A Bibliometric Analysis of Astronomical Sciences Publications

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May 2005

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Acknowledgements

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1 Introduction

1.1 Background

In 1995 the Research Evaluation and Policy Project (REPP) was commissioned to undertake a bibliometric analysis for *Australian Astronomy: Beyond 2000* which covered the period 1981-1993. In late 2004, REPP was contracted to update that report for the Australian Academy of Science's Decadal Plan for Australian Astronomy, extending the previous analysis and covering in detail the period 1994 to 2003. The analysis is based on the REPP database which contains all Australian publications indexed in the Institute for Scientific Information's (ISI) three main indices: the Science Citation Index, the Social Sciences Citation Index, and the Arts and Humanities Citation Index.

1.2 Analyses undertaken

The report provides an analysis of Australia's total publication output in journals indexed by ISI and classified to their Astronomy and Astrophysics journal set. The journals in this set are listed in Appendix 1. The analysis seeks to determine:

- Australia's share of world publications and citations, using five year overlapping windows;
- Australia's citation rate, using five year overlapping windows, compared to the world citation rate;
- the journal placement of Australia's astronomy publications;
- the distribution of astronomy journals to impact quartiles based on their average citation rate and the changes in Australia's presence in these quartiles over time; and
- trends in collaborative activity

In addition, an institutional analysis of astronomy publications is presented. This analysis seeks to determine:

- the major institutions contributing to Australia's journal output;
- where Australia's most highly cited publications come from (i.e. the top 1% and 5% most highly cited Australian publications); and
- how the actual citation rates of institutions compare to the rate that would be expected given the journals in which they publish.

It is only possible to confidently undertake a comparative analysis for those institutions with a minimum of 100 publications – citation analysis based on publication numbers less than this threshold are statistically unreliable because of the skewed nature of the distribution of citations (very few publications are highly cited, and it is these that drive averages). The institutions with more than 100 publications in astronomical sciences in the last 5 years were:

The Australian National University
Anglo-Australian Observatory
Australia Telescope National Facility
University of Melbourne
University of New South Wales
University of Sydney
University of Tasmania

Four additional institutions that had less than 100 publications, but more than 75, were included in the analysis, but extreme caution needs to be exercised in the interpretation of the data. These are:

Australian Defence Force Academy (ADFA)
Monash University
Swinburne University
University of Adelaide

It should be noted that the data for ADFA is also included in the total for the University of New South Wales.

After a draft analysis was completed and discussed with the project's reference group, an additional time series analysis was undertaken using a reduced journal set. Ten geophysics journals were deleted from the analysis. These journals are marked with an asterisk in Appendix 1. A detailed investigation of the influence of highly cited publications was also undertaken to determine their impact of average citation rates. These two additional analyses are reproduced in Appendix 2.

2 Methodology

2.1 Coverage of ISI database

The use of bibliometric analysis as a tool for evaluating research performance cannot be universally applied across all fields of research (Bourke, Butler and Biglia 1996; NBEET 1994). ISI does not comprehensively cover the output of Australian research in a number of fields, such as most humanities and social science disciplines, or engineering and other applied sciences. However, ISI's coverage of the journals in which Australian researchers in astronomical sciences publish is very comprehensive, and data REPP has analysed in a number of previous studies suggests it covers approximately 95% of total output (Butler and Visser 2005).

2.2 Using bibliometrics

Bibliometric data answer no single evaluative question in their own right. This information must be seen alongside other measures of esteem, performance, visibility and the testimony of expert peers in the activity that is being analysed.

2.3 Small Numbers

A special note of caution is required concerning the small numbers of publications tabulated in some research fields or subject categories. In the ISI system as a whole, many publications receive no citations at all, and the majority receive less than 5 citations (Garfield 1989). The number achieving a high citation count is extremely small. The very nature of citation practice means that averages can be disproportionately affected by a single highly cited publication. The smaller the number of publications being analysed, the greater the effect such an item will have on the average.

Analyses based on any units with less than 100 publications are unreliable. For the bibliometric measures used in this analysis, some citation information based on units with less than 100 publications have been included for comparative purposes (ie. ADFA, Monash University, Swinburne University and University of Adelaide) but are highlighted in the analyses and must be interpreted with extra caution.

2.4 The Research Evaluation and Policy Project Database

The REPP database was created from data files purchased from the Institute for Scientific Information (ISI) and, at the time this study was commissioned, covered the period 1981 to 2003. It captures all publications with an Australian address in the three major ISI Indices: Science Citation Index (SCI), Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI). The database also contains the yearly counts of citations to each of the Australian publications.

The focus of the database is the departmental and the institutional address(es) given for each publication rather than the names of authors. REPP 'cleans' the addresses in the database to enable analysis to be done at different levels of aggregation. 'Cleaning' means ensuring that all variations of the same address are identified and that all publications with variants of that address are allocated to the one 'standardised address'. The standardised addresses for all Australian universities and other major research institutions are set up in a hierarchical format, from the institution down through faculties or schools to the department, enabling tabulations at these different levels of aggregation to be produced. Addresses in most other sectors are 'cleaned' only to the institution level. The REPP database as it now stands contains close to 350,000 Australian publications.

Since there is no consensus in the research policy community about the 'best' way to count publications and citations, we list a series of options available in the REPP database and used in the tables compiled for this report:

- the types of publications counted were limited to research articles, research notes and review articles;
- data were compiled on a tape-year basis (i.e. the year its details were entered in ISI's database not the year the item was published);
- the institutional analysis was based on data from the 2002 version of the REPP database, as unified addresses were not available for the 2003 version. The analysis therefore focused on 1998-2002, the most recent five year period available; and
- the analysis was based on whole publication counts (i.e. where more than one institution collaborated in a publication, each was given a count of 1 for that publication).

2.5 Subject classification

In this report, publications are classified to 'Astronomical Sciences' on the basis of the journal in which they appear, using the journals listed in ISI's subject category 'Astronomy and Astrophysics'. A list of journals classified to this category between 1981 and 2003 is given in Appendix 1.

2.6 Performance measures

This section gives a general description of the standard bibliometric measures used in the study. Notes relevant to particular points of discussion are included throughout the report as required.

2.6.1 Shares of world publication and citation totals

Australia's share of all publications indexed by ISI in the astronomy journal set is calculated. The citations these publications have received are also tabulated and the share these represent of the world total is calculated.

Tabulations were made using five-year windows, 1981–85 to 1999-03. For each window, the share is calculated on the basis of publications from the specified five-year period and the citations those publications received within the same five-year period. ISI publication and citation totals have been calculated on the same basis. In addition to providing a common basis across time, the use of windows tends to eliminate the sharpest yearly swings in citation per publication rates.

2.6.2 Relative Citation Impact

The relative citation impact (RCI) compares Australia's share of publications with the share of citations these publications achieve. If the field has equivalent shares of publications and citations, it will have an RCI of 1.00. If it achieves a greater share of citations than publications, its RCI would be greater than 1.00. Conversely, if its share of citations falls below its share of publications, then its RCI would be less than 1.00.

2.6.3 Collaborative Activity

The REPP database enables us to distinguish between publications with different types of authorship, *viz*:

Single author	one author only (ie no collaboration)
Group	more than one author from the same organisational unit
Intra-institutional	more than one author from different organisational units
National	more than one author from different institutions in Australia
International	more than one country listed in the author addresses

The classification is not hierarchical and all collaborations present in a publication will be ascribed to it. For instance, if a publication involves collaboration between a number of Australian institutions as well as an overseas institution, it will be classified as both *International* and *National*.

As this measure relies on 'cleaned' addresses to calculate the level(s) of collaboration involved in a publication, our analysis cannot go past 2002, the last year for which this data is available.

2.6.4 Actual and expected citation rates

In this measure, the term *Actual Citation Rate* refers to the average number of citations actually achieved by the publications of the unit under study. The term *Expected Citation Rate* refers to the average number of citations achieved by all publications in the journals carrying the articles of the unit under study. ISI has supplied REPP with average citation rates for all publications in its journals for each year of publication and for each type of publication. The calculations are weighted by the year of publication and the frequency of publication in particular journals. The expected citation rate is a different calculation to ISI's journal impact factor[1], though the measures are related.

[1] The calculation for ISI's 1996 impact factor is a/b, where:

This analysis is depicted graphically, allowing a comparison to be made between actual and expected citation rates. The diagonal on the graph indicates the point at which actual and expected citation rates converge so that, where the unit under study appears above this diagonal line, it is achieving a rate of citation higher than the 'world' average for the journals in which it publishes; and where it appears below the line, it is achieving a rate of citation lower than the 'world' average for its publications in those journals. Where a vertical line is drawn on a graph, it indicates the citation per publication figure for all publications in all journals in the field under study, that is, the ISI average.

In these graphs, the relationship to the diagonal and vertical lines is the salient point to observe. A point above the line and to the right of the ISI average indicates above world performance in high impact journals; a point below the line and to the left indicates below world performance in low impact journals. Between these extremes, there are many possibilities, such as appearing in high impact journals below the world expected rate or appearing in low impact journals but performing at a higher rate of citation than the expected world rate. Judgments about these relationships should be made carefully.

2.6.5 Most highly cited publications

The number of citations required to rank a publication from 1998 to 2002 in the top 1% and 5% of 'Astronomical Sciences' publications in Australia was calculated. By extracting details about the publications that fell within these bands from the REPP database, it was possible to identify the institutions with which the authors of these articles were associated.

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a = 1996 citations to articles published in the journal in 1994 and 1995
b = number of articles published in the journal in 1994 and 1995;

The calculation for 1996 expected values used in this report is x/y, where:
x = number of citations received between 1996 and 2000 to all articles published in the journal in 1996
y = number of articles published in the journal in 1996.

3 Profile of Astronomical Sciences

3.1 Publication and citations trends

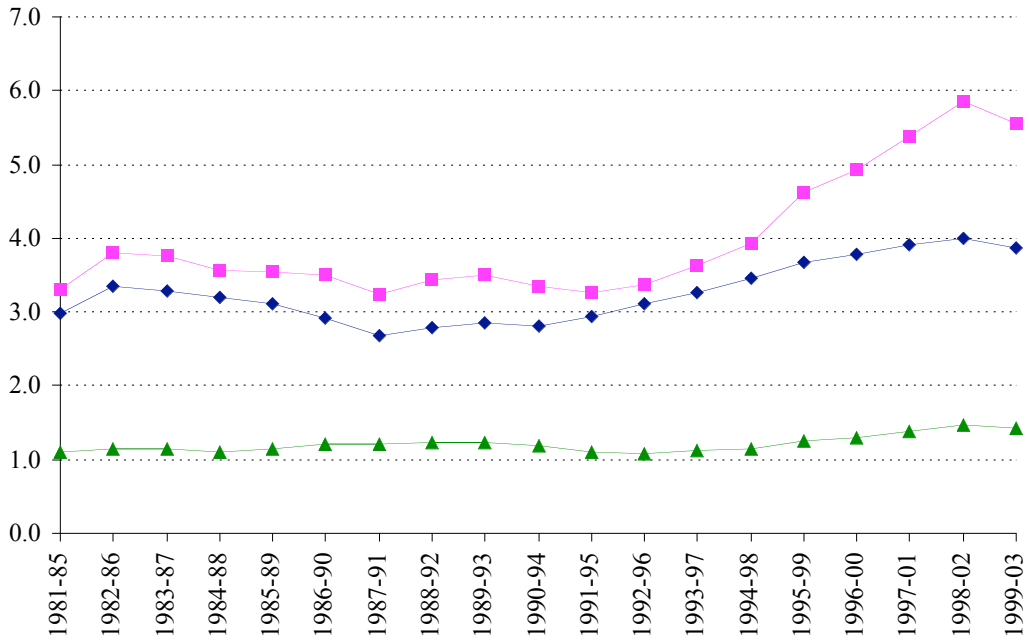

Figure 1: Australia's share of world publications and citations: Astronomical Sciences 1981-85 to 1999-2003

(■ citations, ◆ publications, ▲ relative citation impact)

There has been a marked change in Australia's publication output and citation impact since the last review was undertaken. In line with most other fields (see Butler 2001), output has increased since the early 1990s. This coincided with the introduction of the publication element of the Research Quantum that applies to all universities, whereby a proportion of block-funding for research is distributed on the basis of raw publication counts.

In contrast to most other fields, Australia's share of citations to astronomy publications has increased at an even greater rate than its share of the publications themselves. As a consequence, the relative citation impact for astronomy has climbed well above one.

3.2 Placement of Australian astronomy publications

Table 1: Australian Percentage of Publications in Astronomical Sciences Journals 1994-2003

	Journal	% Total Publications that have an Australian author(s)										Total		
Journal	impact*	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Aust	World	%Aust
ANNU REV ASTRON ASTR	*37.31*	0.0	0.0	0.0	0.0	0.0	7.1		3.2	6.3	0.0	3	154	1.9
ANNU REV EARTH PL SC	*9.97*	0.0	0.0	0.0	0.0	11.1	7.1	10.0	0.0	6.3	6.3	7	155	4.5
ASTROPHYS J SUPPL S	*9.86*	4.0	3.0	7.4	5.0	2.2	6.7	3.6	3.9	8.9	2.9	63	1357	4.6
ASTROPHYS J	*9.43*	2.8	3.6	3.9	3.7	4.2	4.6	4.3	4.9	4.6	3.8	915	22378	4.1
ASTRON J	*7.80*	4.1	4.5	4.0	4.7	7.1	7.0	5.3	5.3	6.7	5.9	262	4779	5.5
J GEOPHYS RES-ATMOS	*6.82*	2.2	3.0	2.8	3.9	5.0	3.3	3.0	2.6	2.1	3.0	243	7586	3.2
MON NOT R ASTRON SOC	*6.61*	9.4	10.5	8.9	9.7	10.0	10.8	9.4	11.4	10.6	8.9	859	8580	10.0
J GEOPHYS RES-SOL EA	*5.56*	2.6	2.8	2.0	2.6	6.7	4.0	3.3	2.1	4.0	2.5	134	4315	3.1
ASTRON ASTROPHYS	*5.52*	1.3	0.9	1.6	1.8	2.4	1.6	2.2	2.6	2.1	2.0	279	14375	1.9
ICARUS	*5.29*	1.1	0.9	2.2	0.0	1.1	0.5	2.3	1.7	0.4	1.0	23	2101	1.1
J GEOPHYS RES-OCEANS	*5.14*	4.5	5.9	5.6	2.7	5.6	4.0	3.1	5.4	3.9	3.9	155	3396	4.6
PUBL ASTRON SOC JPN	*5.05*	0.0	0.0	1.0	1.2	0.0	2.2	0.8	4.4	1.7	2.3	16	1028	1.6
ASTROPART PHYS	*4.83*		0.0	0.0	0.0	0.0	0.0	0.0	11.5	4.7	3.6	14	658	2.1
ASTRON ASTROPHYS SUP	*4.54*	1.8	3.9	4.2	1.8	1.1	3.3	3.9	0.0			63	2291	2.7
J GEOPHYS RES-PLANET	*4.51*	1.4	0.9	1.6	1.7	4.2	0.0	0.7	0.0	0.0	0.4	12	1328	0.9
SOL PHYS	*4.29*	2.1	3.1	3.1	2.5	2.0	2.9	3.7	3.0	1.8	4.6	57	1975	2.9
PUBL ASTRON SOC PAC	*4.28*	3.0	2.0	4.4	2.0	3.2	5.2	4.5	2.3	5.3	2.6	51	1468	3.5
J GEOPHYS RES-SPACE	*4.28*	0.0	0.0	0.0	2.6	3.2	2.9	1.9	1.8	2.1	3.2	90	5147	1.7
NEW ASTRON	*4.08*				3.8	1.7	0.0	3.5	7.3	0.0	1.2	9	357	2.5
SPACE SCI REV	*3.24*	1.0	0.6	0.0	4.0	3.2	0.0	1.9	0.0	0.0	11.6	27	1230	2.2
ANN GEOPHYS-ATM HYDR	*2.53*	0.0	0.0	0.0	1.7	1.4	2.8	2.1	7.7			13	1015	1.3
GEOPHYS ASTRO FLUID	*2.10*	5.3	13.1	9.1	5.4	12.0	0.0	16.7	0.0	0.0	0.0	23	316	7.3
PLANET SPACE SCI	*2.06*	0.7	0.5	0.9	1.8	4.1	0.0	0.9	0.6	2.2	0.9	17	1435	1.2
REV MEX ASTRON ASTR	*1.81*	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	270	0.4
Q J ROY ASTRON SOC	*1.74*	5.0	0.0	0.0	0.0							1	71	1.4
PUBL ASTRON SOC AUST	*1.72*		92.3	76.2	77.8	53.6	67.4	73.7	74.4	51.3	44.6	305	467	65.3
INT J MOD PHYS D	*1.64*	0.0	0.0	2.9	0.0	1.4	1.8	1.6	0.0	0.8	0.7	6	740	0.8
Z NATURFORSCH A	*1.41*	1.7	2.2	0.5	0.0	0.6	0.9	0.6	2.8	0.6	0.0	16	1581	1.0
EARTH MOON PLANETS	*1.36*	0.0	0.0	3.7	6.7	0.0	0.0	0.0	1.4	0.0	1.3	12	721	1.7
OBSERVATORY	*0.79*	5.0	6.7	0.0	0.0	3.1	4.5	0.0	0.0	5.6	0.0	6	257	2.3
ASTRON NACHR	*0.78*	0.0	1.9	0.0	0.0	4.4	0.0	2.3	0.0	0.0	0.6	10	767	1.3
ADV SPACE RES	*0.60*	0.8	1.0	0.9	0.4	0.9	2.0	2.3	3.2	0.5	0.8	74	5935	1.2
J ASTROPHYS ASTRON	*0.56*	0.0	18.2	18.2	5.6	0.0	0.0	0.0	0.0	0.0	0.0	7	266	2.6
ASTROPHYS SPACE SCI	*0.54*	0.5	1.4	1.6	2.7	0.4	0.9	2.4	3.1	2.5	3.4	79	3981	2.0
ASTROPHYS LETT COMM	*0.54*	0.0	1.7	0.0	0.0	3.6		1.9				9	567	1.6
ASTRON GEOPHYS	*0.42*				0.0	7.9	0.0	4.2	2.9	0.0	0.0	5	217	2.3
CHINESE ASTRON ASTR	*0.12*						0.9	0.0	0.0	0.0	0.0	1	362	0.3
IAU SYMP	*0.01*	5.6	0.2	5.3	7.6	2.9	2.8	2.8		4.0	5.0	217	5226	4.2
CR ACAD SCI IV-PHYS	*0.00*							0.0	2.3	0.0		3	242	1.2
P ASTRON SOC AUST		96.2										50	52	96.2
ANN GEOPHYS-GERMANY									1.0	0.6	6.0	5	310	1.6
INDIAN J RADIO SPACE		0.0	2.1									1	116	0.9

* world cites/world pubs in the year 2000

The data in Table 1 is provided primarily for information. The journals are sorted on the basis of average citation rates for 2000. Obviously the ranking of journals will change from year to year, so it was necessary to choose one period as a reference point. There were also three journals for which the calculation could not be made, most probably because of a name change for the journal.

Over the last 10 year period the journal that had the highest presence of Australian publications was, not surprisingly, *Publications of the Astronomical Society of Australia.*

However, it is interesting to note that Australian authors now appear on less than half the publications carried by the journal, down from over 90 percent in 1995.

3.3 Analysis of journal impact quartiles

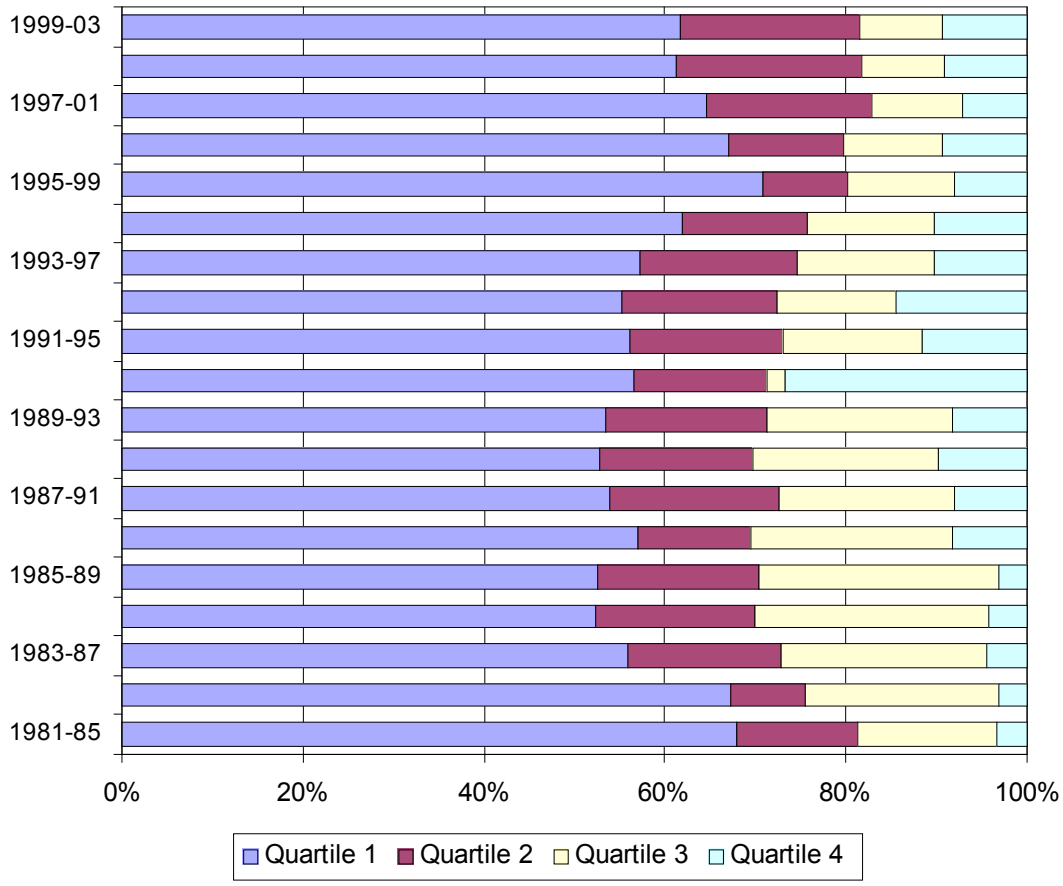

Figure 2: Quartile distribution, five year windows, 1981-2003

While journals are spread evenly between the four quartiles in this analysis (i.e. 25 percent in each quartile), the distribution for articles is not even. To put the data in Figure 2 into perspective, it should be noted that approximately 45 percent of articles appear in journals in the top quartile. Australian output in astronomy exceeds this benchmark level, and particularly in recent years has done so by a considerable margin.

The sudden jump then decline in publications appearing in quartile 4 journals was due to the brief classification of the *Proceedings of the Astronomical Society of Australia* to this category.

3.4 Collaborative Activity

Table 2: Level of collaboration in Astronomy, 1998-2002.

	Number	Percentage
Sole Author	212	9
Group	279	12
Intra-institutional	113	5
National	478	21
International	1727	77

The most recent five year window for which collaboration data is available is 1998-2002. Only the sole author and international figures are directly comparable to our previous analysis, as the method of calculating collaborative activity now enables us to identify all collaborations, not just the 'highest' level. Comparing this data to the previous analysis, we note that single author publications have decreased from 19 percent to 9 percent, and internationally co-authored publications have increased from 55 percent to 77 percent. This change is in line with trends exhibited in all other disciplines – there is a general trend in all fields to the increasing internationalisation of research and a decline in single authored papers.

3.5 Institutional Analysis

The results of two analyses that focus on institutional performance in astronomy are presented in Figure 3 and Table 3. In both the table and chart, those institutions where the analysis rests on less than 100 publications are denoted in grey, and extra caution is required in interpreting the data.

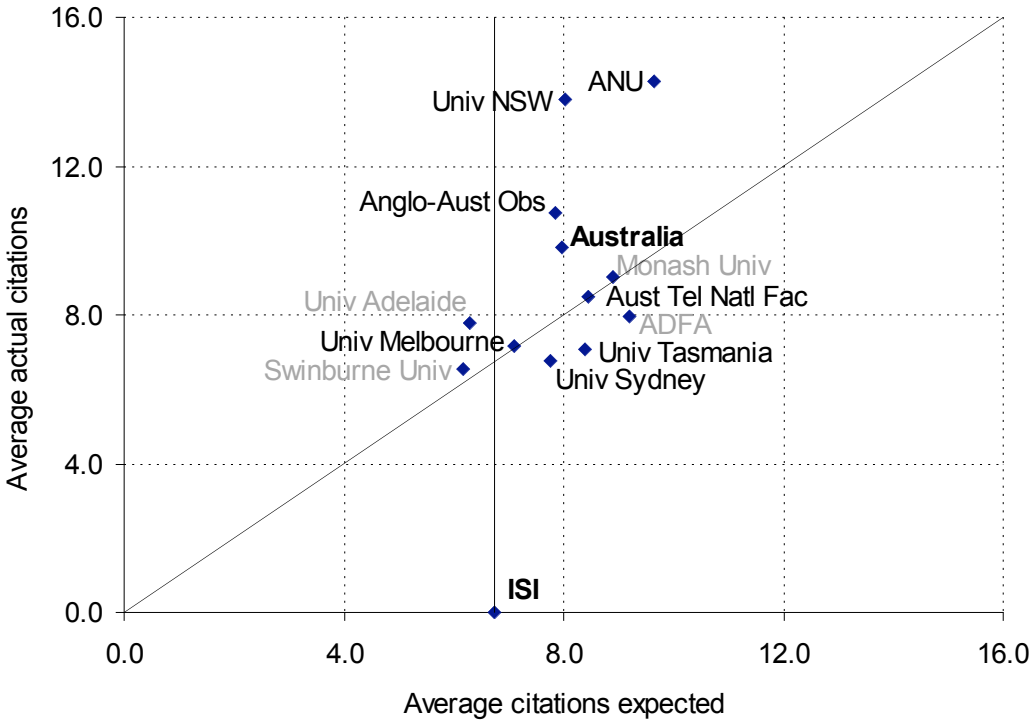

Figure 3: Actual and expected citation rates Astronomical Sciences 1998-2002

All institutions with a significant output in Astronomy are at or above the world benchmark and most publish in a high impact set of journals. The two institutions that appear to the left of the vertical line have less than 100 publications. In the case of Swinburne University, further analysis alerted us to a particular concern for this institution – most of its publications appeared in 2001 and 2002, and hence had little time to attract citations, thus deflating their average and expected citation rates relative to other institutions. We have not investigated whether this is also the case for the University of Adelaide.

The Australian National University and the University of New South Wales clearly stand out from other institutions in terms of their citation impact, followed by the Anglo-Australian Observatory. This performance can also be seen in Table 3, which details where authors of Australia's most highly cited publications for the period 1998-2002 are to be found.

Table 3: Most highly cited publications Astronomical Sciences, 1998-2002

Top 1% = 93 cites (22 pubs)

Top 5% = 37 cites (108 pubs)

	Total Pubs	Pubs in top 1%		Pubs in top 5%	
	No.	No.	%	No.	%
The Australian National University	607	13	2.1	51	8.4
Anglo-Australian Observatory	285	2	0.7	24	8.4
University of New South Wales	253	7	2.8	20	7.9
Australia Telescope National Facility	386	2	0.5	16	4.1
University of Tasmania	112			3	2.7
University of Melbourne	109			2	1.8
University of Sydney	392			7	1.8
Monash University	84	1	1.2	7	8.3
University of Adelaide	77	1	1.3	4	5.2
Australian Defence Force Academy	77			3	3.9
Swinburne University	82	1	1.2	2	2.4

In this analysis, jointly-authored publications were allocated to each Australian institution involved, so some double-counting exists. The University of New South Wales has close to three times the expected number of very highly cited publications (top 1% in Australia), and the Australian National University has double the expected number (and accounts for 60 percent of this band of publications). These two universities, together with the Anglo-Australian Observatory, were also the most prominent in the second tier of publications.

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Appendix 1

List of journals in the ISI's Astronomy and Astrophysics journal set.

JOURNAL	FULL_TITLE
ACTA ASTRONOM	ACTA ASTRONOMICA
ADV SPACE RES	ADVANCES IN SPACE RESEARCH
ANN GEOPHYS A-UPPER	ANNALES GEOPHYSICAE SERIES A-UPPER ATMOSPHERE AND SPACE SCIENCES
*ANN GEOPHYS-ATM HYDR	ANNALES GEOPHYSICAE-ATMOSPHERES HYDROSPHERES AND SPACE SCIENCES
ANN GEOPHYS-GERMANY	ANNALES GEOPHYSICAE
ANN SOC SCI BRUX	ANNALES DE LA SOCIETE SCIENTIFIQUE DE BRUXELLES SERIES 1
ANNU REV ASTRON ASTR	ANNUAL REVIEW OF ASTRONOMY AND ASTROPHYSICS
*ANNU REV EARTH PL SC	ANNUAL REVIEW OF EARTH AND PLANETARY SCIENCES
ASTRON ASTROPHYS	ASTRONOMY & ASTROPHYSICS
ASTRON ASTROPHYS REV	ASTRONOMY AND ASTROPHYSICS REVIEW
ASTRON ASTROPHYS SUP	ASTRONOMY & ASTROPHYSICS SUPPLEMENT SERIES
*ASTRON GEOPHYS	ASTRONOMY & GEOPHYSICS
ASTRON J	ASTRONOMICAL JOURNAL
ASTRON LETT+	ASTRONOMY LETTERS-A JOURNAL OF ASTRONOMY AND SPACE ASTROPHYSICS
ASTRON NACHR	ASTRONOMISCHE NACHRICHTEN
ASTRON REP+	ASTRONOMY REPORTS
ASTRON ZH+	ASTRONOMICHESKII ZHURNAL
ASTROPART PHYS	ASTROPARTICLE PHYSICS
ASTROPHYS J	ASTROPHYSICAL JOURNAL
ASTROPHYS J SUPPL S	ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES
ASTROPHYS LETT COMM	ASTROPHYSICAL LETTERS & COMMUNICATIONS
ASTROPHYS SPACE SCI	ASTROPHYSICS AND SPACE SCIENCE
B ASTRON I CZECH	BULLETIN OF THE ASTRONOMICAL INSTITUTES OF CZECHOSLOVAKIA
CELESTIAL MECH	CELESTIAL MECHANICS
CHINESE ASTRON ASTR	CHINESE ASTRONOMY AND ASTROPHYSICS
CR ACAD SCI IV-PHYS	COMPTES RENDUS DE L ACADEMIE DES SCIENCES SERIE IV PHYSIQUE ASTROPHYSIQUE
CR PHYS	COMPTES RENDUS PHYSIQUE
*EARTH MOON PLANETS	EARTH MOON AND PLANETS
*GEOPHYS ASTRO FLUID	GEOPHYSICAL AND ASTROPHYSICAL FLUID DYNAMICS
IAU SYMP	IAU SYMPOSIA
ICARUS	ICARUS
INDIAN J RADIO SPACE	INDIAN JOURNAL OF RADIO & SPACE PHYSICS
*INT J MOD PHYS D	INTERNATIONAL JOURNAL OF MODERN PHYSICS D
J ASTROPHYS ASTRON	JOURNAL OF ASTROPHYSICS AND ASTRONOMY
*J GEOPHYS RES-ATMOS	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES
*J GEOPHYS RES-OCEANS	JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS
*J GEOPHYS RES-PLANET	JOURNAL OF GEOPHYSICAL RESEARCH-PLANETS
*J GEOPHYS RES-SOL EA	JOURNAL OF GEOPHYSICAL RESEARCH-SOLID EARTH
*J GEOPHYS RES-SPACE	JOURNAL OF GEOPHYSICAL RESEARCH-SPACE PHYSICS
J ROY ASTRON SOC CAN	JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA
MON NOT R ASTRON SOC	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY
MOON PLANETS	MOON
MOON PLANETS	MOON AND THE PLANETS
NEW ASTRON	NEW ASTRONOMY
OBSERVATORY	OBSERVATORY
P ASTRON SOC AUST	PROCEEDINGS ASTRONOMICAL SOCIETY OF AUSTRALIA
*PLANET SPACE SCI	PLANETARY AND SPACE SCIENCE
PUBL ASTRON SOC AUST	PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF AUSTRALIA
PUBL ASTRON SOC JPN	PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF JAPAN
PUBL ASTRON SOC PAC	PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC
Q J ROY ASTRON SOC	QUARTERLY JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY
REV MEX ASTRON ASTR	REVISTA MEXICANA DE ASTRONOMIA Y ASTROFISICA
SKY TELESCOPE	SKY AND TELESCOPE
SOL PHYS	SOLAR PHYSICS
SOV ASTRON LETT+	SOVIET ASTRONOMY LETTERS
SPACE SCI REV	SPACE SCIENCE REVIEWS
VESTN LENIN U MMA	VESTNIK LENINGRADSKOGO UNIVERSITETA SERIYA MATEMATIKA MEKHANIKA ASTRONOMIYA
VESTN MOSK U FIZ AS+	VESTNIK MOSKOVSKOGO UNIVERSITETA SERIYA 3 FIZIKA ASTRONOMIYA
VISTAS ASTRON	VISTAS IN ASTRONOMY
Z NATURFORSCH A	ZEITSCHRIFT FUR NATURFORSCHUNG SECTION A-A JOURNAL OF PHYSICAL SCIENCES

Appendix 2 Additional Astronomy Analysis

1. Removal of geophysics journals

A repeat of the analysis shown in Figure 1 above was undertaken after deleting the following geophysics journals:

Ann Rev Earth Pl Sc	AnnGeophys-Atm Hydr
J Geophys Res – Atmos	Geophys Astro Fluid
J Geophys Res - Sol Ea	Planet Space Sci
J Geophys Res – Oceans	Int J Mod Phys D
J Geophys Res – Planet	Earth Moon Planets
J Geophys Res – Space	Astron Geophys

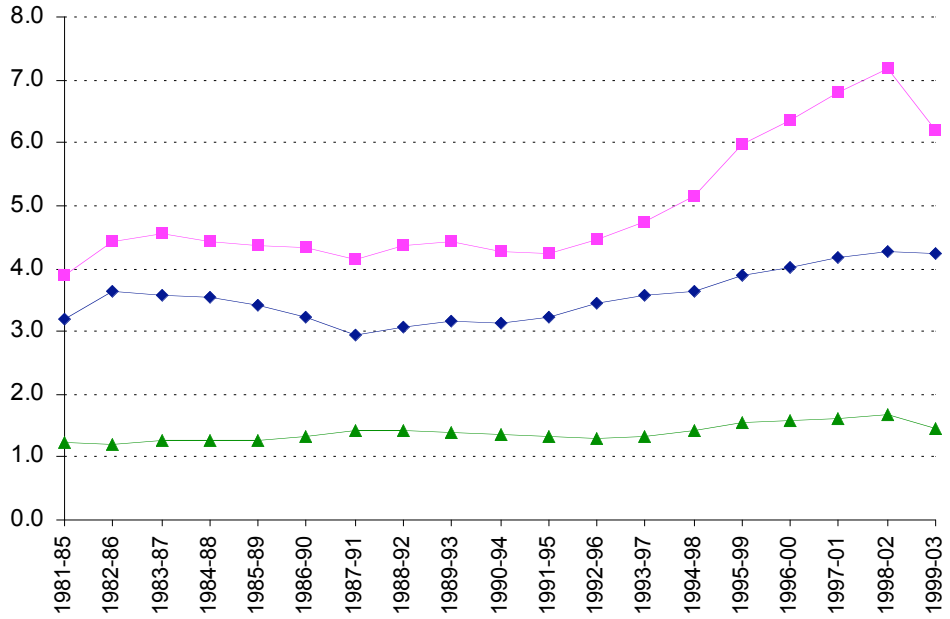


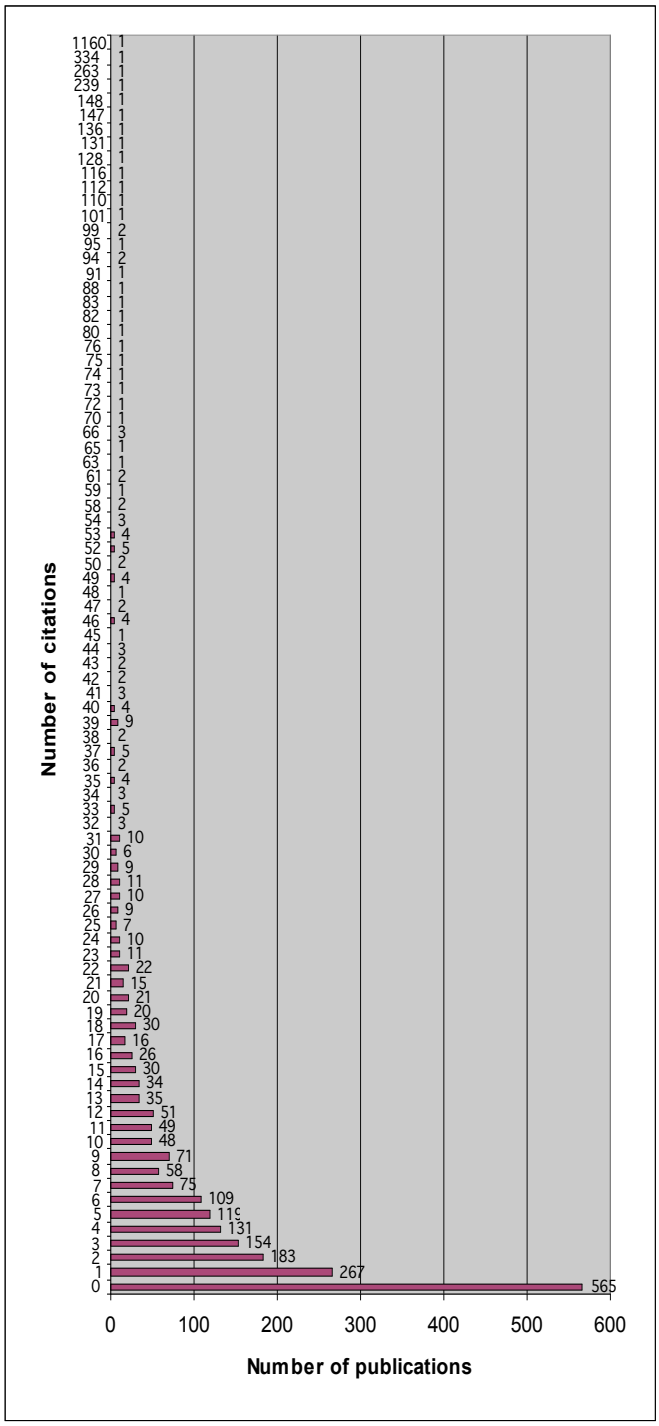
Figure 4: Australia's share of world publications and citations, restricted journal set.

(■ citations, ◆ publications, ▲ relative citation impact)

The reduced journal set made little difference to the general trends, although it is noted that Australia's share of both publications and citations is higher for this set.

2. Investigation of very highly cited publications

Citation distributions are extremely skewed – this is true for all research disciplines not just astronomy. Because of this skewed nature, average data can be heavily influenced by a small number of very highly cited publications. REPP was asked to look at the distribution of citations for astronomy publications to see how this may affect the interpretation of Australian data. The two figures below show the distribution of publications by the number of citations they receive for two five year windows, taken 10 years apart. In both cases, citation counts are limited to the same five year period covered by the publication counts, and so are directly comparable.


Number of citations
1160 1
334 1
263 1
239 1
148 1
147 1
136 1
131 1
128 1
116 1
112 1
110 1
101 1
99 2
95 1
94 2
91 1
88 1
83 1
82 1
80 1
76 1
75 1
74 1
73 1
72 1
70 1
66 3
65 1
63 1
61 2
59 1
58 2
54 3
53 4
52 5
50 2
49 4
48 1
47 2
46 4
45 1
44 3
43 2
42 2
41 3
40 4
39 9
38 2
37 5
36 2
35 4
34 3
33 5
32 3
31 10
30 6
29 9
28 11
27 10
26 9
25 7
24 10
23 11
22 22
21 15
20 21
19 20
18 30
17 16
16 26
15 30
14 34
13 35
12 51
11 49
10 48
9 71
8 58
7 75
6 109
5 11
4 131
3 154
2 183
1 267
0 565
0
100
200
300
400
500
600
Number of publications

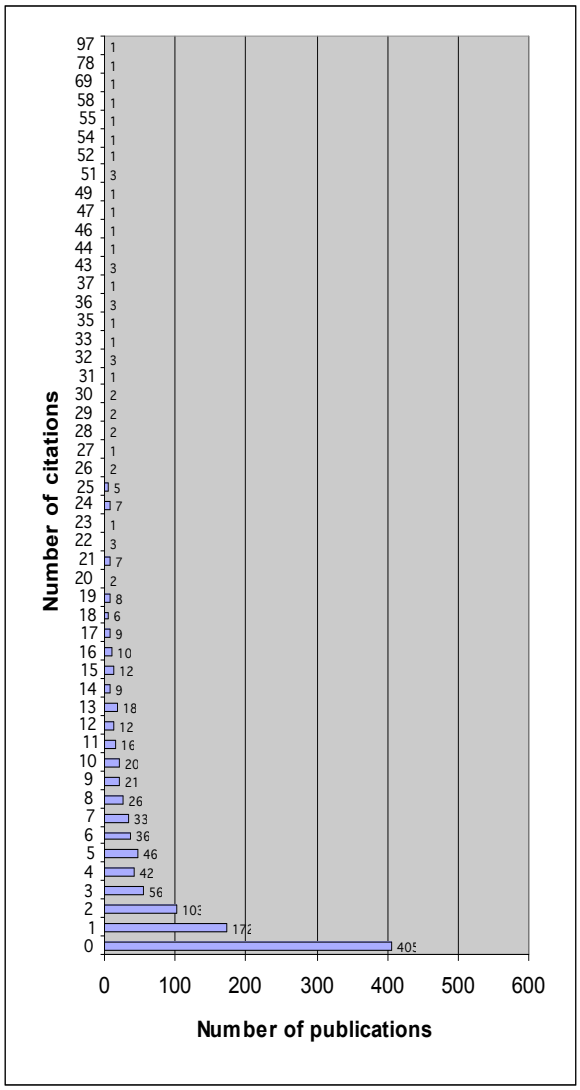


Figure 5: Distribution of citations, 1999-2003

Figure 6: Distribution of citations, 1989-93

Comparing these two periods, there are two factors that can be seen in the data which is reflected in the improved performance of Australian astronomy publications:

(i) The proportion of publications uncited in the period has decreased from 36% in 1989-93 to 24% in 1999-03.

(ii) 1999-03 contains 13 publications with 100 or more citations (and one with more than 1,000), while there are none for 1989-93.

In addition, citation rates world-wide have been increasing. In 1989-93 the world average was 4.02, but by 1999-03 had climbed to 6.21.

All three factors have an influence on the trends shown in Figure 1 above. I doubt that these factors are unique to Australia, but we cannot analyse other countries to confirm or disprove this.

Appendix 3

Data underlying charts in main body of the text

(Figure 1)

	World		Australia		Share		
Tape year	Pubs	Cites	Pubs	Cites	Pubs	Cites	RCI
1981-85	29408	125839	877	4168	2.98	3.31	1.11
1982-86	30249	125497	1011	4764	3.34	3.80	1.14
1983-87	31949	129148	1048	4853	3.28	3.76	1.15
1984-88	32930	130791	1056	4653	3.21	3.56	1.11
1985-89	33812	134672	1049	4767	3.10	3.54	1.14
1986-90	35245	138011	1029	4835	2.92	3.50	1.20
1987-91	36330	141646	977	4579	2.69	3.23	1.20
1988-92	37428	148117	1043	5096	2.79	3.44	1.23
1989-93	39220	157854	1121	5514	2.86	3.49	1.22
1990-94	42956	171950	1206	5743	2.81	3.34	1.19
1991-95	45790	195977	1344	6388	2.94	3.26	1.11
1992-96	49050	224359	1529	7556	3.12	3.37	1.08
1993-97	51112	243876	1662	8828	3.25	3.62	1.11
1994-98	52656	250106	1819	9843	3.45	3.94	1.14
1995-99	53399	277134	1962	12814	3.67	4.62	1.26
1996-00	54289	292638	2051	14416	3.78	4.93	1.30
1997-01	54874	313481	2149	16865	3.92	5.38	1.37
1998-02	56274	330056	2247	19289	3.99	5.84	1.46
1999-03	**59982**	**372696**	**2324**	**20732**	**3.87**	**5.56**	**1.44**

(Figure 2)

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
1985	596	116	135	30
1986	680	84	215	32
1987	585	178	238	47
1988	553	185	274	44
1989	552	187	278	32
1990	586	129	230	84
1991	526	183	190	78
1992	551	176	213	103
1993	598	200	231	92
1994	683	176	26	321
1995	754	228	207	155
1996	844	263	202	220
1997	950	291	252	169
1998	1126	253	253	187
1999	1389	183	232	158
2000	1376	258	224	193
2001	1388	393	216	152
2002	1374	461	208	204
2003	1435	459	215	215

(Table 1)

	1994		1995		1996		1997		1998		1999		2000		2001		2002		2003	
Journal	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**	**Aust**	**World**
ACTA ASTRONOM		45		29		22		22		34		38		32		21		25		27
ADV SPACE RES	5	661	9	883	3	331	2	450	6	649	8	400	19	826	13	401	3	576	6	758
ANN GEOPHYS-ATM HYDR		122		136		136	3	177	2	144	4	141	3	146	1	13				
ANN GEOPHYS-GERMANY															1	103	1	157	3	50
ANNU REV ASTRON ASTR		14		17		17		16		14	1	14			1	31	1	16		15
ANNU REV EARTH PLSC		17		14		10		12	2	18	1	14	2	20		18	1	16	1	16
ASTRON ASTROPHYS	16	1198	10	1065	20	1224	24	1346	33	1353	19	1166	27	1223	54	2042	38	1822	38	1936
ASTRON ASTROPHYS REV		3		6		7		2		4		7		2		3		5		5
ASTRON ASTROPHYS SUP	4	225	10	257	13	309	8	438	4	363	14	422	10	259		18				
ASTRON GEOPHYS								29	3	38		29	1	24	1	34		23		40
ASTRON J	17	412	20	449	20	505	21	451	35	490	31	444	27	507	28	526	37	552	26	443
ASTRON LETT+		175		125		103		117		117		109		96		113		105		109
ASTRON NACHR		35	1	53		34		43	4	91		23	4	174		34		99	1	181
ASTRON REP+								53		87		141		84		113		106		107
ASTRON ZH+		123		99		140		31												
ASTROPART PHYS				43		70		58		51		130		59	6	52	4	85	4	110
ASTROPHYS J	55	1982	78	2141	80	2055	83	2227	54	1298	142	3109	97	2232	127	2587	106	2300	93	2447
ASTROPHYS J SUPPL S	10	251	4	134	6	81	8	160	2	91	8	119	6	167	5	127	11	123	3	104
ASTROPHYS LETT COMM		8	1	59		147		11	3	83			5	259						
ASTROPHYS SPACE SCI	2	422	7	508	3	193	8	293	1	264	4	423	14	574	17	546	8	318	15	440
CHINESE ASTRON ASTR											1	109		75		65		42		71
CR ACAD SCI IV-PHYS														92	3	129		21		
CR PHYS																		87		90
EARTH MOON PLANETS		48		50	8	218	2	30		11		28		165	1	72		23	1	76
GEOPHYS ASTRO FLUID	2	38	8	61	4	44	2	37	3	25		16	4	24		20		18		33
IAU SYMP	33	589	1	481	62	1168	17	224	15	522	3	109	4	144			67	1688	15	301
ICARUS	2	187	2	211	4	178		255	2	181	1	183	6	263	3	173	1	269	2	201
INDIAN J RADIO SPACE		69	1	47																
INT J MOD PHYS D		79		57	1	34		47	1	69	1	55	1	64		65	1	125	1	145
J ASTROPHYS ASTRON		23	4	22	2	11	1	18		35		12		22		81		32		10
J GEOPHYS RES-ATMOS	10	445	14	463	20	706	30	766	42	848	26	777	24	787	19	742	8	386	50	1666
J GEOPHYS RES-OCEANS	14	308	23	391	20	354	7	263	22	396	14	346	8	262	18	332	6	155	23	589
J GEOPHYS RES-PLANET	1	73	1	110	2	129	2	119	4	95		174	1	139		127		107	1	255
J GEOPHYS RES-SOLEA	12	459	13	464	10	505	12	469	24	359	15	376	15	450	7	326	8	199	18	708
J GEOPHYS RES-SPACE		529		518		551	12	468	16	500	14	491	9	481	11	612	7	340	21	657
J ROY ASTRON SOC CAN		43		21																
MON NOT R ASTRON SOC	55	583	69	659	62	693	73	751	87	871	95	876	79	842	116	1014	115	1084	108	1207
NEW ASTRON							2	53	1	58		34	2	57	3	41		32	1	82
OBSERVATORY	1	20	2	30		37		37	1	32	1	22		27		14	1	18		20
PASTRON SOC AUST	50	52																		
PLANET SPACE SCI	1	152	1	203	1	112	3	164	6	145		171	1	111	1	170	2	90	1	117
PUBL ASTRON SOC AUST			36	39	32	42	49	63	30	56	29	43	28	38	32	43	40	78	29	65
PUBL ASTRON SOC JPN		89		90	1	100	1	86		66	2	92	1	123	6	135	2	116	3	131
PUBL ASTRON SOC PAC	5	164	3	151	7	160	3	151	5	158	9	173	7	154	3	128	6	114	3	115
Q J ROY ASTRON SOC	1	20		16		22		13												
REV MEX ASTRON ASTR	1	92		17		15		20		16		15		7		34		26		28
SOL PHYS	4	194	6	191	6	191	5	204	5	253	5	170	9	245	5	165	3	166	9	196
SPACE SCI REV	2	196	1	155		115	2	50	2	63		141	3	160		136		68	17	146
VESTN MOSK U FIZ AS+		180		53																
Z NATURFORSCH A	3	181	4	178	1	194		160	1	159	1	107	1	170	4	142	1	172		118

(Figure 3)

Institution	Pubs	Actual	Expected	Act./Exp	Av. Exp	Av./Act
The Australian National Univ	607	8676	5856	1.5	9.6	14.3
Anglo-Australian Observatory	285	3061	2240	1.4	7.9	10.7
Aust Telescope National Facility	386	3276	3256	1.0	8.4	8.5
Univ Melbourne	109	779	773	1.0	7.1	7.1
Univ New South Wales	253	3494	2030	1.7	8.0	13.8
Univ Sydney	392	2645	3042	0.9	7.8	6.7
Univ Tasmania	112	792	939	0.8	8.4	7.1
Aust Defence Force Academy	77	613	708	0.9	9.2	8.0
Monash Univ	84	756	748	1.0	8.9	9.0
Swinburne Univ Technology	82	536	506	1.1	6.2	6.5
Univ Adelaide	77	598	484	1.2	6.3	7.8
Australia	**2256**	**22109**	**17962**	**1.2**	**8.0**	**9.8**
World	**55838**	**375669**	**375669**	**1.0**	**6.7**	**0.0**