6. Federal Arctic Observing Activities: Tomorrow

a. Agencies' Future Plans

BLM

BLM is responsible for the National Petroleum Reserve-Alaska (NPRA), an area nearly 24-million acres, all of which is above the Arctic Circle. Most of the area has been mapped using Landsat Thematic Mapper in the mid-1990s. BLM is developing a long-term monitoring strategy relative to mitigation effectiveness of permitted activities for oil and gas exploration and development of the NPRA. In addition, BLM as a member of NSSI is currently working to monitor the long-term effects of climate change such as coastal erosion, hydrology and land cover change. Most of the BLM's current activities in the NPRA are providing information to establish a baseline of conditions in which to measure trends in the future.

CDC

Currently focused on the invasive bacterial diseases, the ICS network will expand to include a surveillance system for tuberculosis in Arctic countries in 2007. Expansion of participating public health entities to include northern regions of the Russian Federation is planned for 2008-9. Other potential areas of expansion could include surveillance of climate sensitive infectious diseases, intentional and unintentional injuries, birth defects, and chronic diseases such as cancer, cardiovascular diseases, obesity and diabetes.

DOD

The IABP is expected to continue and become an integral part of AON. Ground temperature measurements to monitor permafrost are also expected to continue, with the goal of upgrading sites to include automated data collection and reporting system, and incorporating sites into a larger, coordinated network.

At CRREL's Fox Permafrost Tunnel, major renovation and upgrades are planned over the next three to five years to allow the tunnel to continue to be a major research facility.

DOD, in collaboration with NSF, is developing a plan to continue the SCICEX program, looking to maximize the opportunities to use the unique research platforms offered by submarines operating in the Arctic Ocean.

DOE

DOE observing plans include continued support of the measurement capabilities at the DOE ACRF sites (Barrow, Atqasuk) on the North Slope of Alaska. Plans for the continued development of the Barrow site include a multi-scale observing facility for characterizing the 3-D structure of clouds. Plans for the continued development of the Atqasuk site include support for NOAA CRN precipitation measurement instrumentation, and possible aerosol and gas chemistry instruments to provide baseline air quality measurements related to oil and gas exploration and production in the area.

The ACRF also plans to enhance its measurement capabilities by supporting the use of unmanned aerial vehicles and tethered balloons in the Barrow, Atqasuk and Prudhoe Bay/Oliktok areas. These deployments would include airborne instrument packages for *in situ* cloud properties, aerosol size and chemical composition, and remote sensing to measure water vapor and other parameters.

DHS

USCG will continue operating polar icebreakers, conducting the IIP and participating with the US Navy and NOAA in NIC. USCG will also prepare for increased maritime activity in the Arctic by continuing the ADA program and beginning plan-

ning for Forward Operating Locations on the North Slope of Alaska. This has created the possibility of science-of-opportunity projects on ADA C-130 flights.

USCG envisions significant growth in all of its missions in the Bering Sea and north of the Arctic Circle. It is important that operational observing products useful to all elements of the maritime community - commercial, scientific, and military - be available. Thus, organizations from these communities also need to be involved in the development of AON data collection and products.

EPA

EPA plans to continue NARS, a program that monitors coasts, streams, rivers, lakes, and wetlands. The NARS final report for lakes is scheduled for completion in 2009, for rivers and streams in 2011, for coasts in 2012, and for wetlands in 2013.

MMC

MMC currently is developing circumpolar monitoring plans for Arctic marine mammals in conjunction with relevant US, foreign and international agencies. The Commission held a workshop in March 2007 to initiate development of plans for ringed seals and beluga whales, with the goal of identifying key biological and ecological parameters to monitor for the purpose of characterizing the impacts of changing oceanographic, sea ice and climate conditions on marine mammals and their ecosystems. These plans are intended to contribute to AON and other similar efforts, particularly the Arctic Council's CBDP. One of the key findings from this effort to date is the need for monitoring of key ecosystem components in addition to marine mammals, especially important lower trophic organisms like arctic cod (*Boreogadus saida*), which is a dominant food item for many upper trophic organisms in the Arctic and is tightly linked to sea ice and cold water temperatures.

MMC will continue its efforts to develop circumpolar monitoring plans for Arctic marine mammals and to integrate those plans with other ongoing efforts to monitor other components of the ecosystem. As the Arctic changes, marine mammals and their host ecosystems will be impacted not only by environmental changes but also by new and increased human activities. The Commission will initiate efforts to develop a framework for assessing the cumulative impacts of increasing human activities on marine mammals as the Arctic becomes more accessible. To effectively manage human activities, it will be necessary to determine not only the individual impact of each activity but also the combined and perhaps synergistic impacts of all activities together (e.g., fishing, coastal development, oil and gas development, commercial shipping, military activities, subsistence harvest, and tourism).

MMS

MMS will continue its history of research monitoring to obtain information for resource management decisions related to oil and gas leasing, exploration and development in the Beaufort and Chukchi Seas, and potential leasing in the southeast Bering Sea. These efforts include continuation of aerial surveys of Bowhead whales in the Beaufort, which, in partnership with NOAA, will now expand into the Chukchi Sea. These annual aerial surveys focus on the Bowhead whale migration, but gather observational information on all marine mammals observed in the survey area. MMS will also continue periodic sediment and benthic surveys and chemical analyses in the Beaufort Sea and expand collections to the Chukchi Sea.

MMS will also undertake short term fishery surveys and bird surveys, in cooperation with its federal partners, which will take advantage of and complement longer term monitoring undertaken by others. MMS will continue to utilize its partnership with the University of Alaska Fairbanks Coastal Marine Institute to collaborate on interdisciplinary arctic research and monitoring in the near shore ocean, atmosphere, and human environment.

NASA

In the immediate future, NASA will continue to operate the satellite constellation currently in orbit (Figure 13), which includes GRACE and ICESat.

NASA also has seven satellite missions in development that will be launched in 2008-2014. Satellite missions of Arctic interest include the Orbiting Carbon Observatory (OCO) atmospheric carbon dioxide, Glory aerosol characteristics, NPP ocean color, GPM (Global Precipitation Measurement) rainfall, LDCM land imagery, OSTM (Ocean Surface Topography Mission) global mean sea level, and Aquarius sea surface salinity. These missions are described in the 2007 NASA Science Plan.
For 2014 and beyond, future Arctic observing missions are described in the NRC report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (NRC, 2007). NASA is planning to start the SMAP (Soil Moisture Active Passive) and ICESat-II ice sheet mass missions as quickly as feasible and is planning to initiate other NRC Decadal Survey missions as feasible. SMAP and ICESat-II launch dates are expected to be 2012 and 2015, respectively. ICESat-II is a follow-on mission to the current ICESat mission to measure the topography of Greenland, and in coordination with radar altimeter observations, will measure sea ice thickness. SMAP will provide valuable observations of soil moisture and freeze/thaw state of the soil.

As part of its IPY activities in cooperation with other Federal agencies and international partners, NASA will conduct the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) mission in April and July 2008. ARCTAS has four scientific themes: (1) long-range transport of pollution to the Arctic including arctic haze, tropospheric ozone, and persistent pollutants such as mercury; (2) boreal forest fires and their implications for atmospheric composition and climate; (3) aerosol radiative forcing from arctic haze, boreal fires, surface-deposited black carbon, and other perturbations; (4) chemical processes with a focus on ozone, aerosols, mercury and halogens. ARCTAS is a contribution to the larger POLARCAT experiment that also includes NSF, NOAA (Aerosol, Radiation and Cloud Processes affecting Arctic Climate-ARCPAC), DOE (Semi-Direct Aerosol Campaign-ISDAC) and international partners.

More information about ARCTAS, POLARCAT, ARCPAC and ISDAC is available online at:

ARCTAS: *http://www.espo.nasa.gov/arctas/*
POLARCAT: *http://www.polarcat.no*.
ARCTAS: *http://www.esrl.noaa.gov/csd/arcpac/*
ISDAC: *http://acrf-campaign.arm.gov/isdac/*

NOAA

NOAA envisions that its Arctic Ocean contribution to AON will follow the implementation design presented in the SEARCH Implementation Plan (SEARCH, 2005).

NOAA will continue to support the 13 radiosonde stations in Alaska and possibly update many stations with the Radiosonde Replacement System in the coming years.

NOAA is in the process of revitalizing its Cooperative Observer Program by providing new observation systems to the sites with long records and reliable results, while phasing out or redirecting other sites to support operational programs. NOAA's CRN has four of 29 planned sites operating.

The international network of atmospheric observatories consists of the sites at Eureka and Alert in Canada and at Tiksi in Russia. The sites in Canada depend greatly on support by Canadian research programs that end in 2012. At Tiksi, the basic instrumentation has been installed, but top-end instruments, e.g., cloud radar and profiling lidar, are lacking. The Summit Greenland site is functioning at a low level and requires significant instrumentation. No work has been done on the planned sites in northern Finland and Svalbard.

NOAA is working with external partners and stakeholders to update the precipitation frequency estimates (PFE) for the State of Alaska. PFEs are a climate-related precipitation tool for proper infrastructure development included in regulations of many Federal, state and local agencies. They are statistically-derived precipitation amounts for a range of durations and recurrence intervals. The statewide PFE data currently available for Alaska are contained

in two reports by the Department of Commerce called Technical Papers 47 and 52, last revised in 1963 and 1965, respectively. These were based upon data from a sparse network of gauges with a short period of record.

The PFE data are commonly used to reduce the risk of runoff-related loss of life and property, and to prevent pollution. They provide rainfall related criteria used extensively by the engineering and environmental communities for the design of structures such as sewers and drainage systems, for environmental studies and design, and for sediment control. The criteria are used by the Federal Emergency Management Agency to update National Flood Insurance rate maps and by the EPA National Pollution Discharge Elimination System Program to regulate pollution control in streams. Results from climate change investigations in Alaska suggest the seasonality, amount, and type of precipitation are changing in many locations. NWS uses these criteria for comparison during rainstorms that could produce flash flooding.

NPS

NPS continues to expand its vital signs monitoring across 54 million acres of NPS lands in Alaska (including two thirds of the entire National Park System). Phased development, field testing, and implementation of long-term monitoring plans are underway in all four of Alaska's Inventory and Monitoring networks (Arctic, Central Alaska, Southeast Alaska, Southwest Alaska). Monitoring to determine resource status and trends, and research to understand natural and anthropogenic processes will be critical to inform decision-makers and preserve park ecosystems. The NPS Alaska Regional Science Strategy identified five primary resource management challenges for the 21st Century, including climate change, global and local contaminants, exotic species, increasing human use, and development within and surrounding parks. The NPS is currently working with the USGS, University of Alaska, and others on proposals to model the probable future effects of climate change on park resources and operations.

NSF

NSF sees AON is seen as integral to SEARCH and fundamental to achieving its contribution to the goals of SEARCH. NSF investments in AON will be guided by the SEARCH Implementation Plan, and based on peer and panel review of proposals submitted in response to either special AON solicitations or the annual Arctic Research Opportunities solicitation. NSF will contribute to the development of a multinational, pan-Arctic AON through SEARCH and ISAC.

NSF observing plans in the Arctic also include NEON (National Ecological Observatory Network) tundra and taiga sites, respectively, at (1) Toolik Lake (currently an LTER site) on the North Slope of Alaska and (2) Caribou-Poker Creeks Research Watershed near Fairbanks (currently part of the Bonanza Creek LTER site). Information about NEON is available at *http://www.neoninc.org/* and *http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13440&org=DBI*.

NSF is coordinating cyberinfrastructure (CI) for NSF-supported environmental observatories, e.g. LTER, NEON, OOS and AON. The main goals are to identify common areas of CI needs and potential areas of coordinated development, possibly even leading to shared cyberinfrastructure.

Continued NSF support for the National Ice Core Laboratory, and US participation in the NEEM ice core and the POLENET/GNET projects will be based on the submission and review of proposals. The award for the CReSIS Science and Technology Center is nominally for 10 years (FY05-FY14) with a site review due to occur in FY2008.

USDA

USDA is committed to maintaining its current observation programs in Alaska for the coming years.

USFWS

The USFWS National Wildlife Refuge system in Alaska is developing an intranet-based database that will enable the following:

1. Allow USFWS biologists, and others, to determine quickly what monitoring efforts are occurring (and have been done recently) in the region, by species, information objective (abundance versus demography like survival or fecundity rates), area, and perhaps broad method class (telemetry, mark recapture, physiology, aerial surveys);
2. Allow the refuges' supervisory biologists to enter their inventory and monitoring study-specific details only once and automatically export them for inclusion in the refuge's Inventory and Monitoring Plan and other organizational data calls;
3. Allow for efficient updating and archiving of monitoring plans and efforts;
4. Support development of region-wide inventory and monitoring strategies for efficiency and region-scale insight.

USGS

USGS has several ongoing monitoring programs within the Arctic and Sub-Arctic environment that will continue for the foreseeable future. These programs are explained in detail at the USGS Alaska Science Center Website (*http://alaska.usgs.gov*), and include biological (ecosystems and habitats, mammal, birds and fisheries), hydrological, geographical and meteorological data collection and analysis at a range of temporal and spatial scales. For example, USGS water gauges are currently operational at 113 stream and river stations, with records ranging from 88 years at Fish Creek near Ketchikan to the recently installed gage on Bonanza Creek near McCarthy. Median length of streamflow record in Alaska is 19 years. Several of these ongoing data collection and research activities will serve as a foundation for new monitoring and research in support of an integrated assessment of permafrost thaw and its effects on carbon flux, ecosystem stability and the sustainability of native culture in the Yukon River basin beginning in 2008.

b. A Conceptual Framework for Integration and Coordination of Existing and New Observing Activities

Section 5 clearly shows that Federal agencies are engaged in myriad observing activities in each of the SEARCH Implementation Plan categories. However, most of these disparate activities pre-date SEARCH and were designed to meet the specific mission of a particular agency rather than address a broader goal, i.e., enabling SEARCH. Moreover, with few exceptions, there is little inter-agency coordination and integration of Arctic observing activities. This section presents a conceptual framework (referred to as "CORE," Committee on Environmental and Natural Resources, 1997) for organizing data from disparate programs so that data synthesis can be performed in order to address common questions, e.g., the seven core SEARCH questions presented in Section 3a.

In addition to the lack of coordination of the many different Arctic observing elements, logistical limitations impose inherent tradeoffs between the number of variables that can be measured, the frequency at which they can be measured, and the number of measurement sites. Different methods, at different scales, are required to understand the myriad interactive processes and their consequences for specific systems. No single method can provide the complete suite of information that scientists and resource managers need. These constraints lead to a hierarchical structure for data collection, which can be represented by a triangle, with the measurements that can be made at the greatest number of sites at the base and the measurements that, because of their complexity, number and frequency can only be made at a limited number of sites, at the apex (Figure 27). The types of monitoring within the framework are divided into four general classes: Tier 1 - Intensive integration and research areas; Tier 2 – Condition gradient network; Tier 3 – National and regional surveys; and Tier 4 – Inventories and remote sensing programs. Each is described below.

Tier 1 - Intensive integration and research areas typically measure a greater number of properties and at a higher frequency than any of the higher-numbered tiers, but at a small number of locations. The critical feature of this level is that all of the major potential causes of environmental change are measured at the same locations where environmental responses of concern to society are also measured. This level is essential for understanding processes that occur at local scales, for integrating the effects of multiple processes, for understanding the causes of changes detected by programs at Tiers 2, 3 and 4 of the Framework, and for developing and testing predictive models of environmental response. Measurements at this level also provide information for determining the level of uncertainty associated with inventory, remote sensing and survey results, as well as of model predictions.

Tier 2 – Condition gradient network studies monitor common variables at several locations representing the range of condition relative to a specific environmental issue or ecosystem state and process in order to determine the range and variability of possible responses to a given environmental condition or stressor. Regression relationships relating stress and response variables typically are used to estimate spatial or temporal variability in system condition. The results from gradient studies are also used to evaluate the application of models that incorporate information from Tier 1 studies. Such evaluation is important for reconciling scaling issues in the spatial application of models developed from fine-scale knowledge.

Tier 3 – National and regional surveys are designed to characterize specific properties of a region by sampling a subset of the total area, rather than the entire area. These programs are typically designed to address specific resources or environmental issues, and may cover the entire country, or only the region where a specific issue is important. Integration between Tiers 2 and 3 can help identify changes in the environment detected by remote sensing (i.e., provide "ground truth"), but generally cannot indicate why a specific change has occurred. These two levels are essential for quantifying the extent, distribution, condition, and rate of change of specific environmental properties, and for understanding processes that occur over large areas.

Tier 4 – Inventories and remote sensing programs involve basin-scale, wall-to-wall monitoring and analysis such as satellite remote sensing and aerial photography. The primary objectives are development of spatially- and temporally-continuous information, such as land use and land-cover change, forest species distributions, forest fragmentation, fire occurrence and history, albedo, ecosystem performance (e.g., production), seasonal phenology and ecosystem metrics, snow cover, and lake area.

With the tier design as a template, AON could categorize existing capabilities and determine the additional data collection necessary to meet SEARCH objectives. Application of enhanced system models using the data collected could then be used to create regional observing strategies. Each tier of this framework provides unique observations that contribute to a comprehensive, multi-component, multi-scale information system. For example, intensive monitoring and research sites are necessary for developing process-level, cause-and-effect understanding that underpins predictive models. These models are critical to predict changes in temperature, precipitation, fire risk, water supplies, and other features that are central to management decisions.

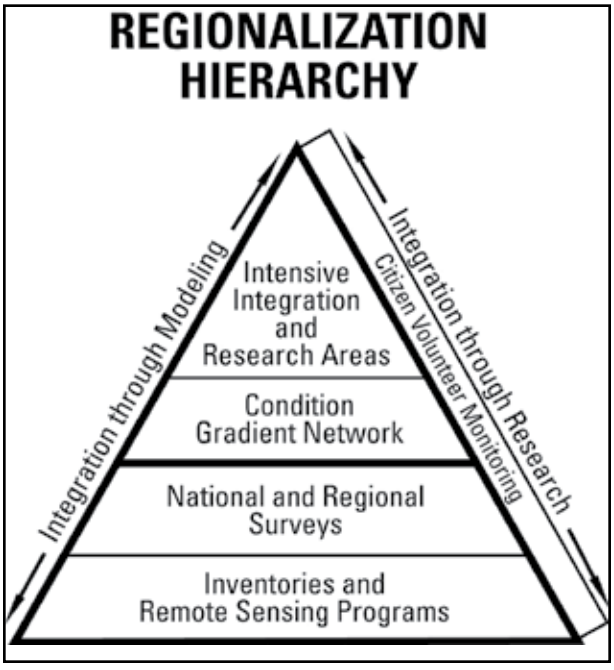

Figure 27. Conceptual framework for achieving the multiple goals of environmental monitoring and research; distribution, condition, and rate of change of specific environmental properties; and for understanding processes that occur over large areas.

Spatially-distributed observations are then needed to calibrate the models to new areas and to scale results up to a regional or national scale. New remote sensing tools developed through calibration with this ground-based network will eventually lead to earlier detection and more cost-effective tracking than has been possible to date. Scientists and managers have long recognized the inadequacy of existing data for solving complex ecosystem problems, and the need for a more integrative and synthesis-based understanding that is designed to address key management issues. The purpose of the framework is, therefore, to create a structure within which the complex effects of climate change can be addressed in a systematic and long-term manner.

c. Data and Information Management

Data and information management is integral to AON (Figure 12). The data and information must be digitally archived and preserved over the long-term, while remaining easily, freely and openly accessible to a broad range of users and stakeholders. Free, open and guaranteed access to data and information are vital for maximizing the value-added services and societal benefits of AON.

The Federal Arctic observing activities described in Section 5 produce large volumes of data and information from multiple sources and operators. Most Federal Arctic data and information holdings are widely distributed, and relatively easy to access online via the Worldwide Web (URLs for many federal and federally-supported online data and information sources are given in Section 5). However, there is no portal, i.e., a single point-of-entry, to Arctic data and information. A portal would have numerous advantages for the agencies and for their users and stakeholders – it would raise the visibility of the data and information holdings, making them more accessible to a broader audience and increasing their use (as both sinks and sources of data), thereby maximizing the value-added services and societal benefits to be derived from AON.

As a coordinated service providing a coherent, cohesive, and integrated approach to long-term Arctic data and information management, CADIS has the potential to be the portal to all US Federal agencies' Arctic data and information. CADIS would not replace or make redundant existing federal systems for Arctic data and information management. Rather, CADIS would enhance them, as described in the previous paragraph. CADIS is currently funded solely by NSF. If it is to become the portal to Federal Arctic data and information it will need to be adapted, upgraded and maintained with funding from multiple agencies.

CADIS would focus on being a portal to Arctic data and information obtained by federal agencies, and their grantees and contractors. Its value would increase if it is linked to data and information centers in the seven other Arctic countries (Canada, Greenland/Denmark, Norway, Sweden, Finland, Iceland, Russia), and also provide links to any data and information centers outside the Arctic that have relevant holdings. Since AON will be a significant addition to global environmental observing capabilities, CADIS would also be linked to the data and information management systems of the USGEO and GEOSS.

To realize the advantages of CADIS as a portal to federal Arctic data and information will require coordinated technical approaches to enable ready exchange of data and metadata across organizations and disciplines, i.e., inter-operability among data systems and centers. A data policy that ensures free and open access will also be required. Federal agencies, and/or those operating on behalf of an agency, must strive towards open, timely, and equitable access when working with Federal government information. This includes private entities or universities contracted by an agency to perform R&D by a Federal agency. In this context, the SEARCH data policy would be an appropriate model for inter-agency collaboration in the development of CADIS as a portal to all federal Arctic data and information. The SEARCH data policy is currently available in draft form at *http://www.arcus.org/search/downloads/SEARCH_Data-Policy_051207.pdf*.

An Arctic data and information portal could also play a role in coordination and integration of Federal Arctic observing activities and the development of a coherent AON. NSF, for example, views CADIS as one approach to using cyberinfrastructure to realize coordination and integration of its AON projects (Appendix 1) into a virtual observatory.

One possible model for an Arctic data portal, and one to which it could be linked, is the Global Observing Systems Information Center (GOSIC, *http://gosic.org*), a facility operated by the US Global Climate Observing System (GCOS) program at the NOAA NCDC. Run on behalf of the international observing community, GOSIC provides a broad spectrum of users with a centralized resource to aid in finding international observing system datasets and related information in a consistent fashion across a diverse array of international data centers and observing domains (e.g., atmospheric, oceanic, and terrestrial). Access tools are provided for data discovery and retrieval of global climate, ocean and terrestrial data such as the Essential Climate Variable Data and Ocean Data Access Matrices. As the GOSIC evolves it will form part of the overall data management structure associated with GEOSS.