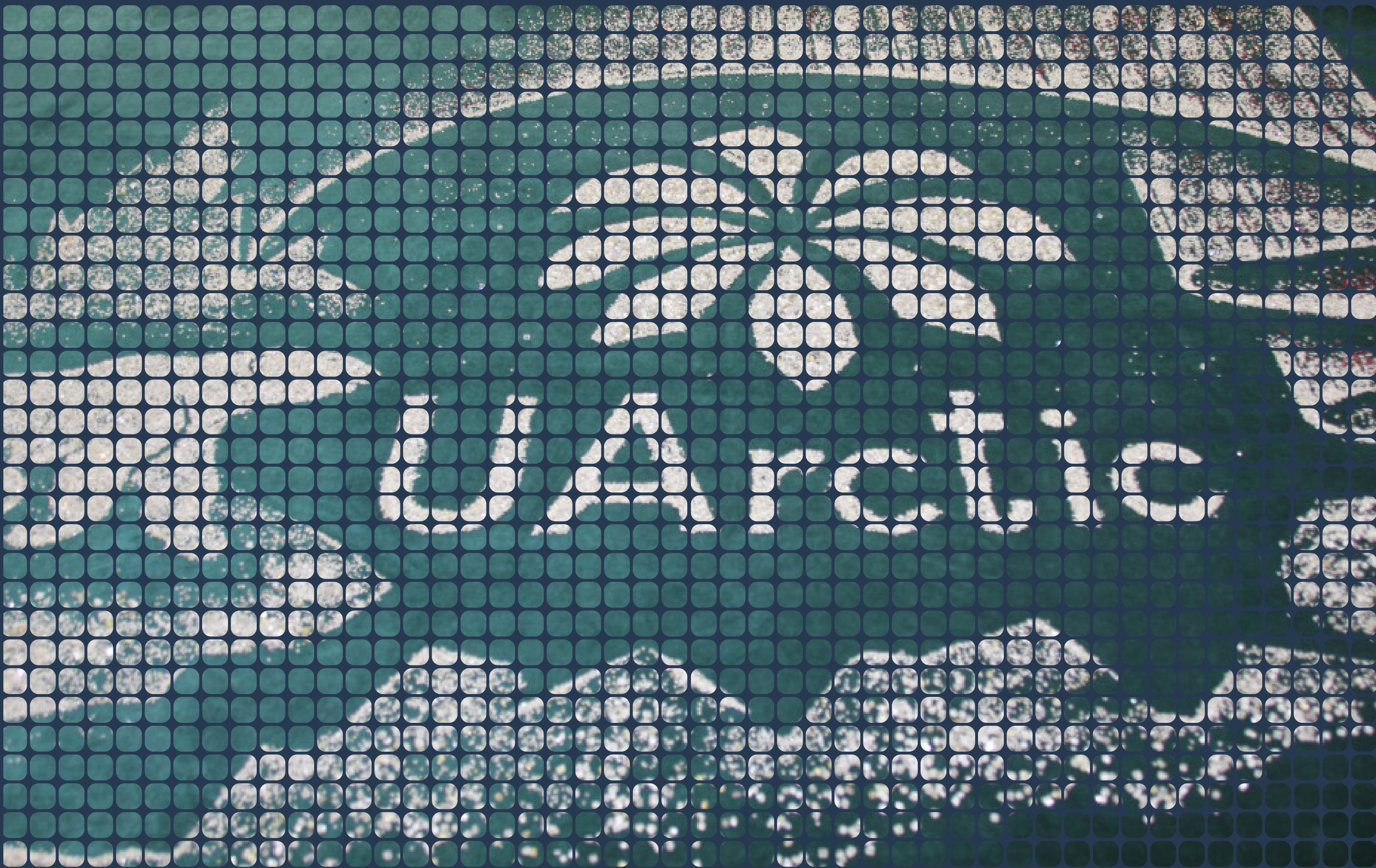

Digital Science Report

International Arctic Research

Analyzing Global Funding Trends
A Pilot Report (2017 Update)

By Dr. Igor A. Osipov, Giles Radford, Dr. Dag W. Aksnes, Dr. Lars Kullerud and Dr. Diane Hirshberg

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APRIL 2017

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Acknowledgement

The project team is grateful to the following organizations for their support of this pilot report: Far Eastern Federal University (Russia), NordForsk (Norway), St. Petersburg State University (Russia), GRID-Arendal (Norway), NIFU (Norway), University of Umea (Sweden) and University of Alaska System (USA).

This report has been published by Digital Science, which is operated by global media company, the Holtzbrinck Publishing Group.

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How to Cite this Report

Osipov, I. A. *et al* (2017). International Arctic Research: Analyzing Global Funding Trends: A Pilot Report (2017 Update). Digital Science Reports, ISBN: 978-0-9956245-4-2. https://doi.org/10.6084/m9.figshare.4829455

ISBN: 978-0-9956245-4-2
DOI: 10.6084/m9.figshare.4829455

The challenge of monitoring problems and gaps in Arctic focused research – a practical approach using funding information as an indicator

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It is obviously an important endeavor to identify challenges and gaps in knowledge about the Arctic. In such a context the using of big-data analyses, and especially biometric/scientometric approaches looking at the research outputs like publications and citations, are key considerations. These approaches, however, only reflect the outcomes of research that has had sufficient time to be completed, published, and cited.

This report takes another approach by not only analyzing the resources dedicated to Arctic related research in the past, but also taking into account committed funds which will facilitate the publication of further research in the coming years. This is an important shift because it provides insight into the levels of commitment and engagement of governments and funders to advance research on Arctic related research over the coming years.

Three observations, which have been obtained by working with local governments in the field, reinforce the idea that Arctic-related research needs to be looked at in this more comprehensive way:

1) The use of scientific literature to solve daily practical challenges of local governments is remarkably low. When asking representatives from the local governments, their perception is usually that the research literature is far from related to the challenges that local government is working with. Grey literature or specialists from companies with documented experience are far more likely to be consulted.

2) Related to the first observation, which is not only relevant for Arctic related research, is the fact that the 'production process' of scientific articles involves peer review by other researchers. This means that the subsequent analysis of outputs in scientometric studies has the inherent risk that publications are influenced by the reviewer's theories and becoming scientifically repetitive. In the Arctic context especially, originality and new practical approaches are key. This leads to the third observation:

3) "Academic" literature does not stand-alone but is strengthened through more practice related literature, often considered as 'grey literature' – compiled and developed under conditions for use to solve practical problems. "Scientific literature", meanwhile, is seen to apply more generally, and thereby misses the actual points in the problem and the specific case being dealt with (Kristensen & Hussain, 2016, p. 34). Grey literature is normally not reflected in scientometric analysis, leading to a bias in scientific direction at the expense of practical results and impact.

The approach of this report, which examines the funding going into Arctic related research, is a step in the right direction. The projects funded will result not only in scientific articles, but also in grey literature focusing on the practical challenges. In finding ways to address the challenges outlined above it is, possibly, the analysis of the funded projects which will help provide a much more up to date and 'practical' view on the levels of engagement and investment of governments and funders towards advancing solutions for the important challenges in the Arctic region.

Executive Summary

Scope & Objective

This pilot analysis is the result of an exploratory collaboration between the UArctic Science & Research Analytics Task Force and Digital Science international research teams. The aim was to assess the global funding landscape around Arctic-related research for the decade spanning 2007 to 2016, using the funding data from the Dimensions[1] dataset, which includes information from over 250 funders on more than 3,000,000 projects with funding totalling $1.1 trillion+ (in US Dollars). This project is the first ever attempt to create a comprehensive view of global Arctic research funding using a dataset of such magnitude, and this report is a 'refresh' of that first report, showing new data from Denmark and Japan.

Special attention was given to analyzing trends in the countries of the Arctic Council - both members[2] and observers[3] - as well as their key funding agencies and institutional members of the University of the Arctic. A significant effort was made around creating and refining subject area categories and removing irrelevant grants that showed up in the searches, using Natural Language Processing technology.

In this revised version of the report, some funding data for 2016 has been added. Moreover, some new funders have been included in the database. In particular, it should be mentioned that Denmark is now better covered through the addition of funding data from multiple Federal Danish Funders.

Key Findings

The key findings of the pilot report, based on the available data, highlight the following trends:

- Arctic research accounts for approximately just less than 1% of all funded research in the database.
- "Earth Sciences" is the largest proportion of Arctic research funding, specifically due to funding attributed to 'oceanography'.
- The proportion of funding dedicated to Arctic research is stable over time, at about just under 1%.
- Approximately a third of all global Arctic research presented in this funding data is undertaken by UArctic Member Institutions.
- Arctic Council Observer states provide about 0.5% of their total research funding to Arctic research, compared to 7% on average for the Arctic Council Member states.
- Arctic research from non-Member states has been significantly increased due to boosted by the addition of Japanese Federal funding into the Dimensions database.

In general, the largest sources of funding for Arctic research come from the United States (US), Russia, Canada and Norway, with the US being the biggest net contributor. However, more data on the public funding of Arctic research in Russia, Canada and Denmark is needed to verify this finding.

Outlook for the Future

These initial analyses demonstrate a significant potential for further study of research funding for the Arctic. For example, it would be useful to determine whether Arctic research funding priorities match the most critical challenges facing the Arctic as identified by the scientific community (e.g. in the ICARP process), by the Arctic Council, and by the peoples of the north. Many questions have only been briefly addressed by this pilot report and will benefit from further investigation. One of the most important opportunities for further research is to collaboratively deliver a comprehensive view of how public Arctic research funding has translated into global scientific output data (publications, books, etc.). It is also important to look at alternative ways of measuring the impact of Arctic scientists and institutions[4] on the global research community as well as on international and national decision makers.

1 *by ÜberResearch, a Digital Science portfolio company*

2 *Canada, Finland, Iceland, Kingdom of Denmark, Norway, Russian Federation, Sweden, United States of America.*

3 *France, Germany, Italian Republic, Japan, the Netherlands, People's Republic of China, Poland, Republic of India, Republic of Korea, Republic of Singapore, Spain, United Kingdom.*

4 *An Altmetric data approach is analysed in a corresponding working paper*

Arctic Research

In recent years increasing numbers of policymakers and industry leaders across the globe have turned their attention to the Arctic and Polar North due to a number of important issues, including resource competition, the vulnerability of Arctic environments and Northern communities, the development of local and indigenous knowledge, and the opening of new transportation routes across the North. While international Arctic research collaboration has existed since the 19th century, irrespective of political conditions, it has grown noticeably over the last two decades through initiatives such as the "International Polar Year" (2007-2008).

The Arctic is truly a highly connected international and interdisciplinary laboratory.

In the midst of increasing international turmoil, the Arctic has become one of the few transnational arenas for collaboration, discussion, and mutual interest among leading global players. From the earth and life sciences to the arts, humanities, and social sciences the Arctic is truly a highly connected international and interdisciplinary laboratory. It contains an abundance of sea- and land-based natural resources, unique indigenous peoples, cultures and historical treasures, and emerging opportunities for trade and communication across the globe. Perhaps most critically, the Arctic is the region most impacted by global climate change.

The international Arctic research community, including the University of the Arctic (UArctic), the International Arctic Science Committee (IASC), and the International Arctic Social Sciences Association (IASSA), as well as the Arctic Council, have infused strategies for Arctic research into national research priorities across the globe. The growth of data and periodic efforts in individual countries to analyse research and science in the Arctic has triggered interest in launching broader transnational efforts at gathering and measuring the volume and impact of research in the Arctic.

The key instrument of governmental collaboration in the Arctic today is the Arctic Council. It is a policy shaping collaboration between the eight countries surrounding the Arctic - Canada, Kingdom of Denmark (including Greenland and Faroe Islands), Finland, Iceland, Norway, Russia, Sweden, and the US. The Arctic Council is a unique international organization that welcomes the indigenous people of the Arctic as permanent participants in the collaboration. The council also provides observer status to a broad array of non-Arctic states, inter-governmental, inter-parliamentary, global, regional and non-governmental organizations. The UArctic, IASC, and IASSA are the observer organizations that represent the scientific community in the Arctic Council.

The primary objectives of the Arctic Council are to develop the Arctic as region of peace and collaboration, and raise awareness of the main environmental, development and economic issues affecting the Arctic and its peoples. The Arctic Council has negotiated two binding agreements between the member states, one on search and rescue and the other on Marine Oil Pollution Preparedness and Response. The council has also created two independent organizations - the University of the Arctic, and more recently the Arctic Economic Council. In spring 2017 the Arctic Council is scheduled to conclude a binding agreement on Arctic scientific collaboration intended to improve scientific research cooperation among the eight Arctic States.

UArctic & UArctic Science and Research Analytics Task Force

The University of Arctic (UArctic - www.uarctic.org) was created in 2001, based on the Arctic Council Iqaluit Declaration 1998 signed by the eight Arctic Council Member states[5] (http://library.arcticportal.org/1269/1/The_Iqaluit_Declaration.pdf). UArctic is one of the three observers of the Arctic Council in the field of higher education and research alongside IASC and IASSA. UArctic unites more than 170 research-focused universities, colleges and institutes covering the entire Circumpolar North of the eight Arctic Council Member states, as well as members from the Arctic Council Observer states[6].

Following a discussion at the August 2015 UArctic Rectors meeting hosted by Umeå University, UArctic decided to form an international research analytics task force. The task force members include a small but diverse international group of subject-matter experts who are willing to participate in and contribute to this unique and challenging endeavour. Experts represent all key macro-regions of the UArctic and the Arctic Council – North America, Russia, and the Nordic countries - as well as UArctic partners in IASC and IASSA, and expertise from the International Polar Year.

The task force is working on a number of unique data analysis projects in close partnership with the largest global funders, publishers, and producers of research datasets as well as web-based big-data analytics tools that cover Arctic research and funding.

This report is the first comprehensive attempt by the UArctic to look at available global funding data in relation to Arctic research, not only in retrospective terms of publications and patent records, but also in terms of current and prospective projects which have been or are currently being funded. Relative to publications, funding data provide an opportunity to look at research trends much earlier, by including scientific projects that are just starting and likely to continue for several years before producing any publications.

Methodology, Definitions, Assumptions & Limitations

The analyses in this report were conducted using the Dimensions Tool (http://www.uberresearch.com/). The Dimensions database contains information on funded research projects from over 250 grant funders worldwide, and is currently the most comprehensive curated international grants database. It provides unique insights in the research funding landscape years ahead of results being published and represents one component of the resource input into the research system. Data from Dimensions have previously been used to analyse research funding in many fields and countries (Hook & Szomszor, 2016; ÜberResearch, 2015).

5 *Canada, Finland, Iceland, Kingdom of Denmark, Norway, Russian Federation, Sweden, United States of America.*

6 *France, Germany, Italian Republic, Japan, the Netherlands, People's Republic of China, Poland, Republic of India, Republic of Korea, Republic of Singapore, Spain, United Kingdom.*

Defining the 'Arctic' - Overview

There are many ways to define the Arctic, and there are a myriad of approaches to defining it in daily use. This includes self-perception by its people, culture and history, latitude (Arctic circle), political definitions (where the rationale for borders is often driven by national economic or political goals), as well as a set of natural science-based definitions, using climate, ecosystems and ecoregions, animals, vegetation, sea ice, permafrost and so forth. There also are many historical, and partly mythological definitions of the North. Examples include http://arcticcentre.ulapland.fi/pole_arctique.htm and http://arcticcentre.ulapland.fi/arctic_map_old.htm.

A useful definition of "the Arctic" should be able to separate the North and the Arctic as an area with definable ecological/natural systems that are clearly differentiated from those farther south, preferably in a manner that also reflects "northern", as opposed to "not so northern", human realities and activities.

Furthermore, the definition should preferably be close to "common understandings" of the North and or the Arctic, even if this understanding varies by audience. In addition, it should be consistent with national (sometimes policy driven) definitions, but not be influenced by country borders. Finally, it must be practical to use. If these goals are attainable, that indicates that easily recognizable concepts can be used to separate the Arctic from the non-Arctic.

The *UArctic Science & Research Analytics Task Force* definition follows the general trend of the Arctic Council-related definitions of the Arctic. This choice is pragmatic; it acknowledges the general acceptance of the Arctic Council as the body representing the Arctic globally.

More specifically the *UArctic Science & Research Analytics Task Force* follows the Arctic Human Development Report (AHDR) definition of the Arctic (based on administrative boundaries for land areas) when looking at research on socioeconomic and human related issues, while using the southernmost of either the Arctic Monitoring and Assessment Program (AMAP) or the Conservation of Arctic Flora and Fauna (CAFF) boundaries for research addressing natural phenomena on land. It uses the AMAP border for research on marine topics with the flexibility that the Search And Rescue Agreement boundaries can be used when that is considered more appropriate for marine areas.[7]

7 *For AHDR, CAFF, AMAP lines see http://arcticportal.org/images/maps/small/1.9.jpg and for the Arctic Search and Rescue Agreement see https://en.wikipedia.org/wiki/Arctic_Search_and_Rescue_Agreement.*

Map produced by GRID-Arendal

http://www.grida.no/graphicslib/detail/boundaries-of-the-arctic-council-working-groups_8385

Methodology Overview

The Task Force selected a keyword search query approach in order to identify Arctic research projects. The key challenge was to identify research in and about the Arctic as per the above definition and avoid research carried out on objects and issues outside the Arctic as defined. Given the magnitude of the challenge, we decided to concentrate on two types of terms: geographical and indigenous peoples names. In addition, a few general terms assumed unique to the Arctic (e.g. Arctic, tundra) have been included. The category was crafted by UArctic members with assistance from Digital Science staff. Details of this approach can be found in Appendix 3 but some top level points to consider are:

Key Concepts

- Categorization of 'Arctic Research' was undertaken using natural language processing. In Dimensions this involves a sophisticated Boolean search which allows the boosting of non-Boolean terms to allow for a threshold to be set to exclude false positive returns.
- Currency conversion is based upon the exchange rate at the time of the start date of the project. No adjustment for inflation is used.
- 'Start year' means the calendar year in which the project started.
- 'Country' means the country of the project lead.
- Funders sometimes provide support in countries other than their own, so the total funding a country gets may be a mixture of home funders, overseas funders and the European Commission, etc.

Data Errors and Refinements

It is important to acknowledge potential sources of errors in the data, and what we were or were not able to address. First, it is possible that certain relevant projects have not been identified in the findings because the projects do not specify where the research was (is to be) carried out, or because geographical names other than those included in the study were mentioned. In order to reduce this problem, field-specific search terms (e.g. "sea-ice", "polar bear" etc.) could have been used in addition. However, this has not been done in this pilot to avoid discipline bias.

Second, the method might still identify some irrelevant projects, i.e. projects which should not have been considered as Arctic research. This may be due to the fact that some words have more than one meaning or are used in contexts other than Arctic research. Although we attempted to avoid this problem by excluding words with multiple meanings, and testing the dataset output based on various scenarios to identify problems of double meaning or words which trigger massive false positive references without any relevance to Arctic research.

In the process of creating the 'Arctic' category we were, however, able to eliminate a long list of irrelevant grants based upon a threshold rule. 4,175 projects which were considered false positive results from the result set were omitted, representing 21% of the initial set. This led to quite precise data being used for this report.

Further details on the search terms and data processing can be found in Appendix 1.

Analysis: Arctic Research - Landscape Overview

In the remainder of the report we describe the results of the analyses conducted. Indicators showing different dimensions of Arctic research funding are described in sections covering topics such as overall funding, distribution by field of study, and national and institutional profiles. Each section includes tables and/or graphs and explanatory text. Within the scope of this pilot report, however, we are not able to provide a full analytical elaboration on all of the issues presented.

A. Overview of Arctic research funding

Comparison to Total Research Activity

The Dimension database includes 1,700,000 grants, totalling $860 billion for the period 2007-2016. Our analysis shows that 16,000 of these grants fall into the area of Arctic research, with funding totalling $7 billion. This means that just less than 1% of all recorded global research funding in Dimensions is in the area of Arctic Research (projects: 0.95%, funding: 0.8%). As described in the methodology section, some funders are missing. This affects both the total and the Arctic funding. However, as data is lacking for Russia (project funding amounts), which is a significant contributor to Arctic research, it is likely that the proportion would have been slightly higher than 1% with more complete data.

Breakdown of Activity by Broad Research Areas

Arctic research covers a variety of different fields and disciplines. In order to provide an overview of this breadth, the projects have been classified by subject areas. In the Dimension database, all projects are classified according to the *Fields of Research Classification system*, originally developed for analysis of research and experimental development (R&D) undertaken in Australia and New Zealand.[8] The advantage of this system is that it collapses academic classifications into 22 high level areas. These are listed below.[9]

8 The Australian and New Zealand Standard Research Classification (ANZSRC) is the collective name for a set of three related classifications developed for use in the measurement, see: http://www.arc.gov.au/rfcd-seo-and-anzsic-codes.

9 For further information of the content of the catergories and the underlying sub-disciplines, see: http://www.uq.edu.au/research/research-management/era-for-codes#Built_environment

01 Mathematical Sciences	**08** Information and Computing Sciences	**15** Commerce, Management, Tourism and Services
02 Physical Sciences	**09** Engineering	**16** Studies in Human Society
03 Chemical Sciences	**10** Technology	**17** Psychology and Cognitive Sciences
04 Earth Sciences	**11** Medical and Health Sciences	**18** Law and Legal Studies
05 Environmental Sciences	**12** Built Environment and Design	**19** Studies in Creative Arts and Writing
06 Biological Sciences	**13** Education	**20** Language, Communication and Culture
07 Agricultural and Veterinary Sciences	**14** Economics	**21** History and Archaeology
		22 Philosophy and Religious Studies

Looking at funding totals by subject, we see that the fields of Earth Sciences and Biological Sciences are the two largest recipients of Arctic research funding (Figure A). The funding for Earth Sciences is almost twice as high as for Biological Sciences. These are followed by Environmental Sciences and Engineering, while the Medical and Health Sciences rank fifth in funding.

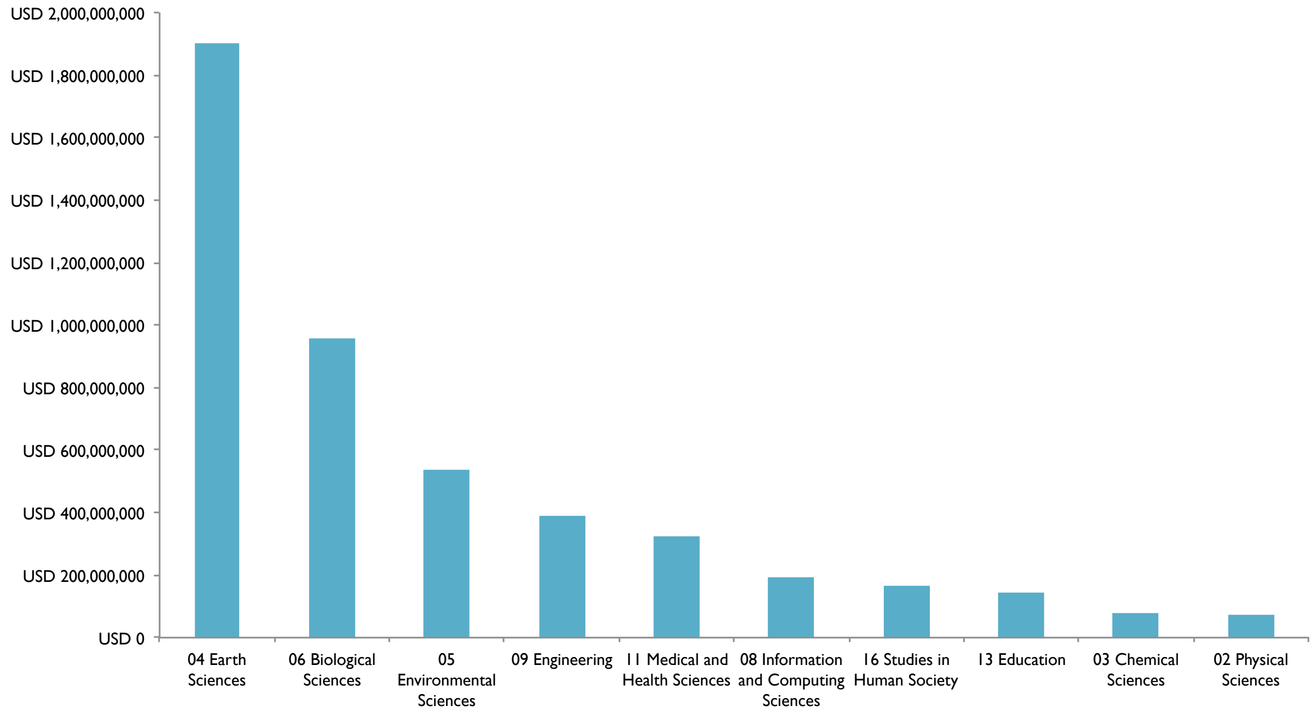


Figure A - Top Ten Fields of Arctic Research by Category, Total Funding for Projects Starting 2007 - 2016*

**Please note that a grant may fall into multiple areas and therefore values cannot be summed.*

By comparing all research funding in the Dimensions database with Arctic research funding in the same areas we can examine the depth of Arctic research in each broad area, and how much that varies from the overall average of approximately 1% of all research funding (found in Dimensions). Measured as a percentage of overall funding we find that Arctic "Earth Sciences" research accounts for nearly 14% of all funding in that category (see Figure B). This is a clear indicator that a significant proportion of the global research within Earth Sciences directly relates to the Arctic. The proportions for the other research areas are much lower. However, the proportions are above the overall average of 1% of all funding in Dimensions for several categories, including Environmental Sciences, Built Environment and Design and History and Archaeology. This trend generally corresponds to the global publication output dynamics for comparable fields in the same time period even if the proportions are not quite the same.[10]

Interestingly, while Biological Sciences represents the second largest category in terms of total Arctic research funding, it only reaches eighth out of the top ten in terms of the proportion of Arctic vs. all funding. Similar dichotomies are also found for other categories, in particular for Medical and Health Sciences (Figure C), which represents a large part of overall research funding, but is limited in Arctic regions.

10 Arctic Research - Publications Trends (A Pilot Study) 2016, by Aksnes D, Osipov I, Moskaleva O, Kullerud L..

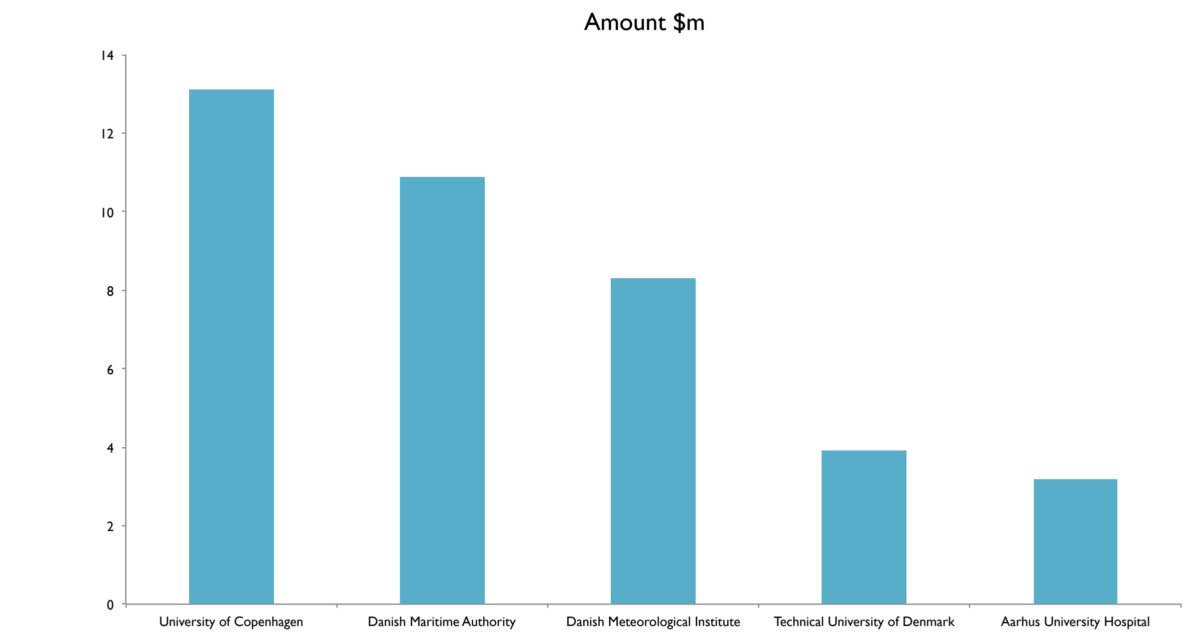


Figure A1 - Danish Overview - Top 5 Denmark Organisations in Arctic Research 2007 - 2016 by Funding Amount

In the previous report we did not have federal funding data for Denmark. We have now received over 25,000 projects from over 20 Danish federal funders amounting to over $7B. There were 286 grants falling into the Arctic category, at $61.7m during 2007 - 2016.

There is at least $60M worth of funding from Danish funders, but it should be noted that this figure is conservative: some of the Danish data lacks abstracts, and some lack an organisation, making attribution difficult.

In the figure above we see that, even with these limitations, a great deal of research is being undertaken in Arctic research in Danish institutions.

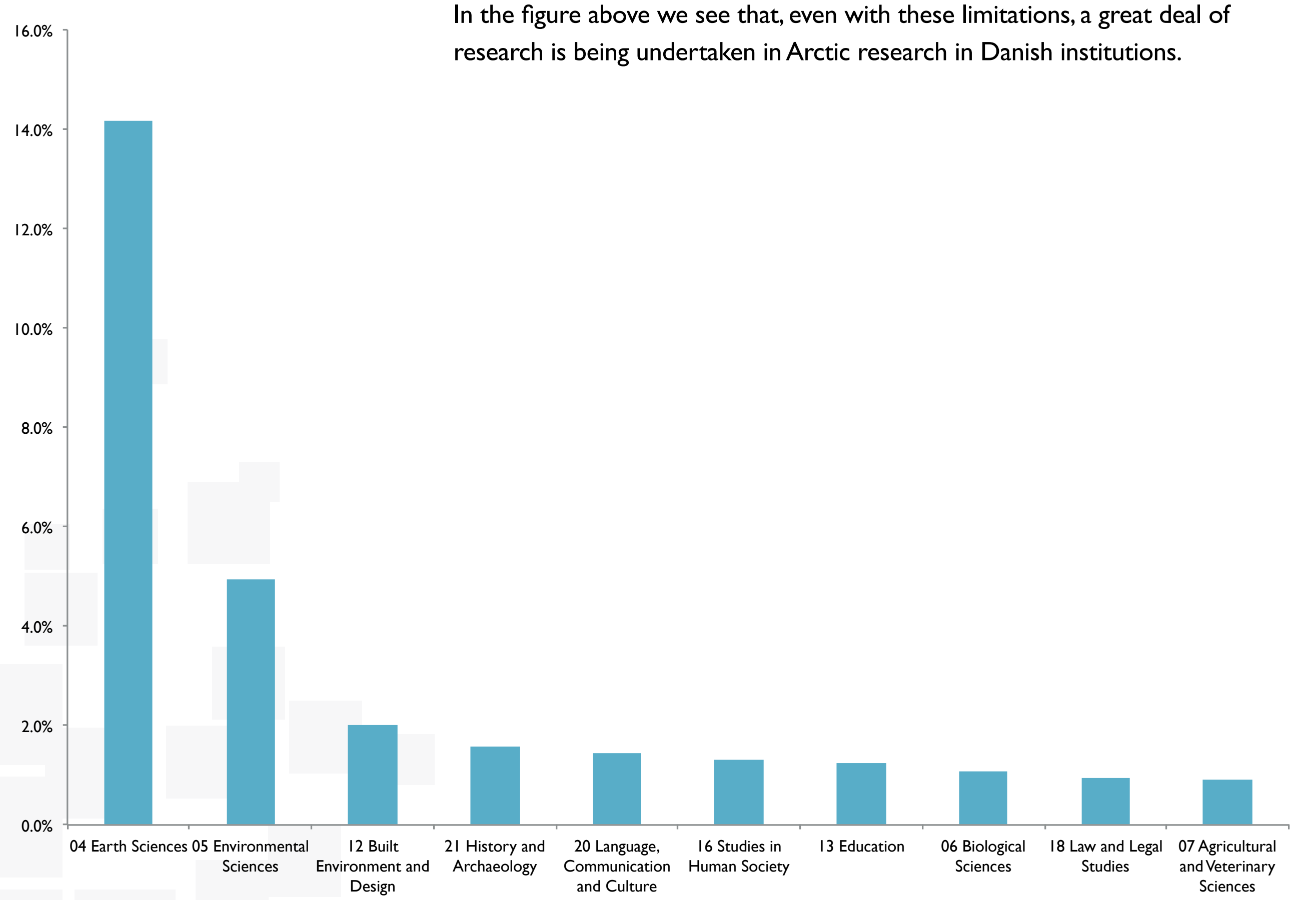


Figure B - Top Ten Fields of Study in Terms of Arctic Research Funding Amounts as a Percentage of Total Global Research Funding, for Projects Starting 2007 - 2016

As shown in Figure B, Earth Sciences is the research area with the highest proportion of Arctic research funding as a proportion of the global research total. As is shown in Figure A it also is the area that receives the most Arctic research funding overall.

In order to provide further insights into funding by area, we have analysed the funding by sub-areas. The top three areas in terms of the proportion of funding going to Arctic research are Oceanography, Ecology and Physical Geography and Environmental Geosciences, two of which fall into within the Earth Sciences heading. Figures for these sub-areas are shown in Table A. In these more specialised areas Arctic Research represents up to approximately 20% of all funding (Oceanography and Physical Geography and Environmental Geosciences).

Area	All Funding $m	Arctic Funding $m	All Numbers	Arctic Numbers
Oceanography	5,200	1,100	8,182	1,602
Ecology	9,200	812	27,171	2,018
Physical Geography and Environmental Geosciences	3,200	752	10,339	1,963

Table A - Top Three Fields of Research Arctic Research Areas Compared to All Grants 2007 - 2016

The analysis above shows that Arctic research funding is much greater in some areas of research than others and in some fields Arctic research receives a significant portion of total funding. At the same time, it should be noted that the distribution of funding grants is very skewed. Some projects may account for a significant proportion of the overall Arctic funding within a category. For example, one reason the Earth Sciences figure is so large is because of one very large grant, the "Construction and operation of the Alaska Region Research Vessel: Phase III - Shipyard Construction Costs" given by the National Science Foundation - Directorate for Geosciences in 2009 for $148 million. The same foundation gave $208 million in 2006 for the "US Coast Guard Polar Icebreaker Program FY06 Program Plan to the National Science Foundation" although this grant didn't clearly fall into any of research area categories. If it had fallen into Earth Sciences then the overall percentage would have been even larger.[11]

Similarly, there were some significant grants boosting the Environmental Sciences area. The United Kingdom's Natural Environment Research Council (NERC) gave a grant for 'BAS Ecosystems' (Polar ecosystems) in 2009 for $13.6 million. In 2007 the National Science Foundation - Office of the Director provided $11.2 million for a study on 'Resilience and Vulnerability in a Rapidly Changing North: The Integration of Physical, Biological and Social Processes' and in 2009 the European Commission gave $10.8 million for 'Hotspot Ecosystem Research and Man's Impact on European seas'.

11 While such sums do not totally dominate, and represent acceptable variation in the method, it also demonstrate a methodology problem as similar projects in other countries are often funded outside the normal grant scheme system and will therefore not be picked up in this database.

The History and Archaeology category was boosted by one large grant from the Research Council of Norway: the "Ice Age development and human settlement in Northern Eurasia (ICEHUS II)' project, awarded $1.4 million in 2007. The Swedish Research Council also made a significant contribution to this area with "Collecting Sápmi: Early Modern Globalization of Sámi Material Culture and Contemporary Cultural Heritage" for $1.1 million in 2013.

Figure C shows the research areas where Arctic research accounts for the smallest proportions of all research funding. Medical and Life Sciences is the largest Fields of Research area, with 246,000 projects and $148 Billion in funding given across the ten years in question, but only 584 awards totalling $327 million, or just over 0.2% of funding went to Arctic research. That even includes a significant grant from the National Institute of Dental and Craniofacial Research for $20.4 million in 2008 for the 'Center for Native Oral Health Research (CNOHR)' (health care focusing on American Indians and Alaska Natives). Despite a few other large grants the medical and life sciences activity in the Arctic remains comparatively small.

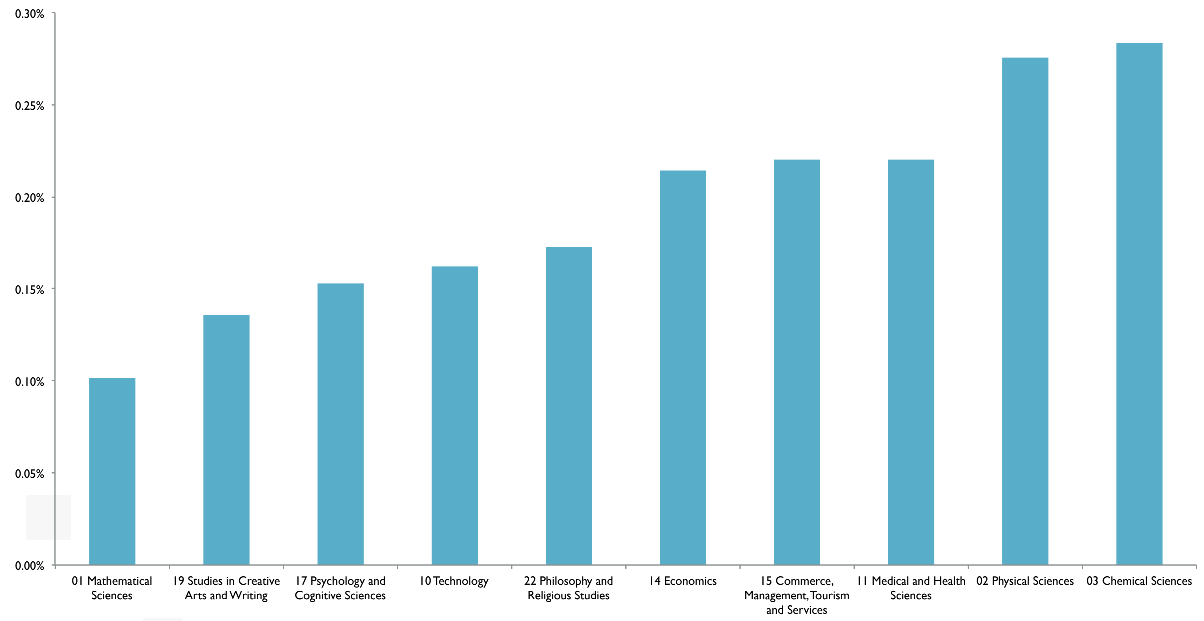


Figure C - Arctic Research as a Percentage of Total Research Funding in Fields of Research Classification - Bottom Ten Areas Start Years 2007 - 2016

B. Funding Trends

The Dimensions database contains annual data extending back many years. Based on these data, we analysed the temporal funding aspects of Arctic Research. It should be noted, however, that there are various limitations in the datasets which makes such analyses difficult to carry out. Over time, funders are continuously being added to the database. Therefore, annual figures are influenced by changes in the coverage of the database. Within the scope of this pilot report, we have not been able to investigate the implications of these changes in detail. Therefore, the analysis and the results should be interpreted only as exploratory.

When we look at Arctic research projects by the year they started, from 2007-2013, the trend is for neither growth nor decline, with around 1,400-1,600 grants starting each year (Figure D).

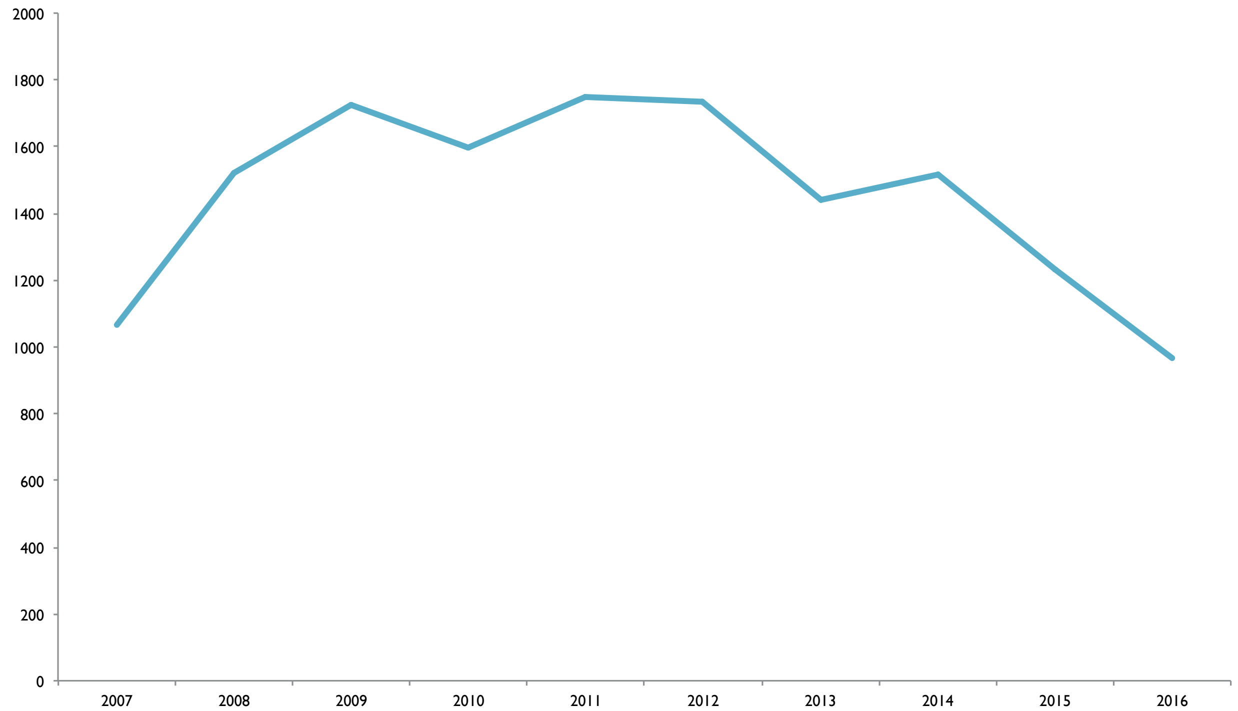


Figure D - Number of Arctic Research Projects by Year, Started 2007 - 2016

Figure D also shows that there is a strong growth from 2007 to 2008. From 2012 to 2016 there is a significant decrease. In order to provide more details for this issue, in Table B we have shown the project counts per year by the top ten funders (by number of starting projects). We see that the largest funder, the Russian Foundation for Basic Research (RFBR), did not report figures in 2015 and 2016, and there is a significant decrease in 2013 and 2014, which explains much of the overall decrease for Arctic research in 2013 - 2016. As this new analysis was undertaken early in 2017 it is not surprising that many funders have not updated their 2016 award data.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
RFBR[12]	387	436	439	385	503	480	198	207	00		3035
NSF-GEO	273	185	335	252	235	265	222	232	240	261	2500
NSERC	222	229	249	211	197	241	216	262	209	47	2083
RCN	165	93	107	108	87	119	157	157	169	150	1312
SSHRC	54	70	57	62	64	55	89	70	62		583
NERC	35	45	38	90	86	83	55	34	31	47	544
JSPS	44	41	44	40	36	27	28	39	25	36	360
CIHR	20	13	24	32	34	39	41	25	37	30	296
NASA	4	47	35	38	29	20	49	38	30	1	291
DFG	30	29	17	16	32	24	26	16	18	43	251
Total	1234	1188	1345	1234	1303	1353	1096	1107	865	647	

Table B - Number of Projects Starting in 2007 - 2016 by Funder, Top 10 Arctic Research Funders

12 *Russian Foundation for Basic Research; National Science Foundation - Directorate of Geoscience, USA; National Sciences and Engineering Research Council, Canada; Research Council of Norway; Social Science and Humanities Research Council, Canada; Natural Environment Research Council, UK; Canadian Institutes of Health Research; National Aeronautics and Space Administration, USA; German Research Foundation; National Oceanic and Atmospheric Administration*

Table B highlights gaps in funder records in red. The data is reasonably solid between 2008 - 2015. If the data anomalies are removed then the trend suggests neither growth nor shrinkage in Arctic research over this period. For 2016, there are gaps in the data for several funders, and it is not possible to make a reliable assessment of the trend.

2007-2008 was the International Polar Year (IPY), an internationally coordinated campaign that represented a major initiative to strengthen research activities in the polar regions. Several countries increased their budgets for polar research as part of their IPY participation. One might expect that this campaign would be reflected in increased funding amounts in 2007-2008 and a reduction in the following years. Due to the lack of coverage for the year 2006, however, we are not able to assess whether there is an increase in 2007-2008. Still, interestingly, there is no decline in the period 2009-2012.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
UArctic Canada Members	128	151	153	126	143	138	154	157	129	16	1295
UArctic USA Members	115	100	116	95	115	102	95	84	82	100	1004
UArctic Norway Members	83	44	42	64	43	68	85	86	97	89	701
UArctic Sweden Members	0	7	19	14	6	27	18	21	12	4	128
UArctic Finland Members	4	6	5	11	15	22	8	14	35	18	138
UArctic non Arctic members	17	9	19	24	17	19	12	9	11	8	145
UArctic Iceland Members	18	6	5	5	3	7	10	9	15	8	86
UArctic Denmark Members[14]	0	0	1	4	3	2	1	1	9	10	31

Table B1 - Projects Starting in 2007 - 2016 for UArctic Members in Arctic Research by Number of Grants[13]

C. Funding by Countries

We analysed Arctic research funding by country. In these analyses, the country of the entity receiving grants is used in the measurements. Usually, the funding country and the receiving country are the same, but this does not always hold true.

The chart below (Figure E) shows both the funding and number of projects starting during the period 2007 - 2016 for the largest contributors. Not surprisingly, the US is the largest Arctic research nation both in total spending and the number of projects started. Canada and Russia are almost equal in size in terms of the number of projects started, followed by Norway and the UK. There is also a significant number of Arctic projects from Japan, Denmark, Germany, Sweden, Finland, but compared with the larger nations the figures are much lower.

13 *Please note that Russian data is not shown as the funded project organisational affiliation is not included in the data by the country funders.*

14 *Organisational affiliation is missing from some Danish funder data*

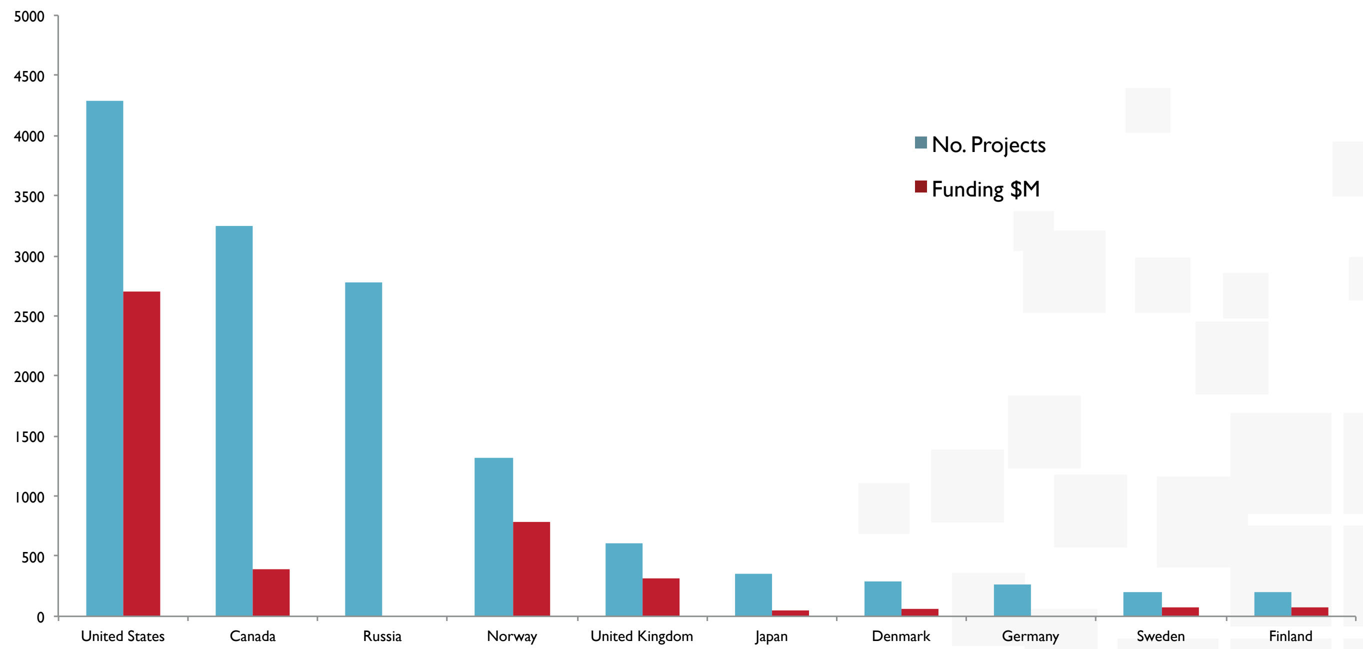


Figure E - Arctic Funding by Country of Funder, Grants Starting 2007 - 2016

When interpreting this figure, the limitations of the Dimensions data are important to take into consideration. We don't have funding amounts for Russia, only numbers of projects. However, there are nearly 3,000 Arctic grants supported by Russian Funders from a total of the 13,500 Arctic projects that fall into the 2006-2015 period, meaning Russia is supporting about 22% of all Arctic research (by number of projects).[15]

15 There are also various Federal Targeted Programs aiming at the Arctic development, projects funded by profile Ministries and Agencies of the Federal Government, other sources of federal, regional, and corporate funding related to the research conducted in the Russian Arctic regions, which are not captured in the current version of the dataset used in this pilot report.

This graph also demonstrates the large number of smaller value grants provided by the Canadian Research Agencies. Only a handful of the 3,200 Canadian Projects presented have no funding amount in the database, and the average funding amount of just USD $121,000 per project suggests that a large number of small grants are being awarded by Canadian funders. For the US, the average funding is $639,000, but that also highlights that there are some very large grants impacting averages. In the first report we found it surprising that Norway in terms of total funding amount was almost three times as large as Canada. Part of the reason was then the lack of data from important Canadian funders in 2015. Now the 2015 data is in, this ratio has fallen to 2:1. Nevertheless, the difference is larger than one would expect based on previous knowledge (see e.g. Aksnes & Hessen, 2009). This is an issue that needs further exploration.

D. UArctic Members, Observers and Non-Members

In this section we have analysed research funding for the UArctic network of research organisations, which comprises 170+ institutions globally. The main focus is on the UArctic members, but figures are also provided for universities and institutions outside the UArctic university network. The caveats to this analysis are identical to those described in the section above and it should be noted that the Russian data is not complete enough for a comparable analysis. The total number of Arctic grants by country received by UArctic members for the top seven countries are shown in Figure F. This graph suggests that UArctic members are central actors in Arctic research for all countries, but that there are also significant contributions from non-members. Overall, UArctic members are undertaking approximately 41% of all the Arctic research, based upon total funding of $4.1B for the ten year period for all research, with $1.7B from UArctic members. However, for the US the proportion is much lower, and the majority of the projects are carried out by UArctic non-members. For example the Woods Hole Oceanographic Institute in Falmouth, Massachusetts, received Arctic research funding of $107 million for the period in question. Further analyses with Dimensions could easily identify significant institutions that are currently not members of UArctic.

Since the first report we have added in federal funding from 28 Funders in Denmark as well as Japanese federal funding.

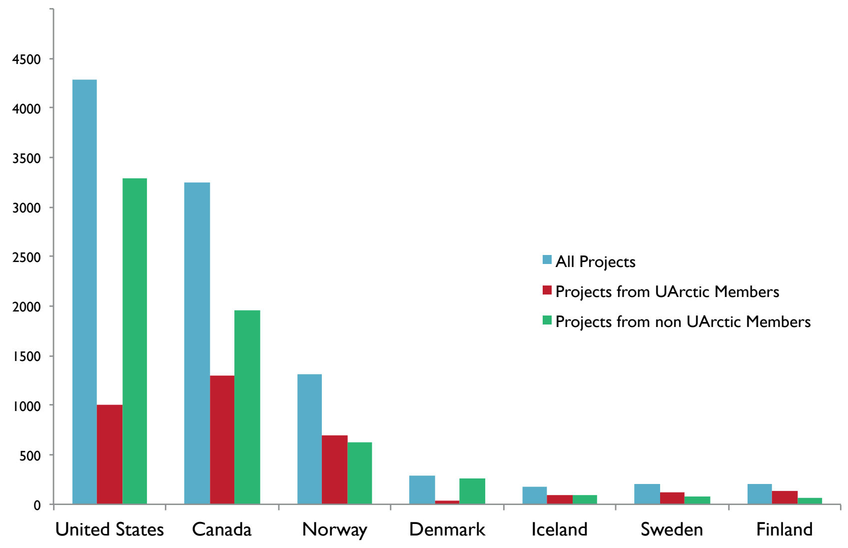


Figure F - Arctic Research - Number of Projects Started 2007 - 2016 by Researchers in UArctic Member Institutions Compared to Non-Members

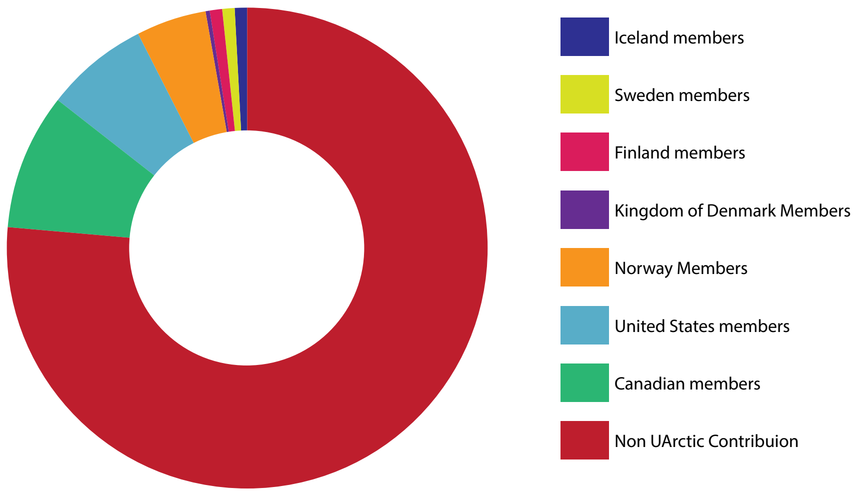


Figure F1 - Arctic Research - Number of Projects Started 2007 - 2016 by Researchers in UArctic Member Institutions Compared to All Non-Member Institutions - Project Number Pie Graph

Figure G shows a similar picture as Figure F based on funding amount. Tables C and D give the underlying numbers for Figures G and F.

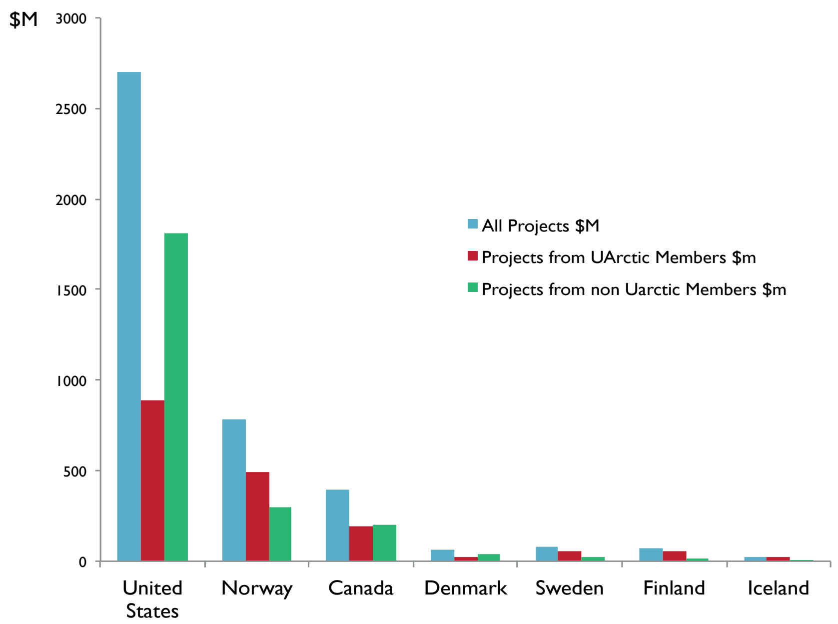


Figure G Funding Amount for Arctic Research Projects Starting in 2007 - 2016 at UArctic Member Institutions Compared to Non-Members[16]

Member Country	All Arctic Projects	Projects by Members	Projects by Non Members
United States	4287	998	3,289
Canada	3253	1295	1,958
Russia	2,773	Unknown	Unknown
Norway	1315	690	625
Denmark	286	31	255
Sweden	202	127	75
Finland	199	138	61

Table C - Number of Arctic Research Projects Starting Between 2007 - 2016. UArctic Member Institutions Compared to Non-Members

Table D and Figure H show similar figures for the top five observer states, (based on number of Arctic starting projects). These observer countries only have about 0.1% - 0.8% of their research falling into Arctic Research, which, given they are not found in the Arctic regions is perhaps unsurprising. However, the UK in particular still has a considerable number of Arctic research projects. In fact, the number of Arctic projects is higher for the UK than for several Arctic Council member countries. In Table D and Figure H below the contribution from Japan can be seen. With the new federal funding data from Japan added to Dimensions since the last review we can see the significant Arctic research funded by the Japan Society for the Promotion of Science.

Observer States	All Research Projects	Arctic Research Projects	Proportion %
United Kingdom	83620	657	0.79%
Japan	272620	358	0.13%
Germany	49158	250	0.51%
Poland	19081	159	0.83%
People's Republic of China	82709	109	0.13%

Table D - Total Number All Research Projects and Arctic Research Projects Starting 2007 - 2016 for Top Five Observer Countries in Arctic Research

Table E gives the funding amount and number of Arctic projects for the 25 largest member institutions in terms of funding 2007 - 2016. The largest recipient of funding is the University of Alaska Fairbanks, largely because of a single award of $148m for the construction of the Alaska Region Research Vessel, followed by the University of Washington. These two institutions are very different, however. The University of Washington is a very large institution with more than 5,100 funded projects of which 4% are Arctic. The University of Alaska Fairbanks has approximately 750 projects overall, of which 64% are Arctic. Thus, the University of Alaska Fairbanks is strongly specialised in Arctic research. Similar patterns can be found for other member institutions listed in the table. When interpreting this table, it should be recalled that the numbers include external grants only. Most institutions will have a considerable amount of basic funding in addition. The ranking of institutions would appear different if this funding had been included.

16 *Funding amounts for the projects are not provided for both the Russian Foundation for Basic Research (RFBR) and the Russian Science Foundation (RSF).*

17 *Russian contribution by members can't be shown as the funders RFBR and RSF do not include information on organisational affiliation.*

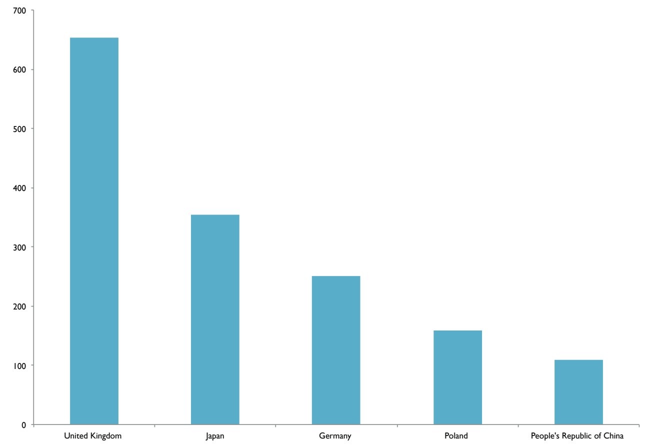


Figure H - Top Five Observer States Contribution to Arctic Research by Number of Projects 2007-2016

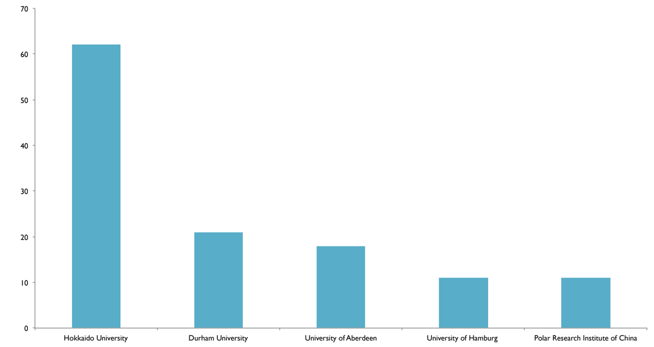


Figure H1 - Top 5 Observer Organisation start dates 2007 - 2016 by number of grant

Since the introduction of Federal funding data from Japan we can now see that Hokkaido University has 62 grants in Arctic research with over $10m in funding. We can also see that the Polar Research Institute of China makes it into the top five with 11 grants.

Research Organization	No. of Projects Arctic Research	No. of projects, Total	% of Projects in Arctic Research	Arctic Funding Amount $ million
University of Alaska Fairbanks	492	766	64%	544.3
University of Washington	212	5155	4%	204.3
University of Bergen	133	1171	11%	165.9
The Arctic University of Norway	220	563	39%	162.5
Norwegian University of Science and Technology	86	918	9%	107.2
Laval University	317	8866	4%	90.8
University of Colorado Boulder	163	2501	7%	77.5
University of Oslo	102	2115	5%	75.4
Dartmouth College	47	896	5%	64.7
University of Alberta	237	10569	2%	64.7
University of Manitoba	126	4736	3%	55
University of Alaska Anchorage	72	101	71%	47.6
Memorial University of Newfoundland	204	2333	9%	44.3
University of Iceland	80	310	26%	42.6
Stockholm University	55	1700	3%	35.5
Arctic Research Consortium of the USA	8	8	100%	34.6
University Centre in Svalbard	112	136	82%	32.1
University of Helsinki	49	2370	2%	31.2
Umea University	36	1040	3%	30.3
Lulea University of Technology	13	427	3%	30.2
University of Copenhagen	21	654	3%	29.6
Finnish Meteorological Institute	26	137	19%	28.3
University of Agdar	1	116	1%	28
University of Quebec at Montreal	82	4716	2%	26
Lund University	23	2636	1%	26

Table E - Top 25 Arctic Research by UArctic Member Organizations 2007 - 2016 by Funding Amount and Number of Projects

Institutional Comparison

Using data from Dimensions, the funding profile of each institution can be analysed and compared with others. Within the scope of this report, we are only able to provide some examples of such analyses. The following images come directly from Dimensions, where two institutions are shown side by side for comparison. Using the table above we have looked at three pairs of institutions from Sweden, Finland and Japan.

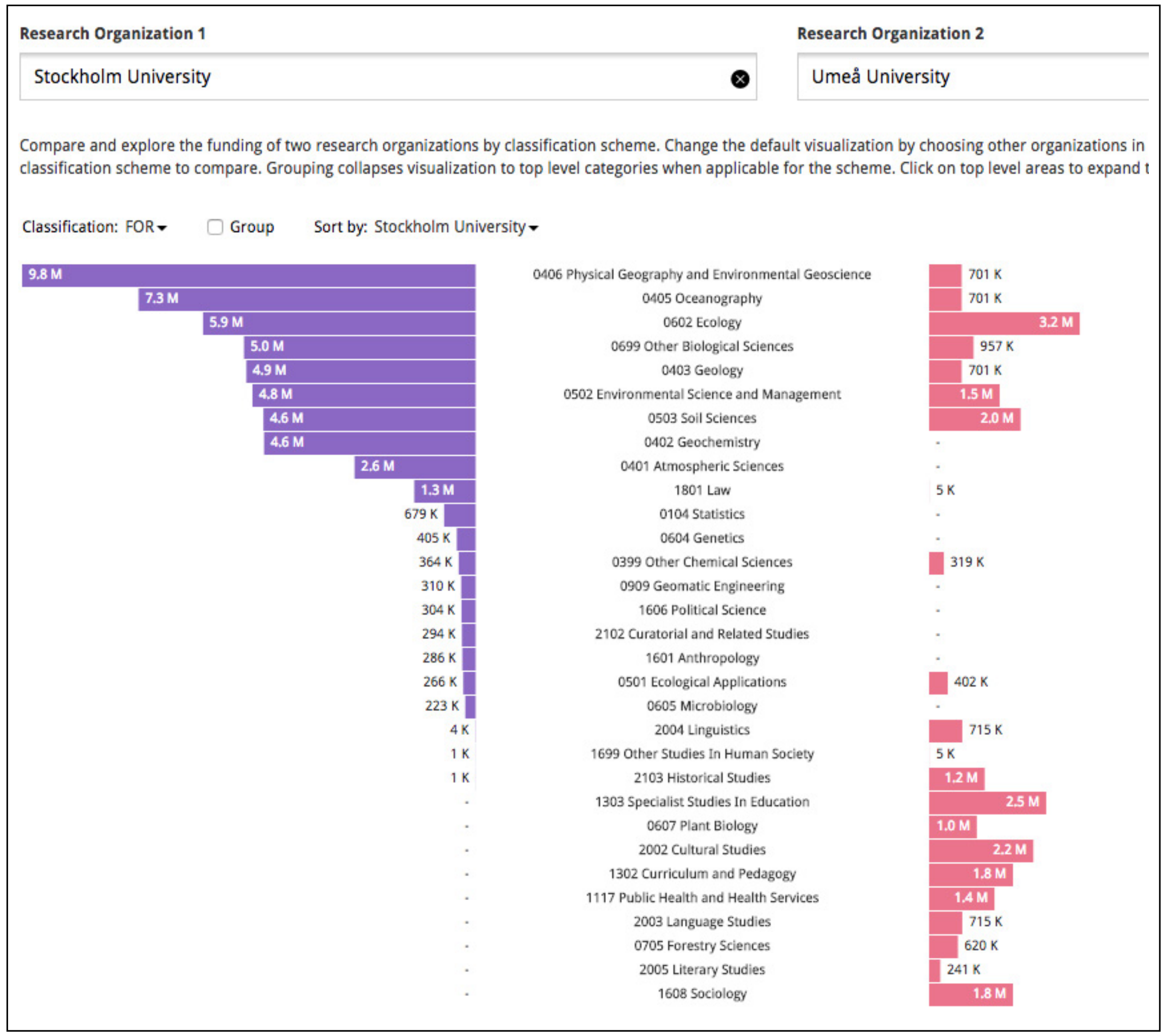


Image 1 - Sweden: Stockholm University compared to Umeå University for Arctic Research Start Years 2007 - 2016

Although funding levels are similar, with Stockholm funding about $16m and Umeå funding about $14m the two institutions fund in very different areas, with Stockholm predominantly funding core STEM subjects whilst Umeå has funding in arts, humanities and sociology.

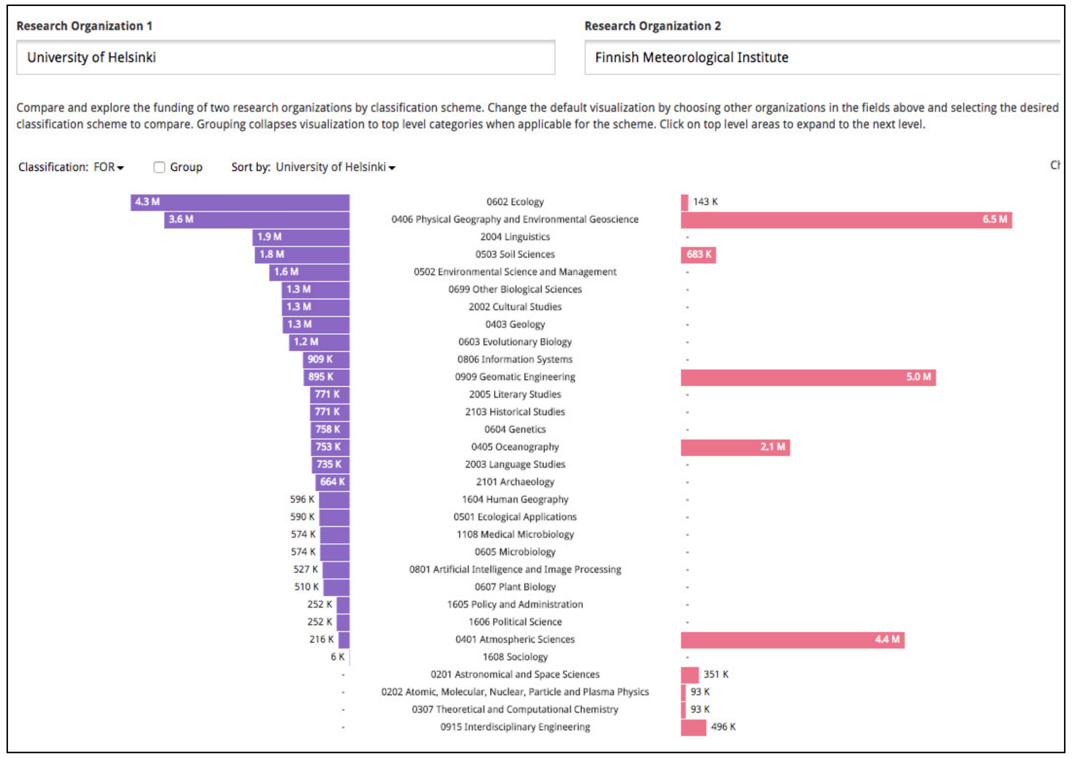


Image 2 - Finland: University of Helsinki compared to Finnish Meteorological Institute Start Years 2007 - 2016

Funding values are again not too dissimilar - with $19.8m at Helsinki and $13.1 at the Finnish Meteorological Institute, but whereas spending is across multiple disciplines at Helsinki there are just for dominant area at the Meteorological Institute.

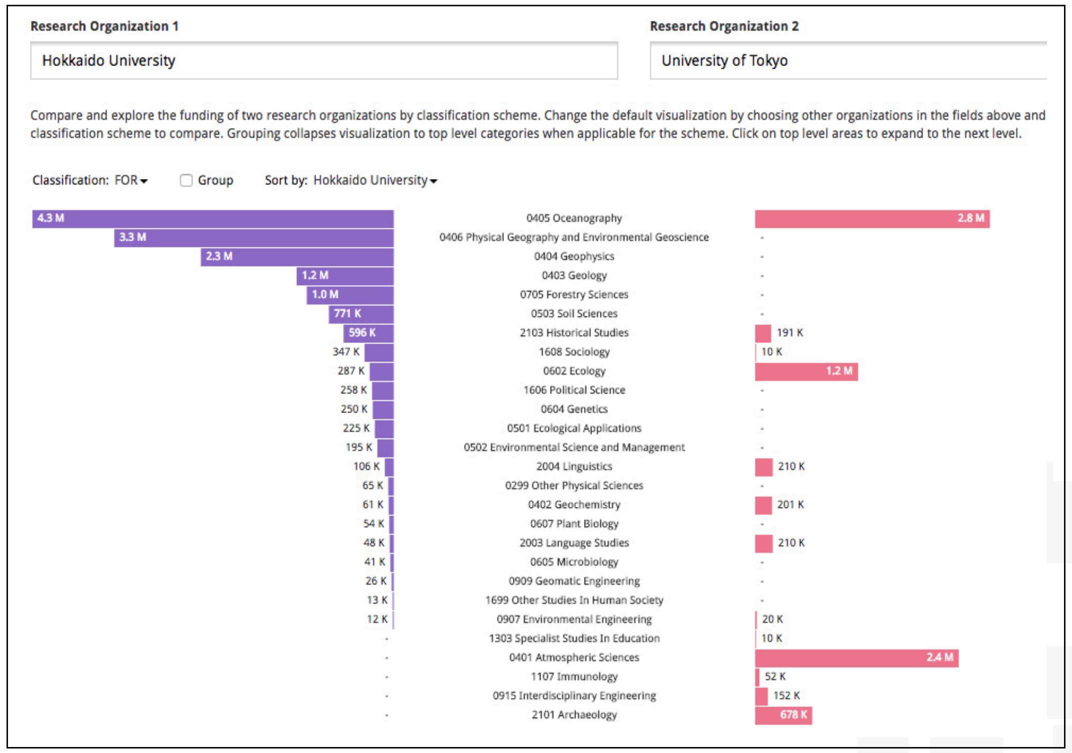


Image 3 - Japan: Hokkaido University compared to University of Tokyo Start Years 2007 - 2016

There is more funding at Hokkaido than at Tokyo for Arctic research, but the differences are interesting. Tokyo has $2.4m for atmospheric sciences, whilst Hokkaido has none. Whereas Hokkaido has $3.3m for physical geography and environmental geoscience, and $2.2m for geophysics whilst Tokyo has no funding in these areas.

Figure I - Top 10 UArctic Member Organizations by Total Arctic Research Funding 2007 - 2016

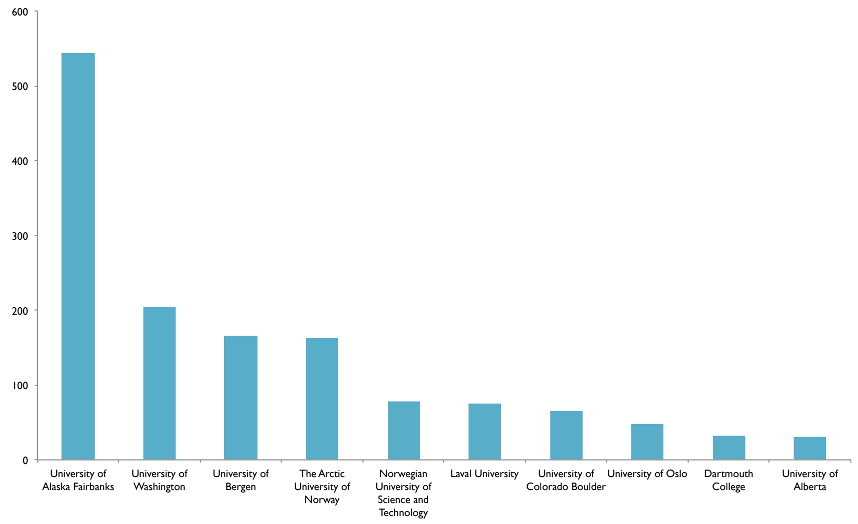
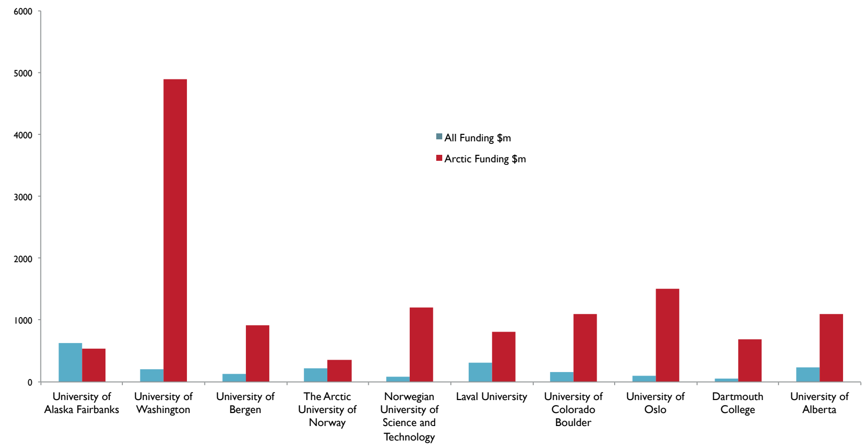


Figure J - Top 10 UArctic Member Organizations by Arctic Research Funding 2007 - 2016 with Comparison to Non-Arctic Research Funding



Trend Analysis

We saw earlier that there seems to be little evidence for either an increase or decrease in Arctic research globally, but that this might not be the case for all subject areas. The trends are interesting to analyze for individual institutions. As an example, we have selected the University Centre in Svalbard. Figure K shows some increase (generally) in both the number of grants starting and related funding since 2011 at the University Centre in Svalbard. Please note that this is only by grant funding. Block funding is not available. In 2015 there was a large ($4.1 million) grant given for the "Svalbard Integrated Arctic Earth Observing System - Knowledge Centre (SIOS-KC)." Nearly all funding at the institution is provided by the Research Council of Norway (RCN). Their statistics are presented below.

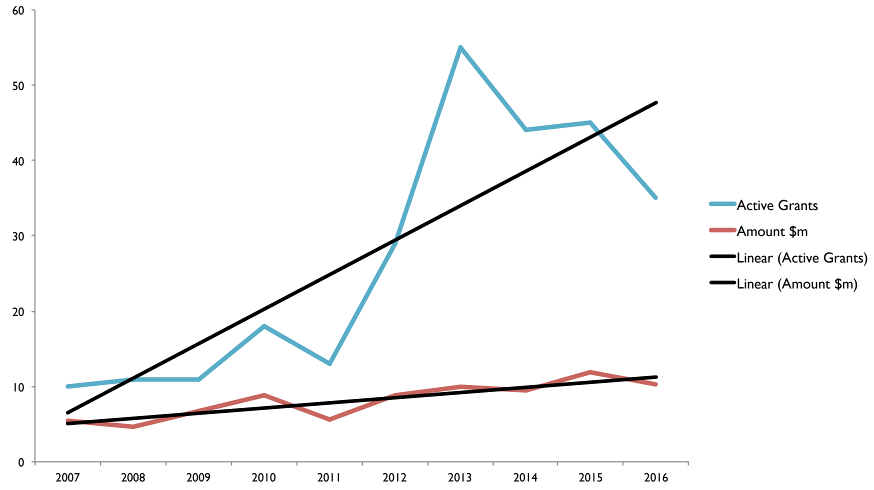


Figure K - University Centre in Svalbard Start Grants 2007 - 2016 Showing Number of Start Grants and Funding for Arctic Research

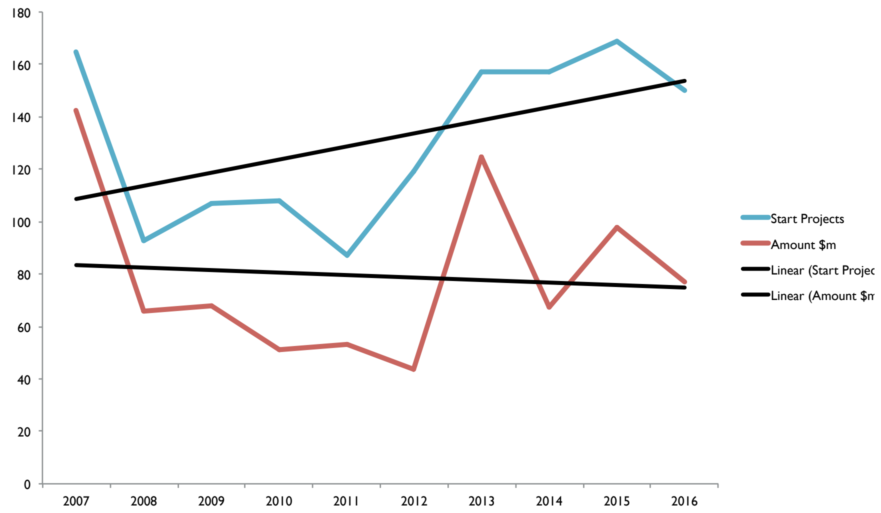


Figure L - Research Council of Norway Start Grants Arctic Research Funding and Grants Starting 2007 - 2016

The RCN funded a lot of Arctic research in 2007 before dropping back, but, since 2012, funding has increased, albeit with annual fluctuations. Their awards include many large grants in the Arctic research domain. For example, in 2013 they awarded $22 million for the "Centre for Autonomous Marine Operations and Systems (AMOS)". During the 2007 - 2016 period there were 12 grants in Arctic research over $10 million. To compare the rise in Arctic research the graph below shows all RCN funding during the same period and shows a much flatter graph.

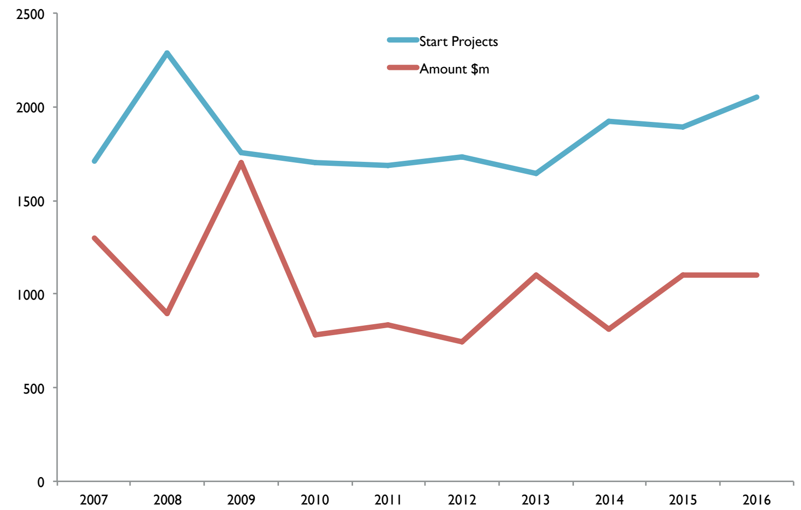


Figure L.1 - Research Council of Norway Research Grants in All Subjects 2007 - 2016

Conclusion

In this 2017 update of our pilot report we have analyzed Arctic research by funding indicators using the Dimensions database. The project and the methods applied are still in an exploratory phase, and the results are significantly influenced by a lack of data from several important funders. This affects some countries more than others. Nevertheless, we have been able to identify several interesting patterns characterizing Arctic research during the period of the last decade (2007-2016):

- Overall, just under 1% of all recorded global research funding in Dimensions is in the area of Arctic Research. It represents a significant amount of investment by the global scientific community in the exploration of various aspects of this important region.
- The fields of Earth Sciences and Biological Sciences are the two largest recipients of Arctic research funding. However, the funding for Earth Sciences is almost twice as high as for Biological Sciences.
- The US is the largest Arctic research nation both in total spending and number of projects started. It also has the most comprehensive coverage of funding sources in the dataset. Canada and Russia are the second and third largest nations in terms of number of projects started, followed by Norway and the UK.
- UArctic institutions are central actors in Arctic research globally. Overall, researchers from UArctic member institutions represent approximately 35% of all the Arctic research funding, based upon a total of $4.8 billion in funding for the ten year period covered by the currently available data.
- Researchers from Arctic Council Observer nations are increasingly doing more research on the Arctic. UK and Japan are extremely active, followed by Germany and China with considerable number of Arctic-related research projects.
- The analysis suggests that there is neither growth nor shrinkage in the volume of Arctic research funding over the period 2008 - 2014.
- Better collaboration with funders on data specifics (timely submission, affiliation indicators, amounts indicators) will help create a more comprehensive picture to facilitate a regular review of trends both in funding as well as subject areas.
- Linkages between funding and outputs show a strong correlation but need to be improved greatly in order to see a more detailed picture.

Using project funding data to understand Arctic research trends, rather than publications, provides a unique viewpoint on the field. It allows us to see where public funding is being spent now and into the future. Although this report looked at projects that started between 2007 and 2016, Dimensions shows some 2,640 grants active in 2017 and beyond, totalling $2.2 billion. This represents Arctic research that is currently being conducted. Understanding where (geographically/institutionally) and in which sub-classification areas this research is being undertaken will help both UArctic and Arctic Council officials be able to provide feedback to their members in order to consider its strategic priorities.

In addition, by understanding who is funding Arctic Research (and who is not) UArctic and Arctic Council science officers can liaise with funders armed with information about their Arctic efforts. Every month the data in Dimensions will both be refreshed (that is, data from existing funders will be updated) and expanded (approximately 5 new funders are added every month). For this annual update report, we have added 28 Danish public and private funders information to run this analysis, thanks to the Danish Ministry of Higher Education and Science. This means that this analysis can be undertaken again, on exactly the same like-for-like basis (using the same Arctic Category as explained in Appendix 1 but with a bigger database of funding data). This would allow for an analysis that compares activity in the future to the activity captured in this pilot report.

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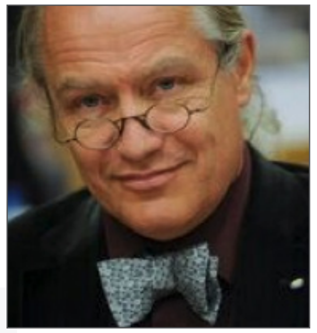

Lars Kullerud

Lars Kullerud has held the position of President of UArctic since May 2002. As the first president of UArctic Lars has had the pleasure to take part in the journey of developing UArctic. Before joining UArctic he represented UNEP in the early life of the Arctic Council and its predecessor AEPS since 1992 as Polar Manager for GRID-Arendal - UNEP's Key Polar Centre. Lars has background as geologist and have worked for the Norwegian Petroleum Directorate.

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Aaron came to Digital Science from Temple University School of Medicine where his research centered on the analysis of large datasets to gain an understanding of the roles collaboration and competition play within the context of scientific discovery. Prior to Temple, Aaron held similar positions at Johns Hopkins University, GE Healthcare, Collexis, and Elsevier. Aaron currently serves as the inaugural Scientometrics Editor for the Journal of Alzheimer's Disease and lives with his family in Philadelphia, Pennsylvania in the US.

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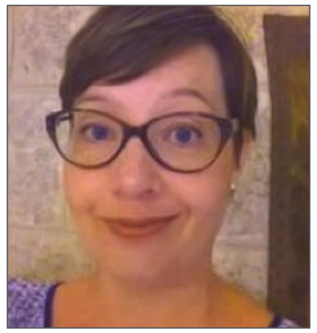

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Appendix 1 - The Arctic Category

A Category is a Boolean expression with proprietary caveats unique to Dimensions. This means terms can be 'boosted' to influence inclusion and the long tail or irrelevant grants can be excluded, to give a cleaner and more precise definition. The Arctic category was worked up using UArctic staff and assistance from ÜberResearch staff familiar with Category creation. It contains a large number of terms, some generic to Arctic research and others specifically relating to the places and peoples of the Arctic. The category is not reproduced in full to retain rights of usage.

In order to identify projects relating to the Arctic, we have applied geographical search terms and carried out a search through the titles and abstracts of all the projects in the database. We have assumed that the geographical locality in which the research will be performed or relates to would generally appear either in the title or in the abstract of the projects. Names of geographical areas in the Arctic were therefore used as an indication of Arctic research content. Based on the geographical delimitation of Arctic, names of mainland areas, islands, oceans, lakes, rivers and cities were included. In principle, the number of potential geographical search terms is almost infinite. For practical reasons, however, we have limited the numbers to the main geographical localities, which total 350.

In addition, names of peoples living in the Arctic were used as search terms (e.g. Inuit, Saami etc). We included these names in order to ensure that the relevant research within social sciences and arts and humanities would also be captured our study. In total 225 such search terms were applied.

We believe the method we have applied is adequate for the purpose of providing an overall analysis of Arctic research. However, there are also various sources of potential errors. First, it might be the case that certain relevant projects have not been identified because the projects have not specified where the research will be carried out, or because other geographical names than those included in the study were mentioned. In order to reduce this problem, field-specific search terms (e.g. "sea-ice", "polar bear" etc.) could have been added. However, this was not done for this pilot report.

Second, the method might identify some irrelevant projects, i.e. projects which should not have been considered as Arctic research. This may be due to the fact that some words have more than one meaning or are used in contexts other than Arctic research. Although we attempted to avoid this problem by excluding words with multiple meanings, there might still be cases left where this is a problem. In addition, there might be cases where particular geographical names are mentioned in the abstract, for example Greenland, but where the research mainly relates to other areas.

Third, the study is based on the Dimensions database. This database does not cover all scientific and scholarly funding (see above). Therefore, only part of the Arctic research projects will be covered. Although there are limitations with our approach, we believe the study still provides interesting and useful indicators on Arctic research.

Appendix 2 - Notes on Data

This report was generated in March 2017, and there are some notable data issues that need reporting:

1. The RFBR data (Russian Foundation for Basic Research) held no funding amounts, no names of organizations and only partial data after 2012.
2. Data for the Russian Science Foundation was only for 2014 and no funding amounts were available.
3. We have incorporated federal data from Denmark and Japan, but have yet to incorporate federal data from South Korea, Singapore or India.
4. The NordForsk data includes neither funding amounts nor organizational links.
5. The Netherlands Organization for Scientific Research has no funding amounts.
6. The National Natural Science Foundation of China has no funding amounts.

Despite these limitations, the Dimensions database includes enough project data to allow for a comprehensive overview of Arctic research for the 10 year period under investigation.

In addition, the Dimensions database does not cover all funders worldwide. Thus, some projects relevant for Arctic research will be missing, and this problem affects some countries more than others. ÜberResearch is working closely with the funders to harmonize the different data models to assure that the data is comparable; however, project data is provided by funders based on internal policies which can result in some funders making no data available, others not providing it in a timely manner or not including all data elements (like funded organization or even funding amount) due to internal funder policies. Moreover, block funding for institutions is not considered due to the chosen policy to focus on project level funding, although block funding is important for the operation of some Arctic Institutions. For other sources the database has data on projects, but not the project amount. While looking at the results of these analyses it is therefore important to keep the limitations in mind. In spite of this, this database provides a unique insight into Arctic research funding as a share of global research funding, as well as into the sources and recipients of this support. This data should prove extremely valuable in understanding the trends and structures that drive Arctic research.

Appendix 3 - Methods Details

As noted in the report, the Task Force adopted a keyword search query approach to identifying projects relating to the Arctic. A notable difficulty was identifying research in and about the Arctic as per the above definition and avoiding research carried out on objects and issues outside the Arctic as defined. We concentrated on two types of terms in the searches: geographical and indigenous peoples names. In addition, a few general terms assumed unique to the Arctic (e.g. Arctic, tundra) were included. The category was crafted by UArctic members with assistance from Digital Science staff.

First, we applied geographical search terms for identifying the projects, and carried out a search through the titles and abstracts of all the projects in the database. A similar method has been used in studies which have analysed polar and Arctic research bibliometrically (Dastidar, 2007; Aksnes & Hessen, 2009; Côté & Picard-Atiken, 2009). We assumed that the geographical locality in which the research was performed or relates to would generally appear either in the title or in the abstract of the projects. Names of geographical areas in the Arctic were therefore used as an indication of Arctic research content. Based on the geographical delimitation of Arctic (as above), names of mainland areas, islands, oceans, seas, lakes, rivers and key cities and settlements were included. In principle, the number of potential geographical search terms is almost infinite. For practical reasons, however, we have limited the terms to the main geographical localities. A total of 350 terms were included covering the key geographical regions of all eight countries of the Arctic Council member states.

In addition to the geographical terms, which embody a direct affiliation to the areas, considered "Arctic" by their respective countries, we also assumed that using indigenous nations, peoples, bands, and tribes names (e.g. Inuit, Saami, Nenets, etc.) as search terms would provide further precision to the output of the search. In particular, we included these names in order to ensure that the relevant research within social sciences, history, arts, humanities and life sciences would also be captured by our study. According to a variety of anthropological, ethnographic and historical studies (Mousalimas 1997, Ingold 1992, Cruikshank 1992), indigenous people and their place names are usually well connected with the land and space, thus providing additional dimension to the geographic search. It also reflects the Arctic Council focus on Arctic Peoples as a key constituency of its work. In total 225 such search terms were applied covering the official names and variety of their spelling (including Cyrillic, Swedish, etc.) to the search query, covering all eight countries of the Arctic Council member states.

The list of search names and keywords is far from complete and this is a pilot study, which, we hope, will trigger significant methodological and substantive discussion on both the data and the approach. However, we do believe that the method we have applied is adequate for the purpose of providing an initial analysis of the global Arctic research.

Dimensions provides functionality to define research areas very precisely by allowing to eliminate false positive results automatically. These research areas can be then saved as permanent definitions called 'categories'. Now that this category has been created and saved, further analyses, using the same category (and therefore on an exact like-for-like basis) can be undertaken quite easily.

The Dimensions database of funders grows every month by about 4-5 funders, meaning repeating this exercise in a year or two would strengthen the analysis even further.

Traditionally, Russia has been using its own FOS categorization of scientific subjects and cannot be compared directly to Fields of Research codes with the global data, but nevertheless we see clear similarities, with Earth and Biological sciences topping both global and local funding priorities graphs

Dimensions uses Machine Learning techniques to emulate the Fields of Research categorization. Although ÜberResearch has undertaken many tests to prove the accuracy of these techniques we thought it would be instructive to validate that semantic classifications are trustworthy. To do this we used the fact that there are some 'hand coded' classifications found within the Russian Foundation for Basic Research data, as in Figure A1 above.

We created a comparator case to verify whether machine learning categorization, used in Dimensions (Figure A), would return similar output - by number of projects - when looking at the Russian Foundation for Basic Research data (Figure A1), using exactly the same keyword query for Arctic subject area definition.

The similarities between the two sets of data suggests that the semantic approach must be achieving reasonably accurate coding.

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