

Mapping the global structure of Antarctic research *vis-à-vis* Antarctic Treaty System[§]

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ANTARCTICA is a continent of science and peace, a common heritage of mankind. This fifth largest continent is governed by a set of guiding principles, the Antarctica Treaty System (ATS)¹. The ATS is the basic instrument for managing the activities in this icy continent. Conducting science is occupying a central place in ATS. Currently, there are 45 treaty member nations: 28 consultative (voting) and 17 acceding states. This icy, coldest and windiest continent is covered with a sheet of ice with more than 2 km average thickness (4.7 km at its thickest point). Locked up in thick ice sheet is a record of past climate for the last 500,000 years. Antarctica provides an ideal setting for conducting frontier science (Figure 1). It has a scanty flora, but a rich fauna, including many species of fish, birds and mammals. It has no permanent human population. Today, there are 37 year-round research stations, run by 20 nations, operating in the continent. Belgium, The Netherlands, Ecuador, etc. (Consultative Parties) do not have any permanent bases, but instead use the infrastructure of other nations in collaborative efforts. In this paper we have attempted to visualize the structure of science that is being pursued by the countries in the framework of the ATS.

Materials and methods

Title search on 'Antarc*' retrieved 10,287 papers from *SCI* database (CD-Rom), published in 934 journals during the last 24 years (1980 through 2003). These papers formed the basis of our analysis. To bring uniformity in country names, Fed Rep Ger and Ger Dem Rep were merged into Germany, while the USSR was merged into Russia. Bibexcel algorithm² was used to derive citations between countries and joint authorship papers. Most productive 35 countries were considered for constructing the network map. Multidimensional scaling technique was used to map the collaboration structure among the countries. The size of the circles is proportional to the size of productivity, while lines between the countries indicate colla-

boration links and widths indicate size of the frequency. Bonacich power centrality³ is used to indicate the position of the countries in the network.

Results

The interest about Antarctica is on the rise, as evident from the increasing number of articles published in the peer-reviewed journals; fishing and tourism in this continent is getting popular. There is a distinct upward trend in the number of publications over the years; the year 2002 saw a rise to 735 papers against a meagre 169 in 1980. 60% (fraction count) output in Antarctic science is generated by four countries, viz. USA, UK, Australia and Germany. USA accounts for a third of the papers. The international papers are also on the rise, signifying increasing number of multinational projects in the field (Figure 2).

The new Concordia station, jointly managed by Italy and France is a unique collaborative venture. It appears that the location of the station is ideal for making accurate astronomical observations. Their research endeavour is aimed to contribute to space exploration in the future. This collaboration trend will add a new dimension to the annals of ATS and Antarctic science. The network map of

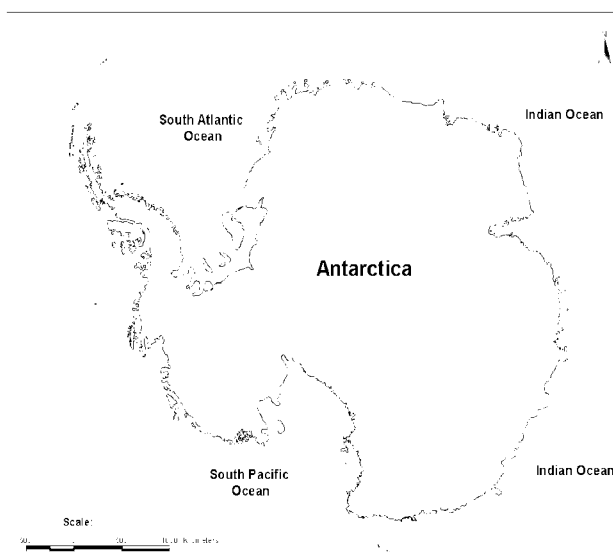


Figure 1. Map of Antarctica, surrounded by South Atlantic Ocean, Indian Ocean, and South Pacific Ocean.

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[§]The opinions expressed in the article are those of the authors and not necessarily of the organization to which they belong.

Table 1. Citations given to and received from other countries

Sl. no.	Country	Papers	Citations given	Citations received	Citations gained (%)	Citations per paper	Mean publication year of papers
1	USA	3311	7635	10080	32.0	3, 0	1993
2	UK	1738	5183	6590	27.2	3, 8	1994
3	Australia	1259	3367	3782	12.3	3, 0	1995
4	Germany	1191	4165	3485	-16.3	2, 9	1995
5	Italy	734	2724	874	-67.9	1, 2	1997
6	France	701	2115	2209	4.4	3, 2	1995
7	New Zealand	549	1312	1994	52.0	3, 6	1993
8	Japan	539	1082	1028	-5.0	1, 9	1993
9	Russia	366	642	824	28.4	2, 3	1993
10	Spain	286	1029	313	-69.6	1, 1	1999
11	South Africa	256	778	603	-22.5	2, 4	1993
12	Argentina	224	787	548	-30.4	2, 5	1997
13	Netherlands	206	1199	556	-53.6	2, 7	1998
14	Canada	174	654	775	18.5	4, 5	1995
15	Belgium	157	561	512	-8.7	3, 3	1997
16	Sweden	151	704	463	-34.2	3, 1	1997
17	India	133	233	89	-61.8	0, 7	1995
18	Norway	131	510	703	37.8	5, 4	1994
19	Poland	117	309	270	-12.6	2, 3	1992
20	P. R. China	113	330	86	-73.9	0, 8	1997
21	Denmark	91	324	485	49.7	5, 3	1996
22	Switzerland	89	347	269	-22.5	3, 0	1996
23	Chile	84	262	217	-17.2	2, 6	1995
24	Austria	73	204	294	44.1	4, 0	1997
25	Brazil	64	209	76	-63.6	1, 2	1997
26	Finland	50	218	56	-74.3	1, 1	1999
27	South Korea	48	329	112	-65.96	2, 33	2000
28	Hungary	17	14	5	-64.29	0, 29	1998
29	Czech Republic	16	61	24	-60.66	1, 50	1999
30	Ireland	16	55	23	-58.18	1, 44	1994
31	Israel	16	42	87	107.14	5, 44	1996
32	Taiwan	11	25	10	-60.00	0, 91	1995
33	Ukraine	11	45	19	-57.78	1, 73	1994
34	Bulgaria	10	6	4	-33.33	0, 40	1995
35	Greece	10	18	13	-27.78	1, 30	1999

Note: Citations among the papers. Country self-citations excluded.

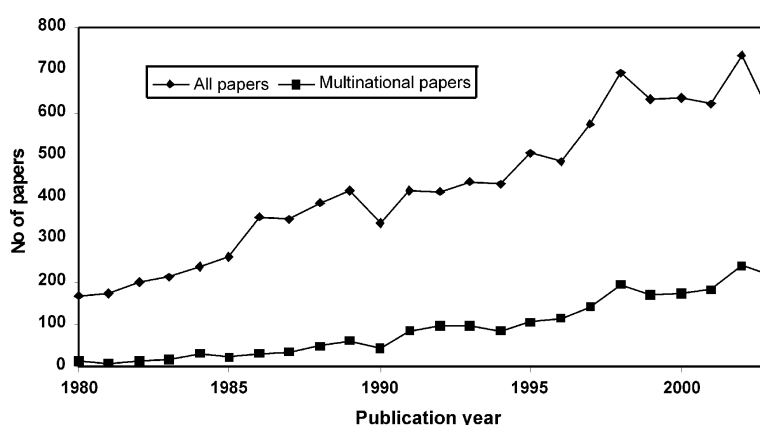


Figure 2. Rising trend of Antarctic research publications and multinational papers.

the countries shows a distinct core periphery structure (Figure 3). The higher centrality values of USA (2.20), UK (1.68), Germany (1.67), France (1.40), Australia

(1.28) and Italy (1.0) indicate their interest and commitment in undertaking collaborative projects in the spirit of ATS. Individually also, they are the most productive

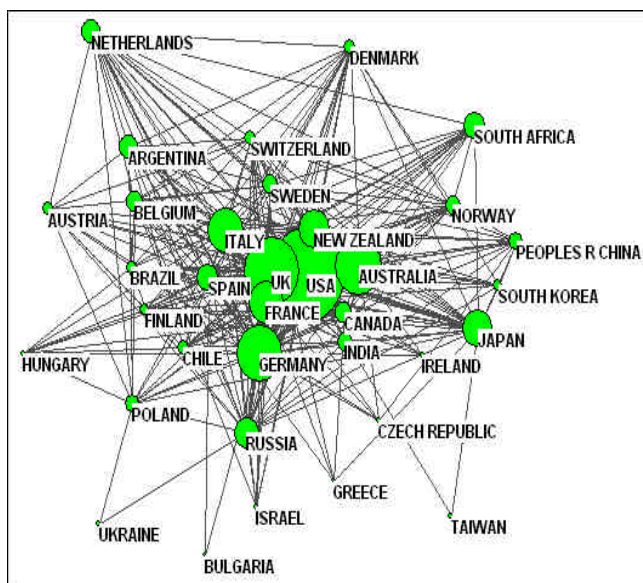


Figure 3. Collaboration map of 35 most productive countries involved in Antarctic research.

countries, occupying a central position in Antarctic science. Top 20 countries except Canada are consultative parties. Non-consultative parties like Canada, Denmark, Switzerland, Austria, Hungary and the Czech Republic showed their substantial interest in Antarctic science as evident through their productivity. Although countries like Ireland, Israel, Taiwan, etc., have not ratified ATS, they have continuously exercised their interest in Antarctic science and producing noticeable outputs. On the other

hand, consultative parties like Ecuador, Peru and Uruguay did not show much evidence of scientific activity.

Citation behaviour of the countries

To map the preferences of the countries in citing other countries, a country-to-country citation matrix was created; from that matrix the sum of citations given and received was calculated (Table 1). Interestingly enough, we see that there is no clear cut Matthew effect⁴ at work here, since small producers like Norway and Denmark appear among the winners in this citing game by receiving more citations than they give. However, time is at work here, and the winners appear to have been longer in the game.

Conclusion

The present analysis throws light on the research structure of Antarctic science that is being practised by the nations under the ATS. Bibliometric analysis of Antarctic science on a regular basis will help visualize the functioning of the ATS, where science is occupying a central place.

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