

Peer review status:

This is a non-peer-reviewed preprint submitted to EarthArXiv.

Changing the Chilly Climate: Observations on Gender Diversity and Inclusion at a Geoscience
Conference in the Netherlands

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Declaration of competing interests: no competing interests to declare.

Abstract (250 words)

The aim of this study was to observe audience participation in a conference where the planned structures (presenters, keynotes and chairs) had an equal gender balance. The collected data can give an indication of the effectiveness of diversity and inclusion initiatives beyond the planned structures of the conference itself. We observed behaviours of attendees of the annual Dutch Earth and Environmental Science conference (NAC) in 2025.

While there was equal gender distribution amongst attendees, senior female researchers were underrepresented. During the keynote Q&A's male attendees were 8.5 times more likely to ask a question. Observations of the parallel sessions showed that 60.9% of all the first questions were asked by male audience members. Given the attendance distribution, mid and late male researchers asked significantly more questions and female early-careers asked significantly less questions than expected. A binary logistic regression showed that the odds that a female attendee asked a question was 2.72 times higher when presenter was female. An analysis of the subdisciplines showed a clear gender gap in that Environmental Sciences had relatively more female presenters and Geology more male presenters. Hallmarks indicating chilly climate were not observed during the presentations and Q&A's.

These findings indicate that gender-balanced conference organization alone does not eliminate participation disparities in geoscience conference discussions. Recommendations are made to improve inclusive diversity and inclusion for geoscience conferences.

Keywords: SDG5, Diversity, Conference, Gender, Observation, Geoscience, Inclusion

1. Introduction

In a time where diversity initiatives are challenged by politicians and budget cuts in science hinder structural DEI (Diversity Equity and Inclusion) initiatives at universities and research institutes (Hipólito, et al., 2022; Lucas et al., 2025; Lyerly, 2025; Woolf, 2025), it is important to keep monitoring the effectiveness of already implemented policies that strive to promote gender equality. In this article we report the findings from an observation study during the Dutch Earth and Environmental Science Conference of 2025, where we investigated the role of gender in scientific conference dynamics.

Diversity within the scientific community is of critical importance: foremost it is a matter of ethicality. Career prospects should be based on merit rather than one's gender, age, or (ethnic) background. Furthermore, innovative solutions and scientific progress often emerge when diverse perspectives challenge dominant assumptions through a critical discourse (Fehr, 2011; Nielsen et al., 2017; Smith & Schonfeld, 2000). Diversity in the scientific workforce can improve the relevance and applicability of research findings across different populations (Asmal et al., 2022). This is important in fields like geosciences, where understanding diverse environmental and societal contexts is crucial to address complex local and global challenges (Cigala et al., 2022; Rubbia, 2022).

Gender imbalances are now widely recognized in the scientific community, where women still tend to be particularly underrepresented at more senior levels (Beede et al., 2011; European Commission, 2024). This is called the 'leaky pipeline' effect, where gender parity declines with increasing seniority. The pipeline phenomenon has also been observed within the geosciences, resulting in what is called 'geoscience pipeline', affecting not only women, but several marginalized groups at all transition points, starting from second to third level education (Levine et al., 2007). For example, the most recent figures in the US show that the number of women earning an earth science degree is not representative of the number in faculty positions (Glass, 2015; Holmes et al., 2015) and once in faculty positions representation attritions with each career step (Ranganathan et al., 2022). It should be noted that there is variation between different disciplines within earth sciences, where the environmental disciplines show a more equal ratio in terms of gender diversity compared to geological disciplines (Handley et al., 2020; King et al., 2018; Piccoli & Guidobaldi, 2021). These patterns highlight that gender diversity challenges in geosciences are systemic, discipline-dependent, and persist despite the growing awareness on the issue.

The leaky pipeline effect is not simply the result of historically lower numbers of women entering geosciences, but a reflection of systemic barriers that limit career progression. Systemic barriers such as biases in the awarding of funding, prizes and grants (Cruz-Castro et al., 2023; Ranga et al., 2012, van der Lee & Ellemers, 2015), the publication process (e.g., Fox et al., 2016; Pico et al., 2020),

conference participation (Farr et al., 2017; King et al., 2018; Lefebvre & Bernard, 2024; Martin, 2015) and representation in general (e.g., Henriques & Garcia, 2022; Holman et al., 2018) continue to hinder progress. Recent research found that when committees believe biases do not exist, fewer women get promoted (Régner et al., 2019).

In geosciences specifically, there is a considerable body of research that identified and analyzed barriers for different minority groups (e.g., Latina's, Cisneros & Guhlincozzi, 2022; prospective students with disabilities, Mol & Atchison, 2019) and increasingly, attention is being given to improving the general diversity of the geosciences community (Gates et al., 2019; Harris et al., 2021; Huntoon & Lane, 2007). It is crucial to identify not only structural and historical issues (Bernard & Cooperdock, 2018; Reyes-Sánchez & Irazoque, 2022) that have often been blamed for the current non-diverse community, but also to identify current aspects of geosciences careers which are non-inclusive and potentially push out minority groups in early career stages (Glass, 2015; Pollack, 2013).

Gender equality has been spurred on by clear mission statements from international institutions such as UNESCO (e.g., Galán-Muros et al., 2023) and the United Nations (i.e. SDG 5 Gender Equality). The importance of SDG 5 is slowly trickling down in society and into academic institutions through targeted policies and EDI programs. Especially target 5.5 '*Ensuring women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life*' has led to a proliferation of policy recommendations for scientific institutions. For example, more publishers and journals strive towards a gender balance in their editorial boards (e.g. Springer Nature, 2024). Filling out a Gender Equality plan is a mandatory component in EU research fundings structures since 2022 (European Commission, 2021; European Institute for Gender Equality, 2022). And in the Netherlands, the Dutch Research Council (one of the largest funding bodies) has adopted the creation of an open, inclusive and diverse research climate as one of their core ambitions (NWO, nd.).

To prevent well-meaning diversity policies resulting in mere 'tokenism', it is important to provide quantitative information on the presence or absence of minorities. Furthermore, it can be helpful to specifically investigate the conditions that ensure diversity also translates into *inclusion*. Research on diversity has proposed that to avoid tokenism and promote diverse potential there should be 1) a space to voice dissonant ideas, 2) a shared understanding of what is considered the dominant viewpoint, 3) a guarantee that dissonant ideas are listened to and 4) an agreement that each group member is viewed as equally capable of contributing with their perspective (Longino, 2002; Fehr, 2011). To evaluate diversity initiatives, it is therefore necessary to observe not only representations of minority groups but also the behavior and treatment of those groups in the professional/academic setting.

1.1 Conferences

One key activity for academic progression is participation in scientific conferences. Conferences are important for the professional development of researchers as they grant them the opportunity to showcase their research results to the broader community and are essential to build professional networks. Conferences can thereby foster a sense of belonging to a particular academic field (King, 2004; Sanders et al., 2022). Research has shown that identification with a field is an important motivator to pursue and continue an academic career (Cidlinska et al., 2023; Wilcox et al., 2025).

A range of elements can contribute to a lack of diversity and inclusion at conferences. Regarding diversity, prior research showed that there is typically a lack of female representation among keynote speakers or invited talks (e.g., Farr et al., 2017; Martin, 2015; Sardelis et al., 2016, 2017), even in fields where women make up the majority of researchers (Isbell et al., 2012). Moreover, there are practical barriers that reduce possibilities to attend conferences, including the lack of available childcare and a lack of awareness that conferences were organized (Bos et al., 2019; Calisi et al., 2018; Jain et al., 2019). With regard to inclusion, there seems to be a deeper inequality in the broader research environment that is emphasized when in conference settings, leading to the experience of a 'chilly climate' for minorities in terms of gender, geographical location, race and career stage (e.g., Bevan et al., 2013; Biggs et al., 2018; Case & Richley, 2013). These negative conference experiences may affect the capacity and opportunity for an individual to pursue a scientific career (Walters et al., 2021).

1.1.1 Conference behaviors

Many studies have focused on diversity in terms of representation in key roles in the conference, including presenters and chairs (Davenport et al., 2014; Piccoli & Guidobaldi, 2021; Pourret et al., 2021; Segarra et al., 2020; Shishkova et al., 2017). These gender observation studies showed that many conferences did not take EDI principles into account when recruiting presenters, nor did they focus on finding solutions regarding poor representation. Hence, the advice based on these findings is to purposefully promote equality in the programmed structures such as (keynote) speakers and chairs (e.g., Farr et al., 2017; Mehta et al., 2018; Segarra et al., 2020; Woodfield et al., 2021). Indeed, promoting EDI principles within conference organization can lead to a more diverse program in terms of presenter representation (Stadmark et al., 2025). However, diversity of presenters and other key roles at a conference does not necessarily equate to inclusivity in the full conference participation.

Examples of conference behaviors that are conducive to a 'chilly climate' are presenters who take more than their allocated time (resulting in less time for other presenters), presenters who use exclusive language (e.g. jargon heavy, derogatory comments, inside jokes, or using metaphors that reaffirm stereotypes) and inattentiveness of the audience during the presentation (Biggs et al., 2018). Furthermore, during the Q&A the climate for both the presenters and audience can be determined by who is given the opportunity to ask questions (and hence be more visible in the community) and what

type of questions are asked (e.g. evaluative, inquisitive, or ‘more of a comment than a question’, etc.) (King et al., 2018; Jarvis et al., 2022).

In the current study we look at audience participation in a conference where the planned structures (presenters, keynotes and chairs) have an equal gender balance and hence qualifies as being gender diverse. This enables us to study to what extent gender diversity also translates into gender inclusiveness, i.e. the behavior of conference attendees. The aim is to use these observations to provide recommendations to prevent a chilly climate at scientific conferences beyond accounting for gender diversity in the programmed structures.

1.2 Conference history and organization

The NWO NAC – Dutch Earth and Environmental Science Conference is an annual two-day conference (NWO-NAC, 2025). The conference was founded in 1991 by KNAW (Royal Dutch Academy of Science), KNGMG (Royal Dutch Geological-Mining Society) and NWO (Dutch Research Council). The conference generally has around 500 attendees, from universities and knowledge institutes from all over the Netherlands. While researchers from non-Dutch institutions are not barred from participating, such involvement has been rare, except for invited keynote speakers, because of the focus of the conference on the Dutch Earth and Environmental sciences. Historically, the conference has had a strong focus on the geological part of earth science. Since 2023, the scope of the conference has expanded to include environmental and hydrological sciences as well. In 2025, the conference name was changed from the Dutch ‘earth science’ to the Dutch ‘earth and environmental sciences’ conference to reflect a broader interdisciplinary approach.

This year the conference took place in March 2025 in Noordwijkerhout, the Netherlands. Attendees could join either one or two days of conference activities (with an optional overnight stay). Online participation was not possible. On both days, there were two keynote speaker presentations, one poster session, one workshop, and two blocks of eight parallel session presentations. Each presentation block lasted one hour with four presentations of 15 minutes (the recommended time division as communicated by the conference organizers in advance was 12 minutes presentation and 3 minutes question time).

The organizing committee met many of the recommendations from earlier gender observation studies (e.g., Corona-Sobrino et al., 2020; King et al., 2018). The committee, consisting of 5 men and 4 women, represented eight different research institutes in the Netherlands. Discussions on how to ensure diversity at the conference took place amongst the program committee while designing the program. The organization of the conference actively promoted gender diversity by ensuring a balance of invited chairpersons and presenters. There were two female and two male keynote speakers. The reviewers for the abstract selection consisted of 20 men and 13 women (authors’ observation). The conference had a code of conduct for a harassment-free conference (<https://nwonac.nl/disclaimer>) and

used badges on lanyards instead of clip-on badges (which are more suitable for typical male attire such as front-button shirts) (e.g., Sardelis et al., 2017).

Abstract submission was only mandatory for those who wished to present. It was possible to register for attendance only (non-presenting). For those presenting research, the program committee selected or rejected the submitted abstracts for the conference based on their suitability regarding their topic. The selected abstracts were then sent out to reviewers. Once reviewed, all abstracts were ranked per subdiscipline on quality, history of presenting and career stage. Abstracts were ranked higher if the presenter had not presented the previous year and when the presenter was an early career researcher (i.e., bachelor or master's student, PhD candidate or post-doc). The program committee received no specific instructions regarding the gender diversity of the presenters. Based on their ranking, abstracts were picked for an oral presentation. Those not willing to or not selected to give an oral presentation then received a poster presentation slot. Additionally, there were two workshops with a DEI theme: one concerning organizing safe and inclusive fieldwork and the other focused on ethical and fair use of natural resources.

2. Method

2.1 Research design and procedure

This study has a cross-sectional research design, meaning that we cannot draw any causal inferences as the data was collected at one point in time. The conference was held over two days and consisted of 8 parallel sessions. Each oral presentation session was observed by at least one member of the research team. The plenary (keynote) sessions served as calibration sessions for all observers who were present that day. The observations were recorded systematically by filling out an online form programmed in Qualtrics (<http://qualtrics.com>) for each session. This ensured that the data was immediately stored on the secured server of Utrecht University. The conference participants were not informed of the study taking place to avoid the 'Hawthorne effect', where individuals modify their behaviors because they are aware of being observed (Taylor, 1911). The observers were instructed to limit their visibility and audibility in the room and were prohibited to ask questions themselves. We therefore suspect that the data was not subjected to change by virtue of the presence of the observers.

In this manuscript we refer to gender as the socially constructed roles, behaviors and identities of women, men and gender-diverse people. Where possible we report self-disclosed gender (for the presenters this was either through their conference registration or indicated pronouns on their presentation slides), in the absence of this we made assumptions based on names and appearance.

The methodology and expected outcomes were pre-registered at OSF before the data was analyzed. Prior to the data collection, a data management plan and a privacy scan were conducted to ensure the

ethicality of the research and the privacy of the data. The pre-registration is available on (<https://doi.org/10.17605/OSF.IO/G5NBD>), data and analysis scripts are available upon request.

2.2 Observation forms

The observation form was set up following earlier accounts of similar studies to fit the structure of the conference program (King et al., 2018; Lefebvre & Bernard, 2024). A compact version of the observation form can be found in Appendix A. The observations were recorded in different blocks on the form. Below we will describe the information gathered in each of the blocks.

2.2.1 Session details

Observers recorded observational metadata regarding the session they attended. This included the session name and presentation number, whether something changed in the programmed structure of the session, and the observer's name. This information was collected to contextualize observational data and ensure traceability without compromising the anonymity of the conference attendees.

2.2.2 Presenter details

For each presenter, a list of characteristics were documented. Observers noted the presenter's gender both as perceived (observed) and, when available, as self-identified (e.g., by pronouns on the opening slide). Gender categories included male, female, non-binary/third gender, or unknown. The presenter's career stage was classified as student (bachelor or master), early career (PhD candidate), mid-career (postdoctoral researcher, assistant professor, associate professor or equivalent), late career (full professor), or other with space for notes. Observers also evaluated whether the presenter was Dutch, using the categories 'yes', 'no', 'maybe/some evidence', or 'unknown'. Inferences were made based on typical Dutch names and accents. Visible minority status (e.g., disability or ethnic minority) was assessed as either 'yes' or 'no', with space provided for additional notes.

The presenters' language use and communication style were assessed. Fluency in English was rated as 'yes', 'mostly', or 'no', with accompanying notes. The use of inclusive language, such as gender-neutral or culturally sensitive examples, was evaluated as 3 ("yes"), 2 ("not sure"), or 1 ("no"), again with space for comments (e.g., King et al., 2018). A higher score indicates better use of inclusive language. Observers indicated whether the presenter actively engaged with the audience (e.g. by asking questions or responding to reactions), and they scored presenter confidence on a five-point scale, ranging from 1 ("uncertain, stumbles") to 5 ("confident, at ease"). In the result section we report the mean (*M*) and standard deviation (*SD*). The presenter's time management was evaluated as 'too short', 'on time', 'too long' or 'way too long' (defined as more than 25% over the allocated time of 15 minutes). Audience disturbances during the presentation were also recorded and coded by type (i.e., walking in or out, side conversations, use of technology and other noises) and level of intrusiveness.

Lastly, open-ended notes could be added regarding the presenter's language use, including technical terminology, humor, and gendered language.

2.2.3 Question details

During the Q&A after each presentation observers noted for each questioner the observed gender and academic position, similar to the presenter details. The type of question was coded into predefined categories, including 'clarification', 'request for further information', 'contestation of the presenter's argument', 'statement of the questioners' own knowledge', 'multi-part questions', 'follow-up questions', 'interruptions', 'compliments', or 'reflections on new topics' (adopted from King et al., 2019). Additionally, the tone of each question was rated as supportive, inviting, condescending, polite, inquisitive, or argumentative (King et al., 2018). For both the type of question and tone there was room for comments and multiple options could be checked. The presenter's response was assessed in terms of confidence and whether the question was answered directly, avoided, or met with uncertainty. This part of the survey was repeated for each new question from the audience.

2.2.4 Chair details

The behavior of the session chair was also documented. Observers recorded the chair's gender using the same categories as above. Specific actions were noted: giving time warnings, cutting off presenters or questioners (either bluntly or politely), moderating discussions, asking the first question, or stepping in when the audience remained silent. Additional qualitative observations could be recorded in an open comment field.

2.2.5 Other

Lastly, technical issues or other noteworthy things that happened during the presentation or Q&A part could be noted. Other additional observations could again be recorded in an open comment field.

2.3 Data from conference organization

The conference organization provided anonymized data on the demographics of the conference attendees. This included the career stage as registered by the attendee (i.e., BSc. Student, MSc. Student, PhD candidate, Post-Doc, Assistant professor, Associate professor, Governance, Industry and Other) and the prefix registered by the attendee (Ms./Mr./Mx.) was used as an indicator of their gender. We have been in contact with the conference organization prior to, during and after the conference. Additionally, we interviewed the chairperson of the plenary sessions and a member of the program committee after the conference to gain insights on the intentions of the organizers to achieve a diverse and inclusive conference. The information we gained through these conversations relating to the set-up of the keynotes and presentation sessions was used to document the intention setting of the conference organization. Our contact with the organization began after the program of the conference

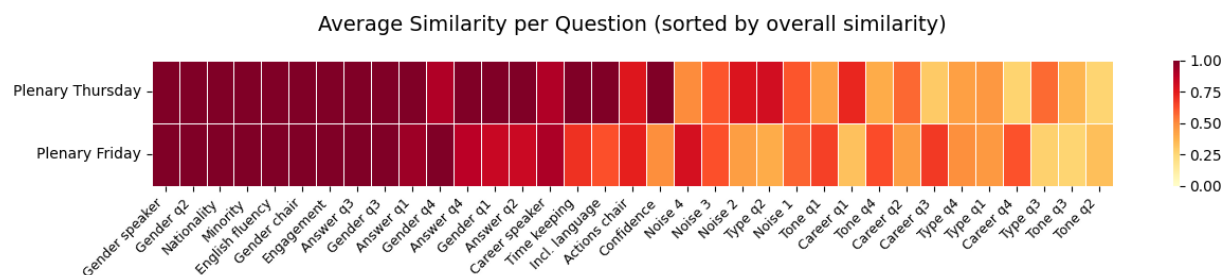
had been finalized and we did not advise or interact with any of the ‘intention setting’ of the committee.

2.3.1 *Quality of the collected data*

Several measures were taken to assert and improve the reliability of the observational data. First, all 15 observers joined a training session prior to the conference with the purpose to become familiar with the protocol and practice with recognizing tone and question type. Secondly, we triangulated the inferences of career stage during the observations with information from the conference program and found a match of 82%, most deviations resulted from the allocation of post docs to either early or mid-career.

Thirdly, the observations during one plenary keynote session for each day were analyzed for similarity amongst observers using a Jaccard index that determines the overlap of the ticked boxes by the observers. The average score was 0.74. Categories with high similarities (>0.9) between the observers are the presenter's identity traits (gender, career stage, nationality etc.), the gender of questioners and the chair, and the presenters' responses to questions. Categories that score moderately high (~0.5-0.9) are related to the career stage of the questioner, noise in the room, and the actions of the chair. The latter two can be explained by the different positions of the observers in the larger plenary room. The similarity scores for tone and type of question score were relatively low (~ 0.26-0.80, indicated in yellow to orange in Figure 1). This is not surprising as these two categories are the most subjective, and the observation form allowed for multiple boxes to be ticked. We regard the results related to gender, nationality and career stage as trustworthy. The results related to tone and type of question are interpreted with caution.

Figure 1
Jaccard Index of Observer comparison for Plenary sessions



2.4 *Data processing*

The data on conference attendance made available by the conference organization needed little processing. In four instances, missing career stage was filled in by notes made in the forms.

The observation data collected during the conference needed to be processed slightly. We merged the variables *Observed* and *Self-identified* gender into one variable of gender identification. Eight out of 32 presentation session blocks were observed by two observers, here the results of one observer were picked randomly for analysis. In 22 instances, the career stage of a questioner was indicated by two checked boxes, one for the career stage and one for 'unknown' to indicate uncertainty about the career stage. The unknown was removed for these cases. In six instances, a multiple-choice answer was updated based on the text written by the observer in the open comment box. For example, when for career stage *Other* was checked and the text box stated '*MSc Student*' the variable career stage was changed to Student. For the audience members, we simplified the data by merging the different career stages into two categories: *Early* (including students and early career (PhD candidates)) and *mid-late* (including Middle, Middle/Late and Late career stage). The 32 occasions where both the boxes for *Early* and *Middle* career stage were checked the entries were split equally amongst the two classes. Lastly, two presentations during the conference were given by multiple presenters, these were left out of the analysis. One presentation was given by a (male) volunteer in the audience due to an absent presenter and was also left out. Two scheduled presentations did not take place due to the absence of the presenter, leaving in total 123 observed presentations with Q&A sessions for the analysis. The data was analyzed with Excel, Python3 and SPSS 29.

3 Results

The results are split into two main sections: diversity data (section 3.1) and behavioral data (section 3.2). The behavioral data section reports on the behavior of the presenters, audience members and chairperson separately for the keynotes (section 3.2.1) and the session presentations (section 3.2.2). For exploratory purposes (i.e. not preregistered), we report the diversity and behavior observations for the sessions split up by scientific discipline: Environmental Science vs. Geology.

3.1 Diversity

The conference program showed a roughly equal gender balance among the attendees, chairpersons and presenters (see Table 1). On the first day of the conference the two keynotes were given by female speakers and on the second day by two male speakers. The category of non-binary/other is omitted from further analysis because it had too few observations to provide statistically meaningful results (Franke et al., 2012) and analysis would make our de-identified data traceable to individuals.

Table 1

Gender distribution of attendees, chairs and presenters

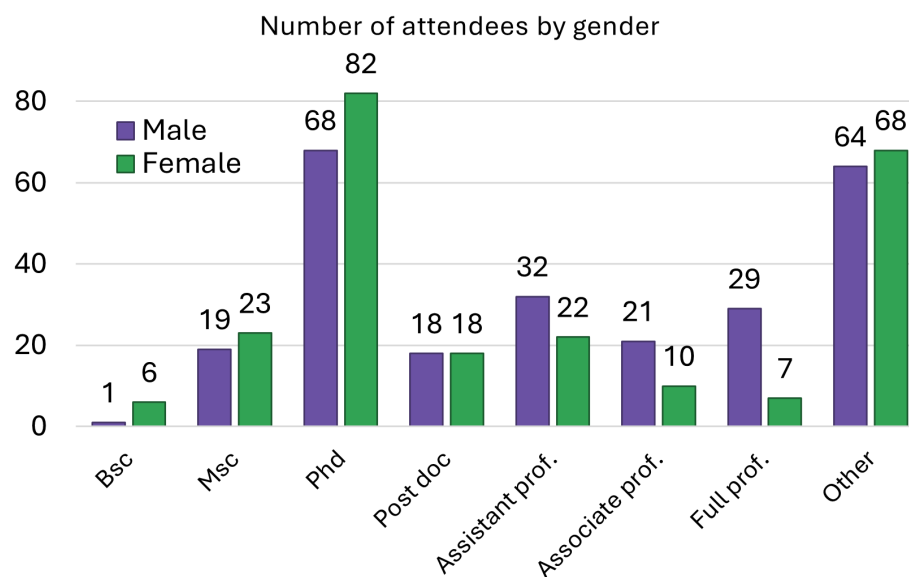
Observed gender	Role			
	Attendees	Chairpersons**	Oral presenters	Poster presenters*
Male	253	58	60	57
Female	238	64	62	49
Non-binary/other	6	-	1	-
Total	497	122	123	106

Note. *Conference behaviors were not observed for the poster presentations. ** Chairpersons are organized as chairing per presentation (not per session).

However, when we take career stage into account (see Figure 2) we see a skewed gender distribution. Among students and *PhD candidates* category there are relatively more female attendees. The distribution is equal amongst *Postdocs* and the *other* category (i.e., governance, industry, organization committee, etc.). But male attendees are overrepresented in the more senior academic roles. When comparing the gender distribution of PhD candidates to that of the combined group of assistant-, associate, and full professors, a chi-square test of independence shows a statistically significant difference in gender composition ($\chi^2(1) = 16.45, p < .001$). This indicates that women were substantially underrepresented in senior academic roles relative to their presence at the PhD level.

Figure 2

Gender Distribution of Attendees per Career stage



For the remainder of this article, we will report the results for two career categories for the questioners: early career (i.e. bachelor students, master students and PhD candidates) and mid-late career (i.e. Postdoc, Assistant, Associate and full Professor or equivalent).

Nearly all attendees were affiliated with Dutch universities or research institutions, however just over half of the presenters (54.9%) were non-Dutch. There were no presenters reported with visible disabilities.

3.2 Conference behavior analysis

3.2.1 Keynotes

During the conference four keynotes were given, two by male speakers and two by female speakers. To preserve the anonymity of the keynote speakers we refrain from discussing details such as speaker manners, time keeping and tone and type of questions. We will only describe the number of questions asked divided by gender and career stage.

The Q&A after the keynotes can set the tone of what is considered ‘normal’ behavior at a particular conference (i.e. a display of so called descriptive norms, Gelfand & Harrington, 2015). Especially for first time audience members, it can give an insight into the ‘unwritten rules’ with regard to who is supposed to ask a question and what type of questions are socially appropriate in this setting. A total of 19 questions were asked during the Q&A of the four keynotes. Two of the questioners were identified as female and 17 as male. Considering the equal gender distribution amongst all attendees, male attendees asked significantly more questions. The odds that a male attendee asked a question during the Q&A after a keynote was 8.6 times higher compared to female attendees.

Questions from audience members were unevenly distributed across career stages relative to their representation among attendees. From the observed questions, none were asked by students, two by early career researchers and 17 by mid/late-career researchers. It appears that the distribution of questions was skewed towards more senior attendees. The probability of asking a question given the attendee distribution shows that mid- and late career attendees are 5.4 times more likely to ask a question in the plenary sessions compared to early-career attendees.

3.2.2. Chair behaviour

An interesting observation was that each time after the keynote, the chair specifically encouraged early career researchers to ask a question. However, the data showed that the chair, a mid-career male researcher, asked the first question in every instance.

3.2.3. Types of questions and tone

In the plenary sessions half of the question askers started with compliment. Most of the questions were aimed at receiving more detailed information, only one questioner asked to clarify a statement

before following up for more detailed information. Five questioners asked the keynote speaker to reflect on a topic not covered in the presentation. There was only one case where an audience member contested the keynote speaker.

3.3.2. *Parallel sessions*

3.3.2.1. *Presenters behavior*

In the parallel sessions most of the presenters (58.6%) used inclusive language. The contributions to the research from other people were typically acknowledged and jargon and abbreviations were explained. The overall inclusive language score across the sessions was $M = 2.53$, $SD = 0.78$. Examples of non-inclusive language were slides that were partially in Dutch, politically tainted jokes and condescending comments about a paper by authors of specific nationality (“... not so well written”). Notable was that many presenters talked about their findings in the “we” form, referring to their research team, instead of the “I” form. There was no significant difference between early and later career stages in terms of inclusive language use ($t(126) = 0.35$, $p = .725$). Female presenters however, used significantly more inclusive language ($M = 2.63$, $SD = 0.65$) than male presenters ($M = 2.20$, $SD = 0.11$, $t(124) = -3.24$, $p < .001$). Most presenters (63.8%) stuck to the allocated time regardless of their gender or career stage (p 's $> .416$). Mid- and late career presenters appeared significantly more confident ($M = 4.21$, $SD = 0.94$) than early career presenters ($M = 3.88$, $SD = 0.82$, $t(128) = -2.02$, $p = .045$). Examples of confidence were speaking clearly and calmly and making eye contact with the audience. There was a significant correlation between presenter confidence and engagement with the audience ($r_s = .187$, $p = .034$) in the form of asking for a show of hands to respond to a statement, checking in with the audience when using technical terms, passing around a sample and making jokes. Dutch presenters were rated significantly more confident ($M = 4.27$, $SD = 0.71$) than non-Dutch presenters ($M = 3.77$, $SD = 0.93$, $t(122) = -3.25$, $p < .001$). A linear regression showed that Dutch nationality and career stage independently from each other predicted presenter confidence levels (respectively $\beta = .287$, $p = .001$ and $\beta = .189$, $p = .032$). There was no difference in confidence between genders, $p = .851$.

3.3.2.2 *Audience disturbances*

The most common type of disturbances from the audience was walking in and out of the session during the presentation and the use of technology (See Table 2). An analysis with Chi Square tests showed no significant systematic differences in the amount of disturbances depending on the gender or career stage of the presenter, p 's $> .163$. With the exception of audience members walking in or out more during early career presenters' presentations (during 74.2% of all early careers' presentations vs. 52.5% for mid-late career presenters), but this difference did not reach the threshold for statistical significance ($\chi^2(2) = 5.91$, $p = .052$).

Table 2*Audience disturbances during presentation sessions*

	None	Some	A lot
People walking in or out	42 (32.3%)	78 (60%)	9 (6.9%)
Talking to each other	101 (77.7%)	24 (18.5%)	3 (2.3%)
Use of technology	33 (25.4%)	91 (70%)	5 (3.8%)
Other noises	65 (50%)	60 (46.2%)	3 (2.3%)

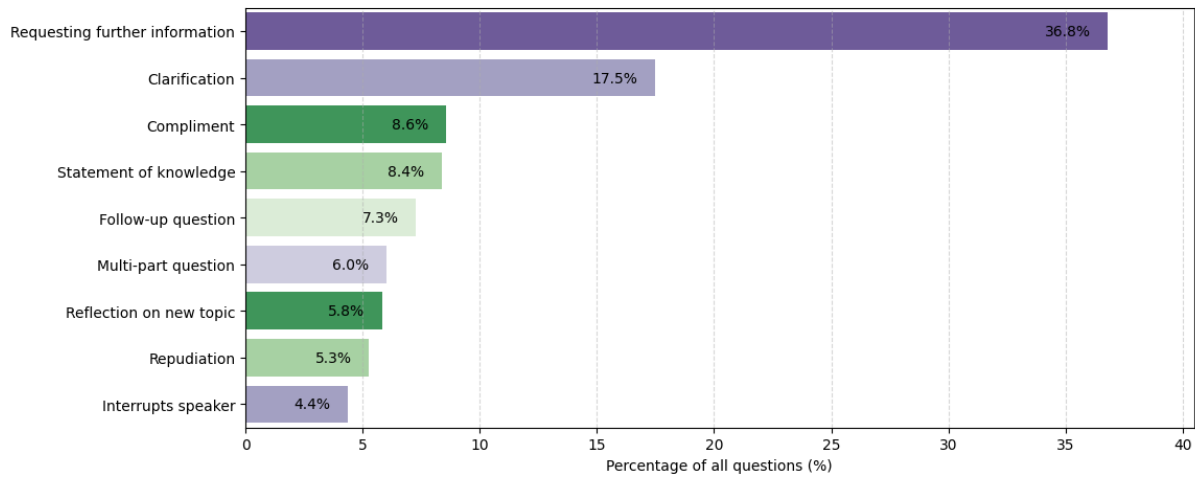
3.3.2.3 Receiving questions

In this section we discuss analyses of the who received what kind of questions during the parallel sessions. This includes the gender and career stage of the questioners and presenters. The type and tone of questions and the question environment are analyzed in two separate subsections. The results in these last subsections require careful interpretation, because of the large uncertainty of this collected data.

We first focus on the distribution of the number of questions received by gender and career stage. There were a total number of 297 questions asked in the parallel sessions. The maximum number of questions after a presentation was seven. There was only one presenter (male, early career) who received no questions at all due to time constraints. Male and female speakers received on average the same number of questions ($M_{\text{malePresenter}} = 2.26$, $SD = 1.15$, $M_{\text{femalePresenter}} = 2.54$, $SD = 1.23$, $t(125) = -1.34$, $p = .183$). There was also no significant difference in the number of questions for presenters of different career stages ($M_{\text{earlyCareer}} = 2.40$, $SD = 1.22$, $M_{\text{mid_lateCareer}} = 2.33$, $SD = 1.15$, $t(127) = 0.29$, $p = .772$).

We analyzed the type of questions that presenters received as well as the tone with which they were asked. Figure 3 depicts the frequency of each question type, note that multiple types can apply to the same question. The most frequent type of question was requesting further information or clarification. There was no difference in the type of questions for Dutch vs. Non-Dutch speakers (p 's $> .274$), nor for early vs. mid-late career presenters (p 's $> .074$). Nor was there a difference in type of questions for male or female presenters apart from bringing up a new topic in question. Female presenters received statistically significant more questions about a topic not covered in their presentation ($M_{\text{male}} = 1.00$, $SD = 0.00$; $M_{\text{female}} = 1.26$, $SD = 0.45$, $t(38) = -2.39$, $p = .022$). However, to place this difference in perspective, 17 male presenters and 17 female presenters each received *one* off-topic question, and six female presenters received *two* off-topic questions.

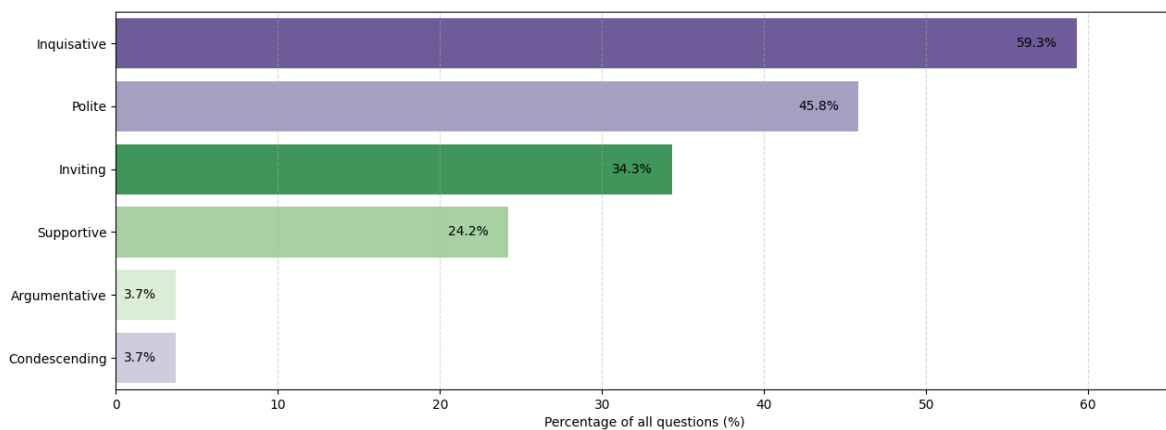
Figure 3*Frequencies of types of questions asked during Q&A of parallel sessions*



In terms of the tone of questions, the most common was inquisitive or curious. Figure 4 summarizes the frequency of the different tones. There was no significant difference in the tone of the questions for presenters of different career stages (p 's > .222) nor for the gender of the presenter (p 's > .184). Interestingly, the questions asked to non-Dutch presenters were significantly more often supportive compared to questions towards Dutch presenters ($M_{\text{non-Dutch}} = 1.58, SD = 1.06, M_{\text{Dutch}} = 1.11, SD = 0.32, t(40.85) = 2.37, p = .023$). This might be explained by the earlier mentioned lower confidence levels of the presenters. Nationality of the presenter made no difference for the other tones of the questions. An example of when a condescending tone question was observed was when another audience member answered the question for the presenter.

Figure 4

Frequencies of the tone of the questions during Q&A of parallel sessions



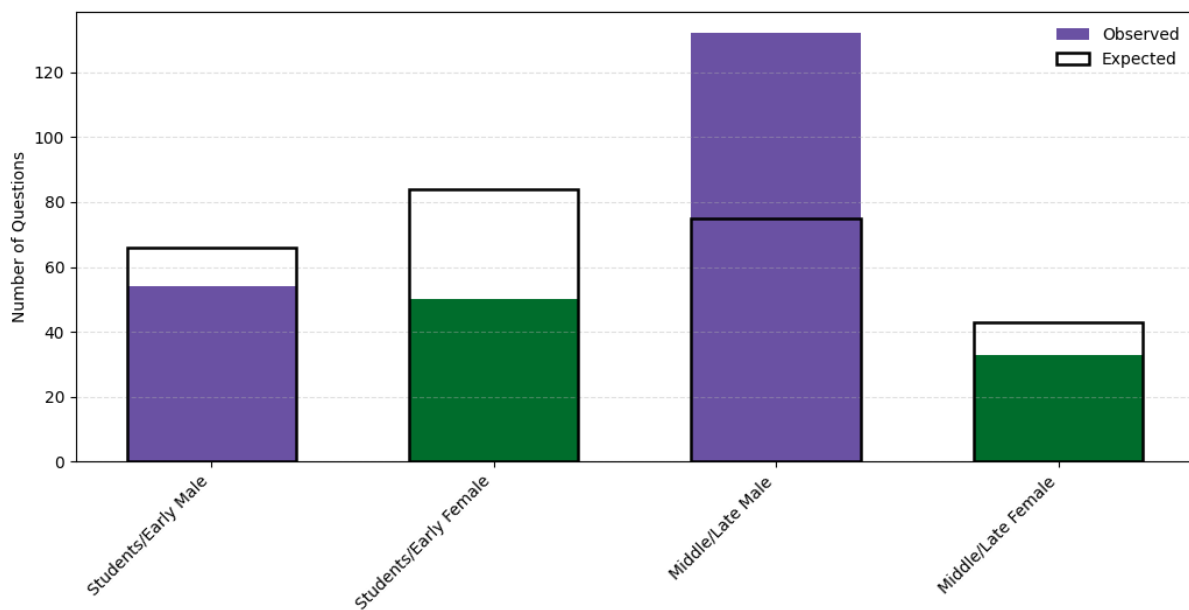
3.3.2.4 Asking questions

The data of the Q&A of the parallel sessions showed that 60.9% of all the first questions were asked by male audience members, 38.3% by female audience members and the one other question (making up the 0.8 remaining percentage point) was asked by an audience member who identified as non-binary.

We tested the representation assumption (i.e. the same distribution of minority groups amongst the attendees would also be reflected amongst those who asked questions after the presentations). Figure 5 depicts the expected number of questions given the attendee demographics. All groups, except mid-late career males, ask fewer questions than expected based on the number of attendees in their demographic group. The most striking difference between expected questions and questions asked is in the early career stage female attendees' group. Given a chi-square test goodness-of-fit comparing the four groups of Figure 5, the difference between the expected and observed number of questions asked per career group is significant, $\chi^2(3) = 56.66, p < .001$. In summary, early-career female attendees asked markedly fewer questions than was expected based on their numbers in the audience, whereas mid to late career male attendees asked significantly more than would be expected based on their numbers in the audience.

Figure 5

Gender and career stage of questioners expected based on attendance versus observed.



We ran a binary logistic regression to test whether we could predict the gender of the questioner based on the gender and career stage of the presenter, the subdiscipline of the session (Environmental Sciences vs. Geology), whether the previous question was asked by a female audience member and the gender of the chair (see Table 3). The results showed that only the gender of the presenter significantly predicted the gender of the individual asking a question ($B = 1.00, SE = .50, Wald = 4.05, p = .044$). When the presenter was female, the odds that a question was asked by a female audience member was 2.72 times higher (95% CI: 1.03–7.23) than when the presenter was male.

Table 3

Logistic Regression Predicting Questioner being female

Predictor	<i>B</i>	<i>SE</i>	Wald	<i>df</i>	<i>p</i>	<i>OR</i>	95% <i>CI</i> for <i>OR</i>
Gender presenter	1.00	0.50	4.05	1	.044	2.72	[1.03, 7.23]
Career stage presenter	0.98	0.61	2.64	1	.104	2.67	[0.82, 8.74]
Subdiscipline	-0.67	0.58	1.34	1	.247	0.51	[0.17, 1.59]
Previous questioner female (1 = yes, 2 = no)	0.48	0.52	0.87	1	.351	1.62	[0.59, 4.43]
Gender chair	0.59	0.50	1.39	1	.238	1.80	[0.68, 4.78]
Constant	-2.00	0.62	10.52	1	.001	0.14	—

Note. OR = odds ratio. *CI* = confidence interval. Predictor coding: 1 = male, 2 = female (unless otherwise specified); 1 = early career, 2 = mid-late career; 1 = Environmental Sciences, 2 = Geology.

3.3.2.1 Type and tone of question

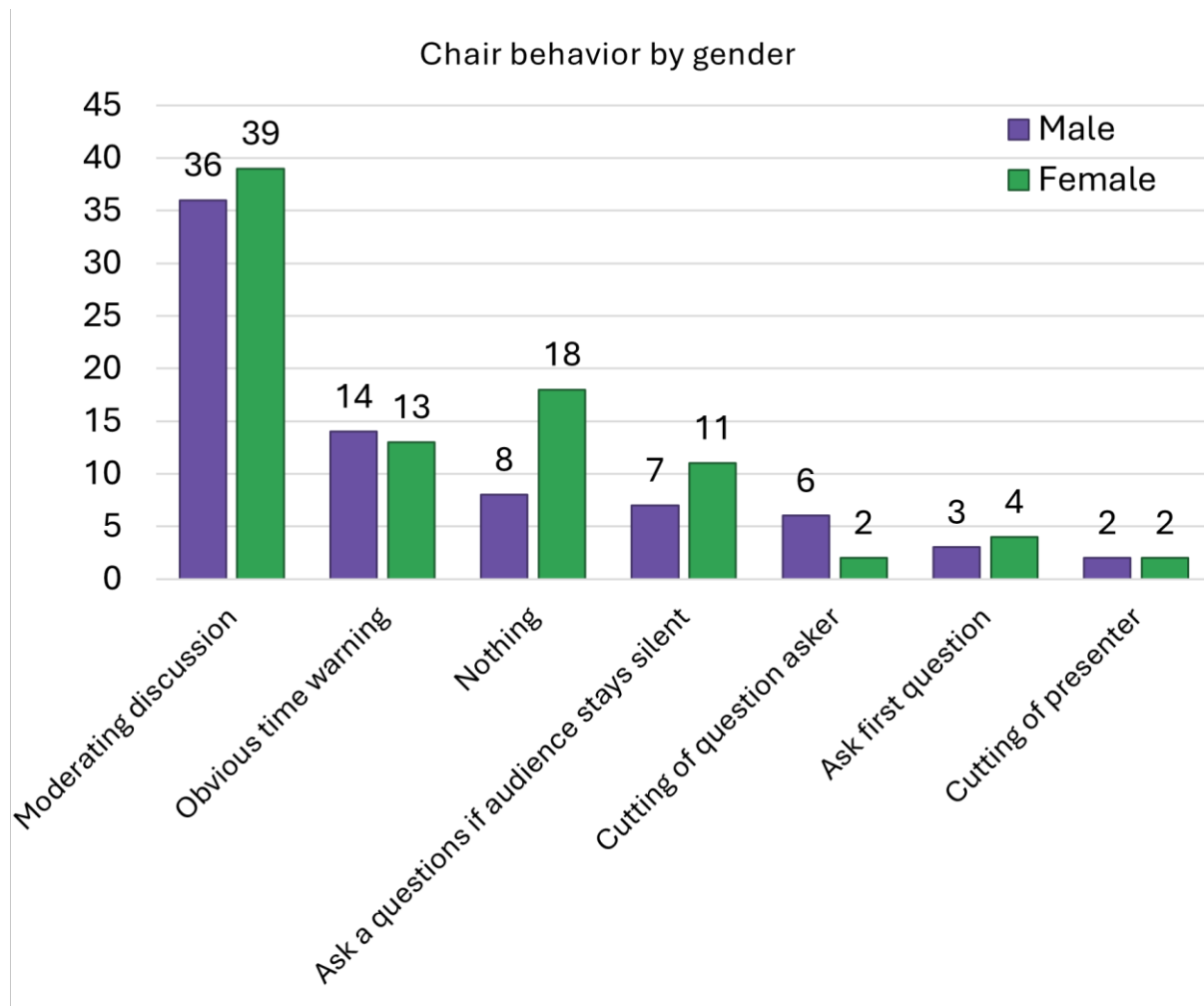
We tested whether there is a difference in career stage and gender with regard to the type and tone of the questions audience members asked. The gender of the questioner was not related to the type of question (p 's > .05) apart from statement of knowledge. Of the 46 statements of knowledge, 38 were by male questioners, this was significantly more compared to female questioners ($\chi^2(1) = 4.97, p = .026$). Forty-two of the statements of knowledge were made by mid-late career attendees. While a trend was observed that late career audience members were more likely to ask an argumentative question or give a statement of knowledge, these differences did not reach statistical significance (respectively, $p = .090$ and $p = .110$).

3.3.2.3 Chair behavior

The conference organization had appointed a same number of female as male chairs to the session presentations. As can be expected, the most common observed action of the chair was moderating the discussion, see Figure 6. There were no significant differences in observed chair behaviors between male and female chairs, p 's > .118.

Figure 6

Observed chair actions across genders



3.3.3 Discipline specific nuances: Environmental Science versus Geology

So far, we have analyzed the data of the conference assuming that the observed behavior is consistent across the entire conference. However, since Environmental Science is a more recent addition to this conference, we decided to analyze the observations separately for the subdisciplines. Based on abstract descriptions we divided the parallel sessions in Environmental sciences (43 presentations), Geology (47 presentations) and other (32 presentations). Examples of Environmental sciences sessions were Biosphere, Soil sciences, Biogeochemical cycles and Water resource management. Examples of sessions allocated to Geology were Geochemistry, Mineralogy, Petrology & Volcanology, Tectonics and Structural Geology and Mineral Resources. Finally, examples of sessions categorized as ‘other’ were Earth observations & remote sensing, Natural & human induced hazards & threats and Ocean Sciences.

Figure 7 shows that the gender balance of the presenters across the subdisciplines is unequal.

Environmental Science sessions had significantly more female presenters ($\chi^2(4) = 10.49, p = .033$)

whereas Geology sessions had significantly more male presenters, as well as presenters in more senior career stages, $\chi^2(2) = 24.48, p < .001$.

Figure 7

Distribution of gender and career stage presenters across subdisciplines.

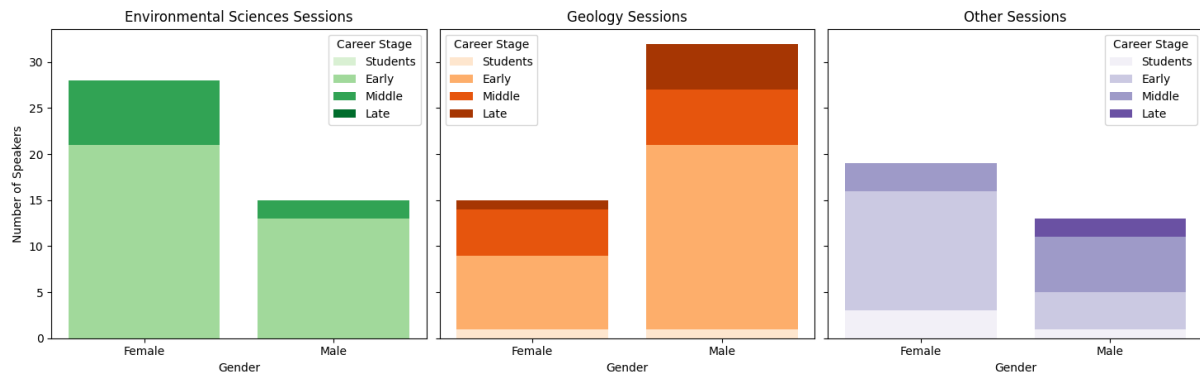
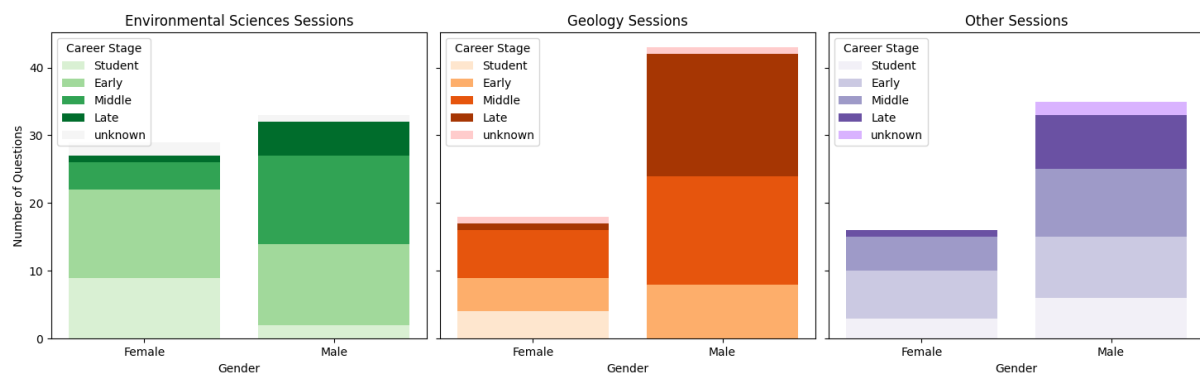


Figure 8 shows the gender of the questioner dependent on the session type. Here it shows that regardless of the distribution of the gender of presenters across the disciplinary sessions, most questions came from male attendees. However, there are relatively more questions asked by female attendees in the environmental session compared to all other sessions (~47% in Environmental sciences session versus ~30% in the geology sessions and ~31% in the other sessions), this difference was however not statistically significant (see Table 3).

Figure 8

Distribution of gender and career stage of questioners across subdisciplines.



4. Discussion

The aim of this study was to observe audience participation in a conference where the planned structures (presenters, keynotes and chairs) had an equal gender balance. We observed behaviours of participants of the annual Dutch Earth and Environmental Science conference (NAC).

4.1 Diversity

Prior research suggests that to achieve gender diversity at a conference, there should be an equal number of female and male presenters, especially for keynotes and more visible talks (Davenport et al., 2014; Pourret et al., 2021; Segarra et al., 2020; Shishkova et al., 2017). The conference organizers strove to adhere to these guidelines and the data shows that this conference can be said to be diverse in terms of gender as it had equal contributions of females and males in all roles that could be foreseen beforehand (presenters, key notes, organization committee, chairs etc.). One interesting finding regarding diversity was that when accounting for subdisciplines, the gender diversity was actually skewed with relatively more female presenters in Environmental science sessions and relatively more male presenters in Geology sessions. Our data does not allow for inferences on whether this is the result of self-selection of presenters or selection of the organization.

The most striking observation with regard to diversity however, was the underrepresentation of mid and late career female researchers. It is striking given the overall gender balance of attendees at the NAC. On the other hand it is in line with other recent gender studies in geoscience conferences (e.g., Piccoli & Guidobaldi, 2021). There are a number of possible causes. Firstly, the conference was targeted towards early career (PhD) researchers, which explains why this group was well represented amongst both presenters and attendees. It is possible that more senior female academics in the field chose to go to other (more high profile or international) conferences. Research suggests that female academics might have to think more strategically about which conferences to go to, as they typically have less research time due to more education and administrative responsibilities compared to male colleagues (Llorens et al., 2021; Teelken & Kee, 2023). The other possibility is that there currently *are* fewer mid and late career female researchers in the field, and that our observation is a consequence of the ‘leaky pipeline’ phenomenon.

The fact that mid-to- late career female academics were unrepresented in attendance and consequently were also less visible during the Q&A sessions could have had an impact on the female early career attendees. This group was well represented, which bodes well for the future gender diversity of the field— given the trends observed in other European countries, such as Switzerland (Piccoli & Guidobaldi, 2021). However, research has shown that one important contributor to the leaky pipeline effect is the lack of (female senior) role models (Zhang et al., 2023; Pugh et al., 2019; Fried & MacCleave, 2009; Schmader & Major, 1999). Conferences are opportunities to encounter these role models outside of one’s department.

4.2 Questions: a matter of gender and career stage

This study’s results show that the gender balance amongst attendees did not automatically lead to equal conference participation. We observed that male audience members asked significantly more questions during the plenary Q&A sessions and were more likely to ask the first question during the parallel sessions. While this observation aligns with previous studies (e.g., Carter et al., 2018; King et

al., 2018; Lefebvre & Bernard, 2024; Lupon et al. 2021) it a surprising finding because in these other studies in the geoscience field gender diversity was also an issue (i.e. women were underrepresented across conference roles). Carter et al. (2018) and Lupon et al. (2021) reported that questions were more often asked by a woman if the first questioner, presenter or chair was female. We only found an effect of the gender of the presenter, with the likelihood that a question was asked by female attendees almost three times higher when the presenter is also female (compare to a male presenter).

Another difference between our results and earlier studies is the gender balance of questioners amongst early career researchers. Hinsley et al. (2017) reported that in the group of early careers men asked significantly more questions than women. Our study showed no absolute difference for the number of questions asked between male and female early career audience members. However, given that there were ~26% more early career females than males the average the male early career still asked relatively more questions. The difference, however, does not seem to be as large as reported by Hinsley et al. (2017).

Based on the observations we cannot draw inferences as to why female audience members asked fewer questions. It could be combination of fewer raised hands and the selection amongst the raised hands by the chair or presenter. Future observation studies are strongly advised to also tally the gender of the attendees who raise their hands, to provide better insights for what organization committees can do to make their Q&A sessions more inclusive. Lupon et al. (2021) conducted surveys among conference participants and found that women less frequently ask a question when they want to, except for women in senior positions. Jarvis and colleagues (2022) further explain that the motives for holding back a question differed between genders. Women were more likely to hold back from asking questions due to anxiety or fear of backlash, while men were more likely to hold back to create space for others to participate.

The organizing committee was aware that the Q&A's after keynote sessions could set an example of what is considered socially acceptable behavior at a conference, hence the chair encouraged early careers to ask a question. But compared to the parallel sessions these keynote Q&A's might be experienced as more difficult or intimidating to ask a question, due of the size of the audience, size of the room, the enforced use of a microphone and clearer visibility/attention when asking a question. Earlier work showed that people were less discouraged by such aspects when they experience more authority, or a close relationship to the organization, chair of convener (Carter et al., 2018; Karpowitz et al., 2012; King et al., 2018). This might explain why questions were predominantly asked by male, mid-to-late career, researchers in the keynote Q&A's.

4.3 Chilly climate

In contrast to earlier research (Lefebvre & Bernhard, 2024; King et al., 2018) male and female presenters received on average the same number of questions and these questions did not differ

significantly in the type or tone. There was also no difference in the amount of audience disturbance nor any differences with regard to going over the allocated time. Together with the observation that most presenters used inclusive language, the important hallmarks that signal a 'chilly climate' were absent at this conference as a whole.

4.4 Session topic: environmental sciences versus geology

The gender distribution across different earth science disciplines within the conference warrants attention. At first glance, the presenter's diversity at the conference is about fifty-fifty, indicating a fair gender balance. Yet, in environmental science sessions the majority of presentations was given by female presenters (60.8 %). Whereas in geology most presentations were given by male presenters (41.1% female). In all subdisciplines male attendees asked the more questions than female attendees (58.8% from male attendees in environmental sciences, 75.8% in the geology sessions and 70% in the other sessions). This study highlights the hotspots of lacking diversity and can be referred to as horizontal gender segregation (Piccoli & Guidobaldi, 2021). Meaning that without accounting for the differences between earth science disciplines, these biases are often overlooked.

Why certain fields attract and retain more female scientists needs to be studied further. Lack of female representation in the more geological fields is often cited to discourage early career scientists from pursuing that career path. Alternatively, or additionally, these barriers could also be related to issues with lab and field work accessibility and diversity (Hamylton et al., 2023; Giles et al., 2020; John & Khan, 2018), which are more common in geological fields. Gender equality in geoscience has received considerable academic interest in the last couple of decades. From the literature it seems that steps toward more gender equality have been made in both geoscience education as well as in research (e.g., Legg et al., 2023; Gates et al., 2019). Studies such as these are important to keep monitoring progress.

4.4 Research caveats and future research

The choice for an observational research design has the clear advantages of monitoring diversity and inclusion initiatives beyond individual anecdotes. First, it allows for the detection of any systematic patterns, especially when repeated across multiple years (e.g., Piccoli & Guidobaldi, 2021). Secondly, objective data can be used to address any biases and misperceptions, both to stay vigilant as field but also as a source of comfort for individuals in minority positions. For example, Hatherly and colleagues (2025) analyzed the gender of first author publications before and around covid years and found that male and female geology researchers published articles in nearly identical rates proportional to their gender distribution in the field. But the perceptions of female researchers regarding their productivity led them to be more anxious and unsatisfied. A disadvantage of this research design is that we could not capture the *perceptions* of diversity and inclusion amongst conference attendees. Moreover, while falling outside of the scope of our observations, we

acknowledge that behaviors that impact an inclusive environment also occur outside the presentation sessions, such as during the poster sessions, coffee breaks, dinner and other socializing parts of the conference.

We would like to stress that diversity and inclusion also go beyond a binary division in gender and career stage. In this study we only tested indicators of chilly climate for minority groups based on rudimentary *observable* indicators of a person's gender, career stage, nationality and visible disabilities. Effects on other minority groups, for example people who are non-binary, LHBT, from the global south, people of colour, different ethnicities and religions or who are differently abled were either not systematically accounted for in the data collection or were left out of the data analysis because their small numbers make them easily identifiable. We recognize that intersectionality is of great importance and that for individuals who are part of more than one underrepresented minority the challenges faced become more extreme (Marín-Spiotta et al., 2020).

Future researchers are strongly encouraged to systematically count how many hands were raised in the Q&A session. An important limitation of to the interpretation of our results is that we could not account for the extent the floor was given to questioners and to what extent it was taken. Our data showed that not all chairpersons actively moderated the Q&A, hence it might be that presenters appointed questioners (who they already knew) or that questioners just started talking without being given a turn.

4.5 Recommendations for conference organizers

Based on the results there are a couple recommendations to conference organizers. First, that striving for a gender balance in all foreseen roles (keynotes, chairs, organizing committee, and presenters) was an effective measure to promote gender diversity. Based on the data we would recommend to not only account for gender, but also career stage. Apart from targeting early careers, extra efforts should be made to invite more senior female researchers, and also include this in the ranking of abstracts for presentations.

The organizing committee could instruct chair persons to wait 10 seconds before appointing a questioner, to give everyone in the audience the chance to raise their hand for questions. Chair persons could receive pointers and training to reformulate and repeat inappropriately phrased questions in a more respectful way to bridge the question for the presenter. Especially in large plenary sessions it is important to guard an equal gender balance when selecting questions from the audience as these can set the stage for the parallel sessions. However, rather than urging underrepresented groups to behave more assertive by asking a question, we suggest to consider the use of technology (e.g., Mentimeter, Wooclap) to allow for a mix of digital and physically asked questions. For example, the study of Caspi et al. (2008) showed that while men are more likely to participate in a classroom discussion, women are more likely to post on forums. Another advantage of this mix is that also attendees who

are less confident in their English, can ask their questions. Asking all questions digitally is not recommended as this would imply that the whole audience would turn to their screens after the presentation. Positive experiences with having one's question answered can help to boost confidence (e.g., Gallus et al., 2025). By lowering the barriers to ask questions the likelihood of this positive experience is enhanced and might serve as a stepping stone for more conference participation.

4.6. Contribution and conclusion

This study provides an insight into gender diversity and inclusion in the Dutch geoscience context. There was an equal gender balance for the conference as whole, but when accounting for career stage mid- and late female researchers were underrepresented. Also we still observed unequal gender distributions when demarcating the data into subdisciplines. Classic hallmarks of a 'chilly climate' were not observed. Yet male senior attendees were overrepresented during the Q&A's.

5 Acknowledgements

The authors would like to thank Nico Wanders, NAC, KNMG for their cooperation, and Ole de Keijzer, Bente Huizinga, Stefanina Wagenaar, Dolores Hooijschuur, Rosannah van Halsema, Julietta Achieng, Dean Bucciarelli, Jacob Wasserman, Renske Beck, Ytse Roorda, Saar van Dijk and Smilla Tenner for their help with the data collection.

6. Funding sources

This work was supported by NWO, they waved the registration fees for the observers, but they had no influence on the research aim, design, analysis and interpretation of the data, writing the report or the decision to submit for publication.

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