Next-Generation Ecosystem Experiments – NGEE Arctic

Quarterly Report
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A progress report submitted to

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Performance Reporting via NGEE Arctic Project Dashboard

A NGEE Arctic dashboard is being developed that when completed will provide project participants and BER Program Managers with on-line access to a variety of progress and performance indicators. Multiple drilldown options will be available in areas of interest. This dashboard will constitute a new approach to scientific project reporting as it will leverage lessons learned in the business world to gain a quick and efficient "at-a-glance" summaries of project metrics and indicators. A preliminary definition of the metrics and indicators has been completed that integrates the relevant performance criteria with important project management metrics for cost, schedule, resources, risk, and safety. A series of traffic light and other visual indicators will characterize management criteria across the project and for each of the science teams, and will allow users to view up-to-date project and task-specific highlights. The user will be able to drill down to lower-level scorecards that provide performance information on specific metrics for each of the dashboard categories. Project reporting for a particular task will include:

- Progress against proposal,
- Status of the budget,
- Resource availability and staffing,
- Safety performance,
- Risks and mitigation strategies, and
- Science highlights

Selecting any task description will open a scorecard listing the subtasks and their status. Periodic re-planning by the Core NGEE Arctic Science Team can cause subtasks to be added or deleted and start and end dates to be modified. Scorecards will be updated after re-planning to accurately reflect those changes.

Initial implementation of the project dashboard is planned to be manual with monthly updates, but real-time connection to a database will be available later in the calendar year. Once the database connection is implemented and teams are routinely providing their information, the dashboard will contain the most-current view of project information. That information will be available to project team for project planning and integration, and to the DOE Program Managers for project status reporting.

Details at a Glance

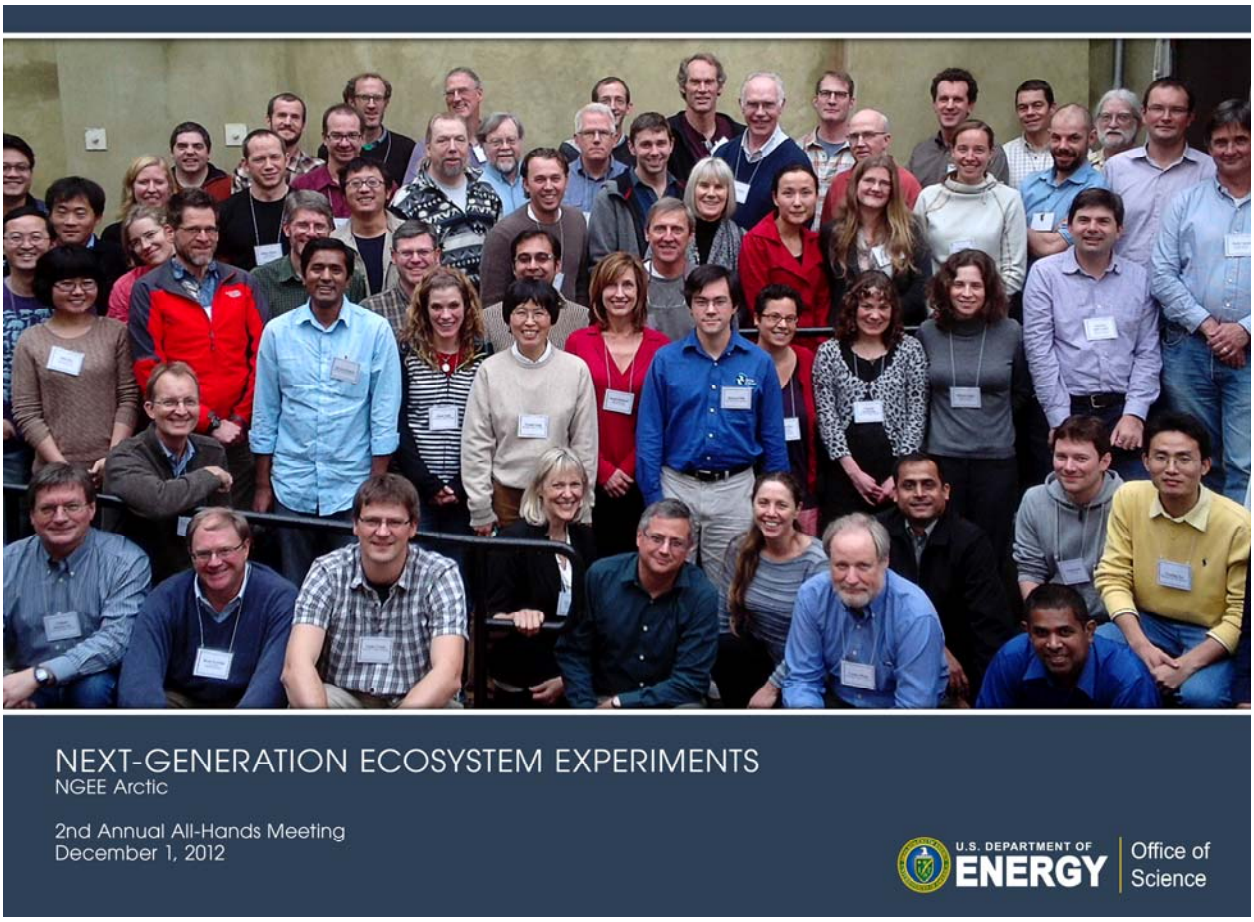
Activities during the October 1 to December 31, 2012 quarter include:

- NGEE Arctic hosts second annual All-Hands meeting
- Permafrost degradation and deforming topography – A modeling challenge
- Linking vegetation composition to geomorphic units in tundra landscapes
- Considerations of scale in characterizing hydrological processes for polygonal ground
- Microbial ecology heterogeneity and pathways as a function of tundra geomorphology
- Photosynthetic characterization of plant functional types from coastal tundra to improve representation of the Arctic in Earth System Models
- Topography influences snow cover, thermal regime, and hydrology for polygonal terrain

Progress and Accomplishments

NGEE Arctic hosts second annual All-Hands meeting:

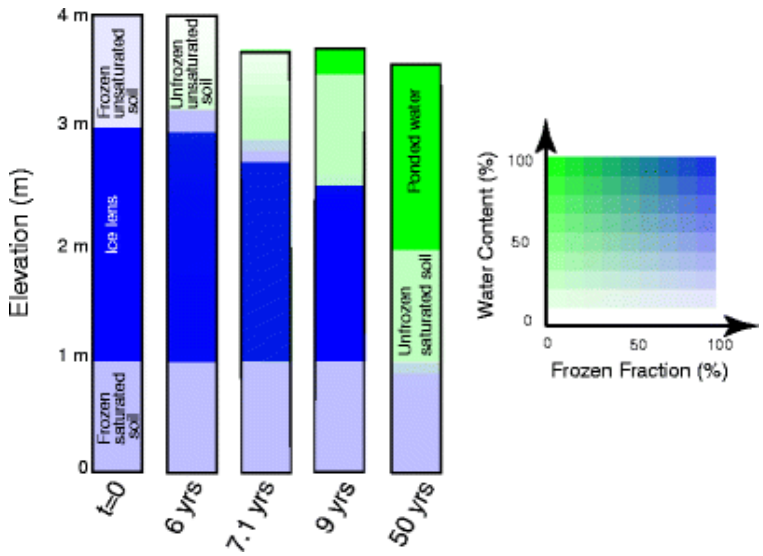
More than seventy participants in the NGEE Arctic project met on December 1, 2012 for the team's second annual All-Hands meeting. The one-day meeting was held at the Shattuck Hotel in Berkeley, CA (agenda in Appendix). The objectives were to (1) review FY12 milestones, accomplishments, and highlight project deliverables; (2) evaluate and emphasize interactions among teams and between experiments and models; and (3) develop FY13 plans. Summaries were presented by task leaders designated for each of the process understanding and modeling tasks followed by breakout sessions that provided ample opportunity to elaborate upon specific research topics of interest. Presentations focused on results from field, laboratory, and modeling activities. A poster session provided opportunities for individuals to present their research findings and engage in more direct discussion of topics. Field plans for FY13 are now being developed based on initial decisions made at the All-Hands meetings. Discussions with NGEE Arctic Chief Scientist and task leaders after the meeting indicate that although a one-day format prior to the American Geophysical Union (AGU) meetings is convenient, the team needs more time to exchange information during future meetings. Therefore, the All-Hands meeting in 2013 will be expanded to two days with different dates and venues being considered.



Participants in the 2012 NGEE Arctic All-Hands meeting held in Berkeley, CA.

Permafrost degradation and deforming topography – A modeling challenge:

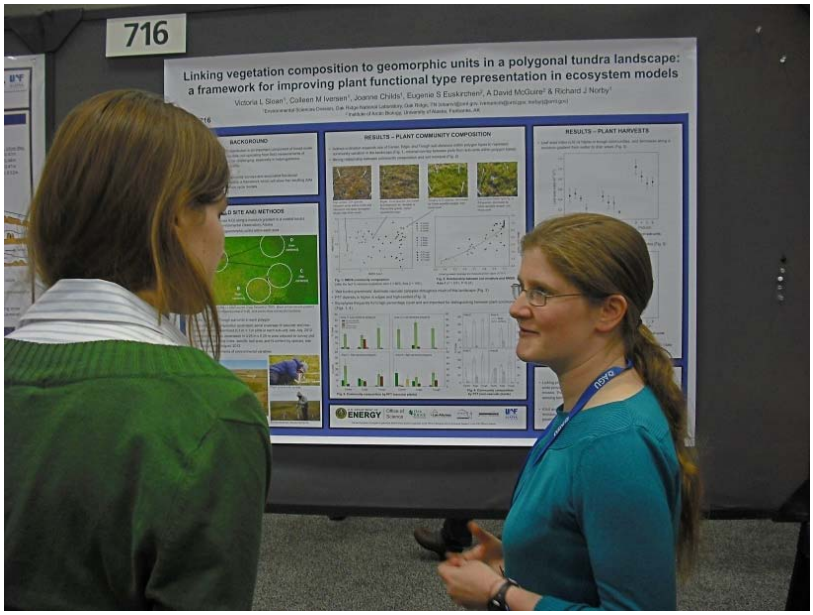
Modeling mechanical displacements caused by permafrost thaw and the associated evolution of surface topography and drainage networks are challenging but important parts of the scientific questions being addressed by the NGEE Arctic team. In an article recently published by Scott Painter and others at LANL in the journal Hydrogeology, the challenges are characterized as being twofold. First, the model must represent physical displacements due to ground subsidence. Second, the model must accommodate the wide range of subsurface conditions: fully frozen to fully thawed soils; unsaturated to fully saturated soils; and massive ice accumulations to low-porosity soils. Although several approximate representations of these processes and properties can be envisioned, systematic understanding of the range of applicability and the consequences of the various approximations is currently lacking. One approximation is shown in the figure that, while simple, captures some aspects of the landscape deformation problem. In this approximation, computational cells are tagged as representing soil regions or massive ice regions. The soil cells are assumed to be of low enough porosity to support the weight of the overlying soil column, while the ice cells are assumed to have high strength in the frozen state and negligible strength once thawed. When an ice cell starts to melt, the volume of the cell is decreased by the volume of melted ice. The overlying soil column is then rigidly displaced downward into the melted volume. In the figure, the blue-green hue represents the fraction of water that is frozen. The color saturation represents the degree of water content; saturated blue and green represent massive subsurface ice and liquid water ponded on the surface, respectively. In the initial state, an ice lens (100 % ice content) is situated above a frozen ice saturated soil (25 % porosity) and below an unsaturated frozen soil. The simulation is started by increasing the surface temperature from –3 to 1 °C over a period of 5 years. As the ice lens starts to melt, computational cells representing the massive ice are decreased by the volume of melted ice and the overlying soil cells move downward into the space left by the melted ice. The melt water raises the saturation in the sinking soil column until it becomes saturated with water; the water then ponds above the soil column (9 years). Eventually, the ice lens is completely melted; the top of the soil column has subsided about 2 m, and more than 1.5 m of ponded water remains above the soil column. This 1-D simulation does not allow for surface flow.



Linking vegetation composition to geomorphic units in tundra landscapes:

Fractional coverage of plant functional types within a grid-cell is a key parameter in broad-scale carbon and nutrient cycle models, but the heterogeneity of Arctic landscapes, where plant communities dominated by differing plant functional types vary at scales of tens of meters,

makes this challenging to estimate. Victoria Sloan (ORNL) elaborated on these challenges in a poster at the 2012 AGU conference where she and her colleagues presented data that quantified plant community composition in relation to geomorphic units (centers, ridges and troughs) associated with a gradient from low-centered to high-centered polygons in the coastal tundra at Barrow, Alaska. They surveyed plant communities in 1 x 1m plots across four polygon types, and undertook destructive harvests to characterize leaf area index, above- and below-ground biomass and plant carbon and nitrogen stocks. Victoria and her team hypothesized that the functional type composition of plant communities is predictable from elevation throughout the gradient, with higher productivity, sedge–dominated communities at wet, low elevation positions and low-productivity lichen-dominated communities at drier, higher elevation positions. Based on data collected, their results support this hypothesis with respect to center and trough communities, but suggest that further classification of polygon type is required to accurately predict ridge community composition. Improved understanding of the links between plant community composition and recognizable geomorphic units in these complex tundra landscapes will provide a framework from which to upscale ecosystem functional measurements, and also to predict the effects of a changing climate on sensitive Arctic landscapes.

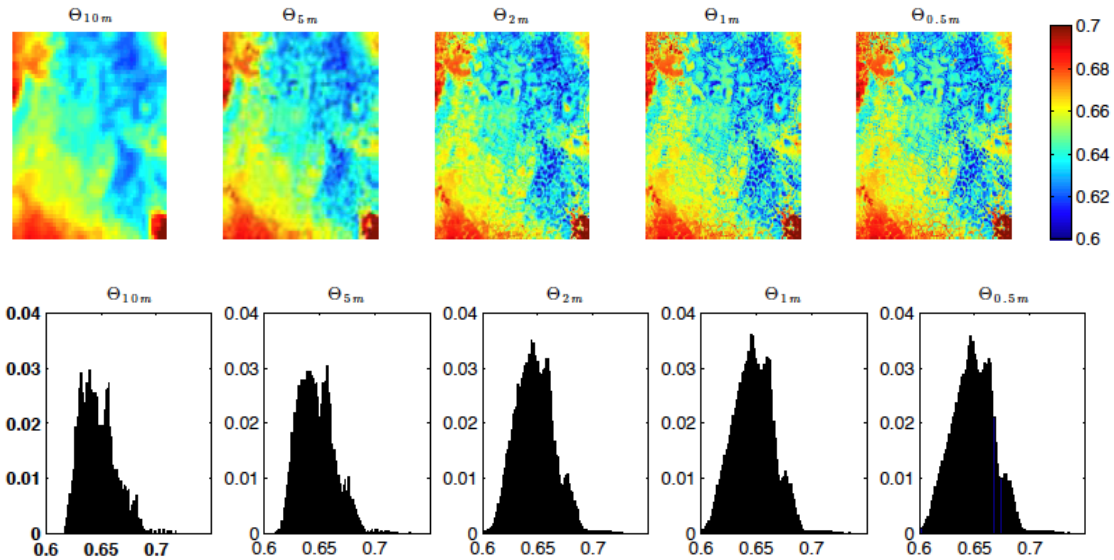


Victoria Sloan (ORNL) talks about her poster at the AGU meetings.

<u>Considerations of scale in characterizing hydrological processes for polygonal ground</u>:

Investigators at LBNL (Gautam Bisht and Bill Riley) are developing methods to characterize and model spatial variability in hydrological processes relevant to polygonal ground at the NGEE Arctic field site in Barrow, Alaska. Low- and high-centered polygons dominate the local hydrologic environment, thereby impacting the energy balance, biogeochemical dynamics, vegetation communities, and carbon releases from the subsurface. Modeling hydrological processes, in particular, and their relationship with geomorphological functional types, will require intermediate (~100-1000 m) scale representation. Currently, process understanding is being implemented in the PFLOTRAN model, while future work will include representing these

processes in the Amanzi model. Simulations across a 500×500 m domain that encompasses the NGEE Arctic domain in Barrow, Alaska were performed with PFLOTRAN to characterize the various soil moisture statistical moments and their dynamics (see figure below). Preliminary results indicated that the system exhibits non-simple spatial scaling behavior, i.e., the statistical moments of the soil moisture do not follow the expected power law relationship with spatial resolution. Gautam and Bill, joined by others from across the NGEE Arctic team plan to use these results to develop surrogate representations that better describe the hydrologic response of various geomorphological functional types that can then be integrated into the intermediate-scale model and ultimately into the grid-scale Community Land Model (CLM).

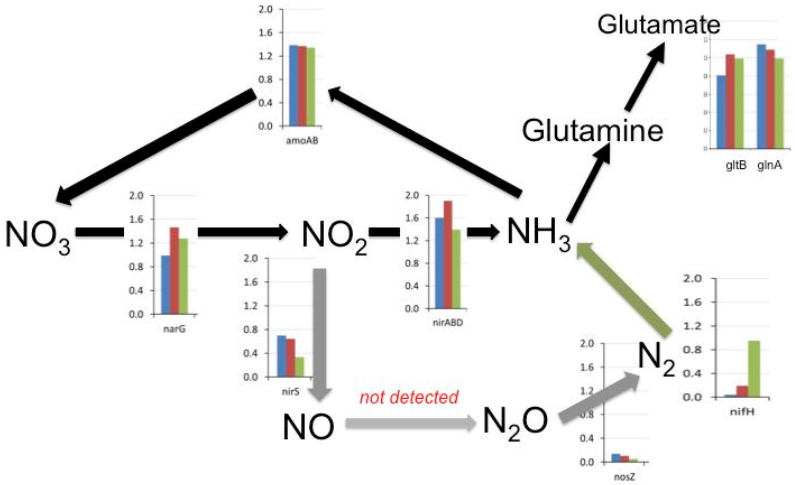


Predicted soil moisture prior to a precipitation event at five model resolutions, along with the corresponding probability density functions of soil moisture. The structure of the probability distribution functions indicate strong spatial correlation of soil moisture across the site.

<u>Microbial ecology heterogeneity and pathways as a function of tundra geomorphology</u>:

Janet Jansson and her LBNL team of microbiologists recently sequenced DNA extracted from soils collected across a 475-m transect on the Barrow Environmental Observatory (BEO) just outside Barrow, Alaska. Samples included organic and mineral soils from centers, edges, and troughs of high-centered, transitional and low-centered polygons. DNA was also sequenced from pore water from the same locations. In addition, Janet and her colleagues extracted and sequenced DNA from a 3 m core from the Barrow site that was sectioned to determine the vertical microbial composition profile. Prior to sectioning, the core was CT-scanned to determine the physical heterogeneity throughout the core. The microbial community compositions in the samples were determined by 16S rRNA gene sequencing and correlated to environmental variables collected from the samples. The microbial community composition varied across polygonal features and the pore water communities were different than communities in the soil samples. Methanogenic archaea were more abundant in low-centered and wetter polygons than high-centered polygons. These data corresponded to higher methane flux measurements from the low-centered polygon. The total metagenomic DNA was also sequenced to obtain information about the functional gene composition. Although many functional pathways were found in all samples, including genes involved in chitin degradation, some pathways were unique to one type

of sample. Genes for sucrose metabolism, for example, were only found in the high-centered polygon and genes involved in methanogenesis only in the low-centered polygon, as predicted by flux data and microbial community analysis. The pathways for assimilatory nitrate reduction and nitrification were found, but not the entire pathway for denitrification (see figure). These data indicate that the potential for N_2O production is not very high in these samples.



Genes involved in the nitrogen cycle detected across the NGEE Arctic trnsect. Relative gene abundances: blue, high centered polygon; red, transitional polygon; green, low-centered polygon.

<u>NGEE Arctic scientists travel to Russia to collaborate on permafrost vulnerability</u>:

A team of university and national laboratory scientists from the NGEE Arctic project traveled to Moscow to discuss research interests in permafrost-dominated ecosystems. The meeting was held November 8-9, 2012 at the Russian Academy of Sciences (RAS) and was co-chaired by RAS Academician Vladimir Melnikov, NGEE Arctic Project Director Stan Wullschleger, and Vladimir Romanovsky from the University of Alaska Fairbanks. This meeting was preceded by one held in December, 2010 at which time DOE, Office of Science Director William Brinkman and RAS Academician Vladimir Fortov agreed to advance collaboration in several energy-related areas of catalysis, hydrogen production, and biofuels separation, and in areas including the current state and future trajectory of arctic permafrost as a significant greenhouse gas feedback to climate. Research priorities for the meeting were agreed upon ahead of time and focused on those topics that have the largest uncertainty in climate models, hold the greatest potential to impact model-based projections of ecosystem feedbacks to climate, and present opportunities where collaboration between US and Russia scientists would yield near-term deliverables. Session topics included (1) thermal state of permafrost in Arctic regions; (2) microbial dynamics in the active layer and upper permafrost; and (3) changes in surface topography (e.g., thermokarst and thermal erosion) associated with thawing permafrost. During the two-day meeting participants reviewed measurements of ground temperature collected from a network of monitoring stations. The Alaskan and Eurasian borehole data sets provide the baseline to reconstruct past surface temperatures, to assess the future rates of change in near-surface permafrost temperatures and permafrost boundaries, and to provide spatial data for validation of climate scenario models. Borehole temperatures show a substantial warming of permafrost during the last 20 to 30 years. The magnitude of warming was typically from 0.5 to 2

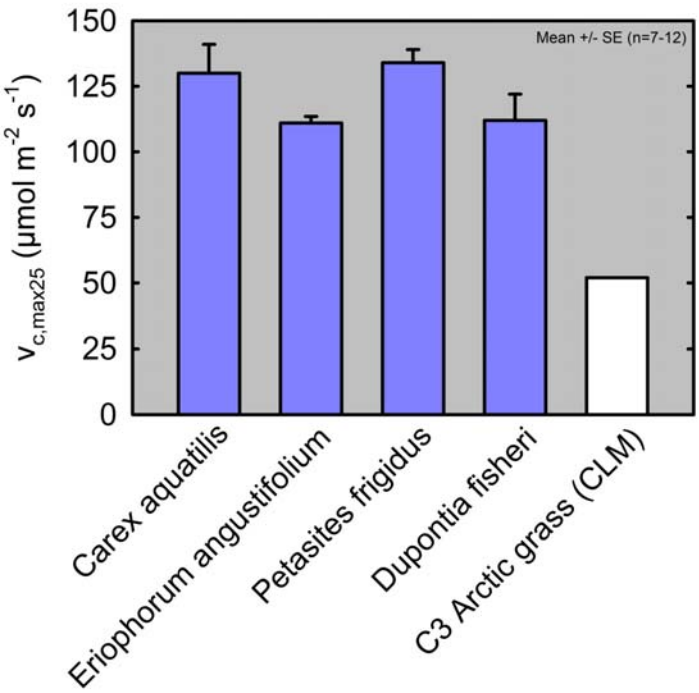
^{o}C. Temperature increases of this magnitude suggest a potential vulnerability of organic carbon stored in permafrost, although the availability of that carbon to decomposition by microbes is uncertain. Opportunities exist to learn more about future greenhouse gas emissions through application of genomic and metagenomic approaches to soil samples collected across the arctic. A warming climate is expected to increase the flux of CO_2 and CH_4 to the atmosphere as a result of thawing permafrost, but also through melting of ground ice, physical subsidence of the landscape, and thermal erosion. Changes in topography associated with permafrost degradation are already being observed across Alaska and Western Siberia. Improved inventories of satellite-derived imagery would facilitate detection, monitoring, and characterization of landscape processes and properties. Task Leaders have been assigned to each of the three session topics and it will be their responsibility to coordinate and track deliverables in the coming months. Quarterly reports will be prepared and submitted to DOE to document progress.

Participants in the two-day Clean Energy Technology *"Permafrost in the Arctic"* Working Group meeting held in Moscow, Russia.

<u>Photosynthetic characterization of plant functional types seeks to improve representation of the Arctic in Earth System Models</u>:

A goal of Earth System Models (ESMs) is to improve understanding and projection of future global change. In order to do this they must accurately represent the carbon fluxes associated with the terrestrial carbon cycle. Photosynthetic CO_2 uptake is well described by the Farquhar, von Caemmerer and Berry model of photosynthesis, and most ESMs use a derivation of this model. One of the key parameters required by the model is an estimate of the maximum rate of carboxylation by the enzyme Rubisco ($V_{c,max}$). In ESMs the parameter $V_{c,max}$ is usually fixed for a given plant functional type (PFT) and often estimated from the empirical relationship between leaf N content and $V_{c,max}$. However, uncertainty in the estimation of $V_{c,max}$ has been shown to account for significant variation in model estimation of gross primary production, particularly in the Arctic. Alistair Rogers, a plant physiologist and biochemist at Brookhaven National Laboratory (BNL) has begun to characterize photosynthetic parameters and N acquisition in the key Arctic PFTs. He measured the response of photosynthesis (A) to internal CO_2 concentration (ci) *in situ* in two sedges (*Carex aquatilis, Eriophorum angustifolium*), a grass (*Dupontia fisheri*) and a forb (*Petasites frigidus*) growing on the Barrow Environmental Observatory, Barrow,

Alaska. The values of $V_{c,max}$ (normalized to 25°C) currently used to represent Arctic PFTs in ESMs are approximately half of the values he measured in these species in July, 2012, on the coastal tundra in Barrow. Alistair, working with others in the NGEE Arctic Vegetation Dynamics Team, hypothesize that these plants have a greater fraction of leaf N invested in Rubisco (F_{LNR}) than is assumed by the models. The parameter $V_{c,max}$ is used directly as a driver for respiration in some ESMs, and in other ESMs $V_{c,max}$ is linked to leaf N content and N acquisition through F_{LNR}. Therefore, these results have implications for ESMs beyond photosynthesis, and suggest that physiological characterization of a more extensive list of PFTs would be a useful resource for ESMs.



Measured rates of carboxylation for Arctic plant species growing on the Barrow Environmental Observatory (BEO).

<u>Advanced inversion method improves geophysical imaging of active layer and permafrost</u>:

Improving the characterization of subsurface variability of the thaw layer and permafrost at high-resolution and over large spatial scales is critical to gain understanding in surface and subsurface processes driving microbial decomposition of organic carbon. A step toward this goal lies in the development of a robust inversion approach for surface electromagnetic induction (EMI) data. Although EMI methods can be used to survey large areas in a limited amount of time, the estimation of electrical conductivity from such data is often strongly non-unique. As such, prior information is often used to constrain the inversion, but there is little guidance about the value of or protocol for using such constraints. Baptiste Dafflon and his colleagues at LBNL developed an approach that permits: (1) a reliable understanding of the electrical conductivity inversion solution space in a manner tractable for large datasets and (2) flexibility in applying prior constraints (obtained from detailed observations at local scale) while still maintaining a clear

understanding of their effects on the inversion results. The approach was applied to Barrow EMI data collected in 2012, which improved the utility of the data for interpreting active layer and permafrost characteristics; two important parameters required for models. A manuscript describing the inversion method has been submitted to the Vadose Zone Journal.

Topography influences snow cover, thermal regime, and hydrology for polygonal terrain:

Ice-wedge polygons are common features in Arctic terrain underlain by permafrost. Permafrost degradation could transform low- into high-centered polygons, causing profound changes in the hydrologic regime of Arctic lands, which in turn, could affect the energy balance and subsurface biodegradation of organic carbon responsible for greenhouse gas production. Understanding the linkages between microtopography, snow cover, thermal properties, and thaw depth is critical for developing a predictive understanding of terrestrial ecosystems and their feedbacks to climate. In this study, Alessio Gusmeroli (UAF) and his colleagues used high frequency (500-1000 MHz) ground penetrating radar (GPR) data acquired at NGEE Arctic field sites in Barrow, Alaska to characterize the spatial variability of snow distribution. Alessio and his team analyzed snow distribution in relation to microtopography, estimated using LIDAR data, and thaw depth, also estimated using GPR collected at different times during the year and simulated over time using mechanistic thermal-hydrologic modeling. The high spatial resolution offered by LIDAR and GPR permit detailed investigations of the control of microtopography on snow and thaw layer depth. Results suggest that microtopographical variations are responsible for substantial differences in snow accumulation. In low-centered polygons, snow depth can be up to four times greater in the troughs than on the rims. Both modeling and observations suggest that the microtopography-governed snow thickness affects the thermal properties of the subsurface and thus the thaw layer thickness; regions with thicker snowpack generally correspond to regions of greater thaw depth. Alessio concludes that a transition from low- to high-centered polygons will not only impact watershed runoff but could additionally impact thaw depth and the propensity for microbial degradation of organic carbon and production of greenhouse gasses.

Science Advisory Board selected for NGEE Arctic project:

Membership on the NGEE Arctic Science Advisory Board (SAB) has been finalized. Members include David Lawrence (National Center for Atmospheric Research), Steven Oberbauer (Florida International University), Walt Oechel (San Diego State University), Mark Parsons (National Snow and Ice Data Center), and Ted Schuur (University of Florida). The SAB is chartered to provide advice, guidance, and counsel regarding the management and strategic direction of the NGEE Arctic project. The SAB is the primary external advisory body to the project and is expected to comment on scientific strategy, research directions, and quality of deliverables from the project's various field, laboratory, and modeling activities. The SAB will review the NGEE Arctic project annually and evaluate progress towards its goal of d*eveloping 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.* The SAB will specifically:

- Review NGEE Arctic project scientific directions and plans,
- Provide advice on scientific and technical issues relevant to the NGEE Arctic mission,
- Monitor progress of the NGEE Arctic team toward project goals,

- Assess scientific quality and timeliness of project deliverables, and
- Prepare a written report documenting advice and recommendations of the SAB to the NGEE Arctic Project Director.

The SAB will have opportunities throughout the year to interact with participants in the NGEE Arctic project. Members of the Board will be invited, but not required, to listen in on monthly conference calls (i.e., Science Talks) during which one or more project participants will summarize a given area of research. Quarterly Reports prepared by the Project Director and submitted to the BER Program Manager will be distributed to members of the SAB. The SAB will meet annually to gain in-depth knowledge of relevant science and technology activities.

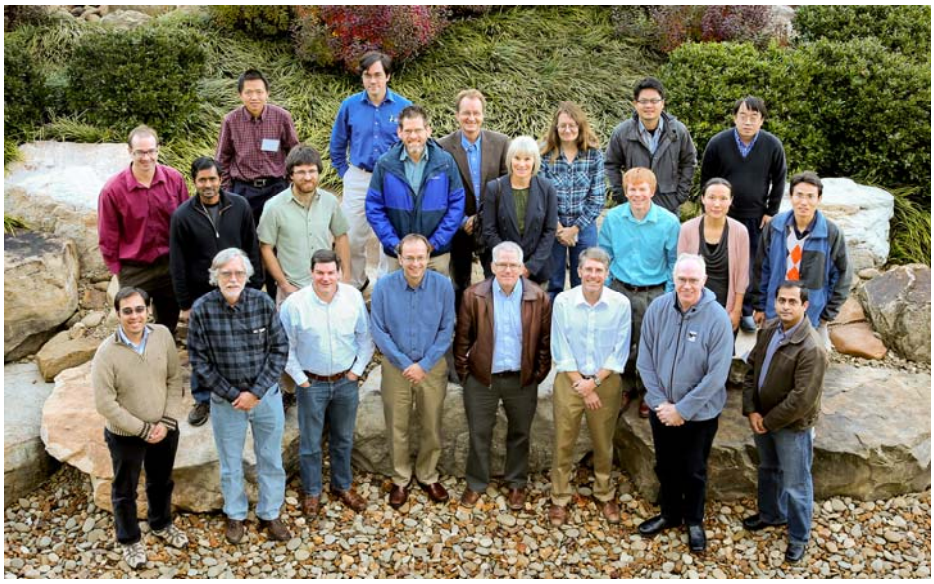
Characterization of deep permafrost structure using seismic surface wave methods:

Deep (> 2m) permafrost structure is relevant to determination of modern and future carbon fluxes in cases where significant unfrozen organic carbon exists co-located with abundant liquid water despite temperatures below 0 ^{o}C. Structures below the active zone with this combination of features are generally under-sampled due to their relative inaccessibility except through deep drilling efforts and geophysical methods including seismic techniques. To assess ice and deep unfrozen water content of permafrost subsoils at the NGEE Arctic site in Barrow, Alaska, seismic surface-wave data were collected by the LBNL Geophysics Team along a 475-meter-long survey line during the spring campaign. Despite the fact that permafrost at the study site was thought to be continuous, ice-rich, and thick (> 350 m), our surface wave study suggests the existence of pronounced low-shear-velocity zones that emerge around 3 to 5 m below the ground surface and extends deeper than 30 m. These zones generally have shear-velocity values that are comparable to unfrozen or partially frozen soils (438−682 m/s). The corresponding spatial extent is also largely consistent with previously observed low electrical resistivity. With both seismic velocity and electrical resistivity values significantly lower than typical values in frozen ground, the deep permafrost subsoils (deeper than 3–5 meters below the surface) along the measured transect are likely to be unfrozen or only partially frozen. Because the ground temperatures of the low-shear-velocity zones are estimated to be around -9 to -8 °C, the team hypothesizes that hypersaline pore-water is one of the plausible mechanisms to prevent these subsoils from being fully frozen. Such hypersaline subsurface features, if confirmed, may have a significant impact on the estimates of carbon degradation and the hydrogeological conditions at the NGEE Arctic site below the active layer.

NGEE Arctic hosts fine- and intermediate-scale modeling workshop:

A workshop was held November 15-16, 2012 at ORNL to discuss implementation of fine-and intermediate-scale modeling for the NGEE Arctic project (agenda in Appendix). The workshop was attended by 20 modelers from across the team. It was agreed that two tracks would be used to achieve Phase 1 deliverables and thereby to position the project strategically for Phase 2 success. Track 1 modeling will use a static representation of surface topography, even where melting of massive ice in the subsurface is occurring. This was a unanimous requirements decision made at the workshop, and reflects the difficulty of the geomechanics problem as well as the need to demonstrate a successful approach to upscaling and downscaling within the Phase 1 effort. By pursuing two parallel development tracks, we expect to commence scaling exercises

using Track 1 models while effort continues to develop and test geomechanics algorithms for the Track 2 models. Our current schedule provides time for the Track 2 models to be at least partially exercised in a scaling framework once code development is complete in July 2014 and before the end of Phase 1 activity in December 2014. Peter Thornton (ORNL) drafted a workshop report and shared that with the NGEE Arctic team and sponsors at BER.



Participants in the fine- and intermediate-scale modeling workshop at ORNL.

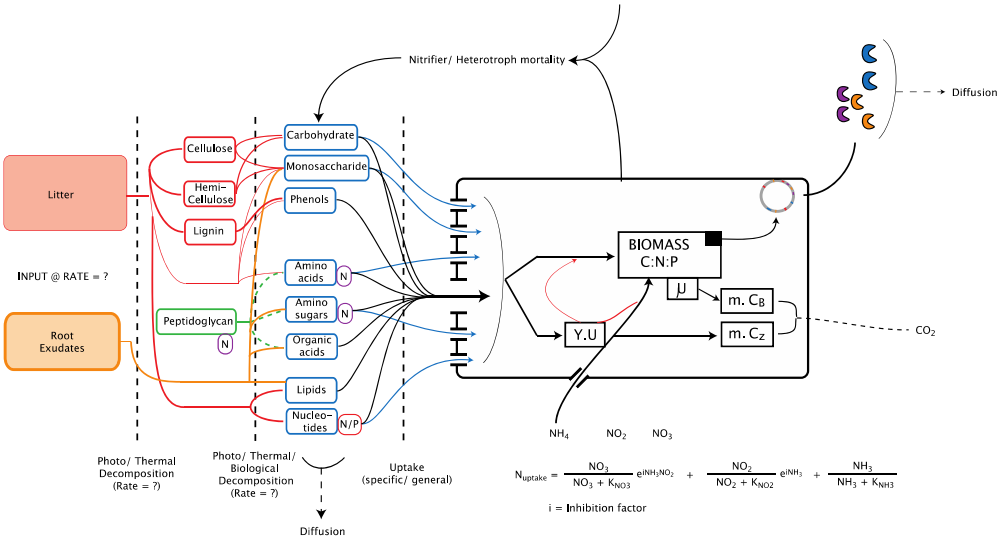
NGEE Arctic initiates monthly "Science Talks":

Monthly science talks in which project participants, collaborators, members of the Science Advisory Board (SAB), and BER Program Managers can call in and hear about recent scientific accomplishments of the NGEE Arctic team are now being held. Science Talks are scheduled for the last Thursday of every month, 3:00pm eastern. Agenda and presentation materials are distributed ahead of time. Four science talks were held in the months of October, November, and December (see attached agendas). Chandana Gangodagamage (LANL) spoke in October on the topic of predicting active layer thickness using statistical learning from remotely sensed high resolution data. Two presentations in November summarized interactions with staff at two prominent BER User Facilities. Janet Jansson (LBNL) spoke about her Community Sequencing Program (CSP) activity at the Joint Genome Institute whereas Baohua Gu (ORNL) spoke about his user proposal at the PNNL Environmental Molecular Science Laboratory (EMSL). Stan Wullschleger spoke in December on his recent trip to Russia. Upcoming presentations include a talk by Haruko Wainwright (LBNL) on Bayesian analysis of Arctic landscape attributes (January 31) and a presentation by Ken Williams (LBNL) on measuring microbial metabolism in Arctic permafrost (February 28, 2013).

Developing trait-based models of microbial processes to inform climate models:

Nick Bouskill, Jinyun Tang, Bill Riley, and Eoin Brodie at LBNL are developing numerical models of subsurface biogeochemistry that explicitly include microbial traits, thereby allowing

prediction of microbial community composition, adaptation, and response to perturbations. In the first application of the method relevant to NGEE Arctic, Bouskill and others introduced a trait-based modeling framework focused on nitrification that represents the ammonia-oxidizing bacteria (AOB), ammonia-oxidizing archaea (AOA), and nitrite-oxidizing bacteria (NOB) using traits related to enzyme kinetics and physiological properties. This team evaluated the model against site level chemical datasets from the interior of Alaska and accurately simulated ammonia oxidation rates and the relative ratio of AOA:AOB biomass. The predicted community structure and activity indicated that (1) parameterization of a small number of traits may be sufficient to broadly characterize nitrifying community structure and (2) changing decadal trends in climate and edaphic conditions could impact nitrification rates in ways that are not captured by extant biogeochemical models. The NGEE Arctic team is currently working to develop surrogate models of the more complex trait-based model for inclusion in the climate model CLM. Along analogous lines, Bouskill and his colleagues are currently developing a trait-based model of heterotrophic microbial communities. The model represents a dynamic energy budget that is scaled against the availability of electron donors and acceptors. Traits encoded in individual guilds include growth rate, carbon use efficiency, and the possession of up to 11 distinct monomer transporters linked to exoenzymes within the guild (see figure below). Emergence of the heterotrophic community depends on the presence of various polymers and trade-offs between physiological traits. Bouskill et al. plan to use this detailed trait-based model to developer lower-order models appropriate for representing biogeochemistry at high latitudes and for inclusion in CLM.



Heterotrophic decomposition model structure for the trait-based representation.

Interactions with other Agencies, Universities, and National Laboratories

NGEE Arctic scientists traveled to Moscow, Russia to explore opportunities for collaboration in areas of carbon cycle processes and permafrost vulnerability. Russian Academy of Sciences, November 9-11, 2012. Moscow, Russia.

Larry Hinzman, Vladimir Romanovsky, Forrest Hoffman, Jitendra Kumar, and Stan Wullschleger met with Julia Boike, project coordinator for PAGE21 to discuss conducting representativeness analyses for their sites in Siberia and those of NGEE Arctic in Alaska. December 4, 2012. San Francisco, CA.

Larry Hinzman and Stan Wullschleger met with Hajo Eicken (UAF) to discuss role of the NGEE Arctic project in the upcoming development of a 5-year strategic plan for the SEARCH program. December 5, 2012. San Francisco, CA.

Stan Wullschleger spoke with Chris Potter, NASA about remote sensing capabilities for the Arctic Coastal Plain and delineation of polygonal ground and thermokarst features. December 19, 2012.

Professor Lise Øvreas, University of Bergen, Norway, is currently visiting the Jansson Lab (LBNL) on a prestigious Fulbright Arctic Chair fellowship for her sabbatical. During her stay, she is collaborating with Jansson on analysis of intact permafrost cores collected from Svalbard, Norway, that will be useful for comparison to the Barrow cores.

Janet Jansson was invited to join the Danish National Center of Excellence on Permafrost Research (CENPERM) as an Adjunct Professor (2012-2015). This will include several trips to Greenland to obtain samples. The goal is to coordinate with NGEE to have a more complete analysis of microbial community structure and function in the high arctic.

Publications, Presentations, and Posters

Publications:

Bouskill, N.J., J. Tang, W.J. Riley and E.L. Brodie (2012). Trait-based representation of biological nitrification: model development, testing, and predicted community composition, Frontiers in Microbiology 3: 1-17.

Dafflon, B., S.S. Hubbard, C. Ulrich, and J.E. Peterson (2012). Electrical conductivity imaging of active layer and permafrost in Arctic ecosystem through advanced inversion of electromagnetic induction data. Vadose Zone Journal (in review).

Gangodagamage, C., J.C. Rowland, C. Wilson, S.P. Brumby and G. Altmann (2012). Spatial and spectral characterization and mapping ice-wedge polygons using high resolution Lidar data: a metric to quantify the degradation level of Arctic polygonal ground. Permafrost and Periglacial Processes (in preparation).

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Beede, M., A. Wagner, S.D. Wullschleger, and J. Zufelt (2012). Simulating soil warming on a permafrost ecosystem in Fairbanks, Alaska. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Bisht, B., J. Kumar, A.K. Liljedahl, W.J. Riley, and P.E. Thornton (2012). Scaling of hydrologic flows due to polygonal ground features in Arctic ecosystems. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Bouskill, N.J., J. Tang, W.J. Riley, and E.L. Brodie (2012). Developing a high-latitude soil carbon cycle model with a focus on trait-based representation of decomposition. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Busey, R., W.R. Bolton, J.E. Cherry, and L.D. Hinzman (2012). Parameterization of an active thermal erosion site, Caribou Creek, Alaska. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Cable, J.M., and W.R. Bolton (2012). Ecohydrology in interior Alaska boreal forest systems. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

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Hayes, D.J., D.W. Kicklighter, A.D. McGuire, M. Chen, Q. Zhuang, J.M. Melillo, and S.D. Wullschleger (2012). The impacts of permafrost thaw on land-atmosphere greenhouse gas exchange in recent decades over the northern high latitudes. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Hinzman, L.D., W.R. Bolton, J. Cable, B. Nijssen, D.P. Lettenmaier, S.D. Peckham, and D.D. Morton (2012). Quantifying interdependence among processes and characterizing dynamic controls across spatial scales by linking climate, hydrology and ecosystem models. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Jansson, J.K., N. Tas, E.L. Brodie, D.E. Graham, T.J. Kneafsey, M.S. Torn, Y. Wu, S.D. Wullschleger, and S.S. Hubbard (2012). Horizontal and vertical profiling of microbial communities across Arctic landscape features near Barrow, Alaska. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Jansson, J.K. Invited speaker: Soil metagenomics. Lake Arrowhead Microbial Genomics Conference. September 17-21, 2012. Lake Arrowhead, CA

Jansson, J.K. Invited speaker: Impact of permafrost thaw on microbial succession. Evolution and Ecology of Microbiota Workshop. September 10-14, 2012. Basel, Switzerland.

Kumar, J., P.E. Thornton, G. Bisht, S. Karra, S. Painter, A.K. Liljedahl, F.M. Hoffman, and R.T. Mills (2012). Active layer and permafrost thermal regimes in ice wedge polygon dominated regions of Alaska. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

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Riley, W.J., F. Maggi, N. Guerry, M.S. Torn, and M. Kleber (2012). Testing hypotheses of soil organic matter dynamics in a mechanistic reactive transport model. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

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Rowland, J.C., C. Gangodagamage, D.I. Moody, and S. Brumby (2012). Application of unsupervised clustering using sparse representations on learned dictionaries to develop land

cover classifications in Arctic landscapes. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Scott, S.E., A.K. Liljedahl, and M. Sturm (2012). Five years of variability in snow depth and active layer hydrologic and thermal regime across an ice wedge polygon in Barrow, Alaska. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Sloan, V.L., C. Iversen, J. Childs, E.S. Euskirchen, A.D. McGuire, and R.J. Norby (2012). Linking vegetation composition to geomorphic unites in a polygonal tundra landscape: a framework for improving estimates of plant functional type coverage in ecosystem models. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Tang, J., W.J. Riley, C.D. Koven, and M.S. Torn (2012). Characterizing the measurements necessary to constrain soil biogeochemistry structural uncertainty in CLM4: a measurement-oriented modeling approach. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Wainwright, H., S.S. Hubbard, C. Gangodagamage, J.C. Rowland, A.K. Liljedahl, A. Gusmeroli, B. Dafflon, C. Ulrich, Y. Wu, C.E. Tweedie, and S.D. Wullschleger (2012). High resolution characterization of heterogeneous Arctic tundra subsurface properties using a multiscale Bayesian fusion approach with geophysical datasets. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Wilson, C.J., J.C. Rowland, D.E. Graham, L. Liang, R.J. Norby, P.E. Thornton, S.D. Wullschleger, L.D. Hinzman, S.S. Hubbard, and A. Rogers (2012). Scaling process studies and observations in the Arctic for improved climate predictability. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Wu, Y., S.S Hubbard, C. Ulrich, B. Dafflon, and S.D. Wullschleger (2012). Monitoring freeze thaw transitions in Arctic soils using complex resistivity methods. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Wullschleger, S.D., D.E. Graham, L.D. Hinzman, S.S. Hubbard, L. Liang, A.K. Liljedahl, R.J. Norby, A. Rogers, J.C. Rowland, P.E. Thornton, M.S. Torn, W.J. Riley, and C.J. Wilson (2012). Improved climate prediction through a system level understanding of Arctic terrestrial ecosystems. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Xu, X., D.A. Elias, D.E. Graham, T.J. Phelps, and P.E. Thornton (2012). Simulating CO_2 and CH_4 production and consumption from incubated permafrost soils: how important are the microbial mechanisms. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Xu, C., R.A. Fischer, J.A. Vrugt, S.D. Wullschleger, and N.G. McDowell (2012). Next-generation carbon-nitrogen dynamics model. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Yuan, F., P.E. Thornton, A.W. King, D.M. Ricciuto, and W.M. Post (2012). Community land model (CLM) assessment on simulating and analyzing water, carbon and nitrogen cycles in Arctic Coast tundra at Barrow, Alaska. American Geophysical Union, December 3-7, 2012. San Francisco, CA.

Workshops Attended:

Society of Exploration Geophysics Annual Meeting November 4-8, 2012. Las Vegas, NV.
Russian Academy of Sciences, November 9-11, 2012. Moscow, Russia
NSF Research Coordination Network (RCN) meeting, December 1, 2012, San Francisco, CA.
American Geophysical Union Annual Meeting, December 3-7, 2012, San Francisco, CA.

Upcoming Meetings:

Joint SEG/AGU Cryosphere Geophysics Workshop (January 6-8, 2013)
North American Carbon Program (February 4-7, 2013)
NGEE Arctic Scaling Workshop (March, 2013)
European Geosciences Union (April 7-12, 2013)
1st Arctic Observing Summit (April 30 – May 2, 2013)

Press Releases and News Clips

Vladimir Romanovsky (UAF) and others associated with the NGEE Arctic project contribute to recent UNEP report on permafrost.
http://www.unep.org/newscentre/default.aspx?DocumentID=2698&ArticleID=9338

Appendix

Next-Generation Ecosystem Experiments (NGEE Arctic)

Second All-Hands Meeting
December 1, 2012
Shattuck Hotel, Berkeley, CA

Meeting Goals:

1. Review FY12 milestones, accomplishments, and highlight project deliverables,
2. Evaluate and emphasize interactions among teams, and between experiments and models, and
3. Develop FY13 plans for the field, laboratory, and modeling tasks.

Tentative agenda:

7:15am – Poster setup; Boiler B

7:30am – Continental breakfast

General Session: Crystal II

8:00am – Introduction (Hinzman)

8:05am – Review FY12 deliverables (Wullschleger)

Task milestones, accomplishments, and next steps

8:15am	Multi-Scale Modeling (Thornton)
8:45am	Landscape Characterization (Rowland, Hoffman)
9:15am	Site Characterization (Hubbard)
9:45am	Hydrology-Geomorphology (Wilson)

10:15am – Break

Task milestones, accomplishments, and next steps (cont.)

10:30am	Biogeochemistry (Graham)
11:00am	Vegetation Dynamics (Norby)
11:30am	Independent Tasks for Model Evaluation (Torn)

12:00 noon – Working lunch

- Polygon nomenclature (Wilson and Graham)
- Field implementation and access plan (Liljedahl, Sloan, and Altmann)

1:15pm – Breakout Groups (Targeting improved interactions between models and experiments)

- Fine- and Intermediate-scale modeling (Painter and Kumar); Boiler A
- Climate-scale modeling (Thornton and Riley); Boiler C

2:30pm – Breakout Group Reports (e.g., uncertainties and action items); Crystal II

2:50pm – Break

3:00pm – Team Discussions (Wullschleger and Thornton)

- Discuss critical outcomes identified in the morning session; make task-specific recommendations for FY13 based on progress and deliverables
- Discuss uncertainties and action items from the afternoon breakout group sessions; identify gaps in field and laboratory data for models and issues related to scaling, and make task-specific recommendations for FY13 based on progress and deliverables

Note: The above discussions will be framed in the context of several integrated questions. For example, task-specific feedback can be provided under a set of overarching questions that might include:

- How can we improve communication and integration among science areas?
- What are the next steps as we include broader range of geomorphological features?
- Are we collecting the right data to inform the models, and what are the gaps?
- What do the measurement and modeling teams need next?

4:00pm – Conclusions and FY13 Plans (Wullschleger)

4:30pm – Must vacate Crystal II, but will still retain use of the three breakout/poster rooms

4:30pm – Breakout Groups (Important topics for FY13 field and modeling activities)

- Upscaling and downscaling methodologies (Thornton); Boiler A
- Identification of DTLB and other sites for FY13 (Wilson); Boiler C

5:30pm – Poster session; Boiler B

6:30pm – Adjourn

NGEE Arctic
Fine and Intermediate-Scale Modeling Workshop

Draft Agenda – last revised 11/5/2012
[Breakfast both days at the ORNL Guest House]

Thursday, November 15th

8:00a – 8:30a	Introductions (30 min) (all)
8:30a – 9:00a	Review of charge, agenda, ground rules (30 min) (P. Thornton)
[9:00a – 2:00p]	Presentation of Requirements Document
9:00a – 10:30a	Fine-scale modeling requirements (90 min)
	Hydrology/thermo-hydrology
	Biogeochemistry
	Vegetation dynamics
10:30a – 10:45a	Break (15 min)
10:45a – 12:00p	Intermediate-scale modeling requirements (75 min)
	Hydrology/thermo-hydrology
	Biogeochemistry
	Vegetation dynamics
12:00p – 1:00p	Lunch (Climate-scale modeling discussion) (1 hr)
1:00p – 2:00p	Software engineering and computational requirements (1 hr)
	Fine-scale modeling
	Intermediate-scale modeling
	Scaling framework (including interaction with CLM)
[2:00p – 5:30p]	Current capabilities, near-term developments
2:00p – 3:00p	AMANZI (1 hr)
3:00p – 4:00p	PFLOTRAN (1 hr)
4:00p – 4:15p	Break (15 min)
4:15p – 5:00p	UAF codes (45 min)
5:00p – 6:00p	Dinner (continued code discussion during dinner) (1 hr)
6:00p – 7:00p	Mapping capabilities to requirements (1 hr)
	Science requirements
	Software engineering and computational requirements
7:00p – 7:30p	Straw proposals (30 min)

Friday, November 16th

8:00a – 10:30a	Framework decisions
10:30a – 10:45a	Break
10:45a – 12:45p	Work plans
12:45p – 1:45p	Lunch (recap of meeting highlights, next steps and solicit final feedback)
1:45p	Depart

Next-Generation Ecosystem Experiments (NGEE Arctic)

Team "Science Talk" Conference Call

October 25, 2012

Agenda

1. Update on recent activities (Wullschleger and others)

    - Briefing of BER Program Managers in Germantown, MD
    - Cathy Wilson's (LANL) trip to Fairbanks, AK
    - Colleen Iversen (ORNL) and Marc Conrad (LBNL) present at Cornell University seminar series
    - Interactions with PIs on current TES solicitation
    - Field implementation and access plan (Anna Liljedahl, Victoria Sloan, and Garrett Altmann)
        - Data implementation checklist
        - Instrumentation contact list and description page
        - Digital and hardcopy visual references (maps)
        - Limited access or no access zones
        - Timeline for map updates, history, documentation of new instrumentation, etc.
        - Implement an instrumentation ID system
        - Identify need for new trail mat and wooden bridges for sustainable site access
    - Future direction of water sample analyses (Jeff Heikoop, Brent Newman, Cathy Wilson)
    - Progress on abstracts and publications

2. Science talk – Predicting Active Layer Thickness using Statistical Learning from Remotely Sensed High Resolution Data (Chandana Gangodagamage)

3. Logistical Support from UMIAQ (Stan Wullschleger)

4. Upcoming events (All)

    - Travel to Moscow, Russia (November 5-11, 2012)
    - Multi-scale modeling meeting at ORNL (November 15-16, 2012)
    - NGEE Arctic All-Hands (December 1, 2012)
    - Permafrost Vulnerability RCN (December 2, 2012)
    - American Geophysical Union (December 3-7, 2012)

5. Future Science Talks
    - November 29, 2012 – Janet Jansson (CSP) and Baohua Gu (EMSL)
    - December 27, 2012 – Stan Wullschleger (Summary of trip to Moscow, Russia)
    - January 31, 2013 – Haruko Wainwright (Bayesian analysis of Arctic landscape attributes)
    - February 28, 2013 – Ken Williams (Measuring microbial metabolism in Arctic permafrost)

6. Action items and notes:

Next-Generation Ecosystem Experiments (NGEE Arctic)

Team "Science Talk" Conference Call

November 29, 2012

Agenda

1. Update on recent activities (Wullschleger and others)

    - NGEE Arctic Publications
        - Bouskill et al. (2012) – Trait-based representation of microbial communities in models
        - Lewis et al. (2012) – Drainage subsidence associated with Arctic permafrost degradation
        - Painter et al. (2012) – Challenges in modeling degrading permafrost
    - UNEP Report: Policy Implications of Warming Permafrost
    - Clean Energy Technology Commission: Trip to Russia

2. Science talk – NGEE Arctic DNA sequencing update (Janet Jansson)

3. Science Talk – Interactions with Environmental Molecular Sciences Laboratory, EMSL (Baohua Gu)

4. Upcoming events (All)

    - Multi-scale modeling meeting at ORNL (November 15-16, 2012)
    - NGEE Arctic All-Hands (December 1, 2012)
    - Permafrost Vulnerability RCN (December 2, 2012)
    - American Geophysical Union (December 3-7, 2012)
    - Science Advisory Board (SAB) meeting (December 4, 2012)

5. Future Science Talks

    - December 27, 2012 – Stan Wullschleger (Summary of trip to Moscow, Russia)
    - January 31, 2013 – Haruko Wainwright (Bayesian analysis of Arctic landscape attributes)
    - February 28, 2013 – Ken Williams (Measuring microbial metabolism in Arctic permafrost)

6. Action items and notes:

Next-Generation Ecosystem Experiments (NGEE Arctic)

Team "Science Talk" Conference Call

December 27, 2012

Agenda

1. Update on recent activities (Wullschleger and others)

    - Multi-scale modeling meeting at ORNL (November 15-16, 2012)
    - NGEE Arctic All-Hands (December 1, 2012)
    - NSF-sponsored Permafrost Vulnerability RCN (December 2, 2012)
    - American Geophysical Union (December 3-7, 2012)
    - Science Advisory Board (SAB) meeting (December 4, 2012)

2. Science talk – Russian Trip Report; Clean Energy Technology Commission (Wullschleger)

3. Upcoming events (All)

    - Joint SEG/AGU Cryosphere Geophysics Workshop (January 6-8, 2013)
    - North American Carbon Program (February 4-7, 2013)
    - NGEE Arctic Scaling Workshop (March, 2013)
    - European Geosciences Union (April 7-12, 2013)
    - 1st Arctic Observing Summit (April 30 – May 2, 2013)

4. Future Science Talks

    - January 31, 2013 – Haruko Wainwright (Bayesian analysis of Arctic landscape attributes)
    - February 28, 2013 – Ken Williams (Measuring microbial metabolism in Arctic permafrost)

5. Action items and notes: