







## Social Sciences

# Education and outreach activities by the Antarctic Treaty Parties: topics and target audiences

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## Abstract

The relevance of education and outreach (E&O) activities about the Antarctic Treaty has been recognized at the Antarctic Treaty Consultative Meetings (ATCM) and at the Committee for Environmental Protection (CEP). This study examines the key topics and the target audiences detailed in papers submitted to the ATCM on E&O. Since the Antarctic Treaty entered into force in 1961, a total of 216 ATCM papers on E&O have been produced. The number of papers has increased substantially since the mid-1990s. ‘Science’ (76.9%) and ‘Wildlife/Biodiversity/Environment’ (75.5%) were the most addressed topics in these papers, while the ‘Public’ (81.0%) and those attending ‘Schools’ (69.0%) are the main target audiences. ‘Science’ in ATCM papers increased ~120-fold from 1961–1997 to 2015–2023, while ATCM papers discussing engagement with the ‘Public’ increased ~40-fold during the same period. ‘Climate change’ was first mentioned in 2006, and the number of papers per year increased fourfold by 2015–2023. This study shows the increasing interest in E&O through time, addressing key topics to relevant audiences related to the Antarctic region. From an educational perspective, attention should be paid to emerging topics (e.g. equity, diversity and inclusion), and the engagement of early-career professionals and educators should be made a priority.

**Key words:** Antarctic educational cooperation, Antarctic Treaty, diversity and inclusion, equity, Intersessional Contact Group on Education and Outreach, science communication

(Received 10 January 2024; revised 2 May 2024; accepted 2 May 2024)

## Introduction

The Antarctic region has unique elements critical to the Earth system that makes it essential for education and outreach across a

wide range of disciplines. In biology, examples used for education and outreach include the small size of Antarctic terrestrial animals (i.e. none are larger than a few millimetres in length), the unique winter breeding ecology of the emperor penguin *Aptenodytes forsteri* and Antarctic gigantism illustrated by the colossal squid *Mesonychoteuthis hamiltoni* (Xavier *et al.* 2016). In the discipline of physiology, Antarctic fish live without red cells or haemoglobin (Cheng & Chen 1999). In geography, the remoteness of the South

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**Cite this article:** Xavier JC *et al.* (2024). Education and outreach activities by the Antarctic Treaty Parties: topics and target audiences. *Antarctic Science* 36, 514–523. <https://doi.org/10.1017/S0954102024000257>

Pole is commonly referred to (Walton 2013), while in the discipline of physics, the discovery of the ozone hole was of great importance (Farman *et al.* 1985). In the discipline of history, the 'Heroic' (c. 1897–1922) and 'Mechanical' ages (1922–c. 1950) of Antarctic exploration are also particularly relevant for educational purposes (Kaiser *et al.* 2010, Walton 2013). Within such a context, disciplines related to social sciences on Antarctic issues (e.g. power, geopolitics, injustice, values, aesthetics, equity, diversity and inclusion, anthropology, tourism; Nielsen & Philpott, 2018, Liggett *et al.* 2023, 2024, Seag *et al.* 2023), while also addressing scientific issues of global relevance (e.g. climate change, sea-level rise, thermohaline ocean current circulation; Chown & Brooks, 2019, IPCC, 2022, 2023), are also educationally important. Additionally, the Antarctic has significant environmental, scientific, historical and intrinsic values that require urgent protection and need educational awareness (Kaiser *et al.* 2010, Hughes *et al.* 2018, Salmon & Priestley, 2019, Xavier *et al.* 2019b). Therefore, while promoting international, interdisciplinary and collaborative research, fostering education and outreach on the Antarctic region is important to inform stakeholders on a wide range of issues, such as the relevance of the region (e.g. fostering the broader understanding of the Antarctic), raising scientific and educational awareness of this fragile environment (e.g. understanding how the Antarctic contribution to sea-level rise could, in the future, affect the daily lives of people around the world) and environmental stewardship (e.g. for environmental protection and sustainable practises). In addition, climate change education (e.g. as Antarctica is a critical region for understanding the impacts of climate change), historical/cultural significance (e.g. understand the role of Antarctic explorers and scientists in fostering cross-cultural understanding) and policy and advocacy (e.g. helping citizens to become more engaged in supporting science-based policies that protect Antarctica) are important issues. Finally, issues directly related to public engagement (e.g. fostering curiosity about the Antarctic natural world) and inspiring future generations (e.g. encouraging young people to pursue careers in Antarctic science through various disciplines, including STEAM (Science, Technology, Engineering, Arts, Mathematics)) reinforces the broader relevance of education and capacity-building regarding the Antarctic region.

The Antarctic Treaty, which entered into force in 1961, recognizes the Antarctic Treaty area (i.e. the area south of latitude 60°S) as a region for peaceful purposes, promoting international scientific cooperation (Walton 2013, SAT 2014, Dodds *et al.* 2017). The Antarctic Treaty, together with further legal agreements and associated bodies developed *a posteriori*, constitute the Antarctic Treaty System (Dodds *et al.* 2017). The most recent component of the Antarctic Treaty System was the Protocol on Environmental Protection to the Antarctic Treaty (signed in 1991 (ATCP, 1991); entered into force in 1998), which was developed to address environmental concerns, and it focused on the challenges that the Antarctic region faces (e.g. conservation of biodiversity, prevention of marine pollution, the need for environmental impact assessments prior to the start of all Antarctic human activities in the region). The Committee for Environmental Protection (CEP) was established through the Protocol to provide advice to the Antarctic Treaty Consultative Meeting (ATCM) on matters relating to environmental protection.

The Antarctic Treaty established the now annual ATCM to provide a regular opportunity for Treaty Parties (see <https://www.ats.aq/devAS/Parties>) to exchange information,

consult with other Parties on matters of common interest related to the Antarctic and recommend measures to their governments to improve the governance and protection of the Treaty area. A total of 56 Parties are signatories to the Antarctic Treaty, of which 29 Parties have Consultative status (i.e. Parties that have the right to participate in decision-making at the ATCM) and 27 Parties have non-Consultative status (i.e. Parties invited to attend the ATCM but that do not participate in decision-making). During the first 20 years of the ATCMs, the agreed legal actions and ATCM papers were confidential, and there was no responsibility to inform the public (Xavier *et al.* 2019b). However, during the 1980s, ATCM papers became publicly available following the conclusion of each meeting (for those papers produced since 1961) and could be a source of information (e.g. working papers (which must be discussed in the ATCMs), secretariat papers (which relate to the management of the ATCMs), information papers (which provide supporting information for working papers) or background papers (which provide contextual information to support ATCM discussions)). Prior to the 1990s, education and outreach were still considered as low priorities by Treaty Parties and were rarely discussed at the ATCMs (Xavier *et al.* 2019b). However, with the entry into force of the Protocol on Environmental Protection to the Antarctic Treaty and the commencement of CEP meetings in parallel to the ATCM, the number of ATCM papers relating to education and outreach increased. The International Polar Year 2007–2008 boosted activities on education and outreach worldwide, with Parties encouraging national educational programmes (Kaiser *et al.* 2010, Salmon & Priestley 2019), which served as the basis for the first ATCM Education and Outreach Workshop held at ATCM XXXVIII in Bulgaria in 2015 and the subsequent establishment of the ATCM Intersessional Contact Group (ICG) on Education and Outreach (Xavier *et al.* 2019b). Since then, education and outreach have been elements of the ATCM multi-year strategic work plan and/or of the CEP 5 year work plan.

Information on the number of papers submitted to the ATCM since 1961 has been provided previously (Xavier *et al.* 2019b); however, the topics and the intended audiences of these ATCM papers have not been assessed. Examination of the key topics in the ATCM papers will help to demonstrate how important issues such as climate change, science or the Antarctic Treaty System have been considered by Parties. Similarly, understanding the targeted audiences in the ATCM papers will allow us to understand whether the ATCM papers were aimed at informing other Parties about the capacity-building of their Antarctic programme personnel, the general public or policymakers. Therefore, this study aims to relate the number of ATCM papers on education and outreach to the key topics and the target audiences mentioned in the ATCM papers since the entry into force of the Antarctic Treaty.

## Materials and methods

A search for the words 'education' and/or 'outreach', as well as ATCM papers within the category 'Education Issues' (which was named 'Education and Training' and 'Educational issues'), at the documents page of the Antarctic Treaty System (ATS; <http://www.ats.aq>) between 1961 and 2023 (noting that there was no ATCM in 2020) was carried out. A small number of papers on the topics of education and outreach may have been categorized under category headings other than 'Education Issues' and 'Education and Training'. However, due to the subjective nature of interpreting which of these papers might be

adequately relevant to this work, it was decided not to include these in this analysis.

For each ATCM paper, key topics and audiences were identified from the papers of each Party, Observer and Expert organization. In terms of topics, the chosen ones were: 'Cooperation', 'Wildlife/Biodiversity/Environment', 'Science', 'Climate change', 'ATS/Protocol legislation' and 'Equity, Diversity and Inclusion' (EDI). For audiences, the chosen ones were: 'Policymakers', 'Antarctic personnel', 'Artists', 'Journalists', 'Public' and 'Schools' (including universities). Additionally, references to the Association of Polar Early Career Scientists (APECS) and Polar Educators International (PEI) were also identified due to their role in Antarctic education and outreach (Baeseman *et al.* 2011, Beck *et al.* 2014, Hindshaw *et al.* 2018, Roop *et al.* 2019) in the last decade. Therefore, an ATCM paper may address more than one topic, audience or education and outreach organization. Due to the importance of the entry into force of the Protocol on Environmental Protection to the Antarctic Treaty (1998) and the first ATCM Workshop on Education and Outreach (2015), more detailed analyses were undertaken across three time periods (i.e. 1961–1997 (early Antarctic Treaty period), 1998–2014 (Environmental Protocol period) and 2015–2023 (post-ATCM Workshop on Education and Outreach)) to assess differences between them in terms of key topics and audiences addressed in the ATCM papers by Parties, Observers and Experts.

We recognize that the methods employed in this study may not allow for all the nuances and subtleties associated with ATCM communication on education and outreach to be described (e.g. by the categorization of the topics and audiences under a limited number of terms and the exclusion of papers relevant to education in outreach under categories other than 'Education Issues' and 'Education and Training'). However, we believe that the analysis undertaken should have adequately captured the general trends apparent over the study period. We also recognize that Treaty papers are not the only source of information on the topics of education and outreach. For example, analysis of how these topics were considered by Parties as revealed in the text of ATCM reports might be a subject of a future study but was beyond the scope of this work.

## Results

A total of 216 ATCM papers concerning education and outreach were submitted to the ATCMs between 1961 and 2023 (Fig. 1).

Up until the mid-1990s, the number of ATCM papers about education and outreach was low, with a marked increase in numbers occurring since then (Fig. 1), which reached a peak during the most recent full 5 year period of 2015–2019 (Fig. 1). Over half (57.3%) of the 56 Antarctic Treaty Parties published at least one ATCM paper on education and/or outreach, which included 89.7% of the 29 Consultative Parties and 33.3% of the non-Consultative Parties. In relation to organizations that attend the ATCM as Observers and Experts, 100% of the Observers and 31.3% of Experts published at least one paper on education or outreach (for further details on participants in the ATS, see Hughes *et al.* 2023). The level of paper output by Parties on the topics of education and outreach varied greatly, with Chile, the UK, Portugal and Bulgaria producing the highest numbers (Fig. 2). Of the papers produced, 15.3% were authored by two or more Parties, Observers or Experts. When the output of the Parties that submitted at least 10 ATCM papers on education and outreach was examined, it was found that all of the main

topics included in our analysis were included (i.e. 'Cooperation', 'Wildlife/Biodiversity/Environment', 'Science', 'Climate change', 'ATS/Protocol legislation'; Fig. 3a), while the 'Public' and 'Schools' were their main audiences (Fig. 3b).

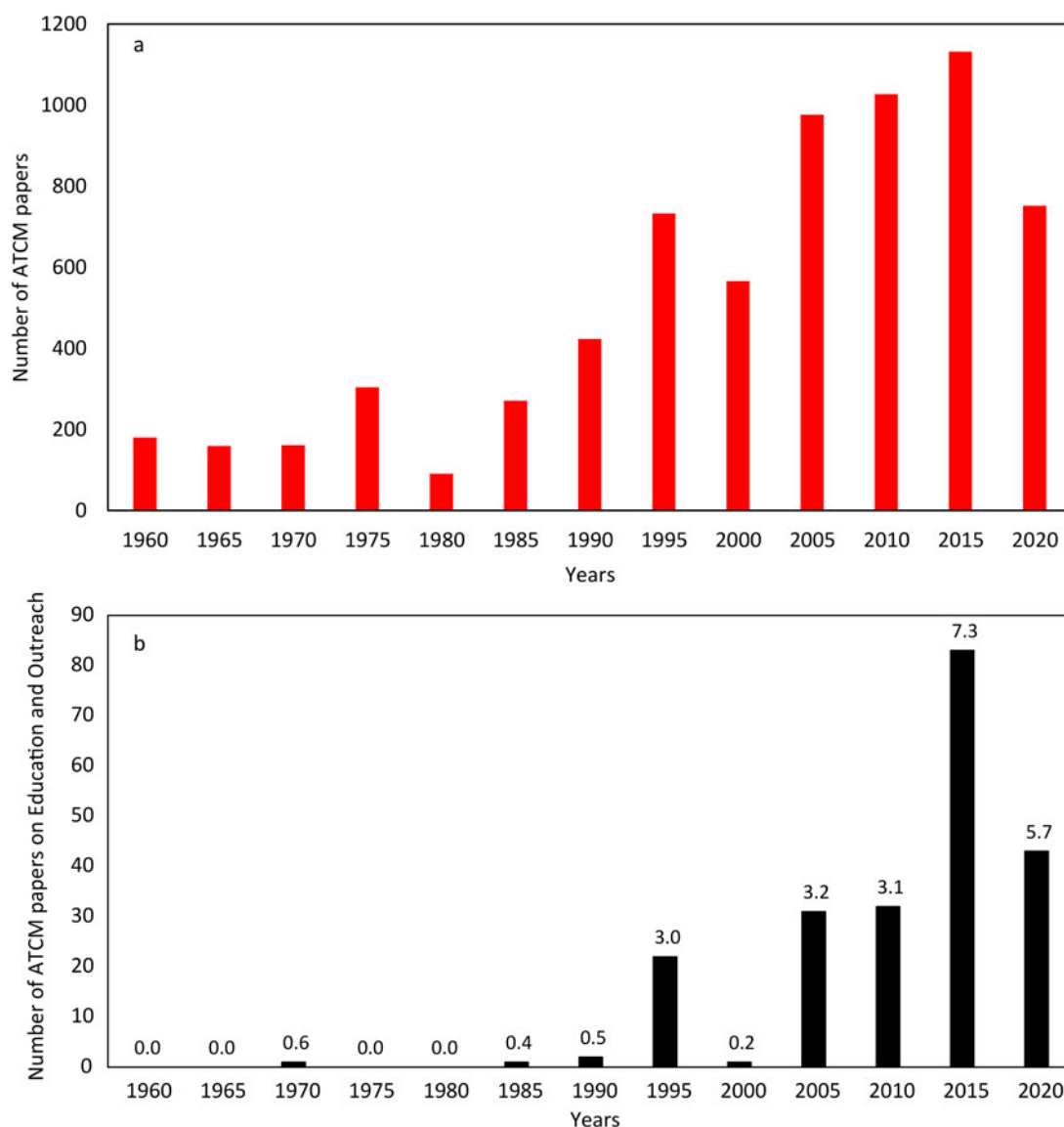
The topics most commonly addressed in the ATCM papers were 'Science' (76.9% of papers) and 'Wildlife/Biodiversity/Environment' (75.5%; Table 1). Information concerning 'ATS/Protocol legislation' was provided in 57.4% of ATCM papers. 'EDI' was barely addressed, being discussed in only 4.6% of the papers. The targeted audiences by the papers' authors were also considered. Most papers discussed education and outreach activities that were directed to the 'Public' (81.0%) and to 'Schools' (69.0%; Table 1).

The number of Parties that submitted to ATCMs in the periods 1961–1997 ('early Antarctic Treaty' period), 1998–2014 ('Environmental Protocol' period) and 2015–2022 ('post-Workshop on ATCM Education and Outreach' period) increased through time, with 7 Parties (all Consultative Parties) in the period 1961–1997, 20 Parties (17 Consultative Parties and 3 non-Consultative Parties) in the period 1998–2014 and 35 Parties (26 Consultative Parties and 9 non-Consultative Parties) in the period 2015–2023. In terms of Observers and Experts, their numbers were higher in the last period of 2015–2023 (i.e. period 1961–1997: 1 Observer and 2 Experts; period 1998–2014: 2 Observers and 2 Experts; period 2015–2023: 3 Observers and 3 Experts).

There was a continuous increase in the number of ATCM papers submitted per year (majority of the topics) over the three time periods previously established and a clear and marked difference when comparing between them (Table 2). The only exception was 'EDI', which has been little discussed across any of the three periods, although paper numbers have increased significantly since 2015 (1.1 papers/year). The topic 'Wildlife/Biodiversity/Environment' was the subject of the highest number of papers per year for the periods 1961–1997 (0.4 papers/year) and 1998–2014 (3.7 papers/year), while 'Science' was the topic with the most papers per year for the period 2015–2023 (13.4 papers/year; Table 2). The topics that had the greatest increase in papers per year between the periods 1961–1997 and 2015–2023 were 'Science' (with a 120-fold increase), followed by 'EDI' (a 41-fold increase), 'ATS/Protocol legislation' (a 32-fold increase), 'Cooperation' (a 29-fold increase) and 'Wildlife/Biodiversity/Environment' (a 25-fold increase). No ATCM papers were submitted on 'Climate change' during the period 1961–1997; however, between the periods 1998–2014 and 2015–2023, the number of papers per year on this topic increased fourfold.

In relation to target audiences, the number of papers submitted per year that were directed to all audiences increased across the three periods (Table 2). Papers on education and outreach activities that were directed to the 'Public' had the highest numbers across all three evaluated periods. The target audiences that had the highest growth in terms of papers per year between the periods 1961–1997 and 2015–2023 were the 'Public' (with a 40-fold increase in papers/year) followed by 'Schools' (a 33-fold increase), 'Journalists' (a 32-fold increase), 'Artists' (a 21-fold increase), 'Policymakers' (an 18-fold increase) and 'Antarctic personnel' (a 7-fold increase).

The number of ATCM papers mentioning APECS and PEI increased over the evaluated periods. There were no ATCM papers in this area in the first period, as both organizations were created after 1997 (Table 2). However, papers mentioning



**Figure 1.** Numbers of Antarctic Treaty Consultative Meetings (ATCM) papers on education and outreach submitted to the ATCMs between 1961 and 2023 (grouped by 5 year clusters; e.g. 1970 = 1970–1974). Note that ATCMs have not been held every year. The data for the 5 year cluster '1960' include data for 1961, 1962 and 1964; data for '1965' include data for 1966 and 1968; data for '1970' include data for 1970 and 1972; data for '1975' include data for 1975, 1977 and 1979; data for '1980' include data for 1981 and 1983; data for '1985' include data for 1985, 1987 and 1989; data for '1990' include data for 1991, 1992 and 1994; data for '2000' include data for 2001, 2002, 2003 and 2004; data for '2020' only include data for 2021, 2022 and 2023. **a.** Total number of ATCM papers and **b.** the number of ATCM papers on education and outreach, with the percentage of the number of ATCM papers on education and outreach from the total number of ATCM papers given above the bars.

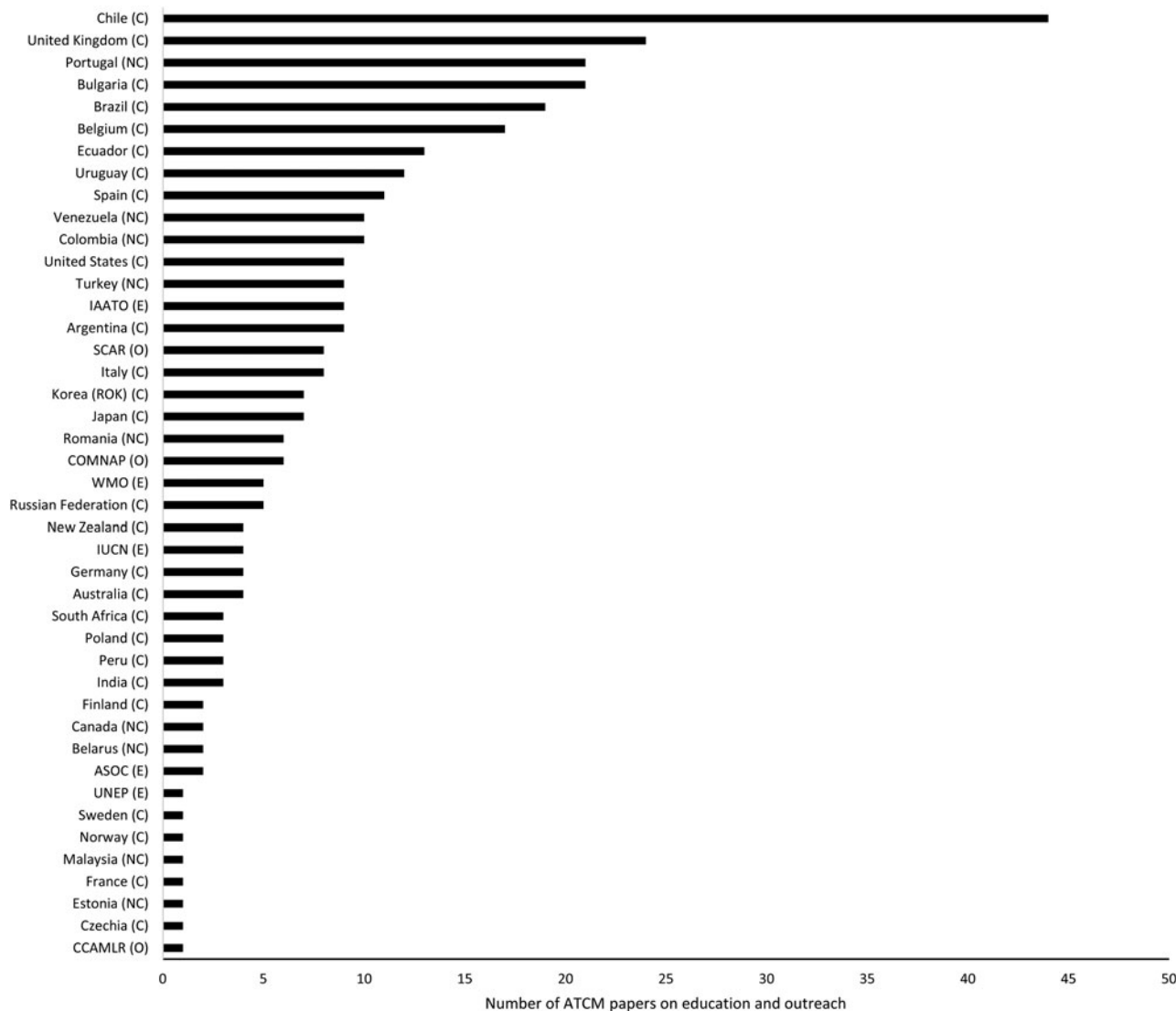
APECS and PEI increased ~10-fold and ~11-fold, respectively, between the periods 1998–2014 and 2015–2023.

## Discussion

### *Increase in the number of ATCM papers*

A previous paper by Xavier *et al.* (2019b) reported the recent increase in the number of ATCM papers on education and outreach, although it should be noted that there has been a general increase in the overall number of papers submitted to the ATCM over time and, in particular, since the CEP was established in 1998. Similar data are presented here, but an additional 125 ATCM papers were added that were not previously identified

within the 'Educational Issues' section of the documents search page of the ATS (despite including the words 'Education' and/or 'Outreach' in the title). Up until the mid-1990s, most ATCM delegations considered education and outreach to be low priorities (Xavier *et al.* 2019b), as reflected in the low number of ATCM papers submitted on the topic (Fig. 1). The increase in the number of ATCM papers that commenced in the late 1990s (Xavier *et al.* 2019a) followed 1) the implementation of the Protocol on Environmental Protection to the Antarctic Treaty in 1998 (with education being an increasing priority for Parties due to earlier initiatives such as the Scientific Committee on Antarctic Research (SCAR) and International Union for Conservation of Nature (IUCN) workshop in 1993; Dingwall & Walton 1996), 2) the creation of the expert group on education within

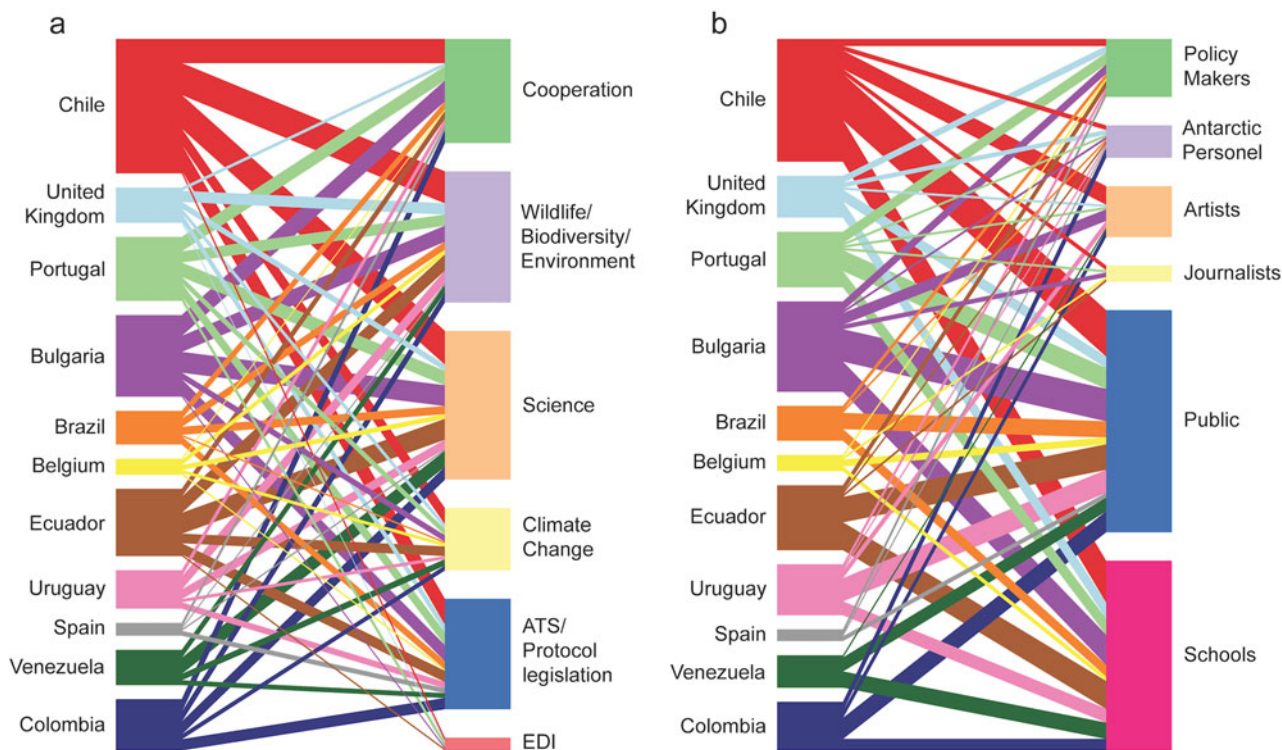


**Figure 2.** Number of Antarctic Treaty Consultative Meetings (ATCM) papers on education and outreach submitted to the ATCMs between 1961 and 2023 by Parties, Observers and Experts. ASOC=Antarctic and Southern Ocean Coalition; C=Consultative Party; CCAMLR=Commission for the Conservation of Marine Living Resources; E=Expert; IUCN=International Union for Conservation of Nature; NC=non-Consultative Party; O=Observer; SCAR=Scientific Committee on Antarctic Research; UNEP=United Nations Environment Programme; WMO=World Meteorological Organization.

Council of Managers of National Antarctic Programs (COMNAP) in 1998 and 3) the creation of the SCAR advisory group on Capacity Building, Education and Training in 2002 (Xavier *et al.* 2019b). The peak in the number of papers observed during the 2015–2019 period was due to the establishment of the ATCM ICG on Education and Outreach and their subsequent work. This ICG was created as a product of the first ATCM Workshop on Education and Outreach in 2015. The workshop aimed to share information about projects relevant to education and outreach, understand their national/international nature and secure support to facilitate further education and outreach projects. The workshop gathered much interest, with 37 Parties, Observers and Experts in attendance (Xavier *et al.* 2019b). The number of ATCM papers submitted to the ATCM since 2020 (which account for 3 years of data) is already more than during the 5 year periods of 2005–2009 and 2010–2014 (Fig. 1), which shows the growing interest of Parties regarding education and outreach in the ATCM. However, certain Parties, such as Chile, have valued

education and outreach even before then (i.e. since the 1990s), with various ATCM papers showing their commitment to education and outreach as important elements to its national programme.

Although no means of quantification exist, similar observations can be made regarding papers belonging or relating to the social sciences and their growing importance to our understanding and management of Antarctica. This is something that has already been recognized by SCAR with the creation of the Humanities and Social Sciences Expert Group (HASSEG) in 2014 and of the Standing Committee on Antarctic Humanities and Social Sciences (SC-HASS) in June 2018 (for more information on the history of this process, see <https://scar.org/science/hass#members>). While distinct from the field of education and outreach, which has its specific topics and target audiences, the social sciences can be regarded as an umbrella category under which many education and outreach papers could be located, considered and cross-examined with other social science-related



**Figure 3.** Number of papers submitted to the Antarctic Treaty Consultative Meetings (ATCMs) on **a.** key topics and **b.** concerning different audiences relevant to education and outreach between 1961 and 2023 by Parties that produced at least 10 ATCM papers on education and outreach identified in this study. ATS = Antarctic Treaty System; EDI = equity, diversity and inclusion.

**Table 1.** Percentage of Antarctic Treaty Consultative Meeting (ATCM) papers on education and outreach submitted to the ATCMs between 1961 and 2023 ( $n=216$ ) concerning different topics, aimed at different audiences and mentioning different education and outreach organizations.

		Percentage of ATCM papers
Topic	Science	76.9
	Wildlife/Biodiversity/Environment	75.5
	ATS/Protocol legislation	57.4
	Cooperation	53.2
	Climate Change	33.8
	Equity, Diversity and Inclusion	4.6
Target audience	Public	81.0
	Schools (including universities)	69.0
	Polymakers	24.1
	Antarctic personnel	18.5
	Artists	17.6
	Journalists	11.1
Education/ outreach organization	Association of Polar Early Career Scientists (APECS)	17.1
	Polar Educators International (PEI)	8.8

topics. Considering the many crossovers between education and outreach and the social sciences generally, doing so would potentially enrich and substantiate discussions on education and outreach within the ATCMs. The first problem to address, however, is that there is no ‘Social Sciences’ category on the documents search page of the official ATS website. Nor are there categories for other social science subcategories such as Antarctic ‘History’ or ‘Humanities’. The difficulty that must be recognized, however, is that the social sciences do indeed overlap with the majority of the sections already proposed on the website’s category menu.

**Key topics**

Science is one of the pillars of the Antarctic Treaty (Orheim 2013, SAT 2014); thus, it is not surprising that ‘Science’ was the most mentioned topic. The importance of science was recently reaffirmed in the Helsinki Declaration on Climate Change (2023) and in the Declaration on the 25th anniversary of the signing of the Protocol on Environmental Protection to the Antarctic Treaty (2016; Chile 2016, France 2021, Finland 2023), with SCAR playing an important role in providing independent scientific advice (Walton *et al.* 2011, CEP 2016, Chown 2021). Unsurprisingly, the topic of ‘Wildlife/Biodiversity/Environment’ was second most mentioned. Antarctic biodiversity is emblematic and can be used to communicate to wider audiences (Casasanto *et al.* 2018): penguins and their role within the Antarctic marine food webs, the diversity of life adapted to cold environments and the potential impacts of sea-level rise and changes in ice mass

**Table 2.** Number of papers on education and outreach submitted per year to the Antarctic Treaty Consultative Meeting (ATCM) for each study period (i.e. ‘early Antarctic Treaty’ period (1961–1997), ‘Environmental Protocol’ period (1998–2014) and the ‘post-workshop on ATCM education and outreach’ period (2015–2023)) concerning different topics, aimed at different audiences and mentioning different education and outreach organizations. Individual ATCM papers may contain reference to more than one topic/target audience/education and outreach organization.

		Time period		
		1961–1997	1998–2014	2015–2023
Topic	Science	0.1	3.4	13.4
	Wildlife/Biodiversity/Environment	0.4	3.7	11.0
	ATS/Protocol legislation	0.3	2.2	9.8
	Cooperation	0.3	2.0	9.0
	Climate Change	0.0	1.4	6.3
	Equity, Diversity and Inclusion	< 0.1	0.0	1.1
Target audience	Public	0.3	3.6	13.3
	Schools (including universities)	0.3	3.1	11.0
	Policymakers	0.2	1.1	3.5
	Artists	0.1	0.9	2.4
	Journalists	0.1	0.5	1.8
	Antarctic personnel	0.3	0.9	1.9
Education/outreach organization	Association of Polar Early Career Scientists (APECS)	<sup>a</sup>	0.4	3.9
	Polar Educators International (PEI)	<sup>a</sup>	0.2	2.0

<sup>a</sup>Organization did not exist during this period.  
ATS = Antarctic Treaty System.

have been regular topics of Antarctic educational activities (Kaiser *et al.* 2010, Xavier *et al.* 2016, 2019a, Roop *et al.* 2019). The number of ATCM papers mentioning ‘Science’ increased between 1961–1997 and 2015–2023 by more than 100-fold. These results clearly demonstrate the increased importance placed on science education by Parties, which is intended to improve Antarctic literacy but also to aid communication between scientists, policymakers and the general public (Hughes *et al.* 2018, Chown & Brooks 2019, Pertierra *et al.* 2021). Additionally, efforts have been made within the ATCMs to exchange information on educational activities through the closed forum of the ICG on Education and Outreach (with information from national programmes available at <https://www.ats.aq/e/links.html>; Bulgaria *et al.* 2015a,b, 2016, 2017, 2019, 2021, 2022, 2023). Indeed, Parties, Observers and Experts have recognized the relevance of fostering collaborations on education and outreach relevant to the ATS (Salmon & Priestley 2019, Xavier *et al.* 2016, 2018, 2019a), including as a step towards achieving Consultative status to the Antarctic Treaty (Karatekin *et al.* 2023).

The mentioning of ‘ATS/Protocol legislation’ in more than half of the ATCM papers suggests that Parties, Observers and Experts are increasingly aware of the need to educate the public and stakeholders about the importance of the ATS and the Protocol on Environmental Protection to the Antarctic Treaty, particularly since 2015, when papers increased 32-fold compared with 1961–1997 (Table 2). ‘Cooperation’ was also mentioned in 53.2% of papers, which reflects its important role as another pillar of the Antarctic Treaty (SAT 2014; Article III of the Antarctic Treaty and Article VI of the Protocol on Environmental Protection to the Antarctic Treaty), and it saw a more than a 29-fold increase in mean number of ATCM papers between the 1961–1997 and 2015–2023 periods (Table 2).

Despite the first Intergovernmental Panel on Climate Change Assessment (IPCC) report being published in 1990 (see <https://www.ipcc.ch/about/history/>; Table 1), no ATCM papers on education and outreach mentioned ‘Climate change’ during the period 1961–1997. Indeed, the first ATCM paper on education and outreach that mentions climate change was published as late as 2006 (Pertierra *et al.* 2021). The Antarctic region is well known to be highly affected by climate change (Turner *et al.* 2014, IPCC 2022, 2023), with its consequences affecting Antarctic and global physical and biological environments (Gutt *et al.* 2021, Xavier *et al.* 2022, Li *et al.* 2023). Consequently, there has been greater urgency for more cooperative and internationally coordinated actions on Antarctic science, governance, education and outreach on this issue (Chown & Brooks 2019, Chown *et al.* 2022, Hughes *et al.* 2022). For example, various educational activities related to climate change (e.g. sea-level experiments comparing both the Arctic and Antarctic) have been instigated that are directed to schools and the general public (e.g. APECS Polar Week programme ‘What happens at the poles affects us all’ regarding the global impact of climate change in 2009 (<https://www.ipy.org/hidden/item/2269-polar-weeks-2009>), with some cases translated into native languages (to reduce language barriers; Kaiser *et al.* 2010, Salmon & Priestley 2019).

The topic ‘EDI’ was only mentioned in 4.6% of the ATCM papers focusing on education and outreach but has shown a 41-fold increase in ATCM papers between the periods 1961–1997 and 2015–2023 (Table 2). Renewed discussions at the ATCM in Helsinki in 2023 showed a strong desire to promote EDI, with Parties agreeing, for example, to use gender-neutral language in all CEP and ATCM sessions and reports (Bulgaria *et al.* 2023). Indeed, various Parties have provided guidance on how to address these issues in their national and/or research programmes

(UK, 2021, 2023, USA & UK 2021, SCAR 2023, Spain 2023, USA 2023). Greater efforts are needed within the Antarctic community to tackle existing inequalities related to Antarctic activities. Specifically, there is a need to promote diversity within polar organizations and to improve opportunities for underrepresented groups by, for example, building more positive and inclusive Antarctic fieldwork environments (Karplus *et al.* 2022). The SCAR Equality, Diversity and Inclusion Action Group, established in 2022, will contribute to such efforts (Gulisano *et al.* in press).

### Target audiences

As expected, the most relevant audiences mentioned in ATCM papers on education and outreach were the 'Public' (discussed in 81.0% of the ATCM papers) and 'Schools' (69.0%; Table 1), with substantial growth occurring in the mean number of papers submitted each year across the three study periods (Table 2). This confirms the tendency found in previous studies that Parties, Observers and Experts have shown a growing interest in being highly engaged in education and outreach activities with these audiences (Kaiser *et al.* 2010, Salmon *et al.* 2011, Roop *et al.* 2019, Xavier *et al.* 2019a,b), as the general public and schools are known to be important audiences for making significant changes in global issues today and in the future (Salmon *et al.* 2011, Buckler & Creech 2014, Weiss & Barth 2019, UNESCO 2020).

Other audiences were mentioned in < 25% of the ATCM papers (Table 1), but these numbers have generally increased over the time periods, which may reflect the consistent yet slowly increasing support of national programmes for directing educational activities towards policymakers or towards facilitating programmes to engage artists and the media. Indeed, the engagement of artists has been successful in other world regions, with studies showing that using movies has a positive impact on raising awareness and supporting other education and outreach activities (Yong *et al.* 2011). ATCM papers concerning education and outreach activities directed to 'Antarctic personnel' represented 18.5% of the ATCM papers (Table 1). However, ATCM papers related to 'Antarctic personnel' have not increased (i.e. only 1.9 papers/year during the 2015–2023 period) as much as those related to other target audiences (Table 2). This could be because ATCM papers produced in the 1990s were directed more towards the education of the scientists and personnel of the Antarctic programmes on how to work in the Antarctic (coinciding with the implementation of the Protocol on Environmental Protection to the Antarctic Treaty; another reason is that Antarctic programmes possibly already provide information to 'Antarctic personnel' in their annual Antarctic expedition programmes), whereas later ATCM papers were more focused on reaching more general audiences and younger generations (e.g. the 'Public' and 'Schools').

Due to the rapid expansion of tourism industry activities in the Antarctic region (Bender *et al.* 2016, Hughes & Convey 2020), the Antarctic tourism industry, represented by the International Association of Antarctica Tour Operators (IAATO), has developed numerous initiatives to educate and inform tourists/visitors (and other interested stakeholders) regarding the importance of Antarctica. These initiatives includes IAATO visitor guidelines (<https://iaato.org/visiting-antarctica/visitor-guidelines-library/>), lecture programmes, IAATO codes of conduct, workshops, presentations, visits to research stations, citizen science, the Antarctic Ambassador programme, blogs and the 'Antarctica' app. From an ATCM perspective, IAATO has led seven ATCM papers that focus on education and outreach to inform Parties about such

initiatives (J.C. Xavier & K.A. Hughes, unpublished data 2024; IAATO 2015, 2019).

The recognition of early-career researchers (through APECS) and educators (through PEI) in Antarctic education and outreach work has increased (Table 1). As these organizations were established relatively recently (APECS in 2007; PEI in 2012) as legacies of the International Polar Year 2007–2008, their recognition and level of discussion within ATCM papers is likely to be higher in the future.

### Conclusion

Overall, the importance of sharing information related to education and outreach is now recognized by most ATCM Parties, Observers and Experts, as illustrated in the ATCM multi-year strategic work plan and CEP 5 year work plan. The number of ATCM papers submitted to the ATCM on education and outreach has greatly increased, particularly in the past decade, due to the increased priority given to these issues by Parties, by the implementation of the Protocol on Environmental Protection and by the contribution of the ATCM ICG on Education and Outreach. The evidence provided here shows that Parties, Observers and Experts should continue to organize, disseminate and collaborate nationally and internationally in education and outreach initiatives related to the Antarctic Treaty if they wish to build on earlier successes, with all stakeholders playing an important role (e.g. scientists, educators, policymakers, artists, musicians, writers, students and the public). Future ATCM papers should also describe the science carried out in more detail while learning from the past (e.g. the need to increase the number of papers on education and outreach focusing on 'Climate change') and addressing recent relevant topics (e.g. 'EDI') with the close engagement of more Parties, Observers and Experts (e.g. within the SCAR Equality, Diversity and Inclusion Action Group) and the next generations of scientists (e.g. via APECS) and educators (e.g. via PEI and national programmes such as EDU-SCIENCE (Poland), Educação PROPOLAR (Portugal) and InterAntar (Brazil)).

**Acknowledgements.** This work had the support of national funds through Fundação para a Ciência e Tecnologia, IP (FCT), under the projects UIDB/04292/2020, UIDP/04292/2020, granted to MARE, and LA/P/0069/2020, granted to the Associate Laboratory ARNET. This paper is a contribution to Theme 2 'Human Impacts and Sustainability' of the SCAR Scientific Research Programme 'Integrated Science to inform Antarctic and Southern Ocean Conservation' (Ant-ICON). AW is a Senior Research Associate of the Fonds de la Recherche Scientifique - FNRS. JF is supported by a PhD scholarship funded by FCT and FSE (2022.12075.BD). JPQ is supported by a PhD scholarship funded by FCT and FSE (SFRH/BD/144320/2019). JS was also funded by FCT through an Individual Scientific Employment (2021/00624/CEECIND).

**Competing interests.** The authors declare none.

**Authors contributions.** JCX and KAH developed the concept of the paper. JCX, JPQ and KAH carried out the analyses. All authors prepared and edited the manuscript prior to submission.

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