THESIS

CAREER GOALS, CHALLENGES AND RESOURCES FOR WOMEN IN ATMOSPHERIC SCIENCES

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Lauren M. Lessner

Department of Human Development and Family Studies

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY LAUREN M. LESSNER ENTITLED CAREER GOALS, CHALLENGES AND RESOURCES FOR WOMEN IN ATMOSHERIC SCIENCES BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE.

Committee on Graduate Work

James Banning

Alicia Cook

Advisor: David MacPhee

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Co-Advisor: Silvia Sara Canetto

Assistant Department Head: Karen Barrett

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ABSTRACT OF THESIS

CAREER GOALS, CHALLENGES AND RESOURCES FOR WOMEN IN ATMOPSHERIC SCIENCES

Women are underrepresented in education and careers in the geosciences. One of the many obstacles to women's greater participation in the sciences in general is that they disproportionately shoulder family responsibilities. It is not clear, however, if multiple role involvements are what prevent women from getting ahead in the geosciences. Among the geosciences, atmospheric sciences have received minimal research attention despite the growth in the field. The few available studies on women in atmospheric sciences focus on women in academia. A critical time for career decision making is graduate school. To fill this gap in the literature, this study focused on women in atmospheric sciences who are in graduate school or a recent graduate. Because knowledge about this population and the issues they face is so limited, the present study used a qualitative method. Semi-structured interviews with 12 female atmospheric science graduate students and recent graduates were conducted and coded via interpretative phenomenological analysis (IPA) to identify challenges and resources related to education, career, partnership and parenthood. This study found that at the time of graduate school, women in atmospheric science: (1) felt social expectations and pressures to prioritize family, (2) experienced challenges pursuing their career goals in conjunction their partner's career, (3) often viewed career and parenting roles as

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conflicting or incompatible, (4) benefited from exposure to role-models who balanced these domains, (5) were positively influenced by supportive partners, and (6) desired flexibility in career and family paths. The narratives shared by women in atmospheric sciences at graduate school time underscore how family and career expectations interact to challenge and support women's persistence in atmospheric sciences.

> Lauren M. Lessner Department of Human Development and Family Studies Colorado State University Fort Collins, CO 80523 Summer 2010

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Women are underrepresented in education and careers in the geosciences. A recent National Science Foundation (NSF, 2002) publication reports that several of the trends present in 1982 regarding women in the sciences still exist today. Among these trends are the relatively small percentages of women and ethnic minorities who earn degrees and who are employed in science and engineering, the higher rates of part-time employment and unemployment for women than for men, the lower salaries earned by women than by men, and the lower percentages of women than men in full professorships. One of the many obstacles to women's greater participation in geoscience education and careers is that they disproportionately shoulder the burden of balancing career and family. However, limited literature exists on this tension for female scientists, and what is known is drawn primarily from samples of university faculty. This study focused on female atmospheric science graduate students' perceptions of partnership and parenthood as related to their education and career pursuits.

The Leaky Pipeline

As women progress towards higher levels of education and more prestigious academic careers, they become more likely to drop out or discontinue pursuit of advanced achievements (Cavallaro, Hansen, & Wenner, 2007). This gendered effect, often referred to as the leaky pipeline, is well documented in women's progress towards tenured faculty positions. Mason and Goulden (2004) highlighted the multiple points that women disproportionately drop out of the academic pipeline. They reported that women are 23% less likely than men to become associate professors and 25% less likely than men to become a full professor within a maximum period of 16 years. Married women and those with children face additional disadvantages. Women who are married are 20% less likely

than single women to enter a tenure-track position, and women with children are 29% less likely to enter a tenure-track position than women without children (Mason & Goulden). These findings indicate that even though women are less likely than men to achieve high-status academic positions, those who shoulder family responsibilities face even more challenges.

Women in Science

Science is similar to many other professional fields in that women make less money and advance through the ranks more slowly than men (Valian, 2007). However, smaller percentages of women get advanced degrees in science as compared to the humanities, medicine, law, and business specializations (Valian). Similar to the experiences of female faculty, graduate women are less likely than their male counterparts to complete their doctorate and continue on to obtain high-status careers in science. Although women are well represented in terms of earning graduate degrees in social sciences as well as biology – 40% to 58% – they comprise small numbers of those earning Ph.D.s in engineering (12.3%), the physical sciences (22.4%), and geosciences (23.7%; NSF, 2000).

In recent years, women's underrepresentation in scientific fields has resulted in a number of studies on women's status in the sciences, the effect of women on science, and the effect of science on women (Macfarlane & Luzzadder-Beach, 1998). However, these studies of women in science have focused on four major subfields of science - physics, chemistry, mathematics, and biology - to the exclusion of the geosciences (Macfarlane & Luzzadder-Beach).

Although little research focuses on the geosciences, some researchers attempt to explain the gender disparity of women in science through distinguishing between peopleand object-oriented professions. These studies highlight women's involvement in the biological and social sciences versus men's involvement in inorganic sciences (Halpern, 2007). However, this explanation lacks the complexity and depth to explain the sex disparities in multiple disciplines at various educational and occupational levels.

Even though such sex disparities are well documented, a consensual explanation for them is yet to emerge. Instead, researchers in the field continue to debate the biological and social factors that may potentially affect women's participation in scientific fields.

Biological and Social Explanations

Among the explanations offered for women's underrepresentation in science are biological factors (e.g., brain organization and functioning, hormonal differences) and social influences (e.g., gender schemas, cultural values, discrimination and stereotypes). Biologically based arguments highlight sex differences in spatial abilities, cognitive functioning, and math performance. However, a recent review of the biological and sociocultural explanations for women's underrepresentation in science, conducted by Ceci, Williams, and Barnett (2009), concluded that biological findings are contradictory and inconclusive, and sociocultural factors provide more consistent and logical explanations.

Ceci and colleagues (2009) drew support from several cross-cultural studies in which women perform as well as or better than men on advanced tests in math and science at various developmental periods. For example, the 2002-2003 report of *Trends*

in International Mathematics and Science Study of eighth grade students showed boys to score higher on mathematical tests as compared to girls in both Japan and the United States (Valian, 2007). However, this same study found that Japanese girls scored higher than American boys. Similarly, male and female students from Singapore performed even better – a full standard deviation better than American children, suggesting cross-national differences are greater than sex differences (Valian). Findings showing cross-cultural variability in women's participation and performance in science and math contradict biological explanations for women's underrepresentation in the sciences. Additionally, Ceci and colleagues found that in U.S. samples, sex differences are inconsistent across cultural, ethnic, and socioeconomic groups.

Furthermore, support for sociocultural explanations is corroborated by changes in the past 30 to 40 years in women's roles and access to higher education in the U.S., as demonstrated by cohort studies. That is, women now attain more degrees in fields such as biology, veterinary medicine, and medical sciences (National Science Foundation, 2004), fields traditionally viewed as only appropriate for men due to women's "inferior" cognitive abilities. Although Ceci and colleagues do not entirely dismiss biological processes, they do conclude that social and cultural explanations more strongly account for women's underrepresentation in science.

However, broadly stating that sociocultural factors are likely to affect women's participation in science does not provide insight into the specific social and cultural dynamics that affect female scientists on a daily basis. In fact, sociocultural researchers support theories ranging from sex-typed activities for boys and girls and differential

treatment of emerging scientific and technological abilities (see Spelke & Grace, 2007; Hyde, 2007) to gender schemas (Valian, 2007) and discriminatory practices in scientific programs and careers (Spelke & Grace).

Although no simple explanation currently exists for the gender differences in scientific fields, researchers continue to draw from females' experiences in academia and explore both biological and sociocultural contributions. Although future studies are unlikely to reveal a single source or solution to women's underrepresentation in science, they may shed light on particular mechanisms or unique factors that contribute to this complex and multifaceted phenomenon. In an attempt to better understand women's participation in the geosciences, this study focused on women's perceptions of work and family roles. This study explored how graduate women's current and future plans for partnership and parenthood enhance or challenge their atmospheric science education and career experiences.

Work-Family Roles

This review will first address women's experiences of work-family conflict as well as the potential benefits of multiple role involvement. Then, I will provide a feminist perspective on the gendered nature of role responsibilities. Next, incompatibilities in these domains for female faculty will be explored, and finally work-family domains as related to female graduate students and scientific careers will be discussed.

Work-family conflict, also referred to as multiple-role or interrole conflict, refers to conflicting role pressures between career and family that are incompatible so that participation in one role is made more difficult by engagement in the other (Greenhas & Beutell, 1985). The fact that work-family conflict is widely experienced is established,

but the specific mechanisms are yet to be elucidated (Treistman, 2004). In fact, not all individuals who are involved in both work and family roles experience conflict (Conlon, 2002). According to Damiano-Teixeira (2006), work-family conflict takes place when considerable time and effort is devoted to a single role, making it practically difficult if not impossible to respond to the demands of other roles. Although career-family conflicts can exist for both genders, especially in demanding occupations such as scientific careers, women typically experience higher levels of work-family conflict than men (Duxbury & Higgins, 1991). This gender difference has been linked to the tendency for women to shoulder the bulk of the household, childcare, and familial responsibilities. Therefore, the demands of multiple roles often fall disproportionately on women (Philips & Imhoff, 1997), and are one potential reason for their smaller numbers in occupations that demand much investment of training and time.

On the other hand, although much research exists on the conflicting and sometimes detrimental nature of multiple roles, other research suggests that there are benefits to multiple role involvement (e.g., Greenberger & Goldberg, 1989; Barnett & Hyde, 2001; Halpern, 2005). In their 2005 study, Barnett and Hyde argued that classical theories of gender and multiple roles have changed so radically in recent years that prior theories have become obsolete and that empirical data fail to support multiple role conflict. In fact, these researchers point to a number of processes that suggest beneficial effects of multiple roles.

One of these processes is that the negative effects of stress or failure in one role can be buffered by successes and satisfaction in another role. Also, multiple role involvement provides additional opportunities for extra income, social support, and

opportunities to experience success. Barnett and Hyde (2005) further discussed the benefits of having an expanded frame of reference, gender-role identity, and selfcomplexity. Finally, they highlighted the benefits for dual-earner couples who have similar and relatable experiences in multiple domains. The next paragraph will expand on this point, exploring potentially positive outcomes for children of parents with multiple roles.

Contemporary research has debunked the myth that maternal employment is detrimental to children. Rather, maternal employment has been shown to have few, if any, negative effects on child outcomes; in some instances, children with working mothers have more positive outcomes such as increased academic achievement and fewer behavioral problems (Halpern, 2005). Additionally, women with high commitments to both work and parenting were found to be more likely than others to engage in authoritative parenting, which is the parenting style associated with favorable child outcomes such as independence, self-control, and prosocial skills (Greenberger & Goldberg, 1989).

Thus, the literature on multiple role involvement paints a complex, sometimes contradictory picture of its effects on women's careers and home life. There is a lack of consensus as to whether women's involvement in multiple roles leads to spillover and impairs performance in one or both roles, or if it has positive effects on women and their children. Clearly, additional research is needed to better understand the potentially detrimental as well as beneficial elements of multiple role involvement. Barnett and Hyde (2001) argued that role quality, experienced through personal or professional fulfillments, has the greatest impact on an individual's health, and that the benefits of multiple roles

depend on the number of roles and the demands of each. This suggests that multiple roles are beneficial to an extent but involvement in numerous or highly demanding roles may lead to overload and distress. The next section will focus on the gendered nature of role assignment and the tendency for women to shoulder the bulk of household and childcare responsibilities.

Gender Role Theory

Roles, as explained in role theory (Barnett & Gareis, 2006; Sarbin & Allen, 1968), are socially constructed expectations of individuals and groups. In several industrialized countries, including the United States, women are socialized into the caregiving role (Baber & Allen, 1992). As family caregivers, women, more than men, are expected to be responsible for childcare, household, and family duties. Furthermore, women's caregiving role extends beyond their immediate family to include relatives, friends, and kin. Although the act of caregiving is inherently valuable, from a feminist perspective women are subordinated and devalued in their role as caregivers in American society (Baber & Allen).

Social status and power in America are associated with monetary gain and occupational achievement (Polatnick, 1983). From a feminist perspective, men enjoy a superior power position in relation to women as they are expected to work in occupational fields where both money and achievement can be earned. In contrast, women are expected to labor in the home, which limits their access to social status and power. The labor of familial caregiving earns no monetary reward and is not associated

with increases in status, power, or achievement. Instead, women are devalued in this role and those who fail to live up to these expectations are denigrated for not fulfilling their adult developmental task (Baber & Allen, 1992).

To the extent that women have internalized this culture's definition of the female role, they should value various adult activities differently than their male peers (Eccles, 1994). In particular, they should rate parenting and spouse-support roles as more important than professional career roles, and they should be more likely than their male peers to resolve life's decisions in favor of family roles. In contrast, men are more likely to make decisions in favor of career development. Although feminist scholars suggest that women bear the bulk of household and childcare responsibilities and thus experience more work-family tensions than men, is there empirical evidence in support these gender differences?

Several studies have examined the amount of time that men and women spend completing household and childcare responsibilities. Across multiple studies, women spend significantly more time on housework than do men regardless of women's employment status (e.g., Shelton, 2006). Empirical findings suggest that women in the United States spend approximately 19.5 hours per week on housework compared to 9.8 hours per week for men (Shelton). One would expect a more egalitarian division of labor when both spouses are employed full time, but even in these instances, women still assume the majority of domestic chores and childcare (Pleck, 1997; Renk et al., 2006; Yeung, Sandberg, Davis-Kean, & Hofferth, 2001). The majority of these studies, with few exceptions, focus on middle- to upper-class Caucasian Americans.

Additionally, research on dual-earner couples shows that gender matters: Women

do more housework and childcare, even when spouses work equal hours and the woman earns more money than the man (Bond et al., 2002). Although men have increased their time spent on housework and childcare in recent years, women continue to bear the majority of responsibility for child-related activities (Renk et al., 2006). As a result, men are more likely to "help out" and are less likely to assume executive functions of knowing what need to be done, when it needs to be done, and owning responsibility for child well-being (Halpern). Pervasive cultural scripts that portray women as homemakers and caregivers and men as financial providers reinforce these gender ideologies. Individuals of both sexes who align with these cultural scripts receive social approval; those who do not are met with criticism and disapproval (Riggs, 1997).

Although empirical findings suggest that women continue to shoulder the bulk of household and childcare responsibilities, the literature on the impact of these gender differences in work and family domains is limited, at least with regard to women in science. Research to date suggests that the redistribution of roles within the family has not yet occurred to match increased role responsibilities for women outside the home (Bond et al., 2002; Duxbury & Higgins, 1991). Within heterosexual relationships, the demands of multiple roles often fall disproportionately on women (Phillips & Imhoff, 1997) and women experience greater work-family conflict than their male partners (Duxbury & Higgins). However, experiences of work-family conflict and multiple role benefits have not been examined among female scientists. Women in academia are the focus of the next section because more research has been conducted with this population, in terms of work-family roles, than with female scientists.

The Impact of Marriage and Children on Female Faculty

Academia is a microcosm for the gendered nature of work-family conflict. For instance, men who achieve tenured faculty positions are commonly married with young children (Mason & Goulden, 2004). However, as discussed previously, the opposite trend is true for women, such that those who are single and childfree achieve the highest rates of academic promotion.

Mason and Goulden (2004) provided an example of the negative impact marriage has on women's but not men's careers. Women are more willing to suspend their careers (e.g., move to another city) for their partner's educational or occupational achievement than are their male counterparts. Furthermore, in regard to motherhood, Mason and Ekman (2007) documented the conflict female faculty members face between their tenure-track and biological timelines. They noted that the Ph.D. and tenure tracks compete with women's family planning, particularly the timing of children. The tenure process often requires individuals to be the most productive at the beginning of their careers, which conflicts with the age most women bear children.

Female faculty who have children or become a parent during this time report spending fewer hours working (Ceci et al., 2009), experience feelings of guilt for leaving their children at home, fear that they will not be taken seriously by peers, and are concerned about not excelling as either a mother or worker (Mason & Ekman, 2007). Research validates these concerns. Single women without children are seen as more career oriented than those who are married or have children; once again, men experience the opposite effect, with fathers being perceived as more career oriented than those who are single or childless (Damiano-Teixeira, 2006). In an attempt to balance multiple role responsibilities, some women make significant professional and personal sacrifices. Women who received prestigious postdoctoral awards, interviewed by Sonnert and Holton (1995), used a variety of strategies to cope with the competing demands of work and family. These strategies included remaining single, not having children or having fewer than initially desired, postponing childbirth until careers were established, collaborating with partners and colleagues, and engaging in complex time-management strategies. However, for most women, these temporary support strategies are not long-term practical solutions. Therefore, the work-family conflict that women in academia experience may result in women being forced to sacrifice education and careers they have worked years to achieve or to give up the options of romantic partnership and having children.

Although some information is known regarding women's underrepresentation in top-tier faculty positions, less is known about graduate students' experiences; specifically, those pursuing degrees in the geosciences. Much research attention has been devoted to why are there so few women in science (for a review, see Ceci et al., 2009), yet there is a paucity of research on how graduate women experience work and family domains.

The Experiences of Female Graduate Students

Graduate education can be a time of multiple and rapid changes when stressful life events and multiple personal, familial, and career-related issues may lead to role overload and stress (Mallinckrodt & Leong, 1992; O'Bryan, 2008; Treistman, 2005). Although graduate school is often stressful for both men and women, it can be especially challenging for women due to increased role strain, gender role socialization, and gender-

based discrimination (Mallinckrodt & Leong). In fact, women in graduate school experience higher levels of psychological distress and receive less support from their families and academic departments as compared to men at the same educational stage (Mallinckrodt & Leong).

Furthermore, the age at which many students enter into graduate school often coincides with the age that many individuals get married and that women commonly bear children. However, in many heterosexual relationships, women but not men are expected to accommodate the new role of graduate student or working spouse without significant lessening of their responsibilities as wife, homemaker, and mother (Treistman, 2004). The limited research on this topic documents female graduate students' struggles to advance academically while also juggling childcare, household, and familial responsibilities (Mallinckrodt & Leong, 1992; Younes & Asay, 1998) and there is a lack of research addressing the impact of multiple role involvement for female graduate students. Thus, there is a need for information on this population, especially as related to how multiple roles may challenge or enhance female graduate students' education and career persistence. The next section will discuss the importance of women's involvement in a prestigious and growing career field, atmospheric science.

Scientific Career Fields: Atmospheric Sciences

Atmospheric science, a subdiscipline of the geosciences, mirrors the same underrepresentation of women that is visible in other science disciplines. Data from a recent unpublished study on women in atmospheric science departments indicates that 38% of graduate students and 16% of university affiliated faculty and scientists are women (D. MacPhee, personal communication, March 23, 2010). As noted previously,

limited research exists on the geosciences and on atmospheric science in particular. Initial findings in this area suggest persistent gender disparities; 43% of female graduates have no female mentors, significant salary gaps exists between male and female faculty, and women report experiencing more negative effects from dual-career arrangements than men (Macfarlane & Luzzadder-Beach, 1998; Winker, Tucker & Smith, 1996). Due to the small proportion of women in atmospheric science, sample size is a common limitation to these studies.

As the field of geosciences expands there is a need for capable individuals with creative ideas and unique perspectives. Women are a relatively untapped resource that may contribute new expertise and promote scientific advancement. To address significant pressing global concerns, such as climate change, all individuals' perspectives are important, and women as well as men should be given opportunities to contribute. Furthermore, many careers in science are well-paid and highly prestigious. Women have the potential to bring new ideas and further developments to this fast-growing and economically competitive career field. Therefore, it is essential to address women's underrepresentation in atmospheric sciences and gain greater understanding of the complex contributors to this underrepresentation.

Research on career and family roles is one avenue by which more information can be gathered to better understand women's experiences in science. However, the participation of women in scientific fields is a complex issue that most likely involves multiple interrelated factors. As noted previously, it is unlikely that a single study would uncover a specific biological or sociocultural explanation for this phenomenon, but rather it is through the culmination of multiple studies, perspectives, and approaches that the

experiences of women can be revealed. The present study explored female atmospheric science graduate students' perceptions of partnership and parenthood as a possible explanation for women's underrepresentation in this field. The goal of this study was to gain greater insight into supportive and challenging factors related to career and family and women's current and anticipated means of balancing multiple roles.

This study was part of a larger National Science Foundation longitudinal study investigating educational and career trajectories of male and female university students, postgraduates, and faculty in science, technology, engineering, and mathematics (STEM). The current study focuses on responses from a subset of atmospheric science graduate students because they represent a sub-discipline of the geosciences and no current literature exists on their experiences of work and family. Because traditional quantitative methods can only assess the impact of factors that have been previously identified in research, the present study addresses the critical gaps in the literature through semistructured interviews with women in atmospheric science.

Although there is a wide array of methods available to study work and family issues, qualitative researchers highlight the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and develop rich descriptions of individual and group experiences (Benoit & Holbert, 2008). A qualitative research method was well suited for this study because it is exploratory in nature and the researcher aimed to gain an in-depth understanding of women's experiences and perceptions.

Method

Research Design and Perspective

Phenomenology is a qualitative approach that strives to gain insight into individuals' lived experiences and the prescribed meaning they assign to those events. The aim of phenomenology is gaining deeper understanding of the meaning of everyday experiences. Researchers are concerned with how individuals make sense of their experiences and translate their experiences into individual and shared meanings. According to Patton (1990), phenomenological research is based on:

...the assumption that *there is an essence or essences to shared experience*. These essences are the core meanings mutually understood through a phenomenon commonly experienced. The experiences of different people are bracketed, analyzed, and compared to identify the essences of the phenomenon, for example the essences of loneliness, the essence of being a mother, or the essence of being a participant in a particular program. (p. 106, italics as in original)

In this study, a phenomenological framework allowed the researcher to focus on graduate women in atmospheric science. Through a detailed examination of their experiences, rich descriptions were developed to describe the essence of their experiences and the meaning they attached to current and future plans for education, career, partnership, and parenthood.

Researcher's perspective. The researcher is a central tool in qualitative methodologies. Although quantitative studies attempt to minimize or reduce researcher bias, qualitative studies bring the researcher's background, theoretical orientations, and biases into the light. It is through this illumination of perspective that the reader may come to acknowledge the researcher as actively shaping the development and direction of the study.

In the present study, I approached the exploration of women's experiences in science from a feminist framework. Always being interested in gender dynamics and the analysis of power, I was influenced by the interplay of these elements in my own life, in the lives of those around me, and in my therapeutic work with individuals, couples, and families. It was through these personal and professional experiences that I became intrigued by how individuals experience the career and family roles. Furthermore, as a female graduate student, I was able to relate to the experiences of other women in the pursuit of higher education. I value education and the pursuit of advanced career placement as well as family, partnership, and parenthood.

Participants Recruitment and Sample

Convenience sampling techniques were used to recruit participants. Participants were accessed through their involvement in the larger National Science Foundation study investigating education and career pathways of individuals in science, technology, engineering, and mathematics. Participants from all fields were informed of the study through e-mail communication (see Appendix I). Additionally, through collaboration with the Colorado State University atmospheric science department faculty, students, and staff, participants were also informed through personal communications. Finally, snowball sampling techniques were employed.

Purposeful selection criteria ensured all individuals in the study were current female Master's or Doctoral atmospheric science students or recent graduates (i.e., individuals who obtained a graduate degree within the last year). Furthermore, because the challenges of balancing career and family are more acutely felt by females, the sample was limited to female participants.

Participants. Participants consisted of 11 female atmospheric science graduate students and one recent graduate. The mean age was 26 years, with a range of 22 to 28 years. All participants were United States citizens, 11 identified as White/European American, and 1 identified as Black/African American. They had earned bachelor's degrees in meteorology, geology, mathematics, physics, and environmental, earth, computer, atmospheric, and oceanic sciences.

The majority of students were in a romantic relationship with male partners; 6 were married or had participated in a commitment ceremony, 5 were attached, and 1 was single and not attached. Length of relationship varied from less than 1 year to over 11 years, with a mean of 5.1 years. Eight participants lived with their romantic partner, and 3 lived with other roommates, and 1 lived alone. The partners' mean age was 28 years, with a range of 23 to 36 years. Partners' careers included both blue collar and professional pursuits. Examples of partner career fields include but are not limited to retail, media, law, and engineering fields. Additionally, two respondents indicated they had partners currently pursuing degrees in atmospheric sciences.

None of the interviewees currently had children, but all indicated that they probably or definitely wanted children in the future. One respondent indicated that her partner had a child from a former relationship who lived in their home part-time. *Instrumentation*

Data collection included a written questionnaire and semi-structured interviews.

Questionnaire. Participants completed a questionnaire to gather information about their age, ethnicity, educational background, relationship status, current number of children, desire to have children, and other demographic information (see Appendix II).

Semi-structured interviews. In-depth interviews are particularly useful when the research purpose is to investigate people's perceptions of the world and the meaning they make of the events they experience (Sprenkle & Moon, 1996). To gain insight into women in atmospheric sciences' perceptions of challenges and resources related to education, career, partnership and parenthood, participants completed a 45-90 minute semi-structured interview, with open-ended questions.

Interview questions related to the challenges and resources encountered by participants on their educational paths were used to structure the interview, with followup questions providing flexibility to explore emerging themes. The open-ended format of the questions allowed participants to have control over their responses options and promoted participants' sharing of their experiences and prescribed meanings. Of the various topics about education and career experiences explored in these interviews, the current study focused on two specific question groups:

- If you are currently in a romantic relationship, describe how this partnership enhances and how it challenges your educational and career goals.
- Do you have or plan to have children? How do you think these plans have been or will be affected by your career choice?

Procedures

Colorado State University's institutional review board approved the larger National Science Foundation study, of which the current study was a part. Prior to each interview, the participants were sent a demographic questionnaire and were instructed to bring the completed form to the interview. On the day of the interview, participants were provided additional information regarding the study's purpose, procedures, and the structure of the interview. Participants were given the opportunity to ask questions prior

to the start of the interview and each filled out a consent form for participation (see Appendix III). Participants were compensated \$12 for their time. Interviews were conducted individually in a private room on the university campus. Interviewers familiar with the interview protocol and research study conducted the interviews. Interviews were audio recorded and than transcribed verbatim into a text document, for later analysis, by a team of research assistants. Each interview transcript was reviewed and edited by a second party to ensure accuracy of the transcription. Participants' confidentiality was maintained through the use of identification numbers and pseudonyms for each participant.

Data Analysis

The researcher completed a phenomenological study using interpretative phenomenological analysis (IPA). IPA is a version of the phenomenological method, which accepts that it is impossible to gain direct access to the participant's lived experiences (Willig, 2001). Instead of accessing the experience directly, the researcher acts as an interpreter and seeks to discover the essence of the experience through an interpretation of the rich, textual data provided by participants describing the particular experience being studied (Demarrais, 2004).

In alignment with IPA's focus on individual experiences and sociocultural, historic, and linguistic shaped meanings, each interview was analyzed one at a time and then integrated during the late stages of analysis. Coding was completed by a fourmember coding team, consisting of two female graduate students and two female

undergraduate research assistants. Coding members were selected based upon their background in feminist studies, familiarity with literature on women in sciences, and experience with qualitative coding and other research methods.

Training of the coding team began with all coding team members reading and analyzing the same interview transcript independently, and assigning labels or that were one to three words in length to segments of text that they judged to be significantly related to the research questions. Emerging codes were discussed at team meetings, where each team member discussed the codes she had created to represent the data and her rationale for this coding; through examination and reexamination of the data and its interpretation, we arrived at a consensus on which codes most accurately represented the emerging themes when there was disagreement among team members. Once team members were trained in the coding process, each transcript was coded in accordance with Willig's (2001) four stages of analysis.

In the first stage, the coding members read each transcription in its entirety to establish a sense of familiarity with the text. The members took notes that reflected any initial thoughts and observations. Next, the coding team reread the line-by-line transcription more slowly and identified and labeled codes or themes that characterize each section of the text. Theme titles were conceptual and captured the essential quality of what is represented in the text (Willig). In the third stage of analysis, lists of identified themes were organized in relation to one another data (e.g., adding new codes or rearranging existing codes). Concepts were clustered by shared meanings, hierarchical relationships, and other significant groupings. The fourth stage involved the production of a summary table of the structures themes, together with quotations that illustrated each

theme. The coding team met on a weekly basis to determine consensus on the emerging themes, coding structures, and example quotations. Themes that were not well represented within the text or which were marginal to the purpose of the study were excluded. The decision about which themes should be retained and which were abandoned was determined by the purpose of the study and the researcher's interest and orientation (Willig). A committee member, with experience in qualitative analysis, also periodically visited team meetings to review the emerging coding structures and request justification of coding choices.

After all 12 interviews were analyzed according to these four stages, the final stage of integration allowed the coding team to view all of the interviews in a comprehensive fashion. A cyclical process of rereading and recoding earlier interviews was important to crosscheck later developing themes. Viewing the interviews in this fashion allowed the team to take a more holistic view of the concepts to determine similarities in themes that needed to be combined or clustered as well as the need for new or different categories or groupings. During this stage, the team used NVivo 8 software (QSR International) to review the emerging themes and example quotations. Team members carefully examined each code using NVivo to ensure that the text fit the assigned codes and that the coding structure reflected the main findings. Finally, team members wrote a brief description of the characteristics that defined each code and its relationship to the research questions. The research team discussed their written descriptions of the codes to develop finalized descriptors that accurately described the data. These descriptions of coding themes, in combination with the use of quotations from the transcripts, provided the final explanation of the research findings.

Trustworthiness

Many researchers argue that validity and reliability, measures traditionally used to establish rigor in quantitative studies, do not apply to qualitative methodologies and should be replaced by other measure of "trustworthiness" in such research (Shah & Corley, 2006). Researchers have proposed numerous ways of establishing trustworthiness in qualitative research. In this study, trustworthiness was established through the clarification of research bias; rich, thick descriptions; audit trails; and peer debriefing.

IPA recognizes the relationship between the researcher and participant as central to the investigative process. The researcher is the tool of exploration into the participant's experience and, therefore, the researcher's assumptions and biases affect the inquiry. To establish trustworthiness in this study, the researcher was transparent regarding experiences, biases, and orientations that likely shaped the interpretation and approach of the study (Creswell, 1998).

Additionally, usage of rich, "thick" descriptions of participant experiences and interpreted meanings, as presented in the results section to follow, allow readers to make decisions regarding the content's transferability. The researcher aspired to clearly report content supported by the data and applicable to the research question. Furthermore, direct quotations are used to ensure that any interpretations accurately reflect the original meaning conveyed in the interview.

Strauss and Corbin (1990) encourage the use of "adjunctive procedures" as part of qualitative research. These include the use of memos, notes, and diagrams as to supplement primary sources of information. As means to deepen understanding and maintain an audit trail, the researcher used journaling during data collection and analysis

that included initial responses to interview content, thoughts and feelings on the topic, and theoretical, ethical, and practical considerations. These notes acted as an additional source of information and were used to enhance the results and discussion sections of this report.

The researcher also enlisted the help of other trained individuals to crosscode the transcriptions to gain additional perspectives and review any interpretations of the text. Feminist researchers Demo and Allen (1996) encourage the use of multiple and often competing perspectives as means to accurately represent the multiple perspectives and interpretations of people's experiences. Additional coding members asked challenging and thoughtful questions, provided unique perspectives and input, and collaborated toward the desired outcome of consensual analysis. Additionally, the researcher also debriefed with committee members as a means to gain additional perspectives and insights in the developing and final analyses.

Results

The following main themes emerged from the analysis: women in atmospheric science (1) felt social expectations and pressures to prioritize family, (2) experienced challenges coordinating their career goals in conjunction their partner's career goals, (3) often viewed career and parenting roles as conflicting, (4) benefited from exposure to role-models who balanced these domains, (5) benefited from having supportive partners, and (6) desired flexibility in career and family paths. Each of these six themes is discussed in detail below.

Women in Atmospheric Science Felt Social Expectations and Pressures to Prioritize Family

Participants discussed feeling pressured to conform to conventional gender ideologies and to prioritize family over career. Some female atmospheric science graduate students described noticing differences between their own experiences and those of their peers who did not pursue graduate or professional level training. One interviewee discussed the divide she felt between herself and her peers in her hometown:

...differences between women who have chosen to have a family or chosen not to have a family...I feel like a lot of weird stigmas associated with that...I'm like 25 and have no kids...Whereas, people in my hometown are already married and have one or two kids... it's a weird divide...you feel like people expect that of you but then, it's like, 'Nope, not, for me.'

Other participants also discussed this traditional path for women and the pressure they felt from family members, partners, and society to conform to this typical gender role. Women discussed feeling pressures to get married, buy a house, and start a family. Some participants felt an expectation from partners that they would leave school early in order to be home to spend time with their spouse or partner. Most commonly, participants described the pressure they felt to start a family or to have children. One interviewee discussed the challenge of

...getting over the expectation I'm married, I'm almost thirty. Why am I still a student? Why am I not starting a family and going where my husband wants to be? And I get that from his parents sometimes. They're very supportive of what I'm doing, but there's that pressure sometimes to start a family and do the things that women are supposed to do.

Although all participants did indicate a desire to have children in the future, many women expressed guilt due to the fact that they did not already have children or that they were not currently prioritizing family over education and career goals.

Women in Atmospheric Science Experienced Challenges Coordinating their Career Goals in Conjunction with their Partner's Career Goals

Participants discussed the challenge of dual employment for themselves and their partners. They described how often their and their partner's career aspirations seemed to conflict. One interviewee described the difficulty of balancing her career ambitions with those of her partner:

As far as challenges, we're having to give and take because we both have all these professional ambitions and I'm finishing my degree and then he gets to start his... So there's a give and take, and not tension, but we both want so much... I know it's his turn and I would love for him to have a turn but I also want to be able to take care of myself and to take care of us.

Female scientists described barriers that limited their ability to find employment for themselves and their partner. The most common barrier to career development for both partners was geographic location. Multiple students described limiting their search of graduate institution or employment opportunities based on proximity to their partner's work or school location or their partner's likelihood to secure a job in the same location. One woman discussed the possibility of moving and putting her education on hold so her partner could find a job:

... he was unemployed for a little while and that had an influence in that, if he couldn't find a job by the time I was done with my Master's then we probably would need to move...so that he could find a job somewhere else. I would maybe have to put my education on hold so that he could find something to do...

Although some women discussed the individual challenge of factoring in their partner's employment or schooling into their career decisions, most described mutual compromise or sacrifice by both partners. Participants shared how the couple often would make career decisions based on the individual who had the *least* flexible career options or could gross the *most* financially. One woman described how flexibility shaped her and her

boyfriend's future career plans: "...whoever had more flexibility would move to the other person. I mean, if I'm gonna be done in a year, I can move to him, but, if he's done in a year, also, then we can move to wherever I need to be, maybe." Another described her hopes for balancing both of their careers while taking into account geographic limitations:

...I think we're limited by where I can get jobs more than where he can get into med school. 'Cuz, he can apply to 25 schools...so I came up with a list some cities I thought I would have the most likely spots to get atmospheric science jobs and then he's going to apply to schools in those cities, basically, and we'll try to match.

This quote also demonstrates the additional challenge of positions in atmospheric science

being concentrated in limited areas of the country. Multiple graduate students reported

how the concentration of atmospheric science schools and jobs increased the difficulty of

finding a location where both persons could be employed.

Women in Atmospheric Science Viewed Career and Parenting Roles as Conflicting

Interviewees discussed how the demands associated with their education and

career path were often perceived as conflicting with the demands of motherhood.

Participants viewed the challenge of balancing these multiple roles as more difficult for

women than their male counterparts. One interviewee stated:

I think with women in sciences in general it's harder for them to have children. Like, if they were compared to a man at that same level, cuz there's a lot of men in our department who have had kids. And it's different for...women because they have to take off from work...

Another interviewee expanded on these perceived role incompatibilities, suggesting it may be one potential reason women discontinue careers in atmospheric science:

...I think the whole having-a-family thing starts to pull women away from their careers because, I don't think, atmospheric science as a career has found a way to really work with women and family that well.

Women expressed concern for balancing these roles in the future; they were uncertain as to how they would navigate future career and family decisions. Women highlighted academia, specifically the tenure track, as particularly incompatible with having children. Participants described the tenure requirements as daunting and as somewhat incompatible with women's biological timeline for childbirth. One participant shared the advice she was given to delay having children during the tenure process:

Every, female I've talked to said, 'Don't have kids before you have tenure.'...by the time you have tenure, you're like 37 and 38, 40, and...I also don't wanna be raising a teenager when some of my friends are retiring.

Other participants considered abandoning the pursuit of an academic track altogether

because of the perceived inability to have children during the appointment process:

...to be a professor as a woman seems really hard because you're trying to get tenure at the same time that you wanna have kids and so that's been so discouraging: that I don't think I will become a professor.

...I just wish there was a way to delay the tenure process...I mean it's really stressful. You have to publish a certain amount of papers and get grants and have graduate students, and it's just a *horrible* time. Everyone who is a professor at the time from the age of 28 to 35, which is just like the time you're having-, you want to have kids, so I don't know. I think, a lot of women, probably could handle, all doing their work and having a family, but I just don't know if I could.

The perceived role incompatibility between high-status academic positions in

atmospheric science and the ability to have children resulted in some interviewees

thinking that they had to make personal or professional sacrifices. For some women in

atmospheric science, this seemed to take the shape of career sacrifices, as these two

interviewees stated:

I want to have a career but I also don't want to become so wrapped up that my personal life doesn't lose out...I mean, you really can't do it all. Like, something you have to compromise somewhere. So, I personally would rather compromise my work than family...

Well, we just decided that we're going to put our family first. And...even if it comes down to the fact that I'm unemployable because I put my family first, that's the way it's gonna be...I'd rather have a solid family...than a solid career and ignore my kids.

These anticipated tensions between career and family engendered in some women feelings of guilt or discomfort when making personal or professional sacrifices. One

student explained:

I feel like honestly if I don't put my family first, I'm going to feel guilty about it. But, I also feel like if I get a Ph.D. in atmospheric science and I have all these great opportunities presented to me and I'm going to be able to do whatever I want with this, that turning away from that is going to make me feel guilty.

In summary, women in atmospheric science perceived education and career

responsibilities and goals as conflicting with those related to parenting. The academic

track was viewed as particularly incompatible with childrearing. The next section will

discuss how interviewees perceived role models who balanced these domains.

Women in Atmospheric Science Benefited from Exposure to Role Models Who Balanced Career and Family Domains

Exposure to female role models provided some interviewees with career guidance, especially how they would balance work and family. Interviewees discussed gender-specific challenges of balancing these roles and how observing female professors, advisors, and professionals in the field contributed to their array of viable options for balancing these demands in the future. Women also reported looking to peers and their mothers, to learn strategies for balancing multiple roles. One graduate student described how she admired her advisor's ability to balance career and family:

...she's just really well balanced in her life. She does a lot of research and does well in her career, but then she, also, has two kids that she's doing a great job raising. ... She could do both the home and the work and neither person, neither end of it really seemed to suffer, too much.

Women in atmospheric science described how this exposure to female role models demonstrated the ability to achieve both career and family goals and provided them with specific strategies for balancing these domains. Strategies such as delaying child bearing and use of substitute childcare options are discussed in the last section.

Participants also highlighted the benefits of having conversations with female atmospheric science professionals who had balanced work and family. Interviewees appreciated the opportunity to talk with other women about their experiences and learn how they made choices regarding career and family. One student shared the impact it had on her plans for completing her Ph.D.:

I really appreciated her talking to me about that because there's not many other chances to talk about that in our department. And it actually did make a difference in my mind... whether I wanted to stay and get my Ph.D. right away, or if I was gonna go somewhere else for my Ph.D....it was really nice to hear her talk about, it's possible to have kids and a job...

Although most participants discussed the benefits of having female role models in the department or exposure to female professionals in the field, one interviewee noted the benefit of online resources as means to network and communicate about gender-specific challenges. This student discussed participating in *The Earth Science Women's Network* mailing list and how receiving daily e-mails helped her recognize that other women in science were also facing similar challenges. Finally, some female students conveyed the desire for mentorship but reported a lack of females available to them.

Women in Atmospheric Science Benefited from Having Supportive Partners

Participants discussed emotional and practical ways that their partners supported their pursuit of graduate school and career goals. Partners were a resource to talk through challenges, provide encouragement, and convey understanding. Interviewees often said they vented or talked through tough decisions with their partners. Interviewees highlighted the benefit of having someone to share their frustrations with or work through complicated situations. Furthermore, interviewees discussed the benefit of having a partner who showed confidence in interviewee's abilities and offered motivation, compliments, and words of affirmation, as these three excerpts illustrate:

"My husband has been phenomenal through all of this. He's just constantly, 'It's okay,' 'Don't worry, I'm proud of you and you're doing good' and, stuff like that."

"...he has so much faith in me, more so, than he probably should... but I mean it's nice to have that kind of support."

"...he's very encouraging, so overall it enhances-yeah it enhances my career goals..."

Women in atmospheric science described how their partner's ability to relate and empathize with academic or work-related challenges supported their career goals. Some interviewees highlighted that having a partner in graduate school or specifically in atmospheric science allowed for additional support due to their ability to understand specific academic and field-related challenges.

Participants also discussed the benefit of concrete supports from partners, such as

financial assistance or academic advice, examples of which included practicing their

presentations or asking for assistance in understanding complex problems. One

interviewee stated,

Well, positives is that he's very supportive, just someone to support you and to listen to my talks-, presentation at a conference. And he tries to be very interested in what I do. So he's always asking questions and stuff. So it's a good support basically...

Other examples of instrumental support included these:

"During my thesis writing, he did everything around the house for a solid three months so I could just write."

"... we basically live on his salary, so that's been huge and he's so supportive of the whole thing."

In conclusion, these forms of instrumental as well as emotional support were seen by women in atmospheric science as promoting their education and career paths by buffering the stresses of interpersonal conflicts, demanding workloads, and research responsibilities.

Women in Atmospheric Science Desired Flexibility in Career and Family Paths

Interviewees expressed the desire to have a flexible enough career to permit child rearing. This included part-time work and jobs that offered maternity leave, flexible hours, and the ability to work from home. Interviewees specified some research positions as having more flexibility regarding scheduling and location. Here, one student discusses the benefit of a research career:

...if I stay in research, it's great because you have such flexible hours and you basically work for yourself...I can stay home and if the kid's sleeping, I can knock out three hours on my paper and it doesn't really matter where I work.

Another discussed the flexibility in government work:

...they put importance on the family and maternity leave and stuff like that. So, that's more the type of job I want to do because my family will be just as important as my job and so I don't want to have to sacrifice my time with my family...

In addition to seeking atmospheric science careers with flexibility, atmospheric science women considered other options to allow for family time, such as seeking alternative careers, use of childcare options, and delayed child bearing. Due to predicted difficulties in obtaining academic atmospheric science positions while also accommodating for partner and parenting responsibilities, two students discussed considering other career options: ...I would have to consider looking at something, sort of an alternate career path at that point...I could always be a high school science teacher. I think that that would be interesting and fun.'

...maybe kind of adapting and maybe branching out a little bit and saying, 'Okay, well, I've been studying atmospheric science, but maybe I could also teach computer stuff or geography or related things and maybe build a bit more broad thought...'

In addition to seeking flexibility in careers, female scientists also discussed multiple substitute child-care options including daycare, babysitters, extended family, and having their partner stay home. Female scientists desired flexibility in career and family paths as it increased their perception of being able to achieve in both domains.

Discussion

This study explored career goals, challenges, and resources for women in atmospheric science. In particular, this study focused on perceptions of partnership and parenthood as related to education and career pursuits. The goal of the current study was to gain greater insight into challenging and enhancing factors related to these domains and women's strategies for balancing multiple roles.

Although the underrepresentation of women in science has been well documented (NSF, 2000) and recent literature on women in science has surfaced (Macfarlane & Luzzadder-Beach, 1998), there is a lack of research on how women balance scientific careers with family life. Previous studies of women in academia have shown some negative interactions between family and work domains. However, due to the relatively unstudied nature of women in atmospheric science, the current study used an exploratory approach to address theses gaps in the literature.

The present study was conducted to gain insight into enhancing and challenging factors related to work and family domains and women's current and anticipated means

of balancing multiple roles. Six major themes emerged from the data analysis that can be grouped into challenging factors or resources and strategies used to cope with those challenges. In the sections that follow, the key findings will be explored in relation to the existing literature, potential applications of these findings will be highlighted, and limitations of the study will be discussed.

Challenges

One recurring theme discussed by interview participants was experiencing social expectations or pressure to prioritize family. Women reported pressures related to partnership, having children, and fulfilling conventional female role responsibilities. Although some interviewees noted that partners, parents, or in-laws conveyed specific expectations, the source of these messages was not addressed in the interview protocol. However, one could speculate that female graduate students experienced these social expectations and pressures due to dominant cultural scripts that portray appropriate gender roles for males and females.

As previously discussed in the section on gender role theory, women are socialized into caregiving roles (Baber & Allen, 1992) and shoulder the bulk of household and childcare responsibilities (Renk, et al., 2006). Gender expectations are based on pervasive social scripts. For example, although various models and experiences of women have existed throughout time, the stay-at-home post World War II mother is commonly accepted as a standard model of motherhood (Dillaway & Paré, 2008). Encapsulated by popular cultural icons such as June Cleaver from the television show *Leave It to Beaver*, women are portrayed as self-sacrificing and melding one's own needs and interests into those required for the family (Dillaway & Paré; Mintz & Kellogg,

1988). These cultural archetypes convey messages about women's roles in society and place pressures on women to fulfill these gendered roles. In addition to these cultural pressures, some researchers suggest that women may actually experience scientific programs and careers differently than men. For example women may face additional barriers in male-dominated fields and be subject to discriminatory practices (Spelke & Grace, 2007). Although this link to larger cultural scripts or discriminatory practices was not explicitly addressed in the interview questions, women did describe feeling pressured to prioritize family. Experiencing these pressures created stress for the women due to incongruence between their educational and career development choices and the idealized social role for women.

Interviewees also described the challenge of pursuing their own education and career paths in conjunction with their partner's career goals. Interviewees expressed feeling particularly challenged by geographic job availability for both partners, with job opportunities in atmospheric science being particularly limited to only a small number of places in the United States. Also, having a partner in the field was mentioned as challenge due to the need to find two similar positions in the same area.

Geographic challenges related to employment are common among professionallevel dual-earning couples (Ferk, 1999). In fact, there are multiple factors that influence couples' decisions to relocate. A study on women's reluctance to relocate for their career suggested that couples weigh potential gains and losses in job and family investments for both individuals and are influenced by gender-role ideologies (Bielby & Bielby, 1992). For professional women with husbands who had the greatest earnings (and presumably, greatest potential loss of earnings caused by geographic relocation), their wives were

more reluctant to relocate for their own career development (Bielby & Bielby). In the present study, the majority of the women interviewed had partners who also had upperlevel education or professional careers with presumably strong earning potential. Therefore, because these women had partners who also had professional-level careers, finding a location where both partners can be pursue career goals may be particularly challenging. Furthermore, specific limitations such as the availability of atmospheric science institutions may leave women in the field feeling limited by career options.

Therefore, women in atmospheric science, as well as students from other disciplines, may benefit from increased mentoring from faculty who can expand their knowledge of potential career paths and options available in their field. University departments are in a unique position to mentor and provide resources to students that encourage them to think more broadly regarding career prospects (Kay, Hagan, & Parker 2009; Dansky, 1996). For example, women may be encouraged to explore options beyond university settings such as government-sponsored research and private industries. Diverse career opportunities exist for atmospheric scientists through organizations such as the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA). Some atmospheric scientists work in National Weather Service stations throughout the country or are employed by the U.S. Department of Defense in forecasting and other meteorological work (Bureau of Labor Statistics). New jobs are also expected to arise in private industry, including the demand for private weather consulting services that target specific client groups such as famers, commodity investors, insurance companies, utilities, and transportation and construction firms (Bureau of Labor Statistics). Although openings for academic researchers may be limited

due to the small number of positions, mentors can support new atmospheric scientists by increasing their awareness of diverse employment and career opportunities available to them.

Finally, some female atmospheric science interviewees perceived career and parenting roles as incompatible. Some of the women expressed a belief that they would "have" to take time off from work to raise children. Furthermore, interviewees highlighted academia as particularly incompatible with parenting. Women thought that it was nearly impossible to achieve both career and family goals while in academia.

Other studies confirm women's perceptions of education and work outside the home as incompatible with family responsibilities (e.g., Dillaway & Paré, 2008; Springer, Parker, & Leviten-Reid, 2009). These studies highlighted cultural scripts as contributing to perceived incompatibilities between work and family roles. Dillaway and Pare discussed how dominant American culture portrays women as either work *or* family oriented. They suggested that social constructs of women's identity allow them to be workers *or* mothers, but not both. This dichotomous portrayal of women's roles by popular culture may contribute to female scientists' views of work and family as incompatible.

Conversely, other studies have suggested that women are able to incorporate balancing strategies that allow for meaningful participation in both work and home spheres and that they benefit from multiple role involvements (e.g., Barnett & Hyde, 2001; Greenberger & Goldberg, 1989; Halpern, 2005). In fact, some women in the present study mentioned knowing female atmospheric science professionals who balanced work and family roles. The next section will address how communication with

and observation of female role models who balance multiple domains may shape women's appraisals of being able to balance education, career, partnership, and parenthood.

Resources and Strategies

Previous studies document the benefits of female role models and mentors to women in underrepresented fields (Cohoon & Aspray, 2006; Wentling & Camacho, 2008). Cohoon and Aspray noted that same-sex role models are essential to participation, retention, and progression in the subdisciplines of science and engineering. In the present study, women in atmospheric science discussed the benefits of having role models who have experience balancing work and family domains. Women discussed how communication with and exposure to women using various techniques to balance work and family contributed to the perception that multiple role involvement is viable for their future.

This finding, in conjunction with the previous finding on women's perceived incompatibilities between multiple roles, suggests that mentorship related to work and family domains may contribute to women perceived ability to balance these domains. That is, female atmospheric scientists without mentors may view these roles as incompatible and believe that they have to choose career or family. Conversely, exposure to female mentors who balance career and family may alter this perception and provide women with techniques to balance a career in science with partnership and parenthood. These findings support existing literature on the benefits of mentorship in scientific fields (Wentling & Camacho, 2008) and, once again, suggest that atmospheric science departments' personnel have a unique opportunity to impact younger generations of

female scientists. Although additional research may be needed on effective mentorship in atmospheric science departments, women may benefit the presence of female faculty or formal mentorship programs offered through departments, universities, or even online.

Another source of support that participants highlighted was their romantic partner. Female atmospheric scientists discussed how having a supportive partner enhanced their current and future plans for education and career. Women outlined both concrete (i.e., financial assistance, academic advice) and emotional (i.e., encouragement, motivation, understanding) means of support. Previous studies of women in various occupational fields have also documented spousal support as an important factor related to employed women's stress and mental health (Adams, King, & King, 1996; Erdwins, Buffardi, Casper, & O'Brien, 2001; Kulik & Rayyan, 2006). Spousal support has been associated with reduced work-family conflict (Adams et al.; Erdwins et al.). In particular, research has shown that the domain-specific effects of social support are especially strong; support from one's partner reduces family-to-work conflict, whereas support from one's supervisor or co-workers reduces work-to-family conflict (Seiger & Wiese, 2009). Therefore, interviewee's with supportive partners may have experienced less family-towork conflict than those without partners who supported their academic or career pursuits. Furthermore, relevant to the previous discussion on geographic job availability and relocation, Starker (1990) found that spousal support is significantly related to successful adaptation for women in dual-career couples following relocations.

Another means of reducing work-family conflict relates to flexibility in couples' roles. Specifically, female atmospheric science participants expressed a desire for flexibility in career and family pursuits. Considering the career stage (graduate students

and a recent graduate) and age (22-28 years old) of the participants in the current study, flexibility may have been particularly salient and desirable due to their developing career status and being at the age that many women have children. Furthermore, previous research has documented the benefits of flexible work arrangements on personal health and well-being in addition to reducing work-family conflict (Allard, Haas, & Hwang, 2007). Previous research shows that a lack of job flexibility may deter some women from staying in male-dominated occupation fields, such as science (Frome, Alfeld, Eccles, & Barber, 2006). The current study replicates prior findings that women desire job flexibility. As discussed previously, participants viewed research positions as having flexibility in regard to scheduling and location. However, interviewees did not specify the research type (i.e., lab or field based) or career track (i.e., academic, private or public industry, etc.) that might affect some aspects of career flexibility. Additionally, the present study also demonstrated how flexibility in a partner's career is desirable: The more flexible an interviewee and her partner are in work and family domains, the more options are available to them. On the other hand, for persons with rigid career or family needs, participants discussed how the couple would make decisions surrounding the individual with the least flexibility or highest income. The next section will expand on how dual-earner couples make decisions around work and family domains, as documented in the literature.

Participants described a variety of current or anticipated strategies they thought could help balancing work and family, many of which were most feasible if one or both partners were flexible. Becker and Moen (1999), in their interviews with over 100 people in middle-class, dual-earner partnerships, found that many couples engaged in what they

called "scaling back strategies." These scaling back strategies reduced and restructured the couple's commitment to paid work over the life course, and thereby buffered the family from work encroachments (Becker & Moen). Example of scaling back at work included placing limits, distinguishing between a job and a career, and trading off periods of employment with a spouse. Examples of scaling back at home might include having fewer children, limiting leisure time, and reducing expectations for housework. Female graduate students in the present study highlighted similar strategies. However, the experiences of scaling back are not immune to the larger influences of gendered roles. In fact, men and women do not equally participate in scaling back strategies; women disproportionately engaged in more scaling back strategies than did men (Becker & Moen). This trend is also true for women in science careers, showing that women are more likely than men to have inconsistent employment histories due to turn-taking or other means of scaling back (Ceci et al., 2009).

Limitations

Generalizations from this study are limited by several factors. First, the participants were rather homogenous in nature. The women in the sample were primarily European American (n=11) and, for the most part, they came from middle class backgrounds. As well, all but one were in some form of committed relationship, although none of them had children. Although the similarities among these women may have contributed to saturation in the findings, these findings must be interpreted with caution. The present study lacked significant diversity in ethnicity, socioeconomic status, and relationship and parental status. It is possible that if there was greater diversity among the

participants or if the sample focused on a different subgrouping (i.e., women with children) the main findings might have been different.

Another limitation of this study is that it only included participants from a single university. Therefore, the findings are based on a specific academic environment that may not be true of other institutions in various areas of the country. Furthermore, because the participants were all volunteers, the sample may have been skewed towards students who were particularly outgoing or active members of their campus communities. Although efforts were made to minimize this sampling bias by enlisting a wide range of individuals to help with recruitment (i.e., atmospheric science professors, advisors, staff, and former participants), the requirement that participants give at least two hours of their time to be interviewed may have served as a filter that deterred some women from participating.

Implications

One of the resources that women in atmospheric science highlighted as positively impacting their education, career, and family goals was exposure to female role models. As previously discussed, the benefit of female mentors has been reviewed in the literature and studied in other scientific fields. While the women in the present study seemed to struggle with social pressures to prioritize family and perceived conflicts between their career goals and partnership and parenthood, these women also discussed the benefit of having role models who have balanced these domains. However, in order for the positive impacts of mentoring to occur, mentors need to be available and understand the impact they have on women in scientific career fields.

Graduate school is a critical time for women in atmospheric science to make decisions about their future career and plans for partnership and parenthood. Therefore, university departments have an unique opportunity to support women in their decisions regarding work and family. Female mentors (i.e. faculty, advisors, research scientists) play a crucial role in helping these developing scientists better understand the unique challenges of being a female atmospheric scientist and how to navigate work and family domains. From informal communications to implementation of a formal mentoring program, faculty and staff in university departments can help women recognize the various job opportunities available to them and how they can balance family roles while in pursuit of an atmospheric science career.

Conclusion

Considering the limited literature available on women in geosciences, especially pertaining to work and family domains, this study shed light on women's career goals and the challenges and resources they experienced in their pursuit of careers in atmospheric science. Despite the dearth of attention to how women in this field fare at the graduate level, these respondents seemed to be struggling with issues similar to those experienced by university faculty and other professionals further into their careers. Female interviewees experienced pressures to prioritize to family, experienced difficulty balancing their and their partner's career goals, and viewed parenting as conflicting with their career aspirations. Furthermore, resources and strategies accessed by these participants also mirrored the experiences of other professional women in the existing

literature. Female respondents in atmospheric science benefited from exposure to rolemodels who balanced career and family, were positively impacted by supportive partners, and desired flexibility in career and family paths.

The narratives shared by the 12 interviewees illuminated women's perceptions of challenges and resources experienced in atmospheric science. Due to the longitudinal nature of the overarching National Science Foundation study, it will be of interest to see how these women's experiences develop in the future and how their multiple role involvements and balancing strategies shift or remain constant across time. Although much remains unknown regarding women's experiences in the geosciences, this study accentuated the intersection of family and career roles and how they interact to challenge and support women's participation in atmospheric science.

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Appendix I

We would like to invite you to participate in a study of career pathways in science, technology or engineering. The purpose of the study is to describe the career trajectories and experience of science/technology/engineering students or postgraduate individuals. This information is important to developing effective programs to recruit and retain capable students who are interested in careers in these fields. Personal benefits to you may include clarification of your career goals and challenges vs. resources needed for achieving them. We do not foresee any risks to this study. Participation in this study is voluntary. If you do participate, you will be interviewed 1 to 3 times over the next three years. Each interview is projected to last from 45-90 minutes (depending on how much you have to say in response to the questions), and you will be given \$12 for each interview, as compensation for your time. The interviews will focus on your aspirations, expectations, challenges, resources, career options, and so forth related to career directions. If you are interested in participating in this study, please contact Lauren Lessner (laurenlessner@vahoo.com) or Silvia Canetto at 491-5415 (silvia.canetto@colostate.edu). They will answer any questions you have about the study.

Appendix II

1. ID Number*: ____

*Note: for confidentiality purposes, demographic forms and interview transcripts will be labeled only with a randomly assigned ID number and a student-selected alias. A coding form linking student names with ID numbers/aliases will be stored separately from the demographic forms and transcripts, for the purpose of contacting students and linking data for follow up interviews in future years.

2. Age:_____ 3. Sex: _____

Relationship Information:

4. Current Relationship Status:

___Single and Unattached

___Single and Attached

___Married/Commitment Ceremony

5. Please describe your current living situation:

__living alone

__living with romantic partner

__living with roommate(s) \rightarrow please specify relationship (e.g., close friend)_____

__living with relative(s) \rightarrow please specify relationship (e.g., sister)

__other \rightarrow please specify _____

6. If currently in a committed relationship, how long have you been in a relationship with this person?: _____

7. If currently in a committed relationship, please provide the following demographic information <u>for your partner</u>:

Age: _____ Citizenship: ____

(please indicate dual citizenship, if applicable)

8. Check if you have ever been:

Divorced: __yes __no Widowed: __yes __no

9. If currently in a committed relationship, please indicate whether or not your partner is a student, and his/her average number of credits per semester:

 $_Student Part-time \rightarrow \\ _Student Full-time \rightarrow \\$

→ Average number of credits _____

Average number of credits _____

10. If currently in a committed relationship, indicate your partners' current employment status and indicate the number of hours for each line checked:

Employed Part-time	\rightarrow	Average number of hours per week
Employed Full-time	\rightarrow	Average number of hours per week
Not Employed		

11. If you checked "Employed Part-time" or "Employed Full-time" on question #10, what does your partner do for work? _____

12. If you checked "Student Part-time" or "Student Full-time" on question #9, what does your partner study? _____

13. Do you have children?

__yes __no

14. If you answered "yes" to #14, please indicate age, sex, and living arrangements for each child:

15. If you are currently in a committed relationship, does your partner have children from a previous relationship?

__yes __no

16. If you answered "yes" to #16, please indicate age, sex, and living arrangements for each child:

	Age	Sex	Avg. number of days/week the child lives with you
1.)			
2.)			
3.)			
4.)			
5.)			
(cont	inue on rev	verse if necessary)	

17. If you currently have at least one child living in the home, please estimate the average number of hours per week (excluding time in school) that someone *other than you* provides childcare: _____

18. If you do not currently have children, do you plan to have children? (please check one)

- ___definitely yes
- __probably yes
- __probably no
- ___definitely no

Cultural Background Information:

19. Citizenship:______(please indicate dual citizenship, if applicable)

If you are NOT a U.S. citizen, please skip to question #23:

20. Please indicate your ethnicity (select all that	at apply):	
Black/African American	American Indian/Native	
American		
Asian American or Pacific Islander	White/European American	
Latino/a or Hispanic American	Other (please specify)	

If you ARE a U.S. citizen, please skip to question #25:

22. Please specify your ethnicity as it would be described in your country of origin:

23. Please describe your residency status: _____

24. Please indicate your visa status: _____

25. What culture do you most identify with? ______

26. What is the career that you plan to pursue after graduation? ______

27. How would you rate the *prestige* of the career field you named in question #26 within the culture you specified above? (circle one number)

Not prestigi prestigious	ious				Extremely
1	2	3	4	5	6
28. How im	iportant w	as this (presti	ge) to you in n	naking your	career decision?
Not importe	ant				Extremely important
1	2	3	4	5	6
29. How we above? (cire	ould you ra cle one nur	ate the <i>pay</i> of t nber)	his career fiel	d within the	culture you specified
Poorly paid					Very well-paid
1	2	3	4	5	6
30. How im	iportant w	as this (pay) to	o you in makir	ng your care	er decision?
Not importe	ant				Extremely important
1	2	3	4	5	6
31. How lor in the U.S. p	ng have yo part-time)	u lived in the l	United States?	yea	rs (include years living
32. How ma on the past	any months three year	s per year do y s)?	ou spend in th	ne U.S., on av	verage (estimate based

33. Do you plan to stay in the U.S. after finishing your current degree?

- ____definitely yes
- ____probably yes
- ____probably no
- ____definitely no

34. If you have lived in a country other than the U.S. in the past, please list the countries and ages and dates when you lived there (continue on reverse side if necessary):

Country Name (e.g., France)	Ages (e.g., 7-8)	Dates (e.g., 1983-1984)

35. What was your first language?_____

36. What language(s) did you speak growing up? ______

37. What languages do you currently speak fluently?

Education:

38. Current Level in School (please check one):

First Year Undergraduate

____ Master's Program

Second Year Undergraduate

____ Doctoral Program

____ Third Year Undergraduate

____ Fourth Year Undergraduate

_____ Fifth Year or higher Undergraduate

39. Indicate number of years in current program: _____

40. If you are currently enrolled in a Master's or undergraduate program, do you think you will continue your education in this field to earn a Ph.D.?

- ___definitely yes
- ___probably yes
- ___probably no

___definitely no

41. Please list schools you have attended, location, degree, and major (include anything post-high school or equivalent, **and include current enrollment**):

School (e.g., Colorado State University)	Location (e.g., Fort Collins, CO, U.S.A.)	Number of Years at this School	Degree (e.g., B.S.)	Major Field of Study (e.g., Chemical Engineering)

(continue on reverse if necessary)

41. Please indicate your current student status and indicate the average number of credit hours you enroll in per semester and the approximate number of hours you spend engaged in schoolwork per week (lab, studying, classes, etc.):

- $_Part-time Student \rightarrow Estimated number of credits ____$
- __Full-time Student → Estimated number of credits ____

____ Estimated number of hours of schoolwork per week

 \rightarrow

 \rightarrow

42. Please indicate your current job status and indicate the number of hours that you work each week outside of school:

- ___Employed Part-time ___Employed Full-time
- Estimated number of hours per week _____
- Estimated number of hours per week _____

___Not Employed

44. Please estimate your total annual household income:

\$12,000 or below	\$50,000-\$75,000
\$12,000-\$25,000	\$75,000-\$100,000
\$25,000-\$50,000	\$100,000+

45. How many individuals depend on the income level you indicated above? _____

46. What kind of financial resources support (or have supported) your studies? Please indicate <u>those that apply</u>, by estimating the percentage of your total support that has been provided by the following sources. For example, if about 30% of your support comes from your partner's employment, write "30%" on the line next to that option (the percentages should add up to 100%):

Family information:

47. Please provide the following information regarding the members of your family specified below (if known):

Family member	Country of Birth (e.g., France)	Current Country of Residence (e.g., U.S.)	Citizenship (e.g., French)	Languages spoken fluently (e.g., French, English)
Mother				
Other primary female caregiver (specify:)				
Father				
Other primary male caregiver (specify:)				
Maternal Grandmother				
Maternal Grandfather				
Paternal Grandmother				
Paternal Grandfather				
Maternal Great- Grandmother				
Maternal Great- Grandfather				
Paternal Great- Grandmother				
Paternal Great- Grandfather				

48. Do you have any relatives other than those listed on the previous table who currently live in the U.S.?

__yes

__no

49. If you answered yes to #48, please specify relationship (for up to five relatives, starting with the relatives with whom you feel the closest relationship)



50. Do you have any other relatives other than those listed on the previous table who currently live *outside of* the U.S.?

__yes __no

51. If you answered yes to #50, please specify relationship (for up to five relatives, starting with the relatives with whom you feel the closest relationship)



5.)_____

52. The following questions apply to the individual(s) who played a primary role in raising you (e.g., mother, father, grandmother, step-mother, etc.). Please fill out this information for the caretakers who played the most prominent roles in your childhood (at least one but no more than four individuals):

Relationship	Highest level of education	Field of highest degree (if applicable)	Current Employment (please indicate if retired)	Employed Part-time or Full-time?*
<u>Example:</u> Mother	<u>Example:</u> Ph.D.	<u>Example:</u> Mechanical Engineer	<u>Example:</u> Professor, retired	<u>Example:</u> FT

*if retired, please refer to their last job when answering whether this was a part- or full-time job.

53. When you were growing up, did you know anyone who worked in science, technology, math or engineering?

__yes ___no

54. If you answered yes to #53, please list relationship and occupation *(continue on reverse if needed):*

Relationship	Occupation
<u>Example:</u>	<u>Example:</u>
Family friend	Professor of Mechanical Engineering

55. Please estimate the total annual income of the family that raised you:

\$12,000 or below	\$50,000-\$75,000
\$12,000-\$25,000	\$75,000-\$100,000
\$25,000-\$50,000	\$100,000+

56. How many individuals depended on the income level you indicated above? _____

57. How would you describe your family's economic status in the culture you came from?

__lower class __middle class __upper class __other (please describe: _____

)

52. The following questions apply to the individual(s) who played a primary role in raising you (e.g., mother, father, grandmother, step-mother, etc.). Please fill out this information for the caretakers who played the most prominent roles in your childhood (at least one but no more than four individuals):

Relationship	Highest level of education	Field of highest degree (if applicable)	Current Employment (please indicate if retired)	Employed Part-time or Full-time?*
<u>Example:</u> Mother	<u>Example:</u> Ph.D.	<u>Example:</u> Mechanical Engineer	<u>Example:</u> Professor, retired	<u>Example:</u> FT

*if retired, please refer to their last job when answering whether this was a part- or full-time job.

53. When you were growing up, did you know anyone who worked in science, technology, math or engineering?

__yes ___no

54. If you answered yes to #53, please list relationship and occupation *(continue on reverse if needed):*

Relationship	Occupation
<u>Example:</u>	<u>Example:</u>
Family friend	Professor of Mechanical Engineering

55. Please estimate the total annual income of the family that raised you:

\$12,000 or below	\$50,000-\$75,000
\$12,000-\$25,000	\$75,000-\$100,000
\$25,000-\$50,000	\$100,000+

56. How many individuals depended on the income level you indicated above? _____

57. How would you describe your family's economic status in the culture you came from?

__lower class __middle class __upper class

___other (please describe: _____

)

Appendix III

COLORADO STATE UNIVERSITY INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT – FORM A

PROJECT TITLE:	Socialization of and Support for Women in Science
INVESTIGATORS:	Silva Canetto, David MacPhee, and David Randall
PROJECT SPONSOR:	National Science Foundation

Please contact Silvia Canetto (491-5415), David MacPhee (491-5503), or Aki Hosoi (491-2968) if you have any questions or concerns about this study.

PURPOSE OF THE RESEARCH:

The purpose of this research study is to describe the career trajectories and experiences of university students and postgraduates in science/technology/engineering. It is meant to find out about aspirations, expectations, challenges, resources, and so forth that encourage or inhibit individuals from entering careers in these fields. The ultimate goal is to identify ways to recruit, retain, and mentor individuals who are underrepresented in science, technology and engineering.

PROCEDURES TO BE USED:

You will be interviewed up to five times over the course of three years. Each interview will take 45-90 minutes to complete, including completion of a demographic form that will take 10-15 minutes to fill out and which may be completed prior to the interview. The interviews, which may be completed by phone if you have moved out of the area, will focus on the following topics:

- Your experience in science/technology/engineering in general terms of rewards, challenges, and how you were treated by teachers and peers.
- Your aspirations and expectations in relation to a career in science/technology/engineering.
- Unique resources that you brought to a career in these fields.
- Challenges that you might have faced in pursuing a career in these fields.
- Factors that might discourage one from pursuing a career in science/technology/engineering.
- Your future career plans.
- Personal, academic, financial and cultural characteristics, and family situations or demands that might contribute to your career decision making.

The interviews will be digitally recorded and then transcribed for analysis. The digital audio files and transcribed interviews will be identified only with an ID number, and kept for up to five years in case the researchers need to refer back to the data.

Interviewees will be compensated \$12 for each interview that they complete.

RISKS INHERENT IN THE PROCEDURES:

There are no known risks. It is not possible to identify all potential risks in research procedures, but the researchers have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

BENEFITS OF THE STUDY:

The interviews are likely to help clarify challenges that some participants might face in pursuing careers in science/technology/engineering, and the resources that they might bring to bear in surmounting those challenges. As well, the interviews will prompt participants to consider career options, which is a key aspect of career development. This study lays the groundwork for developing more effective mentoring and support programs for individuals who are underrepresented in science/technology/engineering. As a result of this study, we hope that more effective methods will be developed to help high school and college students with career development related to careers in science/technology/engineering, and to recruit, retain, and mentor underrepresented individuals in these fields. Ultimately, this research addresses equal opportunity. If more individuals from underrepresented groups enter careers in science/technology/engineering these careers will be more representative of our society, providing more diverse role models, and there will be more opportunities for rewarding, high-paying occupations for all citizens.

CONFIDENTIALITY:

The transcribed interviews will have ID numbers but no other identifying information in them. A list with names with IDs and contact information, as well as signed consent forms, will be kept in a locked file cabinet separate from the interview transcripts, so that the information you provide about your career pathway cannot be linked to your name. The list of names and IDs will be kept for five years after the conclusion of the study because we may want to conduct periodic followups of how many participants do pursue careers in science/technology. After five years, the list will be destroyed. Computer files that contain the data also will use IDs. Only general findings will be shared with the public, not the specific information about participants.

LIABILITY:

The Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

Questions about participants' rights may be directed to Janell Barker at (970) 491-1655.

Your participation in this research is voluntary. If you decide to participate in this study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled. Your signature acknowledges that you have read the information stated and willingly sign this consent form. Your signature acknowledges that you have received, on the date signed, a copy of this document containing two pages.

Participant name (please print)

Participant signature

Date

Witness to signature (project staff)

Date