Earth Science for all? The economic barrier to Geoscience conferences

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Abstract

Scientific meetings are vital for research development and networking. However, these events often perpetuate unconscious biases and barriers to diversity, particularly affecting ethnic minorities. The future success of geosciences depends on diversity, which enhances problem-solving and innovation through varied perspectives. This study examines the attendance diversity at the European Geosciences Union (EGU) General Assembly from 2005 to 2024, focusing on the impact of economic factors, distance, and population size on participation. Using publicly available data from the World Bank and EGU, this study finds that gross national income (GNI) is the primary determinant of attendance, with a strong correlation between GNI and participation, especially post-COVID. Distance also influences attendance but to a lesser extent, while population size shows a weak correlation. To improve diversity in academic conferences, we suggest facilitating donations, offering affordable accommodations, establishing additional travel funds, and rotating the conference location. Our actions must go beyond the EGU General Assembly and other geoscience conferences, extending to barriers to inclusivity within our community. By addressing these financial and systemic barriers, geoscience conferences can become more inclusive, benefiting the entire scientific community.

1. Introduction

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29   Academic conferences are crucial for researchers to promote their work,
30 establish new connections and collaborations through networking, and be informed of
31 the up-to-date research that is taking place across the globe. Such events are also
32 places where the identities of scientists are constructed and how scientists are
33 perceived within their community, often inadvertently reinforcing unconscious biases.
34 Scientific conferences tend to reproduce barriers to diversity in the geosciences,
35 meaning there is an underrepresentation of people from ethnic minorities (King et al.,
36 2018), who are therefore more likely to face barriers to their career progress.

37   Diversity is essential to the future success of geoscience. As a community, we
38 tackle complex global problems that transcend artificial geographical boundaries
39 imposed by historical biases (Raja et al., 2022). Some of these problems are urgent
40 and can have dramatic consequences, such as natural resource depletion, disaster
41 risk reduction, and climate change (Rogers et al., 2022). Addressing these subjects
42 requires scholars with diverse backgrounds, including a representative mixture of
43 cultures and ethnicities. Different perspectives and life experiences lead to unique
44 questions and approaches to problem-solving, and inspire more creative alternatives
45 to relevant challenges, ultimately leading to higher levels of scientific innovation
46 (Medin and Lee, 2012; Hong and Page, 2004).

47   Within this context, scientific meetings play an important role in bringing
48 together and promoting knowledge exchange among scholars from diverse
49 backgrounds. But how diverse are geosciences meetings? Here, we probe into
50 attendance figures for Europe's largest geoscience meeting, the European
51 Geosciences Union (EGU) General Assembly, held in Vienna (Austria) since 2005.
52 Using publicly available historical data (EGU, 2024), we highlight the persistence of
53 economic factors as the primary control for conference attendance (Fig. 1). From our
54 perspective of participating in the 2024 EGU assembly, we note that while the theme
55 of Equality, Diversity, and Inclusion (EDI) is significantly featured in the conference
56 program, the actual diversity observed falls short of ideal standards.

57

58

59   **2. Dataset and Methodology**

60   We examine geographical diversity and representation at the EGU General

61   Assembly (hereafter referred to as the *EGU meeting, assembly, or conference*), one

62   of the largest geosciences meetings in the world. For each country, we analyze

63   attendance figures from 2005 to 2024 relative to three variables: (i) distance to the

64   event, (ii) gross national income (GNI) per capita, and (iii) population size. All

65   demographics are publicly available and derived from the World Bank and EGU's

66   website (EGU, 2024 – see supplementary data). We favor these metrics because they

67   are simple and not codependent/derived from each other (e.g., the human

68   development index and Henley passport index, which derive from a series of political

69   and economic factors). Because the selected metrics vary over several orders of

70   magnitude and are not necessarily linearly correlated to participation, we calculate the

71   Spearman's rank correlation coefficient (ρ) to examine their relative impact on EGU's

72   conference participation. To avoid post-COVID biases in travel patterns and truthfully

73   represent historical attendance trends, we exemplify these relationships by analyzing

74   data from the last pre-COVID edition of EGU's meeting, in 2019. In addition to

75   correlation coefficients, we compute income-independent over- and

76   underrepresentation by dividing the normalized attendance by the product of

77   population and the distance to the conference.

78

79   **3. Results**

80   3.1. Gross national income over time

81   Over the years, EGU's assembly attendance exhibits a strong correlation GNI,

82   as illustrated in Figure 1, where the correlation coefficient (ρ) typically exceeds 0.6.

83   Notably, these correlation values have consistently been significant at the 99%

84   confidence level, demonstrating remarkable stability throughout the EGU meeting's

85   history. This strong relationship between attendance and income is only disrupted by

86   countries with large populations, such as China and India (Fig. 2b). While there has

87   been a decreasing trend in the correlation between attendance and GNI since the

88   inception of the EGU assembly, the latter half of the 2010s witnessed a reversal of this

89   trend, with a notable increase in the correlation between attendees and GNI after

90   2015. Post-COVID metrics (2022 to 2024) reveal the strongest correlation ever
91   recorded, with a ρ exceeding 0.8. Unsurprisingly, in the virtual versions of the event
92   (held from 2020 onwards), this correlation between attendance and GNI is less strong
93   (ρ < 0.6; Fig. 1a).

94

95   3.2. Distance to conference site over time

96   The impact of distance to the conference site on attendance emerges as a
97   secondary factor, with low correlation coefficients typically hovering around 0.35 (Fig.
98   1). Although this correlation is relatively weak, it remains stable and statistically
99   significant at the 95% confidence level over the years. Despite its independent
100   influence, distance often interacts with GNI as a combined socioeconomic limiting
101   factor, since individuals from more distant countries have higher travel expenses. This
102   pattern is disrupted by distant, wealthy countries, such as Australia, Japan, and New
103   Zealand, which have all maintained robust participation throughout EGU assembly's
104   history (Fig. 2a). As expected, in virtual versions of the event, distance shows the
105   weakest correlation with attendance (Fig. 1a, ρ < 0.4).

106

107   3.3. Population over time

108   In contrast to gross national income, the total population of a country typically
109   shows a poor correlation with attendance for the majority of EGU assembly's history,
110   with ρ values consistently below 0.3 from 2005 to 2017 (Fig. 1). Despite that, there
111   has been a steady increase in the correlation coefficient for population until 2018, with
112   2012 marking the first instance of statistical significance at the 99% confidence
113   interval. This is particularly noticeable by examining the change in attendance figures
114   for populous countries such as India, China, and Indonesia during a 10-year pre-
115   COVID period (2009-2019; Fig. 2). Nonetheless, post-COVID figures for 2022 to 2024
116   indicate a significant drawback in this correlation, as evidenced by a ρ below 0.2,
117   representing the lowest value ever recorded in EGU assembly's history. In the virtual
118   versions of the assembly, held between 2020 and 2024, the population shows a
119   stronger correlation (ρ ~ 0.4) when compared with the in-person format of the event (ρ
120   < 0.2).

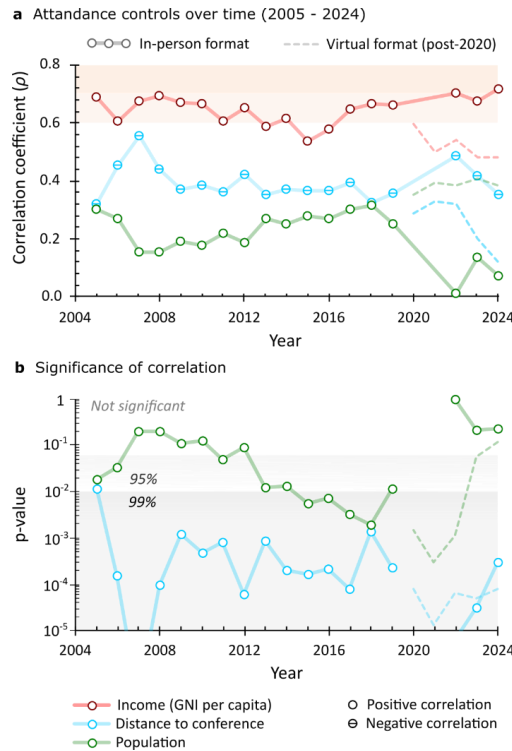



Figure 1. Correlation between the EGU General Assembly participants and distance to the conference, total population, and GNI per capita. (a) Spearman's rank correlation coefficient (ρ) and (b) their respective significance (p-values); whenever a p-value is not visible it indicates that the p-value $< 10^{-5}$.

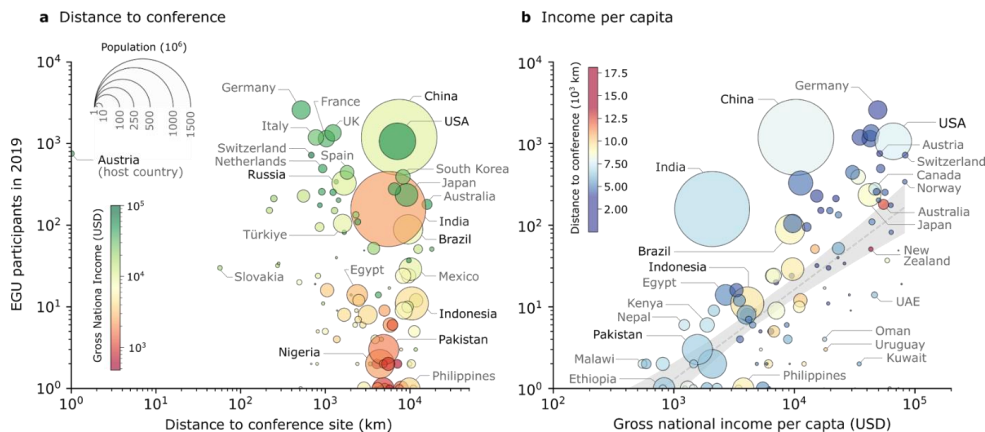



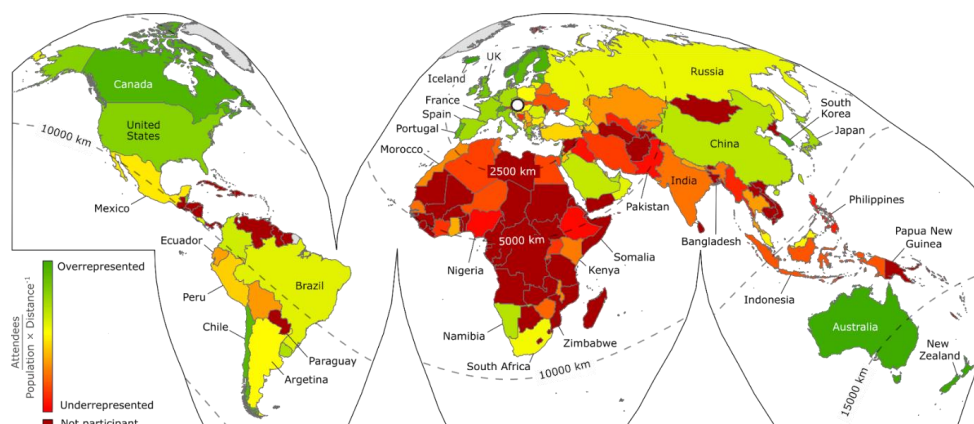
Figure 2. EGU's General Assembly attendance for the last pre-COVID meeting in 2019. a, participation vs. distance to the conference; b, attendance vs. Gross national income per capita. Gray shading regions in b denote 95% confidence intervals for a linear regression.

4. What controls the in-person EGU assembly participation?

Our data reveals that attendance at EGU's General Assembly is primarily and consistently controlled by income metrics (GNI), with the strongest correlation ever recorded in the past three years (Fig. 1, 2022-2024). Distance to the conference site also influences attendance, albeit with a weaker correlation. In contrast, a country's total population has historically shown a poor correlation with attendance (Figs. 1 and 2).

When comparing countries with similar populations and distances to the conference site, it becomes evident that income stands out as the main influencing factor in attendance (Fig. 2a). Nations with similar distances to the conference tend to exhibit higher participation rates with increasing GNI (Fig 2a). Examples include, from lower to higher GNI, Pakistan, South Korea, and the USA. This pattern is disrupted by populous countries such as India and China. Similarly, a similar trend is observed among countries with comparable populations. For instance, Ethiopia and the Philippines have significantly fewer participants compared to Japan (Fig 2b). In this context, our compilation reveals that attendance is dictated by a power-law relationship with income, with wealthier nations having two to three orders of magnitude more participants than poorer countries (Fig. 2b).

Under an income-independent participation scenario, we would expect to see participation depending only on distance and population. To identify the impact of income, the map in Figure 3 shows the relative representation of each country in the EGU assembly of 2019 after normalizing for distance and population. Notably, countries in Europe, northern North America, and Oceania (the Global North) exhibit the highest representation. Not coincidentally, these are the countries with the highest GNI per capita values (Fig. 2b; World Bank, 2024). Conversely, numerous countries in Latin America, Africa, and Asia are moderately to highly underrepresented in the conference. Based on correlation metrics (Fig. 1) and attendance plots (Fig. 2a), the distance from the conference venue can be ruled out as the primary reason behind representativity. From a global perspective (Fig. 3), curves of equidistance reveal that countries located at comparable distances from Austria present varying levels of representation. For instance, despite all being approximately 7,500 km away, India and nations in central Africa are notably underrepresented, while Canada stands out

162 as overrepresented in conference attendance (Fig. 3). Additionally, Australia, despite
163 being one of the most distant countries from Austria, maintains a high level of
164 representation in the event (Figs. 2b and 3).

165

166 **Figure 3.** Representation attendance map for EGU General Assembly 2019 corrected for both distance
167 and population. Dashed lines represent the distance to EGU's conference site in Vienna, Austria.

168   Ultimately, what controls attendance in the in-person EGU assembly is money.
169 With registration fees ranging from €525 to €765 for non-students in 2024, the
170 economic burden varies significantly across countries. For instance, in our home
171 country Brazil, registration costs can amount to nearly three times the monthly
172 minimum wage. In African nations like Angola, Nigeria, and the Democratic Republic
173 of Congo, fees can exceed ten times the monthly minimum wage. In contrast, in
174 Canada, fees equate to roughly half of the monthly minimum wage. In addition, travel
175 expenses are generally much higher than registration fees, which are only a fraction
176 of the total cost. Additional expenses including transportation, accommodation, and
177 meals, priced in the local currency (euros), significantly add to the overall financial
178 commitment of participation.

179

180   **5. What can be done about it?**

181   It is clear that the European Geoscientists Union acknowledges the importance
182 of diversity and is actively working towards a more equitable future. In 2018, the EGU
183 Council established an equality, diversity, and inclusion (EDI) Committee to raise
184 awareness and promote EDI initiatives (EGU, 2024b). Similar efforts have been

185 observed in other geoscience conferences. For instance, the American Geophysical
186 Union Meeting, the world's largest geoscience conference, also adopted a Diversity &
187 Inclusion Strategic Plan in 2018 (AGU, 2024).

188 Additionally, since the COVID-19 pandemic in 2020, the EGU introduced a
189 virtual version of the meeting. This version offers lower fees, and free enrollment for
190 (i) undergraduate or master students and (ii) low- & lower-middle-income countries.
191 These initiatives are readily observed in correlation metrics for the virtual version of
192 the EGU assembly, which show record-breaking increased ρ for population and
193 decreased ρ for GNI and distance (Fig. 1a). Clearly, the virtual event increased
194 accessibility and diversity by reducing the cost. However, in our and others' personal
195 experience, the virtual event shows limited engagement and interaction with
196 presentations and reduced networking opportunities between attendees. Furthermore,
197 the EGU offers financial assistance to encourage participation in the in-person event.
198 The Roland Shlich travel support includes a waiver of registration fees, reimbursement
199 of the abstract processing charges, and travel expenditure aid up to €300. Even
200 though this initiative is commendable and impactful, the overall cost of attending
201 remains prohibitive for scholars from low-income countries.

202 To increase diversity at events like the EGU assembly and other geoscience
203 events, we must alleviate financial barriers for attendees from lower-income countries.
204 Here we explore some possibilities to achieve that goal. Firstly, consider rotating the
205 conference's host country within Europe, making it more accessible to participants
206 from different regions. Secondly, facilitate affordable accommodation options for
207 scholars from lower-income countries through partnerships with hotels and hostels, or
208 university housing. Thirdly, accepting donations from attendees that will serve to fund
209 scientists from underrepresented countries. Lastly, establish a travel fund targeted at
210 assisting attendees from lower-income countries and underrepresented regions (Fig.
211 3).

212 Our discussion around increasing diversity and representation cannot be limited
213 to the EGU General Assembly or geoscience conferences in general; rather, it must
214 extend to acknowledging how conference attendance perpetuates barriers to
215 inclusivity within our community. The attendance patterns in the EGU assembly
216 highlight the prevalence of the Global North (i.e. developed) countries, which reflects

217   the historical dominance of these societies in shaping the field of geosciences until the
218   present.

219   Ethnic and cultural underrepresentation not only hinders the career
220   advancement of marginalized groups but also underscores the persistent dominance
221   of the Global North in many scientific fields, including geosciences (Rogers et al.,
222   2022; Raja et al., 2022). Academic neo-colonialism is not only reflected in conference
223   participation patterns, but it also extends to the selective prestige accorded to
224   universities and journals and the imposition of curricula, educational systems,
225   languages, and epistemologies on formerly colonized societies (Nagtegaal and de
226   Bruin, 1994; Rogers et al., 2022).

227   To promote equal research opportunities and equitable conference attendance,
228   structural changes are necessary. We need to recognize and praise the true
229   achievements and potential of scholars from outside the Global North. North-South
230   scientific collaborations must become more symmetrical and founded on mutual
231   respect, ensuring that knowledge production is collaborative, rather than extractive
232   (Jeffrey, 2013; North et al., 2020; Rogers et al., 2022). Funding disparities ought to be
233   tackled by the development of multi-partner and multi-national co-funded research
234   projects (Jeffrey, 2013). Biases inherent in the peer review process of both papers and
235   grant applications must be acknowledged and addressed (Rogers et al., 2022).
236   Geoscience conferences need to be accessible to all, allowing scholars from
237   underrepresented regions to share their research and perspectives, and to expand
238   their networking opportunities. By recognizing and valuing the contributions of
239   scientists from diverse backgrounds, we can move towards a more inclusive and
240   equitable scientific community.

241

242   **Author contribution**

243   **Francyne Bochi do Amarante**: Conceptualization, Formal analysis, Investigation,
244   Project administration, Visualization, Writing – original draft preparation. **Maurício**
245   **Barcelos Haag**: Conceptualization, Data curation, Formal analysis, Investigation,
246   Methodology, Visualization, Writing – original draft preparation

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248 **Competing interests**

249 The authors declare that they have no conflict of interest.

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