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Asian Arctic Research 2005-2012:

Harder, Better, Faster, Stronger

Iselin Stensdal

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Abstract

Interest in the Arctic has surged in recent years; as the ice has melted, so has interest risen. One dimension of this new attention to the Arctic is the emergence of non-Arctic states. Their research-oriented presence in the region is sometimes seen as a strategy for legitimizing their role as stakeholders there. While several European countries have been operating for decades without being littoral states, since India opened its research station in Ny-Ålesund on Svalbard in 2008, attention towards Asian countries in the Arctic has increased. The Asian countries are sometimes met with suspicion, but such judgements are at best based on fuzzy and partial information. Hence came the idea for gathering statistical information on Asian Arctic Research. I here ask: How can the scientific Arctic research carried out by China, India, Japan and South Korea be described? What fields of research are in focus? How integrated are these countries into the larger international Arctic scientific community?

Key Words

China, India, Japan, Kaorea, Arctic research, science, bibliometry

Preface

This report was initiated as part of the FNI–IFS AsiArctic Programme, which also provided funding.

Many people have helped me along the way. I am especially indebted to Elisabeth Råstad at Kings Bay A/S and to Kirsten Haraldsen, librarian at the University of Oslo, for assistance in obtaining data. Olav Schram Stokke commented on an early version of the manuscript. I later received helpful comments from the following people: Anne-Marie Brady, Neil Gadihoke, Shinji Hyodo, Justin Kim, Nalan Koc, Fujio Ohnishi, Vijay Sakhuja, Uttam Sinha, Xia Liping, Xu Shijie, Zhang Pei and Zhang Xia. Susan Høivik has revised the language.

Any remaining faults and shortcomings are of course entirely my own.

Shanghai 19.04.2013

Contents

Abbreviations

AERC	Arctic Environment Research Center, Japan
AFoPS	Asian Forum of Polar Sciences
AOSB	Arctic Ocean Sciences Board
CAA	Chinese Arctic and Antarctic Administration
CAS	Chinese Academy of Sciences
CASS	Chinese Academy of Social Sciences
CHINARE	Chinese National Arctic/Antarctic Research Expeditions
COMPAC	COMposition of Polar Atmosphere and Climate Change, Korea
EISCAT	European Incoherent Scatter Scientific Association
FARO	Forum of Arctic Research Operators
GRENE	Green Network of Excellence, Japan
IASC	International Arctic Science Committee
ICWA	Indian Council of World Affairs
IDSA	Institute for Defence Studies and Analyses, India
IPA	International Permafrost Association
IPY	International Polar Year
ISAR	the International Symposium on Arctic Research, Japan
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JAXA	Aerospace Exploration Agency, Japan
JCAR	Japan Consortium for Arctic Environmental Research
KASCO	Korean Arctic Science Council
KIOST	Korea Institute of Ocean Science and Technology
KONPOR	Korean National Committee on Polar Research
KOPRI	Korea Polar Research Institute
KORDI	Korea Ocean Research and Development Institute
KRCF	Korea Research Council of Fundamental Science & Technology
MEST	Ministry of Education, Science and Technology, Korea
MEXT	Ministry of Education, Culture, Sports, Science & Technology, Japan
MLR	Ministry of Land and Resources, China
MLTM	Ministry of Land, Transport and Maritime Affairs, Korea
MoES	Ministry of Earth Sciences, India

NCAOR	National Centre for Antarctic & Ocean Research, India
NEEM	North Greenland Eemian Ice Drilling, research project
NIPR	National Institute of Polar Research, Japan
NySMAC	Ny-Ålesund Science Managers Committee
PAG	Pacific Arctic Group
PRIC	Polar Research Institute of China
ROIS	Research Organization of Information and Systems
RiS	Research in Svalbard
SaGAA	National Conference on Science & Geopolitics of Arctic & Antarctic, India
SOA	State Oceanic Administration, China
SOKENDAI	Graduate University for Advances Studies, Japan
SSF	Svalbard Science Forum
WoS	Web of Science

Tables and figures

Introduction

Interest in the Arctic has surged in recent years; as the ice has melted, so has interest risen. One reason for this interest is the often-quoted 2008 US Geology Survey assessment which estimated that as much as 30% of the world's undiscovered oil reserves are in the Arctic (USGS Circum-Arctic Resource Appraisal Assessment Team 2008). The Arctic has become a frequent topic in the media and popular literature alike, including discussion of the promising prospects and potential conflict-lines with emerging non-littoral actors. While scenarios are outlined and discussed on paper, less activity has occurred in the Arctic – with the exception of *research*. Climate change is perhaps the greatest challenge facing the human race today, and the Arctic has been shown to be an important first-instance as regards climate change. Understanding climatic changes in the Arctic can also help predictions for changes in other parts of the world. Thus, it is no wonder that many states are putting resources in Arctic research. One dimension of this new attention to the Arctic is the emergence of non-Arctic states. Their research-oriented presence in the region is sometimes seen as a strategy for legitimizing their role as stakeholders there. While several European countries have been operating for decades without being littoral states, since India opened its research station in Ny-Ålesund on Svalbard in 2008, attention towards Asian countries in the Arctic has increased. The Asian countries are sometimes met with suspicion, but such judgements are at best based on fuzzy and partial information. Hence came the idea for this report, and for gathering statistical information on Asian Arctic Research. I here ask: How can the scientific Arctic research carried out by China, India, Japan and South Korea be described? What fields of research are in focus? How integrated are these countries into the larger international Arctic scientific community?

In investigating Asian research on the High North and the Arctic I have used a range of sources, such as consulting databases, statistics, using bibliometry, as well as consulting range of relevant research publications. In this report, I begin by explaining my approach to studying the Arctic research of China, India, Japan and South Korea, and the challenges I encountered. The volume of these countries' Arctic research has increased over the eight years investigated here. The countries are presented alphabetically. Finally, I offer some comments and comparisons.

Methodical approach and challenges

How to do research on science in a way that can enable comparison between countries? Here, I have focused on one good indicator of research activity: publication output. In addition I have emphasized activity in the Arctic region, such as sea expeditions and overnight researcher stays at their Ny-Ålesund facilities and other research stations in the region. Further, I have looked into the scientific research infrastructure of these countries, such as research stations and research vessels. Money flows to research are usually a good indicator of a government's seriousness in pursuing a given topic, but comparable data

can be difficult to obtain. More accessible parameters are Arctic research conferences hosted by the Asian countries, and Asian involvement in various relevant international bodies and committees. Finally, I have gathered information on manpower figures and how Arctic research is organized through the polar institutes within these countries studied here. All data on each country's number of overnight stays at the research facilities in Ny-Ålesund, Svalbard come from Kings Bay A/S, a state-owned company that facilitates research in Ny-Ålesund.

The sources I have used in locating Asian Arctic research articles[1] are the large worldwide databases Web of Science (WoS) and Scopus. However, while these are excellent for finding work published in Europe or North America, they are not comprehensive as to publications in Asia. Therefore I have also checked Korea Science,[2] the Indian database NISCAIR Online Periodical Repository,[3] the China Academic Journals Full-Text Database[4] and the gateway Science Links Japan[5]. Furthermore, I have consulted library resources from the polar institutes of these countries. Nevertheless, I do not claim that my findings are exhaustive; there certainly exists Arctic research that I have not located, for example in Asian languages. On a more macro-level, however, the figures should give a fair indication of publication trends. I chose to look at research for the years 2005 to 2012, as I wished to see whether there had been any recent changes. The latest International Polar Year (IPY) was 2007/2008, and I thought there might have been particularly high levels of activity around that time. Therefore, I also included two years prior to the IPY to account for this possible hike in activity level.

Counting 'research' is not as straightforward as is might seems at first. Since I was most interested in the Asian countries' research activity rather than the influence of individuals, I focused on publication counts, not citation statistics. I have 'whole-counted' the articles. That means that for each article with at least one, say Japanese author, I have counted the articles as one. Another option would be to do fractional counting: taking one article and dividing it by the number of authors (Pendlebury 2008:4). Using the fractional method, an article with one Japanese and one Canadian author would give each author 0.5 articles. As I was more interested in the output tendencies for the four countries in question than individual authors I opted for the whole-counting method. However, when articles are counted in this manner, one cannot simply add co-authorships: a figure of, say, 25% US co-authors and 25% Canadian co-authors does not necessarily mean that there were US and Canadian co-authors for half of the articles. Most likely some articles had both US and Canadian co-authors, and these were counted twice. In bibliometry where large databases are used for finding data based on searches of 'Arctic' in the title, keywords or abstract, there are possible sources of error. Not every article with 'Arctic' in it refers to the Arctic region. One

[1] I searched for articles from scientific periodicals; monographs and edited volumes were not included in this study.
[2] http://www.koreascience.or.kr
[3] http://nopr.niscair.res.in/
[4] http://www.cnki.net
[5] http://sciencelinks.jp/

example is the CMU ARCTIC[6] database, which has 'Arctic' in its name, but consists of statements and is used in speech recognition. I have removed such articles from the count. In other cases, some geographical areas might not be called 'Arctic' by all definitions, but as long as the authors themselves refer to the place of study as 'Arctic', I have counted these as part of Arctic research. Further, articles are arranged by country, on the basis of the author's institutional affiliation. Quite a few researchers are working abroad, and thereby represent another country than their native one. Given the number of Asian scientists working outside their native country, the picture could have looked different if this phenomenon could have been taken into account. In short, it should be noted that the publication statistics are not necessarily objective or free from human error.

I here define 'Arctic research' as 'research on the basis of material from the Arctic region, around Arctic-based phenomena or which is directly aimed at usage in the Arctic region'(Aksnes et al. 2012:12). Thus, this definition does not necessarily require the scientist to have been physically present in the Arctic area (Aksnes, Rørstad, & Røsdal 2012:13).

Arctic Research in Context

The USA is the largest Arctic research nation by publication volume, with the Fairbanks University of Alaska as the largest institution in this respect. The other littoral states – Canada, Denmark, Norway and Russia – also rank among the top seven countries on Arctic research publishing. Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden and the USA all have permanent research stations and facilities in their own countries within or close to the Arctic Circle. Canada has numerous stations, centres and facilities scattered in the northern parts of its territory. Denmark has the Danish Polar Center in Greenland; Sweden has stations in Abisko and Tarfala, as well as radar facilities in Kiruna. Finland has its Arctic Centre at the University of Lapland in Rovaniemi. The US Arctic Research Commission has offices in both Washington DC and Anchorage, Alaska. The four Asian countries covered in this study – China, India, Japan and South Korea – have research stations on the Svalbard archipelago, Norway. Longyearbyen is the largest settlement on Svalbard; it houses the University Centre in Svalbard, established in 1994, radar stations and other equipment. The Norwegian government has established the town of Ny-Ålesund as the international base for natural sciences on Svalbard. Here Norway as well as France, Germany, Italy, the Netherlands and the UK have established research stations, in addition to the four Asian countries covered in this study. Russia's research base on Svalbard is located in the old mining settlement of

[6] CMU_ARCTIC database was constructed at the Language Technologies Institute at Carnegie Mellon University. It consists of around 1150 utterances selected from out-of-copyright texts from Project Gutenberg. The prompt file used in the CMU_ARCTIC database were originally designed as US English single speaker prompt file for Speech Synthesis research (i.e. Text to Speech). Since it is phonetically balanced, it is used to generate prompt files for the creation of Speech Recognition Acoustic Models http://www.voxforge.org/home/docs/faq/faq/what-is-the-cmu-arctic-database

Barentsburg. Also Poland has a Svalbard research station outside Ny-Ålesund, at Hornsund.

Svalbard is the world's most northerly place equipped with modern infrastructure and research facilities. It is also ideal for reading of satellites with polar orbits. Already in the 1800s systematic exploration of the Svalbard archipelago commenced, and continued throughout the 1900s. Research in Ny-Ålesund is coordinated by the Ny-Ålesund Science Managers Committee (NySMAC), whose members are representatives from institutions with permanent research installations in Ny-Ålesund. The Svalbard Science Forum (SSF) is another coordinating organ for research; it maintains a database, Research in Svalbard (RiS), on all research projects conducted on Svalbard (Aksnes, Rørstad, & Røsdal 2012:57-59). Let us now turn to the four Asian countries of this study, starting with China.

China

In the summer of 1951, a team from Wuhan University's Surveying and Mapping Institute visited the magnetic North Pole and conducted surveys there. That was China's first scientific Arctic experience. China's first Antarctic expedition set off in 1984, followed by the opening of the Antarctic Great Wall Station in 1985. Then, during the 1990s, Chinese scientists several times joined the Arctic expeditions of other countries, and in 1999 China launched its first national Arctic expedition. However, it was not until 2004 that China opened a research station in the Arctic region: the Yellow River Station in Ny-Ålesund (AOSB 2005:19; CAA 2008). Since then, China's Arctic endeavours have steadily increased.

National Polar Institutions

China has two government-organized bodies for polar science, the Chinese Arctic and Antarctic Administration (CAA) in Beijing, and the Polar Research Institute of China (PRIC) in Shanghai. CAA and PRIC both report to the State Oceanic Administration (SOA), which in turn reports to the Ministry of Land and Resources (MLR).

The Chinese Arctic and Antarctic Administration (CAA)

In 1981 the Antarctic Expedition Committee was established, replaced in 1996 by CAA. CAA has a staff numbering around 40, including one Party Secretary. It has responsibility for organizing and drafting national polar research strategies, plans and regulations. Further, CAA supervises and coordinates China's polar expeditions and other research activities. It also has responsibility for raising Chinese public awareness and knowledge of polar issues, and coordinating international affairs. CAA has five sections, each dealing with different aspects of its responsibilities. The General Section functions as the secretariat and also undertakes responsibility for dealings with the Communist Party, while the Policy and Planning Section draws up polar plans and strategies and assumes the daily running of the Chinese Advisory Committee for Polar Research. The Science and Technology Development Section manages and plans annual science and technology projects and goals, while the International Section deals with all foreign ties (Brady 2010:762-765; CAA 2011a, 2011b, 2011c). The Advisory Committee was established in 1994. Its 14th meeting in 2012 was attended by representatives from the following bodies attended: the Ministry of Foreign Affairs, the National Development and Reform Commission, the Ministry of Education, the Ministry of Industry and Information Technology, MLR, the Ministry of Health, the Chinese Academy of Social Sciences (CASS), the Chinese Academy of Engineering, China Meteorological Administration, the National Natural Science Foundation, the National Mapping Geographic Information Bureau, the Navy Bureau, the Chinese Academy of Sciences (CAS), the Resources, Environment and Technology Bureau, and CAA (Brady 2010:765; The Central People's Government 2012).

The Polar Research Institute of China (PRIC)

PRIC was founded in 1989 and is located in Shanghai. While CAA has a generally administrative role, PRIC has more of a hands-on role. In addition to the research conducted through its divisions for various research fields, main tasks of PRIC include supervising polar research, as well as organizing polar expeditions, the Chinese National Arctic & Antarctic Research Expeditions (CHINARE), and serving as their domestic base. PRIC also has logistical responsibilities like management of China's research stations at both poles, and the research vessel and icebreaker XUELONG. As of 2006 PRIC had a staff of 124, one third of them scientists. PRIC also manages numerous laboratories, most notably SOA's Key Laboratory of Polar Science, along with other ones such as the Polar Snow Ice and Global Change Laboratory, Ionospheric Physics Laboratory, Auroral and Magnetospheric Physics Laboratory and Polar Organism Analytical Laboratory. Further, PRIC has information and data responsibilities: for example, it manages the Chinese Polar Science Database, a polar information network, the National Polar Archives of China, a Polar Library, polar science journals and a polar museum (Brady 2010:764; PRIC 2006).

In 2006 SOA founded the Research Fund for the Chinese Polar Science Strategy, which in the course of three years awarded more than 70 research applications a total of RMB 5,600,000 in funding (CAA 2010:58). Further, in 2012 SOA announced a new five-year polar research project on environmental issues and climate change, involving three Arctic missions and five Antarctic expeditions (CAST 2012a).

Research

Chinese scientists undertake studies in the Arctic in the fields of meteorology, glaciology, marine biology, atmospheric studies and the Arctic environment. One example is the ongoing Arctic Marine Scientific Investigation, which examines the rapid changes in the Arctic sea ice, and how marine ecosystems are responding. In 2010 the Chinese team completed a 24-hour observation sequence at depths of more than 3,700 meters in the Bering Sea (CAA 2010:5) In 2009, CAA accounted 12 Arctic research projects as completed; in the following year 21 projects were underway, and two completed (CAA 2009:7; 2010:5-8).

Publications

Measured in publication output, China's Arctic research increased markedly in the period 2005 to 2012. The yearly volume of Chinese Arctic journal articles more than doubled, with a clear increase between 2008 and 2009, and again between 2010 and 2012.

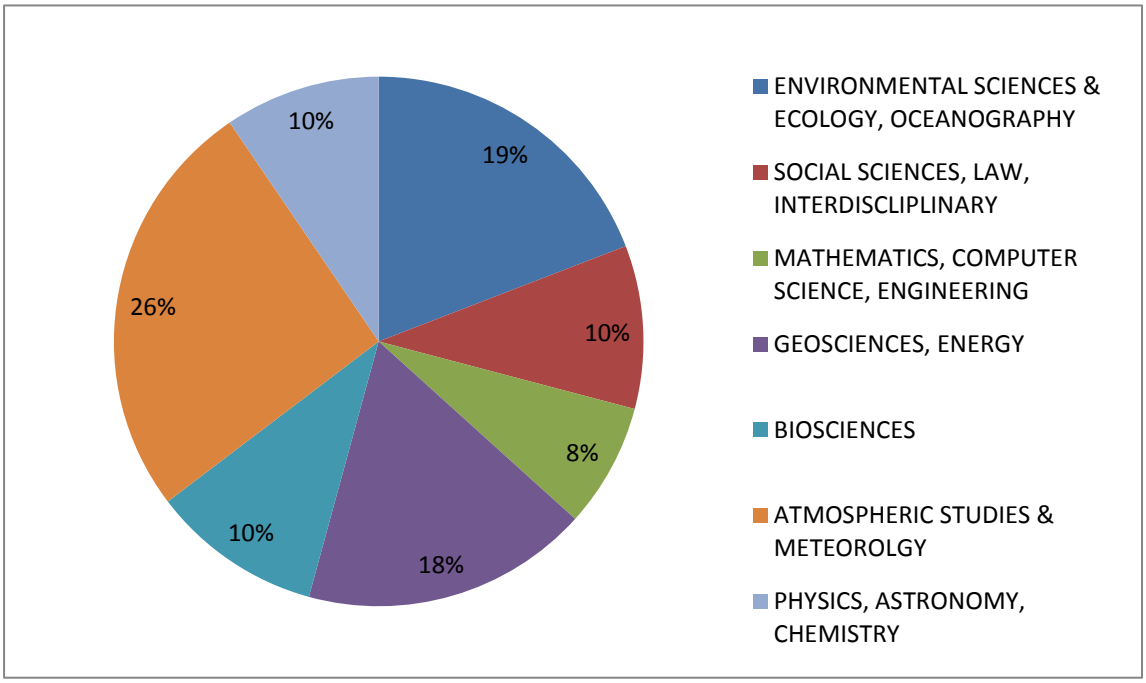
Table 1 Arctic research publications with Chinese author(s), 2005–2012

Year	*Number of publications*
2005	63
2006	62
2007	67
2008	85
2009	132
2010	141
2011	142
2012	189
Total	*883*

Of these articles, 44.4% (392) had only author(s) from China. Regarding co-authorship, USA was the largest collaborating partner, with co-authorship of 28.7% (253) of the publications, followed by the UK, with 9.1% (80) of the publications. Further, 40.5% (358) of the publications involved co-authorship with at least one scientist based in an Arctic Council state. There was collaboration with authors from the other three Asian countries in 8.0% (66) of the articles, with Japan as the most frequent Asian collaborating country (40, or 4.5%).

Thematically, the natural sciences dominate China's Arctic research. Atmospheric and meteorology studies are by far the most frequent topic (228), which reflects the importance of the Arctic region for understanding climate change. One example is Chen and Zhou's (2012) study of how Arctic Oscillation (atmospheric pressure patterns in the Arctic) affects the East Asian winter climate. Interestingly, a significant share concerned Arctic policy and governance: I found 45 articles (5.1%) concerning various governance aspects of the Arctic, all published after 2008. The *Journal of Ocean University (Social Science Edition)* published most of those (33, or 3.7%). Specific topics in policy articles ranged from country studies of Arctic Council member countries to resources and environmental problems, but all employed legal lenses, and explored the juridical implications for China.

Figure 1 Chinese publications 2005-2012 by discipline



The journals with the most publications by Chinese authors were the *Chinese Advances in Atmospheric Sciences* (36 articles) and *Acta Oceanologica Sinica* (28), both issued in China. Further, Chinese scholars frequently published in the international journals *Journal of Geophysical Research-Atmospheres* (27), *Journal of Climate* (23) and *Geophysical Research Letters* (23). There were many Chinese periodicals which published Chinese Arctic research. In fact, 22.1% (195) of the publications with Chinese authors I have gathered were published in Chinese journals. In total, I counted 62 Chinese journals. Journals which published Arctic research between 2005 and 2012 included *Science in China, Series D: Earth Sciences* (21), *Acta Meteorologica Sinica* (17) and *Chinese Science Bulletin* (15). PRIC and CAA publish the journal *Advances in Polar Science*.[7]

Arctic activity

Expeditions

China had by 2012 conducted five Arctic research expeditions. The first set out already in 1999, and the next two were in 2003 and 2008. The fourth Arctic expedition was conducted in the summer of 2010, and lasted 82 days. The research vessel and icebreaker XUELONG sailed to the Bering Sea, the Chukchi Sea and the Canada Basin with a research team of 121 on board. During the expedition Chinese scientists obtained a record-high number of biological samples from sea depths below

[7] It was first published in 1988 as *Chinese Journal of Polar Science*, with an English version starting in 1990. In 2011 the name changed to *Advances in Polar Science*. The journal is not covered by WoS or Scopus, so I have not counted articles published there.

3,000 m. The most recent expedition lasted for 85 days, and was conducted during the summer of 2012. This was the first time that a Chinese vessel had traversed the Arctic Ocean at such high latitudes. CAA has signalled that China is already planning two new expeditions by 2015. (CAA 2008; 2010:5,68; CAST 2012b; Xinhua 2012). Furthermore, China plans to build a second icebreaker research vessel, with work set to start in 2013. The new icebreaker is estimated to cost RMB 1.25 billion ($198 million) (CAST 2012b).

Ny-Ålesund

China has been active on Svalbard since 2004 when the country opened its Yellow River Station in Ny-Ålesund. The Yellow River Station lies on the same magnetic field line as the Chinese Zhongshan Station in the Antarctic. This allows for conjugated observations on upper atmospheric phenomena. Around the Yellow River Station, scientific studies have been conducted of the ionosphere, of the surrounding ecological environment, and of bacteria cultures (AOSB 2005:19; CAA 2010:87). China is the Asian country with the greatest share of nights on Svalbard in the period 2005–2012, and was the third largest in overnight stays in 2010, 2011 and 2012, after Norway and the German–French operations. As was the case with publication volumes, China almost doubled the number of scientists' nights on Svalbard between 2005 and 2012, with 2011 as the peak year.

In 2009 there were 32 scientists staying at the Yellow River station over the summer, and two in the winter season; in 2010 the corresponding numbers were 27 and eight. China's first Antarctic station was established in 1985. By 2012 the country had two year-round stations and one seasonal research station, with manpower volumes of 29 to 90. (CAA 2009:7; 2010:4; COMNAP 2012c).

Table 2 China's share of scientist overnight stays, Ny-Ålesund, 2005–2012

Year	*Number of registered nights*	*% of total nights*
2005	557	6.8
2006	595	6.3
2007	911	7.8
2008	749	6.0
2009	798	5.9
2010	914	6.7
2011	1215	9.3
2012	1029	8.4

The increase in China's Arctic scientific inquires has been rapid, but for the period 2005–2012 its Antarctic research was still proportionally greater. Also, in 2005, China made a breakthrough in Antarctica, reaching 'Dome A', a scientifically interesting Antarctic area previously unexplored. The ice under Dome A is important for understanding climate change; and information from the ice can be valuable for China's climate-change policy (Brady 2010:766-769).

Academic institutions

Many institutes and universities contribute to China's Arctic research. In the 1990s the Chinese Academy of Sciences (CAS), China Association for Science and Technology, and SOA were researching the Arctic regions (CAA 2008). Of the publications I noted, authors from various institutes under the larger CAS umbrella accounted for 40% (352) of the articles. Especially frequent were the University of Science and Technology of China in Hefei, the First and Third Institutes of Oceanography, SOA in Qingdao and Xiamen, National Center of Ocean Standards and Metrology in Tianjin, Ocean University of China in Qingdao, the Marine Development Strategy Research Institute of SOA, PRIC, CAS, CASS, Wuhan University and Dalian Maritime University. Policy research is conducted at the Ocean University of China, the China Institute for Maritime Affairs, the Marine Development Strategy Research Institute of SOA, PRIC, CASS, the Shanghai Institutes of International Studies, Dalian Maritime University, Fudan University, Wuhan University, Tongji University's Polar Research Center and the East China University of Politics and Law (CAA 2010:76; Jakobson & Peng 2012:5-6).

Conferences, cooperation & memberships

China is involved in many international scientific committees and bodies. Already in the 1990s, before the country had established a permanent Arctic facility, Chinese scientists were working together with scientists from Canada, Finland, Germany, Norway, Russia, and the USA (CAA 2008). China has continued its international cooperation activities in the present century. Both in 2009 and in 2010 Chinese and US counterparts held workshops on CO_2 observations and acidification of the Arctic Ocean. Other collaborating nations include Iceland and Korea. Chinese scientists are also active in participating in conferences outside China (CAA 2009:79; 2010:56,73-76). As regards scientific committees, bodies and research networks, China is represented in the International Arctic Science Committee (IASC), NySMAC, Pacific Arctic Group (PAG) and Arctic Ocean Sciences Board (AOSB), to mention a few. Further, China was also one of the founding members of the Asian Forum of Polar Sciences (AFoPS).

China has hosted a range of international Arctic symposia and conferences (see Table 3).

Table 3 Selected Arctic conferences hosted in China, 2005–2012

Year	*Conferences (hosting organization)*
2005	– 7th Arctic Science Summit Week, Kunming, 17–24 April, (CAA)
	– 24th AOSB Annual Meeting 2005 Kunming, 17–18 April
2009	– PAG marine carbon-cycle seminar, 29 June–1 July, Xiamen
	– 10th Asian Forum on Polar Sciences, July 9–10, Shanghai
	– PAG IPY Summing-up Meeting, 21–22 October, Beijing (PRIC)
2010	– Sino-Canadian Workshop on the Arctic, 25– 27 Feb, Beijing & Shanghai (CAA & PRIC)
	– 11th AFoPS Meeting Suzhou, 7-9 July

In conclusion, China's Arctic scientific research has grown considerably from 2005 to 2012, in publication output as well as activity in the Arctic region. Three of five Arctic expeditions were conducted during the timeframe studied here, each two years apart. Also, the number of over-night stays at the Ny-Ålesund research station doubled from 2005 to 2012. Apart from PRIC and SOA's various labs and locations, many centres and institutes under CAS and other research institutions published Arctic-relevant research. Nevertheless, China's Arctic endeavours are on a smaller scale than its Antarctic undertakings. Also noteworthy is that some Chinese academics have put emphasis on the legal and governance aspects of the Arctic.

India

Of the four countries studied here, India is the most recent to commence Arctic research. However, the country is no stranger to polar research; although it established its Arctic research station as recently as 2008, India's Antarctic research endeavours started in 1981 and a research station was established already in 1983 (COMNAP 2012a). Antarctica seems to be the focal point of India's polar research, but, as will become apparent, the Arctic has become increasingly prioritized. The Arctic is of particular interest to Indian research, as several studies have indicated that there are tele-connections between the Arctic region and Indian monsoon intensity (Nayak 2008:356). With stations at both poles, India has an advantage in data collection and comparison. As a developing country with prospects to experience climate change, India is committed to understanding the mechanisms behind climate change, and this has been signalled as the focal point of Indian research for the two coming decades (The Hindu 2011). The Arctic region is suitable for such studies. Further, India's management of its Himalayan areas requires a comprehensive understanding of glaciology.

National Polar Institutions

It is the **National Centre for Antarctic & Ocean Research (NCAOR)** in Goa which coordinates and has overall responsibility for the implementation of India's Antarctic and Arctic research programmes. The Centre is autonomous, but part of the Ministry of Earth Sciences (MoES). In addition to the Antarctic Programme and Southern Ocean Expeditions, the NCAOR's responsibility for the Arctic Programme involves both coordination and execution of multidisciplinary research (NCAOR 2012a). NCAOR has a core staff of about 50, but with affiliated researchers and project members the number reaches approximately 110. The centre was important in facilitating India's 2010 submission of claims to an extended continental shelf to the UN (NCAOR 2011a:7,24). Further, NCAOR administers and maintains India's oceanic research vessel SAGAR KANYA. India is planning to build a polar research vessel. At the time when this report was prepared, six companies had been shortlisted for construction of the vessel (NCAOR 2012a).

MoES, formerly was called the Department of Ocean Development, has overall responsibility for development of technology needed for marine harvesting and for understanding the chemical and climate processes in the polar regions. In 2006, the India Meteorological Department was incorporated into MoES, in order to facilitate better understanding of atmospheric and earth dynamics (SaGAA 2011a). Also the Ministry of Environment & Forests and the departments of Science & Technology and of Biotechnology at the Ministry of Science & Technology, Legal and Treaty Division at the Ministry of External Affairs have been involved in polar research (SaGAA 2011a, 2011b).

Research

Publications

India's Arctic research includes atmospheric, biological, marine and earth sciences and glaciological studies. The country's atmospheric research include investigations into aerosols and precursor gases as regards their radiative, physical-chemical and optical properties (NCAOR 2011a:37) and studies of the effects of space weather on the auroral ionosphere (NCAOR 2011b:7). Biological studies include sea-ice microbial communities; and in marine research, surface sediments and sea-water salinity have been investigated (NCAOR 2011a:37; 2011b:7). Earth sciences and glaciological observations include studies of snow-pack production of carbon monoxide and its diurnal variability. One project, started as early as in 2007, maps the Broggen glacier on Svalbard (NCAOR 2011a:38; 2011b:7).

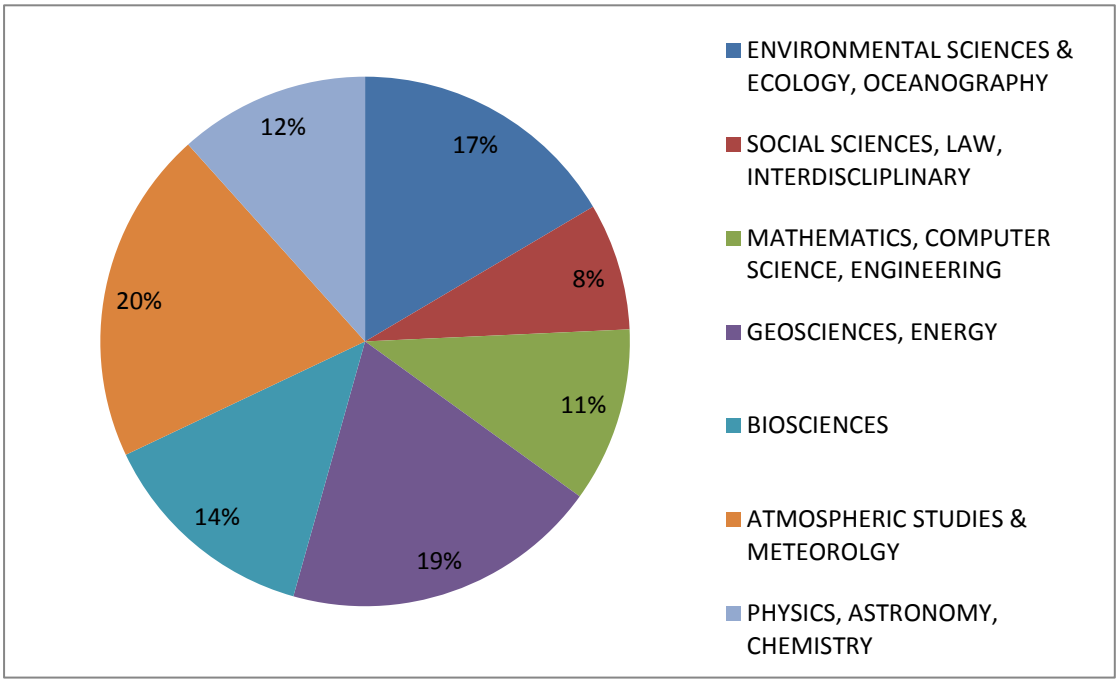
Table 4 Arctic research publications with Indian author(s), 2005–2012

Year	*Number of publications*
2005	6
2006	5
2007	4
2008	12
2009	17
2010	9
2011	29
2012	21
Total	103

Looking at India's research activities in terms of publication output the annual numbers have been modest. After a dip in 2010, the trend is now an increase. In fact, from 2005 to 2012 the increase is 300%. Annual outputs reflect the opening of the Himadri station in Ny-Ålesund in 2008; since then, research output has increased considerably.

Thematically, the largest share of articles concerned atmospheric studies and meteorology (21, or 20%). Quite similar in size was the output for geosciences (20, 19%) and environmental sciences (17, 17%). Furthermore, 12% (12) of the articles pertained to observations of sea ice using radiometry or other forms of remote sensing. One example is Oza et al. (2011), who used scatterometer data to construct an algorithm for predicting sea ice.

Figure 2 Indian publications 2005–2012 by discipline



Collaboration across countries was not prevalent: 63.1% (65) of the articles had Indian author(s) only. The country with most co-authorships was the USA (18.4%, 19); authors from Arctic Council countries appeared as co-authors in 27.2% (28) of the articles; and 9.7% (10) of the articles were co-written with colleagues from the three other Asian countries.

Almost one fourth of the articles – 24.3% (25) – were published in Indian periodicals. The Indian journal with most Arctic research articles was *Mausam* (five articles) and *Journal of the Geological Society of India* (four). Of international journals, *Polar Research*, *Polar Biology* and *Journal of Geophysical Research D: Atmospheres* were the most frequent publication outlets (four articles each). In total, I found 12 Indian periodicals which published Arctic research.

Since the Himadri station was opened in 2008, some attention has been devoted to studying Arctic policy and governance. At the two conferences held in India in 2011 and 2012, the geopolitics of the polar regions were among the themes (SaGAA 2011b, 2012). The Indian Council of World Affairs (ICWA) published some issue briefs focusing on the role of Russia, China or the Artic Council role in Arctic governance (Sakhuja 2010a; 2010b; 2010c; 2010d; 2010e; 2010f).

Arctic activity

In August 2007 a five-member Indian scientific team for the first time stayed in Svalbard for a prolonged time. The team were there for one month, undertaking atmospheric science, microbiology, and earth science and glaciology research. This expedition was followed in March 2008 by a seven-member Indian research team who followed up on the summer

2007 research (NCAOR 2011b:7). India opened its research station Himadri in Ny-Ålesund in 2008, becoming the tenth country with a research station in Ny-Ålesund. Priority research areas, as announced in the plan for Himadri, are biochemistry, genetics, geology, glaciology, long-distance pollutants, atmosphere and space weather (Kings Bay AS 2010:12). May 2010 marked the beginning of a long-term marine-science monitoring programme of Kongsfjorden on Svalbard (NCAOR 2011a:37). For comparison, India's Maitri station in Antarctica has an average researcher winter population of 25, with as many as 65 in peak season (COMNAP 2012a).

Table 5 India's share of scientist overnight stays, Ny-Ålesund, 2005–2012

Year	*Number of registered nights*	*% of total nights*
2008	493	3.9
2009	420	3.1
2010	436	3.2
2011	843	6.5
2012	688	5.6

In June 2010 the Indian Minister of Earth Sciences, the Norwegian Minister of Education and India's ambassador to Norway together visited India's research station on Svalbard. On that occasion an Indian Arctic web portal was launched[8] (Kings Bay AS 2011:20; NCAOR 2011a:9). Further, India leased 15.8% (316 days) of the days, at the Kings Bay Marine laboratory[9] in 2011, and was thus among the most active countries using the laboratory that year (Kings Bay AS 2012:19). India has sent expeditions to the Arctic and Svalbard a few times every year since 2007. NCAOR plans to send expeditions yearly at least until 2014 (NCAOR 2012b:3,9; Sakhuja 2010:4).

Academic institutions

The first Indian expedition to Svalbard included staff from NCAOR, Centre for Cellular and Molecular Biology, the Indian Institute of Tropical Meteorology and from the Department of Geology at Lucknow University (NCAOR 2011b:7). Other institutions which conduct Arctic research include the Space Applications Centre, Bhabha Atomic Research Centre, the National Geophysical Research Institute and the Centre for Cellular and Molecular Biology.

Conferences, cooperation & memberships

Two conferences were held both in 2011 and 2012, *National Conference on Science & geopolitics of Arctic & Antarctic*,(SaGAA) supported by

[8] http://210.212.160.135:5050/website/index.html Not operational as per 16.05.13
[9] opened in 2005 and owned by Kings Bay AS

NCAOR and MoES (SaGAA 2011b, 2012). In September 2012 the Association of Indian Diplomats at the Indian Council of World Affairs (ICWA) held a discussion on 'Arctic and India', where participants came from also the Institute for Defence Studies and Analyses (IDSA) (IDSA 2012). Further, in 2012, IDSA in New Delhi arranged a workshop: *Governance and Resource Use: The case of the Arctic.*

Judging from the academic studies I have found, Indian scientists publish mostly in collaboration with other Indian institutes. Internationally, the UK is the main collaborating country for Indian scientists. There are also quite a number of publications written jointly with scientists from US institutions. Regionally, Japan is the country India has collaborated most with as regards Arctic publishing in 2005–2012. India is a member to the NySMAC, IASC, Interridge and Polenet. India was also one of the founding members of AFoPS.

All in all, India is the most recent Asian country to engage in Arctic research, but has more than 30 years' experience with Antarctica. It is an active participant in relevant Arctic science forums and committees. While its publication output is small in comparison to the other three countries, India's Arctic research focuses on atmospheric, marine and glaciological science, and there is a growing domestic interest in governance issues.

Japan

Japan has a polar history more than a century long. The country's first polar expedition was led by Lieutenant Nobu Shirase 1910–1912, reaching Antarctica in January 2012. 45 years later, the Japanese established their Syowa Station in Antarctica. Japan was also one of the 12 original signatories to the Antarctic Treaty in 1959. Since then, Japan has conducted research and scientific expeditions around the South Pole, although exploration of the Arctic did not begin until the 1990s (NIPR 2012d:39). Reflecting its long history of polar research, Japan is also the Asian country with most international scientific body affiliations.

National Polar Institutions

National Institute of Polar Research (NIPR)

NIPR was established as early as in 1973 under the Ministry of Education, Culture, Sports, Science & Technology (MEXT). It is Japan's key institution for polar science, with management responsibility for Japan's stations in Antarctica and on Svalbard. NIPR's Division for Research and Education is organized in groups focusing on space and upper atmospheric science, meteorology and glaciology, geoscience, bioscience, polar engineering; there is also one group dedicated to advanced scientific research. In 2012, NIPR conducted 13 additional research projects, two of which solely on the Arctic region. Both focused on environmental aspects of climate and environmental change in the Arctic. NIPR has about 250 employees, with an administrative staff of 27, but in 2012 an additional 300 researchers were associated with the institute through its various collaboration projects. In 1990 **the Arctic Environment Research Center (AERC)** was established within NIPR. AERC was reorganized in 2004; its main tasks are to manage the Ny-Ålesund research station and to facilitate research activities for Japan's research organs in the Arctic region. Further AERC-designated responsibilities include data collection and maintenance of a homepage[10] and the annual publication, *Arctic Research Directory*.[11] NIPR also manages several databases, including a database for polar biodiversity and the World Data Center for Aurora (which started back in 1981), and the Polar Data Center, which has continuous communication with the Antarctic by satellite, and the Arctic through the internet. In addition to these, NIPR has an extensive polar library, and supports awareness-raising activities and informing the public through its Polar Science Museum and public lectures. As of May 2012 NIPR's operations were estimated to cost YEN 3,906,593,000, (approx. USD 47,600,000), up from YEN 3,176,000,000 and YEN 3,318,000,000 in 2010 and 2011 (COMNAP 2012b; NIPR 2012a, 2012b, 2012c, 2012d).

Polar research is an integral part of Japan's greater science structure. NIPR is under the Research Organization of Information and Systems

[10] http://www.nipr.ac.jp/aerc/
[11] http://www-arctic.nipr.ac.jp/E-direct-top.html

(ROIS), a parent organization to NIPR and the other national institutes, the National Institute of Informatics, the Institute of Statistical Mathematics and the National Institute of Genetics.[12] The intention is to facilitate holistic and interdisciplinary research on issues vital to humanity in the 21st century. In turn, RIOS is one of Japan's four Inter-University Research Institute Corporations. They were organized as such in 2004 on the basis of the National University Corporation Act, and reflect how the Japanese government has focused on the country's scientific advancement. NIPR itself had been made an Inter-University Research Institute Corporation in 1973. Under ROIS, NIPR and the other three institutes are linked through the Transdisciplinary Research integration Center, which is aimed at creating new paradigms in the fields of Earth Environment, Life and Human and Social Systems. Here NIPR is contributing life and earth science knowledge. Further, NIPR is teaching the courses at the Department of Polar Science within the ROIS realm, the Graduate University for Advanced Studies (SOKENDAI), which offers only doctoral courses. In 2012,15 students were enrolled at the department (NIPR 2012d:4,32; ROIS 2011:2-19).

Further, there is the **Japan Consortium for Arctic Environmental Research (JCAR),** a network for Japanese scientists with approximately 300 members. The secretariat is located at NIPR. In addition to supporting members' research JCAR organizes research plans and infrastructure. Its Steering Committee has 20 members, from various universities and research institutes. JACR's three working groups deal with data archiving, research interaction and early career development. Beyond the network itself, JCAR makes recommendations to MEXT and disseminates research outcomes to the public (JCAR 2012).

Research

Japanese polar scientists are engaged in research in many areas from oceanography, biology, glaciology, to geoscience and geochemistry and atmospheric studies in the Arctic. In many cases, the research is applied in tandem with data obtained from Antarctica.

Some 6% of the patents or patent applications based on Arctic genetic resources were filed in Japan – the only Asian country of the four studied here to have a record of patent applications based on Arctic resources. The largest applicant country in this regard is the USA (66%), followed by Russia (10%). Japans shares third place with Finland and Norway , which also hold 6% each (Leary 2008:23).

The Green Network of Excellence's (GRENE) Arctic Climate Change Project.

Following a cabinet decision on new growth strategies for Japan in 2010, MEXT initiated the Green Network of Excellence's (GRENE) Arctic Climate Change Project in 2011. AERC at NIPR is the core institution for

[12]as well as the Transdisciplinary Research Integration Centre and the Database Centre for Life Sciences.

this project, which is scheduled to run from 2011 to 2016. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is an associated institute. The project engages close to 300 researchers at 35 organizations. The focus of the project is four-fold: to understand the mechanisms of increased warming in the Arctic; to understand how the Arctic is influencing the global climate; to assess how the changes in the Arctic region will impact on Japan's weather, climate marine ecosystems and fisheries; and fourthly, to elaborate projections of how ice distribution will change and influence Arctic sea routes. The budget for the Arctic Climate Change Project was approximately EUR 6.5 million in 2011 and EUR 5.7 million in 2012.

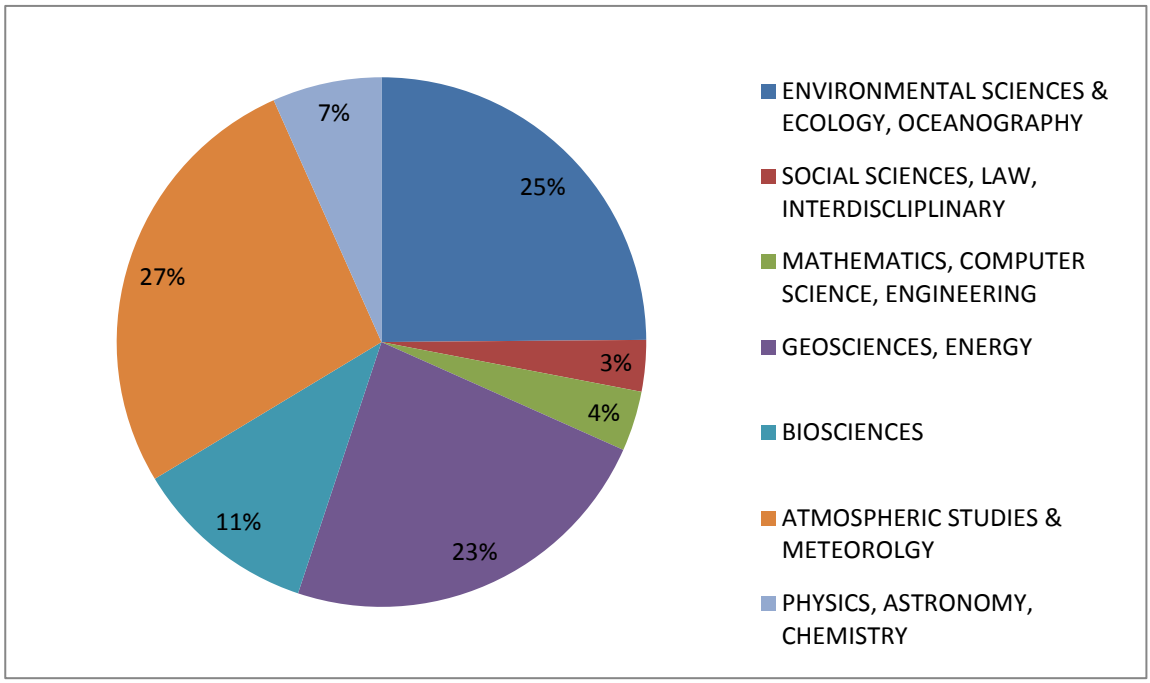
Table 6 Arctic research publications with Japanese author(s), 2005–2012

Year	*Number of publications*
2005	97
2006	102
2007	91
2008	85
2009	96
2010	96
2011	94
2012	103
Total	764

Publications

Research output remained high and relatively stable from 2005 to 2012. Japanese researchers collaborated across borders on 61.1% of the publications, most frequently with researchers in the USA – in 34.9% (267) of the articles. Canadian partners came next, co-authoring 15.2% (116) of the articles, followed by German scholars, with 13.6% (104). Scholars from Arctic Council countries co-authored half of the articles (50.9%, 389). By contrast, only 7.9% (60) of the articles were co-written with one or more partner from China, Korea or India. As to content, atmospheric and meteorological studies made up the largest portion (206, or 27%) of the articles. One example is the article by Yukimoto et al. (2012), at the Meteorological Research Institute, which formulated a new global climate model, MRI-CGCM3, improving on earlier models. This category of research is closely followed by environmental sciences (190, 25%) and geosciences (179, 23%). Together, they make up 75% of all the publications.

Figure 3 Japanese articles 2005–2012 by discipline



Japanese researchers published most in the two periodicals *Geophysical Research Letters* and *Journal of Geophysical Research-Atmospheres* (63 articles in each). Articles in these two journals alone made up 16.5% of Japan's total Arctic publication output. Other frequently-used international periodicals were *Journal of Geophysical Research-Oceans* (25) and *Atmospheric Chemistry and Physics* (21). In addition, Japanese scientists published in NIPR's various journals, such as *Polar Science*[13] (20), *Polar Bioscience* (6) and *Antarctic Record* (16). Further, NIPR issues *NIPR Arctic Data Reports* and *Memoirs of National Institute of Polar Research* on an irregular basis. Also, *the Journal of the Meteorological Society of Japan* (27) and *SOLA* (Scientific Online Letters on the Atmosphere) (14), published by The Meteorology Society of Japan, were frequent outlets between 2005 and 2012. 17.8% (136) of the articles were published in Japanese periodicals, of which I found 17 in total.

Arctic activity

At Japan's Ny-Ålesund station, research is conducted on radiation, clouds, aerosols and greenhouse gases, vegetation and soil microbiology. As part of the international NEEM project, ice cores from Greenland are used to study environmental changes in the past. Japan is also involved in observation of marine ecosystems in the Arctic Ocean (NIPR 2012d:23). Japan has been active on Svalbard since 1990 and was the first of the Asian countries studied here to set up an Arctic research station, in 1991.

[13] This journal was founded in 2007, and merged the earlier periodicals *Advances in Polar Upper Atmosphere Research*, *Polar Meteorology and Glaciology*, *Polar Geoscience* and *Antarctic Meteorite Research (NIPR 2013).*

Also, NIPR has an office at the University Center in Svalbard. Moreover, Japan was one of the first countries to set up an Antarctic research station – as early as in 1957 (COMNAP 2012b; NIPR 2012b).

Table 7 Japan's share of scientist overnight stays, Ny-Ålesund, 2005–2012

Year	*Number of registered nights*	*% of total nights*
2005	252	3.0
2006	198	2.1
2007	90	0.8
2008	249	2.0
2009	281	2.1
2010	417	3.1
2011	299	2.3
2012	302	2.5

Japan is the Asian country with lowest share of scientist overnight stays at Ny-Ålesund. One explanation is perhaps that Svalbard is not the only Arctic location where Japanese researchers conduct research. In 2012 Japanese scientists also worked in Iceland, Greenland and at stations in northern Scandinavia (NIPR 2012d:4). As Japan has several ships fitted for Arctic scientific explorations, more of the research can be conducted at sea. Japan's focus on Antarctica has been even greater than its Arctic undertakings: as of 2012, Japan had one year-round Antarctic station, three seasonal ones and one camp in operation, with manpower ranging from 28 to 125 (COMNAP 2012c).

Academic institutions

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) is important in polar research because it has been mandated to manage Japan's research vessels. JAMSTEC operates the Compact Arctic Drifter, whose sensors provide information on water temperature, salinity, current direction and velocity, and the Marine Robot MR-X1, built to handle oceanographic observations in parts of the Arctic Ocean where it is difficult for manned vessels to conduct surveys. Additionally, JAMSTEC manages the icebreaking-capable research vessel MIRAI, which is equipped with Doppler radar, among other instruments (JAMSTEC 2007a, 2007b, 2011). Further, **the Aerospace Exploration Agency (JAXA)** is important in satellite observation of the Arctic. Other Japanese institutions engaged in Arctic science include the University of Tohoku, Hokkaido University, the University of Tokyo, the University of Tokyo of Science and Technology and the Meteorological Research Institute.

Conferences, cooperation & memberships

Quite a few Arctic conferences and meetings were held in Japan during the 2005–2012 period studied here. Japan has taken the initiative to two symposium series, the International Symposium on Arctic Research (ISAR) and the Symposium on Polar Science, the latter held in conjunction with other, thematically narrower symposia.[14]

Table 8 Selected Arctic conferences hosted in Japan, 2005–2012

Year	*Conferences (hosting organization)*
2005	– Third International Symposium on the Arctic Research & the Seventh Ny-Ålesund Scientific Seminar, Tokyo, 22–24 February (NIPR)
2007	– International Symposium Asian Collaboration in IPY 2007–2008, Tokyo, 1 March (Science Council of Japan)
2008	– First International Symposium on Arctic Research (ISAR-1) Tokyo, 4–6 November (Science Council of Japan)
2010	– Symposium on Polar Science, Tokyo, 1–2 December (NIPR) – Second International Symposium on Arctic Research (ISAR-2) Tokyo, 7–9 December (Science Council of Japan)
2011	– Second Symposium on Polar Science Tokyo, 14–18 November (NIPR)
2012	– Third Symposium on Polar Science, Tokyo, 26–30 November (NIPR)

NIPR and Japan's Arctic research, universities, institutes and programmes are organized to promote cooperation across institutional borders and seek to foster interdisciplinary research results. Internationally, Japan is also the most active country of the Asian countries studied here. NIPR has a total of 18 international exchange agreements with 11 countries, including with the Chinese and Korean counterparts PRIC and KOPRI. Other relevant agreement institutes for Arctic research include the International Arctic Research Center, University of Alaska; the Science Institute, University of Iceland; the Swedish Institute of Space Physics; the University of Tromsø, Norway, and the Norwegian Polar Institute. Already in 1996 NIPR joined the European Incoherent Scatter Scientific Association (EISCAT), whose satellites make exploration of the upper atmosphere possible. Further, Japan is a member of many international Arctic science organizations and networks, such as IASC, AOSB, NySMAC and AFoPS; and NIPR has members represented at each of these organizations (NIPR 2012d:15,28,38). Moreover, Japan was the

[14] In 2012 the following meetings were held simultaneously: the Third Symposium on Polar Science, the 36th Symposium on Space and Upper Atmospheric Sciences, the 35th Symposium on Polar Meteorology and Glaciology, the 32nd Symposium on Polar Geosciences, the 34th Symposium on Polar Biology and the 35th Symposium on Antarctic Meteorites (NIPR 2012e)

only Asian country represented at the 2009 UNESCO International Expert Meeting, 'Climate Change and Arctic Sustainable Development: scientific, social, cultural and educational challenges' (UNESCO 2009).

To sum up, over the period investigated here, Japan showed a solid foundation in Arctic research. It was first Asian country with research stations at both poles. In terms of publication volumes, research output between 2005 and 2012 was stable at a relatively high level. Polar research is situated within a larger domestic R&D structure, aimed at promoting the future development of the country. Further, Japan is the Asian country involved in most internationally scientific bodies and networks.

Korea

Korea's history of polar research extends back to the 1980s. In 1985 it acceded to the Convention on the Conservation of Antarctic Marine Living Resources, and signed the Antarctic Treaty in the following year. In 1988 the Antarctic King Sejong Station was inaugurated, marking the first time a Korean research team conducted surveys in Antarctica. In 2011, Korea celebrated its 25th anniversary of Antarctic overwintering teams. As for Arctic ventures, the Korean Arctic Science Council (KASCO) was set up in 2001, and in 2002 the Arctic Dasan Station was opened. The same year the Korean National Committee on Polar Research (KONPOR) was established as well. Another milestone in Korea's polar history came with the completion of the research icebreaker ARAON in 2009. The vessel was swiftly put to use, and sent on an expedition to the Arctic the following month, and again in the summer of 2010 (KOPRI 2012a).

National Polar Institutions

The Korea Polar Research Institute (KOPRI)

KOPRI conducts scientific research, surveys and long-term observations on issues that require data from the polar regions, and coordinates domestic and international cooperation research projects. It also contributes to Korean policy and public services by delivering information to the Korean government and other stakeholders (KOPRI 2012c). KOPRI has close to 300 employees in total; around 220 of these are scientists, including doctoral students. Most of these scientists and specialists are working with natural science topics; the Department of Policy has only four specialists (KOPRI 2012b).

In accordance with its 2011 Marine Technology Road Map, the Ministry of Land, Transport and Maritime Affairs (MLTM) has decided to devote about KRW 3.6 trillion (approx. USD 3.3 billion) by the year 2020 to marine and polar technology development, in order to strengthen national competitiveness in the marine and polar fields. This will also mean increased emphasis on Arctic and Antarctic research. (KIOST 2012a). MLTM opened the **Korea Institute of Ocean Science and Technology (KIOST)** in July 2012, as a successor to the Korea Ocean Research and Development Institute (KORDI), which had been opened in 1973. KIOST is Korea's only government-run research institute in the field of ocean sciences. Korea has ambitions for its polar research and the country's development. KIOST's personnel is planned to increase to 1,100 and it has promises of governmental budgeted funds to reach KRW 700 billion (approx. USD 640, 000) by 2020. KIOST aims at helping the marine industry and polar research in Korea to flourish, by introducing a new model of academic–industrial cooperation where positions are to be held simultaneously at universities and KIOST. Further, KIOST aims at increasing status of Korean coastal cities of Busan and Incheon as hubs for ocean and polar research and industry (KIOST 2012b).

Research

Korea has undertaken oceanographic research in the Arctic Ocean since 2000. This was started with the aim to understand the global environmental and climate change. The first cruise visited the Barents and Kara Seas and was a collaborative undertaking with Russian research institutes.

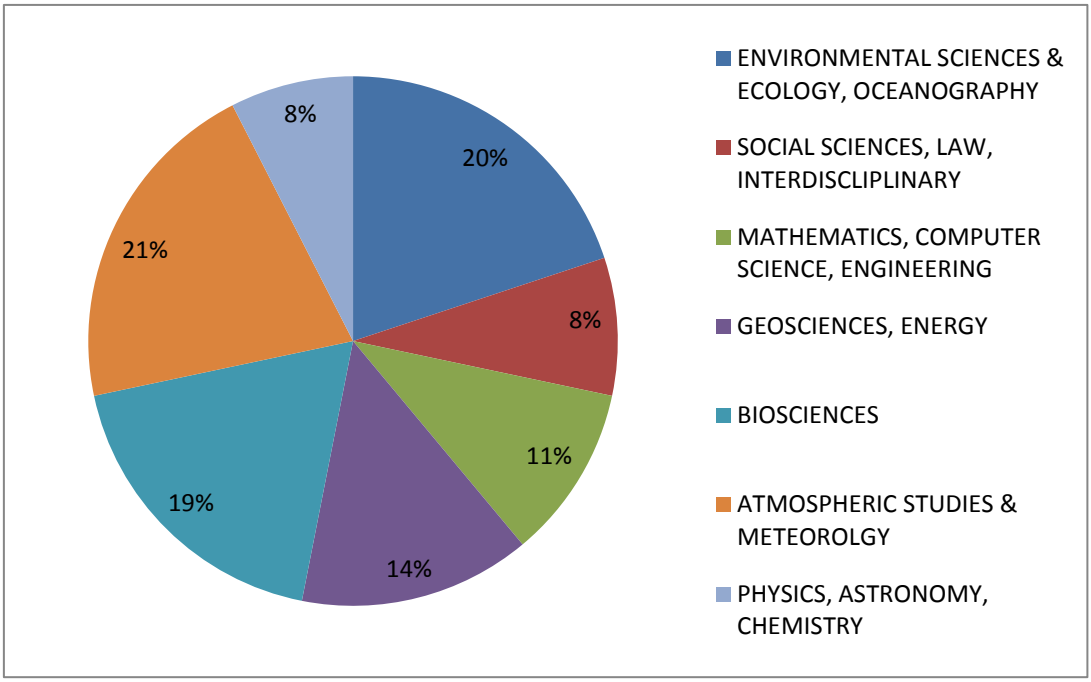
Table 9 Arctic research publications with Korean author(s), 2005–2012

Year	*Number of publications*
2005	14
2006	12
2007	23
2008	27
2009	22
2010	38
2011	46
2012	44
Total	226

As to annual research output, despite a dip in the 2009 number, the tendency is clear: the increase from 2005 to 2012 is over 130%. My publication review shows that atmospheric and meteorological studies (47, 21%), together with environmental sciences and oceanography (45, 20%) were the most recurrent topics of the Korean research articles. However, across the categories also another theme: shipping, tanker and vessel constructions were in focus in 13% (29) of the articles. Kwon et al.'s (2008) discussion of LNG transportation in the Arctic is one example here.

When it comes to co-writing with international partners, colleagues from the USA were by far the most frequent (94, 42%). Canadian colleagues were the second largest group, appearing as co-authors in 9% (21) of the articles. Researchers from the Arctic Council countries were listed as co-authors in more than half of the articles (116, 51%,). Co-authors from the three other Asian countries studied here accounted for total of 18% (41), whereas 38% (85) of the articles were written solely by Korean author(s).

Figure 4 Korean publications 2005–2012 by discipline



Korean scientists published most frequently in international journals, especially in *Journal of Geophysical Research-Atmospheres* (9, 4%), *Journal of Bacteriology* (9, 4%) and *Geophysical Research Letters* (8, 4%). In addition to publications in international journals, 24% (55) of the articles were published in national periodicals. The Korean Ocean Research and Development Institute publishes the journal Ocean *and Polar Research* (11, 5% of the articles), a quarterly publication founded in 2001 in both English and Korean. Other journals which also have published on Arctic research include *Journal of the Society of Naval Architects of Korea* (6, 3%), *Journal of Microbiology* (5, 2%) and *Journal of Ocean Engineering and Technology* (4, 2%). I found 24 Korean journals which had published one or more articles on Arctic research.

Arctic activity

Korea opened its research station Dasan in Ny-Ålesund in 2002. As of September 2010, 48 researchers had been at the station that summer season, working on studies of biodiversity, micro-scale microbial diversity in the coastal region of Ny-Ålesund and optimization of satellite data usage for accurate monitor of Arctic marine ecosystems. KOPRI conducted the project 'Integrated research on COMposition of Polar Atmosphere and Climate Change' (COMPAC), from 2006 to 2010. The aim of this project was to understand the role played by the polar regions in climate change for mid-latitude areas (KOPRI 2010). The number of Korean overnight stays has varied from 318 to 541. The peak came in the years around the International Polar Year; and in 2010, the first year the research vessel ARAON was operational, the volume dropped somewhat (KOPRI 2009).

Table 10 Korea's share of scientist overnight stays, Ny-Ålesund, 2005–2012

Year	*Number of registered nights*	*% of total nights*
2005	318	3.7
2006	541	5.7
2007	497	4.3
2008	488	3.9
2009	508	3.8
2010	320	2.3
2011	370	2.8
2012	459	3.8

Academic institutions

In addition to KIOST and KOPRI, Korea Maritime University is an important Arctic research institution (KIOST 2012b). Other leading universities include Seoul National University, Hanyang University, Pukyong National University, Pohang University of Science and Technology, and Incheon University. The Korea Maritime Institute (KMI) is a think-tank of Korean government under the umbrella of the National Research Council for Economics, Humanities and Social Science, has responsibility for developing research on the international ocean policy including Arctic Ocean issues.

Conferences, cooperation & memberships

KOPRI hosts an international polar sciences symposium series which started in 1994. In May 2012 the 18th symposium was held in Jeju Island in Korea. Around 200 participants from 19 countries attended, and the conference was supported by the Korean Ministry of Education, Science and Technology (MEST), MLTM and Korea Research Council of Fundamental Science & Technology (KRCF). Panels at the 18th symposium included atmospheric sciences, oceanography, glaciology, geosciences, biology and paleoclimate and paleoceanography. Further, five side-events were held in conjunction with the symposium, including a meeting for the Association of Polar Early Career Scientists and a business meeting on the Arctic paleoceanographic expedition of the Korean research vessel ARAON. At the previous symposium, held at KOPRI's offices in Incheon in May 2010, the topics discussed all related to physio-ecological responses to climate change in the polar regions. The 16th symposium, held in June 2009, gathered some 150 participants from 11 countries. In March 2011, Korea took hosted the Arctic Science Summit Week, sponsored by MEST, MLTM, KRCF and the Ministry of Foreign Affairs and Trade. In 2012, KMI and the US East–West Center established the North Pacific Arctic Conference, planned to run from 2012 to 2016, where participants from Canada, China, Japan, Korea, Norway Russia and the USA, are to explore options for developing a

North Pacific Rim conference on emerging Arctic issues (Young et al. 2012). Korea is a member of many international Arctic scientific organizations, among them AFoPS, AOSB, the Forum of Arctic Research Operators (FARO), IASC, Polenet and PAG.

In short, the Korean government has in the period 2005 to 2012 dedicated considerable resources to the country's polar research, with the completion of the icebreaker AROAN in 2009, and opening of KIOST in 2012. The country is also an active partner in the international Arctic scientific community.

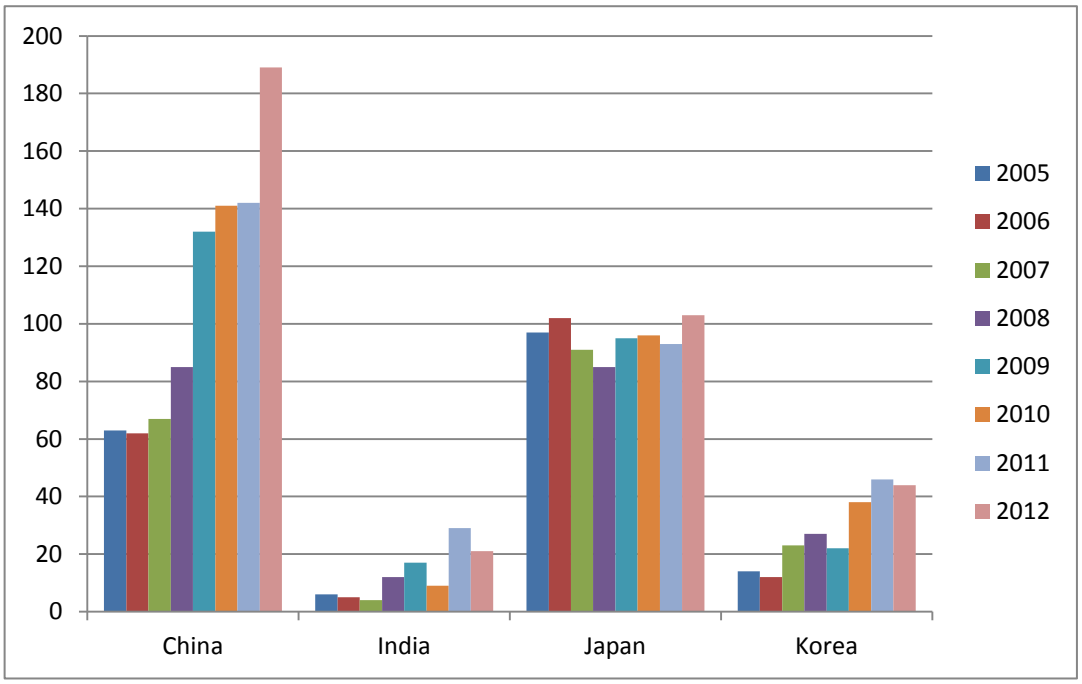
Comparisons and comments

There are both similarities and differences in the Arctic research efforts of these four Asian countries. An underlying concern with the impacts that climate change is having and will have on the future coupled, with the Arctic region as a precursor, can explain the high level of research related to climate change.

In the period 2005 to 2012 all four stepped up their investments and resources for Arctic research. China initiated a Polar Research Fund in 2006 and commissioned a second research vessel with icebreaking capacities. Japan started the GRENE Arctic Climate Change Project in 2011. Korea saw the completion of its icebreaker ARAON and in 2012 the establishment of KIOST, as well as the MLTM grant for marine and polar technology. And India opened its Svalbard station and commissioned an icebreaker.

Figure 5 shows the output tendencies of the four countries. All except Japan have had an increase of more than 100% in publication volumes. Whereas Japan's output remained relatively stable, the two jumps in China's statistics – between 2008 and 2009, and then again between 2011 and 2012 – stand out particularly. As of 2012 China was by far the biggest Arctic research country in terms of the volume of articles published. China's 2012 record is impressive. By contrast, investments of the type made by Korea and India might take longer to impact on publication figures.

Figure 5 The four Asian countries' Arctic research publication output, 2005–2012



Thematically, variations among the countries' scientific disciplines were not that great; the natural sciences are essential to Arctic research. Atmospheric studies and meteorology were the most frequent research field for all four countries' Arctic research. As the Arctic is especially well-suited for studies of phenomena like the cryosphere (i.e. locations where water occurs in the form of ice) and the ocean, and indeed climatic changes (also for climatic variations in the past), the thematic breakdowns are in line with what could be expected. Nevertheless, we can note some differences: shipping-related research was a significant topic for Korean researchers, whereas for China, policy and governance research stood out. Some articles were published in the native languages, e.g. Korean or Chinese. Quite a few of the Korean shipping-related articles and most of the Chinese policy articles were published in national periodicals in Korean or Chinese respectively. These articles were not intended for an international audience, but that does not necessarily mean they are of lower quality than publications in English.

Figure 6 The Asian countries' Arctic research discipline, 2005–2012

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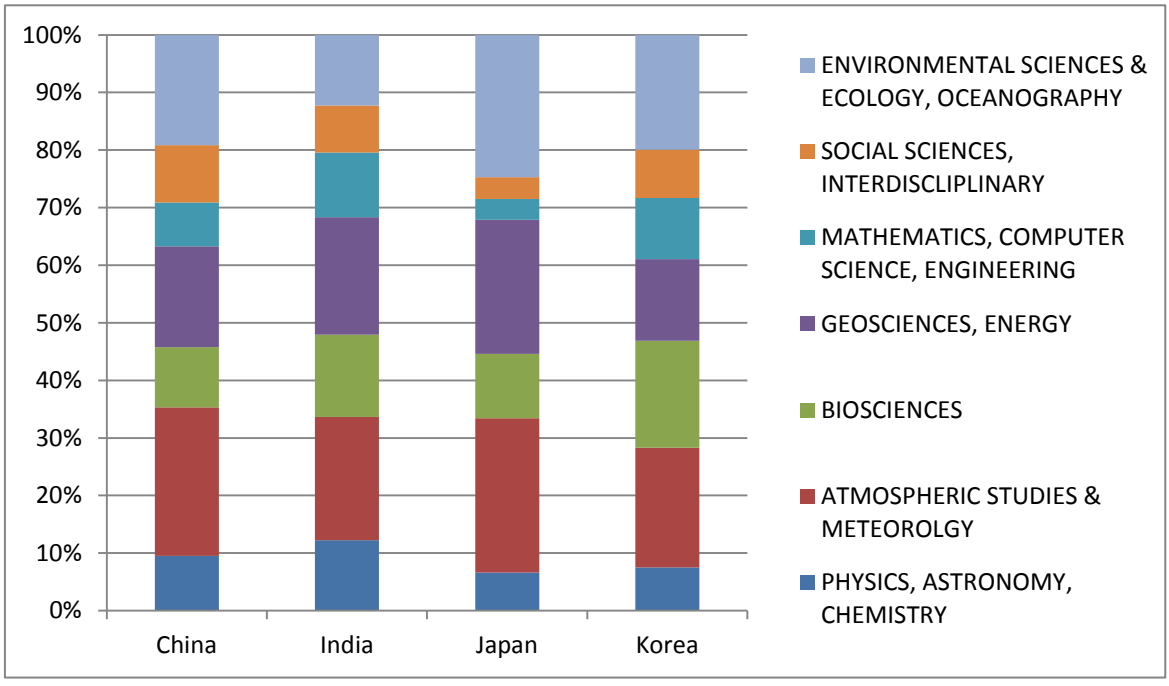


Moreover, the overall finding of this survey is that researchers from these four Asian countries published mostly in English, thereby making their accessible to the larger international scientific community. A few international journals were the most frequent publishing outlets across the board. First, *the Journal of Geophysical Research-Atmospheres* was the periodical with most articles by Asian researchers (China 27, India 3, Japan 63, Korea 9), closely followed by *Geophysical Research Letters*, (23, 2, 63, 8, respectively). Also among the top journals were *The Journal of Climate* (23, 1, 16, 5) and *Polar Biology* (10, 4, 11, 7).

Table 11 Asian countries' memberships in international scientific Arctic bodies

Organization (acronym)	*Purpose/ full name*	*Memberships by country*			
		China	*India*	*Japan*	*Korea*
AFoPS	Asian Forum for Polar Sciences	V	V	V	V
IASC	International Arctic Science Committee	V	V	V	V
Interridge	International cooperation network on ocean-ridge crest research	V	V	V	V
NySmac	Ny-Ålesund Science Managers Committee	V	V	V	V
Polenet	Polar earth observing network	V	V	V	V
AOSB	Arctic Ocean Sciences Board	V	–	V	V
ClIC	Climate and Cryosphere research project, co-sponsored by IASC	V	–	V	V
FARO	Forum of Arctic Research Operators	V	–	V	V
IPA	International Permafrost Association	V	–	V	V
ISAC	International Study of Arctic Change: research programme started by IASC & AOSB	V	–	V	–
NEEM	North Greenland Eemian Ice Drilling: international ice-core research project	V	–	V	V
PAG	Pacific Arctic Group, under IASC	V	–	V	V
EISCAT	European Incoherent Scatter Scientific Association: studies various atmosphere layers and ionosphere	V	–	V	–
ARCTOS	Arctic Marine Ecosystem Research Network	–	–	V	–
SAON	Sustaining Arctic Observing Networks	–	–	V	–

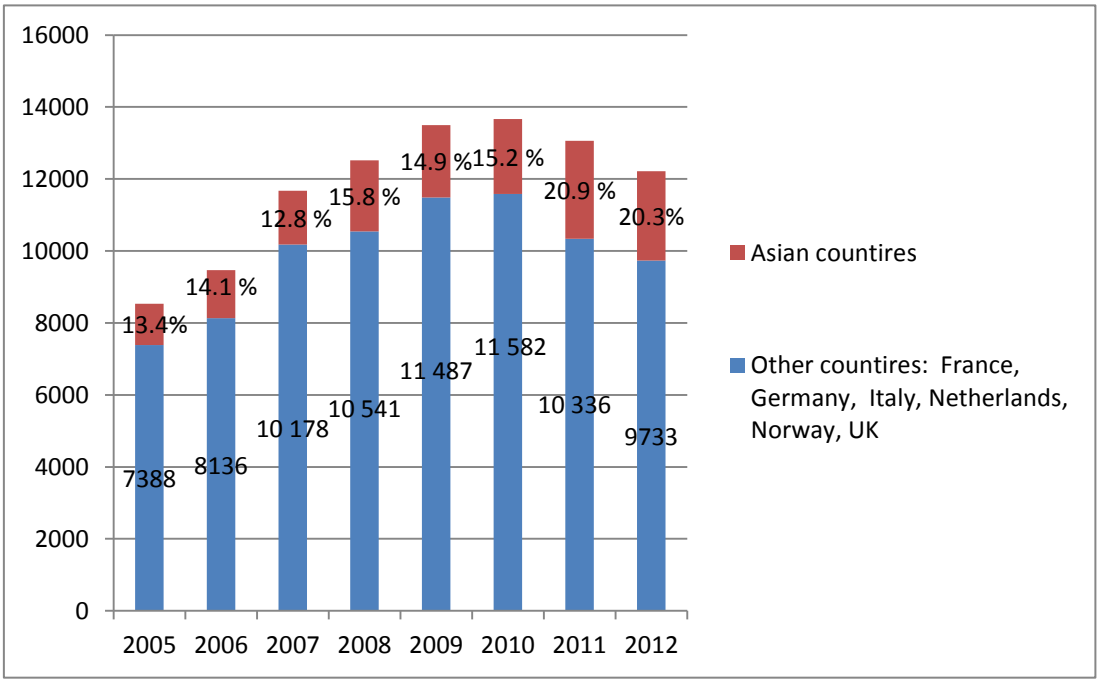
The share of publications in national journals ranged from 17–24%, and also there many articles were in English. The orientation towards the international scientific community is also apparent in the involvement in international Arctic scientific organs, where Japan is the most internationally connected country, as seen in Table 11. Note that what I have counted here is simply the existence of some form of involvement or membership in the organizations, without regard for the importance of, qualitative differences among these organizations or the extent of the Asian countries' involvement.

That Japan is the country most in contact with the international scientific community was also supported by the articles I gathered, where Japanese researchers co-authored articles with international colleagues in 61% of the cases. Also Korea was involved in considerable international collaboration (62% of the articles), while the corresponding figures for

Chinese authors were 52% and Indian for researchers 37% of the articles. India is relatively new to the Arctic, with its station opening as recently as 2008, so its membership and co-authorship figures may well look different in a few years' time. In 2009, the four countries established the Asian Forum of Polar Sciences (AFoPS), aimed at strengthening cooperation among Asian scientists.

How governments choose to organize issues can tell us something about how they perceive the issues. As to the organizational set-ups of the national polar institutes and their links to the government, in China, India and Korea polar science falls under ministries with fairly similar responsibilities, all in connection to natural resources. Japan's placement of the national polar institute within a larger science organization (ROIS) and then under MEXT with a greater focus on education is thus a slightly different organizational approach. On the other hand, for all four countries much of the research was undertaken at other scientific bodies than the national polar institute, for example at various universities and research institutes.

Figure 7 The Asian countries' share of scientist overnight stays, Ny-Ålesund, 2005–2012



The Svalbard archipelago is a key place for Arctic research. Since India also set up Himadri in 2008, all four Asian countries studied here have had permanent research structures in the Arctic. Indeed, they now have stations at both poles, which can be an advantage in regard to gathering comparable data material. The general trend is an increase in scientists' overnight stays in Ny-Ålesund, as measured in frequency and in proportion of all overnight stays. In 2005 the then-three countries together

accounted for 1,147 nights, where by 2012 that figure had risen to 2,478 for the four countries. Even with the total numbers increasing, the Asian countries' share increased from 13.4% in 2005 to 20.3% in 2012. With a total of 13,669 overnight stays, 2010 was the year with the highest amount of activity overall, but 2011 was the year with the greatest number of overnight stays for scientists from the four Asian countries – 2,727 nights altogether. India joined from 2008, which can explain some of the increase since then. There also were individual changes from country to country. China and India both peaked in 2011, whereas Japanese activity dropped markedly that year. Korea's share varied; the country had most researchers staying overnight already in 2006. Comparing the Asian countries' share of researcher stays in Ny-Ålesund *prima facie* gives a good indication of their research activity in the Arctic. However, there also are research facilities on Svalbard outside Ny-Ålesund, such as both Poland's and Russia's stations. Also the littoral Arctic countries Canada, Denmark, Finland, Norway, Sweden and the USA, have permanent research stations on their own territories. Thus, this material does not give an accurate picture of the *total* research conducted in the Arctic region. Furthermore, scientists staying outside the research town of Ny-Ålesund, such as Polish, Russian scientists or scientists staying at the University Centre in Svalbard have not been included here. In a Ny-Ålesund context, however, comparing the Asian share of over-night stays to those of other countries is telling.

Finally, the amount of activity at the Ny-Ålesund stations and the facilities there can be better understood by comparing them to the corresponding research structures these countries have in Antarctica. All the Asian countries have longer experience with Antarctic research. Japan set up a base in the 1950s; China, India and Korea in the 1980s. In Antarctica Korea has one year-round station, and India has two. China has two year-round stations and a seasonal one, whereas Japan has three seasonal stations, one year-round station and a seasonal camp (COMNAP 2012a). As regards both timespan and research facilities, the Antarctic has been more in focus in the polar research efforts of these countries.

In conclusion, the Asian countries' Arctic research efforts are largely related to climate change. Output volumes increased considerably between 2005 and 2012, but I did not find that the IPY 2007/2008 resulted in notably higher levels of activity, as I originally assumed. During the period under study the four governments also prioritized investing further in Arctic research, for instance by establishing polar and Arctic research funds and projects, and by infrastructure investments. Researchers from the four countries were found to publish mostly in international periodicals, thereby contributing to the international research community. That said, the Antarctic scientific activities of these four Asian countries remain considerably greater than their Arctic efforts.

Appendix 1:
Construction of publication discipline categories

Publication categories were constructed on the basis of on the Web of Science (WoS) and Scopus journal classifications of the journals where I found Asian researchers had published. I chose this procedure both to avoid faulty classifications due to my personal shortcomings in judging what kind of discipline a given article belonged to, and also to simplify operations: instead of having to examine each article individually, I could determine all articles from each periodical simultaneously. Aiming to strike a balance between accuracy and details, I limited the number of categories to seven. Assigning each publication into one category was not always easy, since many of the journals are listed as covering more than one of the categories I had constructed, such as biosciences and geosciences. When in doubt, I chose to define the journal on the basis of both the WoS and Scopus classification systems and the journal title. If the title gave no indication, then I put the journal in the category most resembling my constructed categories. One example is *European Food Research and Technology*. Its Scopus classification reads: 'Agricultural and Biological Sciences: Food Science; Biochemistry, Genetics and Molecular Biology: Biochemistry, Biotechnology; Chemistry; Engineering: Industrial and Manufacturing Engineering'. Chemistry belongs to category 1, and Engineering to category 5, but as most of the classification listings pertained to biology, I categorized it as category 3 'biosciences'. 'Environmental sciences' is a multidisciplinary label that can encompass many of the other categories such as biology and atmospheric sciences. When a more specific topic than 'Environmental sciences' was given, I classified the journal articles accordingly.

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