International Polar Year 2007–2009

– An Opportunity for Danish and Greenland Polar Research –

Climate changes witnessed in the Arctic are vivid and greater than changes in the mid-latitudes or tropics. We must understand these changes in context with the past in order to make informed choices for the future.

The upcoming International Polar Year (IPY) is an excellent opportunity for everyone involved in Polar research or concerned with the polar regions to partake in an international, concerted and synergetic campaign launching a broad suite of projects in natural science, social science, humanities, community outreach and education.

IPY will provide a framework to undertake projects that normally could not be achieved by any single nation. New and innovative observations and research will be initiated and efforts are taken to attract and capture a new generation of polar researchers.

The overall international themes during the two years (March 2007 – March 2009) allocated to IPY are:

- Present Environmental Status of the Polar Regions
- Past and Present Environmental and Human Change
- Enhancing our Understanding of Polar – Global Interactions
- Developing and Enhancing Observatories for Earth and Space using Vantage Points in Polar Regions
- To investigate the cultural, historical, and social processes that shape the resilience and subsainability of circumpolar human science

The strategic role of Greenland renders Danish and Greenland researchers unique possibilities to coordinate international experiments and observational networks in Greenland. Therefore, the Danish National IPY Committee is focusing on research themes in and around Greenland expecting Danish and Greenland researches to undertake coordinating and leading roles in international programmes launched under the following themes:

- **Arctic Climate – Variability, Change and Impact**
- **Greenland's Ice Sheet – Scientific Frontiers**
- **Man, Nature and Arctic Societies**

These themes are proposed because they represent key issues in contemporary, cutting-edge Arctic research, they are multi- and inter-disciplinary by nature, they require extensive international collaboration in order to succeed, they are apt for stimulating novel research approaches and solutions, and they offer a wide range of intellectual stimuli and professional challenges. Due to the unique physical, geological, biological and societal features that Greenland offers, it will – most certainly – attract an array of high profile research interests from foreign countries during the IPY. The themes are described in details below.

The approaching IPY is the fourth of its kind. During the first IPY, 1882-83, Danish research interests were represented through the participation of the Danish Meteorological Institute (DMI) which conducted Aurora borealis studies from an observatory in Nuuk, Greenland. During the second IPY, 1932-33, DMI performed magnetic observations at three sites in Greenland, and in connection with the third IPY (aka International Geophysical Year), 1957-58, ionosphere studies were intensified in Greenland by the Technical University of Denmark. The third IPY was also the event that launched large-scale international geophysical research on Greenland's Ice Sheet, - and Danish participation, initiative and leadership has developed significantly in this research field during the past five decades.

Arctic Climate – Variability, Change and Impact

Greenland's Ice Sheet, the permafrozen land areas, the Arctic Ocean, and its outlets through the Fram Strait and Nares Strait, the Transpolar Current, the Oceanic Deep Water Formation, and the Arctic/North Atlantic Oscillation are essential factors in shaping the Arctic climate system.

General climate variations in the Arctic are closely tied to changes in total heat transport from the south where the oceanic component is associated mainly with thermohaline circulation (THC) and deepwater formation considered an important driver. The atmospheric dynamics and radiation processes transport heat and provide a pathway for CO_2 exchange between the atmosphere and the deep ocean.

Targeted climate monitoring from surface-based observation stations and satellites in, around, and above Greenland in combination with regional and global atmospheric and oceanic modelling will be the backbone of Arctic climate research which is proposed as a Danish coordinated component of the IPY. There is also a need to recover, validate, and incorporate long-term climate observations from past centuries and to deveolop palaeo-climatic and oceanographic models based on records obtained from Quarternary marine and lacustrine sediment cores.

Anthropogenic climate change may lead to abrupt changes in oceanic heat transport and present knowledge suggests that the Arctic will experience a warming stronger than the global average. To quantify the magnitude of global warming in Greenland it is proposed to perform and analyse simulations with state-of-the-art global and regional models.

The ecosystems are highly sensitive to changes in the Arctic climate. The ecosystems as well as the physical and bio-geochemical conditions in Greenland and surrounding waters are susceptible to climate variations and changes. It is proposed to perform manipulated impact studies based on both observations and modelling. Furthermore, system studies of the feedbacks associated with release of carbon from land and ocean surfaces must be carried out. CO_2 and CH_4 feedbacks may be particularly strong in the Arctic since the largest climate changes are expected here.

Greenland covers wide latitudinal and longitudinal climate gradients in land-based as well as marine ecosystems. Profiles along the gradients offer superior opportunities for studying the impact of climate changes on

biological interactions in ecosystems and their mutual interplay. Latitudinal transect studies in the High Arctic north-east as well as longitudinal transects studies in the east and west will highlight the effects of climate change and the ecosystem adaptation to these changes.

Vast areas unaffected by anthropogenic activities as those in Greenland are found no where else in the Arctic. This promotes studies of climate effects and the use of sediment cores in lakes and marine areas north and west of Greenland to elucidate climate changes and the subsequent effects throughout the Holocene.

Future changes in sea ice and water temperatures around Greenland will have significant impact on traditional Inuit hunting conditions and also on the economically important fishing industry. Reduced sea ice coverage around Greenland, for example, will facilitate ship traffic and make exploration of living and non-living resources, in particular oil, easier.

Special focus should be on changes in sea ice extent and thickness which is believed to interact directly and significantly with temperature changes. The ice of the Arctic Ocean undergoes substantial changes on decadal scales and dedicated new satellite missions such as Cryosat will monitor the integrated changes in time during IPY. Observations and modelling efforts on sea ice changes should include surface and airborne ground-truthing.

Greenland's Ice Sheet – Scientific Frontiers

The single most unique feature in the physical nature of the Northern Hemisphere is the vast ice sheet covering 82% of the total land area of Greenland.

Greenland's Ice Sheet offers outstanding opportunities for studies of its present state and interaction with climate as well as its archive of palaeo-climatic information. One of the very important questions to address is the mass balance of the ice sheet, especially in relation to global climate change.

There are indications that the margin of Greenland's Ice Sheet is thinning with as much as 1 m annually and satellite data show the melting zone reaching increasingly higher altitude. Mass balance measurements at the

central part of the ice sheet are still at the verge of being possible but in the coming years they will most likely be available. New methodology utilizing satellites and geodetic monitoring of rock movements at automatic observatories located on Greenland's Ice Sheet will provide constraints on the overall dynamics and mass balance of the ice sheet.

The unknown nature of the bedrock and deep structures under the ice sheet represents new scientific frontiers. Through integrated geophysical measurements from traverses, aircraft and satellites, new measurement programmes can provide insight into subsurface structures, identify possible subglacial lakes, and enhance the understanding of anomalies in the heat flow from beneath the ice sheet and its impact on the ice sheet dynamics. The detection of subglacial fluid water, including possible subglacial lakes, represents challenges for chemical, environmental and biological sciences.

The present mass balance of Greenland's Ice Sheet is directly related to sea level changes. It is, therefore, highly relevant to address the reaction of the ice sheet to past and present climate changes through studies of current as well as earlier conditions. These issues may be addressed through satellite and surface measurements in combination with ice sheet modelling and studies of ice sheet dynamics, water and subglacial melting ice, ice sheet margins, and glacier outlets. Ice sheet models simulating the last five decades should be forced by modelled high resolution atmospheric data (e.g. net accumulation, net total energy budget at surface) based on so-called re-analysed data.

The unique storage of palaeo-climate information in Greenland's Ice Sheet can be accessed through deep ice cores and by ice margin studies. The ice sheet covering Greenland contains detailed annual information reaching back several 100.000 years while studies of moraines and bottom ice including ancient biological material may reach several millions of years back in time.

The existing palaeo-climatic records obtained in Greenland represent the Northern Hemisphere climate and – when compared to similar records from Antarctica – they present an exceptional opportunity to reveal and understand climatic interactions between north and south. During the last glacial period, abrupt climate changes of 15°C over just a few decades occurred with regular intervals of 2000 to 3000 years. These changes are believed to be caused by internal Earth system connections, e.g. ocean circulation, ice

sheet performance, and atmospheric circulation and coupled models should be developed to simulate the observed climate curves.

Greenland's Ice Sheet is not only a research target in itself – it can also be used as a platform by researchers for upward directed studies of the troposphere, stratosphere, mesosphere, thermosphere and space – as well as downwards into the lithosphere. A year-round manned research site at the top of the ice sheet would also provide unprecedented possibilities for astronomical studies and other monitoring activities.

IPY activities on Greenland's Ice Sheet could include coordinated airborne and surface traverses, procuring basic data for interpreting and evaluating satellite measurements of ice sheet change, as well as geophysical measurements to understand the subice structures. Other activities could include an international programme of low-cost automated observatories around the ice sheet margin providing basic geophysical, geodetic, ecological, climate and environmental data, coordinated with similar automatic offshore buoy and subice sensors programmes.

Man, Nature and Arctic Societies

Dynamic Arctic – Facing Challenges in a Changing Environment

During millennia Man has established societies throughout the Arctic and throughout centuries they have experienced cultural encounters and local changes on varying scales and with varying consequences.

These societies are now facing new challenges due to increasing globalization, internal development and different levels of economical and political independencies. The present rapid environmental and social changes in the Arctic are influencing all aspects of human life: Economy, communication patterns, family structures, social and political organization, knowledge regimes, health situation as well as other living conditions.

Arctic societies and landscape still hold unique and valuable information on the responses and the experience that these societies developed to maintain a life in the Arctic from the distant past to the present. This information is embedded in language, social organization, cultural landscape, local and regional settlement patterns, traditional and local

ecological knowledge, norms and value systems, as well as through mythology, tales and spiritual life, oral tradition etc.

The advent of IPY is an excellent opportunity to establish a status of the present knowledge on major processes and interaction patterns, and at the same time to outline and focus on crucial elements which will be structuring the development process during the next decades. As IPY is an international event, the emphasis on comparative analyses in the circumpolar North will be an obvious challenge.

In order to understand how changes affect Arctic societies and how people have dealt with these changes through centuries, it is important to apply a diachronic as well as a synchronic view during the research process, and to develop multi-disciplinary research programmes incorporating the interaction between Man and Nature as well as the cultural landscape.

Interactions, Processes and Trends

The concepts of *interactions* and *processes* are the keys to understand both the past and present changes. Arctic societies are affected by and have to interact with international and global mechanisms driven by change in environmental conditions, as well as the challenges of cultural encounters due to increasing globalization, internal developments and different levels of economical and political interdependencies.

These encounters are transformed through processes of changes within the Arctic societies, including their economical and political structures, intellectual and cultural inputs presently dominated by the internet and other media, as well as the physical and mental impacts caused by changes in ways of life, access to western foods, beverages, drugs etc.

These interactions and processes are often most clearly revealed as distinct *trends* in connection with the analysis of long-term time series, and the accumulated knowledge holds a rationale for Arctic peoples as well as for all peoples on World facing rapid environmental and cultural changes.

Long-term Trends

Arctic societies hold unique and valuable information on the mechanisms of interactions among human beings, and between Man, society and Nature from the distant past to the present. Such long-term records as well as more recent time series studies on socio-economic changes enable us to

pinpoint ongoing processes and events which have been crucial in the transformation of social and cultural characteristics.

Human – Environment Interactions

Knowledge of the interaction between human activity, natural resources and ecosystem dynamics is crucial for understanding both past and present living conditions in the Arctic. In this context the research programme "West Greenland's Ecosystem" can serve as a model for integrated studies of interaction patterns. A core issue is the understanding of socio-economic effects of variations in availability of living resources; – an issue that has gained importance due to the influence of global warming on daily life for communities dependent on renewable resources.

The interaction patterns are very much dependent on the perception of and attitude towards risks, threats and crises in Arctic societies. During recent years the understanding of this interaction has been enhanced by the growing focus on possible implications of non-renewable mineral and energy resource exploitation.

Global – Local Interaction

Changes of interaction patterns of Arctic communities from hierarchical structures towards more direct interaction stress the need to understand how global conditions are influencing – and eventually structuring – everyday life in the communities. On a personal level through the mass media impact on norms and values, on the community level by impacting the economic conditions and by transfering authority to new institutions crossing both traditional administrative and national borders.

In this context the world market is challenging the traditional economies by its emphasis on productivity, but also opening up for new possibilities, e.g. in connection with the growing role of ICT in business development. And it obviously generates a new focus on the need to adjust education to both global and local needs.

Socio-economic Processes

In order to understand the socio-economic processes shaping the interaction between the natural environment and the ways of life at unprecedented speed, the information available in Arctic societies about their own past and present must be further investigated and put at the disposal of the involved societies and the international community. This should, of course, be done in partnerships with residents of the Arctic.

This research activity on one hand raises the question of overall living conditions and general status of health, impacts of infectional diseases and nutritional status. On the other hand it poses the question of social conditions and their dynamics, including major questions on gender relations, domestic violence and social exclusion.

Socio-cultural Processes

The accumulated knowledge is embedded in language, social organization and their norms and value systems, as well as the cultural landscape and spiritual life. Research in the socio-cultural processes prepares the way for an improved understanding of past, present and future changes, and empowers Arctic societies to face and deal with the multitude of challenges affecting their lives.

Major Logistics Needs

The relative accessibility of Greenland as a High Arctic region and its proximity to populated areas are core factors in promoting coordinated and concerted activities during IPY. Logistics must be multi-facetted to accommodate the highly diverse research needs.

The remoteness and the extreme environment of parts of Greenland and adjacent waters will require large-scale logistical solutions that could involve costly logistics such as long-term ecosystem monitoring and research stations, ice camps on the Ice Sheet, a fine-meshed automated climate station network on ice and land, floating ice camps in the sea ice, buoys, robotic submarines, as well as icebreaking surface vessels.

Platforms, such as research facilities at Summit, and ice traverse options should be established and maintained. The experiences of Danish scientists in operating camps and drilling activities on Greenland's Ice Sheet provide good opportunities for a significant Danish leadership in coordinated, international activities on the ice sheet.

The ongoing extensive and integrated long-term ecosystem monitoring and research at Zackenberg Station, north-east Greenland, is a model concept to copy and launch at other sites in the Arctic. Indeed, it would be a valuable accomplishment of the upcoming IPY to be instrumental in establishing

a long-term ecosystem monitoring network built on the basic concept of Zackenberg.

Research often requires demanding and costly airborne or surface based logistics. The accessibility of the ice sheet from Kangerlussuaq and other coastal access points, the possibility to drive vehicles to and on the ice sheet, and the availability of ski-equipped aircraft should be utilized for concerted science efforts on Greenland's Ice Sheet during IPY. Such efforts could also include traverses with seismic, glaciological and environmental research focus.

It would be desirable and facilitating if all logistics support for activities on Greenland's Ice Sheet during IPY could be coordinated. It appears obvious for Danish or Greenland authorities to take a lead role in this, including arrangements for ice sheet access points other than Kangerlussuaq.

The special national efforts planned for the coming decade to map the bathymetry and geological structures of the Arctic Ocean north of Greenland, as part of preparations to claim continental shelf beyond 200 nm, could provide opportunities for Danish led cooperative international programmes in this hard-to-access region.

Special focus will be directed to the region between northernmost Greenland and the North Pole while coordinated logistic efforts on land, sea ice and on icebreakers will support a large range of inter-disciplinary activities across biological, geological, geophysical and oceanographic disciplines, involving both land, coastal and marine studies.

The promotion of multi-national and regional research efforts poses the question of access to necessary means for exchange of information resources. The increased use of ITC raises the question of establishing common standards in relation to data exchange and access, and in addition to this the need of server capacity enabling continuous on-line access to information resources.

International Collaboration

Greenland as a main IPY theme is an indisputable "golden opportunity" and naturally invites massive international collaboration to develop integrated, multi-disciplinary approaches to handle the associated complex science questions and challenging logistics. Therefore, an orchestrated and closely coordinated international collaboration is a necessity.

The Danish National IPY Committee finds it natural and needed that Denmark and Greenland make a visible impact by taking an international lead, by coordinating programmes and by providing platforms for research in, under, and around Greenland.

Community Outreach Opportunities

The high diversity of research activities during IPY will create outstanding possibilities for developing and implementing community outreach activities covering the entire educational spectrum.

In order to empower Arctic societies to cope and deal with the multitude of present challenges, the information present in Arctic societies about their own past and present must be further investigated in partnerships with the residents of the Arctic and put at the disposal of the involved societies and the international community.

The planned national and international IPY activities in Greenland render excellent opportunities to inspire and engage young researchers in Polar research by providing gateways to national and international programmes.