Witness the ARCTIC

Chronicles of the NSF Division of Arctic Sciences Fall 2012, Volume 16 Number 3

In this Issue

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Study of Environmental Arctic Change (SEARCH) Progress and Activities

SEARCH Goals and Implementation

The SEARCH Science Steering Committee (SSC) (http://www.arcus.org/search/sciencecoordination/ssc-committee) made significant progress over the past few months in moving SEARCH towards full implementation (see Spring 2012 Witness the Arctic article (http://www.arcus.org/witness-the-arctic/2012/2/article/19159)). The SEARCH SSC revised the five-year science goals and objectives to incorporate input from the broader scientific community (http://www.arcus.org/arctic-info/archive/19096). The revised goals are available through the SEARCH website:

Study of Environmental Arctic Change

- Improve Understanding, Advance Prediction, and Explore Consequences of Changing Arctic Sea Ice (http://www.arcus.org/search/sea-ice)
- Document and Understand How Degradation of Near-Surface Permafrost Will Affect Arctic and Global Systems (http://www.arcus.org/search/permafrost)
- Improve Predictions of Future Land-ice Loss and Impacts on Sea Level (http://www.arcus.org/search/land-ice)
- Analyze Societal and Policy Implications of Arctic Environmental Change (http://www.arcus.org/search/society)

The SSC has developed a plan for a suite of activities to support the five-year goals, cross-cutting synthesis, and the Arctic Observing Network. The SSC will submit a proposal to NSF and other agencies in support of a new SEARCH organizational structure to implement these activities.

SEARCH at the American Geophysical Union (AGU) 2012 Fall Meeting

A Town Hall meeting, "SEARCH: Current Activities and Future Directions," is scheduled at the AGU fall meeting on Monday, 3 December from 6:15-7:15 p.m. Pacific Standard Time in Moscone West, Room 2010. Refreshments will be served. Discussion topics will include:

- Recommendations for the Arctic Observing Network (AON), including a report for AON Design and Implementation (see: http://www.arcus.org/search/aon/adi);
- SEARCH five-year goals (see: http://www.arcus.org/search/goals); and
- Development of a new SEARCH implementation strategy.

Members of the arctic science, education, and policy communities are invited to attend, and young investigators are particularly encouraged to participate.

In addition to the Town Hall, a SEARCH poster presentation will take place Monday, 3 December from 8:00 a.m. – 12:20 p.m. in Moscone South, Hall A-C in the session "Climate Change Science for Sustainability Planning" (Session GC11B-0999), offering an opportunity to discuss the program.

Arctic Observing Network (AON) Design and Implementation

The AON Design and Implementation (ADI) effort has provided guidance to the National Science Foundation (NSF), the

scientific community, and others engaged in arctic environmental observations on how to achieve a well-designed, effective, and robust arctic observing system.
ADI activities are overseen by an ADI Task Force and have included a combination of virtual and in-person meetings and a community survey. The Task Force has released its final report, "Designing, Optimizing, and Implementing an Arctic Observing Network (AON)." The report includes the following:

1. An assessment of the present state and near-term implementation plans of the AON and related efforts;
2. A synthesis of lessons learned from other observing systems;
3. A discussion of promising approaches and options for system design and optimization; and
4. ADI Task Force findings and recommendations.

The report is available online at: http://www.arcus.org/search/aon/adi. Requests for hardcopies can be sent to Helen Wiggins at helen@arcus.org.

Sea Ice Outlook and Sea Ice for Walrus Outlook

The 2012 arctic sea ice minimum, at 3.41 million square kilometers, was the lowest extent in the satellite record since 1979—18% below 2007 and 49% below the 1979 to 2000 average. The arctic sea ice extent averaged for September 2012 was 3.61 million square kilometers (see the National Snow and Ice Data Center website (http://nsidc.org/arcticseaicenews/2012/09/arctic-sea-ice-extent-settles-at-record-seasonal-minimum/) for more details.

The 2012 Sea Ice Outlook provided insight into the sea ice conditions and methods of sea ice prediction. A post-season analysis that examines the causes of this summer's sea ice minimum and the success of the Outlook projections will be available soon through the Sea Ice Outlook website.

In addition, a multi-disciplinary group of Sea Ice Outlook organizers and participants submitted a collaborative proposal to build on current Outlook activities. If the proposal is successful, the Outlook will undergo significant expansion in the 2013 season.

The Sea Ice for Walrus Outlook (SIWO), which provides weekly reports on sea ice conditions relevant to walrus in the Northern Bering Sea and southern Chukchi Sea regions of Alaska, ended its third season in June. Due to increasing demand of SIWO products, SIWO organizers are also developing a proposal to expand activities for next year.

For more information about the Sea Ice Outlook, go to: http://www.arcus.org/search/seaiceoutlook/index.php

For more information on the Sea Ice for Walrus Outlook, go to:
http://www.arcus.org/search/siwo

For more information on all SEARCH activities, please contact Helen Wiggins, ARCUS (SEARCH Project Office) at helen@arcus.org, or Hajo Eicken (SEARCH SSC Chair) at: hajo.eicken@gi.alaska.edu.

A Conversation with Dr. Neil Swanberg, NSF Arctic System Science Program Director

Witness the Arctic (WTA) had a conversation with Dr. Neil Swanberg, Program Director for the Arctic System Science Program (ARCSS) at NSF. He shared his perspective about how opportunities for arctic research are evolving at NSF, the value of and characteristics of successful interdisciplinary or transdisciplinary arctic science efforts, and the challenges and opportunities for the SEARCH program as it continues to develop.

WTA: In your view, how are opportunities for arctic research evolving at NSF?

Swanberg: I would say the most significant change in the Arctic Sciences competitions over the last few years has been the amalgamation of the Arctic Systems Science (ARCSS) and Arctic Natural Sciences (ANS) programs for the purpose of the competition. We take all proposals on arctic environmental science, review them jointly, and we parse out where we think the funding fits best. This is not the only way for ARCSS or ANS to fund proposals—we also have special competitions—but for the purpose of the general competition that's the way we're handling things, which also makes it easier for the PIs. In the past we heard from PIs that there was a great deal of angst over whether they should submit to ARCSS or ANS. Now there is an intentionally fuzzy boundary between the two programs, making that choice a nonproblem. It also makes it easier for us to look at the whole picture from the standpoint of money. Having said that, we are heading into some serious financial issues in the federal government. Budgets are going to be tight. That implies both science budgets and logistics budgets. There's a great deal of concern about the "fiscal cliff" and the debt ceiling. Either of those things could cause draconian changes in the way we're able to fund science. Public information in the press suggest that most budget scenarios are downward, and that would probably mean fewer things funded. We would do the best we could to minimize the impact, but there's only so much we could do—I think we just have to wait to see what happens.

I would add that we're not finished evolving, and we're looking at programs constantly. We are certainly interested in the role of the Arctic Observing Network (AON) and the intersection between ARCSS and AON, for example. Nothing is cast in stone; we try to make changes in response to community input. Another thing I would say to PIs concerned about this is that we will have town hall meetings at AGU. People should come, talk, and let us know what they think. We are always ready to listen.

WTA: From the program management perspective, why is transdisciplinary science valuable?

Swanberg: Setting aside that this is a priority at the foundation; I would say it's a priority because there is a sense that a lot of the really exciting cutting-edge science happens at the interface of disciplines. I would define transdisciplinary science questions as ones that are above the levels of individual disciplines, so that in order to answer the question you really have to use the tools of more than one discipline. There is a synergy that arises from people of different backgrounds looking at problems together. You find that people from different disciplines may have completely different approaches to a problem, which leads to new solutions. You also find that disciplines aren't real in the natural world--they're a human construction. Often we find that breakthroughs are happening at the intersection of those artificial human barriers. That's one of the strong motivations at the foundation for pursuing transdisciplinary science.

WTA: What challenges and opportunities do solicitations such as Arctic SEES and INSPIRE present to the

research community?

Swanberg: Although I wasn't very involved in writing Arctic SEES, from my reading of the solicitation I suspect the challenge for a lot of PIs is in understanding the juncture of social science and natural science. I think the solicitation is largely focused on social science impacts--impacts on people--and the natural science has a lesser role as driver. I could be mistaken, but from the proposals I've seen I think a lot of other people have had difficulty with that as well. So I think that really understanding the solicitation is going to be the key. The opportunity certainly is the funding available and the effort to promote real interdisciplinary science as well as interagency and international science.

The opportunities offered by INSPIRE are obvious; it's a large pot of money with relatively little review. It is intended to solicit relatively simple proposals representing out-of-the-box ideas that people think could not get funding under the normal mechanisms because review panels seem too conservative.

It really is supposed to support projects that could not be done with the normal review process. I think the biggest challenge for PIs is figuring out whether their ideas fit this mechanism and identifying their intellectually distinct disciplines. For example, I would say that the combination of biology and chemistry is not really intellectually distinct in that we have biochemistry. There are other combinations like that, which are fairly obvious. A lot of environmental science unfortunately may also fit into that category. Some of the things people were thinking about when they put this thing together were engineering and biology, for example, or engineering and molecular genetics--fields that don't normally work together. Looking at the suite of proposals that were funded last year, I think there was a reasonably good effort at identifying those that were intellectually distinct, out-of-the-box, and transformative ideas. We're hoping that we see similar responses this year.

WTA: Do you have an idea how the arctic research community might respond to that?

Swanberg: Well, that's an interesting question. There was some disappointment that the community didn't respond very much to the opportunity last year. There were a handful of inquiries and one award that included polar research: it was not predominantly a polar proposal but we were included in it. Other parts of the foundation were very aggressive with INSPIRE.

The message to the arctic community is to pay attention to the INSPIRE solicitation and think out of the box; think very hard about how you can fulfill the motivations in the announcement. There will be another foundation-wide solicitation this year so there's more material to read. My advice, as always, is don't try to force an idea to the announcement. Read the announcement and try to develop your idea. The key things we're looking for are exciting transformative science and proposals that involve widely distant fields and do not fit the normal review process.

WTA: In your experience, what are the challenges to developing successful transdisciplinary science efforts?

Swanberg: As I see it, there is one overriding challenge and that is communication. If you're really looking at widely different fields, you find the vocabulary and language is different. You really have to learn each other's language.

WTA: What are the characteristics of successful efforts?

Swanberg: Both tractable and attractive questions are needed. Tractable questions can actually be answered in a reasonable time frame. Attractive questions appeal to several different fields. One of the great successes of the Fresh

Water effort we funded some years ago is that they identified a question that really resonated with people and that they can answer--this motivates people. I think the question needs to be not just of interest to field "A" needing the expertise of field "B" to answer. That will never work. As an example, in the 1980s as biological oceanographers were getting interested in how the physics influenced the biology, they would try to entrain physical oceanographers into their efforts. But the questions they were asking weren't terribly interesting to the physical oceanographers, so it was difficult. I think that is less true now the fields have changed. Another example is in the arctic sciences; many arctic natural scientists are interested in addressing questions that touch on social science issues. They want to engage with social scientists, but they don't really know what questions interest social scientists. The key to making a true interdisciplinary effort work is not looking to another discipline to provide a service but developing a real partnership.

WTA: Is this the kind of effort that INSPIRE would support?

Swanberg: Certainly, as long as it is something that could not get funded in the normal review process because it's perceived as being high risk. They are very keen on transdisciplinary research.

WTA: In your view, has SEARCH supported interdisciplinary or transdisciplinary arctic science efforts?

Swanberg: SEARCH started out very definitely as a disciplinary effort and has expanded. It started out as atmospheric and oceanographic physics and expanded to include a whole system-wide look. In producing its science plans and vision of how the arctic system works, it did support interdisciplinary efforts. But in terms of having fostered actual transdisciplinary research, aside from some of the things that SEARCH has taken under its wing such as the Fresh Water effort, I don't think there's been a lot of that. I don't level that as a criticism; this is extremely difficult to do. SEARCH has been such a huge idea for people to get their heads around that they've attacked it from the standpoint of disciplinary and subdisciplinary pieces. This approach has been the same in most of the global change programs. They tend to take the huge view of the global system and then break it into the disciplinary units and try to address those. To start looking the whole system level in an interdisciplinary way, SEARCH has to get more engaged at the highest level in doing the actual science rather than just planning it. I think this is why I was so keen on seeing how it would move forward with the "Understanding Change" component and engagement in a really proactive effort to do some of this synthesis, because that's probably where the interdisciplinary stuff is going to happen.

I have been speaking from the standpoint of what has been done and not what's going to be done. I think that in moving to the themes and science goals and so forth that have been established--if SEARCH pursues those themes and does not make them disciplinary--I think it could become VERY interdisciplinary in how it approaches things and could even develop a fairly hands-on way of managing them. That could change the answer to that question considerably. They could well be moving in the right direction. Neither the foundation nor SEARCH nor the community has reached maturity in the way they are doing interdisciplinary and transdisciplinary stuff. This work is pretty hard, and even the definitions defy some people, so I wouldn't fault anyone for not completing this task. That is particularly true for much of the work the arctic community is doing. It's not easy.

WTA: What is the value of the SEARCH science goals and framework?

Swanberg: In principle, setting out an agreed-on set of questions and a plan for addressing them should enable a community to focus its attention on various pieces of the problem that are appealing to them. In practice, I think the initial SEARCH science plan and goals of about a decade ago were probably too encompassing and too broad. That was

true of both the SEARCH science plan and the SEARCH implementation workshop. The value of the science plan and goals is in identifying some priorities and developing a good target. And everyone is helped if the agencies can buy into those priorities. Once again, moving to the themes that SEARCH is now considering may help considerably because they define a smaller target and more tractable problems than the SEARCH science plan from the early 2000s. This suggests again that SEARCH is moving in the right direction on identifying themes. I think it's not coincidental that at the same time IARPC is doing the same thing.

WTA: What potential does ACADIS offer?

Swanberg: ACADIS was part of an initial effort to improve the coordination of SEARCH, and I see it as a critical step in the synthesis activity. As we discovered in ARCSS synthesis activities, access to data was the first thing people needed to actually do synthesis. There was no place to go for that access; people knew only where some data were. I think the challenges to ACADIS will be in discovering the data and in finding imaginative ways to manipulate and view the data. Most data centers will let you discover data by the discipline or the name of the PI or geography. But suppose you're a social scientist and you want to know about something to do with sea ice--or maybe you don't know exactly what your question is--how do you discover useful data? Somehow we need to define something like an expert system that will allow people to find out what kinds of data exist—data they don't know about but may be very important to them. I laid this challenge before ACADIS during our site visit last summer. I think this is going to be one of the big challenges in the next few decades as interdisciplinary research expands, for SEARCH and a lot of environmental science. There will be people in one discipline who do not understand what kinds of data exist in another discipline, what data they need, and that the conventions about presenting and talking about their data are different from what they are used to. This is a huge challenge ahead of us. I see ACADIS as being a very important activity, and my hope is that ultimately it will be much more than just a data center. I see ACADIS as being a critical piece of what will probably be a larger puzzle to do synthesis, and we need to figure out what the other pieces are and try to build them.

WTA: From the perspective of a federal agency, what are the challenges and opportunities for the SEARCH program as it evolves?

Swanberg: That's a good question. What struck me first is the challenge of matching expectations with shrinking budgets. But in a larger sense the really difficult thing is trying to align the motivation for involvement with the objectives of the program. By that I mean that people get involved with large programs like this because they want to foster their own science or they want to make sure that their piece of science is included in the science plan. That level of motivation is necessary because people are not paid to do these things. The only way they can get paid is if ultimately their science achieves some sort of notice in a large program. But a large program needs to be more than an umbrella. To make a program like SEARCH function well, you need people who can think at a very high level—people who are thinking above and beyond their own discipline and addressing the large questions, which helps create a whole that is greater than the sum of its parts.

Another challenge is getting buy-in from other agencies. I think we're seeing more agency involvement, but interagency activities are always difficult. Agencies have different cultures, traditions, rules, and obviously different budget priorities. The ideal is for SEARCH to be the "go to" place for knowing about the Arctic. Other agencies would want to buy in because involvement will help them complete their missions. The same applies to international activities.

Ultimately this isn't about SEARCH. It's about understanding the Arctic. Scientists in other agencies and other parts of the world are trying to do the same thing. We want to complement their efforts, not duplicate them. We have to see SEARCH as a tool to engage with partners in other parts of the world. And obviously again NSF can't do it all. We've got to make it very attractive to other parties to get involved with whatever SEARCH is doing. SEARCH has to be a beacon. I think that you can never force people to be involved but if they see it as valuable, then they will engage.

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Implications of Thawing Permafrost on the Structure of Arctic Landscapes

An interdisciplinary team of researchers has applied a systems science approach to investigate how dramatic changes in permafrost features influence the structure and function of the arctic landscape. This study, led by W. B. Bowden of the Rubenstein School of Environment and Natural Resources at the University of Vermont, focuses on the composition of vegetation, the distribution and processing of soil nutrients, and exports of sediments and nutrients to stream and lake ecosystems to help understand how thawing permafrost will change the arctic landscape and other implications.

Changes in Permafrost

A warming arctic climate may have significant impacts on systems in the arctic region, including thawing of a substantial portion of the permafrost in coming decades. Permafrost is defined by the primary condition of soil temperature that remains below 0˚ C (32˚ F) for two years or longer. Most permafrost in the Arctic contains some amount of frozen water. In areas where the content of ground ice is particularly high, the risks of permafrost thaw are greater. The threats of thermal erosion to civil infrastructure have been recognized for some time. More recently attention has turned to the impacts that thermal erosion might have on undeveloped arctic ecosystems.

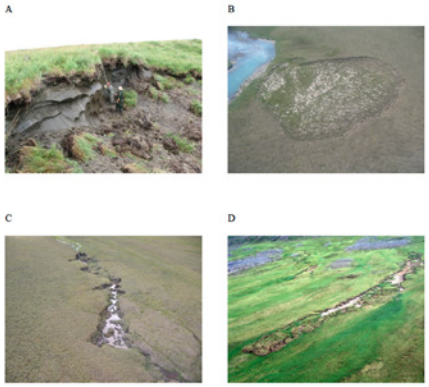


Figure 1. Examples of upland thermo-erosional features induced by permafrost thaw, including glacial thermokarst (A), retrogressive thaw slumps (B), gully thermokarst (C), and active layer detachment slides (D). Photos credits: A-C by W.B. Bowden, D by A.W. Balser.

One of the most obvious effects is the formation of thermo-erosional features (see Figure 1), an extreme case of thermokarst formation. The term "thermokarst" generally refers to the uneven ground that occurs when permafrost—especially ice-rich permafrost—thaws and the ground surface subsides as the soil structure weakens and becomes plastic. In extreme cases, the soil becomes so fluid and weakened that it fails entirely, creating a variety of features that resemble landslides as seen in non-arctic areas. These thermo-erosional features appear to have become more common in recent decades in upland areas like the foothills of the Brooks Range in Alaska (Gooseff et al. 2009). This suggests that the rate of thermo-erosional processes has increased at the same time as significant warming of arctic air and soil has been observed. These thermo-erosional features may be a warning of future impacts of arctic warming (Bowden 2010).

Thermo-erosion of permafrost is important because it sets in motion a series of changes to the arctic landscape that include, but are not limited to, fundamental changes in hydrology, patterns of snow accumulation, soil microbial processing, vegetation communities, and habitats and resources available to wildlife. All of these and more will have direct and indirect impacts on human communities.

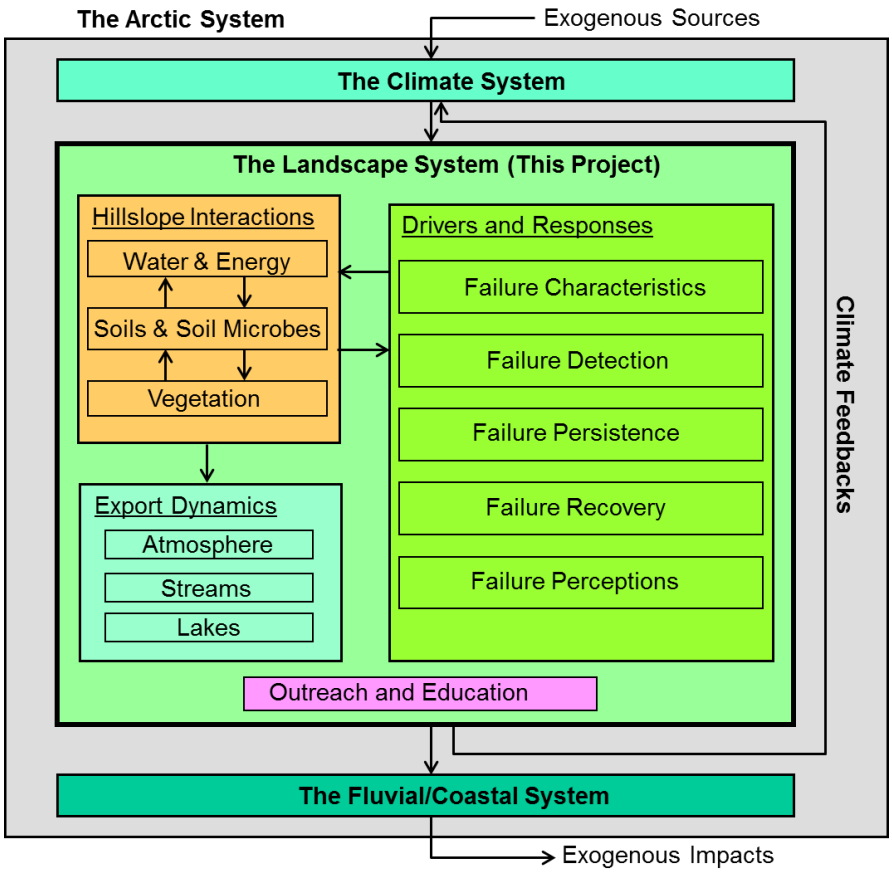


Figure 2. Framework for the ARCSS/Thermokarst Project. Each of the smaller boxes within the large central box is specific objective involving one or more collaborating principal investigators and their students. Image courtesy W.B. Bowden.

Thermokarst Project Framework

The Arctic System Science/Thermokarst project, supported by NSF's Arctic System Science Program (ARCSS), was established in 2008 to use a systems approach to investigate how the structure and function of upland landscapes will change as permafrost thaws (see Figure 2). The project focused on the dynamics of permafrost degradation and thermo-erosion in upland regions because a large portion of the Arctic is in upland areas, because less is known about this region compared to coastal plains and peat plateaus, and because thermo-erosional processes might differ in upland regions compared to these other areas due to fundamental differences in topography, precipitation regimes, and runoff characteristics.

The ARCSS/Thermokarst project was designed to address a set of interrelated questions that included:

- What physical factors predispose hill slopes to fail when permafrost thaws?
- How do soil and water chemical characteristics change when thermo-erosional features form?
- How do the fluxes of carbon, nutrients, and sediment change?
- What are the short-term and long-term trajectories of carbon and nutrient accumulation, including vegetation regrowth?
- What are the implications of past and future landscape change?

This research was conducted in the vicinity of NSF's Toolik Field Station in northern Alaska (N68˚ 38', W149˚ 36'), which is approximately 255 km north of the Arctic Circle and at an average elevation of 720 m above sea level in the

foothills of the Brooks Range. The mean annual temperature ranges from -6 to -11˚C, with summer highs of 10 to 18˚C and winter lows of -30 to -40˚C. Mean annual precipitation ranges from 250 to 407 mm, with 30 to 40% falling as snow between September and May. The dominant vegetation community is tussock tundra, defined by the tussock-forming grass *Eriophorum vaginatum* intermixed with shrubs, primarily dwarf birch (*Betula nana*) and several species of willows (*Salix* spp.). Vegetation and soils in the study area have developed in response to interactions among the glacial legacy of the area, topography, and climate.

Study Findings

The team found that the common thermo-erosional features in this region are thaw slumps, thermo-erosional gullies, and active layer detachment slides (see Figure 1). These features significantly redistribute and reduce soil carbon and nutrients. Sediments and nutrients are exported from thermo-erosional features and may impact streams and lakes. In general, productivity was greater in streams and lakes influenced by thermokarst inputs; i.e., nutrient stimulation outweighed sediment interference. The effects seem to be transitory on the time scale over which these thermo-erosional features form, stabilize, and are re-vegetated—perhaps on the order of several decades.

The team found that field measurements of the rates at which carbon and nutrients accumulate after these thermo-erosional features stabilize led to estimates that were much faster than their estimates based on model predictions. This finding suggests that alternative sources of carbon and nutrients must be available.

For the research team, one of the most intriguing results from this work is the realization of how numerous thermo-erosional features have become. In one area the team studied intensively, there were over 7,000 identifiable thermo-erosional features in an area of about 1,681 km2, or more than four features per square kilometer. Given the local impacts identified by studying individual thermo-erosional features, the team concludes that these features are likely to be important agents of change in the structure and function of the arctic landscape and may become even more important as the permafrost continues to thaw.

For further information about the ARCSS/Thermokarst project, see the project website: http://thermokarst.psu.edu/ or contact W. B. Bowden (breck.bowden@uvm.edu).

References

Bowden, W. B. 2010. Climate Change in the Arctic: Permafrost, Thermokarst, and Why They Matter to the Non-Arctic World. 2010. *Geography Compass* 4(10): 1553–1566. DOI: 10.1111/j.1749-8198.2010.00390.x. Article first published online 3 October 2010.

Gooseff, M. N., A. Balser, W. B. Bowden, and J. B. Jones. 2009. Effects of Hillslope Thermokarst in Northern Alaska. *Eos* 90(4): 29-36. (27 January 2009.)

Healy Winter Cruise Reveals Surprisingly Active Arctic Ecosystem

In the last months of 2011, scientists and crew aboard the U.S. Coast Guard Cutter *Healy* conducted the first winter research cruise in the Arctic. The purpose of the forty-day cruise was to collect baseline information on the winter physical and biological characteristics of three important arctic seas: the Bering, the Chukchi, and the Beaufort.

The chief scientist for this cruise, Carin Ashjian of Woods Hole Oceanographic Institution, led the team of 18 scientists in this effort to gain understanding of arctic sea conditions and ecosystems during the winter. Information available before the 2011 cruise was severely limited by difficulties in accessing these regions during winter, the geographically restricted nature of ice camps, and by limitations of the sensor technology deployed over the winter season.

CMDR Laura King, the first female EO (Engineering Officer or Chief Engineer) of Healy, Chief Scientist Carin Ashjian, and CAPT Beverly Havlik, the first female Captain of Healy. Photo courtesy of Carin Ashjian.

Ashjian particularly aimed to understand the overwintering strategies of one of the dominant copepod genera, *Calanus* spp., which is critical to ecosystem modeling efforts. Increased knowledge about how this copepod overwinters could improve efforts to model and to predict arctic ecosystems and understand the potential impacts of ongoing climate change.

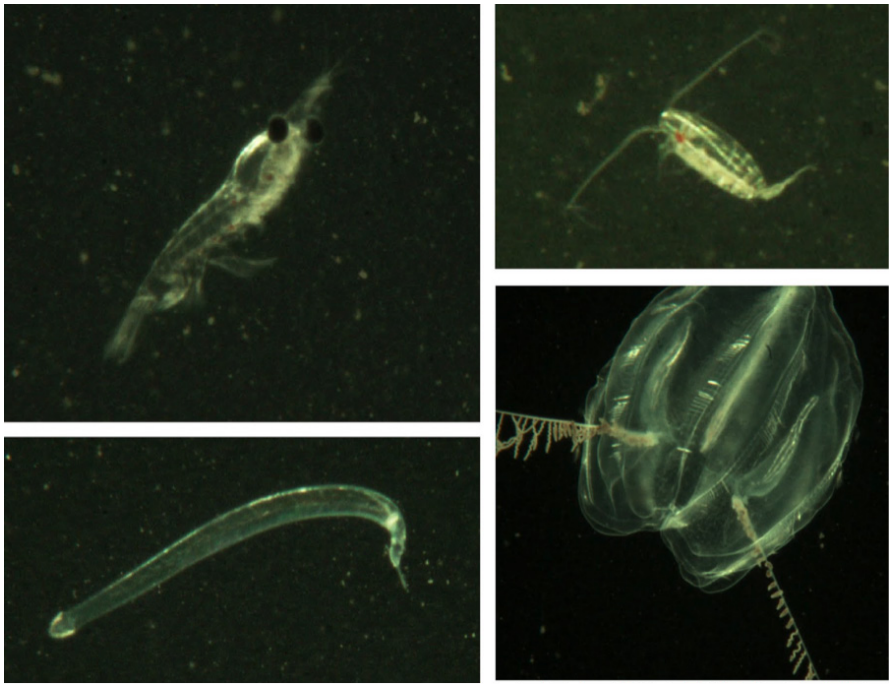
The view from the Healy bridge 4 December 2011. Winds were about 40 knots at the time. Photo courtesy of Carin Ashjian.

Copepods are small crustacean plankton (6 to 10 mm or smaller) and are important components of the oceanic food web. They eat phytoplankton (plant plankton), ice algae (algae growing on or under ice), and microzooplankton (zooplankton smaller than copepods). In turn they are a crucial link in the arctic food chain as a food source for larger crustaceans, jellyfish, fish, sea birds, and marine mammals such as the bowhead whale. In terms of overall biomass, species of the genus *Calanus* are one of the more important types of copepod.

Calanus spp. follow a life cycle in which they spend the productive summer months near the surface of the ocean, feeding on phytoplankton and microzooplankton, and then migrate to deeper water (~100 to 200 m) to overwinter in a type of hibernation called diapause. It is well understood that *Calanus* spp. found in other parts of the world ocean, such as the northwest Atlantic, can only diapause in deep water; they are not found on the shallow continental shelves in winter. According to what was known about their life history, the Bering and Chukchi shelves are too shallow for *Calanus* spp. to diapause. It was also thought that during the dark arctic winter season, with the resulting scarcity of ocean plant life, copepods would be semidormant.

During the 2011 cruise, scientists conducted sampling to describe the seasonal hydrography, circulation, and aspects of the planktonic and chemical environments. Specific sampling included physical (e.g., hydrography and circulation), chemical (e.g., nutrients and organic matter), and biological (e.g., zooplankton, microzooplankton, chlorophyll, and bacteria). The main objective was to identify the overwintering habitat of *Calanus* spp., determine the condition and activity of *Calanus* spp. and euphausiids, and describe the interconnectedness between species and populations of *Calanus* and euphausiids in these regions. The team also sought to identify the transformations of Pacific water on the Chukchi Shelf, describe the off-shelf flow of Pacific water into the Arctic Ocean and the circulation and hydrography of

Barrow Canyon, and quantify the course- and fine-scale vertical distributions of plankton and particles in relation to the vertical structure of the water column.



Four plankton photographed by the Video Plankton Recorder, an underwater microscope that uses a camera and a strobe. Top left: A euphasiid, or krill. Top right: a Calanus copepod, Bottom left: a chaetognath, or arrow worm, voracious predators of copepods. Bottom right: A ctenophore, voracious predators of both copepods and krill. Photos are not to scale. Photo courtesy of Carin Ashjian.

Preliminary Findings

The team found a surprisingly active ecosystem despite the low light conditions of the arctic winter season. The *Calanus* copepods and euphausiids were not dormant but rather were active and were feeding on the very low concentrations of chlorophyll present, suggesting that an active food web was present in this late fall to early winter time frame and that the *Calanus* copepods may have been continuing to grow and develop through this period. Sea ice and winter water were forming during the cruise. Multiple water mass types were observed with cross- and along-shelf distributions that were sensitive to local wind forcing. For example, populations of *Calanus glacialis/marshallae* observed in Barrow Canyon, where Atlantic water from the Canada basin was observed, had greater proportions of a younger life stage (i.e., copepodid stage 4) than did populations elsewhere, suggesting a mixing of Arctic basin and shelf populations. Additional analysis is presently being done on bacterial activity and production, primary production, phytoplankton activity and taxonomic composition, zooplankton genetics, RNA/DNA (a measure of metabolic activity), and carbon and nitrogen content. Ultimately, these results will provide key data on ecosystem functioning during the late fall and early winter, which can be used in modeling to better constrain the timing and magnitude of carbon fluxes, the life histories of the important plankton types, and the ecosystem structure before the beginning of primary production in the spring.

Sunrise on 1 December 2011 at 10:00 a.m. near Nome, Alaska. Photo courtesy of Carin Ashjian.

For further information about the cruise, see: http://arctic-winter-cruise.blogspot.com/ or contact Carin Ashjian (cashjian@whoi.edu).

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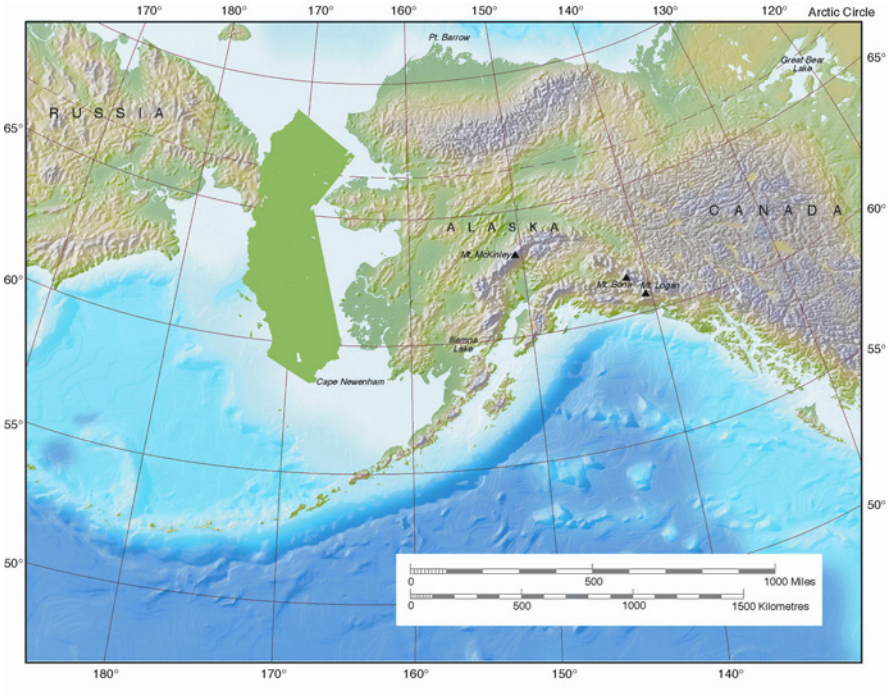
Interagency Cooperation in Support of Bering Sea Ecosystem Science – by George L. Hunt, Jr.



The Bering Sea shelf covers an area greater than the combined areas of the states of California (green shaded area), Oregon, and Washington, which together are about 863,800 km2. Image courtesy of George Hunt.

The Bering Sea Project (http://bsierp.nprb.org/) is a multiagency integrated ecosystem study of the eastern Bering Sea. This six-year project received over $50 million from a 2007 NSF and North Pacific Research Board (NPRB) (http://www.nprb.org/) partnership plus significant contributions from the National Oceanic and Atmospheric Administration's (NOAA) Pacific Marine Environmental Laboratory (http://www.pmel.noaa.gov/) and the National Marine Fisheries' Alaska Fisheries Science Center (http://www.afsc.noaa.gov/). It has supported 43 collaborative research projects, nearly 100 principal investigators, plus postdoctoral scholars, graduate students, and technicians. With assistance from the U.S. Fish and Wildlife Service and other agencies, the Bering Sea Project assembled monetary and ship resources that would have been beyond the reach of any one agency. Now in the synthesis and writing phase, the Bering Sea Project promises to deliver a wealth of new knowledge and understanding of the mechanisms controlling the flow of energy and material through Bering Sea pelagic and benthic food webs, and an enhanced ability to anticipate the inevitable changes that will occur with global warming.

A Brief History of Eastern Bering Sea Oceanographic Programs

A large marine ecosystem requires a major scientific effort to investigate in its entirety. The eastern Bering Sea shelf is over 1,200 kilometers in length and 500 kilometers in width, constitutes about 50% of the Bering Sea extent of 2,304,000 square kilometers. Despite being the source of some of the largest and most lucrative fisheries in the United States, the eastern Bering Sea received surprisingly little oceanographic study prior to the Bering Sea Project, relative to its size and economic importance (see inset below right).

After the conclusion of the Inner Shelf Transfer and Recycling (ISHTAR) program, most eastern Bering Sea programs were relatively small, resource-limited, and focused at a regional level within the eastern Bering Sea. However, these programs were important precursors to the current Bering Sea Project because they were interdisciplinary in nature and involved collaborations among NOAA scientists and academics, and in many cases involved significant sharing of resources.

Recent NOAA Programs Have Contributed to the Knowledge Base

- The North Pacific Climate Regimes and Productivity (NPCREP) (http://www.pmel.noaa.gov/foci/NPCREP) has collaborated with the Bering Sea Project by providing important data from times of the year and areas not covered in the other studies.
- The United States portion of the [North Pacific Anadromous Fish Commission's Bering-Aleutian Salmon International Survey (BASIS) (http://www.npafc.org/new/science_basis.html), begun in 2000, has evolved into an ongoing component of NOAA's management tools for the Bering Sea.
- The Alaska Fishery Science Center has continued and expanded the BASIS survey over the eastern Bering Sea shelf, providing coverage of the shelf ecosystems in late summer and early fall—times not otherwise sampled in the Bering Sea Project.
- BASIS and the Pribilof Islands Project provided important oceanographic sampling during the warm years of 2000–2005.

The Seed for NSF's Bering Sea Ecosystem Study (BEST) Science Plan

In early 2002, Hunt and others submitted to NSF a draft manuscript that described the possibilities of a large-scale oceanographic program focused on the potential impacts of climate change on the eastern Bering Sea ecosystem. Neil Swanberg, NSF Arctic Natural Sciences Program Manager at that time, subsequently funded an international planning workshop to review available data and provide advice as to the feasibility and value of proceeding with a large interdisciplinary study of the Bering Sea (see Ecosystem Studies of Sub-Arctic Seas: Results of a Workshop (http://www.arcus.org/bering/meetings/essas/index.html) held in Laguna Beach, California, 6 September 2002). Workshop participants included oceanographers working in the North Atlantic Ocean, the western North Pacific Ocean, and the Bering Sea. Both Neil Swanberg and Clarence Pautzke, the newly appointed Executive Director of the North Pacific Research Board (NPRB), attended the workshop and identified the potential value of collaboration between NSF and NPRB in developing an integrated ecosystem studies in the Bering Sea. In March 2003 a second planning workshop convened in Seattle, Washington resulting in the development of the 2004 Bering Ecosystem Study (BEST) Science Plan (http://www.arcus.org/bering/reports/index.html). NSF launched the first BEST field season in spring of 2007.

NPRB Develops a Science Plan

Contemporaneous with development of the BEST Science Plan a long-term science plan for NPRB was drafted. The draft, written largely by Jim Schumacher, received guidance from a National Research Council panel tasked with developing a plan for guiding the NPRB funding program. The resulting NPRB Science Plan emphasized the importance of large-scale integrated studies of the marine ecosystems of the eastern North Pacific, similar to that being developed by BEST for the Bering Sea. NPRB launched its first Integrated Ecosystem Research Program in the Bering Sea in 2008. The question was: could the two agencies with very different cultures and goals collaborate or would they compete for ship time and scientific manpower? There was much good will and talk of cooperation, but there were also institutional stumbling blocks.

Summary of Eastern Bering Sea Oceanographic Programs

Mid-1970s to the Mid-1980s
Department of the Interior's Bureau of Land management (BLM) (now BOMRE), in collaboration with NOAA, conducted a $100 million study of the Bering Sea region called the Outer Continental Shelf Environmental Assessment Program (OCSEAP): This study provided baseline information on the Bering Sea environment in support of lease sales for hydrocarbon exploration and exploitation on the outer continental shelf of the eastern Bering

Collaboration Begins

The first opportunity for collaboration came in the early spring of 2007 when NSF announced funding for the first round of the BEST funding competition. The initial cohort did not include programs for conducting the basic hydrographic, chemical, and plankton measures, nor a primary production component. The BEST Science Steering Committee and NOAA scientists active in the southeastern Bering Sea expressed concern about these missing elements and offered a solution. A group of NOAA scientists would forego their planned and funded spring 2007 cruise and join the BEST scientists on the U.S. Coast Guard Cutter Healy. Their work would ensure a full suite of oceanographic measurements to complement those being funded by NSF. The sticking point was that NSF initially wanted the NOAA scientists on the Healy to sail on a "not to interfere" basis, giving them little or no say in the planning or execution of the cruise. After high-level interagency negotiations an agreement was reached: the Chief Scientist would be an NSF-sponsored scientist, otherwise all Principal Investigators on board were on an equal footing. Excellent collaboration was achieved and the beginnings of a broadly collaborative effort were underway.

Both NSF and NPRB planned to issue calls for proposals for fieldwork commencing in 2008. Clarence Pautzke, Executive Director of NPRB, and Bill Wiseman, the current Arctic Natural Sciences Program Manager at NSF, engaged in a series of negotiations that resulted in an historic partnership for work in the Bering Sea. The agreement was to partition the work with NSF funding climate, ocean physics, and lower trophic-level through zooplankton studies, and the NPRB funding studies of large zooplankton through fish, seabirds, and fisheries. The agreement included a major commitment to modeling in this joint program. To ensure that the programs would mesh well, there was also a precedent-breaking agreement that there would be representatives of each of the funding communities on both the NSF and the NPRB proposal review panels. Although NSF elected to fund a series of individual proposals and NPRB selected to seek fully integrated large proposals, there were strong mechanisms in place to ensure that the work funded by NSF and NPRB would be well integrated.

NOAA Joins the Program

Sea. Many issues were explored, from contaminant analyses to social and economic studies, with oceanographic studies focused primarily on investigating the ecosystems of potential lease areas and developing a broad suite of studies of the life histories, food habits, abundances, and distributions of the key species or groups that were of ecosystem or economic importance.

1974–1982 (Overlapping OCSEAP)
NSF-funded Processes and Resources of the Eastern Bering Sea Shelf (PROBES): This program focused primarily on examining variability, from physics to seabirds, across the southeastern Bering Sea shelf from Cape Newenham to the shelf edge. PROBES was a process-oriented program, but despite overlap between the principal investigators participating in PROBES and OCSEAP, there was little joint planning, division of effort, or sharing of resources between the two programs.

1983–1989
Inner Shelf Transfer and Recycling (ISHTAR): This project was a multiyear interdisciplinary program that focused on the sources of nutrients that supported the high rates of production in the northern Bering and Chukchi Seas.

1991–1997
NOAA-funded program Bering Sea Fisheries Oceanography Coordinated Investigations (BS FOCI).

1997–2001
Inner Front Project, which overlapped and built on work from BS FOCI. These two programs collaborated in producing a series of papers in 2001 documenting the unusual conditions encountered in 1997 and two special volumes

NOAA scientists interested in Bering Sea also threw their full weight behind the new integrated Bering Sea program, seeing immediately its potential value for enhancing understanding of the mechanisms affecting fish stocks in the Bering Sea. With the strong support of Doug DeMaster, Director of the Alaska Fisheries Science Center, NOAA scheduled extra surveys in the Bering Sea and supported geographic enlargement of planned surveys, thereby complementing the work funded by NSF and NPRB. The result was the support of scientific cruises to the Bering Sea from early spring—when moorings were put out by NOAA scientists accompanied by others taking hydrographic, chemical, and biological samples—to major broad-scale sampling of the eastern shelf in late August and September.

These combined NSF, NPRB, and NOAA efforts provide the first shelf-wide scientific coverage of the eastern Bering Sea and the first nearly continuous seasonal coverage from early March through to mid-September. The stage was set to gather an unprecedented quantity of data and to do it in a fashion that supported the development of comprehensive climate-to-fish and fisheries models that would provide an integration of the immense and complicated dataset to be gathered. The Bering Sea Project, as it has become known, had a Science Advisory Committee with representation of all parts of the project. The Bering Sea Project also had an Ecosystem Modeling Committee, funded by NPRB, that consisted of scientists who were not funded in the program who were charged with overseeing the development of the modeling program and providing advice to the funding agencies to help the modelers obtain the resources that they needed, both in terms of the equipment and the data necessary to run the models.

that focused mainly on the eastern Bering Sea.

Contributions of Recent NOAA Programs

- The North Pacific Climate Regimes and Productivity (NPCREP) program has collaborated with the Bering Sea Project by providing important data from times of the year and areas not covered in the other studies.
- The U.S. portion of the North Pacific Anadromous Fish Commission's Bering-Aleutian Salmon International Survey (BASIS), begun in 2000, has evolved into an ongoing component of NOAA's management tools for the Bering Sea.
- The Alaska Fishery Science Center has continued and expanded the BASIS survey over the eastern Bering Sea shelf providing coverage of the shelf ecosystems in late summer and early fall, times not otherwise sampled in the Bering Sea Project.
- BASIS and the Pribilof Islands Project provided important oceanographic sampling during the warm years of 2000–2005.

The First Results Emerge

Although the Bering Sea Project is just now in its final phase of writing up results and synthesizing the multiple lines of evidence about how climate influences the eastern Bering Sea marine ecosystem, some exciting highlights are already emerging. These include, but are not limited to:

1. A new ability to downscale from global climate models to the Bering Sea region, thus allowing modelers to use the predictions of global modals to predict the range of future conditions to be anticipated in the Bering Sea.
2. A new appreciation of wind-driven water movement on the eastern Bering Sea shelf and how they can lead to either upwelling or down-welling in the Inner Shelf Domain.
3. A new appreciation of the along-shelf heterogeneity of the hydrography, and how the hydrography north of about 60°N differs from that in the southeastern Bering Sea.

4. A greatly enhanced understanding of the relative importance of advection and re-mineralization in the nutrient supply of both the northern and southern regions of the shelf.
5. A new understanding of the role of sea ice and its associated ice algae in the support of zooplankton in the southeastern Bering Sea.
6. A new appreciation for the major role played by micro-zooplankton in the food web and the sensitivity of these organisms to ambient temperatures.
7. A new focus on conditions in summer and fall and the importance of on-going primary production and zooplankton for the overwinter survival of walleye pollock.
8. A new understanding of the relative importance of top-down and bottom-up processes in the structuring of the eastern Bering Sea food web.
9. Exciting new studies that show where marine birds and fur seals from the Pribilof Islands and Bogoslof Island forage and the types of prey aggregations that are of value to them.
10. The development and use of a complex set of fully coupled models from climate to physics, nutrients, phytoplankton, zooplankton, fish, fisheries, and communities that will allow development of scenarios of what we may expect in the Bering Sea and its fisheries-dependent communities in the face of climate change.

These results, and those to come, will change our view of the Bering Sea and the factors that are most important for its continued role in supporting the Nation's most productive fisheries. The new results are already having an impact on the management of the Bering Sea ecosystem and will become increasingly valuable as we move into the uncharted waters of a warming Bering Sea. The managers who had the vision to embrace a big-picture approach to ecosystem science and found the resources to support it, and the cadre of marine scientists and social scientists who conducted the field research, have created a treasure trove of new knowledge and have paved the way for truly collaborative, interdisciplinary science supported by multiple agencies with very differing agendas and cultures. Neither the quantity nor the quality of the science accomplished in the Bering Sea Project would have been possible without the level of cooperation that was achieved.

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Atmospheric Dynamics and their Role in the Changing Arctic Climate System

A research team at the International Arctic Research Center of the University of Alaska Fairbanks has strived to improve understanding of atmospheric dynamics and their role in the rapidly changing arctic climate system. The research is funded in part by the NSF Arctic Sciences Division in collaboration with national and international scientists and students from North Carolina A&T State University, the University of Wisconsin–Madison, North Carolina State University, the Georgia Institute of Technology, the NASA Cryospheric Sciences Laboratory, the Japan Agency for Marine-Earth Science and Technology, the Bjerknes Centre for Climate Research, the Alfred Wegener Institute for Polar and Marine Research, the Met Office Hadley Centre, and the Chinese Academy of Sciences.

The atmosphere is an integral component of the earth's climate system. In addition to its direct impact on our daily lives, including wind, rain, and hot and cold temperatures, atmosphere also consists of a broad spectrum of motions that are governed by internal dynamic and physical processes and external forcings, and that steer daily weather phenomena. These dynamically varying atmospheric states can be representatively described by the large-scale general circulation pattern and the embedded synoptic-scale weather systems. Not only do the atmospheric circulation pattern and weather systems fluctuate over time and move spatially, but they also interact strongly with other components of the climate system. To understand the variability of and changes in sea ice, ocean, hydrology, and land surface processes, various observed and analyzed atmospheric data are used for statistical and diagnostic analysis and as forcing for numerical model simulations. Therefore, better understanding of atmospheric dynamics and their role in the rapidly changing arctic climate system is a central piece in climate research.

Arctic atmospheric circulation and weather systems have exhibited dramatic changes during past decades in conjunction with the amplified warming trend in arctic climate. For example, the leading atmospheric circulation pattern experienced a radical spatial shift during the first decade of the twenty-first century, and this shift enhanced heat transport into the Arctic Ocean and circulated cold polar air to lower latitudes, leading to the record low in summer sea ice and extreme cold weather in Eurasia in 2007 (e.g., Zhang et al. 2008; Overland and Wang 2010; Graversen et al. 2011). A poleward shift in storm tracks and an intensification of storm activity were also detected and suggested as important players in the precipitation increase and sea ice reduction (e.g., Zhang et al. 2004; Serreze and Barrett 2008; Sorteberg and Walsh 2008; Simmonds and Keay 2009).

To further understand the arctic climate as a system, the research team has also recently examined the role of atmospheric dynamics in changes in the arctic water and heat energy cycle, as introduced below.

Enhanced Poleward Atmospheric Moisture Transport and Intensified Water Cycle

Observational studies and greenhouse-gas-emissions-forced climate model projections have indicated an acceleration in northern high-latitude and arctic water cycles. A notable example of this is an increase in Eurasian Arctic river discharge into the Arctic Ocean (e.g., Peterson et al. 2002; Kattsov et al. 2007; Figure 1). The most recent data further revealed that the increasing rate of the river discharge has amplified in the latest decade, and a record-high discharge occurred in 2007 (e.g., Shiklomanov and Lammers 2009; Rawlins et al. 2009). This accelerated water cycle and the resulting river discharge into the Arctic Ocean may intensify interactions among climate system components and further advance climate change, including greater down-welling long-wave radiation and a warmer arctic surface, a fresher Arctic Ocean,

and larger Arctic Ocean freshwater export. These have important implications for the arctic sea ice mass balance, the North Atlantic thermohaline circulation, and global climate variability.

Figure 1. The Lena River, one of the three selected large Eurasian Arctic rivers in this study. It discharges about 560 km3 water per year into the Arctic Ocean. Photo courtesy of Yoshihiro Lijima, JAMSTEC

To locate the major driver for the accelerated water cycle or increased river discharge, the research team improved a mass correction approach. By employing this approach, they corrected mass biases in the National Centers for Environmental Prediction (NCEP)-National Center for Atmospheric Research (NCAR) reanalysis data so that its dry air mass is conserved globally throughout the study time period. They then computed atmospheric moisture transport converged into the three large Eurasian Arctic river basins, including those of the Ob, Yenisei, and Lena rivers. They found that the converged atmospheric moisture transport over the three river basins captures 98% of the measured river discharge. The atmospheric moisture transport converged into these river basins has significantly increased during the last sixty years, with a record high in 2006. This enhanced transport has clearly increased precipitation and played a significant driving role in the increased Eurasian river discharge into the Arctic Ocean. Specifically, the moisture transport has increased by about 15.6% and the river discharge has increased by about 10.6% from the 1940s to the 2000s. The increasing rate in the last decade and the 2006 record high in moisture transport can be attributed to the radically shifted atmospheric circulation spatial pattern (Figure 2).

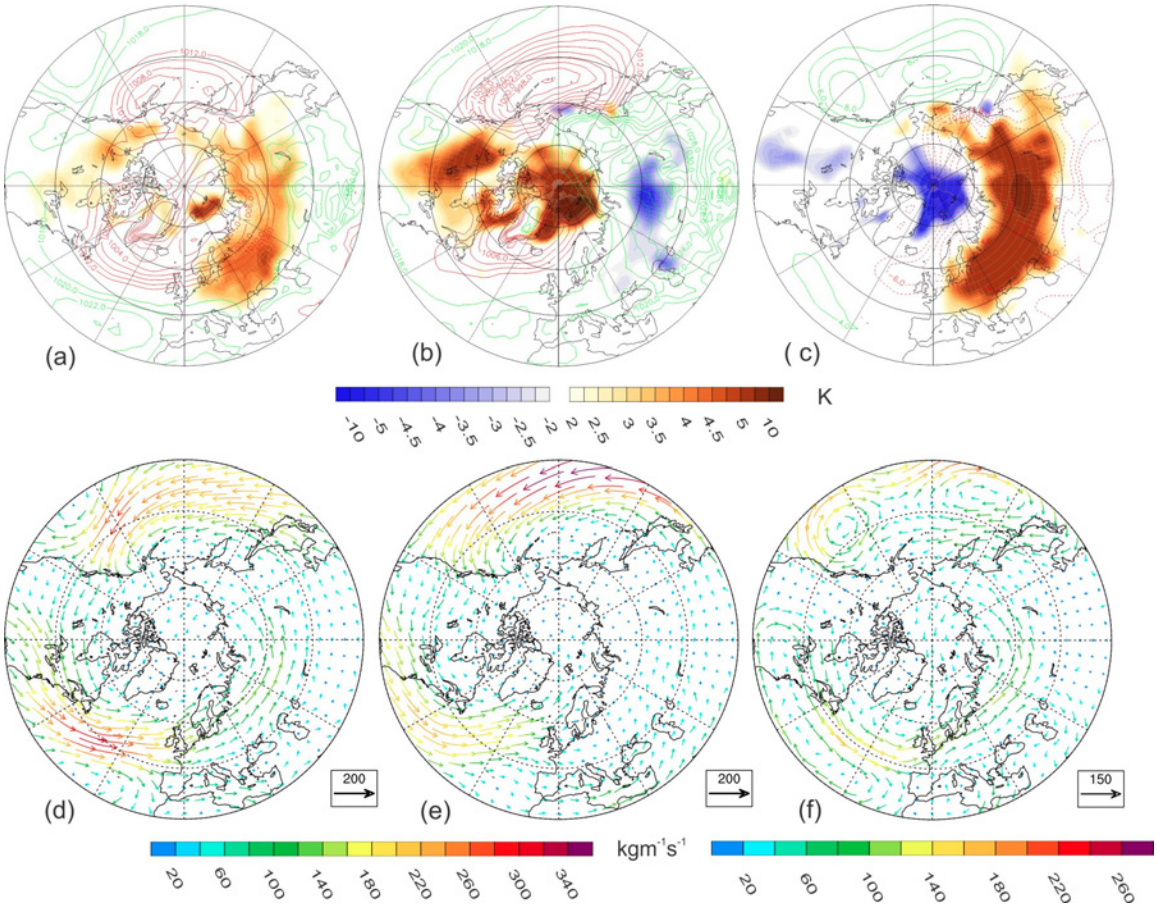

Figure 2. Composite analysis of sea level pressure (red and green lines) and surface air temperature (shaded in colors) in the (a) positive and (b) negative arctic rapid change pattern phases. Atmospheric moisture transport (AMT) is shown in the (d) positive and (e) negative arctic rapid change pattern phases; (c) and (f) show their differences. Surface air temperature anomalies were computed using climatology derived from 1958 through 1997. The colors in (d) through (f) show the magnitudes of atmospheric moisture transport. Image courtesy of Xiangdong Zhang (Previously published in Nature Climate Change, Zhang et. al. 2012).

Meanwhile, the record high in moisture transport occurred in 2006, earlier than the record low for sea ice in 2007. This indicates that the record-high river discharge in 2007 may not be attributed to a hypothesized increase in evaporation due to more open water in the Arctic during the period of record-low sea-ice cover. Incidentally, the increasing rate of moisture transport is larger than that of the river discharge, suggesting a wetting trend of the underlying soil.

Finally, this study suggests that, although increased global atmospheric water content is attributed to rising air temperature, a changed atmospheric circulation is the route by which global-warming forcing changes water redistribution. Atmospheric circulation is a fundamental dynamic mechanism for continuing poleward atmospheric moisture transport and a maintained hydrological cycle. A change in moisture transport may intensify regional or global water cycles and cause extreme hydrological events, such as the upward trend of and the 2007 record high in Eurasian Arctic river discharges.

For more information about this water cycle study, see the project website: http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate1631.html or contact the contributing author of this article Xiangdong Zhang (xdz@iarc.uaf.edu).

Some content in this article, including Figure 2 was previously published in Nature Climate Change (2012)

References

Graversen, R. G., T. Mauritsen, S. Drijfhout, M. Tjernström, and S. Mårtensson, 2011: Warm Winds from the Pacific Caused Extensive Arctic Sea-Ice Melt in Summer 2007, *Clim Dyn* 36, 2103-2112, DOI: 10.1007/s00382-010-0809-z.

Kattsov, V., J. E. Walsh, V. Govorkova, T. Pavlova, and X. Zhang, 2007: Arctic Ocean Freshwater Budget Components in Simulations with the IPCC AR4 AOGCMs. *J. Hydrometeor.*, 8, 571-589.

Overland, J. E., and M. Wang, 2010: Large-scale Atmospheric Circulation Changes are Associated with the Recent loss of Arctic Sea Ice. *Tellus A*, 62, 1–9, doi:10.1111/j.1600-0870.2009.00421.x

Peterson, B. J., R. M. Holmes, J. W. McClelland, C. J. Vörösmarty, R. B. Lammers, A. I. Shiklomanov, I. A. Shiklomanov, and S. Rahmstorf, 2002: Increasing River Discharge to the Arctic Ocean. *Science*, 298, 2171-2173, doi:10.1126/science.1077445.

Rawlins, M. A., M. C. Serreze, R. Schroeder, X. Zhang, and K. C. McDonald, 2009: Diagnosis of the Record Discharge of Arctic-draining Eurasian Rivers in 2007. *Environ. Res. Lett.*, 4, 045011, doi:10.1088/1748-9326/4/4/045011.

Serreze, M. C., and A. P. Barrett, 2008: The Summer Cyclone Maximum over the Central Arctic Ocean. *J. Climate*, 21, 1048–1065, doi:10.1175/2007JCLI1810.1.

Shiklomanov, A. I., and R. B. Lammers, 2009: Record Russian River Discharge in 2007 and the Limits of Analysis. *Environ. Res. Lett.*, 4, 045015, doi:10.1088/1748-9326/4/4/045015.

Simmonds, I., and K. Keay 2009: Extraordinary September Arctic Sea Ice Reductions and Their Relationships with Storm Behavior Over 1979–2008, *Geophys. Res. Lett.*, 36, L19715, doi:10.1029/2009GL039810.

Sorteberg, A., and J. E. Walsh, 2008: Seasonal Cyclone Variability at 70N and its Impact on Moisture transport into the Arctic *Tellus A*, 60, 570-586.

Zhang, X., J. E. Walsh, J. Zhang, U. S. Bhatt, and M. Ikeda, 2004: Climatology and Interannual Variability of Arctic Cyclone Activity, 1948-2002. *J. Climate*, 17, 2300-2317.

Zhang, X., A. Sorteberg, J. Zhang, R. Gerdes, and J. C. Comiso, 2008: Recent Radical Shifts in Atmospheric Circulations and Rapid Changes in Arctic Climate System. *Geophys. Res. Lett.*, 35, L22701, doi:10.1029/2008GL035607.

Zhang, X., J. He, J. Zhang, I. Polaykov, R. Gerdes, J. Inoue, and P. Wu, 2012: Enhanced Poleward Moisture Transport and Amplified Northern High-Latitude Wetting Trend. *Nature Clim. Change*, doi: 10.1038/NCLIMATE1631.

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Information Security and Risk Management Program for Arctic Sciences

NSF's Arctic Sciences (ARC) has established an Information Security and Risk Management Program to protect the confidentiality, integrity, and availability of information supporting and generated by scientific research. This initiative is designed to manage Information Technology (IT) risk to better secure information and systems and empower well-informed risk management decisions.

The IT security arm of the U.S. Navy known as the Space and Naval Warfare Systems Command (SPAWAR) worked with the Division of Arctic Sciences through an effort entitled "SPAWAR Office of Polar Programs" (SOPP), which serves as the Arctic Information Security Team. SOPP provides information security strategic and programmatic support, privacy support, security assessment and authorization, continuous monitoring, and risk management of Federal IT assets and support services on behalf of Arctic Sciences programs. In 2012 the Arctic Information Security Team visited arctic sites and worked with arctic IT service providers and users to assess the current state of IT and IT security, and plan approaches for addressing identified risks.

The SOPP facilitates the Arctic Sciences Information Assurance Working Group (IAWG). The IAWG is comprised of individuals representing key partners, contractors, and IT service providers supported by ARC. This group serves to represent and inform the arctic research and support communities regarding information assurance efforts and ongoing risk management plans and guidelines.

The IAWG was formed to ensure that Information Security requirements are tailored to arctic operational program needs and that processes, policies, and procedures are applied consistently. The IAWG provides vital input to strategies for reducing the overall Arctic Program risk by contributing to:

1. Information Security policies and procedures appropriate for ARC
2. ARC IT strategy
3. Management of risks to ARC operations
4. ARC success when audited by the NSF Chief Information Officer (CIO) and the Federal Office of the Inspector General (OIG)

For more information on the Arctic Information Security Program please refer to the first edition of the *Arctic Sciences Program Information Security 101 Newsletter*, available on NSF's Arctic Research Support and Logistics website: http://www.nsf.gov/od/opp/arctic/res_log_sup.jsp.

ACADIS Expands Data Management Services

Advanced Cooperative Arctic Data and Information Service

The Advanced Cooperative Arctic Data and Information Service (ACADIS) system has expanded to meet data management needs of all research projects sponsored by the NSF's Arctic Sciences Division. ACADIS, funded in 2011 (http://www.arcus.org/witness-the-arctic/2011/3/article/1774) with investigators from the National Snow and Ice Data Center (NSIDC) (http://nsidc.org/), the University Corporation for Atmospheric Research (UCAR) (http://www2.ucar.edu/), and the National Center for Atmospheric Research (NCAR) (http://ncar.ucar.edu/), builds on the Cooperative Arctic Data and Information Service (CADIS) project that supported data management needs associated with the Arctic Observing Network (AON). The updated ACADIS Gateway portal (http://www.aoncadis.org) now provides data preservation and access services for all projects funded by Arctic Natural Sciences (ANS), Arctic System Sciences (ARCSS), and Arctic Social Sciences (ASSP) programs.

ACADIS offers data management planning, sharing, preservation, and consultation to the arctic research community. Second year activities have included infrastructure augmentation and metadata work that will enable additional services such as cross-archives searches. Based on user feedback the ACADIS team has improved the data submission forms to better facilitate data sharing. ACADIS also now provides a citation and corresponding Digital Object Identifier (DOI) for submitted data. To submit data, contact ACADIS Support (support@aoncadis.org).

Several ACADIS team members plan to attend the 2012 American Geophysical Union (AGU) Conference 3 – 7 December in San Francisco, California. They will be available at the NSIDC or NCAR booths to answer questions about the data management services.

For more information about ACADIS, go to: http://www.aoncadis.org or contact Mark Serreze (serreze@nsidc.org) or Jim Moore (jmoore@ucar.edu).

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Joint Science Education Program: Hands-On Arctic Science for High School Students

In July 2012, a group of high school students from three arctic nations visited research facilities in Greenland to participate in the Joint Science Education Program (JSEP), a cultural and scientific exchange between Denmark, Greenland, and the United States. For the past five years this program has brought students together for first-hand experience with arctic research and to learn about each other's language, customs, and cultures. Under the guidance of teachers from all three nations, the students worked alongside researchers in activities that included gathering snow samples to gauge the effects of atmospheric pollution, measuring methane release from arctic lakes, and descending into an ice pit to see how annual layers of snow turn into layers of ice.

JSEP is divided into two complementary programs. The Greenlandic-led Field School is based in the community of Kangerlussuaq, which is an international logistics hub for arctic science located in southwest Greenland. The Science Education Week is coordinated by NSF and based at Summit Camp, which is NSF's high-elevation, geophysical, and atmospheric research station at the top of the ice sheet in central Greenland.

Student participant Marisa LaRouche of Denver, Colorado, samples for methane. Photo courtesy of Peter West.

Field School students observed and interacted with professional researchers, worked cooperatively in groups to conduct their own field measurements, and culminated their experience with presentations of their research data and conclusions.

Field School students also observed dramatic effects of a rare warming of the atmosphere over the ice sheet and subsequent surface melting during the 2012 summer season. The climate in Kangerlussuaq is arctic, with temperatures averaging 5–18°C (41–64°F) in July. During the unusually warm July of 2012, local temperatures exceeded 21°C (70°F) and students saw water in the Watson River—which they had sampled earlier to determine flow rate—rise high enough to damage the bridge spanning the river.

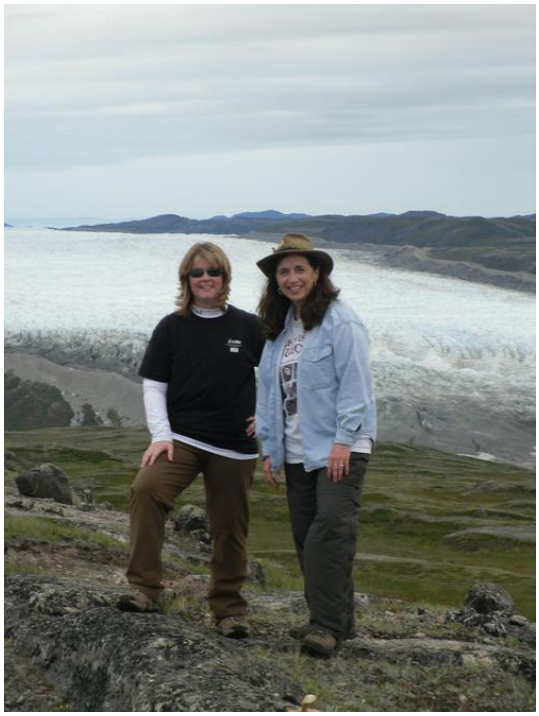
Student participant Nivi Rosing of Nuuk, Greenland, measures depth of fluid penetration into ice during an experiment at NEEM. Photo courtesy of Peter West.

During the Science Education Week at NSF's Summit Camp a small group of students spent several days working in science field camps on the Greenland ice sheet at altitudes of thousands of meters above sea level. In one field experience—provided by Kaitlin Keegan, a PhD student at Dartmouth College—students descended into a backlit snow pit where they were able to observe layers of snow, firn, and ice. JSEP student Marisa LaRouche reflected on this experience, saying, "I thought that was really interesting. Particularly because you can see the different storm patterns and different ways the snow forms and crystalizes. It was really cool to see that in action because I've heard so much about it." LaRouche had previously been a

summer intern at the University Corporation for Atmospheric Research in Boulder and is now a student at the Colorado School of Mines.

At Summit, students also participated in an NSF-funded distance-learning pilot project, led by Brant G. Miller and R. Justin Hougham of the University of Idaho. This project allowed students to take measurements with off-the-shelf hand-held instruments that mimic the functions of the more sophisticated scientific instruments at Summit Station as part of the Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation at Summit (ICECAPS) project. For example, students used thermal imagers and infrared thermometers to determine how clouds affect the surface temperature of the ice sheet. Through the use of Miller and Hougham's "Adventure Learning" approach to distance education students in Greenland were able to share their measurements with students in Idaho via the Internet.

Following their week at Summit station, students spent a night at the international North Greenland Eemian Ice Drilling (NEEM) project. They arrived just as the Danish-led team of researchers concluded a multiyear project to retrieve an ice core that included a climate record as far back as the last interglacial period: the Eemian Period of 130,000 to 114,000 years ago.



Shelly Hynes (left) and Lynn Foshee Reed (right), Albert Einstein Distinguished Teaching Fellows in NSF's Office of Polar Programs, coordinated Science Education Week at NSF's Summit Camp. Photo courtesy of Peter West.

While at the NEEM camp, the students experienced another event related to the warming atmosphere over the ice sheet. In the days before students arrived there had been rain instead of snow at the NEEM camp. Alejandra Borunda, an NSF-funded PhD student at Lamont-Doherty Earth Observatory in New York, gave students an opportunity to help with a novel experiment in which various nontoxic and brightly colored liquids were poured on the surface and allowed to permeate into the ice sheet and disperse. Students then excavated pits and measured the depth and extent to which the various liquids infiltrated into the ice in order to understand the effect that the rain would have had on the ice layers.

Through their experiences at JSEP, the students were exposed to dimensions of science, logistics, geography, and culture that they might only have been vaguely aware of before. The experience also had its benefits for the researchers who worked with the students. After sharing her work at Summit camp, Kaitlin Keegan of Dartmouth College reflected, "All the students pointed out their favorite part of the snow pit wall, and that really allowed me to see it from a fresh perspective again. And they were so excited. That helped me to be even more excited about my research."

To view the NSF Web feature video about JSEP 2012 season, go to: http://www.nsf.gov /news/news_videos.jsp?cntn_id=125251&media_id=72992. For information about JSEP media, contact Peter West (pwest@nsf.gov).

For further information about JSEP, see: http://www.arcus.org/jsep or contact 2012 Albert Einstein Distinguished Educator Fellow, Lynn Foshee Reed, (lreed@nsf.gov) or by phone at NSF Polar Programs (703- 292-8051).

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Polar Educators International - Professional Network for Outreach Activities

Discussions during 2012 IPY set the stage for polar educators network. Photo courtesy of Sandra Vanhove.

Polar Educators International (PEI) is an international professional network for everyone who educates in, for, and about the polar regions. Evidence shows that education and outreach associated with the 2007-08 International Polar Year touched 24 million people through the work of teachers, scientists, writers, filmmakers, policymakers, government agencies, and many others. PEI was organized to continue this momentum. The network began to form during discussions at the IPY meeting in 2010 and was realized during the IPY meeting in 2012 with a formal announcement from Peter Harrison, chair of the IPY 2012 Montreal conference.

PEI is a legacy of the IPY theme, "From Knowledge to Action," with a mission to connect, energize, and foster collaboration in polar education and science across the globe. Representing 24 countries, the group of more than 250 leading educators, scientists, and community members will develop innovative resources and best practices in advocating for polar education and scientific literacy at all ages. They aim to excite students about science learning in the context of the polar regions, thereby changing the terms of debate and the framework of education to rekindle student and public engagement with global environmental changes.

In the first six months, the PEI steering committee made concrete progress in becoming a strong voice for international coordination in polar education. In a partnership with APECS (http://apecs.is/) for International Polar Week, PEI initiated a global snow science activity called "Flakes, Blobs, and Bubbles: An Ice Core Art Project." The activity was translated into twenty-one different languages, gathered 1,600 submissions of ice-core art, and is the basis for globally crowd-sourced ice core visualizations. Individual art, mosaics, and related resources can viewed at icecoreart.weebly.com (http://icecoreart.weebly.com/).

PEI is currently supported through in-kind support from the Arctic Research Consortium of the United States (ARCUS) (http://www.arcus.org/arcus/index.html) and the International Polar Foundation (http://www.polarfoundation.org/). The organization will continue bringing together polar communities and individuals to advance scientific literacy about the polar regions and environmental change.

For further information or to become a member, please email polareducators@gmail.com or ask to join the Facebook group: http://www.facebook.com/groups/247660677828.

Update from the Interagency Arctic Research Policy Committee (IARPC)

The White House Office of Science and Technology Policy and NSF are completing production of the Interagency Arctic Research Policy Committee (IARPC) 5-Year Arctic Research Plan. Although details about the Plan have not been released yet, a draft version released for public comment in June 2012 (http://www.nsf.gov/od/opp/arctic/iarpc/arc_res_plan_index.jsp) identified seven key research areas that would benefit from coordination and collaboration—not only among Federal agencies but also with state and local stakeholders, industry, academia, and non-governmental organizations. The seven research areas identified in that draft Plan were:

- Sea ice and marine ecosystem studies
- Terrestrial ice and ecosystem studies
- Atmospheric studies of surface heat, energy, and mass balances
- Observing systems
- Regional climate models
- Adaptation tools for sustaining communities
- Human health studies

Within each area research goals and milestones were identified which, when implemented, would lead to improved coordination of Federally-funded research in the Arctic. The draft Plan did not attempt to coordinate all Federal research in the area or even identify all Federally-funded research relevant to the Arctic. Rather, it focused on research that could gain the most in terms of efficiency and productivity if coordination among Federal agencies in those areas were enhanced. For example, several agencies are undertaking or are planning research activities in the Chukchi and Beaufort seas over the next decade. Communicating these activities and plans with one another and state and local stakeholders could improve coordination, reduce duplication of effort, and improve efficiency.

There is broad scientific consensus that rapid changes in global climate are altering ice and snow cover and affecting arctic ecosystems, indigenous societies, and natural resource development. Research is needed to increase fundamental understanding of these challenges and opportunities and to inform development of sound, science-based management decisions. The draft IARPC 5-year plan represented a focused attempt to address these challenges, and release of the final report is expected to inform a number of important pending policy decisions.

Notification of the Plan's release will be made over the ArcticInfo mailing list (http://www.arcus.org/arctic-info).

For further information, please see NSF's IARPC website: http://www.nsf.gov/od/opp/arctic/iarpc/start.jsp or contact Brendan P. Kelly (Brendan_P_Kelly@ostp.eop.gov).

Office of Naval Research News: Arctic and Global Prediction Program

The Office of Naval Research (ONR) Arctic and Global Prediction Program is motivated by the significant sea ice retreat that has occurred in recent summers in the Arctic Ocean, and the implications for the U.S. Navy of the observed and predicted increase in maritime activity due to the diminishing summer ice cover. The overarching goal of the program is to improve the coupling of arctic system modeling and sea ice prediction capability at a variety of space and time scales in support of safe and efficient Navy mission planning and execution. To achieve this goal, the program supports basic research in three inter-dependent efforts:

- Improve integrated atmosphere-ice-ocean-wave earth system models;
- Understand the physical environment, processes, and feedbacks in the Arctic Ocean; and
- Develop sensors, platforms, and communications for sustained operation and observation.

Research supported by core program funds covers a range of topics, including sea ice dynamics and mass balance; ocean hydrography and heat storage; atmospheric temperature profiles, circulation, and cloud properties; sea spray and icing; and high resolution eddy-resolving regional arctic climate modeling. In fiscal year 2012 (FY12), the first year of the program, 22 awards for 17 projects were made with core funds. Among these awards is a suite of six projects that will be integrated into a single atmosphere, ice, and ocean observing effort: Seasonal Ice Zone Reconnaissance Surveys (SIZRS). It is coordinated by the University of Washington Applied Physics Laboratory and takes advantage of U.S. Coast Guard Arctic Domain Awareness flights by C-130 aircraft out of Air Station Kodiak, Alaska.

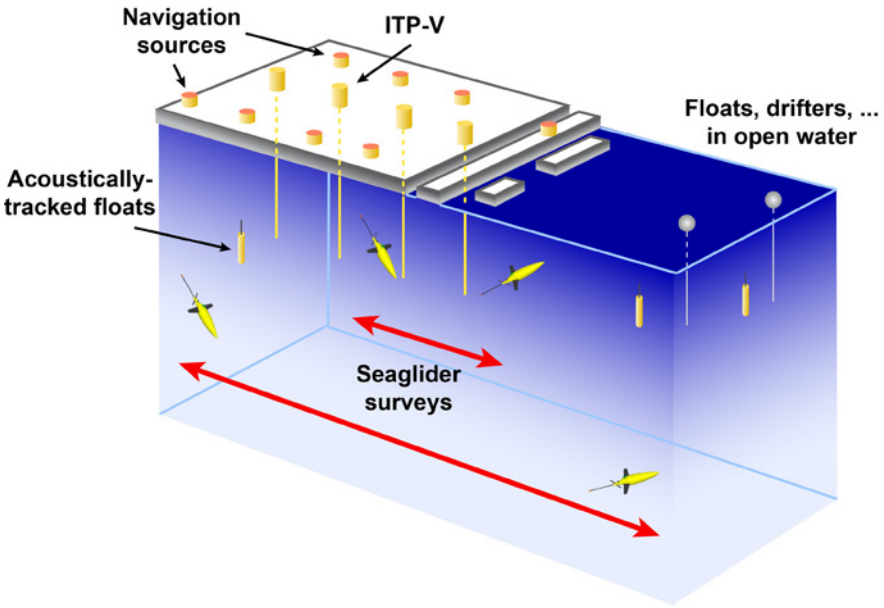
Also in FY12, 11 awards for nine projects were made with Marginal Ice Zone (MIZ) Departmental Research Initiative (DRI) funds. The MIZ DRI is a five-year project (FY12 through FY16) with the following objectives:

- Collect and analyze a benchmark data set that resolves the key processes controlling the evolution of the marginal ice zone with sufficient spatial and temporal scope to capture a broad, representative range of environmental conditions;
- Understand the processes that govern the evolution of the marginal ice zone, identify key interactions and feedbacks in the ice-ocean-atmosphere system, and investigate how these might change with the predicted increased seasonality of the arctic sea ice cover; and
- Evaluate the ability of existing models to predict the seasonal evolution of the marginal ice zone and improve the parameterization of key processes to enhance seasonal forecast capability.

The DRI team has met twice and drafted a science and experiment plan that is expected to be released in late 2012. The field experiment, planned for spring through autumn 2014 in the Beaufort Sea and Canada basin, will involve the deployment and operation of a suite of sensors and platforms, including: ice mass balance and wave buoys, ice-tethered profilers, ocean flux buoys, automated weather stations, acoustic navigation and communication arrays, gliders and polar profiling floats, open ocean wave buoys, acoustic wave and current (AWAC) meters, waveriders, and wavegliders.

In February 2012, the program issued a call for planning letters for a new Departmental Research Initiative: Sea State

and Boundary Layer Physics in the Emerging Arctic Ocean. This is also a five-year project (FY13 through FY17), with field experiments planned for spring through autumn of 2015 in the Beaufort and/or Chukchi seas. The Sea State DRI has the following provisional objectives:



The ONR MIZ DRI observation array will include ice-tethered profilers and ice-tethered acoustic sources that will provide under-ice geolocation and navigation for ice-capable seagliders and polar profiling floats. Image courtesy of U.S. Navy, Office of Naval Research.

- Develop a sea state climatology, identify factors affecting the spatial and temporal variability of sea state, and improve forecasting of waves on the open ocean and in the marginal ice zone;
- Develop a climatology and improved theory of wave attenuation/scattering in the sea ice cover;
- Use wave scattering theory directly in integrated arctic system models and indirectly to define an ice rheology for use in arctic system models; and
- Understand the wave-mediated physics of heat and mass transfer from the ocean to the atmosphere and the seasonal variability of fluxes during summer ice retreat and autumn ice advance.

For further information about the ONR Arctic and Global Prediction Program, go to http://www.onr.navy.mil/Science-Technology/Departments/Code-32.aspx or contact contributors of this article, Martin Jeffries (martin.jeffries@navy.mil) or Scott Harper (scott.l.harper@navy.mil).

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International Study of Arctic Change Plans Arctic Observing Summit

The International Study of Arctic Change (ISAC) (http://www.arcticchange.org/) is an interdisciplinary program of research on arctic environmental change initiated in the wake of the 2003 Study of Environmental Arctic Change (SEARCH) Open Science Meeting (http://www.arcus.org/search/meetings/2003/index.php). A legacy of the International Polar Year (IPY), ISAC facilitates cooperation and collaboration in international arctic research and full integration of stakeholders into the research process. ISAC seeks to extend study of the Arctic from basic science to offer insight into options for solving real-world problems intrinsic to a changing planet.

International Study of Arctic Change

ISAC takes an iterative, integrative, and pan-arctic approach to advancing the science needed to address arctic environmental change. ISAC seeks to drive forward observations and research activities that are significant for science and for society. In pursuit of these goals, ISAC activities lead to new ways to integrate stakeholders into research planning and execution.

A major ISAC undertaking for 2013 is the inaugural Arctic Observing Summit (http://www.arcticchange.org/arctic-observing-summit-2013), scheduled for 30 April–2 May 2013 in Vancouver, British Columbia.

The Arctic Observing Summit (AOS) will be a high-level biennial summit that aims to provide community-driven and science-based guidance for the design, implementation, coordination, and sustained long-term operation of an international arctic observing system over several decades. The AOS will provide a platform to address urgent and broadly recognized needs of arctic observing systems. It will foster international communication about and coordination of long-term observations aimed at improving understanding and responding to system-scale arctic change. The Summit will be a forum for optimizing resource allocation through coordination and exchange among researchers, funding agencies, and others involved or interested in long-term observing activities, while minimizing duplication and gaps. It will also identify observing network issues that require the attention of the Arctic Council's Sustaining Arctic Observing Networks (SAON) (http://www.arcticobserving.org/).

Background

The AOS is led by ISAC. It is a SAON task and part of the broader SAON implementation process, which is led by the Arctic Council jointly with the International Arctic Science Committee (IASC) (http://www.iasc.info/) and the World Meteorological Association (WMO) (http://www.wmo.int/pages/index_en.html). Current organizing partners include the U.S. Interagency SEARCH Program (http://www.arcus.org/search/index.php), the ArcticNet Network of Centres of Excellence Canada (ArcticNet) (http://www.arcticnet.ulaval.ca/), the European Union's Arctic Climate Change Economy and Society project (ACCESS) (http://www.access-eu.org/), and the International Arctic Research Center (IARC) (http://www.iarc.uaf.edu/) at the University of Alaska Fairbanks.

Participants and Target Audience

The AOS agenda will be based on input from a broad range of stakeholders, including academic and research communities, nongovernmental organizations, arctic residents, government agencies, and the private sector. The AOS

will be an iterative event, during which previously prepared white papers and shorter statements will be refined at the Summit through discussions, working sessions, and panels. The AOS is scheduled to enable the organization of side events that help advance planning, coordination, and integration of activities. AOS products will be prepared for arctic communities, decision-makers in government, the research community, the private sector, and the general public.

Outcomes and Products

The key outcome of the AOS will be an assessment of the fit between stakeholder needs, science objectives, and observing networks. The tangible products produced will include, but will not be restricted to, the following:

1. Succinct policy briefs for the optimization and coordination of existing systems.
2. The definition and operationalization of one or more initiating projects to network two or more observing systems to achieve a common set of science/mission objectives.
3. One or more collections of peer-reviewed articles related to the AOS themes in special journal edition(s), as well as the publication of summit proceedings.
4. The establishment of long-term AOS goals (e.g., unify data access, distribution and archiving practices, improve international access to the Arctic).

ISAC will convene a town hall meeting on Monday, 3 December, during the 2012 American Geophysical Union fall meeting (http://fallmeeting.agu.org/2012/). The town hall meeting will be dedicated to discussion of AOS. For more information, contact organizing committee members (AOS@arcticchange.org).

For further information about the Arctic Observing Summit, go to http://www.arcticchange.org/arctic-observing-summit-2013.

For further information about ISAC, go to http://www.arcticchange.org or contact Maribeth Murray (murray@arcticchange.org).

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ARCUS Brings Value to the Arctic Research Community

Recently an ARCUS member institution representative asked for my help in making the case for our consortium dues to his department dean. Together we successfully outlined the value that member institutions receive from their ARCUS dues. It is a message worth sharing more broadly.

ARCUS provides a number of services for the arctic research community that our members rate highly. Prime among them is publicizing significant research, events, and relevant policy news through ARCUS-sponsored vehicles; for instance, our ArcticInfo email distribution list (http://www.arcus.org/arctic-info), which has 6,500 subscribers; and this digital publication, *Witness the Arctic*, which also includes member institution profiles. The current issue features a member highlight for Sandia National Labs.

ARCUS is internationally recognized for the PolarTREC program: Teachers and Researchers Exploring and Collaborating (http://www.polartrec.com/). PolarTREC recruits K-12 teachers to spend two to six weeks participating in hands-on field research experiences in the polar regions. The teachers share the experience, excitement, and knowledge with their students. The researchers get a better understanding of and engagement in K-12 education. Two years ago NSF identified this groundbreaking program as "potentially transformative" for the way it helps integrate research and education and the way it strengthens and enriches outreach and dissemination of research.

ARCUS convenes workshops, conferences, and other face-to-face opportunities for polar researchers to collaborate. This work advances science and enhances understanding of the complex issues involved in a rapidly changing climate. In 2010, ARCUS convened the State of the Arctic conference (http://soa.arcus.org/). This all-hands meeting provided an international forum to discuss future research to better understand the arctic system and its trajectory. Tackling an issue as complicated as climate change requires diverse perspectives, specialties, and expertise. Because ARCUS stands as an independent entity, as the "Switzerland" of arctic research, we are able to ensure the right voices are sitting at the right tables at the right time.

ARCUS also serves as the research community's voice in Washington, DC, communicating regularly with NOAA, NSF, and other key agencies, relaying valuable information, and serving as a conduit between agencies and researchers. Increasingly, ARCUS addresses climate policy issues of national and international importance.

When asked in a member survey why they belonged to ARCUS, member institutions responded:

- To be seen as one of the institutions with a significant arctic focus.
- To be knowledgeable about, participate in, and be active in arctic policy matters.
- To support ARCUS as a strong promoter and advocate for arctic research, education, and outreach. ARCUS membership is an asset to the institution.

In short, ARCUS connects and supports our member institutions (http://www.arcus.org/arcus/institutes.html) in order to advance polar research conducted by an increasingly broad set of scientific disciplines. As an independent entity, we are uniquely able to bridge, unite, and amplify the work of each of our member institutions. As we enter our twenty-fifth year, we look forward to building on past success, recognizing that a sustainable future can only be achieved through collaborative partnerships. ARCUS is proud to be a strong partner in this strong community.

— Susan E. Fox

Executive Director, ARCUS

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A Note from a Member of the Board of Directors

In May 2012 the ARCUS Board met in its first face-to-face meeting of recent years. The ARCUS Annual Meeting (http://www.arcus.org/annual_meetings/2012), convened in Washington, D.C. following the inaugural AGU Science Policy Conference (http://sites.agu.org/spconference/) and the ARCUS Arctic Forum, was the opportune time for a one-day retreat. The ever-growing myriad of arctic-related organizations emphasizes the increasing need for interdisciplinary science research that will form the basis for informed arctic policies. An organization such as ARCUS, whose membership is largely academic institutions, can play an important role in enabling this necessary research and transmitting relevant data to effective receptor agencies, both nationally and internationally. Given the global commons of changing arctic ecosystems and the heightened awareness of issues concerning arctic governance, security, and energy development, communications at a circumarctic (international) level are equally important to those at the north-south (national) level. For these reasons, ARCUS should be connecting with international organizations from the eight circumarctic states.

ARCUS plays an important role in promoting arctic science and education, and encouraging interdisciplinary research with broad participation including social scientists and stakeholders. As a result, programs that use real-time data, such as the Sea Ice for Walrus Outlook (http://www.arcus.org/search/siwo), are proving useful to a number of communities and stakeholders at a local and national/international level. Its ability to connect arctic-related organizations and assist in producing integrative science programs and information outreach (e.g., ArcticInfo (http://www.arcus.org/arctic-info), *Witness the Arctic*, Arctic Visiting Speakers Program (http://www.arcus.org/arctic-visiting-speakers) is a model for other circumarctic nations to follow. ARCUS is in many instances the "go-to" place for information about programs and events relevant to the Arctic. Many arctic-related organizations could make their own lives easier by increasing their engagement with ARCUS, who can partner effectively with them and amplify their findings to ensure that their data are used in effective arctic science policies. A first step would be to become an ARCUS member (http://www.arcus.org/arcus/mem_app.html). The latest International Polar Year culminating conference was titled "From Knowledge to Action," and this is what ARCUS fundamentally espouses.

Marianne Douglas
Canadian Circumpolar Institute and Earth and Atmospheric Sciences
University of Alberta
Member, ARCUS Board of Directors