 of whom were principal investigators with the Opportunities for Enhancing Diversity in the Geosciences [OEDG] program), and only two (graduate) geosciences students. The main finding of Levine and colleagues' study was that entry into a geoscience career was facilitated by positive educational experiences (such as having a mentor) and resources (such as fiscal abilities), as is the case for other STEM disciplines, as well as by factors unique to the geosciences, such as love for the outdoors and having taken geoscience field trips during college. It is unknown whether female and male geoscientists in this study offered different explanations for their choice of a geoscience career because the responses of women and men were not examined separately. Finally, one study retrospectively examined the problems women faced while pursuing graduate studies in the geosciences in Canada and in the U.S.—its main sample being female geoscientists who were associated with universities and government and/or who were members of the Association for Women Geoscientists (Larocque, 1995). In a short summary of the study, the author reported that lack of confidence was the most common problem reported by female geoscientists, with 63% of respondents remembering it as an issue in graduate school. Passive neglect (e.g., lack of encouragement by male advisors and faculty) and active discrimination/harassment (e.g., sexual harassment by faculty and male peers) were the second (47% of the sample) and the third (45% of the sample) most common problems experienced during graduate school by female respondents. Forty-five percent of female participants also stated that graduate studies had a negative impact on their relationships and family life, while 31% remembered being concerned about job prospects, with 12% recalling having felt that job opportunities were particularly discouraging for women. The findings of the survey by Larocque echo those of a survey by Simpson (1974) of 275 female meteorologists (including 30 master's degree students and 35 doctoral students). In Simpson's 1970s survey, married female students reported the most serious "sex-related problems" (p. 127) (for example, "finding employment in the same location as their husbands" [p. 129] and/or finding childcare), while single female students did not describe "severe sex-related" difficulties (p. 127). By contrast, sex-related problems and discrimination were noted by the majority (73%) of surveyed female professional meteorologists—several of these professionals being "the outwardly most productive and successful women" in the field (p. 129). A weakness of both Larocque's and Simpson's studies is that their data are limited in scope and informally presented, and, by now, also dated.

In conclusion, there is still a significant gap in ATS degree completion by women, compared to men, relative to other geosciences, especially at the doctoral level. Even in

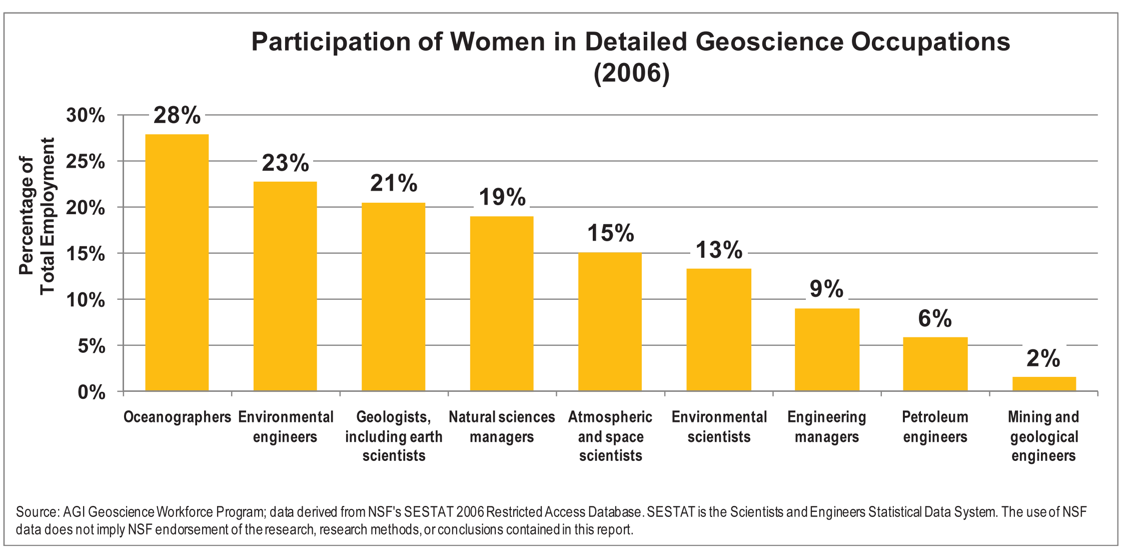


**FIGURE 2:** Women in geoscience occupations, 2006. Source: Figure reprinted with permission. L. Gonzales (2010), Participation of Women in Geoscience Occupations, American Geological Institute Geoscience Currents, v. 33, p. 1.

the past decade (2000–2009) women earned only about 29% of ATS doctorates (NSF, 2012b). In addition, the percentage of women in ATS (15% ATS/space scientists combined in 2006) occupations lags behind the percentage of women completing degrees in the discipline (Gonzales, 2010). The factors involved in the persisting gender gap in ATS educational and career choice and retention are unclear. Considering the scarcity of women among ATS doctorate holders and academic faculty, the lack of studies of ATS female graduate students is striking. Research on ATS graduate students is critical to understand and address the ATS gender gap because a graduate degree is the passport for a career as a scientist and leader in the field (Bernstein, 2011).

This study was designed to explore how female and male ATS graduate students explain their choice to pursue ATS studies. This study also sought to explore ATS female and male graduate students' career plans as well as their perceptions of career challenges. Given the limited research in this area, and consistent with the method choice of the only other study of geoscience career choice (Levine et al., 2007), in this study we focused on a carefully selected, small sample, we conducted interviews as the primary data collection modality, and we used qualitative methods for data analyses.

# METHOD

## Participants

Ten (6 female, 4 male) students from a large (over 30,000 students) research-university ATS graduate program in the western region of the United States were interviewed for this study. Half ($n = 5$) were master's level, and the other half ($n = 5$) were doctoral-level students. The participants' undergraduate majors, including double majors, were ATS/meteorology ($n = 6$), mathematics ($n = 4$), and physics/astrophysics ($n = 4$). Participants ranged in age from 22 to 32 y ($M_{age} = 25$ for women; $M_{age} = 26$ for men). Eight described themselves as European American, and the other two were U.S. ethnic minorities who are underrepresented in STEM. Four of the female students reported being in a committed heterosexual relationship (two via marriage). None of the female students had children of their own. Among the male students, three were in a committed heterosexual relationship (one via marriage), and one had children. The participants for this study were chosen to represent a diversity of career plans: four (2 female, 2 male) expressed an interest in an academic career, four (2 female, 2 male) in a research career, and two (both female) in a consulting career. This study did not include men interested in a consulting career because none of the male graduate students recruited for participation expressed such an interest.

## Procedure

Potential respondents were recruited via electronic mail invitation and via peer and faculty referrals. Upon consenting for participation, respondents were mailed and completed a questionnaire about their personal and educational background and about their career plans. Semistructured interviews were conducted in person by psychology researchers. Respondents were given a small compensation for their participation in the study. The study's procedures were approved by the institutional review board of the university where data collection took place.

## Instruments

### *Written Survey*

The written survey gathered information about respondents' demographic characteristics, including their age, ethnicity, nationality, relationship status, and number of children. The survey also included questions about respondents' educational milestones and career plans.

### *Interview Questions*

Three main interview questions were the focus of the current study: (1) "What led you to where you are now in your educational and career path?" (2) "What are your education and career plans and goals?" (3) "What are the biggest challenges to achieving these goals?" Follow-up questions were used to clarify and explore the respondents' answers.

## Data Analyses

Interviews were audio-recorded, transcribed verbatim, edited for accuracy, and coded by a team of psychology researchers. The coding team included one undergraduate student, two graduate students, one postdoctoral fellow, and one professor. The coding process was based on Interpretive Phenomenological Analysis (IPA) theory and method. IPA aims to document individual experiences and to explore the personal meaning of those experiences. In IPA, themes are identified through a process of inductive analysis (Willig, 2001). In this study, three coders first independently read all interview transcripts and assigned preliminary labels to interview text related to the study's research questions. These preliminary labels were discussed by the three-member team until a common preliminary coding structure was established. Next, the five-member coding team: (1) used the preliminary coding structure to assign codes to relevant sections of text, (2) condensed codes into themes, (3) reviewed all coded text for consistency, and (4) created narrative descriptions of the themes. Theme descriptions, together with quotations from the transcripts for each of the themes, constitute the study's findings.

## Data Trustworthiness

To ensure the trustworthiness of the analyses, the coding structure was developed, revised, and applied to the data via team discussions until consensus was reached, as recommended in the literature (Lincoln and Guba, 1985; Creswell, 1998). Specifically, the coding process featured (1) independent coding of all transcripts by multiple coders, (2) all coding decisions being evaluated by the team with direct reference to the interview data, and (3) periodic review of coding categories by the senior-faculty member of the coding team. This senior reviewer provided feedback on coding at each stage of the coding process.

# RESULTS

## What Led You to ATS?

### *Chance Events*

Both women and men told stories about random events leading them to ATS. Many used words like "accidental" and "stumbled" to describe their path to ATS:

> *[I] stumbled into . . . Earth Sciences [classes and] realized that I . . . really liked them. —Female Student*

> *[ATS] is actually . . . something that was [never] in my list. I went to . . . college . . . with the intent of studying Spanish or Sociology, and . . . you're required to take . . . a natural science. [The ATS class was] an easy A . . . but that was certainly never [a career plan], I mean, I was just doing it to fulfill a requirement. —Female Student*

> *[I found ATS] because it was [in] the 'A' [section of the student guidebook], and I started at the beginning of the book. I really was interested in history at the time . . . [but the ATS] class . . . sounded interesting. I really feel . . . but if I started in a different place [in the student guidebook], I might have been in a different place [and might have ended up in a different career] . . . I never thought I would have been here, ever, never . . . [I] accidentally found [ATS]. —Female Student*

> *I wanted to go back into science and . . . stumbled upon environmental sciences and then . . . one day . . . it just . . . clicked, . . . That's what I want to do. —Male Student*

Some respondents came to ATS through an interest in other sciences. Other respondents started with an interest in math and a desire to apply their math skills to something practical.

> *I knew I wanted to do something in the sciences. —Female Student*

> *I liked science as a kid, and I do not really know why weather stuck . . . it was just trying to figure out why certain things happen. —Female Student*

> *I liked math, but I never was . . . into pure math . . . [I] wanted to apply it to something. —Female Student*

> *I didn't want to go back into theoretical math, or statistics [because] . . . people were . . . telling me my [math] degree wasn't worth anything because you don't have real world skills . . . [ATS is] one of the fields that . . . actually . . . uses . . . my degree. —Male Student*

> *I wanted to go back into science . . . so I went back to get an atmospheric science degree. —Male Student*

Only men in this study's sample seemed to believe that ATS is what they were "meant" to do.

> *I knew I wanted to do . . . [meteorology] since I was eight years old. —Male Student*

> *I have been drawn to severe storms ever since I was really little . . . my true calling was obviously meteorology. —Male Student*

### *Dramatic Weather Experiences*

Both women and men connected their ATS choice with memories of childhood severe weather experiences. They remembered these experiences as frightening and attractive at the same time.

> *A tornado actually went through my hometown and . . . I thought that . . . was the coolest thing ever . . . That's . . . when I decided to go into meteorology and atmospheric science. —Female Student*

> *As . . . a child I was interested in weather . . . [I was] just fascinated by it and mostly because I was scared of thunderstorms and tornadoes. —Female Student*

> *I used to be terrified by weather and so I'd watch The Weather Channel all the time just to know what was going on . . . We [would] get a tornado warning . . . and that really freaked me out. —Female Student*

> *I grew up in [a Midwestern state] so we had a lot of severe storms . . . we would get tornado warnings and watches . . . My brother and sister would try to scare me . . . but . . . [I] thought everything they said was really cool. —Male Student*

> *I grew up [where there was] severe weather . . . that's . . . what drew me into ATS. —Male Student*

### *Hands-On, ATS-Related Research Experiences*

Both women and men reported that hands-on, ATS-related research (including field) experiences had an impact on their choice of ATS studies. According to them, these experiences enabled them to engage in, and test their abilities in ATS work. The following quotes illustrate the importance of hands-on research experiences in these students' choice of ATS:

> *I did a summer [ATS] internship . . . where I . . . really found what I was interested in. —Female Student*

> *You're required to do four semesters of research . . . the second one was actually in atmospheric science . . . and I was like "I really like this, . . . and I'm . . . good at it." —Female Student*

> *I wanted to do television meteorology . . . but I found this research internship. I spent ten weeks out there, and I really enjoyed the research . . . I came back and I said, "Alright, I'm going to graduate school, not going to do TV anymore." —Male Student*

> *I didn't know exactly what I wanted to do . . . but I knew I wanted it to be within [meteorology] . . . and then . . . working as research assistant . . . I really liked . . . that [academic] environment. —Male Student*

### *Models and Mentors*

Both women and men mentioned models, mentors, and/or the support of others as important in their ATS educational and career choices. Family and high school teachers were said to have helped to identify and encourage their interest and strengths in math and/or science, and to introduce them to ATS-related experiences, as referenced in the following quotes:

> *I liked science as a kid . . . I was interested in weather [and] . . . I had teachers that were pushing me to make sure I do what I'm interested in, and telling me . . . "This is what you can do as a career." —Female Student*

> *Ever since I was a kid I've always excelled in math and my dad was a . . . biologist. He dragged me out in the field . . . Now I really appreciate it [even though I didn't at the time]. —Female Student*

> *My dad is . . . [a] biologist. He spends . . . a lot of time doing research and publishing, and . . . a lot of the people he hangs out with do that. So I was . . . preconditioned to go into something like this. —Male Student*

The positive influence of college professors and advisors was also recognized as significant in these students' ATS educational and career choices, as referenced in the following quotes:

> *It was really personal . . . between professors and students and I really liked being in that environment . . . working as a research assistant for my advisor . . . so I really kind of figured out that being a professor would kind of be a really cool thing. —Male Student*

> *Basically I found one person [who worked in ATS] . . . [I thought], "I like what you do, that sounds interesting." —Female Student*

> *I was in an astronomy class and a really good professor . . . said, "If you want to do astronomy or atmospheric sciences you should do a physics major because it's kind of a broad major that will . . . teach you a lot about the mathematics that are used in [those fields]." —Female Student.*

However, for women, college professors and advisors did not always function in a career-supportive role. Some women stated that they made it into ATS graduate studies in spite of their college teachers and advisors.

> *The person who taught the class [on climate change] . . . was really influential as a teacher, but then as an advisor . . . he was [not] . . . that helpful when it came to . . . future career. —Female Student*

> *One of my physics professors . . . recruited me to be a physics major and then toward the end . . . [he said]: "I don't know if grad school is the place for you." —Female Student*

## What Do You Plan to Do in Terms of Future Education and Career?

### *Have a Positive Social Impact, Said Women*

It seemed important for ATS women that their career would include opportunities for positive social impact. Below are some illustrative quotes:

> *I've always been interested in environmental causes . . . With climate change being an issue, [studying ATS is] a way for me to help . . . the world in some way but still be involved in academia and mathematics. —Female Student*

> *Science is . . . something you can have a real impact in . . . especially climate science. —Female Student*

### *Find, Retain, and Succeed at My Job, Noted Men*

In contrast, men's responses to the question about career plans focused on finding, retaining, and being successful at their job.

> *I'm going to worry a lot . . . when I finally get a job . . . not screwing up and getting fired. —Male Student*

> *My main issue . . . [is] where I want to be for a career . . . working my way up the ladder. Shifting priorities [from] personal towards professional issues. —Male Student*

## What Are the Biggest Challenges to Achieving Your Career Goals?

### *For Women, Family Goals and Responsibilities*

Fitting career with family goals and responsibilities was perceived as a major challenge by ATS women. This theme is illustrated by the following quote:

> *The biggest challenge I think I'm going to face in the future is finding a job that has stable money [and] can support me . . . and also gives me the freedom to . . . have a kid. —Female Student*

Resolving the tension between career and family goals was achieved by some women by putting their male partners' professional needs and goals first. These women seemed to believe that focusing on their own career would be selfish.

> *I've more or less applied for research positions at . . . schools that were his first choice . . . I don't' want him to be stuck at a job he hates just for me to finish my degree. —Female Student*

> *I was always very focused on career . . . [but] I can't be selfish anymore . . . I need to . . . focus on what's best as a couple. —Female Student*

None of the men mentioned taking into account their female partners' educational or career goals as a challenge to achieving their personal career goals, even though three out of four men were in a committed relationship, and one had children.

### *For Men, Making Money*

Making money and being able to provide financially for a wife and/or children was perceived as a career challenge by men, as illustrated by the following quotes:

> *I'd like to . . . become a research scientist but . . . it really depends on . . . funding. —Male Student*

> *If I get married and have a family or even just getting married . . . money does start becoming important . . . I'm gonna do what pays a little bit more. —Male Student*

The same male student who said that money would become an issue if he got married also stated that it would be important for him to fit career goals with leisure activities:

> *[My] challenges are . . . making sure that I'm balancing my professional career path with just what I like to do for fun. I'm gonna do whatever makes me happy. —Male Student*

As suggested by the first female quote about family challenges, as well as the quote below, making money for ATS women seemed important but not a major challenge.

> *Being [an] ATS scientist . . . doesn't pay as much as a doctor . . . but it's . . . a good job. —Female Student*

## DISCUSSION

The present study explored educational and career motives, plans, and challenges of ATS female and male graduate students. A richness of detail about women's and men's ATS educational and career path was generated by this study's interview method.

For the graduate students in this study, choosing ATS seemed the unexpected outcome of chance events and choices, particularly for women. As a female student emphasized, an ATS education was not a remote possibility for her even while in college. Another female student recounted being introduced to the field via an ATS undergraduate class she chose based on its being listed at the beginning of the catalogue. By contrast, some male students in this study perceived ATS as a true calling, something they wanted to do since childhood—a finding consistent with observations reported by Charlevoix (2010). For both women and men, engagement with ATS was facilitated by interest and proficiency in science and math. What these findings suggest is that information about ATS education and careers is not easily available to students, perhaps especially to female students, with implications for the ATS pipeline. As suggested by Levine et al. (2007), based on their study's similar finding (i.e., the limited availability and visibility of geoscience courses at all stages of education), increasing the availability of ATS content in the curriculum, beginning with elementary school, may go a long way to stimulating interest and expanding participation in ATS (for a similar analysis, see Lewis and Baker, 2010).

Increasing women's interest, persistence, and success in ATS may also require breaking down gender stereotypes regarding who belongs in ATS. It may be that even when women become aware of ATS, they stay away from it because they perceive ATS as unsuitable and/or unwelcoming to them. As argued by Trower and Chait (2002) in relation to the scarcity of women in academia, despite the significant growth in women's doctorates, "the pipeline empties into territory [that] women . . . too often experience as uninviting, unaccommodating, and unappealing. For that reason, many otherwise qualified candidates forgo graduate school altogether, others withdraw midstream, and still others—doctorate in hand—opt for alternative careers." Studies indicate that interest, persistence, and success in science and engineering by individuals from underrepresented groups, including women, require a change in the science and engineering culture, not just a change in the choices of individuals from underrepresented groups (for a review, see de Pillis and de Pillis, 2008).

One way in which ATS seems to become visible and interesting to people is through exposure to weather events. Both women and men in this study connected their ATS choice with childhood memories of severe weather events and their frightened curiosity about these events. This finding is similar to a geosciences-choice critical event that Levine et al. (2007) named "outdoor experiences" (p. 463). Interventions aimed at increasing interest and participation in ATS careers may thus be particularly effective if they build on students' exposure to, and curiosity about, severe weather events, as demonstrated by a recent evaluation of a severe-weather undergraduate field course (Godfrey et al., 2011).

Hands-on, ATS-related research (including field) experiences during formative and career choice years were mentioned as important for ATS choice by the graduate students in this study—as was the case for the senior geoscientists interviewed in the study by Levine et al. (2007). Because of the wide acceptance of the role of hands-on research experiences in geoscience choice (e.g., Levine et al., 2007; Godfrey et al., 2011), these experiences are often at the core of programs (e.g., Significant Opportunities in Atmospheric Research and Science [SOARS], Pandya et al., 2007; Geoscience Research at Stormy Peak [GRASP], Hallar et al., 2010) aimed at broadening and diversifying participation in the geosciences. A question raised by this study's findings is whether women may be less likely than men to participate in ATS-related research and field experiences, and if so, why.

Having positive science models and mentors was perceived as influential for ATS career-choice by both women and men in this study. For women as for men, these models and mentors included family members (often fathers) as well as high school teachers and college professors. The role of models and mentors is featured prominently in just about every career development model and intervention, including in the geosciences career literature (e.g., Huntoon and Lane, 2007; Levine et al., 2007; Pandya et al., 2007; Hallar et al., 2010). For example, in the SOARS program, students (or prot*égé*s as they are called in SOARS) are given access to four mentors—a science, a writing, a community, and a peer mentor. According to SOARS external evaluations, "the multiple-mentor structure [is] critical . . . in promoting student achievement and SOARS' success" (Pandya et al., 2007, p. 503).

Given the critical role of mentors in career choice, persistence, and success, it is notable that in this study's interviews, we heard about undergraduate teachers and mentors who were *undermining* rather than supporting female students' educational aspirations. The negative mentoring reported by female graduate students ranged from neglect to active discouragement. This study's findings about undermining teachers and mentors are not unique. Larocque's (1995) study of female geoscientists' experiences as graduate students also included reports of "passive neglect" and "active discrimination" (p. 130). More recently, Mukasa (2009) pointed to the near absence of women and ethnic minorities among geoscience societies' award nominees and winners (despite their significant scientific contributions) as an indication of mentoring problems at the highest professional levels as well.

In any case, given that women represent less than 15% of scientists in ATS/space science occupations (in 2006)

(Gonzales, 2010) and an estimated 11% of ATS faculty (in 2005) (Tucker et al., 2009), at this time models and mentors for women in the ATS educational and career path are overwhelmingly male. The scarcity of female mentors and models may be a factor in women's underparticipation in ATS education and careers. It may be that male mentors are less likely to support female students' professional development—as indicated by the negative mentoring incidents described by female graduate students in this study. It may also be that female graduate students are reluctant to commit to ATS careers no matter how supportive their ATS male mentors are because they see few or no female role models in the field. A question for future studies is: What do women in the ATS career path think of the scarcity of female models and mentors in terms of their career choice and persistence? As of now, there are clues that access to female role models matters to ATS women. For example, female GRASP participants were quoted as being energized by interactions with ATS female scientists. "I think that GRASP . . . definitely gave me a broader view of what women could do in science and atmospheric science," said one participant. "[GRASP] has really opened my eyes because all the women that we have been introduced to are doing huge, huge things," noted another participant (p. 99).

With regard to future career plans, the female graduate students interviewed for this study perceived as important that their career have a potential for positive social impact. A clear value was attached by ATS female students to providing service via their careers. By contrast, ATS male graduate students in this study did not mention benefiting society as a career goal. Male students' focus was on finding, retaining, and being successful at their job. A service orientation has been documented as a factor in U.S. women's career choices (e.g., Sax, 1994; Morgan et al., 2001; Diekman et al., 2011). A likely reason is that, in the U.S., women more than men are socialized to value, enact, and evaluate themselves in terms of communal purposes (Pöhlmann, 2001; Prentice and Carranza, 2002). Taken together, these findings suggest that educating the public about the career potential of ATS for social contributions may be a way to recruit and retain women in the field. An added benefit of spreading the message that ATS careers have a potential for positive social impact is that this message may also help recruit individuals from other ATS-underrepresented groups, including socioeconomically disadvantaged students as well as Native American students, for whom positive social impact is important in terms of career choice (Conrad et al., 2009). As stated by Diekman and colleagues, "the ability of STEM fields to communicate more clearly about their communal goals and activities . . . has the potential to increase appeal among a wide range of communally oriented people, both male and female" (2011, p. 912).

Finally, ATS female and male students differed in what they viewed as major career challenges. For women, the main concern was fitting in both family and career goals. In fact, some women thought it would be selfish for them to articulate their career goals without taking into account their male significant others' needs and goals. By contrast, no man in this study expressed a concern about conciliating their career goals with those of their female partners, or with parental responsibilities. These findings are consistent with those that emerged from a survey of female and male professional geoscientists (Larocque, 1995). In that retrospective study, women reported that gendered social expectations about family responsibilities during graduate studies had a negative impact on their professional development. To be successful, many of them sacrificed family life altogether. As highlighted by the study's author, at the time of the survey, 33% of female respondents over age 40 were single, and 51% had no children—with only 3% of men in the same age group being single, and 9% without children. It is also notable that, of the female geoscientists in a committed relationship, 44% were partnered with other earth scientists, and another 16% had partners in engineering and science. By contrast, only 11% of male geoscientists were partnered with other earth scientists, and 3% with scientists or engineers. The demographic characteristics of ATS professionals have changed since the 1990s. A 2005 survey of the American Meteorological Society (AMS) membership (Tucker et al., 2009) recorded an increase (relative to 1993 AMS survey data) in the proportion of female and male geoscience tenure-stream faculty who were married. However, ATS female assistant and associate professors were considerably less likely (33% and 43%, respectively) than male assistant and associate professors (58% and 76%, respectively) to have children under the age of 18, while ATS female full professors were more likely (53%) than male full professors (37%) to have young children. The survey also documented that 83% of ATS postdoctoral women were married, and 50% had children. Finally, at the time of the survey, women represented an estimated 11% of ATS tenure-stream faculty. According to Tucker and colleagues, the 2005 AMS membership demographic trends presage persisting slow progress of ATS-doctorate women into academic positions. With only 11% of tenure-stream faculty being women, and few female assistant and associate professors having children, ATS will likely continue to look unattractive and uninviting to women. As Holmes and O'Connell (2003) put it: "The message students take from this lack of role models is that it is not possible to have both family and an academic career . . . students are watching what we do, not listening to what we say" (p. 564).

Making money was reported by ATS male graduate students as a potential career challenge. Making money, particularly making money to support a family, is conventionally a male role—though these days many women have sole or primary financial provider responsibilities. In any case, pressure to make money is stressful and can lead to career derailment if the level of pay in one's career of choice is not commensurate with what one perceives as necessary to fulfill the provider role. Some male respondents in this study might have been alluding to this pressure when they said things like, "I'm gonna do what pays a little bit more." At the same time, there are career advantages for men in the ideology of the male family provider. This is because, according to that ideology, male family and career roles are congruent with each other, not in conflict with each other. In other words, men are expected to *invest* in their career as a way to take care of their families. The male provider ideology also comes with the expectation that wives' careers will be secondary, and also that wives will contribute to their husbands' careers. This alignment and, in fact, synergy of work and family goals and resources in dominant masculinity ideology is likely a reason why married men with children are the best paid and most professionally successful of ATS scientists (Winkler et al., 1996), and of academics in general (Bellas, 1992; Toutkoushian, 1998; Bellas and Toutkoushian, 1999; Mason and Goulden, 2004; Toutkoushian et al., 2007). For women on an ATS career path, the implications of dominant gender ideologies of family and career are multifaceted. As discussed by Libarkin and Kurdziel (2003), since ATS women are more likely than ATS men to be in a dual-career couple, supporting ATS women's engagement and retention in ATS occupations, including academia, will require, for example, generating in-house or external career opportunities for their partners. Furthermore, to address the burden women carry with regard to parental responsibilities, supporting women's participation and success in ATS employment will involve flexibility in the workplace, including variable work time, family-leave policies, job sharing, and, in academia, an extended tenure clock (de Wet and de Wet, 1997; de Wet et al., 2002; Libarkin and Kurdziel, 2003).

## CONCLUSIONS

The increasing importance of ATS expertise nationally and globally lends urgency to understanding how the best and brightest individuals can be recruited and retained in the field. With women's talent still seriously underrepresented and undertapped in ATS occupations, especially in senior and academic positions, this exploratory study of ATS female graduate students' career motives, goals, and challenges, relative to those of males, is, we believe, an overdue contribution. We also think that our study's interview methodology was a good fit to the goal of exploring the interaction of individual and societal factors in ATS women's career choice and retention, as compared to those of ATS men.

Many of this study's findings are consistent with those of studies of other STEM fields (AAUW, 2010), thus providing evidence of common issues for U.S. women in STEM fields. At the same time, some of this study's findings are unique—likely related to ATS-specific culture and demands as a science and an occupation (e.g., its being field-based; Holmes et al., 2008), and also related to ATS-unique history (Nentwich, 2010) and recent trends (Tucker et al., 2009) with regard to participation by U.S. women. Taken together, our findings argue for the importance of discipline-grounded analyses of gender gaps in education and employment. Simply stated, while U.S. women are underrepresented in several STEM fields, the degree and forms of their underparticipation, and the resources and obstacles they encounter in their educational and career path, vary across STEM disciplines, requiring discipline-specific focus (Tucker et al., 2009; Diekman et al., 2011; Hosoi and Canetto, 2011).

This study is among the first to apply to ATS questions and methods used to understand the gender gap in other STEM disciplines. We hope that this study raises visibility on the persisting underrepresentation of women in ATS, and on evidence indicating that time alone will likely not solve the gender gap (Kulis et al., 2002; Libarkin and Kurdziel, 2003; Holmes et al., 2008). We also hope that this exploratory study generates insights and questions about the ATS career path to be pursued by future research.

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