

The Future of Polar Science*

by Karin Lochte¹

In many scientific fields a new orientation towards future goals is sought. Polar science is not exempt from that search. Many interesting scientific talks and posters are being presented during this symposium including many new ideas. But this is not sufficient in my view. We are entering a new era of science and we should think about how we shape the future of – not only – polar science in our country, in Germany but as well in Europe and beyond.

I have taken the opportunity of this symposium to present some ideas of future challenges and how polar science may develop. I am convinced that Antarctic and Arctic science is at a turning point and I want to initiate a discussion on this issue. This is a talk without pictures – and it is more a talk on science strategy than on science topics.

The International Polar Year, the IPY of 2007/08, has been a great boost to polar science and it stood in line with the previous IPYs. It facilitated international coordination of research and collection of valuable data sets. It was shown that climate change will affect the high North and parts of Antarctica more severely than the rest of the world. The IPY also helped to intensify outreach to the public and education, which has created increased awareness for polar issues in society. It has become clear for many politicians and the general public that we observe substantial changes at the poles, which are of high relevance for society – may it be seen as a threat or as a chance.

A major new development of the IPY is the inclusion of the Humanities. The futures of the lives of the indigenous people, economical and legal consequences are being discussed. It is no longer a research field for natural sciences alone. Our research field is no longer just a description of the natural processes that shape the polar regions; it has become a societal challenge of the people living in the Arctic regions, but also for us, the global society. It is not only the question whether the sea level rise is affecting our coastal cities or whether atmospheric changes influence our weather. It is the question which responsibility we are assuming for the polar future. Polar change is a global challenge. We need to take that seriously and respond to that challenge.

How do we (i.e. society) want to deal with the polar regions in future? Should they be a protected heritage of mankind? Should they provide much needed resources for our future demands? After all much oil and gas is stored in the Arctic Ocean floor and Antarctica is also rich in mineral resources.

Which role can science play in these questions? It is clear that the traditional polar research based on natural science has to change shape. Therefore, it is necessary that we include new fields of research and that we learn to tackle these new fields in transdisciplinary projects much more than we do it up to now. Just a question to the audience: who is an engineer, an economist, a legal scientist or a physician? – there are no hands up! Alternatively, who is physical oceanographer, a biologist, a chemist, a geoscientist, or a meteorologist? – all hands are up! We need to ask ourselves how the polar regions will look like in future – say in 20 years? This has to guide our research.

Climate change is progressing fast in the Arctic, but also at the Antarctic Peninsula. Major alterations are expected in sea-ice coverage, thawing of permafrost regions and related export of organic matter into the coastal areas, melting of ice sheets that affects the surrounding ocean and exposes new areas of land. So how will the polar system look like in 20 years? Which investigations do we have to focus on in order to address these questions? I think that some of this is already well in focus of the scientific community. But in addition to projected changes in the environment there will be other developments:

- Increased use of the natural resources – in the Arctic of oil, gas, and minerals; in the Antarctic fisheries and perhaps more shipping with increased danger of accidents and most likely substantial environmental impacts.
- Legal changes can come up that may impede access for research. This concerns in the extensive claims for exclusive economic zones in the Arctic Ocean which leaves very small areas in the centre of the Arctic that remain according to the International Law of the Sea international regions. In the Antarctic Marine Protected Areas will be installed with protective conditions. This means that we have to realign research to accommodate the restrictions in Exclusive Economic Zone's (EEZ) waters and in protected areas.
- Human use of the polar environment (e.g. Shipping) and public interest (e.g. tourism) in the pristine environment rises. This will change the pollution in the polar regions regardless of strict regulations for prevention of pollution. It cannot be avoided that increased amounts of CO₂, aerosols, and other substances will enter the polar regions. The human "footprint" will increase.
- Invasion of alien species is likely to happen, partly due to the changing environment and partly due to transport into the polar regions by human activities. Introduced species would have a higher potential to survive under warming conditions.

All these changes will alter the face of the polar regions more rapidly than we may anticipate at the moment. It is a combination of climate change, human impact and reactions of nature to the external forcing. This will affect some regions more than others. Hot spots are most likely the Antarctic Peninsula,

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¹ Alfred-Wegener-Institut – Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Am Handelshafen 12, 27570 Bremerhaven.

Svalbard, coastal and harbour areas around the Arctic Ocean and probably some more. This requires that we observe these changes attentively and that we identify the most problematic processes and pin point regional hot spots.

Another point is the new technology that will be available to improve observation, modelling and data exchange. At present much of our knowledge of the polar regions is based on insufficient data. In the harsh environment it is usually only possible to carry out research during the summer seasons. Only few exceptional expeditions have managed to collect data in the winter season, such as the Russian ice drift stations in the Arctic Ocean and the overwintering teams of some stations in Antarctica. This year RV "Polarstern" is carrying out a winter experiment in the Atlantic Sector of the Southern Ocean to investigate the big question: Why is the sea ice around Antarctica increasing while the Arctic sea-ice is suffering strong reductions? How do biological processes function during winter.

Autonomous observations with data transfer via satellites are now gaining ground. This is an important development that needs to be expanded. Only if we can gain information all year round in a range of representative areas throughout the polar regions will we have sufficient data that allow improvement of models and predictive capacity. This requires development of sensor technology that is robust and reliable even at low temperatures and high mechanical stress. It requires independent energy supply and intelligent energy use (i.e. instruments switch off when not needed ...). It also requires data storage on site and transmission via satellites and perhaps even the possibility to control and readjust the measurement systems via the satellite link. I think we can learn a lot from space technology in this respect.

Another technological development is the need to properly store data ashore and make them available to a larger user community. This is already underway in many European and international projects, but it is still far from ideal. In the aftermath of the IPY, data storage and open access is a major issue and I hope it will succeed. Only if open access to the major data sets is safeguarded will we be able to improve models of future scenarios in the polar regions. This is absolutely necessary considering afore mentioned anticipated changes.

In respect to models, of course we have to improve the physical models and reduce the error bars on future projections. However, it is most important that we develop ecosystem models if we want to understand how the biogeochemistry and the biological system will respond to changes and also influence them in turn. This is still a wide-open field – not only for polar research.

In consequence, we need to make best use of available technology and share new developments, wherever possible. It is too expensive for one nation alone.

The issues above: inclusion of new fields of science, attention to hot spots of changes occurring in the polar regions and improving our technology and data availability are already well known and we are aware of it. But how can we implement it? Many countries have developed national plans for polar research. New polar research institutes are founded, new polar

stations are being built, new ice-breakers are commissioned. The necessity to invest into research of polar issues is apparent to many politicians as these regions are of high geopolitical interest. What I find distressing is that these developments and plans are so little coordinated. At least in Europe we could try to make more coherent efforts.

In Germany, the Ministry for Education and Science (BMBF) jointly with the national SCAR/IASC Committee (SCAR = Scientific Committee on Antarctic Research, IASC = International Arctic Science Committee) has developed an Arctic strategy called "*Rapid changes in the Arctic: Polar research in global responsibility*" (Schnelle Veränderungen in der Arktis: Polarforschung in globaler Verantwortung). It focuses on topics of societal relevance and global significance:

- Past, present and future of climate development in the Arctic;
- Impact of the Greenland ice sheet in sea level rise;
- Reduction of Arctic sea-ice and feedback to the Arctic atmosphere and the ecosystem;
- Permafrost and gas hydrates as unknown forces in the climate system;
- Adaptation of polar organisms to the changing Arctic environment;
- Chances and risks of increasing economical use of the Arctic.

Many of you will present papers on these topics in the course of the symposium and discuss the latest developments. So I will not say more about it and leave the scientific treatment for the experts.

This BMBF strategy paper focuses on some of the most important questions arising from the predicted changes in the Arctic and in particular on the question, how the challenge of sustainable development can be achieved. However, in view of my consideration this strategy is still too "traditional" and too much focused on our well-known science. It is mentioned in the strategy paper that it is necessary to include the social and economic sciences, but we have not yet made a transition to the new transdisciplinary science.

It is obvious that also an Antarctic strategy paper is needed to complement the Arctic strategy paper. In fact, Germany would need a national polar research programme (Polarforschungsprogramm). Such a plan did exist in the past, but would need to be renewed now in the time of increased scientific and political interest in the polar regions. I think that a national plan is very important now, that it should include Arctic and Antarctic research and that it should also include all areas of science. Furthermore, it should represent the unified voice of Germany in respect to polar research and therefore it should be a plan of the German Government and not just the Research Ministry. In a recent round table discussion it became clear that there is considerable interest from several Ministries in polar research: apart from the research ministry (BMBF), it includes the ministry of economy (BMWi), the ministry of the environment (BMU), the ministry of defence (BMV), the Foreign Office (AA), the ministry of transport (BMVBS) as well as the ministry of agriculture, fisheries and consumer protection (BMELV).

A German national Strategy for Polar Research would be a great help to bind those different interests together in a unified

concept. It would help the scientific community to work more coherently together and also to link plans internationally.

An interesting development is the “Horizon Scanning” exercise of SCAR. SCAR has realized that after the IPY it is necessary to check how to continue and to develop Antarctic science into the future. So many new ideas were developed, that one needs to “scan the horizon” to find the right way forward. This is a very interesting exercise that I want to tell you about and I also want to solicit your support. “Horizon scanning” is a new method, a new tool, developed to check within a very wide community which new trends and ideas are around. It has been successfully applied to a number of science applications. Its aim is to arrive at the 100 highest priority science questions in the field. The procedure comprises the following steps:

- A questionnaire is sent to a wide community soliciting the nomination of the most compelling questions in polar (here Antarctic and Southern Ocean) science. People are asked to explain briefly, why they think the question is relevant – this will produce probably around 1000 questions!
- These questions will be sorted into topical bins – 10 bins of about 100 questions.
- The scientific community is also asked to nominate the top scientists in their field. From these nominations a group of about 80 scientists from different disciplines is selected that will discuss the questions collected in the topical bins in a joint workshop in spring 2014.
- In the discussions during the workshop the questions in each bin will be assigned a score between 0 (reject) and 10 (retain) by the expert scientists and this way a number of questions in a bin will be excluded. In second and third steps the selected questions of different bins will be combined and again the experts discuss them and score them again which again reduces the number of retained questions.
- In the end it is supposed that the top 100 questions (or perhaps a smaller number) can be identified and ranked.
- The final output will be a high level publication that outlines the highest priority questions in polar (Antarctic) science.

This whole exercise depends very much on the broad participation of scientists from many different fields. This is essential! Therefore, I would like you to participate in this SCAR Horizon Scanning activity and submit your favourite questions.

These questions that have been widely solicited and intensively discussed would form a very solid basis on which national plans can be developed. Only the national plans can

then put the scientifically identified questions into action and finance the relevant research.

I think that it would be ideal, if we can base our national plans on such solid horizon scan for future research and that the different national plans are in some ways coordinated – at least within Europe.

We have already vehicles for such a Europe-wide coordination of polar research plans – the European Polar Board (EPB). We should use it wisely to improve our collaboration.

There is already one activity under the umbrella of the EPB that may be of interest in respect to shared technology that I briefly want to mention: the development of an European Ice Breaker Consortium (ARICE). In Europe there are only two heavy icebreakers available for research and several ice-strengthened ships. Perhaps new ships will become available in future. It would be excellent if we can make the ship time available for the European science community. It would require agreements on access and finances, but it would really be a better way than each nation developing its own icebreaker. The same can be, by the way, applied to the polar stations or airplanes.

Sharing the technology amongst the researchers is in my opinion the most efficient and sensible way to develop strong and well-coordinated international polar research.

To summarize, a way into the future of polar science should consider new aspects:

- (i) Natural science and humanities need to collaborate on an equal footing as the research questions gain more and more socio-economic relevance. Fields of science outside the “normal” polar science need to be explored.
- (ii) Observations of both Polar Regions have to be improved by new technologies in order to provide much needed data for model development. It should include year round, automated observations in the sea and on the ground to complement satellite measurements. These data need to be easily accessible.
- (iii) International coordination of polar infrastructure is required to improve access to the remote Polar Regions for all scientists and to use the available infrastructure most effectively. This would be an excellent task for the Horizon 2020 programme of the EU.

We should strive for the International Polar Decade in a well-coordinated way – our finances will not increase, but the questions will!!