Research note

National and institutional productivity and collaboration in Antarctic science: an analysis of 25 years of journal publications (1980–2004)

Prabir G. Dastidar

Ministry of Earth Sciences, Block No. 9 & 12, CGO Complex, Lodi Road, New Delhi 110003, India

Keywords
Antarctic science; journal articles; knowledge mapping; network analysis; Science Citation Index; scientometrics.

Correspondence
Prabir G. Dastidar, Ministry of Earth Sciences, Block No. 9 & 12, CGO Complex, Lodi Road, New Delhi 110003, India.
E-mail: prabirgd11@rediffmail.com

doi:10.1111/j.1751-8369.2007.00017.x

Abstract

Journal publications on Antarctic science were analysed for a period of 25 years (1980–2004) through a set of scientometrics and network analysis techniques. The study is based on 10 942 records (research articles, review articles, letters, etc.) with the word fragment "antarc*" in the title published in 961 international, peer-reviewed journals and retrieved from Thomson Scientific's Science Citation Index database. During the period under investigation, productivity increased threefold and there was a 13-fold increase in journal publications co-written by authors from different countries. The five nations with the highest output were the USA (with 26.7% of the total output), the UK (13.8%), Australia (9.7%), Germany (8.8%) and Italy (6.0%). The top five institutions in terms of journal publications were the British Antarctic Survey (972 publications), the Alfred Wegener Institute of Polar and Marine Research, Germany (475), the Australian Antarctic Division (312), the University of Tasmania, Australia (305), and the National Aeronautics and Space Administration, USA (293).

Antarctica is the fifth largest continent. This coldest, windiest and highest continent is covered with an ice sheet more than 2-km thick, on average. Having remained comparatively undisturbed and unpolluted for millions of years, the Antarctic environment is a treasure trove of information about the Earth's past. The Indian, Atlantic and Pacific oceans meet around Antarctica, and the mixing process of cold and warm waters contribute to a special regime with unique physical, chemical and biological characteristics. These waters constitute one of the world's richest biological provinces. For all these reasons, Antarctica provides unique opportunities for scientific research in diverse fields. The Antarctic Treaty System—one of the world's most successful international agreements—ensures that Antarctica remains a natural reserve for science. There are 26 countries with seasonal or year-round stations in Antarctica (Table 1).

This paper analyses a data set of journal publications for the period 1980–2004. An attempt has been made to identify the major players in Antarctic science by identifying the nations and institutions that produced the greatest number of journal publications about Antarctica. As conducting scientific research is central to the Antarctic Treaty System, an analysis of scientific output—measured here in terms of journal publications—in part reflects the functioning of this set of international agreements. Similar analyses have been previously undertaken for journal publications in ocean science and technology (Dastidar 2004; Dastidar & Ramachandran 2005), along with an earlier effort for Antarctic science (Dastidar & Persson 2005).

Materials and methods

The data for this study were drawn from Thomson Scientific's Science Citation Index, a database available on a series of annual CD-ROMs. The Science Citation Index covers about 3700 of the world's interntional, peer-reviewed scientific and technical journals, and includes publication details for research articles, review articles, news items, book reviews, letters, communications, editorial material and so forth (see http://scientific.thomson.

Table 1 Number of stations in Antarctica and manpower deployment contributed by the 28 consultative parties to the Antarctic Treaty System (www.comnap.aq/facilities).

Country	No. of stations (year when first station was established)	Manpower (annual peak)
Argentina	6 (1904)	417
Australia	3 (1954)	213
Belgium	—	—
Brazil	1 (1984)	40
Bulgaria	1(1988)	15
Chile	5 (1948)	224
Ecuador	2 (1990)	88
Finland	1(1989)	20
France	4 (1956) (one jointly with Italy)	145
Germany	2 (1981)	78
India	1 (1989)	65
Italy	5 (1986) (one jointly with France)	135
Japan	2 (1957)	150
the Netherlands	0	—
New Zealand	1 (1957)	85
Norway	2 (1985)	44
China	2 (1985)	70
Peru	1 (1989)	28
Poland	1 (1977)	40
Russia	7 (1956)	429
South Africa	1 (1962)	80
South Korea	1 (1988)	60
Spain	2 (1989)	28
Sweden	1 (1989)	20
UK	5 (1947)	205
Ukraine	1 (1996)	24
Uruguay	1 (1984)	60
USA	3 (1955)	1250

—, Data not available.

com/products/sci/ and http://thomsonscientific.com/free/essays/selectionofmaterial/journalselection/). The database on the CD-ROM for each year from 1980 to 2004 was searched for publications with "antarc*" in the title. This yielded 10 942 records, which formed the basis of the present analysis.

To assess publication output for individual countries, each publication was given a value of 1. In the case of a multinational publication—a publication co-written by authors with addresses in two or more different countries—each contributing country was given a fraction value where the sum of fractions equalled 1. For example, in the case of a publication written by one author with a US address and one with an address in the UK, the USA and the UK would each receive a value of 0.5. These fractional values were summed to asssess the productivity of individual countries. It should be emphasized that this method of calculation makes no attempt to assess the *actual* relative contributions of the co-authors (neither, by extension, the nations they represent) by, for example, weighted scores. Rather, each co-author of an article was assigned an equal fraction. It is a widespread practice to place the co-author who has contributed disproportionately to the the work of preparing a scientific article first on the author byline (Yank & Rennie 1999). However, other conventions may be applied and these vary across the international scientific community. Among teams of scientists who frequently publish together, the co-authors may take turns being named as lead authors (O'Connor & Woodford 1978). In some scientific circles it may be customary to name heads of departments, laboratories or research groups as first authors (O'Connor & Woodford 1978). Some journals have clear policies about how to determine the order of authors; most do not and there is apparently no clear consensus about the meaning of the order of authors among journal editors (Yank & Rennie 1999).

For the purposes of the analysis, publications authored by writers in the Federal Republic of Germany and the German Democratic Republic were merged under "Germany", whereas publications from writers with addresses in the USSR and Russia were combined under "Russia".

The country and names of institutions associated with the publications were isolated separately and rank ordered (Persson 2004). The most productive units were chosen to form co-occurrence matrices to which a multidimensional scaling algorithm (a SYSTAT subroutine) was applied to produce the network maps. The relative size of the circles in these diagrams indicates the relative productivity of each entity, and the lines between the circles indicate the presence of collaboration links, whereas the line thickness indicates the strength of the interconnections (Dastidar 2004; Dastidar & Persson 2005; Dastidar & Ramachandran 2005).

An important limitation of this study is that the data were limited to the journals in Thomson Scientific's Science Citation Index. Alhough non-English publications are included in the database, Thomson Scientific's selection criteria make it easier for English-language publications to be included for coverage (see http://thomsonscientific.com/free/essays/selectionofmaterial/journalselection/). In addition, journal publications that concerned Antarctica but which did not have "antarc*" in their titles were not included in this study.

Results

During the study period the output of journal publications with "antarc*" in the title increased threefold, rising from 165 in 1980 to 552 in 2004 (Fig. 1). Output peaked in 2002, with 729 publications.

Over 80 nations were represented among the authorship of the publications being analysed (Table 2). The output is highly skewed, with two countries—USA and

Table 2 Country-by-country output of journal publications with "antarc*" in the title, based on the annual CD-ROMs of the Science Citation Index, 1980–2004 (N + 10 942). Each publication was given a value of 1. In the case of a multinational article, each contributing country was given a fractional value where the sum of fractions equalled 1. These fractional values were summed to asssess the productivity of individual countries. Consultative parties to the Antarctic Treaty System are indicated. (Ecuador, also a consultative party to the treaty, is not included in the table because of its very low journal publication output.) Data on per capita gross domestic expenditures on research and development are from the UNESCO Institute for Statistics (http://www.uis.unesco.org/ev.php?ID=5182=201&ID2=DO_TOPIC).

	Country	Output	% of world total	Per capita gross domestic expenditure on research and development, in purchasing power parity USD (year of data in parentheses)		Country	Output	% of world total	Per capita gross domestic expenditure on research and development, in purchasing power parity USD (year of data in parentheses)
1	USA[a]	2886.90	26.7	954 (2002)	42	Pakistan	2.5	0.0	5.2 (2002)
2	UK[a]	1491.83	13.8	490.6 (2002)	43	Estonia	2.25	0.0	98.9 (2002)
3	Australia[a]	1051.85	9.7	404.5 (2000)	44	Philippines	2	0.0	
4	Germany[a]	948.87	8.8	686 (2002)	45	Romania	2	0.0	24.9 (2002)
5	Italy[a]	653.21	6.0	288.7 (2001)	46	Singapore	2	0.0	525.7 (2002)
6	France[a]	526.08	4.9	611.2 (2002)	47	Antarctica	1.83	0.0	—
7	Japan[a]	492.22	4.5	836.6 (2002)	48	Monaco	1.83	0.0	—
8	New Zealand[a]	430.22	4.0	246.1 (2001)	49	Reunion	1.5	0.0	—
9	Russia[a]	305.86	2.8	102.2 (2002)	50	Ciskei	1	0.0	—
10	Spain[a]	241.37	2.2	222.4 (2002)	51	Colombia	1	0.0	10.5 (2001)
11	South Africa[a]	232.99	2.2	68.7 (2002)	52	Indonesia	1	0.0	—
12	Argentina[a]	188.37	1.7	44 (2002)	53	Ivory Coast	1	0.0	—
13	the Netherlands[a]	152.82	1.4	536.6 (2001)	54	Kenya	1	0.0	—
14	India[a]	126.29	1.2	20.5 (2000)	55	Papua New Guinea	1	0.0	—
15	Belgium[a]	117.06	1.1	614.7 (2002)	56	Peru[a]	1	0.0	5.2 (2002)
16	Canada	109.65	1.0	588.4 (2002)	57	Portugal	1	0.0	170.2 (2002)
17	Sweden[a]	107.30	1.0	1082.5 (2001)	58	Saudi Arabia	1	0.0	—
18	Poland[a]	107	1.0	62.7 (2002)	59	Vanuatu	1	0.0	—
19	China[a]	90.74	0.8	—	60	Zimbabwe	1	0.0	—
20	Norway[a]	88.73	0.8	612.2 (2002)	61	Bolivia	0.5	0.0	6.9 (2002)
21	Chile[a]	63.16	0.6	51.9 (2001)	62	Belarus	0.5	0.0	35.1 (2002)
22	Brazil[a]	58.49	0.5	76.9 (2000)	63	Comoros	0.5	0.0	—
23	Switzerland	50.78	0.5	740.4 (2000)	64	Costa Rica	0.5	0.0	34.5 (2000)
24	Denmark	45.97	0.4	777.6 (2002)	65	Latvia	0.5	0.0	42.8 (2002)
25	South Korea[a]	44.53	0.4	492.3 (2002)	66	Luxembourg	0.5	0.0	961.1 (2000)
26	Austria	37.84	0.3	645.2 (2002)	67	Morocco	0.5	0.0	—
27	Finland[a]	35.99	0.3	905.2 (2002)	68	Namibia	0.5	0.0	—
28	Czech Republic	13.99	0.1	—	69	New Caledonia	0.5	0.0	—
29	Bulgaria[a]	10.5	0.1	34.9 (2002)	70	Niger	0.5	0.0	—
30	Hungary	9.16	0.1	135.3 (2002)	71	Nigeria	0.5	0.0	—
31	Greece	9.08	0.1	115.8 (2001)	72	Qatar	0.5	0.0	—
32	Ukraine[a]	9	0.1	57.6 (2002)	73	Slovenia	0.5	0.0	286.2 (2002)
33	Ireland	8.91	0.1	369.2 (2001)	74	Sri Lanka	0.5	0.0	5.1 (1996)
34	Taiwan	8.5	0.1	—	75	Uruguay[a]	0.5	0.0	20.6 (2002)
35	Israel	7.91	0.1	997.2 (2002)	76	Venda	0.5	0.0	—
36	Mexico	6.16	0.1	38.3 (2002)	77	Vietnam	0.5	0.0	—
37	Turkey	4.5	0.0	42.6 (2002)	78	Yugoslavia	0.5	0.0	—
38	Bermuda	4.33	0.0	27.4 (1997)	79	Fiji	0.33	0.0	—
39	Iceland	3.90	0.0	925.7 (2002)	80	French Polynesia	0.33	0.0	—
40	Jamaica	3.33	0.0	3.0 (2002)	81	French Guiana	0.33	0.0	—
41	UKSSR	3	—	—	82	Venezuela	0.2	0.0	20.7 (2002)

[a] Consultative parties. —, Data not available.

UK—each contributing shares larger than 10%, 16 countries each contributing shares between 1 and 10%, and all the remaining countries contributing shares of less than 1% each. The share for the USA was 26.7%, almost double that of the UK, which was the next most productive country, with 13.8%. The five most productive countries (USA, UK, Australia, Germany and Italy) together contributed 65% of the total output.

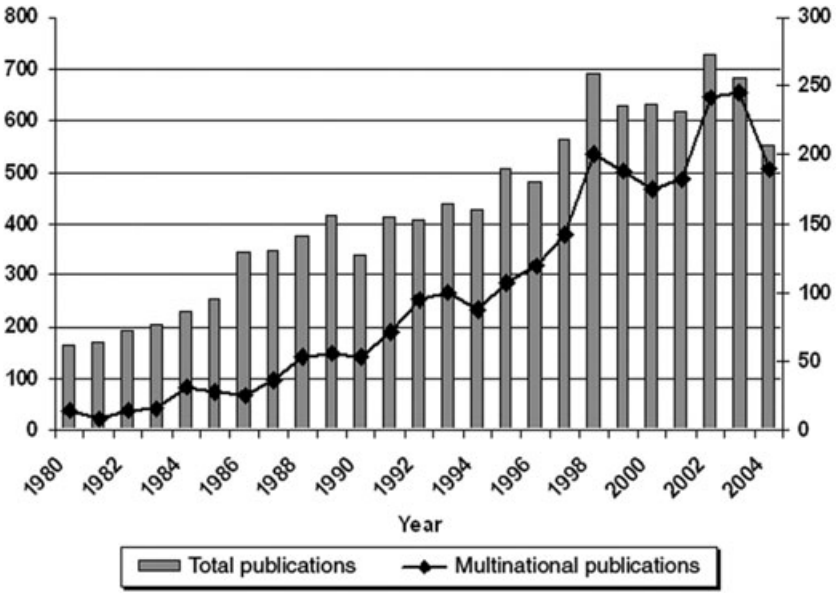

Fig. 1 Overall number of journal publications with "antarc*" in the title, and the number of these publications co-authored by writers from different countries, based on the annual CD-ROMs of the Science Citation Index, 1980–2004. The scale on the left-hand side of the figure indicates the overall number of publications and the scale on the right-hand side indicates the number of multinational publications.

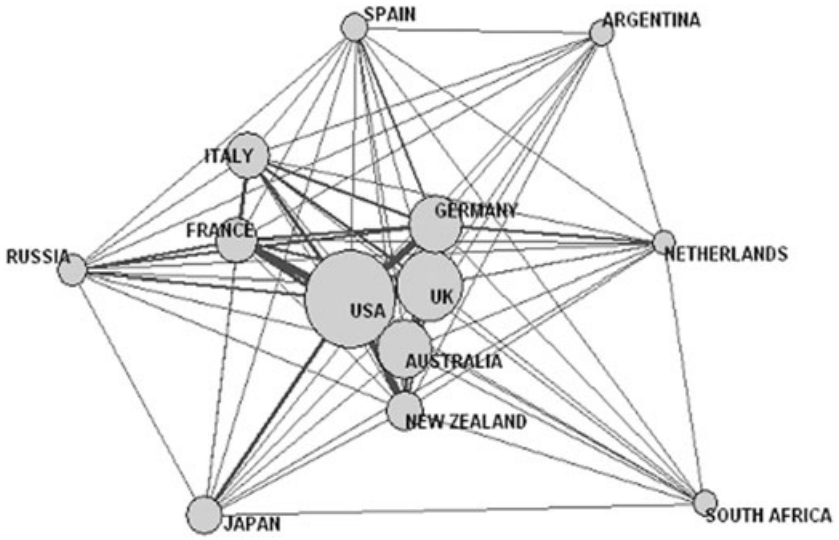

Fig. 2 Collaboration network of the top 13 countries in terms of the output of multinational journal publications with "antarc*" in the title, based on the annual CD-ROMs of the Science Citation Index, 1980–2004 ($N = 82$). Line thickness and proximity of the circles indicates collaboration intensity between the countries.

As shown in Fig. 1, the number and proportion of publications co-written by contributors from different countries increased over the period being examined. There were 15 multinational publications in 1980, which represented 9.09% of the total for that year. By 2004 there were 190 multinational publications, which constituted 34.42% of the total for that year. Figure 2 gives an indication of the collaborative ties between countries, with the countries with writers who most frequently co-author publications lumped together in the middle of the diagram. American authors most frequently contribute to multinational journal publications, followed by the UK, Australia and Germany.

About 2837 organizations contributed to journal publications with "antarc*" in the title during the period studied. The 75 most productive institutions are presented in Table 3. The British Antarctic Survey topped the list, having contributed to 972 publications. In second place was the Alfred Wegener Institute for Polar and Marine Research, with 475 publications. The remaining institutions among the top five were the Australian Antarctic Division (312 publications), the University of Tasmania, Australia (305 publications), and the National Aeronautics and Space Administration, USA (294 publications). The country with the most institutions appearing in the top 75 was the USA, with 26 institutions. Australia had

Table 3 Rank list of the 74 most productive institutes in terms of journal publications with "antarc*" in the title, based on the annual CD-ROMs of the Science Citation Index, 1980–2004.

Ranking	Institution	No. articles	Ranking	Institution	No. articles
1	British Antarctic Survey, UK	972	39	University of Cape Town, South Africa	75
2	Alfred Wegener Inst. for Polar & Marine Res., Germany	475	40	Texas A&M University, USA	72
3	Australian Antarctic Div., Australia	312	41	University of Cambridge, UK	72
4	University of Tasmania, Australia	305	42	University of California, Santa Barbara, USA	71
5	NASA, USA	293	43	University of Illinois, USA	71
6	Ohio State University, USA	244	44	University of California, Santa Cruz, USA	71
7	University of California, San Diego, USA	220	45	Lab Glaciol & Geophys Environm, France	70
8	NERC, UK	216	46	University of Texas, USA	69
9	CNR, Italy	214	47	Arctic & Antarctic Research Institute, Russia	69
10	CNRS, France	205	48	Macquarie University, Australia	68
11	National Institute of Polar Research, Japan	196	49	Woods Hole Oceanographic Institution, USA	67
12	University of Colorado, USA	163	50	University of Paris, France	67
13	CSIRO, Australia	146	51	Polish Academy of Sciences, Poland	66
14	Russian Academy of Sciences, Russia	148	52	University of Siena, Italy	65
15	NOAA, USA	137	53	University of Alaska, USA	64
16	CALTECH, USA	135	54	University of Bremen, Germany	62
17	University of Washington, USA	127	55	Nat Inst Water and Atmospher Res, New Zealand	60
18	CSIC, Spain	124	56	University of Wyoming, USA	60
19	University of Melbourne, Australia	123	57	University of Copenhagen, Denmark	60
20	Columbia University, USA	103	58	University of Pretoria, South Africa	60
21	University of Wisconsin, USA	102	59	Consejo Nacl Invest Cient & Tecn, Argentina	60
22	University of Maine, USA	101	60	University of Hawaii, USA	59
23	University of Genoa, Italy	100	61	Chinese Academy of Sciences, China	58
24	Antarctic CRC, Australia	98	62	Oregon State University, USA	58
25	Argentinean Antarctic Institute, Argentina	95	63	Monash University, Australia	56
26	University of Tokyo, Japan	94	64	University of California, USA (no specific campus stated)	54
27	University of Canterbury, New Zealand	94			
28	US Geological Survey, USA	92	65	University of Bern, Switzerland	54
29	University of Kiel, Germany	89	66	University of California, Los Angeles, USA	53
30	University of Alabama, USA	88	67	University of Waikato, New Zealand	53
31	University of Otago, New Zealand	88	68	Department of Science, Australia	52
32	University of Buenos Aires, Argentina	85	69	University of Liege, Belgium	52
33	Australian National University, Australia	84	70	Montana State University, USA	52
34	Christian Albrechts University of Kiel, Germany	83	71	Victoria University of Wellington, New Zealand	52
35	DSIR, New Zealand	82	72	University of New South Wales, Australia	49
36	Hokkaido University, Japan	82	73	National Center for Atmospheric Research, USA	48
37	University of Auckland, New Zealand	81	74	University of Bristol, UK	47
38	University of Utrecht, the Netherlands	76			

10 institutions among the top 74, New Zealand had seven, and Argentina and Germany each had four.

Data for the ten most productive organizations were used to produce the network map presented in Fig. 3. The diagram indicates frequent co-authorship between the British Antarctic Survey and the Alfred Wegener Institute for Polar and Marine Research.

Discussion

Scientific journal publications about Antarctica in the period 1980–2004 were dominated by the nations with a strong interest in the continent. Nineteen of the 20 countries producing the most publications are consultative parties to the Antarctic Treaty, and the top 20 countries included all 11 original signatories of the treaty (Table 2). Setting aside Canada and the 11 original signatory nations, the remaining eight countries in the top 20 gained consultative status by having conducted substantial research activity there, as provided by Article 9 of the treaty (http://www.ats.aq/).

Productivity in science is investment dependent, as is shown by the strength of the contribution to journal publications about Antarctica in 1980–2004 by the USA.

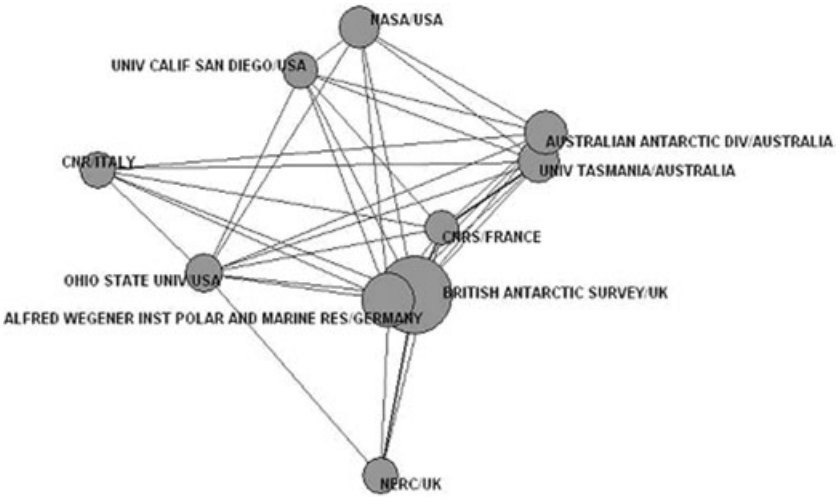

Fig. 3 Collaboration network among the ten most productive organizations in terms of the output of multinational journal publications with "antarc*" in the title, based on the annual CD-ROMs of the Science Citation Index, 1980–2004 ($N = 2726$). Line thickness and proximity of the circles indicates collaboration intensity between the institutions.

The USA alone contributed more than one quarter of all publications during the period, and, of the most productive individual organizations, one of three institutions in the list was American. The USA deploys the greatest manpower to the continent and maintains the largest research complex there. The USA has one of the highest per capita gross domestic expenditures on research and development, which is almost double that of the UK (Table 2). As was also seen in the case of journal publications in ocean science and engineering (Dastidar 2004), the most productive countries have higher per capita gross domestic expenditures on research and development.

International collaboration is an important element in the Antarctic Treaty, which was originally signed in 1959 (http://www.ats.aq/uploaded/treaty_original.pdf). To promote international cooperation, Article 3 of the treaty calls for the exchange of personnel and scientific results between the parties to the treaty. The 16th Antarctic Treaty Consultative Meeting declared 1991–2000 the Decade of International Antarctic Scientific Cooperation (Cohen 2002). This study has shown a marked increase in one indicator of international scientific cooperation in Antarctica: publications authored by writers from different countries.

An important subject beyond the scope of this brief paper is the research topics of the journal publications relating to Antarctica during the period in question. It would be extremely interesting to identify Antarctic research trends in this way, and it is hoped that this will be the subject of further analysis.

Acknowledgements

The author expresses his gratitude to Prof. Olle Persson, Dept of Sociology, Umeå University, Sweden, for his guidance and constructive suggestions. The author is thankful to Dr José Retamales, director of the Chilean Antarctic Institute and chairman of the Council of Managers of National Antarctic Programs, for his suggestions and for showing keen interest in the work. The author is also thankful to Dr B.S. Aggarwal for editing an earlier version of the manuscript.

References

Cohen H.K. (ed.) 2002. *Handbook of the Antarctic Treaty System*. 9th edn. Washington DC: US Department of State.

Dastidar P.G. 2004. Ocean science & technology research across the countries: a global scenario. *Scientometrics 59*, 15–27.

Dastidar P.G. & Persson O. 2005. Mapping the global structure of Antarctic research vis-à-vis Antarctic Treaty System. *Current Science 89*, 11552–11554.

Dastidar P.G. & Ramachandran S. 2005. Engineering research in ocean sector: an international profile. *Scientometrics 65*, 199–213.

O'Connor M. & Woodford F. P. 1978. *Writing scientific papers in English*. London: Pitman Medical.

Persson O. 2004. Bibexcel. Downloaded from the internet at http://www.umu.se/inforsk/Bibexcel on 27 February 2007.

Yank V. & Rennie D. 1999. Disclosure of researcher contributions: a study of original research articles in *The Lancet*. *Annals of Internal Medicine 130*, 661–670.