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Ionosphere, Magnetosphere and Geomagnetism (IMG): A Quantitative and Qualitative Study

Md. Nurul Alam
Library and Information Science, School of Social Science, IGNOU, New Delhi – 110068
&
Library and Information Services, Physical Research Laboratory,
(Unit. of Department of Space, Govt. of India)
Navrangpura, Ahmedabad- 380009, India.

ABSTRACT

The present study explores the characteristics of the literature and growth of Ionosphere Magnetosphere and Geomagnetism (IMG) research in India during 1960-2014, based on Web of Science (WoS) database and make quantitative and qualitative assessment by way of analysing various features of research output by using the scientometric techniques. A total of 2748 journal articles were published on Ionosphere Magnetosphere and Geomagnetism (IMG), which received total 20705 citations. The average number of publications per year is 119.40 and Compound Annual Growth Rate (CAGR) is 6.96% and the average number of citations per publication was 7.53. The publications peaked in the year 2014 with 504 publications and the highest number of citations (3248) was in 2006. This study analyzes the research studies based on year of publication, journal, international collaboration, spatial distribution and keyword occurrence frequency. The results of this work reveal that the publication on the Ionosphere Magnetosphere and Geomagnetism (IMG) have grown high at a slow rate over the past 54 years and the curve fits the polynomial curve with $R^2 = 0.863$. Publications on Ionosphere Magnetosphere and Geomagnetism (IMG) appeared in 267 journals of which most active journal was "Journal of Geophysical Research Space Physic" published by American Geophysical Union

originating from USA and 324(11.790 %) of the total 2748 publications. A total of 3332 authors contributed on Ionosphere Magnetosphere and Geomagnetism (IMG) research. The most active author was Rastogi RG produced maximum no. of publications 165(6.004%) of total publications. 1073 institutions contributed of which Indian Institute of Geomagnetism; Mumbai, India is the most productive institution. For globalization of Ionosphere Magnetosphere and Geomagnetism (IMG) Research in India, the results show there were 73 Countries/territories which participated in Ionosphere Magnetosphere and Geomagnetism (IMG) research. USA produced maximum publications 274 that is 9.971% of total publication with higher citations (4978). A Keyword analysis reveals that "Plasma", "waves", "Irregularities" and "F-region". are the most used keywords.

Keywords: Ionosphere, Magnetosphere, Geomagnetism, Quantitative Study, Qualitative Study, Citation Indicator, Bibliometric Indicator, INDIA

1. Introduction

Space Science research in India started through the studies in scientific astronomy in India is known to date back at least to the 5th century astronomer-mathematician Aryabhata. A new development took place in the 1920s when S.K. Mitra in Calcutta initiated interesting activities in radio research. Space science took a more organised approach with scientists, Homi Bhabha and Sarabhai. Both of them founded an institution each for the basic research, namely The Tata Institute of Fundamental research in Bombay by Bhabha in 1945 and the Physical Research Laboratory (PRL) in Ahmedabad by Sarabhai in 1947 which were a sucess and thus yielded productive results. PRL had two primary concerns. One, long-term monitoring of secondary cosmic rays – the muons and neutrons at sea level as a function of latitude and longitude and two, the upper atmospheric studies over low latitudes, including meterology, ionosphere investigations, geomagnetism and solar-terrestial relations.

For the first time, discovery of reflections from meteor trails by the Research Department of All India Radio Tashkent were observed. With the Colaba Observatory in Bombay in 1823, studies of the geomagnetic field begun at various stations all over India. Equatorial Rocket Launching Station at Thumba acted as the starting point for a variety of international collaborations with scientists from UK, USA, France, West Germany, USSR and Japan and did considerable amount of work on equatorial aeronomy and X-ray astronomy. In late sixties, under an agreement with France, India started fabricating Centaure Rockets at the Bhabha Atomic Research Centre, Bombay. Rockets were used for studies related to the neutral atmospheric winds and temperatures using sodium vapor cloud and chaff payloads. Magnetic fields were measured by proton precession magnetometers, and electric fields by barium release technique. Which further lead to giving results on the equatorial electrojet and ionosphere, ionisation irregularities, the neutral atmosphere and a number of the other parameters (Daniel, 1992).

There has been increasing importance of the research on Ionosphere, Magnetosphere and Geomagnetism (IMG) over the last few decades but a question arises what is the present status of Ionosphere, Magnetosphere and Geomagnetism (IMG) research in India? Which institutions are involved? To address these question an attempts to provide a qualititative as well as quantative assessment of the current status and trends of this research by using Scientometric technique.

2. Database, Methodology and scope

To assess the trend of research publication on Ionosphere, Magnetosphere and Geomagnetism (IMG) research and locate and collect the literature i.e. journal articles

only, Web of Science (WoS) was used. The Search Strategy used to conduct Web of Science (WoS) search is as mentioned below:

TS= "Ionosphere" OR "Magnetosphere" OR "Geomagnetism"= (Search Term) ; Where TS is a topic search that retrieves occurrences of the search term in the article title, abstract, keywords within a time span of 1960-2014, were used to locate publications that contained these words in publications' titles, abstracts, and keyword lists.

3. Results and Analysis

There were 2748 articles that met the selection criteria which appeared in the WoS database during 1960-2014 and these were analyzed. The specific characteristics of the publications such as no. of publications, the no. authors involved in the production of these publication, institutions, journals etc were taken into consideration.

3.1 Publication characteristics of Indian IMG Research during 1960-2014.

The total 2748 articles of Indian scientists during 1960-2014 were abstracted from WoS related to IMG Science publication. From Table 1 and 2, the output of 2748 paper received a total of 20705 citations during the said period with an average 7.53 citations per paper. The average number of publications per year is 63.90 and Compound Annual Growth rate (CAGR) is 6.96%

Table 1: Bibliographic Record of IMG Science research in India during study period

Bibliometric indicators `	No.
Total Article found:	2748
Total No. of Countries contribution	73
Total No. of Author's contribution	3332
Total No. of Institution's contribution	1073
Total No. of Journal appeared	267
Total No. of Keywords (raw) appeared	5885

Source: WoS

Table 2: Citation Metrics of IMG research in India

Citation-based Bibliometric indicators	No.
Total Article found:	2748
Sum of the Times Cited	20705
Sum of Times Cited without self-citations	14278
Citing Articles	11098
Citing Articles without self-citations	9355
Average Citations per Item	7.53
h-index	48

Source: WoS

3.2. Publication Pattern

Publication Pattern of IMG research from 1960 to 2014 is presented in figure 1. The lowest (9) and highest (152) numbers of publications were in 1972 and 2014.It is important to mention here that initial publication observed in the year 1972. A near about 16 time's increase was observed over the study period, (from 9 in 1972 to 152 in 2014).

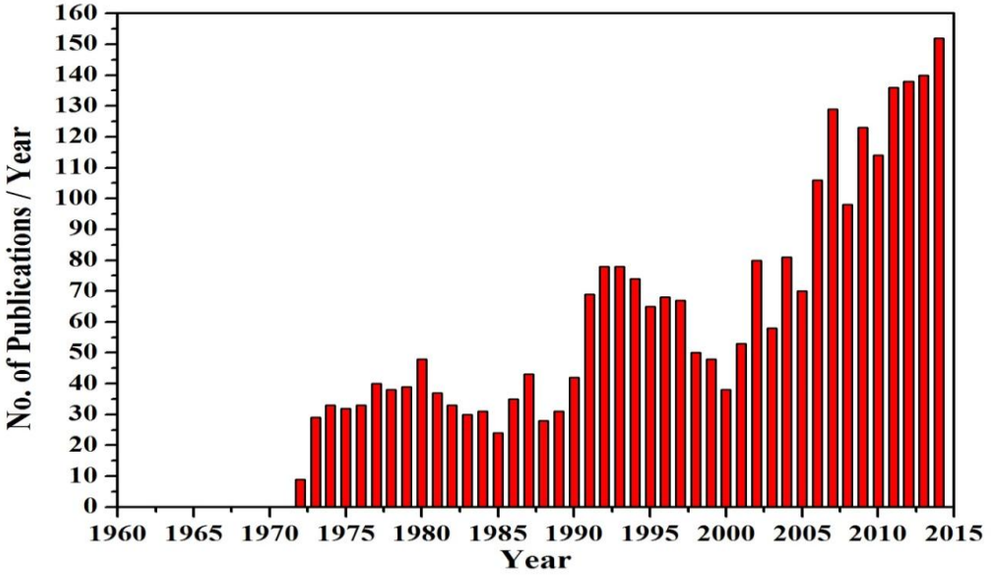

Figure 1: Publications pattern of IMG research in India during 1960-2014

3.3. Growth Pattern

The cumulative progression was represented by a 3rd degree power law distribution during 1960-2014 giving an idea of the polynomial growth rate (Figure 2). The fit produced a high regression coefficient (Table 3) of determination to the collected data ($R^2 = 0.863$). The polynomial best fit as shown in table 3 for IMG research was found to be: $y = 0.003x^3 - 22.50x^2 + 44692x - 3E+07$, where y is the cumulative number of publications and x is the number of years since 1960.

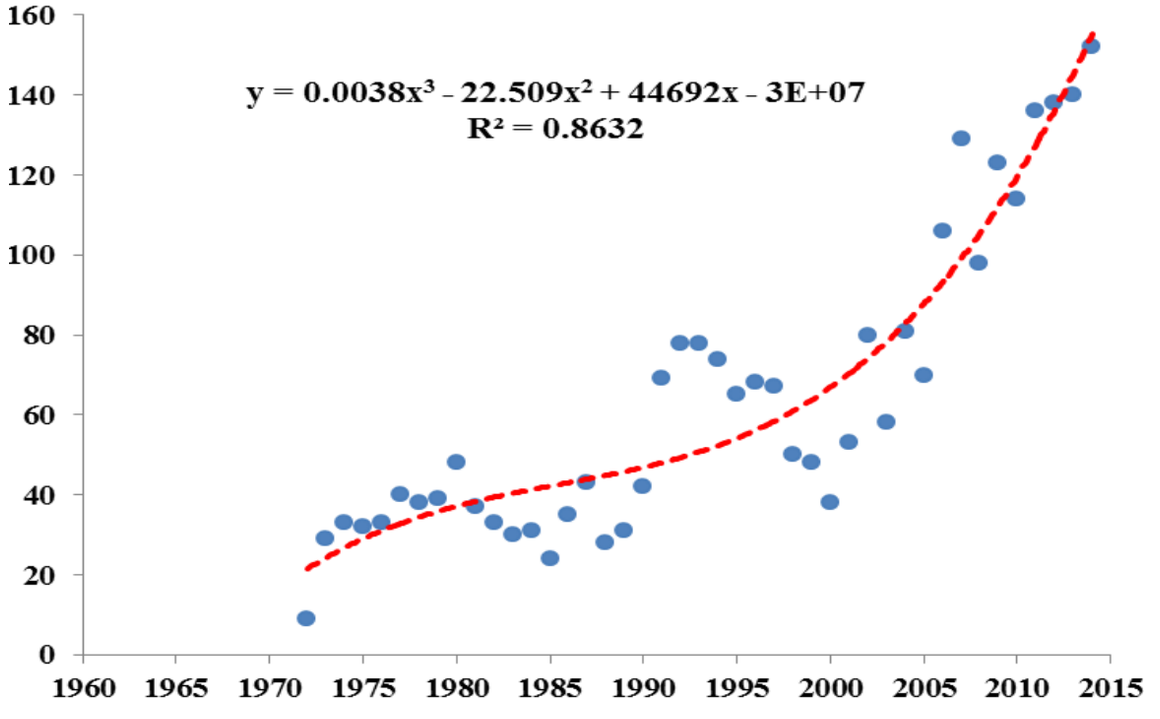

Fig 2: Growth pattern of IMG research in India during 1960-2014.Blue dot describe the distribution of publication (observed value) and red dashed line describe the correlation of distribution of publication where regression coefficient $R^2 = 0.863$

Table 3: Different Regression Type with Regression coefficient

[Table-3] See in ANNEXURE (Tables)

The growth of literature shown in figure 2 can be divided into 2 parts, in 1st part (1960-1971) there is no literature published by Indian scientist as (India) is an affiliation country found in Web of Science (WoS). In 2nd part (1972-2014), follows polynomial growth rate which indicate that the number of papers concerning IMG research were growing at a high but slow growth rate

3.4. Citation pattern

Fig 3 and 4 represents the year wise growth of citations received by Indian author and total no. of publications per year and no. of citations per year during 1960-2014 on IMG research. The total 2748 articles of Indian scientists during 1960-2014 were abstracted from WoS related to IMG research publication which received a total of 20705 citations.

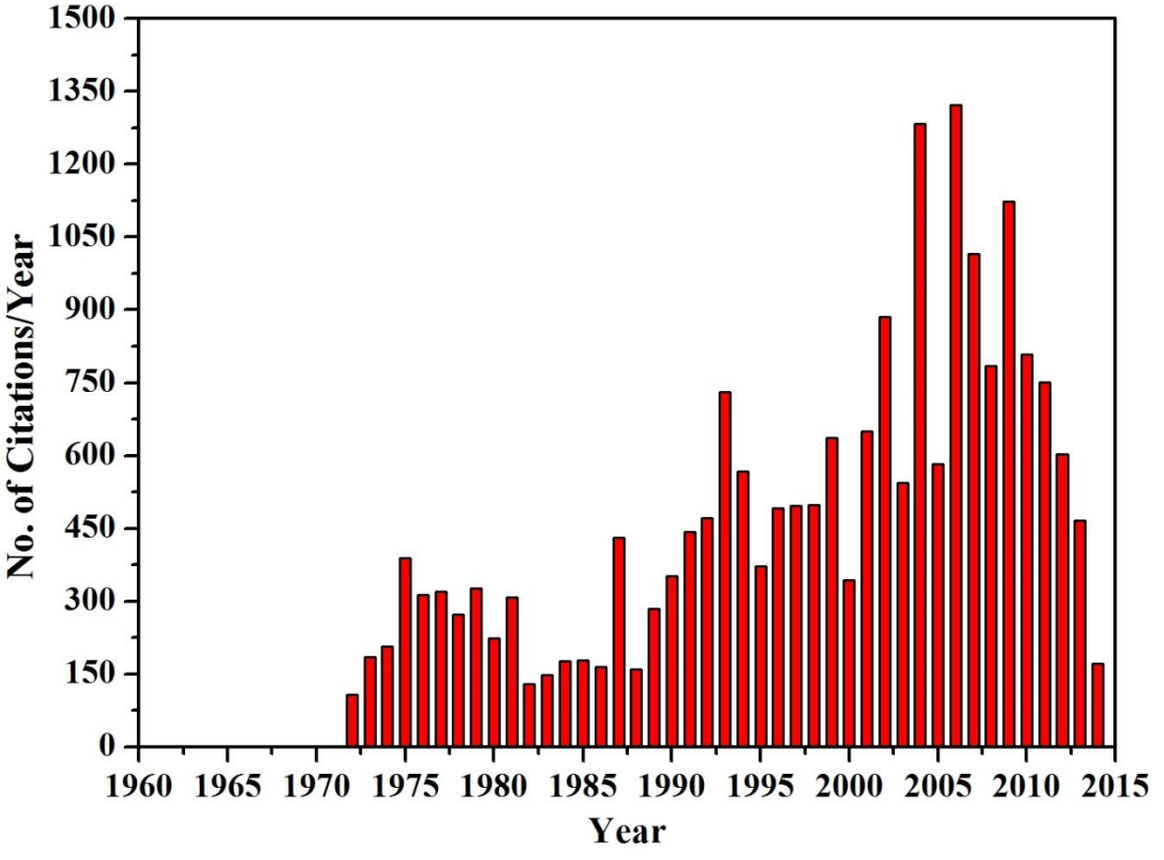

Figure 3: Citation Pattern of IMG research in India during 1960-2014

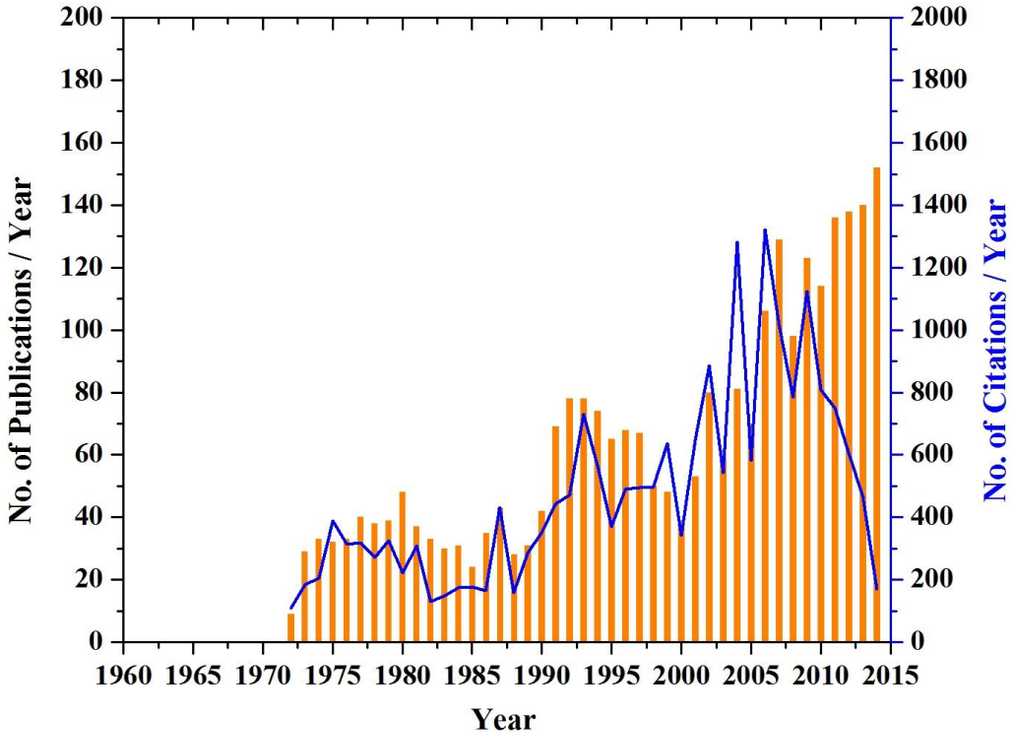

Fig 4: Citation pattern of IMG research in India during 1960-2014: no. of publications Vs no. citations. Blue line (right Y axis) indicate the citation pattern against orange bar describe the publication pattern.

The pattern of citation received during the said year is very fluctuating .In the starting year 1972, the total number of citation received 108 which is also a minimum citation during the said period with an average citation 12.The maximum citation received in the year 2006 is 1322 with average citation 12.47. It is important to note here that after the year 2009 publication increases but citation decreases.

3.5 Top Institutions and their research impact

The contribution of different institutions was estimated by affiliated institution of at least one author. A total of 2748 articles on IMG research appeared from 1073 institutions. Out of 1073 institutions, 580 institutions appeared once and 161 institutions appeared twice. Table 4 shows the top 20 productive institutions during the last 54 years, 1960-2014. Out of these top 20 institutions, 16 institutions are Indian

institutions. Indian Institute of Geomagnetism which contributed highest publication had published 532 paper followed by Physical Research Laboratory (401),Vikram Sarabhai Space Center VSSC (232), National Physics Laboratory (207), Banaras Hindu University (160) and Indian Institute of Astrophysics (98). Comparatively less research was published by Barkatullah University 45 followed by University of Delhi 47, Gujarat Univ 50, Indian Institute of Technology IIT Delhi 54 and University of Kerala 56. while the other 4 are foreign institutions. Among these three belong to USA namely National Aeronautics Space Administration (NASA), Goddard Space Flight Center and California Institute of Technology; another to France namely Centre National De La Recherche Scientifique CNRS,

Table 4: Top Institutions and their research impact

[Table -4] See in ANNEXURE (Tables)

TP= Total no. of IMG related articles published by an institution; **TC** = Total no. of citation received; **AvgCPA**= Average no. of citations per article; h**-index**=defined by the no. of h papers among an institution's no. of publications that have at least h citations each. **Source: WoS**

Table 4 reveals the impact of research in terms of quality of papers. The AgCPA (the average no. of citation per article) indicates the average impact of articles published by a institution and the h-index (defined as the no. of h papers among a institution's no. of publications that have at least h citation each) are used to identify which institution has the largest no. of high quality articles in the IMG research. It is seen from the above table that IMG research related articles authored in foreign institution (National Aeronautics Space Administration, USA) have the highest average impact (AvgCPA=19.55).Among Indian institution, Tata Institute of Fundamental Research highest average impact (AvgCPA=17.28) in AvgCPA index.

3.6 Top Journals and their research impact

IMG research papers appeared in 267 journals. Papers have appeared in highest no. in the journal "Journal of Geophysical Research Space Physic" published by American Geophysical Union originating from USA. Table 5 shows the top 20 productive journals. These 20 out of the 267 journals had published 1871 of the total 2748 articles. The "Journal of Geophysical Research Space Physic" ranked first with 324(11.790 %); "Indian Journal of Radio Space Physics 216 (7.860%)"," Journal of Atmospheric and Solar Terrestrial Physics 175 (6.368%)", "Advances in Space Research 150(5.459 %)", "Annales Geophysicae 128(4.658 %)"; ranked at 2nd, 3rd, 4th, and 5th, respectively.

Table 5: Top 20 Journals and their research impact

[Table-5] See in ANNEXURE (Tables)

TP= Total no. of IMG related articles published by a Journal (followed by the percentage of IMG related articles in the journal of a total IMG related articles); **TC** = Total no. of citation received ; **AvgCPA**= Average no. of citations that IMG related articles in a journal received ; **h-index**= no. of h papers among a journal's no. of publications that have at least h citations each. **SJR** = SCImago Journal Rank is weighted by the prestige of a journal. Subject field, quality and reputation of the journal have a direct effect on the value of a citation. SJR also normalizes for differences in citation behavior between subject fields; **IPP** = Impact per Publication (IPP) measures the ratio of citations per article published in the journal; **SNIP** = Source Normalized Impact per Paper measures contextual citation impact by weighting citations based on the total number of citations in a subject field. **Source: WoS and SCOPUS**

Table 5 shows the citation impact on top 20 journals. The AvgCPA (Average no. of citations that IMG related articles in a journal received and the h-index (defined by the no. of h papers among a journal's no. of publications that have at least h citations each) are used to identify which journals have the largest no. of high quality articles in the IMG research. It is seen from the above table that the journal "Astrophysical Journal" published by IOP Publishing for the American Astronomical Society in USA has

the highest average impact (AvgCPA=20.98) although the journal "Journal of Geophysical Research Space Physics" has the highest no. of publication but ranked 4th in the AvgCPA index.

3.7 Top most Prolific Authors and impact of their research output

A total of 2748 articles included the author addresses. Articles on IMG research have been contributed by 3332 authors. Top 20 productive authors were ranked based on the no. of total articles. Rastogi, RG produced maximum no. of publications 165 of total publications with ranked first followed by Lakhina, GS ; Singh, RP; Singh, AK ; Sridharan R ; ranked at 2nd , 3rd , 4th and 5th respectively. Table 6 showed the top 20 productive authors during the last 54 years, 1960-2014.

Table 6: Top most Prolific Authors and impact of their research output

[Table-6] See in ANNEXURE (Tables)

TP(%): Total no. of IMG related articles published by a author (followed by percentage of IMG related articles by a author of the total IMG related article) **TC:** Total no. of citation**; TC woSc:** Sum of Times Cited without self-citations**; CI:** Citing Articles **; CIwoSC:** Citing Articles without self-citations**; AvgCPA:** Average Citations per Article**; h-index :** no. of h papers among a author's no. of publications that have at least h citations each. **Source: WoS**

Table 6 reveals the impact of research in terms of quality of papers. The AvgCPA (the average no. of citation per article) indicates the average impact of articles published by an institution and the h-index used to identify which author has the largest no. of high quality articles in the IMG research. It is seen from the above table 4 that IMG research related articles authored by Lakhina, GS have the highest average impact (AvgCPA=15.24) followed by Devasia, CY (AvgCPA=12.13) although Rastogi, RG ranked 5th in the AvgCPA index.

3.8 Top Cited Publication in IMG research in India during 1960-2014

Table 7: Top 20 most Prolific papers and impact of their research output

[Table-7] See in ANNEXURE (Tables)

Citation Style: APA (6th edition); **TC**: Total Citations; **AgC:** Average Citations

3.9 Spatial Distribution of Indian IMG research Publications at Globel Level

Based on the author attributions, we can map the world-wide geographic distribution of IMG research publication. As shown in figure 5, the major spatial clusters of research institutes located in Europe followed by Asia, Africa and South America. Minor clusters distributed in North America and Australia.

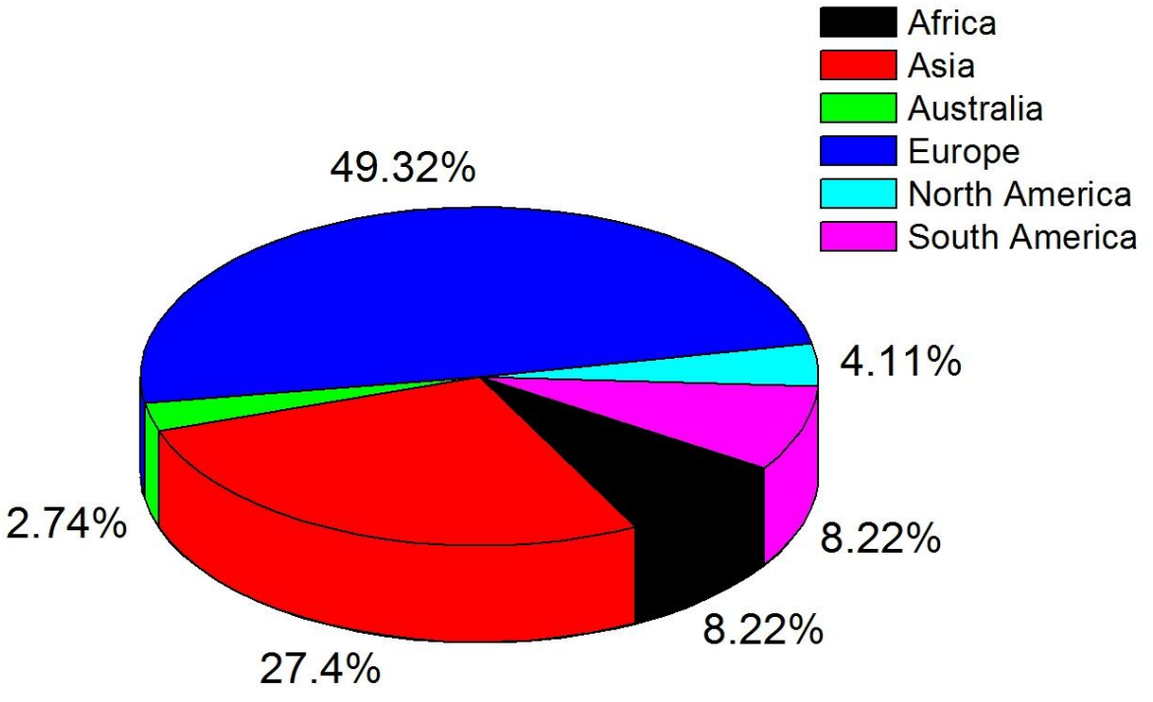

Figure 5: Geographic distribution of IMG research publication

2748 articles which included author address, source country and research institute. There were 73 collaborating Countries/territories except India which participated in

IMG research. Out of the 2748 papers, 1650 (60.04%) papers appeared in India's own publications without international collaboration and the remaining 1098 (39.95%) appeared with international collaboration. Out of 73 Countries/territories there are two countries with which the collaboration is high, over 100 publications: United States (274) and Japan (114) and three countries with medium-high collaboration, over 50 publications: England (73), Brazil (67) and Germany (56) and there are 5 countries with little collaboration over 25 publications and rest of 27 Counting just 1–2 collaborations, 25 with just 3–10 and 11 with just 11-25.

3.10 Top Countries International Collaborations and impact of their research output

Top 20 countries / territories were ranked based on the no. of total articles, along with the citations, percentage of internationally collaboration publications (Table-8). Out of these 20 countries / territories, The USA produced maximum publication 274 that is 9.971% of total publication with higher citations (4978).The AvgCPA (the average no. of citation per article) indicates the average impact of articles published by a country and the h-index (define as the no. of h papers among a country's no. of publications that have at least h citation each) are used to identify which country has the largest no. of high quality articles in the IMG research. It is seen from the below table 8 that IMG research related articles authored in Italy (Europe) have the highest average impact (AvgCPA=50.58) followed by Australia AvgCPA=29.20 although USA ranked 8th in the AvgCPA index. Data regarding international research collaboration shows that it become more prevalent during study period and fruits of cooperation contributed to the overall scientific output in various countries and in the broad field of IMG research (Niu et. al., 2014).

Table 8: Countries working collaboratively with Indian institutions on IMG research during period 1960-2014.

[Table-8] See in ANNEXURE (Tables)

TP= Total no. of IMG related articles published by a country (followed by the percentage of Stellar Physics related articles in the country of a total IMG related articles); **TC** = Total no. of citation received; **AvgCPA**= Average no. of citations; **h-index**= no. of h papers among a country's no. of publications that have at least h citations each. **Source: WoS**

3.11 Analysis of keywords

Keyword analysis in research paper is very interesting in order to follow and identify the trends in the science and engineering branch (Montoya et. al, 2014). As a result of our work a total of 5885 different keywords, from 1960 to 2014 in the IMG have been identified. The no. of analysed publications during the study period was 2748. In order to acquire correct results, the keywords with same meanings and in singular and plural forms were merged. A total 54747 unique Keywords are obtained. Among these unique keywords 1587 (28.99 %) appear once or twice at the most, we can deduce that this can be a sign of lack of research continuity or of a wide range of research focus. Table 9 shows the most used keywords during the considered period.

3.11.1 Top most frequently used keywords for the study period

The top 20 most frequently used keywords for the study period are listed in Table 9. With the exception of ''Ionosphere", "Magnetosphere'' and "Geomagnetism", which is the search word in this study, the four most frequently used keywords were ''Plasma'', ''waves'', ''Irregularities'' and "F-region".

Table 9: **Top 20 most frequently used keywords for the study period**

[Table-9] See in ANNEXURE (Tables)

NO: Number of time occurrences; R : rank; **Source: WoS**

3.11.2 Quick rising themes

To identify the top most frequently occurring keywords and quick rising themes, the Compound Annual Growth Rate (CAGR) was put to use. The quick rising theme can symbolise the future research trends. The Compound Annual Growth Rate (CAGR) of top 20 keywords was calculated using the below mentioned formula:

$$\mathrm{CAGR}(t_0, t_n) = (V(t_n)/V(t_0))^{\frac{1}{t_n - t_0}} - 1$$

$V(t_0)$: Initial observed value, $V(t_n)$: last observed value, $t_n - t_0$: number of years ("Compound annual growth rate," 2016).

The CAGR provides smoothed growth rates free from the annual fluctuations of keywords occurrences during the study period (Niu et. al., 2014). Table 10 lists the top 20 keywords according to the CAGR and sorted them by their rank. The ranks in the said table show that ''Waves'' and ''Plasma'' and "TEC" are three leading fields which attract more attention. ''Waves'' (CAGR, 14.72%) is dominant quantity and annual growth rate respectively.

Table 10: Top Quick rising themes for the study period

[Table-10] See in ANNEXURE (Tables)

t0: the Initial (first) year (The Year in which no. of keywords occurrence first time) ; **tn**: the last year (No. of keywords occurrence); **V(t0)**: Initial observed value (no. of keywords occurrence); **V(tn)**: last observed value (no. of keywords occurrence); **CAGR(%):** Compound Annual Growth Rate (CAGR); **R:** Rank. **Source: WoS**

4. Conclusion:

Results of this study relating to the scientometric analysis of the research on the IMG research during 1960-2014 provided helpful insights into the research on the IMG fields in many fronts including the patterns of publication outputs, journals, geographic and institutional contributions, and the keyword frequencies. In total 2748 journal articles were published during the investigation period. The following conclusions have been drawn from this study:

(1) IMG related research has significantly increased in the last 54 years. The growth curve fit 3rd degree polynomial with the R^2 = 0.863. This growth has been at a slow rate but significantly high though not exponential in nature. It is concluded that the growth is on a rise and will surely increase further.

The results also provided valuable information on the citations made to the IMG research papers. Total Number of Citations, Average Citations per Item, and H-index. There were 20705 total citations with 7.53 average citations to 2748 papers on the IMG research from this study. The research field has had a significant impact on the general literature with H-index of 48, a rough measure of its impact.

(2) A total of 267 journals had published 2748 articles on IMG. The most active journal was "Journal of Geophysical Research Space Physic" published by American Geophysical Union originating from the USA, it published 324(11.79 %) papers and "Indian Journal of Radio Space Physics published 216 (7.860 %) papers. The results also provided valuable information on the citations received by the journals. The

journal “Astrophysical Journal” published by IOP Publishing for the American Astronomical Society in USA has the highest average impact (AvgCPA=20.98) although the journal “Journal of Geophysical Research Space Physics” has the highest no. of publication but ranked 4th in the AvgCPA index.

(3) A total of 2748 Articles on IMG appeared from 1073 institutions. Indian Institute of Geomagnetism which contributed highest articles had published 532 papers followed by Physical Research Laboratory (401), Vikram Sarabhai Space Center VSSC (232). It is found that IMG related articles authored in foreign organizations (National Aeronautics Space Administration NASA) have the highest average impact (AvgCPA=19.55), Among Indian institutions, Tata Institute of Fundamental Research has the highest average impact (AvgCPA=17.28) in AvgCPA index.

(4) A total of 3332 authors contributed to the IMG research. The most active author was Rastogi, RG, who produced maximum no. of publications 165 of total publications 2748 ranked first followed by Lakhina, GS ; Singh, RP; Singh, AK ; Sridharan R. It is important to note that IMG related articles authored by Lakhina, GS have the highest average impact (AvgCPA=15.24) followed by Devasia, CY (AvgCPA=12.13) whereas Rastogi, RG ranked 5th in the AvgCPA index.

(5) For globalization of IMG Research in India, 73 Countries/territories participated in IMG research. USA produced maximum publications 274 followed by Japan (114) and England (73). Italy (Europe) have the highest average impact (AvgCPA=50.58) followed by Australia AvgCPA=29.20 although USA ranked 8th in the AvgCPA index

(6) The keyword analysis of the studied publications revealed the hot direction and quick rising themes of IMG research. ‘‘Plasma’’, ‘‘waves’’, ‘‘Irregularities’’ and “F-region” were the hottest issues of IMG research. There are 20 top quick rising themes which calculated by CAGR. ‘‘Waves’’, ‘‘Plasma’’, “TEC” and “Geomagnetic storm” are four leading hot issues that continue to attract broad attention.

References

1. Daniel, R. R. (1992). Space Science in India. Indian Journal of History of Science, 27(4), 485–499.
2. Montoya, F .G et. al. (2014). The Research on Energy in Spain: A scientometric approach. Renewable and Sustainable Energy Reviews, 29,173-183.
3. Compound annual growth rate (2016). . In Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Compound_annual_growth_rate
4. Niu, B., Loáiciga, H. A., Wang, Z., Zhan, F. B., & Hong, S. (2014). Twenty years of global groundwater research: A Science Citation Index Expanded-based bibliometric survey (1993–2012). *Journal of Hydrology*, *519, Part A*, 966–975. http://doi.org/10.1016/j.jhydrol.2014.07.064

ANNEXURE (Tables)

Ionosphere, Magnetosphere and Geomagnetism (IMG): A Quantitative and Qualitative Study

Table 3:

Regression Type	Equation	Regression (R^2)
Exponential	$y = 2E\text{-}34e^{0.041x}$	$R^2 = 0.741$
Linear	$y = 2.560x - 5039$	$R^2 = 0.739$
Logarithmic	$y = 5098.\ln(x) - 38668$	$R^2 = 0.737$
Polynomial	$y = 0.003x^3 - 22.50x^2 + 44692x - 3E+07$	$R^2 = 0.863$
Power	$y = 7E\text{-}26x^{81.79}$	$R^2 = 0.741$

Table - 4

Institution	Region	TP (%)	TC	AvgCPA	h-index
Indian Institute of Geomagnetism	Indian	532(19.360)	4156	7.81	27
Physical Research Laboratory	Indian	401(14.592)	3782	9.43	28
Vikram Sarabhai Space Center	Indian	232(8.443)	2407	10.38	24
National Physics Laboratory	Indian	207(7.533)	1430	6.91	19
Banaras Hindu University	Indian	160(5.822)	713	4.46	14
Indian Institute of Astrophysics	Indian	98(3.566)	1266	12.92	20
National Aeronautics Space Administration	USA	94(3.421)	1838	19.55	23
Andhra University	Indian	88(3.202)	573	6.51	13
National Atmospher Research Laboratory	India	83(3.020)	465	5.60	11
University of Calcutta	Indian	81(2.948)	305	3.77	9
Tata Institute of Fundamental Research	Indian	65(2.365)	1123	17.28	2
National Geophysical Research Institute	Indian	61(2.220)	518	8.49	13
Instituto Nacional De Pesquisas Espaciais	Brazil	61(2.220)	857	14.05	15
University of Kerala	Indian	56(2.038)	614	10.96	15
Indian Institute of Technology IIT Delhi	Indian	54(1.965)	301	5.57	9
Gujarat University	Indian	50(1.820)	261	5.22	9
University of Delhi	Indian	47(1.710)	153	3.26	6
Goddard Space Flight Center	USA	46(1.674)	983	21.37	17
California Institute of Technology	USA	46(1.674)	872	18.96	18
Barkatullah University	Indian	45(1.638)	196	4.36	8

Table - 5

				Journal Metrics (2013)			
Journal	TP (%)	TC	AvgCPA	SJR	IPP	SNIP	Country
Journal of Geophysical Research Space Physics	324(11.790)	3400	10.49	-	-	-	USA
Indian Journal of Radio Space Physics	216(7.860)	449	2.08	0.408	0.604	0.487	India
Journal of Atmospheric and Solar Terrestrial Physics	175 (6.368)	1126	6.43	0.890	1.397	0.889	UK
Advances in Space Research	150(5.459)	689	4.59	0.727	1.506	1.237	Netherlands
Annales Geophysicae	128(4.658)	1234	9.64	0.996	1.441	0.855	Germany
Geophysical Research Letters	98(3.566)	1451	14.81	2.896	4.014	1.413	USA
Planetary and Space Science	83(3.020)	814	9.81	1.018	1.890	0.922	UK
Current Science	75(2.729)	275	3.67	0.293	0.841	0.771	India
Earth Planets and Space	73(2.656)	392	5.37	1.465	2.122	0.996	Japan
Journal of Geomagnetism and Geoelectricity	68(2.475)	387	5.69	-	-	-	Japan
Physics of Plasmas	63(2.293)	495	7.86	0.947	1.623	1.020	USA
Astrophysics and Space Science	62(2.256)	200	3.23	0.760	1.750	1.028	Netherlands
Annales Geophysicae Atmospheres Hydrospheres and Space Sciences	61(2.220)	738	12.10	-	-	-	Germany
Radio Science	58(2.111)	448	7.72	0.994	1.265	1.078	USA
Annales De Geophysique	52(1.892)	371	7.13	-	-	-	France
Earth Moon and Planets	46(1.674)	42	0.91	0.254	0.660	0.600	Germany
Proceedings of the Indian Academy of Sciences Earth and Planetary Sciences	43(1.565)	145	3.37	0.467	1.152	0.939	India
Astrophysical Journal	37(1.346)	708	19.14	2.808	4.494	1.192	UK
Indian Journal of Physics	30(1.092)	104	3.47	0.349	1.174	0.801	India
Advances in Space Research Series	29(1.055)	104	3.59	-	-	-	UK

Table - 6

Author	TP (%)	TC	TC woSC	CI	CIwoSC	AvgCPA	h-index
Rastogi, R.G.	165(6.004)	1585	1183	852	727	9.61	20
Lakhina, G.S.	105(3.821)	1600	1358	954	881	15.24	22
Singh, R.P.	82(2.984)	404	292	244	197	4.93	13
Singh, A.K.	82(2.984)	272	167	179	127	3.32	9
Sridharan, R.	78(2.838)	776	634	500	452	9.95	15
Patra, A.K.	70(2.547)	534	317	275	213	7.63	13
Chandra, H.	67(2.438)	573	511	455	420	8.55	14
Pant, T.K.	64(2.329)	366	299	270	235	5.72	11
Sastri, J.H.	58(2.111)	665	591	472	438	11.47	17
Gwal, A.K.	53(1.929)	241	223	216	203	4.55	8
Mahajan, K.K.	52(1.892)	291	261	240	218	5.60	10
Kumar, S.	52(1.892)	225	189	179	155	4.33	8
Dabas, R.S.	52(1.892)	498	418	354	319	9.58	13
Gurubaran, S.	51(1.856)	396	339	275	247	7.76	11
Arora, B.R.	51(1.856)	311	264	222	193	6.10	9
Pathan, B.M.	49(1.783)	308	266	243	222	6.29	9
Ravindran, S.	48(1.747)	403	356	309	281	8.40	11
Rao, D.R.K.	47(1.710)	389	363	338	321	8.28	10
Devasia, C.V.	46(1.674)	558	502	384	355	12.13	14
Rangarajan, G.K.	45(1.638)	159	117	120	97	3.46	7

Table 7:

S.N	Bibliography	TC	AgC
1	Iyemori, T., & Rao, D. R. K. (1996). Decay of the Dst field of geomagnetic disturbance after substorm onset and its implication to storm-substorm relation. *Annales Geophysicae-Atmospheres Hydrospheres and Space Sciences*, *14*(6), 608–618. http://doi.org/10.1007/s005850050325	154	7.7
2	Tsurutani, B. T., Gonzalez, W. D., Lakhina, G. S., & Alex, S. (2003). The extreme magnetic storm of 1-2 September 1859. *Journal of Geophysical Research-Space Physics*, *108*(A7), 1268. http://doi.org/10.1029/2002JA009504	130	10
3	Desilets, D., Zreda, M., & Prabu, T. (2006). Extended scaling factors for in situ cosmogenic nuclides: New measurements at low latitude. *Earth and Planetary Science Letters*, *246*(3-4), 265–276. http://doi.org/10.1016/j.epsl.2006.03.051	127	12.7
4	Deshpande, A. A., & Rankin, J. M. (1999). Pulsar magnetospheric emission mapping: Images find implications of polar cap weather. *Astrophysical Journal*, *524*(2), 1008–1013. http://doi.org/10.1086/307862	124	7.29
5	Singh, S. V., & Lakhina, G. S. (2001). Generation of electron-acoustic waves in the magnetosphere. *Planetary and Space Science*, *49*(1), 107–114. http://doi.org/10.1016/S0032-0633(00)00126-4	115	7.67
6	Gladstone, G. R., Waite, J. H., Grodent, D., Lewis, W. S., Crary, F. J., Elsner, R. F., … Cravens, T. E. (2002). A pulsating auroral X-ray hot spot on Jupiter. *Nature*, *415*(6875), 1000–1003. http://doi.org/10.1038/4151000a	94	6.71
7	Gangadhara, R. T., & Gupta, Y. (2001). Understanding the radio emission geometry of PSR B0329+54. *Astrophysical Journal*, *555*(1), 31–39. http://doi.org/10.1086/321439	92	6.13

8	RAO, N. (1993). LOW-FREQUENCY WAVES IN MAGNETIZED DUSTY PLASMAS. *Journal of Plasma Physics*, *49*, 375–393.	91	3.96
9	Rastogi, R., & Patel, V. (1975). Effect Of Interplanetary Magnetic-Field On Ionosphere Over Magnetic Equator. *Proceedings of the Indian Academy of Sciences Section A*, *82*(4), 121–141.	88	2.15
10	Kremer, J., Boezio, M., Ambriola, M. L., Barbiellini, G., Bartalucci, S., Bellotti, R., … Zampa, N. (1999). Measurements of ground-level muons at two geomagnetic locations. *Physical Review Letters*, *83*(21), 4241–4244. http://doi.org/10.1103/PhysRevLett.83.4241	85	5
11	Rastogi, R., & Klobuchar, J. (1990). Ionospheric Electron-Content Within The Equatorial F2 Layer Anomaly Belt. *Journal of Geophysical Research-Space Physics*, *95*(A11), 19045–19052. http://doi.org/10.1029/JA095iA11p19045	83	3.19
12	Balan, N., Bailey, G., Jenkins, B., Rao, P., & Moffett, R. (1994). Variations Of Ionospheric Ionization And Related Solar Fluxes During An Intense Solar-Cycle. *Journal of Geophysical Research-Space Physics*, *99*(A2), 2243–2253. http://doi.org/10.1029/93JA02099	70	7
13	Bhardwaj, A., Elsner, R. F., Gladstone, G. R., Cravens, T. E., Lisse, C. M., Dennerl, K., … Kharchenko, V. (2007). X-rays from solar system objects. *Planetary and Space Science*, *55*(9), 1135–1189. http://doi.org/10.1016/j.pss.2006.11.009	70	3.18
14	Bellotti, R., Cafagna, F., Circella, M., De Marzo, C. N., Golden, R. L., Stochaj, S. J., … Ricci, M. (1999). Balloon measurements of cosmic ray muon spectra in the atmosphere along with those of primary protons and helium nuclei over midlatitude. *Physical Review D*, *60*(5), 052002. http://doi.org/10.1103/PhysRevD.60.052002	68	7.56
15	Rao, P. V. S. R., Krishna, S. G., Niranjan, K., & Prasad, D. S. V. V. D. (2006). Temporal and spatial variations in TEC using simultaneous measurements from the Indian GPS network of receivers during the low solar activity period of 2004-2005. Annales Geophysicae, 24(12), 3279–3292.	66	3.88
16	Sridharan, R., Raju, D., Raghavarao, R., & Ramarao, P. (1994). Precursor to Equatorial Spread-F in OI-630.0-Nm Dayglow. *Geophysical Research Letters*, *21*(25), 2797–2800. http://doi.org/10.1029/94GL02732	63	6.3
17	Chandra, H., & Rastogi, R. (1972). Equatorial Spread-F Over A Solar-Cycle. *Annales De Geophysique*, *28*(4), 709–715.	63	2.86
18	Rajaram, M., & Mitra, S. (1981). Correlation Between Convulsive Seizure And Geomagnetic-Activity. *Neuroscience Letters*, *24*(2), 187–191. http://doi.org/10.1016/0304-3940(81)90246-9	61	1.39
19	Lakhina, G. S., Kakad, A. P., Singh, S. V., & Verheest, F. (2008). Ion- and electron-acoustic solitons in two-electron temperature space plasmas. *Physics of Plasmas*, *15*(6), 062903. http://doi.org/10.1063/1.2930469	59	1.69
20	BALAN, N., BAILEY, G., & JAYACHANDRAN, B. (1993). Ionospheric Evidence For A Nonlinear Relationship Between The Solar Euv And 10.7 Cm Fluxes During An Intense Solar-Cycle. *Planetary and Space Science*, *41*(2), 141–145. http://doi.org/10.1016/0032-0633(93)90043-2	57	7.12

Table - 8

Country	Continent	TP (%)	TC	AvgCPA	h-index
USA	North America	274(9.971)	4978	18.17	36
Japan	Asia	114(4.148)	1399	12.27	21
England	Europe	73(2.656)	1950	26.71	24
Brazil	South America	67(2.438)	861	12.85	15
Germany	Europe	56(2.038)	1072	19.14	18
France	Europe	41(1.492)	841	20.51	17
Australia	Australia	40(1.456)	1168	29.20	16
Russia	Europe	37(1.346)	578	15.62	14
Taiwan	Asia	35(1.274)	223	6.37	7
Canada	North America	29(1.055)	433	14.93	13
South Africa	Africa	23(0.837)	418	18.17	10
Italy	Europe	19(0.691)	961	50.58	13
Peoples R China	Asia	17(0.619)	248	14.59	8
South Korea	Asia	16(0.582)	95	5.94	5
Sweden	Europe	14(0.509)	472	33.71	10
Poland	Europe	14(0.509)	213	15.21	7
Netherlands	Europe	14(0.509)	219	15.64	7
Hungary	Europe	13(0.473)	126	9.69	5
Fiji	Australia	12(0.437)	39	3.25	3
Belgium	Europe	12(0.437)	300	25.00	9

Table - 9

Keywords	NO	%	Ranking
Disturbances	103	1.88	13
Drifts	89	1.62	16
Electric-fields	101	1.84	14
Emissions	89	1.62	16
Equatorial electro jet	82	1.49	17
F-region	158	2.88	5
Instability	138	2.52	7
Ionization	81	1.47	18
Irregularities	248	5.43	3
Latitudes	109	1.99	12
Magnetic equator	54	0.98	19
Magnetic-field	156	2.84	6
Plasma	449	8.20	1
Propagation	135	2.46	8
Radiation	115	2.10	9
Scintillations	90	1.64	15
Spread-f	179	3.27	4
TEC	110	2.00	11
Thermosphere	113	2.06	10
Waves	364	6.64	2

Table - 10

Keywords	V (t0)	V (tn)	t0	tn	CAGR (%)	R
Disturbances	3	11	1991	2014	5.81	19
Drifts	2	8	1992	2014	6.50	16
Electric-fields	2	8	1991	2014	6.21	17
Equatorial electro jet	1	9	1991	2014	10.02	10
F-region	5	20	1991	2014	6.21	17
Ionization	3	12	1991	2014	6.21	17
Irregularities	7	26	1991	2014	5.87	18
Latitudes	1	11	1990	2014	10.51	7
Magnetic-field	1	10	1990	2014	10.07	9
Plasma	1	39	1987	2014	14.53	2
Propagation	1	13	1988	2014	10.37	8
Radiation	1	7	1991	2014	8.83	11
Spread-f	5	23	1991	2014	6.86	15
TEC	1	18	1990	2014	12.80	3
Thermosphere	1	13	1991	2014	11.80	5
Waves	1	27	1990	2014	14.72	1
Airglow	2	11	1991	2014	7.69	14
Anomalies	1	7	1990	2014	8.45	13
Bubbles	1	11	1991	2014	10.99	6
Electron-density	2	5	1996	2014	5.22	20
Equatorial spread f	2	8	1991	2014	6.21	17
Geomagnetic storm	1	12	1992	2014	11.96	4
Geomagnetic activity	1	4	1997	2014	8.50	12