The Financial Dilemma of Students Pursuing an Atmospheric Science Graduate Degree in the United States

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ABSTRACT: Graduate school provides an opportunity for students to enhance their knowledge and skill sets and to develop the qualifications to seek high-skilled employment. However, many graduate students are plagued with personal and financial stressors that can decrease research productivity and professional growth. With ballooning student loan debt and economic inflation, stakeholders should review the financial well-being of our current and future graduate students with greater frequency to ensure the continued fast-paced advancement of science. This study investigated the annual stipend, university fees, housing costs, cost of living, and the state income tax rate of 39 atmospheric science graduate programs in the United States to determine the effective income for first-year graduate students in the 2020–21 academic year. Results showed a large spread in advertised stipend amounts ranging between \$19,139 and \$41,520 (USD). After taking into account annual university fees, housing costs, and state income tax and normalizing by the cost of living, effective income had a decreased spread ranging between \$12,287 and \$25,240. Prospective graduate students should not focus on the advertised stipend when deciding between schools since it does not always accurately represent the affordability of the graduate program. The future of scientific research relies on the next generation of scientists. Therefore, graduate programs across the country should focus on providing fair financial compensation in order to attract students with exceptional research skills who otherwise may leave academia to pursue higher-paying jobs after college.

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Graduate school is a time when students devote themselves to growing professionally and mastering various scientific skills. While earning an undergraduate degree in the atmospheric sciences is usually indicative of a working knowledge and general awareness of the subject, a graduate degree is indicative of specialized knowledge, project experience, and a more refined skill set (e.g., theoretical knowledge, data analysis, scientific programming, and professional networking). There are numerous factors that may impact a prospective atmospheric science graduate student's decision on where or whether to attend graduate school. These include employment opportunities after completing their undergraduate education, potential graduate advisor(s), research project, classes offered, location of the school, and size and reputation of the program (e.g., Gilmore and Toracinta 1998).

Another critical factor often included in a student's decision is the affordability of the graduate program. Most graduate programs in Science, Technology, Engineering, and Mathematics (STEM) generally provide higher stipends for graduate assistantships compared to programs in social sciences or humanities (Greiman et al. 2015). In addition, many STEM students are funded through federal fellowship programs [e.g., National Science Foundation (NSF) Graduate Research Fellowships Program (GRFP) and Department of Defense (DoD) SMART Scholarship-for-Service Program] especially at the Doctor of Philosophy/Science degrees (PhD/ScD) level (Kuenzi 2008). Therefore, graduate coursework and experience is often considered as full-time employment and substitutable for professional experience (e.g., the AMS Certified Consulting Meteorologist Program). As professionals, graduate students naturally evaluate the financial package and benefits provided by a graduate program either before they apply or when comparing offers from multiple graduate programs. Furthermore, with increasing student loan debt in recent years (Looney and Yannelis 2015; Friedman 2018), the affordability of a program may gain higher relevance in a student's decision on where or whether to attend graduate school. Therefore, prospective graduate students may carefully evaluate their financial health and well-being, including taking active measures to avoid struggling financially while working toward their graduate degree.

When a prospective student receives a graduate school offer, their award letter states the stipend that they will receive. Sometimes the individual program will explain in the offer letter any tuition or fee expenses that the student will be required to pay. However, information on other living expenses is usually absent and difficult to independently obtain given the multiple, often-obscure resources that must be referenced to acquire this information. Therefore, students often compare the advertised stipends among the programs they have received offers from. However, students should accurately determine their effective income by taking all expenses into account (e.g., tuition, fees, state income tax, and housing). Gilmore and Toracinta (1998) conducted a study to highlight the importance of understanding these expenses, including health insurance, in order to determine the effective income at a given atmospheric science graduate program. They recommended that information regarding cost of living and program expenses be readily available to prospective students, yet these recommendations were never followed. In fact, this pioneering study has recorded zero citations from 1998 to 2020 according to Google Scholar. This study serves to update the work of Gilmore and Toracinta (1998) by compiling and making public the information of 39 atmospheric science graduate programs in terms of stipends, tuition, fees, state income tax, and housing costs. Furthermore, a simple method is provided for prospective graduate students to determine their effective income for programs not included in this study.

While the results of this study may be useful for prospective students, graduate programs and universities may also strategically use the information presented in this paper to advance their program goals. For example, if a highly reputable program in the field has an undesirable lower-than-average advertised stipend but is also characterized by desirable low living expenses and cost of attendance, the program may calculate the difference between the

stipend amount and expenses. This way, they can highlight a potentially comparable and/or higher effective income when compared to other graduate programs in the United States. On the other hand, graduate programs/universities who are failing to attract high-caliber students due to financial packages characterized by a lower-than-average effective income may consider increasing their spending for graduate assistantships and benefits in order to attract and retain top-quality graduate students. Sometimes funding streams, both internal (e.g., state government support) and external (e.g., research grants from government or industry), can create unique funding challenges for universities which limit the amount of funding departments can offer students. University leadership/administrators could use the information to work strategically to improve or maintain the research productivity of their respective institutions.

The remainder of this paper is organized as follows. The data and methods utilized in this study are outlined, followed by a discussion of the limitations. Next, some simple statistics on stipend amounts, expenses, and effective income are presented. Statistical correlations between stipend amounts, effective income, and expenses are then discussed. Finally, concluding remarks and policy recommendations are presented.

Data

An in-depth analysis of the stipends of 39 out of 46 graduate programs in the United States offering degrees in meteorology or atmospheric science was conducted (Table 1). The list of programs was obtained from the National Hurricane Center Library (www.aoml.noaa.gov/general/lib/lib1/nhclib/SCHOOLS.html). Initially, stipend and university fee information were obtained from department and university websites. These numbers were later verified or corrected by contacting each program individually since many of the websites were not updated with current information and/or were unclear about summer pay and full-time equivalent (FTE) hours for graduate students. The authors directly contacted faculty and staff members for all 46 graduate programs to report stipend and fee information. A total of 34 programs responded to the request for this information. While multiple faculty and staff members from each department were contacted numerous times, some programs chose not to respond. The editor of this paper then contacted the remaining 12 programs and the authors received additional responses, bringing the total responses to 39 programs.

Only schools which offer a PhD in meteorology or atmospheric science were included in this study. Incoming first-year graduate student stipend amounts for graduate research or teaching assistantships and associated required university fees for the 2020–21 academic year were obtained by contacting administrators or faculty members of the various departments. Many graduate programs do not offer funding for terminal Master of Science (MS) students. However, MS students that are funded typically receive the same benefits as incoming PhD students (without an MS). Some schools reported estimates of the stipends and university fees for the 2020–21 academic year, as they had not yet been set by the department, university, or the state. Stipends were obtained and totaled for the entire school year and summer months, i.e., annual stipends are reported.

For data on mandatory cost of attendance/fees, several assumptions were made when requesting the total annual required university fee amounts. Such assumptions include that first-year students are either U.S. citizens or U.S. permanent residents without a (MS) degree, that the mandatory university fees are charged at a full-time student status rate, and that the student elects to opt out of paying particular optional fees. Often, international and non-first-year students pay different fee amounts. Additionally, all programs surveyed in this study offered tuition waivers to students.

Information on housing cost (rent) for each graduate program's location was obtained from the Fair Market Rent (FMR) data that were determined by the U.S. Department of Housing

Table 1. List showing the annual stipend, annual mandatory fees, state income tax, annual housing costs, meal and incidental (M&IE) rates, standardized cost of living (SCL), raw income, and effective income for the 39 universities analyzed in the study. All values except SCL are in U.S. dollars.

Institution	Stipend	Mandatory fees	State income tax	Housing costs (yearly)	M&IE	SCL	Raw income	Effective income
Colorado State U.	34,500.00	2,815.22	1,031.55	7,464	61	0.97	23,189.23	23,880.41
Columbia U.	41,520.00	195.00	1,793.66	11,700	76	1.21	27,831.34	23,004.13
Florida State U.	25,462.37	2,121.87	0.00	6,114	61	0.97	17,226.50	17,739.96
Georgia Institute of Technology	28,500.00	2,000.00	1,045.95	6,900	66	1.05	18,554.05	17,659.57
Harvard U.	37,932.00	0.00	1,691.77	13,866	71	1.13	22,374.23	19,795.90
Iowa State U.	25,104.00	1,142.17	805.84	5,142	55	0.88	18,013.99	20,574.66
The Johns Hopkins U.	33,333.00	500.00	1,283.32	8,016	71	1.13	23,533.68	20,821.73
North Carolina State U.	27,500.00	2,576.00	918.50	6,978	56	0.89	17,027.50	19,100.65
The Pennsylvania State U.	31,185.00	0.00	957.38	5,718	61	0.97	24,509.62	25,240.16
Princeton U.	30,800.00	0.00	452.00	8,736	61	0.97	21,612.00	22,256.17
Purdue U.	22,000.00	596.00	677.60	5,022	56	0.89	15,704.40	17,616.46
Rutgers, The State U. of New Jersey	33,170.00	0.00	494.23	10,620	61	0.97	22,055.77	22,713.17
Saint Louis U.	22,000.00	654.00	292.60	5,430	66	1.05	15,623.40	14,870.21
Scripps Institute of Oceanography	32,000.00	0.00	592.00	15,420	71	1.13	15,988.00	14,145.59
South Dakota School of Mines and Technology	24,216.00	5,600.70	0.00	5,046	61	0.97	13,569.30	13,973.75
U. at Albany, State U. of New York	26,500.00	1,614.00	871.85	6,324	61	0.97	17,690.15	18,217.43
Texas A&M U.	24,300.00	0.00	0.00	5,628	56	0.89	18,672.00	20,945.38
Texas Tech U.	22,200.00	3,000.00	0.00	5,148	55	0.88	14,052.00	16,049.47
The Ohio State U.	24,000.00	496.80	0.00	5,952	61	0.97	17,551.20	18,074.34
U. of Alabama in Huntsville	24,000.00	0.00	909.60	4,692	55	0.88	18,398.40	21,013.71
U. of Alaska Fairbanks	25,223.00	0.00	0.00	7,950	N/A	N/A	17,273.00	N/A
The U. of Arizona	19,139.00	1,333.42	179.91	5,694	61	0.97	11,931.67	12,287.31
U. of California, Irvine	34,867.00	0.00	707.80	13,296	66	1.05	20,863.20	19,857.40
U. of California, Los Angeles	37,478.00	0.00	847.00	11,736	66	1.05	24,895.00	23,694.83
U. of Colorado Boulder	39,735.00	1,730.00	1,275.49	10,296	66	1.05	26,433.51	25,159.16
U. of Hawai'i at Mānoa	31,798.00	1,000.00	1,691.65	12,300	N/A	N/A	16,806.35	N/A
U. of Illinois at Urbana–Champaign	28,784.04	850.00	1,312.55	5,172	55	0.88	21,449.49	24,498.51
U. of Oklahoma	27,926.27	2,808.15	840.58	5,436	55	0.88	18,646.54	21,519.84
U. of Maryland, College Park	28,663.02	634.00	1,063.40	10,500	76	1.21	16,465.62	13,609.74
U. of Miami	30,312.00	598.00	0.00	9,750	66	1.05	19,964.00	19,001.55
U. of Missouri	21,852.00	1,890.00	286.26	5,364	55	0.88	14,311.74	16,346.13
U. of Nebraska–Lincoln	20,500.00	2,350.00	438.70	5,190	55	0.88	12,521.30	14,301.19
U. of North Dakota	23,683.51	919.65	125.52	4,992	55	0.88	17,646.34	20,154.74
U. of Texas at Austin	27,132.00	0.00	0.00	8,136	61	0.97	18,996.00	19,562.20
U. of Utah	28,000.00	1,200.00	1,386.00	7,056	56	0.89	18,358.00	20,593.15
U. of Washington	33,623.00	745.00	0.00	12,594	76	1.21	20,284.00	16,765.84
U. of Wisconsin–Madison	29,810.00	1,452.00	894.30	7,116	61	0.97	20,347.70	20,954.19
U. of Wisconsin–Milwaukee	23,222.00	1,507.30	522.50	5,532	66	1.05	15,660.21	14,905.24
U. of Wyoming	27,035.00	0.00	0.00	5,700	55	0.88	21,335.00	24,367.74

and Urban Development (HUD) for every county in the United States in 2020 (www.huduser.gov/portal/datasets/fmr.html). Generally, the FMR for an area is the amount needed to rent modest housing, including the cost of all utilities except telephone, cable or satellite television, and

Internet (U.S. Department of Housing and Urban Development 2019). FMR accounts for local differences in rent rates and utility costs at the county or metropolitan area level; however, this may not be representative of where graduate students actually live. Similar to Gilmore and Toracinta (1998), data were obtained for a two-bedroom apartment, thereby making the assumption that graduate students have at least one roommate with whom they would evenly split rent.

To determine the cost of living, per diem meal and incidental (M&IE) rates were obtained from the U.S. General Services Administration (GSA)'s website (www.gsa.gov) for 2020. M&IE data were used to normalize income to account for differences in local cost of living. GSA does not directly calculate M&IE for Hawaii and Alaska, so they were omitted from this part of the analysis. Although M&IE is a metric for cost of visiting (e.g., Doyle 2011) and represents the money needed to purchase food and incidentals, it should be closely related to the cost of living. In fact, M&IE and the Bureau of Economic Analysis (BEA) regional price parities (RPP) track very similarly (Aten and Figueroa 2014). State taxes were also included in this analysis as they differ largely by state and income amount. State income tax rates were determined based on the total stipend amount and individual state tax tables and obtained from Smart-Asset (smartasset.com/taxes/), which is a financial technology company.

Methods

First, the advertised stipend amount that an accepted student would see on their award cover letter was compared among all programs. The breakdown of expenses (i.e., rent, university fees, and state tax) for each program was then computed as well as the total dollar amount of these expenses. A raw income was then computed for each program using the following equation adapted from Gilmore and Toracinta (1998):

$$\text{Raw Income} = S - \left(\text{MF} + \text{ST} + \frac{\text{FMR}}{2} \right), \quad (1)$$

where S is the annual stipend, MF is annual mandatory university fees (not including any health-insurance-related expenses), ST is state tax, and FMR is the annual housing cost for a two-bedroom apartment. Note that the FMR is divided by 2 based on the aforementioned assumption that most graduate students will share this cost equally with a roommate. Next, effective income was determined by dividing the raw income by the standardized cost of living (SCL). The SCL was calculated by the following equation, which compares the local M&IE and the mean M&IE ($\overline{\text{M\&IE}}$) of the schools in the contiguous United States:

$$\text{SCL} = \frac{\text{local M\&IE}}{\overline{\text{M\&IE}}}. \quad (2)$$

Here, an effective income was calculated, which was not done in Gilmore and Toracinta (1998), in order to represent how the cost of living dramatically differs across the United States. For instance, if two schools have approximately the same raw income but are located in areas of the United States with distinctly different costs of living, standardizing these results provides an estimate for effective income.

The analysis presented here also included determining the correlation between various factors based on Pearson's r correlation, which inherently quantifies linear relationships. The first relationship determined was between advertised stipend and effective income to understand whether programs with high advertised stipends also have the highest effective incomes. The second relationship calculated was between expenses and effective income to determine whether programs with high expenses correlate with low effective incomes. This would also show if students are paid the same across institutions with a variety of fees and differing living expenses. Finally, the relationship between advertised stipend and expenses

was analyzed to understand whether graduate programs offer a higher stipend in order to offset and compensate for higher expenses.

Limitations

A limitation of this work pertains to not including health insurance as a part of expenses. While health insurance can be a major expense for some students, there is a great deal of complexity in determining the cost and benefits of health insurance plans due to the various options that exist (e.g., employee-sponsored, state-sponsored, or marketplace health insurance plan). Health insurance options, benefits (including dental and vision plans), and costs vary significantly between programs and are therefore difficult to quantify. Additionally, many graduate students may be under the age of 26 and could be a dependent on their parent's health insurance policy. Students dependent on their parent's health insurance policy may partially pay toward the total health insurance costs. Furthermore, students on their parent's health insurance may have the insurance at a reduced rate since they are a dependent on a pre-existing policy. Prospective students should also factor health insurance or any other personal financial circumstances when determining their effective income.

In this study, the 12-month incoming student stipend amount was analyzed, and the authors have made no distinction between research and teaching assistantships (RA and TA). It is common practice for programs to use a combination of these assistantships to fund students for a 12-month period (e.g., TA during the fall and spring semesters and RA during the summer months). The effects of using multiple funding lines usually has a minimal impact on the total 12-month stipend. Furthermore, some programs such as the University of Maryland, College Park, offer "Enhancement Fellowships" and "PhD Flagship Fellowships" to incoming students in addition to their regular stipend. Additionally, the University of Wisconsin–Madison offers a \$500 welcome/moving allowance in advance of a student's first university paycheck and offers a competitive counteroffer policy to students with multiple graduate school offers.

Advertised stipend amounts, expenses, and effective income

The comparison of the advertised stipends among the 39 programs is shown in Fig. 1. The mean and median advertised stipend amount was \$28,400 and \$27,900. Eighteen schools have advertised stipends greater than both the mean and the median, while 19 schools have advertised stipends less than both the mean and median. Overall, the highest advertised stipend was found for Columbia University (\$41,520) and the lowest advertised stipend was found for The University of Arizona (\$19,139). Thus, there is a difference of \$22,381 between the highest and lowest advertised stipends.

The estimated mandatory and living expenses among the 39 programs are shown in Fig. 2. Overall, rent is the largest expense for most programs, with a mean value of \$7,790 per year. The school with the highest rent expense was the Scripps Institute of Oceanography at the University of California, San Diego (\$15,420), and the lowest was the University of Alabama in Huntsville (\$4,692), which creates a range of \$10,728. The second highest expense incurred for first-year graduate students in the 2020–21 academic year was annual university fees, which has a mean expense of \$1,085. The highest fee expenses were for South Dakota School of Mines and Technology (\$5,600),¹ and the lowest non-zero fees were for Columbia University (\$195). These values create a range of \$5,405. All programs typically covered tuition costs via tuition waivers given to research assistants funded by research grants and teaching assistants funded by the department, but do not typically cover university fees.

¹ This program requires funded students to pay a part of their tuition and mandatory fees.

State taxes were the smallest expense, with a mean value of \$700. The highest state tax was incurred at Columbia University (\$1,793), and the lowest non-zero state tax incurred was for the University of North Dakota (\$125), resulting in a range of \$1,668. Several programs are

Fig. 1. The advertised stipend amount (in $\times 1,000$ U.S. dollars) from 39 universities for incoming first-year graduate students during the 2020–21 academic year. The mean (dashed blue line) and median (dashed red line) are shown for reference and reported in the legend.

located within states that do not require a state income tax, which include Alaska, Florida, South Dakota, Texas, Ohio, Utah, Washington, and Wyoming. Therefore, students attending programs in any of these eight states did not incur a state income tax expense. For overall expenses incurred, the highest was determined for the Scripps Institute of Oceanography (\$16,012) and the lowest was determined for University of Alabama in Huntsville (\$5,601), thus creating a range of \$10,410.

Analysis of the effective income for each of the programs is shown in Fig. 3. The mean and median effective income was \$19,332 and \$19,796. Eighteen schools have an effective income greater than both the mean and the median, while 17 schools have an effective income less than both the mean and median. The Pennsylvania State University (\$25,240) boasted the highest effective income, and the range between highest and lowest was \$12,953. Therefore, after taking expenses into account, effective income has a smaller range than the range between the advertised stipends among the 39 programs.

Correlation between stipend amounts, expenses, and effective income

The relationship between advertised stipend and effective income is shown in Fig. 4a and is a positive statistically significant relationship (Pearson's $r = 0.586$, p value = 0.00). Therefore, schools with a high advertised stipend are expected to have a high effective income. An example of this relationship is shown at The Johns Hopkins University, which has a high advertised stipend and a high effective income. Conversely, The University of Arizona has a low advertised stipend and a low effective income. However, the relationship is not perfect because

Fig. 2. Estimated mandatory and living expenses (in $\times 1,000$ U.S. dollars) from 39 universities for incoming first-year graduate students during the 2020–21 academic year. The mean rent (dashed blue line), mandatory fees (dashed orange line), state taxes (dashed green line), and total expenses (i.e., sum of the three dashed lines depicted using a solid black line) are shown for reference and reported in the legend in parentheses.

effective income is likely influenced by the inability of M&IE to capture all the variability in the cost of living pieces, and/or the unequal adjustments of stipends by individual schools.

Figure 4b shows a nonsignificant and slightly inverse relationship between expenses and effective income (Pearson's $r = 0.013$, p value = 0.938). In an ideal world all schools would fall along a horizontal line, indicating that regardless of expenses, all graduate students are effectively paid the same amount across the United States. It would also be favorable to have the effective income as high as possible. For example, programs that are far below the others in the effective income could consider raising their base stipend in order to raise this horizontal line in Fig. 4b.

The relationship between advertised stipend and expenses is shown in Fig. 4c. There is a statistically significant relationship between advertised stipend and expenses (Pearson's $r = 0.774$, p value = 0.000). This implies that most graduate programs across the country are doing well at actively taking steps to ensure that stipends reflect the given graduate program expenses (e.g., university fees and living expenses). However, more efforts may be considered in order to attain a Pearson's r correlation closer to 1.00. Some policy recommendations that may result in a more uniform effective income among atmospheric science graduate students across the country are detailed in the next section.

Further comparison of the advertised stipends and effective income highlights the importance of a prospective student determining their effective income when deciding between

Fig. 3. The effective income (in $\times 1,000$ U.S. dollars) from 37 universities for incoming first-year graduate students during the 2020–21 academic year. The mean (dashed blue line) and median (dashed red line) are shown for reference and reported in the legend.

programs, and not simply comparing the advertised stipends. For example, analysis of the advertised stipends (Fig. 1) showed that Iowa State University had a low advertised stipend and was \$2,796 and \$3,296 less than the median and mean. However, the effective income for Iowa State University was approximately \$1,243 and \$779 more than the mean and median (Fig. 3). A counterexample to Iowa State University is the University of Washington, which had an advertised stipend well above the mean and median (Fig. 1). However, after taking expenses into account, the effective income for the University of Washington decreased below both the mean and median (Fig. 3).

Concluding remarks and policy recommendations

In this study, the stipends of 39 meteorology/atmospheric science programs for first-year PhD students without an MS degree in the 2020–21 school year were evaluated. The primary motivation for this study was to investigate the affordability of graduate programs across the country, which showed that prospective students should not only focus on the advertised stipend in an offer letter, but also focus on the local cost of living. Students should also weigh non-financial metrics such as the reputation of the institution and the PhD advisor as key factors in their decision-making process. For instance, citation indices from Google Scholar may be used to evaluate a potential advisor's and program's research quality and quantity. Additionally, students and future studies could use the S-Rank and R-Rank from the National Research Council (The Chronicle of Higher Education 2010) as a viable metric to assess these reputations more quantitatively.

Fig. 4. The relationship between (a) advertised stipend amount and effective income (Pearson's $r = 0.586$, p value = 0.000), (b) expenses and effective income (Pearson's $r = 0.013$, p value = 0.938), and (c) advertised stipend amount and expenses (Pearson's $r = 0.774$, p value = 0.00) for incoming first-year graduate students during the 2020–21 academic year. The dashed red lines represent the means of the variables on each axis.

The Department of Health and Human Services (HHS; <https://aspe.hhs.gov/poverty-guidelines>) sets the poverty line as an estimated minimum level of income needed to secure the necessities of life. An annual income of \$51,040 is 400% of the poverty line. People below this annual income can often take advantage of various federal assistance programs, including subsidized health insurance through the Affordable Care Act. An annual income of \$38,280 is 300% of the poverty line. People below this annual income can take advantage of more extensive federal and state assistance programs. Only two of the graduate programs analyzed in this study, namely, Columbia University and the University of Colorado Boulder, are above the 300% poverty line before the payment of expenses.

These financial situations tend to impact people from underrepresented and economically disadvantaged backgrounds more so than other graduate students. For instance, students from higher-income families may have some financial support from their parent(s) or other family members (Zhang 2005; Cole and Espinoza 2011). This may directly hinder the goals of graduate programs, as well as the weather, water, and climate enterprise to increase diversity. Economically disadvantaged students may choose not to attend graduate school due to immediate and long-term financial concerns (Allen-Ramdial and Campbell 2014).

Furthermore, prospective graduate students accepted with funding to pursue a graduate degree in atmospheric science are typically students with high grade point averages, extracurricular activities, and work and research experience (e.g., NOAA's Hollings Scholars, NSF-sponsored Research Experiences for Undergraduates programs, and NCAR/UCAR's Significant Opportunities in Atmospheric Research and Science program). Given that the typical timeframe for completing a PhD is between 4 and 7 years (NCSES 2018), it is indeed unfortunate to put students with so much potential in a poor economic situation for a considerable period of time. This poor economic situation may also discourage or inhibit graduate students from completing their degree.

As inflation and the cost of living continues to increase in the United States, stipends will need to increase to keep up with economic trends and sustain higher effective incomes for graduate students. Otherwise, graduate students may find it increasingly difficult to purchase their basic necessities, afford an enjoyable life, and save money for potential emergencies and retirement. On a more concerning note, the most talented prospective graduate students may choose not to pursue a graduate education or decide to discontinue their studies and research work after obtaining a bachelor's or master's degree, therefore diminishing the overall research productivity and scientific output from the United States (Malcom and Dowd 2012; Xue 2014). Action should be taken to ensure graduate students do not fall below the poverty line, can lead a comfortable life, and can fully embrace graduate coursework and research. There is considerable evidence indicating the emotional/mental health stresses of pursuing a graduate education (Panger et al. 2014; Walker et al. 2015; Milrad 2016). Reducing the financial burden for graduate students may considerably mitigate these stressors and improve research productivity.

Also, universities should be more transparent in their reporting of stipends and mandatory university fees. For instance, the authors of this paper were forced to contact schools after many inconsistencies were found on university and departmental websites. It would be helpful for students if these items were clearly displayed on departmental websites and in offer letters provided to prospective students. Additionally, departments should be more responsive to student email inquiries about stipend and fee information, as some universities did not respond to the authors' requests for information but did respond to the editor's request. It is also unethical that some schools only provide stipend and fee estimates to prospective students in offer letters. Departments, universities, and state agencies should be prudent and decide their stipend and fee amounts in advance of providing offer letters to students. This information is crucial for graduate students in order for them to create personal budgets and compare offers from various institutions. Additionally, the status of stipends may impact the reputation of certain departments if students choose to attend a different program or choose not to attend graduate school. A recurring issue of this nature would ultimately decrease research activity and graduate enrollment for the given program. Compilation of current stipend and expenses data may be of great utilization for departments that strive to remain competitive and attract top-quality students.

If programs cannot increase their advertised stipends, perhaps they can compensate for some of the incurred expenses, such as university fees. Many universities, especially public universities, have been increasing fees to increase revenue, and to compensate for "tuition freezes" and state-/board of trustees-mandated restrictions on state funding (Bell et al. 2011). While many scientific research grants that support graduate students are from the NSF, as per the Code of Federal Regulations OMB Circular A-21, the NSF cannot pay university fees. Therefore, mandatory university fees cannot be paid through NSF grant funds; however, they could be paid or partially paid using funds from the department/college. On average, 4% of the stipend amount (Table 1) is spent on university fees, effectively making this part of the advertised stipend unusable income that is taxed at both the state and federal level.

One option to mitigate the impact of university fees is to withhold the amount directly from the advertised stipend. In this case, a student would be taxed on a lower income, which is a better reflection of the true take-home salary.

In summary, this study has served to address the financial dilemma that many prospective graduate students face when evaluating the affordability among graduate programs across the country. Results from this study suggest that graduate students in the atmospheric sciences earn a mean annual stipend less than \$38,280, which is 300% of the poverty line, and the poor financial plight of graduate students appears to be accepted and institutionalized. This study also encourages prospective students to determine their effective income. For example, some universities may advertise an above-average stipend, but higher expenses (e.g., rent and university fees) may significantly lower the effective income. Graduate school increases research aptitude and creativity and benefits students by helping them grow intellectually and professionally. This study encourages university administrators and federal and state agencies/representatives to conduct reviews at a higher frequency on the affordability of a graduate education and financial well-being of graduate students. We also recommend that professional societies such as AMS, AGU, or UCAR track, update, and make available the stipend information of all graduate programs.

An active competition among universities to attract and retain students with great potential, creativity, and determination should ensure the high-quality science and research productivity being generated at well-regarded atmospheric science graduate programs in the United States. While budgetary constraints are widespread, programs being slow or unwilling to make investments in graduate education may be unable to attract and recruit highly skilled candidates. Failing to attract the best candidates will most likely diminish research output, which goes against most universities' strategic plans. Overall, the framework provided in this study, i.e., the effective income calculation, should be utilized by current and prospective graduate students of any discipline to consider the affordability of the program. We also hope this article will spark conversations between departments and university officials on how to improve the financial dilemma and well-being of graduate students.

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