Earth and Space Science Collaboration During a Pandemic: An Analysis of AGU Journal Submissions and AGU Fall Meeting Abstract Authors, 2018-2020

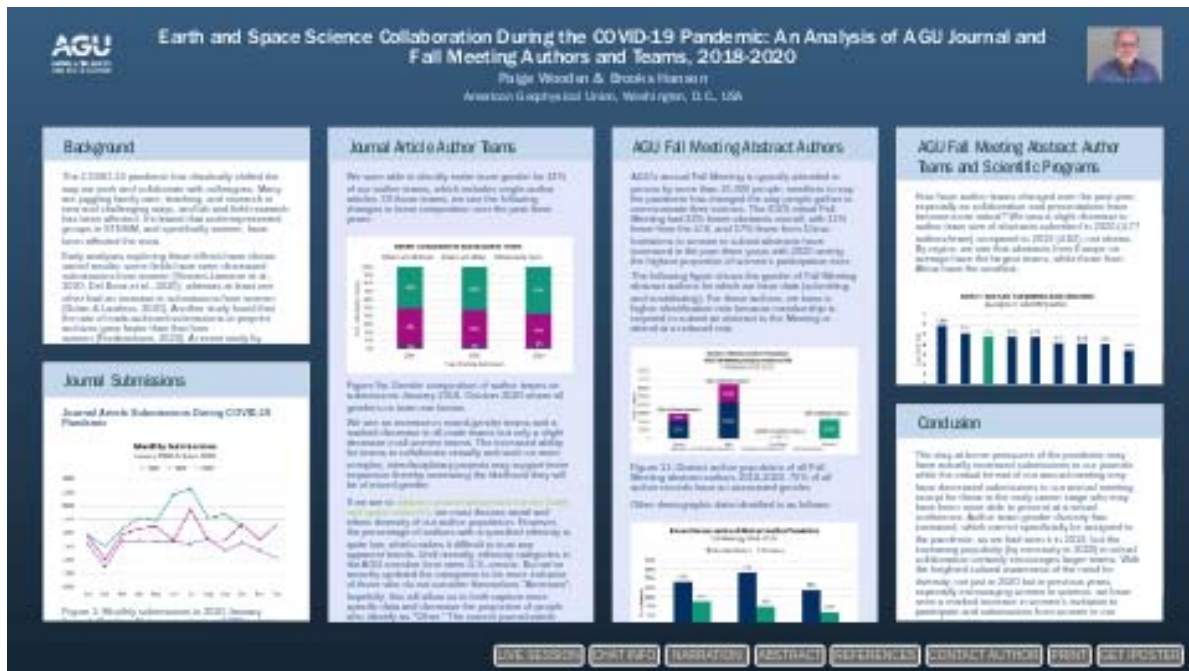Paige Wooden[1] and Brooks Hanson[1]

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Abstract

The American Geophysical Union (AGU) has extensive journal submission and annual meeting abstract data that we can use to study effects within the Earth and space science (E&SS) community. We had provided an initial analysis based on data through June of 2020 (Wooden, 2020), and here we provide journal submission data analysis through October 2020 and analyze author team demographics of both journal submissions and our annual Fall Meeting abstracts. This most recent analysis shows: 1) Monthly journal article submissions have increased in 2020, while the proportion submitted by women have remained at 23% with monthly fluctuations of +/- 1-3 points. 2) 2020 journal article submissions from China surpassed those from the U.S. in every month except April. However, AGU Fall Meeting abstracts from China decreased 57% compared to last year. 3) Submissions from men and women in their 20s decreased while submissions from women in their 30s and 50s and men in their 40s increased. 4) Among journal articles and meeting abstracts, average author team size has increased; the proportion of mixed gender teams have increased while all-male teams have decreased. All-female teams have remained steady. 5)The age of submitting abstract authors has decreased but surprisingly with a smaller proportion of students submitting and a larger proportion of early-career researchers submitting abstracts.

Earth and Space Science Collaboration During the COVID-19 Pandemic: An Analysis of AGU Journal and Fall Meeting Authors and Teams, 2018-2020

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PRESENTED AT:

BACKGROUND

The COVID-19 pandemic has drastically shifted the way we work and collaborate with colleagues. Many are juggling family care, teaching, and research in new and challenging ways, and lab and field research have been affected. It's feared that underrepresented groups in STEMM, and specifically women, have been affected the most.

Early analyses exploring these effects have shown varied results: some fields have seen decreased submissions from women (Vincent-Lamarre et al., 2020; Del Boca et al., 2020), whereas at least one other had an increase in submissions from women (Dolan & Lawless, 2020). Another study found that the rate of male-authored submissions to preprint archives grew faster than that from women (Frederickson, 2020). A recent study by Squazzoni et al, 2020 found that of submissions to Elsevier journals (February and May), women in more advanced stages of their careers were submitting proportionally fewer manuscripts than men. And finally, recent survey data from the American Geosciences Institute showed that by August 2020, most U.S. academic institutions commenced lab activities and field work for both graduate students and faculty. On the one hand, this increased access may anticipate an increase in future research outputs, but on the other, with evolving instructional formats and family obligations, it still might not be feasible for some groups to take advantage of this increased access. And, as of December 2020, with an increase in cases in much of Europe and the U.S. and colder temperatures, we've seen a return to social distancing regulations, which could again curtail in-person lab and field work.

The American Geophysical Union (AGU) has extensive journal submission and annual meeting abstract data that we can use to study effects within the Earth and space science (E&SS) community. We had provided an initial analysis based on data through June of 2020 (Wooden & Hanson, 2020), and here we provide journal submission data analysis through October 2020 and analyze author team demographics of both journal submissions and our annual Fall Meeting abstracts.

This most recent analysis shows that:

- Monthly journal article submissions have increased in 2020, while the proportion submitted by women have remained at 23% with monthly fluctuations of +/- 1-3 points.
- 2020 journal article submissions from China surpassed those from the U.S. in every month except April. However, AGU Fall Meeting abstracts from China decreased 57% compared to last year.
- Submissions to AGU journals from men and women in their 20s decreased while submissions from women in their 30s and 50s and men in their 40s increased. However, Fall Meeting abstract submissions from people in their 20s and 30s increased while submissions from all older age groups decreased.
- Among journal articles, average author team size has increased but slightly decreased on 2020 Fall Meeting abstracts; the proportion of mixed gender teams have increased while all-male teams have decreased while the proportion of all-female teams have remained steady.
- Invitations to women to present at the Fall Meeting have increased as have meeting abstract submissions from women.

Scope of this analysis includes:

Journal article submissions January 2018- October 2020 and AGU Fall Meeting abstract submissions from 2018-2020. Data includes:

- Counts of new (first version) articles; excludes revised article submissions. Resubmissions of rejected articles are counted as new articles.
- Author gender, year of birth (to calculate age cohort in the year of submission), career stage, ethnicity, and country from matched records in our member database.
- We used Gender-API.com to guess the authors with unknown gender. From the Gender API results, we included ~64,000 additional authors' gender in our analysis in which Gender API has a 90+% confidence rating.
- Author team analysis and gender composition of teams with all known gender (41% of journal articles and 72% of abstract author teams).

JOURNAL SUBMISSIONS

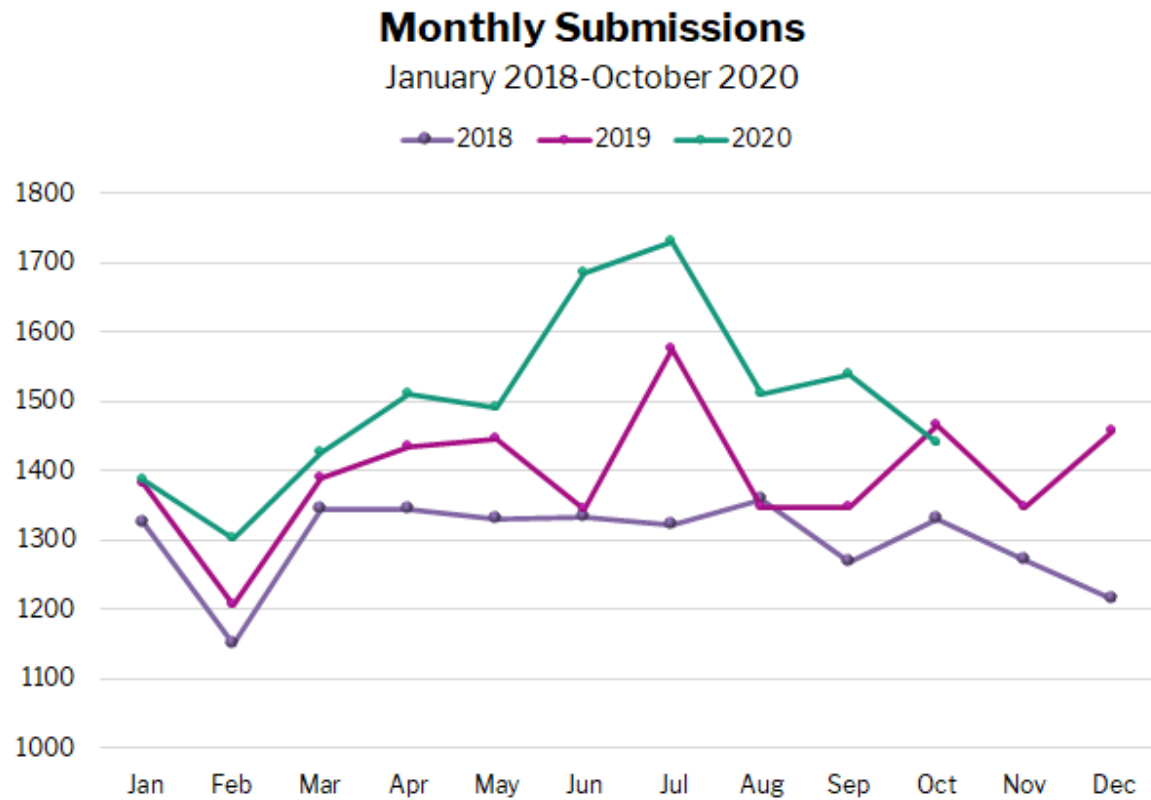**Journal Article Submissions During COVID-19 Pandemic**

Figure 1: Monthly submissions in 2020 January through October. Note y-axis starts at 1000 to better show differences.

Submissions in 2020 were nearly the same as or higher than submissions in the same month in previous years with the largest differences seen this summer. We see similar seasonal fluctuations in 2020 compared to 2019. October 2020 was the first month this year where submissions were lower than the same month in the previous year. This does coincide with an earlier Fall Meeting poster and recorded talk deadline.

Overall, submissions have increased during the COVID-19 pandemic: January-October submissions in 2020 were 15016, compared to 13932 in 2019 and 13102 in 2018.
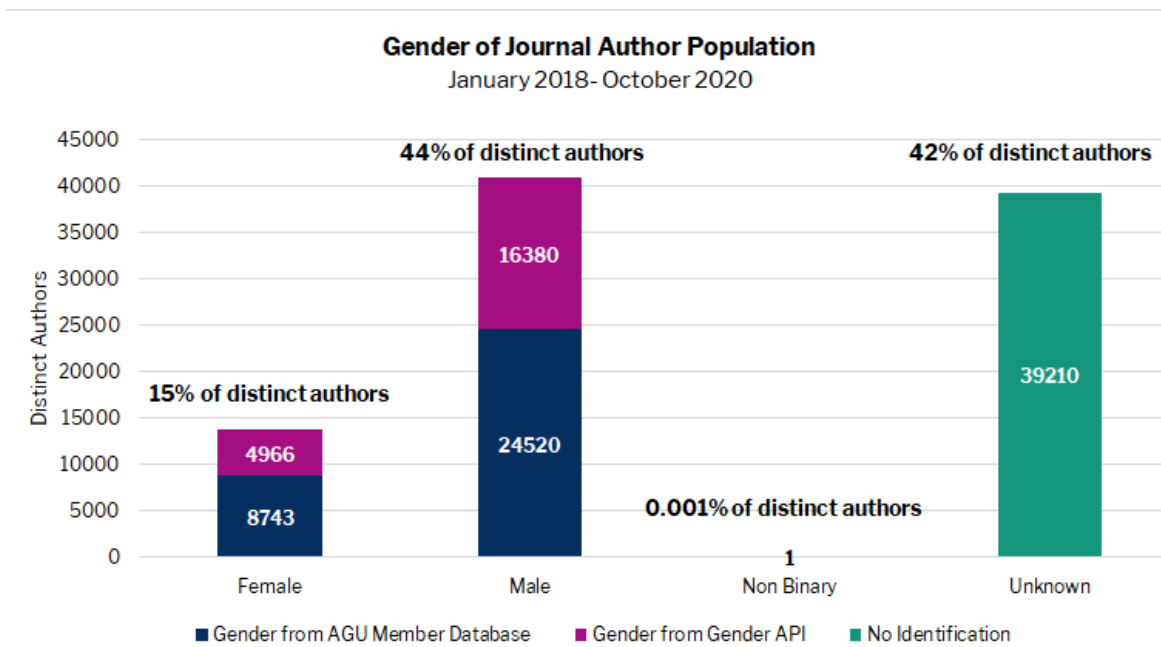
Author Population Demographics

Figure 2: Distinct author population of all journal article authors January 2018-October 2020. 15% of authors are female, 44% male, and 42% unknown gender. Overall, 68% of all author records have an associated gender. Of papers where we know the gender, 23% of submitting authors are women.

This was also the first year AGU offered the gender category "non-binary" in our member form and have seen this category appear in journal submission and Fall Meeting abstract analysis. Hopefully showing this data gives others who identify as such stronger feelings of inclusiveness in the AGU community.
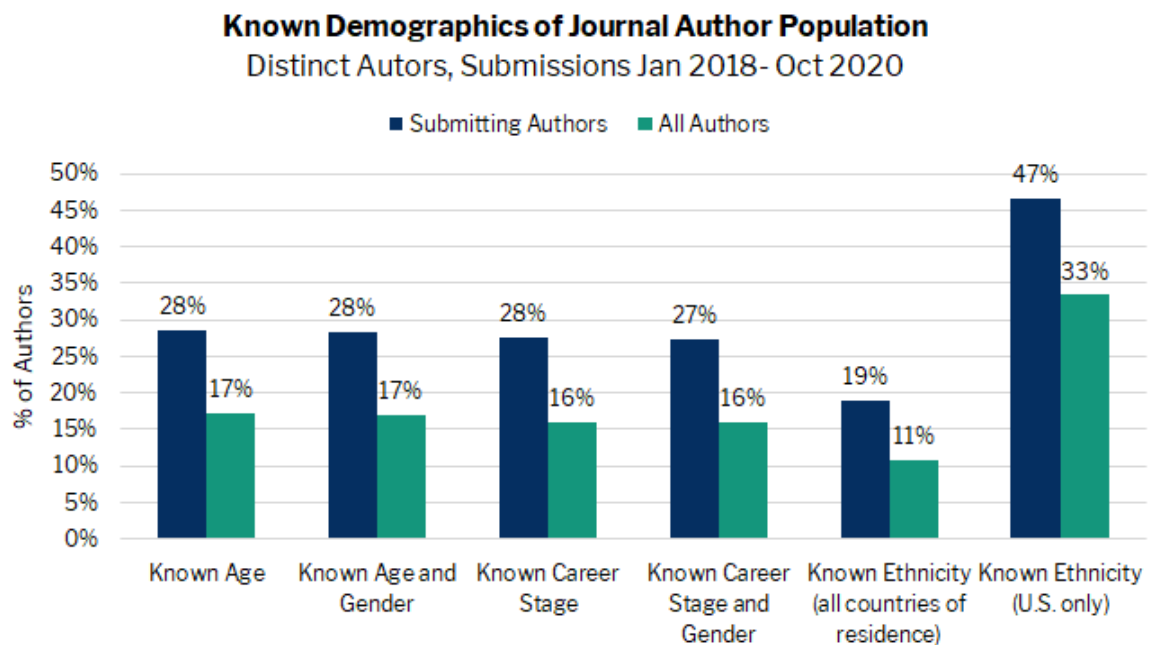

Figure 3: Proportion of distinct author population in dataset with demographic data from our member database.

Submissions by Country

Figures 4a and 4b shows the monthly submissions in 2020 from top submitting countries. Authors from China submitted slightly more papers than those from the United States during this time.

We did see a drop in submissions from most countries from January to February, but as seen in overall submissions (Fig. 1), February submissions were lower than surrounding months in previous years as well. After March, we saw a steady increase

until July, which had the highest number of submissions ever. After July, we saw a decrease in submissions and have witnessed this trend into October. Exceptions include submissions from U.K., Germany, Canada, and Australia, which were strong in September and/or October.
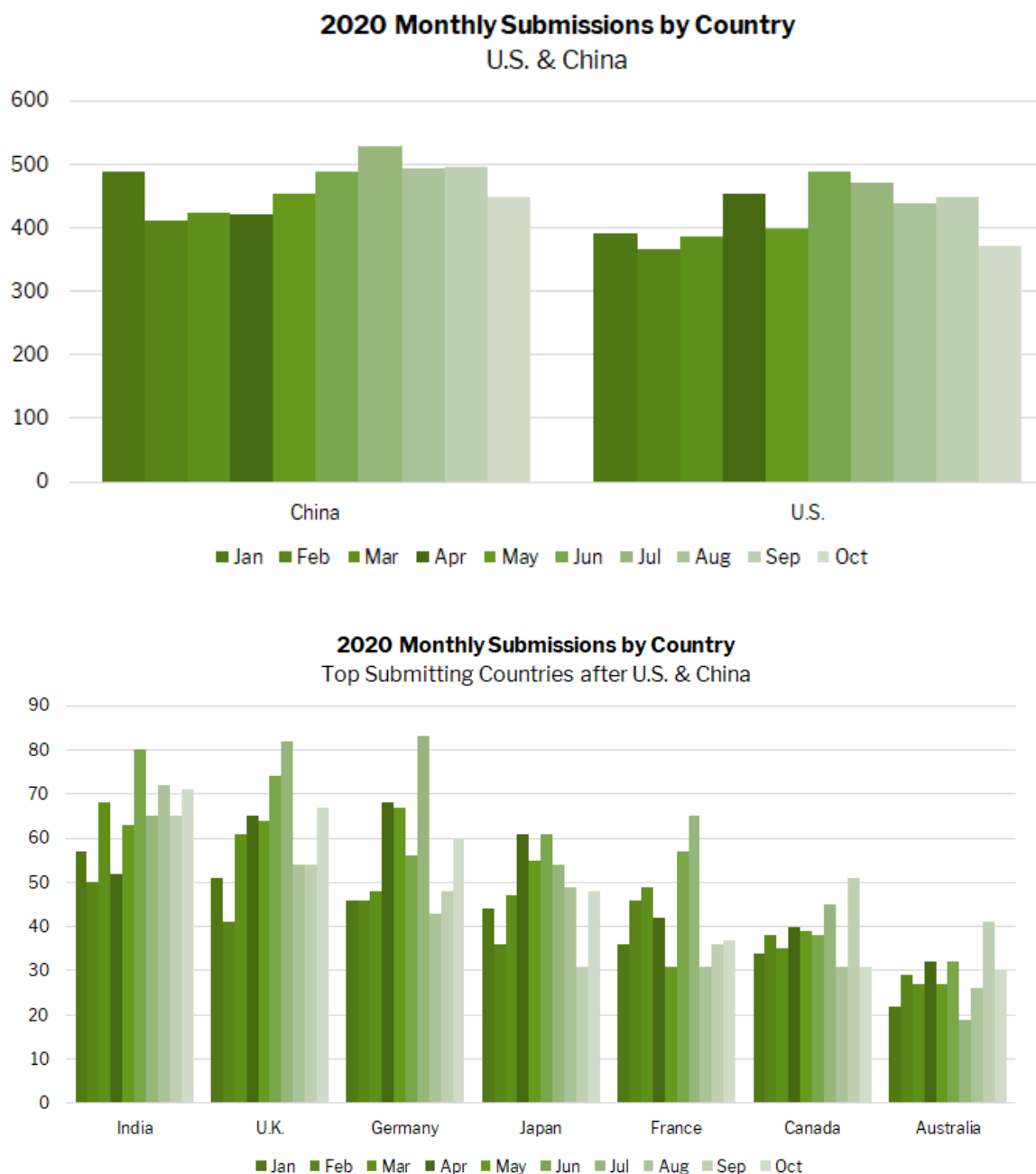
Figures 4a & 4b: Submissions by country of submitting author; China and U.S. separated for scale.

Annual Submissions by Country Jan - Oct (YTD), 2018-2020
U.S. & China

Annual Submissions by Country Jan - Oct (YTD), 2018-2020
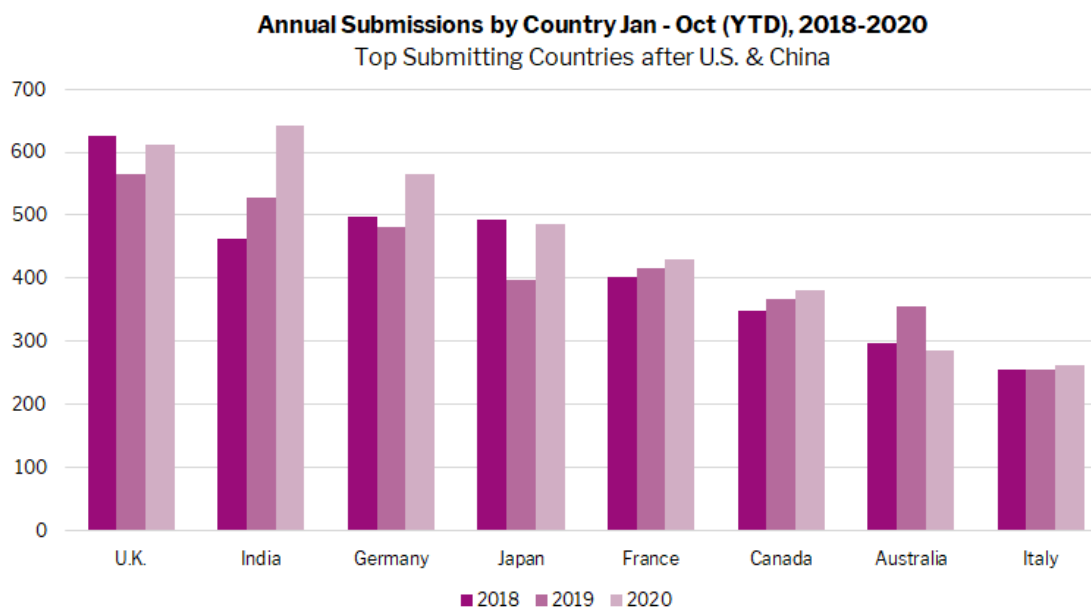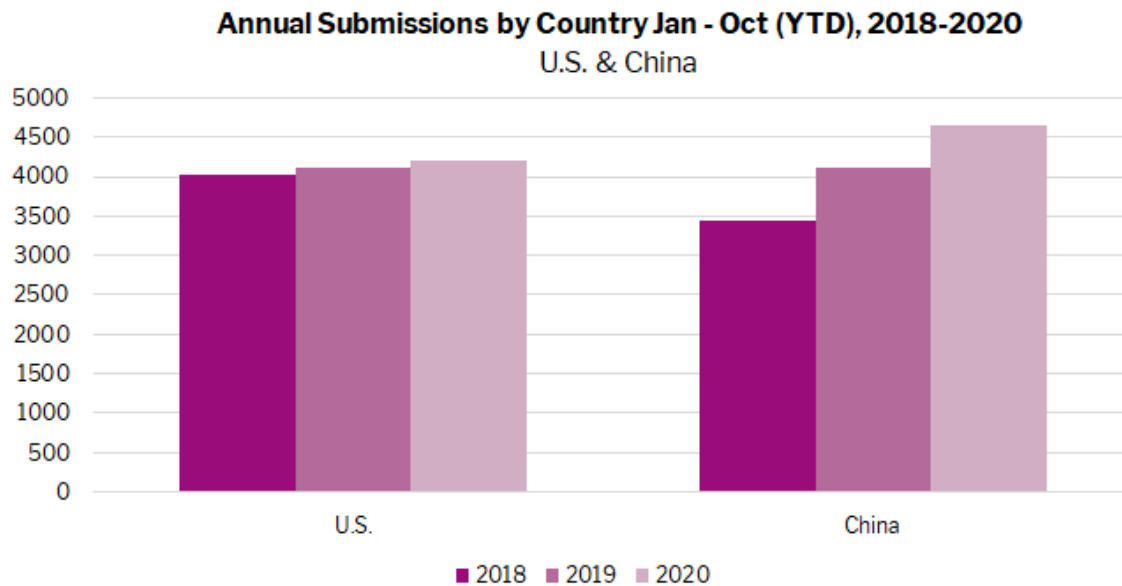### Top Submitting Countries after U.S. & China

Figure 5a & 5b: Submissions in January- October 2020 (YTD) to the previous 2 years showing the country of submitting author (only top submitting countries shown).

We have seen a slight increase in submissions from the U.S. compared to previous years, but significant increases in papers from China and India. Smaller increases compared to last year-to-date were seen from Germany, Japan, France, Canada, and Italy.

Submissions from women

Percentage of Monthly Submissions from Female Authors
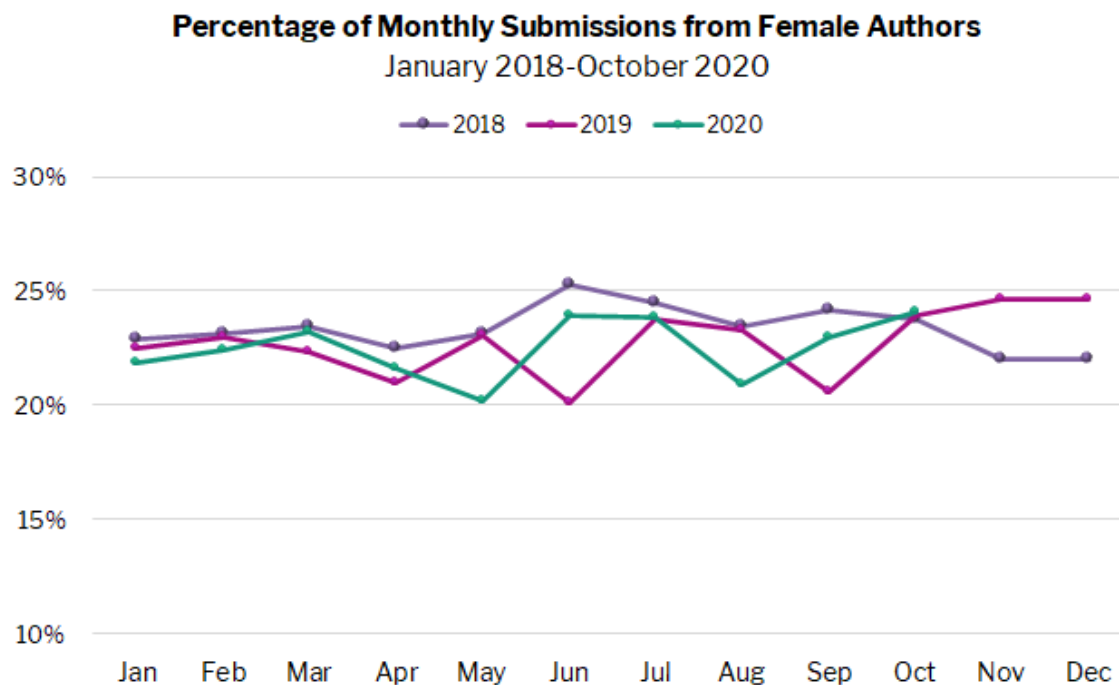### January 2018-October 2020

Figure 6: Percentage of women submitting articles by month of submission. Percent calculation excludes those with unknown gender. Note the y-axis starts at 10% to better show differences.

2020 levels are close to those in previous years with similar seasonal trends. The exceptions are May and August, which saw proportional decreases in submissions from women compared to submissions from men in those months. Overall, the proportion of annual submissions from female corresponding authors has remained at 23% from 2018- 2020 YTD. The absolute number of submissions from women have increased YTD compared to the previous two years, as shown in Figure 7:

Submissions from Female Submitting Authors
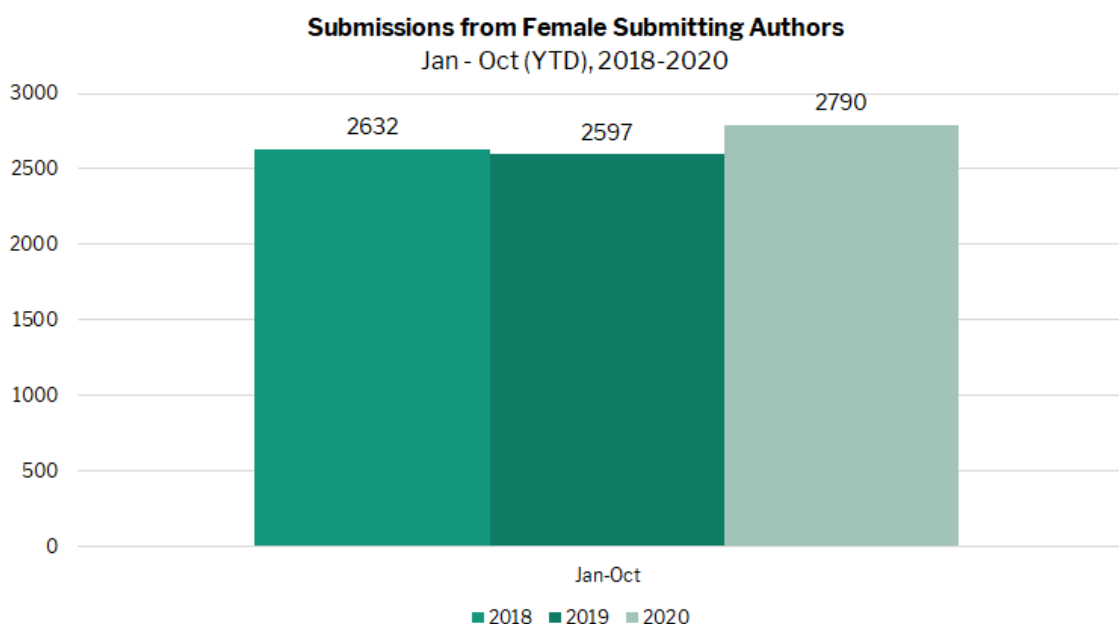### Jan - Oct (YTD), 2018-2020

Figure 7: Year-to-date comparisons of the absolute number of submissions from women. Counts are non-distinct (each person is counted for each new manuscript submitted).

Age cohorts of submitting authors

Figures 8a and 8b show a year-to-date comparison of submissions from women and men in each age group. Percentages are out

of all submitting authors with known age and gender, January- October of that year. We see a **decrease** in men and women in their 20s submitting manuscripts and an **increase** in submissions from people in their 40s. But submissions from people in their 30s differ between men and women: while women in this age group are submitting more, men are submitting slightly fewer manuscripts this year.
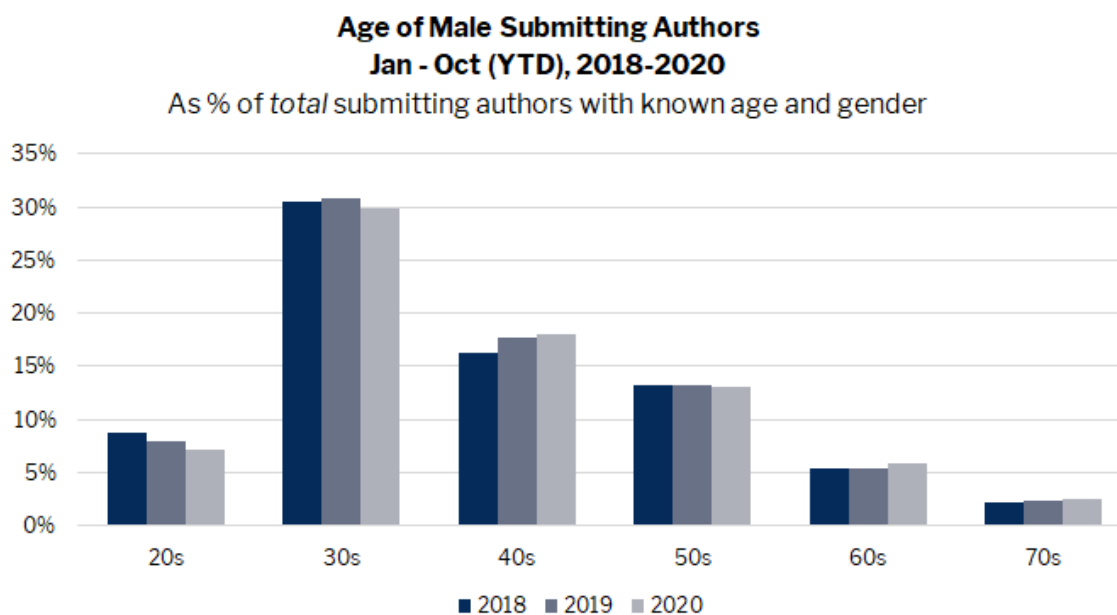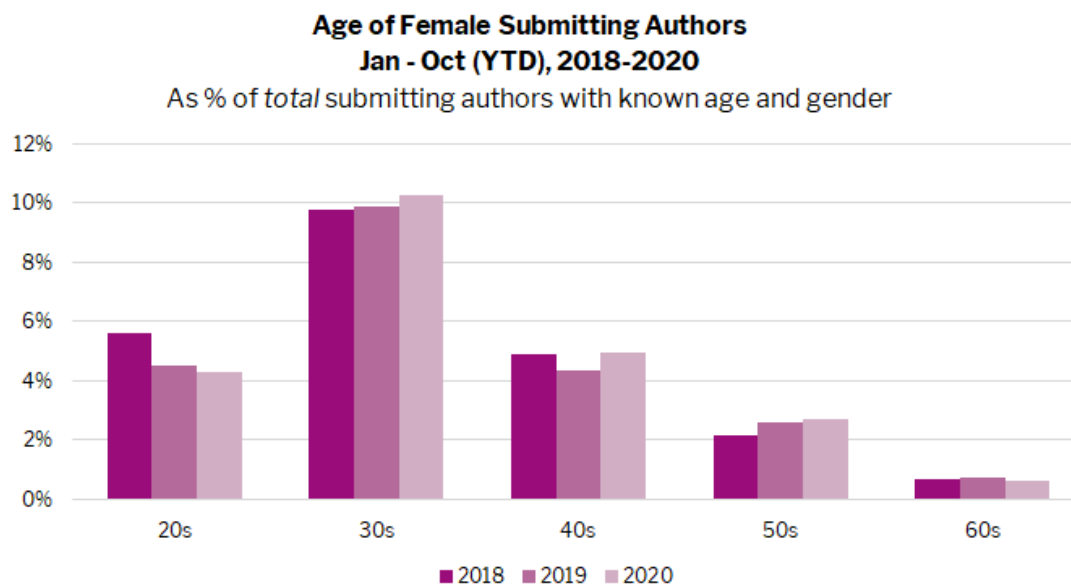

Figure 8a and 8b: Age of non-distinct female and male submitting authors shown as a percentage of all non-distinct submitting authors with known age and gender during indicated year. Age groups 80s and 90s not shown (<1%).

These graphs show a steady decrease in the proportion of men and women in their 20s submitting articles over the past three years. Women in their 30s and 40s have taken up the decrease in submissions from women in their 20s; men in their 40s and 60s have taken up this decrease. These changes in age and gender groups don't suggest that additional responsibilities imposed by the pandemic (e.g., changes in instructional format, childcare, and/or homeschooling) have decreased the rate of submissions from certain vulnerable age groups. One hypothesis is that submitting files and metadata is less intellectually taxing than conducting and analyzing the research itself and can be done from home any time of the day.

JOURNAL ARTICLE AUTHOR TEAMS

We were able to identify entire team gender for 41% of our author teams, which includes single-author articles. Of those teams, we see the following changes in team composition over the past three years:
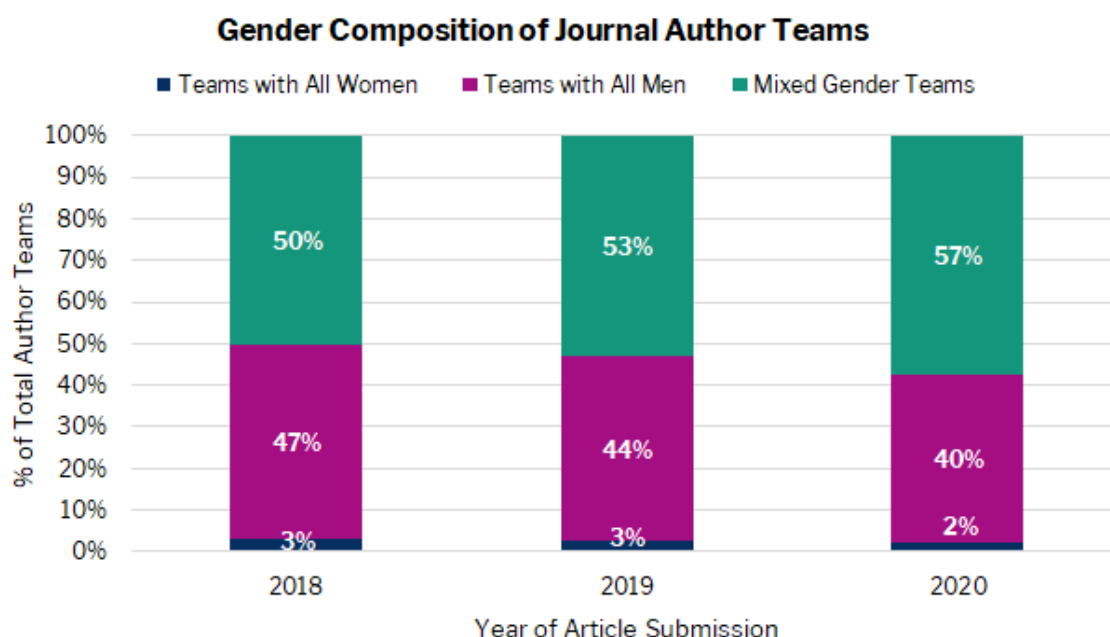

Figure 9a: Gender composition of author teams on submissions January 2018- October 2020 where all genders on team are known.

We see an increase in mixed-gender teams and a marked decrease in all-male teams but only a slight decrease in all-women teams. The increased ability for teams to collaborate virtually and work on more complex, interdisciplinary projects may support team expansion thereby increasing the likelihood they will be of mixed gender.

If we are to address underrepresentation in the Earth and space sciences (https://fromtheprow.agu.org/agu-commits-to-8-action-areas/), we must discuss racial and ethnic diversity of our author population. However, the percentage of authors with a specified ethnicity is quite low, which makes it difficult to trust any apparent trends. Until recently, ethnicity categories in the AGU member form were U.S.-centric. But we've recently updated the categories to be more inclusive of those who do not consider themselves "American"; hopefully, this will allow us to both capture more specific data and decrease the proportion of people who identify as "Other." The current journal article author population (2018-2020) includes 35% of U.S. authors reporting a specific category, and the following graph is restricted to authors in the U.S. (~25% of the distinct author population in this dataset). The following graph shows 0.1% increase in authors identifying as African American, and a 0.7% increase in those identifying as Hispanic/Latino (the latter of which we also see later in Fall Meeting abstract author population).

Race/Ethnicity of All Journal Article Authors
Distinct autors (submitting and contributing) by submit year
U.S. only, excludes "other," "prefer not to answer," and unknown

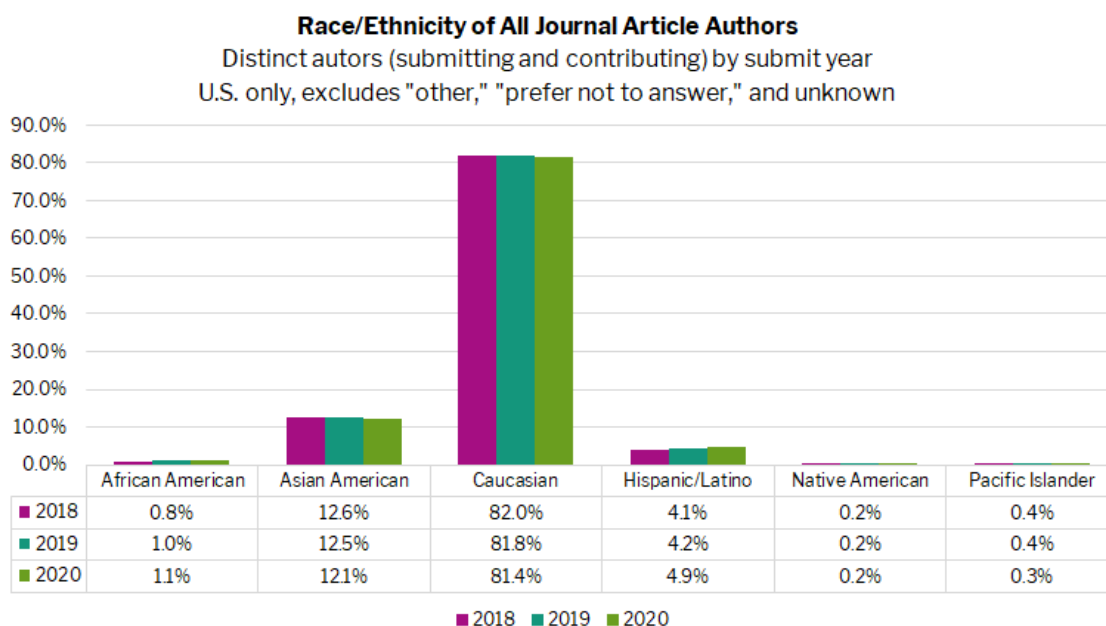|	African American	Asian American	Caucasian	Hispanic/Latino	Native American	Pacific Islander
2018	0.8%	12.6%	82.0%	4.1%	0.2%	0.4%
2019	1.0%	12.5%	81.8%	4.2%	0.2%	0.4%
2020	1.1%	12.1%	81.4%	4.9%	0.2%	0.3%

Figure 9b: Race/ethnicity of all journal article authors, distinct by year (submitting and contributing). Since categories imply American citizenship/identification, proportions only include U.S.-based authors who declared a specific race/ethnicity in AGU member profile (excludes unknown, and those who selected "prefer not to answer" and "other.")

We have also seen an increase in average author team size over the past three years: submissions in 2020 had an average of 5.42 authors while submissions in 2018 had an average of 5.2 authors.
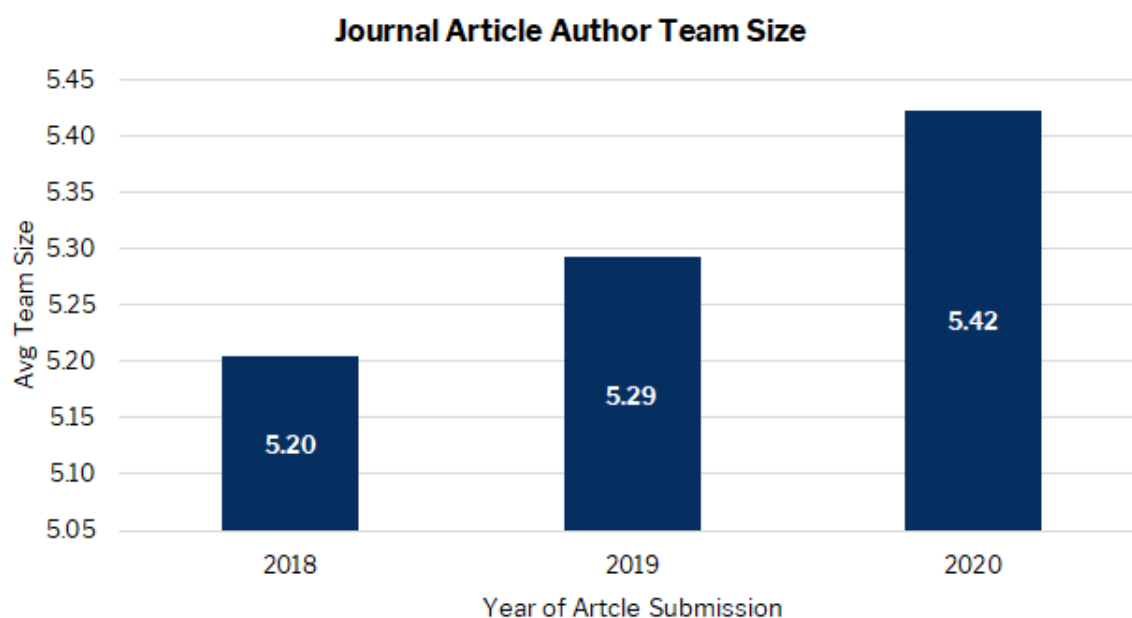
Journal Article Author Team Size

Average Team Size: 2018 = 5.20, 2019 = 5.29, 2020 = 5.42

Figure 10: Average journal article author team size from January 2018- October 2020.

Journal Article Submission Summary

Overall, from January through October, we have not seen significant increases or decreases in submissions or changes in relative submissions by men or women or from any age group that we can clearly assign to the pandemic. We do see an increase in submissions in general. We will continue to monitor these data and trends. Team size has increased slightly as have mixed gender teams.

AGU FALL MEETING ABSTRACT AUTHORS

AGU's annual Fall Meeting is typically attended in person by more than 25,000 people; needless to say, the pandemic has changed the way people gather to communicate their science. The 2020 virtual Fall Meeting had 22% fewer abstracts overall, with 11% fewer from the U.S. and 57% fewer from China. Invitations to women to submit abstracts have increased in the past three years with 2020 seeing the highest proportion of women's participation ever.

The following figure shows the gender of Fall Meeting abstract authors for which we have data (submitting and contributing). For these authors, we have a higher identification rate because membership is required to submit an abstract to the Meeting or attend at a reduced rate.
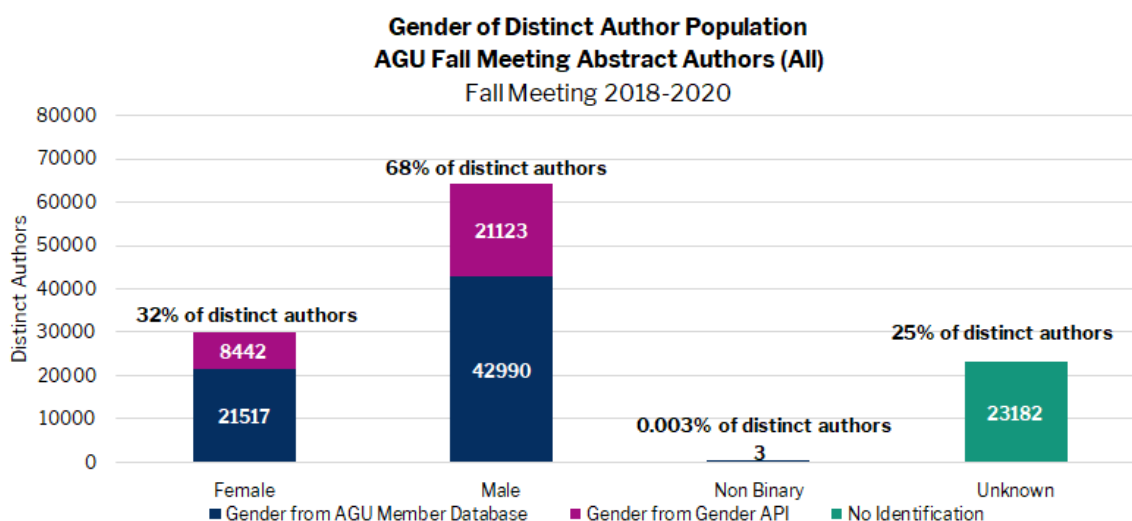

Figure 11: Distinct author population of all Fall Meeting abstract authors 2018-2020. 75% of all author records have an associated gender.

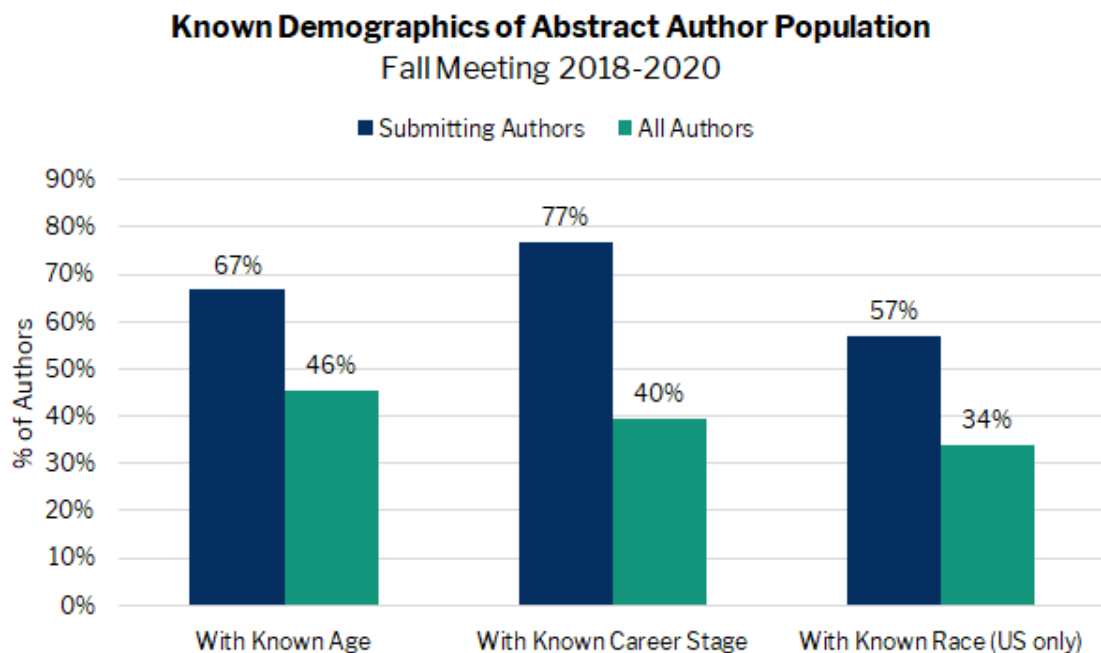Other demographic data identified is as follows:

Figure 12: Proportion of authors on Fall Meeting abstracts with known age, career stage, and race (U.S.-based authors only).

Invitations and Submissions

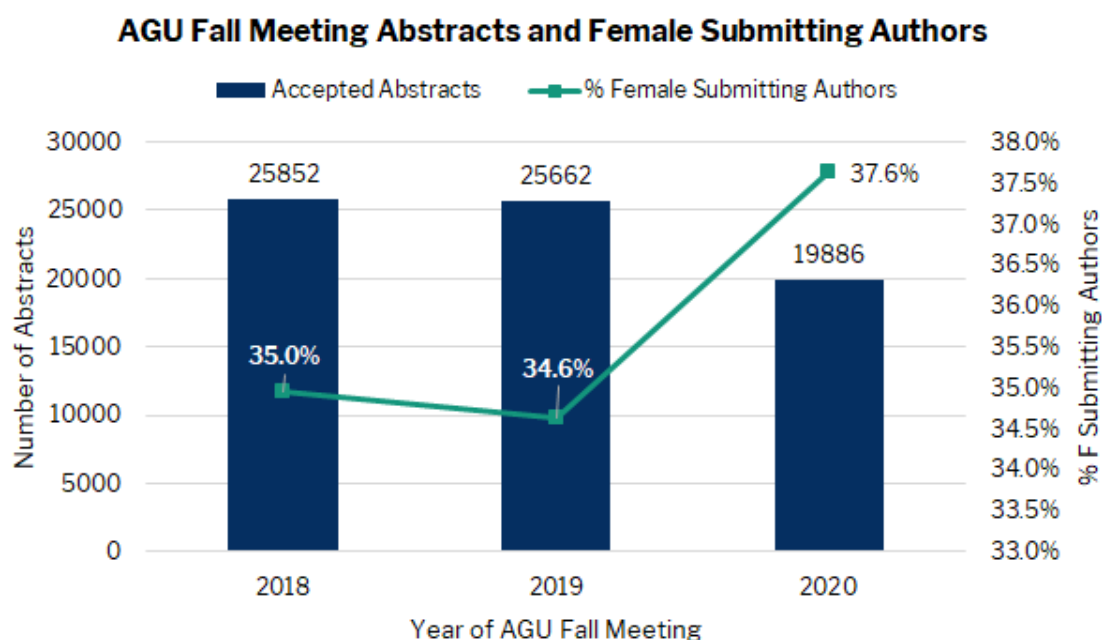Overall, we have seen an increase in the proportion of women submitting abstracts (+2.6%) since 2018:

Figure 13: Total submitted and accepted Fall Meeting abstracts and proportion of women submitting authors. The change in meeting format may have decreased intertest in presenting research this year.

The proportion of invited talks increased slightly this year, but invitations to women increased 7% from 40% to 47%. This may have helped increase submissions from women overall as seen in Figure 14 below.
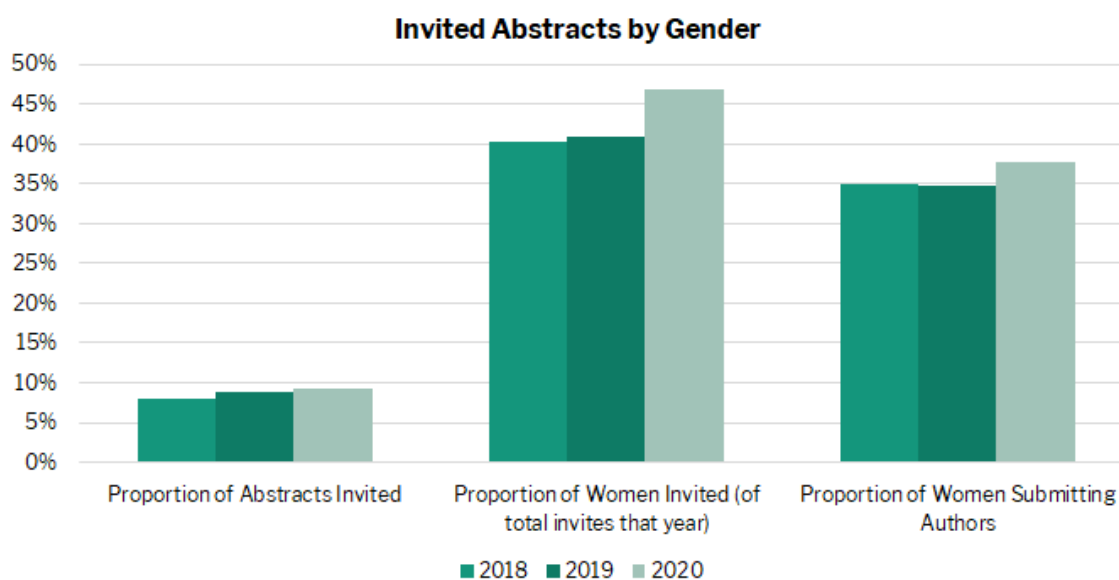

Figure 14: Proportion of invited abstracts, invited women, and women submitting abstracts each year.

Abstract submissions by country

Fall Meeting abstract submissions have historically been dominated by the U.S. due largely to the fact the meeting is held every year in the U.S. In spite of the virtual format of 2020, it continues to be dominated by abstract submissions from the U.S. In

2020, we saw abstract submissions from both China, the U.S., and Japan decrease, but we see increases from UK, Canada, and Australia (remember that earlier in this discussion, Australia was the only major country to see a decrease in journal submissions).
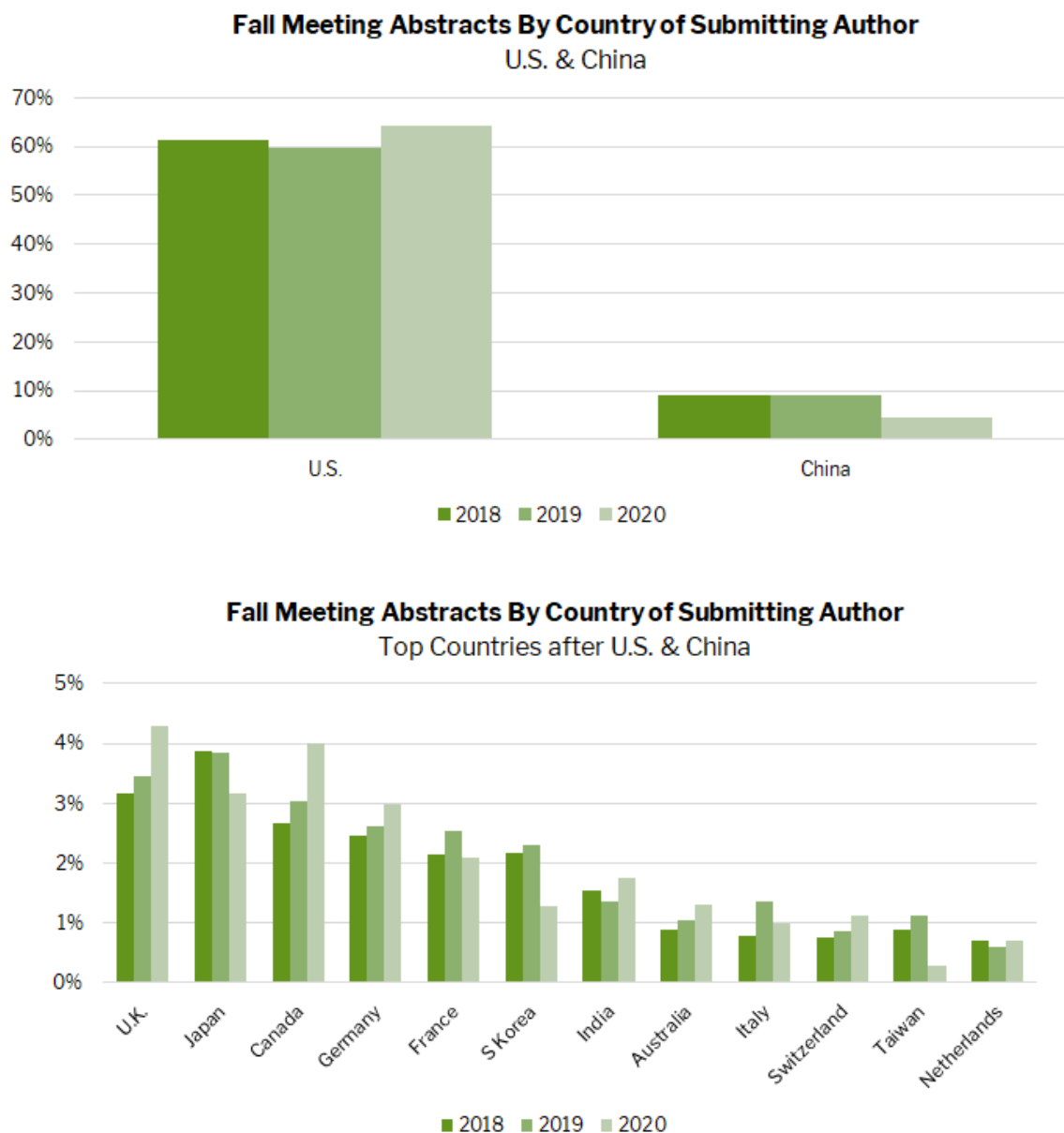

Figure 15a and 15b: Abstract submissions from top countries by percent of total annual submissions.

Although absolute counts of abstracts from the U.S. decerased this year compared to last (not shown), submissions from the U.S. increased proportionally compared to submissions from other coutries. The most notable decreases in participation are seen from China, Japan, and South Korea. Increased submissions were seen this year from the U.K., Canada, Germany, India, and Australia. Figures separated for scale.

Age groups of submitting authors

Over the last three years, proportionally more abstracts have been submitted by members in their 20s and 30s as seen in the graphs below.

Age of Distinct Female Submitting Abstract Authors
As % of ALL submitting authors with known age and gender

Age of Distinct Male Submitting Abstract Authors
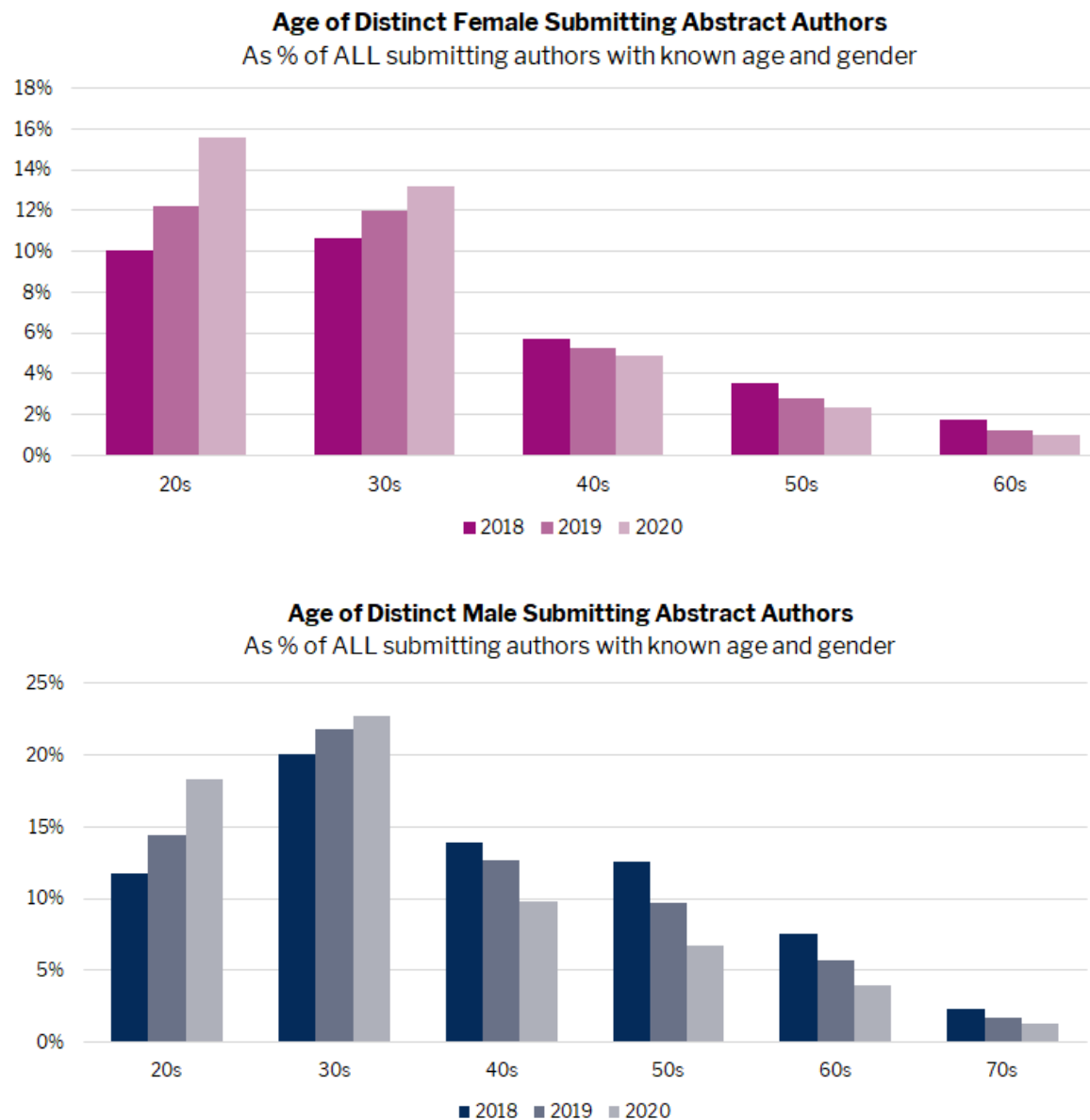As % of ALL submitting authors with known age and gender

Figure 16a and 16b: Age groups of female and male distinct submitting authors (counted only once each year they submit an abstract) as a percentage of total annual submitting authors with known age and gender.

The increases in submissions from those in their 20s and 30s are seen in both gender groups with clear declines in submissions from men and women in the 40s and older age groups. This contrasts with what see in journal article submissions where fewer people in their 20s submitted this year to date than in previous years (though remember we only have 28% of submitting journal article authors with age and gender data).

However, when we look at career stage and gender of submitting abstract authors, we see that the increase in submissions from individuals in their 20s and 30s is coming not from students but from men and women in the early career stage:

Career Stage of Distinct Female Submitting Abstract Authors
As % of ALL submitting authors with known gender & career stage

Career Stage of Distinct Male Submitting Abstract Authors
As % of ALL submitting authors with known gender & career stage
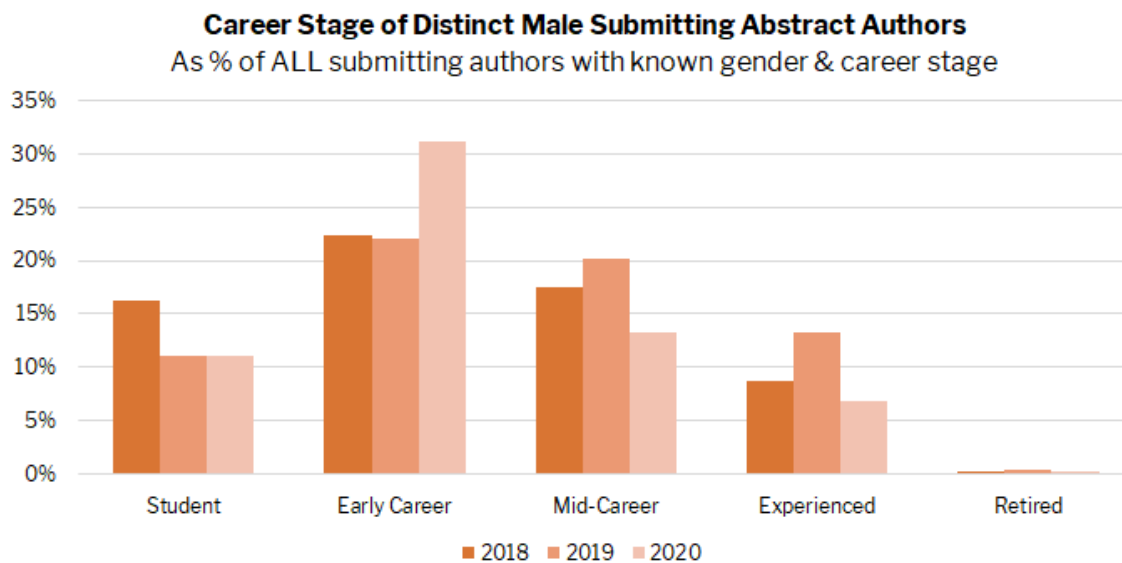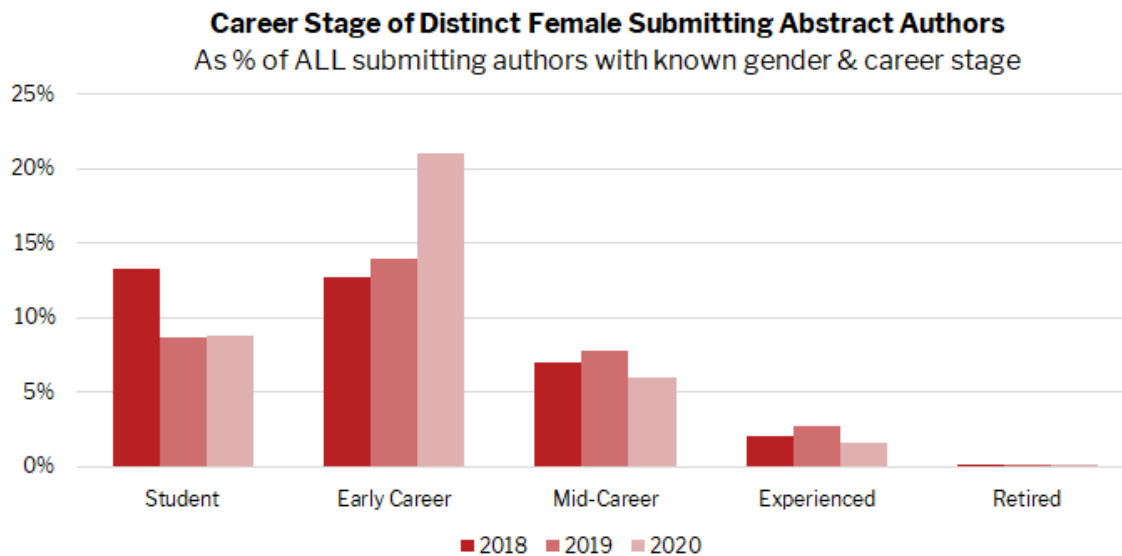

Figure 17a and 17b: Career stages of female and male distinct submitting authors as a percentage of all submitting authors with known age and gender. The increases in submissions are from early-career men and women.

This could be for a variety of reasons, but perhaps the virtual format appealed to early career scientists; this year, the format allows people with families and/or teaching obligations to present (virtually) at the conference without traveling away from these other commitments.

Regarding ethnicity, we see an increase in participation from all ethnic groups (see figure 18 below), but proportionally, the only increase we see is from authors identifying as Hispanic/Latino (1% increase; not shown). There was a 4% increase in authors identifying as "Other" and could be most fitting for those who reside in the U.S. but are from another country. To improve our ethnicity data, AGU has recently updated our categories to be more inclusive of people who don't identify as American.

Race/Ethnicity of Fall Meeting Abstracts Authors
Distinct autors (submitting and contributing)
Excludes unknown race/ethnicity

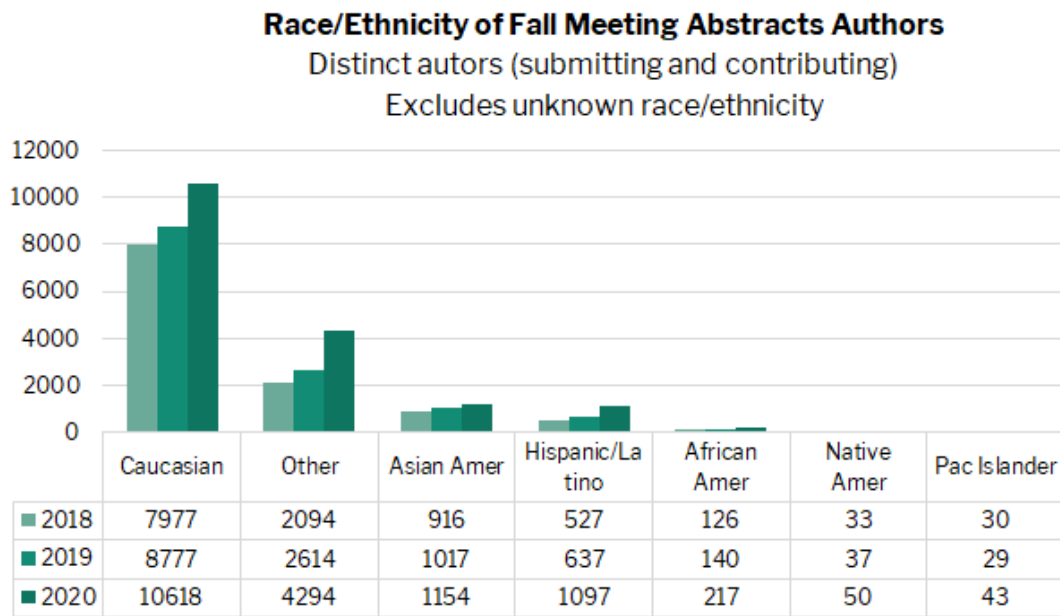|	Caucasian	Other	Asian Amer	Hispanic/Latino	African Amer	Native Amer	Pac Islander
2018	7977	2094	916	527	126	33	30
2019	8777	2614	1017	637	140	37	29
2020	10618	4294	1154	1097	217	50	43

Figure 18: Absolute counts of distinct authors identifying with each ethnic category by year of Fall Meeting abstract on which they are listed as an author (includes submitting and contributing authors).

AGU FALL MEETING ABSTRACT AUTHOR TEAMS AND SCIENTIFIC PROGRAMS

How have author teams changed over the past year, especially as collaboration and presentations have become more virtual? We saw a slight decrease in author team size of abstracts submitted in 2020 (4.77 authors/team) compared to 2019 (4.82), not shown. By region, we see that abstracts from Europe on average have the largest teams, while those from Africa have the smallest:
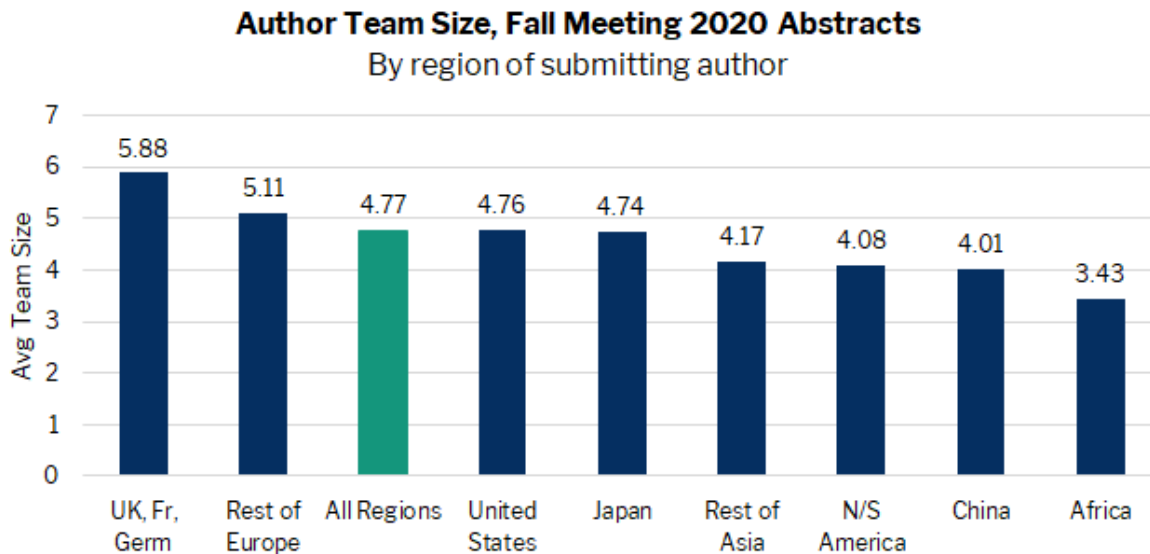

Figure 19: Average author team size by country-region of submitting author of 2020 Fall Meeting abstracts.

The overall averages are smaller than what we saw with journal submissions which are in the 5 range for average size of author teams. Proportion of mixed-gender teams has increased slightly while proportion of all-male teams has decreased.
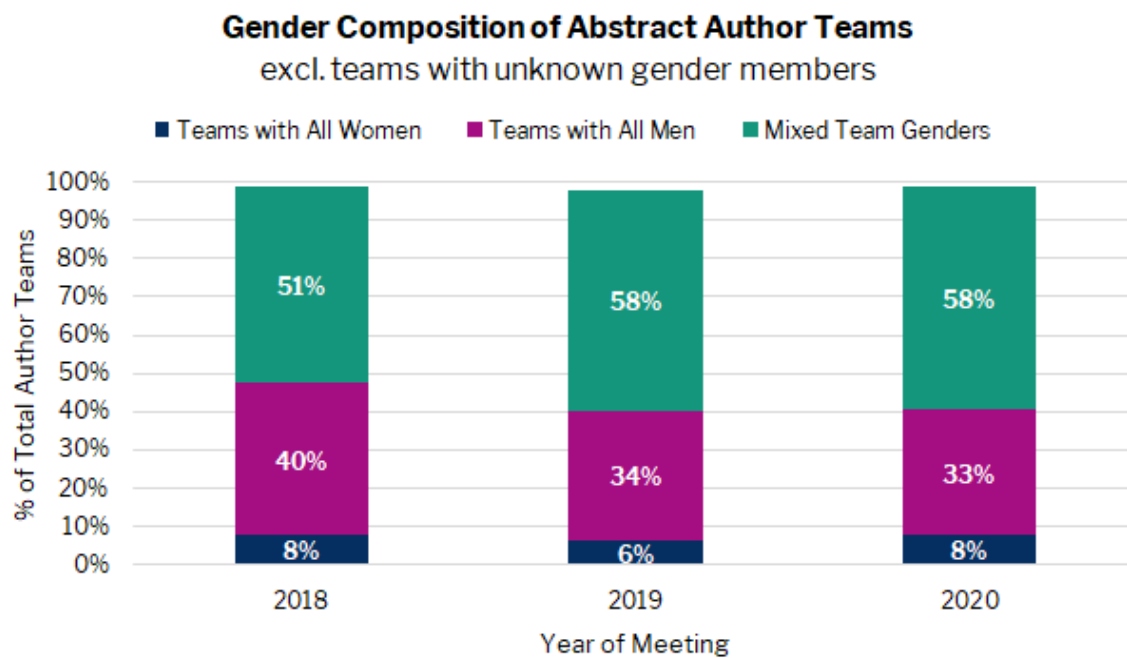

Figure 20: Gender composition of author teams on meeting abstracts where all gender of all team members are known. Teams are non-distinct (i.e., counts teams each time they are listed on an abstract).

Scientific Topics

The AGU Fall Meeting sessions are designed by scientific topic. This year has seen some changes in the proportion of abstracts under each topic. Atmospheric sciences continues to grow, with a slight decreases in hydrology and biogeosciences. The below graphs show all scientific program topics and the proportion of submissions each year, with an indicator of the proportion of submissions from female submitters (of the submissions with known gender of submitting author). Women have the highest representation in Education, Public Affairs/ Science and Society, GeoHealth, and Paleoceanography sections.
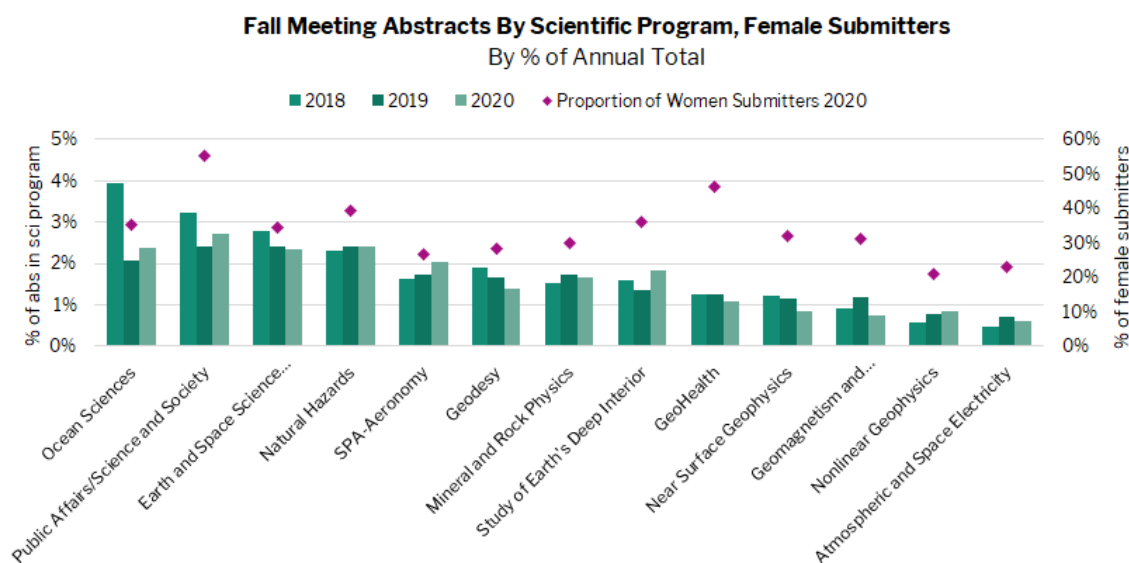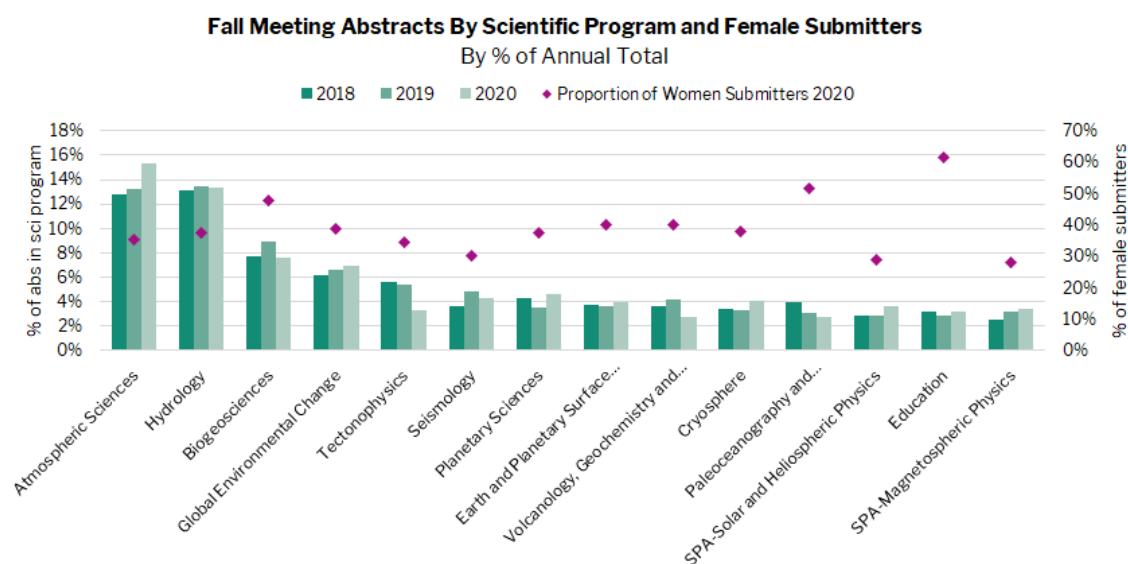
Figures 21a and 21b: Proportion of scientific program of abstracts compared to all abstracts in that year. Magenta diamonds indicate the proportion of women who submit abstracts to the scientific program topic.

CONCLUSION

The stay-at-home pressures of the pandemic may have actually increased submissions to our journals while the virtual format of our annual meeting may have decreased submissions to our annual meeting, except for those in the early career stage who may have been more able to present at a virtual conference. Author team gender diversity has increased, which cannot specificially be assigned to the pandemic, as we had seen it in 2019, but the increasing popularity (by necessity in 2020) in virtual collaboration certainly encourages larger teams. With the heighted cultural awareness of the need for diversity, not just in 2020 but in previous years, especially encouraging women in science, we have seen a marked increase in women's invitation to participate and submissions from women to our annual meeting.

ABSTRACT

The COVID-19 pandemic has shifted the way many Earth and space scientists work. Onsite research is curtailed while instructors adjust to remote teaching and parents add homeschooling and childcare to their schedules. As we saw in a preliminary analysis of AGU journal submissions (https://jpgu-agu2020.ipostersessions.com/Default.aspx?s=19-EB-C7-AC-B0-C9-3F-0D-94-7F-20-93-19-B4-B5-98), there has been an *increase* in submissions from both male and female corresponding authors (and no significant changes in rates from women) and an increase in submissions from around the world to AGU's journals. This may be due to the relatively low cognitive load of uploading files and submitting metadata compared to conducting research and analyzing data. However, how will submission data look by the end of 2020, and how might author teams be affected by the pandemic? This analysis will look at author teams of AGU journal and Fall Meeting abstracts with a focus on team size, author country, and author gender and age/career stage. Author team analysis of the Fall Meeting abstracts will also help to understand how collaborations are affected by shifting such a large physical conference to a virtual one.

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