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Minority women get too few talks at world's largest earth science conference

Researchers from racial and ethnic groups underrepresented in US geoscience are the least likely to be offered opportunities to present at the field's biggest meeting, find Heather L. Ford[1*], Cameron Brick[2,3*], Margarita Azmitia[4], Karine Blaufuss[5], & Petra Dekens[6]

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Biases—structural, implicit, and explicit—exclude many people from Science, Technology, Engineering and Mathematics (STEM) education and employment and devalue their contributions[1,2]. Most studies focus on bias against women. Few datasets offer enough generalizability or statistical power to evaluate the representation of ethnic and racial minorities, or to examine intersectionality[3]—the compound obstacles that block, for example, a woman of colour in the US.

We offer just such a dataset here.

Presenting at scientific conferences is key to academic career progression. Scientists don't just communicate results; they also develop relationships with collaborators and mentors and identify job and funding opportunities. Giving a talk confers recognition and prestige, particularly for students and early career researchers. Despite historical inequities, women are now presenting more at conferences[4,5] and colloquia[6]. These gains are especially visible in conferences that are organized by women or that specifically support early career participants.

We found that US scientists from racial and ethnic minority populations already under-represented in science had relatively fewer speaking opportunities at a key scientific conference over a four-year period than their numbers at each career stage should predict. This disadvantage held across career stages; it was more severe for women of colour.

Our results underscore the pressing need to support minorities in conferences—as elsewhere in STEM—to advance equity and improve research.

Methods and Dataset

The American Geophysical Union (AGU) is an international non-profit scientific association with around 60,000 members in 137 countries. Since 2013, AGU has collected self-reported demographics from its membership including gender, ethnicity (for U.S.-based academics only), career stage, and birth year.

The AGU Fall Meeting is the world's largest earth and space science conference. The attendance each year from 2014 to 2017 was approximately 24,000 – 28,000 people. Approximately 22,000 abstracts are submitted each year; few are rejected (<0.05%). Membership is necessary for submitting, though not for attending the meeting.

Abstracts are submitted to topical sessions. Sessions are proposed and organized – and abstracts vetted – by a group of conveners – academics, industry members, government scientists and others. The primary convener must be an AGU member. There are three tracks by which geoscientists present at AGU FM – two by submission, one by invitation. Either authors can submit abstracts to conveners who decide: talk or poster? Or they submit abstracts just to give a poster. Finally, session conveners invite scientists to speak (strictly, to send in abstracts which generally result in a talk).

The database of 87,544 accepted abstracts from the meetings between 2014 and 2017 offers a unique opportunity to probe inequities of opportunity between demographic groups[5]. Presentations are approximately 34% talks (**about 29% of which are directly invited)** and 66% posters.

Career Stage. Of U.S.-based authors, 98% (n = 53,247) provided career information. Either researchers had verified themselves as students (undergraduates and graduates) or the AGU had calculated career stage from years since highest degree obtained: early career (0 to < 10 years), mid-career (10 to < 20 years), and experienced (≥ 20 years). Controlling for career stage is critical because racial and ethnic minorities are concentrated in the student and early career stages (Figure 1). This is due to both a leaky pipeline[7] and because older groups more strongly bear the imprint of historical biases.

Race, Ethnicity, Gender. AGU recorded self-reported ethnicity and race from U.S.-based authors only. Of these, 71% (n = 38,768) reported a category (see Supplement): *White* (58%), *Asian American* (7.3%), *Hispanic/Latino* (3.9%), *African American* (1.1%), *Native American* (0.3%), or *Pacific Islander* (0.2%). The remainder marked *Other* (29%), *Prefer not to answer* (13%), or didn't respond (2.8%). We did not verify whether Native American respondents were citizens of tribal nations; we acknowledge that self-reported identity is not the same as tribal citizenship. *Other* may refer to individuals that are multiracial or who do not identify with the categories listed.

Prior to analyses, we decided to exclude authors who were based outside the U.S. (n = 33,098), identified as *Other* and who did not supply ethnicity or race.

Of our sample of U.S.-based authors who reported their ethnicity, 99% (n = 38,716) identified as female or male (the third option was "Prefer not to answer"). We appreciate that this binary treatment does not incorporate the full spectrum of gender identity.

Underrepresented Minorities. Minority ethnic and racial groups represent 31% of the U.S. population[8]. All things being equal, we would expect these groups to have similar representation in the STEM work force; however they are underrepresented in the STEM (11%), and specifically the physical science work force (<9%, i.e. geoscience, chemistry, etc)[9]. In the AGU dataset, African American, Hispanic/Latino, Native American, and Pacific Islander are 7.7% of the analyzed sample and we combine them together into one measure – Underrepresented Minorities (URM). We did this to increase the statistical power to detect differences, limit the risk of multiple comparisons generating false positives, and avoid potentially identifying information for rare groups. We admit that this approach erases meaningful differences in lived experiences between these groups, particularly those with the lowest representation. There are unique barriers for participation in each minority group.

We combined White and Asian Americans into Non-URM. Asian Americans (4.8% of the U.S. population[8]) are well-represented in the STEM work force (20.6%, physical sciences is 17.5%)[9] and in the current AGU dataset (7.3% of first author abstracts). Of course, Asian Americans do face career barriers including implicit and explicit biases. In the Supplemental, we report exploratory analyses on Asian Americans as a separate group, and also examine career stage further because of problems specific to the geosciences in the recruitment and representation of Asian Americans[10].

Results

Our analyses focus on the chances of scientists from racial and ethnic minorities underrepresented in the earth and space sciences being given speaking opportunities compared to non-URM applicants. The key proportions are normalized relative to the population of each group, so the results indicate representation. See Supplement for all inferential statistics.

First authors from URM contributed 7.7% of all the abstracts in the sample (n = 2,981; Figure 1A). The URM applicants were disproportionately students or early career stage scientists (78% compared to 59% of non-URM authors; Figure 1B). Even when we control for career stage, URM authors have fewer opportunities – though the low numbers of URM researchers sometimes led to low statistical power to detect differences.

***Talk or poster submissions*:** URM authors were offered fewer talks than non-URM authors (42.9% vs. 50.8% normalized within each population; Figure 2B). This difference was statistically significant overall and in the early career stage.

***Invitations*:** URM authors were invited to give talks less often than non-URM authors (8% vs. 14%, normalized; Figure 2A). This was statistically significant overall and in the early career stage.

Poster-only. URM authors applied to only give a poster more than non-URM authors (35% vs. 24%; Figure 2C). This was significant overall and for each career stage except for mid-career.

URM Women had strikingly few opportunities at the AGU fall conferences. Women authors (taking all races and ethnicities together) had equal or more opportunities to speak than men at the meetings[5]. But women from underrepresented minorities were invited to give fewer talks and applied for posters more often than non-URM women or URM men, and were assigned talks less often than non-URM women (Figures 3A, 3B).

In sum: Scientists from underrepresented racial and ethnic minorities (URM) were selected for fewer talks, invited less often, and opted for poster presentations more than non-URM researchers.

Caveats & confounders

We did not assess abstract quality. Some may posit that an alternative explanation for our results could be that URM scientists submitted abstracts of lower quality. Even if the AGU selection were perfectly meritocratic, any gap in abstract quality would still in our view suggest bias in the STEM pipeline, for example due to discrimination in earlier education[7] and career development. These obstacles result in fewer URM scientists holding positions at elite institutions that confer more resources and stronger collaborators.

We did not investigate why URM geoscientists applied to only give posters more often than others overall and at every career stage except mid-career. Several factors may be at play. People may be held back by psychological factors such as less self-confidence[11]. For example, URMs often report experiencing 'impostor syndrome'—feeling isolated and vulnerable in academia because they perceive themselves as having lower competence than peers[12]. Conversely, some URM scientists may value poster presentations – they may align with different goals, interests, or lived experiences such as communicating scientific findings in one-on-one conversations.

There were people we left out of our analysis – those based outside the U.S, those who identified as *Other*, and those who did not supply ethnicity or race. This will likely have excluded relevant individuals – people who identify as multi-racial, for example. Our main analyses therefore represent a more conservative test of speaking opportunities between minority and majority groups.

Discussion

To recap: a woman from a racial or ethnic minority that is underrepresented in US geosciences is less likely to gain a speaking slot at the field's most important conference than her male and non-Hispanic White peers. These findings hold sobering lessons for AGU and other STEM conferences and activities. We pre-registered our data cleaning and main confirmatory analyses at the Open Science Framework, increasing generalizability (see Supplement).

One of AGU's goals for invited authors is to "enhance diversity and/or feature early-career scientists." It is particularly concerning that even where URM authors are most numerous—in the least established career stages—they still get fewer invitations than their proportion would predict. Such early inequities are likely to affect the retention and promotion of URMs across geosciences.

There are three clear steps for AGU to take. First, conference conveners should be blinded to information that is not necessary to rate the quality of submissions. Identifying details such as names and institutions introduce bias[13,14] even in people committed to equity, because many thinking processes such as stereotype activation occur outside awareness or control. For instance, double-blind review decreased bias in the allocation of time on the Hubble Space Telescope[15].

Second, AGU should encourage more scholars from URM to participate as conveners. Third, AGU should provide more travel grants to URM presenters, which could increase the overall population of URM attendees both directly and by shifting norms. We encourage other STEM conferences to also make these changes.

Meanwhile, the rest of the community has work to do to (see box). Established scholars can support minority scientists by encouraging them to submit talk abstracts and by providing opportunities to practice presenting in local, domestic, and international venues. These can increase confidence and foster the development of people's identity as scientists.

It is critical for universities and funding agencies to support organizations that provide openings and mentorship to young and minority scholars. Examples include the Society for Advancement of Chicanos/Hispanics and Native Americans in Science. The NSF aims to broaden participation through proposal award criteria and initiatives such as NSF INCLUDES: Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science[16]. Such programs can liaise with professional societies.

Racial, ethnic and gender bias harms individuals and undermines the quality of science. Even if all demographic gaps were plugged tomorrow at the level of graduating PhDs, and even if these graduates didn't have to run the gauntlet of systemic bias that their predecessors faced, it could still take generations to achieve fair representation among senior professors.

We therefore urge more organizations to measure and share the outcomes of minority scholars. With this information and the growing literature on effective interventions, together we can create a more equitable scientific community.

BOX

BOXHEAD: Inclusion—why so slow?

BOXSTRAP: Laws, policies, training, research, and tracking must benefit all

In the U.S., affirmative action is a set of laws, guidelines and policies that aim to increase the representation of historically excluded groups in higher education and professional careers. Overall, White women have been the primary beneficiaries[17] as our results underscore.

A recent report by the U.S. National Science Foundation (NSF) showed that ethnic and racial minorities are underrepresented in graduate programs and this results in reduced economic and social opportunities[16].

An inclusive environment and visible role models are key for underrepresented minority participation and success in STEM[18]. A growing body of research has highlighted the subtle, indirect, and often unintentional actions perpetuated on URMs by majority groups that impact a sense of belonging in STEM spaces[19-22], career persistence, and wellbeing[23,24]. Intersectionality[3] considers the interwoven systems that impact marginalized groups, locate them in systems of oppression, and limit their upward mobility.

Small interventions can help, such as asking STEM community members to be mindful of equity diversity and inclusion. Reminding individuals, particularly men, to consider diversity when selecting potential reviewers can improve gender representation[25]. However, the effects of these reminders on ethnicity bias have not been studied, and reminders may not be effective in the long-term in reducing implicit biases in STEM[26]. Implicit bias trainings are well-meaning but largely ineffective[27,28].

Figure Captions

Figure 1. Total Abstracts by Race, Ethnicity, and Career Stage. White and Asian Americans (non-URM) submitted more abstracts than underrepresented minorities (URM), even relative to their populations (a). URM abstracts were from disproportionately student and early career researchers (b).

Figure 2. Speaking Opportunities by Race, Ethnicity, and Career Stage. URM authors were invited to give talks relatively less than non-URM authors, particularly in the early career (a). URM were assigned talks less than non-URM, particularly in the early career (b). URM also chose poster-only presentations more non-URM both overall and across career stages (c). Figures (a) and (c) are shown as the proportion of total abstracts and (b) as the proportion of abstracts assigned by committee. There were too few invited student or experienced authors to test in a contrast at those stages and these values are shown with hashed bars. * $p < 0.05$.

Figure 3. Speaking Opportunities by Race, Ethnicity, and Gender. Compared to URM men, URM women were invited relatively less, chose posters more, and were assigned talks at a similar rate (a). Compared to non-URM women, URM women were invited less, assigned talks less, and chose posters more. Figures (a) and (c) are shown as the proportion of total abstracts and (b) as the proportion of abstracts assigned by committee. * $p < 0.05$.

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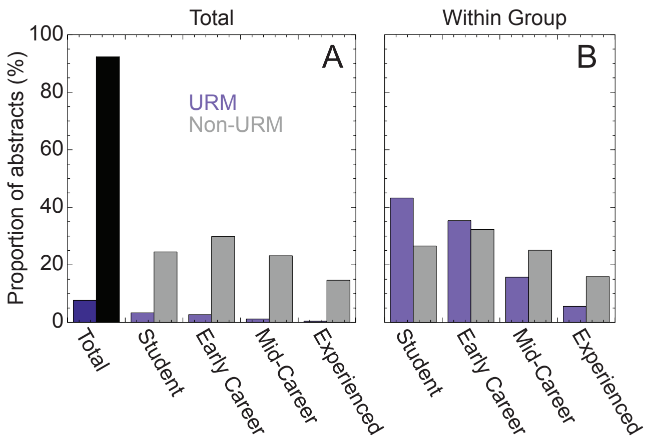
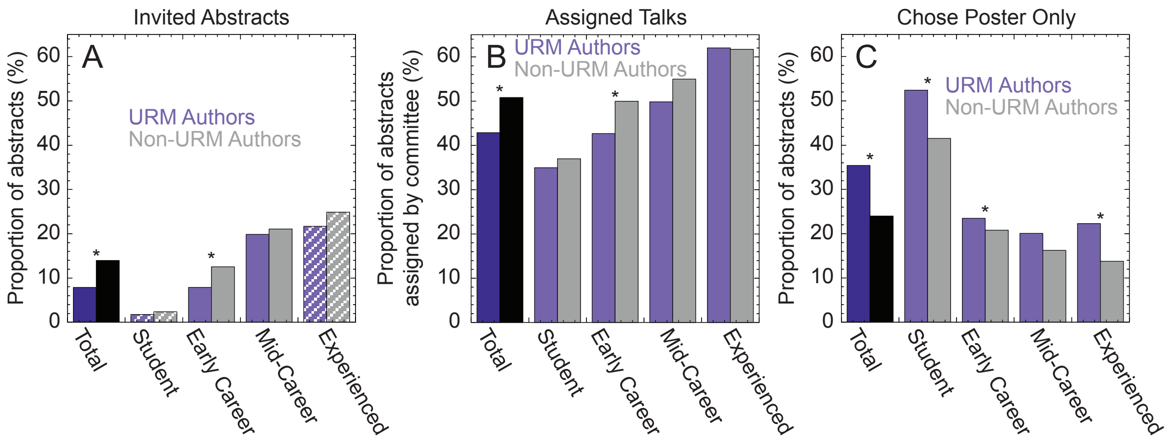

Total
Within Group
A
B
URM
Non-URM
Proportion of abstracts (%)
100
80
60
40
20
0
Total
Student
Early Career
Mid-Career
Experienced
Student
Early Career
Mid-Career
Experienced


Invited Abstracts
A
URM Authors
Non-URM Authors
Proportion of abstracts (%)
Total
Student
Early Career
Mid-Career
Experienced
Assigned Talks
B
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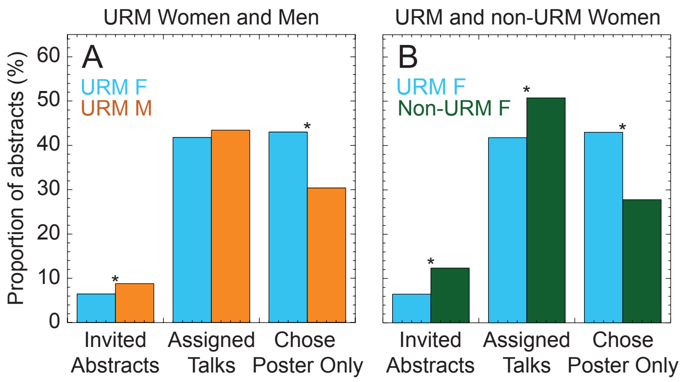
Proportion of abstracts (%)



URM Women and Men
URM and non-URM Women
Proportion of abstracts (%)
0
10
20
30
40
50
60
A
URM F
URM M
B
URM F
Non-URM F
*
Invited Abstracts
Assigned Talks
Chose Poster Only

Supplementary Materials

Women from under-represented minorities are given too few talks at world's largest earth science conference

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Table of Contents

1. Materials and Methods

The analysis plan and hypotheses were pre-registered at the Open Science Framework: https://osf.io/eqwj2/

The American Geophysical Union (AGU) is the world's largest geoscience conference with over 22,000 abstract submissions each year. Since 2013, AGU has collected demographic data from conference participants (authors and primary conveners) including gender, year of birth, race/ethnicity (for U.S.-based individuals), and country.

To protect membership privacy, the AGU membership database is not publicly available. The abstract database without demographic information is publicly available at https://meetings.agu.org/abstract_db/. Our analyses are based on the 2014-2017 AGU abstract database and this represents those AGU members that are active in research.

1a. AGU Fall Meeting Organization

Topical sessions at the AGU Fall Meeting are self-organized by a group of conveners within a given Section/Focus Group. Section and Focus Groups are a collection of members with a particular interest such as atmospheric sciences, volcanology, or space physics.

The primary convener and co-convener(s) may invite authors (up to four in 2014 and 2015, up to two in 2016 and 2017) to submit abstracts. We call these Invited Authors. At the time of submission, authors request “Assigned by Program Committee (Oral or Poster)” or “Poster Only.” The author that submits an abstract (invited or otherwise) we call the First Author.

Based on the number of submissions, a topical session is scheduled as oral and/or poster presentations. The primary convener and co-convener(s) allocate the oral and poster presentations for the authors within their topical sessions.

1b. Variables

For these analyses, the data was accessed in May 2018.

Our variables are:

1. **Gender:** Male, Female
2. **Ethnicity:** Underrepresented Minorities, White, Asian American, Other
3. **Career Stage:** Student, Early Career, Mid-Career, Experienced, and Retired

AGU members are asked to self-identify their gender and race/ethnicity (SI Figure 1). For gender, members may choose male, female, or prefer not to answer. Prefer not to answer was excluded from our gender analyses as it represents a small portion of the data (<1%). Here we report the historical AGU demographic categories for race and ethnicity. The categories used to collect AGU demographic information are under review at the date of this publication. For race/ethnicity, U.S.-based members may choose *African American, Asian American, Caucasian, Hispanic/Latino, Native American, Pacific Islander, Other* or *Prefer not to Answer*. These categories were informed by the US Census Categories for **race**[1] (https://www.census.gov/topics/population/race/about.html)

> *White* – A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.
> *Black or African American* – A person having origins in any of the Black racial groups of Africa.
> *American Indian or Alaska Native* – A person having origins in any of the original peoples of North and South America (including Central America) and who maintains tribal affiliation or community attachment.
> *Asian* – A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
> *Native Hawaiian or Other Pacific Islander* – A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.

and **ethnicity** https://www.census.gov/mso/www/training/pdf/race-ethnicity-onepager.pdf[2]

Ethnicity determines whether a person is of Hispanic origin or not. For this reason, ethnicity is broken out in two categories, Hispanic or Latino and Not Hispanic or Latino. Hispanics may report as any race.

Throughout the text and supplemental we refer to Caucasian as White. For members that self-identify as *Native American*, tribal affiliation is not investigated or documented. *Other* may refer to individuals that are multiracial, do not identify with the provided ethnicity/race categories, international scholars that are working at U.S.-based institutions that do not identify with the provided ethnicity/race categories, and/or other reasons.

African American, *Hispanic/Latino*, *Native American*, and *Pacific Islander* were grouped as Underrepresented Minorities (URM). *Asian Americans* and *Whites* were grouped as Non-Underrepresented Minorities (Non-URM). The National Science Foundation does not consider Asian Americans an underrepresented minority because given their proportion in the population, they are well-represented in many STEM fields. Below we explore ***Asian Americans as a Separate Group***.

Career Stage for First Author is self-identified as Student (and verified by an academic advisor) or calculated based on number of years since highest degree obtained: Early Career (0 to <10 years), Mid-Career (10 to <25 years), Experienced (>25 years). This career stage calculation does not consider career breaks. Retired members were excluded from our analyses due to relatively low numbers.

2. Statistics

Personally Identifying Information: To avoid personal identifying information, if a category has fewer than 50 abstracts in a category for the First Author Poster Only/First Author Invite/First Author Oral hypotheses results are not presented for that subgroup. Additionally, some results are shown as approximated. This precludes some of the interactions (e.g., whether URM women request poster presentations at a higher rate than other groups across their career stages). These conservative thresholds were chosen by looking at previous literature on protecting identifiable participants, and by considering that individual Primary Conveners sometimes handle many abstracts.

FA = First Author, PC = Primary Convener, URM = Underrepresented Minority

Each analysis below will be completed separately for the three outcomes: (1) Invited by Conveners, (2) Abstract Submission Option, and (3) Presentation Assigned by the Conveners. These outcomes are collectively referred to below as having worse/better outcomes.

URM and Gender Hypotheses (estimated # of contrast tests for each of the three outcomes)

1. URM FA have worse outcomes than non-URM FA. (1)
2. URM FA women have worse outcomes than:
    a. URM FA men (1)
    b. non-URM FA women (1)

We used chi-squared tests (χ_2) to test the *hypotheses* below. χ_2 is used throughout to determine whether there is significant difference between the expected and observed frequencies. Because nearly the entire population of data is available, these inferential tests are not necessary to see the outcomes of these AGU authors for these time periods.

The symbols used below are μ (mean), σ (standard deviation) and *n* (number of individuals). Results are reported as: χ_2 (degrees of freedom, sample size) = the χ_2 value, and the associated *p*-value. The results are plotted in SI Figure 2.

2a. Hypotheses

Some results are shown as approximated to avoid potentially personal identifying information.

1. *URM are invited to submit abstracts at a lower rate than non-URM.*

$\chi_2(1, 38767) = 87.5$, $p < 0.001$

$\mu_{URM} =$ 7.9%, $\sigma = 0.27$, $n_{URM} = 2981$

$\mu_{Non\text{-}URM} =$ 14.0%, $\sigma = 0.35$, $n_{Non\text{-}URM} = 35787$

Total Ethnicity	URM	Non-URM	Total
Not Invited	2746	30784	33530
Invited	235	5003	5238
Total	2981	35787	38768

2. *URM are invited to submit abstracts at a lower rate than non-URM at all career stages.* URM are invited to present at a lower rate in the Early Career stage.

Data for **Student** career stage not provided due to personally identifying information.

Early Career - results are shown as approximated

$\chi_2(1, 12559) = 19.6$, $p < 0.001$

$\mu_{URM} =$ 7.9%, $\sigma = 0.08$, $n_{URM} = 1050$

$\mu_{Non\text{-}URM} =$ 12.5%, $\sigma = 0.13$, $n_{Non\text{-}URM} = 11510$

Early Career	URM	Non-URM	Total
Not Invited	970	10070	11040
Invited	80	1440	1520
Total	1050	11510	12560

Mid-Career - results are shown as approximated

$\chi_2(1, 9414) = 0.40$, $p = 0.529$

$\mu_{URM} =$ 19.9%, $\sigma = 0.20$, $n_{URM} = 470$

$\mu_{Non\text{-}URM} =$ 21.1%, $\sigma = 0.21$, $n_{Non\text{-}URM} = 8950$

Mid-Career	URM	Non-URM	Total
Not Invited	380	7060	7440
Invited	90	1890	1980
Total	470	8950	9420

Data for **Experienced** career stage not provided due to personally identifying information.

3. *URM are less likely to be assigned an oral presentation than non-URM after requesting "Assigned by Program Committee (Oral or Poster)."*
$\chi_2(1, 29122) = 45.4$, $p < 0.001$
$\mu_{URM} =$ 42.9%, $\sigma = 0.50$, $n_{URM} = 1926$
$\mu_{Non\text{-}URM} =$ 50.8%, $\sigma = 0.50$, $n_{Non\text{-}URM} = 27197$

Total Ethnicity	URM	Non-URM	Total
Assigned Poster	1100	13373	14473
Assigned Oral	826	13824	14650
Total	1926	27197	29123

4. *URM are less likely to be assigned an oral presentation than non-URM at all career stages after requesting "Assigned by Program Committee (Oral or Poster)."*
URM are assigned oral presentations at a lower rate in the Early Career stage.

Student - results are shown as approximated
$\chi_2(1, 6142) = 0.96$, $p = 0.328$
$\mu_{URM} =$ 35%, $\sigma = 0.65$, $n_{URM} = 610$
$\mu_{Non\text{-}URM} =$ 37%, $\sigma = 0.63$, $n_{Non\text{-}URM} = 5540$

Student	URM	Non-URM	Total
Assigned Poster	400	3490	3890
Assigned Oral	210	2050	2260
Total	610	5540	6150

Early Career - results are shown as approximated
$\chi_2(1, 9917) = 16.1$, $p < 0.001$
$\mu_{URM} =$ 42.6%, $\sigma = 0.57$, $n_{URM} = 800$
$\mu_{Non\text{-}URM} =$ 50.0%, $\sigma = 0.50$, $n_{Non\text{-}URM} = 9110$

Early Career	URM	Non-URM	Total
Assigned Poster	460	4560	5020
Assigned Oral	340	4550	4890
Total	800	9110	9910

Mid-Career - results are shown as approximated
$\chi_2(1, 7866) = 3.6$, $p = 0.058$
$\mu_{URM} =$ 50.0%, $\sigma = 0.50$, $n_{URM} = 380$
$\mu_{Non\text{-}URM} =$ 55.0%, $\sigma = 0.45$, $n_{Non\text{-}URM} = 7490$

Mid-Career	URM	Non-URM	Total
Assigned Poster	190	3370	3560
Assigned Oral	190	4120	4310
Total	380	7490	7870

Data for **Experienced** career stage not provided due to personally identifying information.

5. *URM request poster presentations at a higher rate than non-URM.*
$\chi^2(1, 38757) = 191$, $p < 0.001$
$\mu_{URM} = 24.0\%$, $\sigma = 0.48$, $n_{URM} = 2979$
$\mu_{Non\text{-}URM} = 35.4\%$, $\sigma = 0.43$, $n_{Non\text{-}URM} = 35779$

Total Ethnicity	URM	Non-URM	Total
Assigned by Committee	1924	27189	29113
Opt for poster-only	1055	8590	9645
Total	2979	35779	38758

6. *URM request poster presentations at a higher rate than non-URM at all career stages.*
URM request poster-only presentations at a higher rate in the Student, Early Career and Experienced stages.

Student - results are shown as approximated
$\chi^2(1, 10746) = 55$, $p < 0.001$
$\mu_{URM} = 52\%$, $\sigma = 0.48$, $n_{URM} = 1280$
$\mu_{Non\text{-}URM} = 42\%$, $\sigma = 0.58$, $n_{Non\text{-}URM} = 9460$

Student	URM	Non-URM	Total
Assigned by Committee	610	5530	6140
Opt for poster-only	670	3930	4600
Total	1280	9460	10740

Early Career - results are shown as approximated
$\chi^2(1, 12555) = 4.2$, $p = 0.039$
$\mu_{URM} = 24\%$, $\sigma = 0.76$, $n_{URM} = 1050$
$\mu_{Non\text{-}URM} = 21\%$, $\sigma = 0.79$, $n_{Non\text{-}URM} = 11500$

Early Career	URM	Non-URM	Total
Assigned by Committee	800	9110	9910
Opt for poster-only	250	2390	2640
Total	1050	11500	12550

Mid-Career - results are shown as approximated
$\chi^2(1, 9412) = 4.9$, $p = 0.028$
$\mu_{URM} = 20\%$, $\sigma = 0.80$, $n_{URM} = 460$
$\mu_{Non\text{-}URM} = 16\%$, $\sigma = 0.84$, $n_{Non\text{-}URM} = 8940$

Mid-Career	URM	Non-URM	Total
Assigned by Committee	370	7490	7860
Opt for poster-only	90	1450	1540
Total	460	8940	9400

Data for **Experienced** career stage not provided due to personally identifying information.

7. *URM women are invited to submit abstracts at a lower rate than URM men.*
$\chi^2(1, 2976) = 5.4$, $p < 0.02$
$\mu_{URM\ Women} = 6.5\%$, $\sigma = 0.246$, $n_{URM\ Women} = 1188$
$\mu_{URM\ Men} = 8.8\%$, $\sigma = 0.28$, $n_{URM\ Men} = 1790$

	URM women	URM men	Total
Not Invited	1111	1632	2743
Invited	77	158	235
Total	1188	1790	2978

8. *URM women are less likely to be assigned an oral presentation than URM men.*
$\chi^2(1, 1922) = 0.50$, $p = 0.482$
$\mu_{URM\ Women} = 41.8\%$, $\sigma = 0.50$, $n_{URM\ Women} = 677$
$\mu_{URM\ Men} = 43.5\%$, $\sigma = 0.50$, $n_{URM\ Men} = 1247$

	URM women	URM men	Total
Assigned Poster	394	705	1099
Assigned Oral	283	542	825
Total	677	1247	1924

9. *URM women request poster presentations at a higher rate than URM men.*
$\chi^2(1, 2974) = 49.9$, $p < 0.001$
$\mu_{URM\ Women} = 43.0\%$, $\sigma = 0.50$, $n_{URM\ Women} = 1188$
$\mu_{URM\ Men} = 30.4\%$, $\sigma = 0.46$, $n_{URM\ Men} = 1788$

	URM women	URM men	Total
Assigned by Committee	677	1245	1922
Opt for poster-only	511	543	1054
Total	1188	1788	2976

10. *URM women are invited to submit abstracts at a lower rate than Non-URM women.*
$\chi^2(1, 13784) = 36.2$, $p < 0.001$
$\mu_{URM\ Women} = 6.5\%$, $\sigma = 0.246$, $n_{URM\ Women} = 1188$
$\mu_{Non\text{-}URM\ Women} = 12.4\%$, $\sigma = 0.33$, $n_{Non\text{-}URM\ Women} = 12598$

	URM women	non-URM women	Total
Not Invited	1111	11037	12148
Invited	77	1561	1638
Total	1188	12598	13786

11. *URM women are less likely to be assigned an oral presentation than Non-URM women.*
$\chi^2(1, 9769) = 13.9$, $p < 0.001$
$\mu_{URM\ Women} = 41.8\%$, $\sigma = 0.50$, $n_{URM\ Women} = 677$
$\mu_{Non\text{-}URM\ Women} = 49.2\%$, $\sigma = 0.50$, $n_{Non\text{-}URM\ Women} = 9094$

	URM women	non-URM women	Total
Assigned Poster	394	4617	5011
Assigned Oral	283	4477	4760
Total	677	9094	9771

12. *URM women request poster presentations at a higher rate than Non-URM women.*
$\chi^2(1, 13781) = 121$, $p < 0.001$
$\mu_{\text{URM Women}} =$ 43.0%, $\sigma = 0.50$, $n_{\text{URM Women}} = 1188$
$\mu_{\text{Non-URM Women}} =$ 27.8%, $\sigma = 0.45$, $n_{\text{Non-URM Women}} = 12595$

	URM women	non-URM women	Total
Assigned by Committee	677	9091	9768
Opt for poster-only	511	3504	4015
Total	1188	12595	13783

13. *URM women are invited to submit abstracts at a lower rate than Non-URM men.*
$\chi^2(1, 24375) = 64.4$, $p < 0.001$
$\mu_{\text{URM Women}} =$ 6.5%, $\sigma = 0.25$, $n_{\text{URM Women}} = 1188$
$\mu_{\text{Non-URM Men}} =$ 14.8%, $\sigma = 0.36$, $n_{\text{Non-URM Men}} = 20428$

	URM women	non-URM men	Total
Not Invited	1111	19747	20858
Invited	77	3442	3519
Total	1188	23189	24377

14. *URM women are less likely to be assigned an oral presentation than Non-URM men.*
$\chi^2(1, 18778) = 25.2$, $p < 0.001$
$\mu_{\text{URM Women}} =$ 41.8%, $\sigma = 0.50$, $n_{\text{URM Women}} = 677$
$\mu_{\text{Non-URM Men}} =$ 51.6%, $\sigma = 0.50$, $n_{\text{Non-URM Men}} = 18103$

	URM women	non-URM men	Total
Assigned Poster	394	8756	9150
Assigned Oral	283	9347	9630
Total	677	18103	18780

15. *URM women request poster presentations at a higher rate than Non-URM men.*
$\chi^2(1, 24370) = 284$, $p < 0.001$
$\mu_{\text{URM Women}} =$ 43.0%, $\sigma = 0.50$, $n_{\text{URM Women}} = 1188$
$\mu_{\text{Non-URM Men}} =$ 21.9%, $\sigma = 0.41$, $n_{\text{Non-URM Men}} =$ 23184

	URM women	non-URM men	Total
Assigned by Committee	677	18098	18775
Opt for poster-only	511	5086	5597
Total	1188	23184	24372

2c. Asian Americans as a Separate Group

For the pre-registered analyses, Asian Americans were combined with Whites. The United States National Science Foundation does not categorize Asian Americans as underrepresented in STEM. However, if we consider the recent trends PhD completion in geoscience, Asian American representation is complex. Asian Americans represent 4% of PhD graduates since 2001 versus 6% of the population[3]. Furthermore, Asian Americans likely have different experiences than White in conference settings, for example in formal networking or other social interactions.

For completeness, we also examined Asian Americans separate from Whites here (see hypotheses below, Supplementary Figure 2 and 3). All analyses separating Asian Americans from Whites were exploratory (non-pre-registered). We performed statistical tests on URM, Asian Americans, and White as three separate groups. We did not perform statistical tests on URM, Asian Americans, and White by career stage. We present descriptive results for Asian Americans as a separate category as we do not always have the statistical power to detect differences, are at risk of non-pre-registered multiple comparisons generating false positives, and are avoiding potentially personally identifying information in small cells.

Overall, 1) Asian Americans were invited less often than White but more than URM [12%, 14%, and 8% respectively, Supplementary Figure 2, χ^2 (2, 38766) = 107, $p < 0.001$], 2) Asian Americans were assigned oral presentations less than White and more than URM [45%, 52%, and 43% respectively, Supplementary Figure 2, χ^2 (2, 29121) = 95, $p < 0.001$] and 3) Asian Americans opted for poster presentations at a lower rate than URM and White [21%, 35%, and 24% respectively, Supplementary Figure 2, χ^2 (2, 38756) = 210, $p < 0.001$]. These results highlight Asian Americans were at a disadvantage in comparison to their White peers and at an advantage in comparison to URM with respect to author invitations and assigned oral presentations.

When we consider URM, Asian Americans and White by career stage the results are more complex. When controlling for career stage, Asian Americans were invited less often than White. Asian Americans were invited more often than URM at the student and early career stages and less often at the mid-career and experienced career stages (SI Figure 3a). When controlling for career stage, Asian Americans were generally assigned oral presentations less often than URM and White (SI Figure 3b). An exception is the early career stage where URM were invited less than Asian Americans and White. Overall, Asian Americans had more oral presentations than URM because Asian Americans were concentrated in more senior roles that were more likely to be allocated an oral presentation, in comparison to the student career stage where URM were concentrated. Asian Americans opted for poster presentations less often than URM and Whites across most career stages (SI Figure 3c). These results highlight the unique experience Asian Americans have in the geoscience community.

All analyses separating Asian Americans from Whites were exploratory (non-pre-registered).

1. *URM are invited to submit abstracts at a lower rate than Asian Americans and Whites.*
$\chi^2(2, 38766) = 107.1$, $p < 0.001$
$\mu_{URM} = 7.9\%$, $\sigma = 0.27$, $n_{URM} = 2981$
$\mu_{AsianAmerican} = 11.7\%$, $\sigma = 0.32$, $n_{AsianAmerican} = 3984$
$\mu_{White} = 14.3\%$, $\sigma = 0.35$, $n_{White} = 31803$

Total Ethnicity	URM	Asian American	White	Total
Not Invited	2746	3517	27267	33530
Invited	235	467	4536	5238
Total	2981	3984	31803	38768

Data for **Student** career stage not provided due to personally identifying information.

Early Career - results are shown as approximated

Early Career	URM	Asian American	White	Total
Not Invited	970	1080	8990	11040
Invited	80	110	1330	1520
Total	1050	1190	10320	12560

Mid-Career - results are shown as approximated

Mid-Career	URM	Asian American	White	Total
Not Invited	380	1180	5880	7440
Invited	90	220	1660	1970
Total	470	1400	7540	9410

Data for **Experienced** career stage not provided due to personally identifying information.

2. URM are less likely to be assigned an oral presentation than Asian Americans and Whites after requesting "Assigned by Program Committee (Oral or Poster)."

$\chi_2(1, 29121) = 95$, $p < 0.001$
$\mu_{URM} =$ 42.9%, $\sigma = 0.50$, $n_{URM} = 1926$
$\mu_{AsianAmerican}$ 44.9= %, $\sigma = 0.50$, $n_{AsianAmerican} = 3140$
$\mu_{White} =$ 51.6%, $\sigma = 0.50$, $n_{White} = 24057$

Total Ethnicity	URM	Asian American	White	Total
Assigned Poster	1100	1730	11643	14473
Assigned Oral	826	1410	12414	14650
Total	1926	3140	24057	29123

Student - results are shown as approximated

Student	URM	Asian American	White	Total
Assigned Poster	400	330	3150	3880
Assigned Oral	210	150	1900	2260
Total	610	480	5050	6140

Early Career - results are shown as approximated

Early Career	URM	Asian American	White	Total
Assigned Poster	460	550	4010	5020
Assigned Oral	340	430	4130	4900
Total	800	980	8140	9920

Mid-Career - results are shown as approximated

Mid-Career	URM	Asian American	White	Total
Assigned Poster	190	620	2760	3570
Assigned Oral	190	570	3550	4310
Total	380	1190	6310	7880

Data for **Experienced** career stage not provided due to personally identifying information.

3. URM request poster presentations at a higher rate than Asian Americans and Whites.
$\chi^2(1, 38756) = 210$, $p < 0.001$
$\mu_{URM} = 35.4\%$, $\sigma = 0.48$, $n_{URM} = 2979$
$\mu_{AsianAmerican} = 21.1\ \%$, $\sigma = 0.41$, $n_{AsianAmerican} = 3984$
$\mu_{White} = 24.4\%$, $\sigma = 0.43$, $n_{White} = 31795$

Total Ethnicity	URM	Asian American	White	Total
Assigned by Committee	1924	3140	24049	29113
Opt for poster-only	1055	844	7746	9645
Total	2979	3984	31795	38758

Student - results are shown as approximated

Student	URM	Asian American	White	Total
Assigned by Committee	610	480	5050	6140
Opt for poster-only	670	330	3600	4600
Total	1280	810	8650	10740

Early Career - results are shown as approximated

Early Career	URM	Asian American	White	Total
Assigned by Committee	800	970	8140	9910
Opt for poster-only	250	220	2180	2650
Total	1050	1190	10320	12560

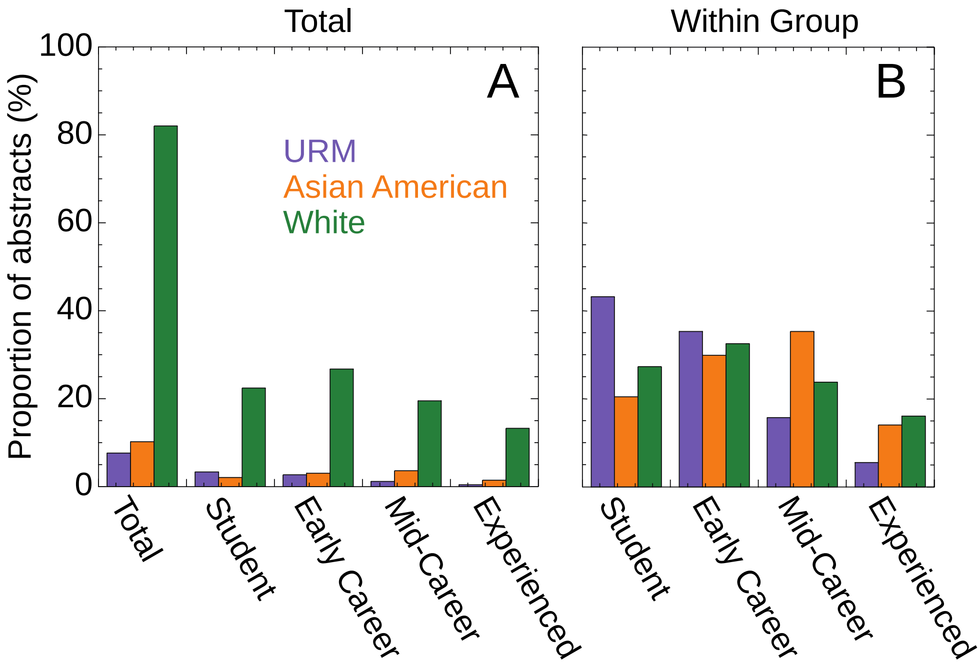
Mid-Career - results are shown as approximated

Mid-Career	URM	Asian American	White	Total
Assigned by Committee	370	1190	6310	7870
Opt for poster-only	90	220	1240	1550
Total	460	1410	7550	9420

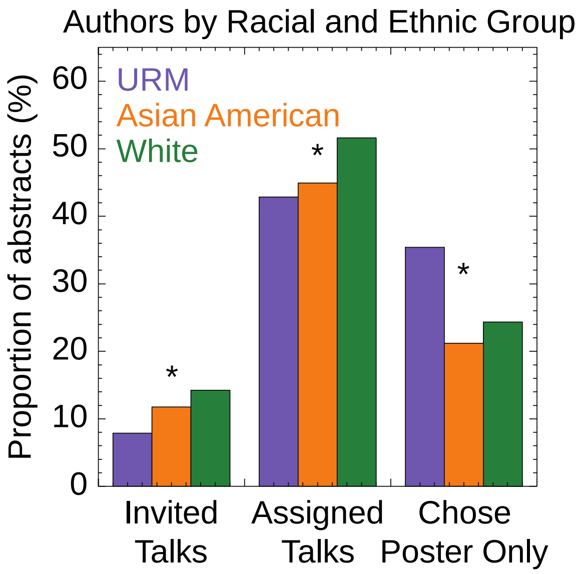
Data for **Experienced** career stage not provided due to personally identifying information.

3. Figures

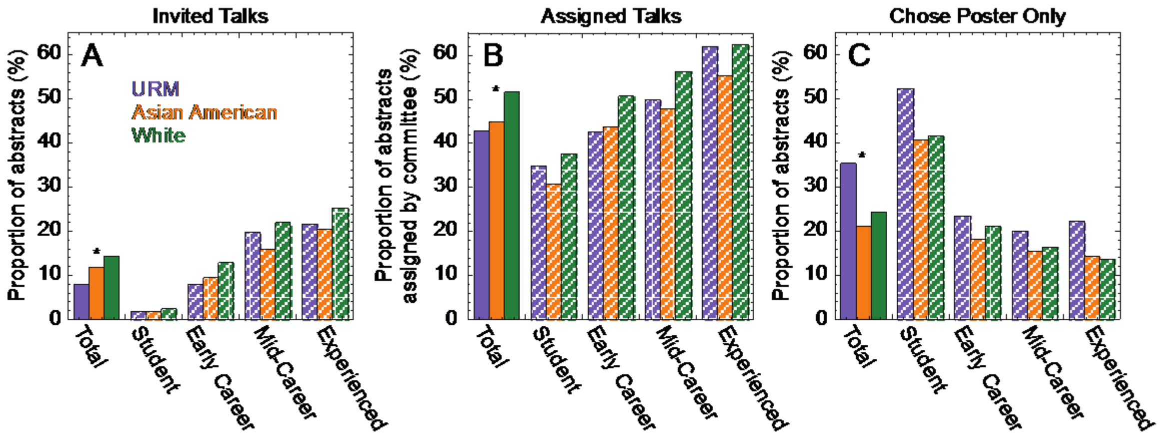
Supplementary Materials Figure 1. Demographics of the American Geophysical Union Fall Meeting authors based on career stage and ethnicity. Demographics as a proportion of all ethnicities (a) and within a given ethnicity (b). URM were concentrated in the student and early career stages. The modal Asian American author was mid-career stage while the modal White author was early career and the modal for URM was student and early career.



Supplementary Materials Figure 2. Author submissions to the American Geophysical Fall Meeting by ethnicity. In descending order, authors being separately invited, and authors being selected for oral presentations: Whites > Asian American > URM. In descending order of authors opting for posters, URM > Whites > Asian American. The "invited" and "opted for poster" values are shown as the proportion of total abstracts. The "assigned oral" is shown as the proportion of abstracts assigned by committee.



Supplementary Materials Figure 3. Author submissions to the American Geophysical Fall Meeting by race/ethnicity and career stage. When controlling for career stage, Asian Americans were invited less often than Whites. Asian Americans were invited more often than URM at the student and early career stages and less often at the mid-career and experienced career stages (a). When controlling for career stage, Asian Americans were assigned oral presentations less often than URM and Whites (b). In total, Asian Americans have more oral presentations than URM because they are concentrated in more senior roles where they are more likely to be allocated an oral presentation in comparison to students where URM are concentrated. When controlling for career stage, Asian Americans mostly opted for poster presentations less often than URM and Whites (c). The "invited" and "opted for poster" values are shown as the proportion of total abstracts. The "assigned oral" is shown as the proportion of abstracts assigned by committee. An asterisk indicates a significant result at $p < 0.05$ for the totals only. We did not perform statistical tests based on career stage (hashed bars) because we did not always have the statistical power to detect differences, are at risk of non-pre-registered multiple comparisons generating false positives, and are avoiding potentially personally identifying information in small cells.



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