**Ideas for SEARCH Pilot Projects**

**From Feb 2012 SEARCH SSC Meeting**

**Permafrost Data Clearinghouse**

Description: There are numerous examples of field research sites and programs for which data relevant to the permafrost goal exist. Some – but not all – of these data are safely archived and reasonably accessible. These data are archived in disparate locations and with different levels of accessibility, making it hard to discover and use. As one example, CADIS was intended to archive AON data only. The evolution to ACADIS has been envisioned as a repository for any NSF-funded arctic project data. However, other agencies have databases of their own, designed to meet their own programmatic needs. To meet the SEARCH permafrost objective the ACADIS data base would need to accept data from many other sources. But to be of greatest use to the permafrost community it might be necessary to highlight the most permafrost-relevant data. Rather than seek the objective of a unified dataset, it may be more pragmatic to create a clearinghouse that could serve as a permafrost-focused portal to several different databases.

Relevant SEARCH Objective(s):

1. **Identify gaps in arctic observing network datasets and the resources needed to fill those gaps.**
	1. Position SEARCH to coordinate observing efforts focused on permafrost dynamics, identify gaps, and encourage individual science projects to produce data that will complement the data collected by various data collection and observing networks.
	2. Help coordinate the exchange of data necessary for modeling studies and review how model predictions identify new needs for data from observing or data collection networks.
2. **Identify partners who can facilitate the science objectives of this permafrost research goal**
3. Work directly with key partners such as NASA’s Arctic-Boreal Vulnerability Experiment (ABoVE), DOE’s Next Generation Ecosystem Experiment (NGEE), and DOI’s Landscape Conservation Cooperative (LCC) initiative, to leverage resources to achieve the greatest science benefits.
4. Explore whether industry partners would be willing to share proprietary data that could help fill gaps about the spatial (and perhaps temporal) distribution of permafrost characteristics.

Timeline/timeframe: This is a supporting need that should be initiated earlier rather than later and that could yield results in 1 to 2 years.

Implementation: Currently DOI Landscape Conservation Cooperative (LCC) has begun to develop a database of climate and hydrological study sites and data sets, to be housed by UAF GINA. Additional data resources might be identified by funding a number of post-doctoral fellows who would be tasked to organize and synthesize key data sets of interest to the permafrost research community.

Estimated Resources: Depending on the scope of the effort and the number of post-doctoral fellows support this effort might cost $100,000 to $500,000.

Elevator Speech: With the funding made available we have been able to create a web portal that allows anyone to find and access data about the physical, chemical, and biological characteristics of permafrost any place in the pan-arctic region.

**Improved Permafrost Mapping**

Description: The distribution of permafrost extent and types is currently known at a crude level of resolution. In Alaska, for example, the most recent permafrost map of Alaska (Jorgenson et al, 2008) portrays landforms and ice content at a statewide scale. The surficial geologic base map used to create the ground ice and thermokarst landform layers dates from 1964 and is at a small scale (1:1.5 million). Additional, more spatially resolved information on ice content, thermal characteristics of geological materials, and characteristics of permafrost to different landforms are needed to foresee expected impacts associated with future climate change. These impacts include threats to civil infrastructure, changes in landscape characteristics that will affect important fish and wildlife resources, and increased emissions of important greenhouse gases as permafrost thaws.

Relevant SEARCH Objectives

1. **Quantify the nature, timing, and location of permafrost thaw.**
	1. Identify indicators of change in the state of permafrost, to serve as early warning signs for possible tipping points in the state of the arctic system.
	2. Determine which arctic landscapes are most sensitive to permafrost thaw and pose the greatest risks to human infrastructure and to ecosystem services.
2. **Improve prediction of how permafrost loss will influence energy, water, and carbon dynamics in the arctic.**
	1. Refine estimates of the total mass and quality of soil carbon by depth and region.
3. **Determine how permafrost degradation will influence ecosystem structure and function, ecosystem services, and human infrastructure and communities.**
	1. Quantify important physical, chemical, and biological changes that are likely to occur in the arctic landscape as permafrost thaws.

Timeline/timeframe: Several different groups have identified this permafrost mapping objective as a high priority need. However, there is limited funding currently dedicated to these efforts. As these objectives underpin other efforts within the permafrost goal it is important that we make progress on them sooner rather than later.

Implementation: The NSF-funded Permafrost Carbon Vulnerability Research Coordination Network (RCN) is an example of one multi-organization and multi-national group that is currently working to refine the needs relevant to this objective. Important new agency programs including NASA’s Arctic-Boreal Vulnerability Experiment (ABoVE), DOE’s Next Generation Ecosystem Experiment (NGEE), and DOI’s Landscape Conservation Cooperative (LCC) initiative, have identified at least some aspects of this objective as priority needs. There is willingness to cooperate but few means to do so. To avoid duplication of efforts and to maximize coordination it would be helpful to hold a workshop to bring these groups together to develop a detailed workplan.

Estimated Resources Needed: The Arctic LCC has identified a detailed workplan and decided to allocate $100,000 to an effort focused on the Alaskan arctic. Other agency programs have defined plans and outlined budget needs. Depending on the extent of field work done to refine and validate data sets, considerable progress could be made with resources totaling several $100,000s.

Elevator speech: With $*X*00,000 we have been able to define *Y* critical characteristics of permafrost in a region of *Z*00’s square kilometers and we have been able to relate these permafrost characteristics to *W* critical landform types in the arctic. The success of this effort shows that we know how to produce a product that is highly useful the stakeholder community and that – with additional funding – could be expanded to the pan-arctic region.

**Permafrost Modeling II – Model Inter-Comparison**

Description: Current estimates for the timing and extent of permafrost thaw are highly uncertain. Furthermore, interactions among physical, chemical, topographic, hydrological, and biological characteristics before, during, and after permafrost thaws are complex. Several groups have developed models to describe these dynamics. However, these different models have different conceptualizations of interactions of permafrost degradation with environmental change and have often been driven by different data inputs, and so results are difficult to compare. A controlled comparison of the responses of these models to projected climate change is important to conduct in order to establish a metric by which improvement can be compared. We propose a model inter-comparison to quantify the uncertainty in future projections of CO2 and CH4 emissions from thawing permafrost. This model inter-comparison would complement a just completed effort to quantify the range of uncertainty in expert opinions, inform climate change policy decisions, identify conceptual issues affecting uncertainty, and identify metrics that can serve as the basis for judging improvements in the ability to predict carbon feedbacks of arctic terrestrial ecosystems to the climate system.

Relevant SEARCH Objective(s):

1. **Quantify the nature, timing, and location of permafrost thaw.**
	1. Develop models and probabilistic forecasting tools to quantify uncertainties in the timing and extent of permafrost thaw in the next few decades and centuries.
2. **Improve prediction of how permafrost loss will influence energy, water, and carbon dynamics in the arctic.**
	1. Support field and modeling efforts to predict how climate change and permafrost loss will alter surface energy and water fluxes at local to regional scales.
3. **Determine how permafrost degradation will influence ecosystem structure and function, ecosystem services, and human infrastructure and communities.**
	1. Determine how these changes will affect soil stability, vegetation communities, and the distribution and availability of water.

Timeline/timeframe: Considerable progress could be made in a period of 2 years to coordinate various modeling efforts that are currently underway.

Implementation: We propose to create a standardized set of data inputs to be utilized by a suite of existing models that will each predict the trajectory the emission of of CO2 and CH4 as permafrost thaws. This modeling effort would complement and benefit from the modeling efforts planned as parts of the NGEE and ABoVE programs and of direct interest to the Arctic LCC.

Estimated Resources: We expect that each of 4 to 5 modeling groups would need support for a post-doc (~ $100,000 annually) plus central support for coordination of the input data sets and collation of the results ($200,000 annually). We expect that significant progress could be made in two years with a total investment of $1.2-1.4 million.

Elevator speech: With the funds invested we have been able to complete an inter-comparison of X models that predict carbon dynamics as permafrost thaws and have found that model projections for total C release range from Y to Y Pg/yr with a total release of methane ranging from Z to Z Pg/yr. These emissions would be sufficient if create a global radiative forcing that is W to W watts/m2 higher than current levels.

**two no-regrets / "shovel-ready" pilots on data evaluation**

2 no-regrets, "shovel-ready" pilots of broad use (interagency, interdisciplinary, … SEARCH):

Justification

Demand for high-resolution climate information (weather, seasonal to decadal, centennial) is rapidly increasing. Data and access to it is also increasingly easier, but what is lacking is information about its scientific characteristics and qualities, and particularly in accessible form to users, managers and decision-makers that are non-specialists. These pilots try to address these needs through the development of protocols of how to best do this.

The goal of these pilots is not to develop the perfect data, but to develop tools that allow evaluation of existing and future datasets with regards to specific needs. The underlying objective is to make data more useful by providing information and specific scientific characteristics about the data so that users understand what they can rely on and where the sources and extent of uncertainties currently are. Ideally, this would serve as a platform on which the scientific community (SEARCH) could help define "best practices" and "best available science".

**Pilot: Development of an Arctic precipitation (snow?) data evaluation protocol**

**(this pilot to aimed to develop a process for future evaluation of other meteorological/climatological products)**

Aligns with SEARCH goals: #1-4

Objective: Provide access to precipitation (snow) datasets with all the necessary translational information for users to make best use of the existing data that is best adapted for their needs.

Collaborative approach :

- catalog existing data products and downscaling efforts for and with A-CADIS

- develop metrics to evaluate key characteristics of datasets and products for Arctic applications (SEARCH, USGS, NCPP, …)

- assemble translational information for existing high-resolution downscaled products (Univ Alaska, NCPP, NCAR, METAFOR)

- provide access to data and associated translational meta-data through A-CADIS

Duration: ~1.5 years (Spring/Summer 2012 - end 2013)

aligns with NCPP, National Academy effort for downscaling

Cost: 250k

- PostDoc: 1.5 years   (probably most suitably located at Univ. Alaska)

- Programmer: 3 months

- A-CADIS Data management: 3 months (implementation of meta-data and diagnostics suite)

**Pilot: Development of a prototype for an operational sea-ice data evaluation protocol**

(closely aligned and integrated with SIO and SIWO)

Aligns with SEARCH goals: #1 (2-4)

Objectives:

(a) Provide access to sea-ice data products with all the necessary translational information for users to make best use of the existing data that is best adapted for their needs.

(b) Develop an operational evaluation tool for sea-ice seasonal forecasts and hind-casts

Collaborative approach :

- catalog existing data products and downscaling efforts for and with A-CADIS / NSIDC

- develop metrics to evaluate key characteristics of datasets and products for Arctic applications (SEARCH, NSIDC, Coast Guard/Transportation, Energy exploration, …)

- assemble list of key prediction targets (NCAR-CESM, NSIDC, Univ. Alaska, Univ. Washington, …SEARCH, Agencies)

- develop prototype for an extended SIO and SIWO target suite

- develop prototype of an evaluation of forecasts with observations incl. hind-cast evaluation suite

- assemble translational information for existing high-resolution / downscaled products (NSIDC, NCPP, NCAR, METAFOR)

- provide access to data and associated translational meta-data through A-CADIS

Duration: 2 years (Fall 2012 - Summer 2014: first prototype for summer/fall 2013, evaluation into spring/summer 2014)

aligns with NCPP, National Academy effort for downscaling

Cost: 500k

- Science: 6 months  (probably ideally in Boulder area … NSIDC, NCAR-CESM, NOAA, NCPP)

- PostDoc: 2 years

- Programmer: 1 year

- A-CADIS Data management: 3 months (implementation of meta-data and diagnostics suite)

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National Center for Atmospheric Research

RAL - Climate Science and Applications Program

## Ocean-Outlet Glacier Interaction: Developing functional relationships to improve projections of future land ice loss and sea level rise

#### Justification:

The rate of sea level rise has increased with warming climate in recent years. This increase is expected to continue for decades to come although details of its evolution are not yet possible. Satellite observations of the spatial patterns of change identify the ocean as the primary forcing of most of the recent acceleration and retreat of outlet glaciers and their consequent loss of ice volume. More limited ocean observations in waters proximal to outlet glaciers confirm that warm sub-surface water masses arrive immediately prior to phases of increased outlet glacier activity (i.e., calving, acceleration, thinning, and retreat). What is lacking is a deterministic link between the circulation of ocean water masses and the eventual response of the glacier. Functional relationships capturing this interaction are required before larger-scale climate models can produce credible predictions of the contributions of glaciers and ice sheets to future sea level.

#### Description:

Oceanographic observations must encompass the full spatial scope of this interaction: from deep ocean waters, across the continental shelf and into the fjord of a suitable outlet glacier. Bottom tethered buoys and gliders could be employed to collect the necessary data by sampling in both space and time to record the movements of different water masses driven by general circulation patterns and modulations driven by changing atmospheric winds. Extending the observations onto the glacier must include monitoring the speed of the glacier, calving at the ice front and thickness changes along the length of the glacier extending upstream a distance at least 20 times the ice average glacier thickness. These data could likely be collected by time-lapse cameras augmented by occasional aerial surveys.

Understanding the links between these data requires sophisticated ocean circulation models and ice dynamics models. Initialization of these models requires the additional collection of basin geometry: bathymetry in the ocean portion, and ice sounding in the ice-filled portion.

#### Objective:

Functional relationships of ocean-ice interaction that allow the quantification of glacier response (particularly ice volume loss) when ocean circulation patterns are known. This “missing link” will enable climate models capable of projecting such ocean circulation patterns to extend their projections to quantitative values of future land ice loss.

#### Remarks:

This pilot study will demonstrate a research strategy to allow global climate models to significantly improve predictions of future sea level. It will not, by itself, provide this full capability and will have to be repeated on other outlet glaciers to expand understanding of ocean-outlet glacier interaction to other oceanographic and glaciological situations.

The initial site for this study should either seek a site with simple fjord geometry and/or a site where existing observations are ongoing to leverage off the considerable costs of making the required observations. Known large seasonal variations in both ocean and ice conditions require observations to extend at least a full year and hopefully multiple years.

Metrics of success will include the collection of new bathymetric and ice sounding data; development and deployment of new technology to collect oceanographic data over a full year; links between ocean circulation and ice flow models; and the arrival of functional relationships that allow climate models to deterministically include land ice loss via ocean forcing.

**Mobile ARM Facility**

Goals/Objectives: *Goal #1 (sea ice changes)*

Objective #1 (diverse and new tools to improve sea ice prediction), sub-objectives “b” (AON implementation plan. . . ensuring optimal observation deployment) and “e” (assess present and evolving state of the ice cover)

Objective #2 (breadth of consequences of a seasonally ice-free Arctic Ocean), sub-objective “c” (prioritize observation sites for investigating linkages between sea ice, marine ecosystems and impacts)

Description: The Department of Energy has developed a mobile Atmospheric Radiation Measurement (ARM) facility that allows flexible positioning of its ground-based remote sensing system. The mobile ARM measures the same variables as the stationary ARM facility and therefore can be used to measure radiative fluxes, heating rate profiles, and cloud properties. This facility has already been “marine hardened” to resist corrosion and thus could be deployed at sea. This versatility makes it possible for locating the mobile ARM in the Arctic Ocean, and there is considerable interest within the Arctic research community to do so. An especially attractive option is to position this system in roughly the same location as the former SHEBA project, so that a direct comparison could be made between conditions within the thick, multiyear sea ice of the 1990s and the more recent conditions with considerably thinner, more open pack ice. The typical deployment time of one year for the mobile ARM is also favorable for tracking conditions over an annual cycle, in the same manner as SHEBA.

Timeline: There is a two-year lead time to utilize the mobile ARM if a proposal for usage is approved. This activity is thus more appropriate as one of the later pilot projects, but it still could be done within SEARCH’s five-year timeline to accomplish this round of goals.

Ideas for Implementation: Because DOE already has in place a proposal review process to approve requests to utilize the ARM facility, the major role of SEARCH could be to coordinate ideas for usage into a competitive proposal to address the most important atmospheric measurement needs over the Arctic ice pack. This facilitation could take the form of organizing a targeted workshop to bring together interested participants and coordinating to obtain ship time.

Cost estimates: DOE supports successful proposals with around $150,000 for science support and they also provide support for equipment maintenance, data processing, and quality control services. There is no cost to use the system, but the facility does require a ship for deployment.

**Precipitation on the North Slope**

Goals/Objectives: ***Goal #1 (sea ice changes)***

Objective #2 (breadth of consequences of a seasonally ice-free Arctic Ocean), sub-objective “e” (interactions between Arctic sea ice and societal impacts)

***Goal #2 (Permafrost)***

Objective #4 (Identifying gaps in arctic observing datasets)

***Goal #3 (Land-ice)***

Objective #3 (Improve predictions of pan-arctic surface precipitation), sub-objective “b” (to test how to incorporate precipitation at multiple scales into models )

Description: The Department of Energy deployed an X-band scanning ARM precipitation radar (X-SAPR) in June 2011 in Barrow, Alaska. This radar is able to detect precipitating light rain and snow events that typically occur in Barrow. This instrument measures distributed precipitation along a 100-150km swath along the coastal terrestrial-ocean zone and will help scientists investigate the role of precipitation in multi-disciplinary studies This includes synthesis between oceanic, atmospheric, terrestrial, and hydrological in case studies and with ground measurements. This special data set should be brought to the attention of the Landscape Conservation Cooperatives (LCC) in Alaska to assist in identifying possible needs. The aim is for scientists to use this data in new and creative ways. There is a second radar planned for the North slope borough in Oliktok Point by ???? (date), making distributed precipitation available for a fairly large area.

Timeline: The data is already available through the ARM site.

Ideas for Implementation: Ongoing projects would need to be linked up with the available data. Planning to include analysis of the precipitation data would be facilitated for future proposals. North Slope precipitation from available reanalysis data sets (MERRA, CFSR, ARR and other) could be validated with this data.

Cost estimates: The main cost would be human time required to match projects with the data.

**SEA ICE - PILOT PROJECT IDEAS**

Broader goals and objectives
*(1) Build a sea-ice prediction community of practice:*
• Improve the content, format and delivery of existing and future products from the SIO and SIWO to address information and research needs of key stakeholders (including federal and state agencies) and build a more informed public.
*(2) Evaluate and improve sophisticated predictive models of sea ice on weekly to seasonal time scales:*
• Establish a core group of coupled ice-ocean models that can explore the limits of predictability of the Arctic sea ice as a function of spatial and temporal scales
• Evaluate the types of data that bring about measurable improvements in model performance and predictive capacity and provide guidance on model-based prediction approaches
• Provide a synthesis of different predictive skill assessments for selected high-priority variables
*(3) Address demands for localized prediction and stakeholder-relevant and general-public information:*
• Explore the effectiveness and predictive skill of different approaches to predict ice conditions at the local scale against the reference standard of a geospatial statistical model
• Investigate predictive skill of statistical models in the context of predictability of atmosphere-ice-ocean interaction on seasonal timescales
• Develop rigorous definitions of key sea-ice variables or observables that are applicable and transferable in the context of observing (incl. remote sensing) and modeling
*(4) Improve predictions through targeted observations and data integration*
• Define and assemble data sets to evaluate model performance
• Develop integrated data sets to constrain and improve seasonal predictions at the start of the season
• Validate standard remote sensing ice concentration products in the context of improved model performance

**A. Sea ice prediction on the weather scale**

1. Title: **Improving/Providing Sea Ice Forecasts on the Weather Scale**

2. Which of the draft 5-year Goal(s)/Objective(s) will it advance? **Apply diverse and new tools to improve sea ice prediction from daily to decadal timescales**

3. Description:

* **Data Assimilation – Development and Improvements**
* **Development of a Sea Ice Testbed**
* **Observer Network**

Develop and implement a coordinated, ship-based and coastal community-based observations program that follows a standardized code (and is responsive to ice uses and hazards), reports into a central database, and is used by forecasters or is of value in improving standard products.

4. Timeline/timeframe: **1-5 years**

5. Ideas for how it could be implemented:

* **Targeted workshop on data assimilation with NOAA, NASA, ONR, Environment Canada ($50K)**
* **Workshop on Observer Network with NOAA/NWS, UAF, ACCAP ($25K)**
* **Support of SIF cross-agency coordination body ($25K)**
* **Targeted multi-agency SIF AO supporting all the scales ($5M per year for 3 years)**

**B. Sea ice prediction on the seasonal scale**

1. Title: **Improving/Providing Sea Ice Forecasts on the Seasonal Scale**

2. Which of the draft 5-year Goal(s)/Objective(s) will it advance? **Apply diverse and new tools to improve sea ice prediction from daily to decadal timescales**

3. Description:

* **Integration of remote sensing ice thickness and snow depth data into numerical and statistical prediction models**

The SEARCH Arctic Sea Ice Outlook has underscored the value of integrating data on the state of the ice cover in spring prior to the onset of melt to improve predictions and anticipate regional patterns and anomalies. There is great value in a concerted effort to integrate airborne ice thickness and snow depth data, such as from NASA IceBridge campaigns, and to provide such data sets for assimilation into ensemble simulations of seasonal ice evolution. Such an effort would not only improve seasonal prediction, but may also provide quantitative guidance on where ice thickness and snow depth observations would be of greatest value in a seasonal prediction framework.

4. Timeline/timeframe: **1-5 years**

5. Ideas for how it could be implemented:

* **Compilation of profile/gridded data sets of ice thickness and snow depth from spring airborne surveys ($100k for 1-3 years)**
* **Ensemble simulations with assimilated ice thickness and snow depth data to assess relative merit of observation campaigns for seasonal-scale predictions ($100k for 1-3 years)**

**C. Sea ice prediction on the climate scale**

1. Title: **Improving/Providing Sea Ice Forecasts on the Climate Scale**

2. Which of the draft 5-year Goal(s)/Objective(s) will it advance? **Apply diverse and new tools to improve sea ice prediction from daily to decadal timescales**

3. Description:

* **Improving representation of ice albedo in climate models through remote-sensing and ground-based studies**

First-year ice is now the predominant ice type in the Arctic, yet parameterizations of sea ice albedo in climate models are mostly based on multiyear ice data. Moreover, we are lacking information on regional and interannual variations in ice albedo as driven by large-scale Arctic climate change. The latter limits our ability to predict future, rapid change as a result of ice albedo feedback. A concerted effort, centering around existing aircraft campaigns (such as NASA IceBridge Flights) and a focused pilot experiment at a first-year sea ice site can help develop a strategy to improve climate models and provide guidance on remote sensing programs in addressing this shortcoming. Moreover, such a pilot project would also provide help evaluate the potential synergies and mutual benefits of seasonal prediction and studies of interannual variations and trends in the state of the Arctic ice cover.

4. Timeline/timeframe: **3-5 years**

5. Ideas for how it could be implemented:

* **Pilot study at coastal location in conjunction with airborne/satellite remote sensing data to evaluate program concept ($250k for 1 year)**
* **Full-scale surface-based and remote sensing observations at a representative site in first-year sea ice ($5M for 1 year)**

**SEARCH Sea Ice Outlook – unique synthesis approach**- Expand comparative graphics (time, regional)
- Iconic datasets
- New research notes