The State of Diversity, Equity, and Inclusion in the Cloud Physics Community

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Abstract. The Geosciences are amongst the least diverse research fields, where women and other underrepresented groups face systemic biases. This paper presents the state of diversity, equity, and inclusion (DEI) in the cloud-physics community, by combining a metadata analysis of 6987 cloud-physics peer-reviewed journal articles published between 1970 and 2020 with responses from a survey of 198 participants from the cloud-physics community. Women first-author contributions are evident only after 1997 and presently only ∼17% of studies in the cloud physics field are led by women. Authors from the Global North dominate first and corresponding-author positions, with only ∼5% of studies led by tropics-based scientists (TBS). The latter's participation was low even for study sites in the tropics, suggesting widespread practice of parachute science. Of the survey respondents, 23% identified as historically and currently excluded and feel that belonging to this group has had a negative impact on their scientific career, in terms of collaborations, promotions, publishing, funding, salary, and citations. Although the survey data shows the general experiences of cloud physicists globally, the perspectives from this work can aid the cloud-physics community to develop strategies to improve DEI in institutions beyond a business case for a diverse science community. Rather we should consider an equity-centered approach by understanding our ethical responsibilities to benefit research of the climate system, as it is promoted by the International Association for Promoting Geoethics (IAPG) in Geosciences.

1 Introduction

Diverse teams improve the quality of scientific research by fostering innovation, as well as offering unique and culturally sensitive perspectives in a variety of disciplines (Swartz et al., 2019; Almouzni, 2024; Perez-Sepulveda et al., 2025; Titirici et al., 2025). Climate change research represents such an area that transcends academic research into a global equity issue. Its study demands diverse and inclusive perspectives in order to customize and optimize strategies that will inevitably influence developing countries that are already being disproportionately impacted (Dervis, 2007). Diversity, equity, and inclusion (DEI) refers to efforts and actions to create awareness and shift mindsets, practices, and policies to sustain an environment that is equitable and sensitive to people with diverse needs, with the goal of promoting inclusivity. A diverse, equitable, and inclusive workplace supports greater employee engagement, innovation, and attraction of talent, arising from the sharing of varied perspectives and experiences, thus enriching knowledge production and fostering innovation (Nielsen, 2016). In scientific research, diverse teams improve the quality of research and findings - a reality to which the research community has become increasingly aware in the past decades as the recognition of the importance of diversity in science has grown (Plaut, 2010). For example, ethnic diversity among authors increases the scientific impact of a publication (AlShebli et al., 2018). Although various programs, policies, and inclusive environments are being developed to address issues such as gender inequality in academia (Ranganathan et al., 2021; Bernstein, 2024), many gaps in other historically and currently excluded groups such as Hispanic, black, indigenous communities, scientists with disabilities, and LGBTQIA+ scientists still remain (Bernard and Cooperdock, 2018; NCSES, 2019; Gewin, 2020; Odekunle, 2020; Berhe et al., 2022; Marin-Spiotta et al., 2023). Thus, we must recognize that developing a diverse, equitable, and inclusive workplace is a very challenging task (e.g., Apaaril, 2021; Reisch and Jani, 2025) and requires considerable reform of systemic deeply rooted institutionalized practices.

Many fields lack diversity in gender, ethnicity, disability, and language including health (Wenneras and Wold, 1997; Landman and Dandolu, 2009; McDermott et al., 2018), science, technology, engineering and mathematics (STEM)(Nadis, 1999; Watt, 2005; Haak, 2002; Barber et al., 2020; Ceci and Williams, 2011; Leslie et al., 2015), as well as humanities, in particular philosophy (Nielsen, 2016; Botts et al., 2014; Herfeld et al., 2022). The lack of diversity, equity, and inclusion in academia is one of the manifestations of a system originally structured to privilege dominant groups and exclude marginalized populations, a pattern that has historically characterized most fields in science and that continues to influence their institutional practices. Studies on practices in academia have found bias against under-represented groups (Gates, et al., 2019) that affect hiring and promotion processes (McDermott et al., 2018; Nielsen, 2016) and other career outcomes like the number of citations (Aksnes et al., 2011; Lerback et al., 2020), scientific productivity (Abramo et al., 2018), publication acceptance rate (Lerback et al., 2020), funding and awards (Mehta et al., 2018), and recognition (Odekunle, 2020). Recently, Chen et al. (2022) found evidence of racial disparities when investigating data from the National Science Foundation, USA. The authors report that White principal investigators (PIs) were consistently funded at higher rates than most PIs belonging to the global majority (GM). Systemic bias, historically excluded groups, and a lack of recognition of researchers in and from developing countries (Global South) are reflected in the limited scientific collaborations between research groups from developed (Global North) and developing countries (Gewin, 2023). For example, Wight (2021) highlights the lack of recognition of African collaborators and the difficulties they experience publishing in high-impact journals.

Geosciences are among the least diverse fields, in which historically excluded groups are exposed to systemic biases that prevents them from equal progress and recognition compared to their more privileged counterparts (Simarski, 1992; Stokes et al., 2015; Bernard and Cooperdock, 2018; Dutt, 2020; Hall et al., 2022; Berhe et al., 2022; Marin-Spiotta et al., 2023; Rubbia, 2025). Although the reasons for the low diversity in geosciences are not fully understood, Marín-Spiotta et al. (2020) listed historical legacies of exclusion, hierarchical power dynamics, culture of impunity, and the discriminatory and unsafe practices during fieldwork, as some of the most important barriers that goes against diversity. Ford et al. (2019) reported that historically excluded groups including women are less often invited to give talks, which are essential to establish a network, funding, and academic collaborations. Similarly, individuals with disabilities report not only feeling less safe and included in geoscience space like fieldwork (Lawrence and Dowey, 2021; Castro and Atchison, 2024), but also receiving less research assistantships, internships, fellowships, scholarships, and grants than their able-bodied counterparts (NCSES, 2021). Pico et al. (2020) found that woman first-authorship on peer reviewed papers was underrepresented in several geoscience sub-fields and extended to establishing collaborations. For example, although there has been an increase in the number of international research networks in the last two decades of the 20th century (Adams et al., 2005; Wagner, 2005), the inclusion of researchers from new geographical locations was not significant from 1990 to 2000 (Wagner, 2005), but it was significant between 1990 and 2013 (Wagner et al., 2017). While scientific collaborations are also determined by the degree of the economic development of a country (Gazni et al., 2012), the authors found that existing scientific collaboration networks between USA, UK, Germany, France, Italy, and Canada are less likely to cooperate with countries with low scientific development. Even though DEI has been evaluated in geosciences as a whole, there are very few studies focusing on specific geosciences subfields such as atmospheric, oceanic, solid Earth, aquatic, planetary, and environmental sciences, among others (Dyess and Teplitzky, 2022; D'Elia, et al., 2023; Pruitt et al., 2023, de Vos et al., 2023).

Recently, Gewin (2023) highlighted that parachute research, a practice where well-funded researchers often conduct short-term research in the Global South countries which are typically poorer without seeking equal partnerships and intellectual exchange, is very common in the geosciences, and needs to be curtailed in favor of equitable collaborations. The existing collaboration networks mentioned by Wagner (2005) and Gazni et al. (2012) highlight the limited connections between Global North and Global South research groups. The limited coordination and data sharing between Latin America and scientists from developed countries was also recently discussed in Wheeling (2021). Collaborations across a diverse set of individuals influence the degree of science quality (Katz and Martin, 1997; Gazni et al., 2012; Abramo et al., 2013) and the ability to effectively communicate science to different target audiences. Fostering collaborations between different geographic locations is therefore necessary. Given that the atmosphere and clouds containing air pollutants transcend continental and oceanic boundaries, studies from all over the globe are needed by scientists with a richly diverse set of perspectives. In this study, we explore the regional representation bias of collaborations in the cloud physics community for tropics-based scientists, (TBS, anyone from a country who lives and works in the tropics), i.e. within the latitudes of 23.5° N and 23.5° S. Multiple studies show that this region is one of the least studied in the field (Yakobi-Hancock et a., 2013, Petter and Wright, 2015; Kanji et al., 2017; Irish et al., 2017; Welti et al., 2020; Metcalfe et al., 2025). For example, input observations are often calculated rather than sampled for the tropics in studies that evaluate the role of aerosols and cloud formation in climate models (e.g., Cesana et al, 2023; De Vera et al., 2024). The overlooked observations from the tropics is a perpetuation of the historical marginalization of the region and its populations, based on historical legacies of colonialism, natural resources extractivism, and slavery (Rini, 2020; Pereiria and Tsikata, 2021; Atiles and Rojas-Paez, 2022; Feijo and Orre, 2024; Meyfroidt et al., 2024), and that today the effects of this history are still present in scientific practices

(Godrie, 2025; Arosoaie et al., 2026). Therefore, this study not only focuses on the biases based on the location of scientists, but expands the discussion to evaluate the overall state of DEI in scientific spaces in the cloud physics community. It is important to note that the cloud physics community is a multidisciplinary field where meteorologists, physicists, biologists, oceanographers, chemists, environmental engineers, and chemical engineers, among others, work together in cloud and climate modelling, field, theoretical, and laboratory studies which implies variabilities in issues related to DEI.

We achieved this by first combining objective insights from a metadata analysis of 6987 published papers in the cloud physics field. Second, we contextualized these results with personal insights from community members via a survey for the cloud physics community. This approach allowed us to gain firsthand knowledge of the experiences of the cloud physics community demographic, including those who identify as historically excluded. We discuss how diverse, equitable, and inclusive the cloud physics community is based on the survey responses. Using the metadata analysis, we address Global North collaborations with Global South by evaluating publication statistics and impact factors of journals.

We present findings that reveal biases in historically excluded groups and their experiences, as well as publication biases, and discuss the implications that these observations might have for research and performance. We propose recommendations for strategies on how to encourage and motivate collaborations between scientists, and thus increase diversity within the cloud physics field. To arrive at these recommendations, we discuss how to tackle the lack of infrastructure, resources, and training of TBS to perform high-quality research in cloud physics. Finally, the grander question of systemic barriers in cloud physics is discussed.

2 Materials and Methods

To evaluate the state of DEI in the cloud physics community, two approaches were used to gather data. First, we assessed the current state of DEI and the systemic experience of the cloud physics community members, via a survey of the community conducted prior to the International Commission on Clouds and Precipitation (ICCP) meeting in 2021 hosted virtually in Pune, India. Second, we conducted a metadata analysis of peer-reviewed published studies between 1970 and 2020 as a publicly accessible metric to trace the temporal evolution of authorship in the field.

2.1 Survey data

The survey was created by the authors of the present study using Google Forms and distributed by email. The questions were designed and discussed amongst the authors and after being finalized it received the Texas Tech University Institutional Review Boards (IRB) approval (IRB2021-472; Title: Diversity, Equity, and Inclusion in the Cloud Physics Community). The survey was conducted anonymously and did not contain any direct identification (i.e., name or place of employment of the participants). It contained a total of 42 questions (67 questions including sub-questions, as shown in Table S1). We distributed the survey via the ICCP mailing list (938 as the upper limit of the listserv) and a list used to advertise a virtual colloquium related to the topics of ice nucleation and/or aerosol-cloud interactions. The latter targets research scientists who may identify with ice nucleation research, but not necessarily with the wider cloud physics community. The survey was also distributed through the list of registrants of the 2021 ICCP conference held virtually and hosted in Pune, India from August 2-6, 2021. It was distributed and open for responses from July 1 to August 4, 2021. The closing date was deliberate because part of the survey results was presented at the ICCP conference in 2021 as a plenary talk on August 5, 2021. After the talk, we did not collect any responses to avoid biases after presenting the preliminary results at the conference.

The survey was completed by 231 respondents, but the sample size used in the analysis here decreased to 198 after data quality assurance in which participants who did not identify with either the ice nucleation field and/or cloud physics field were removed. We estimate that the sample of this survey is representative of the membership and distribution list of the ICCP based on a comparison to the attendance of three previous ICCP meetings carried out in Leipzig 2012 (665 attendees, 3% Indian, 22% German), Manchester 2016 (429 attendees, 1% Indian, 19% UK), and Pune 2021 (570 attendees, 28% Indian). This brings us to a percentage coverage of 30-47% normalized to the attendee numbers from the three previous conferences and 21.1% as the lower limit of the response rate, calculated as a percentage of the listserv, which is 198/938. For the survey, the number of local respondents (Indian) was proportionally higher (14% of survey respondents) compared to previous Indian affiliation registrants likely due to the ICCP 2021 conference being hosted in India. This was also the case for increased registrants from local scientists when the host countries in previous meetings were Germany and UK. Germany, UK, and USA also have a noticeably higher participation rate because there is a large research presence of cloud physics historically from these countries, with established cloud chamber facilities. The survey covered 30-47% of the cloud physics membership based on the past attendee statistics. Although the ICCP membership is representative of the international cloud physics community, there could be some unintended biases in the survey data coming from the overrepresentation of respondents born in India, Germany, and US (above 15% each) as well as the overrepresentation of respondents younger than 40 years old (64%). Specific questions (see supplementary information) were asked to allow an assessment of the biographic data, career stage, experience regarding career progress, promotions, hostile environments, bullying, and diversity of working with students and supervisors from the Global South. The results were stratified by gender, age, and ethnicity with all analysis and plotting performed in Microsoft Excel and Origin Pro. We used Chi-square tests in R (version 4.3.1) to assess group differences, reporting Cramér's V as effect size (0.1 = small, 0.3 = moderate, 0.5 = strong; Cohen, 1988).

The assignment of which ethnicities and cultures are considered historically excluded can differ depending on the geographical location. This may arise from the prevailing ethnicity in the location of the survey respondents. Therefore, in further analysis, we classify the Caucasian, White or European categories as "White", while all other ethnicities are classified as people of global majority (POGM or simply GM) with the exception of participants who preferred not to identify their ethnicity.

2.2 Metadata analysis

2.2.1 Study search and criteria

For the metadata analysis, the Scopus database was used. The search algorithm for the papers that were analyzed in the present study is described in Fig. S1 (supplementary information). The following criteria were applied for papers written in English and published in indexed journals: In the "Search within Article title, Abstract, Keywords" option, "cloud physics" was added with an additional search field with the word "cloud microphysics" linked with the option "OR". Subsequently, the following filters were applied. a) year range: 1970 to 2020, b) subject area: Earth and Planetary Sciences, c) document type: Article, Review, and Letter, d) publication stage: final, and e) source type: Journal. Although 8199 papers were pre-selected (from the documents available in Scopus on December 2021), those papers published in Astronomical and Astrophysical journals and other papers not related to cloud physics or written in a language different from English were removed leaving us with a total of 6987 papers as shown in Fig. S1. We note that the number of papers (i.e., 97) removed because of language could slightly impact the outcome of the present analysis; however, this was necessary because the authors of the present study were unable to translate them to get the needed information. Also, it is important to highlight that the conclusions raised from the metadata analysis could be biased as Scopus, and most databases, does not cover all areas of interest leaving out important information from e.g., non-English-speaking countries or Global South countries (Martín-Martín et al., 2018; Tennant, 2020; Pranckuté, 2021).

2.2.2 Coding procedure

The author's name, year of publication, title of the paper, journal name, DOI, affiliations, first author country, and funding agencies were directly extracted from Scopus. The journal's impact factor was obtained from the Journal Citation Report 2021 which was updated in November 2022 (https://impactfactorforjournal.com/ wp-content/uploads/2022/11/JCR-2021-Impact-Factor-PDF-list.pdf). On the other hand, the first authors' gender, the number of woman/man co-authors, and if any of the co-authors were TBS were assigned by a self-written automated script in Python (an open-source code used for this analysis is available at https://doi.org/10.3929/ethz-b-000654489). Each co-author's gender was evaluated employing the genderize.io web server (Demografix ApS, 2022) and included in the analysis if the certainty estimate provided by the tool was larger than 75% (a somewhat arbitrary, but conservative choice). The genderize.io tool relies on web-collected data and has previously been used for similar demographic science research (e.g., Holman et al., 2018; Shen et al., 2018). It is important to note that genderize.io assigns a binary (female or male) gender based on the person's first name. This can only be an approximation, as names cannot always be used to infer the gender (e.g., Sebo, 2021; Lockhart et al., 2023; Marty et al., 2023). Critically, the binary gender assumption inherent in this methodology reinforces cisgender normativity and erases non-binary and possibly also trans identities. While being aware of these important limitations, the superficial approach necessitated by the quantitative analysis of the large amount of data cannot avoid them. Therefore, the results presented below must be taken with caution and considering the aforementioned bias. Each paper was checked for TBS co-authors by comparing their affiliations with a list of tropics-based countries. For a country to be considered tropics-based in this study, at least 50% of its inhabitants need to live in the tropics, i.e., between 23.5° N and 23.5° S and be considered a low-income country, except for Taiwan, Singapore, and Hong Kong (See Table 1). From our analysis, the total number of countries (where the first authors were located at the publication time) represented in the publications were 72, of which 23 countries were coded as being in the tropics. However, it is important to note that 11 additional countries were coded as being in the tropics when considering the coauthors.

2.3 Position statement

The author team for this article comprises scientists with a range of disciplinary backgrounds, upbringing, and experiences related to DEI. We were born, and have lived or worked in Canada, Colombia, Ecuador, Finland, France, India, Israel, Kenya, Mexico, the United States of America, and Switzerland. Our disciplines span from chemistry, over atmospheric science, to sociology and not all of us are currently working in the cloud physics field. We are able-bodied and cis-gender. Our academic positions cover PhD students, post-doctoral fellows and professors. In one regard or another all of us are part of a historically excluded group, be it as born in the tropics, first generation who attended university, person of color, woman, indigenous person, sexual orientation, religion or nationality. This background has undoubtedly sensitized us for DEI, albeit from different angles.

We are committed to building bridges that help this community to be more diverse, equitable, and inclusive. For many of us, being part of the GM and excluded nationality, our lived experiences from intersectionality are different from the Global North. Also, many of us do hold privileged positions and acknowledge that the access to western education systems and structures have afforded us privileges. Our experiences thereby may both sensitize and limit our engagement with the full range of intersectional and geographic dimensions of marginalization explored in this study. The focus of the survey and study design being on the tropics and gender effects may reflect our experiences, but our differing backgrounds also allowed us to add many and question each other’s perspectives.

3 Results and discussion

3.1 DEI as evidenced from the metadata analysis

For several decades the participation of women was relegated to secondary roles in scientific articles in many fields (e.g., Pico et al., 2020). As shown in Fig. 1a, only after ca. 1997, the role of women as leading authors is evident. Since then, the number of studies led by women has increased with time. As of 2020, only ca. 17% of the studies published by our community were led by women. Although the number of women working in the cloud physics community has an increasing trend; the number of women as leading authors is far from being equitable (Fig. 1). Figure 2 shows how gender inclusive published articles led by women and men are. The metadata analysis clearly shows that the papers led by women are better balanced (i.e., the number of women co-authorship and the number of total coauthors is closer), yet still not balanced in the gender of co-authors (Fig. 2a,b). It is important to note that this trend is stronger for articles with a low number of co-authors. Women first authors thus are more likely than men first authors to choose women co-authors. This was also found in a recent study in ice-core science where women-led studies had 20% more-women co-authors than men-led studies (Koffman et al., 2023). This may not be the result of them being more equitable, but could rather mirror a preference for working with people similar to oneself. Nevertheless, it implies that one route to increase women co-authorships is to have women authors in the lead. This could happen if more women get senior scientists and professorship positions. Similarly, TBS first authors are likely to bring in other TBS co-authors (Fig. 3). It is important to note that typically most of the senior authors get listed at the end in the cloud physics community.

The methodology used in the metadata analysis to assign gender to authors (genderize.io) assumes a gender binary, risking the misclassification of non-binary and gender-diverse individuals. We acknowledge this as a limitation of the present study that could have introduced a gender exclusion bias. As shown by the results in the survey described in section 3.2, at least three respondents self-identified outside of the gender-binary system, which shows the active participation of non-binary individuals in the cloud physics community. In section 3.3, we expanded the discussion on the experiences related to gender in the cloud physics community. Future metadata analysis should incorporate self-identification methods to include non-binary genders. For example, Son and Bell (2022) analyzed publications in which individuals self-identify their gender during manuscript submission.

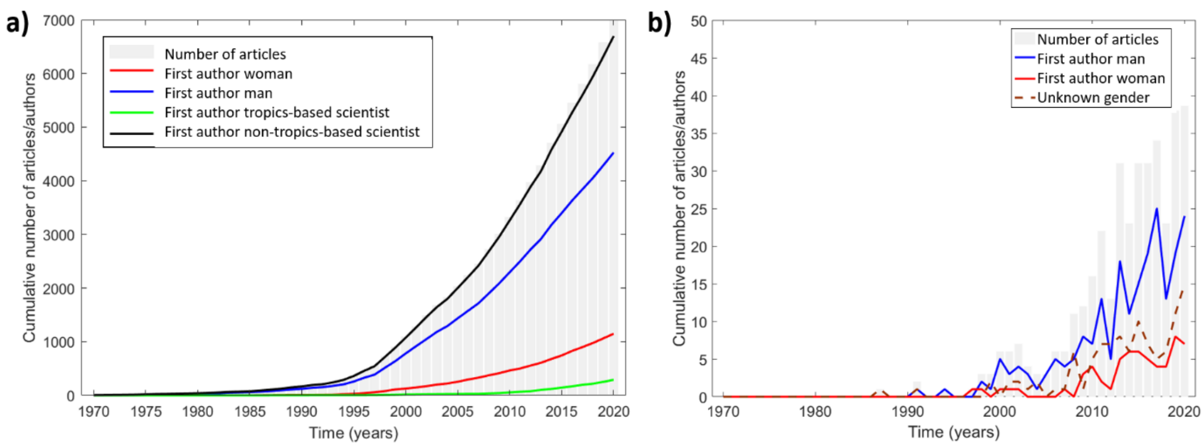

Figure 1: Cumulative number of articles published in the cloud physics community during the last 50 years for a) all geographic locations and b) tropics-based authors. In panel a) the red, blue, green, and black lines indicate if the first author is woman, man, a tropics-based scientist, or a non-tropics-based scientist, respectively. In panel b) the blue, red, and brown lines indicate if the first author is man, woman, and with unknown gender, respectively.

Figure 2: Distribution of women co-authorship versus the number of total coauthors, split by a) man and b) woman first author. The black dashed line shows where the number of men and women co-authors would be equal, i.e., the same amount of men and women contributing to each paper.

TBS have contributed only 5% of the total number of cloud physics publications, with most of them coming from India, Brazil, Taiwan, Mexico, Indonesia, and Thailand. Table 1 shows that 77% of all analyzed studies were led by authors from only seven countries from the Global North (i.e., Canada, China, France, Germany, Japan, the UK, and the US). On the other hand, Fig. 1a also shows that the number of TBS PIs has increased with time, especially in the last decade. However, the number of studies coming from this part of the world is very low. Although there are differences in the gender first authorship (Fig. 1b) in the articles published TBS, the gender gap is smaller when no geographic distinction is applied (Fig. 1b). Figure 3 shows that it is extremely rare that a TBS is included as co-author in articles led by non-TBS. It was also found that the number of TBS coauthors does not change if the lead author is a woman or man (not shown). The absence of leadership and participation from TBS is an example of the biased international collaboration network existing in the cloud physics community. The factors associated with this gap can be the limited funding, scientific facilities and infrastructure, lack of security for tenure, and underrepresented groups' equality (Gazni et al., 2012; Yáñez-Serrano et al., 2022).

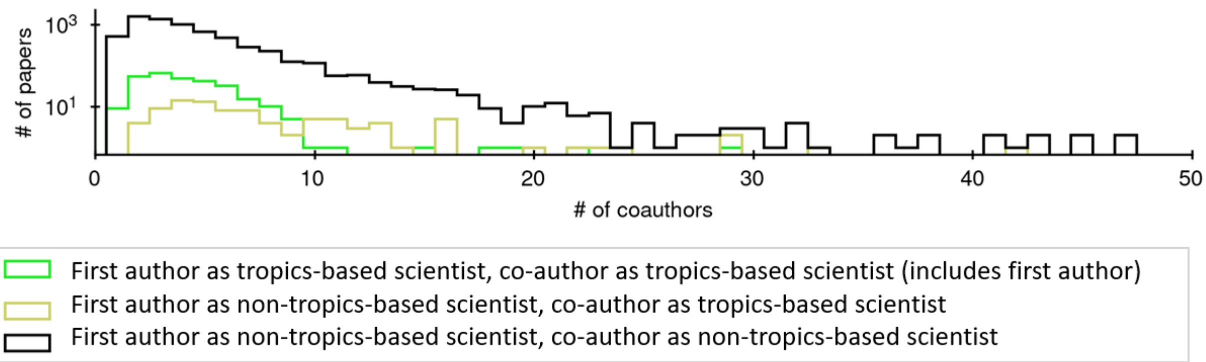

Figure 3: Distribution of the number of papers versus the number of coauthors for three different categories for tropics-based scientists and non-tropics-based scientist.

The present data shows that in addition to the low number of studies published by TBS, on average, their indexed studies get published in lower-impact journals (impact factor IF=3.91, 95% confidence interval (CI): 3.72, 4.10 (n=287)) compared to non-TBS (IF=4.58, 95% CI: 4.28, 4.88 (n=6638)). However, it is important to note that the lower rates of English proficiency and the apparent "narrow impact" of some studies from the tropics (based on e.g., desk rejections by Editors), could pressure authors to publish some of their studies in local (mostly non-indexed) journals with low visibility or accessibility to the community contributing to their overall lower IF (e.g., Solarino, 2012; Chavarro et al., 2017). Also, the lack of English skills leads to linguistic discrimination, exacerbating the marginalization of non-native English authors, as demonstrated in different sociolinguistic studies (e.g., Dovchin, 2025; Brown and Laihonen, 2025). The publications led by women are accepted and published by journals having a similar IF (average IF 4.37, 95% CI: 4.26, 4.47 (n=1140)) as those led by men (average IF=4.62, 95% CI: 4.29, 4.96 (n=4491)). This is a positive finding indicating that papers usually get published in equally ranked journals from our community regardless of gender.

It was found that the inclusion of TBS in the analyzed cloud physics studies is limited. Just 383 studies out of the 6987 analyzed papers have TBS as coauthors. Additionally, a qualitative analysis shows that out of the 6987 analyzed papers, 44 studies were performed in African tropics or used data from this geographical region (as stated in the paper title); however, only seven of them (i.e., 16%) included a TBS as coauthor. Research practices in which scientists from wealthier countries conduct studies in lower-income countries, often without meaningful collaboration or involvement with local researchers or communities and then publish the results without authorship acknowledgement or benefit to the locals, have been termed helicopter or parachute science. These practices have a colonial and extractivist legacy and may be perpetuated by the belief that Global North institutions have knowledge to be transferred to partners in the Global South (Gewin, 2023; Stefanoudis et al., 2021; Odeny and Bosurgi, 2022; de Vos and Schwartz, 2022, and references therein). Our results suggest that parachute science is unfortunately common in the cloud physics community. It is important to note that our conclusion on parachute science needs to be caveated as the non-English papers were excluded from the present analysis. Therefore, it is possible that a different scenario would emerge if the excluded papers were considered. In support of this conclusions, a recent article reported that across 82 natural science journals tracked by The Nature Index, between 2015 and 2022, only 2.7% of the articles published featured collaborations between scientists in higher-income and lower-income countries (Baker et al., 2023). In these articles, for every three authors in the richer countries one author from the lower-income country was featured (Baker et al., 2023). It is desirable that field studies performed in the tropics by research groups from the Global North guarantee the active inclusion and involvement of local research groups (or local scientists/students) to pursue more equitable collaborations. In doing so, local trainees acquire new knowledge and develop new local capacities to strengthen their scientific independence. It is important to note that this gap will be reduced more effectively if these collaborations involve technology transfer, equipment loan/donation, teaching courses to locals, and if the proposals are submitted by both parties. Although there is not a clear way to eliminate these practices, as highlighted by Ramírez-Castañeda et al. (2022) the following four principles should stand out when performing field work: be collaborative, be respectful, be legal, and be safe.

Table 1. Percentage of cloud physics publications led by different countries in the last 50 years. Each country represents the location of the first author affiliation. Bold text highlights the countries classified as the tropics in this study.

First author country	Fraction of publications	First author country		Fraction of publications
USA	43.90	New Zealand		0.10
Germany	8.09	Croatia		0.10
China	7.54	**Indonesia**		**0.07**
UK	6.43	**Thailand**		**0.07**
France	4.59	**Bangladesh**		**0.06**
Canada	3.48	Chile		0.06
Japan	3.45	Romania		0.06
India	**2.86**	**Hong Kong**		**0.06**
Israel	1.85	**Cuba**		**0.06**
Russia	1.79	**Singapore**		**0.04**
Switzerland	1.60	Egypt		0.04
South Korea	1.43	Turkey		0.04
Australia	1.30	**Vietnam**		**0.04**
Italy	1.20	**Philippines**		**0.04**
Netherlands	1.19	United Arab Emirates		0.03
Sweden	1.13	Saudi Arabia		0.03
Finland	0.77	**Rwanda**		**0.03**
Spain	0.64	**Zimbabwe**		**0.03**
Taiwan	**0.64**	North Macedonia		0.03
Poland	0.57	Estonia		0.03
Brazil	**0.46**	Slovakia		0.03
Greece	0.39	**Puerto Rico**		**0.03**

Norway	0.34	**Malaysia**		**0.03**
Argentina	0.24	**Nigeria**		**0.01**
Hungary	0.23	**Peru**		**0.01**
Austria	0.21	**Cote D'ivoire**		**0.01**
Belgium	0.20	**Niger**		**0.01**
Serbia	0.17	Nepal		0.01
Denmark	0.17	Armenia		0.01
Mexico	**0.17**	Afghanistan		0.01
Iran	0.16	**Cameroon**		**0.01**
Czech Republic	0.14	Algeria		0.01
South Africa	0.13	**Kenya**		**0.01**
Bulgaria	0.11	Cyprus		0.01
Belarus	0.11	**Botswana**		**0.01**
Ireland	0.10	Unknown		0.82
Portugal	0.10			

3.2 Biographic description of sample from survey data

The biographic information of the survey respondents is summarized in Fig. 4. Sixty seven percent of the participants were < 40 years old and 57.1% of the participants identified themselves as men, 41.4% as women, with 1.5% not identifying with the convention binary gender. The other categories possible for the 1.5% were Agender, two-spirited, nonbinary, and prefer not to respond which we categorized together as “other” due to the low numbers (pie chart in Fig. 4a). Seventy three percent of women and 58% of men were < 40 years old, while 26.8% of women and 41.6% of men were > 40 years old (Fig. 4a). The majority of participants identified themselves as heterosexual with 8% as LGBTQIA+ (Homosexual, Queer, Bisexual or Pansexual-listed by the respondents), and 5.6% preferred not to provide information on sexual identity (Fig. 4b). Figure 4b also shows the distribution of the highest academic degree obtained. The majority of the participants were students (from undergraduate to PhD) with 37% of women and 32% of men reporting this category. Also, most women (57%) were early career researchers (undergraduate to Post-doctoral level inclusive) compared to 53% of men being mid-senior career (above Post-doctoral level), as shown in Fig. 4b. The highest missing data rates from “prefer not to respond” options came from questions about perception and experience (8-19%, n=15-35 from Qs 27, 31 and 47). These are rather qualitative questions in the survey and therefore could be a reason for the high missing data, if respondents were not confident that their perceptions of experience were in fact too qualitative for a response. In other words, the highest missing data were from questions that seeked a yes/no qualitative opinion. The missing data for questions that may be considered private or intrusive is quite low (Table S2) with the highest being that about ethnicity (n=4, 2.2%), whereas the highest in the survey came from a question on perception of the increase in women in research past the PhD level (n=35, 19%).

Information on the ethnicity of the participants can be found in Fig. 4c, with the majority identifying as White (115 respondents), followed by POGM (77 respondents), and 6 respondents preferred not to identify their ethnicity. This trend agrees with the overall geoscientist PhD awardees in the US, where White people represent >90% (Dutt, 2020). For a given race, there were more men than women or hardly any difference between the two genders, except for Hispanic or Latin X where women represented 79% of this race. In the participants' own perception, only 23% identified themselves as historically excluded. We note that these numbers do not match up with the ethnicity stratified by gender in Fig. 4c because three respondents either preferred not to respond to the gender question, identified as non-binary or as scientists. Participants came from a wide variety of countries (by birth and country of residence) as seen in Fig. 4d, with the majority from USA, Germany, and India. The difference between these two bars (residence vs. birth country) indicates the number of foreign researchers in each country. For example, if the country of birth bar is lower than the country of residence, this implies that more foreigners occupy research positions (at all levels) in that country. However, if these two bars are similar it does not necessitate the absence of foreigners. On the other hand, if the country of birth bar is higher than the country of residence, it shows that more local scientists are working in the country at the time of the survey.

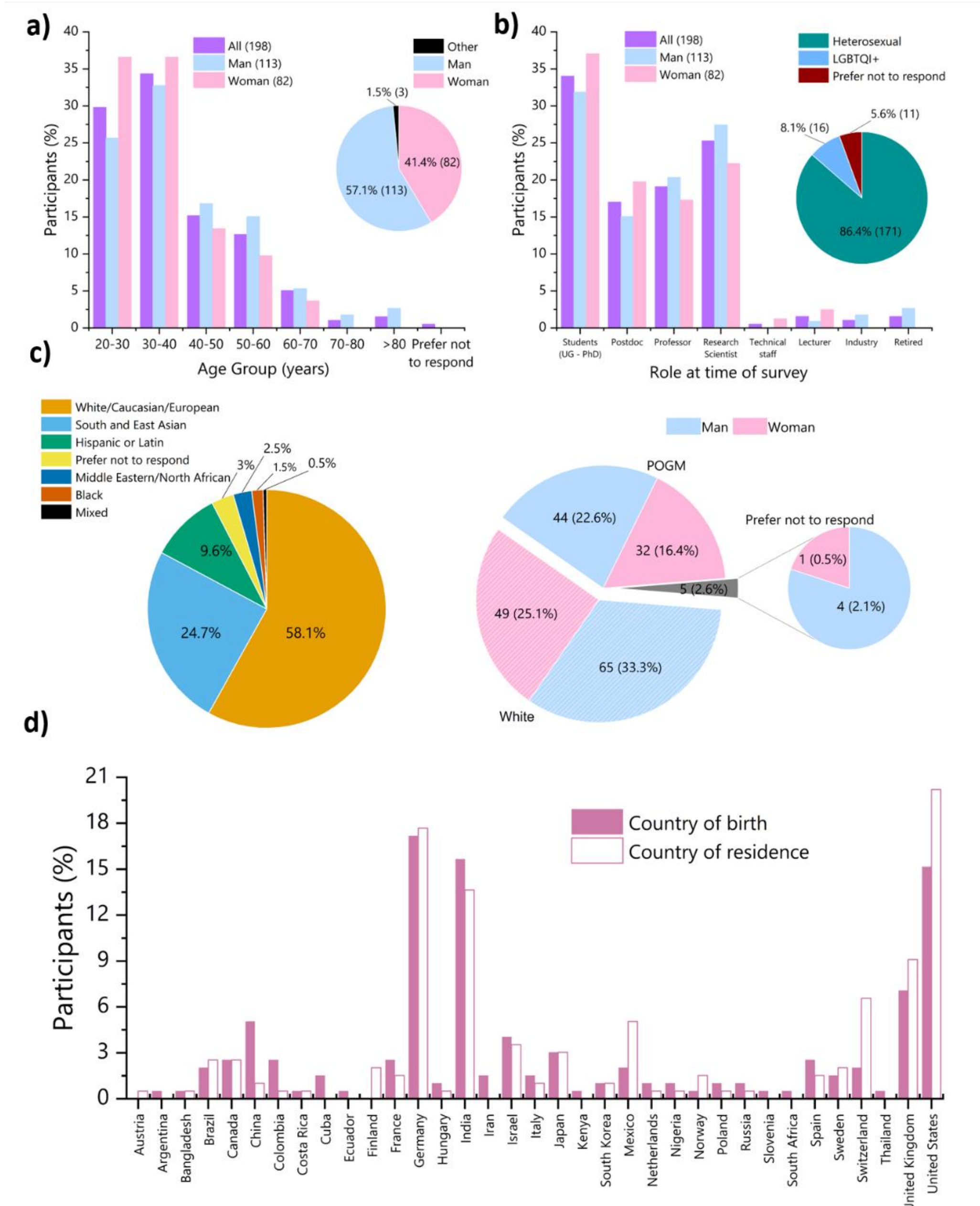

Figure 4: Cloud physics survey biographic data obtained from a total of 198 respondents showing their age, gender, ethnicity, and role distributions.

3.3 DEI general perceptions from the survey

To evaluate the general experiences of the cloud physicists about inclusivity in their working environments, we first describe our findings and then present the outcomes on questions regarding hostility, bullying, and supervision across those who identify as White and historically excluded. We use the terminology of women and men in preference to male and female to represent gender and not biological sex, consistent with the question asked in the survey (see supplementary information for questionnaire).

It was encouraging that most respondents (70%) felt included in the cloud physics community, but a closer look at the 30% who did not feel included reveals that the majority were < 40 years old; 35% of this age group did not feel included in the community (Fig. 5a). Out of the total respondents, the percentage of men and women who do not feel included is similar. When considering the feeling of exclusion amongst participants who identified as part of the LGBTQIA+ community the fraction increases from 30% to 44% (not shown). This is not exclusive to the cloud physics community as this is also the case for LGBTQIA+ geoscientists (Le Bras, 2021; Marin-Spiotta et al., 2023). We also found that a third (28%) of those who identified as POGM (i.e., South- or East-Asian, Hispanic, LatinX, Black or Mixed-race) indicated not feeling completely included in the cloud physics community (not shown). It is important to note that the feeling of inclusion means different things to different people. Therefore, these results must be interpreted with caution.

Majority of respondents (60%) perceived their workplace to be sensitive to gender issues, of which women and men comprised 58% and 61%, respectively. The small difference is consistent with random variation. Statistically and practically, there is no meaningful differences between genders, suggesting a concerted effort for workplace sensitivity (see Fig. 5b). This perception changes when considering the LGBTQIA+ community (N = 16) as 56% of them (N = 9) did not perceive their workplace to be sensitive to gender issues. A large portion of participants (75%) reported that their gender does not impact their scientific career, but for the remainder 25%, who do feel an impact, 69% were woman (Fig. 5c). This difference is statistically significant ($\chi^2(1) = 18.60$, $p < 0.001$, Cramér's V = 0.31), indicating a moderate association between gender and perceived career disadvantage, as reported in other fields (e.g., Cambois et al., 2017; Gibney, 2017). Participants indicated different ways in which they felt gender sensitivity was lacking. For example, one participant indicated that during her interview process for professorship, several instances of topics that are illegal in the respective country were raised surrounding marital status and family planning. In their role, the respondents thought that “women in the program were disproportionately asked for service work and to serve on more committees than the men faculty”. On the other hand, a small number of respondents indicated that they were at a disadvantage due to positive discrimination because they belonged to the most represented gender group (men). The majority of comments from women referred mostly to childbirth and childcare as a disadvantage and included a claim that not enough institutional support is available for normalizing these rights of passage for women. Finally, when the participants were asked if their perception of the number of women at the post-doctoral level and above has increased over the course of their career, 65% of men agreed vs. only 50% of women (the difference is not statistically significant ($\chi^2(1) = 2.14$, $p = 0.144$, Cramér's V = 0.13). Despite the disparity, these opinions resonate with the numbers of the survey which showed early career researchers were mostly women. Note that we have targeted women because there has been a huge focus in the geosciences in the last decade (Stokes et al., 2015; Popp et al., 2019; Pico et al., 2020; Ranganathan et al., 2021; Koffman et al., 2023; Bernstein, 2024), to bring in gender equality and the gender parity has largely been assessed on men and women using binary genders.

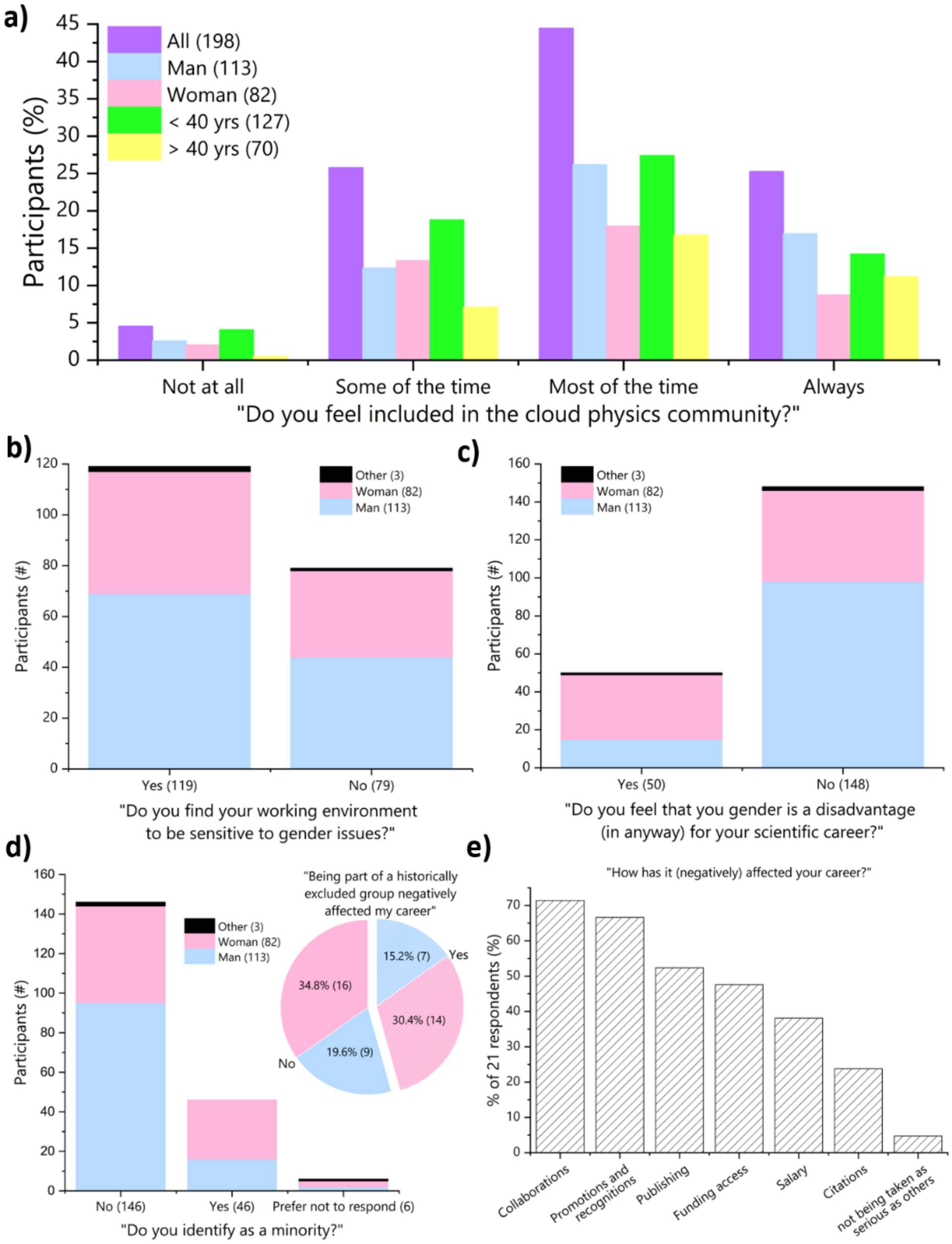

Figure 5: Cloud physics survey (total 198 respondents) on inclusivity and negative impact of gender issues and historically exclusion identity on scientific careers. For all panels, in parenthesis the number of absolute respondents for the respective category is given. Panels with questions below indicate the main question and those with questions above the plot are sub-questions.

When asked if students or colleagues from a historically excluded group (specified as minority and disability in the survey) are equitably treated in their working environment, 81% agreed. Although 46 respondents (24%) identified themselves as part of a historically excluded group (Fig. 5d), only 21 (46%) reported that their career was negatively affected (Fig. 5d) by being underrepresented in different ways, spanning from collaborations to publishing and having access to funding, among others (Fig. 5e). Seventy-six percent of the respondents who self-identified as being part of historically excluded groups indicated working with research group members who also belong to a historically excluded group. This percentage is lower (48%) for those who did not identify as historically excluded, suggesting a lower diversity in the non-historically excluded cases. Ten participants indicated they have disabilities including physical, mental, and neurological, potentially placing them in a historically excluded group. Six of the 10 participants felt excluded in their academic career or working environment because of their disability, and four of them felt that being part of a disability group negatively affected their scientific career. However, is it important to note that this number can be higher as adults with disabilities are typically underreported (Schneiderwind and Johnson, 2021).

Although the terms bullying and harassment are not strictly synonyms (Einarsen, 2000), the way the question was formulated in the survey could have led participants to understand that these concepts were the same. One third (33%) of the respondents experienced a form of bullying or harassment from someone in the cloud physics community (Fig. 6a). A higher fraction of women, 44% compared to 27% of men reported having experienced harassment, a difference that was statistically significant ($\chi^2(1) = 5.70$, $p = 0.017$, Cramér's $V = 0.18$). This aligns with the concept of intersectionality, where overlapping historically excluded social identities and positions can increase the likelihood of discrimination (Crenshaw, 1991). Women being a targeted in higher proportions was also reported in Namie et al. (2014). The proportion of respondents who experienced harassment increased with age (see Fig. 6a) with 41% of participants > 40 years old having experienced harassment. This trend could be explained by the increased probability of experiencing harassment with time spent in the field, or a more recent evolution in an awareness of harassment behavior related to work activities resulting in less harassment experience in the lower age category; however, since we did not ask when the bullying occurred it is not possible to identify which aspect explains the outcome. When stratified by ethnicity (Fig. 6a), 40% of the White vs. 26% of POGM respondents reported harassment. The difference is not statistically significant ($\chi^2(1) = 2.63$, $p = 0.105$, Cramér's $V = 0.12$). A lower fraction of GM women (30.5%, n=36) reported experiencing bullying and harassment whereas this number was 69.5% for White women. The sample size prevents statistical verification of this pattern. At first this is surprising as it does not align with expected intersectionality. However, we speculate that there could be a difference in perception between White and GM women of what bullying and harassment entails and its perception. Indeed, it has been reported that personal life circumstances and a strong sense of identity in GM groups heavily confound how bullying is perceived and can be difficult to measure (Xu et al., 2020). The reference to intersectionality is interpretive, it offers a possible lens for understanding, not a statistically proven explanation. Therefore, the reported percentages are to be taken with a caveat because of the small numbers. The present results are in somewhat in agreement with those reported by Marin-Spiotta et al. (2023), who found in a much larger survey applied to geoscientists, that harassment (specifically sexual harassment) is experienced by historically excluded groups at higher rates.

The term hostility used below is related to a hostile working environment, as stated in the survey. Most respondents did not experience hostile working environments because of their gender, ethnicity, sexual orientation or disability (Fig. 6b). However, from the 21% who did experience hostility (see Fig. 6b), women were the majority, with 37% compared to 10% of men reporting having experienced hostile working environments. This difference is statistically significant ($\chi^2(1) = 18.46$, $p < 0.001$, Cramér's $V = 0.33$), indicating a moderate association between gender and reported hostility. By age, the trends were similar for the harassment, where 25% of respondents > 40 years old reported having experienced hostile working environments versus 18% of respondents under the age of 40. Both the time spent in the field and the recent evolution of sensitivities in the workplace could account for the lower percentage in the younger group. Lastly, 24.4% of the White and 14.3% of the GM participants reported experiencing hostile environments. This difference was not statistically significant ($\chi^2(1) = 2.38$, $p = 0.123$, Cramér's $V = 0.118$), indicating a very small association.

Only 29% of respondents (9% women and 20% men) had supervised tropics-based students (BSc., MSc. or PhD.) or employees. This translates to 35% of the men and 21% of the women respondents supervising tropics-based personnel (Fig. 6c). When stratified for ethnicity, men were still the majority to have supervised tropics-based employees in both the White and GM categories. The majority of respondents who had supervised tropics-based people were unsurprisingly dominated by older respondents (70% were above 40 years), who were majority men in the White category (Fig. 6c). White respondents who supervised tropics-based personnel increased with age, whereas in the POGM category the proportion decreased with age. This reflects the decreasing proportion of senior to mid-career respondents in the POGM category as seen in Fig. 6c or the recent increase in awareness of DEI and thus only reflected in the younger (< 40 years population) population of the GM respondents. The percentage of White respondents (31%) who supervised tropics-based personnel was not significantly different from the POGM category (27%), ($\chi^2(1) = 0.15$, $p = 0.70$, Cramér's $V = 0.03$) indicating no meaningful association between ethnicity and supervision. There was a statistically insignificant difference between the proportion of men supervisors by ethnicity, where 40% of White men and 29.5% of GM men ($\chi^2(1)=0.84$, $p=0.36$, Cramér's $V=0.09$) had supervised tropics-based personnel (Fig. 6c), while the trend was opposite (still not significant) in women, where 18.4% of White women and 25% of GM women ($\chi^2(1)=0.19$, $p=0.66$, $V=0.05$) had supervised tropics-based people.

Only 28% of total respondents (22% of women and 32% men respondents) were supervised by someone from a developing or the tropics. Most of the 28% was made up of younger participants (< 40 years old, 76% vs. above 40 years old, 20%) regardless of ethnicity. Most respondents who had a supervisor from a developing or the tropics country were POGM (74.5%) vs White (22%) (Fig. 6d). Fifty-three percent of the GM respondents had a supervisor from a developing or the tropics compared to only 10.4% of the White respondents. This implies that GM respondents were more likely to get an offer from or accept a position in a group led by someone from a developing or the tropics.

Overall, from the survey it is evident that women researchers are disproportionately affected by harassment, bullying, and hostile working environments regardless of ethnicity (see Fig. 6). This aspect may result in a negative gender feedback, discouraging women from remaining in academia and research in the cloud physics community (see Section 3.5). The diminishing number of women scientists as they move up the career ladder has been described as a leaky pipeline (Wolfinger et al. 2008). However, as Berhe et al. (2022) argue, a hostile obstacle course more aptly reflects the structural and systemic problems, the fact that barriers have at least unconsciously been put in place and are sustained, and that the obstacles selectively slow down scholars from historically excluded groups. We find a consensus (67% of total respondents) that collaborating with colleagues and institutions from developing countries (no latitudinal definition was given for this question) is key for the further development of the cloud physics field yet only 42.4% of the respondents had already done so. In fact, a large fraction of the survey participants (60.6%) were not planning to avail themselves to the opportunity in the future. In fact, 33% of the respondents did not have an opinion or did not agree that it was important to collaborate with colleagues from developing countries. The 33% who did not agree or have an opinion were made up of 34% of the women vs. 30% men. There is also a bias for GM respondents being supervised by GM people (Fig. 6d), but for the majority of GM students or employees, their supervisors are White (Fig. 6c). Only 35% of men and 21% of women supervised tropics-based students or staff.

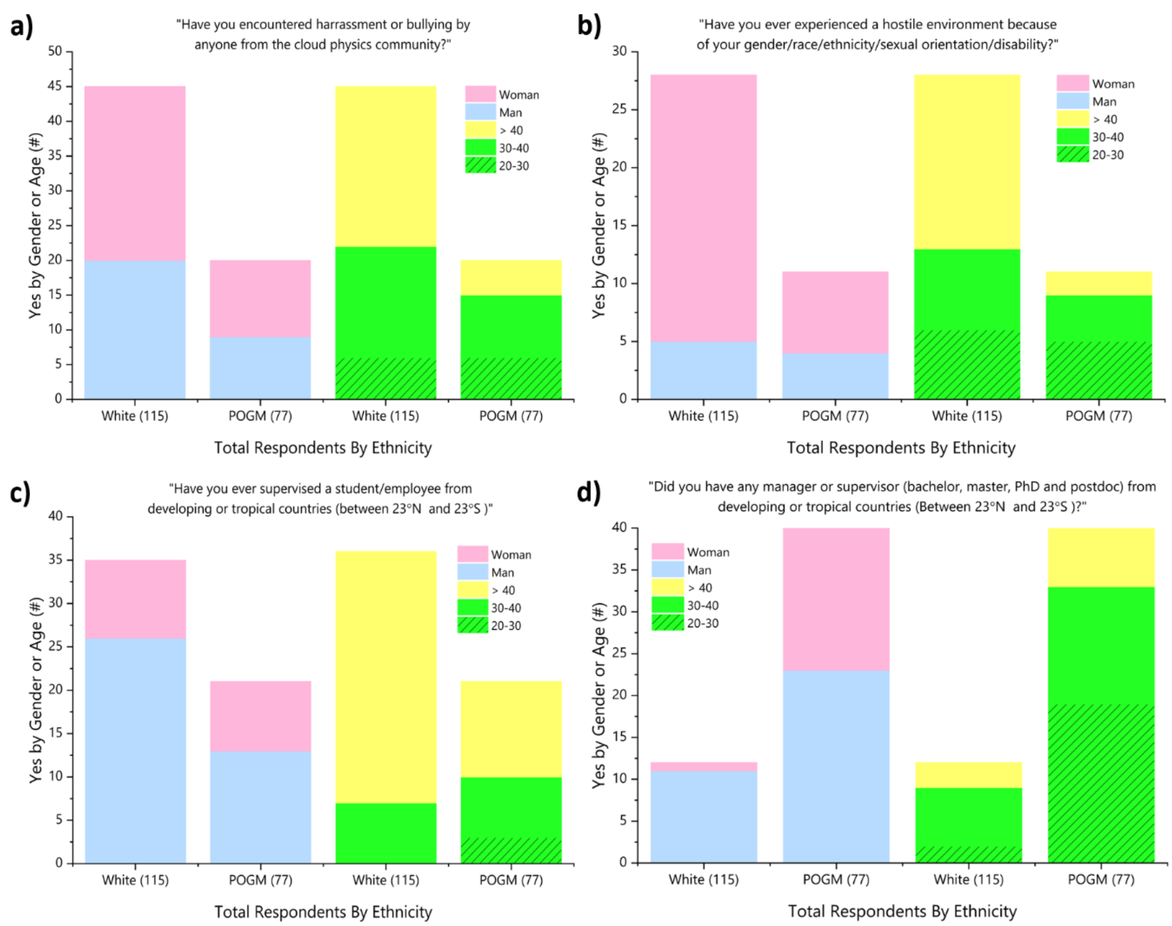

Figure 6: Stratification by age, gender, and ethnicity for respondents who a) experienced bullying and harassment by someone from the cloud physics community; b) experienced a hostile working environment due to their gender, ethnicity, sexual orientation or disability; c) supervised personnel from a developing country or the tropics defined as between 23°N and 23°S; d) were supervised by someone from a developing or the tropics defined as between 23°N and 23°S. Note that 6 respondents opted not to disclose their ethnicity. The text above each panel quotes the question as it appeared in the survey.

3.4 Improving future climate projections by increasing data coverage in the Tropics

To better describe the climate and develop future projections, it is fundamental to improve field observation coverage globally. Although the social, economic, environmental, pollution, biodiversity, and geographical characteristics of the tropics significantly differ from those in mid- and high-latitudes, the majority of the cloud physics field studies (both continental and maritime), have been performed in the Global North countries (e.g., DeMott et al., 2010;

Beswick et al., 2015; Paramonov et al., 2015; Welti et al., 2020; Choudhury and Tesche, 2022). This excludes important information related to aerosols and clouds needed to accurately simulate the climate of our planet. The tropics represent a rich source of biodiversity (Raven et al., 2020) that produce aerosol particles with a range of physicochemical properties (Adams et al., 1983; Raemdonck et al., 1986; Li et al., 2003; Després et al., 2012; Mayol et al., 2017; Ladino et al., 2019), such as biomass and waste burning, incomplete combustion of low-quality fuels, agricultural, and industrial emissions, mineral dust emissions (Wentzel et al., 1999; Eck et al., 2003; Beirle et al., 2004; Le Canut et al., 1996; Tian et al., 2015) with implications to impact the climate system on a regional and global scale (Andreae et al., 2009; Yakobi-Hancock et al., 2013). The tropics are also characterized by vast amounts of precipitation and cloud cover, especially at the Intertropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ) (Lohmann et al., 2016; Mülmenstädt et al., 2015). Mesoscale convective systems (MCSs) resulting in vast amounts of precipitation are prevalent in the tropics between December and February (Wang et al., 2019). The aforementioned characteristics place the tropical latitudes as important data spots for field measurements to determine the role that tropical emissions play in the climate system at different scales, aiding improved future climate projections (Baumgardner et al., 2012; Cesana and Storelvmo, 2017; Schneider et al., 2017; Heymsfield et al., 2017; Finney et al., 2018; Burrows et al., 2022). Cloud physics field studies are also very important to obtain in-situ information to validate satellite observations, validate reanalysis calculations, and to develop parameterizations for their inclusion in climate models (e.g., DeMott et al., 2010; Baumgardner et al., 2012; Reutter et al., 2020; Burrows et al., 2022).

The role of TBS PIs or collaborators is limited as shown in the analysis of the work presented here (see Figure 1). Even though the survey respondents agree that establishing collaborations with scientists working in a country is important for the development of the cloud physics field, as stated above 60% of them are not planning for this. We need to incorporate changes and strategies in our community to increase the global coverage of field measurements that would provide the needed information for model validation to improve future climate projections for the whole globe, including the tropics. Achieving this with avoiding parachute science and promoting studies led by TBS is crucial, as is reflected by the low number of TBS co-authorships (Figure 1).

3.5 Tracing Scopus author ID to identify the rate of gender retainment

The Scopus author ID allows counting the scientific contributions of each (co-)author in the metadata database. To investigate how long each author stayed in the cloud physics field, we classified the year they first (co-)authored a publication and the years until their last indexed cloud-physics-focused contribution. The frequency analysis of this data is shown in Fig. 7 We found that the number of entries into the field has increased in each five-year interval. However, rates of decline (the slopes in Fig. 7), i.e. scientists leaving the field, have increased at the same time. This is in line with the common perception that while scientific fields are growing, secure positions and long-term prospects for staying in academia are not increasing (Afonso, 2014).

As shown in Fig. 1, women scientists started appearing in the community only after 1985. Initially, they left the field faster than men (1990-1995). However, in recent years, after 1995, we see no difference in years between the genders in how long they remain in the cloud physics field judging by publication activity. Since this analysis did not take academic positions into account, we cannot make a definitive statement on the retention and success of women in cloud physics. Judging from the publication output alone, we do not find evidence for women leaving the field faster than men. With increasing proportions of women starting in the field, this can act to increase their proportions in the field overall (Jacob and Teichler, 2011; Hirschauer, 2016). However, while the relative number of scientists staying in the field seems to have become equal, the total numbers of scientists entering the field are far from being equal (see Figure 7). The share of women has increased for each age class, but even in the most recent age class, between 2015 and 2020, only about a third of new-coming scientists were women.

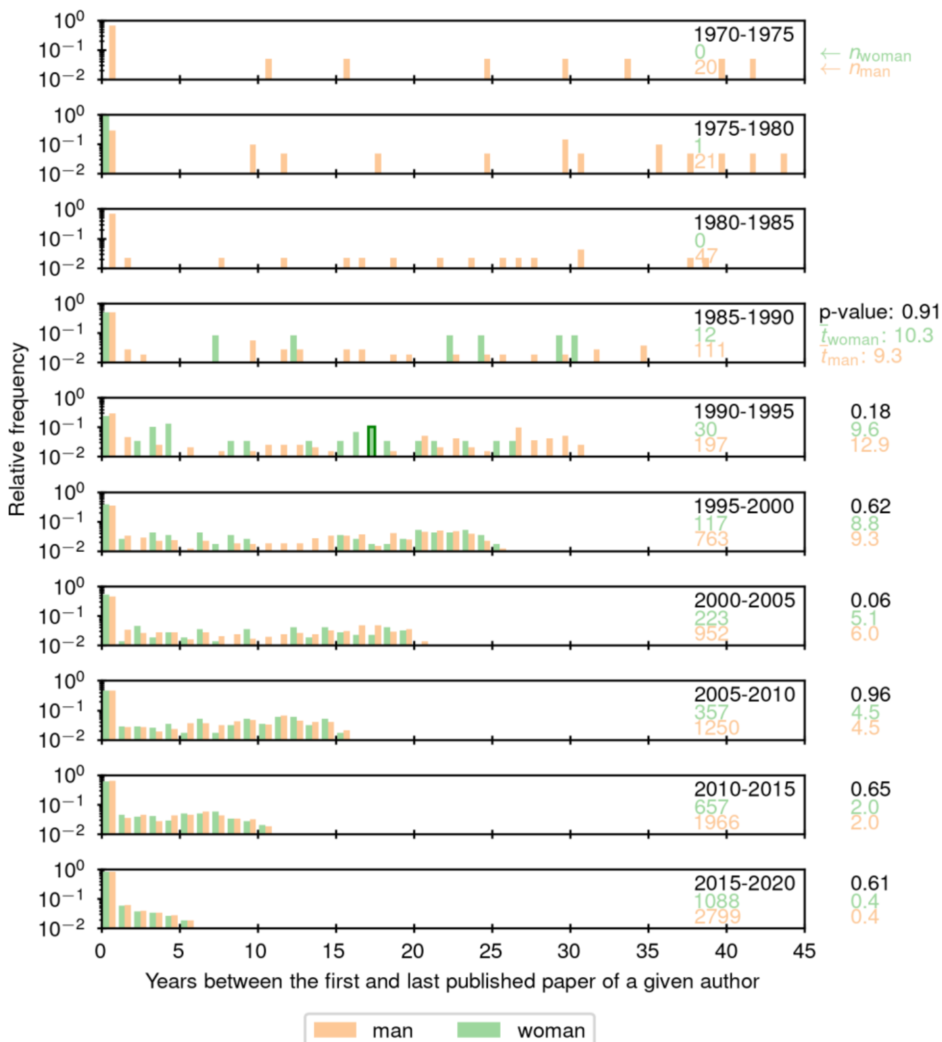

Figure 7: Frequency distribution of the years that specific scientists were co-authoring publications in the metadata analysis database, separated by gender. The rows represent the time period in which any given scientist's first co-authored paper was published. The last paper the scientist co-authored determines the position on the x-axis and is taken to be an indication of when the scientist left the field or academia. The time periods as well as the total numbers of woman (man) authors are given in green (orange) on the right, inside of each plot. The mean time

period within the field is given on the right outside each plot ($\bar{t}$), together with the p-value for a Mann-Whitney test comparing the distributions for men and women, which indicates that they show no significant differences at a significant level of 5% (which would be even smaller taking multiple testing into account). An example is given in the fifth panel, highlighted with a dark green edge: of the 30 women co-authoring their first publication, i.e. entering the field between 1990 and 1995, 10% stayed in the field for 17 years (the years until their last co-authored publication).

3.6 Limitations

Although the present study reached important conclusions to understand how diverse, equitable, and inclusive the cloud physics community is, there are different limitations that inhibit us from going deeper into our analysis and that did not allow us to reach more robust conclusions. For example, the number of the survey respondents is small (n=198), and hence, some of the conclusions need to be taken with caution. On the other hand, in the metadata analysis, non-English publications (n=97, 1.18% of the publications) were included, which could have biased the conclusions related to parachute science as well as those for TBS. It is also important to note that the usage of genderize.io to assign the gender of the authors is only a good approximation, it is binary, and it has some bias. Additionally, as IF was the only used journal metric to evaluate the access of the authors to high profile journals, and as it has been highlighted as a flawed metric of the performance of individual researchers (Editorial, 2013), the obtained conclusions could be misleading. Finally, as the authors could have taken career pauses and/or shifts, and this may be different between men and women, the analysis shown in Section 3.5 could be slightly bias.

4 Conclusions

To evaluate how diverse, equitable, and inclusive the cloud physics community is, two different approaches were used: a survey, which was distributed in summer 2021 within the community and an extensive metadata analysis of 6987 cloud physics peer-reviewed articles from Scopus, which were published between 1970 and 2020. The survey focused on topics of diversity and inclusion.

The overall conclusion from this study is that the cloud physics community follows other geosciences fields and needs continued efforts on DEI. Although the representation of women in the cloud physics community has increased after ca. 1997, the community is still far from reaching a gender parity. It is remarkable that most of the publications in this field (77%) come from just seven countries, all in the Global North. Additionally, the lead authors on papers are mostly White men with a clear lack of gender diversity and collaborators with TBS. The observed gender inequality highlights the fact that although programs, policies, and inclusive environments are developed to promote gender equity, there are still gaps that require attention.

While the majority of the cloud physics community feel included, a considerable number, particularly those who are young (< 40 years old), women, or LGBTQIA+, do not feel fully included in the community. The survey data also indicates that there are concerns with harassment and hostility of scientists within the cloud physics community, with a larger proportion of older women scientists reporting such issues. TBS co-authors is also limited compared to those from the Global North. The absence of leadership and engagement from TBS, as shown in Fig. 1, is an illustration of the cloud physics community's geographically biased worldwide collaboration network.

Despite the observed lack of diversity and equity in the cloud physics community, it was found that men and women authors publish their indexed articles in journals with comparable IF. However, the articles from TBS typically get published in indexed journals with lower IF, and in some cases, their articles inevitably end up being published in local non-indexed and non-English journals due to language barriers which we believe is compounded by lack of funding for research (including the additional services for language editorial services).

Is the lack of diversity a problem of gate keeping, or historically excluded groups being unable to sustain career paths in the field? The present results suggest that on the one hand, women report more frequent concerns with harassment and hostility which supports the notion of people from historically excluded groups are unable to sustain career paths in the field. Nevertheless, the metadata paints a different picture: the difference between the academically active years of men and women has decreased in the past 50 years, meaning that women are increasingly retained in the cloud physics community. At least this can be concluded by the absence of a notable difference between the frequency of first and last year of publication between the genders. However, the prevalence of women entering the publishing process in the cloud physics field remains far from equitable.

Increasing inclusion and diversity is essential to promote fairness and equal chances for all authors. Furthermore, expanding data coverage in the tropics is critical for a better understanding of the Earth's climate. As a result, the scientific community must collaborate to address these gaps and encourage fair collaboration and opportunities for all scientists in order to increase the quality of scientific research. Finally, fostering a more inclusive and welcoming environment within the cloud physics community will benefit not only individuals who are currently underrepresented, but it will also help to foster a more productive and collaborative research culture that can better address the complex challenges facing the field. Lastly, the following recommendations could provide a guideline on how to achieve a more diverse, equitable, and inclusive community:

- Provide institutional resources for diversity and inclusion training that align with the ethical responsibilities to be adhered to at all levels, from undergraduate students to senior professors. This should extend beyond just recruiting, but be available to facilitate the careers after recruiting.
- Promote, facilitate, and secure the participation of graduate students and early careers scientists from the Global South in the most important cloud physics academic events that take place annually, especially those organized by the ICCP (i.e., workshops, conferences, etc.)
- Persons in reviewer roles for conferences, funding applications, and peer-reviewed articles should receive training on how to avoid unconscious bias in treating submissions from women, scientists from historically excluded groups and TBS fairly, solely focusing on the science.
- Seek a gender balance and pursue individuals from historically excluded groups for faculty positions, editorial boards, scientific committees, awards, and review panels.

- Foster a culture of inclusivity in which scientists of all backgrounds experience a sense of belonging (instead of bullying or harassment). This can be achieved by promoting respect for diverse opinions and increasing the visibility and retention rate of diverse opinions and ideas.
- Journals should implement policies to avoid the practice of parachute or helicopter science and promote fair collaborations where support for colleagues from the Global South prevails.
- Increase the number of submitting proposals led by TBS in collaboration with Global North research groups. Building partnerships and collaborations across institutions and regions can help break down silos in science and promote diversity of thought.
- Funding agencies should prioritize projects conceived and led by TBS and must provide partnership, mentorship and supervision programs that encourage underrepresented groups in science, which aim to build resources in economically disadvantaged countries.
- Foster a sense of community which can be a powerful motivator for collaboration and engagement, which can be achieved through events and activities that bring different scientists together, such as workshops, seminars or social events.
- Support and promote DEI initiatives such as the Latin America Early Career Earth System Scientist Network (LAECESS, Yáñez-Serrano et al 2022) or the *Directions for future research and applications on clouds, precipitation, and extreme weather in Africa* workshop (https://www.cloudsfor.africa/).

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Data Availability Statement

The survey questionnaire and the algorithm used to collect data and analyze the articles can be found in the supplementary information file. The code for analysis of the metadata can be found at https://doi.org/10.3929/ethz-b-000654489. The data presented in this study are available at https://doi.org/10.3929/ethz-c-000804477 (Ladino et al., 2026).

Declarations

This research has been approved by the Texas Tech University Institutional Review Boards (IRB) named IRB2021-472: Diversity, Equity, and Inclusion in the Cloud Physics Community. The survey was conducted anonymously and did not contain any direct identification (i.e., name or place of employment of the participants).

Conflict of Interest

The authors declare that they do not have any conflict of interest. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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