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The emerging contribution of Türkiye to Antarctic science and policy

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Abstract: Antarctica is a continent dedicated to 'peace and science' and subject to international consensus-based governance through the Antarctic Treaty System. Through the Treaty, decision-making powers are reserved to Consultative Parties, which are those countries recognized as demonstrating 'substantial scientific research activity' in Antarctica. Türkiye acceded to the Antarctic Treaty in 1996. In its National Polar Science Program (2018–2022) it first declared a desire to attain consultative status to the Treaty. Here, we examine Türkiye's recent development across Antarctic science, policy and logistics. Since 2016, Türkiye's national Antarctic scientific output has increased threefold, ranking seventh amongst the current 27 non-Consultative Parties, and this output is greater than some Consultative Parties. Türkiye has submitted more papers to the Antarctic Treaty Consultative Meetings than any other non-Consultative Party and is actively participating in the development of the Antarctic Protected Area system. To facilitate longer-term research goals, Türkiye is constructing an Antarctic research station (Horseshoe Island, Antarctic Peninsula), has joined several polar organizations, including the Scientific Committee on Antarctic Research (SCAR) and the Council of Managers of National Antarctic Programs (COMNAP), and has developed scientific and logistical collaborations with many established Antarctic nations. The exceptionally rapid growth of Türkiye's Antarctic activities provides a firm foundation for the development of a future application for consultative status.

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Key words: Antarctic logistics, Antarctic Treaty System, APECS, Committee for Environmental Protection, education and outreach, polar research

Introduction

Humans first set foot on Antarctica - on King George Island in the South Shetland Islands - in 1820, and, over time, the region has been used for the exploitation of marine living resources (including seals, whales and fish), as a target of geographical exploration and territorial claims, for scientific research and, most recently, as an increasingly popular destination for the tourism industry (Tin *et al.* 2009, Kennicutt *et al.* 2019, Grant *et al.* 2021, Tejedo *et al.* 2022). Substantial international research activities on the continent began in the build up towards the International Geophysical Year (1957/1958), which saw the construction of research stations on the continent and surrounding islands, some of which are still in use today (Dodds 2010). Currently, there are over 80 research stations and associated logistical facilities spread across the continent, and typically up to 5000 researchers and support personnel visit the continent each year, generally spending several weeks to months undertaking their work (COMNAP 2017). Approximately 40 stations currently operate year-round, with personnel numbers falling to ~1000 during the winter. These stations support research on a wide variety of important issues, including the role of Antarctica in the Earth system, the impacts of ice-sheet change on sea level and the responses of Antarctica's biota and ecosystems to change (Kennicutt *et al.* 2015).

Nations have multiple motivations for investing in the development of an Antarctic presence and research programme (National Research Council 2011). These include, for instance, 1) contributing to global efforts to understand Antarctica (including the effects of climate change in the region) and its influence on the rest of the

planet, 2) showcasing national scientific and logistical capabilities to both domestic and international audiences, 3) securing present and long-term access to resources, 4) demonstrating political dominance, 5) securing or maintaining the basis to territorial claims, 6) providing monitoring information to support obligations under the Antarctic Treaty System (e.g. to help determine fishery catch limits associated with the Commission for the Conservation of Antarctic Marine Living Resources; CCAMLR) and/or 7) providing a means of demonstrating substantial scientific research activity in order to support the attainment of consultative status under the Antarctic Treaty and, thereby, entitlement to participate in governance decision-making for the area and increase the nation's influence in the region (Pannatier 1994, Dodds 2006, Elzinga 2011, Hemmings 2011, Hemmings *et al.* 2015, Chinese Arctic and Antarctic Administration in State Oceanic Administration 2016 (in Chinese; cited in Zhai *et al.* 2021), Teschke *et al.* 2021, Yao 2021, Chown *et al.* 2022).

The Antarctic Treaty, negotiated by its 12 original signatory Parties after the International Geophysical Year and at the height of the Cold War, was signed in 1959 and entered into force in 1961 (Naylor *et al.* 2008). It sets out a regime for the international governance of the Antarctic Treaty area (defined as all land, permanent ice and sea south of latitude 60°S). Nations signing the Treaty agree that Antarctica shall be used for peaceful purposes only. Military activity (except in the logistical and operational support of scientific activities), nuclear testing and the disposal of nuclear waste in Antarctica are prohibited. The Treaty places pre-existing territorial claims into abeyance and confirms freedom of movement and of scientific investigation around the continent. It states that scientific observations and results from Antarctica shall be made freely available (Scott 2003). The Treaty also established the requirement for regular meetings of Parties to 1) consult on matters of common interest concerning Antarctica, 2) exchange information and 3) recommend to their governments measures to further the objectives of the Treaty (Triggs 2011). The meeting takes place annually and is known as the Antarctic Treaty Consultative Meetings (ATCM). The original 12 signatory nations to the Treaty were Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Soviet Union, the UK and the USA. Since then, other nations have acceded to the Treaty and, currently, there are 56 signatory nations, of which 29 are Consultative Parties that participate in consensus-based decision-making during the ATCM. The remaining 27 signatory nations are termed non-Consultative Parties, with the right to attend and submit papers to the ATCM but not to participate in governance decision-making (Pannatier 1994). In order to attain consultative status under the Treaty, a nation must demonstrate its interest in Antarctica by conducting 'substantial scientific research activity there' (Article IX, para. 2). Historically, this has been demonstrated by the establishment of a research station or the dispatch of a scientific expedition (Pannatier 1994, Hughes 2010). Conscious of the environmental impact caused by station construction, the ATCM has reminded Parties wishing to attain consultative status that station construction is not an essential requirement. However, at present, only one Consultative Party (the Netherlands) operates its national Antarctic programme without the construction of a station, although it has established the Dirck Gerritsz Laboratory at the UK's Rothera Research Station (Noor 2018). The Protocol on Environmental Protection to the Antarctic Treaty (hereafter referred to as 'the Protocol'; signed in 1991, entered into force 1998) designates Antarctica as a 'natural reserve, devoted to peace and science', sets out a framework for the environmental protection of the Treaty area through six Annexes and contains wording relevant to Parties wishing to attain consultative status (ATS 2023). The Protocol states that a Party's application to become a Consultative Party can be considered once it has 'ratified, accepted, approved or acceded to the Protocol' (Article 22.4) and approved all Annexes to the Protocol that have become effective (Decision 2, 2017).

Elzinga (2011) highlighted that, in the context of Antarctica, science has a dual function, 'both advancing new knowledge and manifesting a country's serious interest and presence', with the latter demonstrated most clearly through the process of becoming a Consultative Party. However, while credibility in Antarctic research is important for attaining consultative status, so too is political status, as demonstrated by the rapid elevation of China, India and Brazil to become Consultative Parties in the 1980s in order to strengthen the global profile of the Antarctic Treaty System (Dodds 2010). The appropriateness of the existing science-focused criterion for the attainment of consultative status has been questioned. For example, Roberts (2023) highlighted that the model of Antarctica as an isolated laboratory may not take into consideration the connectedness of Antarctica with the rest of the world. Specifically, melting of Antarctic ice as a consequence of climate change (itself resulting from global greenhouse gas emissions) may lead to rising sea levels and associated negative impacts for low-lying countries. Roberts therefore proposed that authority within the Antarctic Treaty System should be assigned to states affected by climate change, rather than states with the resources to undertake Antarctic research, many of which have played a large part in contributing to climate change.

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For those non-Consultative Parties seeking to attain consultative status, the level of the requirements remains poorly defined by the ATCM, despite recent efforts such as the production of the 'Guidelines on the procedure to be followed with respect to Consultative Party status' that were agreed through Decision 2 (2017) (ATS 2017). The guidelines set out the need for the Party seeking to attain consultative status to produce a dossier detailing 1) all scientific programmes and activities performed in or on Antarctica during the last 10 years, 2) all information that points to sustained contributions to science, 3) a description of all the planning, management and execution of its scientific programmes and logistical support activities in Antarctica and 4) details about its ability and willingness to promote international cooperation in accordance with Article III of the Antarctic Treaty. Factors such as the history of the Party's engagement with the Antarctic Treaty System and its engagement with bodies such as the Council of Managers of National Antarctic Programs (COMNAP) and the Scientific Committee on Antarctic Research (SCAR) would also be taken into consideration when assessing whether the Party has fulfilled the requirements necessary for consultative status. The lack of precision regarding the requirements may be due to the considerable diversity in Parties' characteristics, the levels of development of their scientific communities and the scales of their national Antarctic programmes, which may necessitate some level of flexibility in the requirements for consultative status.

Pragmatically, current non-Consultative Parties can be divided into two main groups: 1) Parties that have little physical presence in Antarctica and do not actively participate in Antarctic affairs and 2) Parties that are taking active steps to demonstrate substantial scientific research activities within the continent, which may at some point lead to the attainment of consultative status under the Antarctic Treaty (e.g. Shah *et al.* 2015). The Czech Republic/Czechia was the most recent Party to attain consultative status in 2014, while Canada, Belarus and Venezuela have subsequently indicated their interest in attaining consultative status to the ATCM (Belarus 2021, Canada 2021, Molenaar 2021). A recent analysis of the development of the Portuguese Antarctic programme revealed substantial science delivery and policy engagement and suggested that 'the rapid growth of Portugal's Antarctic research may make it well placed to consider attaining consultative status to the Antarctic Treaty in the near future' (Xavier *et al.* 2018). Furthermore, an analysis of Antarctic Treaty Parties' research outputs showed that the non-Consultative Parties Canada, Denmark and Switzerland produced the equivalent or more Antarctic research than not only the Czech Republic but also six Parties that had previously attained consultative status (Gray & Hughes 2016). The assessment of a Party's level of engagement with the Antarctic Treaty System and delivery of scientific research is not a simple process. Quantifying the number of papers submitted to the ATCM and academic papers relevant to Antarctica published in the literature provides only a crude metric, as the resulting policy and scientific impacts of these outputs can vary greatly (Dudeney & Walton 2012, Jabour 2019). Consideration of other factors such as membership of or engagement with international science, operational and policy bodies will also be important, as will the level of scientific (as opposed to operational) activity undertaken on the continent (Dudeney & Walton 2012, Xavier *et al.* 2018).

Inevitably, geopolitical factors come into play when Consultative Parties at the ATCM consider confirming a new application for consultative status. For example, Venezuela made applications to attain consultative status in 2016 and 2018, but these were unsuccessful, possibly due to opposition by some Consultative Parties from South America that were influenced by the deteriorating domestic situation in Venezuela at the time and the lack of a full dossier of information relevant to the application (Molenaar 2021). The application of Belarus for consultative status prior to ATCM XLIII (2021) received little attention by the meeting, possibly linked to the limited time available for discussion due to the meeting's virtual format, but also due to international concerns relating to the legitimacy of the 2020 Belarusian presidential election and the forced landing of Ryanair Flight 4978 at Minsk in 2021 to arrest opposition activist and journalist Roman Protasevich (Belarus 2021, Molenaar 2021). More recently, Canada formally submitted a request for consultative status that was discussed at ATCM XLIV in 2022 (Canada 2021). However, China and the Russian Federation raised concerns regarding Canada's request, stating procedural as well as substantive grounds for not taking a decision at this ATCM, and as a result the application did not proceed (ATCM XLIV Final Report, paras 118–122; ATS 2022), despite Canada having the greatest scientific output of any non-Consultative Party (and exceeding that of several Consultative Parties), with, for example, its scientists having produced > 80 Antarctic research papers per year in the period 2011–2018 (Ommanney 2015, Gray & Hughes 2016, Canada 2021).

Türkiye is a relative newcomer to state-sponsored engagement in Antarctic affairs. Türkiye's interest in Antarctica may date back as far as 1513, when the Turkish cartographer Piri Reis depicted Antarctica as a landmass over the South Pole, ~300 years before the continent was first discovered (Hapgood 1966). The first researcher from Türkiye to visit Antarctica was Prof Atok Karaali in 1967, who worked with the US Antarctic Programme and was awarded the US Antarctica Service Medal (Caymaz *et al.* 2021). He was

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Fig. 1. Timeline of major events in Türkiye's engagement in Antarctic legal and institutional affairs. APECS = Association of Polar Early Career Scientists; COMNAP = Council of Managers of National Antarctic Programs; SCAR = Scientific Committee on Antarctic Research.

followed by a small number of other researchers including Prof Umran Inan and Dr Serap Tilav, the latter being the first female researcher from Türkiye to visit the continent in 1991 (Day 2013). The activities of these researchers were not supported as part of a formal Turkish polar programme. On 24 January 1996, Türkiye signed the Antarctic Treaty. However, a further 20 years were to elapse before the country initiated more substantial engagement with Antarctic affairs (see Fig. 1).

Türkiye submitted its first paper to the ATCM in 2016 and undertook its first independent scientific expedition to Antarctica in early 2017 (Bilgic 2022). In Türkiye's National Polar Science Program (2018–2022), Dr Faruk Özlü, then Minister within the Ministry of Science, Technology and Industry, made the country's ambitions for consultative status clear, stating '[i]t is important for Turkey to upgrade its status and become a Consultative Party, if it wishes to have a say in Antarctic affairs, which requires regular scientific expeditions to be made in the continent, establishment of scientific cooperation with other countries, preparation of the National Polar Science Program and setting up a scientific research base in Antarctica'.

While many non-Consultative Parties have shown no overt desire to attain consultative status (e.g. Cuba, Papua New Guinea, Guatemala and the Democratic People's Republic of Korea), several others have made their interest clear (e.g. Belarus, Canada, Portugal, Türkiye and Venezuela). In this paper, we explore the preparations undertaken by non-Consultative Parties in their efforts to attain consultative status, using Türkiye as a case study. We 1) describe the development of Türkiye's Antarctic activities across the fields of science, policy and logistics, 2) compare Türkiye's level of scientific output and engagement in Antarctic affairs with that of other non-Consultative Parties and 3) assess how well-placed Türkiye may be should it wish to consider formal application for consultative status under the Antarctic Treaty at some point in the future.

Methods

Bibliometric overview of Türkiye's Antarctic outputs

To identify total academic publication outputs, bibliometric data were collected from the Web of Science using the search string below (taken from Gray & Hughes 2016 - the term 'candida' was specifically excluded to eliminate false positives produced by the fungus *Candida antarctica*). The results were then filtered by type to include only articles and reviews published between 2016 and 2022.

> Topic Search (TS) = ((antarc* NOT (candida OR 'except antarctica' OR 'except the antarctic' OR 'not antarctica' OR 'other than Antarctica')) OR 'transantarctic' OR 'ross sea' OR 'amundsen sea' OR 'weddell sea' OR 'southern ocean')

Use of the search string and filter produced 94 results on Web of Science. A similar search with revised syntax was used in Scopus; however, slightly fewer results were obtained overall (89). Web of Science also appeared to index a greater variety of sources, including a small number of Turkish-language journals, and so was it selected as the bibliographic database. The outputs of Türkiye were compared with those of other non-Consultative Parties using Web of Science data, filtered using the search terms above and refined by country/region. This draws on data from the author affiliation and selects any papers that include a Turkish authorship. Country data from the list of non-Consultative Parties were taken from the Antarctic Treaty Secretariat website (www.ats.aq). Estimates of a country's total research output as compared against the

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proportion of Antarctic papers was made using the total number of Web of Science results by country.

As Web of Science yielded the most data, citation analysis was carried out using the 'InCites Benchmarking & Analysis' tool - another Clarivate product. The results from the searches were extracted from Web of Science and imported into InCites. There were fewer records available to analyse than the total found in the search, as the InCites dataset is updated on a monthly basis and the Web of Science data cut-off is earlier than the InCites release date. The InCites dataset used for this analysis was updated on 27 January 2023 and contained Web of Science content indexed through to 31 December 2022. Although publication data for 2022 are still incomplete - as it takes time for papers to be indexed and citations to accumulate - it was felt worthwhile to include in order to provide as full a picture as possible. Given the caveat on sample size, the analysis still proved useful for providing a general indication of overall research trends and collaborations and for providing a basis for future study.

Due to the limited size of the pool of papers identified, one or two outliers can significantly skew citation analysis. As a result, one multi-collaborative 2020 paper with > 200 citations was removed from the InCites dataset prior to analysis. To study the impact of papers, the category-normalized citation impact (CNCI) indicator was used. As opposed to total citation numbers, this indicator compares papers of the same type, publication year and discipline. The method for the underlying calculation of CNCI is available on the InCites website (http://help.prod-incites.com/inCites2Live/indicatorsGroup/aboutHandbook/usingCitationIndicatorsWisely/normalizedCitationImpact.html).

Data on international collaborations were calculated using in-built indicators within InCites, which use affiliation data to determine papers that include at least one other international co-author.

Analysis of papers submitted by Türkiye to the Antarctic Treaty Consultative Meeting and the Committee for Environmental Protection

Papers (i.e. Working Papers, Information Papers and Background Papers) can be submitted to the ACTM by Parties, Observers and Experts and to the Committee for Environmental Protection (CEP) by Members and Observers to the Committee. Papers submitted to the ATCM provide a useful source of information on the development of a Party's engagement in Antarctic affairs and the range of subjects in which they have a particular interest. Working Papers can only be submitted by Consultative Parties or Observers (i.e. representatives of CCAMLR, COMNAP and SCAR), are translated into the four Antarctic Treaty languages (English, French, Russian and Spanish), should contain recommendations that require the consideration of the meeting and should be presented at the meeting. Information Papers can be submitted by all meeting participants, are made available to the meeting only in the language in which they were submitted and do not contain recommendations, and their oral presentation at the meeting is not guaranteed. Background Papers are similar to Information Papers, with the exception that they are not presented at the meeting. Papers submitted by Türkiye to the ATCM and CEP were retrieved from the Meeting Document Archive of the Secretariat of the Antarctic Treaty (https://www.ats.aq/devAS/Meetings/DocDatabase?lang=e). All data used in this part of the study were retrieved on 30 August 2022. The search period used was from 2016 to 2022, as this was the period that Türkiye has been an active participant in the ATCM (there were no papers submitted by Türkiye to the ATCM before 2016). Six ATCMs took place during this period, with no ATCM held in 2020 due to the COVID-19 pandemic (see Hughes & Convey 2020). To ensure that papers produced specifically by Türkiye were identified, an additional filter was added following 'submitted by' with 'Türkiye'. Different types of paper were quantified separately (i.e. Working Papers, Information Papers and Background Papers). Papers submitted by Türkiye were also categorized based on their subject under the headings 'science', 'logistics', 'membership of international bodies', 'education and outreach' and 'collaborations'. 'Science' papers provided details of scientific activities undertaken by Türkiye, 'logistics' papers provided information on logistical activities undertaken by Türkiye in Antarctica, papers on 'membership of international bodies' detailed the organizations with an Antarctic focus that Türkiye had joined, papers on 'education and outreach' detailed the largely domestic activities that Türkiye had undertaken to promote understanding of Antarctica and papers under the category 'collaborations' detailed the work Türkiye has undertaken jointly with other national operators in Antarctica.

Results

Bibliometric overview of Türkiye's Antarctic research output

Figure 2 shows the total number of research papers produced by Turkish authors between 2016 and 2022 based on Web of Science data. Although publication data for 2022 are incomplete, they so far have exceeded the output of 2021, with the expectation that this upward trend will continue into 2023. There is a high level of diversity in publication sources for this period,

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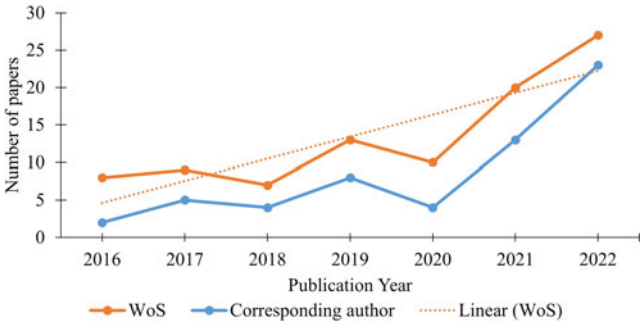

Fig. 2. Total number of research articles, 2016–2022, and number of articles with a Turkish corresponding authorship. WoS = Web of Science.

with identified research articles published in over 80 different academic journals.

To date, nearly half of the total output for this period has been published during the past 2 years, and a third of papers cite the Scientific and Technological Research Council of Türkiye (TUBITAK) in the funding information. This gives an indication of the impact of funding on increasing the total number of outputs. There has also been a dramatic increase in the number of papers that carry a Turkish corresponding authorship: 75% from 2021 to 2022. Over the period 2016–2022, 58% of papers carrying a Turkish affiliation had at least one co-author from another nation. The greatest number of collaborative papers involved researchers from the USA, Germany, Australia, the UK, Norway and China (see Fig. 3).

Analysis of the CNCI gives an indication of the degree to which research papers are being cited (see Fig. 4). A CNCI baseline for global Antarctic papers was created for comparison, which had an average CNCI for the period of just under 1. In broad terms, publication years that are above the baseline have performed better and vice versa. For example, a CNCI of 0.5 would be half the average for Antarctic papers. A degree of variability can be seen in the Turkish data, probably due to the limited size of the sample being analysed, where a small number of high-performing papers are sufficient to skew the CNCI. Papers including international collaborations were cited more often than papers with authors from Türkiye alone and, excepting a dip in 2019, were cited more often than the global Antarctic papers baseline for the same period.

The Organisation for Economic Co-operation and Development (OECD) Category Scheme was used for analysis of subject areas of the Turkish papers from 2016 to 2022. A breakdown of topics and sub-topics as defined within this schema showed that the majority fell within the high-level topic of 'Natural Sciences' (86%). Other high-level topics were 'Engineering and Technology' (18%) and 'Agricultural Sciences' (13%). These topic headings

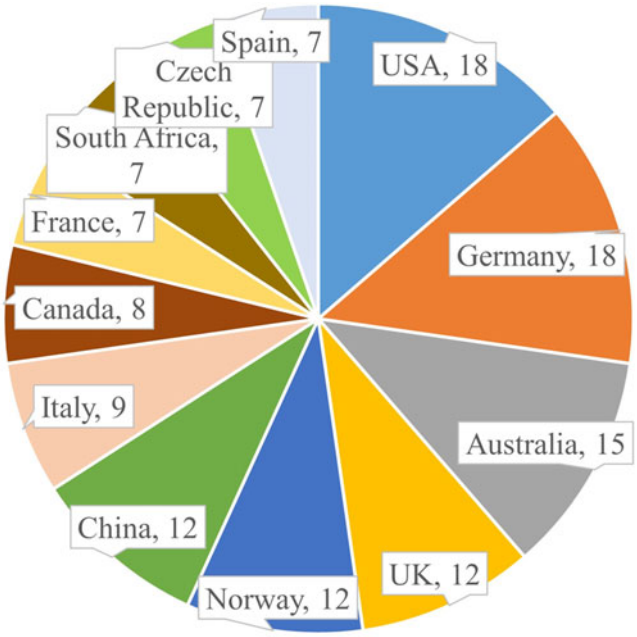

Fig. 3. Nations collaborating most often with Türkiye based on numbers of research articles during the period 2016–2022.

are broad and cover diverse subject areas; for example, within the context of Antarctic research, 'Agricultural Sciences' tends to relate to fisheries research. Note also that papers may be assigned to more than one topic. The remaining topics and sub-topics contributed a low proportion of the total output (< 10%), with a number of topics associated with just a few papers (e.g., 'Social Sciences', with seven papers). Within 'Natural Sciences', the key sub-topics were 'Biological sciences' and 'Earth and related environmental sciences' (see Fig. 5) - as is also the case with the global pool of Antarctic papers baseline. Both areas performed similarly in terms of citation

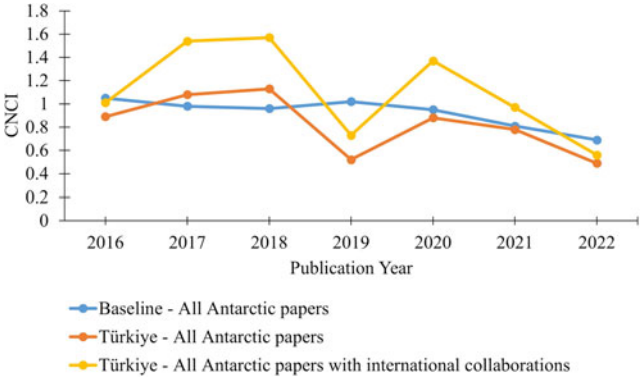

Fig. 4. Category-normalized citation impact (CNCI) for Antarctic research papers published during the period 2016–2022, including authors from Türkiye alone (orange), compared to papers including international collaborators (yellow) and the baseline average of all Antarctic papers (blue).

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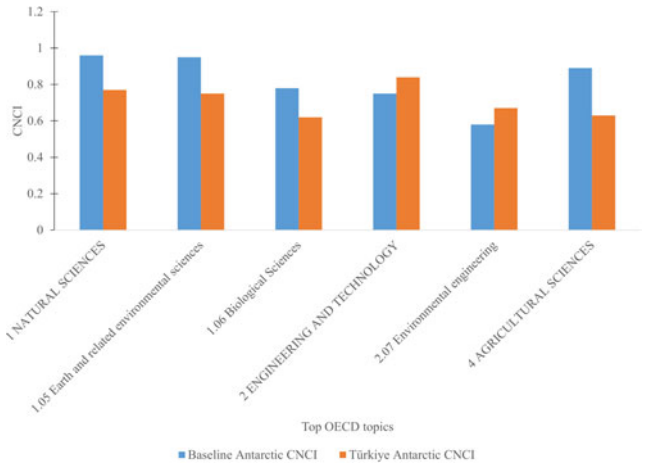

Fig. 5. Category-normalized citation impact (CNCI) for research papers including authors from Türkiye under the dominant subject topics compared with baseline data for all Antarctic papers under those topics. OECD = Organisation for Economic Co-operation and Development.

impact when compared to global Antarctic output by topic. Where Turkish papers perform better than the baseline, this is through the influence of a small number of highly cited papers, which limits the present ability to analyse research areas with a great degree of granularity. Figure 6 shows the number of Antarctic research articles produced by the non-Consultative Parties during the period 2016–2022 (San Marino became a non-Consultative Party to the Antarctic Treaty on 22 February 2023 and is therefore excluded from this analysis). Türkiye lies above the median line in seventh position overall. As well as numbers of papers, a comparison of Antarctic output against a country's overall research output can be a useful metric for indicating national focus (Gray & Hughes 2016). Here, Fig. 7 shows that Türkiye's Antarctic output is considerably lower as a proportion of national output (0.02%) in comparison to several other non-Consultative Parties (~0.1–0.2%), some of which have shown an interest in attaining consultative status, as well as that of the Czech Republic, the newest Consultative Party (0.16%).

Analysis of papers submitted by Türkiye to the Antarctic Treaty Consultative Meeting and Committee for Environmental Protection

During the six ATCMs that took place between 2016 and 2022, 1,430 papers were submitted in total, with Türkiye contributing 78. Of the latter, 58 were submitted by Türkiye alone. The remaining 20 papers were submitted

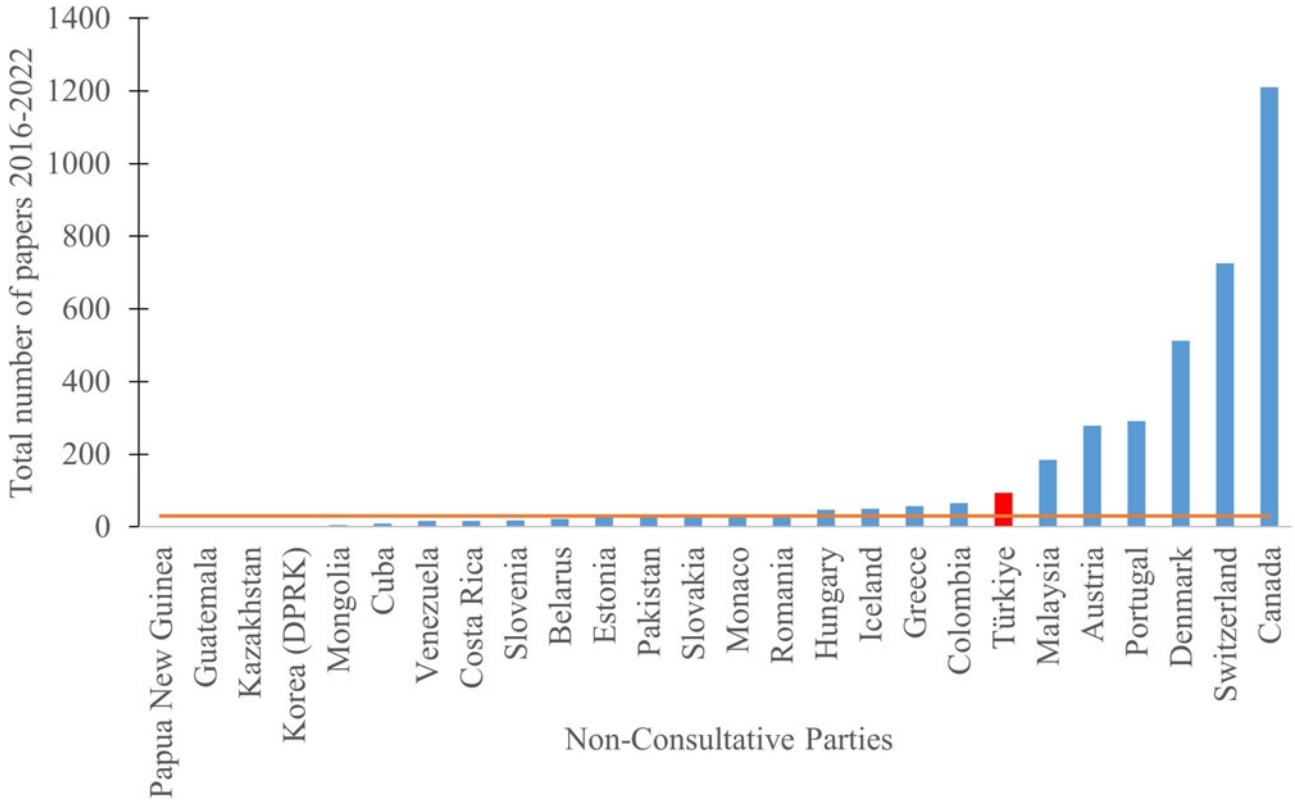

Fig. 6. Research article output of Türkiye compared to other non-Consultative Parties during the period 2016–2022. The orange line represents the median. San Marino only became a non-Consultative Party to the Antarctic Treaty on 22 February 2023 and is therefore excluded from this analysis.

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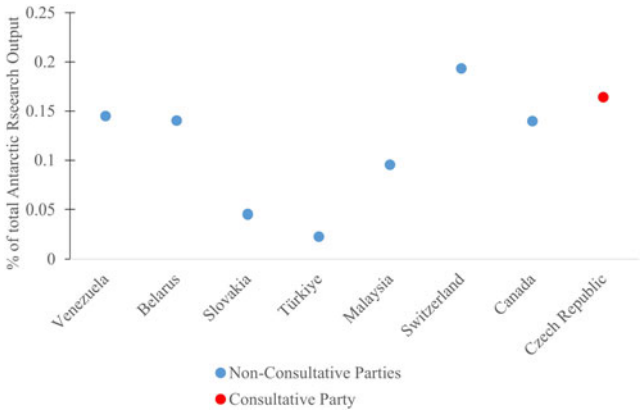

Fig. 7. Proportion of Antarctic output compared to total research output by country. Blue circles: non-Consultative Parties. Red circle: Consultative Party. The Czech Republic was the most recent Party to attain consultative status in 2014.

jointly with other Parties, including Bulgaria (5), Ukraine (4), Belarus (2), Czech Republic (2), Spain (2) and the UK (2). Figure 8 shows numbers of Working Papers, Information Papers and Background Papers submitted by Türkiye each year between 2016 and 2022 (totalling 2, 60 and 16, respectively). Türkiye recently jointly submitted a Working Paper proposing the designation of a new Antarctic Specially Protected Area with two Consultative Parties (Belgium and the UK), which indicates an interest in greater engagement in the use of existing Antarctic Treaty System conservation management tools.

The numbers of papers submitted by Türkiye between 2016 and 2022, compared to other non-Consultative Parties, are shown in Fig. 9. Of the 230 papers submitted by the non-Consultative Parties during this time, Türkiye contributed the highest proportion (34%), followed by Colombia (24%). Thirteen non-Consultative Parties (Austria, Costa Rica, Cuba, Denmark, Greece, Guatemala, Hungary, Democratic People's Republic of Korea, Mongolia, Pakistan, Papua New Guinea, Slovakia and Slovenia) submitted no papers to the ATCM or CEP between 2016 and 2022.

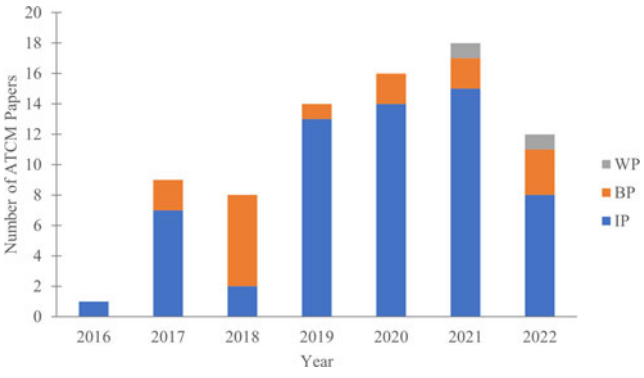

Fig. 8. Numbers of Working Papers (WPs), Information Papers (IPs) and Background Papers (BPs) submitted by Türkiye to the Antarctic Treaty Consultative Meetings (ATCM) and meetings of the Committee for Environmental Protection (CEP) since 2016.

Türkiye's papers submitted to the ATCM and CEP have addressed a variety of topic categories (Fig. 10). The categories generating most papers concerned the scientific activity of Türkiye in Antarctica and the predominantly scientific collaborations with other Treaty Parties. Fewer but still substantial numbers of papers concerned logistical activities, education and outreach and membership of international organizations. A list of nations with which Türkiye has developed formal scientific links as indicated through papers submitted to the ATCM up to 2022 is given in Table I. Major events indicating the increasing engagement of Türkiye in Antarctic affairs are shown in Fig. 1.

Discussion

Türkiye has made considerable efforts in recent years to participate in international Antarctic affairs across scientific, logistical and policy areas and to raise the profile of Antarctica within its domestic population.

Science

There has been considerable growth in Antarctic research activity by Türkiye (Fig. 2), with 94 research articles produced during the 2016–2022 sample period compared with 21 during the period 2011–2015 (Gray & Hughes 2016). This increase can be attributed to several factors. Since 2019, Turkish polar science has been specifically funded by TUBITAK (see Republic of Turkey, Ministry of Science, Industry and Technology 2017), and, to ensure that the Turkish Antarctic Science Program is delivered with appropriate international collaboration, the Polar Research Institute (PRI) was formally established in December 2019 (Türkiye, 2020a). Before this date, national polar activities were coordinated by the Polar Research Center (PolReC), which was established in 2015 under Istanbul Technical University. Concerted efforts have been made to increase awareness of polar research opportunities within Türkiye's domestic research community through conferences and workshops (Türkiye 2021a). Following these developments, scientific studies carried out by Turkish researchers in Antarctica have increased across the fields of Natural Sciences, Engineering and Technology, Medical and Health Sciences and Agricultural Sciences. In 2021 in particular the number of papers within Natural Sciences over other fields, perhaps indicates an increasing focus over other research areas. Although the scientific contribution of Türkiye is currently modest compared to nations with a long-standing engagement in Antarctic research, such as

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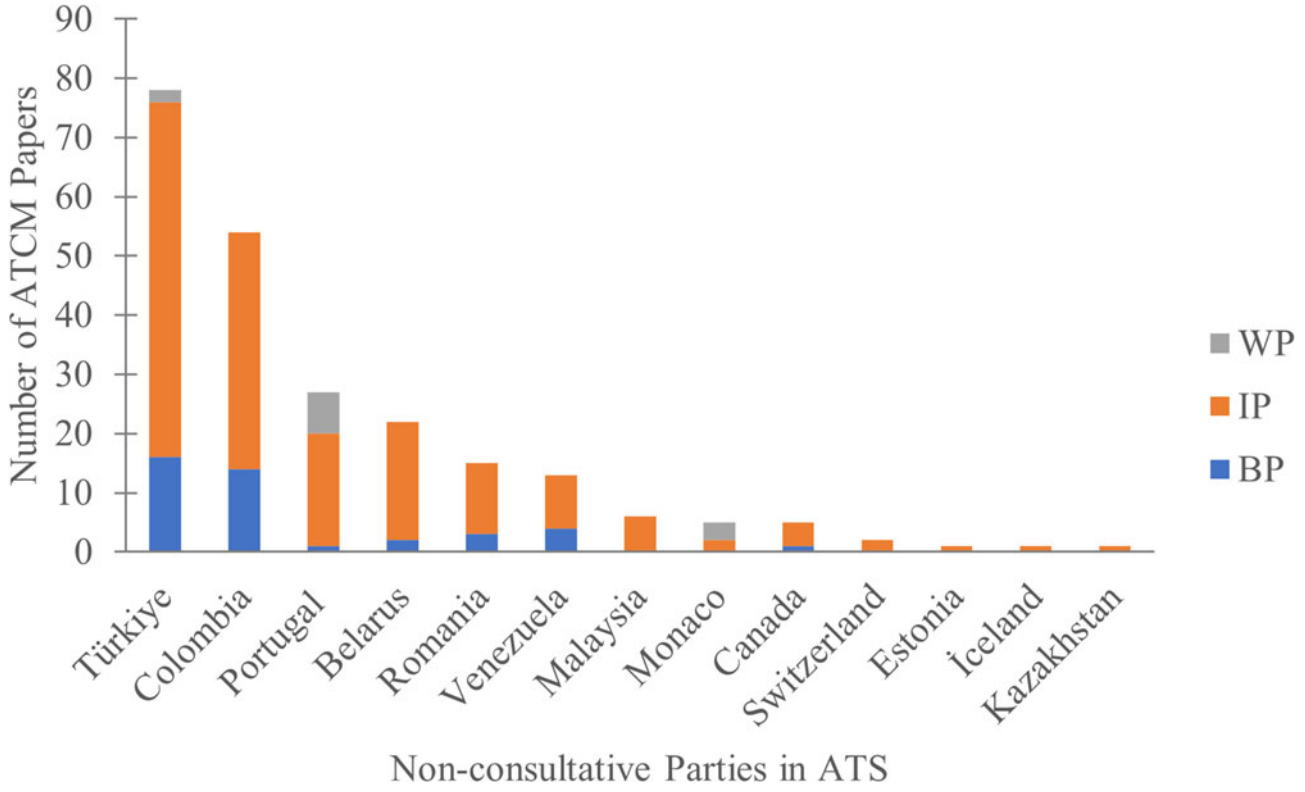

Fig. 9. Numbers of Working Papers (WPs), Information Papers (IPs) and Background Papers (BPs) submitted by non-Consultative Parties to the Antarctic Treaty Consultative Meetings (ATCM) and meetings of the Committee for Environmental Protection (CEP) during the period 2016–2022. Non-Consultative Parties that did not submit any papers to the meetings during this period are not shown (Austria, Costa Rica, Cuba, Denmark, Greece, Guatemala, Hungary, Democratic People's Republic of Korea, Mongolia, Pakistan, Papua New Guinea, Slovakia and Slovenia). San Marino became a non-Consultative Party to the Antarctic Treaty after the most recent ATCM and CEP meeting and is therefore excluded from this analysis. ATS = Antarctic Treaty System.

the USA, the UK, Germany and Australia (Ji *et al.* 2014), the level of national output is increasing and already has an impact that matches the average for Antarctic research across Parties. Earlier studies have shown that the level of scientific output by Parties differs considerably, with levels

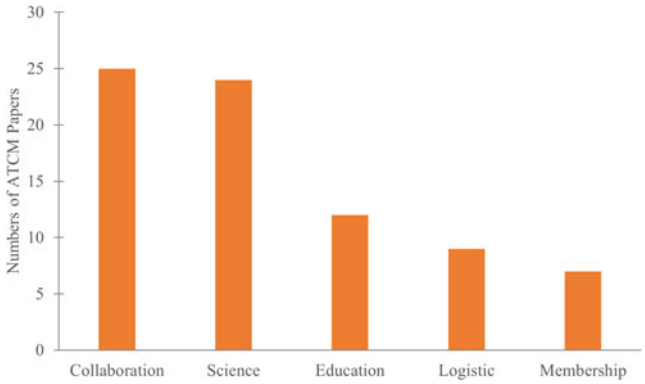

Fig. 10. Numbers of papers submitted by Türkiye to the Antarctic Treaty Consultative Meetings (ATCM) and meetings of the Committee for Environmental Protection (CEP) on different subject areas of policy interest.

produced by non-Consultative Parties, and even some non-Treaty countries, exceeding those of some Consultative Parties (Dastidar & Persson 2005, Gray & Hughes 2016). To ensure the ongoing production of high-quality international science, particularly once consultative status was attained, Dudeney & Walton (2012) encouraged Parties to hold regular international peer reviews of their individual science programmes.

The independent SCAR (www.scar.org) has a dual role to 1) initiate, develop and coordinate high-quality international scientific research in the Antarctic region (including the Southern Ocean and other linked and dependent regions) and 2) provide objective and independent scientific advice to the ATCM and other international organizations on issues of science and conservation affecting the governance of Antarctic. In common with all nations active in Antarctic research, Türkiye has become a member of SCAR, in contrast to the non-Consultative Parties Costa Rica, Cuba, Estonia, Greece, Guatemala, Hungary, Iceland, Kazakhstan, Democratic People's Republic of Korea, Mongolia, Papua New Guinea, Slovakia and Slovenia. Türkiye joined SCAR as an Associate Member in August 2016

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Table I. List of nations with which Türkiye has developed formal cooperative links, as indicated through papers submitted to the Antarctic Treaty Consultative Meetings (ATCM) up to 2022.

Year	Collaborating nation	ATCM paper number and title
2022	Spain	Spain & Türkiye. 2022. A Memorandum of Understanding between the Ministry of Science and Innovation of the Kingdom of Spain and the Scientific and Technological Research Council of Turkey. Information Paper 103. Antarctic Treaty Consultative Meeting XLIV, 23 May–2 June 2022, Berlin, Germany. Retrieved from https://documents.ats.aq/ATCM44/ip/ATCM44_ip103_e.docx
2022	Japan	Japan & Türkiye. 2022. A Memorandum of Understanding between the Scientific and Technological Research Council of Turkey, Marmara Research Center, Polar Research Institute and the National Institute of Polar Research, the Research Organization of Information and Systems. Information Paper 104. Antarctic Treaty Consultative Meeting XLIV, 23 May–2 June 2022, Berlin, Germany. Retrieved from https://documents.ats.aq/ATCM44/ip/ATCM44_ip104_e.docx
2021	Republic of Korea	Korea (ROK) & Türkiye. 2021. A Letter of Intent between the Scientific and Technological Research Council of Turkey, Marmara Research Center, Polar Research Institute and the Korea Polar Research Institute. Information Paper 71. Antarctic Treaty Consultative Meeting XLIII, 14–24 June 2021, Paris, France. Retrieved from https://documents.ats.aq/ATCM43/ip/ATCM43_ip071_e.docx
2021	Bulgaria	Bulgaria & Türkiye. 2021. A Memorandum of Understanding between the Scientific and Technological Research Council of Turkey, Marmara Research Center, Polar Research Institute and the Bulgarian Antarctic Institute. Information Paper 72. Antarctic Treaty Consultative Meeting XLIII, 14–24 June 2021, Paris, France. Retrieved from https://documents.ats.aq/ATCM43/ip/ATCM43_ip072_e.docx
2021	Ukraine	Türkiye & Ukraine. 2021. A Memorandum of Understanding between the Scientific and Technological Research Council of Turkey, Marmara Research Center, Polar Research Institute and the State Institution National Antarctic Scientific Centre of Ukraine. Information Paper 73. Antarctic Treaty Consultative Meeting XLIII, 14–24 June 2021, Paris, France. Retrieved from https://documents.ats.aq/ATCM43/ip/ATCM43_ip073_e.docx
2019	Belarus	Belarus & Türkiye. 2019. Signing of Memorandum of Understanding with Belarus. Information Paper 67. Antarctic Treaty Consultative Meeting XLII, 1–11 July 2019, Prague, Czechia. Retrieved from https://documents.ats.aq/ATCM42/ip/ATCM42_ip067_e.doc

and became a full member in May 2021 (Fig. 1). In September 2022, Prof Burcu Özsoy (TUBITAK, Marmara Research Center) was elected as a Vice-President of SCAR, indicating both the importance that Türkiye attaches to Antarctic scientific collaborations and supporting the work of SCAR and the international recognition of Türkiye's standing within SCAR. Prof Özsoy has also sat on the Steering Committee of the Southern Ocean Observing System (SOOS), which is a joint initiative of SCAR and the Scientific Committee on Oceanic Research (SCOR). SCAR awarded the Turkish PolReC a visiting professor award, which enabled Dr Yeadong Kim, from the Korean Polar Research Institute (KOPRI) and current President of SCAR, to visit Türkiye for educational and information exchange purposes (Türkiye 2018). Türkiye's desire for engagement in international research is also evidenced by the large number of formal collaborative agreements that Türkiye has developed with other nations active in the Antarctic Peninsula region (see Table I). Almost two-thirds of Antarctic academic papers produced by Turkish authors are co-authored with researchers from other nations, further indicating a high degree of collaboration, as is common within the Antarctic research community (Ji *et al.* 2014, Colombo 2018). In general, these collaborations have involved researchers from nations that are Consultative Parties, probably as a result of these nations having existing infrastructure and established science programmes in the region (Fig. 3). For example, researchers from Türkiye have undertaken projects based at the Belgian Princess Elisabeth Station (Türkiye 2019a), the Bulgarian St. Kliment Ohridski Base on Livingston Island (Bulgaria & Türkiye 2020), the Korean King Sejong Station on King George Island (Türkiye 2019b), the Ukrainian Vernadsky Station, Argentine Islands (Türkiye & Ukraine 2016) and on Chilean research vessels (Türkiye 2019c). Academic outputs have been shown to be positively correlated with the economic development and academic investment of a country (Solarin & Yen 2016). Türkiye's Antarctic output is currently much lower as a proportion of national output in comparison to several other non-Consultative Parties (Fig. 7). Nevertheless, the establishment and operation of an Antarctic research station, as planned by Türkiye, has also been shown to have a positive effect on academic outputs, as it may increase access to study locations (Dastidar 2007, Ji *et al.* 2014).

Policy

Türkiye acceded to the Antarctic Treaty in 1996 and to the Protocol on Environmental Protection to the Antarctic Treaty in 2018, which was enacted into its domestic legislation on 13 June 2020. With no direct fishing interests in the Southern Ocean, Türkiye has not acceded to the Convention for the Conservation of

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Antarctic Marine Living Resources (CAMLR Convention). Like many other more recent Parties to the Antarctic Treaty, Türkiye has not acceded to the Convention for the Conservation of Antarctic Seals (CCAS), as this has been largely superseded by the Protocol.

Türkiye initiated active participation in the ATCM and CEP in 2013 and submitted its first papers to these meetings in 2016. In 2017, an Antarctic Treaty Secretariat Internship Grant was awarded to Türkiye to enable a legal advisor to visit the Secretariat in Buenos Aires to become familiar with the workings of the Treaty System (Türkiye 2017a). During the period 2016–2022, Türkiye submitted more papers to the ATCM and CEP than any other non-Consultative Party (78), addressing a wide range of subject areas. The high number of papers relating to 'Science' and 'Collaboration' give an indication of the importance that Türkiye attaches to these areas (see Fig. 10, Table I & Supplemental Table 1). Türkiye has co-authored ATCM papers with Australia, Belarus, Bulgaria, Chile, Colombia, Czech Republic, Finland, India, Japan, Korea, Spain, Ukraine and the UK (for examples, see Table I & Supplemental Table 1).

While the number of papers submitted by Türkiye is high relative to other Parties (including both Consultative and non-Consultative Parties), no papers led by Türkiye have resulted in specific governance outcomes or outputs (such as Decisions, Measures or Resolutions), which in large part may be due to limitations placed on non-Consultative Parties' participation in the governance of Antarctica. However, in 2022, Türkiye demonstrated its willingness to participate in the active development of the Antarctic protected area system by acting as a co-proponent, alongside the Consultative Parties Belgium and the UK, for a proposed new Antarctic Specially Protected Area (ASPA) on Farrier Col, Horseshoe Island (Hughes & Grant 2017, Hawes *et al.* 2023). This represents an unusual step for a non-Consultative Party, with very few being involved in such proposals previously. The proposed ASPA is intended to protect the outstanding environmental and scientific values associated with the area's oligotrophic lakes, which are extremely rare in the region, and researchers from Türkiye have actively engaged in the development of the draft ASPA Management Plan. Türkiye has also provided some support to the UK Antarctic Heritage Trust in their management of Base 'Y' on Horseshoe Island, which is designated as Historic Site and Monument No. 63 and is a regular tourist visitor site, through provision of photographs showing the state of repair of the building.

Dudeney & Walton (2012) suggested that the seven claimant nations (Argentina, Australia, Chile, France, New Zealand, Norway and the UK), the USA and the Russian Federation had set the political agenda in Antarctica and also provided most of the science to that point in time. However, in more recent years, other nations, such as China, have increasingly expressed their views at ATS meetings and shaped the pace and direction of policy development. It remains to be seen whether emerging Antarctic nations, such as Türkiye, intend to follow a similar path.

Logistics

In support of its scientific activities in Antarctica, Türkiye has made progress in the development of its logistical capabilities in the region. Türkiye does not operate a dedicated polar research vessel but has chartered vessels flagged to other nations in support of its Antarctic scientific activities, such as the RV *Aurora Australis* (flagged to Australia) and the MV *Betanzos* (flagged to Chile). During the 2018–2019 Antarctic season, a temporary scientific research camp comprising three iso-container-sized modules (each ~6.0 × 2.5 m) was installed on Horseshoe Island, Marguerite Bay, to support eight researchers and an increasing number and diversity of science projects (see Fig. 11; Yavaşoğlu 2019). The modules were intended to be removed during the 2021–2022 season to allow for the construction of a new, larger permanent research station on the same site that will be able to accommodate up to 50 personnel (Wenger 2021, Türkiye 2022a), although this has been temporarily delayed. Under Annex I to the Protocol, all activities within the Treaty area are subject to an environmental impact assessment (EIA), with the level of assessment determined by whether the activity is likely to result in an impact that is less than, equal to or greater than 'minor or transitory'. It should be noted that the Protocol does not provide a definition of these terms, thereby leaving interpretation open to individual Parties (Bastmeijer & Roura 2008). Activities likely to result in an environmental impact deemed to be greater than 'minor or transitory', such as the construction of a permanent research station, are subject to the highest level of EIA, a Comprehensive Environmental Evaluation (CEE), and this was deemed appropriate in the planning process for the new Turkish research station. Therefore, in 2021, Türkiye submitted its draft CEE to the ATCM to facilitate international consultation on the plans for the station's construction (Türkiye *et al.* 2021b). Planning for the new year-round station aimed to minimize its impact on the Antarctic environment (e.g., through the use of renewable energy sources) and maintain the safety and well-being of personnel. Türkiye has also established infrastructure to support scientific research, including two Global Navigation Satellite Systems and an automatic weather station operated by the Turkish State Meteorological Service (see https://www.mgm.gov.tr/sondurum/antarktika.aspx). Finally, the Turkish Navy's Office of Navigation, Hydrography and Oceanography

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Fig. 11. Maps showing the location of the proposed Turkish Antarctic Research Station on Horseshoe Island, Marguerite Bay, Antarctic Peninsula.

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has undertaken a bathymetric survey of Lystad Bay, near Horseshoe Island, providing the data to the International Hydrographic Organization.

COMNAP aims to develop and promote best practice in managing the support of scientific research in Antarctica. The Turkish Antarctic Science Program applied to join COMNAP in 2018 and was accepted as a Member in 2022. Through COMNAP, Türkiye may further develop both existing and new areas of operational cooperation. Türkiye has already reported bilateral cooperation agreements on science and logistics with Belarus, Bulgaria, the Czech Republic, Japan, the Republic of Korea, Spain and Ukraine (see Table I & Supplemental Table 1) and in recent months has signed further cooperative agreements with Brazil and Ecuador (A. Yilmaz, personal communication 2022).

Education and outreach

Türkiye has made considerable efforts to increase awareness of the polar regions within its domestic population, including publicizing the role of the country in the delivery of Antarctic scientific research. Initiatives, largely coordinated by TUBITAK, Marmara Research Center (MAM) and the PRI, have been delivered that engage with schoolchildren, the general public, university students and the national research community.

Projects aimed at schoolchildren include but are not limited to: the 'Collaboration Project for Supporting Educators for Polar Regions' initiative, where educators are sent to Antarctica to directly communicate their experiences to schoolchildren (Türkiye 2020b); the Polar Research Projects Contest for High School Students in Türkiye (Türkiye 2021c); the Marie Sklodowska-Curie Actions-funded 'Education about Climate Change and Polar Science' project 'Researchers' Night 2022' event (https://educate-night.org/); two Polar Science Festivals in 2019 and 2020; the opening of the first Polar Science Center in Istanbul in 2018 (https://kare.mam.tubitak.gov.tr/en/news/house-polar-sciences); and the publication of several popular books on polar research and expeditions aimed at different age groups (Özsoy & Büyüksağnak 2021, Yirmibeşoğlu 2022).

Wider public engagement has been promoted through the SCAR photographic exhibition 'Our Antarctica - images from the great white south' in Türkiye in 2016 (Türkiye 2017b) and the broadcasting of several documentaries introducing Turkish Antarctic expeditions, including 'Antarctic diaries: a trip to the end of the world', 'The black box of the planet: Antarctica', 'Focal Point: Frozen Frontier' and 'You have a message from the polar regions!' (Türkiye 2021d).

Since 2017, Türkiye has held regular Polar Science Workshops to promote polar research amongst students and the wider research community (Türkiye 2022b), and it has also harmonized polar research terms through its Turkish Polar Encyclopedia Project (Türkiye 2021e). Students are encouraged to engage in Antarctic research through the Turkish Students' Polar Research Team (PolSTeam), which is a body of Istanbul Technical University Polar Research Center (ITU PolReC, the former national operator), and new polar student clubs are being founded at other universities. The Turkish National Committee of the Association of Polar Early Career Scientists (APECS; https://www.apecs.is/) is also active in promoting Antarctic research (Türkiye 2021a).

Progress assessed against Türkiye's National Polar Science Program aims

In its National Polar Science Program (2018–2022), Türkiye outlined its plans to attain consultative status to the Antarctic Treaty through 1) conducting national science expeditions to the continent, 2) promoting bi- and multilateral cooperation on polar science including the deployment of Turkish researchers on the stations of other nations and hosting researchers from other national programmes at Turkish facilities, 3) ensuring a Turkish Antarctic research station is established, 4) encouraging Turkish scientists to undertake polar research, 5) increasing the number of polar science programmes for Turkish researchers at different stages of their careers, 6) joining the membership of international organizations working on polar issues and increasing the effectiveness of Türkiye's contributions within such organizations; and 7) creating awareness of global climate change. The results of this study demonstrate that, in large part, Türkiye is making considerable progress in delivering these objectives. Türkiye regularly sends national science expeditions to Antarctica and has established an interim scientific research camp on Horseshoe Island in advance of the construction of the Turkish Antarctic research station. Türkiye has made substantial efforts to integrate, and in some cases take leadership roles, in existing organizations that have a focus on Antarctica, including COMNAP, SCAR, the European Polar Board (EPB) and APECS, often to a greater degree than is typical of non-Consultative Parties (Table II). In the past 7 years, Türkiye has submitted a greater number of papers to the ATCM and CEP than any other non-Consultative Party, many of which describe the development of Türkiye's Antarctic activities. Türkiye has demonstrated its interest in Antarctic conservation through its participation in the expansion of the Antarctic Protected Area system and has developed scientific and logistical collaborations with a broad range of Antarctic partner nations (Supplemental Table 1). Substantial efforts have been made to promote Antarctic research and climate change issues amongst early-career researchers and the general

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Table II. Non-Consultative Parties and details of their accession to Antarctic Treaty System agreements, and membership of Antarctic-focused organizations (●: Full Member of SCAR, Member of CCAMLR, Full Member of COMNAP; ○: Associate Member of SCAR, Acceding State to the CAMLR Convention, Observer to COMNAP). Costa Rica, Cuba, Guatemala, Hungary, Kazakhstan, the Democratic People's Republic of Korea, Mongolia, Papua New Guinea, San Marino, Slovakia and Slovenia are non-Consultative Parties, but have not signed the Protocol, CCAS or the CAMLR Convention, nor are they members of SCAR, COMNAP, the European Polar Board or APECS.

Treaty Party	Antarctic Treaty System agreements				Antarctic-focused organization			
	Antarctic Treaty	Protocol on Environmental Protection to the Antarctic Treaty	Convention for the Conservation of Antarctic Seals	Convention on the Conservation of the Antarctic Living Marine Resources	SCAR	COMNAP	European Polar Board	APECS National Committee
Canada	1988	●	●	○	●	●	[1]	●
Türkiye	1996	●			●	●	●	●
Portugal	2010	●			●	●	●	●
Switzerland	1990	●			●	○	●	●
Malaysia	2011	●			●	○	[1]	●
Colombia	1989	●			○	○	[1]	●
Venezuela	1999	●			●	○	[1]	
Austria	1987	●			○		●	
Denmark	1965				○		●	●
Belarus	2006	●			○	●		
Pakistan	2012	●		○	○		[1]	
Monaco	2008	●			○			
Greece	1987	●		○				
Romania	1971	●			○			
Iceland	2015						●	●
Estonia	2001				○		●	

[1]indicates that the Party is unlikely to be eligible to join the European Polar Board.

public in Türkiye. While its scientific outputs are modest relative to more established Antarctic nations, it is increasing the number and diversity of research outputs and is currently the seventh most scientifically productive non-Consultative Party.

Conclusions

International political interest in the polar regions has increased steadily in recent decades, with 56 nations having now acceded to the Antarctic Treaty. After initially acceding to the Treaty in 1996, Türkiye did not actively participate in the ATCM until 2013, but, since that time, its level of engagement with the Meeting has increased rapidly. It has been suggested that Türkiye's Antarctic policy forms part of a broader ambition of expanding Turkish political, economic, scientific and humanitarian influence globally (Adnan 2021, Yanık & Karaoğuz 2021, Bilgic 2022). This is further evidenced by Türkiye's interest in the Arctic through its recent applications for Observer Member status to the Arctic Council (which have so far been unsuccessful) and its decision to ratify the Svalbard Treaty (Çetin & Büyüksağnak 2021, Limon 2021, Pedersen 2021, Wenger 2022) and more broadly by its increasing development of outer space research and technology though the establishment of the Turkish Space Agency (Ercan & Kale 2017, González Levaggi & Blinder 2022)

The information presented in this study confirms that Türkiye is no longer a 'watching' non-Consultative Party but, since 2013, has taken active steps towards the demonstration of substantial scientific research activity within the continent. Other non-Consultative Parties that may also be well placed to attain consultative status, at some point in the future, include Canada, Portugal, Switzerland, Malaysia, Colombia, Venezuela and Belarus (Table II). The Czech Republic was the last nation to become a Consultative Party in 2014, and the 153 papers it produced during the period 2011–2015 could be considered an appropriate benchmark of scientific output for attaining consultative status. In comparison, over the period 2016–2022, Türkiye produced 94 papers, with annual paper numbers increasing in later years, suggesting that a similar level of output to the Czech Republic will be delivered soon. Furthermore, the planned construction of a new year-round research station on Horseshoe Island provides a clear indication of Türkiye's longer-term commitment to research in Antarctica and may strengthen any case for eligibility to participate in governance of the Antarctic Treaty area.

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Author contributions

KAH conceived the original idea. KAH and PC supervised the work. FK, FRU, BJA and KAH collated the data. All authors discussed the results and contributed to the final manuscript.

Supplemental material

A supplemental table will be found at https://doi.org/10.1017/S0954102023000172.

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