Bibliometric analysis of research in the field of Earth System Science

Ministry of Earth Sciences, Government of India

December 2017

सत्यमेव जयते
Ministry of Earth Sciences
Government of India

Clarivate Analytics

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FOREWORD

India, one of the fastest growing economies of the world, is also a leading country in Science & Technology research and innovation. India's scholarly output has shown tremendous growth of 11.8% (Compound Annual Growth Rate) during 2006-2015, a sharp increase from 5.6% (1995 to 2005). Research & Development plays a pivotal role in shaping the economy of a country and overall national development. Expert analysis of global research outputs is an essential prerequisite to understand global structure and dynamics of research and development, and integrate it into policy documents. Latest tools and techniques of *Bibliometrics* and *Scientometrics* are routinely used for such analysis.

Understanding the importance of this activity, a project was taken up for the first time in the Ministry of Earth Sciences (MoES) to carry out intensive analysis of research landscape of Earth System Science in India and the world, in two time periods: 1996-2005 and 2006- 2015. Publication of the report titled ***"Bibliometric analysis of research in the field of Earth System Science"*** is the outcome towards that end. The report will help to understand research and development scenario in Earth System Science, and the position of India in international landscape. It will, no doubt, provide an opportunity to realize our strengths and weaknesses better, and tap the opportunities in right earnest. We can also implement corrective measures to improve Research & Development outputs.

It is expected that the analysis will also contribute significantly to improve the quality of services being provided by MoES in the areas of Weather, Climate, Ocean and Seismology.

I congratulate the MoES team for bringing out this report.

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Acknowledgement:

We wish to acknowledge with thanks the valuable contribution and guidance imparted by MoES Expert Committee in shaping the outcome of this study.

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We would also like to give special thanks to Dr. M. Rajeevan, Secretary, Ministry of Earth Sciences (MoES), Government of India for giving further valuable insights.

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TABLE OF CONTENTS

List of Tables

List of Figures

List of common abbreviations used in the report

CMLRE	Centre for Marine Living Resources and Ecology
ESSO	Earth System Science Organization
ICMAM	Integrated Coastal and Marine Area Management
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
INCOIS	Indian National Centre for Ocean Information Services
JIF	Journal Impact Factor
JSC	Journal Subject Category
mNCI	Mean Normalized Citation Impact
MoES	Ministry of Earth Sciences, Government of India
NCAOR	National Centre for Antarctic and Ocean Research
NCESS	National Center for Earth Science Studies
NCI	Normalized Citation Impact
NCMRWF	National Centre for Medium Range Weather Forecasting
NIOT	National Institute of Ocean Technology
USA	United States of America
UK	United Kingdom
SWOT	Strengths, weaknesses, opportunities, and threats

1 EXECUTIVE SUMMARY

This report was commissioned by the Indian Government's Ministry of Earth Sciences (MoES) and produced by Clarivate Analytics to analyze the volume and quality of research activity and international collaboration in global research in Earth System Science. In addition, India's performance in this research field and evaluation of MoES institutes were provided.

1.1 KEY FINDINGS

Part I Global Earth System Sciences Research

- Overview of global research
  - Global research in Earth System Science published 340,905 papers between 1996 and 2005 and 571,616 papers between 2006 and 2015, a nearly 70% increase between the two decades. The proportion of internationally collaborative papers also increased from 27.6% to 36.7%.
  - The proportion of highly-cited Papers and mean Normalized citation impact (mNCI) in both periods remained unchanged at approximately 11% and 1.13 respectively.
  - Between 1996-2005 and 2006-2015, the level of international collaboration increased in the most recent period in all six subject areas.
- Annual research output and citation impact
  - Among six subject areas: Geo Research (553,699) was ranked first by paper volume, followed by Ocean Research (230,930) and Atmospheric Research (166,664). Antarctic Research (16,367), Arctic Research (16,024), and Himalayas Research (6,170) all had significantly smaller number of papers.
  - Annual research output in all subject areas increased in the 20 year period, especially between 2006 and 2015.
  - Citation impact of papers in Geo Research, Ocean and Atmospheric was all above the world average and remained relatively stable in the entire 20-year period. Among these three subject areas with large research output, Geo Research papers (mNCI=1.20) had the highest average citation impact.
  - Arctic Research papers had the highest citation impact (mNCI=1.30) in the second ten-year periods among all subject areas respectively. In Himalayas Research, annual output of papers nearly tripled in the 2006-2010 period compared to that of the 1996-2005 period. Citation impact of these papers was below 0.85, the lowest in all subject areas.
- Top countries ranked by output and citation impact

- Countries in North America, Europe and Asia Pacific ranked relatively higher in output and citation impact. In all six subject areas except Himalayas Research, the United States (USA) led in research output.
- India ranked first in research output in Himalayas Research.
- The USA, the United Kingdom (UK), France, Germany and Canada were among the countries that led in both paper volume and citation impact.
- Measured by output of papers, between 2006 and 2015, China ranked second in Geo Research, Atmospheric Research, and Ocean Research and third in Himalayas; it is a dramatic improvement from the previous decade. India increased research output too, particularly in Himalayas Research. However, neither country was ranked in the top countries by citation impact.

- Top Journals ranked by Journal Impact Factor (JIF)
  - In Geo Research, Ocean Research and Atmospheric Research, there were a substantial amount of papers published in multidisciplinary journals with high JIF such as Nature, Science.
  - The research in Antarctic, Arctic and Himalayas was less covered in multidisciplinary journals, but more in more specialized journals with relatively low JIF.
- Internationally Collaborative papers
  - Both the number of internationally collaborative papers and its share in total output increased in all subject areas. The share increased at a faster pace in the first 10-year period. Given that the total research output in each subject area also increased, it is reasonable to conclude that the increase of international collaboration outpaced that of the overall research.
  - Antarctic Research and Arctic Research had over 40% of papers published out of international collaboration, which was the highest among all subject areas. Himalayas Research had the lowest share of internationally collaborative papers in each decade, at 24% and 28% respectively.
- Most common international collaborating country pairs
  - Most of the highest productive international collaborating country pairs involved the USA.
  - USA had the most productive partnership with UK, Canada, Germany, and France. The USA-UK pair ranked the highest in both 10-year periods by collaborative output in Geo Research and Antarctic Research. The USA-Canada pair achieved the same in Ocean Research and Arctic Research.
  - Countries such as Norway (Arctic Research) and India (Himalayas Research) were important partners in international research collaboration in subject areas that they had strong performance.

Part II Earth System Science Research of India

- Overview of India's research
  - India more than doubled its research output from 8,753 to 19,938 between the two 10-year periods.
  - Citation impact of India's papers, by mNCI, increased from 0.62 to 0.72, and the share of international collaboration in India's research increased from 22.6% to 29.9%. However, both were below the world average.
  - More than 61% of Himalayas Research had Indian authors, while India's contribution in Arctic Research was relatively low.
- Contribution from Indian funding agencies
  - Between 2-3% of papers in Geo, Atmospheric, Ocean and Antarctic Research areas were funded by Indian funding bodies. Only 0.7% of papers in Arctic Research acknowledged Indian funding agencies, while more than half (51.3%) in Himalayas research was funded (partially funded) by India.
  - In each subject area, except Antarctic and Arctic Research, the highest amounts of India's highly-cited papers were funded by Indian government funding agencies. Department of Science and Technology (DST), MoES, Council of Scientific and Industrial Research (CSIR), and Department of Space (DoS) were the important funders among them.
  - Foreign funders in the USA, Europe and Japan were also active in India's highly-cited papers, mostly through international collaboration.
- India's International collaboration
  - India mainly collaborated with countries in North America, Europe, and Asia pacific.
  - The USA was India's most important research partner, ranked the highest by collaborative papers in the two 10-year periods of all subject areas, except in Antarctic Research (1996-2005). Japan also had a high level collaboration with India; Japan had published the highest number with India in Antarctic Research between 1996 and 2015 and also ranked second in at least one period in Atmospheric, Geo and Arctic Research.
  - As a result, India's top international collaborating institutions were mainly from USA and Europe. In Asia, Japanese and Chinese institutions were also important.
- The share of Indian papers in world's highly-cited papers
  - India's share in world's highly cited papers is generally low in all categories (top 1%, top 5%, top 10%, and top 25%), and normally lower than the share of Indian papers in total research.
  - In Geo Research, Ocean Research, and Atmospheric Research India's share in the top 10% and top 25% categories slightly increased over time. But, its number of top 1% highly-cited papers was small.

- India had no or few top 1% or top 5% papers in most years in Antarctic and Arctic Research.

- Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of Indian research
  - Web of Science Journal Subject Categories (JSC) were used as proxy for subdisciplines in each Subject area to identify Strengths, Weaknesses, opportunities and Treats in Indian's research.
  - In Geo research, "Geography" is an opportunity for India. JSCs such as "Water Resources", "Environmental Sciences", "Engineering,Geological", "Geosciences,Multidisciplinary", and "Meteorology & Atmospheric Sciences" were threats. "Mineralogy", "Geography, Physical", "Geology", and "Geochemistry & Geophysics" were India's weaknesses.
  - Antarctic Research and Arctic Research share a similar SWOT profile because of the extensive overlap of JSCs (nine out of 10). "Environmental Sciences", "Geosciences,Multidisciplinary" and "Meteorology & Atmospheric Sciences" were India's threats. Another seven JSCs were weaknesses.
  - Among all JSCs of Himalayas Research, Indian papers were cited less than word average (mNCI=1). In six JSCs that were determined as threats, India had a larger than world average share of output in each with the largest in "Agronomy". Its performance in the other four JSCs, "Geography, Physical", "Ecology", "Geology", and "Geochemistry & Geophysics", were characterized as weaknesses.

Part III MoES Institutes

- Overview of MoES institutes
  - Three MoES institutes published more than 300 Web of Science indexed papers each; IITM (1,248), IMD (755) and NCAOR (310).
  - NIOT (271) and NCESS (254) and NCMRWF (215) each published more than 200 papers between 1996 and 2015.
  - ICMAM (67) and CMLRE (46) published less than 100 papers over the period covered by this report.
  - Papers published by IITM had the highest citation impact (mNCI=0.86), followed by INCOIS (mNCI = 0.80) and NIOT (mNCI=0.75)
- Annual research output and citation impact
  - In the 20-year period, all institutes increased the output of papers over time. IITM, IMD, NCAOR, and NIOT all had substantial amount of papers published annually in the most recent years.
  - Citation impact of these Institute's papers also increased in general, though with fluctuations.
- International collaborating institutions
  - Overall, top collaborating institutions of MoES were primarily from the USA, Japan, the UK, France, and Germany. Institutions from other countries ranked high by collaborating papers

include National Autonomous University of Mexico and King Abdulaziz University (Saudi Arabia). They had productive partnership with IMD and NCMRWF respectively.

- Institutions in the USA and Europe had more collaborating papers ranked highly by citation impact.

- SWOT analysis
  - SWOT analysis was conducted on seven MoES institutes which had more than 100 papers published in total.
  - NCESS had strength in “Mineralogy” and an opportunity in “Optics”.
  - INCOIS and NIOT both had strengths in “Engineering, Ocean”. In addition, INCOIS had only two weaknesses, the least of all institutes.
  - IITM and IMD did not have identified strengths, but each had an opportunity in “Environmental Sciences” and “Geography, Physical” respectively.

2 INTRODUCTION

2.1 BACKGROUND

The Ministry of Earth Sciences (MoES) of India is interested in understanding research trend in the field of Earth System Science between 1996 and 2015. The following six subject areas that are most relevant to MoES' agenda and mission were selected as representative of the field:

- Geo-science and Technology (Geo Research)
- Atmospheric Science and Technology (Atmospheric Research)
- Ocean Science and Technology (Ocean Research)
- Antarctic Research
- Arctic Research
- Himalayas Research

In each of the six subject areas, we will profile research activity and impact, in which research and funding performance of India is highlighted. In addition, 9 selected institutions and centers of MoES will be assessed.

2.2 ABOUT THE MINISTRY OF EARTH SCIENCES

MoES provides services in forecasting the monsoons and other weather/climate parameters, ocean state, earthquakes, tsunamis and other phenomena related to earth systems through well integrated programmes. The Ministry also deals with science and technology for exploration and exploitation of ocean resources (living and non-living), and plays a central role in Antarctic/Arctic and Southern Ocean research.

The governmental organization in this function was originally created as the Department of Ocean Development (DOD), a part of the Cabinet Secretariat, in July 1981. DOD came into existence as a separate Department in March 1982. Through a series of mergers and re-organizations, the new MoES came into being on July 12, 2006.

MoES implements its mission through its executive arm, the Earth System Science Organization (ESSO). ESSO promotes research and development in four branches of earth system science: (i) Ocean Science & Technology (ii) Atmospheric and Climate Science and (iii) Geoscience and Technology and (iv) Polar Science and Cryosphere.

2.3 ABOUT CLARIVATE ANALYTICS

Clarivate Analytics accelerates the pace of innovation by providing trusted insights and analytics to customers around the world, enabling them to discover, protect and commercialize new ideas faster. We own and operate a collection of leading subscription-based services focused on scientific and academic research, patent analytics and regulatory standards, pharmaceutical and biotech intelligence,

trademark protection, domain brand protection and intellectual property management. Clarivate Analytics is now an independent company with over 4,000 employees, operating in more than 100 countries and owns well-known brands that include *Web of Science™*, *Cortellis™*, *Derwent™*, *CompuMark®*, *MarkMonitor®* and *Techstreet ™*, among others. For more information, visit clarivate.com.

Clarivate Analytics Research Data & Services team provides reporting and consultancy services within Research Analytics using customized analyses to bring together several indicators of research performance in such a way as to enable customers to rapidly make sense of and interpret a wide-range of data points to facilitate research strategy decision-making. We have extensive experience with databases on research inputs, activity and outputs and have developed innovative analytical approaches for benchmarking, interpreting and visualization of international, national and institutional research impact.

For over half a century we have pioneered the world of citation indexing and analysis, helping to connect scientific and scholarly thought around the world. Today, academic and research institutions, governments, not-for-profits, funding agencies, and all others with a stake in research, need reliable, objective methods for managing and measuring performance.

Our consultants have up to 20 years of experience in research performance analysis and interpretation. In addition, the Clarivate regional Sales team will provide effective project management and on-site support to maximize values of our projects and meet the expectations of MoES.

2.4 SCOPE OF THIS REPORT

The analyses and indicators presented in this report have been specified to provide an analysis of global research in Earth System Sciences and how Indian and MoES institutes performed against benchmarks for research management purposes:

- Section 3 describes the data sources and methodology used in this report along with definitions of the indicators and guidelines for interpretation.
- Section 4 explains the methodology of how six subject areas of Earth System Sciences were defined and how the associated papers were identified.
- Section 5 summarises, in each subject area, the trends of global research, in terms of publication number, citation impact, and other metrics. The time frame of this report, between 1996 and 2015, is divided into two periods. Research trend between periods is compared.
- Section 6 profiles India's performance and benchmarked it against the global trend.
- Section 7 evaluates 10 MoES' institutions and centers.

In addition to this report, please refer to the volume 2 of this report which provides supporting tables for this report.

3 METHODOLOGY AND DATA SOURCES

This section outlines key concepts and methodology. Additional description of bibliometric methodology is provided in the Appendix.

3.1 DEFINITIONS

Papers/publications: Clarivate Analytics abstracts publications including research journal articles, editorials, meeting abstracts and book reviews. The terms "paper" and "publication" are often used interchangeably to refer to printed and electronic outputs of many types. In the analyses presented here, the term "paper" is used exclusively to refer to substantive journal articles, reviews and some proceedings papers and excludes editorials, meeting abstracts or other types of publication. **Papers** are the subset of publications for which citation data are most informative and which are used in calculations of citation impact.

Research field: Standard bibliometric methodologies use Web of Science journal categories or **InCites: Essential Science Indicators**[SM] fields as a proxy for research fields.[1] Essential Science Indicators aggregate data at a higher level than the journal categories – there are only 22 Essential Science Indicators research fields compared to 252 journal categories. Journals are assigned to one or more categories, and every article within that journal is subsequently assigned to that category. Papers from prestigious, "multidisciplinary" and general medical journals such as *Nature*, *Science*, *The Lancet*, *The BMJ*, *The New England Journal of Medicine and the Proceedings of the National Academy of Sciences* (PNAS) are assigned to specific categories based on the journal categories of the references cited in the article. The selection procedures for the journals included in the citation databases are documented at the Clarivate Analytics master journal list website.

Highly cited publications: Highly cited work is recognized as having a greater impact and Clarivate Analytics has shown that high citation rates are correlated with other qualitative evaluations of research performance, such as peer review. In the analysis presented here, publications that are in the top 10% in terms of citation frequency, taking into account year of publication and field, are considered to be highly cited. This threshold was selected after the review of a number of previous analyses showed this to be a useful value for general management purposes.

Co-authorship of publications: The metadata associated with every research publication include the addresses of the authors. It is thus possible to develop an analysis of the organizations that co-author publications by extracting and examining these data. Co-authorship is generally accepted as an indicator of collaboration, although there are collaborations that do not result in co-authored publications and co-

[1] Essential Science Indicators are defined by a unique grouping of journals with no journal being assigned to more than one field. These fields are focused on the science, technology, engineering and medicine subjects and arts & humanities subjects are excluded. Customized analyses, however, can be designed to include these as an additional category.

authored publications which involve limited collaboration. Conceivably other indicators of collaboration such as co-funding and international exchanges could be used but comprehensive and consistent data are not available.

Internationally collaborative publications: The number of internationally collaborative research publications is increasing rapidly. This is because such collaboration provides access to a wider range of resources, including intellectual resources, and accelerates the rate of discovery as well as increasing the intellectual content and therefore the impact of individual outputs. For this reason, internationally collaborative publications tend to be more highly cited than those that are solely domestic. In the analysis, publications will be considered to be international if more than one country is included in the addresses associated with a paper.

Strengths, weaknesses, opportunities, and threats (SWOT): Bibliometric analysis can be used to determine strengths, weaknesses, opportunities, and threats in a research portfolio by research area. This is done by comparing the institution's subject area output and normalized citation impact to the world's average output and performance. ***Strengths*** are subject areas of high citation impact and with a relatively large share of institutional research output. ***Weaknesses*** are subject areas that are poorly cited relative to similar research at a global level that do not form a significant part of the institutional research portfolio. ***Opportunities*** are subject areas of high normalized citation impact relative to the world but with a lower share of the institutional research portfolio. ***Threats*** are subject areas that are poorly cited relative to similar research but form significant parts of the institutional research portfolio.

Figure 3.1.1 shows an example SWOT diagram based on an institution's outputs, showing which ESI categories are strengths, weaknesses, opportunities, and threats when compared to global output.

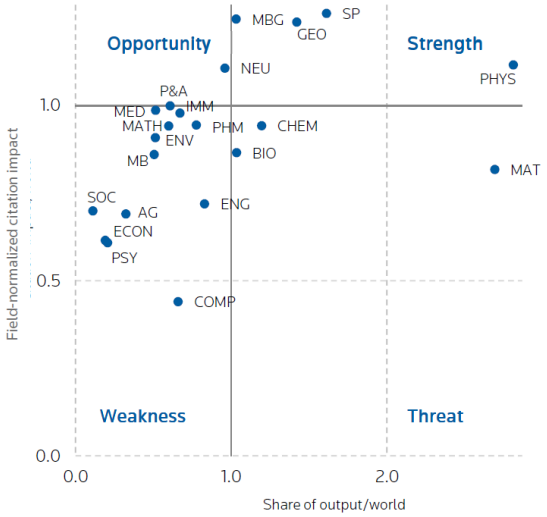


Figure 3.1.1 Example SWOT diagram

3.2 DESCRIPTIONS OF DATA SOURCES

For the bibliometric analysis, data were sourced from the databases underlying the **Web of Science**, which gives access to conference proceedings, patents, websites, and chemical structures, compounds and reactions in addition to journals. It has a unified structure that integrates all data and search terms together and therefore provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The **Web of Science Core Collection** is part of the Web of Science, and focuses on research published in journals and conferences in science, medicine, arts, humanities and social sciences. The authoritative, multidisciplinary content covers over 18,000 of the highest impact journals worldwide, including over 3,800 Open Access journals and over 187,000 conference proceedings. Coverage is both current and retrospective in the sciences, social sciences, arts and humanities, in some cases back to 1900. Within the research community, these data are often still referred to by the acronym "ISI".[2] Clarivate Analytics has extensive experience with databases on research inputs, activity and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

3.3 METRICS

Citation count: The citation count is the number of times that a citation has been recorded for a given publication since it was published. Not all citations are necessarily recorded since not all publications are indexed. However, the material indexed by Clarivate Analytics is estimated to attract about 95% of global citations.

Citation impact: "Citations per paper" is an index of academic or research impact (as compared with economic or social impact). It is calculated by dividing the sum of citations by the total number of papers in any given dataset (so, for a single paper, raw impact is the same as its citation count). Citation count declines in the most recent years of any time-period as papers have had less time to accumulate citations (i.e., papers published in 2007 will typically have more citations than papers published in 2010).

Normalized Citation Impact (NCI): Citation rates vary between research fields and with time. Consequently, analyses must take both field and publication year into account. In addition, the type of publication will influence the citation count. For this reason, only citation counts of papers (as defined above) are used in calculations of citation impact. The standard normalization factor is the world average citations per paper for the year and journal category in which the paper was published. This normalization is also referred to as "rebasing" the citation count.

[2] The origins of citation analysis as a tool that could be applied to research performance can be traced to the mid-1950s, when Eugene Garfield proposed the concept of citation indexing and introduced the Science Citation Index, the Social Sciences Citation Index and the Arts & Humanities Citation Index, produced by the Institute of Scientific Information – ISI (now Clarivate Analytics).

Mean normalized citation impact (mNCI): The mean normalized citation impact (mNCI) indicator for any specific dataset is calculated as the mean of the NCI of all papers within that dataset. For worldwide research, the mNCI is 1.

3.4 BIBLIOMETRICS AND CITATION ANALYSIS

Research evaluation is increasingly making wider use of bibliometric data and analyses. Bibliometrics is the analysis of data derived from publications and their citations. Publication of research outcomes is an integral part of the research process and is a universal activity. Consequently, bibliometric data have a currency across subjects, time and location that are found in few other sources of research-relevant data. The use of bibliometric analysis, allied to informed review by experts, increases the objectivity of, and confidence in, evaluation.

Research publications accumulate citation counts when they are referred to by more recent publications. Citations to prior work are a normal part of publication and reflect the value placed on a work by later researchers. Some papers get cited frequently and many remain uncited. Highly cited work is recognized as having a greater impact and Clarivate Analytics has shown that high citation rates are correlated with other qualitative evaluations of research performance, such as peer review. This relationship holds across most science and technology areas and, to a limited extent, in social sciences and even in some humanities subjects.

Indicators derived from publication and citation data should always be used with caution. Some fields publish at faster rates than others and citation rates also vary. Citation counts must be carefully normalized to account for such variations by field. Because citation counts naturally grow over time, it is essential to account for growth by year. Normalization is usually done by reference to the relevant global average for the field and for the year of publication.

Bibliometric indicators have been found to be more informative for core natural sciences, especially for basic science, than they are for applied and professional areas and for social sciences. In professional areas the range of publication modes used by leading researchers is likely to be diverse as they target a diverse, non-academic audience. In social sciences there is also a diversity of publication modes and citation rates are typically much lower than in natural sciences.

Bibliometrics work best with large data samples. As the data are disaggregated, so the relationship weakens. Average indicator values (e.g., of citation impact) for small numbers of publications can be skewed by single outlier values. At a finer scale, when analyzing the specific outcome for individual departments, the statistical relationship is rarely a sufficient guide by itself. For this reason, bibliometrics are best used in support of, but not as a substitute for, expert decision processes. Well-founded analyses can enable conclusions to be reached more rapidly and with greater certainty, and are therefore an aid to management and to increased confidence among stakeholders, but they cannot substitute for review by well-informed and experienced peers.

3.5 DATA COLLECTION AND DISAMBIGUATION

Organization Unification: Correctly associating research outputs with institutions is an essential component of the analysis process, given that authors represent their institutional affiliations in a variety of ways. The identification of institutions is performed using the author addresses from the Web of Science Core Collection.

Clarivate Analytics has, through its Global Institutional Profiles Project, unified data for over 6,000 institutions worldwide – accounting for the majority of academic research produced. In order to produce these unifications, multiple variants for each institution are considered, weighing input from a network of external advisors employed to correctly assign affiliations. As part of this process, Clarivate Analytics staff may contact institutions to seek verification of specific unification issues and document changes in organizations and how organizations relate to one another (parent-child relationships). Names and entities are updated to reflect organizational changes, and this unification is applied to addresses in new articles published in the Web of Science. This method relies on the accuracy of this information as provided by the authors; reported institutions may have variant names that are not unified.

Wherever possible, Clarivate Analytics used existing institution name unifications (of author-provided address variants) available on the InCites platform for the Web of Science Core Collection. Please refer to the InCites Indicators Handbook under the institution section (http://researchanalytics.thomsonreuters.com/m/pdfs/indicators-handbook.pdf).

For this report, further unification of addresses of institutions was conducted focusing on parent-child relationship that may exist between institutions. Researchers may use names of a parent, a child or both in their papers. Clarivate Analytics selected names of the most appropriate organization in the report.

In summary, there are normally three cases:

- **Case 1**: Parent and child relationship exists between a university system and individual participating universities. For instance, University of California System (parent)/University of California, Berkeley (child). In such cases, only child organization is counted because the child institution is an organization that receives funding and carries out a wide range of academic and research activity independently.
- **Case 2**: Parent and child relationship exists between a government agency and a scientific research body within the agency. Examples include relationship between the United States Department of Interior (parent) and United States Geological Survey (USGS, child) as well as between the United States Department of Commerce (parent) and the National Oceanic and Atmospheric Administration (NOAA, child). In both cases, only USGS and NOAA were used in analysis because they are scientific agencies with missions that are different from other agencies in the same government departments.
- **Case 3**: Parent and child relationship exists between an organization and its subsidiaries institutions, but only parent institutions were used in analysis. The National Aeronautics and Space Administration (NASA) of the United States (USA) is such an example. In their publications, researchers at NASA often list names of both NASA and its many research

laboratories, such as the Goddard Space Flight Center and the Jet Propulsion Laboratory. Since scientific research is an important mission of NASA, all its laboratories were unified under a single entity.

4 IDENTIFICATION OF PAPERS PUBLISHED IN SUBJECT AREAS OF EARTH SYSTEM SCIENCE

This section describes the process by which Web of Science indexed papers were identified in each of the six subject areas in Earth System Science. In addition, the method Clarivate Analytics used to identify India-based funder and to collect papers published by MoES institutions and centres is provided.

4.1 DEFINITION OF SUBJECT AREAS

Earth System Sciences is a branch of science that studies the physical constitution of the earth and its atmosphere. A precise definition of all scientific topics included in the Earth System Sciences may vary by individual scientists. But consensus agrees that it covers the field of research in geology, meteorology, oceanography, and may extend to areas such as astronomy, paleontology, and environmental science. In this report, MoES chose six subject areas to focus on.

- Geo-science and Technology (Geo Research)
- Atmospheric Science and Technology (Atmospheric Research)
- Ocean Science and Technology (Ocean Research)
- Antarctic Research
- Arctic Research
- Himalayas Research

It's worthy of note that research topics of these subject areas are not mutually exclusive. Research in Geo Research may include topics that also belong to Ocean Research or topics that are related to a geographic location, such as the Antarctic.

4.1.1 Papers of Geo Research, Atmospheric Research, and Ocean Research

In this report, papers that are associated with Geo Research, Atmospheric Research, and Ocean Research were identified by using Web of Science Journal Subject Category (JSC). Journals indexed in Web of Science Core Collection are categorized into at least one JSC by journal selection editors at Clarivate Analytics. For these three subject areas, one or more JSCs had been found to sufficiently cover the research topics of the subject areas. Journal papers that were assigned to these JSCs were identified and combined into initial datasets.

The initial datasets were then expanded by including papers of multidisciplinary science journals that are associated with the three subject areas. While multidisciplinary journals publish articles on a wide array of topics, individual articles in those journals focus on one area of research, which may cover the three subject areas of interest. Clarivate Analytics reassigns documents from multidisciplinary journals to their most relevant JSC to allow these specialized articles to be appropriately compared with articles of similar citation characteristics and topic focus.

By using the information found in the cited references of each publication it is possible, in most cases, to algorithmically reassign them to a subject area. In cases where it is not possible to accurately reassign

the publications (for example when the article does not have cited references) the articles are left as multidisciplinary.

For each paper, Clarivate Analytics obtained all the cited references, along with the respective JSC assigned to the journals in which the cited references occur. We then determine which JSC most frequently occurs; the paper is then reclassified to the most frequently occurring category from this distribution.

For example, if the majority of the cited references of a paper published in Multidisciplinary Sciences are documents published in Geoscience journals, the paper will be assigned to Geoscience. Documents will retain the previously assigned categorization under the following circumstances:

- There are no subject areas to rank.
- The most frequently occurring category is the original subject area.
- There is a tie between the top two subject areas.

This reclassification process allows articles to be appropriately compared with articles of similar citation characteristics and topic focus, and was applied to all journal publications that fall in the categories of "Multidisciplinary Sciences".

For this report, papers from multidisciplinary journals will be considered only if reclassification falls into JSCs of the three subject areas. For example, if a paper falls into any of the following subject categories, we will include that paper in Geo Research.

- Geochemistry & Geophysics
- Geosciences, Multidisciplinary
- Geology
- Engineering, Geological
- Mining & Mineral Processing
- Geography
- Geography, Physical

Similarly, Multidisciplinary Science journal papers that were reassigned to JSCs relevant with Ocean Research and Atmospheric Research were also included in the dataset.

4.1.2 Papers of Antarctic Research, Arctic Research, and Himalayas Research

For Antarctic Research, Arctic Research, and Himalayas Research, no individual JSC was identified as closely associated with these subject areas, thus a keyword-based method was used. Specifically, for each subject area, MoES expert provided a list of keywords that was used to query the database underlying Web of Science. Papers that contain at least one subject area specific keyword in article title were obtained.

For each of the six subject areas, a list of JSCs or key terms was provided in the Excel data companion file.

4.2 IDENTIFICATION OF PAPERS THAT ACKNOWLEDGED INDIAN FUNDING AGENCIES

Web of Science indexed papers published from August 2008 and forward contain funding acknowledgement data, from which funders that support the publication can be identified. Although many funders mandate that papers based on the research they have supported must include an acknowledgement, a standardized way to report funder names and grant numbers in papers is still lacking because of policy variations of journals and funding agencies. Names of the same funder may be reported differently in the same journal. Despite the overall high quality funder information in Web of Science, some funders' names may be missing.

In order to identify Indian funding agencies, we applied additional unification process. Clarivate analysts who have extensive knowledge of Indian funding agencies reviewed and unified Indian funders from the dataset that was described above.

4.3 IDENTIFICATION OF PAPERS PUBLISHED BY MOES INSTITUTIONS AND CENTRES

To obtain a complete record of papers that were published by MoES institutions and centers is challenging for two reasons. First, similar to the case of funders, there is a lack of standardization in reporting researcher's affiliation and address. Second, MoES and its predecessor agencies had used several names between 1996 and 2015, and many of the 9 institutions and centers also had name changes and restructures that would result in more name variations that may appear in the papers.

Clarivate Analytics followed a step-by-step process to create a MoES paper dataset.

1. We collected name variations that may exist for each unified name of MoES institutes and centers, following a process that was described in **Section 3.5**.
2. MoES experts had provided a list of historical names of the 10 institutes and centers. In addition, from the MoES website, we searched and downloaded all available annual reports of MoES and its institutes and centers. Publication records in the annual reports were sampled in order to yield additional historical names which were then combined with name variations that appear in Web of Science. From these names, a search string for each institute and center was created and used to query Web of Science and establish a dataset of MoES papers.
3. A data quality control (QC) step was conducted by comparing the search results with publication records in a group of selected annual reports to ensure the dataset had sufficiently good quality. For data QC results, please refer to **A.12**.

Part I. Global Earth System Science Research

5 RESEARCH IN EARTH SYSTEM SCIENCE

This section analyzes global research trend in Earth System Sciences by summarizing research paper output, citation impact, share of highly-cited papers, level of international collaboration and top journals. Data were provided at an annual level or aggregated over a 20-year time frame, split into two 10-year periods: 1996-2015 and 2006-2015.

Analyses for Earth System Science as a whole (**Section 5.1**) include graphs, charts, and interpretative commentary for:

- Number and mNCI of global papers, aggregated by two 10-year periods
- Percentage of highly-cited and internationally collaborative papers, aggregated by two 10-year periods
- Number of global papers in each of the six subject areas, aggregated by two 10-year periods

Analyses for each subject area (**Section** 0 to **Section 7**) include graphs, charts, and interpretative commentary for:

- **Annual number of papers and mNCI over the 20-year time frame**: The citation impact were normalized based on 2016 baseline data
- **Annual percentage of highly-cited papers over the 20-year time frame**: percentage of papers that were cited within the top 10% of world papers.
- **Top 30 countries ranked by output in two 10-year periods:** The countries that produce highest volume of research output. The list of top 30 countries is provided as annexure A13.
- **Top 30 Countries ranked by mNCI in two 10-year periods**: The countries that ranked highest in mNCI. With the exception of Himalayas Research, only countries with more than 50 papers were included. The list of top 30 countries is provided as annexure A14.
- **Top 10 journals with the highest Journal Impact factor (JIF) over the 20-year time frame**: Journals with the highest JIF in this 20-year time frame. Only journals with 100 or higher papers published in a subject area were reported.
- **Annual number and percentage of internationally collaborative papers over the 20-year time frame**: Annual number and percentage of papers that were published by researchers from collaboration that involves two or more countries.
- **Top 10 most common international collaborative country pairs in two 10-year periods**: Top 10 pairs of countries that produced the highest number of collaborative papers.

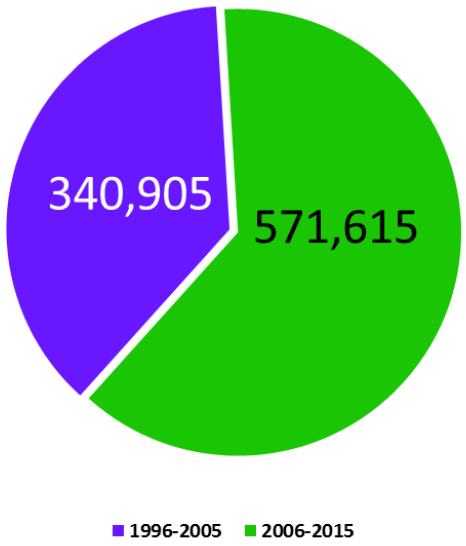
In addition, additional data were presented in Excel companion data file:

- Top 10 institutions of top 30 countries with highest number of papers in two 10-year periods**.**

5.1 OVERVIEW OF RESEARCH IN EARTH SYSTEM SCIENCE

5.1.1 Research output and citation impact of global Earth System Science

Figure 5.1.1 Number and Citation impact of global papers in six subject areas, 1996-2015



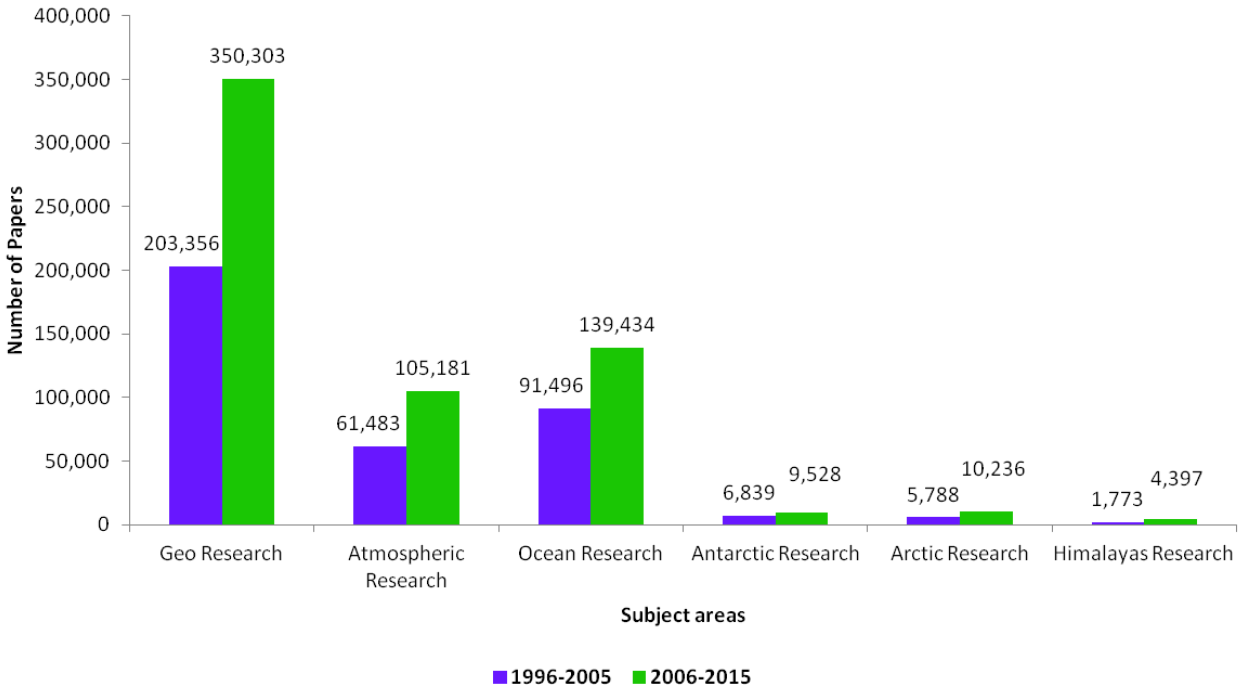
Global research across all six subject areas between 2006 and 2015 produced over half of a million papers (571,615), a nearly 70% increase over the previous decade. In fact, in all six subject areas research output in the second 10-year period had at least a 40% increase. Papers of Himalayas research from 2006 to 2015(4,397) more than doubled the first decade level (1,773). **Table 5.1.1** provides high level statstics of global research which is dicussed in detail in following sub-sections.

Table 5.1.1 Summary statistics of global earth system science

Summary statistics in global research	Time frame	Geo Research	Atmospheric Research	Ocean Research	Antarctic Research	Arctic Research	Himalayas Research
Number of Papers	1996-2005	203,356	61,483	91,496	6,839	5,788	1,773
	2006-2015	350,303	105,181	139,434	9,528	10,236	4,397
Number of Highly-cited Papers	1996-2005	22,614	7,439	10,243	604	698	225
	2006-2015	38,735	11,539	15,236	936	1,501	386
Number of Internationally Collaborative Papers	1996-2005	61,684	16,121	21,117	2,180	1,987	426
	2006-2015	139,774	35,367	41,288	3,906	4,432	1,232

5.1.2 Overview of global research in each of subject area

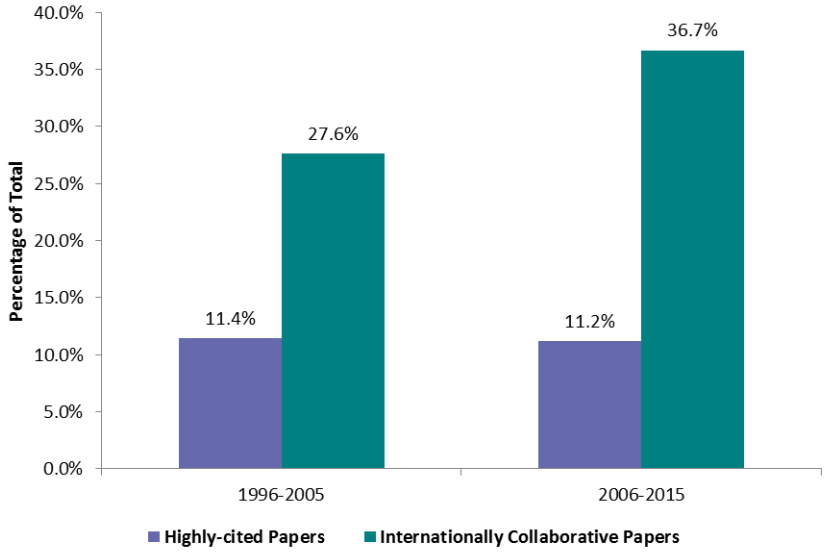
Figure 5.1.2 Number of global papers in each subject area, 1996-2005 and 2006-2015



Within six subject areas, Geo Research had the highest number of papers in both decades (203,356 and 350,303), more than doubled the second highest subject area, Ocean Research. Because of their relatively narrow focus on a geological region, the other subject areas – Antarctic research, Arctic Research and Himalayas Research – produced a considerably smaller number of papers.

5.1.3 Share of highly-cited and internationally collaborative papers

Figure 5.1.3 Percentage of Highly-cited and Internationally Collaborative papers, 1996-2005 and 2006-2015



The share of internationally collaborative papers also increased from just over a quarter (27.6%) to one third. The proportion of highly-cited papers remained approximately 11% in both 10-year periods. Similarly, citation impact of the papers between these two periods were essentially unchanged (mNCI = 1.13 and 1.14 respectively).

Within six subject areas, Geo Research, Atmospheric Research and Ocean Research all had approximately 11% or higher share of highly-cited papers in both decades. The proportion of highly-cited papers varies in the other three subject areas. Arctic Research had the highest share of highly-cited papers; more than 12% in each 10-year period. However, less than one tenth Antarctic Research was cited highly in each period.

In each of the six subject areas, the proportion of internationally collaborative papers increased in 2006-2015 from 1996-2005 period. In the two polar research areas, the proportion of internationally collaborative papers was the highest. However, in Ocean research and Himalayas Research, only less than a third of papers were coauthored by more than one country.

5.1.4 Share of highly-cited and internationally collaborative papers in each of subject areas

Figure 5.1.4 Percentage of highly-cited papers in each subject area, 1996-2005 and 2006-2015

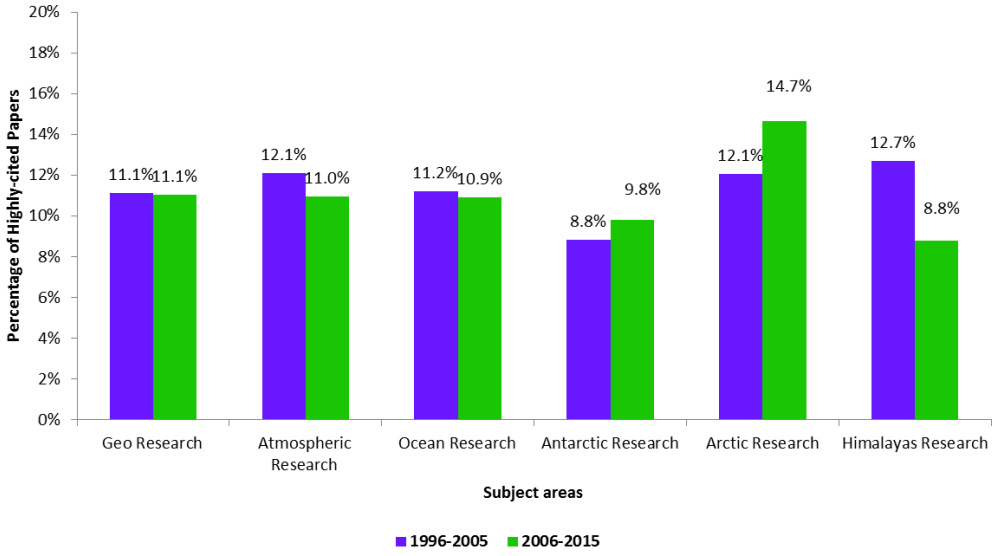
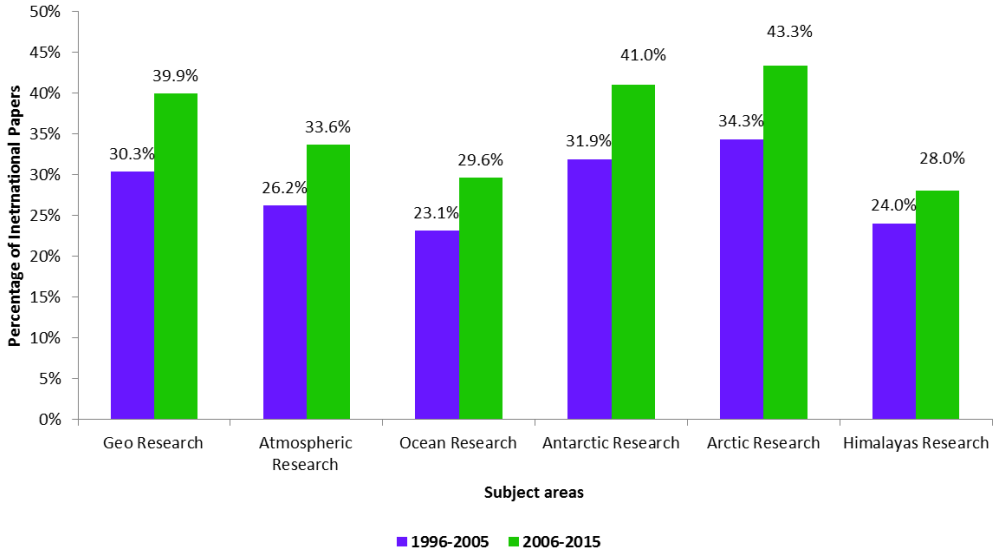


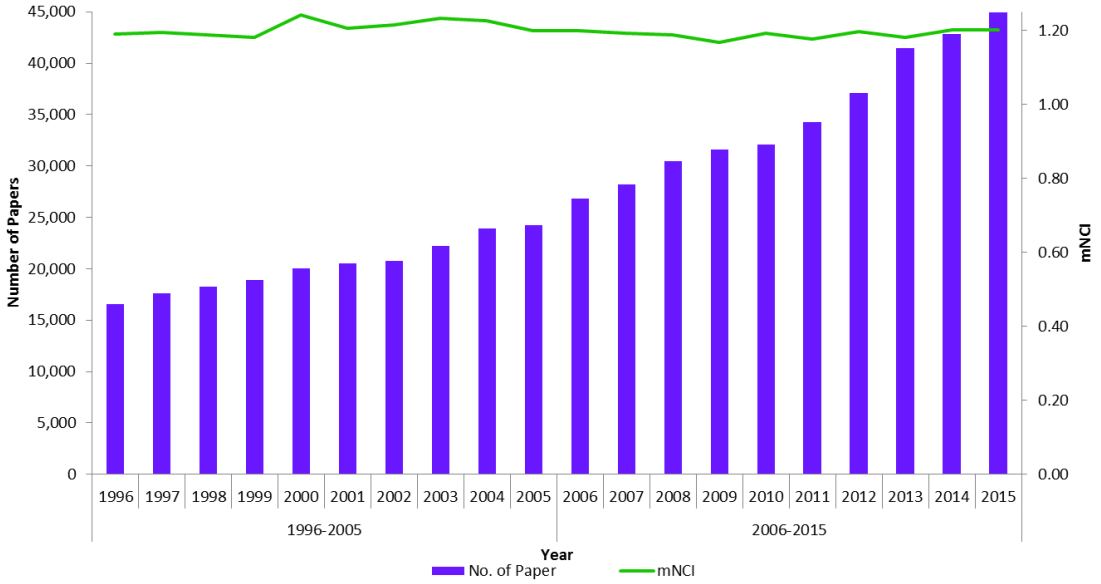
Figure 5.1.5 Percentage of internationally collaborative papers in each subject area, 1996-2005 and 2006-2015



5.2 TREND IN GEO RESEARCH

5.2.1 Annual research output and citation impact

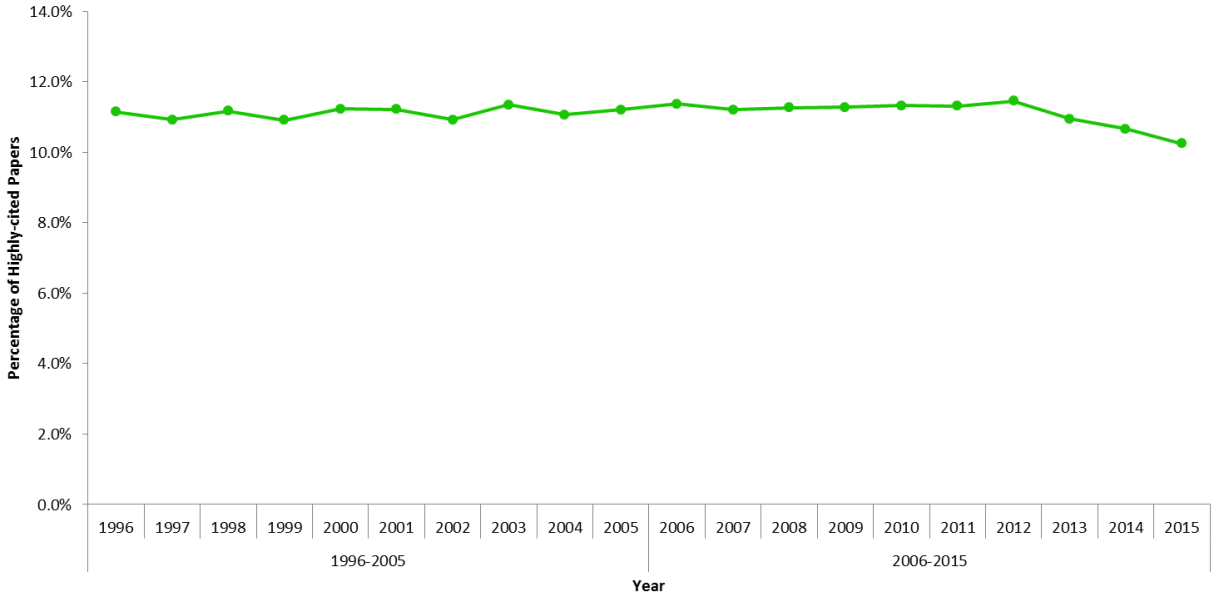
Figure 5.2.1 Annual research output and mNCI, Geo Research, 1996-2005 and 2006-2015



In Geo Research, annual research output steadily increased from 16,589 papers in 1996 to 24,309 papers in 2005, and then to 44,957 in 2015. Annual mNCI of these papers was well above the world average (mNCI=1) in all years and remained relatively flat.

5.2.2 Percentage of highly-cited papers

Figure 5.2.2 Annual percentage of highly-cited papers, Geo Research, 1996-2005 and 2006-2015



On average, approximately 11% of global research in Geo Research papers was highly-cited in each year in both 10-year periods. Annual share of highly-cited papers in the first decade had little change. However, in the most recent years, between 2013 and 2015, the share of highly-cited papers decreased to just over 10% in 2015.

5.2.3 Top 30 Countries ranked by output

Figure 5.2.3 Top 30 countries by research output, Geo Research, 1996-2005

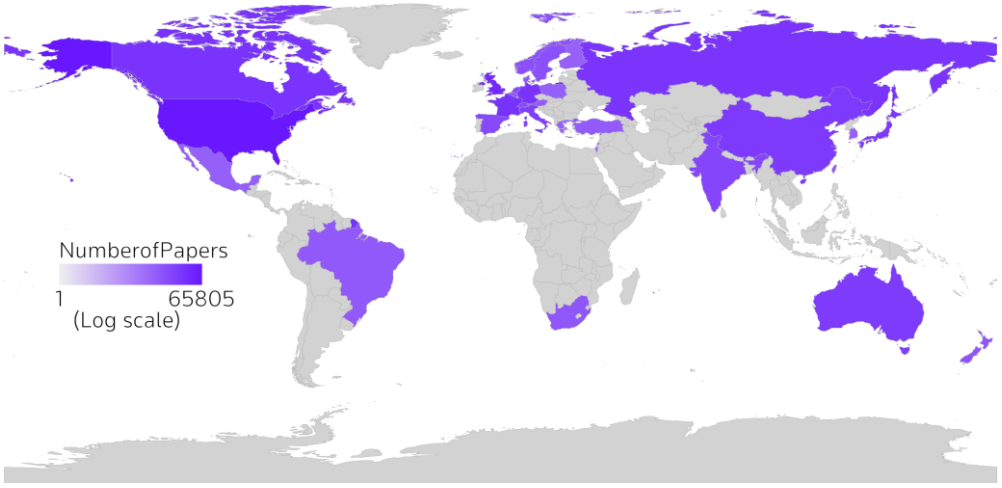
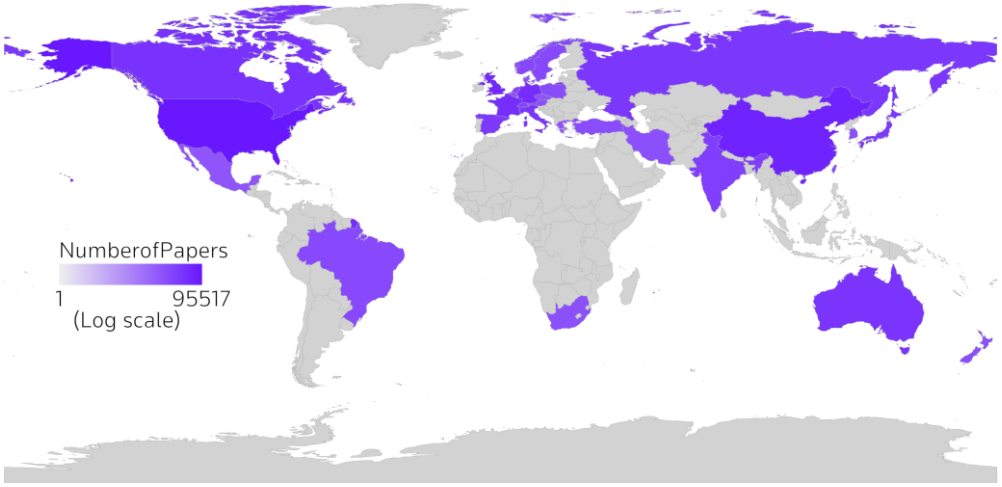


Figure 5.2.4 Top 30 countries by research output, Geo Research, 2006-2015



Countries in North America, Europe and Asia Pacific produced the highest number of papers in Geo Research. Between 1996 and 2005, the USA led with 65,805 papers followed by the United Kingdom (UK 25,565) and France (16,478). India (5,711) ranked 11th in terms of total output.

USA continued to lead with 95,517 papers in the next 10 years, while China ranked second to the USA and published 48,657 papers in this period, a nearly 5-fold increase from the previous one. The research output of India (ranked 12th) more than doubled.

Figure 5.2.5 Bubble chart of selected top countries by research output, Geo Research, 1996-2005[3]

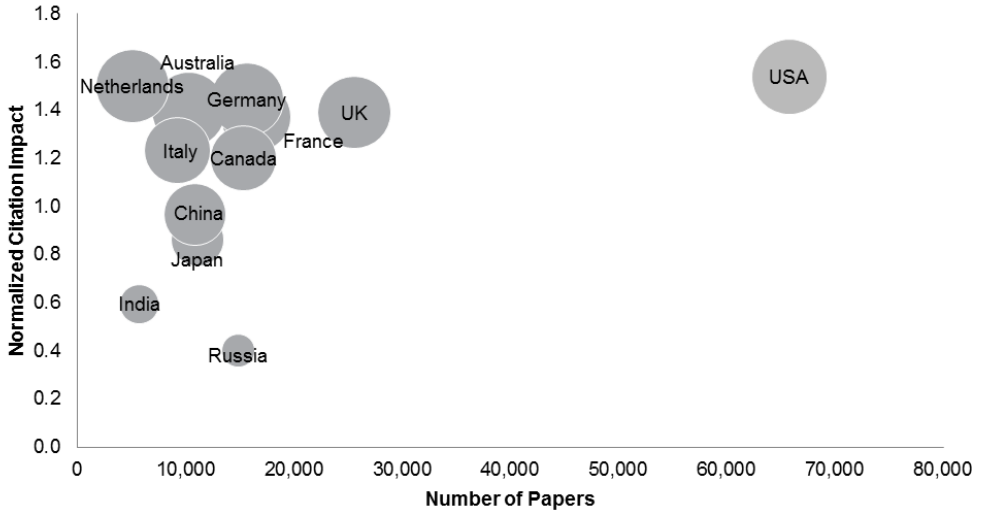
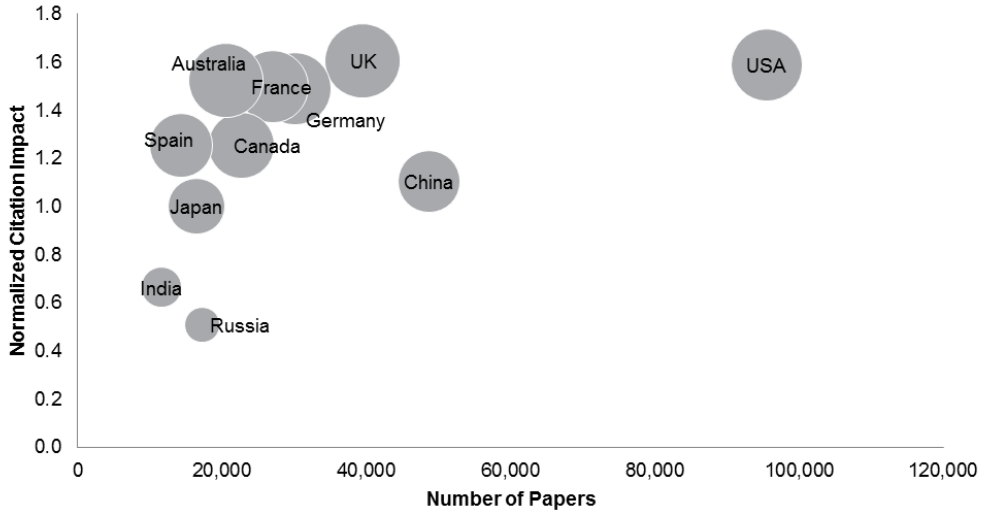


Figure 5.2.6 Bubble chart of selected top countries by research output, Geo Research, 2006-2015



[3] Bubble charts of a selected group of countries, among the top 30 countries by research output or mNCI, are used to provide complementary information. The x axis of the bubble chart represents a country's paper count while the y axis depicts the mNCI of these papers. The size of a bubble represents the share of highly cited papers. Because of the possible overlap, not all 30 countries were included in a bubble chart. India was always included in the bubble chart in the subject areas when it is one of the top 30 countries by output or mNCI.

5.2.4 Top 30 Countries ranked by mNCI

Figure 5.2.7 Top 30 countries by mNCI (Number of Papers >=50), Geo Research, 1996-2005

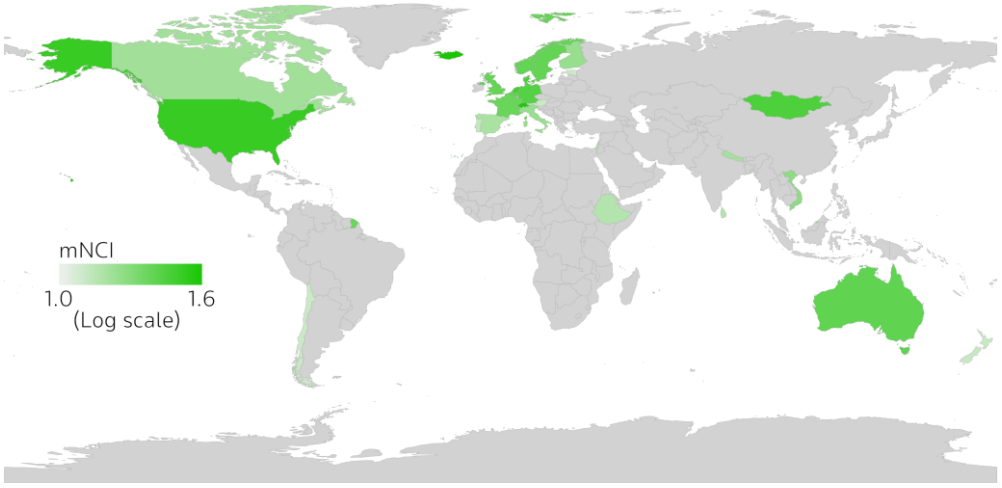
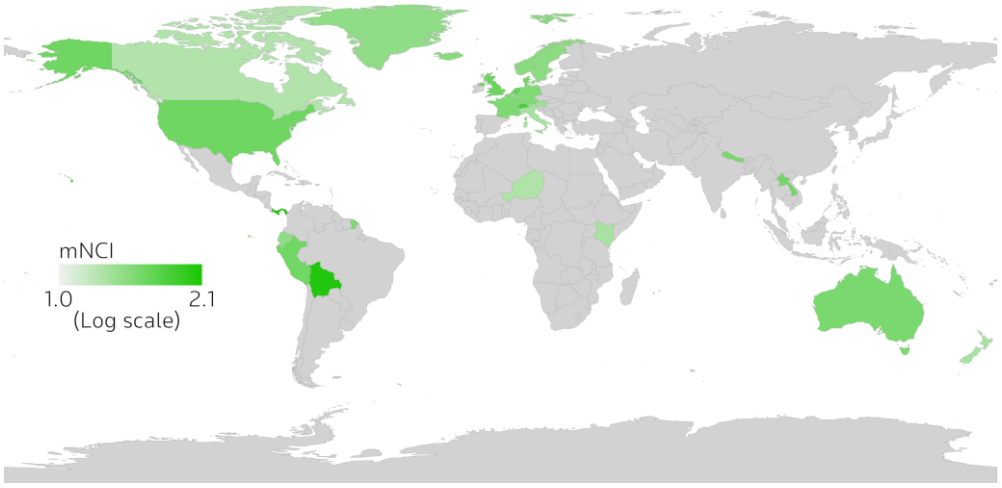


Figure 5.2.8 Top 30 countries by mNCI (Number of Papers >=50), Geo Research, 2006-2015



Iceland (mNCI = 1.65) had the highest mNCI in the first 10 year period, while Bermuda (mNCI =2.17) led from 2006 to 2015. However, both countries had a relatively small number of papers. The USA, UK and Germany, among other countries, had the highest mNCI with a substantial amount of papers.

Please be advised that the citation impact of a country's papers should always be interpreted together with the number of papers it published.

Figure 5.2.9 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Geo Research, 1996-2005

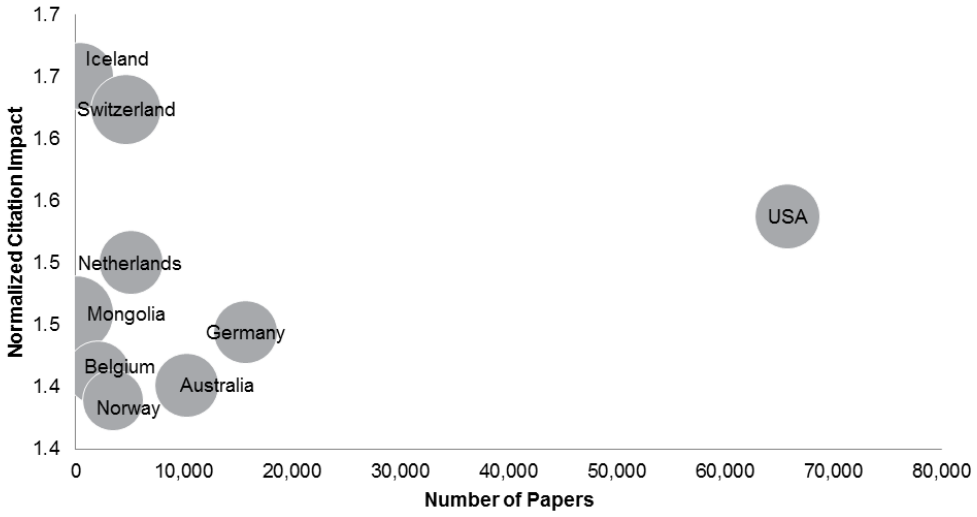
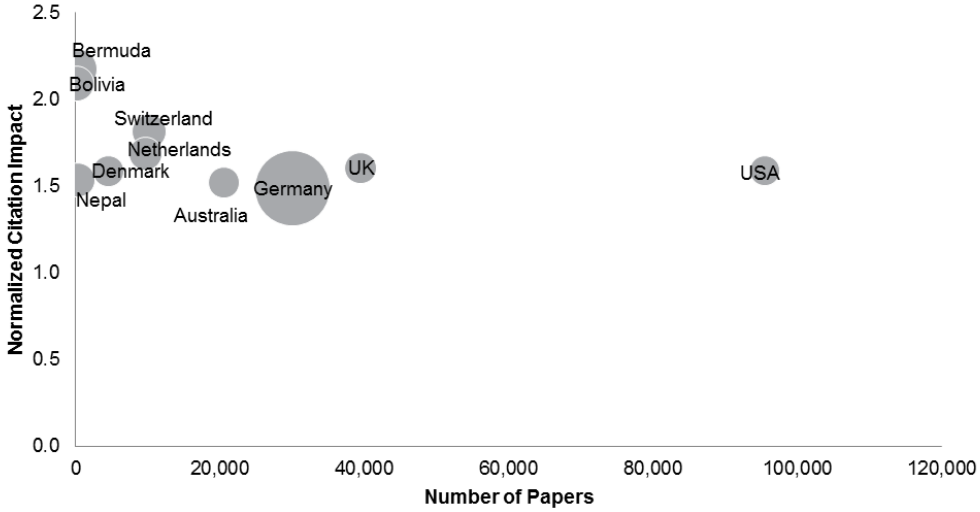


Figure 5.2.10 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Geo Research, 2006-2015



5.2.5 Top 10 journals with the highest JIF

Table 5.2.1 Top 10 journals with the highest JIF, 1996-2015

Journal Name	Publishing Country	JIF	No. of Papers
NATURE	UK	38.14	1,321
SCIENCE	USA	34.66	1,383
NATURE GEOSCIENCE	UK	12.51	1,169
REVIEWS OF GEOPHYSICS	USA	11.44	358
NATURE COMMUNICATIONS	UK	11.33	211
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	USA	9.42	633
GONDWANA RESEARCH	Netherlands	8.74	1,734
EARTH SYSTEM SCIENCE DATA	Germany	8.29	103
ANNUAL REVIEW OF EARTH AND PLANETARY SCIENCES	USA	7.81	251
EARTH-SCIENCE REVIEWS	Netherlands	6.99	1,025

Seven of the top 10 journals are multidisciplinary or review journals. Nature (JIF=38.14) and Science (JIF=34.66), as widely circulated multidisciplinary journals, had the highest JIF. Nature Geoscience (12.51) had the highest JIF among journals that are specialized in Geo Research.

5.2.6 Number and share of internationally collaborative papers

Figure 5.2.11 Number and percentage of internationally collaborative papers, Geo Research, 1996-2005 and 2006-2015

The number of internationally collaborative papers steadily increased from 3,536 in 1996 to 8,417 in 2005. In 2015, 18,922 papers were published with international collaboration. The share of internationally collaborative papers also increased. In 2015, more than two fifths of papers in Geo Research were published through international collaboration. The increased share of internationally collaborative papers suggested that the growth of international collaboration outpaced that of the total research.

5.2.7 Most common internationally collaborative country pairs[4]

Table 5.2.2 Top 10 internationally collaborative country pairs, Geo Research, 1996-2005

Country 1	Country 2	No. of Collaborative Papers
USA	UK	3,574
USA	Canada	2,929
USA	Germany	2,831
USA	France	2,701
USA	Japan	1,792
USA	Australia	1,571
USA	China	1,487
UK	Germany	1,474
UK	France	1,424
USA	Russia	1,290

Table 5.2.3 Top 10 internationally collaborative country pairs, Geo Research, 2006-2015

Country 1	Country 2	No. of Collaborative Papers
USA	UK	7,510
USA	China	7,369
USA	Germany	5,712
USA	Canada	5,610
USA	France	5,382
UK	Germany	3,708
USA	Australia	3,358
UK	France	3,110
USA	Japan	2,874
Germany	France	2,871

The USA participated in eight of the top 10 internationally collaborative pairs between 1996 and 2005 and seven in the next decade. The USA-UK pair produced the highest number of papers in each decade. The number of papers published by the USA-China pair increased almost five fold.

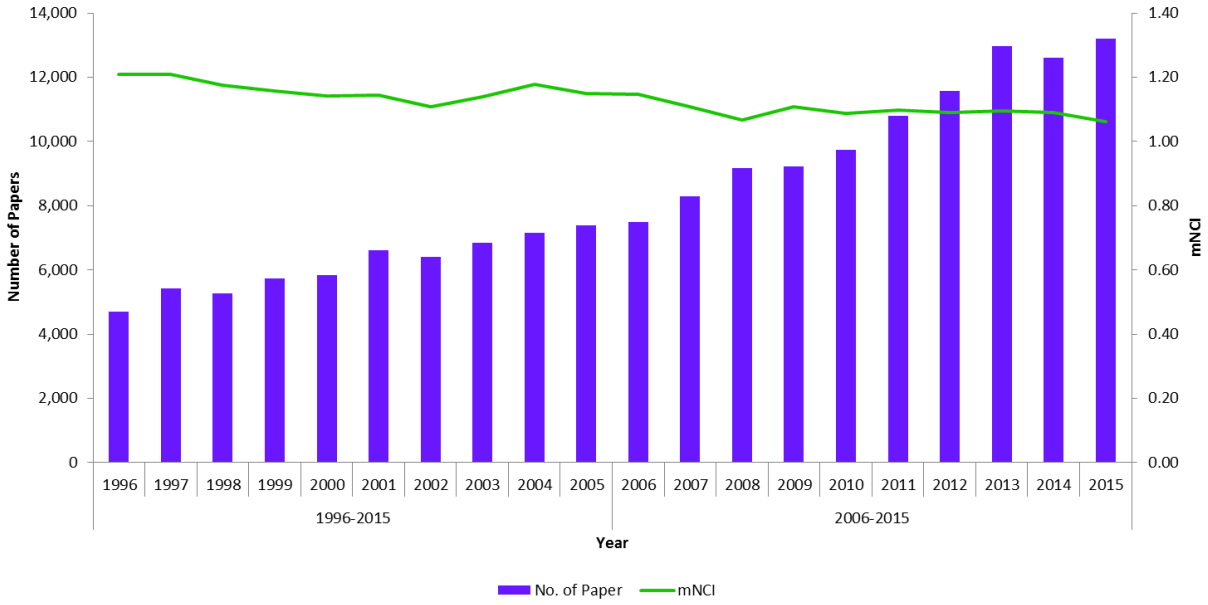
The dominance of the USA in international collaboration is mainly due to the fact that USA published the highest number of papers. International collaboration without the USA was also provided in the Excel companion data file.

[4] The most common internationally collaborative country pairs are country pairs that produced the highest number of co-authored papers.

5.3 TREND IN ATMOSPHERIC RESEARCH

5.3.1 Annual research output and citation impact

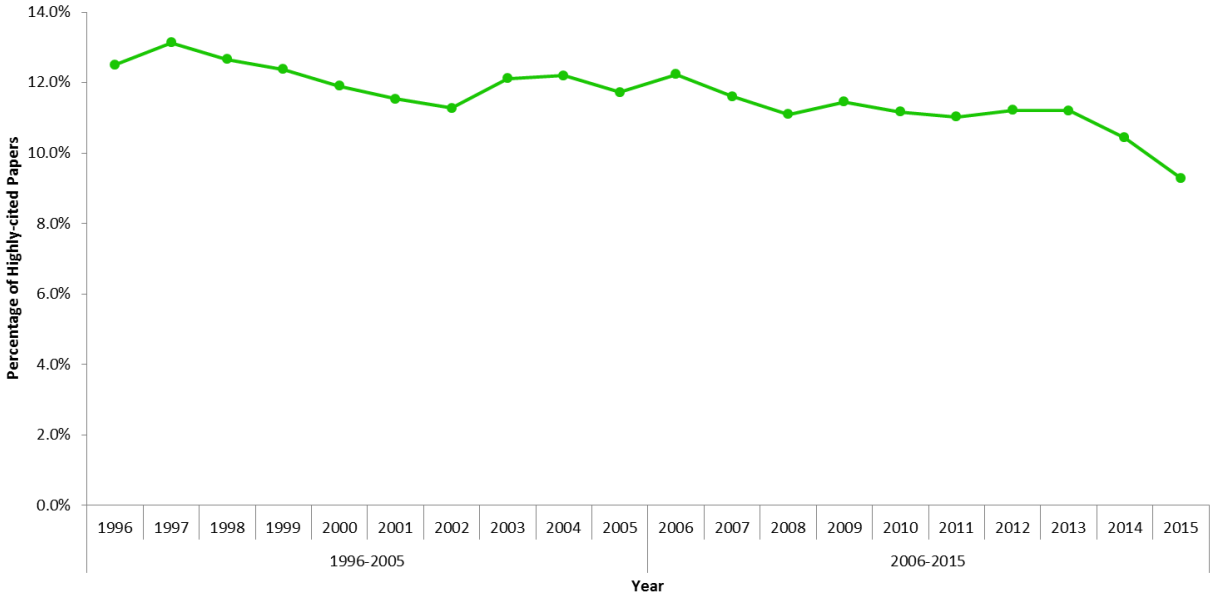
Figure 5.3.1 Annual research output and mNCI, Atmospheric Research, 1996-2005 and 2006-2015



In Atmosphere research, annual research output kept a general upward trend. In the first 10 year period, the number of papers increased from 4,702 to 7,397. The growth in output in the following decade, from 7,508 to 13,224, was slightly faster. Citation impact, however, had an opposite trend. The mNCI of Atmosphere research papers in 1996 and 1997 was 1.21, the highest in all years. It since decreased to 1.16 in 2005 and further decreased to 1.06 in 2015.

5.3.2 Percentage of highly-cited papers

Figure 5.3.2 Annual percentage of highly-cited papers, Atmospheric Research, 1996-2005 and 2006-2015



The share of highly-cited papers decreased from 12.5% in 1996 to 11.7% in 2005. The decrease is more obvious between 2006 and 2015; less than one tenth (9.3%) of papers published in Atmosphere Research were highly-cited. This finding is consistent to the downward trend of citation impact observed in **Figure 5.3.1**.

5.3.3 Top 30 Countries ranked by output

Figure 5.3.3 Top 30 countries by research output, Atmospheric Research, 1996-2005

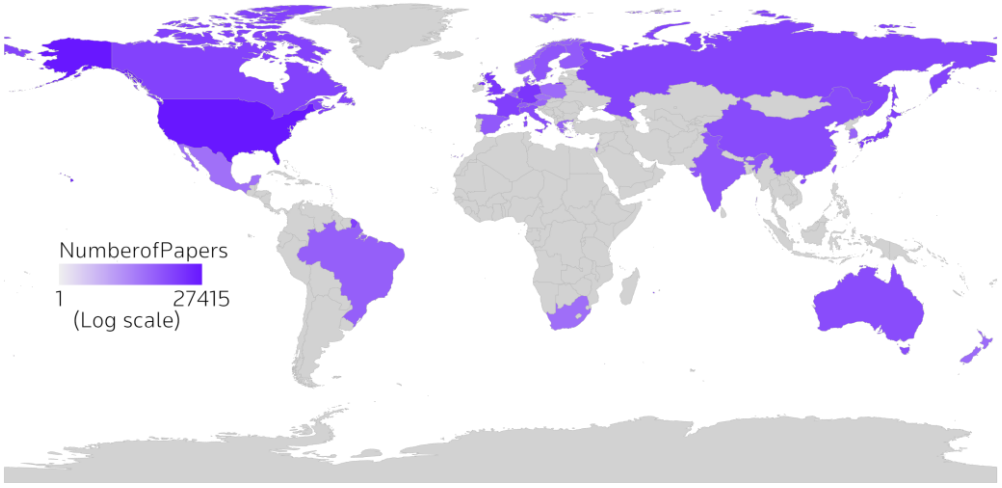
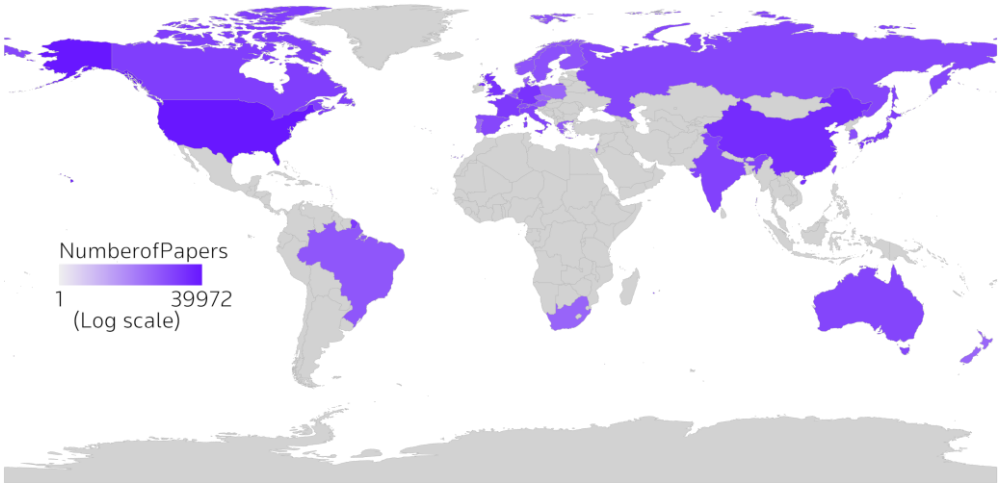


Figure 5.3.4 Top 30 countries by research output, Atmospheric Research, 2006-2015



Similar to the case in Geo Research, countries in North America, Europe and Asia Pacific led the research effort in this subject area. Again, the USA published 27,415 and 39,972 papers in each decade enjoying a large marginal lead over the next country in ranking. Between 1996 and 2005, Germany (6,553) produced the second highest volume of research, followed by the UK (6,188).

In the next 10 years, China (14,198) published six times more than what it did in the 1996-2005 period and surpassed six other countries to the second position. There is also a remarkable growth in the number of papers published by India, from 1,457 in the first decade to 4,955 in the next. India's ranking also reached within the top 10 in the second decade.

Figure 5.3.5 Bubble chart of selected top countries by research output, Atmospheric Research, 1996-2005

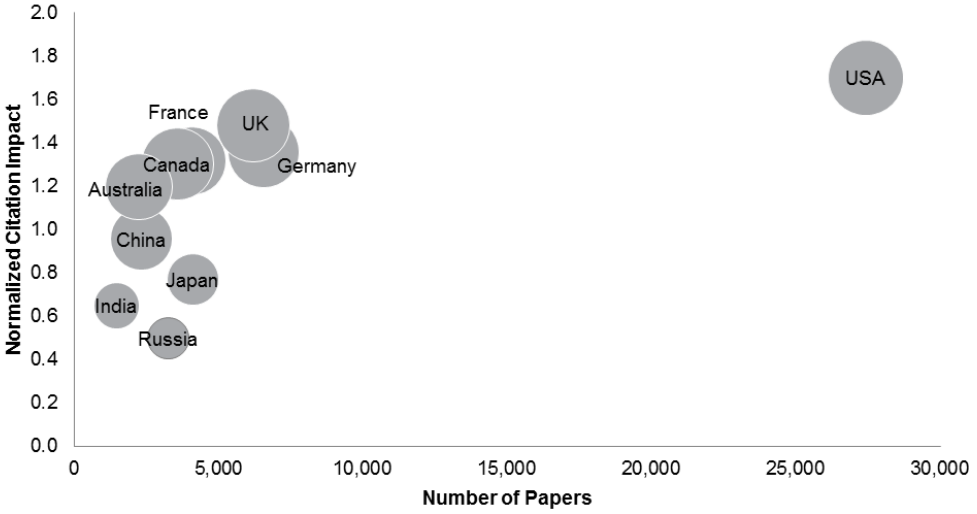
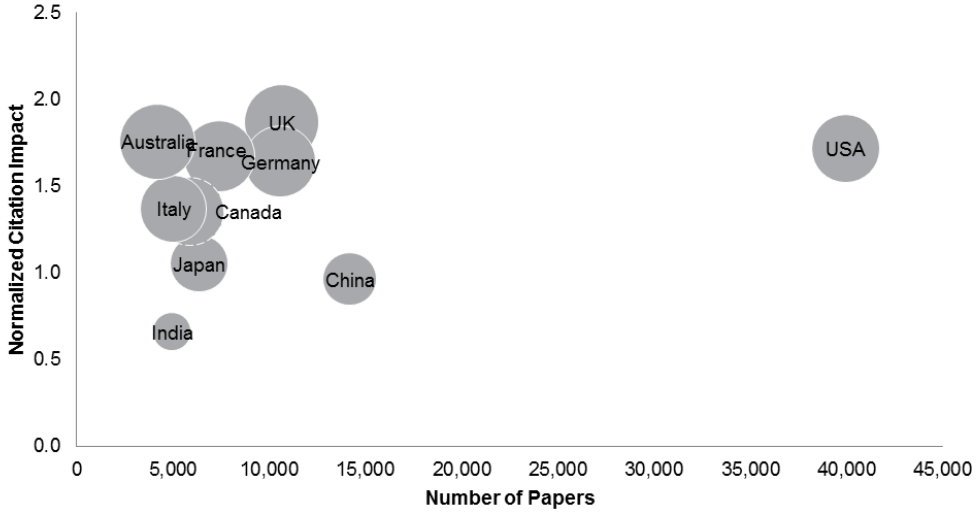


Figure 5.3.6 Bubble chart of selected top countries by research output, Atmospheric Research, 2006-2015



5.3.4 Top 30 Countries ranked by mNCI

Figure 5.3.7 Top 30 countries by mNCI (Number. of Papers >=50), Atmospheric Research, 1996-2005

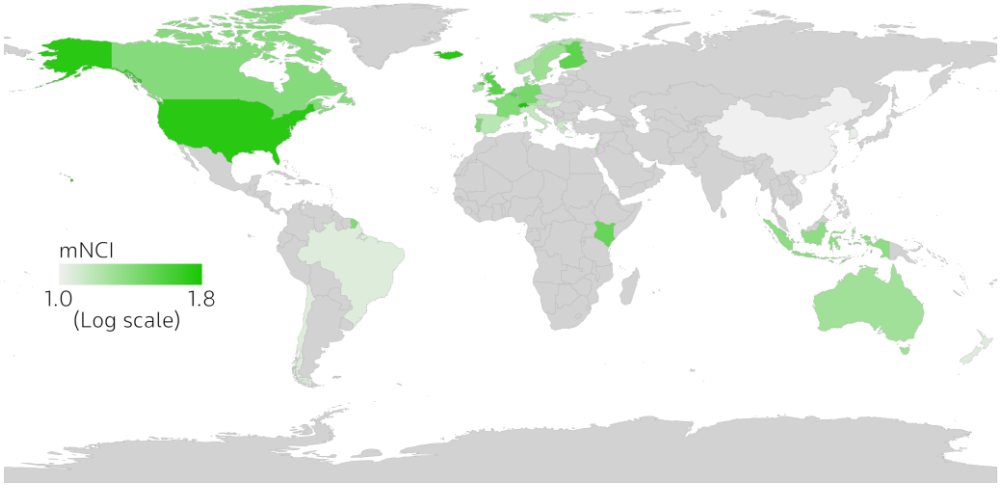
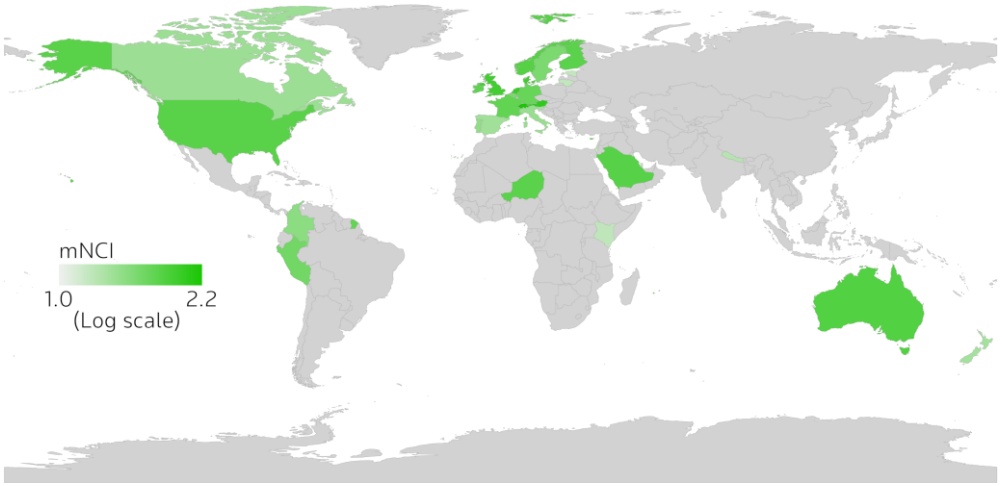


Figure 5.3.8 Top 30 countries by mNCI (Number of Papers >=50), Atmospheric Research, 2006-2015



Switzerland (mNCI=1.77), Iceland (mNCI=1.71) and the USA (mNCI=1.70) led in citation impact in Decade 1. In Decade 2, Switzerland (mNCI=2.16) continued the lead with Austria (mNCI=1.99) and Netherlands (mNCI=1.94) followed. Other European countries, particularly ones in Northern Europe, such as Denmark and Finland, also produced research with high citation impact. India's research was not ranked within the top 30 countries by citation impact in any decade. It is of note that Nepal (No.26, Decade 2) published 95 papers with a mNCI of 1.23.

Please be advised that the citation impact of a country's papers should always be interpreted together with the number of papers it published.

Figure 5.3.9 Bubble chart of selected top countries by mNCI (Number. of Papers >=50), Atmospheric Research, 1996-2005

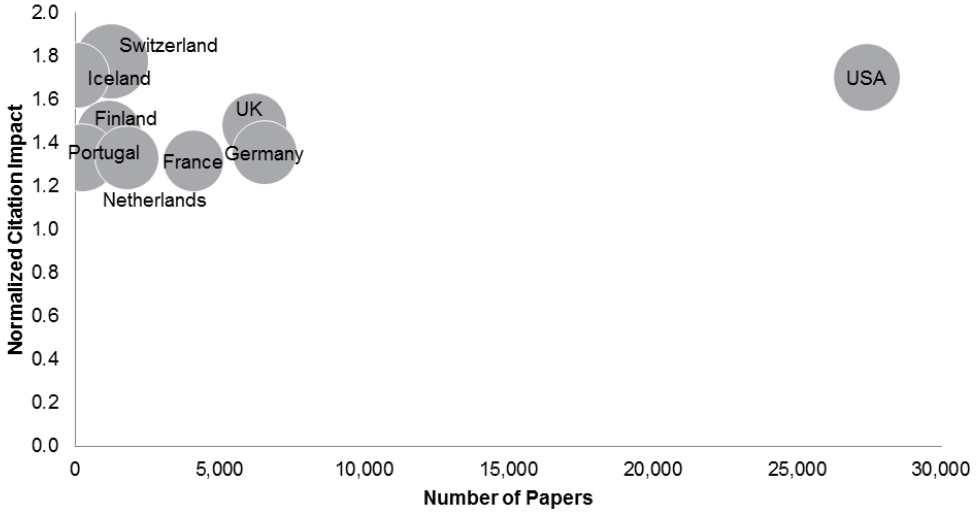
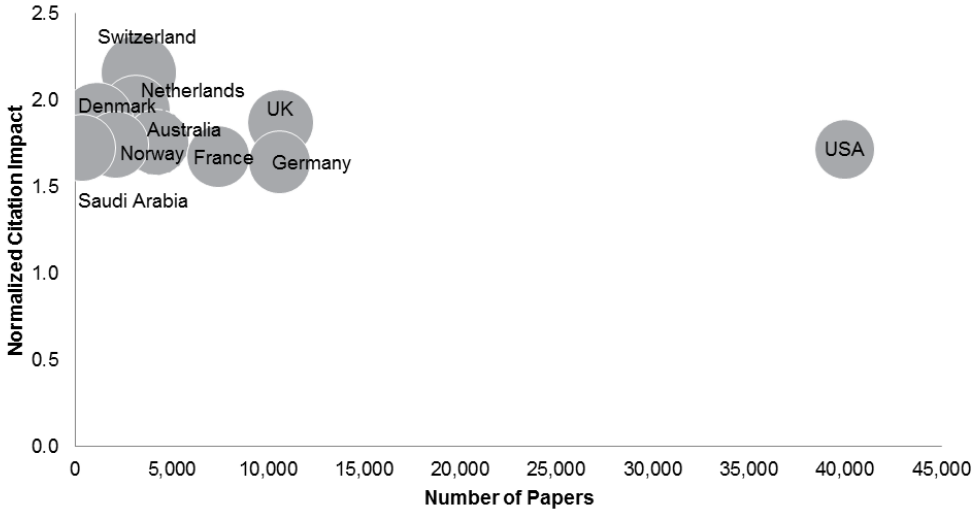


Figure 5.3.10 Bubble chart of selected top countries by mNCI (Number. of Papers >=50), Atmospheric Research, 2006-2015



5.3.5 Top 10 journals with the highest Journal Impact factor

Table 5.3.1 Top 10 journals with the highest JIF, 1996-2015

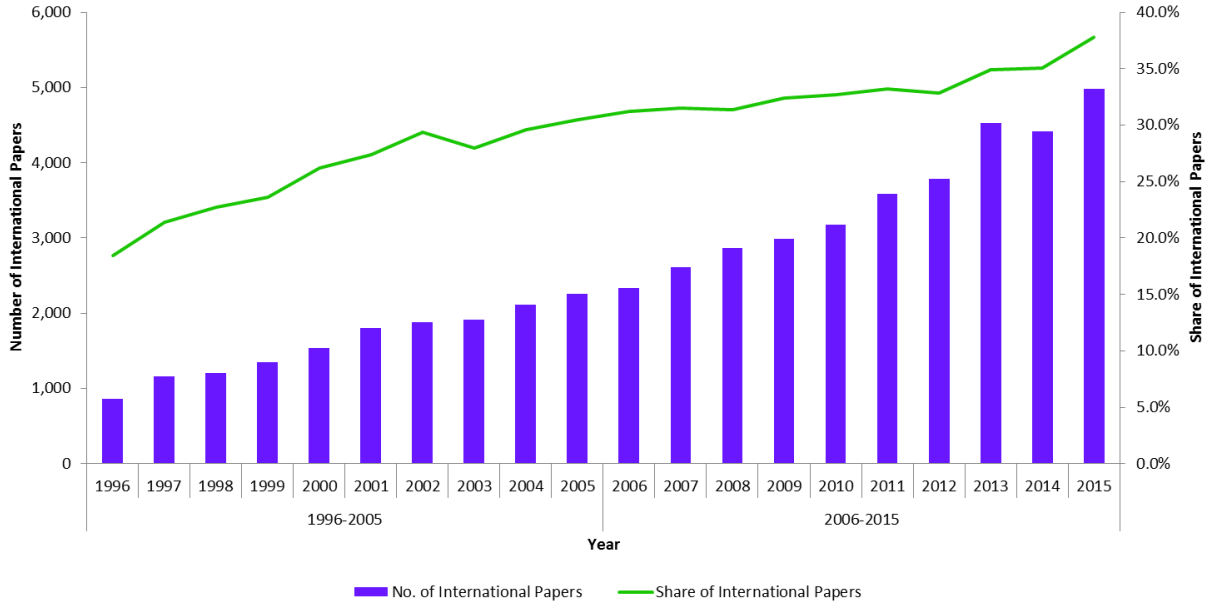
Journal Name	Publishing Country	JIF	No. of Papers
NATURE	UK	38.14	326
SCIENCE	USA	34.66	374
NATURE CLIMATE CHANGE	UK	17.18	608
NATURE COMMUNICATIONS	USA	11.33	60
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	Germany	9.42	438
EARTH SYSTEM SCIENCE DATA	USA	8.29	103
NATIONAL SCIENCE REVIEW	USA	8.00	2
BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY	UK	7.93	1,778
JOURNAL OF ADVANCES IN MODELING EARTH SYSTEMS	Germany	6.42	303
EARTHS FUTURE	USA	5.62	71[5]

Nature and Science, as widely circulated multidisciplinary journals, had the highest JIF and published substantial amount of papers in this subject area. Nature Climate Change had the highest JIF as an Atmospheric specialized journal. The journal, Bulletin of the American Meteorological Society, published the highest number of papers (1,778).

[5] Only nine journals published 100 or more papers in this subject area. Earths Future, with only 71 papers published, was also listed in **Table 5.3.1.**

5.3.6 Number and share of internationally collaborative papers

Figure 5.3.11 Number and percentage of internationally collaborative papers, Atmospheric Research, 1996-2005 and 2006-2015



Internationally collaborative papers increased from 863 to 2,253 in the first 10 years. Its share in total papers also grew from less than one fifth (18.5%) to almost one third (30.5%). In the following decade, the number of internationally collaborative papers continued increasing from 2,340 to 4,984. However, the growth of its share, from 31.2% to 37.8%, was slower.

5.3.7 Most common international collaborative country pairs

Table 5.3.2 Top 10 internationally collaborative country pairs, Atmospheric Research, 1996-2005

Country 1	Country 2	No. of Collaborative Papers
USA	Germany	1,551
USA	UK	1,364
USA	Canada	1,165
USA	France	1,063
USA	Japan	858
UK	Germany	739
Germany	France	625
UK	France	588
USA	Australia	588
USA	China	504

Table 5.3.3 Top 10 internationally collaborative country pairs, Atmospheric Research, 2006-2015

Country 1	Country 2	No. of Collaborative Papers
USA	China	3,533
USA	UK	2,902
USA	Germany	2,786
USA	France	2,074
USA	Canada	1,983
UK	Germany	1,789
USA	Japan	1,523
UK	France	1,387
Germany	France	1,361
USA	Australia	1,211

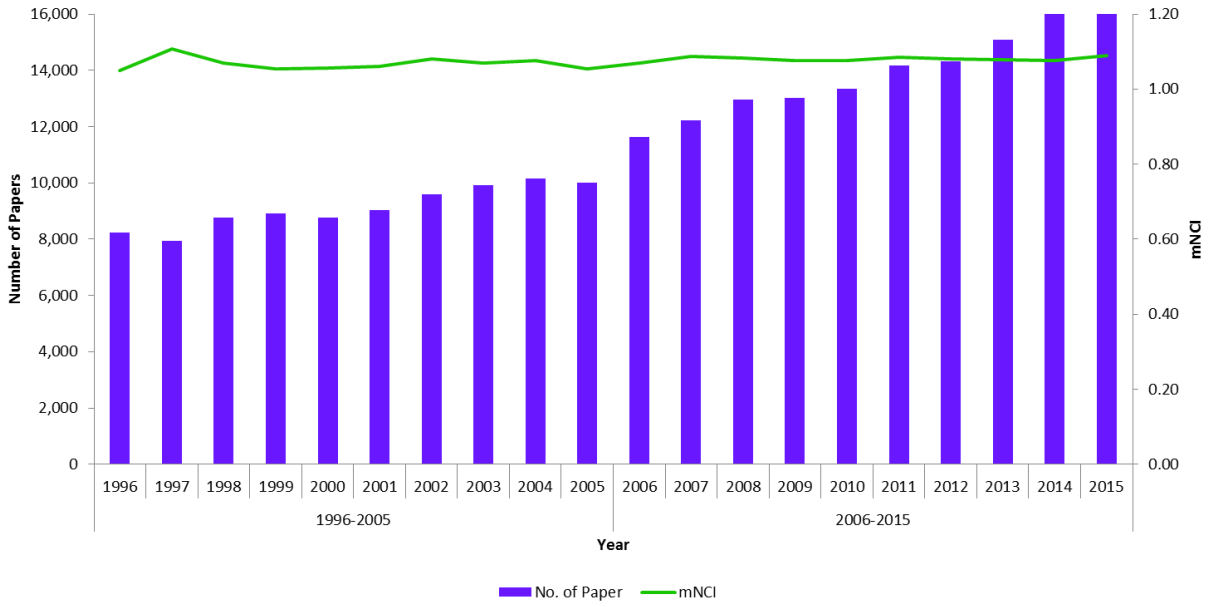
In Atmospheric Research, the USA, with the highest number of papers published, dominated international collaboration. More specifically, the USA took part in seven of the top 10 internationally collaborative pairs in both decades. The UK participated in three international collaboration country pairs in each decade. The USA-UK and USA-Germany pairs produced the highest number of papers in the first decade. It is worth noting that the collaboration between USA and China increased seven times in the second decade and produced the second highest number of papers in that time frame.

The dominance of the USA in international collaboration is mainly due to the fact that the USA published the highest number of papers. International collaboration without the USA was also provided in the Excel companion data file.

5.4 TREND IN OCEAN RESEARCH

5.4.1 Annual research output and citation impact

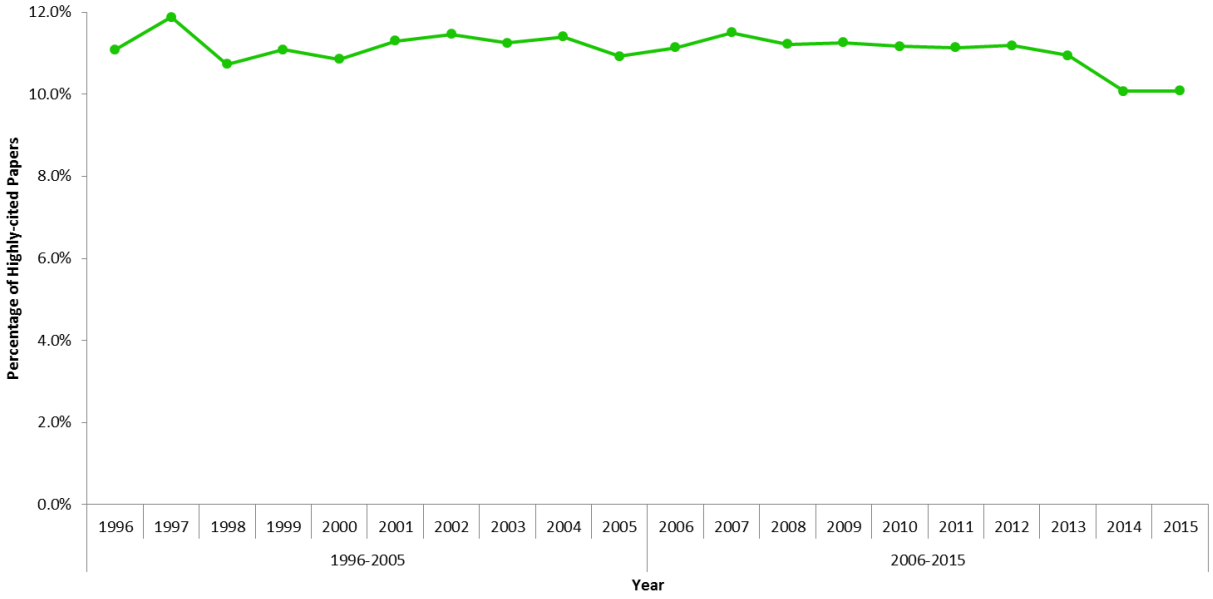
Figure 5.4.1 Annual research output and mNCI, Ocean Research, 1996-2005 and 2006-2015



Annual research output in Ocean research grew at a relative slow pace, from 8,254 papers in 1996 to just over 10,000 in 2005. The annualized rate of increase was approximately 2%. The pace of increase doubled in the next 10 years at an annual rate of 4%, with more than 16,000 papers published in 2015. Citation impact is generally flat, except for a peak in 1997 (mNCI =1.17). Overall, papers in Ocean research were cited slightly over world average (mNCI =1.07).

5.4.2 Percentage of highly-cited papers in Ocean Research

Figure 5.4.2 Annual percentage of highly-cited papers, Ocean Research, 1996-2005 and 2006-2015



In most years of these two decades, approximately 11% of papers published in Ocean research were highly-cited. The share of highly-cited papers between 2006 and 2015 is higher than that of the first decade, though a notable decrease was observed in the last three years.

5.4.3 Top 30 Countries ranked by output

Figure 5.4.3 Top 30 countries by research output, Ocean Research, 1996-2005

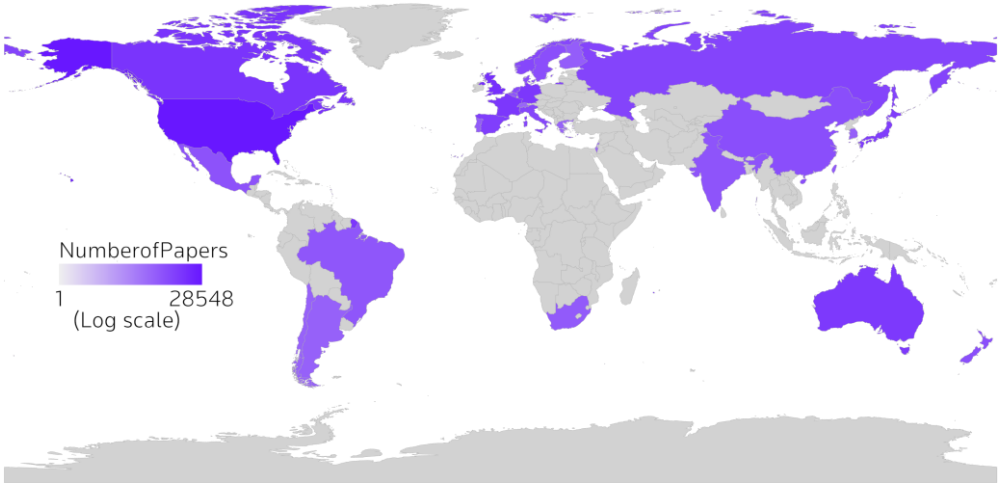
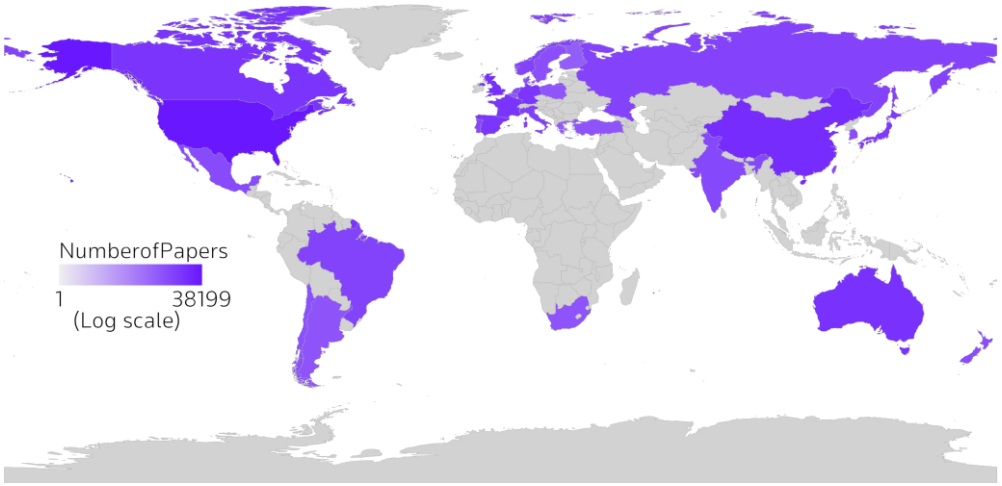


Figure 5.4.4 Top 30 countries by research output, Ocean Research, 2006-2015



In both decades, majority of Ocean Research activity was conducted in North America, Europe and Asia Pacific, though countries in South America also made significant contribution. The USA (28,548), the UK (9,431) and Canada (6,989) produced the highest number of papers from 1996 to 2005. In the second decade, China (13,245) became second to USA (38,199) in research output, with the number of papers increasing more than five times than that of the first decade. India more than doubled its number of papers and ranked 18th and 15th respectively in each decade.

Figure 5.4.5 Bubble chart of selected top countries by research output, Ocean Research, 1996-2005

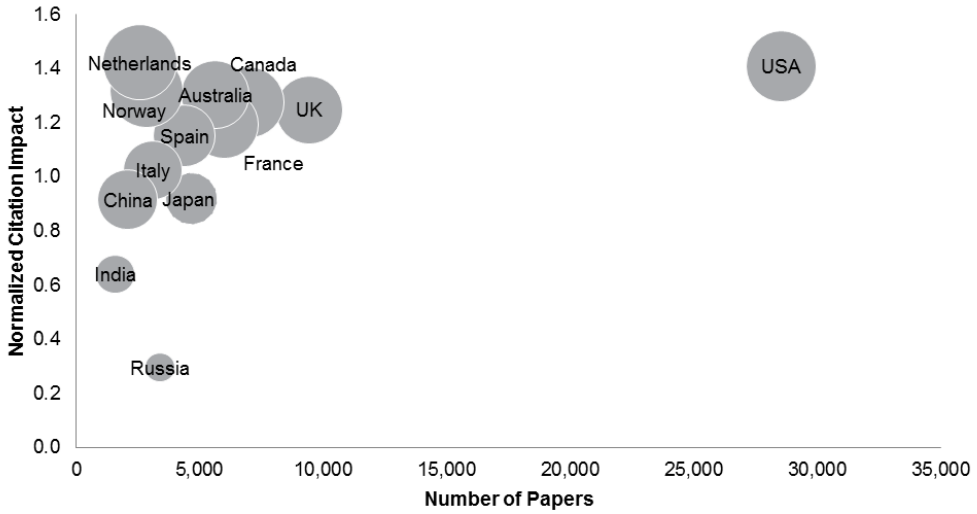
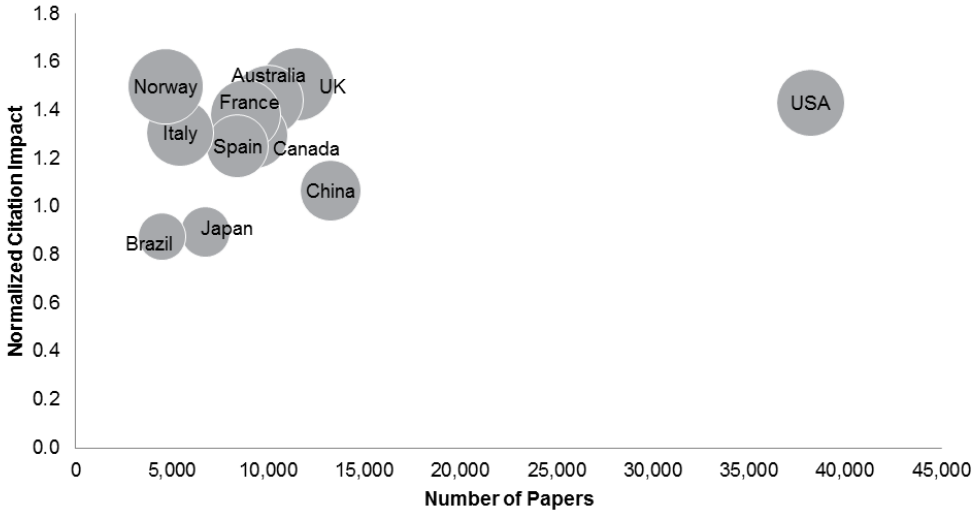


Figure 5.4.6 Bubble chart of selected top countries by research output, Ocean Research, 2006-2015



5.4.4 Top 30 Countries ranked by mNCI

Figure 5.4.7 Top 30 countries by mNCI (Number of Papers >=50), Ocean Research, 1996-2005

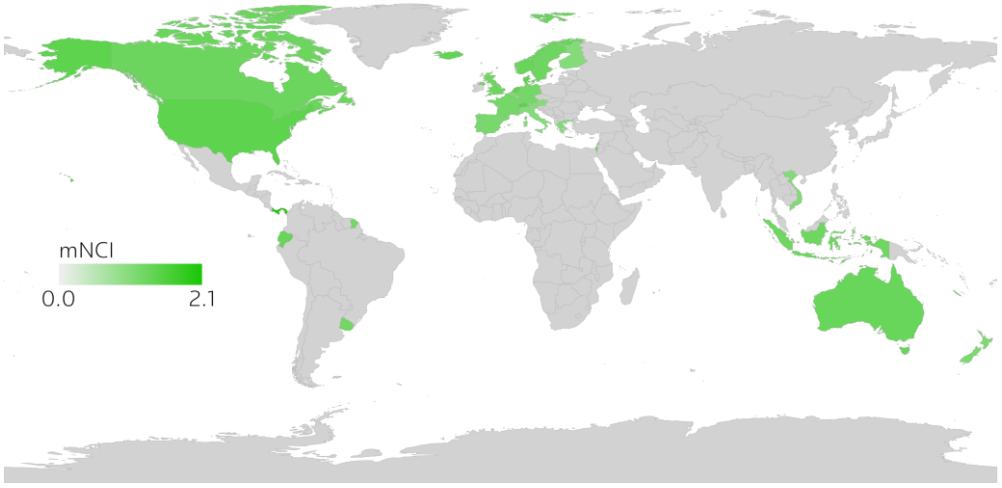
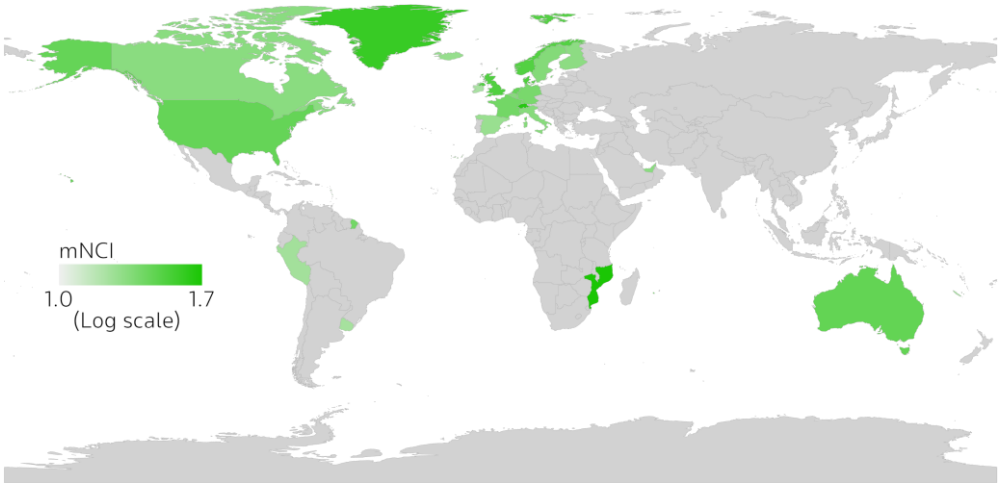


Figure 5.4.8 Top 30 countries by mNCI (Number of Papers >=50), Ocean Research, 2006-2015



Panama (mNCI=2.06), Bermuda (mNCI=1.96), and Monaco (mNCI=1.49) led in citation impact in the first 10-year period. Monaco (mNCI=2.05) and Bermuda (mNCI=1.99) again had the highest citation impact in the second decade. These countries are not known for their scientific research, nor did they publish a substantial amount of papers. Collaborating with “powerhouse” countries in Ocean Research is likely a source for their highly-cited research.

Denmark, Switzerland, and the UK were among the countries that produced a substantial number of high impact papers. Neither India nor China was ranked within the top 30 countries by mNCI.

Please be advised that the citation impact of a country’s papers should always be interpreted together with the number of papers it published.

Figure 5.4.9 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Ocean Research, 1996-2005

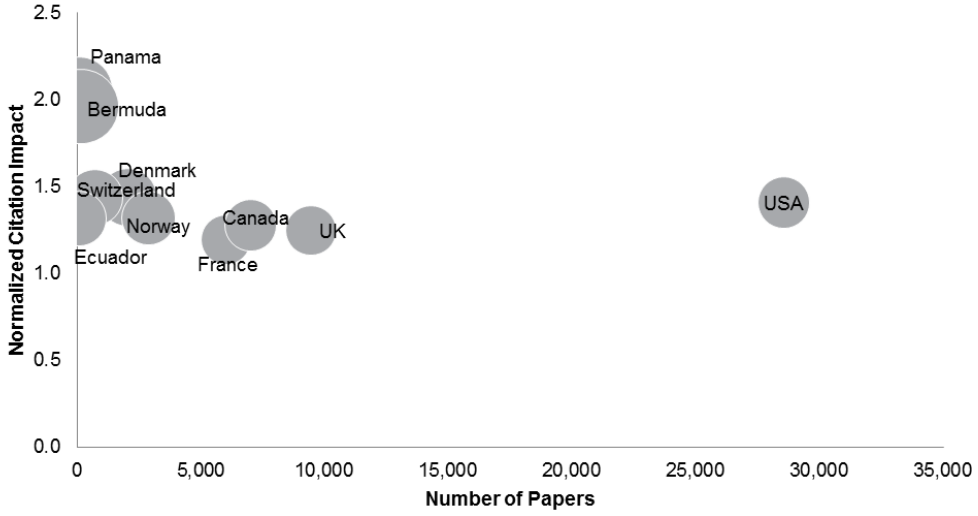
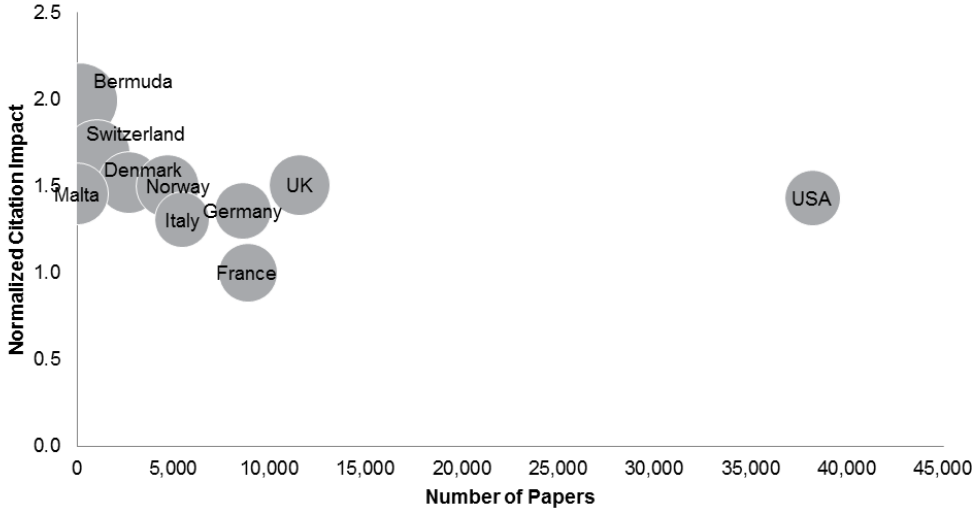


Figure 5.4.10 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Ocean Research, 2006-2015



5.4.5 Top 10 journals with the highest Journal Impact factor

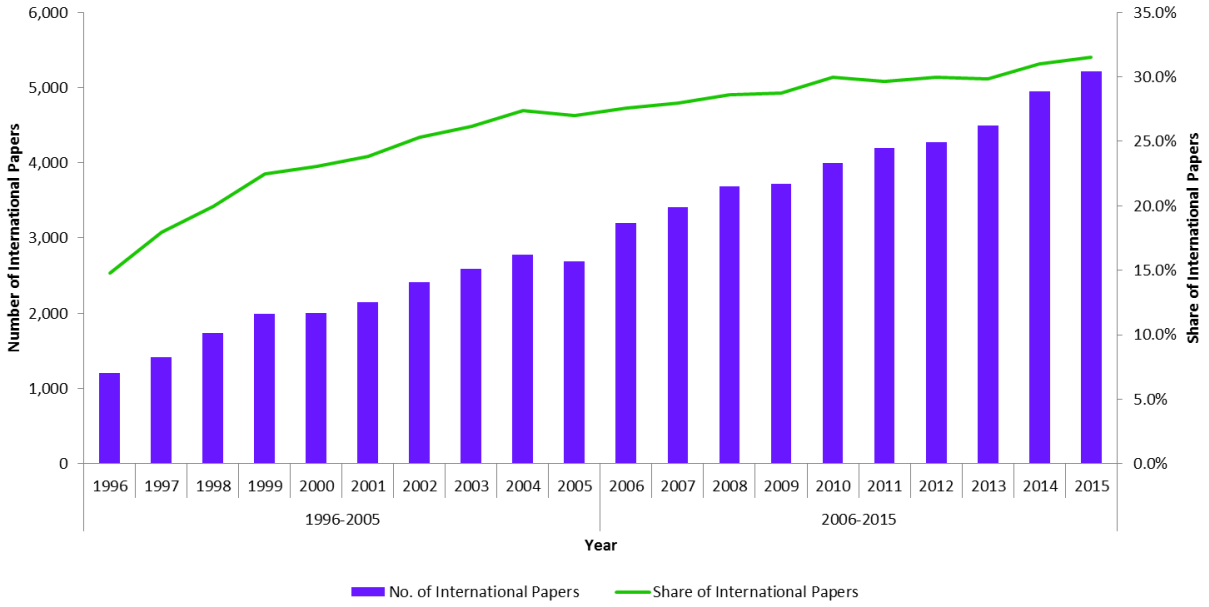
Table 5.4.1 Top 10 journals with the highest JIF (Number of papers >=100), Ocean Research, 1996-2015

Journal Name	Publishing Country	JIF	No. of Papers
NATURE	UK	38.14	262
SCIENCE	USA	34.66	213
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	USA	9.42	205
SCIENTIFIC REPORTS	UK	5.23	130
OCEANOGRAPHY	USA	3.88	566
LIMNOLOGY AND OCEANOGRAPHY	USA	3.66	4,013
AQUATIC TOXICOLOGY	Netherlands	3.56	3,311
PROGRESS IN OCEANOGRAPHY	UK	3.51	1,450
PALEOCEANOGRAPHY	USA	3.43	1,493
MARINE CHEMISTRY	Netherlands	3.41	1,929

LIMNOLOGY AND OCEANOGRAPHY and AQUATIC TOXICOLOGY each published the highest number of papers as one of the top journals in Ocean Research. Four multidisciplinary journals namely, NATURE, SCIENCE, PNAS, and SCIENTIFIC REPORTS had the highest JIF, but their volume of papers in this subject area is relatively low.

5.4.6 Number and share of internationally collaborative papers

Figure 5.4.11 Number and percentage of internationally collaborative papers, Ocean Research, 1996-2005 and 2006 -2015



The trend of international collaboration in Ocean Research is similar to that of Atmospheric Research. In the first 10 years, internationally collaborative papers more than doubled from 1,209 in 1996 to 2,688 in 2005. The pace of growth slowed a little between 2006 and 2015, from 3,197 to 5,219. The slower acceleration is more obvious when measured by their share in the total research; the percentage of internationally collaborative papers grew from 14.8% to 27.0% in the first decade but only from 27.5% to 31.5% in the next one.

5.4.7 Most common internationally collaborative country pairs

Table 5.4.2 Top 10 internationally collaborative country pairs, Ocean Research, 1996-2005

Country 1	Country 2	No. of Collaborative Papers
USA	Canada	1,467
USA	UK	916
USA	Germany	700
USA	Australia	670
USA	France	621
USA	Japan	481
UK	France	442
UK	Germany	439
UK	SPAIN	394
USA	Spain	350

Table 5.4.3 Top 10 internationally collaborative country pairs, Ocean Research, 2006-2015

Country 1	Country 2	No. of Collaborative Papers
USA	Canada	2,387
USA	UK	1,868
USA	China	1,632
USA	Australia	1,630
USA	Germany	1,292
USA	France	1,289
UK	France	973
UK	Germany	960
USA	Spain	862
USA	Japan	854

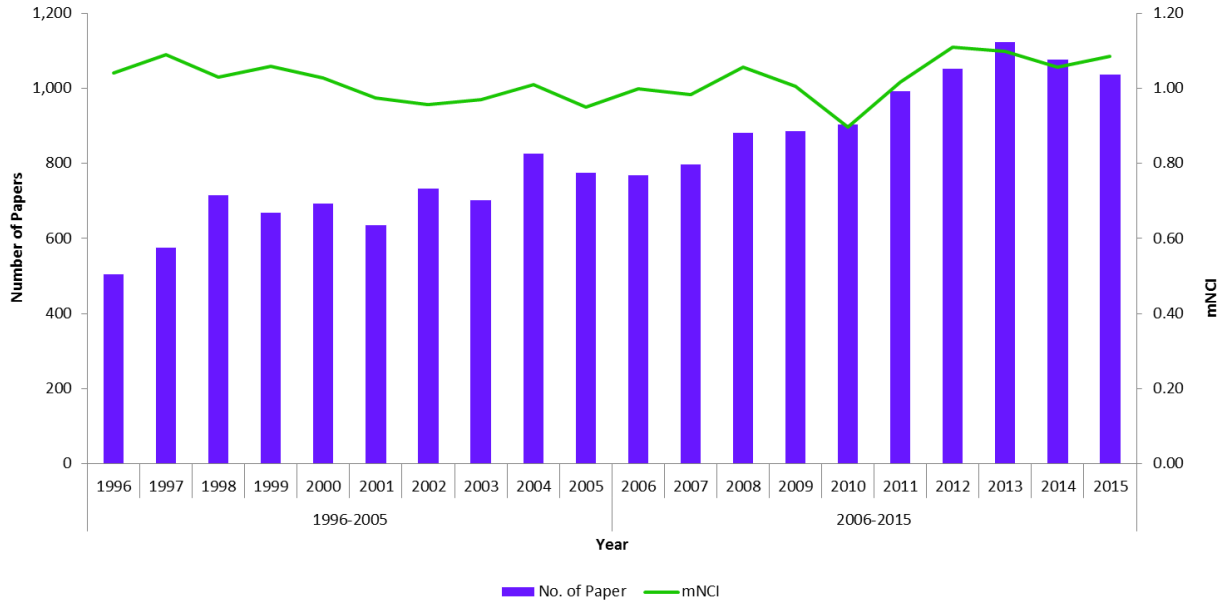
In Ocean Research, the USA, with the highest number of papers published in Ocean Research, dominated the international collaboration. More specifically, the USA was involved in six and eight of the top 10 international collaborative pairs in the first and second decades respectively. In addition, the USA-Canada pair produced the highest number of papers in each decade, followed by the USA-UK pair. The USA-China collaboration became an important pair between 2006 and 2015.

The dominance of the USA in international collaboration is mainly due to the fact that the USA published the highest number of papers. International collaboration without the USA was also provided in the Excel companion data file.

5.5 TREND IN ANTARCTIC RESEARCH

5.5.1 Annual research output and citation impact

Figure 5.5.1 Annual research output and mNCI, Antarctic Research, 1996-2005 and 2006-2015



Except between 2012 and 2015, annual output in Antarctic Research was less than 1,000 papers. Due to the relatively small output, annual number of papers slightly fluctuated especially in the first decade. In the next 10 years, annual output increased from 769 to 1,038 papers with a peak (1,124) in 2013. The annual citation impact kept relatively flat and maintained a level that was very close to the world average (mNCI=1.02).

5.5.2 Percentage of highly-cited papers in Antarctic Research

Figure 5.5.2 Annual percentage of highly-cited papers, Antarctic Research, 1996-2005 and 2006-2015

There was significant volatility in the annual percentage of highly-cited papers in Antarctic Research in each decade. The trend of share of highly-cited papers in 1996-2005 period was also generally downward. Taken this 20 year time frame as a whole, in more than half of the years, less than 10% of papers were highly cited. Share of highly-cited papers were particularly low between 2001 and 2005 and between 2009 and 2011. In 2005 and 2010, only around 7% of papers published were highly-cited.

5.5.3 Top 30 Countries ranked by output

Figure 5.5.3 Top 30 countries by research output, Antarctic Research, 1996-2005

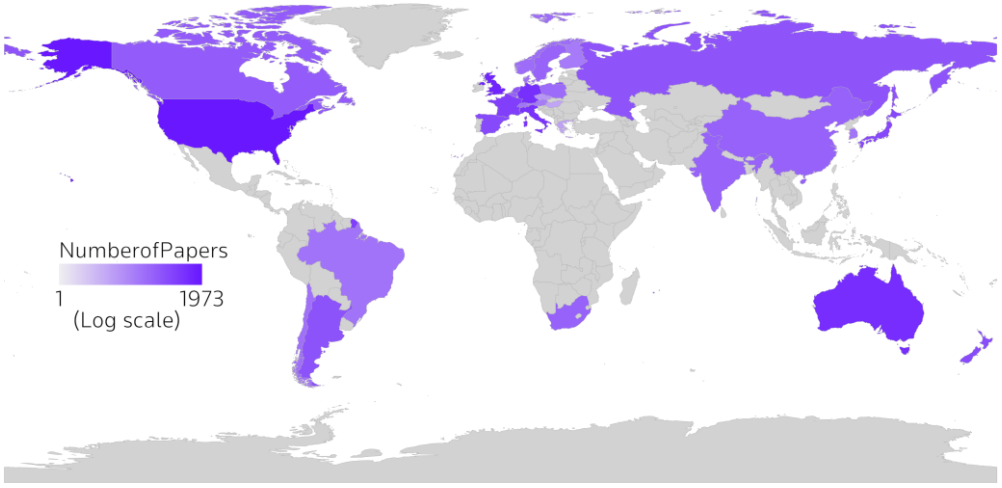
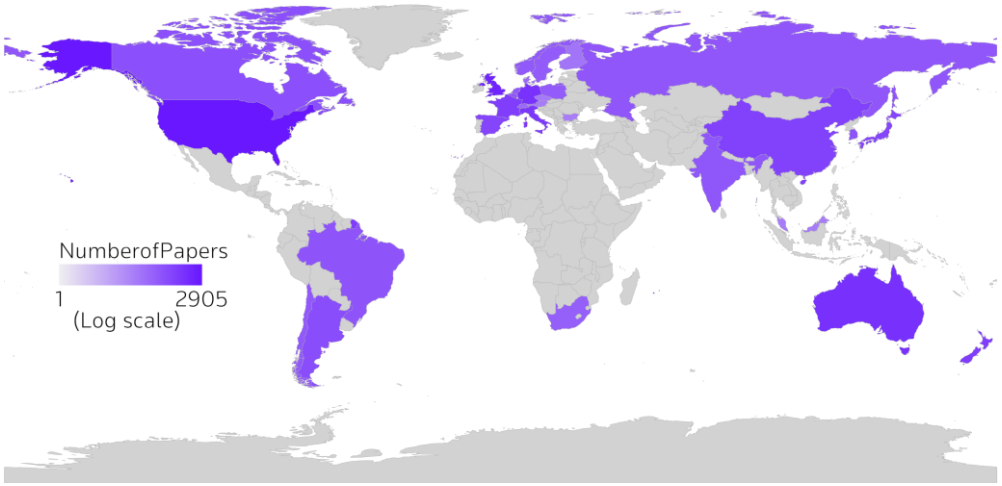


Figure 5.5.4 Top 30 countries by research output, Antarctic Research, 2006-2015



In Antarctic Research, USA (ranked first in both decades) and European countries, such as the UK and Germany, led in research output. However, due to the proximity to the Antarctic region, Australia (ranked third in both decades) and New Zealand (ninth and seventh in the two decades) also had strong performance. For the same reason, developing countries such as Argentina, Chile and South Africa, all had stronger performance than themselves in other subject areas. India published 137 papers (17th) between 1996 and 2005 and 279 papers (16th) in the next 10 years.

Figure 5.5.5 Bubble chart of selected top countries by research output, Antarctic Research, 1996-2005

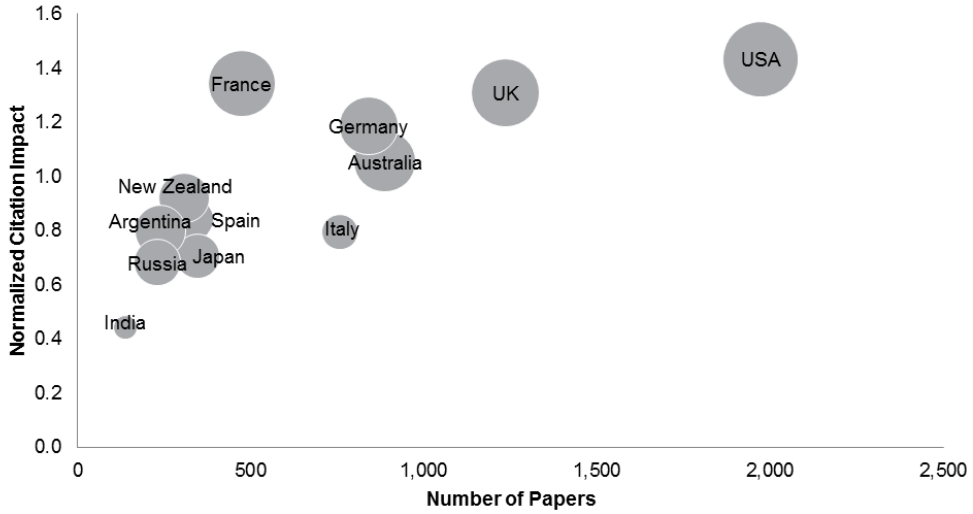
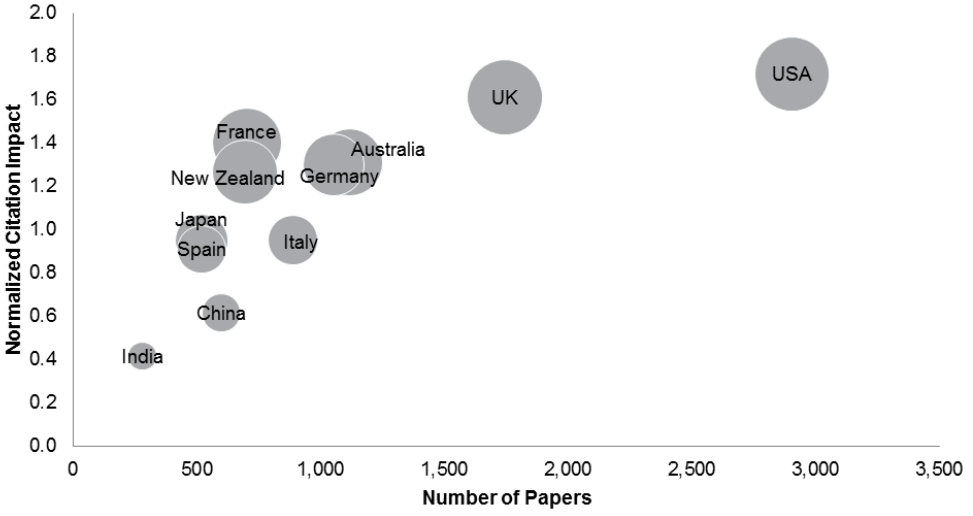


Figure 5.5.6 Bubble chart of selected top countries by research output, Antarctic Research, 2006-2015



5.5.4 Top 30 Countries ranked by mNCI

Figure 5.5.7 Top 30 countries by mNCI (Number of Papers >=50), Antarctic Research, 1996-2005

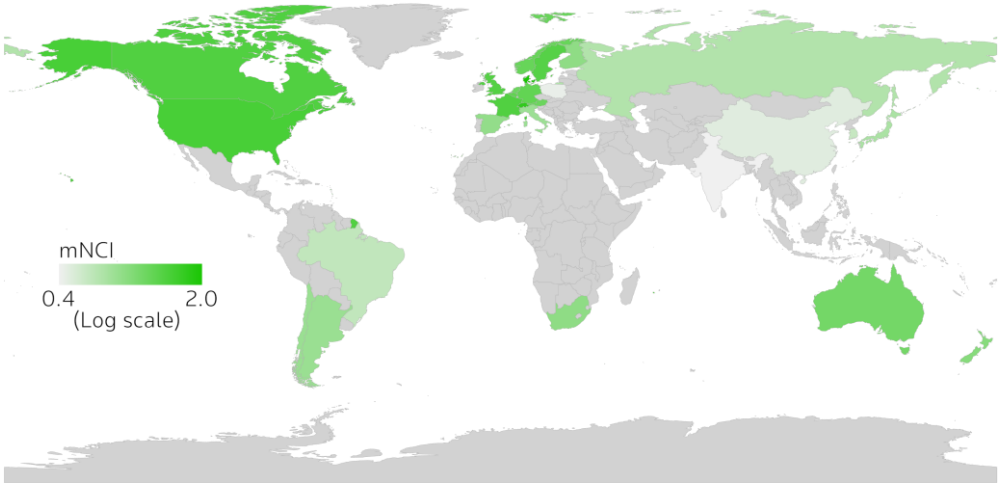
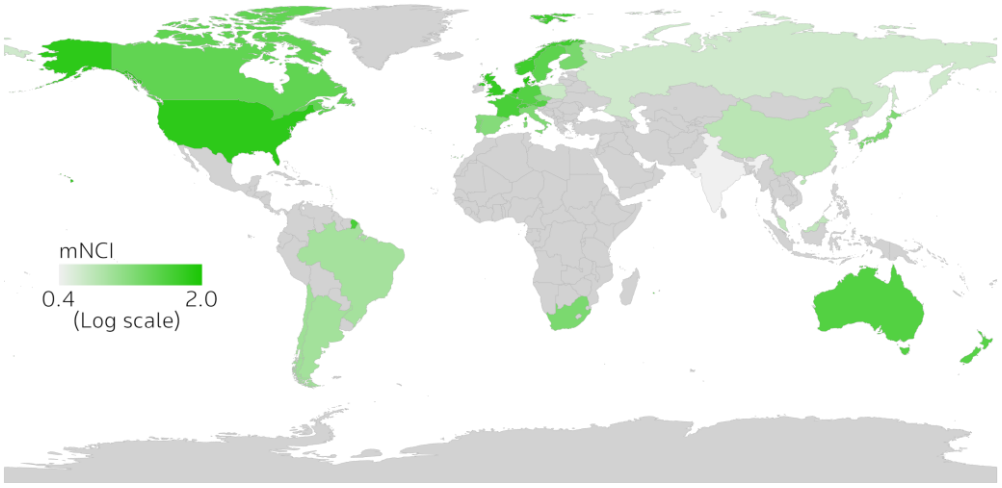


Figure 5.5.8 Top 30 countries by mNCI (Number of Papers >=50), Antarctic Research, 2006-2015



Denmark (mNCI=1.98), Switzerland (mNCI=1.69) and the USA (mNCI=1.43) had the highest citation impact between 1996 and 2005. In the next decade, Netherlands (mNCI=1.98), Denmark (mNCI=1.83), and the USA (mNCI=1.72) led. It is worth noting that, within them, the USA published significantly more papers. UK and Germany were among the countries that were ranked highly in both citation impact and research output. India's research were cited less than half of the work average (mNCI=0.44, Decade 1; mNCI=0.42, Decade 2), ranked 30th in both decades.

Please be advised that the citation impact of a country's papers should always be interpreted together with the number of papers it published.

Figure 5.5.9 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Antarctic Research, 1996-2005

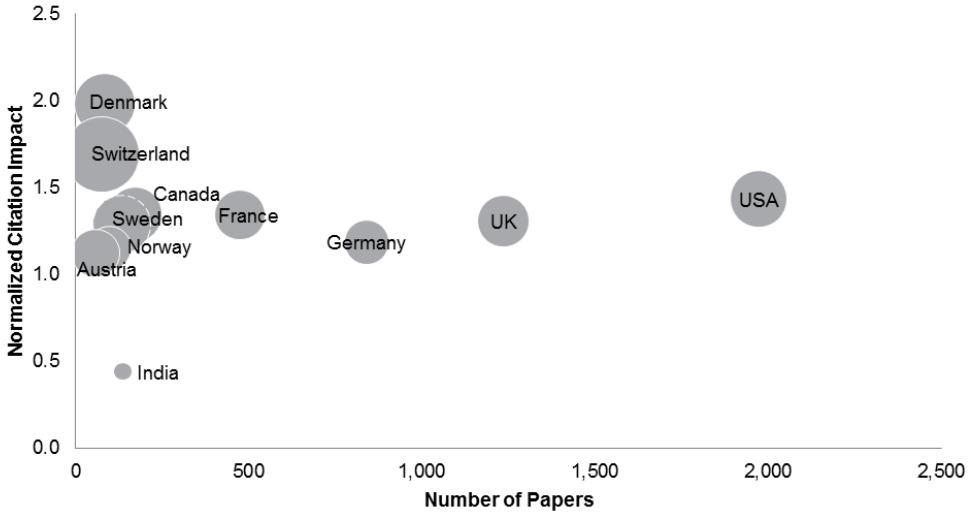
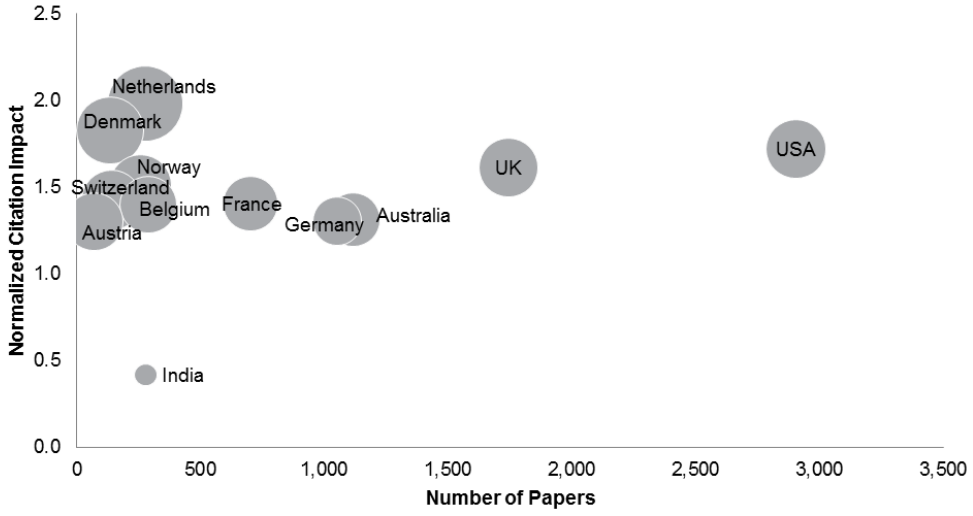


Figure 5.5.10 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Antarctic Research, 2006-2015



5.5.5 Top 10 journals with the highest JIF

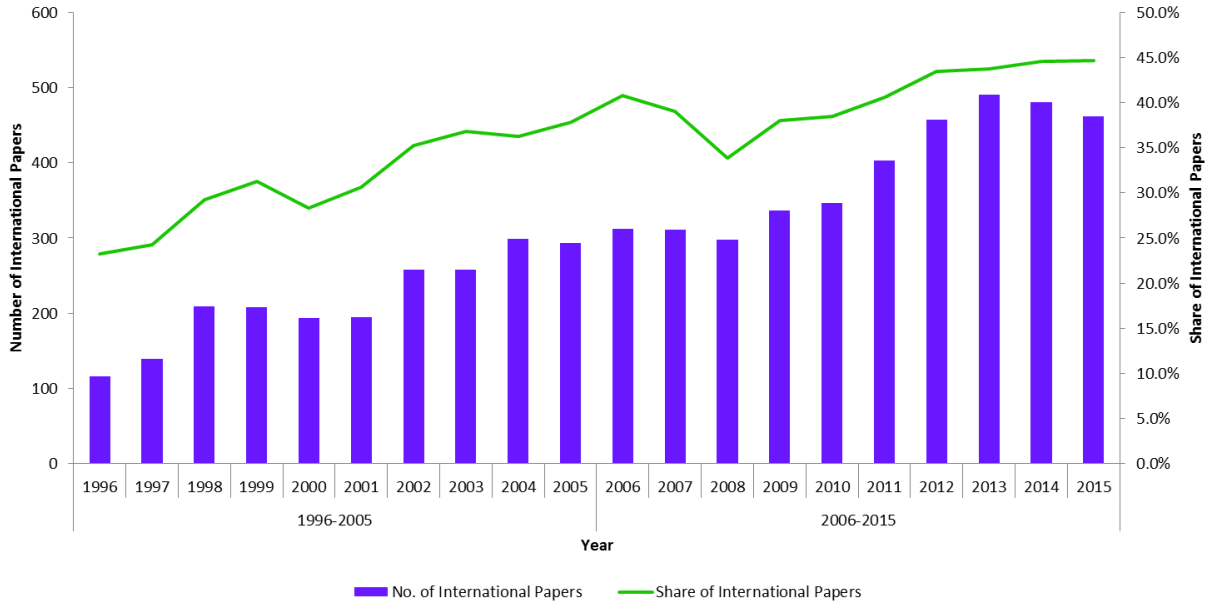
Table 5.5.1 Top 10 journals with the highest JIF (Number of Papers >= 100), Antarctic Research, 1996-2015

Journal Name	Publishing Country	JIF	No. of Papers
ATMOSPHERIC CHEMISTRY AND PHYSICS	Germany	5.11	115
CRYOSPHERE	Germany	4.91	104
JOURNAL OF CLIMATE	USA	4.85	131
GEOLOGY	USA	4.55	117
QUATERNARY SCIENCE REVIEWS	UK	4.52	130
EARTH AND PLANETARY SCIENCE LETTERS	Netherlands	4.33	200
GEOPHYSICAL RESEARCH LETTERS	USA	4.21	555
GLOBAL AND PLANETARY CHANGE	Netherlands	3.55	115
JOURNAL OF GLACIOLOGY	UK	3.11	286
PLOS ONE	USA	3.06	120

Nine of the top 10 journals with the highest JIF in Antarctic Research had a focus on Earth System Science. Among them, ATMOSPHERIC CHEMISTRY AND PHYSICS had the highest JIF (5.11). PLOS ONE was the only multidisciplinary journal in the list.

5.5.6 Number and share of internationally collaborative papers

Figure 5.5.11 Number and percentage of internationally collaborative papers, Antarctic Research, 1996-2005 and 2006-2015



Measured by number of papers, international collaboration had steadily increased from 116 to 293 in the first 10-year period, and, then from 312 to 462 in the next decade. Due to the relatively small number of papers, volatility can be observed, especially between 1996 and 2005. In 1996, less than a quarter (23.2%) of the papers were published out of international collaboration; that share increased to over a third (37.9%) in 2005. In 2015, nearly half (44.6%) of papers in Antarctic research were internationally collaborative.

5.5.7 Most common international collaborative country pairs

Table 5.5.2 Top 10 internationally collaborative country pairs, Antarctic Research, 1996-2005

Country 1	Country 2	No. of Collaborative Papers
USA	UK	210
USA	Australia	181
UK	Germany	124
USA	Germany	113
UK	Australia	85
USA	New Zealand	84
USA	France	83
USA	Italy	77
Italy	France	76
France	Australia	63

Table 5.5.3 Top 10 internationally collaborative country pairs, Antarctic Research, 2006-2015

Country 1	Country 2	No. of Collaborative Papers
USA	UK	484
USA	Australia	273
UK	Germany	255
USA	Germany	245
USA	New Zealand	240
UK	Australia	195
USA	France	185
USA	Italy	169
USA	Canada	159
UK	France	144

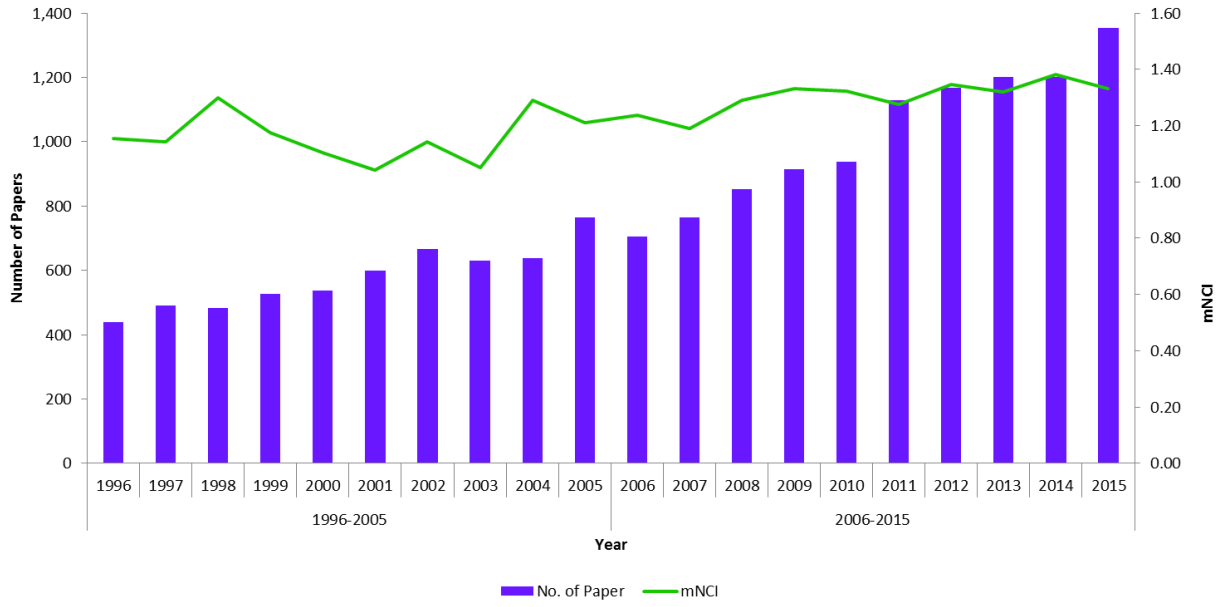
In Antarctic Research, the USA, with the highest number of papers published in Antarctic Research, dominated the international collaboration. More specifically, the USA and the UK were the most important countries in international collaboration. The USA was involved in six and seven of the top 10 international collaborative pairs in each decade, respectively. Moreover, the USA-UK and USA-Australia pairs produced the two highest numbers of papers in each decade.

The dominance of the USA in international collaboration is mainly due to the fact that the USA published the highest number of papers. International collaboration without the USA was also provided in the Excel companion data file.

5.6 TREND IN ARCTIC RESEARCH

5.6.1 Annual research output and citation impact

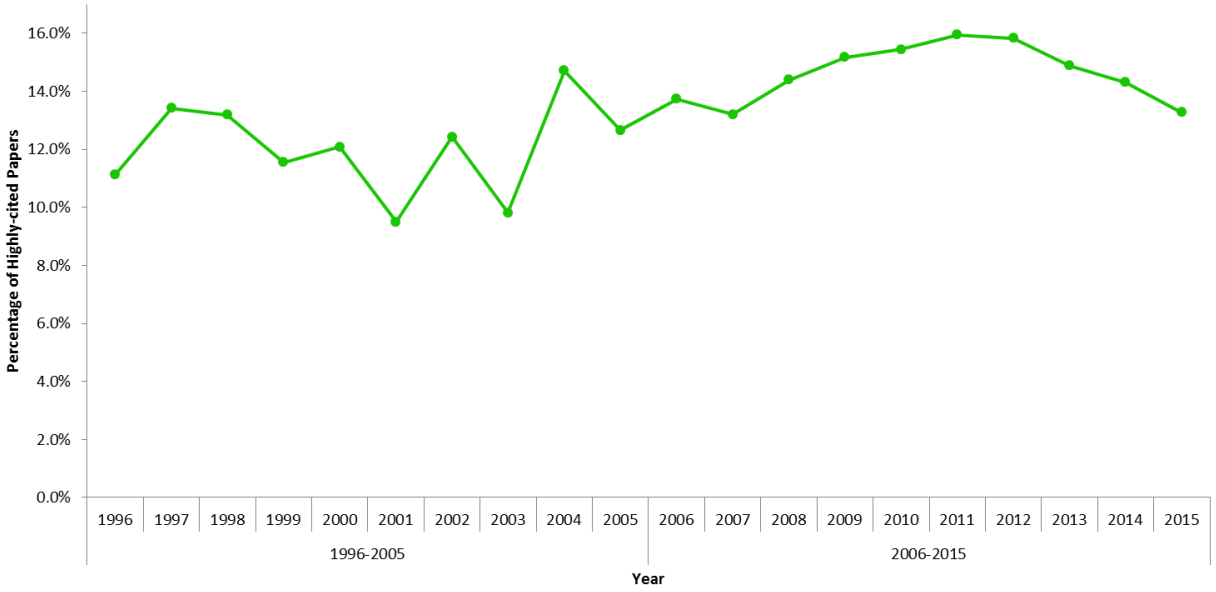
Figure 5.6.1 Annual research output and mNCI, Arctic Research, 1996-2005 and 2006-2015



Annual research output in Arctic Research increased from 440 papers in 1996 to 766 in 2005. In the second decade, the pace of increase accelerated slightly, and 1,356 papers were published in 2015. Although there was similar amount of papers published in Arctic Research as it was in Antarctic Research, average citation impact of the latter (mNCI=1.23) was substantially higher. In fact, it was the highest in all subject areas in this report. Furthermore, citation impact of the papers that were published in Decade 2 (mNCI=1.30) was higher than that of Decade 1 (mNCI =1.16).

5.6.2 Percentage of highly-cited papers

Figure 5.6.2 Annual percentages of highly-cited papers, Arctic Research, 1996-2005 and 2006-2015



On average 13.3% of Arctic Research papers were highly-cited papers, the highest among all subject areas. This is consistent with the high mNCI observed in **Section 5.6.1.** Annual share of highly-cited papers fluctuated around 12% in the first decade. Annual share of highly-cited papers in the second decade, in general, was higher than that of the first decade. Between 2009 and 2011, more than 15% of papers in this subject were highly-cited.

5.6.3 Top 30 Countries ranked by output

Figure 5.6.3 Top 30 countries by research output, Arctic Research, 1996-2005

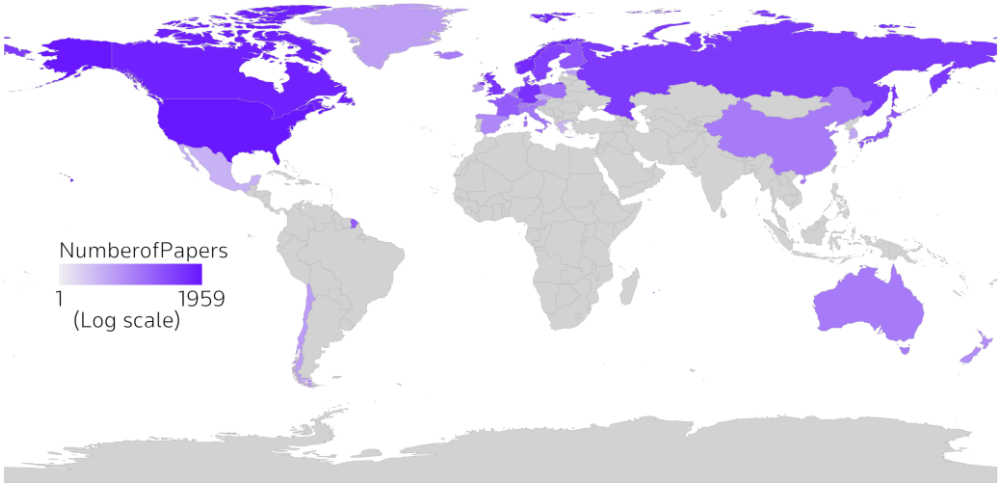
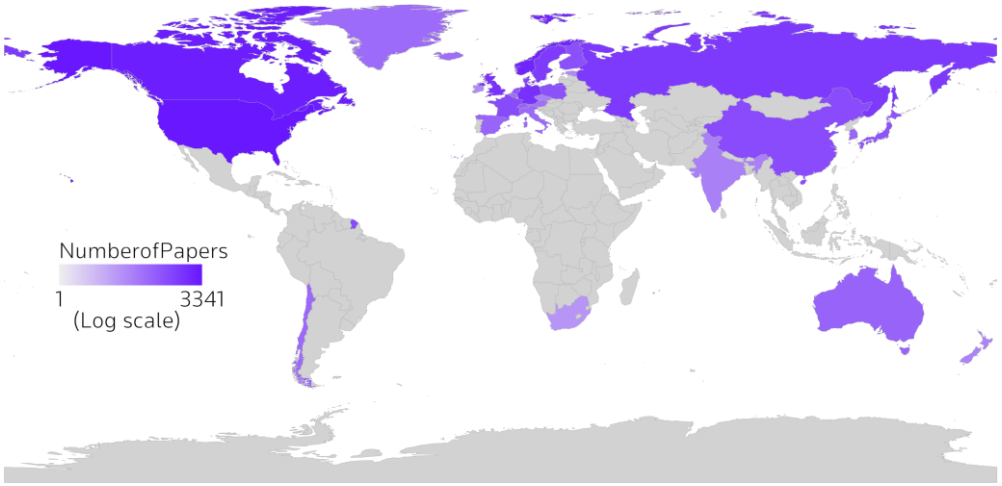


Figure 5.6.4 Top 30 countries by research output, Arctic Research, 2006-2015



Due to their strong geoscience research and proximity to the Arctic region, the USA and Canada dominated in Arctic Research, occupying the first and second position in both decades. Countries like Norway (ranked third in each decade), and to a lesser degree, Sweden, Denmark and Finland, all had strong research performance in this field. The fact that these European countries lie partially in the Arctic Circle certainly helped. India ranked in the top 30 countries by number of papers in the first decade. It published 65 papers published in the next 10-year period and ranked 25th.

Figure 5.6.5 Bubble chart of selected top countries by research output, Arctic Research, 1996-2005

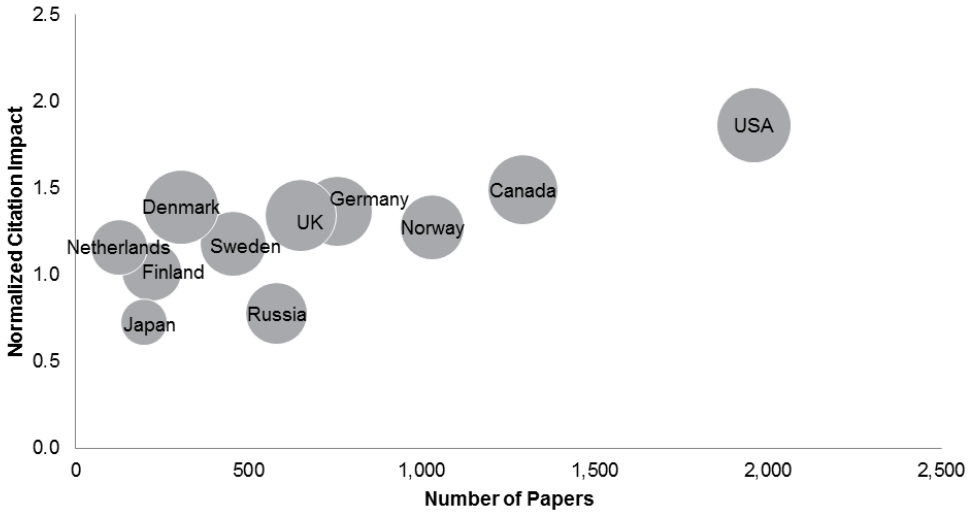
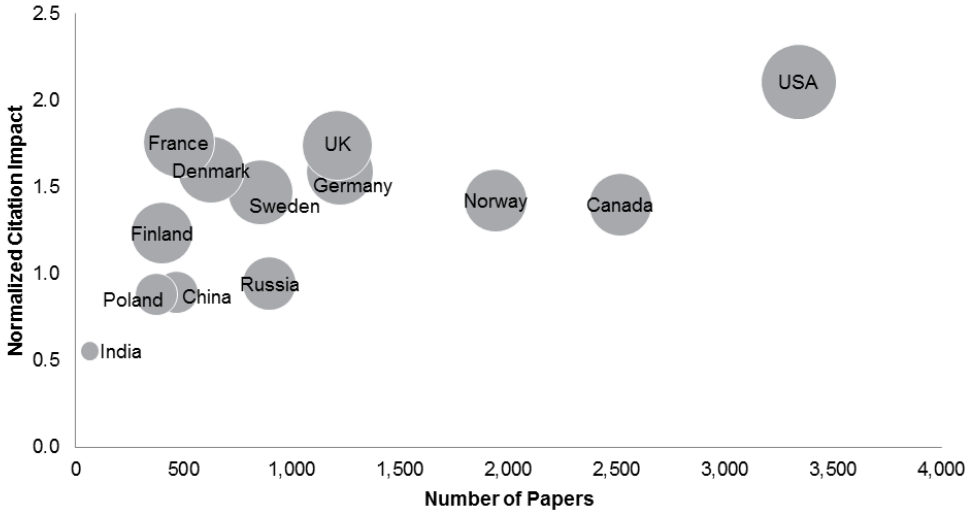


Figure 5.6.6 Bubble chart of selected top countries by research output, Arctic Research, 2006-2015



5.6.4 Top 30 Countries ranked by mNCI in each decade

Figure 5.6.7 Top 30 countries by mNCI (Number of Papers >=50), Arctic Research, 1996-2005

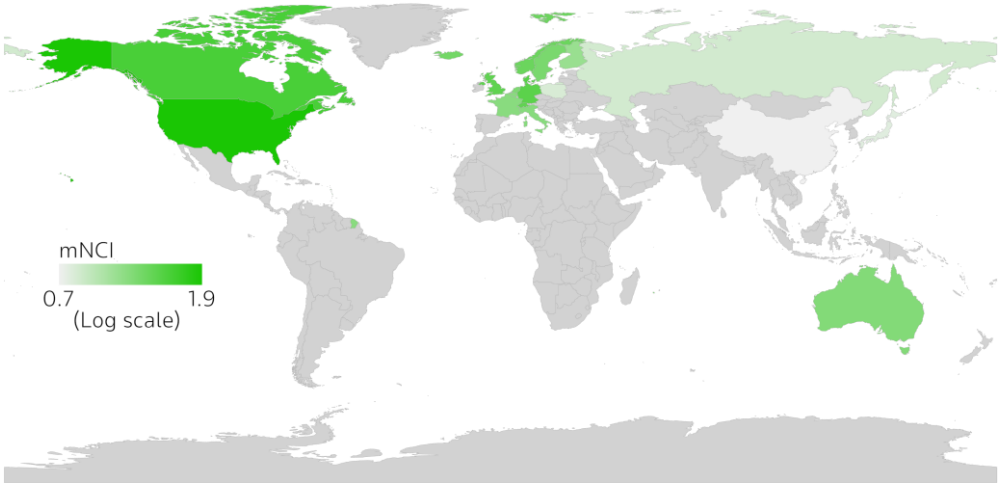
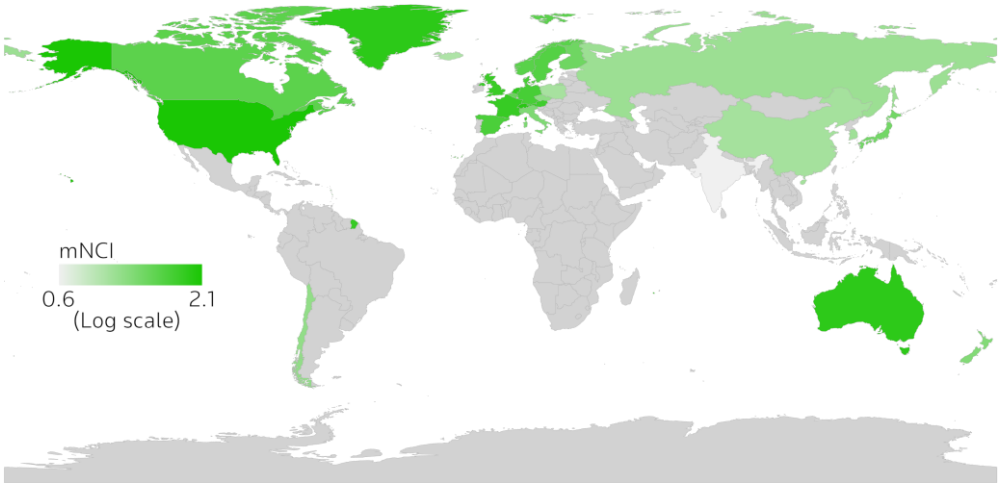


Figure 5.6.8 Top 30 countries by mNCI (Number of Papers >=50), Arctic Research, 2006-2015



Only 19 countries had more than 50 papers in Arctic Research between 1996 and 2005. Among them, the USA (mNCI =1.86) and Canada (mNCI=1.49) had the highest citation impact. In the second decade, the USA (mNCI =2.11) still led in citation impact among 27 countries with more than 50 papers, followed by Switzerland (mNCI =1.93). India had 56 papers between 2006 and 2015, ranked 27th by citation impact (mNCI=0.56) in this period.

Please be advised that the citation impact of a country's papers should always be interpreted together with the number of papers it published.

Figure 5.6.9 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Arctic Research, 1996-2005

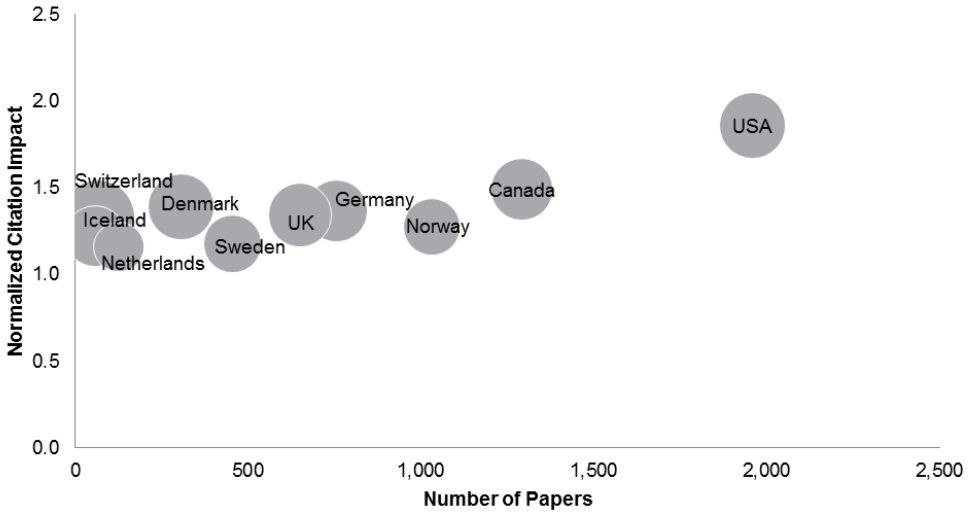
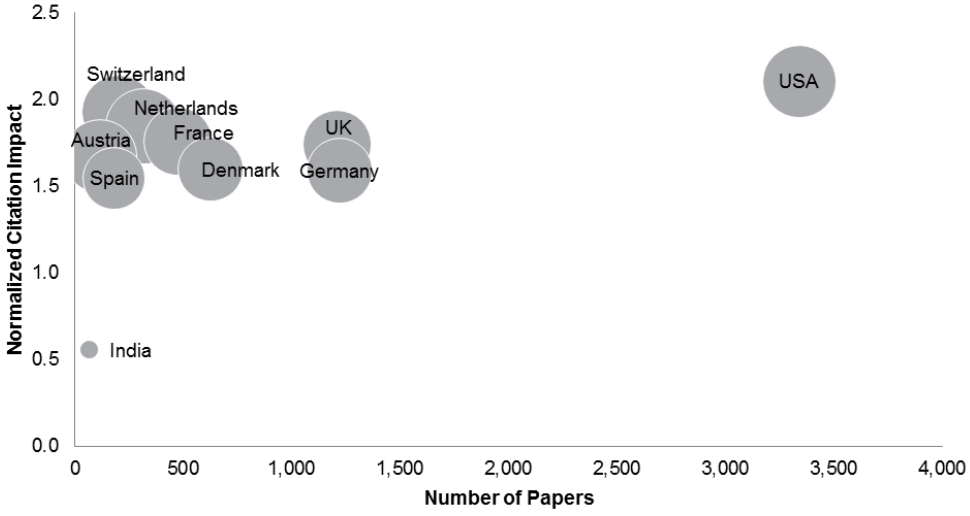


Figure 5.6.10 Bubble chart of selected top countries by mNCI (Number of Papers >=50), Arctic Research, 2006-2015



5.6.5 Top 10 journals with the highest JIF

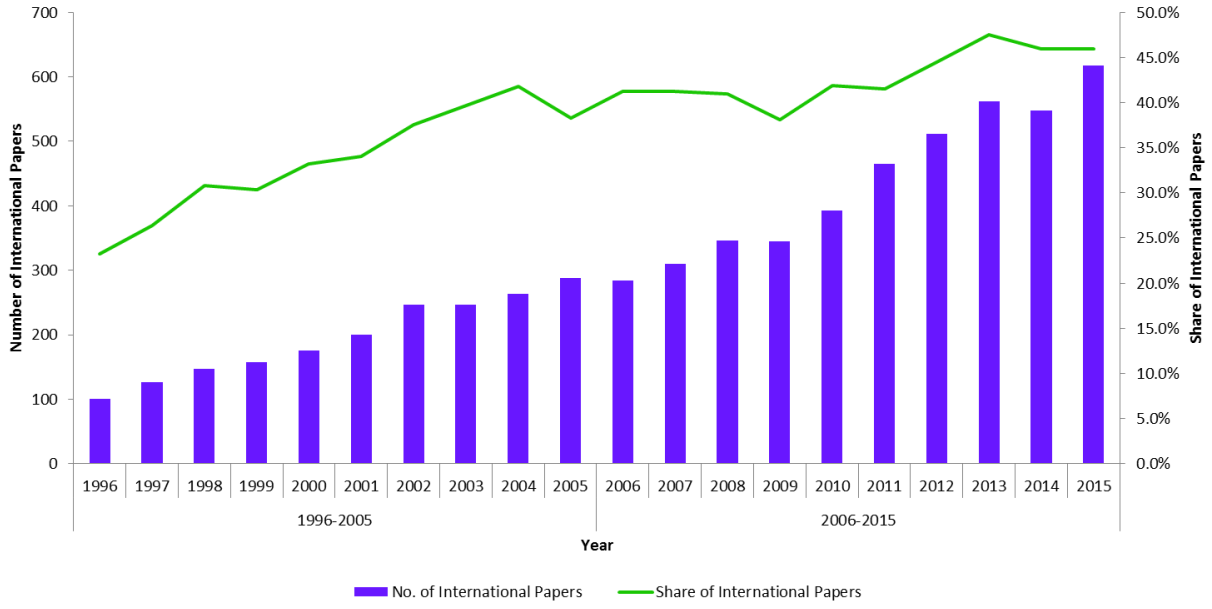
Table 5.6.1 Top 10 journals with the highest JIF (Number of Papers >=100), Arctic Research 1996-2015

Journal Name	Publishing Country	JIF	No. of Papers
ENVIRONMENTAL SCIENCE & TECHNOLOGY	USA	5.39	205
ATMOSPHERIC CHEMISTRY AND PHYSICS	Germany	5.11	254
JOURNAL OF CLIMATE	USA	4.85	247
QUATERNARY SCIENCE REVIEWS	UK	4.52	151
GEOPHYSICAL RESEARCH LETTERS	USA	4.21	647
SCIENCE OF THE TOTAL ENVIRONMENT	Netherlands	3.98	179
BIOGEOSCIENCES	Germany	3.70	113
ATMOSPHERIC ENVIRONMENT	UK	3.46	104
PLOS ONE	USA	3.06	117
MARINE ECOLOGY PROGRESS SERIES	Germany	2.36	179

ENVIRONMENTAL SCIENCE & TECHNOLOGY (5.39) and ATMOSPHERIC CHEMISTRY AND PHYSICS (5.11) had the highest JIF. It is of note that five of the 10 top journals by JIF in Arctic research overlapped with those in Antarctic Research (**Section 5.5**). This finding reflects the shared topics between the research on Earth's two Polar Regions. Also, PLOS ONE is the only multidisciplinary journal on both lists.

5.6.6 Number and share of internationally collaborative papers

Figure 5.6.11 Number and percentage of internationally collaborative papers, Arctic Research, 1996-2005 and 2006-2015



The trend of international collaboration in Arctic Research shares a high level of similarity with that of the Antarctic Research. International collaboration steadily increased from 101 to 288 in the first 10-year period, and, then from 284 to 617 in the following decade. In 1996, less than a quarter (23.3%) of the papers were published out of international collaboration; that share increased to over a third (38.2%) in 2005. In 2015, close to half (46.0%) of the papers in Arctic research were internationally collaborative.

Among all subject areas, the share of internationally collaborative papers was the highest in Arctic Research and Antarctic Research.

5.6.7 Most common international collaborative country pairs

Table 5.6.2 Top 10 internationally collaborative country pairs, Arctic Research, 1996-2005

Country 1	Country 2	No. of Collaborative Papers
USA	Canada	314
USA	Germany	196
UK	Norway	154
USA	Russia	129
USA	Norway	128
USA	UK	108
Norway	Canada	95
Sweden	Norway	92
Russia	Norway	90
UK	Germany	86

Table 5.6.3 Top 10 internationally collaborative country pairs, Arctic Research, 2006-2015

Country 1	Country 2	No. of Collaborative Papers
USA	Canada	665
USA	Germany	328
USA	Norway	323
USA	UK	313
UK	Norway	274
Norway	Canada	241
Sweden	Norway	229
USA	Russia	228
Norway	Germany	227
USA	Sweden	226

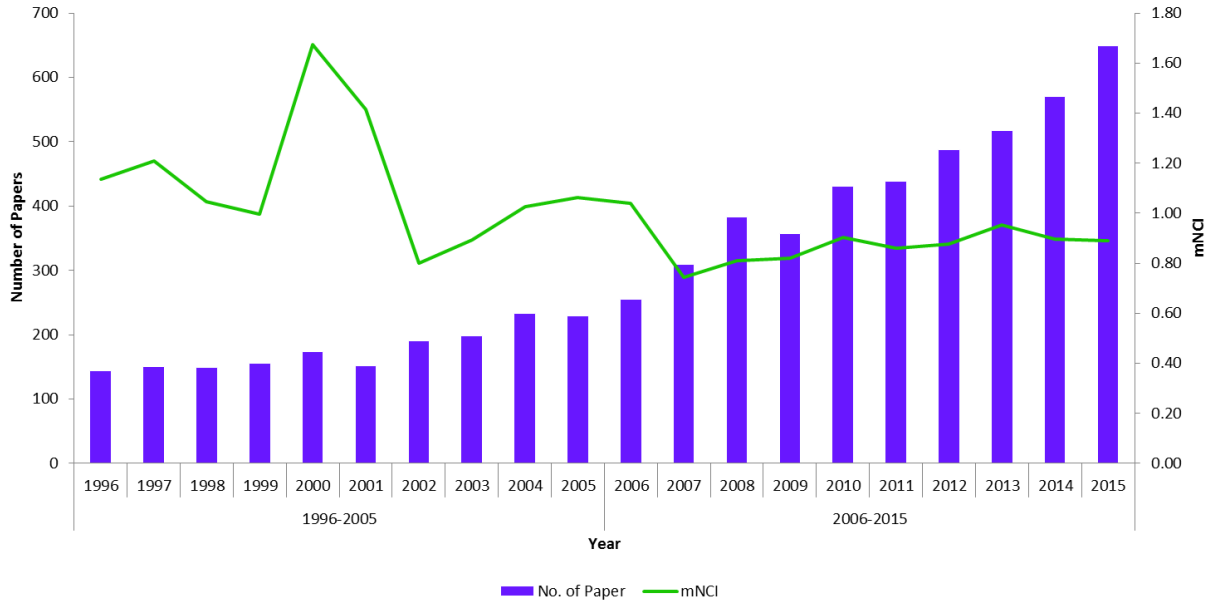
The most productive international collaboration happened exclusively in countries in North America and Europe. The USA and Norway participated in international collaboration in Arctic Research with the highest level of engagement. The USA involved itself in five and six country pairs in each period; Norway followed closely. In both decades, the USA-Canada pair and USA-Germany published the highest number of papers.

The dominance of the USA in international collaboration is mainly due to the fact that the USA published the highest number of papers. International collaboration without the USA was also provided in the Excel companion data file.

5.7 TREND IN HIMALAYAS RESEARCH

5.7.1 Annual research output and citation impact

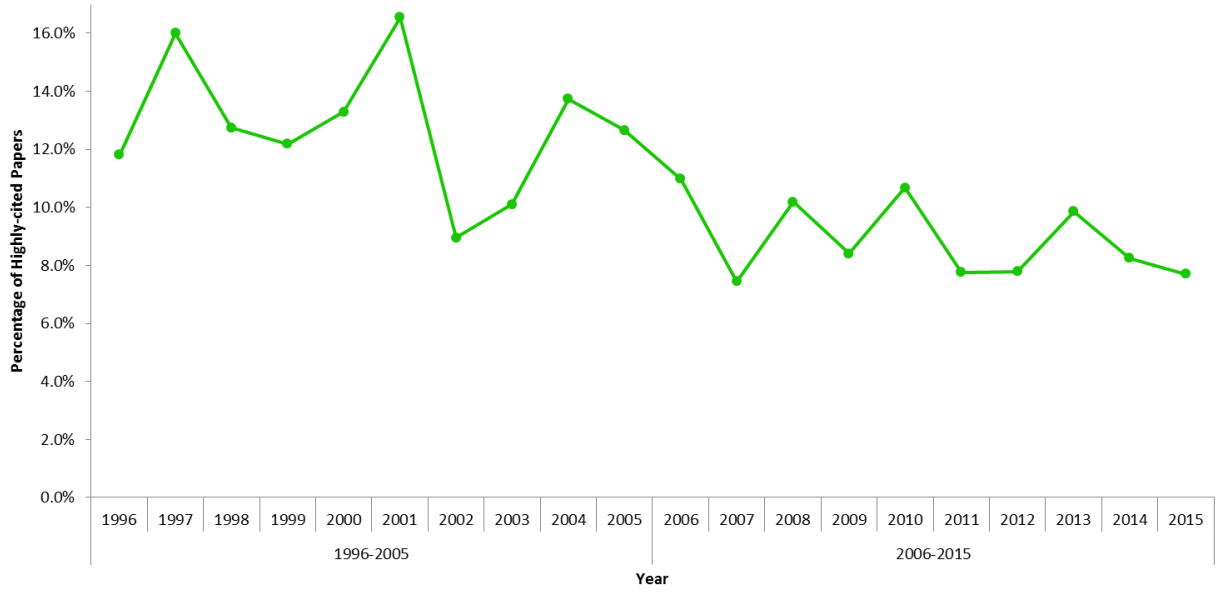
Figure 5.7.1 Annual research output and mNCI, Himalayas Research, 1996-2005 and 2006-2015



Himalayas Research produced the least amount of papers in all subject areas. Research activity was generally flat in the first period with, on average, 177 papers published each year. The pace of publication accelerated in the following decade at 440 papers per year on average. In contrast to the increase in output, citation impact dropped. Papers of Decade 1 (mNCI = 1.13) were generally cited over word average with a peak (mNCI=1.67) in 2000. However, mNCI of the papers in Decade 2 was only 0.88, substantially lower than the world average.

5.7.2 Percentage of highly-cited papers in Himalayas Research

Figure 5.7.2 Annual percentage of highly-cited papers, Himalayas Research, 1996-2005 and 2006-2015



Although the number of papers in the second decade increased, the share of highly-cited papers (8.9%) was significantly lower than that of the first decade (12.8%). Research published between 1997 and 2000 had a particularly large share of highly-cited papers (16%). But, in the last five years of the second decade, only less than 10% of papers were highly-cited. In both decades, annual share of highly-cited papers fluctuated.

5.7.3 Top 30 Countries ranked by output

Figure 5.7.3 Top 30 countries by research output, Himalayas Research, 1996-2005

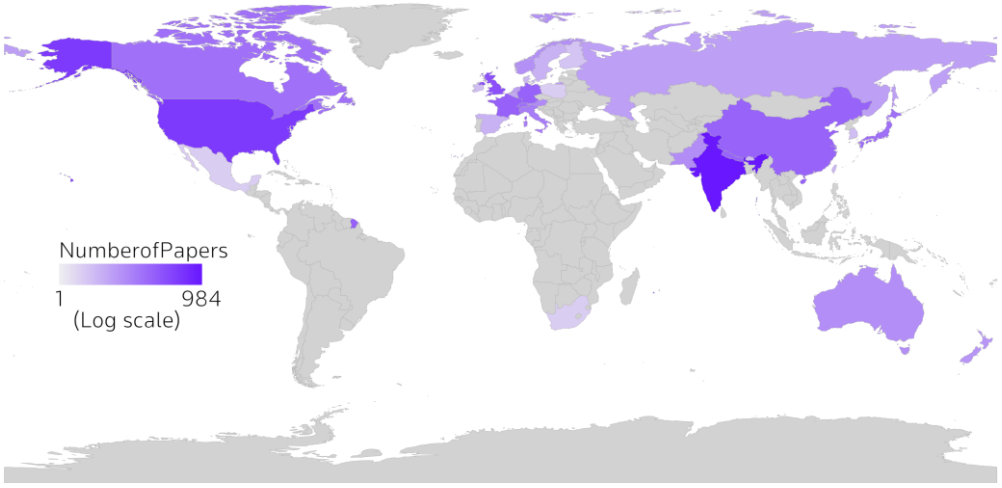
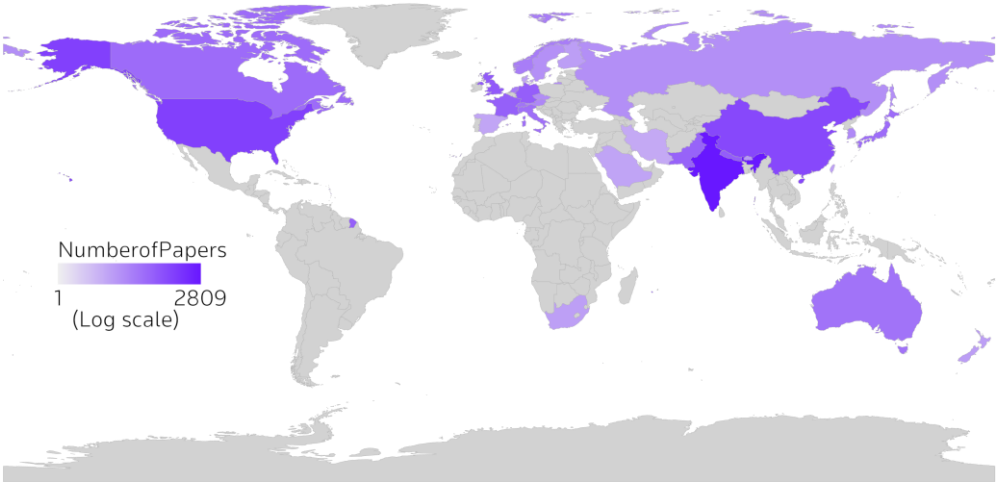


Figure 5.7.4 Top 30 countries by research output, Himalayas Research, 2006-2015



Himalayas Research is a strong field for India, which took the lead in producing the most research papers in both decades. Moreover, India's research output in this subject area nearly tripled, from 984 to 2,809, between the two decades. The USA also had strong performance and ranked second in both decades, though the number of papers it published (321 and 614 respectively) was significantly smaller than India. China increased its output from 88 to 452 between two decades and ranked third in the second decade. Nepal (seventh and fifth respectively), Pakistan and Bhutan, none of which made it into the top 30 country list in other subject areas, contributed significantly to the research focusing on a region that they call home.

Figure 5.7.5 Bubble chart of selected top countries by research output, Himalayas Research, 1996-2005

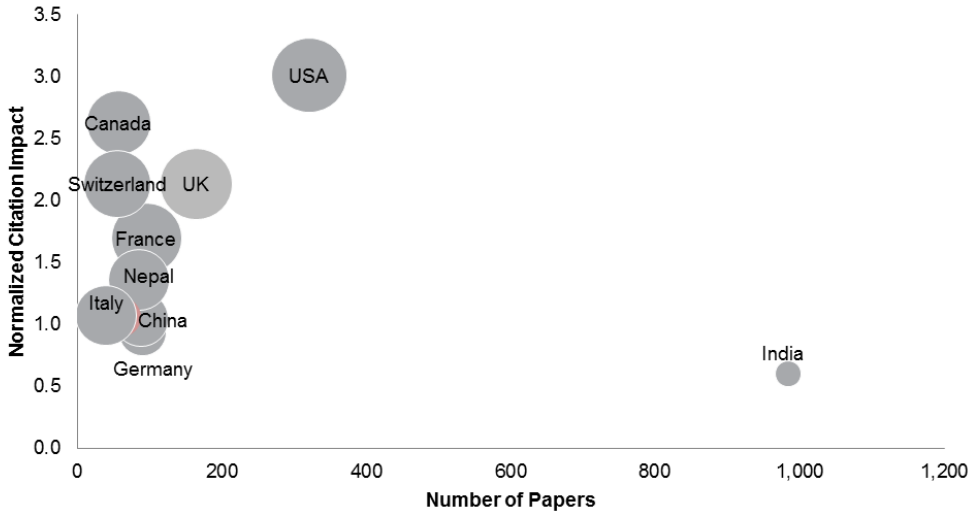
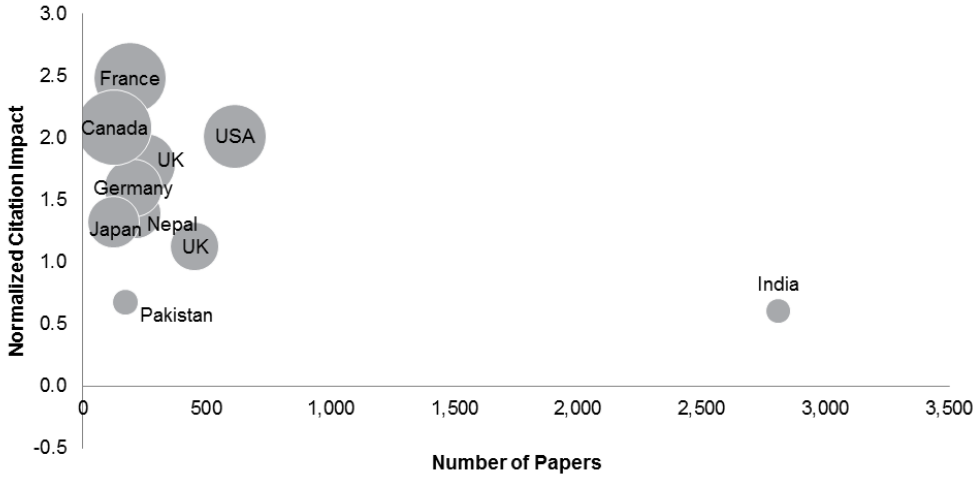


Figure 5.7.6 Bubble chart of selected top countries by research output, Himalayas Research, 2006-2015



5.7.4 Top 30 Countries ranked by mNCI

Figure 5.7.7 Top 30 countries by mNCI, Himalayas Research, 1996-2005

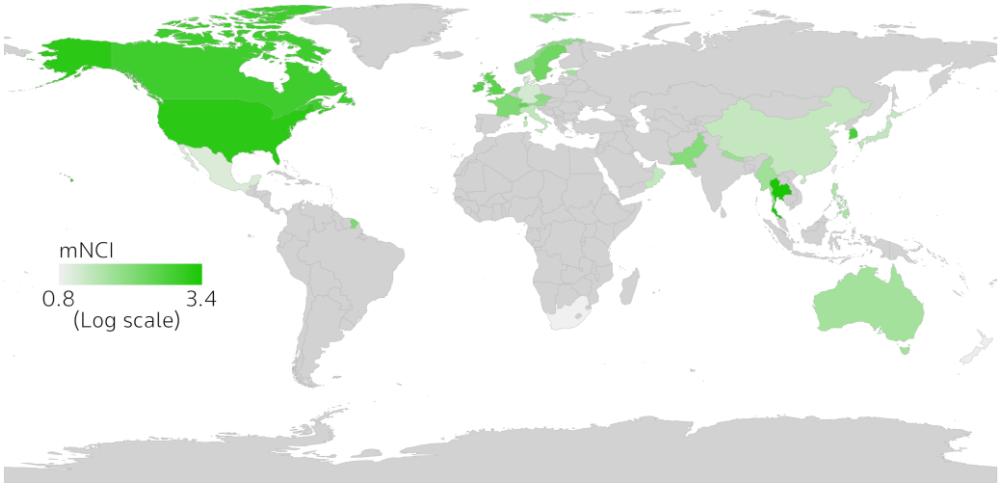
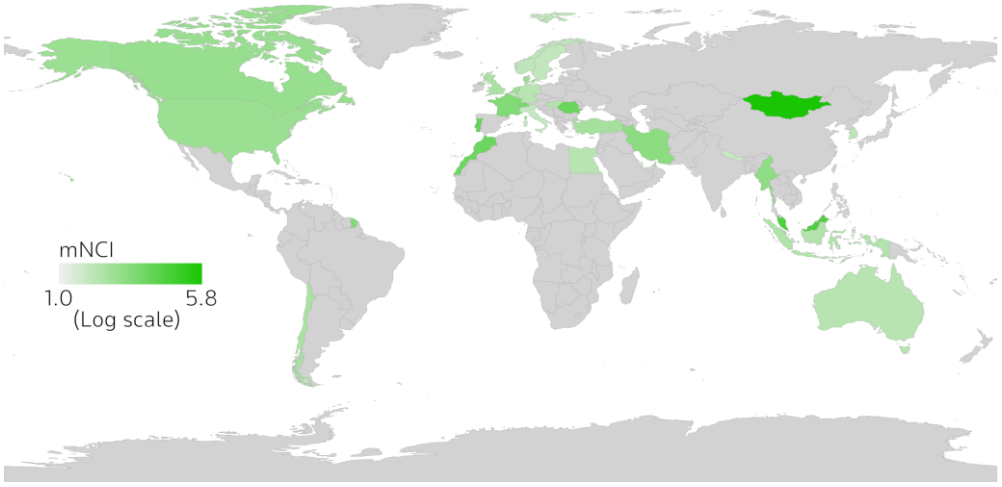


Figure 5.7.8 Top 30 countries by mNCI, Himalayas Research, 2006-2015



Thailand (mNCI=3.39), the USA (mNCI=3.01), and Canada (mNCI=2.63) led in citation impact in the first period. Mongolia (mNCI=5.84), Malaysia (mNCI=3.80), and Singapore (mNCI=3.66) were ranked the highest in the next decade. It is interesting to find countries like Thailand and Mongolia ranked at the top. Because they only published 2 and 3 papers, respectively, these papers must have been published through international collaboration. USA, Canada, UK and France were countries leading in citation impact as well as in research output.

India's research in Himalayas Research was strong in output, but not in citation impact.

Please be advised that the citation impact of a country's papers should always be interpreted together with the number of papers it published.

Figure 5.7.9 Bubble chart of selected top countries by mNCI, Himalayas Research, 1996-2005

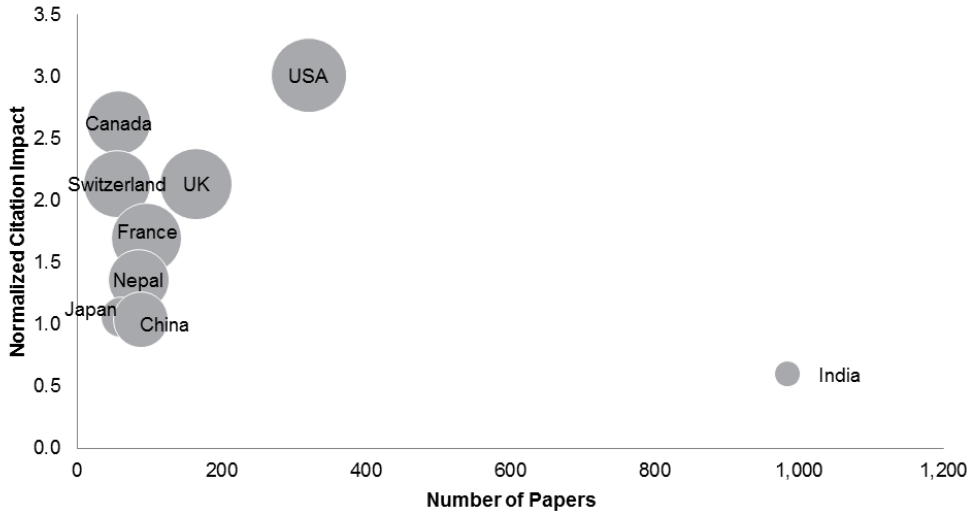
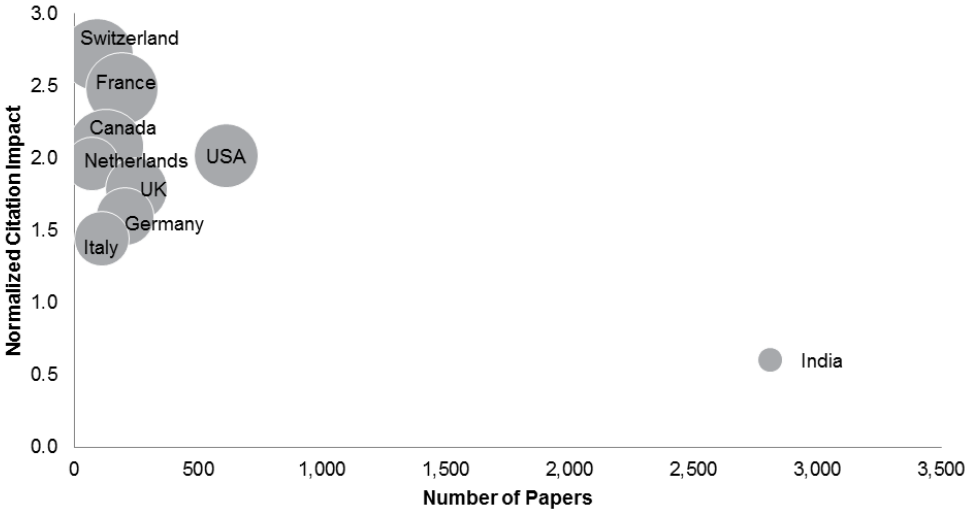


Figure 5.7.10 Bubble chart of selected top countries by mNCI, Himalayas Research, 2006-2015



5.7.5 Top five journals with the highest Journal Impact factor

Table 5.7.1 Top 5 journals with the highest JIF (Number of Papers >=100), Himalayas Research, 1996-2015

Journal Name	Publishing Country	JIF	No. of Papers
EARTH AND PLANETARY SCIENCE LETTERS	Netherlands	4.33	117
JOURNAL OF ASIAN EARTH SCIENCES	UK	2.65	167
CURRENT SCIENCE	India	0.97	372
JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	India	0.55	207
HIMALAYAN GEOLOGY	India	0.35	149

Only five journals published more than 100 papers in Himalayas Research from 1996 and 2015. EARTH AND PLANETARY SCIENCE LETTERS is one of the five journals that published more than 100 papers and had the highest JIF (4.33). It is of note that three journals, CURRENT SCIENCE, JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA, and HIMALAYAN GEOLOGY, were published by India.

5.7.6 Number and share of internationally collaborative papers

Figure 5.7.11 Number and percentage of internationally collaborative papers, Himalayas Research, 1996-2005 and 2006-2015

Annual numbers of internationally collaborative papers doubled in the first decade, from 24 to 49 with a peak (76) in 2004. The growth in the next 10 years, from 71 to 202, was even faster. However, measured by their share in total, there is a more noticeable upward trend in Decade 1.

On average, 23.5% (Decade 1) and 27.5% (Decade 2) of the papers in Himalayas Research were internationally collaborative; this shares were both less than that of the Antarctic Research and Arctic Research.

5.7.7 Most common internationally collaborative country pairs

Table 5.7.2 Top 10 internationally collaborative country pairs, Himalayas Research, 1996-2005

Country 1	Country 2	No. of Collaborative Papers
USA	India	40
USA	UK	34
USA	Nepal	30
USA	China	29
India	Germany	19
USA	France	18
USA	Germany	15
USA	Canada	14
UK	India	13
Japan	India	12

Table 5.7.3 Top 10 internationally collaborative country pairs, Himalayas Research, 2006-2015

Country 1	Country 2	No. of Collaborative Papers
USA	India	155
USA	China	90
India	Germany	62
USA	UK	54
USA	France	50
UK	India	47
USA	Nepal	46
USA	Germany	45
USA	Canada	44
UK	China	37

In Himalayas Research, the USA and India were the most active countries in international collaboration. The USA is involved in seven pairs respectively in each decade; India participated in four and three in the two periods respectively. The collaboration between them produced the highest number of papers in each time frame.

As in other subject areas, international collaboration without the USA was also provided in the Excel companion data file.

Part II. Earth System Science research of India

6 INDIA'S EARTH SYSTEM SCIENCE RESEARCH

This section profiles India's contribution to Earth System Science research. An overview of India's research activity across all six subject areas was summarized in **Section 6.1**. It includes:

- Number and mNCI of Indian papers in each 10-year period.
- Percentage of highly-cited and internationally collaborative Indian papers in each 10-year period
- Number of Indian papers in each of the six subject areas in each 10-year period

In this report, the contribution from India includes India-sourced research funding and India-based research effort. Specifically, in **Section 6.2 -** 0**,** we provided:

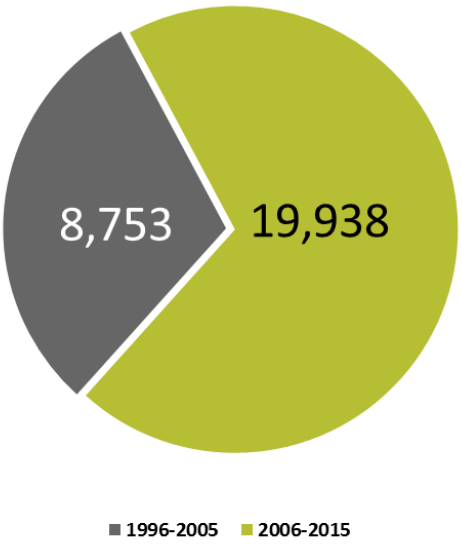
- **Annual share of papers acknowledging Indian funding agencies since 2008**: Papers indexed in Web of Science after 2008 had the most reliable funder information.
- **Annual share of highly-cited papers that were authored by Indian researchers**: In this analysis, highly-cited papers were further classified into four categories based on different thresholds; world's top 1%, 5%, 10%, or 25% of most frequently cited papers. Annual share of Indian papers in each category was reported with reference to the annual share of India's total output in each subject area.
- **Top 20 funding agencies of highly-cited Indian funding Agencies since 2008**: This section identifies the 20 most frequently acknowledged funders, Indian and foreign funders together, that sponsored India's top 10% highly-cited papers.
- **Top 15 collaborating countries of India in two 10-year periods**: The countries that collaborated with India most frequently.
- **Top 15 international collaborating institutions for India in two periods**: The institutions that collaborated with India most frequently.
- **Performance of Indian research in top 10 JSC with the highest number of papers:** In four subject areas, Geo Research, Antarctic Research, Arctic Research, and Himalayas Research. The 10 JSCs with the highest number of papers were used as proxies for subdisciplines. Profiles of Indian research papers in selected JSCs include:
  - Number and mNCI of papers by JSC between 1996 and 2015, in aggregate.
  - Share and mNCI of Indian papers by JSC.
  - Because papers of Atmospheric Research and Ocean Research were selected from only single or two JSCs, research topics of these papers are more narrowly focused than the other four. These two subject areas, therefore, were not included in this analysis.
- **Strength, Weakness, Opportunities and Threats (SWOT) of India's research in 10 JSCs:** Clarivate Analytics also extended the analyses of the subject area datasets to the entire JSCs to benchmark India's overall performance in each JSC against global research.

In addition, bibliographic information of India's papers in the top 10% highly-cited papers and annual research output and mNCI of selected JSCs was supplied in the Excel companion data File.

6.1 OVERVIEW OF INDIA'S RESEARCH IN EARTH SYSTEM SCIENCE

6.1.1 Research output and citation impact of Indian research in Earth System Science

Figure 6.1.1 Number and citation impact of Indian papers in six subject areas, 1996-2015



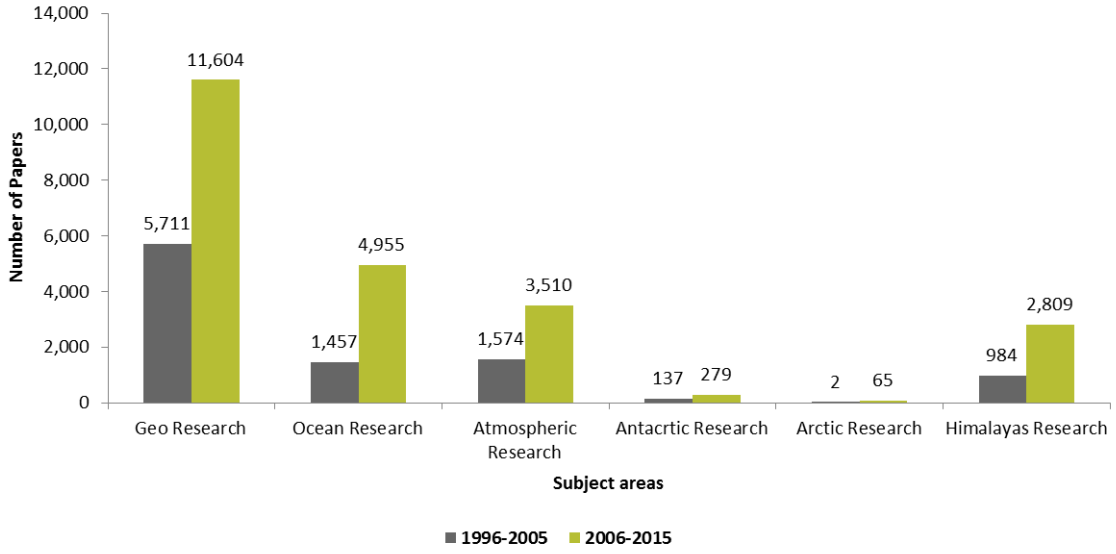
India published 19,938 papers in Earth System Science between 2006 and 2015, which more than doubled its output from the previous 10 years (8,753). Between the two decades, India research published more papers in Earth System Science at a faster rate than the global research. Citation impact of Indian papers also increased, however, at a moderate pace. In each period, India's papers were cited below world average. Further details of **Table 6.1.1** will be discussed in later subsections.

Table 6.1.1 Summary statistics of Indian research

Summary statistics in India's research	Time frame	Geo Research	Atmospheric Research	Ocean Research	Antarctic Research	Arctic Research	Himalayas Research
Number of Papers	1996-2005	5,711	1,457	1,574	137	2	984
	2006-2015	11,604	4,955	3,510	279	65	2,809
Number of Highly-cited Papers	1996-2005	247	88	68	2	1	42
	2006-2015	611	257	276	7	1	114
Number of Internationally collaborative Papers	1996-2005	1,343	392	267	31	2	984
	2006-2015	3,839	1,318	781	50	17	485

6.1.2 Overview of Indian research in each of the six subject areas

Figure 6.1.2 Number of Indian papers in each subject area, 1996-2005 and 2006-2015

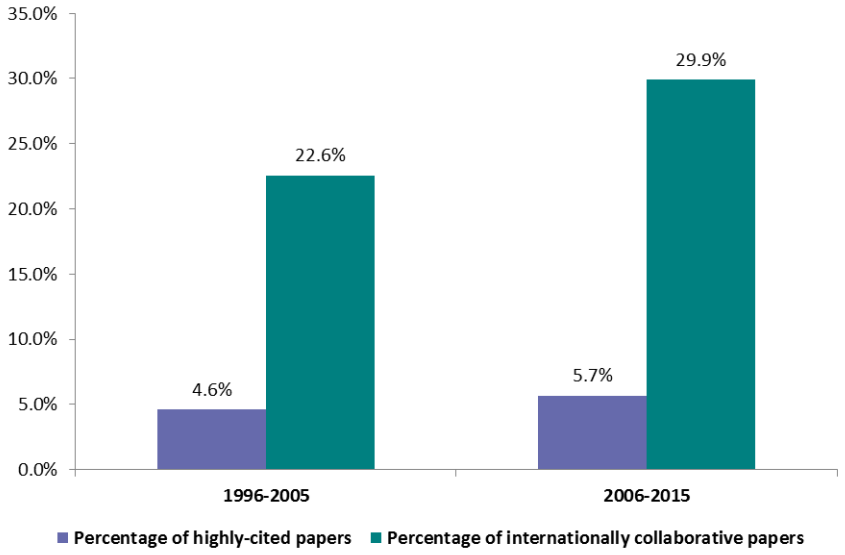


Among the six subject areas, India had the largest number of Geo Research papers, approximately equal to the summation of that of the other subject areas. India's output in Antarctic and Arctic Research was small, but it contributed a large share of papers in global Himalayas Research; nearly two thirds of worldwide Himalayas Research papers had Indian authors.

India's research output in each of the six subject areas increased significantly from the first ten year period to the second. Research output increased approximately two folds In Geo Research and Atmosperic Research and three folds in Ocean Research and Himalayas Research.

6.1.3 Share of highly-cited and internationally collaborative Indian papers

Figure 6.1.3 Percentage of highly-cited and internationally collaborative Indian papers, 1996-2005 and 2006-2015



India's proportion of highly-cited papers was lower than half of the world average in both periods. Its share of internationally collaborative papers was also below world average, though the gap was smaller. However, between two periods, there was significant increase in both shares. (The list of Indian papers that were in the world's top 1% highly cited papers is provided in annexure A15).

The share of India's highly cited papers increased in Geo Research, Ocean Research and Antarctic Research from the first ten year period to the second. But, in Atmospheric Research and Himalayas Research, the share in 2006-2015 period is lower than that of 1996-2005.

With regard to partnering with foreign researchers, India's share of internationally collaborative papers in Atmospheric Research and Antarctic Research decreased in the 2006-2015 period from 1996-2005 period, unlike the increasing trend observed in Geo Research, Ocean Research and Himalayas Research.

Because there are only two Indian papers in the field of Arctic Research between 1996 and 2005, comparing its proportion of highly-cited papers and international collaborative papers in this subject area to that of the other subject areas is less meaningful.

6.1.4 Share of highly-cited and international collaborative Indian papers

Figure 6.1.4 Percentage of highly-cited Indian papers in each of subject area, 1996-2005 and 2006-2015

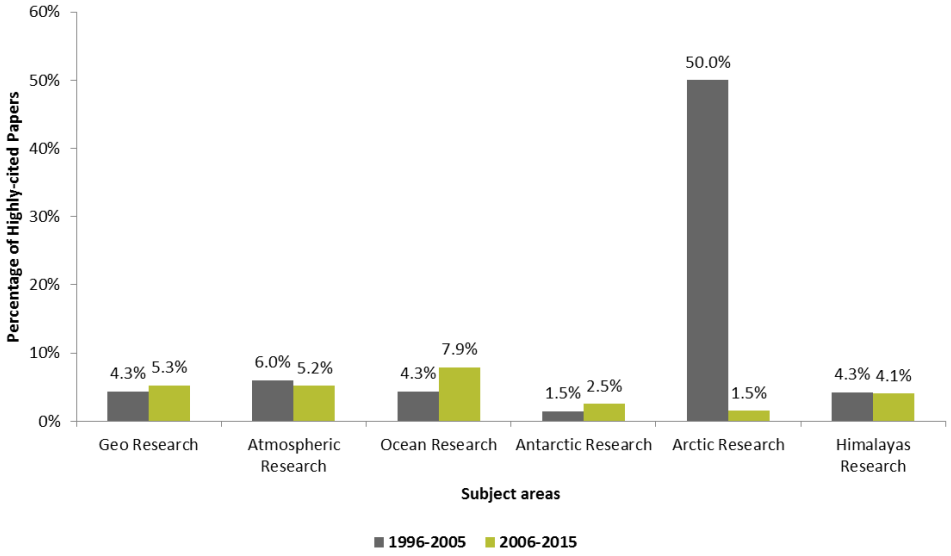
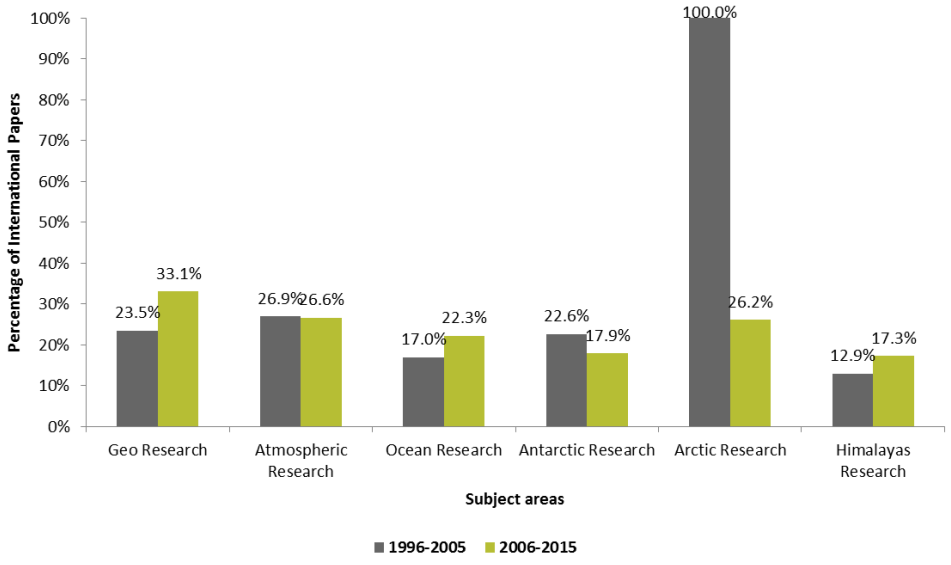


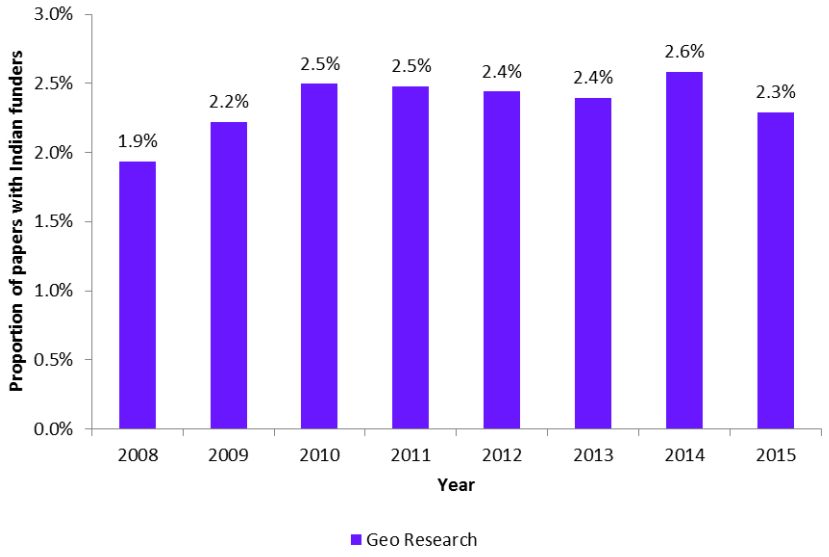
Figure 6.1.5 Percentage of internationally collaborative Indian papers in each of subject area, 1996-2005 and 2006-2015



6.2 INDIAN PERFORMANCE IN GEO RESEARCH

6.2.1 Annual share of papers acknowledging Indian funding agencies since 2008, Geo Research

Figure 6.2.1 Annual percentage of papers acknowledging Indian funding agencies, Geo Research, 2008-2015



On average, 2.4% of Geo Research papers had support from Indian funders. In contrast, Indian papers accounted approximately 3.3% of worldwide research output in the same period. The share of papers with Indian funding was considerably stable over the years.

6.2.2 Annual share of Indian papers in top most cited papers, Geo Research

Table 6.2.1 Annual number and share of Indian papers in world's top highly-cited papers, Geo Research, 1996-2015

Year	No. of India's Total papers	No. of Papers Published Worldwide	No. of India's Top 1% Papers	No. of Top 1% papers worldwide	No. of India's Top 5% Papers	No. of Top 5% papers worldwide	No. of India's Top 10% Papers	No. of Top 10% papers worldwide	No. of India's Top 25% Papers	No. of Top 25% papers worldwide
1996	479	16,589	0	184	4	922	13	1,850	55	4,444
1997	540	17,647	0	184	4	973	10	1,929	52	4,788
1998	498	18,297	1	206	7	1,026	15	2,044	49	4,943
1999	520	18,931	1	214	6	1,033	18	2,066	62	5,016
2000	504	20,040	1	243	5	1,171	20	2,250	73	5,393
2001	543	20,528	2	224	13	1,162	33	2,302	95	5,551
2002	589	20,817	1	245	12	1,161	27	2,274	78	5,572
2003	600	22,226	1	249	15	1,266	33	2,527	89	6,110
2004	714	23,972	3	288	12	1,355	37	2,653	99	6,503
2005	724	24,309	3	283	29	1,420	41	2,727	99	6,622
2006	834	26,868	4	317	24	1,544	49	3,054	135	7,301
2007	907	28,259	0	333	15	1,615	42	3,169	117	7,577
2008	975	30,530	2	372	15	1,791	42	3,441	121	8,302
2009	956	31,674	5	393	21	1,841	51	3,574	135	8,678
2010	1,045	32,148	5	415	34	1,894	69	3,640	164	8,586
2011	1,126	34,336	3	434	20	1,996	51	3,886	160	9,119
2012	1,261	37,113	3	466	24	2,149	58	4,249	172	9,826
2013	1,455	41,537	8	520	41	2,329	90	4,547	227	11,125
2014	1,509	42,881	9	508	38	2,368	83	4,571	211	10,712
2015	1,536	44,957	4	480	25	2,310	75	4,608	197	10,954

Figure 6.2.2 Annual share of India's highly-cited papers in four thresholds, Geo Research, 1996-2005

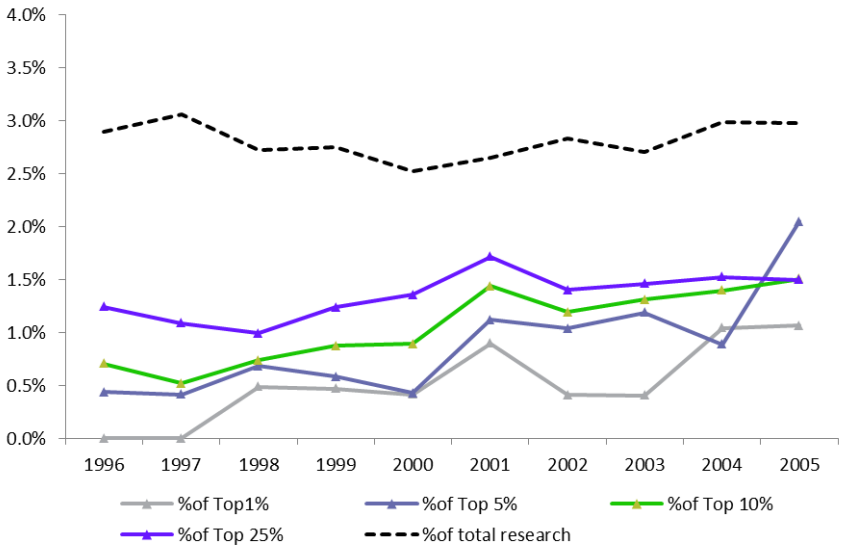
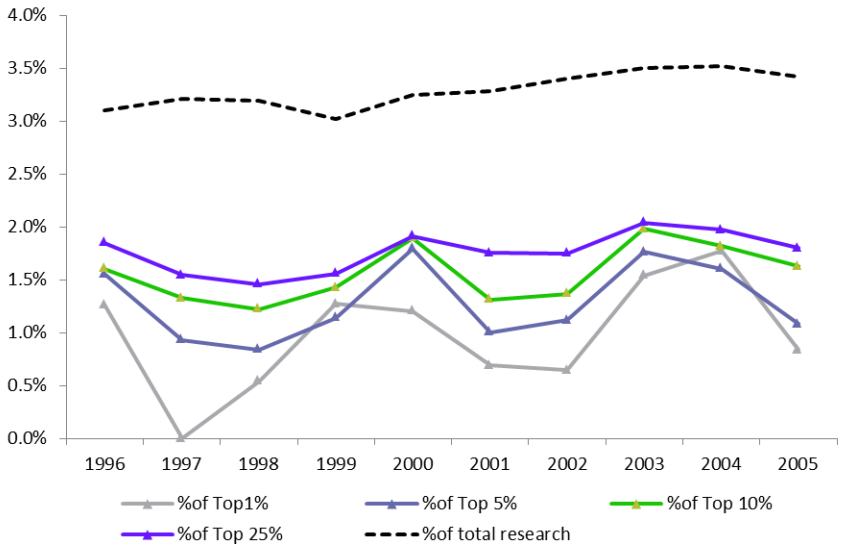


Figure 6.2.3 Annual share of India's highly-cited papers in four thresholds, Geo Research, 2006-2015



Except in three years, 1996, 1997 and 2007, India had papers in each of the four highly-cited categories. Between 1996 and 2005, in four highly-cited categories (from top 1% to top 25%), India published 0.5%, 0.9%, 1.1%, and 1.3% of the total papers published globally. From 1996 to 2005, India's share in all highly-cited categories all increased at a varied speed. Between 2006 and 2015, the share of Indian papers in all highly-cited categories increased to 1%, 1.3%, 1.6%, and 1.8%, respectively. The share of India's highly-cited papers in all highly-cited categories was smaller than that of Indian papers in Geo Research as a whole (black dashed lines).

6.2.3 Top 20 funders, by number of papers, of highly-cited Indian papers, Geo Research

Table 6.2.2 Top 20 funders of the highly-cited Indian papers, Geo Research, 1996-2015

Funder	Number of Papers
Department of Science and Technology (DST), Government of India	91
National Science Foundation (NSF)	56
Council of Scientific and Industrial Research (CSIR), Government of India	35
German Research Foundation (DFG)	28
Ministry of Earth Sciences (MoES), Government of India	24
Department of Space, Government of India	20
National Aeronautics & Space Administration (NASA)	18
Australian Research Council	16
NERC Natural Environment Research Council	14
National Natural Science Foundation of China	11
Natural Sciences and Engineering Research Council of Canada	11
Chinese Academy of Sciences	8
European Union (EU)	7
European Space Agency	7
National Basic Research Program of China	6
Australian Government	5
Japan Society for the Promotion of Science	5
Indian Institute of Science (IISc)	5
Alexander von Humboldt Foundation	5
University Grants Commission (UGC), India	4

DST sponsored 91 highly-cited papers co-authored by Indian researchers, the highest among all funders. Other Indian funders, CSIR and MoES, also made sizeable contribution. MoES supported 24 highly-cited Indian papers. Although the majority of funders of India's highly-cited papers, 15 out of 20, were foreign funding agencies, they might collectively supported less than Indian funders. Most of the foreign funders were USA, European and Chinese funding agencies, in most cases contributed through the international collaboration.

6.2.4 Top 15 collaborating countries of India

Figure 6.2.4 Top 15 collaborating countries of India, Geo Research, 1996-2005

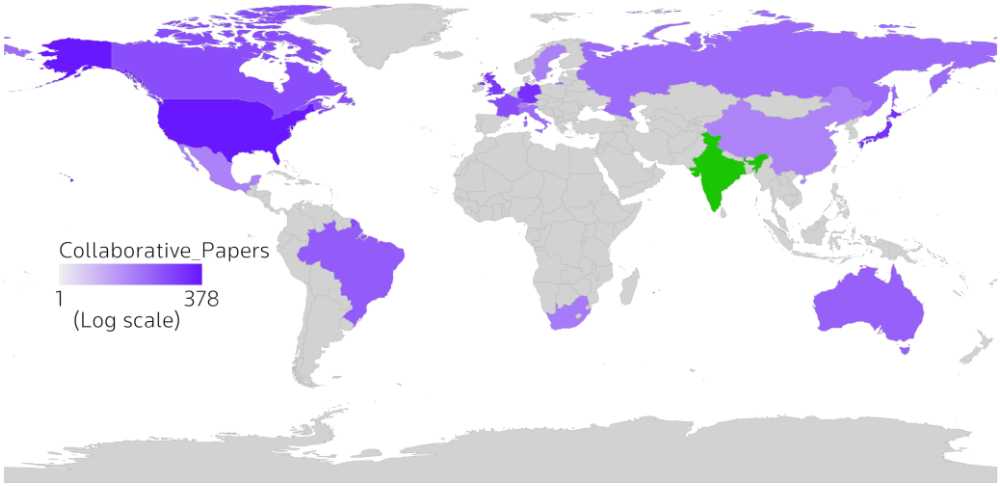


Figure 6.2.5 Top 15 collaborating countries of India, Geo Research, 2006-2015

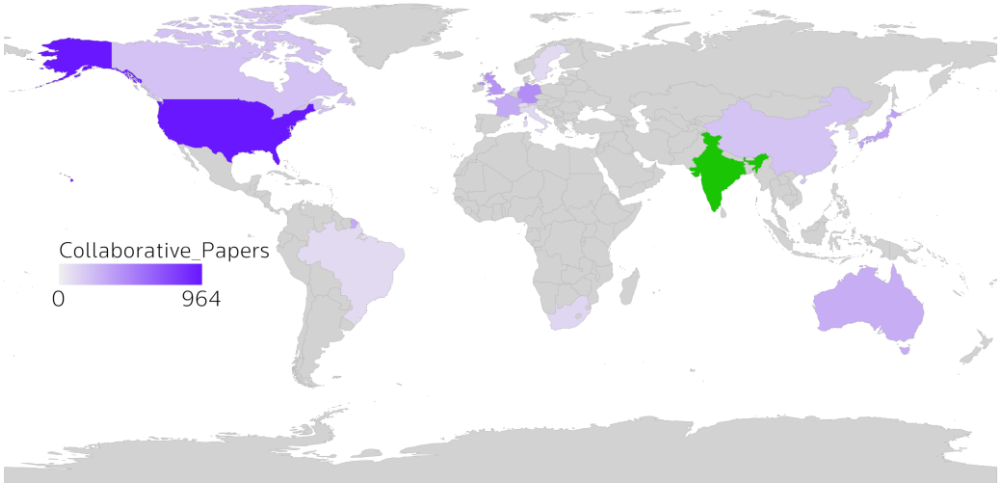
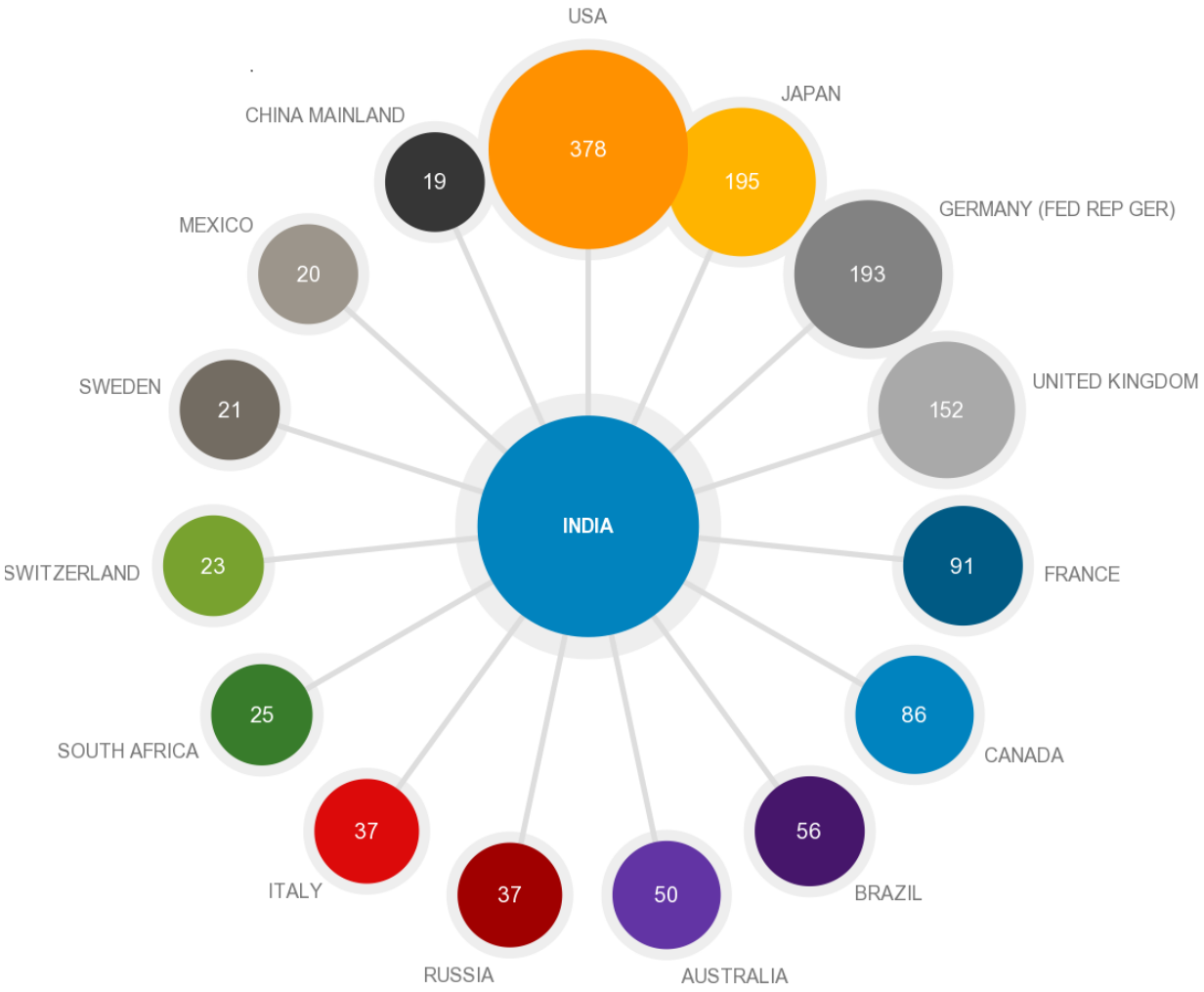


Figure 6.2.4 and **Figure 6.2.5** show the countries that published the highest number of collaborative papers with India (shown in green) in each decade.

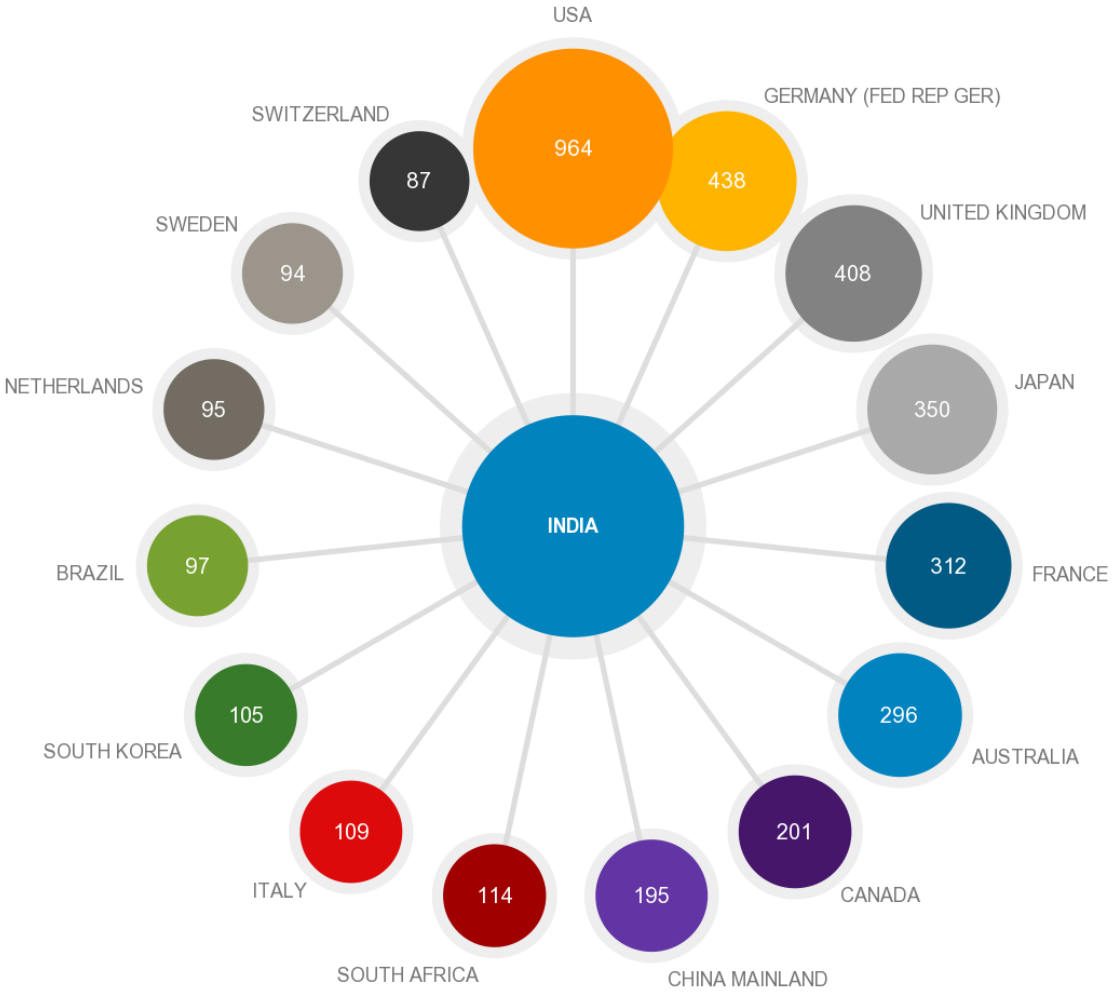
India collaborated mainly with countries in North America, Europe, and Asia Pacific. From 1996 to 2005, India published most often with USA (378), Japan (195) and Germany (193). The number of papers India published with its partners increased from 2006 to 2015. The USA (964) remained as the most collaborative partner of India, followed by Germany (438) and the UK (408).

Figure 6.2.6 Bubble chart of top 15 collaborating countries of India, Geo Research, 1996-2005[6]



[6] Bubble charts that exported from InCites provide further details of the top 15 collaborative countries of India.

Figure 6.2.7 Bubble chart of top 15 collaborating countries of India, Geo Research, 2006-2015



6.2.5 Top 15 international collaborating institutions of India

Table 6.2.3 Top 15 international collaborating institutions of India, Geo Research, 1996-2005

Collaborating Organization	Country	No. of Papers
California Institute of Technology	USA	31
Kyoto University	Japan	25
University of Cambridge	UK	24
University of Bonn	Germany	23
Russian Academy of Science	Russia	23
Osaka City University	Japan	23
The National Aeronautics and Space Administration	USA	22
Centre National de la Recherche Scientifique	France	22
University of Arizona	USA	19
University of California at San Diego	USA	18
Max Planck Society Institute of Chemistry	Germany	18
Nagoya University	Japan	18
The National Autonomous University of Mexico	Mexico	16
University of Western Ontario	Canada	16
Geoforschungszentrum Potsdam	Germany	15

Table 6.2.4 Top 15 international collaborating institutions of India, Geo Research, 2006-2015

Collaborating Organization	Country	No. of Papers
Chinese Academy of Sciences	China	68
The National Autonomous University of Mexico	Mexico	53
University of Tokyo	Japan	53
The National Aeronautics and Space Administration	USA	47
University of Texas at Austin	USA	47
Kyoto University	Japan	46
Centre National de la Recherche Scientifique	France	45
China University of Geoscience	China	45
US Geological Survey	USA	44
Kochi University	Japan	42
University of Cambridge	UK	39
Australian National University	Australia	37
University Leicester	UK	36
California Institute of Technology	USA	36

Collaborating Organization	Country	No. of Papers
Texas A&M University	USA	36

California Institute of Technology, Kyoto University, and University of Cambridge were the institutions that collaborated most frequently with India between 1996 and 2005. It is interesting to see that, in the second 10-year period, the top two international collaborating institutions, Chinese Academy of Science, and National Autonomous University of Mexico were both from emerging countries.

6.2.6 Percentage of Indian papers and citation impact in top 10 journal categories of Geo Research, 1996-2015

Table 6.2.5 Percentage and mNCI of Indian papers in 10 JSCs, Geo Research, 1996-2015

Category code	Category name	Number of world Papers	Number of Indian papers	Percentage of Indian papers	mNCI of Indian papers
LE	Geosciences, Multidisciplinary	280,010	11,409	4.1%	0.65
GC	Geochemistry & Geophysics	147,952	3,601	2.4%	0.63
KV	Geography, Physical	62,043	1,018	1.6%	0.95
KU	Geography	45,877	161	0.4%	1.14
KY	Geology	39,317	665	1.7%	0.64
ZR	Water Resources	37,951	1,729	4.6%	0.88
QQ	Meteorology & Atmospheric Sciences	37,159	2,088	5.6%	0.54
IX	Engineering, Geological	32,921	1,346	4.1%	0.77
JA	Environmental Sciences	29,197	994	3.4%	0.77
RE	Mineralogy	27,596	619	2.3%	1.22

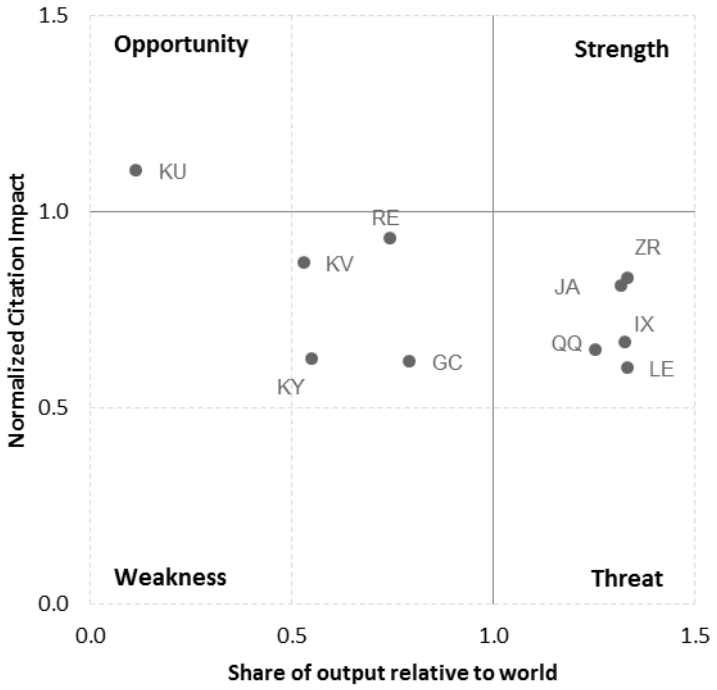
Six of the Seven JSCs that were used in defining Geo Research were listed in **Table 6.2.5**. Because a journal can be assigned into multiple JSCs and the inclusion of reassigned multidisciplinary papers, Mining & Mineral Processing was replaced by a JSC with similar focus, Mineralogy, which had more papers.

Beside these geoscience JSCs, subdisciplines in Geo Research also include atmospheric science and environmental related subjects, such as water Resources.

In Geo Research, Indian research had relatively high shares of papers in Meteorology & Atmospheric Sciences and Water Resources. Its papers in Minerology and Geography were both cited greater than world average.

6.2.7 SWOT analysis of India's performance in selected Journal Categories in Geo Research

Figure 6.2.8 SWOT analysis of India's research in 10 JSCs, Geo Research, 1996-2015



In one of the 10 JSCs, Geography (**KU**), India's research had a citation impact greater than the world average. However, its share of output is smaller than that of the world research. This JSC is an opportunity.

In five JSCs, Water Resources (**AR**), Environmental Sciences (**JA**), Engineering/Geological (**IX**), Geosciences/Multidisciplinary (**LE**), Meteorology & Atmospheric Sciences (**QQ**), the share in India's research is greater relative to the world, but these research were cited lower than the world average. These JSCs, therefore, were categorized as Threats.

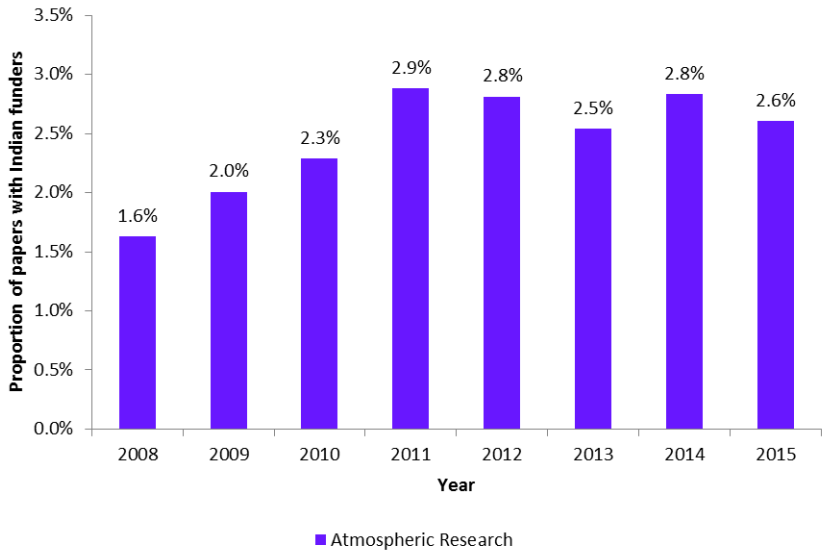
India had relatively lower output relative to world in Mineralogy (**RE**), Geography/Physical (**KV**), Geology (**KY**), and Geochemistry & Geophysics (**GC**). These researches were also cited below the world average. They were considered as weaknesses

No Strength was identified in Geo Research.

6.3 INDIAN PERFORMANCE IN ATMOSPHERIC RESEARCH

6.3.1 Annual share of papers acknowledging Indian funding agencies since 2008, Atmospheric Research

Figure 6.3.1 Annual percentage of papers acknowledging Indian funding agencies, Atmospheric Research, 2008-2015



On average, around 2.5% of Atmospheric Research received funding from Indian funders between 2008 and 2015. The level of contribution from Indian funders was slightly higher after 2010, approaching 3%. As a reference, nearly 5% of worldwide research had Indian researchers' participation during the same period.

6.3.2 Annual share of Indian papers in top most cited papers, Atmospheric Research

Table 6.3.1 Annual number and share of Indian papers in world's top highly-cited papers, Atmospheric Research, 1996-2015

Year	No. of India's Top papers	No. of Papers Published Worldwide	No. of India's Top 1% Papers	No. of Top 1% papers worldwide	No. of India's Top 5% Papers	No. of Top 5% papers worldwide	No. of India's Top 10% Papers	No. of Top 10% papers worldwide	No. of India's Top 25% Papers	No. of Top 25% papers worldwide
1996	110	4,702	0	66	1	299	5	588	10	1,377
1997	133	5,446	1	73	1	365	4	715	15	1,659
1998	103	5,285	0	69	3	339	6	669	19	1,575
1999	125	5,736	3	80	6	369	8	710	13	1,668
2000	109	5,861	0	79	5	366	6	707	17	1,685
2001	179	6,616	2	90	6	393	12	763	28	1,862
2002	172	6,417	0	86	4	370	10	724	23	1,778
2003	165	6,860	0	92	1	409	11	831	26	2,037
2004	197	7,163	0	101	3	447	13	874	39	2,140
2005	164	7,397	1	97	4	462	13	867	37	2,123
2006	218	7,508	4	98	10	475	21	919	49	2,145
2007	300	8,307	0	108	5	498	15	964	46	2,303
2008	454	9,171	1	112	4	522	14	1,018	40	2,455
2009	387	9,247	3	108	12	579	26	1,059	65	2,554
2010	446	9,740	2	119	13	574	25	1,088	62	2,656
2011	553	10,806	2	143	12	601	29	1,192	84	2,819
2012	621	11,575	0	134	15	676	29	1,299	86	3,118
2013	647	12,978	3	179	14	762	31	1,454	113	3,487
2014	651	12,625	5	151	17	672	33	1,317	101	3,251
2015	678	13,224	1	150	19	668	34	1,229	103	3,196

Figure 6.3.2 Annual share of India's highly-cited papers in four thresholds, Atmospheric Research, 1996-2005

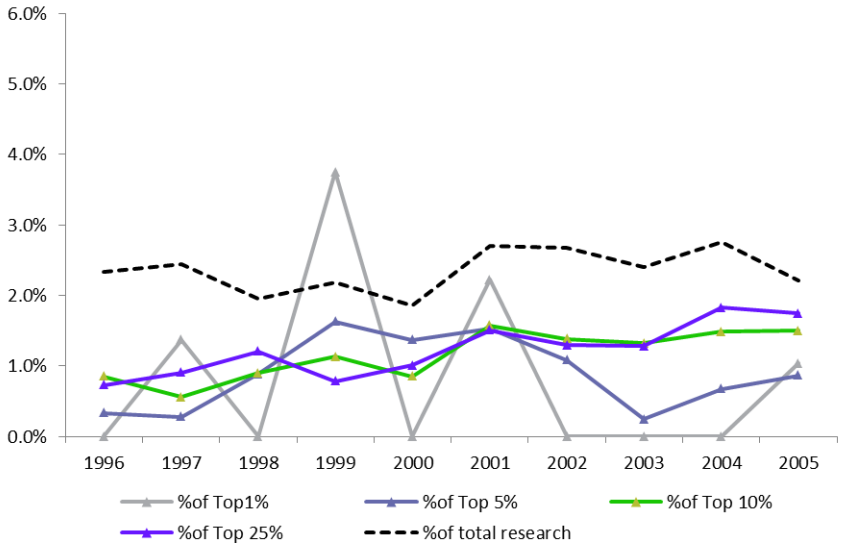
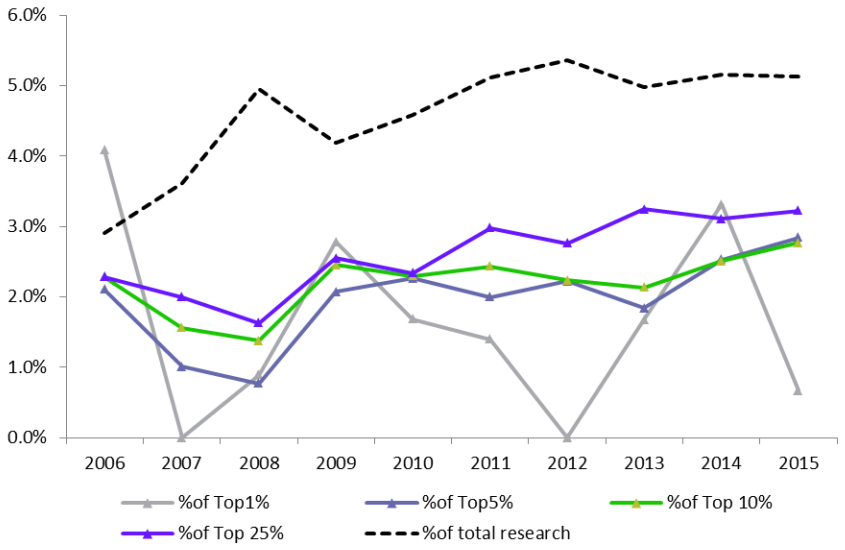


Figure 6.3.3 Annual share of India's highly-cited papers in four thresholds, Atmospheric Research, 2006-2015



Between 1996 and 2005, India had no top 1% papers in six years and its share in world's top 1% papers fluctuated greatly in the other four years, as well as over 2006-2015. In other highly-cited categories, India's annual shares were less volatile. On average, between the two decades, its share increased from 0.8% to 1.6% (top 1%), 0.9% to 2.0% (top 5%), from 1.2% to 2.2% (top 10%), and from 1.2% to 2.6 %(top 25%). In 1999 and 2006, the share of top 1% highly-cited papers was higher than the share of Indian

papers in world output, suggesting that there were small numbers of disproportionally highly-cited papers published in these years.

6.3.3 Top 20 funders, by number of papers, of highly-cited Indian papers, Atmospheric Research

Table 6.3.2 Top 20 funders of the highly-cited Indian papers, Atmospheric Research, 1996-2015

Funder	Number of Papers
Ministry of Earth Sciences (MoES), Government of India	29
Department of Space (DoS), Government of India	23
Department of Science and Technology (DST), Government of India	23
National Science Foundation (NSF)	18
National Aeronautics & Space Administration (NASA)	15
Council of Scientific and Industrial Research (CSIR), Government of India	12
Ministry of Education, Culture, Sports, Science and Technology, Japan	8
National Oceanic Atmospheric Admin (NOAA) - USA	7
Ministry of the Environment, Japan	6
Max Planck Society	6
United States Department of Energy (DOE)	5
Australian Research Council	5
Department for Environment, Food & Rural Affairs (DEFRA)	4
Swedish International Development Cooperation Agency (SIDA)	4
Japan Society for the Promotion of Science	4
European Union (EU)	4
NERC Natural Environment Research Council	4
Centre National de la Recherche Scientifique (CNRS)	3
Japan Science & Technology Agency (JST)	3
The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS)	3

MoES funded 29 highly-cited Indian papers, while other Indian funders, DST and DoS, followed with 23 papers each. NSF (USA) and NASA (USA) sponsored 18 and 15 India's highly-cited papers through international collaboration. In Atmospheric Research, 16 of the funders who sponsored highly-cited Indian papers were foreign funding agencies. However, Indian funders supported the majority of India's highly-cited papers. It is of note that Japanese funders had a relative high level of support for atmospheric research that involves Indian researchers; with four of the top 20 funders based in Japan.

6.3.4 Top 15 collaborating countries of India

Figure 6.3.4 Top 15 collaborating countries of India, Atmospheric Research, 1996-2005

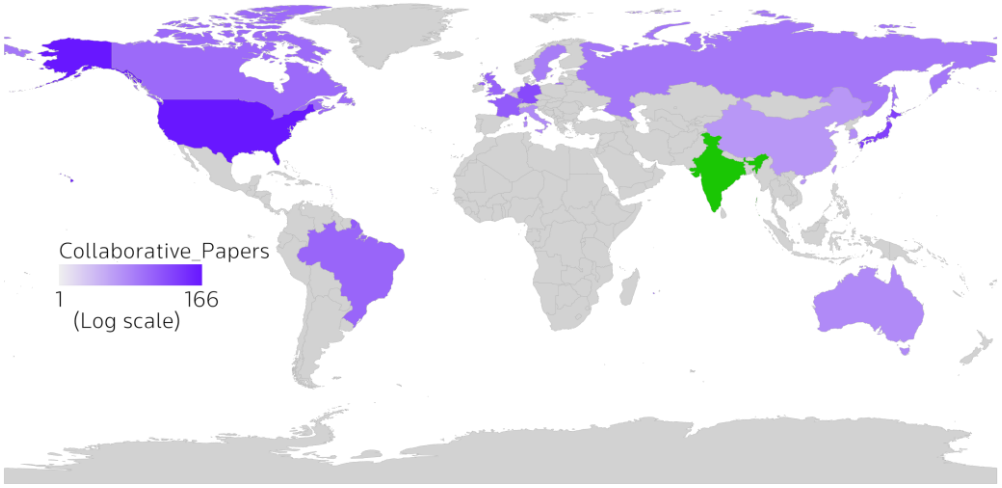


Figure 6.3.5 Top 15 collaborating countries of India, Atmospheric Research, 2006-2015

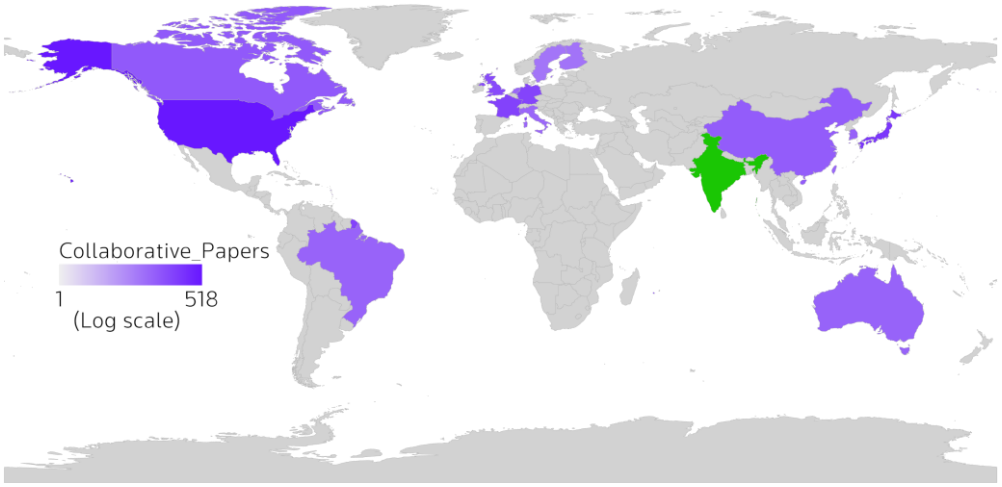


Figure 6.3.4 and **Figure 6.3.5** show the countries that published the highest number of collaborative papers with India (shown in green) in each 10-year period.

India mostly collaborated with countries in North America, Asia Pacific, and Europe in Atmospheric Research. In Decade 1, India published most often with USA (166), Japan (64) and Germany (51). The number of papers India co-authored with its partner increased in Decade 2. The USA (518) remained as the most frequently collaborating partner of India, followed by Japan (207) and France (147).

Figure 6.3.6 Bubble chart of top 15 collaborating countries of India, Atmospheric Research, 1996-2005

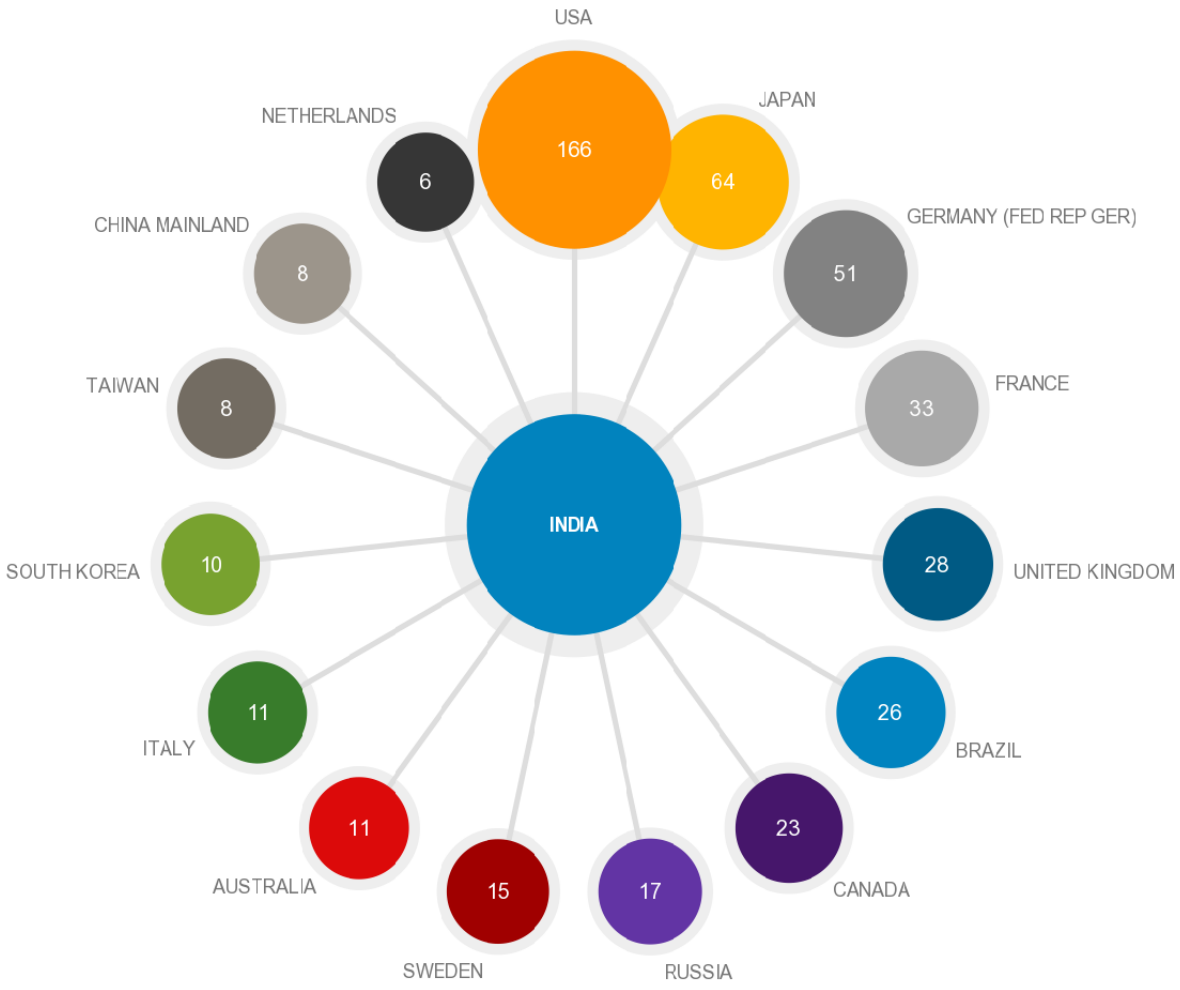
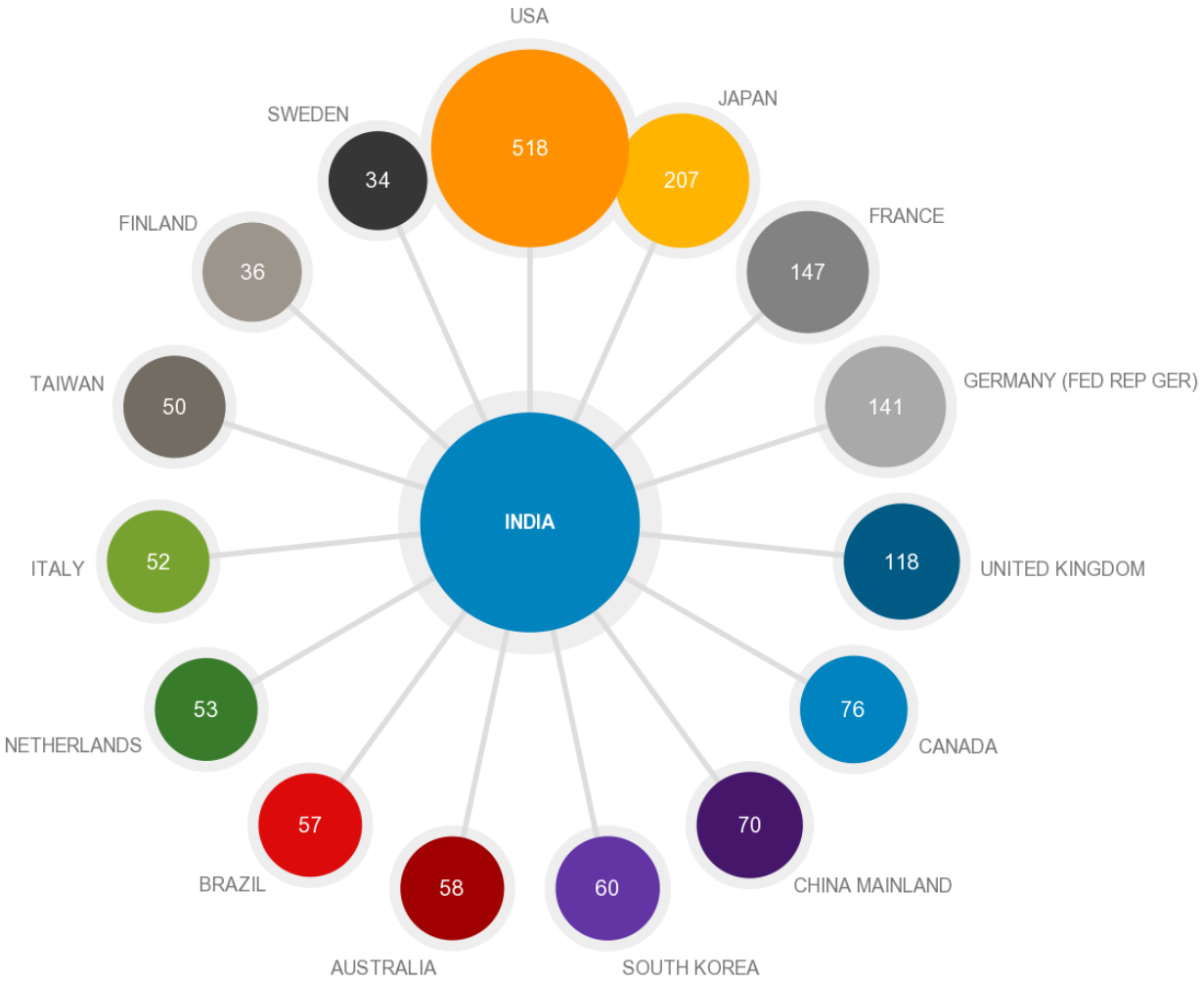


Figure 6.3.7 Bubble chart of top 15 collaborating countries of India, Atmospheric Research, 2006-2015



6.3.5 Top 15 international collaborating institutions of India

Table 6.3.3 Top 15 international collaborating institutions for India, Atmospheric Research, 1996-2005

Collaborating Organization	Country	No. of Papers
The National Aeronautics and Space Administration	USA	34
Florida State University	USA	20
The National Oceanic and Atmospheric Administration	USA	18
University of California at San Diego	USA	14
Kyoto University	Japan	14
California Institute of Technology	USA	13
North Carolina State University	USA	12
University of Maryland	USA	11
Max Planck Society Institute of Chemistry	Germany	11
National Center of Atmospheric Research	USA	10
George Mason University	USA	10
Princeton University	USA	9
Nagoya University	Japan	9
University of Iowa	USA	9
Russian Academy of Science	Russia	8

Table 6.3.4 Top 15 international collaborating institutions for India, Atmospheric Research, 2006-2015

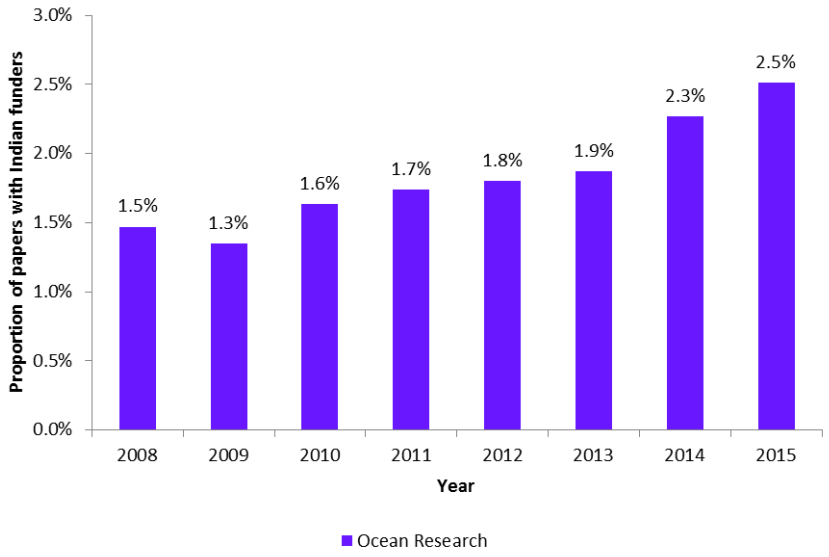
Collaborating Organization	Country	No. of Papers
The National Aeronautics and Space Administration	USA	66
The National Oceanic and Atmospheric Administration	USA	49
National Center of Atmospheric Research	USA	43
University of Tokyo	Japan	40
Max Planck Society Institute of Chemistry	Germany	39
Kyoto University	Japan	37
University of Maryland	USA	34
California Institute of Technology	USA	30
Hokkaido University	Japan	27
National Central University	Taiwan	26
Chinese Academy of Sciences	China	25
Florida State University	USA	24
University of Paris 06	France	23
University of Colorado	USA	21
Purdue University	USA	20

USA organizations, particularly USA government agencies such as NASA (ranked first in each decade) and NOAA, are the most frequently collaborating foreign partner of India in both periods. A noticeable trend between 2006 and 2015 is that more Asian institutions, Chinese Academy of Science (China) and National Central University (Taiwan), became more important collaborators.

6.4 INDIAN PERFORMANCE IN OCEAN RESEARCH

6.4.1 Annual share of papers acknowledging Indian funding agencies since 2008, Ocean Research

Figure 6.4.1 Annual percentage of papers acknowledging Indian funding agencies, Ocean Research, 2008-2015



The proportion of global research output that received Indian funding continuously increased from 1.5% in 2008 to 2.5% in 2015.

6.4.2 Annual share of Indian papers in top most cited papers, Ocean Research

Table 6.4.1 Annual number and share of Indian papers in world's top highly-cited papers, Ocean Research, 1996-2015

Year	No. of India's Top papers	No. of Papers Published Worldwide	No. of India's Top 1% Papers	No. of Top 1% papers worldwide	No. of India's Top 5% Papers	No. of Top 5% papers worldwide	No. of India's Top 10% Papers	No. of Top 10% papers worldwide	No. of India's Top 25% Papers	No. of Top 25% papers worldwide
1996	149	8,254	1	92	3	458	4	915	14	2,230
1997	159	7,955	0	104	2	495	5	949	12	2,231
1998	162	8,795	2	106	3	491	3	944	10	2,337
1999	162	8,931	1	96	3	489	4	990	13	2,407
2000	167	8,778	1	99	2	487	6	953	19	2,409
2001	131	9,044	3	98	5	530	6	1,022	17	2,438
2002	158	9,613	0	111	3	554	9	1,104	28	2,669
2003	141	9,928	1	120	4	576	8	1,117	21	2,648
2004	172	10,182	2	128	6	606	12	1,161	38	2,791
2005	173	10,016	2	119	6	556	11	1,095	25	2,577
2006	220	11,636	1	135	13	654	26	1,296	50	3,082
2007	219	12,249	2	152	11	727	23	1,418	49	3,328
2008	272	12,964	4	162	12	734	25	1,454	59	3,519
2009	240	13,021	0	156	15	759	30	1,466	62	3,549
2010	303	13,357	1	151	13	756	25	1,492	50	3,606
2011	347	14,189	1	171	9	813	24	1,580	63	3,764
2012	344	14,326	2	169	13	788	36	1,602	70	3,809
2013	412	15,115	3	170	15	825	31	1,654	77	3,973
2014	560	16,005	0	168	12	855	25	1,612	77	3,823
2015	593	16,572	3	174	18	772	31	1,671	73	3,641

Figure 6.4.2 Annual share of India's highly-cited papers in four thresholds, Ocean Research, 1996-2005

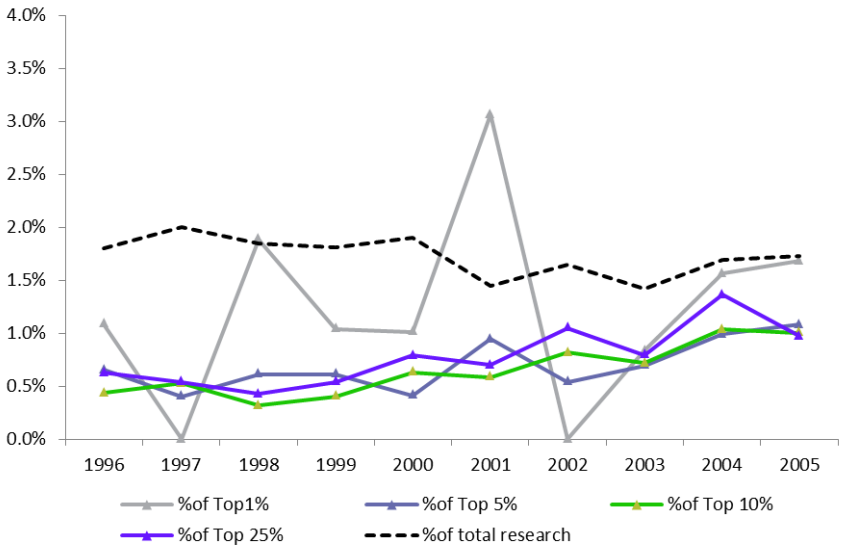
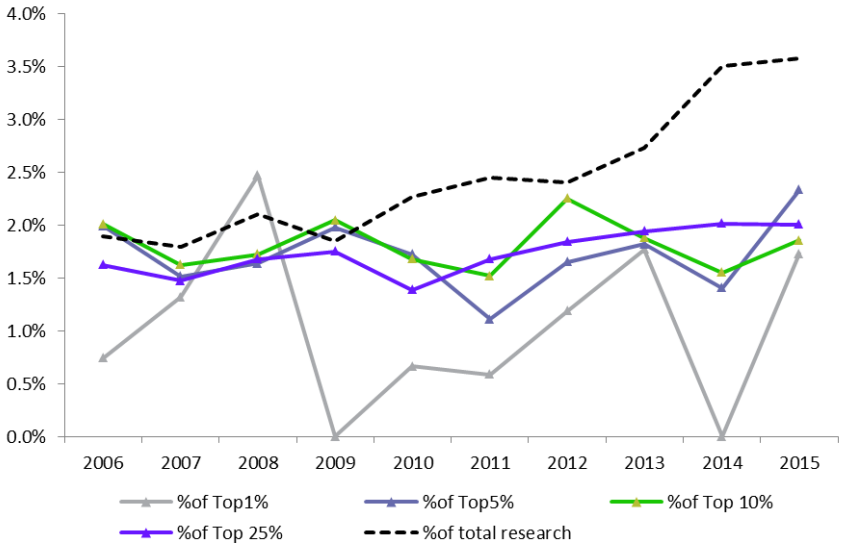


Figure 6.4.3 Annual share of India's highly-cited papers in four thresholds, Ocean Research, 2006-2015



India's share of the world's top 1% highly-cited papers followed a similar pattern in both decades: a wide fluctuation in the years that India had the top 1% highly-cited papers. Annual shares of Indian papers in three categories of highly-cited papers – top 5%, top 10%, and top 25% – were in close range with each other. Overall, for these three categories of highly-cited papers, Indian papers' share was higher in the 2006-2015 period. In the first four years of this period, the share of Indian highly-cited papers was only slightly lower than the share of Indian papers in global output.

6.4.3 Top 20 funders, by number of papers, of highly-cited Indian papers, Ocean Research

Table 6.4.2 Top 20 funders of highly-cited Indian papers, Ocean Research, 1996-2015

Funder	Number of Papers
Council of Scientific and Industrial Research (CSIR), Government of India	46
Department of Science and Technology (DST), Government of India	21
University Grants Commission (UGC), India	16
Ministry of Earth Sciences (MoES), Government of India	13
Department of Biotechnology (DBT), Government of India	11
Indian Council of Agriculture Research (ICAR)	11
Korea Science and Engineering Foundation	9
National Science Foundation (NSF)	8
Ministry of Education, South Korea	7
ABI	5
Institute of Research for Development, France	5
Universiti Malaya	4
Indian Council of Medical Research (ICMR)	4
Indian Council of Medical Research	4
Defence Research and Development Organisation (DRDO)	4
NERC Natural Environment Research Council	4
Department of Space, Government of India	4
Department of Atomic Energy (DAE), Government of India	3
Centre of National Detudes Spatiales (CNES), France	3
National Natural Science Foundation of China	2

In Ocean Research, the top six funders are Indian funders namely CSIR, DST, UGC, MoES, DBT and ICAR. CSIR supported 64 papers, which is the highest among all 20 funders listed above.
Though foreign funding entities accounted as majority of the funders, they sponsored much less papers than the Indian funders. Among them, Korea Science and Engineering Foundation and NSF sponsored the highest number of papers through international collaboration.

6.4.4 Top 15 collaborating countries of India

Figure 6.4.4 Top 15 collaborating countries of India, Ocean Research, and 1996-2005

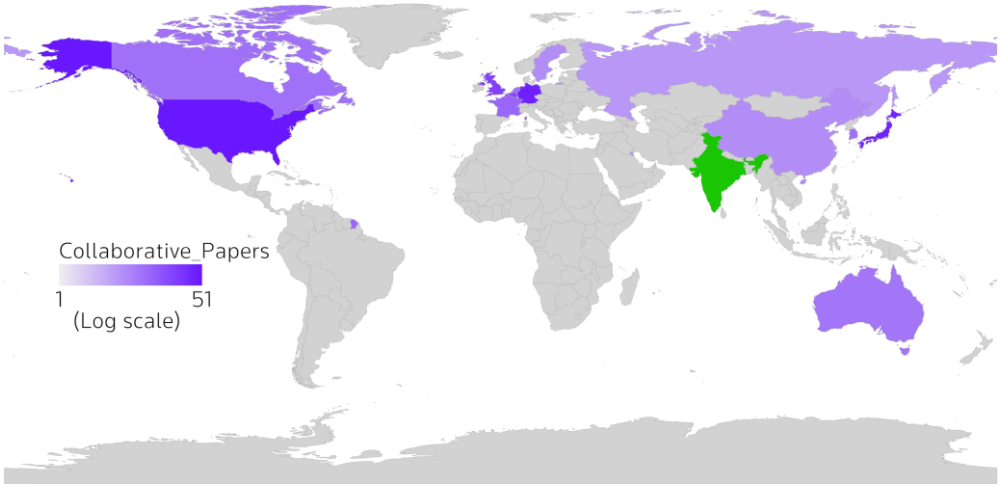


Figure 6.4.5 Top 15 collaborating countries of India, Ocean Research, 2006-2015

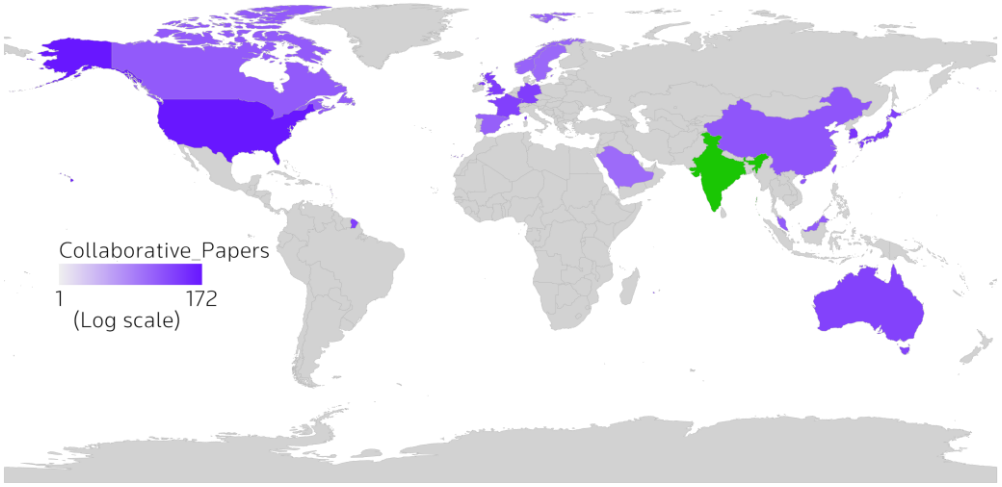


Figure 6.4.4 and **Figure 6.4.5** show the countries who published the highest number of collaborative papers with India (shown in green) in each decade. USA (51), Germany (42) and Japan (39) were the top three most frequently collaborating countries for India between 1996 and 2005. In the next decade, USA (172) still remained the most productive partner, followed by South Korea (85) and UK (72).

It is worth mentioning that, in Ocean Research, none of India's top 15 international collaborators came from Africa or South America.

Figure 6.4.6 Bubble chart of top 15 collaborating countries of India, Ocean Research, and 1996-2005

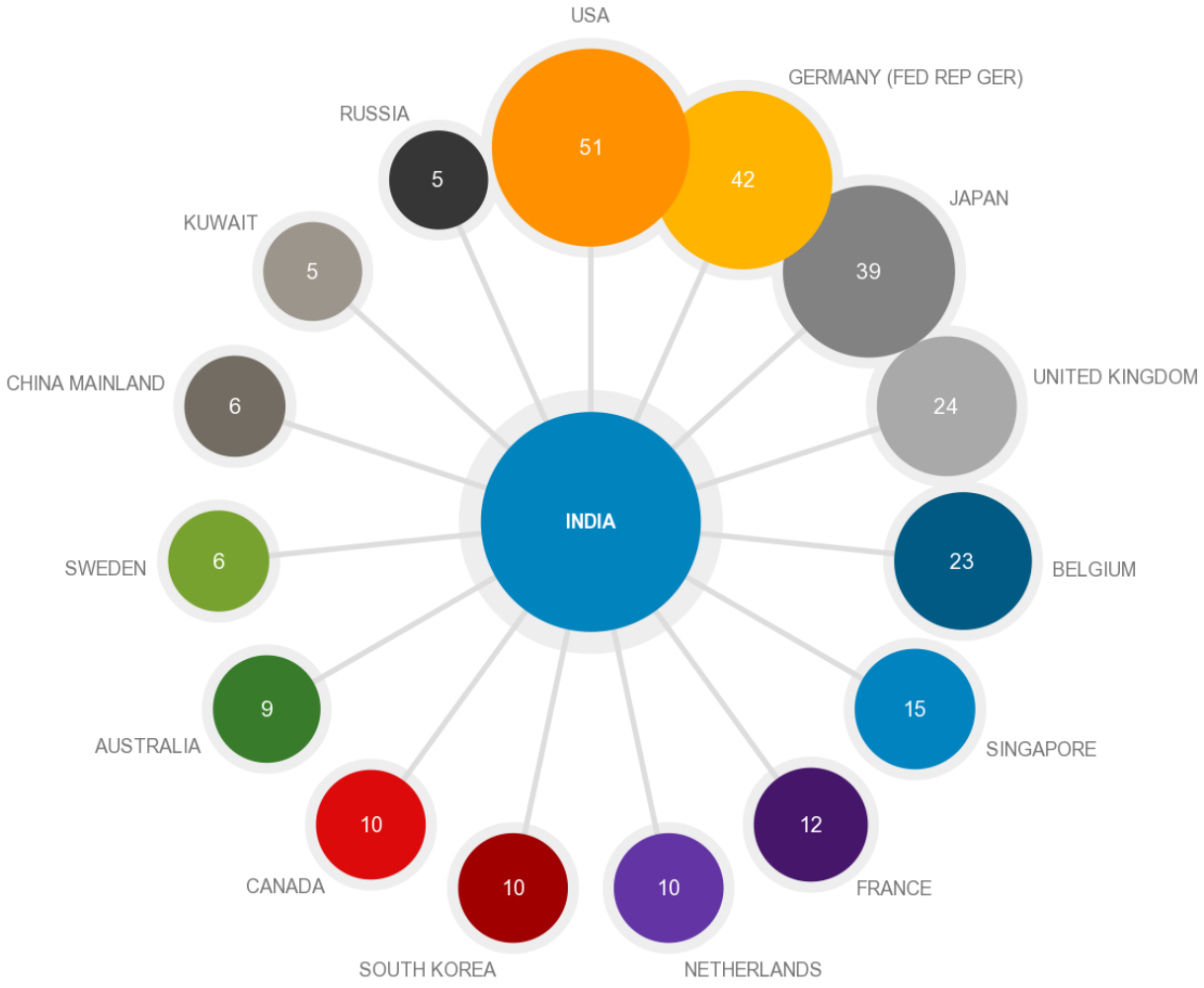
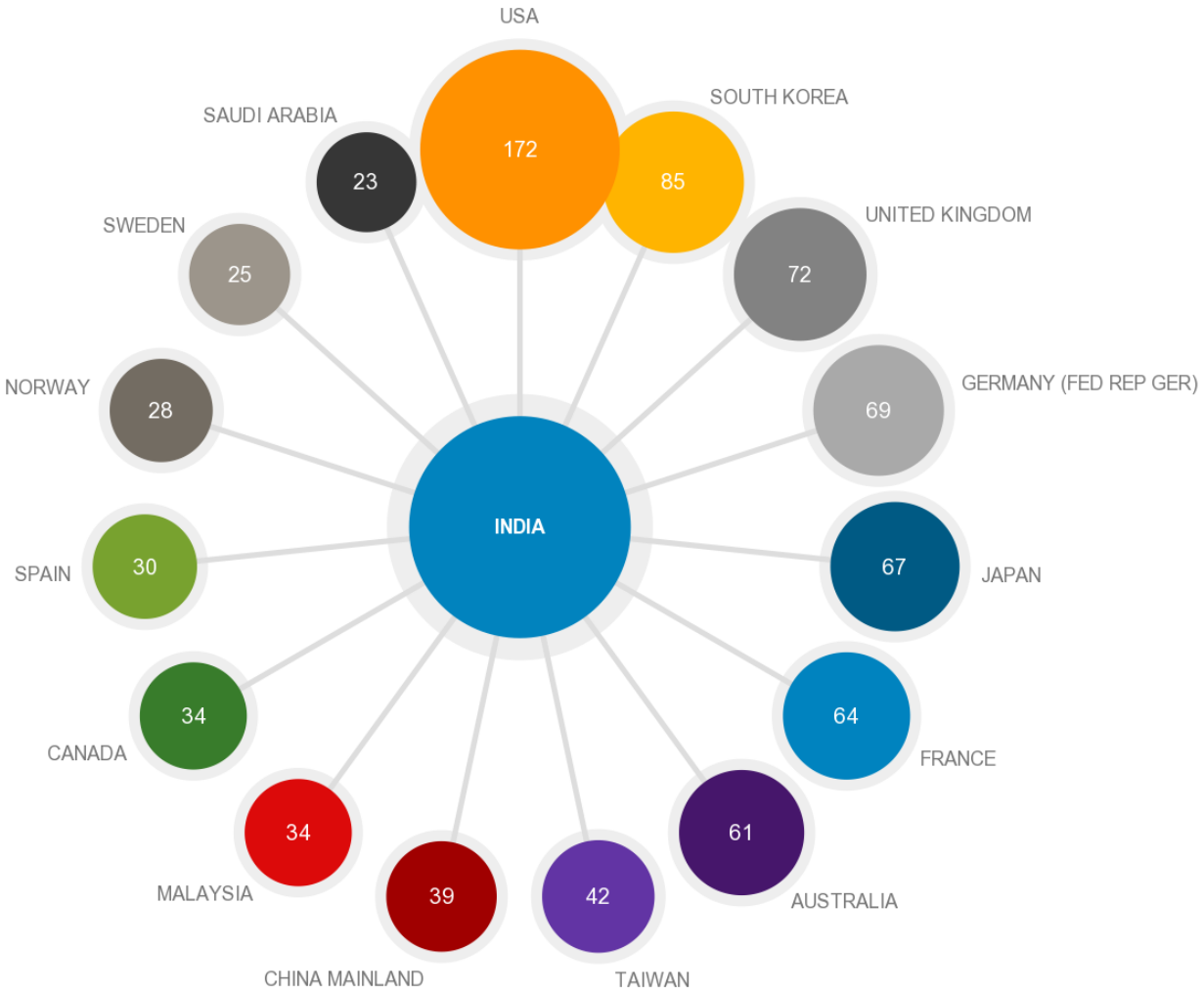


Figure 6.4.7 Bubble chart of top 15 collaborating countries of India, Ocean Research, and 2006-2015



6.4.5 Top 15 international collaborating institutions of India

Table 6.4.3 Top 15 international collaborating institutions for India, Ocean Research, 1996-2005

Collaborating Organization	Country	No. of Papers
National University of Singapore	Singapore	12
State University of Ghent	Belgium	12
Hokkaido University	Japan	8
University of Hamburg	Germany	6
University of Tokyo	Japan	5
Free University of Brussels	Belgium	5
Kuwait Instutite of Scientific Research	Kuwait	5
Mt Allison University	Canada	5
Catholic University Nijmegen	Netherlands	5
Florida State University	USA	5
University of Maryland	USA	4
Queens University Belfast	UK	4
Nova Southestern University	USA	4
Ocean University of China	China	4
New York State Dept of Health	USA	3

Table 6.4.4 Top 15 international collaborating institutions for India, Ocean Research, 2006-2015

Collaborating Organization	Country	No. of Papers
National Taiwan Ocean University	Taiwan	24
Chinese Academy of Sciences	China	18
Jeju National University	South Korea	18
National University of Singapore	Singapore	17
Cheju National University	South Korea	15
The National Oceanic and Atmospheric Administration	USA	12
Ghent University	Belgium	12
University of Gothenburg	Sweden	11
University of Malaya	Malaysia	11
University of Maryland	USA	11
University South Carolina	USA	9
University of Tokyo	Japan	9
PUSn National University	South Korea	9
King Abdulaziz University	Saudi Arabia	9
Leibniz Instutite of Freshwater Ecolology & Inland Fisheries	Germany	9

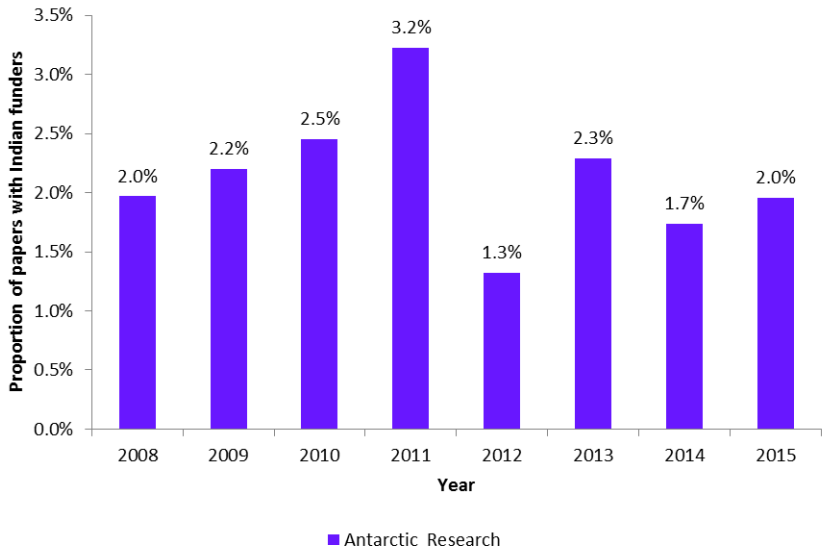
Institutions in Asia, Europe and the USA were the top productive collaborators of India in the first decade. National University of Singapore and State University of Ghent each co-authored 12 papers with

India. India's collaboration with Asian institutions, particularly Korean universities, increased significantly in Decade 2. Asian institutions accounted for nine of the top 15 institutions.

6.5 INDIAN PERFORMANCE IN ANTARCTIC RESEARCH

6.5.1 Annual share of papers acknowledging Indian funding agencies since 2008, Antarctic Research

Figure 6.5.1 Annual percentage of papers acknowledging Indian funding agencies, Antarctic Research, 2008-2015



India's output in Antarctic Research was relatively small, but its contribution to the research funding, measured by percentage of papers of acknowledged Indian funders, is approximately the same level as in Geo Research. In the eight years, the percentage in 2012, 1.3%, is the lowest.

6.5.2 Annual share of Indian papers in top most cited papers, Antarctic Research

Table 6.5.1 Annual number and share of Indian papers in world's top highly-cited papers, Antarctic Research, 1996-2015

Year	No. of India's Top papers	No. of Papers Published Worldwide	No. of India's Top 1% Papers	No. of Top 1% papers worldwide	No. of India's Top 5% Papers	No. of Top 5% papers worldwide	No. of India's Top 10% Papers	No. of Top 10% papers worldwide	No. of India's Top 25% Papers	No. of Top 25% papers worldwide
1996	3	506	0	3	0	24	0	52	0	146
1997	12	576	0	4	0	23	0	60	0	180
1998	16	717	0	4	0	34	0	76	0	201
1999	10	669	0	10	0	25	1	63	2	159
2000	19	693	0	4	0	38	1	68	1	192
2001	13	637	0	3	0	25	0	52	0	159
2002	15	735	0	5	0	25	0	59	2	202
2003	15	703	0	6	0	27	0	54	1	173
2004	14	826	0	8	0	32	0	63	1	223
2005	20	777	0	6	0	29	0	57	1	186
2006	10	769	0	3	0	35	0	77	1	205
2007	19	798	0	4	0	34	0	85	1	200
2008	27	882	0	6	0	42	0	92	0	252
2009	17	886	0	13	0	39	0	79	2	194
2010	31	905	0	3	0	28	0	62	1	203
2011	45	994	0	7	1	41	1	92	4	241
2012	23	1,054	0	11	1	61	1	125	3	286
2013	45	1,124	1	16	2	57	4	109	7	287
2014	28	1,078	0	11	0	50	1	111	3	247
2015	34	1,038	0	10	0	47	0	104	2	237

Figure 6.5.2 Annual share of India's highly-cited papers in four thresholds, Antarctic Research, 1996-2005

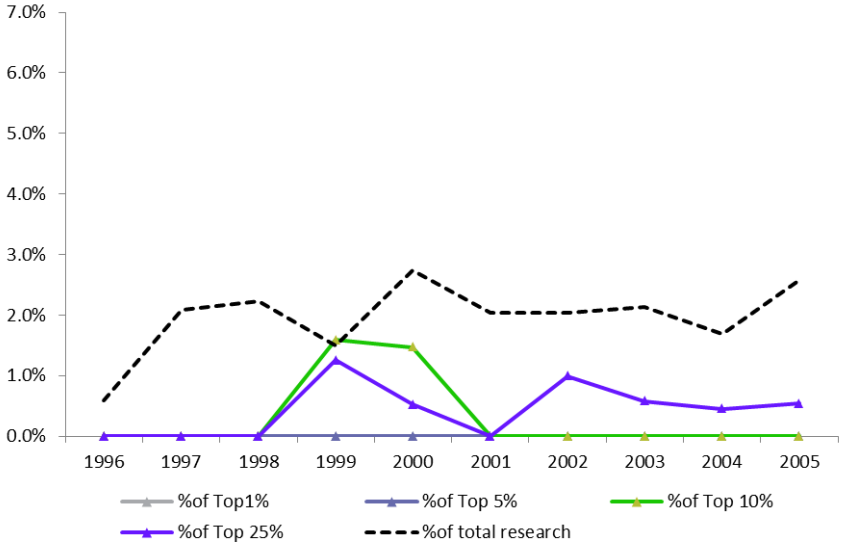
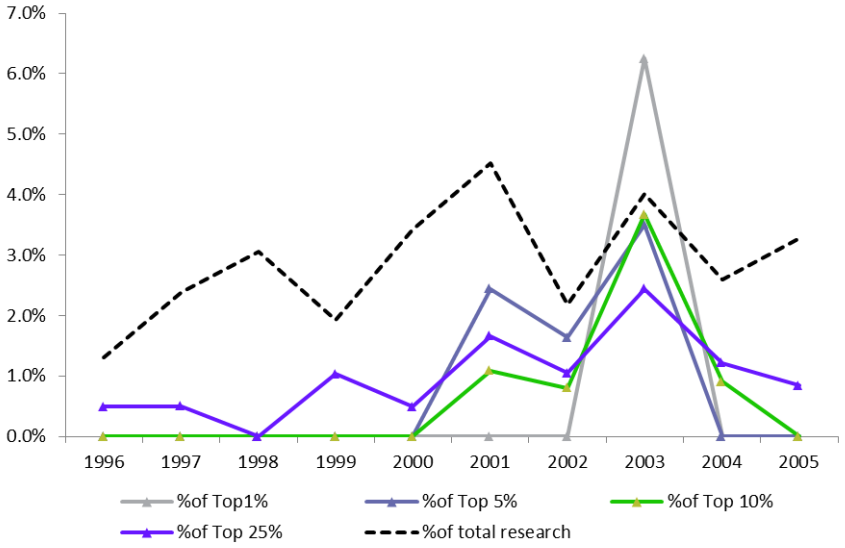


Figure 6.5.3 Annual share of India's highly-cited papers in four thresholds, Antarctic Research, 2006-2015



Overall, except in 2013, India's annual share in all categories of highly-cited papers in Antarctic Research was small. Between 1996 and 2005, India had no papers that were ranked higher or equal to top 5%. Even in the six years that India published top 25% highly-cited papers, the share was never above 2%. Annual shares of Indian papers in world's highly-cited overall increased from 2006 to 2015, especially after 2010. Year 2013 is an exceptional year that a number of highly-cited papers with Indian authors were published; Indian papers accounted 6.3% of top 1% highly-cited papers. The pattern of India's share of highly-cited papers in all categories followed closely with that of the share of Indian papers in world total output.

6.5.3 Top 20 funders, by number of papers, of highly-cited Indian papers, Antarctic Research

Table 6.5.2 Top 20 funders of the highly-cited Indian papers, Antarctic Research, 1996-2015

Funder	Number of Papers
National Science Foundation (NSF)	2
NERC Natural Environment Research Council	2
Netherlands Organization for Scientific Research (NWO)	2
German Research Foundation (DFG)	2
China Scholarship Council	1
New Zealand Ministry of Science and Innovation	1
Statoil	1
Max Planck Society	1
Natural Sciences and Engineering Research Council of Canada	1
Future Academic Stars project of Zhejiang University	1
Japan Society for the Promotion of Science	1
Centre for Ice, Climate and Ecosystems at the Norwegian Polar Institute	1
Deutsche Forschungsgemeinschaft-Cluster of Excellence The Ocean in the Earth System	1
Post-Expedition Activity award	1
UK IODP	1
Spanish Ministry for Science and Innovation	1
Biodiversity and Climate Research Center of the Hessian Initiative for Scientific and Economic Excellence	1
Council of Scientific and Industrial Research (CSIR), Government of India	1
Department of Science and Technology (DST), Government of India	1
European Research Council (ERC)	1

Overwhelming majority of funders who sponsored India's highly-cited papers were foreign funding agencies. All funder support was no more than two papers each. CISR and DST were the only two Indian funders in this area. This finding is not surprising because India did not publish extensively in Antarctic Research.

It is interesting to note that, except a New Zealand agency, all funders of India's highly-cited papers were from the Northern hemisphere, even though a substantial amount of research was conducted by countries in the Southern hemisphere where the Antarctic region is located.

6.5.4 Top 15 collaborating countries of India

Figure 6.5.4 Top 15 collaborating countries of India, Antarctic Research, 1996-2005

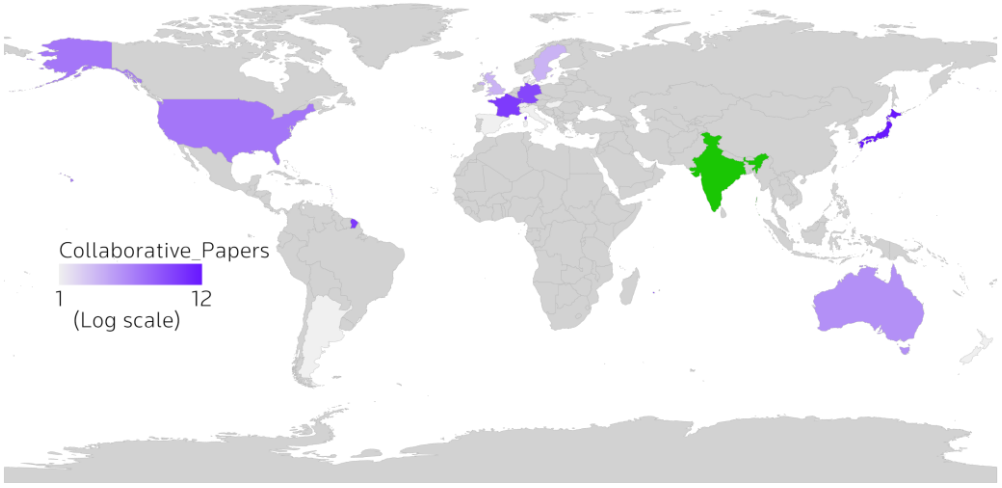


Figure 6.5.5 Top 15 collaborating countries of India, Antarctic Research, 2006-2015

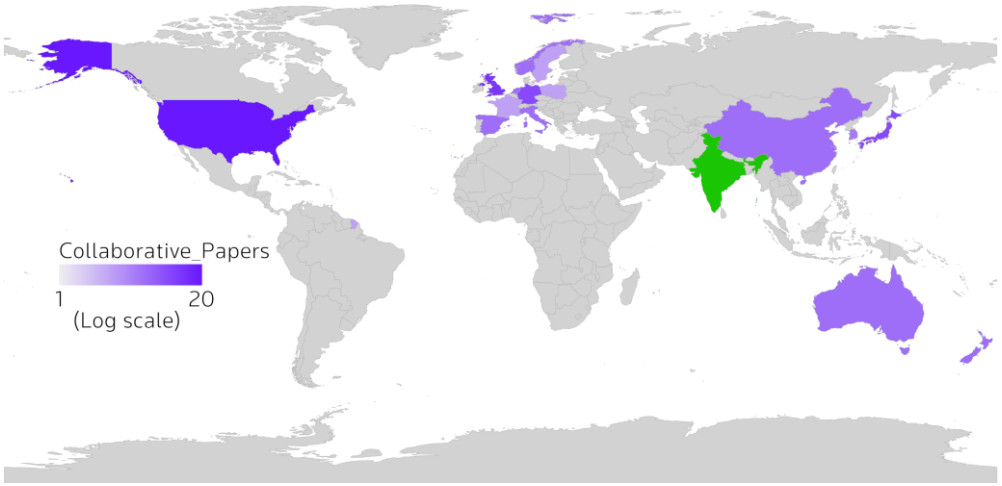


Figure 6.5.4 and **Figure 6.5.5** show the countries who published the highest number of collaborative papers with India (shown in green) in each decade.

The USA and countries in Europe and Asia Pacific were the top collaborators of India in Antarctic Research. Although South American countries were reasonably active in this subject area, India had not yet formed a productive partnership. Japan (12), France (8), and Germany (7) were the most frequently collaborating partners in Decade 1, while the USA (20), the UK (13), and Germany (10) published the highest number of Antarctic Research papers with India in the second 10 year period.

Figure 6.5.6 Bubble chart of top 15 collaborating countries of India, Antarctic Research, 1996-2005

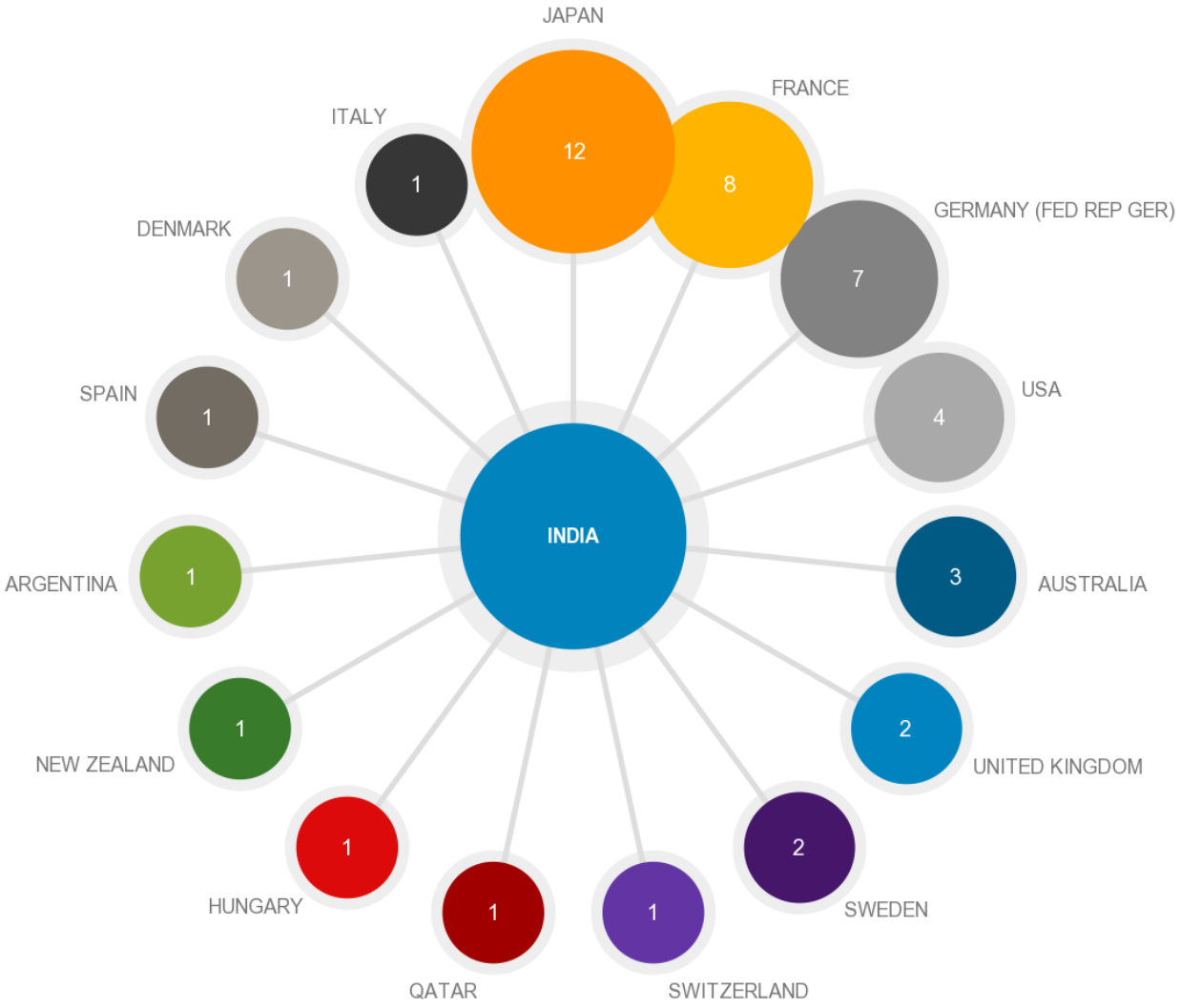
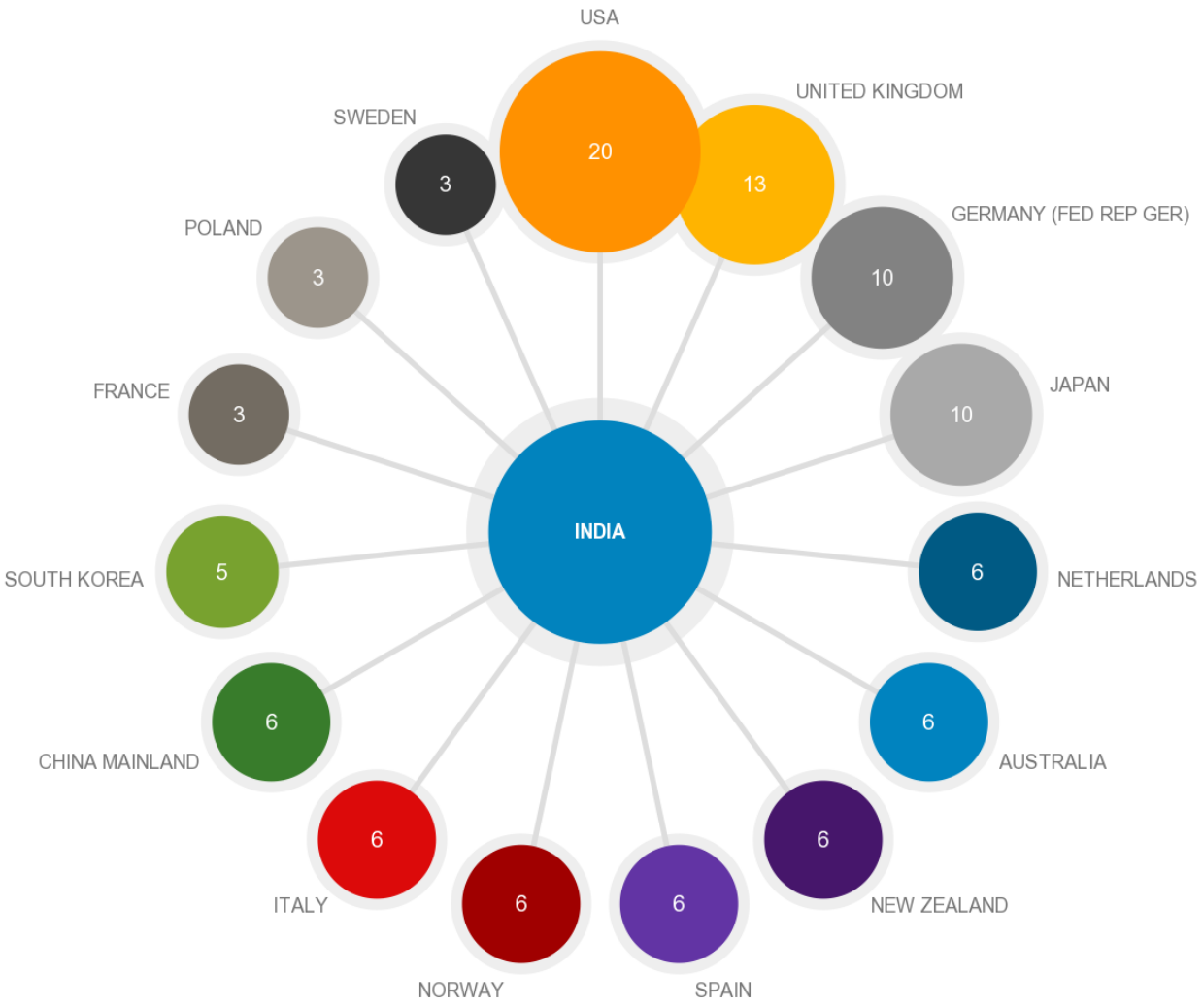


Figure 6.5.7 Bubble chart of top 15 collaborating countries of India, Antarctic Research, 2006-2015



6.5.5 Top 15 international collaborating institutions of India

Table 6.5.3 Top 15 international collaborating institutions of India, Antarctic Research, 1996-2005

Collaborating Organization	Country	No. of Papers
Otsuma Womens University	Japan	8
University of Paris 06	France	4
Hiroshima University	Japan	3
British Antarctic Survey	UK	2
Deutsch Sammlung Mikroorganismen & Zellkulturen	Germany	2
University of Durham	UK	2
University of Lausanne	Switzerland	1
University of Massachusetts at Lowell	USA	1
University New South Wales	Australia	1
Anglo Australian Observatory	Australia	1
DSMZ GmbH	Germany	1
Electro Optic Systems Holdings Ltd	Australia	1
Eotvos Lorand University	Hungary	1
The Saclay Nuclear Research Centre	France	1
Centre d'Etudes des Environnements Terrestre et Planétaires	France	1

Table 6.5.4 Top 15 international collaborating institutions of India, Antarctic Research, 2006-2015

Collaborating Organization	Country	No. of Papers
British Antarctic Survey	UK	6
University of Bremen	Germany	6
Stanford University	USA	5
University of Southampton	UK	5
University of Tokyo	Japan	4
University of Tromso	Norway	4
University of Utrecht	Netherlands	4
Utsunomiya University	Japan	4
Victoria University of Wellington	New Zealand	4
Western Michigan University	USA	4
Montclair State University	USA	4
University of California at San Diego	USA	4
Texas A&M University	USA	4
Texas Tech University	USA	4
Tongji University	China	4

Nine out of the top 15 collaborating institutions of India in Decade 1 were from European countries. However, a Japanese institution, Otsuma Womens Universityy published the highest co-authored papers with India. University of Massachusetts at Lowell was the only USA institution partnered with India in this decade with one paper published. In the second decade, the engagement between USA institutions and India increased with six USA universities joining the list.

6.5.6 Percentage of Indian papers and citation impact in top 10 journal categories of Antarctic Research

Table 6.5.5 Percentage and mNCI of Indian papers in 10 JSCs, Antarctic Research, 1996-2015

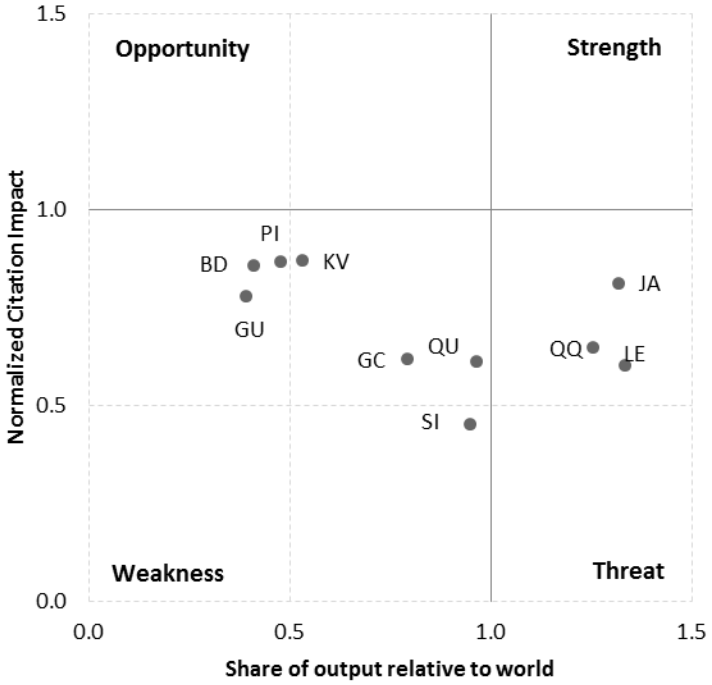
Category code	Category name	Number of papers	Number of Indian papers	Percentage of Indian papers	mNCI of Indian papers
LE	Geosciences, Multidisciplinary	4,388	133	3.0%	0.39
GU	Ecology	2,494	21	0.8%	0.51
KV	Geography, Physical	1,987	17	0.9%	0.52
SI	Oceanography	1,836	33	1.8%	0.35
JA	Environmental Sciences	1,716	33	1.9%	0.47
QQ	Meteorology & Atmospheric Sciences	1,675	53	3.2%	0.31
PI	Marine & Freshwater Biology	1,409	5	0.4%	0.56
BD	Biodiversity Conservation	1,367	5	0.4%	0.41
GC	Geochemistry & Geophysics	1,333	13	1.0%	0.67
QU	Microbiology	767	52	6.8%	0.62

Antarctic Research papers contain subdisciplines of Geo Research, Atmospheric Research and Ocean Research. In addition, there are also topics that are related to environmental science and ecology. It is important to note that life science topics, marine biology and microbiology, were also important.

“Microbiology”, “Meteorology & Atmospheric Sciences”, and “Geosciences, Multidisciplinary” were several research focal point. Share of Indian papers in these JSCs were higher than 3%. India's research in “Geochemistry & Geophysics” and “Microbiology” were cited relatively high.

6.5.7 SWOT analysis of India's performance in selected Journal Categories of Antarctic Research

Figure 6.5.8 SWOT analysis of India's research in 10 JSCs, Antarctic Research, 1996-2015



Although India had many highly-cited researches in these 10 JSCs that constitute the subdisciplines in Antarctic Research, measured by JSC-wide research output and citation impact in relation to the world average, none of the JSCs were identified as strength or opportunity.

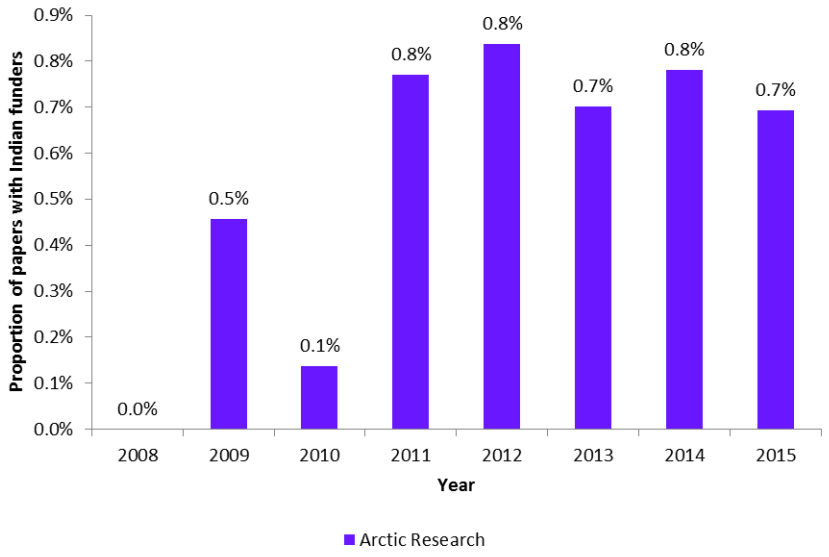
Three JSCs, Environmental Sciences (**JA**), Geosciences/Multidisciplinary (**LE**), and Meteorology & Atmospheric Sciences (**QQ**), were India's threats. In these JSCs, India had relatively high research output, but these researches were cited lower than the world average.

Seven JSCs were India's weaknesses. India had relatively lower output in Biodiversity Conservation (**BD**), Marine & Freshwater Biology (**PI**), Geography/Physical (**KV**), Ecology (**GU**), Microbiology (**QU**), Oceanography (**SI**), and Geochemistry & Geophysics (**GC**). These researches were also cited below the world average.

6.6 INDIAN PERFORMANCE IN ARCTIC RESEARCH

6.6.1 Annual share of papers acknowledging Indian funding agencies since 2008, Arctic Research

Figure 6.6.1 Annual percentage of papers acknowledging Indian funding agencies, Arctic Research, 2008-2015



In Arctic Research, India published a small number of papers, accounting for a very small share of worldwide research. Its contribution to the funding in this subject area was also small. In 2008, no paper was funded by an Indian funder.

6.6.2 Annual share of Indian papers in top most cited papers, Arctic Research

Table 6.6.1 Annual number and share of Indian papers in world's top highly-cited papers, Arctic Research, 1996-2015

Year	No. of India's Top papers	No. of Papers Published Worldwide	No. of India's Top 1% Papers	No. of Top 1% papers worldwide	No. of India's Top 5% Papers	No. of Top 5% papers worldwide	No. of India's Top 10% Papers	No. of Top 10% papers worldwide	No. of India's Top 25% Papers	No. of Top 25% papers worldwide
1996	1	440	0	4	0	29	0	49	0	145
1997	0	492	0	3	0	29	0	66	0	149
1998	0	485	0	3	0	36	0	64	0	167
1999	0	528	0	7	0	31	0	61	0	163
2000	0	538	0	3	0	24	0	66	0	171
2001	0	600	0	6	0	23	0	57	0	174
2002	1	668	0	10	0	36	1	83	1	215
2003	0	632	0	3	0	32	0	62	0	182
2004	0	639	0	11	0	55	0	94	0	227
2005	0	766	0	11	0	49	0	97	0	235
2006	1	706	0	12	0	55	0	97	1	218
2007	1	765	0	9	0	46	0	102	0	249
2008	2	854	0	13	0	68	0	123	0	287
2009	2	916	0	20	0	70	0	139	1	315
2010	4	939	0	19	0	71	0	145	0	330
2011	12	1,129	0	10	0	93	1	182	1	389
2012	14	1,168	0	21	0	91	0	185	1	388
2013	10	1,202	0	25	0	98	0	179	1	406
2014	11	1,202	0	28	0	93	0	172	2	374
2015	8	1,356	0	25	0	88	0	180	0	412

Figure 6.6.2 Annual share of India's highly-cited papers in four thresholds, Arctic Research, 1996-2005

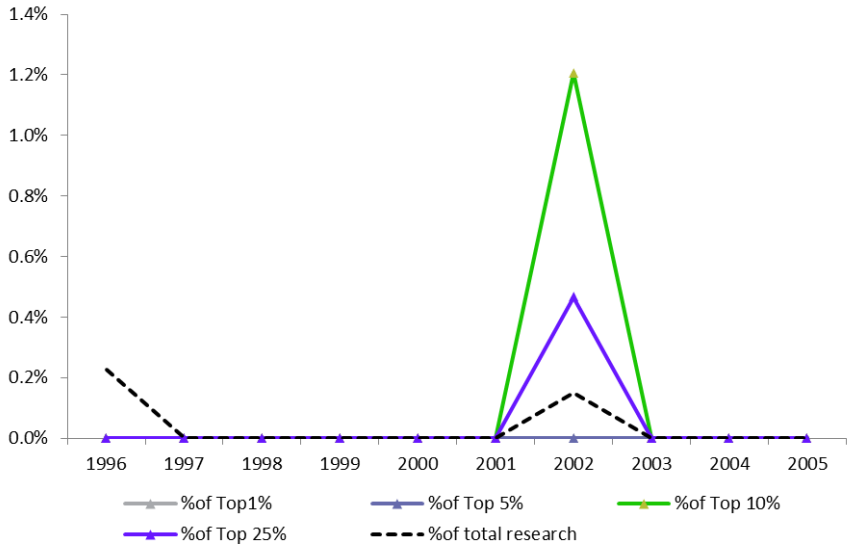
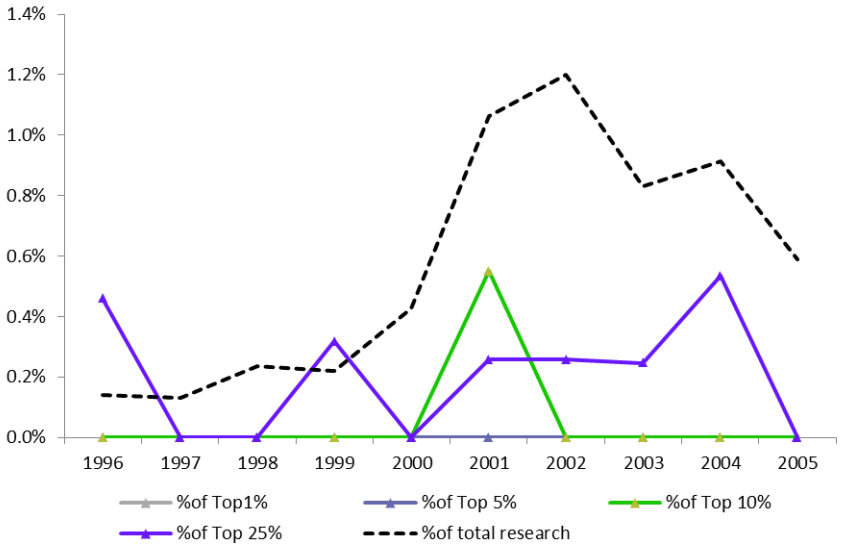


Figure 6.6.3 Annual share of India's highly-cited papers in four thresholds, Arctic Research, 2006-2015



India only published 67 papers in Arctic Research in total. Its share in any highly-cited paper category was small, and, in general, the lowest in all six subject areas. In the first 10-year period, India only had two papers published in 2002; none of them were ranked within top 5% highly-cited papers in the world. Between 2006 and 2015, except in 2011, India had no papers that were ranked within the top 10% in the world.

6.6.3 Top 20 funders, by number of papers, of highly-cited Indian papers, Arctic Research

Table 6.6.2 Top 20 funders of the highly-cited Indian papers, Arctic Research, 1996-2015

Funder	Number of Papers
Austrian Research Promotion Agency (FFG)	1
Japan Science & Technology Agency (JST)	1
Ministry of Education, Culture, Sports, Science and Technology, Japan	1
Ministry of the Environment, Japan	1
National Aeronautics & Space Administration (NASA)	1
Tiroler Zukunftstiftung	1

All funders of India's top 10% highly-cited papers were foreign funders, most likely through international collaborations. Three of them were based in Japan; two in Austria and one in the USA.

6.6.4 Top 15 collaborating countries of India

Figure 6.6.4 Top 15 collaborating countries of India, Arctic Research, 1996-2005

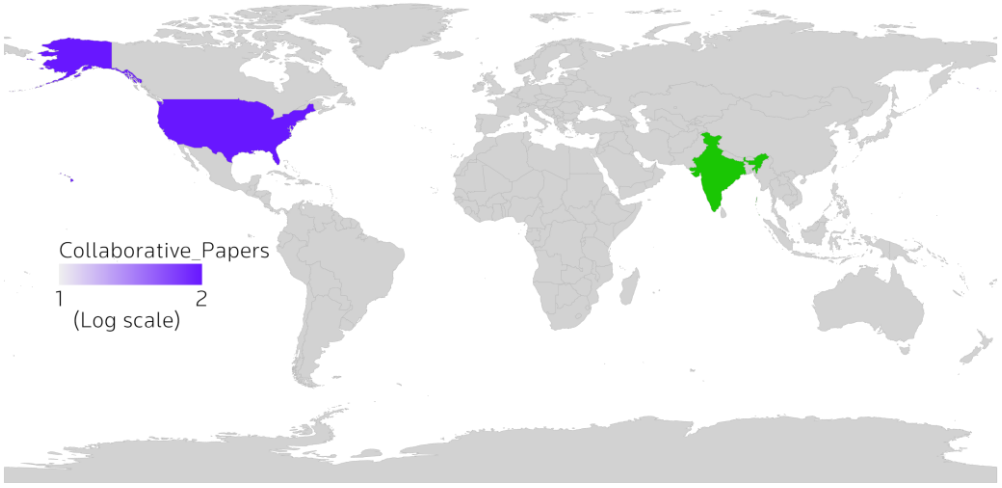


Figure 6.6.5 Top 15 collaborating countries of India, Arctic Research, 2006-2015

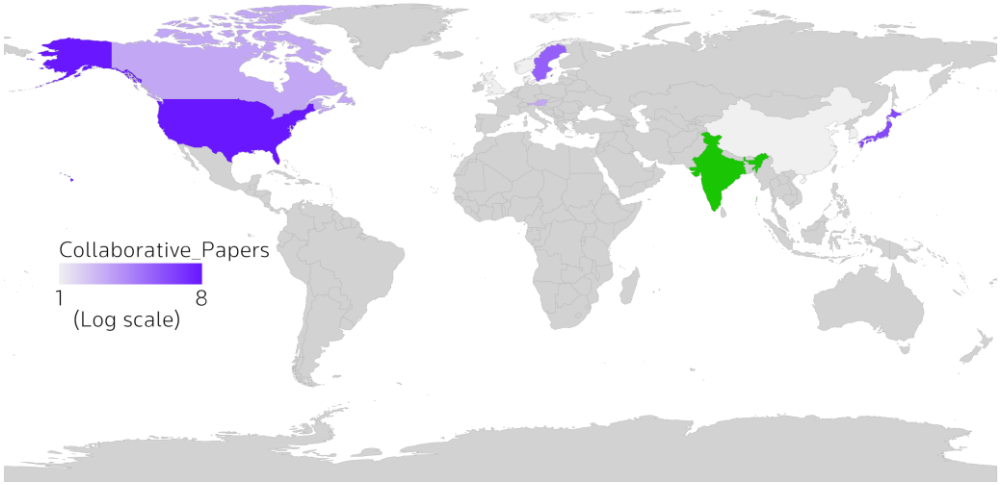


Figure 6.6.4 and **Figure 6.6.5** show the countries published with the highest number of collaborative papers with India (shown in green) in each decade.

In Arctic Research, India only published a small number of papers; it thus had little international collaboration in this subject area. The only country India had collaboration between 1996 and 2005 was the USA with two papers published. In the following decade, the number of India's international research partners increased to 11, with the USA (eight), Japan (five) and Sweden (four) taking the lead.

Figure 6.6.6 Bubble chart of top 15 collaborating countries of India, Arctic Research, 1996-2005

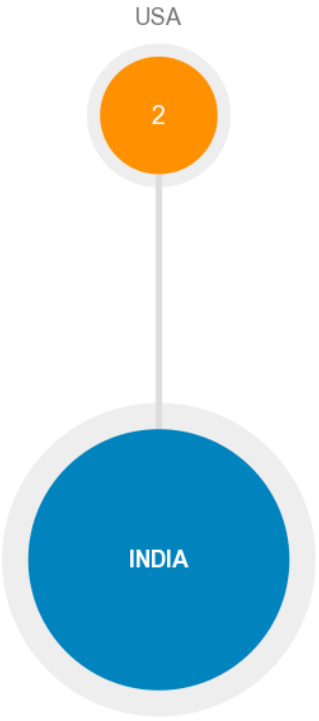
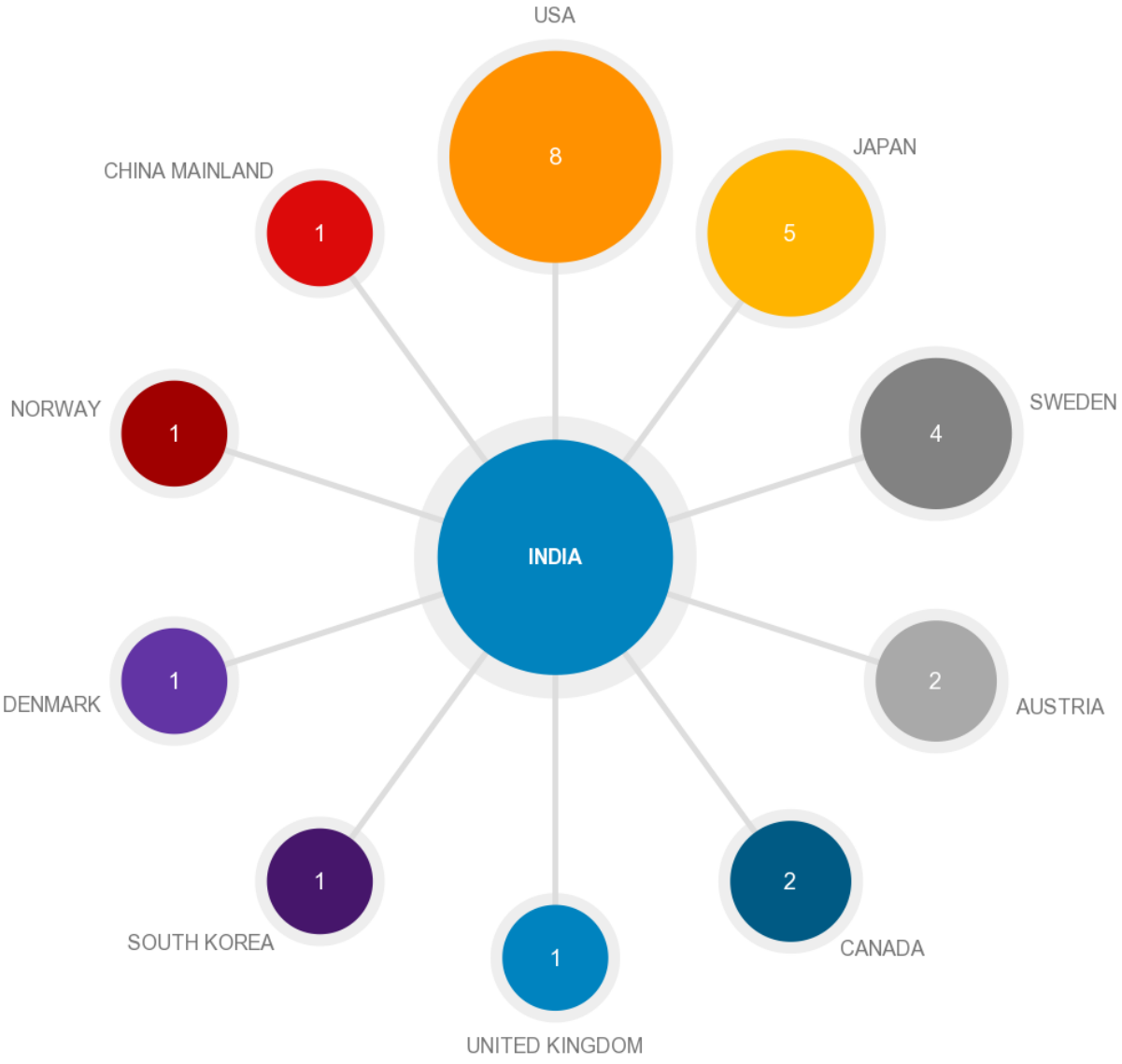


Figure 6.6.7 Bubble chart of top 15 collaborating countries of India, Arctic Research, 2006-2015



6.6.5 Top 15 international collaborating institutions of India

Table 6.6.3 Top 15 international collaborating institutions of India, Arctic Research, 1996-2005

Collaborating Organization	Country	No. of Papers
Princeton University	USA	1
Puedue University	USA	1
Rutgers University	USA	1
University of Alaska	USA	1
University of Hawaii	USA	1

Table 6.6.4 Top 15 international collaborating institutions of India, Arctic Research, 2006-2015

Collaborating Organization	Country	No. of Papers
The National Institute of Advanced Industrial Science and Technology	Japan	3
University of California at Irvine	USA	3
Yale University	USA	3
University of Innsbruck	Austria	2
The National Aeronautics and Space Administration	USA	2
University of Tokyo	Japan	2
Swedish Institute of Space Physics	Sweden	2
University of California at Davis	USA	2
Florida State University	USA	2
Franklin & Marshall College	USA	1
Norwegian Geological Survey	Norway	1
Golder Associates	Canada	1
Hokkaido University	Japan	1
Korea Ocean Satellite Center	South Korea	1
Korea Polar Research Institute	South Korea	1

Five US universities collectively co-authored the only two international collaborative papers of India in first 10 years. The level of international engagement increased in terms of number of countries, institutions, and output in the next decade. India had a diverse group of collaborating partners in Asia, North America and Europe.

6.6.6 Percentage of Indian papers and citation impact in top 10 journal categories of Arctic Research

Table 6.6.5 Percentage and mNCI of Indian papers in 10 JSCs, Arctic Research, 1996-2015

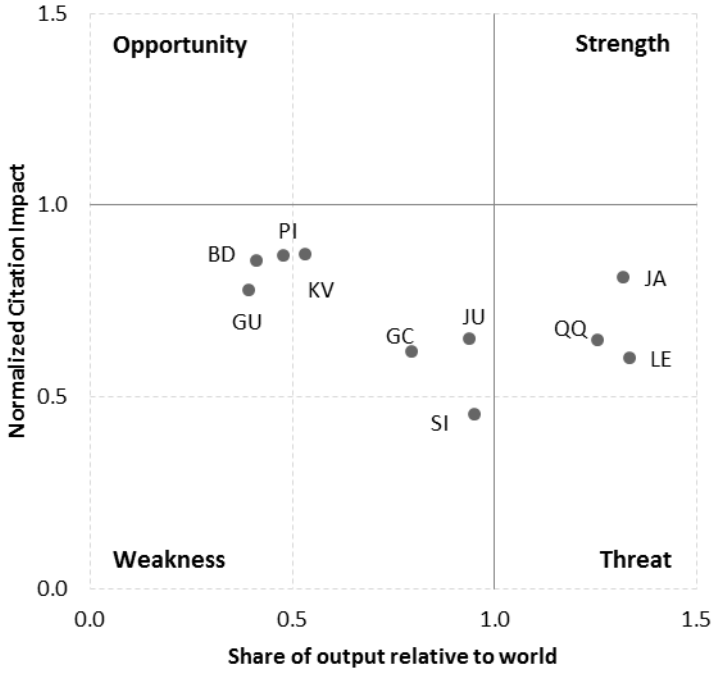
Category code	Category name	Number of papers	Number of Indian papers	Percentage of Indian papers	mNCI of Indian papers
LE	Geosciences, Multidisciplinary	3,319	16	0.5%	0.54
GU	Ecology	2,468	11	0.4%	0.49
JA	Environmental Sciences	2,411	7	0.3%	0.55
QQ	Meteorology & Atmospheric Sciences	2,402	11	0.5%	0.76
SI	Oceanography	2,215	4	0.2%	0.24
PI	Marine & Freshwater Biology	1,605	1	0.1%	1.42
KV	Geography, Physical	1,289	2	0.2%	0.74
BD	Biodiversity Conservation	740	4	0.5%	0.59
JU	Fisheries	568	0	0.0%	0.00
GC	Geochemistry & Geophysics	554	1	0.2%	0.03

Subdisciplines in Arctic Research share a high degree of similarity with that of the Antarctic Research. Nine out of the 10 JSCs were identical with Fisheries replacing Microbiology.

India's Arctic Research in these JSCs had low shares in general. In Marine & Freshwater Biology, India's research was cited well above world average (mNCI=1.42).

6.6.7 SWOT analysis of India's performance in selected Journal Categories of Arctic Research

Figure 6.6.8 SWOT analysis of India's research in 10 JSCs, Arctic Research, 1996-2015



As it was in Antarctic Research, India had no strengths and opportunities identified in the Arctic area.

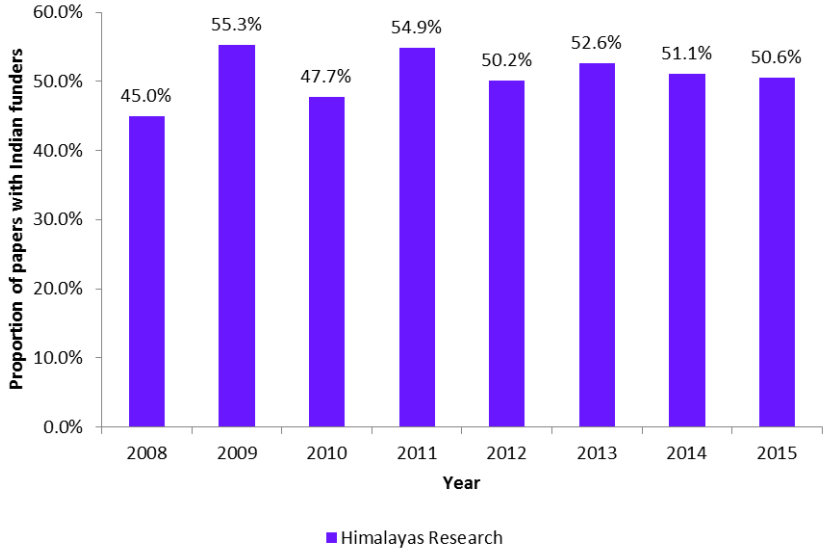
Three JSCs, Environmental Sciences (**JA**), "Geosciences, Multidisciplinary" (**LE**), and Meteorology & Atmospheric Sciences (**QQ**), were India's threats. India had relatively high research output, but these researches were cited lower than the world average.

Seven JSCs were categorized as weaknesses, as India had relatively lower output in Biodiversity Conservation (**BD**), Marine & Freshwater Biology (**PI**), Geography/Physical (**KV**), Ecology (**GU**), Microbiology (**QU**), Oceanography (**SI**), and Geochemistry & Geophysics (**GC**) and these research areas were also cited below the world average.

6.7 INDIAN PERFORMANCE IN HIMALAYAS RESEARCH

6.7.1 Annual share of papers acknowledging Indian funding agencies since 2008, Himalayas Research

Figure 6.7.1 Annual percentage of papers acknowledging Indian funding agencies, Himalayas Research, 2008-2015



From 2008 to 2015, approximately half of all Himalayas Research papers were at least partially sponsored by Indian funders, the highest level in all subject areas.

6.7.2 Annual share of Indian papers in top most cited papers, Himalayas Research

Table 6.7.1 Annual number and share of Indian papers in world's top highly-cited papers, Himalayas Research, 1996-2015

Year	No. of India's Top papers	No. of Papers Published Worldwide	No. of India's Top 1% Papers	No. of Top 1% papers worldwide	No. of India's Top 5% Papers	No. of Top 5% papers worldwide	No. of India's Top 10% Papers	No. of Top 10% papers worldwide	No. of India's Top 25% Papers	No. of Top 25% papers worldwide
1996	81	144	0	3	2	14	4	17	14	39
1997	80	150	0	2	4	14	4	24	13	48
1998	81	149	0	2	0	11	1	19	12	39
1999	72	156	0	0	1	14	1	19	9	42
2000	91	173	0	5	1	16	4	23	14	55
2001	78	151	0	2	1	16	6	25	12	48
2002	104	190	0	0	2	10	3	17	9	33
2003	121	198	0	3	1	13	2	20	13	42
2004	142	233	0	2	2	17	9	32	20	60
2005	134	229	1	2	5	17	8	29	21	59
2006	150	255	1	4	3	15	8	28	24	62
2007	189	309	0	1	4	13	5	23	18	59
2008	249	383	0	2	2	21	7	39	20	79
2009	241	357	0	4	4	14	9	30	27	70
2010	278	431	0	2	8	21	15	46	35	100
2011	296	438	0	3	3	19	8	34	37	84
2012	304	488	1	4	6	21	13	38	41	93
2013	344	517	2	6	6	22	22	51	48	107
2014	367	570	1	7	7	24	16	47	49	119
2015	391	649	0	5	5	27	11	50	43	116

Figure 6.7.2 Annual share of India's highly-cited papers in four thresholds, Himalayas Research, 1996-2005

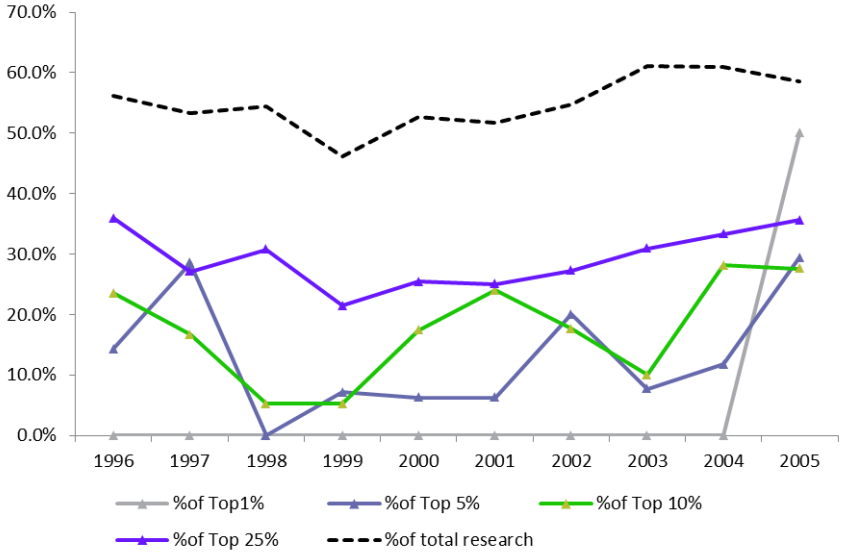
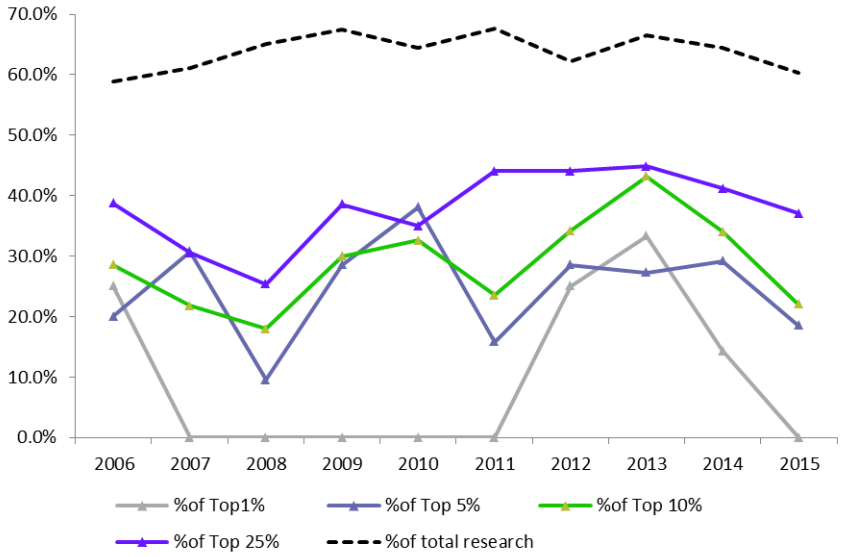


Figure 6.7.3 Annual share of India's highly-cited papers in four thresholds, Himalayas Research, 2006-2015



India was a "powerhouse" in Himalayas Research by paper volume and published approximately 60% of all papers in these subject areas between 1996 and 2015. It also had a much higher annual share of highly-cited papers than all other areas. However, India's share of top 1% highly cited papers was low on average. In the majority of time, nine years of the first 10-year period and six of the second, India had no top 1% papers. Comparing these two periods, India had a higher share of overall highly-cited papers between 2006 and 2015.

6.7.3 Top 20 funders, by number of papers, of highly-cited Indian papers, Himalayas Research

Table 6.7.2 Top 20 funders of the highly-cited Indian papers, Himalayas Research, 1996-2015

Funder	Number of Papers
Department of Science and Technology (DST), Government of India	26
National Science Foundation (NSF)	15
German Research Foundation (DFG)	9
Department of Space (DoS), Government of India	7
Ministry of Earth Sciences (MoES), Government of India	4
University Grants Commission (UGC), India	4
Council of Scientific and Industrial Research (CSIR), Government of India	4
Natural Sciences and Engineering Research Council of Canada	4
National Aeronautics & Space Administration (NASA)	3
Department of Biotechnology (DBT), Government of India	3
Indian Council of Agriculture Research (ICAR)	3
National Geographic Society	3
European Space Agency	3
French Service dObservation GLACIOCLIM	3
Chinese Academy of Sciences	2
Ruhr Universitaet Bochum	2
NERC Natural Environment Research Council	2
European Union (EU)	2
Defence Research and Development Organisation (DRDO)	2
Programme National de Teledetection Spatiale (PNTS)	2

In Himalayas Research, eight of the top 20 funders of India's highly-cited papers were Indian funders. Among them, DST, DoS, and MoES each supported more than four papers. Foreign funders outnumbered the Indian ones only by a narrow margin in term of their numbers.

6.7.4 Top 15 collaborating countries of India

Figure 6.7.4 Top 15 collaborating countries of India, Himalayas Research, 1996-2005

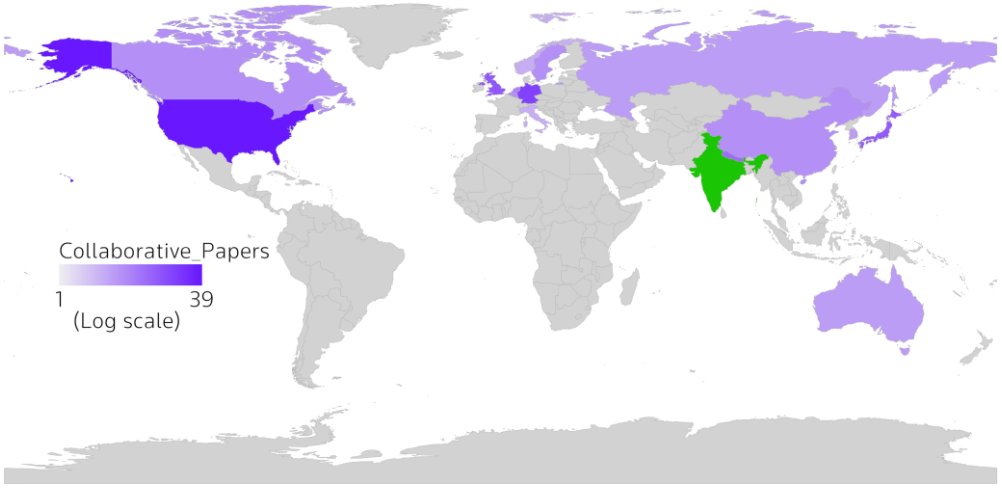
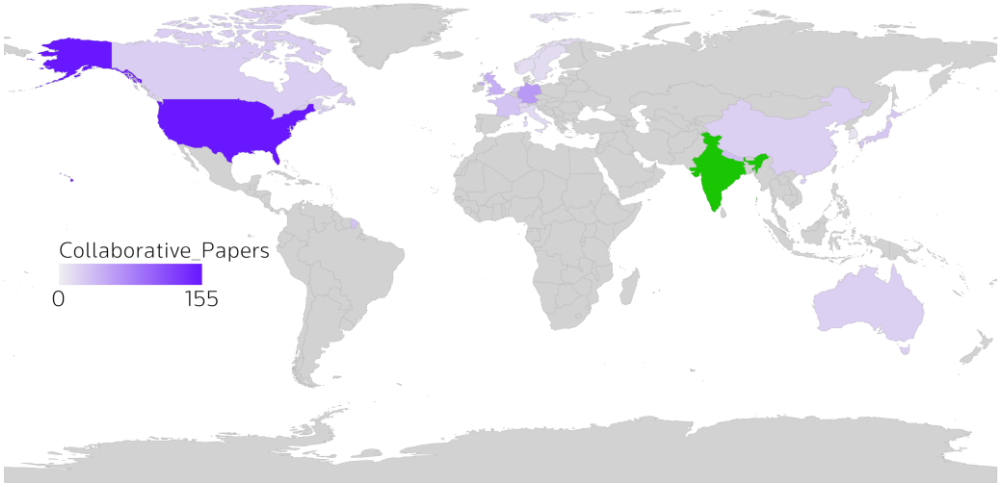


Figure 6.7.5 Top 15 collaborating countries of India, Himalayas Research, 2006-2015



India collaborated mainly with countries in North America, Europe and Asia between 1996 and 2005. The USA (39), Germany (19) and the UK (13) were most frequently collaborating partners. The trio, in the same order, also led in Decade 2 with 155, 62 and 47 papers collaborated with India each. It is also interesting to note that the collaboration between India and other countries in the Himalayas region, Nepal and China, increased in the 2006-2015 period.

Figure 6.7.6 Bubble chart of top 15 collaborating countries of India, Himalayas Research, 1996-2005

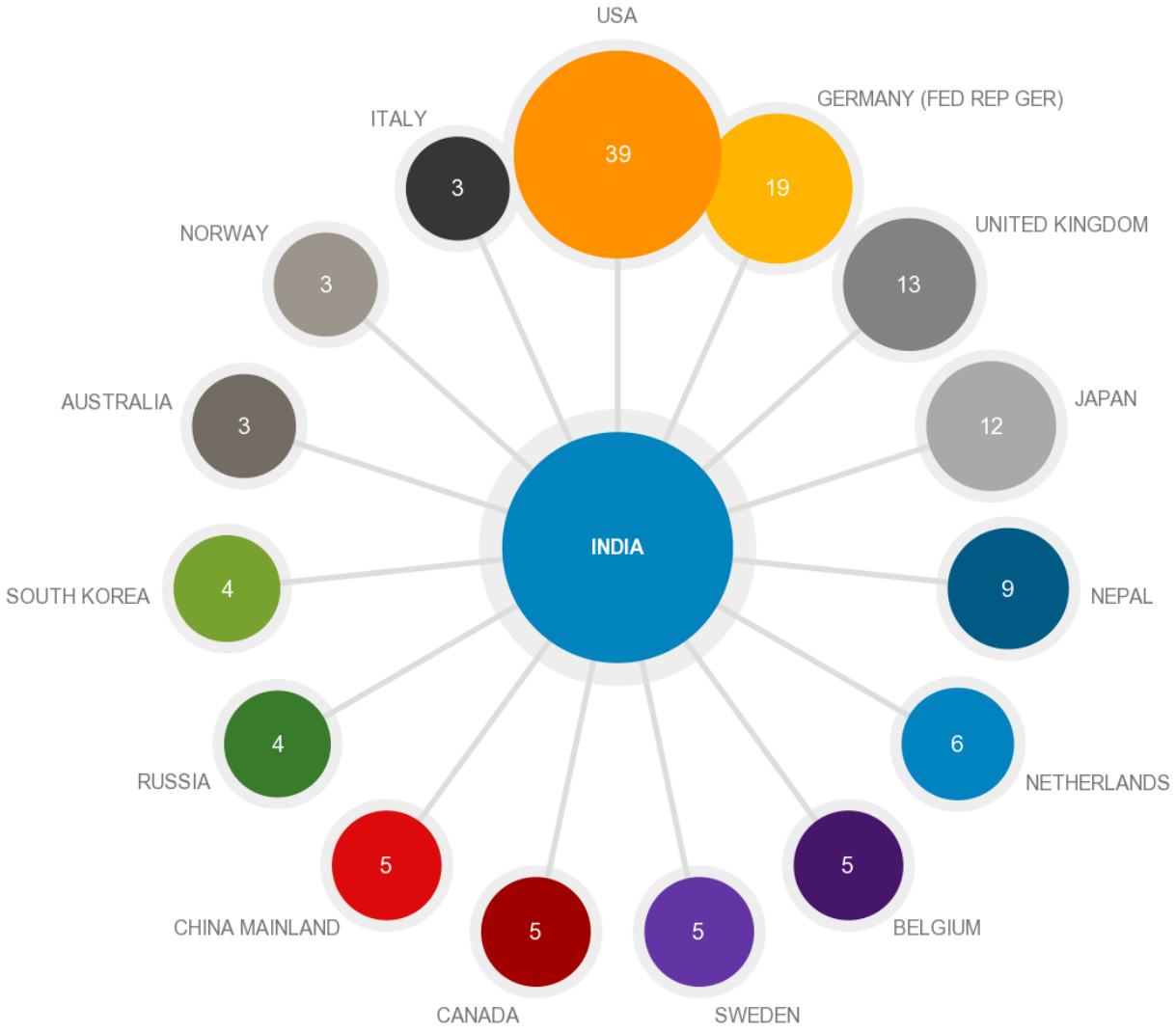
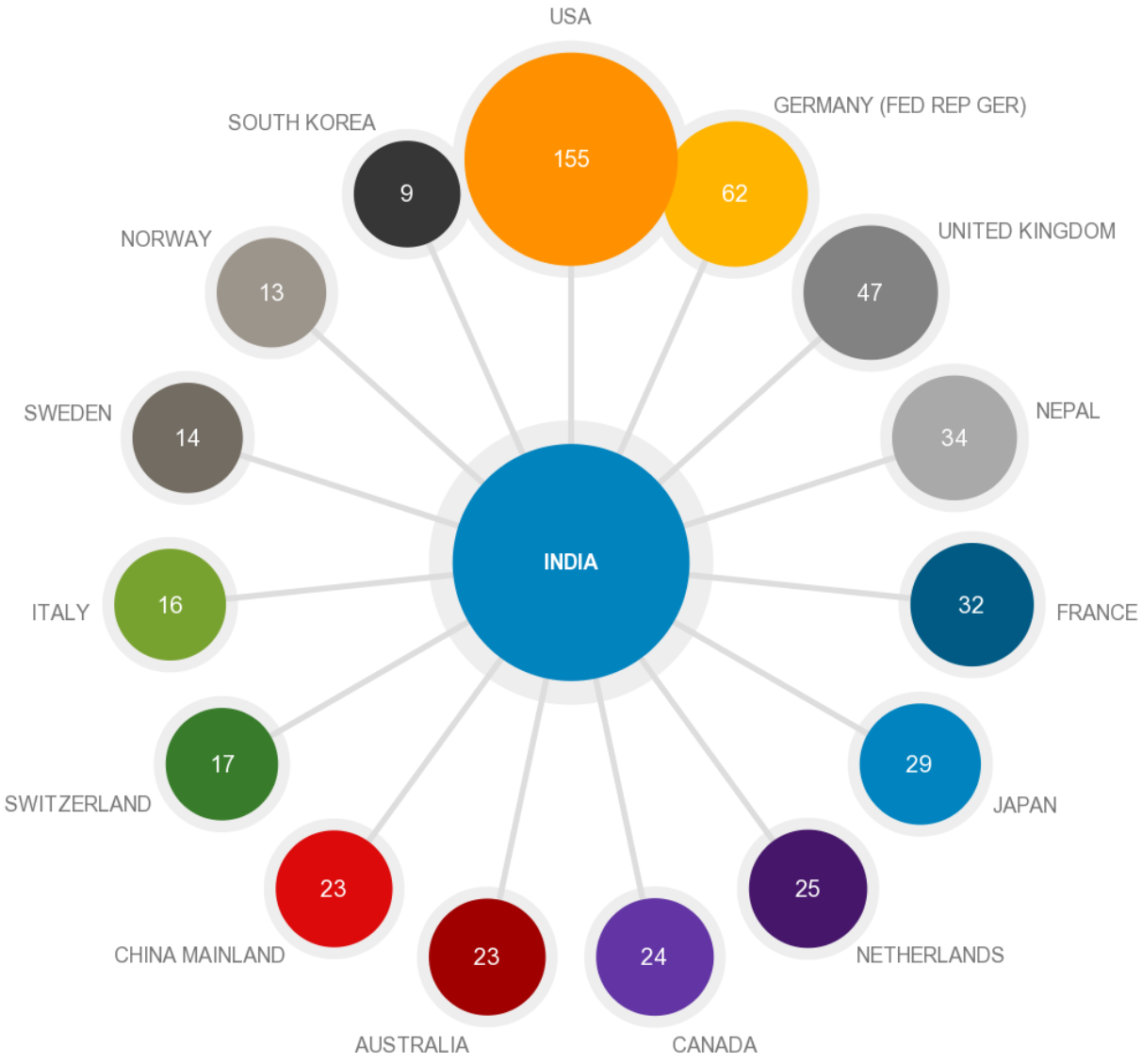


Figure 6.7.7 Bubble chart of top 15 collaborating countries of India, Himalayas Research, 2006-2015



6.7.5 Top 15 international collaborating institutions of India

Table 6.7.3 Top 15 international collaborating institutions of India, Himalayas Research, 1996-2005

Collaborating Organization	Country	No. of Papers
University of California at Riverside	USA	6
University of Tubingen	Germany	5
University of Cambridge	UK	4
Chungbuk National University	South Korea	4
Free University of Brussels	Belgium	4
International Centre for Integrated Mountain Development	Nepal	4
Lawrence Livermore National Laboratory	USA	4
Lund University	Sweden	3
Hiroshima University	Japan	3
Max Planck Society Institute of Chemistry	Germany	3
Russian Academy of Science	Russia	3
Oregon State University	USA	3
University of Colorado	USA	3
University Wageningen & Research Center	Netherlands	3
University of Tokyo	Japan	3

Table 6.7.4 Top 15 international collaborating institutions of India, Himalayas Research, 2006-2015

Collaborating Organization	Country	No. of Papers
Chinese Academy of Sciences	China	16
Tribhuvan University	Nepal	12
University of California at Riverside	USA	11
Colorado College	USA	10
Ruhr University Bochum	Germany	8
University of Nevada	USA	8
University of Twente	Netherlands	8
University of Wisconsin	USA	8
University of Massachusetts	USA	7
University of Potsdam	Germany	7
University of Leicester	UK	7
Open University	UK	7
International Centre for Integrated Mountain Development	Nepal	7
Australian National University	Australia	7
Centre National de la Recherche Scientifique	France	6

Institutions from the USA, Europe and Asia formed the major research partnership with India from 1996 to 2005 with University of California, Riverside leading the highest number of papers. The collaboration with institutions in other Himalayas region countries, China and Nepal, increased dramatically in Decade

2. Chinese Academy of Sciences and Tribuvan University in Nepal each co-authored a substantial amount of papers with India in this period.

6.7.6 Percentage of Indian papers and citation impact in top 10 journal categories of Himalayas Research

Table 6.7.5 Percentage and mNCI of Indian papers in 10 JSCs, Himalayas Research, 1996-2015

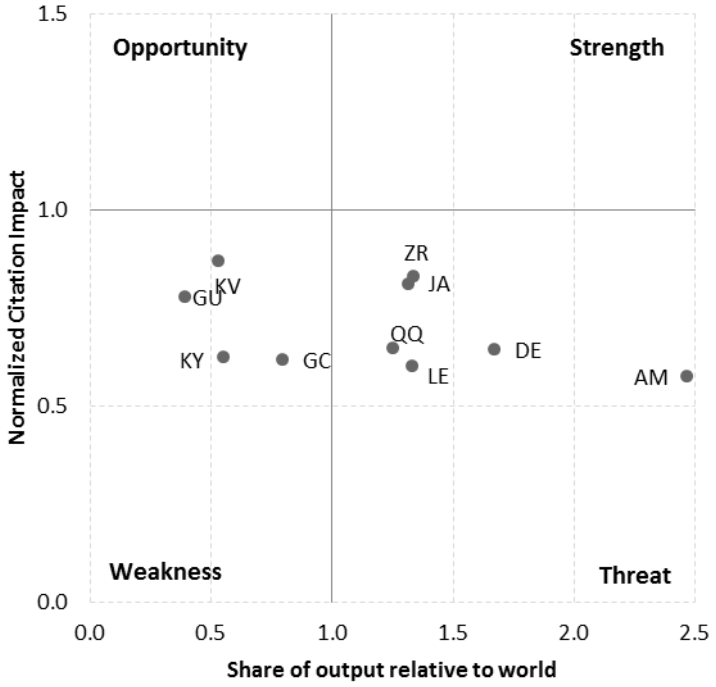
Category code	Category name	Number of papers	Number of Indian papers	Percentage of Indian papers	mNCI of Indian papers
LE	Geosciences, Multidisciplinary	1,553	950	61.3%	0.78
GC	Geochemistry & Geophysics	708	309	43.6%	0.85
JA	Environmental Sciences	617	396	64.3%	0.64
DE	Plant Sciences	574	374	65.3%	0.41
KY	Geology	412	176	42.7%	0.38
KV	Geography, Physical	405	207	51.2%	1.00
QQ	Meteorology & Atmospheric Sciences	335	199	59.4%	0.87
GU	Ecology	333	213	64.0%	0.70
ZR	Water Resources	293	213	72.7%	0.86
AM	Agronomy	180	167	93.3%	0.58

The top disciplines, by volume, in Himalayas Research are “Geosciences, Multidisciplinary”, Environmental Sciences, Ecology, and Water Resources. It’s worth mentioning that Agronomy and Plant Sciences were also important topics in Himalayas Research.

Almost all papers in Agronomy (167 out of 179) involved Indian authors. India had a relatively low share in “Geochemistry & Geophysics” and Geology. In “Geography,Physical”, India papers were cited at world average, the best among all 10 JSCs.

6.7.7 SWOT analysis of India's performance, Himalayas Research

Figure 6.7.8 SWOT analysis of India's research in 10 JSCs, Himalayas Research, 1996-2015



No strengths and opportunities were identified from Indian papers in Himalayas Research.

India had threats in six JSCs, Environmental Sciences (**JA**), "Geosciences,Multidisciplinary" (**LE**), and Meteorology & Atmospheric Sciences (**QQ**), Water Resources (**ZR**), Plant Sciences (**DE**) and Agronomy (**AM**). The shares of output in these JSCs were high, particularly in Agronomy. However, citation impact in these JSCs was relatively low compared to the world average.

Four JSCs were weaknesses. India had a relatively low output in "Geography,Physical" (**KV**), Ecology (**GU**), Geology (**KY**), and Geochemistry & Geophysics (**GC**) and these research areas were also less cited compared to the world average.

Part III. MoES Institutes

7 EVALUATION OF MOES INSTITUTES AND CENTERS

This section evaluates research performance of the 10 MoES institutes and centers (referred as institutes hereinafter).

The analyses of MoES institutes include:

- **Annual total research output and mNCI, between 1996 and 2015**
- **Top 10 international collaborating institutions by output, 1996-2005 and 2006-2015**: For institutes that were established after 1996, there would be less than 20 years of record.
- **Top 10 international collaborating institutions by citation impact, 1996-2005 and 2006-2015**
- **Top 10 journals that were used frequently by institutes, by volume, 1996-2005 and 2006-2015:** Institutes with less paper records might have less than 10 journals in total.
- **SWOT analysis of institutes with at least 100 papers between 1996 and 2015**:
    - SWOT analysis of each institute with at least 100 papers were analyzed by comparing the institution's output and citation impact to the world average. Specifically, in the 10 JSCs that an institute had the highest output, institute JSC share was calculated as dividing institute's paper count in each JSC by its total paper output. Then share of output relative to the world was then determined by dividing institute JSC share by world JSC share, which is worldwide paper count of a JSC by paper count of worldwide total research.
    - Because MoES institutes are highly specialized in their research, in the top JSCs an institute heavily focused on, the share of output relative to the world was expected to be high, much more than what was expected from a diversified funder who sponsors wide disciplines of science. Therefore, in order to have an insightful SWOT analysis, a Logarithmic (log) transformation of the score of the share of output relative to the world was necessary. In the institute SWOT analysis, a relatively large share of institutional research output was defined as larger than one on a log scale.

In addition, in the Excel companion data file, we provided:

- **Annual research output and mNCI for each Journal Subject Category in which the institution had papers**

7.1 OVERVIEW OF INSTITUTES' RESEARCH OUTPUT AND CITATION IMPACT

Table 7.1.1 MoES institutes' research output and citation impact, 1996-2015[7]

MoES Institute	Number of papers	mNCI
Indian Institute of Tropical Meteorology (IITM)	1,248	0.86
India Meteorological Department (IMD)	755	0.54
National Centre for Antarctic and Ocean Research (NCAOR)	310	0.54
National Institute of Ocean Technology (NIOT)	271	0.75
National Center for Earth Science Studies(NCESS)	254	0.58
National Centre for Medium Range Weather Forecasting (NCMRWF)	215	0.47
Indian National Centre for Ocean Information Services (INCOIS)	205	0.80
Integrated Coastal and Marine Area Management (ICMAM)	67	0.59
Centre for Marine Living Resources and Ecology (CMLRE)	46	0.32

Please note that National Center for Seismology (NCS), the newest office of MoES, is not listed in **Table 7.1.1**. Since this report focuses on paper output in the time period 1996-2015, when NCS did not exist, therefore institute level analysis cannot be done for NCS. Thus, we did not include the analysis for NCS in this report. However, it may be noted that publications emanating from the erstwhile Seismology Division are included in the report under IMD.

Among MoES institutes, IITM was the only one that published more than 1,000 papers. IMD, with 755 papers, was the second most productive institute. Two institutes, ICMAM and CMLRE, had less than 100 papers each.

Caution should be exercised when interpreting an institute's paper number as an indicator for its research productivity for the following reasons. First, only Web of Science indexed papers were included in the analyses. An institute may have a large portion of publications that was not indexed in Web of Science. Second, some institutes, such as NCESS, had a shorter history of operation than others. It is expected that these institutes may have less papers published. Finally, institutes vary in their size, budget, and mission. For some institutes, publication may not be an important goal of their research.

[7] Not all institutes existed in the entire duration between 1996 and 2015.

7.2 INDIAN INSTITUTE OF TROPICAL METEOROLOGY (IITM)

Indian Institute of Tropical Meteorology is recognized as a national centre for basic and applied research in Meteorology and Atmospheric Sciences. The Institute is committed to the better understanding of land-atmosphere-ocean system and to the development of improved skills in monsoon predictions. The Institute is constantly evolving to meet the new challenges and changing national and international demands. IITM has strong expertise in theoretical and observational meteorology, oceanography, climate change and Modelling with special reference to monsoon variability and predictability.

Related link: http://www.tropmet.res.in/IITM%20at%20Snapshot-8-Page

7.2.1 Annual research output and citation impact, IITM

Table 7.2.1 Annual research output and citation impact, IITM, 1996-2015

Year	Number of Papers	mNCI
1996	21	0.51
1997	24	0.45
1998	18	0.19
1999	34	0.96
2000	31	0.42
2001	30	0.43
2002	28	0.68
2003	36	0.84
2004	36	0.63
2005	30	0.68
2006	42	1.84
2007	46	0.85
2008	58	0.67
2009	77	0.74
2010	86	0.72
2011	113	0.66
2012	135	0.86
2013	131	1.04
2014	144	1.02
2015	128	1.14

The annual paper output by IITM steadily increased, from 21 in 1996 to over 100 for the first time in 2011, and then to 144 in 2014. In 2015, there was a slight decrease. Over the 20-year period, IITM increased its annual output of papers by more than six times.

Meanwhile, IITM's citation impact also increased over the same period. Papers between 1996 and 2001 were cited generally about half of the world average. In each of the last three years of the 20-year period, IITM's annual mNCI was greater than one. Considering the substantial amount of papers published in these three years, the citation impact was remarkably good.

7.2.2 Top 10 international collaborating institutions by research output, IITM

Table 7.2.2 Top 10 international collaborating institutions by research output, IITM, 1996-2005

International Collaborating Organization	Country	Number of papers
Japan Agency for Marine-Earth Science & Technology	Japan	7
National Center Atmospheric Research	US	6
Meteorological Research Institute	Japan	6
National Oceanic Atmospheric Admin	US	6
Florida State University	US	6
National Aeronautics & Space Administration	US	6
Chinese Academy of Sciences	China	5
Korea Meteorological Administration	South Korea	5
Russian Academy of Sciences	Russia	4
Stockholm University	Sweden	4

Table 7.2.3 Top 10 international collaborating institutions by research output, IITM, 2006-2015

International Collaborating Organization	Country	Number of papers
National Oceanic Atmospheric Admin	US	31
Centre National de la Recherche Scientifique	France	24
Japan Agency for Marine-Earth Science & Technology	Japan	23
National Center Atmospheric Research	US	21
University of Maryland	US	19
University of Maryland College Park	US	18
The Commonwealth Scientific and Industrial Research Organisation	Australia	15
Muséum national d'Histoire naturelle	France	15
Florida State University	US	14
Max Planck Society	Germany	14

JAMSTEC, NOAA and NCAR were the most frequently collaborating institutions with IITM in both 10-year periods.

7.2.3 Top 10 international collaborating institutions by citation impact, IITM

Table 7.2.4 Top 10 international collaborating institutions by mNCI, IITM, 1996-2005

International Collaborating Organization	Country	Number of papers	mNCI
Columbia University	US	1	17.31
University of Hawaii System	US	1	7.75
Institute of Global Environment & Society Inc	US	2	4.58
Seoul National University	South Korea	3	4.38
Princeton University	US	3	4.24
Russian Academy of Sciences	Russia	4	4.18
University Centre in Svalbard	Norway	1	4.08
Langley Research Center	US	1	4.08
Leibniz Institute of Atmospheric Physics	Germany	1	4.08
York University	Canada	1	4.08

Table 7.2.5 Top 10 international collaborating institutions by mNCI, IITM, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
Iran Meteorological Organization	Iran	1	30.19
Meteorological Service of Canada	Canada	1	30.19
National Autonomous University of Mexico	Mexico	1	14.88
University of Montpellier	France	1	14.88
University of Ottawa	Canada	1	14.88
Nat Inst Water & Atmosphere Res Ltd	New Zealand	1	14.88
Universite Catholique Louvain	Belgium	1	14.88
Hydrologic Research Center	US	1	14.88
University of Trieste	Italy	1	14.88
Johannes Gutenberg University of Mainz	Germany	1	14.88

A highly-cited paper might involve multiple collaborating institutions around the globe. For instance, in **Table 7.2.5**, eight of the 10 institutions coauthored with IITM on the same paper. We did not set up number threshold to be included in this analysis, but would advise caution in interpreting results.

7.2.4 Top 10 Journals by volume, IITM

Table 7.2.6 Top 10 journals by volume, IITM, 1996-2015

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	32
INTERNATIONAL JOURNAL OF CLIMATOLOGY	UK	28
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	USA	24
PROCEEDINGS OF THE INDIAN ACADEMY OF SCIENCES-EARTH AND PLANETARY SCIENCES	India	22
METEOROLOGY AND ATMOSPHERIC PHYSICS	Austria	18
GEOPHYSICAL RESEARCH LETTERS	USA	17
THEORETICAL AND APPLIED CLIMATOLOGY	Germany	13
ATMOSPHERIC ENVIRONMENT	UK	12
ATMOSPHERIC RESEARCH	Netherlands	12
PURE AND APPLIED GEOPHYSICS	Switzerland	10

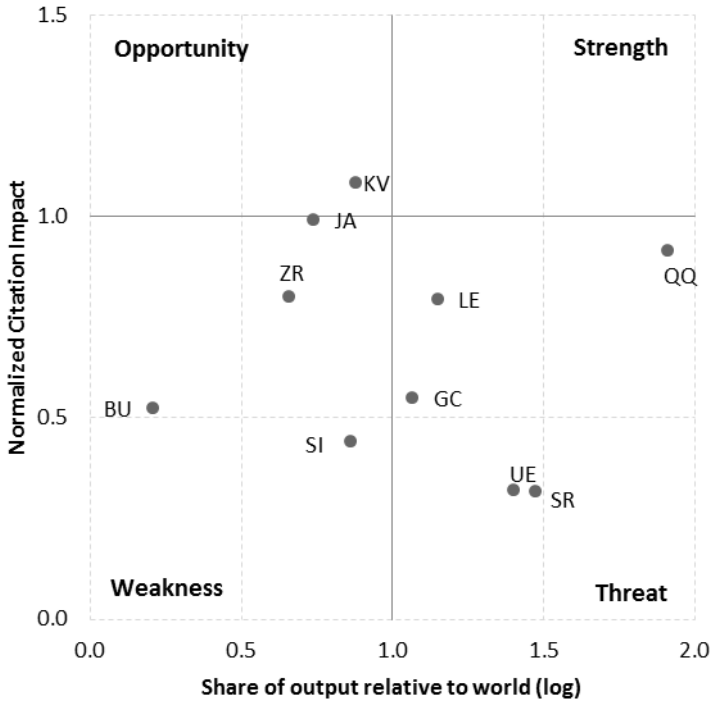
Table 7.2.7 Top 10 journals by volume, IITM, 2006-2015

Journal	Publishing Country	No. of paper
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	USA	84
CLIMATE DYNAMICS	USA	66
INTERNATIONAL JOURNAL OF REMOTE SENSING	UK	51
INTERNATIONAL JOURNAL OF CLIMATOLOGY	UK	50
ATMOSPHERIC ENVIRONMENT	UK	50
JOURNAL OF EARTH SYSTEM SCIENCE	India	49
ATMOSPHERIC RESEARCH	Netherlands	48
JOURNAL OF ATMOSPHERIC AND SOLAR-TERRESTRIAL PHYSICS	UK	44
GEOPHYSICAL RESEARCH LETTERS	USA	41
CURRENT SCIENCE	India	29

IITM published the highest number of papers in CURRENT SCIENCE, a multidisciplinary journal between 1996 and 2005. Between 2006 and 2015, it was JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES.

7.2.5 SWOT analysis, IITM

Figure 7.2.1 SWOT analysis of IITM research, 1996-2015[8]



Geography/Physical (**KV**) is an opportunity for IITM. Papers published by IITM were cited higher than world average. However, its relative share of output among all JSCs was still lower than many others.

IITM had threats in four JSCs, Meteorology & Atmospheric Sciences (**QQ**), Geosciences, Multidisciplinary (**LE**), Geochemistry & Geophysics (**GC**), Imaging Science & Photographic Technology (**UE**), and Remote Sensing (**SR**). The shares of output in these JSCs were high, however, citation impact in these JSCs were relatively low compared to the world average.

Four JSCs were IITM's weaknesses; these are Astronomy & Astrophysics (**BU**), Water Resources (**ZR**), and Oceanography (**SI**), Plant Sciences (**DE**) and Environmental Sciences (**JA**). It might be worth pointing out that, in Environmental Sciences, IITM's papers were cited almost as high as the world average.

No Strength was identified for IITM.

[8] SWOT analysis of MoES institute is different from that of the subject area. Please refer to **Appendix A.11** for details.

7.3 India Meteorological Department (IMD)

India Meteorological Department was established in 1875. It is the National Meteorological Service of the country and the principal government agency in all matters relating to meteorology, seismology and allied subjects.

- To take meteorological observations and to provide current and forecast meteorological information for optimum operation of weather-sensitive activities like agriculture, irrigation, shipping, aviation, offshore oil explorations, etc.

- To warn against severe weather phenomena like tropical cyclones, norwesters, duststorms, heavy rains and snow, cold and heat waves, etc., which cause destruction of life and property.

- To provide meteorological statistics required for agriculture, water resource management, industries, oil exploration and other nation-building activities.

- To conduct and promote research in meteorology and allied disciplines.

- To detect and locate earthquakes and to evaluate seismicity in different parts of the country for development projects.

Related link: http://www.imd.gov.in/pages/about_mandate.php

7.3.1 Annual research output and citation impact, IMD

Table 7.3.1 Annual research output and citation impact, IMD, 1996-2015

Year	Number of Papers	mNCI
1996	13	0.30
1997	8	1.33
1998	12	0.48
1999	19	0.47
2000	21	0.44
2001	15	0.77
2002	10	0.27
2003	16	0.43
2004	13	0.60
2005	16	0.44
2006	19	1.30
2007	60	0.45
2008	58	0.24
2009	40	0.44
2010	62	0.94
2011	58	0.31
2012	79	0.26
2013	77	0.59
2014	73	0.76
2015	86	0.58

In the first 10-year period, IMD produced 14 papers a year on average. The average annual output between 2006 and 2015 jumped to 61 papers, and the year 2007 seems to be the start of the upward transition.

However, there was substantial volatility in citation impact. Moreover, IMD's papers were cited only above world average in only two years over the 20-year period.

7.3.2 Top 10 international collaborating institutions by research output, IMD

Table 7.3.2 Top 10 international collaborating institutions by research output, IMD, 1996-2005

International Collaborating Organization	Country	Number of papers
National Autonomous University of Mexico	Mexico	6
National Oceanic Atmospheric Admin	USA	3
Meteorological Office	UK	3
National Aeronautics & Space Administration	USA	2
Geoforschungszentrum Potsdam	Germany	2
Complutense University of Madrid	Spain	1
University of St Andrews	UK	1
Massachusetts Institute of Technology	USA	1
Jülich Institute for Chemistry of the Polluted Atmosphere	Germany	1
United States Navy	USA	1

Table 7.3.3 Top 10 international collaborating institutions by research output, IMD, 2006-2015

International Collaborating Organization	Country	Number of papers
National Oceanic Atmospheric Admin	USA	10
National Autonomous University of Mexico	Mexico	9
National Center Atmospheric Research	USA	6
SAARC Meteorological Research Centre	Bangladesh	5
Japan Agency for Marine-Earth Science & Technology	Japan	4
The Commonwealth Scientific and Industrial Research Organisation	Australia	4
Purdue University	USA	4
Florida State University	USA	4
Purdue University	USA	4
Crops For the Future Research Center	Malaysia	3

IMD established a strong collaborating partnership with NOAA, NCAR, and, particularly with National Autonomous University of Mexico, which resulted in a relatively high number of collaborative papers.

7.3.3 Top 10 international collaborating institutions by citation impact, IMD

Table 7.3.4 Top 10 international collaborating institutions by mNCI, IMD, 1996-2005

International Collaborating Organization	Country	Number of papers	mNCI
University of East Anglia	UK	1	8.37
Center of Ecology & Biophysics	Brazil	1	2.52
World Meteorological Organization	Switzerland	1	2.52
Geoforschungszentrum Potsdam	Germany	2	1.93
Wageningen University & Research Center	Netherlands	1	1.87
National Institute of Water & Atmospheric Research (NIWA) - New Zealand	New Zealand	1	1.87
Complutense University of Madrid	Spain	1	1.25
United States Geological Survey	USA	1	1.21
National Autonomous University of Mexico	Mexico	6	1.03
University of Maryland	USA	1	0.98

Table 7.3.5 Top 10 international collaborating institutions by mNCI, IMD, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
City University of Hong Kong	China	1	41.04
University of British Columbia	Canada	1	24.86
Alberta Geological Survey	Canada	1	24.86
Université Grenoble Alpes	France	1	24.86
University of Munich	Germany	1	24.86
University of Lethbridge	Canada	1	24.86
University of Otago	New Zealand	1	24.86
University College Cork	Ireland	1	24.86
University of Birmingham	UK	1	24.86
University of Ottawa	Canada	1	24.86

Even though some top collaborating institutions by mNCI had very highly-cited papers, IMD only co-authored one or two papers with most of them. National Autonomous University of Mexico was an exception; it collaborated with IMD on six papers that were overall cited above the world average.

7.3.4 Top 10 Journals by volume, IMD

Table 7.3.6 Top 10 journals by volume, IMD, 1996-2005

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	35
METEOROLOGY AND ATMOSPHERIC PHYSICS	Austria	14
PROCEEDINGS OF THE INDIAN ACADEMY OF SCIENCES-EARTH AND PLANETARY SCIENCES	India	10
INTERNATIONAL JOURNAL OF CLIMATOLOGY	UK	9
BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA	USA	7
GEOPHYSICAL RESEARCH LETTERS	USA	6
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	USA	6
AGRICULTURAL AND FOREST METEOROLOGY	Netherlands	5
THEORETICAL AND APPLIED CLIMATOLOGY	Germany	4
GEOPHYSICAL JOURNAL INTERNATIONAL	UK	3

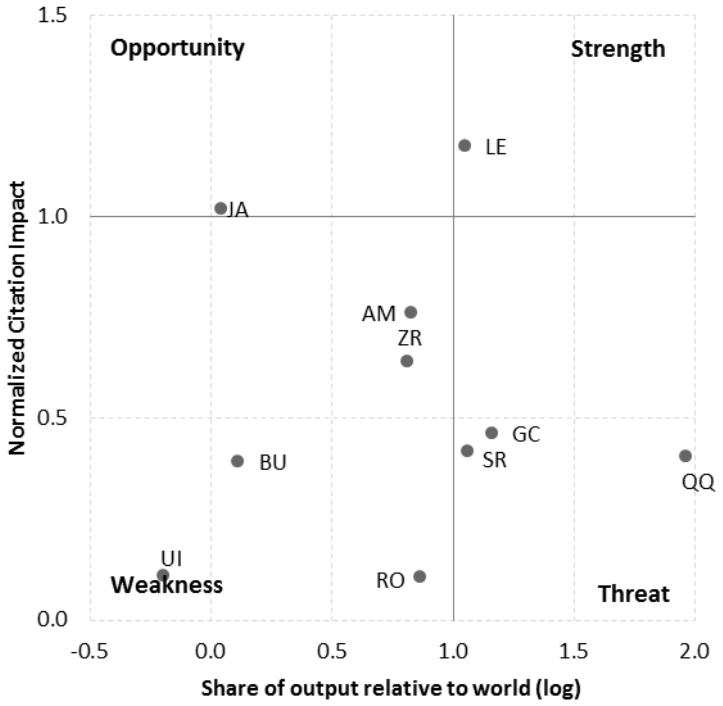
Table 7.3.7 Top 10 journals by volume, IMD, 2006-2015

Journal	Publishing Country	No. of paper
MAUSAM	India	290
NATURAL HAZARDS	USA	35
JOURNAL OF EARTH SYSTEM SCIENCE	India	33
CURRENT SCIENCE	India	24
JOURNAL OF AGROMETEOROLOGY	India	23
METEOROLOGY AND ATMOSPHERIC PHYSICS	Austria	19
PURE AND APPLIED GEOPHYSICS	Switzerland	13
METEOROLOGICAL APPLICATIONS	UK	12
THEORETICAL AND APPLIED CLIMATOLOGY	Germany	9
GEOFIZIKA	Croatia	9
INTERNATIONAL JOURNAL OF CLIMATOLOGY	UK	9
CLIMATE DYNAMICS	USA	9

IMD publishes the journal MAUSAM, therefore had a very high number papers published in this journal between 2006 and 2015. Prior to that, MAUSAM was not indexed in Web of Science, thus not shown in the 1996-2005 results.

7.3.5 SWOT analysis, IMD

Figure 7.3.1 SWOT analysis of IMD research, 1996-2015



The JSC, Environmental Sciences (**KV**), is an opportunity for IMD. The IMD papers published in this JSC were cited above the world average, but its share of output is relatively low within MoES institutes.

IMD had threats in three JSCs, Meteorology & Atmospheric Sciences (**QQ**), "Geosciences, Multidisciplinary" (**LE**), Geochemistry & Geophysics (**GC**), and Remote Sensing (**SR**). The shares of output in these JSCs were high, however, citation impact in these JSCs were relatively low compared to the world average.

Five JSCs were IITM's weaknesses. These are "Physics, Multidisciplinary" (**DE**) and Multidisciplinary Sciences (**RO**), Agronomy (**AM**), Astronomy & Astrophysics (**BU**), and Water Resources (**ZR**).

No Strength was identified for IMD.

7.4 NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH (NCAOR)

The National Centre for Antarctic and Ocean Research (NCAOR) was established as an autonomous Research and Development Institution of the Ministry of Earth Sciences (formerly Department of Ocean Development), Government of India on the 25th May 1998.

With a mission mandate that is quite challenging, the Centre is designated as the nodal organization for the co-ordination and implementation of the Indian Antarctic Programme, including the maintenance of India's permanent station in Antarctica.

Related link: http://www.ncaor.gov.in/pages/display/275-organisation

7.4.1 Annual research output and citation impact, NCAOR

Table 7.4.1 Annual research output and citation impact, NCAOR, 2000-2015

Year	Number of Papers	mNCI
2000	1	0.19
2001	3	0.08
2003	1	0.34
2004	6	0.42
2005	6	0.40
2006	19	0.28
2007	15	0.31
2008	23	0.21
2009	16	0.48
2010	29	0.49
2011	33	0.42
2012	31	0.39
2013	31	1.25
2014	45	0.60
2015	51	0.67

NCAOR published only one paper in 2000 and 2003 and low single digits in other years prior to 2006. Annual output since grew quite significantly to 51 papers in 2015.

NCAOR's papers in early 2000 were cited less frequently. Before 2013, NCAOR's research was cited less than half of the world average. However, its papers in 2013-2015 had improved citation impact.

7.4.2 Top 10 international collaborating institutions by research output, NCAOR

Table 7.4.2 Top 10 international collaborating institutions by research output, NCAOR, 2000-2005

International Collaborating Organization	Country	Number of papers
Woods Hole Oceanographic Institution	USA	1
Tohoku University	Japan	1

Table 7.4.3 Top 10 international collaborating institutions, by research output, NCAOR, 2006-2015

International Collaborating Organization	Country	Number of papers
National Institute of Advanced Industrial Science & Technology (AIST)	Japan	8
NERC Natural Environment Research Council	UK	6
Columbia University	USA	5
NERC British Antarctic Survey	UK	4
University of Edinburgh	UK	3
University of Tasmania	Australia	3
Polish Academy of Science	Poland	3
University of Bremen	Germany	3
Centre National de la Recherche Scientifique	France	3
Nagoya University	Japan	2

In 2006-2015, NCAOR had more international collaborating institutions than in the previous six-year period which also resulted in a higher number of collaborative papers.

7.4.3 Top 10 international collaborating institutions by citation impact, NCAOR

Table 7.4.4 Top 10 international collaborating institutions by mNCI, NCAOR, 2000-2005

International Collaborating Organization	Country	Number of papers	mNCI
Woods Hole Oceanographic Institution	USA	1	0.59
Tohoku University	Japan	1	0.41

Table 7.4.5 Top 10 international collaborating institutions by mNCI, NCAOR, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
Chinese Academy of Sciences	China	1	14.88
University of Helsinki	Finland	1	14.88
University of Texas at Austin	US	1	14.88
University of Colorado Boulder	US	1	14.88
Nevada System of Higher Education	US	1	14.88
GKSS FORSCHUNGSZENTRUM GEESTHACHT GMBH	Germany	1	14.88
University of Washington	US	1	14.88
Federal Urdu University of Arts Science & Technology	Pakistan	1	14.88
University of Montpellier	France	1	14.88
Niels Bohr Institute	Denmark	1	14.88

All the collaborating institutions listed in **Table 7.4.5** were extracted from a single paper that has a NCI of 14.88.

7.4.4 Top 10 Journals by volume, NCAOR

Table 7.4.6 Top 10 journals by volume, NCAOR, 2000-2005

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	3
INTERNATIONAL JOURNAL OF REMOTE SENSING	UK	3
GEOPHYSICAL RESEARCH LETTERS	USA	2
REMOTE SENSING OF ENVIRONMENT	USA	2
COMPUTERS & GEOSCIENCES	UK	1
ENVIRONMENTAL GEOLOGY	Netherlands	1
ENVIRONMENTAL TECHNOLOGY	UK	1
JOURNAL OF EARTH SYSTEM SCIENCE	India	1
JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS	USA	1
JOURNAL OF OCEANOGRAPHY	Japan	1
JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	India	1

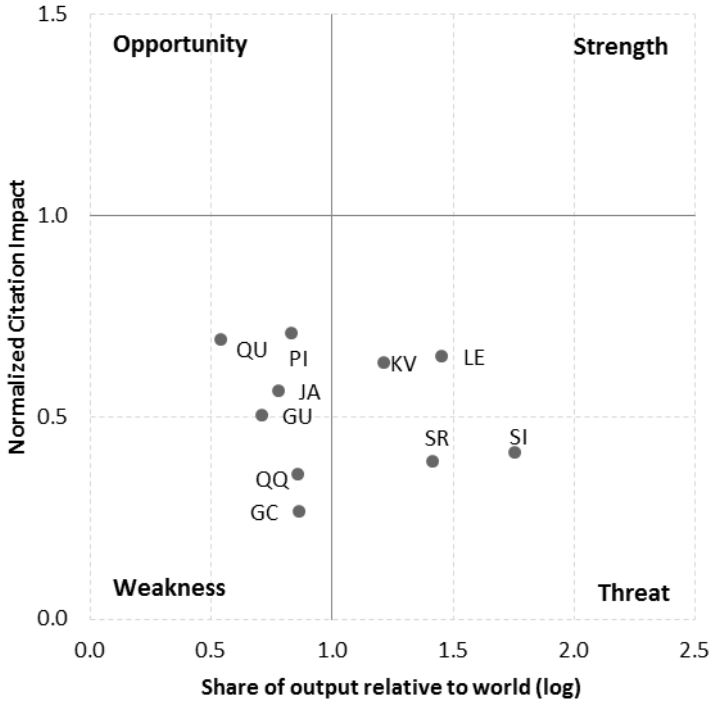
Table 7.4.7 Top 10 journals by volume, NCAOR, 2006-2015

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	44
INDIAN JOURNAL OF MARINE SCIENCES	India	14
JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	India	13
DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY	USA	12
ENVIRONMENTAL MONITORING AND ASSESSMENT	Netherlands	9
JOURNAL OF EARTH SYSTEM SCIENCE	India	9
INDIAN JOURNAL OF GEO-MARINE SCIENCES	India	7
POLAR SCIENCE	Netherlands	7
JOURNAL OF MARINE SYSTEMS	Netherlands	6
GEO-MARINE LETTERS	USA	5

NCAOR published the highest number of papers in Indian journals, such as CURRENT SCIENCE, INDIAN JOURNAL OF MARINE SCIENCES, and JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA.

7.4.5 SWOT analysis, NCAOR

Figure 7.4.1 SWOT analysis of NCAOR research, 2000-2015



NCAOR did not have strength or opportunities in their research.

NCAOR had four JSCs identified as threats, namely Geosciences, Multidisciplinary (**LE**), "Geography, Physical" (**KV**), Oceanography (**SI**), and Remote Sensing (**SR**). The relative shares of output in these JSCs were high, however, citation impact in these JSCs were relatively low compared to the world average.

Six JSCs were categorized as weaknesses. These were Microbiology (**QU**), Marine & Freshwater Biology (**PI**), Environmental Sciences (**JA**), Ecology (**GU**), Meteorology & Atmospheric Sciences (**QQ**), and Geochemistry & Geophysics (**GC**).

7.5 NATIONAL INSTITUTE OF OCEAN TECHNOLOGY (NIOT)

The National Institute of Ocean Technology (NIOT) was established in November 1993 as an autonomous society under the Ministry of Earth Sciences, Government of India. NIOT is managed by a Governing Council and the Director is the head of the Institute.

The major aim of starting NIOT under the Ministry of Earth Sciences, is to develop reliable indigenous technology to solve the various engineering problems associated with harvesting of non-living and living resources in the Indian Exclusive Economic Zone (EEZ), which is about two-thirds of the land area of India

Related link: https://www.niot.res.in/index.php/node/index/1/

7.5.1 Annual research output and citation impact, NIOT

Table 7.5.1 Annual research output and citation impact, NIOT, 1997-2015

Year	Number of Papers	mNCI
1997	3	0.49
1998	4	0.74
1999	2	0.48
2000	5	1.41
2001	6	1.47
2002	11	0.34
2003	3	0.07
2004	7	0.68
2005	15	0.27
2006	5	0.70
2007	12	0.55
2008	9	0.62
2009	12	0.48
2010	17	1.32
2011	14	0.95
2012	11	0.48
2013	32	0.77
2014	51	0.74
2015	52	0.83

Between 1997 and 2006, NIOT, on average, published six papers per year. Annual paper count since grew to 23 for the years following. In each of 2014 and 2015, NIOT had more than 50 papers published.

NIOT's papers also had a relatively higher citation impact, only next to IITM and INCOIS. It was primarily driven by the papers published in the last 5-6 years.

7.5.2 Top 10 international collaborating institutions by research output, NIOT

Table 7.5.2 Top 10 international collaborating institutions by research output, NIOT, 1997-2005

International Collaborating Organization	Country	Number of papers
University of Utrecht	Netherlands	1
National Institute for Basic Biology	Japan	1
University of Rhode Island	USA	1
Oregon State University	USA	1
Gunma University	Japan	1
University of Miyazaki	Japan	1
Duke University	USA	1
Oregon University	USA	1
National Institutes of Natural Sciences (NINS) - Japan	Japan	1
Pare Corporation	USA	1
Southeast Asian Fisheries Development Center	Philippines	1
Portland State University	USA	1
Stanford University	USA	1
Technology Planning and Management Corporation	USA	1

Table 7.5.3 Top 10 international collaborating institutions by research output, NIOT, 2006-2015

International Collaborating Organization	Country	Number of papers
Stanford University	USA	2
Oregon University	USA	2
Gunma University	Japan	2
Portland State University	USA	2
Centre National de la Recherche Scientifique	France	2
Oregon State University	USA	2
King Abdulaziz University	Saudi Arabia	2
URS Corporation	USA	2
J P Singh & Associates	USA	1
Muséum national d'Histoire naturelle	France	1
National Taiwan Ocean University	Taiwan	1
University of Miyazaki	Japan	1

Measured by number of collaborating papers and their identical mNCIs (**Table 7.5.4** and **Table 7.5.5**), NIOT's international collaboration was mainly through a small number of papers that involved multiple institutions.

7.5.3 Top 10 international collaborating institutions by citation impact, NIOT

Table 7.5.4 Top 10 international collaborating institutions by mNCI, NIOT, 1997-2005

International Collaborating Organization	Country	Number of papers	mNCI
Pare Corporation	USA	1	1.00
University of Rhode Island	USA	1	1.00
Technology Planning and Management Corporation	USA	1	1.00
National Institute for Basic Biology - Japan	Japan	1	0.63
University of Utrecht	Netherlands	1	0.63
National Institutes of Natural Sciences (NINS) - Japan	Japan	1	0.63
Portland State University	USA	1	0.46
Oregon State University	USA	1	0.46
Gunma University	Japan	1	0.46
Stanford University	USA	1	0.35

Table 7.5.5 Top 10 international collaborating institutions by mNCI, NIOT, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
University of Toulouse	France	1	4.64
PRES Universite de Toulouse	France	1	4.64
Pierre & Marie Curie University - Paris 6	France	1	4.64
Institut de Recherche pour le Developpement (IRD)	France	1	4.64
University of Paul Sabatier - Toulouse III	France	1	4.64
Muséum national d'Histoire naturelle	France	1	4.64
Centre National de la Recherche Scientifique (CNRS)	France	2	2.95
French Alternative Energies and Atomic Energy Commission	France	1	1.87
University of Versailles Saint-Quentin-En-Yvelines	France	1	1.87
University of Paris-Saclay	France	1	1.87

7.5.4 Top 10 Journals by volume, NIOT

Table 7.5.6 Top 10 journals by volume, NIOT, 1997-2005

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	11
INDIAN JOURNAL OF MARINE SCIENCES	India	5
FISH PHYSIOLOGY AND BIOCHEMISTRY	Netherlands	4
New Zealand JOURNAL OF MARINE AND FRESHWATER RESEARCH	New Zealand	3
JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA	USA	2
MARINE ENVIRONMENTAL RESEARCH	UK	2
INTERNATIONAL BIODETERIORATION & BIODEGRADATION	UK	2
BRAIN RESEARCH BULLETIN	USA	2
BRITISH CORROSION JOURNAL	UK	1
BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY	USA	1
COMPARATIVE BIOCHEMISTRY AND PHYSIOLOGY A-MOLECULAR & INTEGRATIVE PHYSIOLOGY	USA	1
COMPUTERS & STRUCTURES	UK	1

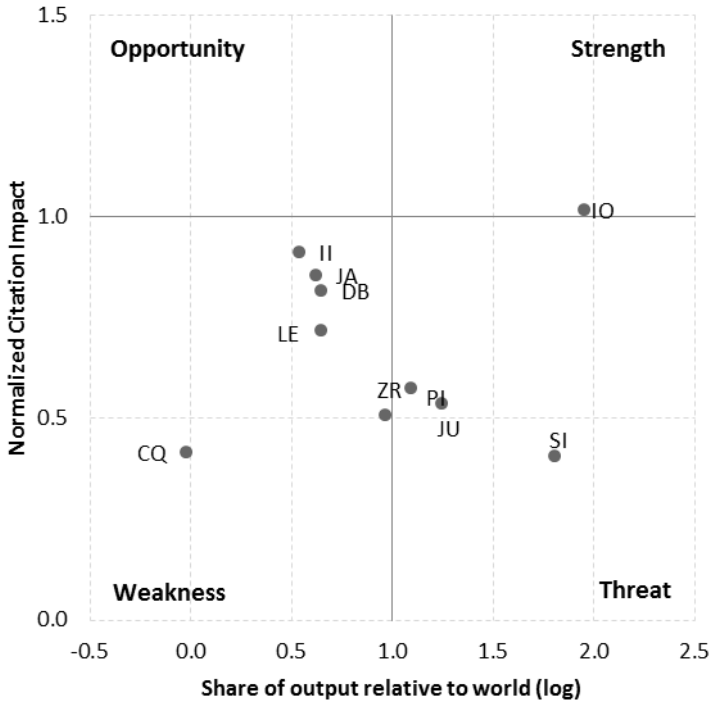
Table 7.5.7 Top 10 journals by volume, NIOT, 2006-2015

Journal	Publishing Country	No. of paper
INDIAN JOURNAL OF GEO-MARINE SCIENCES	India	33
CURRENT SCIENCE	India	16
MARINE TECHNOLOGY SOCIETY JOURNAL	USA	11
COLLOIDS AND SURFACES B-BIOINTERFACES	Netherlands	9
MARINE POLLUTION BULLETIN	UK	6
DESALINATION	Netherlands	5
FLUCTUATION AND NOISE LETTERS	Singapore	4
INTERNATIONAL BIODETERIORATION & BIODEGRADATION	UK	4
APPLIED ACOUSTICS	UK	4
NATURAL HAZARDS	USA	4

NIOT published mostly in several Indian journals – INDIAN JOURNAL OF GEO-MARINE SCIENCES, CURRENT SCIENCE, and INDIAN JOURNAL OF MARINE SCIENCES.

7.5.5 SWOT analysis, NIOT

Figure 7.5.1 SWOT analysis of NIOT research, 1991-2015



NIOT had strength in "Engineering, Ocean" (IO) due to its relatively higher share of papers that were also cited greater than the world average.

The three JSCs, Marine & Freshwater Biology (**PI**), Fisheries (**JU**), and Oceanography (**SI**), were NIOT's threats. The shares of output in these JSCs were very high, however, citation impact in these JSCs were relatively low compared to the world average.

Six JSCs were weaknesses. These are Engineering/Chemical (**II**), Environmental Sciences (**JA**), Biotechnology & Applied Microbiology (**DB**), Geosciences/Multidisciplinary (**LE**), Biochemistry & Molecular Biology (**CQ**), and Water Resources (**ZR**).

No opportunity was identified for NIOT.

7.6 NATIONAL CENTRE FOR EARTH SCIENCE STUDIES (NCESS)

Understanding the earth in its totality, transcending the boundaries of disciplines and gaining knowledge on the interactive and competing processes that shape the earth, from its evolution to the present status of ever increasing demand for natural resources, call for an all encompassing and multidisciplinary approach. Establishment of NCESS in 1978 by Prof. C. Karunakaran was a recognition and realization of this need to study earth's process in its total perspective.

NCESS is a premier institute in India that has strong linkages to researches and studies related to the Earth System. The major two areas are Earth System Dynamics and Earth Science Applications.

Related link: http://www.ncess.gov.in/

7.6.1 Annual research output and citation impact, NCESS

Table 7.6.1 Annual research output and citation impact, NCESS, 1996-2015

Year	Number of Papers	mNCI
1996	22	0.76
1997	8	0.36
1998	18	0.47
1999	12	0.35
2000	13	0.45
2001	3	1.88
2002	4	0.29
2003	3	0.22
2004	5	0.55
2005	11	1.11
2006	14	0.36
2007	15	0.52
2008	21	0.48
2009	12	0.45
2010	15	0.50
2011	15	0.61
2012	13	0.24
2013	18	0.52
2014	19	0.87
2015	13	1.04

Among MoES' institutes, NCESS had a rare prolonged period of decrease in research output; its annual papers between 2001 and 2004 were only a fraction of what it published each year in the 1996-2000 period. Since then, its annual paper count bounced back and maintained at a stable level.

Citation impact, on the other hand, fluctuated in the entire 20-year period. In three years, 2001, 2005 and 2015, NCESS' research was cited greater than world average.

7.6.2 Top 10 international collaborating institutions by research output, NCESS

Table 7.6.2 Top 10 international collaborating institutions by research output, NCESS, 1996-2005

International Collaborating Organization	Country	Number of papers
Osaka City University	Japan	12
Shizuoka University	Japan	4
University of Edinburgh	UK	3
Open University	UK	2
Pontificia Universidad Catolica de Chile	Chile	1
University of Washington	USA	1
National Oceanic Atmospheric Admin	USA	1
Centre National de la Recherche Scientifique	France	1
University of Peradeniya	Sri Lanka	1
University of North Carolina	USA	1

Table 7.6.3 Top 10 international collaborating institutions by research output, NCESS, 2006-2015

International Collaborating Organization	Country	Number of papers
York University	Canada	4
University of Ottawa	Canada	3
China University of Geosciences	China	3
Chinese Academy of Sciences	China	2
Lund University	Sweden	2
University of Glasgow	UK	2
Nordic Center for Earth Evolution	Denmark	1
United Nations University	Netherlands	1
University of Edinburgh	UK	1
National Central University	Taiwan	1

A Japanese institution, Osaka City University, had a very productive collaboration with NCESS between 1996 and 2005. No other institutions co-authored more than four papers with NCESS in all years combined.

7.6.3 Top 10 international collaborating institutions by citation impact, NCESS

Table 7.6.4 Top 10 international collaborating institutions by mNCI, NCESS, 1996-2005

International Collaborating Organization	Country	Number of papers	mNCI
United States Geological Survey	US	1	7.70
Institute Technology of Bandung	Indonesia	1	7.70
National Institute of Advanced Industrial Science & Technology (AIST)	Japan	1	7.70
Pontificia Universidad Catolica de Chile	Chile	1	7.70
National Oceanic Atmospheric Admin (NOAA) - USA	USA	1	7.70
Indonesian Agency for Meteorology, Climatology and Geophysics	Indonesia	1	7.70
University of Washington Seattle	USA	1	7.70
Pontificia Universidad Catolica de Valparaiso	Chile	1	7.70
Universidad de Concepcion	Chile	1	7.70
University of Adelaide	Australia	1	4.26

Table 7.6.5 Top 10 international collaborating institutions by mNCI, NCESS, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
University of Munich	Germany	1	6.48
University of Hong Kong	China	1	6.48
Johannes Gutenberg University of Mainz	Germany	1	6.48
Chinese Academy of Geological Sciences	China	1	6.48
China University of Geosciences	China	3	2.67
Swedish Museum of Natural History	Sweden	1	2.60
University of Edinburgh	UK	1	2.55
Okayama University of Science	Japan	1	2.21
University of Sofia	Bulgaria	1	2.03
Bulgarian Academy of Sciences	Bulgaria	1	2.03

7.6.4 Top 10 Journals by volume, NCESS

Table 7.6.6 Top 10 journals by volume, NCESS, 1996-2005

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	18
JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	India	13
GONDWANA RESEARCH	Netherlands	11
INDIAN JOURNAL OF MARINE SCIENCES	India	8
JOURNAL OF SOUTHEAST ASIAN EARTH SCIENCES	Netherlands	6
ENVIRONMENTAL GEOLOGY	Netherlands	5
TECTONOPHYSICS	Netherlands	4
CHEMIA ANALITYCZNA	Poland	3
GEO-MARINE LETTERS	USA	2
INDIAN JOURNAL OF CHEMISTRY SECTION A-INORGANIC BIO-INORGANIC PHYSICAL THEORETICAL & ANALYTICAL CHEMISTRY	India	2
GEOLOGY	USA	2
PRECAMBRIAN RESEARCH	Netherlands	2
REMOTE SENSING OF ENVIRONMENT	USA	2

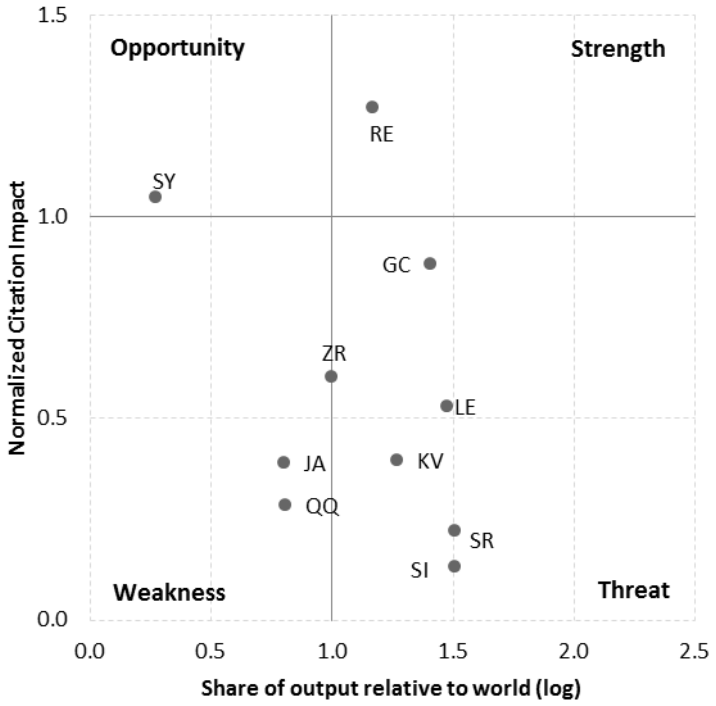
Table 7.6.7 Top 10 journals by volume, NCESS, 2006-2015

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	14
JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	India	14
INDIAN JOURNAL OF GEO-MARINE SCIENCES	India	10
MARINE GEODESY	USA	8
QUATERNARY INTERNATIONAL	UK	6
INDIAN JOURNAL OF MARINE SCIENCES	India	6
ENVIRONMENTAL MONITORING AND ASSESSMENT	Netherlands	6
JOURNAL OF BIOMEDICAL OPTICS	USA	6
ENVIRONMENTAL EARTH SCIENCES	NULL	4
JOURNAL OF COASTAL RESEARCH	USA	4

NCESS published a significant number of papers in Indian journals, such as CURRENT SCIENCE, JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA, and INDIAN JOURNAL OF GEO-MARINE SCIENCES.

7.6.5 SWOT analysis, NCESS

Figure 7.6.1 SWOT analysis of NCESS research, 1996-2015



Mineralogy (RE) is a strength for NCESS; the papers it published in this JSC were cited well above world average (mNCI =1.27) and with high relative share.

NCESS had an opportunity in Optics (**SY**). Research in this area was also cited greater than the world average, though the relative share is small.

Five JSCs were NIOT's threats: Geosciences/Multidisciplinary (**LE**), Remote Sensing (**SR**), Geography, Physical (**KV**), and Oceanography (**SI**), and Geochemistry & Geophysics (**GC**).

Environmental Sciences (**JA**), Meteorology & Atmospheric Sciences (**QQ**), and Water Resources (**ZR**) were weaknesses, though Water Resources JSC lies right between Threat and weakness.

7.7 NATIONAL CENTRE FOR MEDIUM RANGE WEATHER FORECASTING (NCMRWF)

The National Centre for Medium Range Weather Forecasting (NCMRWF) is a Centre of Excellence in Weather and Climate Modelling under the Ministry of Earth Sciences. The mission of the Centre is to continuously develop advanced numerical weather prediction systems, with increased reliability and accuracy over India and neighboring regions through research, development and demonstration of new and novel applications, maintaining highest level of knowledge, skills and technical bases.

Related link: http://www.ncmrwf.gov.in/

7.7.1 Annual research output and citation impact, NCMRWF

Table 7.7.1 Annual research output and citation impact, NCMRWF, 1996-2015

Year	Number of Papers	mNCI
1996	4	0.26
1997	5	0.20
1998	10	0.52
1999	13	0.27
2000	8	0.21
2001	15	0.14
2002	12	0.20
2003	13	0.38
2004	6	0.57
2005	11	0.32
2006	8	0.92
2007	11	0.20
2008	8	0.20
2009	8	0.38
2010	5	0.37
2011	5	0.85
2012	13	0.74
2013	14	0.56
2014	25	0.71
2015	21	0.82

NCMRWF published Web of Science indexed papers in each and every year of the period. However, annual research output of NCMRWF was generally lower than 20, except between 2014 and 2015.

Citation impact of NCMRWF's research papers in most years between 1996 and 2010 were significantly lower than the world average by a large margin. Even though the annual mNCI was still no greater than the world average, a continuous improvement of citation impact can be observed in the last five years.

7.7.2 Top 10 international collaborating institutions by research output, NCMRWF

Table 7.7.2 Top 10 international collaborating institutions by research output, NCMRWF, 1996-2005

International Collaborating Organization	Country	Number of papers
Florida State University	USA	7
National Aeronautics & Space Administration	USA	3
Japan Meteorological Agency	Japan	3
Institute of Numerical Mathematics of the Russian Academy of Sciences	Russia	2
PSL Research University	France	2
Ecole Normale Superieure (ENS) Paris	France	2
Kyoto University	Japan	2
University of Paris-Saclay	France	2
United States Department of Defense	USA	2
Meteorological Research Institute	Japan	2

Table 7.7.3 Top 10 international collaborating institutions by research output, NCMRWF, 2006-2015

International Collaborating Organization	Country	Number of papers
Florida State University	USA	5
King Abdulaziz University	Saudi Arabia	5
SAARC Meteorological Research Centre	Bangladesh	3
Purdue University	USA	3
National Center Atmospheric Research	USA	2
Columbia University	USA	2
International Research Institute for Climate and Society	USA	2
University of Reading	UK	1
University of Tokyo	Japan	1
Department of Hydrology and Meteorology	Nepal	1

Florida State University collectively coauthored 12 papers together with NCMRWF. The five papers from Florida State University-NCMRWF between 2006 and 2015 were also cited above the world average (**Table 7.7.5).**

NCMRWF also had productive partnerships with other USA institutions.

7.7.3 Top 10 international collaborating institutions by citation impact, NCMRWF

Table 7.7.4 Top 10 international collaborating institutions by mNCI, NCMRWF, 1996-2005

International Collaborating Organization	Country	Number of papers	mNCI
Multimedia University	Malaysia	1	2.34
Korea Meteorological Administration	South Korea	1	1.88
University of Nebraska Lincoln	USA	1	0.76
Osaka Electro-Communication University	Japan	1	0.65
Kyoto University	Japan	2	0.58
Florida State University	USA	7	0.46
Massachusetts Institute of Technology (MIT)	USA	1	0.44
National Aeronautics & Space Administration (NASA)	USA	3	0.38
Naval Postgraduate School	USA	1	0.36
Institution of National Meteorology	Spain	1	0.36

Table 7.7.5 Top 10 international collaborating institutions by mNCI, NCMRWF, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
National Centre for Atmospheric Science	UK	1	4.99
University of Exeter	UK	1	4.99
NERC Natural Environment Research Council	UK	1	4.99
University of Reading	UK	1	4.99
Florida State University	USA	5	1.17
Purdue University	USA	3	1.12
International Research Institute for Climate and Society	USA	2	1.09
Japan Agency for Marine-Earth Science & Technology (JAMSTEC)	Japan	1	0.96
University of California Irvine	USA	1	0.94
Korea Meteorological Administration	South Korea	1	0.72

7.7.4 Top 10 Journals by volume, NCMRWF

Table 7.7.6 Top 10 journals by volume, NCMRWF, 1996-2005

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	18
METEOROLOGY AND ATMOSPHERIC PHYSICS	Austria	11
PROCEEDINGS OF THE INDIAN ACADEMY OF SCIENCES-EARTH AND PLANETARY SCIENCES	India	8
WEATHER AND FORECASTING	USA	4
JOURNAL OF THE METEOROLOGICAL SOCIETY OF JAPAN	Japan	4
INTERNATIONAL JOURNAL OF CLIMATOLOGY	UK	4
JOURNAL OF QUANTITATIVE SPECTROSCOPY & RADIATIVE TRANSFER	UK	4
ATMOSFERA	Mexico	4
METEOROLOGICAL APPLICATIONS	UK	4
AGRICULTURAL AND FOREST METEOROLOGY	Netherlands	3
ANNALS OF ARID ZONE	India	3
PURE AND APPLIED GEOPHYSICS	Switzerland	3

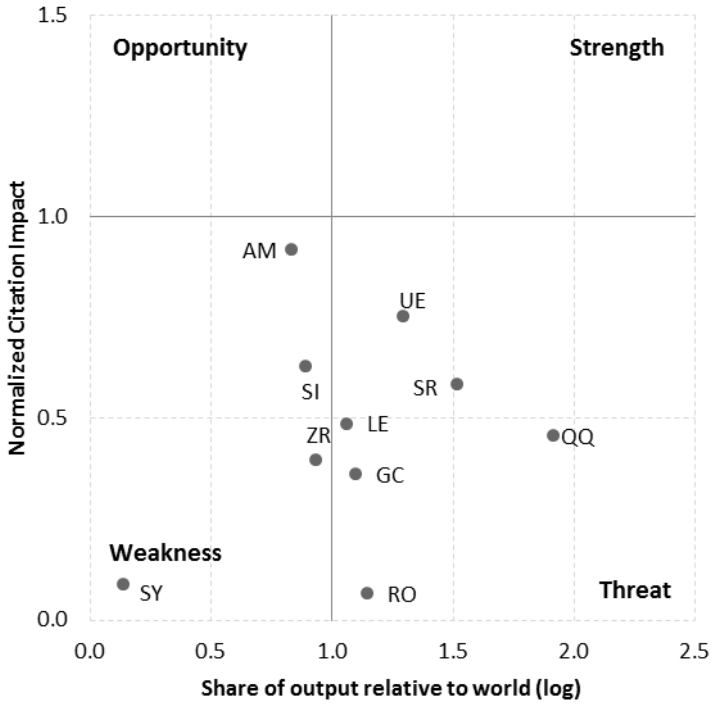
Table 7.7.7 Top 10 journals by volume, NCMRWF, 2006-2015

Journal	Publishing Country	No. of paper
MAUSAM	India	13
JOURNAL OF EARTH SYSTEM SCIENCE	India	12
CURRENT SCIENCE	India	10
PURE AND APPLIED GEOPHYSICS	Switzerland	8
NATURAL HAZARDS	USA	7
METEOROLOGICAL APPLICATIONS	UK	7
INTERNATIONAL JOURNAL OF REMOTE SENSING	UK	7
JOURNAL OF AGROMETEOROLOGY	India	5
INTERNATIONAL JOURNAL OF CLIMATOLOGY	UK	5
THEORETICAL AND APPLIED CLIMATOLOGY	Germany	5

As some of its peers, NCMRWF published the highest number of papers in Indian journals. Among these are MAUSAM (formerly Indian Journal of Meteorology, Hydrology & Geophysics), CURRENT SCIENCE, and JOURNAL OF EARTH SYSTEM SCIENCE (Published by the Indian Academy of Sciences)

7.7.5 SWOT analysis, NCMRWF

Figure 7.7.1 SWOT analysis of NCMRWF research, 1996-2015



In the 10 JSCs presented in the SWOT analysis, NCMRWF did not have strengths or opportunities.

Six JSCs were NCMRWF's threats: Geosciences/Multidisciplinary (**LE**), Remote Sensing (**SR**), Meteorology & Atmospheric Sciences (**QQ**), Multidisciplinary Sciences (**RO**), Imaging Science & Photographic Technology (**UE**), and Geochemistry & Geophysics (**GC**).

Oceanography (**SI**), Optics (**SY**), Water Resources (**ZR**), and Agronomy (**AM**) were weaknesses.

7.8 INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES (INCOIS)

ESSO-INCOIS was established as an autonomous body in 1999 under the Ministry of Earth Sciences (MoES) and is a unit of the Earth System Science Organization (ESSO). ESSO- INCOIS is mandated to provide the best possible ocean information and advisory services to society, industry, government agencies and the scientific community through sustained ocean observations and constant improvements through systematic and focused research.

Related link: http://www.incois.gov.in

7.8.1 Annual research output and citation impact, INCOIS

Table 7.8.1 Annual research output and citation impact, INCOIS, 2002-2015

Year	Number of Papers	mNCI
2002	1	0.03
2004	1	0.55
2005	3	0.25
2006	4	0.48
2007	2	0.71
2008	8	0.41
2009	13	1.12
2010	17	0.86
2011	12	0.87
2012	38	0.93
2013	34	0.87
2014	34	0.81
2015	38	0.62

Even though INCOIS had only a small number of papers produced annually between 2002 and 2007, the pace of its research output accelerated significantly after 2008. It produced a substantial amount of papers between 2012 and 2015.

At the same time, there was also significant improvement in citation impact. Annual mNCI after 2008 was considerable greater than what it was prior to that.

7.8.2 Top 10 international collaborating institutions by research output, INCOIS

Table 7.8.2 Top 10 international collaborating institutions by research output, INCOIS, 2002-2005

International Collaborating Organization	Country	Number of papers
University of Bremen	Germany	1
Fisheries & Oceans Canada	Canada	1

Table 7.8.3 Top 10 international collaborating institutions by research output, INCOIS, 2006-2015

International Collaborating Organization	Country	Number of papers
National Oceanic Atmospheric Admin	USA	13
Institut de Recherche pour le Developpement (IRD)	France	7
Centre National de la Recherche Scientifique	France	6
University of Paul Sabatier - Toulouse III	France	4
Japan Agency for Marine-Earth Science & Technology	Japan	4
University of Toulouse	France	4
PRES Universite de Toulouse	France	4
Muséum national d'Histoire naturelle	France	4
Pierre & Marie Curie University - Paris 6	France	3
Karadeniz Teknik University	Turkey	3

Between 2006 and 2015, INCOIS had several highly productive international collaborators. NOAA IRD, and CNRS each coauthored more than 5 papers. Given INCOIS's relatively small publication portfolio, these papers account for a remarkable share.

7.8.3 Top 10 international collaborating institutions by citation impact, INCOIS

Table 7.8.4 Top 10 international collaborating institutions by mNCI, INCOIS, 2002-2005

International Collaborating Organization	Country	Number of papers	mNCI
Fisheries & Oceans Canada	Canada	1	0.36
University of Bremen	Germany	1	0.30

Table 7.8.5 Top 10 international collaborating institutions by mNCI, INCOIS, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
First Institute of Oceanography	China	1	8.19
Agency for the Assessment and Application of Technology	Indonesia	1	8.19
Woods Hole Oceanographic Institution	USA	1	8.19
University of Tokyo	Japan	1	8.19
University of Tasmania	Australia	1	8.19
Meteorological Research Institute - Japan	Japan	1	4.64
European Centre for Medium-Range Weather Forecasts	UK	1	4.64
Mercator Ocean	France	1	4.64
Nansen Environmental and Remote Sensing Center	Norway	1	4.64
Ist Nazl Geofis & Vulcanol	Italy	1	4.64

The international collaboration of INCOIS, between 2002 and 2005, did not produced highly-cited papers. Citation impact of the collaboration between 2006 and 2015 was very high. However, all 10 institutions in the table were from two papers.

7.8.4 Top 10 Journals by volume, INCOIS

Table 7.8.6 Top 10 journals by volume, INCOIS, 2002-2005

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	1
DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY	USA	1
GEOPHYSICAL RESEARCH LETTERS	USA	1
INDIAN JOURNAL OF MARINE SCIENCES	India	1
PHOTONIRVACHAK-JOURNAL OF THE INDIAN SOCIETY OF REMOTE SENSING	India	1

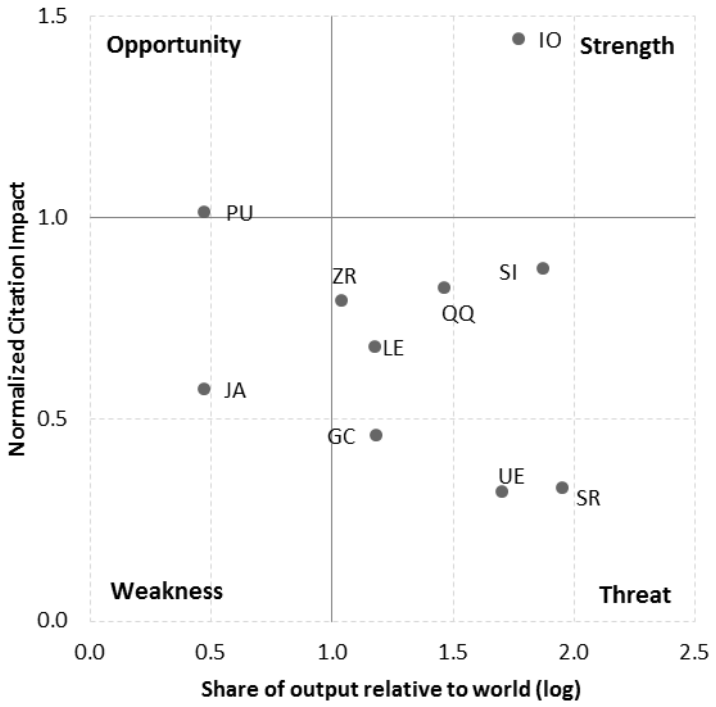
Table 7.8.7 Top 10 journals by volume, INCOIS, 2006-2015

Journal	Publishing Country	No. of paper
CURRENT SCIENCE	India	19
INDIAN JOURNAL OF GEO-MARINE SCIENCES	India	13
JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS	USA	11
NATURAL HAZARDS	USA	11
INTERNATIONAL JOURNAL OF REMOTE SENSING	UK	9
JOURNAL OF EARTH SYSTEM SCIENCE	India	8
MARINE GEODESY	USA	7
NONLINEAR DYNAMICS	USA	5
OCEAN DYNAMICS	Germany	5
REMOTE SENSING LETTERS	UK	5
JOURNAL OF ATMOSPHERIC AND OCEANIC TECHNOLOGY	USA	5
CLIMATE DYNAMICS	USA	5
GEOPHYSICAL RESEARCH LETTERS	USA	5

INCOIS published most frequently in two Indian journals, CURRENT SCIENCE and INDIAN JOURNAL OF GEO-MARINE SCIENCE in both 10-year periods.

7.8.5 SWOT analysis, INCOIS

Figure 7.8.1 SWOT analysis of INCOIS research, 2002-2015



INCOIS's papers (mNCI=1.44) in Engineering, Ocean (**IO**) were cited nearly 1.5 times of the world average. Combined with its relatively higher share of output, this JSC is clearly a strength for INCOIS.

In Mechanics (**PU**), INCOIS's papers (MNCI=1.01) were cited on par with the world average. Given the relatively small share of output, compared to other JSCs of INCOIS's papers, it is identified as an opportunity.

INCOIS had a great deal of JSCs classified as threats: Geosciences/Multidisciplinary (**LE**), Remote Sensing (**SR**), Imaging Science & Photographic Technology (**UE**), Meteorology & Atmospheric Sciences (**QQ**), Water Resources (**ZR**), and Oceanography (**SI**), and Geochemistry & Geophysics (**GC**).

Environmental Sciences (**JA**) is the only weakness area.

Overall, INCOIS scored a strong performance by this SWOT analysis.

7.9 INTEGRATED COASTAL AND MARINE AREA MANAGEMENT (ICMAM)

The Integrated Coastal and Marine Area Management Project Directorate (ICMAM PD), an attached office of Ministry of Earth Sciences (MoES), Government of India, was established at Chennai during Jan.1998 for implementing IDA assisted Environment Management Capacity Building Project. Presently, the Project Directorate is continuing its activities in the field of Coastal Research, fully funded by MoES.

Related link: http://www.icmam.gov.in/;

7.9.1 Annual research output and citation impact, ICMAM

Table 7.9.1 Annual research output and citation impact, ICMAM, 2004-2015

Year	Number of Papers	mNCI
2004	2	0.59
2005	3	0.57
2006	2	0.05
2007	5	0.79
2008	10	0.83
2009	5	0.77
2010	1	0.07
2011	8	0.32
2012	7	0.54
2013	9	0.75
2014	8	0.27
2015	7	0.72

Compared to other institutes, ICMAM had a significantly lower research activity, as measured by number of Web of Science indexed papers published in each year. Between 2004 and 2015, except in 2008, annual paper count was less than 10.

Due to the small number of papers published, citation impact fluctuated significantly. Overall ICMAM papers were cited less often than world average.

7.9.2 Top 10 international collaborating institutions by volume, ICMAM

Table 7.9.2 Top 10 international collaborating institutions by research output, ICMAM, 2006-2015

International Collaborating Organization	Country	Number of papers
University of Ottawa	Canada	3
University of Plymouth	UK	1
Biology Institute of Shandong Academy of Sciences	China	1

7.9.3 Top 10 international collaborating institutions by citation impact, ICMAM

Table 7.9.3 Top 10 international collaborating institutions by mNCI, ICMAM, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
University of Ottawa	Canada	3	0.82
Biology Institute of Shandong Academy of Sciences	China	1	0.30
University of Plymouth	UK	1	0.19

7.9.4 Top 10 Journals by volume, ICMAM

Table 7.9.4 Top 10 journals by volume, ICMAM, 2004-2005

Journal	Publishing Country	No. of paper
SCIENTOMETRICS	Netherlands	2
CURRENT SCIENCE	India	1
ENVIRONMENTAL TOXICOLOGY AND PHARMACOLOGY	Netherlands	1
JOURNAL OF COASTAL RESEARCH	USA	1

Table 7.9.5 Top 10 journals by volume, ICMAM, 2006-2015

Journal	Publishing Country	No. of paper
NATURAL HAZARDS	USA	9
MARINE GEODESY	USA	6
JOURNAL OF COASTAL RESEARCH	USA	6
ESTUARINE COASTAL AND SHELF SCIENCE	UK	5
INDIAN JOURNAL OF GEO-MARINE SCIENCES	India	5
CONTINENTAL SHELF RESEARCH	UK	5
CURRENT SCIENCE	India	3
JOURNAL OF THE INDIAN SOCIETY OF REMOTE SENSING	India	3
JOURNAL OF ENVIRONMENTAL MANAGEMENT	UK	2
JOURNAL OF EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY	Netherlands	1

ICMAM published nine papers in NATURAL HAZARDS, which is a relatively large share considering the overall output. This journal may align closely with the research mission of ICMAM.

7.10 CENTRE FOR MARINE LIVING RESOURCES AND ECOLOGY (CMLRE)

7.10.1 Annual research output and citation impact, CMLRE

Table 7.10.1 Annual research output and citation impact, CMLRE, 2003-2015

Year	Number of Papers	mNCI
2003	1	0.43
2008	2	0.46
2009	3	1.41
2010	1	0.13
2011	4	0.16
2012	9	0.44
2013	5	0.15
2014	7	0.19
2015	14	0.18

CMLRE had relatively low research output, measured by the number of Web of Science index papers published. The most recent four years show an upward trend in research output. However, because of the overall low output, effect of random fluctuation cannot be not entirely ruled out. Citation impact of CMLRE papers was generally well below the world average. The mNCI of year 2009 is likely to be an outlier that was driven by one or a few highly cited papers.

7.10.2 Top 10 international collaborating institutions by research output, CMLRE

Table 7.10.2 Top 10 international collaborating institutions by research output, CMLRE, 2003-2005

International Collaborating Organization	Country	Number of papers
Norwegian Institute of Marine Research	Norway	1
University of Bergen	Norway	1

Table 7.10.3 Top 10 international collaborating institutions by research output, CMLRE, 2006-2015

International Collaborating Organization	Country	Number of papers
Laval University	Canada	1
Pusan National University Hospital	South Korea	1
Laval University	Canada	1
Pusan National University	South Korea	1

7.10.3 Top 10 international collaborating institutions by citation impact, CMLRE

Table 7.10.4 Top 10 international collaborating institutions by mNCI, CMLRE, 2003-2005

International Collaborating Organization	Country	Number of papers	mNCI
Norwegian Institute of Marine Research	Norway	1	0.43
University of Bergen	Norway	1	0.43

Table 7.10.5 Top 10 international collaborating institutions by mNCI, CMLRE, 2006-2015

International Collaborating Organization	Country	Number of papers	mNCI
Pusan National University Hospital	South Korea	1	0.00
Laval University	Canada	1	0.00
Pusan National University	South Korea	1	0.00

Norway, Canada, and South Korea institutions coauthored all CMLRE's internationally collaborative papers.

7.10.4 Top 10 Journals by volume, CMLRE

Table 7.10.6 Top 1 journals by volume, CMLRE, 2003-2005

Journal	Publishing Country	No. of paper
FISHERIES RESEARCH	Netherlands	1

Table 7.10.7 Top 10 journals by volume, CMLRE, 2006-2015

Journal	Publishing Country	No. of paper
ENVIRONMENTAL MONITORING AND ASSESSMENT	Netherlands	7
INDIAN JOURNAL OF GEO-MARINE SCIENCES	India	6
INTERNATIONAL JOURNAL OF REMOTE SENSING	UK	2
MARINE BIOLOGY RESEARCH	Norway	2
OCEANOLOGIA	Poland	2
OCEANOLOGICAL AND HYDROBIOLOGICAL STUDIES	Poland	2
INDIAN JOURNAL OF FISHERIES	India	2
DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY	USA	2
AQUACULTURE	Netherlands	2
PROBIOTICS AND ANTIMICROBIAL PROTEINS	USA	2
ZOOTAXA	New Zealand	2

ENVIRONMENTAL MONITORING AND ASSESSMENT and INDIAN JOURNAL OF GEO-MARINE SCIENCES together published a significant share of CMLRE's papers. It is worth mentioning that CMLRE published a relatively large portion of papers on marine biology and aquaculture.

APPENDIX A BIBLIOMETRICS AND CITATION ANALYSIS

Bibliometrics are about publications and their citations. The academic field emerged from 'information science' and now usually refers to the methods used to study and index texts and information.

Publications cite other publications. These citation links grow into networks, and their numbers are likely to be related to the significance or impact of the publication. The meaning of the publication is determined from keywords and content. Citation analysis and content analysis have therefore become a common part of bibliometric methodology. Historically, bibliometric methods were used to trace relationships amongst academic journal citations. Now, bibliometrics are important in indexing research performance.

Bibliometric data have particular characteristics of which the user should be aware, and these are considered here.

Journal papers (publications, sources) report research work. Papers refer to or 'cite' earlier work relevant to the material being reported. New papers are cited in their turn. Papers that accumulate more citations are thought of as having greater 'impact', which is interpreted as significance or influence on their field. Citation counts are therefore recognized as a measure of impact, which can be used to index the excellence of the research from a particular group, institution or country.

The origins of citation analysis as a tool that could be applied to research performance can be traced to the mid-1950s, when Eugene Garfield proposed the concept of citation indexing and introduced the Science Citation Index, the Social Sciences Citation Index and the Arts & Humanities Citation Index, produced by the Institute of Scientific Information (currently the IP & Science business of Thomson Reuters).

We can count citations, but they are only 'indicators' of impact or quality – not metrics. Most impact indicators use average citation counts from groups of papers, because some individual papers may have unusual or misleading citation profiles. These outliers are diluted in larger samples.

A.1 DATA SOURCE

The data used in this report came from the Clarivate Analytics Web of Science databases which give access not only to journals but also to conference proceedings, books, patents, websites, and chemical structures, compounds and reactions. Web of Science has a unified structure that integrates all data and search terms together and therefore provides a level of comparability not found in other databases. It is widely acknowledged to be the world's leading source of citation and bibliometric data. The Web of Science focuses on research published in journals, conferences and books in science, medicine, arts, humanities and social sciences.

The Web of Science was originally created as an awareness and information retrieval tool but it has acquired an important primary use as a tool for research evaluation, using citation analysis and bibliometrics. Data coverage is both current and retrospective in the sciences, social sciences, arts and humanities, in some cases back to 1900. Within the research community this data source was previously referred to by the acronym 'ISI'.

Unlike other databases, the Web of Science and underlying databases are selective, that is: the journals abstracted are selected using rigorous editorial and quality criteria. The authoritative, multidisciplinary content covers over 12,000 of the highest impact journals worldwide, including Open Access journals, and over 150,000 conference proceedings. The abstracted journals encompass the majority of significant, frequently cited scientific reports and, more importantly, an even greater proportion of the scientific research output which is cited. This selective process ensures that the citation counts remain relatively stable in given research fields and do not fluctuate unduly from year to year, which increases the Usability of such data for performance evaluation.

Clarivate Analytics has extensive experience with databases on research inputs, activities and outputs and has developed innovative analytical approaches for benchmarking and interpreting international, national and institutional research impact.

A.2 DATABASE CATEGORIES

The source data can be grouped in various classification systems. Most of these are based on groups of journals that have a relatively high cross-citation linkage and naturally cluster together. Custom classifications use subject maps in third-party data such as the OECD categories set out in the Frascati manual.

Clarivate Analytics frequently uses the broader field categories in the Essential Science Indicators system and the finer journal categories in the Web of Science. There are 22 fields in Essential Science Indicators and 254 fields in Web of Science. In either case, our bibliometric analyses draw on the full range of data available in the underlying database, so analyses in our reports will differ slightly from anything created 'on the fly' from data in the web interface.

Most analyses start with an overall view across the data, then move to a view across broad categories and only then focus in at a finer level in the areas of greatest interest to policy, program or institutional purpose.

A.3 ASSIGNING PAPERS TO ADDRESSES

A paper is assigned to each country and each institution whose address appears at least once for any author on that paper. One paper counts once and only once for each assignment, however many address variants may occur for the country or institution. No weighting is applied.

For example, a paper has five authors, thus:

Author	Institution	Country		
Gurney, KA	Univ Leeds	UK	Counts for Univ Leeds	Counts for UK
Adams, J	Univ Leeds	UK	No gain for Univ Leeds	No gain for UK
Kochalko, D	Univ C San Diego	USA	Counts for UCSD	Counts for USA
Munshi, S	Gujarat Univ	India	Counts for Gujarat Univ	Counts for India
Pendlebury, D	Univ Oregon	USA	Counts for Univ Oregon	No gain for USA

So this one paper with five authors would be included once in the tallies for each of four universities and once in the tallies for each of three countries.

Work carried out within Clarivate Analytics, and research published elsewhere, indicates that fractional weighting based on the balance of authors by institution and country makes little difference to the conclusions of an analysis at an aggregate level. Such fractional analysis can introduce unforeseen errors in the attempt to create a detailed but uncertain assignment. Partitioning credit would make a greater difference at a detailed, group level but the analysis can then be manually validated.

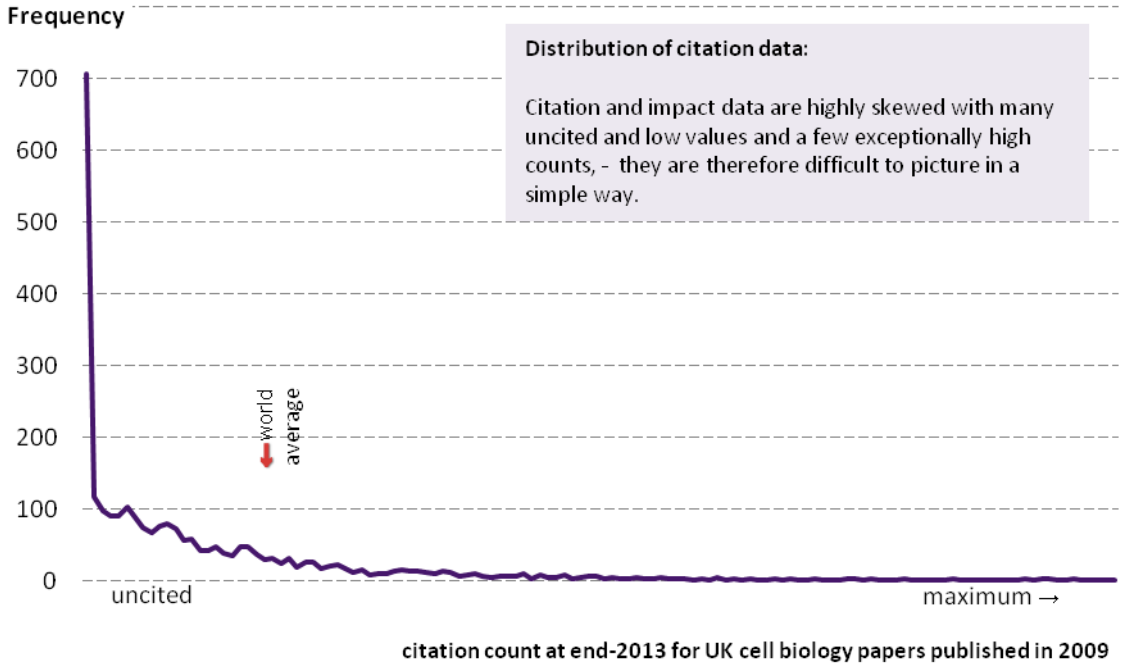
A.4 CITATION COUNTS

A publication accumulates citation counts when it is referred to by more recent publications. Some papers get cited frequently and many get cited rarely or never, so the distribution of citations is highly skewed.

Why are many papers never cited? Certainly some papers remain uncited because their content is of little or no impact, but that is not the only reason. It might be because they have been published in a journal not read by researchers to whom the paper might be interesting. It might be that they represent important but 'negative' work reporting a blind alley to be avoided by others. The publication may be a commentary in an editorial, rather than a normal journal article and thus of general rather than research interest, or it might be that the work is a 'sleeping beauty' that has yet to be recognized for its significance.

Other papers can be very highly cited: hundreds, even thousands of times. Again, there are multiple reasons for this. Most frequently cited work is being recognized for its innovative significance and impact on the research field of which it speaks. Impact here is a good reflection of quality: it is an indicator of excellence. But there are other papers which are frequently cited because their significance is slightly different: they describe key methodology; they are a thoughtful and wide-ranging review of a field; or they represent contentious views which others seek to refute.

Citation analysis cannot make value judgments about why an article is uncited nor about why it is highly cited. The analysis can only report the citation impact that the publication has achieved. We normally assume, based on many other studies linking bibliometric and peer judgments, high citation counts correlate on average with the quality of the research.



The figure shows the skewed distribution of more or less frequently cited papers from a sample of UK authored publications in cell biology. The skew in the distribution varies from field to field. It is to compensate for such factors that actual citation counts must be normalized, or rebased, against a world baseline.

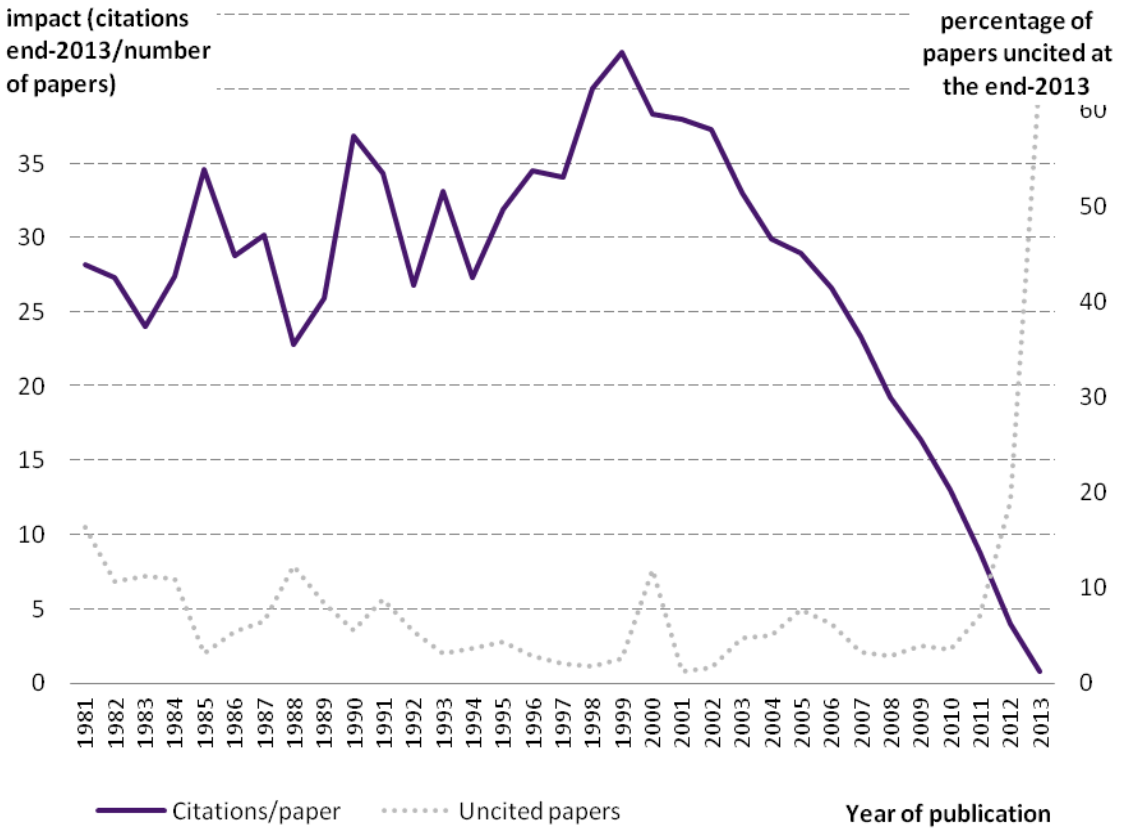
We do not seek to account separately for the effect of self-citation. If the citation count is significantly affected by self-citation then the paper is likely to have been infrequently cited. This is therefore only of consequence for low impact activity. Studies show that for large samples at national and institutional level, the effect of self-citation has little or no effect on the analytical outcomes and would not alter interpretation of the results.

A.5 TIME FACTORS

Citations accumulate over time. Older papers therefore have, on average, more citations than more recent work. The graph below shows the pattern of citation accumulation for a set of 33 journals in the journal category ***Materials Science, Biomaterials***. Papers less than eight years old are, on average, still accumulating additional citations. The citation count goes on to reach a plateau for older sources.

The graph shows that the percentage of papers that have never been cited drops over about five years. Beyond five years, between 5% and 10% or more of papers remain uncited.

Account must be taken of these time factors in comparing current research with historical patterns. For these reasons, it is sometimes more appropriate to use a fixed five-year window of papers and citations to compare two periods than to look at the longer term profile of citations and of uncitedness for a recent year and an historical year.



A.6 DISCIPLINE FACTORS

Citation rates vary between disciplines and fields. For the UK science base as a whole, 10 years produces a general plateau beyond which few additional citations would be expected. On the whole, citations accumulate more rapidly and plateau at a higher level in biological sciences than physical sciences, and natural sciences generally cite at a higher rate than social sciences.

Papers are assigned to disciplines (journal categories or research fields) by Clarivate Analytics, bringing cognate research areas together. Before 2007, journals were assigned to the older, well established Current Contents categories which were informed by extensive work by Thomson and with the research community since the early 1960s. This scheme has been superseded by the 252 Web of Science journal categories which allow for greater disaggregation for the growing volume of research which is published and abstracted.

Papers are allocated according to the journal in which the paper is published. Some journals may be considered to be part of the publication record for more than one research field. As the example below illustrates, the journal Acta Biomaterialia is assigned to two journal categories: ***Materials Science, Biomaterials and Engineering, Biomedical***.

Very few papers are not assigned to any research field and as such will not be included in specific analyses using normalized citation impact data. The journals included in the Clarivate Analytics databases and how they are selected are detailed here http://scientific.thomsonreuters.com/mjl/.

Some journals with a very diverse content, including the prestigious journals Nature and Science were classified as ***Multidisciplinary*** in databases created prior to 2007. The papers from these ***Multidisciplinary*** journals are now re-assigned to more specific research fields using an algorithm based on the research area(s) of the references cited by the article.

A.7 NORMALIZED CITATION IMPACT

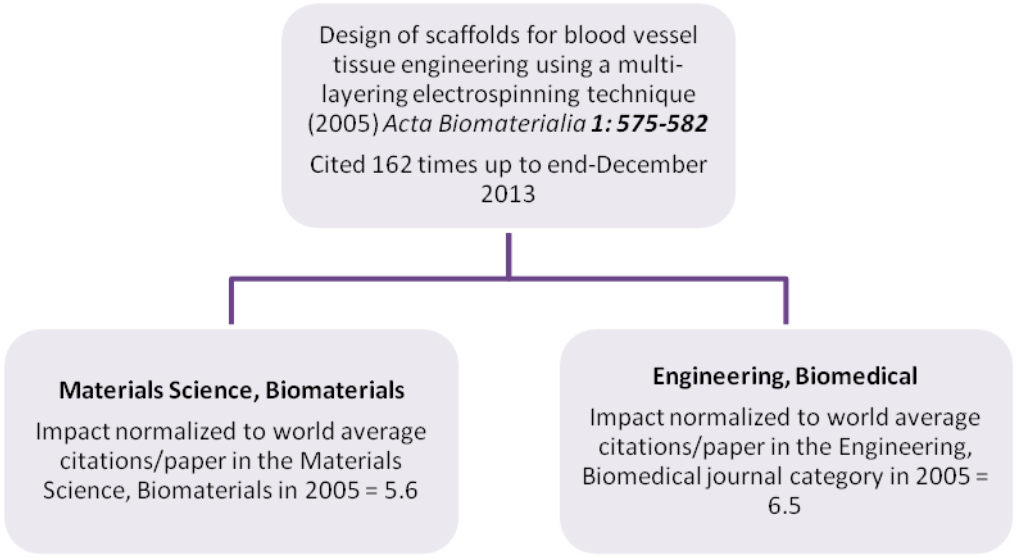
A publication accumulates citation counts when it is referred to by more recent publications. We normally assume, based on many other studies linking bibliometric and peer judgments, high citation counts correlate on average with the quality of the research. Because citations accumulate over time at a rate that is dependent upon the field of research, all analyses must take both field and year into account. In other words, because the absolute citation count for a specific article is influenced by its field and by the year it was published, we can only make comparisons of indexed data after normalizing with reference to these two variables.

We only use citation counts for reviews and articles in calculations of impact, because document type influences the citation count. For example, a review will often be cited more frequently than an article in the same field, but editorials and meeting abstracts are rarely cited and citation rates for conference proceedings are extremely variable. The most common normalization factors are the average citations per paper for (1) the year and (2) either the field or the journal in which the paper was published. This normalization is also referred to as 'rebasing' the citation count.

In the normalization process, only citation counts of papers are used in calculations of citation impact. The standard normalization factor is the world average citations per paper for the year and journal subject category (JSC) in which the paper was published. NCI is calculated in the following formula:

$$Citation\ count\ of\ a\ paper \Big/ Average\ citation\ count\ per\ papers\ for\ all\ papers\ that\ were\ published\ in\ the\ same\ year\ and\ same\ JSC$$

Impact is therefore most commonly analyzed in terms of 'normalized citation impact', or nci. The following schematic illustrates how the normalized citation impact is calculated at the paper level and journal category level.



This article in the journal Acta Biomaterialia is assigned to two journal categories: ***Materials Science, Biomaterials and Engineering, Biomedical***. The world average baselines for, as an example, ***Materials science, Biomaterials*** are calculated by summing the citations to all the articles and reviews published worldwide in the journal Acta Biomaterialia and the other 32 journals assigned to this category for each year, and dividing this by the total number of articles and reviews published in the journal category. This gives the category-specific normalized citation impact (in the above example the category-specific nci_F for ***Materials Science, Biomaterials*** is 5.6 and the category-specific nciF for Engineering, Biomedical is higher at 6.5). Most papers (nearly two-thirds) are assigned to a single journal category while a minority of them are assigned to more than five.

The average (normalized) citation impact can be calculated at an individual paper level where it can be associated with more than one journal category. It can also be calculated for a set of papers at any level from a single country to an individual researcher's output. In the example above, the average citation impact of the Acta Biomaterialia paper can be expressed as ((5.6 + 6.5)/2) = 6.1.

World average impact data are sourced from the Clarivate Analytics National Science Indicators baseline data for 2015.

A.8 MEAN NORMALIZED CITATION IMPACT

Research performance has historically been indexed by using average citation impact, usually compared to a world average that accounts for time and discipline. As noted, however, the distribution of citations amongst papers is highly skewed because many papers are never cited while a few papers accumulate very large citation counts. That means that an average may be misleading if assumptions are made about the distribution of the underlying data.

In fact, almost all research activity metrics are skewed: for research income, PhD numbers and publications there are many low activity values and a few exceptionally high values. In reality, therefore, the skewed distribution means that average impact tends to be greater than and often significantly different from either the median or mode in the distribution. This should be borne in mind when reviewing analytical outcomes.

A.9 WHAT ARE UNCITED PAPERS?

It may be a surprise that some journal papers are never subsequently cited after publication, even by their authors. This accounts for about half the total global output for a typical, recent 10-year period. We cannot tell why papers are not cited. It is likely that a significant proportion of papers remain uncited because they are reporting negative results which are an essential matter of record in their field but make the content less likely to be referenced in other papers. Inevitably, other papers are uncited because their content is trivial or marginal to the mainstream. However, it should not be assumed that this is the case for all such papers.

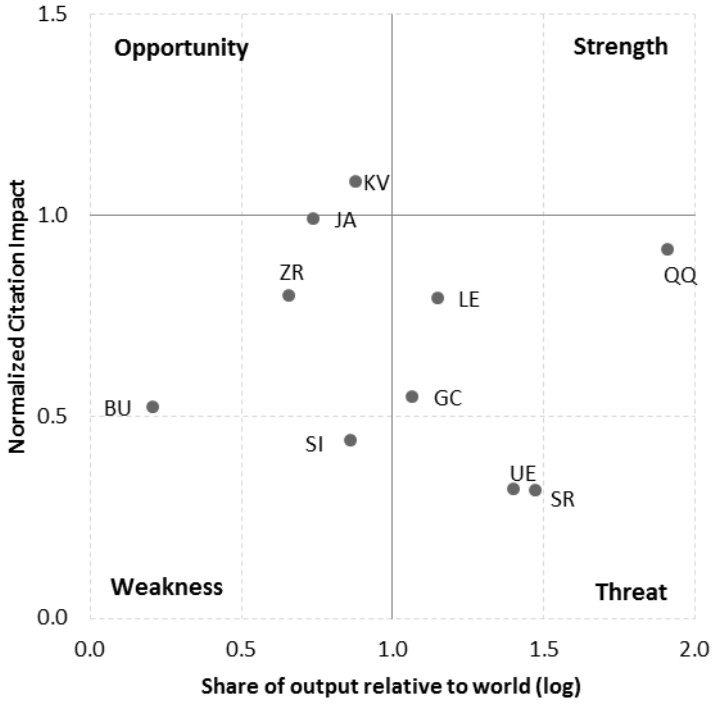
There is variation in non-citation between countries and between fields. For example, relatively more engineering papers tend to remain uncited than papers in other sciences, indicative of a disciplinary factor but not a quality factor. While there is also an obvious increase in the likelihood of citation over time, most papers that are going to be cited within a few years of publication.

A.10 WHAT IS THE THRESHOLD FOR "HIGHLY CITED"?

Clarivate Analytics has traditionally used the term "Highly Cited Paper" to refer to the world's 1% of most frequently cited papers, taking into account year of publication and field. After reviewing the outcomes of a number of analyses, we have chosen a more relaxed definition for our descriptive and analytical work. We deem papers that are in the world's top 10% of most frequently cited papers, taking into account year of publication and field, to be relatively highly cited for national comparisons.

A.11 SWOT ANALYSIS OF MOES INSTITUTE

Figure 7.10.1 SWOT Analysis of MoES institute, IITM



SWOT analysis of MoES institute is different from that of a subject area; the y axis, the share of output relative to world, is log transformed. That is because each of MoES institutes is highly specialized in a few highly related sub-disciplines. For instance, of the 1,248 papers published by IITM, 809, or 64.8%, of them are in Meteorology & Atmospheric Sciences JSC. As a comparison, only 0.8% of worldwide research is in this JSC. The relative output to the world, therefore, is 81. It would be difficult plot that number in chart. Thus, a log transformation is necessary.

The definition of strength, weakness, opportunity and threat is:

- **Strength:** subject areas of high citation impact (NCI>1) and large share of research output relative to world (log(share of output to world)>1).
- **Weakness:** subject areas of high citation impact (NCI<1) and large share of research output relative to world (log(share of output to world)<1).
- **Opportunity:** subject areas of high citation impact (NCI>1) and large share of research output relative to world (log(share of output to world)<1).
- **Threat:** subject areas of high citation impact (NCI<1) and large share of research output relative to world (log(share of output to world)>1).

A.12 DATA QUALITY CHECK ON MOES INSTITUTION PAPERS

Clarivate Analytics queried Web of Science to retrieve papers published by MoES Institutes and conducted quality check procedures to ensure the search result was sufficiently complete.

In order to examine the quality of papers retrieved, annual reports of MoES institutes were downloaded from MoES' website[9]. Most of the annual reports contain publications these institutes published during a calendar or fiscal year. These publication records from the MoES institute were used as a "Gold standard" in quality check. We randomly selected four annual publication records from four institute[10]s, one record for each, and manually matched search result with these records.

The result of the QC was summarized here:

- Overall, by their annual reports, 142 Web of Science indexed journal articles and reviews were published by these four institutes. The Clarivate Analytics dataset contains 139 of these papers. This proved that the dataset used in institute evaluation had sufficiently good quality.
- In the Web of Science index records, author addresses of the three missing papers were uncommon abbreviations of the institute names. Search strings of the institutes did not include these specific abbreviations. As a result, the three papers were not retrieved.
- In general, each institute in its annual reports had publications that were not used in the analysis of this report for the following reasons;
    - The journals of these publications were not indexed by Web of Science. For instance, the journal Mausam, was not indexed in Web of Science until 2007.
    - Publications were conference proceedings, editorials, letters or other document types that were, even though Web of Science indexed, excluded from analysis.
    - There was author affiliation error. For instance, a paper that was listed by NCMRWF as one of the institute's papers had all authors affiliated with IITM only. In another example, author address of a paper listed in INCOIS annual report had only Indian Institute of Technology address.

[9] http://www.moes.gov.in/content/annual-reports-autonomous-institutes-moes-1. Institutes, NIOT, NCESS, NCAOR, INCOIS, and IITM all have annual reports available. NCMRWF, has publications listed on its web site, http://www.ncmrwf.gov.in/NCMRWF-Publication_04Sep.php

[10] The four publication records were IITM (2008-2009), INCOIS (2013-2014), NCMRWF (2003) and NCAOR (2011-2012)

A.13 TOP 30 COUNTRIES BY RESEARCH OUTPUT

Top 30 countries by research output, Geo Research, 1996-2005

Time frame	Country	No. of Papers
1996-2005	USA	65,805
	UK	25,565
	France	16,478
	Germany	15,686
	Canada	15,305
	Russia	14,826
	Japan	11,086
	China	10,811
	Australia	10,273
	Italy	9,219
	India	5,711
	Netherlands	5,088
	Spain	4,870
	Switzerland	4,681
	Sweden	3,579
	Norway	3,450
	New Zealand	2,715
	South Africa	2,570
	Denmark	2,415
	Brazil	2,301
	Belgium	2,064
	Taiwan	1,939
	Turkey	1,905
	Austria	1,884
	Mexico	1,634
	Greece	1,615
	Israel	1,574
	Poland	1,569
	Finland	1,539
	South Korea	1,460

Top 30 countries by research output, Geo Research, 2006-2015

Time frame	Country	No. of Papers
2006-2015	USA	95,517
	China	48,657
	UK	39,524
	Germany	30,090
	France	27,092
	Canada	22,750
	Italy	20,578
	Australia	20,558
	Russia	17,232
	Japan	16,487
	Spain	14,347
	India	11,604
	Switzerland	10,193
	Netherlands	9,630
	Norway	7,215
	Sweden	6,811
	Brazil	6,710
	Poland	5,610
	Turkey	5,474
	New Zealand	5,136
	Belgium	4,761
	Taiwan	4,711
	South Korea	4,695
	Iran	4,613
	Austria	4,588
	South Africa	4,552
	Denmark	4,536
	Czech Republic	3,699
	Greece	3,479
	Mexico	3,452

Top 30 countries by research output, Atmospheric Research, 1996-2005

Time frame	Country	No. of Papers
1996-2005	USA	27,415
	Germany	6,553
	UK	6,188
	Japan	4,103
	France	4,072
	Canada	3,574
	Russia	3,242
	Italy	2,321
	China	2,314
	Australia	2,230
	Netherlands	1,785
	Sweden	1,534
	India	1,457
	Switzerland	1,246
	Spain	1,208
	Finland	1,154
	Taiwan	997
	Brazil	891
	Norway	809
	Greece	777
	Austria	774
	South Korea	751
	Denmark	698
	Belgium	654
	Israel	550
	Poland	526
	New Zealand	518
	South Africa	435
	Mexico	404
	Czech Republic	400

Top 30 countries by research output, Atmospheric Research, 206-2015

Time frame	Country	No. of Papers
2006-2015	USA	39,972
	China	14,198
	UK	10,652
	Germany	10,594
	France	7,414
	Japan	6,361
	Canada	5,889
	Italy	5,020
	India	4,955
	Australia	4,201
	Russia	3,971
	Spain	3,734
	Switzerland	3,273
	Netherlands	3,119
	South Korea	2,835
	Sweden	2,471
	Finland	2,235
	Taiwan	2,180
	Norway	2,069
	Brazil	1,790
	Austria	1,597
	Greece	1,496
	Belgium	1,474
	Denmark	1,134
	South Africa	911
	Poland	864
	Portugal	856
	New Zealand	833
	Israel	783
	Czech Republic	734

Top 30 countries by research output, Ocean Research, 1996-2005

Time frame	Country	No. of Papers
1996-2005	USA	28,548
	UK	9,431
	Canada	6,989
	Germany	6,225
	France	6,002
	Australia	5,622
	Japan	4,648
	Spain	4,382
	Russia	3,399
	Italy	3,080
	Norway	2,860
	Netherlands	2,578
	China	2,075
	Sweden	2,030
	Denmark	2,027
	New Zealand	1,969
	Mexico	1,749
	India	1,574
	Belgium	1,411
	Brazil	1,410
	South Africa	1,174
	Taiwan	1,174
	Portugal	1,132
	Finland	999
	South Korea	914
	Argentina	834
	Greece	823
	Chile	814
	Israel	764
	Switzerland	707

Top 30 countries by research output, Ocean Research, 2006-2015

Time frame	Country	No. of Papers
2006-2015	USA	38,199
	China	13,245
	UK	11,553
	Australia	10,028
	Canada	9,282
	France	8,837
	Germany	8,589
	Spain	8,406
	Japan	6,741
	Italy	5,430
	Norway	4,686
	Brazil	4,496
	Russia	4,326
	Portugal	3,632
	India	3,510
	Netherlands	3,358
	Mexico	2,972
	Taiwan	2,886
	South Korea	2,830
	New Zealand	2,754
	Denmark	2,673
	Sweden	2,590
	Chile	2,364
	Belgium	2,223
	South Africa	1,995
	Turkey	1,899
	Argentina	1,895
	Poland	1,786
	Greece	1,391
	Finland	1,261

Top 30 countries by research output, Antarctic Research, 1996-2005

Time frame	Country	No. of Papers
1996-2005	USA	1,973
	UK	1,235
	Australia	887
	Germany	841
	Italy	758
	France	474
	Japan	346
	Spain	331
	New Zealand	308
	Argentina	239
	Russia	230
	Netherlands	224
	Canada	172
	Belgium	163
	China	142
	South Africa	140
	India	137
	Sweden	134
	Poland	102
	Norway	98
	Denmark	84
	Chile	83
	Brazil	79
	Switzerland	75
	South Korea	74
	Finland	61
	Austria	57
	Czech Republic	23
	Greece	15
	Hungary	14

Top 30 countries by research output, Antarctic Research, 2006-2015

Time frame	Country	No. of Papers
2006-2015	USA	2,905
	UK	1,744
	Australia	1,116
	Germany	1,051
	Italy	888
	France	701
	New Zealand	695
	China	598
	Japan	519
	Spain	519
	Argentina	388
	Canada	353
	South Korea	314
	Brazil	300
	Belgium	290
	India	279
	Russia	278
	Netherlands	275
	Norway	259
	Chile	253
	Sweden	232
	Poland	224
	South Africa	201
	Switzerland	141
	Denmark	133
	Finland	93
	Czech Republic	77
	Austria	71
	Malaysia	70
	Bulgaria	68

Top 30 countries by research output, Arctic Research, 1996-2005

Time frame	Country	No. of Papers
1996-2005	USA	1,959
	Canada	1,291
	Norway	1,030
	Germany	755
	UK	650
	Russia	581
	Sweden	455
	Denmark	305
	FINLAND	220
	Japan	198
	France	171
	Netherlands	126
	Poland	95
	Italy	76
	Switzerland	65
	Australia	60
	China	58
	Iceland	57
	Belgium	51
	Austria	49
	Spain	37
	New Zealand	30
	Ireland	21
	Chile	19
	Greenland	17
	Estonia	16
	South Korea	13
	Czech Republic	12
	Greece	9
	Mexico	9

Top 30 countries by research output, Arctic Research, 2006-2015

Time frame	Country	No. of Papers
2006-2015	USA	3,341
	Canada	2,518
	Norway	1,939
	Germany	1,221
	UK	1,209
	Russia	895
	Sweden	854
	Denmark	625
	France	477
	China	465
	Finland	401
	Poland	374
	Japan	344
	Netherlands	315
	Switzerland	201
	Australia	193
	South Korea	184
	Spain	182
	Chile	156
	Italy	146
	Greenland	140
	Belgium	128
	Iceland	125
	Austria	117
	India	65
	Czech Republic	63
	New Zealand	55
	Estonia	45
	Ireland	44
	South Africa	30

Top 30 countries by research output, Himalayas Research, 1996-2005

Time frame	Country	No. of Papers
1996-2005	India	984
	USA	321
	UK	164
	France	95
	Germany	90
	China	88
	Nepal	85
	Japan	60
	Canada	57
	Switzerland	55
	Italy	39
	Austria	25
	Pakistan	23
	Australia	22
	Norway	21
	New Zealand	17
	Netherlands	13
	Russia	13
	Belgium	9
	Spain	7
	Sweden	7
	Taiwan	6
	Denmark	6
	Ireland	5
	Bhutan	5
	South Korea	5
	Finland	4
	Mexico	3
	South Africa	3
	Poland	3

Top 30 countries by research output, Himalayas Research, 2006-2015

Time frame	Country	No. of Papers
2006-2015	India	2,809
	USA	614
	China	452
	UK	250
	Nepal	214
	Germany	202
	France	192
	Pakistan	171
	Canada	126
	Japan	124
	Italy	109
	Australia	96
	Switzerland	92
	Netherlands	70
	Norway	65
	Austria	46
	South Korea	43
	Czech Republic	37
	Russia	34
	Sweden	33
	Bhutan	24
	New Zealand	20
	Finland	20
	South Africa	19
	Taiwan	18
	Denmark	17
	Saudi Arabia	16
	Spain	15
	Singapore	14
	Iran	13

A.14 TOP 30 COUNTRIES BY CITATION IMPACT

Top 30 countries by citation impact (Number of Papers >=50), Geo Research, 1996-2005

Time frame	Country	mnci	No. of Papers	Ranking
1996-2005	Iceland	1.65	425	1
	Switzerland	1.62	4,681	2
	USA	1.54	65,805	3
	Netherlands	1.50	5,088	4
	Denmark	1.47	2,415	5
	Mongolia	1.46	80	6
	Germany	1.44	15,686	7
	Belgium	1.41	2,064	8
	Australia	1.40	10,273	9
	Sweden	1.39	3,579	10
	Norway	1.39	3,450	11
	UK	1.39	25,565	12
	France	1.37	16,478	13
	Vietnam	1.26	128	14
	Hong Kong	1.23	182	15
	Italy	1.23	9,219	16
	Finland	1.23	1,539	17
	Brunei	1.23	56	18
	Canada	1.20	15,305	19
	Nepal	1.19	107	20
	Spain	1.18	4,870	21
	Singapore	1.18	566	22
	Israel	1.16	1,574	23
	Sri Lanka	1.15	60	24
	Ethiopia	1.15	137	25
	Portugal	1.11	685	26
	New Zealand	1.10	2,715	27
	Chile	1.09	759	28
	Austria	1.09	1,884	29
	Estonia	1.09	251	30

Top 30 countries by citation impact (Number of Papers >=50), Geo Research, 2006-2015

Time frame	Country	mnci	No. of Papers	Ranking
2006-2015	Bermuda	2.17	77	1
	Panama	2.15	194	2
	Bolivia	2.09	157	3
	Switzerland	1.81	10,193	4
	Netherlands	1.69	9,630	5
	UK	1.61	39,524	6
	USA	1.59	95,517	7
	Denmark	1.59	4,536	8
	Laos	1.57	68	9
	Peru	1.57	407	10
	Nepal	1.53	255	11
	Australia	1.52	20,558	12
	France	1.50	27,092	13
	Germany	1.49	30,090	14
	Monaco	1.48	54	15
	Norway	1.45	7,215	16
	Singapore	1.44	1,305	17
	Luxembourg	1.44	276	18
	Iceland	1.44	958	19
	Sweden	1.42	6,811	20
	Ecuador	1.41	284	21
	Greenland	1.41	80	22
	Belgium	1.40	4,761	23
	Austria	1.33	4,588	24
	Italy	1.30	20,578	25
	Kenya	1.29	280	26
	New Zealand	1.29	5,136	27
	French Polynesia	1.28	54	28
	Niger	1.26	65	29
	Canada	1.25	22,750	30

Top 30 countries by citation impact (Number of Papers >=50), Atmospheric Research, 1996-2005

Time frame	Country	mnci	No. of Papers	Ranking
1996-2005	Switzerland	1.77	1,246	1
	Iceland	1.71	51	2
	USA	1.70	27,415	3
	UK	1.48	6,188	4
	Belgium	1.47	654	5
	Finland	1.45	1,154	6
	Kenya	1.42	55	7
	Germany	1.36	6,553	8
	Portugal	1.33	214	9
	Netherlands	1.33	1,785	10
	Hong Kong	1.32	73	11
	France	1.32	4,072	12
	Canada	1.30	3,574	13
	Indonesia	1.27	59	14
	Sweden	1.22	1,534	15
	Australia	1.20	2,230	16
	Israel	1.17	550	17
	Ireland	1.17	157	18
	Denmark	1.17	698	19
	Norway	1.15	809	20
	Austria	1.13	774	21
	Spain	1.12	1,208	22
	Italy	1.09	2,321	23
	Greece	1.06	777	24
	Hungary	1.02	271	25
	New Zealand	1.01	518	26
	Brazil	1.01	891	27
	Chile	1.01	150	28
	South Korea	0.98	751	29
	China	0.96	2,314	30

Top 30 countries by citation impact (Number of Papers >=50), Atmospheric Research, 2006-2015

Time frame	Country	mnci	No. of Papers	Ranking
2006-2015	Switzerland	2.16	3,273	1
	Austria	1.99	1,597	2
	Netherlands	1.94	3,119	3
	Denmark	1.89	1,134	4
	UK	1.87	10,652	5
	Cyprus	1.86	168	6
	Australia	1.76	4,201	7
	Norway	1.74	2,069	8
	Saudi Arabia	1.73	353	9
	USA	1.72	39,972	10
	Finland	1.71	2,235	11
	Niger	1.71	59	12
	Ireland	1.69	467	13
	France	1.67	7,414	14
	Germany	1.64	10,594	15
	Peru	1.57	139	16
	Belgium	1.53	1,474	17
	Sweden	1.52	2,471	18
	Colombia	1.43	145	19
	Portugal	1.40	856	20
	Italy	1.37	5,020	21
	Canada	1.35	5,889	22
	Spain	1.33	3,734	23
	Slovenia	1.31	185	24
	New Zealand	1.31	833	25
	Nepal	1.23	95	26
	Kenya	1.19	151	27
	Lithuania	1.18	73	28
	Estonia	1.18	217	29
	Israel	1.15	783	30

Top 30 countries by citation impact (Number of Papers >=50), Ocean Research, 1996-2005

Time frame	Country	mnci	No. of Papers	Ranking
1996-2005	Panama	2.06	71	1
	Bermuda	1.96	124	2
	Monaco	1.49	150	3
	Denmark	1.44	2,027	4
	Switzerland	1.44	707	5
	Netherlands	1.42	2,578	6
	USA	1.41	28,548	7
	Iceland	1.37	250	8
	Norway	1.32	2,860	9
	Ecuador	1.32	57	10
	Australia	1.30	5,622	11
	Canada	1.28	6,989	12
	Sweden	1.25	2,030	13
	UK	1.25	9,431	14
	French Polynesia	1.24	135	15
	Indonesia	1.24	132	16
	Uruguay	1.21	112	17
	France	1.19	6,002	18
	Germany	1.18	6,225	19
	Spain	1.15	4,382	20
	New Caledonia	1.15	201	21
	Israel	1.15	764	22
	Portugal	1.15	1,132	23
	Belgium	1.10	1,411	24
	NEW ZEALAND	1.10	1,969	25
	Greece	1.04	823	26
	Vietnam	1.04	55	27
	Finland	1.03	999	28
	Italy	1.03	3,080	29
	Austria	1.02	613	30

Top 30 countries by citation impact (Number of Papers >=50), Ocean Research, 2006-2015

Time frame	Country	mnci	No. of Papers	Ranking
2006-2015	Monaco	2.05	168	1
	Bermuda	1.99	130	2
	Mozambique	1.74	51	3
	Switzerland	1.69	1,006	4
	Greenland	1.61	193	5
	Seychelles	1.58	58	6
	Denmark	1.52	2,673	7
	UK	1.51	11,553	8
	Norway	1.50	4,686	9
	Malta	1.45	85	10
	Australia	1.44	10,028	11
	French Polynesia	1.43	194	12
	USA	1.43	38,199	13
	Netherlands	1.43	3,358	14
	France	1.38	8,837	15
	Germany	1.36	8,589	16
	Luxembourg	1.33	70	17
	Sweden	1.32	2,590	18
	Belgium	1.31	2,223	19
	Italy	1.31	5,430	20
	United Arab Emirates	1.30	109	21
	Canada	1.30	9,282	22
	Finland	1.29	1,261	23
	Iceland	1.26	422	24
	Spain	1.25	8,406	25
	Peru	1.22	210	26
	New Caledonia	1.22	409	27
	Uruguay	1.21	286	28
	Singapore	1.21	573	29
	Ireland	1.20	1,029	30

Top 30 countries by citation impact (Number of Papers >=50), Antarctic Research, 1996-2005

Time frame	Country	mnci	No. of Papers	Ranking
1996-2005	Denmark	1.98	84	1
	Switzerland	1.69	75	2
	USA	1.43	1,973	3
	Canada	1.34	172	4
	France	1.34	474	5
	UK	1.31	1,235	6
	Sweden	1.29	134	7
	Belgium	1.20	163	8
	Germany	1.19	841	9
	Norway	1.15	98	10
	Austria	1.12	57	11
	Netherlands	1.11	224	12
	Australia	1.05	887	13
	New Zealand	0.92	308	14
	Finland	0.87	61	15
	South Africa	0.87	140	16
	Spain	0.84	331	17
	Chile	0.80	83	18
	Argentina	0.80	239	19
	Italy	0.79	758	20
	Japan	0.71	346	21
	Russia	0.68	230	22
	Brazil	0.61	79	23
	South Korea	0.59	74	24
	China	0.49	142	25
	Poland	0.46	102	26
	India	0.44	137	27

Top 30 countries by citation impact (Number of Papers >=50), Antarctic Research, 2006-2015

Time frame	Country	mnci	No. of Papers	Ranking
2006-2015	Netherlands	1.98	275	1
	Denmark	1.83	133	2
	USA	1.72	2,905	3
	UK	1.61	1,744	4
	Norway	1.51	259	5
	Switzerland	1.43	141	6
	France	1.40	701	7
	Belgium	1.40	290	8
	Australia	1.31	1,116	9
	Germany	1.30	1,051	10
	Austria	1.30	71	11
	New Zealand	1.27	695	12
	Sweden	1.21	232	13
	Canada	1.18	353	14
	Finland	0.99	93	15
	Portugal	0.98	52	16
	South Africa	0.98	201	17
	Italy	0.95	888	18
	Japan	0.95	519	19
	Spain	0.91	519	20
	Czech Republic	0.90	77	21
	Chile	0.75	253	22
	Argentina	0.73	388	23
	Brazil	0.72	300	24
	South Korea	0.65	314	25
	China	0.62	598	26
	Malaysia	0.59	70	27
	Poland	0.55	224	28
	Russia	0.53	278	29
	India	0.42	279	30

Top 30 countries by citation impact (Number of Papers >=50), Arctic Research, 1996-2005

Time frame	Country	mnci	No. of Papers	Ranking
1996-2005	USA	1.86	1,959	1
	Canada	1.49	1,291	2
	Denmark	1.39	305	3
	Germany	1.37	755	4
	UK	1.34	650	5
	Switzerland	1.33	65	6
	Norway	1.27	1,030	7
	ICELAND	1.22	57	8
	Sweden	1.18	455	9
	Netherlands	1.16	126	10
	Australia	1.13	60	11
	Italy	1.11	76	12
	France	1.10	171	13
	Belgium	1.10	51	14
	Finland	1.02	220	15
	Russia	0.78	581	16
	Poland	0.76	95	17
	Japan	0.73	198	18
	China	0.68	58	19

Top 30 countries by citation impact (Number of Papers >=50), Arctic Research, 2006-2015

Time frame	Country	mnci	No. of Papers	Ranking
2006-2015	USA	2.11	3,341	1
	Switzerland	1.93	201	2
	Greenland	1.88	140	3
	Australia	1.87	193	4
	Netherlands	1.84	315	5
	France	1.76	477	6
	UK	1.74	1,209	7
	Austria	1.67	117	8
	Denmark	1.60	625	9
	Germany	1.59	1,221	10
	Spain	1.55	182	11
	Sweden	1.47	854	12
	Norway	1.42	1,939	13
	Canada	1.40	2,518	14
	Belgium	1.30	128	15
	Finland	1.24	401	16
	Japan	1.21	344	17
	Italy	1.13	146	18
	New Zealand	1.10	55	19
	Czech Republic	1.02	63	20
	Chile	1.00	156	21
	Russia	0.94	895	22
	South Korea	0.92	184	23
	China	0.89	465	24
	Poland	0.88	374	25
	Iceland	0.84	125	26
	India	0.56	65	27

Top 30 countries by citation impact, Himalayas Research, 1996-2005

Time frame	Country	mnci	No. of Papers	Ranking
1996-2005	Thailand	3.39	2	1
	USA	3.01	321	2
	Canada	2.63	57	3
	South Korea	2.45	5	4
	Ireland	2.26	5	5
	UK	2.13	164	6
	Switzerland	2.13	55	7
	Sweden	1.88	7	8
	France	1.70	95	9
	Pakistan	1.60	23	10
	Czech Republic	1.57	3	11
	Norway	1.55	21	12
	Netherlands	1.52	13	13
	Austria	1.47	25	14
	Nepal	1.36	85	15
	Myanmar	1.33	2	16
	Estonia	1.33	1	17
	Australia	1.30	22	18
	Philippines	1.23	1	19
	Italy	1.07	39	20
	Japan	1.06	60	21
	Oman	1.05	2	22
	China	1.04	88	23
	New Caledonia	0.97	2	24
	Germany	0.94	90	25
	Mexico	0.89	3	26
	Denmark	0.88	6	27
	Taiwan	0.85	6	28
	New Zealand	0.79	17	29
	South Africa	0.77	3	30

Top 30 countries by citation impact, Himalayas Research, 2006-2015

Time frame	Country	mnci	No. of Papers	Ranking
2006-2015	Mongolia	5.84	3	1
	Malaysia	3.80	9	2
	Singapore	3.66	14	3
	Portugal	3.16	1	4
	Romania	3.02	1	5
	Morocco	2.93	1	6
	Switzerland	2.72	92	7
	France	2.48	192	8
	Iran	2.26	13	9
	Myanmar	2.21	3	10
	Canada	2.08	126	11
	Denmark	2.06	17	12
	USA	2.01	614	13
	Netherlands	1.96	70	14
	Brunei	1.90	1	15
	Turkey	1.85	7	16
	Chile	1.79	3	17
	UK	1.79	250	18
	Indonesia	1.67	2	19
	Hungary	1.66	5	20
	Australia	1.60	96	21
	Germany	1.59	202	22
	Egypt	1.59	2	23
	South Korea	1.52	43	24
	Norway	1.49	65	25
	Sweden	1.46	33	26
	Belgium	1.46	11	27
	Italy	1.44	109	28
	Nepal	1.39	214	29
	Qatar	1.33	2	30

A.15 LIST OF INDIAN PAPERS THAT WERE IN THE WORLD'S TOP 1% HIGHLY CITED PAPERS

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Rising temperatures reduce global wheat production	NATURE CLIMATE CHANGE	2015	Indian Agr Res Inst ,New Delhi ,India; Int Water Management Inst ,New Delhi ,India	79	ASSENG, S
An exotic Mesoarchean microcontinent: The Coorg Block, southern India	GONDWANA RESEARCH	2015	CSIR India ,Hyderabad ,India; Natl Geophys Res Inst ,Hyderabad ,India; Univ Kerala ,Trivandrum ,India	57	SANTOSH, M
U-Pb geochronology of the Deccan Traps and relation to the end-Cretaceous mass extinction	SCIENCE	2015	Amravati Univ ,Amravati ,India	39	SCHOENE, B
Historically unprecedented global glacier decline in the early 21st century	JOURNAL OF GLACIOLOGY	2015	GEOL SURVEY INDIA ,Lucknow ,India	22	ZEMP, M
A tectonic model reconciling evidence for the collisions between India, Eurasia and intra-oceanic arcs of the central-eastern Tethys	GONDWANA RESEARCH	2015	CSIR Natl Inst Oceanog ,Panaji ,India	19	GIBBONS, AD
Antibiotic Pollution in the Environment: A Review	CLEAN-SOIL AIR WATER	2015	IIT ,Yeddumailaram ,India; IIT HYDERABAD ,Yeddumailaram ,India	21	GOTHWAL, R
Systemic and mucosal immune response of rainbow trout to immunization with an attenuated Flavobacterium psychrophilum vaccine strain by different routes	FISH & SHELLFISH IMMUNOLOGY	2015	Cent Inst Fisheries Educ ,Bombay ,India	13	MAKESH, M
Effect of guava leaves on the growth performance and cytokine gene expression of Labeo rohita and its susceptibility to Aeromonas hydrophila infection	FISH & SHELLFISH IMMUNOLOGY	2015	Jawharlal Nehru Univ ,New Delhi ,India; Periyar Maniammai Univ ,Thanjavur ,India	12	GIRI, SS

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
A new scenario framework for climate change research: the concept of shared socioeconomic pathways	CLIMATIC CHANGE	2014	TERI ,New Delhi ,India	112	ONEILL, BC
A global assessment of precipitation chemistry and deposition of sulfur, nitrogen, sea salt, base cations, organic acids, acidity and pH, and phosphorus	ATMOSPHERIC ENVIRONMENT	2014	Indian Inst Trop Meteorol ,Pune ,India; Minist Earth Sci ,Pune ,India	73	VET, R
An update to the Surface Ocean CO2 Atlas (SOCAT version 2)	EARTH SYSTEM SCIENCE DATA	2014	Natl Inst Oceanog ,Visakhapatnam ,India	67	BAKKER, DCE
Limited potential of no-till agriculture for climate change mitigation	NATURE CLIMATE CHANGE	2014	Natl Agr Sci Ctr Complex ,New Delhi ,India	65	POWLSON, DS
Socio-hydrology: Use-inspired water sustainability science for the Anthropocene	EARTHS FUTURE	2014	Ashoka Trust Res Ecol & Environm ,Bengaluru ,India	36	SIVAPALAN, M
The Randolph Glacier Inventory: a globally complete inventory of glaciers	JOURNAL OF GLACIOLOGY	2014	Wadia Inst Himalayan Geol ,Dehra Dun ,India	135	PFEFFER, WT
An update to the Surface Ocean CO2 Atlas (SOCAT version 2)	EARTH SYSTEM SCIENCE DATA	2014	Natl Inst Oceanog ,Visakhapatnam ,India	67	BAKKER, DCE
Markedly divergent estimates of Amazon forest carbon density from ground plots and satellites	GLOBAL ECOLOGY AND BIOGEOGRAPHY	2014	IIT Roorkee ,Roorkee ,India	60	MITCHARD, ETA
Short-term modulation of Indian summer monsoon rainfall by West Asian dust	NATURE GEOSCIENCE	2014	IIT Bhubaneswar ,Bhubaneswar ,India	45	VINOJ, V
Fly ash for soil amelioration: A review on the influence of ash blending with inorganic and organic amendments	EARTH-SCIENCE REVIEWS	2014	CSIR India ,Dhanbad ,India; Ctr Inst Min & Fuel Res ,Dhanbad ,India	43	RAM, LC
Engineering properties and microstructural characteristics of cement-stabilized zinc-contaminated kaolin	CANADIAN GEOTECHNICAL JOURNAL	2014	IIT Bombay ,Bombay ,India	42	DU, YJ

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Crustal evolution of the Southern Granulite Terrane, south India: New geochronological and geochemical data for felsic orthogneisses and granites	PRECAMBRIAN RESEARCH	2014	Jadavpur Univ ,Kolkata ,India; Univ Mysore ,Mysore ,India	39	BRANDT, S
Onset of Mediterranean outflow into the North Atlantic	SCIENCE	2014	Banaras Hindu Univ ,Varanasi ,India	38	HERNANDEZ-MOLINA, FJ
Socio-hydrology: Use-inspired water sustainability science for the Anthropocene	EARTHS FUTURE	2014	Ashoka Trust Res Ecol & Environm ,Bengaluru ,India	36	SIVAPALAN, M
Niche filling slows the diversification of Himalayan songbirds	NATURE	2014	Wildlife Inst India ,Dehra Dun ,India	57	PRICE, TD
Thick-shelled, grazer-protected diatoms decouple ocean carbon and silicon cycles in the iron-limited Antarctic Circumpolar Current	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2013	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	52	ASSMY, P
Bounding the role of black carbon in the climate system: A scientific assessment	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	2013	IIT Bombay ,Bombay ,India	842	BOND, TC
Uncertainty in simulating wheat yields under climate change	NATURE CLIMATE CHANGE	2013	Indian Agr Res Inst ,New Delhi ,India; IWMI ,New Delhi ,India	209	ASSENG, S
Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	2013	India Meteorol Dept ,Pune ,India; Minist Earth Sci ,Pune ,India	169	DONAT, MG
Continental-scale temperature variability during the past two millennia	NATURE GEOSCIENCE	2013	Indian Inst Trop Meteorol ,Pune ,India; Minist Earth Sci India; Natl Ctr Antarctic Ocean Res ,Goa ,India	120	AHMED, M

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Climate-related changes in peatland carbon accumulation during the last millennium	BIOGEOSCIENCES	2013	Wadia Inst Himalayan Geol ,Dehra Dun ,India	77	CHARMAN, DJ
Neoarchean greenstone volcanism and continental growth, Dharwar craton, southern India: Constraints from SIMS U-Pb zircon geochronology and Nd isotopes	PRECAMBRIAN RESEARCH	2013	Univ Delhi ,Delhi ,India; Univ Mysore ,Mysore ,India	75	JAYANANDA, M
Timescales of crustal melting in the Higher Himalayan Crystallines (Sikkim, Eastern Himalaya) inferred from trace element-constrained monazite and zircon chronology	CONTRIBUTIONS TO MINERALOGY AND PETROLOGY	2013	Indian Inst Sci Educ Res Kolkata ,Kolkata ,India	73	RUBATTO, D
The lower crust of the Dharwar Craton, Southern India: Patchwork of Archean granulitic domains	PRECAMBRIAN RESEARCH	2013	Univ Delhi ,Delhi ,India	62	PEUCAT, JJ
Structure and Composition of the Plate-Boundary Slip Zone for the 2011 Tohoku-Oki Earthquake	SCIENCE	2013	Univ Calcutta ,Kolkata ,India	54	CHESTER, FM
Review of trend detection methods and their application to detect temperature changes in India	JOURNAL OF HYDROLOGY	2013	IISC Bangalore ,Bangalore ,India	46	SONALI, P
Proposal for resources, utilization and processes of red mud in India - A review	INTERNATIONAL JOURNAL OF MINERAL PROCESSING	2013	CSIR India ,Jamshedpur ,India; Natl Met Lab ,Jamshedpur ,India; Sikkim Manipal Inst Technol ,E Sikkim ,India	29	SAMAL, S
Timescales of crustal melting in the Higher Himalayan Crystallines (Sikkim, Eastern Himalaya) inferred from trace element-constrained monazite and zircon chronology	CONTRIBUTIONS TO MINERALOGY AND PETROLOGY	2013	Indian Inst Sci Educ Res Kolkata ,Kolkata ,India	73	RUBATTO, D

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
APPRAISAL OF SOIL EROSION RISK IN THE EASTERN HIMALAYAN REGION OF INDIA FOR SOIL CONSERVATION PLANNING	LAND DEGRADATION & DEVELOPMENT	2013	Cent Soil & Water Conservat Res & Training Inst ,Dehra Dun ,India	45	MANDAL, D
Oxygen, ecology, and the Cambrian radiation of animals	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2013	Andhra Univ ,Visakhapatnam ,India	65	SPERLING, EA
Thick-shelled, grazer-protected diatoms decouple ocean carbon and silicon cycles in the iron-limited Antarctic Circumpolar Current	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2013	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	52	ASSMY, P
Potential probiotic Lactobacillus plantarum VSG3 improves the growth, immunity, and disease resistance of tropical freshwater fish, Labeo rohita	FISH & SHELLFISH IMMUNOLOGY	2013	Periyar Maniammai Univ ,Thanjavur ,India	30	GIRI, SS
The State and Fate of Himalayan Glaciers	SCIENCE	2012	IISC Bangalore ,Bangalore ,India	333	BOLCH, T
Global review and synthesis of trends in observed terrestrial near-surface wind speeds: Implications for evaporation	JOURNAL OF HYDROLOGY	2012	Deemed Univ ,Itanagar ,India	208	MCVICAR, TR
A Cenozoic record of the equatorial Pacific carbonate compensation depth	NATURE	2012	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	93	PALIKE, H
The State and Fate of Himalayan Glaciers	SCIENCE	2012	IISC Bangalore ,Bangalore ,India	333	BOLCH, T

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Deep carbon export from a Southern Ocean iron-fertilized diatom bloom	NATURE	2012	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	117	SMETACEK, V
General overview: European Integrated project on Aerosol Cloud Climate and Air Quality interactions (EUCAARI) - integrating aerosol research from nano to global scales	ATMOSPHERIC CHEMISTRY AND PHYSICS	2011	CSIR India ,New Delhi ,India	116	KULMALA, M
Crop yield forecasting on the Canadian Prairies using MODIS NDVI data	AGRICULTURAL AND FOREST METEOROLOGY	2011	Rubber Res Inst India ,Kottayan ,India	75	MKHABELA, MS
Satellites measure recent rates of groundwater depletion in Californias Central Valley	GEOPHYSICAL RESEARCH LETTERS	2011	INDIAN SCH MINES ,Dhanbad ,India	175	FAMIGLIETTI, JS
When is a forest a savanna, and why does it matter?	GLOBAL ECOLOGY AND BIOGEOGRAPHY	2011	Natl Ctr Biological Sci - NCBS ,Bangalore ,India; Tata Inst Fund Res ,Bangalore ,India	95	RATNAM, J
Trends in reference crop evapotranspiration over Iran	JOURNAL OF HYDROLOGY	2011	NE Reg Inst Sci & Technol ,Itanagar ,India	93	DINPASHOH, Y
Impact of plant products on innate and adaptive immune system of cultured finfish and shellfish	AQUACULTURE	2011	Bharathidasan Univ ,Tiruchchirappalli ,India	92	HARIKRISHNAN , R
Climatological aspects of the optical properties of fine/coarse mode aerosol mixtures	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	2010	IIT Kanpur ,Kanpur ,India	146	ECK, TF
Spatio-temporal variability in atmospheric abundances of EC, OC and WSOC over Northern India	JOURNAL OF AEROSOL SCIENCE	2010	Phys Res Lab ,Ahmadabad ,India	97	RAM, K
Tropical cyclones and climate change	NATURE GEOSCIENCE	2010	India Meteorol Dept ,Pune ,India; Minist Earth Sci ,Pune ,India	671	KNUTSON, TR
The impact of global warming on the tropical Pacific ocean and El Nino	NATURE GEOSCIENCE	2010	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	385	COLLINS, M

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Feature Selection for Classification of Hyperspectral Data by SVM	IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	2010	Natl Inst Technol ,Kurukshetra ,India	172	PAL, M
Active and break spells of the Indian summer monsoon	JOURNAL OF EARTH SYSTEM SCIENCE	2010	IISC Bangalore ,Bangalore ,India; Natl Atmospher Res Lab ,Gadanki ,India	112	RAJEEVAN, M
The fracture toughness of bulk metallic glasses	JOM	2010	IISC Bangalore ,Bangalore ,India	67	XU, J
Immune responses and expression profiles of some immune-related genes in Indian major carp, Labeo rohita to Edwardsiella tarda infection	FISH & SHELLFISH IMMUNOLOGY	2010	Cent Inst Freshwater Aquaculture ,Bhubaneswar ,India	52	MOHANTY, BR
Brown Clouds over South Asia: Biomass or Fossil Fuel Combustion?	SCIENCE	2009	Indian Inst Trop Meteorol ,Pune ,India; Minist Earth Sci ,Pune ,India	206	GUSTAFSSON, O
Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) reasons for concern	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2009	IIT ,Bombay ,India; IIT Bombay ,Bombay ,India	190	SMITH, JB
RAMA The Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction	BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY	2009	Indian Natl Ctr Ocean Informat Serv ,Hyderabad ,India; Minist Earth Sci ,Hyderabad ,India; Natl Inst Oceanog ,Visakhapatnam ,India	190	MCPHADEN, MJ
Character and Spatial Distribution of OH/H2O on the Surface of the Moon Seen by M-3 on Chandrayaan-1	SCIENCE	2009	Indian Space Res Org ,Bangalore ,India; Natl Remote Sensing Agcy ,Hyderabad ,India; Phys Res Lab ,Ahmadabad ,India	222	PIETERS, CM
Dwindling groundwater resources in northern India, from satellite gravity observations	GEOPHYSICAL RESEARCH LETTERS	2009	CSIR India ,Hyderabad ,India; Natl Geophys Res Inst ,Hyderabad ,India	163	TIWARI, VM

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Effects of natural and human-induced hypoxia on coastal benthos	BIOGEOSCIENCES	2009	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	156	LEVIN, LA
Counterclockwise exhumation of a hot orogen: The Paleoproterozoic ultrahigh-temperature granulites in the North China Craton	LITHOS	2009	IISC Bangalore ,Bangalore ,India	118	SANTOSH, M
Prediction of blast-induced ground vibration using artificial neural network	INTERNATIONAL JOURNAL OF ROCK MECHANICS AND MINING SCIENCES	2009	IIT ,Bombay ,India; IIT Bombay ,Bombay ,India; Maharana Pratap Univ Agr & Technol ,Udaipur ,India	67	KHANDELWAL, M
A review of the different methods applied in environmental geochemistry for single and sequential extraction of trace elements in soils and related materials	WATER AIR AND SOIL POLLUTION	2008	GEOL SURVEY INDIA ,Hyderabad ,India	182	RAO, CRM
Rise of the Andes	SCIENCE	2008	IISC Bangalore ,Bangalore ,India; IIT ,Madras ,India; IIT Madras ,Madras ,India; Natl Inst Hydrol ,Kakinada ,India; Natl Inst Hydrol ,Roorkee ,India	262	GARZIONE, CN
Heap bioleaching of chalcopyrite: A review	MINERALS ENGINEERING	2008	CSIR India ,Bhubaneswar ,India	119	PRADHAN, N
Ethnobiology, socio-economics and management of mangrove forests: A review	AQUATIC BOTANY	2008	Wildlife Inst India ,Dehra Dun ,India	185	WALTERS, BB
Enhanced innate immune parameters in Labeo rohita (Ham.) following oral administration of Bacillus subtilis	FISH & SHELLFISH IMMUNOLOGY	2008	CIFA ,Bhubaneswar ,India; CIFE ,Bombay ,India	75	KUMAR, R
Biological effects of bacterial lipopolysaccharide (endotoxin) in fish: A review	FISH & SHELLFISH IMMUNOLOGY	2008	Cent Inst Freshwater Aquaculture ,Bhubaneswar ,India	74	SWAIN, P

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Support vector regression methodology for storm surge predictions	OCEAN ENGINEERING	2008	PSG Coll Technol ,Coimbatore ,India	72	RAJASEKARAN, S
An assessment of the use of sediment traps for estimating upper ocean particle fluxes	JOURNAL OF MARINE RESEARCH	2007	Phys Res Lab ,Ahmadabad ,India	200	BUESSELER, KO
Oral administration of Eclipta alba leaf aqueous extract enhances the non-specific immune responses and disease resistance of Oreochromis mossambicus	FISH & SHELLFISH IMMUNOLOGY	2007	Lady Doak Coll ,Madurai ,India; Cent Inst Freshwater Aquaculture ,Bhubaneswar ,India	89	CHRISTYBAPITA , D
Global observed changes in daily climate extremes of temperature and precipitation	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	2006	Indian Inst Trop Meteorol ,Pune ,India; Minist Earth Sci ,Pune ,India	971	ALEXANDER, LV
Increasing trend of extreme rain events over India in a warming environment	SCIENCE	2006	IISC Bangalore ,Bangalore ,India; Indian Inst Trop Meteorol ,Pune ,India; Minist Earth Sci ,Pune ,India	467	GOSWAMI, BN
High resolution daily gridded rainfall data for the Indian region: Analysis of break and active monsoon spells	CURRENT SCIENCE	2006	India Meteorol Dept ,New Delhi ,India; India Meteorol Dept ,Pune ,India; Minist Earth Sci ,New Delhi ,India; Minist Earth Sci ,Pune ,India	355	RAJEEVAN, M
Nitrogen and sulfur deposition on regional and global scales: A multimodel evaluation	GLOBAL BIOGEOCHEMICAL CYCLES	2006	IIT ,Hyderabad ,India; IIT HYDERABAD ,Hyderabad ,India	312	DENTENER, F
Heavy metal removal mechanism of acid mine drainage in wetlands: A critical review	MINERALS ENGINEERING	2006	Jai Narain Vyas Univ Jodhpur ,Jodhpur ,India	182	SHEORAN, AS
Dowinscaling of precipitation for climate change scenarios: A support vector machine approach	JOURNAL OF HYDROLOGY	2006	IISC Bangalore ,Bangalore ,India	162	TRIPATHI, S
A comparative study of conventional, ANN black box, fuzzy and combined neural and fuzzy weighting procedures for landslide susceptibility zonation in Darjeeling Himalayas	ENGINEERING GEOLOGY	2006	CSIR India ,Roorkee ,India; IIT ,Roorkee ,India; IIT Roorkee ,Roorkee ,India	154	KANUNGO, DP

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Effect of Achyranthes aspera on the immunity and survival of Labeo rohita infected with Aeromonas hydrophila	FISH & SHELLFISH IMMUNOLOGY	2006	Cent Inst Freshwater Aquaculture ,Bhubaneswar ,India; Univ Delhi ,Delhi ,India	119	RAO, YV
Residential biofuels in south Asia: Carbonaceous aerosol emissions and climate impacts	SCIENCE	2005	IIT ,Bombay ,India; IIT Bombay ,Bombay ,India	269	VENKATARAMAN, C
The onset of India-Asia continental collision: Early, steep subduction required by the timing of UHP metamorphism in the western Himalaya	EARTH AND PLANETARY SCIENCE LETTERS	2005	IIT ,Roorkee ,India; IIT Roorkee ,Roorkee ,India	279	LEECH, ML
Predecessors of the giant 1960 Chile earthquake	NATURE	2005	Ctr Earth Sci Studies ,Thiruvananthapuram ,India; IIT ,Kanpur ,India; IIT Kanpur ,Kanpur ,India	236	CISTERNAS, M
Studies on distribution and fractionation of heavy metals in Gomti river sediments - a tributary of the Ganges, India	JOURNAL OF HYDROLOGY	2005	CSIR India ,Lucknow ,India; Ind Toxicol Res Ctr ,Lucknow ,India	232	SINGH, KP
The onset of India-Asia continental collision: Early, steep subduction required by the timing of UHP metamorphism in the western Himalaya	EARTH AND PLANETARY SCIENCE LETTERS	2005	IIT ,Roorkee ,India; IIT Roorkee ,Roorkee ,India	279	LEECH, ML
Coastal mangrove forests mitigated tsunami	ESTUARINE COASTAL AND SHELF SCIENCE	2005	Annamalai Univ ,Parangipettai ,India	187	KATHIRESAN, K
Administration of yeast glucan enhances survival and some non-specific and specific immune parameters in carp (Cyprinus carpio) infected with Aeromonas hydrophila	FISH & SHELLFISH IMMUNOLOGY	2005	Madurai Kamaraj Univ ,Madurai ,India; Spic Ltd ,Tuticorin ,India; TICEL Bio Pk Ltd ,Madras ,India; VOC Coll ,Tuticorin ,India	94	SELVARAJ, V
Natural organic matter in sedimentary basins and its relation to arsenic in anoxic ground water: the example of West Bengal and its worldwide implications	APPLIED GEOCHEMISTRY	2004	Cent Ground Water Author ,Delhi ,India; Cent Ground Water Author ,Kolkata ,India; Univ Delhi ,Delhi ,India	387	MCARTHUR, JM

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
Mapping vulnerability to multiple stressors: climate change and globalization in India	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	2004	CSIR India ,New Delhi ,India	307	OBRIEN, K
A neuro-fuzzy computing technique for modeling hydrological time series	JOURNAL OF HYDROLOGY	2004	IIT ,Madras ,India; Natl Inst Hydrol ,Kakinada ,India	253	NAYAK, PC
Toxicological effects of malachite green	AQUATIC TOXICOLOGY	2004	Cent Inland Capture Fisheries Res Inst ,Barakpur ,India; SMM Town Postgrad Coll ,Ballia ,India	448	SRIVASTAVA, S
Evaluation of metal contamination in coastal sediments of the Bay of Bengal, India: geochemical and statistical approaches	MARINE POLLUTION BULLETIN	2004	Univ Madras ,Madras ,India	153	SELVARAJ, K
The Indian monsoon and its variability	ANNUAL REVIEW OF EARTH AND PLANETARY SCIENCES	2003	IISC Bangalore ,Bangalore ,India	278	GADGIL, S
Asia-Pacific mussel watch: monitoring contamination of persistent organochlorine compounds in coastal waters of Asian countries	MARINE POLLUTION BULLETIN	2003	Annamalai Univ ,Parangipettai ,India	244	MONIRITH, I
A physical SNOWPACK model for the Swiss avalanche warning Part II: Snow microstructure	COLD REGIONS SCIENCE AND TECHNOLOGY	2002	Snow & Avalance Study Estab ,Manali ,India	178	LEHNING, M
Indian Ocean Experiment: An integrated analysis of the climate forcing and effects of the great Indo-Asian haze	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	2001	CSIR India ,New Delhi ,India; Natl Phys Lab - India ,New Delhi ,India; Phys Res Lab ,Ahmadabad ,India; VIKRAM SARABHAI SPACE CTR ,Trivandrum ,India	760	RAMANATHAN, V
The Indian Ocean Experiment: Widespread air pollution from South and Southeast Asia	SCIENCE	2001	CSIR India ,New Delhi ,India; Natl Phys Lab - India ,New Delhi ,India; Phys Res Lab ,Ahmadabad ,India	432	LELIEVELD, J

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
The causes of land-use and land-cover change: moving beyond the myths	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	2001	Ctr Dev Studies ,Trivandrum ,India; Jawaharlal Nehru Univ ,New Delhi ,India	912	LAMBIN, EF
Base isolation for near-fault motions	EARTHQUAKE ENGINEERING & STRUCTURAL DYNAMICS	2001	IIT ,Bombay ,India; IIT Bombay ,Bombay ,India	150	JANGID, RS
The oceanic fixed nitrogen and nitrous oxide budgets: Moving targets as we enter the anthropocene?	SCIENTIA MARINA	2001	CSIR India ,Panaji ,India; Natl Inst Oceanog ,Panaji ,India	367	CODISPOTI, LA
Biology of mangroves and mangrove ecosystems	ADVANCES IN MARINE BIOLOGY, VOL 40	2001	Annamalai Univ ,Parangipettai ,India	364	KATHIRESAN, K
Neural networks for wave forecasting	OCEAN ENGINEERING	2001	IIT Bombay ,Bombay ,India	107	DEO, MC
Late Archaean (2550-2520 Ma) juvenile magmatism in the Eastern Dharwar craton, southern India: constraints from geochronology, Nd-Sr isotopes and whole rock geochemistry	PRECAMBRIAN RESEARCH	2000	Bangalore Univ ,Bangalore ,India	252	JAYANANDA, M
Increased marine production of N2O due to intensifying anoxia on the Indian continental shelf	NATURE	2000	Natl Inst Oceanog ,Dona Paula ,India	271	NAQVI, SWA
A dipole mode in the tropical Indian Ocean	NATURE	1999	IISC Bangalore ,Bangalore ,India	1,736	SAJI, NH
On the weakening relationship between the Indian monsoon and ENSO	SCIENCE	1999	Indian Inst Trop Meteorol ,Pune ,India; Minist Earth Sci,India	644	KUMAR, KK
Improved weather and seasonal climate forecasts from multimodel superensemble	SCIENCE	1999	IISC Bangalore ,Bangalore ,India	414	KRISHNAMURTI , TN

Article Title	Journal Title	Publication Year	Address	Total Citations	Lead Author
A non-linear rainfall-runoff model using an artificial neural network	JOURNAL OF HYDROLOGY	1999	Govt Engn Coll ,Thrissur ,India; IIT Madras ,Madras ,India	175	SAJIKUMAR, N
Real time wave forecasting using neural networks	OCEAN ENGINEERING	1999	IIT ,Powai ,India; IIT Bombay ,Powai ,India	103	DEO, MC
Larger foraminiferal biostratigraphy of the Tethyan Paleocene and Eocene	BULLETIN DE LA SOCIETE GEOLOGIQUE DE FRANCE	1998	LUCKNOW UNIV ,Lucknow ,India	315	SERRA-KIEL, J
Ploidy induction and sex control in fish	HYDROBIOLOGIA	1998	Madurai Kamaraj Univ ,Madurai ,India	165	PANDIAN, TJ
Mooring forces and motion responses of pontoon-type floating breakwaters	OCEAN ENGINEERING	1998	IIT ,MADRAS ,INDIA; IIT Madras ,MADRAS ,INDIA	78	SANNASIRAJ, SA
Evaporation and potential evapotranspiration in India under conditions of recent and future climate change	AGRICULTURAL AND FOREST METEOROLOGY	1997	India Meteorol Dept ,PUNE ,INDIA; Minist Earth Sci ,PUNE ,INDIA	203	CHATTOPADHYAY, N
Mechanism of the biological response to winter cooling in the northeastern Arabian Sea	NATURE	1996	CSIR India ,COCHIN ,INDIA; CSIR India ,PANAJI ,INDIA; Natl Inst Oceanog ,COCHIN ,INDIA; Natl Inst Oceanog ,PANAJI ,INDIA	249	MADHUPRATAP, M

Index

Please refer to the Volume 2 of this report which provides supporting tables for this report.