Alaska Center for Climate Assessment and Policy (ACCAP) Annual Report

Performance Period: May 1, 2010 through April 30, 2011

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Assistant Coordinator & Outreach Specialist: Brook Gamble  
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ACCAP Steering Committee: Ex Officio Members include Director, Alaska Ocean Observing Systems, Molly McCammon; Director, NOAA Alaska Region Climate Service, James Partain; Director, Alaska Region National Weather Service, Frank Kelly; Coordinator, NOAA Alaska Regional Collaboration Team, Amy Holman; Director, Scenarios Network for Alaska & Arctic Planning, Scott Rupp. Members-At-Large include Lawson Brigham, Professor of Geography & Arctic Policy, UAF; David Christie, Director, Alaska Sea Grant; Jackie Kramer, Alaska Climate Change Coordinator, EPA; Vera Metcalf, Director, Alaska Eskimo Walrus Commission, Kawerak Inc.; Caryn Rea, Senior Staff Biologist, ConocoPhillips Alaska, Inc.

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A. CURRENT AREAS OF FOCUS

Work has continued in climate downscaling and sea ice projections. However, the major thrust of ACCAP funded and leveraged work in this reporting period has been in coastal and living marine resources, Native climate adaptation and food security.
1. Coastal and Living Marine Resources (CLMR) –
In 2010 ACCAP hired new research faculty (Loring) to support the development of current and future coastal and living marine resources research. This involves studies of coastal community vulnerability and adaptation to climate change and science issues such as marine biodiversity and invasive species management. Dr. Loring has provided multiple kinds of outreach/education support regarding coastal and marine climate issues to stakeholders, including lectures, roundtable discussions, and participation in planning/steering workshops. Among these stakeholders are the Western Alaska LCC, Kachemak Bay Research Reserve (a NOAA national estuarine research reserve), the Kenai Peninsula school district, and the Bristol Bay Natives Association. Loring was an invited participant at the 2010 science steering workshop for the Western Alaska LCC, and was also an invited participant (2010) by the Yukon River Drainage Fisheries Association (YR DFA) to their "Natural Indicators of Salmon Run Timing and Abundance" project. In the last year, ACCAP funded five projects focused on CLMR, outlined in more detail in section D.3.

2. Native Adaptation –
Rural Native communities in Alaska are among those most directly impacted by the changing climate. ACCAP continues its focus on conducting research and providing decision support for these vulnerable and underserved communities. This includes responding to invitations by tribal service organizations in Alaska such as the Maniilaq Association, the Alaska Native Tribal Health Consortium (ANTHC), and the Environmental Protection Agency’s (EPA) Indian General Assistance Program (IGAP). Sarah Trainor has presented community-specific climate projections and community adaptation planning strategies at various venues, including a workshop on climate and health in Kotzebue in October 2010 and the Alaska Forum on the Environment in Anchorage in February 2011. A draft guidebook on Climate Change Adaptation Planning for Alaska Native Communities is in progress. Ongoing research related to Native adaptation is outlined in section E.3.

3. Food Security –
Co-Investigator Gerlach leads a community-based participatory food systems research program to better understand how changes to Alaska's landscapes and seascapes impact food and environmental security and to more effectively communicate research results to rural and urban communities. Research continues on the impacts of seasonal climatic and environmental variability on agricultural sectors in Fairbanks, Delta Junction, Palmer, and Kenai Peninsula regions. This involves extensive ethnographic research as well as the planning of a statewide workshop on livestock issues related to climate change, to be held in Fall 2011. Likewise, Loring continues to develop related research on food and water contamination, which both have climate change dimensions, e.g., heavy metals in fish and game. He has tested a risk-benefit index for evaluating fish and marine mammal consumption and used this tool to identify regional monitoring needs and data gaps across the state. Brook Gamble represented ACCAP at the Association of Natural Resource Extension Professionals (ANREP) conference in June 2011. Themed "Opportunities for Extension in a Changing Environment: Lessons from the Last Frontier," the conference provided an opportunity to strengthen ties with ANREP professionals focused on rapid ecological and agricultural changes statewide and nationwide. See section C.2. for research findings.
4. **Co-Production of Knowledge** –

ACCAP has a growing focus on analyzing the process and evaluating the effectiveness of climate science communication, application, and stakeholder partnerships. This involves reflexive analysis of the co-production of knowledge and the translation of scientific research findings for use in policy and decision-making. Our analysis includes program evaluation and social science research that increases our understanding of stakeholder information needs and decision processes as well as scientist perception of stakeholder knowledge. Moving beyond a basic examination of scientist-stakeholder interactions, we aim to build an enhanced vision and understanding of the development of “use-inspired science” and the process of science engagement in natural resource management and public planning. (See section C.1.).

B. **STAKEHOLDERS/PARTNERS**

The following is a list of our main stakeholders and partners, including participants in the ACCAP monthly webinar series.

**International Agencies/Entities:** British Columbia Climate Action Secretariat, Consulate of Canada, Fisheries and Oceans Canada, Russian Embassy.


**NOAA and NOAA Funded Entities:** Alaska Ocean Observing System (AOOS), Alaska Sea Grant, Climate Prediction Center, Coastal Services Center, Kachemak Bay Research Reserve, Marine Debris Program, Mid-Atlantic Regional Association Coastal Ocean Observing System (MARCOOS), National Ice Center (NOAA/Navy/Coast Guard), National Ocean Service, National Sea Grant Office, National Snow and Ice Data Center, National Weather Service, National Marine Fisheries Service, Pacific RISA. (See also section H.)

Local Government: Bristol Bay Borough, City of Halibut Cove, City of Homer, City of North Pole, Coastal Villages Region Fund, Fairbanks North Star Borough, Matanuska-Susitna Borough, North Slope Borough, Northwest Arctic Planning Commission, Northwest Arctic Borough, Port of Nome, Southern Kenai Peninsula Communities Project.


University and Public Education: Alaska Climate Research Center, Alaska Pacific University, Aniak University, Arctic Region Supercomputing Center, Duke University, Geophysical Institute, UAF, Harvard University, Institute of Circumpolar Health Studies, International Arctic Research Center, National Center for Atmospheric Research, National Oceanographic Partnership Program, National Science Foundation, Oregon Climate Change Research Institute, University of Alaska Anchorage, University of California Los Angeles, University of Cambridge, University of Alaska Fairbanks, University of Alaska Fairbanks Cooperative Extension, University of New Hampshire, University of Vermont, University of Virginia, University of Washington.


C. Research Findings

1. Climate Science Communication – Data to Knowledge –

Assessing user needs is a key component of climate services. However, to date, very little work has been done investigating how scientists perceive and use stakeholder knowledge. Semi-structured interviews were conducted with nine ACCAP affiliated scientists and graduate students to investigate how scientists communicate with stakeholders, how their perceptions of
stakeholder knowledge affect information exchange in the construction of climate decision-support products, and what role stakeholders play in the scientific research agenda.

Results show that the field of information sciences provides robust theory in distinguishing between data and actionable knowledge and in delimiting a process of translation and knowledge communication. Knowledge is more difficult to communicate than data. However, the steps and awareness required to translate data into knowledge are well worth the effort in order to ensure that scientific inquiry reflects societal needs and that the scientific research results can be readily applied in policy and decision-making. Our research demonstrates that scientists affiliated with ACCAP have developed partnerships with stakeholders beyond data delivery or gap analysis. The stakeholder knowledge that is integral to these partnerships influences research design and guides decision support tool and product development. Scientists have further developed nuanced understandings and awareness of the political, social and cultural contexts within which stakeholders make decisions. Publication in preparation. S. Trainor (ACCAP, University of Alaska, Fairbanks) and S. Paquette (School of Information Sciences, University of Maryland).

2. **Food Security** –
Loring and Gerlach found that the social and economic impacts of a salmon fisheries failure in 2009 on the Yukon River impacted communities disproportionately, with greater vulnerability of communities up-river. They also found that people affected by the failure responded in part by hunting for moose and waterfowl more heavily. In the analysis of the management actions taken in 2009, they identified challenges in existing observation and monitoring procedures that contributed to the uncertainty in outcomes (Loring & Gerlach, 2010).

3. **Impacts of Climate Change and Variability on Hydropower in Alaska** –
With leveraged funding from the NOAA National Marine Fisheries Service, ACCAP scientists completed a project examining observed historical climate variability in Southeast Alaska, where several new and expanded hydropower facilities are proposed. Analysis suggests that climate trends in this region since the 1920s are modest, while trends since the mid-1940s are somewhat stronger. Sparse data collection increases the uncertainty associated with these trends. Variability in temperature, precipitation, snow and discharge is largely dominated by random interannual fluctuations, as well as semi-decadal to decadal climate modes such as the El Niño-Southern Oscillation and the Pacific Decadal Oscillation (PDO) (see Figure 1). The dominance of these modes of variability on the regional climate is useful for risk management because prediction tools exist for season-ahead forecasting. Longer-term climate trends, while smaller in magnitude, will likely lead to warmer and wetter conditions in the coming century. The persistence of a negative PDO may lead to cooler, drier conditions in the short term. Climate variability and change both have implications for shifts in the timing and magnitude of river discharge that could pose challenges to management of capacity-limited reservoir systems. An increasingly interconnected power grid in Southeast Alaska may help mediate these climate impacts, but there are still large data gaps that contribute to management risk. Enhanced monitoring of snow, temperature, runoff and glacial melt, particularly at elevation and in the watersheds feeding hydropower reservoirs, could help operators reduce risk by
eliminating some of the uncertainty about the relationships between climate and water resource availability. The project report is available for download at http://ine.uaf.edu/accap//documents/seak_report_final.pdf.

**Figure 1.** This graph shows the Pacific Decadal Oscillation (PDO)-driven climatological shift in precipitation at stations in Southeast Alaska. Composited climatologies during PDO positive events are shown in red, PDO negative events are shown in blue, and the climatologies over all events are shown in black.

4. **Connecting Alaska Landscapes into the Future** –

With leveraged funding and resources from the U.S. Fish and Wildlife Service and the Scenarios Network for Alaska and Arctic Planning (SNAP), this proof of concept project offers land managers, government agencies, communities, businesses, academics, non-profits and the public a unique and useful new way to approach the question of climate change impacts on Alaska ecosystems. A climate envelope modeling approach was used to assess how future climate scenarios compare with mean temperature and precipitation conditions from the 2000 to 2009 decade. Results presented in the report suggest that, according to the modeled scenarios using June and December mean data, approximately 60% of Alaska may experience a shift to a new climate-biome during the twenty-first century. Models predict that by the end of the century, the extent of the Arctic biome and Alaska Boreal biome that correspond to today's temperature and precipitation parameters will each diminish by approximately 69%, and the Western Tundra biome by 54% - all but disappearing in its original location (Figure 2). The Connectivity Project also examined potential impacts on four selected species: barrenground caribou, Alaska marmots, trumpeter swans, and reed canary grass.

Scenarios planning is not intended to produce a single definitive prediction, but rather to provide stakeholders with a range of descriptions of possible futures in order to better inform risk-taking and decision-making. Thus, although this report is a summary of completed work, it can also be viewed as a jumping-off point for new research and further efforts to ground-truth...

**Figure 2:** The Connecting Alaska Landscapes Into the Future project (with U.S. Fish and Wildlife service and other partners) modeled future shifts in species and ecosystems. These maps compare current biomes (left, 2000-2009), and projected potential biomes (right, 2090-2099). Marked northward shifts are observed, with the Arctic, Alaska Boreal, and Western Tundra biomes all greatly diminished in favor of the Montane Cordillera and Boreal Transition biomes. In addition, nearly half of Southeast Alaska could shift from North Pacific Maritime to the Canadian Pacific Maritime. It would be difficult for the species of these ecoregions to effect such large spatial shifts in a short time or to undergo large changes in physiography in order to adapt to such significant biome changes.

### D. ACCOMPLISHMENTS

#### 1. Coastal and Living Marine Resources (CLMR) Projects –

ACCAP funded five small projects via competitive process to advance our work in CLMR. The goal of the CLMR program is to develop climate change adaptation outreach products and tools for coastal communities. The products assist marine-dependent communities responding to a changing climate. Projects include:

**Ocean Acidification and Fisheries. Torie Baker, Gary Freitag, and Terry Johnson, UAF Alaska Sea Grant Marine Advisory Program**

This project increased stakeholder understanding of ocean acidification (OA) in Alaska and developed outreach material pertinent to global climate change issues in Southeast Alaska. Outreach targeted commercial fishermen statewide attending the annual west coast tradeshow and the Arctic Research Consortium of the U.S. (ARCUS) speaker’s bureau. Content was developed on the fisheries impacts of ocean acidification and included three components: 1) An Alaska Sea Grant DVD will soon be released which includes content on climate change and impacts to fisheries. 2) An OA issues paper is in preparation as part of MAP’s Alaska Seas and Coasts series, examining regional differences in Alaska OA processes (Gulf of Alaska, Bering Sea, Arctic Ocean) and summarizing research initiatives underway in Alaska, such as those at
NOAA, UAF, AOOS, and the North Pacific Research Board. 3) Curriculum materials were developed and presented to University of Alaska Southeast classes and a Ketchikan high school oceanography class.

**Marine Species Range Extension and Invasives in Northern Alaskan Waters: Production of Outreach and Survey Materials. Maribeth Murray and Philip Loring, UAF**

This project will produce a marine species identification guidebook with English, Yup’ik and Inupiaq translations to aid coastal residents of northern Alaska with the identification of invasive species and species undergoing range expansion. The project will also result in a paper, on-line reporting form and web site to be used in conjunction with the booklet, as well as two survey instruments – the first to evaluate the marine species identification booklet and reporting methods, and the second to obtain more detailed species-specific biogeographic information. In a subsequent phase of the project, the products will be tested in five coastal communities as a means for collecting marine ecosystem information relevant to larger initiatives including those of the Alaska Ocean Observing System, COSEE Alaska, the Arctic Ocean Diversity/Census of Marine Life project, and the Alaska SeaLife Center. The ultimate goal is to expand the program to all 35 coastal villages in the Bering/Chukchi/Beaufort seas regions of Alaska and to support a publicly accessible GIS database of information on species range extensions and invasive species distributions.

**Climate Change Adaptation Decision Tool for Marine-Dependent Communities. Terry Johnson, University of Alaska Sea Grant Marine Advisory Program**

This project focused on upgrading the science content and accessibility of existing information and education products. Activities included revising the Climate Change Adaptation Planning Manual and Climate Change Adaptation Planning Tool, producing a complimentary “Climate Change Adaptation for Individuals and Communities” presentation that outlines the principles, opportunities and pitfalls of climate change adaptation planning in Alaska, producing a video and two-page fact sheets which provide Alaska-relevant climate information, and presenting the materials at several relevant conferences and meetings. Products are hosted at a website developed specifically for this project. (www.seagrant.uaf.edu/map/climate)

**Break-up of coastal sea ice: information for stakeholders on processes and implications of climate change. Chris Petrich, Geophysical Institute, UAF**

This project provided a real-time forecast of break-up of coastal landfast sea ice in Barrow, Alaska. The physical processes related to break-up were assessed, compiled and illustrated in a format ready for presentation to a general audience. The break-up forecast was operational and online from May 28, 2010 until break-up occurred on July 7, 2010. Satellite images were reviewed for overpasses between 2001 and 2010. Specifically for this project, ocean current data were analyzed from a near-shore mooring recovered in summer 2010. The process of disintegration of coastal sea ice at specific locations is neither well-studied nor well understood. This work contributed data related to this process and made results available in the form of web presence and outreach material. The Barrow break-up forecast is the only source for up-to-date, comprehensive information on the state of coastal Arctic sea ice during the melt season. This tool has been continued into 2011 with leveraged funding from the National Science Foundation. (http://seaice.alaska.edu/gi/observatories/barrow_breakup)
Intensive Sampling for European Green Crab: Citizen Science/Ecotourism Project. Gary Freitag, Ketchikan Marine Advisory Agent

This project designed a citizen-based sampling program and science program for an established ecotourism group. This is the first time in Alaska that the public and visitor industry joined a scientific project designed to detect the introduction of an invasive species that has serious potential to impact natural resources in Alaska. Daily ecotourism excursions provide a rare opportunity to expand sampling to remote locations that are likely to be the entry point into Alaska by the European green crab. ACCAP’s support for this pilot project includes an outreach component. In development for summer 2011 are sampling protocols, species identification guides, and a website to provide access to participants and the public for data and photos (see Figure 3).

![European Green Crab Identification Key](image)

**Figure 3**: Page from the invasive European green crab identification key from ACCAP-funded project: Intensive Sampling for European Green Crab: Citizen Science/Ecotourism Project (Freitag).

2. **Partnership with DOI Alaska Climate Science Center, Alaska Climate Data Downscaling Workshop, April 28-29, 2011, Anchorage, AK** –

ACCAP partnered with SNAP and the DOI Alaska CSC to organize and implement this day-and-a-half long workshop, the first activity of the DOI Alaska CSC. Workshop goals were to: explore state-of-the-science techniques and methodologies for downscaling climate data; understand current science capabilities applicable to Alaska; learn about new initiatives and future capacity in Alaska; and discuss management and science relevant needs for the State.

The workshop was invitation only with a total of fifty participants from federal agencies (Army COE, BOEMRE, USGS, NOAA, USFWS, BLM, EPA, USFS), State Agencies (DEC, DNR, ADF&G), research and other non-profit organizations (Alaska Native Tribal Health Consortium, Alaska Ocean Observing System, Institute of the North, Pacific Climate Impacts Group Canada, North Slope Science Initiative, U.S. Arctic Research Consortium, the Wilderness Society), and universities (UAF, NC State, Oregon State). DOI is partnering with UAF to organize the center.

A workshop summary white paper is in progress that will present the state of the science in downscaling; best management practices, including research needs, evaluation and diagnostics; a science research plan, including possible index variables, research capacity and feasibility/funding constraints; and outreach and education considerations.
3. **ACCAP Program Evaluation** –

We conducted a two-part program evaluation in June and July 2010. Part one involved a web-based survey evaluating a range of ACCAP products and services including webinars, the seasonal fire forecast, and other decision support tools. Part two was a more detailed analysis of the webinar series involving semi-structured interviews with select webinar participants, conducted by Dr. Karen Taylor in the UAF Department of Communications. Additional information on program evaluation results is available on request.

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| 1. Expand/develop outreach strategies with focus on Anchorage and rural communities | - Invited lectures and workshop participation  
- Exhibition booth and interactive map at Alaska Forum on the Environment, Anchorage Feb. 2011 (See Figure 5) | - Emphasis of re-competition proposal  
- Re-organize and update website, including updated social media |
| 2. Prioritize efforts in analysis and communicating scientific uncertainty associated with climate change scenarios | - Downscaling needs assessment survey in association with DOI CSC workshop (See Section D.2.) | - Next phase to directly work with SNAP outreach and communication  
- New SNAP/ACCAP communications hire in progress |
| 3. Focus research and tool development on Coastal and Living Marine Resources (CLMR - e.g. sea level and storm surge) | - CLMR new hire, Dr. Phil Loring  
- CLMR projects (See Section D.1.)  
- In-progress research (See Section E.3.) | - Emphasis of re-competition proposal |
| 4. Update webinar software to include greater capacity for participant interaction | - Started new interactive webinar software, Feb. 2010 | - Continue to monitor and evaluate webinar effectiveness |

Results from the ACCAP Program Evaluation Survey show that almost 40% of respondents shared information they learned about climate change with others as a result of participating in ACCAP programs. Nearly 20% of respondents followed up with, or informally networked with, an ACCAP affiliated scientist or sought additional information on climate change science as a result of ACCAP programs. 89.1% of respondents felt ACCAP did a good or excellent job of providing climate change information and tools for Alaska (Figure 4).
4. Award Recognition

John Walsh received the W. Bradford Wiley Memorial Best Research Paper of the Year Award from the International Council on Hotel, Restaurant and Institutional Education (ICHRIE) for: Yu, Schwartz and Walsh, 2010. (See section G).

E. RESEARCH PROJECTS AND STAKEHOLDER COLLABORATIONS IN PROGRESS

1. National Assessment Services Project –

We are compiling a synthesis of existing climate change adaptation activities and a preliminary assessment of the capacity for future adaptation in Alaska. Building off of the sectors identified for the Alaska region in the previous National Assessment and expanding to match regional impacts and information needs, we are targeting the following sectors: forestry (fire and insects), coastal vulnerability (flooding, erosion), Native subsistence hunting and fishing, off-shore commerce (fisheries, oil & gas), terrestrial infrastructure (vulnerability to permafrost thaw), and trans-Arctic shipping. This project involves semi-structured interviews with key informants in each sector. We anticipate interviews to be completed by mid-June 2011 at which time preparation of peer-review publication and white paper report will commence.

Related activities during this reporting period include:

- Scoping workshop and focus groups:
  - Association of Tribal Environmental Managers Annual Meeting (ACTEM), October 11, 2010, Anchorage, AK.
  - Bureau of Indian Affairs Providers Conference, November 30, 2010, Anchorage, AK.
  - Alaska State DNR Coastal Management Conference, November 19, 2010, Anchorage, AK.
- Participation in National Assessment Knowledge Management, Data and Review Strategies for the National Climate Assessment Workshop, Sept 20-22, 2010 (J. Walsh).

Figure 4: Results from ACCAP Program Evaluation Survey show that 89.1% of respondents think ACCAP is doing a good or excellent job of providing climate change information and tools for Alaska.

Q: Overall, how would you rate ACCAP’s performance in providing climate change information and tools for Alaska?
• Interactive climate adaptation map at the Alaska Forum on the Environment, February, 2011, Anchorage, AK. (See Figure 5).

![Interactive climate adaptation map](image)

**Figure 5**: Interactive climate adaptation map at the Alaska Forum on the Environment, February, 2011, Anchorage, AK.

2. **Seasonal Fire Predictions: Transition to Operations** –

With funding from National Integrated Drought Information System (NIDIS) Coping with Drought initiative, ACCAP developed a tool to predict annual fire severity in Alaska through collaboration with other RISAs, CPC, and fire managers in Alaska. Designed in close collaboration with fire managers from a range of state and federal agencies participating in the Alaska Wildland Fire Coordination Group, this prototype project takes advantage of the strong weather/fire link in Alaska. NIDIS funding produced estimates for the severity of the 2009 and 2010 fire seasons. The BLM Alaska Fire Service has provided funding to make this Alaska-specific seasonal fire forecast available for the 2011 and 2012 fire seasons, demonstrating stakeholder support and investment as well as the management value of this product. ACCAP is partnering with the Alaska Fire Science Consortium to explore the transition of this tool to operations. ([http://ine.uaf.edu/accap//research/season_fire_prediction.htm](http://ine.uaf.edu/accap//research/season_fire_prediction.htm))

3. **Food Security and Climate Adaptability** –

Loring and Gerlach have developed an integrated food security-climate adaptability research initiative in partnership with Dr. Quentin Fong from Sea Grant/UA in Kodiak, the Kachemak
Bay Research Reserve, Sustainable Homer, the Southern Kenai Peninsula Communities Project, ANTHC and Bristol Bay Natives Association as a part of leveraged funding from the Western Alaska Landscape Conservation Cooperative (LCC). This work will measure food insecurity in a variety of coastal communities, and seeks to establish a method for measuring community adaptability through the collaborative development of an adaptive capacity index for fishing communities to changes in climate and fisheries yields. Some preliminary data gathering has occurred, to be followed up by extensive fieldwork in these regions in the summer of 2011.

4. **Vulnerability of the Tongass National Forest to Climate Change** –
ACCAP and SNAP are in the preliminary stages of scoping a climate change vulnerability project for the Tongass National Forest, with potential leveraged funding from the U.S. Forest Service. We anticipate this project will involve exposure and sensitivity analyses with explicit inclusion of regional stakeholders.

5. **ACCAP Website, Social Media & Multi-Media Outreach** –
We receive significant and consistently positive feedback on the depth and breadth of climate information and resources available on our website. We have undertaken a major website upgrade to add functionality and to streamline the look of the site so it will better display our growing library of photos and videos. In conjunction, we will overhaul the Weather and Climate Highlights tool to include a Google Earth interface, an easily searchable archive, and other interactive features. ACCAP has embraced social media with Facebook, Twitter, LinkedIn, iTunes U, Vimeo, and YouTube accounts. We invite guests on a monthly interview-format show on the KSUA radio station program “Green Talk” to promote programs and discuss relevant climate-related issues. The ACCAP listserv includes 525 members from tribal, local, state and federal government agencies, NGOs, industry, academia, and individuals from communities spanning the entire U.S., including but not limited to the stakeholders listed in Section B. Through these outlets, we can highlight the webinar series, stakeholder workshops, the Alaska Climate Dispatch, Alaska Weather and Climate Highlights, fire forecasts, share collaborators’ and stakeholders’ information, exchange knowledge, and showcase our growing library of audio, video, and animation products to a wider audience. (See sections E and F for more details on these products).

(See sections E and F for more details on these products).

**F. HIGHLIGHTS OF COMMUNICATING OR TRANSLATING SCIENCE TO DECISIONMAKERS**

1. **Monthly Webinars** –
ACCAP webinars continue to promote dialogue between scientists, planners, state and local government, land and resource managers, industry, the news media, and others who need information specific to climate change in Alaska to make informed decisions. Archived videos, podcasts, presentation slides, and associated media coverage from 2007 to present are available on the ACCAP website. More than 680 people participated in ACCAP webinars during this
reporting period. The average number of participants per webinar has increased from 31 in 2007 to 59 in 2010, and continues to draw an increasingly large audience.

**Webinar presentations in this reporting period include:**

- National Ocean Policy & the Arctic region (in partnership with The National Ocean Council and the U.S. Arctic Research Commission)
- Effects of changing soil carbon on ecosystem services in Alaska
- Alaska’s public infrastructure and adaptation to climate change
- Regional variation in sea level change in Alaska
- U.S. and Alaska planning for climate change adaptation
- The Alaska Climate Dispatch: a statewide seasonal summary and outlook
- What we know about walrus and sea ice: The Sea Ice For Walrus Outlook (SIWO) Project.

2. **ACCAP Newsletter: The Alaska Climate Dispatch** –
ACCAP has developed a new climate information tool in partnership with the Alaska Climate Research Center, SEARCH Sea Ice Outlook, National Centers for Environmental Prediction, and the National Weather Service. The quarterly Alaska Climate Dispatch is a newsletter-style document that provides stakeholders with seasonal weather and climate summaries as well as Alaska weather, wildfire, and sea ice outlooks in one easily accessible document. In addition to these regular features, guest columnists may provide information on related topics such as El Niño and La Niña, hydrology, and permafrost. Interpretive and clearly written text, full-color pictures, charts and maps provide decision-makers with a timely snapshot of a wide range of Alaska's diverse weather and climate issues. The Alaska Climate Dispatch is distributed electronically to more than 2500 people, and is made available on the ACCAP website. (See attachments for current issue.) (http://ine.uaf.edu/accap//dispatch.htm)

3. **A Review of Sea-Ice & Related Climate Information Resources for Alaska’s Arctic Coastal Communities: A Manual for Accessing & Using Online Information** –
ACCAP coordinated and published this manual both in print and on the web to improve the availability of current information about sea ice from operational and academic observation programs to key user groups. It provides Arctic Alaska coastal community leaders and local user groups with an up-to-date, comprehensive and practical guide to the current sea-ice and climate information resources that are relevant to their planning, subsistence activities, and way of life. The resources and tutorials in this manual are organized within five main types of sea ice information: sea ice concentration, extent, and type; location and extent of multi-year sea ice; sea ice leads, open water, and shorefast ice extent; local sea ice observatories at Barrow and Wales, Alaska; and sea ice summaries. (http://ine.uaf.edu/accap/research/sea_ice_manual.htm)

4. **Alaska Forum on the Environment** –
In February 2011, ACCAP participated in the Alaska Forum on the Environment (AFE) in Anchorage. Over 1200 people from around the state convene annually for talks, panel discussions, booths, and other activities. There is a strong climate theme throughout the week. ACCAP hosted a booth, talked to over 50 people about climate change responses in their
communities in Alaska as a National Assessment activity (see Figure 5), and was invited to deliver three talks (see Section J). The opportunity to exchange information with people traveling to the Forum from statewide remote communities is unparalleled.

5. Fact sheets, tools, and other resource guides –
ACCAP compiled annotated, regionally relevant resource lists for climate change adaptation and mitigation (see attachments). We provided funding and expert review for Alaska Sea Grant in the production of a climate adaptation manual, adaptation tools and resources, and a coordinated series of fact sheets and videos for marine-dependent and coastal communities in Alaska (see section D.1). Topics include ocean acidification, sea level rise and storm surge, subsistence food supply, and permafrost. (http://seagrant.uaf.edu/map/climate/)

G. COMPLETED PUBLICATIONS, WHITE PAPERS, OR REPORTS
Peer Reviewed


*S.F. Trainor, Rupp, T.S, & Barnes, J. (2010). Meeting Alaska’s fire science and climate information needs for forest managers. Forest Wisdom 16, 4-7. [Communicated to Alaska Fire Managers]


White Papers, Reports, Published Notes, Book Reviews


H. LINKS WITH OTHER NOAA PROGRAMS

1. **NOAA Arctic Regional Collaboration Team** -- ACCAP is a regular, contributing participant in monthly meetings of the NOAA Arctic Regional Collaboration Team (ARCTic), Chaired by Doug DeMaster, Alaska Fisheries Science Center Director, and coordinated by Amy Holman. We have contributed to the NOAA Arctic Vision and Strategy document and have outlined ways in which we are poised to contribute to the NOAA Arctic Strategy Implementation, as funds become available.

2. **NOAA Regional Climate Services. Director, Alaska Region. James Partain.** We have begun collaborations with James Partain and NCEP/CPC on an experimental ‘storminess outlook’ product. ACCAP provided NOAA with a white paper on storminess in the Alaska region at their request. James Partain serves as an ex officio member of the ACCAP Steering Committee.

3. **NOAA National Weather Service** -- NWS Alaska Region Director Frank Kelly is an ex officio member of the ACCAP Steering Committee. Data for the Alaska Climate and Weather Highlights web-tool is provided in part by NWS forecast offices. NWS staff has contributed articles and data for the Alaska Climate Dispatch. Additionally, ACCAP was a local host for the NOAA Climate Change Needs and Related Research Priorities workshop held at UAF March 12-14, 2011.

4. **Alaska Pacific River Forecast Office** – Scott Lindsey, Service Coordination Hydrologist for the Alaska-Pacific River Forecast Center, contributed our feature article in the Spring 2011 issue of the Alaska Climate Dispatch.

5. **NOAA National Marine Fisheries Service** – (See Section C: Research Findings and Contributions to Impacts of Climate Change and Variability on Hydropower in Alaska)

6. **NOAA Alaska Sea Grant** -- Director David Christie is an ACCAP Steering Committee member. Several Sea Grant Marine Advisory Program agents received grants from ACCAP to develop tools and outreach products for climate change adaptation pertaining to coastal and living marine resources in Alaska (See Section D). ACCAP collaborated with Alaska Sea Grant on a several outreach and adaptation tools and served as advisors on a recently released climate change adaptation video (See Section F).

7. **AOOS** – Director Molly McCammon is an ACCAP Steering Committee Member. Future ACCAP collaborations with AOOS include developing an electronic sea ice atlas, sea level rise synthesis, and climate model downscaling for coastal Alaska.

8. **National Ice Center (NOAA/Navy/Coast Guard) and National Snow and Ice Data Center, Boulder, CO** – John Walsh collaborates with these NOAA funded entities in his sea ice data work.
I. CURRENT CROSS-RISA ACTIVITIES

Native American Impacts Assessment and Adaptation Planning
ACCAP has served as consultant for both the Western Water Assessment and the South East Climate Consortium on projects related to vulnerability assessment and climate change adaptation planning for underserved Native American constituents.

J. APPENDICES

Presentations


**Media publicity:**


http://www.publicbroadcasting.net/kuac/news.newsmain?action=article&ARTICLE_ID=1703795


Climate Change Summit Sparks discussion on people and climate. The Arctic Sounder Newspaper. October 2010.  
http://www.thearticsounder.com/article/1040summit_sparks_discussion_on_people_climate
K. LIST OF ATTACHMENTS

1. Alaska Climate Dispatch, Spring 2011 Issue

2. Review of Sea Ice & Related Climate Information Resources for Alaska’s Arctic Coastal Communities: A manual for accessing and using online information

3. Impacts of Climate Change and Variability on Hydropower in Southeast Alaska

4. Regionally relevant annotated guides for climate change adaptation and mitigation
   - 2010 Annotated Inventory of Climate Change Adaptation Resources in Alaska
   - 2010 Annotated Inventory of Climate Change Mitigation Resources in Alaska

5. ACCAP promotional materials
   - Flyer for Alaska Climate Webinars
   - Flyer “Information You Can Use”
   - Assisting with Adaptation Planning: Sample Projects
Spring Breakup and Ice-jam Flooding in Alaska
By Scott Lindsey, Service Coordination Hydrologist
Alaska-Pacific River Forecast Center (APRFC), NOAA/NWS

As the days grow longer and our thoughts turn to summer activities, one thought persists in the minds of those who live on or near Alaska's rivers: When will breakup happen and will it flood this year? Breakup in much of south central and southeast Alaska means melting snow, wet sloppy conditions, dirty roads and dirty cars, and wondering when the last snow will disappear from the yard. For residents of the many villages and towns along the large interior rivers such as the Yukon and the Kuskokwim, breakup means no more snow machine trips to the next village, no boating until the ice has passed downstream, and the potential for minor to devastating flooding if the ice stops running downstream of the village. Predicting when breakup will occur and the likelihood of damaging flooding is a very difficult task, but there are some indicators that can help us understand what might happen (and when).

Hydrologists who study the breakup process know that several factors combine to determine what the coming breakup season holds. The first is to understand how thick the ice grew over the winter and how far it extends across the river bed. If the river level in the fall was very low, then as the water rises in the spring, the ice will be able to move and twist and break into smaller pieces, which reduces the potential for ice-jam flooding. However, if the river level was high at freeze-up, that ice sheet may cover most of the channel and even after the river rises in the spring, that sheet of ice will not have much opportunity to move and

### Types of Breakup Process

**Dynamic breakup**
- Ice remains hard and resistant to breaking up
- Ice moves when pushed by ice from upstream
- Many ice jams form that cause upstream flooding
- Extreme cases are Kenai River in January 1969 and January 2007 and Yukon River in May 2009

**Thermal breakup**
- Ice becomes very rotten (candled) before ice from upstream arrives
- Rotten ice is weak and has less resistance to breaking into very small pieces
- Few if any ice jams form
- Extreme case would occur with very little snow melt inflow and warm sunny weather to rot the ice

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**ACCAP is funded by the National Oceanic and Atmospheric Administration (NOAA) and is one of a group of Regional Integrated Sciences and Assessments (RISA) programs nation-wide. The RISA program supports research that addresses sensitive and complex climate issues of concern to decision-makers and policy planners at a regional level.**
break up into smaller pieces, raising the possibility of ice jams and flooding. The ice thickness affects flood potential in the same manner with thin ice being less likely to cause damaging floods and thick ice being more likely to jam and cause flooding.

Another important factor that determines the likelihood of breakup floods is the amount of water stored as snow in the mountains and lowlands that drain into those large rivers. When a large snowpack persists into April, that snow is subject to very rapid melting as the temperatures may suddenly approach normal or higher in late April and early May. Temperatures in the 60s and 70s can result in the snowpack over an entire basin ripening and discharging tremendous volumes of water into the river in a very short time as occurred in the spring of 2009. Fresh snow
in April also increases the albedo or reflectivity of the snowpack, causing a higher percentage of solar radiation to be reflected back into the atmosphere rather than be absorbed by the snowpack.

The element that determines the timing and severity of breakup more than anything else is the weather from April 1 to May 15. A cold April followed by a rapid warmup to seasonal May temperatures will preserve the snowpack for a rapid melt even when the snow water equivalent is below normal, and will also keep the ice cover from deteriorating. A gradual warmup from early April through the beginning of summer will slowly bleed the snowpack away and weaken the river ice and even a big snowpack with thick ice may not cause any flooding under
this scenario. The first case creates a surge of meltwater traveling from the upstream to downstream, pushing a growing wall of ice and water as it goes. The ice sheets are resistant to breaking into small pieces and tend to jam up at sharp bends and shallow areas of the river, causing upstream areas to flood as the water flow is sharply restricted. This type of breakup is called a Mechanical or Dynamic breakup. The second scenario generally manifests itself with the ice at a number of locations on the river moving, generally where a larger tributary enters the river. The ice sheets in this case have deteriorated and thinned and even a modest amount of meltwater entering the river is enough to break up those sheets into smaller pans and chunks that move more easily around the sharp bends and past the shallow areas of the river. This type of breakup is referred to as a Thermal breakup and may also be called a “Mush-out” as long reaches of the river open up quickly while the ice just melts in place (Figure 1, page 1).

A few images show a distinct contrast of the antecedent conditions and weather from 2009 to 2010. Both 2009 and 2010 showed ice in many places that was thicker than normal. The ice at Eagle in 2009 was 138% of normal compared to 92% of normal in 2010 (Figure 2, page 2). Snow water equivalent was significantly higher across the state in 2009 compared both to normal and to 2010 (Figure 3, page 2). Finally, the cool spring followed by a rapid warm-up in 2009 led to a very dynamic breakup which caused flooding in numerous locations along the interior rivers. The slow gradual warm-up in 2010 combined with the low snowpack caused almost no flooding. (Figures 4 and 5, page 3). For 2011, it is very early to determine if severe flooding will be an issue when there are still 2 months remaining before breakup. But several clues point towards the possibility of moderate to severe flooding this spring. On the Kuskokwim River, a rare early winter rainfall event caused breakup to begin in November after the river had been frozen for a month. The river rose considerably and several long stretches of river became ice free as chunks and pans of ice moved down a good length of the river. Then temperatures grew colder and the river refroze at a higher level than it was previously. The stretches where

Figure 6. Snowfall totals as of March 12, 2011, and +/- (inches) departures from the 30 year average snowfall normal. Figure provided by Todd Foisy, National Weather Service (http://www.facebook.com/US.NationalWeatherService.Alaska.gov).
the jumbled breakup ice refroze may end up causing ice jams as the normal fracture process may not occur when the temperatures warm in the spring. Much of northwest Alaska and the northern interior have received significantly high snowfall amounts (Figure 6, page 4). The Gakona River at Gakona Junction has a large build-up of Aufeis in the river channel which might lead to flooding. Finally, the 3 month climate outlooks for Fairbanks call for equal chances of temperatures being above, near, or below normal in the northern part of the state for the periods of March – May and April – June. But the May – July outlook calls for a 75% chance of near or above normal temperatures (Figure 7, above, and for more information on the outlook see Spring Seasonal Climate Outlook article). If the spring temperature patterns remain cool during March and April before warming up considerably, the chances of ice-jam flooding will rise accordingly. Currently, the flood potential from snowmelt and ice jams for breakup this spring is rated as above average. This means that communities that only flood in years with extreme breakups have a higher chance of flooding this year. Communities that experience minor flooding on a regular basis have a higher chance of experiencing moderate or major flooding. As data is gathered in early April regarding the snow depth and ice thickness and the climate outlooks for April and May become more clear, the forecast for the severity and timing of breakup will improve.

For more information:
- As spring progresses, check out Alaska river conditions: breakup maps, ice summaries, forecasts, 48-hour flood potentials, and 5-day flood outlooks at the National Weather Service Alaska-Pacific River Forecast Center website: [http://aprfc.arh.noaa.gov/](http://aprfc.arh.noaa.gov/)
Winter Weather Conditions in Alaska
Prepared by the Alaska Climate Research Center

This article presents a summary of winter 2010-2011 (December, January, February) temperatures and precipitation from the first order meteorological stations (operated by the National Weather Service meteorologists) in Alaska.

Temperature

Most of Alaska experienced temperatures noticeably colder (i.e. negative deviation) than the normal 30-year average this winter (Figure 8, below). This winter was more typical of the winter weather conditions experienced in the 1960’s and early 1970’s. This is in contrast to autumn 2010, when the temperatures were generally above normal. Interior Alaska was notably below normal, with Bettles (-4.4°F) leading, followed by Big Delta and Gulkana (both -3.8°F) and Fairbanks (-3.7°F). An additional 8 weather stations, mostly located in Interior Alaska, gave less extreme negative departures from average (less than -3°F). More details can be seen from Table 1 (page 8). In contrast to the Interior, Arctic Alaska and the coastal stations of the Bering Sea had above average temperatures. The highest departure from normal was observed for Barrow, with 5.1°F. This is a large departure and continues the trend of warmer than normal temperatures that were observed in fall. This trend is in agreement with the long-term climatic trend, which shows the North Slope of Alaska has experienced a strong warming trend over the last several decades. This can be connected with more open water and thinner sea ice in the Southern Beaufort Sea, as determined from satellite observation. In addition, the coastal weather stations of the Bering Sea were also above normal, with Nome having the greatest deviation of 2.0°F. While the winter of 2009-2010 saw above normal sea ice extent in the Bering Sea, this winter has been nearer to the long-term average (see accompanying article).

Looking at the temperatures for the 3 winter months separately, December started out the winter season with temperatures far below the long-term normal average. Negative departures from average greater than -10°F were observed for Bettles, Big Delta, Fairbanks, Gulkana, King Salmon and McGrath. Negative deviations for other locations were more modest. Furthermore, there were only two stations with above normal temperatures, Barrow (+1.4°F), the most northerly station in Alaska, and Annette (+0.6°F), the most southerly station in the southeast panhandle.

In January, temperatures were above the 30-year average for all stations in Alaska, making it a relatively pleasant month for the deep-winter time of the year. The greatest deviation from the long-term average was 9.1°F observed at Nome.

February was colder than normal for most areas, but less so than was experienced in December. Generally speaking, the Interior was below normal, while Northern Alaska and coastal and island stations in the Bering Sea region were above normal. The highest positive deviations were found for Barrow (+9.8°F), St. Paul Island (+5.4°F) and Bethel (+4.5°F), while
below normal temperatures were more widespread, but less severe than was seen in December.

**Precipitation**

As pointed out in the previous issue, locations throughout Alaska have a broad range of seasonal precipitation. For example, the 30-year average precipitation in Little Port Arthur (1971-2000) is reported at 73.5 inches (186.7 cm), while Barrow averaged only 1.2 inches (3 cm) for the same time annual time frame. This shows that actual departures from the long-term average are not very meaningful because of the wide regional differences. Therefore, Figure 9 (above) presents these deviations as percentages above (+) or below (-) normal, where normal is the 30 year average. As there can be also a strong gradient in precipitation from month to month in the long-term average, the deviations for the seasonal values are the sum of the precipitation for the 3 months, divided by the long-term average for the 3 month (Table 1, page 8). The average of the 3 monthly deviations might slightly depart from these values.

In general the winter precipitation of 2010-2011 was lower than normal (Figure 9, above), as 70% of the stations reported negative deviations. However, northern and western Alaska reported above normal values. Of note were Barrow (+164%) and Kotzebue (+163%) with deviations far above normal. As the precipitation is light in these regions, especially in winter, even a single winter storm with a large amount of precipitation can affect the departures from normal strongly. Also Nome and Bethel, further south along the west coast of Alaska, showed values above normal with 44% and 43%, respectively. On the other hand, all of southern Alaska from St. Paul Island in the West to Annette in the East reported below normal values. The picture for Interior Alaska was more mixed, as can be expected for a large region with a diverse topography. While the majority of the stations reported below normal values, Fairbanks and Gulkana measured above normal precipitation values.

Looking at the months individually, December was overall rather dry; January close to normal, while in February some stations reported snowfall far above the expected amount. In December all of Alaska but 4 stations, namely Kotzebue (+118%), Nome (+45%) Barrow and Bethel (both +8%) reported a negative deviation in precipitation. Interior Alaska was especially dry as Fairbanks had only 31% of the expected amount.

January continued to be dry in Interior Alaska, with the greatest deviation reported for Fairbanks (-66%) and Big Delta (-62%). The resulting thin snow cover in combination with the below normal temperatures of January let the frost penetrate deep into the ground, resulting in frozen water and sewer lines in the Interior. However, precipitation in January was above normal along the West Coast, Bering Sea area and Southeast Alaska. Especially notable is Kotzebue, which recorded more than twice the expected amount.

February was a remarkable month as far as the precipitation is concerned. Strong winter storms brought lots of moisture to Alaska, impacting mainly Northern, Western and Interior Alaska. Barrow reported 417%, Fairbanks 356% Gulkana 215% and Kotzebue 290%
above the expected amount. Fairbanks had the second highest snowfall amount (30.3 inches) ever reported for February; the records, which go back to 1904, show that only February 1966 recorded a larger snowfall. Especially remarkable was the snowstorm of February 20-21 with a total of 18.6 inches. Wind gusted up to 49 mph, and blowing snow and snow drifting could be observed, a fairly rare occurrence for Alaska’s Interior. Due to the heavy snowfall and drifts the roads to the north, the Dalton and Steese Highways were closed.

For more details, see the Table 1 (above,) which presents the temperature and precipitation deviations for the months and season.

### Table 1

<table>
<thead>
<tr>
<th>Station</th>
<th>Temperature Deviation (°F)</th>
<th>Precipitation Deviation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEC</td>
<td>JAN</td>
</tr>
<tr>
<td>Anchorage</td>
<td>-7.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Annette</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Barrow</td>
<td>1.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Bethel</td>
<td>-6.8</td>
<td>5.0</td>
</tr>
<tr>
<td>Bettles</td>
<td>-14.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Big Delta</td>
<td>-14.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Cold Bay</td>
<td>-2.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Fairbanks</td>
<td>-12.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Gulkana</td>
<td>-13.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Homer</td>
<td>-7.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Juneau</td>
<td>-5.6</td>
<td>2.5</td>
</tr>
<tr>
<td>King</td>
<td>-10.3</td>
<td>4.5</td>
</tr>
<tr>
<td>Kodiak</td>
<td>-0.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Kotzebue</td>
<td>-2.1</td>
<td>6.6</td>
</tr>
<tr>
<td>McGrath</td>
<td>-11.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Nome</td>
<td>-3.6</td>
<td>9.1</td>
</tr>
<tr>
<td>St. Paul Island</td>
<td>-0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>Talkeetna</td>
<td>-4.7</td>
<td>3.3</td>
</tr>
<tr>
<td>Valdez</td>
<td>-4.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Yakutat</td>
<td>-0.2</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Table 1. The deviation in temperature (°F) and precipitation (%) from the 30-year average (1971-2000) is presented for all first order stations for each winter month and for the season (http://climate.gi.alaska.edu/).

**Bering and Arctic Sea Ice: The Winter of 2010-2011**

Sea ice during the winter of 2010-11 showed some notable differences from the previous several winters, especially in the Bering Sea. In the Bering Sea, the areal coverage of sea ice reached its peak in mid-February.

Figure 10. Satellite image of ice extent, March 2011. Image from The Cryosphere Today (http://arctic.atmos.uiuc.edu/cryosphere).
ice coverage for the entire Arctic (Figure 12, below) was near a record low for the post-1979 period of satellite data. Preliminary indications, subject to the further evolution of the ice cover in March, are that the 2011 pan-Arctic maximum will be even lower than the previous record low maxima that occurred in 2006 and 2007. The extremely low maximum represents a departure from the seasonal pattern of areal ice coverage during the previous three years, when extremely low summer minima were followed by recoveries to near-normal winter coverage by February or March. The large area of seasonal (first-year) sea ice during these previous winters 

(Figure 11, above), which is several weeks earlier than usual. Moreover, the coverage throughout the winter was close to, or slightly below, the average for the post-1979 period of passive microwave satellite measurements. The maximum coverage of approximately 0.6 million square kilometers was approximately 30% less than the previous year's maximum of about 0.85 million square kilometers in March 2011 (Figure 11, above). In fact, the maximum coverage in 2011 was well below the maxima of each of the previous five years (2006-2010) and was more typical of the lower-ice years of the early 2000s (see time series in the December issue of the Climate Dispatch).

The 2011 maximum of winter 

(Figure 11). Bering Sea sea ice area January 2010 - March 2011. Figure from the National Snow and Ice Data Center (nsidc.org).

(Figure 12). Northern hemisphere sea ice extent 1979-2011. Figure from the National Snow and Ice Data Center (nsidc.org).
was undoubtedly thin ice, which was rapidly lost during the spring and summer melt seasons. Nevertheless, the extremely low coverage of sea ice in March 2011 raises intriguing questions about the trajectory of ice cover as we move into the summer of 2011. The Climate Dispatch will track this evolution, especially in Alaskan waters, and will summarize the September 2011 sea ice outlook in the next issue.

The Climate Prediction Center’s Spring Seasonal Climate Outlook

As described in the feature article of the December 2010 issue of the Climate Dispatch, a La Niña event in the tropical Pacific Ocean has been ongoing since the summer of 2010. The colder-than-normal winter of 2010-11 over much of Alaska is consistent with a La Niña’s impact on wind patterns. National Weather Service/Climate Prediction Center’s winter outlook, based largely on La Niña, indeed called for below-normal winter temperatures over nearly the entire state (see the preceding issue of the Climate Dispatch). La Niña conditions still exist in the Pacific Ocean and are expected by the Climate Prediction Center to persist into spring. The spring (March-May) outlook for 2011, based on this expectation, also calls for below-normal temperatures over southern Alaska (Figure 13, above right). Historically during the spring season, the below-normal temperatures associated with La Niña have been strongest in the southern portion of the state. Over the rest of the state, the La Niña-driven tendency for a cooler-than-normal spring is offset by the recent trend towards warmer conditions, resulting in equal chances of a warmer-than-normal and colder-than-normal temperatures in the northern half of the state. In addition, the Climate Prediction Center’s precipitation outlook for March-May (not shown here) indicates that the odds favor below-normal precipitation south of the Alaska Range. Over the rest of the state, there are equal chances of above-normal and below-normal precipitation.

After the cold winter in much of the Interior of Alaska, a natural question is: Will La Niña’s impact on Alaskan weather continue for a second year, resulting in another winter like the past one? The Climate Prediction Center notes that some La Niñas persist into a second winter, while others do not. On the assumption that the present event will weaken during the spring, the Climate Prediction Center’s long-lead-time outlooks call for increased likelihoods of warmer-than-normal temperatures over most of Alaska in summer 2010 and winter 2011-12. These outlooks are based primarily on recent trends, which have been towards warmer-than-normal temperatures.

Figure 13. Spring (March-May) temperature outlook produced by the Climate Prediction Center (http://www.cpc.ncep.noaa.gov). Blue areas denote areas with greater than 33% likelihoods of temperatures in the coldest third of the historical (1971-2000) distribution of winter temperatures. Orange areas denote areas with greater than 33% likelihoods of temperatures in the warmest third of the historical (1971-2000) distribution of winter temperatures. Deeper colors indicate greater likelihoods.
Review of Sea-Ice & Related Climate Information Resources for Alaska’s Arctic Coastal Communities

A Manual for Accessing & Using Online Information

Published August, 2010 by the Alaska Center for Climate Assessment & Policy (ACCAP)
http://ine.uaf.edu/accap/research/sea_ice_manual.htm
Contributors

This manual was written by Matthew Druckenmiller for the Alaska Center for Climate Assessment and Policy (ACCAP). It is a result of a Sea Ice Information Workshop held in Barrow in November 2008 sponsored by ACCAP, the Seasonal Ice Zone Observing Network (SIZONet), and the Barrow Arctic Science Consortium (BASC). The following organizations and individual contributed financially or in-kind to workshop and manual planning, content, presentations, logistics, and travel support. More than 25 workshop participants from the North Slope Borough Planning Department and Department of Wildlife Management, Alaska Eskimo Whaling Commission (Barrow, Kaktovik, Nuiqsut, Savoonga, Wales), Alaska Clean Seas, faculty from Ilisagvik Tribal College, and Ukpeagvik Inupiat Corporation helped shape the contents of this manual through valuable feedback.

Alaska Center for Climate Assessment and Policy (ACCAP)
Seasonal Ice Zone Observing Network (SIZONET)
Barrow Arctic Science Consortium (BASC)
NOAA and the National Weather Service (NWS) Ice Desk
Alaska Ocean Observing System (AOOS)
Nuna Technologies
Barrow Area Information Database (BAID)
Geographic Information Network of Alaska (GINA)
Scenarios Network for Alaska Planning (SNAP)
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Introduction

As Alaska’s Arctic coasts experience some of the most rapid and dramatic change in the sea-ice and coastal regime anywhere in the Arctic, local and state governments and other stakeholders are increasingly forced to make difficult decisions related to a range of activities that are impacted by sea ice, including subsistence hunting and offshore development. Such decisions, including those related to permitting and other oversight functions, require environmental datasets that are often not easily accessible, digestible or immediately relevant.

This manual’s purpose is to improve the availability of current information about sea ice from operational and academic observation programs to key user groups. The goal is to provide Arctic Alaska coastal community leaders and local user groups with an up-to-date, comprehensive, and practical guide to sea-ice and climate information resources that are relevant to their planning, subsistence activities, and way of life.

This manual is a result of a previously held Sea Ice Information Workshop in Barrow in November 2008 sponsored by the Alaska Center for Climate Assessment and Policy (ACCAP), the Seasonal Ice Zone Observing Network (SIZONet), and the Barrow Arctic Science Consortium (BASC).

This information is current as of July 2010. We anticipate the information will evolve over time and will do our best to keep the manual updated. If you notice an outdated section or would like to suggest a resource to include in the next update, please contact ACCAP at 907-474-7812 or accap@uaf.edu.
How to use this manual

The individual resources in this manual are organized within five main types of sea ice information. These are:

1. Sea ice concentration, extent, and type;
2. Location and extent of multi-year sea ice;
3. Sea ice leads, open water, and shorefast ice extent;
4. Local sea ice observatories at Barrow and Wales, Alaska; and
5. Sea ice summaries.

Each resource under these different types of information has a short list of instructions. Often included after the instructions is a brief list of “tips for interpretation” that should be used to properly interpret the information presented. The instructions for some resources are more detailed than others.

Some resources may be useful for people interested in real-time or at least current-season conditions (for example, hunters and travelers). Other resources may be useful for people interested in either (1) past and historic conditions or (2) lager scale patterns that don't vary too much from year to year. This may apply to people in planning. The MMS Leads Project, for example, presents information on reoccurring lead patterns that haven't changed much over the years, especially in comparison to other variables like the timing of fall freeze-up. During the ACCAP sea ice workshop there were a number of people that were interested in past conditions. To place current conditions into a "change" context, we need to know what things where like in the past, which is why we included these resources.

We have tried to provide enough instruction so that you are able to begin to explore these resources. However, we have also tried to keep the content somewhat brief so that the material can be easily updated as websites change.

If you are interested in datasets that can be placed in a Geographic Information Systems (GIS), such as by using ArcGIS software, look for the label “►GIS Users” throughout the manual to help direct you toward these resources. Likewise, those interested in products that can be viewed in Google Earth should look for “►Google Earth Users”.

Many websites highlighted in this manual require repeated visits to become familiar with their various tools before they can be efficiently used. We recommend visiting the websites in this manual and saving these to your “favorites” so that you can easily return at a later date.
Main Types of Sea Ice Information

Sea Ice Concentration, Extent, and Type

Sea ice concentration and extent describe how sea ice is distributed across a region. In general, reductions in sea ice extent represent one of the most significant changes in Arctic sea ice, which is related to climate as well as to other factors, such as ice dynamics. Ice type and concentration help to assess how mobile an ice pack may be. For example, thin first year ice of low concentration is moved much easier with changes in wind or current than thicker ice of high concentration. These factors may important when activities require information about boating amongst drift ice or when looking for open water. Ice type and concentration are also directly related to the size of forces that the ice can deliver to other objects, such as shorefast ice, ships, or offshore structures.

This section presents resources for sea ice concentration, extent, and type from the following:

1. National Ice Center (NIC)
2. National Weather Service (NWS) Ice Desk
3. National Snow and Ice Data Center (NSIDC)
4. National Center for Environmental Prediction (NCEP)
National Ice Center (NIC)

http://www.natice.noaa.gov/

You will find an interactive display of current daily and weekly products of sea ice concentration, extent, and type produced by the National Ice Center (NIC).

Sample NIC ice chart in the interactive display.

Instructions:

1. Click on the above web address. This will take you to the main page of the National Ice Center.

2. Click on “low bandwidth pages”.

3. On the top menu, click on “Products”.

4. For simple access to ice analysis archive, click on “Products on Demand”. Here you will see an interactive map of the Arctic with the current day’s ice extent shown as default. This will require a faster internet connection.

5. The “Navigation” panel on the left allows you to zoom to a specific region of interest. For example, you can choose to zoom to the Beaufort or Chukchi Seas. The “Navigation” panel also allows you to zoom in and out and to rotate the map. (You can also zoom in and out by rolling your mouse’s wheel if you have one.)

6. The Product Selection panel in the middle allows you to select which product you would like to view. Select a product from the drop down list to view, such as “Arctic Daily” or “Arctic Weekly”. In general, the weekly products provide more detailed information.
7. The “Tools” panel allows you to select the date you want, view the legend, or print the map.

8. In the “Tools” panel, you can also view ice attributes for individual ice areas. To display the attributes, click an ice area on the map. Displayed for each area selected is both the Egg Code (see the special section in the appendix for interpreting this code) and the area coverage in square km.

9. **GIS Users:** In the “Tools” panel, you can also select to download the data in Shapefile or Personal Geodatabase format.
National Weather Service Ice Desk
http://pafc.arh.noaa.gov/ice.php

The Anchorage forecast office produces graphic analyses for Alaska of sea ice as well as five day sea ice forecasts year round. Scheduled sea ice analyses and 5-day sea ice forecasts are produced Monday, Wednesday and Friday.

Sample images of a standard ice chart (left) and of the experimental Google Map ice chart (right).

Instructions:

1. Click on the above web address. This will take you to the main page of the National Weather Service Ice Desk.

2. Located on this page are two relevant products for Alaska’s Beaufort, Chukchi, and Bering Seas. These are a “Sea Ice Analysis” for the current day and a “Five Day Sea Ice Forecast”.
   a. Click on either “Sea Ice Analysis” or “Five Day Sea Ice Forecast” to see either map in its own window. Maps can be saved by right clicking on the image and choosing to “Save image as…” a PNG file, which is a standard type of image file.

3. At the top of the main page, there is a link to the New Experimental Ice Map graphics using Google Maps.
   a. Click on “Ice Map” to view the current day’s ice map in an interactive window. Click on the colors or areas you are interested in to view the pan thickness of the sea ice.
   b. **GIS and Google Earth Users:** On the right side of the window, you can download the current ice map as a Google Earth KMZ file or access KMZ and shapefiles for earlier dates.
**Tips for interpretation:**

- To interpret these maps you must be familiar with the National Ice Center’s “Egg Code.” Please see the special section in the appendix for interpreting the Egg Code.
Sea Ice Index at the National Snow and Ice Data Center (NSIDC)
http://nsidc.org/data/seaice_index/

Here you can find daily images of sea ice concentration, extent, and ice type developed from passive microwave satellites.

![Sample sea ice concentration image.](image)

**Instructions:**

1. Click on the above web address to visit the NSIDC’s Sea Ice Index Page.

2. Here, you will find images of daily or monthly average sea ice concentration and extent in the Arctic.

3. In the center menu, you can choose between daily or monthly results and between extent or concentration (more detailed information).

4. On the far right bottom side of the window, you can click “Archived Data and Images” to access older images of monthly sea ice extent.

   a. You can access older images of sea ice extent and concentration by clicking “Get Extent and Concentration Images”.

      i. You will be transferred to a page where you first have to select the folder for the month you are interest in.

      ii. Next, you must select the PNG image file for the year you are interested in.
1. Files that begin with an N are for the Arctic and files that begin with an S are for the Antarctic.

2. The first four numbers in the file name represent the year.

3. For sea ice extent, choose the files with “extn” in the file name, and for sea ice concentration, choose the files with “conc” in the file name.

b. **GIS Users:** Click “Get GIS Compatible Files” to access shapefiles of older images of sea ice extent and concentration

   i. You will be transferred to a page where you first have to select the folder for the month you are interest in.

   ii. Next, select the “shp_extent” folder for the maximum monthly sea ice extent.

   iii. Next, you must select the zip file for the year you are interested in.

      1. Files that contain an N are for the Arctic and files that contain an S are for the Antarctic.

      2. The first four numbers in the file name represent the year.

**Tips for interpretation:**

- Extent images show the total area of ocean covered with at least 15% ice.
- Concentration images show varying degrees of ice coverage, from 15 to 100%.
- Monthly images show trends in sea ice concentration and extent better than daily images.
National Center for Environmental Prediction (NCEP)
http://polar.ncep.noaa.gov/seaice/Analyses.html

Daily sea ice concentration maps, developed from passive microwave satellites, can be found here.

Sample sea ice concentration map.

Instructions:

1. Click on the above web address to visit the NCEP Sea Ice Analysis Page (The title of the page will say “MMAB Sea Ice Analysis Page”).

2. Under “Current High Resolution Ice Analyses”, select “Northern Hemisphere.” This will show one high resolution image of sea ice concentration.
   a. The map can be saved by right clicking on the image with your mouse and choosing to “Save image as…” a GIF file, which is a standard type of image file.

3. Under “Lower (25.4 km) Resolution Current Ice”, select “Northern Hemisphere.” This will show a series of lower resolution images of sea ice concentration.
   a. On these maps, you can click on a point on the map to get a magnified view of ice in that vicinity.
**Tips for interpretation:**

- The image displays ice concentration. Special colors are pink ('no data'), gray (too close to land for reliable ice concentrations), and black (land). Red indicates low concentration while blues indicate higher ice concentrations. The color bar on the web page gives the full description of the percentages.

- Things other than ice can sometimes show up as ice, even though NASA tries to avoid this. This includes high seas and heavy rains. There is a filter which removes most of this contamination from the ice field, but it is not always effective. In the summer, the puddles of water which can form on the surface of ice floes can lead to an underestimation of total ice concentration.
Location and Extent of Multi-Year Sea Ice

Multi-year sea ice (*piqaluyaq* in Iñupiaq) is ice that has survived at least two summers without disappearing. It is the low salt concentration in multi-year sea ice that allows certain satellite sensors to distinguish multi-year ice from first-year ice. (Second year ice, or ice that has survived only one summer of melt, is “multi-year” ice too, but does not yet have the pronounced salt-free properties that allow it to be easily noticed in most satellite imagery.)

The location of the multi-year ice, whether it is the main ice pack or drifting broken ice beyond the edge of the pack, may be of interest throughout the entire year.

- In summer, the coverage of the pack ice in the Arctic Ocean shrinks as ice melts and ice drift brings the edge further north and away from Alaska’s northern coastline. In general, the further the main pack ice is from the coast, the less likely a boater is to encounter drift ice in the coastal waters off Alaska.
- In late-September, the coverage of the pack ice is at its minimum. The majority of scientific studies that show shrinking of the polar pack ice use the late-September coverage as their measurement. With the satellite record, which goes back to 1979, scientists have seen a reduction in summer extent of about 10% every 10 years. The largest decrease in late summer ice coverage has taken place in the waters north of Alaska.
- In fall and early winter, the closer the multi-year ice is to the coast, the more likely that multi-year ice floes will become a part of the shorefast ice along the coast. These floes can both make the shorefast ice more stable since they often ground to the sea floor, and provide a preferred source of drinking water for hunters and communities.
- Throughout the winter and spring, multi-year ice near the coast is mixed with ice of all different ages and thicknesses. However, drifting ice that is composed of mostly multi-year ice drifts with a lot more momentum and doesn’t change course with shifting winds and currents as easily as thinner younger ice. Also, this heavier ice can collide with the shorefast ice with a lot of force.

This section presents resources for the location and extent of multi-year ice from the following:

1. **NSIDC’s Easy-to-Use Data Products**
2. **QuickSCAT satellite imagery**
NSIDC’s Easy-to-Use Data Products
http://nsidc.org/data/easytouse.html

Here one can view National Ice Center weekly ice charts up until 2007 interactively using a tool produced by the National Snow and Ice Data Center. This resource allows you to look at the multi-year ice coverage and concentration for any given year, and is also a great tool for looking at year-to-year comparisons. (Many other types of information are also available here, but are not specifically discussed since they are already covered by the other resources discussed in this manual.)

Sample image of multi-year ice coverage from September 24, 2007.

Instructions:

1. Click on the above web address to access the NSIDC’s easy-to-use data products page.

2. In the table under the heading of “Sea Ice”, click “National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format”.

3. Click “Browse Images” to be directed to the interactive tool.

4. In the drop-down menu titled “Look at spreadsheet for” near the top of the page, select “National Ice Center: Weekly Chart Products”, and then click the “Go!” button.
5. Using the drop down menus in the table, you can look at concentrations for multi-year ice, total ice, first year ice, and thin ice for any year between 1972 and 2007. Note that data is missing for some years.

   a. Use the “Control Panel” in the top left to set the scale, number of rows, and number of columns. You must click the “Refresh” button for your changes to be made. (You can compare different types of ice concentrations by using multiple columns, and you can compare different dates using multiple rows.)

   b. Choose the year and week of interest in the drop down menu for each row, and choose the map of interest for year column. You must again click the “Refresh” button for your changes to be made.

   c. Any image can be saved by right clicking on the image and choosing to “Save image as…” a GIF file, which is a standard type of image file.
Ocean and Sea Ice Satellite Application Facility (OSI SAF)
http://saf.met.no/p/ice/

Here one can find daily images of multi-year ice coverage in the Arctic. The concentration product produced by the European Space Agency is currently based on Special Sensor Microwave Imager (SSM/I) passive microwave data and a radar scatterometer (similar to QuikScat).

<table>
<thead>
<tr>
<th>OPERATIONAL</th>
<th>Global Sea Ice Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>OSI-403: Sea Ice Type Maps on 10 km Polar Stereographic Grid</td>
</tr>
<tr>
<td>Description</td>
<td>The sea ice type product from the EUNETSAT OSI SAF. Ice classes are assigned from atmospherically corrected SSM/I brightness temperatures and ASCAT bidirectional reflectance factor values, using a Bayesian approach. It is operational since 2005.  <a href="#">access more details</a></td>
</tr>
<tr>
<td>Data used</td>
<td>SSM/I (DHMSP F15), ASCAT (Hflag-A), ECMWF forecast for atmospheric correction</td>
</tr>
<tr>
<td>Formats</td>
<td>HDF5, NetCDF, GRIB</td>
</tr>
<tr>
<td>NRT access</td>
<td>FTP (last 31 days in HDF5 and GRIB), EUNETCast (GRIB) and alternative FTP (NetCDF)</td>
</tr>
<tr>
<td>Archive</td>
<td>FTP (since 2005) and UNMRF</td>
</tr>
<tr>
<td>Links</td>
<td>Quicklooks NH, Quicklooks SH, Validation &amp; monitoring</td>
</tr>
<tr>
<td>Remarks</td>
<td>Note that during Arctic summer season (May-September) the ice type product is dubious because melting of the ice surface obscures the ice type signals.</td>
</tr>
</tbody>
</table>

**Instructions:**

1. Click on the above web address.

2. Scroll down the page until you see the section titled “Global Sea Ice Types” under the purple heading, as shown in the above image.

3. Note that the dates on the images are written in the format of day-month-year (for example, 16.07.2010 is July 16, 2010.)

4. Click on one of the individual images to enlarge it in a new window. Note the legend on the right side. Multi-year ice is shown as white and first year ice is shown as grey.

5. Images can be saved by right clicking on the image and choosing to “Save image as…” a JPG file.
**Sea Ice Leads, Open Water, and Shorefast Ice Extent**

Sea ice leads are important for a number of reasons. They are indicative of regional and pan-arctic scale sea ice dynamics. They are also important biologically and provide a corridor and habitat for marine mammals. Similarly, shorefast ice provides an environment for human travel and hunting. Shorefast ice also provides a buffer between either drifting ice and the beach or ocean waves and the beach. Therefore, shorefast ice is important for coastal erosion.

This section presents resources for sea ice leads, open water, and shorefast ice extent from the following:

1. Geographic Information Network of Alaska’s SwathViewer
2. Barrow Area Information Database (BAID)
3. MMS leads and landfast ice project
Geographic Information Network of Alaska (GINA)’s SwathViewer
http://sv.gina.alaska.edu/

This resource provides access to a range of satellite images that provide information about sea ice leads, open water, and shorefast ice extent.

Instructions:

1. Click on the above web address. This will take you to a welcome page, which should then cause the main SwathViewer page to open. If it doesn’t immediately open, hit the “Click here to launch Swath Viewer” box. Macintosh users: Safari seems to work best. Sometimes Firefox or Internet Explorer won't work.

The welcome page shown here, states if it doesn't load you may need to download a newer version of Java (free) from http://java.com.

The main SwathViewer Page
2. Zoom in on northern Alaska.

Select the zoom-in button from the tool bar, and then select the area you want by holding down the left mouse button. **Warning:** Zooming in too close at this point will not let you see all of the satellite images available. It is best to be zoomed in as far as the image below. You can zoom in further later once you have your image selected.

![Image of zoomed-in view](image.png)

3. View the types of images available. In the list of images on the left hand side, make sure the “Images” folder is opened by clicking on it. When it is opened, there will be a list of folders beneath it. The folders that may contain useful sea ice information are:

   a. **AVHRR** (“Advanced Very High Resolution Radiometry” sensor)

   b. **Aqua-1 / MODIS** (“Moderate Resolution Imaging Spectroradiometer” sensor. Aqua-1 is the name for the satellite.)

   c. **Terra-1 / MODIS** (Terra-1 is the name for the satellite.)

4. Find an AVHRR image for your area of interest (for example, Point Barrow)
a. Click on the “AVHRR” folder. You should see a list of folders labeled by year. Next click on the year. You should see a list of Months. Select the month you are interested in.

b. A list of images will appear in the lower left hand corner. These are the images available for the area that you selected.

c. Select an image from the list. It should appear on the map.
d. Using the zoom-in tool, you can zoom-in on the area you are interested in.

Map zoomed in on Point Barrow. Note that the satellite image shown here does not match up perfectly with the coastline (green line). Often times these types of alignment errors exist.

5. Select maps from other types of sensors or satellites.
   a. Using the zoom-out button, zoom out to the regional scale.
   b. Select another type of image from the list of image folder. For example, select “Aqua-1 / MODIS”.
   c. Next, follow the same steps as with the AVHRR images to select the image that you want and to zoom-in on the area of interest.

Tips for interpretation:

- Both AVHRR and MODIS image sensors can NOT see through clouds as radar can. Therefore, clouds show up in the imagery. This means that on cloudy days you can’t see the ice below. It also means that to get useful information from the image you must learn how to distinguish clouds from sea ice.
The resolution of AVHRR and MODIS images are 1 km or 0.6 miles, which means that one pixel in the image is 0.6 miles across. This prevents individual ice floes smaller than this from being seen.
Barrow Area Information Database (BAID)
http://www.baidims.org/

This resource provides access to radar imagery of shorefast ice extent. BAID is a collection of online, interactive maps and services that support Arctic science with a special focus on the research hubs of Barrow, Atqasuk and Ivotuk on the North Slope of Alaska.

![The BAID internet map server window.](image)

![The Barrow SAR Viewer.](image)

**Instructions:**

1. Click on the above web address. This will take you to a welcome page of BAID. The three main ways to access radar imagery from this site are described below.

2. To access BAID’s internet map server, select “Launch” under the “BAID-IMS” icon.
   a. The map server will open in a separate window.
b. On the right hand side is a list of the many layers in this server. Click the “Imagery”. Next, choose the year you are interested in. Next, choose the “SAR Sea Ice” folder. Lastly, choose the month you are interested in. Now you will see a list of the SAR radar images available for that month. (The first eight numbers represent the date of the image. The first four number are for the year, the second two are for the month, and the last two are for the day.)

c. When an image is selected, it will appear on the map.

d. The toolbar on the left side of the window has tools that allow you to zoom in, zoom out, pan around the image, print the map, etc.

* Note that the map often takes time to load after you click something, so please be patient.

3. To access an easy to use collection of SAR radar imagery for the current year only, select “Launch” under the “Barrow SAR Viewer” icon.

a. A separate window will open to show the most recent SAR radar image for Barrow.

b. Using the zoom bar on the left side of the window you can zoom in an out.

c. Use the “SAR Imagery” panel to select the SAR radar image you want. (The first eight numbers represent the date of the image. The first four number are for the year, the second two are for the month, and the last two are for the day.)

d. You can click-and-hold the map to move the map around to get a better view of your area of interest.

e. The little printer icon on the left side of the window allows you to either print the map or to save it as a JPEG image file.

* Note that the map often takes time to load after you click something, so please be patient.

4. **Google Earth Users:** To access BAID in Google Earth, select “Launch” under the BAID in Google Earth” icon on the main page. This will launch Google Earth.

**Tips for interpretation:**

- See the special section in the appendix for guidelines for interpreting radar maps.
MMS Leads and Landfast Ice Project  
Geophysical Institute, University of Alaska Fairbanks  
http://mms.gina.alaska.edu/

This resource provides images of recurring lead systems and open water off the coast of northern Alaska in the Chukchi Sea between Wainwright and Barrow and the Beaufort Sea between Barrow and the Mackenzie River Delta. Satellite imagery (from Radarsat Synthetic Aperture Radar (SAR) and Advanced Very High Resolution Radiometer (AVHRR) data) is presented for the time period between 1993 and 2003. This project is funded by the US Minerals Management Service (AK-03-06, MMS-71707).

![Study area in the Beaufort and Chukchi Seas.](image)

Sample AVHRR image from March 14, 2001.

**Instructions:**

1. Click on the above web address. This will take you to the project homepage.

2. On the top menu, click “Project Results”.

3. For lead patterns for the years 1993 to 2004, click on “Lead Patterns” on the left side menu.
a. Select the year and month of interest.

b. Here you will find AVHRR images downloadable as compressed zip files. The five numbers in the file name indicate the date: the first two numbers are the year and the last three numbers are for the Julian day, which corresponds to the day of the year (for example, January 1 is Julian day 1 and December 31 is Julian day 365).

c. ► **GIS Users:** ArcGIS Grid and Shapefiles can be downloaded here.

4. For landfast ice extent for the years 1996 to 2004, click on “Landfast Ice Extent” on the left side menu.

   a. Select the year and month of interest.

   b. Here you will find SAR mosaic images downloadable as compressed zip files. The first two numbers in the file name represent the year and the middle three numbers and ending three numbers represent the starting date and ending date, respectively, for the images used to create the mosaic.

   c. ► **GIS Users:** ArcGIS Grid and Shapefiles can be downloaded here.

5. ► **GIS Users:** Other types of GIS data for this project can be found by clicking on “Suppl. Materials and Links” on the top menu. Here you will find additional data related to lead patterns and statistics, landfast ice extent, and bathymetry.
Local Sea Ice Observatories at Barrow and Wales, Alaska

The sea ice group at the Geophysical Institute of the University of Alaska Fairbanks operates coastal ice observatories in the villages of Barrow and Wales, Alaska (shown in the map below). Both sites consist of a coastal webcam and radar. In Barrow, we also maintain a sea ice mass balance and sea level station.

Observatories website: [http://seaice.alaska.edu/gi/observatories/](http://seaice.alaska.edu/gi/observatories/)

Webcams

In addition to providing a visual impression of the sea-ice conditions off Barrow and Wales, webcam images establish a longer-term record of key dates in the seasonal evolution of the sea-ice cover, such as: onset of fall ice formation, formation of a stable ice cover, onset of spring melt, appearance of melt ponds, beginning of ice break-up in early summer, removal or advection of sea ice during the summer months.

Barrow webcam: [http://seaice.alaska.edu/gi/observatories/barrow_webcam](http://seaice.alaska.edu/gi/observatories/barrow_webcam)
Wales webcam: [http://seaice.alaska.edu/gi/observatories/wales_webcam](http://seaice.alaska.edu/gi/observatories/wales_webcam)
Radars

Near-shore ice is monitored with Furuno 10 kW, X-band marine radars, which are positioned close to the shore on rooftops, and can operate at ranges up to approximately 11 km. Xenex digital controllers allow full remote operation from the University of Alaska Fairbanks (UAF). Radar backscatter maps are produced to provide important information on the movement, deformation and stability of the coastal ice cover.

Barrow radar: [http://seaice.alaska.edu/gi/observatories/barrow_radar](http://seaice.alaska.edu/gi/observatories/barrow_radar)
Wales radar: [http://seaice.alaska.edu/gi/observatories/wales_radar](http://seaice.alaska.edu/gi/observatories/wales_radar)
Mass Balance and Sea Level Site

An automated ‘mass balance site’ is annually installed in growing, undeformed landfast first-year ice in a small embayment SW of Pt. Barrow. This site measures snow depth, ice thickness, and the water-ice-snow-air temperature profile. Also at this site are underwater acoustic altimeters that monitor local sea level. The mass balance site has operated in the years from 2006 to 2010.

Barrow Mass Balance and Sea Level Site:
http://seaice.alaska.edu/gi/observatories/barrow_sealevel
Sea Ice Summaries

This section presents unique resources that not only present summaries of data and information as opposed to collections of products. The resources presented here are the following:

1. NSIDC Arctic Sea Ice News and Analysis
2. SEARCH Sea Ice Outlook
3. SEARCH Sea Ice Outlook for Walrus
NSIDC Arctic Sea Ice News & Analysis
http://nsidc.org/arcticseaicenews/

This page presents the National Snow and Ice Data Center’s (NSIDC) summaries of up-to-date scientific analysis of arctic sea ice. Much of the information relates to the current extent of Arctic sea ice and also a comparison between the present year and past years. Information is updated at the first of each month and sometimes more frequently.

Example graph comparing the 2010 Arctic sea ice extent with past years.

Instructions:

1. Click on the above web address to go to Arctic Sea Ice News & Analysis page of the NSIDC. On this page you can find information relating to the current state of arctic sea ice.

2. On the right side, you will find:
   a. An “Archives” menu where older releases of sea ice news are available.
   b. A “Press Resources” menu that has summaries of the reported summer sea ice minimums since 2002.
SEARCH Sea Ice Outlook  
http://www.arcus.org/search/seaiceoutlook/

The SEARCH (Study of Environmental Arctic Change) Sea Ice Outlook is an international effort to provide a summary of the expected September arctic sea ice minimum. Monthly reports released throughout the summer present estimates of the current state and expected minimum of sea ice at both a pan-arctic and regional scale. The intent of the Sea Ice Outlook is not to issue predictions, but rather to summarize all available data and observations to provide the scientific community, stakeholders, and the public the best available information on the condition of arctic sea ice. Sea Ice Outlook activities are supported in part through the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA).

Instructions:

1. Click on the above web address. This will take you to the Sea Ice Outlook homepage.

2. For reports for the given year, click on “Overview” on the center menu. Then, next to “Reports”, click on the month of interest. Here you will find tabs for “Summary”, “Pan-Arctic”, and “Regional” assessments.

3. For reports from past years, click on the specific year’s Outlook archive. For example, click on “2009 Outlook Archive”. Here you can access reports for the individual months, for the sea ice minimum, and for the year’s summary.
SEARCH Sea Ice Outlook for Walrus

http://www.arcus.org/search/siwo

The Sea Ice for Walrus Outlook (SIWO) is a resource for Alaska Native subsistence hunters, coastal communities, and others interested in sea ice and walrus. The SIWO is updated every Friday from April through June with information on sea ice conditions relevant to walrus in the Northern Bering Sea and southern Chukchi Sea regions of Alaska. The SIWO webpage includes: (1) An assessment of current ice conditions relevant to distribution and access of walrus, (2) a 10-day outlook of wind conditions, (3) up-to-date satellite imagery for the Bering Strait and St. Lawrence Island, which are two regions of interest to coastal communities engaging in the walrus hunt, (4) written observations of ice development from Alaska Native hunters, sea-ice experts, or NOAA or university researchers, (5) additional data and resources on ice conditions, and (6) additional comments provided by local experts and other contributors.

2010 was the first year the SIWO was published and the project will likely be continued. Planning for 2011 has started. If you are a local hunter, expert, or a scientist with observations on either the development of sea ice or any other aspect of walrus and sea ice, please contribute and send your comments to Helen Wiggins at the Sea Ice Outlook Central Office at ARCUS, helen@arcus.org or 907-474-1600.

Instructions:
1. Click on the above web address. This will take you to the Sea Ice Outlook for Walrus homepage.
2. The most current report and the latest news will be posted on this homepage.
3. Archives for the weeks the SIWO is published are available in the dropdown menu at the top of the page that says “Past SIWO Reports.” Click on the date you are interested in.
Additional Resources

This section presents resources that are not specifically sea ice resources, but may be useful for those interested in Alaska climate (temperature, precipitation, and freeze and thaw dates) and general mapping resources. For a comprehensive annotated list, including tutorials on the SNAP resources detailed below, see the ACCAP Data Resources webpage: http://ine.uaf.edu/accap//data_resources.html.

The resources presented here are the following:

1. Scenarios Network for Alaska Planning
2. Alaska Mapped: Statewide Digital Mapping Initiative
Scenarios Network for Alaska Planning (SNAP)
http://www.snap.uaf.edu/

This resource provides local and regional temperature, precipitation, and freeze and thaw dates. Both historical data and future scientific projections are available. Here, projections are based on different future scenarios of global greenhouse gas emissions.

**Instructions:**

1. Click on the above web address to visit the SNAP homepage. Here you will find a range of information related to various SNAP projects.

2. For web-based maps of climate projections (freeze up and thaw dates), click on “Web-based Maps” on the left side menu.
   a. Click on “Open SNAP’s Map Selection Tool”. A new window will open with the interactive map.
   b. For information relating to the future projections for the date at which the average temperature drops below freezing, select “Date of Freeze Up” as a map layer, then select an emissions scenario, and finally a decade of interest. You will then see a map of projected dates when the average temperature will be below freezing. The same can be done for “Date of Thaw”

3. **Google Earth Users:** For a Google Earth based method of exploring a wider range of data (temperature and precipitation), click on “Google Earth Maps” on the left side menu.

4. **GIS Users:** For GIS datasets of climate projections (temperature and precipitation) for the state of Alaska based on global climate models, click on “GIS Data” on the left side menu.
5. For projections of temperature and precipitation data for a specific Alaska community, click on “Community Charts” on the left side menu.

a. You can switch between charts for “Temperature” and “Precipitation” by clicking on the different tabs near the top of the page.

b. You can choose from three different greenhouse gas emission scenarios.

Sample Community Chart for Barrow, Alaska
Alaska Mapped: Statewide Digital Mapping Initiative
http://www.alaskamapped.org/

Alaska Mapped provides an interactive mapping service that provides satellite imagery and elevation data collected for the state of Alaska through the Alaska Statewide Digital Mapping Initiative (SDMI) and the UAF Geographic Information Network of Alaska (GINA).

From the Alaska Mapped homepage, you will find a range of products under the heading “Data Services” on the left side menu. We are currently not presenting instructions for this resource here in this manual.
Appendix

The Egg Code: Ice Chart Symbology

Source: [http://www.natice.noaa.gov/products/egg_code.html](http://www.natice.noaa.gov/products/egg_code.html)

The World Meteorology Organization (WMO) system for sea ice symbology is more frequently referred to as the "Egg Code" due to the oval shape of the symbol.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_t$</td>
<td>Total concentration of ice in area, reported in tenths. May be expressed as a single number or as a range, not to exceed two tenths (3-5, 5-7 etc.)</td>
</tr>
<tr>
<td>$C_a$, $C_b$, $C_c$</td>
<td>Partial concentration ($C_a$, $C_b$, $C_c$) are reported in tenths, as a single digit. These are reported in order of decreasing thickness. $C_a$ is the concentration of the thickest ice and $C_c$ is the concentration of the thinnest ice.</td>
</tr>
<tr>
<td>$S_a$, $S_b$, $S_c$</td>
<td>Stages of development ($S_a$, $S_b$, $S_c$) are listed using the code shown in Table 1 below, in decreasing order of thickness. (NOTE: If there is a dot (.), all stages of development codes to the left of the dot (.) are assumed to carry the dot (.) ) These codes correspond directly with the partial concentrations above. $C_a$ is the concentration of stage $S_a$, $C_b$ is the concentration of stage $S_b$, and $C_c$ is the concentration of $S_c$.</td>
</tr>
<tr>
<td>$S_o$, $S_d$</td>
<td>Development stage (age) of remaining ice types. $S_o$ if reported is a trace of ice type thicker/older than $S_a$. $S_d$ is a thinner ice type which is reported when there are four or more ice thickness types.</td>
</tr>
<tr>
<td>$F_a$, $F_b$, $F_c$</td>
<td>Predominant form of ice (floe size) corresponding to $S_a$, $S_b$ and $S_c$ respectively. Table 2 below shows the codes used to express this information.</td>
</tr>
</tbody>
</table>
Table 1. Egg Codes for Stages of Ice Development (Sx Codes)

<table>
<thead>
<tr>
<th>Stage of Development for Sea Ice</th>
<th>Code</th>
<th>Stage of Development for Fresh Water Ice</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Ice-Frazil, Grease, Slush, Shuga (0-10 cm)</td>
<td>1</td>
<td>New Ice (0 - 5 cm)</td>
</tr>
<tr>
<td>Nilas, Ice Rind (0 - 10 cm)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Young (10 - 30 cm)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Gray (10 - 15 cm)</td>
<td>4</td>
<td>Thin Ice (5 - 15 cm)</td>
</tr>
<tr>
<td>Gray - White (15 - 30 cm)</td>
<td>5</td>
<td>Medium Ice (15 - 30 cm)</td>
</tr>
<tr>
<td>First Year (30 - 200 cm)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>First Year Thin (30 - 70 cm)</td>
<td>7</td>
<td>Thick Ice (30 - 70 cm)</td>
</tr>
<tr>
<td>First Year Thin - First Stage (30 - 70 cm)</td>
<td>8</td>
<td>First Stage Thick Ice (30 - 50 cm)</td>
</tr>
<tr>
<td>First Year Thin - Second Stage (30 - 70 cm)</td>
<td>9</td>
<td>Second Stage Thick Ice (50 - 70 cm)</td>
</tr>
<tr>
<td>Medium First Year (70 - 120 cm)</td>
<td>1</td>
<td>Very Thick Ice (70 - 120 cm)</td>
</tr>
<tr>
<td>Thick First Year (&gt;120 cm)</td>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>Old - Survived at least one season's melt (&gt;2 m)</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>Second Year (&gt;2 m)</td>
<td>8.</td>
<td></td>
</tr>
<tr>
<td>Multi-Year (&gt;2 m)</td>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>Ice of Land Origin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forms of Sea Ice</td>
<td>Code Figure</td>
<td>Forms of Fresh Water Ice</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>New Ice (0-10 cm)</td>
<td>X</td>
<td>Belts and Strips symbol followed by ice concentration</td>
</tr>
<tr>
<td>Pancake Ice (30 cm - 3 m)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Brash Ice (&lt; 2m)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ice Cake (3 - 20 m)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Small Ice Floe (20 - 100 m)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Medium Ice Floe (100 - 500 m)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Big Ice Floe (500 m - 2 km)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Vast Ice Floe (2 - 10 km)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Giant Ice Floe (&gt; 10 km)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Fast Ice</td>
<td>8</td>
<td>Fast Ice</td>
</tr>
<tr>
<td>Ice of Land Origin</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Undetermined or Unknown (Iceberg, Growlers, Bergy Bits)</td>
<td>/</td>
<td></td>
</tr>
</tbody>
</table>
Guidelines for Interpreting Radar Maps

Users of the Barrow Area Information Database – internet Map Server (BAID-IMS) should be cautioned that radar maps created from Synthetic Aperture Radar (SAR) imagery can be difficult to interpret. This document is intended to provide some guidelines for interpreting SAR imagery. However, these guidelines should not be accepted as hard fast rules. As a general rule, areas of calm water (including most leads) and other smooth surfaces (like the flat ice on Elson lagoon) appear black since the radar reflects away and is not received by the satellite. However, windy conditions can make leads appear grey and even white.

Freshwater lakes that are not frozen solid appear white. But, shallow freshwater lakes that are frozen to the ground appear black (notice the Twin Lakes and Freshwater Lake in Figure 2.) SAR is a very good tool for determining the depth of freshwater lakes. Buildings and other man-made structures will reflect well and often appear bright white on the images (notice the Village of Barrow.)

Figure 1

Figure 2.

Technical Overview

SAR is an active sensor, mounted on the RADARSAT-1 and ERS-2 satellites. As they orbit the earth, these satellites transmit radar signals and then measure how strongly those signals are scattered back. The SAR sensors can “see” both at night and through clouds. BAID-IMS is incorporating Quicklook imagery from RADARSAT-1’s (ScanSAR Wide Beam) sensor at 100-meter pixel resolution with data frames that are 500 x 500 km and the ERS-2 sensor at 30-meter pixel resolution with data frames that are 100 x 100 km. Both sensors send out C-Band pulses with a 5.66 cm wavelength. These pulses are not harmful to humans or animals.

Surface Variations near the size of the radar’s 5.66 cm wavelength can cause strong backscattering. If the wavelength is a few centimeters long, even a small object might backscatter brightly. Wind-roughened water can backscatter brightly when the resulting waves are close in size to the incident radar’s wavelength. A rough surface backscatters more brightly when it is wet. As melt ponds develop on the ice in spring, it will become more difficult to distinguish features in the imagery.

Scattering Mechanisms

For more information visit the SAR FAQs at: http://www.asf.alaska.edu

Prepared by Nuna Technologies, November 17, 2008
Impacts of Climate Change and Variability on Hydropower in Southeast Alaska: Planning for a Robust Energy Future

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N. Fresco, Scenarios Network for Alaska Planning, University of Alaska Fairbanks

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November, 2010
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IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON HYDROPOWER IN SOUTHEAST ALASKA: PLANNING FOR A ROBUST ENERGY FUTURE

J. E. Cherry (International Arctic Research Center and Institute of Northern Engineering at the University of Alaska Fairbanks), S. Walker (Juneau Office of the National Marine Fisheries, National Oceanic and Atmospheric Administration), N. Fresco (Scenarios Network for Alaska Planning, University of Alaska Fairbanks), S. Trainor (Alaska Center for Climate Assessment and Policy, University of Alaska Fairbanks), A. Tidwell (Institute of Northern Engineering, University of Alaska Fairbanks).

ABSTRACT: The useful lifespan of hydroelectric power infrastructure is 50 years or more; this is long enough that long-term climate change and shorter-term climate variability should be considered when planning new facilities and maintaining existing ones. This study examines observed historical climate variability in Southeast, Alaska, where several new and expanded hydropower facilities are proposed. Analysis suggests that climate trends in this region since the 1920s are modest, while trends since the mid-1940s are somewhat stronger. Sparse data collection increases the uncertainty associated with these trends. Variability in temperature, precipitation, snow, and discharge is largely dominated by random interannual fluctuations, as well as semi-decadal to decadal climate modes such as the El Niño-Southern Oscillation and the Pacific Decadal Oscillation (PDO). The dominance of these modes of variability on the regional climate is useful for risk management because prediction tools exist for season-ahead forecasting. Longer-term climate trends, while smaller in magnitude, will likely lead to warmer and wetter conditions in the coming century. The persistence of a negative PDO may lead to cooler, drier conditions in the short term. Climate variability and change both have implications for shifts in the timing and magnitude of river discharge that could pose challenges to management of capacity-limited reservoir systems. An increasingly interconnected power grid in Southeast Alaska might help mediate these climate impacts, but there are still large data gaps that contribute to management risk. Enhanced monitoring of snow, temperature, runoff, and glacial melt, particularly at elevation and in the watersheds feeding hydropower reservoirs, could help operators reduce risk by eliminating some of the uncertainty about the relationships between climate and water resource availability.

1. INTRODUCTION

This study is motivated by several issues at the forefront of Earth system research and the practical need to plan for the future energy sector. While there is little expansion of hydropower capacity in the contiguous United States anticipated in the near future, Alaska has a number of new facilities and facility expansions proposed over the next two decades. While dams are being decommissioned in the Pacific
Northwest to help revitalize salmon habitat, Alaska has maintained a number of hydropower facilities in areas where topography is extreme enough that there are relatively few impacts on anadromous fish habitat. These geographic features make hydroelectric capacity growth attractive in Southeast Alaska.

Much of the existing hydropower capacity in the United States was built long before engineers and the general public were aware of the impacts of climate change on large infrastructure. With the development of increasingly sophisticated numerical climate models and the science coordination and publication associated with the Intergovernmental Panel on Climate Change (IPCC) assessment reports, there is an increasing awareness of the rapidity of climate change and its impacts, particularly in high latitudes. The scientific consensus is that climate change, particularly warming in winter, is amplified in the high latitudes because of several fundamental physical properties of the climate system. These include feedbacks associated with melting snow and ice, which leads to more absorption of solar radiation and additional warming, feedbacks associated with warming leading to increased formation of clouds and the trapping of additional heat near the surface, and the overall increase in heat transport by the ocean and atmosphere from the lower to the higher latitudes driven by planetary gradients (ACIA, 2005; IPCC, 2007).

Because Alaska is recognized as a ‘front line’ of climate change (Serreze, 2000; ACIA, 2005; Hinzman et al., 2005), agencies and municipalities are increasingly struggling with how to anticipate and mitigate the impacts. Large infrastructure on the scale of hydropower dams, reservoirs, and transmission systems are typically engineered with a lifespan of 50 years or more, under historical environmental conditions. A number of factors make it difficult to predict the impacts of climate change on large-infrastructure in Alaska: the general harshness and remoteness of the environment; the sparseness of long-term historical or even current records of temperature, precipitation, and snow depth; complex system features such as permafrost, glaciers, and seismic activity; and the high likelihood that the environment is undergoing rapid change. Southeast and South Central Alaska, where most of the existing hydropower facilities are located, have a mild, maritime climate relative to the rest of the state. The regional climate characteristics and facility descriptions will be provided in more detail below.

There are underlying economic conditions in Southeast Alaska that make planning for and responding to climate change impacts on the hydropower resources particularly challenging. The Southeast Alaska panhandle is a mountainous archipelago fused to Canada’s British Columbia. Communities are small and isolated—not only from each other but from the rest of Alaska and the United States. Many are accessible only by air or boat. Some communities have relatively healthy tourist and/or fishing sectors, including the state capital of Juneau; others maintain subsistence economies with very few wage-based jobs. While Southeast Alaska represents a ‘Saudi Arabia’ of hydropower resources, the high cost of building facilities in mountainous terrain and transmitting power (often underwater) for such a small market, makes large-scale development prohibitive. Many of these
Climate Impacts on Hydropower in Southeast Alaska

Communities continue to depend on diesel power generation, paying upwards of $1.00 kWh, in contrast to the U.S. average of $0.12 kWh (EIA, 2010). Even Juneau, which already has a multiple-reservoir hydropower system, was forced to rely on diesel fuel when avalanches wiped out transmission lines during spring of 2008 and again in January 2009 (Juneau Empire, April 17 2008 and January 13, 2009). Electricity prices increased nearly five times overnight; not only were diesel prices at a historical high, but drought had reduced the hydropower supply and the utility was already using diesel to supplement hydropower generation.

Facility operators and agency representatives began asking, “Is drought in Southeast Alaska tied to climate change?” around this time. The spring of 2008 and the preceding winter were influenced by a strong episode of cool conditions in the equatorial Pacific known as ‘La-Niña.’ In addition to the La Niña episode, the Pacific Decadal Oscillation, another mode of climate variability in this region, was also in a cool phase associated with offshore winds and decreased winter precipitation in Southeast Alaska (JISAO, 2010). How much of observed change in Southeast Alaska’s hydrologic system is attributable to long-term climate change versus normal climate variability? And how might normal variability change as the global climate enters a new regime? As stakeholders try to plan for a robust future energy sector, they must account for changes in risk associated with climate, and they need guidance from scientists on how best to quantify and attribute climate impacts.

Our work represents a case study in Southeast Alaska for a process that is occurring all over the world; communities are trying to prepare for the impacts of climate change. Sitka is used as an example in the study because the municipality has applied for a license amendment to raise the height of their Blue Lake dam. In many senses, the effort herein is not new; most individuals are accustomed to using weather forecasts produced either through numerical modeling or through local or traditional knowledge to make decisions about their actions for the short term. Some sectors use longer-term forecasts to make decisions for the upcoming season. However, it is only with the advent of global climate models that it is possible to project changes in the climate far out into the future. Regional, downscaled models and numerical techniques are now being used to estimate the likelihood of various future climate outcomes. While many of these questions are pushing the state-of-the-science of present research, stakeholders are asking for this information to support their decisions right now; and attempts must be made to provide them what they need to develop resilient public infrastructure.

To summarize this introduction, this study addresses the following questions:

1. What are the patterns of observed climate change and variability in Southeast Alaska?
2. How are these patterns likely to change in the future?
3. How will existing hydropower and future facilities be impacted?
These questions will be explored below, as well as the potential utility of seasonal and longer-term forecasting for management of water resources in Southeast Alaska.

To some extent the effort here can be generalized to other climate impacts studies. Increasingly, agencies and other stakeholders are being asked to consider downscaled climate projections in their planning process. These include applications such as building design criteria, impacts on wildlife habitat, disturbance frequency by fire, and many other systems subject to climate-related risk. To help others pursue similar analyses, we have provided a guidance document, as an appendix, that outlines the steps taken in this study.

2. A DESCRIPTION OF THE HYDROELECTRIC POWER FACILITIES IN SOUTHEAST ALASKA

The Southeast Alaska Intertie Study Phase 2 final report (D. Hittle & Associates ‘DHA’, 2003) has a comprehensive description of Southeast’s installed hydropower facilities, though several new facilities have been constructed since that time. This report was published about the same time that the Institute of Social and Economic Research at the University of Alaska Anchorage published a report on Alaska Electric Power Statistics 1960-2001 (ISER, 2003). Table 1 shows the facilities described in the DHA report. Electricity is generated at one or more facilities and typically transmitted a short distance to the community served. Service is generally provided by community-based utilities with few transmission links between communities. This intertie study, and those that preceded it, lay out the potential costs and benefits of increased transmission between communities, some of which have now been constructed. Falls Creek is a new 800 kW (2,160 MWh/year) facility near Gustavus; Kasidaya Creek is a new 3-MW (11,900 MWh/year) project near Skagway; and the 14.3-MW Lake Dorothy project is supplying additional electricity to Juneau (Levitt et al., 2010).

One interesting thing to note in Table 1 is that some communities are operating, on average, significantly below their maximum operating capability, but are still burning diesel fuel. Sitka and Petersburg/Wrangell stand out in this regard. This points to limitations in the availability of water, inefficiencies in generation, or other structural problems. Possible solutions depend on the costs and benefits of facility expansion, transmission interties, and future load growth. The Southeast Conference, which is a regional group of governmental and business stakeholders, is advocating for the development of a comprehensive regional energy plan that could explore these options. The present study raises some of the climate-related issues that may impact costs and benefits in this long-term planning.

Several findings in the DHA study point to features of the hydropower sector in Southeast that might make it particularly sensitive to climate variability and change. First, total power supply requirements can be strongly affected by the gain or loss of
a single industrial load or water use such as a pulp mill or mine. If the industry depends on a self-contained electrical supply, there is little impact on the community. However, if the supply depends on the municipal power source, or is tied via transmission lines, change in industrial loads may have a big impact on the price paid per kWh. Future commercial uses for water in the region may include bottling of drinking water (rights have been sold in Sitka’s Blue Lake for this purpose, Walton, 2010) or generating power for docked cruise ships, which is already occurring in Juneau. Any changes in industrial or commercial uses have a large impact on electrical prices in these small communities.

Second, the predominance of diesel generation has created air quality concerns and the future energy generation costs may be impacted by regulations, including the costs of monitoring and compliance. Sitka, for example, has recently installed an EPA approved air quality monitoring site because of air pollution associated with the diesel-generation they need to make up for shortfalls in hydropower availability. The fluctuation in the cost of diesel fuel itself creates a large uncertainty in regional energy planning.

TABLE 1: 2002 Hydropower Statistics In MWh.

<table>
<thead>
<tr>
<th>Load Center</th>
<th>Hydro Generated</th>
<th>Average Generation Capability</th>
<th>% of Capability Used</th>
<th>Electricity Load</th>
<th>Hydro Generated Minus Load</th>
<th>Projected Load (2012)</th>
<th>Hydro Generated Minus Projected Load (2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Lynn Canal Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skagway + Haines</td>
<td>22,247</td>
<td>23,200</td>
<td>95.9</td>
<td>23,614</td>
<td>-1,367</td>
<td>26,090</td>
<td>-3,843</td>
</tr>
<tr>
<td>Chilkat Valley/ Klukwan</td>
<td>1,668</td>
<td>1,800</td>
<td>92.7</td>
<td>1,668</td>
<td>0</td>
<td>2,040</td>
<td>-372</td>
</tr>
<tr>
<td>North Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juneau</td>
<td>327,934</td>
<td>353,000</td>
<td>92.9</td>
<td>337,785</td>
<td>-9,851</td>
<td>372,700</td>
<td>-44,766</td>
</tr>
<tr>
<td>West Central Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitka</td>
<td>98,832</td>
<td>115,700</td>
<td>85.4</td>
<td>99,205</td>
<td>-373</td>
<td>109,560</td>
<td>-10,728</td>
</tr>
<tr>
<td>Tyee-Swan Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrangell + Petersburg</td>
<td>66,452</td>
<td>131,000</td>
<td>50.7</td>
<td>67,386</td>
<td>-934</td>
<td>72,300</td>
<td>-5,848</td>
</tr>
<tr>
<td>Ketchikan</td>
<td>140,684</td>
<td>139,300</td>
<td>101.0</td>
<td>153,972</td>
<td>-13,288</td>
<td>169,900</td>
<td>-29,216</td>
</tr>
<tr>
<td>Metlakatla</td>
<td>14,356</td>
<td>25,045</td>
<td>57.3</td>
<td>14,356</td>
<td>0</td>
<td>15,870</td>
<td>-1,514</td>
</tr>
<tr>
<td>Prince of Wales Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craig/ Klawock/ Thorne Bay/ Kasaan</td>
<td>19,992</td>
<td>22,000</td>
<td>90.9</td>
<td>23,279</td>
<td>-3,287</td>
<td>27,020</td>
<td>-7,028</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>692,165</td>
<td>811,045</td>
<td>83</td>
<td>721,265</td>
<td>-29,100</td>
<td>795,480</td>
<td>-103,315</td>
</tr>
</tbody>
</table>
3. GENERAL TRENDS OF CLIMATE IN SOUTHEAST ALASKA OVER THE 20TH CENTURY

Like many places in Alaska and the far North, long-term records of climate and hydrology in Southeast are sparse. The National Climate Data Center publishes a quality-controlled monthly climatological product that includes nine weather stations in Southeast, which were used for this study: Annette Island, Annex Creek, Gustavus, Haines, Juneau, Ketchikan, Little Port Walter, Sitka-Japonski, and Wrangell. These stations are primarily located at airports. The earliest of these records starts in 1922. There are older stations in the region, including Sitka’s Magnetic Observatory, but they are either no longer in operation (such as in Sitka), were moved, have operated for only a short period, or have some other inconsistency in their record.

Long-term records of river discharge in Southeast are even more sparse. For this reason, all available gage records were analyzed, even where records are short. These include the following stations: Alsek River (near Yakutat), Antler River, Fish Creek (near Ketchikan), Kakuhan Creek (near Haines), Mendenhall River and Montana Creek (both near Juneau’s Auke Bay), Situk River (near Yakutat), Staney Creek (near Klawock), Stikine River (near Wrangell), Taiya River (near Skagway), Taku River (near Juneau), and Upper Earl West Creek (near Wrangell). A map of hydrology and climate stations is shown in Figure 1.

Several key parameters are explored in detail, while the summary of variables is shown in Table 2. The annual time series of mean temperatures at the climate stations shows considerable variability between sites and strong interannual variability over time (Figure 2a). If the long-term station mean is subtracted from each station, the results are station anomalies that are more easily compared (Figure 2b). Not only does interannual variability look consistent between stations, but it is easier to see long-term trends over the whole record, as well as distinct decadal-scale swings in temperature. The overall station mean is shown in heavy black. The trend line (using a least-squares method) is also shown in heavy black. The record for the Sitka station and its trend are shown in red. The mean trend from the 1920s to the

FIGURE 1: locations for climate (black) and hydrologic (red) stations in Southeast Alaska (inset). The Sitka station is shown in green and will be described as a case study.
present is approximately 0.45 °C of warming. If the trend analysis is started in the cool part of the 1940s, as it is for Sitka, the trend looks more like 1.7 °C. The trend at Sitka since mid-century is representative of other stations since that time.

FIGURE 2a

FIGURE 2b

FIGURE 2: (a) shows time series of annual mean temperatures (raw values) and the all station mean (black). Black and red lines show least-squares trend for all stations and Sitka, respectively. (b) Same as for (a) but for the anomalies, i.e. each station’s long-term mean has been subtracted from its record.
Analysis similar to that of average daily temperature is performed for all of the station data by season and for the following variables: daily minimum and maximum temperatures, precipitation, maximum snow depth, and discharge. The results are summarized in Table 2. Winter is defined as December-February, spring is March-May, summer is June-August, and autumn is Sept-November. This trend analysis was conducted on both raw data and the anomalies. The raw data trends are shown in the tables below. If the trend in the anomaly differs in sign from that of the raw data, the numbers are shown in italic. This suggests that those trends are sensitive to changes in the number of stations over time and may not be statistically robust. A Student’s T-test is performed to determine statistical significance at the 0.05 level.

Several interesting results emerge from the trend analysis. Winter is warming: moderately since the 1920s and strongly since the 1940s. In spring, summer, and autumn, daily minimum temperatures have increased since 1920, while daily maximum temperatures have actually cooled. This asymmetry in temperature changes has been noted globally and is generally attributed to global changes in cloud cover (Karl et al., 1993).
Another key finding from the observations is that annual precipitation, snowfall, and daily maximum snow depth have all declined, but that only some of these trends (precipitation and snowfall since 1920 and maximum snow depth since 1940) are statistically significant. Spring precipitation and snow depth have decreased since both the 1920s and 1940s, while autumn has grown drier since the 1920s but slightly wetter since the 1940s (although this increase in precipitation is not statistically significant). Some of the precipitation trends since the 1920s switch signs if the anomalies are considered instead of the raw data. This suggests that short or discontinuous station records, coupled with high variability in the measurements, affect the statistical robustness of these trends.

One key temperature change affecting hydroelectric power is the winter daily temperature minimum, as it directly influences the amount of precipitation that falls as rain versus snow, having major implications for storage. Hydropower watersheds in Southeast tend to store snow starting in late autumn through spring, but this is dependent on the temperature at higher elevations. The average daily temperature minimum in winter has increased in Southeast Alaska by approximately 1.5 °C since 1920 and closer to 3.2 °C since the late 1940s, as seen in the anomalies (Figure 3b). The raw values show that these stations (at sea level, Figure 3a) are very close to the freezing point throughout the winter, such that a warming of 1-2 degrees can often change the phase of precipitation from frozen to
This winter warming is also likely to increase the number of rain on snow events, which can lead to snow melt and an increase in mid-winter reservoir levels.

This sensitivity to changes near the freezing point can be seen in the daily snow maximum data in Figure 4. It is important to remember that while the temperature, precipitation, and snow depth are measured near sea level, where snow rarely falls, the mountain air cools with elevation and the winter snow pack is far deeper in the watersheds feeding the hydropower facilities. Unfortunately, few long-term records of snow pack or temperature at elevation exist in Southeast. The best estimate (used, for example, by the National Weather Service’s River Forecast Center) of conditions in the mountains is to assume a standard lapse rate (change in temperature with height) or to use a dynamical weather model to estimate lapse rates that are dictated by synoptic events.

Precipitation, of course, is the primary factor determining the supply of hydropower. The sector is sensitive to the total annual precipitation, as well as both the timing and amount in spring, when reservoir levels are low and awaiting recharge from snowmelt. Total precipitation for Southeast stations shows statistically significant decreases over the twentieth century on average (Figure 5), autumn, and for spring (Figure 6). In the Sitka records, slight increases in precipitation are shown during autumn and winter since 1948, and decreases during the other seasons. Because of weak trends and strong interannual variability, none of the Sitka trends are statistically significant. The trend of the anomalies

\[ \text{FIGURE 4: raw values for maximum winter snow depth at the stations typically located at sea-level airports. Multi-station means and trends lines are like those in the preceding figures.} \]
versus the raw data values shows the strong effect of station record inhomogeneity (i.e. inconsistency) here. Compared to temperature changes, precipitation changes are far less robust. The long-term variability appears to be largely dictated by decadal-scale swings in precipitation ‘regime’, the cause of which will be discussed in more detail below.

**FIGURE 5a**

**FIGURE 5b**

**FIGURE 5:** (a) raw values for annual means of monthly precipitation totals and (b) the corresponding anomalies. Multi-station means and trends lines are like those in the preceding figures.
FIGURE 6a

FIGURE 6b

FIGURE 6: (a) raw values for spring means of monthly precipitation totals and (b) the corresponding anomalies. Multi-station means and trends lines are like those in the preceding figures.
Increases in autumn precipitation, since the 1940s, have implications for these changes in storage and spill. Autumn is a time when reservoirs such as the Blue Lake in Sitka are already full to capacity because rainfall is plentiful. Additional precipitation at this time, if it falls as a liquid, cannot necessarily be stored for use in the winter or spring. If the lake levels exceed the reservoir capacity, and there is not enough power demanded or no additional turbines to turn on, the water is simply spilled, without being used to generate power. The typical surplus of water this time of year is one reason Sitka and other utilities are planning to raise the height of their dam and thereby increase storage capacity.

Unfortunately, there are too few accurate measurements of evapotranspiration in Southeast to analyze here. In general, atmospheric warming is associated with increased evaporation. The construction of reservoirs can also lead to increased evaporation, although the evaporative potential is less in an already moist climate such as the one in Southeast. The long-term changes in evapotranspiration associated with vegetation are more complex, as they involve changes in the growing seasons length, vegetation type, fire frequency, and forestry. Kelley et al. (2007) summarize a number of studies of climate-driven changes to vegetation in Southeast Alaska, but do not discuss the impact on evapotranspiration. With few historical measurements, any future projections are highly uncertain.

River discharge data were analyzed like the climate data, but raw discharge and seasonal and annual anomalies were calculated for specific discharge (i.e. divided by the drainage area for the river). This makes it easier to compare trends between watersheds of considerably different sizes. The long-term trends for specific discharge are shown in Table 3, but only for three stations: the Fish Creek (near Ketchikan), because it is the only continuous, long-term record in Southeast Alaska, the Stikine (a large, glacial dominated river gaged near Wrangell), and the Mendenhall River (near Auke Bay in Juneau). Fish Creek is a small (83.1 km²) drainage with a relatively small glacial melt contribution to discharge. The Mendenhall is also small (220.4 km²) but has a large glacial contribution to runoff. The Stikine is a large glacial-dominated watershed (51,592.8 km²) which originates in Canada and

FIGURE 7: Annual specific discharge for two continuous records in Southeast Alaska. Trends are shown for Fish Creek for the whole period, as well as for the period for which that record overlaps with the record at Mendenhall.
where gaging began in 1976. The record at Fish Creek started in 1915 and Mendenhall record started in 1965. Annual discharge for the common period of the Fish Creek and Mendenhall records is similar: discharge has increased, as shown in Figure 7. In contrast, longer-term record at Fish Creek and the shorter-term record at Stikine both show a decrease in annual discharge. Few of the trends in the discharge records are statistically significant, according to the Student’s T-test, however. The most robust results for discharge show increases in winter, which suggest impacts of air temperature warming such as precipitation phase change, a decline in snowpack storage in lieu of rainfall runoff, and possibly rain on snow. These observed changes in winter are unlikely to be related to changes in glaciers. Changes in other seasons are not statistically significant due to the large interannual variability. Attribution of observed trends to glacial processes requires a more in depth study than is possible here. Neal et al. (2010) suggest that 10% of total freshwater discharge into the Gulf of Alaska is associated with glacier volume loss.

TABLE 3: trends in discharge per decade for all seasons and various rivers. Negative trends are coded in brown to denote decreasing discharge and positive trends are coded with green to denote increasing discharge. Trends underlined are significant at the 0.05 level.

<table>
<thead>
<tr>
<th>OBSERVED HISTORICAL TRENDS (((M$^3$/sec)/km$^2$)/decade): DISCHARGE</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish (1915-2007)</td>
<td>1.38E-03</td>
<td>-9.14E-05</td>
<td>-2.03E-04</td>
<td>-2.68E-03</td>
<td>-3.91E-04</td>
</tr>
<tr>
<td>Fish (1965-2008)</td>
<td>9.01E-03</td>
<td>-8.05E-05</td>
<td>-1.00E-03</td>
<td>-1.71E-03</td>
<td>1.38E-03</td>
</tr>
<tr>
<td>Stikine (1976-2008)</td>
<td>3.98E-05</td>
<td>2.55E-05</td>
<td>-2.28E-04</td>
<td>-1.83E-03</td>
<td>-2.90E-04</td>
</tr>
<tr>
<td>Mendenhall (1965-2008)</td>
<td>2.39E-03</td>
<td>9.86E-04</td>
<td>-2.70E-03</td>
<td>4.27E-03</td>
<td>9.09E-04</td>
</tr>
</tbody>
</table>

4. GENERAL PATTERNS OF CLIMATE VARIABILITY IN SOUTHEAST ALASKA

As mentioned above, Southeast Alaska is strongly influenced by large-scale modes of climate variability in the Pacific sector. These ‘modes’ such as the Pacific Decadal Oscillation (PDO) and the El Nino-Southern Oscillation (ENSO) have distinct patterns in time and space that help drive temperature, precipitation, and wind anomalies. These two modes of variability in the ocean-atmosphere system have similar spatial patterns, but while the PDO varies on a temporal scale of a decade or longer, ENSO tends to vary more on a scale of 2-4 years. Figure 8 shows the typical sea surface temperature anomalies associated with a positive PDO event, as well as the PDO and ENSO indices. The PDO index is determined using a statistical technique known as Principal Component Analysis. The leading principal component of North Pacific monthly sea surface temperature, poleward of 20°N, is used to define the index (JISAO, 2010), and simply represents the leading pattern of variability. The ENSO index shown here is known as the Nino 3.4 index, which is based on the sea surface temperature anomalies in the equatorial Pacific, from 120°W-170°W and 5°N-5°S. In Alaska, warm events (both PDO and ENSO) tend to be paired with winds blowing from South to North, bringing in warm, moist air from
lower latitudes. In Southeast, the PDO tends to have a much stronger effect on temperatures than ENSO. Papineau (2001) and Bond and Harrison (2006) explore the larger influence of these and other climate modes over the entire state.

FIGURE 8: the Pacific Decadal Oscillation’s pattern in space (a, b) and time (c), as well as the El Niño Southern Oscillation’s pattern in time (d). The PDO index is defined using the principal component of North Pacific monthly sea surface temperature variability, as described in the text. The units in the top panel are anomalies in degrees C. Figures are reproduced from JISAO, 2010.
Composite analysis was used to examine the influence of the PDO and ENSO modes on climate of Southeast. Climatologies were constructed for stations based on the whole period of record, as well as the average (composite) of the 10 strongest PDO positive years and 10 strongest PDO negative years, defined by the index’s average winter values. A composite was also constructed based on the Nino-3.4 index for ENSO. The impacts of the PDO at Juneau, Ketchikan, and Sitka are shown in Figure 9. Changes induced by ENSO are very similar. The biggest temperature impacts in the region occur during winter. Juneau shows an 8 degree C warming during positive PDO in January relative to negative PDO events. Sitka shows a difference of 6 °C between positive and negative PDO.
PDO events, also in January. The impacts on precipitation are largest in autumn and winter, when a timing shift is obvious. Positive PDO events are associated with a dry anomaly in October, followed by a wet anomaly in November and again in January. The winter temperature anomalies associated with the PDO tend to push the average temperatures either above or below freezing, which impacts the snow climatology. Winter has significantly more snow during negative PDO events, suggesting the temperature effect dominates over the precipitation effect. Positive PDO events are associated with very low snow packs. Finally the result on discharge is somewhat different in glacier-dominated versus non-glacier dominated basins. Examples are shown for the Fish River (non-glacier dominated) versus the Mendenhall (glacier dominated). Both types of rivers have a discharge increase during winter in positive PDO events, but autumn has less discharge during positive events in the non-glacier dominated catchments and more discharge from the glaciated basins. Late summer/autumn melt in glacier-dominated catchments is shifted later in the negative PDO events, driven by increased rain, despite cooler air temperatures. Spring melt happens about a month earlier during positive PDO events, in part, because less of the winter precipitation arrived as snow and more of it as rain. Early onset of snowmelt is also driven by a warmer spring during positive PDO events.

One trend to be noted in Figure 8c is the high likelihood that the PDO is shifting back to a negative phase. While this trend may be countered by longer-term warming, it is still likely to have the sort of impacts shown in Figure 9, for Southeast: cooler winters with more precipitation arriving as snow instead of rain. The result is a delay in the availability of the water resource until the snow melts in the spring. The challenges to management may start even earlier, however. The increase in precipitation during a negative PDO occurs when the reservoir is already full in capacity limited systems such as Sitka's Blue and Green Lakes. The operator is already being forced to spill water without generating power during peak precipitation. By mid-winter, Southeast sees a large deficit of precipitation during a negative PDO, making it difficult to manage the spring dry season. This is a key finding of our study.

Longer-term warming may have an impact that more closely resembles a positive PDO event. Some climatologists have discussed the possibility of a 'permanent El Niño.' In both glaciated and non-glaciated basins positive PDO and warm El Niño events appear to have the impact of smoothing out the discharge over the course of the water year because less water is tied up in the snowpack, even though more precipitation arrives in winter. Southeast’s winter climatology is warm enough that liquid water will fall in lower elevations in some of these watersheds through December and beyond. Further implications of these changes on managing these water resources will be discussed after an examination of projected long-term climate changes in Southeast.
5. PROJECTIONS OF FUTURE CLIMATE IN SOUTHEAST ALASKA AND THEIR ROBUSTNESS

The Scenarios Network for Alaska Planning has provided a suite of climate projections for this analysis. From all fifteen models used in the Coupled Model Intercomparison Project (IPCC, 2007), five different climate models were selected for their fidelity in reproducing historical (1958-2000) surface air temperature, surface air pressure, and precipitation in Alaska. An ‘Intermediate’ future emissions scenario (A1B) was used to force these climate models, which were then downscaled to 2 km using a biased map statistical technique based on the 1961-1990 PRISM monthly climatologies (Simpson et al., 2005) for Alaska. More details are described at (http://www.snap.uaf.edu/about). Results are shown for the Southeast Alaska region only and slopes were calculated for the multi-model mean.

**FIGURE 10a**

**FIGURE 10b**

**FIGURE 10:** projected changes in mean annual (a) and winter (b) temperature from downscaled output of five climate models.
Like much of Alaska and the Far North, Southeast Alaska is projected to warm considerably by the end of the century (3-8 °C per model), with much of this warming concentrated in winter (4.6 °C multi-model mean), Figure 10. All five models are consistent in this result, with differences only in the rate of warming. Mean annual precipitation is expected to increase 30-50 percent by the end of century (Figure 11). Changes by season for both temperature and precipitation are shown in Table 4. These projections show considerable interannual variability. There are still cool and dry years projected. What is less evident is the strong decadal variability shown in the observed record. This may due to ‘missing physics’ in the models that underestimate thermal inertia and feedbacks in the climate system.

![FIGURE 11: projected trends in precipitation from downscaled output of five climate models.](image)

**TABLE 4:**

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees C per Decade</td>
<td>0.510</td>
<td>0.382</td>
<td>0.395</td>
<td>0.450</td>
<td>0.434</td>
</tr>
<tr>
<td>mm per Decade</td>
<td>2.939</td>
<td>1.214</td>
<td>1.931</td>
<td>2.613</td>
<td>2.174</td>
</tr>
</tbody>
</table>
A few inconsistencies emerge when comparing the historical trends and the projected trends. Historical trends in the climate models are shown in Table 5. Looking at the trends in historical precipitation, for example, long-term change in precipitation is not very robust and generally shows a decreasing trend. The trends in the mean raw station data are largely the statistical effect of new stations being installed, and then later, some stations missing data. The trends in the anomalies show a very slight increase in annual precipitation since 1920 and a slight decrease at Sitka since the 1940s. The spring anomalies show a slight decline in precipitation over both periods, showing a possible increasing vulnerability during the spring season, when reservoir levels are particularly low because the snowpack has just begun to melt. While the historical drying trends in the raw data are partly a statistical illusion, there is certainly no evidence of the large precipitation increases suggested in the climate projections. Similarly, long-term trends in the anomalies in maximum snow depth are also nearly flat. While temperatures have risen significantly, most of that warming is only since the 1940s. Over that same period snow depths have actually increased, while precipitation trends have been dominated by interannual variability.

TABLE 5:

MULTI-MODEL MEAN TRENDS IN TEMP, PRECIPITATION FOR THE HISTORICAL PERIOD 1980-2010

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees C per Decade</td>
<td>0.123</td>
<td>0.440</td>
<td>0.332</td>
<td>0.153</td>
<td>0.262</td>
</tr>
<tr>
<td>mm per Decade</td>
<td>3.432</td>
<td>1.303</td>
<td>0.809</td>
<td>-0.742</td>
<td>1.200</td>
</tr>
</tbody>
</table>

Some of these inconsistencies may point to shortcomings in the measurement of precipitation. Standard precipitation gages are subject to a whole host of undercatch biases caused by the shape of the gage itself and mechanical failures, etc. These biases tend to be largest for frozen and mixed precipitation, and mechanical failures are especially common during heavy, wet snowfalls. Snow depth can be a more reliable indicator of frozen precipitation changes. Another source of variability between precipitation stations in Southeast is the extreme topography. While all of the climate stations that were analyzed here are near sea level, their orientation on the windward or leeward side of fjord topography varies. Orographic and microclimate effects on precipitation are very large. Variability between temperature stations is far more consistent. This is another argument for enhanced monitoring in the region, especially of snowpack in the watersheds feeding reservoirs.

Does the downscaling process affect the historical fidelity of the model runs? The statistically based downscaling and bias correction method calibrated the projections to consistent, historical spatial patterns of temperature and precipitation, not long-term trends. These bias corrections are based on the same
station data that were analyzed here and suffer the same issues: almost no sampling at higher elevations. The PRISM model attempts to account for this deficiency by taking slope, elevation, and aspect into account via multivariate interpolations, but the results are largely unverifiable.

Another issue is that the climate models currently lack important feedbacks in the Southeast region, particularly the impact of temperature and precipitation changes on glacier mass balance. The majority of glaciers in Southeast Alaska are thought to be retreating (Arendt et al., 2002) suggesting that the temperature changes have lead to a decline in snow deposition on glaciers, despite an increase in precipitation. General circulation models also lack realistic vegetation responses to changes in climate. Measurements of evapotranspiration in Southeast are too sparse to analyze for regional variability over time. However, the feedbacks between climate change and vegetation change may be significant and will also impact the regional freshwater cycle.

6. DISCUSSION: IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON EXISTING AND FUTURE HYDROELECTRIC POWER FACILITIES

Several facts emerge from the above analysis. Natural climate variability has a strong impact on Southeast Alaska on both interannual and decadal time scales. Longer-term climate change is more difficult to detect, when looking at the anomalies of stations and accounting for the effect of inhomogeneous climate records when calculating trends. However, separating the effects of climate change and climate variability, while attributing observed changes to climate mechanisms to one or the other, may be difficult using only the sparse historical record and the current generation of climate models. The authors suggest that adaptation to climate change and variability could include enhanced monitoring of variables such as snow pack depth, snow water equivalent, precipitation, discharge, and temperature. A second useful tool may be use of short-term and seasonal hydrologic forecasting by the facility operators, particularly for delayed spring snowmelt during negative PDO and La Niña events for which models have moderate skill predicting one season in advance.

The Blue Lake and Green Lake facilities at Sitka will be used as an illustration. Figure 12 shows the capacity of the Sitka system, which started with the Blue Lake dam in 1961. The Green Lake dam came on line in 1982 and nearly doubled the system’s capacity. However, even at that time, the system remained ‘under powered’ in low precipitation years. Electricity from hydropower is supplemented with diesel-generated power to meet the local demand. Had climate data been thoroughly analyzed during project planning in the 1950s, it may have proved more cost effective to build the Blue Lake dam higher from the start. Currently, the municipality has begun the licensing process with the Federal Energy Regulatory Commission to raise the dam and add a third turbine, though demand was only slightly higher in the past five years than it was in the early 1980s. As Sitka
considers a completely new facility at Takatz Lake, it may be in their best interest to revise the estimates of energy generation in dry years, based on updated climate statistics that include recent warming and drought years. As these figures are based on precipitation near sea level, uncertainty could also be reduced by monitoring the snow pack properties in the elevated watersheds, using manual or automated instrumentation.

Historically, operators like those in Sitka may not have seen tremendous value in seasonal forecasting. Their system is capacity limited such that ‘when it’s full, we spill,’ and that’s that. However, the vision of the regional energy managers and the Alaska Energy Authority is to link the facilities of the region in a grid. As discussed above, several interties have already been built, and more are proposed. A grid system, like that in climatically similar Norway, makes it possible to take advantage of spatial variability in precipitation and runoff. If a community had plenty of supply, but not enough demand, power can still be generated and transmitted, instead of the water being spilled. Sitka is particularly isolated such that they may benefit more from expanding their current facilities and developing the Takatz Lake project.

Regardless, use of seasonal forecasting would help alert the operators to oncoming ENSO and PDO events. Use of seasonal forecasts must go hand in hand, however, with enhanced monitoring, so that the detailed impact of these modes of variability throughout the watersheds could be better understood. Figure 13 shows a plot of the discharge into Blue and Green Lakes versus the PDO index. There are so few data, it is difficult to establish a robust relationship between the two.
Figure 14 shows example output from a management software (CHEOPS Hydropower Operations Model, HDR Engineering, Inc.) used by the Sitka facility operators. The bars show the portion of the electrical load being met by hydropower generation at the Blue Lake and Green Lake facilities, and the portion being met by diesel generation. One of the inputs to the model is inflow and other hydrologic variables from a typical year. As seen in Figure 13, measured or estimated inflows have not been observed consistently over the multitude of different climate conditions in Southeast Alaska. The model would be even more accurate if, for example, data from the predicted ‘type’ of hydrologic year (i.e. La Niña or negative PDO event) were ingested, rather than an arbitrary past hydrologic year.

FIGURE 13: inflow into the Blue Lake and Green Lake reservoirs in the Sitka system versus the PDO index.
In summary, as hydroelectric capacity grows in Southeast Alaska and the system grows increasingly interconnected along a physical grid, the region will have more options for managing climate risk. These options will require more extensive monitoring of snow water resources, particularly at elevation in the watersheds feeding the reservoirs. Without knowledge of snow water equivalent, for example, it is impossible to verify a synoptic scale or season-ahead hydrologic model. What operators can use now, however, are the seasonal forecasting products from the National Oceanic and Atmospheric Administration’s Climate Prediction Center (http://www.cpc.noaa.gov/) and the International Research Institute for Climate and Society (http://portal.iri.columbia.edu). For the relatively small cost of reservoir inflow measurements, a robust relationship between inflow and the modes of variability such as ENSO and the PDO might be established, which would give operators specific information on what to anticipate when a particular climate event is established. Another value to enhanced long-term climate monitoring would be that the changes of complex features such as glaciers and their impact on local hydrology could be better estimated.

This study is followed by a brief outline, or template, describing the procedure that was used to assess the impacts of climate variability and change on hydroelectric power in Southeast Alaska (Appendix). This template may provide useful guidance to others embarking on similar climate impact studies.
7. APPENDIX: TEMPLATE FOR CLIMATE PROJECTION STUDIES

The following procedure was used to assess the impacts of climate change and variability on hydropower in Southeast Alaska.

a. *We identified the socio-economic system of interest* (Hydro-electric power in Southeast) *and assessed the availability of quantitative measures of impacts* (sparse reservoir inflow data, sparse time series of power generation data).

b. *We identified which underlying components of the climate system were relevant for the study of impacts.* In this case, it was the hydrologic system, the atmosphere-ocean system, glaciers, and changes in evapotranspiration that might relate to climate and anthropogenically-forced changes in the biosphere.

c. *These components were assessed for availability of quantitative data.* Weather station data, gage records, and large-scale climate indices are available. What were not readily available were long-term measurements of stream flow into the reservoirs in Sitka, consistent measurements of evapotranspiration, any time series of the glacial contributions to river discharge, or definitive estimates of how changes in climate, fire, and logging have impacted regional biosphere-hydrology interactions.

d. *We assessed the need for pre-processing station data.* In this case, we decided against creating mean areal temperature, precipitation, and other climate variables from the station data because of the sparseness of observations, the extreme fjord topography, and systematic sampling biases (only observations near sea level). Anomalies were calculated for each variable and each season.

e. *Climate model projections were obtained for the period of interest* (100 years in this example) *and a subset of models were chosen because they represented fidelity to observed climatologies.* One or more emissions scenarios may be chosen to represent one source of uncertainty. In our example the effort to select a subset of models was done in advance by the Scenarios Network for Alaska Planning. We only worked with a single emissions scenario because we ascertained that the uncertainty associated with emissions may be modest relative to other sources of uncertainty.

f. *The model output was downscaled to a grid cell size closer to the area ‘sampled’ by the weather stations.* In this case the model output was downscaled to 2 km. For looking at regional trends, downscaling may not be necessary. In this study, downscaling made it possible to separate changes over land and the ocean more precisely. Normally, a climate model grid cell in a coastal region might straddle both the land and water, leading to errors in the interpretation of modeled change.

g. *We analyzed whether or not the historical data show statistically significant trends and how those are affected by inhomogeneities in station records.* We used Student’s T-tests on the slope of the historical records over two
different time periods (1920s to present and 1940s to present) and compared these to the slopes of the anomalies.

h. We performed correlation analysis between seasonal hydroclimate variables and climate indices. We found direct correlations to be weak, but that the number of independent samples of ‘Pacific Decadal Oscillation negative events’, for example, was very few; the climate system has a strong persistence (i.e. autocorrelation) on very long time scales as well as strong interannual variability.

i. Composite analysis (averaging over a subset of years during particular climate mode phases) made it possible to attribute month-to-month changes in some fields to natural climate variability. Our analysis was performed with El Nino-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) indices.

j. The scales of long-term trends were compared to those driven by natural modes of variability. In our study, this was the best form of attribution that could be achieved robustly, given the limitation of our datasets.

k. We analyzed the trends in the historical period in the climate projections and compared those to the station observations. Few observational data are included in the climate runs, so the magnitudes of fields such as temperature and precipitation are unlikely to match those of the historical observations. The trends, however, should ideally be similar. If they are not, this introduces further uncertainty into the analysis.

l. We analyzed the trends in the climate models future projections and discussed some of the underlying climate physics that explain these trends. The climate projections are consistent with historical trends for some variables (temperature) but not others (precipitation). Because hydropower is so strongly tied to precipitation, the impacts of long-term climate change are highly uncertain. The impacts of interannual to decadal climate variability are more clearly understood.

m. We met with some of the stakeholders and ascertained how the results of our study could be used to inform decision-making. It was clear that hydropower facility operators could benefit from more extensive use of seasonal forecasting and knowledge of large-scale modes of climate variability.

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National Climate Data Center: http://www.ncdc.noaa.gov.


Contributors

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Seasonal Ice Zone Observing Network (SIZONET)
Barrow Arctic Science Consortium (BASC)
NOAA and the National Weather Service (NWS) Ice Desk
Nuna Technologies
Barrow Area Information Database (BAID)
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**Introduction**

As Alaska’s Arctic coasts experience some of the most rapid and dramatic change in the sea-ice and coastal regime anywhere in the Arctic, local and state governments and other stakeholders are increasingly forced to make difficult decisions related to a range of activities that are impacted by sea ice, including subsistence hunting and offshore development. Such decisions, including those related to permitting and other oversight functions, require environmental datasets that are often not easily accessible, digestible or immediately relevant.

This manual’s purpose is to improve the availability of current information about sea ice from operational and academic observation programs to key user groups. The goal is to provide Arctic Alaska coastal community leaders and local user groups with an up-to-date, comprehensive, and practical guide to sea-ice and climate information resources that are relevant to their planning, subsistence activities, and way of life.

This manual is a result of a previously held Sea Ice Information Workshop in Barrow in November 2008 sponsored by the Alaska Center for Climate Assessment and Policy (ACCAP), the Seasonal Ice Zone Observing Network (SIZONet), and the Barrow Arctic Science Consortium (BASC).

This information is current as of July 2010. We anticipate the information will evolve over time and will do our best to keep the manual updated. If you notice an outdated section or would like to suggest a resource to include in the next update, please contact ACCAP at 907-474-7812 or accap@uaf.edu.
How to use this manual

The individual resources in this manual are organized within five main types of sea ice information. These are:

1. Sea ice concentration, extent, and type;
2. Location and extent of multi-year sea ice;
3. Sea ice leads, open water, and shorefast ice extent;
4. Local sea ice observatories at Barrow and Wales, Alaska; and
5. Sea ice summaries.

Each resource under these different types of information has a short list of instructions. Often included after the instructions is a brief list of “tips for interpretation” that should be used to properly interpret the information presented. The instructions for some resources are more detailed than others.

Some resources may be useful for people interested in real-time or at least current-season conditions (for example, hunters and travelers). Other resources may be useful for people interested in either (1) past and historic conditions or (2) lager scale patterns that don't vary too much from year to year. This may apply to people in planning. The MMS Leads Project, for example, presents information on reoccurring lead patterns that haven't changed much over the years, especially in comparison to other variables like the timing of fall freeze-up. During the ACCAP sea ice workshop there were a number of people that were interested in past conditions. To place current conditions into a "change" context, we need to know what things where like in the past, which is why we included these resources.

We have tried to provide enough instruction so that you are able to begin to explore these resources. However, we have also tried to keep the content somewhat brief so that the material can be easily updated as websites change.

If you are interested in datasets that can be placed in a Geographic Information Systems (GIS), such as by using ArcGIS software, look for the label “ ►GIS Users” throughout the manual to help direct you toward these resources. Likewise, those interested in products that can be viewed in Google Earth should look for “ ►Google Earth Users”.

Many websites highlighted in this manual require repeated visits to become familiar with their various tools before they can be efficiently used. We recommend visiting the websites in this manual and saving these to your “favorites” so that you can easily return at a later date.
Main Types of Sea Ice Information

Sea Ice Concentration, Extent, and Type

Sea ice concentration and extent describe how sea ice is distributed across a region. In general, reductions in sea ice extent represent one of the most significant changes in Arctic sea ice, which is related to climate as well as to other factors, such as ice dynamics. Ice type and concentration help to assess how mobile an ice pack may be. For example, thin first year ice of low concentration is moved much easier with changes in wind or current than thicker ice of high concentration. These factors may important when activities require information about boating amongst drift ice or when looking for open water. Ice type and concentration are also directly related to the size of forces that the ice can deliver to other objects, such as shorefast ice, ships, or offshore structures.

This section presents resources for sea ice concentration, extent, and type from the following:

1. National Ice Center (NIC)
2. National Weather Service (NWS) Ice Desk
3. National Snow and Ice Data Center (NSIDC)
4. National Center for Environmental Prediction (NCEP)
National Ice Center (NIC)
http://www.natice.noaa.gov/

You will find an interactive display of current daily and weekly products of sea ice concentration, extent, and type produced by the National Ice Center (NIC).

Sample NIC ice chart in the interactive display.

**Instructions:**

1. Click on the above web address. This will take you to the main page of the National Ice Center.

2. Click on “low bandwidth pages”.

3. On the top menu, click on “Products”.

4. For simple access to ice analysis archive, click on “Products on Demand”. Here you will see an interactive map of the Arctic with the current day’s ice extent shown as default. *This will require a faster internet connection.*

5. The “Navigation” panel on the left allows you to zoom to a specific region of interest. For example, you can choose to zoom to the Beaufort or Chukchi Seas. The “Navigation” panel also allows you to zoom in and out and to rotate the map. (You can also zoom in and out by rolling your mouse’s wheel if you have one.)

6. The Product Selection panel in the middle allows you to select which product you would like to view. Select a product from the drop down list to view, such as “Arctic Daily” or “Arctic Weekly”. In general, the weekly products provide more detailed information.
7. The “Tools” panel allows you to select the date you want, view the legend, or print the map.

8. In the “Tools” panel, you can also view ice attributes for individual ice areas. To display the attributes, click an ice area on the map. Displayed for each area selected is both the Egg Code (see the special section in the appendix for interpreting this code) and the area coverage in square km.

9. ►GIS Users: In the “Tools” panel, you can also select to download the data in Shapefile or Personal Geodatabase format.
National Weather Service Ice Desk  
http://pafc.arh.noaa.gov/ice.php

The Anchorage forecast office produces graphic analyses for Alaska of sea ice as well as five day sea ice forecasts year round. Scheduled sea ice analyses and 5-day sea ice forecasts are produced Monday, Wednesday and Friday.

Sample images of a standard ice chart (left) and of the experimental Google Map ice chart (right).

Instructions:

1. Click on the above web address. This will take you to the main page of the National Weather Service Ice Desk.

2. Located on this page are two relevant products for Alaska’s Beaufort, Chukchi, and Bering Seas. These are a “Sea Ice Analysis” for the current day and a “Five Day Sea Ice Forecast”.

   a. Click on either “Sea Ice Analysis” or “Five Day Sea Ice Forecast” to see either map in its own window. Maps can be saved by right clicking on the image and choosing to “Save image as…” a PNG file, which is a standard type of image file.

3. At the top of the main page, there is a link to the New Experimental Ice Map graphics using Google Maps.

   a. Click on “Ice Map” to view the current day’s ice map in an interactive window. Click on the colors or areas you are interested in to view the pan thickness of the sea ice.

   b. **GIS and Google Earth Users:** On the right side of the window, you can download the current ice map as a Google Earth KMZ file or access KMZ and shapefiles for earlier dates.
Tips for interpretation:

- To interpret these maps you must be familiar with the National Ice Center’s “Egg Code.” Please see the special section in the appendix for interpreting the Egg Code.
Sea Ice Index at the National Snow and Ice Data Center (NSIDC)
http://nsidc.org/data/seaice_index/

Here you can find daily images of sea ice concentration, extent, and ice type developed from passive microwave satellites.

![Sample sea ice concentration image.](image)

**Instructions:**

1. Click on the above web address to visit the NSIDC’s Sea Ice Index Page.

2. Here, you will find images of daily or monthly average sea ice concentration and extent in the Arctic.

3. In the center menu, you can choose between daily or monthly results and between extent or concentration (more detailed information).

4. On the far right bottom side of the window, you can click “Archived Data and Images” to access older images of monthly sea ice extent.

   a. You can access older images of sea ice extent and concentration by clicking “Get Extent and Concentration Images”.

      i. You will be transferred to a page where you first have to select the folder for the month you are interest in.

      ii. Next, you must select the PNG image file for the year you are interested in.
1. Files that begin with an N are for the Arctic and files that begin with an S are for the Antarctic.

2. The first four numbers in the file name represent the year.

3. For sea ice extent, choose the files with “extn” in the file name, and for sea ice concentration, choose the files with “conc” in the file name.

b. ►GIS Users: Click “Get GIS Compatible Files” to access shapefiles of older images of sea ice extent and concentration

   i. You will be transferred to a page where you first have to select the folder for the month you are interest in.

   ii. Next, select the “shp_extent” folder for the maximum monthly sea ice extent.

   iii. Next, you must select the zip file for the year you are interested in.

1. Files that contain an N are for the Arctic and files that contain an S are for the Antarctic.

2. The first four numbers in the file name represent the year.

**Tips for interpretation:**

- Extent images show the total area of ocean covered with at least 15% ice.
- Concentration images show varying degrees of ice coverage, from 15 to 100%.
- Monthly images show trends in sea ice concentration and extent better than daily images.
National Center for Environmental Prediction (NCEP)
http://polar.ncep.noaa.gov/seaice/Analyses.html

Daily sea ice concentration maps, developed from passive microwave satellites, can be found here.

Sample sea ice concentration map.

Instructions:

1. Click on the above web address to visit the NCEP Sea Ice Analysis Page (The title of the page will say “MMAB Sea Ice Analysis Page”).

2. Under “Current High Resolution Ice Analyses”, select “Northern Hemisphere.” This will show one high resolution image of sea ice concentration.
   
   a. The map can be saved by right clicking on the image with your mouse and choosing to “Save image as…” a GIF file, which is a standard type of image file.

3. Under “Lower (25.4 km) Resolution Current Ice”, select “Northern Hemisphere.” This will show a series of lower resolution images of sea ice concentration.
   
   a. On these maps, you can click on a point on the map to get a magnified view of ice in that vicinity.
**Tips for interpretation:**

- The image displays ice concentration. Special colors are pink ('no data'), gray (too close to land for reliable ice concentrations), and black (land). Red indicates low concentration while blues indicate higher ice concentrations. The color bar on the web page gives the full description of the percentages.

- Things other than ice can sometimes show up as ice, even though NASA tries to avoid this. This includes high seas and heavy rains. There is a filter which removes most of this contamination from the ice field, but it is not always effective. In the summer, the puddles of water which can form on the surface of ice floes can lead to an underestimation of total ice concentration.
**Location and Extent of Multi-Year Sea Ice**

Multi-year sea ice (*piqaluyaq* in Iñupiaq) is ice that has survived at least two summers without disappearing. It is the low salt concentration in multi-year sea ice that allows certain satellite sensors to distinguish multi-year ice from first-year ice. (Second year ice, or ice that has survived only one summer of melt, is “multi-year” ice too, but does not yet have the pronounced salt-free properties that allow it to be easily noticed in most satellite imagery.)

The location of the multi-year ice, whether it is the main ice pack or drifting broken ice beyond the edge of the pack, may be of interest throughout the entire year.

- In summer, the coverage of the pack ice in the Arctic Ocean shrinks as ice melts and ice drift brings the edge further north and away from Alaska’s northern coastline. In general, the further the main pack ice is from the coast, the less likely a boater is to encounter drift ice in the coastal waters off Alaska.
- In late-September, the coverage of the pack ice is at its minimum. The majority of scientific studies that show shrinking of the polar pack ice use the late-September coverage as their measurement. With the satellite record, which goes back to 1979, scientists have seen a reduction in summer extent of about 10% every 10 years. The largest decrease in late summer ice coverage has taken place in the waters north of Alaska.
- In fall and early winter, the closer the multi-year ice is to the coast, the more likely that multi-year ice floes will become a part of the shorefast ice along the coast. These floes can both make the shorefast ice more stable since they often ground to the sea floor, and provide a preferred source of drinking water for hunters and communities.
- Throughout the winter and spring, multi-year ice near the coast is mixed with ice of all different ages and thicknesses. However, drifting ice that is composed of mostly multi-year ice drifts with a lot more momentum and doesn’t change course with shifting winds and currents as easily as thinner younger ice. Also, this heavier ice can collide with the shorefast ice with a lot of force.

This section presents resources for the location and extent of multi-year ice from the following:

1. **NSIDC’s Easy-to-Use Data Products**
2. **QuickSCAT satellite imagery**
NSIDC’s Easy-to-Use Data Products
http://nsidc.org/data/easytouse.html

Here one can view National Ice Center weekly ice charts up until 2007 interactively using a tool produced by the National Snow and Ice Data Center. This resource allows you to look at the multi-year ice coverage and concentration for any given year, and is also a great tool for looking at year-to-year comparisons. (Many other types of information are also available here, but are not specifically discussed since they are already covered by the other resources discussed in this manual.)

Sample image of multi-year ice coverage from September 24, 2007.

Instructions:

1. Click on the above web address to access the NSIDC’s easy-to-use data products page.

2. In the table under the heading of “Sea Ice”, click “National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format”.

3. Click “Browse Images” to be directed to the interactive tool.

4. In the drop-down menu titled “Look at spreadsheet for” near the top of the page, select “National Ice Center: Weekly Chart Products”, and then click the “Go!” button.
5. Using the drop down menus in the table, you can look at concentrations for multi-year ice, total ice, first year ice, and thin ice for any year between 1972 and 2007. Note that data is missing for some years.

a. Use the “Control Panel” in the top left to set the scale, number of rows, and number of columns. You must click the “Refresh” button for your changes to be made. (You can compare different types of ice concentrations by using multiple columns, and you can compare different dates using multiple rows.)

b. Choose the year and week of interest in the drop down menu for each row, and choose the map of interest for year column. You must again click the “Refresh” button for your changes to be made.

c. Any image can be saved by right clicking on the image and choosing to “Save image as…” a GIF file, which is a standard type of image file.
Ocean and Sea Ice Satellite Application Facility (OSI SAF)
http://saf.met.no/p/ice/

Here one can find daily images of multi-year ice coverage in the Arctic. The concentration product produced by the European Space Agency is currently based on Special Sensor Microwave Imager (SSM/I) passive microwave data and a radar scatterometer (similar to QuikScat).

<table>
<thead>
<tr>
<th>OPERATIONAL</th>
<th>Global Sea Ice Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>OSI-403: Sea Ice Type Maps on 10 km Polar Stereographic Grid</td>
</tr>
<tr>
<td>Description</td>
<td>The sea ice type product from the EUNETSAT OSI SAF. Ice classes are assigned from atmospherically corrected SSM/I brightness temperatures and ASCAT backscatter values, using a Bayesian approach. It is operational since 2005. &gt;&gt; access more details</td>
</tr>
<tr>
<td>Data used</td>
<td>SSM/I (DMSP F15), ASCAT (Haitop-A), ECMWF forecast for atmospheric correction</td>
</tr>
<tr>
<td>Formats</td>
<td>HDF5, NetCDF, GRIB</td>
</tr>
<tr>
<td>NRT access</td>
<td>FTP (last 31 days in HDF5 and GRIB), EUNETCast (GRIB) and alternative FTP (NetCDF)</td>
</tr>
<tr>
<td>Archive</td>
<td>FTP (since 2005) and UNARF</td>
</tr>
<tr>
<td>Documentation</td>
<td>Product User’s Manual</td>
</tr>
<tr>
<td>Links</td>
<td>Quicklooks NH, Quicklooks SH, Validation &amp; monitoring</td>
</tr>
<tr>
<td>Remarks</td>
<td>Note that during Arctic summer season (May-September) the ice type product is dubious because melting of the ice surface obscures the ice type signals.</td>
</tr>
</tbody>
</table>

Instructions:

1. Click on the above web address.

2. Scroll down the page until you see the section titled “Global Sea Ice Types” under the purple heading, as shown in the above image.

3. Note that the dates on the images are written in the format of day-month-year (for example, 16.07.2010 is July 16, 2010.)

4. Click on one of the individual images to enlarge it in a new window. Note the legend on the right side. Multi-year ice is shown as white and first year ice is shown as grey.

5. Images can be saved by right clicking on the image and choosing to “Save image as…” a JPG file.
**Sea Ice Leads, Open Water, and Shorefast Ice Extent**

Sea ice leads are important for a number of reasons. They are indicative of regional and pan-arctic scale sea ice dynamics. They are also important biologically and provide a corridor and habitat for marine mammals. Similarly, shorefast ice provides an environment for human travel and hunting. Shorefast ice also provides a buffer between either drifting ice and the beach or ocean waves and the beach. Therefore, shorefast ice is important for coastal erosion.

This section presents resources for sea ice leads, open water, and shorefast ice extent from the following:

1. Geographic Information Network of Alaska’s SwathViewer
2. Barrow Area Information Database (BAID)
3. MMS leads and landfast ice project
Geographic Information Network of Alaska (GINA)’s SwathViewer
http://sv.gina.alaska.edu/

This resource provides access to a range of satellite images that provide information about sea ice leads, open water, and shorefast ice extent.

Instructions:

1. Click on the above web address. This will take you to a welcome page, which should then cause the main SwathViewer page to open. If it doesn’t immediately open, hit the “Click here to launch Swath Viewer” box. Macintosh users: Safari seems to work best. Sometimes Firefox or Internet Explorer won't work.

The welcome page shown here, states if it doesn't load you may need to download a newer version of Java (free) from http://java.com.

The main SwathViewer Page
2. Zoom in on northern Alaska.

Select the zoom-in button from the tool bar, and then select the area you want by holding down the left mouse button. **Warning:** Zooming in too close at this point will not let you see all of the satellite images available. It is best to be zoomed in as far as the image below. You can zoom in further later once you have your image selected.

3. View the types of images available. In the list of images on the left hand side, make sure the “Images” folder is opened by clicking on it. When it is opened, there will be a list of folders beneath it. The folders that may contain useful sea ice information are:

   a. **AVHRR** (“Advanced Very High Resolution Radiometry” sensor)

   b. **Aqua-1 / MODIS** (“Moderate Resolution Imaging Spectroradiometer” sensor. Aqua-1 is the name for the satellite.)

   c. **Terra-1 / MODIS** (Terra-1 is the name for the satellite.)

4. Find an AVHRR image for your area of interest (for example, Point Barrow)
a. Click on the “AVHRR” folder. You should see a list of folders labeled by year. Next click on the year. You should see a list of Months. Select the month you are interested in.

b. A list of images will appear in the lower left hand corner. These are the images available for the area that you selected.

c. Select an image from the list. It should appear on the map.
d. Using the zoom-in tool, you can zoom-in on the area you are interested in.

Map zoomed in on Point Barrow. Note that the satellite image shown here does not match up perfectly with the coastline (green line). Often times these types of alignment errors exist.

5. Select maps from other types of sensors or satellites.
   a. Using the zoom-out button, zoom out to the regional scale.
   b. Select another type of image from the list of image folder. For example, select “Aqua-1 / MODIS”.
   c. Next, follow the same steps as with the AVHRR images to select the image that you want and to zoom-in on the area of interest.

Tips for interpretation:
- Both AVHRR and MODIS image sensors can NOT see through clouds as radar can. Therefore, clouds show up in the imagery. This means that on cloudy days you can’t see the ice below. It also means that to get useful information from the image you must learn how to distinguish clouds from sea ice.
The resolution of AVHRR and MODIS images are 1 km or 0.6 miles, which means that one pixel in the image is 0.6 miles across. This prevents individual ice floes smaller than this from being seen.
Barrow Area Information Database (BAID)
http://www.baidims.org/

This resource provides access to radar imagery of shorefast ice extent. BAID is a collection of online, interactive maps and services that support Arctic science with a special focus on the research hubs of Barrow, Atqasuk and Ivotuk on the North Slope of Alaska.

Instructions:

1. Click on the above web address. This will take you to a welcome page of BAID. The three main ways to access radar imagery from this site are described below.

2. To access BAID’s internet map server, select “Launch” under the “BAID-IMS” icon.
   a. The map server will open in a separate window.
b. On the right hand side is a list of the many layers in this server. Click the “Imagery”. Next, choose the year you are interested in. Next, choose the “SAR Sea Ice” folder. Lastly, choose the month you are interested in. Now you will see a list of the SAR radar images available for that month. (The first eight numbers represent the date of the image. The first four number are for the year, the second two are for the month, and the last two are for the day.)

c. When an image is selected, it will appear on the map.

d. The toolbar on the left side of the window has tools that allow you to zoom in, zoom out, pan around the image, print the map, etc.

* Note that the map often takes time to load after you click something, so please be patient.

3. To access an easy to use collection of SAR radar imagery for the current year only, select “Launch” under the “Barrow SAR Viewer” icon.

a. A separate window will open to show the most recent SAR radar image for Barrow.

b. Using the zoom bar on the left side of the window you can zoom in an out.

c. Use the “SAR Imagery” panel to select the SAR radar image you want. (The first eight numbers represent the date of the image. The first four number are for the year, the second two are for the month, and the last two are for the day.)

d. You can click-and-hold the map to move the map around to get a better view of your area of interest.

e. The little printer icon on the left side of the window allows you to either print the map or to save it as a JPEG image file.

* Note that the map often takes time to load after you click something, so please be patient.

4. ▶ Google Earth Users: To access BAID in Google Earth, select “Launch” under the BAID in Google Earth” icon on the main page. This will launch Google Earth.

Tips for interpretation:

• See the special section in the appendix for guidelines for interpreting radar maps.
MMS Leads and Landfast Ice Project
Geophysical Institute, University of Alaska Fairbanks
http://mms.gina.alaska.edu/

This resource provides images of recurring lead systems and open water off the coast of northern Alaska in the Chukchi Sea between Wainwright and Barrow and the Beaufort Sea between Barrow and the Mackenzie River Delta. Satellite imagery (from Radarsat Synthetic Aperture Radar (SAR) and Advanced Very High Resolution Radiometer (AVHRR) data) is presented for the time period between 1993 and 2003. This project is funded by the US Minerals Management Service (AK-03-06, MMS-71707).

Study area in the Beaufort and Chukchi Seas.

Sample AVHRR image from March 14, 2001.

Instructions:

1. Click on the above web address. This will take you to the project homepage.

2. On the top menu, click “Project Results”.

3. For lead patterns for the years 1993 to 2004, click on “Lead Patterns” on the left side menu.
a. Select the year and month of interest.

b. Here you will find AVHRR images downloadable as compressed zip files. The five numbers in the file name indicate the date: the first two numbers are the year and the last three numbers are for the Julian day, which corresponds to the day of the year (for example, January 1 is Julian day 1 and December 31 is Julian day 365).

c. **GIS Users:** ArcGIS Grid and Shapefiles can be downloaded here.

4. For landfast ice extent for the years 1996 to 2004, click on “Landfast Ice Extent” on the left side menu.

   a. Select the year and month of interest.

   b. Here you will find SAR mosaic images downloadable as compressed zip files. The first two numbers in the file name represent the year and the middle three numbers and ending three numbers represent the starting date and ending date, respectively, for the images used to create the mosaic.

   c. **GIS Users:** ArcGIS Grid and Shapefiles can be downloaded here.

5. **GIS Users:** Other types of GIS data for this project can be found by clicking on “Suppl. Materials and Links” on the top menu. Here you will find additional data related to lead patterns and statistics, landfast ice extent, and bathymetry.
Local Sea Ice Observatories at Barrow and Wales, Alaska

The sea ice group at the Geophysical Institute of the University of Alaska Fairbanks operates coastal ice observatories in the villages of Barrow and Wales, Alaska (shown in the map below). Both sites consist of a coastal webcam and radar. In Barrow, we also maintain a sea ice mass balance and sea level station.

Observatories website: [http://seaice.alaska.edu/gi/observatories/](http://seaice.alaska.edu/gi/observatories/)

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Webcams

In addition to providing a visual impression of the sea-ice conditions off Barrow and Wales, webcam images establish a longer-term record of key dates in the seasonal evolution of the sea-ice cover, such as: onset of fall ice formation, formation of a stable ice cover, onset of spring melt, appearance of melt ponds, beginning of ice break-up in early summer, removal or advection of sea ice during the summer months.

Barrow webcam: [http://seaice.alaska.edu/gi/observatories/barrow_webcam](http://seaice.alaska.edu/gi/observatories/barrow_webcam)
Wales webcam: [http://seaice.alaska.edu/gi/observatories/wales_webcam](http://seaice.alaska.edu/gi/observatories/wales_webcam)
Near-shore ice is monitored with Furuno 10 kW, X-band marine radars, which are positioned close to the shore on rooftops, and can operate at ranges up to approximately 11 km. Xenex digital controllers allow full remote operation from the University of Alaska Fairbanks (UAF). Radar backscatter maps are produced to provide important information on the movement, deformation and stability of the coastal ice cover.

Barrow radar: http://seaice.alaska.edu/gi/observatories/barrow_radar
Wales radar: http://seaice.alaska.edu/gi/observatories/wales_radar
Mass Balance and Sea Level Site

An automated ‘mass balance site’ is annually installed in growing, undeformed landfast first-year ice in a small embayment SW of Pt. Barrow. This site measures snow depth, ice thickness, and the water-ice-snow-air temperature profile. Also at this site are underwater acoustic altimeters that monitor local sea level. The mass balance site has operated in the years from 2006 to 2010.

Barrow Mass Balance and Sea Level Site:
http://seaice.alaska.edu/gi/observatories/barrow_sealevel
Sea Ice Summaries

This section presents unique resources that not only present summaries of data and information as opposed to collections of products. The resources presented here are the following:

1. NSIDC Arctic Sea Ice News and Analysis
2. SEARCH Sea Ice Outlook
3. SEARCH Sea Ice Outlook for Walrus
NSIDC Arctic Sea Ice News & Analysis
http://nsidc.org/arcticseaicenews/

This page presents the National Snow and Ice Data Center’s (NSIDC) summaries of up-to-date scientific analysis of arctic sea ice. Much of the information relates to the current extent of Arctic sea ice and also a comparison between the present year and past years. Information is updated at the first of each month and sometimes more frequently.

Example graph comparing the 2010 Arctic sea ice extent with past years.

Instructions:

1. Click on the above web address to go to Arctic Sea Ice News & Analysis page of the NSIDC. On this page you can find information relating to the current state of arctic sea ice.

2. On the right side, you will find:
   a. An “Archives” menu where older releases of sea ice news are available.
   b. A “Press Resources” menu that has summaries of the reported summer sea ice minimums since 2002.
SEARCH Sea Ice Outlook
http://www.arcus.org/search/seaiceoutlook/

The SEARCH (Study of Environmental Arctic Change) Sea Ice Outlook is an international effort to provide a summary of the expected September arctic sea ice minimum. Monthly reports released throughout the summer present estimates of the current state and expected minimum of sea ice at both a pan-arctic and regional scale. The intent of the Sea Ice Outlook is not to issue predictions, but rather to summarize all available data and observations to provide the scientific community, stakeholders, and the public the best available information on the condition of arctic sea ice. Sea Ice Outlook activities are supported in part through the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA).

Instructions:

1. Click on the above web address. This will take you to the Sea Ice Outlook homepage.

2. For reports for the given year, click on “Overview” on the center menu. Then, next to “Reports”, click on the month of interest. Here you will find tabs for “Summary”, “Pan-Arctic”, and “Regional” assessments.

3. For reports from past years, click on the specific year’s Outlook archive. For example, click on “2009 Outlook Archive”. Here you can access reports for the individual months, for the sea ice minimum, and for the year’s summary.
SEARCH Sea Ice Outlook for Walrus

http://www.arcus.org/search/siwo

The Sea Ice for Walrus Outlook (SIWO) is a resource for Alaska Native subsistence hunters, coastal communities, and others interested in sea ice and walrus. The SIWO is updated every Friday from April through June with information on sea ice conditions relevant to walrus in the Northern Bering Sea and southern Chukchi Sea regions of Alaska. The SIWO webpage includes: (1) An assessment of current ice conditions relevant to distribution and access of walrus, (2) a 10-day outlook of wind conditions, (3) up-to-date satellite imagery for the Bering Strait and St. Lawrence Island, which are two regions of interest to coastal communities engaging in the walrus hunt, (4) written observations of ice development from Alaska Native hunters, sea-ice experts, or NOAA or university researchers, (5) additional data and resources on ice conditions, and (6) additional comments provided by local experts and other contributors.

2010 was the first year the SIWO was published and the project will likely be continued. Planning for 2011 has started. If you are a local hunter, expert, or a scientist with observations on either the development of sea ice or any other aspect of walrus and sea ice, please contribute and send your comments to Helen Wiggins at the Sea Ice Outlook Central Office at ARCUS, helen@arcus.org or 907-474-1600.

Instructions:

1. Click on the above web address. This will take you to the Sea Ice Outlook for Walrus homepage.

2. The most current report and the latest news will be posted on this homepage.

3. Archives for the weeks the SIWO is published are available in the dropdown menu at the top of the page that says “Past SIWO Reports.” Click on the date you are interested in.
Additional Resources

This section presents resources that are not specifically sea ice resources, but may be useful for those interested in Alaska climate (temperature, precipitation, and freeze and thaw dates) and general mapping resources. For a comprehensive annotated list, including tutorials on the SNAP resources detailed below, see the ACCAP Data Resources webpage: http://ine.uaf.edu/accap//data_resources.html.

The resources presented here are the following:

1. Scenarios Network for Alaska Planning
2. Alaska Mapped: Statewide Digital Mapping Initiative
Scenarios Network for Alaska Planning (SNAP)
http://www.snap.uaf.edu/

This resource provides local and regional temperature, precipitation, and freeze and thaw dates. Both historical data and future scientific projections are available. Here, projections are based on different future scenarios of global greenhouse gas emissions.

Instructions:

1. Click on the above web address to visit the SNAP homepage. Here you will find a range of information related to various SNAP projects.

2. For web-based maps of climate projections (freeze up and thaw dates), click on “Web-based Maps” on the left side menu.
   a. Click on “Open SNAP’s Map Selection Tool”. A new window will open with the interactive map.
   b. For information relating to the future projections for the date at which the average temperature drops below freezing, select “Date of Freeze Up” as a map layer, then select an emissions scenario, and finally a decade of interest. You will then see a map of projected dates when the average temperature will be below freezing. The same can be done for “Date of Thaw”

3. ►Google Earth Users: For a Google Earth based method of exploring a wider range of data (temperature and precipitation), click on “Google Earth Maps” on the left side menu.

4. ►GIS Users: For GIS datasets of climate projections (temperature and precipitation) for the state of Alaska based on global climate models, click on “GIS Data” on the left side menu.
5. For projections of temperature and precipitation data for a specific Alaska community, click on “Community Charts” on the left side menu.

   a. You can switch between charts for “Temperature” and “Precipitation” by clicking on the different tabs near the top of the page.

   b. You can choose from three different greenhouse gas emission scenarios.
Alaska Mapped: Statewide Digital Mapping Initiative
http://www.alaskamapped.org/

Alaska Mapped provides an interactive mapping service that provides satellite imagery and elevation data collected for the state of Alaska through the Alaska Statewide Digital Mapping Initiative (SDMI) and the UAF Geographic Information Network of Alaska (GINA).

From the Alaska Mapped homepage, you will find a range of products under the heading “Data Services” on the left side menu. We are currently not presenting instructions for this resource here in this manual.
Appendix

The Egg Code: Ice Chart Symbology

Source: [http://www.natice.noaa.gov/products/egg_code.html](http://www.natice.noaa.gov/products/egg_code.html)

The World Meteorology Organization (WMO) system for sea ice symbology is more frequently referred to as the "Egg Code" due to the oval shape of the symbol.

- **C<sub>t</sub>** - Total concentration of ice in area, reported in tenths. May be expressed as a single number or as a range, not to exceed two tenths (3-5, 5-7 etc.)

- **C<sub>a</sub>, C<sub>b</sub>, C<sub>c</sub>** - Partial concentration (C<sub>a</sub>, C<sub>b</sub>, C<sub>c</sub>) are reported in tenths, as a single digit. These are reported in order of decreasing thickness. C<sub>a</sub> is the concentration of the thickest ice and C<sub>c</sub> is the concentration of the thinnest ice.

- **S<sub>a</sub>, S<sub>b</sub>, S<sub>c</sub>** - Stages of development (S<sub>a</sub>, S<sub>b</sub>, S<sub>c</sub>) are listed using the code shown in Table 1 below, in decreasing order of thickness. (NOTE: If there is a dot (.), all stages of development codes to the left of the dot (.) are assumed to carry the dot (.)) These codes correspond directly with the partial concentrations above. C<sub>a</sub> is the concentration of stage S<sub>a</sub>, C<sub>b</sub> is the concentration of stage S<sub>b</sub>, and C<sub>c</sub> is the concentration of S<sub>c</sub>.

- **S<sub>0</sub>, S<sub>d</sub>** - Development stage (age) of remaining ice types. S<sub>0</sub> if reported is a trace of ice type thicker/older than S<sub>a</sub>. S<sub>d</sub> is a thinner ice type which is reported when there are four or more ice thickness types.

- **F<sub>a</sub>, F<sub>b</sub>, F<sub>c</sub>** - Predominant form of ice (floe size) corresponding to S<sub>a</sub>, S<sub>b</sub> and S<sub>c</sub> respectively. Table 2 below shows the codes used to express this information.
<table>
<thead>
<tr>
<th>Stage of Development for Sea Ice</th>
<th>Code</th>
<th>Stage of Development for Fresh Water Ice</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Ice-Frazil, Grease, Slush, Shuga (0-10 cm)</td>
<td>1</td>
<td>New Ice (0 - 5 cm)</td>
</tr>
<tr>
<td>Nilas, Ice Rind (0 - 10 cm)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Young (10 - 30 cm)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Gray (10 - 15 cm)</td>
<td>4</td>
<td>Thin Ice (5 - 15 cm)</td>
</tr>
<tr>
<td>Gray - White (15 - 30 cm)</td>
<td>5</td>
<td>Medium Ice (15 - 30 cm)</td>
</tr>
<tr>
<td>First Year (30 - 200 cm)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>First Year Thin (30 - 70 cm)</td>
<td>7</td>
<td>Thick Ice (30 - 70 cm)</td>
</tr>
<tr>
<td>First Year Thin - First Stage (30 - 70 cm)</td>
<td>8</td>
<td>First Stage Thick Ice (30 - 50 cm)</td>
</tr>
<tr>
<td>First Year Thin - Second Stage (30 - 70 cm)</td>
<td>9</td>
<td>Second Stage Thick Ice (50 - 70 cm)</td>
</tr>
<tr>
<td>Medium First Year (70 - 120 cm)</td>
<td>1.</td>
<td>Very Thick Ice (70 - 120 cm)</td>
</tr>
<tr>
<td>Thick First Year (&gt;120 cm)</td>
<td>4.</td>
<td></td>
</tr>
<tr>
<td>Old - Survived at least one season's melt (&gt;2 m)</td>
<td>7.</td>
<td></td>
</tr>
<tr>
<td>Second Year (&gt;2 m)</td>
<td>8.</td>
<td></td>
</tr>
<tr>
<td>Multi-Year (&gt;2 m)</td>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>Ice of Land Origin</td>
<td></td>
<td>△•</td>
</tr>
<tr>
<td>Forms of Sea Ice</td>
<td>Code Figure</td>
<td>Forms of Fresh Water Ice</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>Belts and Strips symbol</td>
<td>~F</td>
<td>Belts and Strips symbol followed by ice concentration</td>
</tr>
<tr>
<td>New Ice (0-10 cm)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pancake Ice (30 cm - 3 m)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Brash Ice (&lt; 2m)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ice Cake (3 - 20 m)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Small Ice Floe (20 - 100 m)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Medium Ice Floe (100 - 500 m)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Big Ice Floe (500 m - 2 km)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Vast Ice Floe (2 - 10 km)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Giant Ice Floe (&gt; 10 km)</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Fast Ice</td>
<td>8</td>
<td>Fast Ice</td>
</tr>
<tr>
<td>Ice of Land Origin</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Undetermined or Unknown</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>(Iceberg, Growlers, Bergy Bits)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Guidelines for Interpreting Radar Maps

Users of the Barrow Area Information Database – internet Map Server (BAID-IMS) should be cautioned that radar maps created from Synthetic Aperture Radar (SAR) imagery can be difficult to interpret. This document is intended to provide some guidelines for interpreting SAR imagery. However, these guidelines should not be accepted as hard fast rules. As a general rule, areas of calm water (including most leads) and other smooth surfaces (like the flat ice on Elson lagoon) appear black since the radar reflects away and is not received by the satellite. However, windy conditions can make leads appear grey and even white.

Figure 1

Freshwater lakes that are not frozen solid appear white. But, shallow freshwater lakes that are frozen to the ground appear black (notice the Twin Lakes and Freshwater Lake in Figure 2.) SAR is a very good tool for determining the depth of freshwater lakes. Buildings and other man-made structures will reflect well and often appear bright white on the images (notice the Village of Barrow.)

Figure 2.

Technical Overview
SAR is an active sensor, mounted on the RADARSAT-1 and ERS-2 satellites. As they orbit the earth, these satellites transmit radar signals and then measure how strongly those signals are scattered back. The SAR sensors can “see” both at night and through clouds. BAID-IMS is incorporating Quicklook imagery from RADARSAT-1’s (ScanSAR Wide Beam) sensor at 100-meter pixel resolution with data frames that are 500 x 500 km and the ERS-2 sensor at 30-meter pixel resolution with data frames that are 100 x 100 km. Both sensors send out C-Band pulses with a 5.66 cm wavelength. These pulses are not harmful to humans or animals.

Surface Variations near the size of the radar’s 5.66 cm wavelength can cause strong backscattering. If the wavelength is a few centimeters long, even a small object might backscatter brightly. Wind-roughened water can backscatter brightly when the resulting waves are close in size to the incident radar’s wavelength. A rough surface backscatters more brightly when it is wet. As melt ponds develop on the ice in Spring, it will become more difficult to distinguish features in the imagery.

Figure 8.Courtesy of the Alaska Satellite Facility

For more information visit the SAR FAQs at: http://www.asf.alaska.edu

Prepared by Nuna Technologies, November 17, 2008
As the days grow longer and our thoughts turn to summer activities, one thought persists in the minds of those who live on or near Alaska’s rivers: When will breakup happen and will it flood this year? Breakup in much of south central and southeast Alaska means melting snow, wet sloppy conditions, dirty roads and dirty cars, and wondering when the last snow will disappear from the yard. For residents of the many villages and towns along the large interior rivers such as the Yukon and the Kuskokwim, breakup means no more snow machine trips to the next village, no boating until the ice has passed downstream, and the potential for minor to devastating flooding if the ice stops running downstream of the village. Predicting when breakup will occur and the likelihood of damaging flooding is a very difficult task, but there are some indicators that can help us understand what might happen (and when).

Hydrologists who study the breakup process know that several factors combine to determine what the coming breakup season holds. The first is to understand how thick the ice grew over the winter and how far it extends across the river bed. If the river level in the fall was very low, then as the water rises in the spring, the ice will be able to move and twist and break into smaller pieces, which reduces the potential for ice-jam flooding. However, if the river level was high at freeze-up, that ice sheet may cover most of the channel and even after the river rises in the spring, that sheet of ice will not have much opportunity to move and

![Types of Breakup Process](image-url)

**Dynamic breakup**
- Ice remains hard and resistant to breaking up
- Ice moves when pushed by ice from upstream
- Many ice jams form that cause upstream flooding
- Extreme cases are Kenai River in January 1969 and January 2007 and Yukon River in May 2009

**Thermal breakup**
- Ice becomes very rotten (candled) before ice from upstream arrives
- Rotten ice is weak and has less resistance to breaking into very small pieces
- Few if any ice jams form
- Extreme case would occur with very little snow melt inflow and warm sunny weather to rot the ice

Figure 1. Characteristics of two types of breakup processes. Figure provided by the APRFC.
break up into smaller pieces, raising the possibility of ice jams and flooding. The ice thickness affects flood potential in the same manner with thin ice being less likely to cause damaging floods and thick ice being more likely to jam and cause flooding.

Another important factor that determines the likelihood of breakup floods is the amount of water stored as snow in the mountains and lowlands that drain into those large rivers. When a large snowpack persists into April, that snow is subject to very rapid melting as the temperatures may suddenly approach normal or higher in late April and early May. Temperatures in the 60s and 70s can result in the snowpack over an entire basin ripening and discharging tremendous volumes of water into the river in a very short time as occurred in the spring of 2009. Fresh snow
in April also increases the albedo or reflectivity of the snowpack, causing a higher percentage of solar radiation to be reflected back into the atmosphere rather than be absorbed by the snowpack.

The element that determines the timing and severity of breakup more than anything else is the weather from April 1 to May 15. A cold April followed by a rapid warmup to seasonal May temperatures will preserve the snowpack for a rapid melt even when the snow water equivalent is below normal, and will also keep the ice cover from deteriorating. A gradual warmup from early April through the beginning of summer will slowly bleed the snowpack away and weaken the river ice and even a big snowpack with thick ice may not cause any flooding under
this scenario. The first case creates a surge of meltwater traveling from the upstream to downstream, pushing a growing wall of ice and water as it goes. The ice sheets are resistant to breaking into small pieces and tend to jam up at sharp bends and shallow areas of the river, causing upstream areas to flood as the water flow is sharply restricted. This type of breakup is called a Mechanical or Dynamic breakup. The second scenario generally manifests itself with the ice at a number of locations on the river moving, generally where a larger tributary enters the river. The ice sheets in this case have deteriorated and thinned and even a modest amount of meltwater entering the river is enough to break up those sheets into smaller pans and chunks that move more easily around the sharp bends and past the shallow areas of the river. This type of breakup is referred to as a Thermal breakup and may also be called a “Mush-out” as long reaches of the river open up quickly while the ice just melts in place (Figure 1, page 1).

A few images show a distinct contrast of the antecedent conditions and weather from 2009 to 2010. Both 2009 and 2010 showed ice in many places that was thicker than normal. The ice at Eagle in 2009 was 138% of normal compared to 92% of normal in 2010 (Figure 2, page 2). Snow water equivalent was significantly higher across the state in 2009 compared both to normal and to 2010 (Figure 3, page 2). Finally, the cool spring followed by a rapid warm-up in 2009 led to a very dynamic breakup which caused flooding in numerous locations along the interior rivers. The slow gradual warm-up in 2010 combined with the low snowpack caused almost no flooding. (Figures 4 and 5, page 3). For 2011, it is very early to determine if severe flooding will be an issue when there are still 2 months remaining before breakup. But several clues point towards the possibility of moderate to severe flooding this spring. On the Kuskokwim River, a rare early winter rainfall event caused breakup to begin in November after the river had been frozen for a month. The river rose considerably and several long stretches of river became ice free as chunks and pans of ice moved down a good length of the river. Then temperatures grew colder and the river refroze at a higher level than it was previously. The stretches where
the jumbled breakup ice refroze may end up causing ice jams as the normal fracture process may not occur when the temperatures warm in the spring. Much of northwest Alaska and the northern interior have received significantly high snowfall amounts (Figure 6, page 4). The Gakona River at Gakona Junction has a large build-up of Aufeis in the river channel which might lead to flooding. Finally, the 3 month climate outlooks for Fairbanks call for equal chances of temperatures being above, near, or below normal in the northern part of the state for the periods of March – May and April – June. But the May – July outlook calls for a 75% chance of near or above normal temperatures (Figure 7, above, and for more information on the outlook see Spring Seasonal Climate Outlook article). If the spring temperature patterns remain cool during March and April before warming up considerably, the chances of ice-jam flooding will rise accordingly. Currently, the flood potential from snowmelt and ice jams for breakup this spring is rated as above average. This means that communities that only flood in years with extreme breakups have a higher chance of flooding this year. Communities that experience minor flooding on a regular basis have a higher chance of experiencing moderate or major flooding. As data is gathered in early April regarding the snow depth and ice thickness and the climate outlooks for April and May become more clear, the forecast for the severity and timing of breakup will improve.

For more information:

• As spring progresses, check out Alaska river conditions: breakup maps, ice summaries, forecasts, 48-hour flood potentials, and 5-day flood outlooks at the National Weather Service Alaska-Pacific River Forecast Center website: http://aprfc.arh.noaa.gov/
Winter Weather Conditions in Alaska

Prepared by the Alaska Climate Research Center

This article presents a summary of winter 2010-2011 (December, January, February) temperatures and precipitation from the first order meteorological stations (operated by the National Weather Service meteorologists) in Alaska.

Temperature

Most of Alaska experienced temperatures noticeably colder (i.e. negative deviation) than the normal 30-year average this winter (Figure 8, below). This winter was more typical of the winter weather conditions experienced in the 1960’s and early 1970’s. This is in contrast to autumn 2010, when the temperatures were generally above normal. Interior Alaska was notably below normal, with Bettles (-4.4°F) leading, followed by Big Delta and Gulkana (both -3.8°F) and Fairbanks (-3.7°F). An additional 8 weather stations, mostly located in Interior Alaska, gave less extreme negative departures from average (less than -3°F). More details can be seen from Table 1 (page 8). In contrast to the Interior, Arctic Alaska and the coastal stations of the Bering Sea had above average temperatures. The highest departure from normal was observed for Barrow, with 5.1°F. This is a large departure and continues the trend of warmer than normal temperatures that were observed in fall. This trend is in agreement with the long-term climatic trend, which shows the North Slope of Alaska has experienced a strong warming trend over the last several decades. This can be connected with more open water and thinner sea ice in the Southern Beaufort Sea, as determined from satellite observation. In addition, the coastal weather stations of the Bering Sea were also above normal, with Nome having the greatest deviation of 2.0°F. While the winter of 2009-2010 saw above normal sea ice extent in the Bering Sea, this winter has been nearer to the long-term average (see accompanying article).

Looking at the temperatures for the 3 winter months separately, December started out the winter season with temperatures far below the long-term normal average. Negative departures from average greater than -10°F were observed for Bettles, Big Delta, Fairbanks, Gulkana, King Salmon and McGrath. Negative deviations for other locations were more modest. Furthermore, there were only two stations with above normal temperatures, Barrow (+1.4°F), the most northerly station in Alaska, and Annette (+0.6°F), the most southerly station in the southeast panhandle.

In January, temperatures were above the 30-year average for all stations in Alaska, making it a relatively pleasant month for the deep-winter time of the year. The greatest deviation from the long-term average was 9.1°F observed at Nome.

February was colder than normal for most areas, but less so than was experienced in December. Generally speaking, the Interior was below normal, while Northern Alaska and coastal and island stations in the Bering Sea region were above normal. The highest positive deviations were found for Barrow (+9.8°F), St. Paul Island (+5.4°F) and Bethel (+4.5°F), while
below normal temperatures were more widespread, but less severe than was seen in December.

Precipitation

As pointed out in the previous issue, locations throughout Alaska have a broad range of seasonal precipitation. For example, the 30-year average precipitation in Little Port Arthur (1971-2000) is reported at 73.5 inches (186.7 cm), while Barrow averaged only 1.2 inches (3 cm) for the same time annual time frame. This shows that actual departures from the long-term average are not very meaningful because of the wide regional differences. Therefore, Figure 9 (above) presents these deviations as percentages above (+) or below (-) normal, where normal is the 30 year average. As there can be also a strong gradient in precipitation from month to month in the long-term average, the deviations for the seasonal values are the sum of the precipitation for the 3 months, divided by the long-term average for the 3 month (Table 1, page 8). The average of the 3 monthly deviations might slightly depart from these values.

In general the winter precipitation of 2010-2011 was lower than normal (Figure 9, above), as 70% of the stations reported negative deviations. However, northern and western Alaska reported above normal values. Of note were Barrow (+164%) and Kotzebue (+163%) with deviations far above normal. As the precipitation is light in these regions, especially in winter, even a single winter storm with a large amount of precipitation can affect the departures from normal strongly. Also Nome and Bethel, further south along the west coast of Alaska, showed values above normal with 44% and 43%, respectively. On the other hand, all of southern Alaska from St. Paul Island in the West to Annette in the East reported below normal values. The picture for Interior Alaska was more mixed, as can be expected for a large region with a diverse topography. While the majority of the stations reported below normal values, Fairbanks and Gulkana measured above normal precipitation values.

Looking at the months individually, December was overall rather dry; January close to normal, while in February some stations reported snowfall far above the expected amount. In December all of Alaska but 4 stations, namely Kotzebue (+118%), Nome (+45%), Barrow and Bethel (both +8%) reported a negative deviation in precipitation. Interior Alaska was especially dry as Fairbanks had only 31% of the expected amount.

January continued to be dry in Interior Alaska, with the greatest deviation reported for Fairbanks (-66%) and Big Delta (-62%). The resulting thin snow cover in combination with the below normal temperatures of January let the frost penetrate deep into the ground, resulting in frozen water and sewer lines in the Interior. However, precipitation in January was above normal along the West Coast, Bering Sea area and Southeast Alaska. Especially notable is Kotzebue, which recorded more than twice the expected amount.

February was a remarkable month as far as the precipitation is concerned. Strong winter storms brought lots of moisture to Alaska, impacting mainly Northern, Western and Interior Alaska. Barrow reported 417%, Fairbanks 356%, Gulkana 215% and Kotzebue 290%
above the expected amount. Fairbanks had the second highest snowfall amount (30.3 inches) ever reported for February; the records, which go back to 1904, show that only February 1966 recorded a larger snowfall. Especially remarkable was the snowstorm of February 20-21 with a total of 18.6 inches. Wind gusted up to 49 mph, and blowing snow and snow drifting could be observed, a fairly rare occurrence for Alaska’s Interior. Due to the heavy snowfall and drifts the roads to the north, the Dalton and Steese Highways were closed.

For more details, see the Table 1 (above,) which presents the temperature and precipitation deviations for the months and season.

### Bering and Arctic Sea Ice: The Winter of 2010-2011

Sea ice during the winter of 2010-11 showed some notable differences from the previous several winters, especially in the Bering Sea. In the Bering Sea, the areal coverage of sea ice reached its peak in mid-February...
ice coverage for the entire Arctic (Figure 12, below) was near a record low for the post-1979 period of satellite data. Preliminary indications, subject to the further evolution of the ice cover in March, are that the 2011 pan-Arctic maximum will be even lower than the previous record low maxima that occurred in 2006 and 2007. The extremely low maximum represents a departure from the seasonal pattern of areal ice coverage during the previous three years, when extremely low summer minima were followed by recoveries to near-normal winter coverage by February or March. The large area of seasonal (first-year) sea ice during these previous winters

(Figure 11, above), which is several weeks earlier than usual. Moreover, the coverage throughout the winter was close to, or slightly below, the average for the post-1979 period of passive microwave satellite measurements. The maximum coverage of approximately 0.6 million square kilometers was approximately 30% less than the previous year’s maximum of about 0.85 million square kilometers in March 2011 (Figure 11, above). In fact, the maximum coverage in 2011 was well below the maxima of each of the previous five years (2006-2010) and was more typical of the lower-ice years of the early 2000s (see time series in the December issue of the Climate Dispatch).

The 2011 maximum of winter
was undoubtedly thin ice, which was rapidly lost during the spring and summer melt seasons. Nevertheless, the extremely low coverage of sea ice in March 2011 raises intriguing questions about the trajectory of ice cover as we move into the summer of 2011. The Climate Dispatch will track this evolution, especially in Alaskan waters, and will summarize the September 2011 sea ice outlook in the next issue.

The Climate Prediction Center’s Spring Seasonal Climate Outlook

As described in the feature article of the December 2010 issue of the Climate Dispatch, a La Niña event in the tropical Pacific Ocean has been ongoing since the summer of 2010. The colder-than-normal winter of 2010-11 over much of Alaska is consistent with a La Niña’s impact on wind patterns. National Weather Service/Climate Prediction Center’s winter outlook, based largely on La Niña, indeed called for below-normal winter temperatures over nearly the entire state (see the preceding issue of the Climate Dispatch). La Niña conditions still exist in the Pacific Ocean and are expected by the Climate Prediction Center to persist into spring. The spring (March-May) outlook for 2011, based on this expectation, also calls for below-normal temperatures over southern Alaska (Figure 13, above right). Historically during the spring season, the below-normal temperatures associated with La Niña have been strongest in the southern portion of the state. Over the rest of the state, the La Niña-driven tendency for a cooler-than-normal spring is offset by the recent trend towards warmer conditions, resulting in equal chances of a warmer-than-normal and colder-than-normal temperatures in the northern half of the state. In addition, the Climate Prediction Center’s precipitation outlook for March-May (not shown here) indicates that the odds favor below-normal precipitation south of the Alaska Range. Over the rest of the state, there are equal chances of above-normal and below-normal precipitation.

After the cold winter in much of the Interior of Alaska, a natural question is: Will La Niña’s impact on Alaskan weather continue for a second year, resulting in another winter like the past one? The Climate Prediction Center notes that some La Niñas persist into a second winter, while others do not. On the assumption that the present event will weaken during the spring, the Climate Prediction Center’s long-lead-time outlooks call for increased likelihoods of warmer-than-normal temperatures over most of Alaska in summer 2010 and winter 2011-12. These outlooks are based primarily on recent trends, which have been towards warmer-than-normal temperatures.
Permafrost Change
What It Means to Alaskans and How We Can Adapt

How is Alaska permafrost changing?
Alaska’s distinctive ground feature known as permafrost is starting to thaw, which could mean big changes for the state and its people. Permafrost is a combination of soil, rock, and organic materials (partially decomposed plant matter) that has been at or below 0°C (32°F) for at least two consecutive years. Most permafrost is many thousands of years old, and in some places it is as deep as 650 m (about 2,000 ft). The active layer—the upper 30-100 cm (about 1-3 ft) of soil—is not part of the permafrost because it thaws during the summer months.

Permafrost is found on about 80% of the land surface of Alaska. Continuous permafrost (covering 90% or more of the surface area) begins just south of the Brooks Range and extends north to the Beaufort Sea, west to the shores of the Chukchi Sea, and east to the Canadian border. Discontinuous permafrost (50-90% coverage) extends south to about the latitude of Anchorage, where the permafrost becomes sporadic and isolated. Kodiak Island, the Alaska Peninsula, the Aleutian Islands, and Southeast Alaska lack permafrost.

What are scientists telling us?
Scientists say their measurements indicate that the active layer is getting deeper as the seasonal thaw extends farther into the ground. They are finding, primarily through data collected at boreholes, that permafrost temperatures have warmed as much as 2°C (about 3°F) during the last 20 to 30 years, not just in Alaska but also across Russia, the Scandinavian countries, and Canada. Lakes expand when runoff finds its way to overlie continuous permafrost, or disappear when underlying permafrost thaws and water seeps out through the bottom. In the Russian north more than 125 known lakes already have vanished.

Why does it matter?
Thawing permafrost affects vegetation, water supplies, transportation, infrastructure, and even human health. As it thaws, cavernous pits develop when water that was previously frozen drains from the soil. Changing hydrology affects the way water moves through the country. A major thaw in northwestern Alaska a few years back dammed the Selawik River, disrupting the fishing important to nearby villagers. Ice cellars that are used to keep meat frozen have thawed and turned into pits of standing water, and food stored underground

Thawing permafrost on the Ikpikpuk River.
in warmer soil is more susceptible to botulinum toxin. In some places lake and river transportation routes have turned to dry tundra, and elsewhere previously dry terrain and trails have flooded. Buildings whose foundations originally rested on solidly frozen ground are tilting and even breaking apart. Roads, airstrips, sewer and water supply pipelines, and other kinds of infrastructure are sustaining damage. A study by the Institute of Social and Economic Research at the University of Alaska Anchorage estimates that climate change will increase repair and maintenance costs for public infrastructure in Alaska by about 10%.

Thawing permafrost allows nitrates and phosphates previously locked in frozen soil to reach the tundra, essentially changing the chemistry of the soil and allowing invasive species a foothold. It is estimated that the world's permafrost may contain three times the amount of carbon as is held in the atmosphere. As temperatures increase, bacterial action in the soil breaks down plant material and releases carbon dioxide. The huge volumes of organic material in the world's permafrost reinforce the view that the climate will warm even faster than it is now if this gas is released by thawing soil.

**Why is it happening?**

Scientists say that increased permafrost thawing is a result of global climate change, which is evidenced in the far north earlier and more dramatically than across most of the globe. Debate continues on the causes but it is clear that the “greenhouse effect” of carbon dioxide and other byproducts from burning fossil fuels is raising atmospheric temperatures.

**How can we stop permafrost thaw?**

As long as global temperatures continue to rise, the zone of thawing permafrost will continue to expand and the active layer will increase in depth. Once thawed, permafrost will not return to its continuously frozen state unless the earth enters another ice age.

**How can Alaskans adapt?**

Adaptation to permafrost thaw can take many forms, depending on local conditions. Adaptations could include:

- Construct roads, buildings, and other kinds of infrastructure with techniques that don't require frozen subsurface soils for foundations.
- Relocate ice cellars or turn to other means for preserving frozen subsistence foods.
- Reroute transportation corridors to avoid vulnerable areas of permafrost.
- Look for more secure sources of water supply to minimize potential for contamination.
- Most important is to begin a community dialog about permafrost and other local environmental change. Encourage participation by all members, and record observations. Monitor conditions to document changes. Seek input on possible adaptation measures, and draft a plan.

Federal, state, and university resources are available to provide technical assistance and in some cases financial assistance as well. Adaptation is most effective when done before a situation reaches the crisis stage.

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For more information or assistance

**Climate Change Adaptation, Alaska Sea Grant Marine Advisory Program**
http://www.marineadvisory.org/climate

**Alaska Center for Climate Assessment and Policy (ACCAP)**
http://ine.uaf.edu/accap/alaska_arctic.html

**Scenarios Network for Alaska Planning (SNAP)**
http://www.snap.uaf.edu

**Alaska Climate Change Impact Mitigation Program, Division of Community and Regional Affairs (DCRA)**
http://www.commerce.state.ak.us/dcra/ACCIMP.htm

**Permafrost Lab, Geophysical Institute, University of Alaska Fairbanks**
http://www.permafrostwatch.org

**Article on permafrost changes by Vladimir Romanovsky**
http://www.arctic.noaa.gov/essay_romanovsky.html

**Interview with Vladimir Romanovsky, Geophysical Institute, University of Alaska Fairbanks**
http://www.arcticwarming.net/node/70

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This Alaska Sea Grant Marine Advisory Program (MAP) project is supported by the Alaska Center for Climate Assessment and Policy (ACCAP). MAP is a statewide outreach and technical assistance program that helps Alaskans sustain economic development, traditional cultural uses, and conservation of marine and coastal resources. ACCAP’s mission is to assess the socioeconomic and biophysical impacts of climate variability in Alaska, make this information available to local and regional decision-makers, and improve the ability of Alaskans to adapt to a changing climate.
What is ocean acidification?
Carbon dioxide (CO₂) occurs naturally in the atmosphere and the ocean. In addition, the ocean acts like a sponge and absorbs about one-third of human-caused atmospheric CO₂ emissions. Since the industrial revolution, human activities have increased the amount of CO₂ in the atmosphere. When CO₂ dissolves in seawater, hydrogen ions are released, lowering the pH of the seawater. Seawater currently has a pH of 8.1 (7.0 would be neutral)—so a small decrease in pH doesn’t actually make it an acid, but it does make it less basic. A shift toward a lower pH is called “ocean acidification.”

Why does it matter?
This “acidification” is a looming threat to fisheries because of its potential impact on organisms that form protective shells, such as coral, calcifying phytoplankton, crabs, and other shellfish that derive their calcium and carbonate ions from seawater. The calcium carbonate structure of the shells of these organisms may corrode if CO₂ levels in the water increase enough. A more immediate concern, however, is that many organisms depend on carbonate ions dissolved in seawater to build their shells. In seawater, CO₂ reacts with carbonate ions and lowers carbonate concentration. If the carbonate ion concentration is too low, those creatures will be unable to form their shells.

The very basis of the oceanic food chain is made up to a significant extent of calciferous plankton, which are tiny drifting organisms. Of particular concern to Alaska fishermen is the effect acidification can have on a planktonic, free-swimming snail called a pteropod, or sea angel, which is an important food for commercial fish such as pink salmon, herring, and pollock. Entire ecosystems may change with ocean acidification.

Ocean acidification has happened before in the geological record, but the rate at which it is increasing now is at least ten times faster than any change in acidity experienced by marine organisms for the last 20 million years or more.

How do we know that ocean acidification is happening?
Research by many scientists worldwide, including the University of Alaska, has shown that acidification is occurring in deep ocean waters, particularly in the Arctic and North Pacific. Upwelling, possibly caused by changes in weather patterns, brings more of this lower pH water to the surface and coastal zone where most fisheries productivity is.

What are Alaskans observing?
So far, people other than scientists have not observed effects of acidification in Alaska waters, but studies of oyster larvae die-offs in Oregon point to acidification as a possible cause. Some fishermen speculate that recent failures of a few pink salmon runs may be related to pteropod decreases, but this link is not proven.

Is ocean acidification an immediate threat to Alaska’s commercial fisheries, subsistence resources, recreation, or lifestyles?
Scientists think it is unlikely that Alaskans will experience significant general decline in ocean productivity due to acidification over the next decade. However, it is known that some organisms respond more dramatically to environmental change than others. Some scientists believe that by mid-century there will be observable changes in species composition in local seas if immediate steps aren’t taken to slow down or stop the CO₂ emissions that are causing acidification. The question has not yet been studied sufficiently to provide precise estimates of impacts, but it is not too soon to think about ways to halt acidification as well as steps for adapting to the changes likely to come.
What can we do to stop ocean acidification?
Scientists generally agree that the only way to slow or stop ocean acidification is to reduce “greenhouse gases” by cutting fossil fuel emissions.

What can we do to adapt?
- Support increased research into ocean acidification, its causes, and potential responses.
- Stay current on research results and news, especially observations in Alaska and other high-latitude waters.
- Review your commercial fishing business plan, and look for ways to minimize the impacts that changes in species abundance would have on your operation. Options might include diversification of fishing/aquaculture operations or learning new skills to diversify income such as non-fishing/non-aquaculture business or employment.

For more information or assistance
Climate Change Adaptation, Alaska Sea Grant Marine Advisory Program
http://www.marineadvisory.org/climate

Alaska Center for Climate Assessment and Policy (ACCAP)
http://ine.uaf.edu/accap/alaska_arctic.html

European Project on Ocean Acidification (EPOCA)
http://oceanacidification.wordpress.com/

Frequently Asked Questions, EPOCA
http://www.epoca-project.eu/index.php/FAQ.html

Impacts of Ocean Acidification, National Oceanic and Atmospheric Administration (NOAA)
http://www.noaanews.noaa.gov/stories2006/s2606.htm

NOAA Climate Services
http://www.climate.gov

NOAA Pacific Marine Environmental Lab
http://www.pmel.noaa.gov/co2/OA/

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Climate Change and Subsistence
What It Means to Alaskans and How We Can Adapt

How does climate change affect subsistence?
Rural Alaskans harvest more of their food from the sea and land than other Americans. Subsistence activities provide important cultural connections to nature and community, as well as nourishment. The warming climate is causing a host of environmental changes that affect Alaska's subsistence culture.

What are Alaskans observing?
- Ice covers less area and is thinner on seas, rivers, and lakes.
- Ice cellars (underground freezers in permafrost) are thawing.
- More wildfires are changing wild game forage and habitat.
- Animal abundance, distribution, and behavior are changing.
- Permafrost is thawing.
- The health of some subsistence fish, birds, and mammals appears compromised.
- Shrubs and trees are expanding northward.

What are scientists telling us?
- The average temperature in the Arctic has increased by 3 degrees F in the last century, and in some parts of Alaska by as much as 5 degrees F.
- A warmer climate is altering the distribution and abundance of fish, birds, mammals, and plants that subsistence users need.
- Thawing permafrost reduces tundra access, and makes summer travel harder and more destructive to the environment.

How is climate change affecting us now, and what can we expect in the future?
- Decreased ice cover makes winter subsistence activities more difficult, expensive, and dangerous. Ice fishing opportunities are fewer.
- Traditional subsistence resources have become harder to find and often require longer travel and greater expense.
- In some cases new subsistence resources are becoming available. In other cases nuisance animals or predators that compete with people have hampered the success of subsistence activities.

What is causing climate change?
Atmospheric scientists say that the worldwide use of fossil fuels (coal, oil, natural gas) releases gases into the air that trap heat, which would otherwise escape into space. Some scientists also point to the earth's natural climate cycle as a factor in increasing atmospheric temperatures. Though there remains some debate about the causes, scientists agree that the earth is warming.
What can subsistence users do to halt or reverse these changes?
Individuals can't do much to reverse global trends on their own, but they can join a worldwide effort to reduce use of fossil fuels. Even if this happens it will be decades before results are apparent.

How can subsistence users adapt?
- Be flexible with subsistence harvest time and effort.
- Hold local discussions on how changing temperatures and ice affect the family and community. Encourage elders to offer suggestions on how to adapt.
- Take advantage of new subsistence opportunities as they present themselves.
- Be open to utilizing new species coming to the area that usually have not been part of the traditional diet.
- Meet with subsistence hunters, fishermen, and gatherers from other parts of the state to learn how they use the biological resources that are becoming more abundant and how they have dealt with scarcity.

• Engage elders to teach children and youth the values of adaptability, and to temper expectation with appreciation of the resources that are available.
• Expand use of traditional ecological knowledge and community-based monitoring to track changes and develop adaptation strategies.
• Increase use of co-management bodies, including federal, state, local, and regional rural representation, that can respond rapidly to setting seasons and bag limits on fish and wildlife.
• Make full use of available federal, state, and local agency assistance to help locate and fully utilize subsistence foods, and push for resource management plans that increase subsistence access to the available resources.

For more information or assistance
Climate Change Adaptation, Alaska Sea Grant Marine Advisory Program
http://www.marineadvisory.org/climate

Alaska Center for Climate Assessment and Policy (ACCAP)
http://ine.uaf.edu/accap/alaska_arctic.html

Alaska Department of Fish and Game, Division of Subsistence
http://www.subsistence.adfg.state.ak.us

Federal Subsistence Board
http://alaska.fws.gov/asm/board.cfm

Community temperature charts, Scenarios Network for Alaska Planning
http://www.snap.uaf.edu/community-charts

U.S. Fish and Wildlife Service, Office of Subsistence Management
http://alaska.fws.gov/asm/osm.cfm
Sea Level Rise and Storm Surge
What It Means to Alaskans and How We Can Adapt

What is sea level rise and storm surge?
A warmer global climate is causing glaciers and continental ice sheets to melt, sending increased volumes of freshwater into the sea. At the same time higher temperatures cause thermal expansion of the ocean itself. The result is that sea level is slowly rising.

Why does it matter?
Along the southern shores of Alaska the effect so far is hardly noticeable, because most of the coastline also is slowly rising due to tectonic forces and isostatic rebound (springing back of land after the last ice age). On the Bering Sea coast and in the Arctic, however, communities are experiencing increased damage from storm surges (extreme high water events caused by high winds and low atmospheric pressure), shoreline loss to fierce winter storms, and saltwater intrusion into freshwater sources, sanitation lagoons, and fish and wildlife habitats. Indications are that all of this is being made worse by a gradual rise in sea level.

Furthermore, changing climate may cause a change in storm pathways, bringing more frequent or intense storms to some parts of Alaska.

A big factor is the loss of protective sea ice, which makes the effects of storm waves on the shoreline more severe. Decline of sea ice increases ocean fetch (the distance waves travel uninterrupted) which increases wave height. Decline of shore-fast ice leaves the coast unprotected from waves and more vulnerable to wave action, and as ice coverage decreases so does the damping effect it has on wave action. The effects of sea level rise and storm surges are therefore becoming more destructive than they otherwise would be.

What are Alaskans observing?
- Coastal towns and villages report rapidly eroding coastlines, resulting in loss of homes, streets, businesses, and even graveyards.
- Storm surges cause short-term flooding that damages homes and community facilities, and can push small boats some distance inland from the sea.
- Increased seasonal flooding accelerates shoreline erosion, and in a few cases entire villages are being forced to begin moving to higher ground.
- Rapid erosion has threatened homes and forced emergency evacuations.
- Six Alaska communities are planning partial or total relocation, and 160 have been identified as threatened by climate-related erosion by the U.S. Army Corps of Engineers. The Corps estimates relocation costs at $30 to $50 million per village.

What are the facts?
- During the last 100 years, the annual average temperature in the Arctic has climbed slightly more than 3 degrees F.
- The world’s oceans have risen overall about 8 inches in the past century.
- Although sea level rise on the Alaska coast is not yet documented due to a lack of historical data, scientists say that eventually it will affect at least some parts of the state.
- Thawing permafrost (also climate-related) increases the coast’s susceptibility to erosion. When melted water in the soil drains off, it leaves the remaining soil soft and porous, so when it is attacked by waves or moving water, it easily erodes or sloughs off.
- In some places, the shoreline has receded by as much as 100 feet in a single storm.
• Seawater intrusion from storm surges has contaminated water sources and changed the salinity of coastal ponds that are essential to wildlife.

• The National Oceanic and Atmospheric Administration predicts storm surges of 10 feet or more for many western Alaska coastal communities during the next 50 years, and some parts of the western Alaska coast could experience surges as high as 13 feet.

**Why are sea level rise and storm surge happening?**

Atmospheric scientists say burning of fossil fuels (coal, oil, natural gas) releases "greenhouse gases" into the air, which trap heat that would otherwise escape into space. Some scientists say that the earth's natural climate cycle also is at work.

**What can we do to halt and reverse sea level rise?**

Most authorities say that the only solution is using less fossil fuel–based energy wherever possible, driving less, walking more, and using public transport. This is called climate change mitigation. To make significant improvements will require worldwide changes in society and economies, however, and decades or centuries will pass before current trends are completely reversed.

**How can we adapt to these inevitable changes?**

• Encourage communities to work with state and federal agencies to plan for gradual but permanent migration to a safer and more stable location.

• Look into flood and inundation resistant constructions, such as houses that are elevated on pilings or that float.

• Organize other response efforts. For example, make plans to relocate homes and businesses away from the shore.

• Structures and facilities can be fortified, and beaches armored with riprap, concrete, or sheet piling walls, although these expensive options are not always effective.

• Establish protective buffers of vegetation to prevent or moderate the effects of wind wave and storm surge.

• Encourage land use zoning to prevent future building in vulnerable areas.

• Help your community develop emergency evacuation plans. Identify a safe area or building away from the shoreline or riverbank where community members can quickly seek safety. In some cases an evacuation shelter should be built in or near the community.

• Families can develop their own evacuation strategies. Identify a safe meeting place for family members, and store emergency equipment and supplies in an area that will be safe from inundation.

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**For more information or assistance**

- Climate Change Adaptation, Alaska Sea Grant Marine Advisory Program  
  [http://www.marineadvisory.org/climate](http://www.marineadvisory.org/climate)

- Alaska Center for Climate Assessment and Policy (ACCAP)  
  [http://ine.uaf.edu/accap/alaska_arctic.html](http://ine.uaf.edu/accap/alaska_arctic.html)

- CReSIS Sea Level Rise Maps  
  [https://www.cresh.ku.edu/data/sea-level-rise-maps](https://www.cresh.ku.edu/data/sea-level-rise-maps)

- Alaska Department of Commerce, Community & Economic Development  
  [http://www.commerce.state.ak.us/dcra/ACCIMP.htm](http://www.commerce.state.ak.us/dcra/ACCIMP.htm)

- US Army Corps of Engineers Alaska District Alaska Baseline Erosion Assessments  

- Scenarios Network for Alaska Planning—community temperature profile charts  
  [http://www.snap.uaf.edu/community-charts](http://www.snap.uaf.edu/community-charts)

- NOAA Climate Prediction Center Alaska Storm Tracks Monitoring, Outlook and Assessment  

- NOAA sea level trends in Alaska Station location maps, data, and tide predictions  
  [http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml](http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml)
2010 Inventory of Climate Change Adaptation Resources in Alaska

This list includes links to case studies, data & information, and planning & action tools.

For an annotated inventory with the description of the following programs and links to ACCAP projects, podcasts and videos about climate change adaptation, please visit the ACCAP website on adapting to a changing climate in Alaska (http://ine.uaf.edu/accap/adaptation.html).

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Case Studies

- Climate Adaptation Case Studies (CASES) Database http://cses.washington.edu/cig/cases
- CASES Adaptation Library http://cses.washington.edu/cig/cases/library
- Climate Adaptation Knowledge Exchange (CAKE) http://www.cakex.org/case-studies
- Initiative on Climate Adaptation Research and Understanding through the Social Sciences (ICARUS) http://www.icarus.info/about/
- NOAA Coastal Climate Adaptation Website http://collaborate.csc.noaa.gov/climateadaptation/default.aspx

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Data & Information

- ACCAP Alaska Climate Dispatch: A Statewide Seasonal Outlook and Summary http://ine.uaf.edu/accap/dispatch.htm
- ACCAP Alaska Monthly Climate Webinar Archived Podcasts, Presentations, and Videos http://ine.uaf.edu/accap/telecon_archive.htm
- Alaska Native Tribal Health Consortium Center for Climate and Health http://www.anthc.org/chs/ces/climate/index.cfm
- National Research Council reports on climate choices http://www.national-academies.org/
  - Advancing the Science of Climate Change http://americasclimatechoices.org/panelscience.shtml
  - Limiting the Magnitude of Future Climate Change http://americasclimatechoices.org/panelmitigation.shtml
  - Adapting to the Impacts of Climate Change http://americasclimatechoices.org/paneladaptation.shtml
- Scenarios Network for Alaska & Arctic Planning (SNAP) http://www.snap.uaf.edu/home
- NOAA Coastal Climate Adaptation Website http://collaborate.csc.noaa.gov/climateadaptation/default.aspx
Planning & Action Tools

- ACCAP Decision-Making for At-Risk Communities in a Changing Climate
  http://ine.uaf.edu/accap/documents/DecisionMakingForCommunitiesAtRisk.pdf
- Alaska Sea Grant Marine Advisory Program’s Living in a Changing Alaska Manual and Fact Sheets
  http://seagrant.uaf.edu/map/climate/
- Alaska Governor’s Sub Cabinet on Climate Change Adaptation Advisory Group
  http://www.climatechange.alaska.gov/aag/aag.htm
- American Indian & Alaska Native Climate Change Working Group
  http://stemrc.aihec.org/envsci/ccworkgroup/default.aspx
- City of Homer Climate Action Plan: Reducing the Threat of Global Climate Change Through Government and Community Efforts
  http://www.ci.homer.ak.us/CLPL.pdf
- Center for Indigenous Environmental Resources http://www.cier.ca/
- 2009 Interior Issues Council Climate Change Task Force Preliminary Vulnerability Assessment Report
  http://www.investfairbanks.com/Taskforces/climate.php
- Foundation for International Environmental Law and Development’s Ways for Indigenous Peoples’ groups to advance adaptation concerns and solutions
- King County, Washington and Climate Impacts Group. 2007 Preparing for Climate Change: A Guidebook for Local, Regional and State Governments
  http://cses.washington.edu/cig/fpt/guidebook.shtml
- International Union for Conservation of Nature Ocean & Climate Change Tool & Guideline Handbook
  http://cmsdata.iucn.org/downloads/the_ocean_and_climate_change.pdf
- National Congress of American Indians Climate Change Planning Tools for First Nations
  http://climatechange.ncaiprc.org/
- National Esturine Research Reserve System (NERRS) Planning for Climate Change Workshop Materials
  http://nerrs.noaa.gov/CTPIndex.aspx?ID=455
- NOAA Coastal Services Center Risk and Vulnerability Assessment Tools http://www.csc.noaa.gov/rva_tools/
- Northern Climate ExChange http://www.taiga.net/nce/about.html
- Sea Ice for Walrus Outlook (SIWO) http://www.arcus.org/search/siwo
- UK CIP Adaptation Wizard
- World Wildlife Fund Climate Witness Toolkit
2010 Annotated Inventory of Climate Change Mitigation Resources in Alaska

This inventory includes energy audit, incentive/financing and weatherization programs, guidebooks and reports, training and technical assistance programs, and general energy and renewable energy information resources. Additionally, a calendar of upcoming climate change mitigation and energy workshop and training activities as well as much of the information provided below is categorized by region on the Alaska Energy Efficiency and Conservation Working Group website, http://akenergyefficiency.org/.

Energy Audit, Weatherization, & Incentive/Financing Programs

- **Alaska Energy Authority** [http://akenergyauthority.org/eecbg.html](http://akenergyauthority.org/eecbg.html)
  Alaska Energy Authority (AEA) is initiating an energy efficiency audit program to assess electrical load, equipment, lighting, thermal, HVAC and other conservation methods in commercial and institutional establishments. Once designed, AEA will contract with selected service providers to conduct these audits on a cost-share basis with interested workplaces. This site also has links to similar programs.

  **AEA Tool program:** AEA offers the following tools for check-out by Alaskans seeking to assess opportunities for improved efficiency in their homes or workplaces. For Rental Information Contact: (907) 771-3000

  - **Watt Meters** - Plug these meters into an outlet, then plug an appliance into them and read how much electricity they are using.
  - **Light Meters** - These meters help auditors assess the light levels of a room to prepare for energy efficient lighting upgrades. They can assess the levels of natural light, and help you decide what and when artificial lights are appropriate.
  - **Ballast Checker** - Point these checkers at your fluorescent light fixtures, and quickly read the type of ballasts they have. This tool is great for easily assessing the ballast type in order to more accurately calculate the energy savings potential of efficiency improvements.
  - **Occupancy light sensors and data loggers** - These occupancy sensors record whether the lights are turned on, and whether anyone is in the room using them. These tools are for assessing light wastage, as well as feasibility of an occupancy sensor tied to the light switch.

  **AEA Village Energy Efficiency Project (VEEP)** VEEP is designed to perform upgrades rural Alaskan community buildings. Similar to the Village End Use Efficiency Measures (VEUEM) program, VEEP aims to help villages achieve energy savings by replacing or installing energy-efficient lighting, lighting controls, set back thermostats, building thermal envelope improvements, weather stripping and low mass boilers.

  **AEA Whole Village Energy Retrofit project** This program is designed to be a comprehensive look at an individual community's energy needs and a partnership with different agencies to capitalize on a broad
range of energy efficiency opportunities within the community. In the first round of this project, AEA partnered with AHFC, AVEC, AVCP-Housing, the community of Nightmute, Denali Commission, and Rural Cap to perform a "whole village" retrofit in the community of Nightmute. AEA seeks to repeat the process of Nightmute with other communities, to make them broadly more efficient and to assess the effect large-scale changes to reduce energy use.

- **Alaska Housing Finance Corporation** [http://www.ahfc.state.ak.us/grants/weatherization.cfm](http://www.ahfc.state.ak.us/grants/weatherization.cfm)
  The Alaska Housing Finance Corporation (AHFC) administers a home weatherization program that offers free energy efficiency improvements to low-income houses statewide. This includes home weatherization and energy efficiency grants and rebate programs in addition to low-interest financing. Income limits for participation in the program can be found here: [http://www.ahfc.state.ak.us/iceimages/reference/income_limits.pdf](http://www.ahfc.state.ak.us/iceimages/reference/income_limits.pdf). A program fact sheet with more information can be found here: [http://www.ahfc.state.ak.us/iceimages/energy/weatherization_program_factsheet.pdf](http://www.ahfc.state.ak.us/iceimages/energy/weatherization_program_factsheet.pdf)

  - **AHFC Energy Efficiency Interest Rate Reduction Program** [http://www.ahfc.state.ak.us/loans/eeirr.cfm](http://www.ahfc.state.ak.us/loans/eeirr.cfm)
    AHFC offers interest-rate reductions on loans made by AHFC to homebuyers purchasing new homes with 5 Star and 5 Star Plus energy ratings, which exceed the Building Energy Efficiency Standard (BEES). AHFC also offers rate reductions for energy improvements to older, existing home purchases. AHFC has issued more than 10,000 loans under this program, with a total value of nearly $1.8 billion.

  - **AHFC Second Mortgage for Energy Conservation Program** [http://www.ahfc.state.ak.us/loans/second_energy_conserv.cfm](http://www.ahfc.state.ak.us/loans/second_energy_conserv.cfm)
    Homeowners may obtain financing to make energy efficiency improvements in their homes through AHFC's Second Mortgage for Energy Conservation Program. Loans are limited to a maximum of $30,000 and 15 years. For borrowers simultaneously participating in the Home Energy Rebate Program (recommended), the rebate received will be applied toward the outstanding balance of the mortgage program.

  - **AHFC Small Building Material Loan** [http://www.ahfc.state.ak.us/loans/small_building_material.cfm](http://www.ahfc.state.ak.us/loans/small_building_material.cfm)
    AHFC provides direct financing for the renovation or completion of residential properties located in designated "small communities." However, the project may include energy-efficient upgrades and renewable-energy systems.

- **CCHRC Portal (on retrofits, trainings and loans)** [http://www.cchrc.org/portal/default.html](http://www.cchrc.org/portal/default.html)
  The portal was established to assist residents in making their homes more energy efficient through the state's Weatherization program and its Home Energy Rebate program. Homeowners who visit the portal can find the resources they need to start and finish a home energy retrofit, including contractor listings, information about improvement options and help with paperwork. The portal also hosts free consumer workshops through a partnership with the Alaska Craftsman Home Program and the Alaska Housing Finance Corporation.

  Independent federal agency that focuses on providing critical utilities, infrastructure, and economic support to rural Alaskan communities. The Denali Commission’s Energy Program primarily funds design and construction of replacement bulk fuel storage facilities, upgrades to community power generation and distribution systems, alternative-renewable energy projects, and some energy cost reduction projects. The Commission works with the Alaska Energy Authority (AEA), Alaska Village Electric Cooperative (AVEC), Alaska Power and Telephone and other partners to meet rural communities’ fuel storage and power generation needs. Types of projects funded include: Bulk-fuel storage, community
power generation, distribution systems upgrades, energy cost reduction projects, renewable and alternative energy, power line interties.

  Enroll for your office, school or building in the Green Star Award program. This is the step-by-step process for achieving a Green Star Award.

  **RurAL CAP Small Grants Program**
  The RurAL CAP Foundation has a focus on low-income people and rural communities. A limited number of small grants are provided for educational and charitable purposes. Grants up to $1,500 are made to eligible 501(c)(3) nonprofit and governmental organizations in rural Alaska that do not have an open Foundation grant. These can be used to provide support to low-income people to expand their capabilities through training and educational opportunities.

  Through 2009 American Recovery and Reinvestment Act funding, RurAL CAP is employing 120 rural Alaskans in 12 villages to provide low-cost, energy efficiency upgrades and education in over 1,000 homes. Communities not receiving weatherization services recently or in the near future are targeted. In the summer of 2010, 40 youth from 20 VISTA Energy or RAVEN AmeriCorps communities will be employed and trained to conduct community-wide energy efficiency education and distribute residential energy-saving supplies to 1,400 homes. The program serves one community at a time, rather than many houses in scattered communities. Each community project takes one to three years to complete; the 2009 weatherization communities are Alakanuk, Emmonak, Juneau, Kipnuk, Kivalina, Kwethluk, Nome, Nunam Iqua, St. Michael and Tununak.

  **RurAL CAP Rural Energy Enterprises**
  As a wholly-owned subsidiary of RurAL CAP, Rural Energy Enterprises (REE) is a wholesale distributor of energy efficient and money saving products, such as Toyostoves, boilers, woodstoves and water heaters. REE maintains business relationships with 242 small entrepreneur dealerships in rural Alaska.

- **Regional Housing Authorities**
  Regional Housing Authorities help administer and are excellent points of contact for the state-wide weatherization and rebate programs funded by the Alaska Housing Finance Corporation. Contact and other information about the Regional Housing Authorities in your region are below.

  **Aleutian Housing Authority**
  [www.aleutian-housing.com](http://www.aleutian-housing.com)
  907.563.2146

  **Association of Village Council Presidents Housing Authority**
  Contact Information:
  1-800-478-4687

  **Bristol Bay Housing Authority**
  [www.bbha.org](http://www.bbha.org)
  907-842-5956

  **Bering Straits Regional Housing Authority**
907.443.5256

Interior Regional Housing Authority
http://www.irha.org/
713 15th Ave, Fairbanks, AK 99701-6116
907-452-5323

Ketchikan Indian Community Housing Authority
(907)-228-5218

Kodiak Island Housing Authority
http://www.kodiakislandhousing.org/
(907) 486-8111

North Pacific Rim Housing Authority
http://www.nprha.com/index.htm
(888) 274-1444

Northwest Inupiat Housing Authority
http://www.maniilaq.org/home.html
1-800-478-331

Tagiugmiullu Nunamiullu Housing Authority
http://www.tnha.info/
(907) 852-7150

Tlingit-Haida Regional Housing Authority
http://www.thrha.org/index2.asp
(907) 780-6868

  The REAP program is designed for small businesses and agriculture producers (this includes loggers and fishermen), and can help fund energy efficiency projects. It applies anywhere in the state except for the Municipality of Anchorage. Under REAP, USDA can fund up to 25% of a project with grant funds (the maximum grant is $500,000). If applicants later decide to include loans, USDA can cover up to 75% (25% grant, 50% guaranteed loan) under the REAP.

Guidebooks & Reports

- City of Homer Climate Action Plan: Reducing the Threat of Global Climate Change Through Government and Community Efforts http://www.ci.homer.ak.us/CLPL.pdf The impetus for action by the City of Homer was the growing recognition that global climate change is real, it is due primarily to human activities, and it will have catastrophic consequences if immediate action is not taken to curb greenhouse gas emissions.
• City of Homer Sustainability Guidebook http://www.ci.homer.ak.us/guidebook.pdf
A policy guide for City of Homer employees on reducing energy use and waste in local government operations.

• Fairbanks North Star Borough Baseline Greenhouse Gas Inventory, 2007
http://www.uaf.edu/acep/publications/detail/index.xml

• ICLEI - Local Governments for Sustainability The Mitigation-Adaptation Connection: Milestones, Synergies and Contradictions
www.icleiusa.org/actioncenter/planning/The%20Mitigation-Adaptation%20Connection.pdf  A primer that discusses the synergies and differences between climate mitigation and adaptation planning.

The Interior Issues Council Climate Change Task Force is a group of citizens and public employees collaborating to establish and build a sustainable climate resilient community through education, public outreach, and borough-wide actions.

• 2007 Interior Issues Council Cost of Energy Task Force, Fairbanks Energy Plan

• King County, Washington and Climate Impacts Group. 2007 Preparing for Climate Change: A Guidebook for Local, Regional and State Governments
http://cses.washington.edu/cig/fpt/guidebook.shtml

• 2008 Summary Report of Improvements to the Alaska Greenhouse Gas Emission Inventory

Training & Technical Assistance Programs

• ABSN Technical Assistance Programs www.absn.com
Each year ABSN provides technical assistance to dozens of individuals and entities on a variety of building science topics. Sample topics include boiler sizing, vapor retarders, green building products, XPS foam, ice dams, AkWarm, non VOC paint, energy savings, lighting, tax credits and Outside Insulation Techniques. Technical assistance can range from simply answering an email or phone call, to proofing building plans and energy systems, to providing hands-on technical training or inspection of the building envelope or mechanical systems.

• Alaska Finance Housing Corporation Energy Efficiency Education and Workshops
http://www.ahfc.state.ak.us/workshops/workshops.cfm  Energy raters, weatherization assessors, crews, contractors, do-it-yourself homeowners, and the general public are being trained in weatherization-installation techniques, building science, building auditing, energy modeling, combustion safety, moisture control and ventilation, and more. Training programs such as these are essential to ramp up for large program expansion.
- **CCHRC Portal on retrofits, trainings and loans** [http://www.cchrc.org/portal/default.html](http://www.cchrc.org/portal/default.html)
  The portal was established to assist residents in making their homes more energy efficient through the state's Weatherization program and its Home Energy Rebate program. Homeowners who visit the portal can find the resources they need to start and finish a home energy retrofit, including contractor listings, information about improvement options and help with paperwork. The portal also hosts free consumer workshops through a partnership with the Alaska Craftsman Home Program and the Alaska Housing Finance Corporation.

  EPA provides guidance for local governments on designing and implementing Programs. **US EPA Webinars**: [e-GGRT Training Session](http://epa.gov/climatechange/emissions/training.html)
  USEPA is hosting a number of webinars for people involved with reporting under the Greenhouse Gas Reporting Program. These sessions will provide users with information on the electronic GHG reporting tool (e-GGRT) and will provide information on registration, the designated representative, how to use the web forms and other topics. Individuals interested in attending any of the sessions must register in advance as space is limited.

- **VISTA Energy Program** [http://www.ruralcap.com/www/?option=com_content&view=article&id=78&Itemid=254](http://www.ruralcap.com/www/?option=com_content&view=article&id=78&Itemid=254)
  Since 2007, 12 national service Volunteers in Service to America (VISTA) members are recruited each year from their villages in rural Alaska to educate, train and build the capacity of their community to address local energy priorities. VISTA Members receive training and support from RurAL CAP and partners, and serve full-time for one to two years based at their local tribal or city councils. VISTA Energy members have worked with local leaders, youth and volunteers to assess and prioritize energy needs, research renewable energy options, create community energy plans, generate grants and donations, conduct home/community building energy assessments and efficiency upgrades, and organize community-wide energy efficiency education, student-led projects, school events, energy fairs and community gardens.

  Committed to Promoting and implementing energy efficiency and conservation measures, the YRITWC offers hands on technical trainings in wind, solar and solar thermal technology for tribal members.

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### General Energy & Renewable Energy Information Resources

- **Alaska Center for Energy and Power** [http://www.uaf.edu/acep/](http://www.uaf.edu/acep/)
  The Alaska Center for Energy and Power (ACEP) based at the University of Alaska is dedicated to applied energy research and testing focused on lowering the cost of energy throughout Alaska and developing economic opportunities for the State, its residents, and its industries. The website includes a searchable database of energy research, including papers, presentations and reports.

- **Alaska Climate Change Mitigation Advisory Group** [http://www.akclimatechange.us/Mitigation.cfm](http://www.akclimatechange.us/Mitigation.cfm)
  Five Technical Work Groups (TWGs) for the Governor’s
Sub Cabinet on Climate Change analyzed options for mitigating greenhouse gases in Alaska that contribute to climate change. TWGS included Forestry, Agriculture & Waste, Cross Cutting Issues, Energy Supply & Demand, Oil & Gas, and Transportation & Land Use. Final reports and recommendations are available at this website.

  Much of the information in this handout was found on this website. It provides a calendar of training and workshop opportunities, and search options for annotated resources by region and for professionals, homeowners, students, and teachers. It is a collaborative effort of the Alaska Energy Efficiency and Conservation Working Group (EECWG), a partnership of over 20 entities, including state and federal government programs, utilities, state legislative offices, local non-profits, university programs, private businesses and tribal organizations.

  A public networking site that allows people interested in Alaska’s energy matters to share information and connect with others, and to ask energy-related questions that get answered by experts.

- **Alaska Energy Wiki** [http://www.energy-alaska.com/](http://www.energy-alaska.com/)
  Designed to provide information on energy technologies, energy opportunities, and energy projects in Alaska.

- **Alaska Village Electric Cooperative** [http://avec.securesites.net/about-us.php](http://avec.securesites.net/about-us.php)
  Tips on saving energy for rural Alaskans. Free energy conservation video games for kids

  Renewable Energy Alaska Project (REAP) is a coalition of large and small Alaska utilities, businesses, conservation and consumer groups, Alaska Native organizations, and municipal, state and federal entities with an interest in developing Alaska’s vast renewable energy resources. REAP’s goal is to increase the production of renewable energy in Alaska and bring the benefits of clean, economic and inexhaustible renewable power to the citizens of Alaska.

- **Regional Greenhouse Gas Initiative** [www.rggi.org](http://www.rggi.org)
  The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort by Northeastern and Mid-Atlantic states to reduce carbon dioxide emissions. To address this important environmental issue, the RGGI participating states will be developing a regional strategy for controlling emissions. Central to this initiative is the implementation of a multi-state cap-and-trade program. The proposed program will require electric power generators in participating states to reduce carbon dioxide emissions.

- **Bristol Bay Native Association Tribal Energy Program**
  [http://bbna.com/website/Tribal%20Energy.html](http://bbna.com/website/Tribal%20Energy.html)
  A new program of the Bristol Bay Native Association, to promote renewable energy and energy efficiency in Bristol Bay.

- **West Coast Governors’ Global Warming Initiative**
  In November 2004, the governors of Washington, Oregon, and California approved a series of detailed recommendations to reduce global warming pollution and directed their staff members to broaden efforts on mitigation strategies.
Join us each month for a one hour presentation and discussion about Alaska-specific climate related topics that impact you. ACCAP webinars foster discussion and information exchange between scientists and stakeholders in a forum that is accessible state-wide. Webinars are one-hour and begin with 30 minutes of presentation, viewed via web-based software, followed questions and discussion. Participants include state and federal agencies, non-profit organizations, news media, municipal and borough governments, tribal governments, teachers and schools, and trade organizations. Webinars are toll free and presentations are available via standard internet connection.

Recent webinar topics include:
- Changes and uncertainty in Alaska’s water resources
- Permafrost degradation and monitoring
- Climate change and Alaska fisheries
- Experimental wildfire forecasts for Interior Alaska
- Mapping tools for Alaska climate change projections
- Impacts of sea ice change on humans and marine mammals

Archived podcasts and presentations are available at: http://ine.uaf.edu/accap//teleconference.htm
This manual’s purpose is to improve the availability of current information about sea ice from operational and academic observation programs to key user groups. It provides Arctic Alaska coastal community leaders and local user groups with an up-to-date, comprehensive, and practical guide to the current sea-ice and climate information resources that are relevant to their planning, subsistence activities, and way of life. The resources and tutorials in this manual are organized within five main types of sea ice information:

1. Sea ice concentration, extent, and type
2. Location and extent of multi-year sea ice
3. Sea ice leads, open water, and shorefast ice extent
4. Local sea ice observatories at Barrow and Wales, Alaska
5. Sea ice summaries

Many communities in Alaska are faced with multiple threats to infrastructure and quality of life due, in part, to projected changes in precipitation, temperature, and related incidences of flooding and erosion. We have developed a guide with a matrix approach to communities at risk so that decision-makers are well informed on planning related to climate change and uncertainty, risk management, and relocation. The guide includes steps from planning through execution, perspectives on community engagement, partial relocation, site development costs, and timing. Sustainability recommendations focus on defining sustainability, future energy planning, planning for a changing cost of living, and available transportation corridors.

The quarterly Alaska Climate Dispatch is a newsletter-style document that provides stakeholders with seasonal weather and climate summaries as well as Alaska weather, wildfire, and sea ice outlooks in one easily accessible document. Guest columnists may provide information on related topics such as El Niño and El Niña, hydrology, and permafrost. Interpretive and clearly written text, full-color pictures, charts, and maps provide decision-makers with a timely snapshot of a wide range of Alaska’s diverse weather and climate issues. The Alaska Climate Dispatch is distributed electronically and made available on the ACCAP website.
ACCAP listens and responds to what Alaskan agencies, industries and citizens need to respond to a changing climate. ACCAP works directly with stakeholders to inform realistic community plans and climate adaptation strategies using the most scientifically accurate, reliable, and up to date information. ACCAP is funded by the National Oceanic and Atmospheric Administration (NOAA) and is one of a group of Regional Integrated Sciences and Assessments (RISA) programs nation-wide. The RISA program supports research that addresses sensitive and complex climate issues of concern to decision-makers and policy planners at a regional level.

Assisting with Adaptation Planning: Sample Projects

Regional Climate Resilience Planning

ACCAP scientists serve as scientific advisors for the Interior Issues Council Climate Change Task Force. In partnership with the International Council for Local Environmental Initiatives, this task force works closely with Borough staff, university scientists, and community leaders to develop, implement and monitor a climate resilience plan for the Fairbanks North Star Borough.

Collaborating with Alaska Sea Grant on Coastal Community Adaptation

ACCAP partners with the Alaska Sea Grant Marine Advisory Program to develop climate change outreach materials and provide community workshops to assess climate change vulnerability and create adaptation strategies for coastal communities.

Interpreting Climate Projections

ACCAP works closely with the University of Alaska’s Scenarios Network for Alaska Planning to provide downscaled temperature, precipitation, and growing season projections for Alaska, now available in Google Earth format. ACCAP scientists collaborate with the Governor’s Climate Change Sub-Cabinet, local governments, and other stakeholders to:
- Provide accurate, reliable, and timely information
- Interpret the implication of climate projections
- Assist in adaptation and mitigation planning
- Develop products that meet regional adaptation needs

Evaluating Fire Forecast Products to Enhance U.S. Drought Preparedness and Response

ACCAP collaborates in a cross-regional partnership with the Climate Assessment for the Southwest RISA, The Desert Research Institute, and the Western Regional Climate Center to assess the impact of annual seasonal and monthly fire outlooks on decision makers and federal and state agencies who collaborate to plan for and manage wildfires in the Western U.S.

Linking Climate Change Impacts to Community Based Responses in the Alaskan Interior

ACCAP scientists enhance communication about climate change between rural community members, teachers, and scientists in a project that collects and video records local observations on environmental change from elders and active younger hunters.
Best Management Practices for Communities at Risk

Many communities in Alaska are faced with multiple threats to infrastructure and quality of life due, in part, to projected changes in precipitation, temperature, and related incidences of flooding and erosion. We have developed a guide with a matrix approach to communities at risk so that decision-makers are well informed on planning related to climate change and uncertainty, risk management, and relocation. The guide includes steps from planning through execution, perspectives on community engagement, partial relocation, site development costs, and timing. Sustainability recommendations focus on defining sustainability, future energy planning, planning for a changing cost of living, and available transportation corridors.

Improving Seasonal Fire Predictions for Alaska

ACCAP scientists use novel methodology to produce estimates for the severity of upcoming fire seasons. A web-based decision-support tool was designed in collaboration with fire managers from agencies participating in the Alaska Wildland Fire Coordination Group. ACCAP partners with the Alaska Joint Fire Science Consortium to enhance communications between fire science managers and make the research more applicable and useful to people on the ground.

State Drought Planning in the Western U.S.

ACCAP collaborates with other western RISAs to investigate, evaluate, and seek to improve the integration and value of drought information for reducing drought hazards through state drought planning and decision-making. Each RISA brings critical expertise on dealing with drought in their region that, collectively, can lead to a greater understanding about west-wide drought.

Monthly Climate Webinars

ACCAP webinars foster discussion and information exchange between scientists and stakeholders in a forum that is accessible state-wide. The webinar is toll-free and presentations are available via standard internet connection. Archived podcasts, presentations, and summaries from 2007-present are available on our website.

Recent webinar topics include:
- Changes and uncertainty in Alaska’s water resources
- Permafrost degradation and monitoring
- Climate change and Alaska fisheries
- Implications of ocean acidification for Alaska
- Mapping tools for Alaska climate change projections

Training for Sea Ice Decision Support

ACCAP has developed an up-to-date, comprehensive, and practical guide to sea-ice and climate information resources that are relevant to Arctic Alaska coastal community leaders and local user groups for planning, subsistence activities, and way of life.

For more information please contact us at accap@uaf.edu, (907) 474-7812, or on the web at http://ine.uaf.edu/accap/