# Current ARCSS Research: Key Uncertainties and Next Steps
# Online Forum
# February 4–6, 2002

## Introduction

**ARCSS Planning Discussion** > **Introduction** > **Key Uncertainties and Next Steps in ARCSS Research**

---

**Post Title:** Key Uncertainties and Next Steps in ARCSS Research
**Posted by:** *John Weatherly* at 11:38 AM 2/4/2002

---

**Welcome to the online discussion forum!**

This section of the Forum deals with the broad integrative questions that help to unite the various components of arctic research.

The Arctic climate system is tightly coupled, rich in its complexity. ARCSS-funded Arctic research is similarly rich, but it is also somewhat fragmented. To understand the Arctic climate system, we face the challenging task of integrating and coordinating our science both within the U.S. and across the global community. There are several ways this can be done, including:

1. New interdisciplinary initiatives
2. Improved coordination between existing component-driven research
3. Explicit discussion about the 'ARCSS Themes' and the next research steps

Our hope for this online forum over the next three days is to spark discussion about the basic ARCSS questions (see below) and to focus particularly on the **key uncertainties** associated with each one.

**Current ARCSS Research: key uncertainties and next steps**

For the last few years, ARCSS research has been guided by the following big-picture themes:
1. How will the Arctic climate change in the next 10-100 years?
2. How will human responses affect ecosystem/societal sustainability?
3. How will changes in feedback processes and cycles affect the arctic and global systems?
4. Are the predicted changes detectable?

What do you think? Do these umbrella themes leave out any major areas? What are the key scientific uncertainties for each one? How essential is reducing this uncertainty to advancing our understanding of the Arctic system? Are we ready at present to deal with this uncertainty?

You can post general responses to the Themes here in this thread. If you have specific thoughts on any one of the themes, click on the theme's URL above and post your comments and ideas there in that thread.

Thanks! We look forward to hearing from you.

Moderators John Weatherly and Craig Nicolson.

**Post Title:** Re: Key Uncertainties and Next Steps in ARCSS Research (John Weatherly)
**Posted by:** *Johnny Lin* at 2:19 PM 2/5/2002
---
Hi John! Thanks for moderating! Below are some thoughts regarding the issue of uncertainties and next steps in general. It's a little long, but thought I'd throw it into the mix in case it's useful.

It seems to me that the term "uncertainty," as used in science, can have a number of different meanings, which change depending on the context. In laboratory measurements, uncertainty describes that component of the data value that is random and uncontrollable, and is reflective of inherent instrument error. In modeling, however, certainty is really another way of saying "understanding," and that when one says "we are uncertain what the models are telling us" we are really saying "we are not confident that we understand what the model results mean."

What are the sources of this lack of confidence? A few reasons include:

1. Incomplete physics: Too few physical and/or dynamical processes that are strongly suspected to be important are included in the model.

2. Inadequate physics: The processes that are described in the model are strongly suspected of being inadequately described.

3. Incomplete model understanding: Usually, only a fraction of a model's solution space is explored. Thus, the model may behave in a way when perturbed that actually is unlike nature.

4. Inadequate model understanding: Hans von Storch has said that we should not say "this is a model *of*" but rather "this is a model *for*." Often, it is easy to believe that a particular model represents some aspect of the climate system, when in reality it only represents that aspect for a given context. This is more easily seen and acknowledged in simple models vs. complex models like GCMs, but applies for the more complex models too. For instance, an Arctic RCM is not really a model of the Arctic atmosphere, but is more a model for investigating how the internal dynamics in the region responds to large-scale lateral forcing ("information retrieval" vs. a "boundary condition problem," as von Storch suggests).

There might be some confusion as to the difference between #1 and #2, so as a side note let me give an example. In parameterizing surface fluxes, most models use a bulk aerodynamic parameterization, in which the fluxes are linearly dependent on a transfer coefficient, wind speed, and vertical gradient. Such a parameterization leaves out many factors (e.g. stability), so these factors are added to the parameterization through correction factors to the transfer coefficient, etc. However, when you get right down to it, the bulk aerodynamic parameterization really does not have much of a theoretical justification; we use it because it works "ok." It is not at all obvious that the large-scale dynamics understand surface forcing in the way described by the bulk formalism. The incomplete bulk parameterization problem is an example of #1 (as would be the situation where there is no parameterization for a specific process). The lack of theoretical justification for the bulk formalism is an example of #2.

Each of these reasons for model "uncertainty" needs to be addressed in different ways. However, in the Arctic, most of the emphasis thus far has been mainly on addressing #1, and some of #2, through the collection of additional data (both field and remotely sensed) and refinement of parameterizations based on this data.

To address #3 and #4, work needs to be done in understanding how the models behave, and what they truly represent. What is limiting progress in these areas? Here are a few thoughts:

* The lack of appropriate theory to describe possible feedback/interaction mechanisms in the models. Besides ice-albedo feedback and a few other hypothesized mechanisms, there has been little progress in this area.

* Because theory is lacking, there are very few tools that one can use to diagnose the more complex models, in order to help grow our understanding of the models. This is a case where there needs to be a theory in order to guide model use.

* The hierarchy of models currently available is limited to only simple models and GCMs. Intermediate-level models are needed to help bridge the gap between the two. (Conflict of interest disclosure: I am an intermediate-level modeler.) However, an incomplete model hierarchy, though a factor, I don't think is as important as the lack of theory mentioned above.

* The number and type of researchers who are involved in this work. To properly understand how models work, you need to have many different reseachers providing different viewpoints in order to adequately characterize the model's solution space. You also really need applied mathematicians. The Arctic climate research community, it seems to me, is lacking both. (Note: I'm not an applied mathematician; my math ability isn't good enough.)

In my opinion, the deficiencies in state-of-the-art Arctic modeling most severely impacts questions involving:

* nonlinear interactions between physical and dynamical processes
* coupling (to ocean, biome, etc.)

I think we have a reasonably decent grasp on simple model behavior, such as energy balance climate models (EBCMs) and single-column models. Thus, I think questions involving characterizing thermodynamic behavior are reasonably addressable by current models. But once you bring in interaction with dynamics, or coupling to the ocean (beyond a zonally averaged approach), then the deficiencies in our understanding of model behavior really hamper what we can truly learn from applying the models to answer those climate questions.

In sum, I do not believe currently we have: enough candidate theories to guide modeling efforts, a broad enough range of model types, nor a critical mass of modelers and applied mathematicians to make headway on model understanding.
[Modified by Johnny Lin, 2:50 PM 2/5/2002]

**Post Title:** Re: Key Uncertainties and Next Steps in ARCSS Research (Johnny Lin)
**Posted by:** *CraigNicolson* at 6:12 PM 2/5/2002
---
Johnny, these are great points. The ARCSS Program has placed a strong emphasis on modeling, so it behoves us to think carefully and well about how models are used in the business of arctic science.

The main points I hear you making about our modeling shortcomings are:
1. we need more **intermediate complexity** models in our suite of modeling approaches.

2. we need more **reflective thinking** on the modeling process per se, which in turn calls for more involvement of modeling-trained people and applied mathematicians
3. we need **better modeling theory** to guide our *use* of models, especially to understand complex coupled processes and feedbacks.

Is this a fair restatement of what you're saying? If so, it strikes me that in the four years I've been around the ARCSS community, I haven't heard many discussions along these lines. I'm interested to know who else might have an interest in these kinds of issues (aside from me and Johnny)

Johnny, do you have suggestions of other ARCSS people who might be interested? Does anyone else have names to suggest?

**Post Title:** Re: Key Uncertainties and Next Steps in ARCSS Research (CraigNicolson)
**Posted by:** *Johnny Lin* at 10:45 AM 2/6/2002
---
Thanks Craig for your encouraging comments! I think that's a fair restatement of my main points.

Regarding others who I think might be interested in some of these issues, I'd add Manda Lynch and Cecilia Bitz. Jim Maslanik also posted the following in the Modeling Predictions thread which I entirely concur with and which I think also falls along the lines of issues of key uncertainties in understanding the Arctic climate system:

**Post Title:** Re: Model predictions of Arctic climate on different scales (CraigNicolson)
**Posted by:** *Jim Maslanik* at 8:13 PM 2/5/2002
---
Continuing to take the usual track of developing ever more realistic model sub-components of course has merit, but I think ARCSS or SEARCH needs to leave the door open for research that goes in other directions as well - stochastic modeling, complexity theory, greatly-simplified coupled models, or whatever those directions may be. Another aspect to that might fall within ARCSS' area pertains to how best to arrive at a better match between the kinds of data (and level of accuracy, spatial and temporal sampling, and understanding of error characteristics of these data) that are needed to be useful for evaluating and refining the continually-improving models.

## How will the Arctic climate change over the next 10-100 years?

**ARCSS Planning Discussion** > **How will the Arctic climate change over the next 10-100 years?** > **Model predictions of Arctic climate on different scales**
---

**Post Title:** Model predictions of Arctic climate on different scales
**Posted by:** *John Weatherly* at 12:09 PM 2/4/2002
---
Predicting the changes in the Arctic system in next 10-100 years is the one ARCSS theme that may require the greatest amount of collaboration between the Arctic and global climate communities. The key uncertainties in Arctic research that need to be addressed are those that affect both the Arctic climate system and the feedbacks to the global climate system. The ice-

albedo feedback and the cloud-radiative feedback processes are only two of these; improving our knowledge of these will significantly impact the predictions made by Global Climate Models of future global and Arctic climate.

One of the key research problems that has to be overcome in order to make significant progress on these predictions is the representation of the Arctic system in GCMs. Recent studies as well as earlier work have documented the problems in the simulated Arctic climates in GCMs, including biases in the atmospheric circulation patterns, (both in mean and their seasonal and interannual variability), seasonal cloud amounts, and precipitation. In coupled atmosphere-ice-ocean models, the atmospheric biases create further problems for the simulated ice thickness and coverage, ice motion, and ocean circulation.

These problems give rise to significant uncertainties in the predictions of Arctic climate in the next 100 years. Unrealistic changes in Arctic circulation, ice thickness, or ocean structure may be predicted, which are biased by the simulated Arctic climate in the present GCMs.

In some cases, the problems are clear. We have sufficient observational data to know the surface pressures are incorrect. The same is true to some extent for clouds. For precipitation, we have supporting data and methods to improve the analyses of net precipitation, but less data on the true spatial and temporal variability over the Arctic basin.

The uncertainties that need the most effort are the model's physical parameterization and dynamics. Cloud physics in most GCMs is clearly not appropriate for Arctic clouds and their large seasonal changes. The dynamical representation of circulation and moisture transport in GCMs is usually hampered by the numerical noise (or spectral filtering) near the 'pole' of the grid. Improvements in spatial resolution, numerical methods, and physical processes in GCMs all need attention in order to accurately represent the Arctic system.

**Post Title:** Re: Model testing
**Posted by:** *MacDonald* at 12:34 PM 2/5/2002
---
The issue of testing models using relatively short intrumental records available from the Arctic is a classic problem. Particularly when we consider how the model behaves under circumstances which are unlike any found in the observational record. For years paleoclimatologists have argued for the usefulness of paleodate to aid in this. I really do believe in the last decade great progress has been made in developing the reliable quantitative proxies for climate and high temporal resolution records needed for this task. But, I also know there are going to be key variables that we paleoclimatologists cannot recreate. I suppose the trick will be to continue the good integration we have seen with the modeling community to do what we can, and clearly identify what we cannot.

**Post Title:** Re: Model testing (MacDonald)
**Posted by:** *Jim Maslanik* at 2:28 PM 2/5/2002
---
Comparing a fairly short record such as satellite-derived sea ice extents to model output also raises some other issues. For example, GCMs generally seem to be doing a reasonable job of reproducing the negative trend in Arctic ice extent over the last 20 years or so. But, when examined in more detail, the models still are doing a pretty poor job (I think) of reproducing the spatial and interannual variability in ice extent that go into yielding the hemispheric-mean trends. The regional variations may be a chaotic sort of thing that integrate into an overall pattern capable of being represented by larger, dominant processes treated well by the more linearly-

minded GCMs, but pinning this down requires studies at multiple scales - something to which ARCSS/SEARCH might contribute.

**Post Title:** Re: Model predictions of Arctic climate on different scales (John Weatherly)
**Posted by:** *Johnny Lin* at 2:45 PM 2/5/2002
---
John, I agree that the two big problems in model improvement are parameterizations and dynamics. Maybe it might be fruitful to have two new threads, one in which we list what all the problems with the parameterizations are and the other which lists what all the problems of the dynamics are?

Regarding both cases, I'll also throw out the idea that it might be fruitful to focus on listing possible root causes and mechanisms as opposed to a list of where model results do not match observations (i.e. *why* are these problems there as opposed to describing *what* the problems are). This idea is related to some philosophical thoughts on key uncertainties and next steps that I posted here: http://arcss.zeroforum.com/zerothread?id=74&postid=201#201 [see page 2, above, **Post Title:** Re: Key Uncertainties and Next Steps in ARCSS Research (John Weatherly) **Posted by:** *Johnny Lin* at 2:19 PM 2/5/2002]

I'll throw out one possible one for the parameterizations list: The bulk aerodynamic modeling formalism for surface fluxes is rather ad hoc. Refinements of the various terms that go into the formalism will only take us so far; a better theory of surface fluxes needs to be developed. Perhaps one aspect of such a theory could be explicit incorporation of a better understanding of large-small scale intercommunication.

**Post Title:** Re: Model predictions of Arctic climate on different scales (Johnny Lin)
**Posted by:** *CraigNicolson* at 6:33 PM 2/5/2002
---
The two main uncertainties I see emerging in this thread are:

1. uncertainty about how well the models are performing
2. uncertainty about *why* these problems are there

I'm happy to follow Johnny's suggestion that we start two new threads (listing some of the known problems in parameterization and dynamics), but before I do I want to make sure that there's the interest to sustain the discussion...If there are two or three posts on Wednesday on either of these topics, I'll gladly move them into new threads.

Bearing in mind that one of the goals of this part of the forum is to identify key areas for ARCSS to focus attention on, do all you eager readers out there agree that we ought to take more careful stock of key areas of model inadequacy (maybe starting by developing a comprehensive list, as Johnny suggested)?

**Post Title:** Re: Model predictions of Arctic climate on different scales (CraigNicolson)
**Posted by:** *Jim Maslanik* at 8:13 PM 2/5/2002
---
Continuing to take the usual track of developing ever more realistic model sub-components of course has merit, but I think ARCSS or SEARCH needs to leave the door open for research that goes in other directions as well - stochastic modeling, complexity theory, greatly-simplified coupled models, or whatever those directions may be. Another aspect to that might fall within ARCSS' area pertains to how best to arrive at a better match between the kinds of data (and

level of accuracy, spatial and temporal sampling, and understanding of error characteristics of these data) that are needed to be useful for evaluating and refining the continually-improving models.

**Post Title:** Re: Model predictions of Arctic climate on different scales (Johnny Lin)
**Posted by:** *John Weatherly* at 7:07 AM 2/6/2002
---
My thanks to Johnny for posting his thoughtful remarks on the nature of model uncertainties and the application of modeling.

My original points on the uncertainties of (global in particular) climate models fall into several of these categories; mostly #1 and #2, incomplete and inadequate physics that fail to work as a good model for the Arctic climate.

There is also the spectre of #4, 'inadequate model understanding' in the manner in which GCMs are sometimes used to assess the impacts of future climate change in specific regions, such as the Arctic. As Jim Maslanik points out, the regional spatial and temporal variability is not well simulated, and is altered by the larger problems in the models. At present, GCMs cannot be applied to regional assessments of climate change and its impacts, (and maybe fundamentally limited to larger scales, but time may tell).

This is where new intermediate models for the Arctic system (and subsystems) can be developed and applied. Models and methods for downscaling the GCM results to the specific regions have been developed, some (discussed at the ACIA meeting 2001, such as SWECLIM) have been applied to the Scandinavian Arctic. Other theoretical models are needed, as these other threads remark on the climate history of particular locations in context of the overall global patterns.

At the ARCSS All Hands meeting, I will plan to have a break out discussion of the different levels of models that can be developed and applied in this area. This should have some input from the paleo studies that are also crucial to assessing the local climate history and the impacts of change.

**Post Title:** Re: Model predictions of Arctic climate on different scales (CraigNicolson)
**Posted by:** *John Weatherly* at 7:42 AM 2/6/2002
---
Though we are not likely to create the comprehensive lists of the model deficiencies and is causing them on Day 3 of this forum, this is the perfect preparation for the All Hands meeting, and the further session on these Key Uncertainties in ARCSS research.

We can each work on our contributions to these lists, and collect them at the All Hands, or, if you are unable to attend the meeting/session, email them to me and I can include them in the All Hands session.

Some of the topic lists put forward:
1. uncertainty about how well the models are performing
2. uncertainty about why these problems are there
3. New intermediate models for the Arctic system and components

The models in question seem to include GCMs (climate/gen. circulation models), RegCM/Limited Area Models. I also feel we need a discussion of Arctic Ocean/ice circulation models and their key uncertainties.

There are also the discussion from the other themes/threads that will be incorporated, including the 'Are the changes detectable', 'human interactions', and 'hydrologic and biogeochemial cycles'.

**Post Title:** Re: Model predictions of Arctic climate ... (J. Maslanik, J. Weatherly)
**Posted by:** *Johnny Lin* at 11:03 AM 2/6/2002
---
I entirely concur with Jim's comments regarding the need for new directions in Arctic research and the specific need for a better understanding of what kind of data is needed. In particular, it's my own feeling that the approaches in his list of "other directions" will probably prove to be the most fruitful in terms of improving our understanding of how the Arctic climate system behaves as a system.

John, I think your idea of putting together lists at the All Hands meeting is a good one. Will try to come up a few thoughts.

**Post Title:** Re: Model predictions of Arctic climate on different scales (John Weatherly)
**Posted by:** *Manda Lynch* at 3:05 PM 2/6/2002
---
This is a great discussion and I'm sorry to have been slow in replying to anything - I did promise to participate!

I think that while the idea of listing physical paramaterizations and problem areas in Arctic regional and global climate models is an obvious place to start, we need to stay focussed on what we are trying to achieve. These kinds of laundry lists have been done many times before, and if we cull the science plans of the components and the initiatives we'll probably find just about everything we could come up with.

What we need to acheive here, and at the All-Hands, is focus. Hard as it might be, could we each pin our name to two or three (at most) serious deficiencies in models, preventing us from acheiving any kind of useful projections in Arctic climate (define "useful"!) that we are ready and willing to tackle in the *next* phase of ARCSS research?

And as Johnny quoted Hans von Storch, we must remeber we are creating models **for** X, not models **of** Y. There is something wrong with every parameterization and every model, but we need to think about how good they have to be to get us where we want to go.

I'll stick my neck out and say my top three are:

1. Arctic clouds (microphysics, relationship to atmospheric moisture transport, radiative properties and interactions with the underlying surface)
2. The coastal zone - what is happening in that amorphous boundary between land and ocean and do we have any clue how to model it?
3. Getting an "Arctic" understanding into GCMs (inlcuding treatment of the "pole problem").

**Post Title:** Re: Model predictions of Arctic climate on different scales (Manda Lynch)
**Posted by:** *Johnny Lin* at 5:21 PM 2/6/2002
---
Thanks Manda for reminding us to focus! In that spirit, here's my vote on what's hindering model predictions.

My sense is that the single largest problem with current Arctic models has to do with interpretion. We don't know enough about the dynamics of the Arctic system as a whole (i.e. our theoretical understanding is poor) to really know what the model output is telling us. Thus, my recommendation to improving model predictions actually doesn't actually deal directly with models. Rather, if a paradigm (or multiple paradigms) for the Arctic climate system could be better elucidated at a theoretical level, I think it would be greatly improve the usefulness of our models.

This is related in ways, I think, to Manda's third model deficiency. One of the reasons it's difficult to include the Arctic into GCMs is our lack of understanding exactly what that inclusion should look like.

**ARCSS Planning Discussion** > **How will the Arctic climate change over the next 10-100 years?** > **Assessing future near term change in the Arctic**
---

**Post Title:** Assessing future near term change in the Arctic
**Posted by:** *admin* at 4:11 PM 2/2/2002
---
**How will the Arctic climate change over the next 10-100 years?**

A primary goal of ARCSS research is the integration of contemporary and paleoenvironmental observational, process and modeling studies to assess future near term change in the Arctic. The importance of paleoenvironmental studies is highlighted when studies of Arctic change are placed in the context of multidecadal modes of variability in the Arctic system.

Paramount for the assesment of change in the near term future are:
* An integrated understanding of land, ocean, shelf and atmospheric feedbacks.
* An understanding of the ways in which change is manifested as secular trends, and as projections onto preferred existing modes of variability or new modes of variability.
* A clear goal as to the applications for which change is being projected, through a recognition that models are developed not “of a system” but “for an application”.

**Post Title:** Two key uncertainties addressed by PARCS
**Posted by:** *Darrell Kaufman* at 6:14 AM 2/4/2002
---
The PARCS community recently identified two key topics directed at the major research themes posed by ARCSS and its components. The PARCS Steering Committee is presently developing plans for implementing a coordinated effort to address these topics and is looking for input from both the PARCS community and from other ARCSS researchers. How can the new efforts best be integrated with the direction of other on-going and planned arctic-system-science research?

In shorthand, the two research foci are: (1) high-frequency climate variability, and (2) warm climates and their consequences. The goals of these research topics cut across nearly all aspects of ARCSS research. I address the goals of the first research topic in this forum under

the heading "Are predicted changes in the arctic system detectable". Here, I place PARCS' second topic in context of ARCSS' goal of predicting near-term climate change.

The first over-arching research goal posed by ARCSS (1998, p. 28) is: "How will the Arctic climate change over the next 50 to 100 years?" Although ARCSS scientists may not be able to predict the future, we can envisage reasonable constraints on future changes. Paleoenvironmental studies use "natural experiments" of the past to provide an understanding of the causes and consequences of climate change in the Arctic. At least two key uncertainties related to the predication of near-term climate change can be addressed through an improved network of paleoenvironmental records around the Arctic and through new modeling efforts:

Key uncertainty 1: the magnitude, rapidity, and spatial pattern of change as the Arctic shifts to warmer conditions. As the climate changes in the Arctic, regional- and synoptic-scale processes will modulate the spatial and temporal heterogeneity of its effects. Historical and paleoclimate proxy records show pronounced spatial variability in climatic change across the Arctic. Important differences emerge at the continental to sub-regional scale. These differences reflect the effects of multiple oceanic, atmospheric, and terrestrial processes that work in concert with physiography to modulate the effects of broader-scale forcing. PARCS researches are ready to contribute to the prediction of a warmer Arctic by describing the spatial and temporal patterns of change within marine, terrestrial, and biological systems during periods when the Arctic shifted toward, and experienced, warmer conditions in the past. A larger and better-refined network of well-dated, proxy-climate records is needed to sharpen our understanding of these changes with increasingly finer spatial and temporal resolution. Because the various components of the climate system respond differently to the forcing, a multi-proxy approach is needed to comprehend the breadth of these changes. Together, the data will provide realistic constraints on scenarios of future conditions and insights into the dynamics of a warm arctic system.

Key uncertainty 2: the causes and consequences of extreme warmth in the Arctic. Paleoenvironmental records clearly demonstrate that the Arctic experienced warmer-than-present (20th century) conditions in the recent geologic past. Two well-known warm periods are: (1) the early to middle Holocene (ca. 8000 to 5000 years ago) when summer temperatures were generally higher, but the extent of the arctic cryosphere approximately similar to the present; and (2) the more pronounced warm interval of the last interglaciation (ca. 130,000 to 120,000 years ago) when the arctic cryosphere was significantly retracted and sea level significantly higher. How close is the modern arctic system to attaining the state of the earlier-Holocene warm interval? What non-linear processes might lead to the more extreme warmth similar to that experienced during last interglaciation? To better understand the sensitivity of the arctic system to global warming and its feedback to the Earth system, PARCS intends to generate new paleoclimate proxy data for these two intervals of arctic warmth. These "natural experiments" will be used in data-model comparisons to assess the sensitivity of the arctic system to various forcings and to address possible mechanisms of climate change. PARCS intends to integrate its findings with other research efforts focusing on the response to warming of key elements within the arctic system (e.g., sea ice, surface hydrology, and vegetation cover) and their nonlinear feedbacks within the Earth system.

## How will human activities interact with future global change to affect the sustainability of natural ecosystems and human societies?

**ARCSS Planning Discussion** > **How will human activities interact with future global change** > **How will human activities interact with future global change...**

---

**Post Title:** How will human activities interact with future global change...
**Posted by:** *CraigNicolson* at 12:35 PM 2/4/2002

---

**How will human activities interact with future global change to affect the sustainability of natural ecosystems and human societies?**

The primary objective for projections of change over the near term future is to arrive at an assessment of the impacts of these changes on natural ecosystems and human societies, and the responses and adaptations of those systems to change.

Developing models to project pathways of change, be they numerical formulations or theoretical constructs, must be pursued with particular applications in mind, and often in close collaboration with affected communities. What are the key uncertainties in this area? Here are few suggestions to spark off discussion:

* How might animal migration patterns (and therefore subsistence use) be altered by climate change?

* Are sea-level changes and coastal erosion well-enough understood to predict their impacts on Arctic coastal communities?

* Socio-cultural changes could have a far greater impact on arctic communities than climate change. How does our current understanding of these uncertainties compare with our level of knowledge about biophysical changes in the Arctic?

Welcome to the discussion!

Moderators John Weatherly and Craig Nicolson

**Post Title:** Re: How will human activities... (CraigNicolson)
**Posted by:** *ajensen* at 2:45 PM 2/4/2002

---

One thing emerging quite clearly in the paleo- thread is need for integration of such data with current observations, and its use in model building. While I doubt that it is true that there is no new thing under the sun, or that what has been is that which will be in *all* cases, it is probably true for a significant subset. It seems that a fruitful approach to coming up with some solid answers for your first question would be to look at how animals have been affected by climate change. In fact, this approach has been employed (e.g. Vibe 1967; M. Meldgaard 1986) and seems quite useful.

**Post Title:** Re: How will human activities... (ajensen)
**Posted by:** *CraigNicolson* at 3:10 PM 2/4/2002
---
I'm interested in the Vibe and Meldgaard references, and I agree fully with your assessment that we should seek to *learn* better from past changes.

I'm curious about how you would assess the third question...Where you think our socio-cultural understanding of the arctic system stands in relation to our understanding of biophysical processes and changes?

**Post Title:** Re: How will human activities... (CraigNicolson)
**Posted by:** *ajensen* at 3:25 PM 2/4/2002
---
Vibe, Christian
1967 Arctic Animals in Relation to Climatic Fluctuations. Meddelelser om Grønland 170(5). Copenhagen: C.A. Reitzels Forlag.

Meldgaard, Morten
1986 The Greenland caribou — zoogeography, taxonomy, and population dynamics. Meddelelser om Grønland, Bioscience 20.

Will comment on social change in another post.

**Post Title:** Re: How will human activities... (CraigNicolson)
**Posted by:** *Henry Huntington* at 6:16 PM 2/4/2002
---
With respect to the relative levels of understanding in physical, biological, and social systems, I'm reminded of the opening of the NRC report "Human Dimensions of Global Environmental Change," which implies that biological uncertainties in our understanding are greater than physical ones, but social uncertainties are greater still. I would tend to agree, given at least that a plant or animal 10,000 years ago would likely have reacted to change in a similar fashion to a plant or animal today, whereas humans have changed radically in their ability to control their relationship with the environment. To say nothing of socio-cultural change that is not directly related to the environment.

In other words, there is certainly a lot of uncertainty. To my mind, this leads us to a few things about the study of humans and climate change.

First, while speculation is a good exercise in thinking of things that might be considered in a study, we have to be careful to remember that we are talking about the futures of people, who may well read or hear about our conjectures. Igor Krupnik has made this point, emphasizing that our usual fascination with dramatic outcomes should be tempered by the realization that we are discussing someone's future, and he or she may not appreciate being used as a hypothetical test case.

Second, where possible these discussions should be collaborative with the people whose society is being considered. Of course, anyone can talk about what may happen, and it doesn't make sense to fly to the Arctic every time you want to talk about human aspects of climate, but serious projects--even in the planning stages--shouldn't be done in isolation. This is not to say that Arctic residents will have insight into everything that may happen, nor that they will

accurately predict their own responses to environmental change, just that it's likely to be far better if they're involved than if they aren't.

Third, the use of historical and archeological records is important, despite the great changes in human society in recent decades and centuries. We can learn a great deal about adaptation and adaptability, and we can probably use other forms of upheaval as proxies for the anticipated dislocations of climate change. We need not try to invent everything afresh. Anne's right in that not everything has been seen before--either in Arctic societies or in research--but more has probably been seen than we tend to think.

Fourth, prediction is probably too strong a word for what we do with respect to future human societies in this context. Instead of trying to "predict" what will happen, perhaps we should concentrate on anticipating the changes and challenges that we may face. This means less emphasis on what response we expect from our descendants (or ourselves in a few years), and more on the conditions they may face and the options we expect they will have to deal with those conditions. E.g., the second question in the opening about coastal erosion. How well do we understand the conditions coastal communities are likely to face, and given what we understand about those conditions, what are the options we see for dealing with them? This may help identify areas for which options are few or nonexistent, and which therefore may need more attention than areas where impacts may be felt, but alternatives are readily available.

That's enough for now!

**Post Title:** Re: How will human activities... (Henry Huntington)
**Posted by:** *ajensen* at 10:32 AM 2/5/2002
---
Henry makes several very important points here. Working with local communities is important on several levels, and will make for better science. Fear of possible grim futures is a real impact, with potential bad effects, right now. Certainly people on the North Slope have been arguing for years that proposed off-shore drilling (given the likelihood of a spill and no way to clean it up) is causing social problems right now due to pervasive fear and uncertainty.

We are probably all aware of how easily scientific results get twisted into unrecognizability when reported in the popular press. An additional issue for a number of northen communities is the fact that some of their residents were used as experimental subjects in potentially dangerous experiments, without informed consent, and had great difficulty getting a straight story later. If we don't work with, and develop a relationship of real trust with, local communities, residents may well believe what they see or hear in the popular media.

At the same time, per Henry's fourth point, it could be of great benefit to look at the range of possible outcomes for a community, and so they can see what areas require immediate attention, and can make choices (e.g.regarding infrastructure) which are better for the long term.

**Post Title:** Re: Society and Change in Canadian Arctic
**Posted by:** *MacDonald* at 12:28 PM 2/5/2002
---
As an outsider (who finds this discussion very interesting), I wonder if studies of how Canadian barren lands Inuit responded to the collapse of caribou and the eventual resettlement of the interior Inuit to the coast (this happened in the late 1940's-1950's) might provide some insights into the impact of rapid (catastrophic?) changes on northern native socieites?

**Post Title:** Re: Society and Change in Canadian Arctic (MacDonald)
**Posted by:** *Matt Berman* at 7:47 PM 2/5/2002
---
I would like to follow up on Henry Huntington's comment: "...humans have changed radically in their ability to control their relationship with the environment." One might say that putting this ability to use on a global scale has contributed to global climate change. In the Arctic region, I wonder how readers might answer either of these two questions:

1. What human activities in the Arctic might have sufficient effects on regional physical and/or biological processes to lead to environmental effects that spill over to other regions of the globe?

2. What modes of human adaptation to variation in local Arctic environmental conditions might lead to further local or regional biophysical change?

I am not sure of what activities would qualify in the Arctic proper. In the subarctic, management of fisheries in the Bering Sea region may be an example of the first type of activity, and fire control in portions of the boreal forest may be an example of the second.

**Post Title:** Re: How will human activities... (CraigNicolson)
**Posted by:** *ajensen* at 2:23 PM 2/6/2002
---
I pretty much agree with Henry that our understanding of socio-cultural issues lags behind some things in the biophysical realm. This is not surprising, both because social-cultural systems and processes are far more complex and less predicatable (people can think up lots of new ways to act in a given situation while most other entities that people study are somewhat constrained, quantum theory notwithstanding), and because far less effort and funding has been put into studying socio-cutural systems as systems (not just economic systems or religious systems in a vaccuum).

As far as the potential for socio-cultural change to have greater impacts than climate change, true as far as it goes. However, most Arctic communities are still subsistenced based, in cultural ideology even if not in calories consumed. While one might look at Barrow, for example, with modern schools, trucks, a utilidor (for most folks), wage labor, churches, and a large governmental bureaucracy and say that Inupiat culture is completely changed from that of say 200 years ago, I think that would be fundamentally incorrect. Inupiat culture has alway been a highly technological culture; technology was one of the keys to survival here. Technological experimentation and the adoption of new technology when it proved to be superior are fundamentaly aspects of Inupiat/Inuit cultural adaptation. (This doesn't seem to have been as true of the Dorset people, their predecessors in much of the North American Arctic, which may help explain why there don't seem to be any Dorset people left.) Aspects of the culture have changed in various ways, good and bad, with some of the changes balancing other changes. In any event, subsistence, particularly whaling, is still at the center of Inupiat culture, an organizing focus if you will. Significant climate change will certainly alter subsistence possibilities. It has done so in the past. A big enough change there might lead to the most profound cultural change possible.

## How will changes in arctic biogeochemical and hydrologic cycles and feedbacks affect arctic and global systems?

**ARCSS Planning Discussion** > **How will changes in arctic biogeochemical and hydrologic cycles and feedbacks** > **Changes in arctic biogeochemical and hydrologic cycles and feedbacks**

---

**Post Title:** Changes in arctic biogeochemical and hydrologic cycles and feedbacks
**Posted by:** *John Weatherly* at 12:45 PM 2/4/2002

---

**How will changes in arctic biogeochemical and hydrologic cycles and feedbacks affect arctic and global systems?**

The magnitude and even the sign of some of the feedback processes are associated with signifi-cant uncertainties. A major source of uncertainty is associated with the cloud-radiation feedbacks, and how polar cloud characteristics will be altered in a changing climate. Because of the impact of clouds on the surface radiation flux and thus the state of the ocean and land surface, the cloud-radiation feedback processes in the polar regions are inextricably linked with sea ice and snow feedback processes. Our best estimate at present is that most, if not all, of the individual feedbacks in the polar regions are positive, with the possible exceptions of the aerosol/dehydration feedback and, on longer timescales, the vegetation carbon uptake feedback. It remains a major task to explain the relative stability of the polar climate in the presence of these positive feedbacks. Possibilities include unforeseen negative negative feedbacks associated with clouds, the biosphere, or between the sea ice and ocean. Specific strategies for resolving these issues need to consider not just processes, but linkages between them and the relationships between these processes and interannual variability .

**Post Title:** Re: Scale and arctic biogeochemical and hydrologic cycles
**Posted by:** *MacDonald* at 12:21 PM 2/5/2002

---

It seems to me that one of the most important issues confronting us in this question is the matter of spatial and temporal scale. this is particularly true when we try to deal with terrestrial-atmosphere linkages. At the spatial scale we have the difficulting of scaling up from local observations on things such as CH4 fluxes to a pan-arctic view (in all but the roughest approximation). How much does the grain of the arctic terrestial environment impact such scaling up exercises and results? Here some of the work of LAII and RAISE has begun to address this. In the temporal realm, ARCSS has generated some excellent studies on local fluxes over decadal observational periods. Yet the short duration of such records may not allow us to detect underlying trends. Here PARCS and RAISE research can provide important insights. The trick is to merge the questions and answered asked by those operating at different spatial and temporal scales into a more unified scientific thrust.

**Post Title:** Re: Changes in arctic biogeochemical and hydrologic cycles
**Posted by:** *Jeff Welker* at 9:21 AM 2/6/2002

---

I think one of the important issues regarding changes deals with the issue of seasonality. That is, changes in biogeochemcial processes in winter due to deeper snow snow, may have very different feedbacks as opposed to changes

in biogeochemical processes in summer. For instance, deeper snow appears to elevate N mineralization in winter and this N may be captured by plants and or microbes in winter or spring, with very litter export to streams and rivers of DIN or DON. To the contrary, changes in summer biogeochemical processes could result in DIN or DON export, especially under conditioins of heavy summer rain.

Thus, the feebacks may not be consistent across seasons.

The seasonality issue also becomes a factor when you look at the carry-over affects or connectivity between seasons. For instance, deeper snow done not just affect winter processes but it also affects carbon and N dynamics in the subsequent spring, summer and fall.

So, as we look at how to evaluate change and feedbacks, I would suggest that we maintain a year-long perspective on the arctic system.

**Post Title:** Re: Changes in arctic biogeochemical and hydrologic cycles (Jeff Welker)
**Posted by:** *codispot* at 8:11 AM 2/7/2002
---
Here is a brief list of biogeochemical processes that may change under Arctic warming scenarios.

1) The flux of nutrients and light into the photic zone are bost likely to increase due to reductions in ice and snow cover, increased wind mixing, and the possible weakening of the halocline. Thus, I would guess that primary production in the Arctic would increase.
2) Fluxes of organic material into the Arctic would also be increased due to increased coastal erosion.
3) Methane releases into marine sediments and overlying waters might also be increased.
4) The overal increase in flux of organic matter should stimulated other biogeochemical processes such as sedimentary denitrification which is already globally significant in the Arctic.
5) One must also expect species shifts such as we have seen in the Bering Sea with impacts on living resources and implications for the release of DMS.
6) Although, I know little about this subject processes important to ozone concentrations and transport of pollutants such as Hg are associated with ice features such as salt flowers, so I am guessing that reduced ice cover would have a significant impact on the Arctic tropospheric chemistry and on the transport of pollutants into surface waters.

**ARCSS Planning Discussion** > **How will changes in arctic biogeochemical and hydrologic cycles and feedbacks** > **Key uncertainties in modeling response to change in terrestrial systems**
---

**Post Title:** Key uncertainties in modeling response to change in terrestrial systems
**Posted by:** *jhobbie* at 8:32 PM 2/5/2002
---
At a recent meeting of LAII modelers we asked them to identify the key uncertainties in their modeling efforts. These were caused by a lack of understanding of key processes, by missing

data, or by missing formulation of a model. We hoped to identify commonalities that cut across the wide variety of process-based models. One of the values of such a list is that it comes from the scientists actually doing the modeling and is a big step above a laundry list of interesting topics. A follow up at the Allhands meeting could be a discussion of priorities on the list and a possible white paper with more information about the models involved and the uncertainty introduced.

The list follows along with the names of the attendees or responders.

Uncertainties in modeling soils, roots, and the transformation of carbon and nutrients:

* The nature of organic carbon transformations in the soils over time (McGuire)
* Belowground productivity and root distribution (Epstein, Nadelhoffer, Sommerkorn)
* Seasonal dynamics of net nitrogen mineralization and their microclimatic and biological controls (Epstein, Shaver)
* Dynamics of belowgound pools of carbon and nitrogen including roots, microbes, soil organic matter (i.e., controls on the fate of carbon allocated belowground and its implications for nutrient dynamics – Nadelhoffer, Sommerkorn)

Uncertainties in modeling climate

* Modeling the distribution phase, and quantity of precipitation (Lynch)
* The extrapolation/interpolation of climate for regions; both temperature and precipitation are needed (Rastetter)
* The error between the observed temperatures in the Arctic, derived mostly from lowland stations, and the true temperatures that apply over the lowlands and uplands of an entire catchment (Peterson)
* The errors in the measurement of precipitation and interpolation throughout the Arctic (Peterson)

Uncertainties in land/water and material transport

* The unknown quantities of nutrients and organic matter from land entering the riparian zone and streams (Peterson) and the controls on their production (Kling/Sommerkorn)
* The retention and losses of nutrients, greenhouse gases, and organic matter in stream, lake, floodplain, and delta components of large catchments (Peterson)

The uncertainties in modeling terrestrial ecology

* The unknown role of mosses in the carbon cycling in the shoulder season (McGuire)
* The effects on mosses of competition for light (Epstein)
* The importance of the omission of mosses from the land surface model (LSM) (Beringer)
* The unknown controls of plant community composition that govern the difference between acidi and non-acidic (neutral) tundra sites (Epstein)
* The factors governing the establishment of new individual plants on disturbed sites (Epstein)
* The parameterizations of plant functional types needed in the land surface model (Epstein)
* The information on the controls of trace gas fluxes that are needed to explain the large-scale flux measurements (Sommerkorn)

The uncertainties in modeling the hydrology

* Snow heterogeneity as it affects: a) timing and amount of snowmelt; b) surface water and energy balance during snowmelt transition period; c) the impact of different

representations of snow heterogeneity on the evolution of summer soil moisture (Stieglitz)
* Soil moisture heterogeneity as it affects: a) land-atmosphere water and energy fluxes, b) land-atmosphere carbon and methane fluxes (Stieglitz)
* The identification of the near surface flow pathways that affect the flushing of constituents of hills slope soils to the streams (DOC, DIN, etc.)
* There is a lack of understanding of the meteorological forcing as it pertains to precipitation which is the measurement that, compared with air temperature, humdity, and so forth, is most in error, especially in the winter. As the observing network decreases, the only data left are from re-analysis and here too the greatest error is in the precipitation (Stieglitz).
* The lack of hydrology and permafrost in the LSM (Beringer)
* The effect of changes in surface morphology and subsurface structure such as changes in channel networks changes in active layer thickness and permafrost distribution and changes in soil profiles (e.g., in the thickness and properties of organic layers (Hinzman).
* The lack of high resolution digital terrain data is the primary data deficiency for hydrologic modeling
* There is a lack of gridded files on soil properties and geologic substrates (Hinzman)
* There is a lack of year-round, high-resolution (~100 m) atmospheric forcing (e.g., wind speed and direction, temperature, humidity) distributions (Liston)
* There is a lack of information on winter (snow) precipitation quantities and timing (Liston)
* During the winter, there is an unknown amount of sublimation from wind-blown snow (Liston).

The uncertainties for modeling permafrost
* For modeling the active layer thickness and the permafrost temperatures, the biggest uncertainties are the future climates (air temperature and precipitation, especially the snow depth distribution) and the future surface conditions (drainage, vegetation, moss dynamics) (Romanovsky)
* Need to know the geometry (3D, 2D) of development of a talik (Romanovsky).

**Post Title:** Re: Key uncertainties in LAII modeling (jhobbie)
**Posted by:** *CraigNicolson* at 11:33 AM 2/6/2002
---
John,

This is a very helpful (and comprehensive) list! It seems like the current thinking in LAII is well-matched to the upcoming task at All Hands, ie identifying key uncertainties and working out the next steps.

Manda's recent white paper on improving integration in ARCSS research suggested:
1. that we identify the **relative importance** of the various areas of uncertainty and our **readiness for (fastish) progress** in these areas.
2. that we use these broad themes to find **opportunities for coordination** between the traditional ARCSS projects (LAII, SBI, OAII etc)

So first, are there any obvious ways that your list of uncertainties might provide points of contact with other ARCSS initiatives?
And second, is there a sense within LAII that some of the areas you mention are really ripe for progress and need a bit of a push within ARCSS?

## Are predicted changes in the arctic system detectable?

**ARCSS Planning Discussion** > **Are predicted changes in the arctic system detectable?** > **Natural modes of spatial and temporal variability**

---

.

**Post Title:** Natural modes of spatial and temporal variability
**Posted by:** *admin* at 4:19 PM 2/2/2002

---

**Are predicted changes in the arctic system detectable?**

The climate system exhibits natural modes of spatial and temporal variability that are important in assessing our ability to understand and model the climate system. Important modes of variability are forced by the daily and annual variations of insolation. Changes in the magnitude and structure of these modes may be among the most important features of anthropogenic climate change.

Furthermore, the climate system exhibits modes of variability that appear to have no external forcing, but are rather natural internal modes of variability of the climate system. These modes are thus pure expressions of feedback mechanisms internal to the climate system (see section III.) Modes which affect the Arctic climate system include the North Atlantic Oscillation (NAO), the annular mode (AO) and the Pacific Decadal Oscillation (PDO). Some of these modes of variability have shown temporal trends in the past 30-50 years that may be associated with anthropogenic climate change. Understanding natural modes of variability is a promising means of assessing how climate change may express itself in regional shifts of temperature and precipitation.

In the context of these natural and forced modes of variability, the problem of detection leads to requirements that include the development of long term, detailed in situ observations, integration of the paleoenvironmental record, development of long term records utilizing satellite-derived products, and detailed regional reanalysis efforts.

**Post Title:** Key uncertainty addressed by PARCS
**Posted by:** *Darrell Kaufman* at 6:21 AM 2/4/2002

---

One of ARCSS' major goals is to understand whether changes predicted by models are actually taking place. A key uncertainty that underlies this and many other issues addressed by ARCSS is: the long-term structure of natural variability in the arctic system.

Warming in the Arctic during the 20th century is unprecedented within the last four centuries (Overpeck et al., 1997). Whether the magnitude and rapidity of 20th century warming is unique to the present interglaciation is not clear, but it bears directly on the issue of discerning natural versus anthropogenic climatic change. While the instrumental record of climate is restricted to short-term changes over the past century, paleoclimate proxy data capture longer-term climatic processes. These include extreme events not known from the historical record and the persistence (or otherwise) of climatic oscillations over long periods. Paleoclimate proxy records place the prominent 20th century warming in the context of longer-term variability driven by oscillations intrinsic or extrinsic to the climate system. For example, it is not clear whether the inter-annual cycles identified in the historical record (e.g., the Arctic Oscillation) are linked to longer-term centennial or millennial-scale climatic cycles (e.g., Bond et al., 1999, 2001).

Over the next three to five years, PARCS intends to facilitate research aimed at developing the observational basis and theory to understand the temporal modes of natural climatic variability in the Arctic. PARCS researchers will recover and analyze data from the highest-resolution multi-proxy paleoclimate records possible (including ice cores, tree rings, and lake and marine sediment cores) with temporal resolution ranging from annual to decadal. Patterns of climatic change will be reconstructed at a variety of temporal scales and will be compared to the known patterns of historically documented oscillations (e.g., AO, NAO) to elucidate possible driving mechanisms and longer-term behavior of the arctic climate system. PARCS will focus on developing high-resolution proxy records from the present interglaciation, the interval when climate boundary conditions were roughly similar to present. These records will span at least 1000 years and will extend through the 20th century. PARCS will also encourage the development of longer annually to decadally resolved records from earlier intervals of the Holocene to gauge the long-term persistence of climatic oscillations.

References

Bond, G.C., Showers, W., Elliot, M., Evans, M., Lotti, R., Hajdas, I., Bonani, G., and Johnson, S., 1999, The North Atlantic's 1-2 kyr climate rhythm, relation to Heinrch events, Dansgard/Oeschger cycles and the Little Ice Age. In, Clark, P.U., Webb, R.S., and Keigwin, L.D., eds., Mechanisms of millennial-scale global climate change: American Geophysical Union Monograph, 385-394.

Bond, C., Kromer, B., Beer, J., Muscheler, R., Evans, M., Showers, W., Hoffmann, S., Lotti-Bond, R., Hajdas, I., and Bonani, G., 2001, Persistent solar influence on North Atlantic climate during the Holocene: Science 294, 2130-2136.

Overpeck, J.T., Hughen, K., Hardy, D., Bradley, R., Case, R., Douglas, M., Finney, B., Gajewski, K., Jacoby, G., Jennings, A., Lamoureux, S., Lasca, A., MacDonald, G., Moore, J., Retelle, M., Smith, S., Wolfe, A., Zielinski, G., 1997, Arctic environmental change of the last four centuries: Science 278, 1251-1256.

**Post Title:** Re: Natural modes of spatial and temporal variability (admin)
**Posted by:** *John Weatherly* at 12:55 PM 2/4/2002
---

One of the more intriguing questions being debated at present is how much the Arctic sea ice cover has changed in the last 50 years, and what has caused this change. Like the patterns of temperature (and surface pressure) changes in the Arctic, the decrease in sea ice thickness is consistent with (in the general sign of) the warming trends of both anthropogenic and natural (e.g. solar variability) origin. However, the spatial pattern and the shifts in ice motion are consistent with the changing mode of the Arctic Oscillation, which may or may not also be responding to trends in forcing.

The change in sea ice is detectable, with considerable uncertainty as to the origin of the change, and whether similar changes have occurred in the past, to what magnitude.
This question is being addressed by a combination of collected observations and models. Observations include the submarine-based sonar data, under-ice sonar moorings, and the drifting buoys (of particularly high value and importance), and remotely sensed ice concentrations. The models are being used to simulate the history of the Arctic ice distribution of the last 50 years, and diagnosing the separate dynamic and thermodynamic responses to the history of observed atmospheric data, to the extent it can be known.

Data from proxy indicators of past regimes in the Arctic ice motion (such as re-assembled drift scenarios) and ice thickness (if there are any?) would be extremely helpful in this regard.

Some of the key uncertainties in this endeavor are:

* Where is the Arctic sea ice thinning, when did the thinning occur, by how much?
* Where is it not thinning, perhaps because of ice ridging and other dynamical responses? Accessing any new data sources from outside the international 'Box' of submarine data is of critical importance, such as under-ice moorings from coastal Canada.

* How much of the ice changes are due to dynamics and how much is thermodynamics? The response of the ice to AO variability is both dynamic and thermodynamic, and involves both atmospheric and oceanic circulation changes. Ice-ocean models that can diagnose these responses need to be compared closely to the observational data, and in some cases, the 'best' models that are most appropriate for these applications have not yet been created, but the parts of the models already exist.

* How much of the changes are due to natural variability and how much are part of an overall trend forced by both anthropogenic and natural external forcings? This is more in line with the larger question of how much of the change (Unaami) is part of a larger trend. However, the dynamics of the Arctic ice add an apparent feedback on any of the atmospheric forcing, so that the total Arctic ice mass can decrease or increase because of changes in the winds patterns and ice drift.

**Post Title:** Re: Natural modes of spatial and temporal variability (admin)
**Posted by:** *JOverland* at 1:07 PM 2/4/2002
---
We had warming in the 1940s and 1990s. Do we extrapolate this forward?
The Iceland record does not seem to fit this 50 year pattern in the 1800s.
The AO does not seem to have much of a signal before 1960; is this evidence
for a CO2 component to the recent warming?

**Post Title:** Re: Natural modes of spatial and temporal variability (JOverland)
**Posted by:** *John Weatherly* at 1:31 PM 2/4/2002
---
A major question in addressing this is: What controls the major modes of (Arctic) variability? We've only identified some of these modes recently, and haven't gone far towards understanding what are the major controls on their variability.

Global climate models exhibit a representation of the AO/NAO and PNA, but the models differ on what influences these modes. Some GCMs show a trend in the AO with warming climate in the next 100 years, and some do not, and the AO/NAO is a fixed mode, while the overall mean patterns change. . Some show a strong stratospheric influence on the AO, via the polar vortex, while some show a dominating power of Atlantic SSTs over the NAO.

Addressing this question goes beyond ARCSS research exclusively, in modeling the global coupled climate system. Highlighting some of the Arctic-based problems in solving this:

* How does the Arctic stratospheric ozone (and depleted ozone) affect the strength and structure of the polar vortex? How do other gases (water vapor, methane, CFCs) affect the vortex?

* How does the Arctic ice cover, Ocean circulation, and ice/ocean exports into the North Atlantic affect the SSTs and the mode of the NAO? The ice cover and SSTs anomalies do produce an AO-like response in GCMs, but it is not known whether they have played a significant part in the recent history of the NAO/AO signal.

**Post Title:** Re: Natural modes of spatial and temporal variability (John Weatherly)
**Posted by:** *ajensen* at 3:17 PM 2/4/2002
---
Historical climatologists have worked a good bit on sea ice reconstructions (Astrid Ogilivie being a notable example). As Jens Bischoff point out on the paleo thread, among several other good points, there is observation data on ice thickness from more than 50 years ago.

**Post Title:** Re: Natural modes of spatial and temporal variability (admin)
**Posted by:** *JOverland* at 4:18 PM 2/4/2002
---
I tend to think that there is some driving from the stratosphere. Six
of nine years in the 1990s had a cold strong vortex. This vortex
persisted into march, which was uncommon in the 1980s. Temperatures
were cold enough that ozone could have contributed to the persistence.

**Post Title:** Re: Natural modes of spatial and temporal variability (JOverland)
**Posted by:** *MacDonald* at 12:41 PM 2/5/2002
---
On problem we face is extrapolating from one site to another. For example, the patterns for Iceland may look out of synch with other parts of the Arctic over the past 50 years, but observational and historical climate data suggest that areas such as easstern Siberia and Iceland do not always respond in like sign to annual, decadal or even centennial events. It is ashame we can never produce the same long historical (written) records of sea ice that Iceland has for areas such as the Lena Delta or the Mackenzine Delta etc.

**Post Title:** Re: Natural modes of spatial and temporal variability (MacDonald)
**Posted by:** *CraigNicolson* at 5:56 PM 2/5/2002
---
Here are some of the themes I'm hearing in this thread.

We're still uncertain about:
1. The extent of natural climate variability over the last say 1000 years (PARCS is planning to address this over the next 3-5 years)
2. Whether interannual trends in AO, NAO, etc are linked to longer term climatic cycles
3. How sea ice changes (which are one place we expect to detect the predicted changes) are linked to the changing mode of the AO
4. The role of the stratosphere in driving the changes we're observing.

Bearing in mind that one goal of this thread is to explore critical areas of research for immediate attention, which of the above areas seem most important and most amenable to (fastish) progress?

Incidentally, one common theme I've noticed in quite a few posts here and elsewhere has been the need for integrating paleo work with current observations, and also integrating paleo work and modeling.