Section D: ***How can we fund it?***

33. Thoughts on ASOF Funding

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The questions posed by the discussions of Arctic/Subarctic Ocean Fluxes (ASOF) present challenges not only to scientific understanding but also to funding agencies and their standard operating procedures. The latter challenge includes the obvious need for
1) long-term observations of the phenomena; and 2) international cooperation in Arctic research. While few would dare suggest how long our time series need be, it is clear that they must be longer than the typical 3 to 5 year grant. At the same time, the special geography and political landscape of the Arctic require that we harmonize various national or continental funding mechanisms, in the midst of trying to change them.

Here we provide no panacea but rather point out a few halting steps the agencies have taken towards the goals of long-term measurements and international cooperation, with special reference to ASOF. In the US, two of the most concerned agencies are NSF and NOAA. NSF has a mind-set typified as "We don't do monitoring". While NOAA has a mandate to do monitoring, it has typically done so via internal funding of its own laboratories.

NSF's challenge is, therefore, to accommodate the increasingly evident need for long-term measurement programs with its rich heritage of individual, hypothesis-driven research. The NSF's Arctic program has responded with a special competition for "Long-Term Observations (LTO)" and by joining a Foundation-wide effort to increase the duration of all research grants. LTO awards must first make a scientific case for the needed measurements and then, after a 3 to 5 year period, review and rejustify the need and efficacy of continuing the observational program. While the LTO program has only just begun and its effectiveness has not yet been assessed, it appears that we have developed a mechanism to initiate the long-term programs typified by ASOF.

NOAA's challenge is to develop the financial means to support long-term observations in the Arctic. The mission of creating long-term environmental data sets is central to NOAA, but most current activities derive from the need to produce weather forecasts. Climate forecasting is a growing NOAA mission, but resources devoted to long-term observations for climate purposes are quite limited. Most of NOAA's current climate-specific observations are made in the tropics. As we become more certain of the role of higher latitude processes in climate, NOAA must extend its efforts to the Arctic and northern Atlantic and Pacific areas. The model that NOAA is developing for its climate observations relies on partnerships with scientists from other organizations, both nationally and internationally. This is the model that will be used in the Arctic. NOAA views

the potential ASOF program as both a critical scientific activity, and also a test case for establishing circum-Arctic multi-agency and international cooperation.

Ways and means of promoting international cooperation in areas such as ASOF are more difficult. At least initially, we probably must rely on the wide variety of bilateral agreements which already exist (e.g., between the US or its agencies and Norway, Germany, Denmark, Russia and Japan). While the elements of this patchwork of MOUs, MOAs and other alphabet soup have served us reasonably well (and show signs of increased vigor in some instances), we can think of two other examples of broader cooperative efforts that should be further exploited: the first is cooperation between the US and Japan illustrated by the establishment of the International Arctic Research Center (IARC) at the University of Alaska, Fairbanks. Representatives of IARC will be present at theTromso meeting to discuss cooperative efforts in support of ASOF. The second opportunity is provided by the signing of an Agreement for Scientific and Technological Cooperation by the Government of the US and the European Community in 1998. Using this umbrella agreement, a number of Implementing Arrangements in areas such as materials science and digital libraries are under discussion. We suggest that an obvious strategy would be to develop an Implementing Arrangement on “Arctic/Subarctic Climate Change”, or similar title, to include ASOF. If such an agreement could be reached, it would seem possible to initiate joint competitions and coordinated funding for programs such as ASOF. Part of the challenge of doing so will be to rationalize the overlaps/underlaps of existing or long-planned programs, such as SBI (Shelf-Basin Interactions) and SEARCH (Study of Environmental Arctic Change) in the US, with new programs such as ASOF.

So, we can take heart that there is some evidence of change in the funding agencies and that improved mechanisms for international cooperation may be available. The usefulness of such efforts is totally dependent on the interested researchers’ ability to clearly justify the science and to maintain the momentum generated by ASOF discussions in Cambridge and Tromso. Where there is a (scientific) will, there is a (bureaucratic) way.

34. The World Climate Research Programme (WCRP) Arctic Climate System Study (ACSYS) and Cryosphere and Climate (CLIC) Project

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The focus of ACSYS is to understand the physical Arctic climate system, and its interactions with global climate. Its specific objectives are to:

- improve understanding of the interactions between the Arctic Ocean circulation, ice cover, the Arctic atmosphere and the hydrological cycle;
- initiate long term climate research and monitoring programmes in the Arctic so as to determine key Arctic processes and Arctic climate variability and trends;
- provide the scientific basis for a more accurate representation of Arctic processes in global climate models.

Like its sister WCRP projects (WOCE, CLIVAR GEWEX and SPARC), ACSYS acts to promote and provide international co-ordination of physical climate science. It does this through its Scientific Steering Group, the International ACSYS Project Office, located at the Norwegian Polar Institute, Tromso, and via its Panels, Working Groups, Workshops and Conferences. Thus WCRP is not a funding organisation, but a co-ordinating and facilitating body which helps to set the priorities for climate science. In particular, it also encourages and promotes the development of global and regional datasets as a core activity, and their publication and dissemination, increasingly on CD ROM and on the World Wide Web and coordinated modelling experiments such as the Atmospheric Model Intercomparison Project (AMIP).

The ACSYS Implementation Plan calls for a variety of activities on the Arctic Ocean, its sea ice cover, the Arctic atmosphere and Arctic hydrology. Measurement and monitoring of the fluxes of heat and freshwater (both directly by the ocean and via transport of sea ice through the choke points that surround the Arctic Ocean) is a declared aim of the ACSYS Science and Implementation plans. ACSYS has been active in promoting such studies by the international community and members of its SSG, past and present, have been directly involved in making such measurements. In particular, ACSYS has continued to encourage the monitoring of ice thickness with upward looking sonars at key locations, building on the international initiative, coordinated by Torgny Vigne, that was started under auspices of the earlier WCRP Working Group on Sea Ice and Climate. A key focus for ACSYS has also been the understanding and development of datasets on the Arctic Ocean freshwater balance. Particular activities have been the establishment of an Arctic Runoff Data Base (ARDB) at the Global Runoff Data Centre in Koblenz and an Arctic Precipitation Data Archive (APDA) at the Global Precipitation Climatology Centre in Offenbach. Through its Panel on Polar Products from Re-analysis, ACSYS has helped to co-ordinate assessment of the performance of the Atmospheric Re-analysis efforts at ECMWF and NCEP in particular. The panel has also worked with ECMWF to improving the representation of high latitude processes for the next ECMWF Re-analysis (ERA-40). A new Observational Products Panel is concentrating on development of the optimum sea ice analyses for use in climate studies. The ACSYS Numerical Experimentation Group (NEG) is, in the meantime, moving from determination of the best sea ice models for use in global climate models to numerical studies of the variability of the coupled ice-ocean system and regional model intercomparisons.

The 10-year ACSYS Project has a declared 'sunset' date of the end of 2003. However, the high latitude focus will be maintained in WCRP beyond then via collaboration between CLIVAR, GEWEX and a new WCRP Project which has been under development over the past two years on 'Climate and Cryosphere' (CLIC). The Joint Scientific Committee for WCRP approved CLIC at their meeting in Tokyo in March 2000. CLIC is aimed at developing our understanding of the role of the global cryosphere in the climate system, and its interactions with the atmosphere, oceans and land surface. Explicit goals are to:

- improve understanding of the physical processes and feedbacks through which the cryosphere interacts with the climate system;
- improve the representation of cryospheric processes in models to reduce uncertainties in simulations of climate and predictions of climate change;
- assess and quantify the impacts of past and future climatic variability and change on components of the cryosphere, particularly for the global water and energy budgets, frozen ground conditions, sea level change and maintenance of polar sea ice covers;
- enhance the observation and monitoring of the cryosphere in support of process studies, model evaluation, and change detection.

The CLIC Science and Co-ordination Plan includes, amongst other programmatic elements, consideration of the interactions between sea ice, oceans and atmosphere and cryosphere-ocean interactions relevant to the global scale. These sections identify the specific need for ice thickness monitoring and more general need to determine the rates, paths, mixing and residence times of the different water masses involved in the ocean-ice process. CLIC, in concert with CLIVAR, will therefore continue to encourage measurement of the water and ice fluxes across the choke points connecting the Arctic to the wider ocean. ACSYS and CLIC will move forward together over the next few years, as CLIC is spun-up. Next steps for CLIC will be to begin the process of development of a plan for its implementation when the joint ACSYS/CLIC SSG meets in Kiel in October. The ACSYS International Project Office will now expand to become a joint ACYS/CLIC Project Office under its new Director, Dr Chad Dick, who will take up his post in June.

Ways in which ACSYS/CLIC can help encourage the further development of measurements of Arctic fluxes are through:

- promotion of such measurements, including bringing these to the attention of funding agencies;
- continuing to develop relevant related databases such as the ARDB, APDA, and the Arctic Ice Thickness Data Base);
- working for improved atmospheric re-analyses, in particular to provide information of the variability of the driving of the Arctic ocean and its ice cover;
- encouragement of related numerical experiments, and use of the data for model validation, through the ACSYS/CLIC NEG;
- helping to coordinate via facilitation and sponsorship of workshops and meetings.

ACSYS/CLIC is ready to work with others to assist in this process. A forthcoming ACSYS meeting on 'Measurements and Models of the Arctic Ocean' planned to take place late this year or early in 2001 may provide a further opportunity for review of progress, promotion of the activity and development of strategy, particularly in the context of ACSYS/CLIC.

35. CLIVAR and the Arctic
by
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CLIVAR was established as a component of WCRP in 1992 following a report by a study group on how WCRP might build on the TOGA and WOCE programmes.

The Goals of CLIVAR are :-

1. To describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in co-operation with other relevant climate-research and observing programmes.

2 To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets.

3 To extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models.

4 To understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

Clearly the Arctic is a region in which concerns such as the above can and should be addressed. However WCRP has a specific project ACSYS to cover this geographical region and thus CLIVAR has no plans for observational work in the Arctic.

AS well as promoting global observations and modelling (diagnostic and prognostic) CLIVAR has identified a number of principal research areas to provide foci for its research. These are divided into three rather arbitrary timescales Seasonal-Interannual (G PRAs) , Decadal to Centennial(D PRAs) and Anthropogenic (A PRAs).

Those that have direct links to the Arctic are

D1 North Atlantic Oscillation
D3 Atlantic Thermohaline Circulation
D4 Indo-Pacific Decadal Variability

A1 Climate Change Detection
A2 Climate Change detection and Attribution.

Implementation of the Decadal-Centennial components of CLIVAR has lagged behind the Seasonal-Interannual (driven by ongoing ENSO and Monsoon forecasting) and Anthropogenic (driven by IPCC). However an Implementation Panel for the Atlantic sector has been established and a Pacific one is under consideration.

Without prejudging the outcome of these panels it is clear that CLIVAR will need to ensure that the following components are developed and maintained by CLIVAR, by other WCRP projects, by GOOS/GCOS or through the PAGES programme of IGBP.

1) Monitoring of the exchanges of heat and fresh water between the Arctic oceans and the Pacific (via Bering Strait) and Atlantic Oceans. (This through repeated hydrographic sections and in situ monitoring of shallow and deep boundary currents).

2) Monitoring of the strength of the N Atlantic thermohaline circulation and reconstruction from extending and improving the instrumental and paleo record of its past variability.

3) Developing an improved understanding of the nature of the NAO, its coupled nature and its predictability. This through the collection and analysis of atmospheric and ocean observations over the subpolar N Atlantic and adjacent arctic and subarctic regions.

4) Developing a similar understanding of the equivalent variability over the N Pacific.

5) Observing the seasonal/interannual variations in upper ocean properties in the N Atlantic and N Pacific in collaboration with the developing ARGPO float programme.

6) A continuing programme of ocean and coupled model development that satisfactorily describes the interactions (atmospheric and ocean) between the Arctic and the remainder of the globe on all timescales

36. The Study of Environmental Arctic Change (SEARCH)

By
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The Study of Environmental Arctic Change (SEARCH) is motivated by the significant changes in the Arctic environment. The Arctic Ocean water mass structure and circulation have shifted; the frontal boundary between the eastern and western halocline types has swung counterclockwise from roughly over the Lomonosov Ridge to roughly parallel the Alpha and Mendeleyev ridges. The transpolar drift has shifted in a similar sense. Cores of Atlantic Water with increased temperature have been observed over the Lomonosov and Mendeleyev ridges. At the same time there has been a trend of decreasing atmospheric pressure over Arctic Basin. Air temperature over the Russian arctic has risen and permafrost is thawing in many areas.

In reaction to these observations, a NSF-ARCSS sponsored workshop (see http://psc.apl.washington.edu/Arctic_change/Report_5.html) was held in 1997 to explore the extent of the change and to consider a program to study it further. Through these efforts, we have learned that there is temporal correlation between the changes in the Arctic Basin and a fundamental change in the atmospheric circulation of the Northern Hemisphere called the Arctic Oscillation (AO). The physical connections between an increased AO index and the observed arctic changes have been hypothesized. From this effort a SEARCH Science Steering Committee SEARCH SSC was formed to guide the development of a SEARCH Science Plan. They held a NSF sponsored Science Plan Workshop in July 1999. The changes in the Arctic were characterized as a complex of changes (ex. reduced atmospheric pressure and increased cyclonic circulation in the atmosphere). This complex was given the name Onami (Inuit for tomorrow). Plans were made for a research program of long-term observations, modeling, process studies, and assessment of ecological and social impacts. A draft of the SEARCH Science Plan was presented at the ARCSS-OAII meeting in October 1999, and appears on a SEARCH Web site: http://psc.apl.washington.edu/search/index.html; user name = authors; password = $earch. We outline the observational components of the Science Plan below.

Simultaneously with developing its science plan, SEARCH has been seeking its place in the larger community of climate oriented research and the funding schedules of U.S. federal agencies. In the first instance SEARCH has sought status as the arctic component of the US CLIVAR program. At its most recent meeting the US CLIVAR Scientific Steering Committee endorsed this idea. SEARCH treats social and ecological aspects of arctic change that are outside of the usual domain of CLIVAR. Because of this, the organizational details of how SEARCH will comprise a fourth component of US CLIVAR have not been determined. Also, in view of their similar goals, the ACSYS (Arctic Climate System Study) Implementation Plan and CLIC (Climate and Cryosphere) Science and Coordination Plan both include provisions for collaboration with SEARCH.

The most significant recent development has been the incorporation of SEARCH in the Arctic Plan of the U.S. Interagency Arctic Research Policy Committee (IARPC) and the establishment and tasking of the Interagency Working Group on SEARCH (IWGS). The agencies involved include NSF, NOAA, NASA, DOD, NOAA, and DOE. NOAA will chair the IWGS. Over the next several months, the IWGS will develop an interagency

plan for the conduct of SEARCH activities. The broad spectrum of observations and modeling makes such an interagency effort critical.

SEARCH will set out a broad list of required activities, more than the United States can support alone. More importantly, many of the critical observations must be made in other countries or in waters best reached from other countries. For these reasons SEARCH must be an international program. We are hopeful that other countries will support the SEARCH plan through new or existing activities. The key to success is coordination in the early stages of program development as exemplified by the Discussion Meeting on Sustained Monitoring of Arctic Fluxes.To reach its objectives SEARCH requires long-term data sets that describe the atmosphere, ocean, sea ice, land and land ice over the entire Arctic. These data sets will come from a variety of measurements programs. Established observing networks such as the surface synoptic weather stations, the RAWINSONDE station network, and the International Arctic Buoy Program are crucial for SEARCH. These networks are organized internationally as part of the World Weather Watch, and are funded by national agencies responsible for weather forecasting and research.

SEARCH maintains a long-term program of "Core Measurements" is needed. The list of core elements is under development, but examples are:

1. Remote, autonomous drifting stations in the multiyear pack ice of the central Arctic Ocean. These stations will monitor atmosphere, ice, and ocean parameters.
2. Bottom-anchored oceanographic moorings at the North Pole, the Beaufort Sea, the critical straits, and selected other sites. These moorings will acquire time series of ocean properties, and sea ice velocity and ice thickness. The data will be recovered annually.
3. Repeat snapshot surveys of oceanic temperature and salinity, ocean chemistry, and snow and ice properties. These will be acquired along transects of points visited by aircraft, icebreakers, and possibly submarines.
4. Permafrost temperature and extent
5. Precipitation
6. River flow
7. to augment the (recently diminished) network of manned surface and upper air stations
8. Enhanced Satellite monitoring of vertical structure of the atmosphere (e.g. TOVS) in addition to surface properties (ex. Ice and snow cover).

In addition to the core measurements, the conceptual design is for elements of the SEARCH observing program to serve as catalysts for enlarging participation in the project. For example expanded use can be made of the logistics support and basic moored, drifting and airborne platforms to acquire additional spatial coverage and variables in the Arctic Ocean domain. An important part of the SEARCH scientific agenda is to understand the role of the freshwater cycle in Onami. This will require observations of ocean/ice fluxes through Fram Strait, Bering Strait, the Canadian Archipelago, and from the Barents Sea. Conversely, SEARCH data figure to be important to interpreting variations in the Arctic-North Atlantic fluxes, and any feedbacks between variability in MOC and the atmosphere (e.g. the AO). SEARCH will need additional data on the atmospheric and riverine inputs of freshwater to the Arctic Ocean, which will require close coordination with WCRP ACSYS and GEWEX.