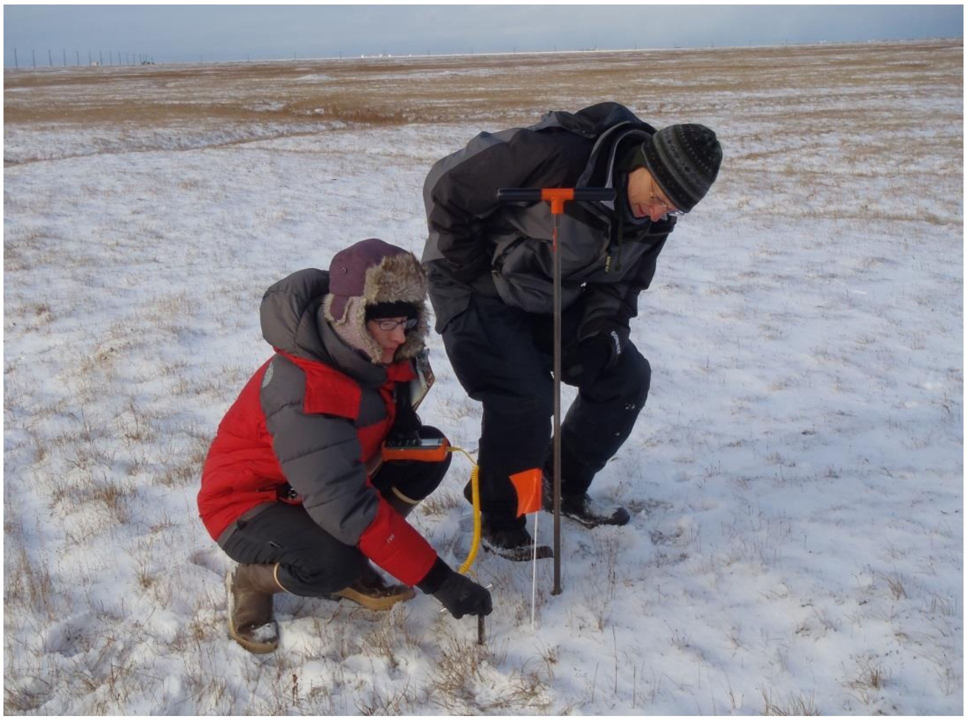
ORNL IDMS 16090

# Project Manual

## Next-Generation Ecosystem Experiments—NGEE Arctic



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OAK RIDGE National Laboratory

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# PROJECT MANUAL
# NEXT-GENERATION ECOSYSTEM EXPERIMENTS—NGEE ARCTIC

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# Applicability

This manual is required reading for all NGEE Arctic participants prior to commencing any work funded through ORNL as part of the NGEE Arctic Project.

Revision Record

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| 0 | 04/15/2013 | Initial Issue | S. Wullschleger |
| 1 | 04/23/2014 | Annual Review | S. Wullschleger |
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# Abbreviated Terms

| | |
|---|---|
| ACTS | Assessment & Commitment Tracking System |
| ARM | Atmospheric Radiation Measurement |
| BARC | Barrow Arctic Research Center |
| BEO | Barrow Experimental Observatory |
| BER | Office of Biological and Environmental Research |
| BNL | Brookhaven National Laboratory |
| CATS | Corrective Action Tracking System |
| CDIAC | Carbon Dioxide Information Analysis Center |
| DAAC | Distributed Active Archive Center |
| DIF | Data Interchange Format |
| DOE | US Department of Energy |
| EESD | Energy and Environmental Sciences Directorate |
| EOMI | Experiments, observations modeling, and investigations |
| ESG | Earth System Grid |
| FGDC | Federal Geographic Data Committee |
| GHG | greenhouse gas |
| IL | institutional lead |
| IPCC | the Intergovernmental Panel on Climate Change |
| ISO | International Organization for Standardization |
| LANL | Los Alamos National Laboratory |
| LBNL | Lawrence Berkeley National Laboratory |
| LRD | laboratory research director |
| NetCDF | Network Common Data Form |
| NGEE Arctic | Next-Generation Ecosystem Experiments |
| NGO | nongovernment organization |
| OOTD | officer of the day |
| ORNL | Oak Ridge National Laboratory |
| POC | point of contact |
| R&D | research and development |
| SCM | software configuration management |
| SIMS | Sample Information Management System |
| SOM | soil organic matter |
| STL | science team lead |
| UAF | University of Alaska Fairbanks |
| UCAMS | Unclassified Computer Account Management System |
| UV-CDAT | Ultra-scale Visualization-Climate Data Analysis Tools |
| WBS | work breakdown structure |

## Quality Policy

It is the policy of the Next-Generation Ecosystem Experiments (NGEE Arctic) project to maintain a cost-effective, risk-based, graded approach to quality assurance. The approach will ensure the safe, efficient, and repeatable performance of work performed by the project participants. Quality is given equal consideration with cost and schedule in the planning, execution, and reporting of this work.

## NGEE Mission

Characterized by vast amounts of carbon stored in permafrost and a rapidly evolving landscape, the Arctic has emerged as an important focal point for the study of climate change. High-latitude ecosystems, particularly those of the Arctic tundra, are sensitive to environmental changes, yet the mechanisms responsible for those sensitivities are not well understood and many remain uncertain in terms of their representation in Earth System models. Increasing our confidence in climate projections for high-latitude regions of the world will require a coordinated set of investigations that target improved process understanding and model representation of important ecosystem-climate feedbacks. The NGEE Arctic project seeks to address this challenge by quantifying the physical, chemical, and biological behavior of terrestrial ecosystems in Alaska. Initial research will focus on the highly dynamic landscapes of the North Slope, where thaw lakes, drained thaw lake basins, and ice-rich polygonal ground offer distinct land units for investigation and modeling. The project will focus on interactions that drive critical climate feedbacks within these environments through greenhouse gas (GHG) fluxes, changes in surface energy balance associated with permafrost degradation, and the many processes that arise as a result of these landscape dynamics.

The overarching goal of the NGEE Arctic project is to reduce uncertainty in climate prediction through improved representation of Arctic tundra processes. A focus on scaling based on process understanding and geomorphological units will allow us to deliver a process-rich ecosystem model, extending from bedrock to the top of the vegetative canopy, in which the evolution of Arctic ecosystems in a changing climate can be modeled at the scale of a high-resolution Earth System model grid cell. This goal includes mechanistic studies in the field and in the laboratory; modeling of critical and interrelated water, nitrogen, carbon, and energy dynamics; and characterization of important interactions from molecular to landscape scales that drive feedbacks to the climate system. A suite of climate-, intermediate- and fine-scale models will be used to guide observations and interpret data; process studies will serve to initialize state variables in models, provide new algorithms and process parameterizations, and evaluate model performance. The NGEE Arctic project will also develop innovative communication and data management strategies as we work both within a multidisciplinary team environment and with the larger scientific community to chart a course for an improved process-rich, high-resolution Arctic terrestrial simulation capability.

## Goals and Objectives

Our goal for NGEE Arctic is to reduce uncertainty in climate prediction through improved representation of critical tundra processes. Initial research will focus on the highly dynamic landscapes of the North Slope of Alaska. We will address, for these complex terrestrial ecosystems, how permafrost degradation in a warming Arctic and how the associated changes in landscape evolution, hydrology, soil biogeochemical processes, and plant community succession, will affect feedbacks to the climate system.

Two objectives will be particularly important as we undertake studies in the Arctic:

- Identify processes likely to have the largest influence on climate, based on current knowledge of the Arctic tundra system, and define a connected (nested) hierarchy of modeling scales necessary to resolve those processes.
- Develop a quantitative scaling framework that provides effective migration of new knowledge gained through process studies and observations to inform model representations and to improve prediction of Arctic ecosystem dynamics and interactions with climate at the global scale.

# Project Organization

The NGEE Arctic project involves interdisciplinary scientists, collaborating across multiple national laboratories and universities in the United States. The project resides within the Energy and Environmental Sciences Directorate (EESD) of Oak Ridge National Laboratory (ORNL). This project is composed of a laboratory research director (LRD), a chief scientist, and science teams, each of which has a science team lead (STL) and contributing research staff and collaborators. Institutional leads (ILs) have been designated to assist the LRD in planning and tracking budgets and deliverables across the science topic areas.

Data management is provided to the project, led by a data management lead. Infrastructure and support are provided through the participating institutions and subcontracted services where prudent. The scientific advisory board (SAB), consisting of experts not affiliated with the project from the academic, government, and nongovernmental organization (NGO) sectors will be created. The SAB, LRD, chief scientist, STLs, and other project personnel will have clearly defined roles and responsibilities

## *Matrix Organization*

The project is managed through a matrixed management process (Figure 1). The project core team consists of the LRD, chief scientist, project manager (PM), and multiple STLs. The core team establishes the management process for the project and meets to discuss progress, interactions, risk management, and issues for the project. It is the decision-making body for the project with ultimate decision-making authority held by the LRD.

## *Roles, Responsibilities, Authorities, and Authorization*

**Laboratory Research Director**—ORNL provides the LRD of the NGEE Arctic project. The LRD has overall responsibility for the NGEE Arctic project and serves as the single point of contact (POC) for direct communications with program managers at the US Department of Energy (DOE) Office of Biological and Environmental Research (BER). The LRD provides scientific leadership and ensures the integration and success of the project by soliciting advice from the external SAB and by seeking feedback from STLs, ILs, and staff. The LRD has full authority to manage all aspects of the NGEE Arctic project with DOE approval and works closely with the chief scientist and the STLs for updates of milestones/deliverables and financial reports. The LRD oversees capability and facilities development, including leadership and succession planning, national and international collaboration, and outreach.

**Chief Scientist**—The University of Alaska Fairbanks (UAF) provides the chief scientist for this project. The chief scientist shares responsibilities for the scientific and technical direction of the project and establishes connections to the national and international scientific community. The chief scientist has the authority to represent the project goals and objectives to the larger Arctic science community and to seek out collaborators on behalf of the project.

**Institutional Leads**—These leads have responsibilities that bridge the gap between the project and their institutions, including the channeling of advice and feedback from their institutions to the LRD, tracking budgets for their institution against the deliverables, providing status updates to the core team, assisting with planning and reviews, and anticipating and resolving any staff issues.

**Science Team Leads—**Each science team plus Data Management has a designated lead with responsibility for planning and tracking progress of their team. In addition to leading their research area, they are also charged with expanding the list of tasks in greater levels of detail, starting with the high-level tasks included in the project proposal. The STL must estimate and track resources, supplies, equipment, and travel to ensure that the tasks can be accomplished within the budget and time allocated for the project. STLs must perform regular risk assessment and risk management planning to ensure that manageable circumstances do not prevent project success.

**Task Lead**—When an STL chooses to delegate responsibility for a key task to a team member, the team member is assigned the role of key task lead for the key task. The key task lead identifies the necessary activities to complete their key task and can delegate those to task leaders. The task leader is responsible for planning and executing the subtask with responsibility for safety, scope, budget, and schedule as defined by the STL. The task lead must ensure that participants in the subtask have been briefed and updated about any changes in the hazards and controls for their work activities related to the subtask.

**Science Teams** are established within each project phase in direct alignment to the specific tasks.

**Officer of the Day (OOTD)** is a special role assigned by the LRD and is considered the on-site person in responsible charge for the assigned day's activities in Barrow and the Seward Peninsula. The OOTD must ensure that the daily briefing is attended by all on-site participants and that the criteria for the daily briefing are fulfilled. Planning and safety responsibility remains with the task leaders, however, the OOTD has the authority to cancel fieldwork due to severe weather or other unpredictable conditions. In the event of an accident or injury, the OOTD is responsible for making sure that the injured receive care and that the situation is mitigated to prevent additional accident or injury. The OOTD performs an investigation and reports to the injured person's supervisor or institutional representative and to the ORNL laboratory shift superintendent.

**Project Participants**—Anyone funded through the DOE award to ORNL for NGEE Arctic to perform work on the NGEE Arctic Project is a project participant and must meet or exceed the project safety requirements identified in the ***Project Field Safety Manual*** and the ***Project Laboratory Safety Manual***; follow the direction provided by the project core team, the institutional representative for his/her institution, and the task leads; and work to achieve the project objectives according to the projects matrix organization structure.

**Project Manager (PM)**—The PM is responsible for financial tracking, maintaining web site and content, outreach, communication, and dashboard reporting for the NGEE Arctic project.

**Data Manager (DM)**—The DM is responsible for managing the data team, interacting with the NGEE science team, and gathering input and feedback from end users. The data team will oversee the design and development of the data system architecture, including data interoperability and systems operations.

**Scientific Advisory Board (SAB)**—The SAB provides input to the NGEE Arctic project LRD through review of plans, progress, and participation in periodic team conference calls and meetings. The members, who are from the national and international community, represent a wide range of disciplines, including researchers in the carbon cycle and subsurface sciences, ecosystem and climate modelers, representatives from other state and federal agencies, data management specialists, and members who possess traditional knowledge of local tribal entities. Initially, the LPD is staggering the appointments of SAB members and is asking them to serve 2 to 3 years. Members of the SAB who as a result of their association with the project become collaborators on the NGEE Arctic project will be asked to step down from their advisory role.

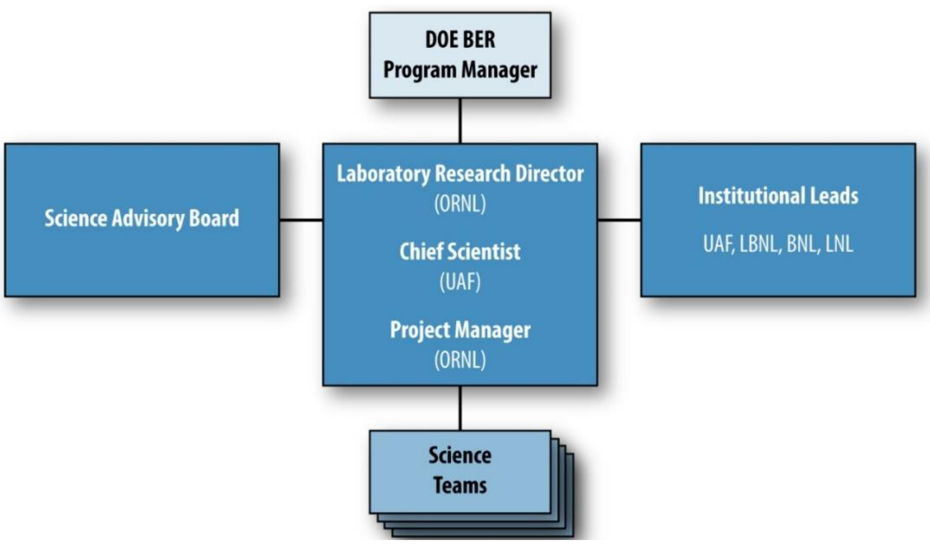


**Figure 1. NGEE Arctic Project Organization.**

# Communication

The NGEE core team recognizes that frequent, clear, and effective communication among research partners is the key to managing a project of this size and complexity and to maintaining its focus on its vision and mission. The NGEE Arctic project has implemented a strategy for communication within the project, with external collaborators, with the larger scientific community, and with program managers and other external stakeholders.

To facilitate the distribution of information, two systems, the NGEE Team mailing list and the NGEE website, have been implemented for the project:

- The NGEE Team mailing list, NGEE_Team@email.ornl.gov, is maintained by ORNL and allows participants to subscribe to group communications and send emails to the group without having to individually maintain lists of active participants. Additional mailing lists have been established for each science team to use for communication specific to their science tasks. These mail lists are moderated by the project manager.
- The NGEE website, ngee.ornl.gov, provides information to participants and nonparticipants about the project. Participants can log onto the site using an ORNL Unclassified Computer Account Management System (UCAMS) or an XCAMS account to upload information or view information restricted to participants.

During trips to Alaska, participants provide discussion and photographs related to their experience via a blog that can be accessed from the NGEE Arctic website. The blog is a public outreach communication mechanism for the project.

In addition, a variety of tools will be utilized to keep team members informed and engaged: conference calls, virtual meetings using web based tools, face-to-face meetings, mini-workshops, and annual retreats will be held to promote discussion, collaboration, and integration within the project. Emerging virtual communication platforms such as that of wiki or social-networking sites will be utilized to support communication with other scientific efforts, the public, and associated stakeholders.

Regular meetings are held (1) between the LRD and the core team (i.e., STLs, ILs, and the chief scientist) to review and resolve any issues with respect to integration and progress and (2) among the NGEE Arctic project team to discuss technical advances in each task. The STLs will meet with their science team and external collaborators regularly to ensure that research tasks are performed appropriately and that progress against outcomes is assessed and reported quarterly.

Quarterly and annual reports will be prepared by the STLs and compiled into final reports by the LRD that will be transmitted to BER so that program managers can review project milestones and research progress.

## *Managing Conflict*

The NGEE Arctic core team's plan is to coordinate a collegial and beneficial project, but they recognize that conflict can occur. Responsibility for the resolution of conflict within the NGEE Arctic Project lies within the project. Conflict shall be resolved by the lowest-level participant with a span of project control over the conflicting parties. The highest level of conflict resolution shall be the LRD.

When conflict cannot be resolved at the lowest level, the project protocol requires the matter to be escalated to the next level: Task Lead to STLs, STLs to LRD. The LRD is the final decision-making authority for the project.

# Training and Qualification

## *Qualified Participants*

NGEE Arctic participants must be qualified through education and experience. Participants who perform research and development (R&D) have both professional degrees in biological sciences, environmental sciences, chemistry, or related scientific disciplines and work experience that constitute qualification. Concern with the quality of the R&D product and individual professional reputation is integral to that background. The knowledge and experience of seasoned researchers is transferred to the less-experienced participants through mentorship within the science teams. Where proficiency must be developed, mentors remain actively engaged until proficiency is achieved. For certain narrowly defined, specific research activities with high risk, more formal performance-based training may be required and implemented.

## *Training*

The project core team has developed and implemented manuals to clearly state the minimum levels of training required for participation in field and laboratory work. These manuals are required reading by project participants prior to engaging in work.

- *The Project Manual*
- *The Field Safety Manual*
- *The Laboratory Safety Manual*

Each home institution may prescribe additional training requirements for their participants.

## *Personnel Recruitment and Succession Planning*

ORNL management, the NGEE Arctic LRD, ILs, and the STLs are committed to successfully staffing this project and to ensuring a continuity of effort. During annual project planning, the core team must assess personnel requirements and must actively manage attrition through,

(1) the strategic hiring of staff, postdoctoral research associates, or graduate students at the national laboratory and university partners;

(2) the development of internal talent to assume increased responsibility; and

(3) establishing external collaborations with researchers who can provide technical expertise. Anticipated personnel changes and planned resolution of staffing gaps must be included in the yearly updates to the program plan and must be included in discussions with DOE program managers.

The core team members, particularly STLs, must lead recruitment of new postdoctoral researchers and strategic staff hires for this project.

# Project Management

## *Facilitating Project Integration*

The NGEE Arctic project has a matrixed organizational structure that was designed specifically to facilitate integration across partner institutions, across disciplines, and of models and experiments.

This organization is strengthened in that many of our measurement tasks contribute directly to models by providing a dataset for model parameterization, process representation, initialization, or evaluation. In turn, many of the modeling tasks are dependent on experiments and observations to provide input.

### Work Planning

Work planning begins with the leadership team where each STL defines the experiments, observations, modeling, and other investigations (EOMI) necessary to execute the project mission. The STL then breaks the EOMI down into key tasks that can at their discretion be delegated for planning to key task leads. Key task leads break the key task down into actionable and can delegate them for complete planning to a task lead.

For work planning, the leadership team is responsible for the following:

- Identifying science questions for the science mission

- Identifying teams and STLs to execute the mission
- Perform Quarterly Review of the work backlog, in-process, and completed to make adjustments
- Further, the STLs:
    - Define the key tasks with appropriate delegation
    - Periodically review their tasking

The key task leader is responsible for the following:

- Breaking down the key task into activities and assign them for planning

The task lead is responsible to actual work planning:

- Estimating the resources needed,
- Potential start and end dates for the activity,
- Identifying the work location for the list approve by the leadership team
- Adding other participants to their task team,
- Update the status of their activities and add appropriate notes
- Safety planning in cooperation with their institutions safety personnel
- Attach relevant files to the task
- Depending on the activity outputs:
    - Developing fieldwork plans if needed,
    - Sample management for samples shipped from the field sites,
    - Identify the data to be collected and completing the data plan
    - Identify model inputs, code location, and outputs when appropriate

## *Periodic Reprioritization of Research Tasks*

The LRD and STLs will evaluate scientific progress and accomplishments during quarterly reviews. It is fully expected that as tasks conclude, opportunities will arise periodically for adding new studies, techniques, and collaborators. The NGEE Arctic projects change control policy for handling such decisions is embedded in the tool used to manage the work. The Core Team will continually assess and implement changes needed for the success of NGEE Arctic goals.

## *Quality Assurance*

The NGEE Arctic project has been planned to include methods for ensuring quality in research and for implementing standard procedures for regulatory requirements. Leadership of the project has been established that provides communication among the teams via the project core team. The core team of this project is committed to the delivery to our sponsor of a process-rich ecosystem model based on the studies and observations of the evolution of Arctic ecosystems in a changing climate.

The project leverages numerous existing systems and is executed with the collaborative efforts of highly qualified researchers. The provision of adequate infrastructure and work environment has been planned in the field and at the participating institutions. Responsibility and budget authority are planned by the LRD and the core team.

The collection of data and samples is planned to ensure long-term viability where appropriate.

# *Risk Assessment and Risk Management*

It is the leadership team responsibility to identify and mitigate risks.

A framework for identifying, monitoring, and managing the risk associated with uncertainties has been established to provide a tool to STLs and the LRD to ensure that risks that threatens the success of the project are mitigated in a timely and efficient manner. Risk assessment/review must be performed quarterly be the STLs and the LRD for their spans of responsibility. While similar to the process used for safety hazard identification and analysis, this process focuses on threats or risks that can prevent the team from achieving the objectives of the project on time and within budget.

## Identify the Risks

A mitigation strategy or action plan must be identified for each risk. Avoidance is normally the best plan for managing risks, and the best mitigation plan is avoidance; however, it is seldom possible. When avoidance is not possible, a strategy for managing the risk by reducing the likelihood and/or the severity must be developed and implemented by the team. If a plan to sufficiently reduce the risk is not possible, then it is important to plan the proper response for use when the risk occurs and ensure that this action plan is communicated to staff who may incur the risk.

Many techniques can be used to identify the risk, for initial risk assessment; brainstorming by the team and/or other experts should be used to identify risks. “Strength, weakness, opportunity, and threat” analysis may also be helpful. The following list contains examples of risks that the project could reasonably expect to encounter:

- Project risks: funding problems, incorrect estimates for schedule or budget, inability to get equipment or supplies, changes in government policy.
- Human risks: loss of a key individual to the project.
- Technical risks: need for a technology advancement that is not yet available, equipment and technical failures, sample integrity during transport.
- Procedural risks: failures of internal systems or controls.
- Environmental risks: safety issues with chemicals, equipment, or wildlife.
- Natural risks: weather, natural disasters, or disease.

Each risk will be assigned to STLs who are expected to incur the risk within their span of control. For risks that span multiple science teams, the risk must be assigned to the LRD.

## Quantify the Risks

A risk value will be calculated for each identified risk. Two values must be estimated to calculate the risk value: likelihood and severity.

***Risk Value = Likelihood x Severity***

Likelihood is a best estimate of the probability of the risk actually occurring and is normally rated according to a simple scale. NGEE Arctic uses a scale of 1 to 5:

5—will occur
4—very likely to occur
3—likely to occur
2—could occur
1—very unlikely to occur

When the project moves past a point where the risk could happen at all, set the likelihood number to zero. This means the risk can no longer be realized and the risk will be hidden from displays, except for history.

Severity is the best estimate of the impact the risk will have to the project when it occurs. The impact of the risk may change over time with the project maturity. It should be evaluated as the impact at the time of the assessment or review of risk. Some projects estimate impact in financial terms and assign a dollar value. NGEE uses a scale of 1 to 5:

> 5—The entire project is disrupted and cannot continue.
> 4—The entire project is disrupted, but with significant re-planning, time, and funding, it can continue.
> 3—Significant cost or delay results, extending the schedule or requiring more funding.
> 2—Additional cost or time is needed, but project may finish on time and on budget.
> 1—The identified risk will have little impact.

Once the risk value is calculated, the project risks are sorted in descending order of risk value. This allows the STLs and the core team to focus on the highest risks to the project.

# Work Processes

## *Safety*

Safety is no accident. It results from the identification of hazards, the planning of controls for the hazards, and the diligent use of the controls coupled with a safety-minded attitude that keeps people aware of changing conditions. The NGEE Arctic core team has established a requirement for a safety process and has included that requirement in the project participants' required reading:

- ***NGEE Arctic Project Field Safety Manual***
- ***NGEE Arctic Project Laboratory Safety Manual***
- ***NGEE Arctic Project Orientation and Safety Video***
- ***Polar Bears, A Guide to Safety Video***
- ***Staying Safe in Bear Country Video***

No work shall begin until hazards are identified, controls are established, and the hazards and controls are described to the task participants. It is required that all participants use the minimum controls established by the project and that any additional controls specified by their home institutions be added.

## *Scientific Investigation*

### Planning

Scientific investigation planning, documentation, and review must be performed prior to the performance of work, including

- Definition of work scope and objectives;
- Description of relevant ideas and concepts pertinent to the research;
- Description of the work planned, methods to be used to perform the work, test equipment inspections, and the results sought;
- Safety planning;
- Risk assessment;
- Identification of samples, equipment, instrumentation;
- Calibration requirements for testing and measuring equipment and analytical instrumentation;
- Identification of computer programs to be used;
- References to pertinent research data and/or other inputs required;
- Requirements for precision and accuracy; as applicable;

- Methods of documentation (reporting) of results;
- Method to manage traceability of input data and output data;
- Names of individuals performing the work;
- Any special controls, environments, or skills anticipated; and
- Identification of and provisions for any special requirements imposed by the partner organization, facility, or local practices.

Items impacting the quality of the research will be identified and selected using sound engineering/scientific principles. Design inputs, as applicable, will be specified, checked, incorporated into the scientific investigation plan, and documented. Specialized equipment may be designed and assembled, as needed, to conduct tasks. The adequacy of the design will be verified prior to implementation.

### Investigation

Scientific investigation activities will be documented using the discipline of the scientific notebook process. This may include hard copy notebooks, but electronic notebooks will be implemented to the extent possible to facilitate interfaces to the data management system. The documentation of scientific investigation activities will provide a description of the work as planned, methods used to perform work, description of method changes, the results obtained, the uncertainty in the results, names of individuals performing work, and names of individuals making the entries.

Scientific notebooks will be reviewed by an independent, technically qualified individual to verify that the detail is sufficient to (1) retrace the investigations and confirm the results or (2) repeat the investigation and achieve comparable results without recourse to the original investigator.

The method for collecting, recording, and evaluating data (analytical results) established in the initial scientific investigation plan must be implemented and augmented as the scientific investigation progresses, in the form of revisions to the plan, additional entries in the scientific notebook, or documentation in additional documents. Identification and traceability of data must be maintained throughout the lifetime of the data. Results will be evaluated by technically competent staff members who did not perform the testing, or by the peer review method as part of verification and validation process for data entering the project databases.

The process for receiving, identifying, handling, analyzing, tracking, and storing samples established in the scientific investigation plan must be implemented.

## Software Development

Software quality assurance practices are an important part of the NGEE Arctic modeling effort. The project has established clear standards for software requirements, design, development, configuration, and verification. It is the responsibility of all members of the modeling team to understand and follow this common set of standards. It is the responsibility of the modeling team lead to communicate these standards clearly to all team members, to address concerns raised by team members and clarify the standards as necessary, and to ensure that the standards are being followed on a task-by-task basis.

NGEE Arctic software quality assurance standards and practices are described here for four categories:

(1) software configuration management,

(2) software procurement and supplier management,

(3) software requirements and design description, and

(4) software verification and evaluation.

## Software Configuration Management

Software configuration management (SCM) is the process of controlling and monitoring change in the life of the software item or software system. SCM activities identify all functions and tasks required to manage the configuration of the software system, including software engineering items, establishing the configuration baselines to be controlled, and the software configuration change control process.

1) NGEE Arctic will use the Subversion software version control system. A primary repository will be maintained at ORNL, with development repositories maintained as appropriate within each modeling task team. Baseline code configurations will be established by the modeling lead for the climate-scale, intermediate-scale, and fine-scale modeling efforts. Modifications to the baseline code configuration will be tracked as revisions in the local development repository, with migration of revisions to the main code repository upon completion of discrete tasks. The repository will persist through the entire NGEE Arctic program.
2) Revisions migrated to the main repository at ORNL will be accompanied by the normal Change Log updates, as currently established by the Software Engineering Working Group of the Community Earth System Model.
3) If the guidelines listed above are followed, subversion repository functionality provides the mechanisms needed to query the history and current status of any software configuration.

## Software Procurement and Supplier Management

The NGEE Arctic modeling STL is responsible for ensuring that subcontracted groups follow the quality assurance practices established within this document and that software revisions uploaded to the central project repository meet the technical and quality requirements established here.

1) For every new revision checked into the central repository at ORNL, the modeling lead ensures that the contributing modeling team has completed the Change Log document (included in the repository).
2) New revisions checked into the main repository will have undergone standard testing. In the case of climate-scale model versions, the relevant parts of the standard test suite will be exercised, and any failures will be documented. In the case of the intermediate-scale and fine-scale models, new tests will be developed and those tests, once established, will be performed, and the results will be documented for any new versions checked into the main repository.

## Software Requirements and Design Description

The requirements for the software being developed and/or acquired will be documented. This is essential to develop and perform effective verification and evaluation activities and to ensure the correctness of the software.

1) Each model development task as defined in the NGEE Arctic Phase 1 proposal and science plan will provide a written statement of requirements and a design approach prior to software development.
2) As the development effort proceeds under each task, the requirements and design document will be updated as needed to reflect changes. For example, requirements may need to be modified if new observations or other modeling effort demonstrates a mechanism that must be represented but was ignored in the initial requirements document.

## Software Verification and Evaluation

Verification is performed throughout the life cycle of the research software. Evaluation activities are performed at the end of the software development or acquisition processes to ensure that the software meets the intended requirements. To maintain objectivity in the verification and evaluation efforts, we rely on standardized test suites for each class of model.

1) As specified in the “Software Procurement and Supplier Management: section, all new revisions checked into the main code repository will have undergone testing through the standard test suites.

2) Any test suite failures will be documented, and it will be the responsibility of the modeling lead to review all test failures to determine the level of severity. Verification will require that new code versions compile and perform according to the requirements document established for each task. In some cases, the existing tests are more stringent than is required for verification, and failures of that sort will be documented and summarized as part of the project annual and final reporting.
3) The NGEE Arctic proposal and science plan provide extensive detail on how the new model versions will be evaluated, relying on data assimilation and parameter optimization methods, and comparing them to independent, integrative observations. Annual and final reporting for each task and for the modeling efforts will document the baseline predictive skill of the models as well as the changes in predictive skill as tasks are completed.

# Data, Document, and Records Management

## *NGEE Arctic Data Portal—Data Management and Framework*

The DMT focuses on producing data guidance, identifying the data being collected, deploying tools to capture metadata and facilitate data submission, educating participants on the use of these tools, creating and maintaining the website, developing scripts to harvest continuous data and ingesting these continuous data into a relational database, generating visualization capabilities for continuous time series, assigning Digital Object Identifiers (DOIs) to data submissions with provider approval, tracking data usage, and continuous improvements to managing data and information throughout the entire program.

For more information on the types and content of data the project will generate, the data formats, sharing, accessing, archiving, privacy policies, and intellectual property rights, please refer to the Data Management Plan document in the Appendix. High-level roles and responsibilities for data management are defined and described in the Management Section of the proposal

### Improvements to Data Management Implementation and Framework

#### Metadata capture

Metadata is captured in the Online Metadata Editor (OME) and materials provided by NGEE investigators. For more information about the OME structure and standards incorporated in the tool, please refer to the Data Management Plan in the Appendix.

The NGEE Arctic portal (**https://ngee-arctic.ornl.gov**) will provide access to the current data sharing policies (i.e., team sharing policies and a fair-use policy), data submission guidance, and data citation recommendations. Communication to the participants about these items will primarily come from the DMT and through the new Data Representatives serving at each institution. The Data Representative assists local team members to apply standards and formatting to the data throughout development while working in collaboration with other Data Representatives and the central DMT to present more consistent datasets across the project.

#### Visualization Planning Tool

The Seward Peninsula Site Key is a beta version visualization-planning tool (projected in Google Earth; **http://ngee.ornl.gov/viz/sites**) to assist in the selection of site locations for major field campaigns. The tool will provide images and information about potential research sites on the Seward Peninsula leading to more informed decision-making for site selections. This tool will be evaluated for its usefulness and growth forward potentially having a description of the site, listing the types of measurements being taken at the site, and links to the associated data.

#### Data Submission and Sharing

To improve communication and implementation of data quality assurance across the project, a Data Representative will be assigned at each major participating institution to serve as a liaison between researchers at the individual institutions and the central DMT. This representative is part of the DMT and will serve as local data support notifying the central DMT of new datasets and synthesis activities; knowledgeable of general metadata standards and guidance in addition to the and DOE SC and BER

"Data Access Plan" and NGEE Arctic; consults on dataset submission preparation; provides assistance and training on NGEE Arctic tools; attends regular DMT meetings; and provides feedback to the DMT of any data related issues, problems and needs.

Data are uploaded using the data submission feature in the Online Metadata Editor (or directly to the secure NGEE Arctic FTP server when data files are large in size or number). A metadata record is required with the data submission. Within the project, data may be shared in participant-provided formats to promote collaboration across the project, awareness of others research, planning for synthesis products, and use by the modeling teams for parametrization and initialization. Data will receive quality levels as defined in quality assurance checks and assigned by STLs in consultation with the DMT. Public data sharing requires consistent data file formats, more complete documentation, and is traceable using a DOI applied to the dataset.

### Data Availability

Data are discoverable through the NGEE Arctic website and NGEE Arctic Search Tool - a tool used by numerous data centers and projects developed using various open-source technologies and providing a distributed metadata harvesting, indexing, and search system. All metadata records are publicly available. Associated datasets and documentation may have access restrictions to project members only until released by the science team to the public. The NGEE Arctic project supports the sharing of data early and often to promote vital scientific collaboration within the project.

Timelines for data submission will vary depending on data type, measurements, analyses, etc. The STLs will define the submission schedules. Data Representatives will monitor these dates at their local institutions following up with STLs when necessary to check on progress and request record updates as needed. Ideal timelines including quality assurance requirements are provided in the Data Management Plan (see Appendix).

### Model Information

The DMT will work closely with the Modeling Teams to enable searches on NGEE Arctic modeling projects and information. The DMT will work with the NGEE Arctic Leadership Team and Modeling Teams to formulate a future strategy for handling model code and output, whether a formal part of the NGEE Arctic data collection or networked elsewhere (e.g., ACME, ESGF).

### Collaboration across BER Projects

Publicly accessible NGEE Arctic data are available to anyone without cost. The NGEE Arctic advanced search interface includes Arctic-relevant data holdings from CDIAC and the ARM Archive. NGEE Tropics data will be included in the interface tool as data become available. CDIAC has proposed a web service and API to interface with CDIAC's NGEE, SPRUCE, and FACE data holdings. Quality checks created for and applied to AmeriFlux data will be applied to NGEE flux tower measurements. Meteorological gap-filling algorithms developed for AmeriFlux by CDIAC will be applied to NGEE Arctic meteorological data to produce the same suite of standardized data files as produced in AmeriFlux. Like FACE and AmeriFlux, NetCDF versions of standard products will be produced to facilitate modeling and synthesis studies. Select, model-relevant NGEE data will be published to the Earth System Grid Federation (ESGF) through the ORNL ESGF node.

### Reporting

The DMT will continue to provide monthly reports to the NGEE Arctic team about the metadata records available in the search tool including new records, updated datasets, DOIs, sharing status, and dataset download information to relevant researchers. The quarterly report submission will provide information on new metadata records for the quarter plus usage statistics including the number of data downloads, the number of unique users downloading data, and internal versus public sharing of metadata records.

The Dashboard on the NGEE Arctic website will provide high-level data summary statistics including the number of NGEE Arctic data collections available publicly, total number of data downloads, and total DOIs assigned to NGEE Arctic data products. Summaries of these statistics will also be included in quarterly reports.

### Community Outreach

The NGEE Arctic website will continue to be upgraded and enhanced to improve the user experience including mobile device access. Website updates provide the public with easy access to released data and model information in addition to existing project descriptions. Participants will continue to have secured access to project restricted information with expanded collaboration capabilities as new modules are added.

### Your User Profile

A profile is established for each participant to provide full contact information to other team members including a face photo, remember we are a large multi-location team it is will be helpful to share what we look like, especially should we meet one day in the field. So please no avatars here, just your smiling face.

Profiles will not be shared publically and will be only searchable by authenticated user. The information that we will request is:

First name and Last name
Email address
Work phone, mobile phone optional
Home Institution
Work Address
Photo

## Measures of Performance

The NGEE Arctic team is committed to tracking and documenting performance related to all aspects of our integrated model-experiment project. As such, we have identified a number of areas for which we will develop quantifiable measures of performance.

Deliverables and outcomes: Each question has associated with it multiple sub-questions, deliverables, and expected outcomes. To achieve their deliverables, each science team has listed Experiments, Observations, Modeling, and other Investigations (EOMIs) that are thought to be necessary. We will use a new project management module on our website to provide real-time access to this work breakdown structure (WBS) to participants and BER program managers. Ultimately, the module will be track deliverables, costs, and achievements of the project. As always, our goal is the timely delivery of tasks and accomplishments within budget.

Scientific productivity: A research project is often defined by publications, abstracts, posters, presentations, and conferences attended. In addition to those normal measures, we add the datasets that we make available for public use and the tools that we release in the form of climate models. We will track and report the statistics in these categories.

Modeling framework: In addition to deliverables, outcomes, and scientific productivity metrics described above for the entire project, important measures of performance for the modeling effort include release of operational, verified, and evaluated code to the broader scientific community, and demonstration of model functional improvements relative to baseline performance using well-defined benchmarking metrics. Our modeling team works under a code sharing policy adopted by consensus, which states (in part): "... our goal as a group is to make developments available to the larger community as soon as possible. Therefore, we will attempt to release codes to the public on submission of the primary paper describing the particular model version." We will generate an annual modeling performance metric quantifying the number of model versions actually released compared to the number potentially releasable under our own policy. Another useful performance metric is the demonstration of improvement in model skill against a common set of benchmarks. The Program will make regular updates to its benchmarking database and will provide an annual review of model benchmarking performance.

Data management infrastructure: It is critical that as we develop a scientific understanding of Arctic ecosystems, through process studies and models, we make that knowledge available to the larger scientific community. The NGEE Arctic project is doing that through a data portal, where information generated through our analyses will be accessible in a user-friendly environment.

Leadership: While we will be careful to focus on the tasks at hand, we will also provide where appropriate scientific leadership through involvement in state and federal agency activities that will benefit from input from our multidisciplinary team of investigators. We will explore international collaborations and/or involvement in activities that will strengthen our ultimate goal of understanding carbon cycle processes across the pan-Arctic.

Safety: Given the remote setting of the NGEE Arctic project, an important measure of performance will be scientific accomplishments in the field and the laboratory supported by a sound safety plan and strong safety record. A safety meeting is held every day that participants will work in the field, we hold people accountable for attention to safety procedures.

We developed a safety plan for NGEE Arctic partners and collaborators that is implemented through two additional manuals and three videos delivered via our required safety training website. Reading and viewing the manuals and videos is mandatory for all participants prior to embarking on a trip for fieldwork. A link to these manuals and videos is also provided within this document, see Appendix - References.

# Procuring Materials, Equipment, and Services

## *Qualified Suppliers*

Each institution must identify qualified suppliers for all instruments, materials, and services that are critical to project success. A graded approach to qualification shall allow appropriate rigor in the qualification commensurate with the criticality of the goods or services purchased. Qualification is typically based on past experience with the supplier, recommendations from peers or colleagues, and supplier documentation. When needed, assessments at the supplier site and other types of supplier monitoring must be designated as a part of the procurement package to ensure the delivered goods or services are of the specified quality, cost, and delivered as required.

## *Deviation and Nonconformance Control*

When goods or services fail to meet the specified requirements they are nonconforming and must be controlled to prevent their inadvertent use. Nonconforming characteristics for services, purchased items, process parameters, or other sub-standard conditions are reviewed when discovered and a suitable disposition is proposed and approved. Those non-conformances for which quality or safety concerns outweigh cost and scheduling restraints are reported to the Science Team Lead for documentation and disposition decision. The disposition decision shall determine if the goods or services must be rejected, must be re-worked to be acceptable, or if the nonconformance is not significant to the research and can be used as-is. Nonconforming goods or services must not be used unless specified for use in the disposition decision:

- Rejected goods or services must be clearly marked as nonconforming and returned to the supplier where practical.
- Reworked goods or services must be re-examined in accordance with the original acceptance criteria. Repaired items must be repaired items must be re-examined to assure that the capability of the item to function reliably and safely in its intended use is not impaired. After successful re-examination, the goods or services are no longer considered nonconforming.
- Accepting nonconforming goods or services requires a deviation note to the Project Director to document the decision by the Science Team Lead to accept the nonconformity and proceed with use.

### Suspect and Counterfeit Items

Items or parts that appear suspect or counterfeit are reported to the Science Team Leader. Identification depends on staff being alert to differences, signs of wear, and other characteristics that make an item or part suspect. If items were procured with DOE, funds the items must be reported to the Institutional Lead for handling according to the procuring institutions requirements. Suspect and counterfeit items must not be used; a nonconformance disposition decision must be obtained and followed.

- A suspect item is one in which there is an indication by visual inspection, testing, or other information that it may not conform to established Government- or industry-accepted specifications or national consensus standards.
- A counterfeit item is a suspect item that is a copy or substitute without legal right or authority to do so or one whose material, performance, or characteristics are knowingly misrepresented by the vendor, supplier, distributor, or manufacturer. An item that does not conform to established requirements is not normally considered an S/CI if the nonconformity results from one or more of the following conditions, which should be controlled by site procedures as nonconforming items: defects resulting from inadequate design or production quality control; damage during shipping, handling, or storage; improper installation; deterioration during service; degradation during removal; failure resulting from aging or misapplication; or other controllable causes.

## *Material Handling Storage and Shipping*

Protective measures are necessary to assure precision instrumentation and sensitive or perishable items to prevent their damage or loss and to minimize deterioration. When protective measures are required, the research team must establish requirements for controlling; handling, storage, cleaning, packaging, shipping, and preservation of items to prevent damage, loss, or deterioration.

# Improvement

## *A Culture of Improvement*

The project core team must promote an atmosphere in which all project participants are encouraged to identify problem areas and to suggest improved methods to meet their research goals and the mission of NGEE Arctic. All project participants are empowered to implement improvement when possible and to communicate problems and suggestions to the core team in a “no fault” environment.

### Preventative Action

The project core team strongly encourages the participants to identify conditions that could lead to problems. These conditions must be reported to the Officer of the Day or the Science Team lead for potential action. When a course of action is determined, these actions are preventative actions because they are taken to prevent a problem that has not yet occurred. It is important in building a culture of preventative action and improvement that the participant(s) reporting a condition receive a written acknowledgement and response from the decision maker that defines what action, if any, will be taken.

Preventive actions are based on various sources of information. Preventive action is ingrained in the research process and typically extends to feedback from the integrated safety management process, employee suggestions, sponsor input, self-assessment results, personal interactions, meetings, problems identified in other organizations, and performance data.

The effectiveness of preventive action is often not directly observable. Therefore, indirect indicators are evaluated with respect to associated risk. Examples of indirect indicators include assessment results, performance metrics, employee performance, incident reports, and project reputation.

### Corrective Action

While the project core time is committed to preventative action, the potential does exist for problems to occur. Problems can be reported or discovered in a variety of ways; direct observation by participants during project execution, during assessment and surveillance activities, project self-evaluations, or based on the analysis of project data.

Actions to prevent recurrence of the problem, corrective actions must be determined, documented, implemented, and tracked. Depending on the scope of the corrective action, it may be logged in the affected institutions corrective action tracking system only, or if multiple institutions are affected a parent entry in the ORNL ACTS and child entries in each institutions CAT systems may be specified by the Project Director.

All corrective actions must be reported to the Project Director by Science Team Leads and/or Institutional Leads. The Project Director can designate that a corrective action is significant enough to require that it be reviewed for appropriateness and adequacy before implementation, the implementation verified upon completion, that an extent of conditions review be conducted by participating institutions, and that can require a surveillance to confirm that the corrective actions were made.

## *Lessons Learned*

During the execution of this research project, it is expected that the project team will encounter obstacles and potential hazards. Participants can log information about their experience in the lessons learned section for review by researchers before undertaking work in similar conditions. The project manager will maintain a database of all submitted lessons learned and provide access via the project website.

Lessons learned are to be shared by the Science Team Leads with the project core team and participants. Several methods of distribution are available including discussion at team meetings, email distribution via **ngee-team@email.ornl.gov**, and publication on the NGEE Arctic project website. Institutional Leads must share relevant lessons learn with their institutions lessons learned coordinators.

# Appendix

## *References*

### *NGEE Arctic Project Field Safety Manual*

**http://ngee-arctic.ornl.gov/sites/ngee.ornl.gov/files/data/NGEE%20Team/Safety/ngee_project_field_safety_manual.pdf**

### *NGEE Arctic Project Laboratory Safety Manual*

**http://ngee-arctic.ornl.gov/sites/ngee.ornl.gov/files/data/NGEE%20Team/Safety/ngee_project_lab_safety_manual.pdf**

### *NGEE Arctic Project Orientation and Safety Video*

**http://www.youtube.com/watch?feature=player_embedded&v=mGM1zCPGva8**

### *Polar Bears, A Guide to Safety Video*

**http://www.youtube.com/watch?feature=player_embedded&v=qYnIk0ksfM4**

### *Staying Safe in Bear Country Video*

**https://www.youtube.com/watch?v=e62eB8nAcsc**

### *Officer of the Day Checklist*

**http://ngee-arctic.ornl.gov/sites/ngee.ornl.gov/files/data/NGEE Team/Safety/OOTD.pdf**