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Murugan Chinnaraj

Sona College of Technology, muruganchinnaraj@gmail.com

R. Balasubramani

lisbala@gmail.com

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Scientometric Mapping of Remote Sensing Research Output: A Global Perspective

C. Murugan
Librarian

Sona College of Technology
Thiyagarajar Polytechnic College Road
Salem-636005
Tamilnadu, India
muruganchinnaraj@gmail.com

Dr. R. Balasubramani
Assistant Librarian
Bharthidasan University, Trichy – 24
Tiruchirappalli – 620 024
Tamilnadu, India
lisbala@gmail.com

Abstract

This paper presents a quantitative analysis of remote sensing, in terms of research output throughout the world during 1975 – FEB 2010. During that period, 1188 papers have been published and the cited references have been 30654. The average number of publications published per year has been 38.07. The highest number of paper (119) was published in the year of 2009. The USA topped the list with 473 (39.8%) publications, followed by UK with 128 (10.8%) publications, India with 93 (7.8%) publications respectively. The highly productive authors are Kaufman YJ with 13 (1.1%) publications, followed by Wagner W with 10 (0.8%) publications. There were 1082 institutions involved in the research with NASA which topped the list with 112 (9.4%), followed by NOAA with 48 (4%) publications. The most preferred journal is IEEE Transaction on Geoscience and Remote Sensing with 103 papers, followed by International journal of Remote Sensing with 95 papers, Acta Astronautica with 64 papers. The most preferred language by scientist is English with 1170 (98.5%) publications.

Key words: Remote Sensing; Satellite; Mapping; Satellites; Sensing

Introduction

Remote Sensing can be used to collect data, unlike other techniques, such as thematic cartography, geographic information systems, or statistics that must rely on data that are already available. The data collected through remote sensing can be transformed into information using analog or digital image processing techniques if appropriate logic and methods are used.

Remote sensing can be used for monitoring several natural (e.g., watershed runoff) and cultural processes (e.g., land use conversion at the urban fringe). In fact, for successful execution of many models that rely on spatially distributed information, remote sensing is essential.

Satellite Remote Sensing is an important application of remote sensing in the field of oceanography. It involves gathering information about the earth's surface using satellites orbiting around the earth and rapid method of acquiring up-to-date information over a large geographical area.

Scientometric analysis is a technique to analyse the scientific publication in particular field of science at global level, performance of a country, performance of institutions and individual scientist.

Objectives

The aim of this paper is to compare the number of journal publications and measure the quality of research by various countries and institutions, under the following categories:

- Year wise publication
- Document type wise Distribution
- Language distribution of the literature
- Geographical distribution
- Institution distribution of contributors
- Authorship pattern
- Most productive authors

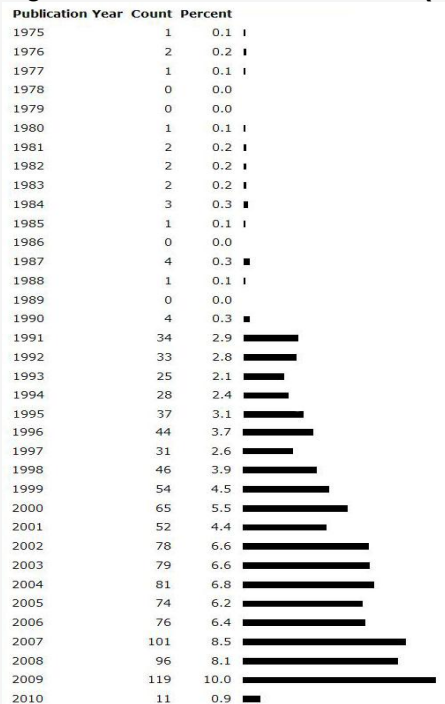
Materials and Methods

Data was collected from the Science Citation Index (SCI) is available via the Web of Science (WoS). The SCI is developed by Thomson Reuters, through which the world's leading basic and applied technical research journals in many areas of science and technology, including the biomedical research literature can be accessed. For this study, total of 1188 records and 30654 citations have been received by using the **Histcite** software for analyzing.

Year-wise Growth of Publications

Figure 1 show that 1188 articles have been published, which have received 30,654 citations, from 1975 to Feb 2010. However, the number of published papers dropped slightly from 44 to 31 in 1997, from 65 to 52 in 2001 and from 81 to 74 in 2005. In the volumes of 1978, 1979, 1986 and 1989, there is no publications. In 2009, total publications were 119. The average number of publication per year was 38.07.

Figure 1: Year Wise Publications (1970 – FEB 2010)



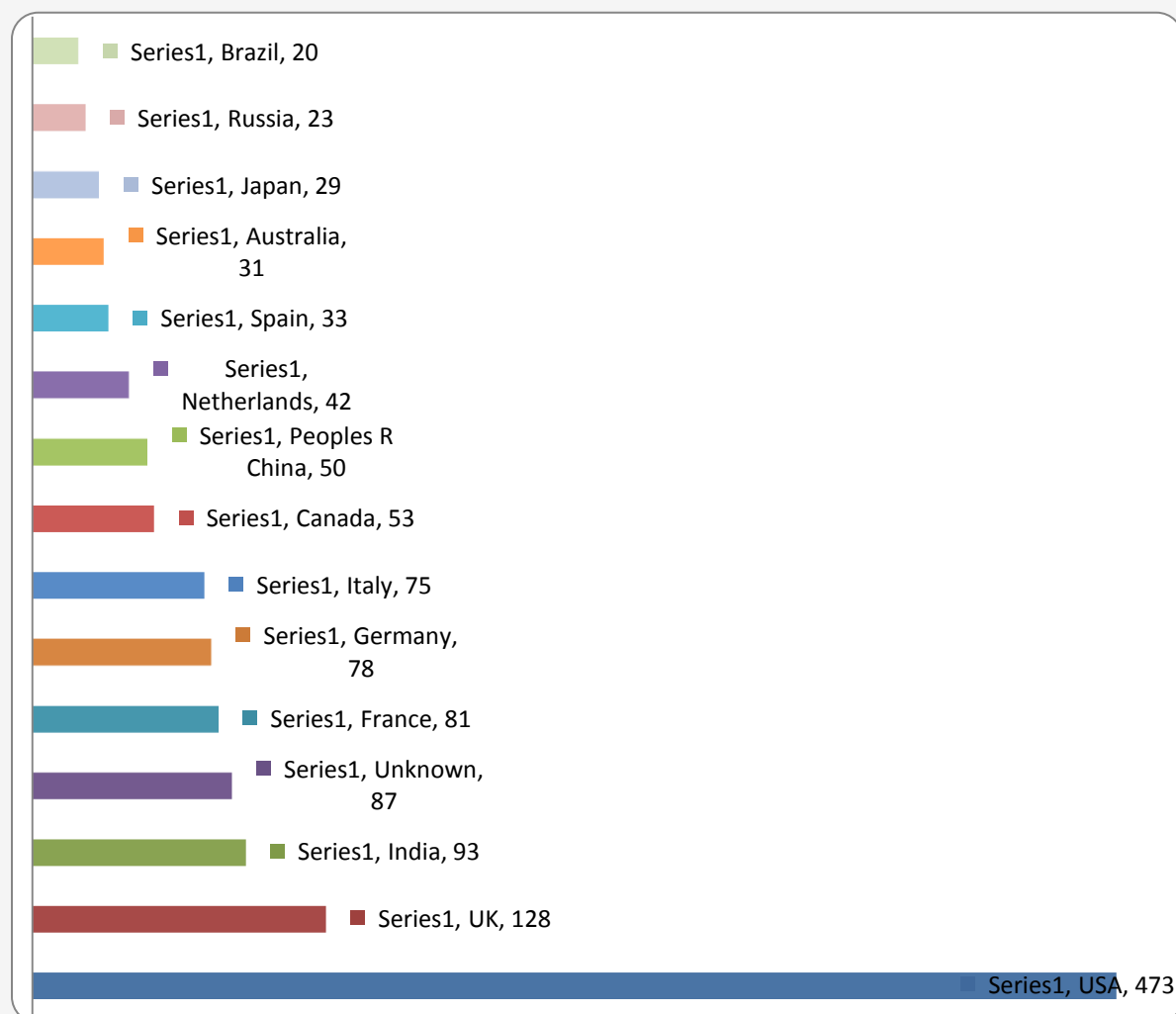
Country-wise Distribution of Publications

There are 59 countries actively doing research in Remote Sensing. Out of that, the paper discusses only top fifteen countries. USA has topped the list with 473 (39.8%) publications, followed by UK with 128 (10.8%) publications and India with 93 (7.8%).

Table 1 Country-wise Distribution of Remote Sensing Publications and Citations

#	Country	Recs	TLCS	TGCS
1	USA	473	315	11290
2	UK	128	60	1593
3	India	93	12	223
4	Unknown	87	27	910
5	France	81	63	2491
6	Germany	78	46	802
7	Italy	75	52	904
8	Canada	53	26	876
9	Peoples R China	50	6	179
10	Netherlands	42	25	937
11	Spain	33	21	664
12	Australia	31	14	542
13	Japan	29	24	1566
14	Russia	23	12	151
15	Brazil	20	7	427

Figure 2 Top Fifteen Highly Productive Countries



Publication Media:

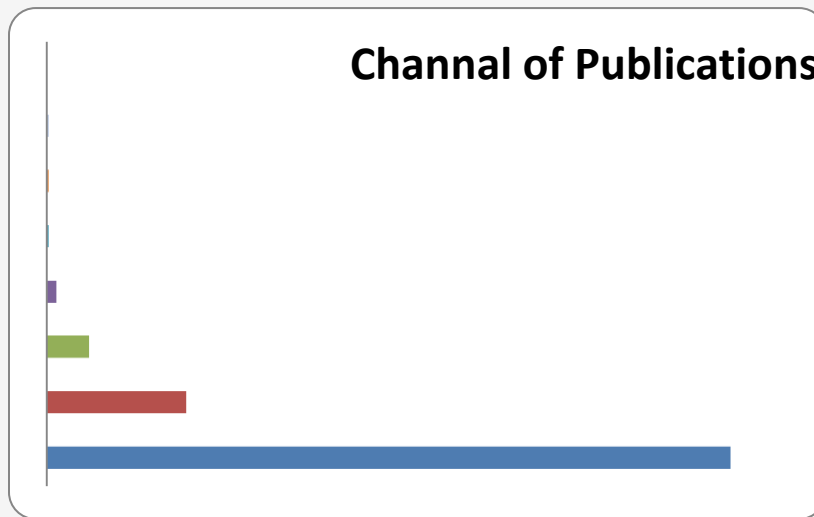
The research outputs published by different media of publications are journal article (77.5%), proceedings paper (15.8%), review article (4.8%), editorial publications (1.1%), news item (0.3%), notes (0.3%), letter (0.2%) and reprint (0.1%). The most preferred channel of publication is journal article.

Table 2 Publication Media wise Distribution

#	Document Type	Recs	TLCS	TGCS
1	Journal Article	921	493	14264
2	Proceedings Paper	188	60	1738
3	Review	57	32	2018
4	Editorial Material	13	1	24

5	News Item	3	0	0
6	Note	3	0	5
7	Letter	2	0	5
8	Reprint	1	0	1

Figure 3 Channels of Publication



Most Productive Authors:

There have been a total of 3735 authors contributing 1188 articles during the period. Table 3 shows the list of top 11 most productive authors among 3735 authors. It reveals that Kaufman YJ is the top most authors with 13 publications followed by Wagner W with 10 and Jayaraman V and Remer LA with 8 publications. There are seven authors who have published six papers; twenty four authors have jointly published five papers and so on.

Table 3 Most Productive Authors

#	Author	Recs	TLCS	TGCS
1	Kaufman YJ	13	40	1900
2	Wagner W	10	16	215
3	Jayaraman V	8	0	12
4	Remer LA	8	15	489
5	Anderson MC	6	14	196

6	Chandrasekhar MG	6	1	15
7	Fiete RD	6	9	98
8	Lehner S	6	15	249
9	Rott H	6	9	141
10	Singh RP	6	4	32
11	Taylor FW	6	4	176

Authorship Pattern

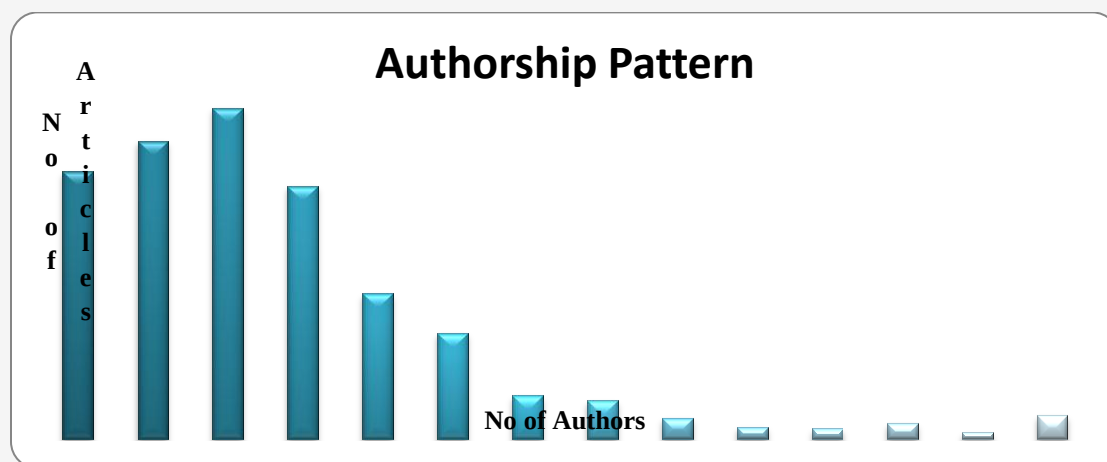
Table 4 explicates the authorship pattern of contributions. Out of 3735 contributors, a single author has contributed 17 per cent of the total articles. 18.94 per cent of the articles have been published with two authors, 21.04 per cent of the contributions have three authors, and 16.08 per cent of the contributions were 4 authors and so on. This study shows that multi authored works are more in number than single authors.

Table 4 Authorship Pattern

No of Author	No of Articles	Percentage
1	202	17%
2	225	18.94%
3	250	21.04%
4	191	16.08%
5	110	9.26%
6	80	6.73%
7	33	2.78%
8	29	2.44%

9	16	1.35%
10	9	0.76%
11	8	0.67%
12	12	1.01%
13	5	0.42%
14<	18	1.52%
	1188	100

Figure 4: Authorship Pattern



Language wise Distribution:

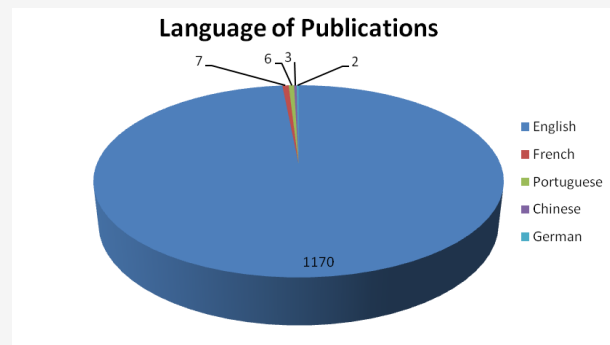
English is the major language of the publications (1170 record counts, 98.5%), followed By French (7 record counts, 0.6), Portuguese (6 record, 0.5%), Chinese (3 record, 0.3%) and German (2 record, 0.2%).

Table 5 Language distribution

#	Language	Recs	TLCS	TGCS
1	English	1170	586	18034
2	French	7	0	12

3	Portuguese	6	0	1
4	Chinese	3	0	8
5	German	2	0	0

Figure 5: Language wise publications



Ranking of Journals

Journals are primary source of information, Table 6 shows that Top 5 journals preferred by researchers are IEEE (T) on Geoscience and Remote Sensing is first with (8.7%) 103 records, followed by International journal of Remote Sensing with (8.0%) 95 record.

Table 6 Ranking List of Journals

#	Journal	Recs	TLCS	TGCS
1	IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	103	78	1765
2	INTERNATIONAL JOURNAL OF REMOTE SENSING	95	55	1635
3	ACTA ASTRONAUTICA	64	15	98
4	REMOTE SENSING OF ENVIRONMENT	55	70	2478
5	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	51	35	1653

Institution-wise Distribution of Publications

There are 1082 institutions involved in research activity in the field. They have contributed 1188 publications, in which NASA topped the list with 112 (9.4%), *National Oceanic and Atmospheric Administration* NOAA with 48 (4.0%), CALTECH with 46 (3.9%), University of Maryland with 38(3.2%), and ISRO and University of Colorado with 21 (1.8%)

Table 7 Institution-wise Distribution of Publications

#	Institution	Recs	TLCS	TGCS
1	NASA	112	126	4459
2	NOAA	48	35	1375
3	CALTECH	46	24	928
4	University of Maryland	38	58	2173
5	ISRO	21	2	23
6	University of Colorado	21	4	457
7	European Space Agcy	19	13	222
8	University of Arizona	19	34	1904
9	Chinese Acad Sci	17	1	74
10	Colorado State University of	17	15	322
11	Indian Space Res Org	17	3	34
12	Sci Syst & Applicat Inc	17	15	714
13	USDA ARS	16	21	660
14	Russian Acad Sci	15	11	123
15	University of Wisconsin	15	23	554
16	Unknown	15	0	2
17	USN	15	13	524

Highly Cited Publications

Table 8 shows highly cited publication. The most cited publication is by Holben, et al., published in Elsevier Science which has been cited 22 times, followed by Huete (1988), which has been cited 18 times.

Table 8 Highly Cited Publications

Publication Details		Number of Citations
1	HOLBEN BN, 1998, REMOTE SENS ENVIRON, V66, P1	22
2	HUETE AR, 1988, REMOTE SENS ENVIRON, V25, P295	18
3	ZEBKER HA, 1992, IEEE T GEOSCI REMOTE, V30, P950	18
4	REMER LA, 2005, J ATMOS SCI, V62, P947	17
5	KAUFMAN YJ, 1997, J GEOPHYS RES-ATMOS, V102, P17051	16
6	MASSONNET D, 1993, NATURE, V364, P138	16
7	TUCKER CJ, 1979, REMOTE SENS ENVIRON, V8, P127	16
8	JAMES ME, 1994, INT J REMOTE SENS, V15, P3347	15
9	SELLERS PJ, 1985, INT J REMOTE SENS, V6, P1335	15
10	TANRE D, 1997, J GEOPHYS RES-ATMOS, V102, P16971	15

Keyword Analysis:

Keywords are one of the best scientometric indicators to find out the growth of the subject field. Keywords that appear in the title or indexer or the author assigned. The high frequency keywords help us to understand the present study. Table 9 shows the keywords which have appeared more than 50 times.

Table 9 Frequency of Keyword <50

#	<u>Word</u>	<u>Recs</u>	<u>TLCS</u>	<u>TGCS</u>
1	REMOTE	329	181	5056
2	SENSING	324	176	4943
3	SATELLITE	216	108	2597
4	DATA	174	113	3487
5	USING	168	88	2432
6	SATELLITES	118	55	1154
7	EARTH	77	22	525
8	MONITORING	66	37	674
9	SURFACE	66	58	1505
10	BASED	65	33	920
11	SYSTEM	59	27	1131
12	SPACE	57	18	442
13	ANALYSIS	55	13	471
14	LAND	55	28	961
15	RADAR	53	30	631
16	OBSERVATIONS	50	13	695

Conclusion

This study facilitates the scientometric analysis of Remote Sensing research output from 1975 – Feb 2010. During this period, 1188 papers have been published. The average number of publications per year is 38.07. There are 59 countries doing research in this area. The USA is ranked first, followed by the UK and India is ranked third place. The most preferred language is English (98.5%), most preferred media is journal article (77.5%). In this study, the authorship pattern shows that more than thirty authors has been jointly published 4 papers.

Scientometric studies help the researcher and scientist to know the growth, development and research impact of particular field of research to know countries, institution and scientist individually.

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